

# **Balancing Authority/Transmission Operator Reliability Readiness Evaluation Report**

**PJM Interconnection, L.L.C.  
Norristown, Pennsylvania**

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## **Introduction and Evaluation Process**

The North American Electric Reliability Corporation (NERC) Reliability Readiness Evaluation and Improvement Program is one of the commitments of NERC and the industry to strengthen the reliability of the North American bulk power system. The program conducts independent evaluations of balancing authorities, transmission operators, reliability coordinators, and other key entities that support the reliable operation of the bulk power system to assess their preparedness to meet their assigned reliability responsibilities. The evaluations identify strengths and areas for improvement in an effort to promote excellence in operations among these organizations.

Since its inception in 2004, NERC and the industry have been working collaboratively to enhance the program. The evaluation process is based on fundamental aspects of reliability: culture, operations, maintenance, planning, and training. The document [\*NERC Readiness Evaluation Procedure\*](#) describes and defines the process used for reliability readiness evaluations. This document and other documents related to the program are available at <http://www.nerc.com/~rap/>.

The reliability readiness evaluation teams, each led by a NERC staff member and a regional co-leader, include industry volunteers with considerable expertise selected to provide representation from other interconnections, other regions, and neighboring operating entities. The teams also typically include representatives from the Federal Energy Regulatory Commission (FERC) staff.

The public version of the reliability readiness evaluation report contains the majority of the evaluation team's findings. Any discussion of findings pertaining to critical infrastructure will be contained in Appendix 1, a confidential appendix to the report that is sent privately to the evaluated entity and is not included in the public version of the report.

An evaluation team met on-site with PJM Interconnection, L.L.C. (PJM) representatives on May 21–24, 2007. This report reflects the views and recommendations of the evaluation team regarding the readiness of the PJM to meet its responsibilities as a reliability coordinator, transmission operator, and balancing authority.

## **Evaluation Team**

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## **Organization Profile**

PJM is a FERC-regulated regional transmission organization (RTO) governed by a 10-member Board of Managers with input from the PJM Members Committee, consisting of a representative from each PJM member. PJM's market and operational authority is derived from various agreements entered into by PJM's members and filed with FERC. PJM administers a FERC-approved open access transmission tariff.

PJM management indicated that PJM originated 80 years ago as a tight integrated power pool, which is the birthplace of the close working relationship that exists today. This working relationship has expanded with recent integrations that have led to a robust transmission system with access to a broad generation portfolio.

PJM reliability functions report to a senior vice president. Reporting to the senior vice president is an executive director who is responsible for PJM system operations. Member local control centers execute specific functions assigned to them according to agreements with PJM, such as transmission system switching. The PJM energy management system (EMS) does not provide direct supervisory control of substation equipment for the PJM system operators.

PJM is the reliability coordinator for the PJM members and manages transmission reliability and wholesale electricity markets in all or parts of 13 states and the District of Columbia. In addition, PJM serves as the reliability coordinator for Ohio Valley Electric Corporation. The PJM service area spans 168,500 square miles and includes 51 million people. The current winter system peak of 119,206 MW was reached on February 5, 2007, while the summer system peak of 145,951 MW occurred on August 2, 2006. PJM's power supply consists of 162,142 MW of generation in the following fuel types: 4.4% hydro, 41% coal, 18.5% nuclear, 6.6% oil, 29% gas, 0.5% solid waste and wind.

The PJM transmission system consists of approximately 56,070 miles of transmission lines ranging in voltage from 34.5 kV to 765 kV (2,125 miles). PJM owns no transmission but oversees the transmission system with members having direct supervisory control of the transmission system equipment.

PJM is a member of the Reliability *First* Corporation and SERC Reliability Corporation (SERC) regions. RFC comprises the bulk of the former MAIN, ECAR, and MAAC regions.

## **Executive Summary**

The evaluation team found no significant operational problems and concluded that PJM has adequate facilities, processes, plans, procedures, tools, and trained personnel to perform the reliability coordinator, transmission operator, and balancing authority functions necessary to maintain the reliable operation of the bulk power system.

Starting with the senior vice president, reliability services, there is a focus on bulk power system reliability and operational excellence. PJM takes a conservative approach to system operations by utilizing a precontingency mitigation strategy for n-1 contingencies and a "Safe Operating

Mode,” developed in conjunction with its neighbor, the Midwest Independent Transmission System Operator (MISO), in which either entity can request the other to take action immediately based on current operating conditions. PJM operates to the most conservative or limiting result in cases where there is a conflict in calculated results between PJM and a PJM transmission owner or neighbor, e.g., MISO. Reliability performance is enhanced through the use of location marginal pricing, which provides a strong financial incentive to follow dispatch signal for balancing and adjusting generation to mitigate transmission congestion. A security-constrained economic dispatch is utilized to ensure that reliable operations are maintained. PJM utilizes two control centers to direct operations.

The evaluation team identified three potential examples of excellence: 1) an effective load shedding implementation plan, 2) capabilities (Smartlog) for collecting EMS and operator-entered event data, and 3) the Daily Review Team, which focuses on continuous daily reliability improvements.

The evaluation team identified 15 positive observations that represent PJM’s ongoing commitment to reliability improvement and reinforce the benefits of the corporate goals of operational excellence and reliability. The positive observations were spread throughout the operational area ranging from training to the implementation of the critical infrastructure protection (CIP) standards.

Eleven recommendations were identified during the evaluation, and PJM identified the following as “key” recommendations: 1) evaluate whether additional alarm processor filtering (alarm types) will improve operator recognition and 2) evaluate consolidating nuclear information into a single nuclear display.

Overall, the evaluation team identified three potential examples of excellence and 15 positive observations. The team also offers 11 recommendations that, if implemented, will enhance PJM’s readiness to operate reliably and maintain the reliability of the bulk power system.

## **Potential Examples of Excellence**

The evaluation team identified the following potential examples of excellence in its reliability readiness evaluation:

- 1) PJM uses a vendor-developed software program called Smartlog, which automatically captures EMS data in an operator log entry format, for post-event analysis, reporting, and shift-change information sharing (Section 2.2.3).
- 2) The load shedding implementation plan includes operator displays (with loadshed allocation by zone) and a notification process to alert transmission owners (Section 2.4).
- 3) The Daily Review Team focuses on continuous reliability improvements by producing a daily analysis and supporting data for a shared Web site and using that analysis to drive process improvements (Section 5.2.1).

## **Positive Observations**

The evaluation team noted the following positive observations during the reliability readiness evaluation process:

- 1) PJM displays a corporate commitment to operations and reliability by engaging employees in the development and implementation of training, tool development, process improvement, and ongoing analysis of operational activities (Section 1.2.2).
- 2) The corporate alignment of performance and compensation with operational goals is focused on reliability (Section 1.2.3).
- 3) PJM uses a transfer limit calculator to monitor real-time voltage transfer limits (Section 2.3).
- 4) PJM incorporates a job task analysis into initial operator training (Section 5.1).
- 5) A mandatory cycle approach to scheduling training activities allows operators to receive about eight weeks of dedicated training time per year (Section 5.1).
- 6) PJM schedules transmission operator visits to member and neighbor operating centers to promote cooperation and a single reliability vision (Section 5.1).
- 7) PJM has established a program to have reliability engineers become NERC certified (Section 5.1).
- 8) Operators are provided with human behavior training to help them identify and avoid common errors (Section 5.1).
- 9) PJM uses a training simulator for emergency preparedness drills involving operators, information technology (IT) employees, and local control center staff (Section 5.1).
- 10) PJM runs an annual three-day seminar for PJM and member-company operators covering procedure updates, emergency operations reviews, and simulator training (Section 5.1)
- 11) Confidential information on physical security redacted from public report. See discussion in Appendix 1. See discussion in Appendix 1.
- 12) Confidential information on physical security redacted from public report. See discussion in Appendix 1. See discussion in Appendix 1.
- 13) Confidential information on cyber security redacted from public report. See discussion in Appendix 1. See discussion in Appendix 1.
- 14) Confidential information on cyber security redacted from public report. See discussion in Appendix 1. See discussion in Appendix 1.
- 15) Confidential information on cyber security redacted from public report. See discussion in Appendix 1. See discussion in Appendix 1.

## **Recommendations**

The evaluation team offers the following recommendations:

- 1) Develop a single display with key frequencies shown over a map of the PJM footprint to help operators check for islanding conditions (Section 2.3).
- 2) Work with MISO and involved transmission and generator operators to develop a common understanding and operating procedure regarding the Kincaid special protection scheme to prepare for contingency events (Section 2.2.1).
- 3) Expand the nuclear bus auxiliary load modeling criteria to increase the accuracy of the security analysis program results (Section 2.1).

- 4) Reorganize the operator document Web site so operators can quickly find the appropriate document (Section 2.2.3).
- 5) Evaluate expanding the seasonal studies to include critical “beyond n-1” (e.g., categories C & D) contingencies identified in long-term studies (Section 4).
- 6) Evaluate whether additional alarm processor filtering (alarm types) will improve operator recognition (Section 2.1)\*.
- 7) Evaluate consolidating nuclear information into a single nuclear display for operators (Section 2.3)\*.
- 8) Confidential information on physical security redacted from public report. See discussion in Appendix 1. See discussion in Appendix 1.
- 9) Confidential information on plans for loss of control facilities redacted from public report. See discussion in Appendix 1. See discussion in Appendix 1.
- 10) Confidential information on plans for loss of control facilities redacted from public report. See discussion in Appendix 1. See discussion in Appendix 1.
- 11) Confidential information on plans for loss of control facilities redacted from public report. See discussion in Appendix 1. See discussion in Appendix 1.

\*Jointly identified by the company and lead evaluator as a key recommendation

## **Discussion**

The reliability readiness evaluation team examined the following key areas during the evaluation. The detailed discussion that follows provides the foundation for the recommendations, positive observations, and potential examples of excellence that the team identified. The report uses the generic term “system operator” to refer to all on-shift operating personnel responsible for executing the functions necessary to operate reliably and maintain the reliable operation of the bulk power system. This term will be used for the discussions unless additional specificity is required, such as the *balancing* system operator, or *transmission* system operator.

### **1. Culture**

#### **1.1 General**

*The corporate organization provides the necessary leadership and management for system operations to sustain high levels of safe, reliable operation.*

The Executive Council, the senior-most group in PJM’s management structure, is highly focused on excellence in reliability performance. The significant investment in the advanced control center program is evidence of that reliability focus. The PJM president addresses all employees on at least a semiannual basis, and his message consistently includes the importance of maintaining PJM’s focus on operational excellence.

The executive director meets with staff on a quarterly basis to ensure that the team’s focus remains on operational excellence and to provide an opportunity for employees to suggest improvements to the management team. In addition, first-line supervision is on the operating floor daily to talk with the operators, solicit feedback, and share information.

#### **1.2 Organizational Effectiveness**

##### **1.2.1 Foundation for System Reliability**

*The organization’s values and behaviors—modeled by its leaders and practiced by its members—serve to make system reliability a top priority.*

PJM has created a culture that is directly tied to people, process, and technology. The corporation believes in an environment that promotes both professional and personal growth. Regarding process, PJM has adopted a conservative operational philosophy that requires detailed procedures and work processes, with the goal of continuous reliability enhancements. To address its technology piece, PJM uses state of the art operational tools and displays a corporate commitment to invest in necessary technology.

##### **1.2.2 Leadership and Management**

*Managers, by leadership, commitment, and example, establish and reinforce high standards of performance and align the organization to achieve safe, reliable system operation.*

PJM’s culture focuses on the involvement of employees in the development and implementation of changes within the organization. This concept spans all aspects of PJM’s operation including

training, tool development, process improvement, and the ongoing analysis of all operational activities. PJM uses a number of mechanisms to directly involve personnel in these activities, including direct project assignments; solicitation of personnel input via focus groups, surveys, and other methods; and periodic discussion of current activities in training sessions and department meetings. The evaluation team recognizes the corporate commitment to operations and reliability as a positive observation.

### **1.2.3 Corporate Oversight and Monitoring**

*Line management is used to strengthen reliability and improve performance. System reliability is kept under constant scrutiny through techniques such as self-assessments, performance indicators, and periodic management meetings.*

The Transmission Owners Designated Officers, which is a group of senior executives from all PJM transmission owners, established a performance metrics team in 2005. The purpose of the team is to develop transmission performance metrics to measure the reliability of the transmission system over a wide range of operating characteristics and report its findings, on a quarterly basis, to the designated officers.

The metrics include, but are not limited to, items such as load forecasting, commitment of regulation resources, mitigation of actual transmission overloads, operation of transfer interfaces within limits, transmission outage request processing, NERC/RFC/SERC compliance, and control performance.

In addition, a system operation uses performance metrics to minimize operational errors and cross-train system operators. Metrics are reviewed at every meeting of the Reliability Committee of the PJM Board of Managers and are highly visible to the organization (posted on a company Web site). The metrics serve as one of the bases for incentive compensation for all PJM employees, not just for the operators. This leads to an environment where everyone at PJM is aware of the performance of the operators and willing to step in to support with new tools and processes if performance is not up to expectations. The team acknowledges the corporate alignment of performance and operational goals with a reliability focus as a positive observation.

PJM performs extensive benchmarking with MISO, where benchmarking is done on project basis (communication equipment for example). PJM is also working with an international operator group (including Tokyo Electric Power, and other large system operators) on benchmarking initiatives and has an open dialogue with FERC and NERC.

### **1.2.4 Human Resources**

*Personnel resource needs are anticipated and individuals are systematically recruited, developed, and assigned positions in the system operations organization.*

PJM has created succession plans for each division. In system operations, a succession plan exists for each management position. The plan is reviewed for any retirement or loss of personnel.

With respect to the system operators, a comprehensive review of the job assignments in the control room was conducted in 2005 in light of the project to implement a second control center. That study recommended retraining and reassignment of tasks in the control center to optimize the talents of the system operators. The results of that study are now being implemented with the goal to have the new job assignments in place to support the startup of the second control center in early 2009. This project envisions that the primary control center will remain while the current secondary center will be replaced with a new control center. Recognizing that not all of the operators will opt to move, PJM's recruiting and staffing effort has been ongoing to ensure that the company could sustain some attrition while retaining the ability to staff the shifts. With respect to the technical support staff, PJM has embarked on a plan to temporarily "overstaff" to account for attrition expected due to retirements.

PJM has a stepped discipline process that can ultimately lead to dismissal. The process starts with written warnings, and steps can be skipped if the violation level warrants it. PJM has a counseling program that is free and confidential for employees. Operations management focuses on work performance, but Human Resources takes over if an issue is non-work related.

### **1.2.5 Corporate Communications**

*System operations communications inform and engage both corporate and system operations employees so they can contribute to the strategic priorities of the organization.*

Encouraging open, multi-directional communication with employees is part of the PJM culture. Semiannual all-hands meetings ensure that employees receive information on critical PJM issues and performance directly from senior executives. Periodic division meetings allow division heads to share information directly with employees and to receive feedback and suggestions personally. The Open Exchange program provides leaders at all levels with tools to communicate key information directly to their employees, seek feedback, and get answers to employee questions.

PJM conducts a biennial employee survey that seeks feedback on all areas of PJM's performance. Survey feedback is used by leaders at all levels to improve performance and communication with employees. As a result of the most recent employee survey, a 2006 corporate goal was established for PJM managers and above to improve communications with employees, both within and across PJM organizations. As measured through two surveys, this goal was met.

## **2. Fundamentals of Operations**

### **2.1 General**

*Operations personnel monitor and control the system in a manner that ensures safe, reliable operation.*

To monitor the system, PJM uses an EMS with a suite of advanced network applications, including a state estimator, alarm processing, real-time contingency analysis, transfer limit calculator, and voltage/transient stability analysis programs. In addition, each transmission owner has a similar capability to check the validity of the PJM calculation. Redundancy and

backup voice and data communications ensure high communication reliability. The PJM reliability coordinator utilizes the same EMS as the PJM balancing authority.

A video wallboard shows various trends and summaries on the left with a network display on most of the central and right side for transmission functions. There is an overview for generation containing area control error (ACE) by zone and by component, frequency info with multiple sources, actual generation by type, deviation, tie error, schedule total, reserve sharing, and load) along with various other displays to see how units are performing. Also included are zone-based summary displays for transmission, such as capacitor and voltage summaries.

Alarming is both visual and audible for the system operator, and the system produces different audible tones based on the type of alarm, e.g., thermal versus frequency. Alarm filtering is done by area (zone) and priority, but not by type. The evaluation team recommends that PJM evaluate whether additional alarm processor filtering (alarm types) would improve operator recognition. Currently, PJM does not have a specific alarm process monitor but has one planned for the new EMS.

The PJM EMS is used to determine voltage adequacy by performing a full ac contingency analysis for all monitored facilities in PJM. A comprehensive review of the voltage limits for the Mid-Atlantic region was undertaken in 1999 as a result of peak load condition voltage and reactive concerns. Low-limit ranges were adjusted as a result. In addition, voltage limits are reviewed for the entire footprint as a part of various seasonal studies. During discussions that took place with PJM staff, the evaluation team learned that PJM is working to coordinate local control center voltage and reactive reserve schedules for generators. The evaluation team encourages PJM to continue these activities.

PJM operators utilize the EMS to perform security analysis to ensure post-contingency limits are honored. Operators use a transfer limit calculator to calculate and monitor reactive interface limits and use PI Visualization (a vendor tool) to observe voltage trends. Voltage control devices on the transmission system (capacitors, reactors, and load tap changers) are under the direction of the PJM operator and are manually switched at the direction of the PJM operator. Voltage control devices on the subtransmission system are generally controlled by the transmission owner. PJM operations and the transmission owner closely coordinate manual voltage control actions. Voltage control may involve maintaining a predetermined voltage schedule or a reactive generation level. Under normal operations, the generator operator shall operate the facility with automatic voltage regulation equipment in service at all times, except for outages of the regulator for maintenance or equipment failure. The PJM Performance Compliance Department analyzes generator reactive performance during system disturbances and provides a quarterly update to the PJM System Operations Subcommittee.

The evaluation team learned during the evaluation that the nuclear off-line auxiliary loads are not modeled in the security analysis program and recommends that PJM expand the nuclear bus auxiliary load modeling criteria to increase the accuracy of the security analysis program.

PJM operators track the status of generator voltage regulators via the eDart tool, PJM's outage management system. The PJM EMS is modified to reflect voltage regulator status. To validate the EMS calculated Mvar reserve information, PJM utilizes the reactive reserve check. PJM

operations generally request a reactive reserve check during capacity deficient conditions or when a heavy load voltage schedule warning is implemented.

The generator notifies PJM and the transmission owner with as much lead time as possible prior to performing all voltage regulator maintenance. PJM has a five-year reactive testing program. Whenever a generating unit's automatic voltage regulation (AVR) status is off (or is planned to be off), the unit's owner or operator must immediately enter a ticket via eDART. For real-time changes, the unit's owner or operator should also notify the PJM power dispatcher and the respective local control center by phone. The PJM power dispatcher will receive the ticket and either temporarily update the unit's reactive capability curve in use by the PJM EMS network applications or temporarily set the unit's AVR status in use by the PJM EMS network applications to "off" for the specified time period.

Some generators in PJM have a power system stabilizer (PSS), but it is not an automatic PJM requirement. PJM evaluates the need of PSS on new units on a case-by-case basis. If need is identified in the impact study, then PJM would require it. If the developer has proposed a new generator with PSS, PJM models it and performs the impact study analysis with the PSS as proposed.

Existing generators with a PSS are studied with the PSS in service in PJM's baseline analysis. If a stability problem for an existing generator is identified for criteria contingencies under some transmission facilities' outage conditions (maintenance, etc.), PJM develops operating limits with and without PSS in service.

During an emergency, the generator operator must participate in a voltage reduction declared by PJM and operate the facility at the voltage level requested by the transmission owner. Unless PJM requests a manual adjustment, the generator operator must maintain the facility's automatic voltage regulator(s) in service during an emergency.

The PJM state estimator tracks the amount of Mvar reserve within the PJM RTO. The calculation is performed for the entire RTO as well as the individual control zones within the footprint.

## **2.2 Operational Focus**

### **2.2.1 Operational Safety**

*System operation activities are conducted in a manner that maintains high levels of safety and reliability for all system conditions.*

Special protection systems (SPSs) and remedial action schemes (RASs) are maintained and tested by the transmission owner. SPSs and RASs do not depend on PJM EMS inputs. Contingency definitions are modeled within the PJM EMS and are manually activated and/or deactivated an SPS is enabled/disabled. A list of schemes is located in manuals for the operator's use.

Kincaid, a power plant that is part of the PJM system, has two generating units and is tied to the rest of the system through several transmission lines. Past studies have shown a potential first

swing and/or oscillatory instability problems for these units under certain multiple contingency situations (relating to NERC TPL-003-0). The Kincaid SPS includes two protection schemes in place to prevent these problems. Under normal system conditions, one scheme is in service at all times. The SPS that is in operation responds to first contingency events (NERC TPL-002-0) and causes a final system state that would normally only be possible during a multiple contingency situation. The evaluation team uncovered information that this SPS may not have been consistently modeled in the single contingency category in the past by PJM and/or its neighbors. There are also differing opinions on whether recent loading issues on the Lanesville 345/138 kV transformer is a subtransmission issue or is tied to the Kincaid SPS. The evaluation team recommends that PJM work with the MISO and involved transmission and generation operators to develop a common understanding and operating procedure regarding the Kincaid SPS. There are current activities, outside of the evaluation process, looking at the Kincaid SPS and its impacts.

### **2.2.2 Operational Decision-Making**

*Operational decisions are reached using a systematic and thorough approach that supports safe, reliable, and efficient system operations.*

PJM is the reliability coordinator, transmission operator, and balancing authority for the PJM regional transmission organization, and is responsible for all regional reliability coordination. PJM operates the transmission grid under a conservative philosophical approach.

PJM directs the operation of the bulk power transmission facilities according to NERC standards. In doing this, PJM considers transmission constraints, restrictions, and/or limitations in the overall operation of the PJM footprint. Transmission owners operate the bulk power transmission facilities in accordance with the PJM agreements, operating manuals, and instructions from PJM in their role as the transmission operator.

The PJM objective is to operate the transmission facilities such that system reliability is maintained. If a contingency occurs, the system is readjusted as required and analysis for the next worst contingency is performed. The PJM operator directs actions to restore the system to an acceptable state. Due to regional historical differences, PJM uses two different regional philosophies when extra high voltage (EHV) lines trip but do not automatically re-close. The basic difference in the regional philosophies focuses on the number of re-close attempts.

Once non-cost measures are exhausted, PJM begins to re-dispatch generation. If reasonable controlling actions are not available with an impact effect generally greater than 5%, PJM will initiate off-cost dispatch. Once off-cost is initiated, unit dispatch system tools will re-dispatch generation based on dollar per MW effect, considering all on-line flexible units with an impact of 1% or greater. PJM staff has the ability to adjust the controlling percentage on an individual constraint basis. PJM will initiate a post-contingency local load relief warning/action if post-contingency flows exceed designated ratings and insufficient resources are available to control the overloaded facilities.

The unit dispatch system software continues to monitor projected flows on constrained facilities and sends ramp-limited set points to re-optimize re-dispatch for constraint control to the designated threshold. The eligibility of units to set locational marginal price is determined by

comparing the desired output as calculated by unit dispatch system to the actual output as calculated by the state estimator.

Prior to reassigning transaction schedules and identifying the associated congestion fees for reallocating the schedules, PJM operators curtail all transaction schedules that are not willing to pay the increased transmission charges. If generation is not available to control these limitations, PJM operators implement the emergency procedures. If the emergency procedure steps (from curtailing non-firm contracts through voluntary customer load curtailment, including implementation of the NERC transmission loading relief procedure) are insufficient to control the transfers, PJM operators issue a manual load-dump warning to all generation and transmission owners, stating the most serious limitation and the estimated amount of load relief required.

If transfers continue to exceed a reactive transfer limit, and voltage conditions are deteriorating, and PJM operator determines that the system cannot withstand the occurrence of the contingency, the PJM operator orders a manual load shed in the most effective area and in an amount sufficient to return the transfers to within the reactive transfer limit.

### **2.2.3 Operational Alignment**

*Organizational structure supports safe and reliable system operation.*

PJM has the necessary agreements in place with its members to fulfill its reliability functions.

PJM operations have the authority to sell emergency generation to other external systems, including contingency reserves, as recallable emergency energy sales under emergency conditions. Reserve sharing agreements exist with the Northeast Power Coordinating Council and VACAR, a subregion of SERC. PJM is responsible to commit generation in response to a reserve sharing activation, modeling the export energy within the PJM System.

All transmission and generation outages are submitted from the transmission owners and generation owners to PJM through PJM's outage scheduling program — eDart. Member companies can either manually submit outage requests, or they have the option of linking their outage schedulers directly to eDart, and PJM reviews for conflicts. If there is a conflict, PJM will coordinate the rescheduling. Real-time operations require a 30-minute prior notification in order to allow time for a load flow to be run. PJM requires a 30-day notification for scheduling a generation outage, while transmission requests must be received by the first of the month prior to the month of the outage. If an outage was not scheduled, PJM will not go off-cost unless the transmission owner is willing to pay off-cost expenses.

For outages in neighboring areas that affect PJM, the normal protocol is for member companies to contact their reliability coordinator, followed by the two reliability coordinators contacting each other. The reliability coordinators may ask two utilities to contact each other. In an emergency, the member outside of PJM can contact neighboring companies directly. The evaluation team learned that in some cases members go directly to other reliability coordinators and encourages PJM to work with members to minimize these types of contacts.

Management-level employees have ownership responsibilities for PJM manuals, which do not get published until the owner signs off. A formal documented revision procedure exists with

checks and balances. Updates usually come from staff review, which is performed at least annually. If the change is important and immediately necessary, the change is sent out as a temporary provision, with the main document updated at a later date. Normal communication and information sharing takes place during the operator training week and a sign off sheet is utilized prior to taking over a shift for information that has not been shared during the normal training week.

As part of the evaluation the team reviewed and had the operators demonstrate their ability to access documents both at the primary and backup control facilities. During one of these demonstrations, the operator had difficulty locating the specific document due to the format of document Web site. Therefore, the evaluation team recommends that PJM reorganize the Web site so operators can quickly find the documents they need.

PJM has a comprehensive vendor-created operator logging tool, called Smartlog, which captures critical system activities and operator actions, permitting operator annotation of events and interactions within PJM and with PJM members. Smartlog can gather information about a process and present it in a way that can assist staff members in their continuous improvement efforts. The tool collects EMS-generated event data and operator-entered information. Operators use Smartlog for daily review processes and during shift change. It features a “turnover” indication for items required for observation as well as a checklist for each desk containing information to review on shift change — outage schedules, updated limits, etc. In addition, the resulting logs are archived and available for after-the-fact analysis, reporting, etc. Due to its multiple uses, the evaluation team recognizes Smartlog as a potential example of excellence.

### **2.3 Managing System Configuration**

*Power system configuration is carefully designed, analyzed, maintained, and controlled throughout the life of the infrastructure, ensuring that system and equipment margins are understood, considered in decision-making, and managed consistent with design and system requirements.*

PJM operates to maintain all facility flows below their normal thermal ratings on a precontingency basis. PJM directs the operation of the bulk power transmission facilities according to NERC reliability standards and operating guidelines. As such, PJM considers transmission constraints, restrictions, and/or limitations in the overall operation of the PJM RTO.

The PJM RTO bulk power electric supply system is operated so that loading on all PJM-monitored bulk power transmission facilities are 1) within normal continuous ratings on a regular basis and 2) within emergency ratings on all remaining facilities immediately following any single facility malfunction or failure. This principle requires that actions should be taken before a malfunction or failure occurs in order to control post-contingency loading on a precontingency basis. Some examples of possible precontingency actions include prearranged approved switching, use of approved special purpose relays, phase angle regulator tap adjustments, re-dispatch, and transaction curtailment.

The power system model is maintained using Siemens proprietary software with some data inputs converted from Common Information Model formats when available and appropriate. Member companies enter equipment data and ratings into a Web-based application, and PJM extracts data from that application to run the proprietary software to check for errors and build the database. Downstream functions are populated from the EMS database once it has been built. Major updates are made four times per year with special updates made as necessary.

Model update (topology) executes every 15 seconds and takes less than a second to run. The state estimator executes every one minute, and takes about 30 seconds to run. The security analysis executes every minute and can run 4,070 contingencies per minute. Operators can view state estimator results on the EMS onelines and toggle between real-time telemetry, state estimator results, or the difference between the two. In addition, there are many customized displays of state estimator and security analysis results available on the system that were shown and demonstrated during the on-site portion of the audit. A summary display shows violations over 92% (configurable) and security analysis results together. The state estimator data can be shown in same layout as the supervisory control and data acquisition, or SCADA, system and operators can toggle between both sources to compare them. There is a bad data display the shows residual (measured versus. estimated) data.

Normally, the PJM Operations Planning department, along with transmission owners, determines contingencies. There are over 4,000 predefined contingencies. The Operations Planning department's mission is to ensure the safety, reliability, and security of the bulk power system. In addition, Operations Planning is charged with understanding customer needs and delivering a valued service through worker knowledge and technology advances.

Operations Planning provides the operators with contingency information. The main contingency list display is broken into contingency list groupings (e.g., East, Special, External, etc.). On the results list, there are display indications for special contingencies such as reliability coordinator or IROL-related devices that are being shown as security analysis potential issues. There is also a display of activated contingencies that are normally deactivated and deactivated contingencies that are normally activated. Reviewing the abnormal list is part of the shift turnover process, and operators can edit the contingency list for unplanned conditions.

The overall EMS availability for 2006 was 99.999 %. The state estimator converged on average 99.595 % of the time for the year 2006.

Frequency is monitored by redundant TrueTime (Symmetricom) Model XL-DC units at the PJM control center, and 22 telemetered frequency points are shown on the frequency source selection display on the EMS. The automatic generation control (AGC) system is designed to use the local frequency sources first, but the system will use the telemetered frequency sources in priority order when the local sources are unavailable. The system operator can also manually select which frequency to use, if desired. Outside the Mid-Atlantic region, there are six regulation zones, each with two possible frequency sources. Normally, these zones run on the TrueTime frequency source on the generation management system (GMS), but each zone has a telemetered source, in some cases two, from within the zone that will be automatically used if the TrueTime source fails. The alternate sources can also be manually selected.

The system frequency input signal comes from an independent source, which is a TrueTime (Symmetricom) Model XL-DC with the FTM-III frequency and time error module. PJM has five of these devices: two for the EMS (primary and backup), two for the GMS (primary and backup), and one at the backup control center site. The frequency is displayed in the control room directly from the TrueTime device such that if the EMS were to fail, the frequency would still be visible to the operator.

System islanding is detected using the topology software in the model update function. Alarms are issued if islanding is detected, and the system operator can look at the frequency sources described above to verify the islanding situation. The evaluation team noticed that the system operator had several alternatives to view frequencies but did not have a single display that portrayed selected frequencies over a geographical map of the PJM footprint. The evaluation team recommends that PJM develop such a display.

The PJM EMS automatically runs a transfer limit calculator every four to five minutes in addition to the complete thermal and voltage security analysis performed every one to two minutes. This transfer limit program automatically calculates the amount of power that can be safely transferred across the predefined PJM reactive interfaces, up to the point at which a 5% voltage drop would occur on the EHV system or a voltage collapse would occur. The PJM unit dispatch system is then used to maintain flows below the calculated limits. The evaluation team acknowledges this practice as a positive observation.

The unit dispatch system uses the PJM state estimator as its starting point and is the primary tool used to dispatch the PJM system. The unit dispatch system uses a neural network load forecasting application to provide zonal load forecast to PJM system operators. The zonal neural net forecasts are aggregated to provide the PJM footprint load forecast. PJM operators have the capability to override neural net load forecasts, which could occur during transitional weather patterns. The case is then modified to recognize the impact of projected load and interchange changes on transmission constraints, honoring unit characteristics and bid data. The PJM operator-approved solution is then bridged to the EMS and unit set-points are sent via intercontrol center communications protocol (ICCP) to generation owners. If the unit dispatch system is unavailable, PJM operations can dispatch the system by entering zonal lambda via the EMS.

Synchronized reserve and regulation scheduling software is used to determine a preliminary forecast of which resources will provide regulation and synchronized reserve. The software performs regulation and synchronized reserve market operations to minimize the total cost of energy, regulation, and synchronized reserve dispatch.

PJM operators, reliability engineers, and support staff utilize the PI ProcessBook application (vendor software) to create visual displays and system overviews. The data supported in PI is directly linked to the real-time information received via the ICCP data links. These data are used to increase system-wide awareness, as well as to track known areas of concern. Such displays are stored and accessed from a common shared drive and can be viewed on an individual computer or on the PJM control center mapboard. The PJM EMS also provides trend capability. PJM operations use both PI displays and video graphic recorders to provide PJM ACE and input data trending.

The PJM weather program includes the National Weather Service which produces several data sets that are available in formats available to import into geographic information systems (GIS), and PJM has the ability to display a real-time weather map of the PJM footprint and surrounding areas directly on the PJM control room mapboard. This weather map displays any storms moving through the region. In addition to the GIS map, the Weather Channel, and a major news channel are always displayed on the mapboard.

PJM staff has developed a new manual, *Nuclear Plant Interface Coordination*, to address nuclear plant requirements. Nuclear operating license holders within the PJM footprint have formed a user group to maintain familiarity with NRC regulatory issues surrounding nuclear plant operation, each plant's transmission design basis, performance, and operational issues that are unique to nuclear generation. The evaluation team noticed during the operator tools demonstration that the PJM operator had several displays that contained nuclear plant information important to reliable system operation. The evaluation team recommends that PJM evaluate consolidating nuclear information into a single nuclear display for operator use.

## **2.4 Emergency Preparedness**

*The organization is prepared to manage and mitigate the impact of system emergencies in order to preserve the reliability of the system and to protect the interests of the public.*

PJM is responsible for determining and declaring that an emergency is expected to exist, exists, or has ceased to exist in any part of the PJM footprint or in any other control area that is interconnected directly or indirectly with the PJM footprint. PJM directs the operations of the PJM members as necessary to manage, allocate, or alleviate an emergency.

If PJM determines that PJM-scheduled resources available for an operating day in combination with capacity resources operating on a self-scheduled basis are not sufficient to maintain appropriate reserve levels for the PJM footprint, PJM will recall energy from capacity resources that otherwise deliver to loads outside the control area and dispatch that energy to serve load in the control area. In addition, PJM purchases capacity or energy from resources outside the control area.

Should PJM determine that the forecasted load in the PJM footprint has fallen below a margin of 2,500 MW above the sum of the output of the self-scheduled resources and the total normal minimum generation of all PJM-scheduled resources, PJM implements an alert and, if necessary, minimum generation emergency procedures, as described later in this section. To the extent it deems appropriate in order to avoid or reduce the cost of a minimum generation emergency, PJM sells energy to other control areas.

For each of the PJM actions, a set of alerts is defined for issue the day(s) before the action as well as warnings that PJM operators will issue as early as possible prior to the action. PJM operators forecast capacity and energy adequacy projections for the operating day and appropriate future operating periods. In addition, PJM operators request supplemental status reports if more information is required.

PJM operators utilize their toolsets to determine if any non-cost measures can be utilized to maximize transfer capabilities. PJM operators re-dispatch generation to reduce reactive losses or increase reactive reserves. If no additional economic generation is available, PJM operators will implement emergency procedures, up to and including load shed, to serve PJM load and prevent voltage collapse. A load dump allocation (load shedding) display shows by zone the allocation of load to be shed based on the operator-entered capacity deficiency expectation. The zone allocation is then divided up locally by the transmission owner based on location of critical loads. The evaluation team recognizes PJM's load shedding implementation plans that include operator displays and a notification process as a potential example of excellence.

PJM has overall responsibility for coordinating the system restoration effort. Immediately after a system blackout, PJM coordinates interchange schedules with external balancing authorities and acts as a restoration coordinator by collecting and disseminating system data in order to provide a preliminary system assessment. PJM continues to collect and disseminate updates on an hourly basis. PJM conducts periodic system operations subcommittee conference calls to discuss restoration progress and propose strategies/opportunities for transmission owners to accelerate the restoration process, focusing on coordination between transmission owners and external entities. PJM focuses on opportunities to implement a top-down approach to system restoration.

Transmission owners implement a bottom-up approach consistent with their restoration plans, which are written to address the restoration of a totally blacked-out system without assistance from external transmission owners. Transmission owners focus on providing cranking power to critical steam units, providing off-site station light and power to nuclear units, and restoring critical loads.

Once two or more transmission owners interconnect, PJM assumes control and begins to calculate ACE and monitor reserves for the island(s). PJM members practice the PJM and internal restoration plans as part of semiannual restoration drills. PJM shift supervisors act as system restoration drill and emergency procedures drill coordinators, strengthening their skill set to ensure they are fully prepared to lead an actual emergency procedure or system restoration effort.

### **3. Fundamentals of Maintenance**

#### **3.1 General**

*Maintenance is conducted by skilled personnel to achieve safe, reliable control center equipment and system performance.*

Telemetered data carries quality code information indicating the quality of the data. If an ICCP link or remote terminal unit (RTU) goes down, the appropriate quality code is set and the data are flagged as not updating. Quality codes are displayed on EMS one-lines and tie-line summary displays and are read by applications so that the data can be treated appropriately, depending upon the application. Quality codes also indicate if data was manually overridden by member companies or by PJM system operators.

PJM has a special stale data function that monitors all line telemetry, including tie lines. This function sets the "stale data" quality code if the value has not changed within the last 30 minutes.

This check is in addition to the quality codes set by the communications functions and catches points that simply stop updating with no other quality code indication. Tie-line data are displayed on an EMS screen showing the primary telemetered flow, the backup telemetered flow, and the state estimated flow for that line. Differences between the telemetered and state estimator flows are alarmed to the operator. MWh checkouts are performed via eMTR at the close of each day. eMTR is an internet-based system that retrieves and calculates revenue meter data for PJM transmission and generation interconnection points. Known errors in tie-line telemetry can be compensated for via a “manual add” offset applied to the ACE calculation.

## **3.2 Equipment Reliability**

### **3.2.1 Equipment Performance**

*The organization achieves high levels of equipment reliability. Equipment problems that impact reliability are resolved in a thorough and timely manner.*

PJM utilizes an on-site information technology operations center, staffed around-the-clock, to perform continuous monitoring and support for critical operations systems. The center was started approximately one year ago; when the evaluation team toured the facility there were five staff members on duty. The center provides the following monitoring and support: EMS, servers, and operations; Tivoli phone and e-mail; Tivoli phone call; ICCP data links; hardware; and the EMS vendor on-call support contract. The center also monitors solar winds and checks EMS health through the use of a program called eSuite.

PJM designates a weekly on-call person for each hardware, application, and network system. Secondary call-out personnel are also available, and there is an on-call support contract with the EMS vendor for around-the-clock support. Call-outs are coordinated by staff at the information technology operations center.

### **3.2.2 Work Management**

*Work activities, including corrective, elective, and preventive maintenance, surveillance testing, and modifications, are managed effectively to support safe, reliable operation during both outage and routine periods.*

Dynamic disturbance recording equipment is installed at strategic locations on the PJM interconnected bulk power transmission system. Bus voltage, line current, and MW and Mvar flow and frequency are recorded at selected 765/500 kV switchyards and 765/500/230 kV substations. Disturbance monitoring equipment is owned and maintained by the PJM transmission owners and includes equipment from various manufacturers.

Mid-Atlantic Area Council (MAAC) requirements for installation of disturbance monitoring equipment will be replaced by RFC requirements when they are available. All new and most existing equipment is time synchronized with the exception of some older legacy equipment. Dominion is required to follow the documented SERC requirements for disturbance monitoring equipment. The equipment is to be time synchronized, and fault recorders and dynamic disturbance recorders are to be time synchronized such that exact Coordinated Universal Time is easily calculable from recorder time at locations that meet the SERC criteria.

## **4. Fundamentals of Operational Planning**

*Operational planning provides the technical information and support necessary for safe, reliable system operation.*

Since the formation of RFC to replace the bulk of the former MAAC, MAIN, and ECAR reliability councils, the inter-regional study forums that conduct short-term and seasonal assessments in which PJM participates have been correspondingly reconfigured. The reconfigured inter-regional study forum structure is in place to facilitate the timely execution of the initial studies under the Eastern Interconnection Reliability Assessment Group, which will be for 2007 summer assessment work. PJM system planning performs forward-looking fifteen-year assessments, consistent with the PJM Regional Transmission Expansion Planning (RTEP) Protocol, to ensure there are sufficient resources to serve projected load. The planning analysis recognizes operational constraints. PJM staff participates in interregional and PJM-focused seasonal assessments that model SOL and IROL limits. IROL limits are generally reactive interfaces, which protect against a deficiency in reactive reserves.

Seasonal studies are performed by multiple task forces/working groups. The PJM Operational Analysis Task Force results are reviewed by the system operations subcommittee, which comprises control room managers. Once the report is approved, it is distributed to the PJM operations training task force and to system operators. If the study results in unusual or significant findings, special operating procedures are created and trained upon in order to assist system operators. Procedures are shared between impacted parties and documented within the PJM transmission operations manual. Depending on the level of impact, procedures can be further trained upon at the annual PJM system operator seminar or shared via the PJM learning management system (PowerPoint voiceover). An area that the evaluation team explored dealt with the depth of transmission studies performed due to the size of PJM and recommends that PJM evaluate expanding the seasonal studies to include critical “beyond n-1” (e.g., categories C & D) contingencies identified in long-term studies.

The PJM EMS models portions of MISO, the Tennessee Valley Authority, Southwest Power Pool, Duke Energy Carolinas, Progress Energy Carolinas, and New York (3,345 stations). PJM operators, reliability engineers, and support staff have created PI process book displays that show actual versus scheduled flows on all PJM tie lines. Displays have also been created to track sensitive external flows and generation patterns.

PJM develops and maintains seasonal models for the next 18 months. These seasonal models are developed from the NERC Multiregional Modeling Working Group case library. PJM available flowgate capacity/available transfer capability (AFC/ATC) calculations are based on these seasonal models. The model builder develops monthly (18 monthly models), weekly (five weekly models), daily (35 days), and hourly (next 168 hours) base-case models. The model builder portion of the PJM AFC/ATC engine modifies these seasonal base cases to reflect anticipated conditions such as load levels, outages, and base transfers for the AFC/ATC time period. The evaluation team encourages PJM to evaluate methods to incorporate disturbance data to validate the dynamic models.

The PJM AFC process utilizes the AFC values from MISO for MISO's flowgates and Mid-Continent Area Power Pool (MAPP) for MAPP's flowgates. Calculated AFC values for these flowgates overwrite the PJM-calculated values. In the absence of MISO- or MAPP-calculated values, the PJM process uses the PJM-generated values. Values provided to the open access same-time information system (OASIS) from the PJM AFC/ATC process are continuously updated on the OASIS to reflect the reservations that were accepted between the calculation cycles.

PJM defines the operational planning timeframe as n-3 days. The PJM Operations Planning and Power System Coordination departments perform this analysis using the study package from the PJM EMS. The EMS study package is an exact replica of the online EMS. The thermal and voltage ratings are modeled the same as the online EMS, with the ability to change the thermal ratings based on projected temperatures.

The PJM reliability coordinator assessment utilized the PJM EMS study package, with the network topology updated from eDart tool and the generation pattern manually modified based on results of the daily dispatch and reliability studies performed. Decisions to commit generation are based on bid parameters.

PJM works with the transmission owners to define and update the SOL and IROL list on a semiannual basis. The next-day reliability analysis summarizes the outage analysis and coordination process. All IROL and SOLs are modeled in the PJM EMS, displayed in the EMS and in the OSI PI visualization system, and reviewed as part of the next-day reliability analysis, ensuring that a comprehensive operating plan can be developed to meet all reliability requirements. Operators of IROL and SOL facilities that require external systems to assist in the mitigation plan are involved in the development of a joint operating guide.

Transmission owners enter facility ratings in PJM's online eDART application via the thermal equipment ratings monitor. All facilities in the PJM EMS model are transferred to eDART immediately after each model update build. Transmission owners enter ratings data in accordance with PJM policy for each facility in the database — lines, transformers, series devices, and phase shifters. PJM operators monitor eDART continuously, and any change to equipment ratings with reliability implications made by a transmission owner is required to be reported immediately to PJM.

Generation owners enter facility ratings, capabilities, derates, and limitations ratings in PJM's online eDART application. The generator dispatch is based on the day-ahead market, reserve-adequacy run dispatch, and projected level of combustion turbines to serve load. PJM procedures require that each generation owner take independent actions to protect its generating plant equipment and preserve as much load as possible during separations.

PJM does not perform ATC analyses on systems external to PJM. The transmission customers must review each transmission provider's OASIS to determine what can feasibly be transferred from generation to load across the transmission system. The transmission customer must contract with all applicable control areas along the desired contract path to determine the availability of ATC and to request transmission service that involves control areas in addition to PJM.

Following the summer and winter peak periods, PJM operations and planning staff meets to discuss operational concerns, ensuring feedback into the planning process.

## **5. Fundamentals of Training**

### **5.1 General**

*Training in both specific job-related skills and broader technical fundamentals is used to provide highly skilled, knowledgeable personnel for safe, reliable operations, and to achieve performance improvement.*

PJM has a formal job qualification process for initial operator training, which includes a job task analysis. The evaluation team acknowledges the continual use of the job task analysis as a positive observation. Training times vary depending on job position. The training process culminates with the trainee taking written and simulator tests, and successful completion of both tests is required for the trainee to perform shift duties.

PJM has four separate training programs for initial qualification and is working on training for reliability engineers. The member training department offers the initial training program. It is a required training program for PJM, local control center, and market operations center operators, who must take the course within two years of assuming shift duties. The program is a four-week instructor-led training course covering generating units, markets, transmission operations, substation equipment, protective relaying, communications, and emergency procedures. The course is NERC approved for about 150 hours of continuing education hour (CEH) credits and includes simulation time. The program is not officially scheduled as part of the operator qualification training but is offered twice a year. If an operator is in training at the time it is offered, his or her training schedule will be extended to accommodate the program.

PJM provides each operator one week of continuing training time during each six-week shift rotation. This allows for about eight weeks of dedicated training time per year for each operator. The evaluation team acknowledges this training cycle process as a positive observation. During these sessions, the operators receive a variety of ongoing training activities, including simulation training, formal instructor-led classes, emergency preparedness drills, member visits, and self-study. Transmission operator visits to member and neighbor operating centers promote cooperation and form a single reliability vision, and the evaluation team recognizes this practice as a positive observation.

PJM has identified on-the-job training as an area in need of improvement. PJM has hired a consultant to perform a cognitive task analysis to identify improvements for on-the-job training and to identify and train specific operators to serve as trainers. PJM is working with Human Resources on compensation issues for trainers. Generally, PJM is moving toward a more structured and measurable on-the-job training process.

Two years ago, PJM instituted cockpit training. PJM contracted with a former military pilot for training in root cause of human error and three-part communication process training. A two-tier operations approach plan was developed and is utilized, and training focuses on identifying and

avoiding common errors. The evaluation team acknowledges as a positive observation PJM's efforts in human behavior training.

PJM coordinates four emergency preparedness drills per year, including two emergency procedure drills and two system restoration drills. These drills are coordinated and led by the PJM shift supervisors. The utilization of the simulator for operator, IT staff, and member training is recognized by the evaluation team as a positive observation.

Operators are given the opportunity to provide feedback on the training programs through the use of formal surveys, operator training simulator debrief sessions, and one-on-one feedback sessions. The feedback is taken into consideration in the development or revision of the training programs.

PJM has established a program where all positions within the control center are NERC certified. The evaluation team recognizes having the reliability engineers certified as a positive observation. PJM has also implemented a local PJM certification exam, which is required for all PJM operators as well as transmission, generation, and local control center operators within PJM. The evaluation team understands the efforts that PJM is undertaking to enhance operator performance through certification. The evaluation team encourages PJM to explore methods to build NERC certification into the local control center certification requirements, since currently only PJM certification is required.

PJM chairs the Dispatcher Training Task Force, which is a group of training representatives from PJM member companies. This group evaluates and offers input into the development of PJM training offerings. PJM gathers input for its member training program offerings through its customer survey process. Also, as part of the continuing education process, PJM collects feedback on each training session. During the evaluation process of seminars, operators are asked to provide input as to what areas they would like incorporated into future year's seminars. This input, along with trainer and management input, is used to prepare the topic matter for the following year's seminar session.

In addition, PJM provides operators with a yearly three-day spring seminar. The seminar provides the operators with updates to procedures, refresher information on emergency operations, and simulation training. The seminar is attended by almost 600 PJM and PJM member-company transmission and generation operators annually. PJM also provides a full curriculum for generation and transmission operator training, including a four-week initial training program. The evaluation team recognizes the annual three-day member training session as a positive observation.

The system operator training department has a manager and six trainers. Three to four trainers are mostly operational focused and serve as the day-to-day trainers, and two trainers are technically focused (one has the sole responsibility of supporting the simulator, while the other is a PhD engineer who gets involved in project work, enhancements to the simulator, and more technical analysis of operations. The member training department has a lead trainer, five trainers, and two administrative positions. PJM does not have a qualification program for trainers; most of the trainers have operations background and receive training in teaching.

PJM uses the ADDIE (analyze, design, development, implement, evaluate) model. Every presentation in initial and cycle training includes objectives and a quiz. PJM is now using a learning management system to track operator training and performance on quizzes. All training is NERC CEH-approved. PJM has moved towards online presentations — it is a more efficient use of time, and it is time-recorded for CEH credits.

PJM keeps track of operator and member training in its vendor-developed learning management system, with records back to 2004. At the time of the evaluations, all but five operators had already met the 32-hour requirement for 2007. The remaining five are new hires who are still in the qualification process.

## **5.2 Organizational Effectiveness**

### **5.2.1 Human Performance**

*Personnel select and apply appropriate human error prevention techniques commensurate with the importance of assigned tasks to minimize the frequency and consequences of events.*

PJM performs both daily and event analyses and reviews to provide a self-assessment of system operations, including the Daily Review Team process, the Detailed Analysis Team process, and the root cause process for significant events. In addition, PJM procedures define an event investigation process, a process established to provide analysis on significant events with assistance of the PJM transmission owners.

The Performance Compliance Department (a department within Market Services and independent of Operations/Dispatch) develops and evaluates operations-related performance indices. Although the Performance Compliance Department monitors compliance with industry and self-imposed standards and provides analysis and reporting of actual system operations, it also evaluates organizational processes related to planning and operating procedures through the “daily review team” and develops/recommends courses of action to improve performance and reliability.

The Daily Review Team meets daily to review operations and market performance in an effort to improve market/operation reliability and efficiency and to assist in employee development. The team is composed of members from operations, performance compliance, system operator training, and markets. Members are expected to work as a cross-functional team (synchronizing PJM divisional efforts), soliciting input from the Detailed Analysis Team members or other subject matter experts as necessary, and serve as liaisons back to their respective groups. The team’s work product is a daily analysis and supporting data posted on a SharePoint site. The review team is responsible for ensuring that daily reviews are kept up-to-date and posted in the SharePoint site according to a specific timeline. The evaluation team recognizes the Daily Review Team focus on continuous daily reliability improvements as a potential example of excellence.

The leadership team and Detailed Analysis Team periodically review the SharePoint site and identify what issues should be reported and/or escalated to other parts of PJM. The Daily

Review Team will escalate any issues to the Detailed Analysis Team that require more extensive analysis.

In addition, The Daily Review Team maintains a scorecard of PJM daily operations as well as a detailed record of PJM operations for the day. These operational metrics are rolled up to a monthly operational goal tracking and contribute to the PJM company-wide goal process related to the PJM employee incentive plan.

The risk analysis process is managed by the shift supervisor with support from PJM management and operations support staff. The process is used for critical decision making when a reliability issue exceeds PJM system limits or violates procedures.

## **APPENDIX 1: Critical Infrastructure**

The following discussion will be presented under private letter to the evaluated entity only and will not be included within the public version of the report.

## **APPENDIX 2: Entity Participants**

The following will be presented under private letter to the evaluated entity only and will not be included within the public version of the report.

### **APPENDIX 3: Documents Reviewed**

The following will be presented under private letter to the evaluated entity only and will not be included within the public version of the report.