NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Balancing Authority/Transmission Operator Reliability Readiness Evaluation Report

Arizona Public Service
Phoenix, Arizona

May 14–17, 2007

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Table of Contents

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 Arizona Public Service (AZPS) representatives on May 14–17, 2007. This report reflects the views and recommendations of the evaluation team regarding the readiness of AZPS to meet its responsibilities as a balancing authority and transmission operator.

Evaluation Team

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Organization Profile

Headquartered in Phoenix, Arizona, AZPS is an investor-owned generation, transmission, and distribution electric utility serving over 1,000,000 customers in a 50,000 square-mile service territory in eleven of Arizona's fifteen counties. AZPS is Arizona's largest and oldest-serving electric utility. AZPS is affiliated with the WECC regional reliability organization and is registered with NERC as a balancing authority, load-serving entity, transmission owner, transmission operator, transmission planner, marketer, generation owner, and generation operator.

AZPS's system has 62 total interconnections with Salt River Project, Western Area Power Administration's Lower Colorado River System, Los Angeles Department of Water and Power, California Independent System Operator, PacifiCorp, Public Service of New Mexico, Tucson Electric Power, and Imperial Irrigation District.

The AZPS service territory stretches from the desert lands of southern Arizona near Yuma, across the mountain ranges of northern Arizona near Flagstaff, to the Canyon lands near Glen Canyon Dam and Page, Arizona and spans from the White Mountains near Show Low and Snowflake, Arizona, in the east, through the Phoenix metro area, and to the Colorado River along Arizona-California border in the West. Approximately 75% of AZPS's load is in the Phoenix metro area.

The AZPS transmission system consists of 2,680 miles of transmission lines: 1,270 miles of 525 kV, 578 miles of 345 kV, 673 miles of 230 kV, and 159 miles of 115 kV. About 60 percent of overhead lines are located in urban forests, 20 percent in upland pine forests, and the remainder in open desert environments. The AZPS system includes distribution voltages of 69, 34.5, 12, and 4.16 kV.

The total capacity of the AZPS-owned generation is 6,157.6 MW. The generation fuel mix is broken down as follows: 52.2% gas, 28.3% coal, 18.3% nuclear, 1.1% oil, and 0.1% solar. The all-time AZPS system peak of 7,652 MW was reached at 4:00 p.m. on July 21, 2006.

Power Operations Strategic Plan Mission Statement (As stated by AZPS)
"Power operations will manage the use of all available generation and transmission resources in the most cost effective and reliable manner to maximize shareholder value and meet or exceed all reasonable customer expectations."

Our Cultural Environment
Treats everyone with dignity and respect.
Fosters a sense of community and teamwork within the workplace.
Demonstrates peer leadership and personal accountability.
Emphasizes learning from mistakes and NOT assessing the blame.
Recognizes opportunity an acts quickly and responsibly
Our success is essential to APS achieving its' vision of being recognized as America's Preeminent Energy Services
Company in Customer, Employee, and Shareholder Value.

Executive Summary

The evaluation team found no significant operational problems and concluded that the AZPS balancing authority and transmission operator has adequate facilities, processes, plans, procedures, tools, and trained personnel to perform the balancing authority and transmission operator functions necessary to maintain the reliable operation of the bulk power system, with two notable exceptions: 1) the energy management system (EMS) replacement project needs to be expedited to the extent possible and 2) AZPS should review staffing adequacy to ensure proper support for the new EMS.

A positive culture exists at AZPS. The management and officers of AZPS have an "open door" policy with system operators, creating a friendly atmosphere among the various levels of operations staff. In addition, there is good cooperation between departments that allows timely implementation of changes or policies. With EMS staff and communications staff assigned at the control center, equipment failures are quickly analyzed and repaired.

The evaluation team observed potential examples of excellence regarding the alternate control facility and the work of the technical project manager. AZPS has an excellent alternate control facility with functionality and layout nearly identical to the primary control center. The work of the technical project manager, who performs stability and dynamic near real-time studies to help determine stability and contingency transmission limits on the system, is recognized both at AZPS and other companies.

In cooperation with AZPS representatives, the team identified two key recommendations related to the planned EMS. The already under way replacement of the EMS should be expedited to the extent possible and avoid any unnecessary delays. The evaluation team believes that AZPS should not allow this project to be stalled. Along with the EMS replacement, the evaluation team recommends AZPS review staffing to support the new advanced applications. It is very likely that additional personnel will be required to support the state estimator, real-time contingency analysis, operator power flow, and operator training simulator applications.

Overall, the evaluation team identified nine positive observations and two potential examples of excellence. In addition, the team offers six recommendations that, if implemented, will enhance Arizona Public Service's readiness to operate reliably and maintain the reliability of the bulk power system. When AZPS completes the issues included in this report, the evaluation team believes that AZPS will have a superb operation. The findings are listed in order of importance.

Potential Examples of Excellence

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

1. The alternate control center functionality and layout is equivalent to the primary (Section 2.4).
2. The highly regarded technical project manager performs stability and dynamic near real-time studies to augment the AZPS planning work and has assisted other companies with similar studies (Section 4).

Positive Observations

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

1. The computer infrastructure in both control centers protects for failures and allows for redundancy of both the primary and alternate energy management systems (Section 2.4).
2. Operations meetings are conducted every five weeks for all operators (Section 1.2.1).
3. The Arizona Security Monitoring Manual provides operators with important system information regarding scheduling paths and reactance (Sections 2.3 and 4).
4. The system operators are involved in most projects affecting operations (Section 1.2.1).
5. The AZPS planning and operations groups have an excellent relationship and report to the same director (Section 1.2.1).
6. Control center management and others actively participate in and lead WECC and NERC committees (Section 1.2.2).
7. AZPS has remote terminal units (RTUs) at all substations (Section 2.3).
8. The area control error alarms at a value less than the L_{10} value (Section 2.1).
9. The EMS has good displays, especially for monitoring control performance standards (CPS), CPS1 and CPS2, in real time (Section 2.1).

Recommendations

The evaluation team offers the following recommendations:

1. Expedite, to the extent possible, the EMS replacement project to provide operators with advanced applications for managing the system during peak demand periods (Section 2.3)*.
2. Review staffing levels to identify whether adequate resources will be available to help operations take full advantage of the increased functionality of the new EMS, especially regarding resource-intensive training simulator scenario development (Section 5.1)*.
3. Develop a reactive reserves summary display in the EMS to provide operators with a single place to view aggregated dynamic and static reactive reserves (Section 2.1).
4. Develop cross-training between the generation and transmission operations positions to increase overall operator knowledge and enhance support capability (Section 5.1).
5. Develop a shift-change procedure document to ensure consistency of information exchange (Section 2.2.3).
6. *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 level of AZPS management has previous experience in operations. The planning and operations groups report to a common director, who visits the control center nearly every morning for a briefing of the day's operating plan. This provides the system operators an opportunity to voice any concerns.

In general, the marketing group provides load forecasting and unit commitment using the reliability parameters by transmission operators and operational planning for the day ahead operating plan. The control center personnel review the plan and have the authority to make any changes for reliability.

The EMS personnel are part of the information technology department and are located in the control center and get nearly all direction from control center operators, supervisors, and management. The communications staff is also located at the control center.

The management and officers of AZPS have an "open door" policy that provides the operators easy access to company initiatives.

AZPS works with local news media to raise public awareness of electric safety, particularly during the rainy season each year when the most public accidents occur.

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.

At AZPS, reliability is second to only safety. The order of priority is safety, reliability, and economy. Safety is of utmost importance for both personnel and equipment. The AZPS operators cooperate with the reliability coordinator, Rocky Mountain Desert Southwest

Reliability Coordinator (RDRC), in all directives. In case of safety or complex directives, the AZPS operators will discuss the issues with RDRC operators.

The system operators at AZPS attend operational meetings every five weeks. These meetings include discussion of any lessons learned since the last meeting and any new or changed policies or procedures. The evaluation team considers these meetings to be a positive observation.

Another positive observation is the involvement of AZPS system operators in projects that affect system operation. At present, the most significant project involving operators is the replacement of the EMS.

System operators and planners have separate managers, but they report to a common director. The director is very experienced and facilitates a good working relationship between the two groups. The evaluation team cites this management structure and working relationship as a positive observation.

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.

The control center manager's office is in the control center, very near the control room. This proximity provides two-way access between the operators and manager.

Every five weeks, AZPS conducts a mandatory operators' meeting. Often, the director and vice president will attend these meetings. Other staff personnel are invited to provide information about special issues.

The AZPS control center manager and others have supported and/or led many WECC and NERC committees, working groups, and task forces. The evaluation team considers this leadership and industry involvement 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.

AZPS uses a variety of methods to analyze performance. The system operators are tested during training sessions and are given annual performance evaluations. In addition, operators hold routine meetings to discuss reliability and other issues. Management and supervisors at the control center make use of lessons learned to ensure that errors are not only corrected but that all system operators are aware of any problematic areas or operational concerns.

1.2.4 Human Resources

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

The human resources department has a succession plan for operations personnel. When a senior system operator departs, a new operator is hired at the lower level. AZPS has a low turnover of operators, but recently several operators have departed for various reasons. AZPS currently has four trainees to replace the departed operators, and two trainees are well into the training program. AZPS currently has sufficient system operators to fill all shifts.

The operations department has a staffing plan to provide for operators retiring or departing for other reasons, such as promotion or taking other jobs. System operators are initially trained on low voltage operations. While performing these low voltage duties, a system operator will be in training for the next (voltage) level of operation, which is an apprenticeship in the control center. It takes six to nine months to complete the initial training, but three to four years to become fully trained in extra high voltage transmission and switching.

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.

Corporate communications are distributed to employees though e-mails, a weekly newsletter, and a safety alert program to provide awareness of any close call or incidents. Safety lessons learned are distributed to all employees. The system operators discuss safety issues during their regular meetings.

2. Fundamentals of Operations

2.1 General

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

All AZPS operations personnel review standards of conduct. Operators are required to complete a Web-based standards of conduct module annually, including passing a proficiency test.

The system operators monitor and control the AZPS electric system using an EMS with supervisory control and data acquisition (SCADA). Operators use alarms, frequency monitoring points, wide-area displays, and other system features to assist them in maintaining reliability.

The alarm system has two monitors to detect a system failure and alert system operators. The system has its own monitor, and AZPS built a custom monitor that provides a special alarm should the alarm processing fail. If the alarm system failed, the EMS would switch to the backup server and clear the problem. Alarms are prioritized into four categories. The alarms are set conservatively for many functions. For example, area control error limits are set at a value of +/-30 MW. This is less than L_{10}, and the evaluation team considers this a positive observation.

AZPS system operators can monitor eight frequency points. These monitoring points are strategically located to help determine system breakup, islanding, or a partial blackout. Two frequency measurements, sourced from two different substations, used for automatic generation control will automatically switch in the event of a failure. The system operators have a digital

strip chart in the control room to monitor frequency and other parameters. The source for this chart can be changed manually.

AZPS system operators have wide-area views of all major facilities in the WECC Interconnection. Operators can monitor AZPS system frequency and voltages on single displays. The EMS has reactive displays that allow quick calculation of reactive reserve; however, this is not well presented to the system operators. The team recommends that AZPS develop a single display to include both static and dynamic reactive displays. Beyond the reactive reserve single display, the other displays provide the system operators with information needed to operate the system reliably. The evaluation team cites the EMS displays, especially the excellent control performance standards displays, as a positive observation. The AZPS generator power system stabilizers and automatic voltage regulator status is telemetered and displayed for the operators to monitor.

The AZPS automatic generation control is normally operated in the tie-line bias mode with WECC automatic time error correction. This mode allows the Western Interconnection to automatically control the time error and correct each balancing area's inadvertent interchange.

AZPS is a member of the Southwest Reserve Sharing Group (SRSG). Each member of the SRSG is responsible for maintaining contingency reserves. The total reserve of the SRSG is sufficient to replace the loss of any member's single largest hazard or contingency. The allocation of each member is based on the ratio of firm load share.

RDRC reported having difficulty making real-time assessments of the contingency reserve due to the difficultly of transferring required quotas from the SRSG terminal to the RDRC EMS. Actual spinning reserve and operating data are received by intercontrol center communications protocol (ICCP).

RDRC monitors the SRSG for reserve adequacy. The actual reserves are compared to the required reserves for each balancing authority as well as the entire SRSG, and a real-time assessment is made by the RDRC for both the reserve group and each member. If at any time the SRSG is in a deficient spinning reserve condition, the RDRC provides a service to SRSG that includes determining what action is required, such as committing additional resources, adjusting interchange, or shedding load to restore adequate spinning reserves for each SRSG member.

The difficulty for the RDRC in providing this service to the SRSG is that the required reserve quota and the actual reserve data are sent to the RDRC via different data platforms. Actual spinning and operating data are provided to the RDRC via ICCP. The required quotas for SRSG, however, are provided to the RDRC by a separate SRSG terminal connected to and isolated from the RDRC EMS. The evaluation team feels that this situation needs attention. However, a recommendation was not made by the evaluation team, since the data are being sent to RDRC.

Currently, RDRC desires, and is currently receiving, real-time generating reserve data (reserves) via ICCP from all of its membership, except for AZPS and one other entity, from which RDRC can monitor reserves from its EMS platform. AZPS has stated that sending the data is not technically difficult. However, AZPS has chosen not to accommodate the RDRC request for

reserves data via ICCP because, in the view of AZPS, RDRC has changed the data requirements from requirements set forth in the original SRSG agreement. AZPS told reviewers that it has been fully compliant and accommodating in regards to data requirements set forth in SRSG. AZPS claims that RDRC has not developed a software link between the RDRC EMS platform and the SRSG server, which would give RDRC access to hourly generating reserve schedules. AZPS is considering sending a software programmer to help RDRC build the link in consideration of what AZPS terms, "RDRC shortage of programming resources." However, this will give RDRC access to hourly reserve schedules, not access to real-time reserve data.

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.

AZPS has eight remedial action schemes (RASs). These schemes are much the same as special protection systems in the Eastern Interconnection and are designed to automatically take action to relieve system problems, faster than an operator could possibly respond. The RAS may include several circuits and generators on a scheduling path to control overloading or voltage problems. These schemes have the ability to be armed or disarmed. Changes in the status of each RAS are reported to the reliability coordinator.

2.2.2 Operational Decision-Making

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

AZPS has a policy for decision-making by personnel at the lowest level. This approach provides the personnel closest to the issue the ability to make the best decisions to resolve any problems affecting operations.

2.2.3 Operational Alignment

Organizational structure supports safe and reliable system operation.

The two main functions in the control room, generation and transmission, fall under one manager. Within the control center, there are two transmission positions and two generation positions staffed 24 hours per day, 7 days per week. In addition, a third transmission operator is normally present for the day shift, Monday through Friday. The power marketing group is at a distance from the control centers.

AZPS has an empowerment agreement with the RDRC the same as other entities under the authority of RDRC.

Four outage coordinators work with neighbors and the RDRC to plan transmission outages. The outage coordinators provide the switching orders to system operators, and at least two system operators check the switching orders prior to implementation. These outage coordinators work

with the operations engineers and often perform outage studies to assure reliability is not compromised with the anticipated outages.

The system operator's authority is stated in a letter that is posted in both the primary and alternate control centers. It is signed by the executive vice president and the manager of power operations at the control center. The letter states that the system operators have the authority to interrupt load and take actions as necessary to maintain reliability.

AZPS has not delegated any functions to others. Although the marketing group provides load forecasts and unit commitment, the system operators have authority to revise the operating plan as necessary for reliability issues such as voltage control by changing unit commitment, requiring marketers to revise purchases or sales to control power flows, or any other special situation. AZPS has not been delegated any functions by other entities.

The procedures and policies are produced in an "e-Doc" application that allows all operators and supervisors to draft and retrieve documents. In response to the 2004 readiness review, AZPS has included nearly all procedures and policies in e-Docs. Some documents are not yet part of e-Docs since they require a review and need specific attributes included. The team determined that since this was under way and the most important documents are updated, a recommendation is not warranted. AZPS is aware of the documents that need to be completed.

Once a document is approved, it is sent to all system operators, and AZPS uses a feedback loop that includes an electronic log for operators to complete to acknowledge they reviewed and understand the material. Policies and procedures are reviewed at each system operator meeting on a five-week schedule.

At shift change, incoming system operators speak with the outgoing operators and read the logs from previous shifts to learn the state of the system and review outages. Although this practice has worked well, the evaluation team recommends that AZPS provide a shift-change document for both transmission and generation system operators that lists the items to be reviewed before beginning a shift.

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.

The AZPS EMS has SCADA ability that is used extensively by the operators to control the AZPS system. Having RTUs at every substation provides a means for the operators to operate any device in the AZPS system, and the evaluation team cites this as a positive observation.

Currently, AZPS does not have a state estimator or real-time-contingency-analysis (RTCA) program. As an alternative to RTCA, AZPS uses the *Arizona Security Monitoring Manual* (ASMM), a comprehensive set of studies resulting in operational guides and nomograms for all critical facilities' contingencies. The ASMM was cited as an example of excellence at the

previous readiness visit in 2004. The ASMM is a manual process that is quite useful and straightforward for analyzing the critical WECC scheduling paths under AZPS control (paths 22, 23, and 49). It includes a considerable amount of information about compensation of reactance on the high voltage system. The AZPS EMS has alarms for the 230 kV system and other facilities based on thermal limits. The ASMM has been praised as a great tool, but it is a manual process and is not state-of-the-art for 2007.

The RDRC has RTCA functionality for its region that runs every 15 minutes, but AZPS has little knowledge of this due to its conservative operation with the ASMM. RDRC will make a contingency study for AZPS whenever requested. The team realizes that it would be best for AZPS to provide RTCA locally, but implementing an RTCA on AZPS's existing EMS is nearly impossible. AZPS is working to install a new, state-of-the-art EMS that includes state estimator and RTCA as well as several other advanced applications. The new EMS completed the factory acceptance test at the time of the readiness evaluation and is expected to be shipped to AZPS in the next few weeks. It is expected to be in service about the end of this year or early 2008. The state estimator and RTCA will follow the installation of the EMS and should be available for 2008 summer peak. AZPS has prioritized the installation of state estimator and RTCA to be completed as soon as possible. The evaluation team recommends that AZPS expedite the EMS replacement project to provide operators with advanced applications for managing the system during peak demand periods.

The tools team inquired whether AZPS would be looking into the feasibility of obtaining state estimator/RTCA warning messages electronically from RDRC's EMS by the 2007 summer peak. The team had concerns about AZPS and other Desert Southwest members not receiving continuous state estimator/RTCA coverage. AZPS personnel remarked that they would continue to devote all resources to the EMS installation before setting up any electronic transfer of state estimator/RTCA AZPS data from RDRC's system. A recommendation to have AZPS investigate the feasibility of receiving RDRC alarms was not adopted by the team. AZPS personnel suggested the AZPS manual process of contingency analysis (i.e., nomograms and use of the AZPS ASMM) was conservative enough to use until the new EMS is in place, and the team accepted the idea that it was better to devote all resources to the AZPS EMS installation, which includes a state estimator and RTCA, than to devote time and resources into establishing links with the RDRC EMS. The ASMM was cited as an example of excellence after the 2004 AZPS report and was cited as a positive observation in this review.

Transmission congestion or overloads are controlled using the WECC unscheduled flow mitigation procedure. Communication of any system operating limit (SOL) violation is accomplished by phone to all affected parties, including the RDRC, and followed by a message sent via the regional communications system, the WECC NET messaging system.

Load and generation balance is accomplished first by the marketing group producing a daily operating plan that includes load forecast, unit commitment, and purchases or sales. The plan is given to the system operators who may accept or revise the plan for reliability. The system operators are fully responsible for control performance standards and load following.

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.

The alternate control center functionality and layout is equivalent to the primary. The alternate control center is identical to the primary except that it has one less console, six instead of seven, and the large screen display is a front projection from the ceiling. The alternate control center is supplied with emergency rations and drinks for several days and has additional supplies for hygiene purposes. The evaluation team cites the functionality of the alternate control center as a potential example of excellence. Further discussion is included in Appendix 1, Section 8.

Similar to the primary center, the alternate center has redundant servers, local area networks, modems, and front-end processors. The communication to both control centers is provided by loops that have no dependency on each other. The evaluation team considers this redundancy a positive observation.

The AZPS load shedding program is in accordance with WECC requirements, specifically the *Southern Island Load Tripping Plan*. There are seven steps in the underfrequency load shedding (UFLS) to enable a smooth load drop that helps to prevent overshoot. The program includes automatic load restoration at certain locations for frequency stability should the frequency rise significantly above 60 Hz. Generator tripping is coordinated such that the generators do not trip until UFLS has completed. AZPS also uses considerable undervoltage load shedding to prevent voltage collapse during disturbances.

The system restoration plan of AZPS is coordinated with members of RDRC. RDRC coordinates the restoration between its members. Some of AZPS neighbors remarked that they do not have the blackstart/restoration plan of AZPS. Though it does not rise to the level of a recommendation, the evaluation team suggests AZPS review the idea of distributing the plan to its neighbors and requesting the plans of others.

AZPS capacity and energy emergency plan has four scenarios:

1. Insufficient generation to meet the reserve quota within the next two hours
2. Insufficient generation to meet reserves in real time
3. Insufficient generation to meet load due to a generator tripping
4. Insufficient generation to meet load due to a transmission outage

The system operators have the authority to implement the plan, and this is included in the operating procedures, *ECC 8.4.1*. The AZPS manual load shedding program it also compliant with WECC requirements. AZPS has implemented a plan to rotate feeders to minimize the impact of outages to its customers, which also provides a method to treat all customers the same.

The nuclear power plant in AZPS's footprint is a large facility with multiple owners who receive shares of the output by dynamic schedules. The voltage requirements of the plant are included in planning studies and provided to the system operators. The system operators have set real-time voltage limits on the main busses more stringent than the nuclear power plant requirements to provide notice to the plant operators that voltages are approaching the limits.

3. Fundamentals of Maintenance

3.1 General

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

AZPS has a staff person available 24 hours per day, 7 days per week to address EMS and communications problems or failures. Other skilled workers inspect and repair field equipment including substations and transmission line hardware. AZPS takes vegetation management seriously and coordinates with the forest service to help the transmission right-of-ways clearance serve as breaks to help control forest fires in the remote areas of Arizona.

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.

The AZPS EMS has an availability of 99.95 percent. The evaluation team learned that during the past six months the EMS had 100 percent availability. With the EMS and communications staff located at the control center facility, any problems with either the EMS or the communications system are quickly analyzed and repaired.

The instantaneous values for generator, tie lines, and wheeled load are separately displayed as integrated over each hour. The EMS compares the integrated values against the accumulated values and displays the difference. This method works well to find meter errors, which are promptly corrected.

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.

AZPS performs routine substation and relay maintenance. Substation relays are tested on either a four- or five-year cycle. Generator relays are tested concurrent with generator outages.

Transmission lines are patrolled by air at least annually with any hardware or vegetation concerns noted and passed along to vegetation management or transmission maintenance.

4. Fundamentals of Operational Planning

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

Seasonal studies are made by the technical projects department. The model validation is performed by a WECC group and results are tested against real time data.

AZPS is a member of the Southwest Area Transmission (SWAT) group that promotes regional planning in the desert southwest. This group includes transmission regulators/governmental entities, transmission users, transmission owners, transmission operators, and environmental entities. The SWAT regional planning group includes four main subcommittees, which are overseen by the SWAT oversight committee. The SWAT is divided into subgroups for each region of the southwest. AZPS has representatives on of the subgroups and the oversight committee.

Transfer capabilities are determined by studies meeting the WECC planning criteria. Available transfer capability (ATC) is determined by subtracting the committed capacity from the total transfer capability. The ATC values are posted to other entities.

AZPS uses the *Arizona Security Monitoring Manual* for transmission limits of major facilities within the AZPS system. This manual was produced by making studies of various configurations of the system with contingencies of transmission and generation, including nearly all possible outages of critical facilities (Positive observation 3).

AZPS load has a "Double – Double" relation between load peaks and valleys. This means that the daily peak can be twice the daily minimum load, and the summer peak can be twice the spring or fall peaks.

Currently, AZPS models the nuclear power plant's high voltage bus voltages in planning studies. The evaluation team requests that AZPS consider including the nuclear power plant auxiliary busses in planning studies to better analyze the effects of system disturbances on the nuclear plant operations. The auxiliary bus voltages might be telemetered to the EMS for system operator monitoring.

The system operators do not have the actual voltage studies for the nuclear plant; however, they do have nuclear plant voltage limits. The system operators set limits in the EMS to more conservative levels to provide a warning of voltage concerns.

The technical projects manager, who leads a three-person department, performs stability and dynamic near-real-time studies. These studies are the basis for the ASMM and augment the studies performed by the AZPS planners. This manager has also been hired out to other companies for similar studies. The evaluation team considers the work of the technical projects manager a potential example of excellence.

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.

AZPS training consists of two basic programs, initial training for new system operators and ongoing training for experienced system operators. Both programs are divided into generation and transmission system operator training. The training is conducted by the power operations training consultant. The training schedule is provided on a year-ahead basis.

The trainer has developed a systematic approach to training. This method provides analytical and competent training for the new hire. When a new hire starts training, a challenge exam is given to determine the level of training needed. The training is designed to fill each individual student's needs. The student may omit portions of the training depending on knowledge and previous experience. The training program for a new hire is in stages by voltage operation. A new transmission system operator works with low voltage system elements first and graduates to increasingly higher voltages. Finally, the operator is trained to operate the extra-high-voltage system. A new system operator works under the direct supervision of an experienced person until NERC certified.

AZPS uses computer-based training from outside vendors to prepare operators for NERC certification. AZPS is a NERC-approved continuing education provider for continuing education hours (CEHs). The recertification of experienced system operators is accomplished through AZPS's CEH program. Currently, AZPS has 18 classes accepted by NERC.

System operators are assigned to either the generation or transmission group in the control center, and they work in teams within their area. There is little cross-training between the two groups. The team recommends that AZPS training develop formal cross-training between the generation and transmission groups in the control center.

AZPS has only a small generic simulator that does not represent the AZPS system. The new EMS includes advanced applications, including a complete operator training simulator. This will prove to be a very useful tool for training system operators. However, any useful simulator must have scenarios that are credible and useful learning experiences, and it takes considerable effort to develop such scenarios. The evaluation team recommends that AZPS review staffing levels to support the new EMS, which includes the operator training simulator and other advanced applications (state estimator, real-time contingency analysis, and operator power flow) and provide ample system operator training time.

The training area consists of an office for the trainer and several tables for classroom-type settings. The area also overlooks the control room as an observation room. There are blackout curtains to restrict view into the control room when observation is not desired.

AZPS system operators are NERC certified, most of them with the reliability operator credential. Three operators in the generation group are certified with the balancing and interchange operator credential. Two of the three have plans to recertify with the reliability operator credential. The team examined the certification list and work schedule. There were no violations of non-certified system operators working independently. Four new system operators are in training to replace four system operators who departed for various reasons.

Any near misses or incidents, such as switching errors, are reviewed and discussed at the operator meetings to avoid future occurrences. These lessons learned are incorporated into the training program.

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.

Human errors are minimized by ongoing training described above. The lessons learned are included in training sessions to provide information to all system operators.

Corporate management is involved with operational decisions. The executives at AZPS operations group are highly regarded for their expertise and therefore receive support from corporate management. Corporate management does not make any risk assessment of operational decisions.

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.