

# NERC

NORTH AMERICAN ELECTRIC  
RELIABILITY CORPORATION

## Reliability Readiness Evaluation Report Balancing Authority/Transmission Operator

Bonneville Power Administration  
Vancouver, Washington

to ensure  
the reliability of the  
bulk power system

**November 9 and 12–15, 2007**

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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. Documents related to the program are available at <http://www.nerc.com>.

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 Bonneville Power Administration (BPA) representatives on November 9 and 12–15, 2007. This report reflects the views and recommendations of the evaluation team regarding the readiness of BPA to meet its responsibilities as a balancing authority/transmission operator.

## Evaluation Team

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## Organization Profile

The Bonneville Power Administration is a federal agency based in the Pacific Northwest. BPA is under the U.S. Department of Energy and is self-funding through the sale of services at cost. The BPA service area covers approximately 300,000 square miles and includes most of Washington and Oregon and portions of Idaho, Montana, Wyoming, Nevada, Utah, and California.

BPA has approximately 15,000 circuit miles of transmission operated at the 115 to 1,000 kV levels. Approximately one-third of BPA's transmission is operated at 500 to 1000 kV levels. BPA has 35 interconnections with neighboring utilities and operates approximately three-fourths of the high-voltage transmission in its service area. Seasonal peak loads for BPA's service area were 7,129 MW in July 2006 and 8,600 MW in November 2006. BPA's customers include 57 cooperatives, 41 municipalities, 29 public utility districts, 7 federal agencies, 6 investor-owned utilities and 5 direct-service industries consisting primarily of aluminum smelters.

BPA markets wholesale electrical power from 31 federal hydro projects in the Columbia River Basin, one non-federal nuclear plant, and several small non-federal power plants. About 40 percent of the electric power used in the Northwest comes from BPA, and approximately 60 percent of the power BPA sells is generated by the federal hydroelectric facilities.

BPA is registered with NERC as a balancing authority, transmission operator, transmission owner, transmission planner, resource planner, transmission service provider, distribution provider, and load-service entity. BPA also has an agreement with Tacoma Power to perform balancing authority functions, as a backup for Tacoma Power, that involves incorporating Tacoma Power's interchange into BPA's area control error and providing load-generation balancing service for Tacoma Power. BPA also has agreements to provide contingency reserves for several independent power producers in BPA's service area, and operates as the path operator for several interconnected transmission lines. BPA is a member of the Western Electric Coordinating Council and the Northwest Power Pool Reserve Sharing Group. The Pacific Northwest Security Coordinator is BPA's reliability coordinator.

## Executive Summary

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

BPA has a culture that focuses on providing reliable operations. The support from senior management is demonstrated by consistently supporting system operator training, ensuring adequate support personnel, and constantly monitoring system reliability through discussions and tracking key reliability metrics. Communications are open regarding system reliability issues, and system operations has the opportunity to provide input on goals and improvements.

The evaluation team makes several positive observations concerning the tools and support provided to support system operations; succession planning and support provided for training of system operators; and the backup control center arrangement, including backup power resources.

The evaluation team makes several recommendations to improve BPA's system operations. The key recommendations that were jointly selected by the team and BPA's management are related to the supervision of non-NERC-certified dispatch trainees, improving senior management's direct communications with system operators, and revisions to procedures to ensure proper separation of capacity and energy emergency plans and business continuity plans.

Overall, the evaluation team identified 13 positive observations and offers 7 recommendations that, if implemented, will enhance BPA's readiness to maintain the reliability of the bulk power system.

### Positive Observations

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

1. Operational planning personnel are available to assist the system operators around-the-clock and can run studies from home, if necessary (Section 4).
2. Outage coordination is performed using BPA's Coordinated Outage System, keeping everyone involved in the process and informed of the plans (Section 2.3).
3. The dispatcher standing orders document control process provides good control of temporary and permanent changes to operating procedures (Section 2.2.3).
4. BPA has displays that show reactive reserves for each generating unit and each generating plant, identifying dynamic reactive reserves in potentially islanded areas around the system (Section 2.1).
5. The Control System Monitor group provides excellent around-the-clock coverage and support for systems used in operations, removing the burden from the dispatch staff (Section 3.1).

6. Confidential information on loss of control center functions has been redacted from the public report. See discussion in Appendix 1.
7. Operators have a high level of confidence in operational planning studies (Section 4).
8. BPA's dedicated training staff is trained in and applies the Analyze, Design, Develop, Implement, and Evaluate (ADDIE) process (Section 5.1).
9. BPA uses outside resources, such as the Pacific Northwest National Laboratory (PNNL), to enhance its system operator training program (Section 5.1).
10. A staff of five technical personnel support the dispatch training simulator; the group develops training scenarios, delivers training sessions, and maintains the simulator (Section 5.1).
11. Confidential information on backup power for the control centers has been redacted from the public report. See discussion in Appendix 1.
12. Confidential information on physical security of the control centers has been redacted from the public report. See discussion in Appendix 1.
13. Succession planning for system operators adequately addresses future needs (Section 1.2.4).

## Recommendations

The evaluation team offers the following recommendations:

1. Revise the current operating policy to ensure that non-NERC-certified dispatch trainees perform critical tasks only under the direct, continuous supervision and observation of the NERC-certified individual filling the required position (Section 5.1).\*
2. Develop and implement a process for improving direct communication between senior management and system operators (Section 1.2.5).\*
3. Expedite the implementation of real-time contingency analysis tools and state estimation so these capabilities are available to system operators (Section 2.3).
4. Implement a uniform method for technical staff to present operational studies to system operators to improve the communications of results (Section 4).
5. Develop formal shift-change procedures that ensure all pertinent information has been exchanged and documented (Section 2.2.3).
6. Revise the BPA procedures, as necessary, to ensure that the procedures involving capacity and energy emergency plans are separated from other emergency response plans (Section 2.4).\*
7. Revise the BPA restoration procedures to specify the interaction necessary between BPA's system operators and the Pacific Northwest Security Coordinator to mirror the Northwest Power Pool (NWPP) restoration plan (Section 2.4).

\*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 and positive observations 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 *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.*

BPA is committed to maintaining and improving system reliability. System reliability is a key part of BPA’s mission statement and is incorporated in its core values as a part of operational excellence. System reliability is a key target and is reviewed monthly, along with performance metrics, by BPA’s Transmission Management Committee. The committee meetings are attended by all of BPA’s senior executives, including the administrator, deputy administrator, senior vice president of transmission services, and other vice presidents. Deviations from expected results are brought to management’s attention on all metrics related to system reliability issues. Maintaining system reliability is included in each executive’s and manager’s annual performance program. Monthly, quarterly, and annual reports are prepared on progress toward meeting these metrics; the reports are provided to all BPA employees, and the Department of Energy, BPA’s customers, and congressional delegation.

In planning for capital expenditures, BPA uses a weighting approach based on its core values, and system reliability has one of the highest ratings in the analysis. Once a project is approved in BPA’s budget, the operating organization takes the lead responsibility for completion, and progress is monitored and tracked at the corporate level.

#### 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.*

BPA has recently launched an initiative to update its response to emergency conditions. BPA has consolidated emergency management, crisis management, and asset management planning into a program intended to produce an integrated and comprehensive set of plans to more effectively respond to system events. This effort was started in July 2007, and a business impact analysis is planned for 2008 to identify BPA’s highest priority products and services the

company must sustain during an emergency — all of which are related to providing safe, reliable, and adequate transmission and generation.

### **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.*

BPA uses a Reliability Council to deal with key policy and strategic issues related to providing reliable operation. BPA also uses an “agency decision framework” to examine all aspects of decisions. System reliability impacts are a key consideration in that framework and BPA has established a Transmission Services Leadership Team with the responsibility for identifying risks associated with reliability of the transmission system. In 2006, BPA identified cascading outages on the BPA system as one of its top 10 corporate risks to manage. BPA developed a cascading outage risk assessment and developed and implemented an improvement program. The program was updated in 2007 and is expected to have further refinement developed in 2008.

### **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.*

BPA recently developed an Efficiency Project Improvement Program aimed at examining all areas of the organization and initiating improvement programs. This effort already impacted the organization. Parts of the organization were restructured, and aggressive targets were set for staff reductions. System operations has not been impacted by these initiatives because of the emphasis placed on system reliability.

### **1.2.4 Human Resources**

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

BPA’s succession planning involves the area managers identifying the critical functions in their organizations and developing explicit succession plans or alternate use of available personnel for short-term purposes. The BPA human resource staff provides demographic analysis, and appropriate plans are put in place through consultation with the management team. The projected needs for additional or replacement personnel are determined and budgeted at least annually. Managers have the flexibility to hire contract employees or offer temporary assignments to existing employees to cover any urgent need, such as an unexpected loss of key personnel.

BPA’s transmission field program has been a primary source of employees for the system operations group, and the field apprentice class of employees has been increased recently. BPA has developed the assistant dispatcher trainee program to allow system operations to bring in new employees from the substation group and from other utilities. BPA has also provided budgeted funds to pay overtime for training new system operators. Similarly, cooperative

students are the pipeline for the engineers in system operations, and an accelerated training program has been developed for them.

From a budgeting standpoint, BPA has clearly recognized the importance of maintaining a trained staff of employees for system operations. Providing the necessary training is an important part of BPA's succession strategy, and the training staff was increased by two people within the past year.

BPA has also developed a close connection between performance and training in its performance plans for system operators and support personnel. BPA has required certain training to be completed, and employees are encouraged to take voluntary training courses. Support staff have annual performance programs that include developmental plans and are evaluated at least twice a year. BPA has a training tracking system that allows the managers to monitor progress in required training.

The competition for trained personnel and demographics of the supply of system operators creates a difficult staffing challenge, and the evaluation team finds, as a positive observation, that BPA's succession planning for system operators adequately addresses future needs.

### **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.*

BPA conducts an annual employee survey as a vehicle for employees to provide input on the strategic priorities of the organizations. BPA's administrator holds briefings periodically throughout each year and solicits employee feedback. The transmission services senior vice president and system operations managers also hold briefings throughout the year; all employees are invited to attend and to offer comments on organizational goals, objectives, and strategies.

As previously mentioned, BPA recently developed several Efficiency Project Improvement Programs, and all employees were given an opportunity to contribute to the development of strategies and setting of priorities. Employees are now involved in the implementation of decisions reached. BPA has an open-door policy for personnel to take concerns to management at any level, and it is expected that the employees will get prompt answers to their concerns.

BPA senior management frequently provides e-mail instructions to managers to make sure they understand the need to communicate with their staff. Monthly manager briefing packages are provided to the senior system operators to share with their team of system operators. Senior management routinely communicates directly with the system operators through the use of e-mails, videos, and visits to the system control center.

While BPA has the programs in place to provide continuous communications with the system operators and the entire organization has recognized the importance of system reliability, the evaluation team finds that the communications within the system operations organization and between senior management and system operations managers is much more effective than the communications between senior management and the system operators. This gives the team a

concern about whether the message that system reliability and the performance of system operators is a top priority at the top of BPA's organization. The evaluation team recommends that BPA develop and implement a process for improving direct communication between senior management and the system operators.

## 2. Fundamentals of Operations

### 2.1 General

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

BPA's energy management system (EMS) and supervisory control and data acquisition (SCADA) system is hosted in two geographically separated control centers — the Dittmer Control Center and the Munro Control Center. The control centers are connected by redundant communication links, with dual redundant EMS configurations at each of the two control centers. Each EMS is capable of controlling the entire BPA transmission system. Each control center is self-sufficient and fully redundant. BPA's Dittmer Control Center has system operator stations for transmission operations, balancing authority functions and monitoring of special action schemes and remedial action schemes, and a separate station for the senior shift operator. Each station has multiple electronic display units. BPA's Munro Control Center has multiple electronic display units for transmission operations and a separate station for a senior system operator. Each control center has spare electronic display units available for support functions and as backup for the operators.

Transmission system line flows, voltages, and associated alarms are available on all electronic display units in the two control centers. One-line diagrams of transmission lines and substations are available on the display units, with color-coded status of lines, busses, and reactive devices. The EMS generates alarms for change of status, limit violations, and abnormal change of actual loadings. Custom applications provide estimates of reactive reserves and nomogram calculations of alarm levels for tie-line capacity, as well as arming levels for remedial action schemes.

The EMS at each control center drives a mapboard of BPA's transmission system, and electronic tagging capabilities are provided at both control centers. The response time of the EMS at each control center is 4 seconds for data and device status associated with BPA's transmission system and 10 seconds for data from neighboring systems.

BPA has 22 continuous frequency measurement points. Additional frequency measurements can be activated for use in synchronizing islanded transmission segments. BPA has more than 20 phasor measurements, from units throughout its system, displayed on a separate electronic monitor not driven by the EMS. BPA has approximately 13 frequency measurements telemetered from neighboring systems. All of the frequency measurements can be shown on a single electronic display or viewed at the substation level. This provides sufficient coverage to monitor for anticipated islanding conditions on the BPA transmission system. BPA has system frequency measurements available from two sources separate from the EMS, monitored on permanent recording charts in the control centers. These measurements are provided by two high-availability global positioning system (GPS) central time systems, one originating at the

Dittmer Control Center and one at the Munro Control Center. Each system has redundant GPS receivers, rubidium oscillators, and dual 60 Hz power system references fed from geographically separate substations. These systems provide frequency and time deviation data to the EMS, and separate signals to the recording charts and system operator displays. The frequency measurements provided by the GPS receivers are used in the calculation of BPA's area control error. If one of the measurements fails, the other is automatically substituted in the calculation.

BPA system operators have special displays dedicated to monitoring critical transmission paths that show the line flows, tap position of regulators, capacitor availability on the paths, and alarms for operating transfer capacity limits. Another special display is dedicated to show the nuclear plant bus voltages. The EMS provides the system operators the capability to import, and perform trending analysis on, historical data by selecting displayed quantities.

BPA's system operators have generation displays that show real-time real and reactive generation, spinning reserves, calculated ramping capability, and status of automatic voltage regulators for each of the generators in BPA's balancing footprint. They also have displays of BPA's area control error and real-time calculations of each generator's ramping capability. The displays are well defined, including BPA's required and available reserves and the reserve requirements for the other members of the reserve sharing group. Reactive reserve displays show the reactive capability of each generating unit and plant in areas that typically could become islanded within BPA's system. An EMS application provides a calculation of the dynamic reactive reserves available. The displays of dynamic reactive reserves aid the system operators in quickly identifying reactive reserve issues and determining whether a voltage collapse is likely to occur, and the evaluation team cites the displays as a positive observation.

## 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.*

BPA has an extensive system of special protection and remedial action schemes, ranging from local schemes to large schemes that impact the bulk power system. BPA has a system control station and a system operator assigned to monitoring the status of these schemes in the Dittmer Control Center. Control action is automatically initiated by the loss of a transmission line, loss of major generation, rapid power change, or rapid voltage drops. Control actions include generation tripping, generation ramping, suspension of generation control, braking resistor insertion, load shedding, or reactive device switching.

BPA's system operators have special electronic displays that show the status of all special protection and remedial action schemes. BPA tests the schemes that impact the bulk power system every 12 to 18 months and local schemes every five years, as specified in BPA's Reliability Centered Maintenance Program. The schemes generally do not depend on EMS inputs in order to take actions. The EMS is used to monitor the health of the schemes, to provide the system operators alarms, and to arm some of the schemes.

BPA's system utilizes a variety of static and dynamic voltage control devices, which are both manually and automatically switched, including shunt capacitors and reactors, series capacitors, static var compensators, under-load and no-load transformer tap changers, and generators. Manual reactive switching is used to maintain voltage schedules and reactive reserve requirements, and automatic voltage control is used for contingencies.

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

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

BPA's system operators utilize a variety of materials, tools, and training to guide their decisions and to weigh the operational risks associated with decisions that could impact the reliable operation of BPA's bulk power system. Operating procedures and policies utilized to make these decisions are available at the system operators' consoles and include dispatcher standing orders, operational memos, work standards, and NWPP and WECC procedures and policies. Dispatcher standing orders deal with line loadings, generation levels, etc., and give the operators worst-case conditions along with system values, considered to be safe, to be followed until new values are established by studies. Operational memos are issued for operational changes specific to a dispatcher standing order that need to be implemented in a more rapid manner than revision of the order will allow. The memos are approved by a control center manager or senior system operator.

Loading limits developed from seasonal studies are provided to the system operators in e-mail notifications, changes in dispatcher standing orders, updates to SCADA, and postings on BPA's OASIS (Open Access Same-Time Information System) site. When seasonal limits change external critical path limits, the limits are communicated to neighboring utilities and path operators.

In dealing with potential system operating limit (SOL) or interconnection reliability operating limit (IROL) violations that involve external paths, the BPA system operators coordinate actions with the path operators to develop reliable resolutions. BPA's reliability coordinator has access to BPA's dispatcher standing orders and is advised of any potential SOL or IROL violations, along with neighboring utilities that may be impacted directly.

Most of the generating units in the BPA balancing authority area are monitored, and any changes in automatic voltage regulator or power system stabilizer status are immediately available to BPA's system operators. The generating owners of non-monitored generators are obligated by agreements to immediately advise BPA's control center of any status change.

Switching orders are normally faxed or sent to BPA's control center for review and coordinated with other switching orders prior to the day actual switching is planned to occur. Prior to switching, the system operators will review and approve the switching order, then repeat it to the field personnel. When the switching is completed, it will be repeated back to the system operators. As the switching is taking place, the event is monitored by the system operators for expected results. If expected results are not seen or switching order events result in unexpected

activity, the system operator stops the switching process until it can be reviewed with the worker performing the switching.

### **2.2.3 Operational Alignment**

*Organizational structure supports safe and reliable system operation.*

BPA has a comprehensive system of policies and procedures that cover normal and emergency operations. The system operators have access to dispatcher standing orders, NERC standards, and Northwest Power Pool and WECC procedures.

Dispatcher standing orders and associated operational memos provide detailed instructions for the system operators in normal daily operations. “Green Memos” are issued for operational changes specific to a dispatcher standing order that needs to be implemented more rapidly than revision of the order will allow. The Green Memo must be approved by the control center manager or a senior system operator. Changes issued via a Green Memo are incorporated into the next revision of the dispatcher standing order. “Yellow Memos” are temporary changes in a procedure until it can be incorporated into a Green Memo or dispatcher standing order. Yellow Memos are issued by a senior system operator and dated, and a copy sent to the control center manager and the dispatcher standing order coordinator. When a Yellow Memo is cancelled, the senior system operator notifies the control center manager and the dispatcher standing order coordinator. All changes to the dispatcher standing orders are routed through the system operators, checked by the system operators, and signed off by everyone involved in developing the changes or impacted by the changes before being approved as permanent changes. When the changes are approved, a memorandum is issued to the operating staff announcing the new dispatcher standing order. The evaluation team finds, as a positive observation, that the dispatcher standing order document control procedure ensures system operator awareness of all temporary and permanent changes in operating procedures.

BPA has a shift-change procedure that describes the steps operators are to perform when turning over a shift. The system operators have electronic displays that show the planned activity for the coming day. It is the responsibility of the operator on shift to cover the planned activity for the position being turned over. The shift-change procedure is used as a guide by the operators, but there is no required checklist to complete for verifying that the steps are completed. The evaluation team recommends that BPA develop a formal shift-change procedure that ensures the intended steps in the current procedure are completed, that all of the pertinent information is conveyed to the system operator taking over a shift, and that the information exchange is documented for future reference.

### **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 BPA system operations group maintains an extensive state estimation and real-time contingency analysis capability that is used by BPA’s reliability coordinator to assess the

reliability for the entire footprint of the reliability coordinator, including BPA's area. State estimation results are made available for BPA's system operators on one-line displays, which are duplicates of the BPA EMS one-lines. The results are also viewable on a semi-graphical tabular display. Real-time contingency analysis results are presented on a summary displays, which shows equipment that would exceed a limit if a contingency occurs. BPA's operational planning staff runs studies based on the WECC system models (updated for current system conditions) and performs contingency analysis for n-2 conditions to provide the system operators conservative results and guidance, as needed, including being on call to provide support around-the-clock.

BPA is in the process of implementing the use of state estimation and real-time contingency evaluation capability for its system operators. The evaluation team recommends that BPA expedite the completion of these applications so its system operators will be able to independently evaluate system conditions. This should also lead to enhancement of BPA's training simulator by providing the capability to capture state estimation cases for simulation exercises.

BPA's transmission group performs interchange scheduling and approves tags. The marketing group provides net interchange schedules to BPA's system operators responsible for balancing authority functions. BPA's system operators have displays of real-time information on each of the generators in BPA's balancing footprint. This includes real and reactive generation, spinning reserves, calculated ramping capability, and status of automatic voltage regulators. The EMS calculates BPA's area control error, provides real-time calculations of each generator's ramping capability, and performs the automatic generation control function.

The NWPP requires outage requests for facilities that impact the bulk power system to be submitted through the Coordinated Outage System a minimum of 45 days prior to the month in which the outage is proposed. This window allows adequate time for coordinating requests with other neighboring NWPP members, developing capacity plans for scheduled paths, and notifying all impacted parties. Approval of outages requested less than 45 days in advance can be accepted depending upon whether the outage affects the capacity of a constrained path and whether other facilities associated with the constrained path are also out of service. Two meetings are held annually to coordinate outages for 6–12 months in the future, to identify the best outage windows, and to eliminate or minimize overlapping outages that severely restrict transmission capability. The NWPP coordinated outage process is completed monthly and used to determine the equipment outages planned for the NWPP area for each day. BPA's planned outages are then modeled in studies performed in advance by BPA's operational planning staff to determine system operating limits for each day and to identify the critical facilities for BPA's system operators to monitor. The evaluation team makes a positive observation that outage coordination is performed professionally and using the Coordinated Outage System keeps everyone involved in the process and informed of the plans.

BPA's system operators continuously monitor the reactive reserve available on generation that affects critical paths. All generators in the BPA balancing authority area are required, by regional standards, to have automatic voltage regulators set in a voltage control mode and to be active at all times so that BPA can deploy the reactive reserve when needed. BPA continuously

receives actual Mvar output for each controllable generator and the reactive capability at each voltage level for each plant. Special applications provide the system operators real-time calculations of reactive reserves and aid in determining voltage collapse determinations.

### **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.*

Most of the load served by the generation marketed by BPA is located in the service areas of other utilities. The load served directly by BPA provides a limited amount of load shedding capability. BPA participates in the NWPP underfrequency load shedding program. The plan requires each NWPP member to shed up to 28 percent of its peak load in five 5.6 percent steps at 59.3, 59.2, 59.0, 58.8, and 58.6 Hz. Automatic load restoration is available for some of the load tripped at 59.3 Hz, when the frequency is restored to 59.8 Hz, or at 60.6 Hz to minimize overfrequency conditions. BPA's system operators can also shed load manually. The system operators have information displayed on pre-arranged feeders that specify the amount of load that will be shed and number of customers impacted. The operators can manually cycle the feeders. Some of the loads available to be shed manually are also included in the automatic underfrequency load shedding program. The system operators' displays show the loads that are included in both load shedding schemes, and the operators are instructed to not use any loads in the automatic scheme for manual load shedding, if possible.

BPA also participates in a NWPP coordinated system restoration plan. BPA's primary responsibility is restoring the high-voltage transmission grid. Designated blackstart plants are used to build generation-load islands, which are then synchronized and interconnections established. BPA's reliability coordinator is consulted before synchronizing with neighboring utilities. In reviewing BPA procedures and the NWPP restoration plan, the evaluation team finds the NWPP plan to be clearer about the required communications with BPA's reliability coordinator, and the team recommends that BPA revise their restoration procedures to specify the interaction necessary between BPA's system operators and the Pacific Northwest Security Coordinator to mirror the NWPP restoration plan.

BPA's capacity and energy emergency procedures clearly authorize BPA's system operators to take the actions necessary to protect the bulk power system. For BPA, these procedures are complex and necessarily cover many issues, such as arrangements with federal hydro projects and other connected generators to adjust generation, arrangements with transmission customers to reduce load, and providing protection for fisheries. In addition, BPA has emergency procedures directed at protecting its resources for business continuity. In each case, emergency response teams are identified to resolve issues and direct actions. In discussions with BPA personnel, it was not clear to the evaluation team that all of these procedures have been reviewed to ensure that the authority of the system operators to take action has been clearly separated from the responsibilities assigned to other response teams. The evaluation team recommends BPA revise its procedures, as necessary, to ensure that the procedures involving capacity and energy emergency plans are separated from other emergency response plans.

## **3. Fundamentals of Maintenance**

### 3.1 General

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

BPA has a Control System Monitor group that provides around-the-clock monitoring of the performance of its power system control, system protection, data acquisition, and telecommunications systems. Control System Monitor employees work rotating shifts at the Dittmer Control Center to provide continuous monitoring of these systems. If a problem occurs, these personnel perform first-line analysis and attempt to repair the problem. If they cannot correct the problem, they call the appropriate maintenance group to resolve the issue. Both control centers have software, hardware, and telecommunications system maintenance support personnel stationed on-site who perform the routine maintenance activities and are available for callout around-the-clock to resolve problems. The evaluation team recognizes the Control System Monitor function providing around-the-clock coverage and support, and relieving the system operators of this burden, as a positive observation.

BPA uses digital fault recorders, sequence of events recorders, and digital relays with a combination of oscillograph and sequence-of-events recording for disturbance monitoring on its system. BPA also uses phasor measurement unit data received by phasor data concentrators and portable power system monitors for tie lines, a few transmission substations, and generator substations.

### 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.*

BPA monitors all of its control, system protection, data acquisition, and communications systems and equipment. This includes the EMS functions, system protection schemes, kWh logging, fault locator reporting, sequence-of-event recordings, power system security analysis applications, plant information system, and data exchanges. Telecommunications systems are monitored by a microwave fault alarms system and a fiber-optic network management system. System failures, data errors, and server status on these systems are alarmed and monitored at the control centers. The system operators can select any displayed data point and test it by forcing it into alarm if they suspect a problem, and if the alarm is not received they can report it for repair.

BPA's performs hourly checkouts for metering errors on all interchanges through after-the-fact accounting. For real-time metering errors, EMS alarms are set to indicate meter squelching, out-of-range data, and loss of interchange metering. If errors are discovered, BPA has a process to either manually replace data with a current value or utilize backup metering capabilities.

#### 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.*

Availability of the SCADA and automatic generation control systems are measured weekly, taking into account the impacts of planned and unplanned outages of the systems. The annual target for availability of the SCADA systems at both control centers is at least 99.94 percent. The target for availability of the automatic generation control system is at least 99.95 percent.

All maintenance and repair activities associated with the EMS/SCADA and display systems are coordinated with the system operators, who ensure that the bulk power system is in a secure mode prior to any activity taking place. If necessary, control can be swapped between control centers for the repair period.

### 4. Fundamentals of Operational Planning

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

BPA relies on its reliability coordinator, using BPA's reliability tools, to perform real-time contingency analysis and keep BPA informed of any issues. BPA's operational planning focuses on next-day and longer-term studies and utilizes conservative n-2 contingency analysis to evaluate expected system conditions.

BPA's transmission planning personnel develop two sets of power-flow base cases annually. One set of base cases is developed to assess the stability and reliability of the transmission in the Northwest and to study requirements for future transmission additions and modifications. These base cases include summer, winter, and spring peak load cases for selected future years. The other set of base cases is developed through a WECC coordinating process, which includes a monthly process for updating the transmission models for the Northwest. WECC base cases are produced for winter peak loads (one winter in two probability of occurring), extra heavy or extreme winter loads (an abnormal cold weather condition, with one-in-twenty probability of occurring), summer peak loads, and spring cases using a peak load forecast for the coming May. These base cases support BPA's operational planning.

The transmission system model is updated annually through a process that includes updating for all changes in the transmission system through out the Northwest for the upcoming year plus future years. Generation information, including unit capacity ratings and generation dispatch patterns, are provided for the different seasons, along with any future generation additions planned by the utilities. This database serves as a master database and is incrementally updated each month through the WECC base cases coordinating process.

Short-term and seasonal studies are coordinated with the Northwest Operations Planning Study Group to perform WECC subregion operating studies of transmission path capabilities. Planned outages are studied at least 45 days in advance in accordance with the NWPP planning process detailed below. In preparation for the peak season, BPA's transmission planning holds a training

program for the system operators to discuss any operating changes expected due to equipment additions or rating changes; updated system operator standing orders are also reviewed.

Outages that impact the backup sources to the nuclear plant on BPA's transmission system are included in the outage planning process to make sure any impacts are identified and modeled in the contingency list used by the reliability coordinator. A weekly conference call is held with the nuclear plant to discuss system conditions and outage plans.

Next-day studies to determine operating transfer capabilities are performed by BPA's reliability coordinator based on state estimation models and by BPA's operational planning group based on the WECC models, updated for current operating conditions. Study results are provided to the system operators and alarm limits are updated, as necessary. BPA's operational planning personnel are available to assist the system operators around-the-clock and can run studies from home, if necessary. The evaluation team notes, as a positive observation, that the operational planning staff has the capability to run studies from home and provides around-the-clock support for operations.

Study results from the operational planning group are provided to the system operators; the evaluation team finds, as a positive observation, that the system operators have a high level of confidence in the support provided by the operational planning personnel. The system operators may have to review the information provided by the operational planning personnel without support. Since different operational planning personnel perform studies and provide results differently, the evaluation team recommends that BPA implement a uniform method of presenting operational studies to the system operators. This will assist the operators in more easily reviewing and understanding the results and associated changes expected in operations.

BPA's operational planning group performs after-the-fact analysis of relay and remedial action scheme operations to confirm that the operation occurred as expected. If an event occurs where performance is not as expected, a detail study is performed to determine the cause, and the hardware or operating procedures are corrected as necessary. The events are also fed back into training for the operators in their fall and spring training sessions, including simulator training. Generator trips are treated similarly, with the generator owner requested to look into what caused the generator trip. Once the determination has been made and corrective action is determined, a report is issued to the system operators.

Following the NWPP planning process, planning for transmission outages on BPA's system begins 45 days before the first day of the month that the outage is planned to occur. The process starts with BPA's operational planning staff providing an estimate of the impact of the outage. The proposed outage is then sent to the path operators for comments. Once their responses are received, a coordinated outage meeting is held with all affected parties. Two weeks before the outage occurs, BPA's operational planning group performs a detailed study of the outage to determine if any changes in facility limits are required. If new limits are required, the limits are sent to affected entities, the reliability coordinator, and BPA's system operators. The system operators can call off the outage up to the point when the outage will occur and can request operational planning to look at the outage if a change in system configuration has occurred since the outage study was originally performed.

## 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.*

BPA is a NERC-approved continuing education provider. BPA's training staff is responsible for providing training to system operations personnel at the Dittmer and Munro Control Centers. The training programs, developed and delivered by the training staff, are called the Assistant System Dispatcher Training Program and the Continuing Training Program. The Assistant Dispatcher Training Program prepares assistant dispatchers to assume the responsibilities of a journeyman system dispatcher. Personnel entering into the Assistant Dispatcher Training Program have met minimum knowledge and skill requirements, through completion of the BPA Substation Operator Training Program or similar training, and have completed an interview process that tests their technical knowledge and ability to work under pressure. The Continuing Training Program is designed for experienced dispatchers to maintain proficiency in transmission system operation skills. Emphasis is placed on application of operating procedures, emergency operations, communications, problem recognition, and situational awareness skills.

For both training programs, learning objectives and training sessions are developed using a systematic process. Learning objectives are provided to the trainees at the beginning of each session. Lectures, facilitated discussion, hands-on activities, and simulator training sessions are used as appropriate to present subject material, and more than one method is typically used to present each subject. Review discussions and simulation debriefings are regularly used to reinforce learning objectives.

BPA has a training coordinator who develops the annual training plan, provides oversight of seasonal training and special training courses, and ensures all system operators receive the training required by the NERC continuing education program and WECC policies. BPA's training coordinator is an electrical engineer experienced in system operations and has received special training in curriculum design and delivery. BPA has a dedicated training staff that develops and delivers the training program, assists subject matter experts in preparing training material, and conducts simulator training sessions. The training staff is composed of experienced senior system operators that have received special training in curriculum design and delivery. Subject matter experts — typically electrical engineers from BPA's transmission operations technical staff — deliver training associated with operating procedures, disturbance analysis, and equipment characteristics. The training staff works with the subject matter experts to ensure that training meets all criteria of the program. The evaluation team notes, as a positive observation, that BPA has a dedicated training staff that is trained in and applies the Analyze, Design, Develop, Implement, and Evaluate (ADDIE) process.

As assistant dispatchers progress in their training, they are assigned to a shift position under the general supervision of a senior system operator. The evaluation team notes that BPA does not have a clear policy requiring assistant dispatchers to be NERC-certified prior to these shift assignments. The team recommends that BPA revise its current operating policy to ensure that

non-NERC-certified trainees perform critical tasks only under the direct, continuous supervision and observation of a NERC-certified individual responsible for the shift position.

System operators are scheduled for time off to participate in all training sessions, and overtime pay is used, if needed, to ensure all required training is completed. The critical operating seasons for BPA are the summer and winter peak periods. Training for these periods is provided through sessions in the spring and fall, and consists of topics relevant to the upcoming operating season and the system operators' annual needs assessment, with emphasis on emergency operations. BPA requires the system operators to attend the two seasonal training sessions each year that provide a minimum of 32 hours of training in emergency operations procedures. Four to eight hours of each training session is dedicated to instruction utilizing BPA's power system simulator at the Dittmer Control Center. Simulator training is integrated into the training sessions and designed to reinforce the material being covered in lectures and emphasize situational awareness and problem solving. BPA also makes simulator training available for neighboring systems and has a staff of five technical personnel who support the development of training scenarios, delivery of training sessions, and maintenance of its training simulator. The evaluation team notes this as a positive observation.

Training participants are given the opportunity to provide feedback on the training program through course evaluations at the end of each session. This feedback process includes a needs assessment for the trainees. BPA has contracted with the Human Performance Department of Pacific Northwest National Laboratory (PNNL) to provide an independent review of the training program and has incorporated many of PNNL's suggestions for improvement, especially in the area of simulator training. The evaluation team recognizes the use of outside resources, such as PNNL, to enhance the system operator training program as a positive observation.

## 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.*

Lessons learned from the analysis of events on BPA's system are incorporated into the system operator simulator training and are covered in the system operator routine meetings. Any system operator that commits an operations error is requested to voluntarily develop a written description of how the error was committed and what should be done differently to avoid it. The open admission of errors is part of the system operations culture.

BPA typically tries to benchmark its system operations with similar utilities across the United States and Canada. BPA is also involved in initiatives to maintain an active research and development program to improve system operations. As a part of the continuous improvement program, BPA's system operations support groups meet regularly to identify any developing problems and implement needed changes.

## APPENDIX 1: Critical Infrastructure

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*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

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*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

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*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.*