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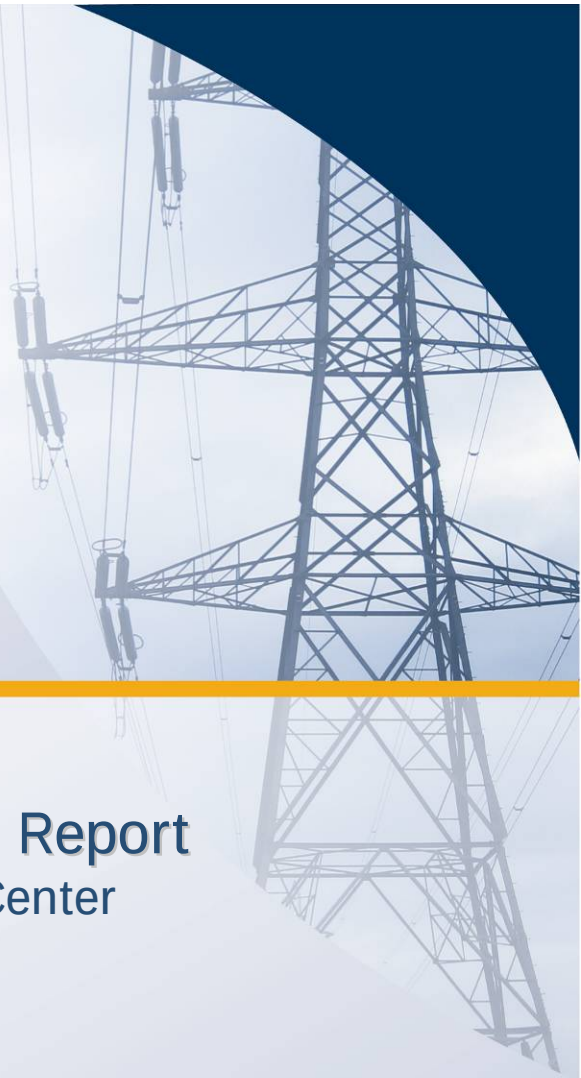

Reliability Readiness Evaluation Report

Transmission Operator/Local Control Center

Dominion Virginia Power

Glen Allen, Virginia

to ensure the reliability of the bulk power system

September 18–20, 2007

116-390 Village Blvd., Princeton, NJ 08540
609.452.8060 | 609.452.9550 fax
www.nerc.com

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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, local control centers, transmission owners, 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. 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 energy infrastructure will be contained in Appendix 1, a confidential appendix to the report that is sent privately to the organization evaluated and is not included in the public version of the report.

The evaluation team for the Dominion Virginia Power (VAP) met on-site with VAP representatives on September 18 – 20, 2007. This report reflects the views and recommendations of the evaluation team regarding the readiness of VAP to meet its responsibilities as a transmission owner/local control center.

Evaluation Team

Darrell Piatt*	NERC
Vinit Gupta*	Entergy
Jeff Mackauer	FirstEnergy Corporation
Alicia Daugherty	PJM Interconnection
Rick Stegehuis	We Energies
Mike Hiestand	Lakeland Electric
Edward Franks	FERC

*Team co-leader

Organization Profile

Dominion Resources produces and delivers energy in 20 American states and western Canada. Dominion Resources consists of the Dominion Delivery business unit with about 5 million retail gas and electric customers in 9 states; the Dominion Energy business unit with 6,000 miles of electric transmission and 7,800 miles of natural gas pipelines; and Dominion Generation business unit with 17,500 MW of regulated and 6,200 MW of merchant electric generation, fueled by coal, nuclear, hydro, gas, and oil.

Virginia Electric and Power Company is the legal name of Dominion's regulated electric system operation; however, it generally operates under the trade names of Dominion Virginia Power and Dominion North Carolina Power or is sometimes simply referred as Dominion. This service area spans an economically growing region of northern, central, and eastern Virginia and northeastern North Carolina. The Virginia service territory comprises about 60% of the land mass and 80% of the population of the state. This service area is known as the PJM South Zone, as the PJM Interconnection is the reliability coordinator, balancing authority, and transmission operator for Dominion Virginia Power, referred to as VAP for the purposes of this report. This PJM South Zone established a peak demand of 19,375 MW on August 3, 2006: 17,115 MW for the VAP load-serving entity and 2,600 MW of other load-serving entities in the zone.

VAP's transmission system has 1,137 miles of 500 kV; 2,491 miles of 230 kV; 64 miles of 138 kV; and 2,276 miles of 115 kV lines. VAP interconnects with Progress Energy Carolina at 500, 230, and 115 kV; American Electric Power at 500, 138, and 115 kV; Allegheny Energy at 500, 138, and 115 kV; and Potomac Electric Power Company at 500 and 230 kV.

Dominion Resources is registered in the SERC Reliability Corporation (SERC), the Regional Entity, as a transmission owner, transmission planner, distribution provider, generation owner, generation operator, load-serving entity, and purchasing-selling entity. Dominion Resources is registered in other Regional Entities consistent with its business operations in that particular Region.

Executive Summary

The evaluation team found no significant operational problems and concluded that VAP has adequate facilities, processes, plans, procedures, tools, and trained personnel to perform the transmission owner/local control center functions necessary to maintain the reliable operation of the bulk power system. The evaluation team identified a number of positive observations and one potential example of excellence. It also offers 11 recommendations that, if implemented, will enhance VAP's readiness to operate reliably and maintain the reliability of the bulk power system. The recommendations are listed in order of importance.

Potential Examples of Excellence

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

1. VAP has implemented an innovative "Team Track Software" tool that includes an attribute database, links to manufacturer's manuals, a graphical user interface, and other value-add options to provide enhanced management of the switchyard maintenance program at its nuclear power plants.

Positive Observations

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

1. VAP has a fully functional alternate control center that closely mirrors the primary control center (Section 9).
2. System operator trainees are subject to an extensive initial training program before going on-desk (Section 5).
3. VAP management is very supportive of resourcing additional training requirements for maintenance of NERC certification of the reliability operator credential (Section 4).
4. VAP has a strong internal candidate pool for system operator position vacancies (Section 5).
5. VAP has excellent system operator and operations support personnel retention rates (Section 5).
6. VAP has an effectively managed outage coordination process (Section 8).
7. VAP has strong area voltage management procedures and practices (Section 12.d).
8. All system operations supervisors and system operators are NERC certified (Section 4).
9. VAP has good internal team work and communications among electric system operations personnel (Section 7).
10. VAP monitors the generator automatic voltage regulator (AVR) status of the generators in the VAP zone to increase situational awareness (Section 12.d).

Recommendations

The evaluation team recommends that VAP take the following actions to address issues discovered during the evaluation process:

1. Implement a training management tool to facilitate training planning, scheduling, tracking, and records management (Section 5).
2. Develop and implement, as appropriate, changes to the display of real-time system voltages and trends to provide operators with enhanced situational awareness (Section 12.d):
    a. Add a wide-area geographic display of transmission system voltages.
    b. Add a graphical representation of transmission system voltage profiles.
3. Implement a document management tool to manage document ownership, review cycles, and system operator check-off of new and revised policies and procedures (Section 6).
4. Implement an alarm processor monitoring function that will immediately alert the system operator in the event of an alarm processor function failure (Section 12.b).
5. Develop and implement a comprehensive training program based on a job task analysis to define training objectives, requirements, training program content, and evaluation criteria (Section 5).
6. Review and revise, as appropriate, the operating policies and procedures naming and numbering protocol to expedite ready access (Section 6).
7. Review the current body of operating practices to ensure that these practices are properly documented in an operating policy of procedure (Section 6).
8. Develop, publish, and implement a shift-change procedure that enhances the existing shift-turnover sheet as well as the requirements for bringing an operator back on-desk after an extended absence to ensure the operator is adequately prepared to fully assume the on-desk operating responsibilities. (Section 6).
9. Implement an EMS geographic screen to display the transmission system frequencies to enhance operator situational awareness (Section 12.c).
10. Develop and implement an expanded wide-area view of the interconnected transmission system to include appropriate portions of the interconnected neighboring systems as part of the next EMS upgrade (Section 12.a).
11. Review and revise the transmission interconnection agreements, as appropriate, to reflect the current operating environment as defined by NERC and regional requirements (Section 1).

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 example of excellence 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 *transmission* system operator.

Agreements

The local control center must have agreements that establish its authority as a transmission owner. The local control center must have agreements that establish the reliability coordinator and balancing authority/transmission operator for its footprint.

PJM is the regional reliability coordinator, balancing authority, and transmission operator for the PJM footprint, which includes VAP. VAP is the transmission owner and local control center operator in the PJM South Zone (sometimes referred to as the Dominion Zone) of the PJM footprint. PJM directs scheduling, real-time load following, generation dispatch, transmission system operation, and congestion management as part of the *PJM Operating Agreement,* of which VAP is a signatory.

As the local control center and transmission owner, VAP is required to physically operate and maintain its transmission bulk power facilities in a safe and reliable manner. The local control center is responsible for monitoring the transmission system voltage and directing the operational aspects of the voltage control equipment. Additionally, the local control center is required to take any additional actions required to prevent an imminent emergency condition and to restore the transmission system from a contingency event. These responsibilities are detailed in *PJM Manual 01*, *03*, *12*, and *13*.

VAP has interconnection agreements with all neighboring utilities, generators, non-utility generators, independent power producers, and nuclear power plants connected to the VAP transmission system. Requirements documents are available for entities desiring to interconnect to the VAP transmission system, and interconnection requests are coordinated through PJM. VAP transmission planning manages the interconnection planning process and performs the required studies for generation and merchant transmission interconnection requests.

Most of the interconnection agreements with VAP's interconnected neighbors pre-date the publishing of NERC reliability standards. The team recommends VAP review and revise these documents, as appropriate, to reflect the operating environment as defined in the NERC reliability standards and associated regional requirements.

Operator Authority

The local control center is responsible for establishing and authorizing the system operator position that will have the on-shift responsibility for the safe and reliable operation of its portion

of the bulk power system in cooperation with neighboring operating entities, the balancing authority/transmission operator, and the reliability coordinator.

The VAP transmission system operators are empowered to operate the transmission system in a safe and reliable manner up to and including the shedding of firm load. This authority is consistent with the documented operating guidance provided to the local control center by PJM as the balancing authority/transmission operator. The VAP transmission system operator job description clearly provides the system operator with the authority to operate the transmission system in a safe and reliable manner. In addition, there is a published empowerment letter from VAP's senior management authorizing transmission system operators to operate the transmission system in a safe and reliable manner up to and including the shedding of firm load.

The transmission system operator interviews conducted by the readiness evaluation team strongly indicate that the VAP system operators are willing, trained, and able to operate the transmission system in a reliable manner up to and including the shedding of firm load. The interconnected neighboring transmission system operators are confident of the VAP system operators' capability and authority to operate the transmission system in a safe and reliable manner.

Delegation of Authority

Any functions that have been delegated must be clearly documented. The documentation must recognize that the balancing authority/transmission operator that is delegating the function continues to be responsible for that function.

PJM has not delegated any reliability coordinator, balancing authority, or transmission operator authority to VAP. VAP has not delegated any local control center or transmission owner responsibilities to PJM or any other entity.

VAP performs some overlapping operating functions in the PJM South Zone with the balancing authority/transmission operator; however, these should not be considered as delegated operational functions. In the opinion of the evaluation team, the net result of these overlapping activities serves to strengthen operational reliability of the interconnected transmission system.

Staff Certification

Local control center operators must be PJM-certified transmission operators. The local control center must have a sufficient PJM-certified transmission operator staff for continuous coverage of the system operator positions. The reliability coordinator and the balancing authority/transmission operator must have sufficient NERC-certified operators for continuous coverage of all operator positions.

PJM Manual 01: Control Center Requirements requires transmission system operators in a local control center to pass the PJM certification exam. The exam's technical content, scope, number of questions, and passing grade requirements are defined by the PJM regional transmission organization's training group. The PJM certification is valid for five years. To re-certify, the transmission system operator must complete 200 hours of training during the five-year period or pass the re-certification exam.

All VAP transmission shift supervisors and system operators in real-time operations are required to be PJM-certified transmission operators. VAP complies with this requirement, and additionally requires that all shift supervisors and switching-desk system operators be NERC certified. As a result, all VAP system operators are NERC certified with the reliability operator credentials even though this certification is not required for a local control center. The evaluation team commends VAP for its commitment to maintaining NERC certification for all transmission system operators and shift supervisors to include the additional training requirements for maintaining NERC certification at the reliability level

Training

The local control center system operators must be adequately and effectively trained to perform their roles and responsibilities. The local control center must have documents that outline the training plans for the system operators. The local control center must have training records and individual staff training records available for review.

VAP's assigned training coordinator has attended the NERC train-the-trainer course and is an approved provider of continuing education hours (CEH). Additionally, VAP has a defined initial training program that uses PJM online training modules, commercially supplied training modules, in-house training supplied by subject matter experts, and on-the-job training with system operators on-desk. The initial training program requires approximately two years for completion. The evaluation team commends VAP for its extensive initial training program for system operator trainees.

The initial training program is not based on a job task analysis but primarily uses *PJM Manual 40* as the guiding document for the program structure. The evaluation team recommends that a job task analysis be performed for all system operator positions so that the initial training as well as the continuing training program for the experienced system operators can be restructured to define training objectives, requirements, curriculum, and the associated evaluation criteria.

VAP has an experienced candidate pool from which to fill system operator trainee vacancies. This pool of candidates has on average 10 to 15 years of experience in the transmission organization, distribution operations, or protection and control. The evaluation team commends VAP for recognition and utilization of this strong internal candidate pool for system operator trainee vacancies. In addition to a strong candidate pool, VAP has good system operator and operations support personnel retention rates; this retention provides for an experienced, stable workforce that is a key element in ensuring that the system is operated in safe and reliable manner. The evaluation team commends VAP for the proactive leadership that has created and supports this positive workforce environment.

VAP builds 120 training hours per year into the operator shift schedule. Additionally, each system operator is required to attend the PJM Operator Seminar for a total of 144 hours of training each year. In general, a system operator is not allowed to use the designated training time in the shift schedule for vacation.

VAP uses a dispatcher training simulator to enhance the training quality and the associated situational awareness. VAP is working on additional integration of the simulator into the

training delivery process as well as increasing the number of courses that qualify for CEH credits.

VAP uses a learning management system to track, schedule, and manage training records; however, this program does not have the capability to provide comprehensive program management for all aspects of training. The evaluation team recommends that VAP investigate, acquire, and implement a comprehensive training management tool to facilitate training planning, scheduling, tracking, and records management.

The evaluation team believes VAP's training program meets current requirements. The recommendations made for this area of operations are necessary, in the opinion of this evaluation team, for the VAP training program to keep pace with industry trends and support the philosophy of continuous improvement.

Operating Policies and Operating Procedures

The local control center must have an established procedure to ensure that system operators and operations staff is aware of any changes to NERC, regional, and/or local policies or procedures prior to taking over control of a shift position.

The local control center system operator must have shift change procedures for updating incoming shift personnel on the current status of the system.

VAP system operators use the *System Operations Procedures Manual* as a reference for the day-to-day operation of the VAP transmission system. This controlled document is reviewed monthly to ensure that all new and revised procedures have been posted to reflect VAP changes as well as changes in NERC, FERC, SERC, or PJM policies or procedures. The evaluation team was not able to easily identify and locate various policies and procedures; therefore, the team recommends that VAP review and revise, as appropriate, the operating policies and procedures naming and numbering protocols to expedite ready access of these documents. Additionally, the team noted that some operating practices are not documented and therefore recommends a comprehensive review of all operating practices to ensure the practice is adequately documented with either an operating policy or procedure, or both.

New or revised operating policies and procedures are communicated initially to system operators via e-mail and the system operations center's Web page. These new postings and revised documents are later integrated into the PJM and VAP learning management system. PJM policy and procedure additions and revisions are covered at the annual PJM Operator Seminar with an associated test to ensure system operator understanding. The evaluation team recommends that VAP investigate and implement an operating policy and procedure document management tool to manage document ownership, review revision cycles, and validate system operator check-off.

VAP's shift-change process involves the use of a Word document to track abnormal conditions. These notes are reviewed with the shift supervisor prior to the end of the shift; however, this document is not archived. The evaluation team recommends that VAP develop and implement a detailed, checklist-driven shift-change procedure with an appropriate document retention

requirement. This procedure should also cover the specific requirements associated with bringing a system operator back on-desk after an extended period of absence.

Planning

The local control center and its supporting planning organizations must have a process for day-ahead planning and for longer-term planning, such as week-ahead, seasonal, and year-ahead, for the operation and outage scheduling of transmission facilities and generation and reactive resources.

The local control center and its supporting planning organizations must have agreements with the reliability coordinator to ensure that day-ahead and longer-term plans for the operation and outage scheduling of transmission facilities and reactive resources will not jeopardize the reliability of the bulk power system.

The VAP network planning group performs comprehensive power-flow analysis using the Power Technologies International Power System Simulator for Engineering (PTI/PSSE) load-flow study tool. Each year, these studies are performed to produce the long-term transmission plan, which is usually published in the late fall. These studies include both ac and dc contingency analysis for the near-term (1–5 years) and long-term (6–10 years) horizons. VAP uses the Managing and Utilizing System Transmission (MUST), load-flow analysis tool to perform sensitivity analysis for special system study requests during the year.

The base cases are updated twice per year, usually in February and August, when the SERC Long Term Power Flow Study Group cases with updated load forecasts are available. VAP uses standard facility rating methodology consistent with IEEE standards, manufacturer's rating, or other documents such as the *Aluminum Conductor Handbook*. VAP has an employee in the planning group that is assigned the responsibility of coordinating facility ratings.

Special studies, such as stability studies, are performed every five years or as needed in conjunction with a generator connection request. PJM performs the initial connection study and then VAP performs a separate set of studies with a closer look at the VAP transmission system. To comply with the NERC standards, VAP also performs studies to evaluate system transfer capabilities. As mentioned, some of the studies performed by PJM are replicated by VAP; in the opinion of the evaluation team, a second look helps validate the findings and expand the shared understanding of the expected performance of the transmission system.

VAP participates on PJM's Operations Analysis Task Force in the study process associated with the transmission expansion plan. VAP also serves on several SERC and VACAR (the Virginia-Carolina subregion of SERC) working groups that perform seasonal assessments, regional studies, and an annual dynamic study.

The operational study process includes the outage coordination study process described in Section 8 of this report. VAP electric system operations performs day-ahead to week-ahead studies using the forecasted loads and all scheduled outages to determine the near-term expected transmission system operating conditions. In addition to this study process, both PJM and VAP have real-time state estimation that runs periodically to determine the best estimate of the state of

the transmission system. This in-turn feeds the real-time contingency analysis program, which runs a set of pre-identified contingencies and presents the system operators with the results following the potential loss of each critical transmission element. The VAP system operators are very complimentary of the transmission planning support they receive and of the effective communications between these working groups. The evaluation team commends VAP for this excellent communication and teamwork among system operations personnel.

Outage Coordination and Communication

Planned outages by the transmission owner of transmission facilities must be coordinated with the balancing authority/transmission operator and reliability coordinator to ensure that conflicting outages do not jeopardize the reliability of the bulk power system.

Information relative to forced outages of transmission facilities that may jeopardize the reliability of the bulk power system must be shared with affected balancing authorities, transmission operators, and the reliability coordinator as expeditiously as possible.

PJM has the overall responsibility for managing outage coordination in its geographic area. VAP has the responsibility to plan, coordinate, and notify its interconnected neighbors regarding outages on its transmission system. The procedural guidance for the outage coordination process is in *PJM Manual 03: Transmission Operations- Section 4 - Reportable Transmission Facility Outages.* The principal communication vehicle used by PJM in administering the outage coordination program is a dispatcher applications and reporting tool called eDART.

The VAP transmission access specialist internally manages the outage coordination process. Outage requests are placed into the advanced switching request database with a VAP and a PJM identification number and submitted to PJM. Additionally, this system is used by the long-range transmission planners and system operators to study, track, and edit all pending outages. PJM and VAP study the proposed outage when upon submittal, again two weeks in advance, and again just before the outage occurs. Short-term studies are performed by either the transmission access specialist or the shift supervisor (or both) if needed to evaluate an outage relative to changes in the transmission system configuration.

Outage notifications generally need to be submitted no later than the first day of the month prior to the outage month. Outage requests for 500 kV transmission system facilities must be submitted at least one year in advance of the scheduled outage. When switching is to be performed on the tie lines with the interconnected neighbors, the neighbors are notified as well as the reliability coordinator. The system operator has the authority to approve or cancel an outage if the scheduled outage will result in an unacceptable level of risk to system reliability.

Overall, the outage coordination process is carefully defined, well managed, and fully communicated to ensure the reliability of the interconnected transmission system in the VAP zone of the PJM geographic area. The team commends VAP for its efforts in this critical area of system reliability.

Plans for the Loss of Control Facilities

The local control center must have a workable plan to continue to perform the transmission owner functions that are required to maintain a reliable bulk power system following the sudden catastrophic loss of its primary control facility, or the partial or full failure of its computer facilities or monitoring tools at the primary control facility.

VAP has a fully functional backup control center that is exercised five times per year — once per year for each shift crew. The functionality and the tools mimic those of the primary control center with the exception of the mapboard, which is a paper map with stick pins at the backup control center. The evaluation team considers the operational quality of this facility to be a positive observation.

VAP's *Technical Recovery Plan* details the transition, start-up, and operation of the backup control center. VAP has a grab-and-go bag with a current list of contact numbers and a cell phone. The operating policies and procedures are available electronically, and the restoration plan and blackstart plan are kept in a cabinet at the backup control center. These documents are inventoried and updated as needed on a monthly basis by the engineering support personnel. In addition, VAP has a separate procedure for testing the telecommunications at both the primary and backup control centers.

Tools

The local control center must have adequate analysis tools to perform the appropriate control and monitoring functions. Such tools include state estimation, pre-contingency and post-contingency analyses capabilities (thermal, stability, and voltage), mapboard (static, dynamic, hardwired, or projected), e-tagging program, weather service, outage scheduling system, trending tools, and a voice recording system.

VAP has a full suite of tools, including a state estimator, a dispatcher training simulator, network study capabilities, automatic generation control, an EMS-driven dynamic mapboard, and an Internet weather service to fulfill its assigned responsibilities for the safe and reliable operations of its transmission system. Additionally, VAP has a voice recording system for all phone lines at the primary and backup control centers as well as an automatic load forecasting tool that uses historical weather and loads to provide an hourly load forecast for a seven-day period. VAP also uses eData, an Internet-based application that enables PJM members to view PJM operational data graphically on one consolidated screen — data include area control error (ACE), load by region, emergency messages, and locational marginal pricing. VAP's other tools — for managing load shedding, controlling voltage and reactive levels, coordinating transmission outages, and tracking real-time events — will be discussed in the section of this report that deals with the specific application of the tool.

Load Shedding Plans

The local control center must establish plans for automatic load shedding for underfrequency or undervoltage conditions, coordinate load shedding plans with other interconnected entities, implement load shedding in steps to minimize further uncontrolled events, and have plans for

operator-controlled manual load shedding to mitigate violations of system operating limits (SOLs) or interconnection reliability operating limits (IROLs).

VAP has an underfrequency load shedding (UFLS) program that uses three trip set points that shed 10% plus load for each step, which conforms to the regional UFLS requirement to shed 30% of the peak hour load in three approximately equal increments. The UFLS plan is reviewed each year and updated as necessary to comply with the regional requirements. VAP does not use automated load restoration on its transmission system.

VAP has a manual load shedding program that identifies a number of distribution circuits throughout the VAP service area. This operation is performed using the distribution management system's supervisory control and data acquisition (SCADA) system. The transmission operator can direct the load shedding or take control and perform the function from the transmission primary control center. There is some overlap between the distribution feeders in the UFLS program and the manual load shedding program; however, this overlap is managed so as not to compromise the desired results of either operation. The load shedding requirements are directed by or coordinated with PJM.

VAP can perform voltage reduction to reduce load if needed. This operation is coordinated with the distribution system operators. VAP does not employ an undervoltage load shedding scheme on its transmission system.

Real-Time Monitoring

System Visibility

The local control center must monitor operating data and status in real time for its area and adjacent areas as necessary to maintain situational awareness of its system.

VAP's internal model includes all transmission facilities down to 69 kV, including the transformers with a 69 kV high-side voltage and the associated load on that bus. Also included are all bus and branch elements, switching devices, and power injections into the transmission system. The external model was built using an exact copy of the PJM model. The model is revised on an as needed basis to correct any state estimator errors or to enhance the accuracy the converged state estimator solution.

The EMS wide-area view of the VAP transmission system has limited visibility into the interconnected neighboring systems. Since the data are readily available and VAP has scheduled an upgrade to its EMS, the evaluation team recommends that VAP expand its EMS wide-area view to include appropriate portions of the interconnected systems outside the VAP footprint. The dynamic mapboard is driven by the EMS; therefore, the wide-area view of the dynamic mapboard can also be expanded as deemed appropriate by VAP.

The evaluation team believes that the current wide-area view is adequate to support the safe and reliable operation of the VAP transmission system. However, this recommendation recognizes an opportunity to enhance the wide-area view and increase VAP's capability to operate transmission system in a safe and reliable manner.

Alarms

The local control center must have effective and reliable alarming capability. This should be supported in the energy management system (EMS) and/or supervisory control and data acquisition (SCADA) system by alarm priority.

VAP runs a central alarm system under a separate process to provide alarm capabilities for a number of programs. Alarms are categorized and prioritized to allow for the proper viewing and response, and all alarms are logged in a central event log and archived. This application program interface has an alarm management function that will only display an alarm on a workstation that has pre-assigned access permission.

If the alarm processor fails, the system process manager program will attempt to restart the program. If the restart fails, a paging message will be issued to a support person. The average response time for support is approximately 10 minutes, which is adequate; however, the system operator is not notified of the alarm processor failure until the support person responds. The evaluation recommends that VAP develop and install an alarm system "health" monitor that will immediately notify the system operator in the event of an alarm function failure.

Frequency

The balancing authority/transmission operator must monitor frequency, direct actions to resolve significant frequency errors, and correct real-time trends that indicate potentially developing problems. Frequency monitoring points should be of sufficient number and from several locations with sufficient area coverage to allow the balancing authority/transmission operator to effectively monitor the balancing authority/transmission operator footprint to determine possible islands.

VAP has nine independent frequency measurement devices located at seven different locations in the VAP footprint. The number and distribution of the frequency monitoring points are adequate to determine if islanding of generation is occurring on the VAP transmission system; however, the EMS voltage readings in a state estimator run are usually the first indicator that islanding of generation is occurring. The VAP system frequency chart recorder in the primary control center is time-error corrected via a global positioning system clock.

All of the nine system frequencies can be monitored on a single EMS screen; however, the display is tabular instead of geographic. The evaluation team recommends that VAP develop and implement a single wide-area geographic EMS screen to display system frequencies.

Voltage/Reactive Reserve

The balancing authority/transmission operator and the local control center must monitor voltage levels and take appropriate actions to support the bulk power system voltage if real-time trends indicate potentially developing problems. Voltage measuring points must be of sufficient number and from several locations and voltage

levels to allow the balancing authority/transmission operator to effectively monitor the voltage profile of its footprint.

The balancing authority/transmission operator must ensure that reactive reserves are available and properly located to satisfy the most severe single contingency.

As the balancing authority/transmission operator for VAP, PJM has the primary responsibility for monitoring and controlling transmission system voltages in VAP's footprint, known as the PJM South Zone. VAP system operators also monitor the transmission system and maintain voltages within the published voltage schedules and operating limits. VAP system operators control system voltages by operating transmission capacitor banks, switching shunt reactors, and using the dynamic reactive capability of the generators in the VAP transmission footprint. The VAP policy is to maintain as much dynamic reactive reserve in the generators as possible during normal operations. VAP has no known areas in its transmission system in which it has trouble maintaining scheduled voltage.

VAP system operators use dedicated EMS screens to monitor system voltages. The screens are categorized by voltage level and geographic area, and a separate EMS screen lists the real and reactive power outputs of all on-line generation, scheduled and actual bus voltages, and generator AVR status. Additionally, VAP has an EMS screen that lists all static reactive resources and their status. The status of all dynamic and static reactive resources is also available on a single page on the Dominion Internet. The evaluation team recommends that VAP develop and implement, as appropriate, the following changes to the EMS display of real-time system voltages and trends:

- Add a wide-area geographic display of transmission system voltages
- Add a graphical representation of transmission system voltage profiles

The evaluation team commends VAP for monitoring AVR status, as this enhances its support of system reliability.

The voltage schedules for the nuclear power plants are published in Section 3 of *PJM Manual 3*. The nuclear engineering group coordinates the development and review of these schedules and communicates the nuclear power plant station voltage limits with the nuclear power plant operators. The voltage schedules are developed using the requirements of *NRC General Design Criteria 17.* The VAP system operator monitors and maintains the critical bus voltage at the nuclear power plants during both normal and contingency operations.

Critical Facilities

Monitoring of facilities that are critical to the reliability of the bulk power system is a joint responsibility of the balancing authority, transmission operator, the reliability coordinator, and the local control center.

An established process must determine which facilities are critical to the reliability of the bulk power system. Real-time operating information (data, status, and operating limits) for these critical facilities must be provided to the balancing authority, transmission operator, and the local control center by the reliability coordinator

PJM defines and monitors the interconnected reliability operating limits (IROLs) for the PJM footprint. In general, these are typically groups of 500 kV or 230 kV circuits or both, and the flows on these circuits are monitored as transfer limits. The IROLs and its associated mitigation procedures are published in *PJM Manual 37*. VAP has no IROLs. VAP considers all bulk power facilities 100 kV and above as critical.

Transmission System Congestion

The transmission operator must monitor transmission flowgates and be prepared to take actions to alleviate congestion in conjunction with, and as directed by, its reliability coordinator.

This area of transmission reliability is managed by PJM. VAP follows any PJM directives related to transmission system congestion.

Load Generation Balance

The balancing authority must monitor the balance of load, generation, and net scheduled interchange in its balancing area. The balancing authority must take actions to mitigate unacceptable load, generation, and net scheduled interchange imbalance.

This area of transmission system reliability is managed by PJM.

Contingency Reserves

The balancing authority must monitor the required reserves and the actual operating reserves in real time, and take action to restore acceptable reserve levels when reserve shortages are identified.

This area of transmission system reliability is managed by PJM.

Special Protection Systems

The balancing authority/transmission operator and the reliability coordinator must be aware of the operational condition of special protection systems that may have an effect on the operation of the bulk power system.

Five special protection systems (SPSs) are installed on the VAP transmission system. VAP system operators monitor the status of these systems and communicate data to PJM via the intercontrol center communications protocol (ICCP). Phone calls are made to communicate any other essential operating data.

The SPSs are studied by VAP on a regular basis to determine that the application is still operationally viable. The SPS relay maintenance, testing, and calibration program is on schedule.

System Restoration

The transmission operator must have a documented system-restoration plan that is consistent with NERC Reliability Standard EOP-005-0 — System Restoration Plans. This restoration plan must be provided to its reliability coordinator.

The transmission operator must be prepared to restore its transmission area following a partial or total collapse of the system and coordinate system restoration with its transmission owners, neighboring transmission operators and with the reliability coordinators.

The role of a local control center in system restoration is to follow the directions of the transmission operator. PJM is VAP's transmission operator and provides guidance in *PJM Manual 36: System Restoration*. VAP has identified specific responsibilities for its personnel and documented these in the *Dominion Electric Emergency Response Plan.* VAP's system restoration plan, of which a copy is located in both the primary and backup control centers, includes the VAP blackstart plan. This plan identifies the use of 31 combustion turbine and hydro generating units at six sites as blackstart generating units and details step-by-step instructions for energizing each designated cranking path. The units and cranking paths are listed in order, indicating the next step in the system blackstart restoration process.

VAP performs an annual emergency operation training that includes a system restoration drill using the dispatcher training simulator. Additional training is received in the annual PJM restoration drill.

Capacity and Energy Emergency Plan

Each balancing authority must have a capacity and energy emergency plan that address the applicable requirements of NERC Reliability Standards EOP-000-1 — Emergency Operations Planning and EOP-002-0 — Capacity and Energy Emergencies.

The capacity and energy emergency plan is owned and administered by PJM, as the balancing authority/transmission operator; accordingly, VAP will respond to any directives by PJM. The areas where VAP may be directed to respond are identified in the *Dominion — PJM Capacity Emergency Plan*:

- Active load management
- Public appeals for load reduction
- Voltage reduction
- Manual load shedding and/or rotation

Equipment Maintenance and Testing

Transmission owners must ensure that maintenance of transmission lines, substation equipment, and transmission protective systems are carried out according to company, regional, and/or NERC requirements.

VAP has a carefully documented and effectively managed relay maintenance, calibration, and testing program. VAP performs UFLS relay maintenance on electromechanical/static relays on an annual basis. The electromechanical/static relays on 500 kV lines and breakers are maintained in general on a two-year cycle. All other non-microprocessor relays on equipment with voltage levels below 500 kV are maintained on a three or five-year cycle, depending on the particular type and application of the relay. Microprocessor relays are generally maintained on an eight cycle. VAP maintains the relay settings in an Aspen database, and work-order process and maintenance records are maintained in the Systems Applications and Products (SAP) maintenance management tool. The relay maintenance, testing, and calibration program for 2006 was completed on-schedule, and the 2007 program was on-schedule at the time of the readiness evaluation.

In accordance with *SERC Supplement PRC-004,* VAP had 13 reportable protection system misoperations. These occurred during the 12-month period of July 1, 2006 to June 30, 2007.

Substation equipment is tested, calibrated, and maintained in accordance with VAP procedures using the SAP tool to manage the work orders. The substation equipment maintenance program for 2006 was not completed on-schedule; however, the 2007 program was on-schedule at the time of the readiness evaluation.

VAP has strategically placed disturbance-monitoring equipment — such as disturbance fault recorders, sequence of events recorders, and dynamic disturbance recorders to perform digital fault and dynamic disturbance recording — on the transmission system at voltage levels ranging from 500 to 69 kV. These devices are time synchronized using a global positioning system satellite clock via a communications processor, a data concentrator, or directly from the satellite clock.

VAP has implemented an innovative "Team Track Software" tool that includes an attribute database, links to manufacturer manuals, a graphical user interface, and other value-add options to provide enhanced management of the switchyard maintenance program at nuclear power plants. This process-based document management system, created by a third party, is used to document equipment and engineering problems, track problem resolution, and support the root cause analysis and continuous processes. The Institute of Nuclear Power Operations (INPO) has cited the use of the software as a best practice. The team commends VAP for the implementation of this innovative tool and considers it to be a potential example of excellence.

Vegetation Management

The transmission owner must have a documented vegetation-management program.

VAP has a well-defined, carefully executed vegetation-management program that uses the SAP software product to track costs, schedules, work orders, and patrol schedules. The VAP transmission footprint is divided into five areas, and each has an assigned forester to direct contractor-supplied vegetation management activities in the particular area. These area foresters also perform or direct line patrolling and inspections, handle encroachments issues, and respond to customer/land-owner concerns.

The VAP vegetation management program is based on a three-year routine activity cycle. When possible, VAP uses an Integrated Vegetation Management program, which includes herbicide application, danger-tree removal, mowing, and brush cutting. Vegetation management activities on tie lines are coordinated with the neighboring transmission owner.

VAP Forestry Department employees have obtained a number of professional certifications. These credentials include International Society of Arboriculture Certified Arborist, Virginia Department of Conservation and Recreation Certified Erosion and Sediment Control Inspectors, and Virginia Department of Agriculture and Consumer Affairs Certified Pest Control Applicators. Some department employees have other licenses and certifications that are useful in vegetation management work coordination.

In accordance with the reporting guidelines in *SERC Supplement FAC-003*, VAP had one reportable vegetation-related outage from the period of June 1, 2006 to June 30, 2007. The vegetation management program for 2007 was on-schedule at the time of the readiness evaluation.

Nuclear Power Plant Requirements

Transmission operators must support nuclear power plants in meeting regulatory requirements that allow the plant operators to maintain voltages within design limits and adequate off-site power sources in both normal and abnormal operating conditions (n-1 and system restoration).

VAP has two nuclear power plants in its transmission footprint, and each plant has two generating units. Dominion owns 100 percent of one plant and 88.3 percent of the other. The critical bus voltage requirements associated with these plants is based on *NRC General Design Criteria 17* and is more restrictive than the voltage limits on non-nuclear generation. The VAP system operator monitors and controls the transmission bus voltage during normal and contingency conditions.

The potential impact of transmission outages on the nuclear plant critical bus voltage is determined in advance by the outage studies performed by VAP and PJM. If the impact of the planned outage may adversely impact the plant, the outage will generally be postponed until the associated risks are mitigated. For the loss of a nuclear generating unit, the load demand transfer for each plant is factored into the contingency analysis or any other study process related to the outage.

The process for normal and emergency communications is detailed in the *Dominion Nuclear Switchyard Interface Agreement — Communications Protocol.* These communications involve both voice and data to and from the nuclear plants, VAP, and PJM.

APPENDIX 1: Critical Energy Infrastructure

APPENDIX 2: Evaluation Participants

APPENDIX 3: Documents Reviewed