Arizona Corporation Commission

Docket No. E-00000J-04-0522

Staff Assessment of Summer 2004 Disturbances

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April 29, 2005

Scope of Staff Assessment

1. Staff Role in APS Investigation
2. Staff Impressions of APS Investigation
3. System Context of Recent Disturbances
4. NERC/WECC Assessments
5. Applicability of 3rd BTA Planning Requirements
6. Conclusions and Recommendations

Staff Role in Investigation

- **Active Member of APS Investigation Team**
- **Unlimited Access to Facilities, Personnel & Data**
  - Multiple Visits to WWG & Deer Valley Substations
  - Multiple Visits to APS Emergency Command Center
  - Observed Equipment Testing by EPRI Solutions and Harold Moore & Associates
  - Participated in Discussions Regarding Scope of Investigation with APS, EPRI Solutions and Harold Moore & Associates Personnel
  - Reviewed & Commented on Draft APS Reports
- **Staff Assessment and Remarks - Today**

Staff Impressions of APS Investigation Efforts

1. Merits of Using Industry Consultants
2. Validity of Investigation Process
3. Significance of Root Cause Findings
4. APS Maintenance and Repair Practices
5. Staff Observations and Suggestions

Investigation Consultants

- **EPRI Solutions: Maintenance & Repair Practices Assessment**
  - Research Organization with Systems Operations & Maintenance, & Hardware Expertise
- **Harold Moore & Associates: Forensic Investigation of Fire Damaged Transformers**
  - Renowned Forensic Expert Regarding Transformers
- **Merits of Utilizing Industry Expert Consultants**
  - Broadened Knowledge Base for Investigation
  - Created Independent Review of Gathered Facts
  - Provided Contrast with Experience of Other Utilities

Investigation Process

- Managed with Professional Integrity
- Utilized 3rd Party Expertise
- Scope Was Broad & Root Cause Search Was Thorough
- Focus on APS Operational, Maintenance and Repair Practices Was Already Underway Before Event Occurred
- Operational Assessment Was Limited to APS Management of Outage Events

Root Cause Findings

- **Staff Agrees with APS' Root Cause Findings:**
  - **June 14, 2004 Disturbance:**
    - Improper Relay Function Led to Event Cascading Beyond Initially Faulted 230 kV Line
    - Miscommunication Between Operator and Field Personnel Contributed to Transformer Overloading
  - **July 4, 2004 WWG Fire:**
    - Result of June 14 Transformer Damage
  - **July 20, 2004 Deer Valley Fire:**
    - Transformer Bushing Failure Unrelated to Either June 14 or July 4 Event
  - **APS Maintenance Practices Did Not Contribute to Any of These Events**

APS Maintenance & Repair Practices

- **Staff Agrees With EPRI Solutions:**
  - APS Maintenance Practices, Processes & Effectiveness
    - Comparable to Industry and its Peer Group
    - Not Contributory to Summer 2004 Outages
  - APS System Reliability is Better Than Average and Has Consistently Improved Since 1996
- **Reliability Indices (SAIFI, SAIDI, CAIDI):**
  - Effective for Managing Distribution Improvements
  - Not as Useful as Transmission Reliability Tool

Staff Observations

- **Potential Effects of Multiple Investigations**
  - Organizational Paralysis / Wheel-spinning
  - Dilutes / Diverts Operational Focus
  - Protracts Conclusion of Investigations
- **Resolving Cause and Effects of Events Should Take Priority Over Mitigating Effects for Future Events**
  - Coordination / Validation of System Protection & Control Schemes Should be Highest Priority
  - Continuous Improvements Warranted Regarding Operational Training & Communication with Field
- **Installation of Fire Walls Are Appropriate and Improvements in Fire Fighting Practices are Needed**

Staff Suggestions

- **Investigation of Transmission System Outages Resulting in Loss of Service to Customers Should Have Priority Over Investigation of Other Events:**
  - Should Proceed Unabated to Determine Cause(s) and Effect(s) as Quickly as Possible (Could the WWG Fires have Been Avoided?)
  - Consolidate Industry Peer Review & Regulatory Review When Multiple Utilities' Customers Affected (ie, 8/14/03 NE Blackout)
- **The Following Should be of Secondary Concern:**
  - Non-Technical Cause(s) or Effect(s)
  - Commercial or Market Impacts
  - Opportunities for Continuous Improvement

System Context of 2004 Summer Disturbances

- **June 14, 2004 Event Resulted in Outage of:**
  - **996 MW Tripped (327 MW Manually)**
  - **31 Transmission Lines:**
    (12 ea – 525 kV, 1 ea – 345 kV,
    8 ea – 230 kV, and 10 ea – 69 kV)
  - **10 Three Phase Transformer Banks:**
    (3 ea - 525/230 kV, 1 ea – 525/345 kV,
    5 ea – 230/69 kV, and 1 ea – 69/12 kV)
  - **11 Generating Units @ 4770 MW:**
    (3 Units Were Outside of AZ @ 188 MW)

System Context (Continued)

- **July 4, 2004 Event Resulted in Outage of:**
  - **4 Three Phase WWG Transformer Banks:** (3 ea - 525/230 kV and 1 ea – 525/345 kV)
  - **No Transmission Lines**
  - **No Generating Units**
  - **No Load**
- **APS Investigation Materials Give A Single Utility Glimpse of Events Effecting Multiple Utilities**

Industry Assessments

- WECC June 14 Disturbance Report
- NERC EHV Transmission System Relay Loadability Review
- NERC/WECC Readiness Audit
- NERC Functional Registration, Certification & Compliance Process for Electric Industry
- NRC's Palo Verde Inspection Reports Treated as Outside the Scope of ACC's Investigation

WECC
June 14 Disturbance Report

- **Confidential and Proprietary WECC Report**
- **WECC Board Approved – April 6, 2005**
- **Scope**
  - System Perspective of Event
  - Sequential Analysis of Disturbance
  - APS Data Supplemented By Others' Data
  - Operational Performance Analysis of All Interrupted Facilities and System Operators

Summary of WECC June 14 Disturbance Report

- **30 Conclusions and Recommendations**
- **WECC Relay Work Group**
  - Facilitate One-Time Review & Mitigation Certification of Single Points of Protection Failure Exposure for Bulk Transmission System (230 kV & Above)
  - Develop Guidelines / Criteria as Needed
    - Echo-Back Relaying Schemes for Overreaching Transfer Trips
    - Backup Protection to Isolate 500 kV System from 230 kV & 345 kV Faults
- **Addressed Lines and Generators That Inappropriately Tripped Due to Incorrect Relay Settings**

Summary of WECC June 14 Disturbance Report

- **Load Shedding Performance**
  - Automatically Tripped 668 MW Due to Under Frequency
  - SRP Manually Tripped 320 MW Interruptible Load
  - Rocky Mtn / Desert Southwest Reliability Coordinator (RDRC) Requested APS to Shed Additional 500 MW
    - Properly Requested to Correct Area Control Error (ACE)
    - Only 7 MW Shed Due to APS' EMS Load Shedding Program Problems
- **Considered Non-Compliant Performance with WECC Off-Nominal Freq. Load Shedding & Restoration Plan**

Summary of WECC June 14 Disturbance Report

- **Operational Procedural Concerns**
  - Failure to Coordinate Load Restoration with RDRC
  - WAPA Test-Closed Faulted 230 kV Line (2nd Fault)
    - Better Communication with Other Control Areas Needed
  - APS Closed Into Fault 3 More Times During Restoration
    - Better Communication with Other Control Areas Needed
    - Miscommunication Between Field Personnel & System Operators
- **APS, SRP, TEP & WAPA Among Control Areas Cited as Exhibiting Good Communication / Coordination with RDRC During Palo Verde and Westwing Restoration**

EHV Transmission System Relay Loadability Review

- **NERC 8/14/03 Blackout Recommendation 8a:**

  By 9/30/04 **evaluate** zone 3 relay settings on all 230 kV and above transmission lines to verify not set to trip on load under extreme conditions. **Mitigate** overreach of those zone 3 relays that are set to trip on load by 12/31/05. Submit **exceptions justification** by 12/31/04.

- **Number of Generator Owners Did Not Report**
- **WECC Transmission Protection System Operators (TPSO) That Did Not Report: CFE, Calpine Energy Services**
- **19 WECC TPSO Requested Temporary or Technical Exceptions (No Arizona Utilities)**

NERC / WECC Readiness Audit

- **Background**
  - “Audit” is Misnomer: Readiness “Assessment” is Continuous Improvement Based
  - An Outcome of 8/14/2003 NE Blackout: Conduct Readiness Assessment of All Reliability Coordinators and Control Areas
  - Not NERC Compliance Related
- **APS, SRP and RDRC Reports are Public**
- **TEP Audited in April - Report Pending**

Need for the Audits

- August 14, 2003 blackout
  - **Deficiencies in control area and reliability coordinator capabilities**
- Standards present a threshold, not a target for excellence in performance
- Reliability coordinators and control areas must
  - **Be ready to perform - Under emergency conditions**
  - **Strive for excellence in their assigned reliability functions and responsibilities**

Readiness Audit Program

- **Purpose of the audit**
  - Provide an independent review of control area and reliability coordinator operations
    - Assure preparedness to meet reliability responsibilities
  - Identify areas for improvement
  - Share best reliability practices
  - Constructive: help control areas and reliability coordinators achieve <u>excellence</u>
  - Transparent – Audit reports posted
- **Not Compliance Audits**

Readiness Audit Findings

- **Most entities audited are generally ready to meet their reliability responsibilities**
- **Some entities have demonstrated best practices**
- **Areas for improvement identified in:**
  - Training
  - Backup control facilities
  - Documenting authority and responsibilities
  - Real time monitoring
  - Reactive reserve monitoring
  - Procedures and policy updates

Operator Certification

- Control Area Operators must be NERC Operator certified.
- The Control Area must have sufficient NERC certified staff for continuous coverage of the Control Area Operator positions.

- Findings – Most entities have adequate NERC certified operators; two entities lacked some certified operators; several employed tracking or methods to prepare operators for the exam that are noteworthy. APS – all but one operator NERC-certified at time of audit and certification exam scheduled for the one. SRP – all but one operator NERC-certified at time of audit and that one operator was in training.

Training

- The Control Area Operators must be adequately and effectively trained to perform their roles and responsibilities.
- The Control Area must have documents that outline the training plans for the Control Area Operators.
- The Control Area must have training records and individual staff training records available for review.

- Findings – several training programs qualify as best practice; training is an area for improvement in 2/3 of the entities (includes APS and SRP).

Authority

- System Operators must be given the authority to take the necessary actions to preserve the reliability of the interconnected system.

- Findings – All indicated they have the necessary authority, however, ½ of the entities should provide better documentation of authority from a corporate officer.
  APS and SRP have authorization documents on file but they should be improved.

Security

- Control Room Security must be maintained.

- Findings – Good control room security identified in all audits with some identified as best practices.

Planning

- The Control Area must have a process for day-ahead planning, as well as a process for longer term planning.

- Findings – most entities planning was identified as adequate; some organization’s planning ranked as a best practice.

Real Time Monitoring General

- The Control Area must provide the Control Area Operators with effective, reliable computer and communication facilities for data and status monitoring, and voice communication at both the Primary and the Back-up Control facilities.

- Findings – A number of best practices were identified as several entities had above average capabilities, 1/3 had areas identified for improvement (includes APS). SRP commended for its enhanced tools and practices.

Alarms

- The Control Area Operator must have effective and reliable alarming capability.

- Findings – Capabilities are generally adequate with some exhibiting enhanced EMS and communication equipment failure alarms; those with areas for improvement were in alarm priority and presentation of critical alarms (includes APS). SRP commended for alarming tool on EMS & its testing of alarms.

Loss of Control Facilities

- **The Control Area must have a workable plan to continue to perform the Control Area functions following the sudden catastrophic loss of their Primary Control facility.**

- **Findings – Some outstanding facilities and plans exist; with 2/3 of the entities areas for improvement were identified including added functionality, redundancy or procedures; a few had no backup center.**
  APS has two backup control centers (one new). Improved documentation and more frequent drills recommended for both APS and SRP.

Monitoring Responsibilities

- **The Control Area Operators must monitor operating data and status in real time.**

- **Findings – most entities demonstrated adequate capabilities; while not required, four entities lacked state estimation or contingency analysis capability. Data inaccessibility at interconnection points inhibits effective state estimation and contingency analysis tools for both APS and SRP.**

System Restoration

- The Control Area Operator must have a documented System Restoration Plan and must be provided to the Reliability Coordinator.

- Findings – most entities had a documented plan and trained on the plan; three entities should perform a comprehensive review and/or develop a new plan. APS' blackstart plan relies on its neighbors. SRP is currently updating its plan.

Outage Coordination

- Planned Control Area transmission facilities and generating unit outages must be coordinated with the Reliability Coordinator to ensure that conflicting outages do not jeopardize the reliability of the Bulk Electrical System.

- Findings – most entities were adequate; one entity used a web-based system that is noteworthy.

Operating Policy/Procedure Updates

- Control Areas must have an established procedure to ensure that operations staff are aware of any changes to NERC, Regional and/or local policies or procedures prior to taking over control of a shift position.

- Findings – while adequate in practice, several entities lack formal process to ensure operators are aware of and understand new or modified procedures.
  APS to update documents and institute document control to ensure documents are current.
  SRP cited in NERC March 2005 Bulletin as example of excellence for its use of electronic tools for control of policy documents.

Nuclear Plant Monitoring Requirements

- Nuclear Power Plants (NPP) have regulatory requirement for voltage and power in both normal and abnormal operating conditions (N-1 and system restoration).

- Findings – four entities used enhanced methods to include nuclear requirements.
  APS controls the voltage at Palo Verde switchyard and SRP operates the switchyard. FERC Standard of Conduct may inhibit sharing of information with Palo Verde. (needs addressed in NRC reports)

Achieving the Goal of Excellence

- **Each audit cycle raises the bar**
  - Second different than first.

- **Identifying best practices**
  - Cataloging and communicating to the industry.
  - SRP received March 2005 citation as example of excellence for Operating Policies and Procedures.

NERC Compliance Programs

NERC and regional staffs are responsible for:

- **Implementing compliance enforcement programs**
  - Each region has its own program
  - NERC oversees the regional programs
- **Identifying standards and monitoring compliance**
  - in the annual program
  - for 48 hour reporting
- **Reporting compliance results**
- **Recommending enforcement actions**

Sanctions and Penalties

- **Current Sanction Matrix at http://www.nerc.com/~comply/sanctions.html**
- **Matrix not formally implemented**
  - Lack of enforcement authority
  - Some regions use the matrix for contract-based enforcement
  - Some regions simulate monetary fines
- **Public disclosure is the current tool for encouraging compliance**

Performance Results 4Q 2004

- **210 violations of NERC and regional standards reported**
  - Level 1- 68 (least severity)
  - Level 2- 49
  - Level 3- 26
  - Level 4- 67 (most severe)
- **148 confirmed violations**
- **All violations judged by the reporting regions to not have a significant adverse affect on reliability**

Performance Results 4Q 2004

- **Three WECC Confirmed Violations in Arizona**

Entity	Violation Category	Level	Mitigation Plan Req/Provided
WAPA	System Protection & Control, Underfreq. Load Shedding	1	Yes/Yes
SWTC	Blackout Restoration Plan	2	Yes/No[1]
SRP	Blackout Restoration Plan	4	Yes/Yes

[1] Response indicates mitigation plan developed but not provided.

NERC Reliability Compliance Next Steps

- **Version 0 Standards Approved/Effective April 2005**
  - Responsive to 8/14/2003 Blackout
  - Enforceable Reliability Standards Format
  - Incorporated NERC Functional Model
- **Industry Functional Registration Completed**
  - Reliability Coordinator
  - Transmission Operator
  - Balancing Authority
  - Planning Authority
  - Transmission Planner
  - Regional Reliability Organization
- **Certification & Compliance Programs Undergoing Refinements**

Applicability of 3rd BTA
Key Planning Requirements

- Utilities & Staff to Develop / Implement More Stringent RMR Study Criteria for 2006 BTA.
- Study Extreme Contingency Outages of Arizona's Major Transmission Stations and Generation Hubs to Identify Associated Risks and Consequences if Mitigating Infrastructure Improvements Not Planned.
- Compliance with WECC and NERC (N-1-1): Single Contingency Criteria Overlapped with Bulk Power System Facility Maintenance for Year 1 of the BTA.

Implementation of 3rd BTA Planning Requirements

- **Study Extreme Contingencies**
  - Lose All Common Voltage Transformers at Each Major Station
  - Update Palo Verde/Hassayampa Hub Assessment
  - Loss of EHV Transmission Corridors
  - Explain How Ten-Yr Plan Facilities Mitigate Impact
  - Protection System:
    - Provide Inventory of All Protection Schemes,
    - Determine Adequacy of Redundancy & Coordination
    - Simulate Events Where Adequacy In Question
    - Quantify Risk Associated w/ Protection Misoperation
- **RMR Study**
  - Study Periods: 2006 - 2007, 2010 - 2011, and 2013-2014
  - Study Most Critical Extreme Contingency For Each Load Area

Staff Recommendations

- Rely On NERC/WECC for Bulk Transmission Reliability Compliance Assessments
- Monitor Development / Implementation of New WECC System Protection Guidelines
- Continue Course of Action Regarding Special Arizona Reliability Concerns per 3rd BTA
- Consolidate Future Investigations of System Events Resulting in Multiple Utility Impacts
- Conclude Commission Investigation of Summer 2004 Outages