A Framework for Considering Multiple Reliability Coordinators in the Western Interconnection.

6/27/2017

Report Prepared for the Western Interconnection Regional Advisory Body

This report introduces a framework for reviewing and assessing the reliability and cost implications of a transition to multiple Reliability Coordinators in the Western Interconnection.

A previous version of this report included criticisms of Peak Reliability from interviews with industry personnel. The criticisms have been removed from this final version. The intent of this report is to introduce an evaluation framework; not to provide an actual assessment of Peak Reliability or of the Mountain West Transmission Group and Southwest Power Pool proposal to create a new Reliability Coordinator.

GridSME SUBJECT MATTER EXPERTS

Western Interconnection Regional Advisory Body

I. EXECUTIVE SUMMARY

The objective of this report is to introduce a framework for objectively reviewing and assessing the reliability and cost implications of a transition from a single Interconnection-wide, Reliability Coordinator (RC) [1] in the Western Interconnection to multiple RCs with smaller RC footprints. The report identifies the tools and technologies currently used by Peak Reliability ("Peak") to provide RC services in the Western Interconnection. The report also provides rough estimates of the cost of a new RC providing similar RC services. In the interests of reliability, policy makers should encourage all interested stakeholders to work with the new RC service provider to ensure reliability in the Western Interconnection is maintained at least at the same level and focus as exists today.

This review is focused on the following issues:

1. The tools and services currently provided by Peak Reliability ("Peak") including a brief exploration of the history of Peak.
2. The challenges that new RC service providers must meet to successfully fulfill their role.
3. A high-level estimate of costs anticipated for establishing a new RC in the Interconnection.

In this review, GridSME reached out to stakeholders of Peak, Mountain West Transmission Group (MWTG) members, and interested observers to obtain the points of view of various stakeholders from both within and outside the Western Interconnection. It is important to note, GridSME did not speak directly to any representatives from Southwest Power Pool (SPP) regarding their proposal to MWTG, their RC function, or any of the assumptions in terms of costs. GridSME was also not able to review the SPP proposal as the document is not publicly available. GridSME spoke with industry veterans (e.g. engineers, operators, and regulators) about comparisons between the Eastern and the Western Interconnection regarding operations and reliability including the experiences of those that have studied major grid events such as the August 14, 2003 Eastern Interconnection Blackout, the September 8, 2011 Desert Southwest Blackout, and other system events.

II. BACKGROUND

The Reliability Coordination function was first established in the Western Interconnection in the late 1990s. The role, initially described as "security coordination," has evolved with the North American Electric Reliability Corporation (NERC) setting forth a defined role in the *Reliability Functional Model*[2] along with the creation of mandatory Reliability Standards, including many specifically written for RCs. NERC's actions established and clarified RC[3] responsibilities and set expectations for ensuring grid reliability.

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[1] The use of capitalized terms in this document indicates that the term is a defined term from either the *NERC Glossary of Terms Used in Reliability Standards* or *Appendix 2 to the NERC Rules of Procedure: Definitions Used in the Rules of Procedure.*

[2] Reliability Functional Model: Function Definitions and Functional Entities, Version 5 published by NERC, 2010. Available at http://www.nerc.com/pa/Stand/Pages/FunctionalModel.aspx.

[3] Reliability Coordinator or RC when capitalized refers to the NERC RC function, however, when this term is presented in lower case it refers to the actual reliability coordinators, the individuals that sit at the RC desk to carry out the RC functions.

In 2005, WECC began the effort to consolidate the RC function from three entities into a single entity. The initiative focused on addressing the following needs:

- Independence – WECC members desired an organization solely focused on reliability, not hosted by any individual operating or market organization
- Creation of a single detailed network model for the entire Interconnection that represented all aspects of the Bulk Electric System; this became known as the West-wide System Model (WSM)
- Visibility of the entire Interconnection - detailed view of displays (wide-area overview, substations, lines, generation), alarms, major paths, capacities, and all the data necessary telemetered from each entity
- Integrated day-ahead and Real-time studies of the entire Interconnection
- Common set of wide area Real-time analytical tools (addressing issues such as voltage and transient stability) based on the WSM
- Event management and coordination of restoration activities, when necessary
- Coordinated equipment outage management tool for the entire Interconnection to use for day-ahead and seasonal studies and provide contingencies analysis
- A central simulator-based training program for reliability coordinators and reliability entities[4] around the Interconnection

This effort culminated with the project to build and staff the Western Electricity Coordinating Council (WECC) RC function at two essentially identical facilities, one in Vancouver, WA, and the other in Loveland, CO and commenced operations on January 1, 2009. The efforts of the WECC RC and, subsequently, Peak Reliability over the last eight years demonstrate a growth of reliability coordinator competencies, improved tools, and enhanced requirements to ensure reliability coordination within the Western Interconnection. The adoption of a continuous improvement model[5] as a response to system events (e.g. Sept 8, 2011 Desert Southwest Blackout) and changing conditions, has enabled WECC RC and, later, Peak to provide greater services, information, and access to state of the art systems to assist the entities within the RC footprint.

The Bulk Electric System, particularly the Western Interconnection, is experiencing tremendous change. One area demonstrating significant change is the expansion of, and proposed new entrants into, organized wholesale electric markets. The California ISO (CAISO) is the only organized wholesale electric market in the Western Interconnection at this time. Over the last few years, CAISO has attempted to grow in two different ways, both by expanding the CAISO Balancing Authority (BA) footprint and developing and expanding the Energy Imbalance Market (EIM). The EIM seeks to offset transmission congestion and balance generation production and load across a vast area of the Interconnection. Moreover, the EIM expansion is often viewed as a precursor to more advanced market opportunities. The EIM is an example of both ongoing market changes, and, also, a product of the dramatic changes in the generation resource mix with variable energy resources such as wind and solar increasing rapidly.

A recent development is the proposed creation of the Mountain West Transmission Group (MWTG) which seeks to establish a wholesale power market, with all services provided by the Southwest Power

[4] NERC refers to reliability entities to collectively address Reliability Coordinators, Balancing Authorities, and Transmission Operators.
[5] A continuous improvement model is "an ongoing effort to improve products, services or processes." American Society for Quality "ASQ" available at http://asq.org/learn-about-quality/continuous-improvement/overview/overview.html (2017).

Pool (SPP). The MWTG is a collaboration of utilities in the central Rocky Mountain and High Plains region of the Interconnection. SPP is proposing to provide market operations, interconnection processes, planning, and RC services. The possible provision of RC services by SPP is the catalyst of this report.

This report introduces a framework for objectively reviewing and assessing the reliability and cost implications of a transition from a single Interconnection-wide RC in the Western Interconnection (with the single exception of the Alberta Electric System Operator[6]) to multiple RCs with smaller RC footprints. The report identifies the tools and technologies currently used by Peak to provide RC services in the Western Interconnection. The report also provides rough estimates of the cost of a new RC providing similar RC services.

III. SCOPE AND METHOD

This project is derived from publicly available information, as well as interviews[7] with individuals who were personally involved in the creation of what is now Peak, industry personnel, who either work, or worked for Peak, personnel who work for entities that are within the Peak RC footprint, and those who interact with Peak from a governance or regulatory perspective. This report attempts to identify the products and services Peak developed and implemented over the past eight years, and the potential costs of an entity providing similar RC services for a segment of the Interconnection. It should be noted, however, that this assessment does not seek to address the value of organized markets or any potential impact, whether positive or negative, such markets may have on reliability.

IV. PEAK RC DISCUSSION

A. Tools and Technologies

The Peak RC employs long-term and Real-time analytical tools within their environment to help maintain situational awareness, assess risks, analyze contingencies, coordinate actions, and focus on critical alarms in the system. Many of these tools were developed, improved, and implemented at the behest of FERC, in response to the September 8, 2011 Southwest Outage.[8] Broadly speaking, the information available to the operators can be classified as visual systems, audible systems, and analytical systems. The interaction between these systems enable the on-shift operations and engineers to respond to changes in the grid in a timely manner.

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[6] The Alberta Electric System Operator (AESO) ended its participation as a Peak funding entity in 2014. While AESO, for all intents and purposes, functions as its own RC, there are only two synchronous interfaces between AESO and Peak and the net flows across those ties are easily managed. AESO disturbances rarely reverberate into the Western Interconnection, and when they do so, the geographical scope of such impacts is limited to adjacent BA Areas. AESO therefore is not a good comparison to MWTG which is networked into the Western Interconnection, with complex flows, and larger amounts of generation and load.

[7] The interviewees are noted within the table in an attachment to this framework. Some interviewees preferred their discussions not be attributed to them, but their relevant opinions and input are included. These interviewees are identified as Anonymous in the attached table.

[8] *Western Electricity Coordinating Council*, Order Approving Stipulation and Consent Agreement, 151 FERC ¶ 61,175 (2015).

1. Study power flow and contingency analysis
    a. Timeframes for use: Outage coordination, Operational Planning Analysis, and Real-time Analysis
    b. Description of use: Performing outage coordination studies, Operational Planning Analysis, next-day studies, near Real-time study tool for reliability coordinators and operations engineers, and after-the-fact analysis tool (event analysis).
2. State Estimator
    a. Timeframe for use: Real-time
    b. Description of use: The state estimator is the base for all the advanced applications. State estimator calculates the current state of the system, including all bus voltage magnitudes, bus voltage angles, branch flows, injections, tap positions, and more. Peak's state estimator model uses over 157,000 SCADA[9] measurements and solves for over 15,000 buses.
3. Real-time Contingency Analysis (RTCA)
    a. Timeframe for use: Real-time
    b. Description of use: RTCA is Peak's primary tool for assessing N-1, N-2, and N-1-1[10] Bulk Electric System conditions on the Western Interconnection. Peak simulates nearly 8,000 contingencies every five minutes with the intent to identify unacceptable operating conditions such as unsolved contingencies (potential voltage collapse), thermal post-contingency System Operating Limit (SOL) exceedances, and post-contingency bus voltage SOL exceedances.
    c. A key factor in the accuracy of Peak's RTCA tool is its modeling of the Western Interconnection's Remedial Action Schemes (RAS). This is an area of focused engineering to stay on top of the fast-paced changes in RAS scheme protections specific to the Western Interconnection.
4. Network Sensitivity Calculator (NETSENS)
    a. Timeframe for use: Real-time and Operational Planning Analysis
    b. Description of use: NETSENS is used to identify the most effective control actions available to mitigate a thermal pre- or post-contingency issue on the BES. NETSENS calculates the optimal generators to be moved, phase shifter taps to be moved, and load that could be shed.
5. Voltage Stability Analysis Tool (VSAT)
    a. Timeframe for use: Operational Planning Analysis and Real-time Analysis
    b. Description of use: Voltage Stability is used to calculate voltage stability limit for Peak's three voltage stability constrained Interconnection Reliability Operating Limits (IROLs): 1) NW Washington load area IROL, 2) San Diego import IROL, and 3) San Diego/CENACE import IROL. Peak assess the voltage stability limit while performing the next-day study

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[9] "Supervisory control and data acquisition (SCADA) is a control system architecture that uses computers, networked data communications and graphical user interfaces for high-level process supervisory management, but uses other peripheral devices such as programmable logic controllers … to interface to the process plant or machinery. The operator interfaces which enable monitoring and the issuing of process commands, such as controller set point changes, are handled through the SCADA supervisory computer system. However, the real-time control logic or controller calculations are performed by networked modules which connect to the field sensors and actuators." Wikipedia (2017), available at https://en.wikipedia.org/wiki/SCADA. SCADA is universally used throughout the electric industry as an industrial control system, to operate and monitor the electric system at both the BES and distribution level.

[10] N-1, N-2, and N-1-1 are study parameters for evaluating system contingencies. N-1 studies examine the likely state of the study area following the loss of the most severe single contingency (MSSC), N-2 studies the loss of the two largest pre-event contingencies, and N-1-1 studies examine the loss of the next largest single contingency following the MSSC.

and communicates that limit to impacted TOPs and BAs. Peak also calculates the voltage stability limits in Real-time and communicates the limits via ICCP to impacted BAs and TOPs.

6. Enhanced Curtailment Calculator (ECC)
    a. Timeframe for use: Real-time
    b. Description of use: The ECC is effective in determining the makeup of flows on any facility or Path in the Western Interconnection. Without the ECC, operators simply know how many megawatts (MW) are flowing on a facility or Path. With the ECC, operators can identify the source of those flows, such as tagged flows, Area Control Error (ACE) contributions, BA generation to load (serving native load) impacts, and DC line impacts. This supports operators' need for understanding what is causing a problem on the system, thus allowing for more effective mitigating actions. On June 15, 2017, the ECC will become the primary tool for managing Qualified Paths and the Unscheduled Flow Mitigation Plan (UFMP). Peak is expanding the ECC functionality in the future to include future hour situational awareness (i.e. look-ahead monitoring) and expanded management of facilities beyond the Qualified Transfer Paths.
7. Real-time Line Outage Distribution Factor Calculator (RTLODF)
    a. Timeframe for use: Real-time
    b. Description of use: RTLODF is a secondary tool for monitoring post-contingency MW flow conditions on key facilities in the BES. RTLODF is used as a backup to RTCA, and as a mechanism to monitor flows on various key facilities in the BES.
8. SCADA visualization/alarming
    a. Timeframe for use: Real-time Situational Awareness
    b. Description of use: Alarm generation, visualization, situational awareness
9. Plant Information System (PI)
    a. Timeframe for use: Real-time situational awareness
    b. Description of use: Peak builds many custom, situationally specific displays in PI to support the reliability coordinator's situational awareness. PI allows for ad-hoc monitoring of developing situations
10. Equinox Coordinated Outage Scheduling system (COS)
    a. Timeframe for use: operational planning, Real-time
    b. Description of use: COS is the mechanism to capture all outages required per Peak's RC data request (IRO-010-2 – Reliability Coordinator Data Specification and Collection). Accurate scheduled outage information is critical to Peak's ability to assess the state of the BES, and even more critical for Peak to be predictive of issues in the upcoming hours or days through Peak's look ahead analysis tools.
11. RCWorkbook
    a. Timeframe for use: Generally Real-time, but some features exist to support study data management.
    b. Description of use: RCWorkbook is a "home grown" tool developed by Peak IT developers. RCWorkbook consolidates data from various sources, such as EMS, PI, COS, and EIDE (schedule data). The RCWorkbook is Peak's primary tool used to monitor RTCA results and allows for greater workflow management than traditional EMS vendor solutions.
12. Transient Stability Analysis Tool (TSAT)
    a. Timeframe for use: Operational Planning Analysis, Real-time
    b. Description of use: By the end of 2017, Peak intends to use TSAT in production to support reliability coordinator and system operators' situational awareness of various

contingencies that typically do not solve in RTCA. Peak intends to continue to share TSAT results with BAs and TOPs to gain confidence in the tool before making it an operator decision tool. A comprehensive high-quality Western Interconnection TSAT tool will be a positive for monitoring the evolving grid, especially variable generation resources, to ensure that the BES remains transiently stable following events. TSAT will also promote efficient operation of the grid, by providing input to TOPs and BAs in how to arm RAS (such as generation dropping) so only the necessary actions are taken following a contingency.

The tools above were developed and implemented by Peak to satisfy the various Interconnection Reliability Operations and Coordination (IRO) family of Reliability Standards. The services provided include Operational Planning Analysis (OPA), determination of IROLs, and Real-Time Assessments as they pertain to the Western Interconnection.

Other RC providers will need similar tools to meet the IRO requirements including; (1) study power flow and contingency analysis, (2) state estimator, (3) Real-time contingency analysis, and (8) SCADA visualization and alarming. Other RC providers will also use either the same or equivalent systems for (9) plant information and (10) a coordinated outage system. In order to provide equivalent modeling accuracy, an RC will have to either leverage Peak's existing tools and information collected across the entire interconnection, or replicate the existing tools and information collection.

The ability to generate the (7) Real-time Line Outage Distribution Factor Calculator can likely be derived through a state estimator. RC candidates may have static voltage stability analysis capability but not all would have a (5) Real-time voltage stability analysis tool in production, tuned for the Western Interconnection.

The need for additional similar tools like those Peak has implemented would be necessary to provide an equivalent level of analysis and coordination capability. The (12) transient stability analysis tool is of high importance in the Western Interconnection, where transmission stability-limits are more common, as opposed to the Eastern Interconnection which is more frequently impacted by thermal constraints. This is important because stability constraints may not be indicated by more traditional state estimation tools, especially when such conditions develop in Real-time due to unique Real-time grid re-configurations. As reaction time becomes more important to issue resolution, the utilization of automated tools to provide Reliability Coordinators specific mitigation steps for the Real-time environment are likely to be necessary, therefore an RC candidate would be motivated to develop a (4) network sensitivity calculator. Other tools that enhance the base tools will likely be in planning shortly after another RC entity is established. The (11) RC workbook is a tool specifically developed by Peak to improve RTCA monitoring though the consolidation of desperate data sources.

Finally, while the ECC (6) is another unique tool to Peak that has been in development with BA and TOP stakeholder input over the last several years, it has potential to provide significant benefits as an SOL management tool, not only for Unscheduled Flow events, but for other overload mitigation as well. It is unclear at this point how another RC would utilize Peak's capabilities or develop their own tools. The ECC intended in-production date occurred during the drafting of this report.

B. Peak Overview

Peak RC resides in two locations to provide for redundant, business continuity capability, as required by good utility practice and the NERC Reliability Standards.[11] Its current footprint includes all the western states entities in the WECC region and through various coordinated agreements with British Columbia, and Centro Nacional de Control de Energía (CENACE). The Alberta Electric System Operator continues to have coordination with Peak through Coordinated Operating Agreement after removing themselves from Peak as a funding entity.[12]

The role of Peak has expanded over time since its operation commenced in 2009. Updates to NERC Reliability Standards have brought increased responsibilities and workloads across a number of different areas including;

- The creation of standardized System Operating Limit (SOL) and Interconnection Reliability Operating Limit (IROL) methodologies for the interconnection (FAC-011-3[13] and FAC-014-2[14]);
- The drafting of a coordinated Interconnection-wide Restoration Plan, as well as implementing the processes to collect, review, and approve the approximately 50 Transmission Operator Restoration Plans (EOP-006-2[15]) within the interconnection;
- The implementation of the RCs outage coordination process for all generation and transmission outages, as required by IRO-017-1[16]; and
- Instituted a program for BAs and TOPs to remotely participate in Peak hosted simulation training to meet the requirements of PER-005-2.[17]

In addition to the required programs above, Peak developed and offers subscription-based advanced analytic reliability tools and is deploying the Enhanced Curtailment Calculator (ECC) to aid in the mitigation of SOLs and unscheduled flow. These tasks have required Peak to substantially increase its efforts around coordination, oversight, and WECC entity engagement.

As these roles expanded, Peak evolved dramatically from its initial launch, to the larger, more sophisticated entity it is today. Listed below are some of the more significant organizational changes. Many of these changers are a response to the growing awareness of issues, greater experience, and a growing list of requirements and obligations sought by both NERC and members. Others are the result of the September 8, 2011, Desert Southwest outage and Peak's implementation of obligations and

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[11] NERC Reliability Standard EOP-008-1 – Loss of Control Center Functionality Requirement R1.
[12] Peak would also be required to have coordinated operating agreements with any other adjacent RC, including MWTG, per NERC Reliability Standard IRO-014-3 Requirements R1 – R7. Peak does not consider their agreement with AESO to be an RC to RC Agreement under IRO-014, per se, because AESO is not registered with NERC as an RC. Peak currently has a RC to RC Agreement with SPP, but this agreement would require substantial revisions if SPP were to run an RC for MWTG. This is because that even though the SPP RC is currently adjacent to Peak the only interfaces are DC asynchronous tie lines between the Western and Eastern Interconnection. Therefore, the traditional seams issues do not apply as there are limited seams management issues or capabilities for SPP to provide emergency assistance to Peak and vice versa.
[13] NERC Reliability Standard FAC-011-3 – System Operating Limits Methodology for the Planning Horizon
[14] NERC Reliability Standard FAC-014-2 – Establish and Communicate System Operating Limits
[15] NERC Reliability Standard EOP-006-2 – System Restoration Coordination
[16] NERC Reliability Standard IRO-017-1 – Outage Coordination
[17] NERC Reliability Standard PER-005-2 – Operations Personnel Training

recommendations by NERC and FERC.[18] Another area of complexity was the Western Interconnection Synchrophasor Project which was a DOE grant supported project taken up just after Peak commenced operations. This resulted in an expansion of infrastructure, Control Center visualization and tools and is currently funded outside of Peak's primary funding mechanism.

Areas of growth or expanded functions at Peak since 2009 include:

- Increased staffing from approximately 55 at startup to 164 today[19]
- Creation of a standalone RC organization, separate from WECC with its own board, member advisory committee, and funding through entities within its footprint
- Around 2012, Peak realigned the RC to have sectional focuses of the Rocky Mountain / Southwest area, and the Pacific Northwest / California area. The RC desk in Loveland primarily focuses on Rocky Mountain / Southwest and the desk in Vancouver primarily focuses on Pacific Northwest / California. This sectional approach provided more clarity and deeper knowledge of specific areas than prior to this change. However, frequent responsibility switching or cross-training continues between the two offices to ensure that either office is prepared to perform all RC duties for the entire Western Interconnection, following the loss of one site.
- Increased capabilities and services - by adding electrical engineers onto the 24X7 RC staff, Peak increased the focus on providing Real-time and short-term studies and forecast analysis of system events, changes in load, generation, unplanned outages, and serious system disturbances
- Increased sophistication and improvement of RC tools - enhanced focus on accuracy in contingency analysis, voltage stability, modal analysis, and issue detection provided for the entire Interconnection
- Development, refinement, and implementation of SOL and IROL methodologies in accordance with FAC-011-3 – System Operation Limits Methodology for the Operations Horizon and FAC-014-2 - Establish and Communicate System Operating Limits. While presenting a significant challenge, Peak improved its ability to identify risks and potential Interconnection-wide weak points not previously evaluated
- The development of System Operating Limit (SOL) management tools – the Enhanced Curtailment Calculator (ECC) system identifies the source of flows that contribute to SOL exceedances, and will replace the tool for managing Qualified Paths per the Unscheduled Flow Mitigation Plan (UFMP). The ECC is envisioned to provide expanded management of facilities beyond the Qualified Paths and to support the management of seams between market areas and non-market areas.
- Hosted Advanced Applications - introduced as a "subscription-based" reliability service offering to those seeking to take advantage of the Peak's infrastructure and tools. This service allows entities to perform day-ahead and Real-time studies and contingency analysis utilizing Peak's Hosted Advanced Applications. Currently, 24 entities are taking advantage of this fee-based service. According to Peak, this reliability service not only benefits the service recipient; Peak and the rest of the reliability entities in the West benefit due to improved model detail, data quality, and analysis accuracy.

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[18] *Western Electricity Coordinating Council*, Order Approving Stipulation and Consent Agreement, 151 FERC ¶ 61,175 (2015).
[19] As discussed above staffing increased in parallel with expanded obligations, stakeholder demands, and requirements. Another factor influencing Peak's growth is due to the fact the WECC RC employed very few administrative staff because WECC could provide services such as human resources, legal, and accounting.

- RC architecture in data collection and redundant systems - Peak serves as a single repository for all static and Real-time reliability data from the entire Interconnection.
- The continuous maintenance of the WSM, and its associated telemetry. By using the model in Peak's energy management system (EMS) system, an Interconnection-wide set of analytical tools, are utilized by Peak for analysis of the entire Western Interconnection. Peak's effort to keep the WSM up to date and accurate is a substantial cost and benefit to the Western Interconnection.
- Peak provides training for numerous entities,[20] including system-wide event and restoration drills, utilizing Peak's training simulator, systems, and trainers, thus allowing Peak members to meet their NERC training requirements. [21] Peak's training simulator fully incorporates the WSM, which would be difficult to replicate, even with access to historical data.
- Responding to changes in NERC Standards, Peak is increasing its functions and services in response to Reliability Standards and events. Most recently, they implemented an outage coordination process for generation and transmission outages in accordance with IRO-017-1 – Outage Coordination, TOP-001-3 – Transmission Operations and TOP-002-4 – Operations Planning.
- The DOE-funded Western Interconnection Synchrophasor Project (WISP) and Peak Reliability Synchrophasor Program (PRSP) are now implemented at Peak and the infrastructure, tools, and systems in place.

V. MWTG PROPOSAL, RELATION TO PEAK, AND OVERVIEW OF SPP

While the evaluation framework outlined in this report may be applied to any new RC service provider in the Western Interconnection, the impetus for this report is the proposal by SPP to include RC services to MWTG members. This section is limited to providing high-level observations regarding the MWTG and SPP proposal. GridSME was not able to review specific details of the proposal and was unable speak with representatives from SPP.

The combined MWTG membership currently is responsible for about $4M annually or about 10% of the Peak RC revenue requirement for RC services. Because providing RC services will have costs attributed to adequately deliver RC functionality and there would be costs associated with staffing, training, and performing those functions, it can be assumed there will be costs to MWTG members embedded in the delivery of MWTG's services. It could not be ascertained through research in preparation for this report, how such costs will compare to what MWTG is currently paying Peak.[22]

The potential reliability value or risk of the proposed market to MWTG members joining a SPP RTO market is not part of this review, however, many commenters maintain that wholesale electric markets likely enhance BES reliability. Part of the perceived increase in reliability stems from the fact that the formation of markets often results in consolidation of Balancing Authority Areas (BAA). This elimination

[20] Peak stated that they trained 1,238 members in 2016. This provided Peak members with 9,968 continuing education hours (CEH) a value estimated at nearly $400,000. Email from Jill Hoyt, Peak Director of Training June 20, 2017.

[21] NERC Reliability Standards PER-005-2 – Operating Personnel Training; Requirement R4, EOP-005-2 – System Restoration from Blackstart Resources Requirement R10; and EOP-006-2 – System Restoration Coordination Requirement R10.

[22] Peak would also face increased costs to deal with the seams issues while working with 10% less revenue. As was discussed upon the withdrawal of AESO from the Peak footprint, Peak's costs are largely fixed and will not scale down upon the shrinking of the footprint and revenue base. *See: North American Electric Reliability Corp.,* Petition of the North American Electric Reliability Corporation for Approval of a Supplemental Assessment to fund the 2014 Budget of Peak Reliability, Inc., FERC Docket No. RR13-9-000 (2014).

of BAA seams leads to a rise in resources freely available to support frequency and generation management in Real-time. Organized markets can resolve congestion and potential overloads with price signals that favor raising or lowering generation in specific areas of their grid. RCs within organized markets in the Eastern Interconnection often use the market to bind Transmission Loading Relief (TLR) to market tools to reposition generation to relieve congestion and oversubscribed transmission. Typically, the preceding aspects of markets can lead to increased reliability within the boundary of the market footprint, so long as market operations do not take precedence over reliability concerns. Some observers were quick to note; however, reliability may decrease outside the market footprint.

A. About the Southwest Power Pool

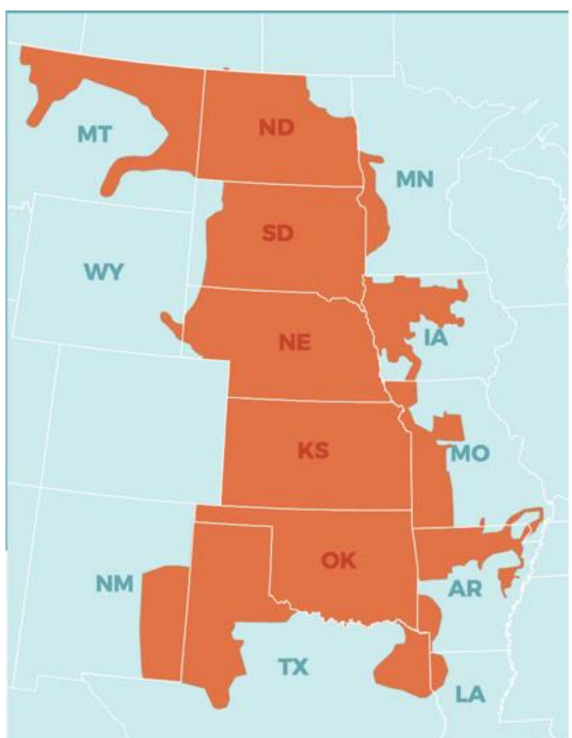
SPP operates out of Little Rock, AR, and forms the Western edge of the Eastern Interconnection. SPP oversees the bulk electric grid and wholesale power market in the central United States in 14 states. It manages operations, plans and develops transmission infrastructure, and operates a competitive wholesale electricity market for a 546,000-square-mile area serving a peak load of 50,622.[23]

B. SPP Functions and Services

SPP has the following designations and functionalities

- Regional Transmission Organization (RTO)
- Balancing Authority
- Reserve Sharing Group
- Reliability Coordinator (RC)
- Integrated Marketplace Operator

The following maps are a depiction of SPP's current footprint (Image 1) and the proposed extension of the market and RC function within the Western Interconnection (Image 2).



[23] 2016 SPP Annual Report

Image 1

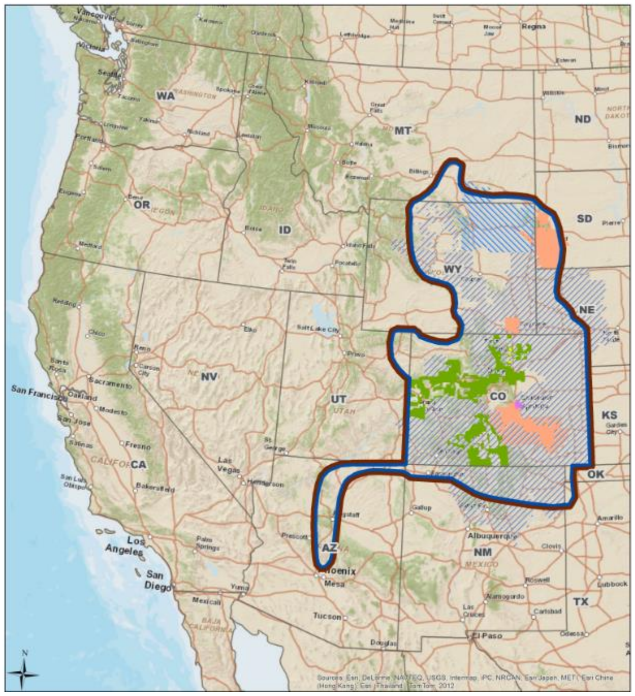


Image 2

VI. CHALLENGES FACING POTENTIAL ENTRANTS AS RELIABILITY COORDINATOR IN THE WESTERN INTERCONNECTION AND MWTG

The Western Interconnection is inherently different from the Eastern Interconnection. These differences may create some challenges for entrants familiar with operations in the Eastern Interconnection, however, these challenges are not viewed as insurmountable. Some of those differences are noted below.

- The primary transmission limits for the Eastern Interconnection are based largely on thermal constraints. Reliability Coordinators focus in both planning and in Real-time contingencies are to manage the grid from a thermal based consideration.
- The Western Interconnection has thermal limitations as well, but also has several significant dynamic constraints which are a primary concern of those who monitor, operate and study the Interconnection. In the late 1990s, a series of blackouts led to increased focus on transient stability and the potential for cascading outages across the major transfer paths in the Western Interconnection with resulting studies and focus on stability limits and management.
- The West is a much more integrated Interconnection. Loss of major transmission paths and generating units can have more widespread impacts than commonly found in the East. The proliferation of Remedial Action Schemes in the West, used to increase transfer ratings despite some of the stability limits discussed above, require close coordination to forecast post-contingency conditions correctly. Conversely, the Eastern Interconnection is more networked, and the area in which SPP is located gains little additional value for situational awareness of faraway regions of the Eastern Interconnection. In the West, a major event on any part of the BES can radiate impacts across the Interconnection. This was the case in the September 8,

2011, Desert Southwest blackout in which several seemingly disparate events combined and resulted in a blackout across the Southwest including San Diego.

- Loop flow mitigation – The Western Interconnections transmission is connected essentially in a large loop around the footprint. Known as the "doughnut," path flows can exceed schedules as physics allow for unscheduled flow to race around grouped together lines known as "paths." When loop flow has a significant impact on a specific path over time, that path can become what is known as a Qualified Transfer Path. Although situated at the eastern edge of the Western Interconnections (see Image 2), three of the four Qualified Transfer Paths in the WECC are located within the MWTG area (see Image 3). Path 30 (TOT 1A), Path 31 (TOT 2A) and Path 36 (TOT 3) are located within MWTG. The other path is the major interface at the California – Oregon border known as Path 66 (COI). Mitigation efforts for any of the Qualified Transfer Paths may impact flows on the others. Presently, Peak coordinates the congestion mitigation of all Qualified Transfer Paths in the Western Interconnection including those currently operated by the Western Area Power Administration inside the MWTG footprint (see Image 3 below). The mitigation steps include the coordination and adjusting of serial devices such as phase-shifting transformers and curtailment of schedules on and off the Qualified Transfer Path.
- The Eastern Interconnection experiences congestion in some of its major corridors but has a different set of challenges than the West in terms of mitigation of congestion. Eastern operators are able to make use of market mechanisms to incorporate Transmission Loading Relief (TLR) instructions to assist in alleviating oversubscribed or inadvertent flows on transmission. These instructions generally do not impact other Reliability Coordinator Areas in the Interconnection. In the circumstance with both Peak and a second entity acting as RCs in WECC, each effort to manage loop flow will require close coordination not only between the RC and the TOP experiencing the congestion, but with the other RC as well which will have the potential to delay or slow the mitigation.
- Training – Peak's experience in training staff that serve in the reliability coordinator roles demonstrated that it typically takes a reliability coordinator three-four months of Western Interconnection training shifts to prepare a reliability coordinator to sit at the desk unsupervised. Training RC, BA or TOP operators who previously worked in the Eastern Interconnection typically added an additional two to four months of training time on top of that required to adequately train a reliability coordinator from the West. Additionally, SPP will need to build a simulator that adequately replicates the operational behavior of the BES, which may prove challenging.
- Seams – seams between Reliability Coordinators present two challenges, reliability and costs. Any new RC will need to ensure operations are coordinated with adjacent RCs under IRO-014-3.[24] Additionally, RCs will need to coordinate a bevy of activities including, but not limited to, outages (IRO-017-1[25]), Operational Planning Analyses and Real-time Assessments (IRO-008-2[26]), unscheduled flow (IRO-006-WECC-2[27]), IROL mitigation (IRO-009-2[28]), and SOL methodologies (FAC-011-3[29]) along the seams of the adjacent RC Areas.
- RC regionalization – several interviewees raised the prospect of further regionalization if an RC joins the Western Interconnection and serves just a small portion of the load. As indicated by

[24] NERC Reliability Standard IRO-014-3 – Coordination Among Reliability Coordinators
[25] NERC Reliability Standard IRO-017-1 – Outage Coordination
[26] NERC Reliability Standard IRO-008-2 – Reliability Coordinator Operational Analyses and Real-time Assessments
[27] NERC Reliability Standard IRO-006-WECC-2 – Qualified Transfer Path Unscheduled Flow (USF) Relief
[28] NERC Reliability Standard IRO-009-2 – Reliability Coordinator Actions to Operate Within IROLs
[29] NERC Reliability Standard FAC-011-3 – System Operating Limits Methodology for the Operations Horizon

Peak's filings in the Peak's Supplemental Assessment Request in 2014,[30] Peak' costs are, by and large, fixed and not scalable. The MWTG members are responsible for roughly 10% of the load in Peak's footprint, and consequently, the same percentage of funding lost through the Net Energy for Load funding calculation would require the remaining funding parties of Peak to shoulder more costs. Moreover, the addition of another RC in the Western Interconnection would likely increase the operating costs for Peak because of the coordination issues that will arise along the seams discussed above. Further defections, will sway the cost calculations dramatically among Western Interconnection entities.

- Travel and participation costs - this will impact Peak funding members and MWTG members, especially those along the seams. Consistent interaction is required between an RC and the BAs, TOPs in its footprint. While, many regional RCs may have a market which unifies the BA, and to some extent the TOPs, there will still need to be collaborative efforts to align planning, operations, SOL methodologies, and training across the RC footprints. For those entities that continue to operate as BAs or TOPs and operate near the interface of the two RC Areas, significant costs may be involved, as the entities attempt to coordinate action with their RC, and with their adjacent BA, that resides within a different RC Area.
- Time to develop tools – the initial procurement of a tool or platform is simply the beginning of what is often a long and costly journey to production and delivery of that tool. As noted in Section IV.A. above, a new RC service provider would have to obtain, or procure access to numerous tools to deliver a comparable level of reliability and service as currently delivered by Peak.

[30] *North American Electric Reliability Corp.,* Petition of the North American Electric Reliability Corporation for Approval of a Supplemental Assessment to fund the 2014 Budget of Peak Reliability, Inc., FERC Docket No. RR13-9-000, at p. 12, Attachment 1 p. 3, Attachment 5 (2014).

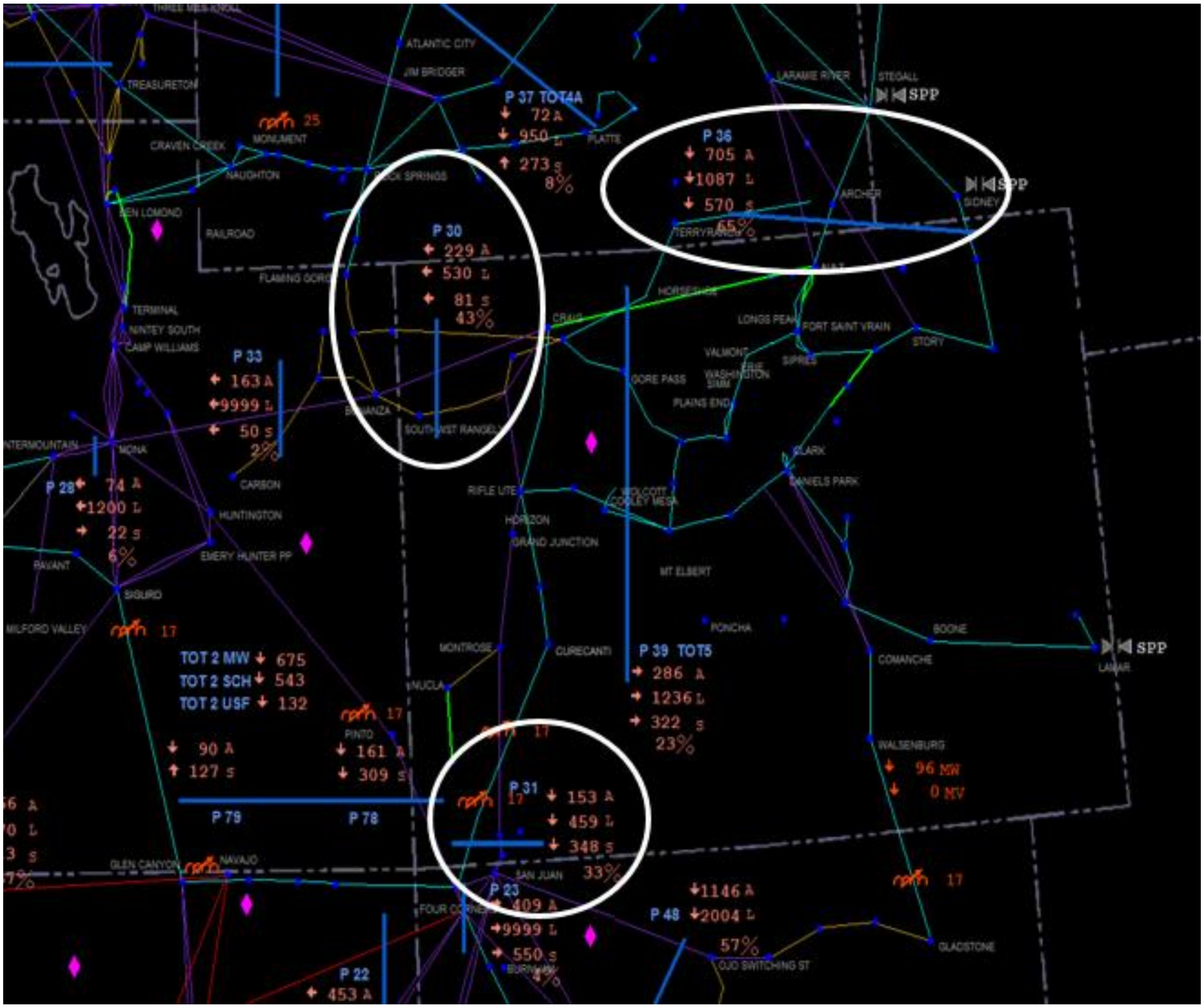


Image 3 Qualified Paths in Colorado and surrounding area.

Because of the close correlation of flows on the eastern side and western side of the WECC paths, managing loop flow could be more complicated between two or more RCs.

VII. IDENTIFICATAION OF COSTS TO OFFER RC SERVICES WITHIN THE WESTERN INTERCONNECTION

As part of this assessment, GridSME analyzed two scenarios to help consider the potential costs of a new RC services provider implementing the tools and technologies currently used by Peak to provide RC services in the Western Interconnection. These scenarios were developed from publicly available information and discussions with those familiar with the MWTG and SPP proposal. The two scenarios help frame the range of potential costs. Both scenarios operate under the assumption that a new entrant will offer a level of reliability services consistent with the requirements of the NERC Reliability Standards.

The scenarios below do not account for the numerous potential variables that SPP may choose to include or exclude. Additionally, no capital costs associated with developing the Western

Interconnection portion of applications, modeling, simulators, etc. were addressed in these rough estimates.

Scenario #1 – SPP uses its existing systems and capabilities (with Western Interconnection details added), to provide RC services in the MWTG footprint.

The RC staffing costs for this scenario are estimated to range around $2m.

This scenario is one where the Reliability Coordinators are physically located at SPP's current facilities. This scenario envisions that the new RC entrant sets aside staff to ensure the focus on their footprint as well as specifics of the Western Interconnection. No additional facility costs are expected and little or no additional systems are procured or built.

Assumptions

- The RC service provider delivers a set of tools specific to the MWTG electrical footprint that meet the various Reliability Standards that incorporate the West-wide System Model, to allow their analytical tools to utilize the Interconnection-wide data and topology. This allows for the state estimator and contingency analysis tools to operate in a comparable manner to Peak's tools.
- The reliability coordinators focus on things like loop flow mitigation, coordinated outage reviews, RAS activation and other events within the system, and are provided Interconnection-wide information and Real-time data to allow their tools to solve for a larger area than just MWTG.
- The new entrant provides specifically focused RC staff that focus on the Western Interconnection.

The estimate does not include any costs considered for obtaining services from Peak, any costs for additional leadership or costs associated with WECC-specific meetings, agendas, or issues.

Cost potential estimated (this is based on staffing only, no infrastructure costs). Details in the table below.

Estimated costs for a small-scale RC startup that provides services in compliance with NERC Reliability Standards. The estimate is derived from experiences with the setup of the original WECC RC in 2008. The costs of labor, facilities, and support is estimated at +/- 20%. The costs for facilities, vendor contracts, etc. are more likely +/- 30%.						
Personnel	Purpose	Est. salary	30% burden rate (taxes, benefits, bonus, etc.)	Total salary	Est. headcount	Total
RC Manager	Provide RC leadership, communication with membership and assist with RC to RC coordination	$150,000	130%	$195,000	1	$195,000

RC Coordinators	Dedicated 24X7 RCs to focus on MWTG area - estimated 5 seats based on typical 12hr rotation needs including relief shift - training and vacation coverage	$125,000	130%	$162,500	5	$812,500
Senior Power Engineer	Specific to voltage stability analysis tools and EMS simulator upkeep	$135,000	130%	$175,500	1	$175,500
Power Engineer	Engineering support for application results, coordination with Peak engineering, studies outages/contingencies, modeling issues etc.	$95,000	130%	$123,500	2	$247,000
NERC Compliance Specialist	NERC compliance specific to RC includes all operation and planning requirements as well as a high impact CIP rating facility for in-scope Cyber Assets	$100,000	130%	$130,000	1	$130,000
EMS Staff	Specific to model maintenance, SCADA maintenance (ICCP, alarm management, situational awareness displays, etc.	$95,000	130%	$123,500	1	$123,500
IT Support Staff	All systems administration, communication systems, cyber security, hardware, and application support	$90,000	130%	$117,000	1	$117,000
Trainer specific to Western Interconnect ion	Support continuous education needs of the RC. Upkeep of EMS simulator, coordination with Peak training for system-wide drills and scenario development	$110,000	130%	$143,000	1.5	$214,500
					Labor	$2,015,000

Scenario #2 – SPP – SPP establishes a Colorado Control Center, that coordinates with the SPP head office for redundancy, to provide RC services in the MWTG footprint.

Total estimated annual cost for this scenario is $3.2 million. This is based on the labor estimates below, including the costs of services needed to support a remote organization in the MWTG footprint, the basic facility requirements, system, hardware, and software costs including communication links. The estimate does not include any costs considered for obtaining services from Peak, any costs for additional leadership or costs associated with WECC-specific meetings, agendas, or issues.

Assumptions

This scenario assumes SPP constructs a Control Center and data center and employs a small support staff inside the MWTG boundaries, most likely Colorado. The redundant backup Control Center is assumed to utilize the SPP headquarter infrastructure with separate set of tools specific to the RC.

Estimated costs for a small-scale RC startup that provides services in compliance with NERC Reliability Standards. The estimate is derived from the setup of the WECC RC in 2008. The costs of labor, facilities, and support is estimated at +/- 20%. The costs for facilities, vendor contracts, etc. are estimated at+/- 30%.						
Personnel	Purpose	Estimated salary	30% burden rate (taxes, medical, benefits, bonus, HR etc)	Total salary	Estimated headcount	Total
RC Manager	Provide RC leadership, communication with membership, and assist with RC to RC coordination	$150,000	130%	$195,000	1	$195,000
RC Coordinators	Dedicated 24X7 RCs to focus on MWTG area - estimated 5 seats based on typical 12hr rotation needs including relief shift - training and vacation coverage	$125,000	130%	$162,500	5	$812,500
Senior Power Engineer	Specific to voltage stability analysis tools and EMS simulator upkeep	$135,000	130%	$175,500	1	$175,500
Power Engineer	Engineering support for application results, coordination with Peak engineering, studies for outages/contingencies, modeling issues etc.	$95,000	130%	$123,500	2	$247,000
NERC Compliance Specialist	NERC compliance for RC function includes all operation and planning requirements as well as a high impact CIP rating facility for all in scope Cyber Assets	$100,000	130%	$130,000	1	$130,000
EMS Staff	Model maintenance, SCADA maintenance (ICCP, alarm management, situational awareness displays, etc.	$95,000	130%	$123,500	2	$247,000
IT Support Staff	All systems administration, communication systems, cyber security, hardware and application support	$90,000	130%	$117,000	2	$234,000
Trainer specific to	Support continuous education needs of the RC	$110,000	130%	$143,000	1	$143,000

western interconnection	upkeep of EMS simulator, coordination with Peak training for system wide drills and scenario development					
RC Administrative Assistant	General office admin support, coordinate travel, schedules etc.	$40,000	130%	$52,000	1	$52,000
Personnel						
					Labor	$2,236,000

Estimated Facility and Infrastructure costs	Details	Monthly Estimated Costs	Annual Cost
Monthly Facility Lease	5,000sq ft facility for control room, small data center, offices and conference / training room	$8,000	$96,000
Utilities	24X7 HVAC, electric, heat, trash, water	$2,000	$24,000
Facility Maintenance	General housekeeping janitorial and facility infrastructure charges	$1,000	$12,000
Communication links	Redundant communication circuits	$6,000	$72,000
Personnel Phones (cells)	Cell phone monthly charges	$1,000	$12,000
General Insurance	General liability, facility insurance	$2,000	$24,000
Security System	Typical security monitoring for critical facility	$1,000	$12,000
Travel	Meetings within SPP, meetings for WECC, Peak, training, etc.	$2,000	$24,000
EMS Support	Assuming the need for a standalone EMS or even additional support due to system customization	$3,000	$36,000
Other reliability vendor support contracts	Relicense or support annual fees	$3,000	$36,000
Hardware vendor support	Annual support contracts	$2,000	$24,000
Remote Support	Estimated annual costs of increase to Little Rock for system redundancies, various support and oversight needs from resources based in SPP	$300,000	$300,000
		Estimated Total Annual Facility Costs	$672,000

VIII. SUMMARY

The transition to multiple Reliability Coordinators in the Western Interconnection has the potential to be a disruptive event. This report introduces a framework for objectively reviewing and assessing the implications of a transition from a single Interconnection-wide RC to multiple RCs within the Western Interconnection. The tools employed by a new RC service provider should at least provide the essential services described within this report.

The annual cost for a new RC service provider providing reliability at only the level required to meet NERC Reliability Standards is estimated to be $2 million to $3.2 million per year. This cost estimate does not include the potential capital costs associated with procuring and developing the Western Interconnection portion of tools, applications, modeling, simulators, etc. necessary to maintain the current level of RC Service in the West.

To ensure reliability is maintained at its current level policy-makers should focus their attention on

- Securing assurances that the new RC service provider either obtains the right tools for operating in the Western Interconnection or has arranged access to such tools;
- Ensuring coordination agreements are well thought out between RC Area footprints;
- Discerning whether lessons learned from the September 8, 2011 Southwest Blackout will be addressed, and the RC has the capabilities outlined in the FERC Order Approving Stipulation and Consent Agreement for the WECC RC.
- Attain confidence that the reliability coordinators are knowledgeable about the operating environment in the Western Interconnection; and
- Identify as many latent costs as possible.

The challenges to the entry of another Reliability Coordinator into the Western Interconnection are real, but as with challenges faced by other reliability entities, if those involved with these projects are dedicated to promoting and ensuring reliability, then the challenges presented can be met.

APPENDIX I – INTERVIEW RECORD

GridSME conducted interviews with the individuals listed below. GridSME also had several "off the record" conversations with industry individuals that asked that their names be withheld.

Entity	Subject Matter Expert	Interviewed by…
Peak	Brett Wangen – Director of Engineering	Eric Whitley
Peak	Terry Baker – Director of Operations	Eric Whitey
CAISO	Dede Subakti - Director of Operations Engineering Services	Nan Liu
CAISO	Nancy Traweek – Director of Grid Operations	Eric Whitley
CAISO	John Phipps - Manager of Grid Operations	Eric Whitley
Peak	Jill Hoyt – Director of Training	Andy Dressel
Peak	Matt Yates - Associate General Counsel	Andy Dressel
NERC	Anonymous	Eric Whitley, Nan Liu, Andy Dressel
WECC BA/TOP and MWTG Participant	Anonymous	Eric Whitley
WECC BA/TOP	Anonymous	Tim Van Blaricom
WECC BA/TOP	Anonymous	Tim Van Blaricom