Federal Energy Regulatory Commission staff paper

Qualitative Assessment of Potential Reliability Benefits from a Western Energy Imbalance Market

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I. Executive Summary

In this paper, Commission staff presents a qualitative analysis of the potential reliability-related benefits from a western energy imbalance market (EIM). This analysis only addresses reliability, and does not address the potential economic benefits of an EIM which are being analyzed in a separate study by the National Renewable Energy Laboratory (NREL), and which have been previously presented to the Public Utility Commissions EIM Group (PUC EIM Group).[1] Importantly, this paper's use of the term "reliability" is not intended to be synonymous with that term as used in the FPA Section 215 context.

In the context of the bulk power system, the North American Electric Reliability Corporation (NERC) defines reliability "as the ability to meet the electricity needs of end-use customers, even when unexpected equipment failures or other factors reduce the amount of available electricity." NERC breaks down reliability into adequacy and security.

- Adequacy — The ability of the bulk power system to supply the aggregate electrical demand and energy requirements of the customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements.

- Security — The ability of the bulk power system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system elements from contingencies.

In this paper, we use the term "reliability benefits" from an EIM in a general sense, as areas in which an EIM could enhance the ability of the system to respond to energy imbalances, effectively manage flows within transmission limits during dispatch and potentially reduce the number of issues that will need to be resolved by other entities such as reliability coordinators.[2] The benefits identified in this paper could enhance both adequacy and security, as defined by NERC, but we do not attempt to clearly draw that distinction in this paper. In addition, we believe reliability benefits identified herein may help registered entities reduce or avoid violations of Section 215 of the FPA, but we do not attempt to identify specific reliability standards at issue. Rather, this paper is

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[1] See http://www.westgov.org/PUCeim/index.htm, *accessed* November 15, 2012.

[2] Reliability coordinators are the NERC functional entities that maintain the real-time operating reliability of the bulk electric system within a reliability coordinator area.

intended to describe “reliability benefits” in a colloquial sense. Finally, nothing in this paper is meant to establish any new standard for reliability.

The paper does not attempt to quantify the degree to which the benefits identified may be realized. We recognize the voluntary nature of an EIM and note that the benefits realized will be a function of participation in the market. We also note that effective coordination and operating relationships between the market operator and other entities such as the reliability coordinator, transmission operators[3] and balancing authorities[4] will be necessary elements for the materialization of the potential benefits identified, and that other challenges also would need to be addressed in order to implement an EIM. This paper does not address all of the issues that could be involved in setting up the coordination and communications that would be necessary to enable the benefits identified.

Staff has found that an EIM could provide reliability benefits through:

- security constrained economic dispatch across the market footprint, which provides better management of imbalances and enhanced ability to manage flows within system operating limits, as well as enhanced opportunities to deliver energy from a diverse set of conventional and emerging technologies, such as demand response resources, for balancing;
- enhanced situational awareness;
- potentially fewer Energy Emergency Alerts;
- faster identification, dispatch and delivery of replacement generation after contingency reserve sharing assistance ends and for contingencies beyond reserve obligations; and
- assisting with the integration of variable energy resources.

Throughout the paper, staff provides examples of events in which the presence of an EIM may have provided faster response or mitigated reliability problems.

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[3] Transmission operators are the NERC functional entities that ensure the real-time operating reliability of transmission assets within a specific area. North American Electric Reliability Corporation Functional Model Working Group, “Reliability Functional Model: Function Definitions and Functional Entities Version 5,” *at* 38 (November, 2009), *accessed* October 29, 2012, http://www.nerc.com/files/Functional_Model_V5_Final_2009Dec1.pdf.

[4] Balancing authorities are NERC functional entities that integrate resource plans ahead of time, maintain generation-load-interchange balance for their balancing authority area and contribute to the management of Interconnection frequency in real-time. *Id.*, at 33.

In preparing this paper, staff consulted a variety of experts in the areas of reliability, energy markets and the western U.S. power system. Staff also consulted existing papers that address reliability and energy markets and researched reliability events to identify instances where an EIM may have mitigated problems.

II. Introduction

Purpose and scope

It has been recognized that power systems can be operated more reliably when coordinated over wide geographic areas,[5] and that electricity markets can enhance reliability management.[6] This staff paper provides a qualitative analysis of ways in which an EIM, through added coordination, could bring reliability benefits to the Western Interconnection.

This paper is not meant to be a quantitative analysis of potential reliability benefits from an EIM. Quantifying reliability benefits is challenging because operating practices have evolved so that loss of load events are rare. Simply quantifying the number of loss of load events or "near misses" would necessarily underestimate the enhanced reliability that an EIM could provide. Similarly, some of the reliability benefit of an EIM is associated with the ability to maintain the same level of reliability at a lower cost. Quantifying the cost savings inherently overlaps with the overall economic benefits of an EIM and this paper is not meant to assess the economic benefits of an EIM. Thus, this paper instead describes the manner by which a western EIM could reduce the chance of a loss of load event by enhancing the ability of the system to dispatch available resources and deliver energy in response to imbalances, effectively manage flows within transmission limits and potentially reduce the chances of load shedding with the intention that such a discussion will highlight the potential reliability benefits of an EIM.

Assumptions about an EIM

In this paper, we assume that the EIM would be a single service, real-time (five minute) market for imbalance energy. The EIM would employ a security constrained economic dispatch (SCED) to allow market participants to use the lowest cost resource available to balance loads and resources while respecting transmission and reliability constraints

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[5] U.S. Department of Energy Secretary of Energy Advisory Board, "Maintaining Reliability in a Competitive U.S. Electricity Industry: Final Report of the Task Force on Electric System Reliability," at 25 (September 29, 1998), *accessed* October 23, 2012, http://www.nerc.com/docs/docs/pubs/esrfinal.pdf.

[6] Eto, J.H. and Lesieutre, B. C., Hale, D.R., "A Review of Recent RTO Benefit-Cost Studies: Toward More Comprehensive Assessments of FERC Electricity Restructuring Policies," at 37-38 (December, 2005), *accessed* November 5, 2012, http://certs.lbl.gov/pdf/58027.pdf.

during both normal operation and postulated contingency events. The automation of the EIM would allow for a more efficient use of the system by providing access to balancing services from resources located throughout the region. We assume that the EIM would not include centralized unit commitment, day-ahead energy and ancillary service markets or capacity markets.[7]

The bilateral markets that have been the dominant paradigm in the Western Interconnection would continue to remain in place and the majority of energy would still be transacted bilaterally. The EIM would be a supplement to the bilateral market and bidding by resources would be voluntary. We assume that an EIM would complement the contract path transmission reservation regime.[8] Suppliers would be able to either offer their output into the market or self-schedule their output.

In this paper we do not make any assumptions about whether an EIM would be accompanied by consolidation of balancing authorities (BAs). We note that BAs may separately choose to consolidate, which could produce additional benefits, but our analysis in this paper addresses potential EIM reliability benefits independent of any potential BA consolidation. The EIM operator would not have a formal reliability role, but it would help provide congestion management by respecting transmission limits when performing automated redispatch in response to imbalances. The reliability coordinator (RC), WECC, and other entities would maintain their reliability functions with transmission operators and balancing authorities acting as early lines of defense against reliability problems and the reliability coordinator taking action when necessary to maintain reliability. An EIM would help to automate certain processes, such as the redispatch of resources in response to energy imbalance and provide proactive management of resources that could relieve transmission constraints during redispatch. An EIM could also be an additional source of information for entities such as transmission operators, balancing authorities, and reliability coordinators.

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[7] We note that on February 12, 2013 PacifiCorp and CAISO released a memorandum of understanding to work towards the creation of an EIM. *See* Energy Imbalance Market Memorandum of Understanding, at http://www.caiso.com/Documents/ISO-PacifiCorpMOU_Effective20130212.pdf, *accessed* February 13, 2013. The assumptions made about an EIM in this document are independent of that initiative.

[8] That is, we assume that the existing transmission reservation and scheduling systems would remain in place, and that the EIM would use transmission based on actual availability. In PUC EIM Group meetings about potential EIM market constructs, it was discussed that EIM market flows would be adjusted first to manage flows within transmission limits.

III. Existing analysis of a western EIM reliability benefits

There have been several efforts to describe the reliability benefits of a western EIM. Notably, Mariner Consulting recently discussed several reliability related benefits from an EIM in a paper, "Why an Energy Imbalance Market Will Make the Western Interconnection More Reliable."[9] In that paper, Mariner stated that both SPP and MISO have reported that the reliability benefits of their real time markets exceed the economic benefits.[10]

In 2011, WECC included a reliability impact assessment in their Efficient Dispatch Toolkit Cost-Benefit analysis.[11] The assessment discussed the potential impact of an EIM on managing flows within system operating limits, Energy Emergency Alerts, system balance and variable resources, and system visibility. This paper builds off of these two analyses, and supplements them based on discussions with industry stakeholders.

IV. Qualitative assessment of EIM reliability benefits

Security constrained economic dispatch (SCED)

SCED has been defined as "the operation of generation facilities to produce energy at the lowest cost to reliably serve consumers, recognizing any operational limits of generation and transmission facilities."[12] An EIM using SCED over its footprint could enhance reliability by managing resources that could relieve transmission constraints more effectively, leveraging a more diverse set of resources to operate the system within limits and creating price signals that lead to actions that could enhance reliability. Currently, in non-RTO/ISO parts of the west, dispatch is performed locally as opposed to using wide-area SCED.[13] In general, the existing process starts ahead of time with a plan for which

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[9] Mariner Consulting, "Why an Energy Imbalance Market Will Make the Western Interconnection More Reliable," (2012), *accessed* November 16, 2012, http://www.westerngrid.net/2011/07/26/how-a-westwide-eim-helps-reliability/.

[10] *Id*.

[11] Western Electricity Coordinating Council, "WECC Efficient Dispatch Toolkit Cost-Benefit Analysis (Revised)," at, *accessed* November 14, 2012, http://www.wecc.biz/committees/EDT/EDT%20Results/EDT%20Cost%20Benefit%20Analysis%20Report%20-%20REVISED.pdf.

[12] *Joint Boards on Security Constrained Economic Dispatch*, 112 FERC ¶ 61,353, at P 14 (2005. The definition was adopted from the definition of economic dispatch in section 1234(b) of the Energy Policy Act of 2005. *See id.* Dispatchable demand-side resources can also be made available as supply within the dispatch algorithm.

[13] The local processes described in this section may refer to the activities carried out by the relevant functional entities that provide generation commitment and dispatch plans, such as generator operators and load serving

resources to use to supply and balance forecasted load. The process may involve the identification of bilateral purchases to lower expected operating costs. As the operating hour approaches, plans to balance resources and actual load will be reviewed, again potentially using bilateral purchases. Transmission service must be reserved and scheduled to sink any purchases in the relevant balancing authority area. The identification of bilateral purchases, reserving and scheduling of transmission service are processes that can involve manual communications such as phone calls and emails.

The current system of individual system dispatch in an era of regional bilateral trade can create a number of challenges. For example, dispatch decisions related to energy imbalance are less coordinated than they would be under an EIM.[14] The resources that can be used to balance load within a balancing authority area are limited to resources within that area[15] and any economic purchases that can be identified and for which needed transmission service is available. The transmission service available to deliver an economy energy purchase may be limited by pre-existing transmission service reservations, despite the fact that some of the pre-existing service is not used. In an effort to identify available transmission service, a complex transmission path may be assembled that is not reflective of the true flow of electricity, thus creating unscheduled flows. Processes associated with bilateral purchases and scheduling transmission service can be inherently limiting when an operator is trying to respond quickly to changes on the system and bring the system back within operating limits. These factors can limit the ability to rely on third party supplies in the bilateral market. We note that an EIM would only provide real-time energy imbalance, but nonetheless would improve the coordination of dispatch for energy imbalance and the delivery of energy to manage imbalance.

Currently in the Western Interconnection, when a system operating limit is exceeded on a path, the path must be brought back within operating limits within 30 minutes.[16] The actions currently taken to manage flows within transmission limits in the Western Interconnection are reactive rather than proactive, involving manual actions by operators that do not necessarily have control over or knowledge of the resources best able to

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entities, the entities that implement commitment and dispatch plans, namely balancing authorities, and the purchasing-selling entities that arrange for transmission service and submit interchange requests for a given area.

[14] United States Department of Energy, "The Value of Economic Dispatch: A Report to Congress Pursuant to Section 1234 of the Energy Policy Act of 2005," at 4, 29 (November 7, 2005), *accessed* November 14, 2012, http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/value.pdf.

[15] Resources referred to here could include generators, including distributed generation embedded in the distribution system, as well as demand response resources.

[16] NERC Reliability Standard TOP-004-2 R4, Transmission Operations, *accessed* November 19, 2102, http://www.nerc.com/files/TOP-004-2.pdf.

manage the limits of interest. Specifically, in the Western Interconnection, when a balancing authority cannot solve a congestion problem, it may be related to unscheduled flow from a neighboring system. WECC has an unscheduled flow management protocol (the Unscheduled Flow Mitigation Plan, or USFMP), but it only applies to six qualified paths. In circumstances where the USFMP is used to manage flows on qualified paths, transmission service schedules are curtailed. When transmission service schedules are curtailed, replacement power must be located, potentially along with transmission service to deliver that replacement power. As compared to the USFMP, an EIM using SCED would provide more precise and discrete congestion management solutions, and could do so more quickly (on a 5-minute basis). Due to these factors, an EIM using SCED would be less likely than the USFMP to over-provide or under-provide congestion relief. In instances where the reliability coordinator has to intervene in response to flows exceeding an operating limit on a non-qualified path,[17] the reliability coordinator will instruct the transmission operator to correct the problem and the transmission operator will follow its own redispatch procedure. By contrast, an EIM using SCED would redispatch using resources from across the market footprint to manage flows within operating limits.

The potential reliability benefits of an EIM using SCED can be illustrated by several events.[18] First, reliability issues associated with the current system can be illustrated by a February 2006 NERC Energy Emergency Alert 3 event on the Public Service Company of Colorado (PSCo) system.[19] During this event, 1000 MW of generation was lost due to gas supply and pressure limitations during a period of low temperatures in the Denver metropolitan area.[20] Interruptible load was curtailed and PSCo appealed to the public to reduce electricity usage. As generating units went out of service, real-time traders manually arranged purchases of additional electricity to be delivered into the PSCo system. However, the delivery did not take place in time to avoid the implementation of controlled outages.[21] During the time leading up to the eventual firm load curtailment, a

[17] Non-qualified paths are those that are not qualified for WECC unscheduled flow mitigation.

[18] Note that these events conceptually illustrate scenarios where an EIM may have the potential to provide benefits. The events involve the loss of generation, and we note that under our assumptions the application of reserves would still occur outside of the EIM market. Therefore, a caveat to each example is that the EIM market would need to be constructed in a way such that it would not over-respond when out of market reserves are being applied.

[19] PSCo performs balancing authority, transmission operator and other reliability functions for its service territory, which covers over 8,000 square miles in the state of Colorado. See http://www.nerc.com/files/NERC_Compliance_Registry_List20120928.pdf, p. 271 and http://www.xcelenergy.com/staticfiles/xe/Corporate/Corporate%20PDFs/2012_PSCotransmission_plan.pdf.

[20] This information was obtained from an Energy Emergency Alert issued by NERC, which is available at http://www.nerc.com/docs/cip/alertlogs/EEA3_Report_PSCo_021806.pdf

[21] Report of Events, Controlled Outages, 2/18/06, at 6 (3/13/2006), *accessed* November 7, 2012, https://www.dora.state.co.us/pls/efi/EFI.Show_Docket?p_session_id=&p_docket_id=06I-118EG

real-time trader had to enter a revised transmission schedule for a lower amount of power into PSCo from another system, due to an incorrect Available Transmission Capacity (ATC) posting.[22] It is not certain that an EIM would have been the solution to prevent load shedding in this example, but an EIM using SCED could have helped by automatically redispatching available resources based on actual transmission availability. Thus, the example conceptually illustrates a potential reliability benefit from an EIM using SCED.

Another event that conceptually illustrates the potential for an EIM using SCED to improve reliability is from June 14, 2004. At 07:41 AM, an auxiliary relay in the southwestern part of the Western Interconnection failed to clear a line fault that ultimately caused approximately 4,589 MW of generation to trip. Despite the reserve sharing group being activated, one entity was directed by the reliability coordinator to shed firm load about nine minutes into the event.[23] NERC's Industry Advisory states that this event had the potential to collapse the entire Western Interconnection.[24] It is possible that the directive to shed load was given because this multiple generator outage exceeded the reserve sharing group's most severe single contingency and the entity was unable to locate and receive enough generation to prevent an unacceptable deviation in its Area Control Error (ACE).[25]

An EIM operator would have seen the imbalance after contingency reserve deployment and SCED would have dispatched available resources to the extent possible. It is not certain that an EIM would have prevented the load shed in this specific example, but it seems likely that an EIM using SCED would have helped by automatically redispatching available resources, in response to energy imbalance in the next five minute interval. Thus, this example also conceptually illustrates a potential reliability benefit from an EIM using SCED.

An EIM that uses SCED could increase reliability in a number of ways. In brief, it could

- automate the identification of resources and transmission to balance load by

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[22] *Id.*, at Exhibit No. 10, p. 9.

[23] WECC Preliminary Summary of System Disturbance (July 2004), *accessed* December, 2012, http://www.nerc.com/docs/oc/rcwg/rcwg_0904a.pdf.

[24] NERC Industry Advisory: Protection System Single Point of Failure (March 2009), *accessed* December, 2012, http://www.nerc.com/fileUploads/File/Events%20Analysis/A-2009-03-30-01.pdf

[25] Area Control Error is "the instantaneous difference between a balancing authority's net actual and scheduled interchange, taking into account the effects of Frequency Bias and correction for meter error." Source: North American Electric Reliability Corporation, "Glossary of Terms Used in Reliability Standards," (February 12, 2008), *accessed* 11/30/2012, http://www.nerc.com/files/Glossary_12Feb08.pdf.

    - dispatching resources based on actual transmission availability rather than transmission reservations, allowing the market to deliver energy from existing and new resources by finding paths around congested areas,
    - creating enhanced coordination that assists with reliable operations, and creating price signals that are consistent with reliable operations;
- internalize and recognize unscheduled flows;
- automate the ability to manage and respond to system contingencies by
    - providing visibility into actual system conditions and transmission loading and proactively dispatching resources to avoid flows exceeding system operating limits and
    - increasing the pool of resources that balance resources and load, provide ramping capability, and managing flows to be within system operating limits.

Therefore, an EIM has the potential to enhance reliability in situations where system operators are responding to contingencies, like the events described. We discuss each of these benefits in more detail below.

An EIM that uses SCED would automate the identification of resources and transmission needed to balance load across the balancing authority areas of the market. It would do so based on actual transmission availability rather than posted available transfer capability. That is, SCED automatically finds available transmission capability not being used by existing transactions to deliver imbalance energy rather than relying on manual processes to reserve and schedule transmission service. Thus, SCED would allow the EIM to deliver energy from existing and new resources to correct real-time imbalances, by automatically searching for and finding paths around congested areas. As a by-product, the EIM's SCED would create incentives for resources to engage in reliable operation. Specifically, SCED calculates resource deployment instructions simultaneously with imbalance prices. The imbalance prices are calculated to reflect the marginal cost of deploying resources to serve load at each location, in each dispatch interval. The prices are calculated using the bids submitted by market participants, along with detailed inputs that represent actual real-time system conditions on a granular (nodal) level.[26] Because the prices themselves are dependent on detailed real-time system information, there is a

[26] The nodal (bus by bus) representation of the system in the market allows imbalance prices to be calculated at the bus level.

direct relationship between imbalance prices and real-time reliability. The imbalance prices inform market participants as to where generation or demand response resources could be dispatched in order to meet imbalances while staying within transmission limits. An EIM with imbalance prices could improve reliability because the price signals are designed to evoke reliability enhancing behavior. Through exposure to imbalance price signals, market participants will have the incentive to take actions that meet system needs. Additionally, the price signals will reveal information about when and where new resources would be the most efficient and beneficial.[27]

Further, if an EIM operator could use WECC's real-time energy management system (EMS) and state estimator data to determine system input information for SCED, the EIM would see actual flows, effectively internalizing unscheduled flows between parties. By using actual flows rather than reservations when determining the available transmission for the most efficient economic dispatch, an EIM using SCED would be able to calculate dispatch solutions that more effectively provide relief across multiple areas.

Moreover, an EIM using SCED could increase reliability relative to the current system by automating the management and response to system contingencies. SCED does this by providing visibility into actual system conditions and transmission loadings and proactively dispatching resources to avoid exceeding system operating limits. In addition, an EIM using SCED could increase the pool of resources that balance resources and load, provide ramping capability, and assist with managing flows within system operating limits.

With an EIM, the management of transmission limits would become more proactive. Security and reliability considerations are explicitly captured in dispatch constraints and SCED assists operators in monitoring system conditions and maintaining secure operations.[28] An EIM using SCED would respect system operating limits in its dispatch decisions, and if SCED would be using the same data and information that the reliability coordinator uses to maintain reliability, resources would be redispatched to address the operating limit beginning with the next five minute dispatch cycle, leading to more reliable operation and a better environment for operators. Thus, the combination of detailed system information with SCED would create a more proactive system for

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[27] In addition, the price signals may be useful in encouraging day-ahead commitment of additional resources, even without a day-ahead market.

[28] United States Department of Energy, "The Value of Economic Dispatch: A Report to Congress Pursuant to Section 1234 of the Energy Policy Act of 2005," at 4, 29 (November 7, 2005), *accessed* November 14, 2012, http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/value.pdf.

congestion management, reducing the need to implement curtailment protocols in reaction to limits that have already been exceeded.

We note that there are operating limits that would need to be captured by the SCED algorithm. In the Western Interconnection, transmission flows are often limited by voltage and stability concerns.[29] This is because long transmission lines tend to be stability-limited rather than thermally-limited (meaning that the stability limit is lower than the thermal limit), and the Western Interconnection has many long transmission lines. In general, system operators typically must maintain a margin below voltage and stability limits.[30] Voltage and stability limits may be represented by complex constraints, which would need to be accurately represented in the SCED algorithm.[31] Similar complexity has been dealt with in existing markets, in which market operators model various types of voltage and stability constraints on a wide geographic basis. The larger

[29] *Version One Regional Reliability Standard for Demand and Resource Balancing*, Notice of Proposed Rulemaking, 130 FERC ¶ 61,202 at P 37 (2010).

[30] Note that within SCED, because limits must be respected both in normal operation and post-contingency, many or most binding flow limits are not binding in normal operation but rather are binding in the contingency analysis. As such, there are effective margins on all flow limits (including thermal limits) that are respected during normal operation flows, but the magnitude of these margins is determined through the dispatch algorithm in the most economical way to meet pre- and post-contingency reliability requirements. In addition to these effective margins, an additional margin is usually respected for voltage and stability limits, since even small violations of these limits can be catastrophic.

[31] The complex constraints are called nomograms. A nomogram is a representation that depicts operating relationships between generation, load, voltage, or system stability in a defined network. On lines where the relationship between variables does not change, a nomogram can be represented simply as a single transmission interface limit; in many areas, the nomogram indicates that an increase in transfers into an area via one line will require a decrease in flows on another line. Source: U.S. Department of Energy National Electric Transmission Congestion Study at 19 (2006), *accessed* November 16, 2012, http://nietc.anl.gov/documents/docs/Congestion_Study_2006-9MB.pdf. We note that nomogram constraints add a degree of complexity to the market design, particularly if an interface in the nomogram lies outside of the market footprint.

A separate issue is dynamic transfer limits. Dynamic transfer limits refer to the portion of transmission capability that can reliably accommodate dynamic transfer. Many long lines in the Western Interconnection have reactive power compensation devices (shunt or series capacitors) that are switched in or out and/or adjusted based on line loading to maintain a reliable voltage level. Until recently, transmission schedules in the Western Interconnection were generally changed only once per hour. With increasing levels of renewable generation and requests for dynamic transfers between balancing areas, transmission schedules in the Western Interconnection are changing more frequently. An EIM would need to be designed carefully and implemented with accurate information about the current state of the system, including operating limits and status of reactive power compensation devices and other such equipment, so that the SCED algorithm always operates based on correct information.

For more information see Northern Tier Transmission Group, Columbia Grid, British Columbia Coordinated Planning Group, Wind Integration Study Team Dynamic Transfer Capability Task Force Phase 3 Report (2011), accessed November 15, 2012, http://www.columbiagrid.org/client/pdfs/DTCTFPhase3Report(Final-12.21.2011%20).pdf.

Similarly, an EIM would need to have accurate information about the status of remedial action scheme (RAS) systems, also known as special protection systems. RAS is an automatic protection system designed to detect abnormal or predetermined system conditions, and take corrective actions. When operating limits are changed due to a RAS, the new limits would need to be accurately represented in SCED.

an EIM footprint, the more likely it would be to have both sides of a given voltage and stability constraint under the control of the market operator.

As the geographic area that SCED dispatches is increased, there is a greater diversity of options available to manage operational limits. The increased dispatch coordination offered by an EIM using SCED could increase reliability. Currently, resources within an individual balancing authority area can be redispatched to address a constraint; an EIM using SCED would have the ability to redispatch generation from across the footprint to relieve the same constraint, increasing the possibility the constraint will be relieved in a more timely and efficient manner. As compared to dispatch at the individual balancing authority level, an EIM using SCED across its footprint would have access to more dispatchable range and ramping capability. In addition, an EIM using SCED would provide opportunities to dispatch a wider range of resource types to provide imbalance energy, including emerging technologies such as demand response resources to the extent that such resources are available to the market.

Finally, we note that Mariner suggested that an EIM using SCED could help to manage flows within system operating limits by quickly identifying and automatically dispatching generators that provide counter flows to alleviate the constrained path. Mariner stated that an EIM would address weaknesses contained in WECC's current congestion management software tools.[32] The WECC Efficient Dispatch Toolkit Cost-Benefit analysis discussed the advantages that an EIM would provide in quickly and automatically attempting to resolve constraints, as the EIM would attempt to redispatch the system to avoid exceeding system operating limits.[33]

Situational awareness

An EIM could provide enhanced situational awareness as a byproduct of the processes and models it would use to run SCED. The models and processes would not necessarily be reliability tools themselves, but they automate the response to some potential reliability issues on the system, and could also be a potential source of information. An

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[32] Mariner Consulting, "Why and Energy Imbalance Market Will Make the Western Interconnection More Reliable," at 2-3. WECC's current congestion management process is called the Unscheduled Flow Mitigation Plan. According to the Mariner Consulting paper, the software tool supporting this process applies to only six transmission paths in the Western Interconnection and will only identify transactions that should be reduced without identifying the best corresponding generation increase to maintain supply and demand balance. *See id.*

[33] Western Electricity Coordinating Council, "WECC Efficient Dispatch Toolkit Cost-Benefit Analysis (Revised)," at 11-12. The WECC analysis also noted that an EIM may dispatch the system closer to system operating limits (SOLs), which would reduce headroom and could have a reliability impact when system events occur. The analysis noted that an EIM may still be able to redispatch the system to below SOLs in these instances, and emphasized the importance of coordination between the market operator and the reliability coordinator.

EIM could provide proactive solutions to potential reliability issues through automated redispatch every five minutes using SCED. The automated SCED process creates market signals that elicit available resources to respond to system imbalances and potentially to correct issues on the system before they would need to be resolved by another entity such as the reliability coordinator. Potentially, this would leave the reliability coordinator with fewer issues to resolve. An EIM could also be a source of additional information to the reliability coordinator, such as information associated with SCED.

An EIM market operator would be another entity with a wide area view of the system, which could complement the existing entities that monitor reliability conditions. We note that the EIM operator would not necessarily be a reliability coordinator.[34] The reliability coordinator, WECC, supervises transmission and balancing operations across the Western Interconnection, receives operational information from and issues direction to other functional entities (including balancing authorities, transmission operators and generator operators[35]) to ensure that the interconnection operates reliably. WECC, in its role as the reliability coordinator, maintains situational awareness that includes a "wide-area" view of the interconnection.[36] Reliability coordinators have a broader scope than separate transmission operators, balancing authorities and other NERC functional entities. For instance transmission operators can, but do not always, have a high level of visibility and situational awareness beyond their own boundaries.[37]

A recent report by Commission staff and NERC staff on the Arizona-Southern California outages on September 8, 2011 (Arizona-Southern California Report) made recommendations related to visibility and situational awareness during real-time grid operations. Specifically, the Arizona-Southern California Report recommended that:

> [transmission operators] should engage in more real-time data sharing to increase their visibility and situational awareness of external contingencies that could impact the reliability of their systems. They should obtain sufficient data to monitor significant external facilities in real-time,

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[34] The parties discussing an EIM have not definitively determined what entity would serve as the EIM administrator. As noted previously, PacifiCorp and CAISO announced a memorandum of understanding to work towards the creation of an EIM on February 12, 2013.

[35] Generator operators are the NERC functional entities that operate generating units and perform the functions of supplying energy and reliability related services. *Id. at* 49.

[36] *Id. at* 30 (November, 2009), *accessed* October 29, 2012, http://www.nerc.com/files/Functional_Model_V5_Final_2009Dec1.pdf.

[37] *Id. at* 38. There are currently many separate transmission operators in WECC, NERC Compliance Registry List (September 28, 2012), *accessed* Nobmeber 16, 2012, http://www.nerc.com/files/NERC_Compliance_Registry_List20120928.pdf.

> especially those that are known to have a direct bearing on the reliability of their system, and properly assess the impact of internal contingencies on the [system operating limits] of other [transmission operators]. In addition, [transmission operators] should review their real-time monitoring tools, such as State Estimator and [real-time contingency analysis], to ensure that such tools represent critical facilities needed for the reliable operation of the [bulk power system].[38]

The Arizona-Southern California event conceptually illustrates the type of situation in which an EIM has the potential to be beneficial. An EIM could coordinate data[39] across transmission operators, automating dispatch for energy imbalance while respecting the limits on facilities external to a given transmission operator area, provided these facilities are part of the EIM footprint. An EIM could proactively address some energy imbalances through redispatch and could be an additional source of information for the reliability coordinator as it monitors the system. A single EIM operator with responsibility to ensure that the system is dispatched properly every five minutes could enable better management of the overall system, and could provide information about the array of options available to manage the system within limits. In this sense, an EIM market operator could complement the reliability coordinator.

We note that the WECC Efficient Dispatch Toolkit Cost-Benefit analysis found that the processes and models involved in running an EIM could improve system visibility by giving the reliability coordinator, balancing authorities and transmission operators improved awareness of system conditions. The analysis also noted that it would be critical for EIM data to be accurate and that close coordination between the EIM operator and reliability coordinator would be essential.[40] Additionally, in the recent announcement of a partnership between CAISO and PacifiCorp to work towards the

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[38] Federal Energy Regulatory Commission staff and North American Electric Reliability Corporation staff, "Arizona-Southern California Outages on September 8, 2011: Causes and Recommendations," at 86, Recommendation 11 (April, 2012), *accessed* October 23, 2012, http://www.ferc.gov/legal/staff-reports/04-27-2012-ferc-nercreport.pdf.

[39] For instance, an EIM using information from a state estimator would coordinate response to that information through the SCED process every five minutes.

[40] Western Electricity Coordinating Council, "WECC Efficient Dispatch Toolkit Cost-Benefit Analysis (Revised)," at 13.

creation of an EIM, it was noted that an EIM would increase the visibility of interconnected systems.[41]

Energy Emergency Alerts

Energy Emergency Alerts (EEAs) are events in which a load serving entity is unable to meet its energy requirements, and requests the reliability coordinator to declare an emergency. After an EEA is declared, the reliability coordinator acts to mitigate the emergency situation including through requests for assistance if necessary.

By providing automated identification of imbalances that lead to shortages in a balancing authority area, and associated redispatch instructions, an EIM could be of assistance in some potential Energy Emergency Alerts situations. An EIM would provide opportunities for energy to be sold to deficient entities as imbalance energy, during potential EEA situations when no other energy is available for purchase.[42] An EIM would enable delivery of the energy by redispatching across a broader footprint and thus enable faster and more effective management of potential EEA situations. Mariner argued that an EIM would reduce the number of Energy Emergency Alerts[43] by automatically identifying and locating needed replacement energy to address supply shortfalls and removing the need for manual communications and negotiation.[44] The WECC Efficient Dispatch Toolkit Cost-Benefit analysis similarly stated that an EIM could improve access to energy in the market footprint, and that the energy would be automatically dispatched, which would increase the likelihood of locating energy to resolve local shortages. Thus, an EIM may reduce the need for Energy Emergency Alerts to be called in some instances.[45] It is important to acknowledge, however, as noted by WECC in its analysis that there may be instances where voltage stability limitations or

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[41] ISO and PacifiCorp EIM partnership FAQ, http://www.pacificorp.com/content/dam/pacificorp/doc/About_Us/Energy_Imbalance_Market/ISOandPacifiCorpEIMpartnershipFAQ.pdf

[42] A representative from SPP also indicated that this was a reliability related benefit from SPP's EIS market. Note that parties in a reserve sharing group may also provide response in some types of EEA events, and that an EIM would have to be constructed so that it does not over-provide response when parties in a reserve sharing group are also acting.

[43] An Energy Emergency Alert (EEA) occurs when assistance is needed to avoid the risk of shedding load. A reliability coordinator issues an EEA to indicate a significant risk to reliability.

[44] Mariner Consulting, "Why an Energy Imbalance Market Will Make the Western Interconnection More Reliable," at 5. Mariner also notes that WECC has recently implemented the Merchant Alert Protocol (MAP) to announce requests to help in addressing potential supply shortages in an effort to reduce the frequency of EEAs

[45] Western Electricity Coordinating Council, "WECC Efficient Dispatch Toolkit Cost-Benefit Analysis (Revised)," at 12.

transmission constraints cannot be managed by redispatch, and in those cases an EIM would not be able to solve all of the shortage problems for an affected area.

Replacement reserves after reserve sharing group assistance ends

The automation provided by an EIM could create reliability benefits by enhancing capabilities for identifying and delivering replacement resources when reserve sharing group assistance ends.

Reserve sharing group agreements are arrangements in which parties share their contingency reserves in emergency conditions. These arrangements can allow reserve sharing group member parties to meet their contingency reserve requirements with less aggregate reserves, and respond to contingencies with a lower likelihood of load curtailment. Under reserve sharing group agreements, reserves are activated when one of the parties requests assistance from the others in response to a contingency. The party requesting assistance is responsible for replacing its contingency reserve obligations before the reserve sharing group assistance ends (after a specified number of minutes).[46] When reserve sharing group assistance ends, the affected balancing authority has to obtain replacement power, which can involve a series of manual communications to make power purchases, identify contract path transmission availability and obtain E-tag approvals.

An example is a fault that occurred on a transformer at PacifiCorp's Huntington generation plant in Utah at approximately 09:15 AM on February 14, 2008, which triggered an immediate loss of approximately 2,800 MW of generation across PacifiCorp East. Reserve sharing ended automatically one hour after the start of the disturbance per the NWPP agreement, notwithstanding the fact that PacifiCorp was still dependent on 1001 MW of NWPP Reserve Sharing Group deliveries. PacifiCorp made a second request for NWPP reserve sharing assistance, which was provided but terminated by the operator at 10:44 AM based on a mistaken concern regarding PacifiCorp's right to make a second request for reserve sharing under the NWPP Agreement. Around this time PacifiCorp started to shed firm load to help restore its ACE, shedding approximately 183 MW.[47]

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[46] For instance, the Southwest Reserve Sharing Group Participation Agreement requires that reserves be restored by the affected party no later than sixty minutes after the start of the event. See "Southwest Reserve Sharing Group Participation Agreement," at A-3 (11/3/1997), *accessed* November 16, 2012, http://www.srsg.org/pdf/agreement/SRSGAGMT.pdf.

[47] 137 FERC ¶ 61,176, Docket No. IN11-6-000

Mariner noted the benefits of an EIM in this regard.[48] An EIM can be designed to coordinate with existing reserve sharing groups in the Western Interconnection, facilitating the resupply of reserves from available resources after reserve sharing assistance ends. While we do not assert that an EIM would have been the solution to prevent load shedding in the PacifiCorp event, it does conceptually illustrate a type of situation in which an EIM has the potential to be beneficial. Specifically, the presence of an EIM could mitigate the potential for load shedding due to inability to find replacement generation by providing automated redispatch, potentially mitigating against manual delays in locating replacement power and obtaining transmission service and creating and approving transmission schedules.

Reliable integration of variable energy resources

An EIM could enhance the reliability of the bulk power system as the system moves towards higher levels of variable energy resources. Balancing authorities need reserves that are loaded and able to reduce output, as well as reserves that are unloaded and able to increase output, in order to respond to the variability from variable energy resources. Without an EIM, the variability from variable energy resource output in the Western Interconnection is not diversified across balancing authorities. An EIM could help manage variable energy resources more reliably by pooling variability over a larger area, and redispatching resources to help manage imbalance energy caused by variable energy resources.

By pooling the variability of resources from across the footprint, an EIM would reduce net imbalances. An EIM would also have access to a wider variety of balancing options. Specifically, resources would self-identify a willingness to either reduce or increase output at a specific price. As a result, individual BAs would not need to hold as many resources in reserve to respond to changes in renewable output and are thus less likely to run out of reserves, which could lead to reduced variable generation curtailments and an increased ability for balancing authorities to offload or replace power during periods of high or low variable generation output, respectively. While an EIM would not be a replacement for capacity adequacy, a larger pool of resources under an EIM footprint could provide more ramping capability and respond to variations and imbalances more quickly.

As an example, Northern States Power Company (NSP) states that it was able to reliably increase its wind generating capability while maintaining the same level of regulating

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[48] Mariner Consulting, "Why an Energy Imbalance Market Will Make the Western Interconnection More Reliable," at 4.

reserve capacity after the start of an energy market with SCED in the MISO footprint. In April of 2005, the month that MISO began operating regional market dispatch across its footprint, the NSP balancing area had approximately 400 MW of wind generation and maintained approximately 80 MW of regulating reserve capacity. Over the next four years, the NSP system expanded to approximately 1200 MW of wind generating resources. NSP expanded its wind portfolio without needing to expand its regulating reserve capacity, and still maintained compliance with the Control Performance Standards established by NERC, which measure the reliable performance of balancing authority areas. The 5-minute dispatch of the MISO market mitigated the requirement for additional regulating capacity despite the additional wind capacity. A representative from Xcel suggested that these experiences show that the regional market mechanism in MISO provides effective integration when compared to stand alone balancing authority area operations. [49]

Mariner noted that an EIM could effectively provide for lower net imbalance from variable energy resources by aggregating imbalances across the EIM footprint. Also, by providing a diversity of redispatch options from across the EIM footprint, an EIM would reduce the risk of any balancing authority being short of supply to respond to imbalances.[50] The WECC Efficient Dispatch Toolkit Cost-Benefit analysis stated that an EIM could automatically locate and dispatch a wider array of available resources to regain system balance with changing variable energy resource output, and may prevent some curtailments of variable energy resources.[51]

Additionally, NERC's Integration of Variable Generation Task Force released a report that identified changes to planning and operations methods that could be required for the reliable integration of variable energy resources. The Task Force concluded that new tools will be required for operators to maintain system reliability with high levels of variable energy resources. Its report recommends that operators investigate the impact of securing ancillary services through larger balancing areas or participation in wider-area balancing arrangements.[52] It also recommends that "minimum requirements and/or

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[49] Summary of statement from Xcel Energy representative on 11/30/2012.

[50] Mariner Consulting, "Why an Energy Imbalance Market Will Make the Western Interconnection More Reliable," at 3-4.

[51] Western Electricity Coordinating Council, "WECC Efficient Dispatch Toolkit Cost-Benefit Analysis (Revised)," at 12-13 (October 11, 2011), *accessed* November 14, 2012.

[52] North American Electric Reliability Corporation, "Special Report: Accommodating High Levels of Variable Generation" at 64 (April, 2009), *accessed* November 2, 2012, http://www.nerc.com/files/IVGTF_Report_041609.pdf. Here we note that we have discussed potential EIM-related impacts on the reliable integration of variable energy resources. These EIM-related impacts come from a small

market mechanisms (e.g., price signals)" be used to elicit system characteristics that maintain reliability in both the short term and the long term.[53]

V. Conclusion

An EIM has the potential to enhance reliability in the Western Interconnection by providing improved visibility and situational awareness, better management of transmission flows and system operating limits and faster, more diverse operational options and automated response to imbalances. Improved situational awareness across an EIM footprint could provide significant benefits, as a market operator should complement the role of the reliability coordinator in monitoring real-time system conditions over a wide area. Automated redispatch every five minutes with SCED would allow faster response to imbalances, which can eliminate delays caused by manual communications, transmission reservations and e-Tag approvals, and allow for a potential reduction in Energy Emergency Alerts. An EIM using SCED would use information about actual limits, actual line flows and generator impacts on transmission lines to proactively manage flows within transmission limits when redispatching to correct energy imbalance. An EIM can aid in the reliable integration of renewable resources, especially by allowing a more diverse set of resources to be redispatched from a wider area in response to imbalances. Without attempting to quantify the reliability benefits of an EIM, FERC staff believes that an EIM, if implemented carefully, with accurate information and effective coordination, could provide reliability benefits of the type identified in this paper.

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subset of the many planning and operations related methods that could impact the reliable integration of variable energy resources.

[53] *Id. at* 65.