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APPROACH TO IMPLEMENT VARIABLE TRANSFER LIMITS IN ENERGY IMBALANCE MARKETS

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SUMMARY

Energy Imbalance Market (EIM) is a real time market to manage transmission congestion and optimize procurement of energy to balance supply and demand. System Operation Limits (SOL) are traditionally computed using cases with well-adjusted voltage levels and with reactive devices set to ensure that system studies show acceptable post-contingency performance. When EIM produce frequent, large variations in power transfer, the actual operating conditions can be significantly different than what was assumed when calculating the SOL. This leaves the system at risk of unacceptable dynamic or post-transient response to critical contingencies. The Variable Transfer Limit (VTL) is the amount of frequent variability in power transfer that can be accommodated while ensuring reliable system operation. This paper presents a novel method to implement upper and lower Variable Transfer Limit in the EIM to ensure reliable system operation.
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KEYWORDS

Variable Transfer – Static Transfer –– System Operating Limit – Variable Resource – Limit Computation Methodology – Dynamic Transfer - Power System Reliability - Power Transmission - Voltage Fluctuation – Energy Imbalance Market.

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I. INTRODUCTION

An Energy Imbalance Market (EIM) helps to manage real-time energy imbalances on the grid economically. EIM also alleviates network congestion by dispatching the optimal units. Deviations in supply and demand results in a mismatch or imbalance in the system. EIM is a real time market to manage transmission congestion and optimize procurement of energy to balance supply and demand. The real time market may include 15 minute market, 5 minute market and other auxiliary services. EIM footprint generally includes multiple Balancing Areas (BAs).

Balancing Authorities (BAs) have managed these mismatches by dispatching additional resources. The additional resources dispatched by BAs may or may not be the most economical units and may not relieve congestions in the system. Also, utilities are integrating increasing amounts of Variable Energy Resources (“VERs”). Much of the attention of power system engineers has been focused on how to balance the increased variability on a wide-area basis. An EIM solves these imbalances in real-time with an automated five-minute security constraint energy dispatch. As more BAs participate in the market, possibilities increase to dispatch more economical units. Economic dispatch lower costs for participants and become even more valuable as additional BAs join the EIM.

Normally entities participating in the EIM are next to each other. Generally the EIM operator also manages the reliability of the system. The system reliability is taken into account when dispatching the units. Now to get diverse resources, EIM operators are trying to signup BAs that are not neighboring, but are connected through intermittence transmission providers. EIM does not manage the intermittence transmission providers so they can see voltage variations and reliability impact due to EIM.

To maintain the reliability and manage the voltage variation in the intermittence transmission provider, restrictions are needed for the amount of variable transfer flows across the interconnected paths. This papers show what type of variations happen due to hourly, 15 minute and 5 minute dispatches and a technique to manage the variation by enforcing upper and lower limits for the EIMs 5 minute dispatches.

II. Background

In August 2005, BPA observed significant voltage variations near the BC-Washington border and unusually frequent switching of local reactive equipment. The unusual system behavior began after a new dynamic transfer service was commissioned between British Columbia (BC) and California, and was due, in large part, to the dynamic transfer ramping from 0 MW to 428 MW and back down, on top of hourly static transfers that were in excess of 2000 MW. The system operators managed the issue by imposing a 300 MW limit on the magnitude of the Dynamic Transfer and requesting a reduction in the frequency of change. They also asked the system planners to determine appropriate limits for dynamic transfers. In Q4 of 2014 PacificCorp is planning to join the CAISO EIM and planning to use part of third party transmission. Hence it is essential to identify the amount of variable transfer that can be accommodated for different flowgates/paths.

Between 2008 and 2014 five studies were conducted to determine dynamic transfer limits, also known as Variable Transfer Limits:

1. Saeed Arabi and Ali Moshref from Powertech Labs presented an approach to compute the dynamic transfer limits for a single path (Path 3 – Northwest US to BC) using a time-stepped power flow simulation [1];
2. R. Ramanathan and Brian Tuck described a methodology for assessing and quantifying the effect on the transmission system by defining the problem as one of generation re-dispatch. This study focused on 11 internal and external paths on the BPA system [2];

3. Kara Clark led a study of the California ISO's transmission system, which concluded that dynamic transfers of VERs into its market would not need to be limited [3];
4. The Dynamic Transfer Capability ("DTC") Task Force developed a quantitative methodology to assess the impacts of variable transfers on the transmission system [4].
5. R. Ramanathan, P. Anand and Brian Tuck desrcibed a method to compute Variable Transfer Limits using State Estimator cases [8].

III. Need for Variable Transfer Limit in North West

In the Northwest region of USA there is no Regional Transmission Operator (RTO). Each balancing authority controls their reactive devices, but no one coordinates and controls the region's reactive devices in real time to maintain the voltage profile. Many shunt devices and transfer taps are manually operated. Remedial Action Schemes (RAS) are manually armed. A lot more Variable Energy Resources are integrated in the region and some of the utilities are planning to participate in the Energy Imbalance markets. Also, utilities are trying to buy the balancing services from the other utilities. These cause more Variable Transfers in the region. Hence it is essential to establish Variable Transfer Limits (VTL) to operate the system reliably without sacrificing the quality of the power delivery.

IV. Variable Transfer Limit (VTL)

System Operation Limits (SOL) are traditionally computed using cases with well-adjusted voltage levels and with reactive devices set to ensure that system studies show acceptable post-contingency performance. When transfers produce frequent, large variations in power transfer, the actual operating conditions can be significantly different than what was assumed when calculating the SOL. This leaves the system at risk of unacceptable dynamic or post-transient response to critical contingencies. The Variable Transfer Limit (VTL) is the amount of frequent variability in power transfer that can be accommodated while ensuring reliable system operation.

The Variable Transfer Limit (VTL) is the amount of frequently anticipated variability in the power transfer across a Flow gate that can be accommodated over a specified intra-hourly timeframe while ensuring the reliable operation of the system and the avoidance of unacceptable adverse impacts on equipment and customers.

The VTL for a flowgate would be the lowest of the Customer, Equipment and Reliability limits:

VTL = MINIMUM of {Customer Limit, Equipment Limit, Reliability Limit}

Acceptable variability is also limited by the resources' ramp rate and operator response time, which is the assumed to be the length of time that the power system would be operating on auto-pilot because the system operators are busy. References 2, 4, 5, 7 and 8 provide the techniques to compute the VTL nomogram. Reference 8 provides a technique to calculate the entire nomogram using the real time state estimator cases. The VTL has upper and lower limit for a static transfer. When static transfer is at SOL, the VTL is zero. The nomogram will be function of static transfer as shown below in figure 1.

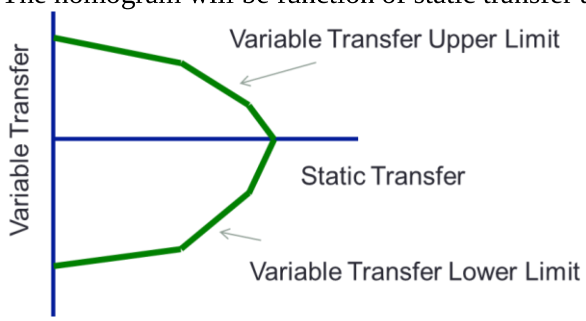

Figure 1 : VTL nomogram

V. Schedules

Following schedules are common in the EIM. They are hourly, 15 minute and 5 minute.

A. Hourly Schedule

Conventional Static Transfers (ST) across a path is fixed by schedules between a Point of Receipt and a Point of Delivery. These schedules remain constant through one or more scheduling periods (historically hours). The operator adjusts the system to the optimal operating point and the system is reliable at the operating point. Normally the hourly ramp starts 10 minute before the hour and ends 10 minute after the hour.

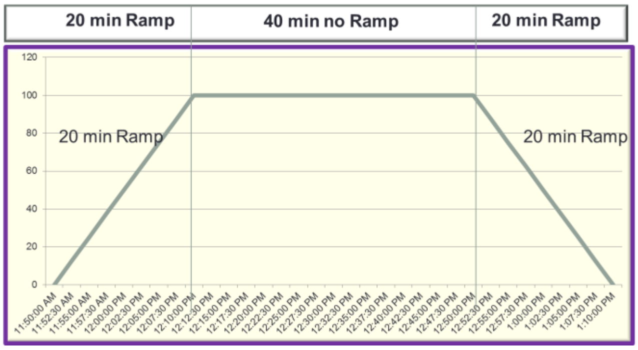

Figure 2: Hourly schedule

B. 15 minute Schedule

The real time markets generally include 15 minute and 5 minute markets. The 15 minute schedule has two forms of energy profiles as shown in figure 3. One is the normal 15 minute energy profile and the other is a top of the hour 15 minute energy profiles. The normal 15 minute schedule will start 5 minute before the start, ramp for 10 minute, flatten for 5 minute and then ramp down for the next 10 minute as shown in figure 3.

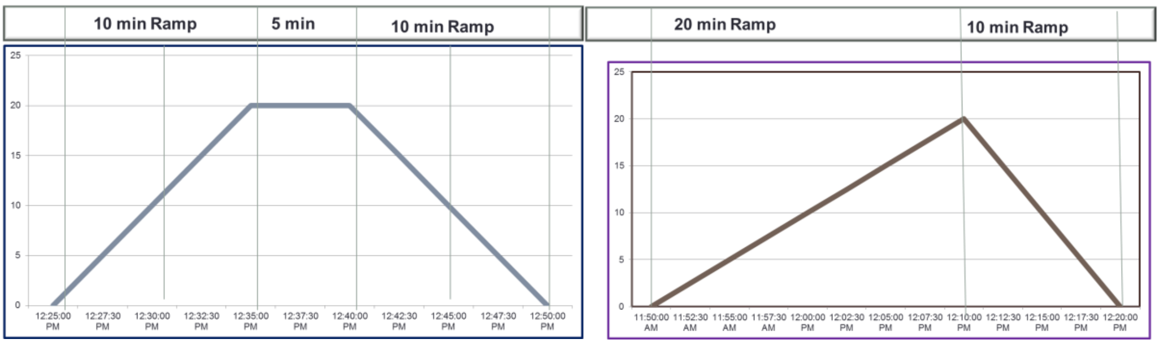

Figure 3: 15 minute schedule normal and top of the hour

The top of the hour 15 minute schedule will start the ramp at the same time as the regular hourly schedule. The ramp ends at the same time as the normal 15 minute schedule as shown in figure 3. The entire hour combines the normal 15 minute scheduling, hour ending 15 minute scheduling and hourly scheduling as shown in figure 4. From the figure it is clear that one is expected to see continuous ramping up and down except during two 5 minute intervals.

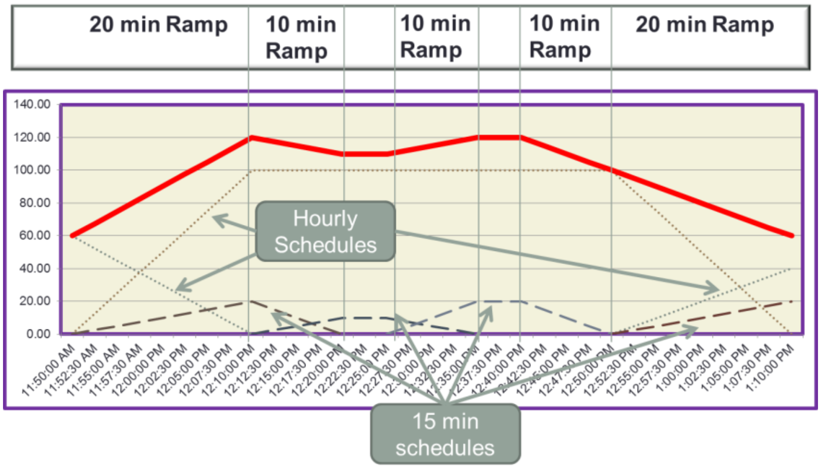

Figure 4: Combined hourly and 15 minute schedule

C. 5 minute dispatch

The 5 minute dispatch the ramp starts 2.5 minute before and ends 2.5 minute after the schedule period. In the 5 minute dispatch, it is always ramping and the total duration is 10 minute from start to end as shown below in figure 5. Consecutive 5 minute dispatches will overlap with each other as shown in figure 5.

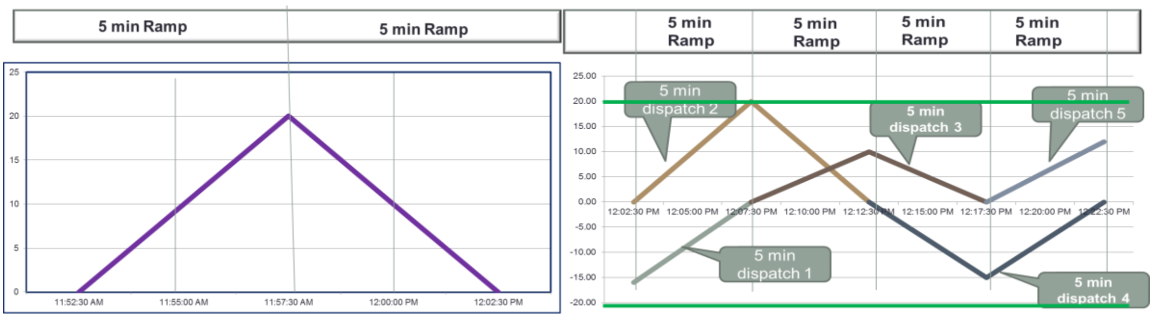

Figure 5: 5 minute dispatch and consecutive 5 minute dispatch

D. Combined dispatch

Figure 6 shows the hourly, 15 minute and 5 minute dispatches combined and shown as net schedule. With the 5 minute schedule, the operator is going to see a continuous ramp. Currently dispatchers are used to the hourly ramp. They adjust the system to the optimal state and the system is in the cruise control mode for next 40 minute till they see any major outages. With the FERC order no 764, utilities are obligated to support 15 minute scheduling. So the system will be adjusted to its optimal state every 15 minute. If the system has manual RAS and manual voltage control devices, the dispatchers cannot frequently adjusts the system every 5 minute to support EIM. If the system adjustments are not made, there is a maximum amount of variable transfer that can be supported. The variable transfer upper and lower limited can be computed as a function of static transfer [2, 4, 5,7and 8]. The 5 minute ramp (Variable Transfer) should be within the upper and lower VTL. The VTL nomogram upper and lower limit can be calculated using the nomogram. The upper and lower limit is shown with the green lines. The green line is function of static transfer on the path. When the static transfer is very close to System Operating Limit (SOL) the variable transfer is zero. For example, once we know the schedule flow from the 15 min scheduling, the actual flow needs to be between the upper and lower VTL limit. The green lines are upper and lower limits for 5 minute dispatch and Security Constraint Dispatch will impose the upper and lower limit.

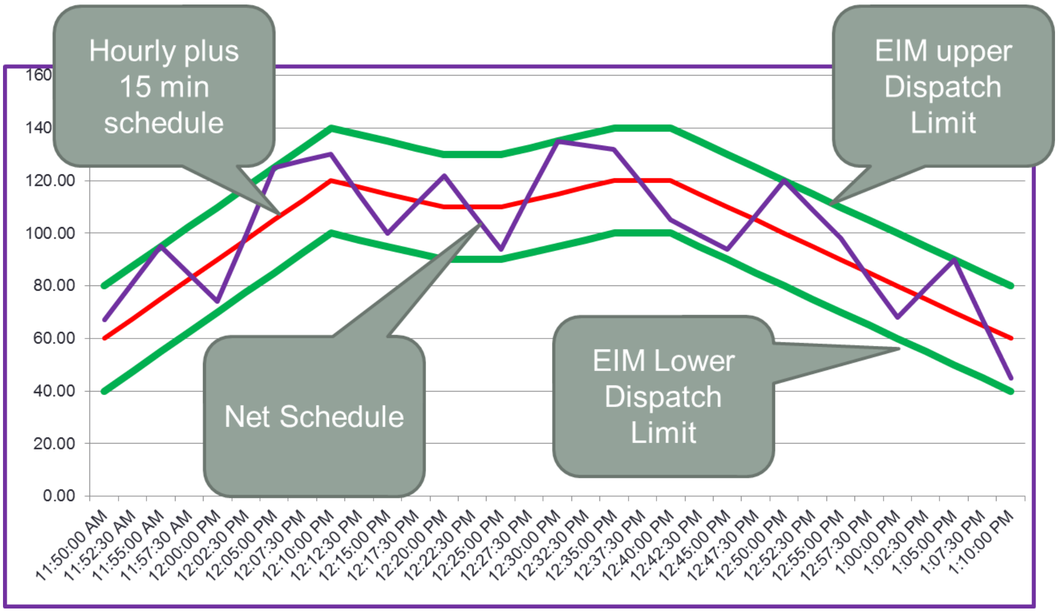

Figure 6: Combined dispatch

VI. Summary

This paper presented a novel method to implement upper and lower VTL in the EIM. The dispatchers are normally used to seeing the hourly ramps. With the 15 minute schedules FERC Order 764 one is going to see the ramp for the entire hour except for two 5 minute periods. With the 5 minute EIM dispatches the ramp will be continuous. With manual RAS and manual reactive control devices it is impossible for dispatchers to adjust the system to the optimal state every 5 minute. Not optimally switching the voltage control devices can deplete the dynamic VAR reserves that are required to mitigate the impact of disturbances and help preserve system reliability. Hence, it is essential to compute Variable Transfer Limit and enforce the EIM dispatch to be within the VTL limits.

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