

# MISO's Existing Methods for Managing Voltage and Plans to Improve Voltage Profiles

FERC Workshop on Future Market Design and Software Enhancements

April 25, 2012

# **EXISTING APPROACH FOR MANAGING VOLTAGE CONSTRAINTS IN THE MISO DAY AHEAD AND REAL TIME MARKETS**

# Reliability Coordination (RC), Transmission Operators (TOP), and Generator Operators (GOP) Coordination

- MISO RC collaborates with the TOPs and GOPs to monitor voltages and manage voltage control devices and reactive resources to maintain proper voltage.
  - RC's monitor and manage pre and post-contingency voltage and reactive power; adjust transfers, generation re-dispatch and commitment; mitigate system emergencies; and perform forward operational planning processes.
  - TOPs' monitor, analyze, and control voltage and reactive power flows as stated in NERC Standard VAR-001. TOPs are also responsible for complying with NERC Standards TOP-001 through TOP-008 pertaining to Voltage and Reactive Power in order to protect equipment and maintain a reliable system interconnection. TOPs determine generator voltage profiles.
  - GOPs' primary responsibility is to provide voltage and reactive power flow control as required by NERC Standard VAR-002, as well as VAR-002 and TOP-001 through TOP-008 as related to the GOP.

# Voltage Assessment Processes

## Real Time Voltage Assessment

- **In Real Time MISO Reliability Coordination monitors:**
  - Voltages through SCADA voltage alarms and/or RTNET voltage results. Voltages compared to TOP defined voltage limits.
  - Circuit flows and bus voltages
  - Predefined constraint boundary flows
  - Load levels
- **RC monitors Real Time Contingency Analysis (RTCA)**
  - RTCA utilizes data from state estimator (RTNET) and performs AC contingency analysis
  - RTCA determines both real and reactive power flow and bus voltages violations.
  - RC will monitor and take corrective action to prevent potential post-contingency voltage violations as determined by RTCA.

# Voltage Assessment Processes (cont.)

## Real Time Voltage Assessment

- **Real Time P-V Analysis Voltage Security Assessment Tool (VSAT)**
  - MISO performs routine voltage assessments of specific areas using Power-Voltage (P-V) analysis on a real time state estimator solution.
  - Analysis performed every 15 minutes on 5 different interfaces
  - Results posted on secure MISO reliability website for TOP review
- **Real Time Reactive Reserve Analysis**
  - Reactive reserve levels are calculated for predefined areas
  - Generator reactive power output is monitored based on generator capabilities, and RC is alarmed when specific generator reserves are depleted

# Processes for Voltage Control

## Reactive Power Requirements and Voltage Constraints

- Thermal proxies are used to represent voltage stability interfaces, and voltage constraints.
  - Thermal proxies cannot represent all voltage constraints.
- Voltage constraints and voltage stability limits are based on Forward Operation and Real Time Operation studies.
- Forward Operation studies also identify voltage issues for local areas through their AC analysis and provide needed generation requirements to mitigate the issues in operating guides to Real Time Operations.
  - TOP is involved in identifying the voltage issue and the steps needed to correct the issue through the development of an operating guide.
- Thermal proxies and associated limits are controlled to in the day ahead and real time markets through Security Constrained Unit Commitment (SCUC)/Security Constrained Economic Dispatch (SCED).
- SCUC cannot effectively recommend all necessary generation commitments for voltage constraints.
  - Real Time Operations will make additional generation commitments to meet reactive power requirements and mitigate voltage constraints.
  - Additional reliability commitments for voltage will create Revenue Sufficiency Guarantee (RSG) payments to needed generation.

# Voltage Control Processes (cont.)

## Day-Ahead (DA) Market

- MISO DA Market uses simultaneously co-optimized SCUC and SCED algorithms to clear and dispatch energy and operating reserves based on predefined constraints. It may also detect additional thermal constraints through Simultaneous Feasibility Test (SFT).
  - Algorithms use a DC solution which is not effective at identifying Voltage Stability issues.
  - Voltage stability issues are represented in DA as predefined thermal proxies.
  - Local voltage issues are controlled using a thermal proxy if one can be identified.
  - Voltage stability and local voltage constraints are determined by Outage Coordination and Next-Day Security Analysis studies.
- DA commits necessary generation to meet the load bid into the market and identified constraints from an economic perspective.
  - Generation re-dispatch and additional unit commitments will occur for a pre-defined thermal proxy for a local voltage issue.

# Voltage Control Processes (cont.)

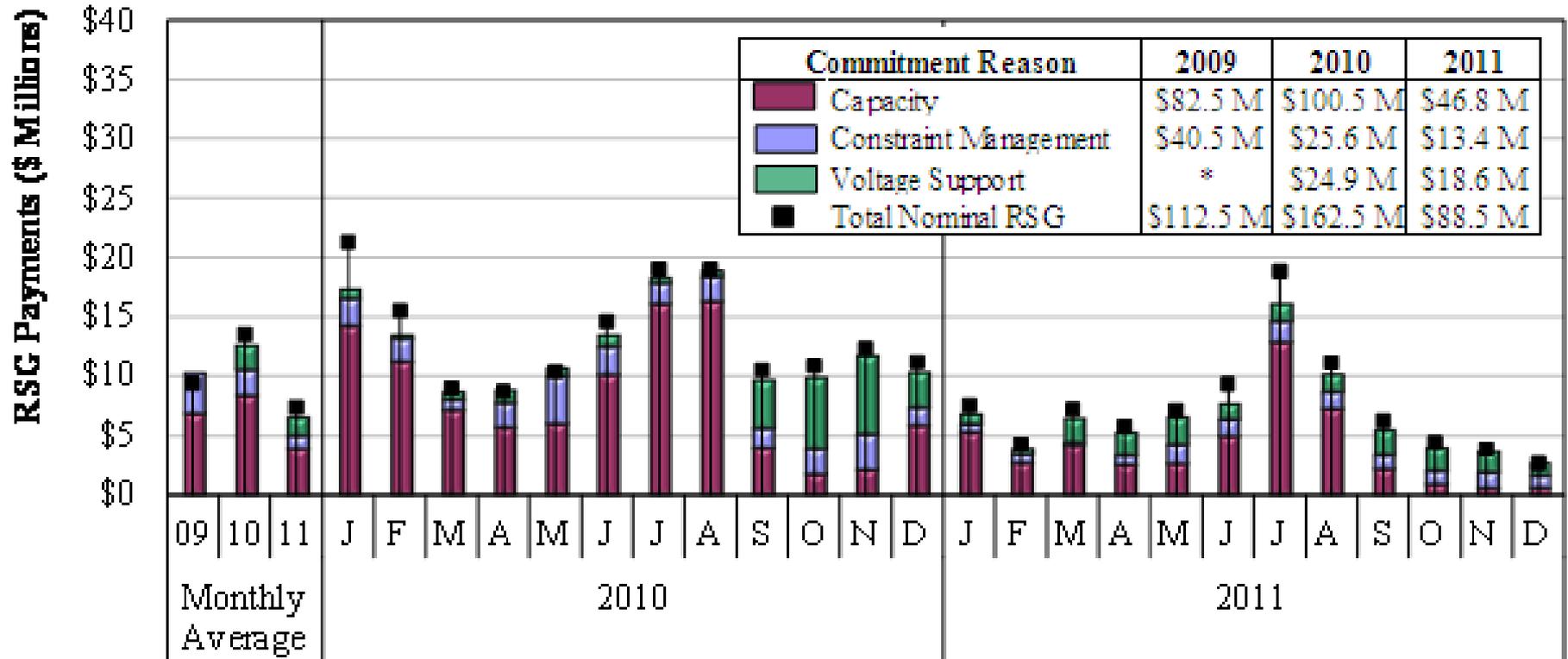
## Real Time Operations

- Reliability Coordinator will monitor the system for any voltage constraints or reactive power needs and take preventative and corrective control actions. General control options:
  - Work with TOP to take zero cost actions by modifying static reactive devices (capacitors, reactors, transformer taps (LTCs), etc.) and generator reactive power output. Goal is to maximize the use of static devices to free up dynamic reserves on generators.
  - Re-dispatch generation using a thermal proxy in Real Time SCED algorithm. Moving real power to reduce regional transfers and reduce real power imports in load pockets.
  - Commit generation to provide dynamic reactive support, and real power support to reduce real power imports.
  - Utilize emergency procedures up to and including the use of demand response resources and load reductions to correct voltage issues.

# Economic Issues Related to Voltage Control

- MISO Market is designed to meet real power demand and control thermal constraints.
- MISO does not directly perform a security constrained economic dispatch of reactive power of resources. Reactive resources are committed and dispatched to reliably maintain security constrained economic dispatch of real power.
- Thermal proxies or flowgates are used to represent voltage stability issues caused by regional transfers. These voltage stability flowgates result in reliable and efficient operations of the Transmission System.
- Thermal proxies or proxy flowgates do not work as well for local voltage issues.
- Local voltage constraints will typically be mitigated by commitment of additional resources with the result of voltage constraints being completely cleared.
- With the voltage constraint cleared, committed generation for voltage control purpose does not receive an economic signal (constraint is not bound in market).
- Without the economic signal these voltage commitments increase uplift, including Revenue Sufficiency Guarantee (RSG) payments.

# RSG Costs for Voltage Support



## Share of Real-Time RSG Costs by Unit Type (%)

Peaking Units	71	54	59	57	54	59	58	64	50	70	71	45	25	26	47	60	53	54	51	45	67	75	67	47	51	43	38
Other Units	29	46	41	43	46	41	42	36	50	30	29	55	75	74	53	40	47	46	49	55	33	25	33	53	49	57	62

Chart provided by MISO IMM Potomac Economics

# RSG Costs for Voltage Support (cont.)

## Voltage and Local Reliability (VLR) Commitments

- Approximately 90% of RSG associated with voltage constraints are due to two local issues.
- MISO proposed tariff revisions in December 2011 to better allocate RSG from VLR commitments to the load benefiting from such a commitment.
  - Refer to Docket Nos. ER12-678-000 and ER12-679-000 for more information
- FERC accepted the tariff on 3/30/12, but suspended implementation until 9/1/12 pending a technical conference and further Commission Order.
  - Technical conference scheduled for May 2012
- Analysis of VLR commitments did show that these commitments do provide a benefit to the entire market by offsetting additional capacity commitments.
  - Tariff allocates 8% of VLR RSG to entire footprint due to the market benefit provided.
- Solutions to mitigate VLR issues are generally isolated to a few units in the local area.
- Optimum Power Flow (OPF) will not have a lot of options to better optimize a solution due to the limited amount of resources to mitigate the VLR issue leading to minimum savings.

# **DEVELOPING METHODS TO IMPROVE VOLTAGE PROFILES**

# Improving Voltage Profiles

- MISO plans to investigate methods to set hourly voltage and reactive power schedules to support real time operations.
  - Schedules will initially be set based on Day-Ahead Market results.
    - May re-run in real-time to update as needed as day progresses.
- Seek to balance two objectives:
  - Minimizing losses
    - Reduce costs to meet losses in real power market.
  - Maximizing reactive power reserves on resources providing/absorbing reactive power
    - Improve ability to maintain operations within voltage limits if conditions change from plan.

# AC OPF

- Plan to investigate the use of a Security Constrained OPF with an accurate AC model of the network.
  - Plan to use scheduled MW dispatch from existing real power SCUC/SCED used to schedule existing real-power markets.
    - Secure in terms of real power schedule.
  - Plan to use AC OPF to produce voltage and reactive schedules to support reactive security and reduce losses without compromising MW security.
- Not planning to implement a reactive power market at this time.

# Possible Objective Function

- Min  $\alpha_1 \cdot \sum_k \text{MW losses}_k + \alpha_2 \cdot \sum_k \text{MVAR losses}_k + \alpha_3 \cdot \sum_i |\text{MVAR}_i|$ 
  - Losses are calculated for all elements (k) of the transmission system
    - Transmission lines, transformers, shunts, etc.
  - Maximizing reactive power reserves is equivalent to minimizing the reactive power generated or absorbed by resources (i) providing reactive power
    - Minimize MVARs supplied/absorbed by generators
    - Minimize MVARs supplied through interfaces.
  - Non-negative weights  $\alpha_1$ ,  $\alpha_2$  and  $\alpha_3$  are used to combine the objective function terms.

# Possible Objective Function

- We do not propose to develop a market for reactive power at present.
  - Assume that resources that provide MVAr can absorb or generate reactive power within their capabilities at no incremental cost.
  - Voltage regulating equipment can be dispatched at no incremental cost.

# Some Reactive Controls that may be Modeled in AC OPF

- Regulated voltages
  - Nodal voltages controlled by generators, LTC taps, SVCs
- Controllable transformer taps
- Shunt MVArS

# Reactive Constraints that may be Modeled in AC OPF

- Pre-Contingency and Post-Contingency Constraints
  - Line flows (in MVA)
  - MVAR interchange limits
  - Generator MVAR limits
  - Voltage limits
  - Voltage magnitude differences between nodes
  - Post contingency voltage change

# Potential Algorithms

- Real and reactive losses in the objective function are non-separable and non-linear.
  - This differs from the objective function used in MISO's real power market.
    - Minimizing total cost of real power generation tends to be separable.
  - Also, losses are approximated by separable function in MISO's real power market.
    - More accurate loss models will be used in software that will set voltage and MVAR schedules.
- This will drive the types of optimization algorithms used.
  - Candidates include successive LP techniques.
  - Could also consider successive QP techniques.

# At Starting Point

- MISO is in the initial stages of considering this problem.
- MISO is discussing the problem with a vendor who has successfully implemented such an approach for a system operator.