Price Enhancements for Real-Time and Day-Ahead Markets

Congcong Wang	Market Design Engineer, MISO
Dhiman Chatterjee	Sr. Manager Market Design, MISO
Juan Li	Sr. Advisor Market Engineering, MISO
Robert Merring	Manager Market Engineering, MISO

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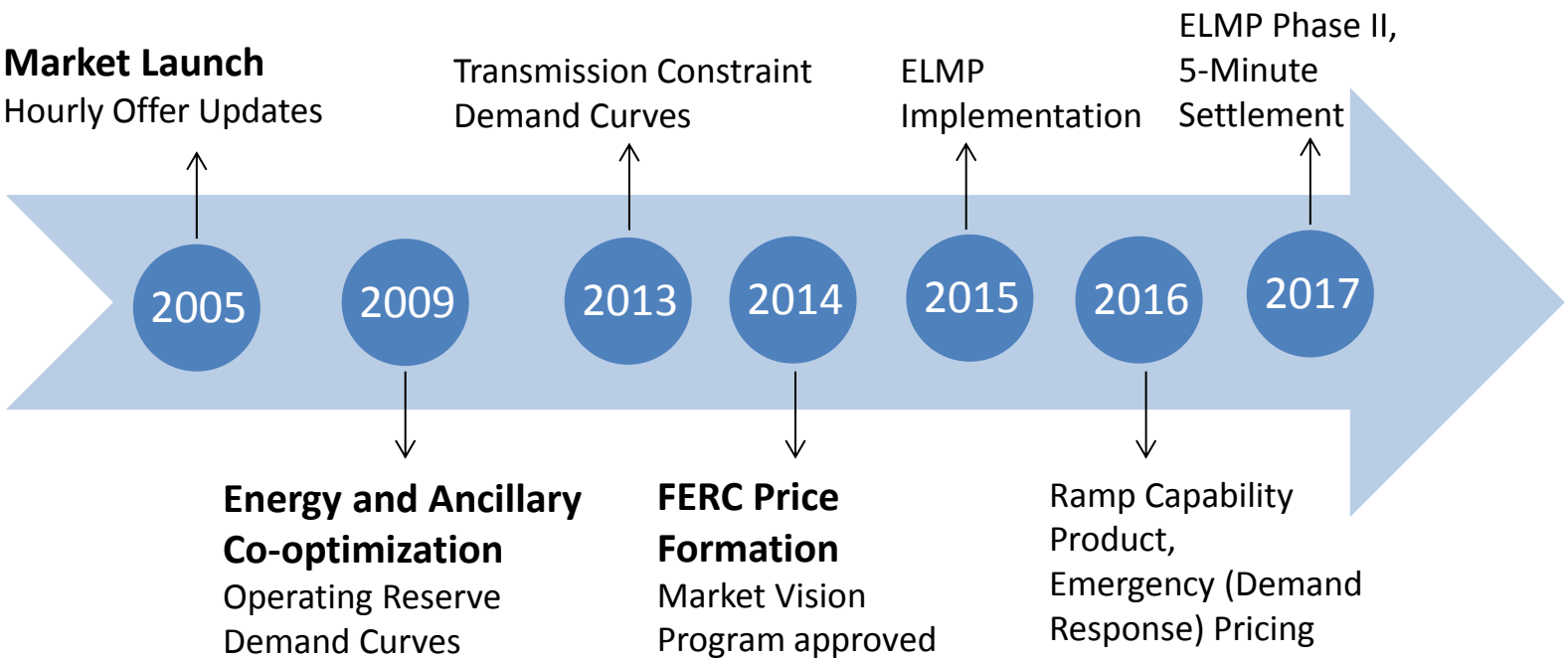
Overview

- **Purpose**
  - Overview MISO market design initiatives
  - Present recent price enhancement under emergency conditions
  - Highlight ELMP production results since effective on 3/1/2015

- **Key Takeaways**
  - MISO Market Vision Program evaluates all market improvement opportunities and price enhancement has been a key focus
  - Recent development of pricing under emergency conditions expands ELMP to resolve current uneconomic price depression
  - ELMP production results confirm the design objectives to allow gas turbines and other Fast Start Resources (FSRs) to set prices including their commitment costs

MISO Price Formation Development



Note: Please refer to the Market Vision Program for a complete list of MISO on-going market enhancement projects

MISO Market Design Guiding Principles

Foster Wholesale Electric Markets that Deliver Reliable and Economically Efficient Outcomes

- Support an Economically Efficient Wholesale Market System that Minimizes Cost to Serve Load
- Facilitate Nondiscriminatory Market Participation Regardless of Resource Type, Business Model, Sector or Regional Location
- Develop Transparent Market Prices Reflective of Marginal System Cost, and Cost Allocation Reflective of Cost-Causation and Service Beneficiaries
- Support Market Participants in Making Efficient Operational and Investment Decisions
- Maximize Alignment of Market Requirements with Reliability Requirements of the System

The Market Vision Program looks comprehensively at MISO's market operations and aligns the market design projects with these guiding principles

– Price formation has been a key focus in recent market enhancement

Pricing under Emergency Conditions

- **Addresses the imminent need for efficient prices under Emergency conditions**
  - MISO is facing tightening supply margins as some coal-fired capacity retires following EPA rules, and some seldom-used emergency only resources may have to be deployed
  - Nevertheless, prices can be depressed under the current way
    - Emergency resources such as Load Modifying Resource (LMR) are fixed schedules in the dispatch and cannot participate in pricing
    - ELMP allows Emergency Demand Response resource to set prices, and needs to be expanded to price other emergency resources
    - Price can still be depressed if an offer price for the emergency resource is not available or cheaper than the economic resource dispatched prior to invoking emergency

Emergency Pricing Objective

Prevent uneconomic price suppression during emergencies and appropriately value emergency resources

- Encourage market participants to have online resources follow dispatch and offline resources be available for dispatch
- Motivate load to reduce consumption and external suppliers to export power into MISO during emergencies
- Incent development of additional supply resources and demand response capability
- Promote competitive offers from market participants along with optimization-based and cost-efficient operation

Proxy Offer – *Appropriately Value Emergency Resources*

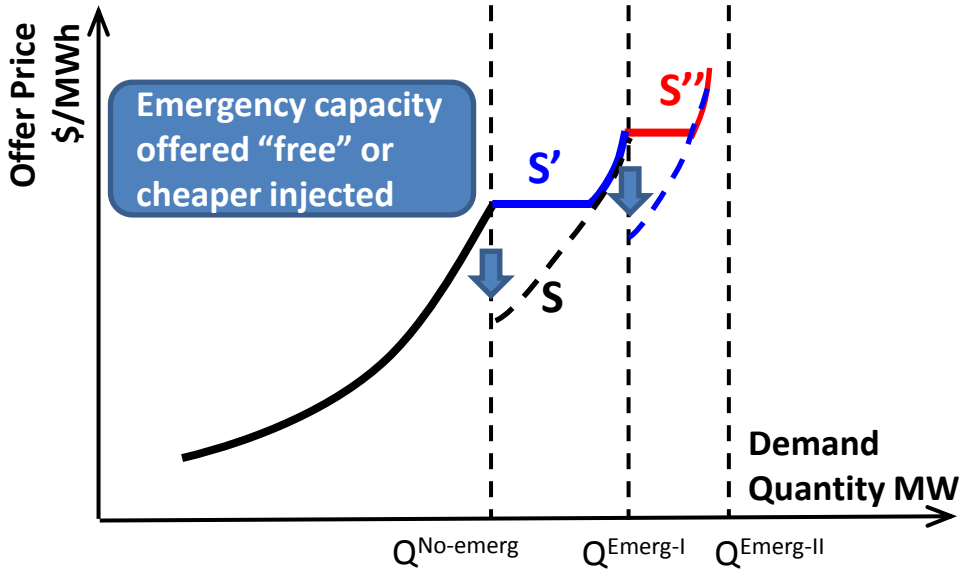
- **Emergency resources require two conditions to be accessible**
  - Recovery of Offer costs, AND
  - MISO implementing emergency operating procedures
- **Proxy Offer is established to capture both their offer cost (if any) and its availability after non-emergency resources are "exhausted"**
  - Emergency Offer Floor is established as the highest available offer in the affected emergency area
  - Proxy Offer is assigned to Emergency resource as

    Max {Resource's offer*, Emergency Offer Floor}

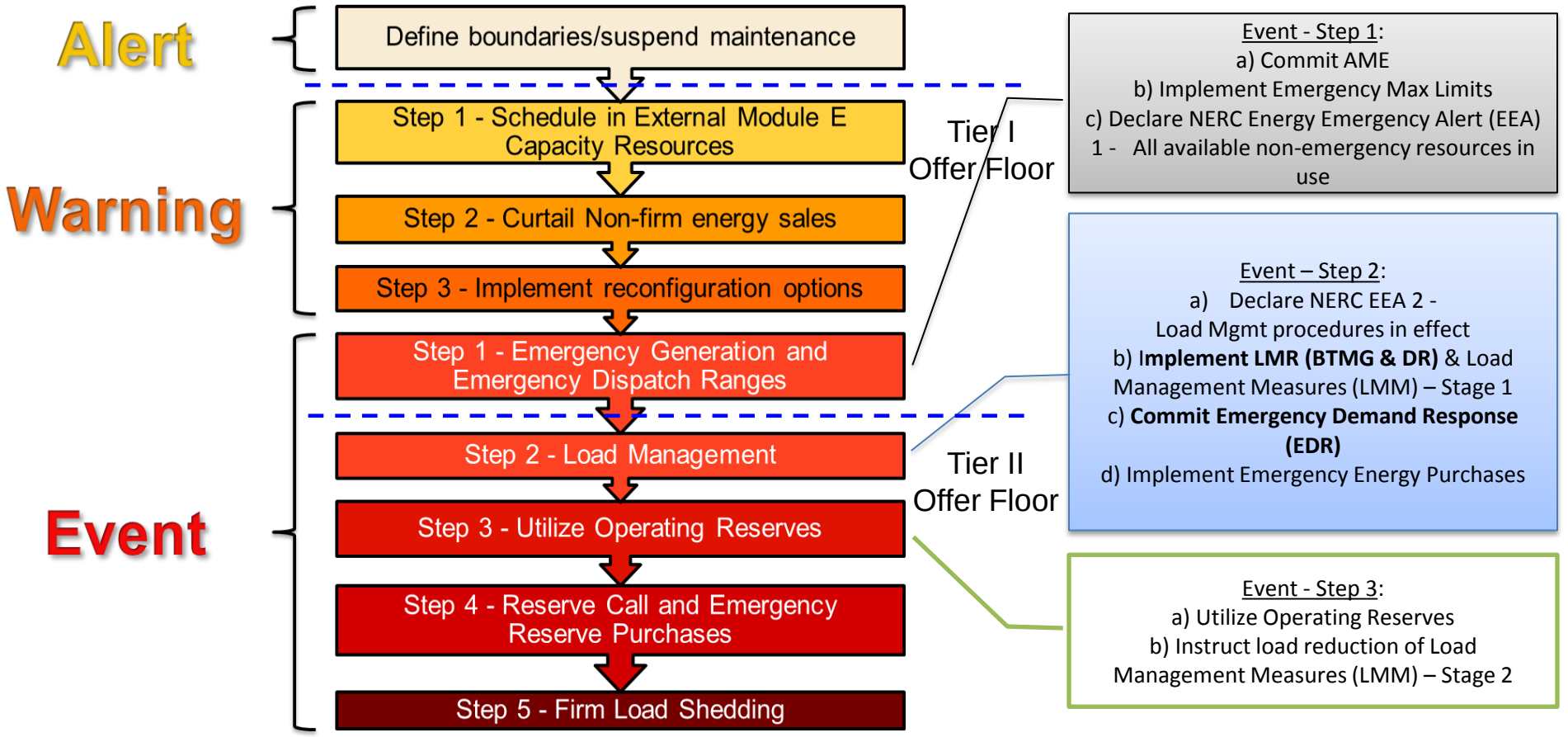
* Note: If an Emergency Resource's offer is not available (e.g., LMR currently has no monetary offer), then the Proxy Offer equals the Emergency Offer Floor

Proxy Offer (cont.)

- **Two Emergency Offer Floors are established when Emergency initiates and deepens**
  - Tier I: Highest available economic offer following Maximum Generation Emergency Warning
  - Tier II: Highest available economic and emergency offer at Max Gen Emergency Event, Step 2



Different resources become accessible while progressing through the Maximum Generation Emergency procedure



Expand ELMP Method – *Price Emergency Resource*

- **ELMP is an important step forward in enhancing energy and ancillary services pricing**
  - The costs of commitment as well as dispatch are incorporated to be more consistent with the underlying cost structure in generating electricity
- **ELMP is calculated for a single interval at a time as LMP is calculated today**
  - Commitment costs of fast start resources are appropriately allocated to individual intervals
- **Use a linear programming relaxation to model fractional commitment for pricing purposes**
  - Commitment variables are treated as continuous variables that can take any value from 0 to 1

Expand ELMP Method (cont.)

- **When MISO calls on Emergency resources, ELMP method is expanded to allow their schedule if fixed to be adjusted for pricing purposes**
  - ELMP represents the fraction of such Emergency Resources by the continuous decision variable on_t satisfying

$$0 \leq on_t \leq 1$$

$$on_t \times EconMin_t \leq EnergyDispatchSchedule_t \leq on_t \times EconMax_t$$

  - Proxy Offers are included in the objective function as

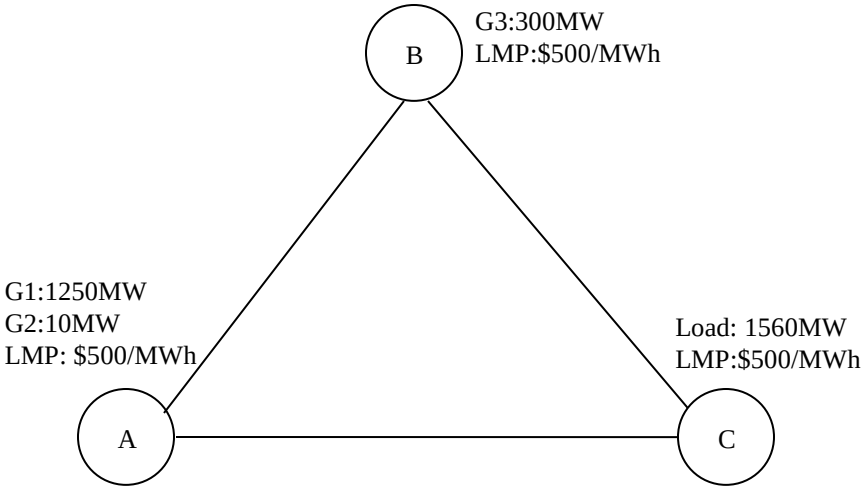
$$\int_0^{EnergyDispatchSchedule_t} ProxyOffer_t\ (x)dx/IntervalsperHour$$

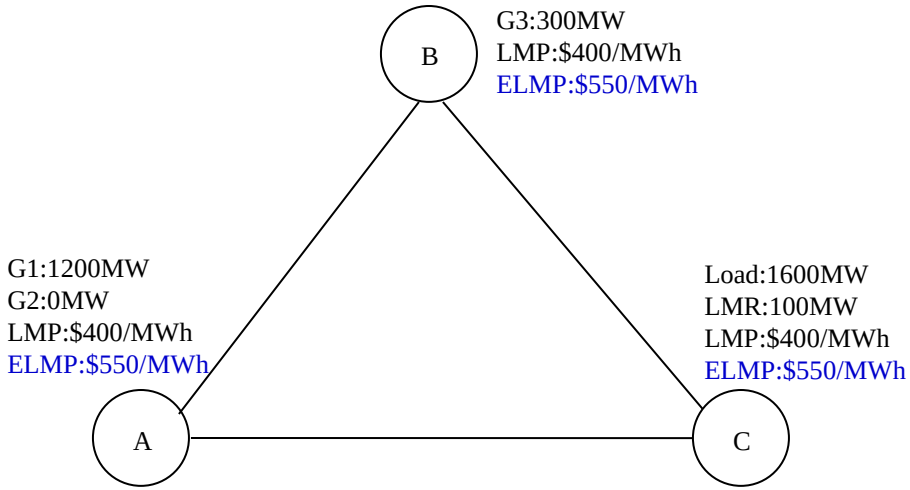
Market Consistency – *Low implementation requirement*

- **The design is implemented for both the Real-Time and the Day-Ahead market to facilitate price convergence**
  - Emergency mainly occurs in Real-Time market. The Day-Ahead market is also modified for consistency and to be prepared if Emergency does occur
- **Existing settlement process will apply**
  - Revised price calculation
  - Original offers will be used in make-whole payment calculations
- **The design is used for pricing purpose and fully respects the priority of reliable operation to resolve Emergency**

A Three-bus Example

- **Consider a capacity emergency (no transmission congestion)**
  - Prior to Emergency, Load is 1560MW and G2 set prices at $500/MWh
  - Under Emergency, Load is 1600MW and LMR of 100MW is deployed
    - Under current pricing, LMR is fixed schedule and LMP is set by G1 at $400/MWh
    - Under Emergency Pricing, LMR is assigned with Proxy Offer of $550/MWh, and it sets prices at $550/MWh





ELMP Production Results

- **ELMP went live in the day-ahead and real-time energy markets on March 1, 2015**
  - ELMP/LMP differences are mainly observed in Real-Time market when FSRs are used to meet demand, while Day-Ahead impacts are very limited
- **ELMP more fully reflects the cost of FSRs in pricing and reduce uplifts**
  - ELMP differs from LMP in 13% of intervals in the first month of launch and is showing consistent pattern as time progresses
  - By allowing online inflexible FSRs to set prices, ELMP is higher than LMP in most of the intervals when ELMP differs from LMP

ELMP Production Results (cont.)

  - The price increases are mostly limited to morning ramp and peak evening hours, when FSRs are committed to meet demand
  - Uplift payments under ELMP and LMP are being compared, and reduction is being observed under ELMP
- **In very small number of intervals, ELMP lowered prices by allowing offline FSRs to set prices during shortages or transmission violations**
  - The participation of offline FSRs is more limited to the feasible and economic units that address the shortages compared to parallel operation
  - In such intervals, ELMP effectively reduced the inappropriate price spikes when MISO is actually not in a true scarcity situation while revealing the true scarcity

Summary

- **ELMP enhances energy and ancillary services pricing to reflect the underlying cost structure**
  - A detailed ELMP production result analysis will be presented at MISO Market Sub-Committee meeting in August
- **The design of Emergency Pricing expands ELMP method to address the current price depression under Emergency conditions**
  - ELMP is expanded to allow Load Modifying Resources and other Emergency actions to participate in pricing
  - The Emergency Pricing proposal has been filed and is expected to be implemented summer 2016