

Ramp Capability Modeling in MISO Dispatch and Pricing

*Congcong Wang, Chuck Hansen, Dhiman Chatterjee, Market Evaluation & Design;
Robert Merring, Juan Li, Sen Li, Market Engineering, Mid-Continent ISO*

FERC Technical Conference on Increasing Real-Time and Day-Ahead Market Efficiency through Improved Software

June 27-29, 2016

Overview

- **Purpose**

- Overview MISO market design initiatives
- Present recent market development of Ramp Capability Product
- Highlight preliminary results and post-implementation analysis

- **Key Takeaways**

- MISO Market Vision Program evaluates market and system operations and proactively identifies market design initiatives
- Ramp Capability Product was developed to manage increasing system ramping needs arising from recent market evolutions
- Value and performance metrics are being developed for post-implementation analysis by leveraging production software

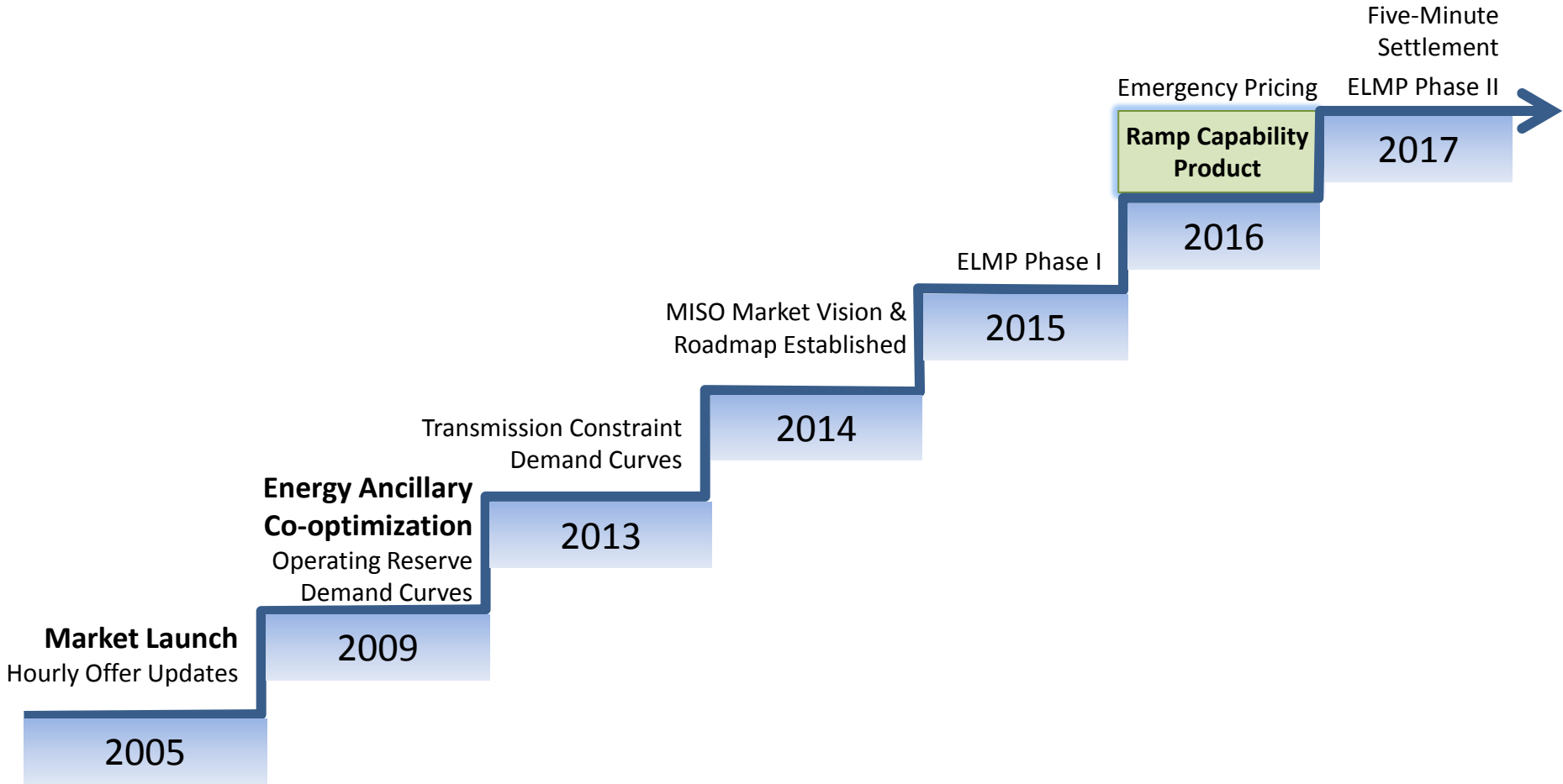
MISO Market Design Guiding Principles

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

Ramp Capability Product better positions resources with flexibility to serve load at reduced cost and improved reliability

Transparent price signals are obtained as an important step of price formation to incent resource flexibility



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

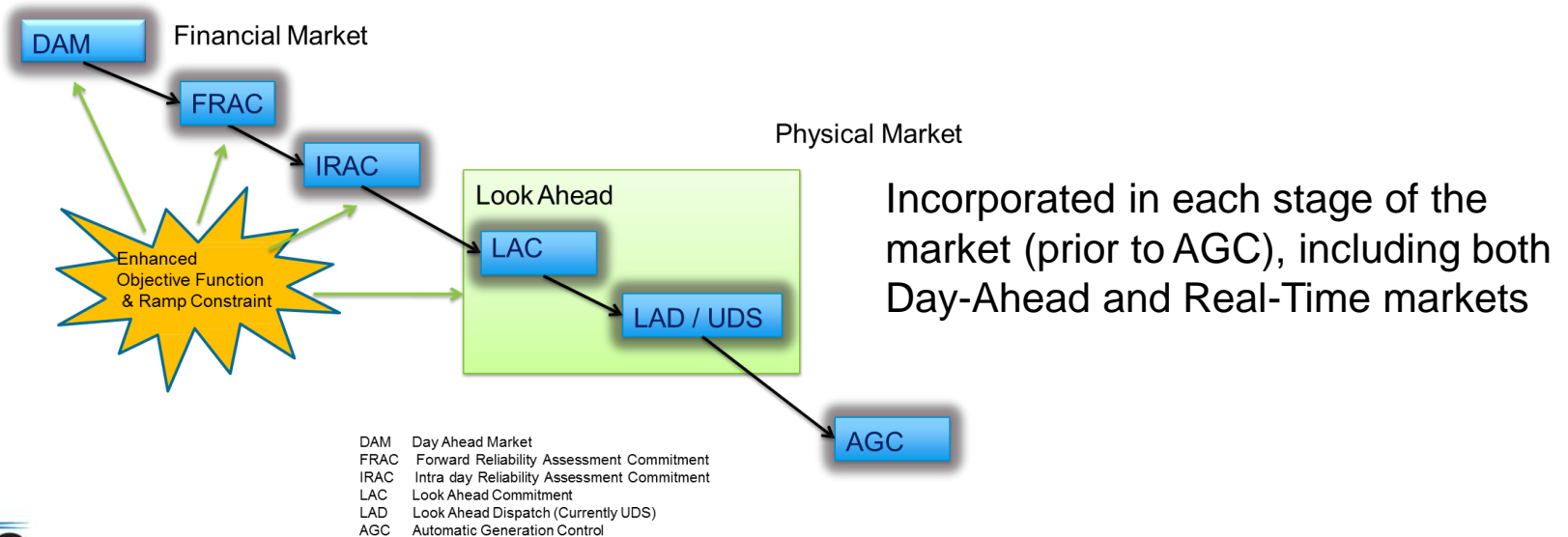


Ramp Capability Product

- **With increasing renewable penetration and interchange flexibility, net load variations and uncertainties impose challenges to maintain real-time power balance**
 - Net Load = Load – Non-controllable generation + NSI*
 - Variations: Expected changes in Load, Wind and NSI
 - Uncertainties: Unexpected changes such as Load and Wind forecast errors, and generator set-point deviations
- **Ramp shortages are the most common cause of short-term scarcities and price spikes**
- **Transparent price signals and economic incentives are needed for resources to provide their flexibility**

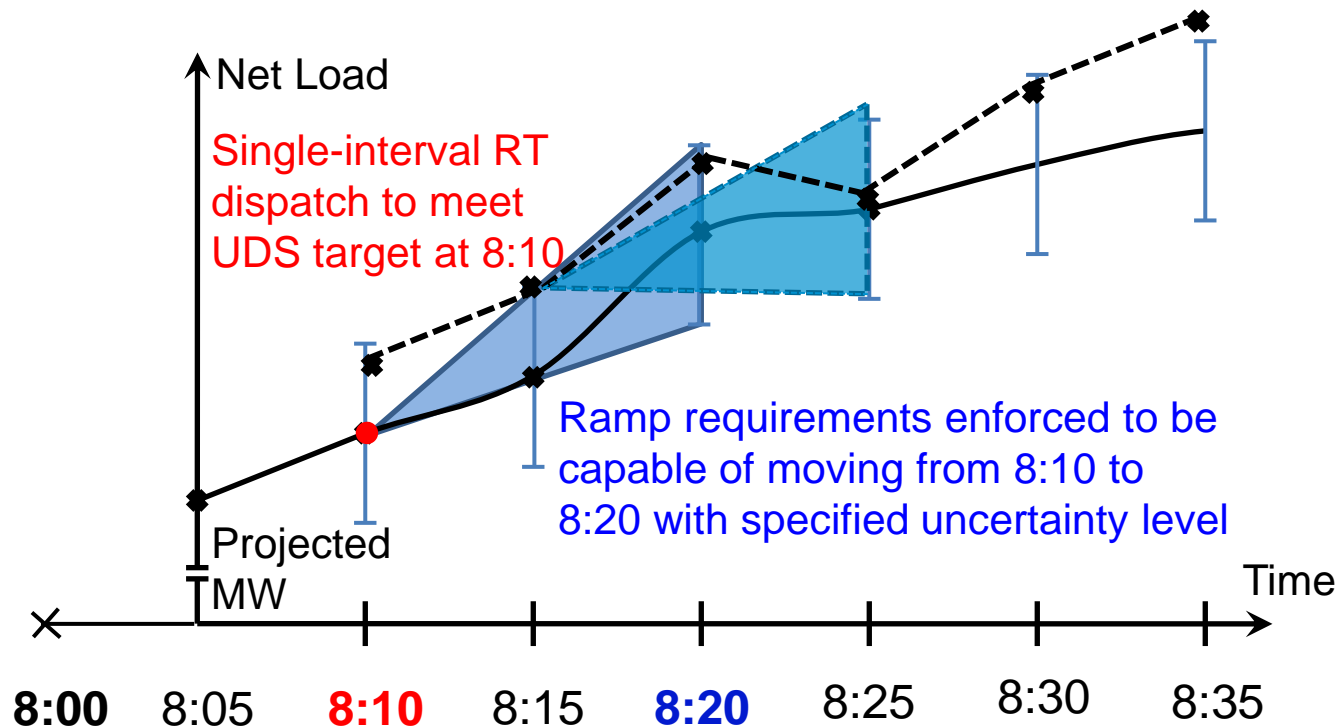
Ramp Capability Product addresses the increasing system ramping needs arising from recent market evolutions

- Develop a market-based approach for ramp management that leverages existing operational experiences
- Systematically pre-position resources with ramp capability to manage net load variations and uncertainties
- Provide transparent price signals to incent resource flexibility and economic investment



Ramp requirements are set to manage net load variations and uncertainties ten minutes beyond dispatch target

- Bi-directional: Up and down ramp requirements are enforced independently with separate quantities
- System-wide: Deliverability captured through ramp procurement post-deployment transmission constraints



Any dispatchable resource is qualified to provide the Ramp Capability Product and participation is voluntary

- Resources can opt out by specifying a new offer parameter
- Participating MW is a resource's ramp rate over ten minutes limited by operating limits
- No monetary offers are associated with

	Energy	Reg	Spin	Supp	Ramp	Capacity
Gen	Y	Y	Y	Y	Y	Y
DRR-I	Y	N	Y	Y	N	Y
DRR-II	Y	Y	Y	Y	Y	Y
SER	N	Y	N	N	N	N
EAR	Y	Y	Y	Y	Y	Y
DIR	Y	N	N	N	Y	Y

Note: Subject to qualification, offer status and commitment

Operators can disqualify a resource as needed; settlement impact associated

DRR: Demand Response Resource; SER: Stored Energy Resource;

EAR: External Asynchronous Resource; DIR: Dispatchable Intermittent Resource

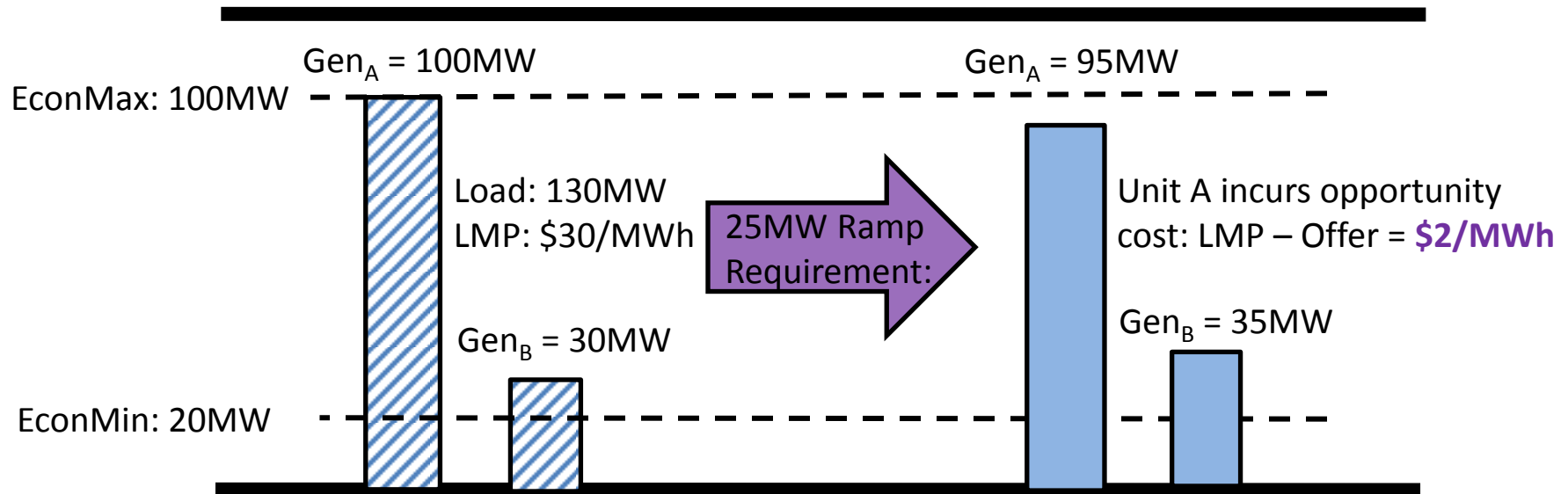
Ramp Capability Product is co-optimized with energy and ancillary services

- Market clearing prices are the marginal costs to meet ramp capability requirements
 - Opportunity cost – the forgone profit a resource could have earned by providing other products instead of ramp products
- Demand curve strikes the balance between how much premium to pay now versus future potential savings
 - Provides a mechanism to limit ramp clearing and associated price impact when cost exceeds demand curve value

Example

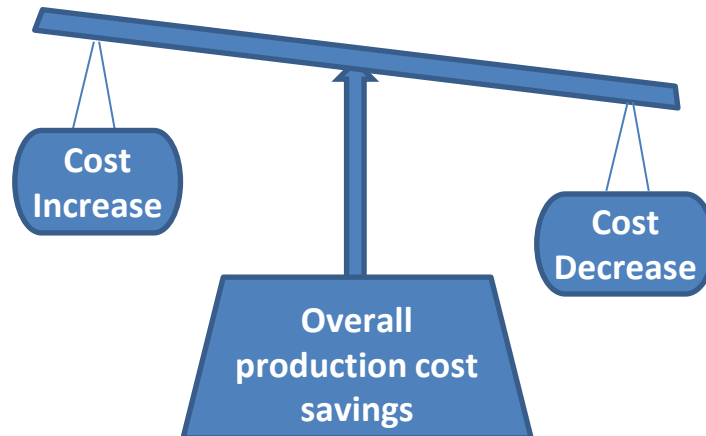
Offer cost: Unit A = \$28/MWh; Unit B = \$30/MWh

Ramp rate: Unit A = 1MW/min; Unit B = 2MW/min



Ramp Capability Product improves price formation

- Explicit price signals provide economic incentives for resources to supply ramp capability and investment in flexible resources
 - Better dispatch following incentive
- Reduces real-time scarcities and price volatility
 - Better pre-positions system with ramping flexibility
- Reduces the need for out-of-market actions such as UDS Offset that are difficult to model in price formation

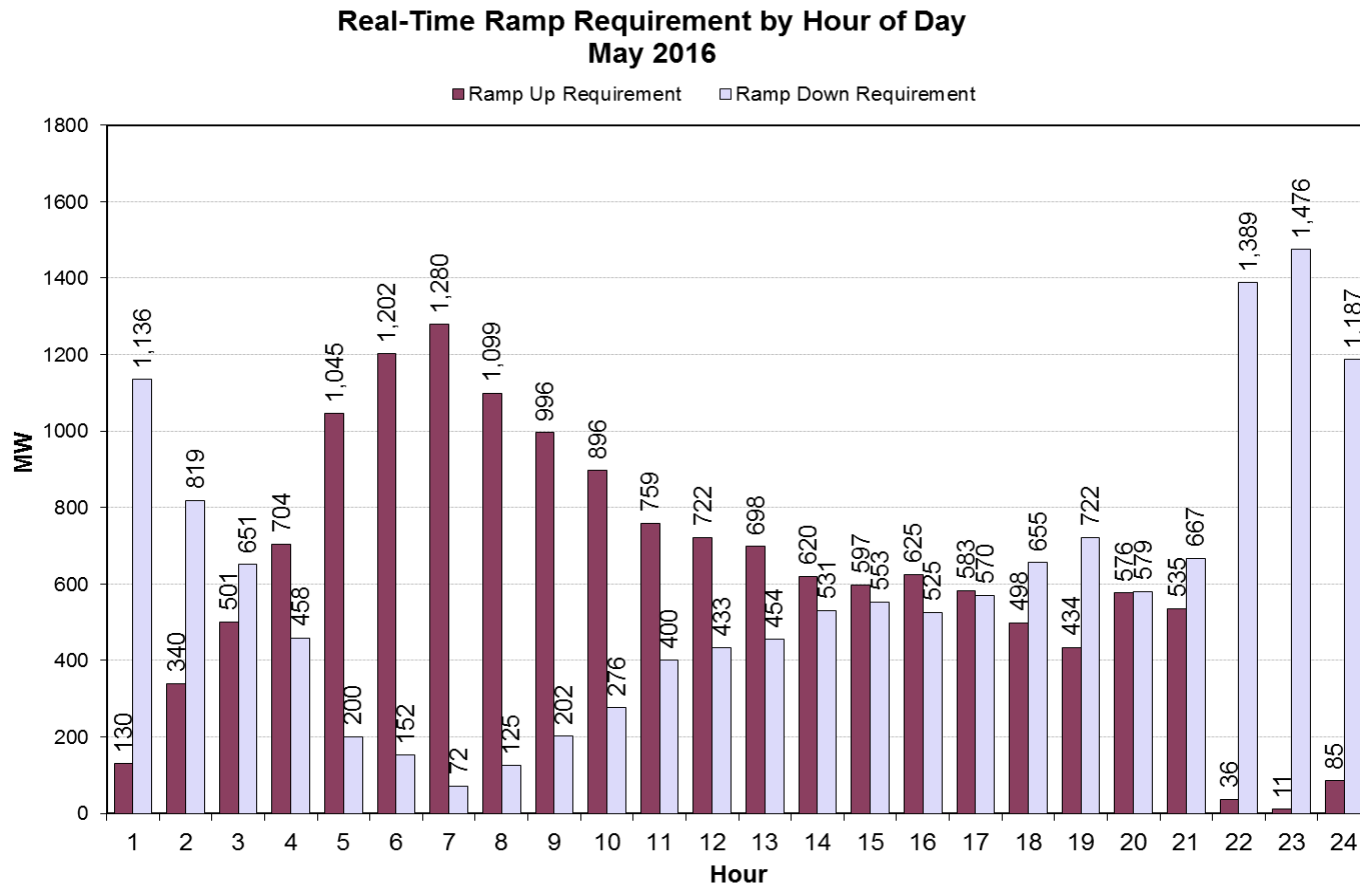


- Additional cost to obtain ramp capability
- Load/export charges to compensate resources who provide ramp

- Reduced cost by using ramp capability (avoid scarcities, CT commitment etc.)
- Load/export payments reduced as a result of the reduced prices

Preliminary Production Results

- Ramp requirements have been working to serve load following need



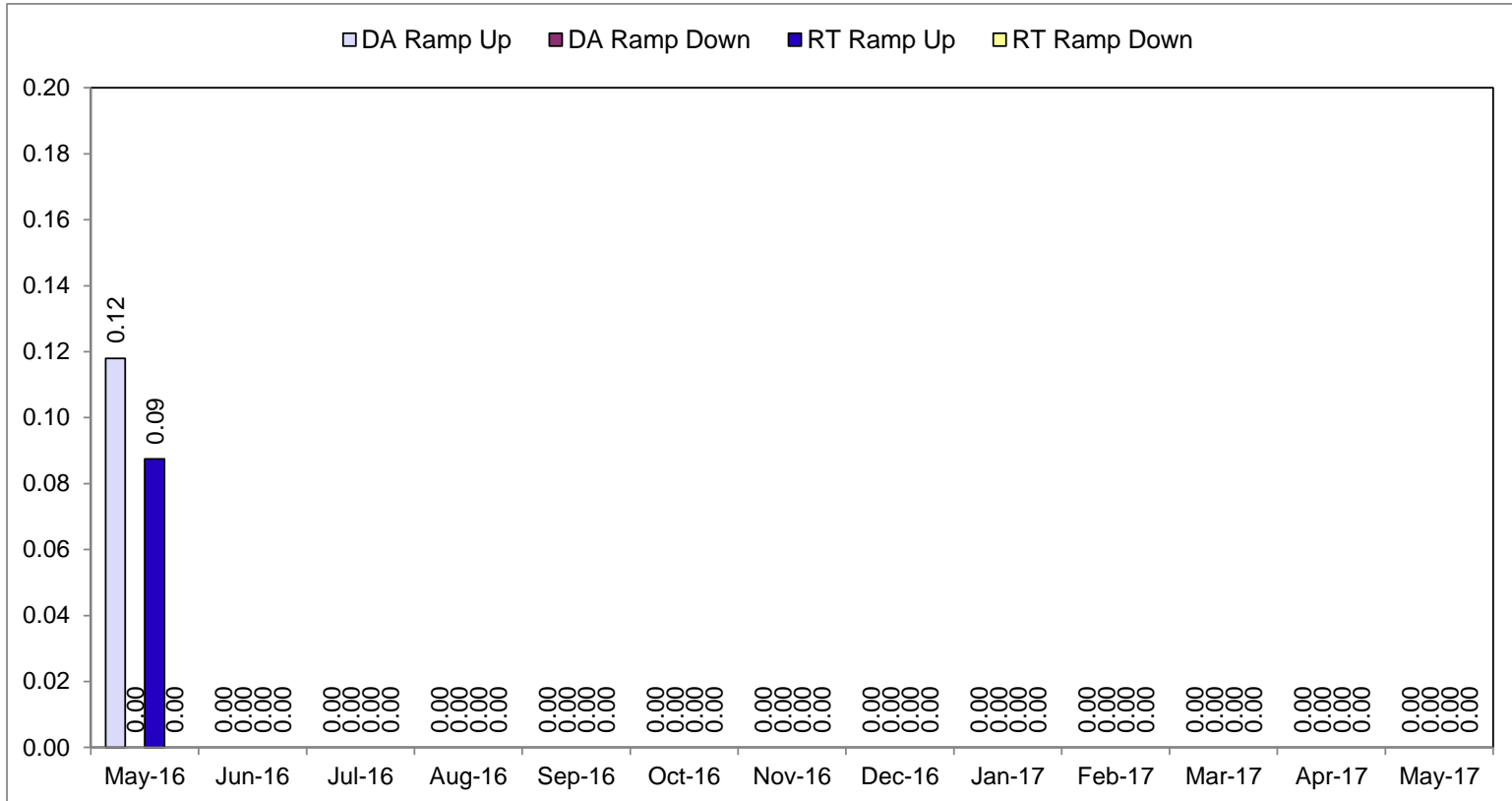
Date of Extraction: June 03, 2016

Source: MISO Market Evaluation and Design Department

- Market Clearing Prices are relatively low as expected

Monthly Average of Market Clearing Price

\$ per MWh

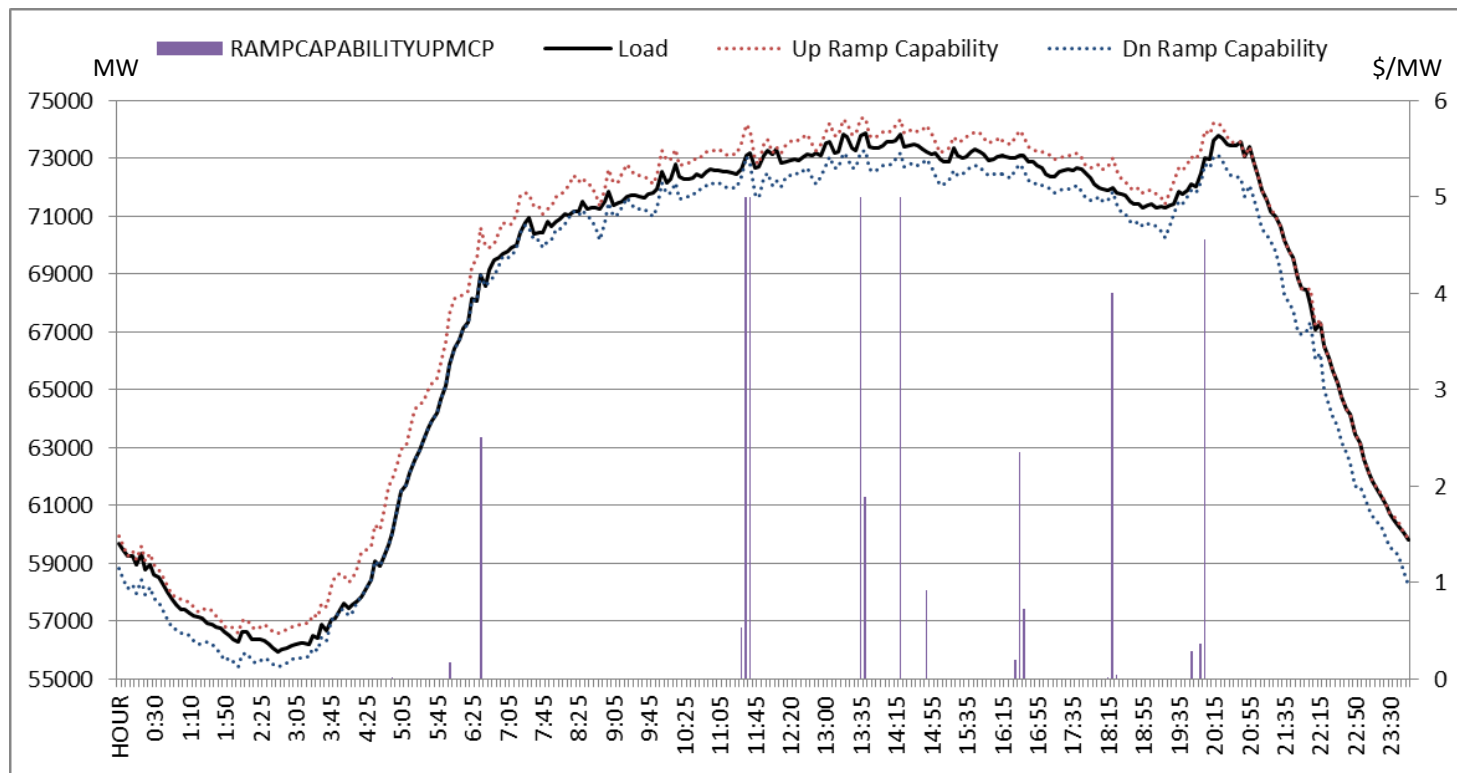


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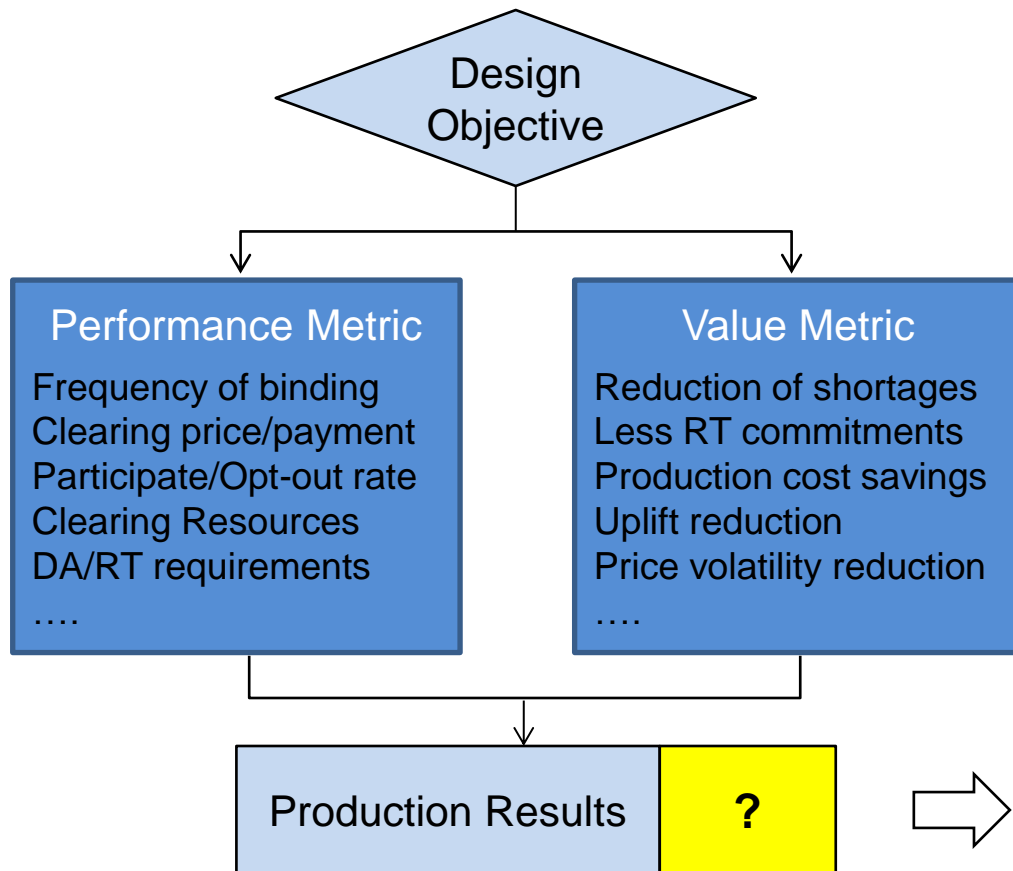
Source: MISO Market Evaluation and Design Department

- Prices are zero when the system is already ramp-sufficient, and become non-zero when ramp capability is valuable to the system

Sample-Day Real-Time ramp requirements and MCPs



Post-Implementation Analysis



- System dynamics impose challenges to measure changes introduced by the new product
- Prototype tool has been built for cost/benefit analysis, but it is difficult to sync with production
- Building in flexibility (soft-coding) can allow production software to be leveraged for analysis and purposes beyond

Summary

- Ramp capability product has been implemented in MISO markets to manage net load variations and uncertainties since May 01, 2016
- Besides improved system reliability and reduced cost to serve load, the product improves price formation to incent resource flexibility, reduce out-of-market actions, etc.
- Preliminary results show requirements following system ramping needs and modest clearing prices as expected from design; more post-implementation analysis is being performed