



MISO ELMP

Goals & Experience

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MISO saw gaps with legacy LMP market designs when its market started in 2005 ; ELMP was the result

MISO has been developing ELMP since 2007

- ELMP theory was developed to fix problems seen in pure LMP markets
 - Fast-start gas turbines or emergency demand response resources could not set prices and caused high, un-hedgable uplift make whole payments
 - LMP would show shortage prices even when offline fast start resources were available; LMP alone did not reflect the real operational need
- ELMP Represents first steps toward a future of more discrete reliability attributes pricing
- ELMP is not a cure-all; it prices flexibility better than LMP



Do improve prices through better signals about cost to serve each incremental MW – Stakeholders will agree



Do focus on what you are incentivizing and take it slow to get those right

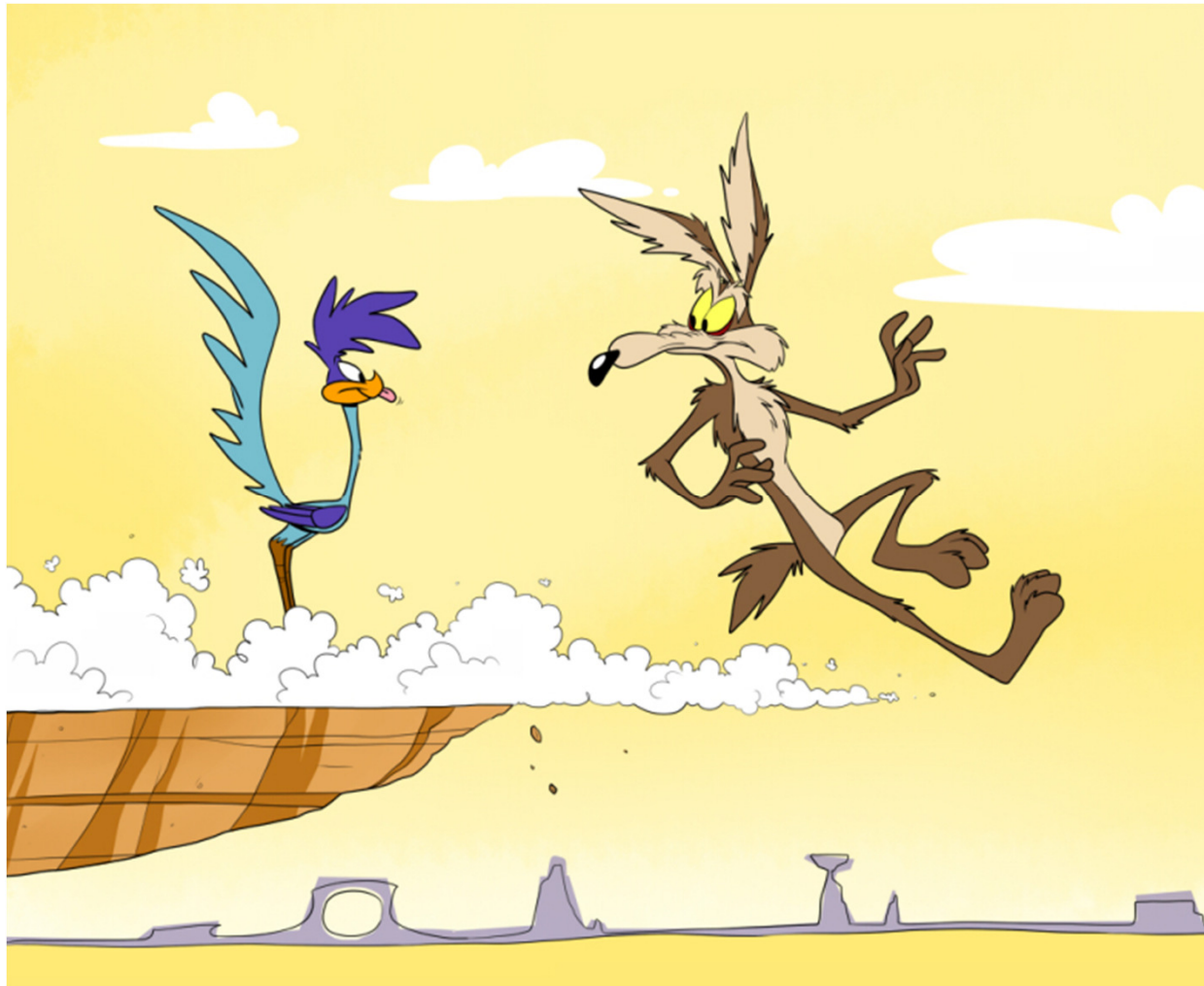
ELMP incentivizes resources to follow market instructions

- Allows fast-start resources to set price, reflects their true operational costs in price and reduces out of market payments
- Signal to load more accurate cost to consume

Learning through phased implementation - Don't let Perfect be Enemy of the Good

- MISO ELMP works as expected
- Single interval integer relaxation by amortizing startup cost
- Only applying to fast start resources
- Full “Convex Hull” is extraordinarily complex computationally; likely beyond current system capabilities.

Don't Rush - Need full understanding of efficiency & reliability implications



Don't let ELMP diverge too much from 5min dispatch instructions – Unintended outcomes could jeopardize reliability and/or increase cost unnecessarily

Target application to avoid unintended outcomes

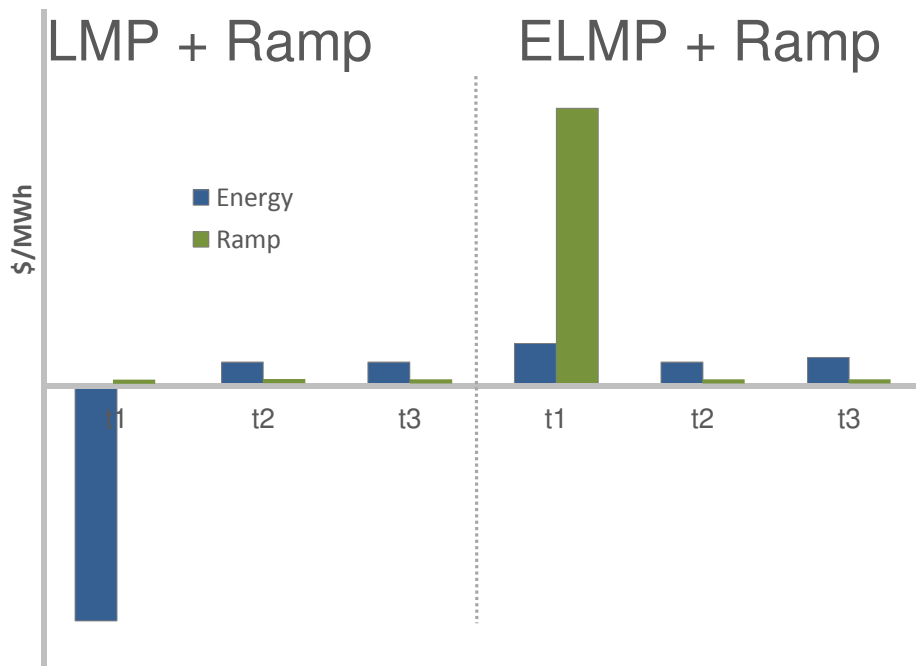
- Use price signal to incent behavior that meets operational needs
 - Including resources committed outside of the market under ELMP may incentivize uncoordinated self commitment creating reliability real-time reliability challenges (e.g., pre-DIR)

Explore before jumping: continue fundamental research

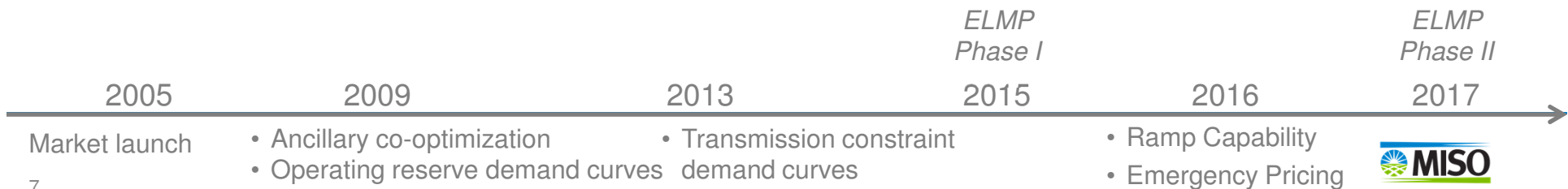
- Reasonable approximation to address computational complexity
- Feasible with current DA and RT (moving window) market structure while maintaining price convergence
- Interaction with other price mechanisms, (e.g., scarcity pricing, ramp product)

MISO is using ELMP to support products that define operating needs

ELMP complements products like ramp by better pricing the total production costs to meet an operating need indicated by a product



- Without ELMP, Ramp reflects only marginal cost
- Without Ramp, ELMP reflects only energy needs



Energy Markets Turned Inside Out

MISO continues to research and innovate on ELMP and other market designs to be ready for the future “de-marginalizing” and “de-centralizing” resource fleet

Enhanced ELMP approximation and potential path towards full ELMP

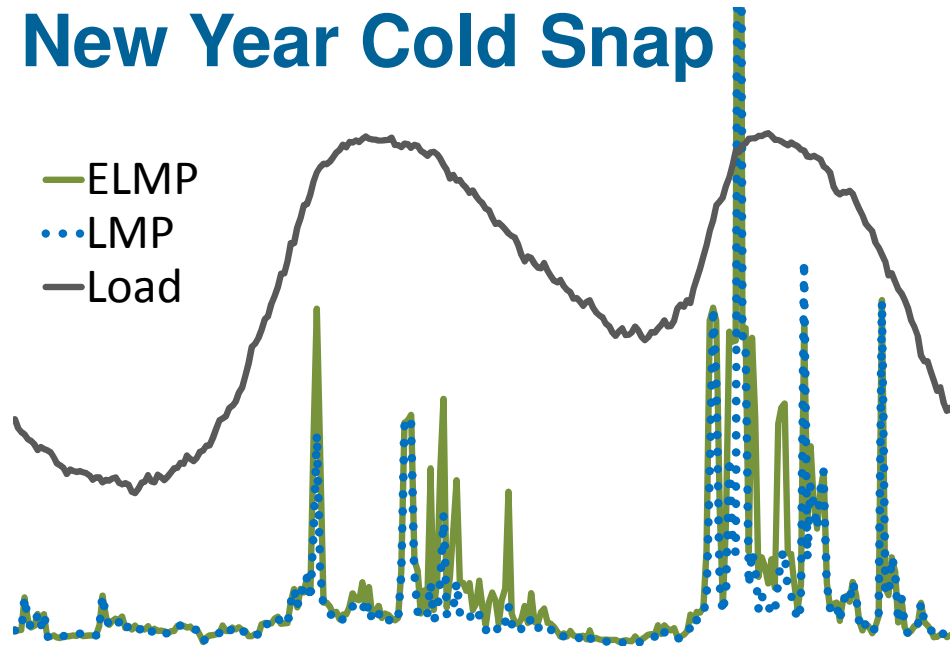
- Enhanced formulation improved MISO commitment performance by 30% (equivalent to Hua and Baldick)
- The improved formulation can also be applied to obtain better approximation of ELMP

Focus on Discrete Reliability Attributes Pricing

- Continue to enhance market clearing model to capture resource characteristics and reliability needs
 - ELMP can appropriately reflect the cost of the service when the service is evaluated within the market clearing model
- Integration with other pricing reforms under evolving generation fleet, especially with scenarios of high renewable penetration

Appendix

New Year Cold Snap



- 82% intervals affected
- Price raised by \$10.6/MWh
- Reflects phase II enhancements

Metric	Phase I	Phase II
Fast Start Resource capacity (GW)	2	10
Real-time participation rate (%)	7	23
Online Fast Start Resource price inc (\$/MWh)*	1	3
Offline Fast Start Resource price dec (\$/MWh)*	35	60
Make whole payment (RSG reduction, %)**	1	9