Fast Start Pricing/ ELMP at MISO

December 19, 2024

Market Evaluation

Executive Summary

ELMP was implemented at MISO through a staged approach. With production experiences and recommendations from IMM, enhancements and improvements were implemented incrementally.

Topics:

- Fast Start Pricing/ELMP at MISO
- ELMP Parallel Operations Review
- ELMP Phase I Result Review
- ELMP Phase II Result Review
- ELMP Phase III Enhancements
- ELMP and Emergency Pricing

Fast Start Pricing/Extended LMP (ELMP)
--Reflect the true cost of commitment as well as dispatch

Deficiencies of LMP and Lumpiness in Wholesale Electric Markets

Fast Start Resources	Demand Response	Uplift Payments
• Certain peaking resource cannot fully set prices* • Offline Fast Start Resources are not considered	Demand Response may not set prices	Inability to fully price costs results in uplift

• Allow online Fast Start resources to set prices, including their commitment costs • Include offline Fast Start Resources in price setting	Allow Demand Response Resources to set prices	More costs reflected in prices and reduced uplift

Effectiveness of ELMP to reflect the true cost to meet demand

**Note: Units that are started quickly in real-time to meet demands but dispatched at limits, e.g., block-loaded gas turbines, cannot set prices. Their commitment costs cannot be reflected in prices either and uplift has to be used to cover the costs*

Fast Start Resources (FSRs)
--Online FSR Definition and Background

Fast Start Resource: An online Generation Resource that is started, synchronized and injects Energy, or a Demand Response Resource that reduces its Energy consumption, within sixty (60) minutes of being notified and that has a minimum run time of one hour or less and that will participate in setting price as described in the process in Schedule 29A of this Tariff. A Fast Start Resource does not include fuel-limited resources such as pumped storage, Distributed Energy Aggregated Resources, Electric Storage Resources, run-of river hydro, and wind resources.

Online FSR eligibility was expanded through phases to capture broader benefits

Current: MISO Commit Only
StartUpTime+Notificationtime<=60min
StartUpTime+Notificationtime<=240min
(under emergency)
MinRunTime<=1 hour

ELMP Phase I: RT MISO Commit Only
StartUpTime+Notificationtime<=10min
MinRunTime<=1 hour

ELMP Phase II:RT MISO Commit Only
StartUpTime+Notificationtime<=60min
MinRunTime<=1 hour

ELMP Phase III:MISO Commit Only
StartUpTime+Notificationtime<=60min
MinRunTime<=1 hour

Fast Start Resources (FSRs)
--Offline FSR Definition and Background

Design Concept: instead of relying solely on administrative prices (such as reserve shortage prices and transmission constraint violation prices), available and economic supply from offline FSRs are considered to more accurately reflect system conditions. Penalties are applied if requirements still cannot be met or if transmission constraints remain violated.

Offline FSR implemented

- Not committed but available
- StartUpTime+Notificationtime<=10min
- MinRunTime<=1 hour
- FastStartEligible
- System Energy or Reserve deficit Or transmission Constraint Violation (raise help and abs(sensitivity)>=6%)

Current: offline FSR is turned off (price depression concerns; software limitation)

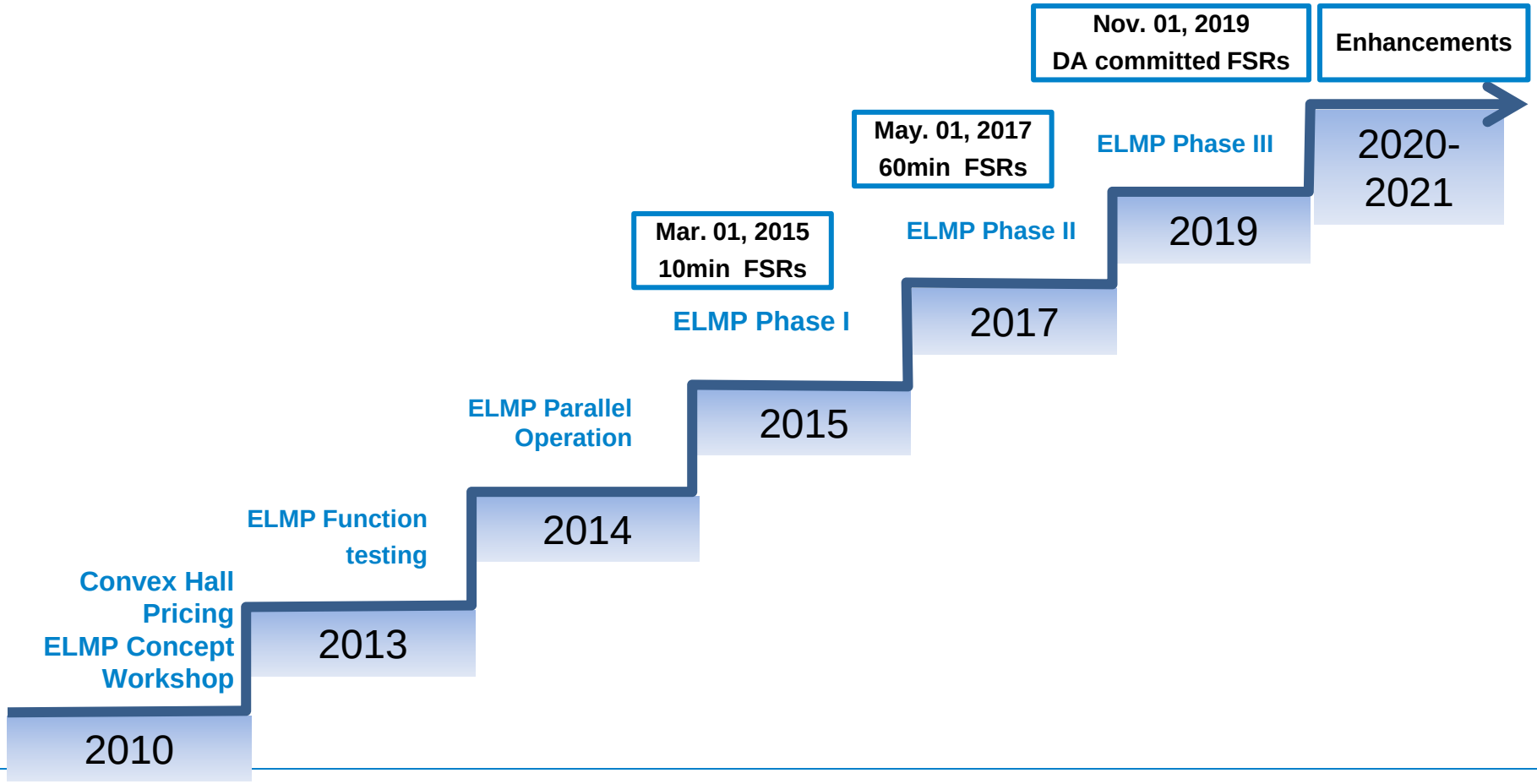
ELMP Mechanism
--Fractional commitment and cost amortization of FSRs

- A linear programming relaxation is used to model fractional/partial commitment of FSRs for pricing purposes; Commitment costs of FSRs are appropriately allocated to individual intervals for ELMP calculations
- The ELMP formulation applies partial commitment variable “On”, to allow EconMin to be relaxed to zero and the commitment related costs to be allocated over EconMax

ELMP Formulations

- Partial On commitment variable (*on*)
  - $0 \le on \le 1$
- Objective Cost Change for online Fast Start GEN and DRR2 Resources
  - $on \times (ACStartUpCost + NoLoadCost)$
  - ACStartUpCost is added if the time is within one hour of the resource's commitment time
- Constraint changes
  - Online Fast Start Gen and DRR2 is not regulation committed
    - $on \times EconMin \le EnergyMW - DownRC$
    - $EnergyMW + Spinning + UpRC \le on \times EconMax$
    - $EnergyMW + STR \le on \times EconMax$
  - Online Fast start Gen and DRR2 is regulation committed
    - $on \times RegMin \le EnergyMW - RegMW - DownRC$
    - $EnergyMW + RegMW + Spinning + UpRC \le on \times RegMax$
    - $EnergyMW + RegMW + STR \le on \times RegMax$
- Objective Cost changes for Offline Fast Start GEN and DRR2
  - $on \times (AllocatedStartUpCost + NoLoadCost)$
- Constraint Changes
  - $on \times EconMin \le EnergyMW \le on \times EconMax$
  - $0 \le OffLineSupp \le (1 - on) \times min\{EconMax, MaxOfflineResponseLimit\}$
  - $0 \le STR \le (1 - on) \times min\{EconMax, MaxOfflineSTRResponseLimit\}$

ELMP Implementations
-- A staged strategy with initial parallel operations in 2014



ELMP Parallel Operations Review

ELMP Parallel Operations
--Timeline 05/04/2014-08/02/2014

Purpose of Parallel Operations

- ELMP Design Verification; ELMP Software Testing; Process refinement

ELMP reports were posted on the website, and ELMP analysis/results were updated in the MSC

- High level
  DA/RT ELMP and LMP comparison
  FSR impacts on ELMP
  Uplift payment/settlement

- Case study
  Compares ELMP and LMP with on-line/off-line FSRs eligible to set price under various situations

ELMP Parallel Operations
--RT ELMP and LMP Relationship

RT LMP and ELMP 5-min MEC data comparison for 05/01/2014----05/10/2014

Status	Comparison of ELMP and LMP	Total # of Intervals	2880	% of Intervals	Average ELMP MEC Increase
When CT is Committed to Meet Requirements	Can be different and expect ELMP > LMP	# of Intervals ELMP MEC > LMP MEC	139	4.8%	$1.36
When in Transitory Scarcity or Transmission Constraint Violation	Can be different and expect ELMP < LMP	# of Intervals ELMP MEC < LMP MEC	26	0.9%	-$122.30
Most Conditions	ELMP and LMP very close	# of Intervals ELMP MEC = LMP MEC	2715	94.3%	$0.00

ELMP Parallel Operations Timeline
--Price impacts of FSRs consistent with design

Analysis shows that price impacts of fast-start units were consistent with design during operation period, 5/1-5/10.

- ✓ There were about 1391 market units and about 60 units could be qualified as fast start resource.
- ✓ When RT unit dispatch cases have no energy/reserve scarcity or constraint violation, there was no energy cleared from offline fast-start units. Cleared energy on online fast-start units raised ELMP.
- ✓ When RT unit dispatch cases have energy/reserve scarcity, offline fast-start units largely mitigated the price spike and lowered ELMP.
- ✓ When RT unit dispatch cases have transmission constraint violation, offline fast-start units reduced the chance of constraint shadow price hitting penalty price. It also helped reduce the price spike and lowered ELMP.

Associated Unit Dispatch Case Solution	# of RT 5 min ELMP Cases	ELMP MEC Increase ($/MW)			Cleared Energy MW			
					Online Fast-start		Offline Fast-start	
		Average	Maximum	Minimum	Average	Maximum	Average	Maximum
w/o scarcity or Violation	1359	$0.09	$6.60	-$0.14	77.4	254.7	0.0	0.0
Energy/Reserve scarcity	6	-$397.61	-$31.40	-$1,035.57	156.8	292.5	274.6	482.5
Transmission Constraint Violation Only	1515	-$0.27	$6.70	-$166.65	18.0	826.6	1.2	315.6

ELMP Parallel Operations
--Minor impact to DA market prices

ELMP had very minor impact to DA market prices since MISO DA market rarely ran into scarcity or transmission violation situations. Average MEC difference between LMP and ELMP was about $0.02/MWh.

DA pricing comparison for 05/01/2014----05/10/2014

Unit:	$/MWh	Operation Period	05/01/2014 ----05/10/2014	
Pricing Type	Average DA MEC	Average DA Regulation MCP	Average DA Spin MCP	Average DA Supplemental MCP
DA-ELMP	$41.09	$18.35	$4.02	$2.52
DA LMP	$41.07	$18.98	$3.88	$2.40
ELMP Increase	$0.02	-$0.62	$0.13	$0.12

ELMP Parallel Operations
--Total uplift payment decreased with ELMP

Uplift Observations

- During the observed parallel operation period, the net total uplift payment decreased with ELMP.
- Although DA and RT RSG increased slightly due to lowered overall ELMP energy prices, the price volatility make whole payment decreased by more primarily because of avoided scarcity pricing

Uplift payment comparison on ELMP and LMP for 05/01/2014----05/10/2014

Unit:Thousand $		Operation Period:05/01/2014 -05/10/2014		
Pricing Type	DARSG	RTRSG	PVMWP	Uplift_total
ELMP	3473.1	1951.3	2749.6	8174.0
LMP	3469.4	1856.1	3042.6	8368.1
ELMP Increase	3.7	95.2	-293	-194.1

Note: Date of Extraction: May 23rd ,2014. Values may change due to resettlement.

ELMP Parallel Operations
--IMM Recommendations and MISO Positions

IMM expressed the concerns regarding the participation of offline FSRs

MISO and IMM reached an agreement to further restrict participation of offline FSRs

- Energy limited resources should not participate as off-line FSR
- Off-line FSR should not participate in setting price for PJM M2M constraints
- Off-line FSR with less than 6% GSF cutoff should not participate in price setting
- For the offline FSR cost amortization, commitment costs should be allocated to 4 intervals instead of the minimum run time

ELMP Phase I Results Review

ELMP Phase I
--went live in DA/RT Markets on 03/01/2015

How We Are Measuring ELMP

Market Value	Metrics
Reflect more fully the cost of committing and dispatching FSRs to meet demand	ELMP/LMP difference VS FSR participation
Send more efficient price signal during ramp up or peak hours when FSR is needed	ELMP/LMP difference VS Load pattern
Provide better cost recovery and dispatch following incentives	Uplift comparison under ELMP/LMP
Reduce transient price spikes when MISO has offline FSR able to solve shortages/violations	Reduction of inefficient price spikes
Improve price signal to facilitate DA scheduling and import/export	Price volatility reduction DA/RT price convergence

- **Study Period: 03/01/2015-08/11/2015**

ELMP Phase I
--Modest price and uplift changes

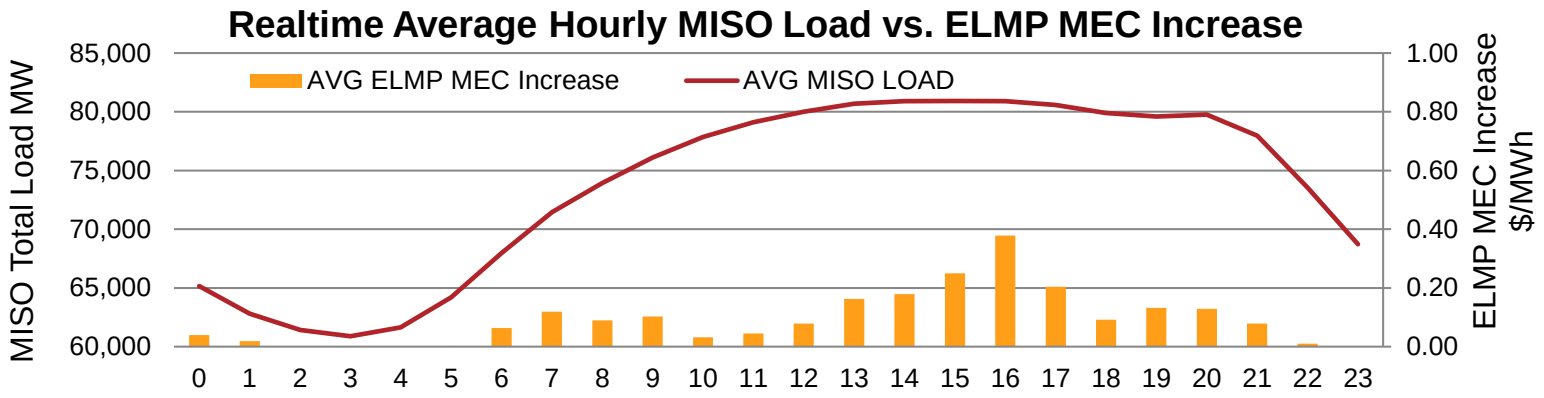
Phase I price and uplift changes were modest as expected, but the directional results validate the design objectives

Concept	Actual Results*
More fully reflect in prices the cost of online Fast Start Resources used to meet demand	~$1/MWh average increase over relevant RT intervals
Reduce uplift costs	~1% RSG (uplift) reduction during expected periods
More accurately price shortage or transmission violation when MISO has offline Fast Start Resources available	~$15/MWh average decrease during relevant RT intervals
Reduce price volatility and improve DA/RT price convergence	DA/RT price deviation reduced by 2.25%

Note: Results were reported to stakeholders based on observation period of 03/01/2015-08/11/2015.

ELMP Phase I
--ELMP price increase aligned with load patterns

ELMP price increases were generally limited to ramp and peak periods when FSRs were committed to meet demand



ELMP Phase II Results Review

ELMP Phase II
--Different options of expansion

Different options of expansion were explored considering IMM recommendation

Options	Start-up/Notification Time	Min Run Time	Commitment
1	30 minutes	1 hour	RT
2	60 minutes	1 hour	RT
3	60 minutes	1 hour	RT & DA
4 (IMM)	60 minutes	2 hours	RT & DA

ELMP Phase II
--Simulation studies performed

Metrics	Simulation Results*
Average market-wide price changes	For different sample days, price increased by $0.2/MWh-$4.12/MWh as compared to increase of 0-$0.59/MWh in the current production
Percentage of intervals affected	Affected at 21.18%-61.11% of real-time intervals as compared to affected intervals of 0-19.1% in the current production
Online fast start resource eligibility	Both the average number of eligible units and percentage of intervals where online fast start resources participated in pricing increased
RSG Make Whole Payment (MWP)	For different sample days, RSG can be reduced by up to 5%-20% compared to 1% in the current production
Price Volatility MWP	Mostly trended down with small magnitude
Real Time Load Energy Payment	The higher prices can raise the Real-Time load payment by 0.3%-7%, noting that Real-Time market only settle the balancing part of load

10min Start-up; 1h min-run; RT 30min Start-up 60min Start-up DA commit 2h min-run

ELMP Phase II
--Online FSRs eligibility expanded to one hour

The decision was made through collaborative efforts and stakeholder process

Expand eligibility for online resources to the extent feasible by current software (60min Start-up)

Retain pricing by offline resources and keep monitoring to ensure units are feasible and economic

Phase I

Allow Fast Start Resources to set price

- Online FSRs-10min Start-up/ 1hour Min Run
- Offline FSR-10min Start-up/ 1hour Min Run

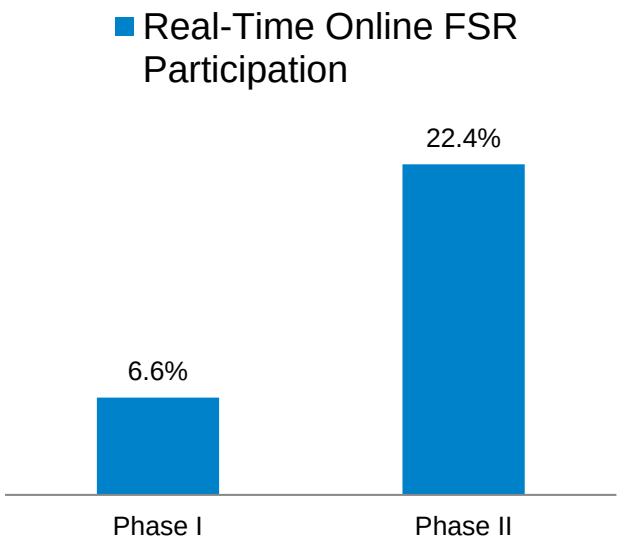
Phase II

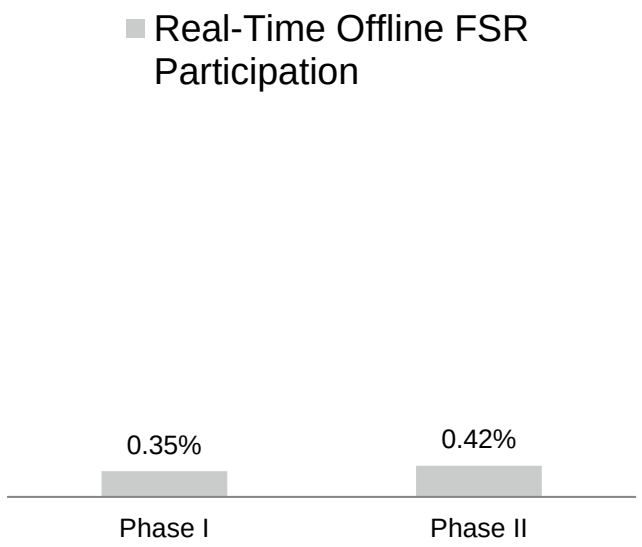
Expand eligibility for online Fast Start Resources

- Online FSRs-60min Start-up/ 1hour Min Run
- Offline FSRs-10min Start-up/ 1hour Min Run

ELMP Phase II
--Capacity and Participation of FSRs

	Phase I (10Min Start-Up/1Hr Min Run)	Phase II (60Min Start-Up/1Hr Min Run)
Number of FSRs	~50	~180
FSRs Capacity	~2 GW	~ 10 GW





*Phase I results: 12 months results after phase I implementation were filed to FERC under ER12-668-000.
*Phase II results: 6 months results after phase II implementation (05/01/2017-10/31/2017).

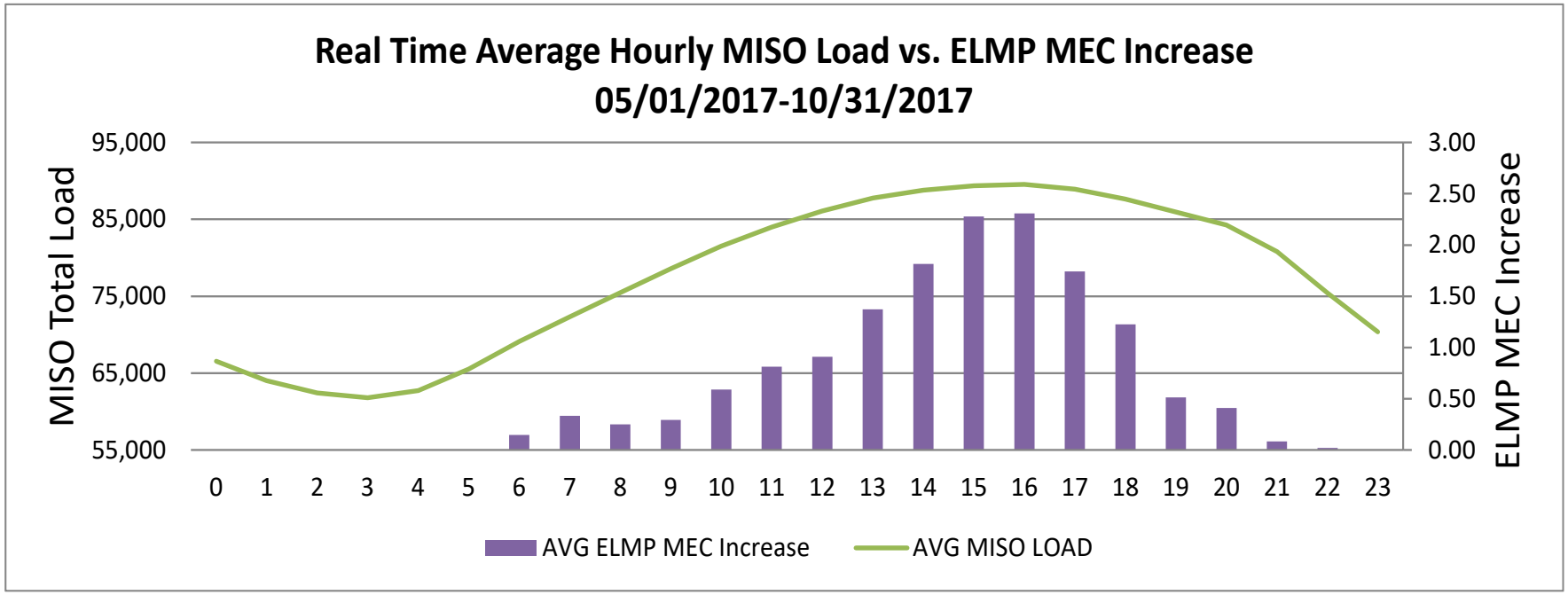
ELMP Phase II
--Broader benefits realized

Metric	Phase I Results*	Phase II Results*
FSR Capacity/Real-Time Intervals with FSR Participation	~ 2 GW / ~7%	~10 GW / ~23%
Online FSR Price Impact	~$1/MWh average increase over relevant Real Time Pricing intervals	~$3/MWh average increase over relevant Real Time Pricing intervals
Offline FSR Price Impact	~$35/MWh average decrease during relevant Real Time Pricing intervals	~$60/MWh average decrease during relevant Real Time Pricing intervals
RSG Make Whole Payment (MWP) Impact	~1% RSG reduction during expected periods	~9% RSG reduction during expected periods*

*Phase I results: 12 months results after phase I implementation were filed to FERC under ER12-668-000.
*Phase II results: 6 months results after phase II implementation (05/01/2017-10/31/2017).
*RSG reduction: IMM's analysis based on 2017 summer data

ELMP Phase II
--ELMP reflected ramp and peak demand needs

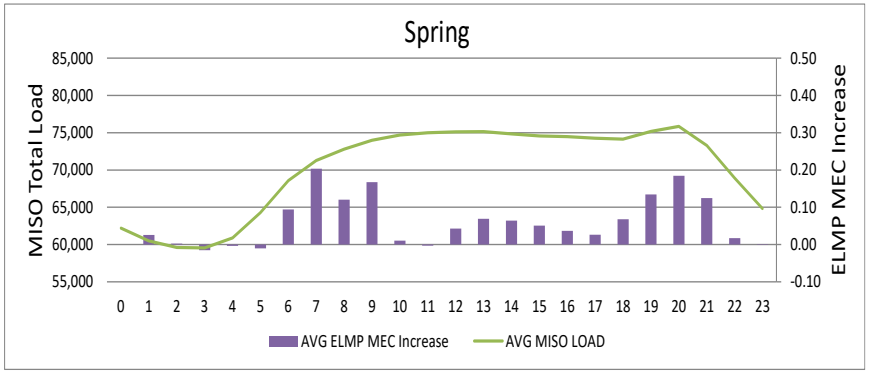
- More accurately reflect ramp and peak demand needs
- No negative price impact to the off-peak periods

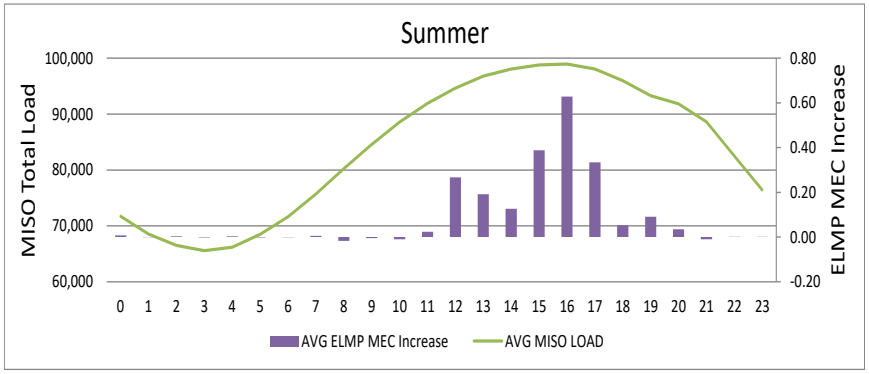


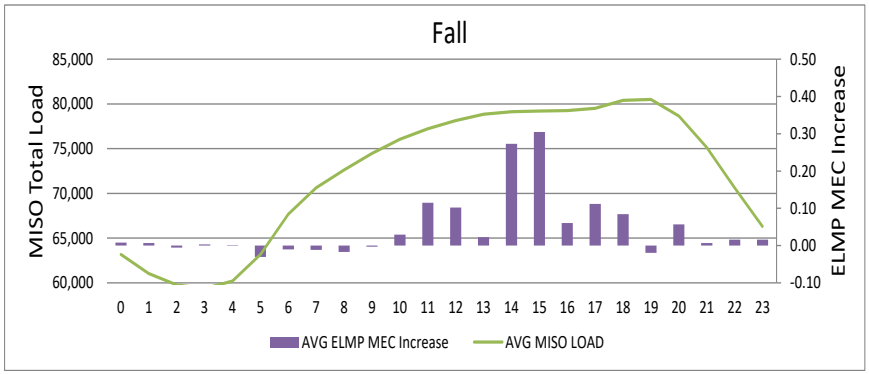
*MEC: The energy component of LMP

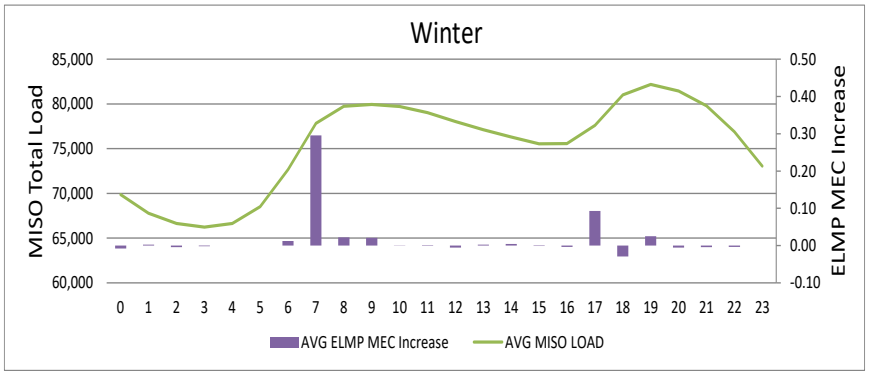
ELMP Phase II

--A production view by season









*MEC: The energy component of LMP

ELMP Phase II
--Regulation Enhancement for DA market

Observations

- Large DA regulation price differences were observed during the ELMP monitoring process

Issues

- A restrictive regulation clearing logic was identified as the cause of the regulation price spikes
- In the DA market clearing process, SCUC specified whether a unit was committed for regulation or not, limiting SCED regulation clearing to "Reg-Commit" resources
- With costs more fully considered in SCED pricing, FSRs could be dispatched down, reducing available room to provide regulation (down)
- Within the very restricted "Reg-Commit" pool, it became costly to make up the required regulation MW (RegMW), which in turn drove regulation prices higher

Solutions

- In December 2017, an enhanced regulation clearing logic was implemented. The enhancement expanded the "Reg-Commit" pool, effectively addressing the regulation price spikes and resulting in modest production cost savings.

ELMP Phase III Enhancements

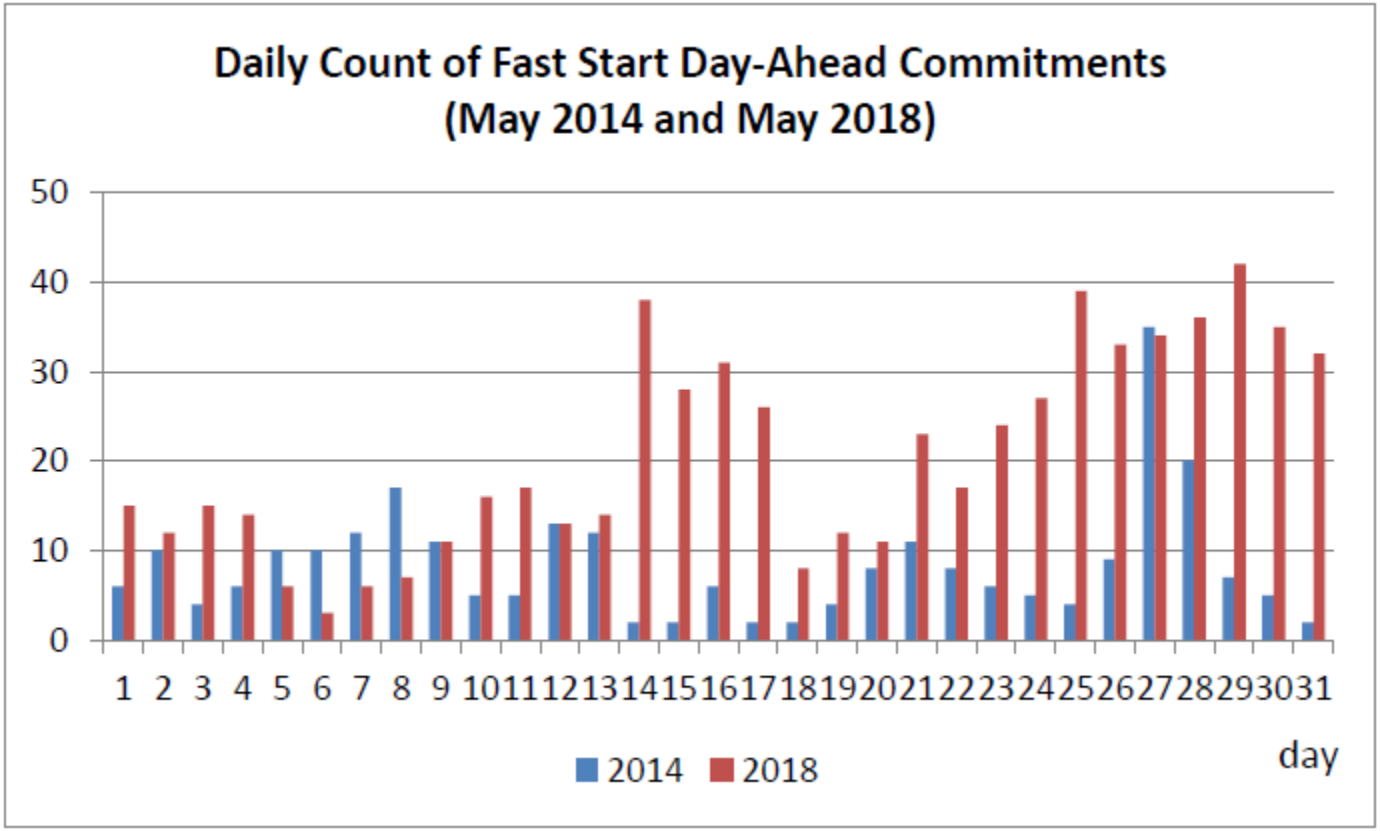
ELMP Phase III
--Include DA Committed FSRs

- Design goal--RT ELMPs should equal DA ELMPs if nothing changes between DA and RT. To meet this goal, the start-up and no-load costs of resources committed in the DA market must be considered when setting RT ELMPs.

- In the initial implementation of ELMP, FSRs (start-up and notification time within 10 minutes under ELMP I) were rarely committed in DA market and the pricing impact was minimal. Therefore, DA committed fast start resources were not included in the RT ELMP pricing.

- As market conditions have changed and the FSRs definition has been revised, more fast start resources are being committed in the DA market.

ELMP Phase III
--More FSRs committed in DA



Number of 60 minutes Fast Start Resources committed in DA for each day of May

ELMP Phase III
--Simulations performed to evaluate the price impact

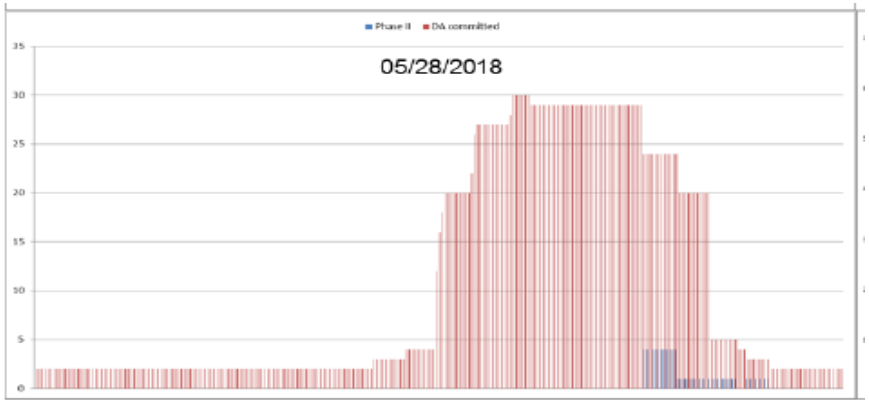
Average price increase from LMP in ELMP Phase II

Day	Highlights	Daily Average ELMP II-LMP
05/06/2018	modest day	$0
05/15/2018	max gen alert; reg deficit	$2.00
05/28/2018	miso hit 100F record	$0.05
05/31/2018	largest ELMP impact	$5.60

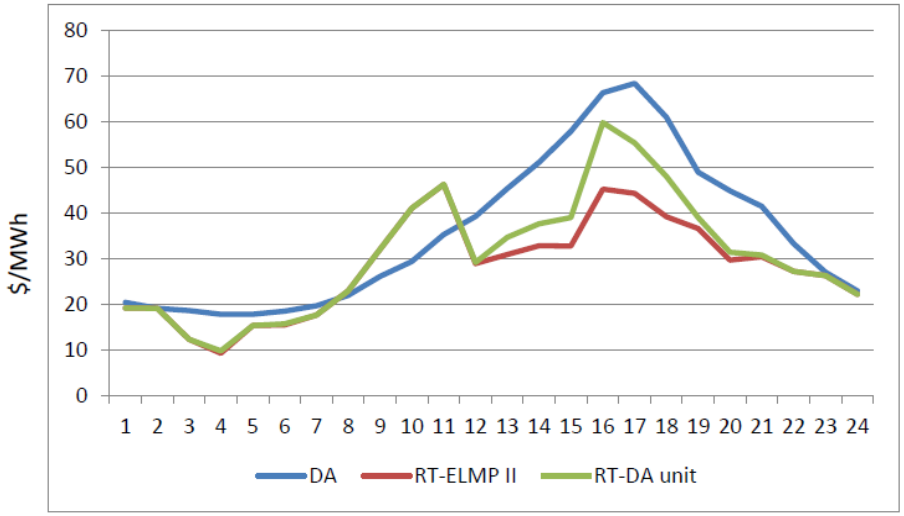
Average price increase from LMP by including DA committed FSRs

	5/6/2018	5/15/2018	5/28/2018	5/31/2018
ELMP II	$0.00	$2.00	$0.05	$5.60
DA Units	$0.00	$3.74	$2.07	$7.79

ELMP Phase III
--Better price signals with DA FSRs included



Number of FSRs participated in ELMP pricing under Phase II and including DA units



- on 5/28/2018 when MISO hit 100F, only a modest ELMP impact was observed in production. That was because on that day Fast Start Resources were mostly committed in the Day-Ahead market but did not participate in the Real-Time pricing.

- By including these units, RT prices increased more than $2/MWh on average, resulting in better convergence with Day-Ahead prices.

ELMP Phase III
--Relax ramp-down limits of FSRs

- Under ELMP, FSRs could be partially committed instead of an on/off decision, so that they could set prices. it was observed that some FSRs still could not set prices when constrained by ramp. FSRs would not be able to set price if constrained by the normal ramp limit from being further dispatched down below EconMin.

- FSRs are usually flexible with high ramp rates. With the original10 minute definition of FSRs, about 75% of FSRs can ramp from EconMin to zero within 5 minutes. With the expansion of the definition to 60 minutes, about 40% of FSRs could have the issue of being ramp constrained from EconMin to zero in 5 minutes.

ELMP Phase III
--Example: FSR is ramp constrained and cannot set prices

Time	t
load	108MW

Unit	min	max	ramp	cost	IntMW
unit1	0	100	100	$10/MWh	100MW
unit2	12	20	10	$20/MWh	20MW
unit3	0	20	100	$30/MWh	5MW

Dispatch Run	**$10/MWh**	**Pricing Run Ramp Enforced**	**$10/MWh**	**Pricing Run Relax Ramp**	**$20/MWh**
unit1	96MW	unit1	98MW	unit1	100MW
unit2	12MW	unit2	10MW	unit2	8MW
unit3	0MW	unit3	0MW	unit3	0MW

- Unit 2 is dispatched at EconMin and cannot set prices dispatch run. It cannot set prices under pricing run with ramp enforced either since it is ramp constrained even if its EconMin is relaxed. By further relaxing the ramp limit, it sets prices.

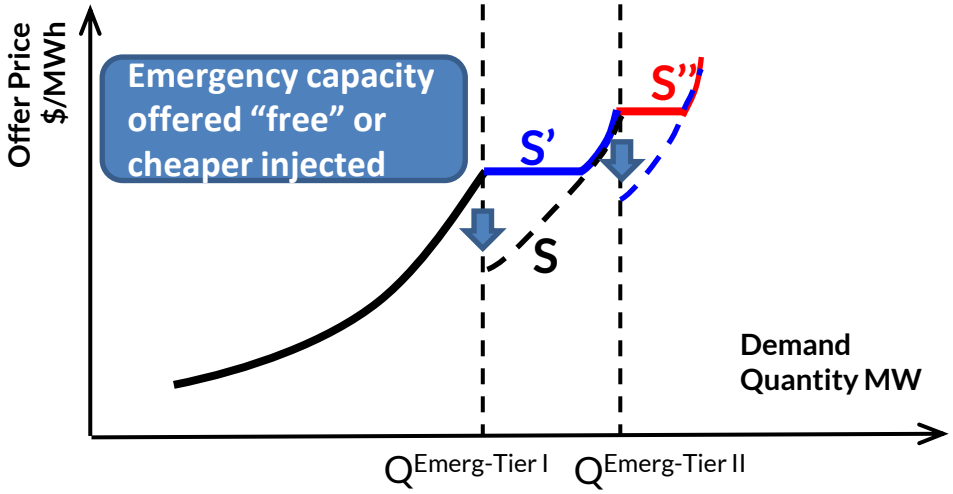
- An enforcement was implemented in the pricing process to address the issue. Online FSRs, which are dispatched at their EcoMin in previous interval, will be allowed to back down to 0 by not enforcing Ramp-Down constraint in the pricing process.

ELMP and Emergency Pricing

Emergency Pricing
---Went live on 07/01/2016

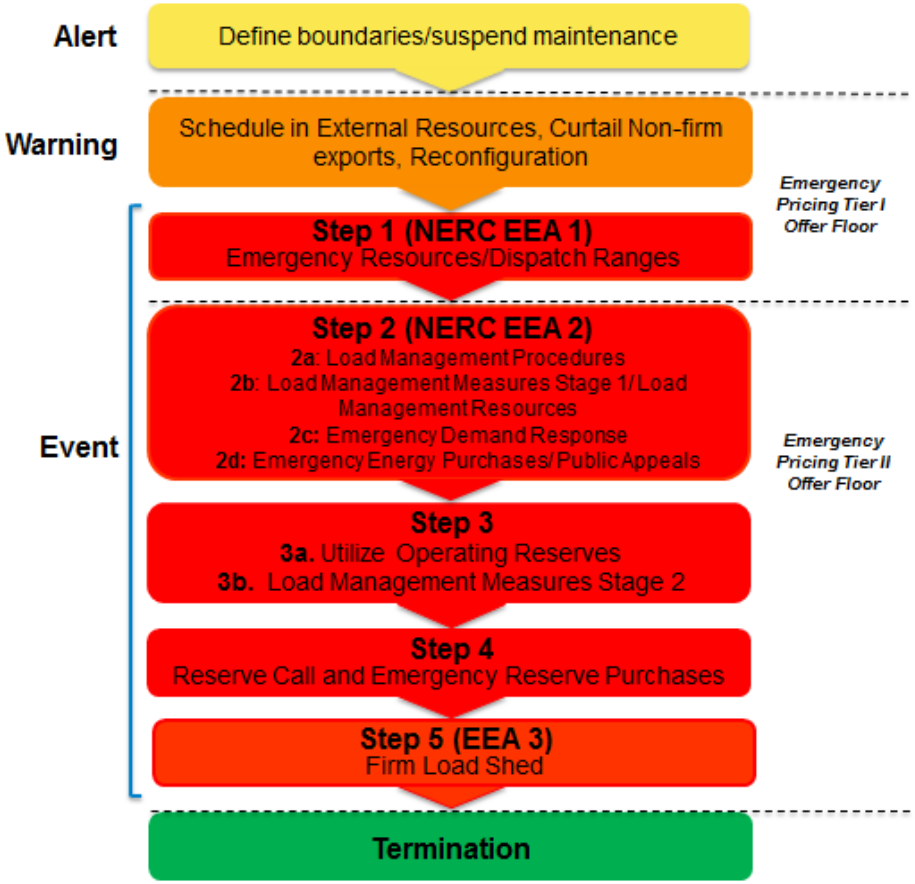
- MISO implemented the Emergency Pricing construct to allow Emergency Energy and Demand Response Resources to set ELMP prices during declared Maximum Generation Warnings and Events.
- Emergency Offer Floors (EOFs) established to resolve price depression when emergency supply capacity is used

- Prices that reflect true cost to serve demand and system conditions
- Motivate Demand Response participation and efficient transactions
- Incentivize resource availability and dispatch following



Emergency Pricing
---EOFs established to resolve price depression

Maximum Generation Emergency Procedures



Tier 0: Expand FSR eligibility to 4 hours for startup/notification time following Max Gen Alert declaration

Tier I: Highest available economic offer following Max Gen Warning declaration

Tier II: Highest available economic and emergency offer following Max Gen Event Step 2 declaration

Emergency Pricing Enhancements in 2020/2021 ---Expanded online FSR eligibility to four hours

Issues: During emergency conditions, the FSR definition does not align with resources committed in RT and therefore prices are not able to reflect the full costs of units serving load.

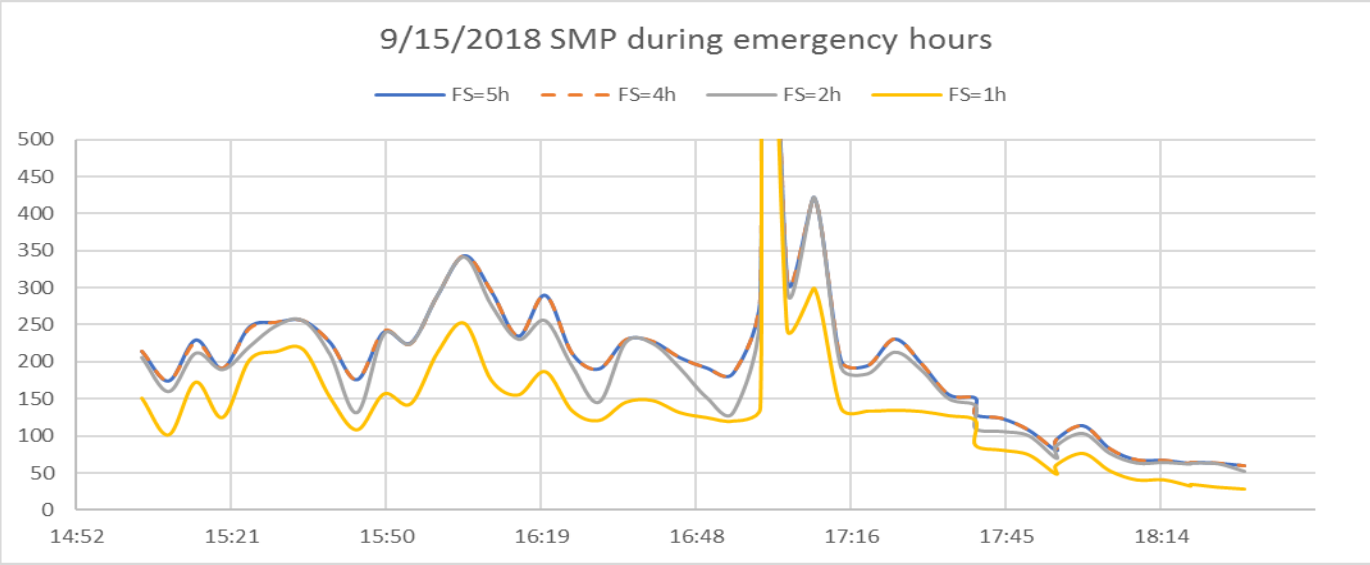
- It is common for operators to commit resources with notification + start-up times and minimum-run times between 1-4 hours during emergencies.
- Resources may be committed ahead of an anticipated shortage and are commonly dispatched at their EconMins for some time.

Solutions: Extend online FSR eligibility to four hours

MISO evaluated the price impacts of various ELMP FSR eligibility requirements. Specifically, resources with notification time and minimum run time between 1 to 10 hours were evaluated. Expanding the set of Resources eligible to set ELMP during declared Emergencies to include Resources with 4-hour or less startup and notification times can make the maximum impact.

Emergency Pricing Enhancements in 2020/2021 ---9/15/2018 Event Simulations

Since operations mainly call on units within 4-hour startup, increasing ELMP online fast start to 4 hour can best reflect the commitment actions



9/15/2018	Online FS=5h	Online FS=4h	Online FS=2h	Online FS=1h
Average SMP	$214.78	$214.67	$202.30	$153.72
Average # of online FS	196	188	127	58
Average online FS MW capacity	10843	9812	6613	2025