Price Formation

PJM Market Participants
February 14, 2019

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Monitoring Analytics

ISSUES WITH PJM ORDC

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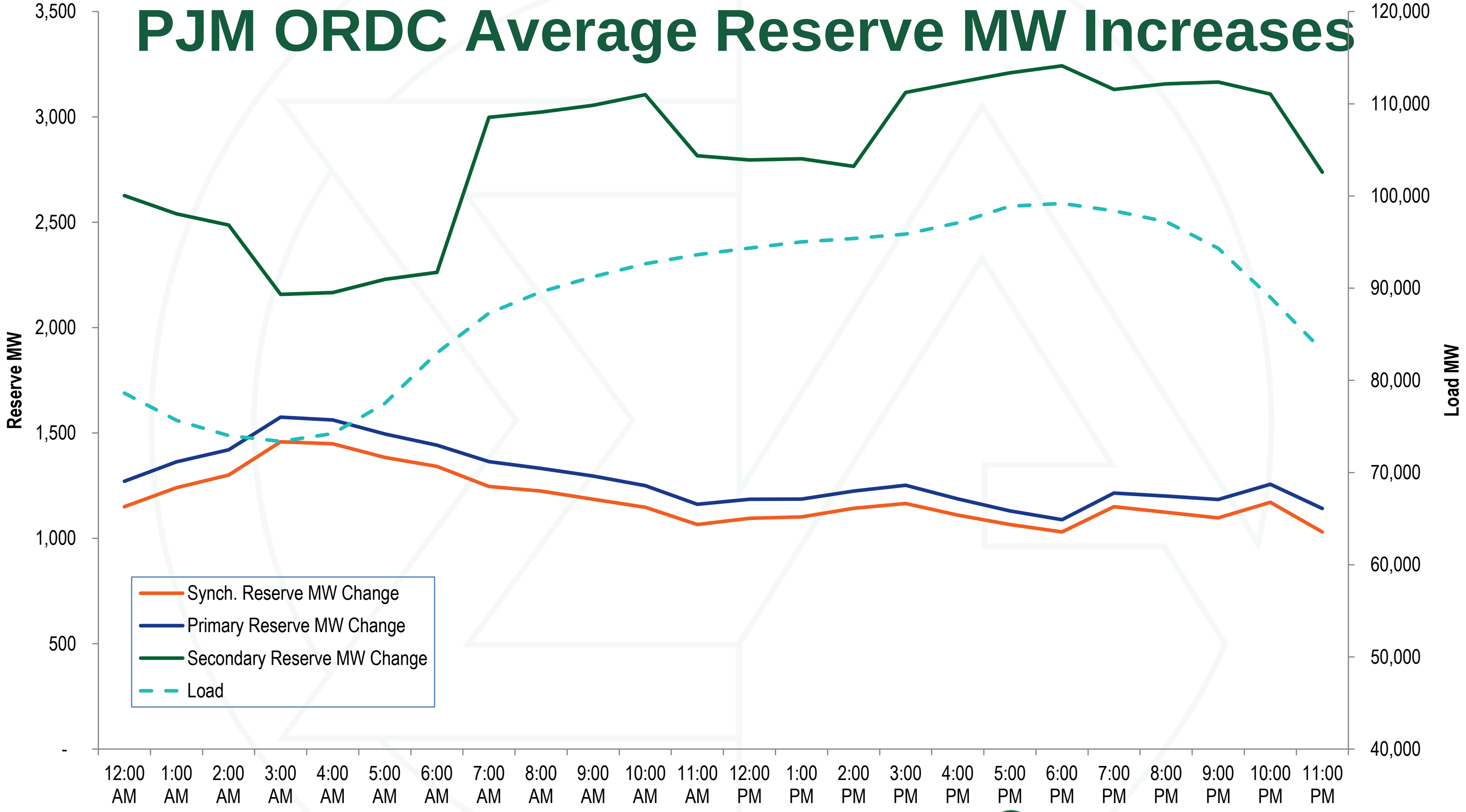
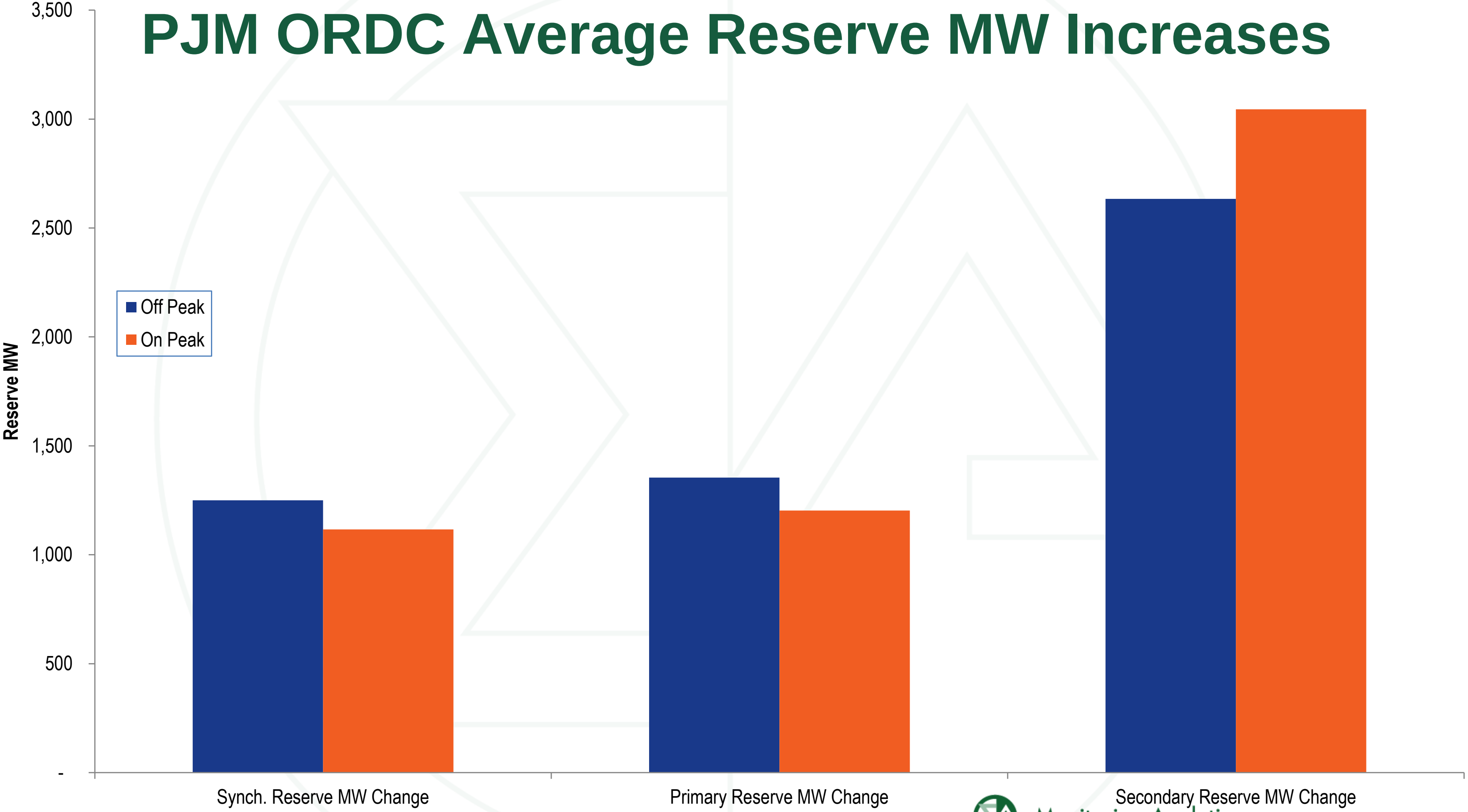
PJM ORDC Shape

- PJM's ORDCs persistently raise prices and procure additional reserves.
- The increases in prices and reserves are not limited to or tied to operator actions that would otherwise suppress prices.
- PJM's simulations show
  - Higher reserve levels in off peak hours
  - Similar LMP increase patterns for on and off peak hours
- PJM's proposal goes beyond addressing price formation for operator actions to raising prices all the time.

PJM ORDC Average Reserve MW Increases



PJM ORDC Average Reserve MW Increases



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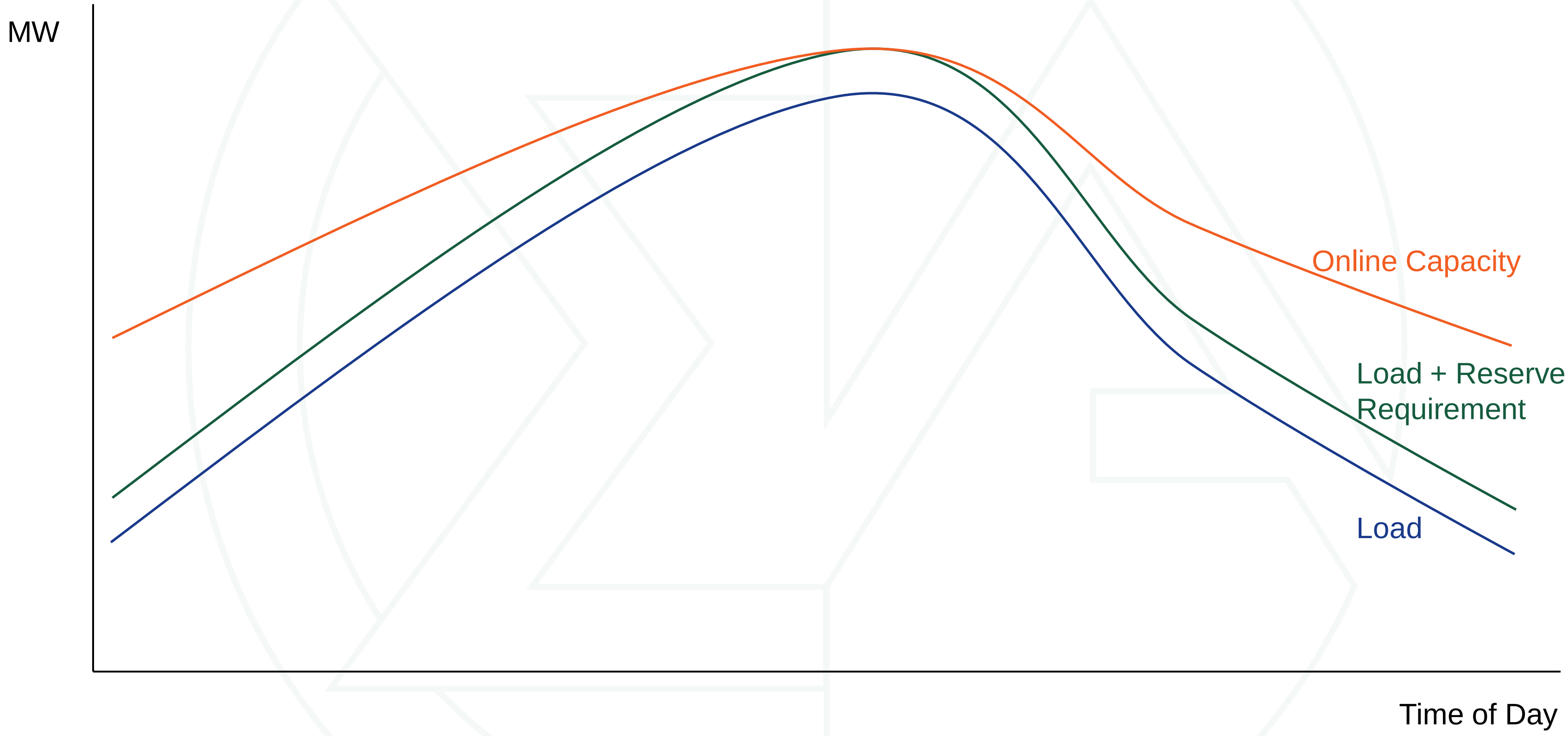
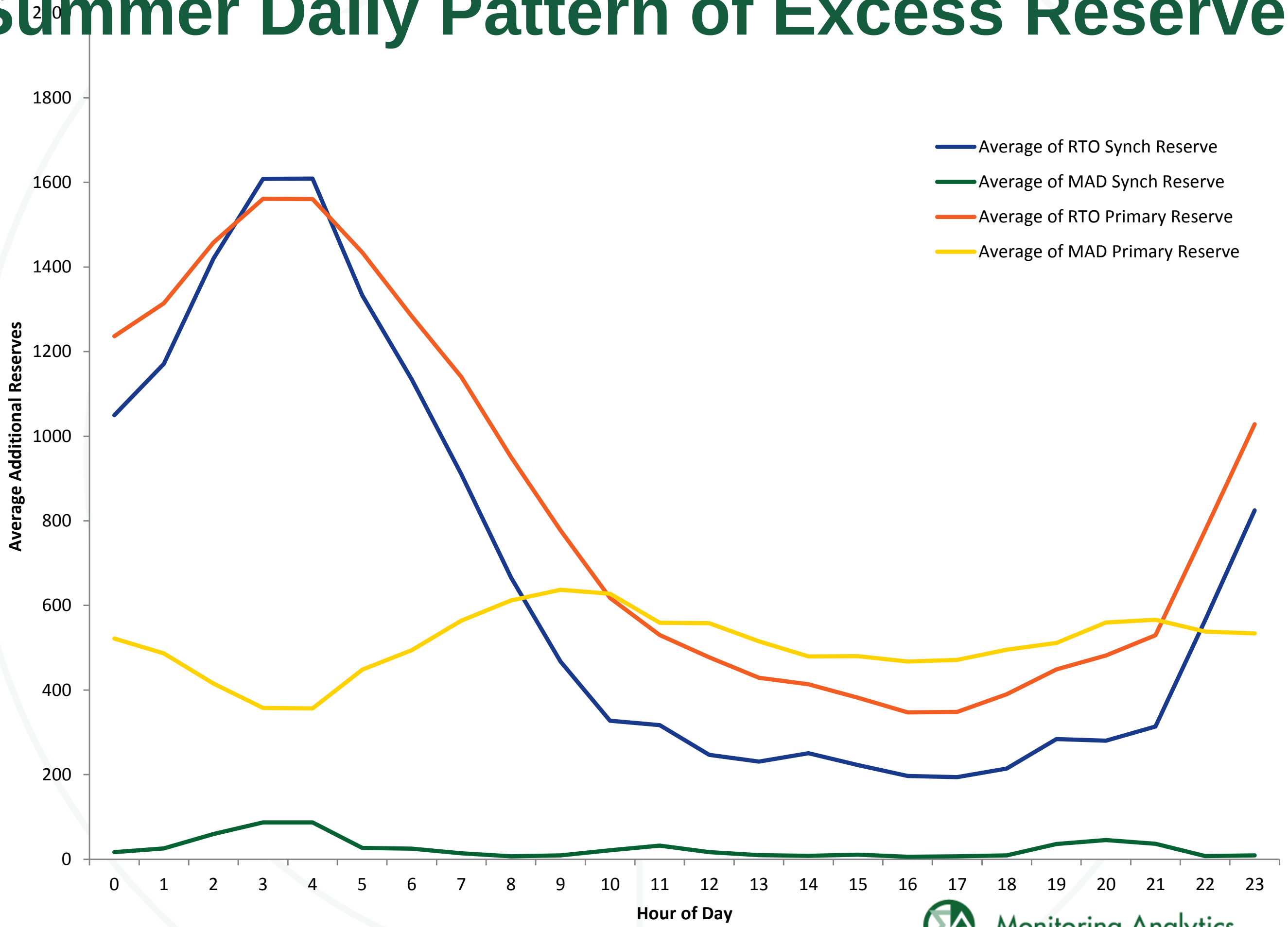
Daily Reserve Pattern



Summer Daily Pattern of Excess Reserves



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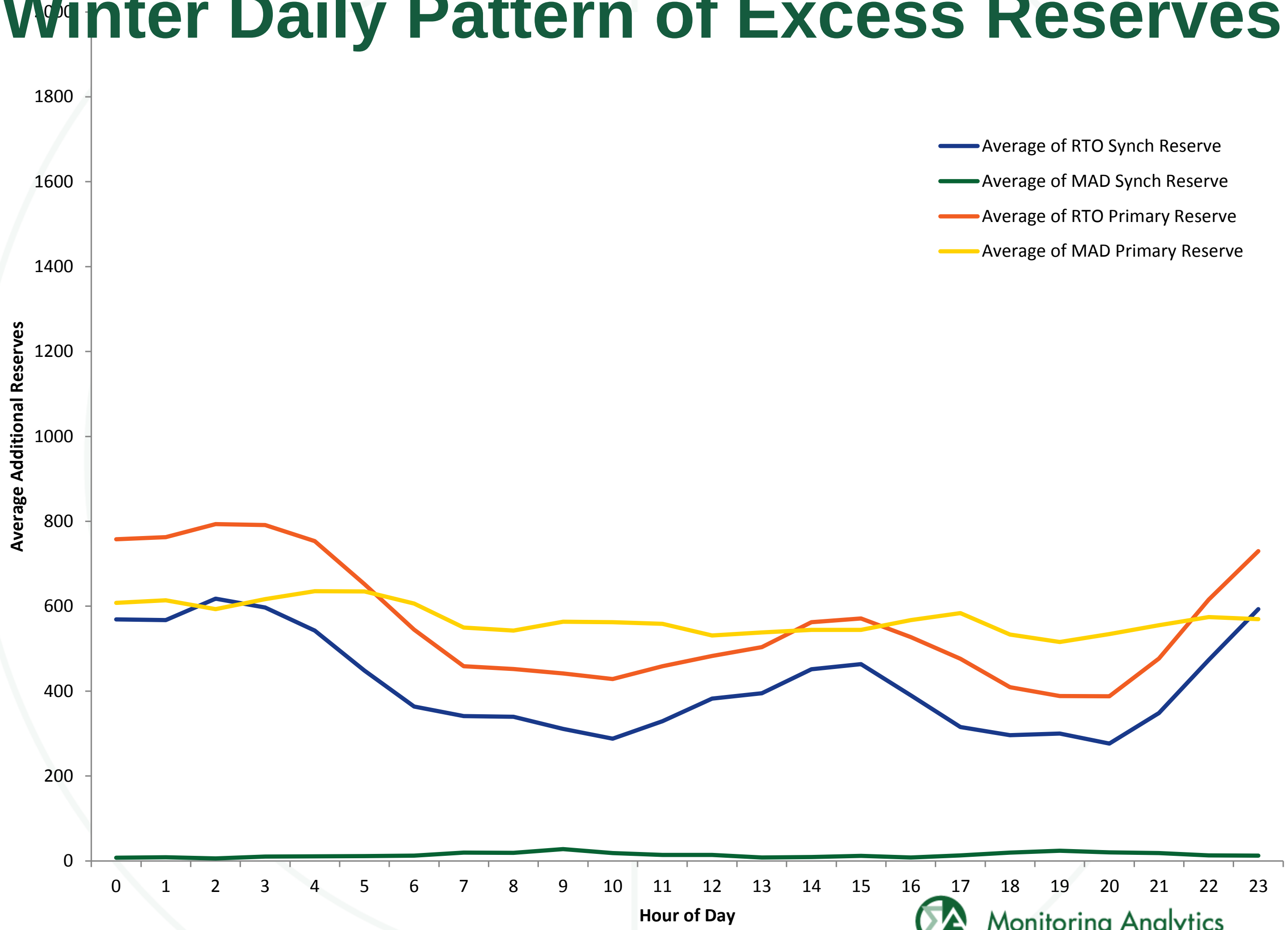
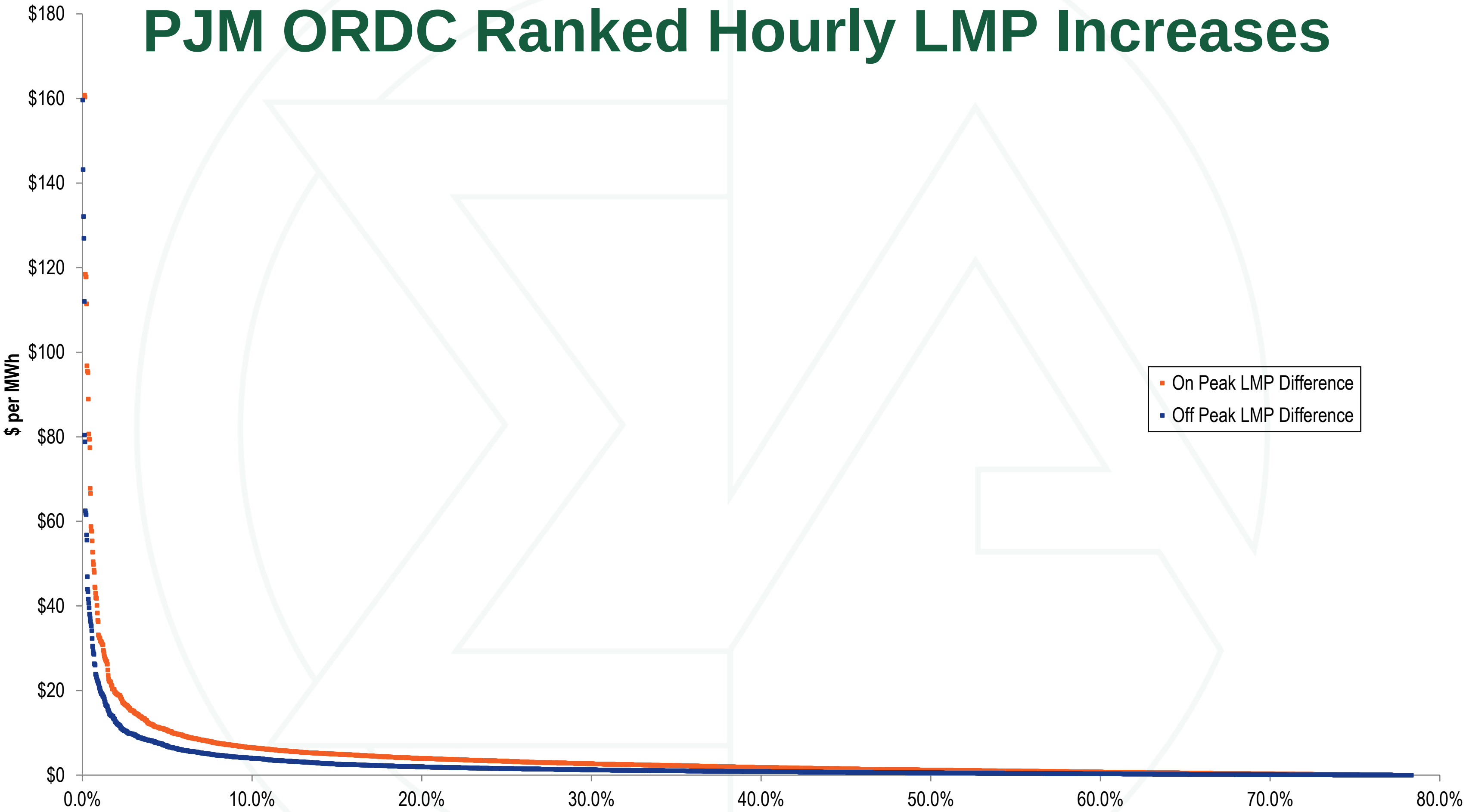
Winter Daily Pattern of Excess Reserves



PJM ORDC Ranked Hourly LMP Increases



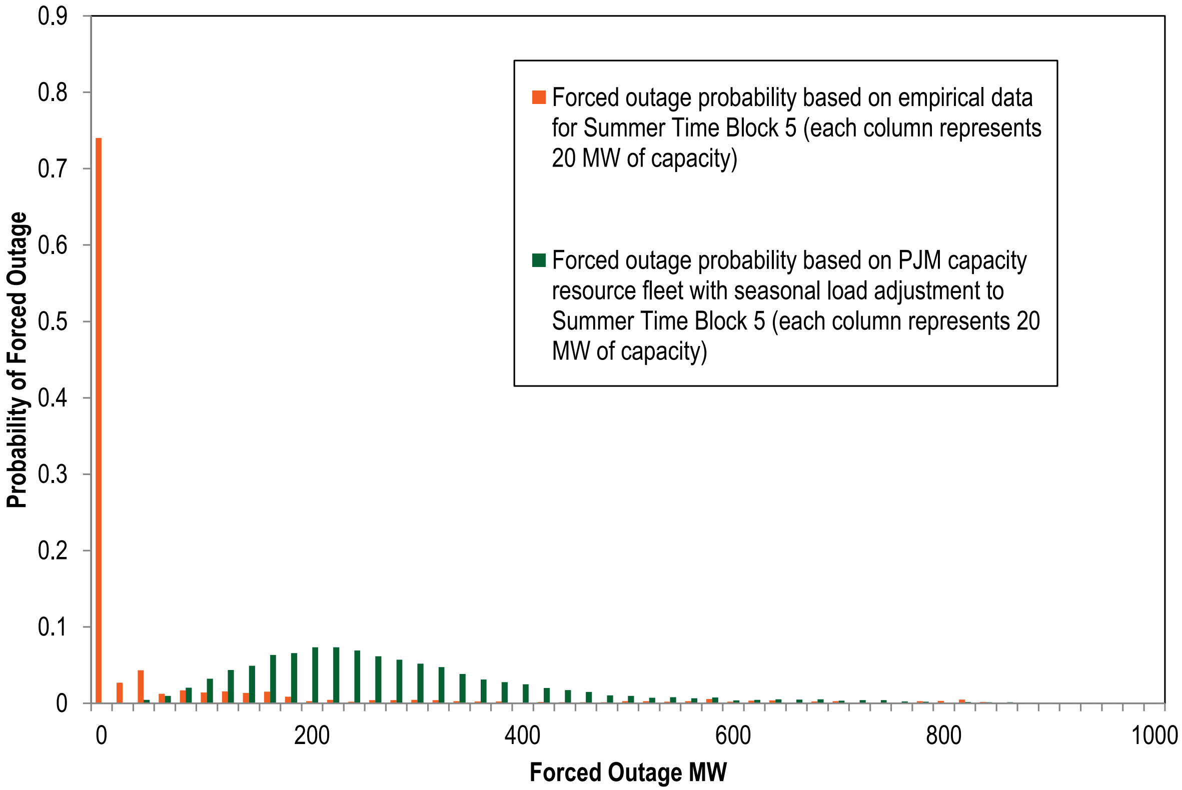
PJM Forced Outage Distribution

- PJM’s approach to the inclusion of forced outages in the ORDC is not accurate.
- PJM’s approach overstates the forced outage MW and the ORDC.
- PJM’s approach assumes that all units are always online.
- PJM’s approach misses the fact that there is a significant probability of zero outages for each 30 minute time horizon.
- The examples in this presentation show the issues with PJM’s approach.

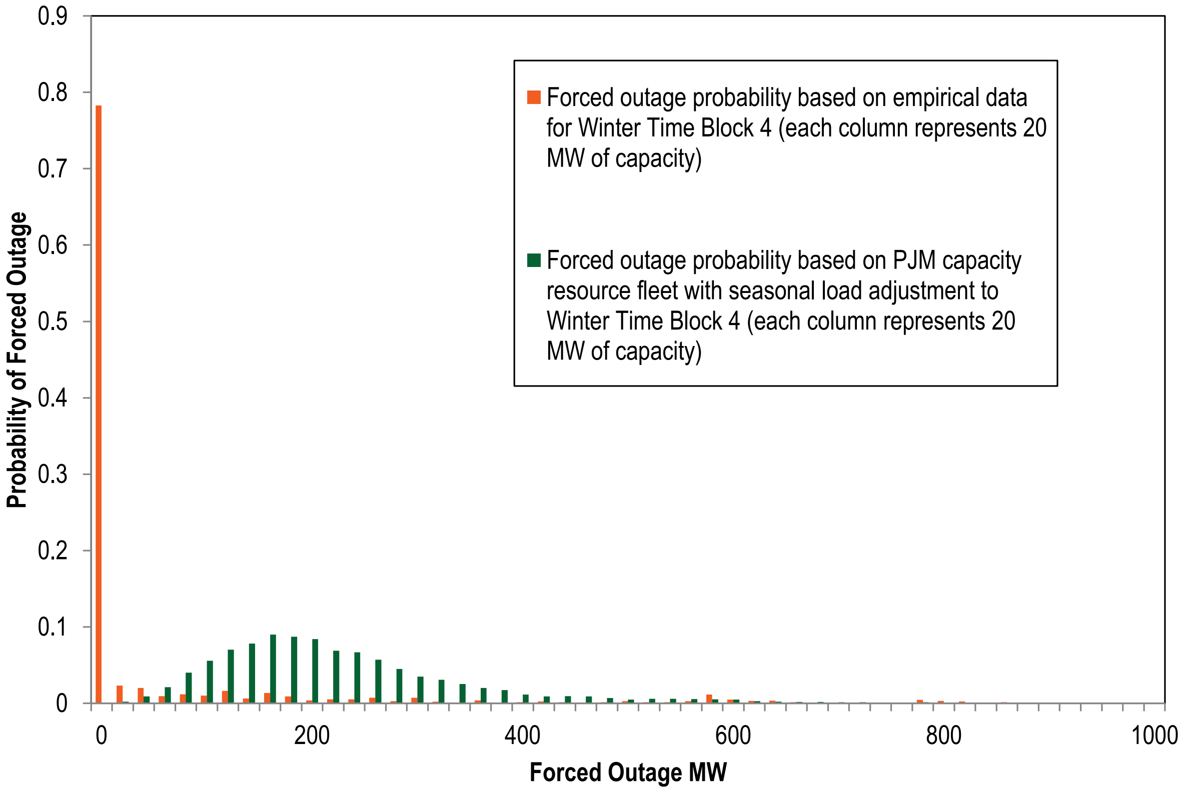
PJM Forced Outage Distribution

- The examples in this presentation show the impact of using outages based on actual data for the last three years.
- PJM's approach is not consistent with the actual data on the distribution of forced outages for PJM units.
- The impact is understated as Capacity Performance incentives were not fully in place during the past three years.
  - CP incentives are expected to reduced forced outage rates.

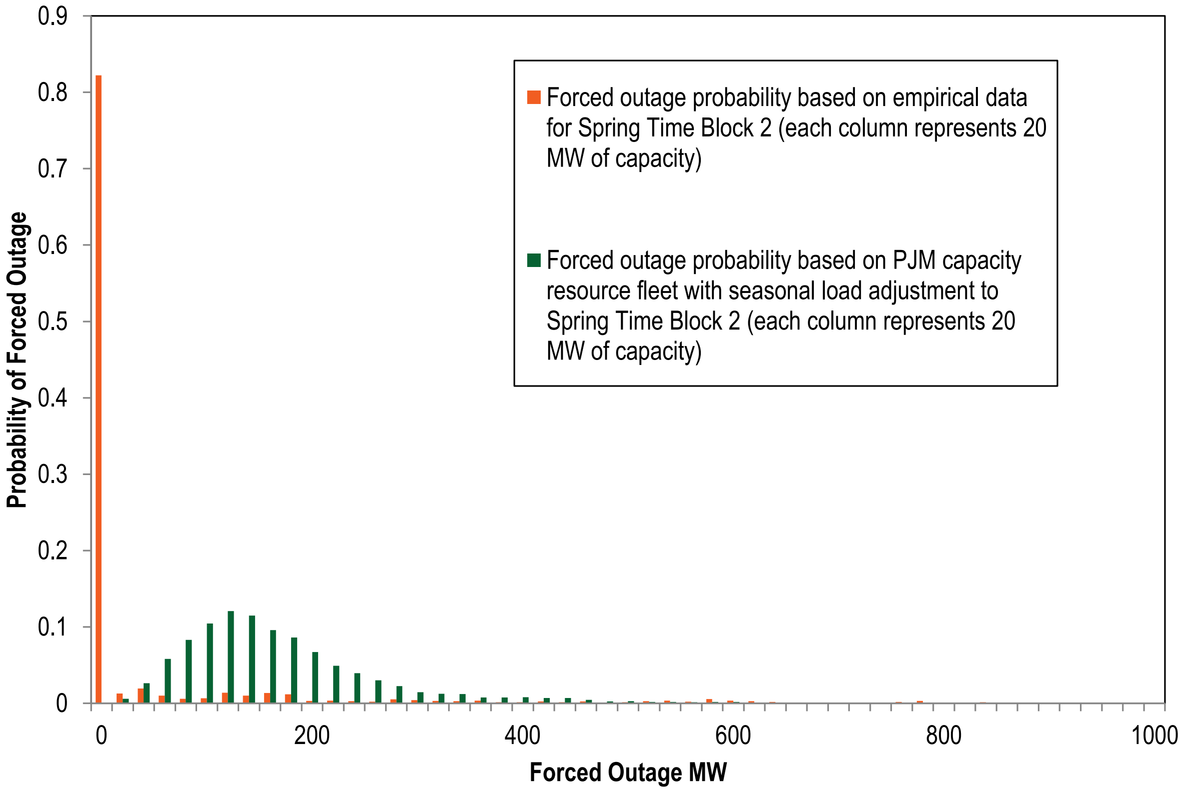
Forced Outage Distributions



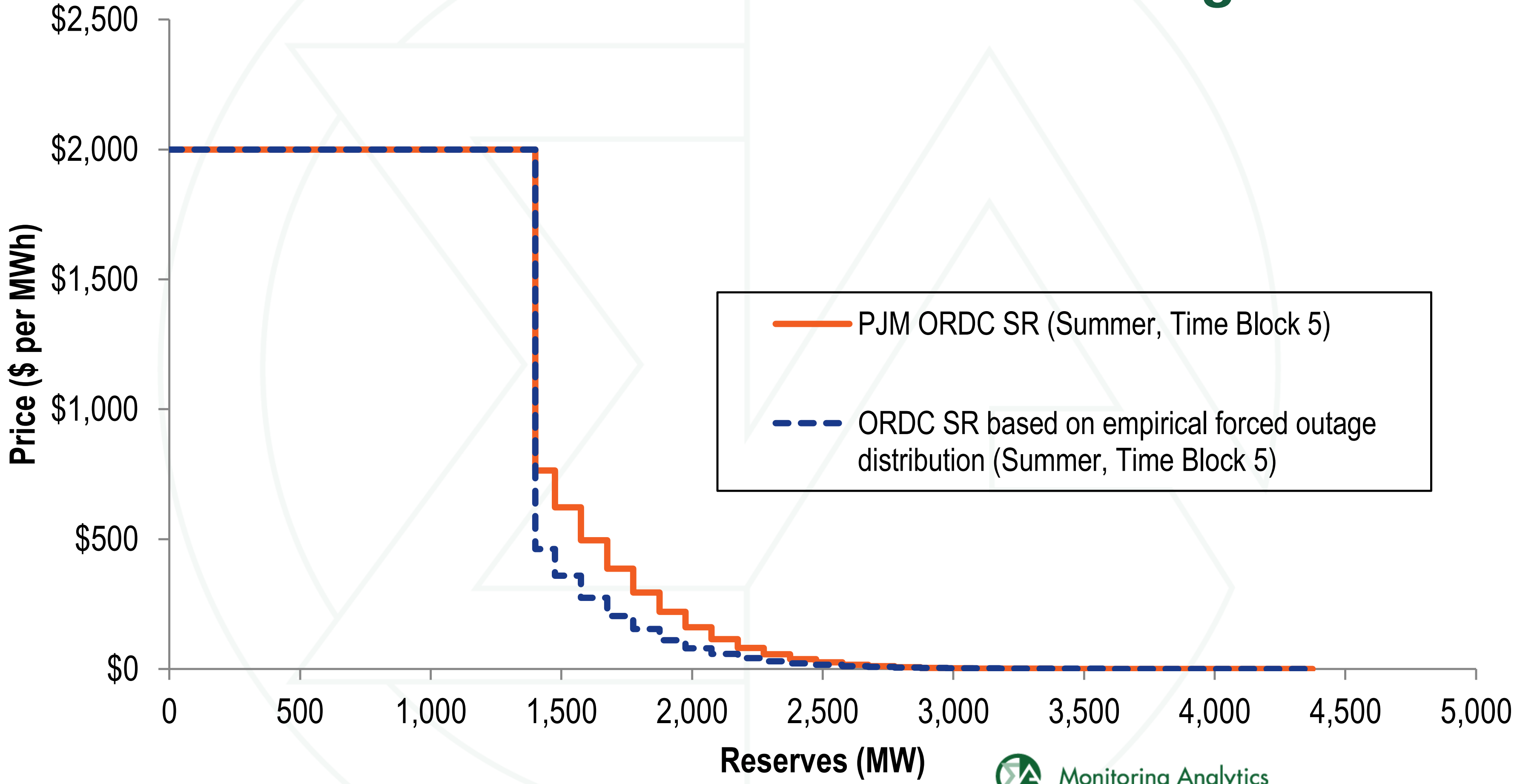
Forced Outage Distributions



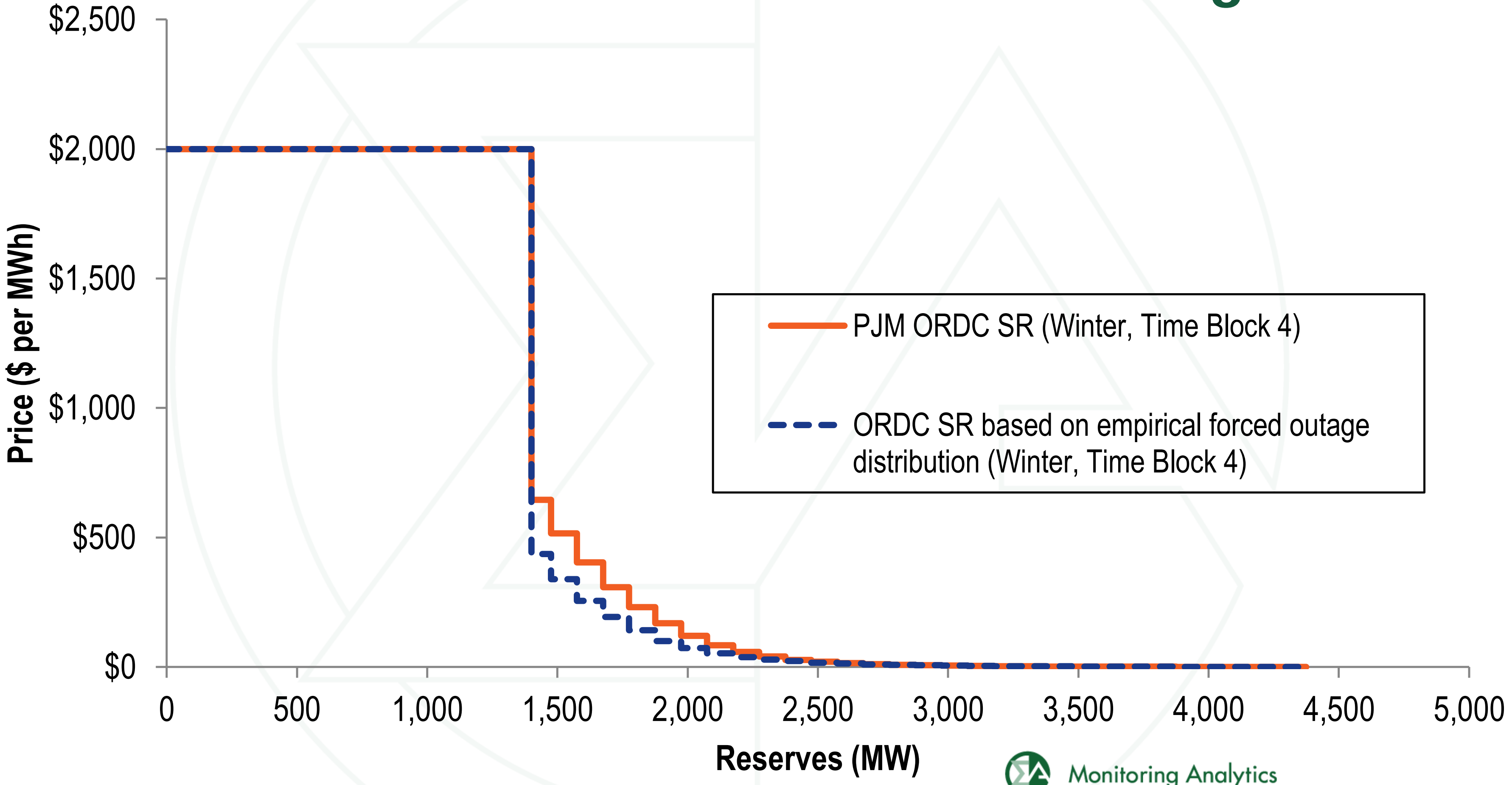
Forced Outage Distributions



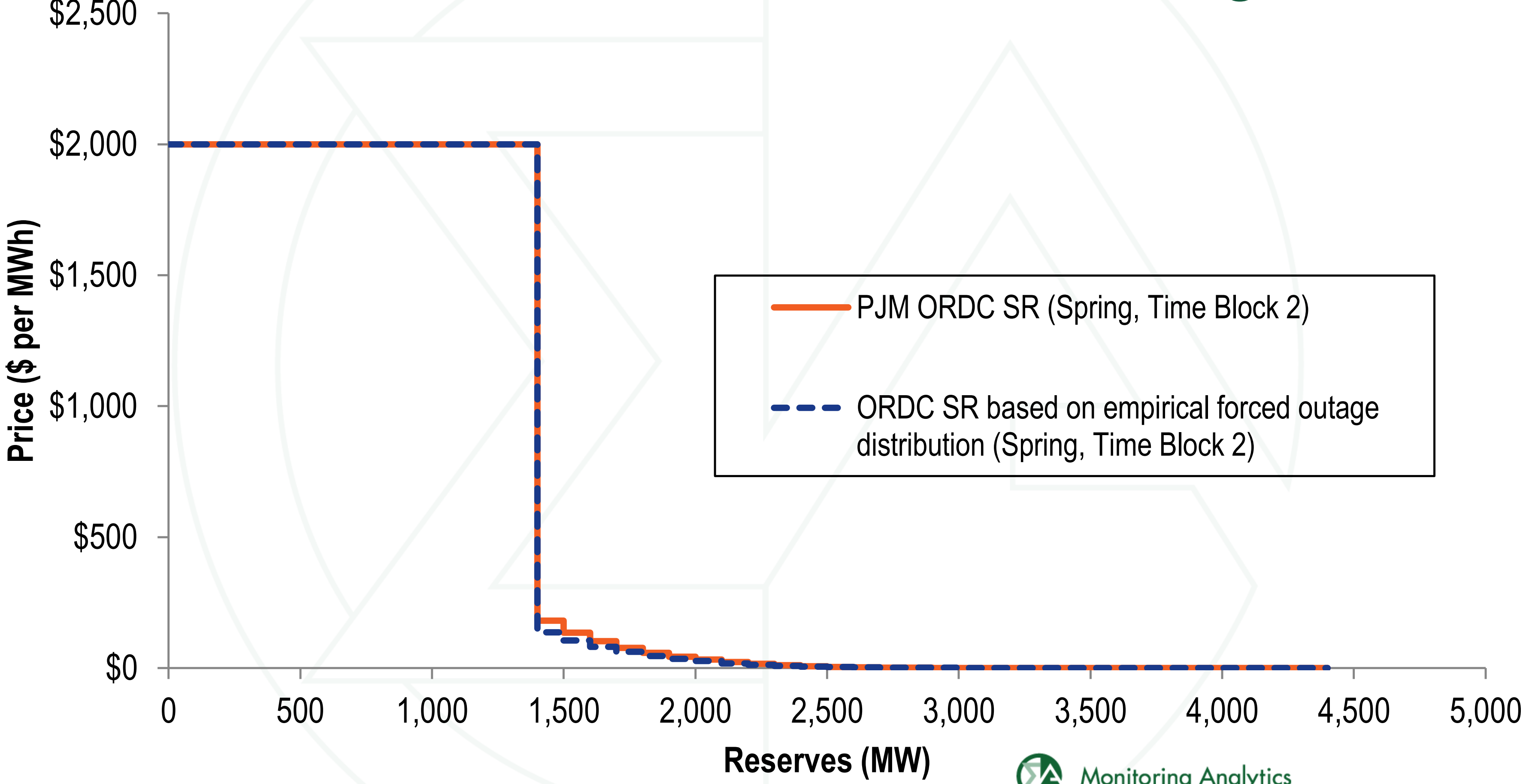
PJM ORDC with Corrected Forced Outage Rate



PJM ORDC with Corrected Forced Outage Rate



PJM ORDC with Corrected Forced Outage Rate



ORDC Price Comparison

		PJM Method Reserve Level (MW)			Using Empirical Forced Outage Distribution Reserve Level (MW)		
Season	Time Block	1500	2000	2500	1500	2000	2500
Summer	1	$213.7	$21.9	$2.7	$135.4	$24.3	$4.8
	2	$145.2	$29.3	$4.1	$100.8	$20.5	$3.0
	3	$206.0	$37.8	$6.1	$136.9	$27.9	$4.5
	4	$191.2	$24.0	$2.5	$101.3	$16.1	$2.3
	5	$622.5	$160.7	$25.3	$358.4	$79.7	$15.4
	6	$396.9	$114.1	$22.0	$244.6	$59.7	$11.0
Winter	1	$426.0	$69.1	$7.6	$282.0	$54.7	$10.9
	2	$304.3	$86.5	$26.1	$217.7	$68.2	$19.9
	3	$651.9	$196.2	$31.3	$459.7	$124.6	$24.8
	4	$515.4	$120.4	$19.6	$338.3	$73.2	$16.6
	5	$435.0	$170.9	$51.1	$316.0	$114.9	$30.9
	6	$300.6	$47.2	$4.1	$153.4	$25.2	$2.8

ORDC Price Comparison

		PJM Method Reserve Level (MW)			Using Empirical Forced Outage Distribution Reserve Level (MW)		
Season	Time Block	1500	2000	2500	1500	2000	2500
Spring	1	$183.7	$12.6	$0.9	$114.1	$16.9	$3.4
	2	$180.7	$42.3	$7.1	$136.7	$34.9	$5.1
	3	$495.5	$115.4	$20.5	$349.7	$81.4	$17.0
	4	$387.7	$50.2	$3.3	$218.2	$31.9	$4.9
	5	$202.1	$40.1	$7.8	$122.5	$28.3	$6.3
	6	$445.4	$186.9	$63.4	$337.0	$137.7	$44.1
Fall	1	$231.7	$18.1	$1.3	$148.2	$21.8	$5.9
	2	$232.2	$76.2	$19.4	$184.4	$61.7	$13.8
	3	$379.6	$56.7	$4.7	$234.4	$36.8	$3.9
	4	$327.7	$36.2	$1.7	$177.0	$23.8	$3.1
	5	$359.9	$131.6	$44.1	$252.6	$97.6	$28.2
	6	$282.6	$106.1	$28.1	$197.6	$77.1	$15.6

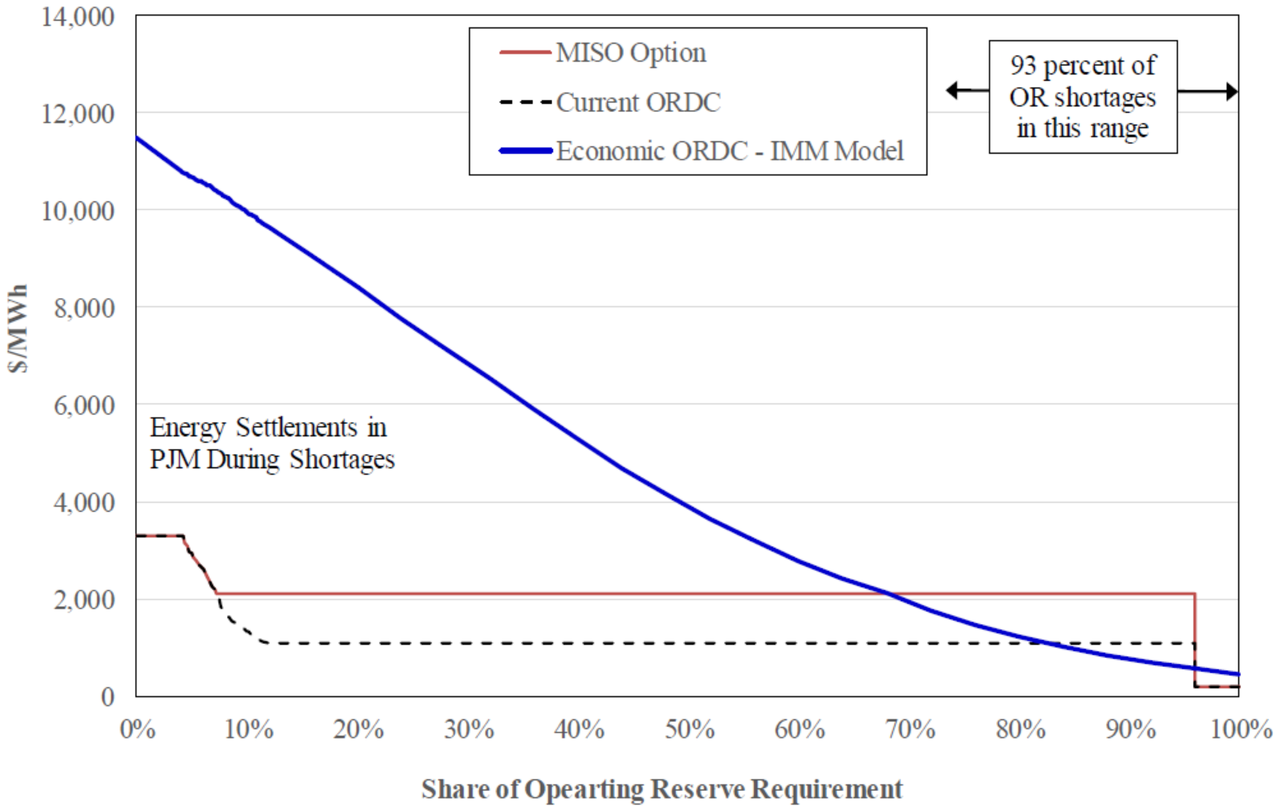
PJM ORDC Proposal

- PJM’s ORDC procures too many reserves and pays the reserves too much.
- The PJM approach is not similar to those used by other FERC jurisdictional RTOs
- With nesting of products and zones, PJM’s ORDC includes higher prices than ERCOT’s ORDC that is meant to substitute for a capacity market.
- The IMM proposes a more conservative ORDC than PJM’s approach.

Review of Other RTO ORDCs

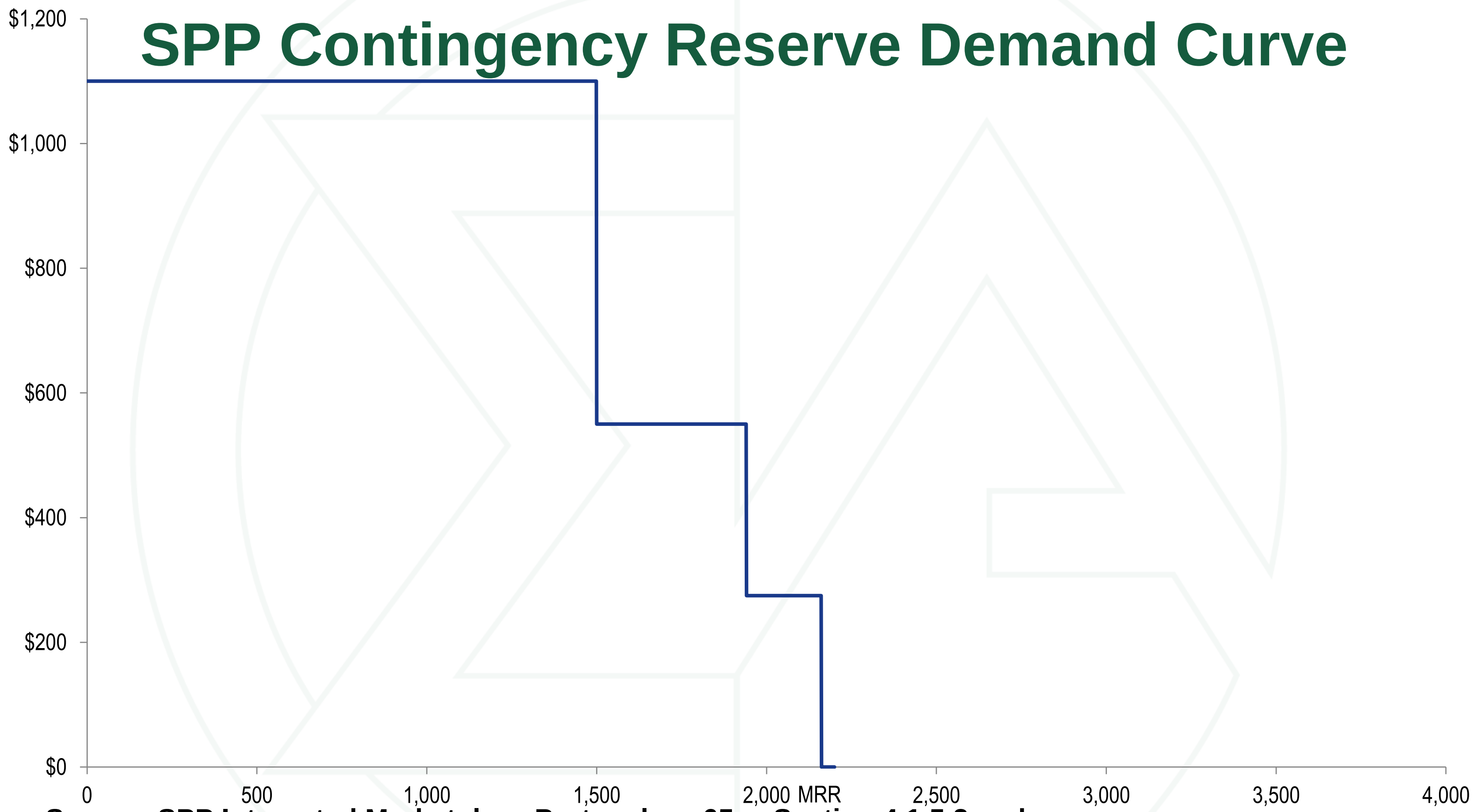
- ISO New England
  - Vertical demand up to penalty factor, no sloped curve
  - Escalating penalty factors for reserve subzones
  - Penalty factors differ by product up to $1,500 per MWh
- New York ISO, California ISO, Southwest Power Pool
  - Stepped demand curves for shortages only
  - Penalty factors $100 per MWh to $1,200 per MWh
- Midcontinent ISO
  - Sloped and stepped curve for shortages only

MISO and MISO IMM Proposed ORDCs



Source: Potomac Economics, 2017 State of the Market Report for MISO, p. 36.

SPP Contingency Reserve Demand Curve



Source: SPP Integrated Marketplace Protocols, v.65.a, Section 4.1.5.2 and https://marketplace.spp.org/groups/scarcity-demand-curve.

IMM PROPOSAL

Consolidated Synchronized Reserve Market

- PJM and IMM share most aspects of the proposal to consolidate the synchronized reserve market.
- Strong must offer requirement enforced by PJM
  - IMM also includes must offer penalty
- Lower offer margin for cost-based reserve offers
  - IMM eliminates the offer margin altogether
- Penalties for nonperformance during reserve events
  - IMM penalty is stronger than status quo PJM penalty

Demand Response

- **There should be no limit on the ability of DR to meet reserve requirements.**
- **PJM proposes to limit DR participation.**
- **PJM has in excess of 5,000 of 30 minute DR that PJM does not include in reserves.**

IMM ORDC Proposal

- **Simple ORDC: vertical demand with penalty factor**
  - **Consistent with precedent of other RTOs**
  - **Used for both synchronized and primary reserve**
- **No sloped curve, no extension beyond MRR**
- **Identical curves in day ahead market**
- **Max price equal to energy offer cap**
  - **$1,000 per MWh, unless PJM has approved a higher cost-based offer, per FERC rules**
  - **Increases at $250 per MWh increments with higher approved cost-based offers, up to $2,000 per MWh**

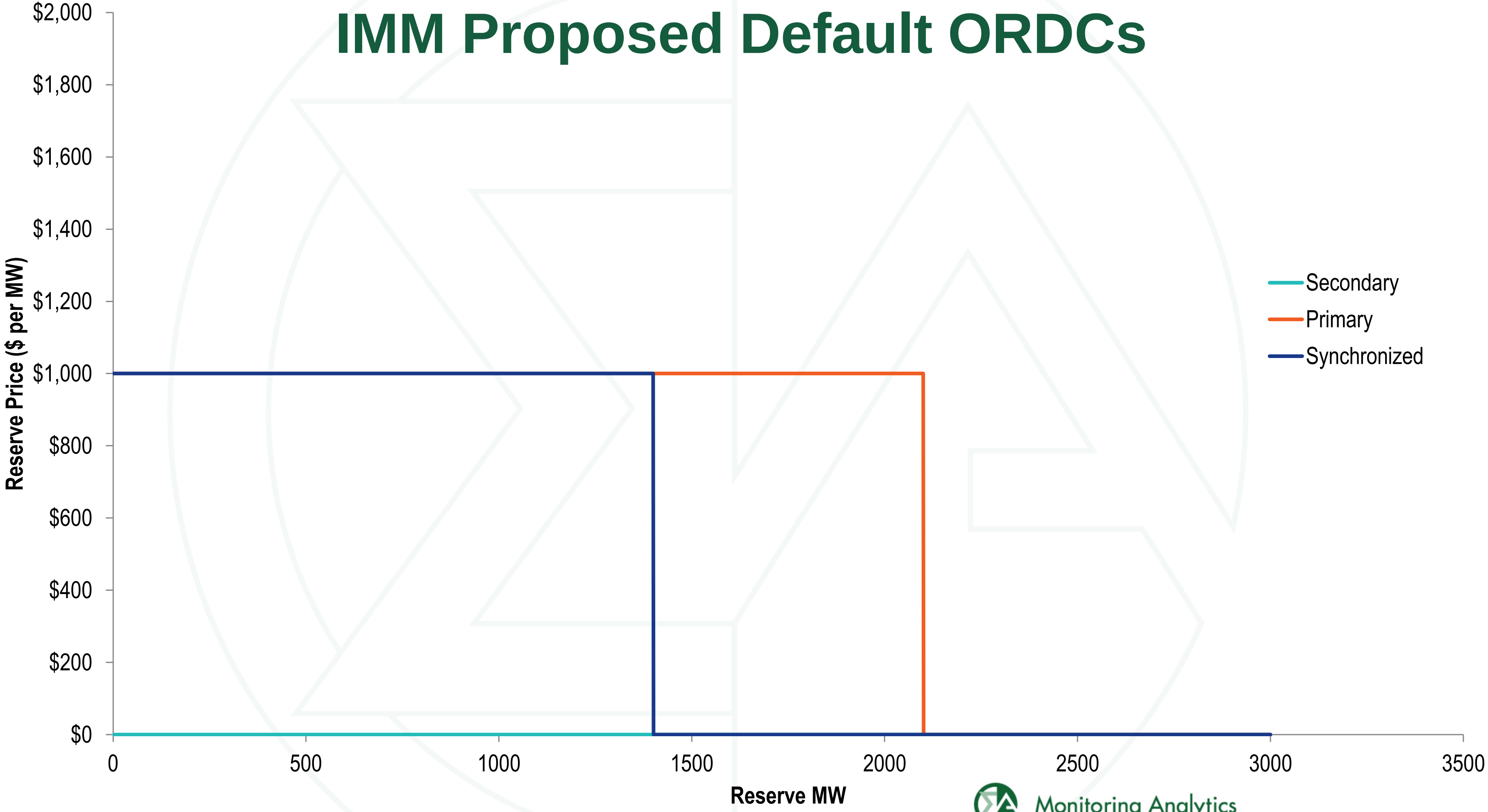
Operator Actions

- Operators may increase the minimum reserve requirements under predefined conditions.
  - Change in the largest contingency (Synch., Primary)
  - Extreme weather (Synchronized, Primary)
  - Gas contingencies (Secondary)
- The increased requirements will have defined start and end times.
- PJM will post on its website:
  - The active minimum reserve requirements
  - The reason for any increased reserve requirements
  - The beginning and end times for the increased reserve requirements

Secondary (30 Minute) Reserves

- Eliminate Day Ahead Schedule Reserves
- Default requirement is zero
  - Consistent with no NERC requirement
- Secondary reserves may be created with an ORDC based on a PJM defined contingency
  - such as a gas contingency
  - defined under the operator actions provisions for increasing a minimum reserve requirement
- Penalty factor is $1,000 to $2,000 per MWh, as with synchronized and primary reserves.

IMM Proposed Default ORDCs



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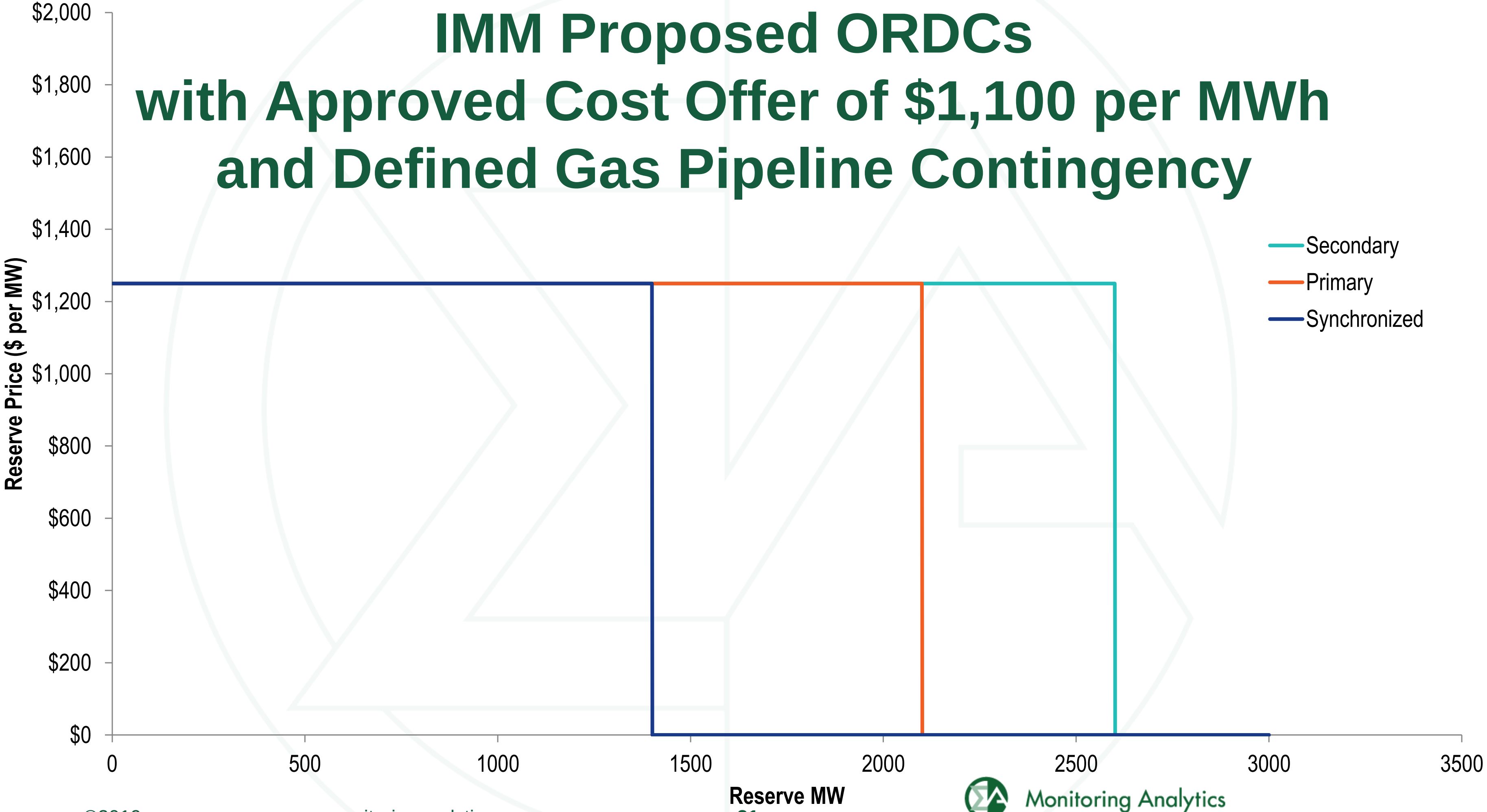
IMM Proposed ORDCs with Approved Cost Offer of $1,100 per MWh and Defined Gas Pipeline Contingency



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Reserve Subzones

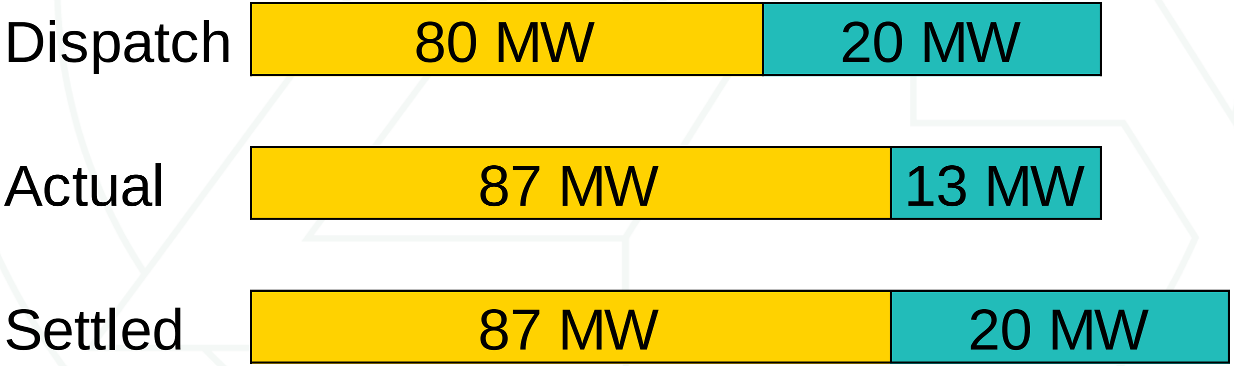
- **Additive reserve prices across products and zones, without a cap**
- **The IMM recommends multiple subzones, but PJM says it cannot model multiple subzones.**
- **The IMM proposal includes only one subzone.**
- **If PJM cannot model multiple subzones, it should not use a subzone for secondary reserves.**
  - **Secondary reserves only RTO wide**

Scarcity Revenue True Up Mechanism

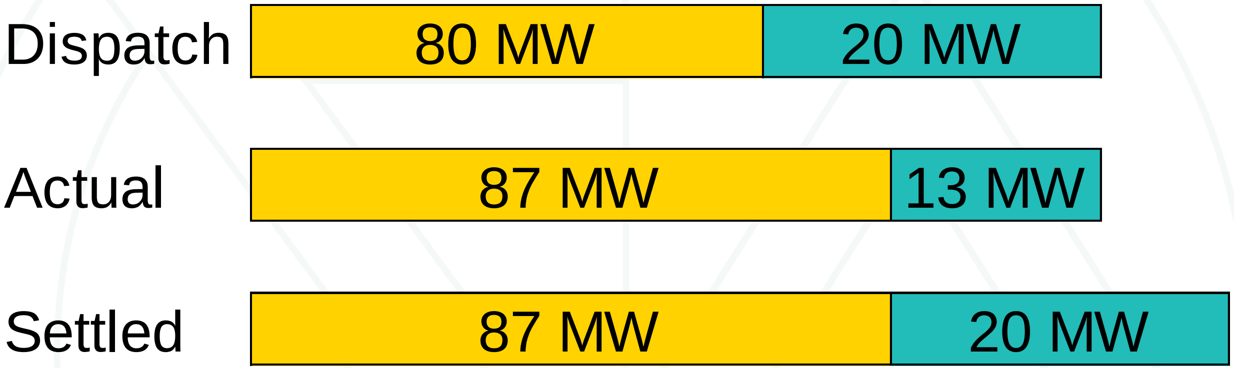
- IMM proposed true up mechanism returns energy market scarcity rents to customers during the four transition years.
- The true up mechanism continues until adequate capacity market changes
  - VRR curve capped at Net CONE
  - Forward looking E&AS offset
- True up delivery year capacity payments by scarcity rents calculated for the reference CT using actual delivery year energy prices to determine the accurate E&AS offset.

Double Payment Issue

- **Real-time energy is settled at the metered output.**
- **Reserves are settled at the dispatch output.**
- **A resource could receive compensation for energy and reserves beyond the resource's actual capability.**



Double Payment Issue



- **Resource receives payment for 107 MW when its capability is only 100 MW.**
- **Deviation is only 7 MW, or 7 / 80 = 8.75 percent, so PJM deems the resource to be following dispatch.**

Settlement Rule Preventing Double Payment

- **The IMM proposes a new settlement rule that a resource cannot receive payment for reserve MW in excess of its applicable economic maximum output limit for the dispatch interval.**
- **Pay the full value for metered energy produced, but would cap the settlement of reserve MW so that payment does not exceed the resource's stated capability.**

$$\boldsymbol{Metered\ Energy\ MW + Reserve\ MW \leq Eco.Max.}$$

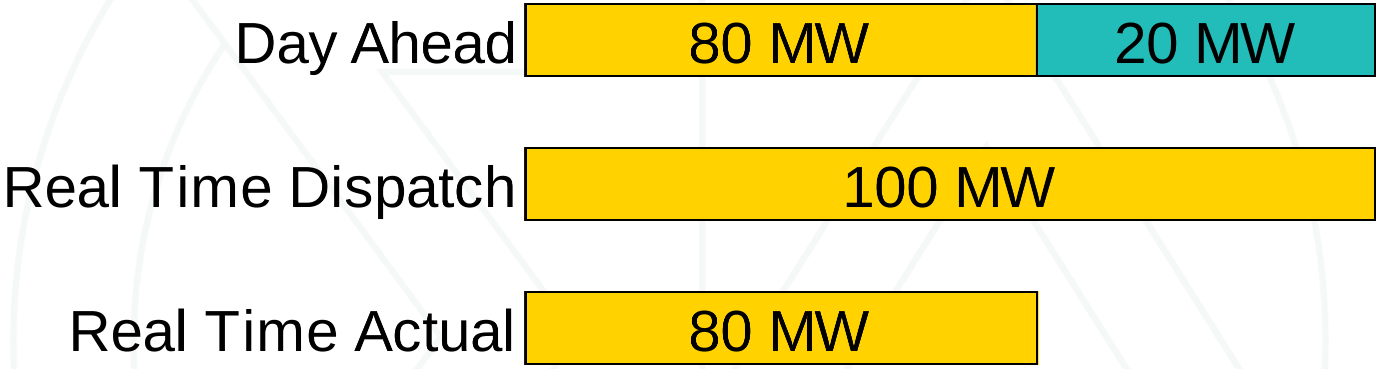
One Energy and Reserves Uplift Payment

- **Market incentives do not require a five minute negative balancing reserve uplift payment.**
- **The IMM proposes one daily uplift calculation that prevents resources that follow dispatch from operating at a loss without creating overcompensation.**
- **The calculation should include costs and revenues in all short term markets (energy, regulation, reserves).**
- **Incorporating reserves in the existing Balancing Operating Reserve Credit accomplishes this.**

Balancing Reserve Uplift Payment

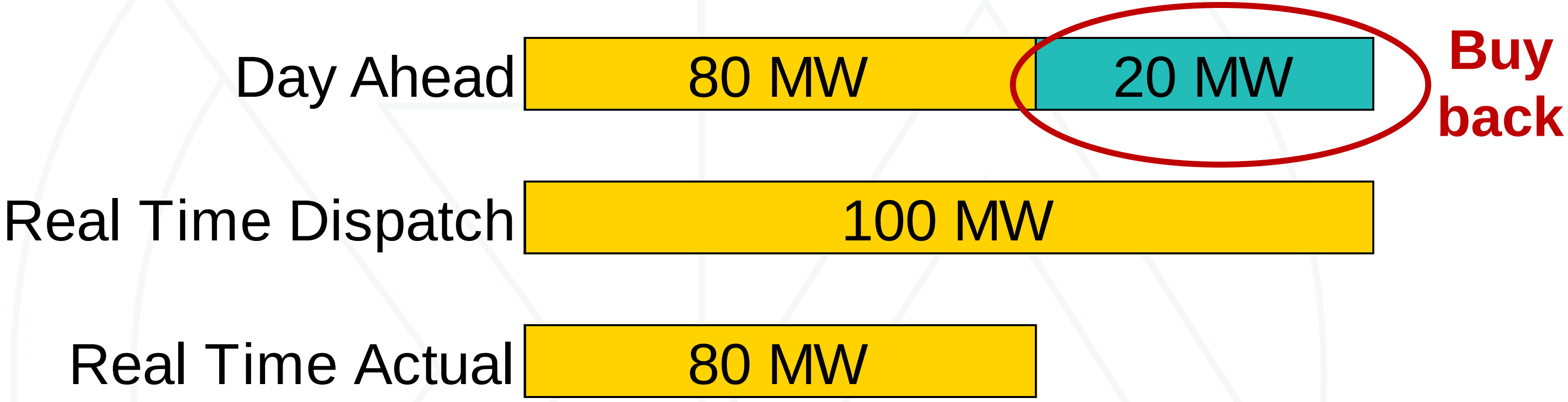
- PJM claims that market incentives for dispatch following require uplift for negative balancing reserve payments for each reserve product for every five minute interval.
- Market incentives do not require such payment.
- Reserves are compensated based on dispatch, not performance.
- PJM takes back the reserve position based on dispatch instructions whether or not the resource follows dispatch.

Balancing Reserve Uplift Payment



- **When the resource follows its day ahead dispatch it must buy back its DA reserve position and receives no balancing energy compensation.**

Balancing Reserve Uplift Payment



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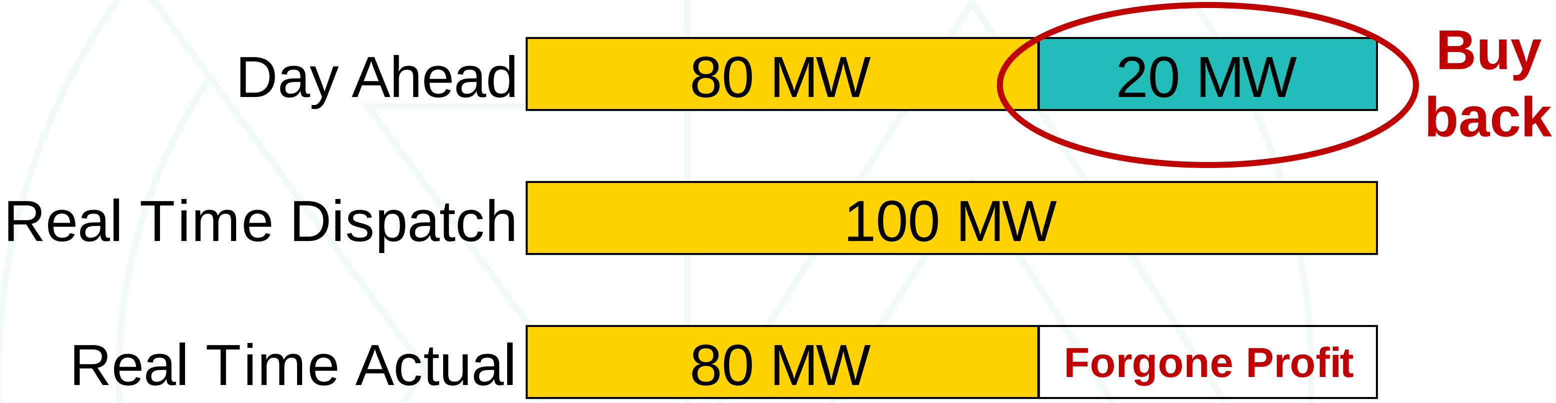

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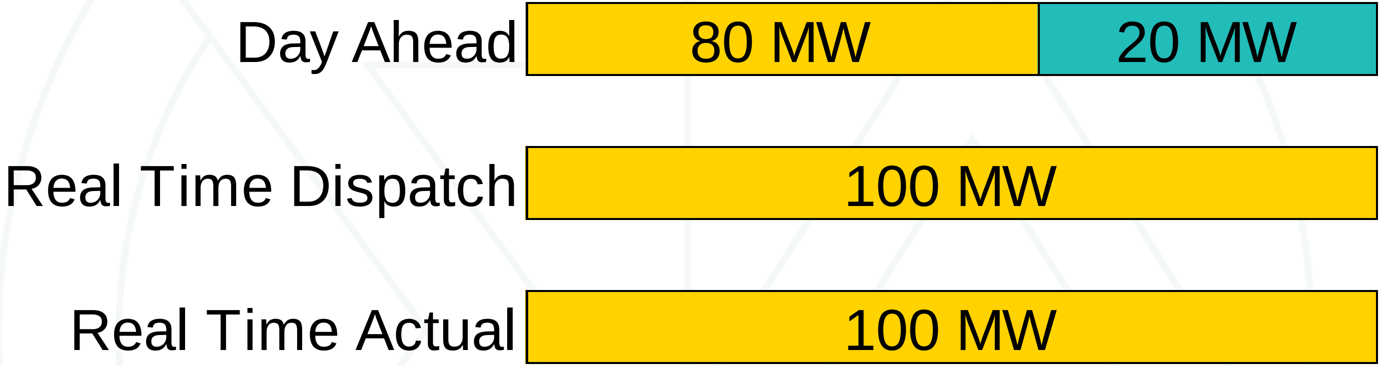
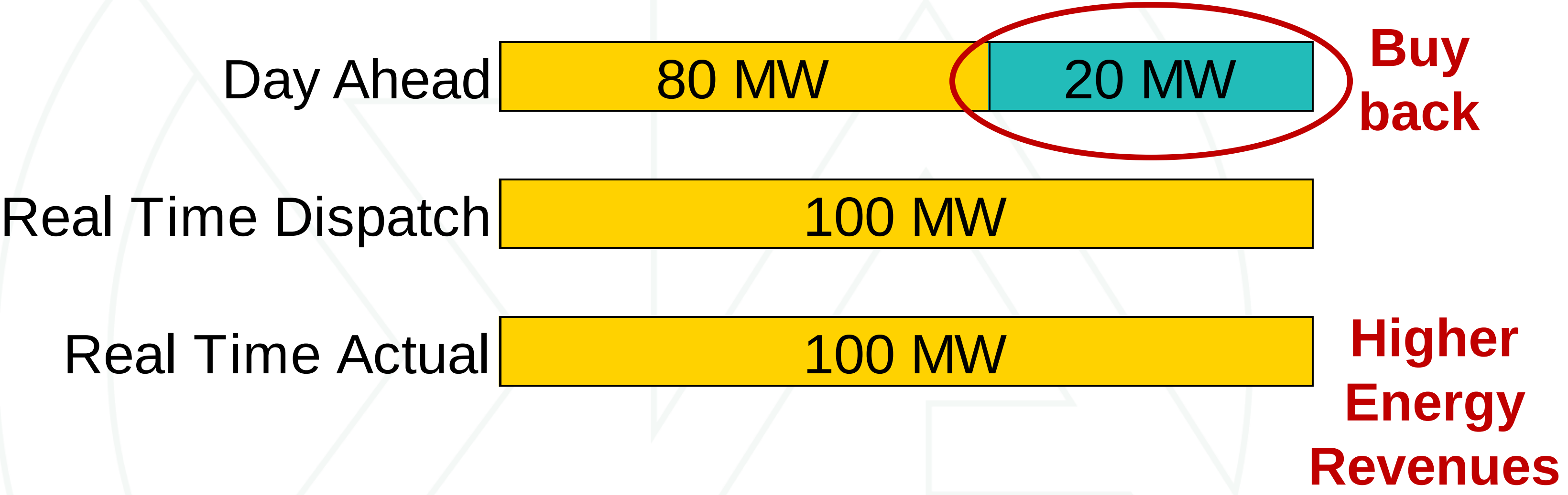


- **When the resource follows its real time dispatch, it must buy back its DA reserve position, which is offset by balancing energy revenues.**

Balancing Reserve Uplift Payment



- **When the resource follows its real time dispatch, it must buy back its DA reserve position, which is offset by balancing energy revenues.**

Following Dispatch

- PJM does not currently have the ability to automatically monitor, identify, and measure whether generators are following dispatch.

- As a result uplift eligibility is not properly enforced and generator deviations are inaccurately calculated.

- PJM's process for determining whether a resource follows dispatch is not an adequate or accurate basis for settling five minute reserves and five minute uplift.

Day-Ahead and Real-Time

- **The match between day-ahead and real-time markets will matter under PJM's proposed ORDC approach.**
- **PJM proposes to pay uplift on a five-minute standalone basis without any offsets during the day, during the hour or during the minimum run time.**
- **The day-ahead and real-time models differ in significant ways.**

Day Ahead Model

- **In 2018, on average, line limits were specified for 29.5 percent of the transmission elements in the network model used for day ahead market clearing.**
- **The line limits for the remaining transmission elements were set at such high levels that they could not bind in the day ahead market.**

Real Time Constraints

- In 2018, 56 percent of real-time constraint hours did not have a corresponding day-ahead constraint hour.
  - Accounting for matching hours and constraints, 56 percent of real-time constraints did not bind in the day-ahead market.
- Congestion is different in the real-time market than in the day-ahead market.
- The result of different binding constraints and congestion will be that different units are dispatched for energy and reserves in day-ahead and real-time markets with corresponding deviations.

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