Energy & Reserve Pricing Solution Overview

Energy and Reserve Pricing Solution

The proposed Energy and Reserve Pricing Solution is comprised of three parts

- Day Ahead resource commitment changes
- Day Ahead Scheduling Reserve requirement changes
- Synchronized Reserve and Primary Reserve requirement changes

Proposed DA Resource Commitment Changes

Commit long lead resources scheduled for the next operating day in the DA market based on the schedule dictated by PJM operations

- Trigger: hot weather alert, cold weather alert or more significant emergency procedures AND long lead resources have been scheduled and are still needed
- Daily checkpoint at 10am to decide which long lead time resources are still needed

Why?

- If resources scheduled outside the DAM are not committed in the DAM clearing, there is still a mismatch between DA and RT in the resources meeting system needs and consequently those setting market clearing prices.
    - This is equivalent to not capturing operator actions in LMP – but this is DA LMP rather than RT LMP

Proposed DASR Requirement Changes

Increase the Day Ahead Scheduling Reserve requirement on “peak” days by the hourly difference in submitted fixed demand and forecasted RT load

- Trigger: hot weather alert, cold weather alert or more significant emergency procedures

Why?

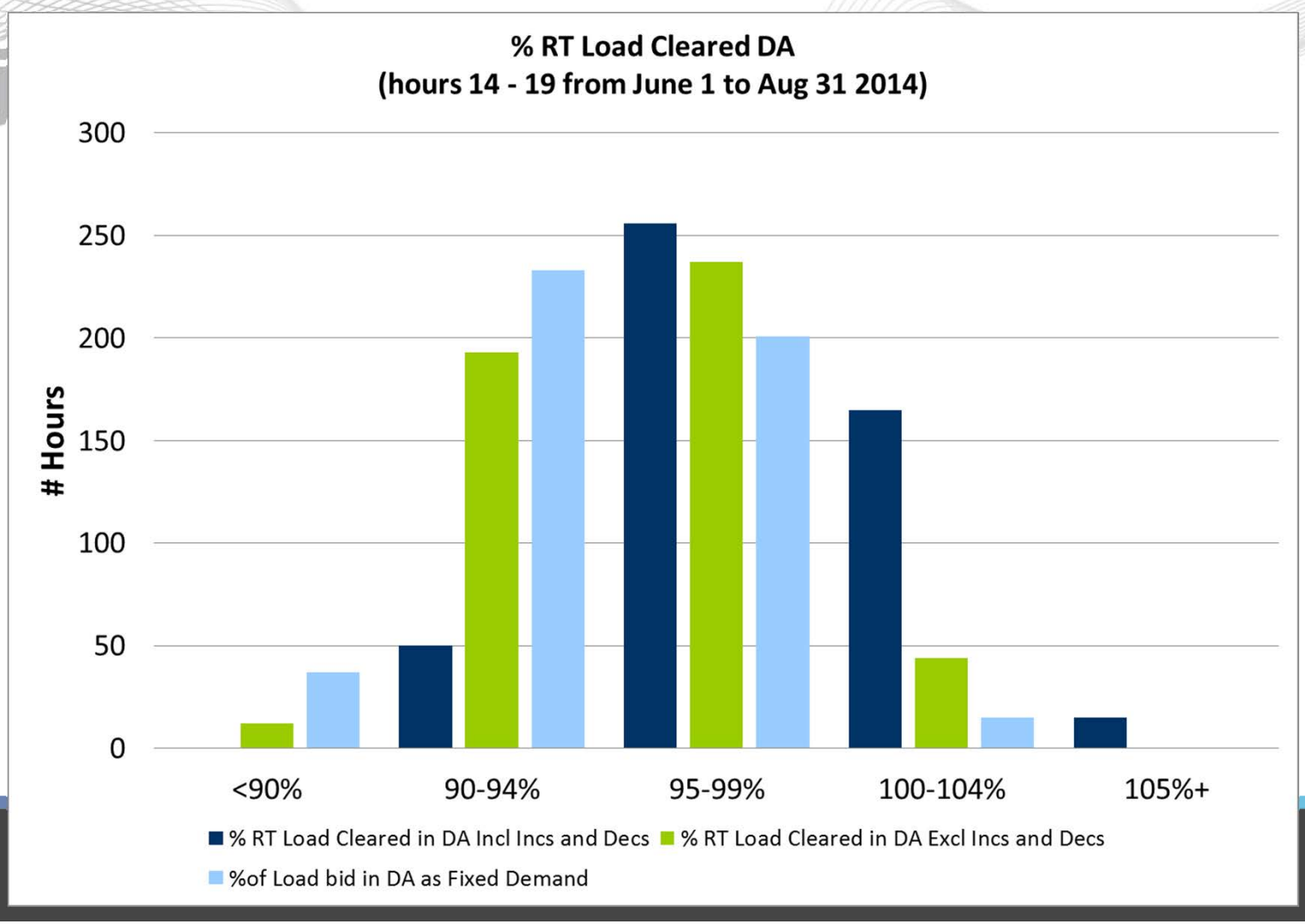
- Increasing the DASR requirement by the expected difference in load ensures that we schedule enough capacity to meet RT Load while also scheduling enough reserves to meet the average LFE and FOR and our normal 10-minute reserve requirements
  - Currently LFE and FOR make up the 6.27% DASR requirement

Proposed Synch and Primary Reserve Changes

The proposed real-time reserve changes are a more flexible version of the short-term solution

	Short-term Solution	Long-term Solution
Trigger	Emergency conditions plus significant additional reserves have been scheduled	Emergency conditions plus additional reserves were committed after the close of the DA market
Increase in SR and PR requirements by:	1300 MW	Sum of additionally scheduled capacity
Shortage Pricing	Yes – when short the extended requirement	Yes – create second, lower step on the SR and PR demand curves

Day ahead design features to be revisited


% RT Load Cleared DA
(hours 14 - 19 from June 1 to Aug 31 2014)
Hours
300
250
200
150
100
50
0
<90%
90-94%
95-99%
100-104%
105%+
% RT Load Cleared in DA Incl Incs and Decs
% RT Load Cleared in DA Excl Incs and Decs
%of Load bid in DA as Fixed Demand

DASR Requirement Increase

The amount added to the DASR requirement will be based on the difference between submitted fixed demand bids and projected RT load for each hour

- Increase would be floored at zero, in the event that submitted fixed demand exceeds projected RT load

Example from 6/18/2014:

Hour	Fixed Demand	Projected RT Load	Amount added to DASR Requirement
0	88,763	100,731	11,968
1	83,266	94,579	11,313
2	79,516	90,346	10,831
3	77,176	87,657	10,481
4	76,892	86,890	9,998
5	80,053	89,480	9,428
6	85,681	94,818	9,137
7	93,873	102,564	8,691
8	100,746	109,693	8,947
9	107,617	116,617	9,000
10	114,677	123,404	8,727
11	120,733	128,656	7,923

Hour	Fixed Demand	Projected RT Load	Amount added to DASR Requirement
12	125,579	131,964	6,385
13	129,164	134,229	5,065
14	131,528	136,200	4,672
15	132,593	138,321	5,728
16	132,767	139,492	6,725
17	131,238	139,049	7,811
18	128,068	136,269	8,201
19	123,745	131,394	7,649
20	120,842	126,597	5,755
21	117,147	122,575	5,428
22	108,341	113,229	4,889
23	97,445	102,589	5,144

DASR Requirement Increase

Beyond the difference between fixed demand and RT load, the DASR requirement may be further increased to capture additional reserves scheduled by PJM operators in advance of the Day Ahead market

Example:

- Operators schedule 4000 MW long lead generation to meet projected load
- Operators schedule 1000 MW additional generation as reserves in response to operational uncertainty. This capacity is scheduled to be online from noon through the end of the day.
- Additional 1000 MW will be added to the DASR requirement for hours 12 - 23

Cost Allocation Options

1. Status Quo
   - Allocate all charges to real-time load

2. Modified Allocation
   - Two buckets
     1. Charges for base requirement allocated to real-time load
     2. Charges for additional DASR requirement allocated to differences in Day-ahead demand and Real-time load when Day-ahead demand is less than Real-time load
        - Day-ahead demand is the sum of fixed and price sensitive demand bids

Status Quo

- Costs for Day-ahead Scheduling Reserves are allocated according to load ratio share
  - Similar to the Regulation and Synchronized Reserve markets, each Load-Serving Entity would carry an obligation to purchase Day-ahead Scheduling Reserve equal to its obligation ratio share of the RTO requirement
- Charges are based on the MW obligation carried by each LSE

DASR Billing Line Items

- Day-ahead Scheduling Reserve Credits
  - DASR Credit = DASR Eligible MWh * DASR Hourly Clearing Price
  - Any excess revenues above the offer will offset BOR credits

- Day-ahead Scheduling Reserve Charges
  - Hourly DASR Obligation MWh = Customer's Real-time load ratio share * Total DASR Eligible MWh
  - DASR Charge = Total DASR Credits * DASR Obligation Ratio Share

Modified Allocation Example

August 27, 2014 Simulation

- DASR requirement = 7,617 MW — 60% of total
- Additional requirement = 5,060 MW — 40% of total
- Total DASR requirement = 12,617 MW

Assume for HE 17 the total hourly DASR Credit is $100,000

- $60,000 is allocated to load based on the status quo charge allocation
- $40,000 is allocated to the demand difference

Modified Allocation Example

Participant	Demand Difference between DA and RT (MW)	Load Ratio Share of Difference	Hourly Charge
A	40	0.20	$ 8,000.00
B	50	0.25	$ 10,000.00
C	60	0.30	$ 12,000.00
D	30	0.15	$ 6,000.00
E	20	0.10	$ 4,000.00
	Total: 200 MW		$ 40,000.00

Modified Allocation

What happens if there are credits that need to be allocated against the additional DASR MW requirements but all participants are long in that hour ?

- Those dollars will be allocated to real-time load per the status quo charge allocation.

DASR Changes Matrix

#	Design Components[1]	PJM Proposal	
	Day Ahead Scheduling Reserve Changes		
1	Clear DASR based on Emerg Max or Eco Max of resources	Currently uses Emergency Max, change market to clear using Eco Max	
2	Eligible DASR capability from offline units (no proposed change to calculation of DASR capability from online units)	min[EcoMax,EcoMin + ((30- (Startup + NotificationTime))*DA Default RampRate]	
3	DASR Locations	RTO only, leave flexibility in manual / tariff language to implement a reserve sub-zone if needed	
4	Reserve Requirement Increase		
4a	Trigger	Hot Weather Alert, Cold Weather Alert, Max Emerg Gen Alert, Weather / Environmental Emergency, Sabotage / Terrorism Emergency	
4b	Increase DASR Req by:	Difference between submitted fixed demand bids and forecasted RT load for each hour Plus additionally scheduled reserves	
4c	On/Off Peak Differentiation	Amount to be added to the DASR requirement will be calculated individually for each hour	
5	Cost Allocation	Two part allocation: - Charges for base requirement allocated to real-time load - Charges for additional DASR requirement allocated to differences in Day-ahead demand and Real-time load when Day-ahead demand is less than Real-time load	Status quo - Allocate entire amount of DASR to real-time load

DA Commitment Changes Matrix

#	Design Components[1]	PJM Proposal
Day Ahead Commitment Changes		
6	Treatment of long lead time units in DA Energy market	Commit long lead time units scheduled by operators based on schedule dictated by PJM operations
7	Trigger for committing long lead time units in DA Energy market	Hot Weather Alert, Cold Weather Alert, Max Emerg Gen Alert, Weather / Environmental Emergency, Sabotage / Terrorism Emergency AND long lead resources have been scheduled and are still needed for the operating day

Proposed Real Time Energy and Reserve Pricing Changes

Energy & Reserve Pricing Proposal Concerns

The following concerns were expressed about the PJM energy & reserve pricing proposal to create a new RT reserve market:

- Complexity of solution vs. infrequent use
- Cost / benefit
- Impact to max energy price (pancaking of additional penalty factor)
- Cost allocation

PJM developed a more simplified proposal in response to these concerns

Revised Proposal Characteristics

The simplified solution is a more flexible version of the short-term solution

- No additional reserve products, settlement, cost allocation
- Increase reserve requirements for existing reserve products
  - Based on operator actions in real-time
  - MW value is adjusted based on resources committed as opposed to being a static adder
- No additional penalty factors or increases to the energy price cap
  - Add a second, lower step to the ORDC for synchronized and primary reserve
  - If short the extended requirement, the lower penalty factor would set the clearing price

Proposals

1. New Reserve Market Proposal *(original – no longer proposed)*
   - Create an additional reserve market in RT to account for and price additional reserve capability scheduled by PJM operators in RT

2. Adjust Current RT Reserve Market Requirement *(new)*
   - Adjust existing SR and PR requirements based on RT operator actions
   - More flexible adaptation of the short-term approach
   - No new reserve product

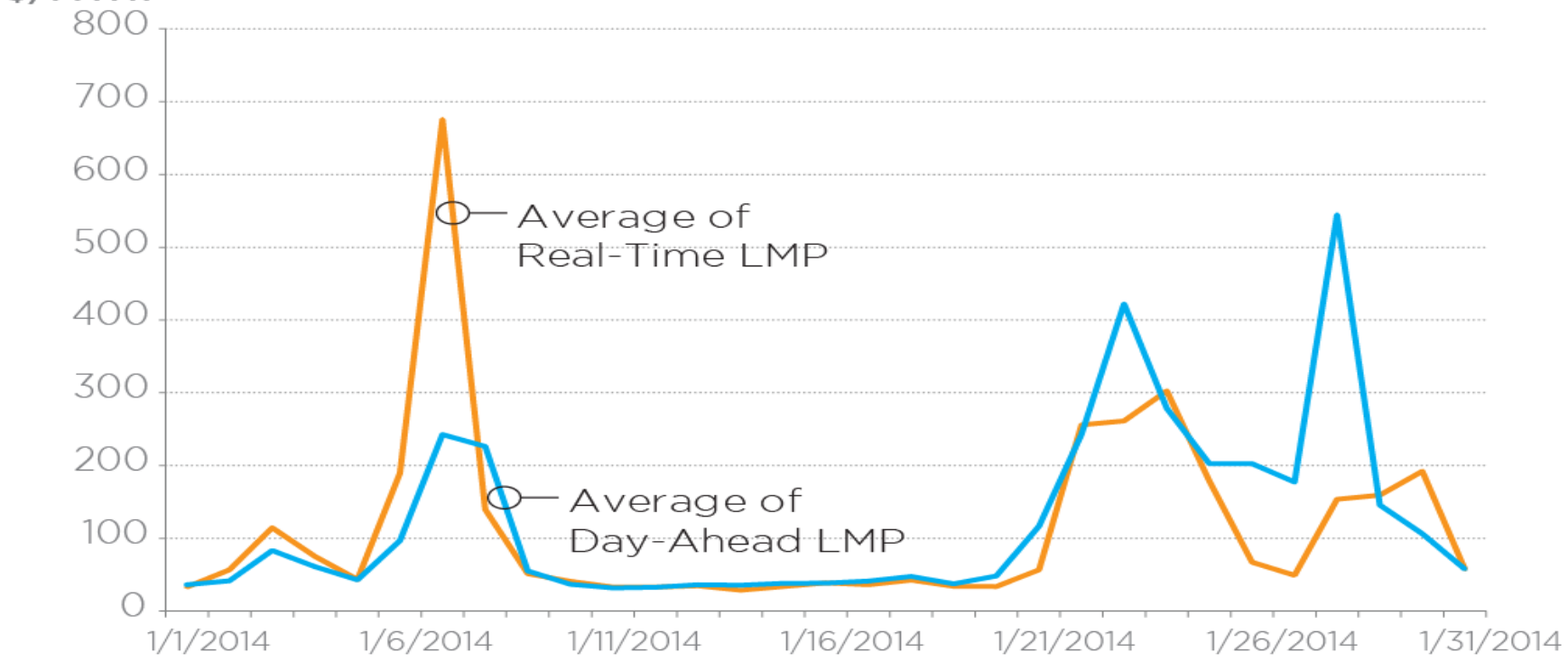
Why do we need a DA and RT component?

- If we perfectly account for the actions taken prior to the operating day, there still remains a potential issue in RT
  - How this can happen is provided on the following slides
- If DA prices are high and RT are low (or vice versa), the DA and RT prices will chase each other creating instability in both markets
- This may occur as a natural course of operations but we should not knowingly create the scenario

Component Goals

- **DASR & Long lead time unit changes:**
  - Capture the desire to schedule dispatchable units to serve load and maintain flexible incremental resources for reserves and peaking needs without overscheduling
  - Allow for increases in the DASR requirement to anticipation of LFE and eFOR being above average
- **Real-time 10-minute reserve requirement increase:**
  - Capture any additional MW scheduled in real-time due to unforeseen uncertainty such as load forecast error, generation at risk, etc.

January 2014 Case Study



#	Design Components[1]	PJM Proposal
8	Method of capturing additional reserves in RT pricing	Increase existing RT reserve requirements
9	Reserve Products Impacted	Synchronized Reserve (SR) and Primary Reserve (PR)
10	Trigger	Hot Weather Alert, Cold Weather Alert, Max Emerg Gen Alert, Weather / Environmental Emergency, Sabotage / Terrorism Emergency AND/OR additional intraday resources have been intentionally scheduled
11	Calculation of updated SR and PR requirements	Existing SR / PR requirement plus sum(eco max) of additional intraday resources that have been committed
12	On/Off Peak Differentiation	Requirements would only be increased during on peak hours, for only those hours where additional intraday resources are scheduled
13	Locations	Synch Reserve and Primary Reserve continue to be cleared for RTO and MAD If anticipating reserve deliverability issues, then the requirements for the sub-zone(s) in which the additional resources are located are increased (ex. resources in MAD increase both MAD and RTO requirements, resources in non-MAD portion of RTO only increase the RTO requirement) If not anticipating deliverability issues, then only the RTO requirements are increased
14	Frequency of Reserve Requirement Change	SR and PR requirements are updated as needed as additional intraday resources are scheduled and released

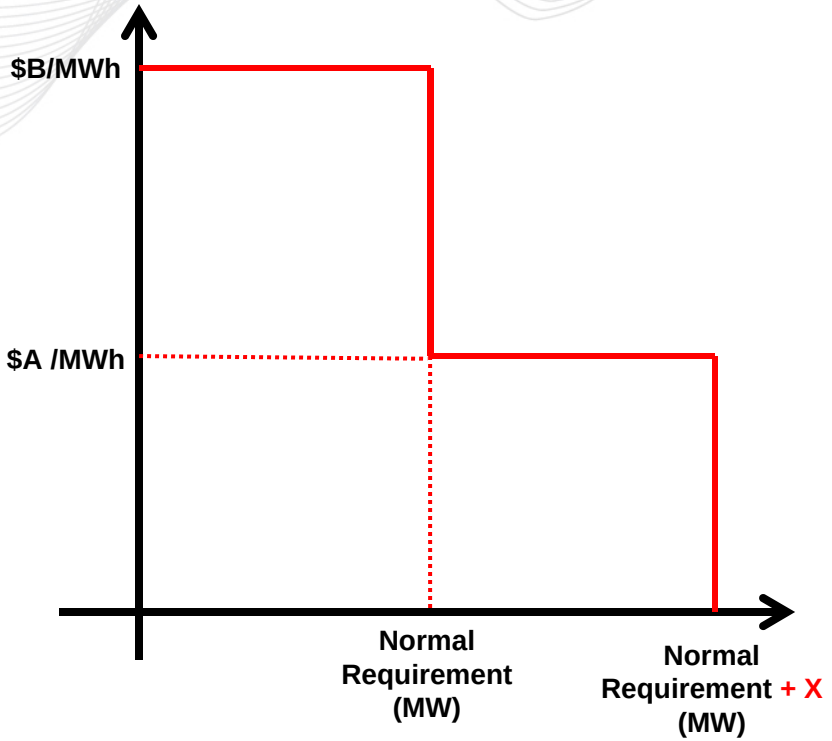
#	Design Components[1]	PJM Proposal
15	Capacity eligible to meet SR and PR requirements	existing synch reserve and non-synch reserve capability
16	Capability	no change to SR or PR capability
17	Must Offer Obligation	status quo
18	Offers	status quo
19	Market Mitigation	status quo
20	*Demand Curve Shape & Level*	*two step demand curve - reliability requirement priced at $850, extended requirement priced at $300 (for DY 2015/2016 and beyond)*
21	Clearing	status quo
22	Method for communicating reserve requirement change and reason	Message in eMKT upon log in indicating new requirement and reason for change plus emergency procedures 'special notification' (which prompts eData alert)
23	Exit Criteria	Hot Weather Alert, Cold Weather Alert, Max Emerg Gen Alert, Weather / Environmental Emergency, Sabotage / Terrorism Emergency no longer effective AND/OR additional intraday resources have been released
24	Settlements	
24a	SR and PR Credits	status quo
24b	BOR Offset	status quo
24c	Cost Allocation	status quo

Settlements

– No proposed changes to SR/NSR cost allocation

Two-Stepped Demand Curve

- *Why?*
  - Articulate that reserves beyond the normal requirement are desired, but of a lesser value.
  - Shows a higher willingness to pay to maintain largest contingency and lower willingness (but non-zero) for reserves beyond that.

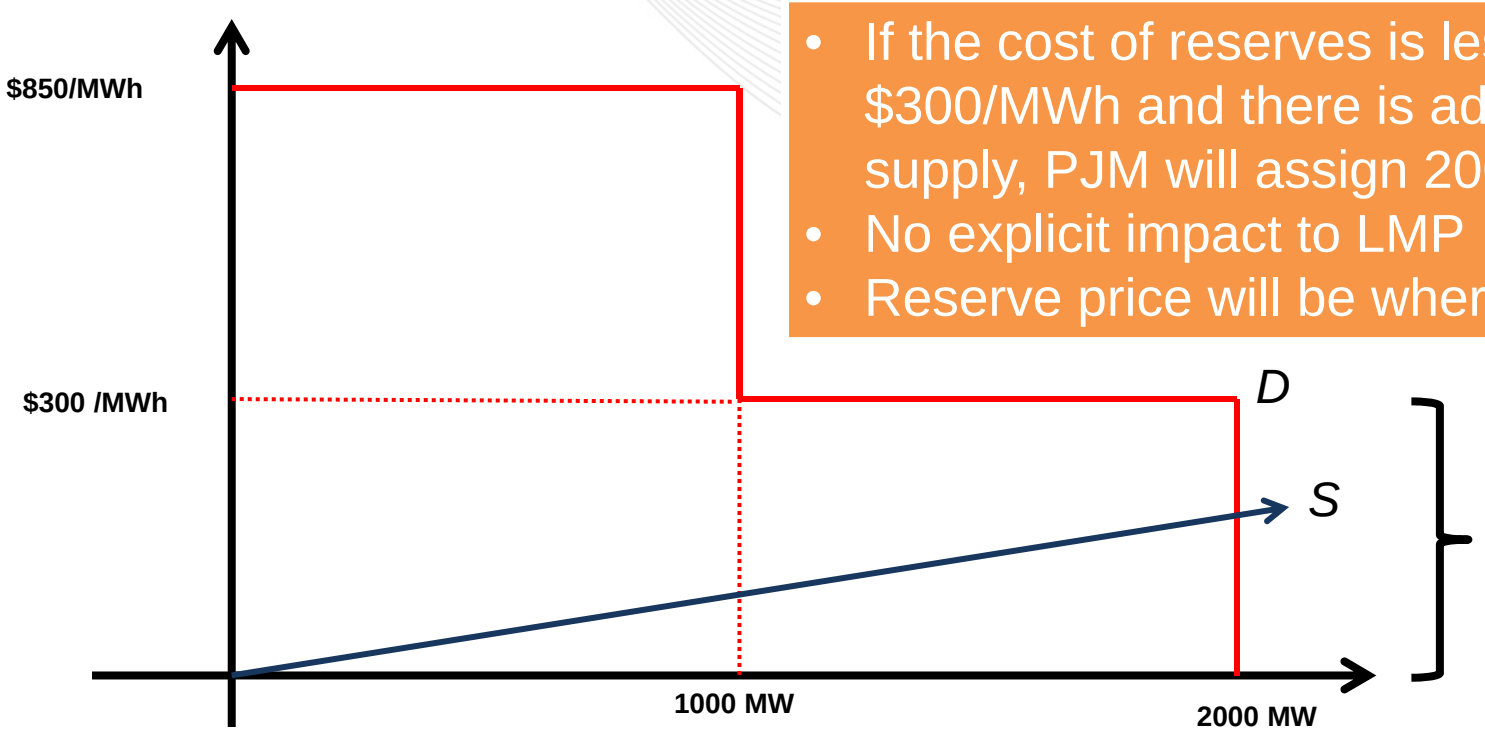


How does the additional step work?

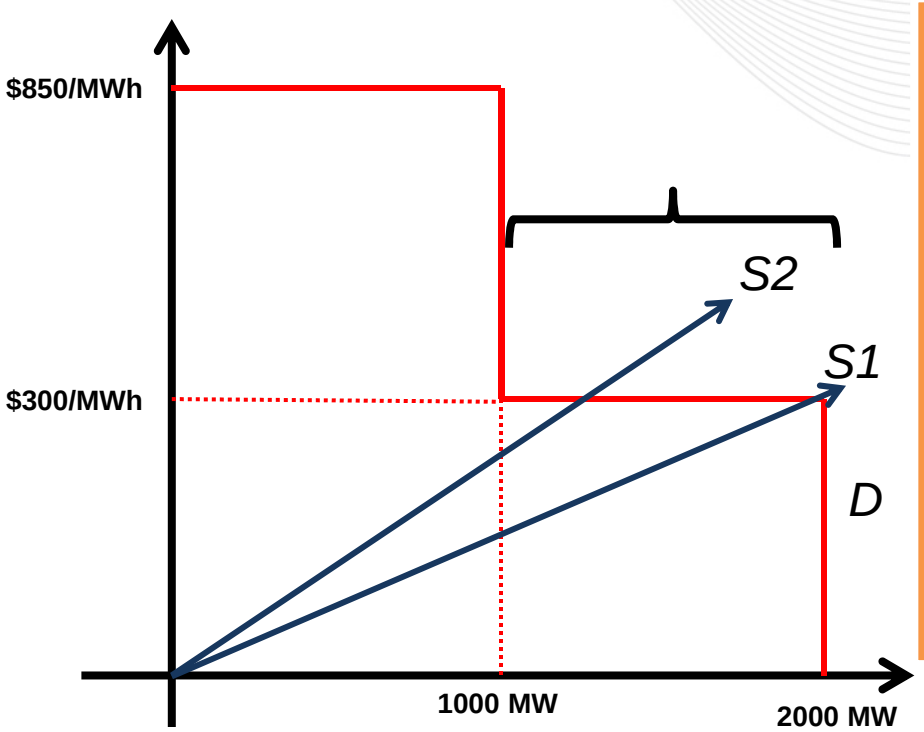
- In words…
  - Reserves are only assigned above the normal requirement when the cost is less than $A/MWh.
  - Reserves will be assigned to meet the normal requirement whenever the cost to do so is less than $B/MWh.
  - If there are adequate economic reserves to meet the normal requirement but not the extended requirement, the reserve MCP will be >= $A/MWh and the penalty factor $A/MWh will influence the LMP.
  - This is the same principle as the current implementation of demand curves, just an added level of complexity.

Reserve Pricing Examples – Meet All Requirements

- If the cost of reserves is less than $300/MWh and there is adequate supply, PJM will assign 2000 MW
- No explicit impact to LMP
- Reserve price will be where S = D

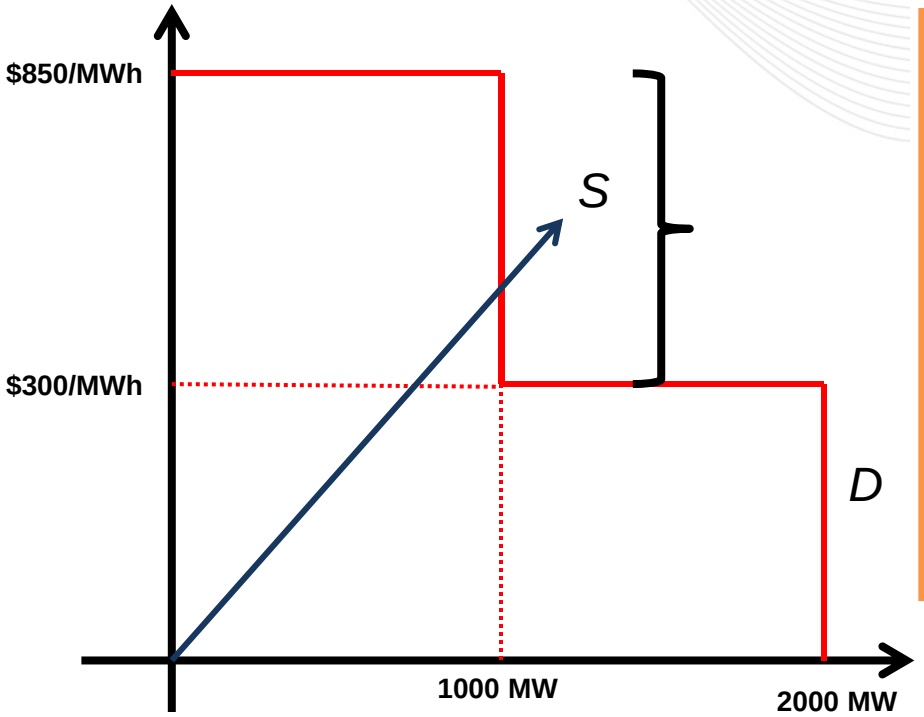


Reserve Pricing Examples – $300 MCP



- If the cost of reserves is $300/MWh…
  - S1: Meeting the requirement at exactly that price
    (No explicit impact to LMP)
  - S2: Is short the extended req. at a price less than $300/MWh
    ($300/MWh penalty factor will influence LMP)

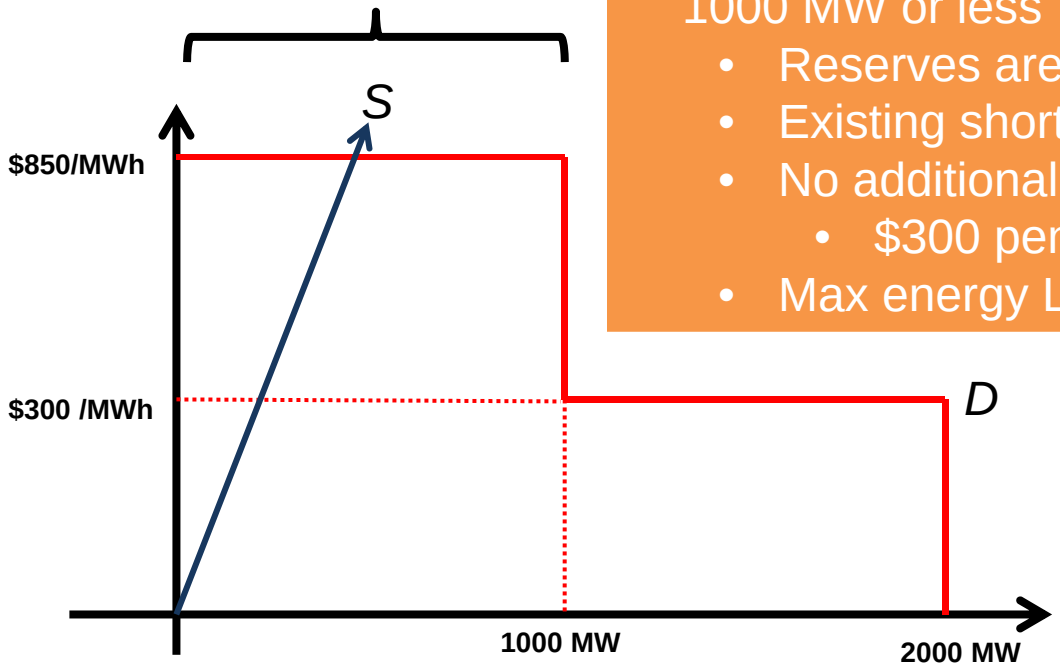
Reserve Pricing Examples – Short Extended Req.



- If the cost of reserves is
  $850 <= MCP > $300
  - PJM is able to meet the normal requirement but the cost to do so is above $300/MWh
  - $300/MWh penalty factor is included in LMP calculation

Reserve Pricing Examples – Short Normal Req.

- If the cost of reserves is $850/MWh PJM will assign 1000 MW or less
  - Reserves are short of the normal requirement
  - Existing shortage pricing provisions kick-in
  - No additional $300/MWh penalty factor in LMP
    - $300 penalty factor increases to $850
  - Max energy LMP remains at $2700



High Level Example

Day Ahead Market Conditions:

- Real-time peak load forecast = 155,000 MW

- Total DA Demand = 145,000 MW
  - DA Fixed Demand = 142,000 MW (~92% of peak load)
  - INCs/DECs/PSD = 3,000 MW of additional demand
  - Base DASR Requirement (all 24 hrs) = 155,000 * 6.27% = ~ 9,700 MW
  - DASR Requirement Adjustment = 155,000 MW – 142,000 MW = 13,000 MW

- Total DA MW Needed =
  - Fixed Demand + Net of INCs/DECs/PSD + Base DASR + DASR Adjustment
  - 142,000 + 3,000 + 9,700 + 13,000 = **167,700 MW**

Notes:
- DASR Adjustment would be based on hourly LF and FD values but shown here once for simplicity
- Net of INCs/DECs/PSD is additional demand in this case but can be a net gen as well

Long Lead Time Commitments by PJM

- Assume 5 units with a total capacity of 2,500 MW
- These resources will be committed in the DAM by PJM for the times PJM has indicated to the GO when committing the units
  - The units will be dispatched economically based on the DAM solution
  - They will be eligible to set in the DAM and in RT as long as they are following dispatch

Why commit them in the DAM?

- Accurately models resources running and setting price in RT
- Will supplant other resources and eliminate overscheduling
  - If the long lead time resources were not committed by PJM in the DAM the 2,500 MW would have been scheduled on different resources
  - The 2,500 MW in long lead time would have appeared as “additional” capacity in RT and likely suppressed prices
    - Potential additional uplift and/or CT LOC
- Current example has PJM scheduling 167,700 MW to meet load and reserves
  - Absent including in DAM these resources would be run in RT in addition to what it scheduled in the DAM

The RAC Run

- If the DAM and DASR changes are done correctly the RAC run should not have much to do

- Enough energy and reserves should be scheduled in the DAM to meet RT needs

In RT…

- The additional DASR scheduled in the DAM will most likely be used to meet the RT load
  - If the DASR requirement adjustment perfectly offsets the DA demand/RT load difference, the remaining 30-minute reserves scheduled will be used to
    - Meet the average LFE and eFOR
    - Meet the RT 10-minute reserve requirements

This is what the product is intended for

RT Component

- The real-time component is intended to capture additionally scheduled MWs due to RT uncertainty
  - Adjustment is made to the 10-minute SR and PR requirements

- The lower step on the demand curve is intended to show that PJM values the additional reserves but not as much as the base amount

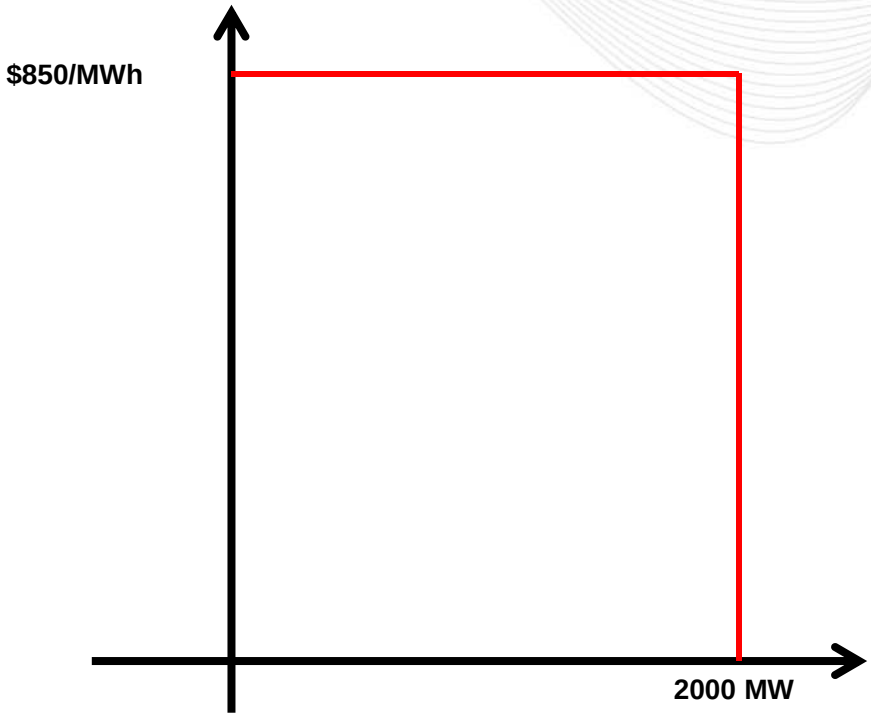
Projected Peak Conditions

Data Point	MW
Load Forecast	158,000
Generation Capability	160,000
Projected Interchange	0
Available DR	5,000
Anticipated Available Reserves**	**2000**

*** Assume a 2,000 MW reserve requirement*

Numbers indicate no action needed.

Current Demand Curve Definition



Single step at $850/MWh

Reserves will be procured to meet the 2,000 MW requirement as long as the $/MWh cost is less than or equal to $850/MWh.

Other Factors

- Things that cause uncertainty…
  - Load trending above forecast
    - Assume load trending to 159,000 MW
  - Generation at risk
    - Assume 1,000 MW of generation at risk
  - Interchange getting cut at the peak (not in this case)

- Net result of these is the desire to have an extra 2,000 MW of supply available so 2,000 MW of DR is called.

Projected Peak Conditions After DR

Data Point	MW
Load Forecast	158,000
Generation Capability	160,000
Projected Interchange	0
DR Called	*2,000*
Anticipated Available Reserves**	**4000**

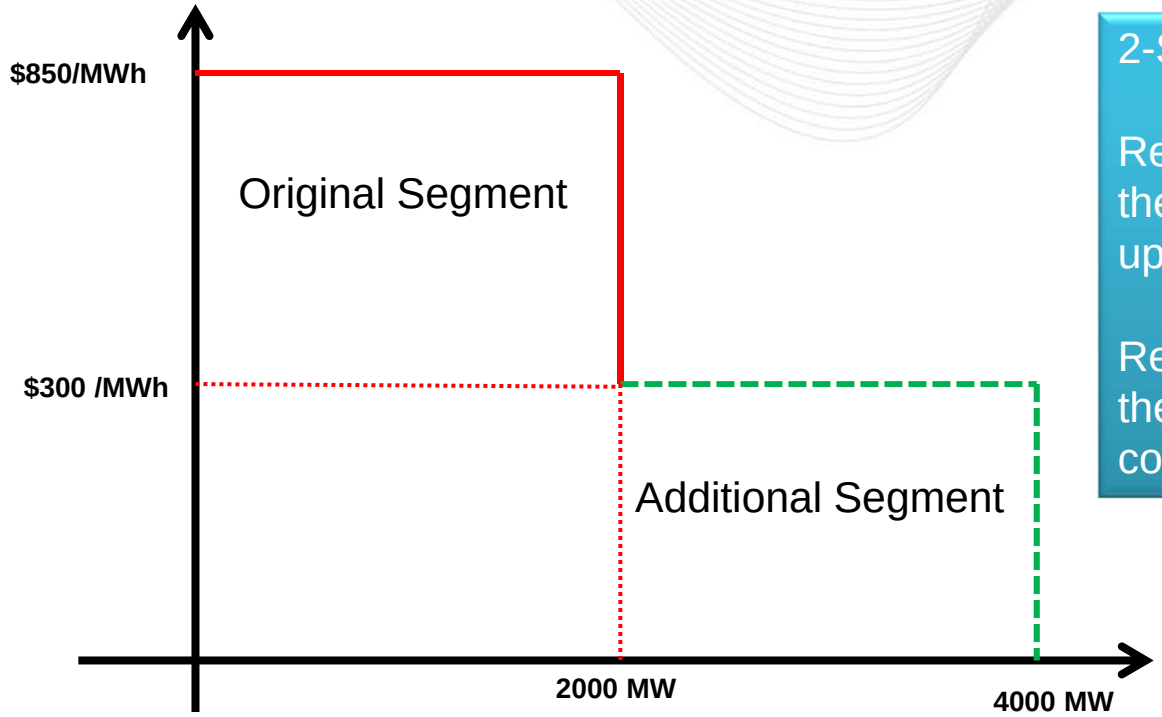
*** Assume a 2,000 MW reserve requirement*

DR called will create more reserves that absent an increase in the reserve requirement will likely suppress prices.

Requirement Adjustment

- Adjustment to the 10-minute reserve requirement in this case would be 2,000 MW
  - Accounts for the additional reserve desired
  - The lower segment on the demand curve would be 2,000 MW long at a $300/MWh price
  - Could be a locational adjustment if DR is specifically called in MAD for transmission issues

Adjusted Demand Curve



2-Step curve

Reserves will be procured to meet the base 2,000 MW requirement up to a cost of $850/MWh.

Reserves will be procured to meet the additional requirement up to a cost of $300/MWh.

Adjustments

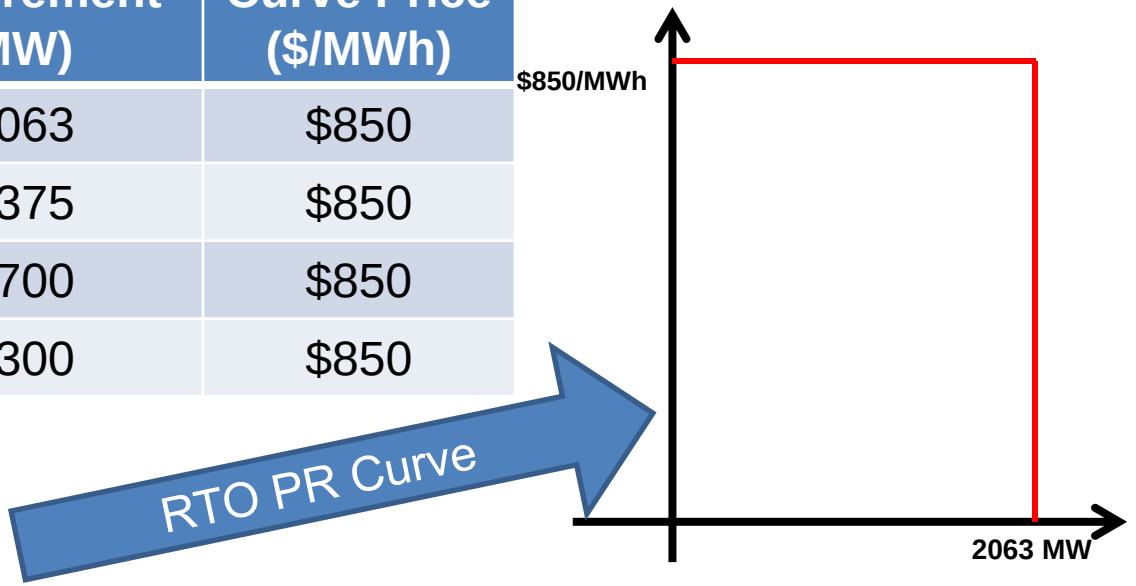
- Will be done when supply is scheduled in excess of apparent need
  - Not just because DR was called
    - Only shown in this case for simplicity
  - DR may be called without curve adjustments
  - Additional generation scheduled may also trigger an adjustment

Rules for Requirement Adjustment

- Example was for one reserve requirement, PJM has two (SR and PR)
  - SR is a subset of PR, MAD is a subset of RTO
  - If additional supply is scheduled in RT independent of location…
    - Only the RTO curves are adjusted, not MAD
    - The additional MW will be added to both the SR and PR requirements at the $300/MWh price
  - If additional supply is scheduled in MAD only…
    - The RTO and MAD curves are adjusted by the same amount
    - The additional MW will be added to both the SR and PR requirements at the $300/MWh price

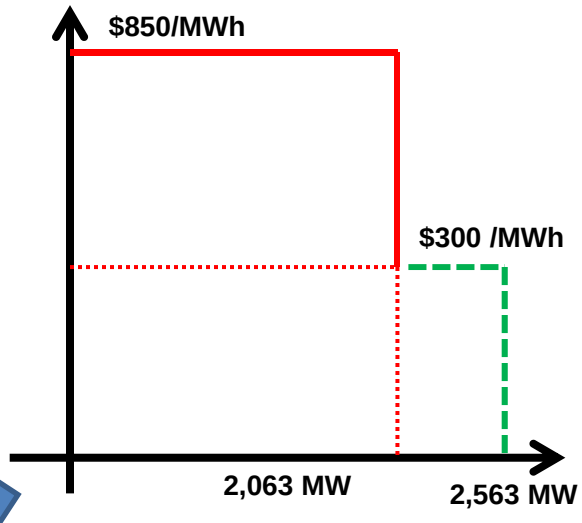
Current Demand Curves (2015)

Region	Product	Base Requirement (MW)	Base Curve Price ($/MWh)
RTO	PR	2,063	$850
	SR	1,375	$850
MAD	PR	1,700	$850
	SR	1,300	$850



Adjustment to RTO of 500 MW (2015)

Region	Product	Base Requirement (MW)	Base Curve Price ($/MWh)	Added Step (MW)	Added Price ($/MWh)
RTO	PR	2,063	$850	2,563	$300
	SR	1,375	$850	1,875	$300
MAD	PR	1,700	$850	N/A	N/A
	SR	1,300	$850	N/A	N/A



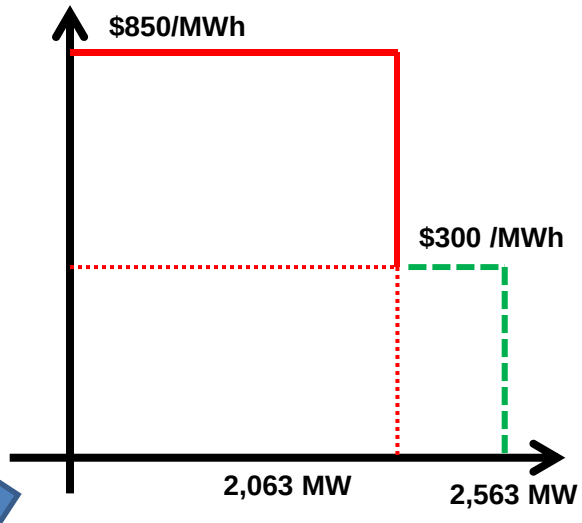
RTO PR Curve

Adjustment to MAD of 500 MW (2015)

Region	Product	Base Requirement (MW)	Base Curve Price ($/MWh)	Added Step (MW)	Added Price ($/MWh)
RTO	PR	2,063	$850	2,563	$300
	SR	1,375	$850	1,875	$300
MAD	PR	1,700	$850	2,200	$300
	SR	1,300	$850	1,800	$300

All requirements are adjusted because MAD is a subset of the RTO

RTO PR Curve



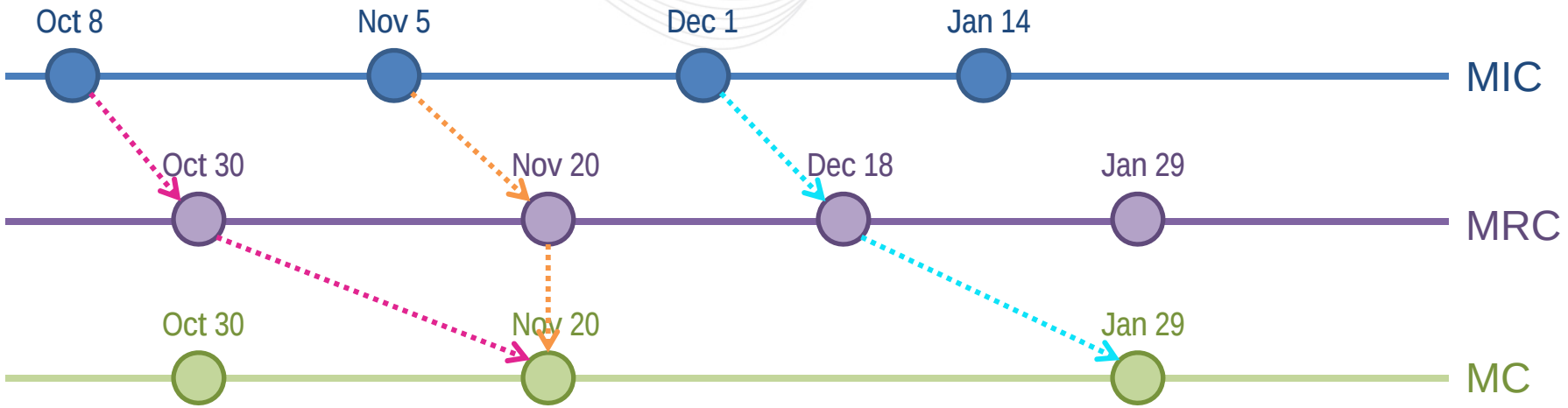
Implementation and Voting Timelines

Implementation Timeline

- Energy and Reserve Pricing Solution (DA and RT reserve changes)
  - Spring 2015
  - Requires manual and OA/OATT changes (MIC, MRC & MC Votes, FERC filing)
- Interchange Volatility Solution (Interchange cap)
  - Dec 2014 via manual curtailment of transactions violating interchange cap
  - Spring 2015 via automated denial of transactions violating interchange cap at time of submission
  - Requires manual changes (MIC & MRC Votes)

Voting Timeline Options

Current path Alternative 1 Alternative 2



Is there a desire to vote the Interchange Volatility proposal before the Energy and Reserve Pricing proposal?

FERC Filing in February

Energy and Reserve Pricing Approach for Winter

Since the long-term energy and reserve pricing proposal cannot be implemented until next spring, what will happen this winter?

- PJM will recommend to the Board that the short-term solution be implemented through the winter with a slight modification
  - Rather than increasing the Synch Reserve and Primary Reserve requirements by a static adder, increase the requirements by the amount of additionally scheduled capacity