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Key Issues and Consideration in Market Design, Operational and Oversight

Public Utilities Commission of Ohio

&

Pennsylvania Public Utilities Commission

December 10, 2014

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PJM RTO Functions

- Grid Operation
 - Non-discriminatory treatment
 - Monitoring transmission system
 - Reliability of the system
 - Generation and load balance responsibilities
- Market Operation
 - Capacity
 - Energy
 - Ancillary Services
- Regional Transmission Expansion Planning
 - Reliability
 - Economic

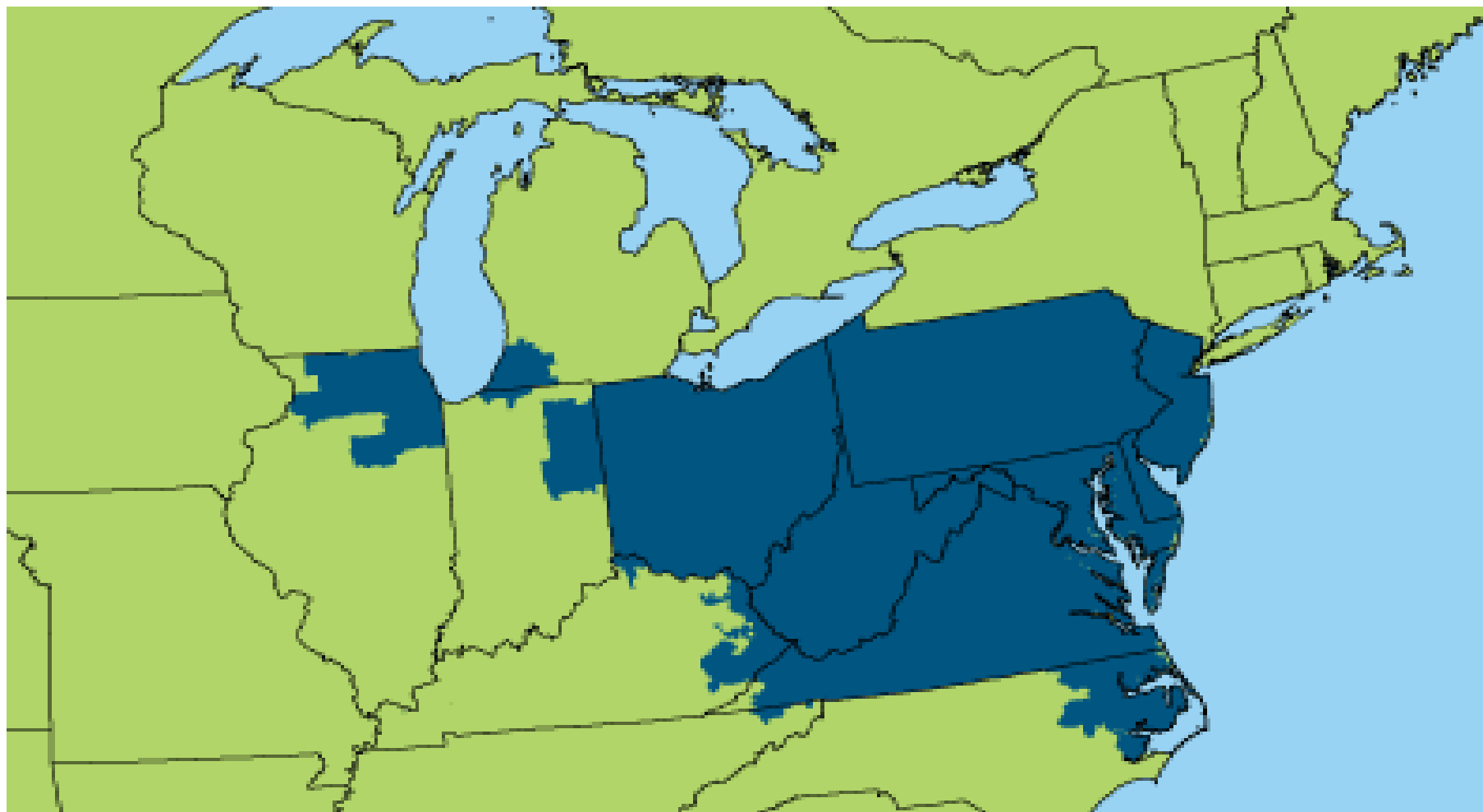


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The PJM RTO Footprint



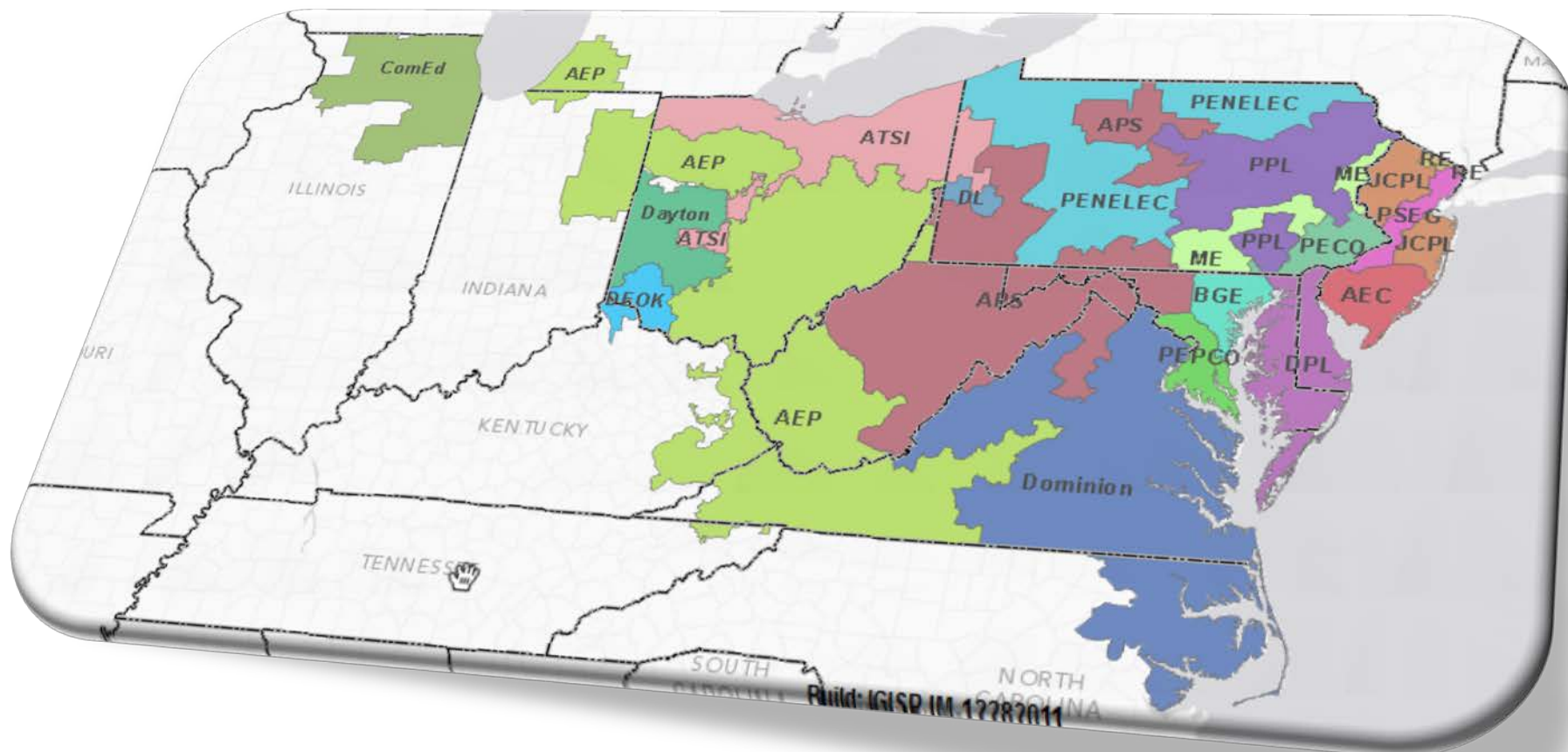


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Transmission Owner Zones





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PJM Data

- 185,600 MW - Generating Capacity
- 158,448 MW - Peak Load
- Over 65,000 Miles of Transmission Lines
- PJM Footprint – 13 States & the District of Columbia
- Over 60 million People in its Footprint
- One Balancing Authority for Dispatch



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PJM Dispatching Center





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RTO vs. Local Utility

Regional Transmission Organization

- Operation of transmission assets
- Maintenance scheduling and coordination
- Match load and generation
- Non-profit

Local Utility

- Owns assets
- Performs maintenance
- Directly serves end use customers
- Publicly traded company



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PJM RTO ADMINISTERED MARKET CONSTRUCTS

Capacity & Energy



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Capacity vs. Energy

Capacity

- A resource commitment (in MW) to provide energy in the day-ahead market, and at anytime the resource is called by PJM.
- Capacity revenues paid to a committed resource whether or not energy is produced by that resource
- Participation in Reliability Pricing Model (RPM) Base Residual Auction
- Daily product, but committed for an entire delivery year (June 1 to May 31 of the following year)

Energy

- Generation of electrical power (in MW-hour)
- Energy revenues paid to resource based on how much clears in Day-Ahead & Real-Time (balancing) markets
- Hourly product



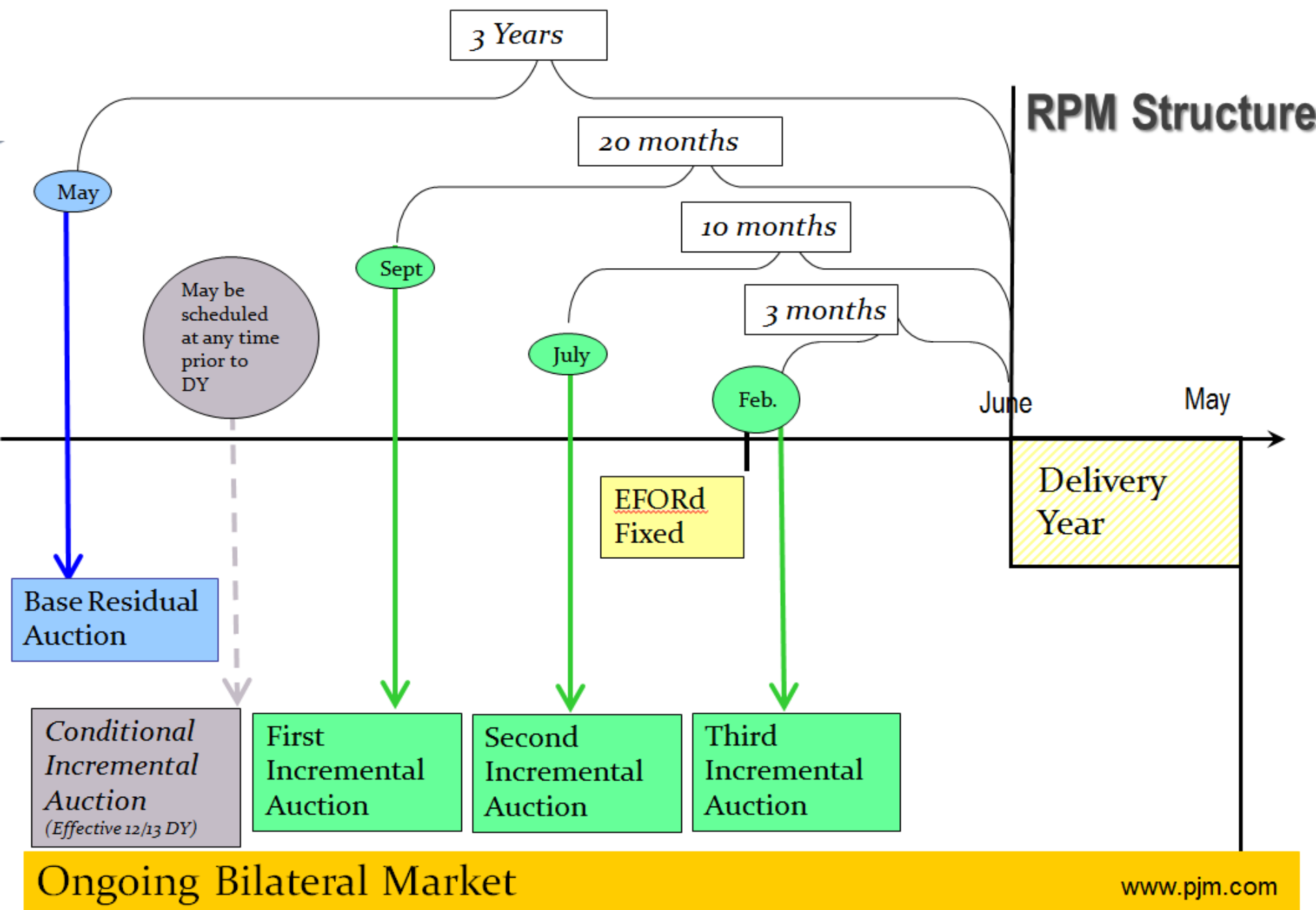
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Wholesale Capacity Market Reliability Pricing Model (RPM)

- Bid-Based Auction Process
- Annually procured product
- A three-year ahead resource commitment
- Capacity bids include
 - Generation Resource
 - Demand Response
 - Energy Efficiency
- Transparency of information





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RPM Auctions

Activity	Purpose	Cost of Procurement
Base Residual Auction	Procurement of Regional Transmission Operator Obligation less an amount reserved for short lead time resources, less Fixed Resource Requirement Obligation	Allocated to Load Serving Entities through Locational Reliability Charge
1 st Incremental Auction	Allows for: (1) replacement resource procurement (2) increases and decreases in resource commitments due to reliability requirement adjustments; and (3) deferred short-term resource procurement	Allocated to resource providers that purchased replacement resources and Load Serving Entities through Locational Reliability Charge
2 nd Incremental Auction		
3 rd Incremental Auction		
Conditional Incremental Auction	Procurement of additional capacity in a Locational Deliverability Area (constrained area) to address reliability problem that is caused by a significant transmission line delay	Allocated to Load Serving Entities through Locational Reliability Charge
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Resource Adequacy Requirement

- The amount of capacity resources required to serve the three-year forward forecasted peak load is determined given a specified reliability objective
- The reliability objective is determined using a Loss of Load Expectation (LOLE) probability event of one day in ten years
- The Installed Reserve Margin (IRM) associated with this reliability objective is in the range of 15.2% to 15.9%
- Resource Adequacy Requirement = Forecast Peak Load * (1+ IRM)

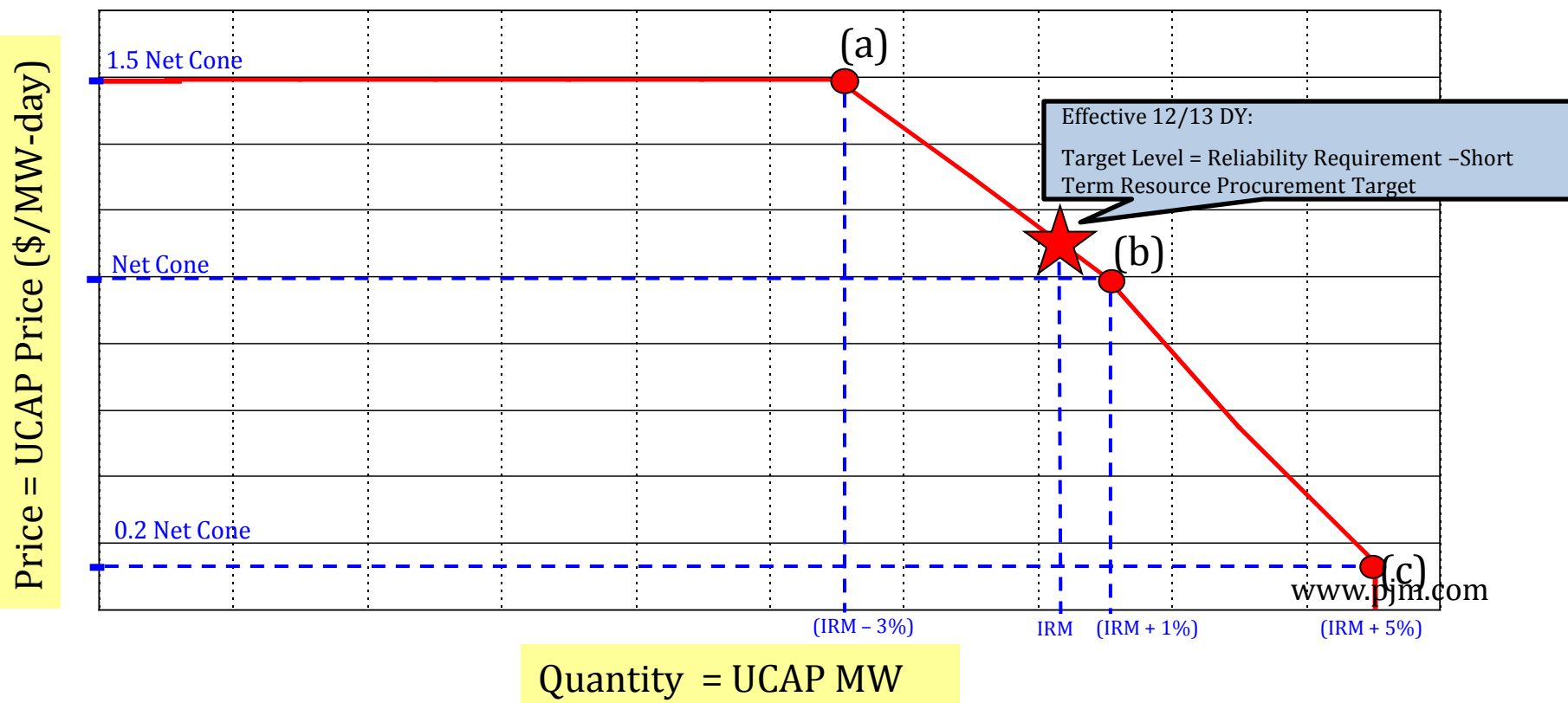


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Illustrative Example of a VRR Curve



A VRR Curve is defined for the PJM Region.

Individual VRR Curves are defined for each Constrained LDA.

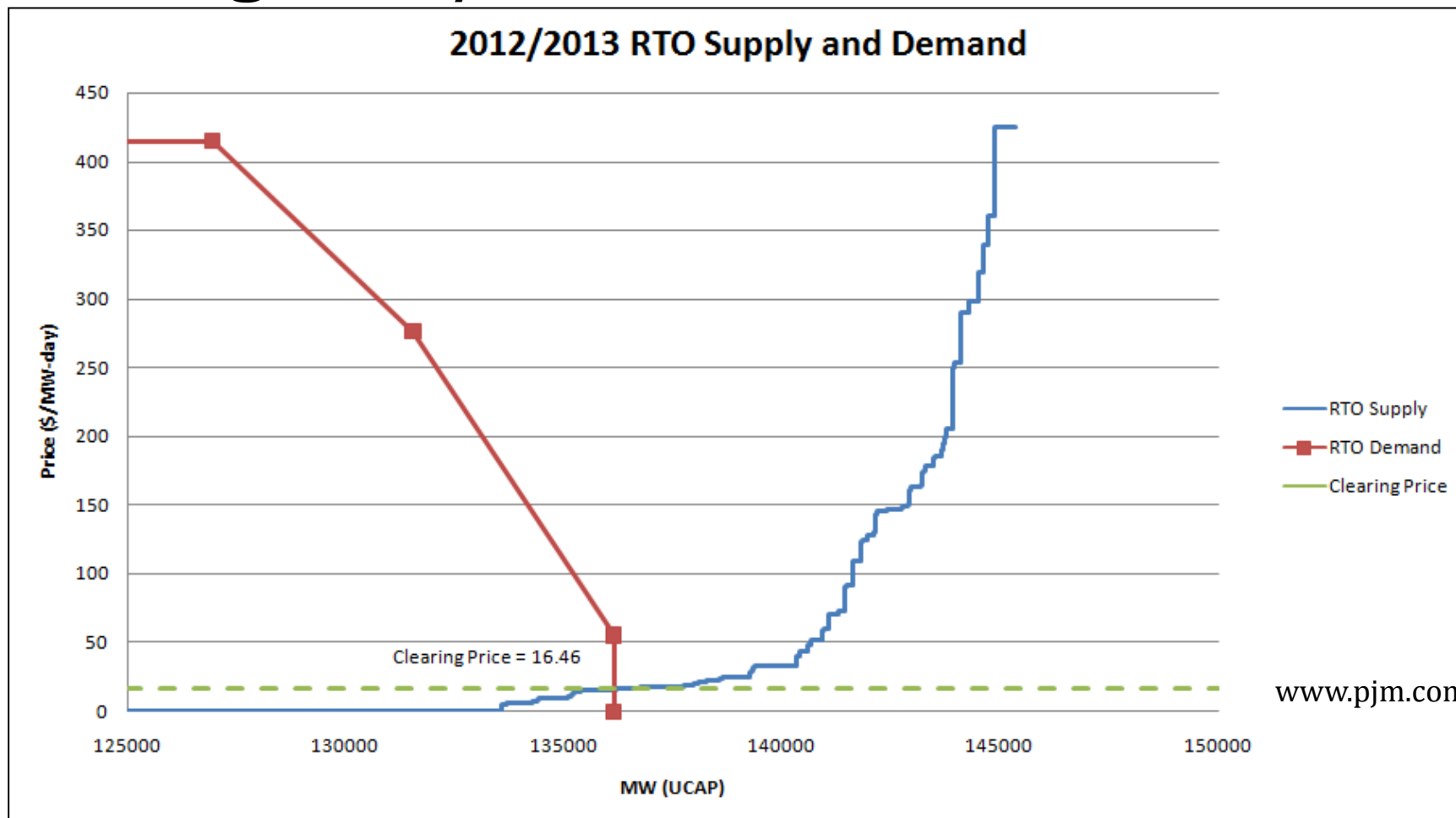


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Clearing 2012/2013 Base Residual Auction



Clearing determined by the intersection of the supply and the demand curves.

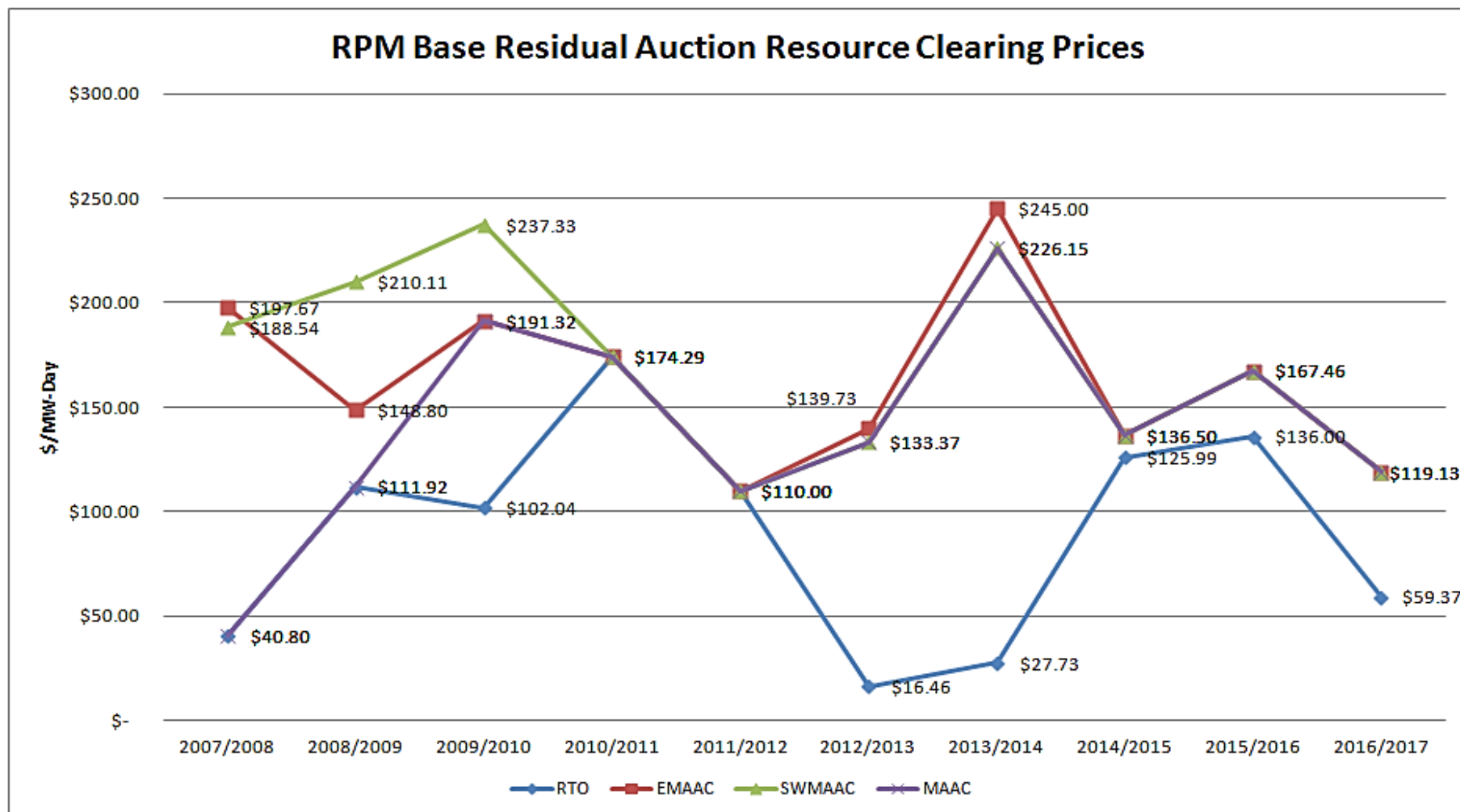


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Forward Capacity Clearing Prices - 2007/2008 to 2016/2017 Delivery Years





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Wholesale Energy Market

- Day Ahead
- Hour Ahead
- Bid-Based
- Security Constrained Dispatch of all Generating Plants in the Footprint



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Security Constrained Economic Dispatch

- Ensure sufficient generation is available to satisfy the demand at any hour of the day
- Monitor, operate and control the high voltage transmission system in a reliable manner



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Locational Marginal Pricing (LMP)

- Cost of dispatching the next MW of load at a given location
- Lowest production cost of generation available
- Recognizes physical transmission limitations
- Physical flow, not contract path

$$\begin{aligned} &\text{Generation Marginal Cost for the system} \\ &\quad + \\ &\quad \text{Transmission Congestion Cost} \\ &\quad + \\ &\quad \text{Cost of Marginal Losses} \\ &\quad = \\ &\quad \text{LMP} \end{aligned}$$



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Generation Cost

- System-wide price
- Optimal dispatch Curve (no congestion or losses taken into account)
- Intersection of the Supply and Demand Curves
- Day ahead and real time calculations

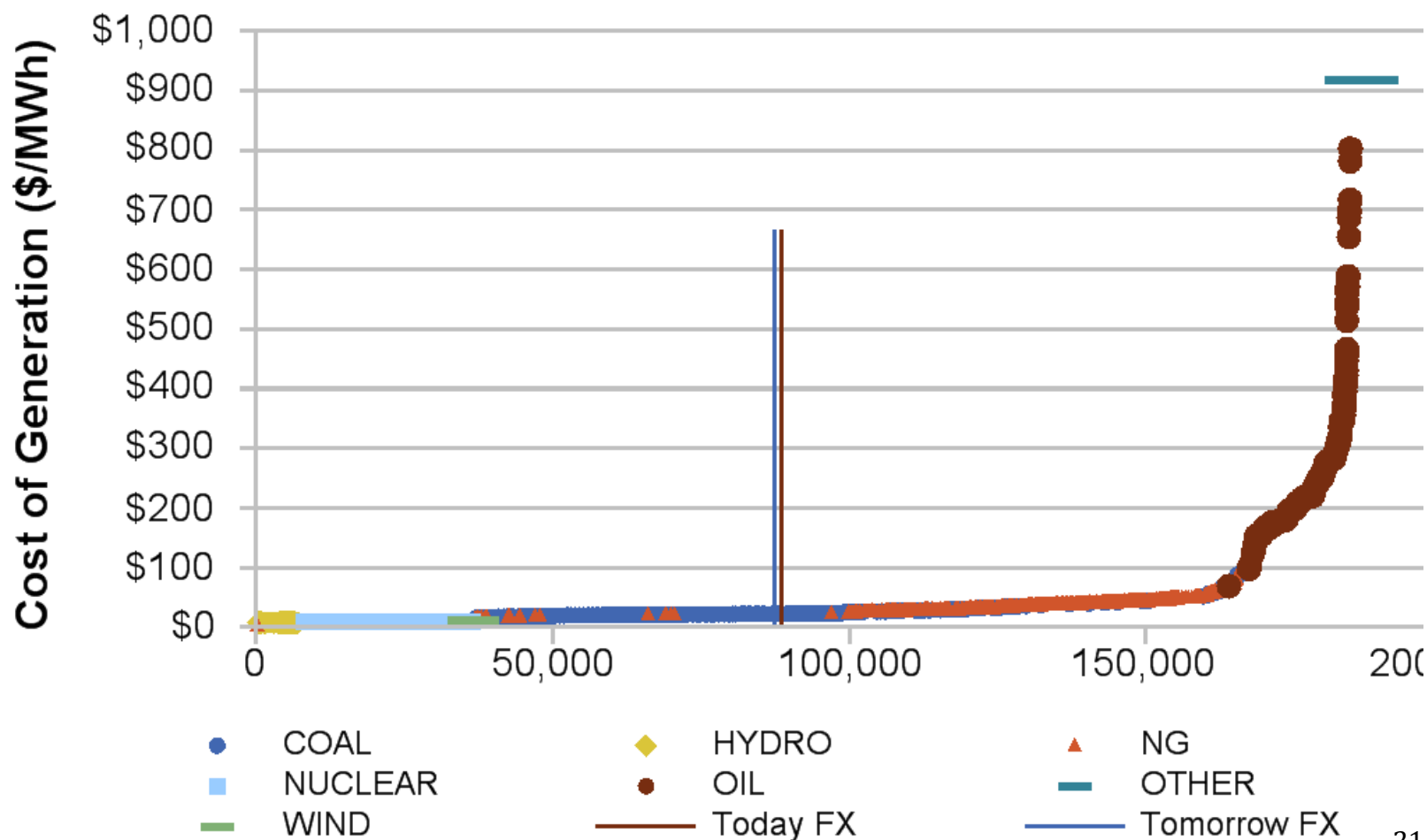


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PJM Dispatch Curve by Fuel Type: 10/06/11





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Transmission Congestion Price

- Price of congestion (transmission constraint) taken into account, calculated using the cost of the marginal unit in the congested region
- No constraints => \$0.00 cost assigned to congestion
- Day ahead and real time calculations



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Transmission Losses

- Price of marginal losses taken into account
- Location by location basis, calculated using penalty factors
 - Distance
 - Voltage
 - Thermal rating
- Day-ahead and real-time calculations



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Two Settlement Markets

Forward markets for electric energy in PJM

- Day-ahead Market
 - Financial market using Bid-In Load
 - Prices calculated hourly
 - Settlements made hourly
- Real-time Market
 - Physical Market based on actual system conditions
 - Prices calculated every 5 minutes
 - Hourly settlements based on deviations from Day-Ahead position

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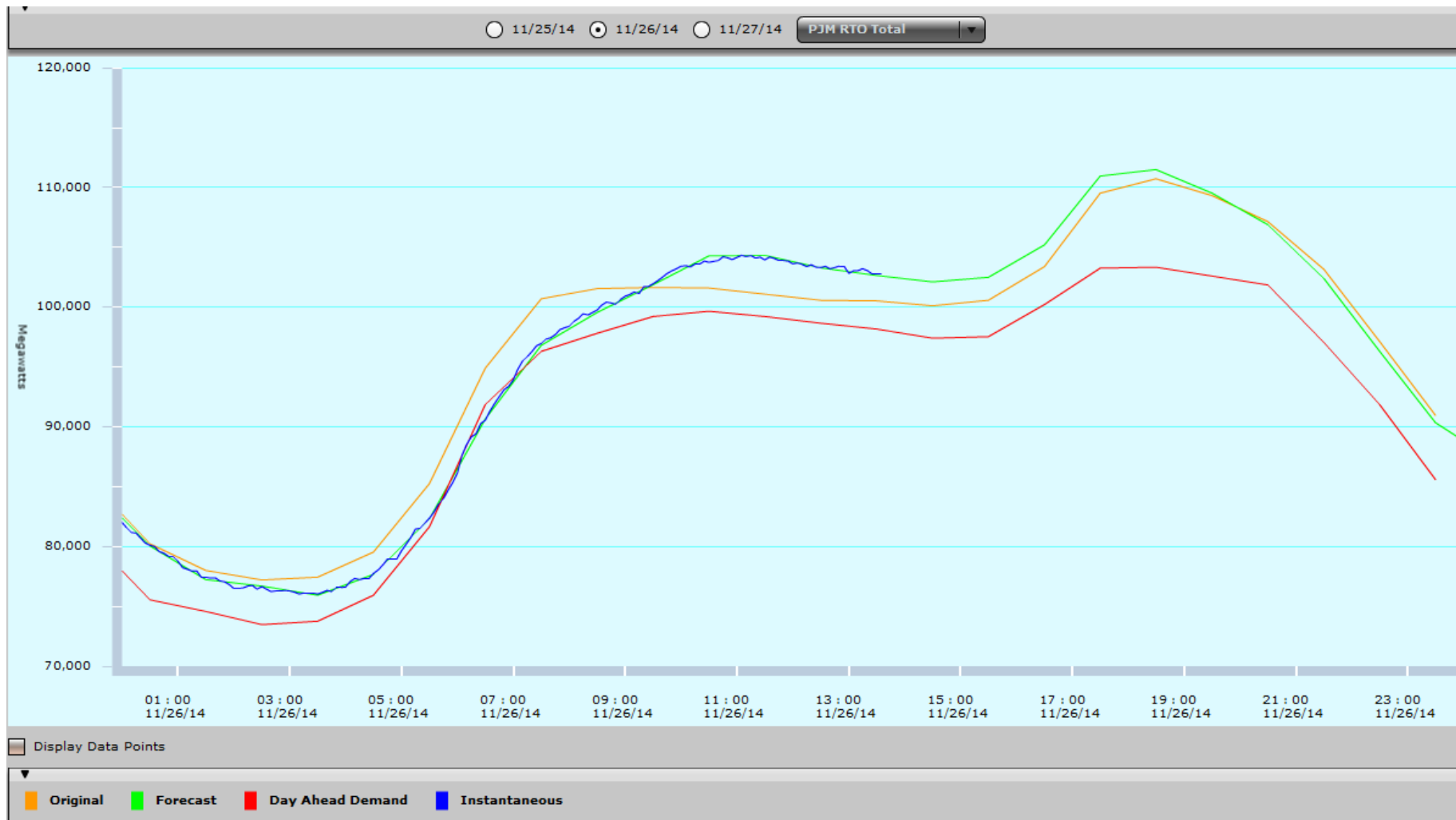


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PJM Load Forecast – 11/26/14 at 1:43PM



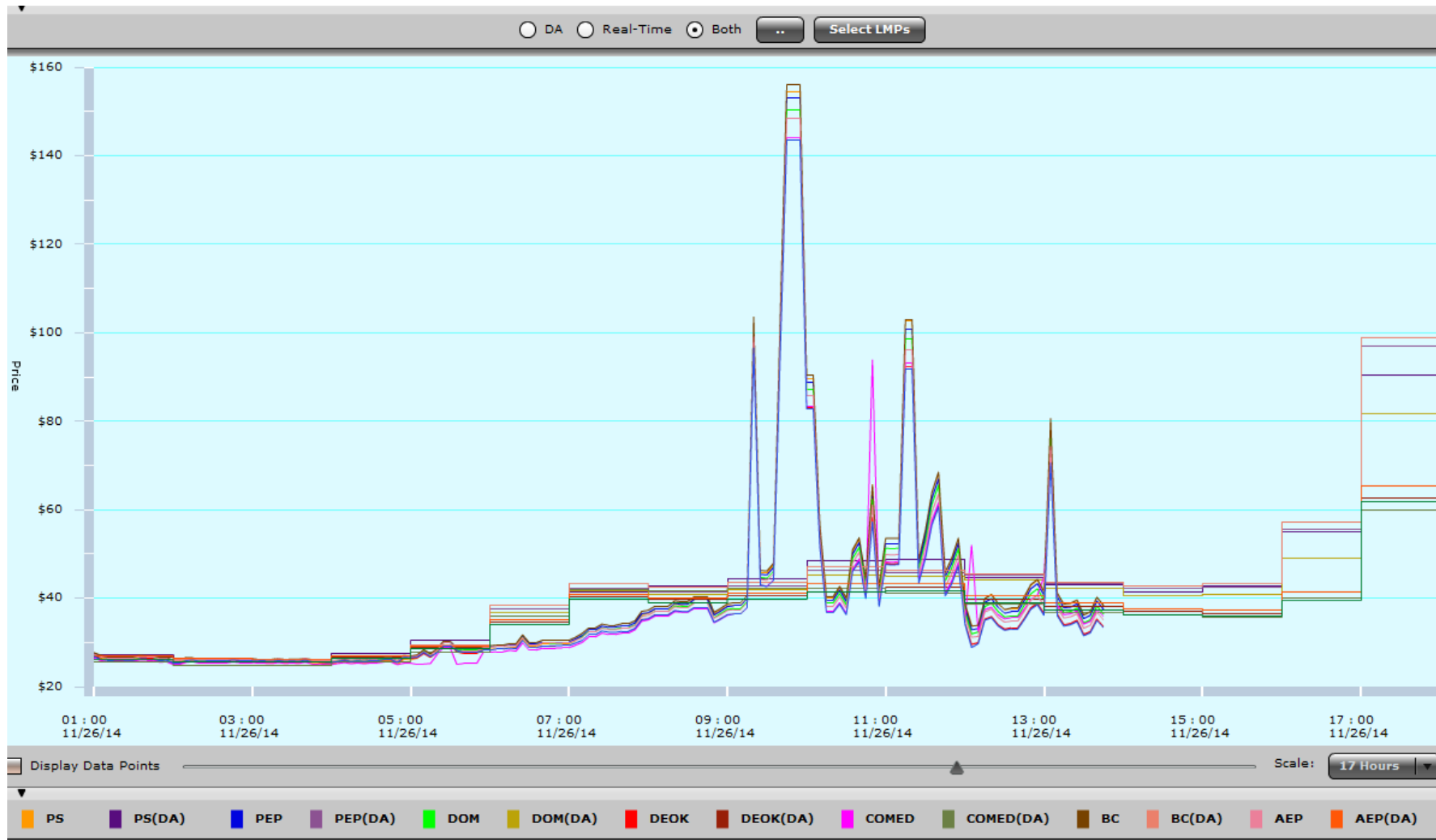


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PJM LMP Pricing – 11/26/14 at 1:43PM



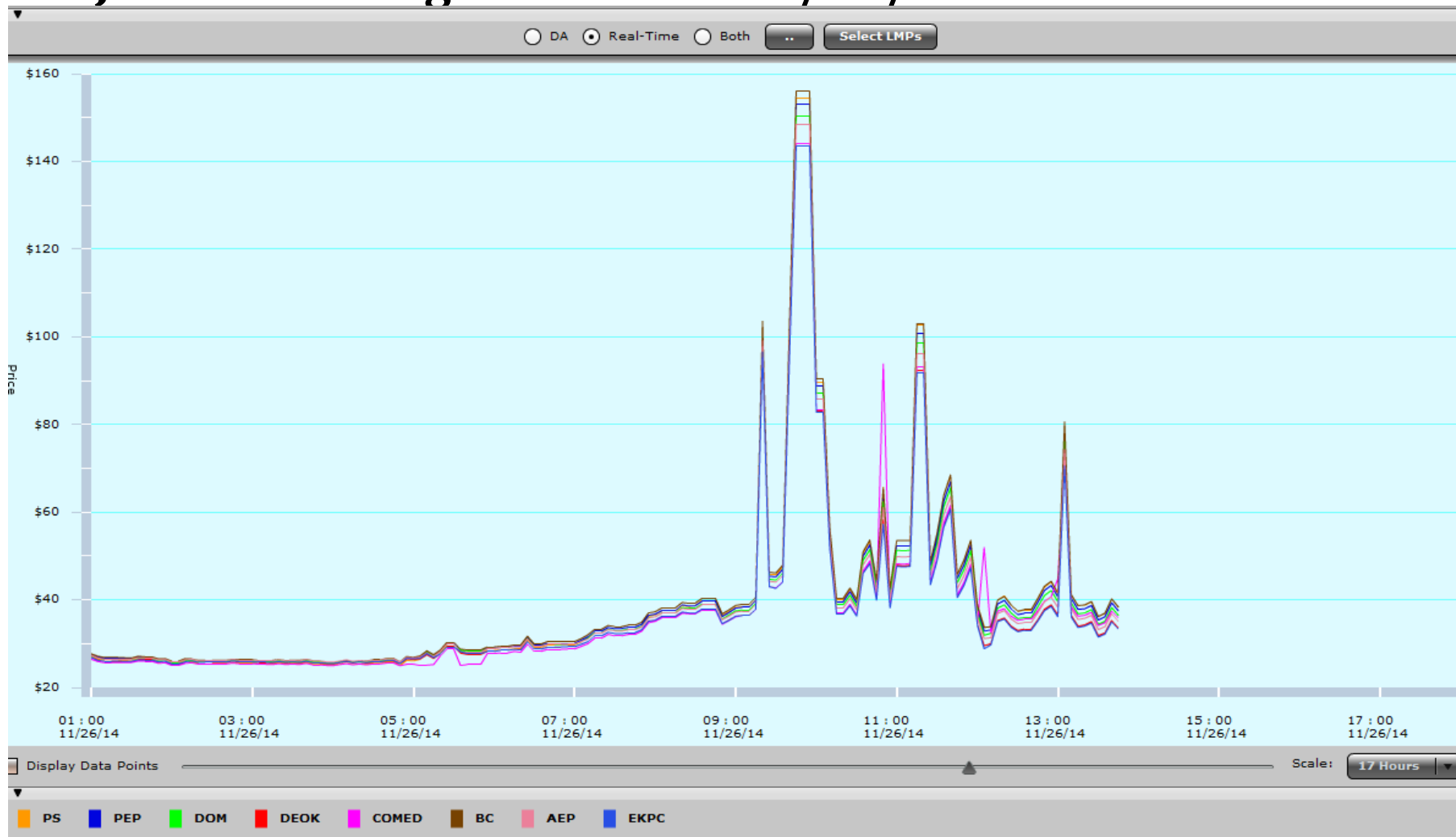


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PJM LMP Pricing Real Time- 11/26/14 at 1:43PM





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Ancillary Services

- Regulation Market: *balancing load and generation*
- Synchronized and non-Synchronized Reserve Market: *bringing balance back between load and generation after loss of generation*
- Black Start Service: *providing generation resources to energize the grid from a complete blackout*
- Reactive Supply: *providing voltage stability*
- Scheduling, System Control & Dispatch: *PJM's operating expenses per Schedule 9 of the tariff*
- *Regulation and reserve markets are market-based and are co-optimized*
- *Black start, reactive supply, and scheduling are all cost-based and approved by FERC*



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Regulation Market

- Resources must be respond to an automated signal from PJM
- Resources must respond within 5 minutes to correct for small load changes to get power system back in balance (Area Control Error – ACE)
- Resources compensated based on their performance (market-based compensation)
- Generators, Demand Response, or Energy Storage
- Regulation Requirement in PJM - 0.7% of peak
- All load serving entities have an hourly obligation based on a load ratio share; a load can use its own resources, contract with a resource, or buy in the market.



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Reserve Market

- Reserves are an additional capacity required above the anticipated peak load
- Sync (already on-line) or non-sync (off-line)
- To maintain reliability in case of a loss of a generating unit or to correct for a forecast error
- Primary (respond within 10 minutes) and secondary (within 30 minutes)
- Reserve Requirement in PJM – 150% of the largest contingency
- All load serving entities have an obligation based on a load ratio share; a load can use its own resources, contract with a resource, or buy in the market.



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Reactive Supply

- Maintain voltage within reliability limits
- Cost-based – approved by FERC
- PJM bills for reactive supply by transmission zone
- Revenues are allocated to generation resources and transmission owners.
- All transmission customers pay for that service



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Blackstart

- A generation unit that can independently start and synchronize to the grid w/o any source of electricity following a complete blackout in the Eastern Interconnection
- These units are distributed across all PJM transmission zones
- These units would provide power to the non-blackstart units
- Cost-based – approved by FERC
- PJM and the transmission owners select the critical blackstart units
- All transmission customers pay for that service



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Scheduling, System Control, and Dispatch

- PJM's operating budget for generation dispatching, overseeing the reliability of the grid, and administering the energy, capacity and ancillary services markets
- Cost-based and is billed to all transmission customers (about \$0.36 to \$0.38/mwh)



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THANK YOU!