Market Monitoring in PJM

Governor's Committee on Energy Choice

Las Vegas, Nevada

09.13.2017

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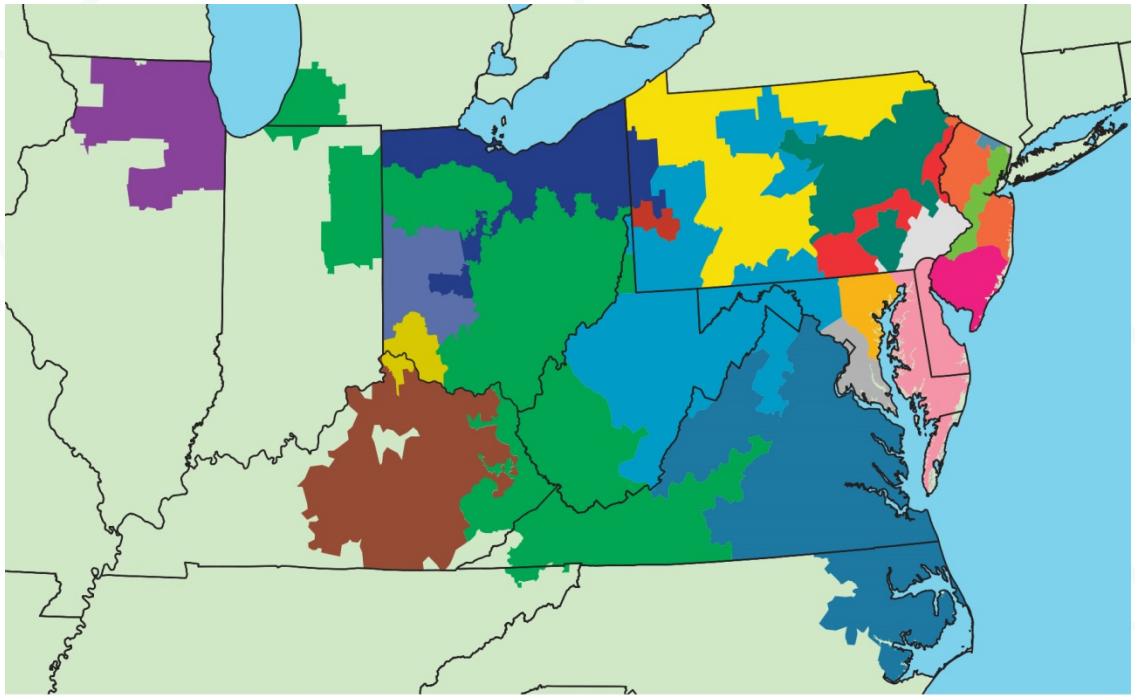
Market Monitor for PJM

Monitoring Analytics

Overview

- **PJM Markets**
- Market Monitoring Function

PJM footprint: 20 control zones



Legend

- Allegheny Power Company (AP)
- American Electric Power Co., Inc (AEP)
- American Transmission Systems, Inc. (ATSI)
- Atlantic Electric Company (AECO)
- Baltimore Gas and Electric Company (BGE)
- ComEd
- Dayton Power and Light Company (DAY)
- Delmarva Power and Light (DPL)
- Dominion
- Duke Energy Ohio/Kentucky (DEOK)
- Duquesne Light (DLCO)
- Eastern Kentucky Power Cooperative (EKPC)
- Jersey Central Power and Light Company (JCPL)
- Metropolitan Edison Company (Met-Ed)
- PECO Energy (PECO)
- Pennsylvania Electric Company (PENELEC)
- Pepco
- PPL Electric Utilities (PPL)
- Public Service Electric and Gas Company (PSEG)
- Rockland Electric Company (RECO)

PJM Summary Statistics

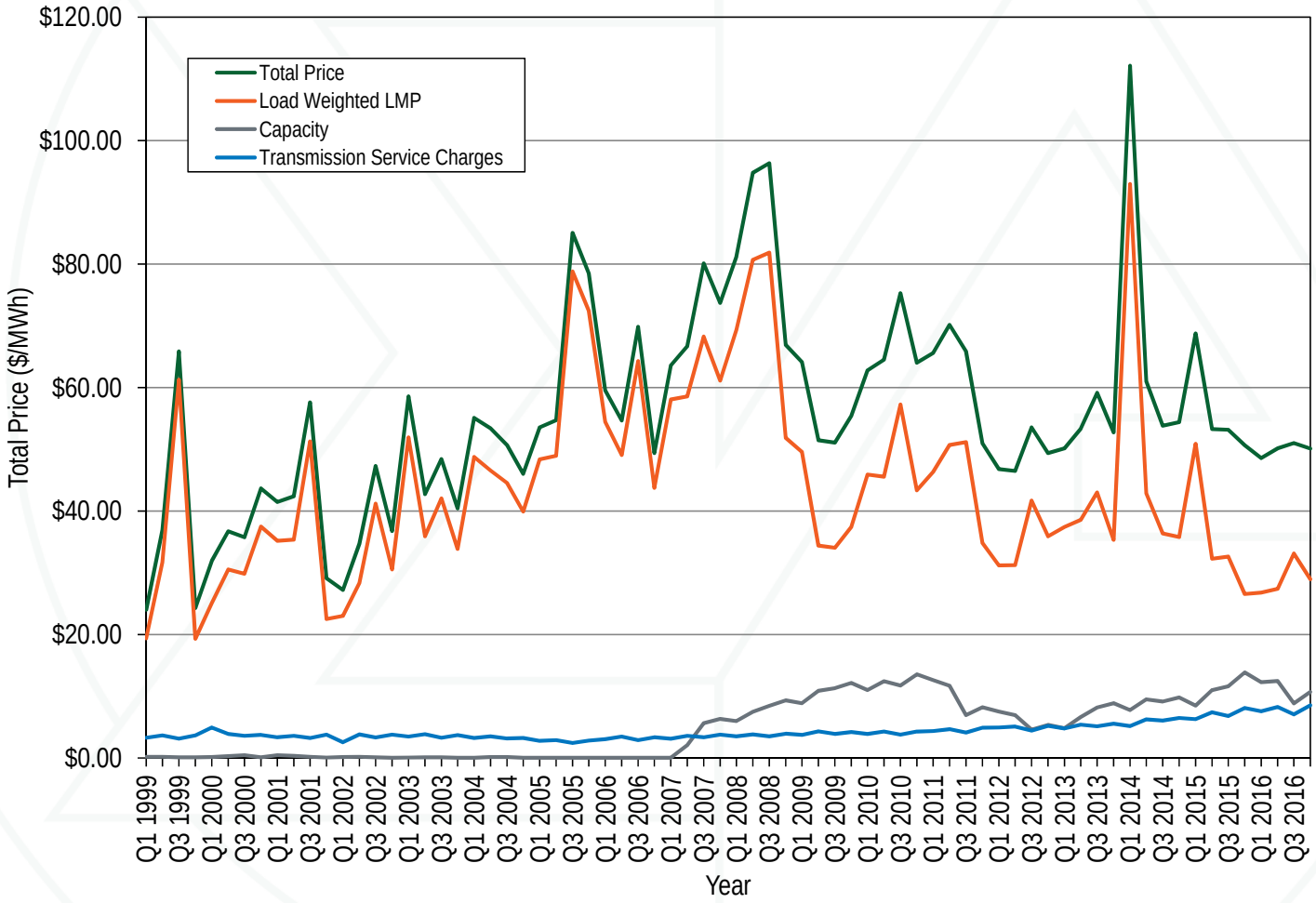
	2015	2016	Percent Change
Load	776,083 GWh	778,269 GWh	0.3%
Generation	786,698 GWh	812,544 GWh	3.3%
Net Actual Interchange	15,368 GWh	(7,967) GWh	(152%)
Losses	16,241 GWh	15,154 GWh	(6.7%)
Regulation Cleared MW*	641 MW	611 MW	(4.7%)
RTO Primary Reserve Requirement	2,175 MW	2,175 MW	0.0%
Total Billing	$42.63 Billion	$39.05 Billion	(8.4%)
Peak	Tue, July 28	Thu, August 11	
Peak Load	143,697 MW	152,177 MW	5.9%
Installed Capacity	As of 12/31/2015	As of 12/31/2016	
Installed Capacity	177,683 MW	182,449 MW	2.7%

* This is an hourly average stated in actual MW.

PJM Markets

- Energy Market
  - Day Ahead
  - Real Time (Balancing)
- Capacity Market (RPM)
  - Base Residual Auctions
  - Incremental Auctions
- Financial Transmission Rights Market (FTR)
  - ARR/FTR
  - Long term/Annual/Balance of period/Monthly
  - Auction Options
- Ancillary Services
  - Regulation Market
  - Synchronized Reserve Market
  - Black Start Service
  - Reactive Service

Top components of total PJM price



Monitoring Analytics

Overview

- PJM Markets
- **Market Monitoring Function**

PJM Market Monitor

- Since 1999, the PJM Market Monitoring Unit has been responsible for promoting a robust, competitive and nondiscriminatory electric power market in PJM by implementing the PJM Market Monitoring Plan.
- Monitoring Analytics is the Independent Market Monitor for PJM.
- Monitoring Analytics was created in 2008 by spinning off the Market Monitoring Unit of PJM Interconnection.

Role of Market Monitoring

- Market monitoring is required by FERC Orders
- Role of competition under FERC
  - Mechanism to regulate prices
  - Competitive outcome = just and reasonable
- Relevant model of competition is not laissez faire
- Competitive outcomes are not automatic
- Detailed rules required – like other markets/exchanges
- Detailed monitoring required
  - Of participants
  - Of RTO: Regional Transmission Organization
  - Of market rules

MMU Functions

- Monitoring
  - Compliance with market rules
  - Exercise of market power
  - Retrospective mitigation
  - Inputs to prospective mitigation
- Reporting
  - State of the market reports
  - Reports on specific issues
- Market Design
  - Adequacy of market rules/market design
  - Recommendations for improved market design

Role of Market Monitoring

- Market Monitoring is primarily analytical
- Market monitoring provides information
  - To FERC
  - To state regulators
  - To market participants
  - To RTO
- FERC has enforcement authority

Actions of MMU

- Discuss issues with relevant Market Participants.
- Identify issues and notify FERC OE.
- Make formal referrals to FERC regarding the behavior of relevant Market Participants.
- Recommend modifications to rules, standards, procedures and practices of PJM.
  - Make recommendations to PJM Committees or to PJM Board.
  - Make regulatory filings to address market issues and seek remedial measures.
- Evaluate additional enforcement mechanisms.

Authority of MMU

- MMU has no authority to modify prices ex post.
- MMU has no authority to make ad hoc adjustments in day to day market activities.
- MMU has no authority to require changes in market participant behavior.
- MMU has no authority to interfere with PJM system operations.

MMU: Inputs to Prospective Mitigation

- MMU receives prospective offers from market participant
- MMU reviews data, applies screens and provides opinion to market participant
- MMU attempts to resolve any issues with market participant
- If agreement, market participant enters offer into PJM systems
- If disagreement, market participant enters offer into PJM systems
  - MMU notifies participant that FERC action will be requested in the event of market impact

Market Monitoring Function

- Diverse staff expertise
  - Developed through experience in monitoring
- Build detailed understanding
  - Market structure: macro/micro
  - Physical infrastructure
  - System operations
  - Fuel supply
- Data access
  - Needs to be built in to PJM data architecture
- IT/storage requirements

Lessons Learned

- Interaction with market participants is critical to understanding markets
- Interaction with state Commissions is critical to understanding retail/wholesale interaction issues
- Interaction with RTO staff is critical to understanding markets
- Coordination with FERC is essential to efficient monitoring and mitigation
- Access to all markets data is essential
- Independence must be defined, transparent and enforceable

Monitoring the RTO

- MMU also monitors PJM
  - Role of PJM in ensuring efficient market outcomes
  - Operating reserves issues
    - Operator decisions
    - Impact on prices
    - Impact on uplift payments
  - Actions when market is tight
    - Scarcity pricing
    - Demand side resources
    - Trigger for actions
  - Dispatch decisions and rules
  - Application of market power mitigation rules
  - Calculation of market prices

Market Monitoring Independence

- Market monitoring authority lies with FERC
- Market monitoring plan is approved by FERC as part of the PJM tariff
- Clear and transparent definitions required in Market Monitoring Plan:
  - Independence/reporting/accountability
  - MMU budget approval process
  - Roles of FERC, the PJM Board and PJM management
  - MMU obligation/ability to prepare analysis, reports, filings
  - MMU role in retrospective mitigation
  - MMU role in providing inputs to prospective mitigation

Market Monitoring Independence

- Requirements for independence
  - Adequate resources
  - Involvement in stakeholder process
  - Involvement in market rule development
  - Authority to do required analysis
  - Access to RTO
- Independence is enforceable by FERC
  - Regular reviews; detailed questions about process
  - Active role
  - Clear rules/expectations

Adequate Resources

- Adequate resources
  - Staff resources
  - IT resources: hardware and software
  - Data resources (external/internal)
  - External resources (consultants)
  - Legal resources
- Budget review process
  - Fair
  - No ability of interests to influence
- Staff of full time employees
  - Market monitoring career path
  - Job security subject to performance

Stakeholder Process

- Full MMU involvement in stakeholder process
  - Attend meetings
  - Present views/recommendations
  - Feedback from participants
- Source of information for participants
- Informed consensus
- Flawed rules are difficult to change

Market Rule Development

- Role in market rule development
  - Ongoing review of adequacy of rules for ensuring competitive outcomes
  - Authority to develop and propose modifications to rules
  - RTO has authority to file rules changes with FERC under FPA Section 205
  - RTO has authority to file rules changes with FERC under FPA Section 206
  - MMU has authority to file rules changes with FERC under FPA Section 206

Authority to Perform Analysis

- Prepare and distribute reports without intervention
- File complaints with FERC
- Make referrals to FERC
- Intervene in proceedings at FERC
- Provide analysis to state commissions
- Perform specific tariff-defined roles
  - Local market power
  - Market power in capacity markets
- Peer review is critical
  - RTO staff
  - Market participants
  - State and federal regulators

Access to RTO

- Access to RTO
  - Unlimited access to all RTO data
  - Access to RTO personnel and facilities
  - Access to RTO models; software; consultants

Market Monitoring Independence

- Dimensions of independence
  - Independent from Market Participants
  - Independent from ISO/RTO management
  - Independent from ISO/RTO board of directors

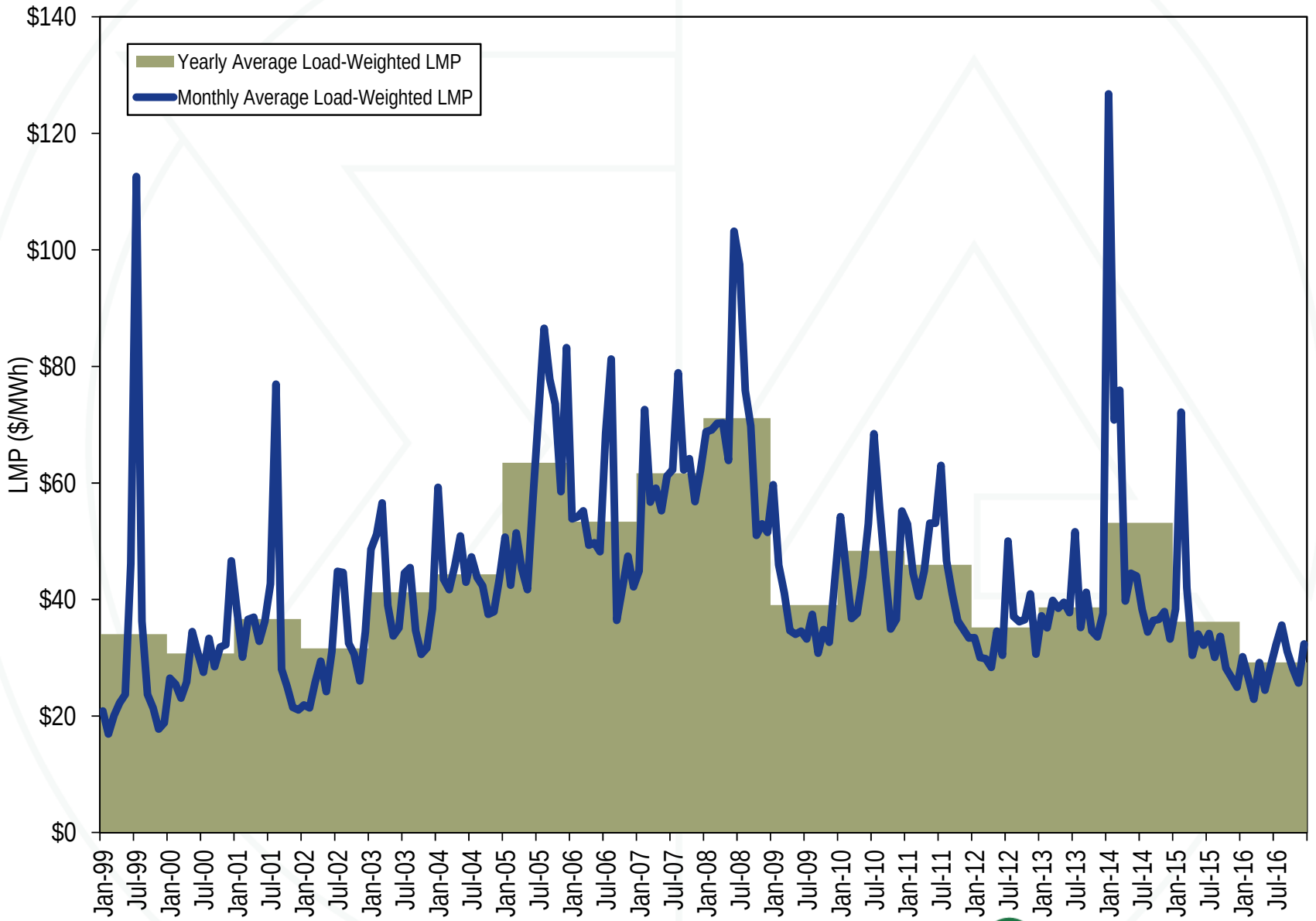
Institutional Requirements for Independence

- External MMU
  - Report to Board administratively only
  - No influence on analysis by Board or management
  - Clear tariff rules governing interactions between MMU and RTO
  - Rules enforceable by FERC; regular request for feedback
  - Contract definition and terms should not permit leverage
- Performance review – periodic renewal
  - Clear standards
  - Objective review
  - No role for influence

Market Design Issues in PJM

- Energy market
  - LMP
  - Prices set by short run marginal cost
- FTR market
  - Rights to congestion revenue
- Capacity market
  - Revenue adequacy
  - Definition of capacity
  - Role of demand side resources
- Ancillary services markets
  - Regulation

PJM real-time load-weighted, average LMP



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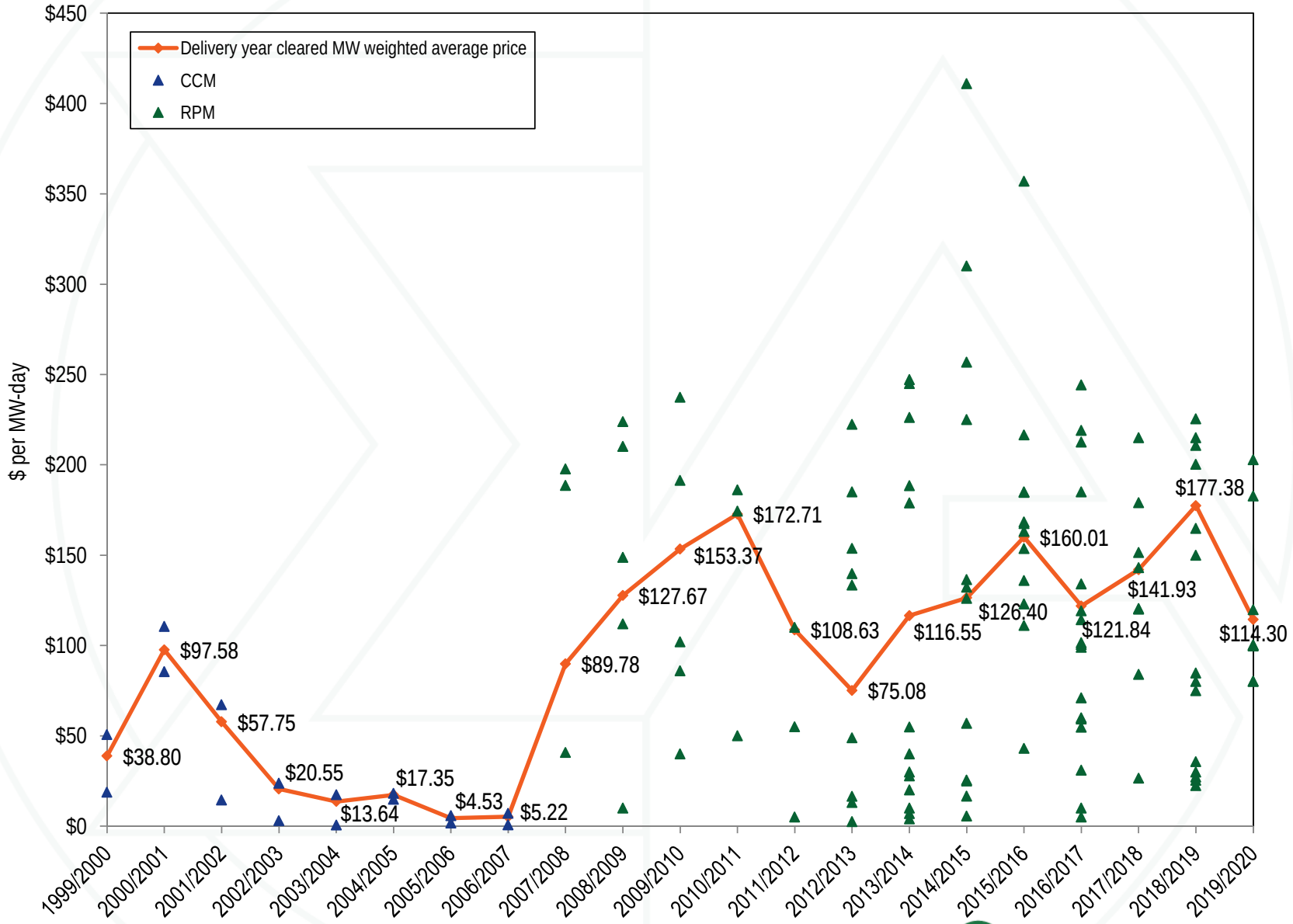
PJM capacity prices



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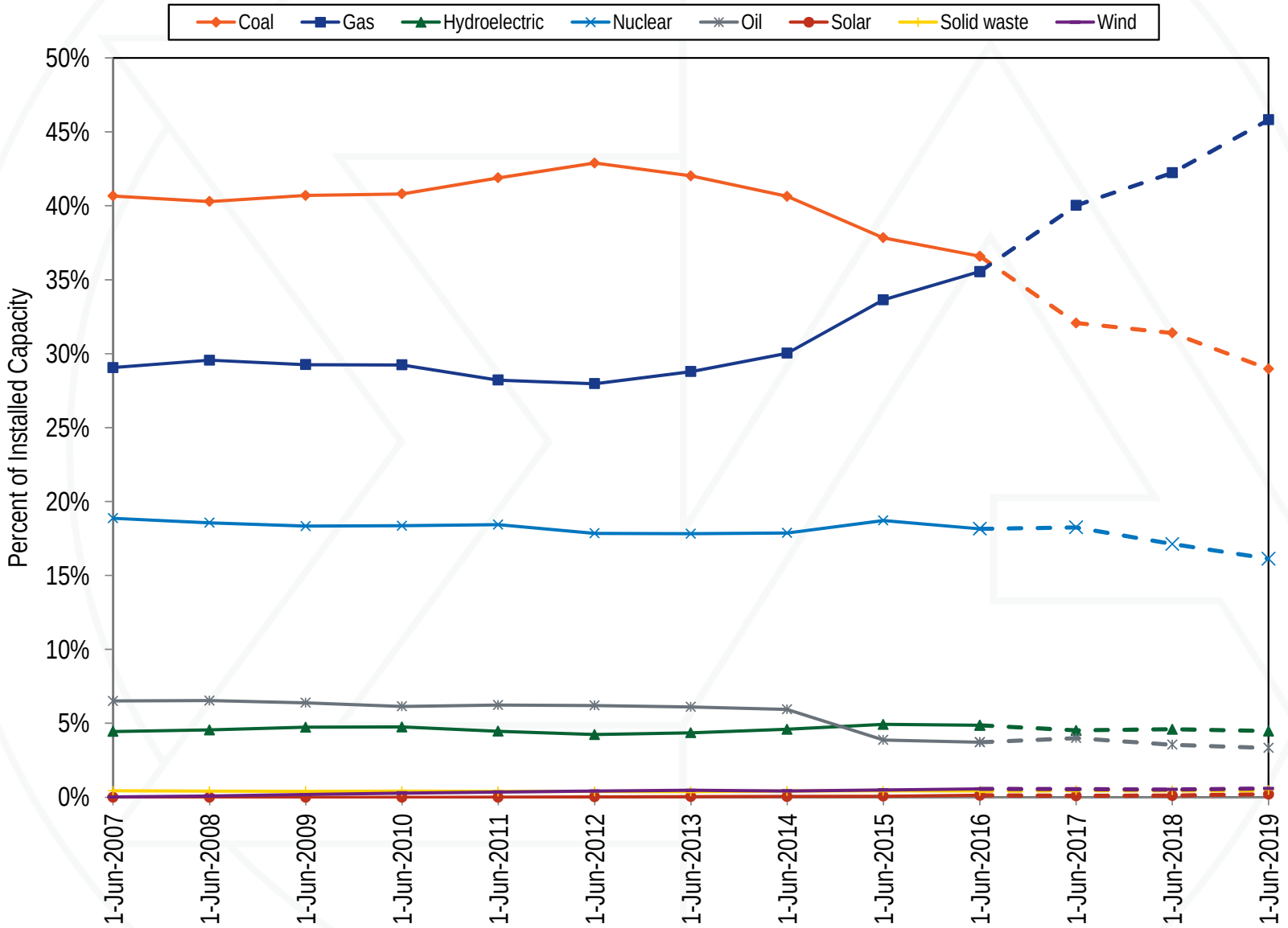
PJM generation by fuel source

	2015		2016		Change in
	GWh	Percent	GWh	Percent	Output
Coal	284,757.4	36.2%	275,281.7	33.9%	(3.3%)
Bituminous	257,700.0	32.8%	241,050.2	29.7%	(6.5%)
Sub Bituminous	22,528.7	2.9%	28,949.7	3.6%	28.5%
Other Coal	4,528.6	0.6%	5,281.7	0.7%	16.6%
Nuclear	279,106.5	35.5%	279,546.4	34.4%	0.2%
Gas	183,650.7	23.3%	217,214.5	26.7%	18.3%
Natural Gas	180,948.7	23.0%	215,022.4	26.5%	18.8%
Landfill Gas	2,275.8	0.3%	2,176.2	0.3%	(4.4%)
Other Gas	426.3	0.1%	15.9	0.0%	(96.3%)
Hydroelectric	13,067.2	1.7%	13,686.8	1.7%	4.7%
Pumped Storage	4,660.2	0.6%	4,840.2	0.6%	3.9%
Run of River	6,736.3	0.9%	7,332.8	0.9%	8.9%
Other Hydro	1,670.8	0.2%	1,513.8	0.2%	(9.4%)
Wind	16,609.7	2.1%	17,716.0	2.2%	6.7%
Waste	4,365.1	0.6%	4,139.8	0.5%	(5.2%)
Solid Waste	4,175.4	0.5%	4,139.8	0.5%	(0.9%)
Miscellaneous	189.7	0.0%	0.0	0.0%	(100.0%)
Oil	3,276.2	0.4%	2,163.6	0.3%	(34.0%)
Heavy Oil	622.9	0.1%	270.6	0.0%	(56.6%)
Light Oil	1,122.0	0.1%	341.1	0.0%	(69.6%)
Diesel	163.8	0.0%	59.4	0.0%	(63.7%)
Gasoline	0.0	0.0%	0.0	0.0%	NA
Kerosene	413.0	0.1%	74.8	0.0%	(81.9%)
Jet Oil	0.0	0.0%	0.0	0.0%	NA
Other Oil	954.5	0.1%	1,417.7	0.2%	48.5%
Solar, Net Energy Metering	548.4	0.1%	1,019.4	0.1%	85.9%
Energy Storage	7.6	0.0%	15.7	0.0%	106.7%
Battery	7.6	0.0%	15.7	0.0%	106.7%
Compressed Air	0.0	0.0%	0.0	0.0%	NA
Biofuel	1,309.6	0.2%	1,760.3	0.2%	34.4%
Geothermal	0.0	0.0%	0.0	0.0%	NA
Other Fuel Type	0.0	0.0%	0.0	0.0%	NA
Total	786,698.5	100.0%	812,544.1	100.0%	3.3%

PJM installed capacity by fuel source



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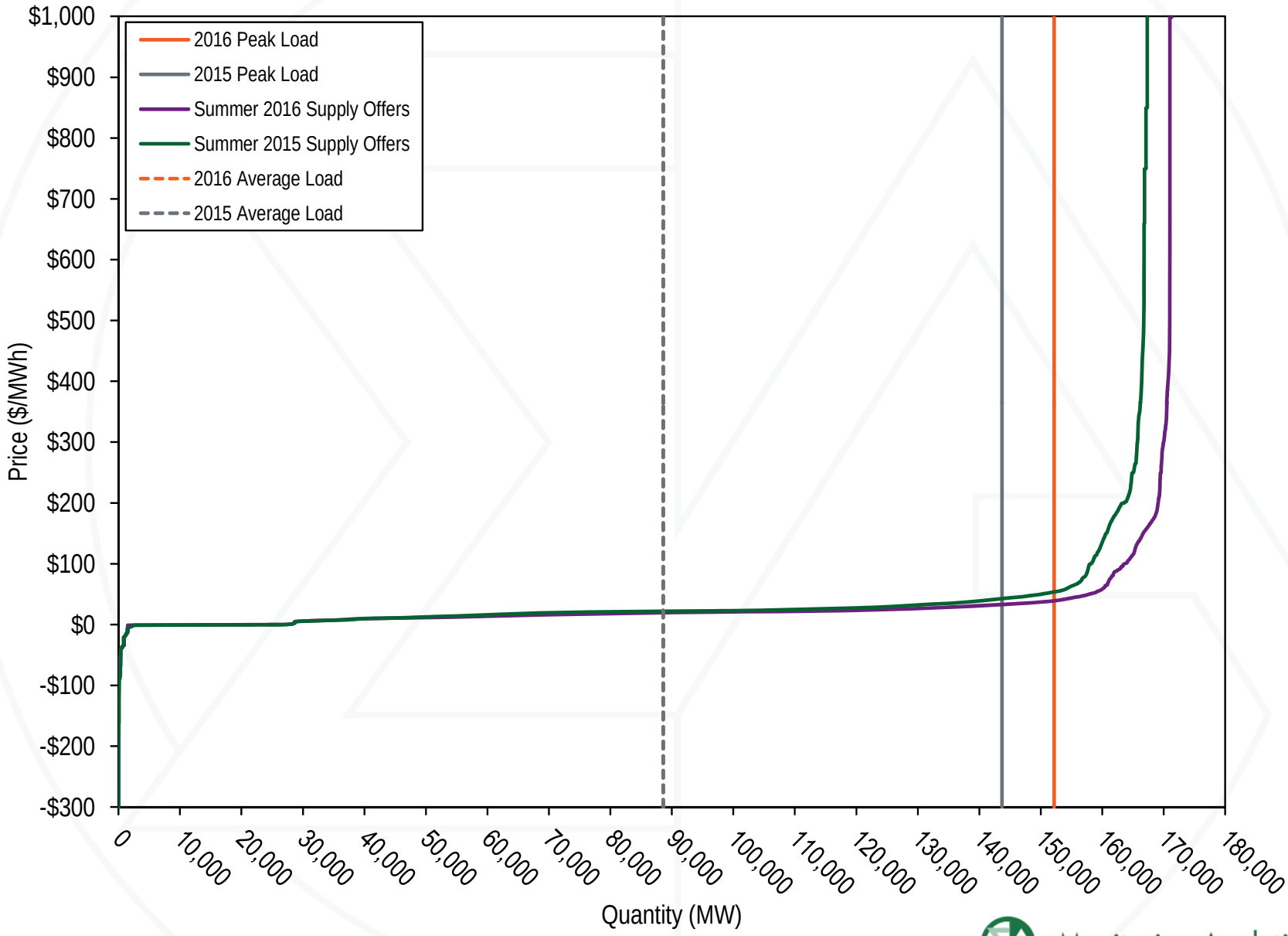
PJM aggregate real-time supply curves



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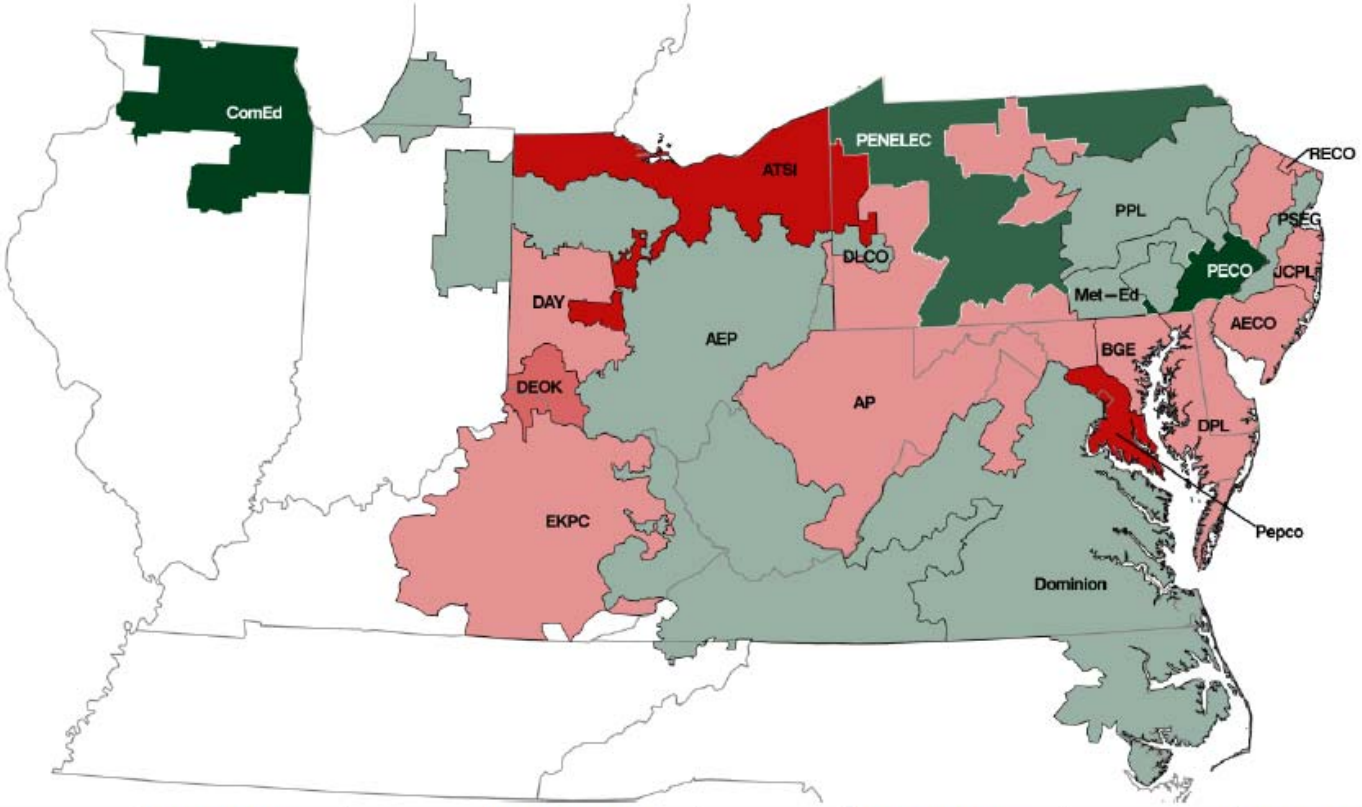
PJM real-time generation minus load: 2016



Zone	Net Gen Minus Load (GWh)	Zone	Net Gen Minus Load (GWh)	Zone	Net Gen Minus Load (GWh)	Zone	Net Gen Minus Load (GWh)
AECO	(3,427)	ComEd	31,369	DPL	(9,806)	PENELEC	20,307
AEP	14,986	DAY	(1,908)	EKPC	(2,765)	Pepco	(20,204)
AP	(574)	DEOK	(10,616)	JCPL	(4,712)	PPL	9,668
ATSI	(24,444)	DLCO	3,361	Met-Ed	6,937	PSEG	1,800
BGE	(9,363)	Dominion	264	PECO	24,506	RECO	(1,481)

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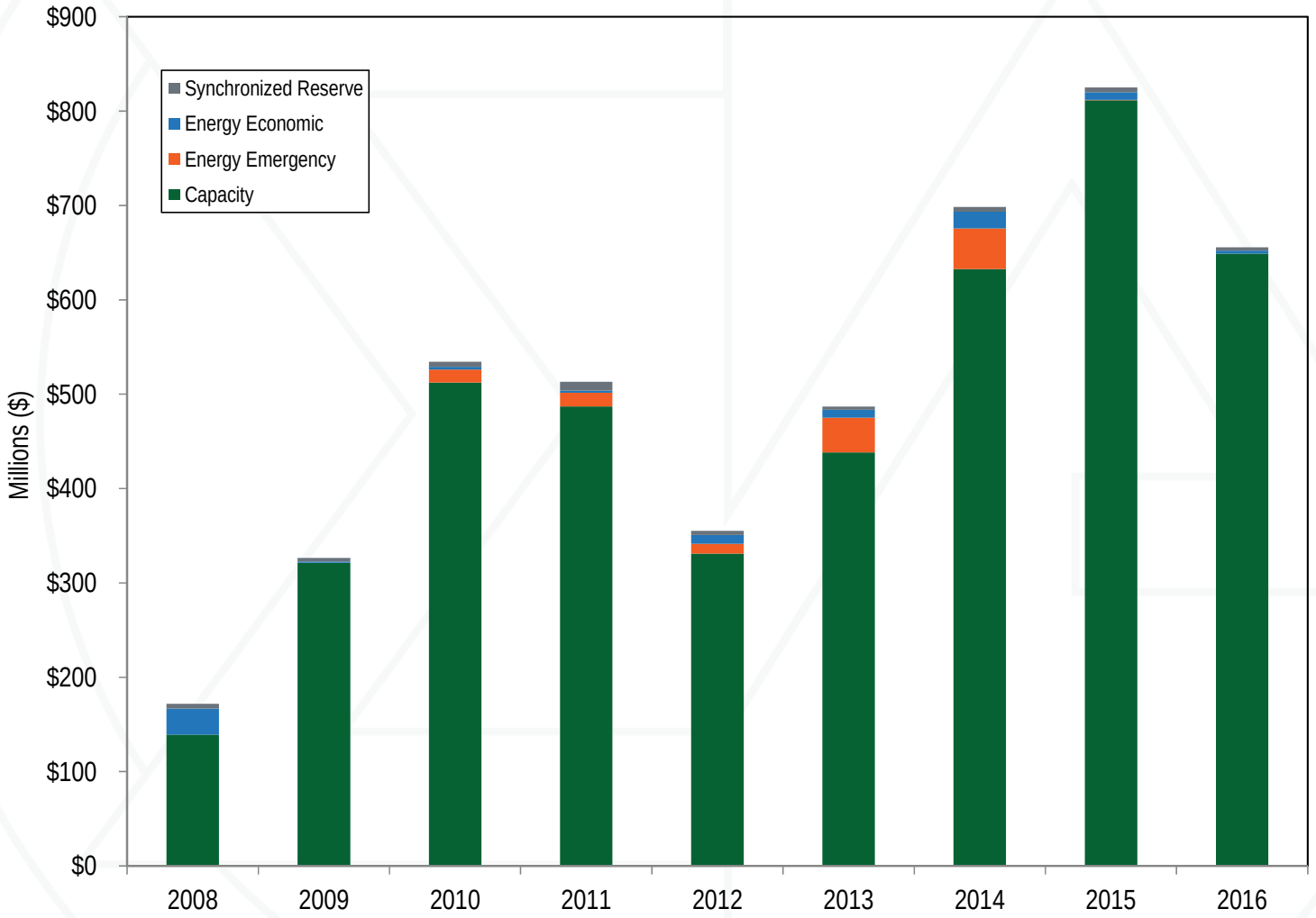
Demand response revenue by market



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