

The Brattle Group

Outlook on Fundamentals in PJM's Energy and Capacity Markets

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Intro: PJM Fundamentals

- ◆ PJM's market is undergoing some fundamental shifts that are changing the way we think about and model the energy and capacity markets going forward:
 - Low gas prices and coal-to-gas switching
 - Wind penetration
 - Environmental coal retirements
 - DR penetration and saturation
 - Scarcity pricing
 - Attracting new generation investments
- ◆ Many of these same factors are affecting other markets across North America in different ways and to different degrees
- ◆ PJM is a good market to explore because the market evidence is already starting to come in on the longer-term trends that will start affecting other markets a few years down the line

PJM Compared to Other Market Designs

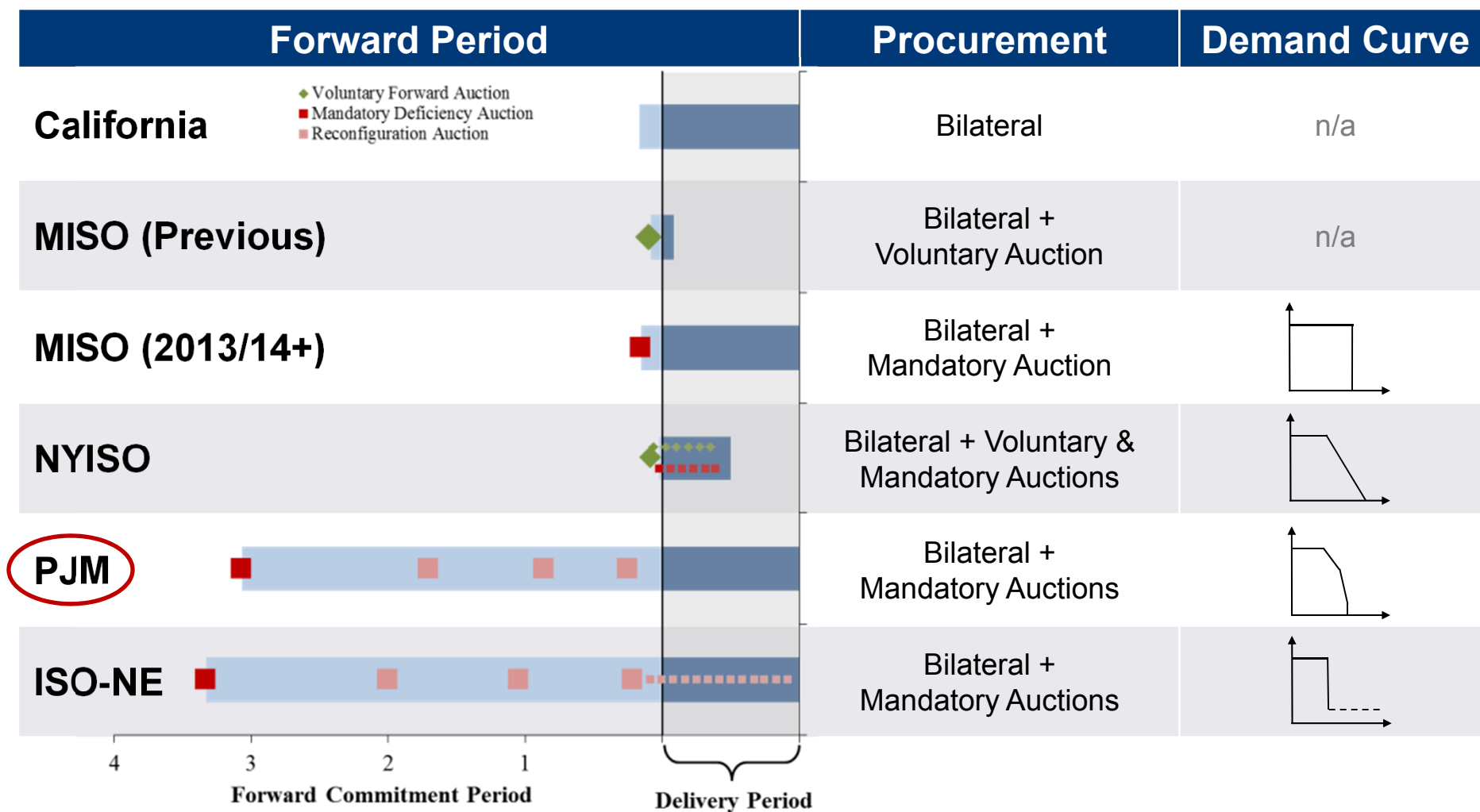
	Regulated Planning (Customers Bear Most Risk)			Market Mechanisms (Suppliers Bear Most Risk)		
	Regulated Utilities	Administrative Contracting	Capacity Payments	LSE RA Requirement	Capacity Markets	Energy-Only Markets
Examples	SPP, BC Hydro, most of WECC and SERC	Ontario	Spain, South America	California, MISO (both also have regulated IRP)	PJM, NYISO, ISO-NE, Brazil, Italy, Russia	ERCOT, Alberta, Australia's NEM, Scandinavia
Resource Adequacy Requirement?	Yes (Utility IRP)	Yes (Administrative IRP)	Yes (Rules for Payment Size and Eligibility)	Yes (Creates Bilateral Capacity Market)	Yes (Mandatory Capacity Auction)	No (RA not Assured)
How are Capital Costs Recovered?	Rate Recovery	Energy Market plus Administrative Contracts	Energy Market plus Capacity Payments	Bilateral Capacity Payments plus Energy Market	Capacity plus Energy Markets	Energy Market

See Also:

Pfeifenberger & Spees (2009). *Review of Alternative Market Designs for Resource Adequacy*.

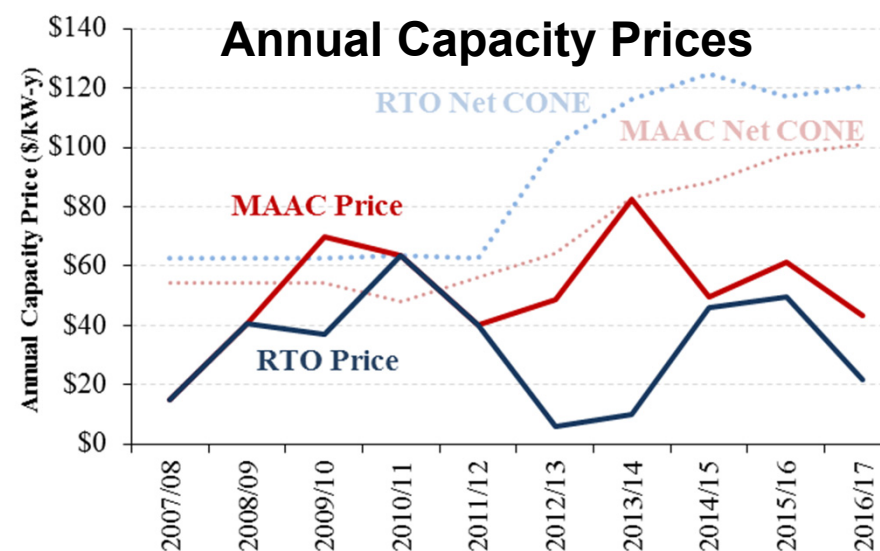
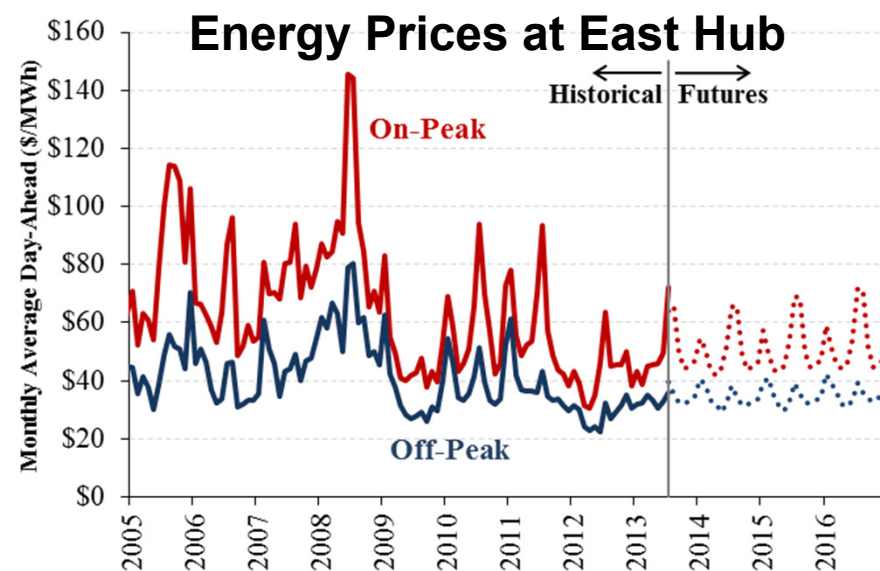
Spees, Newell, & Pfeifenberger (2013). "Capacity Markets: Lessons Learned from the First Decade," *Economics of Energy & Environmental Policy*, Vol. 2, No. 2, Forthcoming Fall 2013.

PJM's Capacity Market Compared to Others



Some Fundamentals Look Poor...

- ◆ A quick scan at the fundamentals looks dim
- ◆ **Energy futures** still trading far below pre-recession levels:
 - Shale gas driving down gas and electric prices, displacing coal units and leaving many in distress
 - Wind penetration driven by state RPS puts downward pressure on energy prices (at least off-peak)
- ◆ **Capacity prices** far below PJM's Net CONE estimate
 - Kept low for almost a decade by low-cost new supply from DR, net imports, uprates, and regulated entry



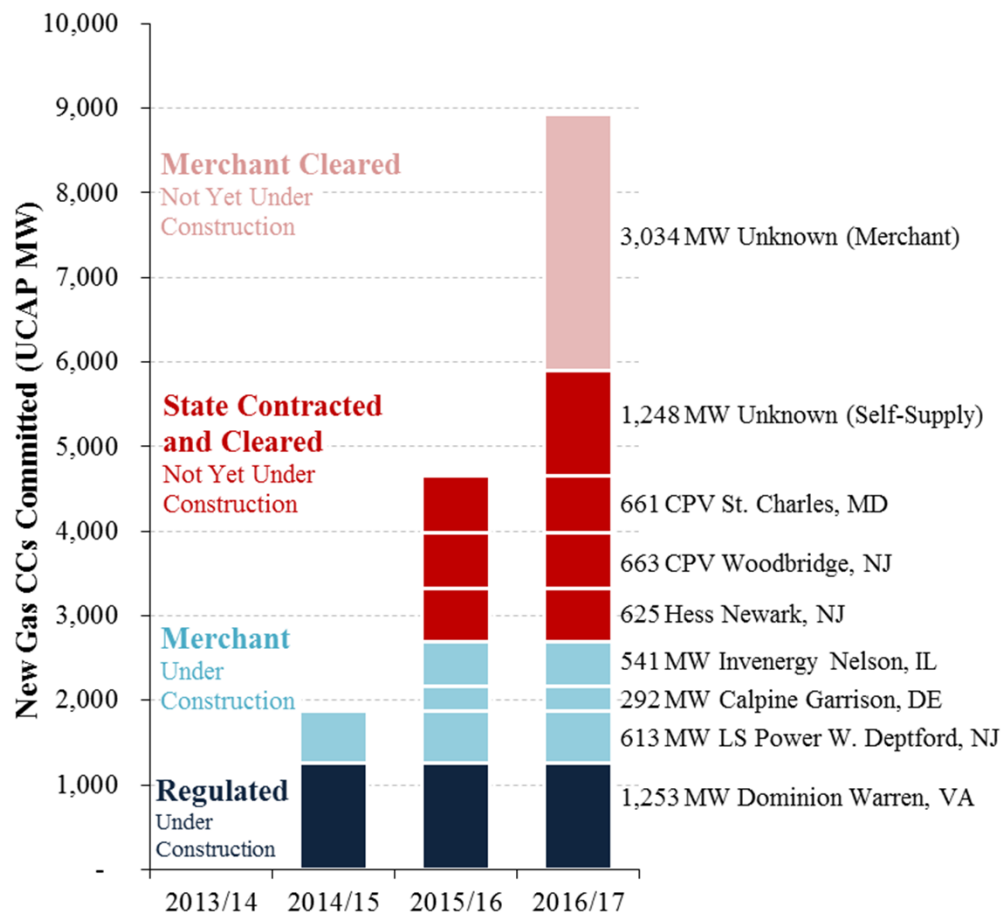
Sources: PJM BRA Results and Parameters, futures from SNL Energy, historical prices from Ventyx.

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...So Why Are Gas CCs Committing to Build?

- ◆ Last auction price was low:
 - \$22/kW-y in RTO and \$43/kW-y in MAAC
 - Only 18% and 43% of PJM's estimate of the Net Cost of New Entry, respectively
- ◆ But almost 9,000 MW of new CCs cleared over two years, representing a commitment to build (4,500 MW merchant)
- ◆ **Question:** Why commit to build at such low prices?

New Gas CCs Committed in PJM



Sources: PJM BRA Results, Ventyx Energy Velocity Suite, SNL Energy, owner announcements of cleared status, and NJ and MD public documentation of contract awards.

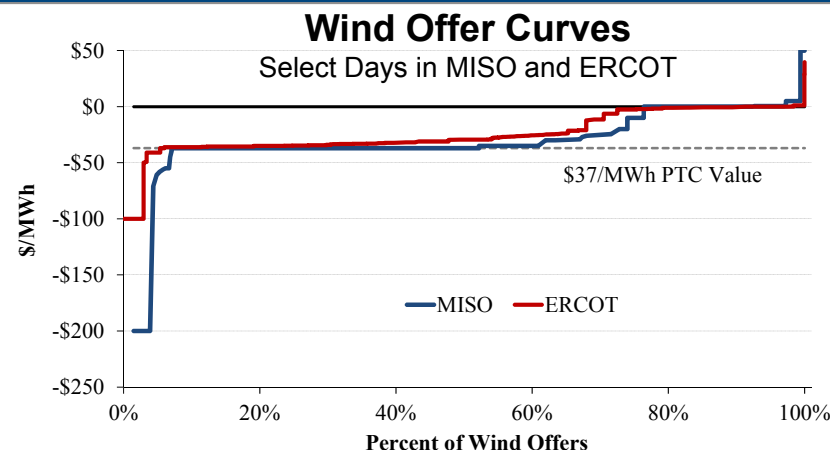
Wind Price Suppression and Volatility Upside

Wind Price Suppression

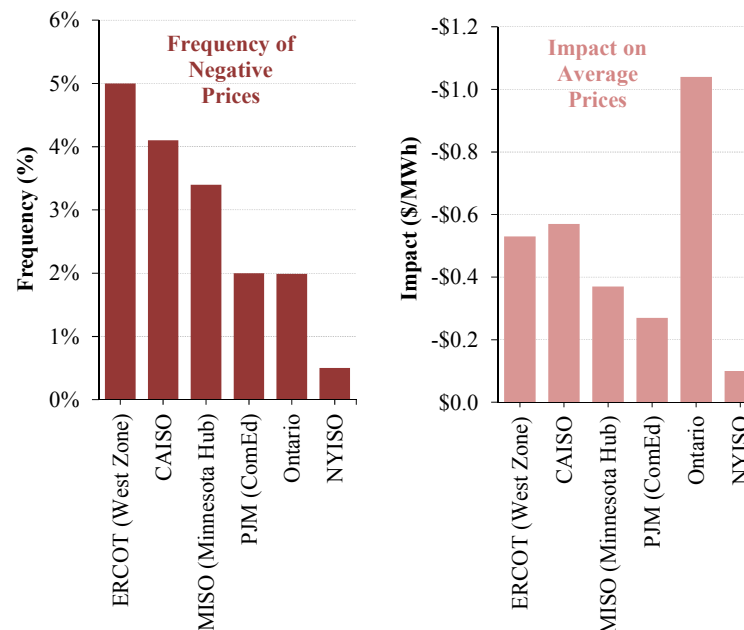
- ◆ Pushing prices down and negative in many locations (especially in West Texas, California, and MISO)
- ◆ Increasing spread between on- and off-peak prices

Volatility Upside

- ◆ Wind also increases energy market volatility (upside for flexible gen even if prices are down on average)
- ◆ Also requiring RTOs to find new ways to compensate flexible resources:
 - Higher reserve requirements and new ancillary services (e.g. MISO ramp product)
 - ISO-NE performance incentives
 - California flexible resource requirements



Negative Prices July 2011-June 2012



Large, Simultaneous Environmental Retirements

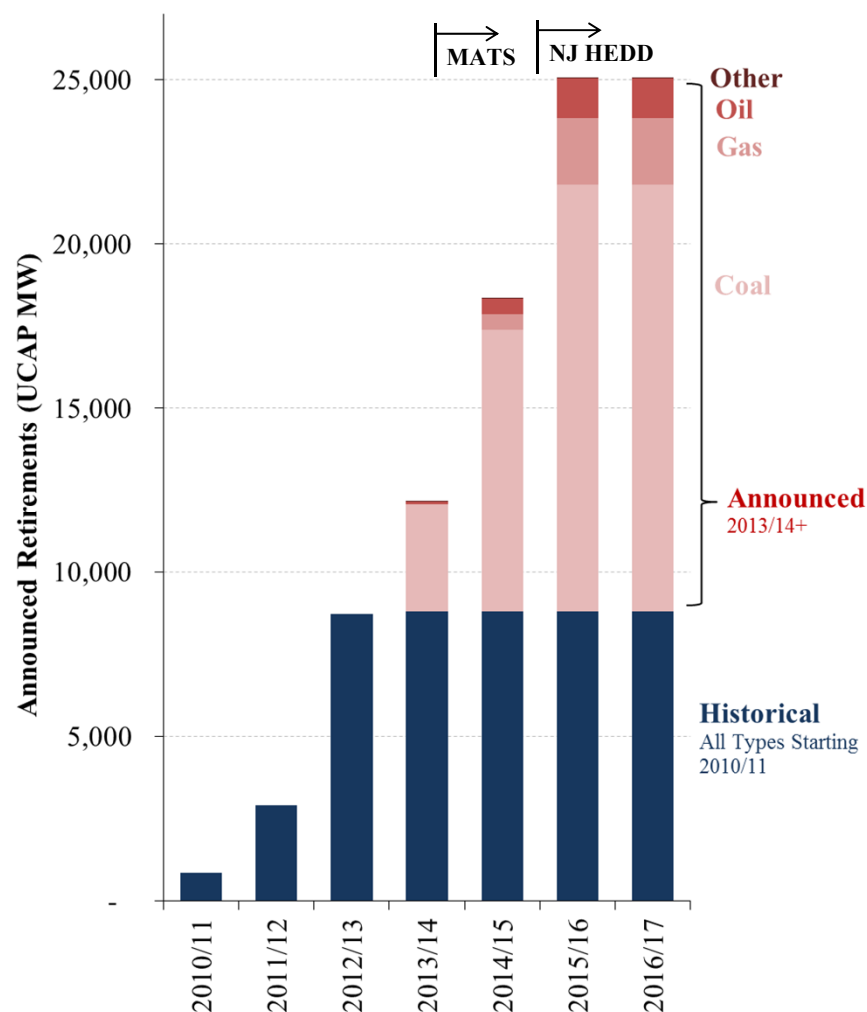
Strict Regulations

- ◆ Strict environmental regulations imposing retire-or-retrofit decisions:
 - EPA MATS (2014/15) and
 - NJ HEDD Rule (2015/16)
- ◆ Many units already in distress due to low energy margins and capacity prices now forced to retire

Exceptional Scale

- ◆ Almost 25,000 MW of retirements announced (8,800 MW already retired, another 16,200 MW announced)
- ◆ Substantial operational challenge as PJM loses 15% of the generation fleet in only four years
- ◆ Upside impact on both energy and capacity markets relative to recent years

PJM Retirements



Sources: PJM pending and historical deactivations, Ventyx Energy Velocity Suite.

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DR, Imports, and New Gen will Replace Retirees

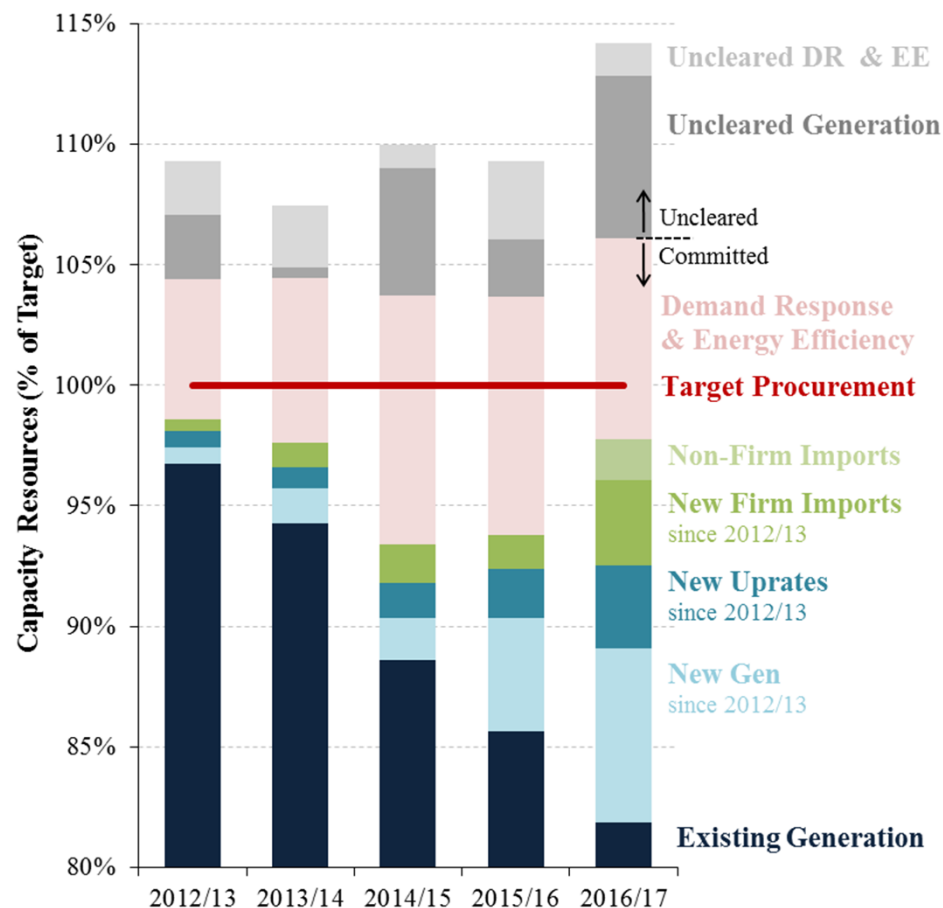
RPM “Stress Test”

- ◆ PJM’s capacity market passed an important test for robustness against environmental retirements
 - Continuing excess capacity at moderate or low prices despite retirements
 - Remaining concern about supply adequacy in short-term auctions and co-located retirements in small zones
- ◆ Other markets face similar concerns, but may have less efficient response w/o forward capacity markets (California w/ OTC, MISO w/ MATS)

PJM Replacement Supplies

- ◆ Excess gen will not be replaced
- ◆ Other retirements replaced by increased DR, new gen, uprates, and imports

PJM Committed Capacity



Sources: BRA results and parameters. Brattle 2011 RPM Review.

DR Reaching “Saturation” Levels

Rapid Growth

- ◆ From less than 2% of peak load in 2007/08 to 9.9% in 2015/16

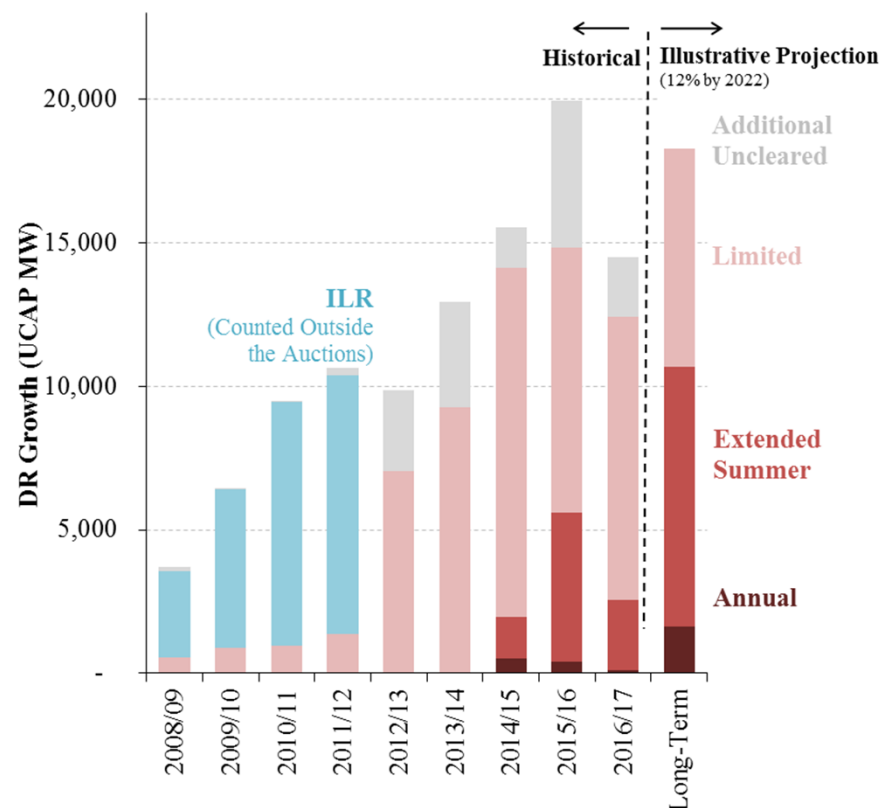
Reaching Saturation

- ◆ DR saturation required PJM to create multiple products to assure reliability (generation, EE, and high-quality DR can now earn a premium)
- ◆ Last auction attracted fewer DR offers (increased M&V, difficulty finding assets, more call hours expected)

Forward-Looking Capacity Price Impact

- ◆ Direct price suppression from DR will subside as DR saturates
- ◆ Will introduce some capacity price stability
 - Flatter supply curve (seen since 2012/13)
 - Easier entry/exit than generation
- ◆ Higher energy prices will reduce capacity prices

DR Commitments in PJM



Sources and Notes: PJM RPM Planning Parameters and Results; Brattle RPM review. Data exclude ILR, percentages reported based on RTO membership as of auction date excluding FRR entities.

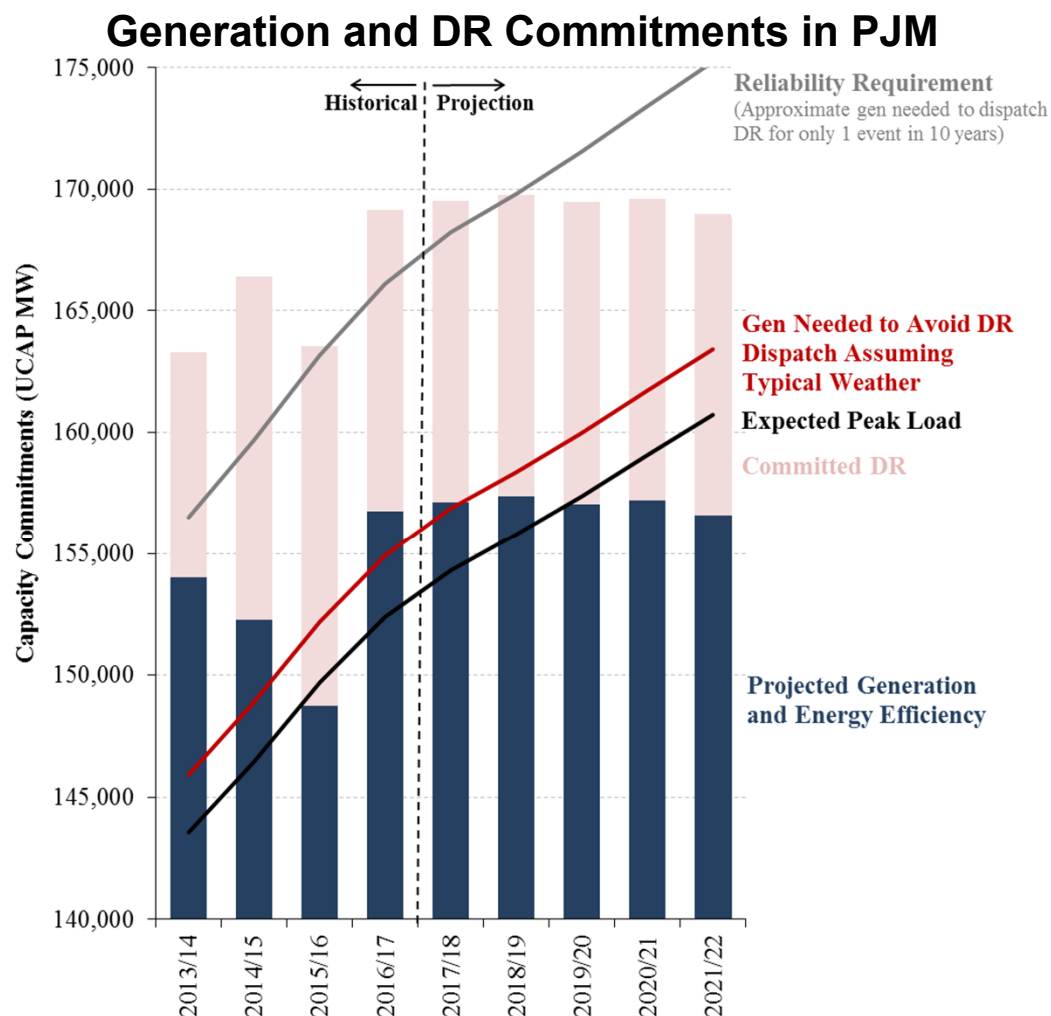
Declining Generation Reserve Margins

DR Displacing Gen

- ◆ Only a portion of the retiring gen will be replaced by imports or new gen
- ◆ Consequence is a dropping generation reserve margin (i.e. reserve margin if excluding DR)

More DR Dispatch Will be Needed

- ◆ With low DR penetration and high generation reserve margins, few DR calls have been needed to date (except in extreme weather)
- ◆ But by 2015 many more DR calls will be needed, even with typical peak weather
- ◆ May surprise some DR providers



Sources and Notes: Excludes FRR resources and load, analysis of PJM data and Ventyx data.

DR is No Longer an Emergency Resource

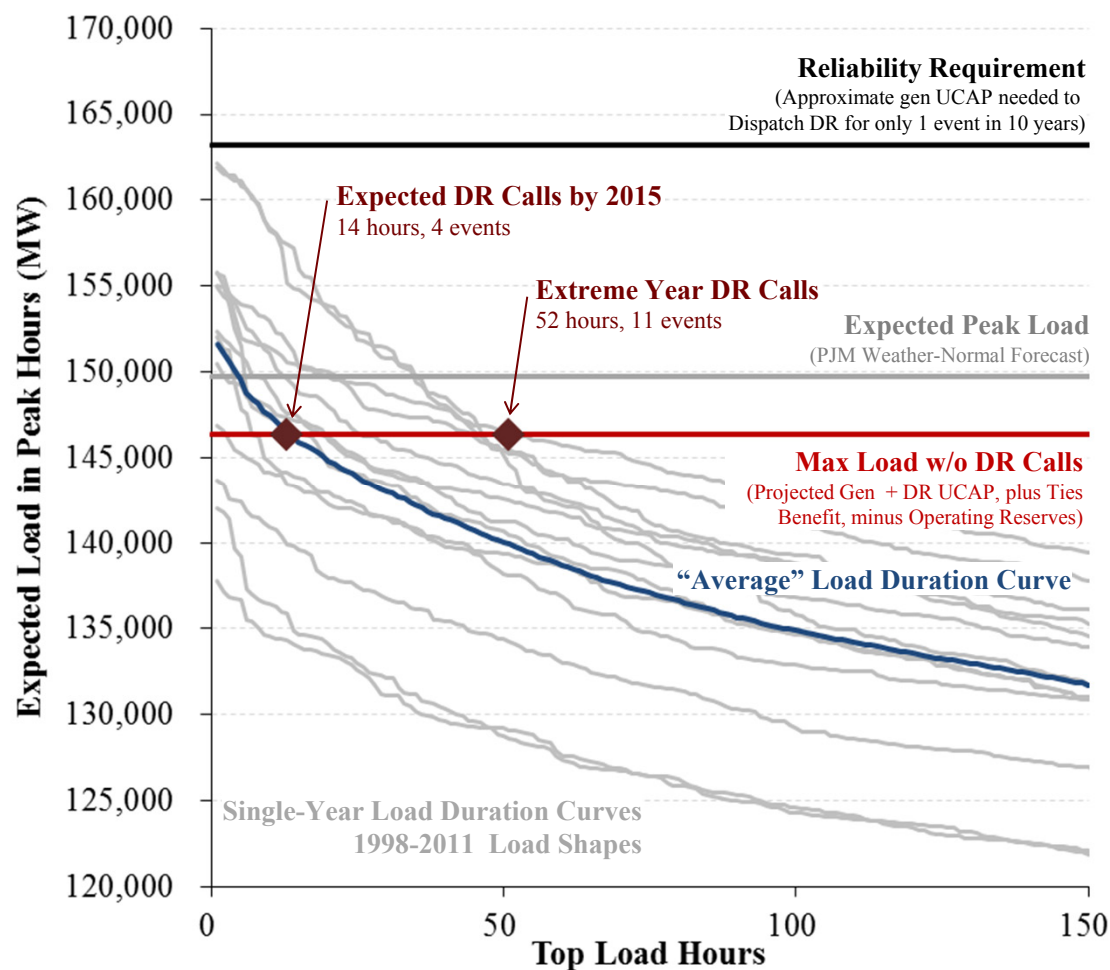
More DR Calls

- ◆ Historically, high reserve margins meant few or no DR calls, but at the low generation levels expected by 2015, DR will have to be called much more often
 - DR may be called ~14 hours (4 events) with typical weather
 - Extreme weather would require ~52 call hours (11 events)
- ◆ Magnitude of DR is under-appreciated by RTOs and market participants

DR as a Peaking Resource

- ◆ DR historically an “emergency” resource, called as a last resort
- ◆ New regime will require DR to schedule more like a peaker, impacting RT and DA markets

Load Duration Curve in 2015/16



Sources and Notes: Excludes FRR resources and load, analysis of PJM data and Ventyx data.

Scarcity Pricing: Evidence from the First Heat Wave

Scarcity Pricing

- ◆ All the U.S. RTOs and some international have been improving their “scarcity pricing” designs
 - Increasing price caps
 - “Penalty factors” during reserve shortages
 - Higher prices w/ other reliability events
- ◆ Especially big topic in ERCOT, tied to debate about capacity market

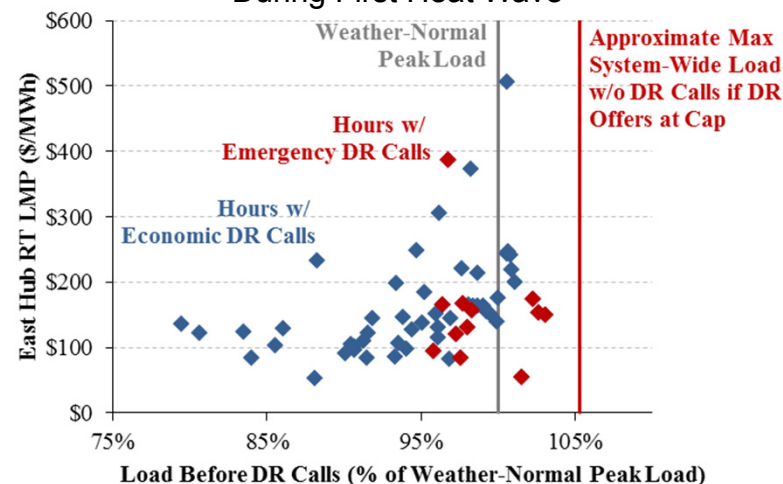
The First Heat Wave

- ◆ PJM’s new scarcity design (since Oct 2012), combined with high DR calls, is a new paradigm with much spikier prices
- ◆ Evidence from the first heat wave coming in on how DR and importers will interact with scarcity pricing

PJM Price Cap Increases

Dates	Reserve Penalty Factor	Energy Price Cap
Oct 2012 – May 2013	\$250	\$1500
Jun 2013 – May 2014	\$400	\$1800
Jun 2014 – May 2015	\$550	\$2100
Jun 2015 +	\$850	\$2700

Load and East Hub Prices During First Heat Wave



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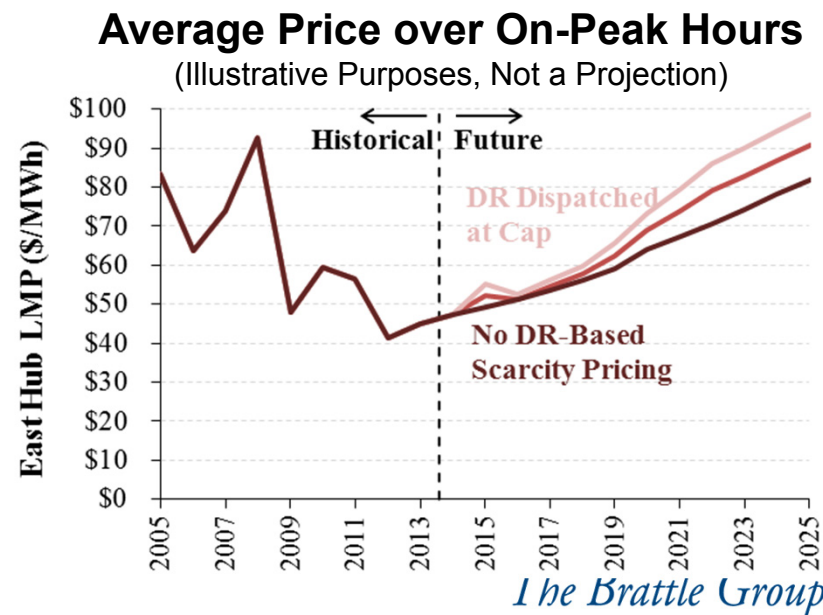
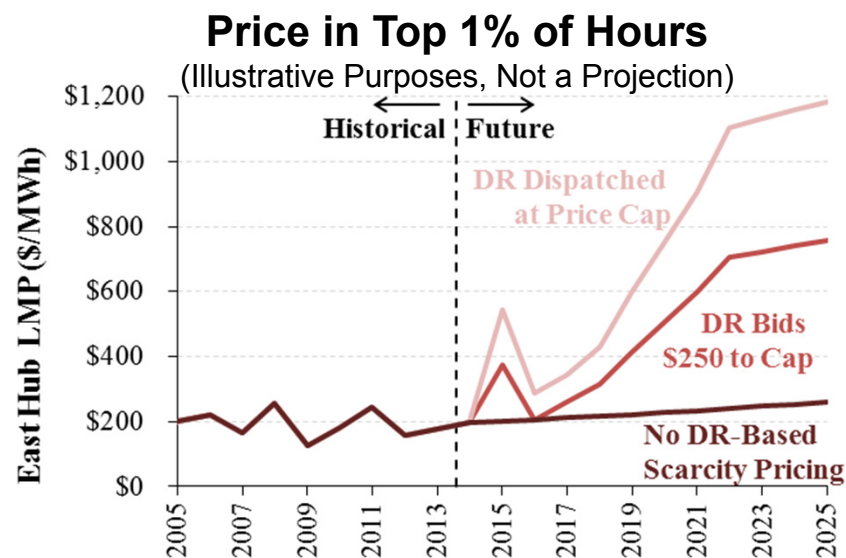
Scarcity Prices to Impact Super-Peak Hours

If All DR Remains “Emergency”

- ◆ Assuming 12% DR penetration by 2022, 30 hours per year would require DR calls
- ◆ If all that DR came in at the future price cap of \$2700/MWh, the energy market impacts would be very large
 - Price in top 1% hours up ~\$850/MWh
 - Price in all on-peak hours up ~\$16/MWh

DR Migrating into Energy Market?

- ◆ Historically, only 20% of all DR participates in the energy market (little to nothing above a few hundred dollars)
- ◆ Spikier, higher prices will push some DR to curtail for energy (illustrative case assumes DR bids over a range for energy)
- ◆ Key part of any energy market view going forward is about how DR offer levels will evolve



Outlook for Gas CC Economics

Energy Margins will Increase

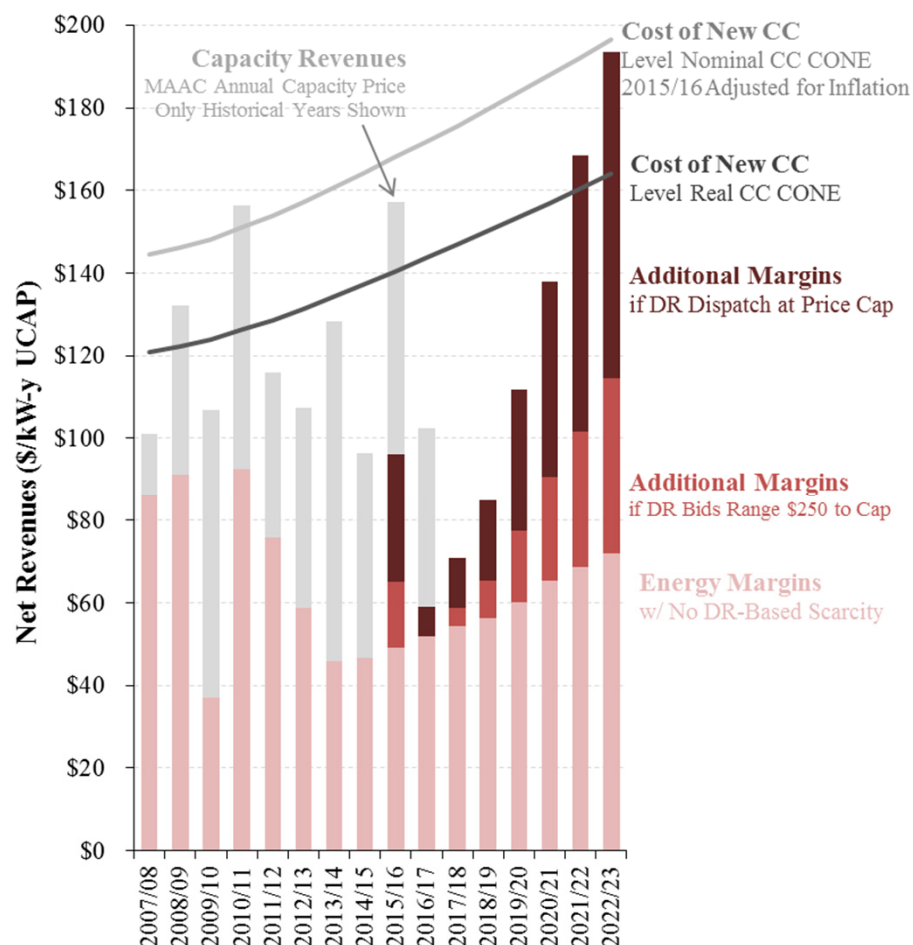
- ◆ Super-peak prices have a disproportionately large impact on generator net revenues
- ◆ Relative to a no-DR case, a 12% DR penetration by 2022 could increase CC energy margins by:
 - \$79/kW-y if DR is priced at the cap
 - \$42/kW-y if DR bids over a range

Long-Run Capacity Prices to Drop

- ◆ Long-run capacity prices should converge to “Net CONE” on average:
 - Gross plant costs minus energy margins
 - Capacity price at which merchants will build
 - Net CONE will drop as energy margins increase
- ◆ Backward-looking administrative Net CONE will not drop as fast as true Net CONE (possible profitable “bump” in total returns for a few years)
- ◆ Outcomes highly dependent on DR-based pricing; but even with conservative assumptions one can see why developers might think this works

Combined Cycle Net Revenue Impact

(Illustrative Purposes, Not a Projection)



Takeaways

- ◆ Fundamental changes to PJM's market are making us re-think old assumptions:
 - How to think about and capture volatility upside created by wind?
 - What do the markets look like with much less coal?
 - Marginal technologies for setting long-run capacity prices: CCs and DR?
 - How will DR economics in energy and capacity markets play out over time?
- ◆ Evidence coming in will help us understand how some of these same questions will play out in other markets
- ◆ Similarly, other markets will be the first places that we see evidence of some other important dynamics, e.g.:
 - Bifurcated capacity markets for new and existing gen (California, MISO, EU)
 - "Flexibility" payments of different flavors (ISO-NE, California, MISO)
 - High scarcity pricing potential (PJM, ERCOT)
 - Conditions for attracting new merchant builds (Alberta, PJM, ERCOT)

Additional Reading

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About the Authors

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Dr. Kathleen Spees is a senior associate at *The Brattle Group* with expertise wholesale electric energy, capacity, and ancillary service market design and price forecasting. Dr. Spees has worked with system operators in the U.S. and internationally to improve their market designs with respect to capacity markets, scarcity and surplus event pricing, ancillary services, wind integration, and energy and capacity market seams.

For other clients, Dr. Spees has engaged in assignments to estimate demand response penetration potential, analyze client questions about virtual trading, FTR, or ancillary service markets, impacts of environmental regulations on coal retirements, tariff mechanisms for accommodating merchant transmission upgrades, renewables integration approaches, and market treatment of storage assets.

Kathleen earned a B.S. in Mechanical Engineering and Physics from Iowa State University. She earned an M.S. in Electrical and Computer Engineering and a Ph.D. in Engineering and Public Policy from Carnegie Mellon University.

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Johannes (Hannes) Pfeifenberger is a principal of The Brattle Group where he leads the firm's utility practice area. He is an economist with a background in power engineering and over 20 years of experience in the areas of public utility economics and finance. He has testified before FERC and numerous other commissions.

On behalf of his clients, which include ISOs, transmission owners, utilities, generators, and regulators, he has addressed RTO market designs, the economic benefits and cost allocation of transmission projects, the reasons behind rate increases, implications of restructuring policies, competitive conduct in electric power markets, and the effects of proposed mergers.

Hannes received an M.A. in economics and finance from Brandeis University and an M.S. ("Diplom Ingenieur") in electrical engineering, with a specialization in power engineering and energy economics, from the University of Technology in Vienna, Austria.

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