

Get Ready for Much Spikier Energy Prices

The Under-Appreciated Market Impacts Of Displacing Generation with Demand Response

February 7, 2013

Prepared for:
Cadwalader Energy Investor Conference

Prepared by:
Sam Newell and Kathleen Spees

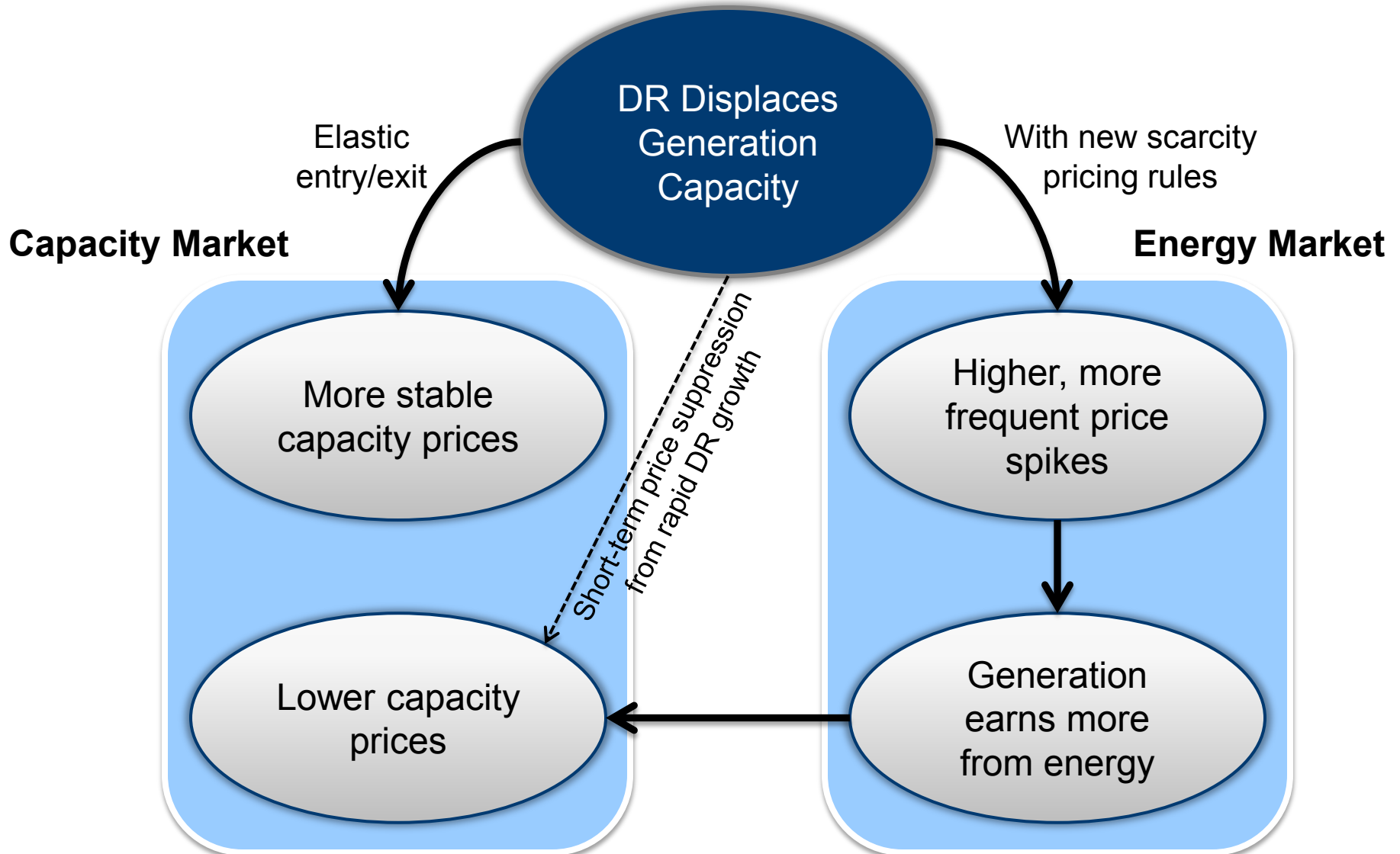
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How DR is Changing Market Fundamentals



Rapid Demand Response Growth

DR Growth

- ◆ DR commitments in PJM's capacity market grew rapidly from 0.1% of peak load in 2007/08 to 9.9% in 2015/16 (excludes ILR)

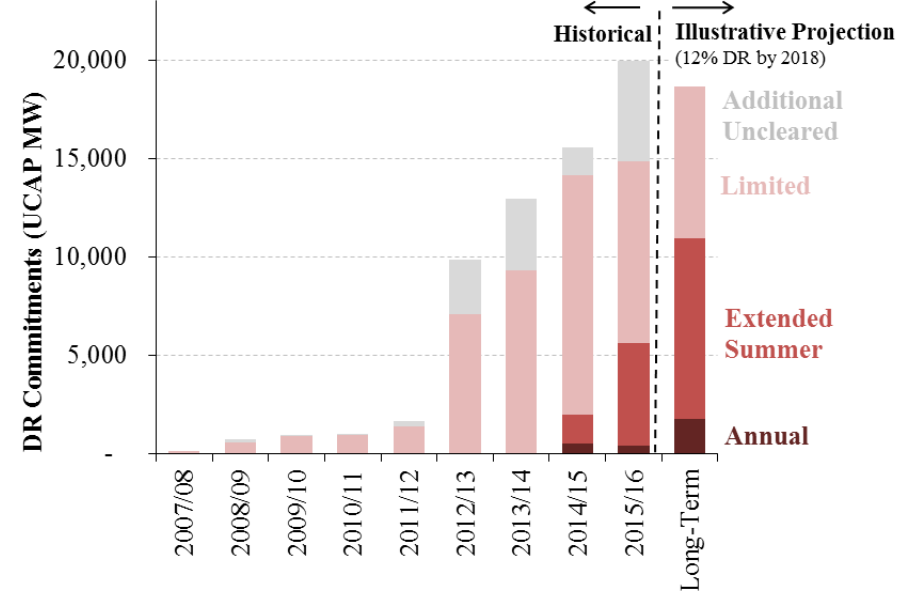
Historical Price Impact in PJM

- ◆ DR was originally counted outside the capacity auctions (not shown on chart)
- ◆ When 8 GW of DR was incorporated in 2012/13, capacity prices dropped dramatically

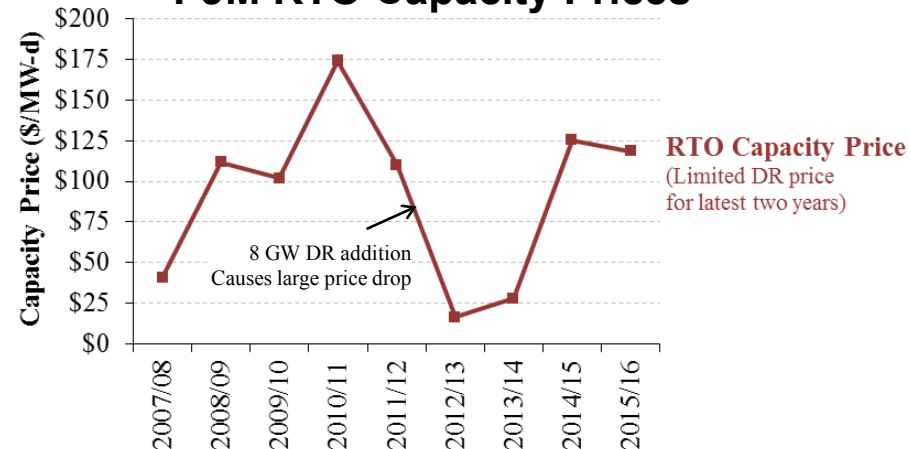
Forward-Looking Price Impact

- ◆ 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
- ◆ High energy prices will reduce capacity prices

DR Commitments in PJM



PJM RTO Capacity Prices



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

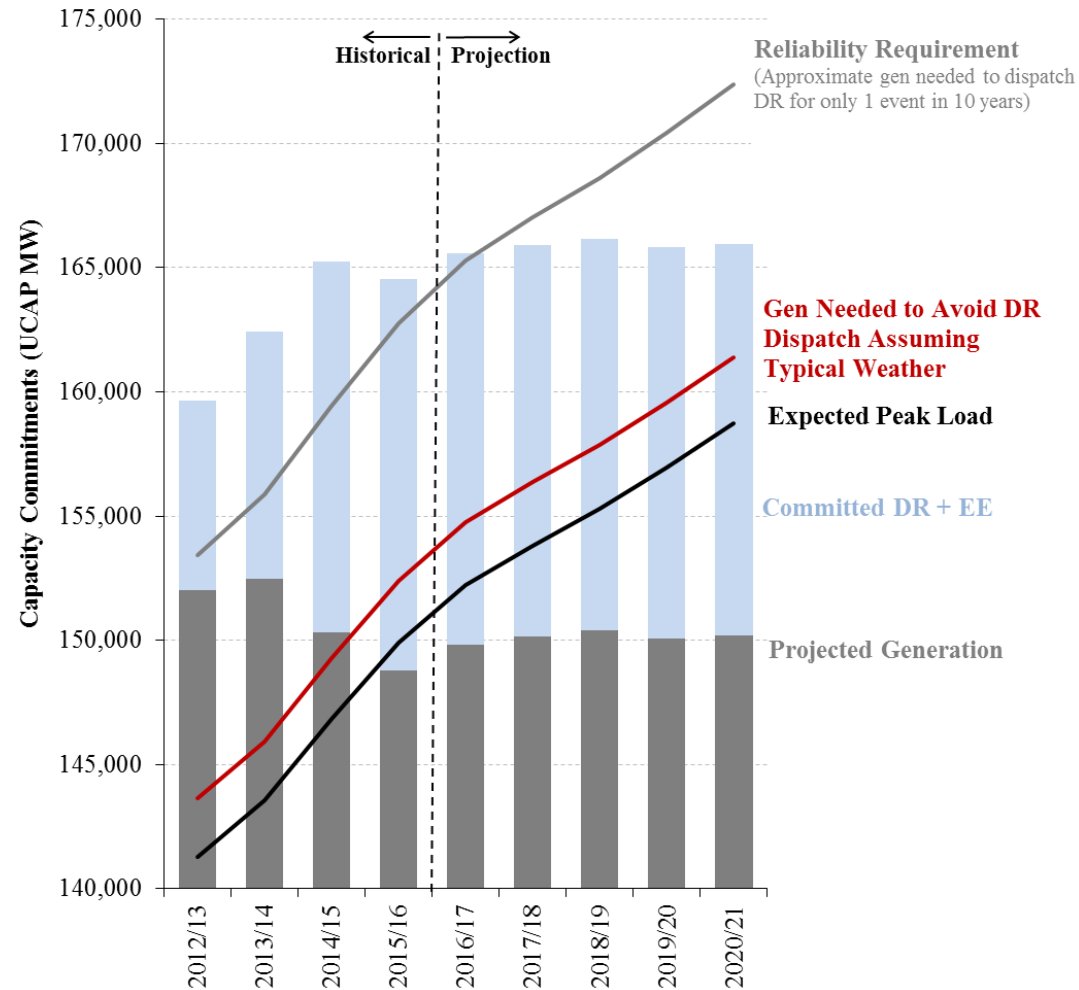
Load Growing and Generation Exiting

- ◆ Approximately 17,500 MW of announced retirements over 2012-16
- ◆ Some not needed due to surplus
- ◆ Some will be replaced by new merchant and regulated generation
- ◆ Rest will be replaced by DR

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 events)
- ◆ But by 2015 many more DR calls will be needed, even with typical peak weather
- ◆ May surprise some DR providers

Generation and DR Commitments in PJM



DR is No Longer an Emergency Resource

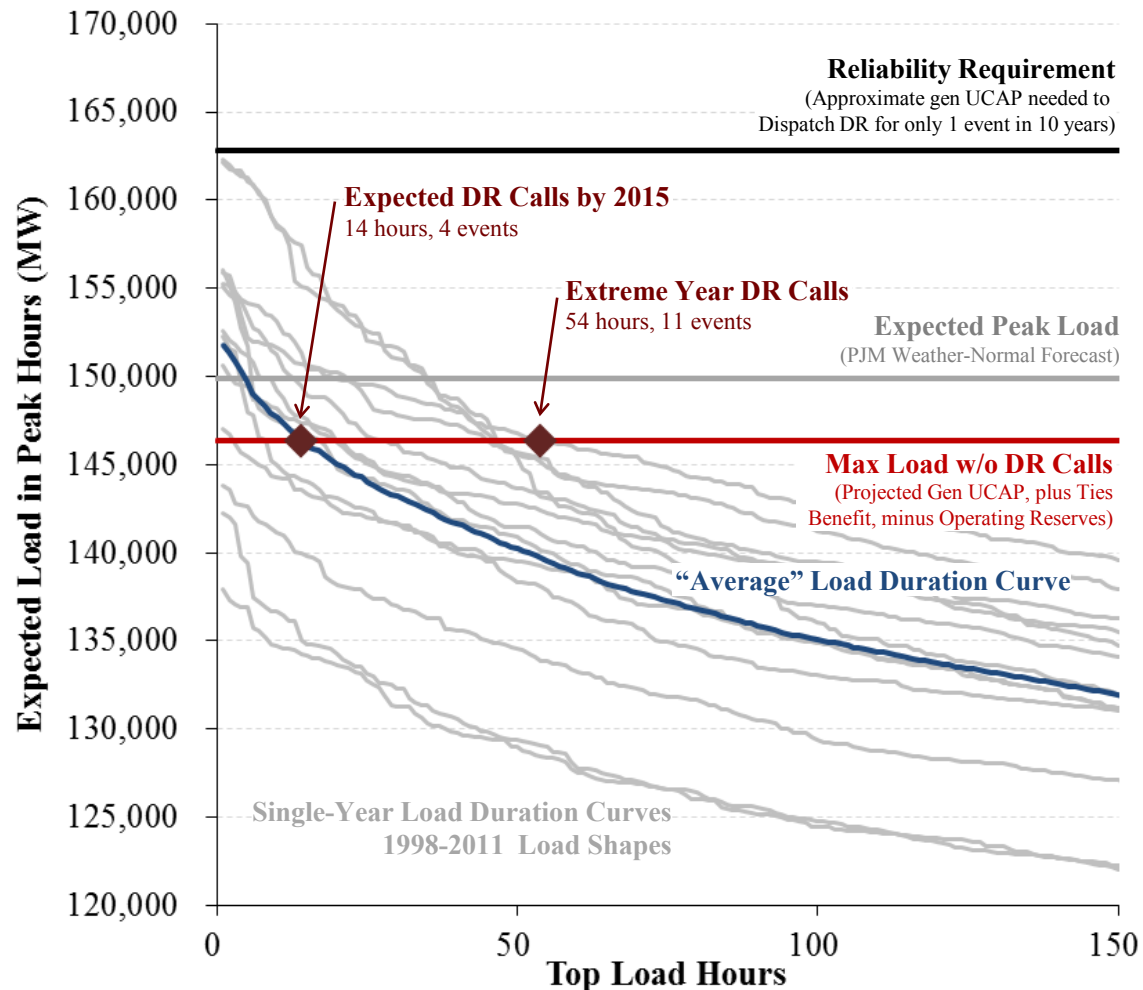
Many More Hours

- ◆ Lower gen reserve margin will require more DR calls
- ◆ Fact is understood in concept but magnitude is under-appreciated by RTOs and market participants
- ◆ By 2015/16:
 - DR will be called ~14 hours (4 events) under typical weather conditions
 - Extreme weather would require ~54 call hours (11 events)

DR as a Peaking Resource

- ◆ DR is usually treated as an “emergency” resource, called as a last resort
- ◆ New regime will require DR to schedule more like a peaker, including in the day-ahead market

Load Duration Curve in 2015/16



Scarcity Prices to Hit Hard in Super-Peak Hours

If All DR Remains “Emergency”

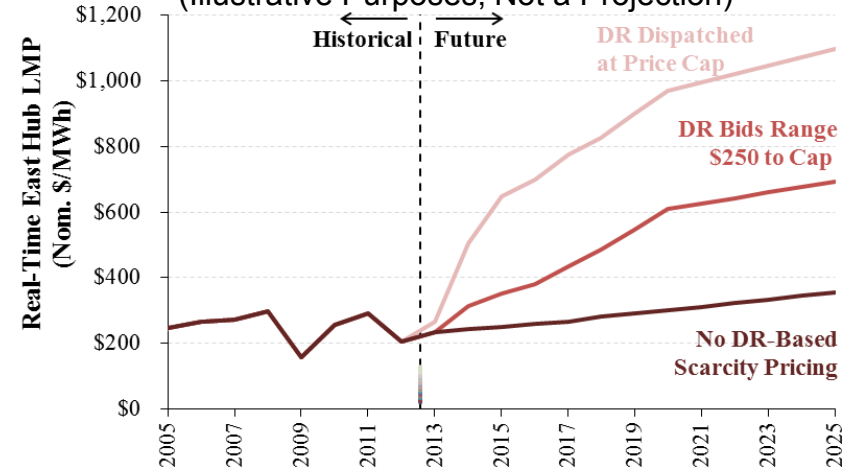
- ◆ Assuming 12% DR penetration by 2020, 34 hours per year will require DR calls
- ◆ If all that DR came in at the price cap of \$2700/MWh, the energy market impacts would be very large
 - Increase price in top 1% of hours by ~\$700/MWh
 - Annual average prices increased by ~\$7/MWh

If Some DR Bids Lower for Energy

- ◆ More likely that at least some DR will participate in the energy market over a range of prices
- ◆ Illustrative case shown here assumes DR will bid over a range of prices \$250 up to the cap
- ◆ Still increases prices by \$300/MWh in the top 1% of hours and \$3 over all hours

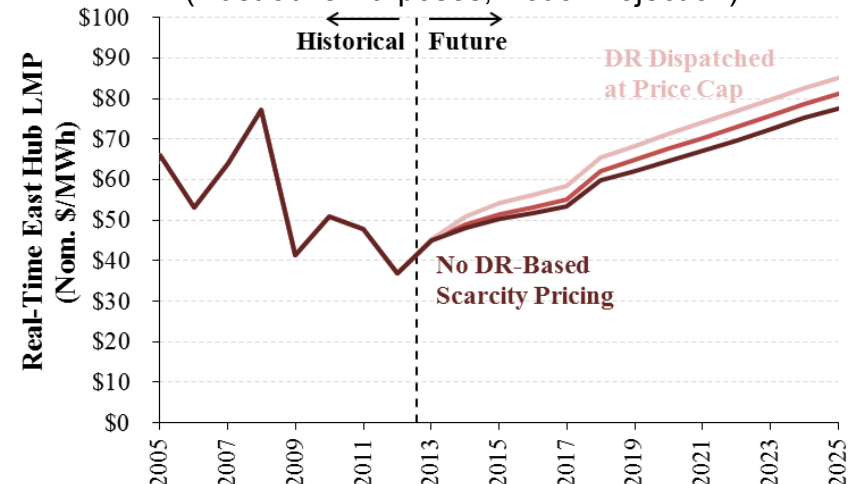
Price in Top 1% of Hours

(Illustrative Purposes, Not a Projection)



Average Price over All Hours

(Illustrative Purposes, Not a Projection)



Generator Value to Shift from Capacity to Energy

Energy Margins will Increase

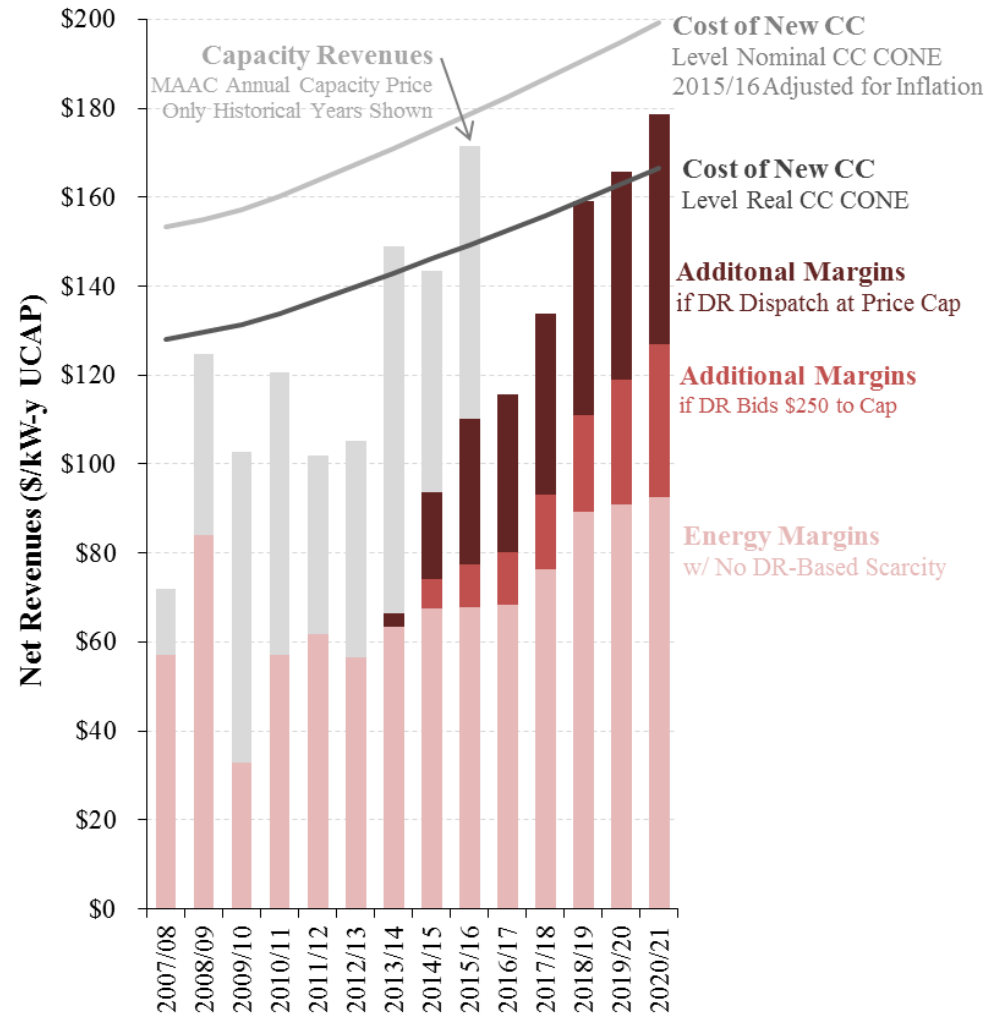
- ◆ Super-peak prices have a disproportionately large impact on generator net revenues
- ◆ Relative to a no-DR case, under 12% DR penetration by 2020, CC energy margins could increase by:
 - \$85/kW-y if DR is priced at the cap
 - \$35/kW-y if DR bids over a range

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
 - Could create a profitable “bump” in total returns for a few years

Combined Cycle Net Revenue Impact

(Illustrative Purposes, Not a Projection)



Takeaways

For PJM

- ◆ Refine pricing and dispatch protocols for emergency DR (i.e. it's no longer an emergency resource, and with high call-hours increased importance of having accurate, efficient price signals)
- ◆ Worries if too many DR suppliers drop out with a sudden increase in calls. Longer-term however, the easier entry and exit of DR will provide some cushion against sudden system shocks (like large simultaneous environmental retirements).

For DR Suppliers:

- ◆ Capacity revenues are no longer “free lunch;” need to be prepared for many more calls and avoid customer attrition
- ◆ Consider participating in the energy market with resources with low dispatch costs

For Generators:

- ◆ Expect higher energy margins, which will eventually lead to lower capacity prices.
- ◆ Greater importance of energy market will reduce the impact of uncertainties in the capacity market
- ◆ Various ways to hedge energy prices; may be credit implications

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About the Presenter



Samuel A. Newell

Principal

Cambridge Office

Samuel.Newell@brattle.com

O: +1.617.234.5725

M: +1.781.801.2652

Samuel Newell is a Principal of *The Brattle Group*. He is an economist and engineer with 13 years of experience in electricity wholesale markets, the transmission system, and RTO rules. He is also an expert in locational energy and capacity market simulation modeling.

Dr. Newell supports clients throughout the U.S. in regulatory, litigation, and business strategy matters involving wholesale market design, generation asset valuation, transmission development, integrated resource planning, demand response programs, and contract disputes. He has written expert reports for RTOs and provided testimony before state regulatory commissions and the FERC.

Dr. Newell earned a Ph.D. in technology management and policy from the Massachusetts Institute of Technology, a M.S. in materials science and engineering from Stanford University, and a B.A. in chemistry and physics from Harvard College.