

“Pitch Black”

or

Microgrid Evolution in Distribution Service Restoration After a Blackout

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Questions We Ask

- Will a microgrid help its host be more resilient?
- Can a microgrid help the local network recover from a blackout?
- Can a bunch of microgrids help prevent a blackout?



OH, SANDY

Power Outage Cost Estimates

Superstorm Sandy

- Nearly \$20 billion in losses from suspended business activity
- Total losses estimated between \$30 to \$50 billion
- Two-day shutdown of the NY Stock Exchange, costing an estimated \$7 billion from halted trading
- Rutgers estimates economic losses of \$11.7 billion for New Jersey GDP



Courtesy of: Tom Bourgeois, US DOE Northeast Clean Energy Application Center

The Brevoort

Manhattan, NY

- Residential high rise with natural gas-powered CHP system
 - Four 100 kW CHP units powered all 290 apartments through Sandy
- Normal occupancy is 720 people. During Sandy, the Brevoort was able to house and provide power to 1,500 people through the storm.
- “Powered by our CHP system, we were the only building on lower Fifth Avenue able to provide energy and full service to our residents.” - Diane Nardone, President of the Brevoort coop board
- The Brevoort was able to maintain power for central boilers, domestic water pumps, all elevators and all apartments



New York Presbyterian Hospital

Weill Cornell Medical Center, Manhattan, NY



- 7.5 MW natural gas-fired CHP system
- New York City's first hospital with grid-independent operating capability
- Maintained full service while the surrounding grid was shut down
- Due to its CHP system, New York Presbyterian not only cared for its own patients during the Hurricane Sandy blackout, but was able to admit patients from nearby hospitals that had lost power during the storm

Fairfield University

Fairfield, CT



“Fairfield University sponsors discussion on lessons learned from Hurricane Sandy”
- *Fairfield University Press Release*

- 4.6 MW on-campus CHP system
- Fairfield University only lost power for a brief period during the peak of Hurricane Sandy
- While the Town of Fairfield was without power, the University’s CHP-powered buildings served as a refuge for off-campus students and the community as a whole

Princeton University

- 15 MW system supplying 100% of the heat and hot water requirements and 50% of electric energy for the campus (27 MW campus peak demand)
- Had a brief trip of the turbine when the utility feed to the plant failed - generator was synchronized with the utility.
- Princeton lost all four utility feeders for two days
- On account of its Microgrid system with CHP, Princeton was able to keep the students dorms, library, all critical research centers, emergency response center, infirmary, and refrigeration powered up.

Co-Op City

Bronx, NY

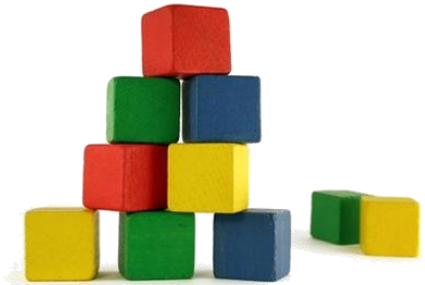
- One of the largest cooperative housing units in the world
 - 35 residential buildings
 - over 55,000 residents
- 38 MW CHP
- Utility savings estimated at \$15,000,000 per year
- The CHP facility provided full power to Co-Op City before, during, and after Superstorm Sandy



Sandy Lessons

- **Black start capability**
 - allows the system to start up independently from the grid
- **Generators capable of grid-independent operation**
 - the system must be able to operate without the grid power signal
- **Ample carrying capacity**
 - system size must match critical loads
- **Parallel utility interconnection and switchgear controls**
 - the system must be able to disconnect from the grid, support critical loads, and reconnect after an event

Courtesy of: Tom Bourgeois, US DOE Northeast Clean Energy Application Center



McAdams Second Theorem: Nothing is impossible, which is currently taking place.

GOING FORWARD

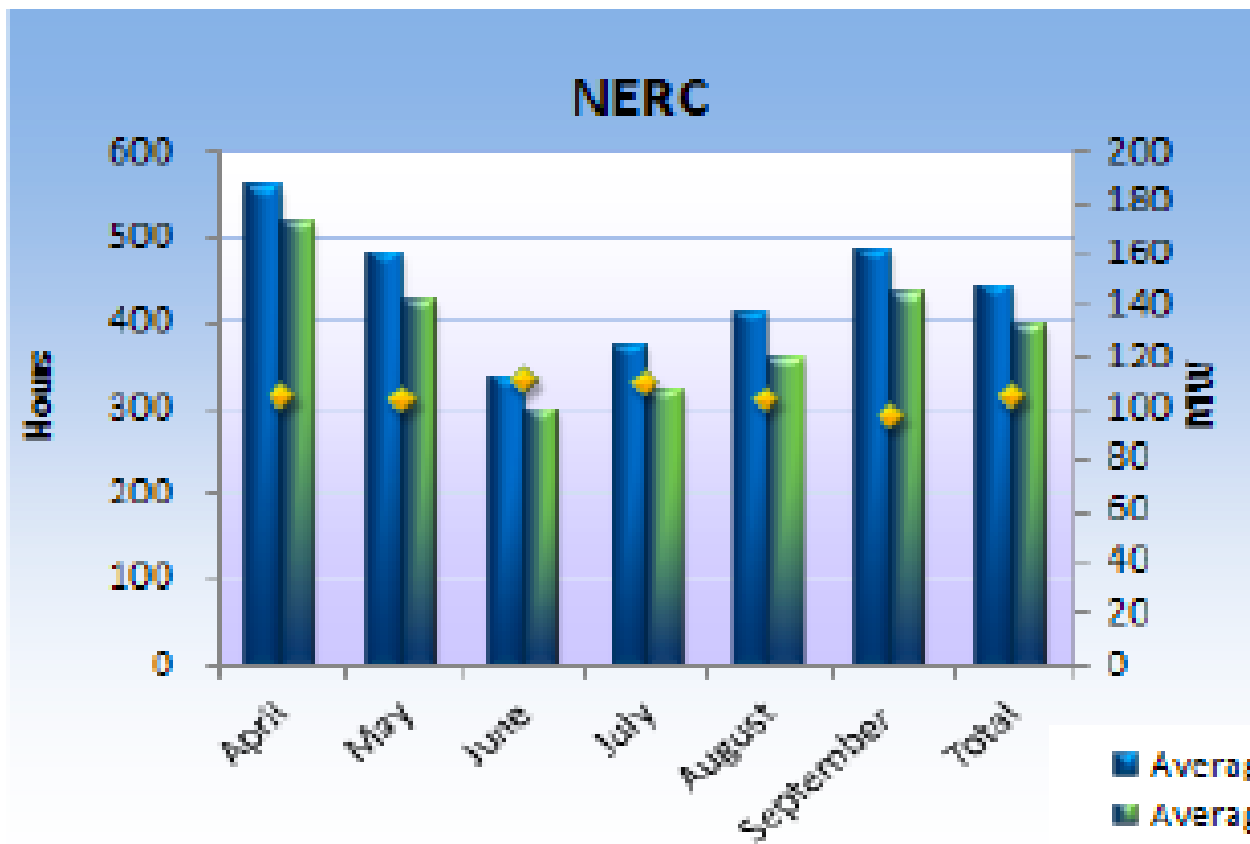
Resiliency Emerges

- Connecticut Microgrid Program – electrically-resilient storm centers
- NY Commission 2100 Report (Jan2013) – accelerate the pace of microgrid deployments as part of resiliency planning
- Emerging NJ microgrid program – resiliency
- Rutgers report on Sandy impact - \$11.7B loss in NJ GDP

Technology Matters to Reliability (SAIDI)

- Japan – finished DMS/DA across country in 2010 - < 3 min
- Istanbul – finished DMS/DA in 2005 - ~10 min
- Scotland – government enforced automation of the distribution network (~1998 – 2004) – 60 sec
- Taipei South, Taiwan – expansive active DMS and DA in “Silicon Valley” – 14 sec
- Boulder Smart Grid City – 2X duration and 3X cost, but according to Xcel VP, reduced outages and O&M – paid for itself already
- Microgrids are showing a 10X improvement in reliability

DR is a Reliable Dispatch Capacity

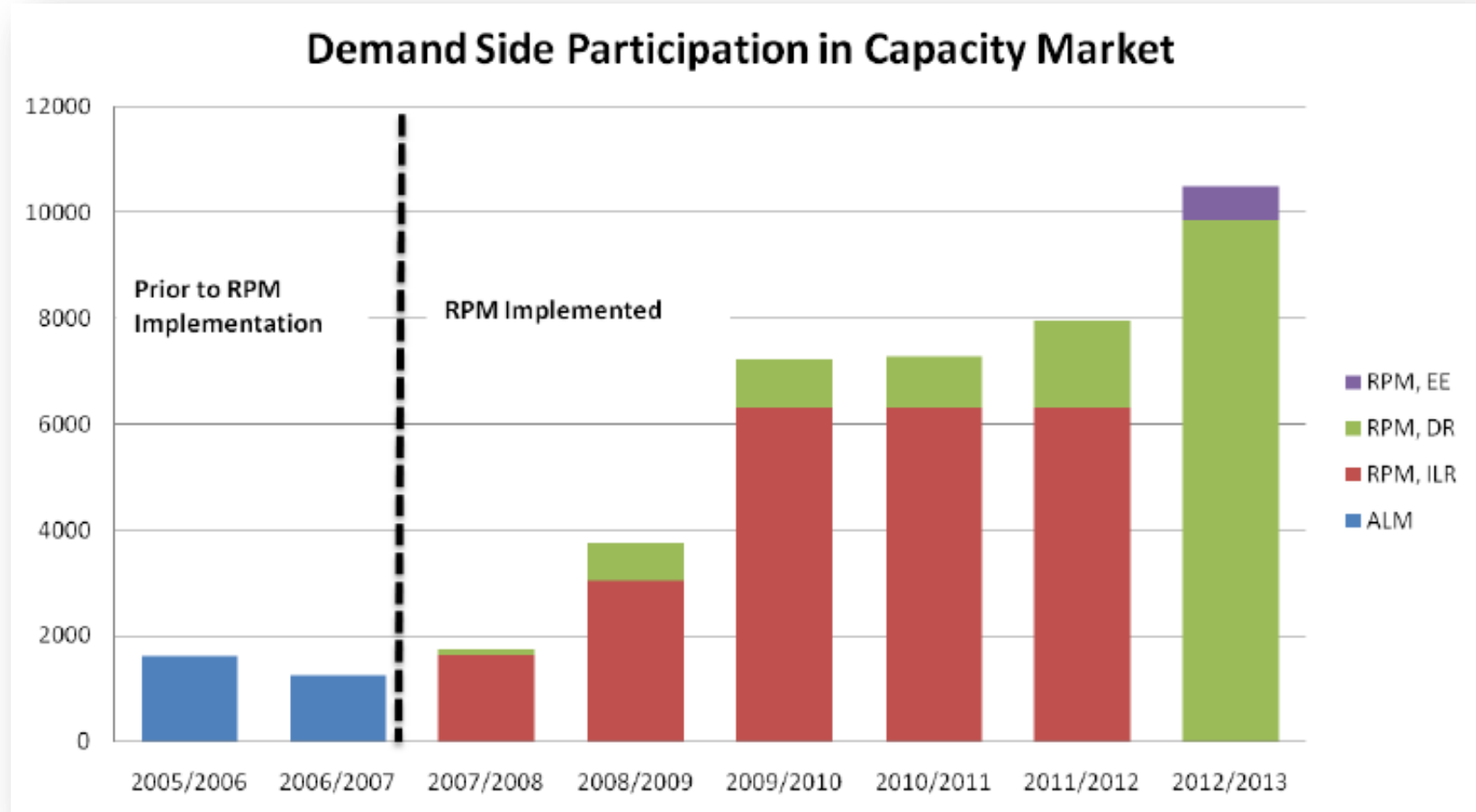


Data shows that DR reliability as a Capacity resource is >80%.

Figure 86: 2011 Summer Spinning Reserves Ancillary Service Availability and Participation by Regional Entity

Source: NERC 2012 State of Reliability

PJM Capacity Market

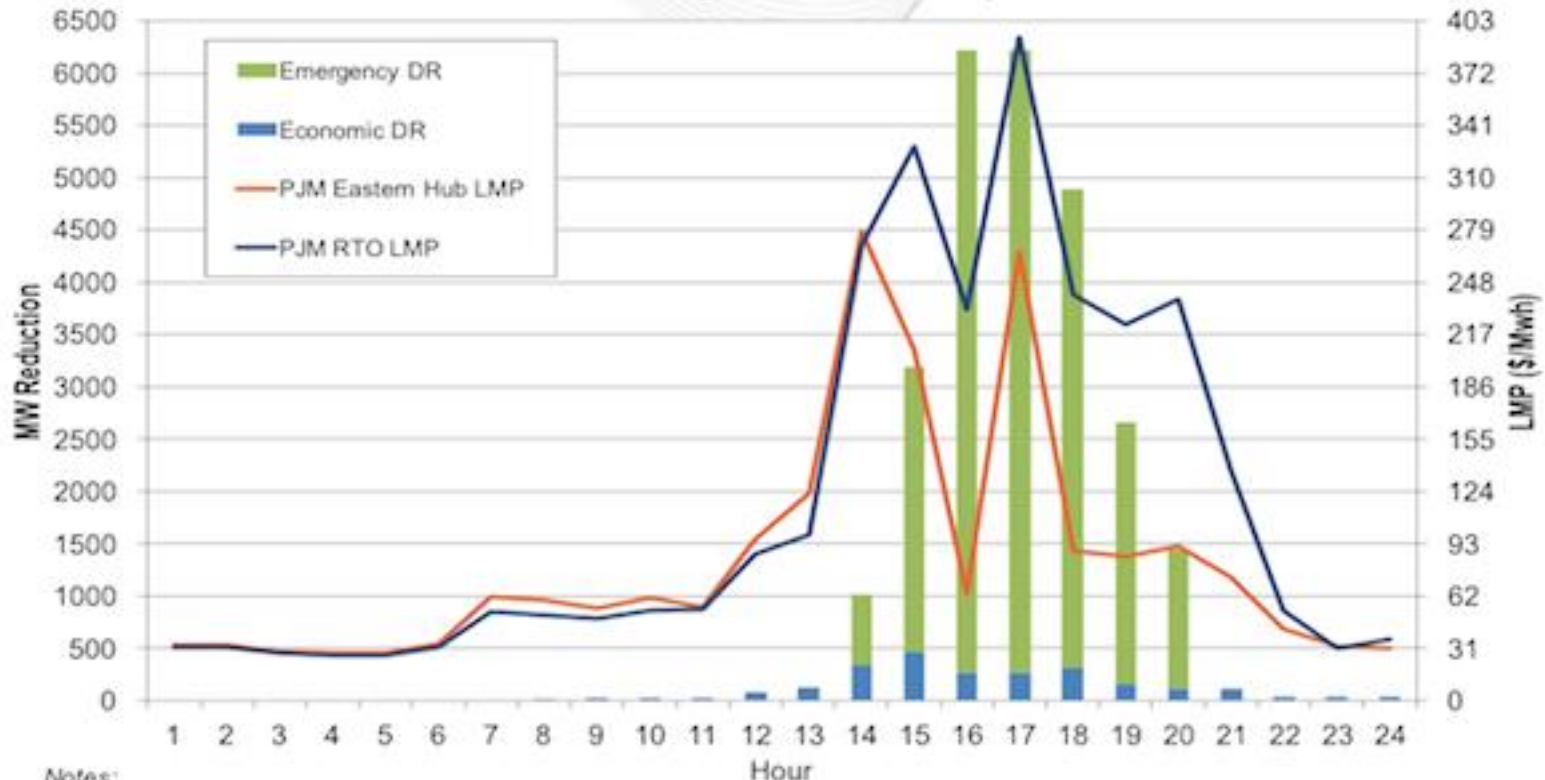


According to PJM, at least half of the DR response is from DER.

The Demand Side is a Reliable Grid Resource



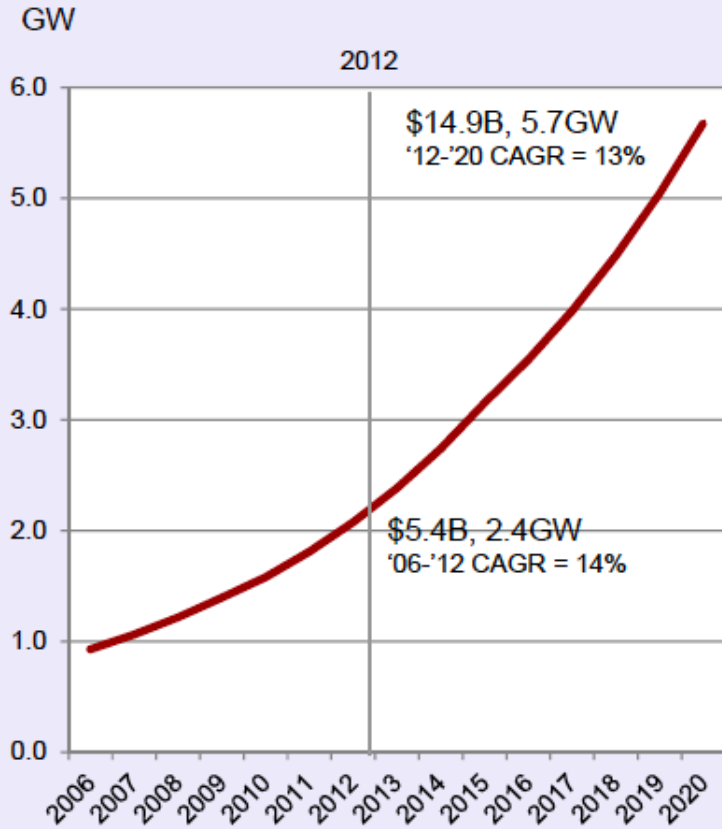
Estimated Demand Response in PJM: September 11, 2013



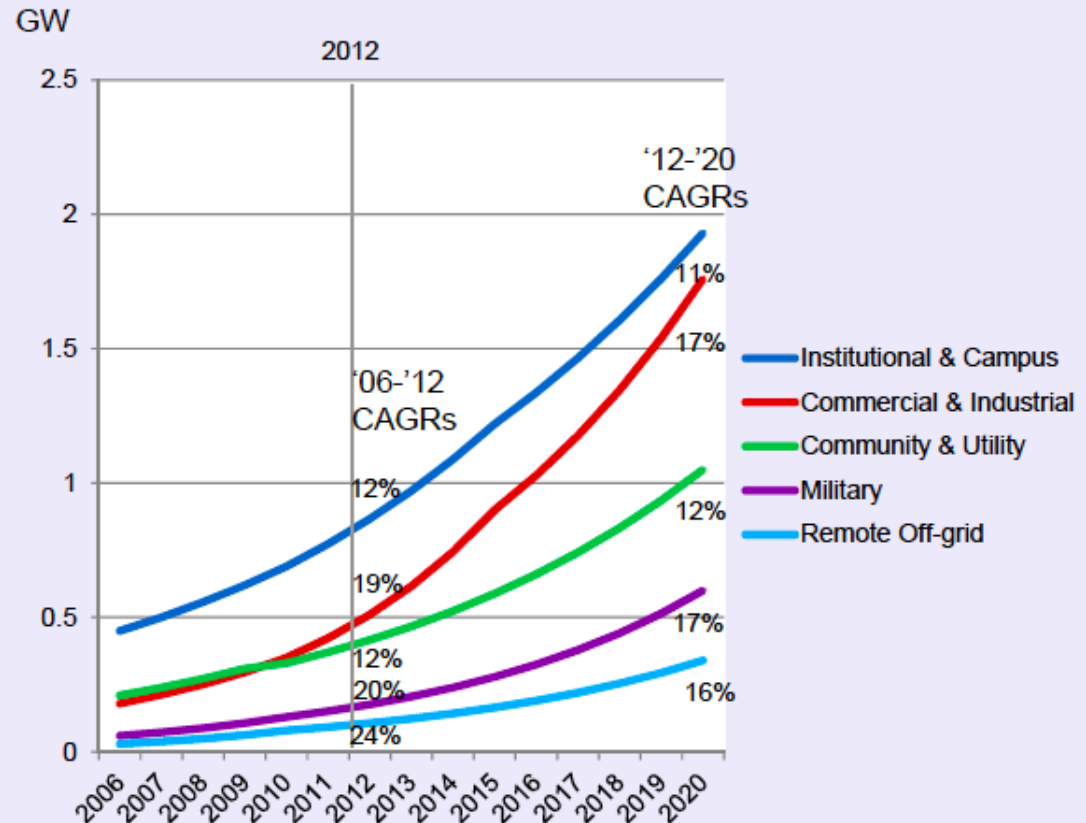
Notes:
 Registered Emergency DR Amounts adjusted for RPM Commitments (do not represent actual energy reductions).
 LMPs included to represent energy market conditions on the operating day and not a relationship between dispatched DR and prices.
 Actual load reductions are not finalized until up to 3 months after event.

Double Digit Market Growth Through 2020

Global Microgrid Capacity



Microgrid Capacity by Market Segment



Source: The World Market for Microgrids 2011, SBI, BBA Team Analysis

Buzz Growth

- “Companies Unplug From the Electric Grid, Delivering a Jolt to Utilities”
(September 2013, Wall Street Journal)
- “Worldwide Microgrid Market Will Surpass \$40 Billion in Annual Revenue by 2020”
(April 2013, Navigant Research)
- “More Than 400 Microgrid Projects are Under Development Worldwide”
(>219 in North America) (April 2013, Navigant Research)
- “Microgrids and distributed electricity generation can firewall the grid, creating local independence and enhanced reliability among many other benefits.”
(June 2013, EnergyBiz)
- “A Galvin Electricity Initiative report found that US outages occur three times as often and 10 times as long as those in places such as Germany and Denmark. Our centralized hub-and-spoke system only adds to the brittleness. Microgrids are emerging as one answer to these challenges. Although they enhance reliability in theory, they also potentially threaten the traditional utility business model.”
(August 2013, SGN)

Vision: Future Distribution Architecture

Actively managed network of portfolio resources and loads...

*What will be the
Central / Distributed
portfolio mix?*

