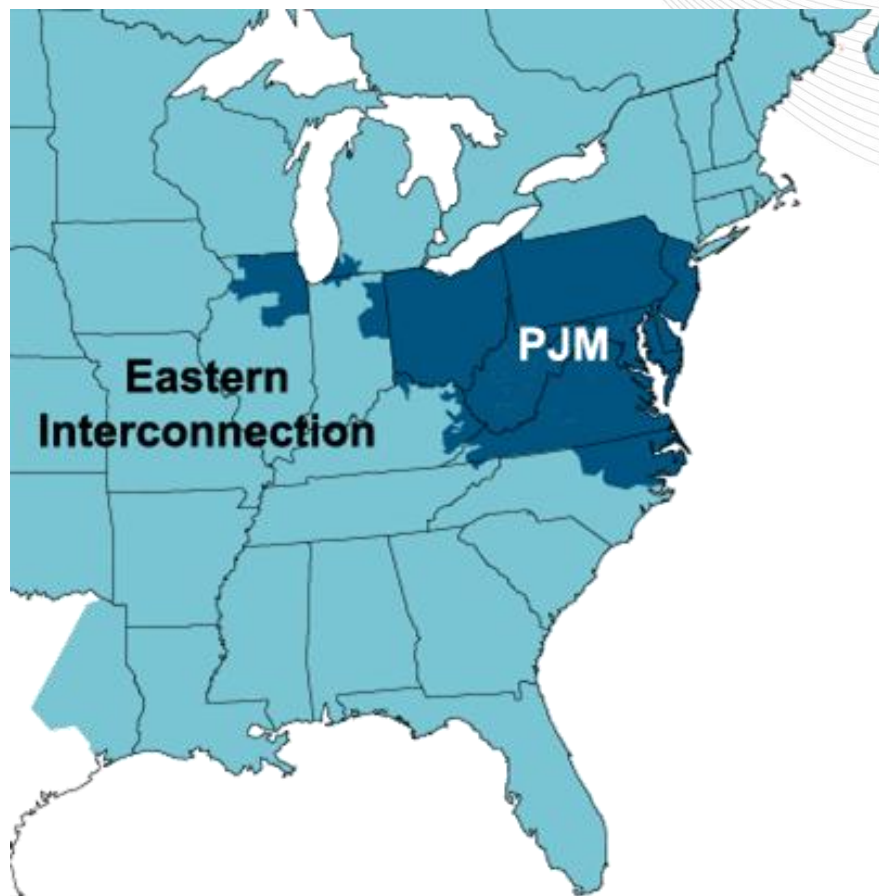


Paying for System Flexibility: Status of New Ancillary Services

Ken Schuyler
Renewable Services
PJM Interconnection, LLC
November 9, 2012



**21% of U.S. GDP
produced in PJM**

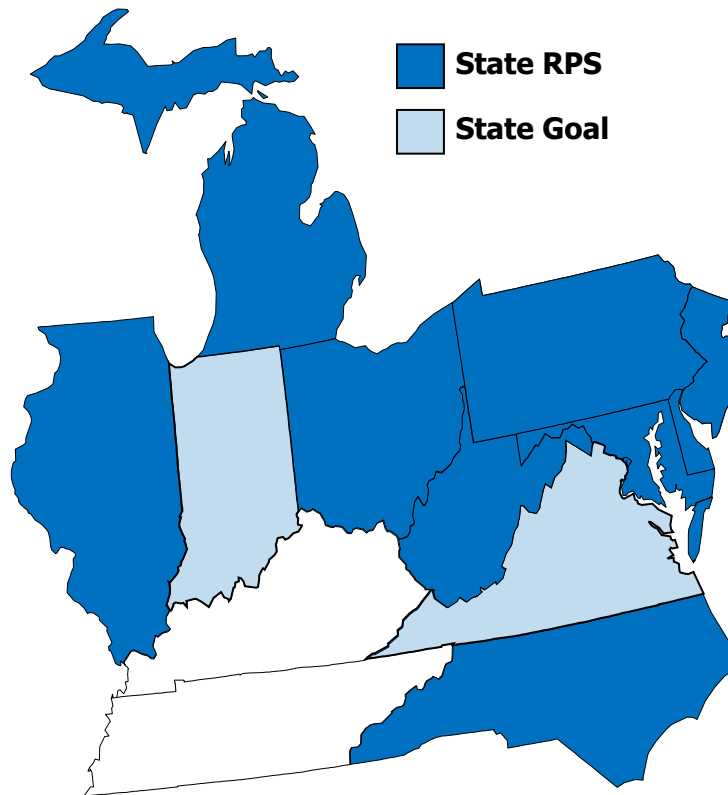
KEY STATISTICS

Member companies	850+
Millions of people served	60
Peak load in megawatts	163,848
MW of generating capacity	185,600
Miles of transmission lines	59,750
GWh of annual energy	832,331
Generation sources	1,365
Square miles of territory	214,000
States served	13 + DC

As of 7/2012

State Renewable Portfolio Standards (RPS) require suppliers to utilize wind and other renewable resources to serve an increasing percentage of total demand.

State RPS Targets:



- ☀ NJ: 22.5% by 2021
- ☀ MD: 20% by 2022
- ☀ DE: 25% by 2026
- ☀ DC: 20% by 2020
- ☀ PA: 18%** by 2020
- ☀ IL: 25% by 2025
- ☀ OH: 25%** by 2025
- ☀ NC: 12.5% by 2021 (IOUs)
- WV: 25%** by 2025
- MI: 10% + 1,100 MW by 2015
- VA: 15% by 2025
- IN: 10% by 2025

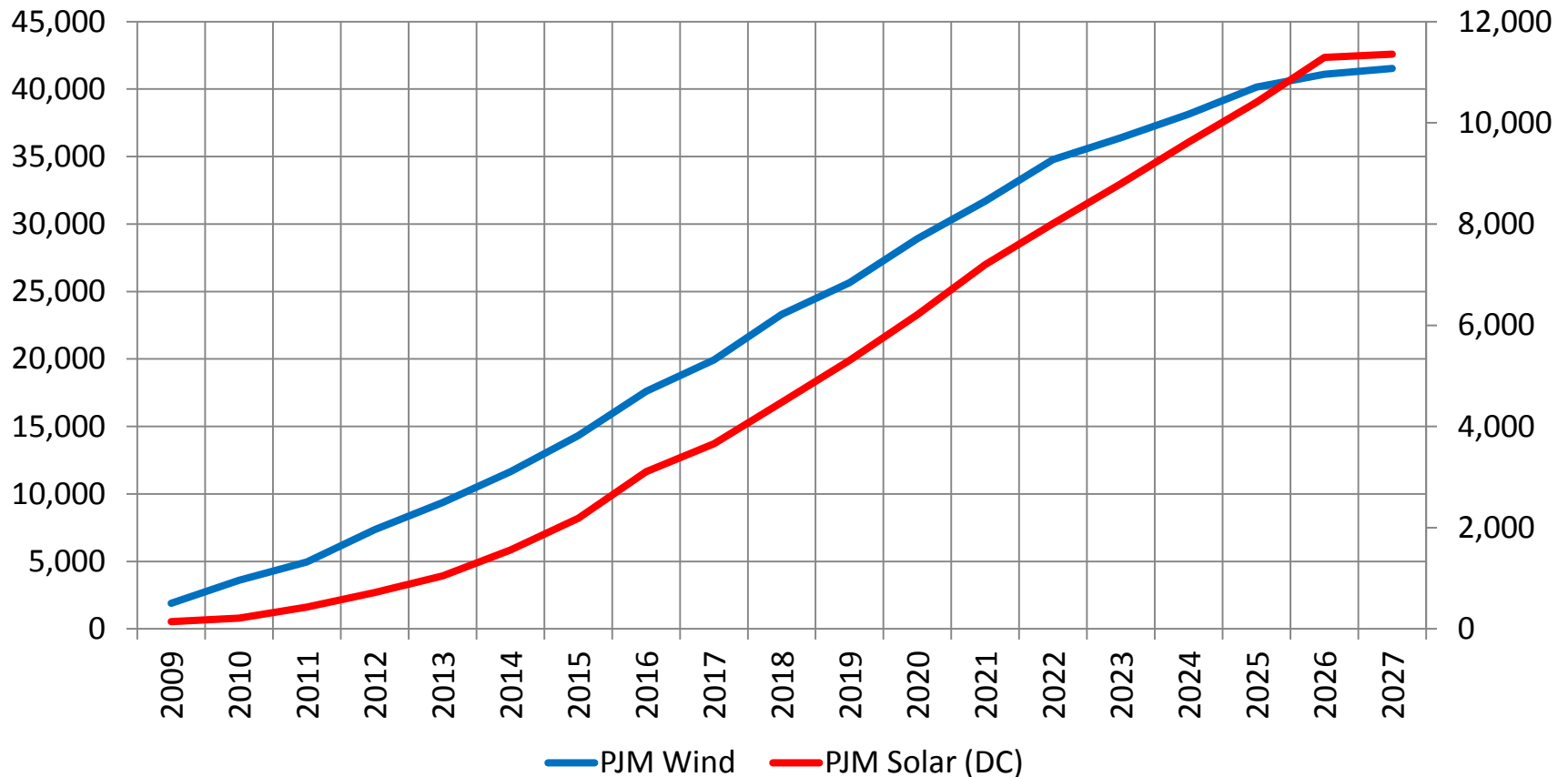
☀ Minimum solar requirement

** Includes separate tier of “alternative” energy resources

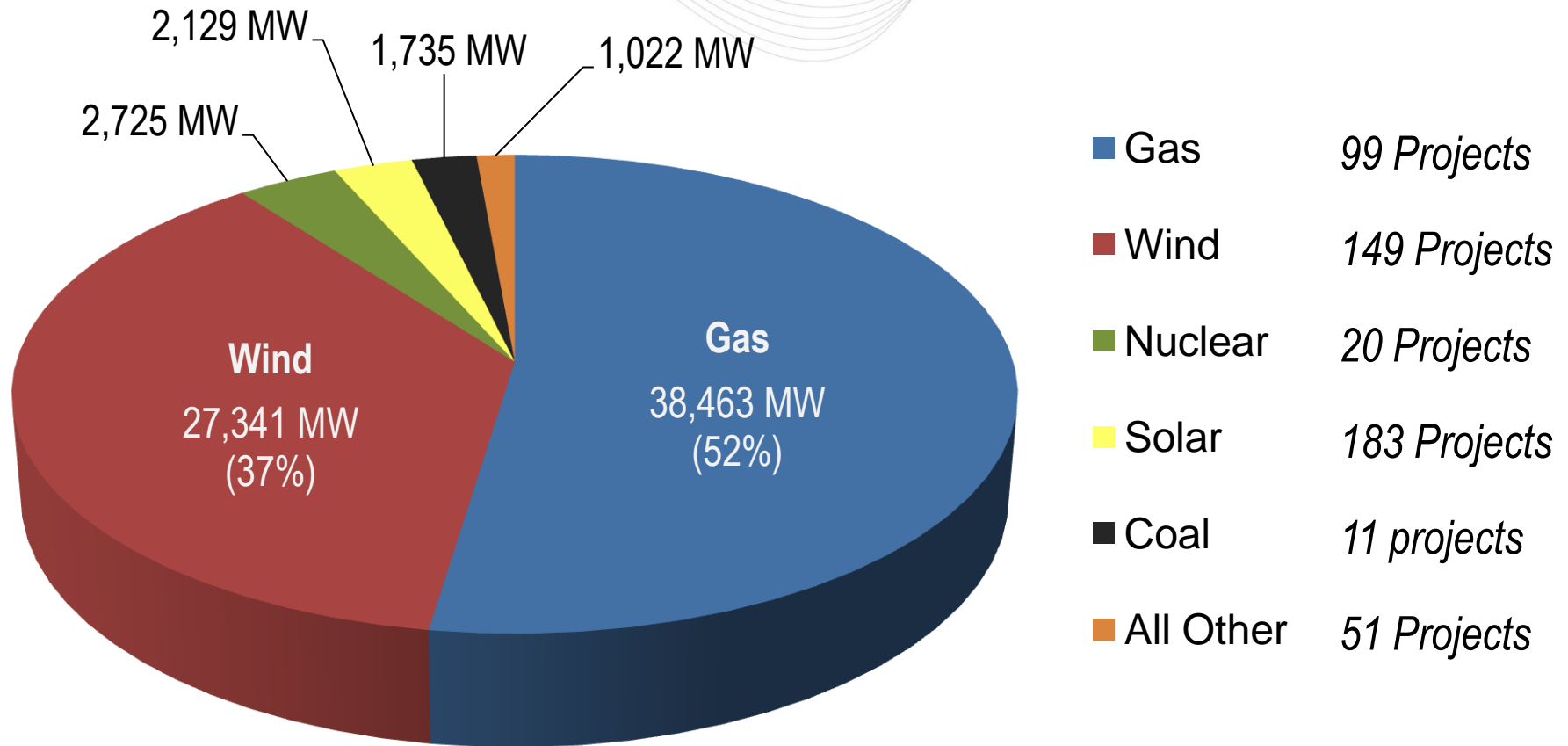
Projected Renewable Energy Requirements in PJM

By 2026: 133,000 GWh of renewable energy, 13.5% of PJM annual net energy
(41 GW of wind and 11 GW of solar)

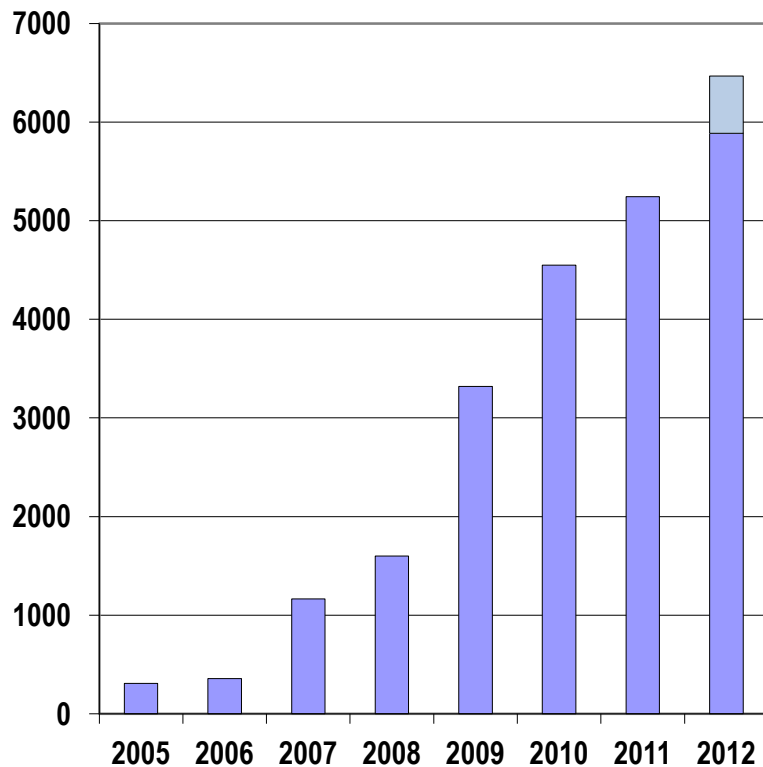
Wind and **Solar** Requirements in PJM (MW)



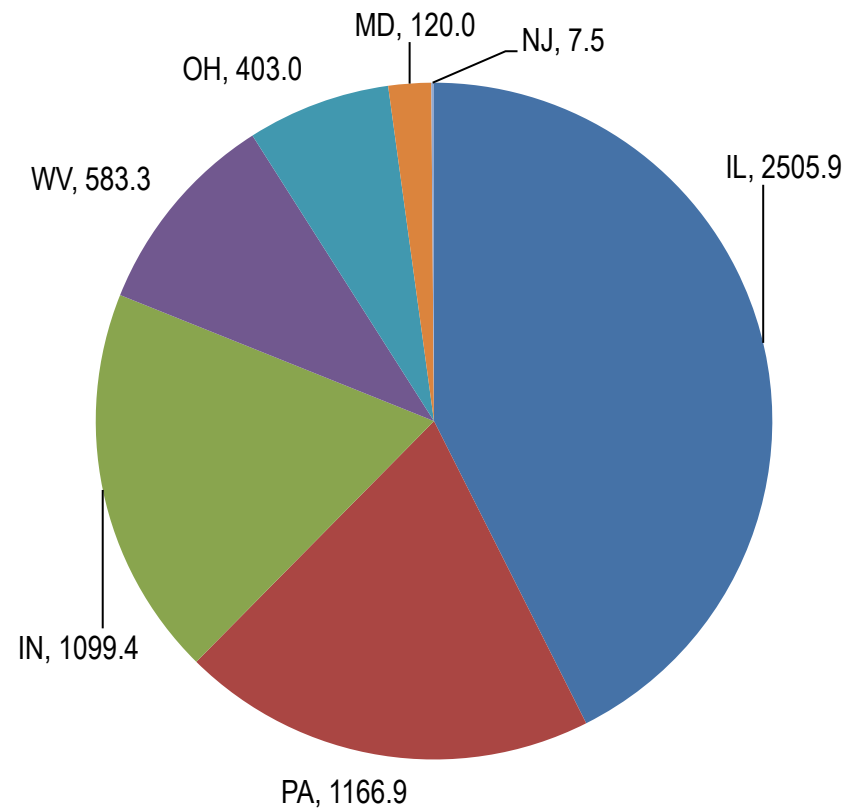
Current Interconnection Queue



PJM Wind Nameplate Capability (MW)

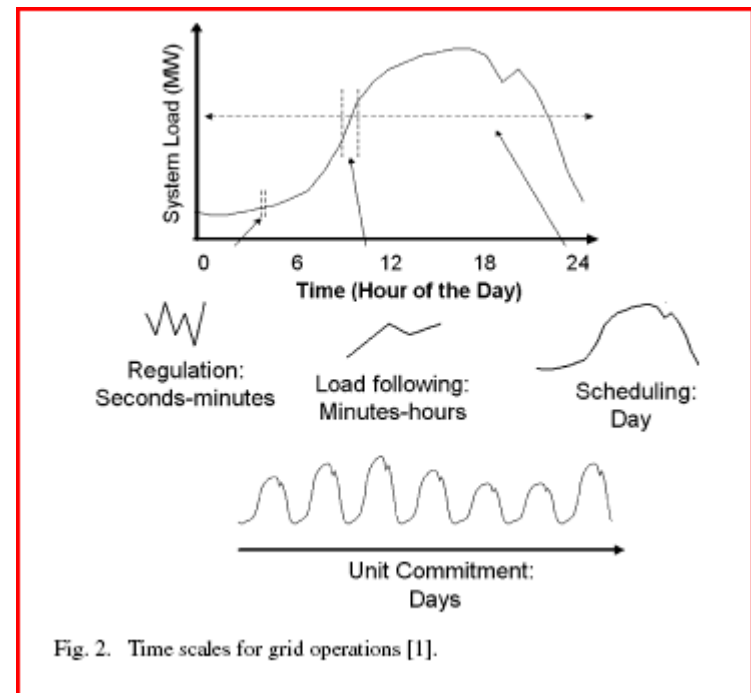


PJM Wind Installed MW by State (Sept 2012)



Impacts of wind power **variability** and **uncertainty**:

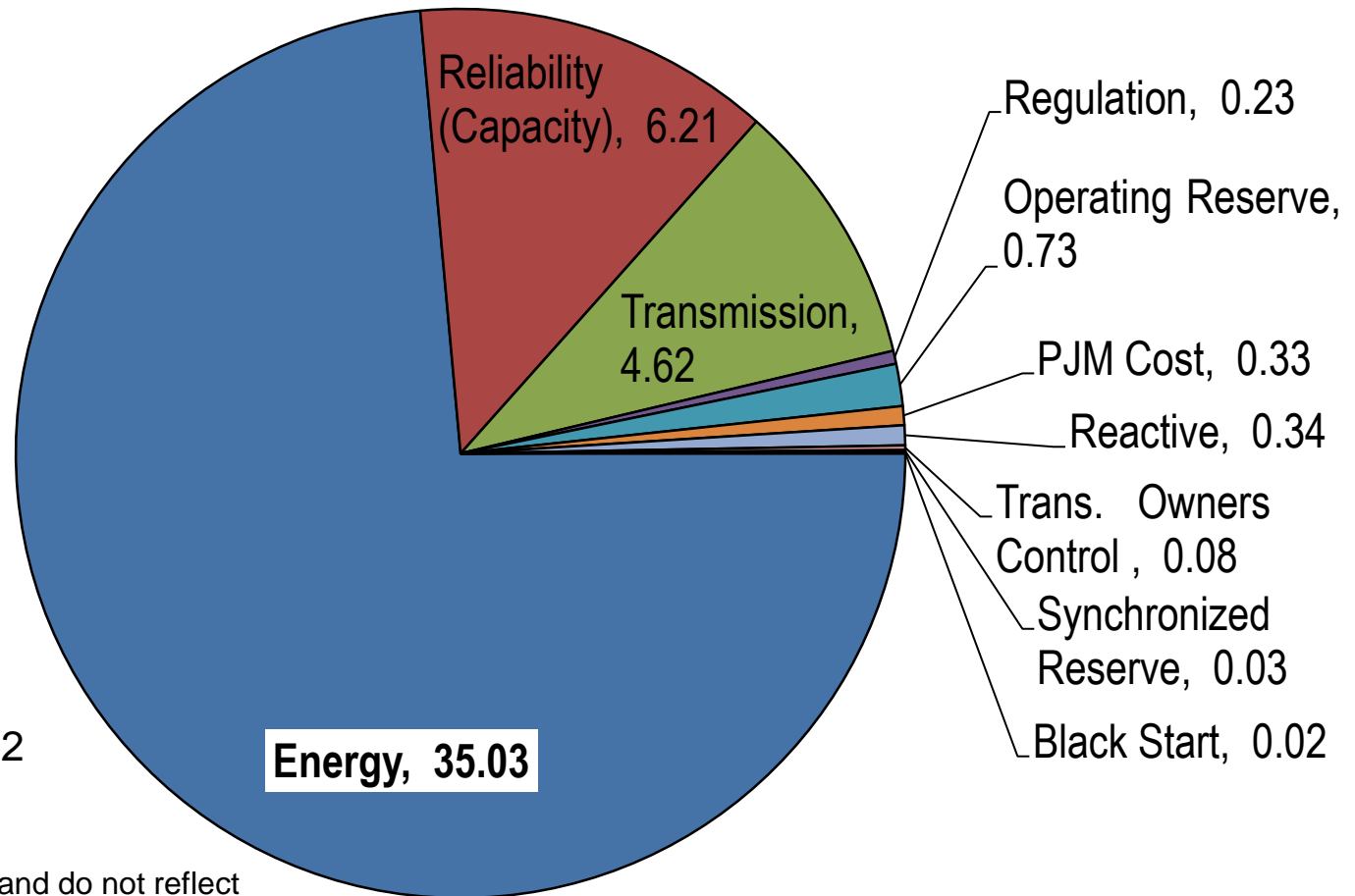
- **Minute-to-Minute**
 - Additional generation needed to provide regulation
- **Intra-Hour**
 - Conventional generators must adjust output
- **Day Ahead**
 - Forecast errors cause over- or under-scheduling



ISOs and RTOs reduce intermittent resource integration costs:

Characteristic	Impact to Wind Integration Cost
Larger balancing areas	<ul style="list-style-type: none">• Reduces overall increase in variability• Less regulation and ramping service required
Faster markets, i.e., shorter scheduling intervals (5-15 minutes)	<ul style="list-style-type: none">• Less regulation required to accommodate intra-hour variations
Larger geographic area	<ul style="list-style-type: none">• Increases wind diversity and reduces overall variability
Centralized wind power forecasting	<ul style="list-style-type: none">• Cost-effective approach to reduce scheduling impacts
Regional / Interregional Transmission Planning	<ul style="list-style-type: none">• Cost-effective upgrades to ensure grid reliability and mitigate congestion

TOTAL: \$47.63/MWh



YTD September 2012
(\$/MWh)

* Values are PJM averages and do not reflect potential locational cost differences.

- **Intermittent Resource Task Force (IRTF)**

- Stakeholder group to address market, operational, and reliability issues specific to variable resources.

- **Energy Markets / Operations**

- Implemented a centralized wind power forecast service.
- Implemented changes to improve wind resource dispatch / control.
- Demand Response / Price Responsive Demand improves operational flexibility

- **Ancillary Service Markets**

- Implemented tariff changes to allow Energy Storage Resources to participate in PJM ancillary services markets
- Frequency Regulation - new methodology to compensate better performing resources (like storage), per FERC Order No. 755
- Reduced minimum size for participating resources from 1MW to 100kW.

- **Transmission Planning**

- Light load criteria implemented to improve grid reliability
- Expansion planning considers public policy impacts (i.e., RPS)
- Grid interconnection requirements for wind and solar being evaluated

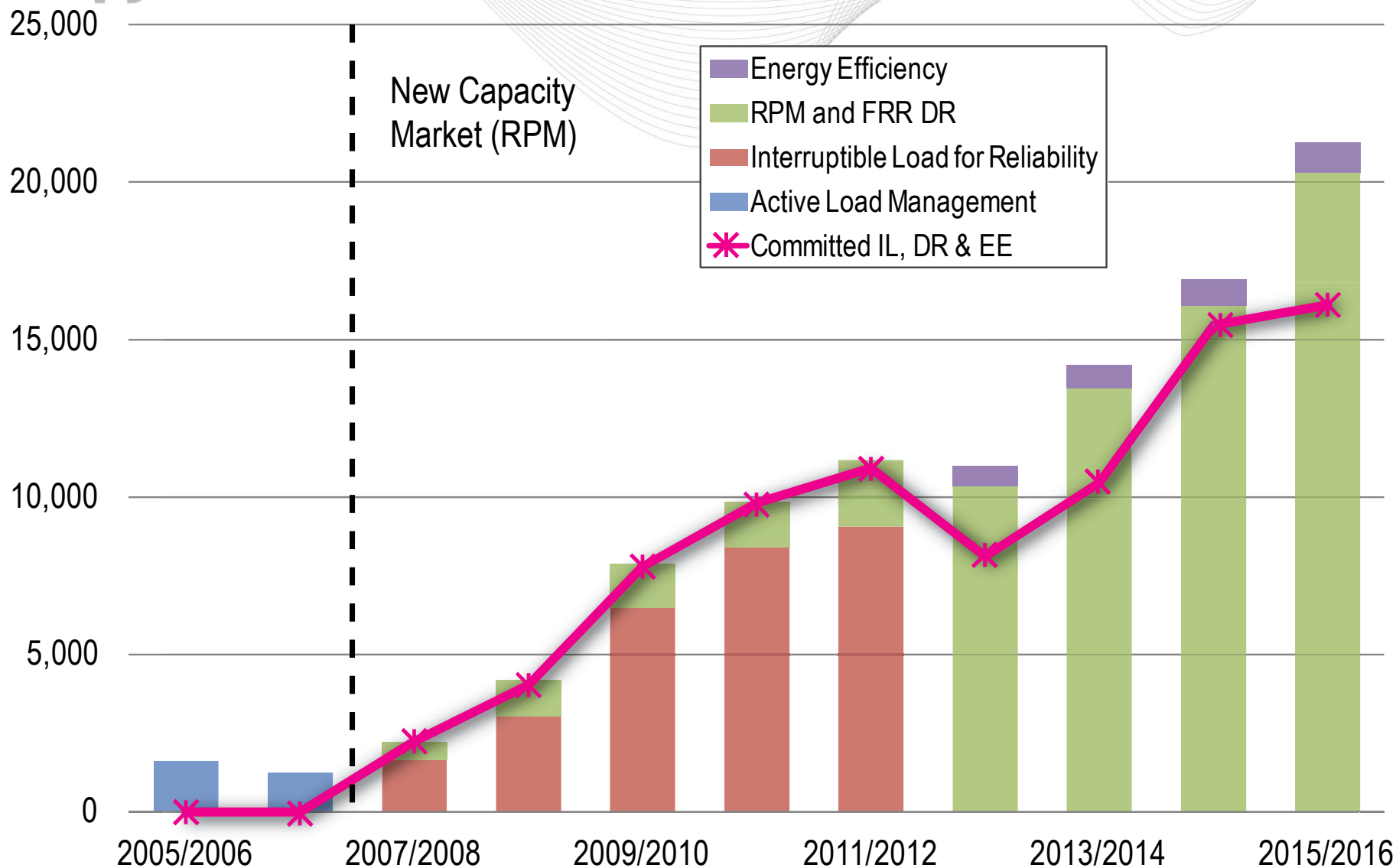
- **Evaluating Potential Grid Impacts**

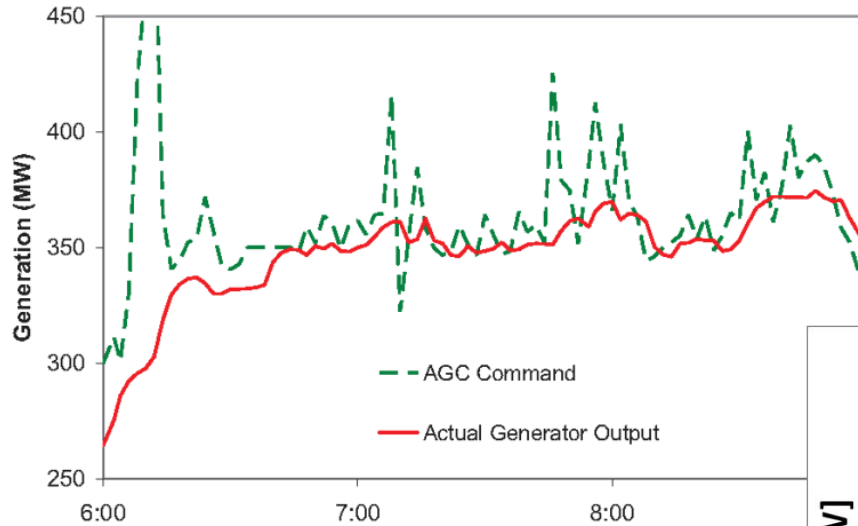
- Initiated a PJM Renewable Integration Study (PRIS) to assess impacts to planning, markets, and operations

- **Advanced Technology Research Program**

- Pilot programs are underway across the PJM footprint to evaluate new technologies and remove barriers to participation in PJM markets and operations.

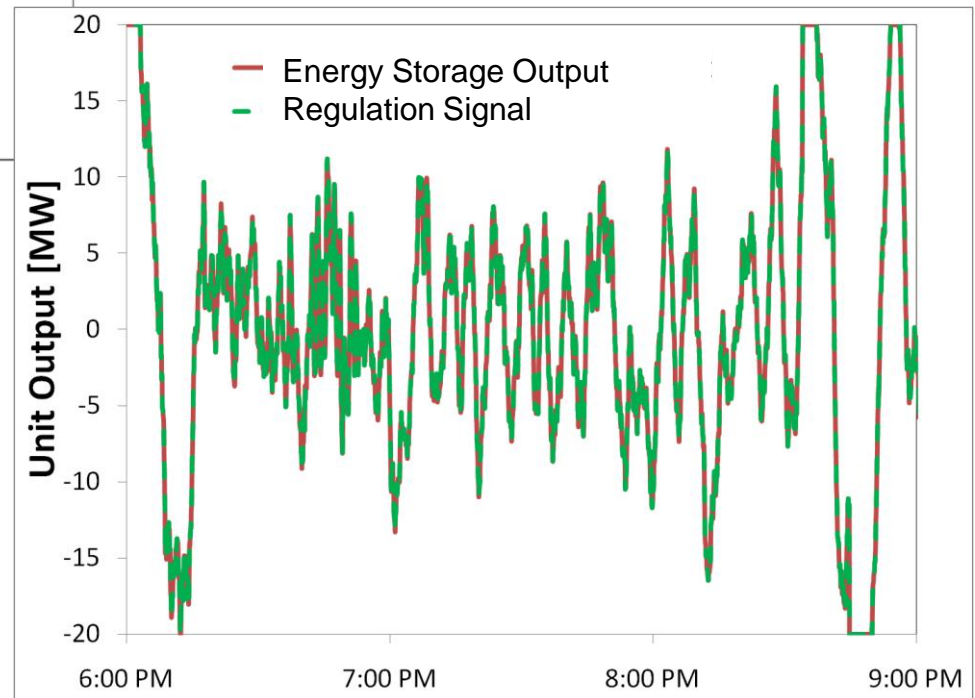
Encouraging Demand Resources





A fossil power plant following a regulation command signal

Energy Storage (batteries / flywheels) accurately following a regulation command signal

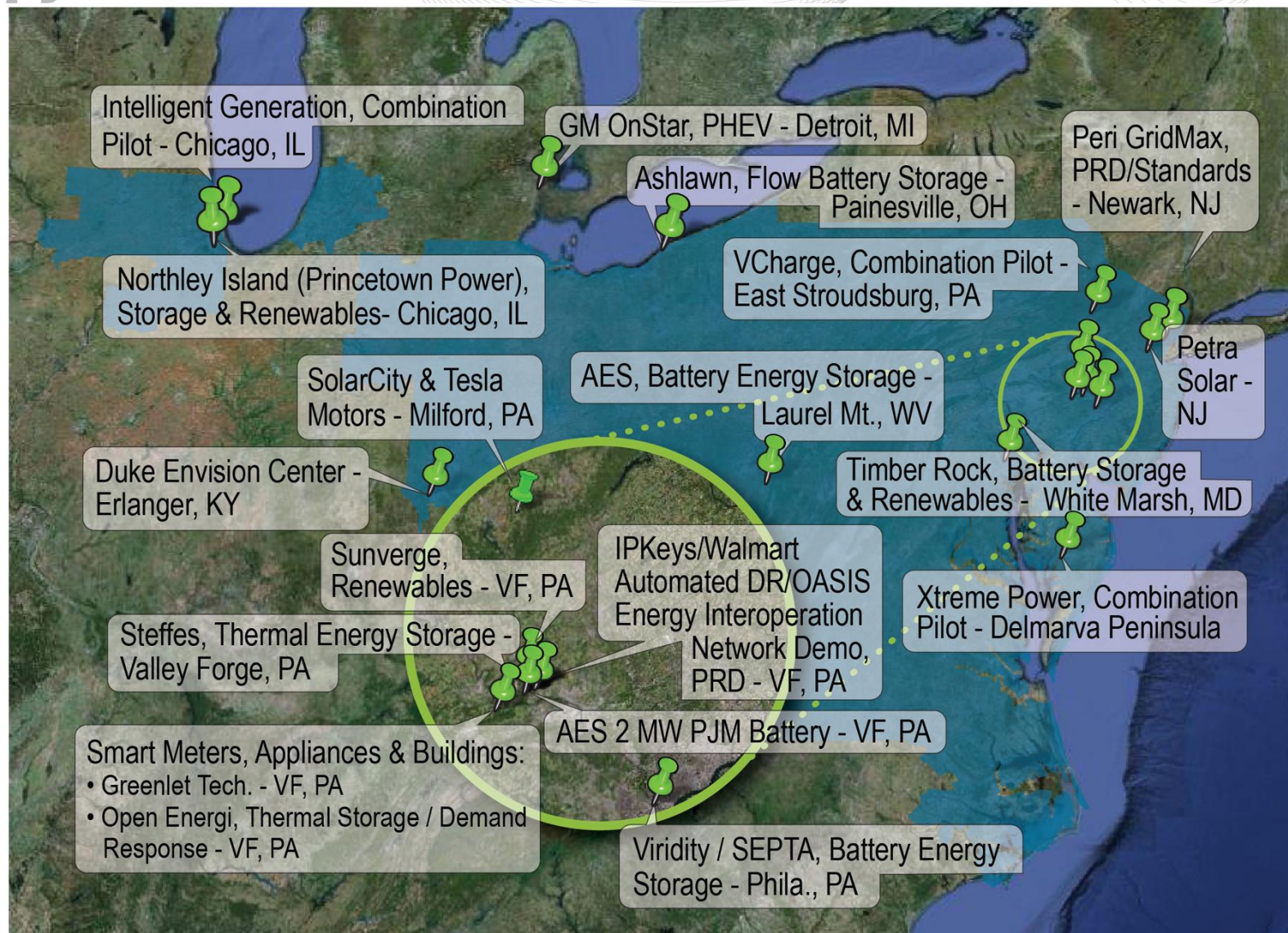


- **Shortage Pricing / Co-optimization (Order 719)**

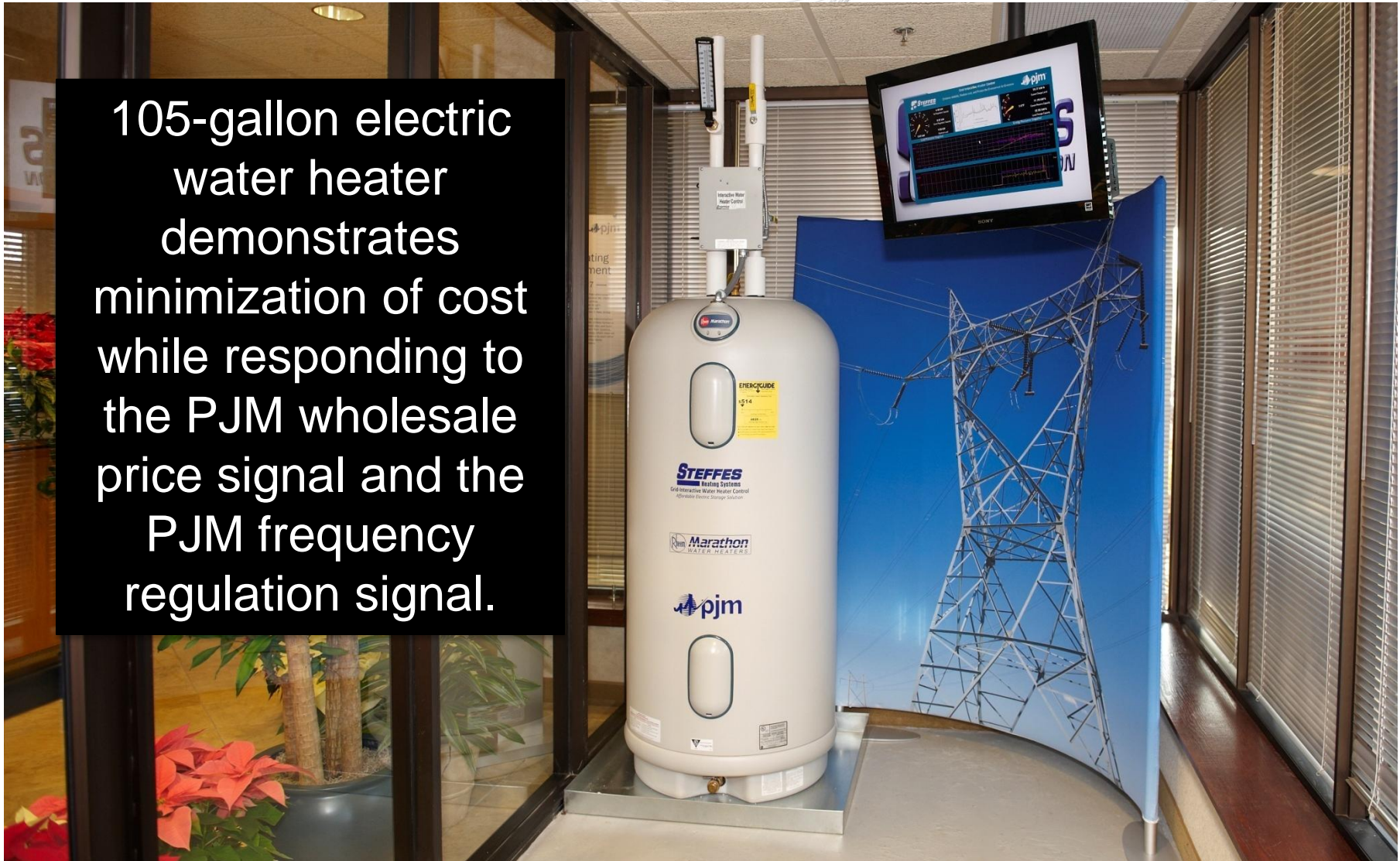
- Shortage Pricing uses a joint-optimization of energy, reserves, and regulation to determine 5-minute prices
- Previous market design used estimated lost opportunity costs (LOC) for regulating resources
 - Results in a significant amount of payments outside the market
 - This suppresses prices which keeps new technologies out of the market
- 5-minute prices capture all of the costs of regulation (including actual LOC) in the regulation clearing price

- **Frequency Regulation Compensation (Order 755)**

- Market clearing and compensation based on performance
- Better performing resources receive a larger share of the regulation compensation
- Drives down the total cost of regulation service over time



105-gallon electric water heater demonstrates minimization of cost while responding to the PJM wholesale price signal and the PJM frequency regulation signal.



- Flexible resources will be needed to offset the impacts of variable generating resources
- New market players:
 - Price Responsive Demand
 - Smart Grid Technologies
 - Energy Storage Resources
 - battery arrays
 - Flywheels
 - plug-in hybrid electric vehicles (PHEVs)
- Potential market changes:
 - New tools to improve forecasting and scheduling capabilities
 - New market mechanisms to incent flexible resources (e.g., paying for performance in regulation market)
 - Market-to-market coordination with neighbors

- For more information about PJM's initiatives:
 - Exploring Tomorrow's Grid: New developments and technologies to advance the grid:
<http://pjm.com/about-pjm/exploring-tomorrows-grid/smart-grid.aspx>
 - Renewable Energy Dashboard: See how PJM is working to bring renewable energy to the grid:
<http://pjm.com/about-pjm/renewable-dashboard.aspx>