Electric Power Delivery System for the 21st Century

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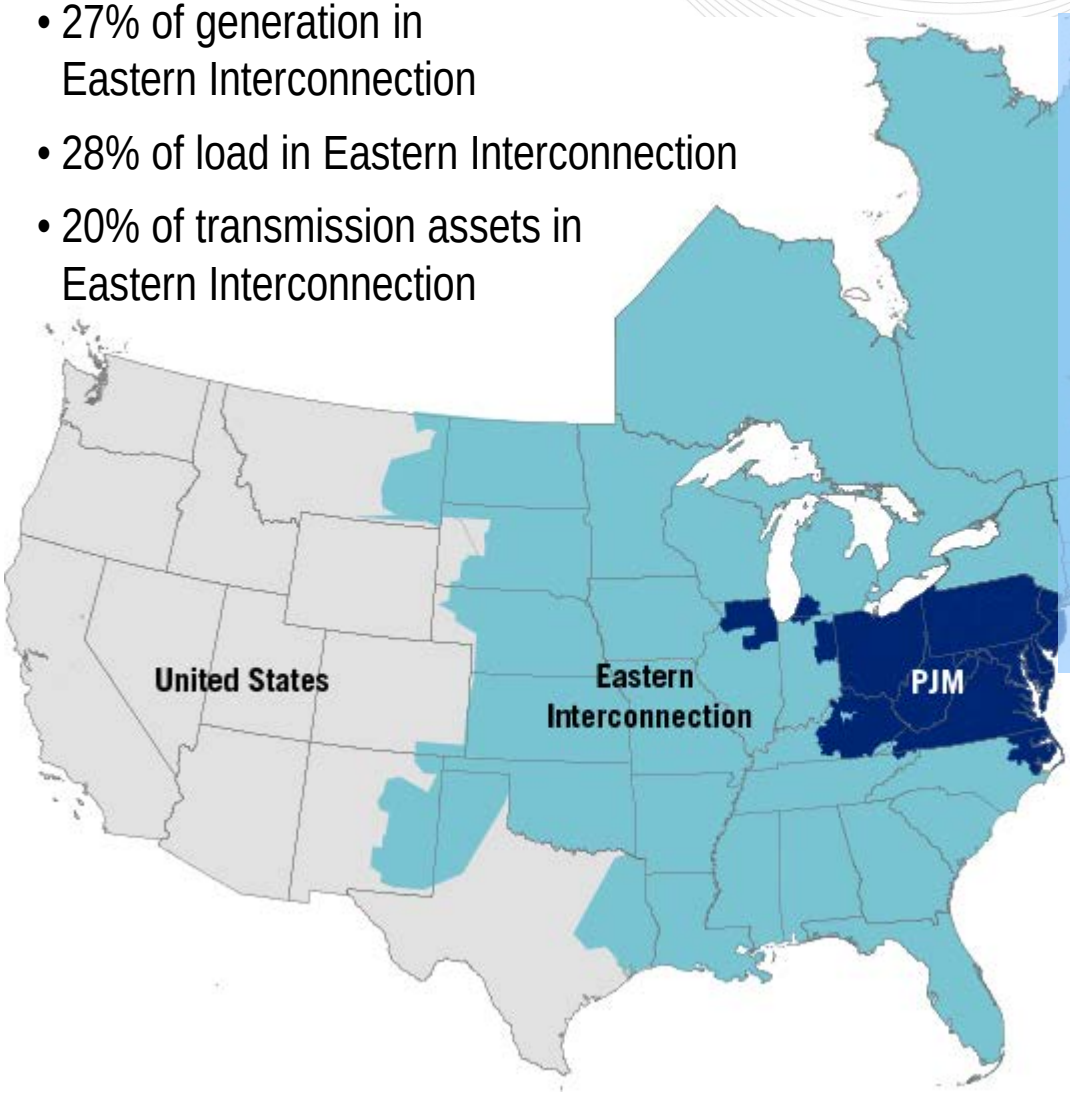
June 16, 2014

PJM as Part of the Eastern Interconnection

- 27% of generation in Eastern Interconnection
- 28% of load in Eastern Interconnection
- 20% of transmission assets in Eastern Interconnection



KEY STATISTICS	
PJM member companies	900+
millions of people served	61
peak load in megawatts	165,492
MWs of generating capacity	183,604
miles of transmission lines	62,556
2013 GWh of annual energy	791,089
generation sources	1,376
square miles of territory	243,417
area served	13 states + DC
externally facing tie lines	191

21% of U.S. GDP produced in PJM

As of 4/1/2014

PJM – Focus on Just 3 Things

Top Challenges Facing the Industry

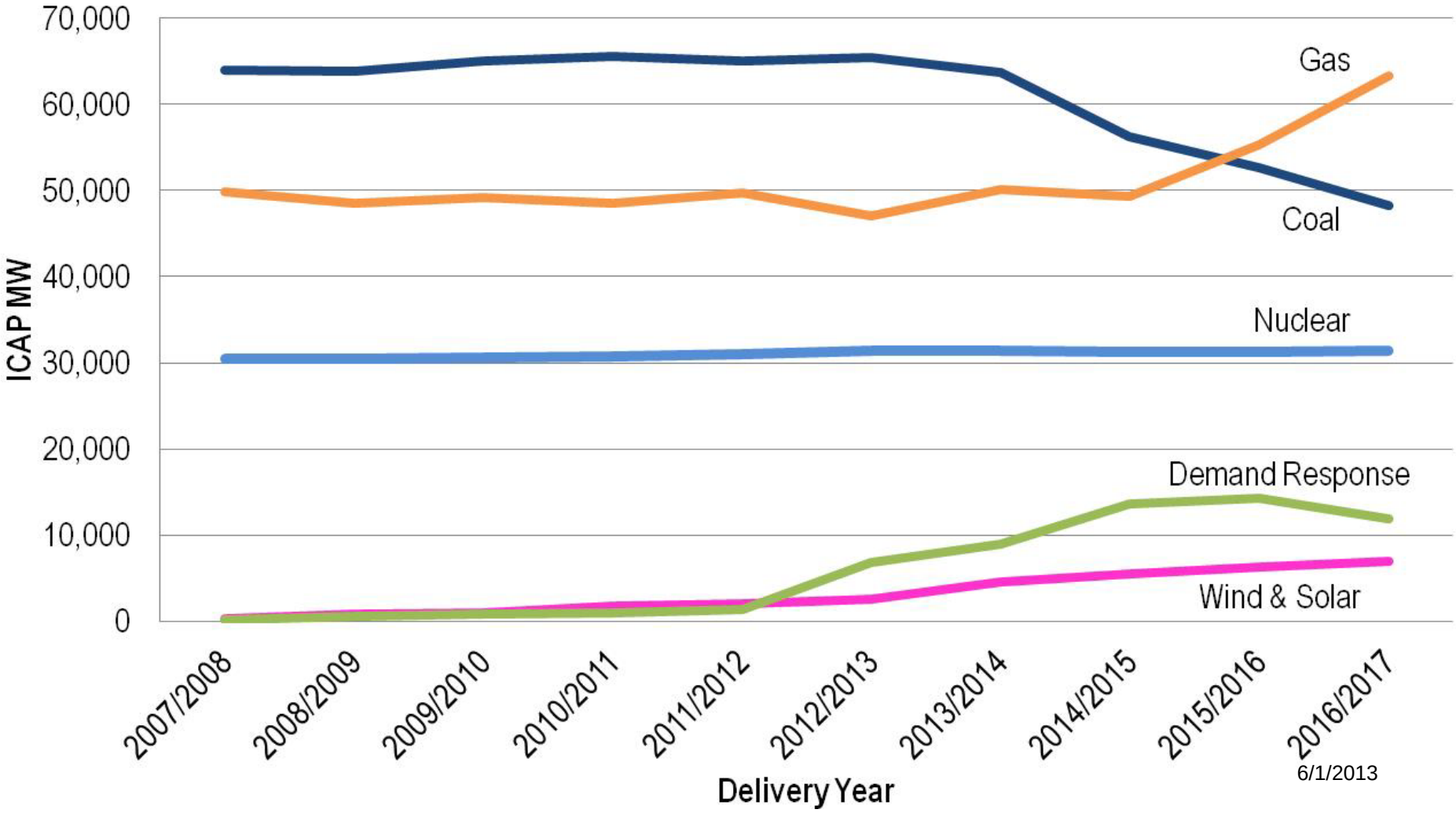
- Electricity Demand
- **World's Largest Fuel Switch**
- Natural Gas Interoperability
- Integration of Intermittent and Demand Side Resources
- Natural and Unnatural Disasters

Each Challenge is Also an Opportunity

Adapted from: EPRI

Managing a Sea-Change

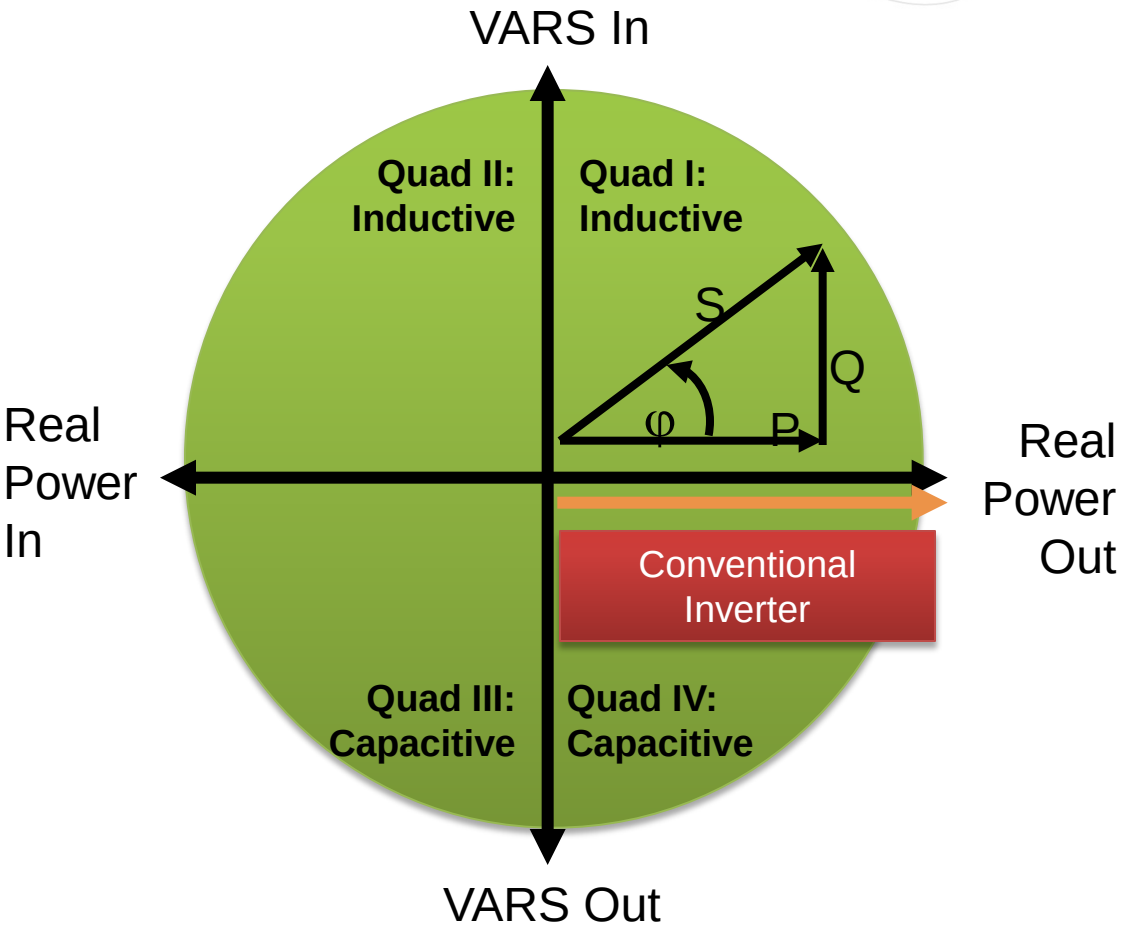
PJM Installed Capacity Cleared



6/1/2013

Need Four Quadrant Voltage Control

Smart Inverter



280,000 in NJ can do voltage control!

Need Four Quadrant Voltage Control

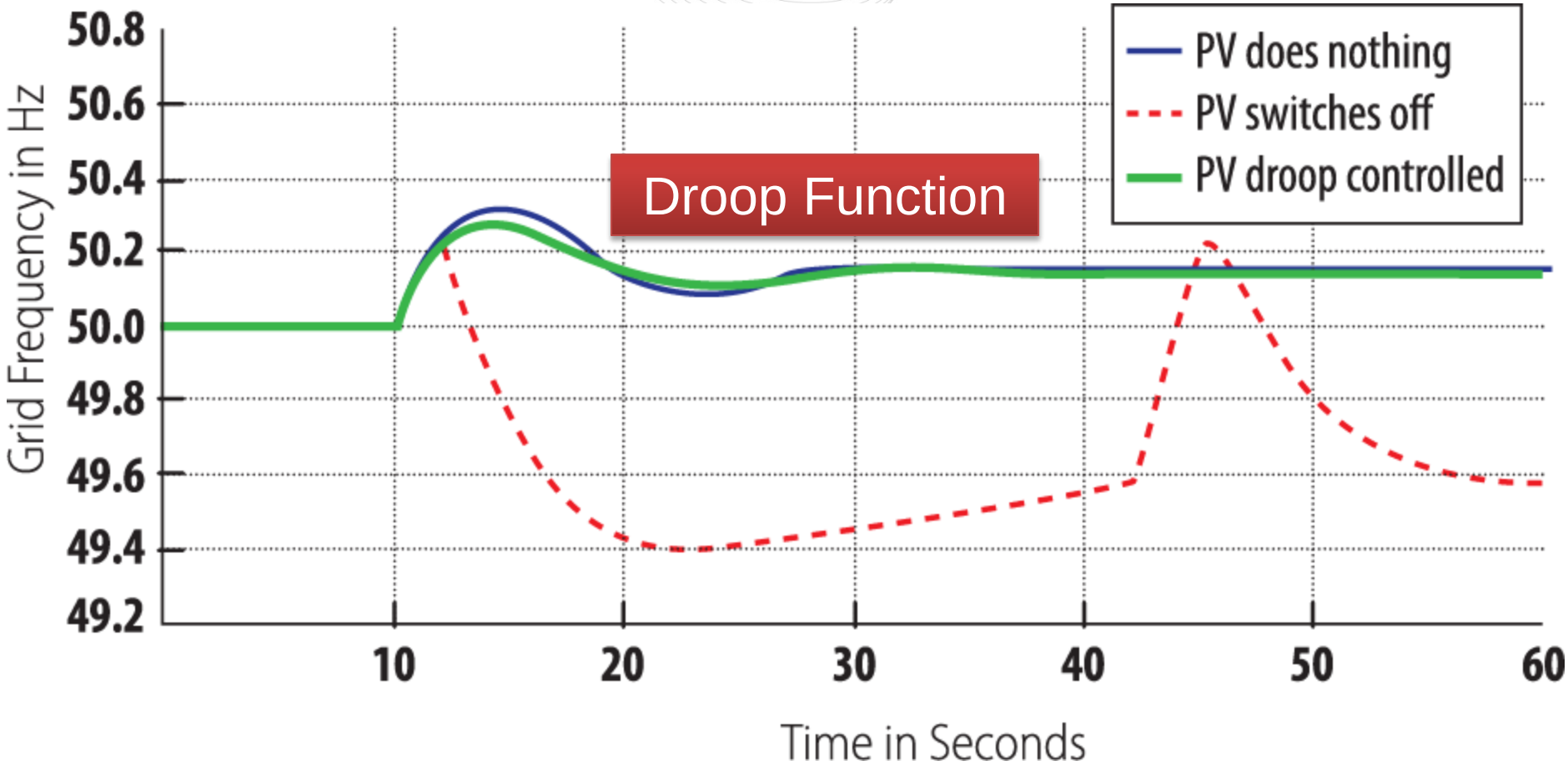
Reactive Power (kvar)

Active/Real Power (kW)

Total System Capacity (kVa)

280,000 in NJ can do voltage control!

Germany to Replace 1,000,000 Inverters



- Required for a conventional generator interconnection
  - Automatic voltage regulators
  - Automatic frequency response
  - Droop control function

Why can't we require this for asynchronous generators

Smart Inverters Can Do This!

Run additional conventional generators dedicated to voltage and frequency support

- Not cost effective
- Causes negative Locational Marginal Prices
- Limits the percentage of renewables (50% in Spain & Ireland)

Forward Looking Smart Inverters = A Smart Choice

- Proactive response
- Most cost effective, only small incremental cost (0.2% increase)*
- Gain distributed control (not all eggs in one basket)
- Close to loads to lower distribution losses.

*EPRI estimate

Can we substitute speed for inertia/rotating mass?

- Need industry collaboration
- Need method to value reactive support
- Prove speed ≅ inertia
- Need to address both transmission and distribution level requirements
- Require smart inverters