Advanced Markets enabling Advanced (Smarter Grid) Technologies in PJM

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PJM Interconnection

July 25, 2011

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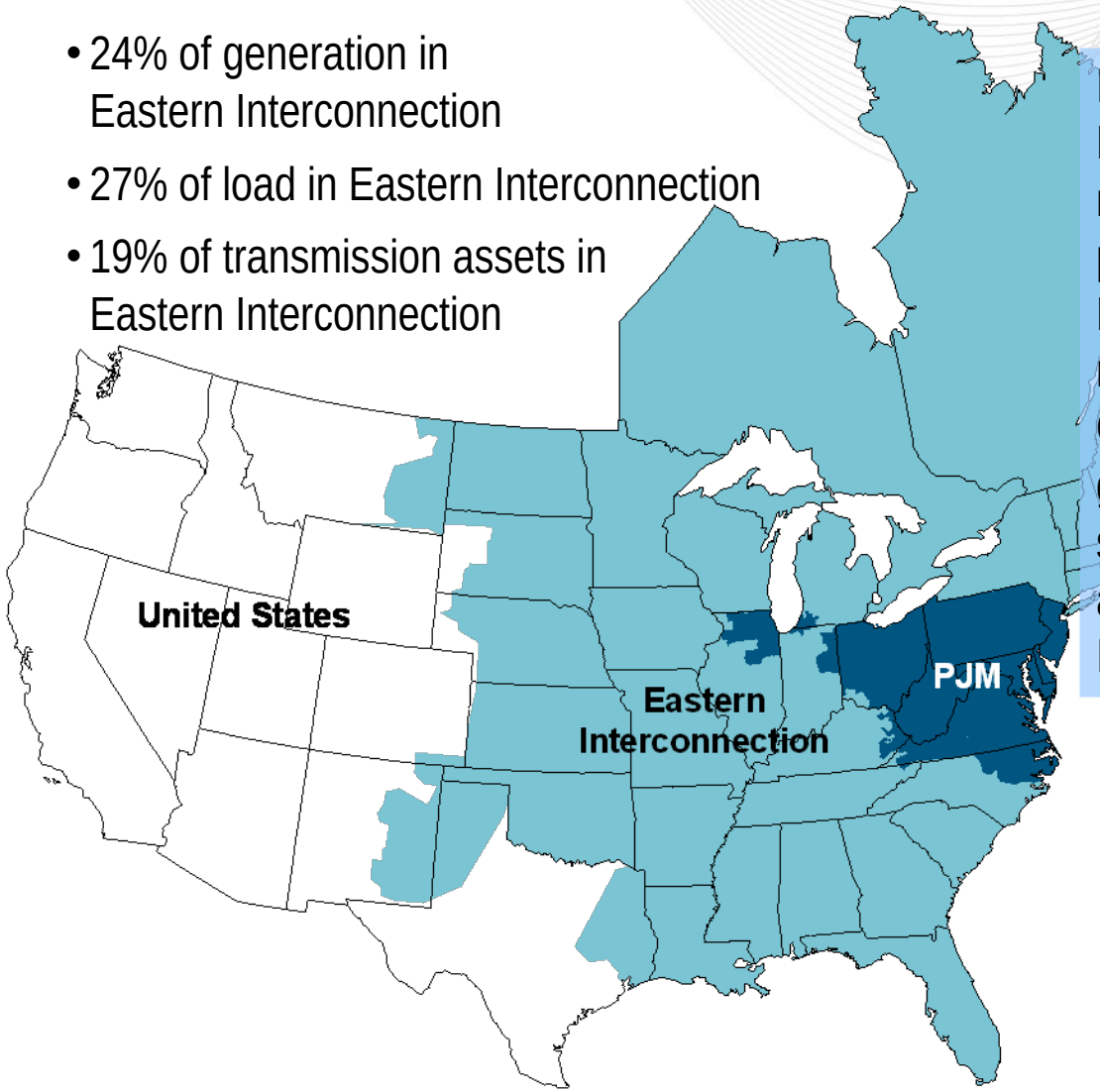
PJM as Part of the Eastern Interconnection

- 24% of generation in Eastern Interconnection
- 27% of load in Eastern Interconnection
- 19% of transmission assets in Eastern Interconnection



KEY STATISTICS	
PJM member companies	700+
millions of people served	58
peak load in megawatts	158,448
MWs of generating capacity	180,400
miles of transmission lines	61,200
GWh of annual energy	794,335
generation sources	1,365
square miles of territory	211,000
area served	13 states + DC
Internal/external tie lines	142

20% of U.S. GDP produced in PJM

As of 6/1/2011

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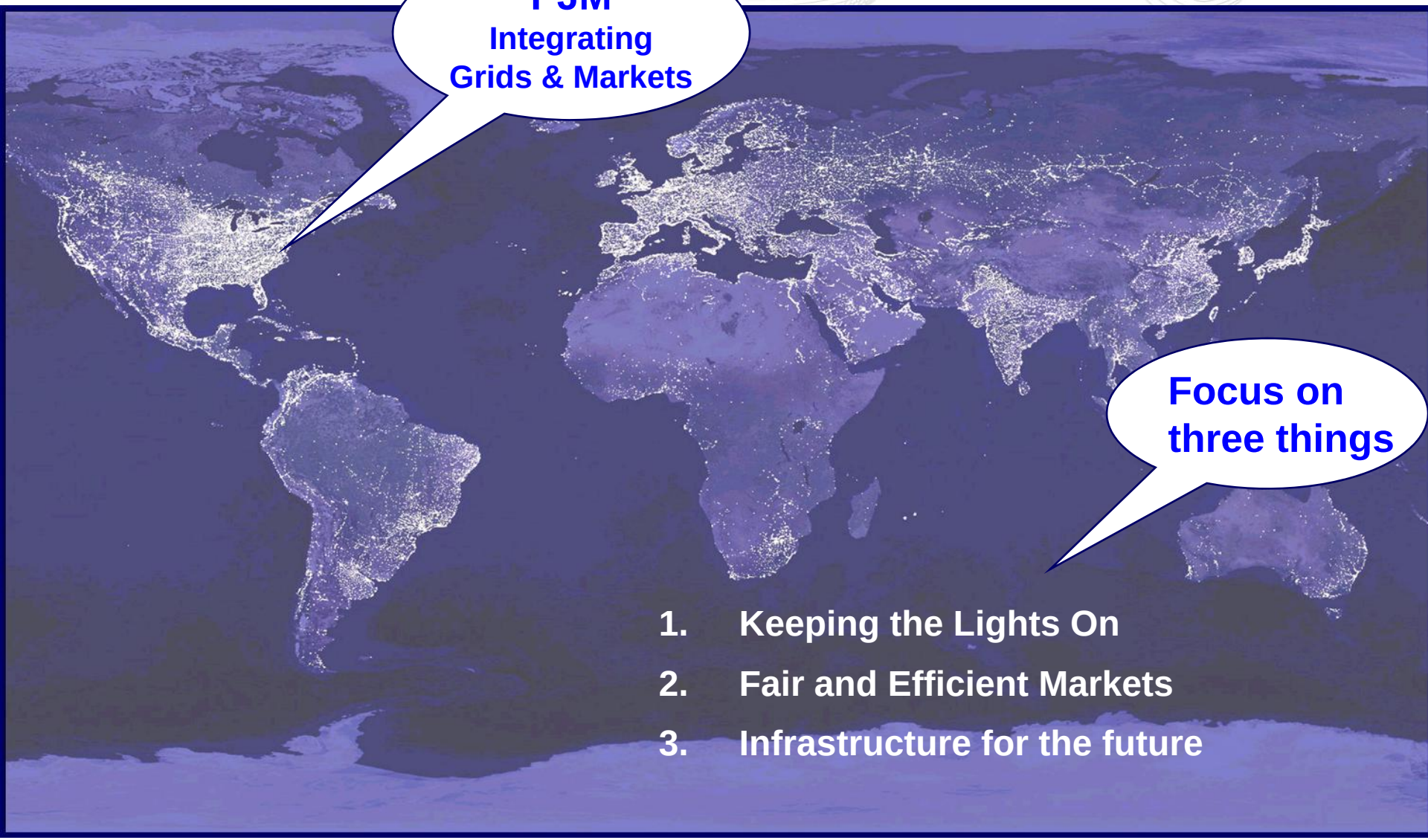
PJM
Integrating
Grids & Markets
Focus on
three things
1. Keeping the Lights On
2. Fair and Efficient Markets
3. Infrastructure for the future

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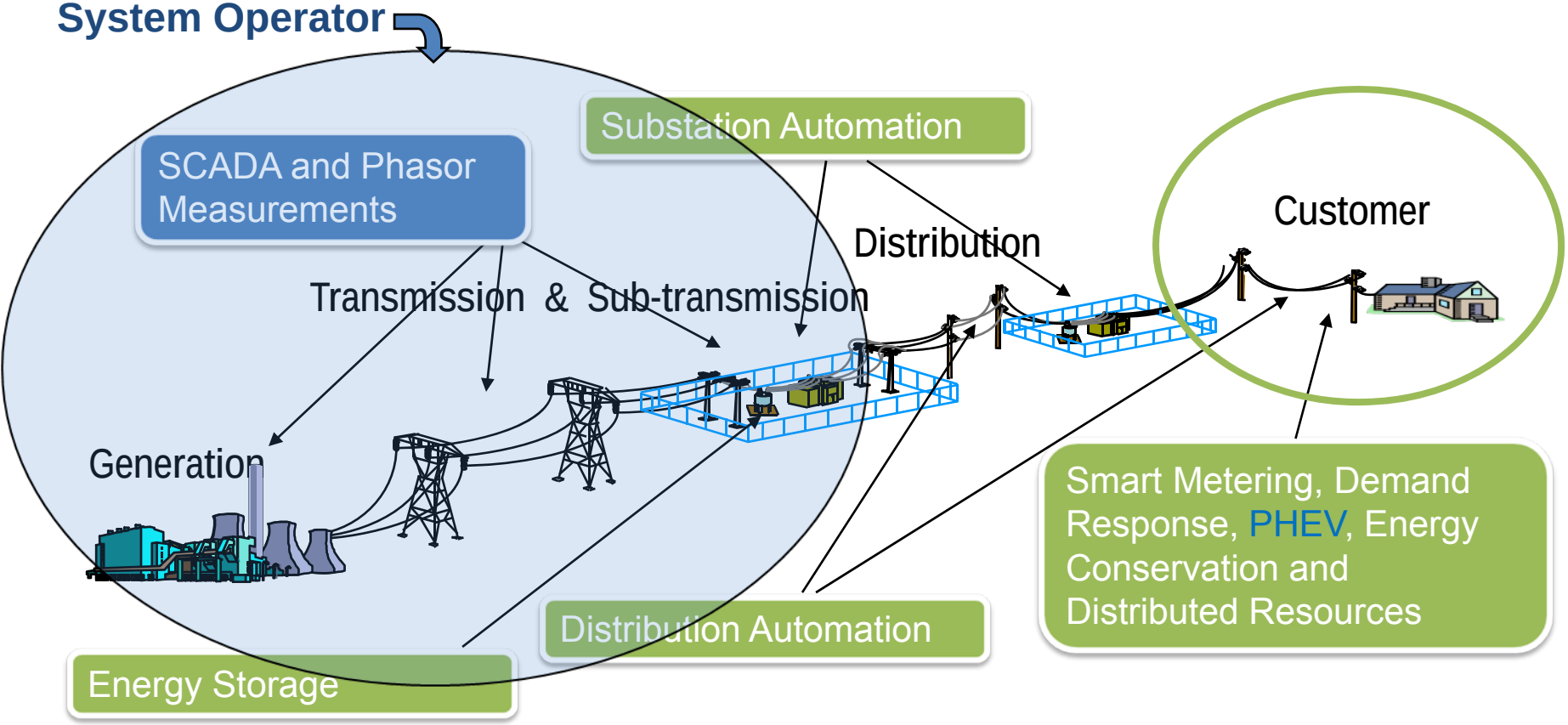
Smart Grid – Two-way Communications and Control

The Smart Grid is realized by merging data from these areas of automation to achieve a total end-to-end systems view by integrating information technology and operational technology.



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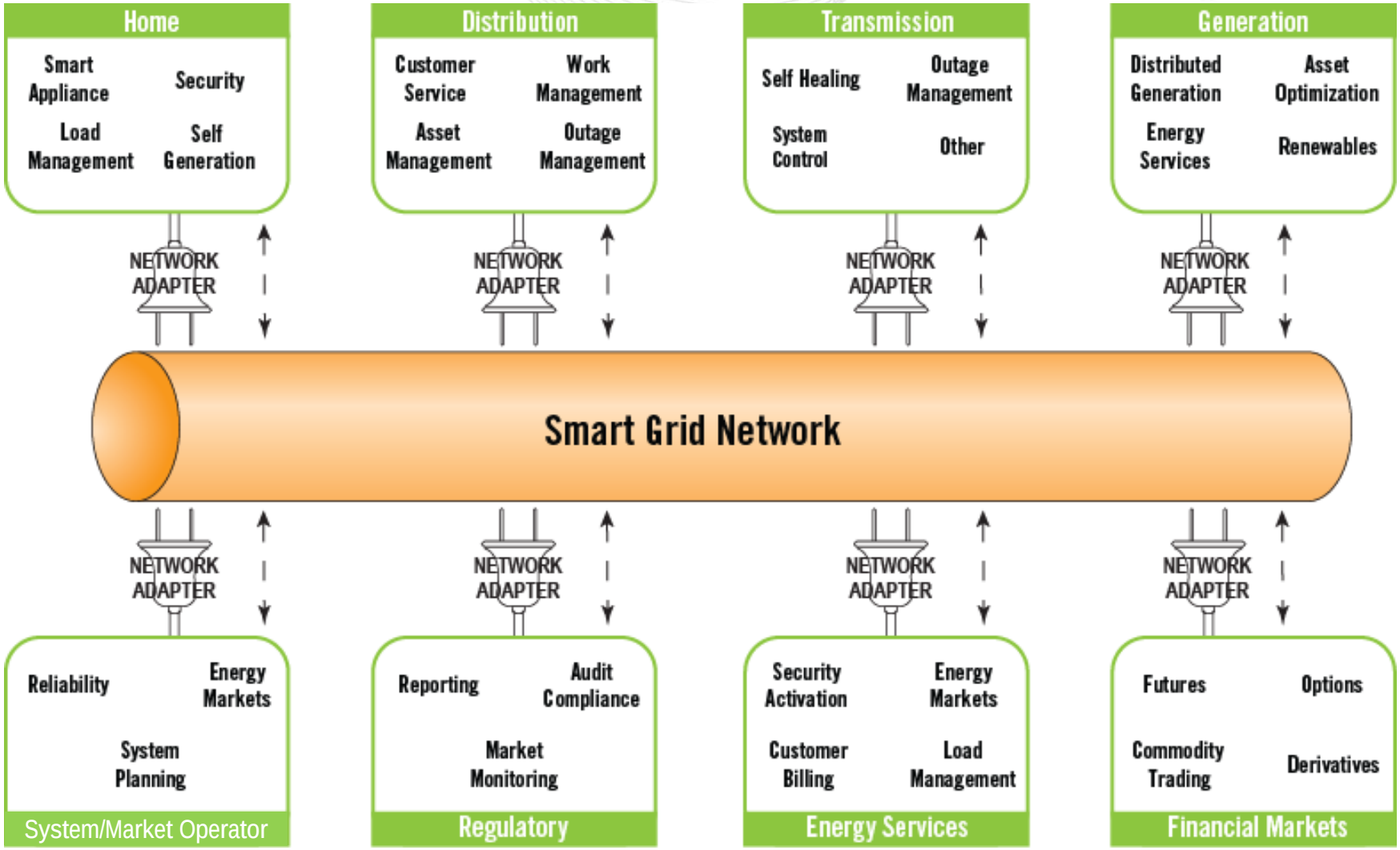
Smart Grid Network



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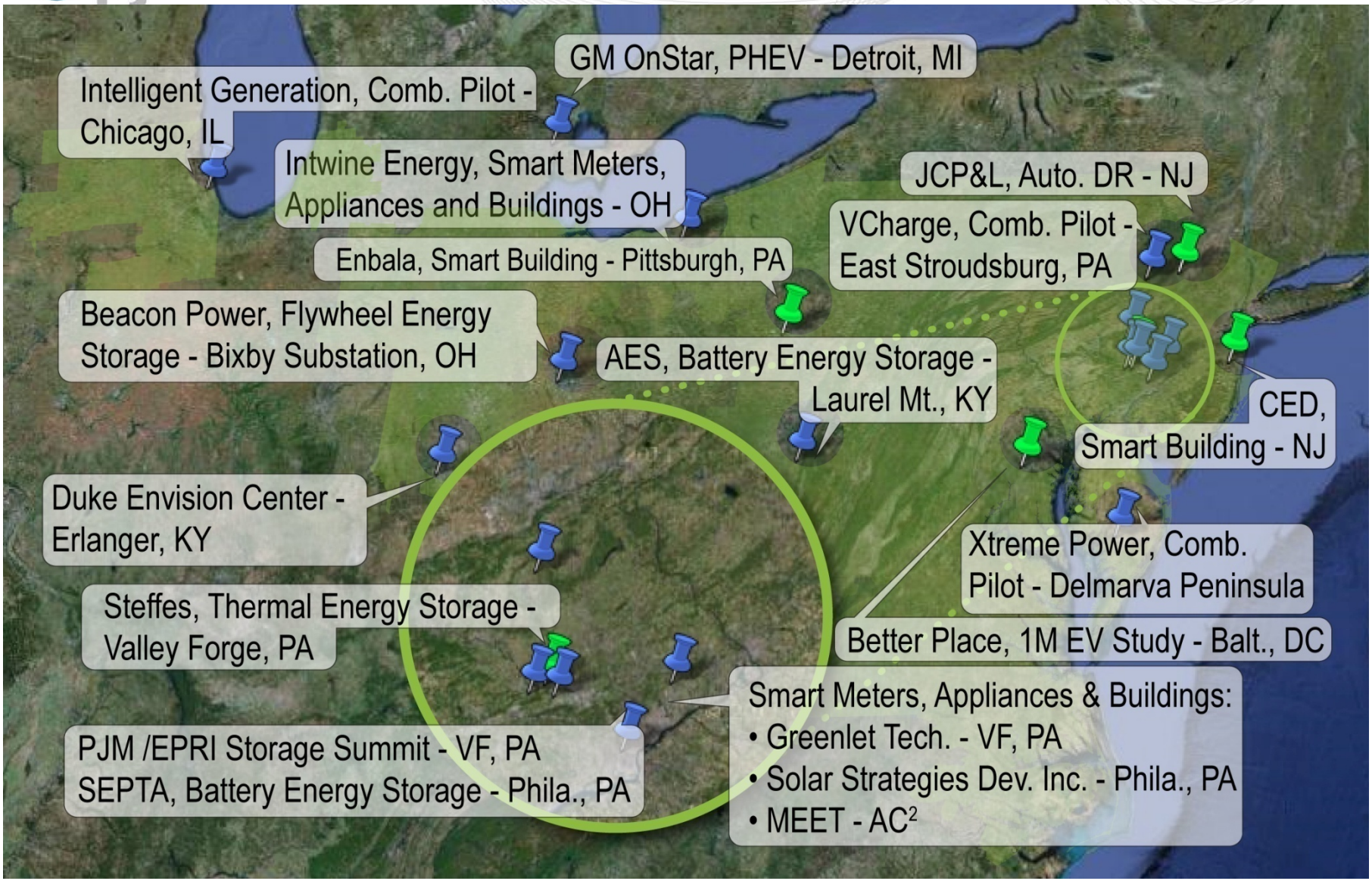
Innovation Activity



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Smart Grid Network - Smart Home

- Smart Appliance Energy Management
- Smart Charger (PHEV) Storage

Home

Smart Appliance | Security

Load Management | Self Generation

NETWORK ADAPTER

Aggregator

Smart Grid Network

NETWORK ADAPTER

Reliability | Grid Signal

System Planning

System/Market Operator

- Regulation Signal
- Price Signal
- Reliability
- Load Curtailment

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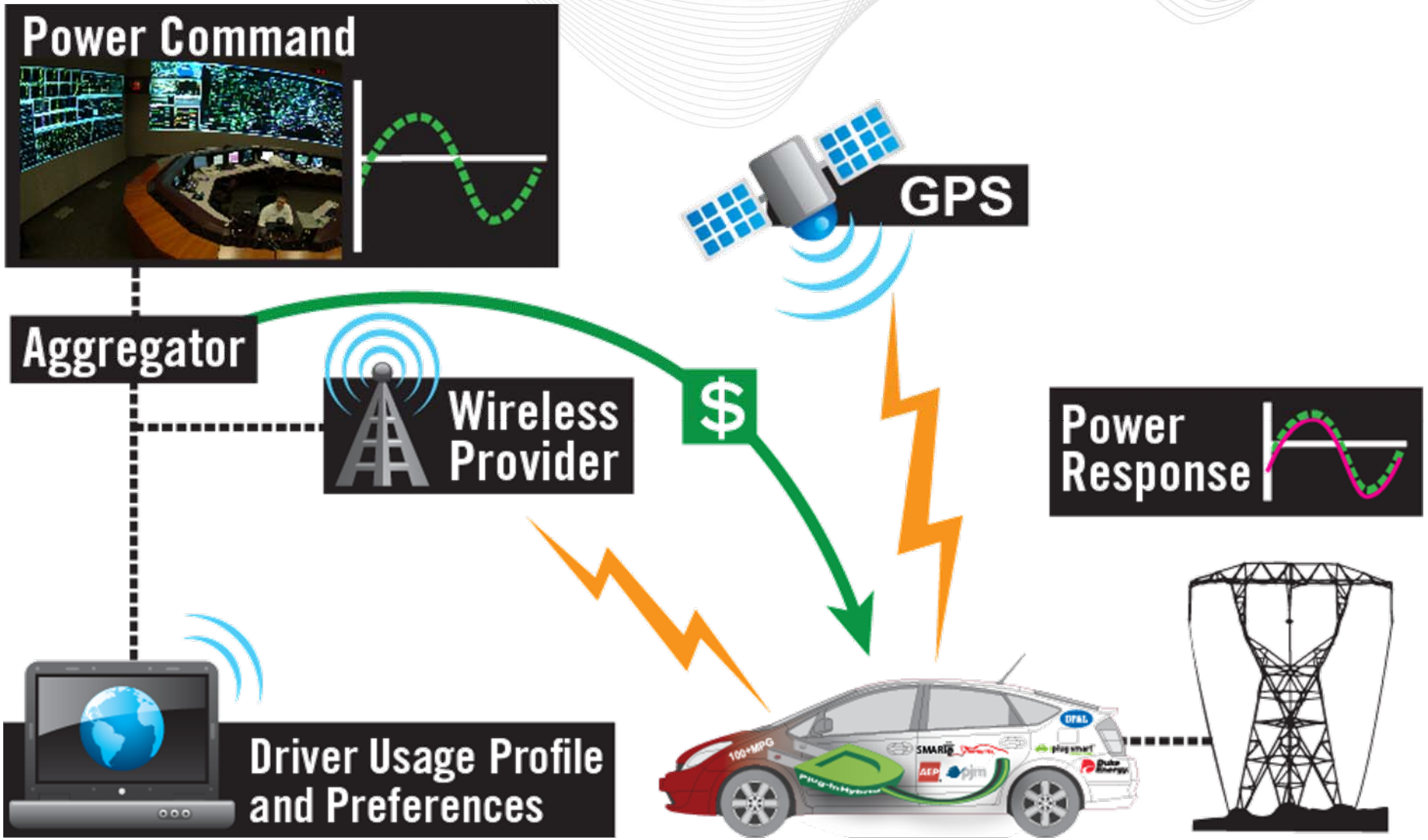
Smart@Car-a connection to the grid



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Smart Grid and Plug-in Hybrid Electric Vehicles (PHEVs)

- Mid-Atlantic Grid Interactive Car Consortium (MAGICC) – electric companies, research institutes, and vehicle manufacturers
- **Over one year experience** with the MAGICC battery electric vehicle responding to the PJM regulation signal

University of Delaware · Pepco Holdings Inc · AC Propulsion · comverge · ACUA

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Smart Grid Network – Alternative Generation Resources

Generation

- Distributed Generation
- Asset Optimization
- Energy Services
- Renewables

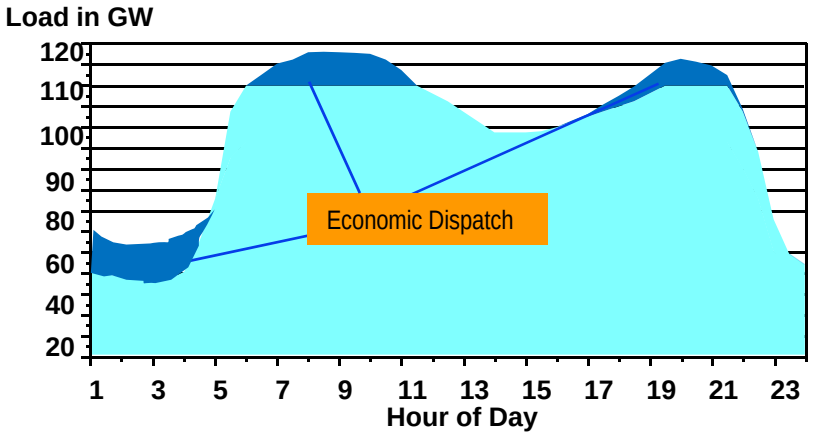
NETWORK ADAPTER

Smart Grid Network

NETWORK ADAPTER

- Reliability
- Energy Markets
- System Planning

System/Market Operator



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Why Storage – Wind Generation in PJM

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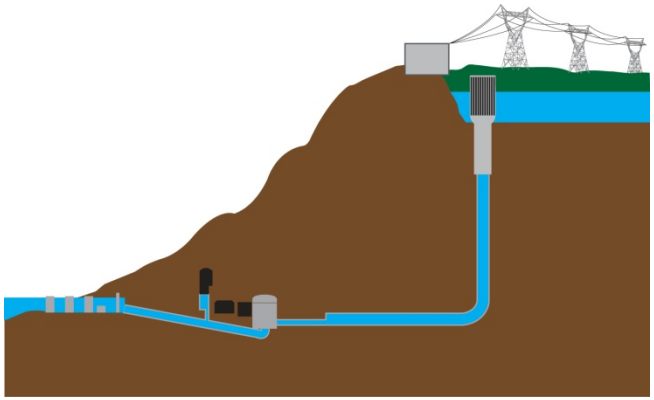
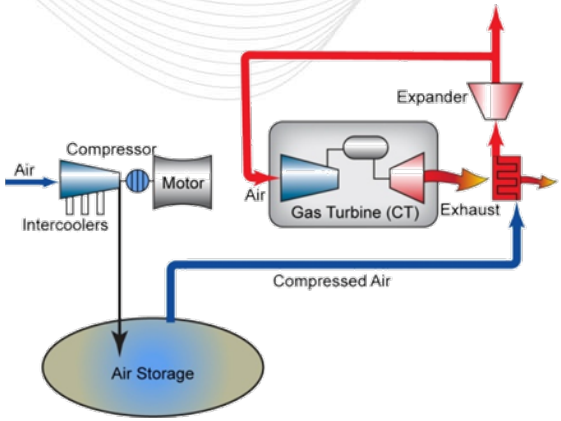
Innovation--What Storage in PJM?



Pumped Hydro



Compressed Air

Flywheels

Stationary Battery

Mobile Batteries

Water Heaters

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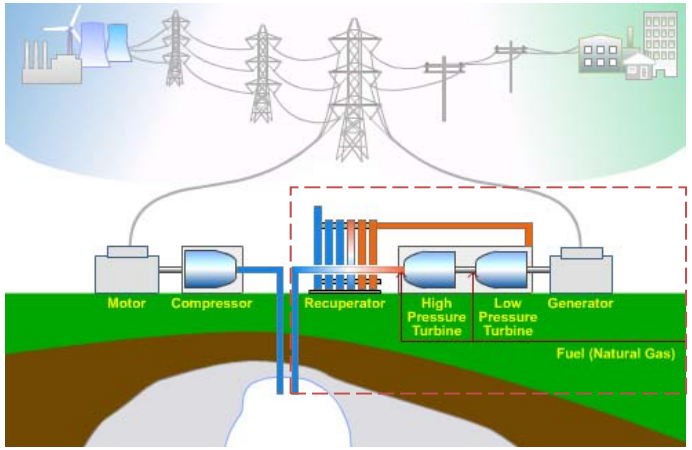
Compressed Air Energy Storage and Norton

- CAES – a highly responsive technology:
  - Combines gas turbine with compressed air
  - Compressor operates at low load periods; gas turbine serves load as needed
  - Smoothes out load/supply profile with quick response
- PJM is working with FirstEnergy on Norton CAES

Large size provides significant advantage:

- 338 million cubic foot cavern provides great flexibility (more than 4 times the size of the Pentagon)
- Approximately 130,000 MWhs of storage
- Longer storage period than typical pumped hydro
- Can add capacity in 150 MW increments, up to 2,700 MW total
- Fully dispatchable by PJM



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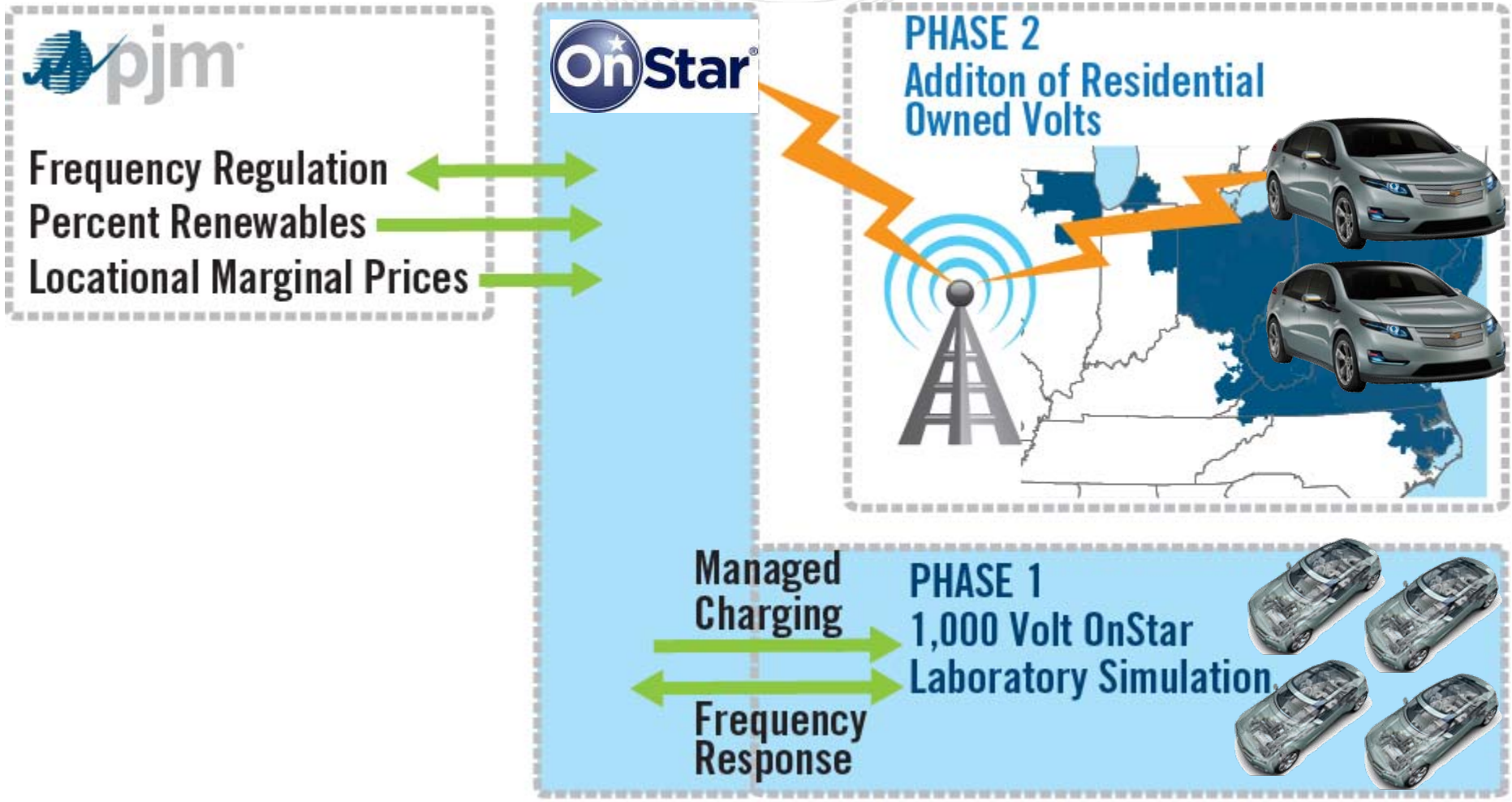
A 1,000 Volts – General Motors OnStar / PJM Pilot



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AES Grid-Scale Energy Storage System

Operational Details

Altairnano, Inc – Lithium Ion nano titanate battery

- Power: 1 MW for 15 minutes
- Energy: 300 kWh
- Usable Charge Range: 5% - 99%
- Efficiency: 90% round trip

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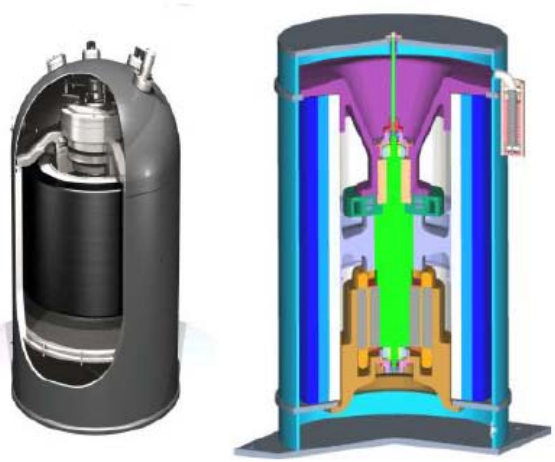
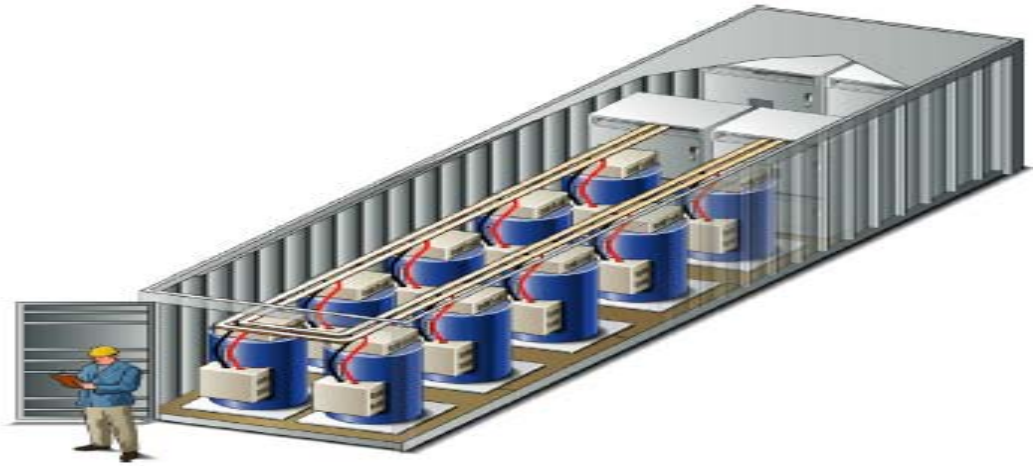
Attributes

- Life expectancy ~20 years
- No capacity decreases over life.
- No overcharge and over-discharge
- Rapid charging – minutes



Status in PJM Generation Queue

–20 MW - Impact Study Underway



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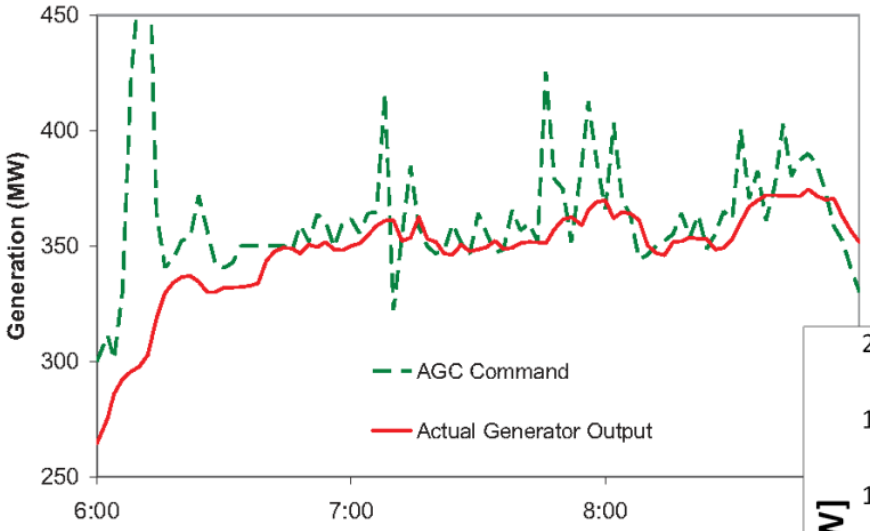
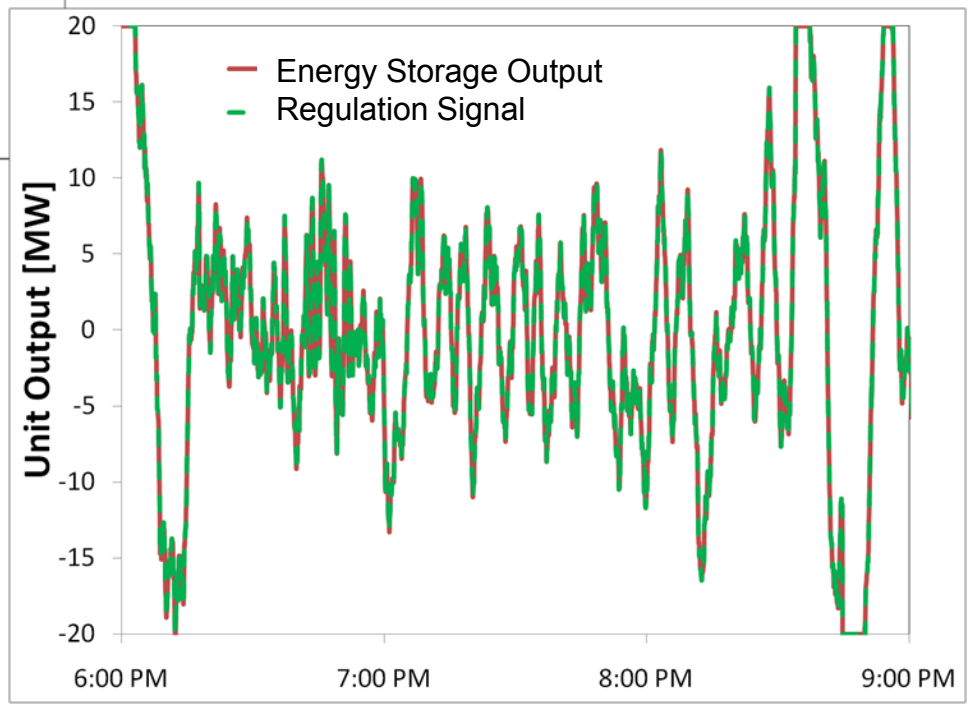
Fast Regulation: Speed Matters…



A fossil power plant following a regulation command signal

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



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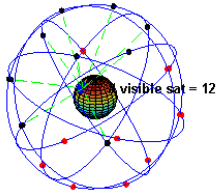
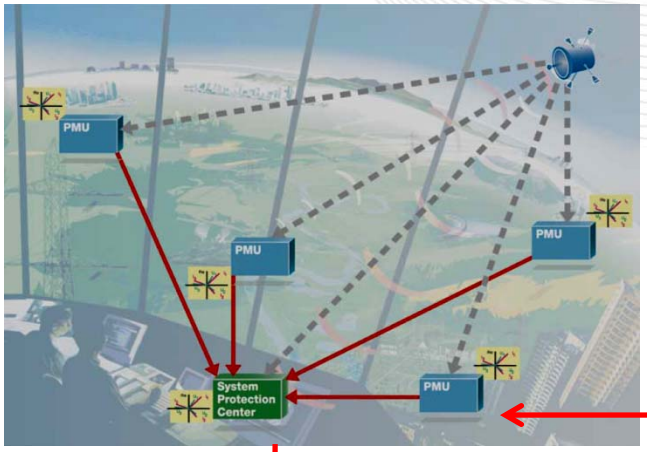
Smart Grid Network – Grid Reliability





Transmission

Self Healing | Outage Management

System Control | Other

NETWORK ADAPTER

Smart Grid Network

NETWORK ADAPTER

Wide Area Measurement System

System/Market Operator

Synchrophasors

- Measuring voltages and currents
- Outputting accurately GPS time-stamped voltage and current phasors

1-2 years

- Angle / Frequency Monitoring
- Disturbance Analysis
- Voltage Stability Analysis

3-5 years

- Improved State Estimation (Boundary conditions)
- Rapid Restoration

The Future

- Real-Time Control
- Early Cascade Detection

Transmission Technologies

- High Voltage DC (HVDC)
- FACTS Devices
- Variable Frequency Transformer (VFT)
- Substation Automation
- Direct Load Control

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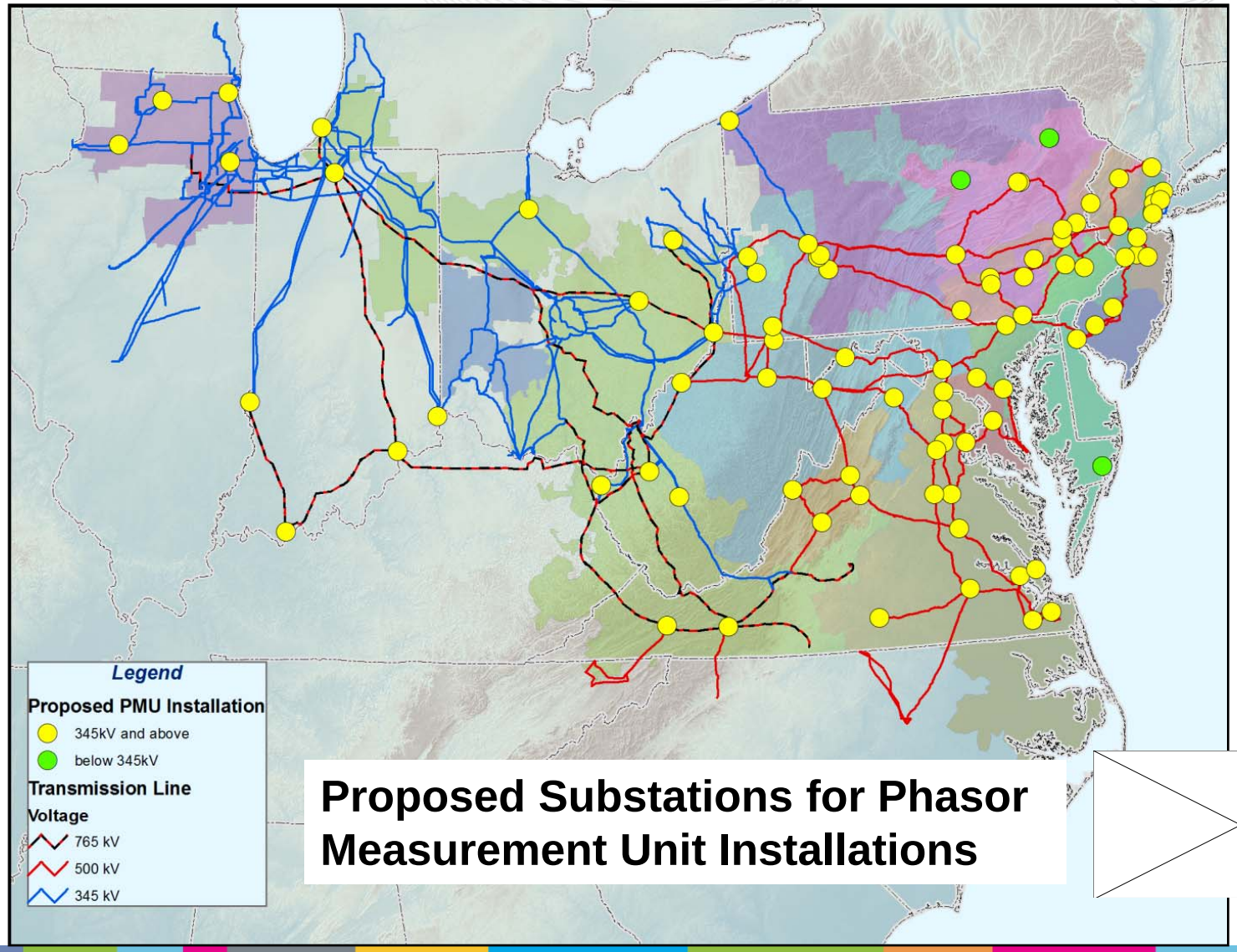
Smart Grid Investment Grant – PJM Lead



Proposed Substations for Phasor Measurement Unit Installations

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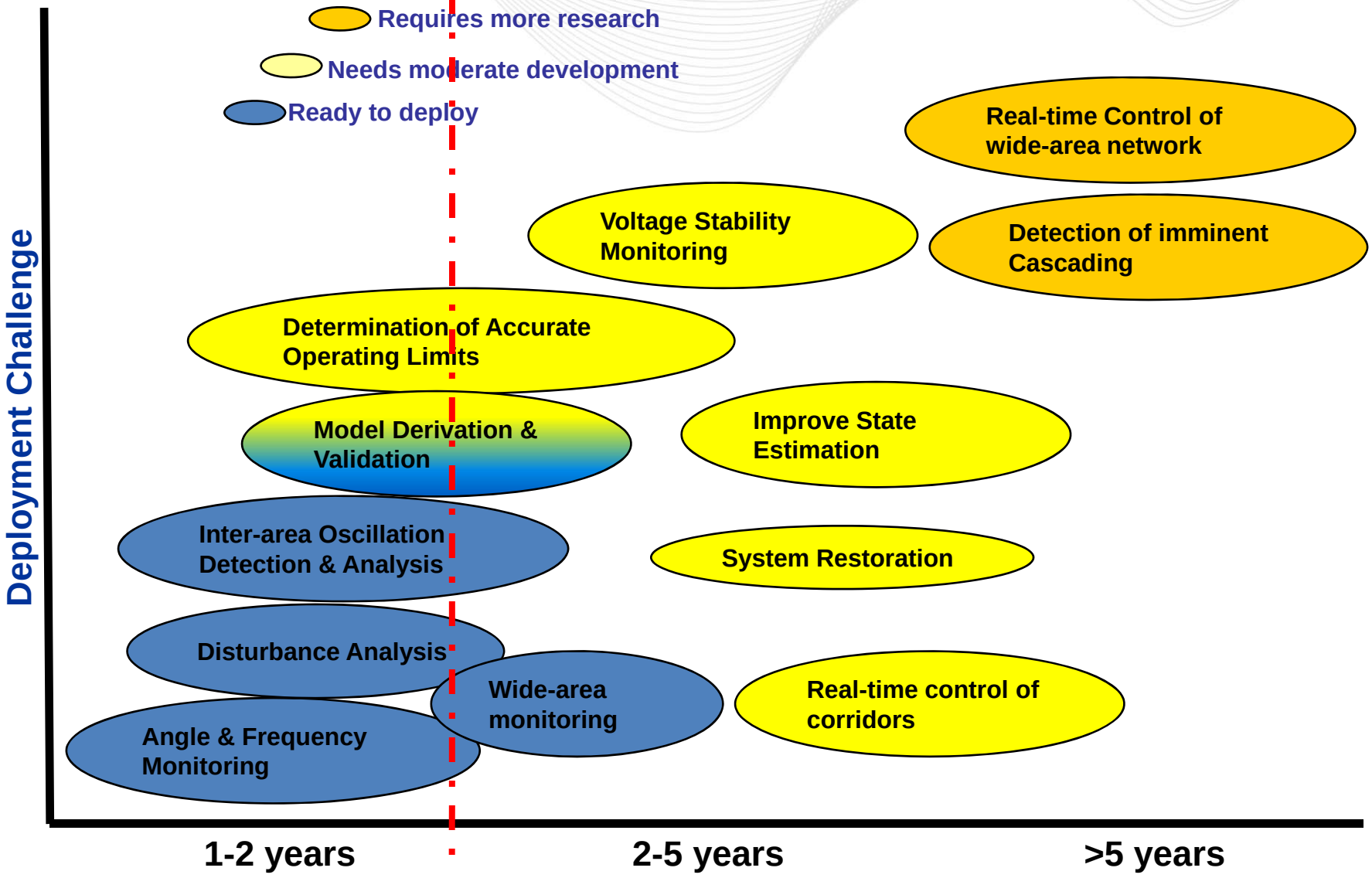
SynchroPhasor Applications



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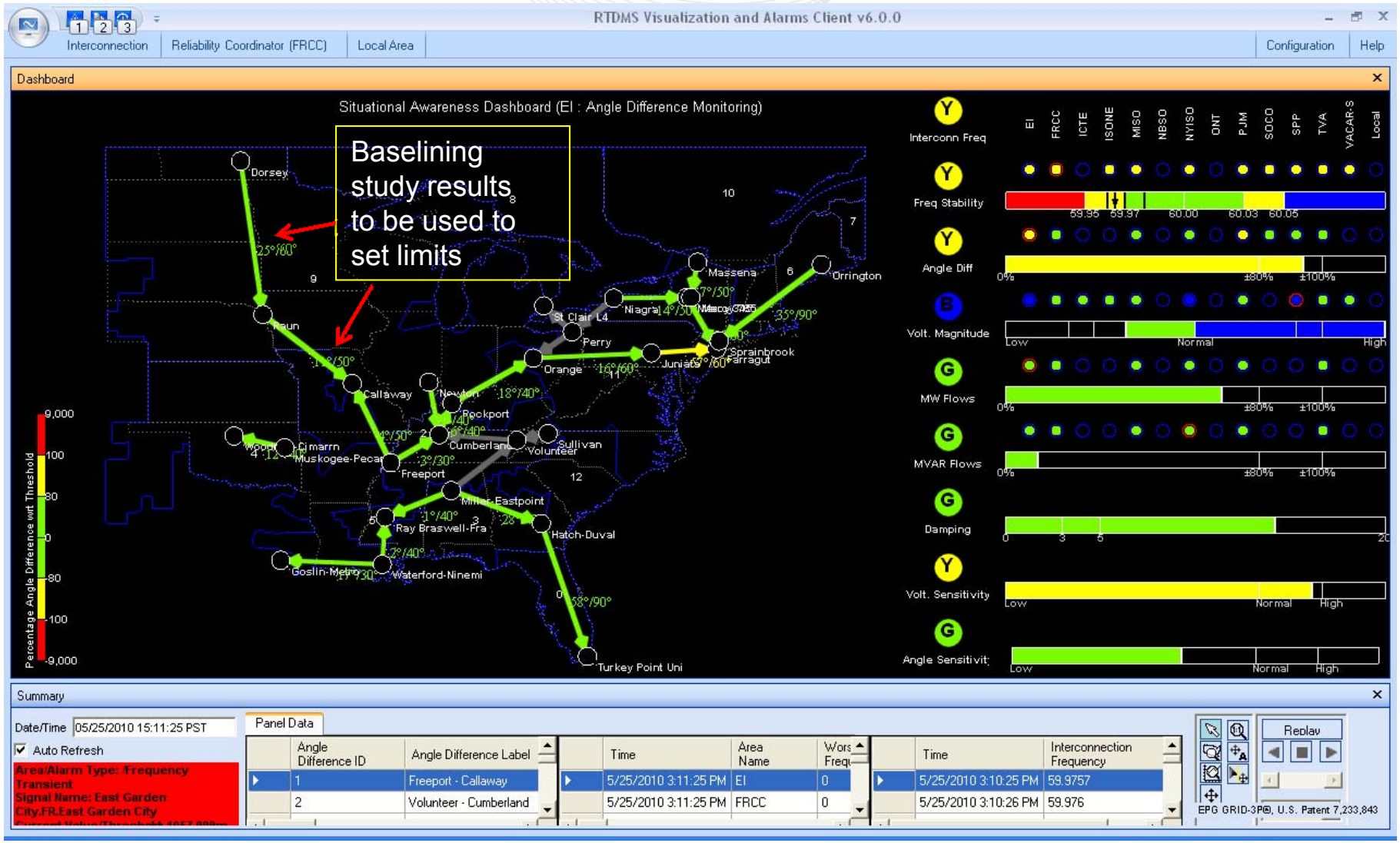
Baselining Results can be Used to Establish 'alerts' for Operations



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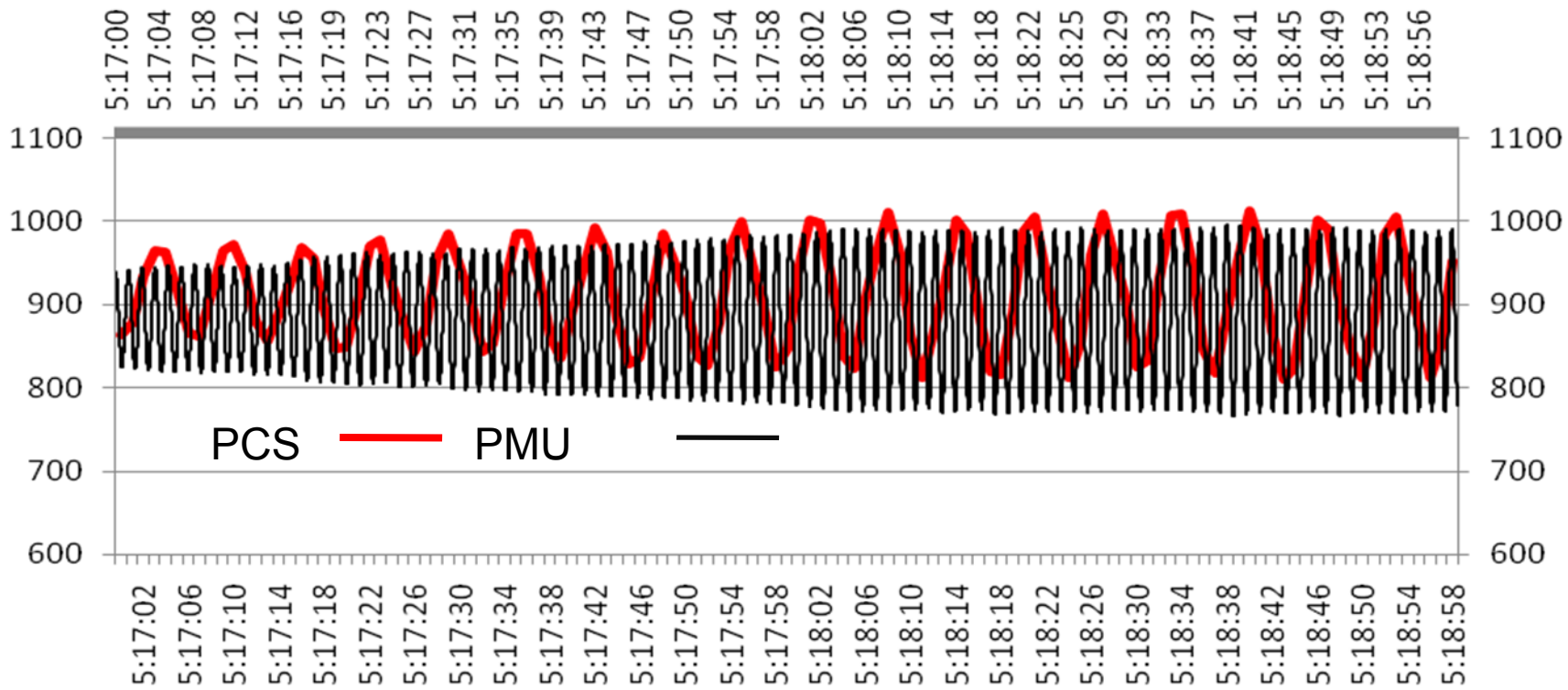
Surry Unit 1 MW



At 01:18hr, Surry reported Unit 1 saw a 200MW swing and Unit 2 experienced a 50MW swing. The SOC did not detect the MW swing. The SOC does not monitor the output of generators in a way that a MW swing would be readily apparent

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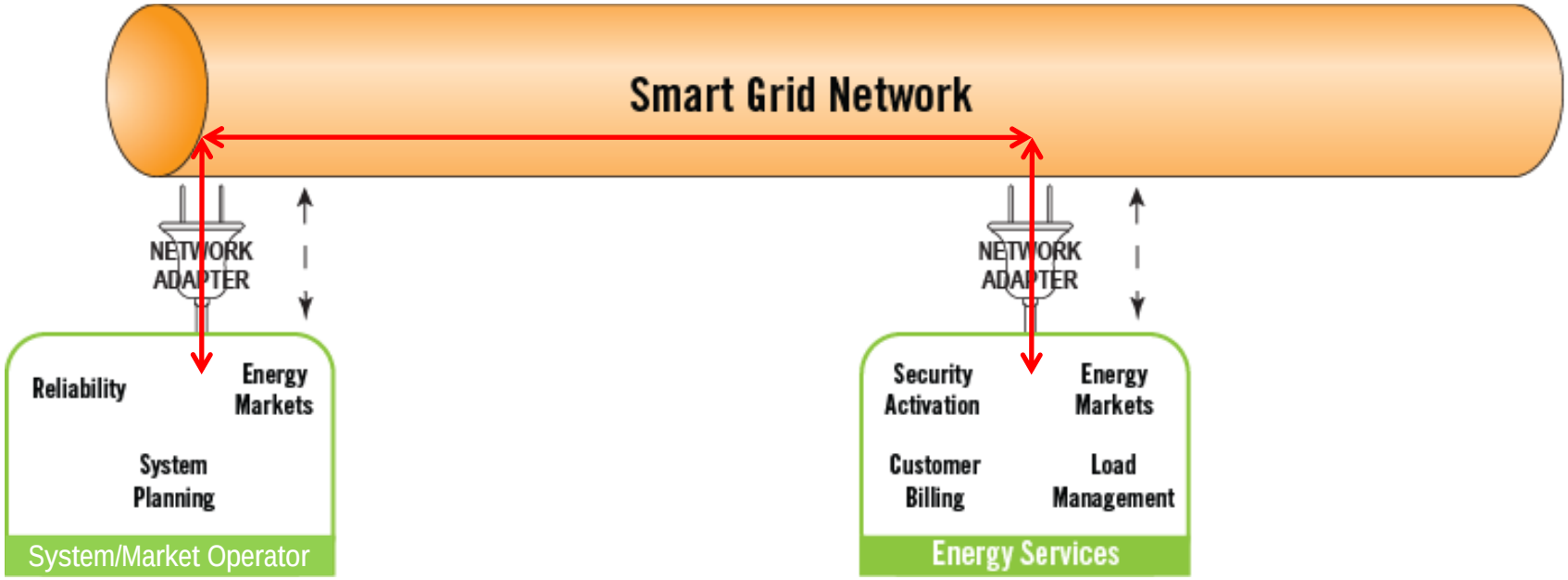
Smart Grid Network – Energy Services

- Demand Response
- Energy Efficiency



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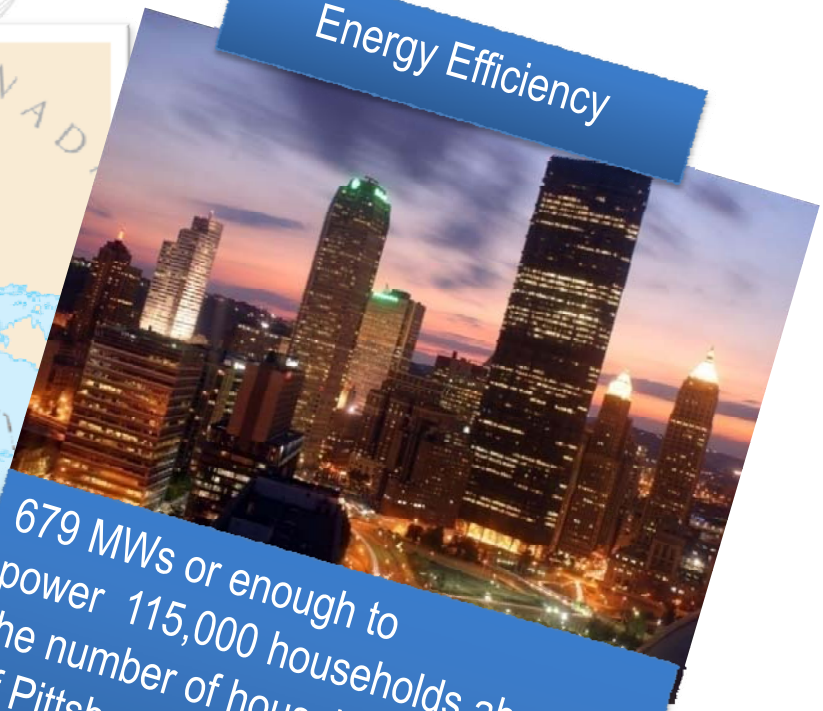
Demand Resource and Energy Efficiency in the Capacity Market-2013/2014

Demand Resources

9,282 MW or enough power for 5 million people or half the number of households in the state of Michigan

Energy Efficiency



679 MWs or enough to power 115,000 households about the number of households in the city of Pittsburgh

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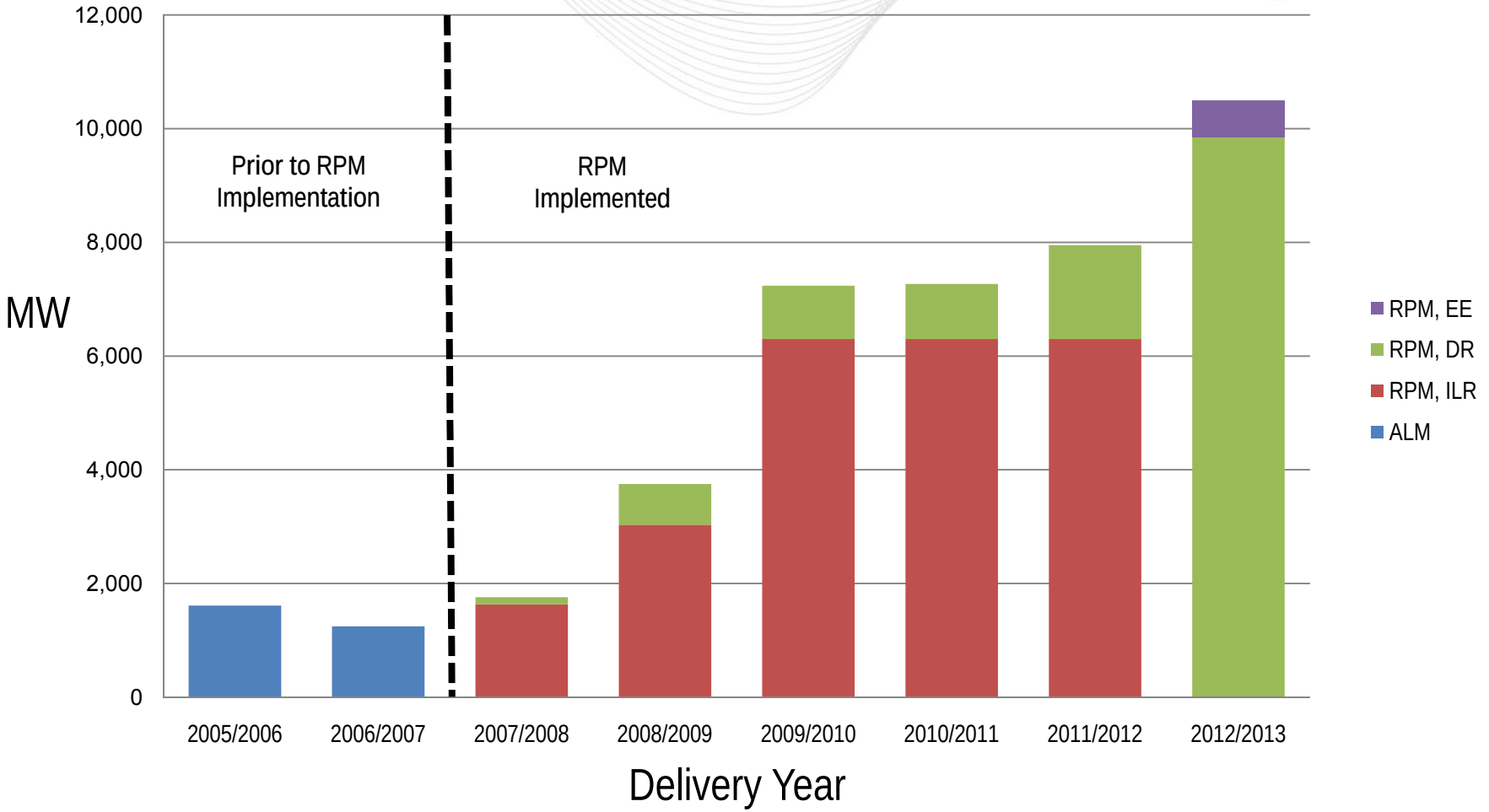
Demand Resource Participation in Capacity Market



RPM = Reliability Pricing Model
ILR = Interruptible Load for Reliability
DR = Demand Response
ALM = Active Load Management

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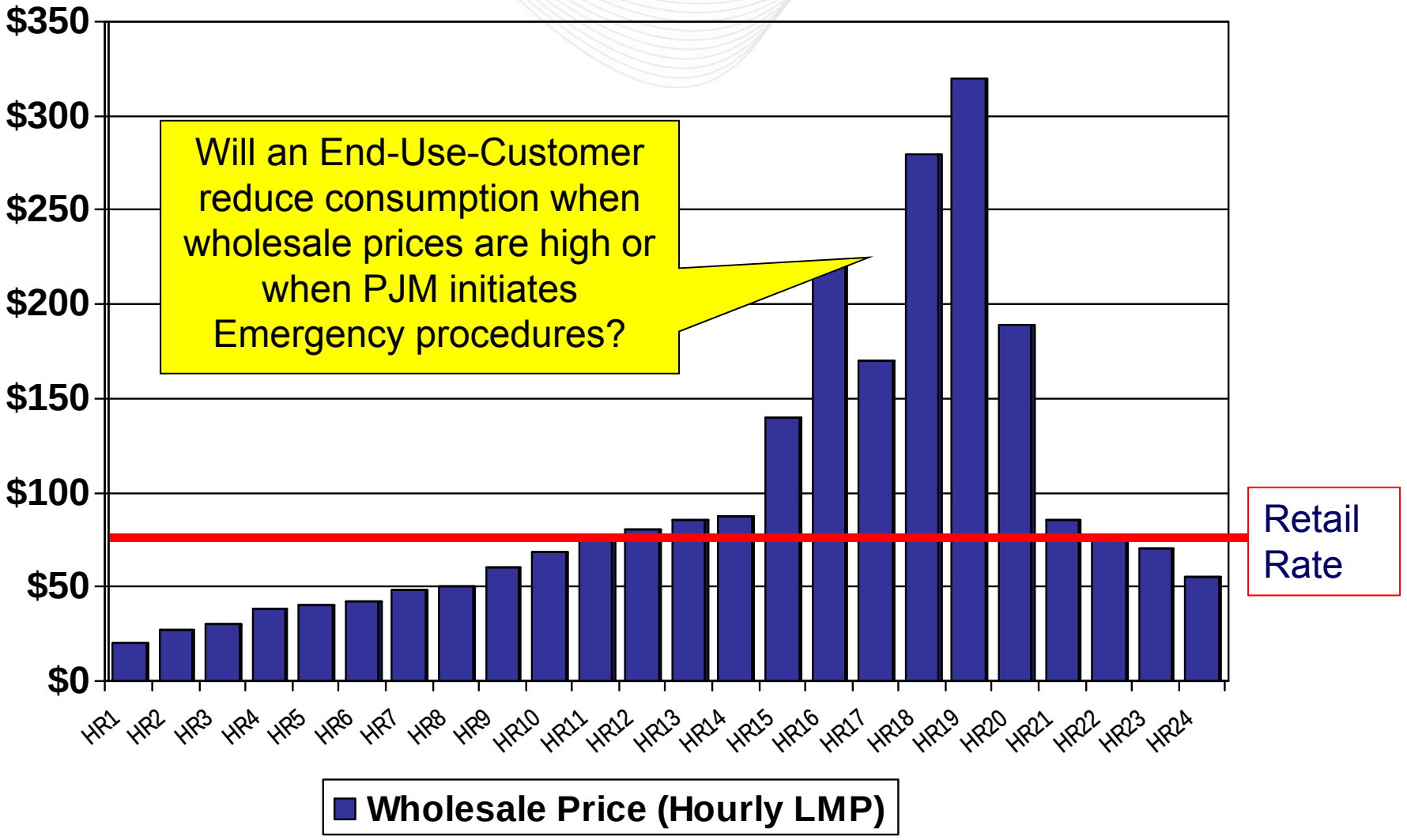
Second Generation: PJM Demand Side Response Programs



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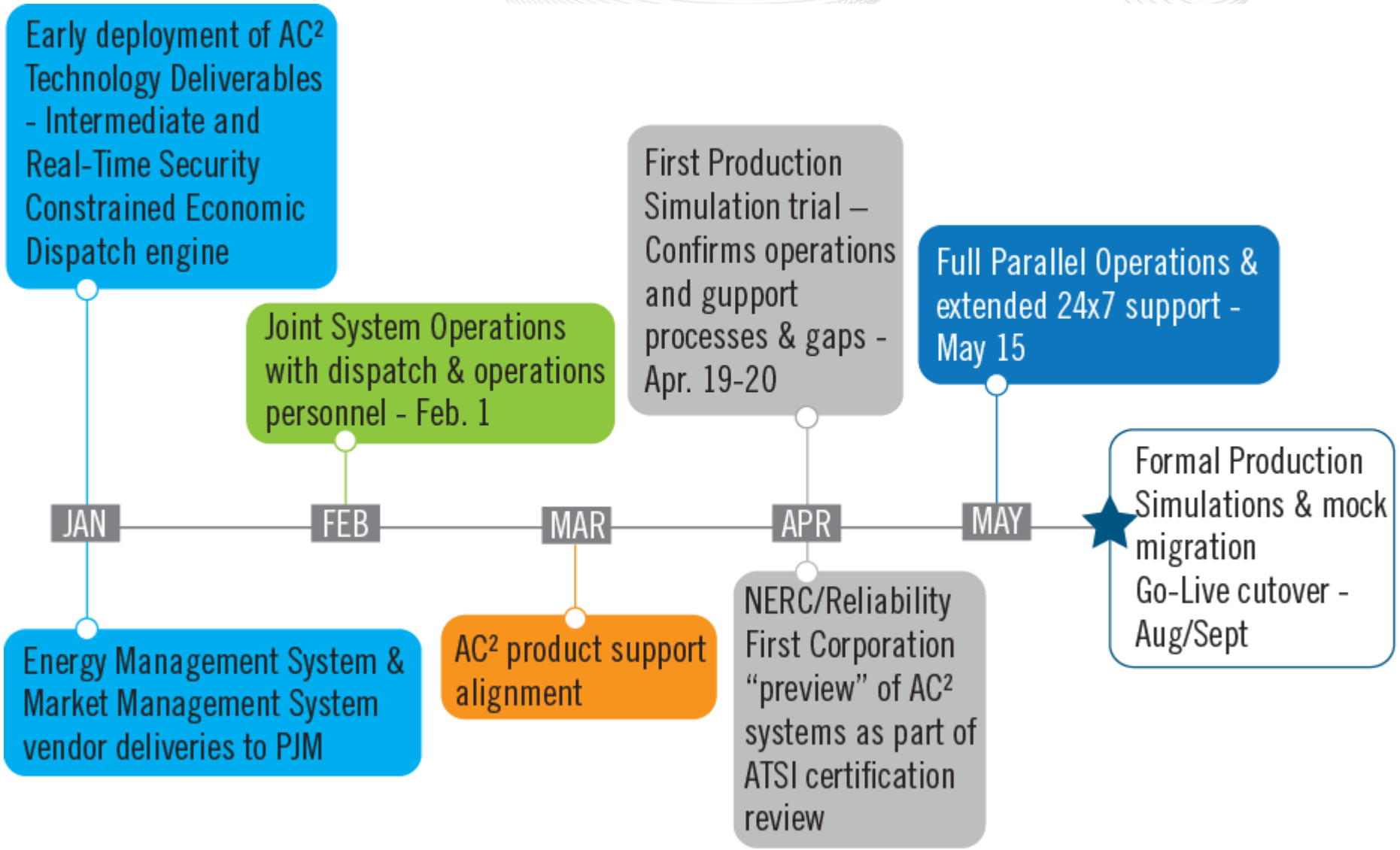
AC² Key Accomplishments



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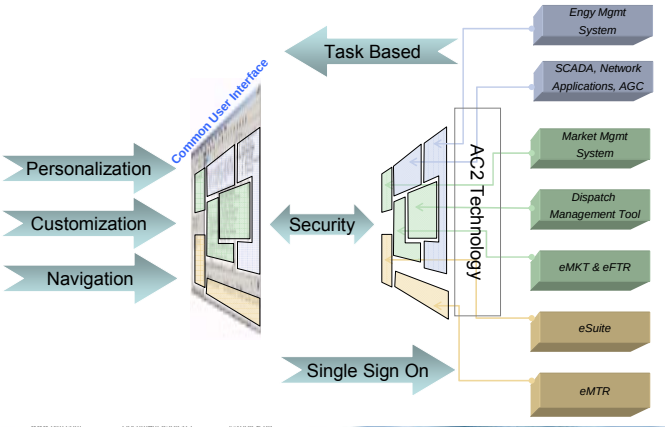
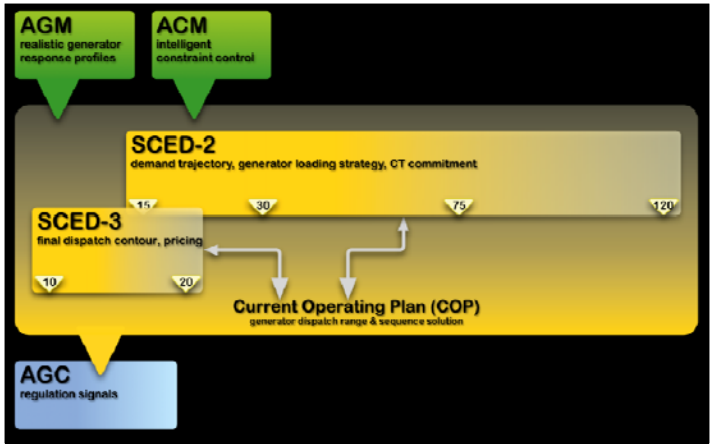
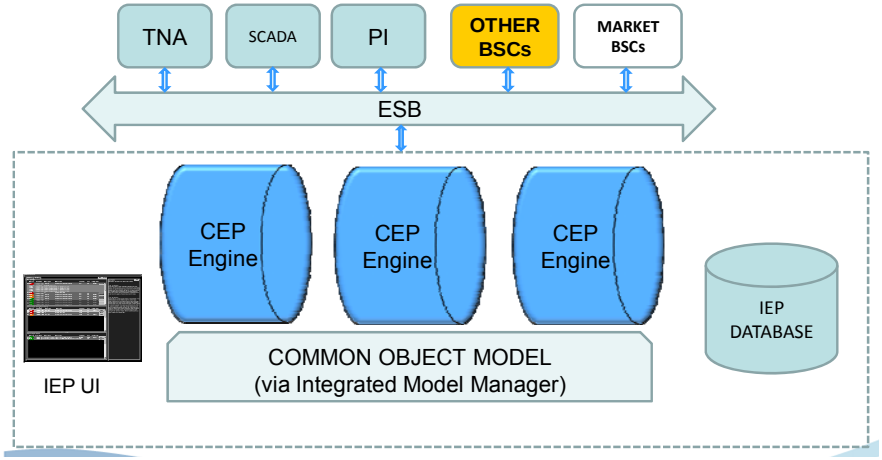
User Experience & Visualization
(advanced dispatcher UI)



Generation Control Application
(multi-interval SCED; adaptive constraint/generator modeling)



Intelligent Event Processor
(complex event processing/correlation)