PJM LMP Market Overview

Andrew Ott
Senior Vice President, Markets
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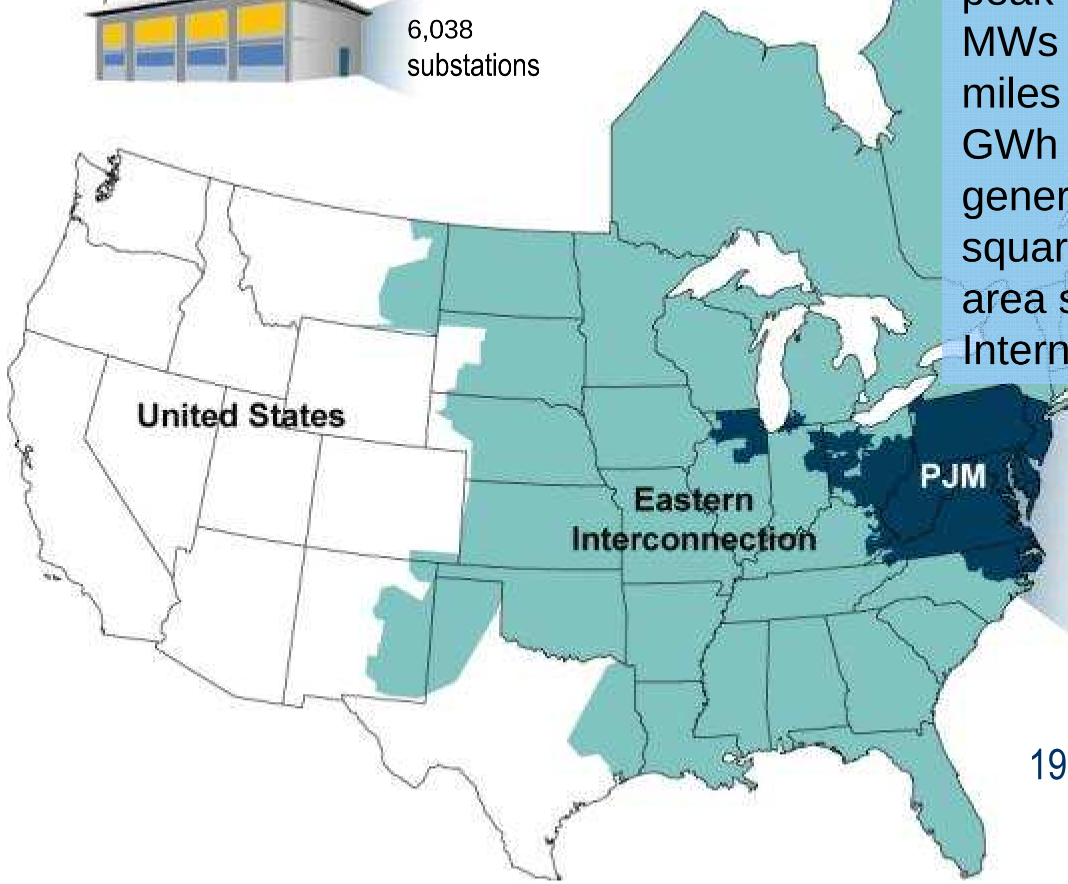
PJM as Part of the Eastern Interconnection

KEY STATISTICS

PJM member companies	600+
millions of people served	51
peak load in megawatts	144,644
MWs of generating capacity	164,905
miles of transmission lines	56,250
GWh of annual energy	729,000
generation sources	1,510
square miles of territory	164,260
area served	13 states + DC
Internal/external tie lines	250

6,038 substations



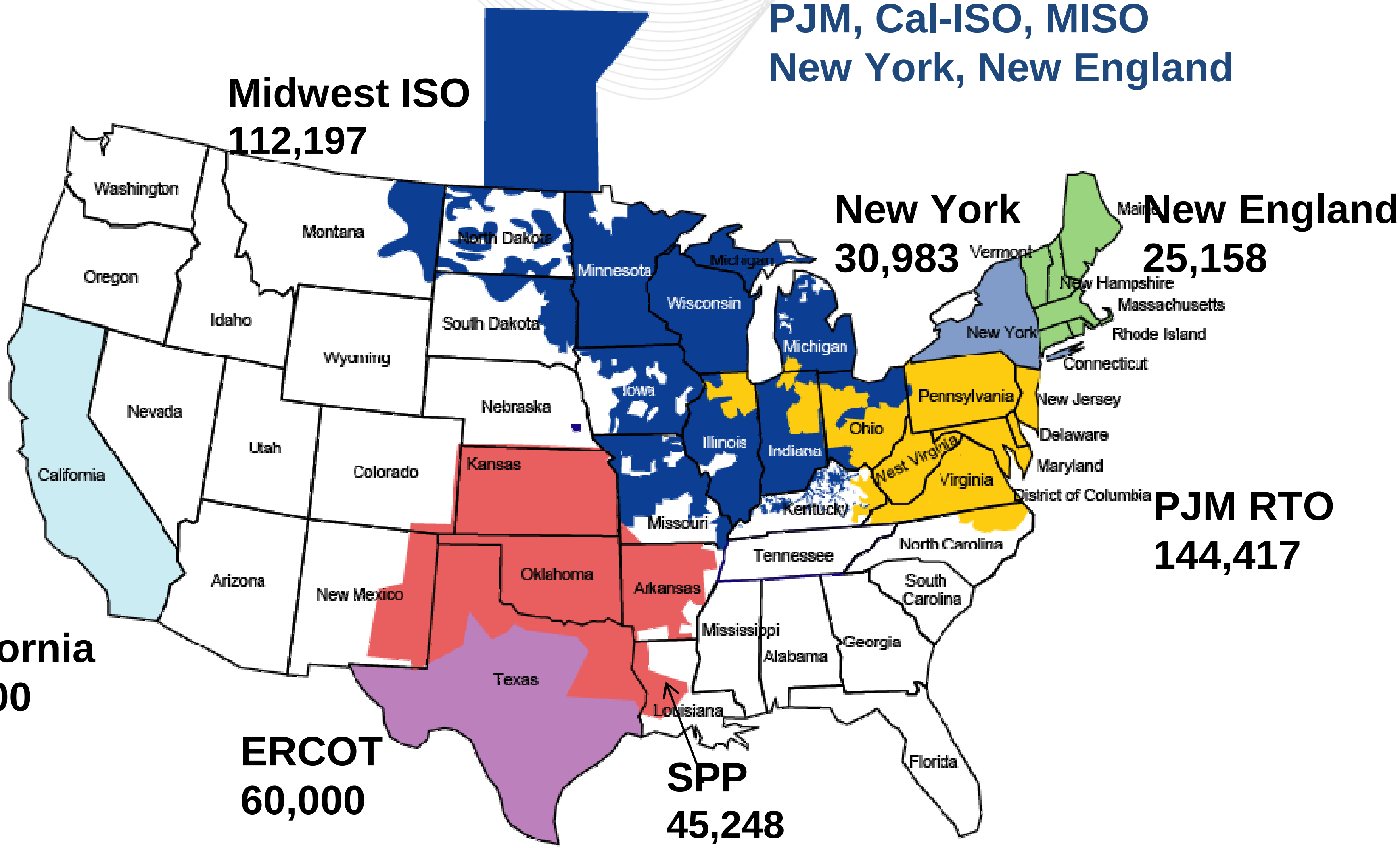
26% of generation in Eastern Interconnection

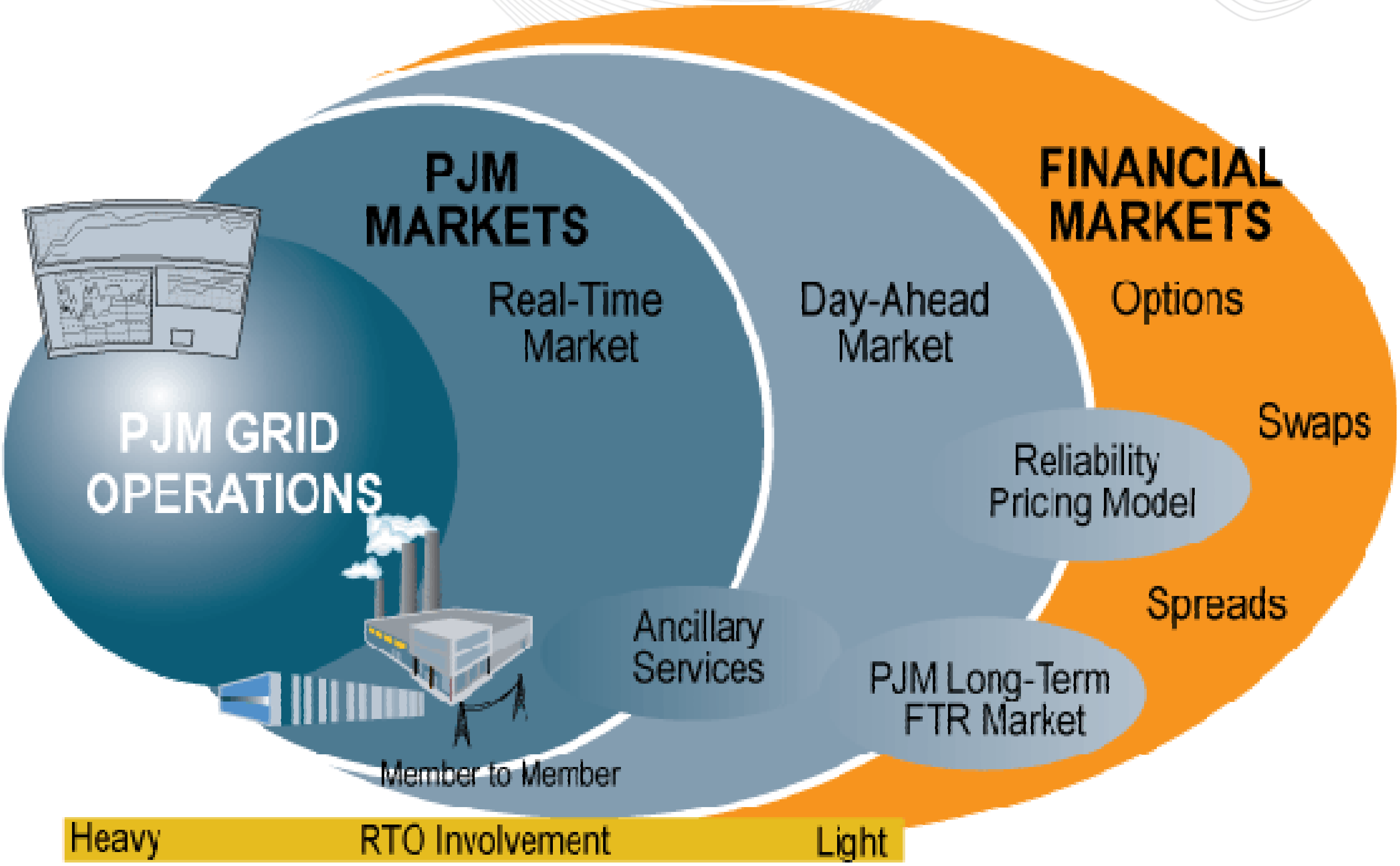
23% of load in Eastern Interconnection

19% of transmission assets in Eastern Interconnection

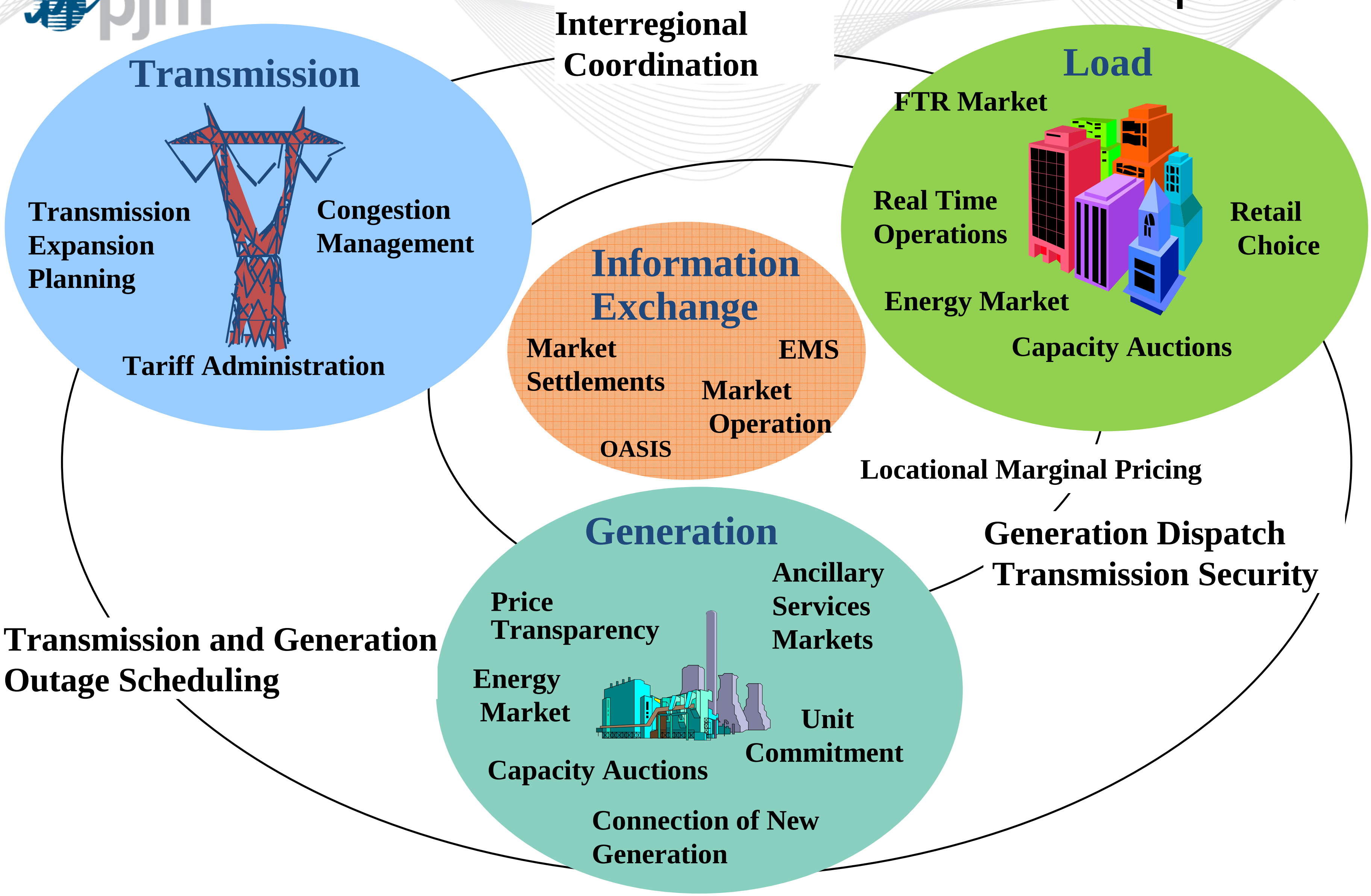
19% of U.S. GDP produced in PJM

RTOs in North America




PJM MARKETS
Real-Time Market
Day-Ahead Market
FINANCIAL MARKETS
Options
Swaps
Spreads
PJM GRID OPERATIONS
Reliability Pricing Model
Ancillary Services
PJM Long-Term FTR Market
Member to Member
Heavy
RTO Involvement
Light

RTO Operation



Day-Ahead / Real-time Market and Dispatch Functions

Day-ahead Market

1200 - Market close

Resource owners, Load Servers and Marketers submit offers / bids

1600 - Results posted

Security-constrained unit commitment and Hourly LMPs

- *Generation schedules*
- *Purchase obligations*

Reliability-based scheduling

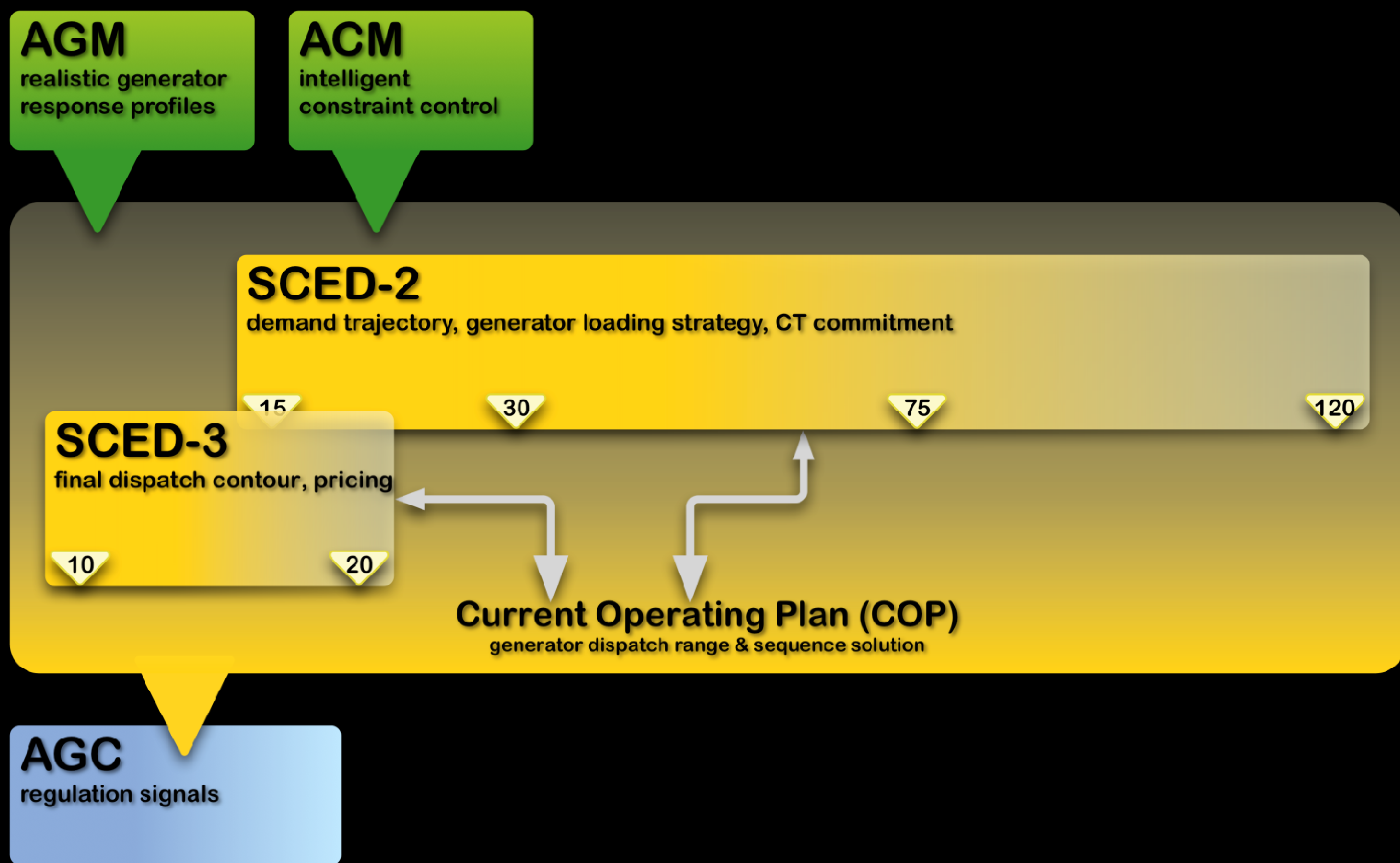
1800- Rebid Period

- *Generation schedules adjusted*
- *Demand Forecast update*
- *Updated security analysis Transmission limitations*

Real-time Market

- *Hourly and Real-time operations*
- *5 minute security constrained dispatch and incremental unit commitment / decommitment*
- *LMP-based balancing market*

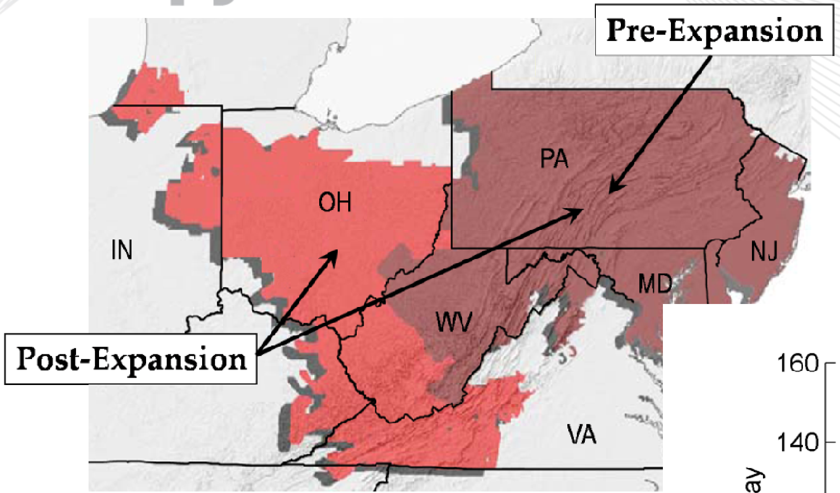
Generation Control Application (GCA)



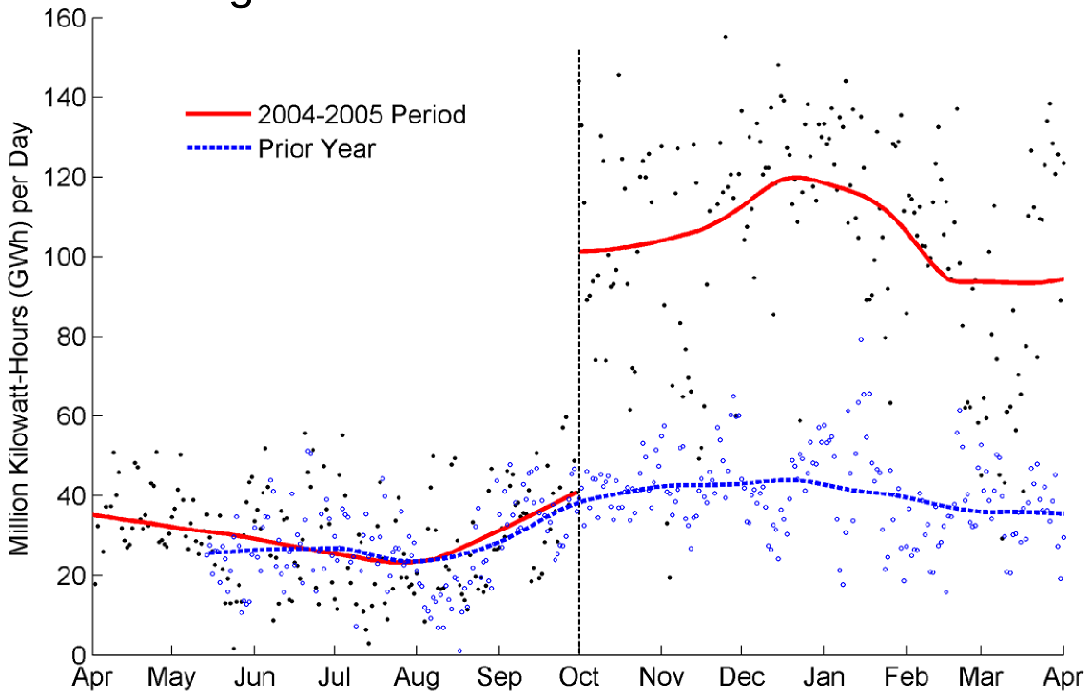
Market Results

PJM Market Expansion – A Case study

AEP / Dayton / ComEd Integration into the PJM Market



Change in Transmission Interconnector flows



Key Study Conclusions:

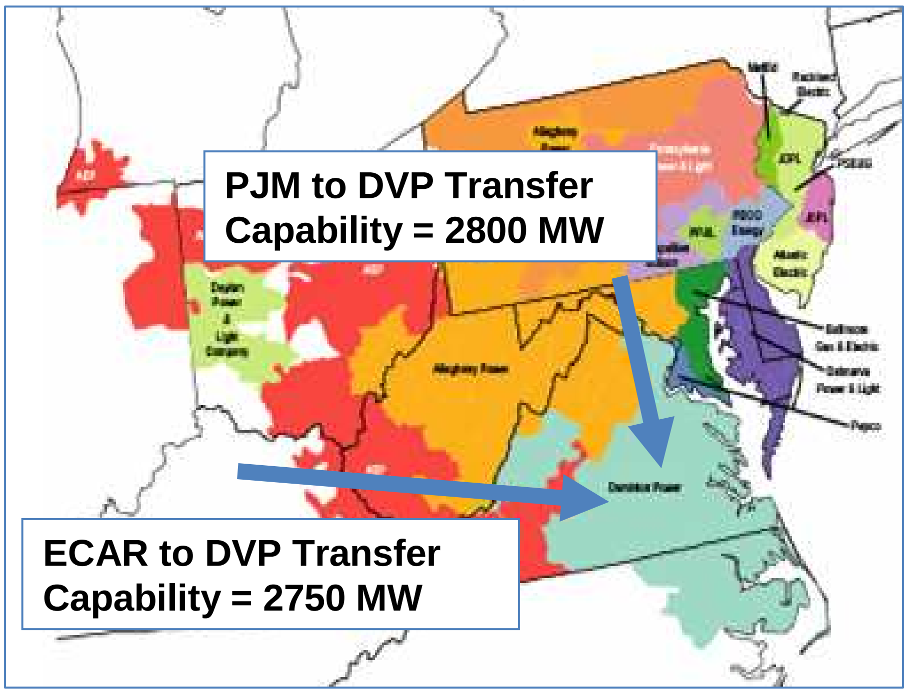
- Bilateral Trading could only achieve 40% of the efficiency gains of LMP-based market
- Incremental benefit of LMP Market Integration = $180 Million annually, Net Present Value over 20 yrs is $1.5 Billion

Referenced with Permission: Source: Erin T. Mansur and Matthew W. White, "Market Organization and Efficiency in Electricity Markets," March 31, 2009, Figure 2,pg 50, discussion draft, (available at http://bpp.wharton.upenn.edu/mawhite/).

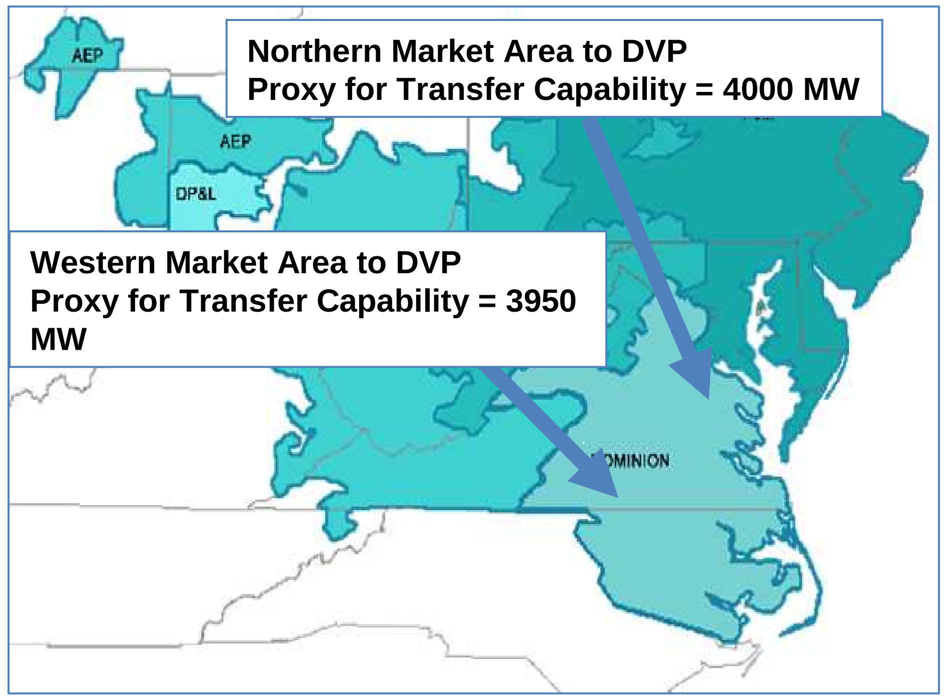
- Projected Benefit to Dominion Zone customers was $291 to $542 Million for Ten year period (2005-2014)[1]
- Actual Benefit[2]
  - $750 Million in avoided fuel costs for the four year period from May 2005 through May 2009
  - In 2008, measured benefit of $240 Million in energy cost savings and $90 Million in net FTR revenue

1. Dominion Study, Reported result in filing before VA State Corporation Commission, 2004
2. Greg Morgan, Dominion Executive, Testimony @ VA State Corporation Commission, June 2009

Prior to Integration



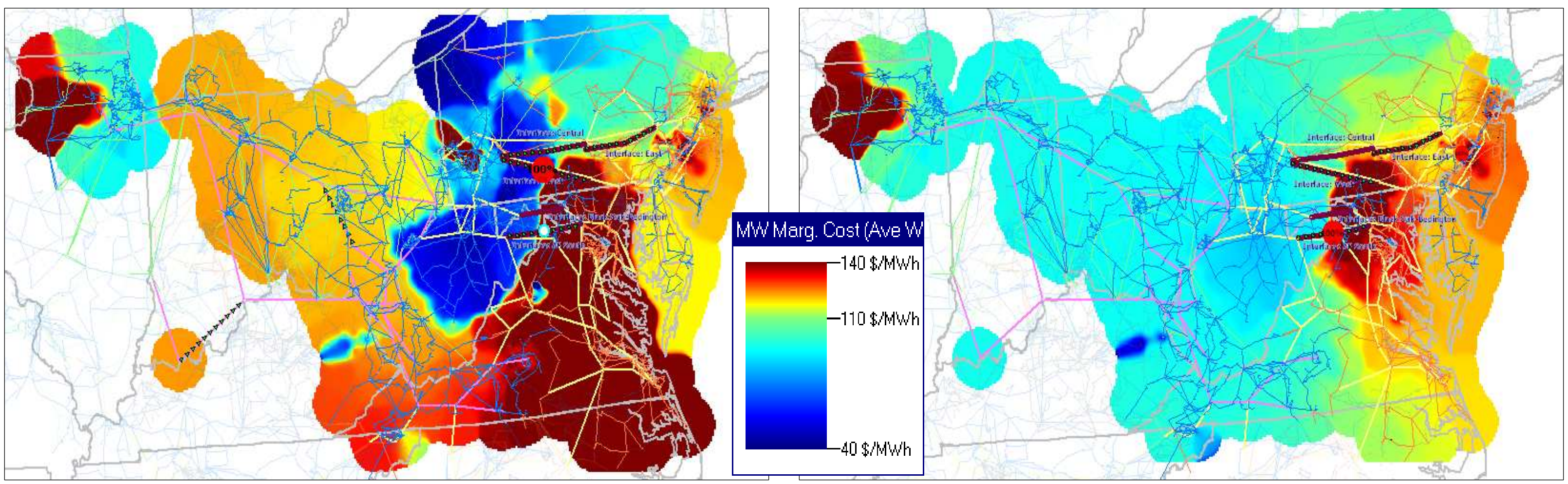
After Integration



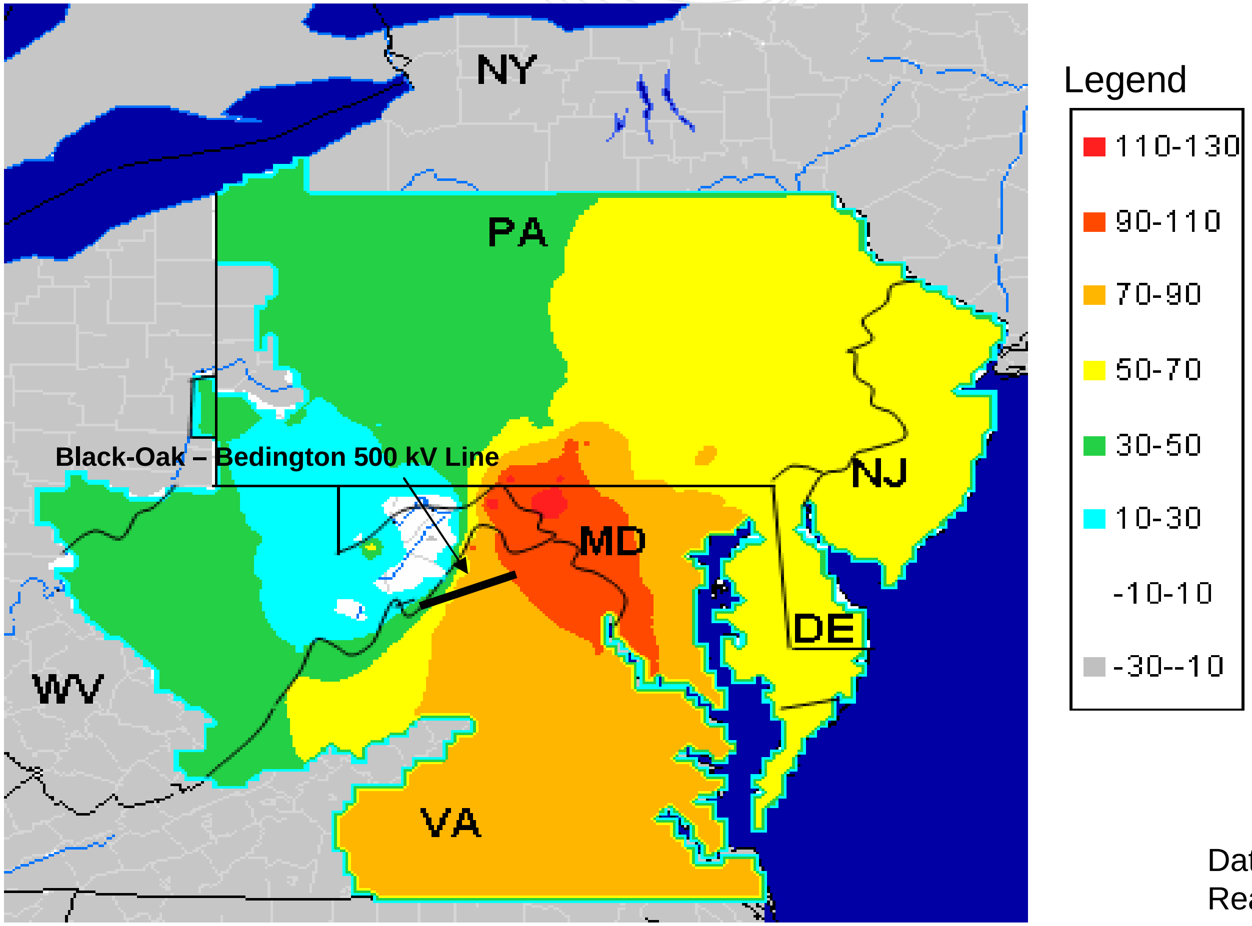
- **Lower energy prices across the expanded PJM region**
  - ESAI’s technical study: region-wide energy price without integration would be $0.78/MWh higher in 2005 than with integration.
  - Spreading these savings over the total PJM RTO’s energy demand of 700 terawatt-hours (TWh) per year yields aggregate savings of over $500 million per year.

Pre-Integration Price Pattern

Post-integration Energy Price Pattern



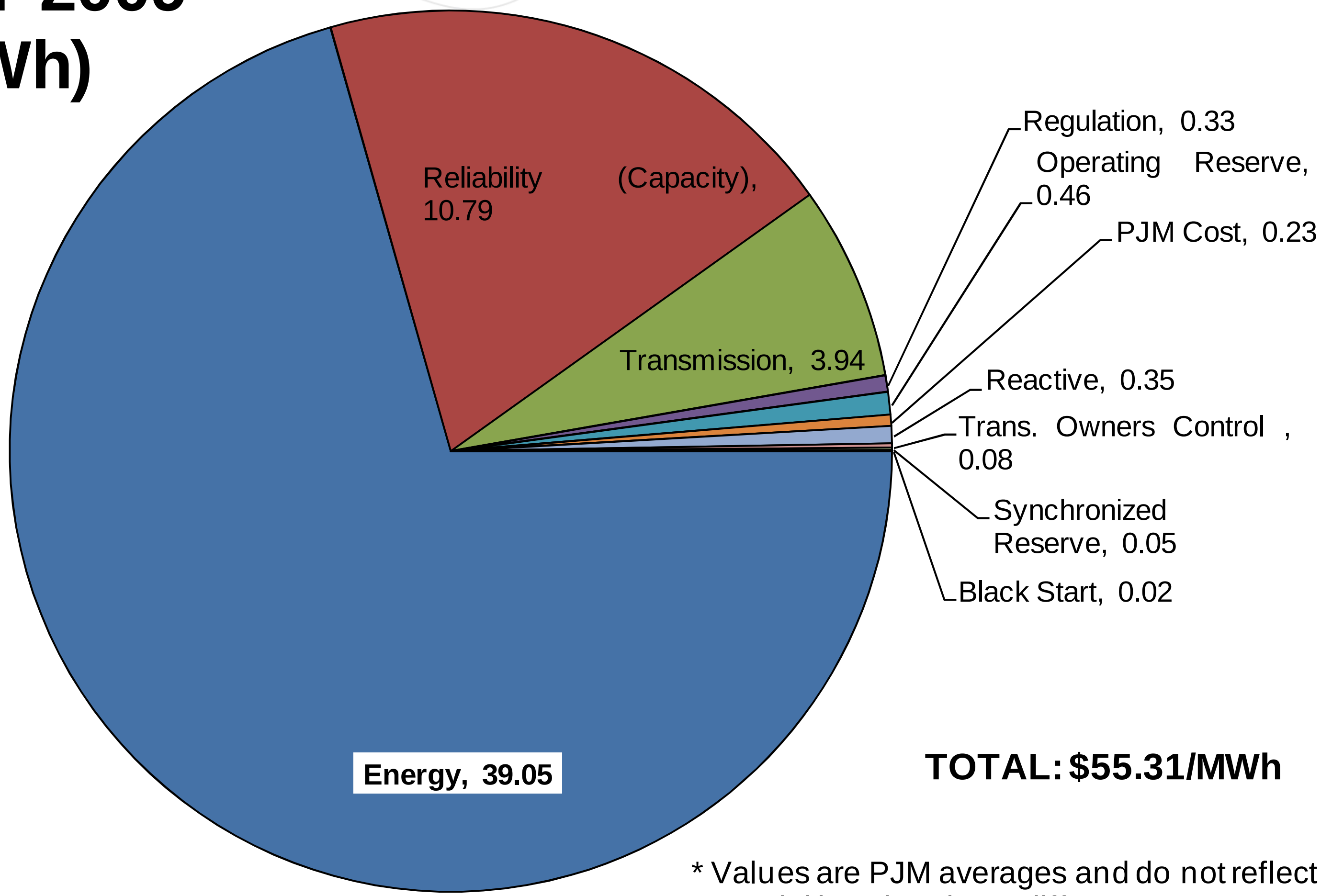
Locational Price Distribution for Black Oak - Bedington 500 kV Transmission Limit (High Congestion Case)



Data taken from PJM Real-time LMP system

System Unconstrained Marginal Price = $63.00

PJM Wholesale Cost Full-Year 2009 ($/MWh)



TOTAL: $55.31/MWh

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

PJM Efficiencies Offer Regional Savings of $2.3 billion

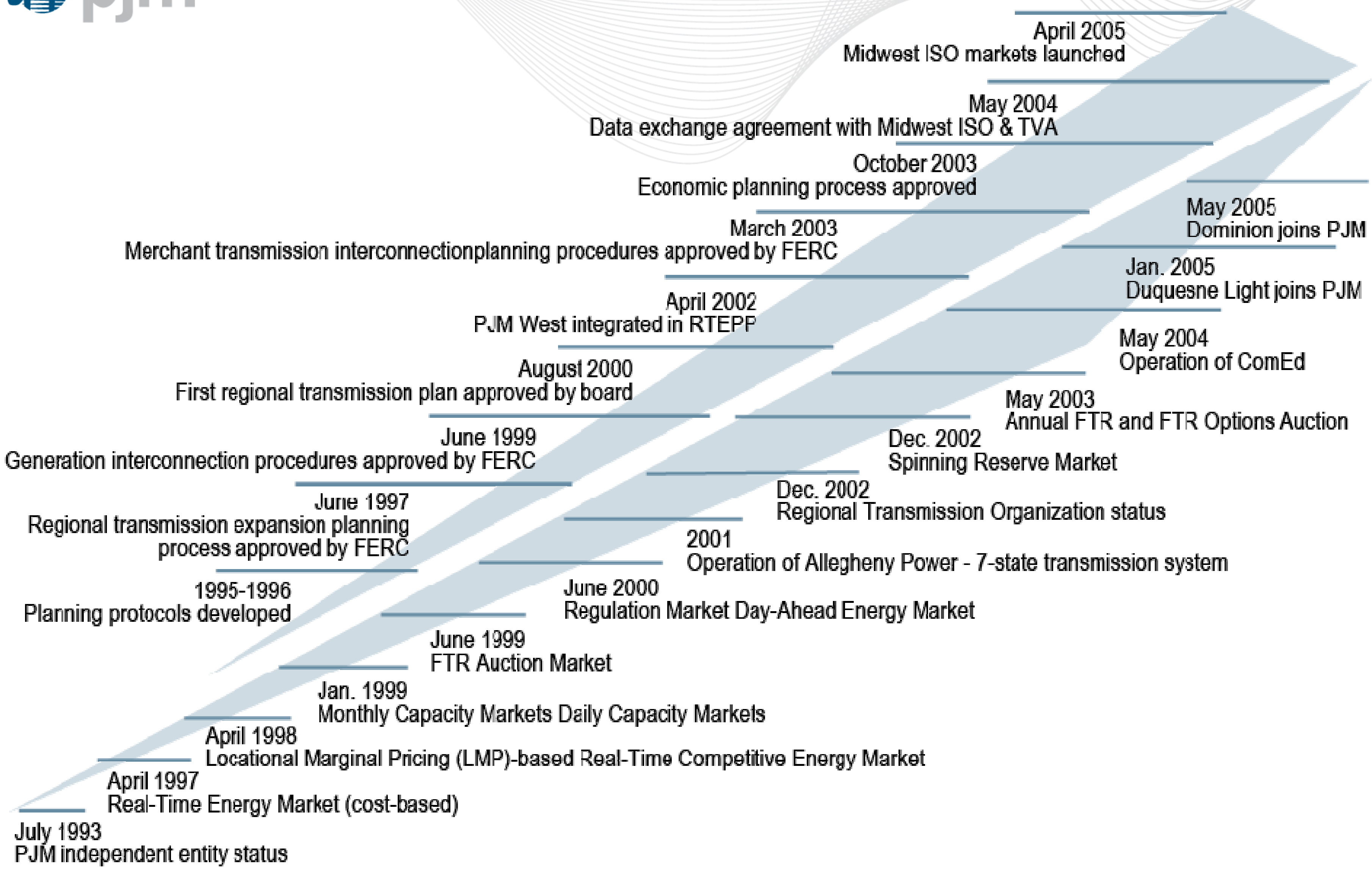
Reliability Compliance –
- **from $470 million to $490 million in annual savings**

Generation investment –
- **from $640 million to $1.2 billion in annual savings**

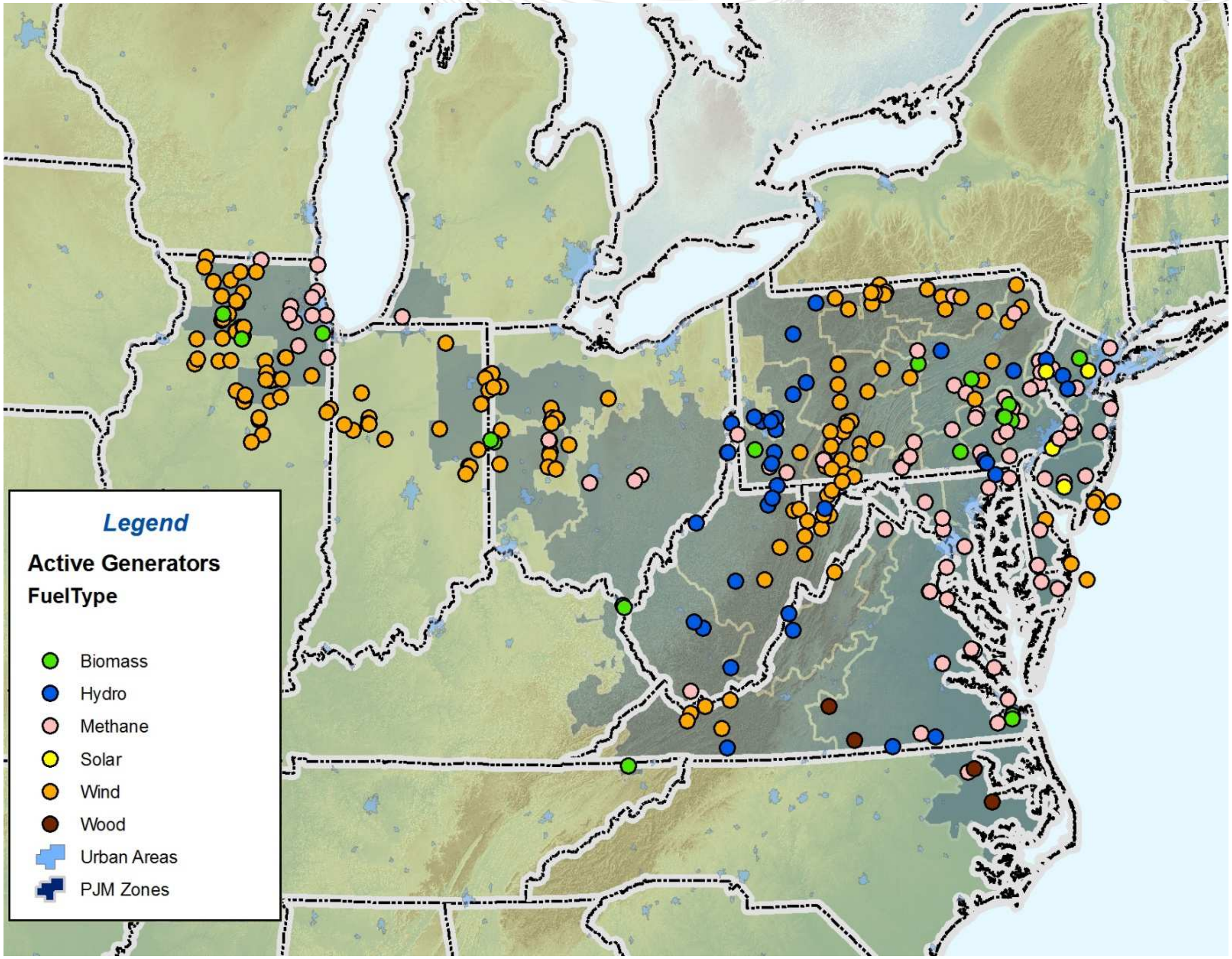
Energy production cost –
- **from $340 million to $445 million in annual savings**

Grid services –
- **from $134 million to $194 million in annual savings**

PJM Evolution



Proposed Renewables In PJM Footprint



Inter-Regional Coordination

Interregional Coordination in Various Market Timeframes

- Real-time Market
  - Least-cost management of transmission constraints through joint, iterative security-constrained economic dispatch
- Day-ahead Market
  - Day-ahead market will recognize flow entitlements of adjacent RTO
  - provides Day-ahead congestion relief upon request
- Reliability Scheduling
  - Transmission security analysis will recognize flow entitlements of adjacent RTO
- Financial Transmission Rights Allocations and Auctions
  - will recognize flow entitlements of adjacent RTO

- Regional Coordinated Flowgate (RCF) – a transmission facility that is impacted by generation to load delivery patterns in both markets
- The set of RCF facilities is defined annually
- RCF flow entitlement is allocated to each RTO based on historic generation delivery to Firm load customers
- Monitoring RTO – the RTO that is responsible for operation of the RCF per tariff

- When any of the pre-identified transmission constraints becomes binding in the monitoring RTO security-constrained dispatch, it is also entered in the non-monitoring RTO security-constrained dispatch.
- Monitoring RTO manages constraint based on **actual facility limit**
- Non-monitoring RTO manages constraint based on flow entitlement and based on the requested MW relief amount.
- RTOs share constraint shadow price information to determine least-costly dispatch alternatives

Real-Time Coordination Steps


Monitoring RTO informs non-monitoring RTO when RCF binds in UDS solution.


Monitoring and non-monitoring RTOs continue to exchange shadow price information throughout operation for constraint to ensure least-cost overall solution.


Monitoring RTO informs non-monitoring RTO when RCF is no longer binding and constraint is ended.