

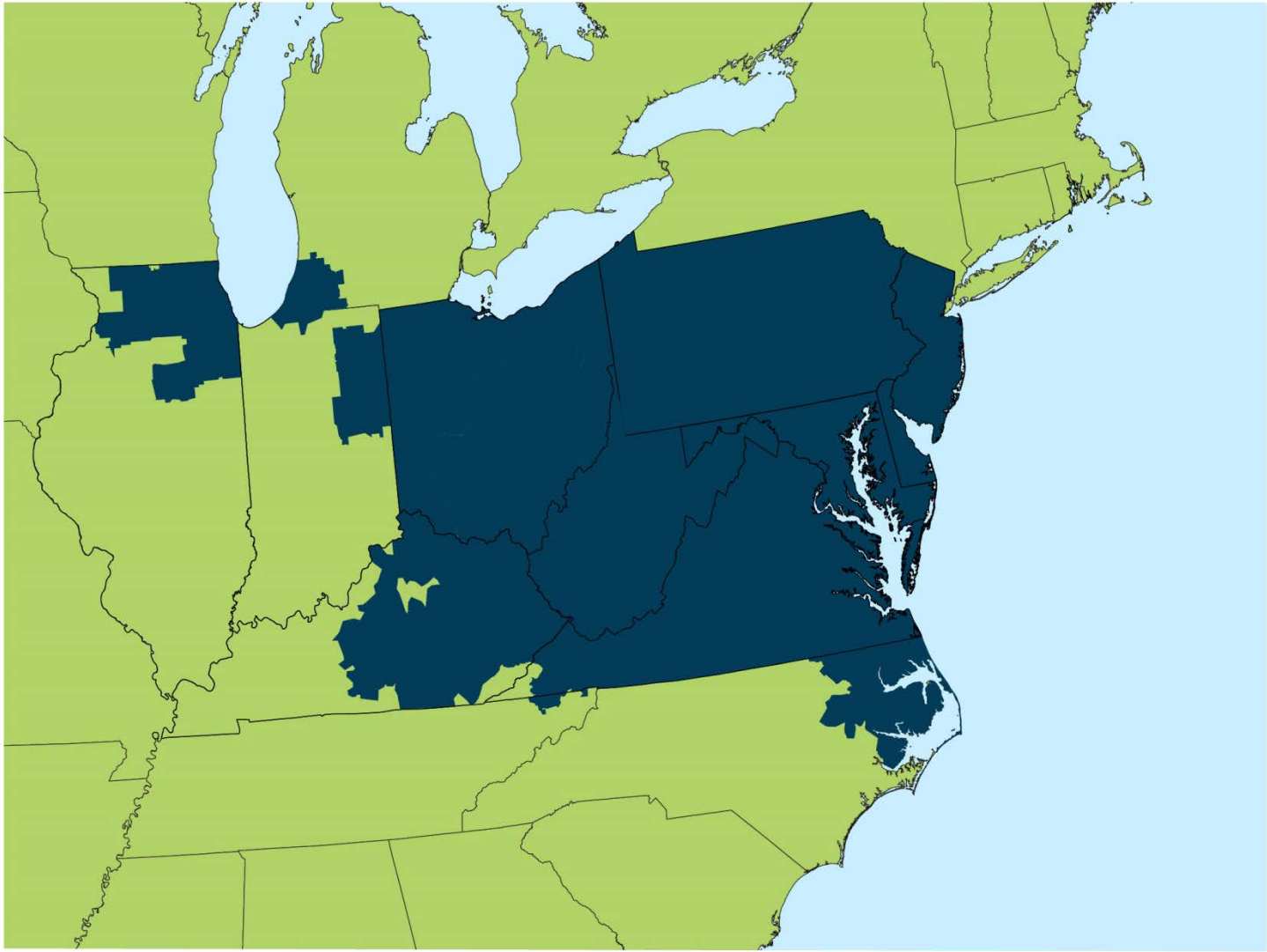
# Presentation for The National Commission for Energy State Regulation of Ukraine

Todd Keech  
Laura Walter  
PJM Interconnection  
June 17, 2014

- What is PJM ?
  - ISO RTO Map
  - Part of Eastern Interconnection
    - Transmission Backbone/  
Service Territory
    - Key Stats

# ISO/RTO Map







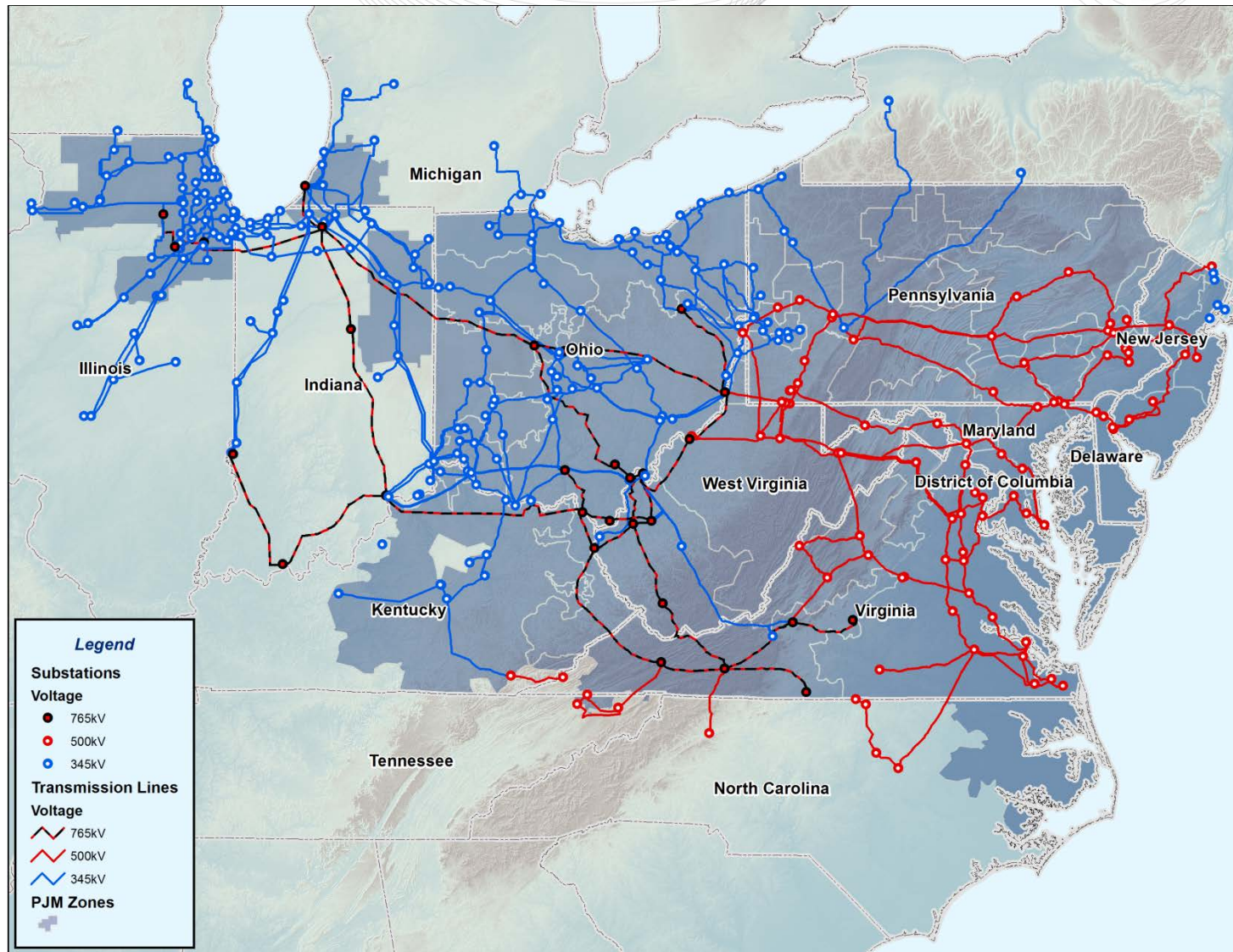
**21% of U.S. GDP  
produced in PJM**

## KEY STATISTICS

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	<b>791,089</b>
Generation sources	1,376
Square miles of territory	243,417
States served	13 + DC

As of 4/1/2014





## Reliability

- Grid Operations
- Supply/Demand Balance
- Transmission monitoring

1

## Regional Planning

- 15-Year Outlook

3

2

## Market Operation

- Energy
- Capacity
- Ancillary Services

- Role as RTO/ Grid Operator
  - Elements of a RTO
  - How is PJM different from a Local Utility?
  - RTO Functions
  - RTO Operations





**Air Traffic  
Controllers for the  
Transmission Grid**



**Match Generation to Load**

**Stock Market  
for Electricity**



LMP (Zone)	LMP (Hub)
AE \$54.09	AEP GEN HUB \$32.77
AEP \$34.22	AEP-DAYTON HUB \$34.08
APS \$39.91	CHICAGO GEN HUB \$32.65
BC \$72.18	CHICAGO HUB \$23.19
COMED \$33.21	DOMINION HUB \$46.14
DAYTON \$35.38	EASTERN HUB \$71.67
DOM \$53.88	ILLINOIS HUB \$32.94
DPL \$32.38	NEW JERSEY HUB \$64.66
DLQ \$35.01	OHIO HUB \$34.45
JC \$67.92	WEST INT HUB \$39.64
ME \$67.69	WESTERN HUB \$53.95
PE \$70.23	
PCP \$70.20	
PJM \$49.93	
PL \$54.60	
PN \$42.61	
\$66.31	
\$63.40	

**Energy Market  
Pricing**

- An independent entity that is responsible for:
  - Operating competitive wholesale markets
  - Administering transmission tariff
  - Safe and reliable operation of regional power grid
  - Ensuring competitive open access to transmission where no member or member group has undue influence
- RTO owns no transmission or generation assets and has no financial interest in the wholesale market or in any of the market participants

# Elements of A Regional Transmission Organization



# How Is PJM Different from a Local Utility?



Agreement for Operational Control

Independent, Neutrality



Coordinate Systems

## PJM **does**:

- Maintain the “big picture” of the transmission system regardless of ownership
- Have, by agreement, operational control of the transmission system
- Operate as “profit neutral”
- Remain totally independent of all PJM members
- Coordinates maintenance of generation and transmission systems



PJM does **not**:

- Own any transmission or generation assets
- Function as a publicly traded company
- Take ownership of the energy on the system
- Perform the actual maintenance on generators or transmission systems
- Serve, directly, any end-use (retail) customers

## RTO Functions - Demand

- Load Forecast for reliability analysis
- Ensure adequate generation scheduled and dispatched to satisfy load forecast
- Accept demand bids in Day-ahead market
- Administer Demand Response
- Set operating reserve requirements
- Set installed capacity requirements

## Load Serving Entity

- Load forecast for commercial position
- Manage energy supply requirements
- Manage generation adequacy contracts
- Enter into hedging contracts
- Enter into contracts with wholesale / retail customers
- Interaction with state regulators

## RTO Functions – Supply

- Perform real-time generation dispatch
- Accept generation offers in day-ahead and real-time markets
  - Unit commitment, generation scheduling
    - Send generation control signals
      - Load following
      - Frequency control
      - Ancillary services
- Coordinate generation outage schedules
  - Administer capacity market

## Generation Owner

- Schedule generation outages
- Manage generator offer information
  - Bilateral Contracts
- Operate generating plants, Maintain plants, etc.
  - Offer various products (energy, capacity, regulation, spin, etc)
- Manage generation portfolio w/ three alternatives:
  - Self-schedule
  - Bilateral sale or
  - Submit offer and follow RTO dispatch

## RTO Functions

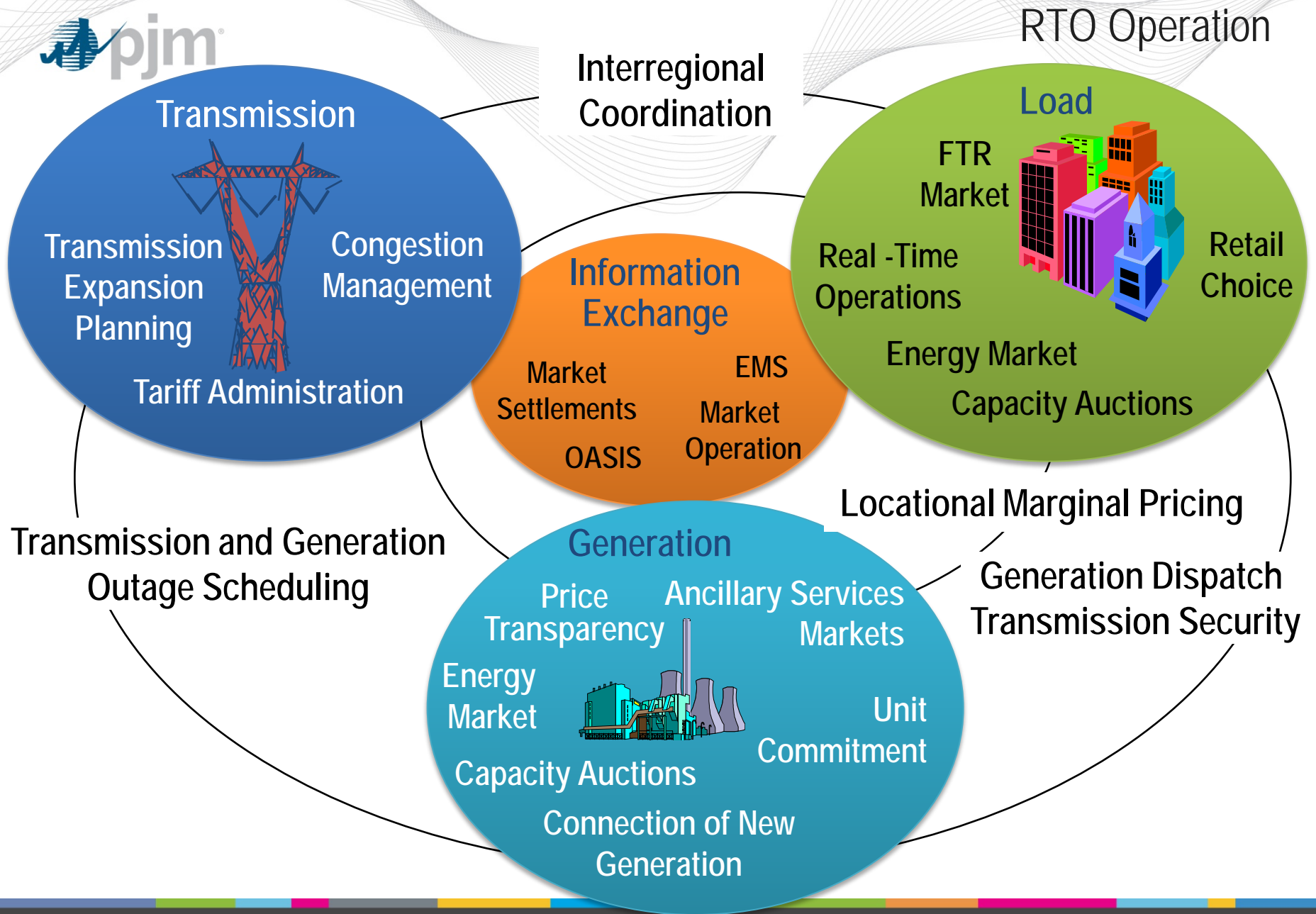
- Manage Control Area ACE
- Set operating reserve, regulation and spinning reserve targets
- Generation Scheduling and real-time security-constrained economic generation dispatch
- Coordination of operation with adjacent control areas
- Regional Reliability coordination, reporting and compliance
- Deploy regulation, spinning and operating reserves
- Operate all of the markets

## RTO Functions

- Transmission provider/ tariff administration
- Coordinate switching and outage scheduling
- Security analysis / maintain operational reliability of grid
  - Regional transmission planning
  - Generation interconnection analysis
  - Transmission capacitor deployment
    - Set regional transfer limits

## Transmission Owner functions

- File transmission rates with Regulator
- Schedule transmission outages
- Perform maintenance and switching
- Set equipment ratings
- Distribution capacitor deployment
- Transmission operations (LTC and PAR settings)
- Distribution system operations
- Distribution security analysis
- Interaction with retail customers
- Operations center coordination with RTO



- **Regional Market Benefits**



- Operational Diversity
- Price, Data, Information Transparency
- Transmission Planning /Coordination
- Regulatory / Reliability Compliance
- Wholesale Market creates platform to enable demand response
- Wholesale Market creates platform to enable renewable resources
- Wholesale market lowers overall cost of environmental compliance

Total – as much as  
\$2.3 billion in savings to  
the region each year

### Reliability –

resolving transmission constraints,  
gains in economic efficiency from  
regional reliability planning – **from  
\$470 million to \$490 million in  
annual savings**



### Generation investment –

reduced reserve requirements and  
increased demand response result in  
decreased need for infrastructure  
investment – **from \$640 million to  
\$1.2 billion in annual savings**



**Energy production cost –**  
efficiency of centralized dispatch over  
a large region – **from \$340 million to  
\$445 million in annual savings**

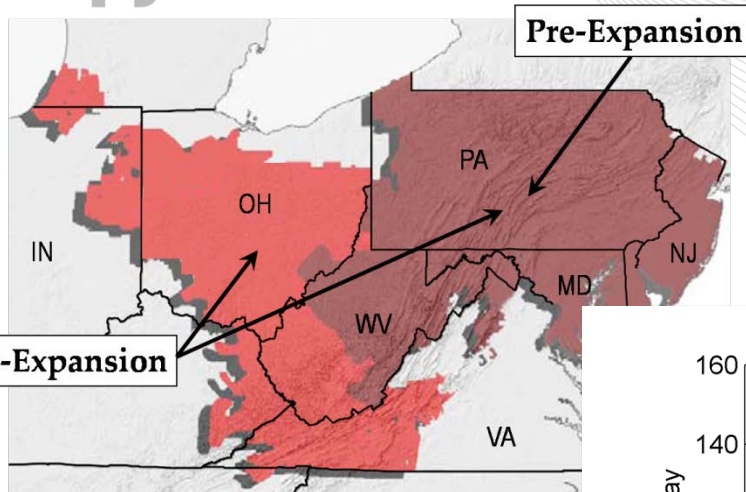


**Grid services –**  
cost-effective procurement of  
synchronized reserve, regulation –  
**from \$134 million to \$194 million in  
annual savings**



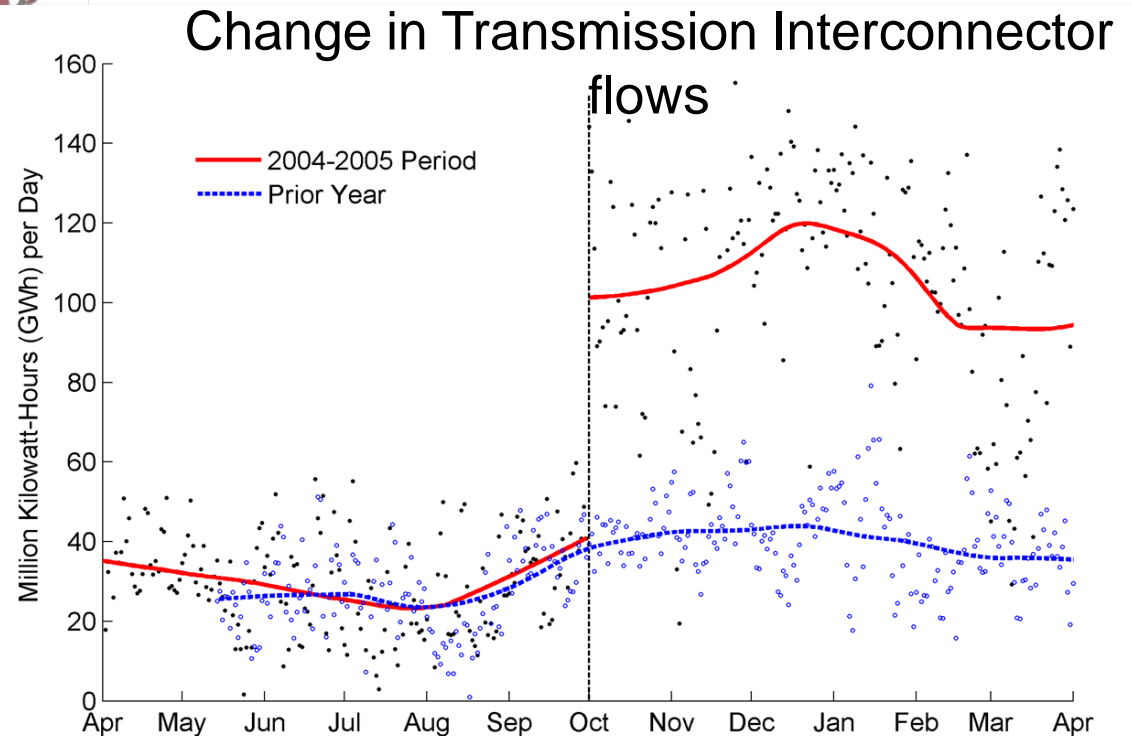
# PJM Market Expansion – A Case study

## AEP / Dayton / ComEd Integration into the PJM Market



### Key Study Conclusions:

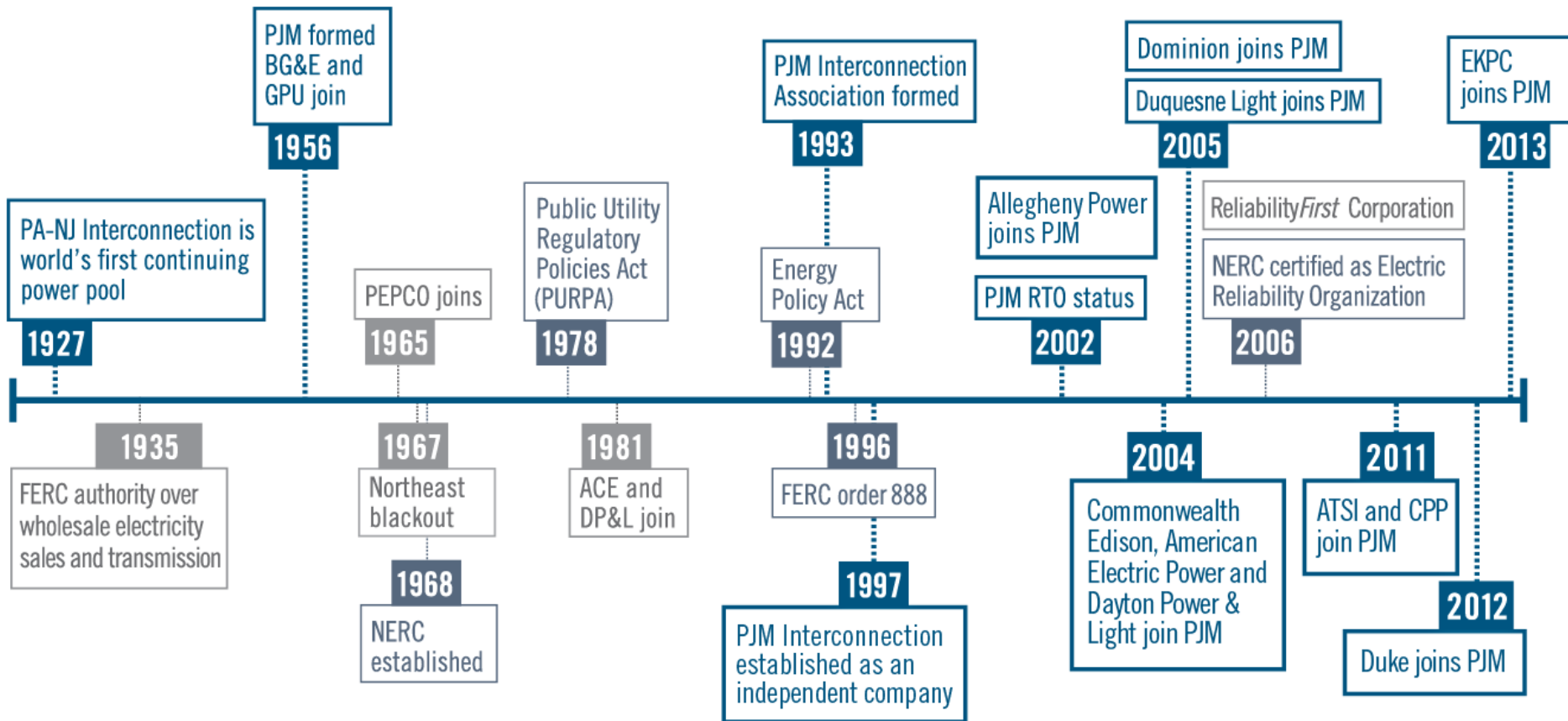
- Bilateral Trading could only achieve 40% of the efficiency gains of LMP-based market
- Incremental benefit of LMP Market Integration = \$180 Million annually, Net Present Value over 20 yrs is \$1.5 Billion



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/>).



- Brief History of PJM
- PJM began in 1927 when three utilities, realizing the benefits and efficiencies possible by interconnecting to share their generating resources, formed the world's first continuing powerpool.
- PJM Focus



PJM Events

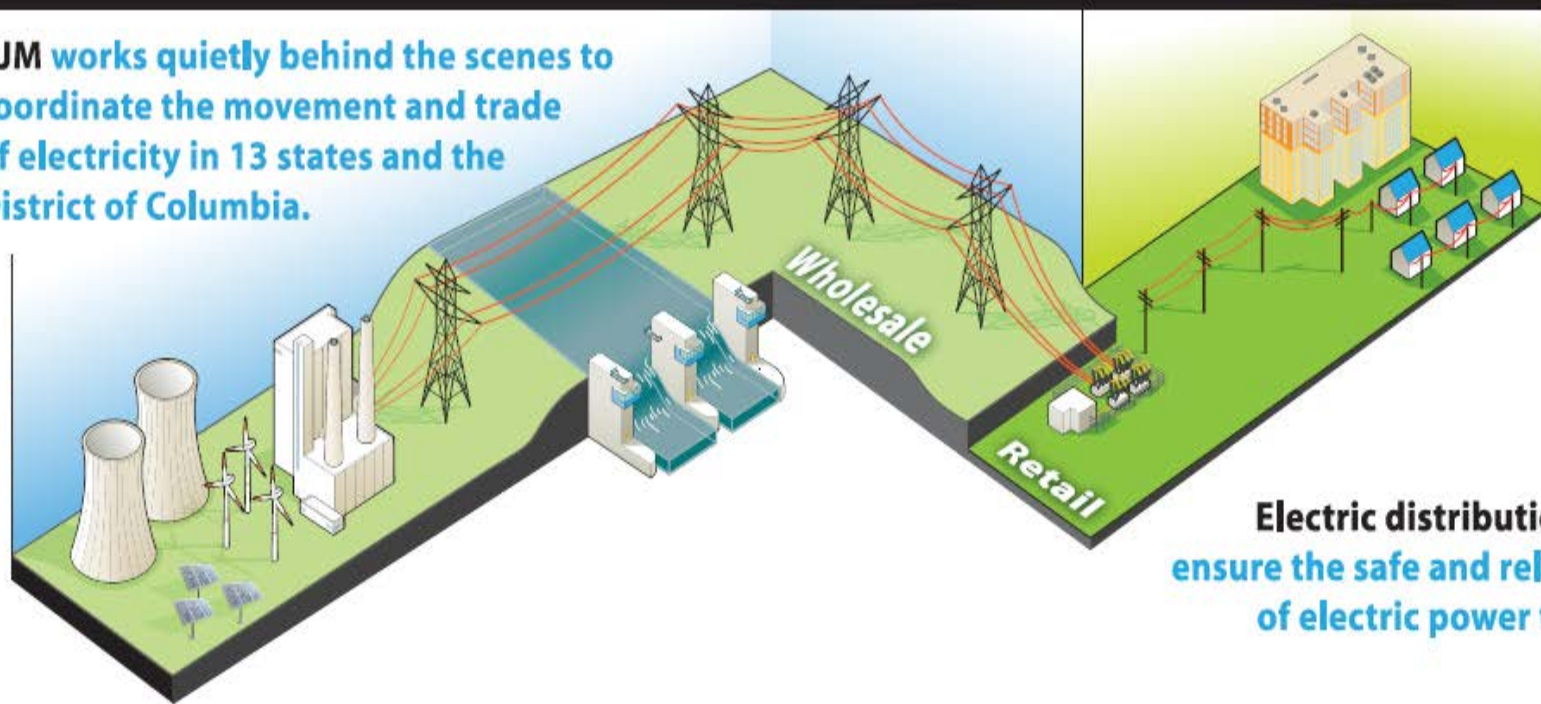
Energy Policy

Industry Events

## 1996 - 1999:

- Promoting Wholesale Competition Through Open Access Non-discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities
- Open Access Same-Time Information System (formerly Real-Time Information Networks) and Standards of Conduct
- Establishment of Regional Transmission Organizations

**PJM works quietly behind the scenes to coordinate the movement and trade of electricity in 13 states and the District of Columbia.**



**Electric distribution companies ensure the safe and reliable delivery of electric power to consumers.**

- **Regulators**
  - PJM coordinates the grid and administers the wholesale power market according to federal laws and regulations as well as within the requirements of each state which it serves.
  - Federal Energy Regulatory Commission
  - OPSI: State public utility commissions



- NERC

- Under the Energy Policy Act of 2005, the Federal Energy Regulatory Commission (FERC) was required to designate an Electric Reliability Organization (ERO) to enforce mandatory reliability standards for all participants in the North American bulk power system.
- NERC named the ERO in July 2006.

- IRC

- An industry organization that includes the ten Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs)
- Delivers two-thirds of the electricity consumed in the United States to two-thirds of its population.
- Works collaboratively to develop effective processes, tools and standard methods for improving competitive electricity markets across North America

PJM is Regulated by FERC

FEDERAL




Federal Energy Regulatory  
Commission


FERC Regulates Transmission and Electric Wholesale Rate

States


The State Utility Commissions Regulate  
Distribution and Electric Retail Rate



DC PSC




DE PSC



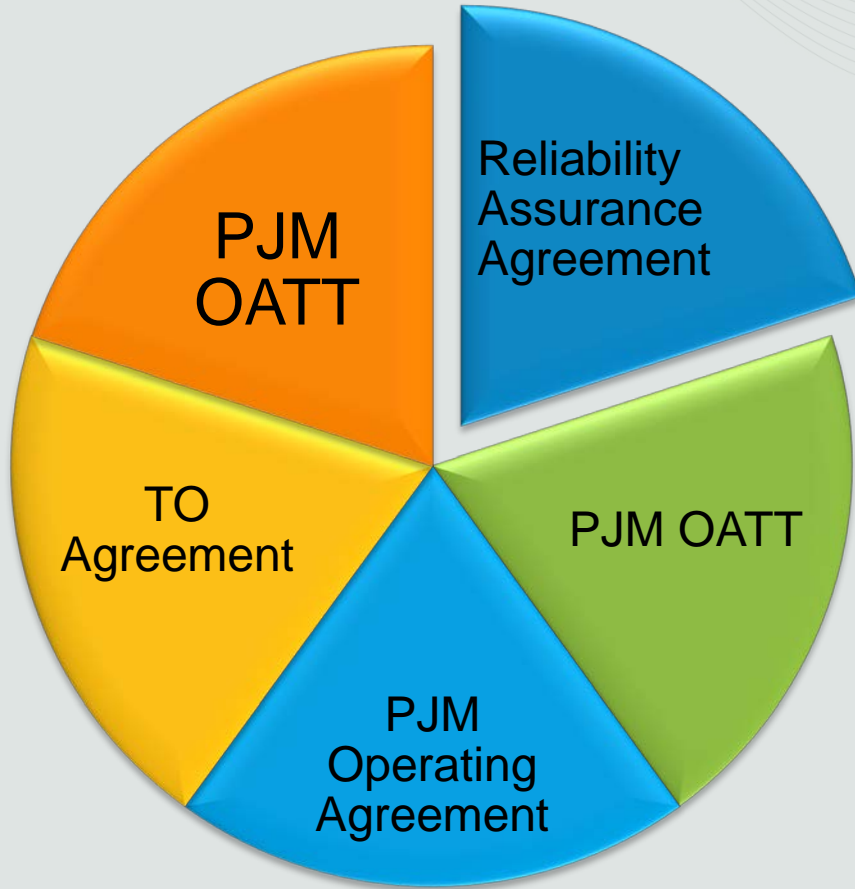
MD PSC



NJ BPU



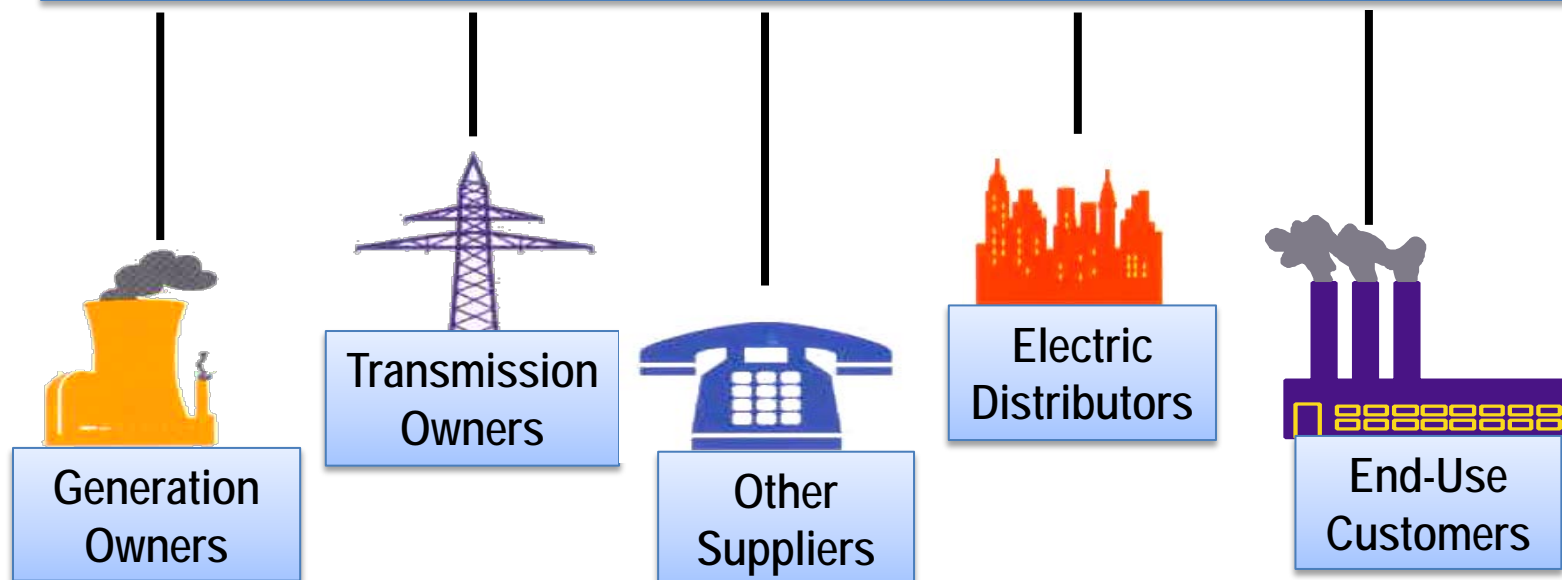
PA PUC

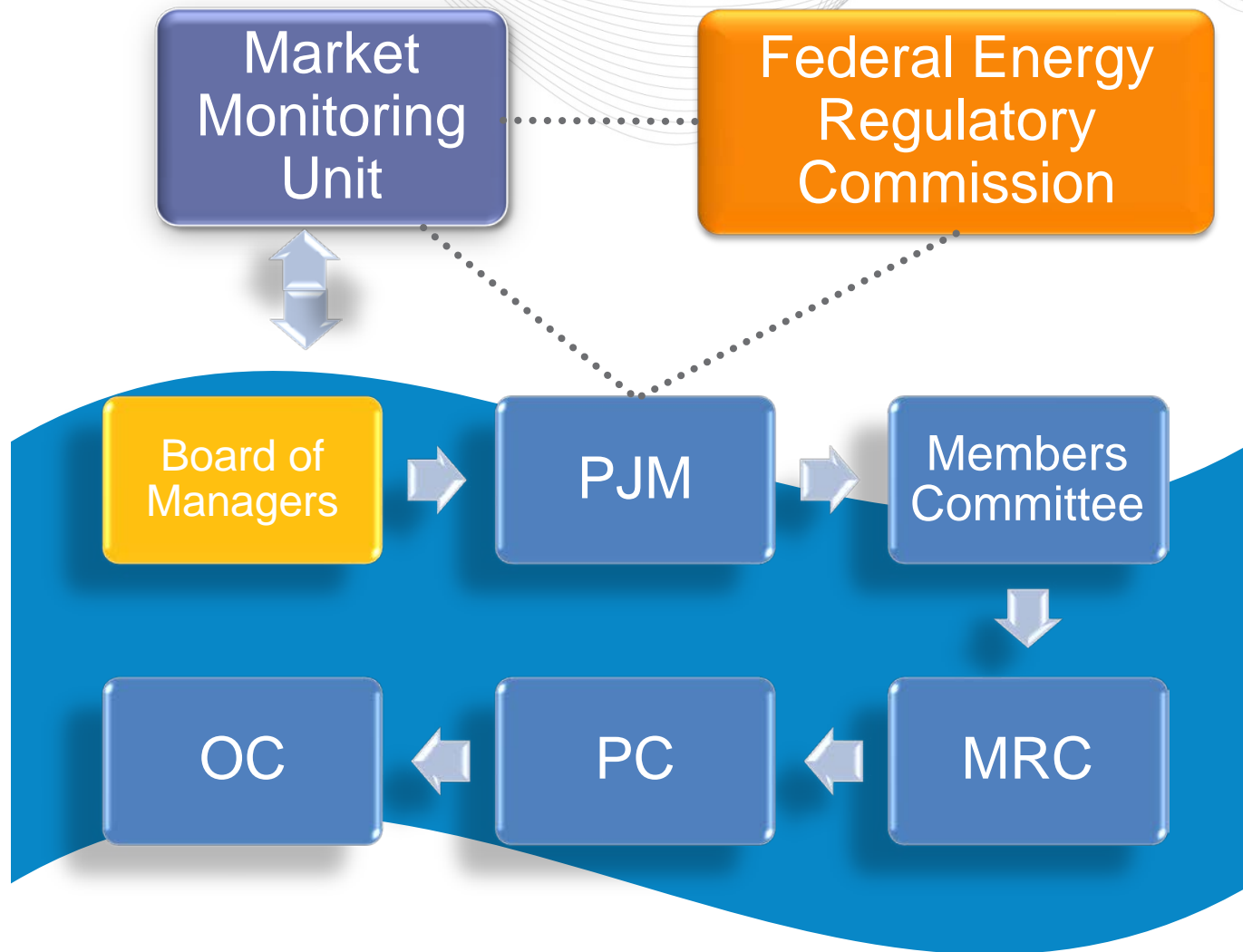


- NERC Security Coordinator
- Regional Transmission Provider
- Regional Control Area Operator
- Market Developer & Coordinator
- Regional Transmission Planner

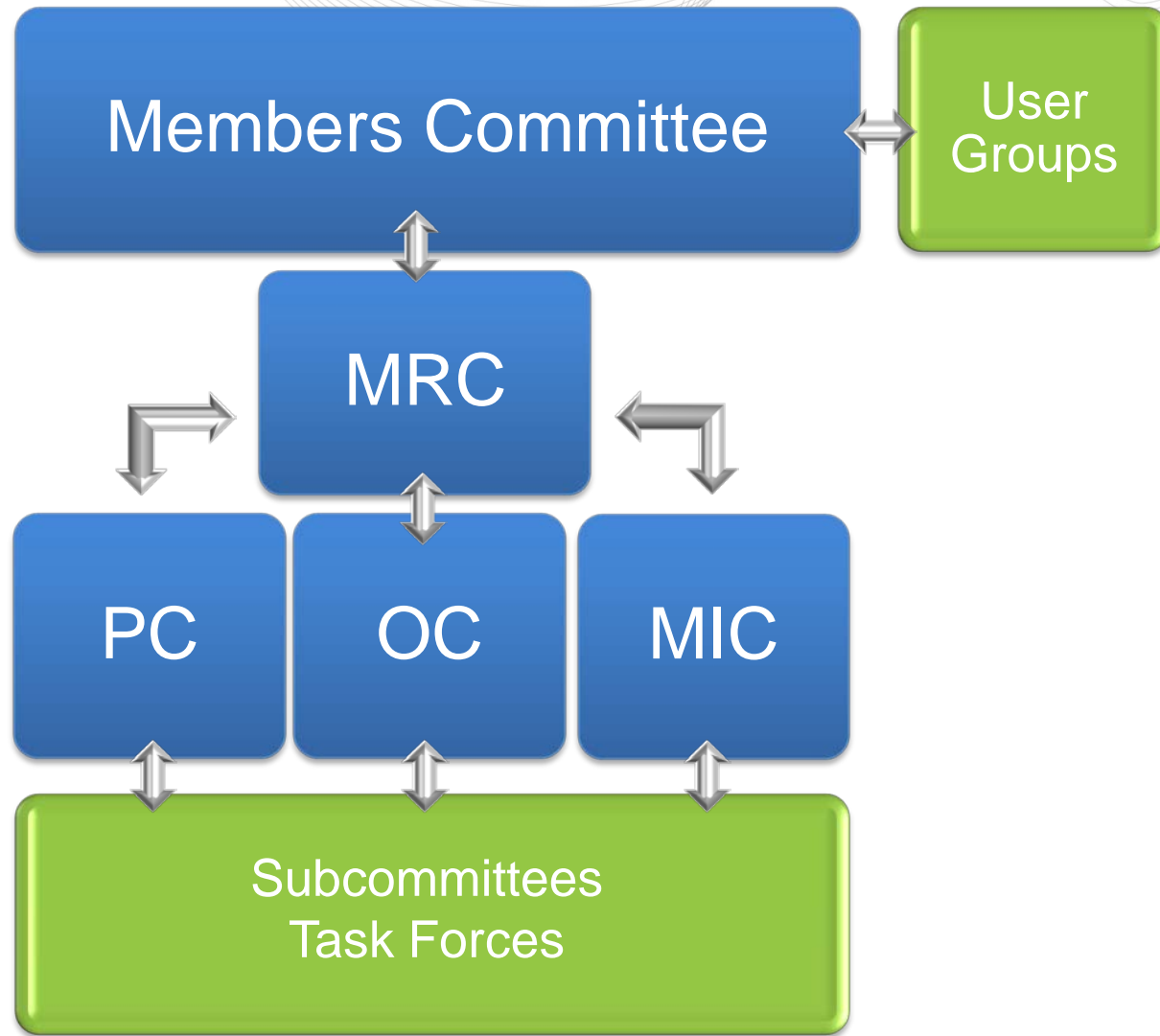
## Independent Board

## Members Committee

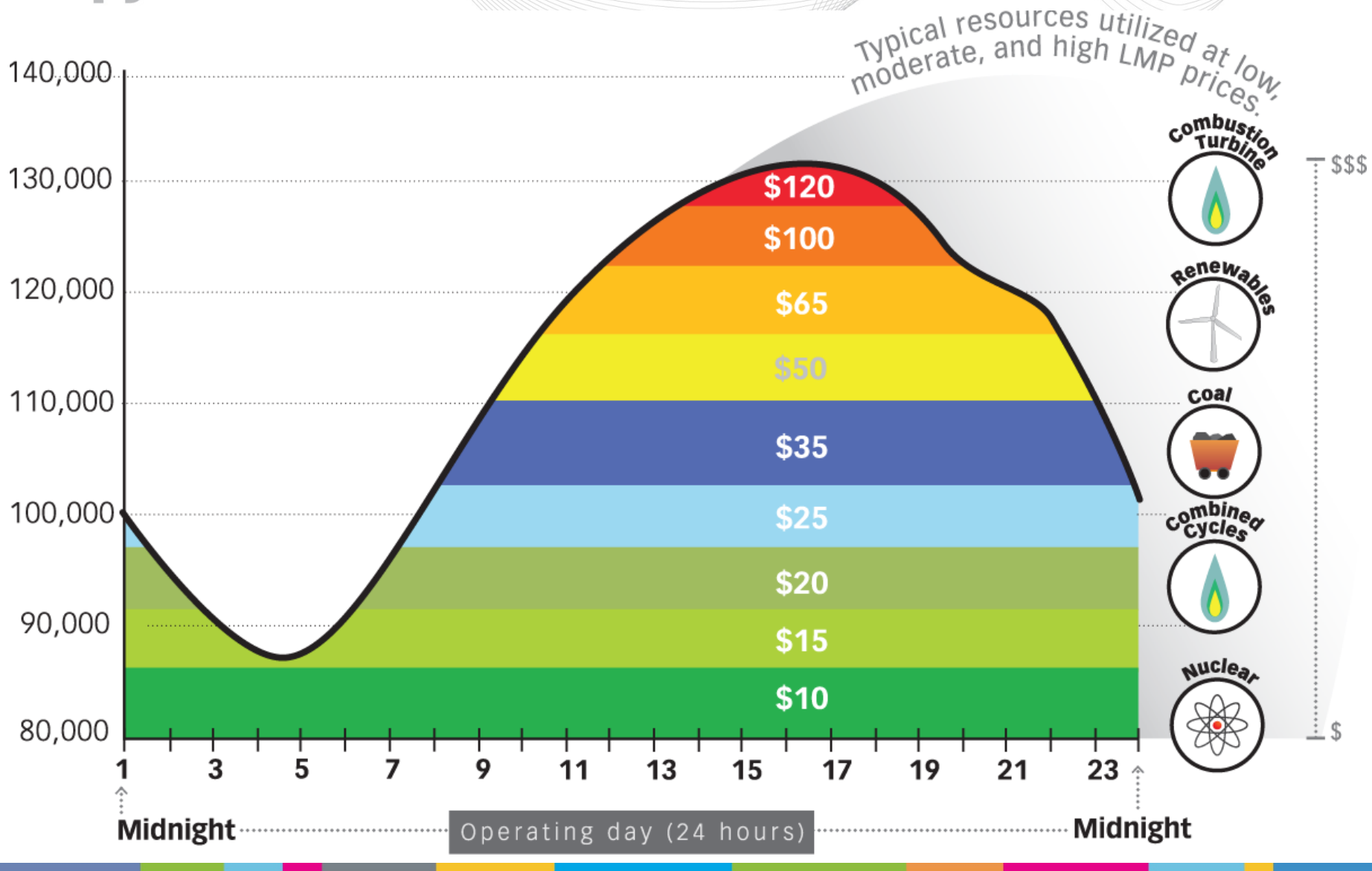








- Economic Dispatch
- This means that PJM selects and utilizes the least expensive resource first to meet energy demand. As energy demand increases, generators that are more expensive are utilized/dispatched to meet demand thereby increasing the price reflected in the Locational Marginal Price (LMP).



## LMP Components

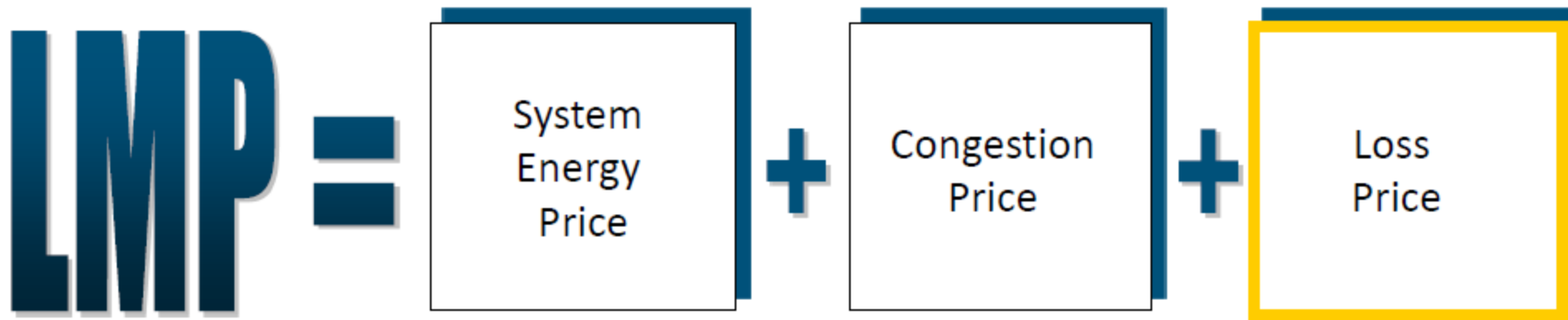
$$\text{LMP} = \text{System Energy Price} + \text{Congestion Price} + \text{Loss Price}$$

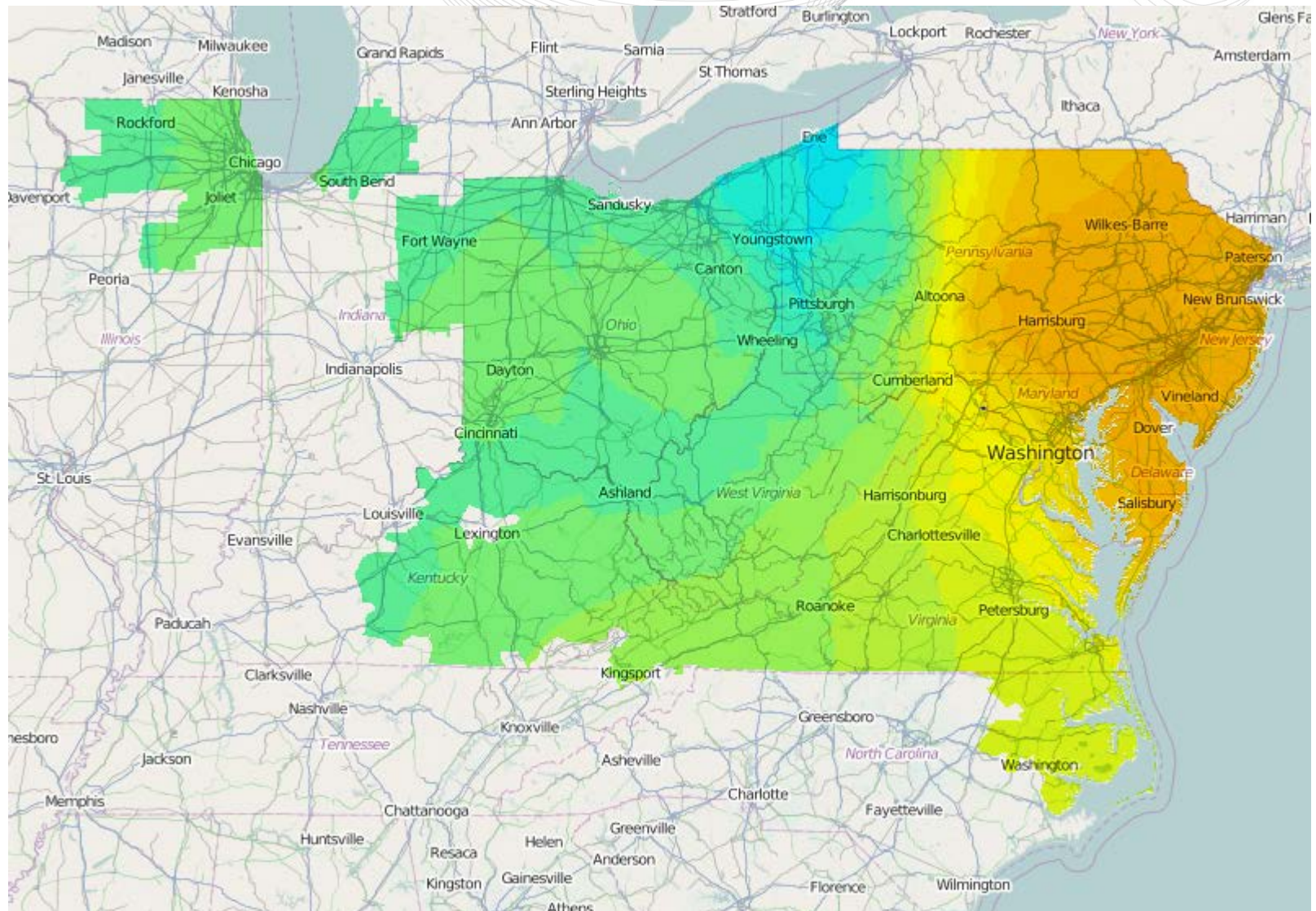
## LMP Components

A diagram showing the components of Locational Marginal Price (LMP). On the left is the large text "LMP". To its right is an equals sign. Following the equals sign are three boxes connected by plus signs. The first box is labeled "System Energy Price". The second box, which has a yellow border, is labeled "Congestion Price". The third box is labeled "Loss Price".
$$\text{LMP} = \text{System Energy Price} + \text{Congestion Price} + \text{Loss Price}$$

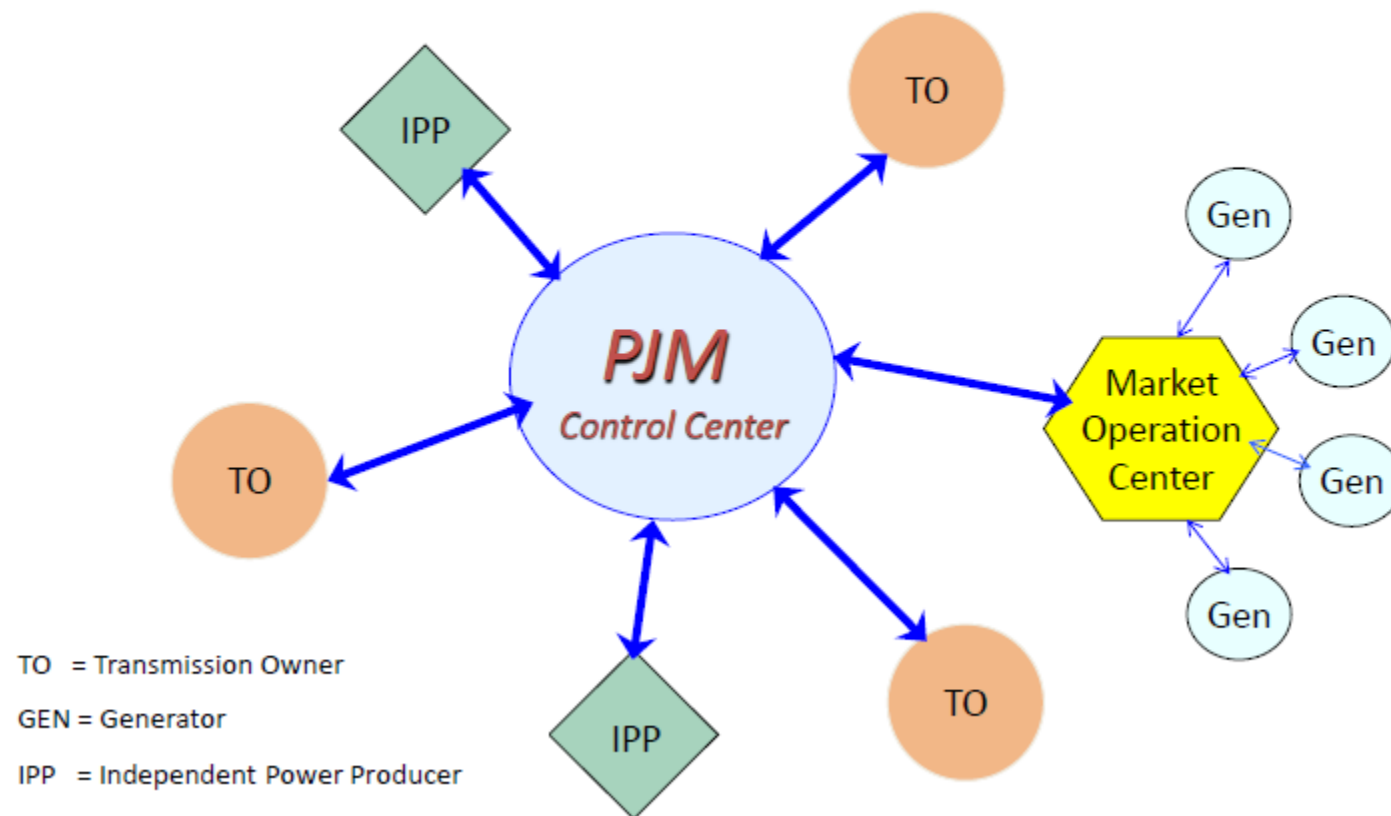


## LMP Components

$$\text{LMP} = \text{System Energy Price} + \text{Congestion Price} + \text{Loss Price}$$
A diagram illustrating the components of Locational Marginal Price (LMP). The equation "LMP = System Energy Price + Congestion Price + Loss Price" is shown. The "LMP" is in large, bold, blue letters. The equals sign is also in blue. The three components are each in a white box with a blue border. The "Loss Price" box has a yellow border. The plus signs are in blue.



## System Operator Communications: Voice and Data to and from Local Control Centers



- Overview of Markets and Governing Documents
- Market Operations
  - Day-ahead
  - Real-time and Ancillary Services
  - Market Settlements
- Application Integration
- Participant Systems and Tools
- Technical and Security Standards

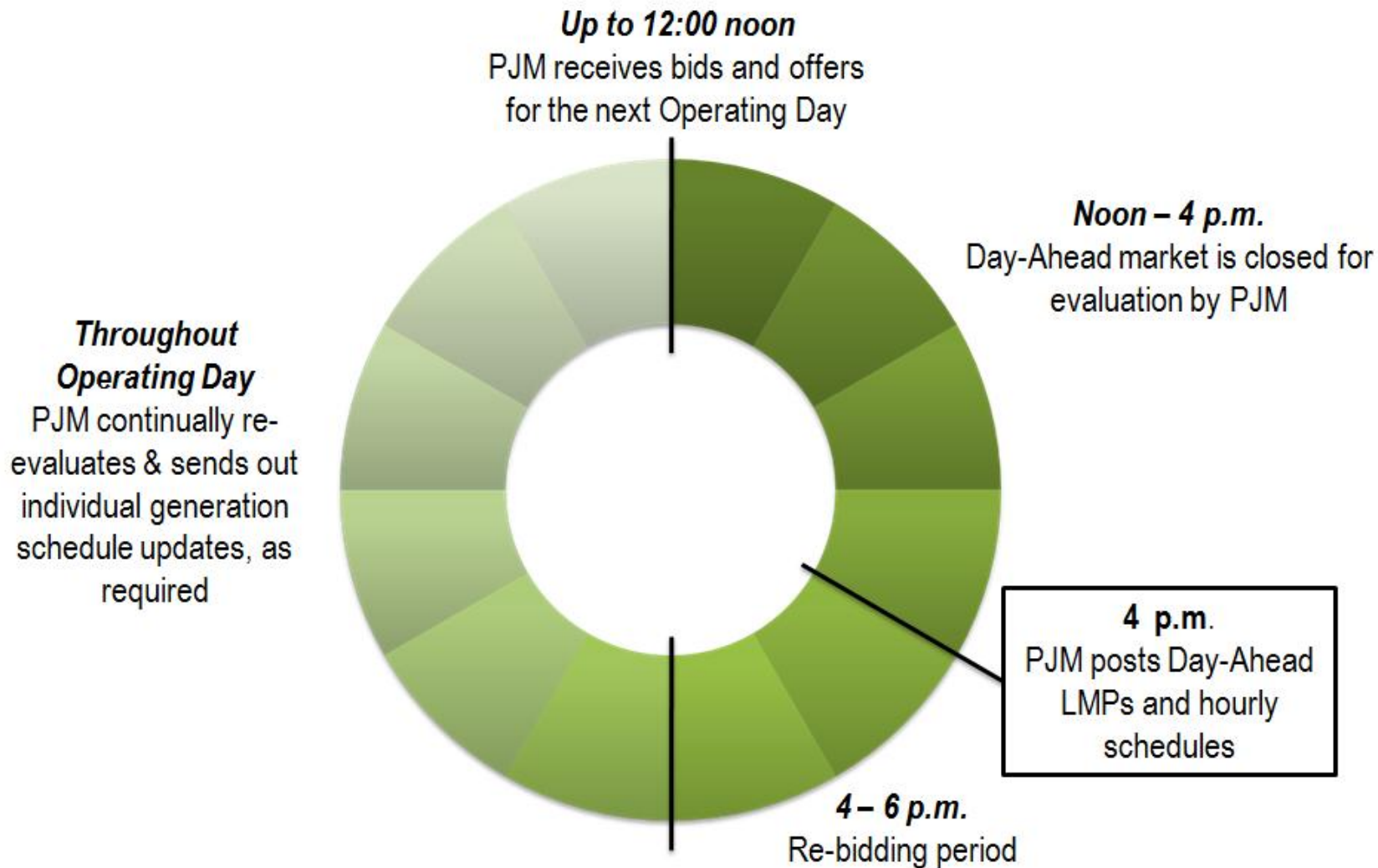
- Day-Ahead
- Real Time & Ancillary Services
  - Energy
  - Regulation
  - Synchronized & Non-synchronized Reserve
- Financial Transmission Rights (FTR)
- Capacity (RPM)



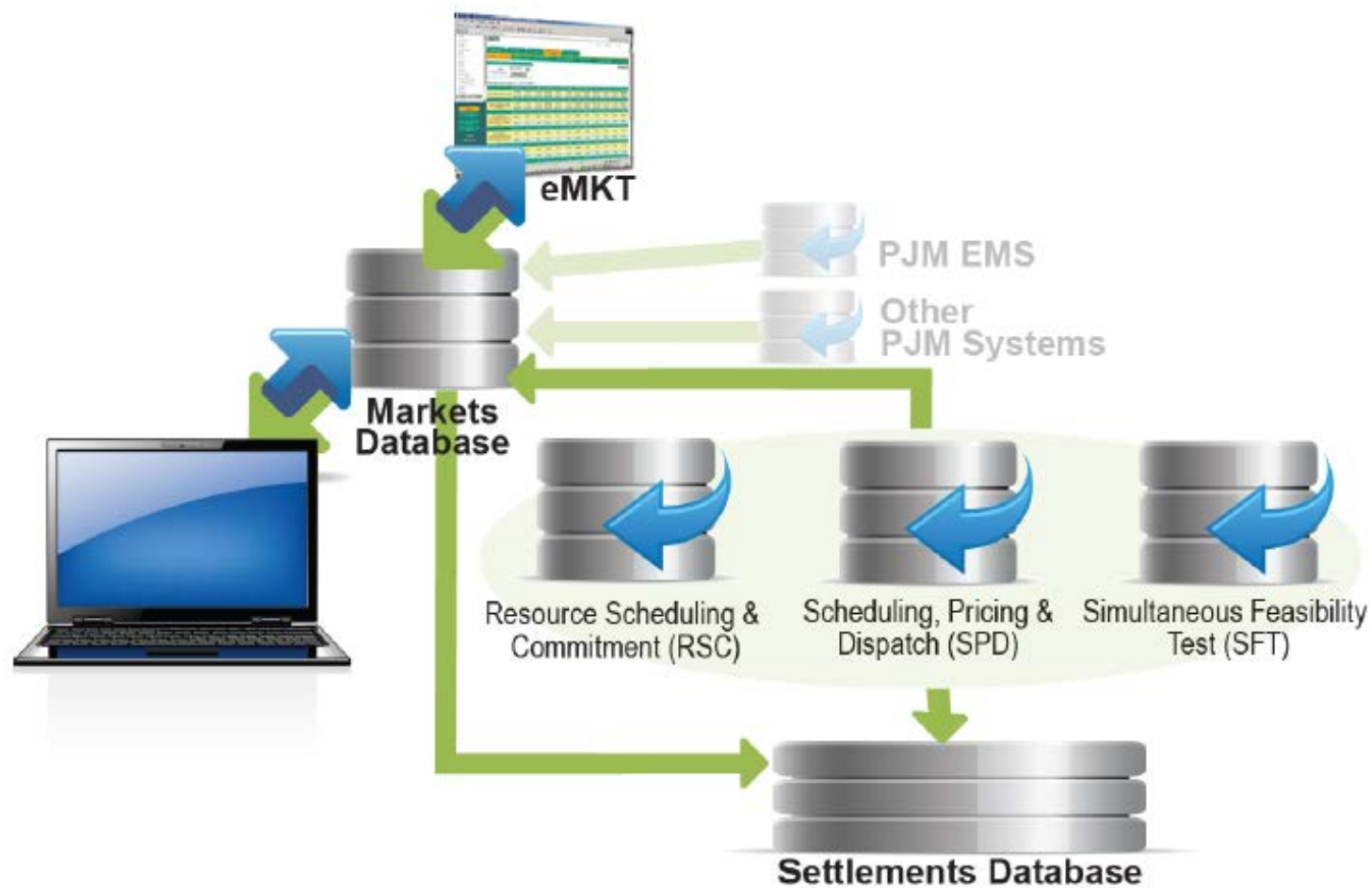
- **Governing Documents**
  - Open Access Transmission Tariff
  - Operating Agreement
  - Transmission Owners Agreement
  - Joint Operating Agreement (JOA)
- Stakeholder Process
- Market Manuals
- Independent Market Monitor

- Overview of Markets and Governing Documents
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- Participants purchase and sell energy at binding Day-ahead Locational Marginal Prices (LMPs)
- Minimize production cost of satisfying demand bids
- Develop day-ahead schedules using least-cost security constrained resource commitment and dispatch analysis





## Shortage Pricing Applications

### Ancillary Services Optimizer (ASO)

Clearing and assignment of all Ancillary Service products

### Intermediate Term Security Constrained Economic Dispatch (IT SCED)

demand trajectory, generator loading strategy, CT commitment

### Real Time Security Constrained Economic Dispatch (RT SCED)

final dispatch contour

### Locational Pricing Calculator (LPC)

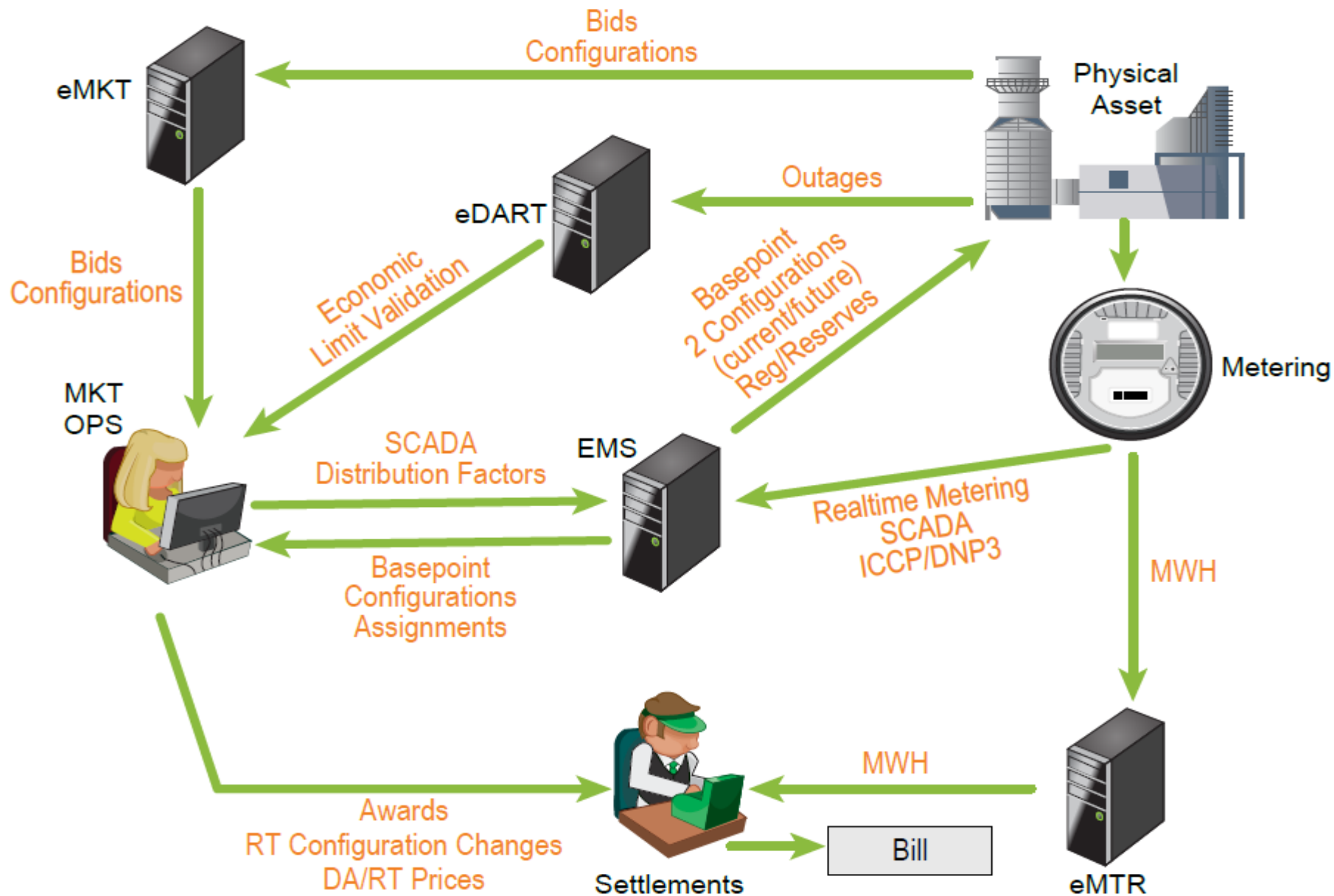
5-minute energy and Ancillary Service prices

- Joint optimization of energy, reserves and regulation
- Makes ancillary service commitments to meet system requirements
- Hourly regulation and inflexible reserve resource commitments are posted to eMKT
  - Inflexible reserve resources are synchronous condensers and demand response

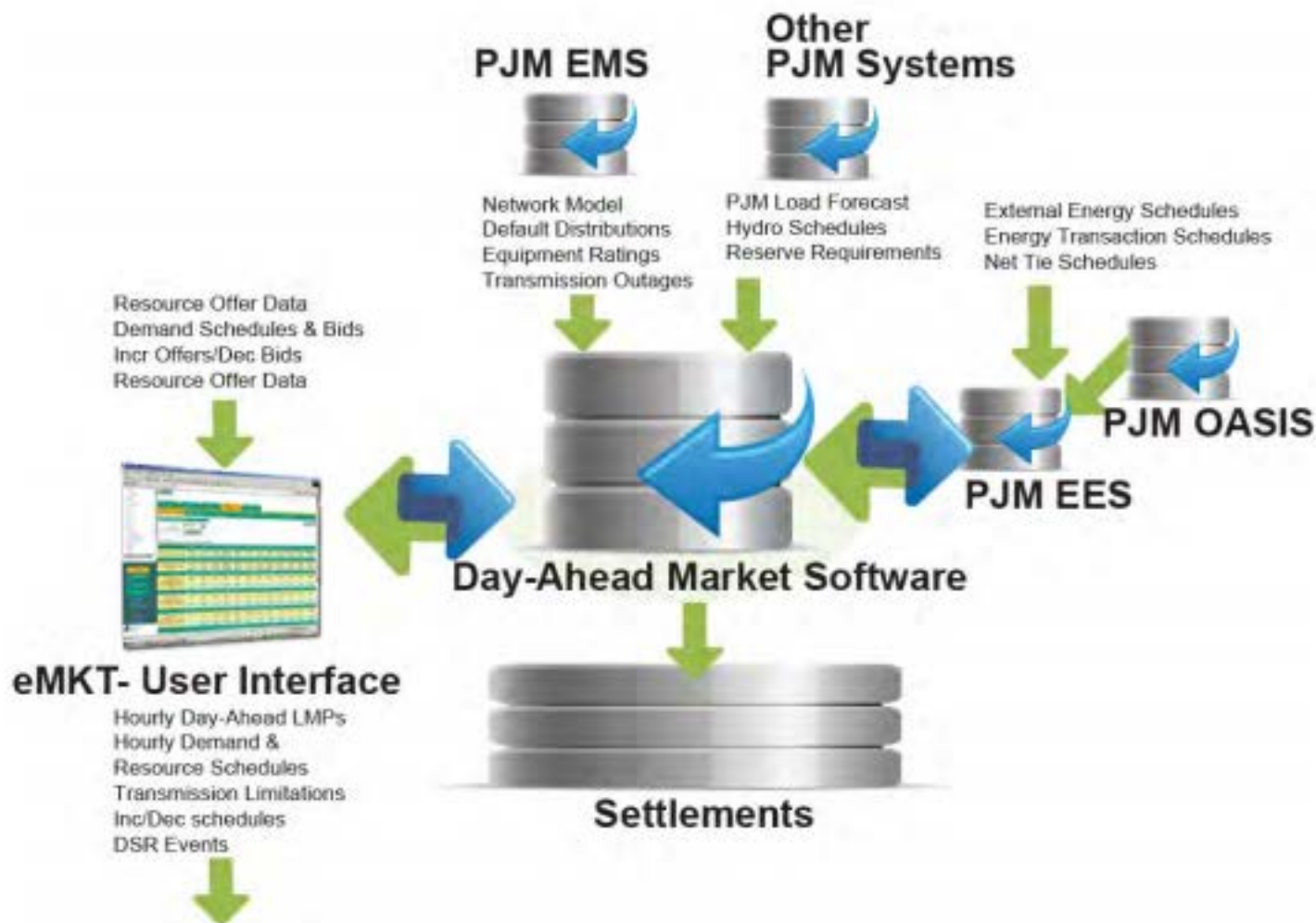
- Provides PJM Dispatch with a time coupled, optimized least cost dispatch solution
- Recognizes system constraint conditions and dispatches generation to control for multiple constraints
- RT SCED produces a Real-Time dispatch solution
- IT SCED produces an Intermediate term dispatch solution

- Calculates energy and reserve prices for the entire PJM network
- Automatic solution data verification checks performed to allow posting of 5 minute clearing prices
- Prices are hourly integrated and passed to Market Settlements

- Billing statements are issued monthly via the PJM Market Settlements Reporting System (MSRS)
- Monthly billing statement lists the amount in dollars due from the Member for each of the services billed under the PJM Operating Agreement
- Documents
  - M-27 – Open Access Transmission Tariff Accounting
  - M-28 – Open Access Agreement Accounting

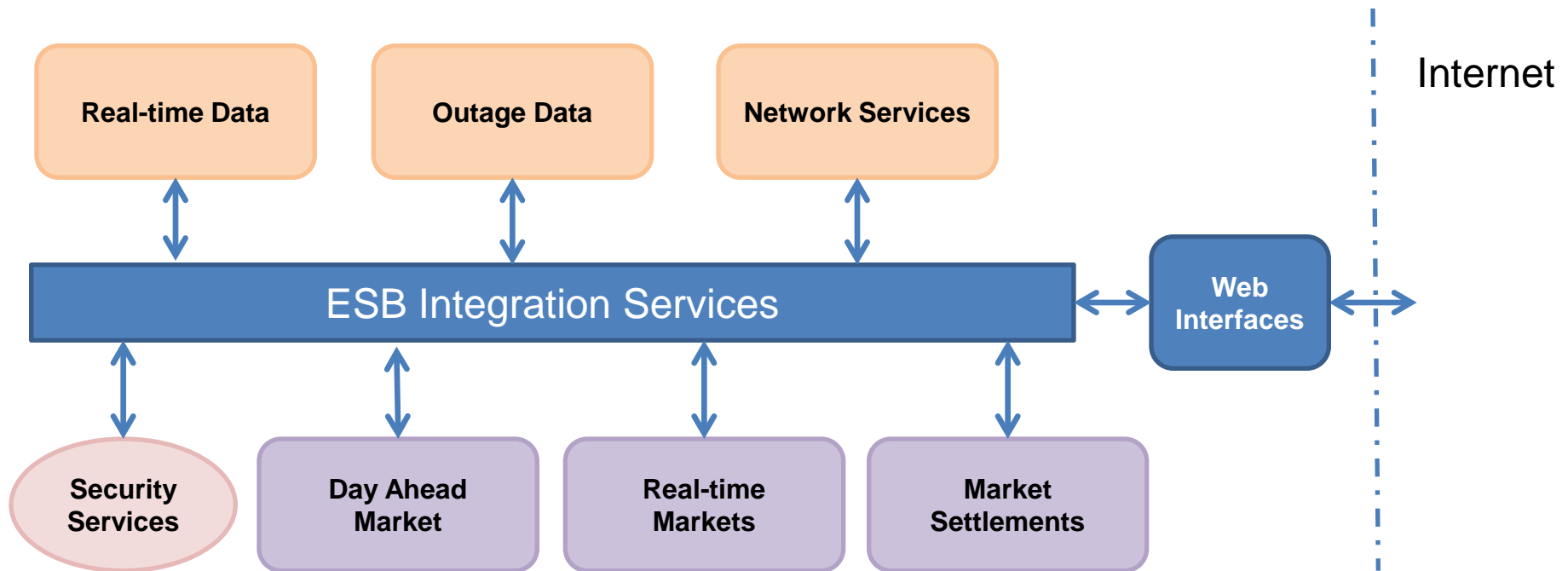






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- **Increases Integration Reliability**
  - Guaranteed Message Delivery
  - Centralized Monitoring
- **Eliminates point-to-point interfaces and proprietary solutions**
- **Lowers integration costs, increases supportability**
  - Less code, promotes service reuse
  - Less complexity (common framework)
  - Quick response to business need
- **Data abstraction**

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- Member access to a continuous flow of real-time energy data through PJM online Tools
- Enable business decision-making
- Transaction and portfolio management
- Emphasis on self-service
- Standards-based to enable integration with third-party applications

- eMKT
- eData and eDataFeed
- eFTR
- eRPM
- eCredit
- PowerMeter
- Market Settlements Reporting System (MSRS)
- Operational Data Posting

- Day-ahead, real-time and ancillary services market interface for market participants
- Generation
- Demand
- Virtual Bidding
- Marketing Information (Load, Constraints, etc.)
- Portfolio Management

[<](#)
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[https://esuitetrain.pjm.com/mui/index.htm](#)
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[Market Results Energy](#)
[Market Results A/S](#)

[Demand Summary](#)
[Market Prices](#)
[Interface Limits](#)
[Net Tie Schedules](#)
[Binding Limits](#)
[RA Sched MW](#)
[DA Sched MW](#)

**Demand Summary**

Date: 5/7/2014  
(mm/dd/yyyy)

Change Date

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**Demand Summary For: 05/28/2014**

	1/13	2/14	3/15	4/16	5/17	6/18	7/19	8/20	9/21	10/22	11/23	12/24
Day-Ahead Demand	75686	73311	72247	72547	74450	80464	91412	96331	96774	96440	96353	95451
	94189	93055	92006	90894	91557	92525	94133	98985	100513	95675	89169	83100
Day-Ahead Load Forecast	85503	85542	84919	85294	87511	92824	104598	109684	109344	107523	105510	103894
	101919	100217	98668	97424	97222	98178	100931	105752	106186	103565	98233	91934
Day-Ahead Scheduling Reserve Objective for area: RFC	6708	6708	6708	6708	6708	6708	6708	6708	6708	6708	6708	6708
	6708	6708	6708	6708	6708	6708	6708	6708	6708	6708	6708	6708
Day-Ahead Scheduling Reserve Objective for area: DOM	427	427	427	427	427	427	427	427	427	427	427	427
	427	427	427	427	427	427	427	427	427	427	427	427

Public

Generator

Demand

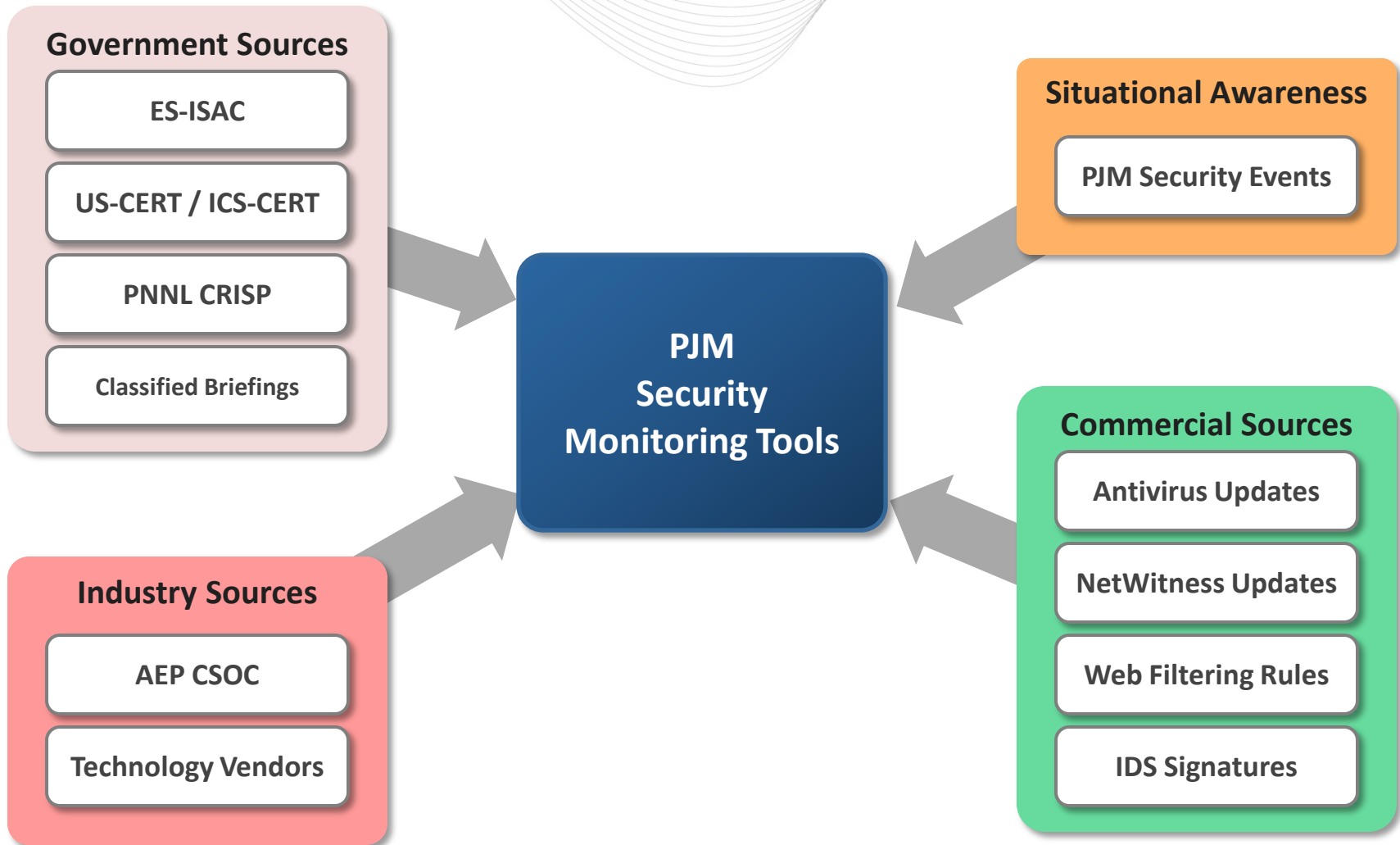
- eData is an Internet tool used to view:
  - LMP data
  - System conditions
  - Other market and operational Information
- eData can be customized based on individual needs and/or preferences
- XML feed for pricing information known as eDataFeed





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- NERC CIP
- SSAE-16
- Internal Architectural and Technical Standards
- Internal Security and Architecture Review Processes

- **PJM.com**

- Training Material <http://www.pjm.com/training/training-material.aspx>
- Online Tools <http://www.pjm.com/markets-and-operations/etools.aspx>