

# Unit Commitment in the PJM Day-ahead and Real-time Markets

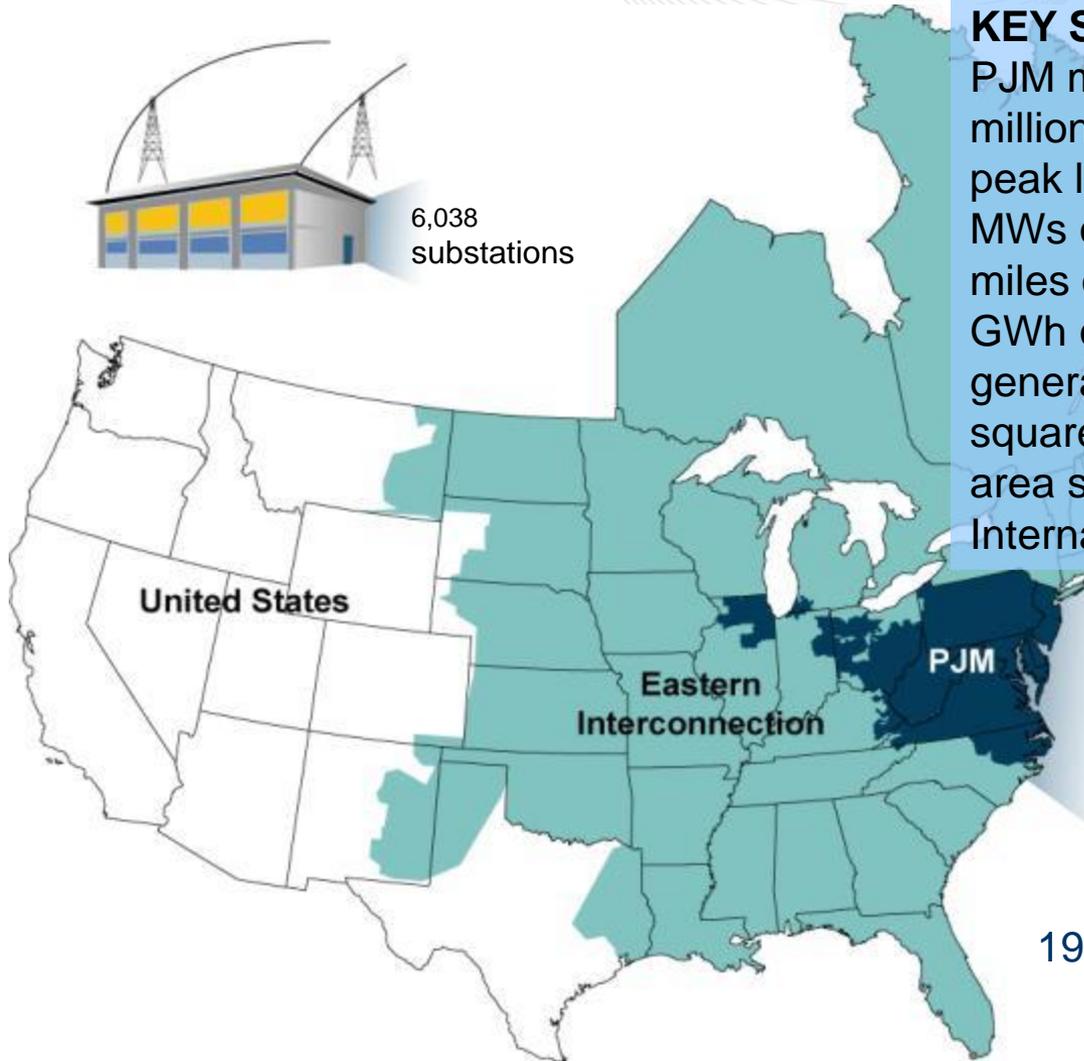
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6,038  
substations

## KEY STATISTICS

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

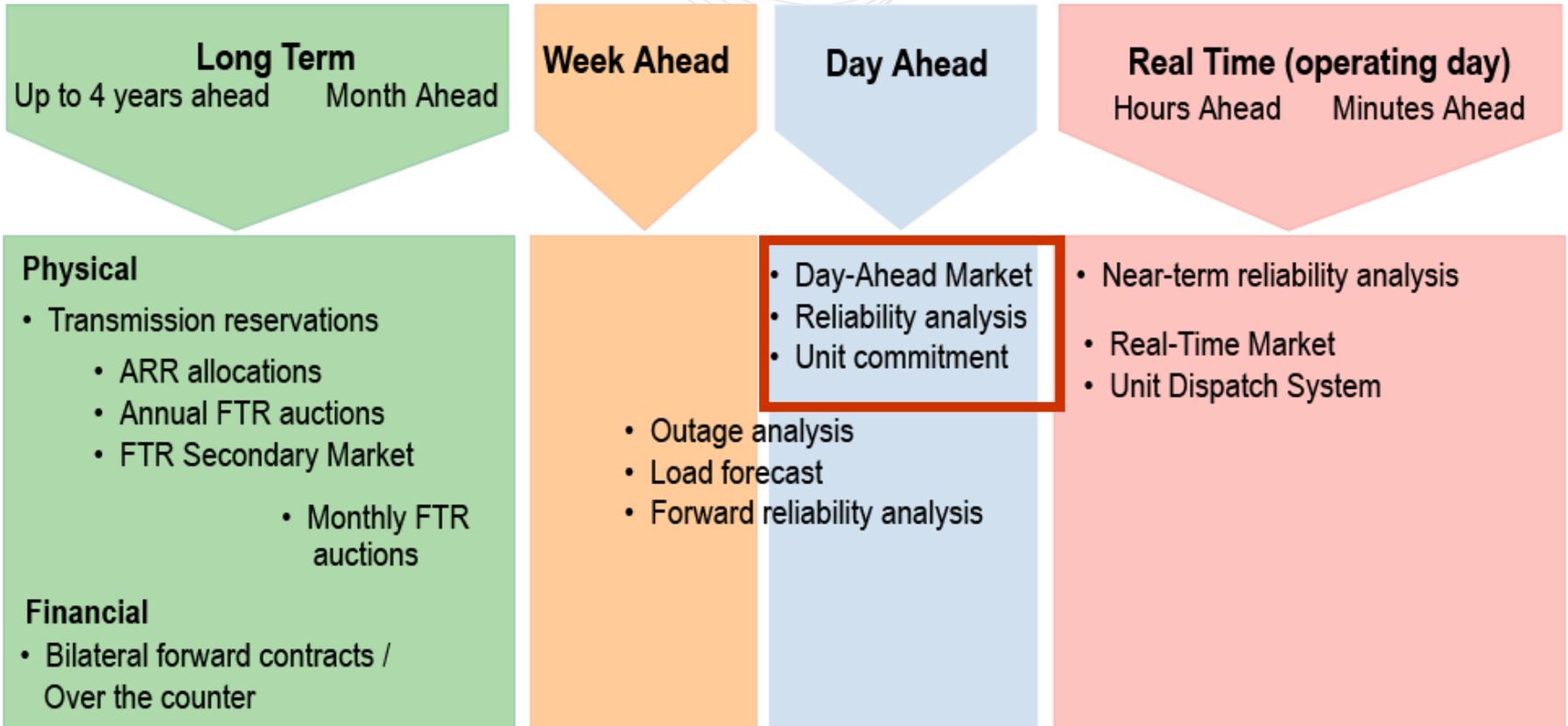


26% of generation in Eastern Interconnection

23% of load in Eastern Interconnection

19% of transmission assets in Eastern Interconnection

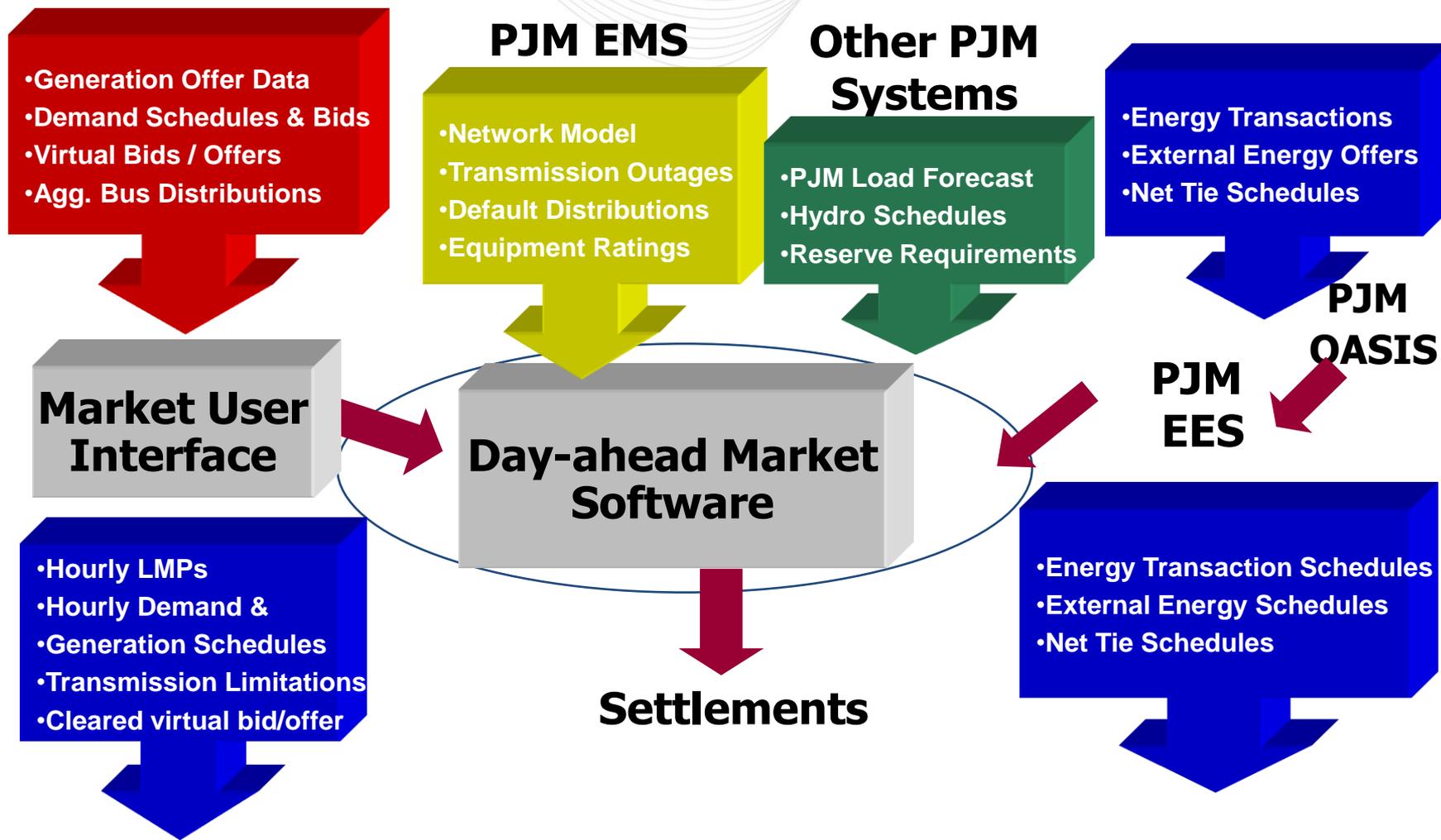
19% of U.S. GDP produced in PJM



- Develop financially binding hourly quantities and LMPs for next operating day based on participant bids and offers while respecting all transmission security constraints, reserve requirements and generator operating constraints.
- Requires solution of security-constrained unit commitment using full transmission model to maintain consistency with real-time market operations

- 1,210 generators, 3 part offers (startup, no load, 10 segment incremental energy offer curve)
- 10,000 - Demand bids – fixed or price sensitive
- 50,000 - Virtual bids / offers
- 8,700 - eligible bid/offer nodes (pricing nodes)
- 6,125 - monitored transmission elements
- 10,000 - transmission contingencies modeled

# Day-ahead Market Data Flow



## 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

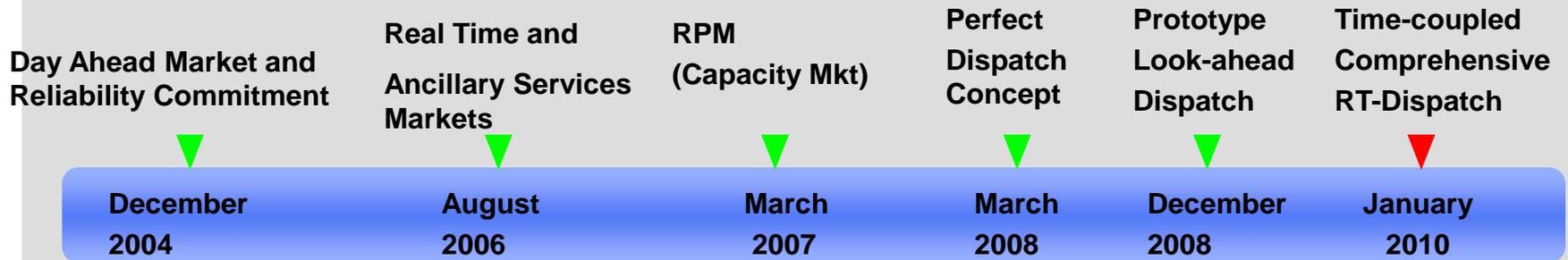
- *Hourly and Real-time operations*
- *5 minute security constrained dispatch and incremental unit commitment / decommitment*
- *LMP-based balancing market*



- Potential expansion of price responsive demand to many substations
- Potential to enhance Interregional Market Coordination
- Increased penetration of distributed resources distributed energy storage devices
- Smart grid innovations
- Potential need to reduce market clearing time

# Mixed Integer Programming-based Unit Commitment and Dispatch

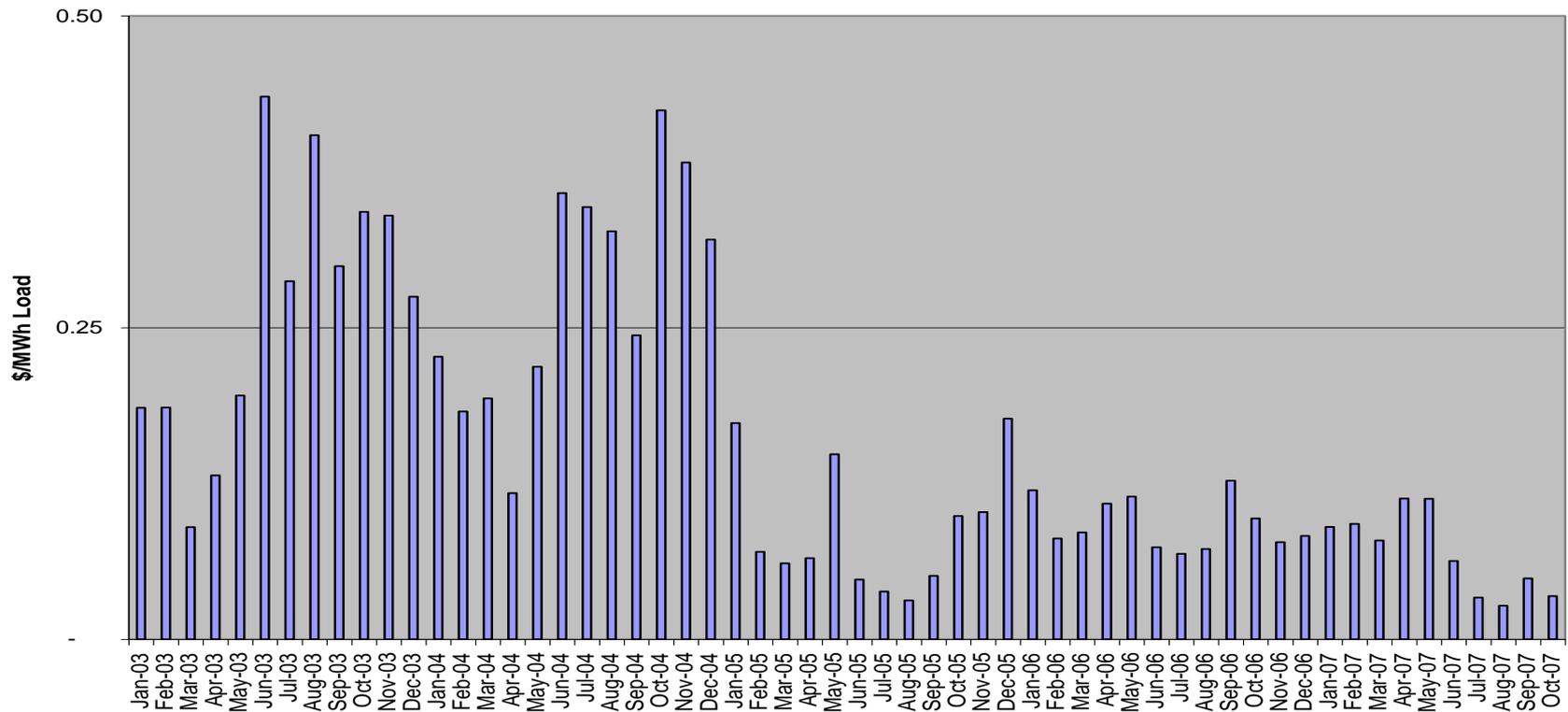
## Timeline of MIP Implementation in Production systems



1. Global optimality
2. More accurate solution
3. Improved modeling of security constraints
4. Enhanced resource modeling capability
  - a) Generation
  - b) Demand response
  - c) Transmission Devices
5. More adaptable problem definition

- Lower cost to maintain operational reliability – Annual Production Cost Savings exceed \$90 Million
- Lower uplift payments

**PJM Day Ahead Market uplift Costs 2003-2007 (\$/MWh Load)**



1. MIP tends to solve faster with more complete transmission model, LR had significant performance issues with transmission constraints
2. Conditional constraints initially created performance problems for MIP
3. Combined cycle model, Hydro unit commitment, etc. - very difficult to implement in LR. MIP handles relatively easily
4. MIP solution speed has improved dramatically