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Modeling, Simulation, and Computational Needs for RTOs: A PJM Perspective

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Modeling, Simulation, and Optimization for the 21st Century Electric Power Grid

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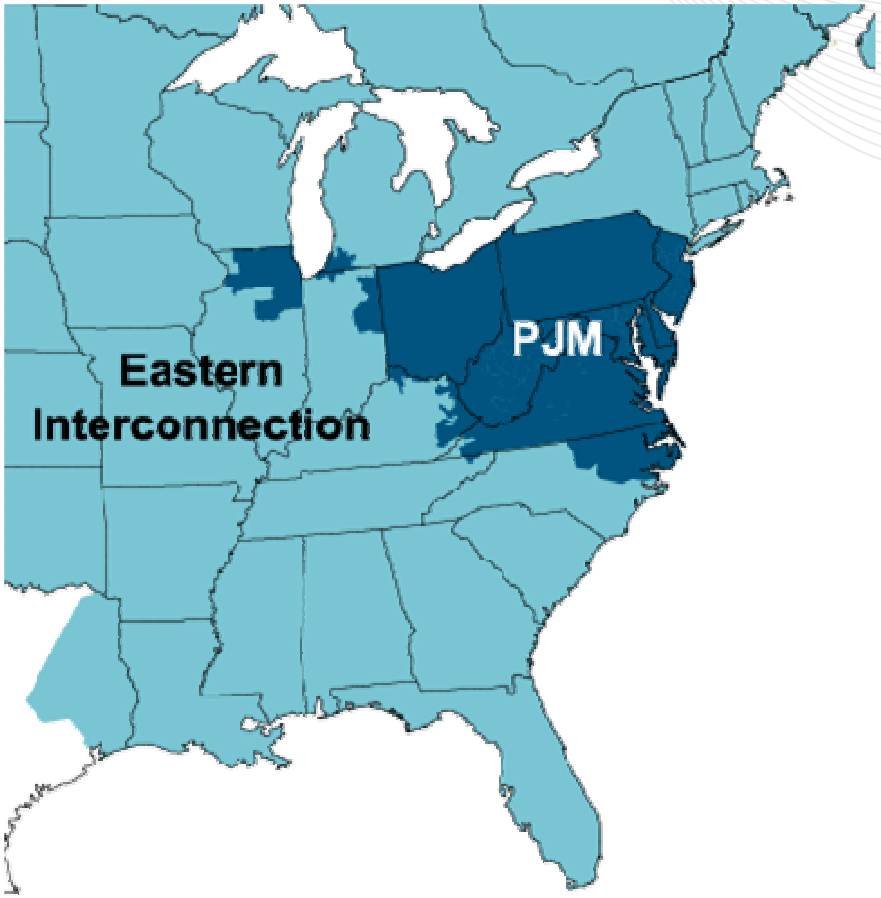
PJM: Who We Are



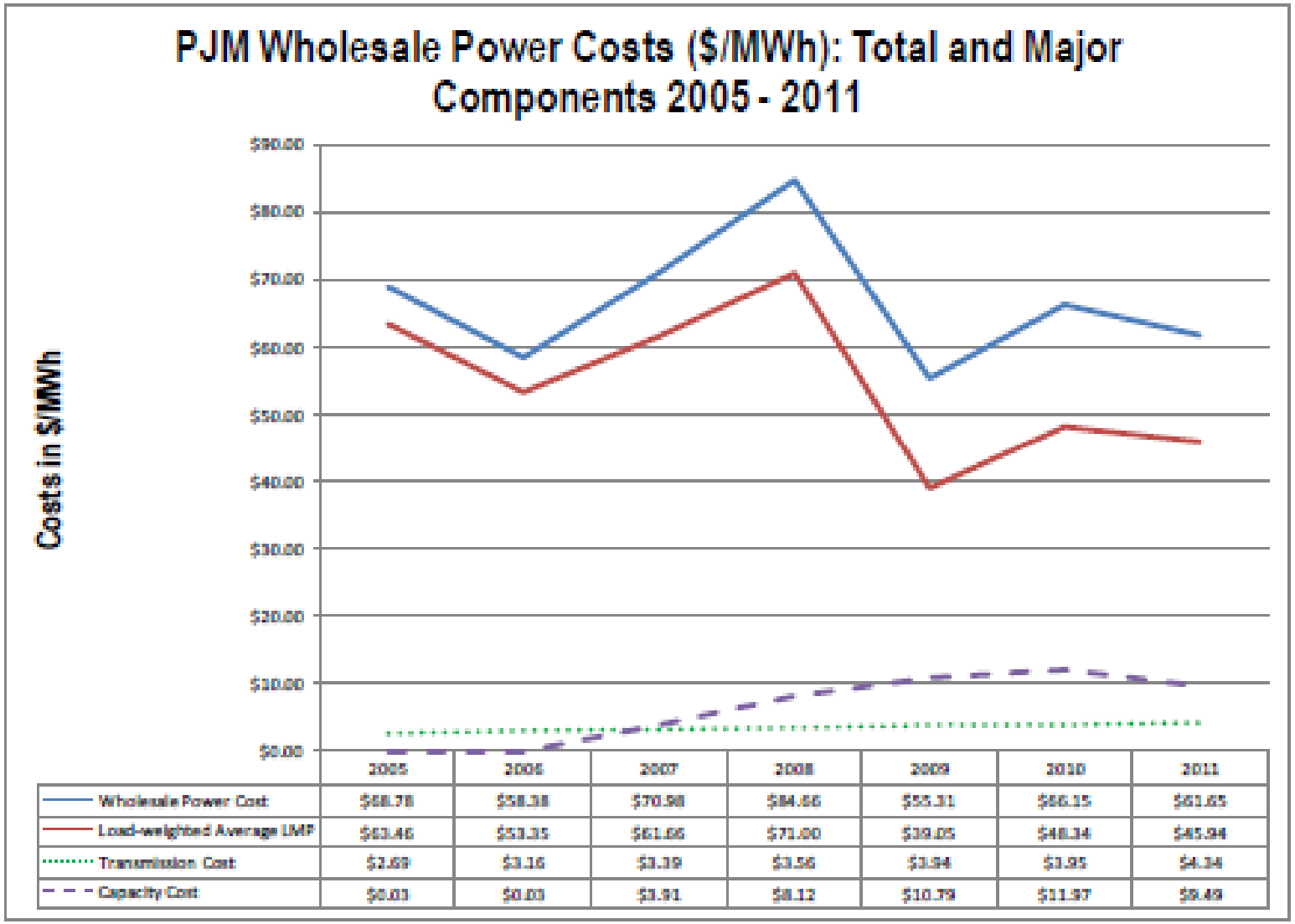
21% of U.S. GDP produced in PJM

KEY STATISTICS

Member companies	800+
Millions of people served	60
Peak load in megawatts	163,848
MWs of generating capacity	185,600
Miles of transmission lines	59,750
GWh of annual energy	832,331
Generation sources	1,365
Square miles of territory	214,000
States served	13 + DC

As of 7/2012

Components of Wholesale Costs: Prioritizing Computational Effort by Contribution to Costs



	2005	2006	2007	2008	2009	2010	2011
Wholesale Power Cost:	$68.78	$58.38	$70.98	$84.66	$55.31	$66.15	$61.65
Load-weighted Average LMP	$63.46	$53.35	$61.66	$71.00	$39.05	$48.34	$45.94
Transmission Cost:	$2.69	$3.16	$3.39	$3.56	$3.94	$3.95	$4.34
Capacity Cost:	$0.03	$0.03	$3.91	$8.12	$10.79	$11.87	$9.49

Order 719: Shortage Pricing and Co-optimization

- Co-optimization of Energy and Ancillary Services
  - Implemented October 1, 2012 in response to Order 719
  - Concurrent implementation of performance based Regulation and Frequency Response
  - Look-ahead (IT SCED) also implemented looking out up to 2 hours
- Computational Need: Even faster dynamic MIP algorithms that tie together 5 min co-optimization and IT SCED
  - Allows for smoother transitions over time especially with implementation of operating reserve demand curve

- What do stochastic unit commitment models provide that we do not have today?
  - Can they be solved in sufficiently short times with realistic distribution of outcomes?
  - What is the improvement in accuracy and efficiency of commitments?
  - We handle uncertainty in demand already
- Day-ahead and Real-time market construct
  - Two-settlement system with allocation of uplift charges provides incentives to schedule accurately
  - Use wind forecasting with updates as we do with load
  - Can commit CTs in real-time
  - Can PRD with knows bids offset intermittent resource uncertainty?

- Optimization with nested parent/child locations
  - Coupled offers from Demand Resources for three types of services (Annual, Extended Summer, Limited)
  - Credit limited offers
  - “Fill-or-kill” block bids
  - Potential for “fill-or-kill” offers based on clearing price
- Computational Need: Even faster dynamic MIP algorithms that can solve this problem
  - Also there is a need for individual rationality checks/constraints that fall out of the algorithm.

- Planning for public policy and controversy surround cost allocation
  - Today we plan for reliability…have recently accounted for policy impacts on reliability
  - RPS, EPA, major shifts in commodity fuel markets
- New objective: maximize market surplus?
  - Subject to constraints on reliability, public policy goals and mandates (e.g. RPS, MATS)
  - Choosing discrete transmission projects
  - Could become combinatorially intensive
  - In theory could identify beneficiaries...both load and generation using a monetary metric

- What are the longer terms effects of various policy and market shifts?
  - Would be great to have models that endogenously determine resource mix, and simulate energy market…
  - …and acknowledge the inherent non-convex decisions on entry, exit, retrofits, operations, account for locations, etc.
- An integrated model of energy and capacity markets that is inter-temporal or dynamic?
  - At its core a large, dynamic MIP
  - Drive for more accurate results/forecasts of the future for policies that are being implemented (e.g. MATS) that linearized, convex models
  - Major database challenge as well

Concluding Thoughts Going Forward

- Concentrate on the areas that have the greatest impact on cost
  - Energy market and operations is the greatest contributor
  - But there is room for work in other areas…especially capacity as we are seeing in other RTOs
- Work on MIP
  - Great strides have been made in the last 15 years…still work to do in speeding up computations and getting prices out of non-convex decision variables.
- Focus attention on more market and policy related matters
  - Look at costs and benefits that can come from some computing and modeling advances.