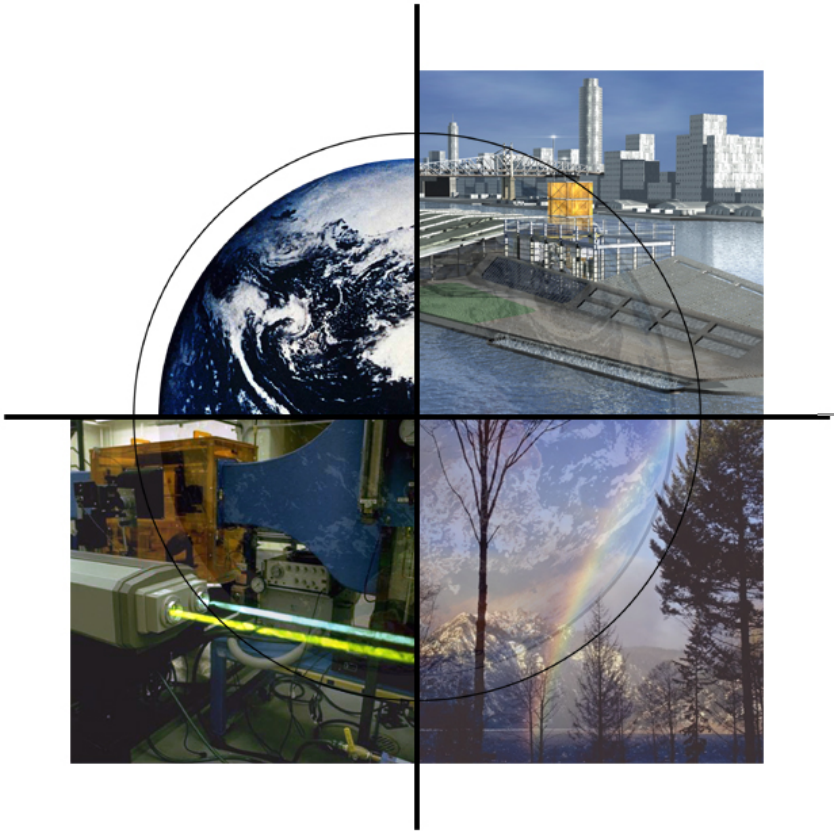
The PJM Region



DOE GEM-SET:

Government
Energy
Market
Segment
Evaluation
Tool

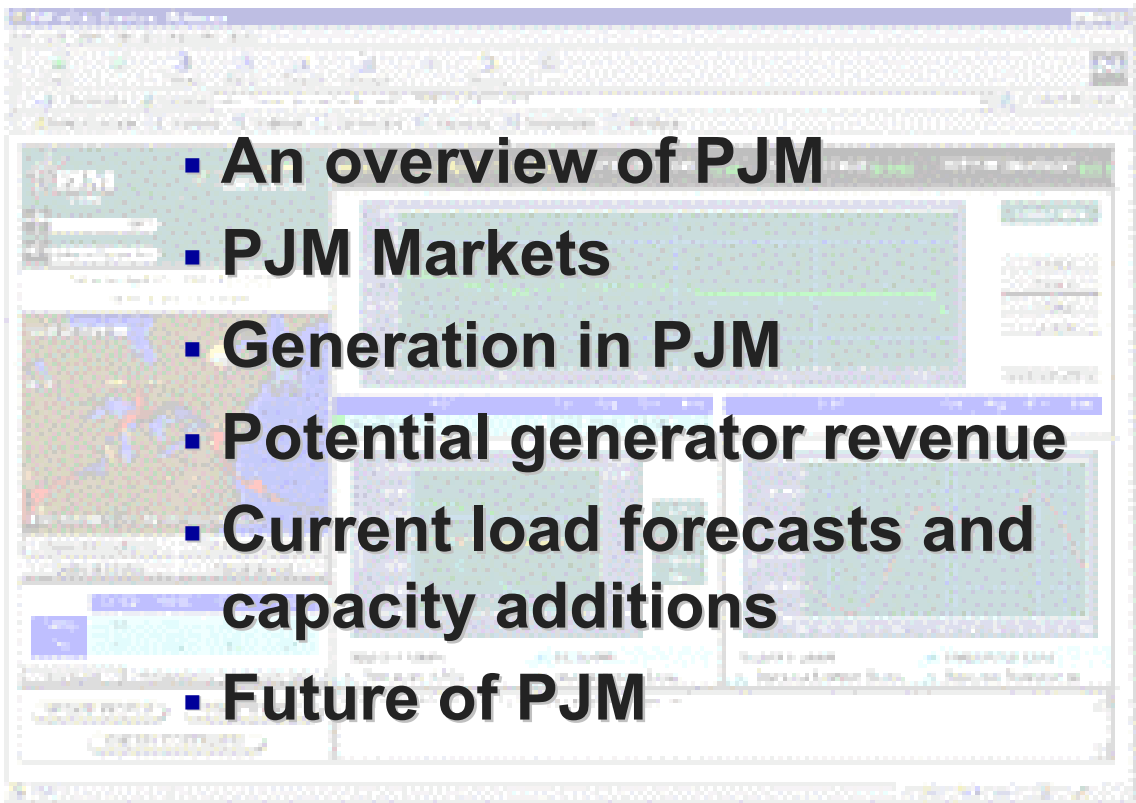
A GEMSET Characterization For DOE

December 13, 2002

Patricia A. Rawls, NETL
Christopher Wiederspahn, Parsons
Albert A. Herman, Jr. Parsons
Richard E. Weinstein, Parsons

www.netl.doe.gov

Agenda



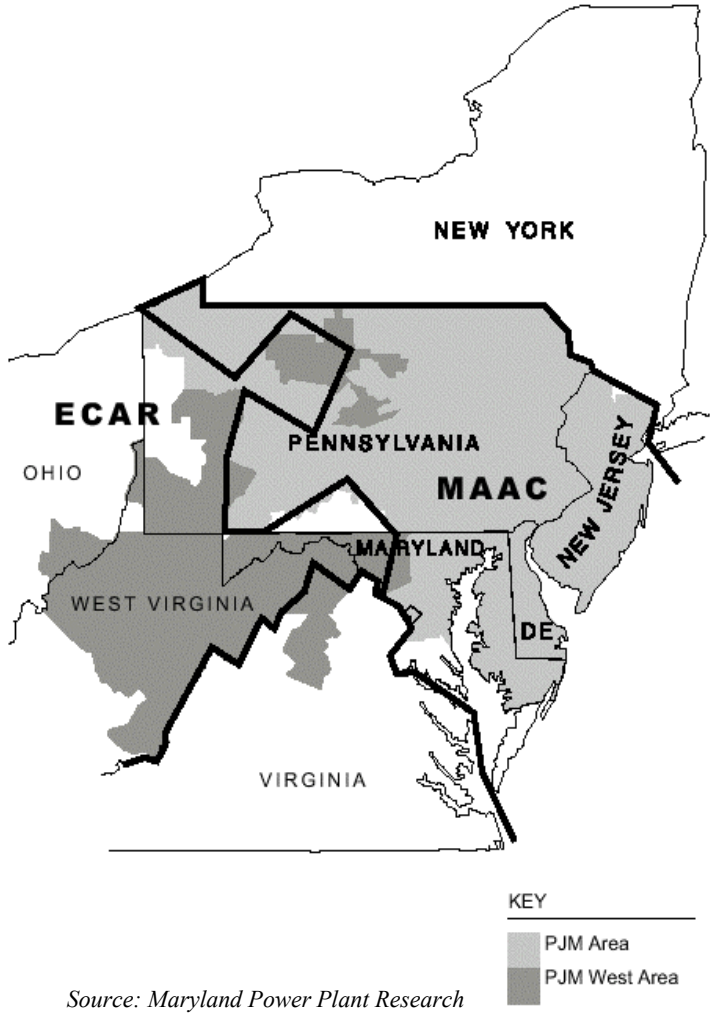
- An overview of PJM
- PJM Markets
- Generation in PJM
- Potential generator revenue
- Current load forecasts and capacity additions
- Future of PJM

The PJM Region

The PJM Region

PJM Region*

- 25.1 million people served
- 64,127 MW (megawatts) of peak load
- 71,639 MW of generation capacity
- 298,011 GWh (gigawatt hours) of energy per year
- 614 generation sources of diverse types
- 13,100 miles of transmission lines
- 200 members
- $9 billion in energy and energy service trades since 1997



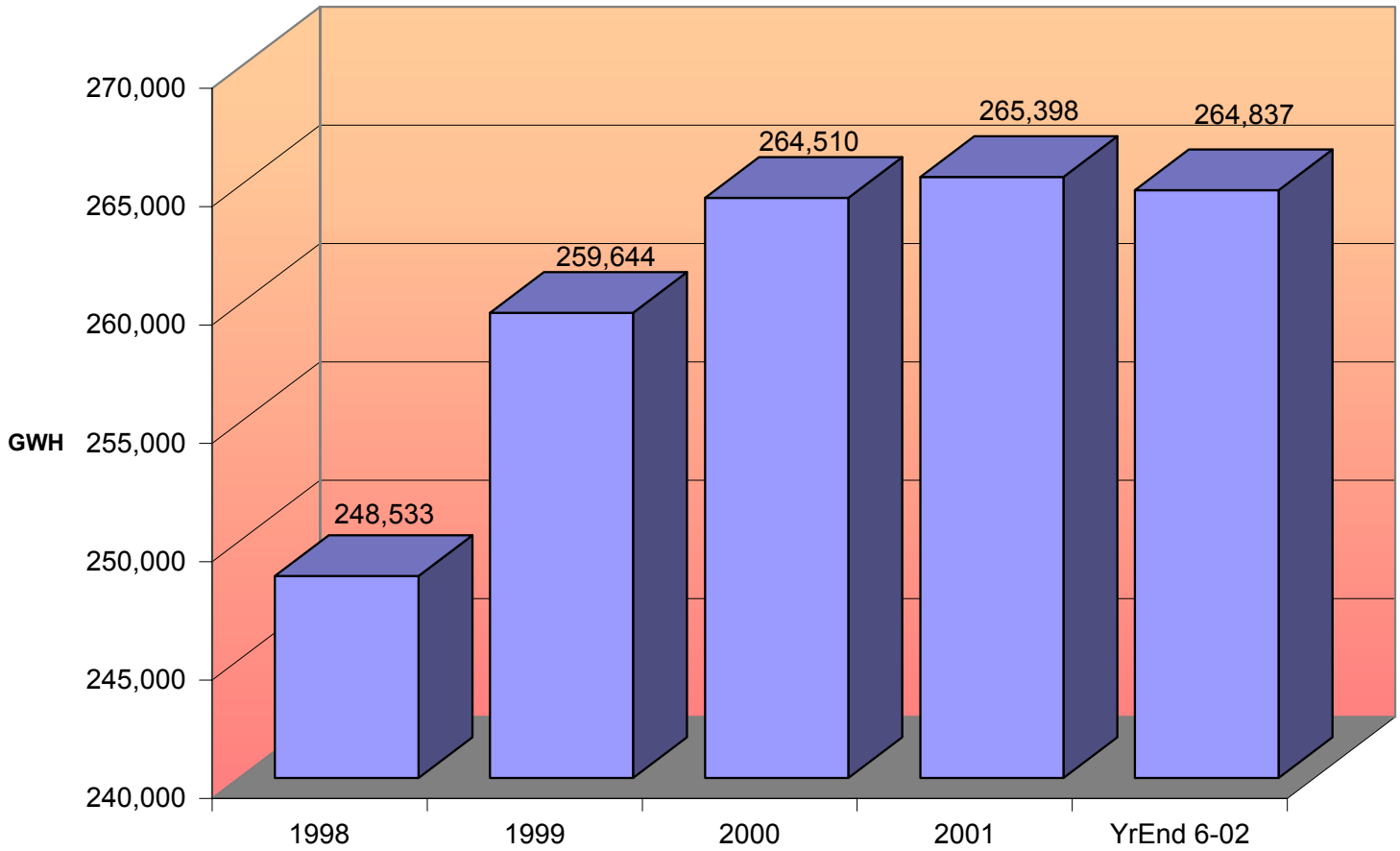
*As of 11/2002

Source: Maryland Power Plant Research Project Website

Roles and Responsibilities

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

PJM East Net Energy Consumption



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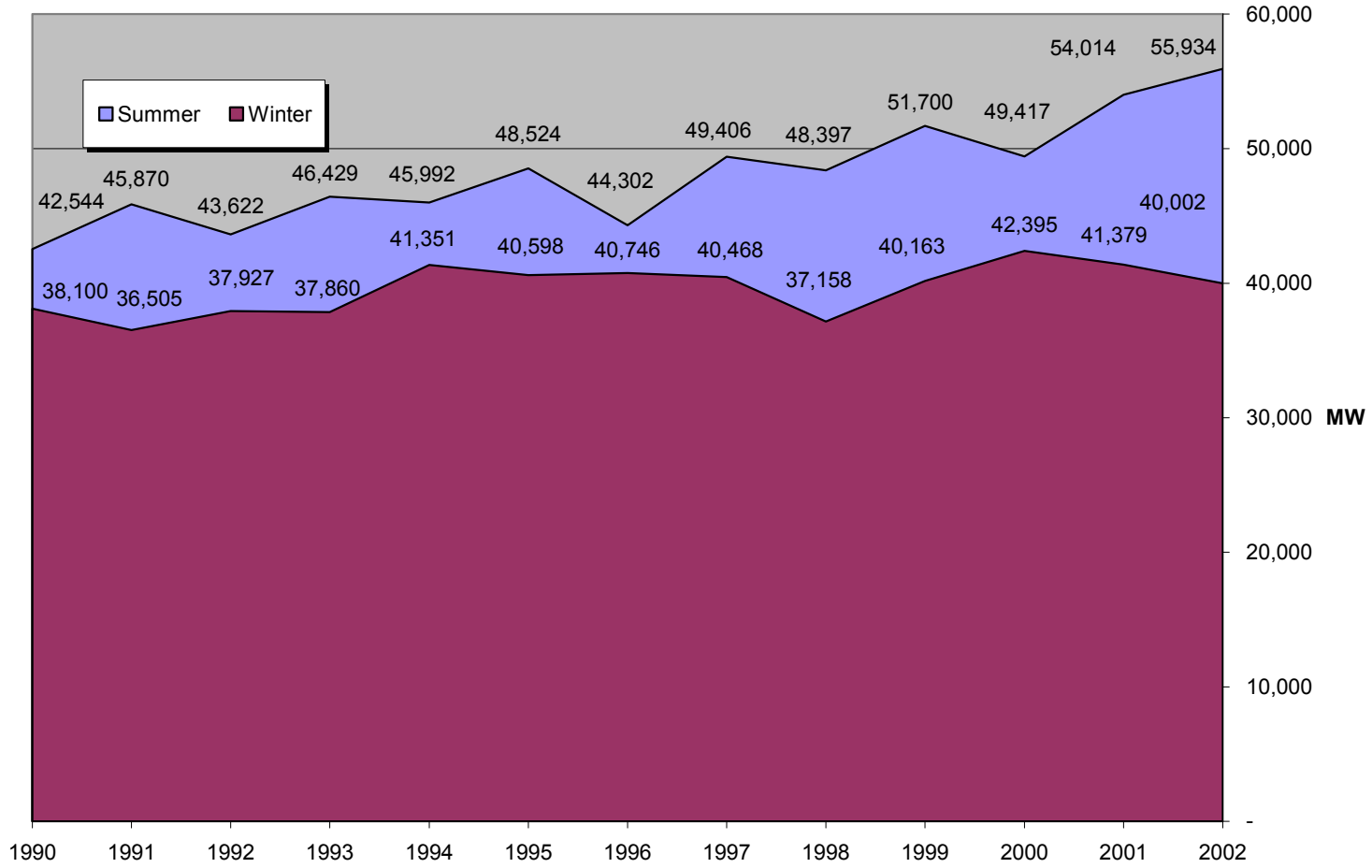
PJM East Peak Loads 1990-2002



Note: 2002 Peak Data preliminary

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Peak and Baseload Trends

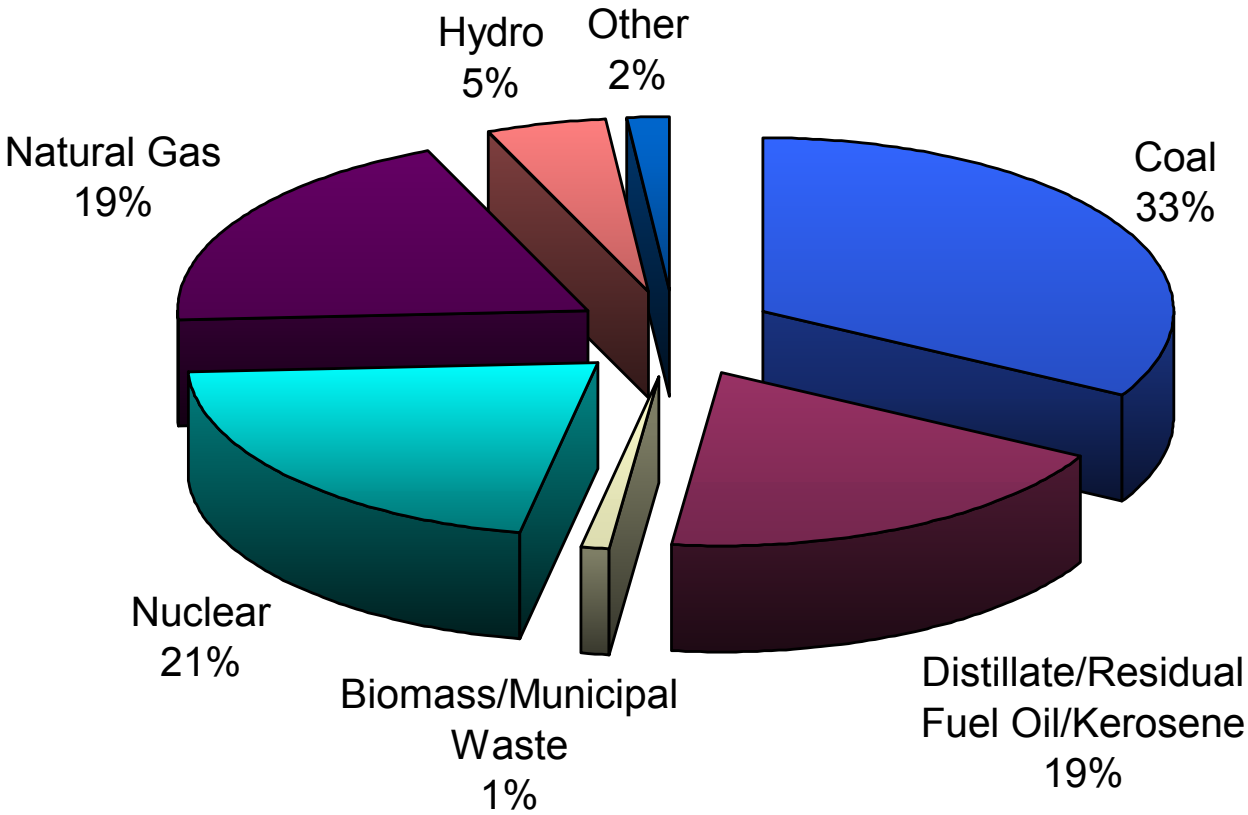
Peak Demand

- All-time system peak was 64,127 MW
- PJM has sufficient peak capacity for the next several years
- Peaking units and baseload units will increasingly be comprised of Natural Gas CC

Baseload

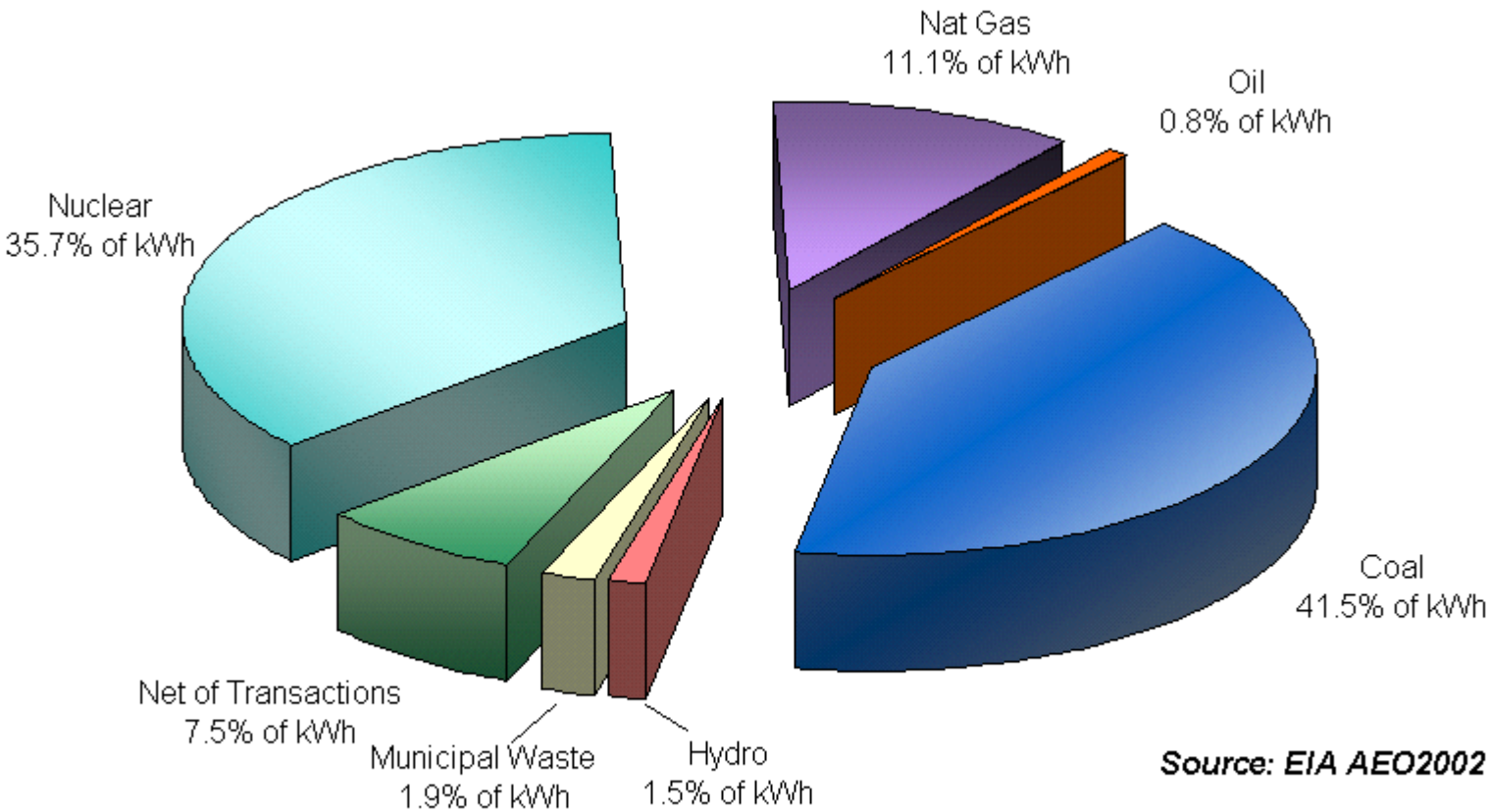
- 31,000 MW or 54% of available capacity fueled by coal or nuclear in PJM East
- Demand is creeping up
- No new coal or nuclear baseload units currently under construction

Installed Capacity by Fuel Type - PJM East
(8/28-02)



Source: GEMSET PJM Generation Stack 8-28-02

2002 PJM kWh Generation by Fuel Type



Source: EIA AEO2002

N:\TechReports\2002_05a_PJM_Characterization\PJM Wiederspahn\[PJM Rev II Exhibits.xls]Generatio - Dec-09-2002 02:21 PM Rev.-01

The PJM Region

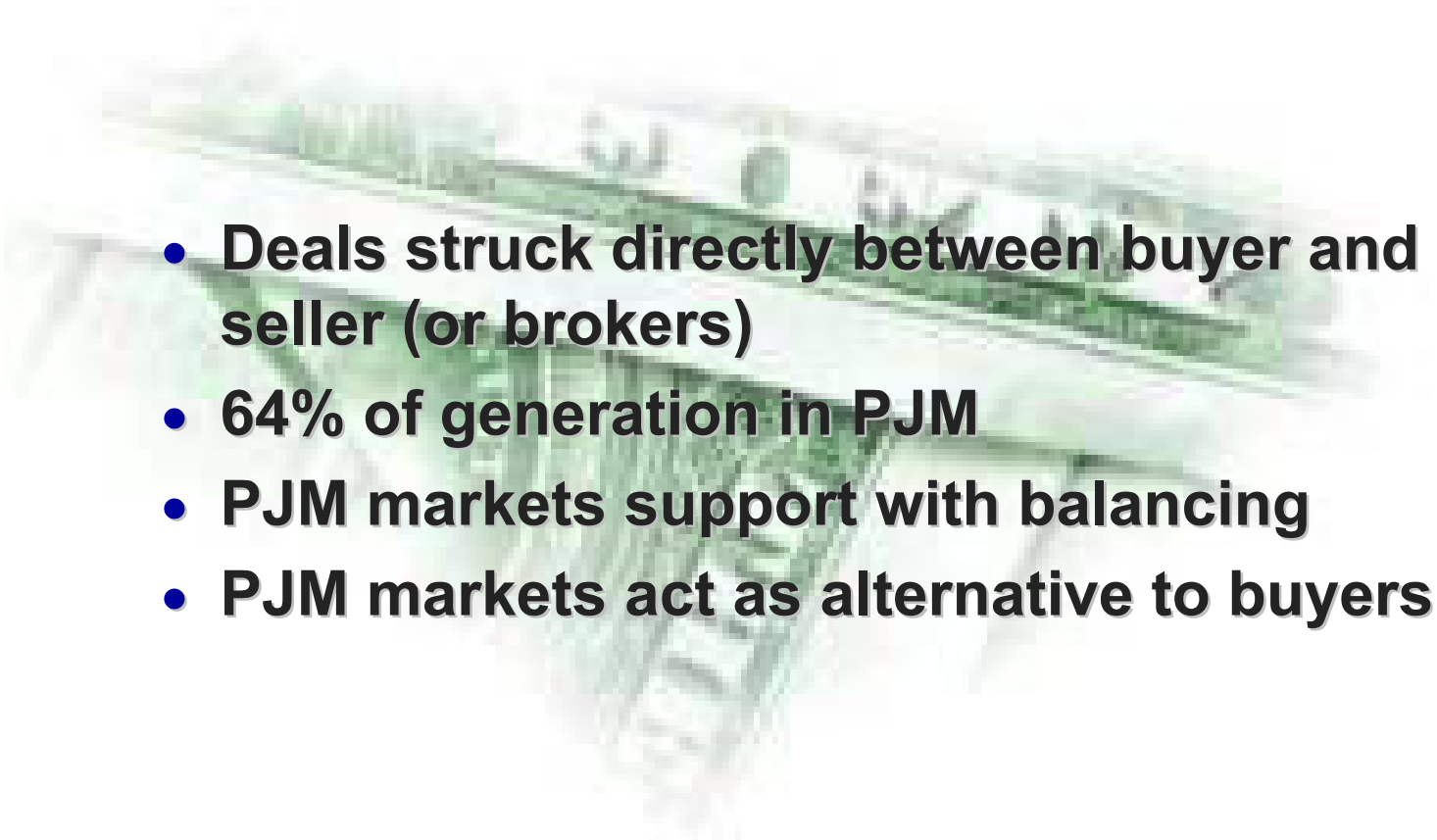
PJM Markets

- Day-Ahead Energy Market
- Real-Time Energy Market
- Bilateral Markets
- Daily Capacity Market
- Monthly/Multi-Monthly Capacity Market
- Regulation Market
- Spinning Reserve Market (2002)
- Monthly Financial Transmission Rights (FTR) Auction

PJM Day-Ahead and Real-Time Energy Markets

- Two-Settlement System
- Bid-based, security-constrained economic dispatch
- Supports bilateral transactions
- Alternative to forward markets
- 36% of all energy in PJM is sold in both markets
- $1,000 bid cap

PJM Bilateral Markets



- Deals struck directly between buyer and seller (or brokers)
- 64% of generation in PJM
- PJM markets support with balancing
- PJM markets act as alternative to buyers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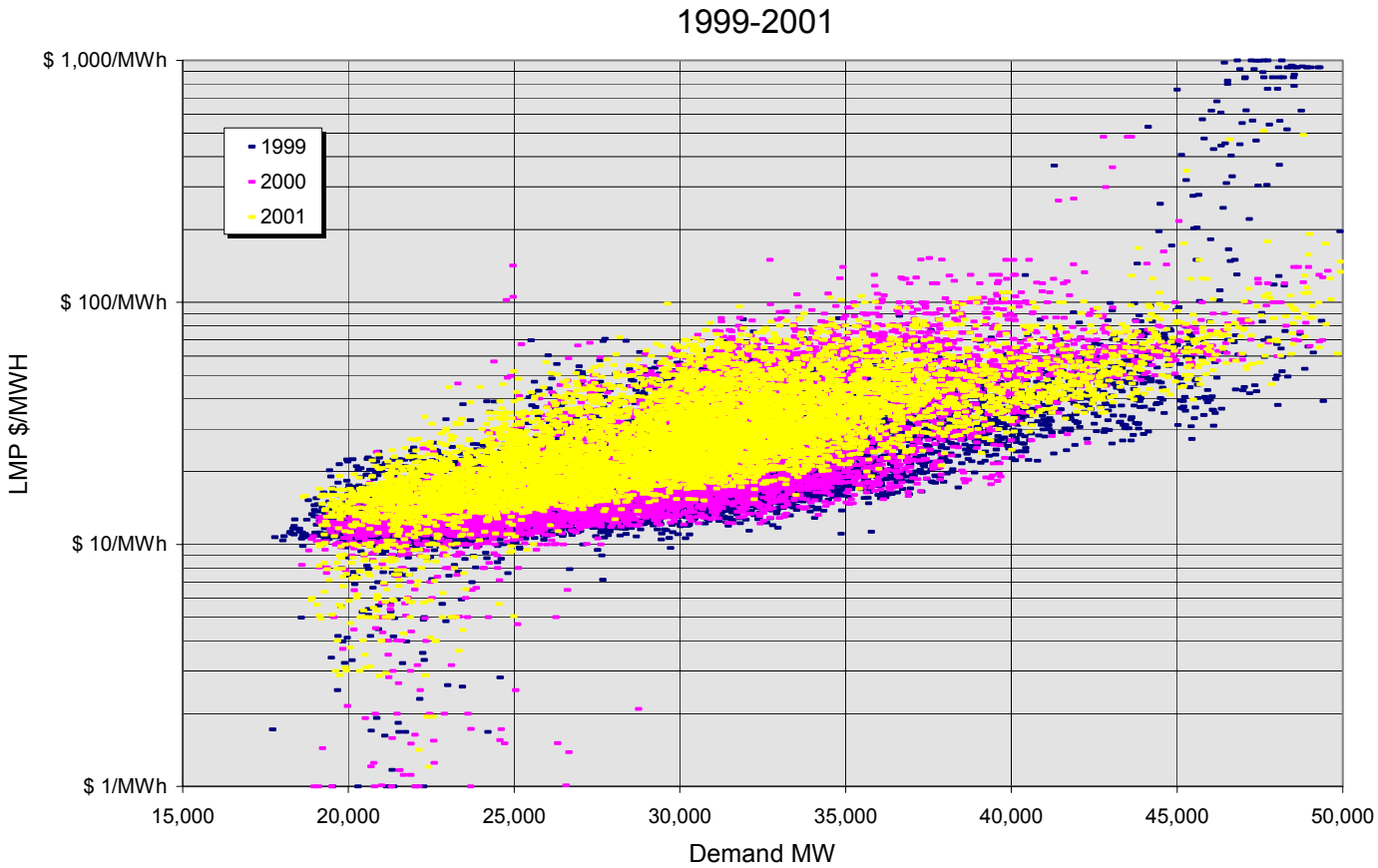
PJM Day-Ahead Energy Market

- 15% of spot markets in 2001
- Financial hedge
- PJM estimates next day demand requirements
- PJM accepts and stacks bids
- PJM publishes next-day hourly prices
- All successful bidders receive highest price bid
- Prices differ based on congestion
- Locational Marginal Pricing, or LMP

PJM Energy Markets - LMP

- LMP - “the cost of supplying the next MW of load at a specific location, considering generation marginal cost, cost of transmission congestion, and losses.”
- Least-cost security-constrained algorithm
- Same at all locations, unless...
- Transmission congestion drives locational differences in LMP

PJM East Day-Ahead LMP vs. Demand

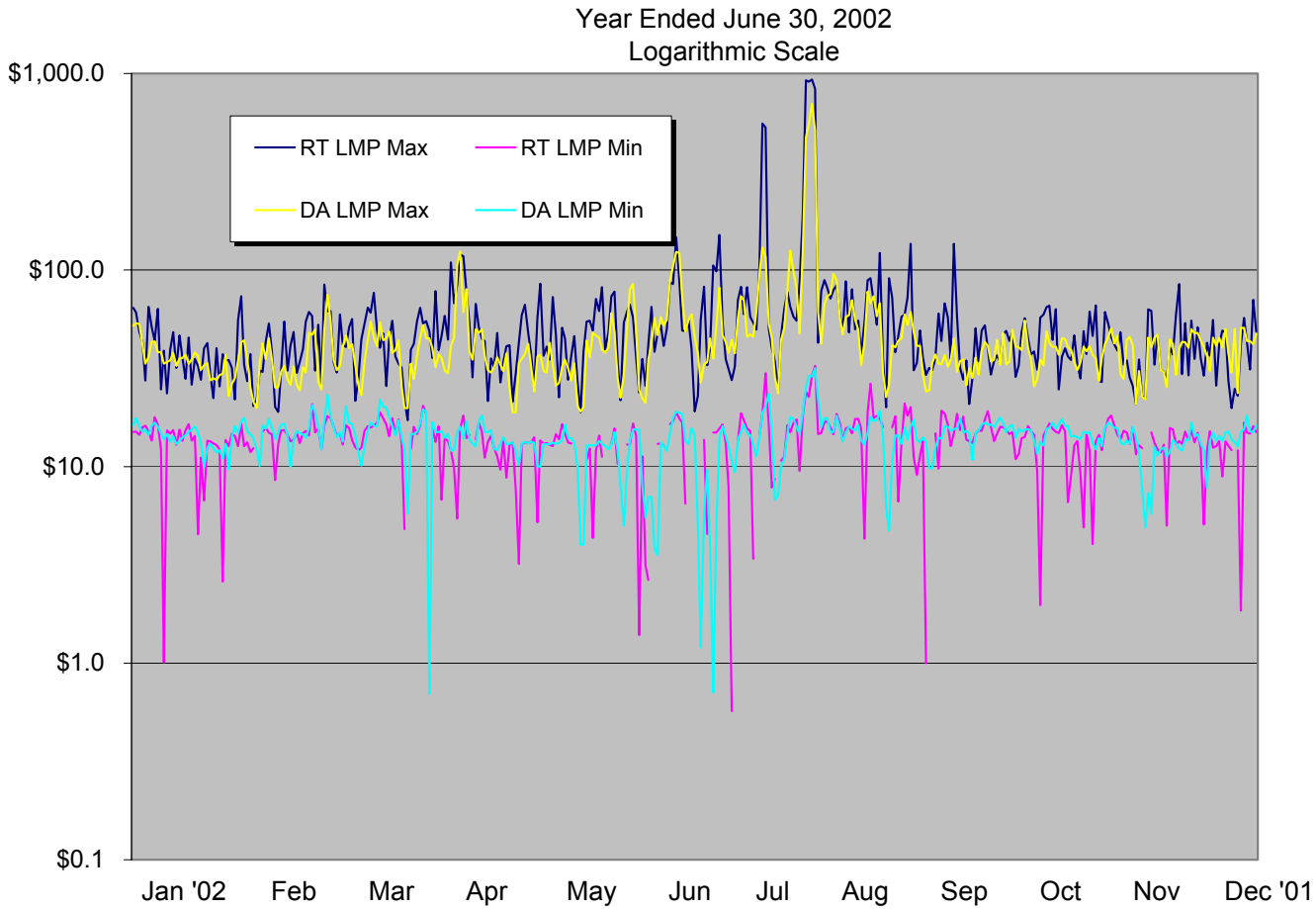


PJM Zone-wide prices

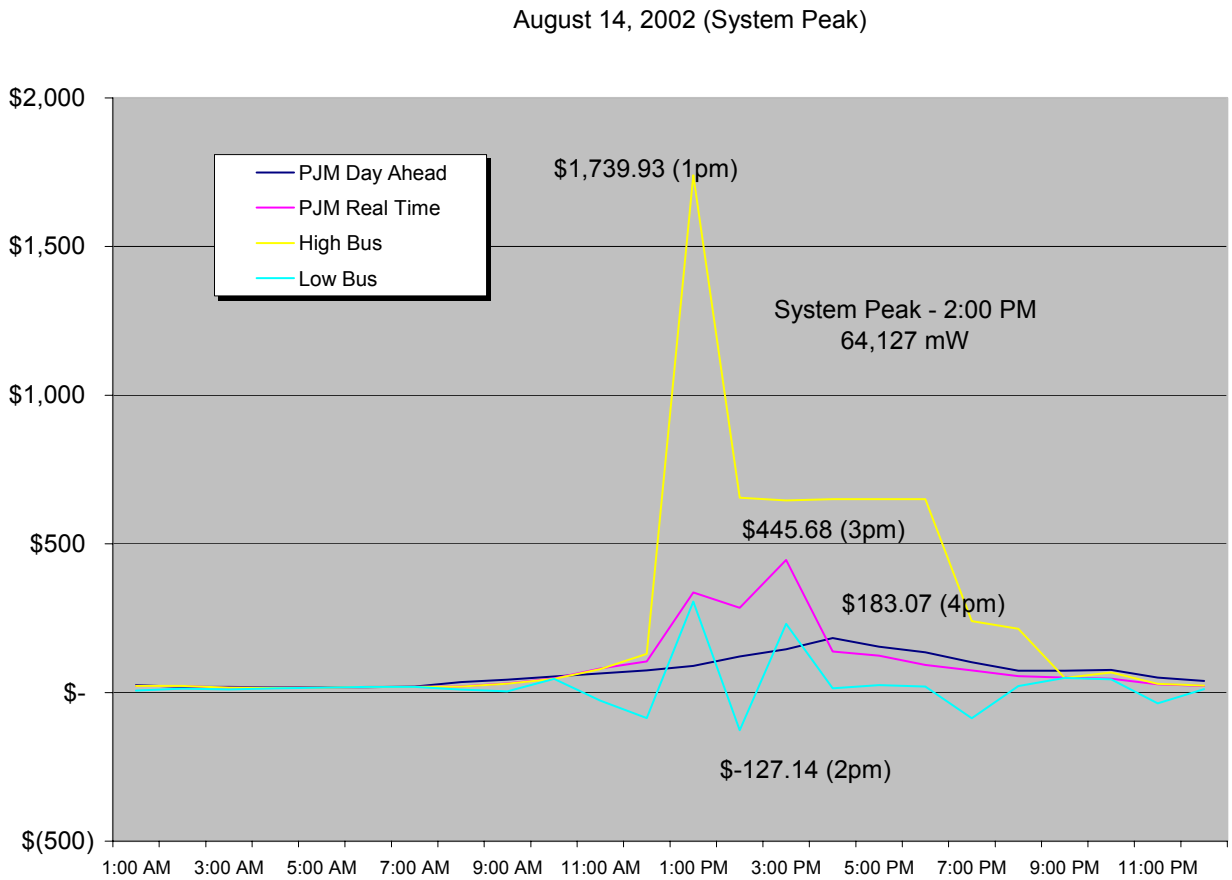
PJM Real-Time Energy Market

- 2001 activity was 21% of average daily loads
- Real-Time prices are based on actual flows
- Market Participants with excess generation are credited
- Market Participants short generation are charged

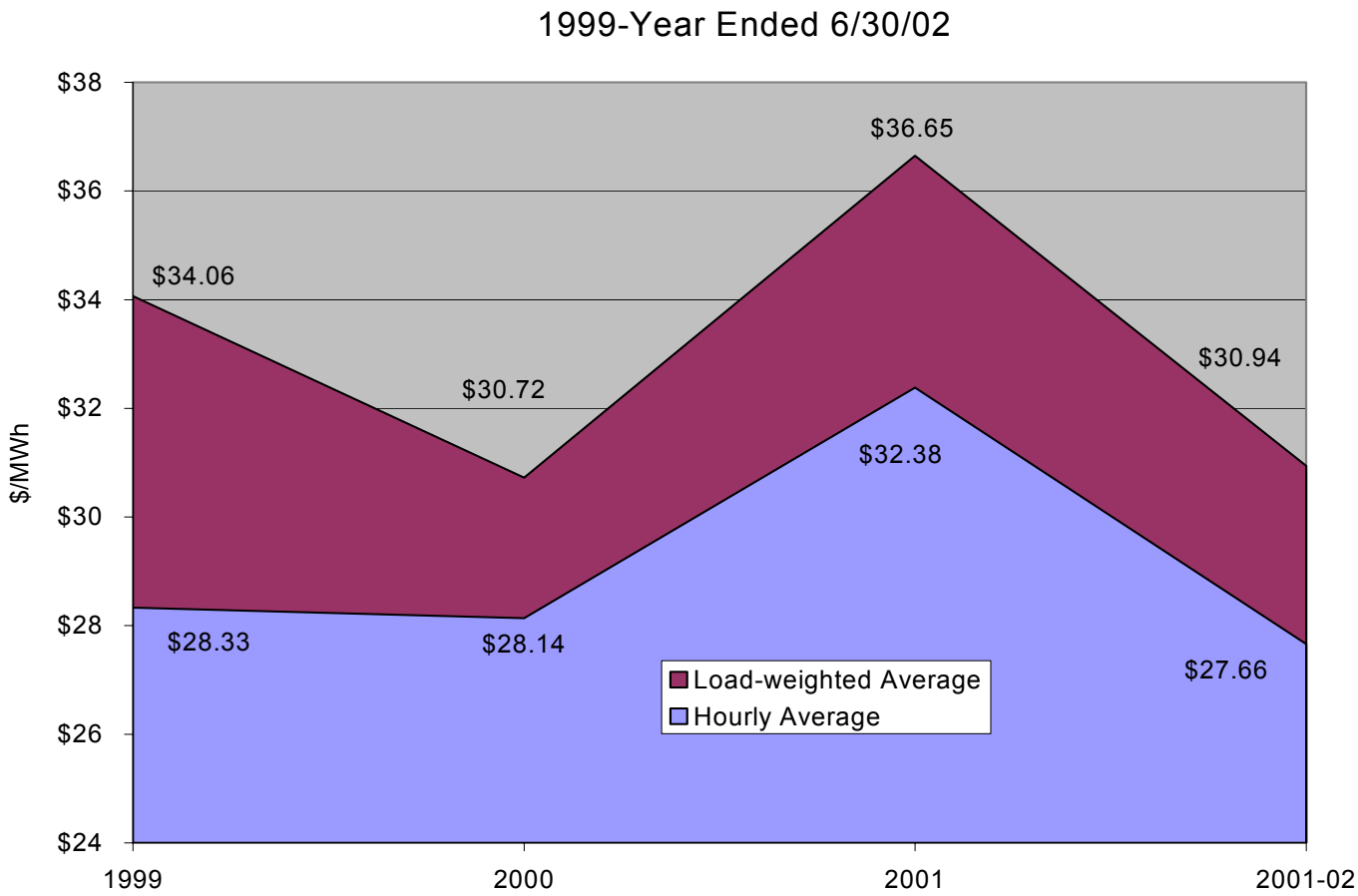
PJM East Real-Time vs. Day-Ahead LMP



Comparison of PJM LMP Spot Prices



Comparison of PJM Spot Prices



Prices and Demand

- Strong correlation between price and demand
- Strong correlation between cost and price
- Volatility has dampened
- Excess capacity
- Addition of PJM West

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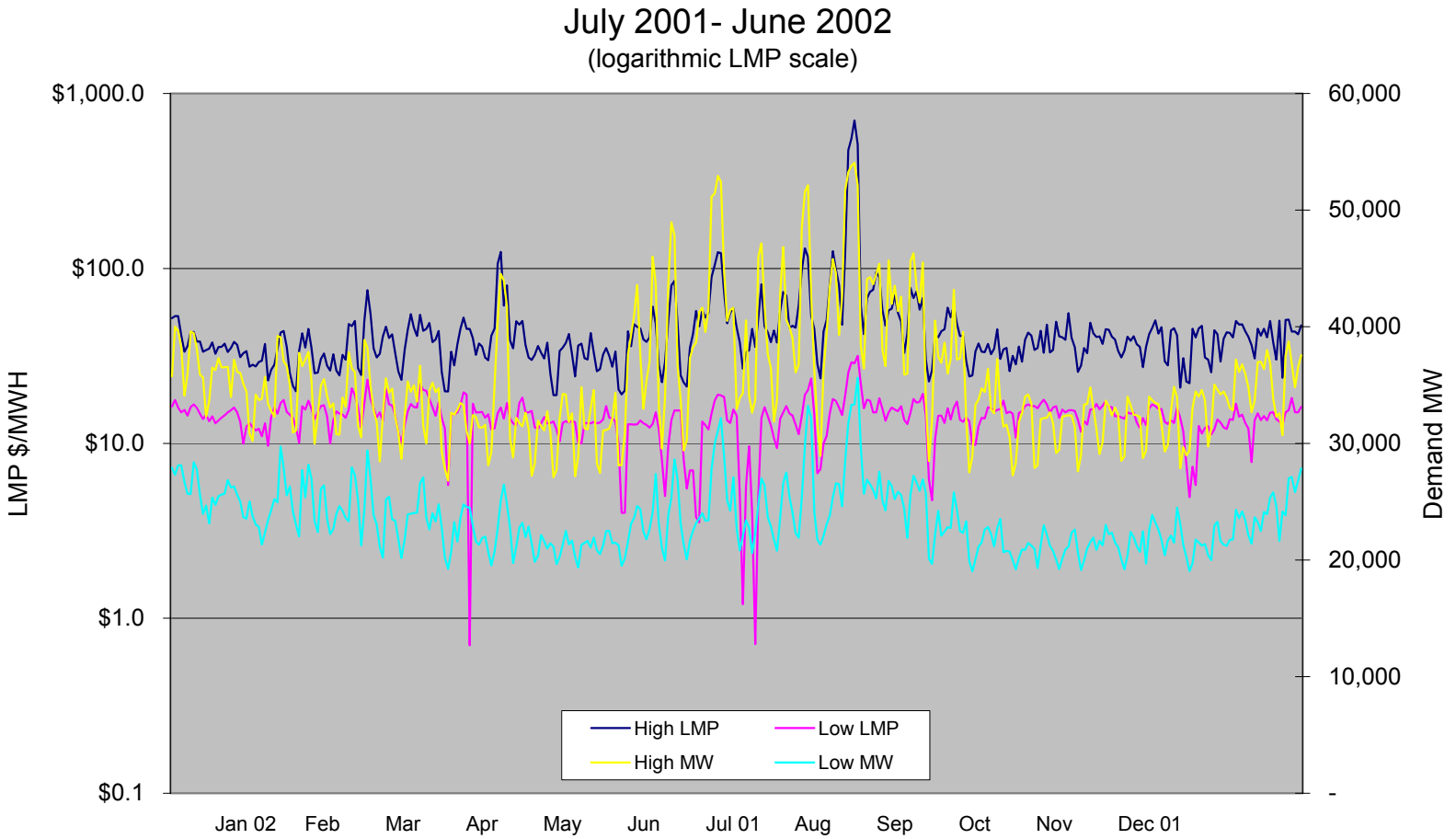
PJM East Prices and Demand
(Day-Ahead)



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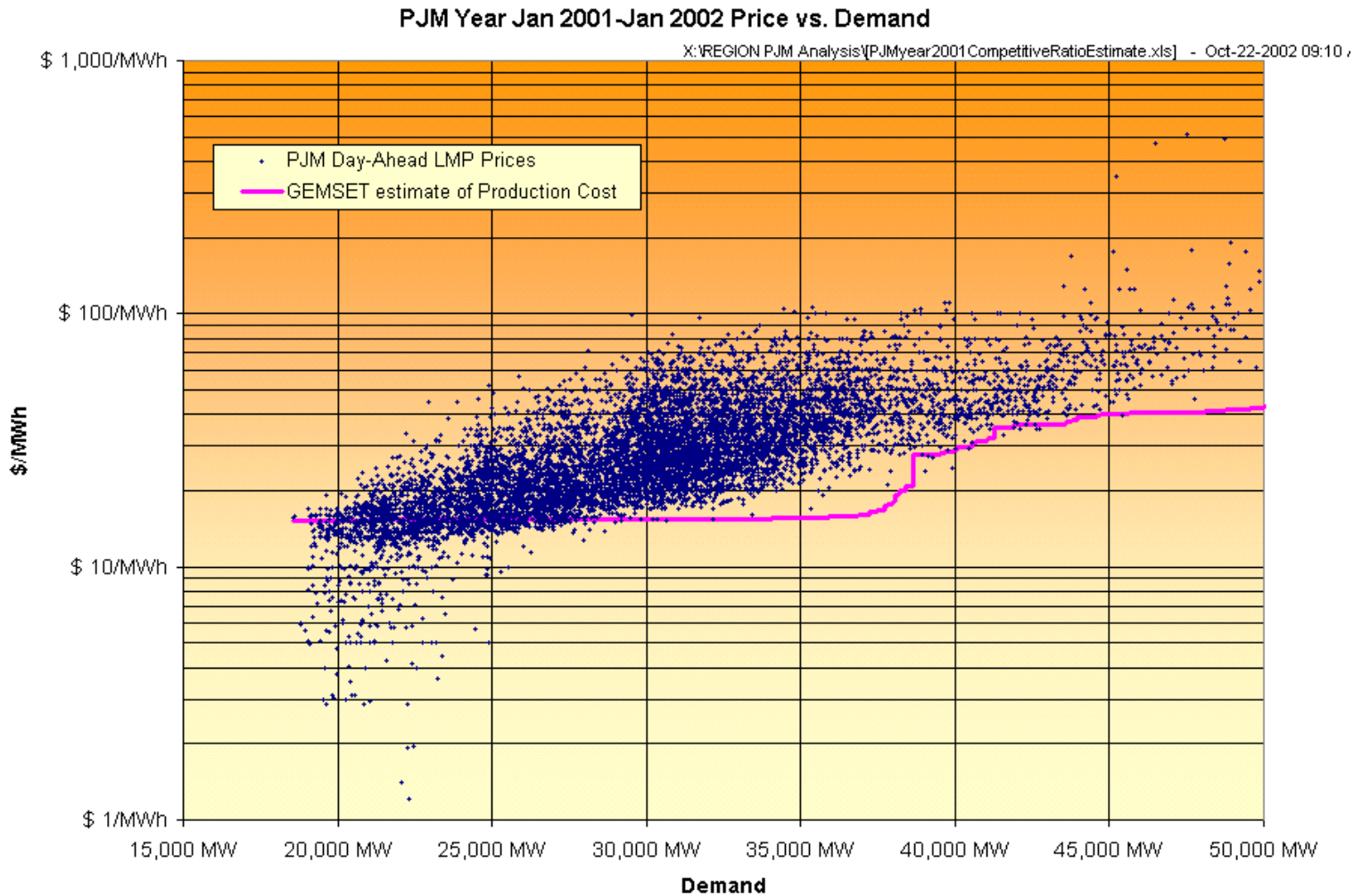
PJM Price vs. Demand Compared to GEMSET Estimate of Production Cost

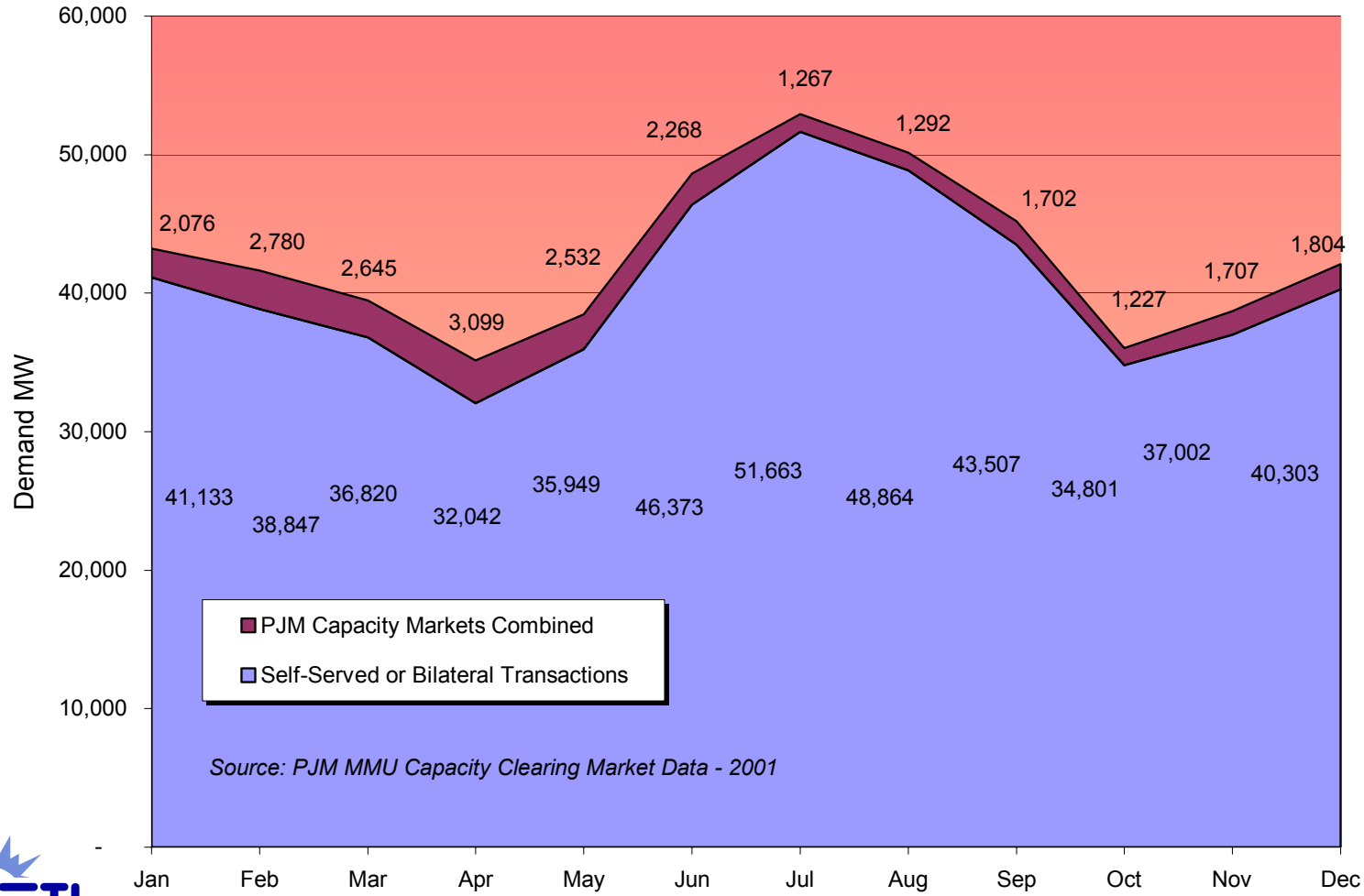


PJM Capacity Markets

- Load Serving Entities (LSEs) must own or acquire Capacity Resources
- Capacity is separate and distinct from energy
- Capacity Resources may be owned, contracted for or purchased in PJM Markets
- Failure to provide Capacity results in Capacity Deficiency Payments for remainder of interval
- Vast majority of capacity is bilateral

PJM East Capacity – Bilateral vs. PJM Markets

2001



PJM Capacity Markets

- Method is called Installed Capacity (ICAP)
- PJM West has different methodology (ACAP)
- Encourage new generation when needed via ICAP and LMP
- Capacity Resources must bid into the Day-Ahead energy market
- Capacity Resources must make energy available for emergencies
- Value of capacity changes as available system generation changes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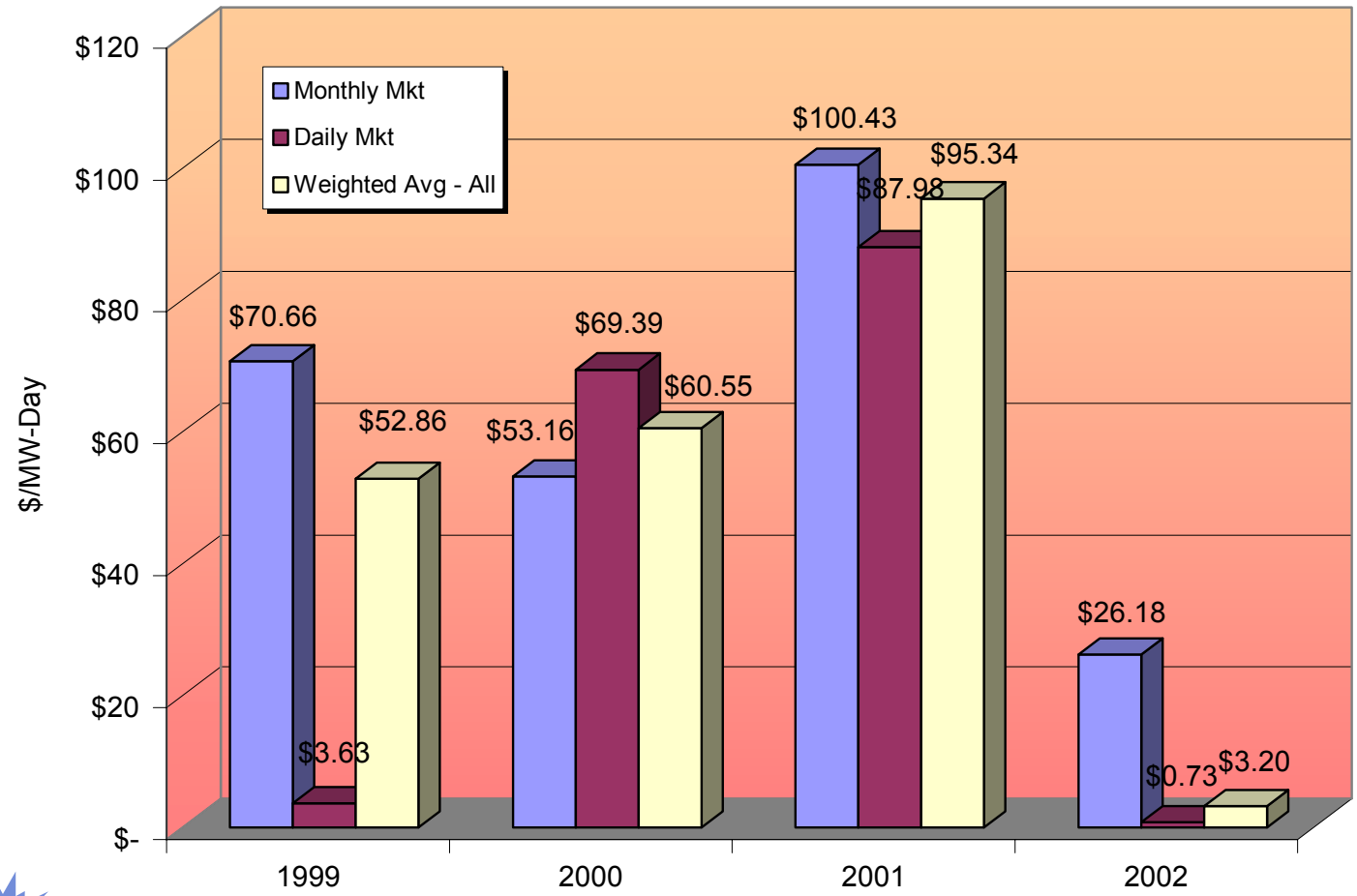
PJM Capacity Markets

- Daily Market allows LSEs to balance their changing requirements
- Monthly/Multi-month markets allow longer-term Capacity sales
- CDR revenues go to Capacity Resources that bid into the interval markets
- Three intervals: Jan-May, June-Sep,Oct-Dec
- Average PJM East Capacity clearing price 2001 = $95.34 MW/Day

PJM East Capacity Credit Market Clearing Prices

1999-2002



Ancillary Services

1. Scheduling, system control and dispatch
2. Reactive supply and voltage control
3. Regulation and frequency response
4. Energy imbalance service
5. Operating Reserve – Spinning Reserve
6. Operating Reserve – Supplemental Reserve

PJM Regulation Market

- Regulation is generation capacity under automatic control that can respond within five minutes
- Regulation Market instituted June 2000
- Bids stack like energy or capacity ($100 max. bid)
- 2001 requirements were for 200-600 MW daily
- 144 units in PJM East can supply
- PJM West bids in at cost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Operating Reserves

- Set aside for emergencies
- PJM East requirement is 19%- West is 11.4%
- Reserve payments include LMP and/or opportunity cost
- Spinning Market to open in 2002 – run similar to Regulation Market
- Average operating reserve revenue per MW in PJM in 2001 = $4,275

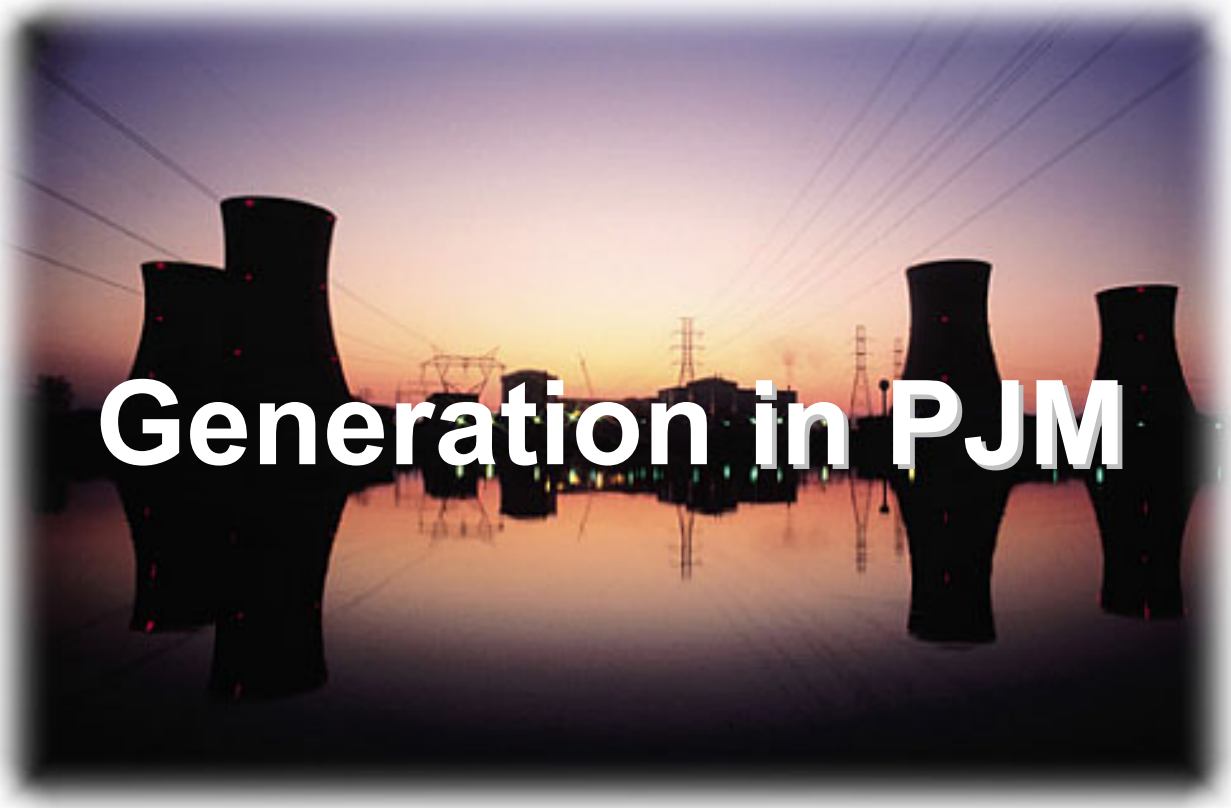
Financial Transmission Rights (FTRs)

- Congestion pricing - thermal limits
- FTRs are a financial hedge
- Defined from sink to source
- Financially binding
- A financial entitlement, not a physical right
- Based on MWs of transmission reservation separate and independent of energy delivery

Financial Transmission Rights (FTRs)

- Credited when in the same direction
- Charged when configured opposite
- Paid by collection of congestion charges
- Traded bilaterally or bought in the PJM FTR auction
- Changes are being discussed at PJM and FERC

The PJM Region



Generation in PJM

- Capacity resource or energy-only
- Rigorous project review and testing
- Responsible for transmission enhancements
- Sign Interconnection Agreement with PJM
- Coordinate operation with PJM

New Generation in PJM

- Feasibility Study
- System Impact Study
- Facilities Study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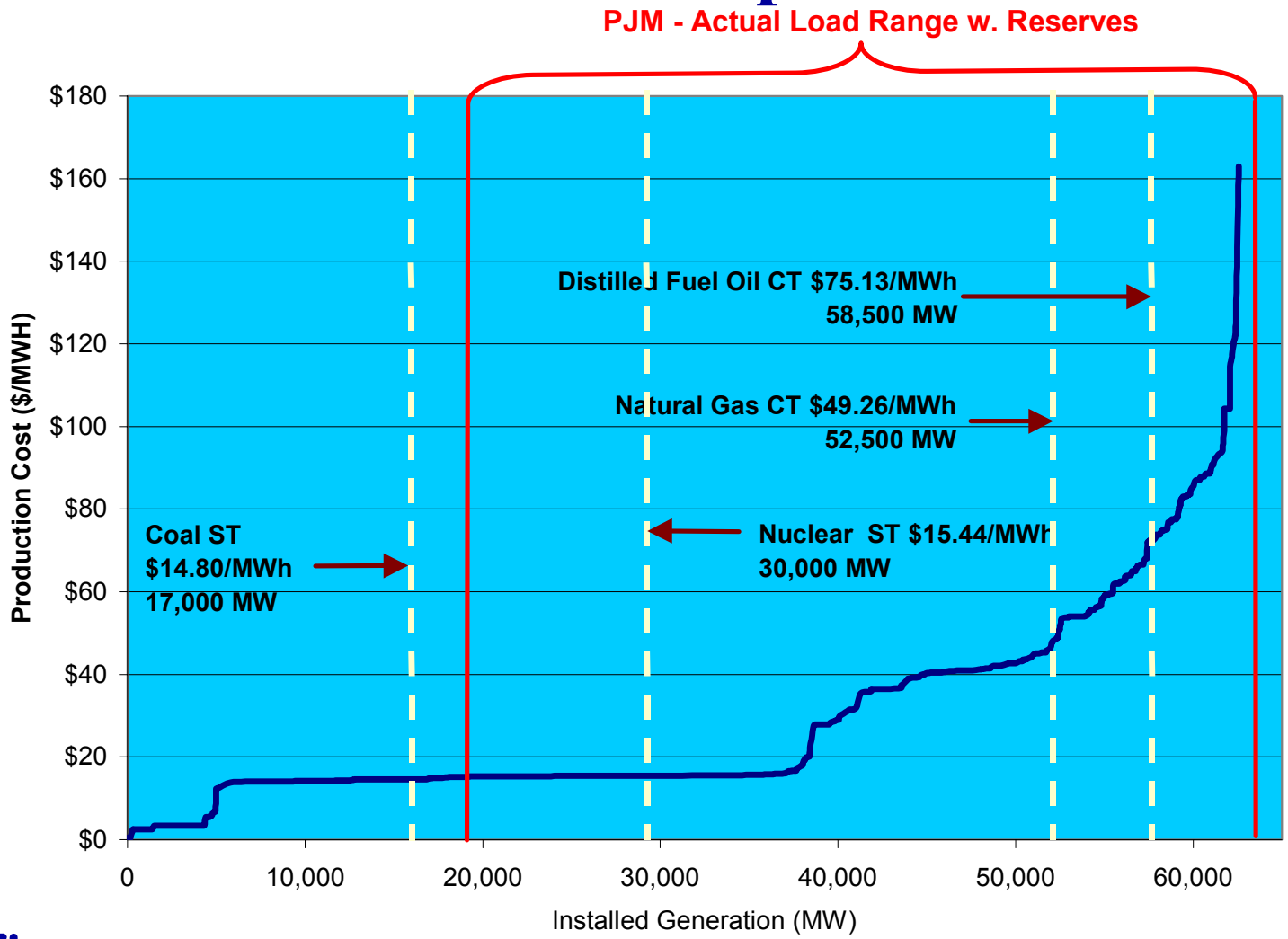
GEMSET Estimate of PJM East Production Costs And Load Dispatch Levels



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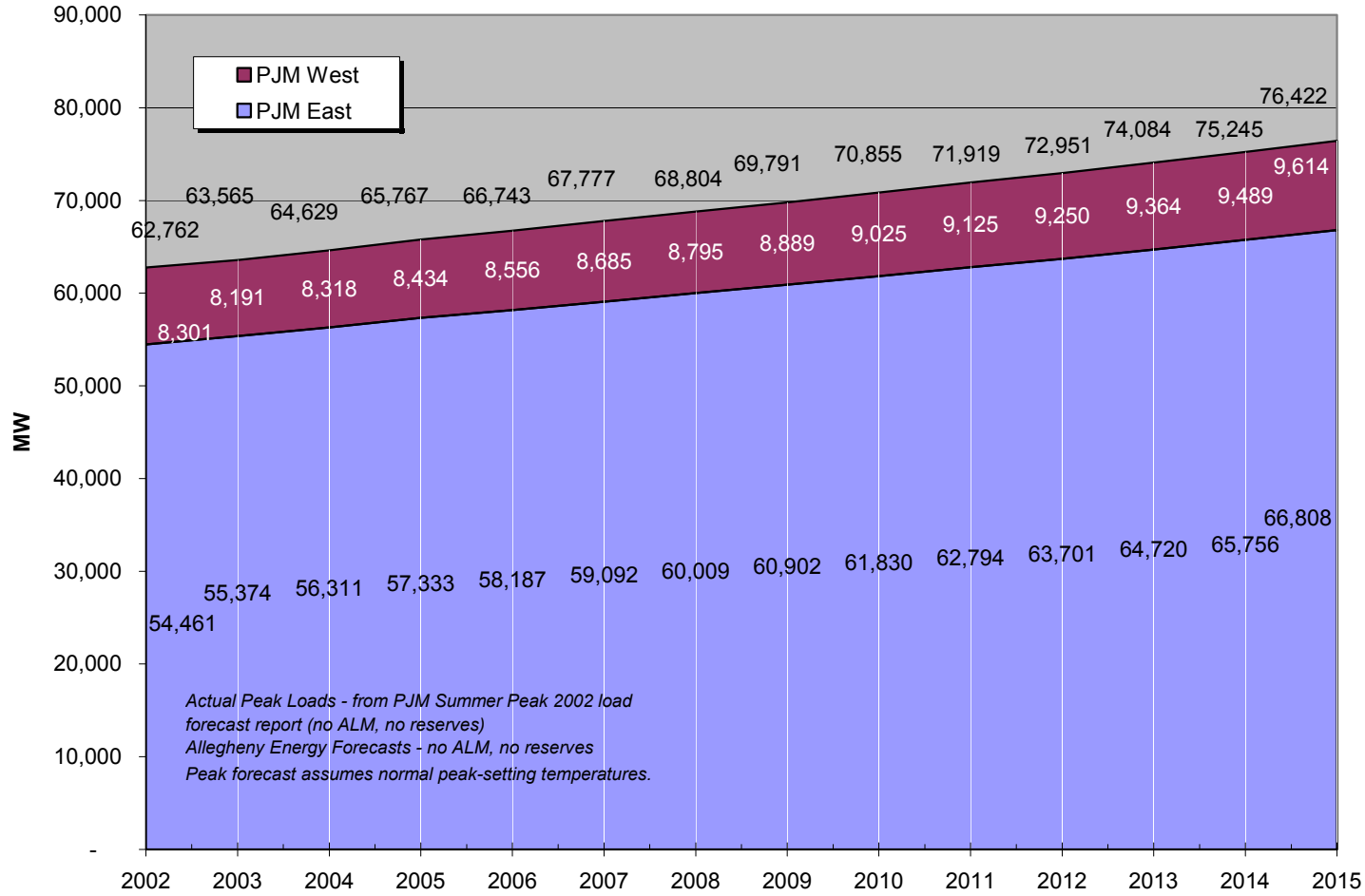
The PJM Region

Load Forecast

- Summer peak expected to grow an average of 1.6% for the next 10 years
- Winter Peak to average 1.5%
- Estimated combined peak (East and West) of > 76,000 MW in 2015
- Load factor constant at 56%
- Future basis of comparison (?)

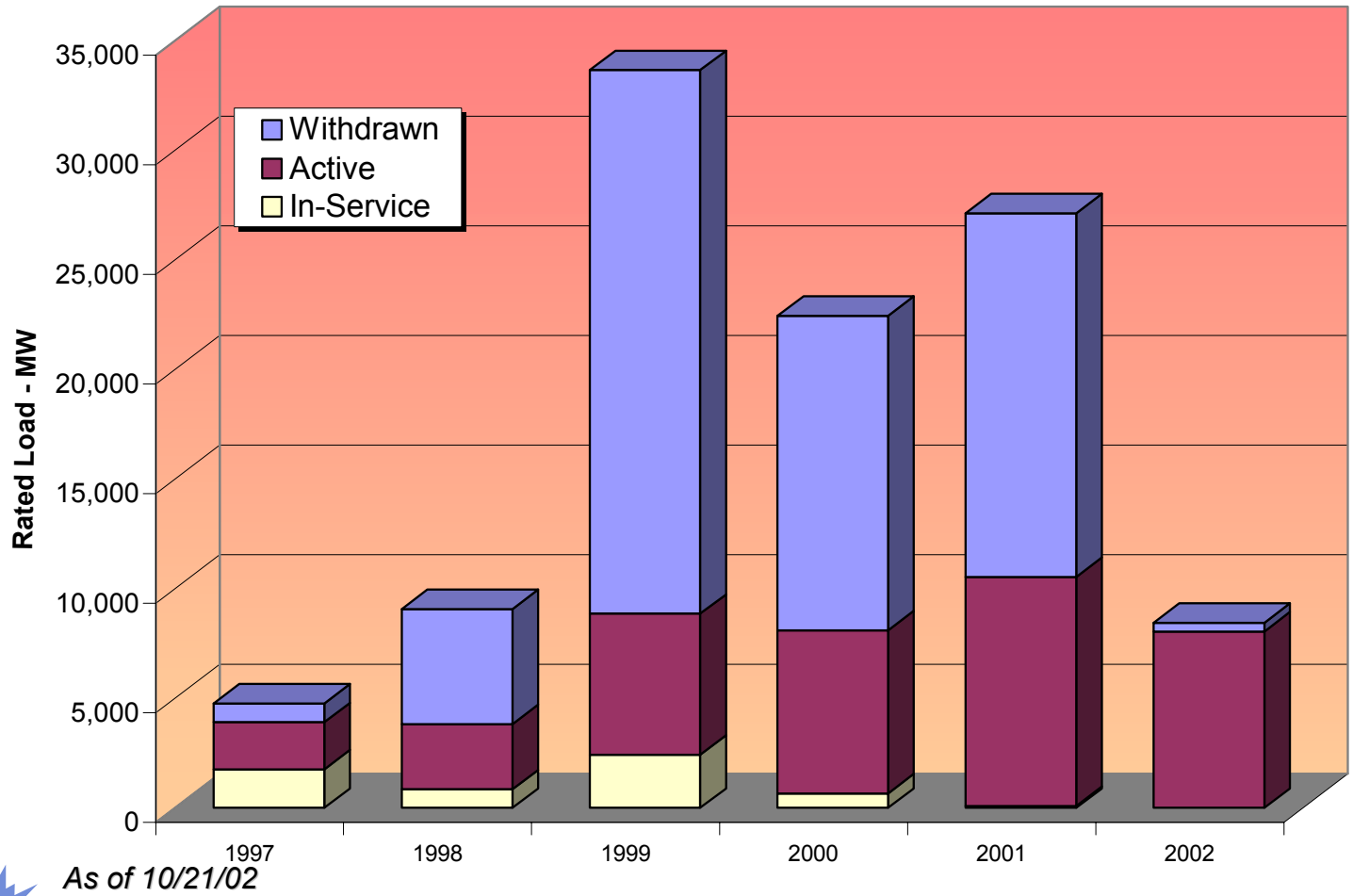
PJM East and West Combined Summer Peak Forecast



Capacity Additions

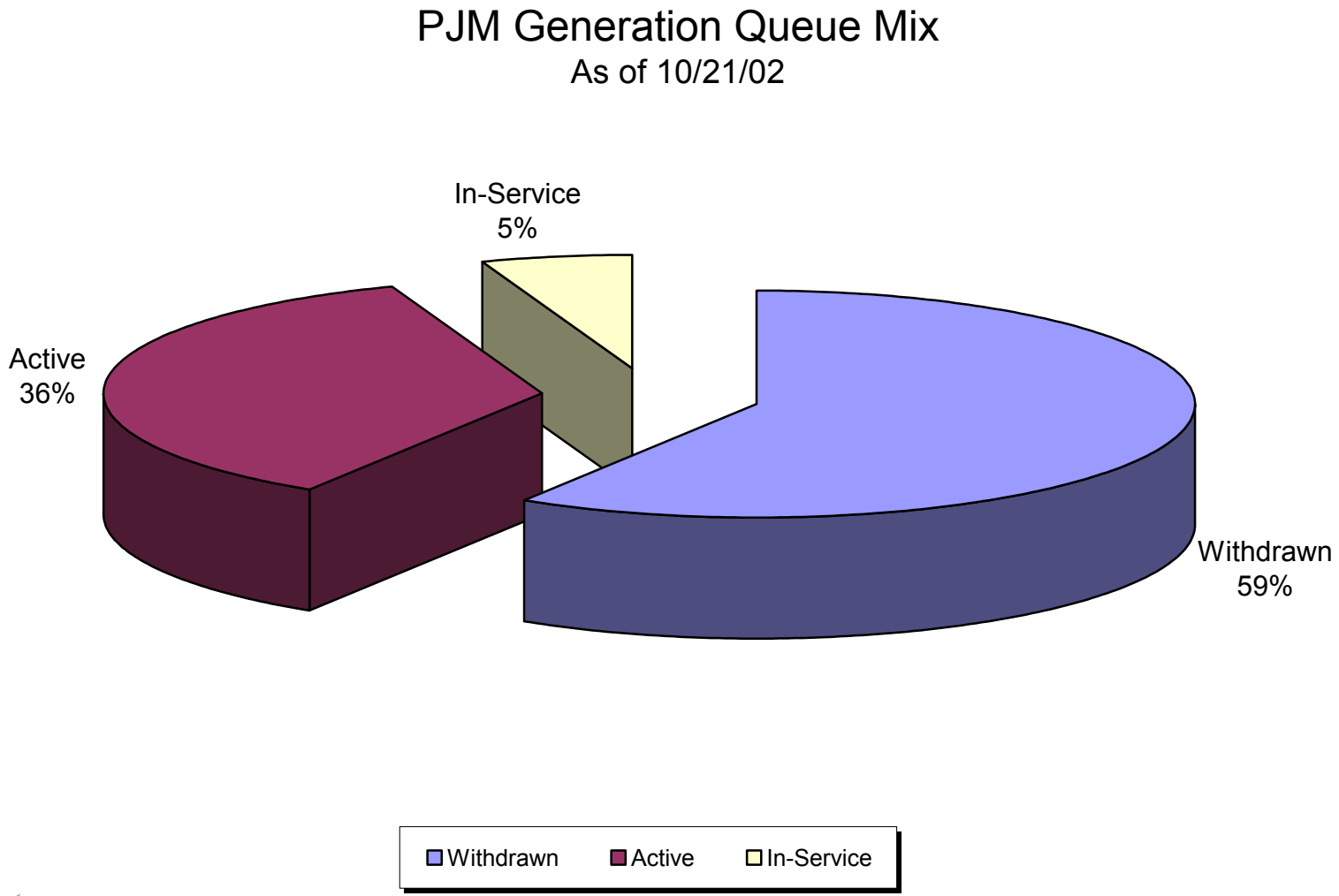
PJM Generation Queue Status

PJM Generation Interconnection Queue
by Queue Date

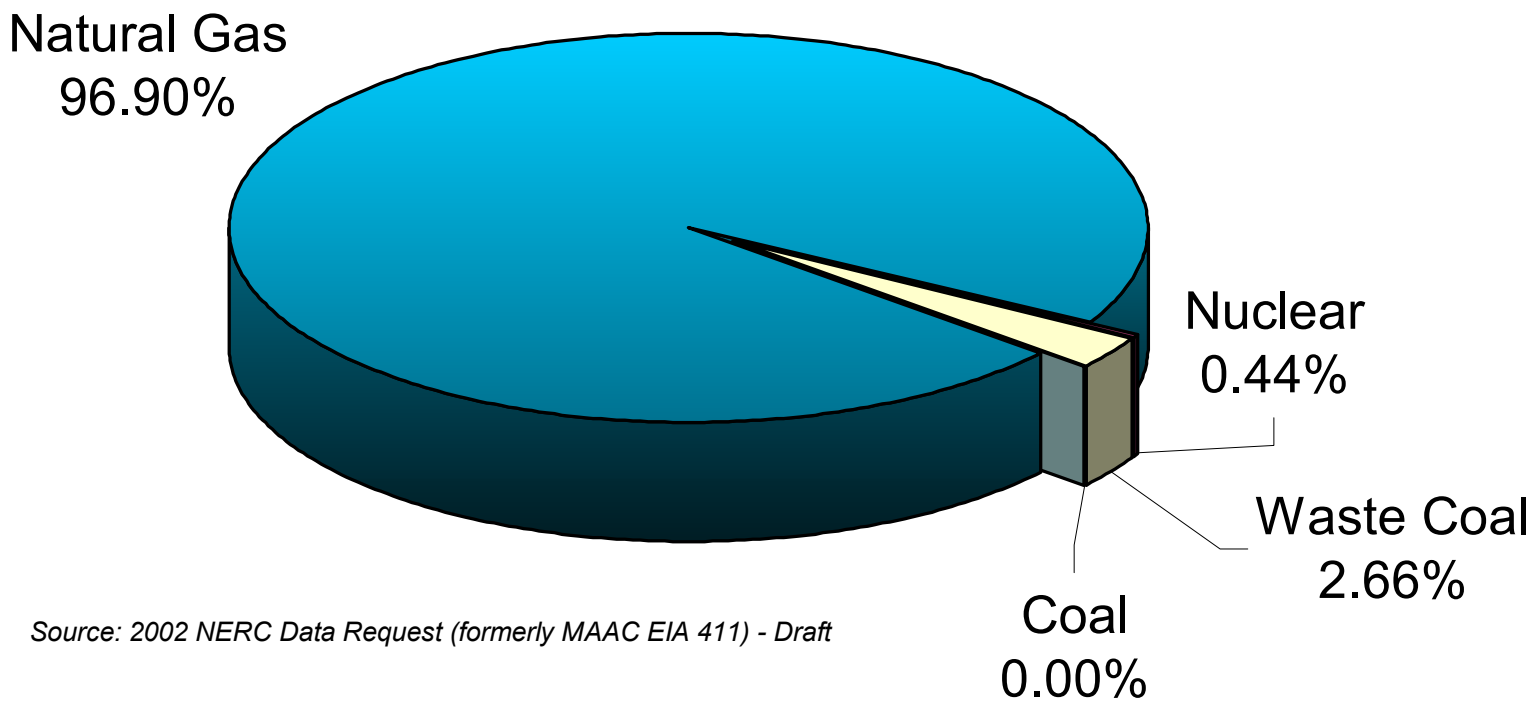


As of 10/21/02

PJM Generation Queue Status

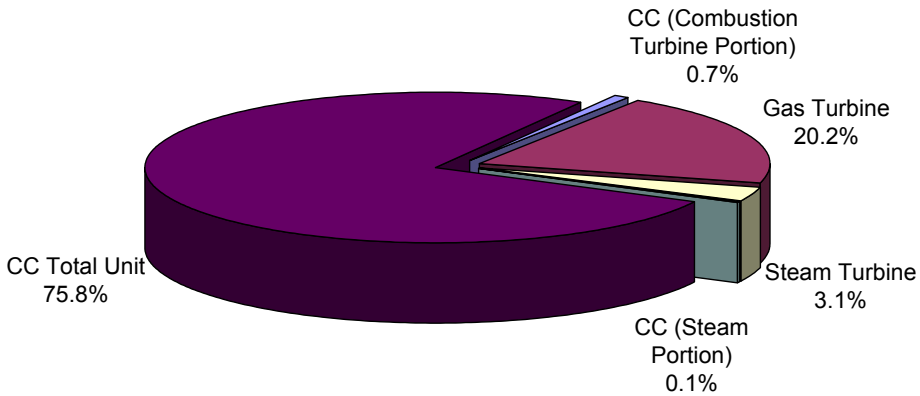


PJM East Planned Generation by Fuel Type

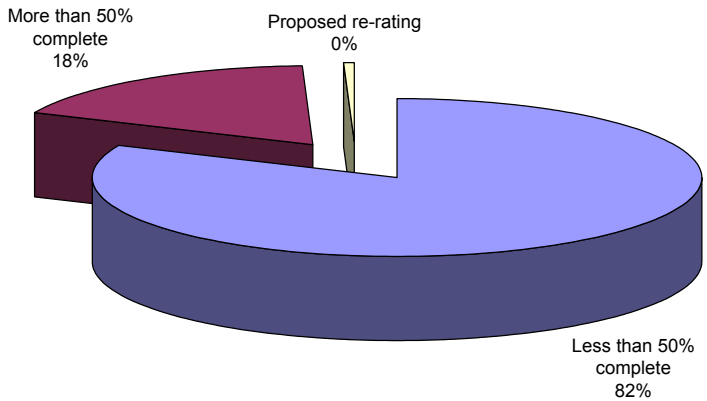


Source: 2002 NERC Data Request (formerly MAAC EIA 411) - Draft

Planned Generation by Prime Mover and Status - PJM East



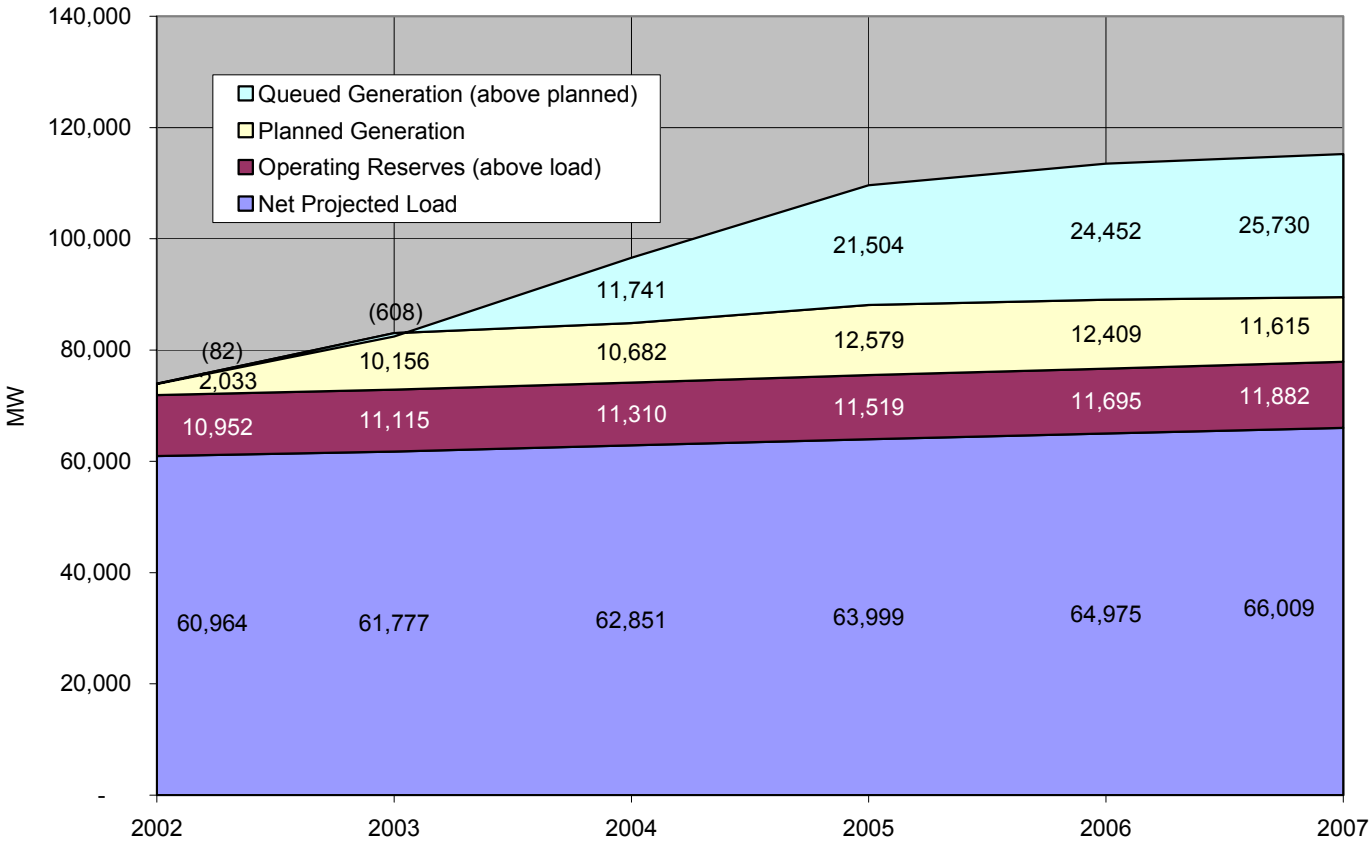
Source: 2002 NERC Data Request (formerly MAAC EIA 411) - Draft



Source: 2002 NERC Data Request (formerly MAAC EIA 411) - Draft

GEMSET Load and Generation Forecast Estimates - Combined PJM

2002-2007

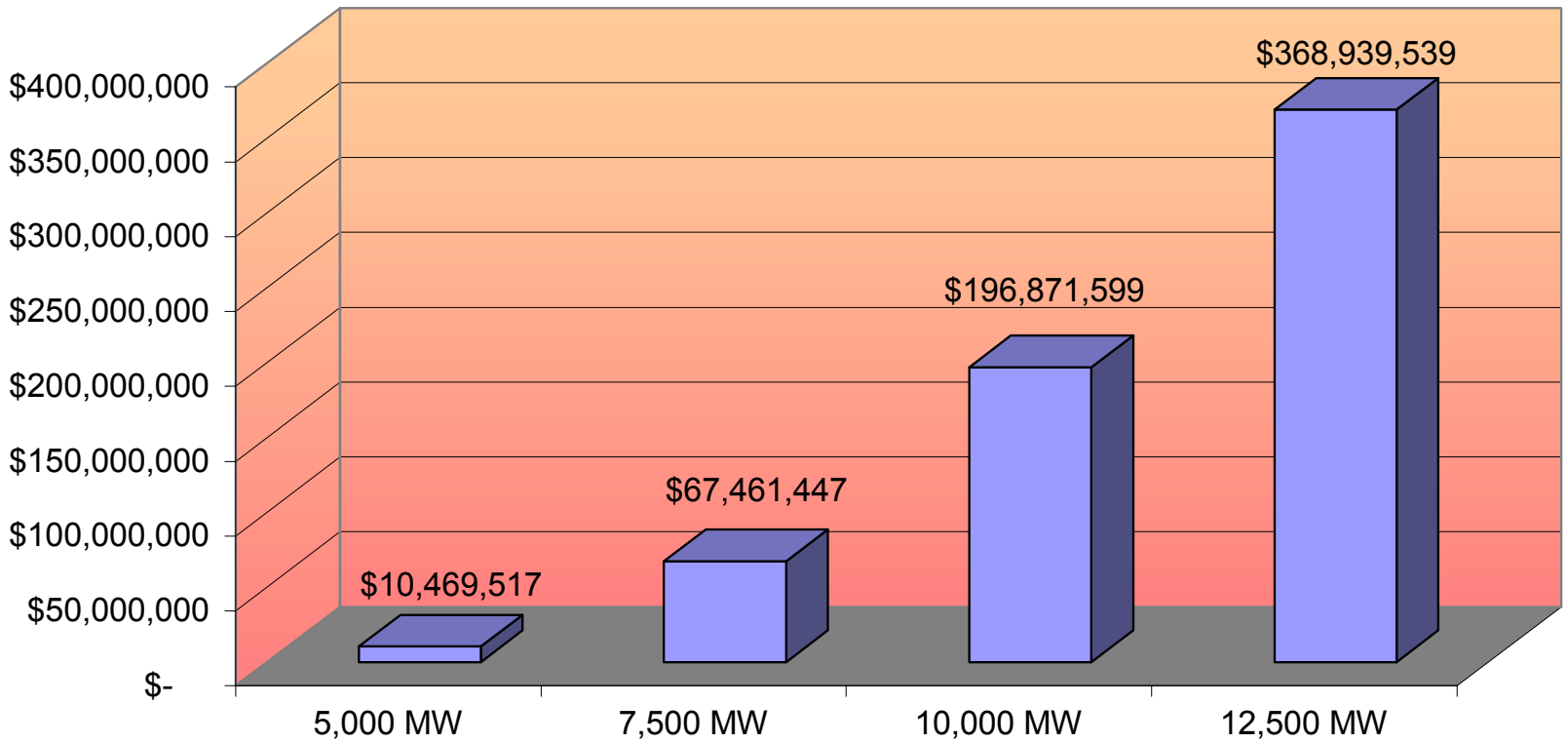


Note: 2004-2007 Data is derived from estimates of queued generation actually being built

DOE GEM-SET Government Energy Market Segment Evaluation Tool

Baseload Migration

GEMSET Projected Price Impact on PJM LMP of Adding Natural Gas CC - Based on 2001 PJM Day-Ahead Market



Assumes same amount of coal or nuclear units retired
Assumes bid prices equal GEMSET composite CC operating costs of $28.32
Total additional costs for oneyear - PJM East

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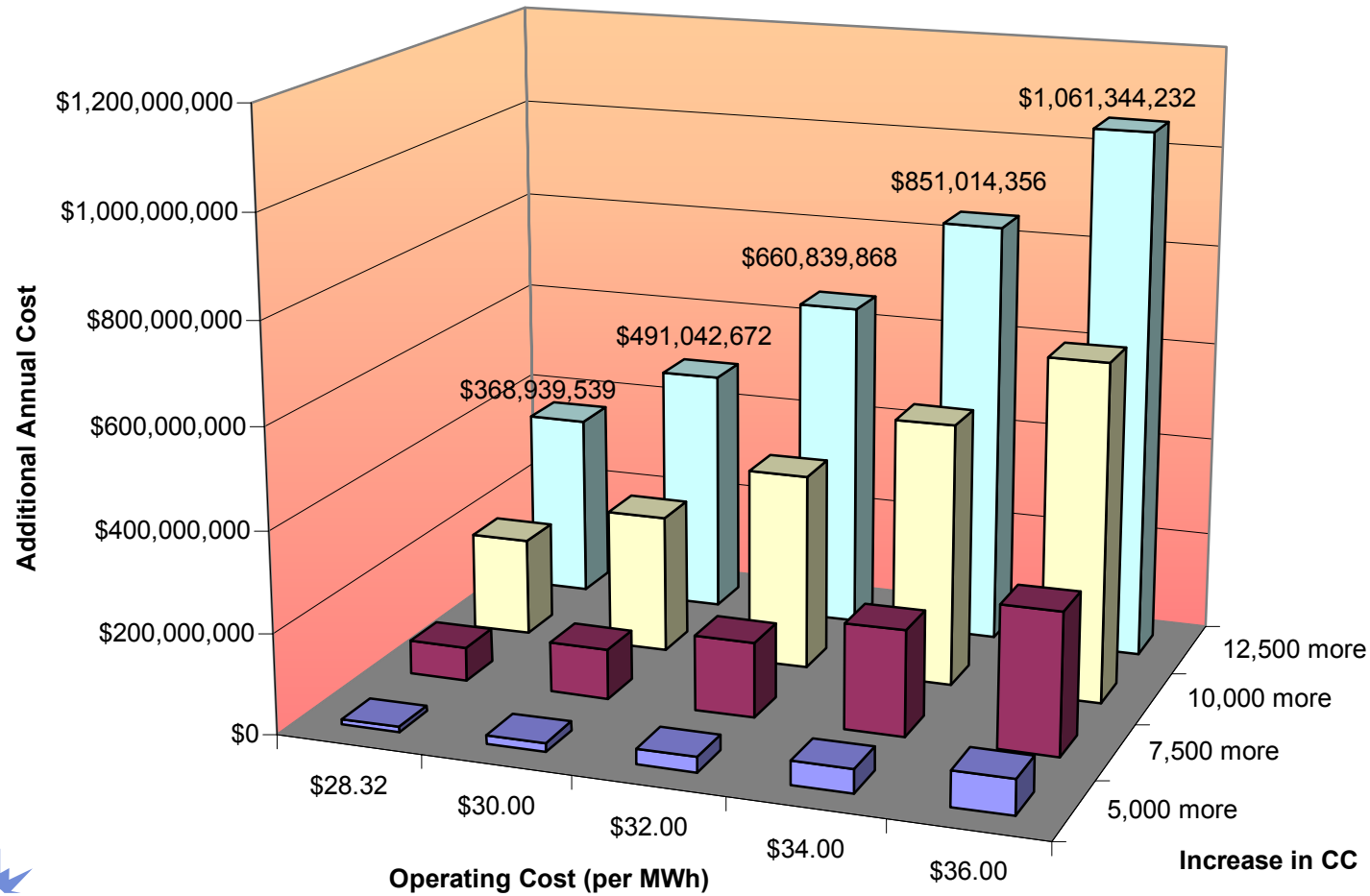
Impact of Natural Gas Prices

Additional Wholesale Costs
Based on 2001 Day-Ahead market



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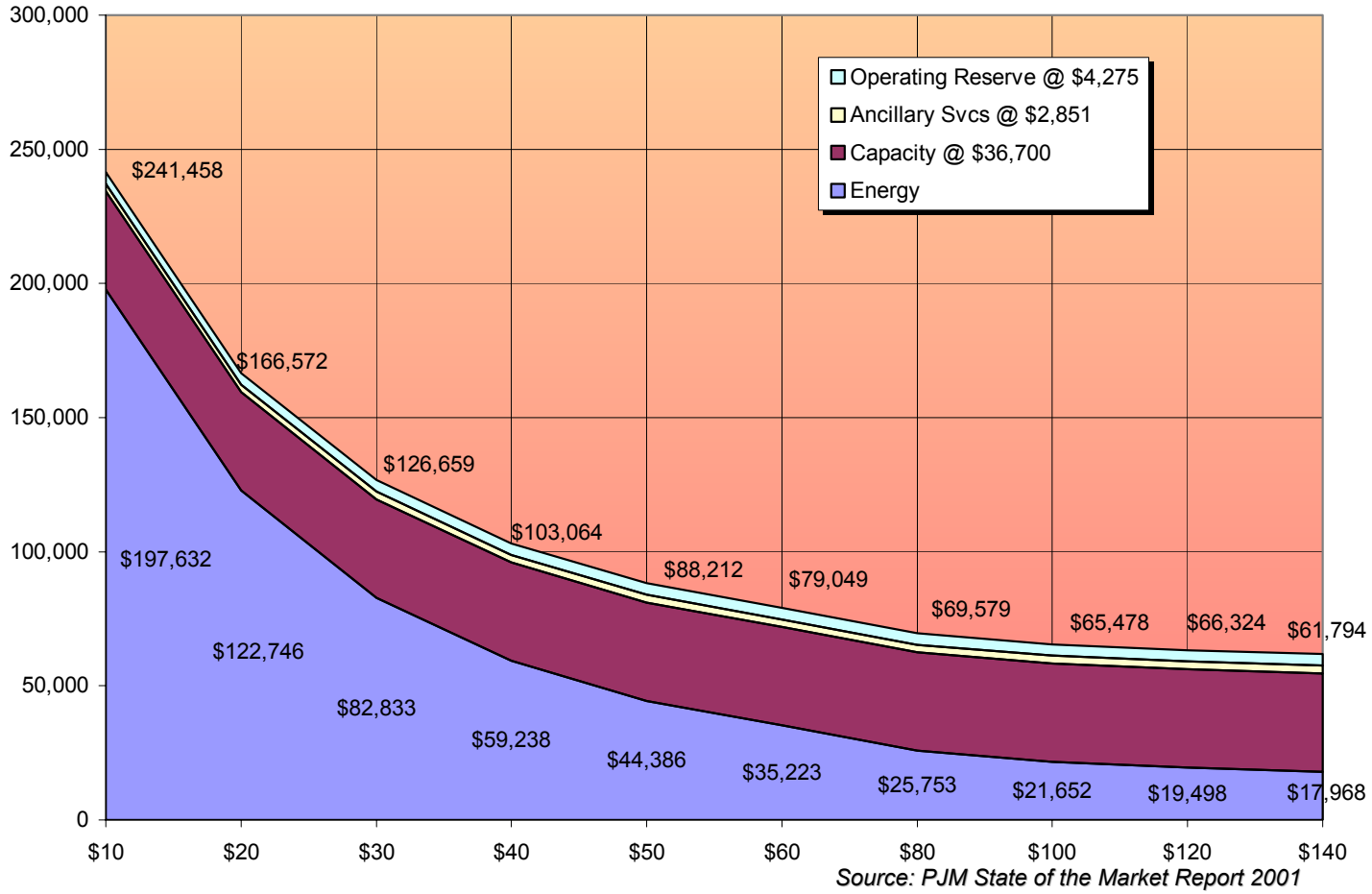
The PJM Region

Potential Generator Revenue in PJM

DOE GEM-SET Government Energy Market Segment Evaluation Tool

Per MW/Year Revenue Projections By Unit Type - PJM East

Based on 2001 Averages - PJM East



Source: PJM State of the Market Report 2001

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DOE GEM-SET Government Energy Market Segment Evaluation Tool

GEMSET Stacking Order

By Fuel/Unit Type - PJM East

Fuel Code	Fuel	Type Code	Unit Type	Avg Cost ($/MWH)	Avg kW	Ttl kW	Percent of Ttl	Weighted Cost	Ttl Units
LFG	Landfill Gas	GT	Gas Turbine	$ 0.31	3	7	0.01%	$ 0.31	2
OBG	Other Biomass Gases	IC	Internal Combustion	$ 0.31	3	13	0.02%	$ 0.31	4
OBG	Other Biomass Gases	ST	Steam Turbine	$ 0.31	9	9	0.01%	$ 0.31	1
OBG	Other Biomass Gases	GT	Gas Turbine	$ 0.31	3.3	3.3	0.01%	$ 0.31	1
LFG	Landfill Gas	IC	Internal Combustion	$ 0.41	3	13	0.02%	$ 0.41	5
LFG	Landfill Gas	ST	Steam Turbine	$ 0.41	27	80	0.13%	$ 0.41	3
OG	Other Gas	ST	Steam Turbine	$ 0.41	11	21	0.03%	$ 0.41	2
BLQ	Black Liquor	ST	Steam Turbine	$ 2.55	42	42	0.07%	$ 2.55	1
MSW	Municipal Solid Waste	OT	Other	$ 2.55	30	60	0.10%	$ 2.55	2
MSW	Municipal Solid Waste	ST	Steam Turbine	$ 2.55	46	370	0.59%	$ 2.55	8
WH	Waste Heat (gas)	CA	CC Steam Part	$ 2.55	127	764	1.22%	$ 2.55	6
WAT	Water	HY	Hydraulic Turbine	$ 3.32	25	1,172	1.87%	$ 3.32	47
WAT	Water	OT	Other	$ 3.32	7	13	0.02%	$ 3.32	2
WAT	Water	PS	Hydro Pumped Storage	$ 3.32	125	1,749	2.80%	$ 3.32	14
WOC	Culm	ST	Steam Turbine	$ 5.53	62	372	0.59%	$ 5.52	6
WC	Waste Coal	ST	Steam Turbine	$ 6.44	55	166	0.27%	$ 6.37	3
WC	Waste Coal	OT	Other	$ 6.89	110	110	0.18%	$ 6.89	1
PC	Petroleum Coke	ST	Steam Turbine	$ 12.35	29	57	0.09%	$ 12.35	2
BIT	**Bituminous**	**ST**	**Steam Turbine**	**$ 15.47**	**290**	**19,430**	**31.06%**	**$ 14.80**	**67**
NUC	**Nuclear**	**ST**	**Steam Turbine**	**$ 15.45**	**1,025**	**13,328**	**21.30%**	**$ 15.44**	**13**
BIT	Bituminous	OT	Other	$ 17.54	68	479	0.77%	$ 17.03	7
BFG	Blast Furnace gas	ST	Steam Turbine	$ 20.18	152	152	0.24%	$ 20.18	1
NG	Natural Gas	CC	Combined Cycle	$ 28.45	165	495	0.79%	$ 28.32	3
NG	Natural Gas	CA	CC Steam Part	$ 28.60	147	147	0.23%	$ 28.60	1
WDS	Wood Solids	ST	Steam Turbine	$ 29.01	13	25	0.04%	$ 28.71	2
NG	Natural Gas	CT	CC Combustion Turbine	$ 34.68	179	1,964	3.14%	$ 33.39	11
RFO	Residual Fuel Oil	IC	Steam Turbine	$ 36.89	6	25	0.04%	$ 36.89	4
NG	Natural Gas	ST	Steam Turbine	$ 41.82	242	3,391	5.42%	$ 39.39	14
RFO	Residual Fuel Oil	ST	Steam Turbine	$ 45.04	206	4,541	7.26%	$ 41.11	22
NG	Natural Gas	CS	CC Single Shaft	$ 43.54	23	47	0.07%	$ 43.54	2
NG	**Natural Gas**	**GT**	**Gas Turbine**	**$ 51.49**	**83**	**5,215**	**8.34%**	**$ 49.26**	**63**
NG	Natural Gas	OT	Other	$ 55.10	54	917	1.47%	$ 54.56	17
NG	Natural Gas	IC	Internal Combustion	$ 57.85	12	12	0.02%	$ 57.85	1
DFO	Distillate Fuel Oil	IC	Internal Combustion	$ 58.02	2	130	0.21%	$ 57.87	55
DFO	Distillate Fuel Oil	ST	Steam Turbine	$ 63.40	275	550	0.88%	$ 63.40	2
DFO	Distillate Fuel Oil	CT	CC Combustion Turbine	$ 72.53	70	280	0.45%	$ 72.53	4
DFO	**Distillate Fuel Oil**	**GT**	**Gas Turbine**	**$ 79.77**	**33**	**5,022**	**8.03%**	**$ 75.13**	**152**
DFO	Distillate Fuel Oil	OT	Other	$ 77.59	16	16	0.03%	$ 77.59	1
KER	Kerosene	GT	Gas Turbine	$ 91.89	76	1,376	2.20%	$ 99.54	18

Sample composite units

Fuel Oil/Kerosene
Biomass/Landfill
Natural Gas
Coal
Water
Other

Bold denotes units used in revenue model

DOE GEM-SET Government Energy Market Segment Evaluation Tool

GEMSET Comparison of Composite Unit Revenues - PJM East 2001

Bituminous Steam Turbine (31%)	
Nominal Rating (MW)	290
Outage Rate	8.43%
Capacity Avail	265.553
Marginal Cost ($/MWh)	$ 14.80

Revenue Source	
Ancillary Services (MW)	$ 2,851.00
Operating Reserves (MW)	$ 4,275.00
Capacity (MW-Day)	$ 95.34

Revenue	
Capacity Factor	92.5%
Hours Run	8,103
Spot Energy	$ 46,169,324
Capacity Revenue	$ 9,241,005
Ancillary Services	$ 826,790
Operating Reserves	$ 1,239,750
Total Net Revenue	**$ 57,476,869**
Net Rev. per hour run	**$ 7,093.28**
Energy Net Rev. MW	**$ 159,204.56**
Energy Net Rev. MWh	**$ 19.65**
Energy Gross Rev. MWh	**$ 34.45**

Nuclear (21%)	
Nominal Rating (MW)	1,025
Outage Rate	8.43%
Capacity Avail	938.5925
Marginal Cost ($/MWh)	$ 15.44

Revenue Source	
Ancillary Services (MW)	$ 2,851.00
Operating Reserves (MW)	$ 4,275.00
Capacity (MW-Day)	$ 95.34

Revenue	
Capacity Factor	89.5%
Hours Run	7,844
Spot Energy	$ 157,956,429
Capacity Revenue	$ 32,662,174
Ancillary Services	$ 2,922,275
Operating Reserves	$ 4,381,875
Total Net Revenue	**$ 197,922,753**
Net Rev. per hour run	**$ 25,232.38**
Energy Net Rev. MW	**$ 154,103.83**
Energy Net Rev. MWh	**$ 19.65**
Energy Gross Rev. MWh	**$ 35.09**

Natural Gas Turbine (8%)	
Nominal Rating (MW)	83
Outage Rate	8.43%
Capacity Avail	76.0031
Marginal Cost ($/MWh)	$ 49.26

Revenue Source	
Ancillary Services (MW)	$ 2,851.00
Operating Reserves (MW)	$ 4,275.00
Capacity (MW-Day)	$ 95.34

Revenue	
Capacity Factor	13.1%
Hours Run	1,145
Spot Energy	$ 2,519,532
Capacity Revenue	$ 2,644,839
Ancillary Services	$ 236,633
Operating Reserves	$ 354,825
Total Net Revenue	**$ 5,755,829**
Net Rev. per hour run	**$ 5,026.93**
Energy Net Rev. MW	**$ 30,355.80**
Energy Net Rev. MWh	**$ 26.51**
Energy Gross Rev. MWh	**$ 75.77**

Fuel Oil Turbine (8%)	
Nominal Rating (MW)	33
Outage Rate	8.43%
Capacity Avail	30.2181
Marginal Cost ($/MWh)	$ 75.13

Revenue Source	
Ancillary Services (MW)	$ 2,851.00
Operating Reserves (MW)	$ 4,275.00
Capacity (MW-Day)	$ 95.34

Revenue	
Capacity Factor	2.8%
Hours Run	246
Spot Energy	$ 523,053
Capacity Revenue	$ 1,051,563
Ancillary Services	$ 94,083
Operating Reserves	$ 141,075
Total Net Revenue	**$ 1,809,774**
Net Rev. per hour run	**$ 7,356.80**
Energy Net Rev. MW	**$ 15,850.09**
Energy Net Rev. MWh	**$ 64.43**
Energy Gross Rev. MWh	**$ 139.56**

Operating Reserve Hours are assumed to be run when not dispatched - 2001 average payment
Capacity is total available unforced capacity sold all year
Ancillary Services and operating reserves assumed to be at 2001 average - from PJM State of the Market report 2001
Energy is dispatched all hours at or above marginal cost - numbers are net of assumed cost
Generator sizes are average of actual composite-type PJM units in the GEMSET Stacking Order

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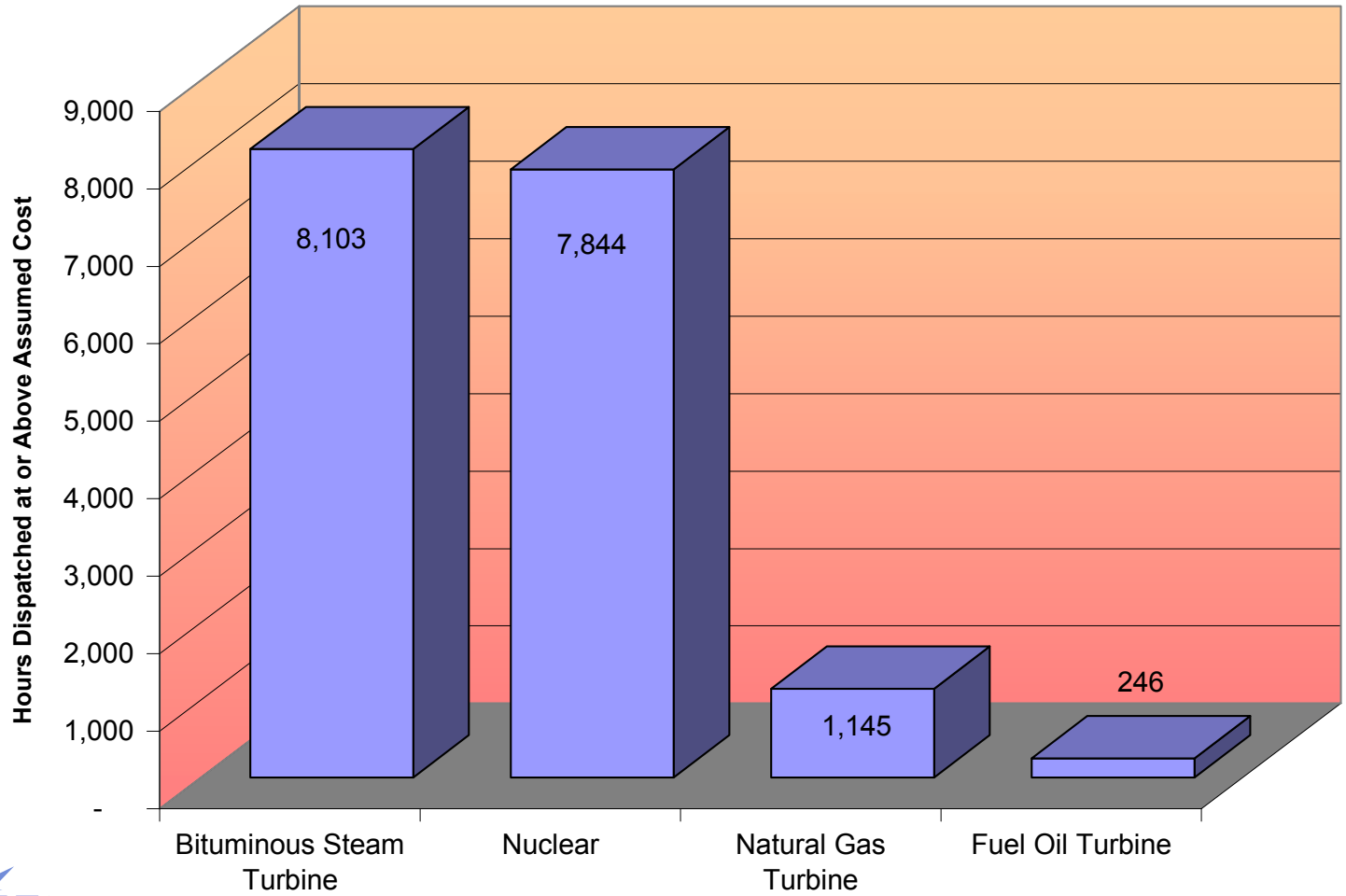
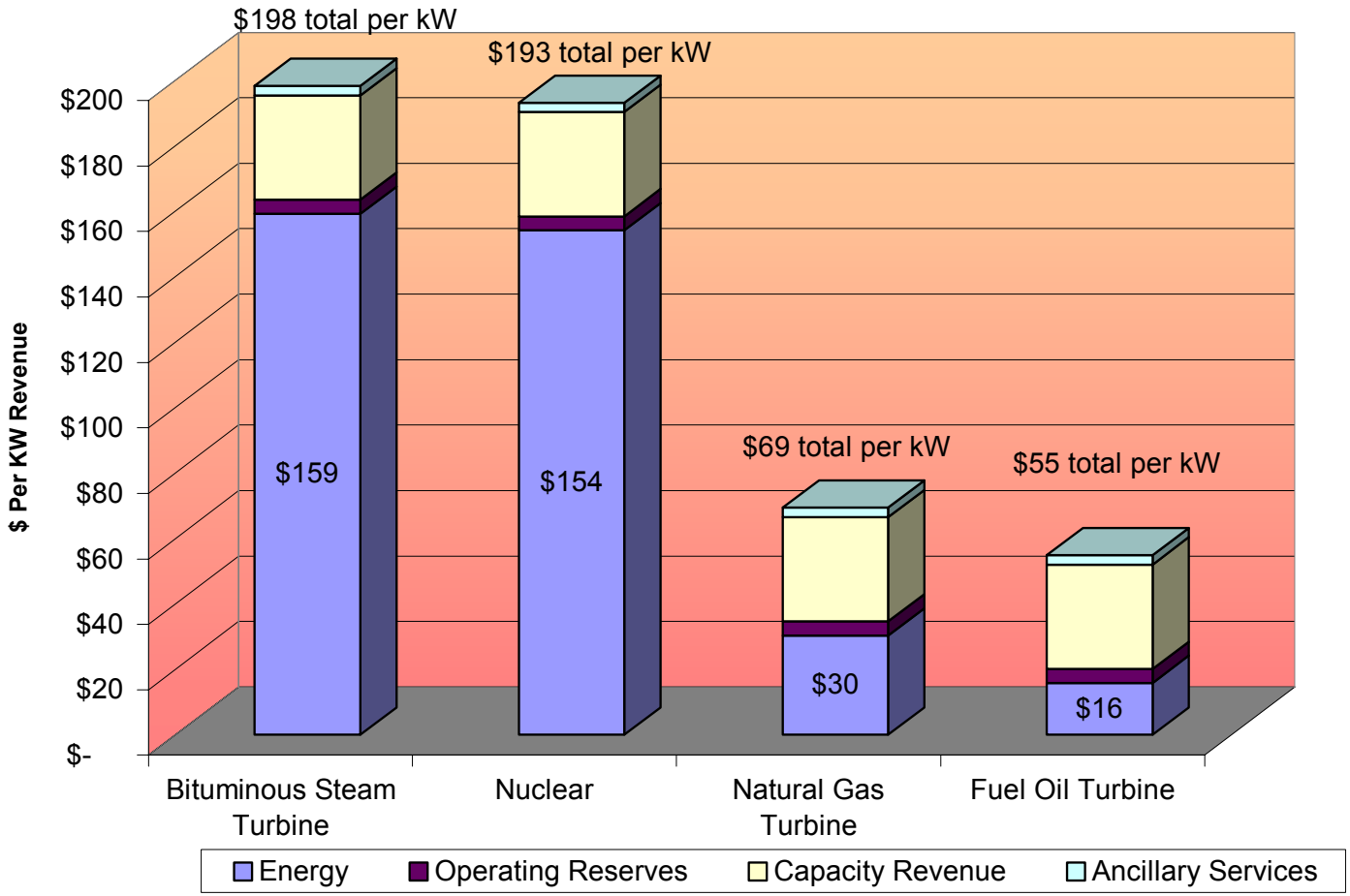
GEMSET Estimate of Composite PJM Unit Hours Run

(Dispatched at Operating Cost or Higher)



GEMSET Estimate of Annual Net Revenue/kW Rating

by Composite Fuel Type
Based on PJM LMP 7/2001-6/2002

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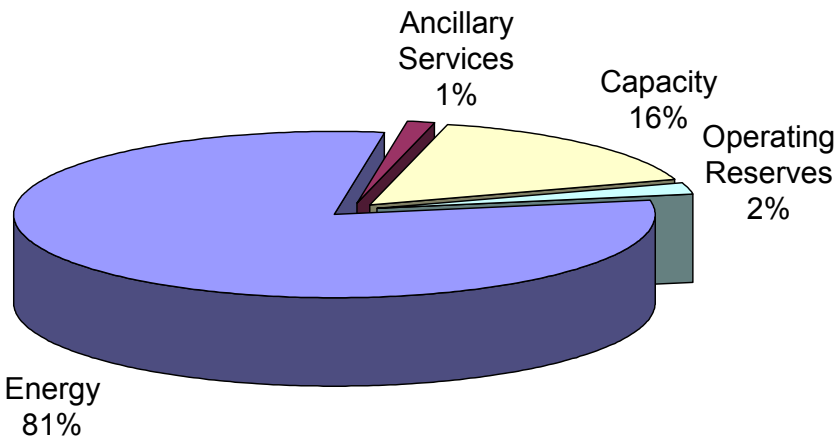
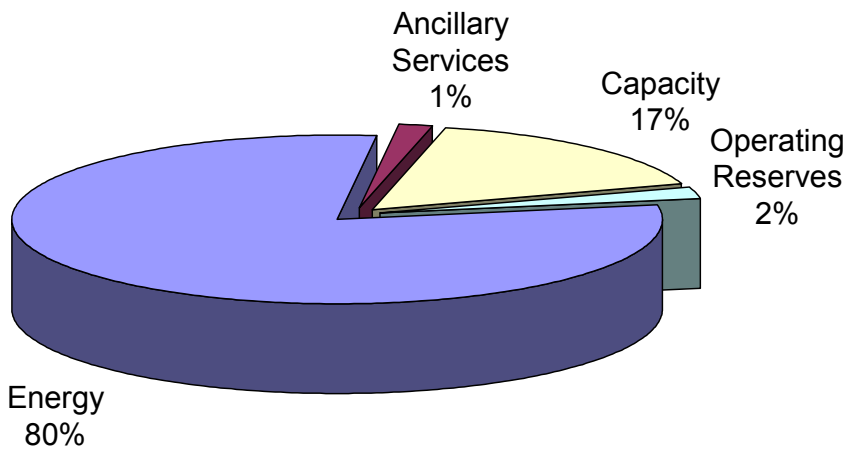
UNITED STATES OF AMERICA

Projected Percentage of Revenue Source by Unit Type - PJM East

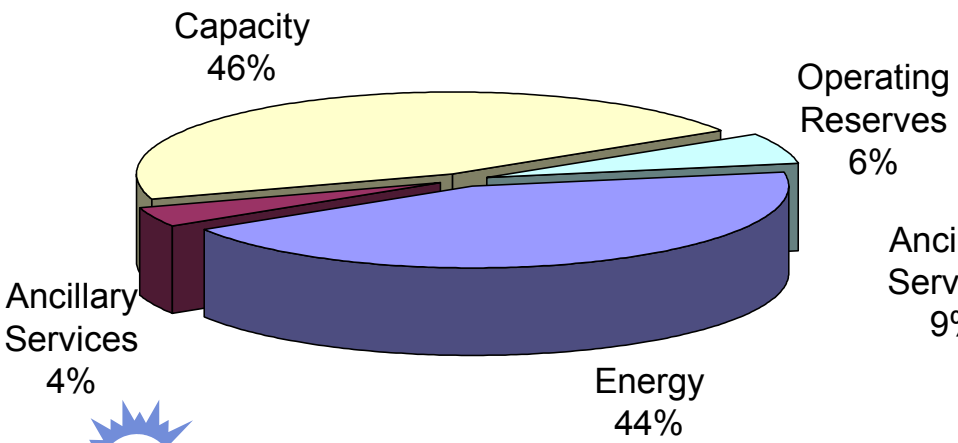
Bituminous Steam Turbine



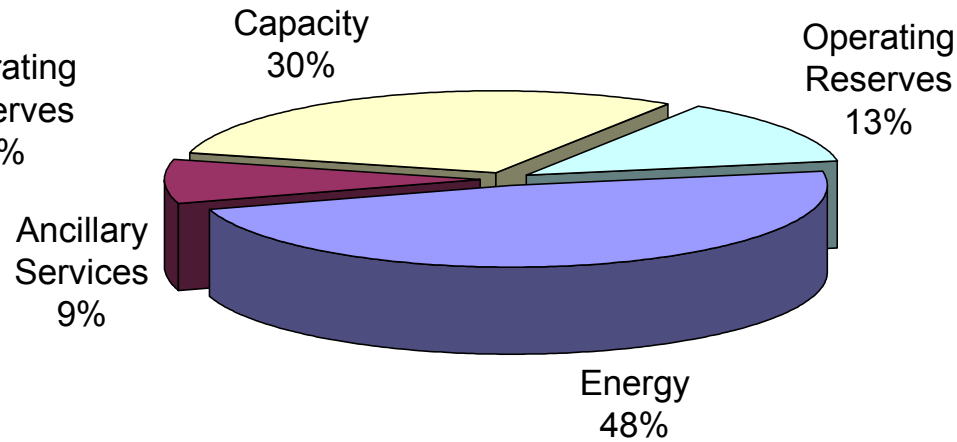
Nuclear Steam Turbine



Natural Gas Turbine

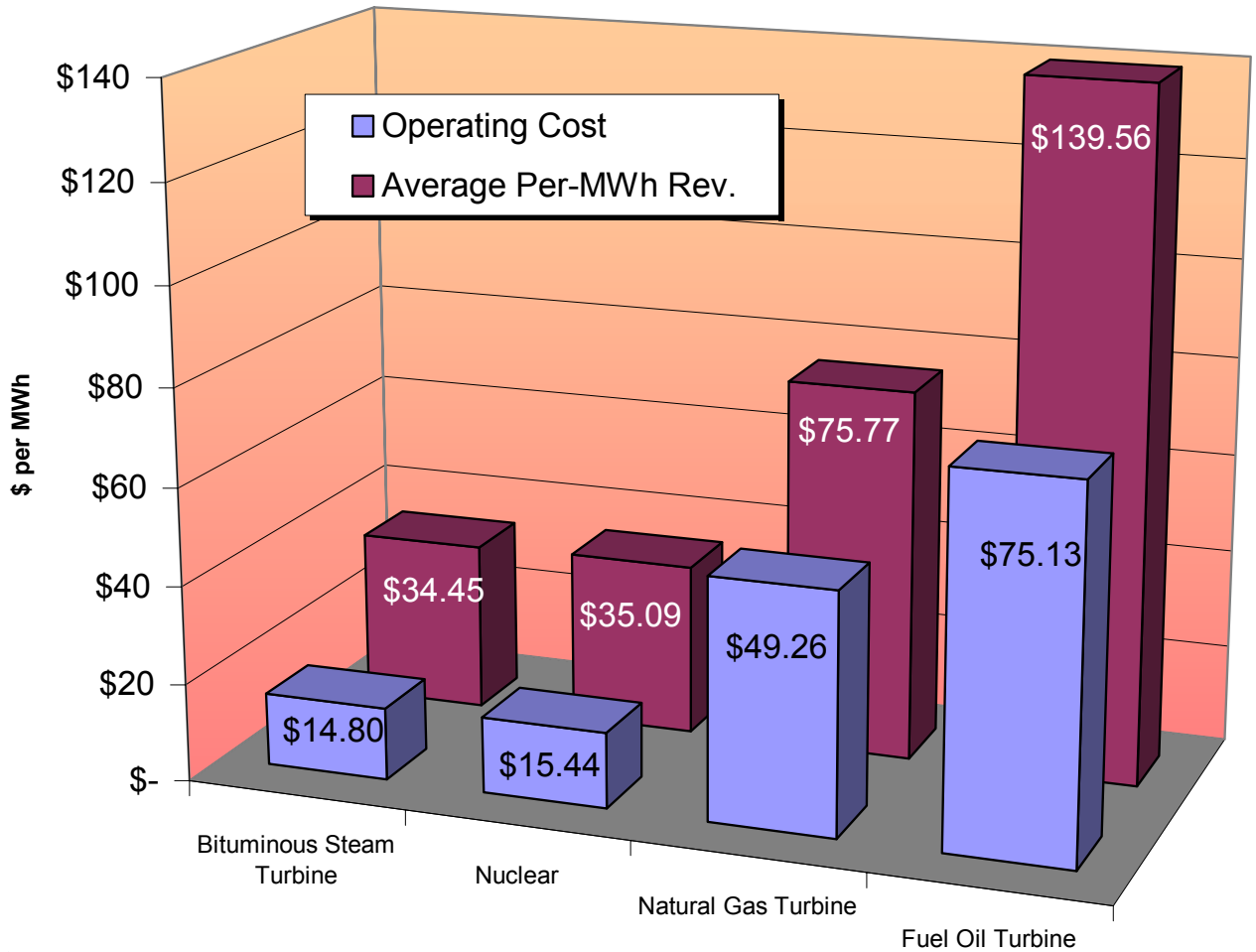


Fuel Oil Turbine



GEMSET Estimate of Composite PJM Unit Gross Revenue

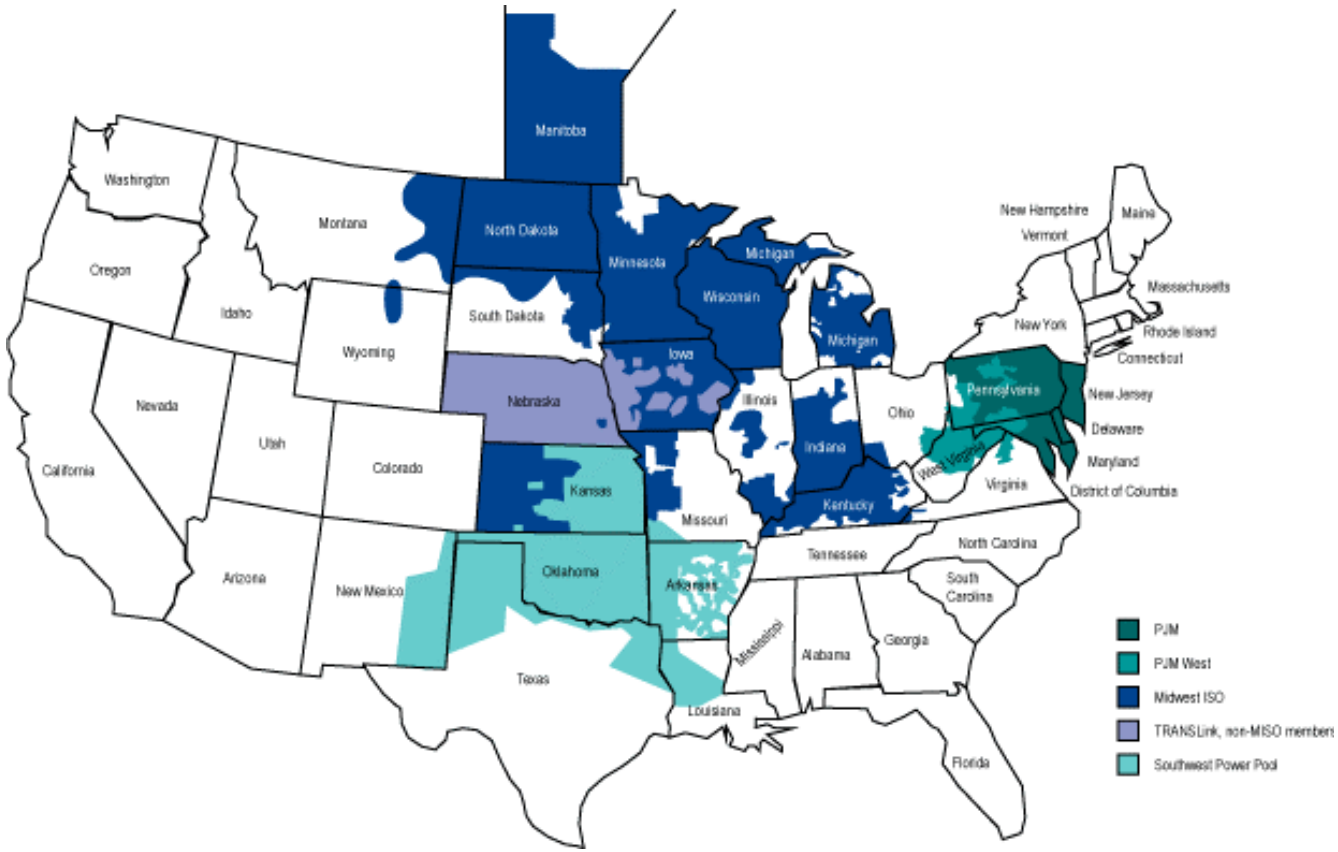
(Energy Only - $/MWh)



The PJM Region

Planned Expansion

Proposed MISO-PJM-SPP Region



MISO-PJM-SPP

- A Joint and Common Market
- 26 States and One Canadian Province
- 184,350 MW peak load
- 203,508 MW generating capacity
- 137,500 miles of transmission lines
- More than 300 members
- More than 30 million customers
- Slated to begin early 2004

Genealogy of FERC's Standard Market Design

Elements of FERC's Standard Market Design (SMD)

- Remove seams issues
- Eliminate transmission discrimination
- Reduce market power
- Encourage building of transmission & generation
- Maintain bid cap = $1000
- FERC and states
- Stakeholder agreement

SMD vs. PJM

- ICAP will be replaced by Resource Adequacy requirement
- FTRs
- Demand Response
- Congestion


DEPARTMENT OF ENERGY
UNITED STATES OF AMERICA

HR4 - Senate Version- Proposed

- Coordination of State energy policies
- FERC powers
- Reliability organizations
- Repeals PUHCA, amends PURPA and Federal Power Act
- Incentives for renewables and increased fossil fuel efficiency
- Calls for Internet information, real-time pricing and advanced metering
- Encourages demand response and distributed generation

Critical Impacts

- Incentives for new generation and transmission
- Resource Adequacy revenue stream
- Electronic infrastructure
- Tug-of-war between reliability and market forces
- Regulated initiatives (state and federal)
- Pending energy legislation (HR4)
- Education of target audiences

Looking Ahead

- Track Standard Market Design
- Study dependence on natural gas
- Analyze potential for technologies in changing markets
- Review state and federal regulations and programs
- Develop super-region analyses
- Prepare to discuss energy technologies in the language of business

The PJM Region

Questions?

Need More Information?

Call: Patricia A. Rawls

Project Manager, Systems and Policy Support

(412) 386-5882

Rawls@NETL.DOE.GOV

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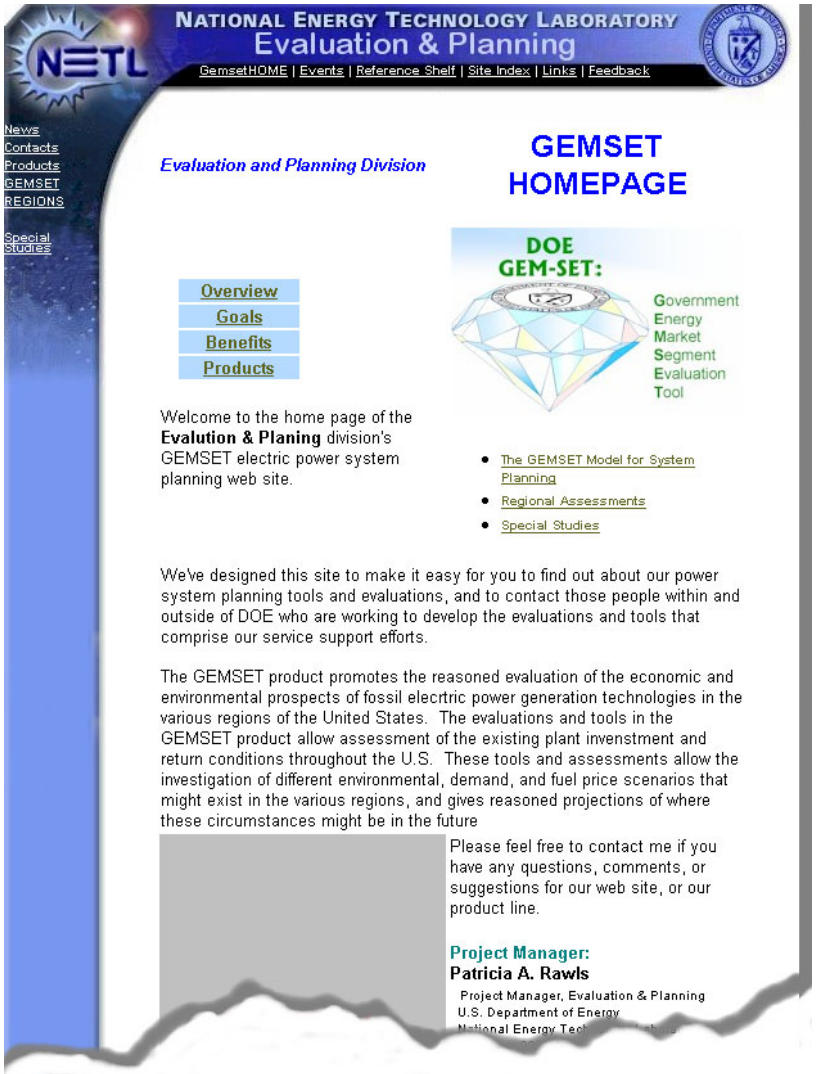
Supporting Materials

GEMSET Web Site



- **Prototype Internet web site under development**
- **This is preliminary, not all links complete, subject to significant change**
- **Prototype site available at:**

  (all lowercase)

  http://www2.epix.net/~parsons

- **Select "GEMSET"**
- **Final version will be on the DOE web when development is completed**

GEMSET

A Powerful Portfolio of Tools to Support Technology Commercialization and Policy Development

GEMSET Structure

New and Existing Power Plants
- Coal
- Oil and Gas Steam
- Combustion Turbines
- Combined Cycle
- QFs
- Nuclear
- Hydro
- Renewables
- Cogeneration
- Other

Existing Power Plant Variable Cost
- Fuel Transportation
- Fuel Costs
- Heat Rates
- O&M Costs

Environmental Compliance Costs

Power Plant Dispatch

New Power Plant
- Capital Costs
- Financing Costs

Projections
- Power/Allowance Prices
- Dispatch Decisions
- Capacity Build Decisions
- Fuel Prices
- Compliance Decisions

Electricity Demand
- Hourly Demand
- Peak & Energy Growth
- Reserve Margins

DOE GEM-SET Government Energy Market Segment Evaluation Tool

GEMSET Strengths

- Price and load-shape forecasting tool
- Comprehensive modeling of fossil fuel forecasts
- Assessments of market and financial merits of electric power plants in regulated and deregulated markets
- Evaluation of revenue from electric sales
- Assessment of hour-by-hour use patterns and capacity factor
- Compares use of very different types of units using different types of fuels
- Evaluation of regional impacts of various policy decisions
- Evaluation of regional environmental impacts of various policies (SO_2, CO_2, NOx, particulates)
- Models effects/costs of environmental compliance strategies

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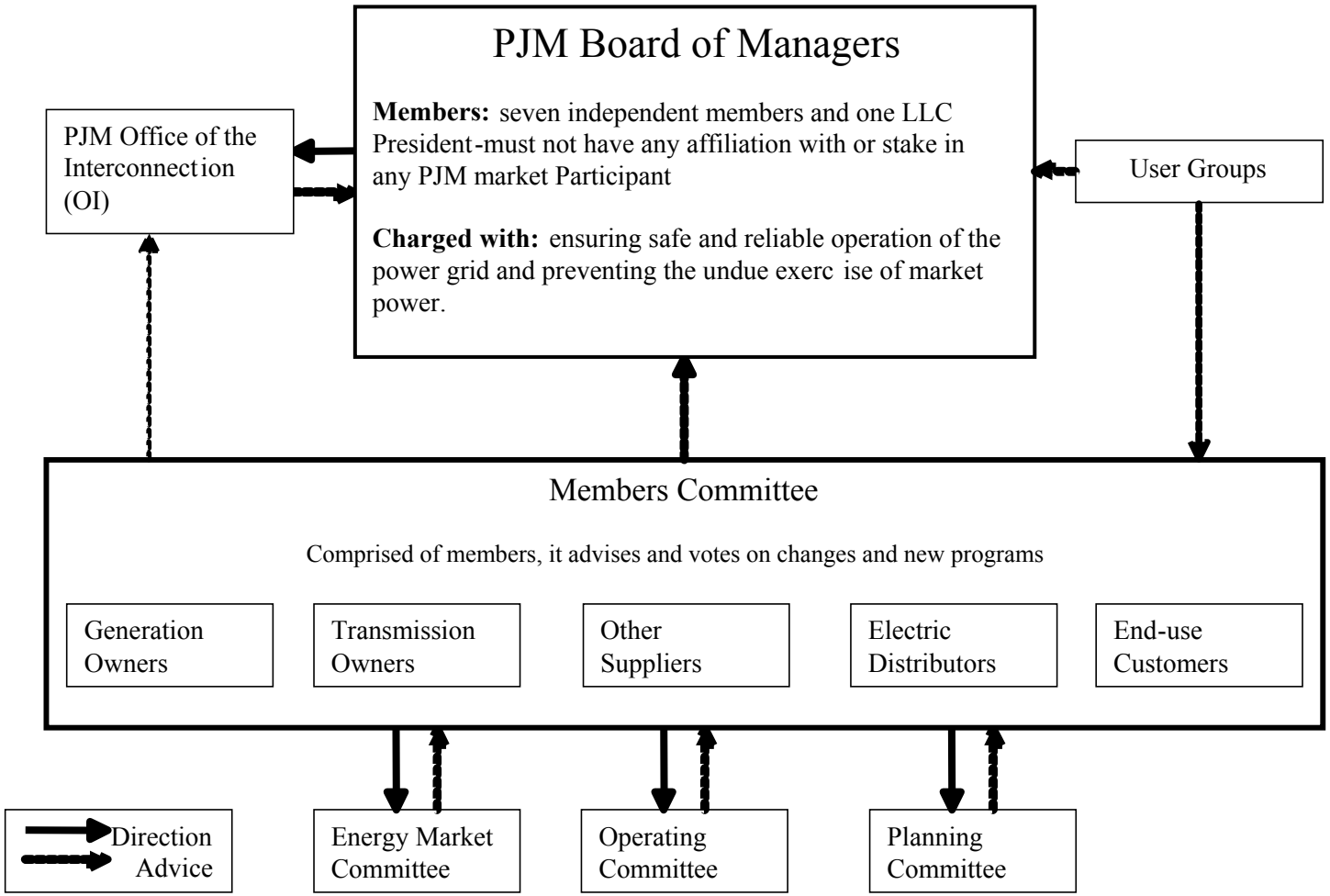
Key Applications

- Power market analysis
- Energy policy analysis
- Forecasting market prospects for new fossil technologies
- Wholesale price forecasting
- Asset valuation and comparison of investment alternatives
- Financial due diligence analysis
- Least-cost planning / integrated resource planning
- Environmental policy analysis
- Environmental compliance planning

PJM Day-Ahead Energy Market Timeline

- Up to 12 noon – PJM receives bids and offers for next Operating Day
- 12 noon to 4 pm – Day-Ahead market is closed for evaluation by PJM
- 4 pm to 6 pm – Re-bidding period
- 24x7 - PJM monitors status and sends out individual generation schedule updates

PJM Organization



Ratio of Price to Estimated Cost vs. Demand