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# The Polar Vortex and Future Power System Trends

## National Coal Council -- 2014 Annual Spring Meeting

May 14, 2014

- Introduction to ICF
- Overview of the Key Issues
- Price Volatility During Winter 2014
- PJM Power Generation Challenges During Winter 2014
- Power System Trends
- Conclusions





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## Introduction to ICF International



# ICF's Broad Client Base – Private Sector (Below) Plus Public Sector

IRP Approval  
RFP Design

Bankruptcy

Environmental  
Compliance

Asset Purchases

M&A Support

IRP Approval  
Asset Build

IRP Approval

Rate Case  
Testimony

Regulatory  
Compliance

Environmental  
Compliance

IRP Approval  
Conversions

M&A Support

Bankruptcy

DOGWOOD ENERGY

Rate Case  
Testimony

Regulatory  
Compliance

IRP Approval

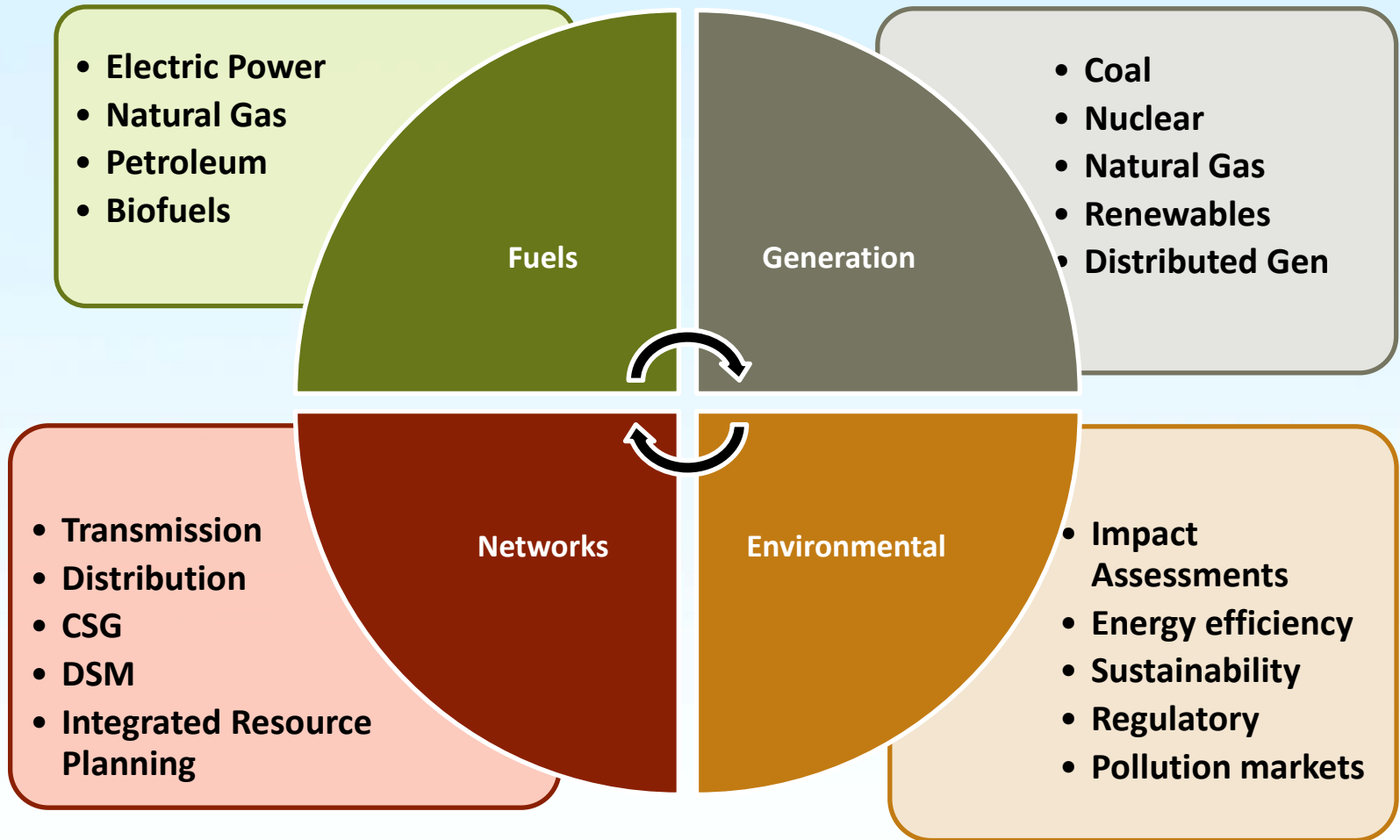
M&A Support

Environmental  
Compliance

Construction  
Approval

Bankruptcy







- Over 40 years of experience—founded in 1969
- Diverse client base—76% U.S. federal, state, and local agencies; 20% U.S. commercial; and 4% non-U.S.
- 2013 revenues of roughly \$1 billion
- Approximately 5,000 employees
- Global presence with more than 50 offices; headquartered in the Washington, D.C. area
- One of America's Best Small Companies, *Forbes* 2005-2011
- One of 10 Fastest Growing Government Contractors, *Washington Technology* 2010 & 2011
- 6<sup>th</sup> Largest Public Relations Firm in America, *PR Week*
- Best Global Environmental Consultancy in 5 of 6 categories, *Environmental Finance Magazine*
- Largest Energy Efficiency Consultancy/Implementation Firm in North America
- Top 5 Consulting Firm in India and Brazil

*World-class domain expertise across the energy, environment, transportation, and health care sectors.*





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## Overview of the Key Issues



- Commercial Issues
  - What are the Commercial Opportunities and Risks from Future Price Volatility?
  - What is the Relationship Between Regulatory Developments and Future Commercial Opportunities?
  
- Regulatory
  - What is the Status of Future Grid Reliability?







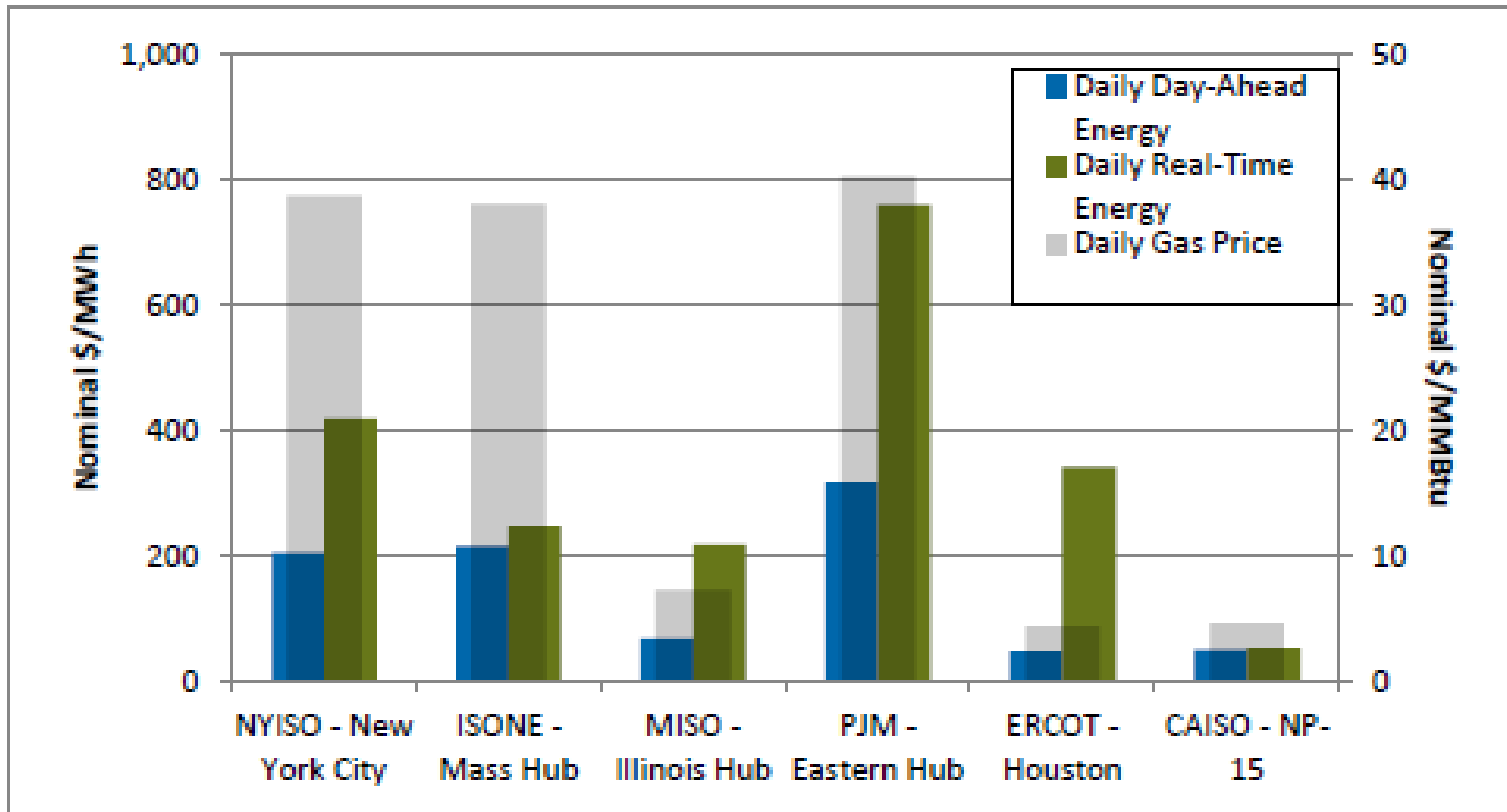
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## Price Volatility During Winter 2014



# Daily Day-Ahead vs. Daily Real-Time Energy Prices; January 6 and 7

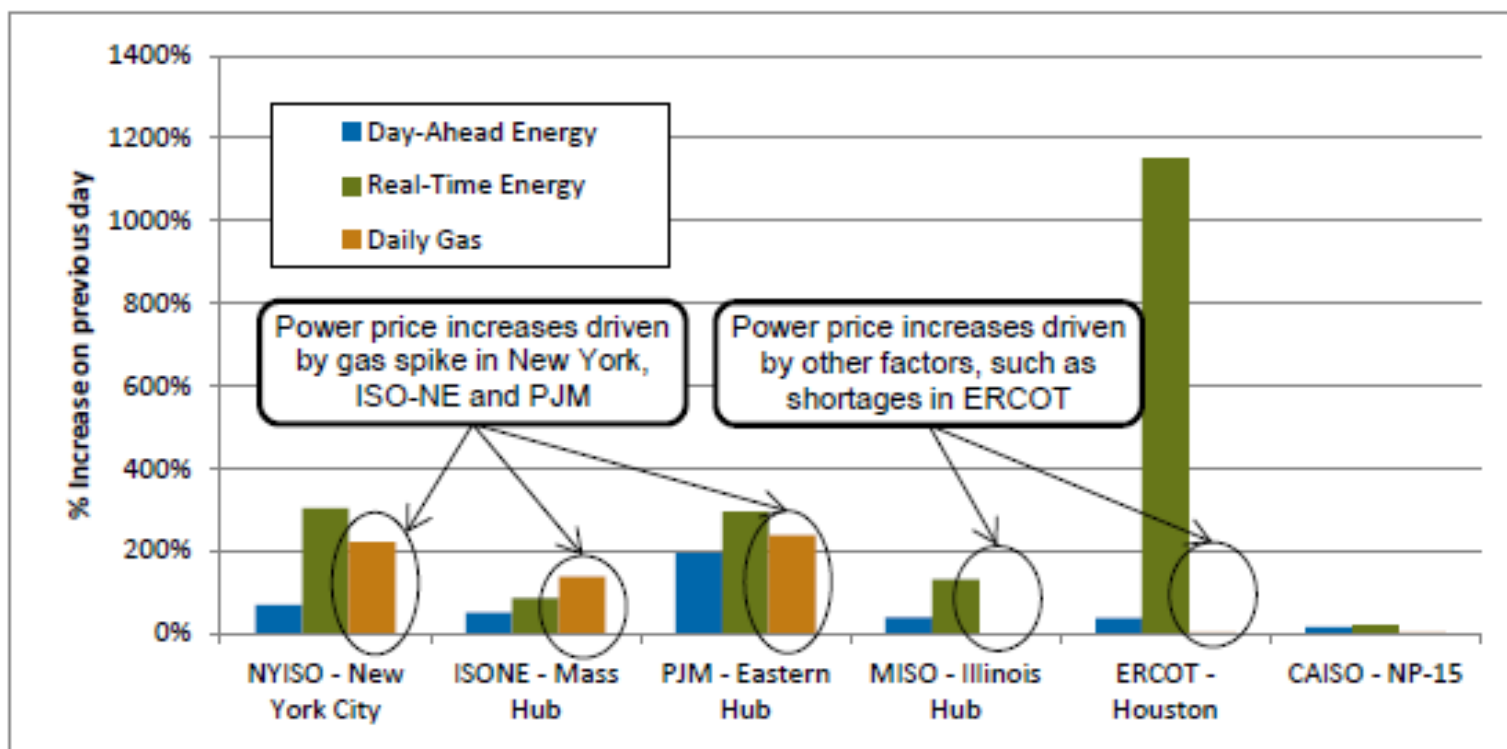


Source: SNL, ISO data

- Original polar vortex set pattern for winter 2014: a combination of volatile and high wholesale power and natural gas prices. Spot natural gas prices reached the highest levels ever recorded in the U.S. in some locations.



# Percent Increase in Day-Ahead, Real-Time, and Gas Pricing: January 6 and 7 – Power Shortages and High Natural Gas Prices

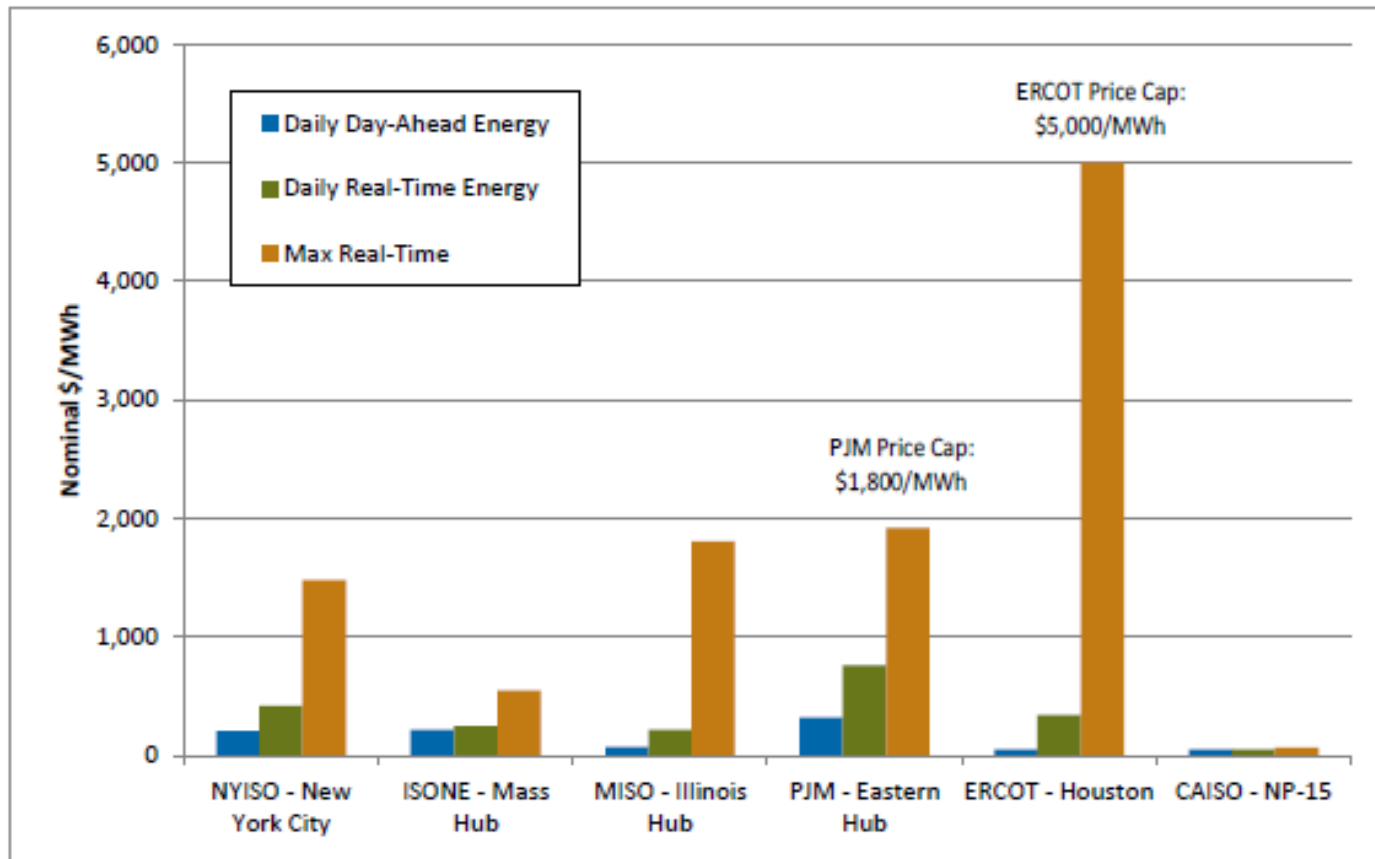


Source: SNL, ISO data

- PJM experienced high generation and natural gas prices. Other regions experienced primarily high generation prices and shortages.



# Daily Day-Ahead, Daily Real-Time, and Max Real-Time Energy Prices; January 6 and 7

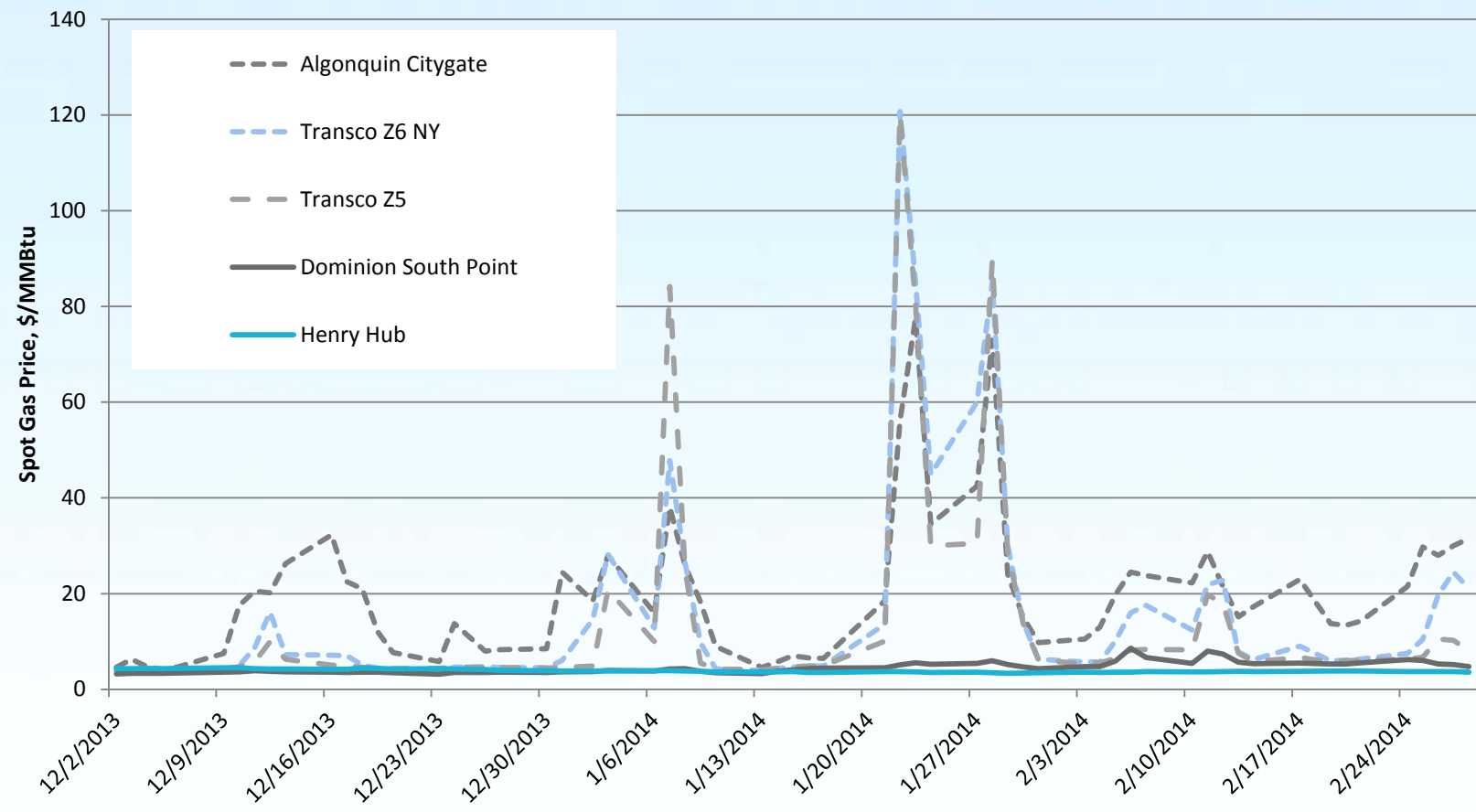


Source: SNL, ISO data

- Wholesale power prices reached price caps for two reasons in January : (1) grid operators accessed operating reserves to meet energy demand triggering price and/or bidding rule changes, and (2) fuel prices caused variable costs to exceed cap levels.



# Spot Natural Gas Prices Indicate the Constraint Was Pipeline Capacity, Not Natural Gas Supply

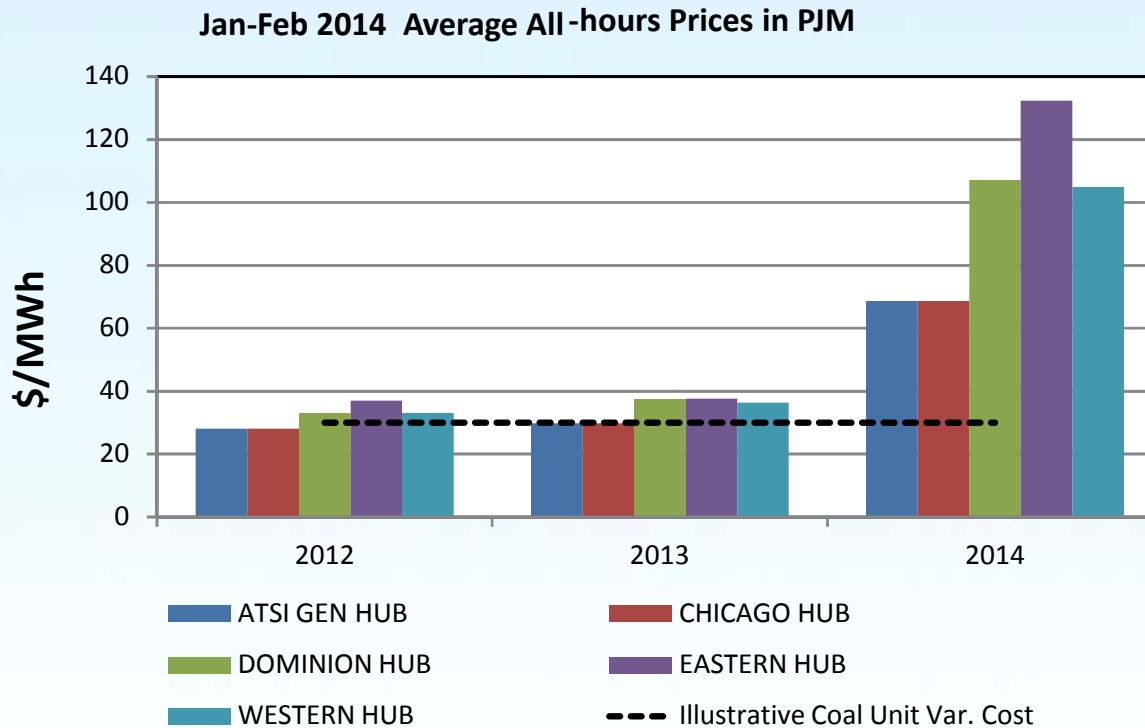


Source: SNL





# Unhedged Coal Power Plant Margins Surge in PJM January – February 2014



# Jan-Feb 2014 Unhedged Coal Power Plant Margins Surge in PJM East and West

Margin for Illustrative Coal Unit in PJM East

	2012	2013	2014
<b>\$/MWh</b>			
Average Price	37	38	132
Variable Cost	35	35	35
Gross Margin	2	3	97
<b>\$/kW</b>			
Gross Margin	2	4	119

Margin for Illustrative Coal Unit in PJM West

	2012	2013	2014
<b>\$/MWh</b>			
Average Price	33	36	105
Variable Cost	30	30	30
Gross Margin	3	6	75
<b>\$/kW</b>			
Gross Margin	4	8	92

- In PJM East, coal plant gross margins over the first 60 days of 2014 were almost comparable to prices paid to purchase coal plants in 2012 to 2013.
- Coal plants can benefit the system during similar winter situations. However, the market needs to provide a level playing field for coal plants.



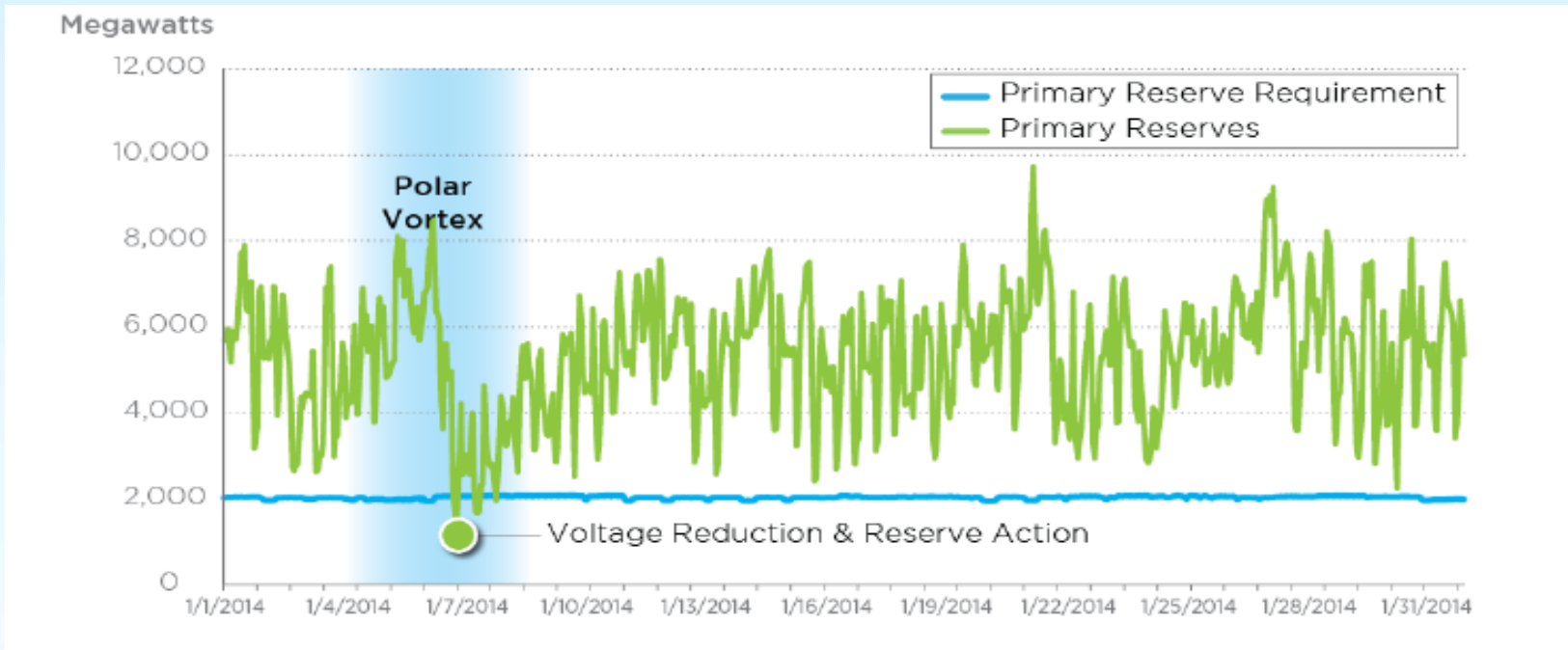


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## Power System Challenges During Winter 2014



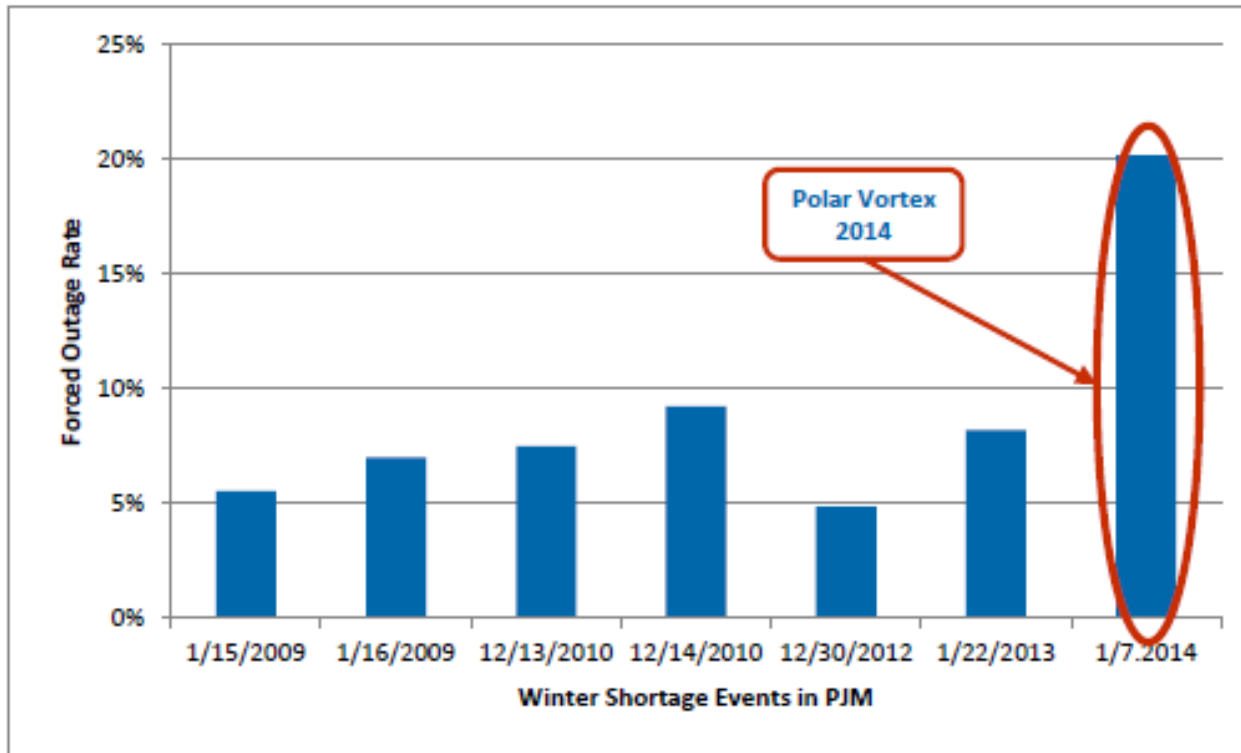


Source: PJM

- PJM was close to voltage reduction in part due to record high plant outages and demand (within 500 MW of triggering voltage reduction on January 7; PJM estimates reductions would lower demand by 2,000 MW). Actual voltage reduction occurred earlier on January 6, but grid conditions were not as challenging. After voltage reduction, the next steps are emergency imports (several thousand MW likely available from neighbor) and then load shedding (rolling black outs).



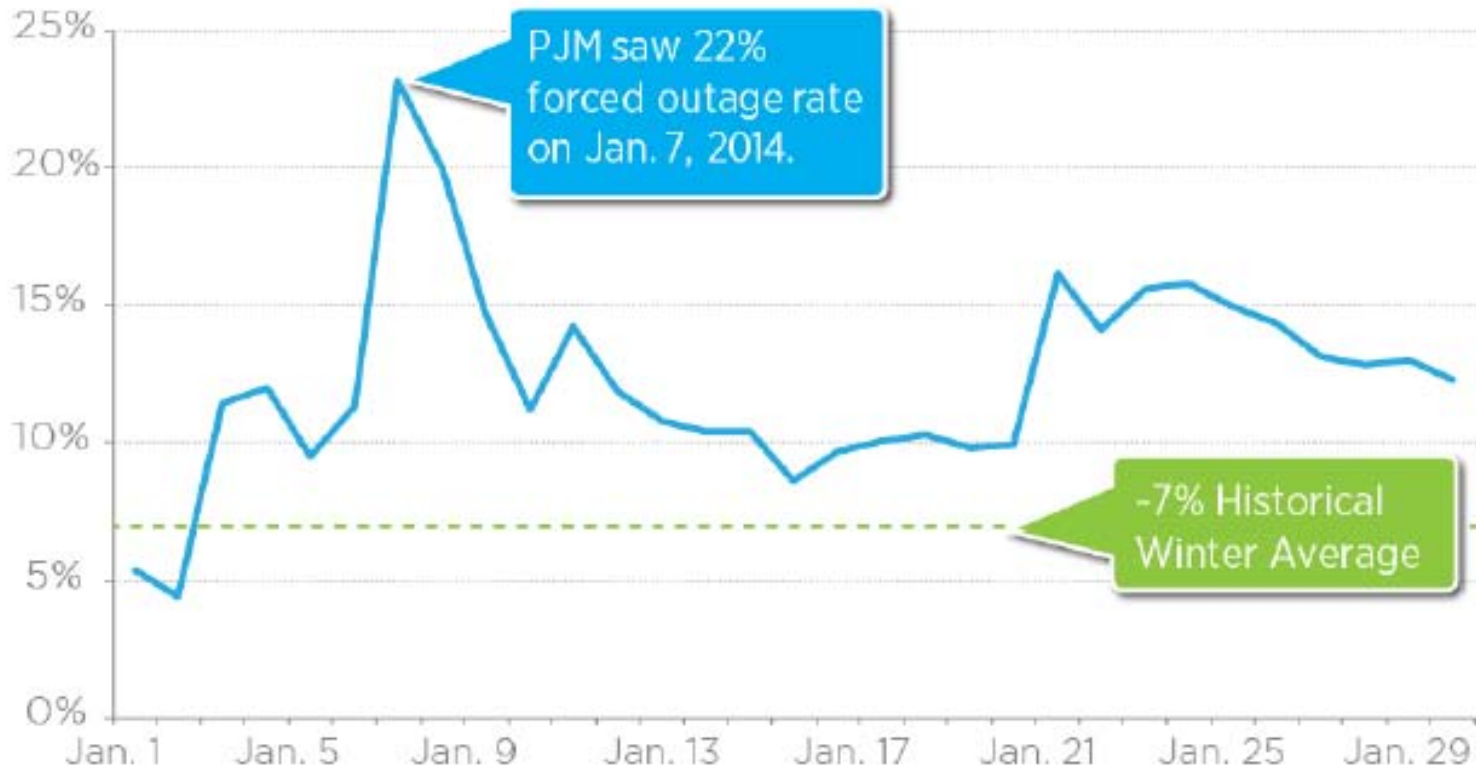
# Historical Comparison of Generation Outages in PJM Over Past Five Winters



Source: PJM<sup>5</sup>



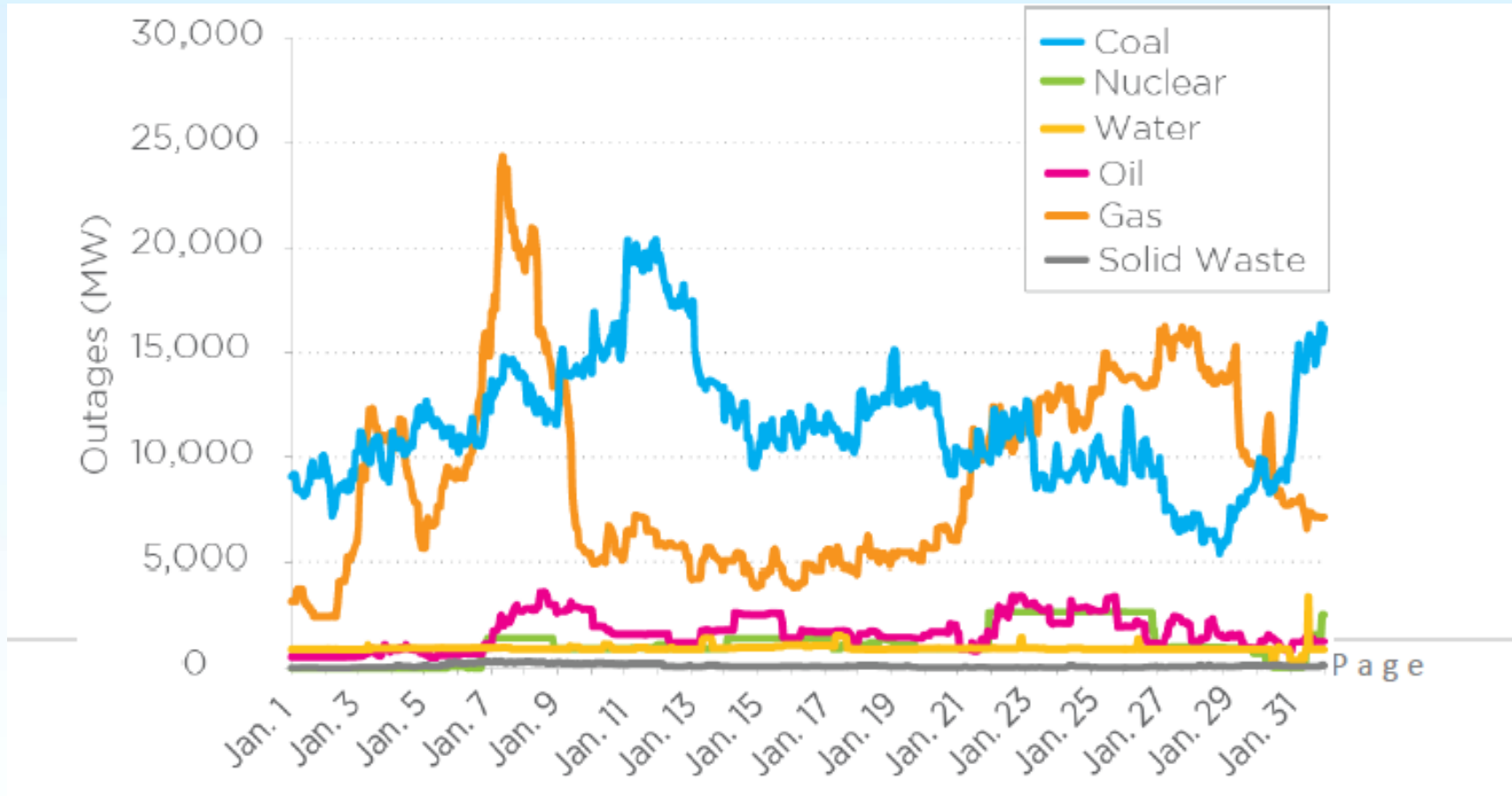
# January 2014 Generation Outages in PJM



Source: PJM

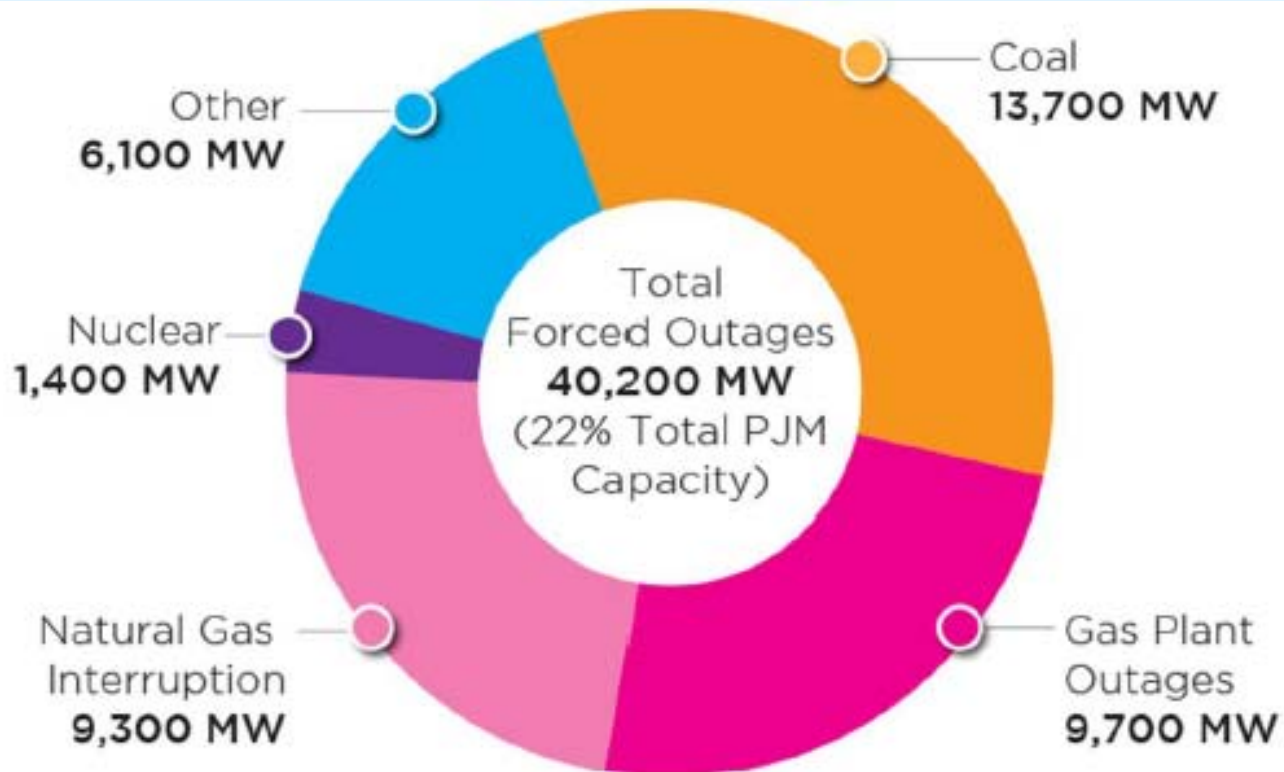


# January 2014 Unplanned Generation Unavailable in PJM by Fuel Type



Source: PJM





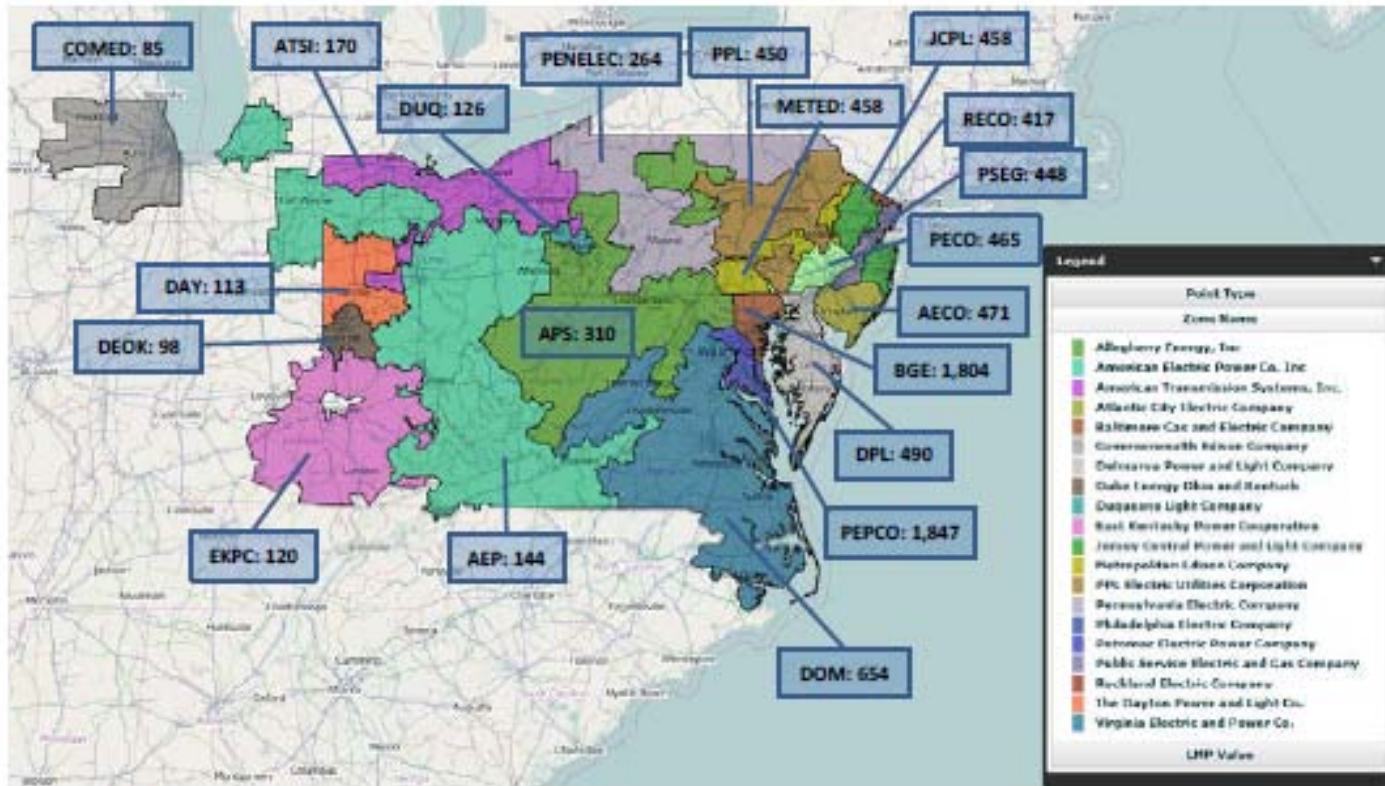
Source: PJM



- While natural gas pipelines were able to meet all their obligations to firm transportation customers, there was no incremental interruptible capacity available due to the high level of firm demand. Close to one quarter of the outages in PJM were due to lack of natural gas delivery capability to generators that rely on interruptible capacity.
- The rapid and growing switch to natural gas in the power sector has exhausted available interruptible service during periods of high non-power winter demand. Firm natural gas transportation capacity and/or adequately tested backup (e.g., oil) is not a requirement in any capacity market. Thus, for example, the costs of firm natural gas transportation are not included in the Cost of New Entrants (CONE), and new entrants are not required to maintain back-up fuel. Quantities of required back up have not been identified.



# PJM Real-Time LMP Energy Pricing (\$/MWh) – Wednesday, January 22, 2014, 8:00 pm – Power Transmission limitations



Source: PJM

- Not only was gas delivery not available to interruptible customers, but power transmission limitations prevented power imports from solving the problem.



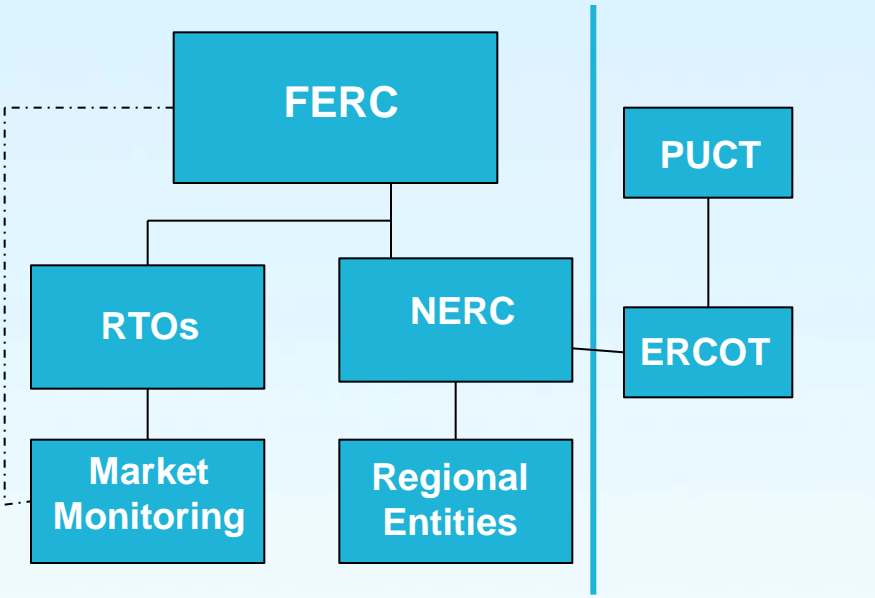


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## Future Power System Trends





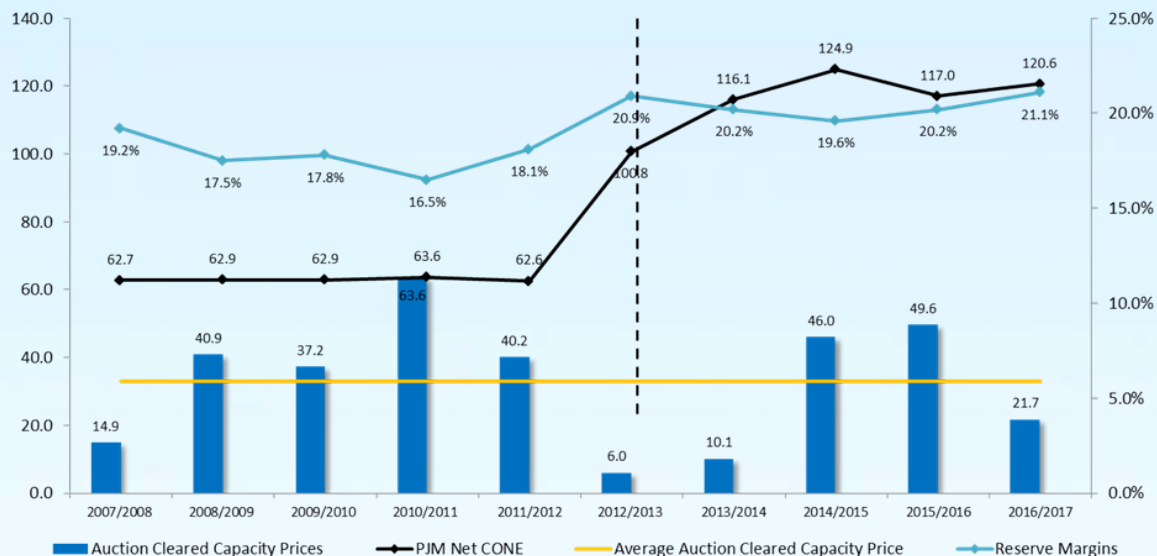
- Many entities are involved in reliability and market structures; FERC has the lead.

## Key Post Vortex FERC Decisions/ Reports Related to PJM

- January 30, 2014 – Implementing Demand Resource Caps and Correcting Inadvertent Errors
- March 3, 2014 – Demand Response Attestation Requirement
- April 22, 2014 – Implementing Import Limits
- Since the Polar Vortex, significant FERC action has occurred to correct problems for auctions with delivery starting in summer 2017. Transition challenges remain.



# PJM RTO Cleared Capacity Prices vs. PJM Net CONE (Nominal UCAP \$/kW-yr)



- Forward auctions have resulted in high procurement levels and low prices.
- Procurement includes large amounts of demand products and imports suppressing prices.

Adjustment	Market Monitor Calculated Percent Increase in PJM Capacity Price in Most Recent Auction
Exclusion of "Inferior Demand" Products	+84%
Require Firm Contracts for Imports	+24%
No Demand Response	+184%

- The PJM market monitor estimated the impact of potential rule changes on clearing prices in the most recent auction. These ranged from an increase of 24 to 184 percent.
- Source: April 18, 2014 PJM Market Monitor Report



# Trends that Affect Price Volatility and Reliability Over Next Few Years

## Exacerbating

- **Additional Powerplant Retirements**
  - Announced Retirements
  - Additional Potential Retirements – June 2014 EPA Announcement, changes in ownership, etc
- **Additional Interruptible Load**
  - 60% Increase in Interruptible Load, 2013 to 2015, mostly summer only limited
- **Fuel Supply**
  - 1.5 Bcfd Increase in PJM alone in Natural Gas Demand within 2 Years Combined With Reliance on Interruptible Service, Status of Interruptible Service Availability
  - Status of back-up fuel
- **Electrical Energy Pricing**
  - Lack of ERCOT-Like Electrical Energy Price Spikes, Especially in Winter
  - Lack of a priori Fuel Indexing of Price Caps
- **System Planning**
  - Plant outage Rate in Winter – Correlated Outages not implemented

## Ameliorating

- **High Procurement Levels**
- **New Gas-Fired Combined Cycles – 8 GW 2014-2016**
- **Recent FERC Orders**
- **Ongoing Review by RTOs/Others**



# PJM Announced and Retired by 2014 Power Plant Retirements

	Retirements (GW)		
Type	Retired 2009 – 2014	Incremental Announced, 2014 – 2016	Total
Coal	11.4	10.3	21.7
O&G	2.1	3.7	5.8
Nuclear	0.0	0.0	0.0
<b>TOTAL</b>	13.6	14.0	27.5

- Half of announced PJM retirements have not yet occurred. New U.S. generation capacity counting toward reserve margin is natural gas-fired and likely to rely on interruptible natural gas delivery service unless policies and market structures change.





# Retiring Unit (Scheduled to Retire Before Winter 2014/2015) Performance on January 7, 7 p.m.

Retiring Unit Performance for 1/7/2014	Unit Count	Units On-Line	% Units On-Line	ICAP MW	MW Output	% MW Output
RTO Units	134	58	43.30%	14,036	7,273	51.80%

Source: PJM



# U.S. Power Plant Retirements – Announced and Retired by 2016

	Retirements (GW)		
Type	Retired 2009 – 2014	Incremental Announced, 2014 – 2016	Total
Coal	25	20	44
O&G	26	11	37
Nuclear	3.7	1.6	5.3
<b>TOTAL</b>	55	32	87

- Retirements outside PJM can affect future availability of emergency imports.

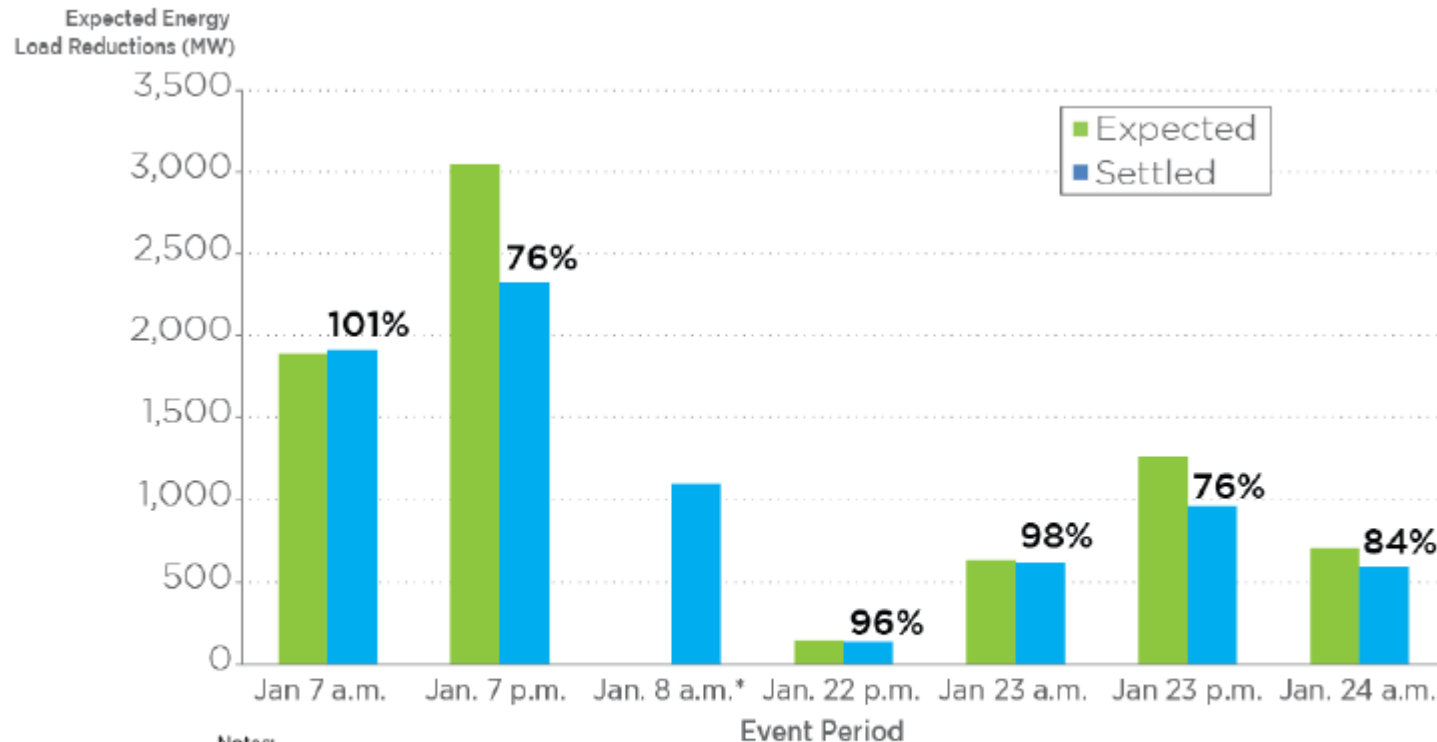


# PJM Demand Resources Including Summer Only, Limited Interruptible Load – 9,300 MW in 2013/2014, and 14,833 MW in 2015/2016 (+60%)

DR Type	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17
ILR	2,107	2,110	2,108	2,110	1,594	NA	NA	NA	NA	NA
DR Cleared	1,365	1,014	2,063	939	1,365	7,047	9,282	14,118	14,833	12,408
EE Cleared	NA	NA	NA	NA	NA	569	679	822	923	1117
Total DR	3,472	3,124	4,171	3,049	2,959	7,616	9,961	14,940	15,756	13,525
<b>Demand Requirements</b>										
Peak Demand	136,961	139,342	141,710	144,592	142,390	144,857	160,634	164,700	163,168	165,424
<b>DR as % of Demand Requirement</b>										
% of Peak	2.5%	2.2%	2.9%	2.1%	2.1%	5.3%	6.2%	9.1%	9.7%	8.2%
% of Reserves	16.4%	14.5%	19.0%	13.6%	13.4%	33.9%	40.0%	58.5%	62.3%	51.0%

\* BRA is the key PJM forward capacity market auction. UCAP is adjusted for generator availability, but not fuel availability.





**Notes:**

1. DR events dispatched during non-compliance period.
2. Expected Energy Load Reductions (MW) - CSP reported estimate based on current market rule.
3. MW value is average hourly load reduction for non-ramp in hours.
4. Event on Jan. 8 was cancelled prior to official start time. PJM allowed CSPs to settle if their load reduction had already started (or needed run for 2 hours).

Source: PJM

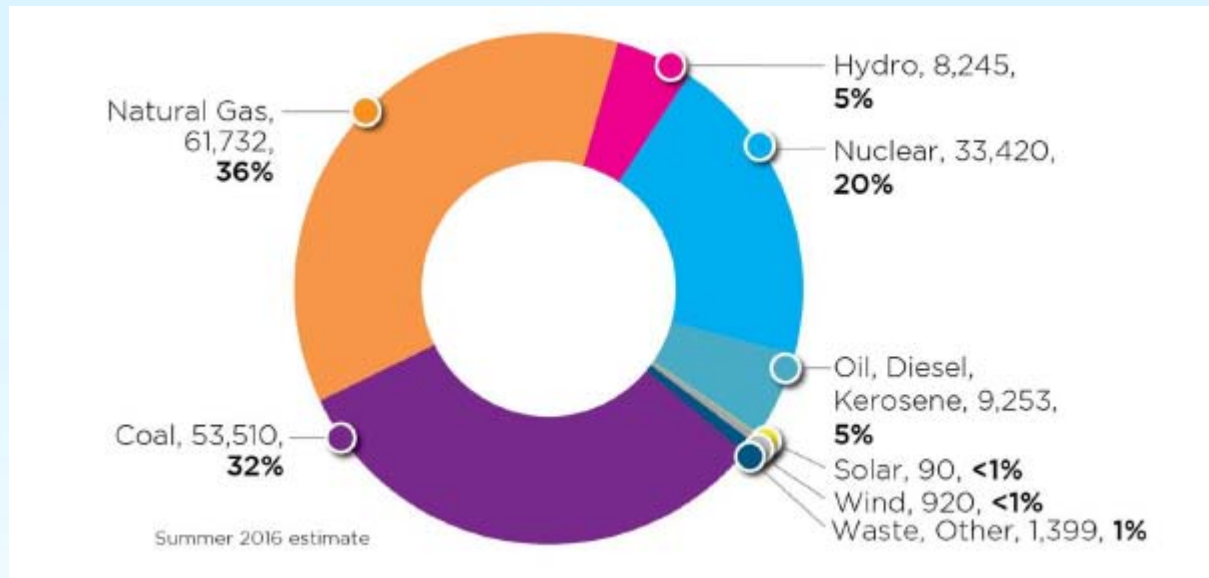


- An important focal point for policy is interruptible load:
  - **Seasonal** – Should seasonal operation be available to all resources, or none?
  - **Limited Operation** – Should limited operation (60 hours a year be available to all resources, or none?
  - **Energy Market Participation** – Should all capacity resources be required to participate into the energy market day ahead and real time or none should be so required? ISO-NE’s newly adopted approach requires participation.
  - **Demand Resource Caps** – Has the FERC PJM January 30, 2014 order adequately corrected multi-year inadvertent capacity market errors?
  - **Fatigue** – What should the penalties be for non-performance by interruptible load? How should interruptible load “fatigue” be addressed? That is, how should the likely lack of persistence of a portion of interruptible load in the face of repeated interruption. Should load need to be prevented from returning to firm power supply for an extended period? Should interruptible load bidding be further restricted?
  - **Qualification Rules** – Should some resources be allowed to have marketing plans or should they be required to secure control of resources/permits? Thus far, interruptible load has had less stringent standards. FERC’s March 3, 2014 decision related to PJM interruptible load changes this.





# Fuel Mix of Future PJM Installed Capacity (MW) and Natural Gas Delivery



Source: PJM

- “Moreover, capacity resources in PJM have procured onsite back-up fuel to address any location-specific pipeline capacity issues. In the longer-term regarding the future natural gas transportation capability to meet the needs of the anticipated new natural gas units: PJM is currently participating in an Eastern Interconnection Planning Collaborative (EIPC) study to determine just that. The EIPC Gas-Electric System Interface Study will determine the future adequacy of gas pipeline infrastructure in PJM and other, neighboring control areas (TVA, NYISO, ISO-NE, MISO and IESO) over 5 and 10 year time horizons. Preliminary results from that study, which deals with natural gas infrastructure capability, will be available this summer.”

Source: PJM, April 18, 2014, page 11.

- Anecdotally, we are told that only approximately 20% of natural gas-fired power plants in ISO-NE have some firm natural gas supply – from plant burner tip to a liquid hub outside of NE. We do not have similar data for PJM even on anecdotal basis, but we believe most natural gas plants do not have firm natural gas supply; they rely on interruptible service.
- The market structures in place do not fully address firm fuel supply – e.g., new entrants are not required to have back-up fuel or firm delivery, data on fuel back-up, and available delivery capacity is not available, quantities required have not been established.
- New natural gas power plants are displacing:
  - Coal plants with 30-60 days of fuel on site (in most cases)
  - 90% of coal is bought under contracts; little is purchased in the spot market
  - Nuclear units typically contract for fuel services for up to 4-5 years forward



- **Review of Winter Resource Adequacy** – Should there be a reexamination of planning and operating reserve requirements during the winter. This includes treatment of the correlation of winter generation outages; when one plant is lost due to lack of firm delivery service and or back up fuel, others will also likely be lost including coal plants in some cases. Similarly, if one plant is lost due to lack of weatherization, others will also likely be lost.
- **Hybrid Model for Capacity and Resource Adequacy** – Should there be a combination of wholesale electrical energy price spikes (already in place in many markets but with widely varying prices and rationales) with forward capacity prices? Should the price spikes equal Value of Loss Load (VOLL) during use of operating reserves? Is this needed because: (1) the complexity of resource adequacy has become too great for administrative mechanisms alone; these mechanisms play a large role in capacity markets, (2) the need for automatic real time and geographically focused responses to resource adequacy problems, and (3) the need for a “belt and suspenders” approach to minimize reliability impacts?



- Under the current FERC regulatory model, interstate pipelines build capacity to meet obligations to shippers holding firm capacity contracts.
  - Without long-term firm contracts, new pipeline capacity will not be built.
- In vertically-integrated power markets, generators will sign long-term pipeline contracts because they can pass through the costs.
- However, in the ISO/RTO power markets, most generators say they can't afford to pay for firm pipeline capacity.
  - Generators' actual gas use may vary from fixed supply agreements, and the ISO/RTO capacity markets won't allow them to recover those costs.
- As a result, most gas-fired generators rely on interruptible pipeline service.
  - Works fine when firm demand is low, but not so well when demand is high.
- Additional operation problems cause by the misalignment of gas and electric system scheduling.





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## Conclusions





- **Not Just Weather** – The system successfully delivered power in spite of the very cold weather, but the grid conditions would have been better if:
  - Demand resource procurement had been generation procurement, and/or handled differently
  - Fuel back-up or firm supply conditions were different
  - Energy market pricing policies additionally incentivized operation
  - Retirements were not such a large challenge
  
- **Commercial Opportunities and Risks** – Near-term commercial opportunities and risks are likely to exist due to price volatility. Careful tracking of infrastructure and policy will be useful in evaluating commercial decisions.
  
- **Future Vortices** – Reliability challenges exist during the next few years in the event of a future repetition of 2014 winter conditions, i.e., a repeat of one year in ten winter weather. Key drivers are:
  - Increase summer only DR
  - Increased retirement off set in part by new gas power plant builds
  - Fuel firmness issues including infrastructure and back up fuel



- Significant stress with material new developments and simultaneous experimentation
  - Capacity markets
  - Demand Resources and Energy Efficiency
  - Renewables
  - Retirements
  - CO2
- Likely increased system emergencies, scarcity events, price volatility
- When systems is stressed, unexpected things happen
- Ramifications for coal plants
  - Significant retirements with potential for more retirements
  - At the same time, large profitability potential for remaining coal plants, with contrarian opportunities particularly at low transaction prices





**Shanthi Muthiah** directs the power team within the energy advisory solutions practice and manages work in wholesale power market assessments and asset valuation and due diligence. Her transactional experience encompasses energy markets advisor for the Dynegy and Calpine Unsecured Creditors Committees and NRG Energy in the bankruptcy and restructuring process; due diligence support for IPPs, utilities and private equity in support of acquisition, development, financing and restructuring; and advisor to power companies in asset management, contracting and optimization.

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