

# Leaning on Line Pack

*Presented by*

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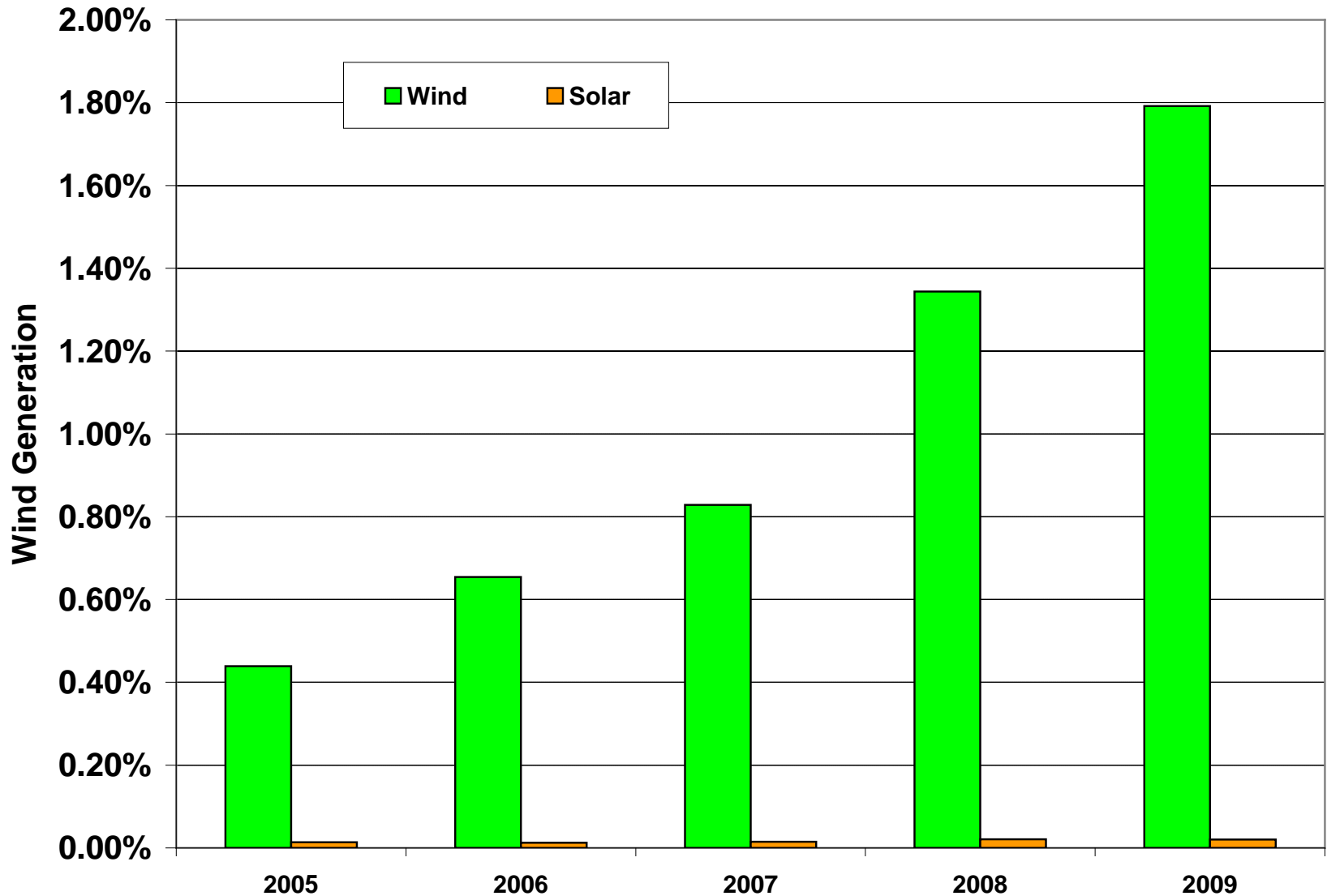
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MARKET DESIGN, ECONOMICS AND POWER SYSTEMS

# Agenda

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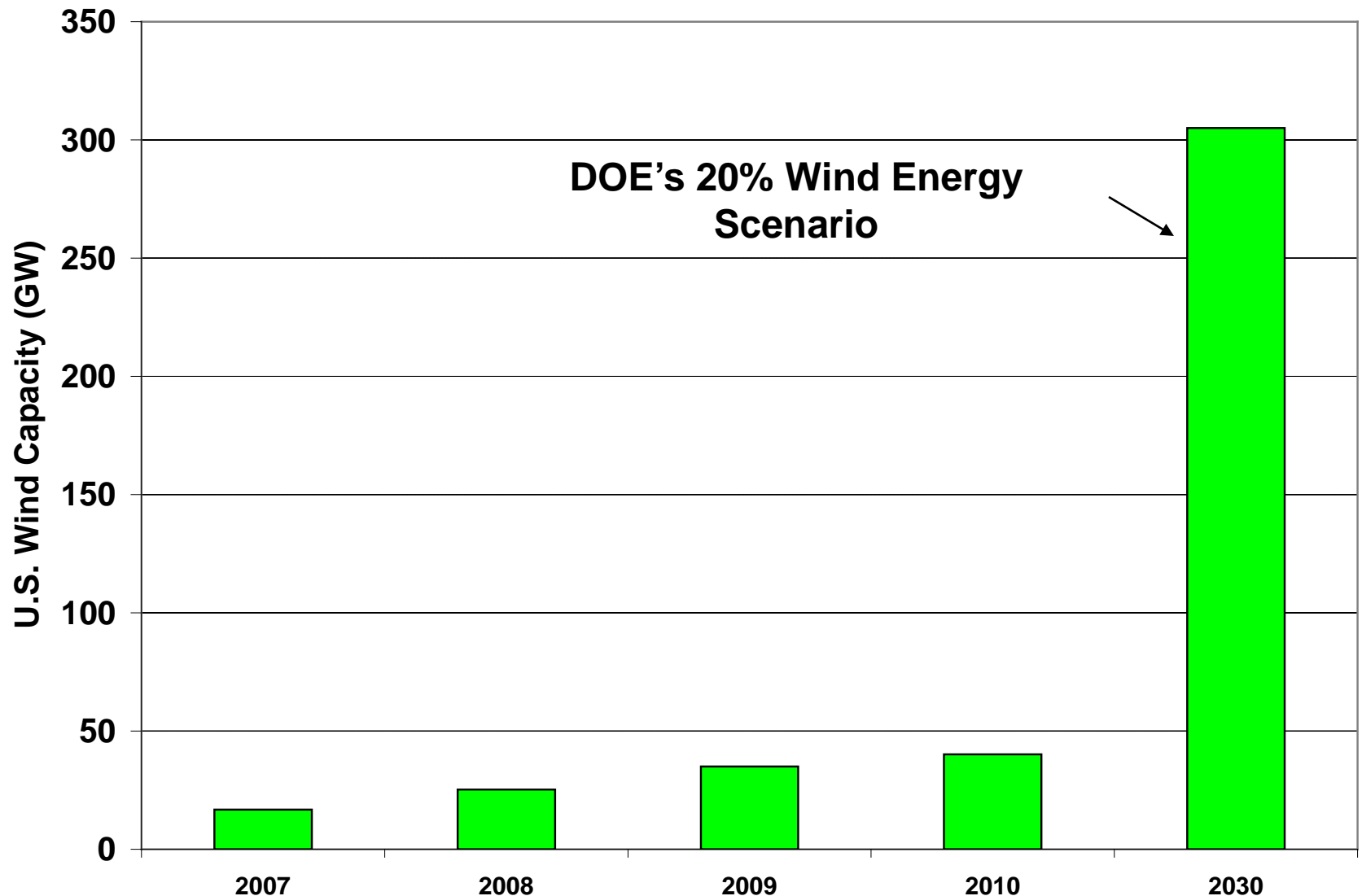
- ◆ Introduction
- ◆ Outlook on intermittent generation
- ◆ Grid integration issues
- ◆ Gas infrastructure constraints/challenges
- ◆ Gas/electric convergence

# Intermittent Generation as a % of Total Generation



Source: EIA

# U.S. Installed and Projected Wind Capacity



Source: AWEA, DOE's 20% Wind Energy by 2030 (May 2008)

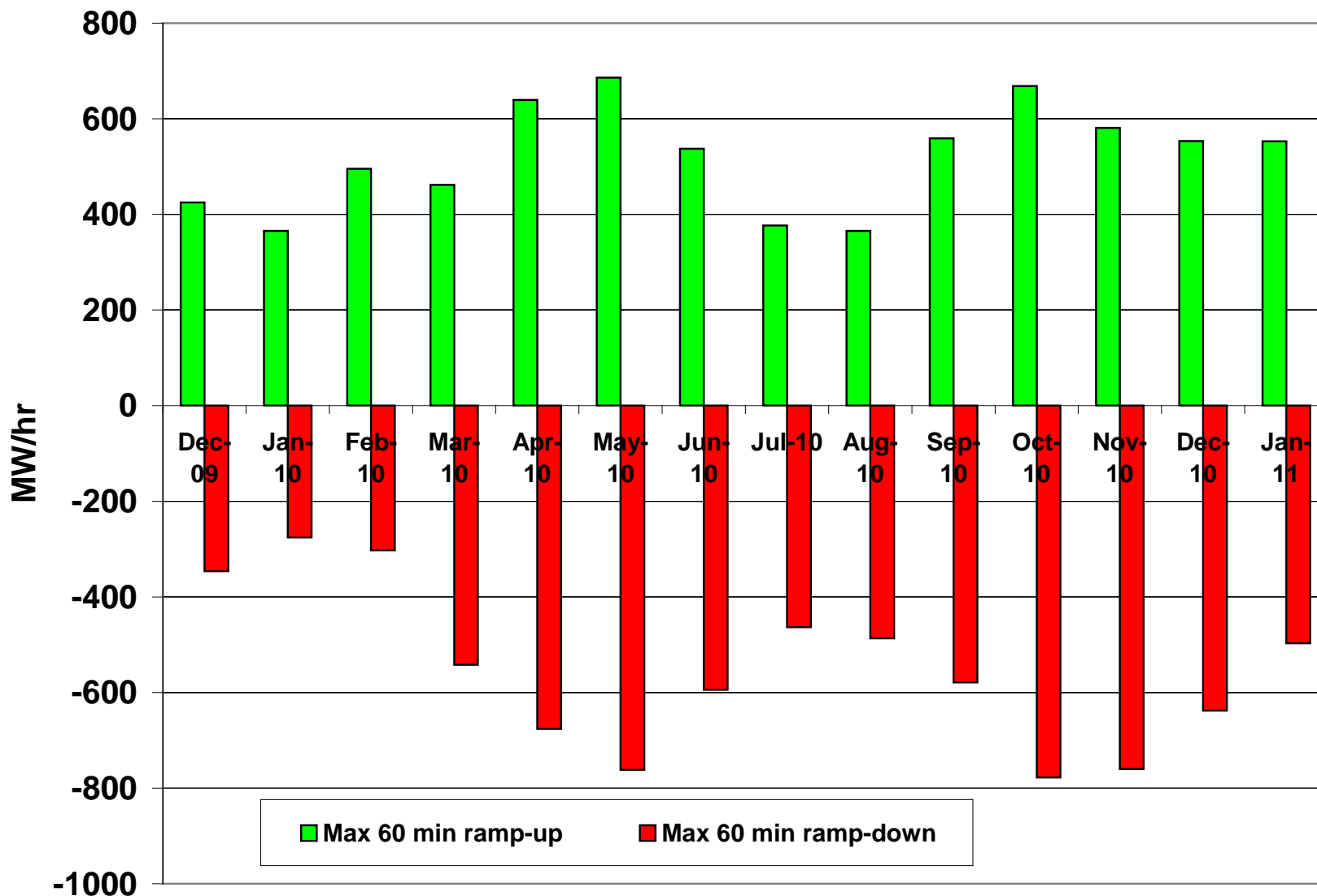
# FERC NOPR to Integrate Variable Energy Resources

- ◆ Nov 2010 NOPR - landmark initiative to reform the Open Access Transmission Tariff
  - Transmission providers will be required to offer intra-hourly transmission scheduling
  - VERs will have to provide meteorological and operational data
  - New generic ancillary service rate schedules for regulation service

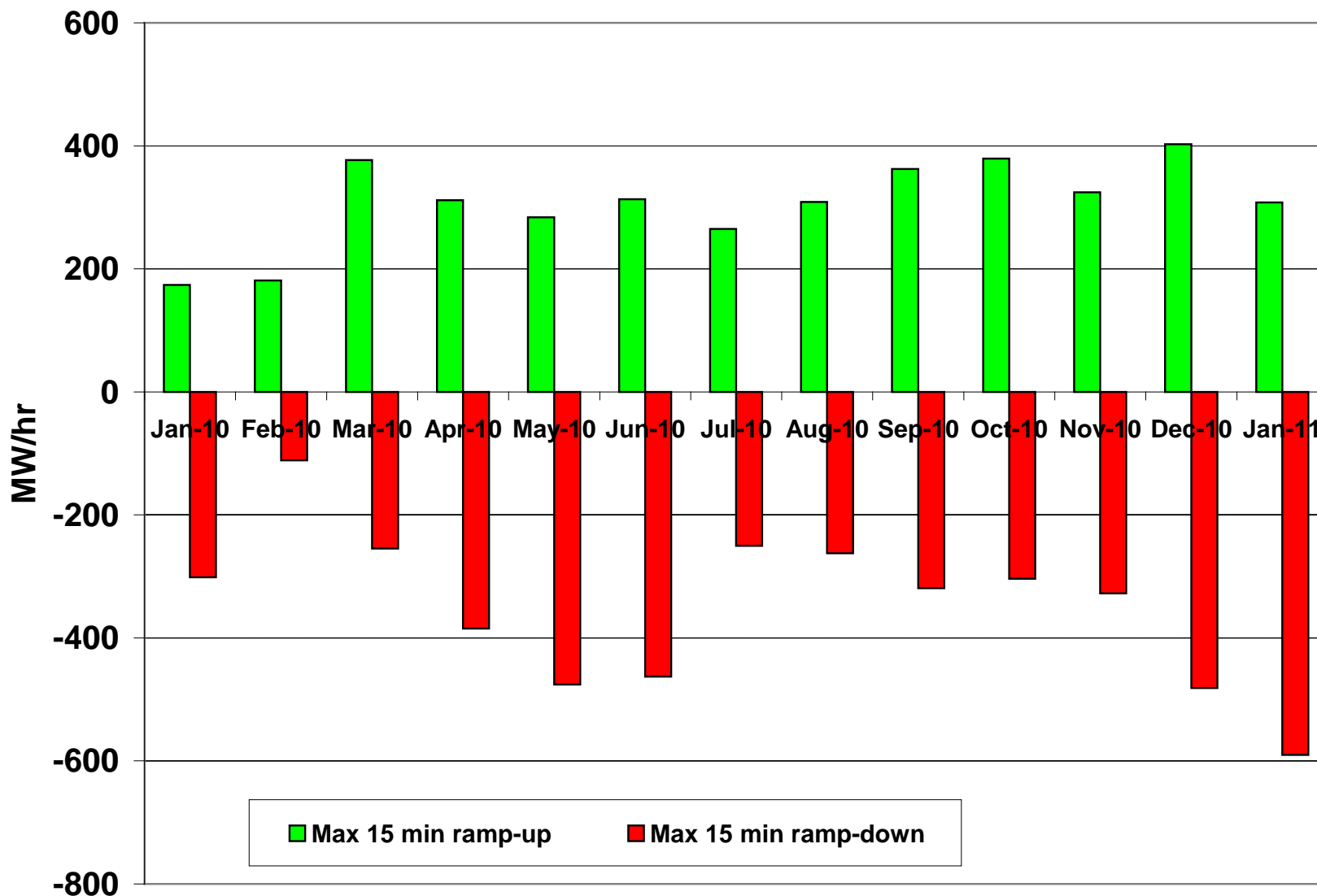
# Existing ISO Procedures

- ◆ Compliance with reliability standards through ancillary services
  - Dispatch and scheduling (**days**)
  - Voltage control and reactive supply (**minutes**)
  - Energy balancing (**hours**)
    - fossil fuels and pumped or other storage
  - Regulation and frequency response (**minutes**)
    - Increases linearly with wind
    - Varies by season and time of day
  - Operating reserve (**hours**)
  - Black start capability
- ◆ Not all ancillary services are market based
  - D & S, VC and RS are not

# Max 60-min Wind Ramp Up and Down in PJM



# Max 15-min Wind Ramp Up and Down in PJM





# Emerging ISO Procedures/Needs

- ◆ Improving wind forecast models
  - 15-20% Mean Absolute Error (MAE)
- ◆ Shortening the forecast horizon from DA to HA
  - Reduces balancing energy due to prediction errors by 50% in northern Europe\*
- ◆ Unavoidable MAE → increased regulation and ancillaries
- ◆ More energy storage
  - Batteries, flywheels, compressed air energy storage when excess wind or coal
- ◆ More interconnection / smarter grid
  - More cross border transmission links

\* "Integrating Wind into Europe's Grid Network", **Wind Directions** (Nov/Dec 2005)

# Myriad Challenges Before ISOs

- ◆ Will market participants tolerate
  - increased inefficiencies associated with re-dispatch?
  - uneconomic commitments explained by frequent and unpredictable swings of large magnitude?
- ◆ Is the supply elasticity of ancillary services sufficient in light of aggressive RPS targets?
  - Maybe today in some ISOs
  - Not likely in the future without compensatory measures and incentives
  - NYISO found no significant increase in regulation requirements for up to 10% of peak load but an increase of 10% (25 MW) for up to 20% peak load\*

\* R. Pike, NYISO, "Complimentary Roles of Storage and Renewable Resources", PJM/EPRI 2010

# The Challenges Before ISOs (cont.)

- ◆ Can ISOs change market rules to accommodate the integration of intermittent resources?
  - Crises such as ERCOT's Feb 26, 2008 grid emergency have resulted in operational changes such as DA and HA wind production forecast modifications and more regulation
  - Market rule changes take a long time
    - Europe is still struggling with market reform
  - Market rule changes necessitate painstaking stakeholder involvement and FERC approval
- ◆ What is the best way to define a stakeholder process oriented around market rule changes?
  - Educate all parties on the issues and invite solutions

# Rationalizing the Use of Pipeline Line Pack

- ◆ Pipeline network like a vast horizontal silo
  - packed and drafted daily
- ◆ Vast untapped potential for wind integration
- ◆ Heavy penalties for unauthorized overpulls hinder generators' reliance on line pack
- ◆ ISOs cannot unilaterally formulate incentives that may deplete line pack
  - Broad stakeholder participation needed to compensate pipelines, safeguard entitlement holders
  - Seasonal operating constraints

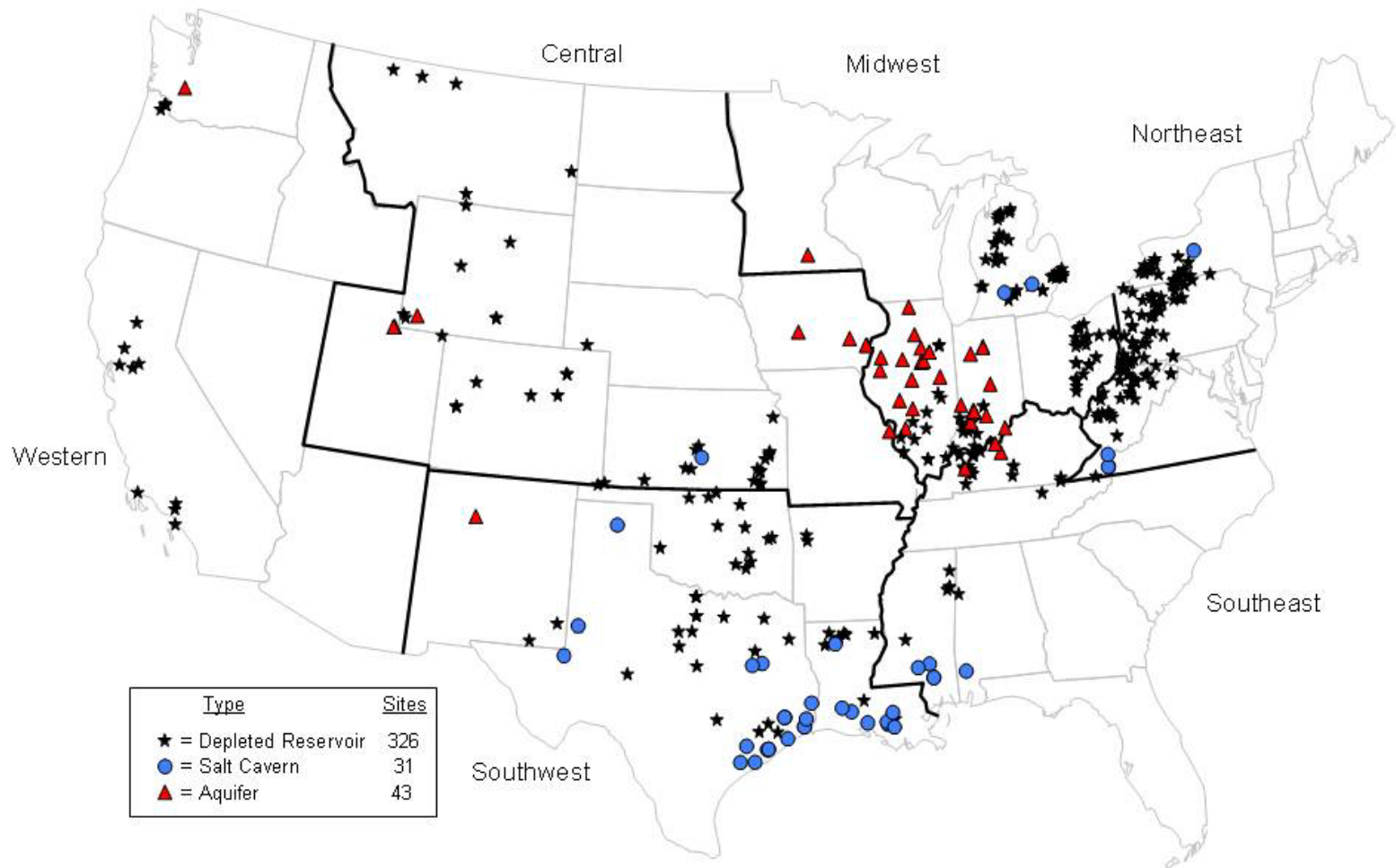
# Pipeline Tariff Restrictions Affecting Peakers

- ◆ Requires shippers to take service on a ratable 1/24 hour take subject to a margin of error of 1-4%
- ◆ Possible for generators to take gas on a non-ratable basis or at enhanced pressures when pipeline operations permit
- ◆ Peaking generators typically have interruptible transportation
- ◆ Back-up generation will require ULSD or firm gas transportation service

# Gas Transportation Services for Backing-up Wind

- ◆ Enhanced line pack
  - Compressors may need to be run more frequently resulting in more fuel charges and maintenance
  - Largest swings in ramp rates **do not** occur in summer at least in PJM
- ◆ New no-notice and gas storage services
  - Storage can act like a shock absorber esp. for intra-hour fluctuations if close enough: gas moves at 15-30 mph and pressure changes move more quickly
  - Storage tariffs might need modification
- ◆ Increasing the number of nomination cycles
  - Currently 4 nomination windows with a 6-hour nomination cycle
- ◆ Reducing the length of nomination cycles
  - Current 6-hour nomination cycle could be reduced to 1-hour

# U.S. Underground Natural Gas Storage (2007)



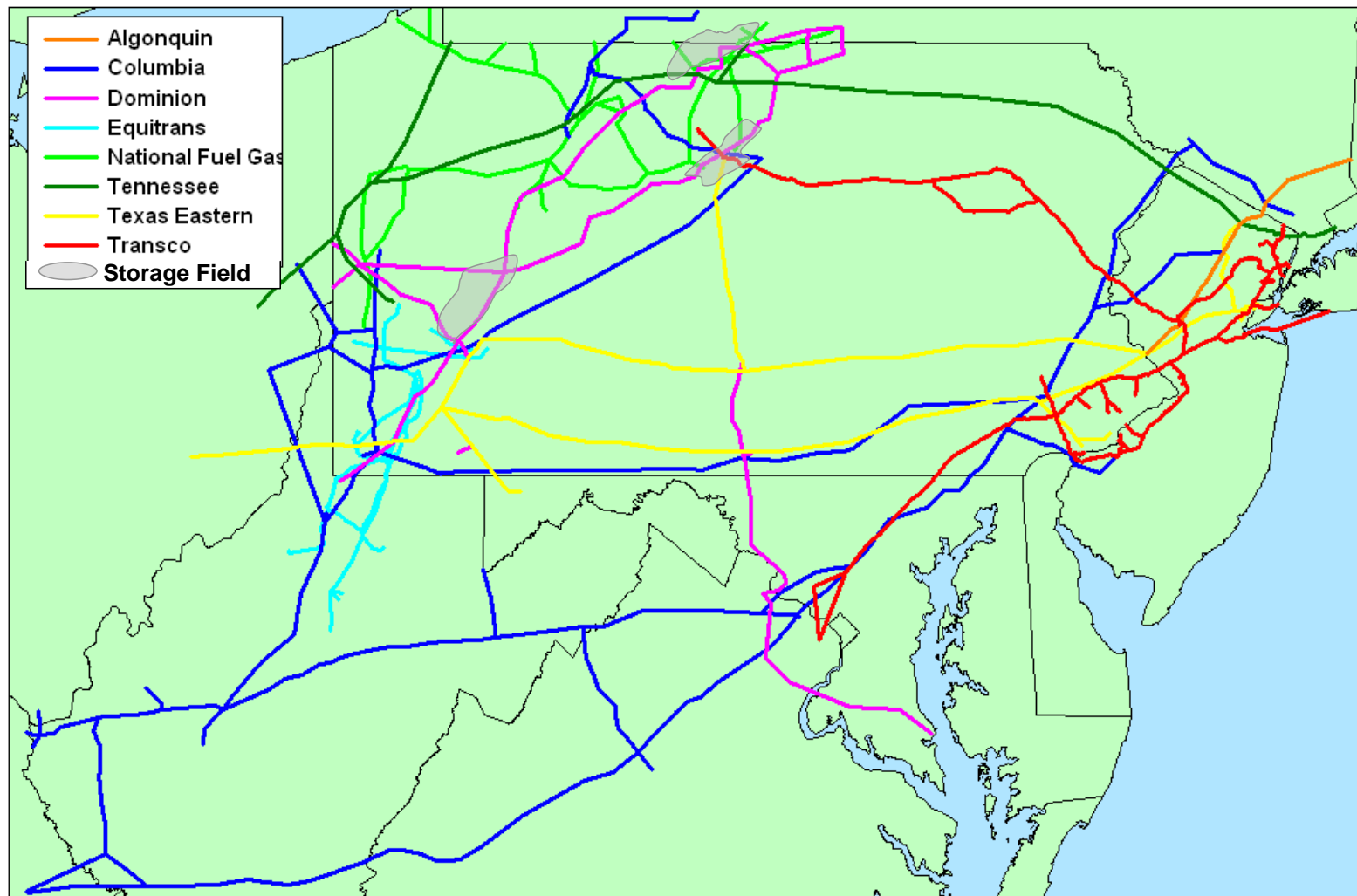
Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division Gas, Gas Transportation Information System, December 2008.

# Transient Modeling & Continuous Measurement

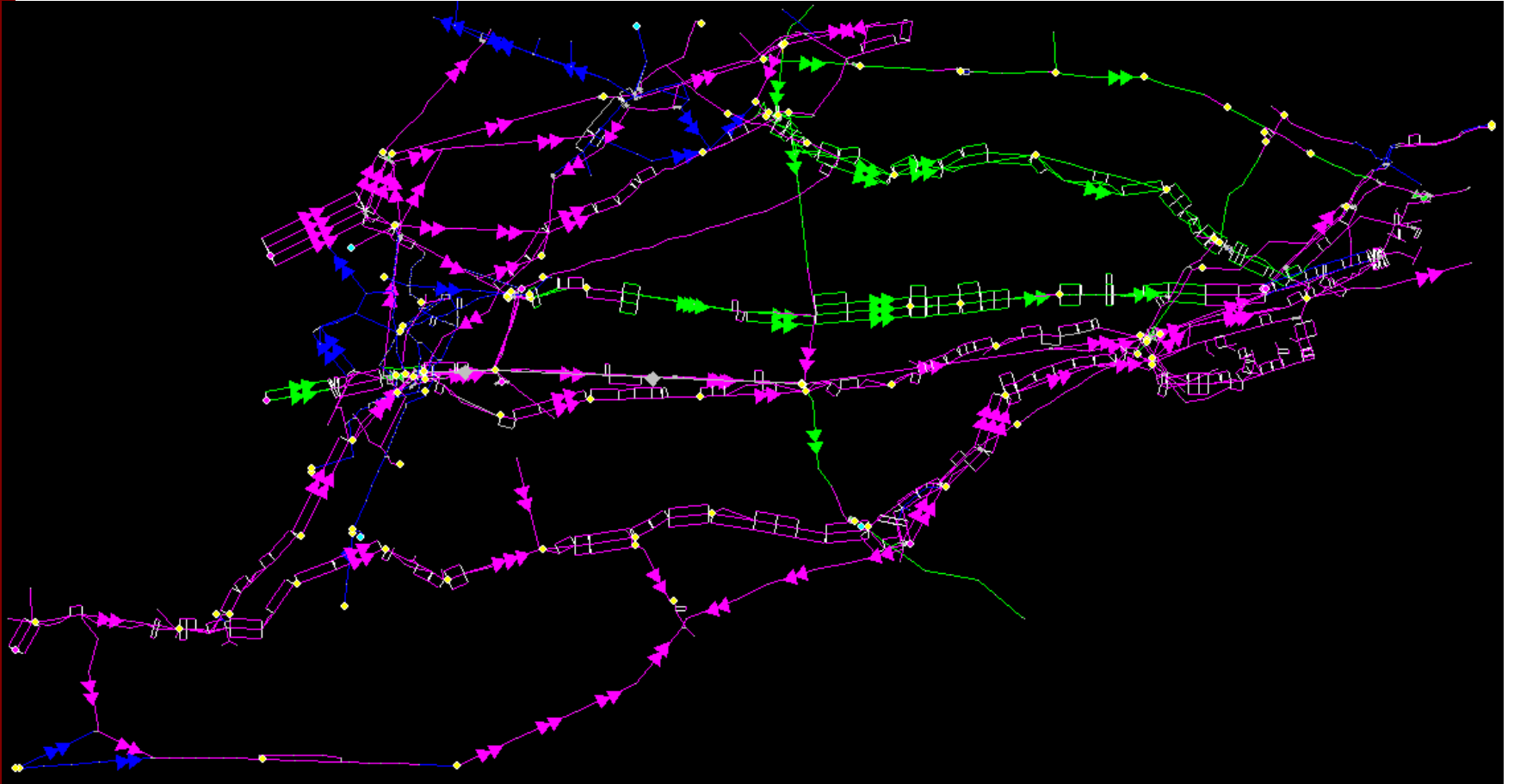
- ◆ Steady state and transient flow models
- ◆ ICF modeled a fictional pipeline for the INGAA Study
- ◆ Compared nomination cycle times
  - Found that 1-hour nomination cycle provides more stable line pack compared to the longer 6-hour nomination cycle
- ◆ Additional measurement sensors and more information management can alert operators to quickly changing conditions in pipeline



# Consolidated Network of Pipelines Serving PJM



# Dynamic Line Transients Across PJM Supply



# Line Pack Depends on Pipeline Specifics

- ◆ Electricity appears to move at the speed of light
  - natural gas moves at twice the speed of world class marathoner
- ◆ Straightforward operational actions affect line pack across the supply chain
  - Increase production at the wellhead and/or at gas gathering facilities
  - Reverse flow across bidirectional segments
  - Increase flows at pipeline interconnects
  - Increase horsepower at key compressor stations
  - Storage withdrawals, including increased regasified LNG

# Gas Pull from Activation of GTs Possible

- ◆ Aggressive management of line pack inventory required for replenishment
  
- ◆ 10 LMS 100 GTs = 1,000 MW
  - ~ 690 MMBtu First 10 minutes Gas Use
  - ~ 7,590 MMBtu First Hour Gas Use
  - ~ 15,870 MMBtu Two Hour Gas Use
  
- ◆ Withdrawal ~ 16,000 MMBtu worse case limit
  
- ◆ Quality of service not degraded

# Stakeholder process

- ◆ Multiple sticky issues
  - If line pack is increased to serve a back-up generator, this benefit may be enjoyed by other pipeline customers. Who should pay?
  - Should quick start peakers be treated differently?
- ◆ Rate design for pipelines: cost recovery should follow cost responsibility
  - Existing contracts and settlements may not allow for adjustment of rates or recovery of costs incurred for the benefit of the entire system

# Tariff Changes Require Stakeholder Participation

- ◆ Green path initiatives involving interstate pipelines may require more than a regulatory “nudge”
  - FERC NOPR
  - State commission participation
  
- ◆ Only so much line pack to go around
  - During cold snaps line pack must be reserved for system integrity to ensure no harm to primary entitlement holders
  - Most other months line pack can be managed and exploited to promote green path objectives
  
- ◆ Streamlined coordination and communication among gas and electric-side participants, including producers and storage operators

# NAESB Scheduling Protocols Rigid by Design

- ◆ Protects primary entitlement holders
- ◆ Ensures system wide integrity
- ◆ Provides intra day renomination / confirmation cycles
- ◆ Not tailored to no-notice or short-notice requirements of quick start GTs
  - Exposed to costly penalties for unauthorized gas use
  - Start up on ULSD

# Conclusions

- ◆ Need stakeholder process to initiate co-operation between pipelines, generators (wind and natural gas) and ISOs
- ◆ Need market rules to compensate both gas suppliers and GTs to provide back-up on short notice
- ◆ Need transient pipeline modeling to explore
  - the availability and limits of linepack for each pipeline
  - the need for more natural gas storage in the market area
- ◆ Need to provide pipeline with real time information about operation of electric grid
  - Especially real time notice of low wind conditions when peakers will need to be dispatched