



# **Planning and Operations Overview**

**Ken McIntyre**

**VP Grid Planning and Operations**

**Dan Woodfin**

**Director, System Operations**

**Warren Lasher**

**Director, System Planning**

**CRE/ERCOT**

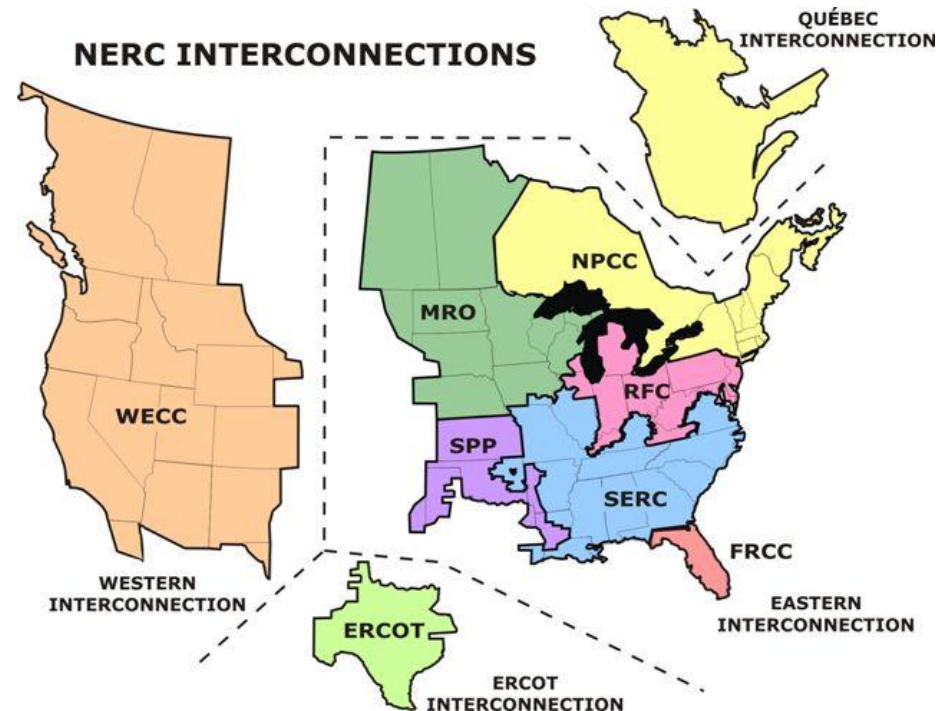
**February 18, 2014**



# The ERCOT Region

The interconnected electrical system serving most of the state of Texas, which has only **Direct Current (DC)** limited interconnections to the rest of North America

- 85% of Texas load
- 68,294 MW peak demand (set August 3, 2011)
- More than 40,000 miles of transmission lines
- 2 DC ties with eastern United States; 3 DC ties with Mexico; 1106 MW total
- 550+ generation units





# ERCOT Independent System Operator (ISO)

## ERCOT Inc.:

**A non-profit corporation designated the “Independent Organization” under state law and assigned these responsibilities [Texas Public Utility Regulatory Act (PURA) 39.151]:**

- Maintaining System Reliability
- Ensuring Open Access to Transmission
- Facilitating the Competitive Wholesale Market
- Facilitating the Competitive Retail Market

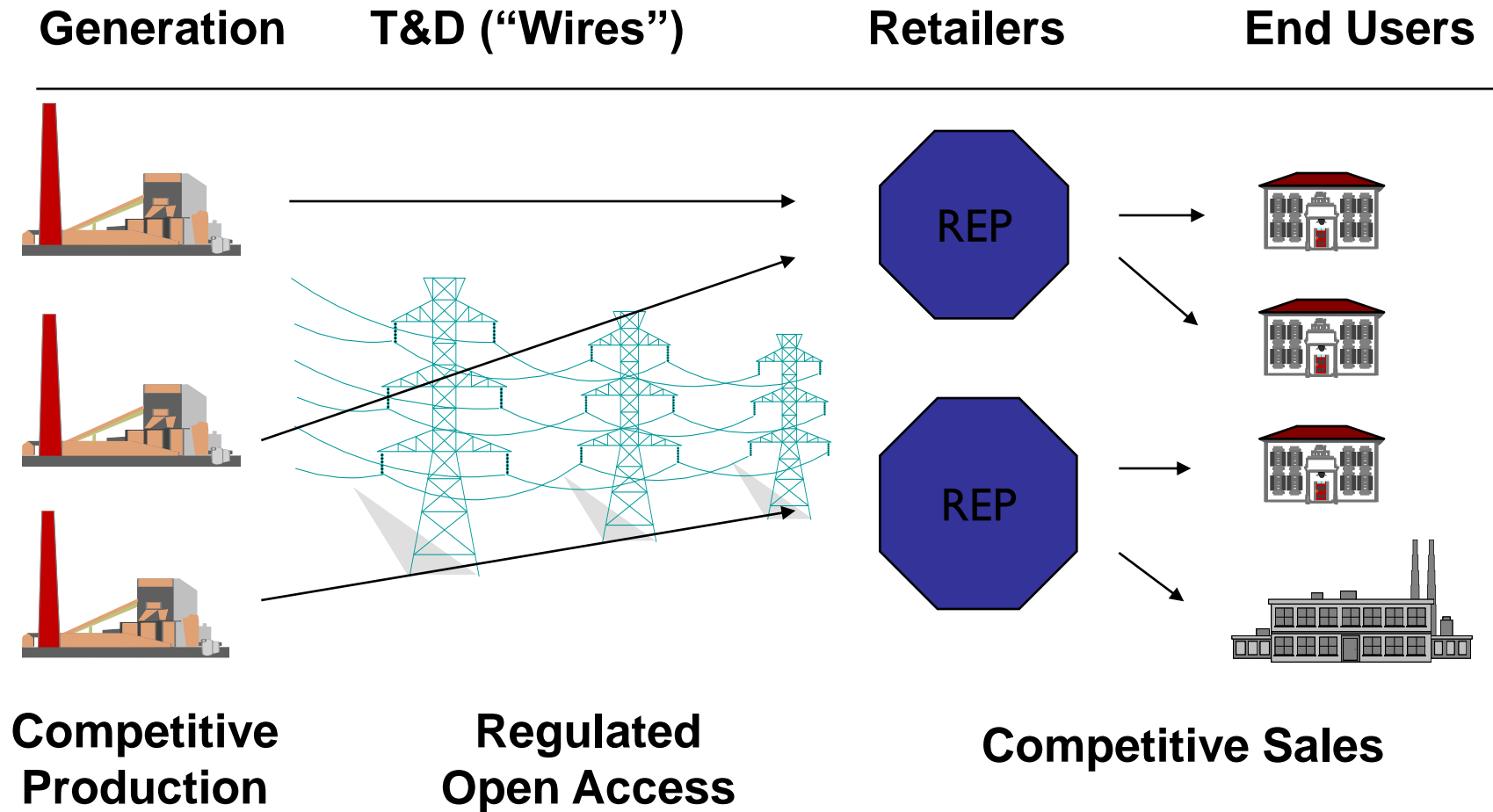


## **Regulatory Characteristics:**

- ERCOT is regulated by the Texas Public Utility Commission with oversight by the Texas Legislature
- ERCOT is not a market participant and does not own generation or transmission/distribution wires



# Texas Competitive Model





## Wholesale

- Fully unbundled Wholesale market
  - ERCOT operates a single Balancing Area
  - 5-Minute security constrained economic dispatch with day-ahead and ancillary services markets
  - Generators are paid Locational Marginal Prices (LMPs) at node
  - Load-serving entities pay averaged load-zone prices
- Transmission
  - All transmission costs rolled-in to single postage-stamp rate paid by load
  - Any transmission owner who transmits power for another entity is a regulated utility under state law
  - No transmission service market

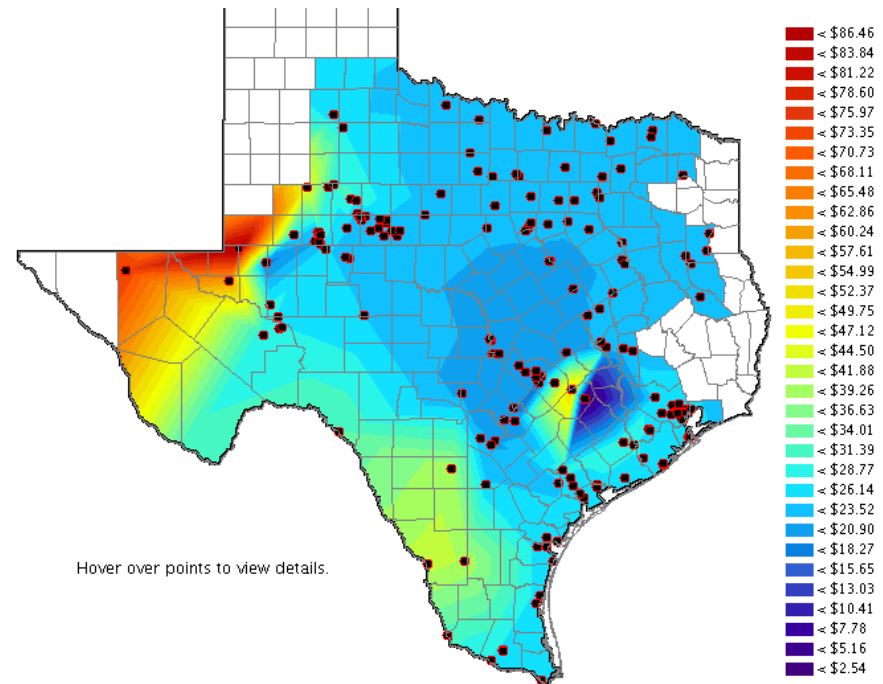
## Retail

- Full Retail competition for all customer types
  - Except in municipal and cooperative utility areas
  - Customers choose retail provider and terms of contract
- Smart meters (which measure time of consumption) installed on all customer types – over 6 million meters



# Normal Operations

- Market participants bring generation on-line; ERCOT may start additional generation needed to maintain reliability
- Market participants submit offers for generation output
- ERCOT clears market every five minutes, using the generation with the lowest bids to serve the load, subject to transmission constraints
- Prices received by generators signal whether more or less output is needed from generators in that area ***at that time***
- Ancillary Services (also procured through markets) are used to cover variation in load within five minute intervals, if a generator trips, or to cover forecast variability



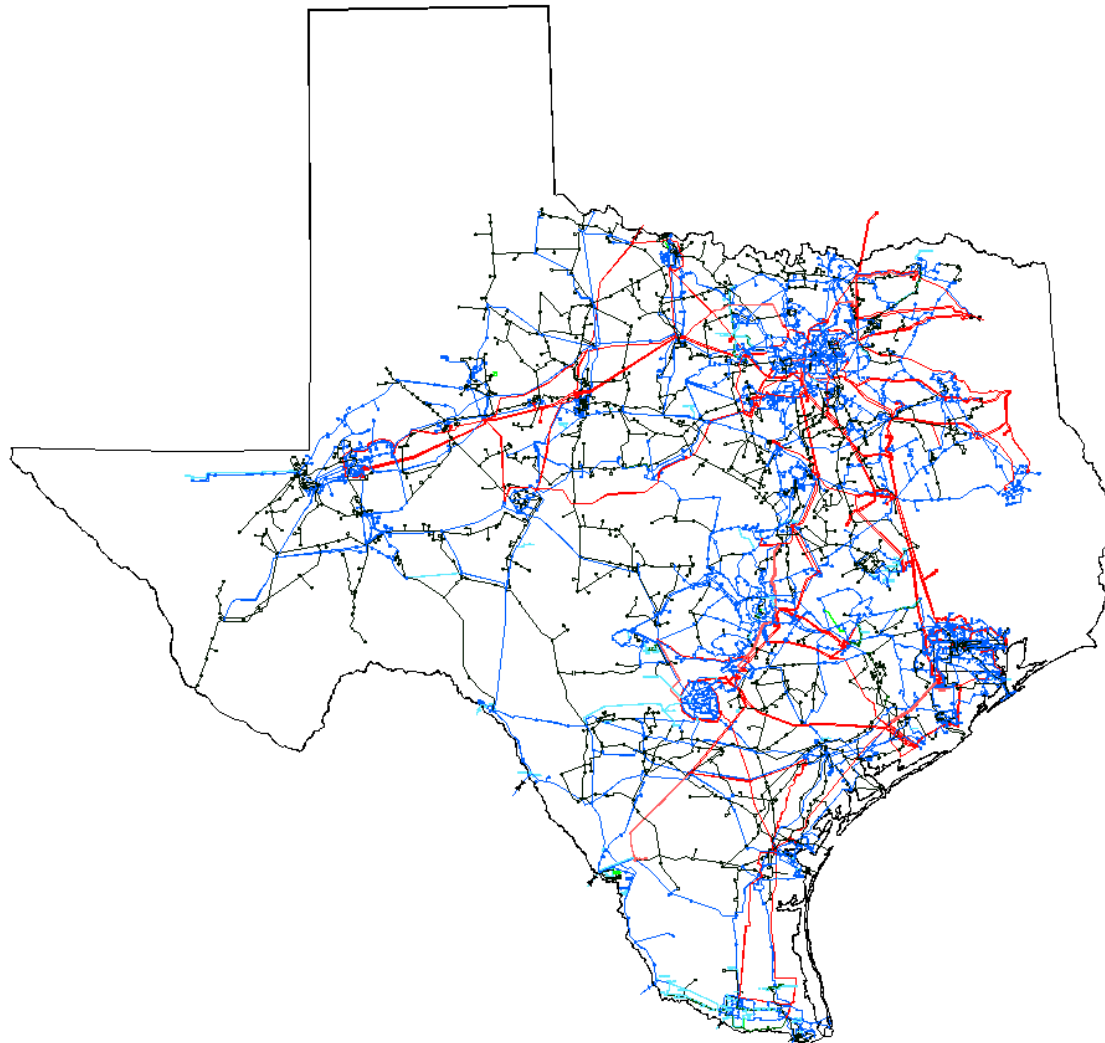


## **“Normal” Transmission Planning and Development**



# ERCOT Region Continues to Add Significant Transmission

- **41,500 Miles of Transmission Lines in ERCOT**



>9,500 circuit miles of transmission (>60kV) built since 1999

~2500 circuit miles of transmission under study

\$14.3 billion investment in transmission placed in service since 1999

~\$3.7 billion under development (including CREZ transmission)



# Regional Planning Framework

<b>Coordinated 5-Yr. Transmission Plan</b>	<b>Long-Term System Assessment</b>
<ul style="list-style-type: none"><li>•Annual study of transmission needs of ERCOT system over next five years</li><li>•Projects identified by ERCOT in coordination with TOs with comment from stakeholders</li><li>•Projects included to meet all identified reliability requirements and congestion reduction projects that meet economic criteria</li><li>•Local and already-Reviewed projects are included without review</li></ul>	<ul style="list-style-type: none"><li>•Study of long-term transmission needs of ERCOT system</li><li>•Includes scenario-based analysis of future resource investment by market participants and resulting transmission system needs</li><li>•Produced in even years and re-evaluated annually</li><li>•Provides directional vision to near-term decisions with goal of long-term efficiency in transmission plans</li></ul>
<b>Transmission Owner Plans</b>	<b>Individual Project Reviews</b>
<ul style="list-style-type: none"><li>• Projects developed by each transmission owner</li><li>• Generally include projects that are “Local” (&lt;\$15M) or “Neutral”</li><li>• Included in Steady-State Working Group (SSWG) powerflow cases</li></ul>	<ul style="list-style-type: none"><li>• Additional projects or studies can be proposed by any Market Participant, Transmission Owner or ERCOT Staff</li><li>• Individual projects included in 5-Yr. Transm. Plan also reviewed at appropriate time</li></ul>



# ERCOT Transmission Development Process

- **Project Need Identified**
  - Either through Five-Year Plan Development Process or Stakeholder Proposal
- **RPG Review of Project**
  - Open RPG(stakeholder) comment period for all non-trivial projects
  - Level of RPG review depends on size of project; Independent Review by ERCOT Staff and ERCOT Board Endorsement for large Projects
  - Rule-based assignment of Project Developer
- **Project Developer responsible for line engineering and routing studies**
- **PUCT determines Need and Routing for lines on new-right of way, through filing by project developer**
  - ERCOT recommendation given “great weight” by PUCT in determining Need
- **Cost recovery through annual transmission rate base adjustment; postage stamp rates paid by loads**



# Generation Interconnection Study Process

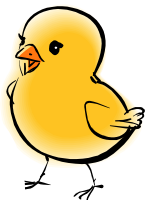
- **ERCOT role in interconnection process**
  - Initial screening studies
  - Participate in the meeting to scope the full I/C study to be performed by the TSP
  - Oversee process (not technical studies) to ensure it is non-discriminatory
  - Review technical I/C studies performed by TSPs
  - Manage consolidated interconnection process to energization
- **TSPs perform full interconnection and facilities studies**
- **ERCOT is not party to Interconnection agreement**



# Competitive Renewable Energy Zones Program

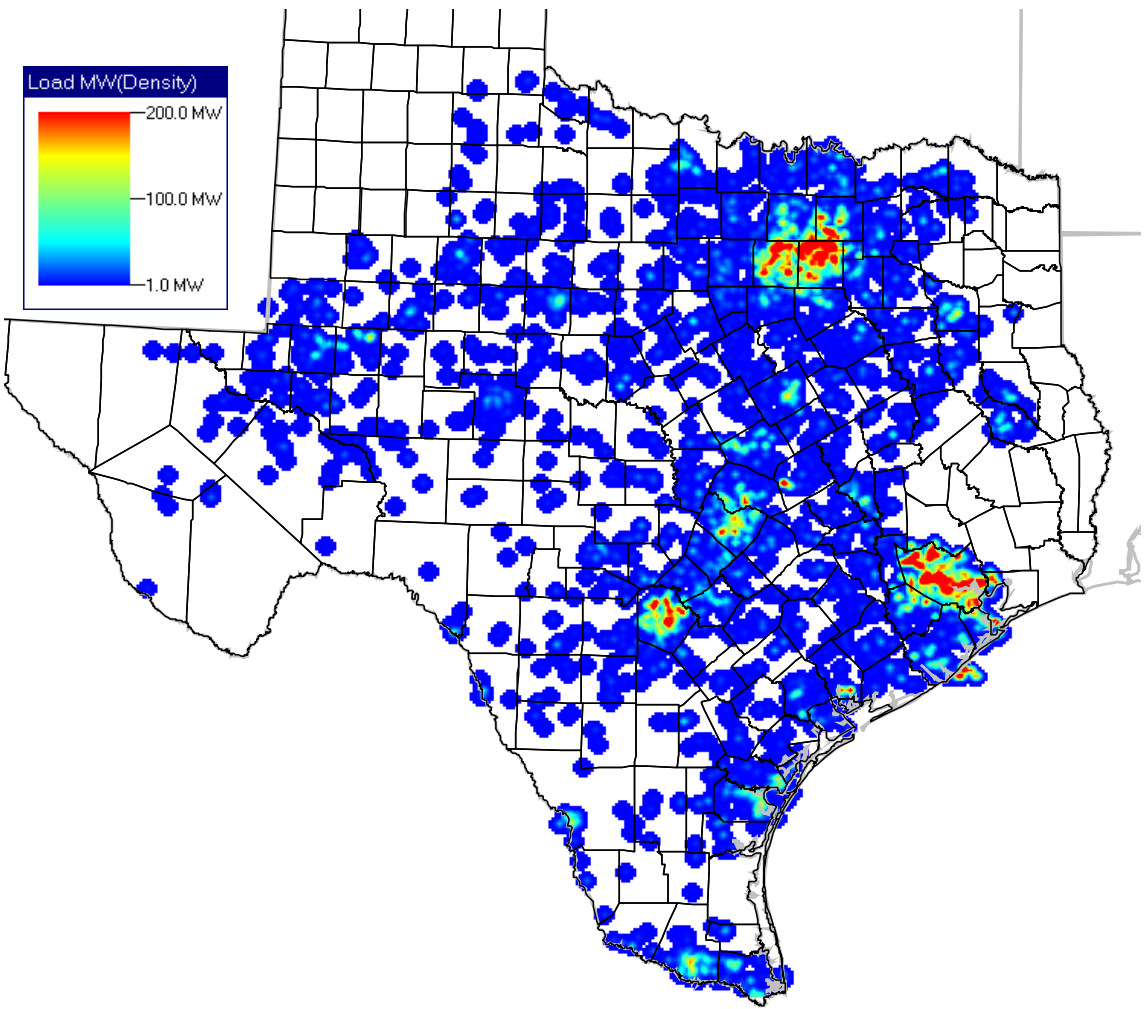


# Competitive Renewable Energy Zones Legislation



- **By 2004, had a Chicken versus Egg Problem with wind development and transmission**
  - Transmission Service Providers (TSPs) needed assurance that transmission would be used and useful
  - To develop transmission project and file CCN, TSPs wanted interconnection agreements, backed by security from wind developer
  - Wind developers were unwilling to commit security for 4-7 years needed to complete new transmission with no guarantee
- **In 2005, Texas Legislature directed the Public Utility Commission of Texas (PUCT), after consultation with ERCOT, to:**
  - Designate areas with sufficient renewable resource potential (CREZs)
    - Consider level of financial commitment by developers
  - Develop a plan for transmission to deliver renewable resource to consumers

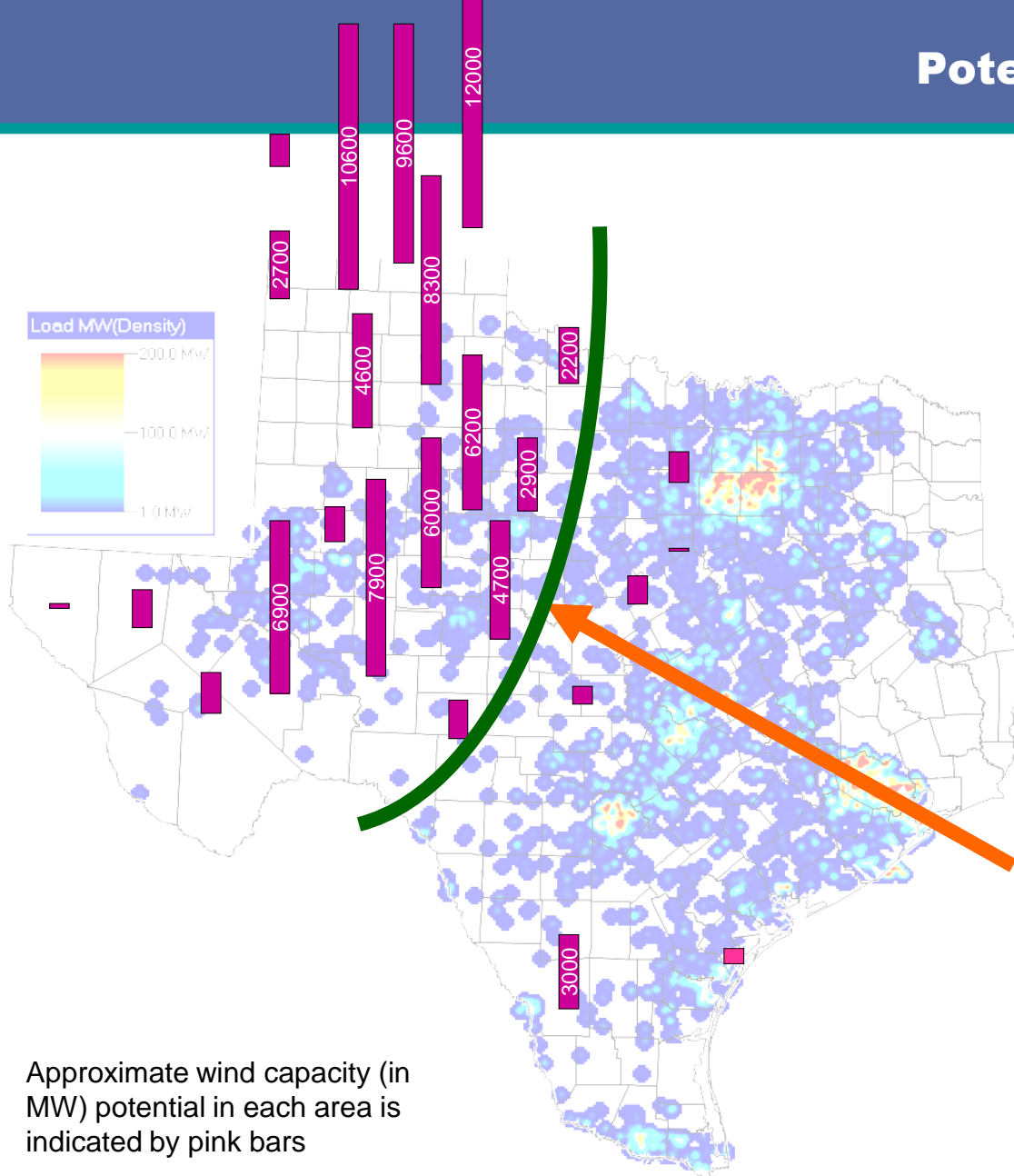




- ~62,000 MW peak demand (2007)
- Majority of load is concentrated in eastern half of state



# Potential Wind Resource



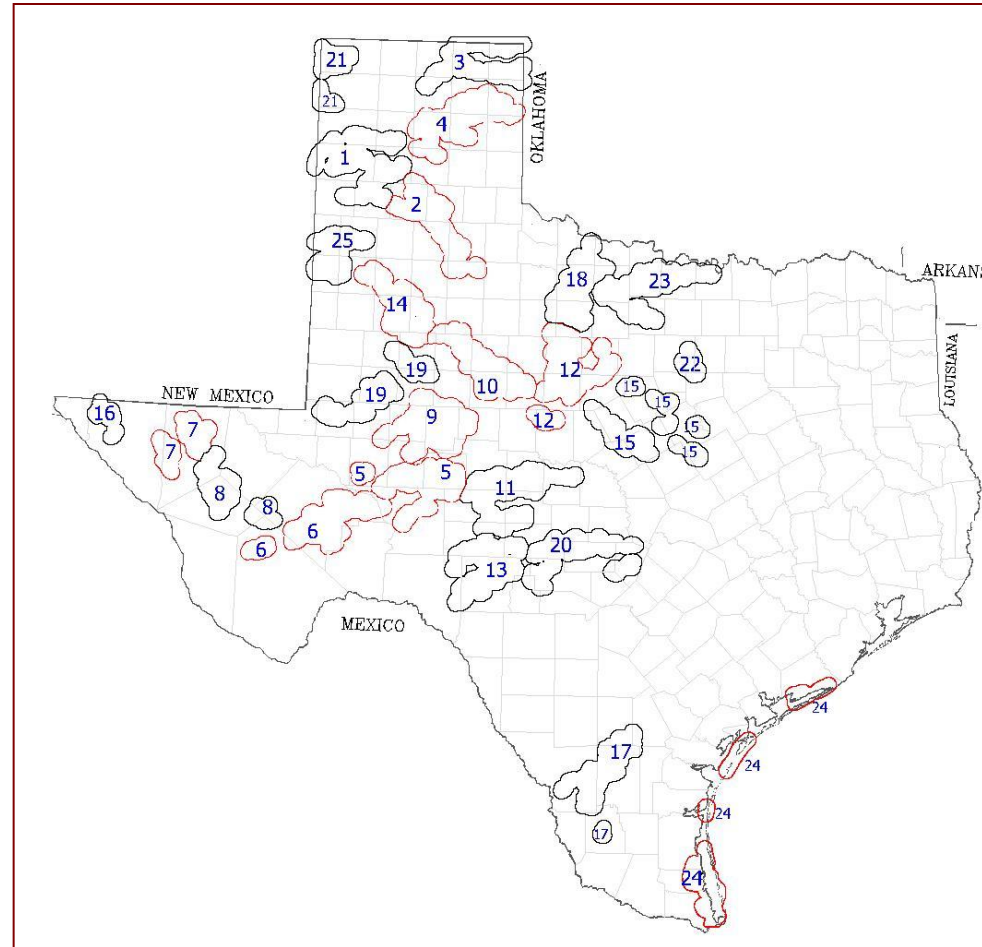
- Nearly 100,000 MW above 35% capacity factor (CF)
- Concentrated in western half of state

**Limited Transmission**

Approximate wind capacity (in MW) potential in each area is indicated by pink bars

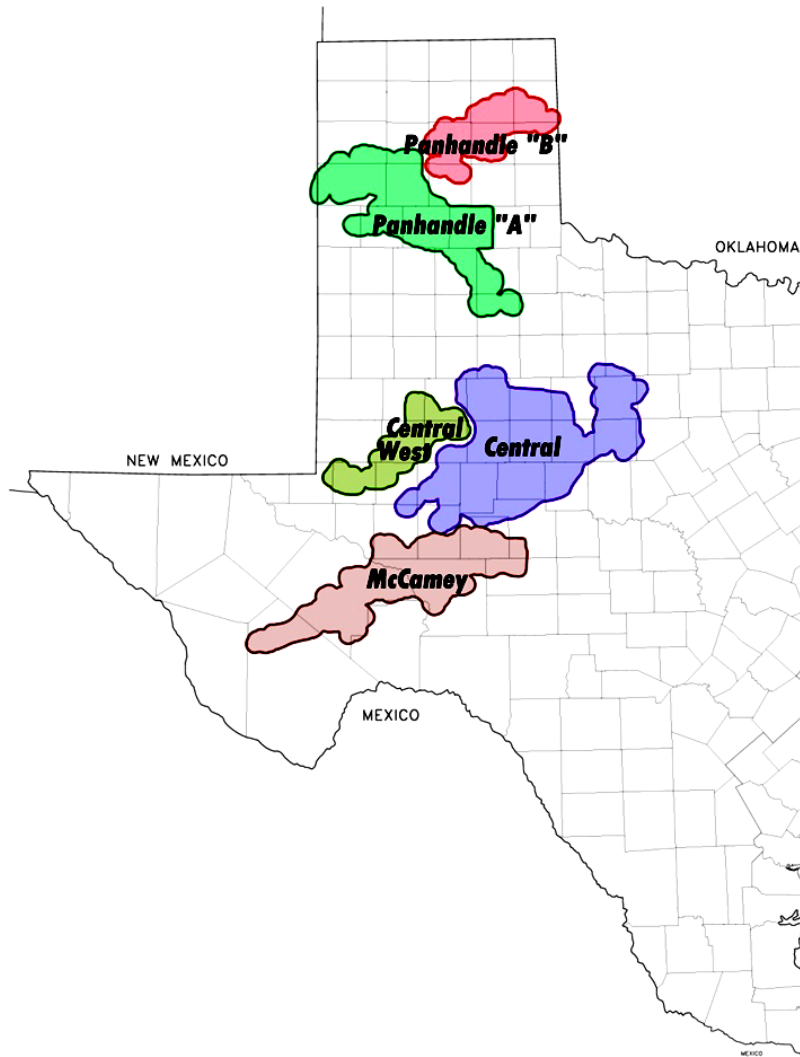


- **ERCOT led study during 2006 to support PUCT determination**
  - Hired wind modeling consultant to identify best wind resource sites and provide expected characteristics of wind generation
  - Developed initial transmission plans through open stakeholder process to accommodate many of the potential zones in various combinations
  - Filed results with PUCT in December 2006





# Designated Zones and Scenario Wind Levels



**Capacity of New CREZ Wind by Scenario (MW)**

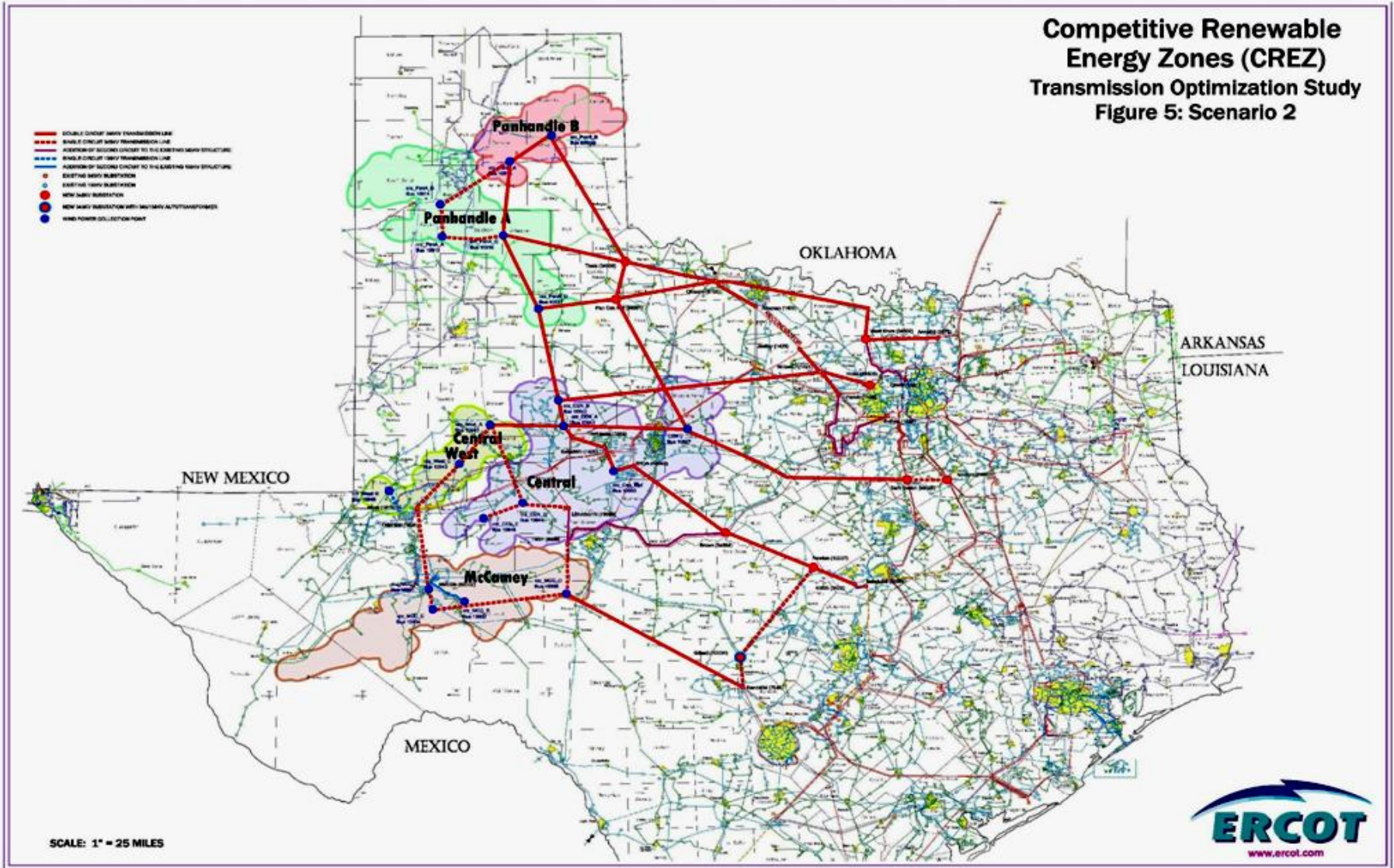
Wind Zone	Scen. 1	Scen. 2	Scen. 3	Scen. 4
Panhandle A	1,422	3,191	4,960	6,660
Panhandle B	1,067	2,393	3,720	0
McCamey	829	1,859	2,890	3,190
Central	1,358	3,047	4,735	5,615
Central West	474	1,063	1,651	2,051
<b>Total*</b>	<b>12,053</b>	<b>18,456</b>	<b>24,859</b>	<b>24,419</b>

\* Assumes 6,903 MW of existing wind capacity



# CREZ Transmission Plan

**Competitive Renewable  
Energy Zones (CREZ)  
Transmission Optimization Study  
Figure 5: Scenario 2**



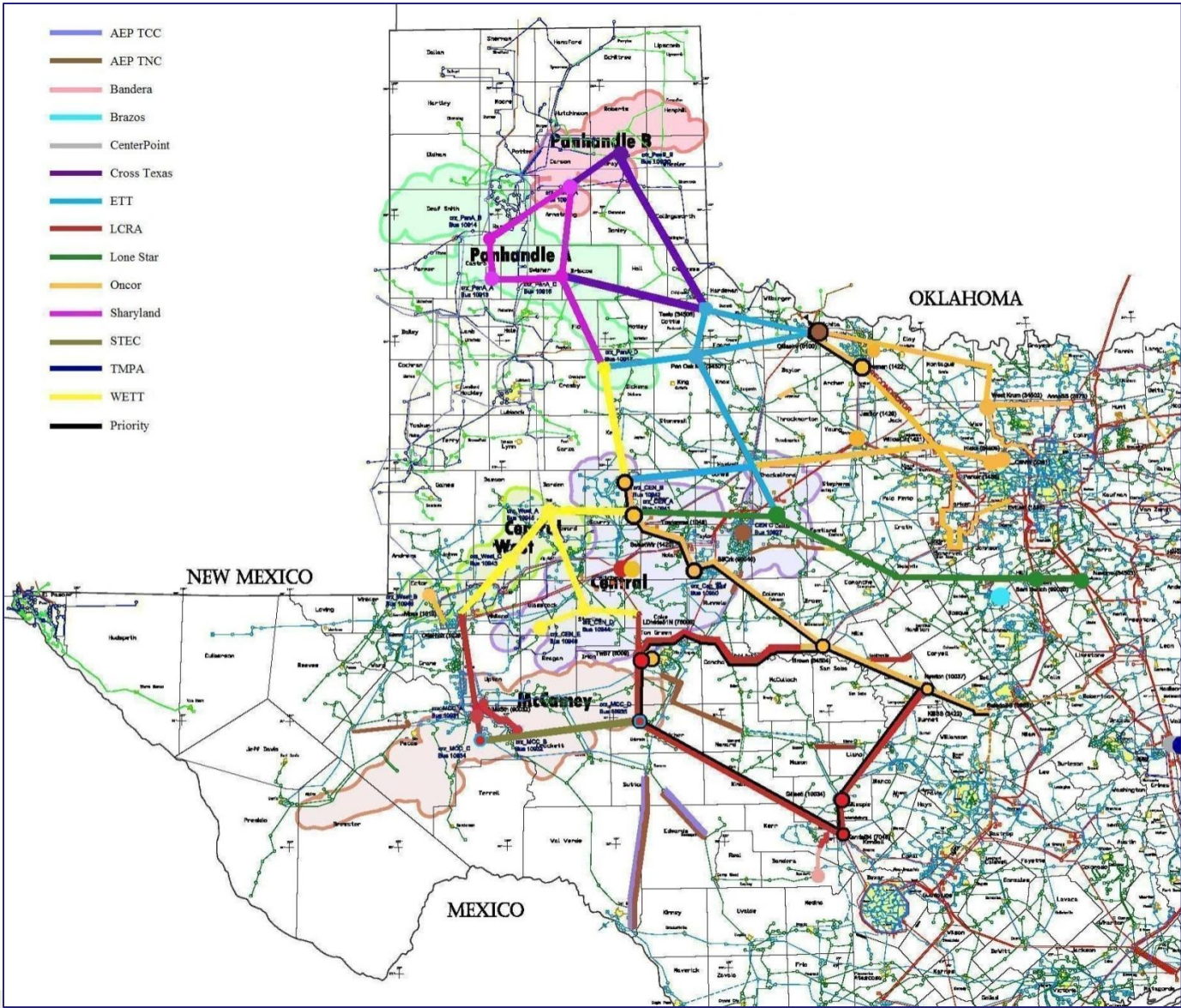


# Transmission Provider Selection

- **PUCT solicits transmission developer interest**
  - Portion of the CREZ Plan of interest
  - Financial and Project Management Capabilities
- **Contested case hearings are held by PUCT**
  - All but one of the proposing companies are selected for a portion of the Plan, determined by PUCT
  - Incumbents, existing utilities expanding into new area, new entities
- **Selected transmission developers begin engineering, routing and certification filings**
  - Line Certification filings at PUCT are made according to a schedule established based on expected time to develop projects

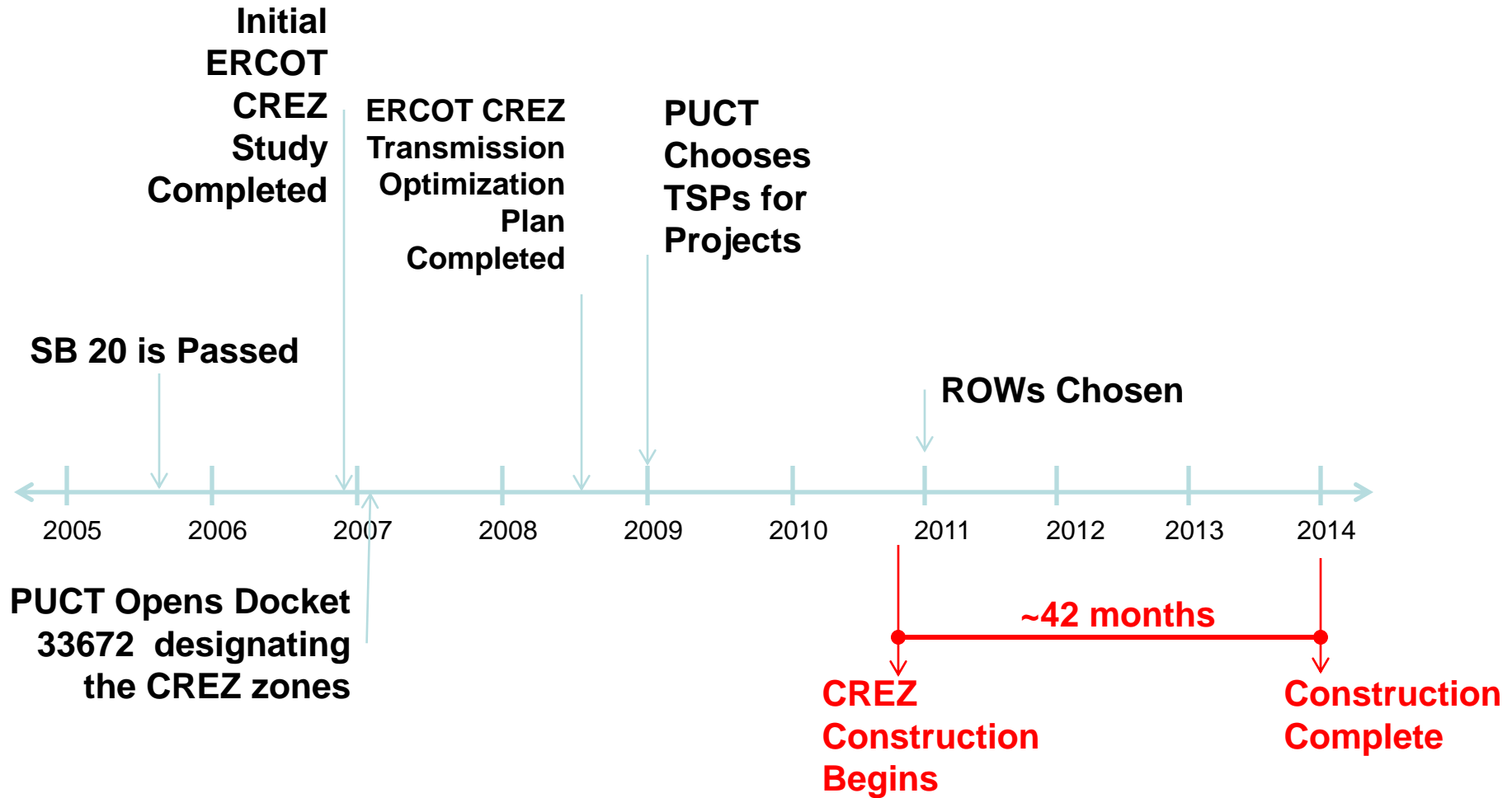


# Transmission Developer Selection



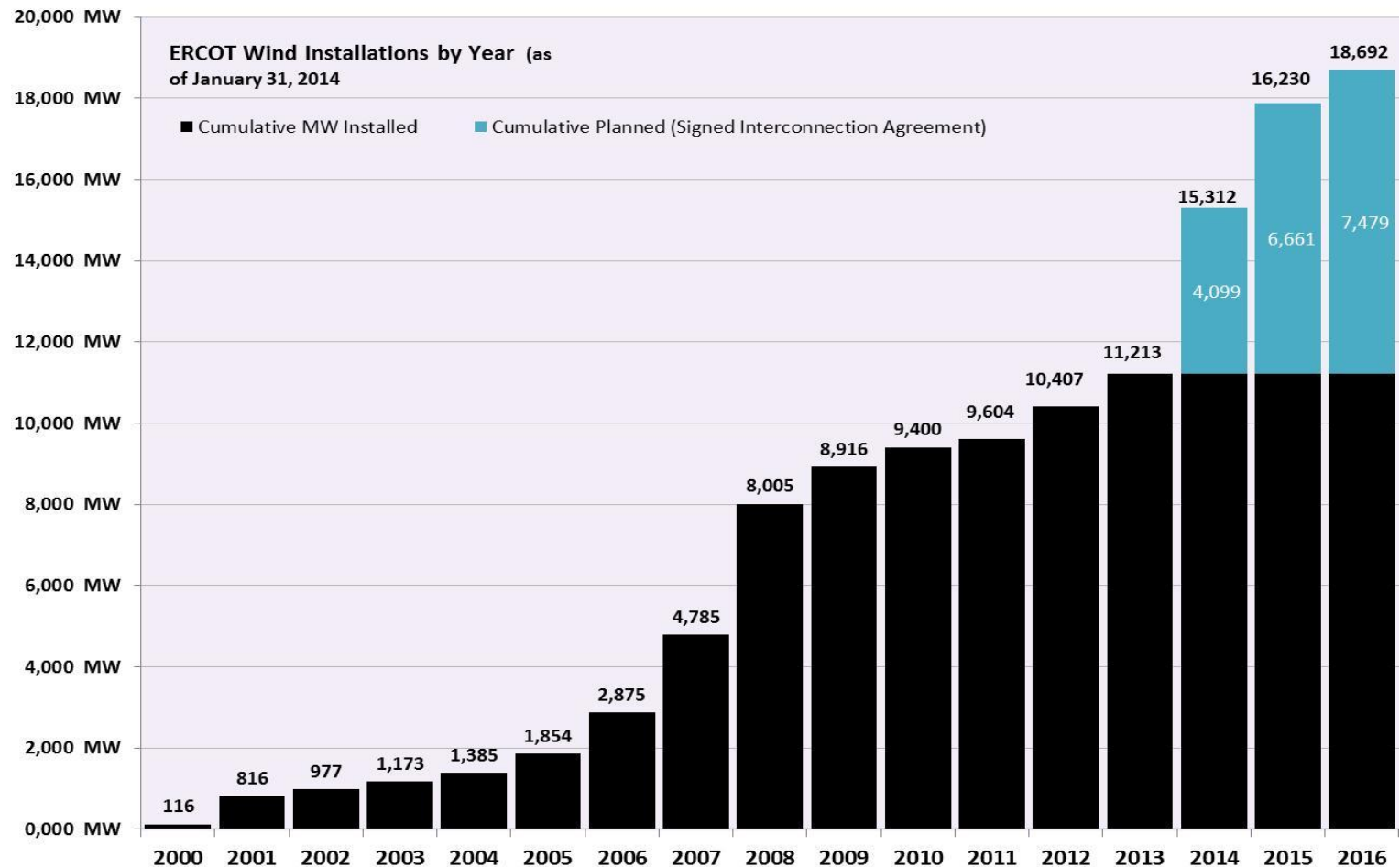


# CREZ Timeline





# Increase in Installed Wind Generation



The data presented here is based upon the latest registration data provided to ERCOT by the resource owners and can change without notice. Any capacity changes will be reflected in current and subsequent years' totals. Scheduling delays will also be reflected in the planned projects as that information is received.

This chart reflects planned units in the calendar year of submission rather than installations by peak of year shown.

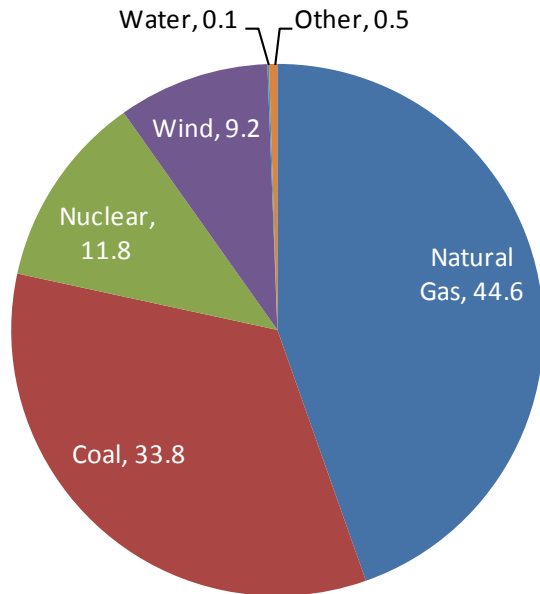


# Wind Integration

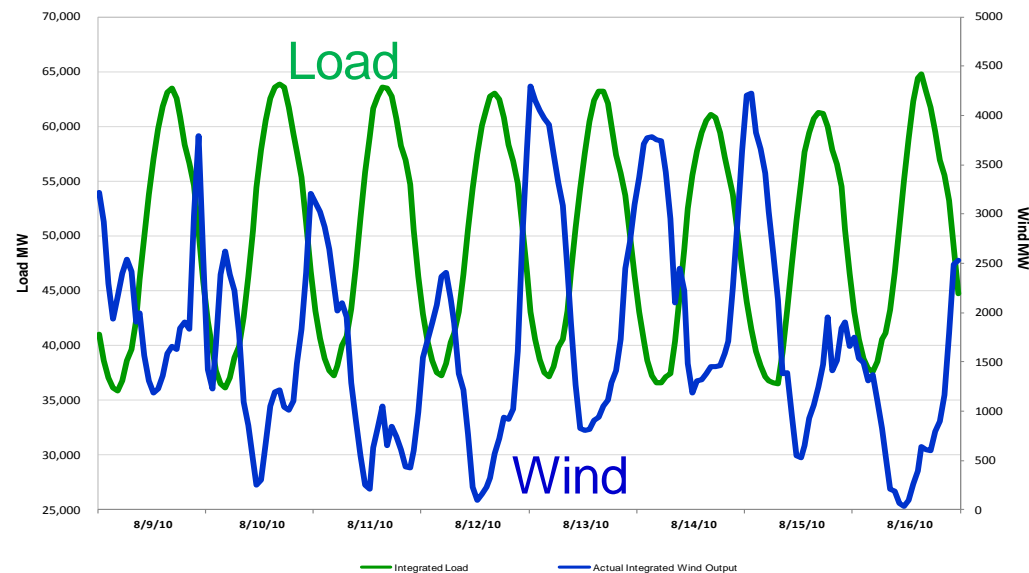


# Wind Output

**% Energy Produced by Fuel Type  
2012**



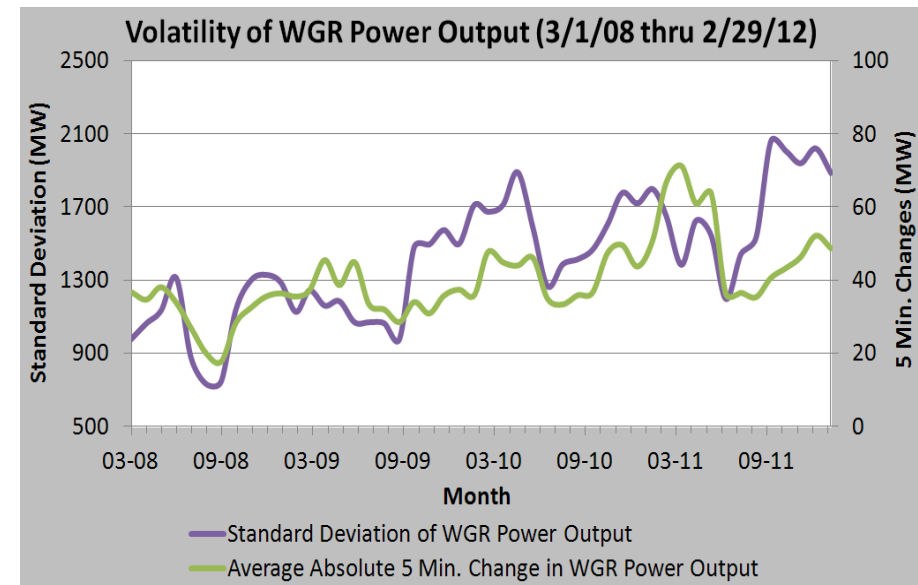
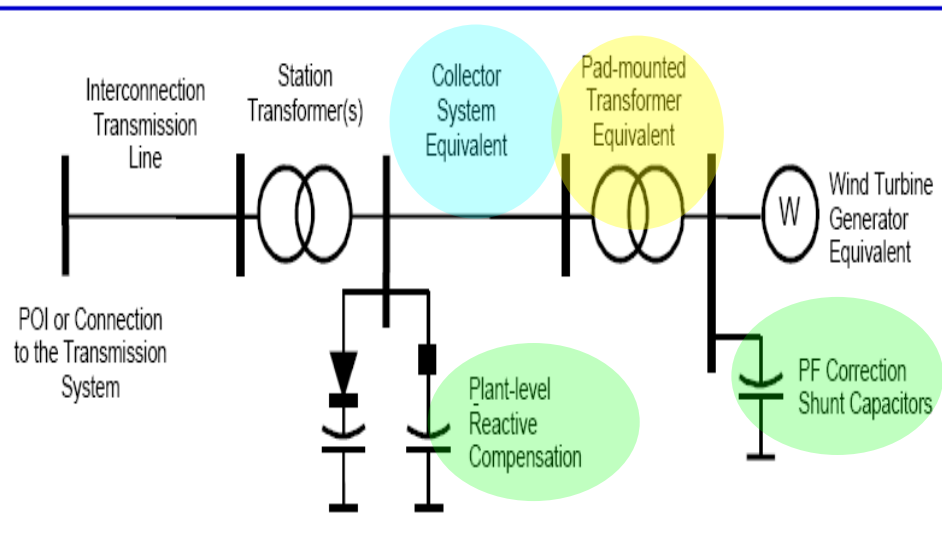
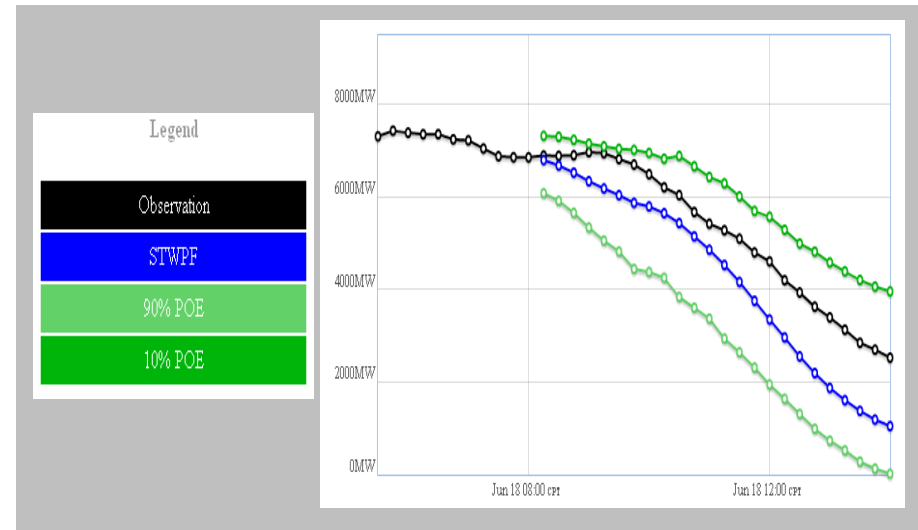
- **Peak wind generation output on 9,674MW on 5/2/13**
- **8.7% of Nameplate Capacity of wind counted towards reserve margin**





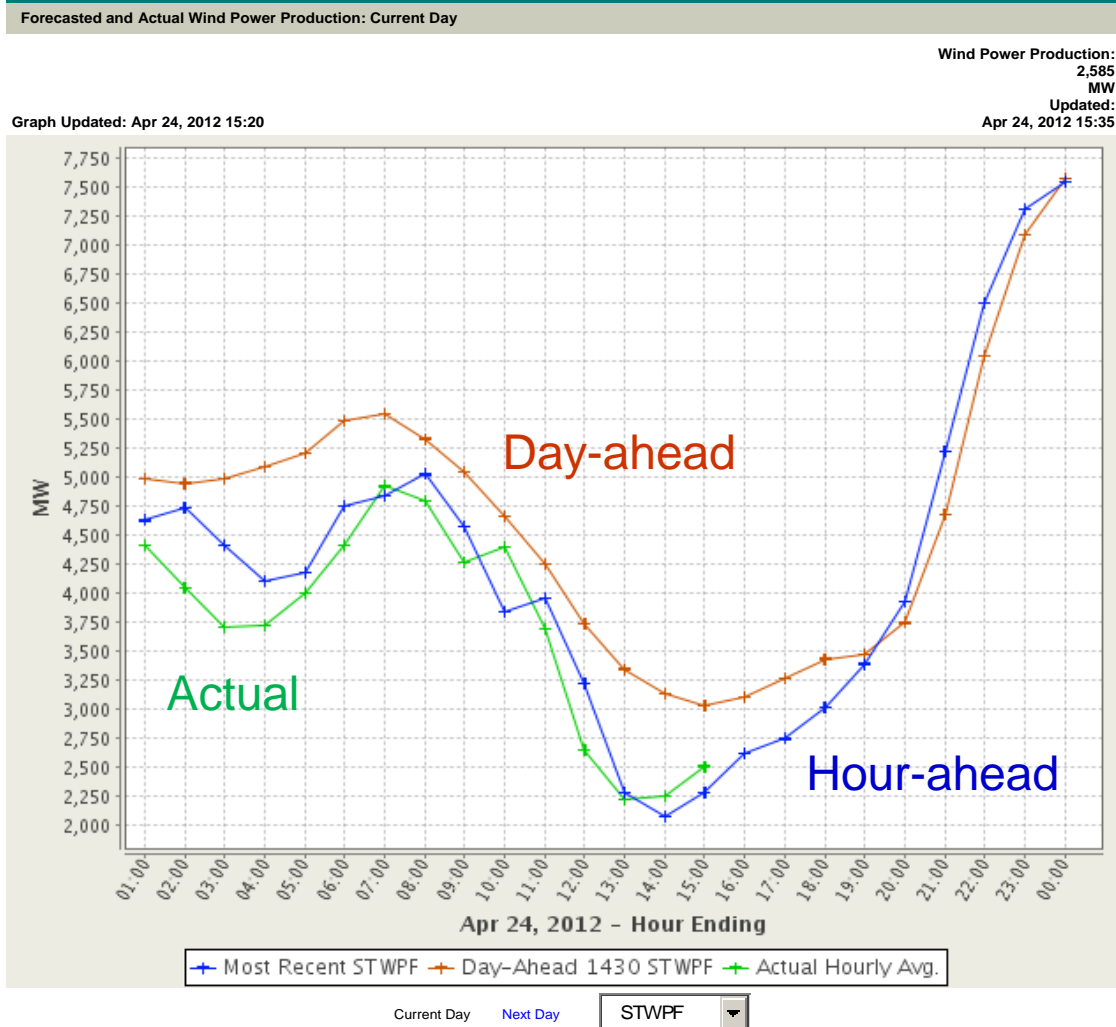
# Operational Challenges for Wind Integration

- **Uncertainty**
- **Variability**
- **Interconnection**





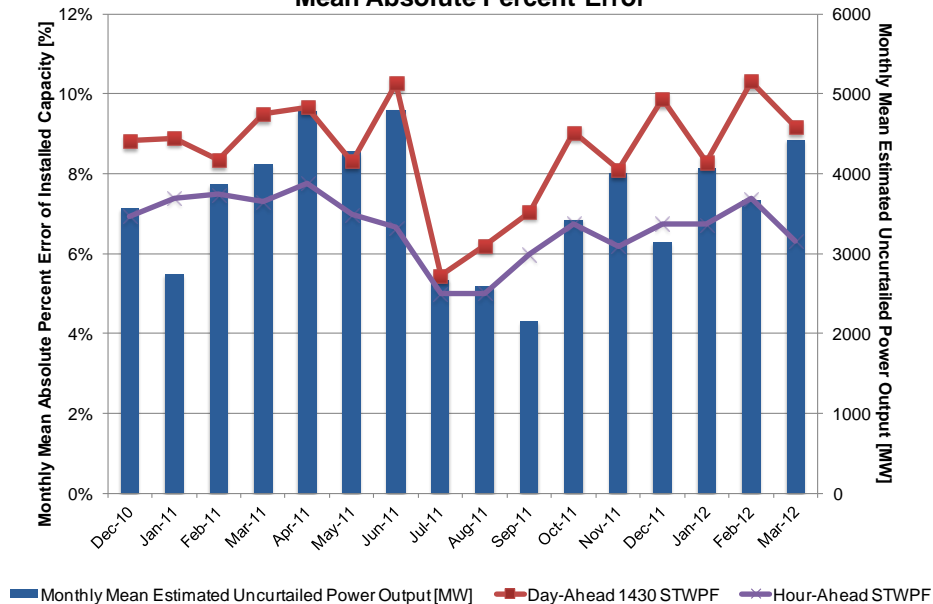
- **Wind power production forecast**
  - Hourly 50% probability of exceedance forecast for a rolling 48 hour period
  - Provided for each wind farm and total for system
- **Used to determine need for “residual” unit commitment**





# Wind Forecast Error

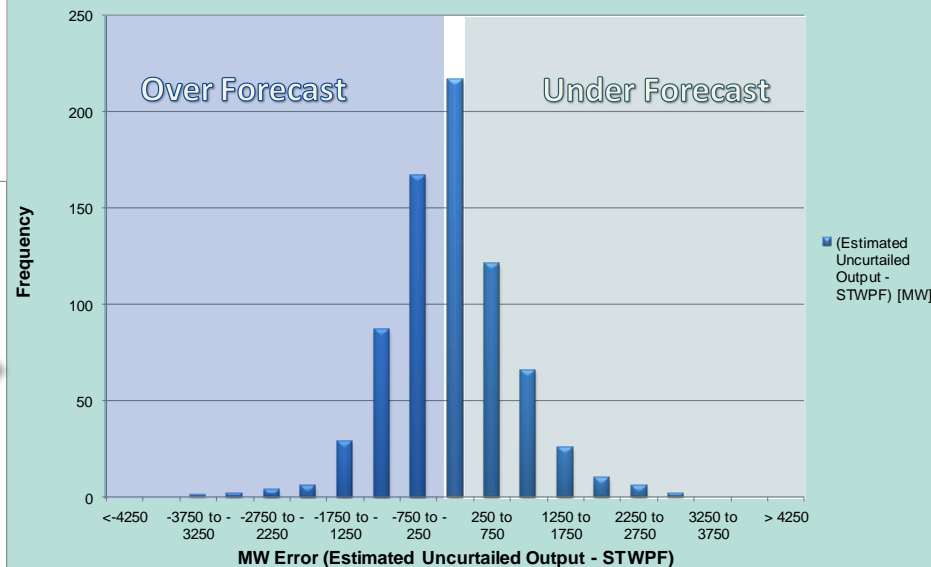
**WIND POWER FORECAST**  
Mean Absolute Percent Error



Average hour-ahead wind forecast error is significant (MAPE is ~7%)

MW errors may be high (>1000 MW; occasionally >2000 MW)

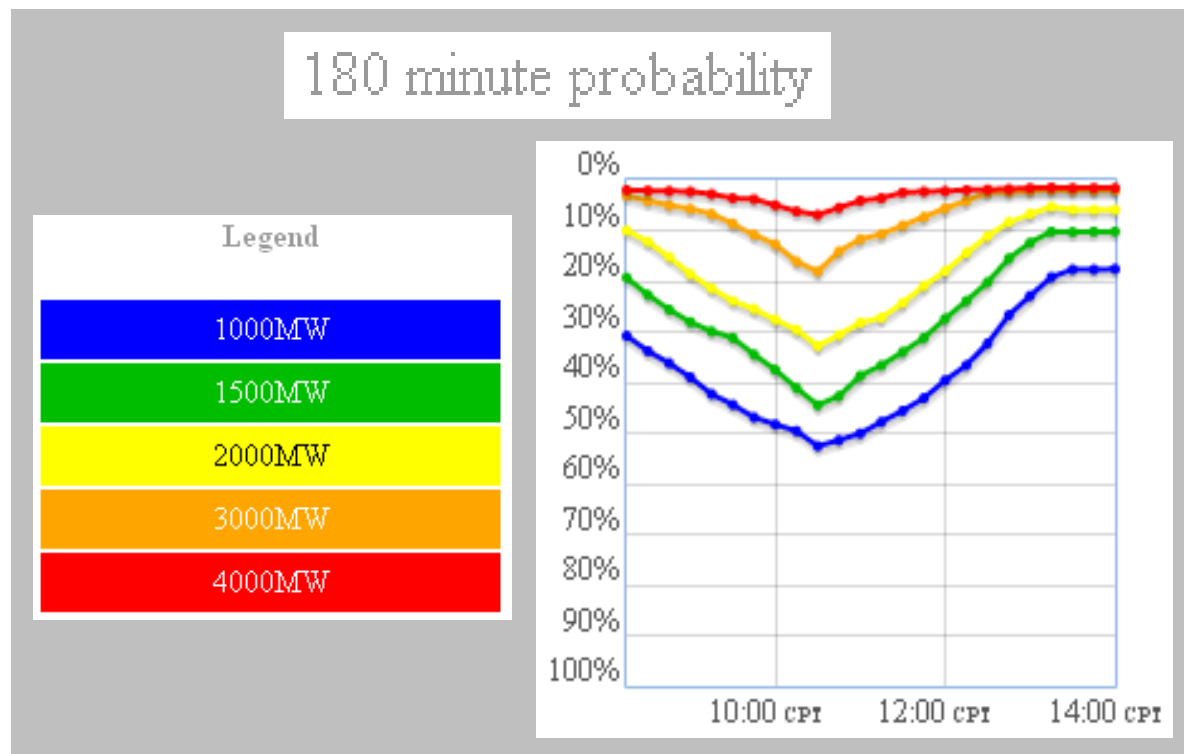
**Histogram of Hour-Ahead MW Forecast Error**  
All Hours





# Predicting Large Ramps in Wind Power Output

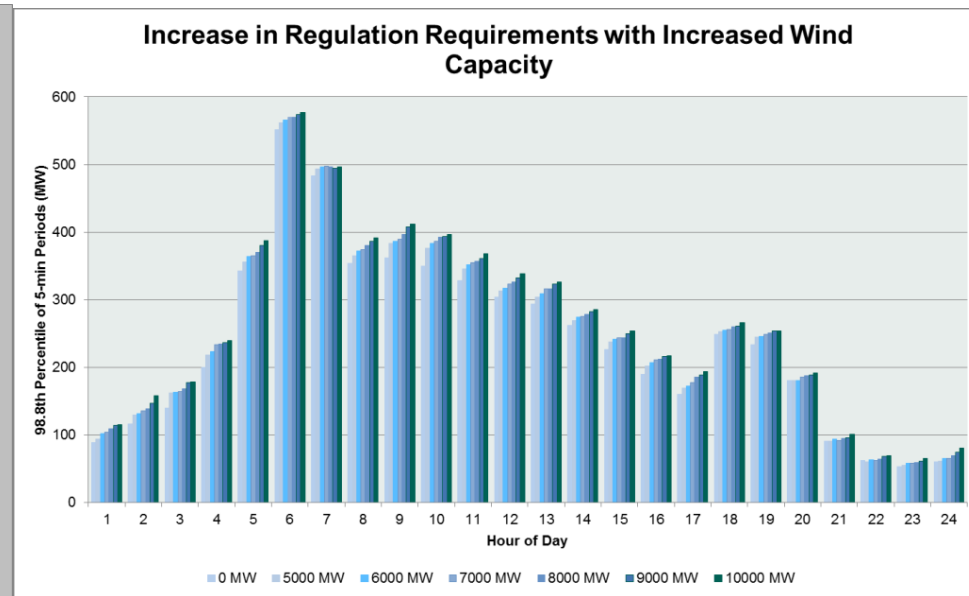
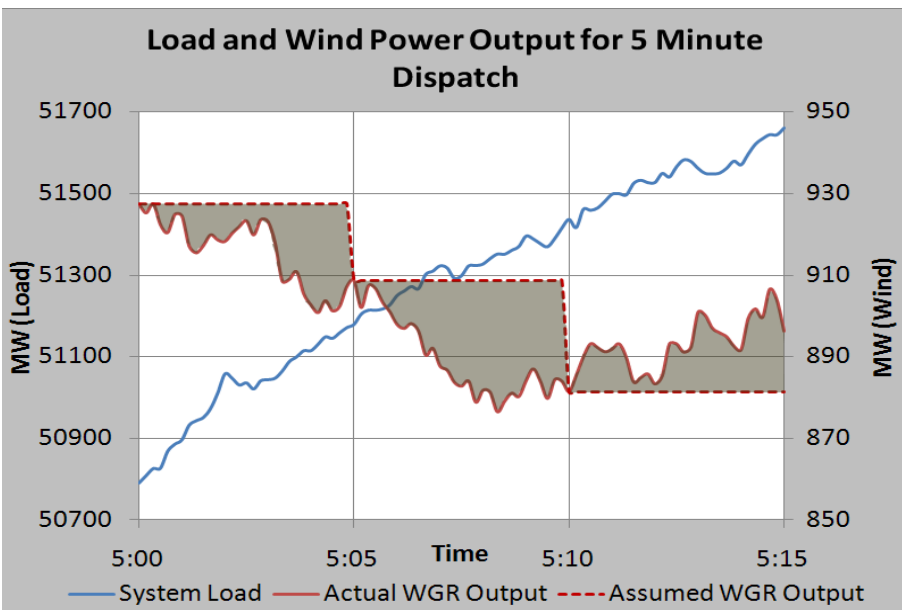
- **ERCOT Large Ramp Alert System (ELRAS)**
  - Probabilistic forecast which alerts Operators of ramps during the next 6 hours
  - Provided on the system and regional level





# Ancillary Services - Regulation

- ERCOT typically dispatches generation each five minutes
- Regulation Service is used to balance the variation in load and generation between five-minute economic dispatch executions
- Primary driver for determining required amount of regulation is historical deployments
  - Adjusted for increase in installed wind capacity

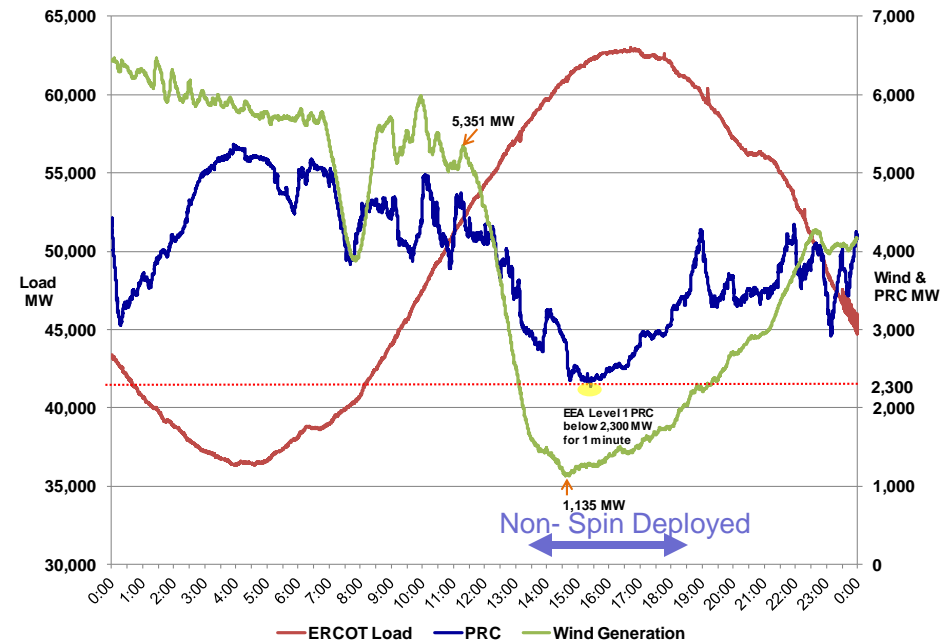
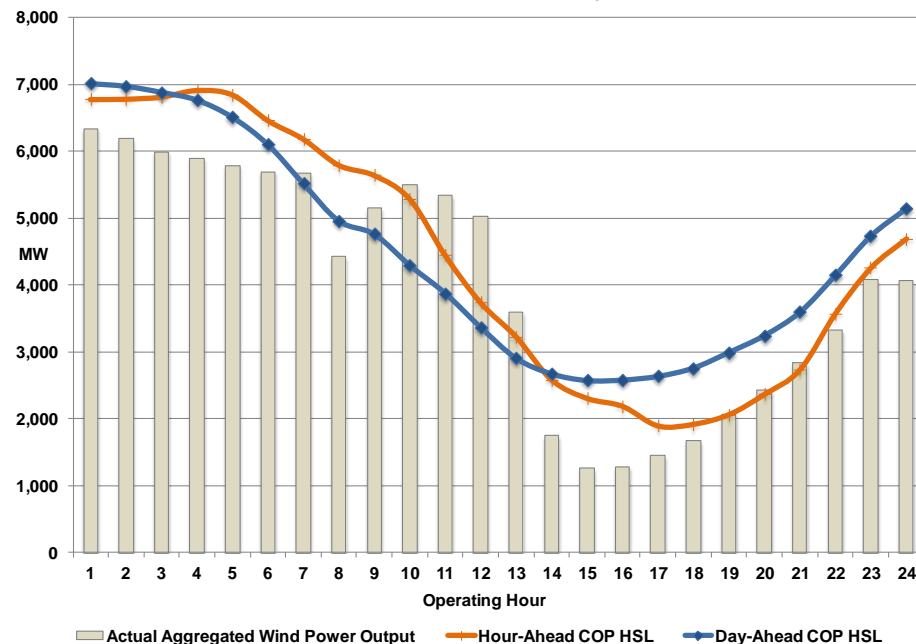




- **Non-spin Reserve Service**

- 30 minute product that can be provided by unloaded capacity, offline Generators, and Load Resources
- Wind power forecast error is one of the inputs used for calculating the requirement for this service

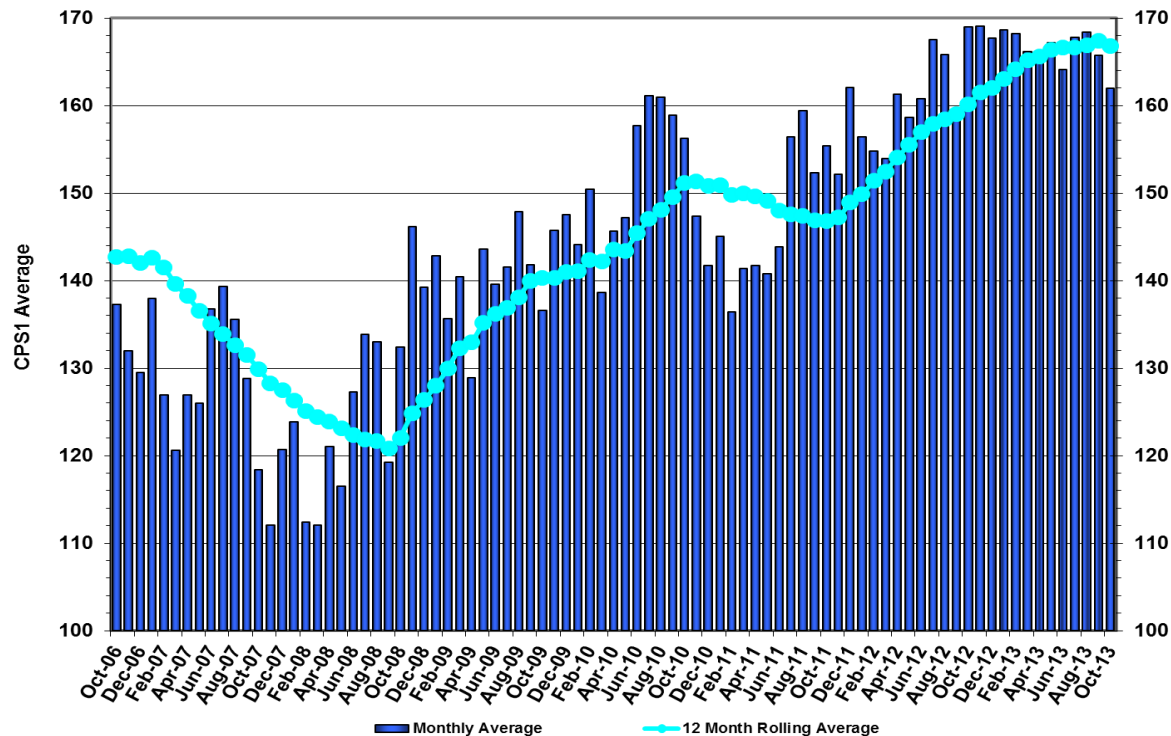
Actual Wind, Wind Hour-Ahead COPs and Wind Day-Ahead COPs on June 27, 2011





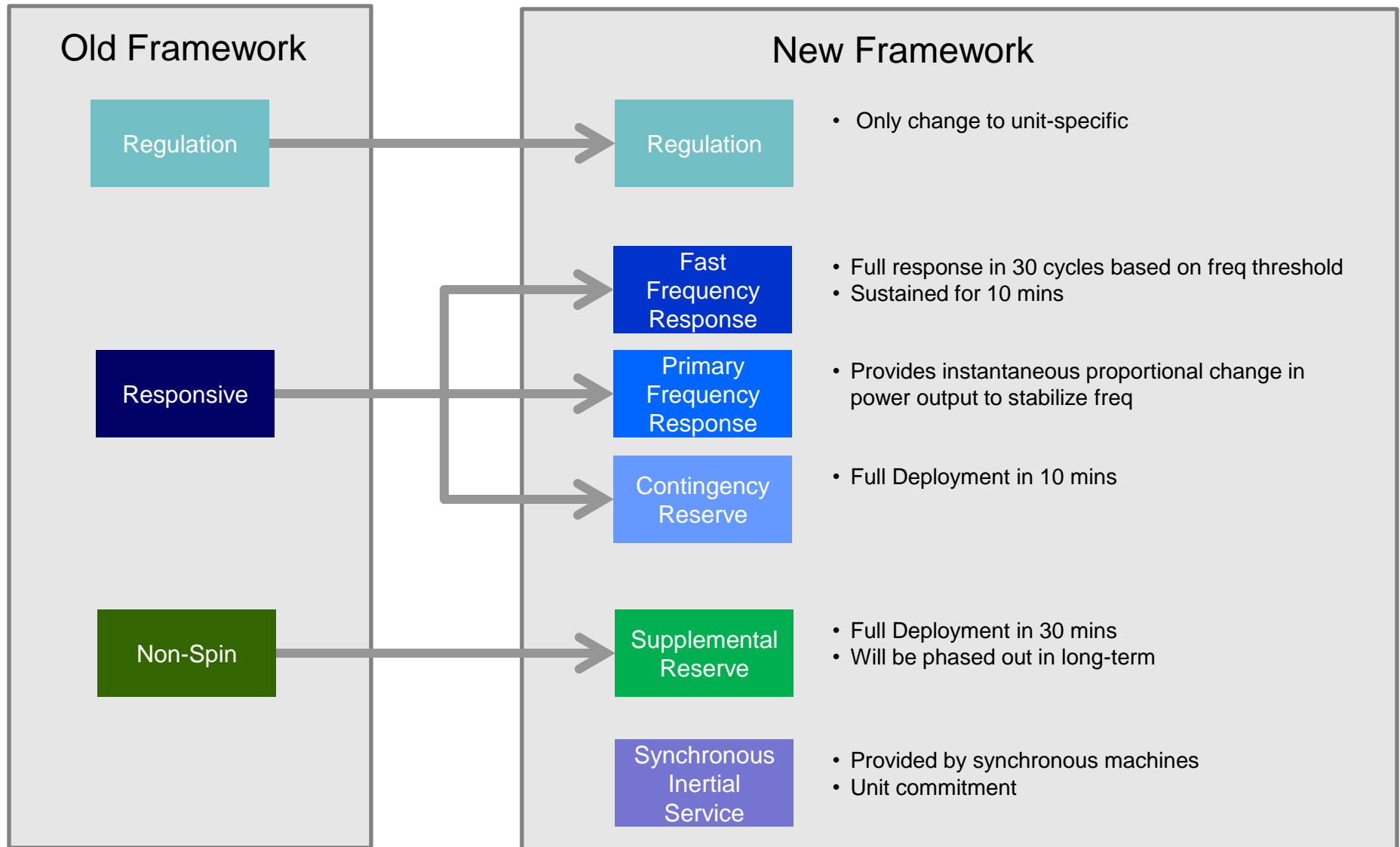
# Primary Frequency Response

- All generation in ERCOT is required to provide governor response with a 5% droop setting
- Wind farms are required to provide primary frequency response to frequency deviations from 60 Hz.



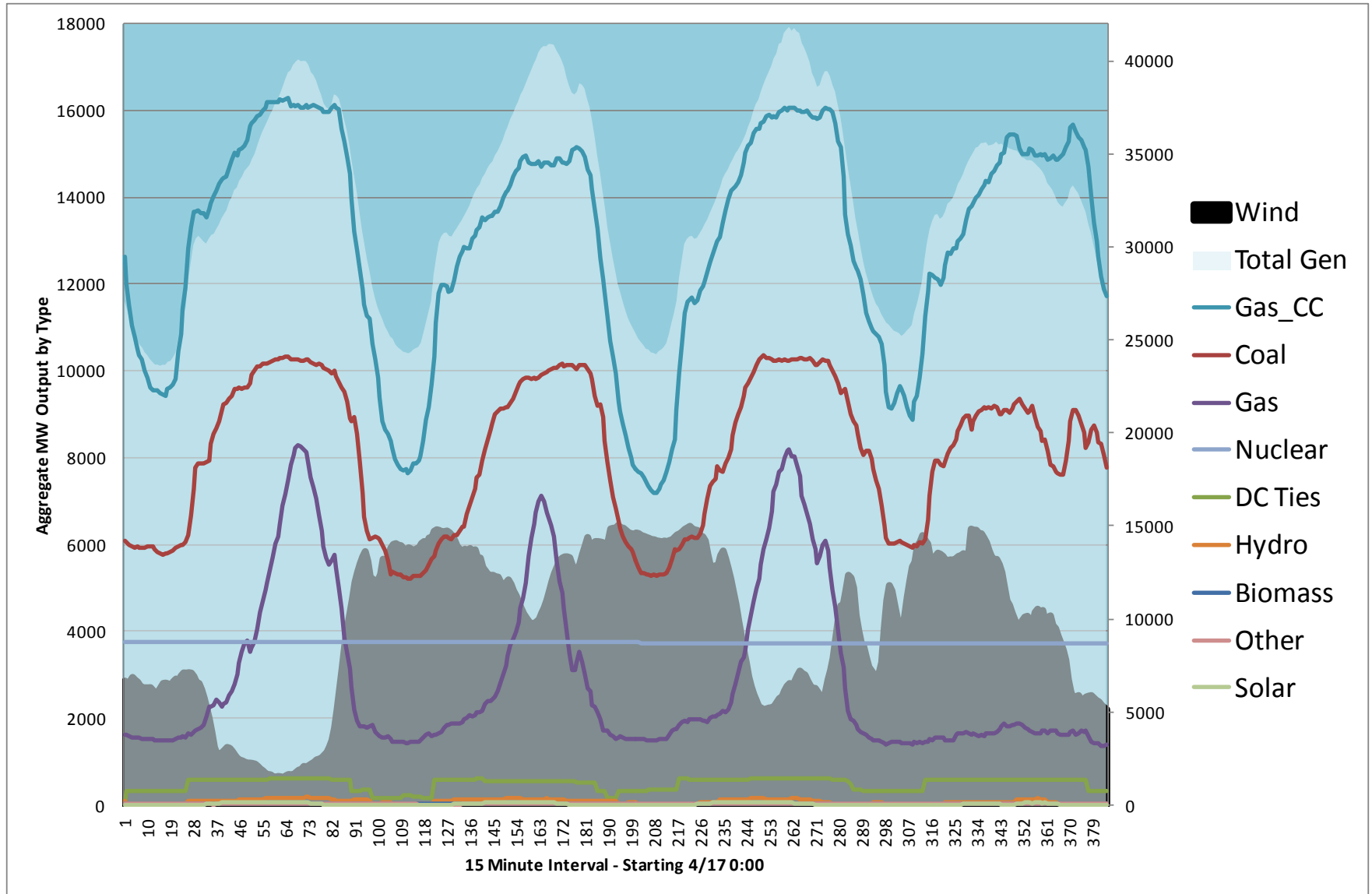


# Proposed New AS Framework – Frequency Control Services





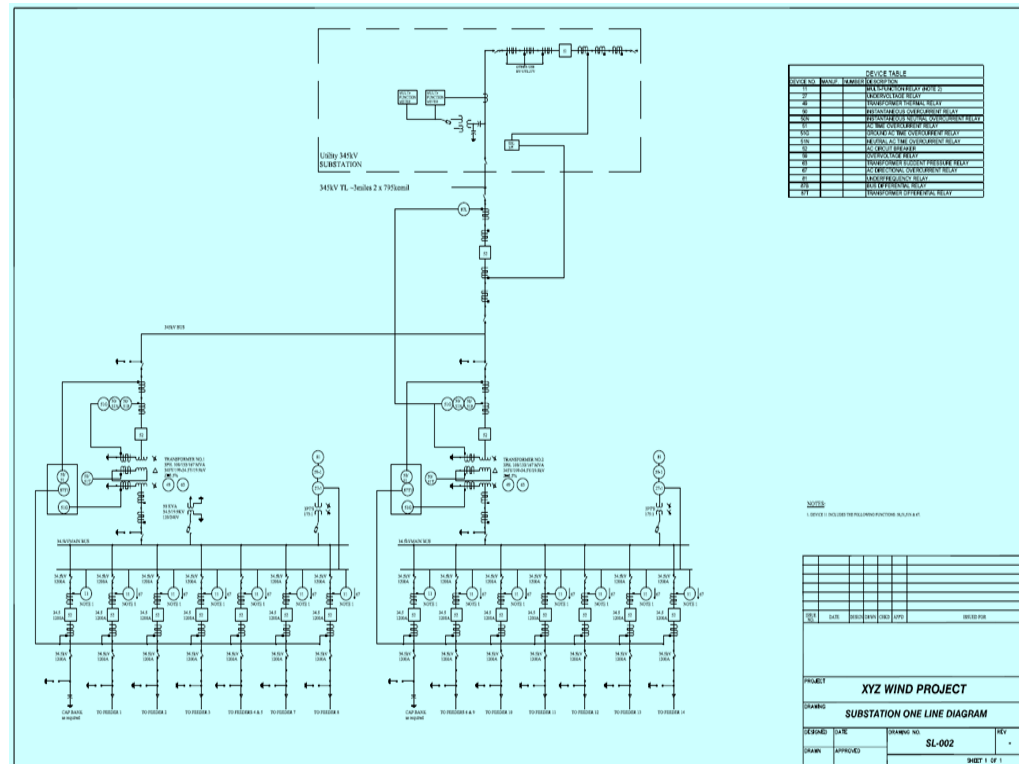
# Generation Ramps





# Interconnection-Related Requirements

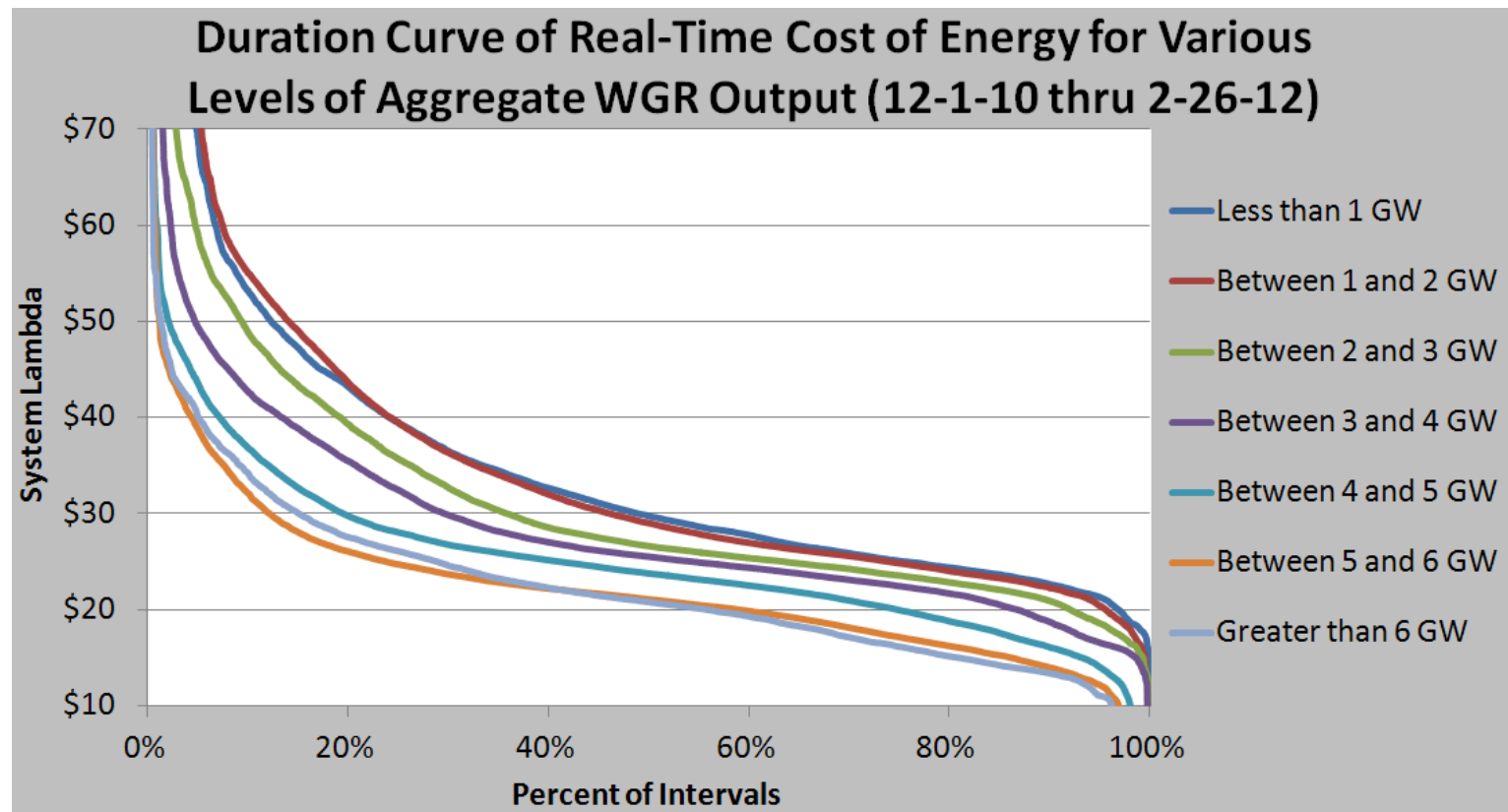
- Inverter-connected resources may not fit with traditional technical requirements
  - Need to address these issues to maintain system reliability:
- **Static and dynamic reactive capability**
  - **Voltage-ride through capability**
  - **Modeling**
    - Collector system and support device modeling
    - Dynamic model and parameters





# Impact of Wind Generation on Prices

- There is a clear shift down in the duration curve of real-time prices for higher levels of wind power output





# Summary of Wind Integration Needs

- **Sufficiently large Balancing Area**
- **Nodal market mechanisms with short dispatch cycle to incent flexibility in generation fleet and efficiently allocate curtailment**
- **Accurate wind forecast and wind ramp projections**
- **All generators required to contribute to system needs for voltage support and frequency control**
- **Incorporation of wind uncertainty and variability into ancillary services requirements**



## **Generation Planning/Resource Adequacy**



# Capacity, Demand and Reserves

## 2012 Report on the Capacity, Demand, and Reserves in the ERCOT Region (December Update)

### Summer Summary

<b>Load Forecast:</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>
Total Summer Peak Demand, MW	67,998	69,807	72,071	74,191	75,409	76,186	76,882	77,608	78,380	79,055
less LRS Serving as Responsive Reserve, MW	1,222	1,222	1,222	1,222	1,222	1,222	1,222	1,222	1,222	1,222
less LRS Serving as Non-Spinning Reserve, MW	-	-	-	-	-	-	-	-	-	-
less Emergency Response Service	432	475	523	575	632	696	765	842	926	1,019
less Energy Efficiency Programs (per SB1125)	392	518	648	781	917	1,054	1,193	1,210	1,225	1,238
<b>Firm Load Forecast, MW</b>	<b>65,952</b>	<b>67,592</b>	<b>69,679</b>	<b>71,613</b>	<b>72,637</b>	<b>73,214</b>	<b>73,702</b>	<b>74,334</b>	<b>75,007</b>	<b>75,576</b>
<b>Resources:</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>
Installed Capacity, MW	64,217	64,217	63,863	63,863	63,863	63,863	63,018	63,018	63,018	63,018
Capacity from Private Networks, MW	4,390	4,390	4,390	4,390	4,390	4,390	4,390	4,390	4,390	4,390
Effective Load-Carrying Capability (ELCC) of Wind Generation, MW	873	873	873	873	873	873	873	873	873	873
RMR Units to be under Contract, MW	-	-	-	-	-	-	-	-	-	-
<b>Operational Generation, MW</b>	<b>69,480</b>	<b>69,480</b>	<b>69,126</b>	<b>69,126</b>	<b>69,126</b>	<b>69,126</b>	<b>68,281</b>	<b>68,281</b>	<b>68,281</b>	<b>68,281</b>
50% of Non-Synchronous Ties, MW	553	628	628	628	628	628	628	628	628	628
Switchable Units, MW	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962	2,962
Available Mothballed Generation, MW	911	1,068	1,200	877	536	229	-	-	-	-
Planned Units (not wind) with Signed IA and Air Permit, MW	961	961	3,149	4,169	5,549	5,549	5,549	5,549	5,549	5,549
ELCC of Planned Wind Units with Signed IA, MW	83	161	226	258	258	258	258	258	258	258
<b>Total Resources, MW</b>	<b>74,950</b>	<b>75,260</b>	<b>77,291</b>	<b>78,020</b>	<b>79,059</b>	<b>78,752</b>	<b>77,678</b>	<b>77,678</b>	<b>77,678</b>	<b>77,678</b>
less Switchable Units Unavailable to ERCOT, MW	317	317	317	317	317	317	317	317	-	-
less Retiring Units, MW	-	-	-	-	-	-	-	-	-	-
<b>Resources, MW</b>	<b>74,633</b>	<b>74,943</b>	<b>76,974</b>	<b>77,703</b>	<b>78,742</b>	<b>78,435</b>	<b>77,361</b>	<b>77,361</b>	<b>77,678</b>	<b>77,678</b>
<b>Reserve Margin</b>	<b>13.2%</b>	<b>10.9%</b>	<b>10.5%</b>	<b>8.5%</b>	<b>8.4%</b>	<b>7.1%</b>	<b>5.0%</b>	<b>4.1%</b>	<b>3.6%</b>	<b>2.8%</b>
(Resources - Firm Load Forecast)/Firm Load Forecast										





# Questions?

CRE/ERCOT

February 18, 2014