

# A Transmission Planning Case Study for Wind Integration – CREZ in ERCOT

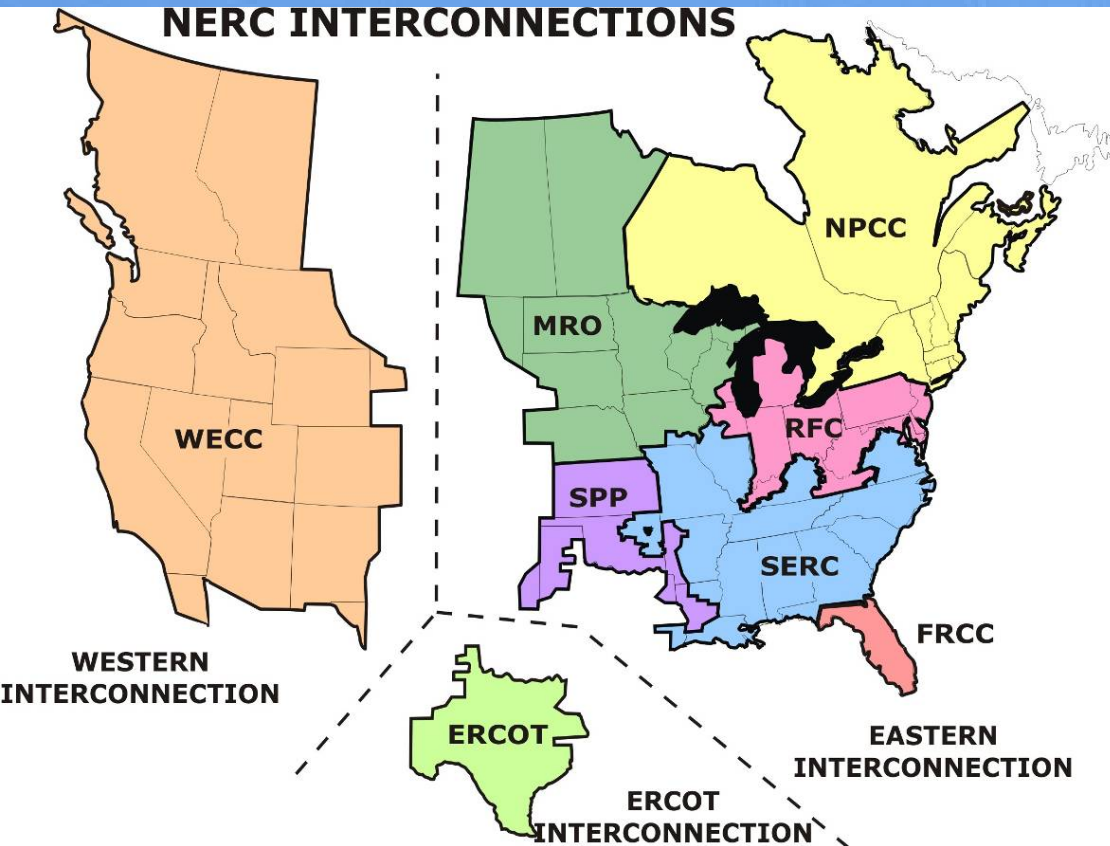
The background of the slide is a photograph of a wind farm. Several white wind turbines are visible on a rocky, brownish hill under a clear blue sky. The foreground shows a flat, dry landscape with sparse vegetation.

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# The ERCOT Region

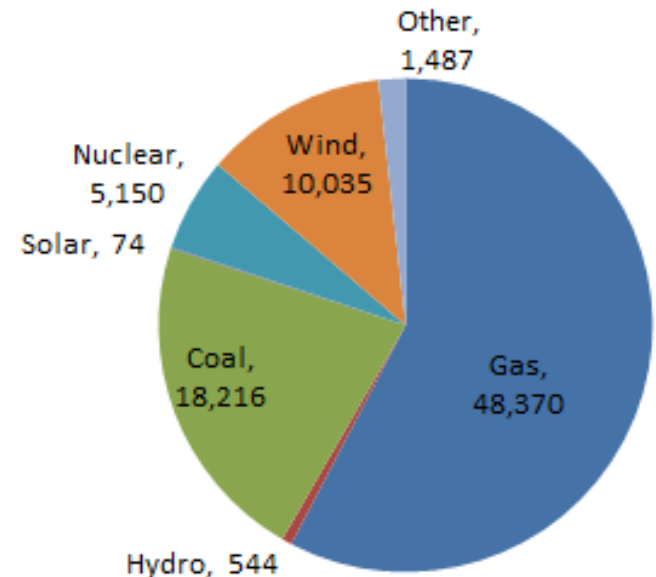


## The ERCOT grid includes:

- 75% of Texas land
- 85% of Texas load
- 38,000 miles of transmission lines
- 550+ generation units
- 68,379 MW peak demand (set 8/3/2011)

**Regional Import Capacity: 1,106 MW of Asynchronous Tie Capacity (820 MW with Eastern Interconnection)**

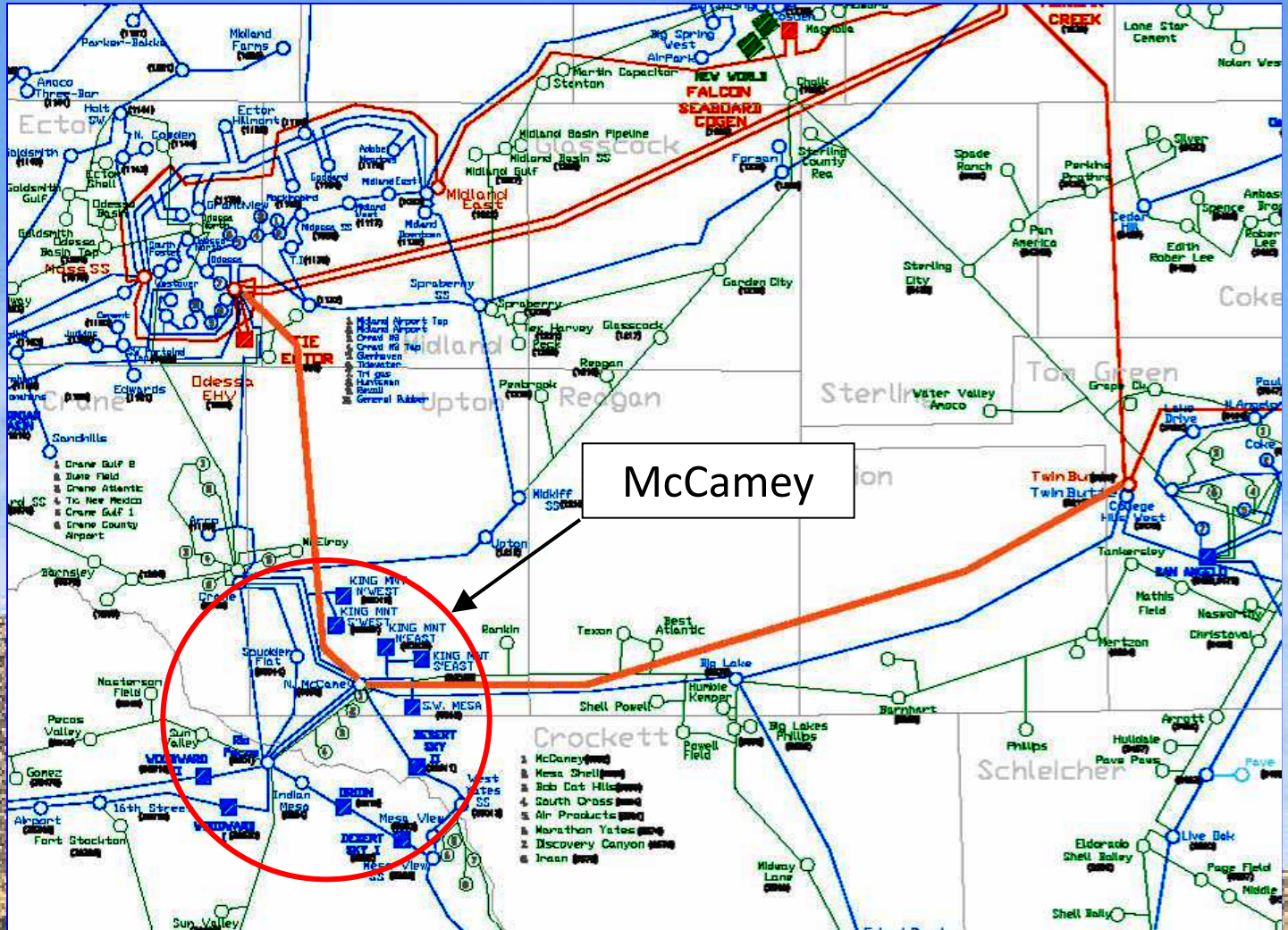
## ERCOT Generation by Fuel (MW)



The ERCOT region has a deregulated energy-only wholesale market and a deregulated retail market.

# McCamey – Where CREZ Was Born

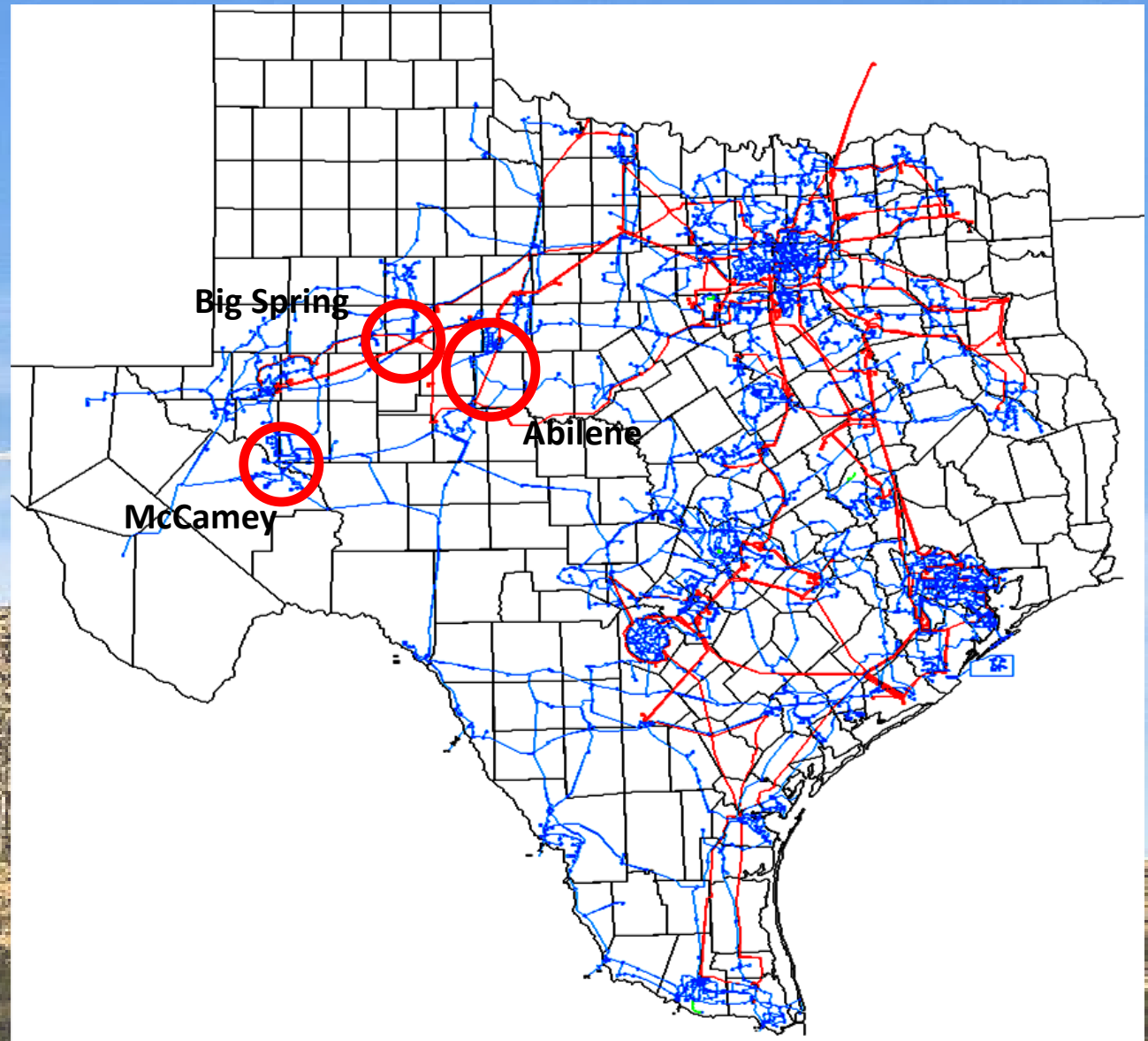
Construction of wind units in the McCamey area stopped after export limits were imposed (due to voltage constraints).



Transmission Infrastructure near McCamey, Texas  
(Blue lines are 138-kV; Orange lines are proposed)

# Early Wind Generation Locations in ERCOT

After the McCamey area became constrained, wind developers sought out locations where transmission capacity was available and wind resources were acceptable. By 2008, most of the wind in ERCOT was aggregated in three areas (red circles).



# Competitive Renewable Energy Zones

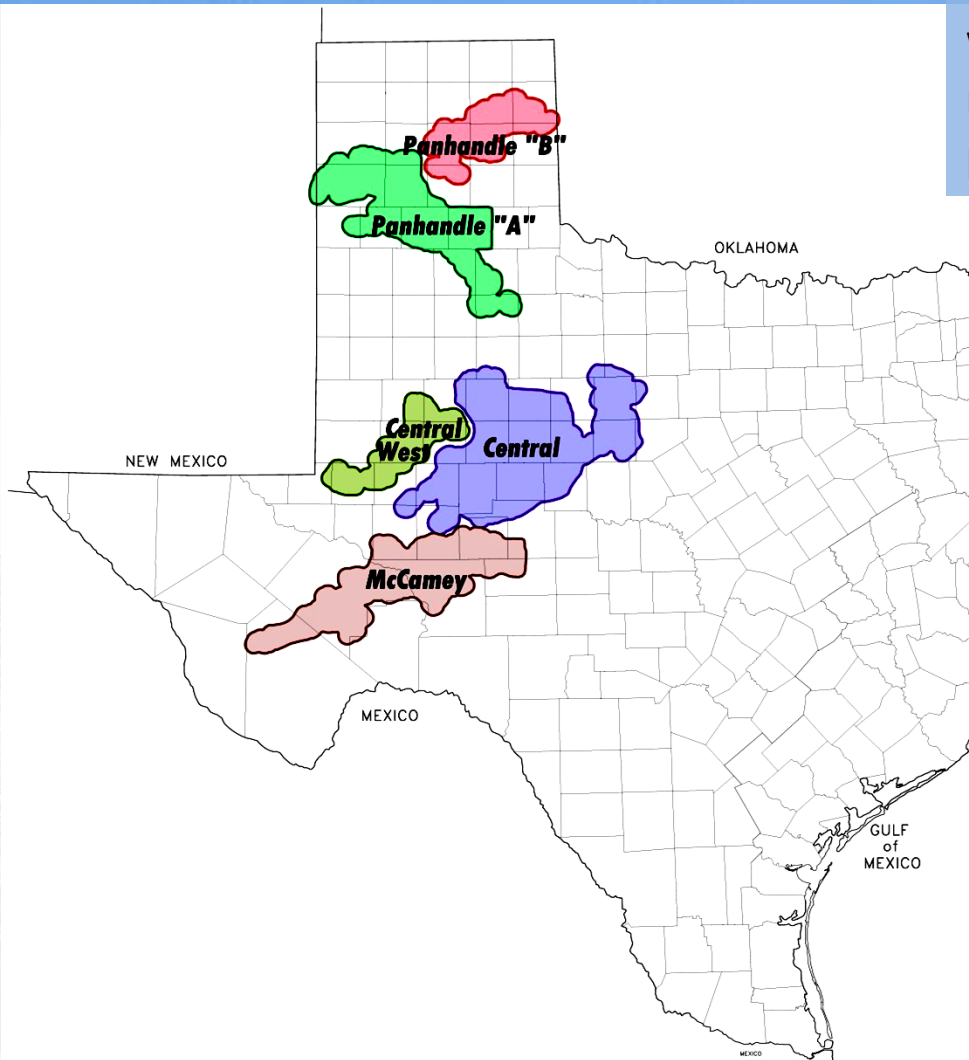
In 2005, the Texas Legislature passed SB 20, instructing the Public Utility Commission of Texas (PUCT) to designate transmission for Competitive Renewable Energy Zones (CREZs)



- The PUCT established contested- case docket 33672 in January, 2007
- Parties nominated CREZs and demonstrated financial commitment
- Transmission service providers proposed transmission solutions
- First Hearing held in June 2007

# Designated Zones and Scenario Wind Levels

In Oct. 2007, the PUCT issued an Interim Order which designated 5 areas as CREZ and requested that ERCOT develop transmission plans for 4 levels of wind capacity.



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>

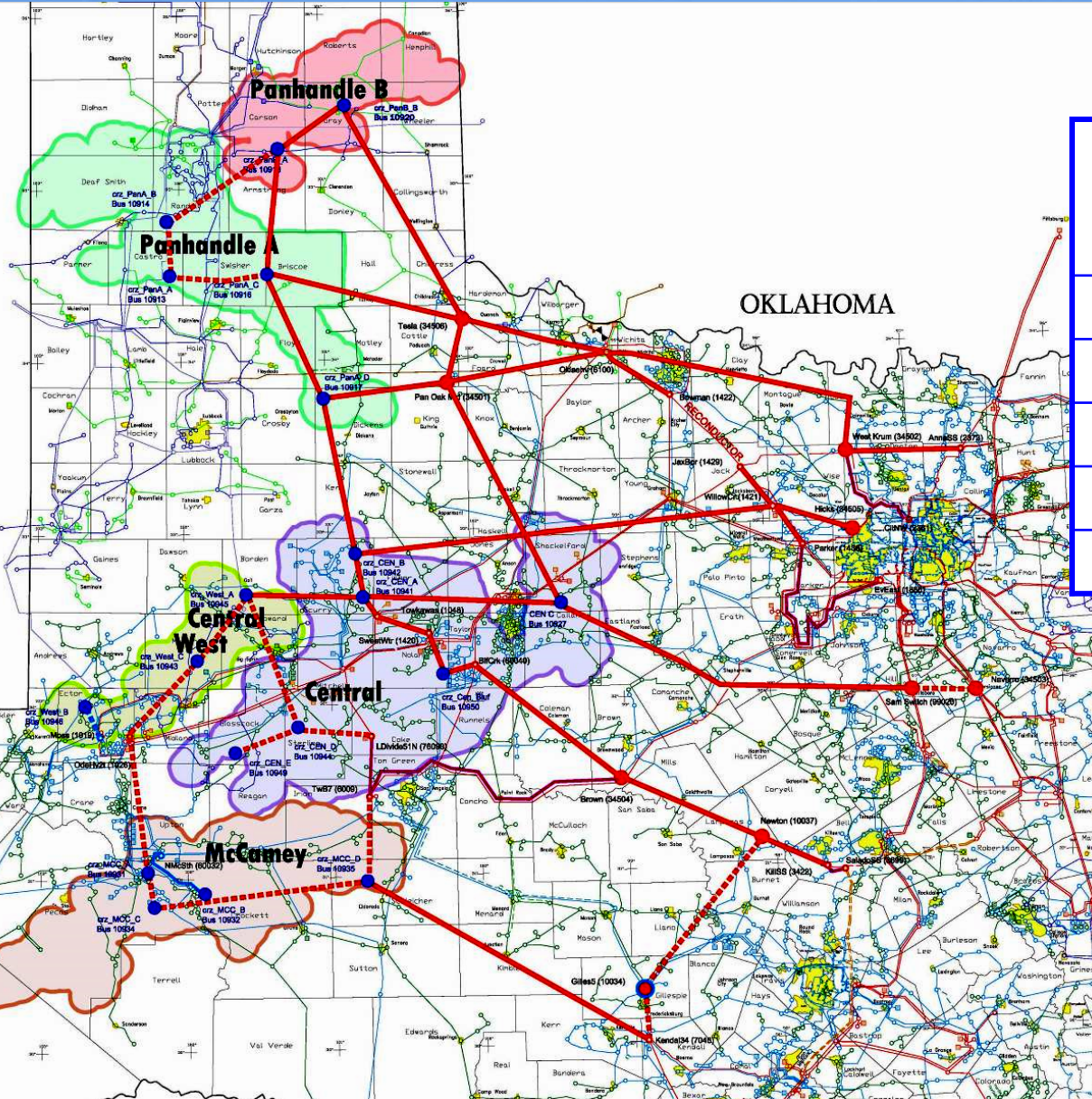
\* Assumes 6,903 MW of existing wind capacity

# CREZ Plan Design Concepts

ERCOT evaluated plans based on five different concepts:

- 1) Incremental 345-kV transmission system for wind in west Texas
- 2) Integrated 345-kV transmission system for wind in west Texas
- 3) Reduced number of right-of-ways using higher voltage circuits (500 kV or 765 kV)
- 4) Low impedance backbone or loop
- 5) HVDC circuit(s) to move power to load centers or between load centers, integrated with 345-kV upgrades

# CREZ Ruling – 2,376 Miles of New ROW



Zone	New Wind Capacity (MW)
Panhandle A	3,200
Panhandle B	2,400
Central	3,000
Central West	1,100
McCamey	1,900

Red lines are new 345-kV double circuit ROW

Dotted red lines are new 345-kV single circuit ROW

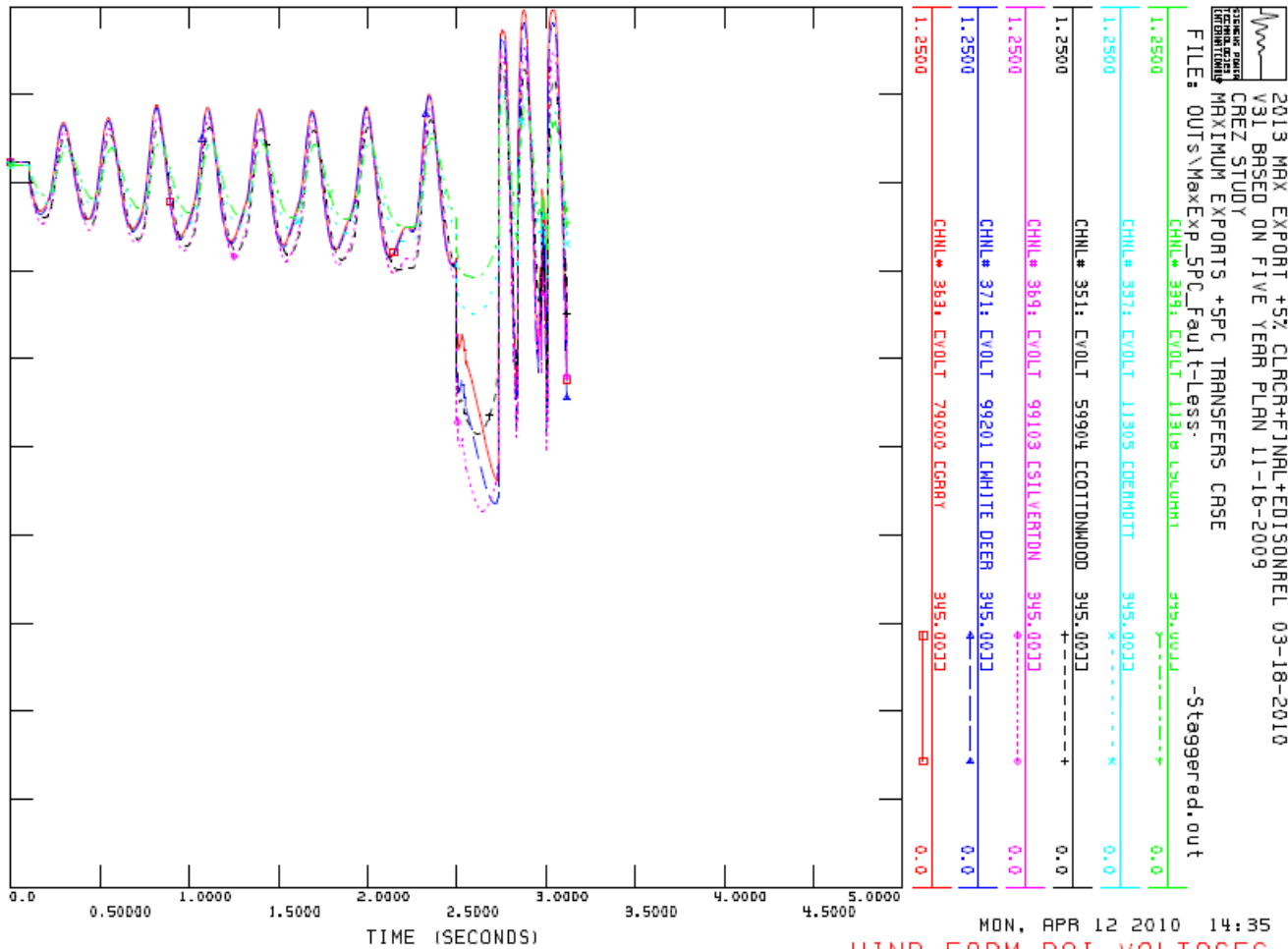


# Initial Stability Results

Initial simulations indicated the presence of two sources of instability: large signal and small signal.

Graphical representation of oscillatory (small signal) behavior

These results are indicative of power system interactions due to low system strength



# Sub-Synchronous Interaction Analysis

Potential issues associated with use of power electronics on transmission systems:

- Sub-synchronous Resonance (SSR) – primarily a concern for large synchronous generation units
- Sub-synchronous Torsional Interactions (SSTI) – results from operation of power electronics devices near large synchronous generation units



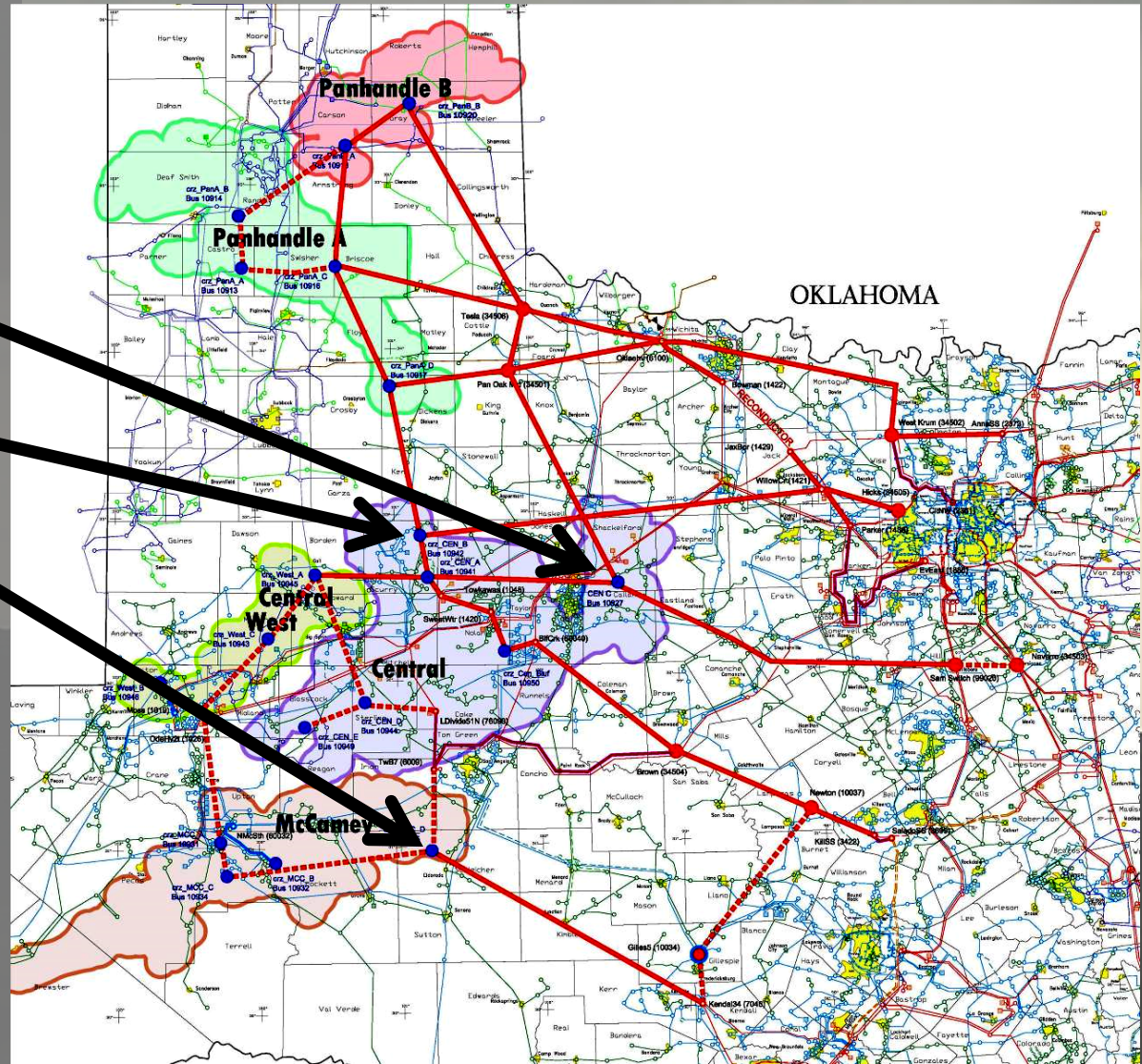
- Sub-synchronous Interactions (SSI) – impacts to wind turbines. Potential impacts noted at several locations on the CREZ system. There are transmission system and turbine-specific mitigation options.

# Geography of SSI

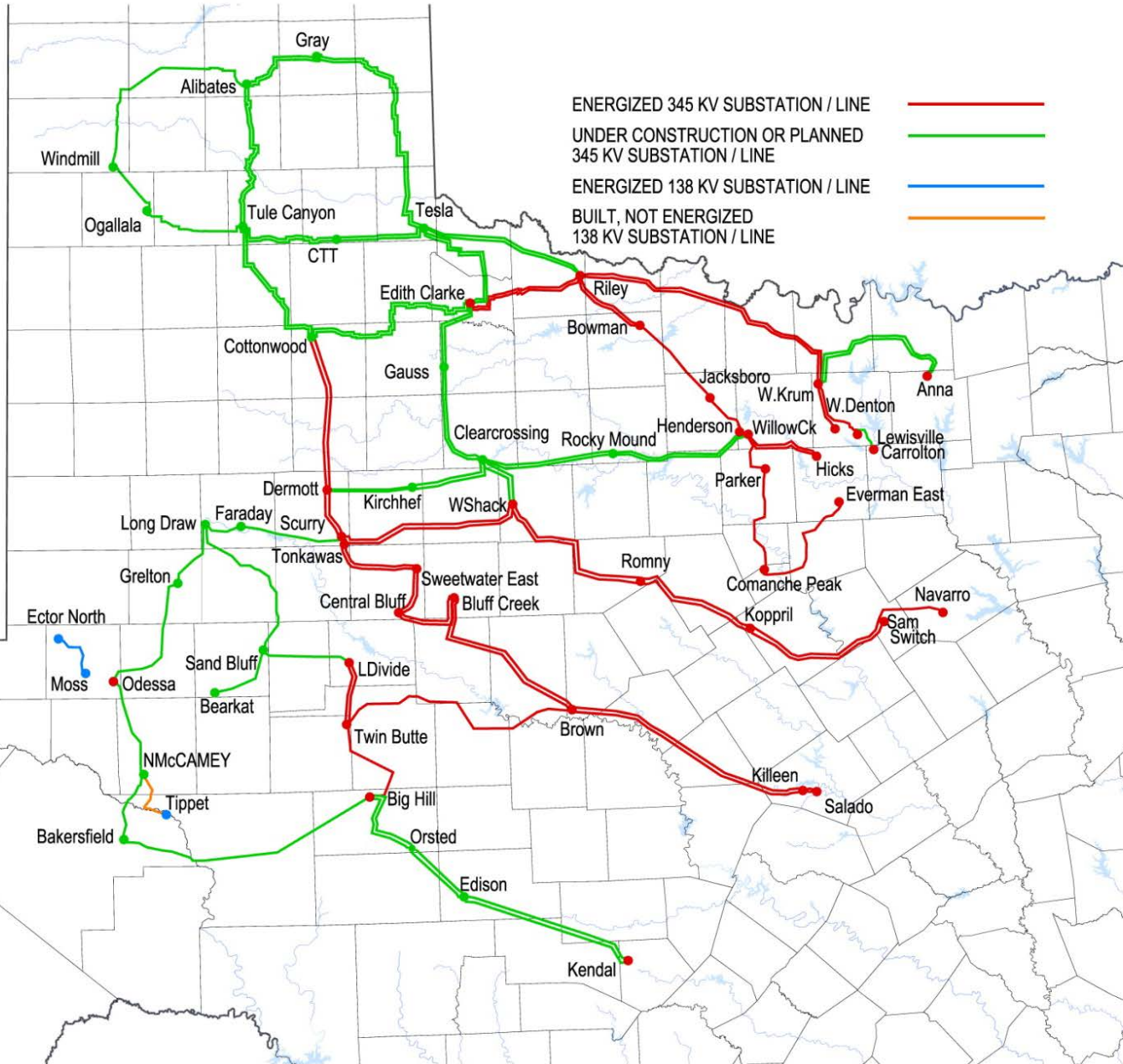
Locations most prone to have Sub-Synchronous Interaction (for Type 3 turbines):

- 1) West Shackelford – SSI with no contingencies
- 2) Dermott – SSI after 1 contingency
- 3) Big Hill – SSI after 1 contingency

Locations directly connected to a compensated line or potentially in a radial or semi-radial configuration following the outage of one or a few nearby circuits will be SSI prone.



# The CREZ Plan Today

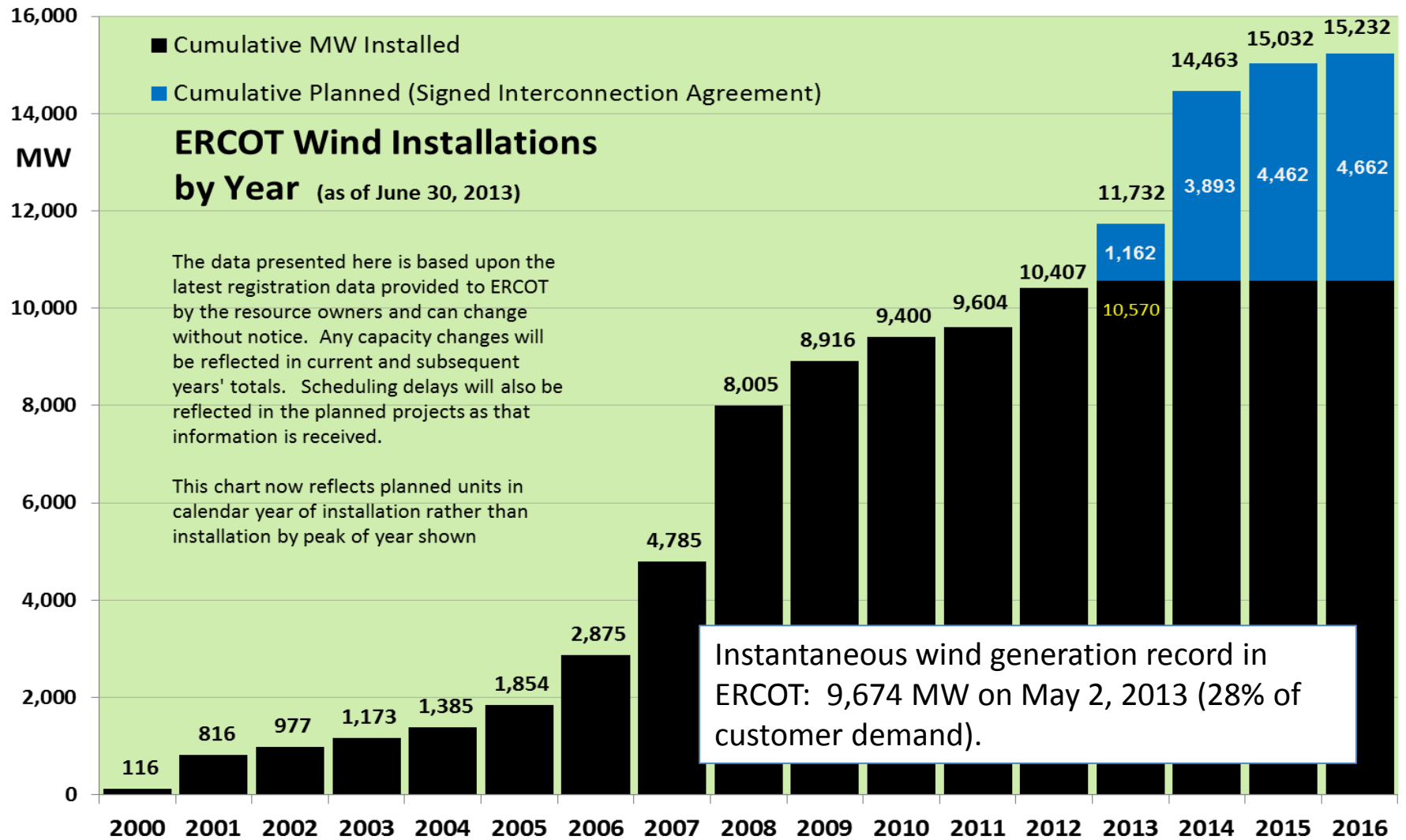


The project will be complete by end of 2013

Latest Cost Estimate of CREZ Transmission Plan: \$6.9 Billion

From legislative discussions to wire-in-the-air in just over 8 years.

# Wind Generation Development in ERCOT



# Questions?

