



The Texas Competitive Renewable Energy Zone Process

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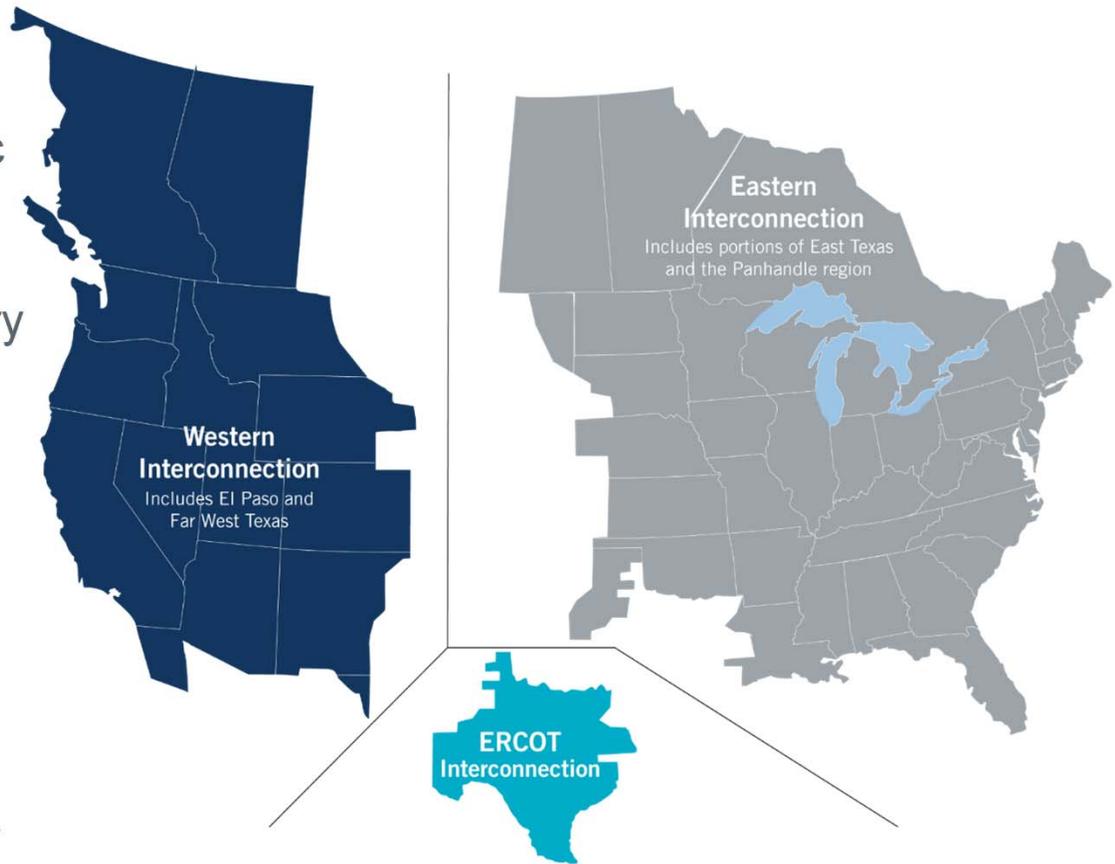
Presentation Objectives

- Understand the transmission planning process for the Texas Competitive Renewable Energy Zone project
- Understand the technical considerations for planning the Texas Competitive Renewable Energy Zone project
- Understand how stakeholders worked together to successfully implement the Texas Competitive Renewable Energy Zone plan

What is ERCOT?

The Texas Legislature restructured the Texas electric market in 1999 and assigned the Electric Reliability Council of Texas (ERCOT) four primary responsibilities:

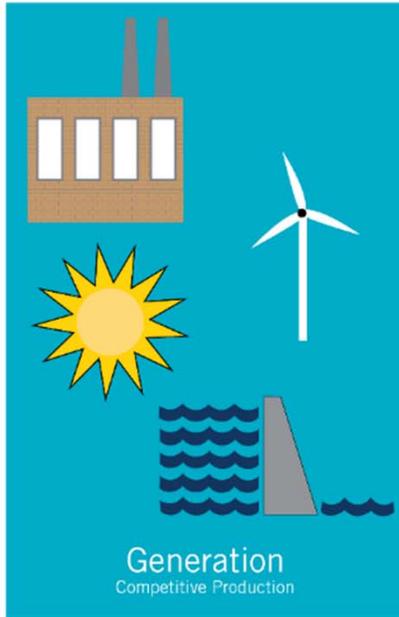
- **System Reliability**
- **Competitive Wholesale Market**
- **Open Access to Transmission**
- **Competitive Retail Market**



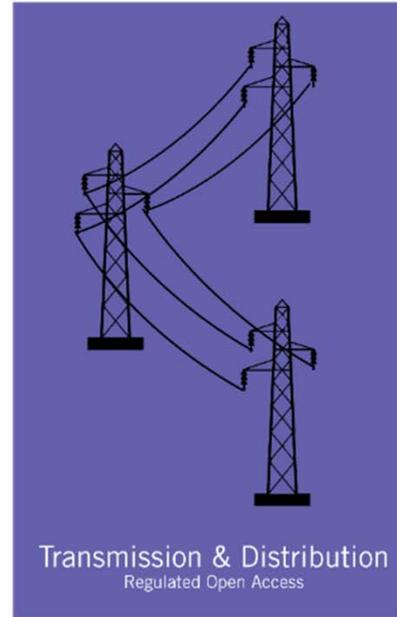
ERCOT is a nonprofit organization and regulated by the Public Utility Commission of Texas (PUCT), with oversight by the Texas Legislature.

ERCOT is not a market participant and does not own generation or transmission/distribution wires.

Texas Competitive Model



- Generating units are owned by privately owned companies
 - Except for municipal and cooperative units
- Compete in ERCOT market to serve load
 - Market is overseen by PUCT.



- Transmission and distribution lines and related facilities are owned and operated by regulated utilities.
 - Utilities are regulated by PUCT.

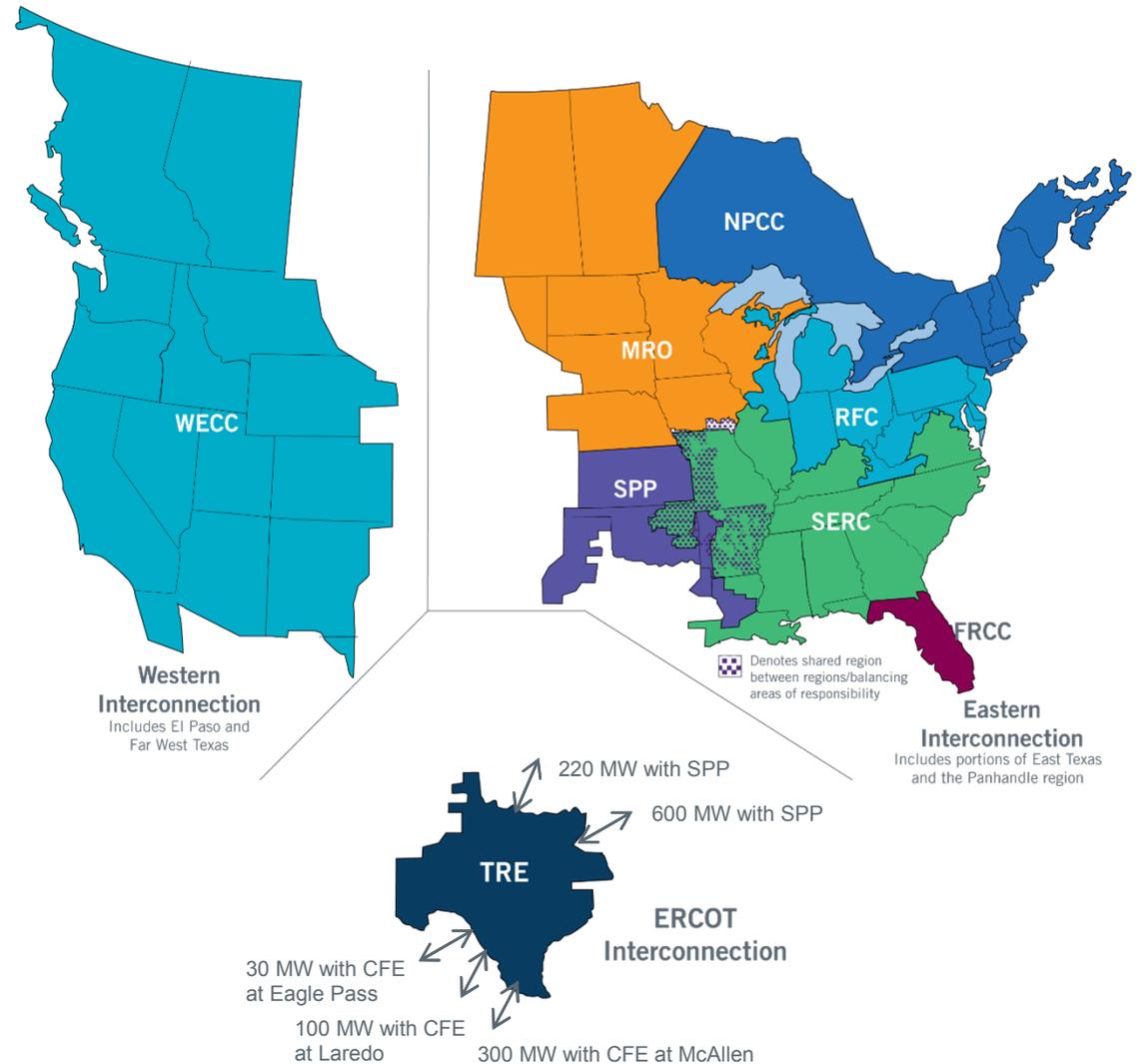


- Consumer's electric load is served by competitive retailers.
 - Except in municipal and cooperative utility areas

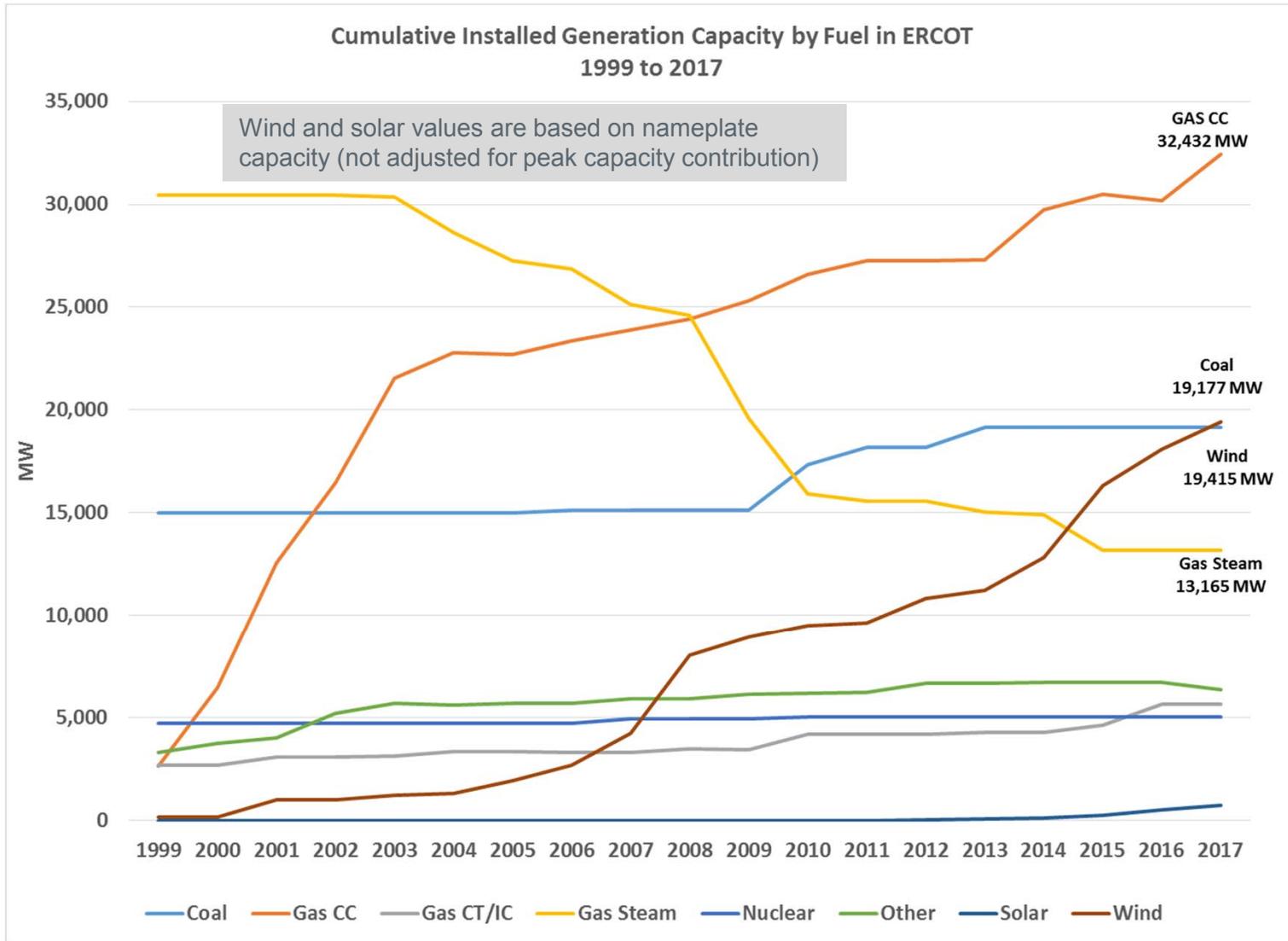
The ERCOT Region

The interconnected electrical system serving most of Texas, with limited external connections

- 90% of Texas electric load; 75% of Texas land
- 71,110 MW peak, August 11, 2016
- More than 46,500 miles of transmission lines
- 16,022 MW wind generation record (instantaneous), December 25, 2016
- 570+ generation units



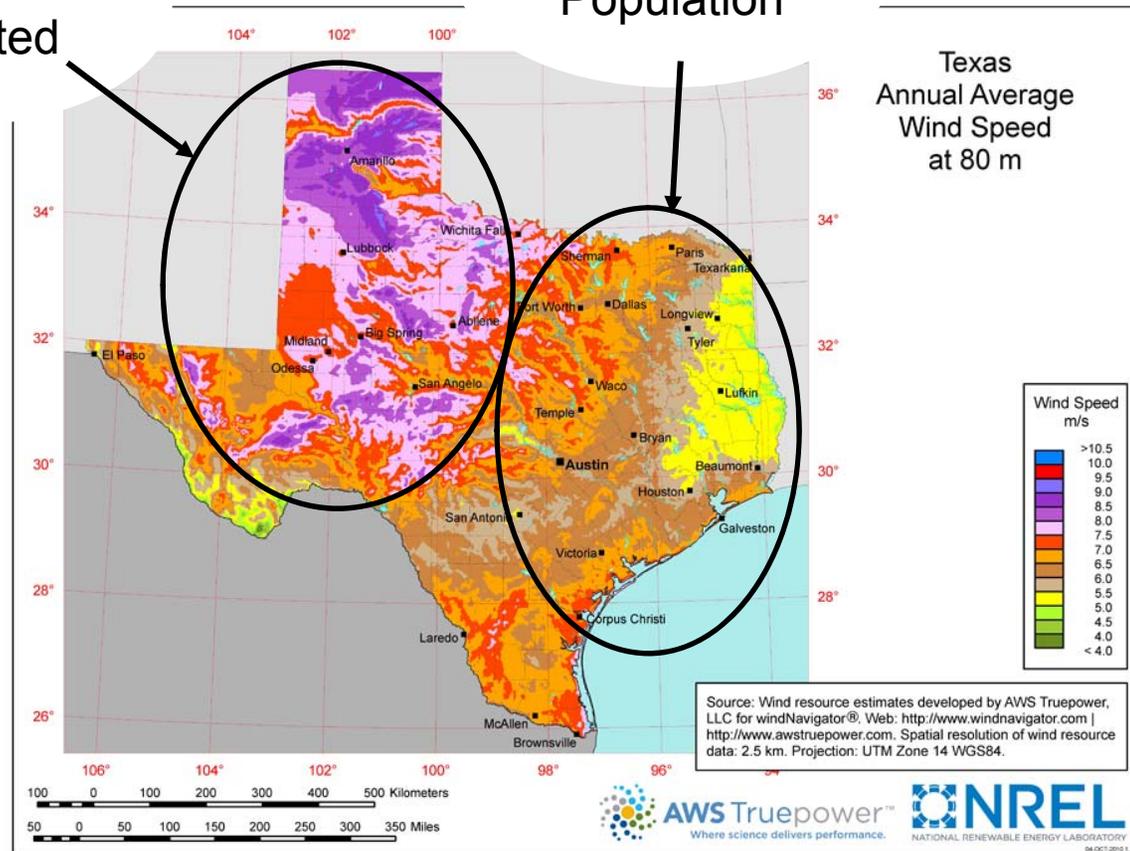
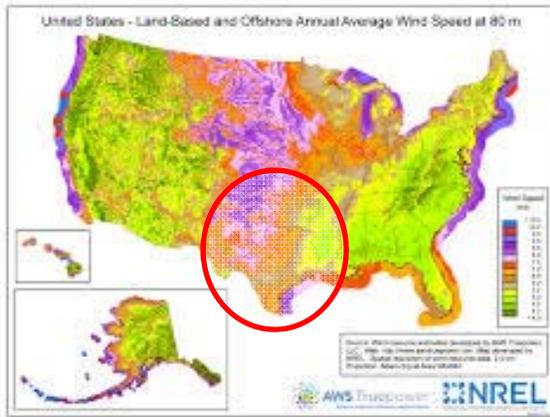
ERCOT Installed Capacity (1999-2017)



Windy West Texas

Windy, Less Populated

Majority of Population



Which came first?



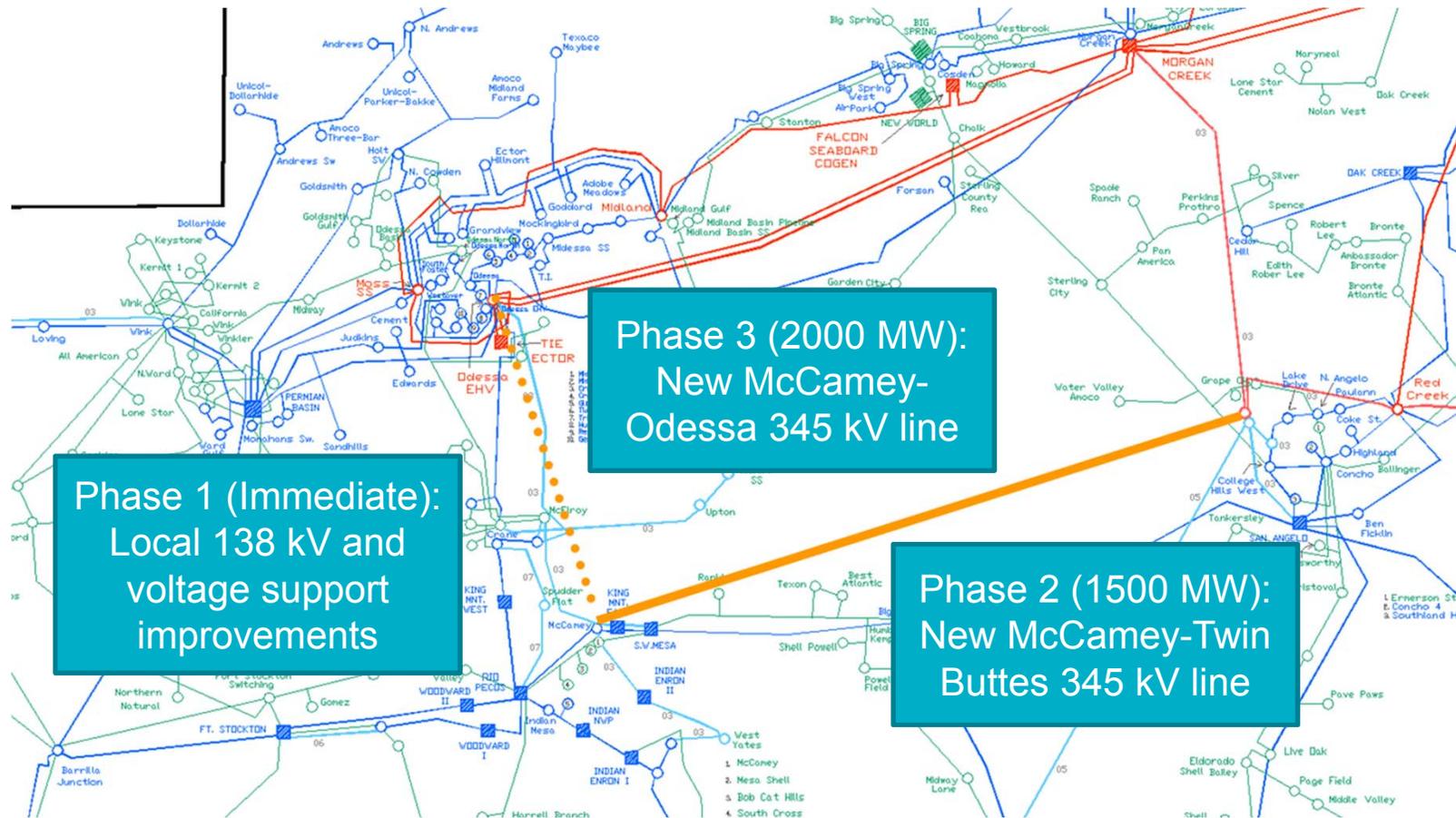
Transmission is built for generation once the generator is committed to build.



Generators will build once the transmission has been committed to be built.

2003 – The McCamey Plan

In 2003 McCamey had 755 MW of wind generation but an export limit of 400 MW

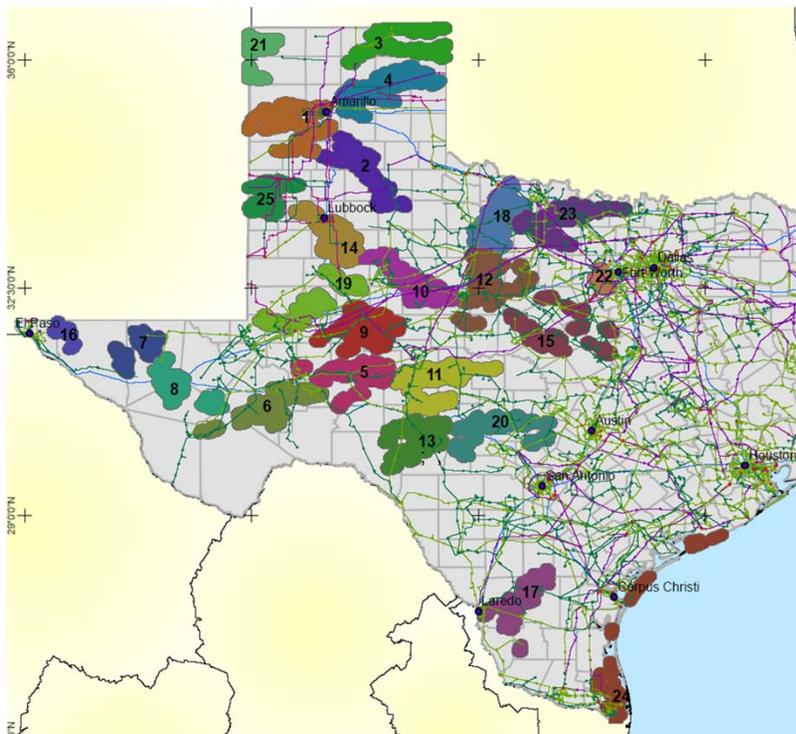


2005 – Texas Senate Bill 20

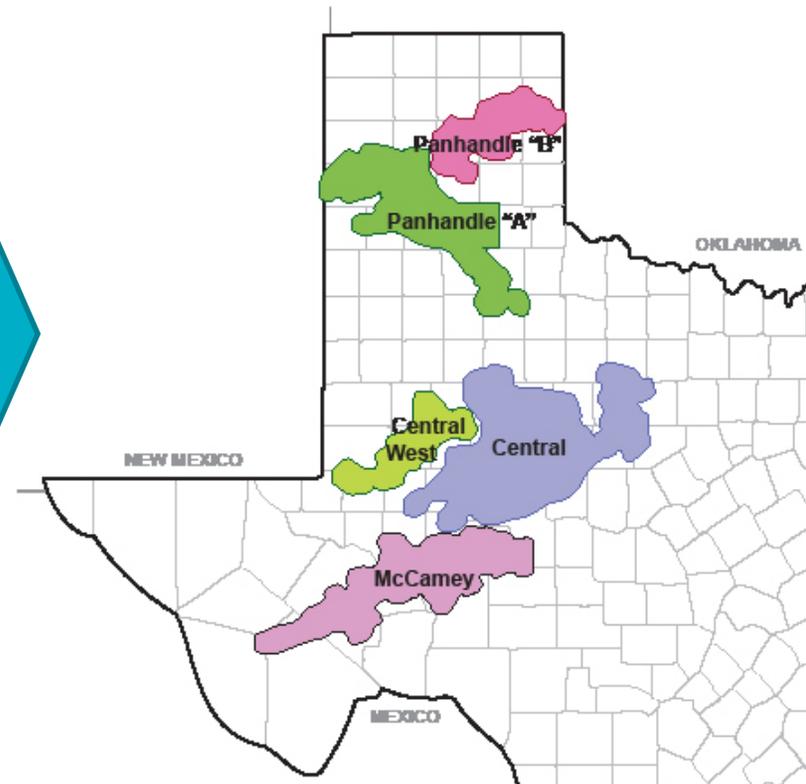
- 2005 Texas Legislature
- Public Utility Commission of Texas (PUCT), with consultation from ERCOT shall:
 - Designate “Competitive Renewable Energy Zones” (CREZ)
 - Competitive – generation in ERCOT competes
 - Renewable Energy – mainly wind (solar not competitive in 2005)
 - Zones – areas with high renewable potential
 - Develop a transmission plan to deliver renewable power from CREZ to consumers
 - Etc.
- SB 20 did not specify how many MWs or where

The Zones

2006: ERCOT contracted with AWS Truepower to determine best wind resource zones in Texas



2007: PUCT identified five CREZs based on preliminary transmission analysis and wind developer interest

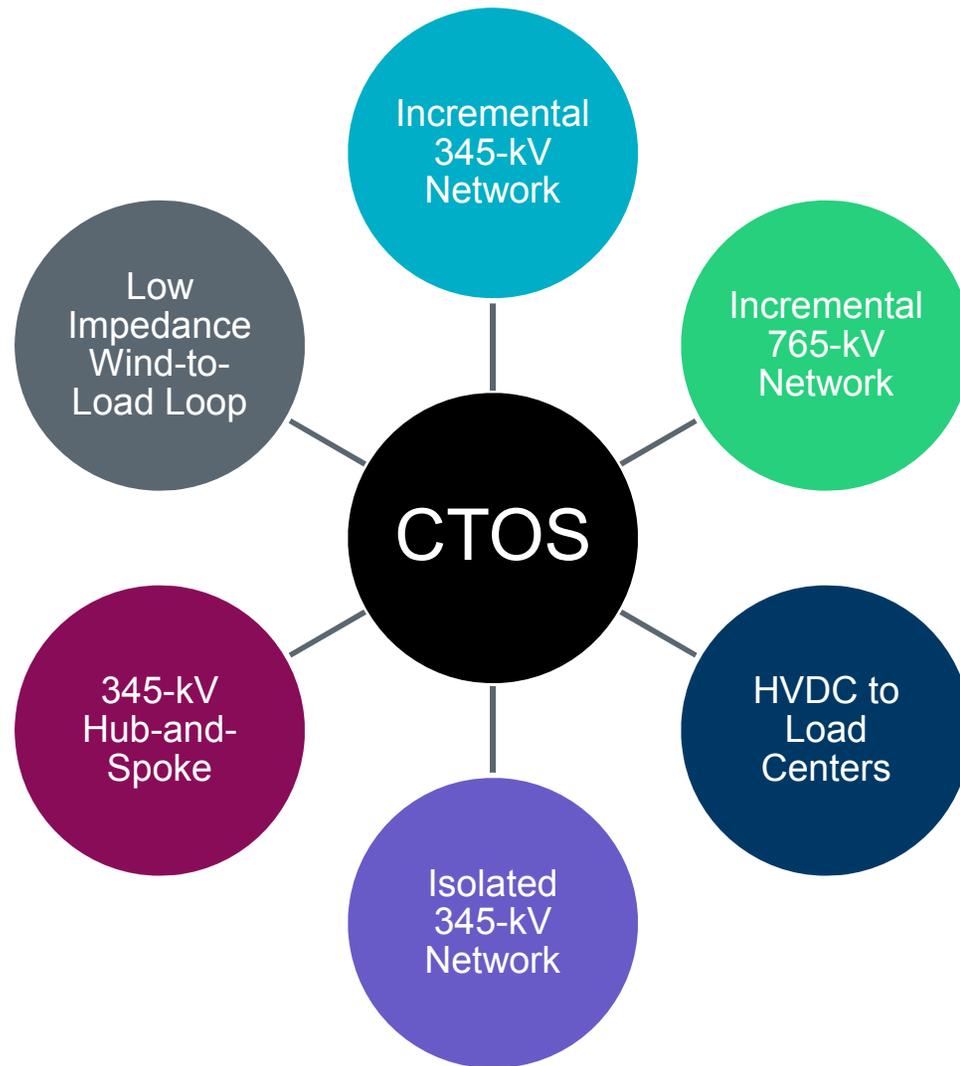


Late 2007

- PUCT asked ERCOT to develop CREZ Transmission Optimization Study (CTOS)
 - MW levels based on wind generation developer interest

	Scenario 1 (MW)	Scenario 2 (MW)	Scenario 3 (MW)	Scenario 4 (MW)
Panhandle A	1,422	3,191	4,960	6,660
Panhandle B	1,067	2,393	3,270	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
Total CREZ Wind Capacity	5,150	11,553	17,956	17,516

ERCOT Study Approach

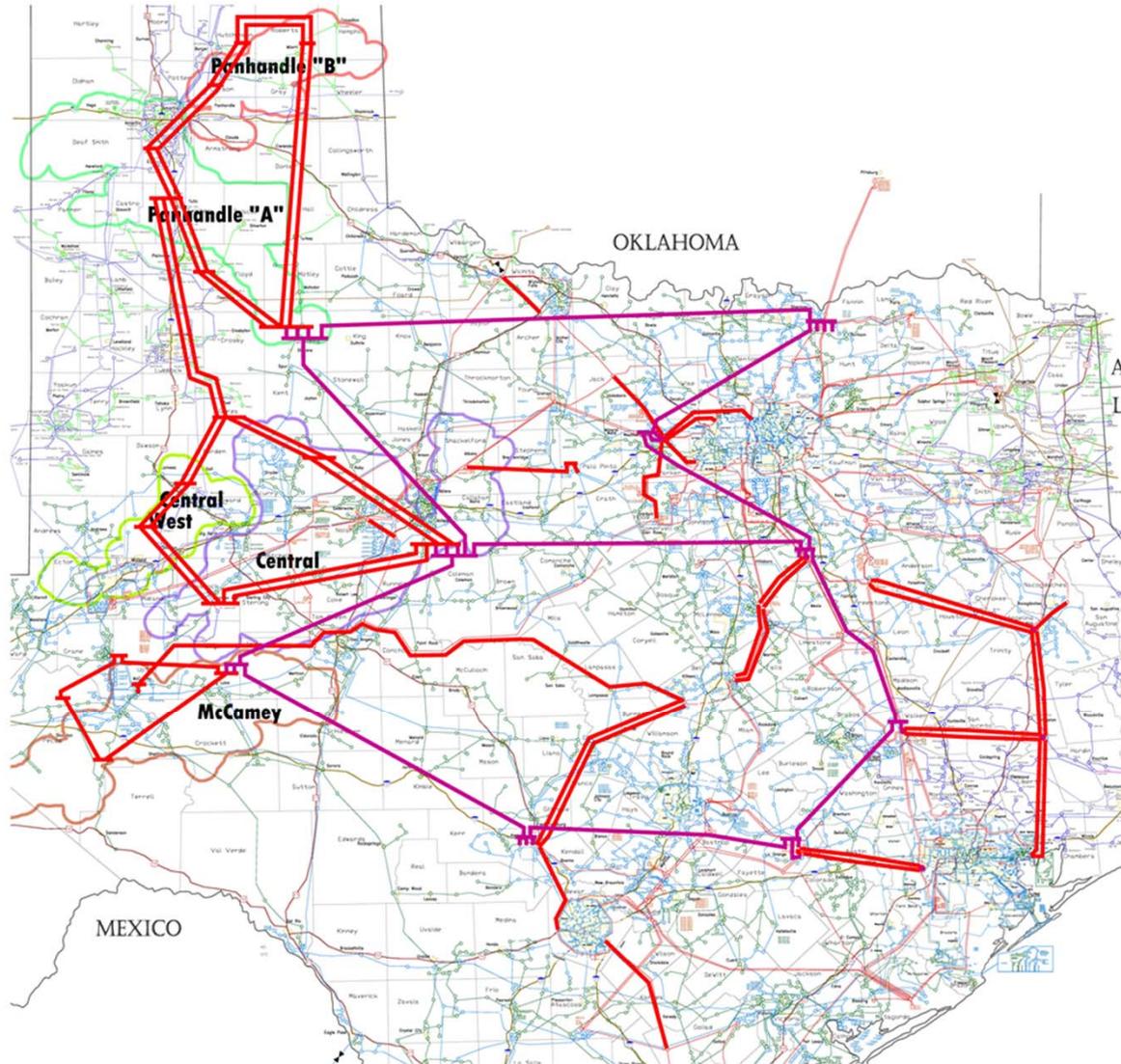


Primary Study

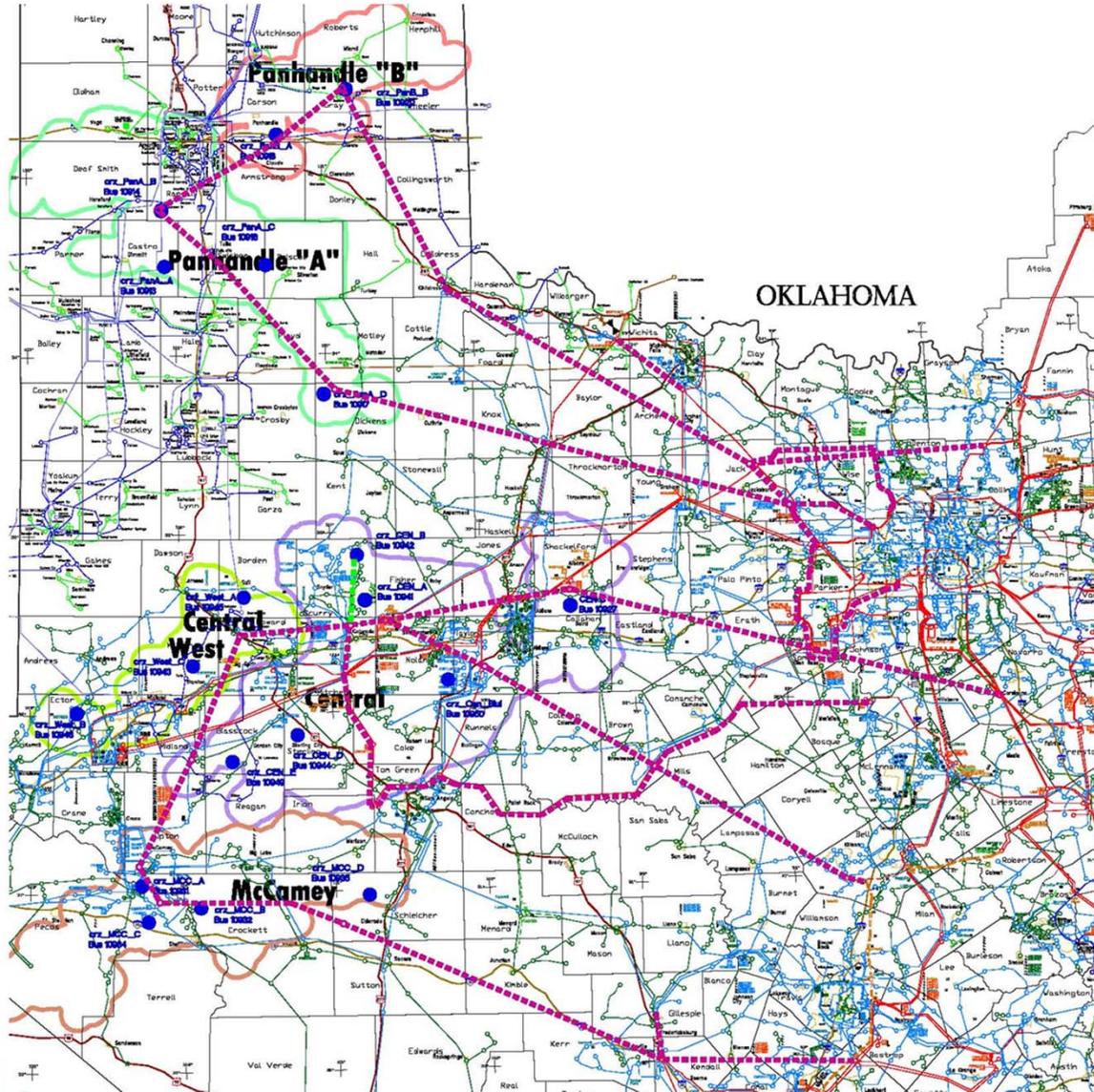
Tools:

1. Production Cost Modeling
 - Objective: <2% Annual Wind Curtailment
2. Stability Analysis

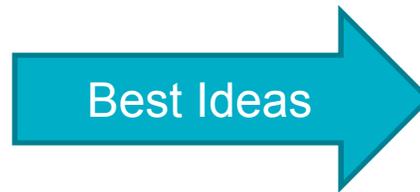
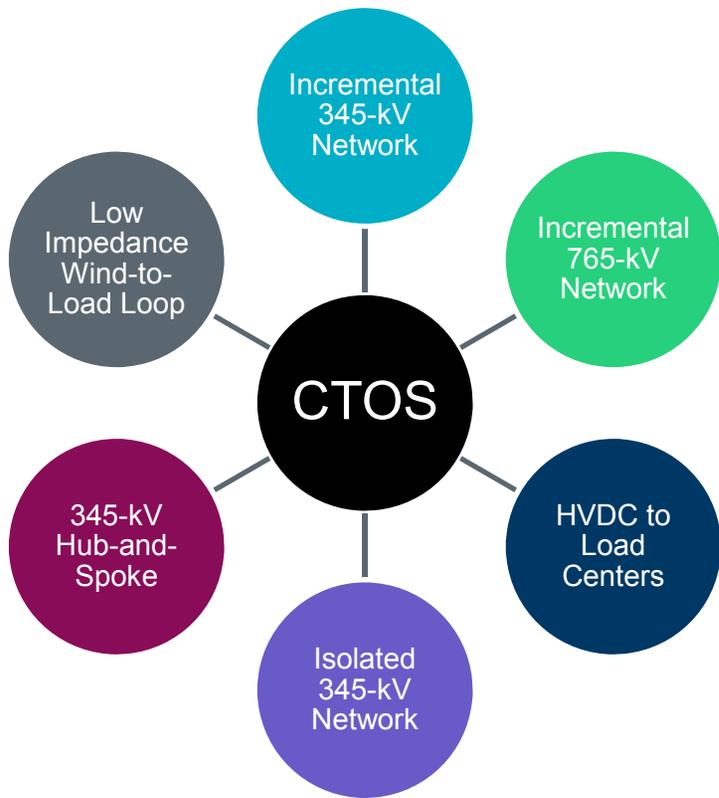
Early Maps



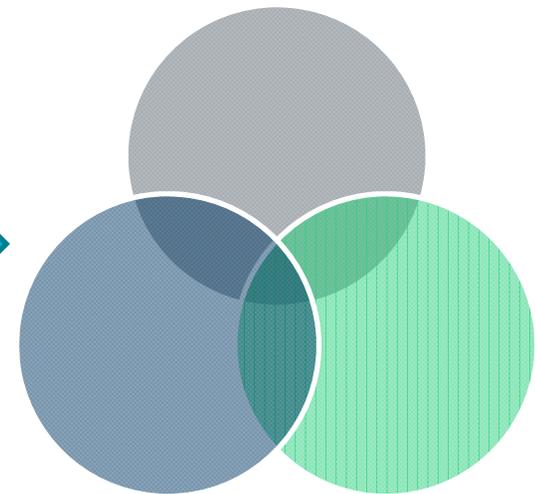
Early Maps



Narrowing Options



Hybrid Approach

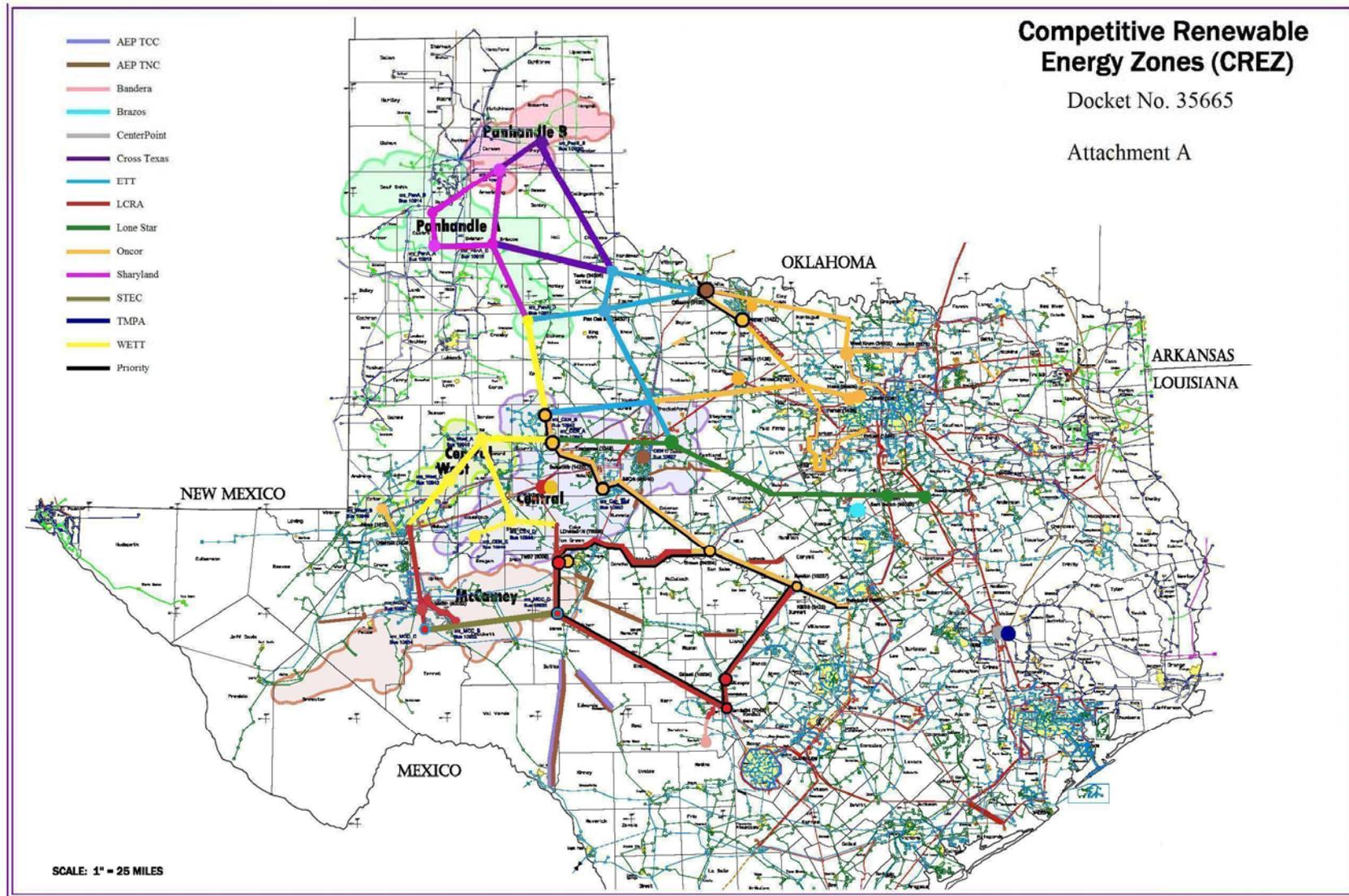


ERCOT Issued CTOS Report April 2, 2008

2008

- The PUCT selected Scenario 2
 - Accommodate 18.5 GW of wind
 - \$6.8 Billion
 - ~3,600 circuit miles 345 kV transmission
- What still needed to be decided
 - Who (Transmission Service Providers) would build the CREZ lines
 - Reactive needs
 - Subsynchronous Resonance
 - Staging

2009 – PUCT Selects Transmission Providers

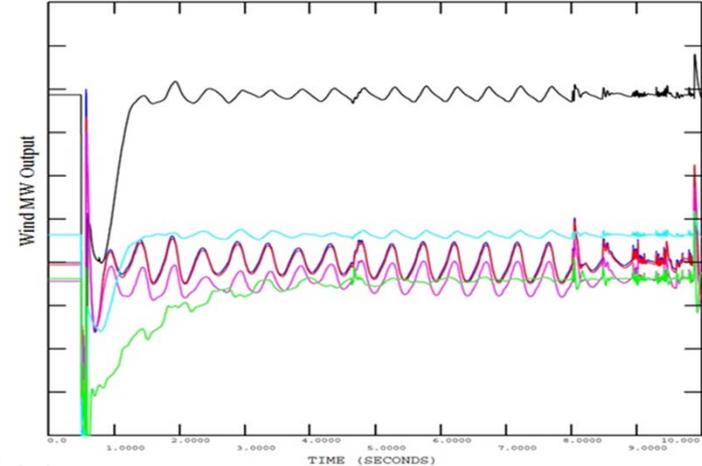


2010-2013

- 2010: Follow-up reactive compensation and stability studies
- 2010-2013: Construction
 - Goal was to have all facilities in-service by December 31, 2013
 - It nearly happened!

Technical Lessons Learned

- Weak grid
 - Inverter based generation needs a strong synchronous signal
- Stability
 - Stability became the most limiting factor
 - Recommend begin stability analysis early in the process if incorporating large amounts of generation and/or if transferring over a long distance
- Grid code
 - Modern turbines and inverters can support grid needs
 - It can be difficult to retrofit after installed
- Economic curtailment
 - It is not economically optimal to plan for 100% wind generation output

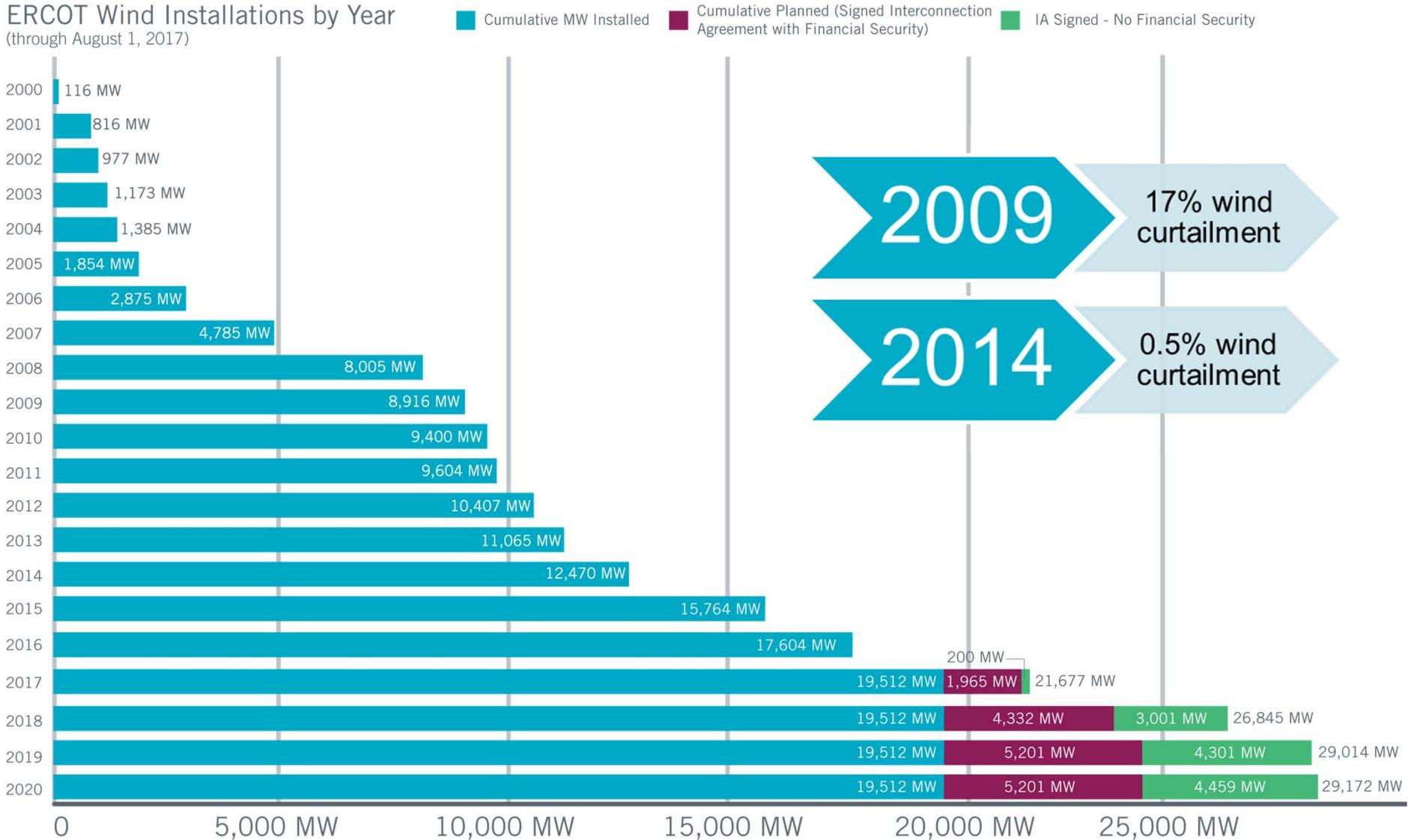


Policy-Related Lessons Learned

- Successful integration of >19 GW of wind generation
 - Eliminated transmission bottleneck issues that could have delayed wind generation development
 - Operating reliably and efficiently
 - In 2016 ERCOT had its lowest ever average wholesale price of electricity (\$24.62/MWh)
 - Low prices attributed to low natural gas prices and abundance of low-cost renewable energy (and other factors)
- Transmission provider competition
 - Incented TSPs to complete construction on time
 - Can be challenging in operational coordination
- Stakeholder collaboration
 - Would not have been successful without participation from a broad cross section of stakeholders

Wind Generation Capacity Today

ERCOT Wind Installations by Year
(through August 1, 2017)



Thank you!

