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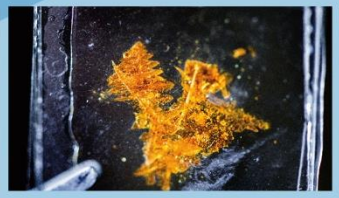


Renewable Energy Zones in the Texas Wholesale Market

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Santiago, Chile

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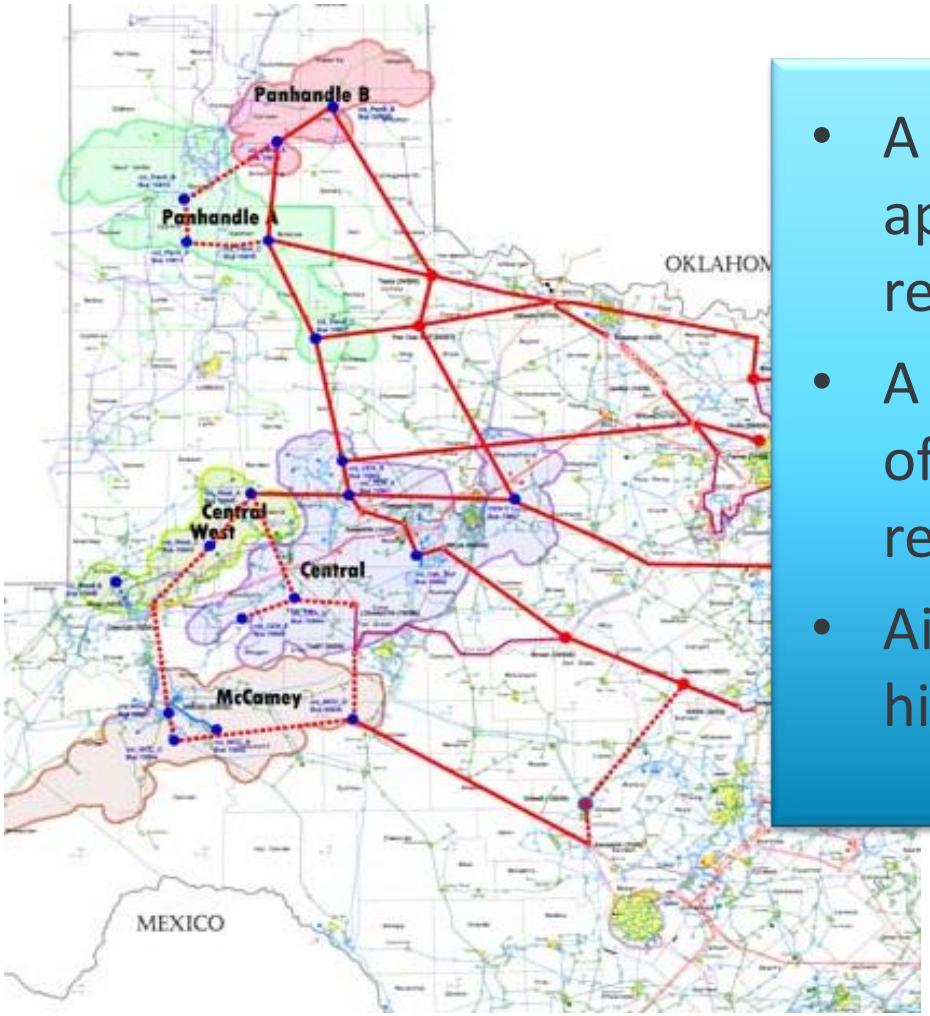
What is a renewable energy zone?



- A transmission planning and approval process customized for renewables
- A zone has a high concentration of high quality, easily developed renewable energy potential
- Aims for fullest utilization of highest-voltage transmission

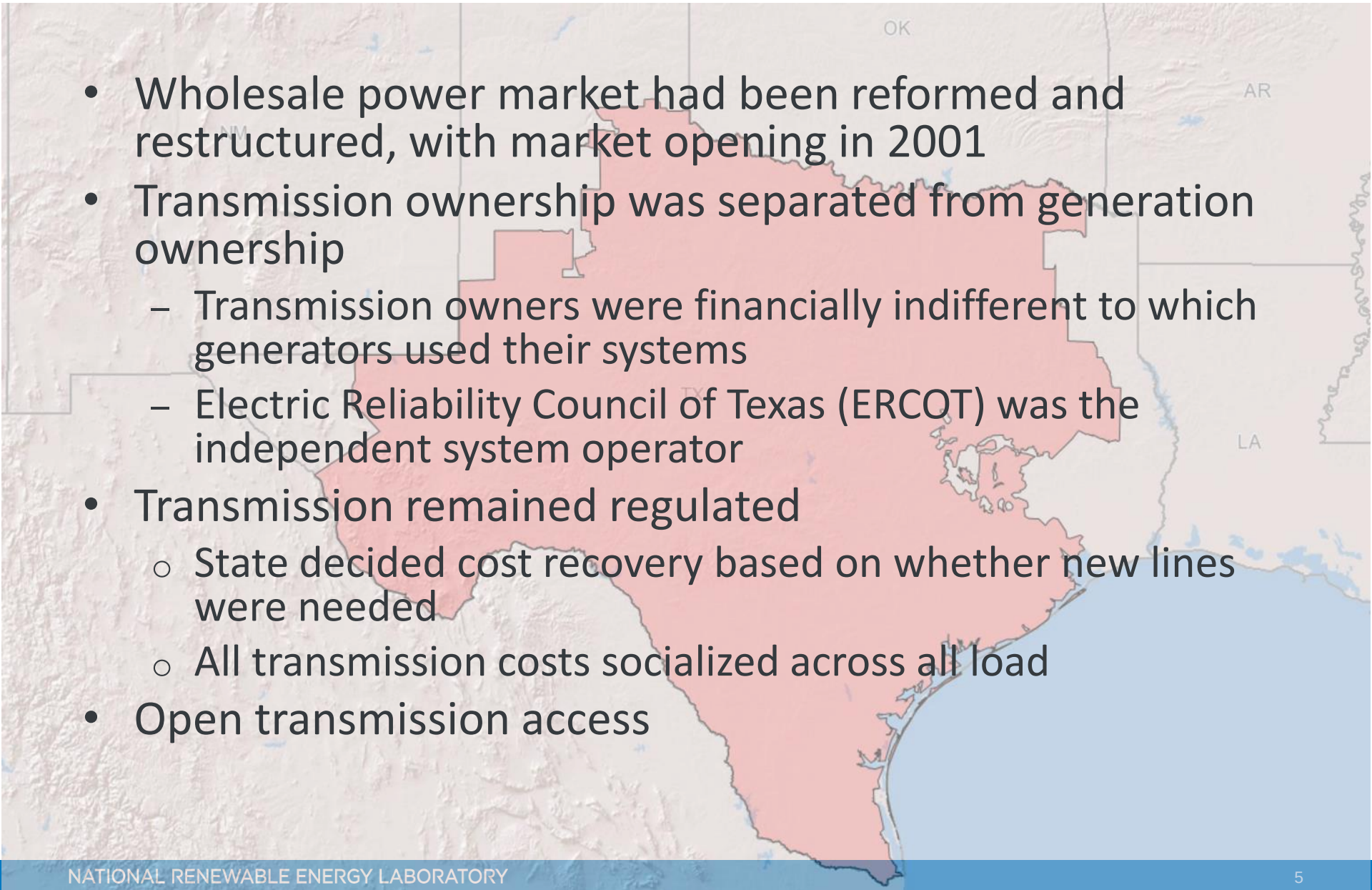
What a renewable energy zone plan ***is not***

- Renewable energy zones do not create demand
  - **Demand comes first**
  - Directs supply to areas where capital will be most productive
- Not for siting renewables on existing transmission
  - Don’t need REZs for that

What led to the invention of CREZ in Texas?

- Wind development created a transmission need that existing laws, regulatory precedent, and financial practice could not accommodate
- Solution required a new approach; rules crafted for conventional generation could not provide useful guidance
- Even after CREZ was conceived, it could not go forward until laws were changed

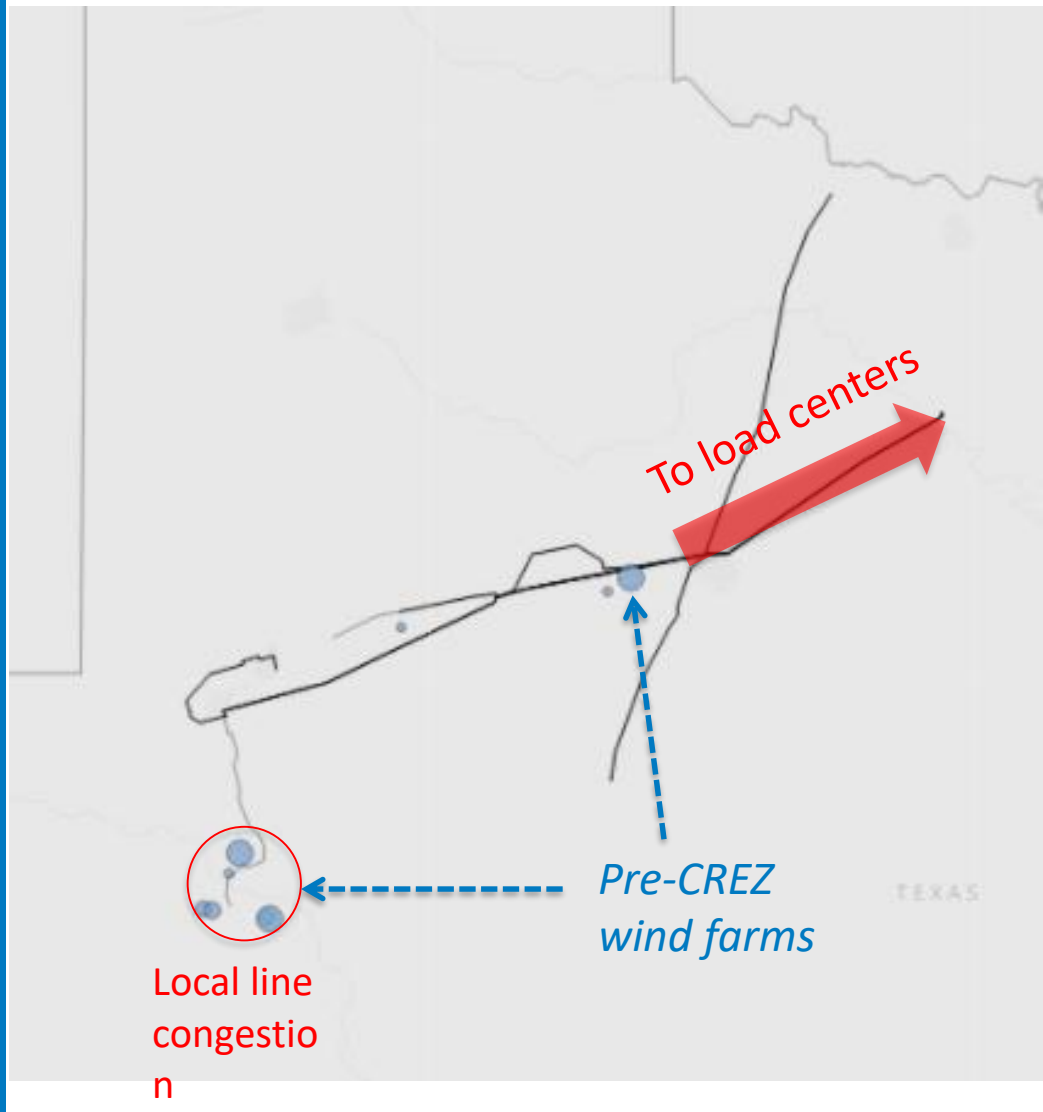
Restructuring of the Texas power market



- Wholesale power market had been reformed and restructured, with market opening in 2001
- Transmission ownership was separated from generation ownership
  - Transmission owners were financially indifferent to which generators used their systems
  - Electric Reliability Council of Texas (ERCOT) was the independent system operator
- Transmission remained regulated
  - State decided cost recovery based on whether new lines were needed
  - All transmission costs socialized across all load
- Open transmission access

Wind responded to the opportunities — but too much

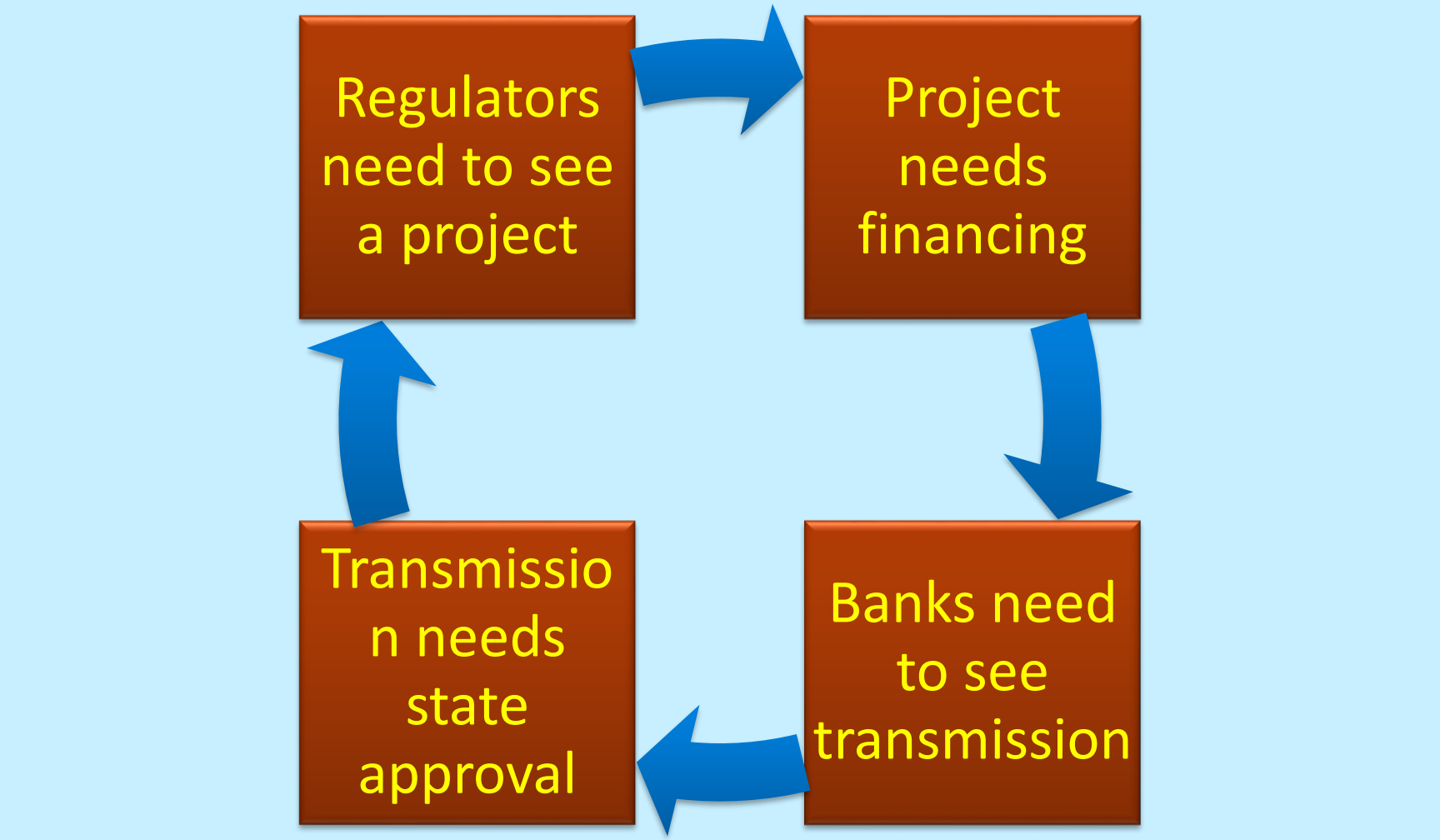
- First wave of wind power development was in West Texas
  - 760 MW of installed wind power by 2002
  - Only 400 MW of total transmission capability
- Operator-ordered curtailments degraded wind's effective annual capacity factor



Engineering answer was clear…

- Upgrade the paths with new extra high voltage lines
- Wind industry wanted additional transfer capacity to accommodate future development
  - But, what future projects? At the time, none had committed to build
- Transmission utilities could not build new lines in advance of generator commitments

…but regulatory, finance answers were not clear



CREZ solution

- Demonstrate that economically compelling demand is there
  - —Market conditions create a reasonable likelihood that tangible projects will come forward
  - —Direct the potential supply to the best areas
- At the time, the source of future demand was the state renewable energy requirement
- Even so, using economic likelihood as a proxy for a tangible project required a change in state utility law
  - —Happened in 2005, along with an increase in state renewable energy requirement

Principle 1: Find the most productive resources

- High capacity factors mean high utilization of transmission assets
- RE projects with high capacity factors have lower cost per MWh
- Most MWh for the amount of capital invested, for both generation and transmission

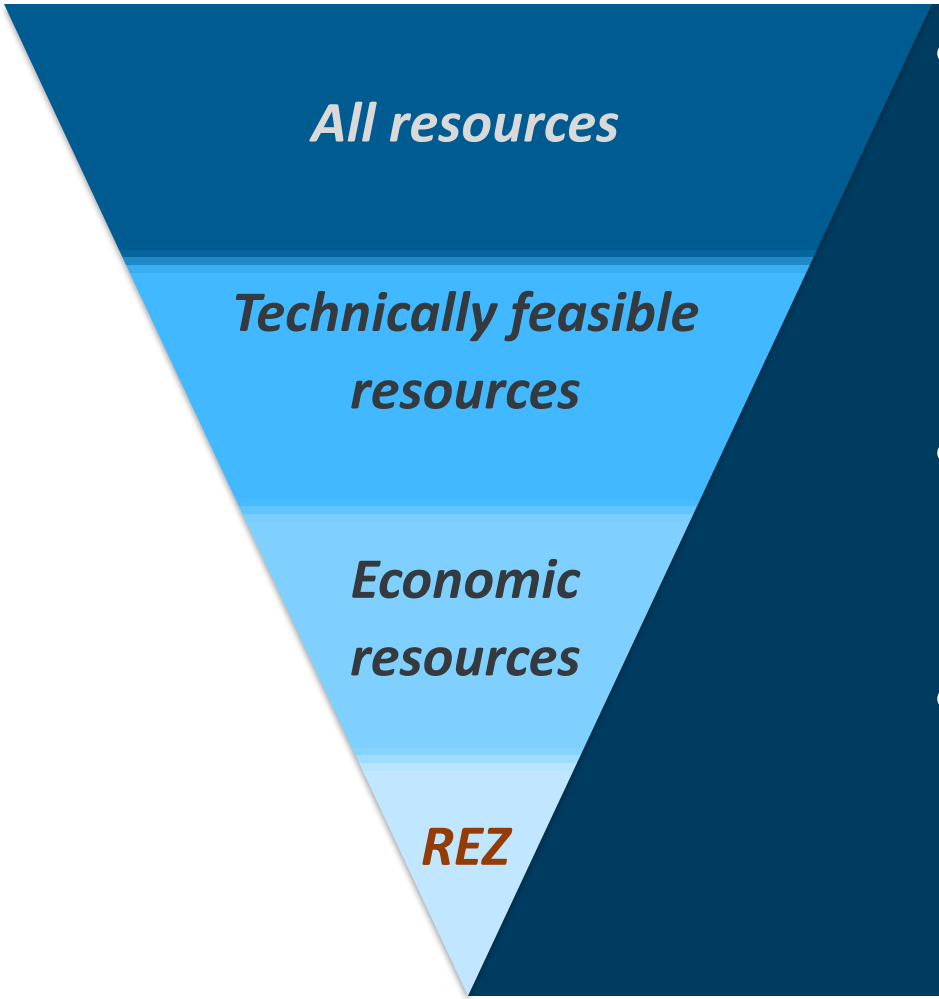
Principle 2: Build a few high-capacity lines

- Higher voltages have smaller losses and are more economically efficient per MW of capability
- Fewer corridors, less environmental damage
- Fewer proceedings for siting and permitting

Principle 3: Harness the power of competition

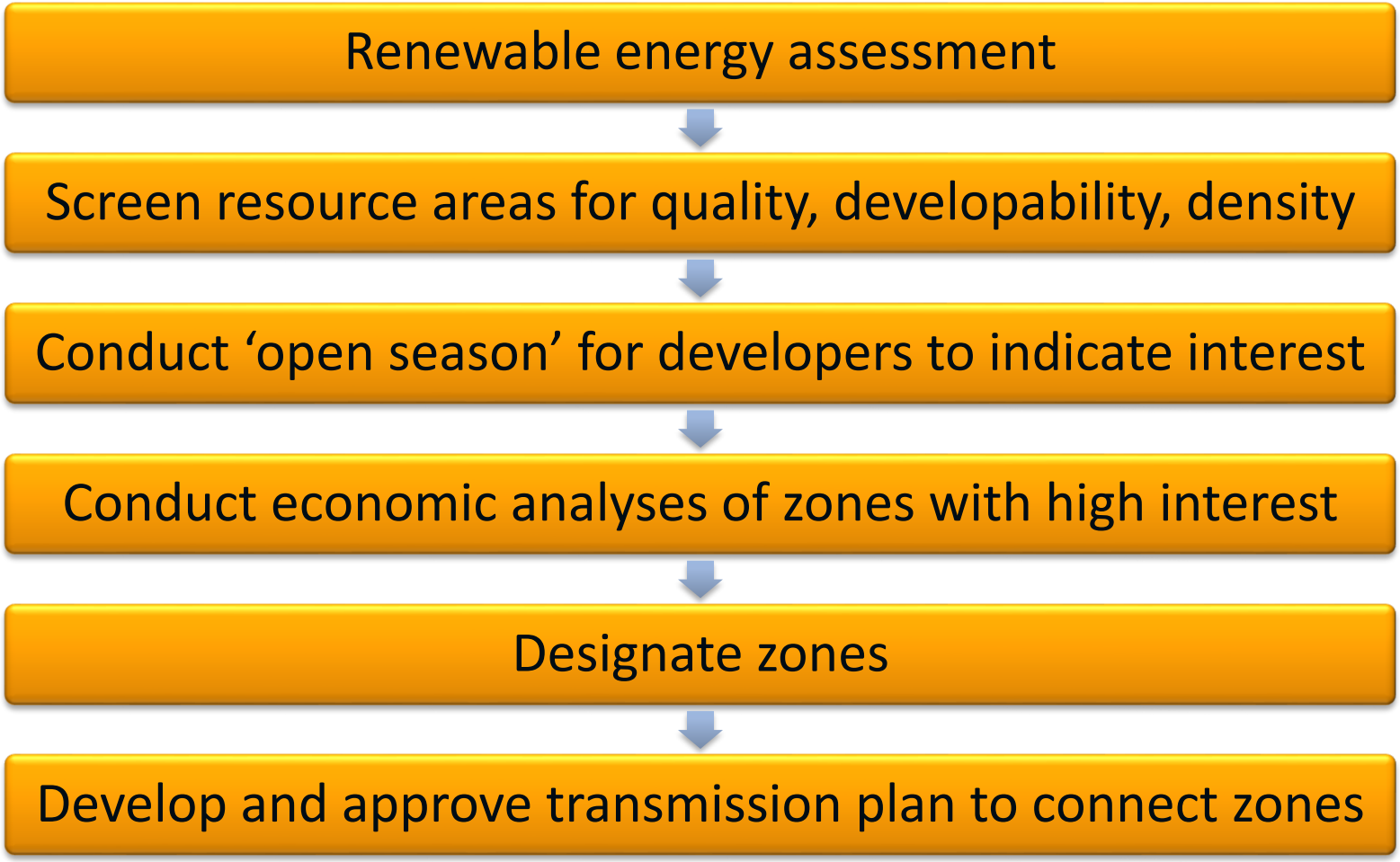
- Let the competitive market decide who builds wind projects
- Transmission plan directs developer interest to the largest concentrations of highest quality resources
- Raw potential should be more than the capacity of the new line

Narrowing down to the best of the best



- Technical and economic analysis establishes the likelihood of whether new projects in the zone will be profitable
- Let competition decide which new projects will connect
- Transmission defines the best of the best resource areas as the venues for competition

Steps in the REZ process

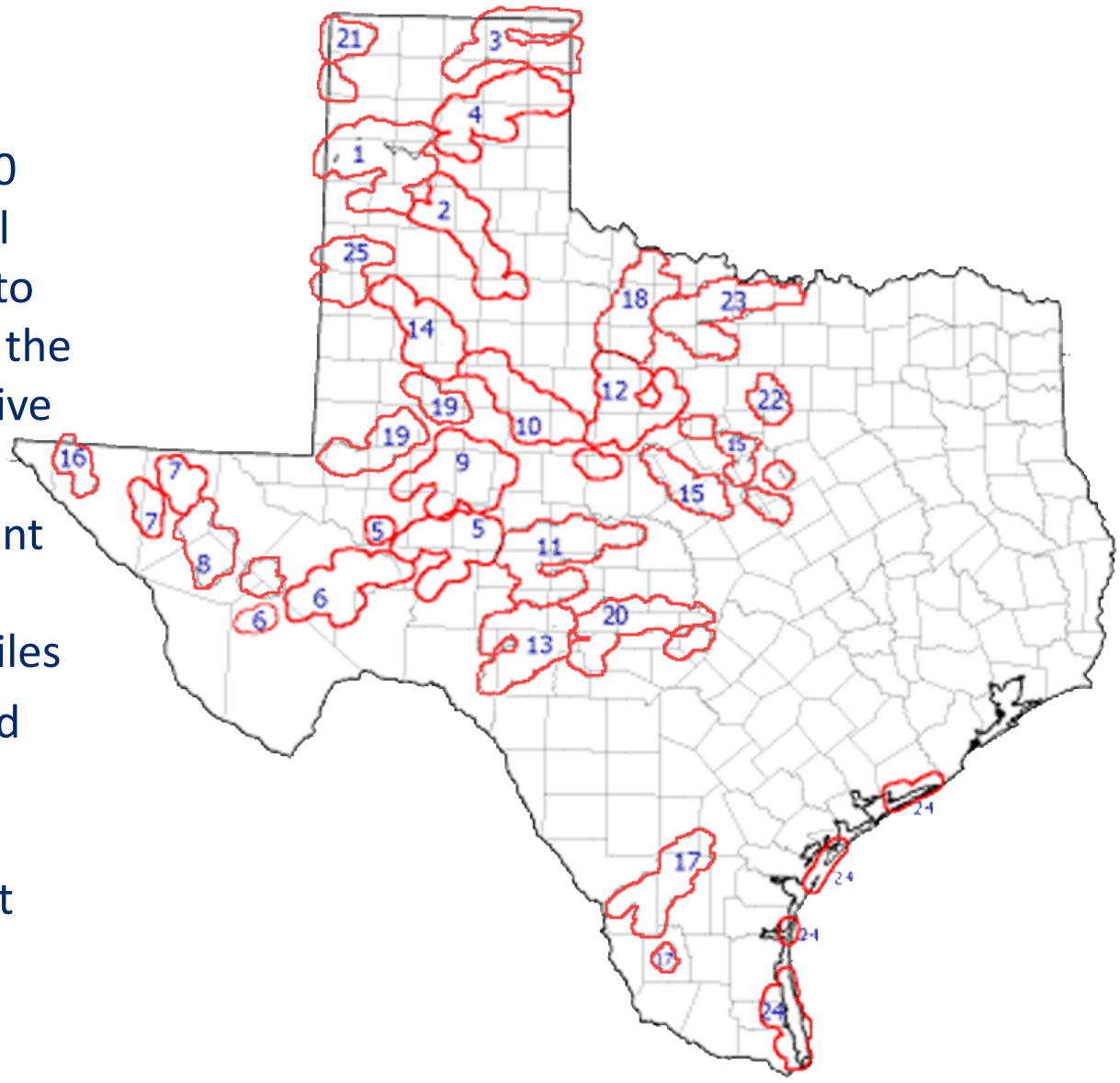


Implementing Competitive REZs in Texas

- ERCOT conducted initial 12-month study
  - Open, informal stakeholder process
    - All wind developers, state Department of Wildlife, transmission utilities, affected cities, commission staff
  - Mesoscale analysis of wind potential
    - Proximity to existing transmission was not a screening criterion
    - Wind modeling has increased significantly since 2005
  - Selected study areas were aggregated into CREZ scenarios
  - Production cost modeling used to compare costs and benefits on a provisional basis
- Report delivered to PUCT Dec. 1, 2006

Study zones identified by ERCOT

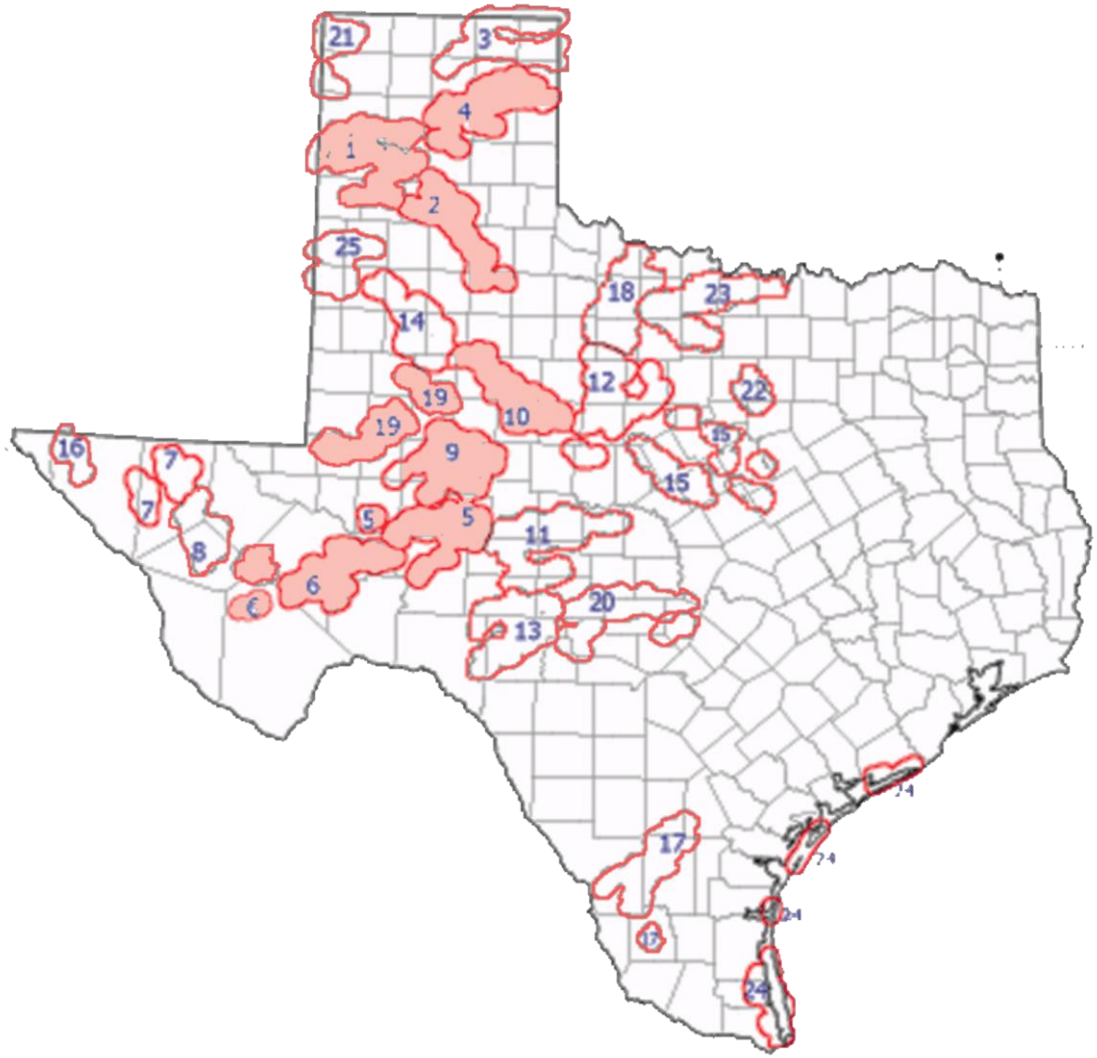
- Areas with 4,000 MW of potential each, screened to identify 25 with the highest productive potential
- Clusters represent similarity of production profiles
- PUC invited wind developers to demonstrate financial interest



Evidence of market demand

- Traditional transmission planning relies on certainty of a known generation project
- Key issue: if there is no specific project at the time a transmission decision is made, how can regulators know that market demand is robust enough?
- REZ approach:
  - Developers provide demonstrations of financial commitment
  - Regulators weigh each proposed zone's combined demonstrations of commitment to determine which ones show the strongest demand

Zones designated by state as CREZs



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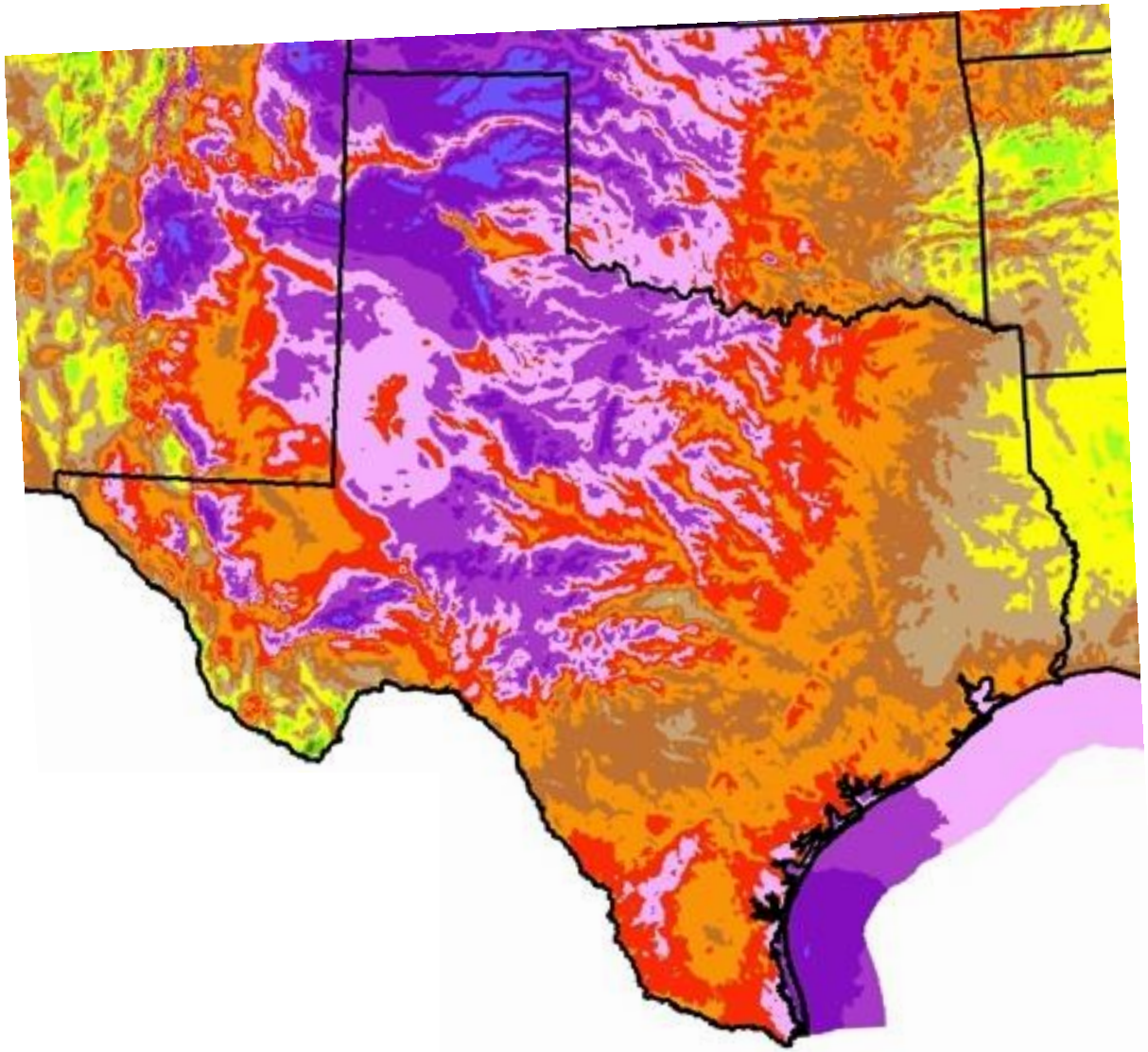


Transmission expansion scenarios

- Conduct stakeholder meetings to develop conceptual scenarios for modeling
  - Accelerated carbon reduction?
  - High/low natural gas prices?
  - Accelerated DG and demand response?
  - Other?
- Ultimate objective is to identify “no regrets” options for transmission expansion that are robust across several scenarios

Economic analyses of REZ scenarios

- Production cost modeling
  - Model dispatch on the entire network to determine how the variable cost of production changes under different REZ scenarios
  - Outcomes include total production costs over a test year, congestion costs (could be more, could be less), local marginal cost of power
- Cost-benefit analysis
  - Production cost savings against the cost of new transmission
  - Scenarios vary by zones included, size of transmission upgrades

Reliability

- CREZ study of ancillary services (2008)
  - Found that reliability effects of anticipated CREZ development levels "can be addressed by existing technology and operational attention, without requiring any radical alteration of operations," but that
    - ✓Forecasting was essential
    - ✓Existing practices could be improved
    - ✓ERCOT should continue to monitor and evaluate the need for new types of ancillary services

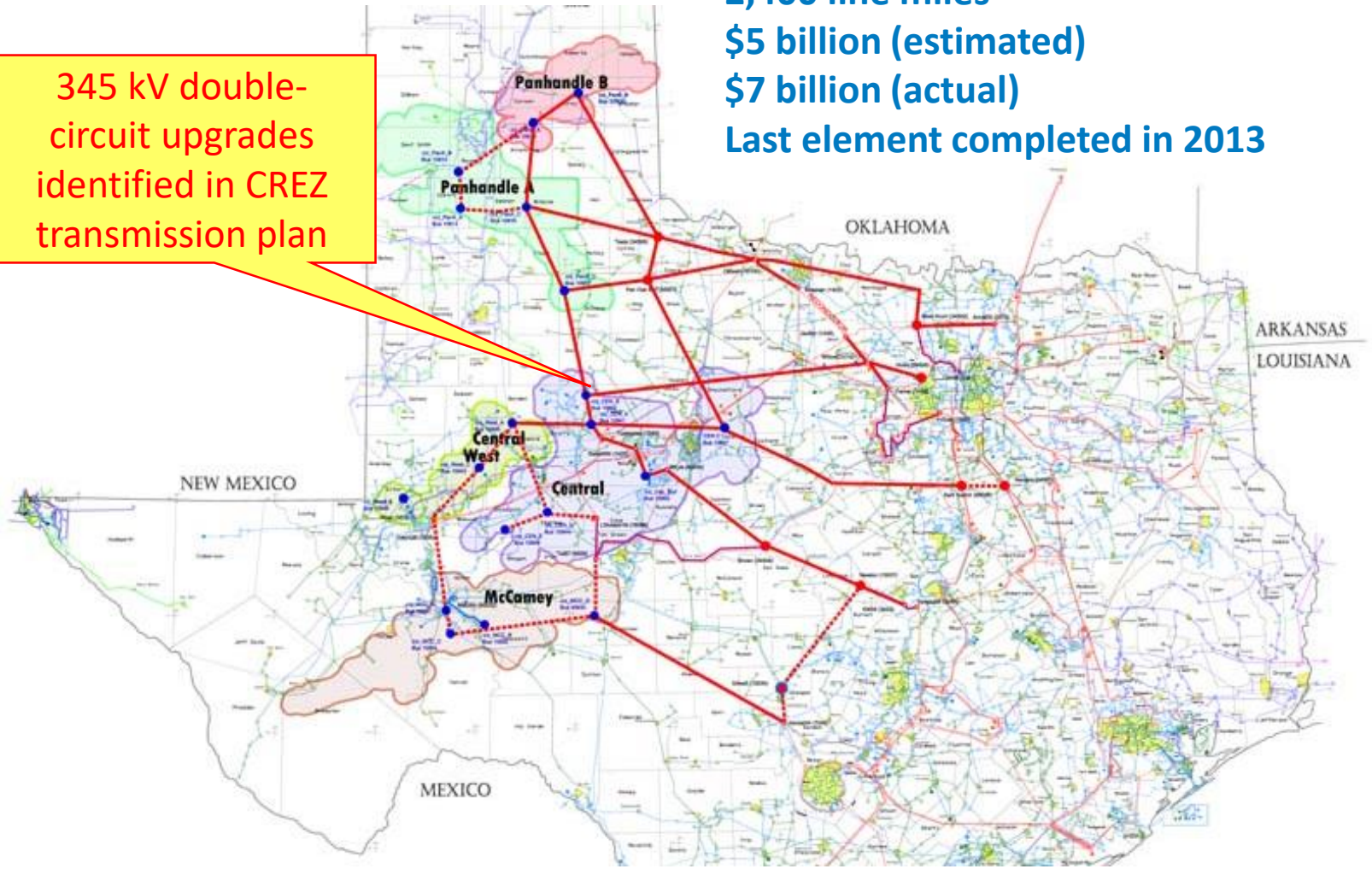
Scenarios evaluated in Texas CREZ

	1	2	3	4
CREZ transfer capability (incremental)	5,150 MW	11,553 MW	17,956 MW	17,516 MW
Total transfer capability	10,000 MW	16,403 MW	22,806 MW	22,366 MW
Estimated cost ($billions)	$2.95 (A) $3.78 (B)	$4.93	$6.38	$5.75
Transmission miles	1,638 (A) 1,831 (B)	2,376	3,036	2,489
HVDC included?	no	no	yes	yes

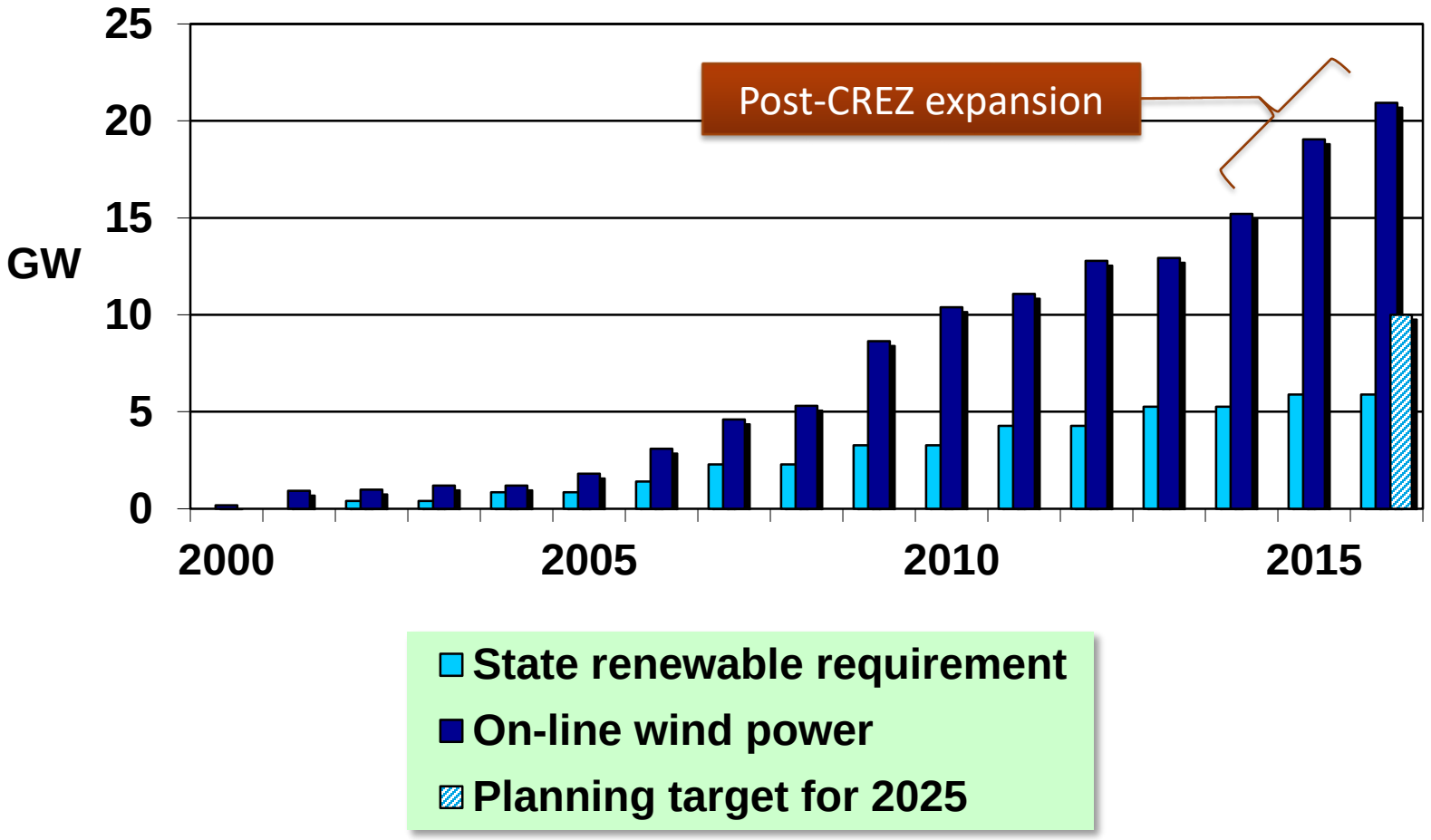
CREZs and transmission approved in 2008

345 kV double-circuit upgrades identified in CREZ transmission plan

2,400 line miles
$5 billion (estimated)
$7 billion (actual)
Last element completed in 2013

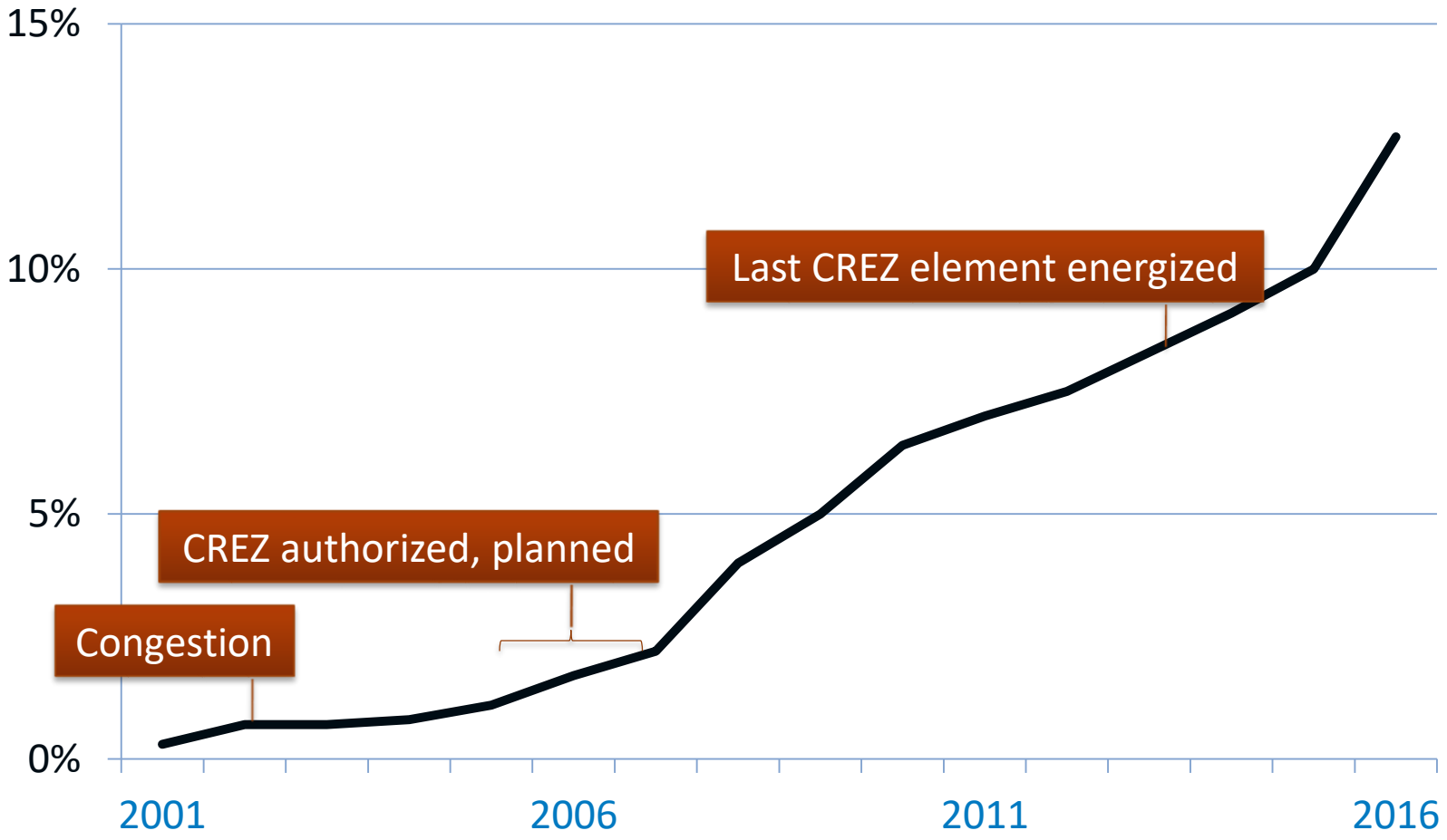


Outcome: Wind growth has beaten goals



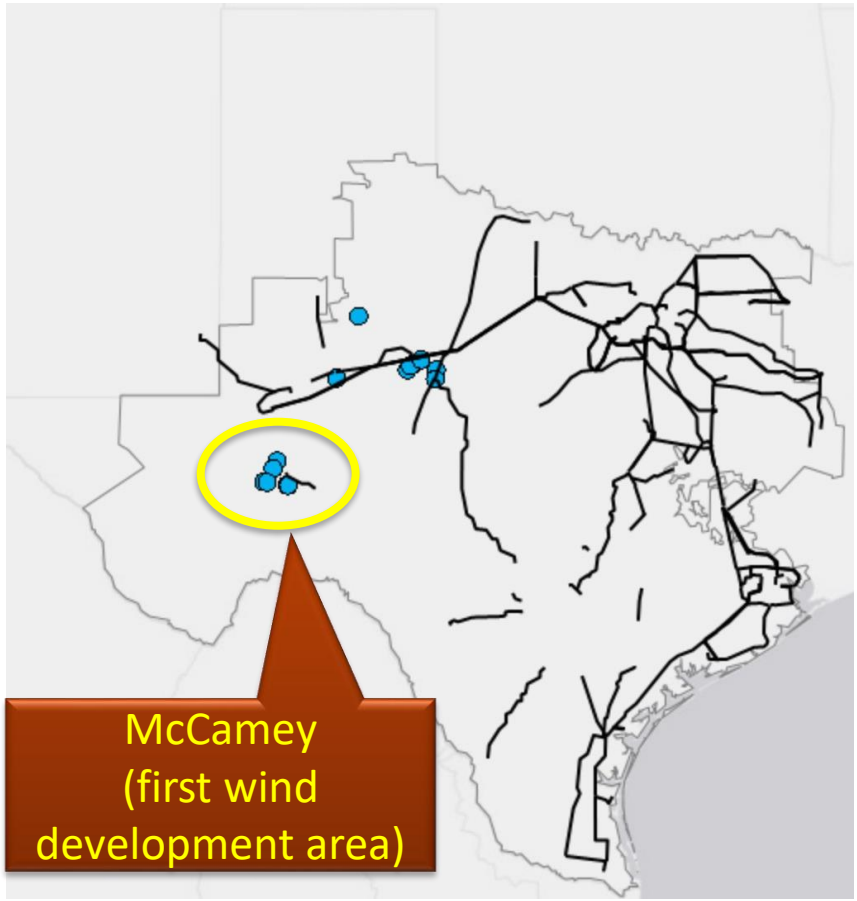
Source: ERCOT, Annual Reports on the Texas Renewable Energy Credit Trading Program

Wind's share of annual generation in Texas

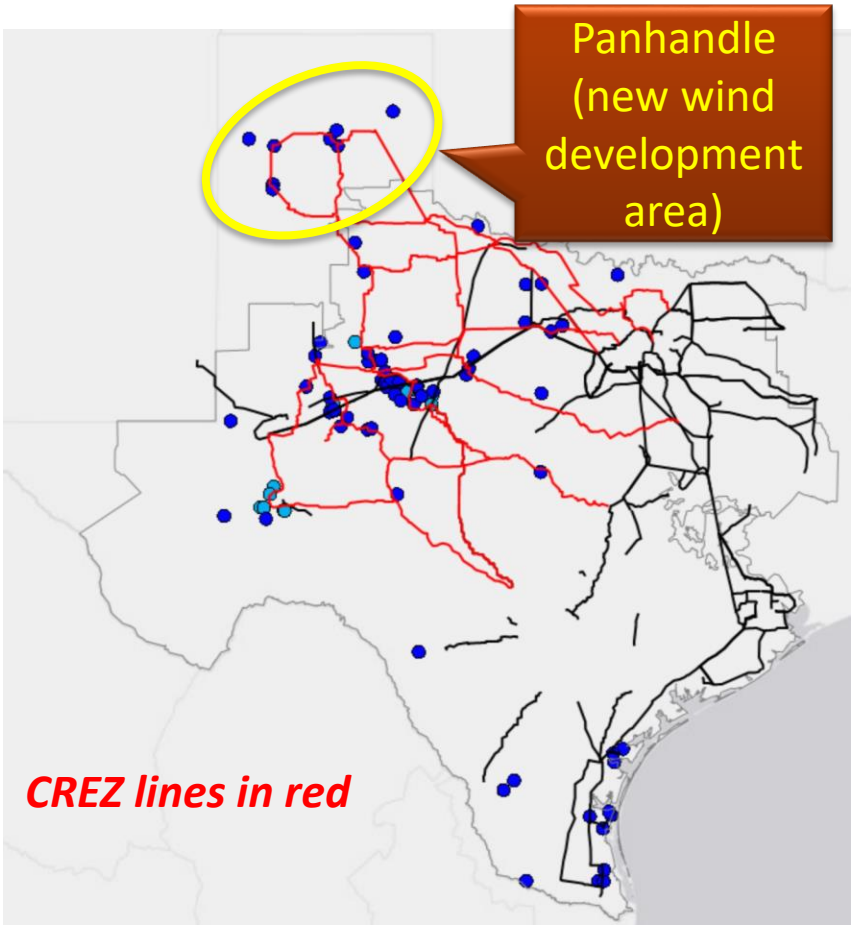


Directing wind development to the best areas

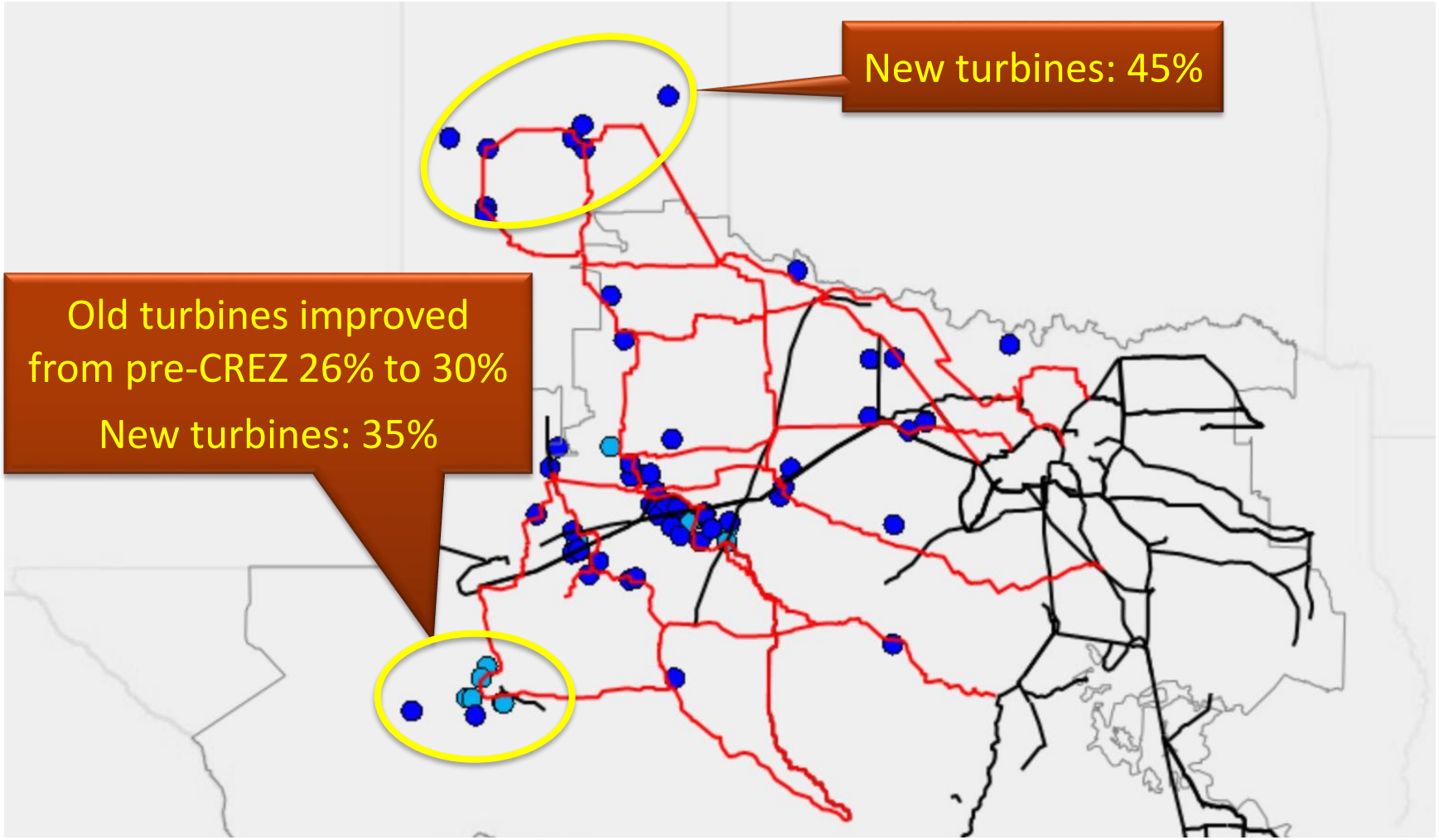
Projects in 2003 (before CREZ)



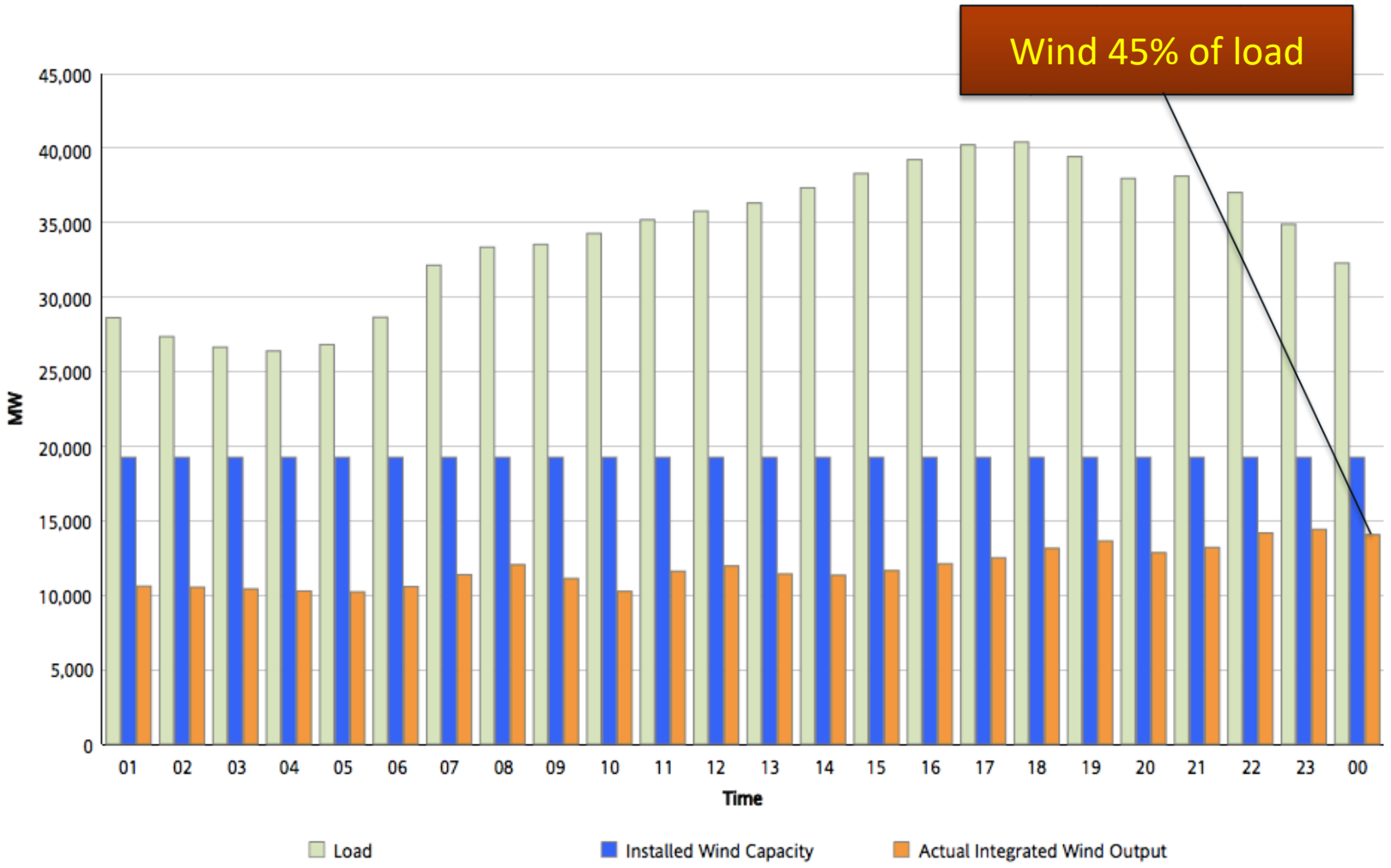
Projects in 2014 (with CREZ)



Better capacity factors for old and new turbines



Wind production and load, 7 April 2017



ERCOT, Wind Integration Report, 8 April 2017

Conclusions about REZs and transmission expansion

- Demand comes first
  - REZ is a response to RE demand; does not create demand
    - Demand can come from government policy or market conditions
- REZ directs new demand-driven RE development to new transmission areas where investments will be most productive
  - REZ not needed for additional development on existing lines
- The most effective REZ process includes authority to build new transmission
  - Without authority, REZ is only a mapping exercise
- The REZ process should include the modeling and analysis needed to integrate variable renewables efficiently
- Process is information-intensive; a strong stakeholder process is essential

Final note: Renewables, planning, and the big picture

How Texas lawmakers framed the "big picture"

"The legislature finds that **the production and sale of electricity is not a monopoly** warranting regulation of rates, operations, and services **and that the public interest in competitive electric markets requires that**, except for transmission and distribution services and for the recovery of stranded costs, electric services and **their prices should be determined by customer choices and the normal forces of competition**. As a result, this chapter is enacted to protect the public interest during the transition to and in the establishment of a fully competitive electric power industry."

Texas Utility Code, Sec. 39.001

Keep an eye on the public interest

- Regulate to nurture competition
  - Transmission is the playing field for fair competition
- Market monitoring is crucial
  - Abuse is less likely if everyone knows the market is being watched
- The ideal market is a direction, not a destination

Thank you!

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