Implementing Renewable Energy Zones for Integrated Transmission and Generation Planning

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ENHANCING CAPACITY FOR LOW EMISSION DEVELOPMENT STRATEGIES (EC-LEDS)

Agenda and Learning Objectives

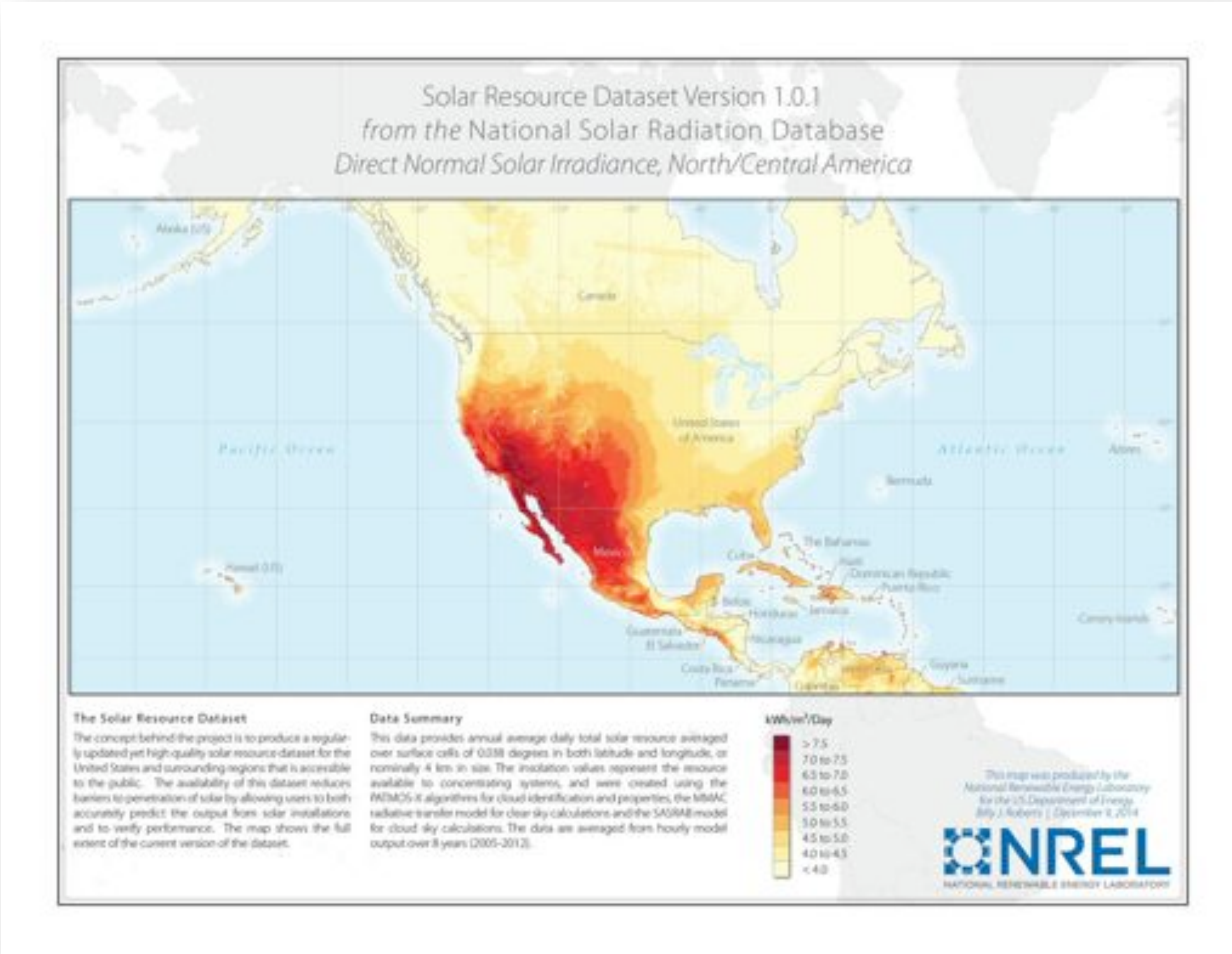
- ***What is a renewable energy zone?***
- ***Assessing renewable energy potential to inform renewable energy zones (REZ)***
  - Understanding resource assessment and the use of geospatial analysis in defining opportunities for REZs
  - Differentiate among theoretical, technical, economic, and market potential for solar and wind resources
- ***The necessary role of policy***
  - Become familiar with the crucial components of the Texas Competitive Renewable Energy Zones process
  - Understand the value of REZ to a power system
  - Identify crucial considerations for applying the REZ in other systems
- ***Questions and panel***

What is a Renewable Energy Zone (REZ)?

- Transmission planning tool
- An area with a high concentration of high-quality, easily-developable renewable energy potential
  - Rule-of-thumb: A new high-capacity transmission line to a zone could be filled 4 or 5 times over with low-cost, high-quality renewable capacity no farther than 100 miles from the substation

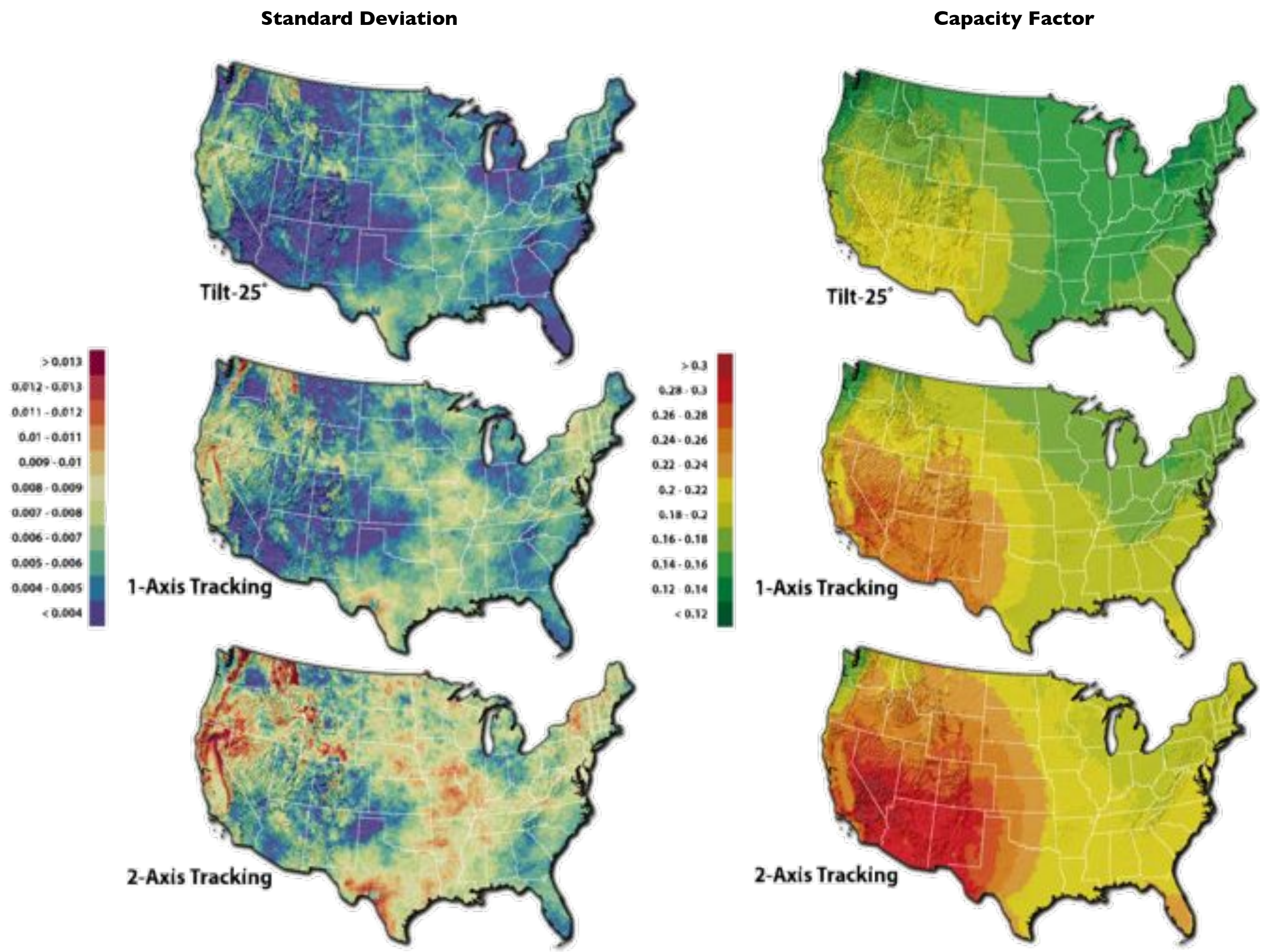
ASSESSING RENEWABLE ENERGY POTENTIAL TO INFORM REZ

Considering RE Potential: Resource Assessment



Considering RE Potential: Closer Look at Resource

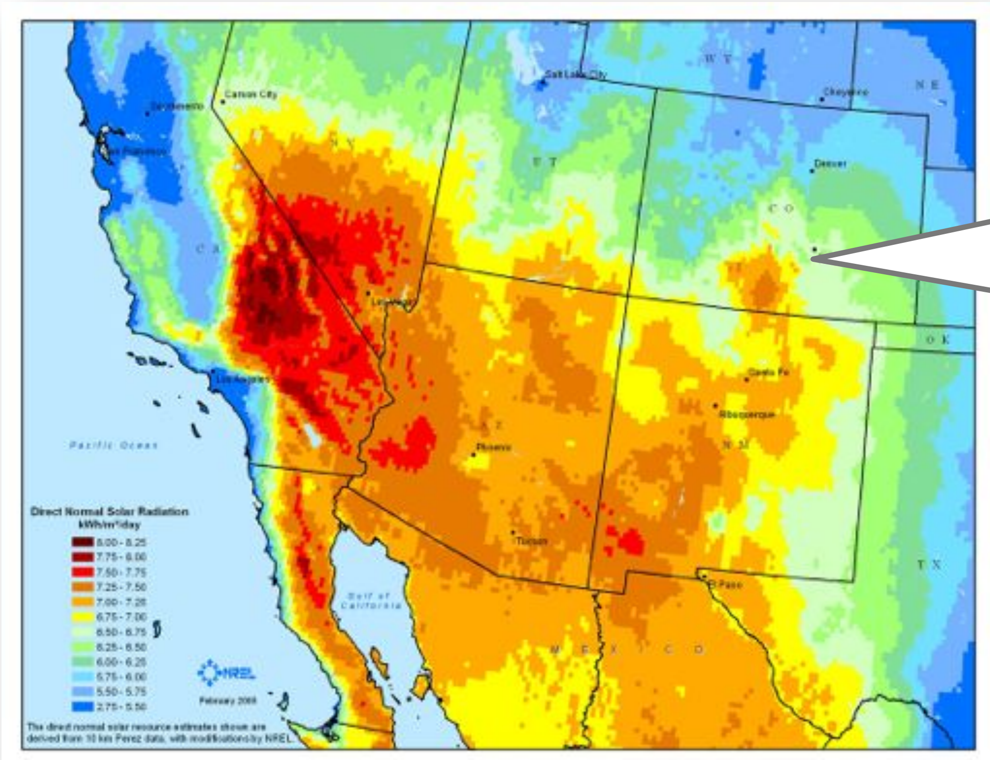
- What is the relative performance of PV systems?
- What is the spatial variation?
- Temporal variation?
- How do technologies compare?



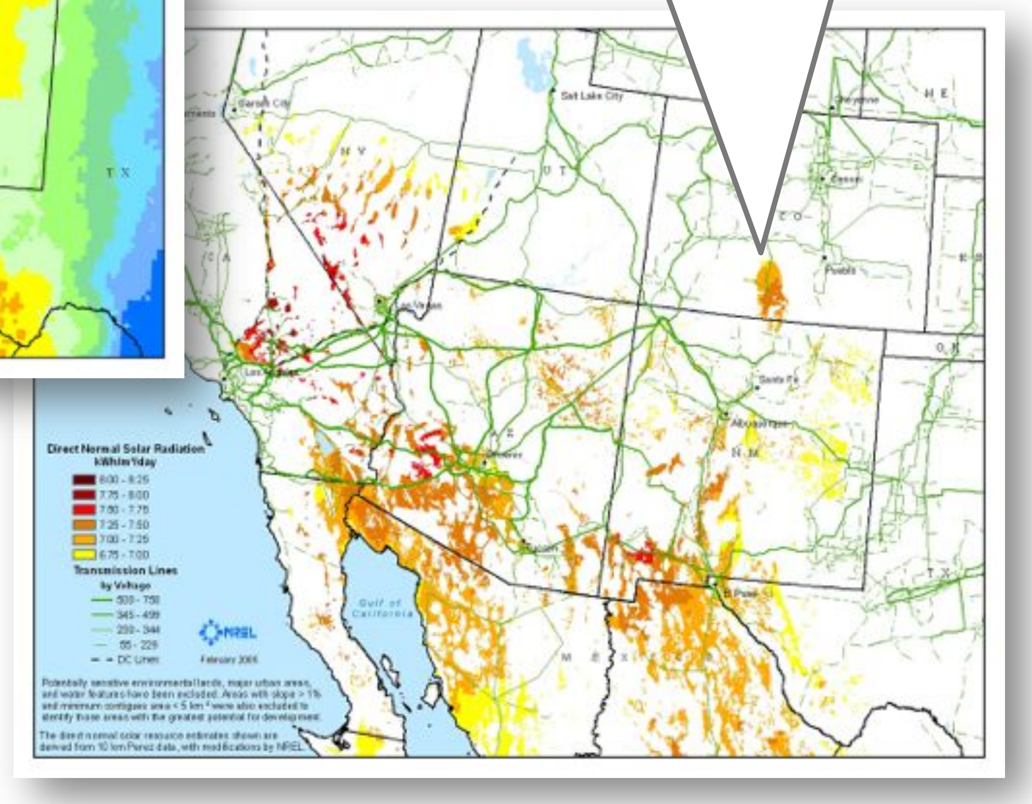
$$\text{map} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(x_i - \bar{x}\right)^2}$$

$$\text{map} = \frac{\text{Annual Energy (kWh)}}{\text{8760 (h) * Power Rating (kW)}}$$

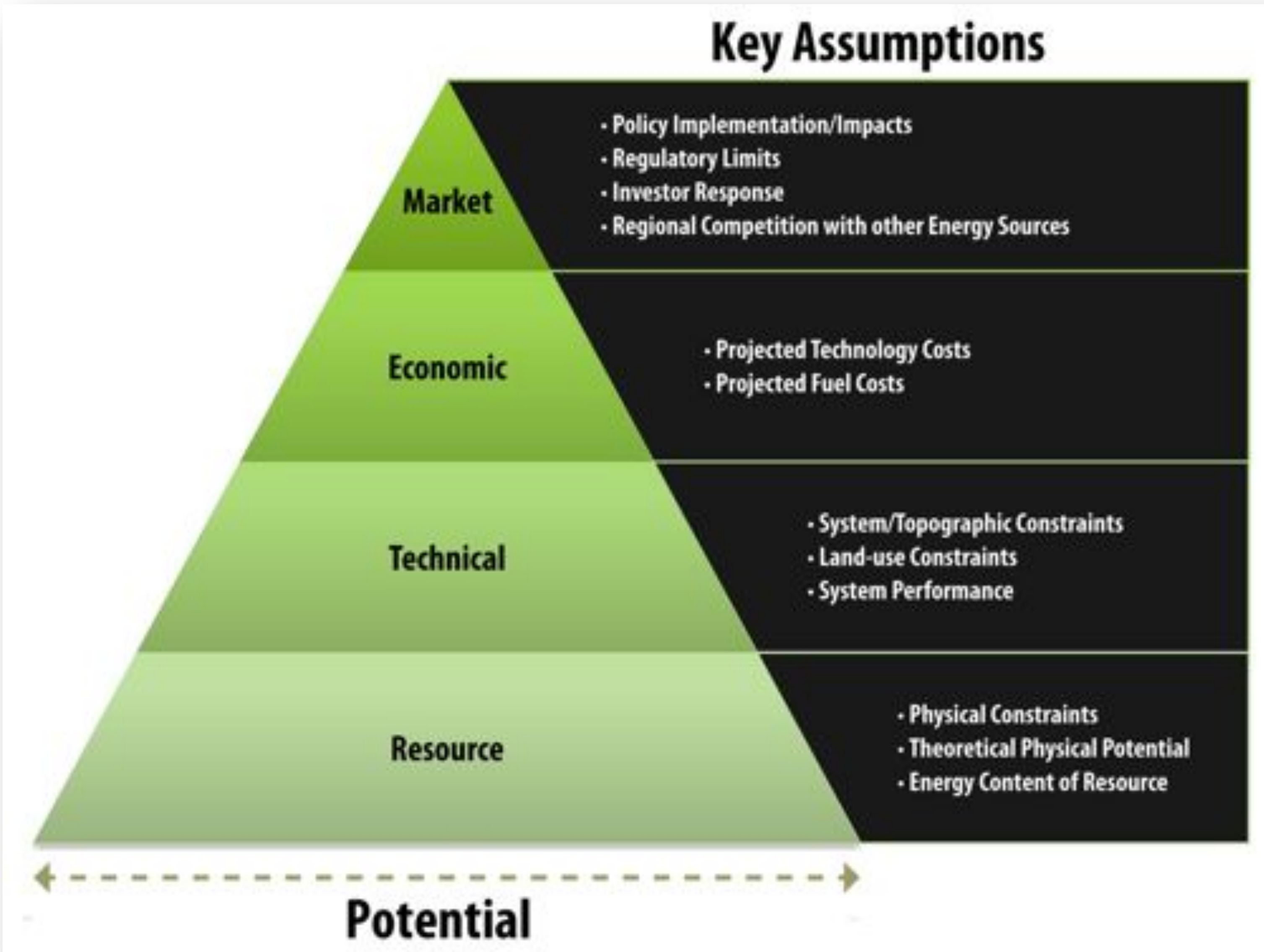
Considering RE Potential: Identifying Opportunities



Understanding the difference between locations where an RE technology ***might work*** and locations where an RE technology ***actually can*** be implemented

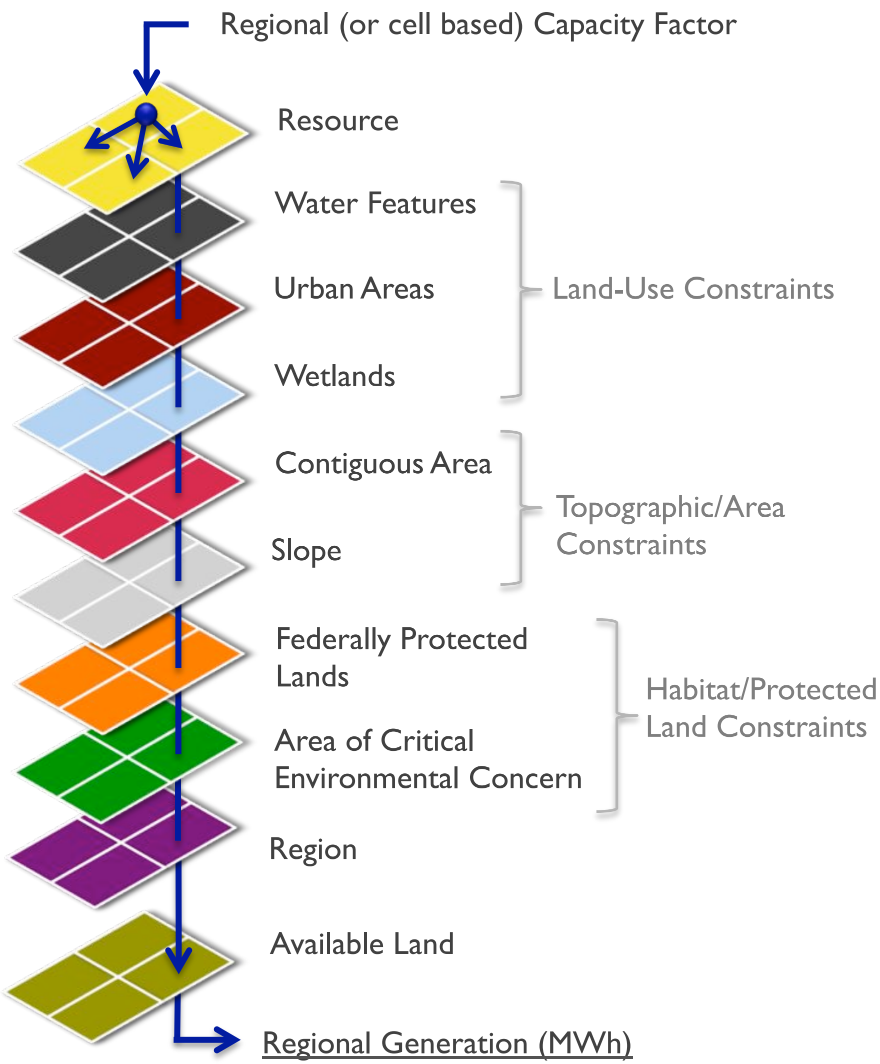


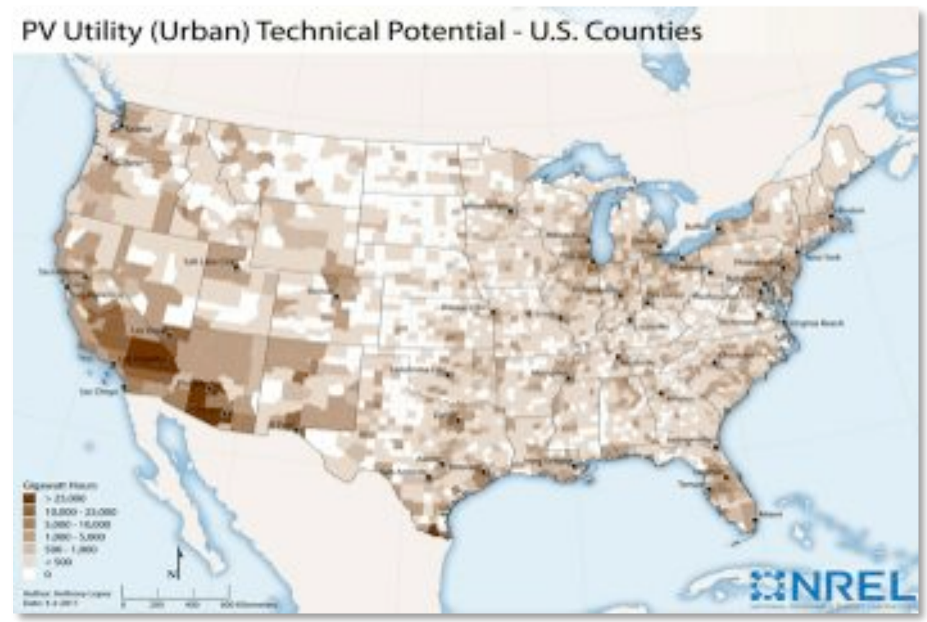
Considering RE Potential: Identifying Opportunities



Considering RE Potential: Identifying Opportunities

Layers in this Analysis





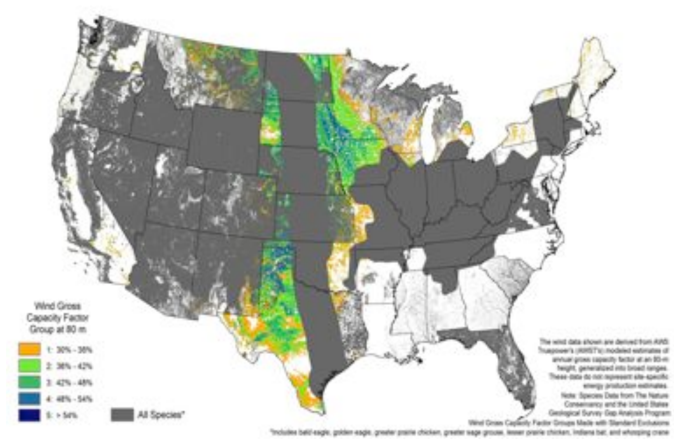
Data are sourced from:

- Department of Energy
- Department of Homeland Security
- Department of Defense
- Department of Agriculture
- Private Industry
  - Utility Companies
  - Climate Modeling Companies
- Many, many others (FAA, DOT, NGA, States, etc.)

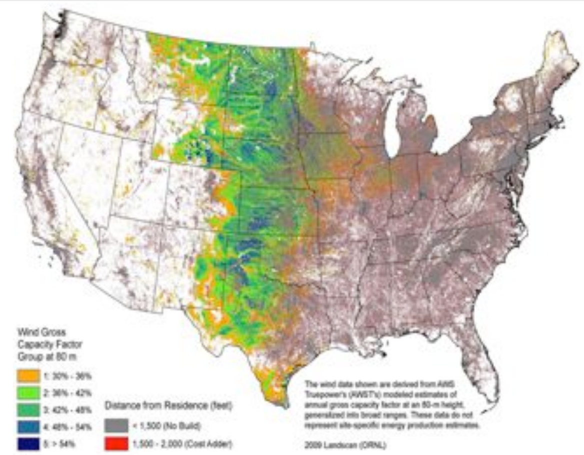
* See Technical Potential Worksheet for data sources, descriptions, and details

Considering RE Potential: Identifying Opportunities

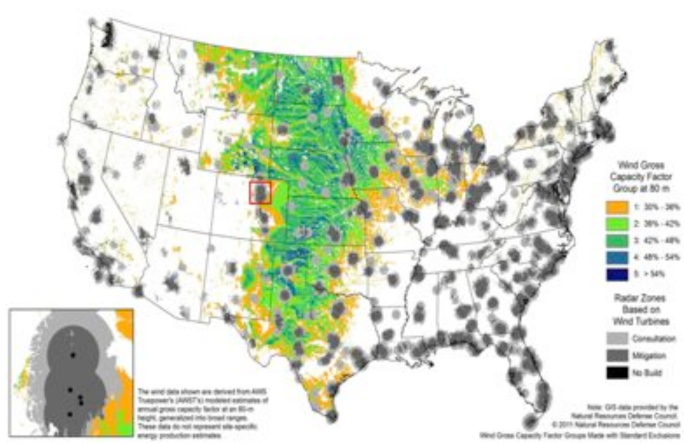
- How much wind is affected if you exclude ____?
- What is the impact on development?



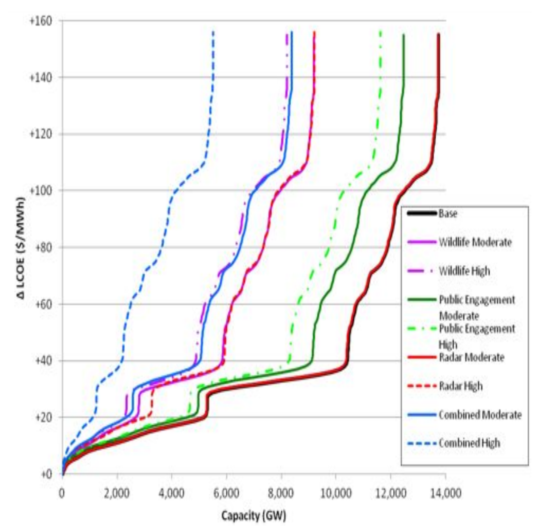
Combined habitat areas of species with wind specific issues, requiring additional consideration



Public Acceptance - additional exclusions and development costs

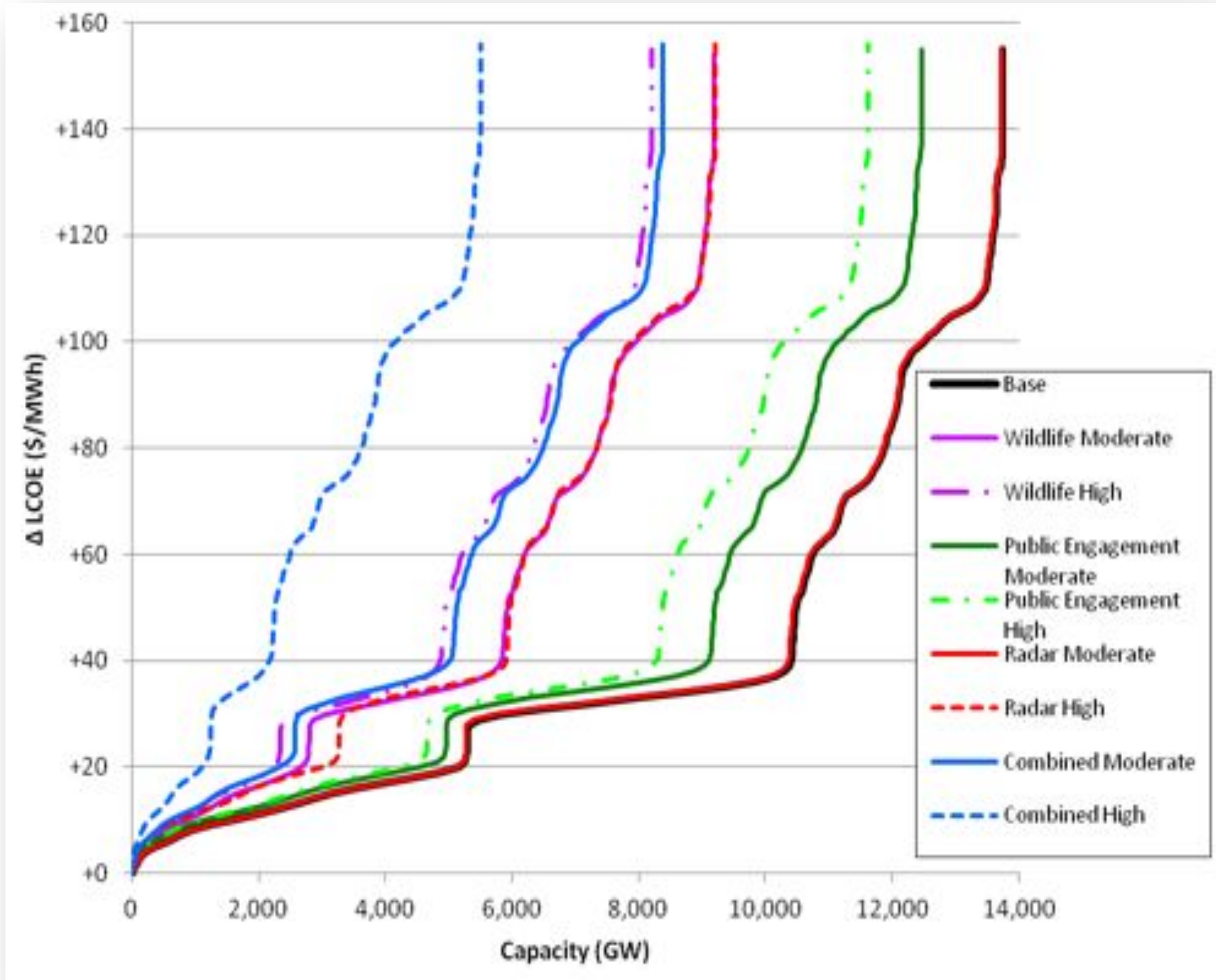


Radar no-build and potential mitigation areas for radar

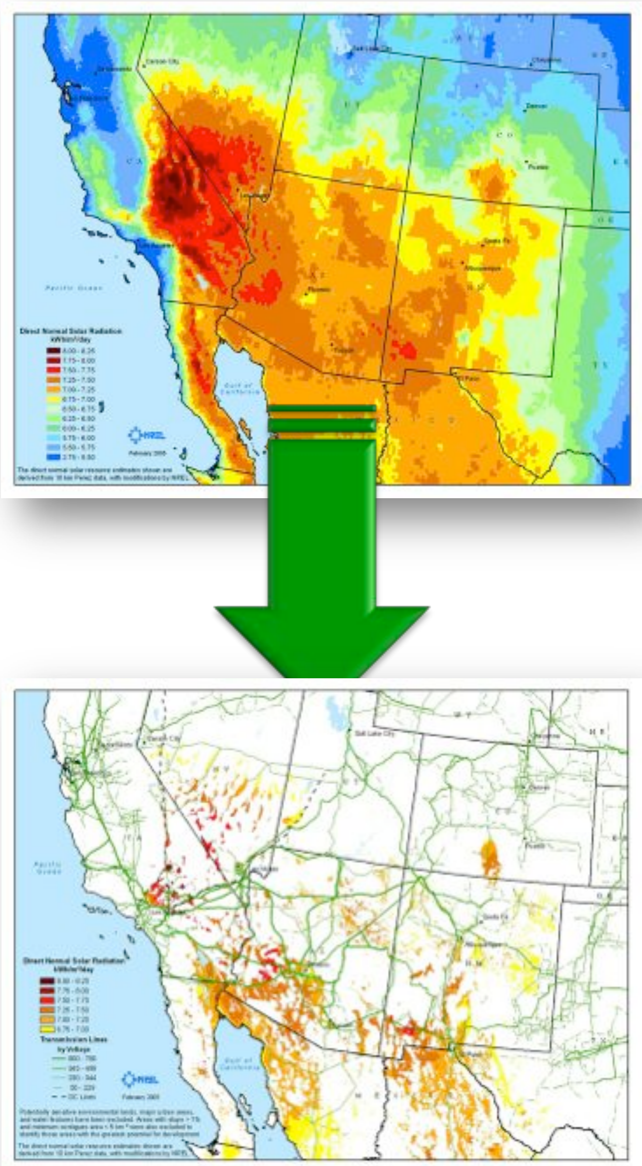


Considering RE Potential: Identifying Opportunities

- How much wind is affected if you exclude X, Y, Z?
- What is the impact on development?



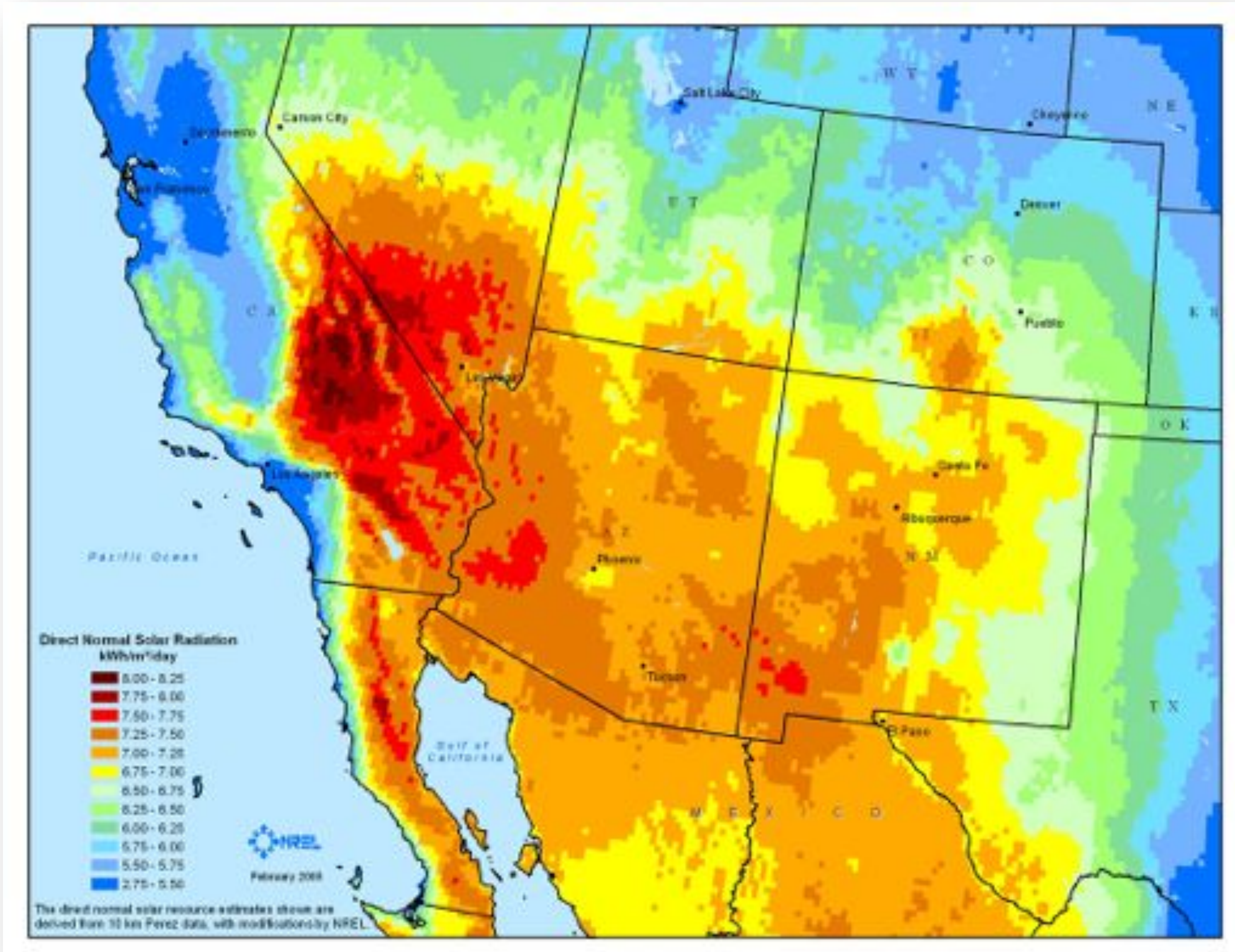
Considering RE Potential: Identifying Opportunities



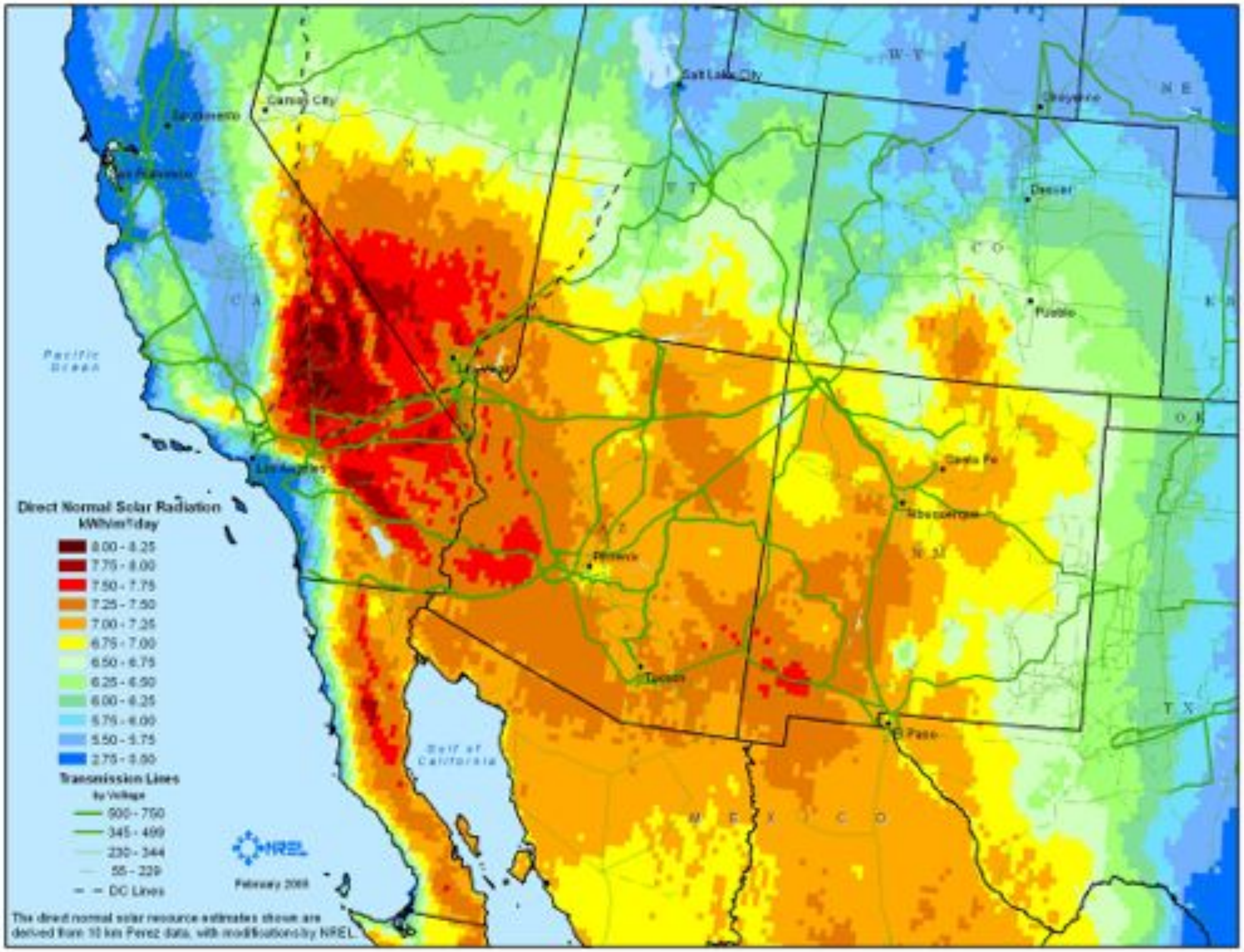
Geospatial screening to identify areas favorable to construction of large-scale concentrating solar power (CSP) systems

1. Start with direct normal solar resource estimates derived from 10 km satellite data.
2. Eliminate locations with less than 6.75 $kWh/m^2/day$.
3. Exclude environmentally sensitive lands, major urban areas, and water features.
4. Remove land areas with greater than 1% (and 3%) average land slope.
5. Eliminate areas with a minimum contiguous area of less than 5 square kilometers.

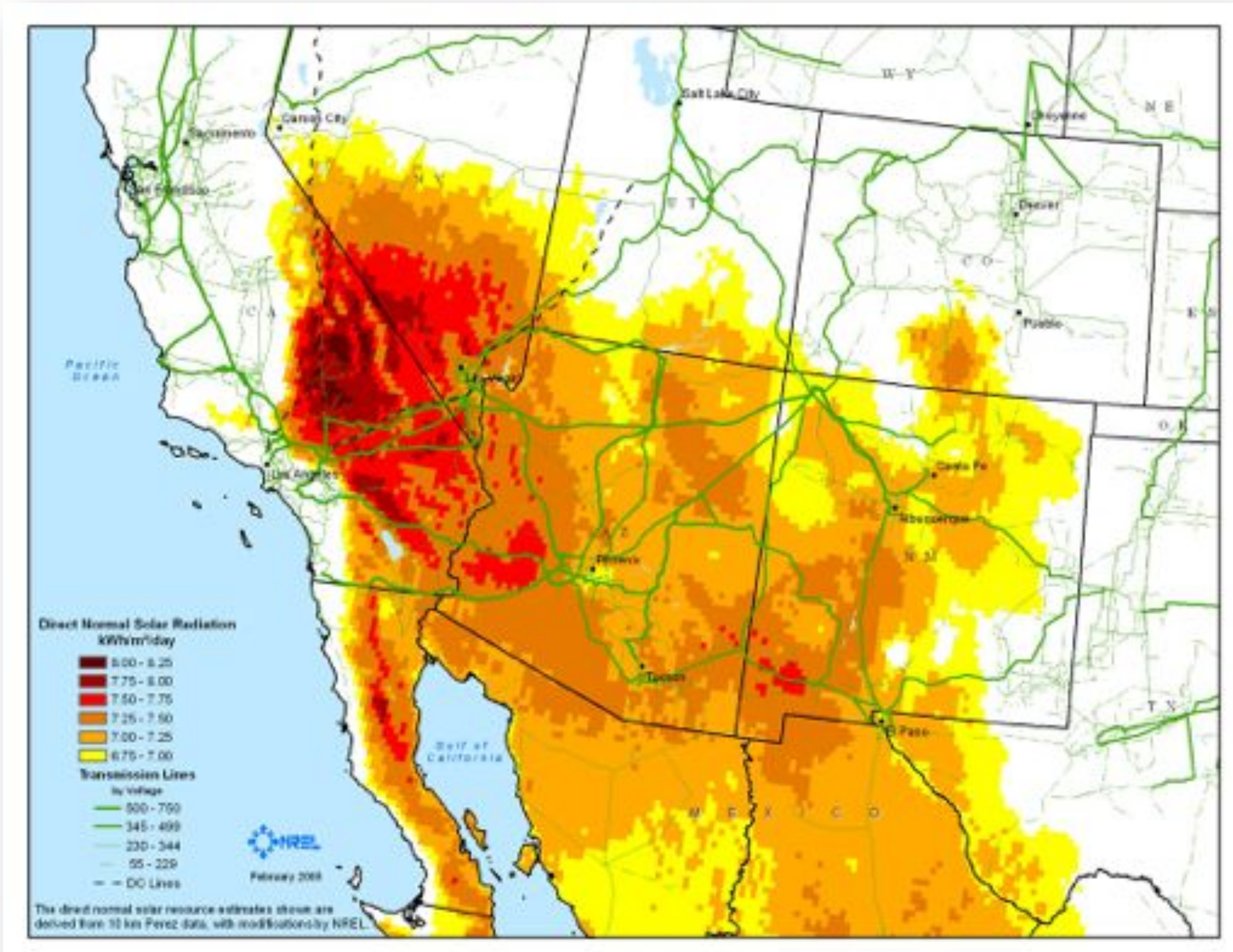
Opportunities for Large CSP: Unfiltered Resource



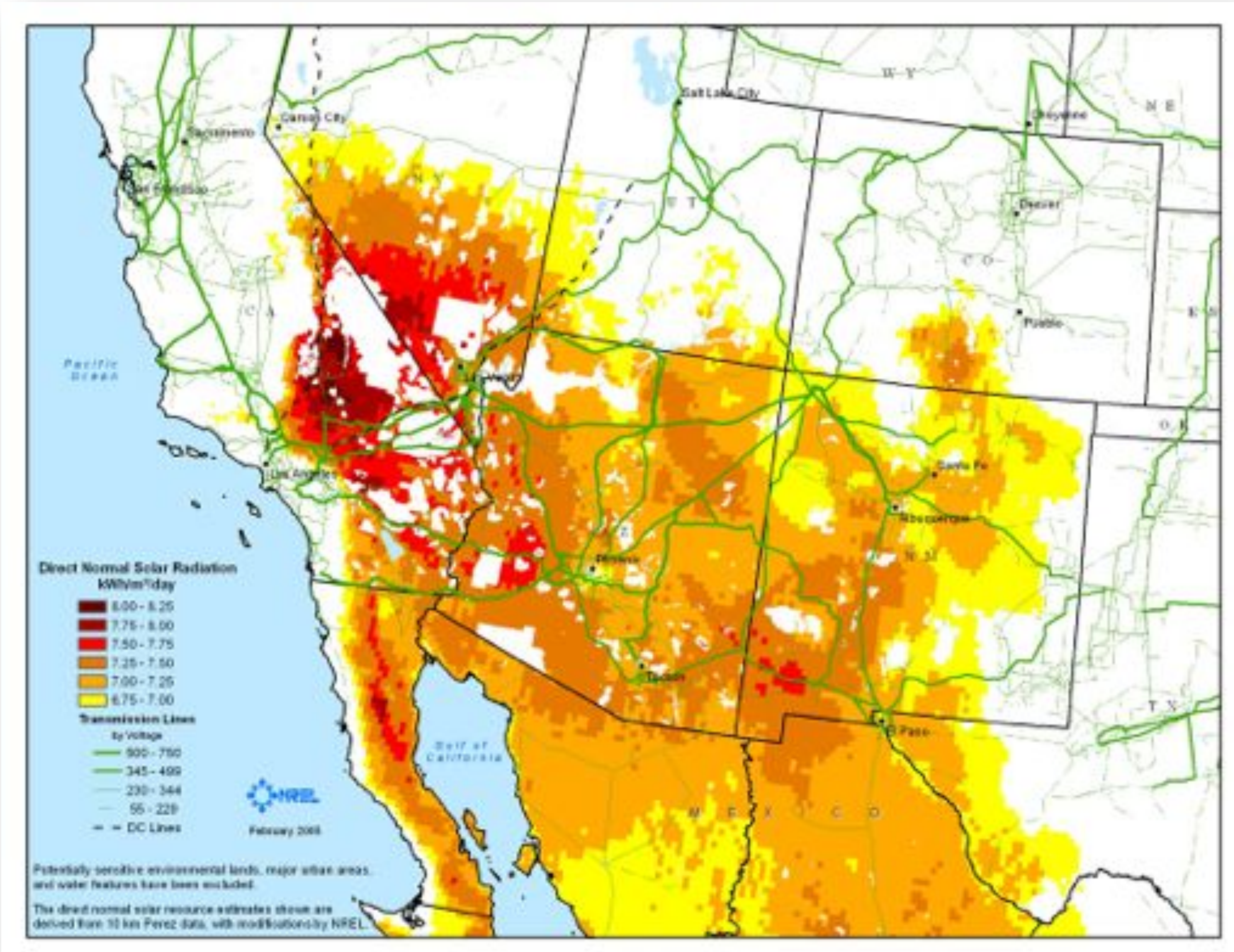
Opportunities for Large CSP: Transmission Overlay



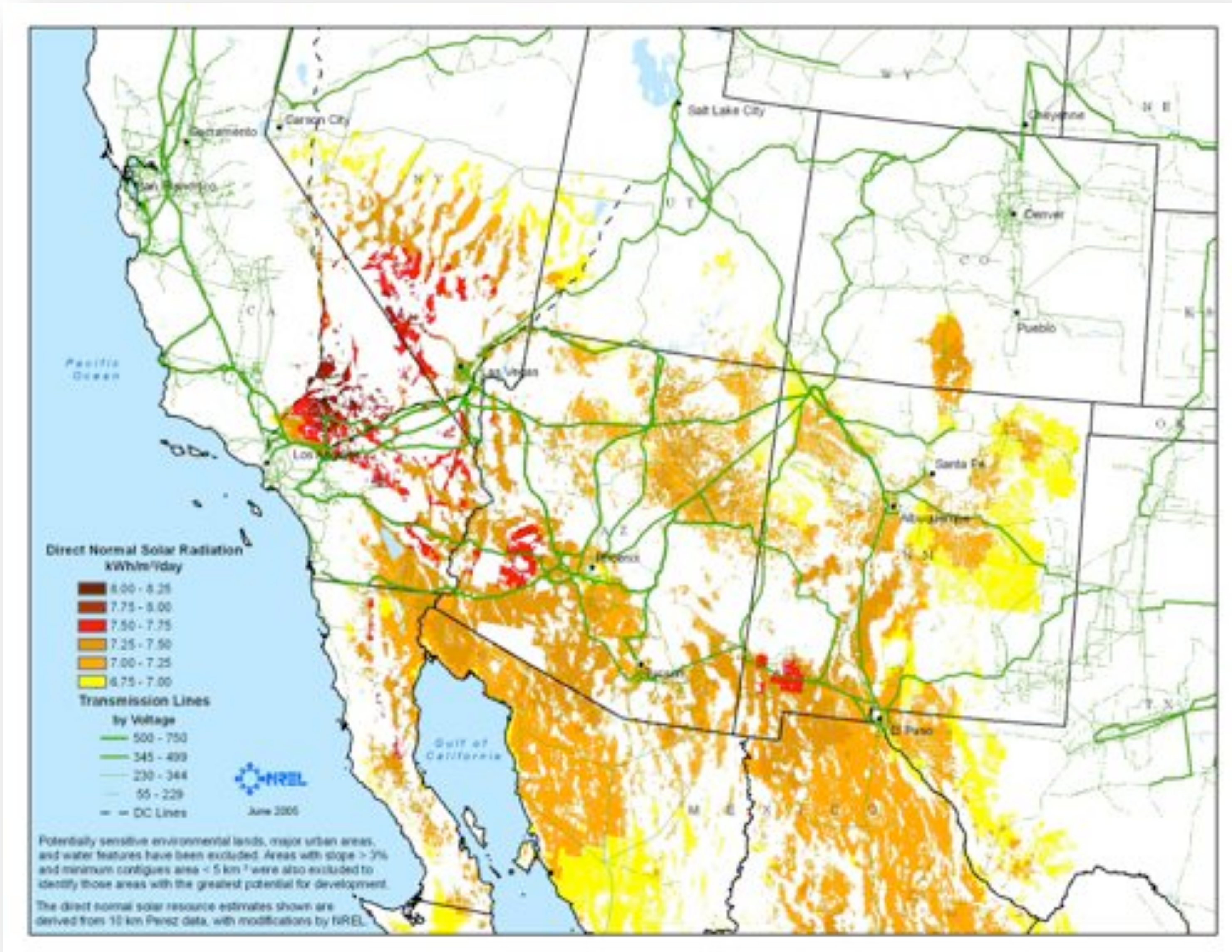
Opportunities for Large CSP: > 6.75 kWh/m2/day



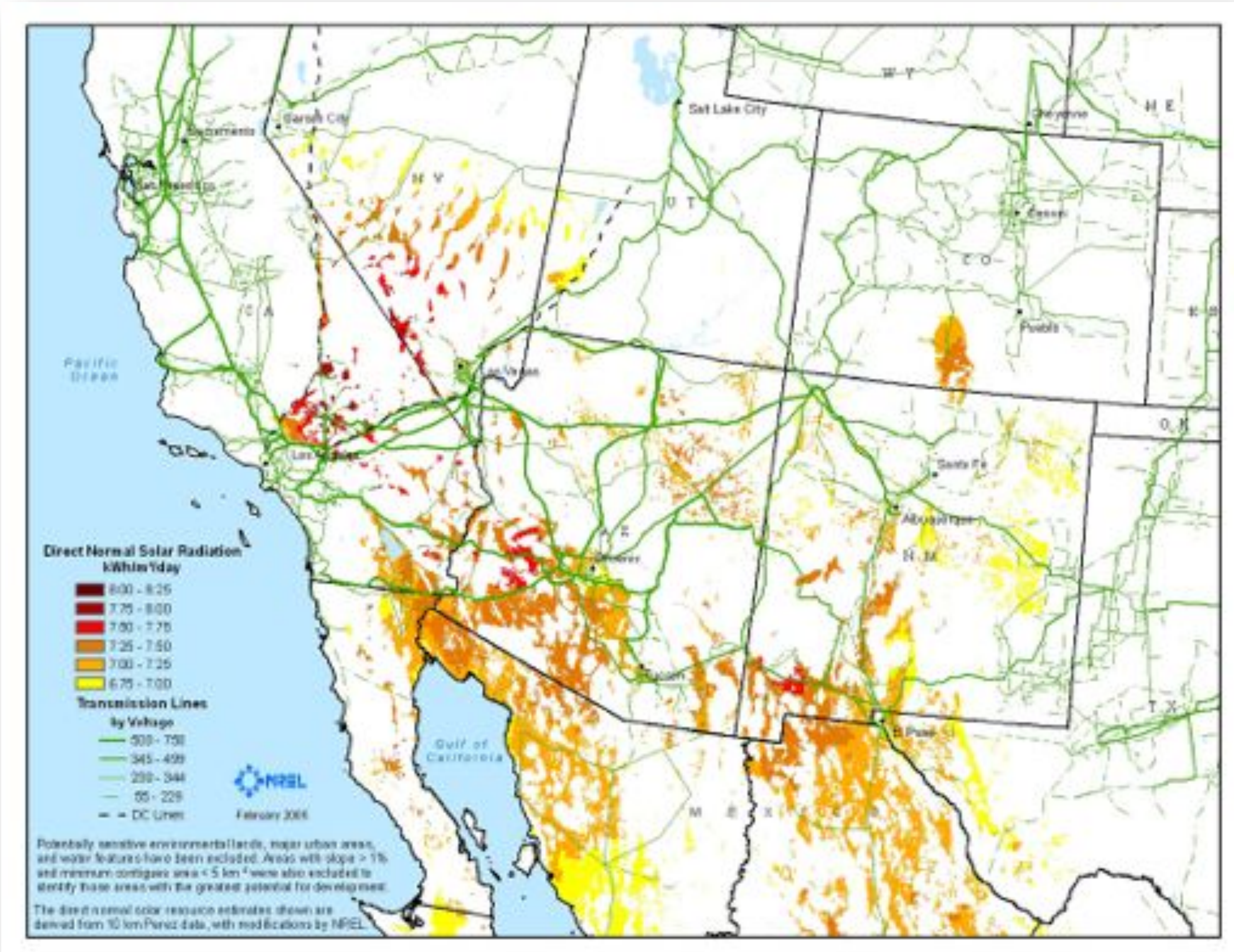
Opportunities for Large CSP: Environmental and Land Use Exclusions



Opportunities for Large CSP: Slope < 3%



Opportunities for Large CSP: Slope < 1%



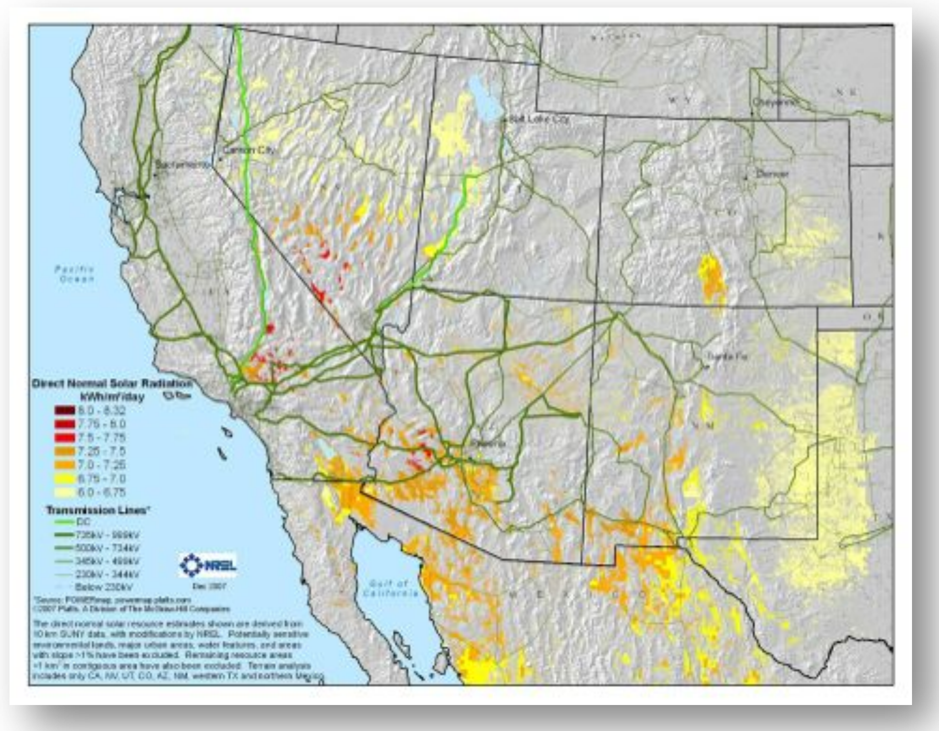
Opportunities for Large CSP: Resulting Potential for CSP

State	Land Area (mi^2)	Solar Capacity (MW)	Solar Generation Capacity GWh
AZ	13,613	1,742,461	4,121,268
CA	6,278	803,647	1,900,786
CO	6,232	797,758	1,886,858
NV	11,090	1,419,480	3,357,355
NM	20,356	2,605,585	6,162,729
TX	6,374	815,880	1,929,719
UT	23,288	2,980,823	7,050,242
Total	87,232	11,165,633	26,408,956

The table and map represent land that has no primary use today, exclude land with slope > 1%, and do not count sensitive lands.

Solar energy resource ≥ 6.0
Capacity assumes 5 acres/MW
Generation assumes 27% annual capacity factor

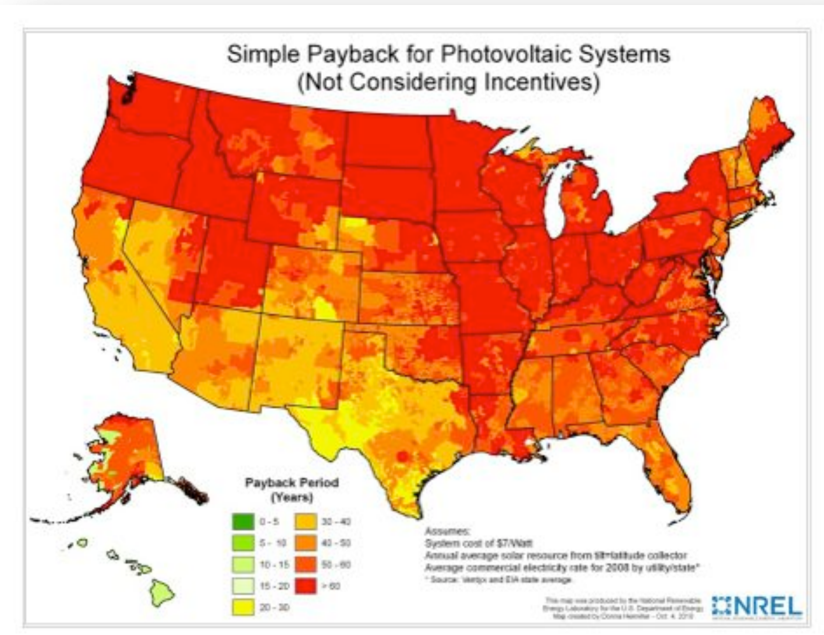
Current total nameplate capacity in the U.S. is 1,000GW w/ resulting annual generation of 4,000,000 GWh

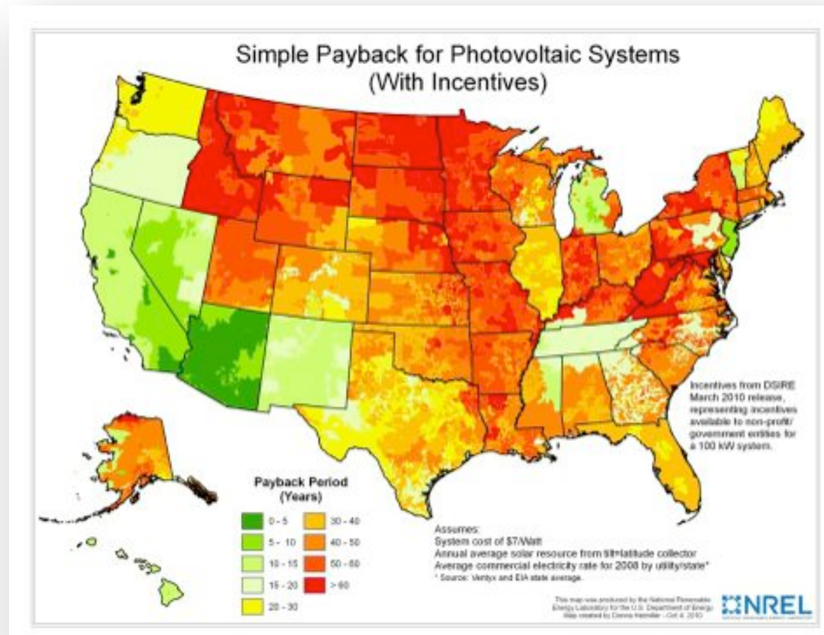


Considering RE Potential: Identifying Opportunities

Combine spatially variable data (solar resource and electricity rates) with other information to highlight opportunities

- where is it cost effective now?
- what can we do to make it cost effective?
- what happens if we change …?





How it Began: Texas Competitive Renewable Energy Zones

THE NECESSARY ROLE OF POLICY

What Led to the Invention of CREZ in Texas?

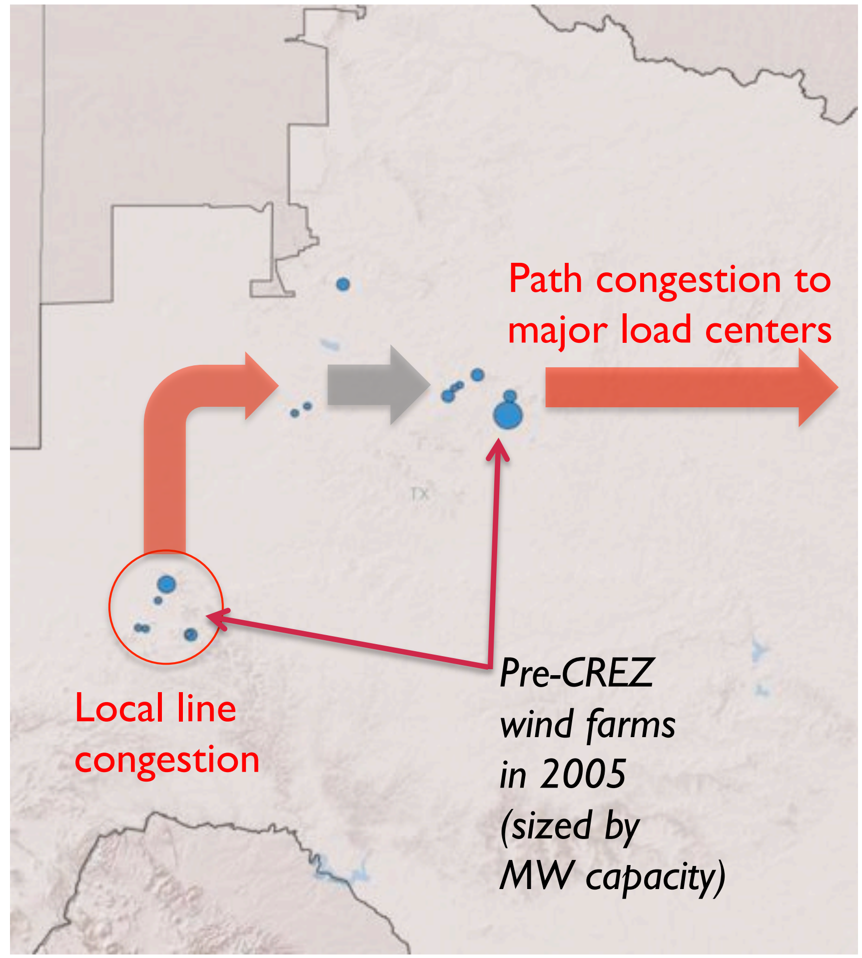
- The peculiarities of renewable energy development created a transmission need that existing laws, regulatory precedent, and financial practice could not accommodate.
- Circumstances required an innovative approach; transmission for conventional generation could not provide useful guidance.
- Even after 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 — But Too Much

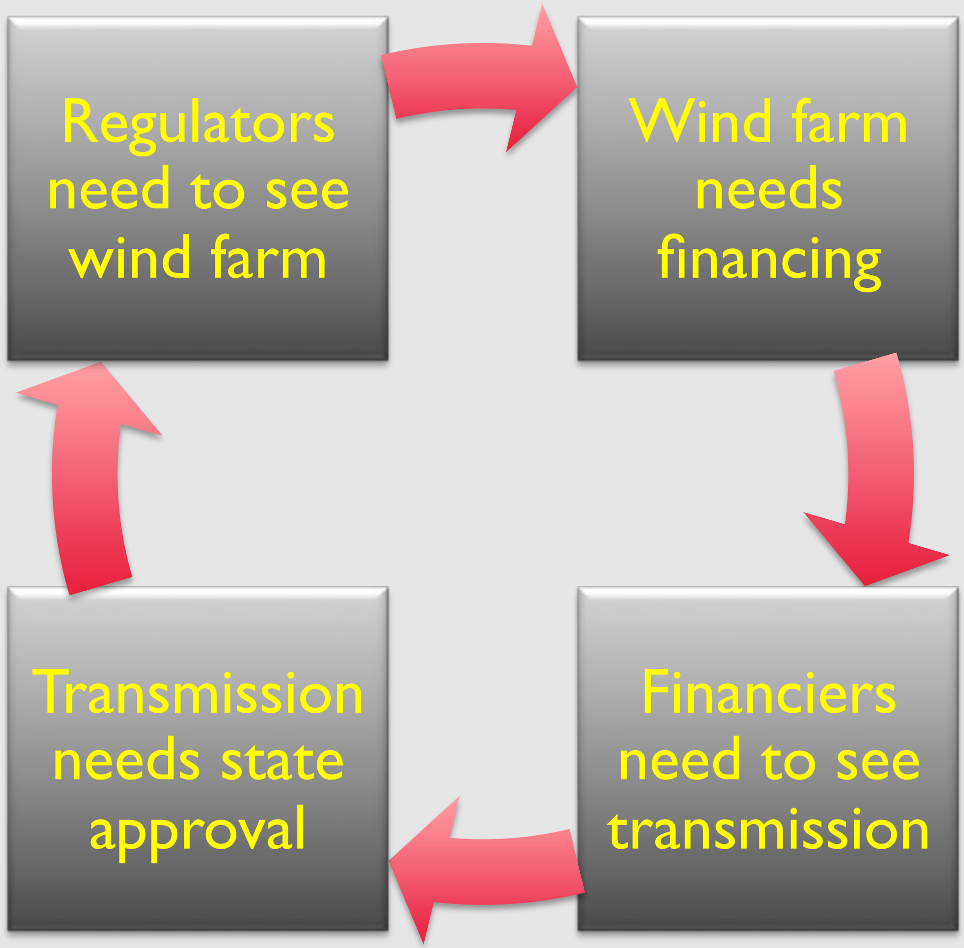
- First wave of wind power development was in West Texas
  - 760 MW of installed wind power by 2002
  - Only 400 MW of total transmission capability
- Operator-ordered curtailments degraded wind's effective annual capacity factor



Engineering Answer Was Clear…

- Upgrade the paths with new extra high voltage lines, or continue to curtail
- Wind industry wanted additional transfer capacity to accommodate future development, but specific future wind projects could not be identified
- Transmission utilities could not build new lines in advance of generator commitments

…But Regulatory, Finance Answers Were Not



CREZ: Use the Most Productive Resources

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

CREZ: Build a Few High-Capacity Lines

- Higher voltages have smaller losses and are more economically efficient per MW of capability
- Minimizing the number of transmission corridors will cause less environmental damage than a large number of small lines will
- Fewer proceedings for siting and permitting

CREZ: Harness the Power of Competition

- Let the competitive market decide who would actually build 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
  - Rule-of-thumb: if the line can handle 1,000 MW, developable potential should be 4,000 MW

Steps in the Texas CREZ Process

1. Renewable energy assessment
2. Screen resource areas for quality, developability, density
3. Conduct 'open season' for developers to indicate interest
4. Conduct economic analyses of zones with high interest
5. Designate zones
6. Develop and approve transmission plan to connect zones

Economic analyses of CREZ scenarios

- Production cost modeling
  - Model dispatch on the entire network to determine how the variable cost of production changes under different CREZ 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

Evidence of Market Demand

- Traditional transmission planning relies on certainty of a known generation project
- Key CREZ 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?
- CREZ 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

Examples of Financial Commitment

- Existing renewable energy resources
- Pending or signed interconnection agreements
- Leasing agreements with landowners
- Letters of credit
- Other projects undergoing an interconnection study
- Other factors for which parties have provided evidence as indications of financial commitment

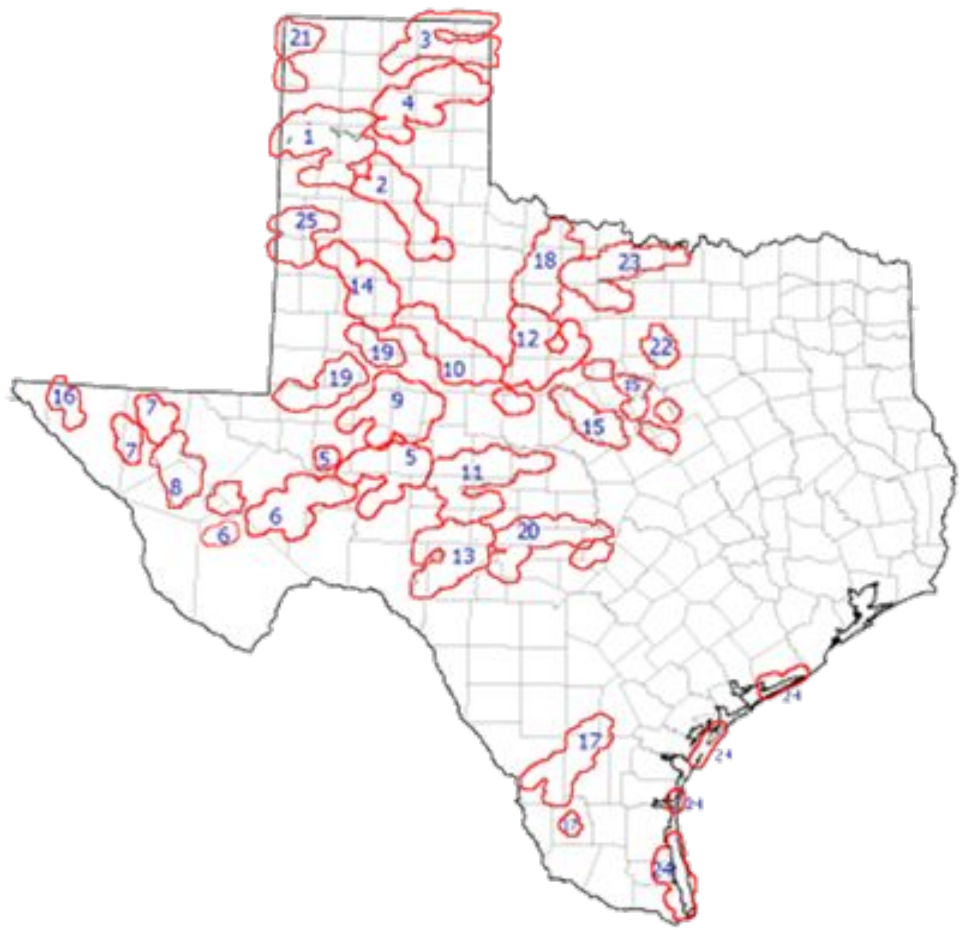
Implementing CREZ

- 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

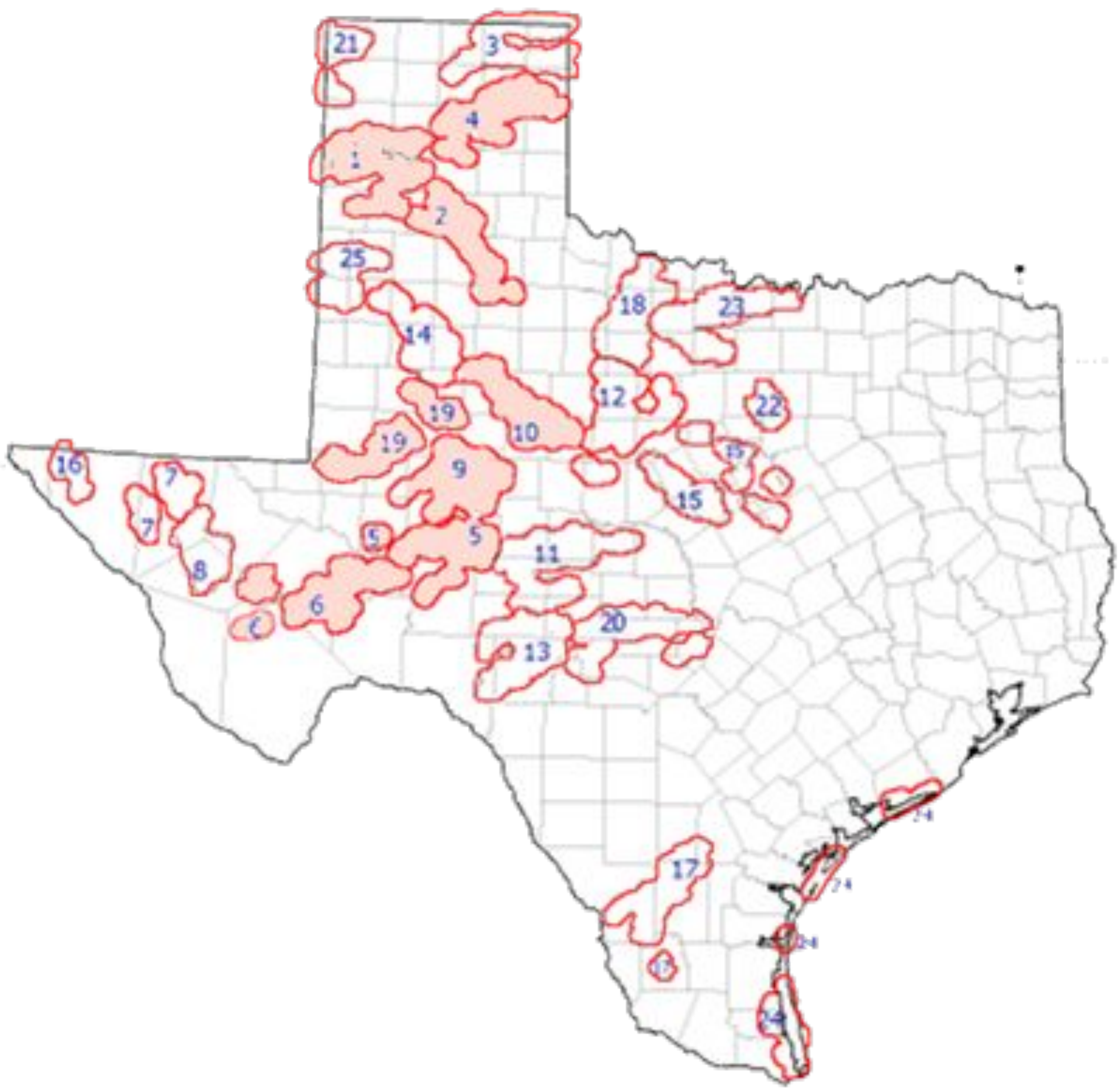
- Report delivered to PUCT Dec. 1, 2006

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



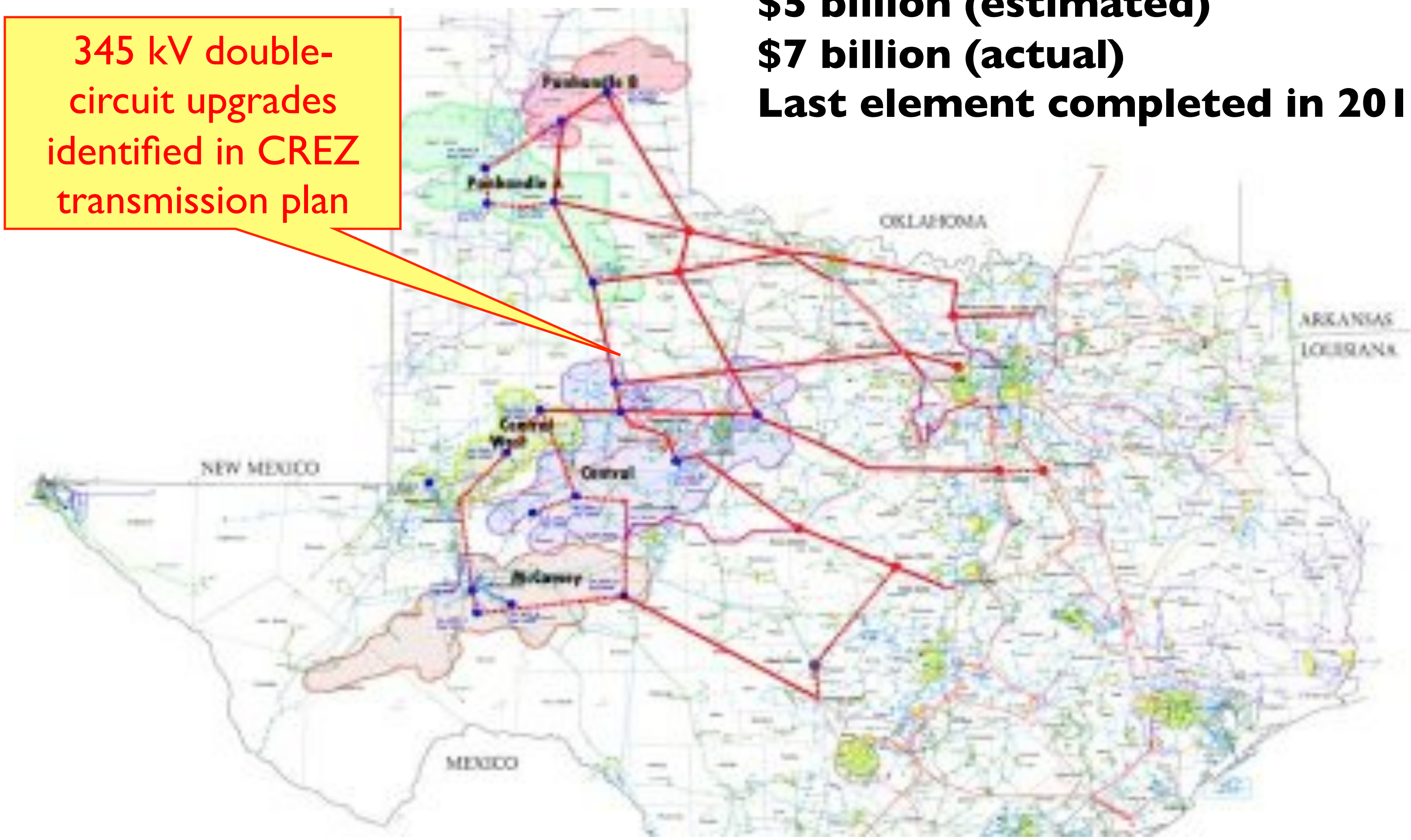
Zones Designated by State as CREZs



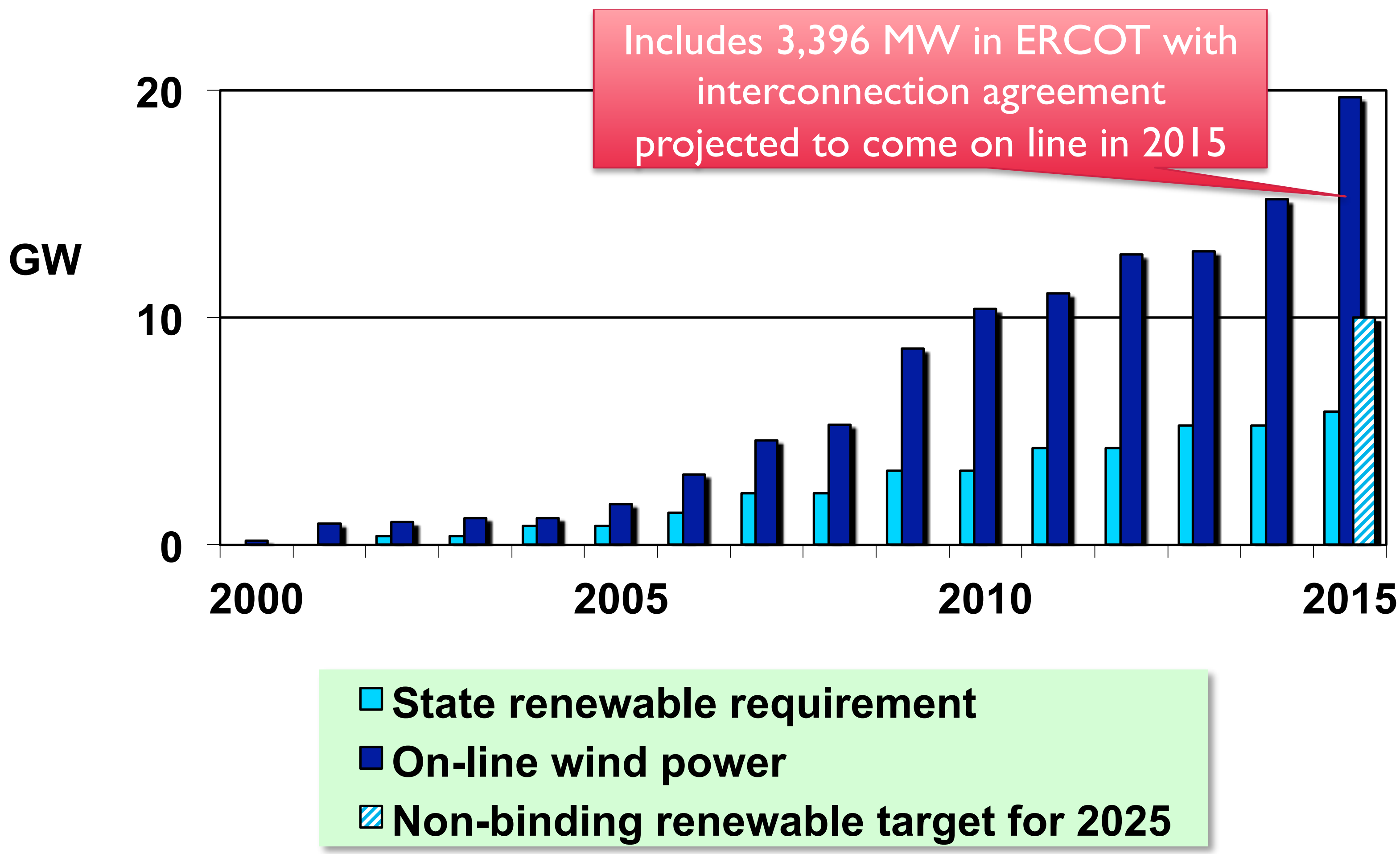
CREZs and Transmission Approved in 2008

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

345 kV double-circuit upgrades identified in CREZ transmission plan

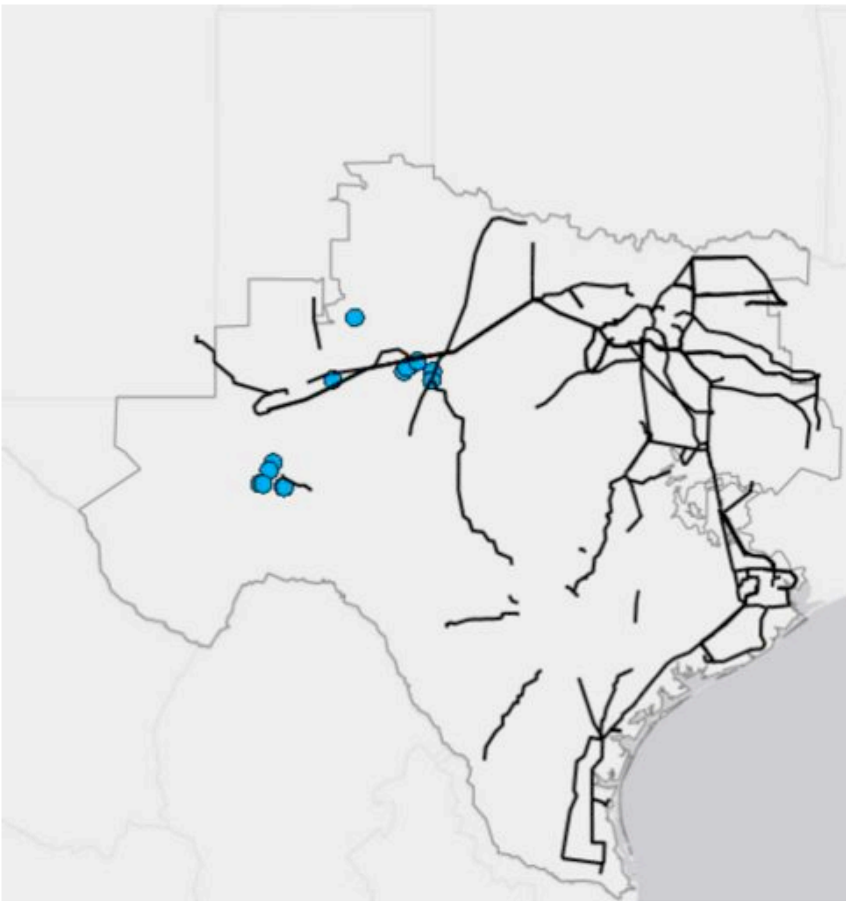


Did It Work?

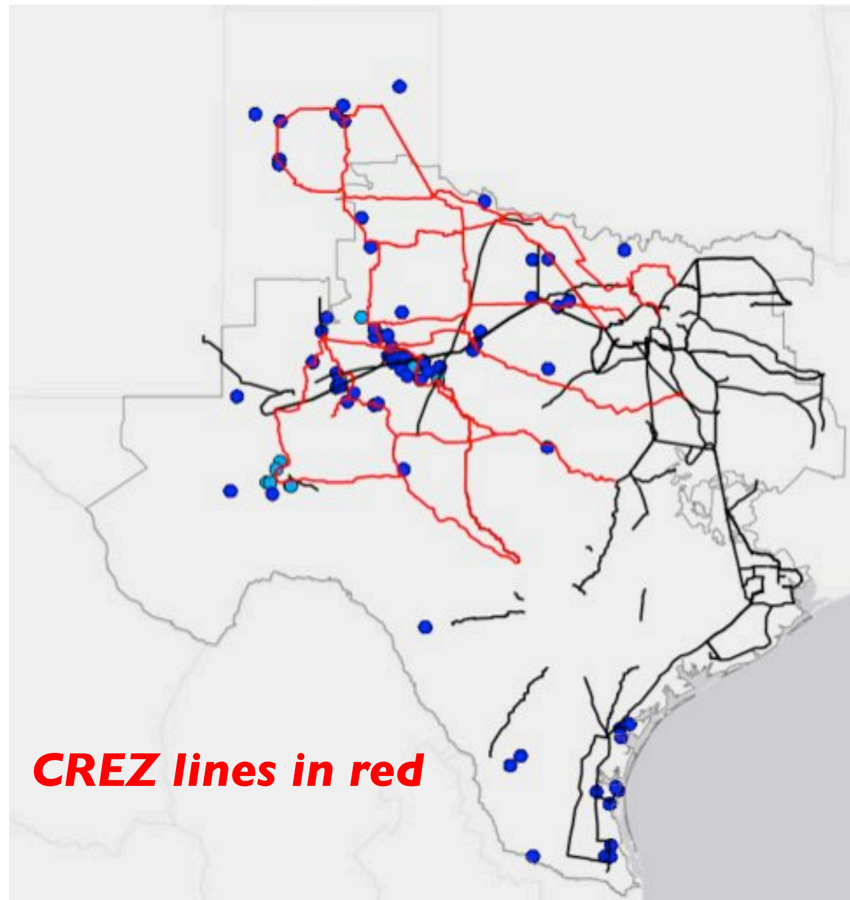

Includes 3,396 MW in ERCOT with interconnection agreement projected to come on line in 2015
GW
20
10
0
2000
2005
2010
2015
State renewable requirement
On-line wind power
Non-binding renewable target for 2025

Growth in ERCOT Wind Development

EHV lines, wind in 2005



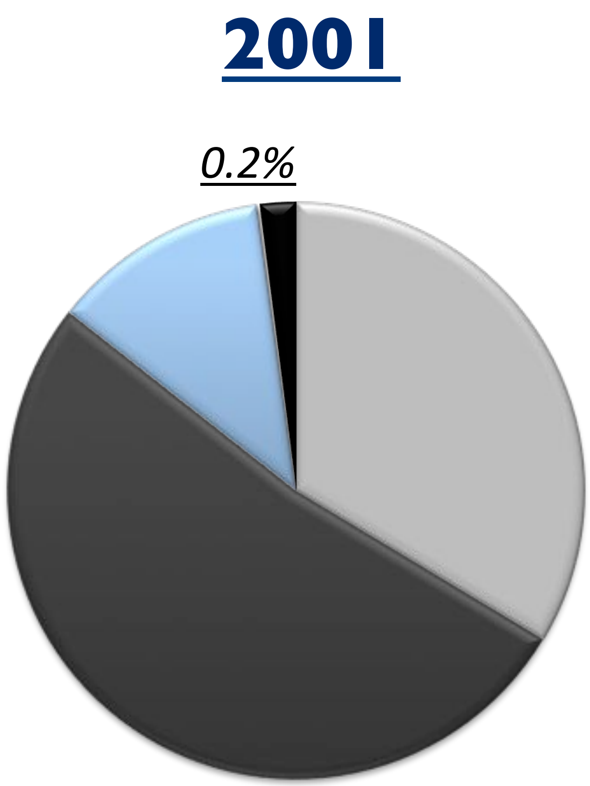
EHV lines, wind in 2015

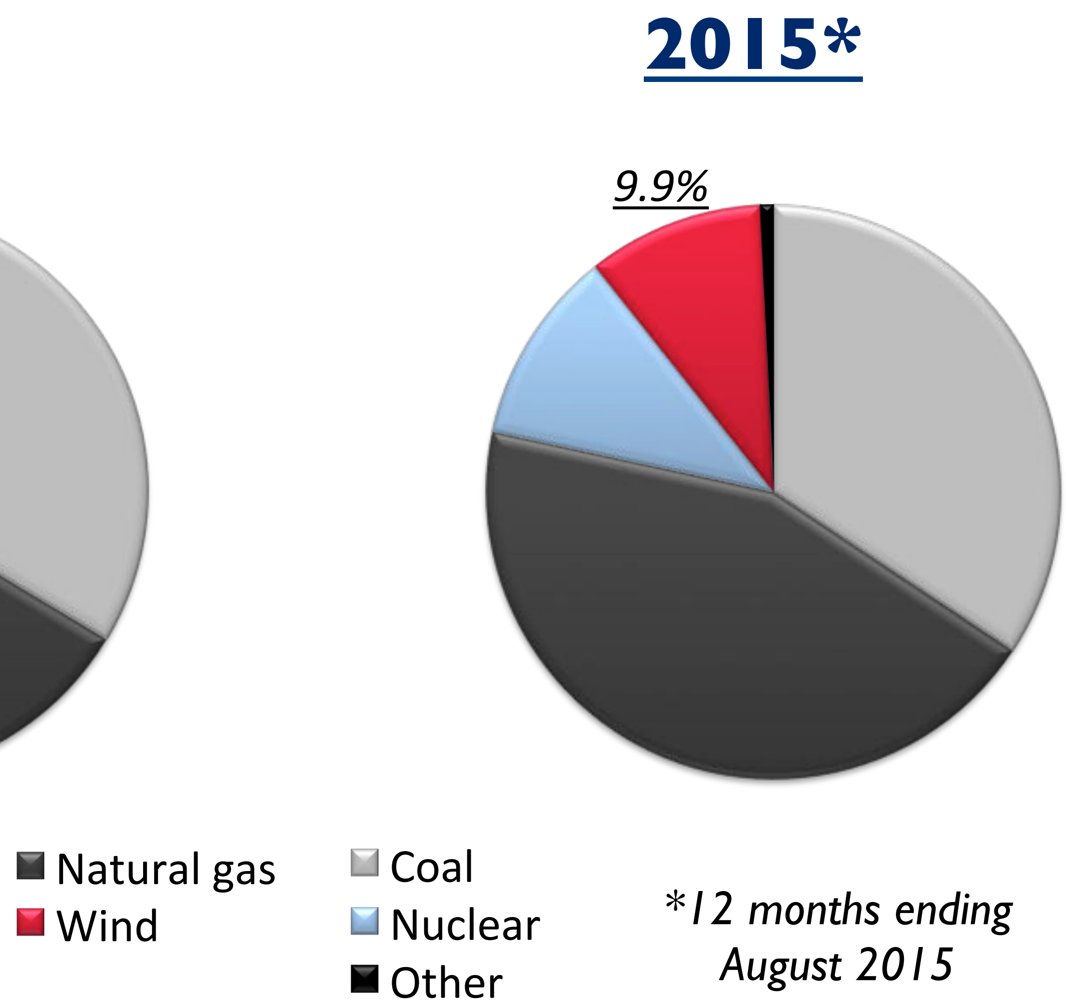


Improved Capacity Factors

Turbine vintage	CREZ	Operating year	Average capacity factor
Old *(on line 2001-2002)*	McCamey	2003	26%
		2014	30%
Older wind turbines performed better because of reduced transmission congestion and less curtailment			
New *(on line 2007-2013)*	McCamey	2014	35%
	Panhandle		45%
New transmission opened up more productive wind areas			

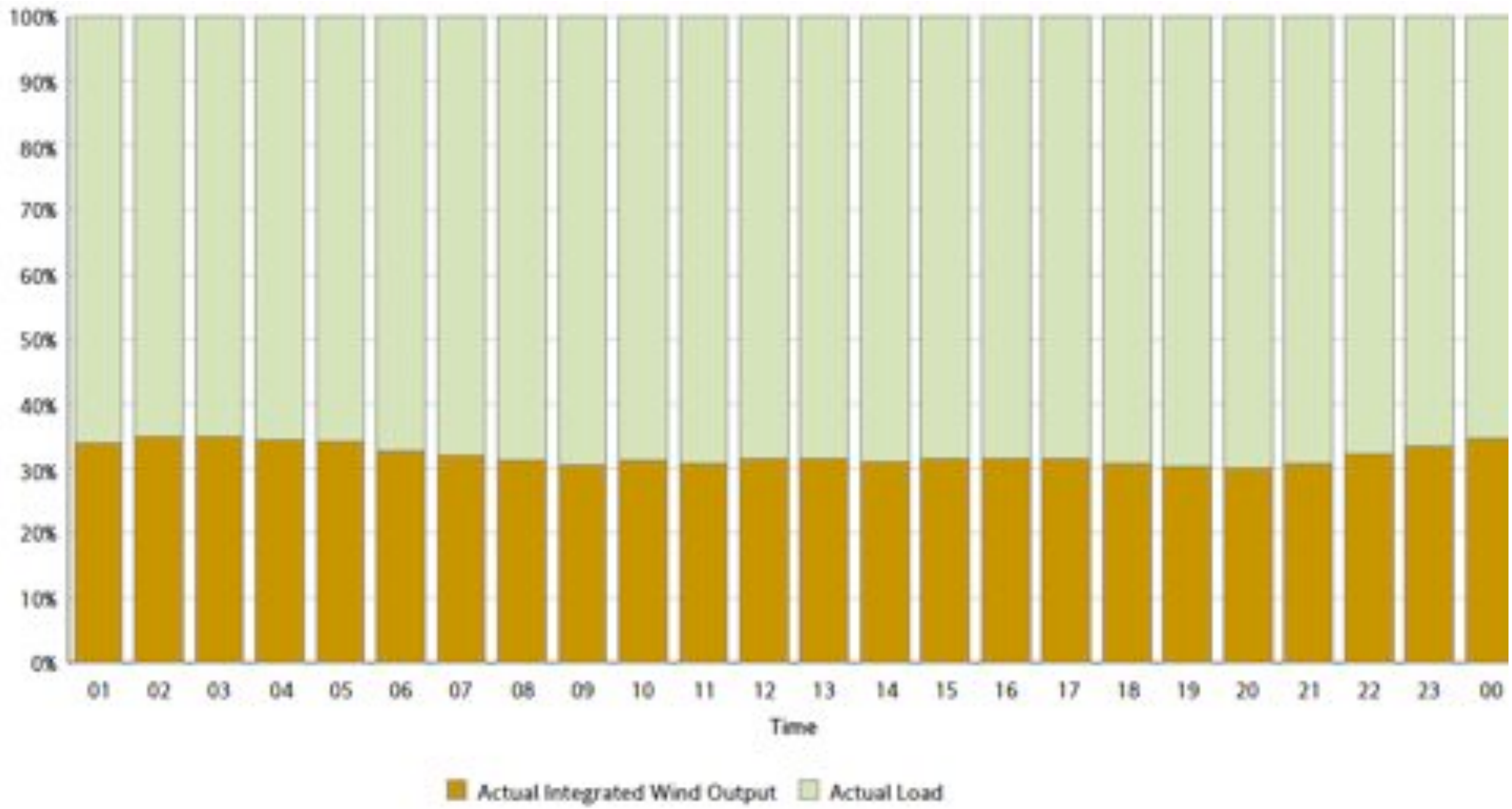
Wind Share of Generation in ERCOT





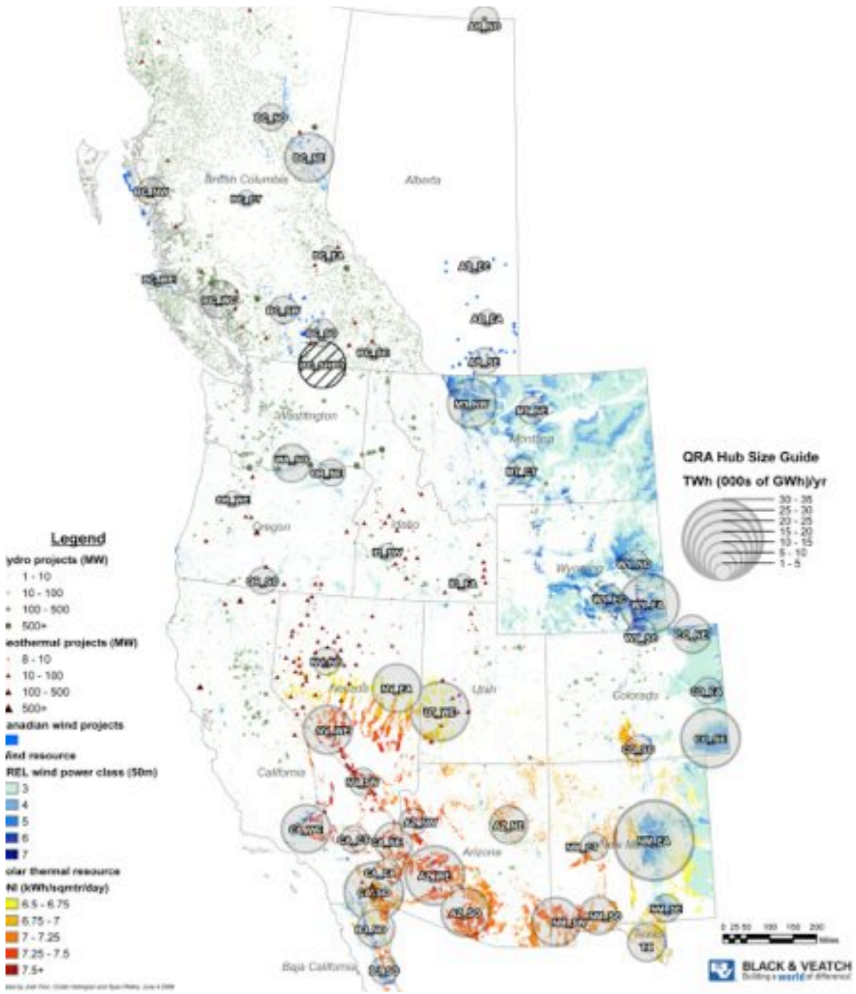
**12 months ending August 2015*

Wind's Share of Actual Load in ERCOT (Recent Day)



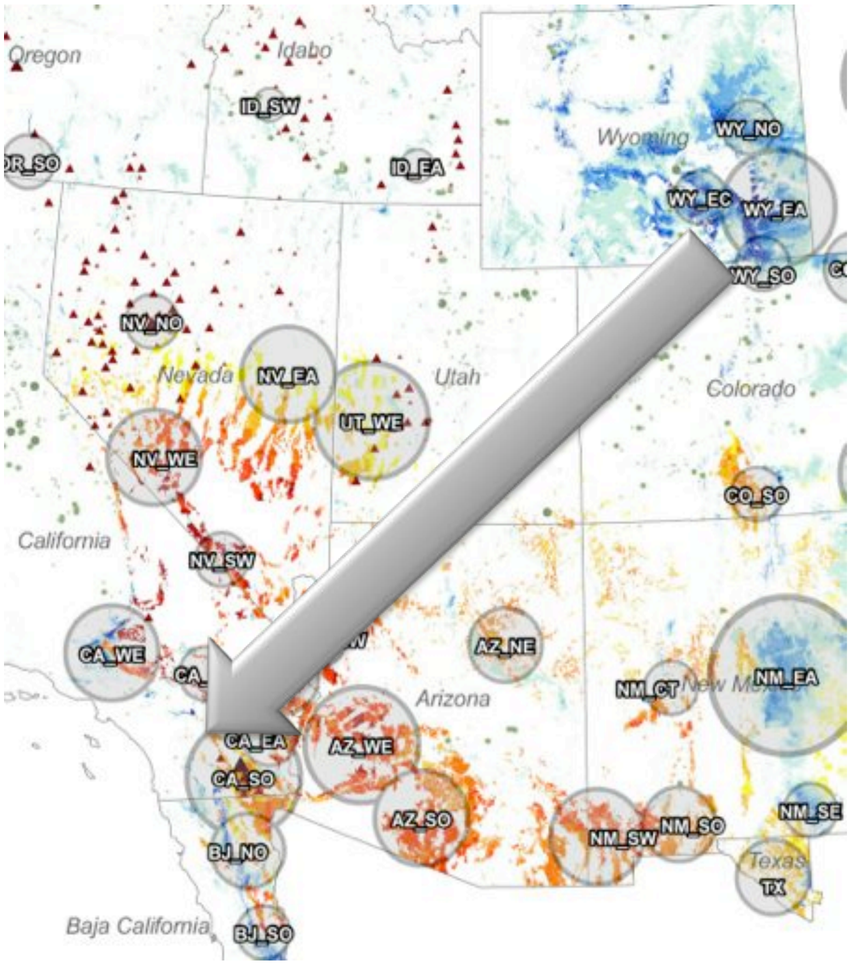
ERCOT, Wind Integration Report, Nov. 16, 2015

Western Renewable Energy Zones



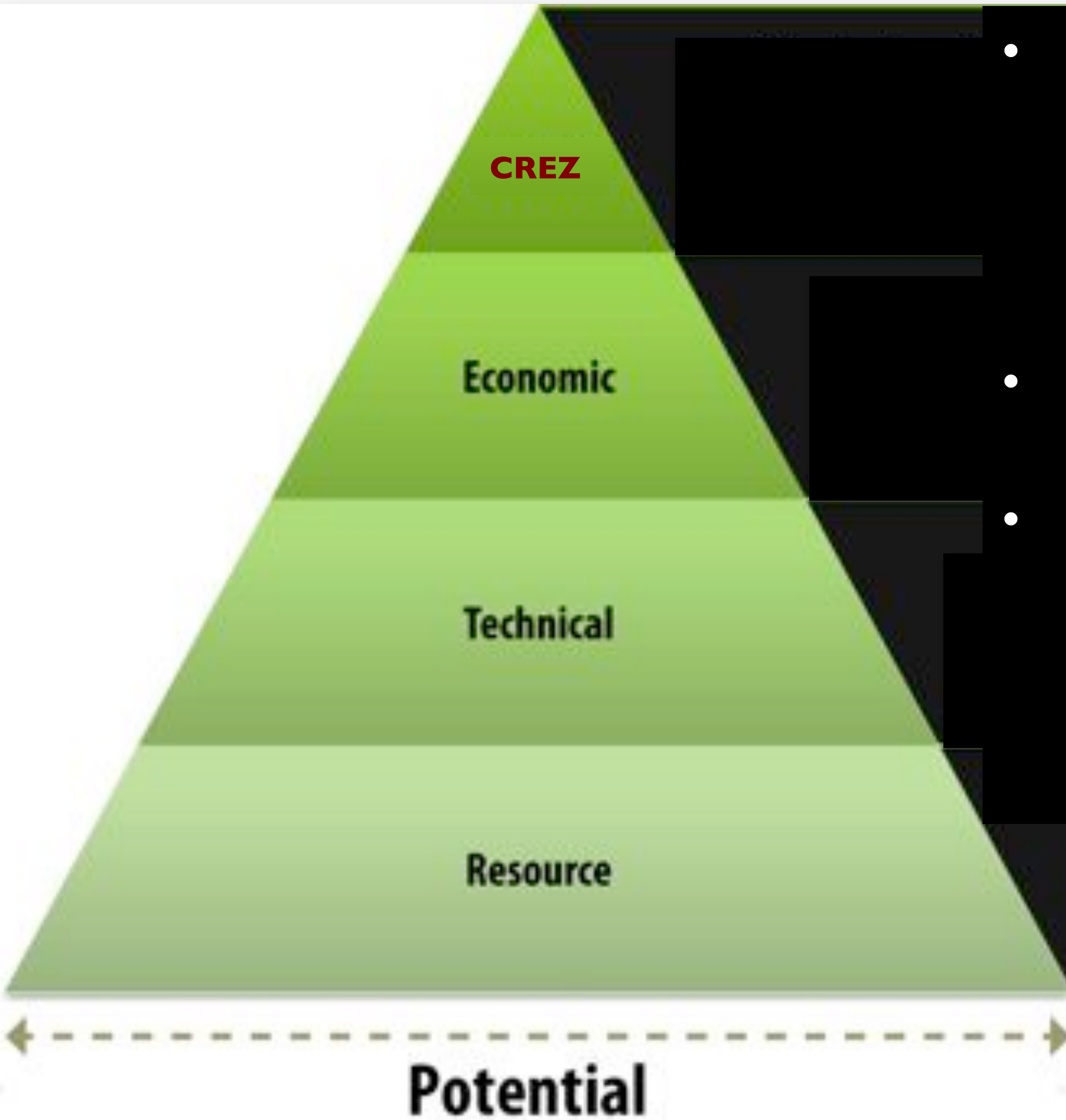
- Governors commissioned study of renewable energy zones across western U.S.
- No direct link to transmission authority
  - Common information for planning efforts in several states

Western Renewable Energy Zones



- Focus has been on regional transmission such as Wyoming wind power to California load
  - Cross-jurisdictional issues
- Wind capacity factors above 50%
- Several 500 kVDC projects now in permitting

Key Elements of the CREZ Process



- Technical and economic analysis reasonably support the expectation that new renewable energy projects in the zone will be profitable
- Designating a zone has ramifications under law
- Transmission planning and approval can proceed without knowing which specific wind generators will be connected

Applicability of CREZ Model Elsewhere

- Development follows transmission
  - Intent of CREZ was to geographically direct new development to where cost per MWh would be lowest
- Authority to order new transmission construction comes before zone designation
  - When analysis begins, question is "where" not "whether"
  - Analysis without authority is advisory
- CREZ focus is on renewable technologies that are ready to compete today
- Jurisdiction needs to be clear

Learn more at greeningthegrid.org

QUESTIONS AND PANEL DISCUSSION

Contacts and Additional Information

Webinar Panel

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