Implementing Renewable Energy Zones for Integrated Transmission and Generation Planning
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

Solar Resource Dataset Version 1.0.1 from the National Solar Radiation Database Direct Normal Solar Irradiance, North/Central America

The Solar Resource Dataset
The concept behind the project is to produce a regularly updated high-quality solar resource data for the United States and surrounding regions that is accessible to the public. The availability of this dataset reduces barriers to penetration of solar by allowing users to both accurately predict the output from solar installations and verify performance. The map shows the full extent of the current version of the dataset.

Data Summary
This data provides annual average daily total solar resource averaged over surface cells of 0.018 degrees in both latitude and longitude, or nominally 4 km in size. The irradiation values represent the resource available to concentrating systems, and were created using the PRMOS-II algorithms for cloud identification and properties; the MMAC radiative transfer model for clear-sky calculations and the SADRE model for cloudy-sky calculations. The data are averaged from hourly model output over 8 years (2005-2012).

kWh/m²/Day
- > 7.5
- 7.0 to 7.5
- 6.0 to 7.0
- 6.0 to 6.5
- 5.5 to 6.0
- 5.0 to 5.5
- 4.5 to 5.0
- 4.0 to 4.5
- < 4.0

NREL
National Renewable Energy Laboratory
What is the relative performance of PV systems?
What is the spatial variation?
Temporal variation?
How do technologies compare?

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

\[
\text{Annual Energy (kWh)} = \frac{8760 \text{ (h)} \times \text{Power Rating (kW)}}{\text{Capacity Factor}}
\]
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

Key Assumptions

- Policy Implementation/Impacts
- Regulatory Limits
- Investor Response
- Regional Competition with other Energy Sources

Economic

- Projected Technology Costs
- Projected Fuel Costs

Technical

- System/Topographic Constraints
- Land-use Constraints
- System Performance

Resource

- Physical Constraints
- Theoretical Physical Potential
- Energy Content of Resource

Potential
Considering RE Potential: Identifying Opportunities

Layers in this Analysis
- Regional (or cell based) Capacity Factor
- Resource
- Water Features
- Urban Areas
- Wetlands
- Contiguous Area
- Slope
- Federally Protected Lands
- Area of Critical Environmental Concern
- Region
- Available Land
- Regional Generation (MWh)

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?
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/m²/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

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
Combining 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 …?
THE NECESSARY ROLE OF POLICY

How it Began: Texas Competitive Renewable Energy Zones
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

Local line congestion

Path congestion to major load centers

Pre-CREZ wind farms in 2005 (sized by MW capacity)
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

Regulators need to see wind farm

Wind farm needs financing

Transmission needs state approval

Financiers need to see transmission
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

- 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
Did It Work?

Includes 3,396 MW in ERCOT with interconnection agreement projected to come on line in 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**

**CREZ lines in red**
# Improved Capacity Factors

<table>
<thead>
<tr>
<th>Turbine vintage</th>
<th>CREZ</th>
<th>Operating year</th>
<th>Average capacity factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old</td>
<td>McCamey</td>
<td>2003</td>
<td>26%</td>
</tr>
<tr>
<td>(on line 2001-2002)</td>
<td></td>
<td>2014</td>
<td>30%</td>
</tr>
</tbody>
</table>

*Older wind turbines performed better because of reduced transmission congestion and less curtailment*

| New                   | McCamey  | 2014           | 35%                     |
| (on line 2007-2013)   |          |                |                         |
| Panhandle             |          |                | 45%                     |

*New transmission opened up more productive wind areas*
Wind Share of Generation in ERCOT

2001

0.2%

- Natural gas
- Wind
- Other

2015*

9.9%

- Natural gas
- Wind
- Other

*12 months ending August 2015

Total generation: 313 TWh
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

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