

# Wind Power Grid Integration in USA



National Wind Technology Center, Boulder, Colorado

European Wind Energy Technology Platform

First Energy R&D Event – Grid Integration

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4 October, 2011, Brussels, Belgium

# Outline

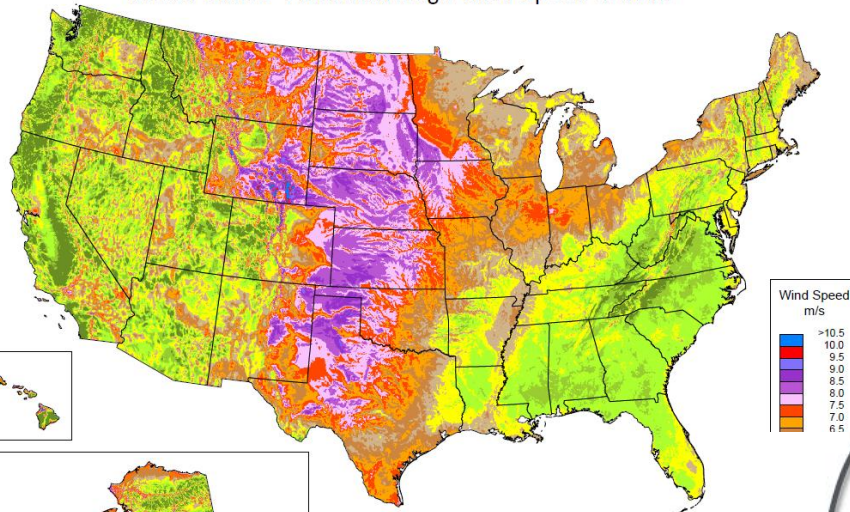
- U.S. Wind Industry Status
- Wind Vision for 2030
- U.S. Grid Integration Activities
- Comparison of U.S. and European





# U.S. Wind Resource is Abundant

United States - Annual Average Wind Speed at 80 m



Source: Wind resource estimates developed by windNavigator LLC for windNavigator®. Web: <http://www.awstruepower.com>. Spatial resolution: 2.5 km. Projection: Albers Equal Area.



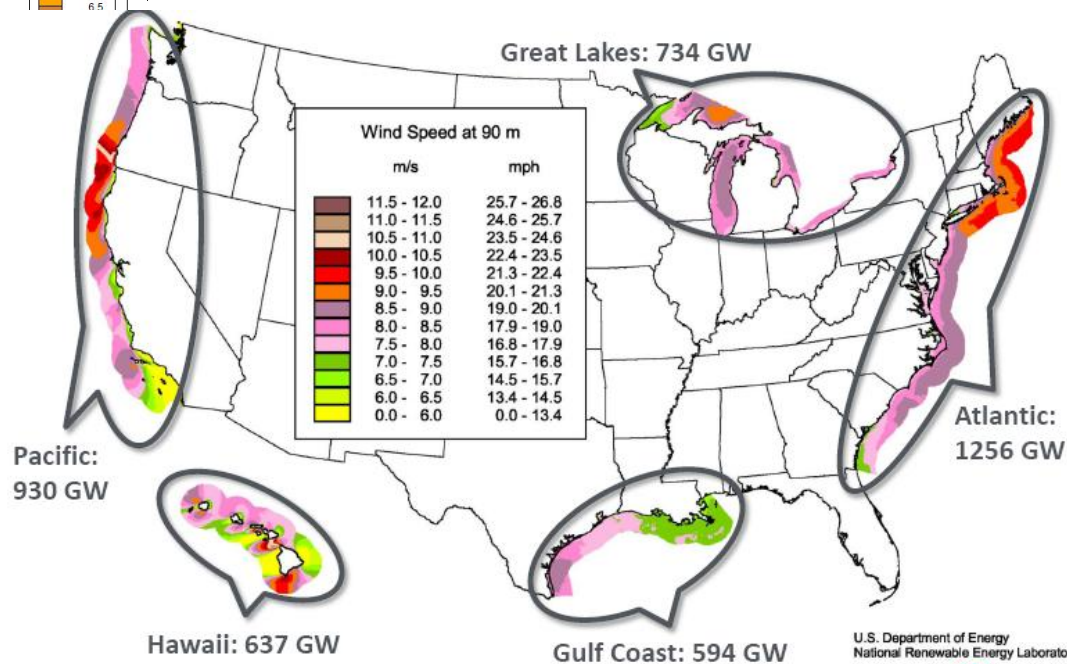
## On Land

Total gross potential: ~11,000 GW

## Offshore

Total gross potential: ~4,150 GW

United States - Annual Average Offshore Wind Speed at 90 m

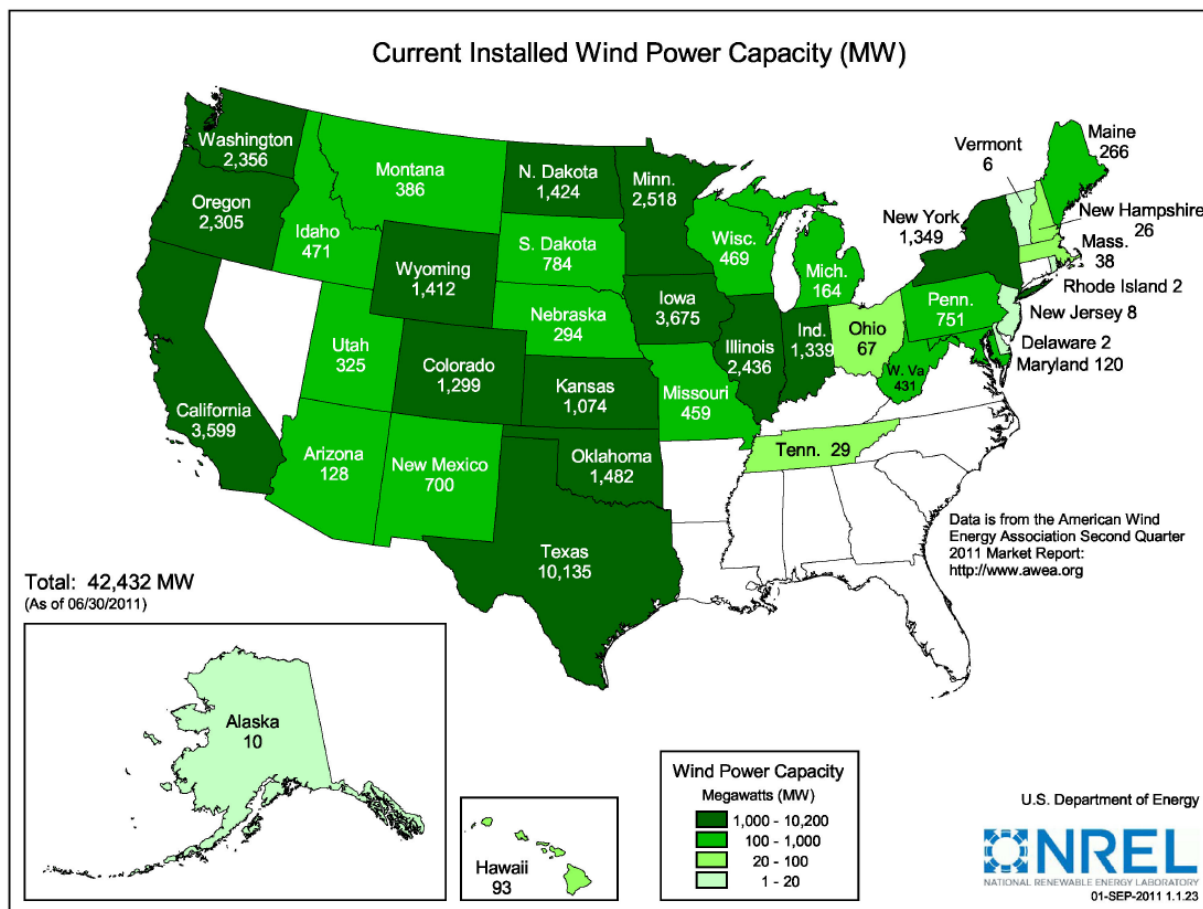


U.S. Department of Energy  
National Renewable Energy Laboratory



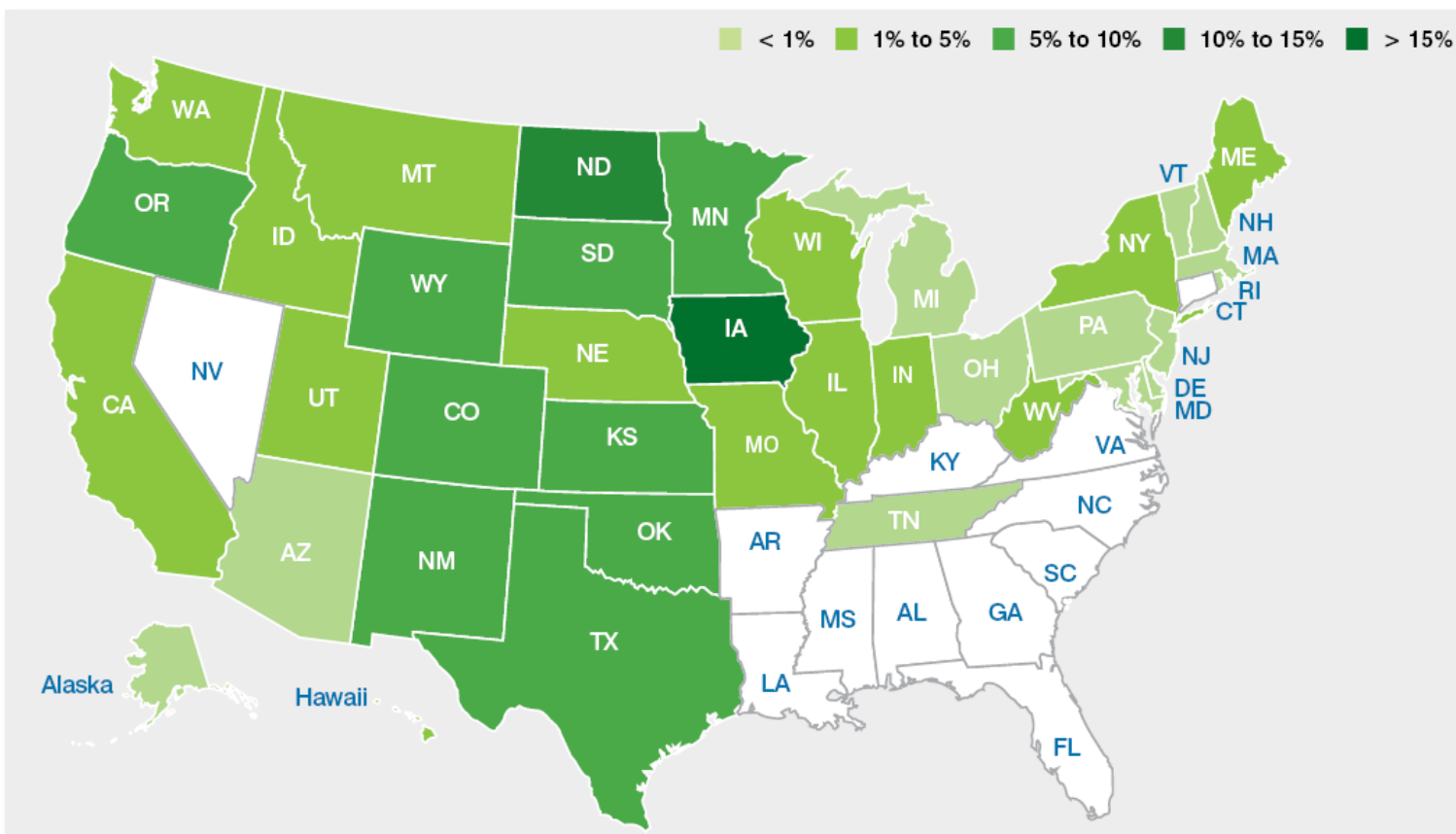
Total gross resource potential does not consider exclusion zones or siting concerns

# U.S. installed wind capacity grew 15% (5,116 MW) and provided 26% of all U.S. electric generation in 2010



- 42,423 MW of total installed wind capacity in the United States (as of 6/30/2011)
- 50 states have utility-scale wind with 14 states > 1,000 MW installed
- 7.4 GW currently under construction
- Over 35,600 commercially operating wind turbines > 1 MW in capacity

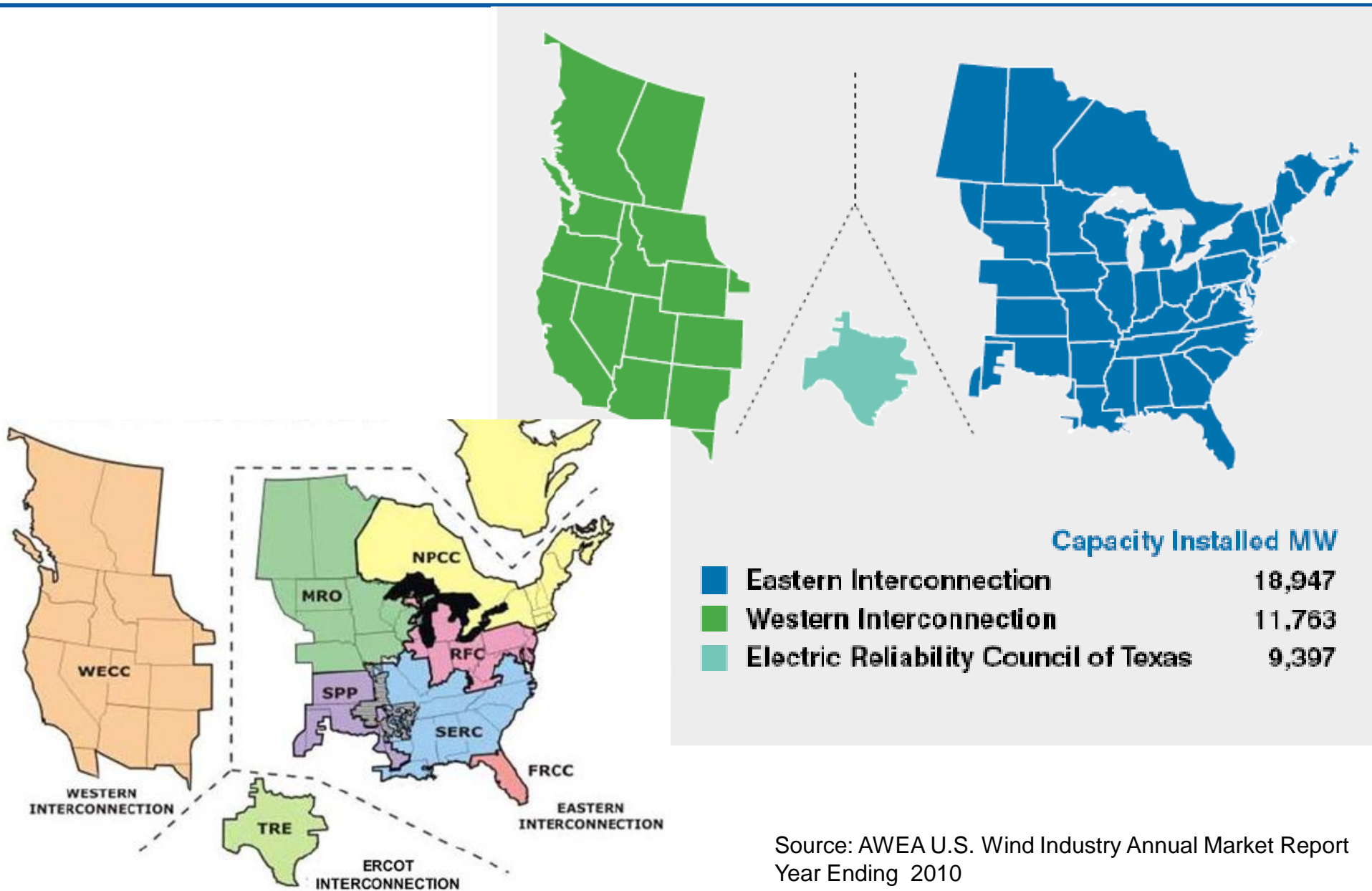
# U.S. wind percentage of electricity rising by State in 2010



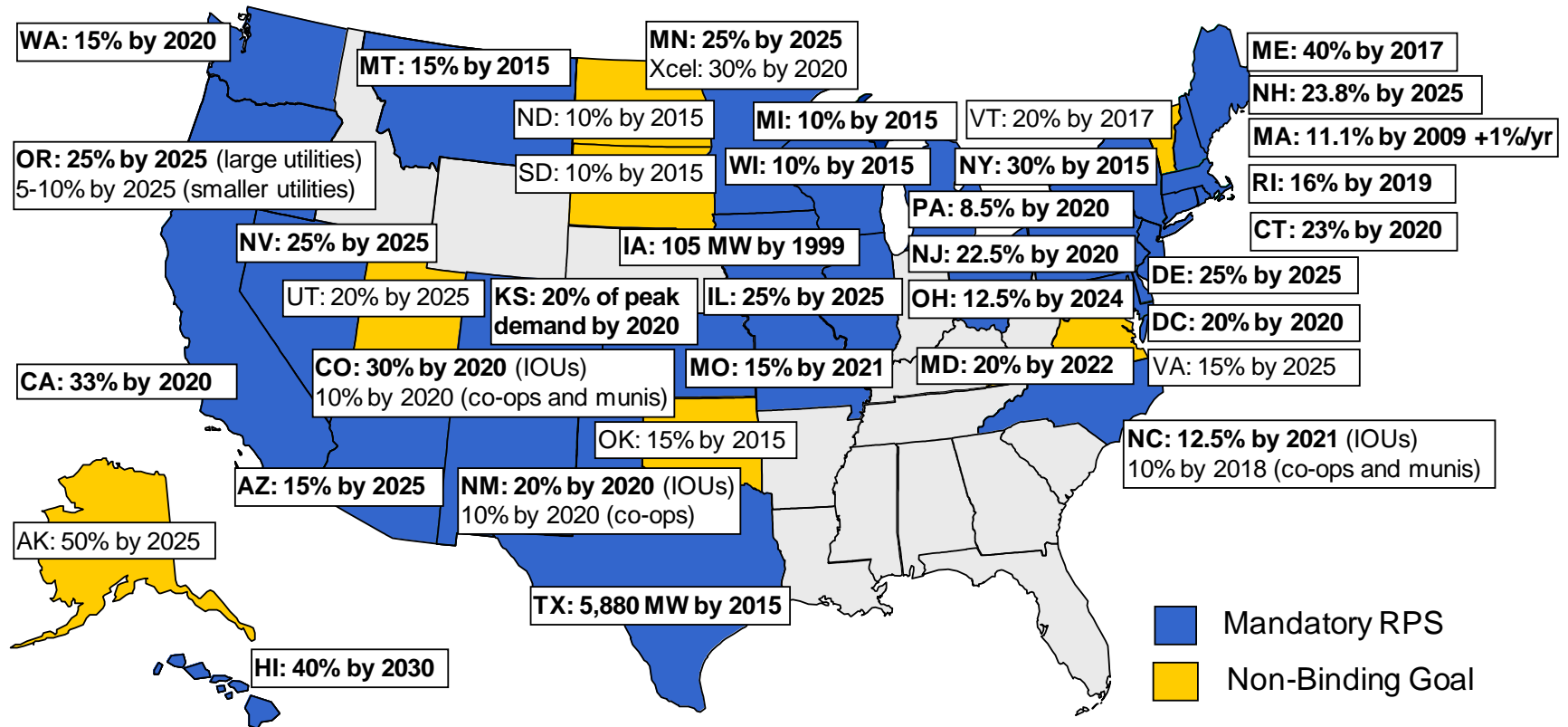
In state with largest wind installation (TX: 10,085 MW), independent system operator ERCOT received 7.8% of electricity from wind in 2010.

Source: AWEA U.S. Wind Industry Annual Market Report Year Ending 2010

# Installed U.S. wind capacity in the 3 interconnections



# State policies help direct the location and amount of wind power development

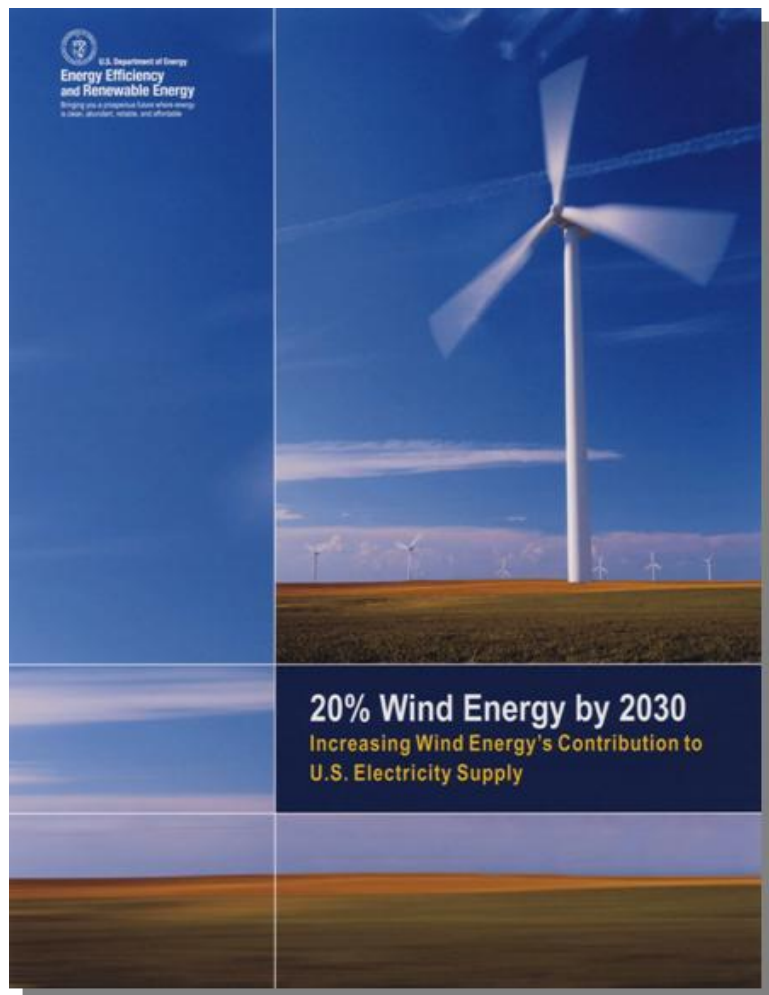


Source: Berkeley Lab

- 29 states and Washington, D.C. have mandatory Renewable Portfolio Standard programs in place
- State renewable funds, tax incentives, utility resource planning, voluntary green power, and concerns about carbon emissions all also played a role in 2010



# A New Vision for Wind Energy – 20% Wind Energy by 2030



## Setting the Stage for Growth

20% Wind Energy by 2030 is a technical analysis of the possible impacts, costs, and benefits of producing 20% of the nation's projected electricity demand using wind technology

## Conclusions for Grid Integration:

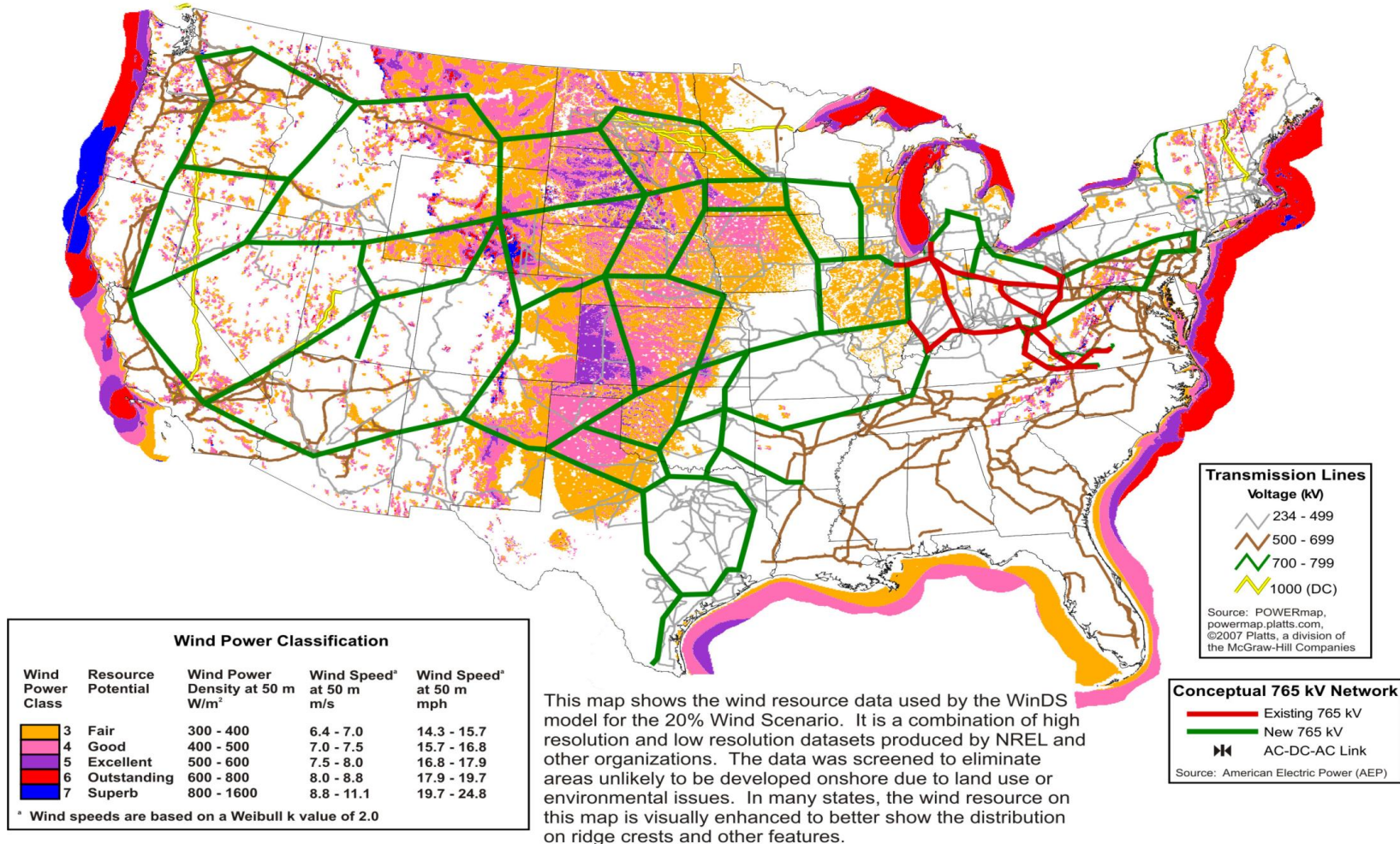
*"There are no fundamental technical barriers to the integration of 20% wind energy into the nation's electrical system," ...but for this to be most economically achieved "the 20% Wind Scenario would require the continuing evolution of transmission planning and system operations, in addition to expanded electricity markets."*

[www.eere.energy.gov/windandhydro](http://www.eere.energy.gov/windandhydro)



# 20% Wind by 2030 Conceptual Transmission Overlay

## “A new transmission superhighway system”



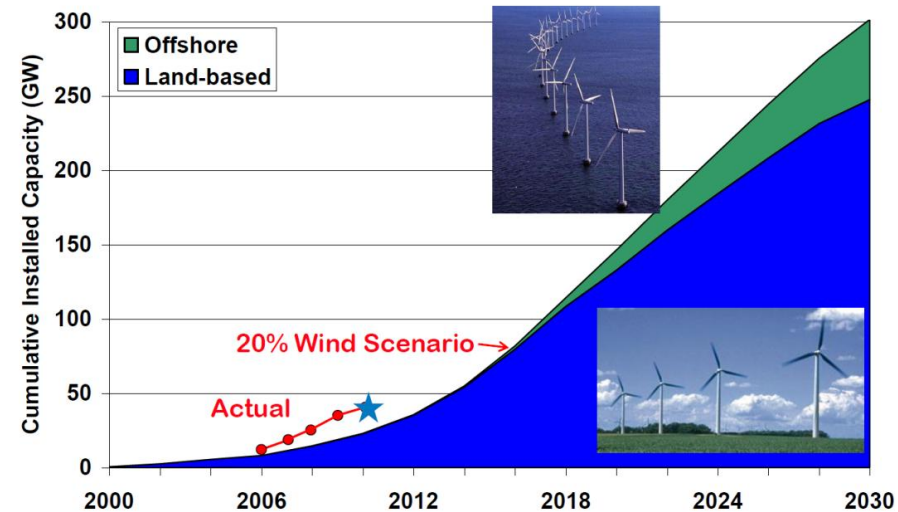
- 19,000 miles of new 765 kV transmission lines
- \$26 billion net present value cost

# 20% Wind Energy by 2030

## Future Needs for Transmission & Integration into U.S. Electric System

### System Planning and Operation

- **More wind integration studies**
- Deploy more flexible generation technologies
- Better wind plant forecasting tools
- Improved grid codes & wind plant models
- **Aggregation of wind plants over large regions**
- **Consolidation of balancing areas**
- Forums to share operating experience



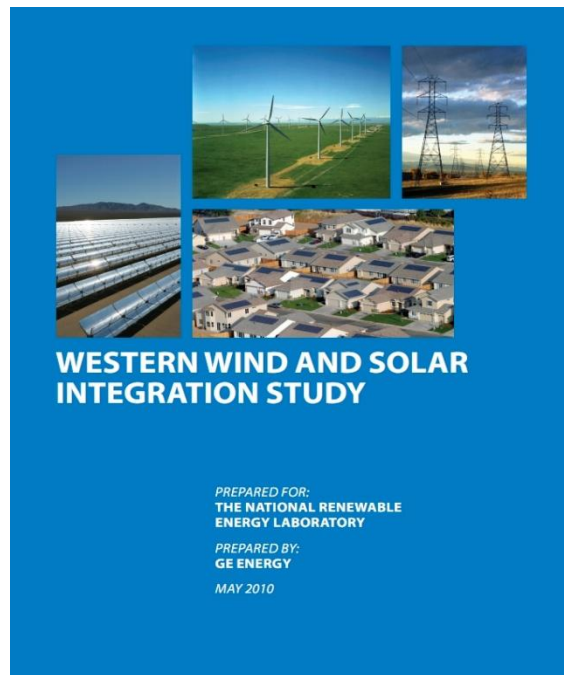
### Transmission Planning

- Develop adequate transmission capacity
- Comprehensive regional planning processes
- Leadership in developing transmission in the national interest
- More certainty of transmission cost recovery
- More robust and flexible “smart” grid

### Market & Transmission Policy

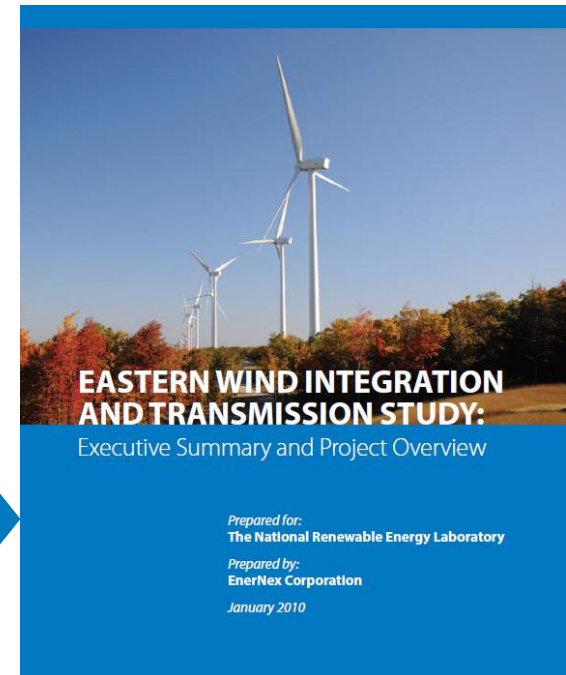
- Develop hour-ahead and day-ahead energy and price responsive load markets
- Adopt market rules and tariff provisions appropriate to weather-driven resources
- Better use of available transmission capacity
- Favorable energy markets and policies

# Major U.S. Regional Studies Completed in 2010



35% Wind & Solar  
penetration scenario

20% & 30% Wind  
penetration scenarios



<http://www.nrel.gov/docs/fy10osti/47781.pdf>

<http://www.nrel.gov/docs/fy11osti/47086.pdf>

## Results are consistent with 20% Wind by 2030 analysis

- Integrating high penetrations of wind is technically feasible
- Transmission and infrastructure investments are necessary for higher penetration levels
- In some cases, changes need to be made to current operational practice
- Use of forecasts is highly valuable

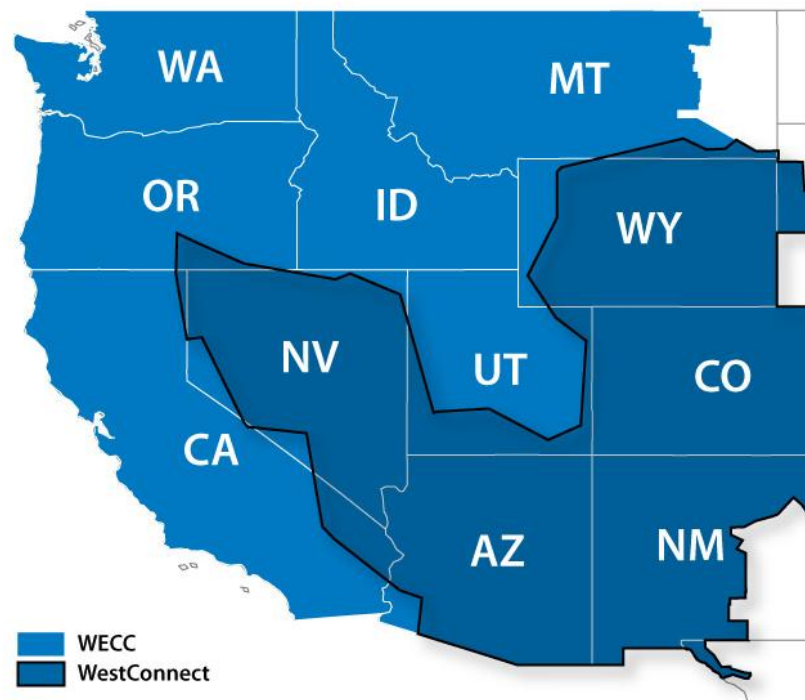
# Western Wind and Solar Integration Study

## Can we integrate 35% wind (30%) and solar (5%) in the West?

**Study Goal:** To assess the operating impacts and economics of wind and solar on the WestConnect grid

### Study Questions:

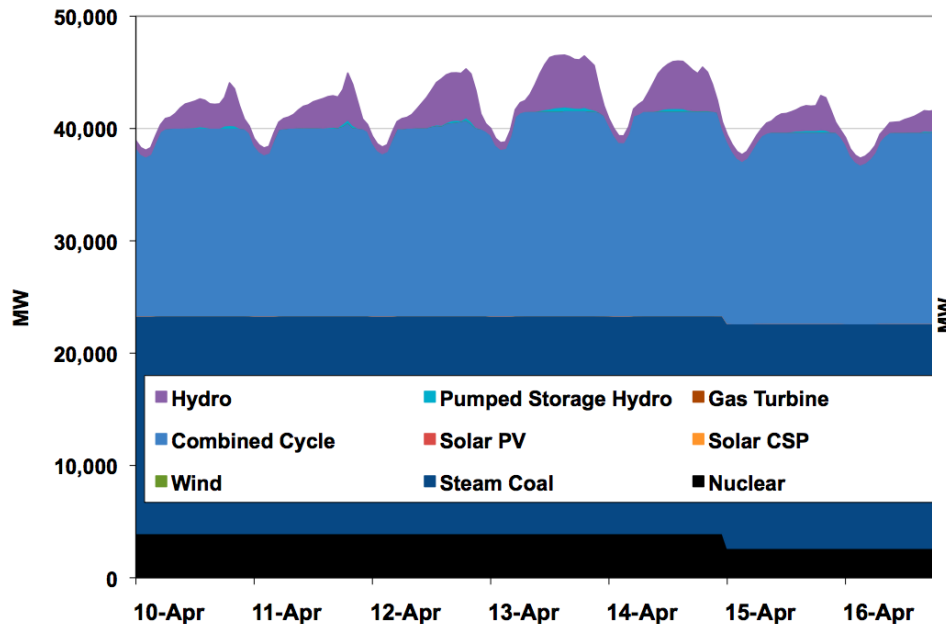
- How do local resources compare to remote, higher quality resources via long distance transmission?
- Can balancing area cooperation help manage variability?
- Do we need more reserves? Do we need more storage?
- How does geographic diversity help?
- What is the value of forecasting?



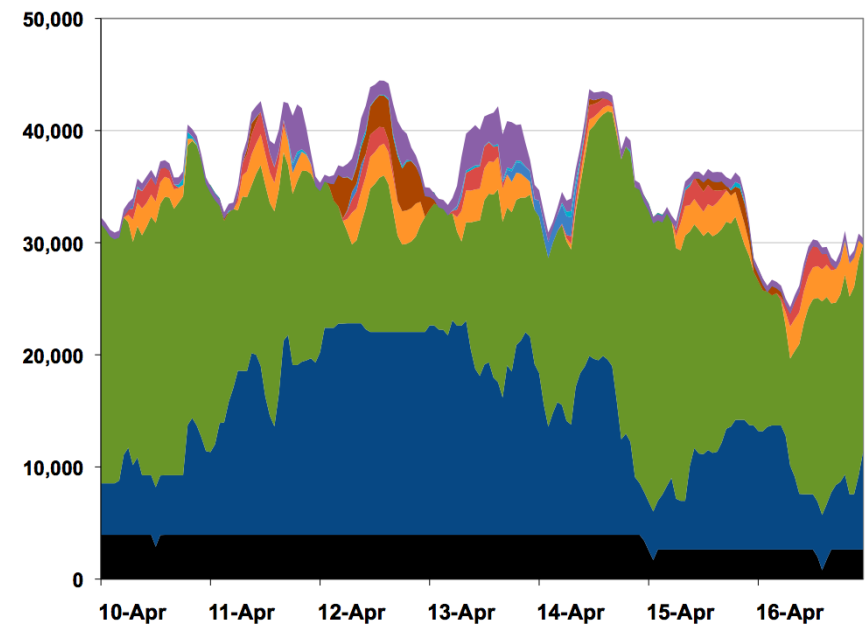


# Operations during a challenging mid-April time period

## No Wind/Solar Case



## High Renewables Case (30% Wind)

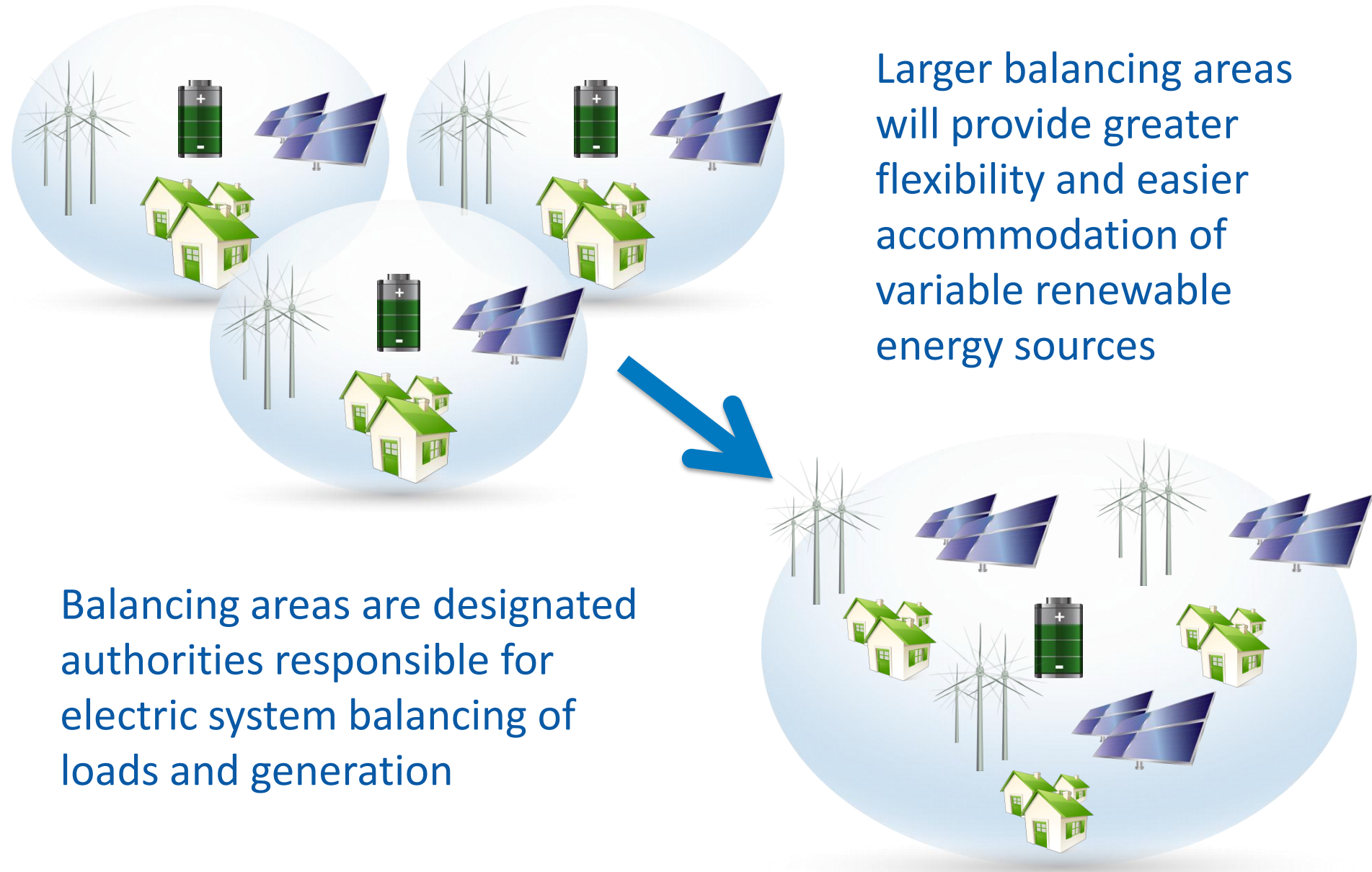


35% renewables have a significant impact on other generation during the hardest week of three years (mid-April 2006)

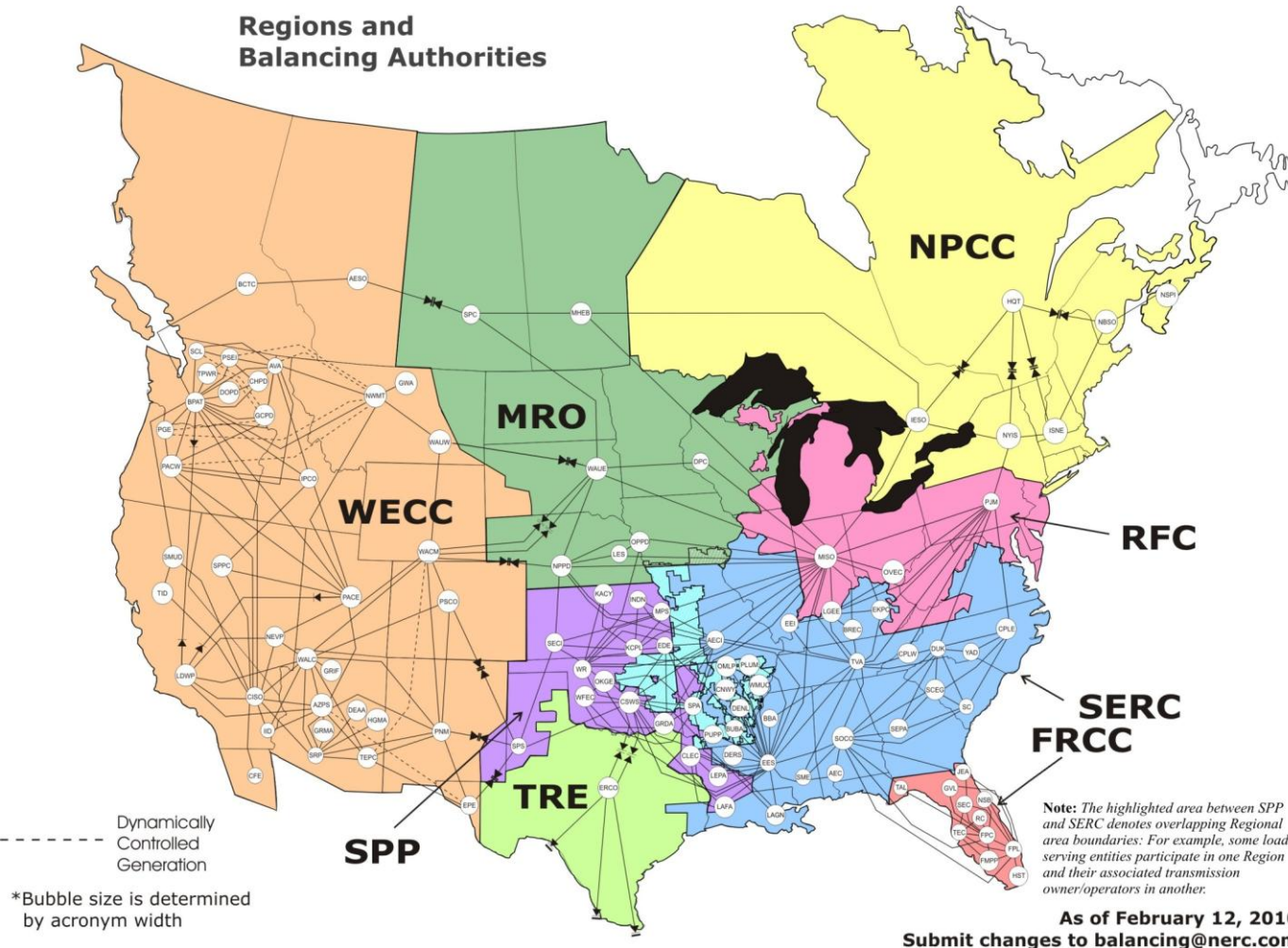
# Balancing area consolidation and cooperation is needed

Larger balancing areas will provide greater flexibility and easier accommodation of variable renewable energy sources

Balancing areas are designated authorities responsible for electric system balancing of loads and generation



# Balance area consolidation and coordination can improve system reliability and economics

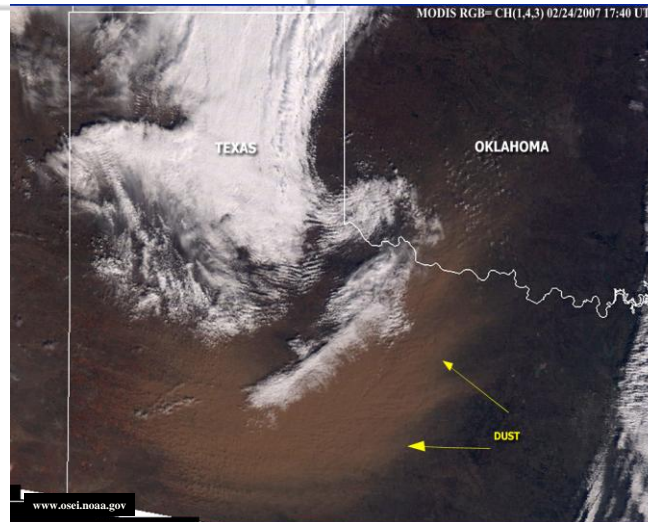
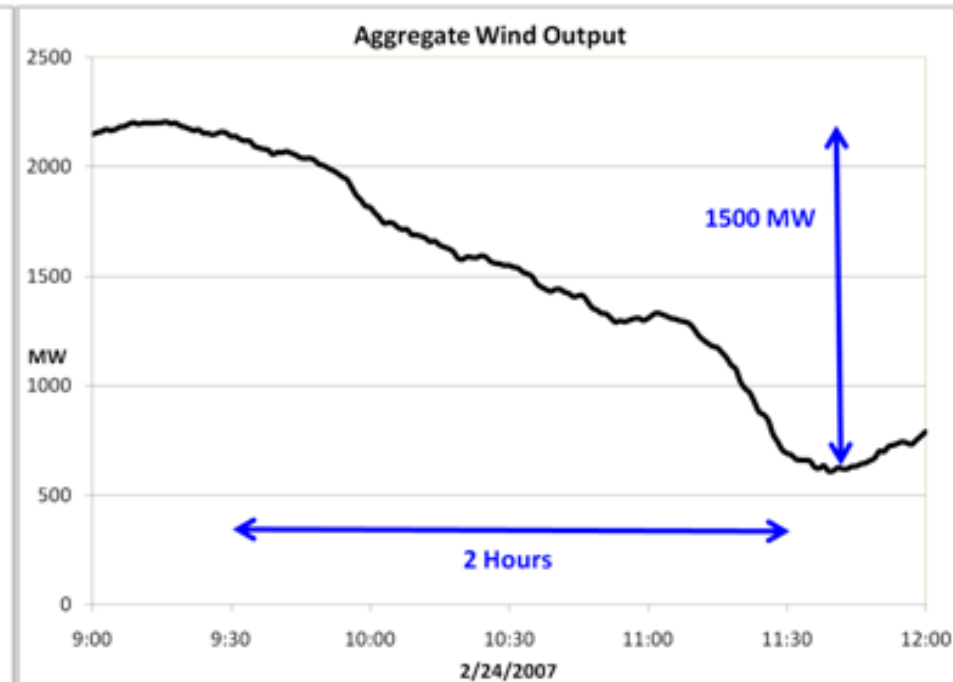
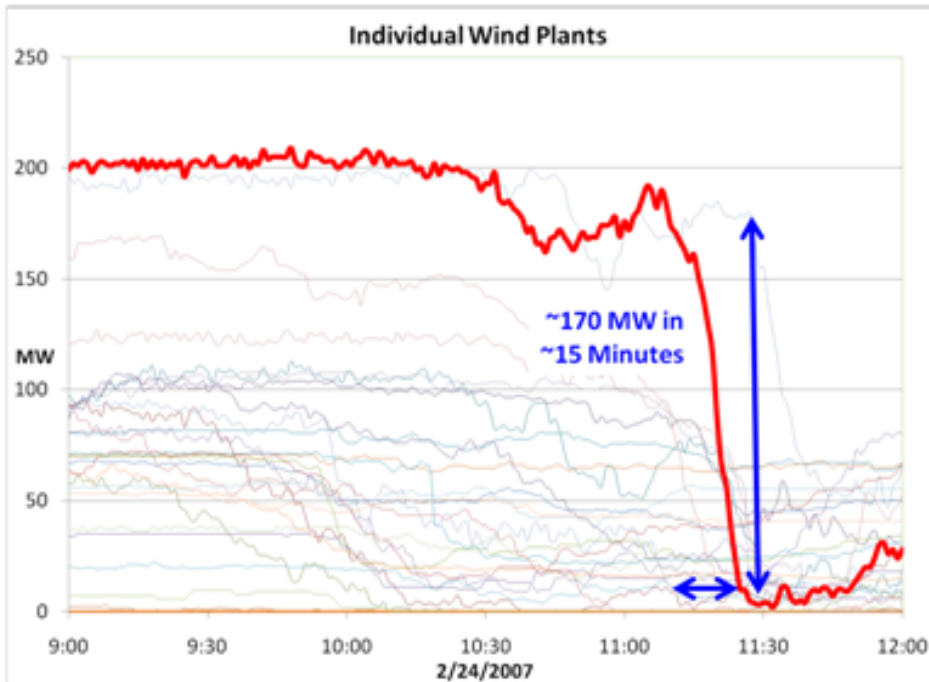


130 balancing areas in U.S. grid

Largest is part of Eastern Interconnection (PJM) with a peak load of 145 GW

Smallest are small utilities with a peak load of a few 100 MW

# Texas ramp events show that aggregated wind power output changes slowly over time



Weather system causing event (a dust storm) can be forecasted

Source: Texas wind plant, supplied by ERCOT and WindLogics



# Comparison of grid integration situation in U.S. and Europe

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## In the U.S.

- No single market approach
  - Integrated energy markets in the East, not in the West
- No national greenhouse gas mandate or federal policy driver
- Transmission planning primarily done at state-level
  - Interstate coordination is a challenge
- Best wind resources tend to be far away from load centers
- Large, land-based wind power plants approaching a GW in size
- No operating offshore wind power plants to integrate

**Much is the same!**

# Thank you!

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