

Implications of Integrating Wind at Scales that Matter for Climate Policy

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CTOTF Workshop on Integrating Renewables into the Generation Mix
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How Much Wind in a Low-Carbon Future?

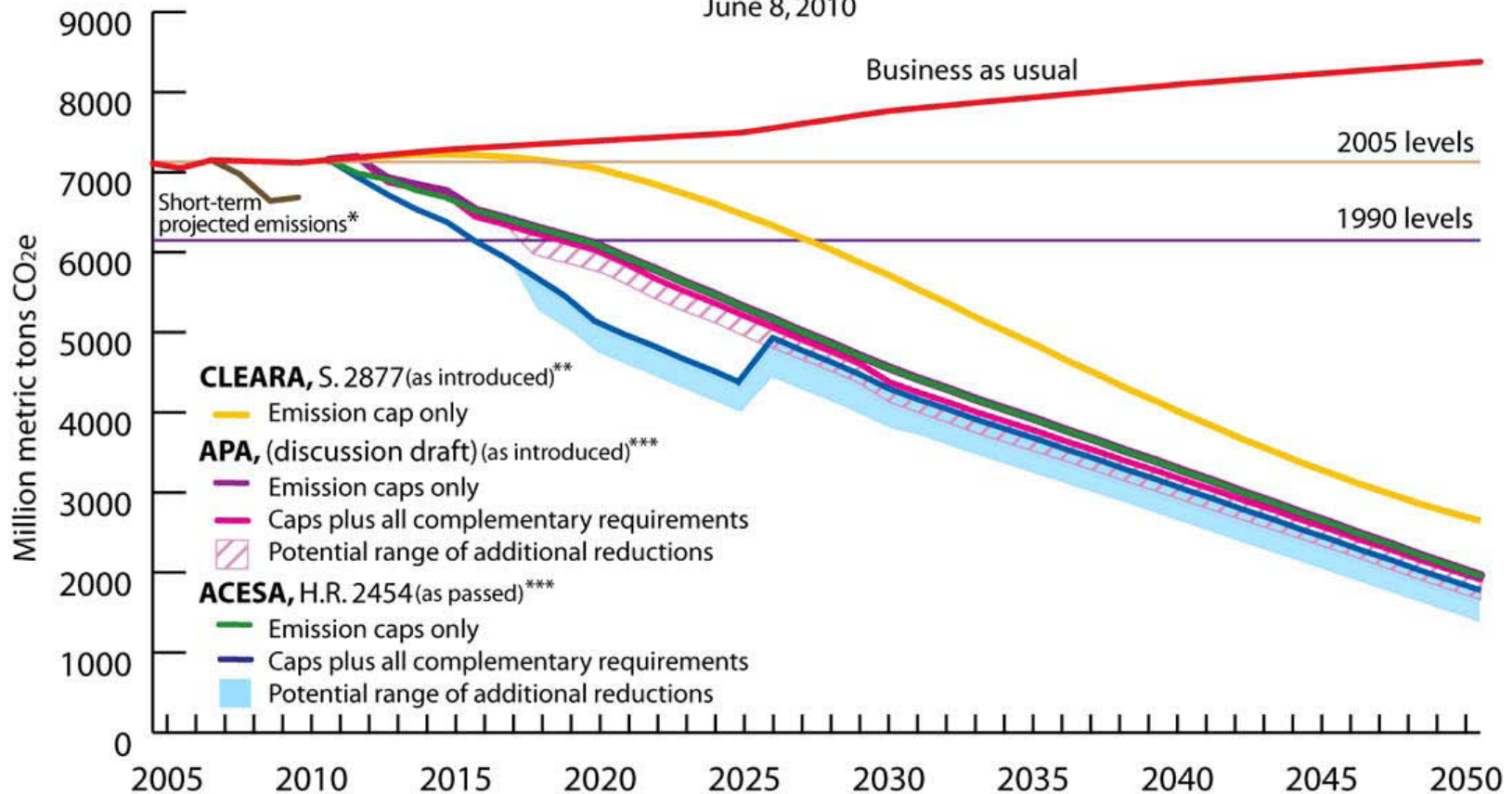
- A national policy to curb CO₂ emissions below existing levels will initiate a competition to replace existing coal
- Wind resource potential is huge
 - exceeds 50% of U.S. electric energy needs at \$90-\$100/MWh
 - potentially exceeding current generation from coal
- Potential is substantially limited by:
 - hours of no output over region
 - rapid hour-to-hour changes
 - anti-correlation of wind w. load
 - cost/ability of new transmission



Climate Legislation Unlikely Soon but Potential for a National Cap-and-trade Program Remains

Net Estimates of Emissions Reductions Under Pollution Reduction Proposals
in the 111th U.S. Congress, 2005-2050

June 8, 2010



Cutting National Emissions Likely to Mean Cutting CO₂ From Existing Coal

Electric sector's share of national total (2006)

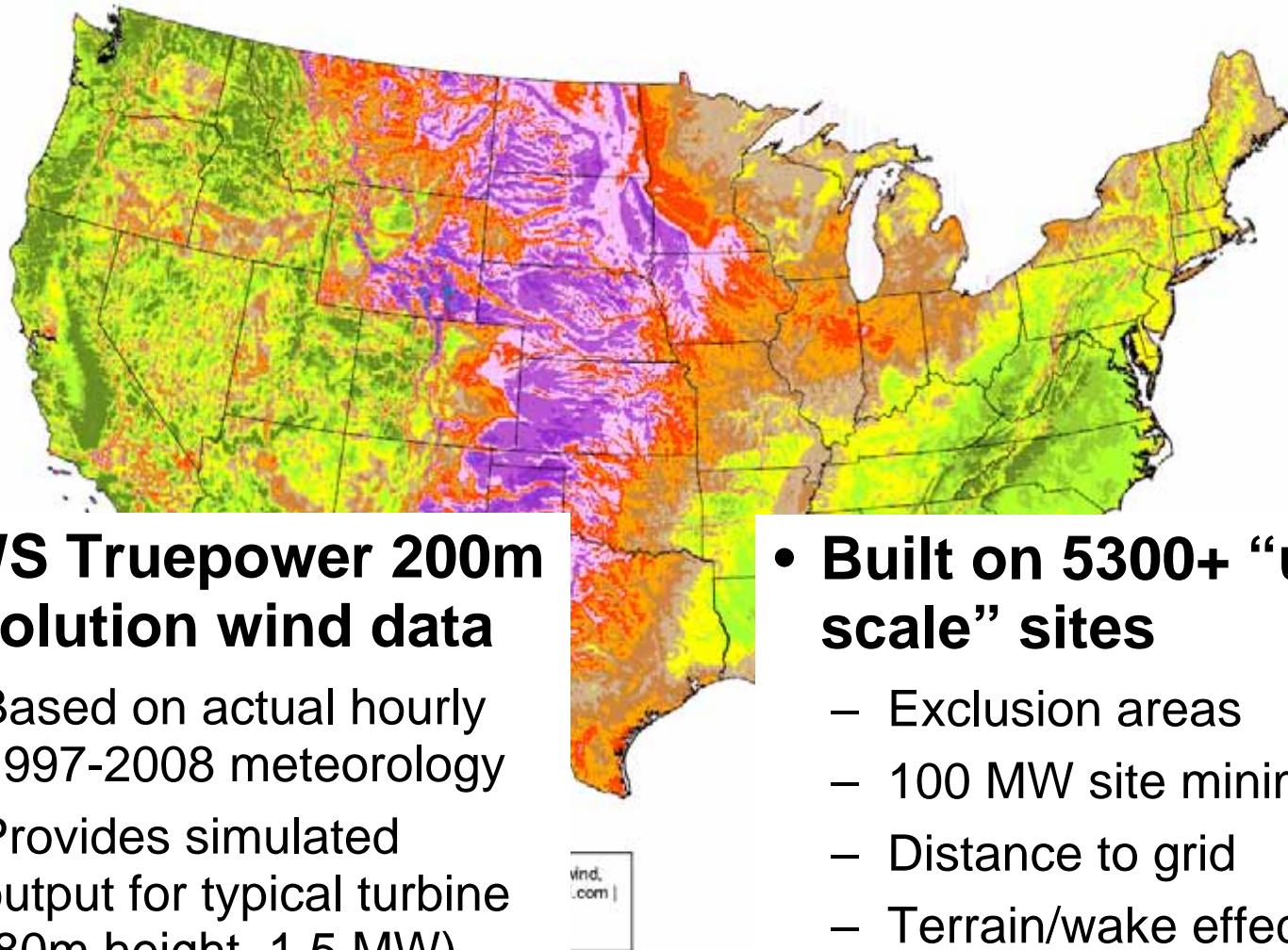
- 33% of total GHGs
- 39% of total CO₂

Shares within the electric sector CO₂

- 15% from natural gas (\$5/MMBtu)
- **83% from coal (\$2.5/MMBtu)**

National CO₂ price will be whatever it takes to displace the existing coal

New Wind Resource Data: Capturing Commercial Potential and Variability of Wind



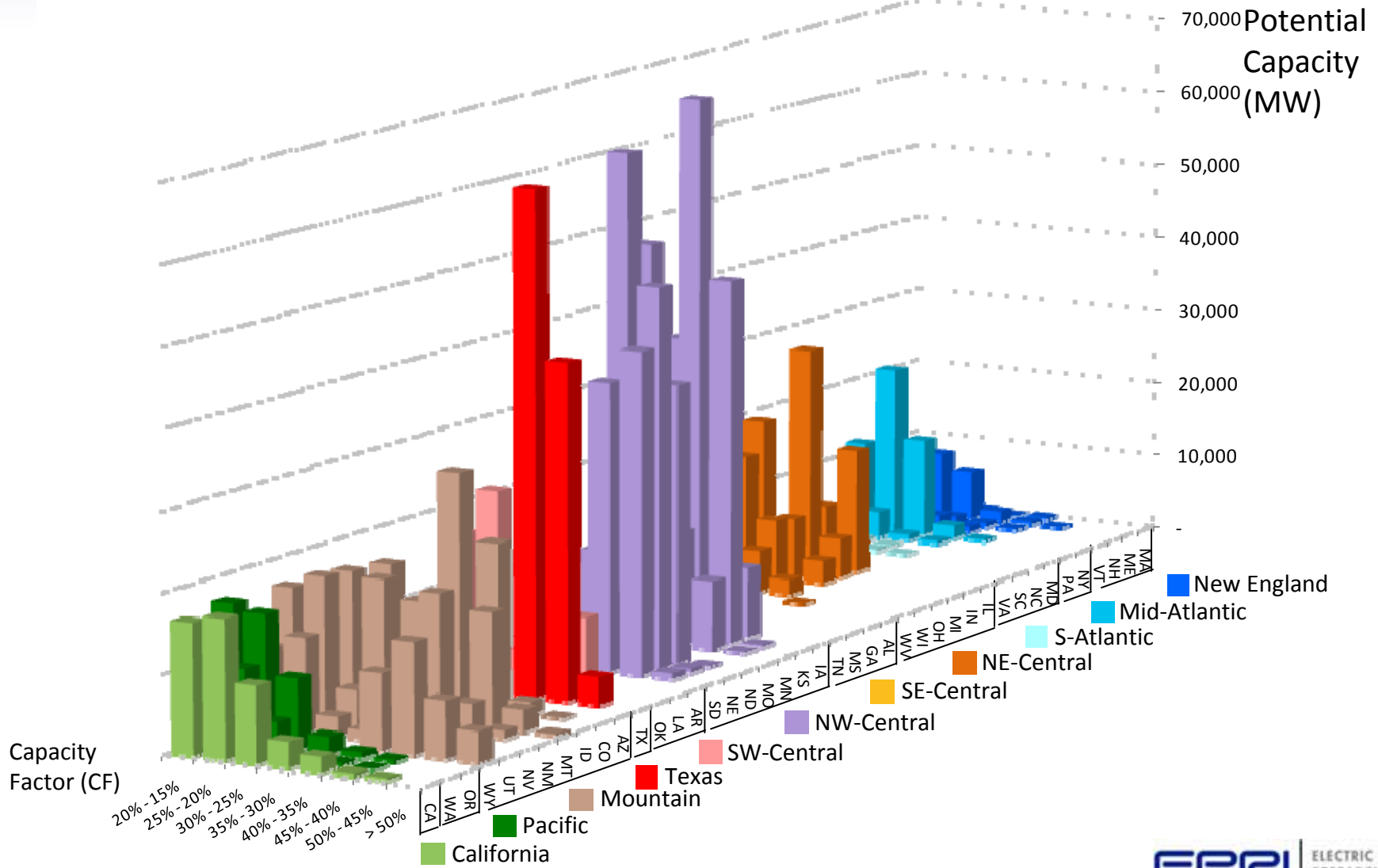
- **AWS Truepower 200m resolution wind data**

- Based on actual hourly 1997-2008 meteorology
- Provides simulated output for typical turbine (80m height, 1.5 MW)

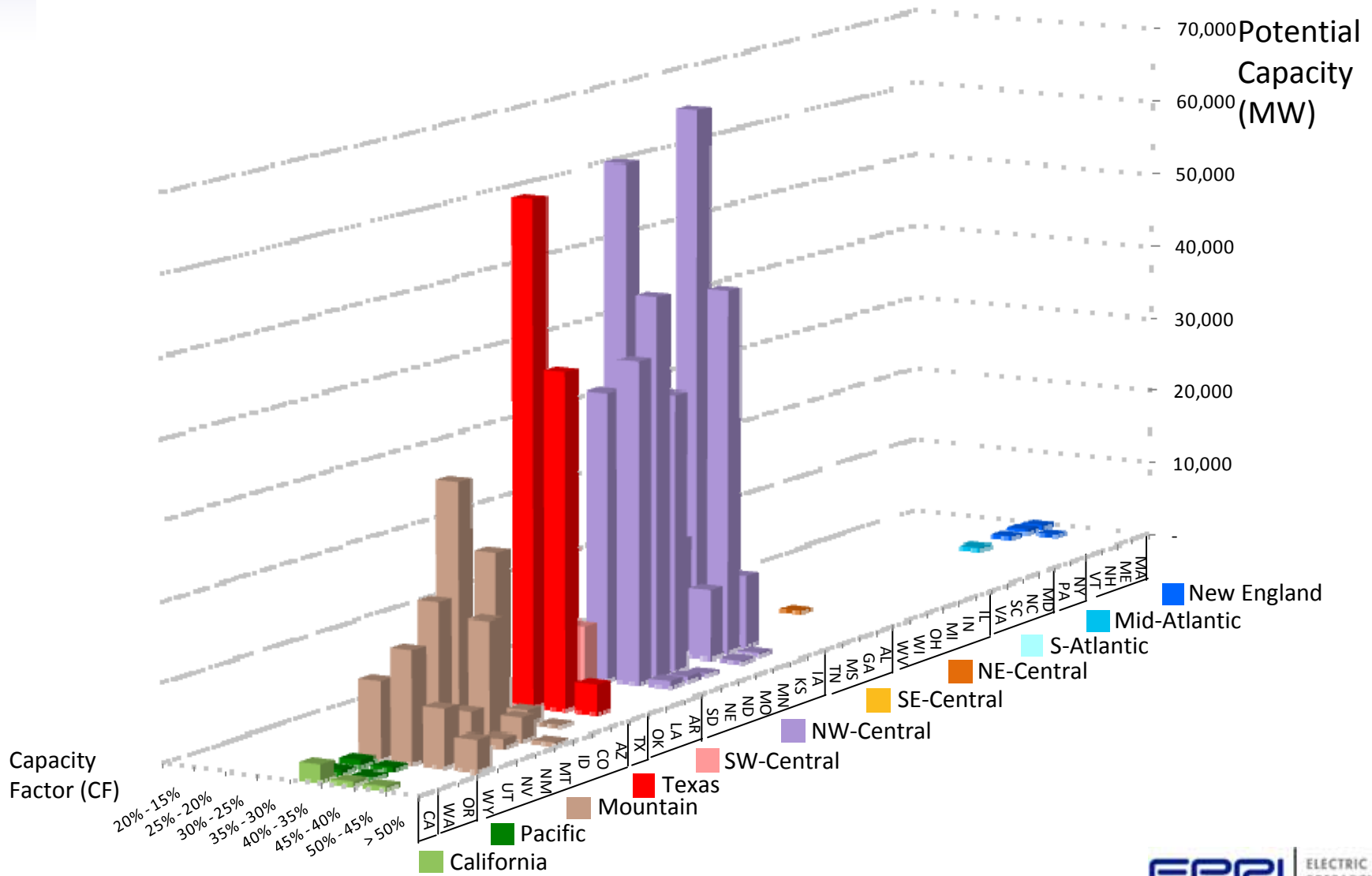
- **Built on 5300+ “utility-scale” sites**

- Exclusion areas
- 100 MW site minimum
- Distance to grid
- Terrain/wake effects

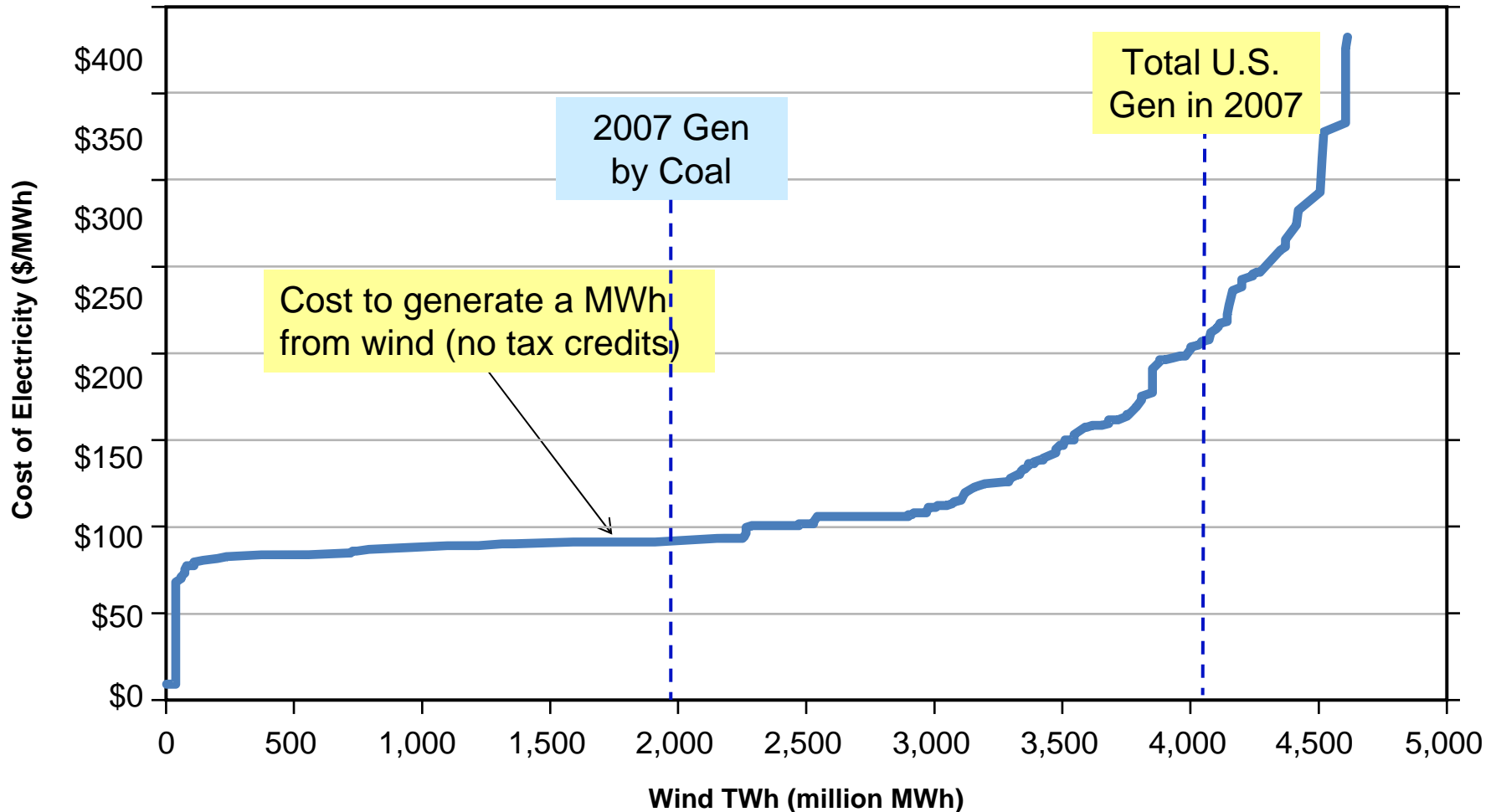
Location of wind resource by state and CF



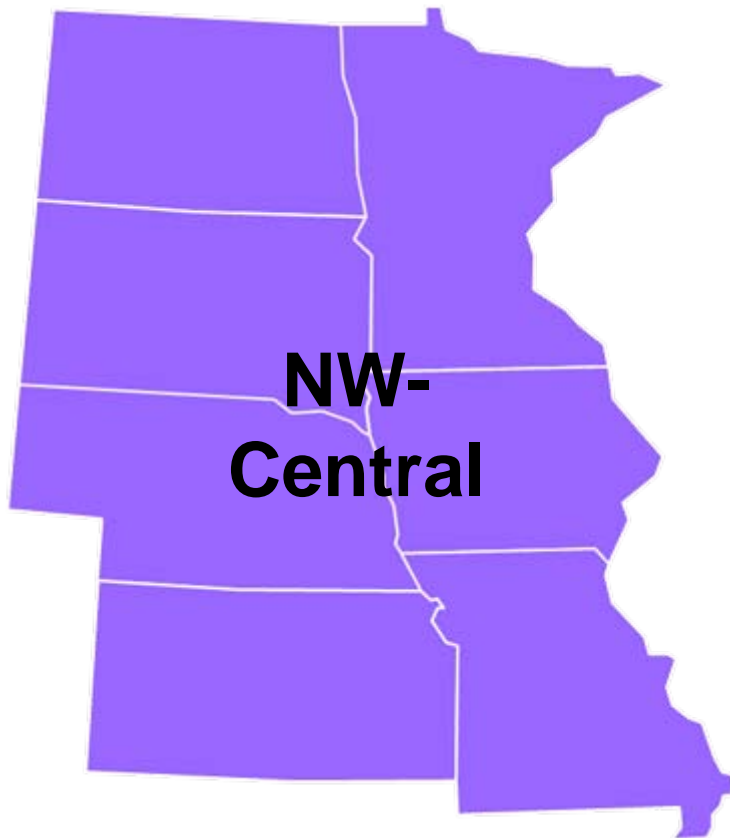
In practice, resource >35% will be most useful



EPRI Wind Resource Assessment from Truepower Shows Vast Generation Potential



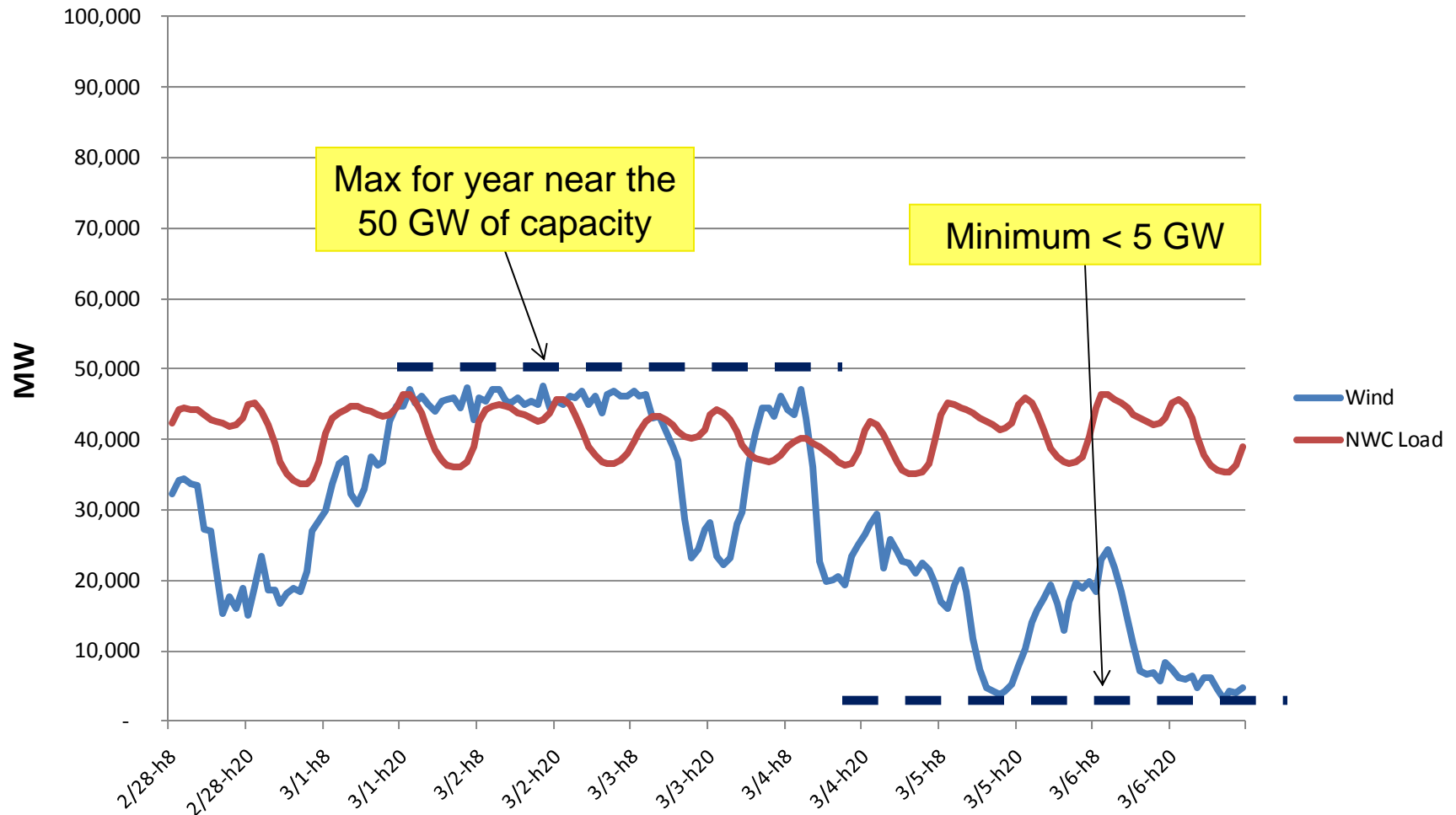
Example Analysis for NW-Central Region



- State hourly load data for 2007 from Energy Velocity
- Hourly loads and wind output synchronized so driven by same 2007 meteorology
- Add 50 GW new installed wind capacity within region
- Rank sites by capacity factor, build best sites first

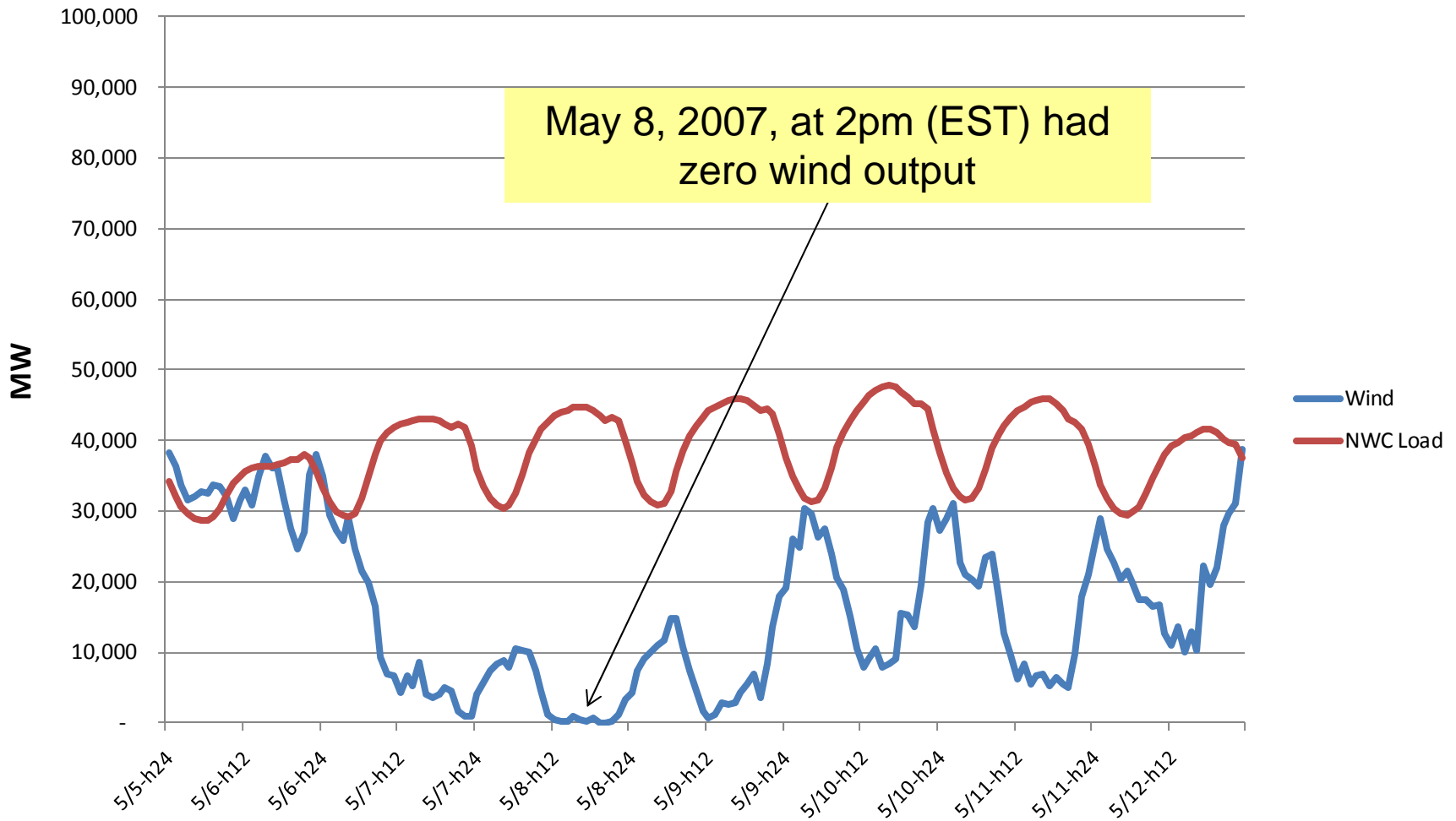
New Wind Data Captures Variability

NWC Time Series from 2/28/07 to 3/7/07 w 50 GW Added

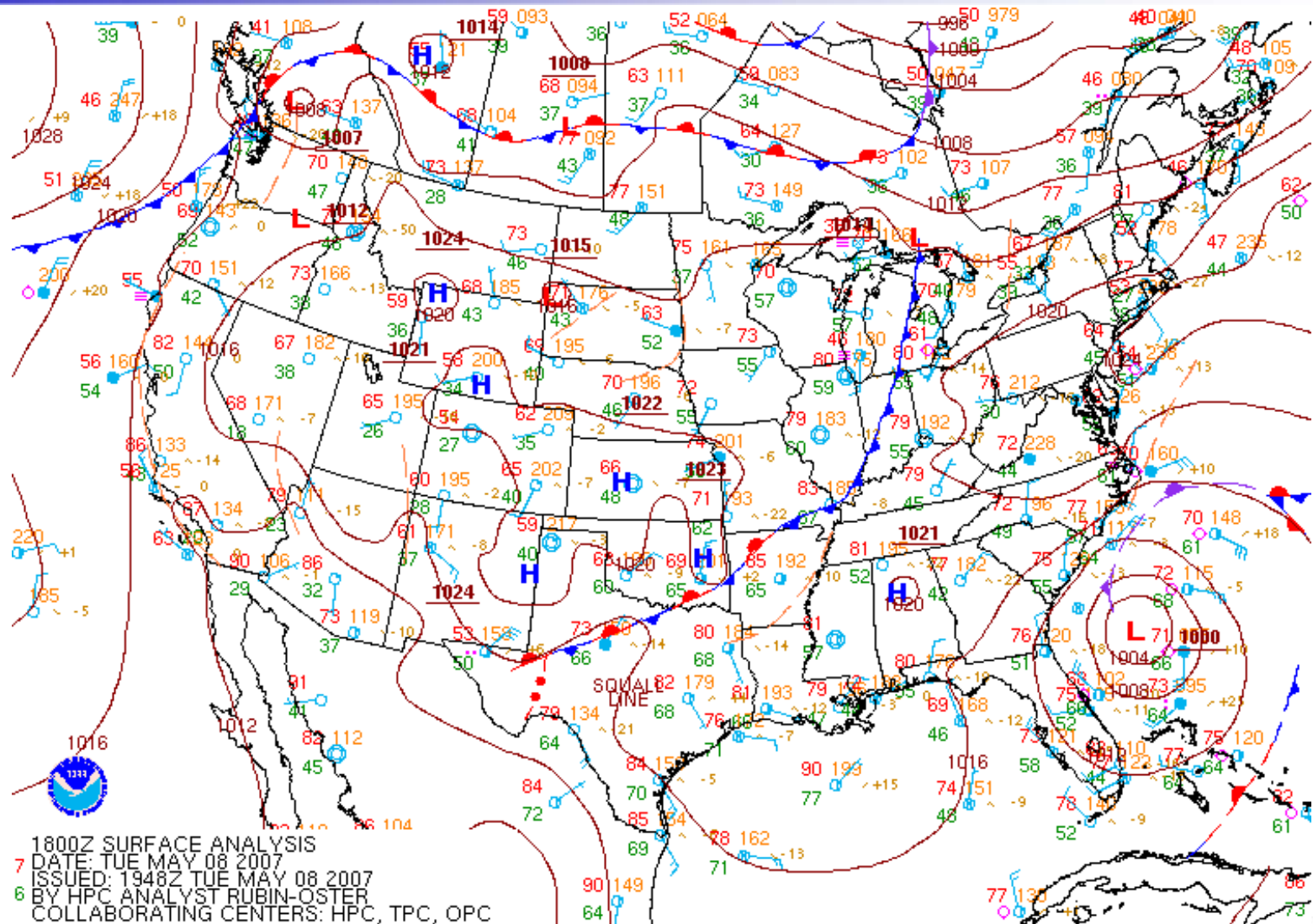


NW-Central Region-wide (7 states) Low Output Can Continue for Extended Periods

NWC Time Series from 5/5/07 to 5/12/07 w 50 GW Added

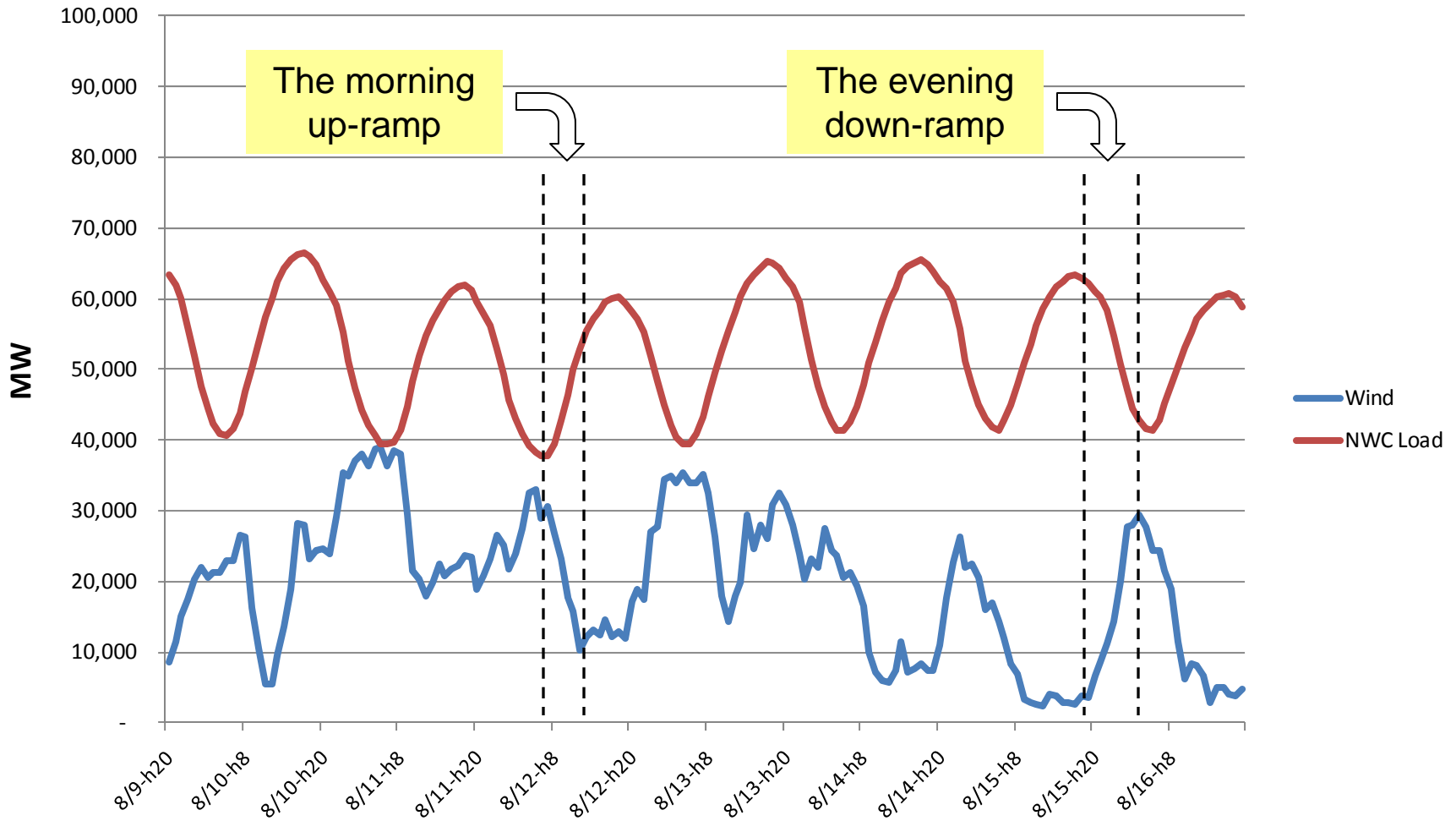


Weather Chart for 5/8/2007, 1800Z (2pm EST)



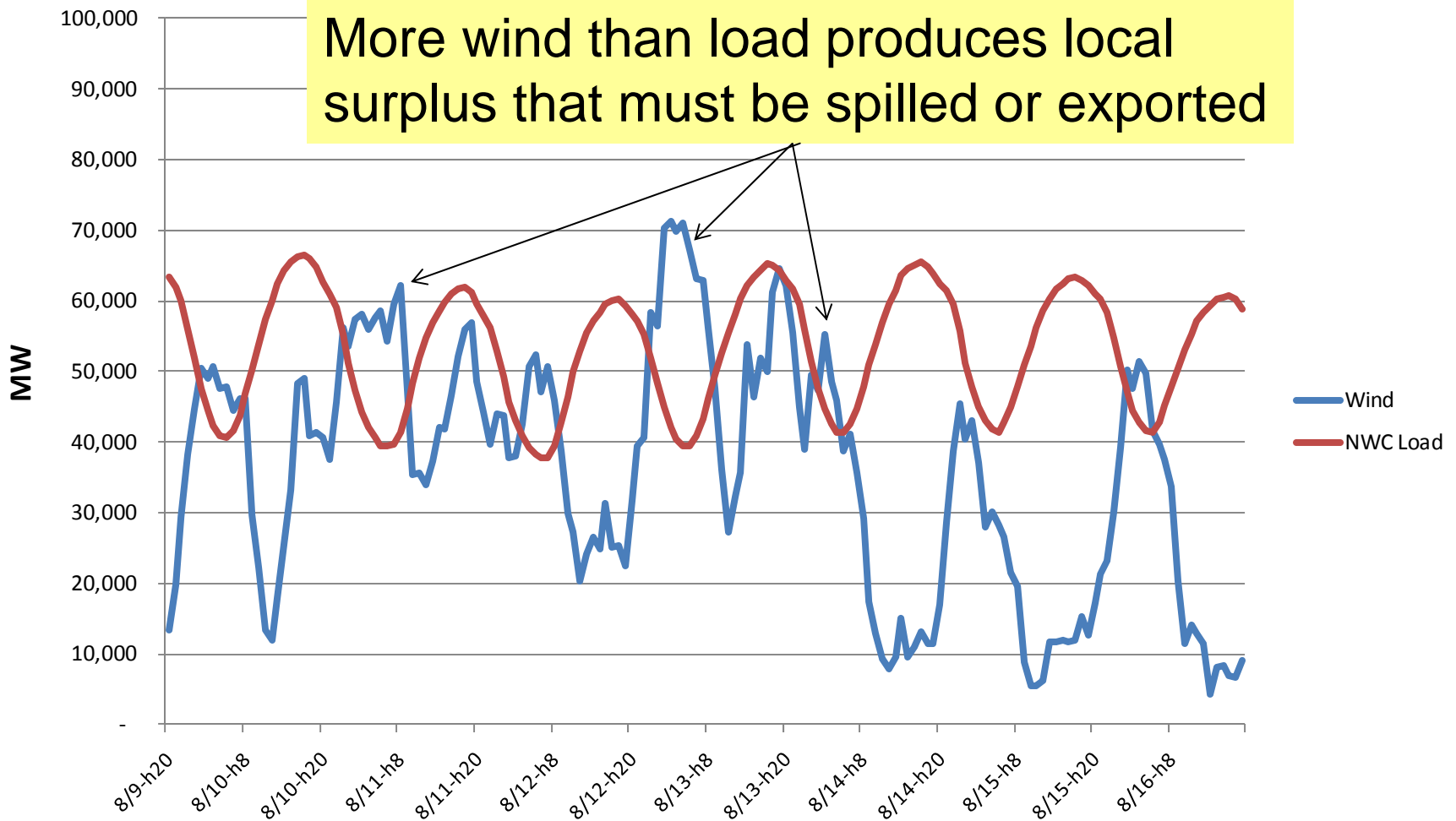
Anti-correlation of Wind with Load Creates Extreme Demand for Ramping Capability

NWC Time Series from 8/9/07 to 8/16/07 w 50 GW Added

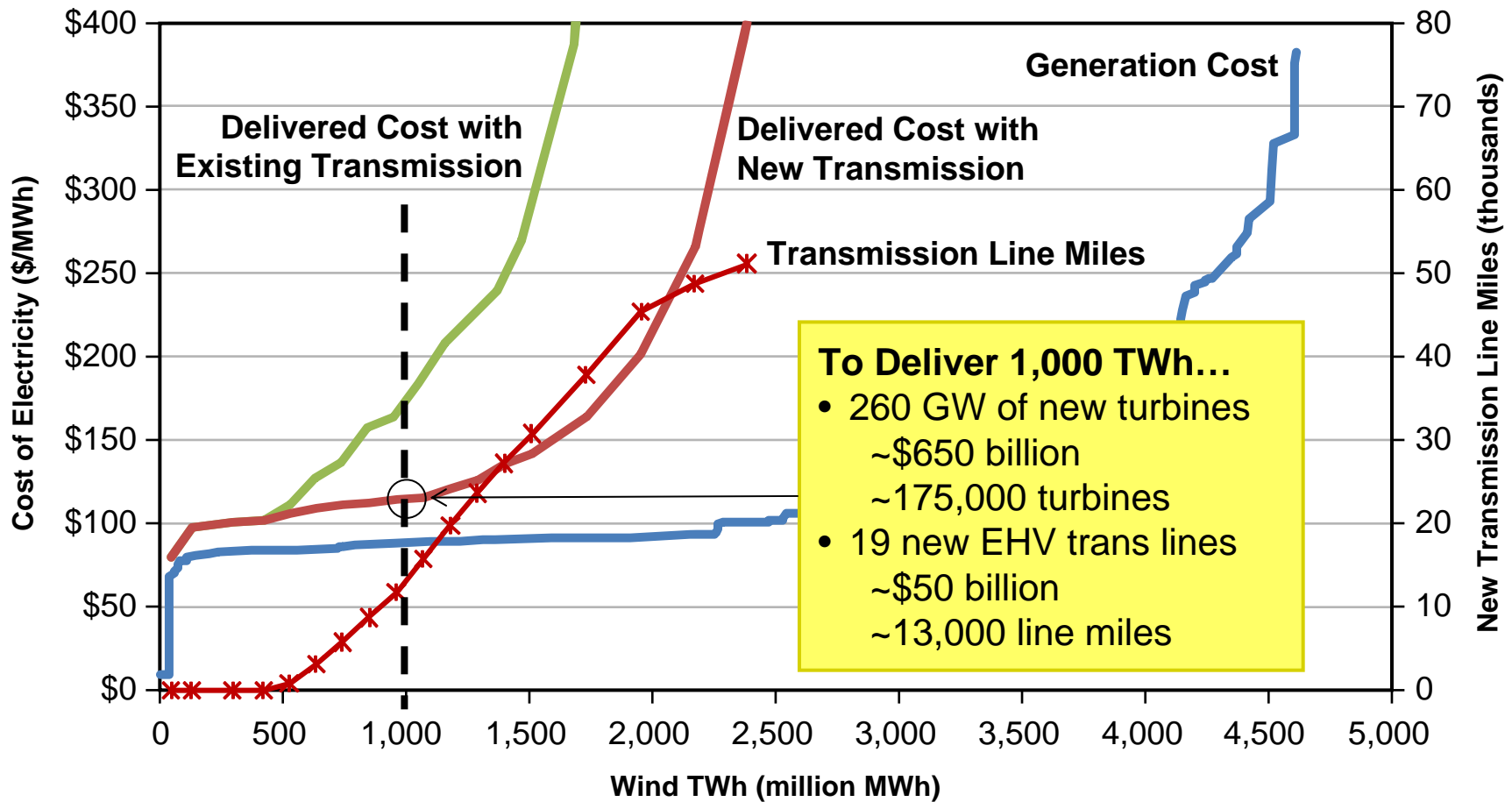


Anti-correlation of Wind with Load Also Forces Diminishing Returns to Wind Additions: 100 GW

NWC Time Series from 8/9/07 to 8/16/07 w 100 GW Added



National Wind Energy Potential Supply Curves* (including delivery costs)



*EPRI – AWS TruePower National Wind Energy Supply Curves

So, How Much Wind?

- Adding transmission enables greater utilization of wind
- Cost of wind delivered to load much higher than simple cost of generation
- Anti-correlation with load and need for new interregional transmission greatly limits the fraction existing coal wind can displace in a decarbonized electric future

Together...Shaping the Future of Electricity