Comparing Renewable Energy Options for Vermont and the Northeast

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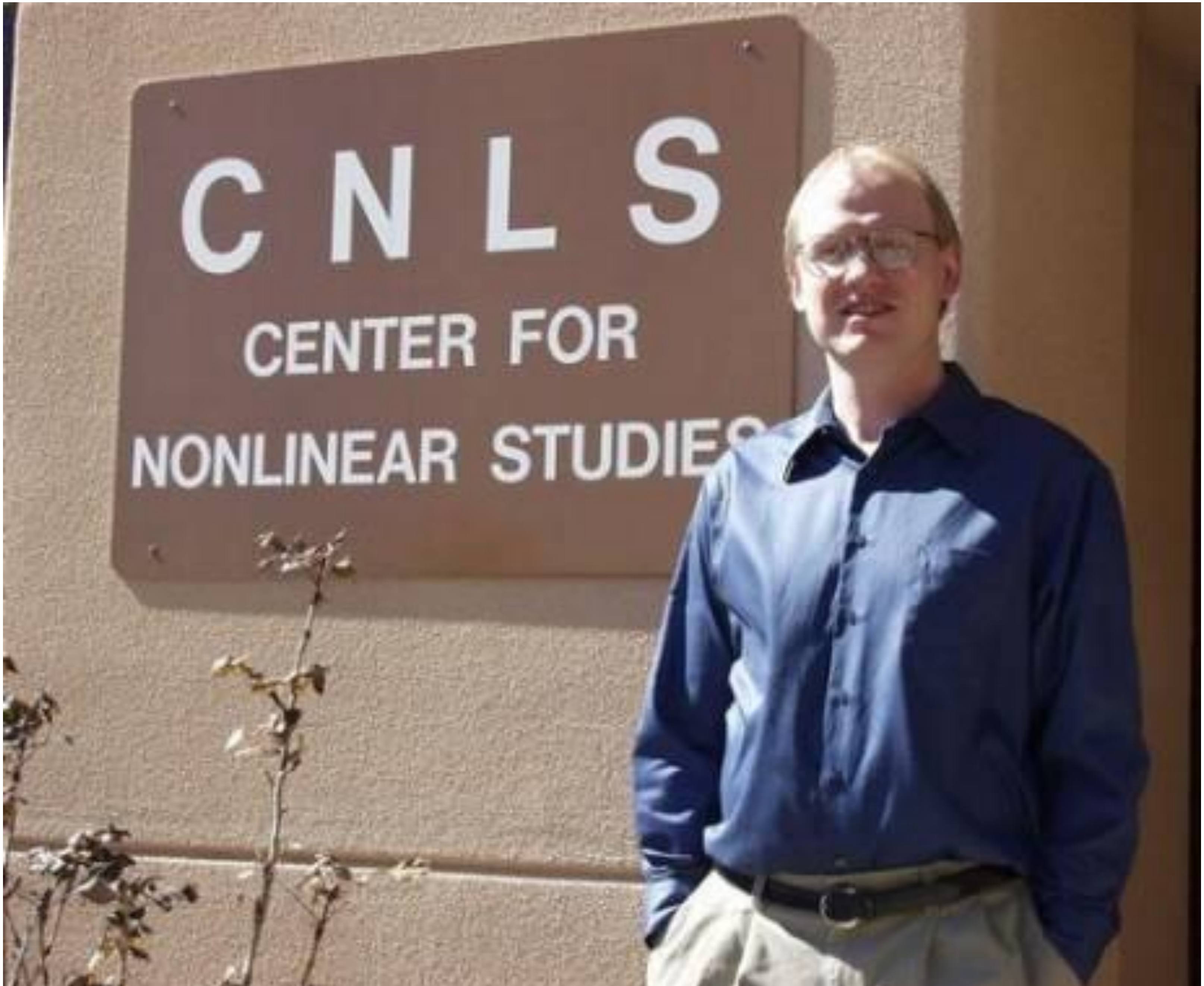
Welcome
— to —
NEW MEXICO
Land of Enchantment

New Mexico – The Heart of the *Sunny* Southwest

Los Alamos National Laboratory, File via AP


CNLS
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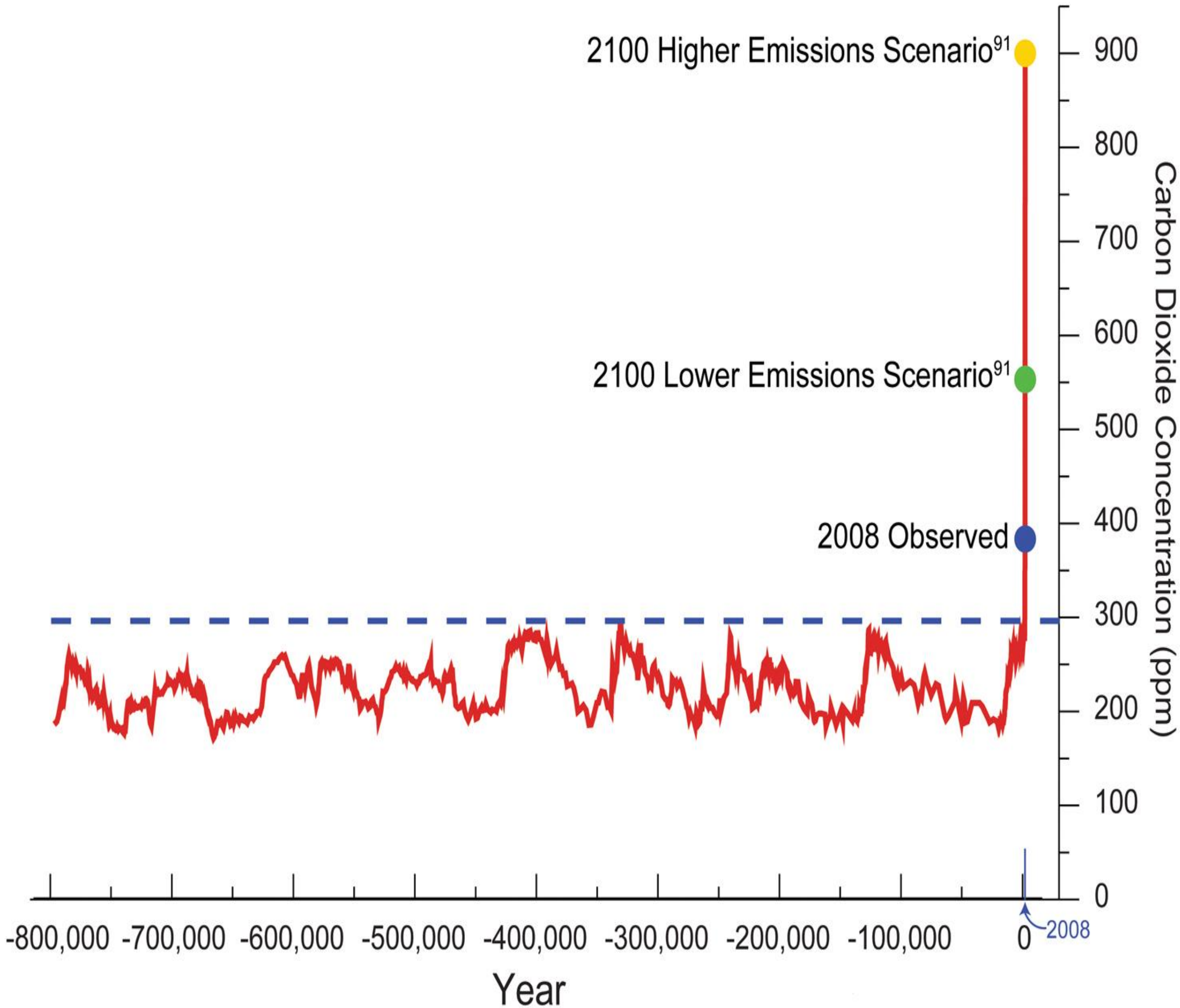
Carbon Dioxide Concentration



Lüthi *et al.*; Tans; IIASA[2]

New Mexico Coalition For Clean Affordable Energy

New Mexico Coalition For Clean Affordable Energy

2004 - Governor Richardson signs the NM Renewable Energy Standard

2006 - Governor Richardson signs the NM Solar Tax Credit

New Mexico Clean Energy Legislation

- State Tax Incentives for Wind
- Renewable Energy Standard
- Solar Tax Credit
- Enhanced Solar Rights
- State Tax Incentives for Concentrating Solar
- Expanded Net-metering
- Feed-in Incentives for PV (RECS buyback program)

Why Compare Renewable Energy Options?

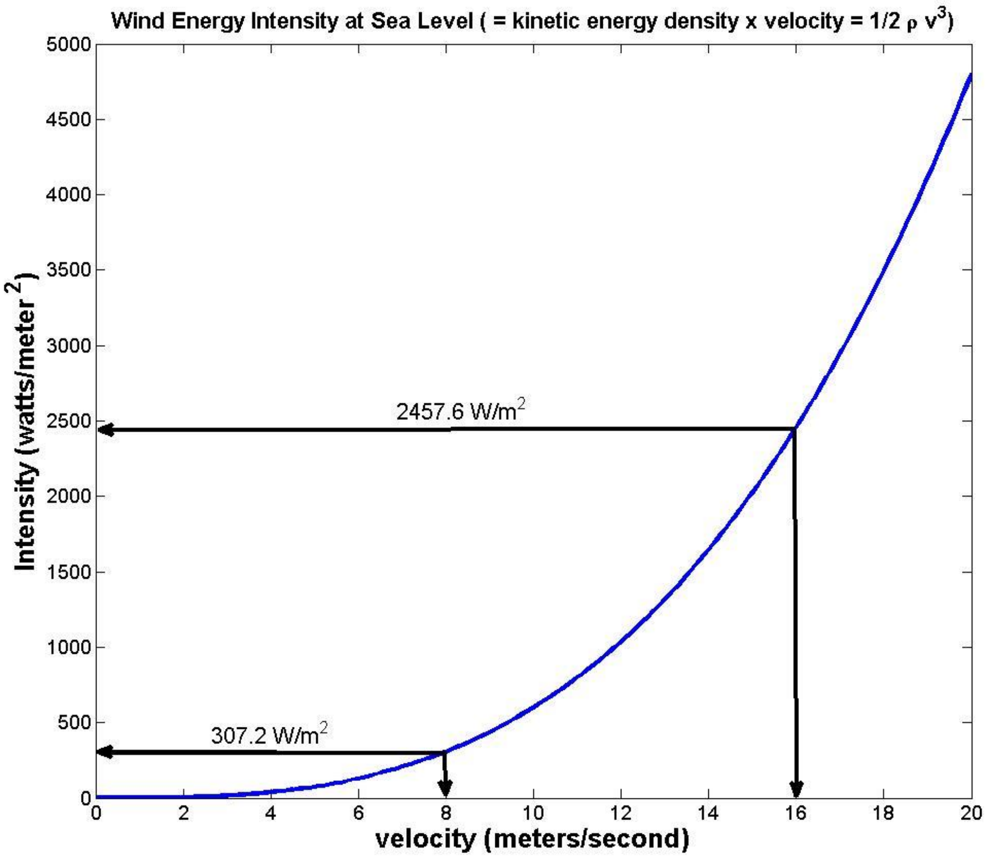
- There are vast differences between resources and technologies in terms of:
  - Resource potentials
  - Costs
  - Impacts to people and the environment
- Money and political will for RE are in meager supply in the US in general:
  - Prioritizing the wrong renewable energy sources is potentially disastrous for efforts to mitigate climate change.

Comparing Wind Power and Solar Power Resources

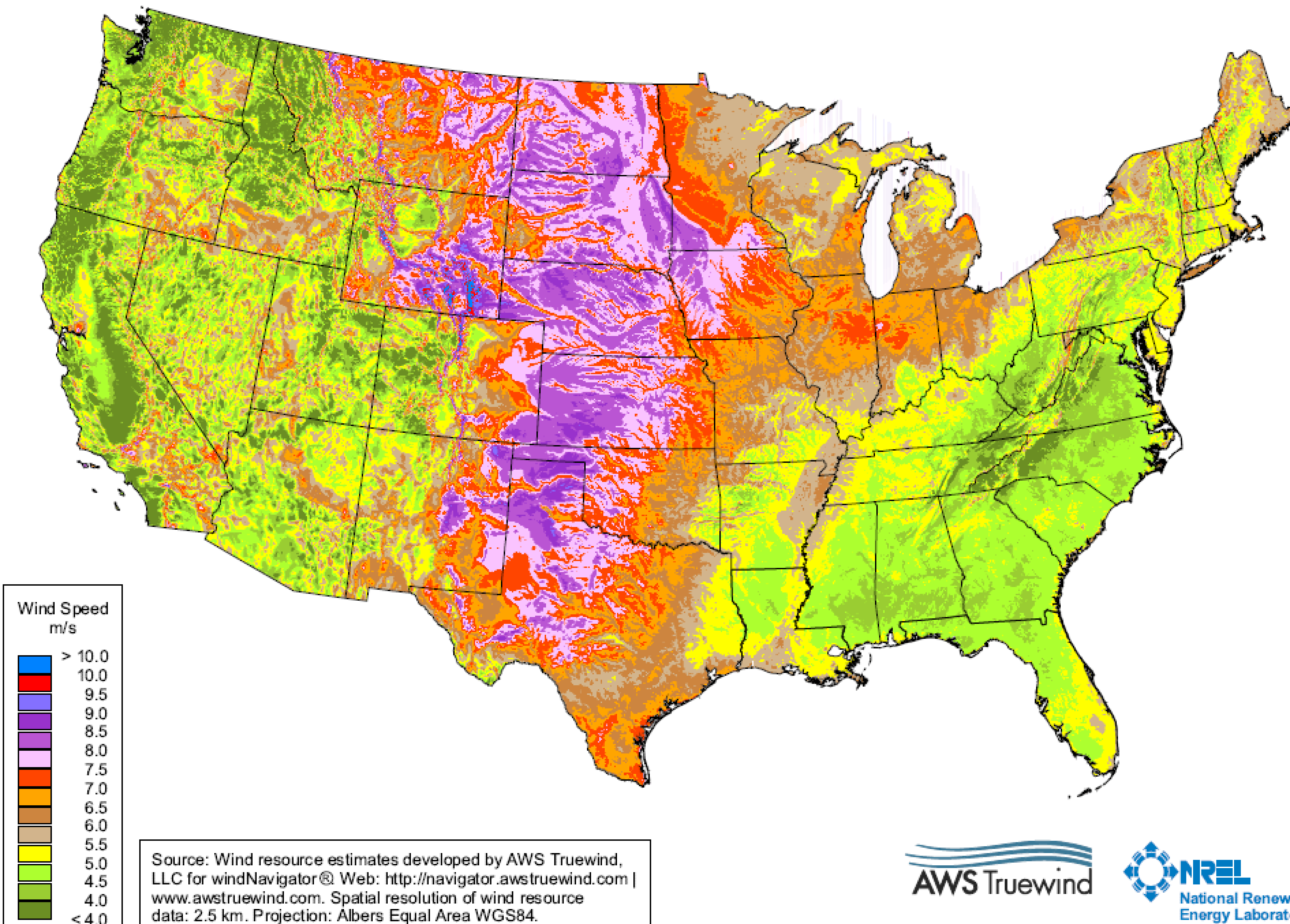
- Use NREL data
- Look Nationally, Eastern US, and Regionally

Wind Energy Physics 101

- Wind power potential is proportional to the ***cube*** of the wind speed:
  - ➢ Power/Area = Kinetic energy density ($\frac{1}{2}\rho$ v^2) x wind speed (v)
  - ➢ Therefore: *2x Speed means 8x Power*
  - ➢ Good Wind Sites Need *Very High* Average Wind Speeds



United States - Annual Average Wind Speed at 80 m



Source: Wind resource estimates developed by AWS Truewind, LLC for windNavigator® Web: http://navigator.awstruewind.com | www.awstruewind.com. Spatial resolution of wind resource data: 2.5 km. Projection: Albers Equal Area WGS84.

AWS Truewind

NREL National Renewa[ble] Energy Laborato[ry]

NREL Solar Resource Estimates: http://www.nrel.gov/docs/fy12osti/51946.pdf

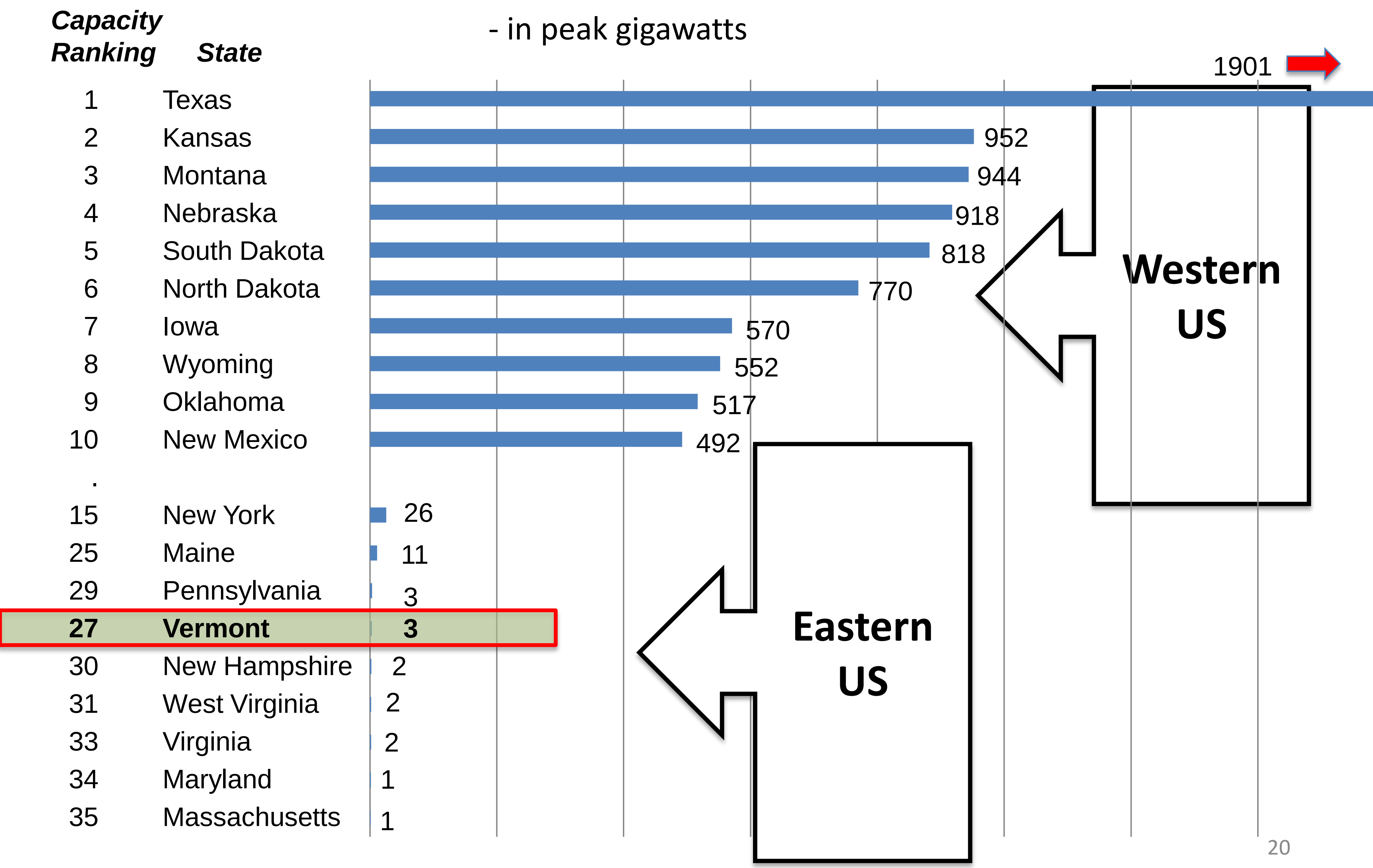
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis

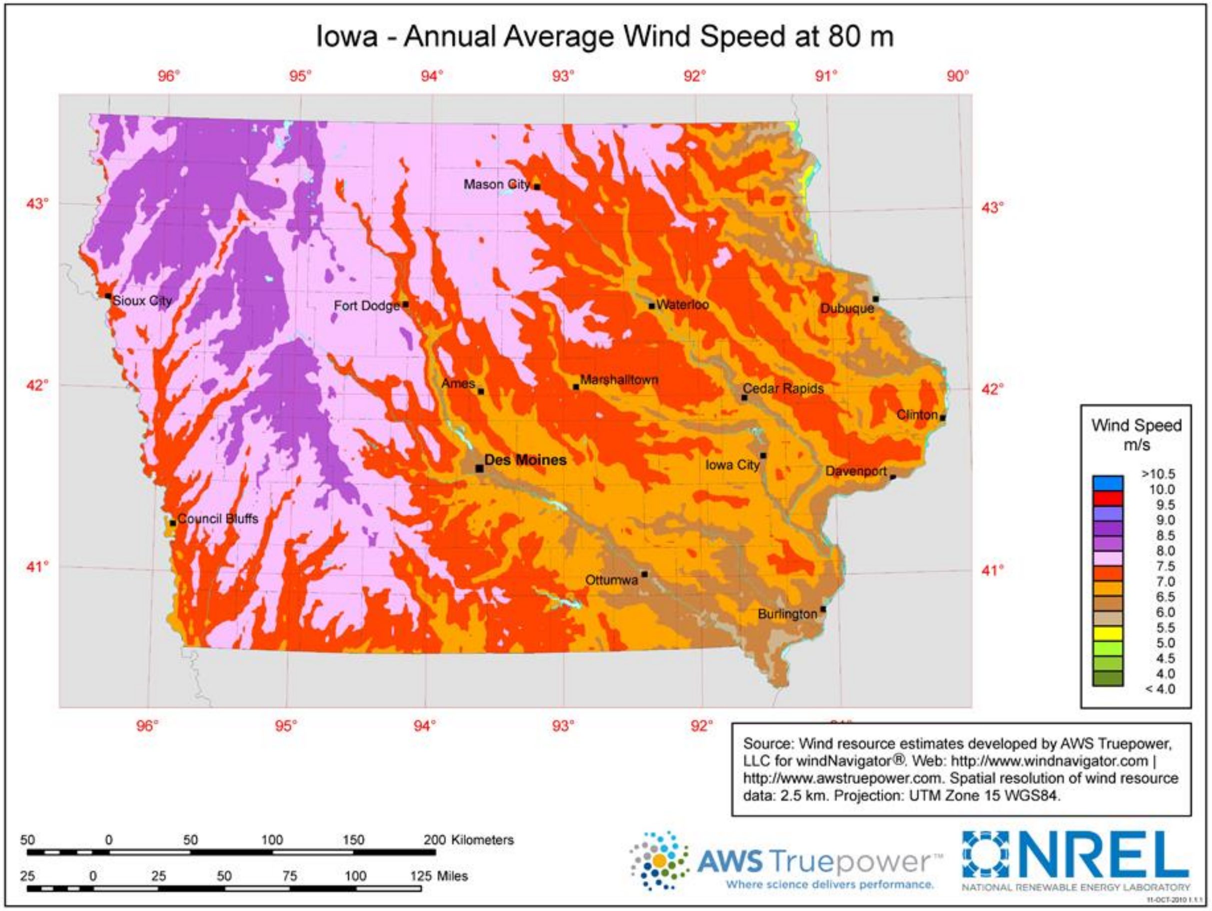
Anthony Lopez, Billy Roberts, Donna Heimiller, Nate Blair, and Gian Porro

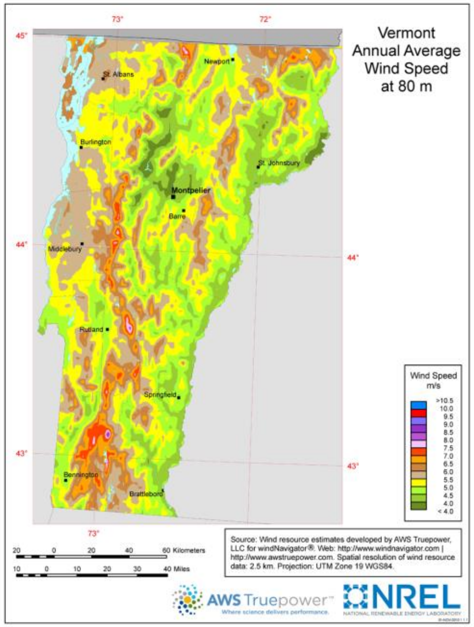
Relative Ranking of State Wind Resources

Source: www.windpoweringamerica.gov (see previous slide)



Iowa vs. New Hampshire





Onshore Eastern Wind Resources

- As estimated by DOE, the wind potential of the best Eastern US states, in peak gigawatts (GW):
  - New York: 26 GW
  - Maine : 11 GW
  - Pennsylvania: 3 GW
  - Vermont: 3 GW
  - New Hampshire: 2 GW
  - Virginia: 2 GW
  - West Virginia: 2 GW
  - Maryland: 1 GW
  - MA: 1 GW
- Total: **51 GW (50% in NY)**

Effective Onshore Wind Power Capacity of the *Entire* Eastern US

- Assume *all* 52 gigawatts are realized
- Effective Wind Capacity: .3*51 GW = 15.3 GW
- Current average US consumption ≈ 470 GW
- **Potential average onshore Eastern wind penetration into *current* US load:**

  (15.3 GW/470 GW) x 100% ≈ 3%
- **Percentage of Eastern Demand ≈ 7%**
- **Real Potential is likely closer to 1%**

These NREL estimates must be considered as gross *upper bounds* on the real onshore wind potential in the East:

Myriad local siting and cost issues were not included:

The real implications of achieving these levels of wind require extensive site-specific study. (NREL should have, but failed, to point this out clearly).

Actual real potential in the Northeast:

~2 gigawatts?

~ 5 gigawatts?

~ 10 gigawatts?

Future NE Wind Targets

- Most discussions of future wind in the NE have not exceeded about 5 GW:
  - About 80 Lowell wind projects

“Capacity Factor” of a Generation Source

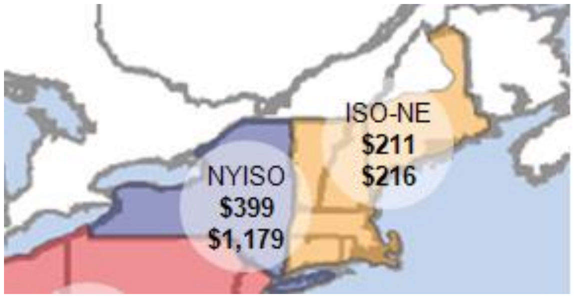
$$\textbf{Capacity Factor} = \frac{\textbf{Actual Annual Energy Produced}}{\textbf{Energy Produced under } \frac{24}{7} \textbf{ Peak Operation}}$$

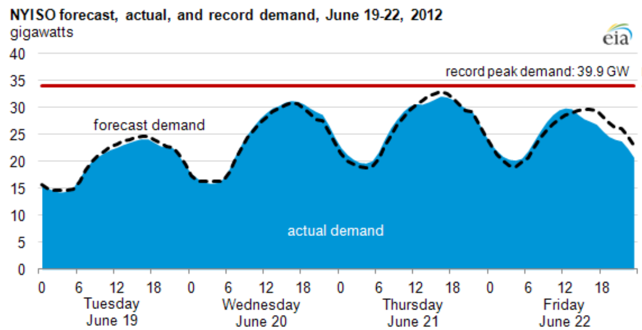
- “Good Wind Sites”: CF > .33
- Actual for Northeast Wind: CF < .25?
  - ➢ *Wind power in the Northeast likely has real capacity factors well below those projected by developers to date.*

- Photovoltaics: CF ~ .14

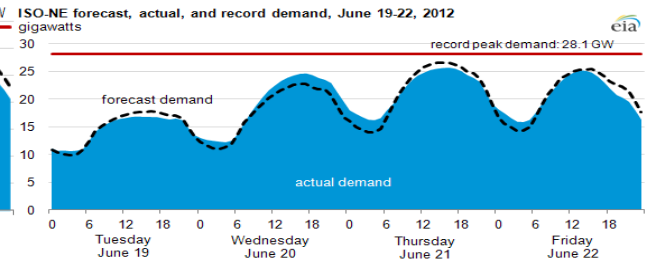
- Other Considerations:
  - Correlation with Seasonal Demand Curve
  - Correlation with Daily Demand Curve
- Solar has a lower capacity factor than wind, but is much better correlated with both the daily and seasonal demand curves.

Fraction of Demand Displaced With 5 Gigawatts of Wind?





40,000 MW (peak)



28,000 MW (peak)

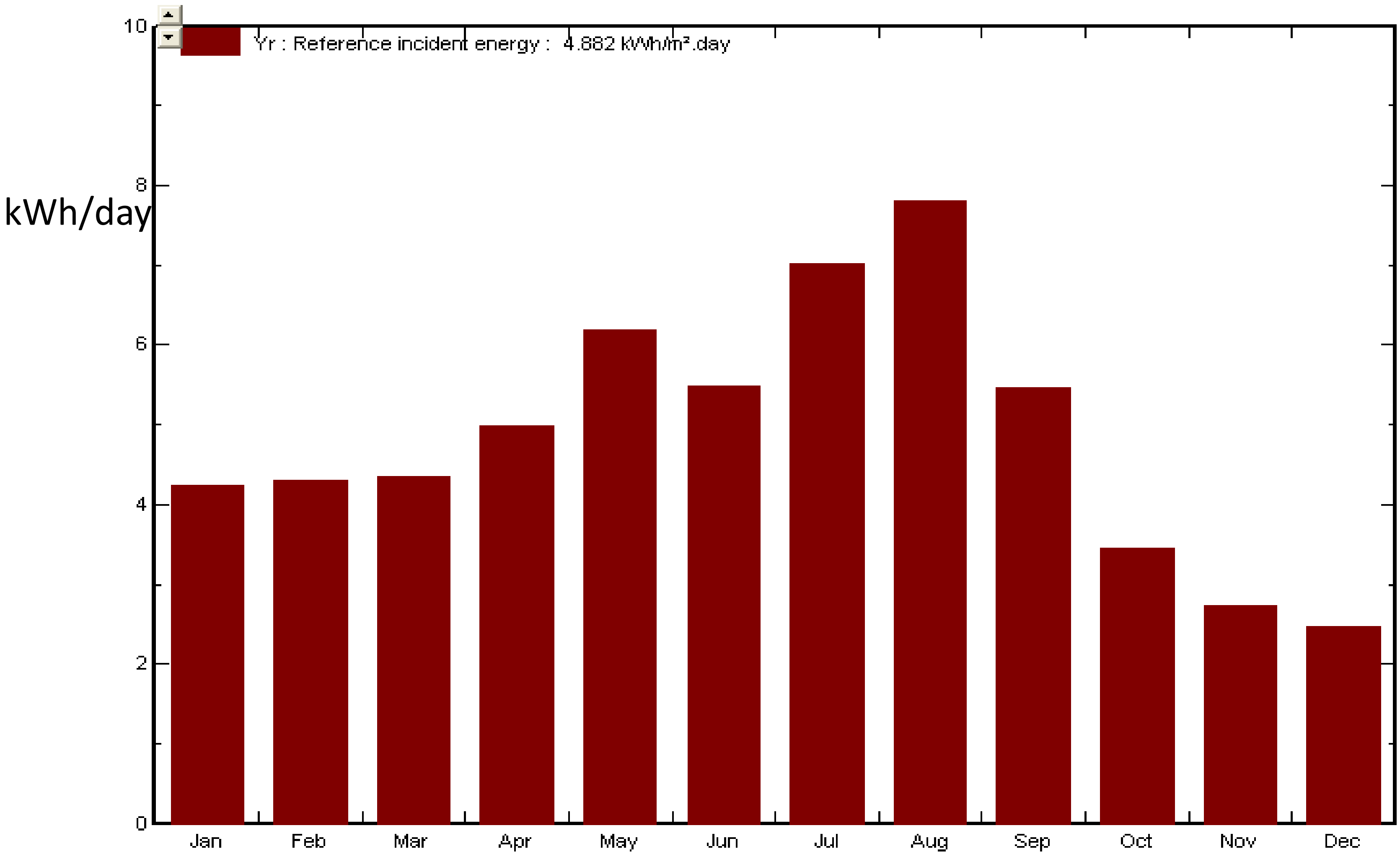
- NREL Data assumes CF ~ .3
- 5 gigawatts x .3= 1.5 gigawatts
    - **Less than 3% of current peak demand**
    - **Less than 6% of average demand**

Data Source: Energy Information Administration, “Today in Energy”, July 12, 2012: http://www.eia.gov/todayinenergy/detail.cfm?id=7070

Conclusions for Ridgeline Wind Power Resources in the Northeast

- Ridgeline wind power cannot even approach being a significant energy source in the Northeast unless the resource is developed to an extreme extent, that is, using most of the high ridges in the region.
- Even with extreme development, its contribution will be modest at best.

The Solar Resource in the Northeast (NREL Solar Insolation for Central VT)



Scale and Flexibility of Solar Resources

- The usable solar resource is extremely large, partially because the raw resource exists everywhere, and partially because the technology is completely scalable.

-10 kw Rooftop Scale

1-10 kw Backyard Scale

10 kw – MW Scale


Multi-Megawatt Scale

Onshore Eastern *Rooftop* Solar Resources

- As estimated by DOE:
  - Alabama 13 GW
  - Connecticut 6 GW
  - Delaware 2 GW
  - Dist. of Col. 2 GW
  - Florida 49 GW
  - Georgia 25 GW
  - Kentucky 11 GW
  - Louisiana 12 GW
  - Maine 2 GW
  - Maryland 13 GW
  - Massachusetts 10 GW
  - Missouri 13 GW
  - New Hampshire: 2 GW
  - New Jersey 14 GW
  - New York 25 GW
  - North Carolina 23 GW
  - Ohio 27 GW
  - Pennsylvania 20 GW
  - Rhode Island 2 GW
  - South Carolina 12 GW
  - Tennessee 16 GW
  - Vermont 1 GW
  - Virginia 19 GW
  - West Virginia 4 GW
- Total: **323 GW**

Even just rooftop solar potential greatly exceeds onshore wind potential in the Eastern US.

Onshore wind in the Southeast is also completely negligible.

Onshore Eastern *Urban Utility-Scale* Solar Resources

- As estimated by DOE:
  - Alabama 20 GW
  - Connecticut 5 GW
  - Delaware 9 GW
  - Dist. of Col. 0 GW
  - Florida 40 GW
  - Georgia 24 GW
  - Kentucky 16 GW
  - Louisiana 32 GW
  - Maine 2 GW
  - Maryland 18 GW
  - Massachusetts 11 GW
  - Missouri 18 GW
  - New Hampshire: 2 GW
  - New Jersey 25 GW
  - New York 33 GW
  - North Carolina 38 GW
  - Ohio 57 GW
  - Pennsylvania 36 GW
  - Rhode Island 1 GW
  - South Carolina 19 GW
  - Tennessee 29 GW
  - Vermont 1 GW
  - Virginia 16 GW
  - West Virginia 2 GW
- Total: **434 GW**

Onshore Eastern *Rural Utility-Scale* Solar Resources

- As estimated by DOE:
  - Alabama 2115 GW
  - Connecticut 12 GW
  - Delaware 167 GW
  - Dist. of Col. 0 GW
  - Florida 2813 GW
  - Georgia 3088 GW
  - Kentucky 1119 GW
  - Louisiana 2394 GW
  - Maine 659 GW
  - Maryland 373 GW
  - Massachusetts 52 GW
  - Missouri 3157 GW
  - New Hampshire: 36 GW
  - New Jersey 251 GW
  - New York 926 GW
  - North Carolina 2347 GW
  - Ohio 2396
  - Pennsylvania 357 GW
  - Rhode Island 9 GW
  - South Carolina 1555 GW
  - Tennessee 1267 GW
  - Vermont 35 GW
  - Virginia 19 GW
  - West Virginia 4 GW
- Total: **25,151 GW**

Solar as a whole utterly dwarfs wind potential in the Eastern US.

Northeast Solar Resources: Rooftop + Urban + Rural

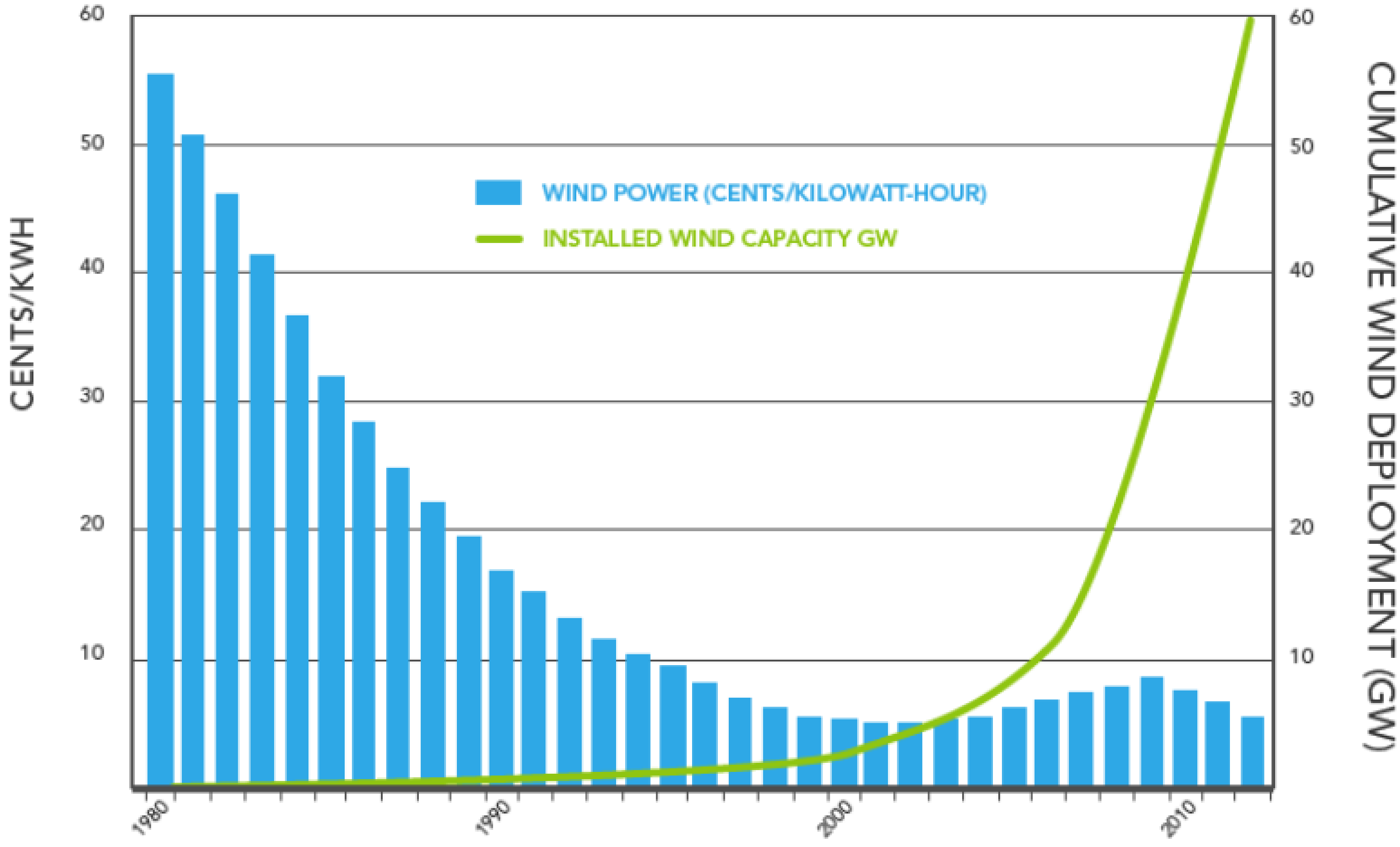
- As estimated by DOE:
  - Maine 2 + 2 + 659 GW
  - Massachusetts 10 + 11 + 52 GW
  - New Hampshire: 2 + 2 + 36 GW
  - New Jersey 14 + 25 + 251 GW
  - New York 25+ 33 + 926 GW
  - Pennsylvania 20+ 36 + 357 GW
  - Rhode Island 2+ 1 + 9 GW
  - Vermont 1+ 1 + 35 GW
- Total: 2512 **GW**
- **Even at a 10% capacity factor, this is equivalent to more than 250 GW of conventional capacity.**

Solar utterly dwarfs wind potential in the NE as well.

Even just rooftop solar potential in the NE (76 GW) significantly exceeds the likely onshore wind potential in the NE.

The Economics of Wind and Solar

Cost Trend of Wind Power (Nationally)



Solar Power Cost Trend

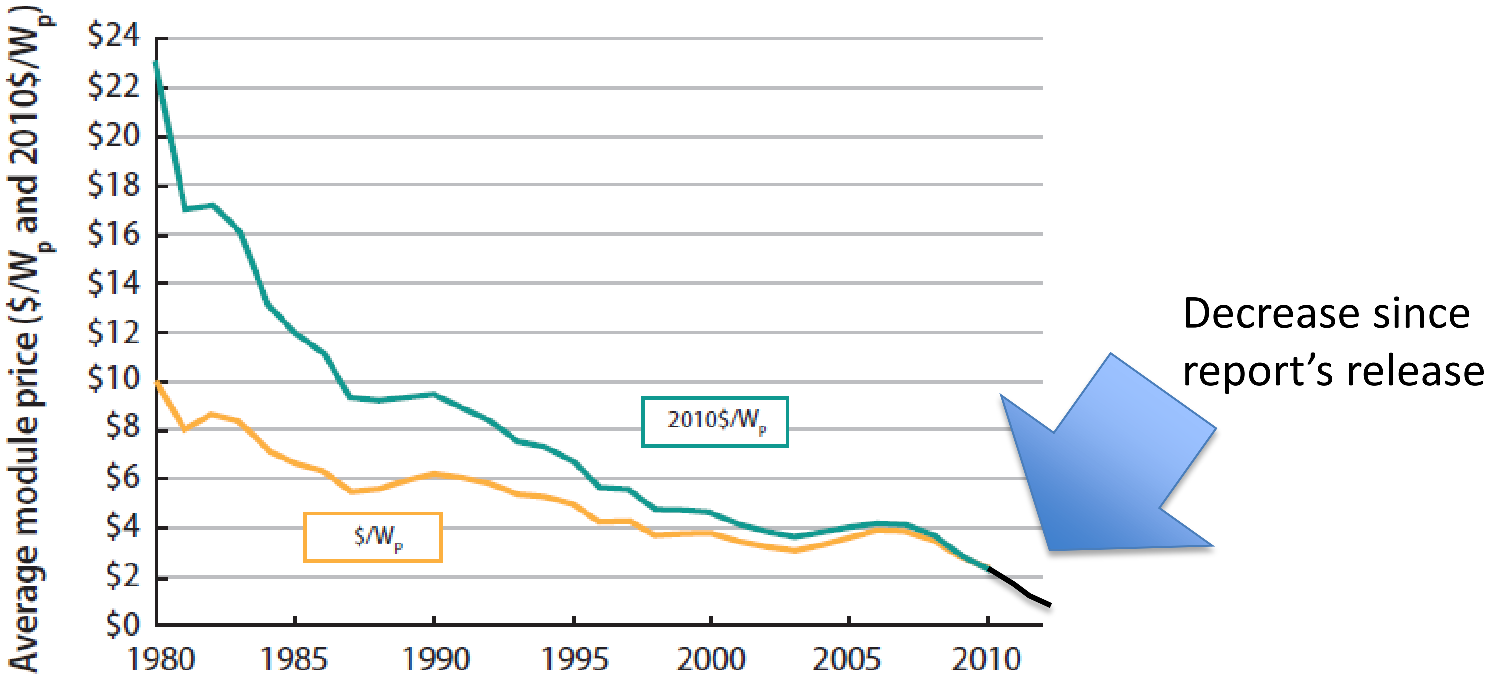
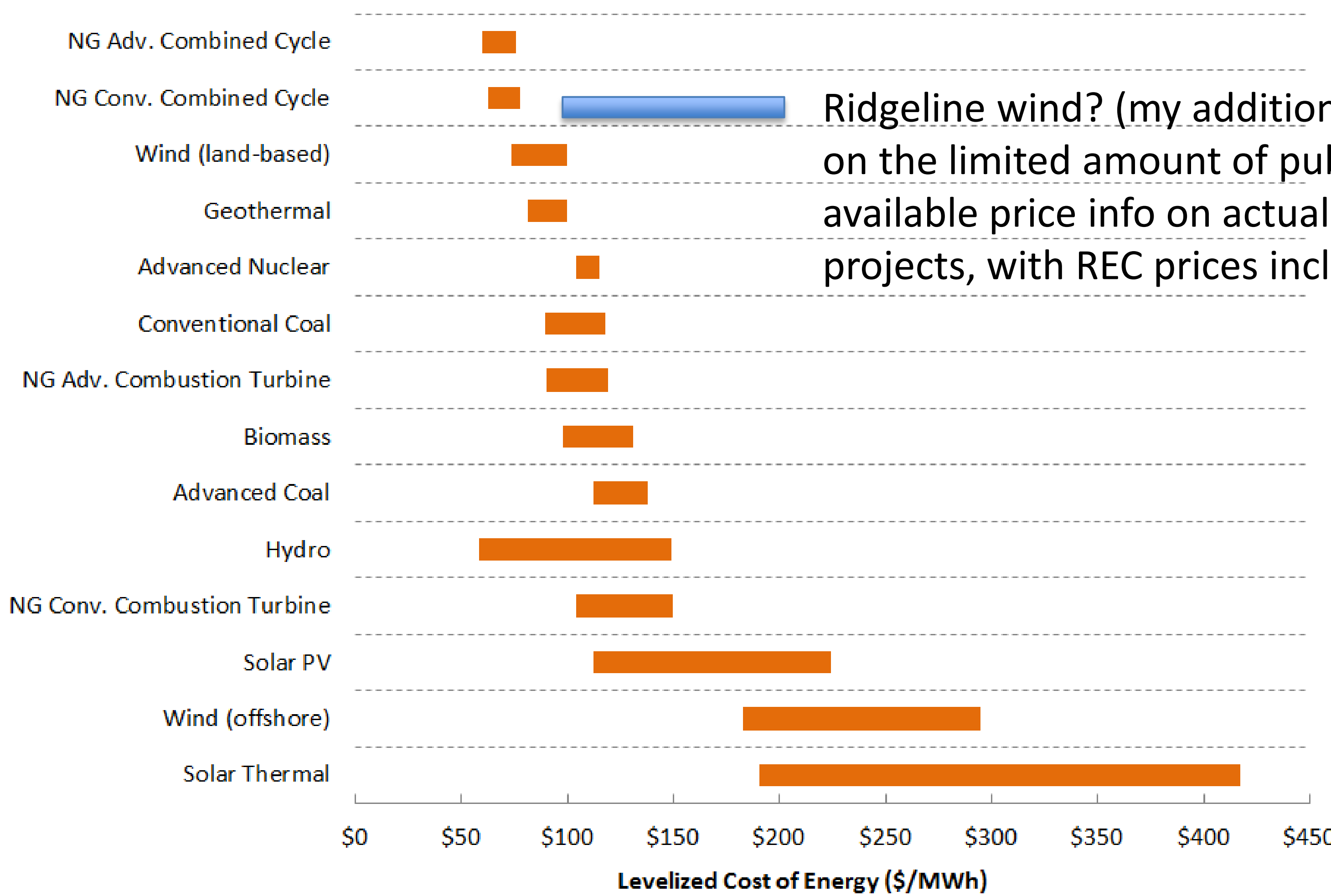


Figure 3.7 Global, average PV module prices, all PV technologies, 1984-2010 (Mints 2011)

- Department of Energy's Solar Technologies Market Report
- http://www.nrel.gov/docs/fy12osti/51847.pdf

Data Source: EIA, Levelized Cost of New Generation Resources in the Annual Energy Outlook 2013 (as quoted on AWEA's website)



Ridgeline wind? (my addition, based on the limited amount of publicly available price info on actual NE projects, with REC prices included)

Additional Transmission Costs for Eastern Wind Power

- The Northeast Grid is already fairly congested
- According to Gordon van Welie, president and chief executive officer of ISO New England Inc: **"A conservative goal for 5,500 megawatts of wind power and 3,000 megawatts of hydro power through 2030 would carry transmission costs of between $7 billion and $12 billion."**
  – From: "New England grid chief: Cooperate on wind power", by David Sharp, Associated Press Writer, August 16, 2010.
- **4000+ miles of new transmission lines**

Summary of Wind vs. Solar Cost

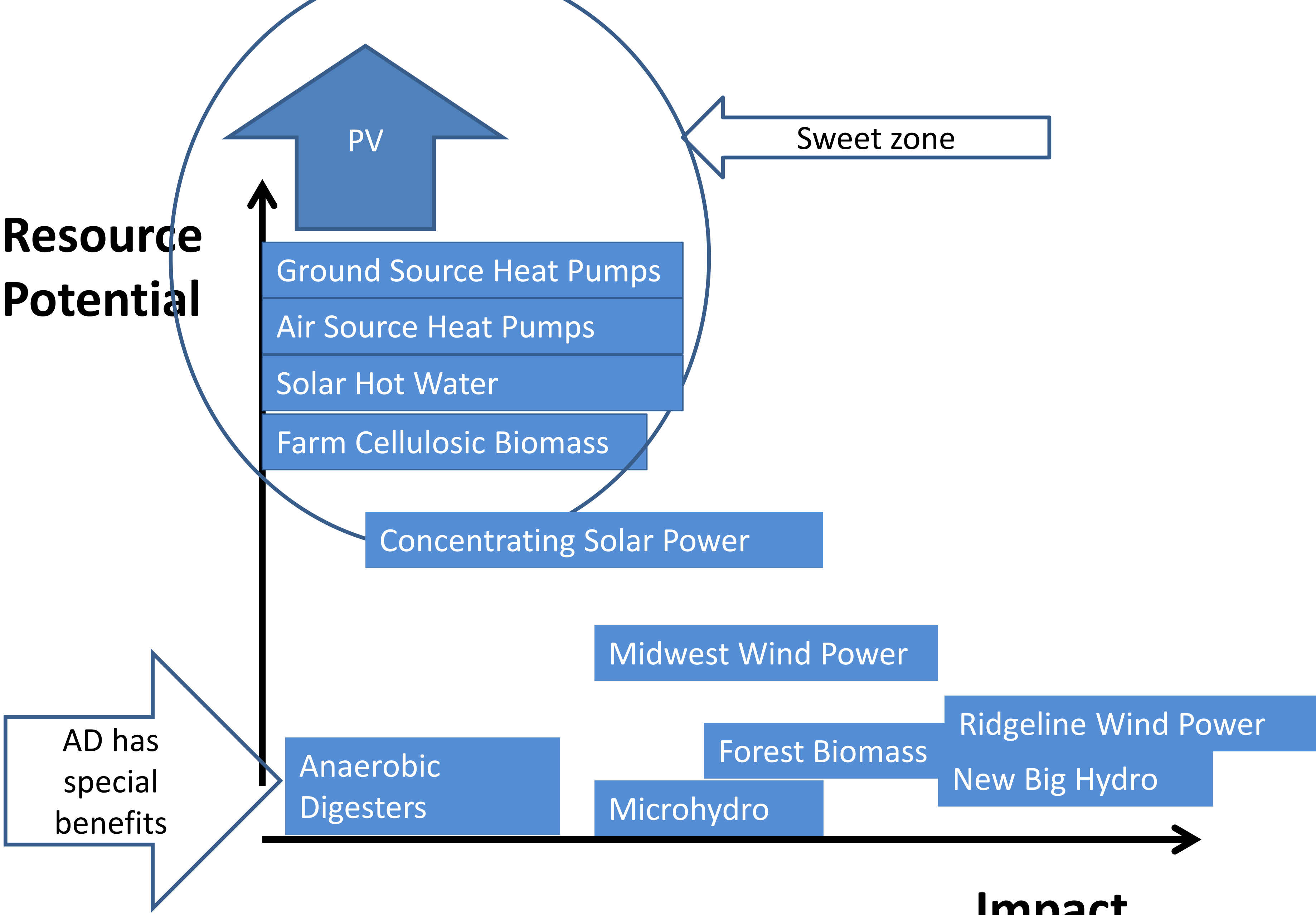
- Costs of solar and ridgeline wind are now roughly in the same ballpark, assuming transmission costs for wind are minimal.
- If transmission costs for a large build-out of wind are included, its difficult to see how wind could be competitive with solar.
- Solar technology is potentially much more susceptible to price reduction through innovation and manufacturing scale up.

Impact Summary

- Topographical Impacts
- Hydrological Impacts
- Habitat Fragmentation & Loss
- Impacts to birds and bats
- Noise Impacts
- Aesthetic Impacts:
  - Ecotourism, etc
  - Environmental valuing of the region
- Impacts to the Social Fabric of local communities
- Implications for the effectiveness of and public support for renewable energy investments

Overall Conclusions

- There is no justification from either a resource or economic point of view to install ridgeline wind projects for the sake of mitigating climate change.
- Continued large investment in ridgeline wind in the Northeast will likely cripple the near-term investment in, and long-term success, of much more viable solutions.


PV
Sweet zone
Resource Potential
Ground Source Heat Pumps
Air Source Heat Pumps
Solar Hot Water
Farm Cellulosic Biomass
Concentrating Solar Power
Midwest Wind Power
Ridgeline Wind Power
Forest Biomass
New Big Hydro
AD has special benefits
Anaerobic Digesters
Microhydro
Impact