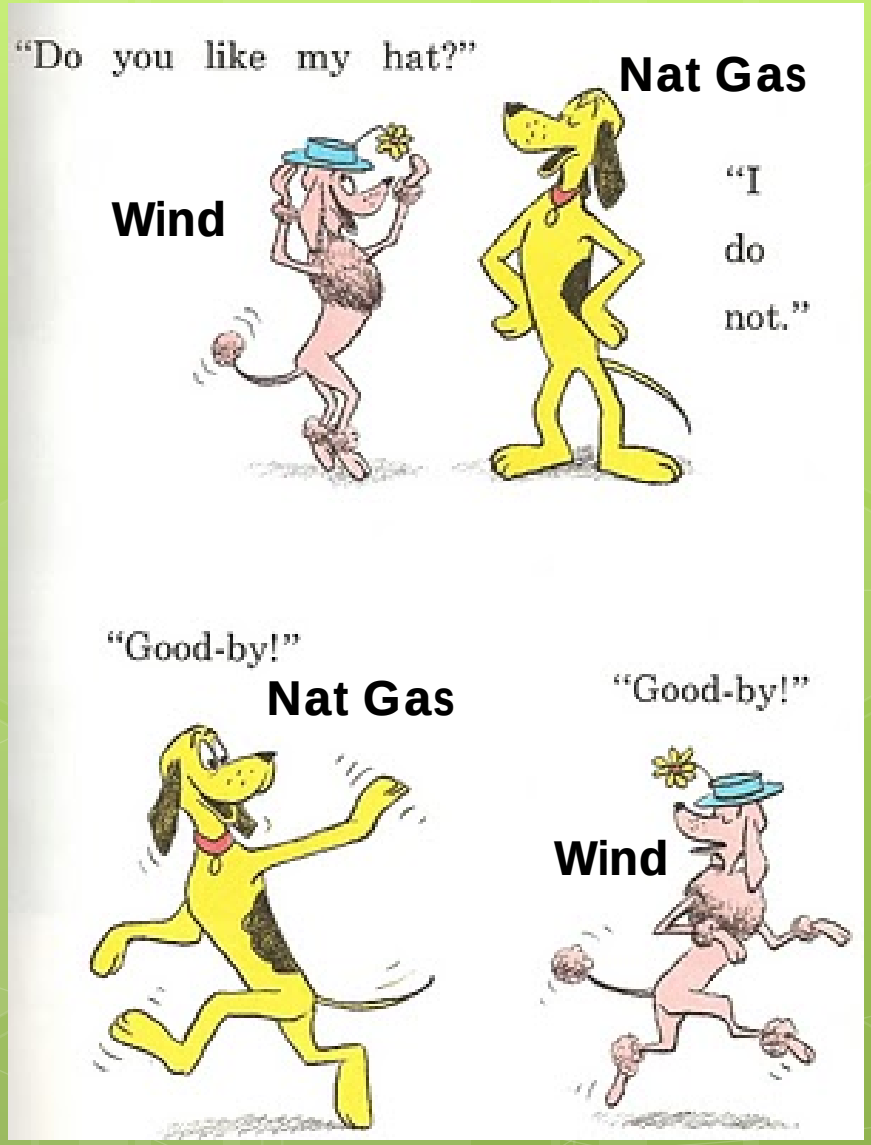
Sunrise at the Cimarron II Wind Farm, Kansas



Wind Energy, Grid Parity, and Strategic Links to Natural Gas

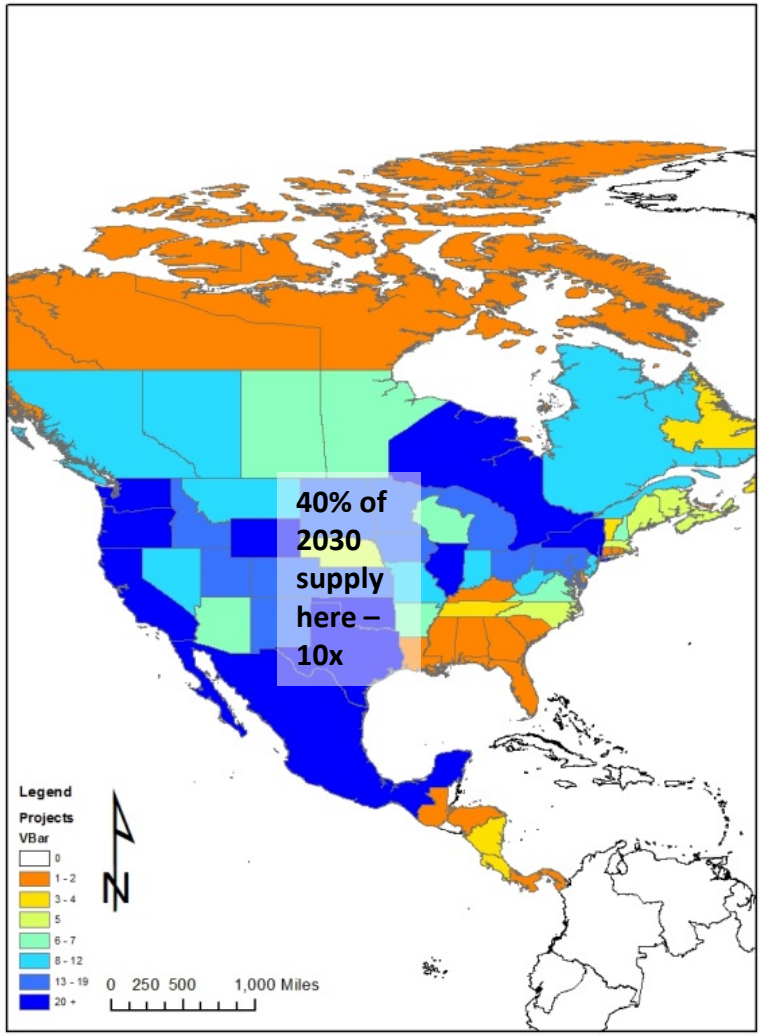
Gregory S. Poulos
Managing Director
V-Bar, LLC
11 March 2015

Introduction

- V-Bar is a small company that has been providing complete meteorological and wind resource assessment support to the global wind energy industry since 1977.
- Sited 20,000 MW of operating turbines globally
- Currently providing analysis for over 30,000 MW of projects under development (small amount of solar)
- 10's of development projects in Wyoming, > 5,000 MW
- > 400 clients worldwide since 2006
- Analyzed wind resource data from 25% of all operating wind turbines in the U.S.

Experience

- V-Bar has worked on hundreds of projects across North America in 36 years
- Wind resource assessment experience in every continent except Antarctica
- An in-house study shows that 40% of the U.S. 2030 projected electricity needs could be inexpensively supplied between the Mississippi River and the Rockies using 1% of the land area.



Main Points

- Wind energy and natural gas can blend collaboratively to create a reliable and reliably low-priced U.S. electricity supply:
  - ***Natural gas generated electricity*** output can be controlled, ramps rapidly to match the electrical load and causes less air pollution than other fossil sources, but has a volatile fuel price, and uses water.
  - ***Wind generated electricity*** has a steady and now low price due to its free fuel, uses no water, and does not pollute air, but has variable, wind-dependent electricity production at each wind energy power plant.
- The global wind industry is robust even if the U.S. is not always: engineering feats will continue to drive wind cost-of-energy (COE) reductions.
- More evenly combined wind and natural gas electricity generation would be reliable, with globally competitive pricing, while preserving water, reducing air pollution, and using local resources.

Electricity and Generation Statistics

Total Electricity Generation in %: Trends 2003 to 2014

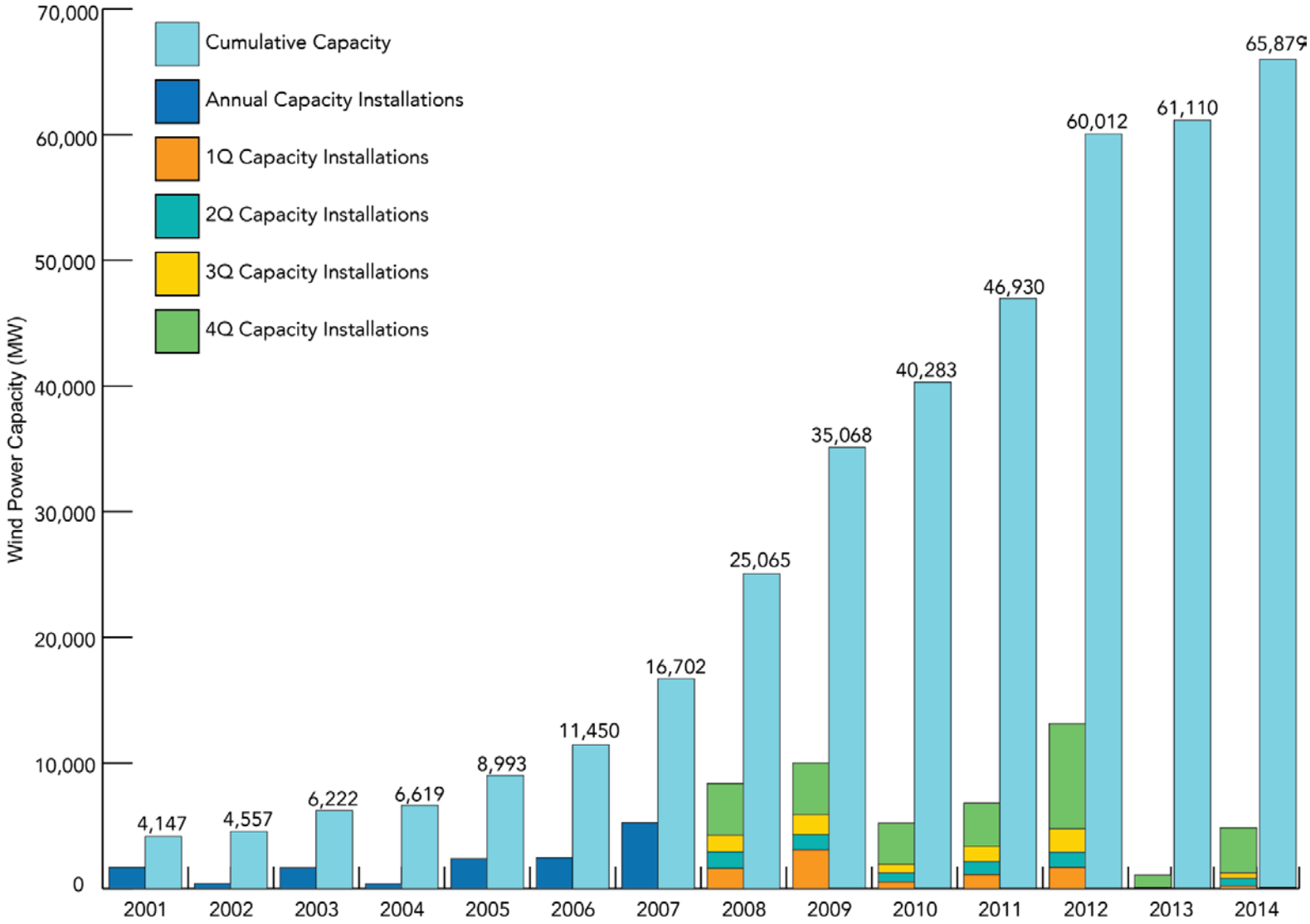
- Coal 51% down to 39%
- Natural Gas 17% up to 28%
- Wind 0.3% up to 4.5% (15x)

NG & Wind up from 17% to 33%, nearly 2x

- Solar* and Oil-fired, small contributions
- Nuclear and Hydro near constant %

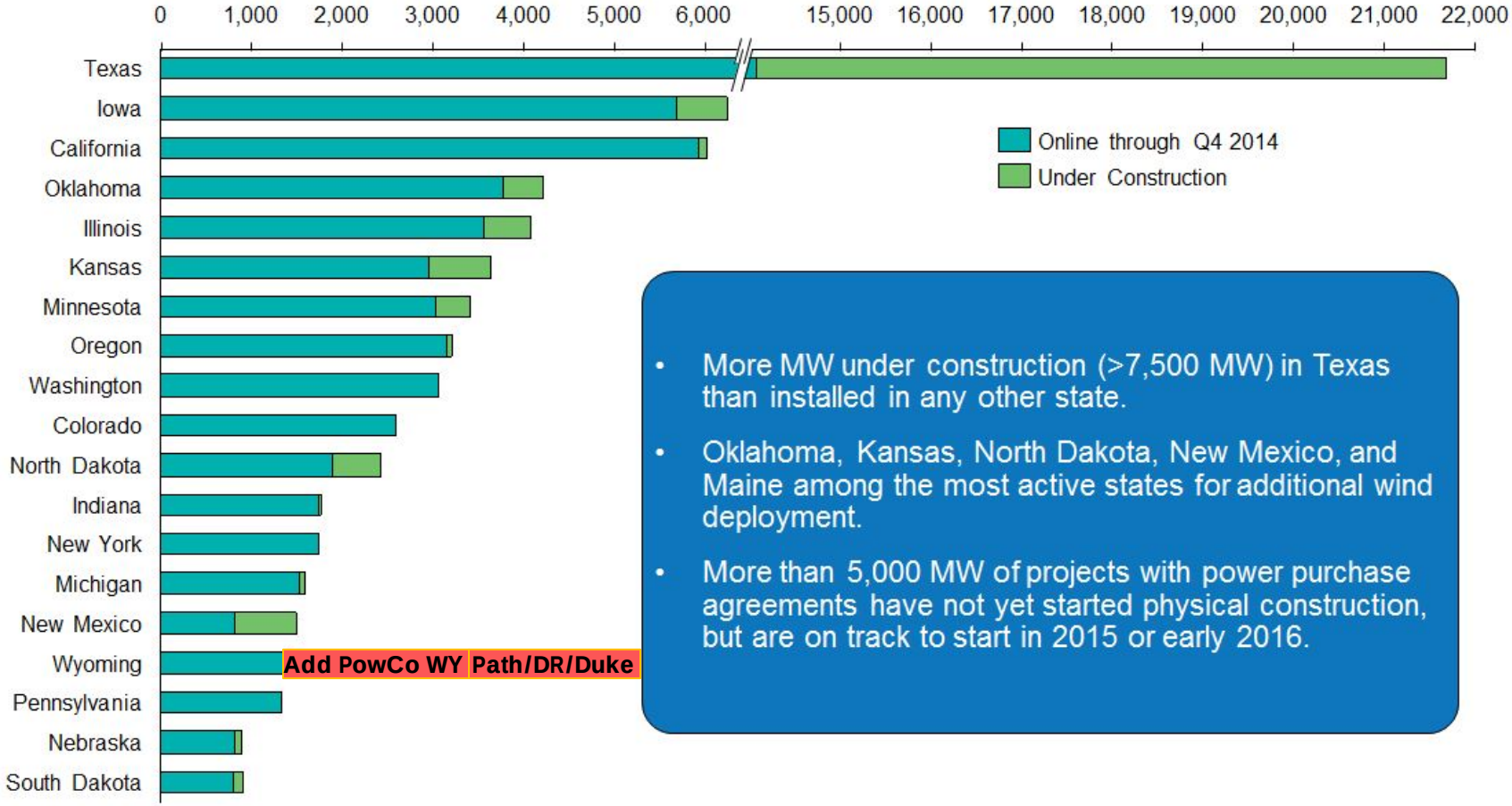
* now growing rapidly

U. S. Wind Energy Installations by Year



Top States for Wind Energy Through 2014

Texas, which gets 10% of its electricity from wind energy, is set to at least double soon due to CREZ transmission lines



- More MW under construction (>7,500 MW) in Texas than installed in any other state.
- Oklahoma, Kansas, North Dakota, New Mexico, and Maine among the most active states for additional wind deployment.
- More than 5,000 MW of projects with power purchase agreements have not yet started physical construction, but are on track to start in 2015 or early 2016.

Source: AWEA U.S. Wind Industry Fourth Quarter 2014 Market Report

Wind Energy Market

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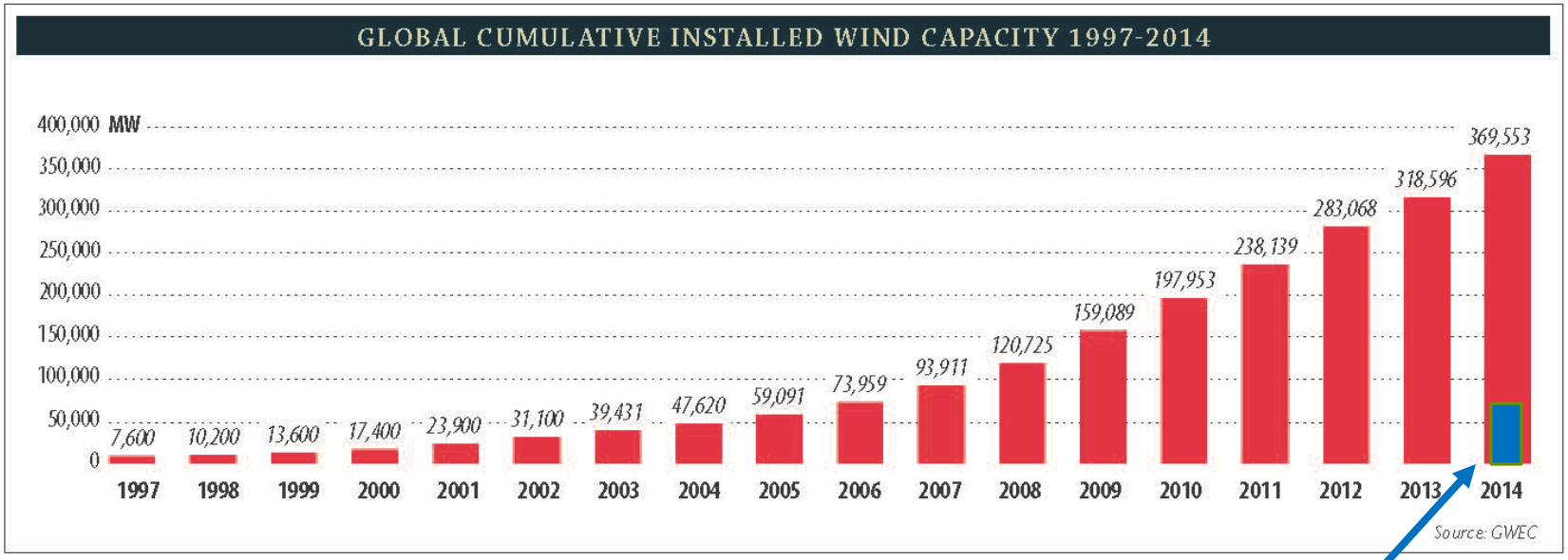
- Global annual growth is 10-15%, 44% in 2014
- U.S. is flaky
- Fast-growing: Brazil, Latin America, S. Africa, India, China, Japan, Eastern Europe
- Due to global volume and business growth capital and engineering improvements will flow to the wind sector resulting in large efficiency gains

Global Growth of Wind Capacity since 1997

Nearly 4% of global electricity production is expected to be from wind energy in 2015.



U. S. portion ~66,000 MW

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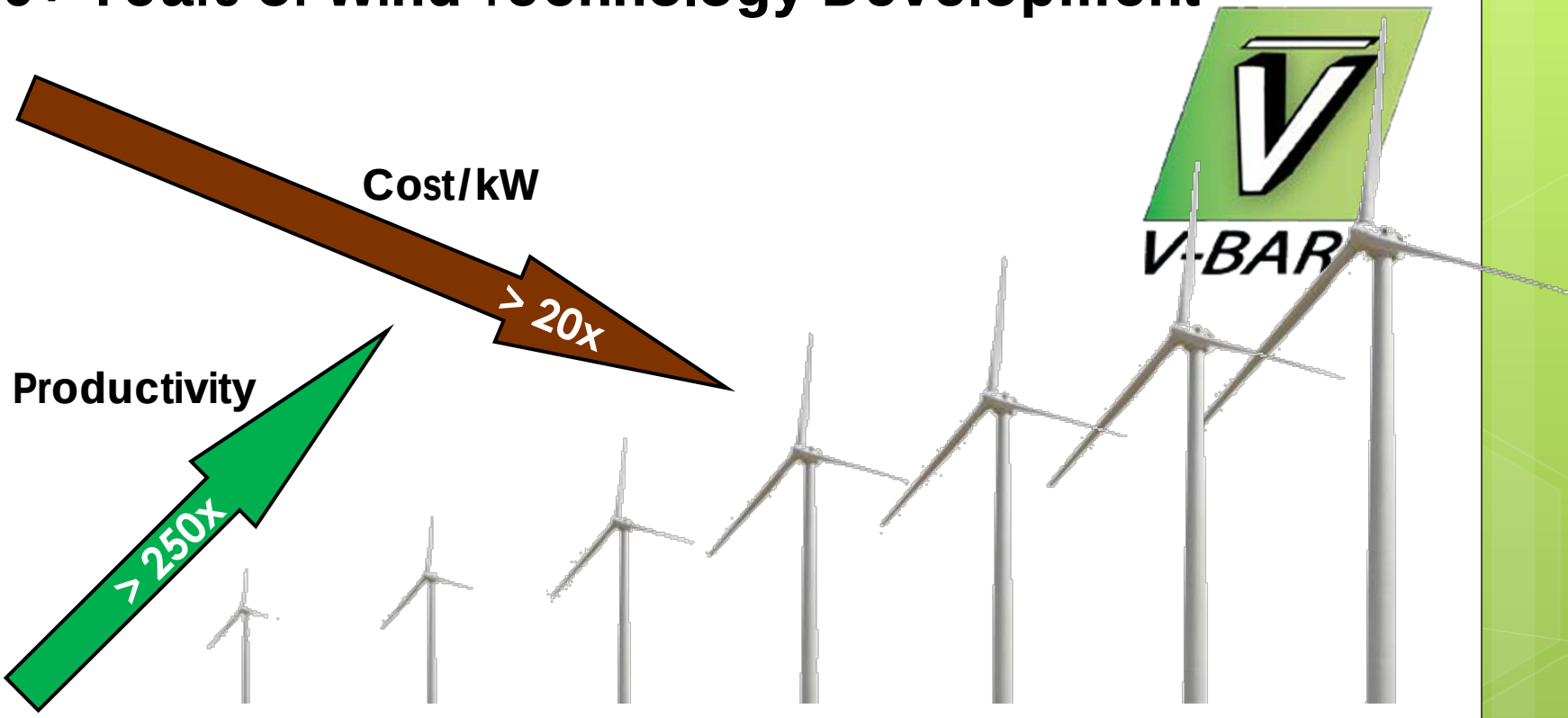
Cost of Energy Trends

Natural Gas and Wind

30+ Years of Wind Technology Development

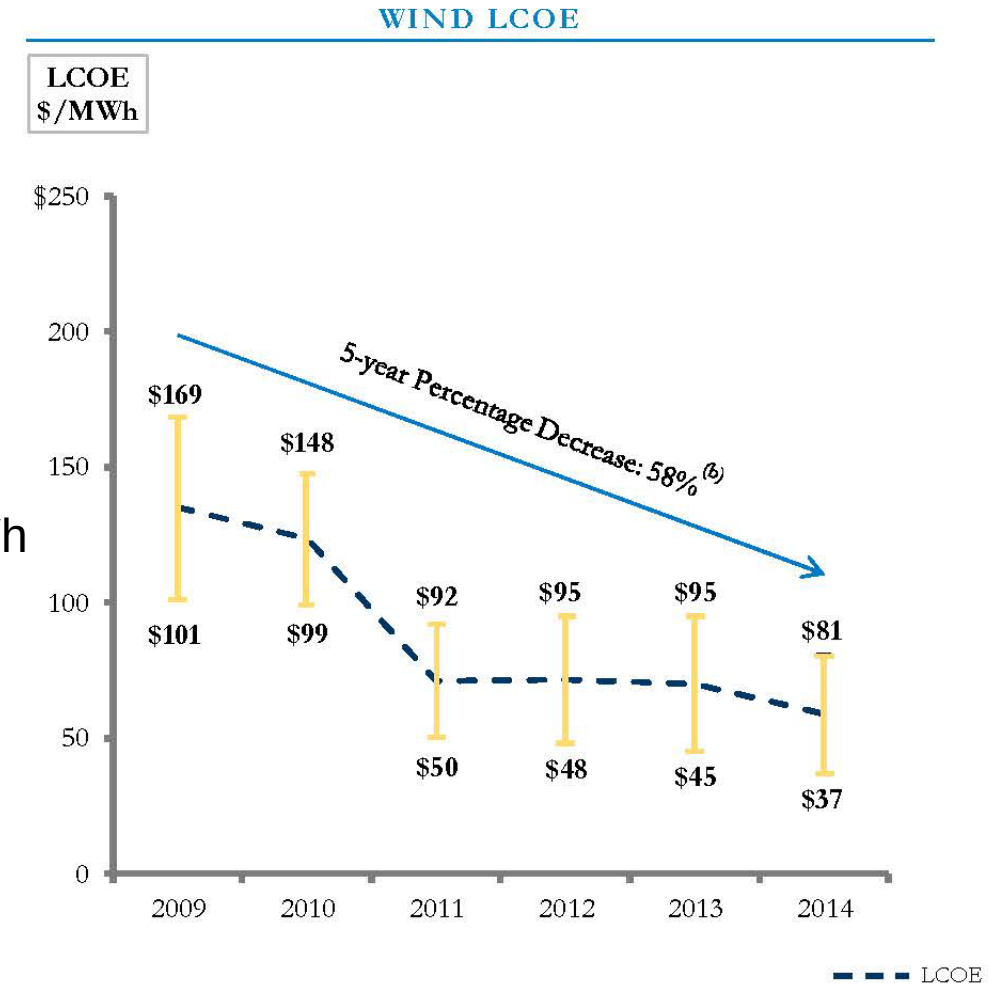


	1981	1985	1996	1999	2002	2007	2015
Rotor (m)	10	17	40	50	76	95	125
kW	25	100	550	750	1500	2500	3000+
MWh/yr	50	200	1500	2200	5600	8000	13000+
% increase		400%	750%	45%	250%	45%	60%

Levelized Cost of Energy—Wind (Historical)

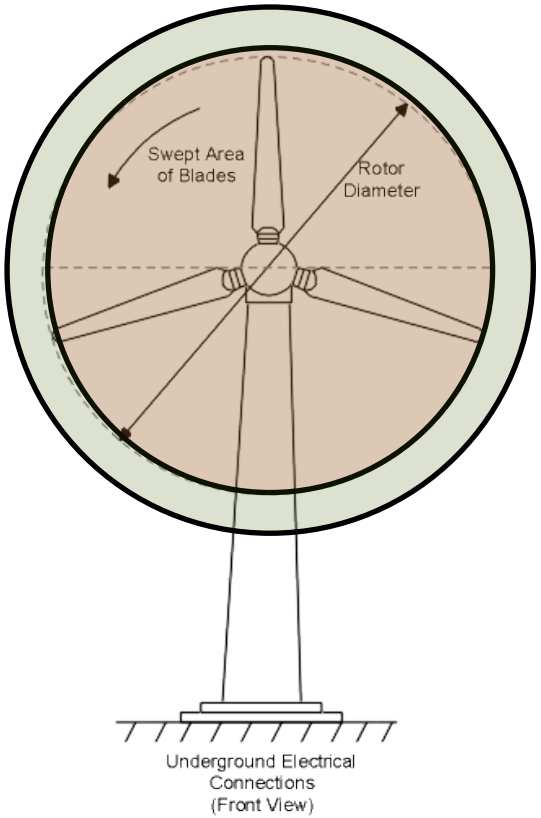
Over the last five years, wind and solar PV have become increasingly cost-competitive with conventional generation technologies, on an unsubsidized basis, in light of material declines in the pricing of system components (e.g., panels, inverters, racking, turbines, etc.), and dramatic improvements in efficiency, among other factors

Unsubsidized Wind Energy COE in $/MWh

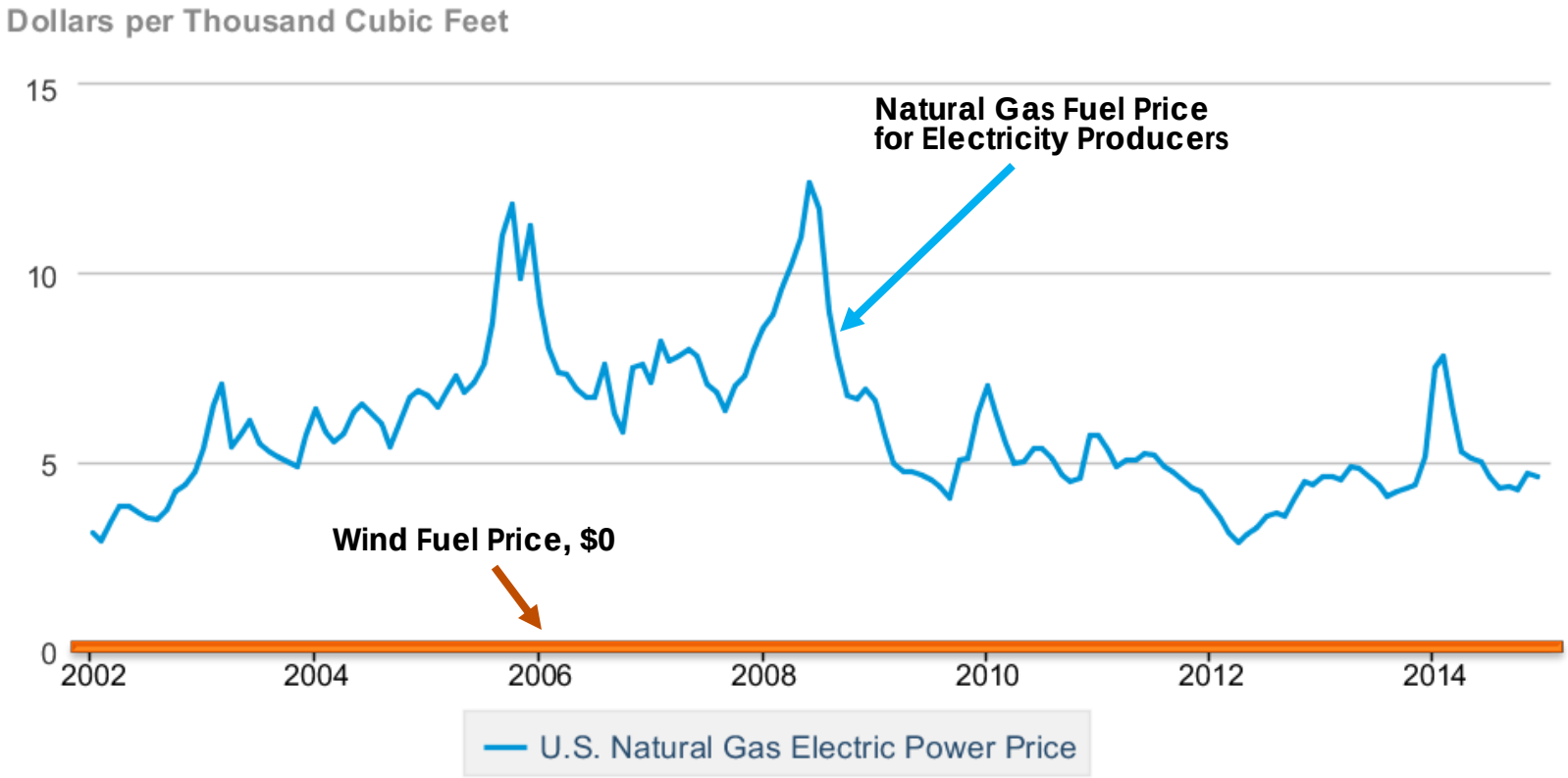


How much more improvement can be made?

- By increasing hub height from 80 to 100 m net energy production can increase 5-8%.
- By increasing blade length from 50 m to 60 m, net energy production can increase 9-15%.
- Both of these things are happening right now.
- 120 m hub and 70 m blades already exist.

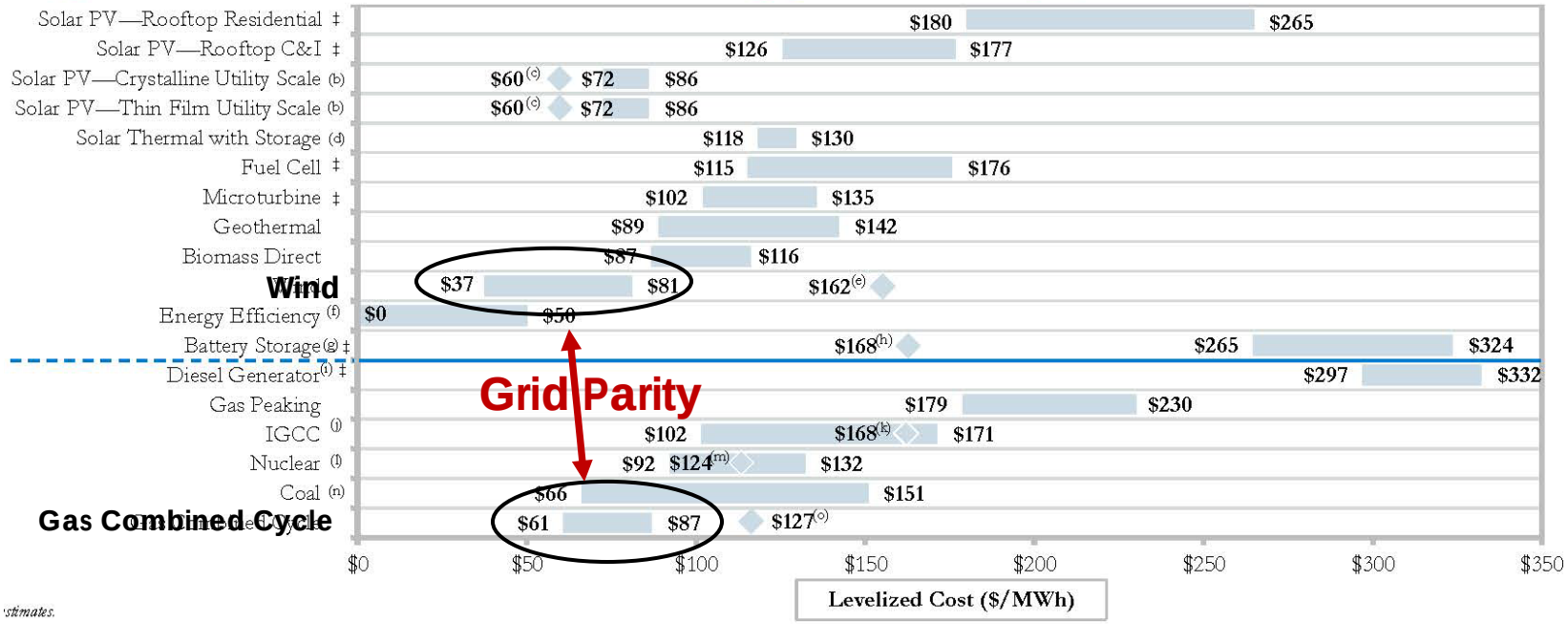


U.S. Natural Gas Electric Power Price



Source: U.S. Energy Information Administration

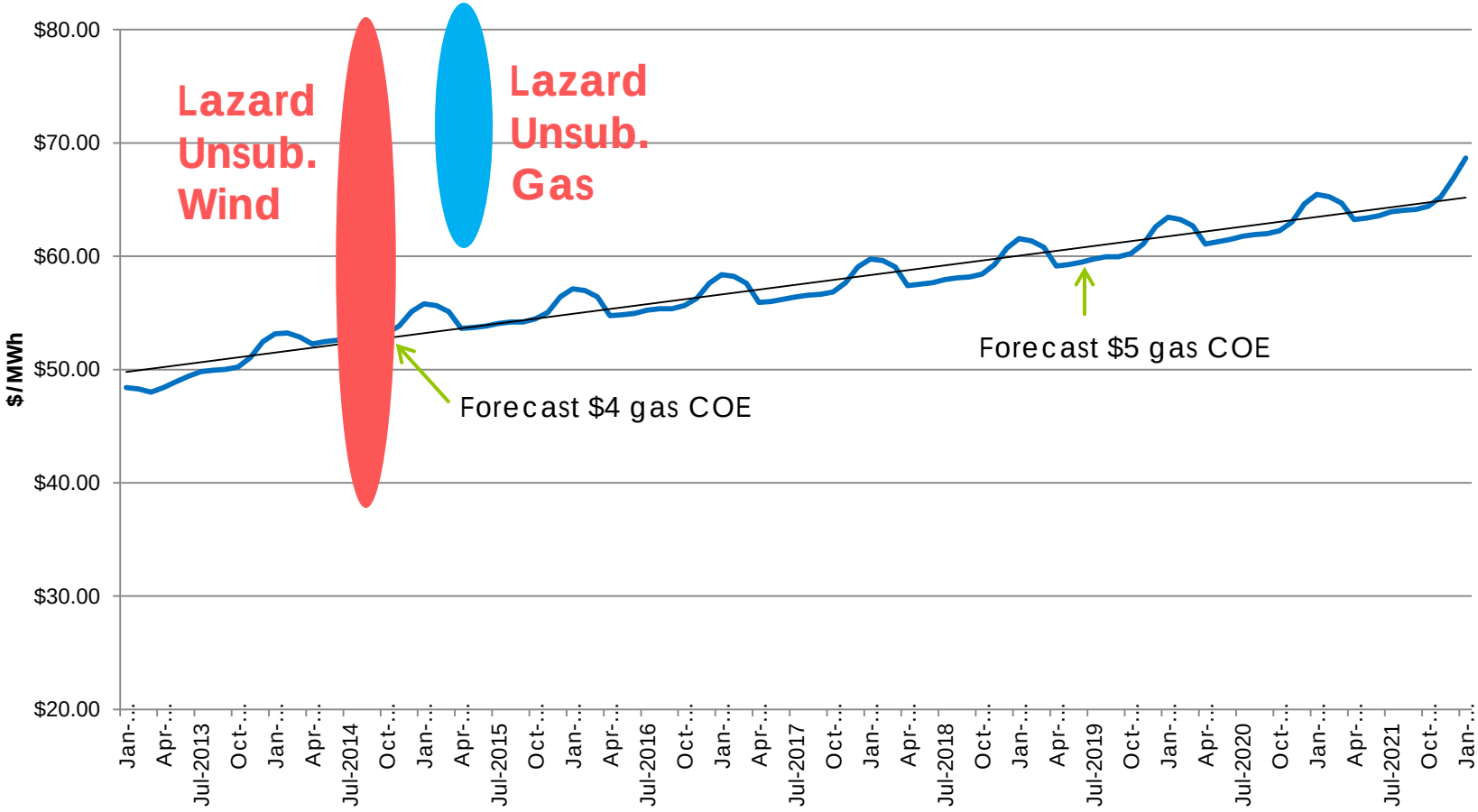
"Lazard's Levelized Cost of Energy Analysis – Version 8.0" released September 2014 - <u>Unsubsidized</u>



Lazard's data indicates that new wind-generated electricity has achieved grid parity.

Natural Gas CC Power Plant and Wind Energy

Levelized Cost of Energy Trends



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The Natural Gas and Wind Partnership

Wind Intermittency and Nat Gas Ramp Rates: A Natural Match

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- Point: Wind energy isn't reliable because the wind varies.
- Counterpoint:
  - Within an electricity balancing area the wind is always blowing somewhere: meteorological diversity steadies delivery. Consider de- or anti-correlated assets.
  - Integration costs are $1-3/MWh. NREL studies show that 35% wind energy can be integrated easily (Paul Denholm). All generation assets require spinning reserves.
  - Natural gas generation can ramp at the wind change pace. Coal and nuclear cannot ramp like that.
  - Grid modernization and transmission reliability build outs reduce the significance of this factor further.

Nat Gas Fuel Price Variability and 20-year Level Wind Energy Pricing

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- Need: The public and manufacturers want steady, low electricity pricing over long periods. How?
- Solution: NG and Wind Plants combine to provide a low cost, relatively steady pricing solution. Other new sources are more expensive.
- U. S. manufacturing becomes more globally competitive with reduced electricity costs.

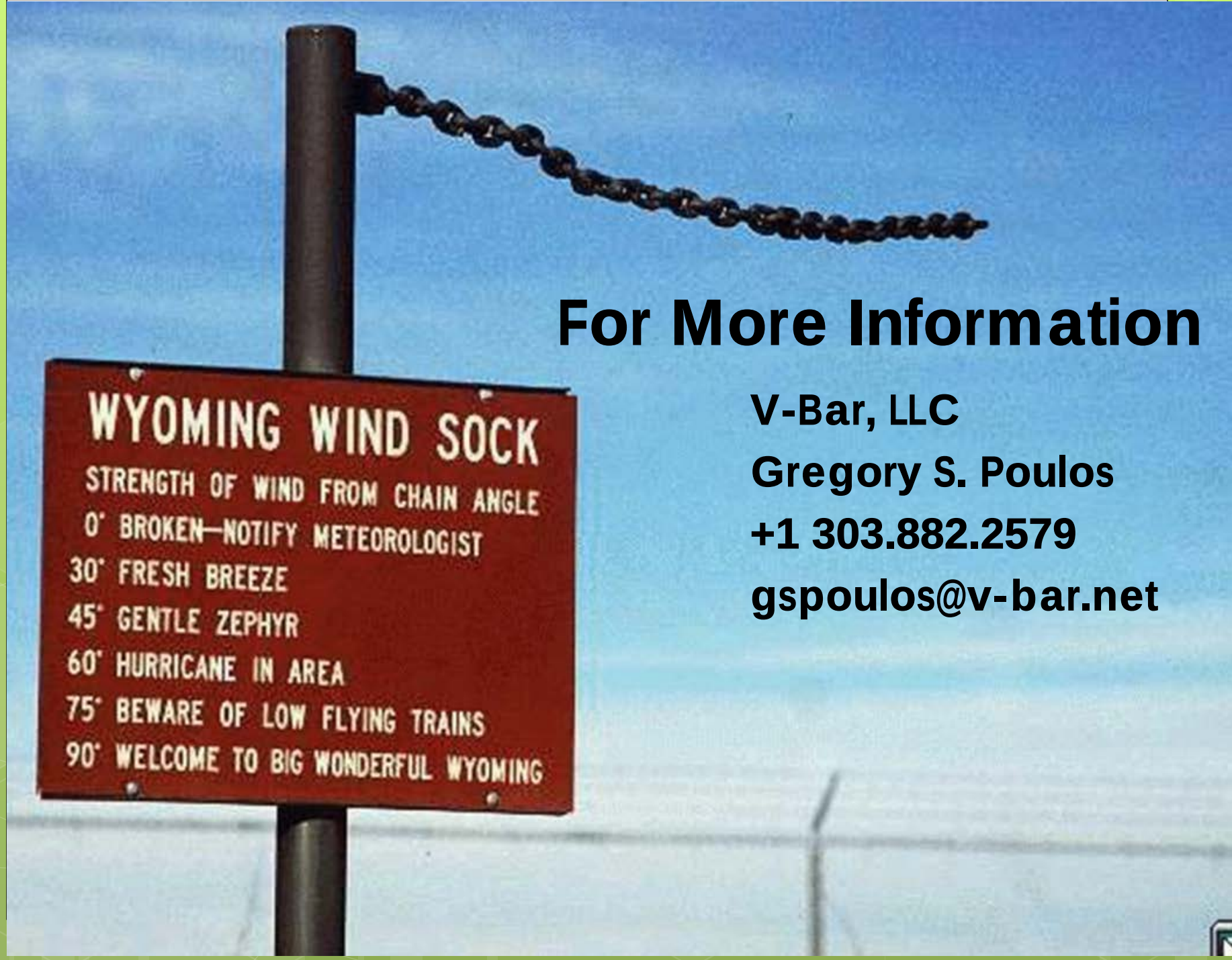
Water and Pollution

- Point: There is carbon/pollution risk, and increasing competition for scarce water resources.
- NG and Wind Plants at a 50/50 mix combine to produce 25% of the carbon of coal and wind uses no water. Limited other pollution risk (e.g. minimal mercury or radioactivity). Hydro is tapped out.
- Nat gas and electric vehicles further address carbon risk and energy self-reliance.

Summary

- Wind cost of energy is near or below that of natural gas, without a subsidy, for new electricity generation
  - Wind and NG are the two lowest cost sources of new electricity
  - The global wind industry is robust and engineering feats are driving wind energy cost reductions
- Wind and natural gas generation combine for apparently large societal benefit:
  - NG fuel price risk trade-off for wind delivery risk minimizes both and minimizes the cost of electricity, increasing U.S. competitiveness
  - Reduce pollution, carbon, water, energy self-reliance risks together

They can get along to create a win-win with major U.S. benefits to boot.



For More Information

V-Bar, LLC

Gregory S. Poulos

+1 303.882.2579

gspoulos@v-bar.net