Understanding the Trade-off: Environmental Costs and Benefits of Industrial Wind Energy Development

(with Focus on Eastern US)

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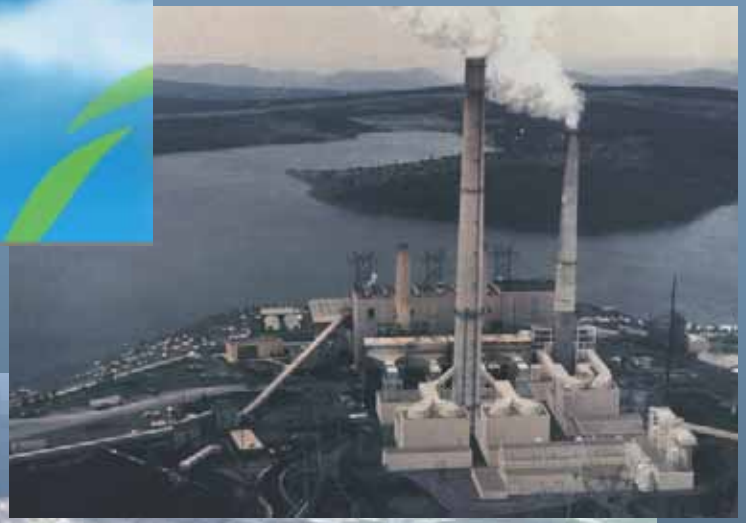
Virginia Wind
www.VaWind.org

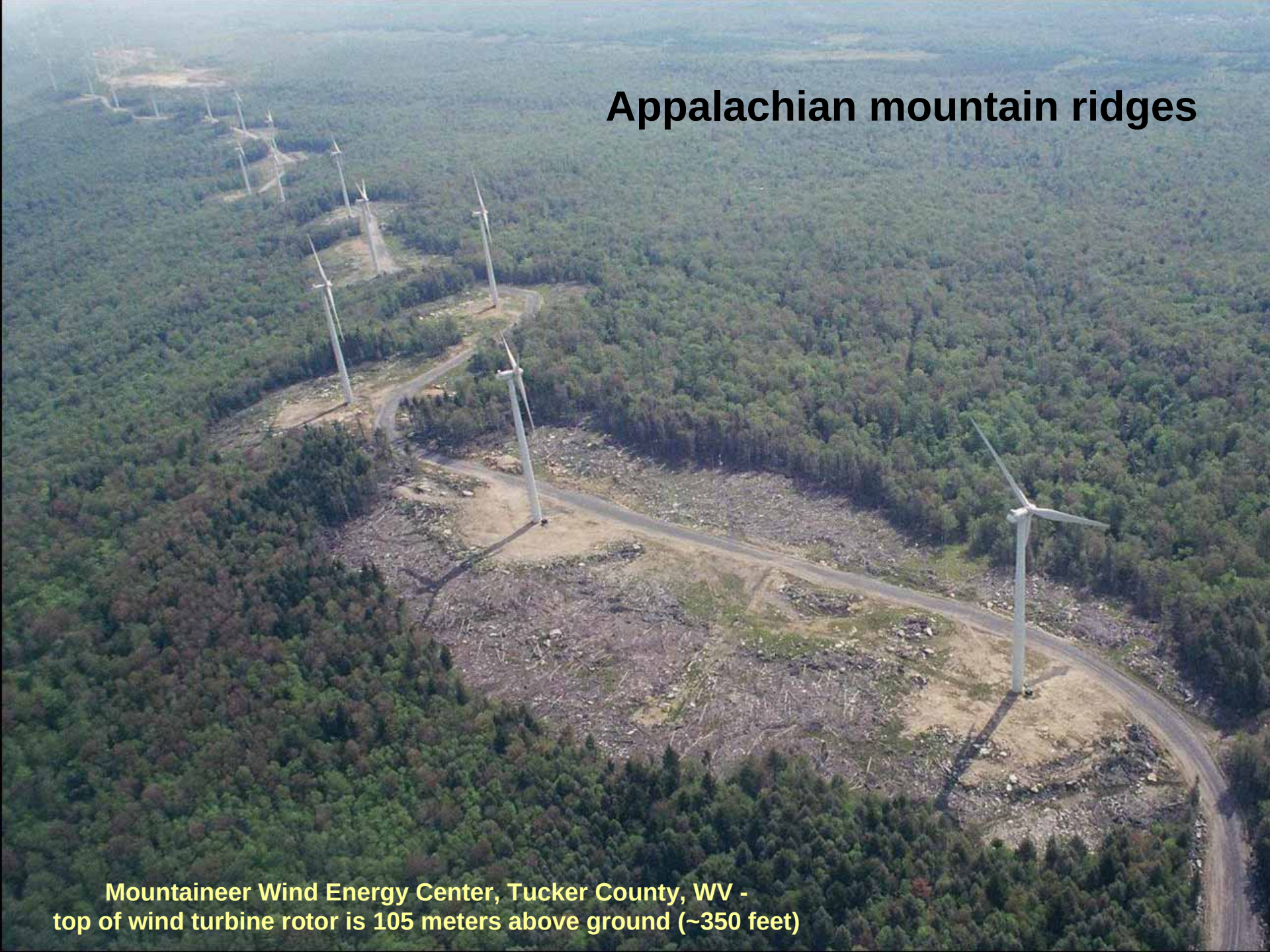
Special Session on Bats and Wind Turbines

38th North American Symposium on Bat Research, Scranton, PA

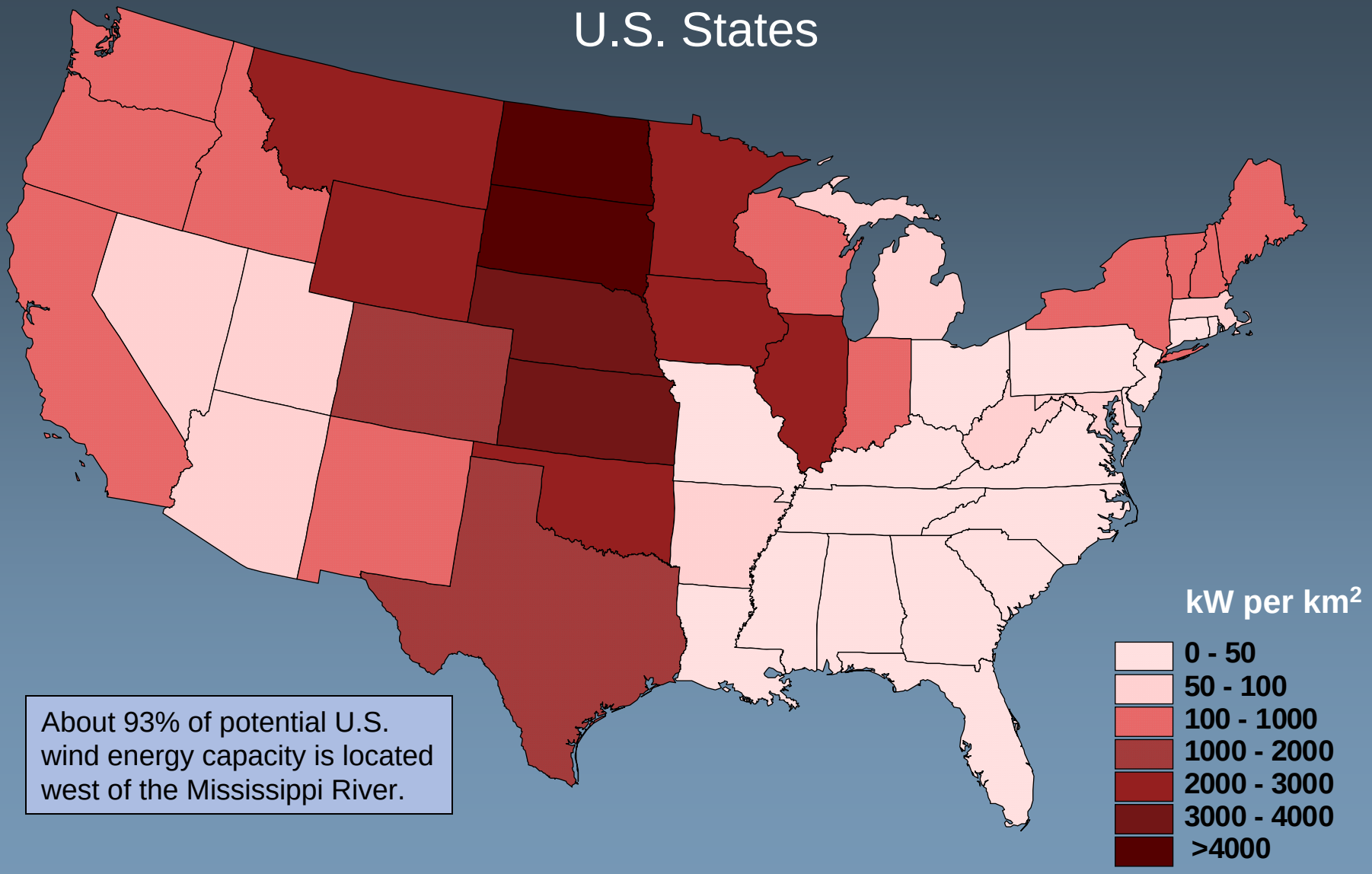
October 24, 2008

Wishful thinking?




Appalachian mountain ridges
Mountaineer Wind Energy Center, Tucker County, WV -
top of wind turbine rotor is 105 meters above ground (~350 feet)

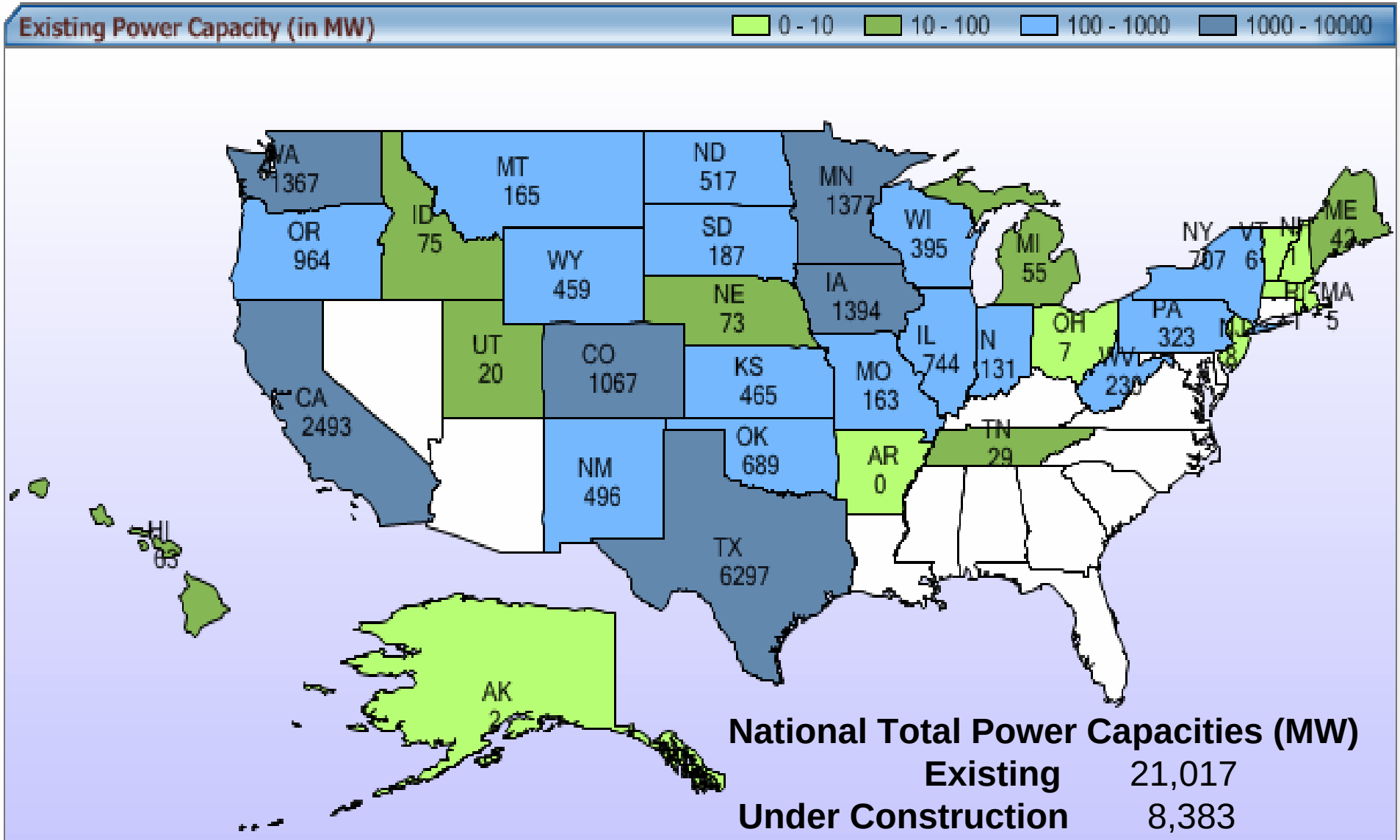
Density of Onshore Wind Energy Resource Among U.S. States



About 93% of potential U.S. wind energy capacity is located west of the Mississippi River.

Environmental Impacts of Wind Energy Projects, National Research Council, 2007

U.S. Wind Energy Projects (As of 09/30/2008)

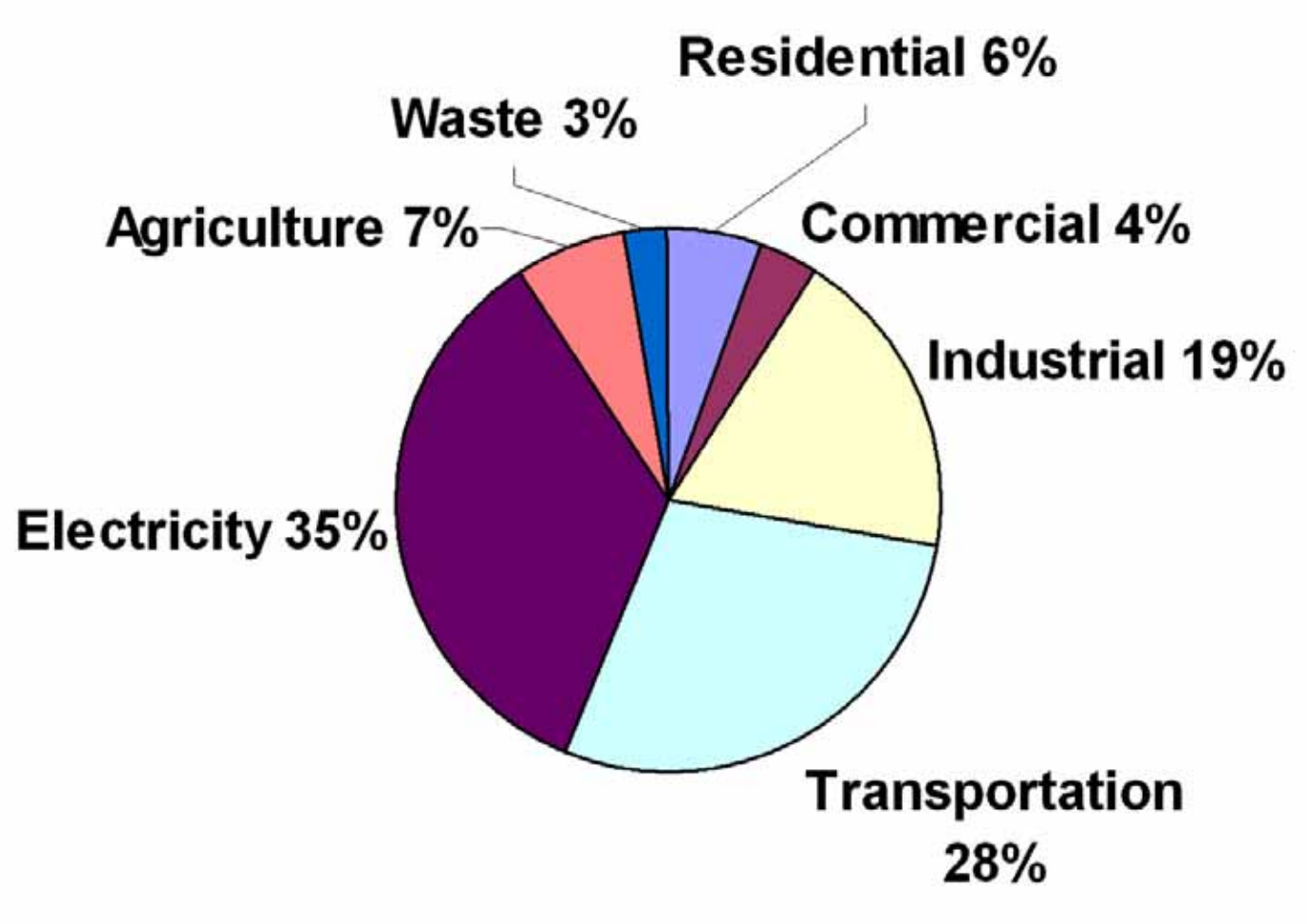


National Total Power Capacities (MW)

Existing	21,017
Under Construction	8,383

Source: http://www.awea.org/projects (accessed 21 Oct 2008)

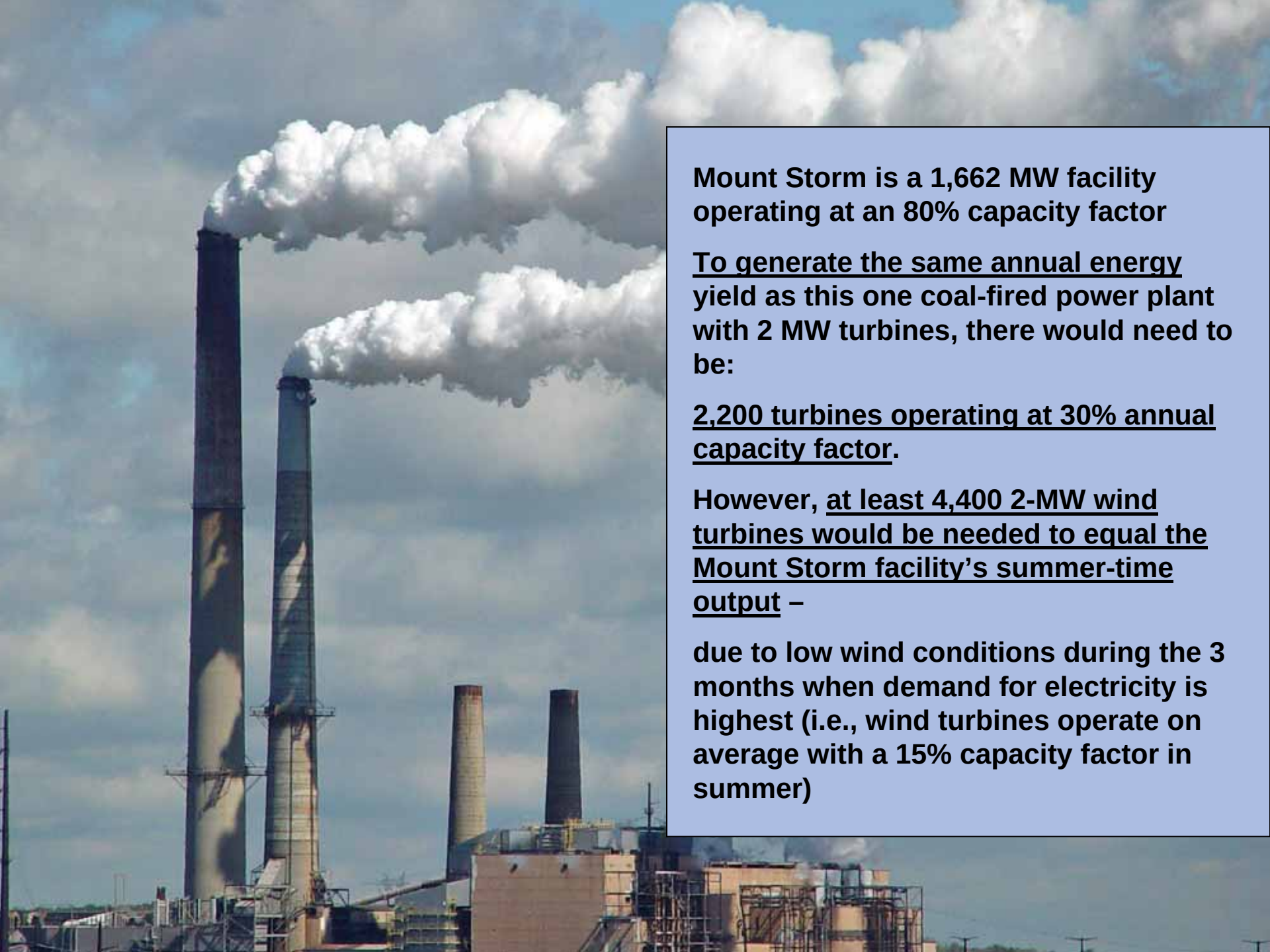
Sources of Total GHG Emissions in the United States by Sector, 2006 - in CO2 Equivalent



ONLY 35% OF THE U.S. TOTAL EMISSIONS OF GREEN HOUSE GASES (GHG) IS DUE TO POWER PLANTS

Note: Excludes emissions from U.S. territories.
Source: US DOE, EIA 2007.

ftp://ftp.eia.doe.gov/pub/oiaf/1605/cdrom/pdf/ggrpt/057306.pdf



Mount Storm is a 1,662 MW facility operating at an 80% capacity factor

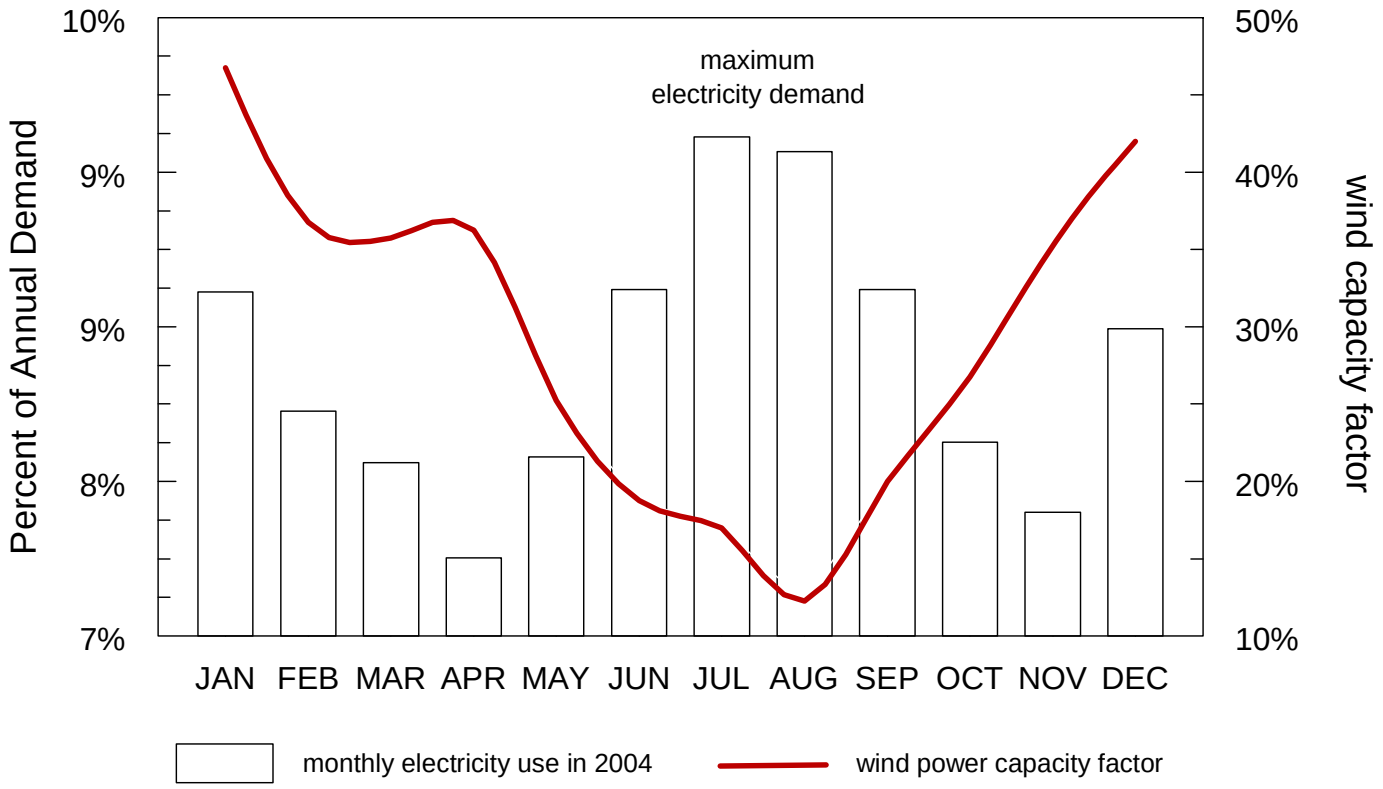
To generate the same annual energy yield as this one coal-fired power plant with 2 MW turbines, there would need to be:

2,200 turbines operating at 30% annual capacity factor.

However, at least 4,400 2-MW wind turbines would be needed to equal the Mount Storm facility's summer-time output –

due to low wind conditions during the 3 months when demand for electricity is highest (i.e., wind turbines operate on average with a 15% capacity factor in summer)

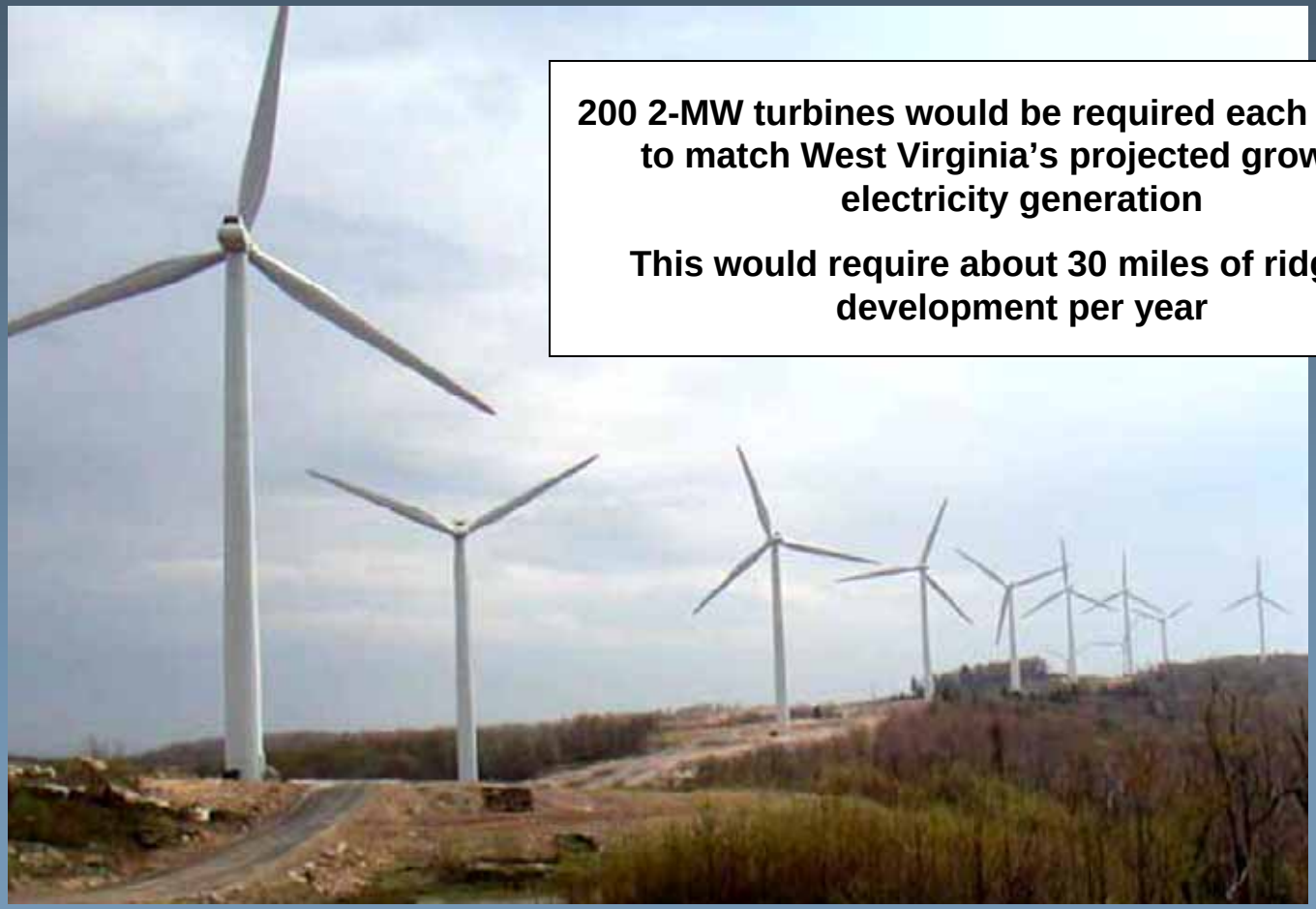
Inverse temporal relationship between wind power and electricity demand in the Mid-Appalachian states



Data for electricity sales and generation from U.S. Energy Information Agency, cited in Environmental Impacts of Wind Energy Projects, National Research Council, 2007

The diffuse nature of the wind resource

Wind projects in the Appalachian Mountains are typically built in strings of about seven turbines per mile along ridgelines.



200 2-MW turbines would be required each year just to match West Virginia's projected growth in electricity generation

This would require about 30 miles of ridgeline development per year

See: www.eia.doe.gov/oiaf/aeo/electricity.html

Environmental Benefits

- Reduced CO2 emissions
- Energy independence
- Improvements in air quality
- Reduced use of coal
- Obviate need for new conventional power plants

Environmental Concerns

- Direct wildlife mortality – esp. bats
- Indirect wildlife impacts – e.g.,displacement and noise effects
- Habitat Loss and Fragmentation
- Impact upon Public Lands
- Aesthetic Impacts
- Opportunity Loss (usurps more effective and less impactful options)

Environmental Benefits?

- Energy supply
  - Energy independence
  - Reduced use of coal
- Air quality improvement
  - SO2 and NOx
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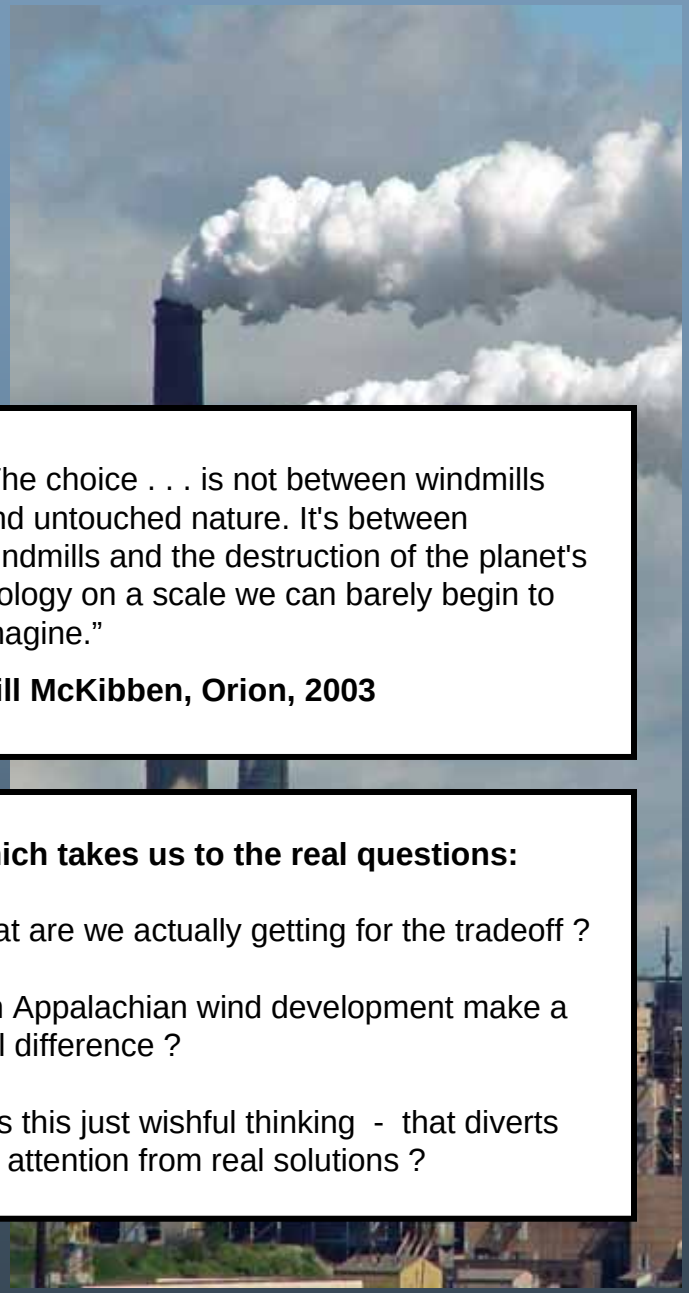

"The choice . . . is not between windmills and untouched nature. It's between windmills and the destruction of the planet's biology on a scale we can barely begin to imagine."

Bill McKibben, Orion, 2003

Which takes us to the real questions:

→ what are we actually getting for the tradeoff ?

→ can Appalachian wind development make a real difference ?

→ or is this just wishful thinking - that diverts our attention from real solutions ?

Environmental Benefits?

- Energy supply
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- Air quality improvement
  - SO2 and NOx
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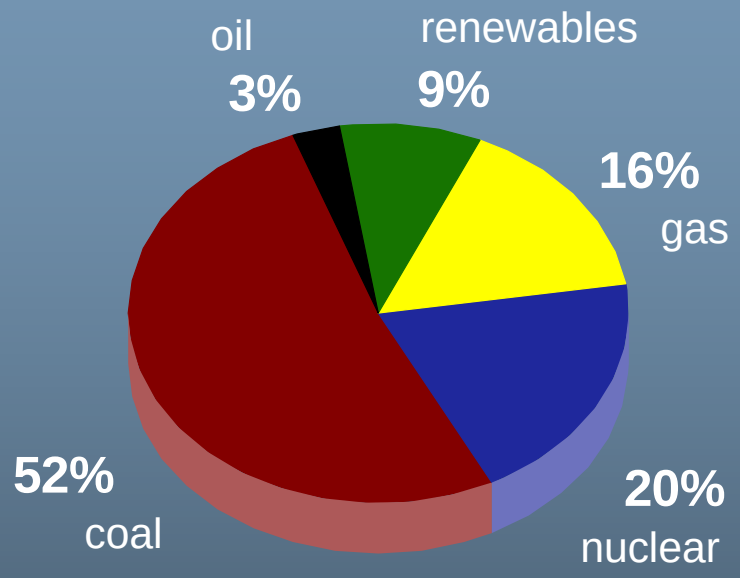
Percentages of U.S. electricity generation by generator type



Very little oil is used for generating electricity

Data from U.S. Environmental Protection Agency, cited in Environmental Impacts of Wind Energy Projects, National Research Council, 2007

Environmental Benefits?

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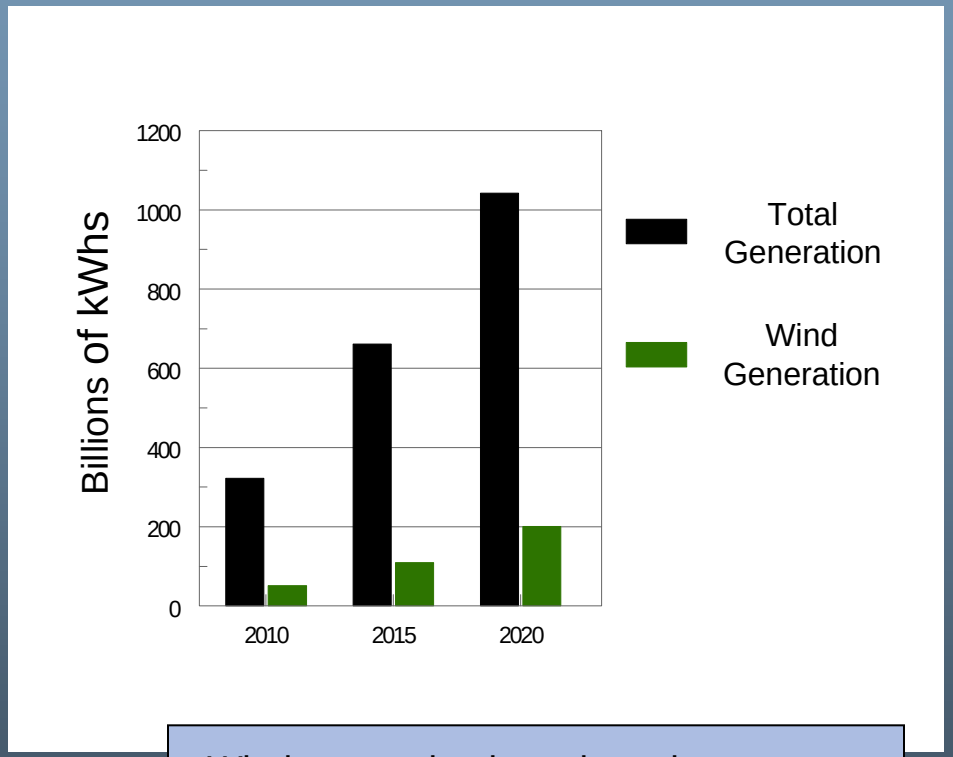
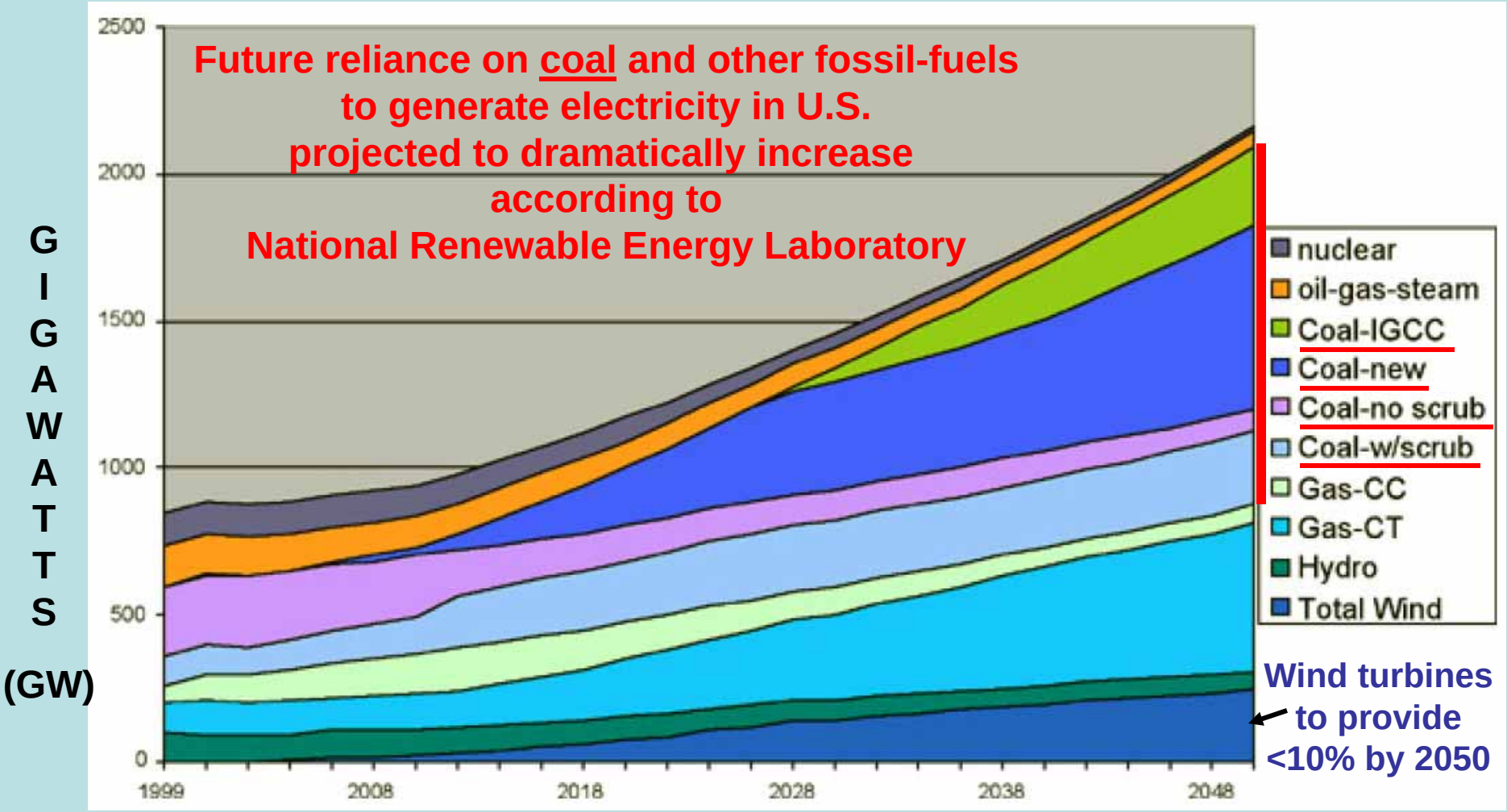
Projected Net Growth in U.S. Electricity Generation: 2005 - 2020



Wind generation is projected to account for up to 19% of net growth in total generation. Sources other than wind will be required for the other 81%.

Department of Energy projections cited in Environmental Impacts of Wind Energy Projects, National Research Council, 2007

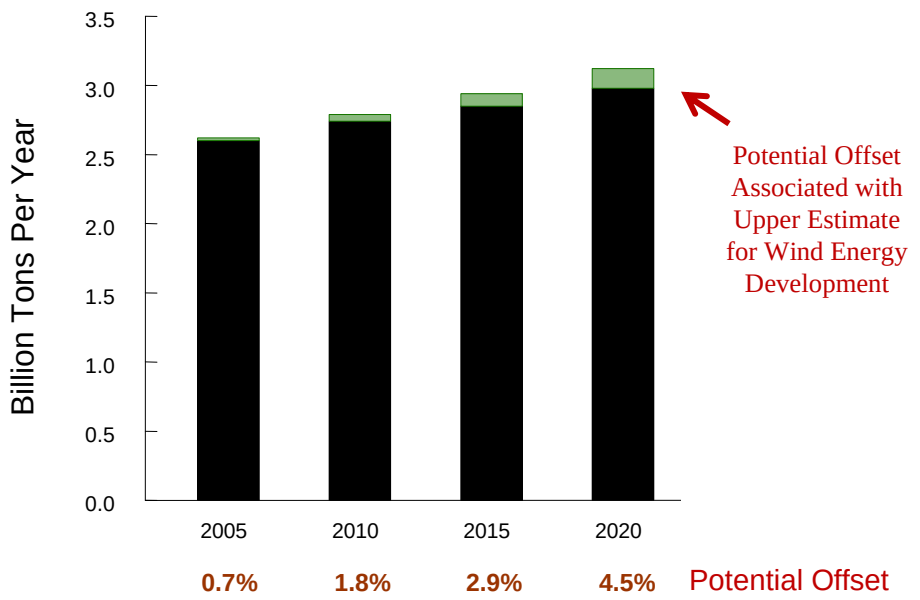


Projected electricity generation capacity for the U.S. by different generator types. Actual generation depends on amount of capacity, as indicated by the thickness of the section of the graph, and on annual capacity factor (effective yield) of each generation source. Due to wind intermittency, the annual capacity factor for wind energy projects is only about 30% - much less than for other utility-scale electricity generator types. (The graphic is from the National Renewable Energy Laboratory, DOE: http://www.nrel.gov/analysis/winds/qualitative.html) NOTE: 1,000 MW = 1 GW & 1,000 kW = 1 MW

Environmental Benefits?

- Energy supply
  - Energy independence
  - Reduced use of coal
- Air quality improvement
  - SO2 and NOx
  - CO2

Projected U.S. CO_2 emissions from electricity generation units and potential offset provided by projected wind energy development



Fossil-fuel-fired generating units account for less than 40% of U.S. CO_2 emissions. The potential **offset** provided by onshore wind energy development is thus less than 2.25%.

Projections cited in Environmental Impacts of Wind Energy Projects, National Research Council, 2007

Environmental Benefits?

- Energy supply
  - Energy independence
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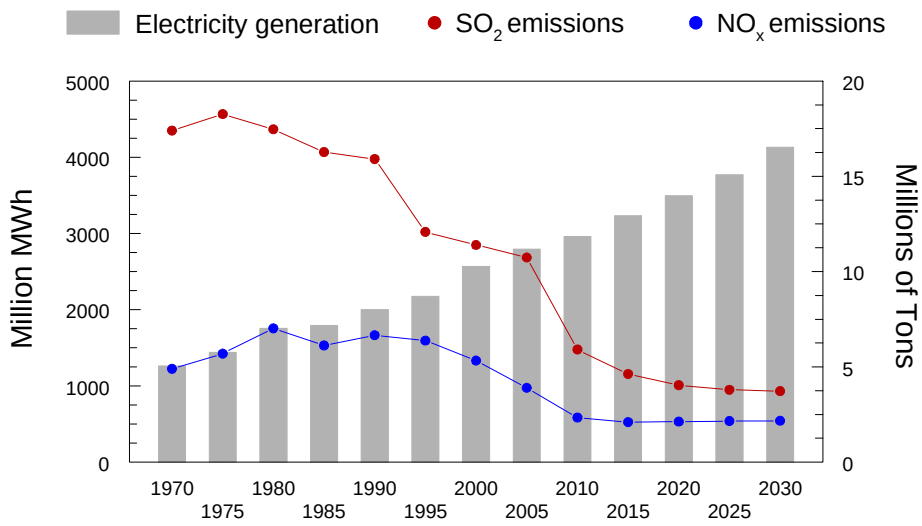
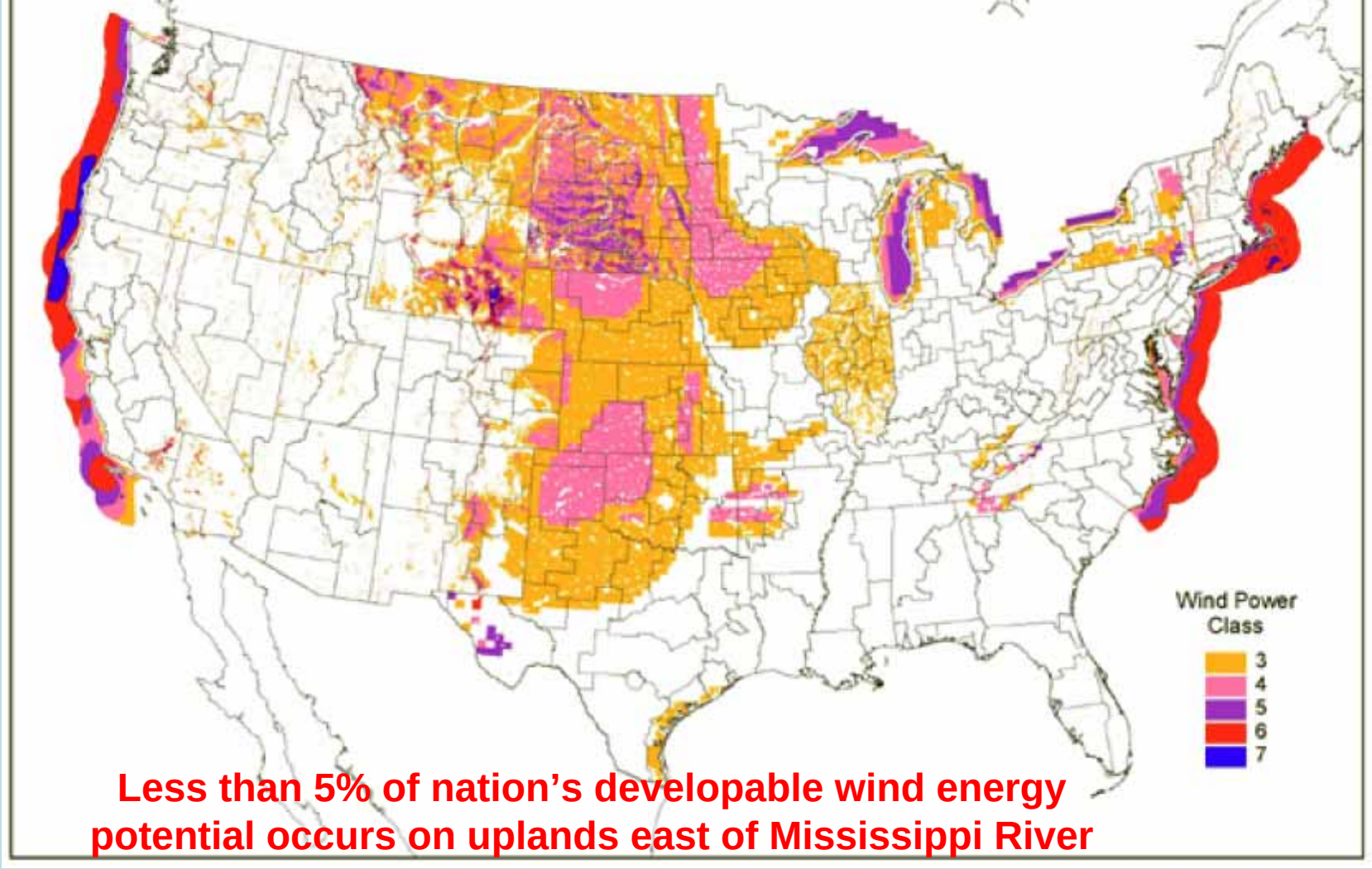
- Air quality improvement
  - SO2 and NOx
  - CO2

Observed and Projected Electricity Generation and Emissions for Fossil-Fuel Electrical Generating Units in the U.S.



In the context of a cap and trade program there is limited opportunity to achieve emission reductions through wind energy development.

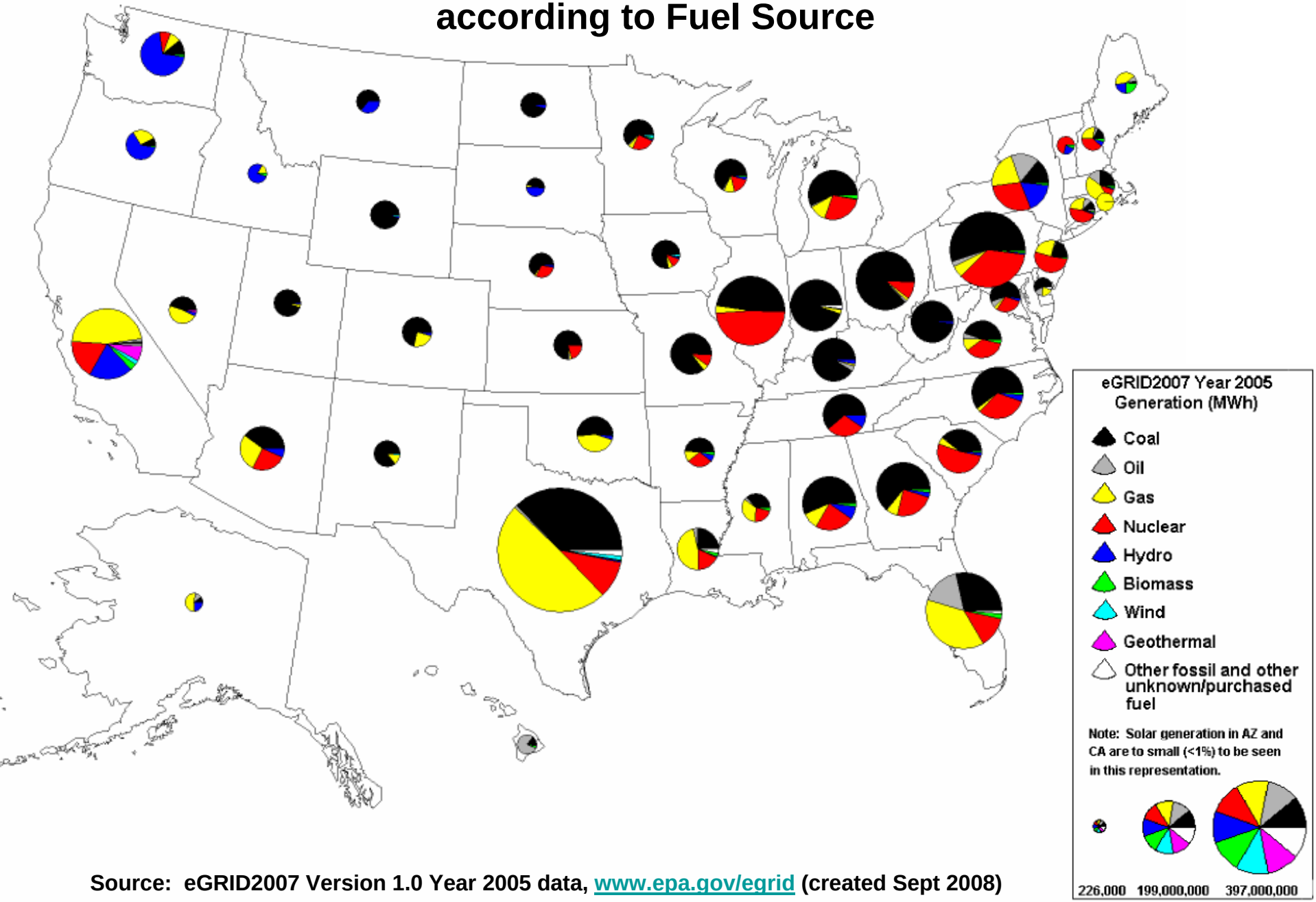
From Environmental Impacts of Wind Energy Projects, National Research Council, 2007



Wind energy potential in the United States. Areas with Wind Power Class 3 and above are considered economical to develop. Most of the inland wind potential is in the Midwest. Areas with high wind potential on the mountain ridges are narrow lines that don't show up well at this map scale.

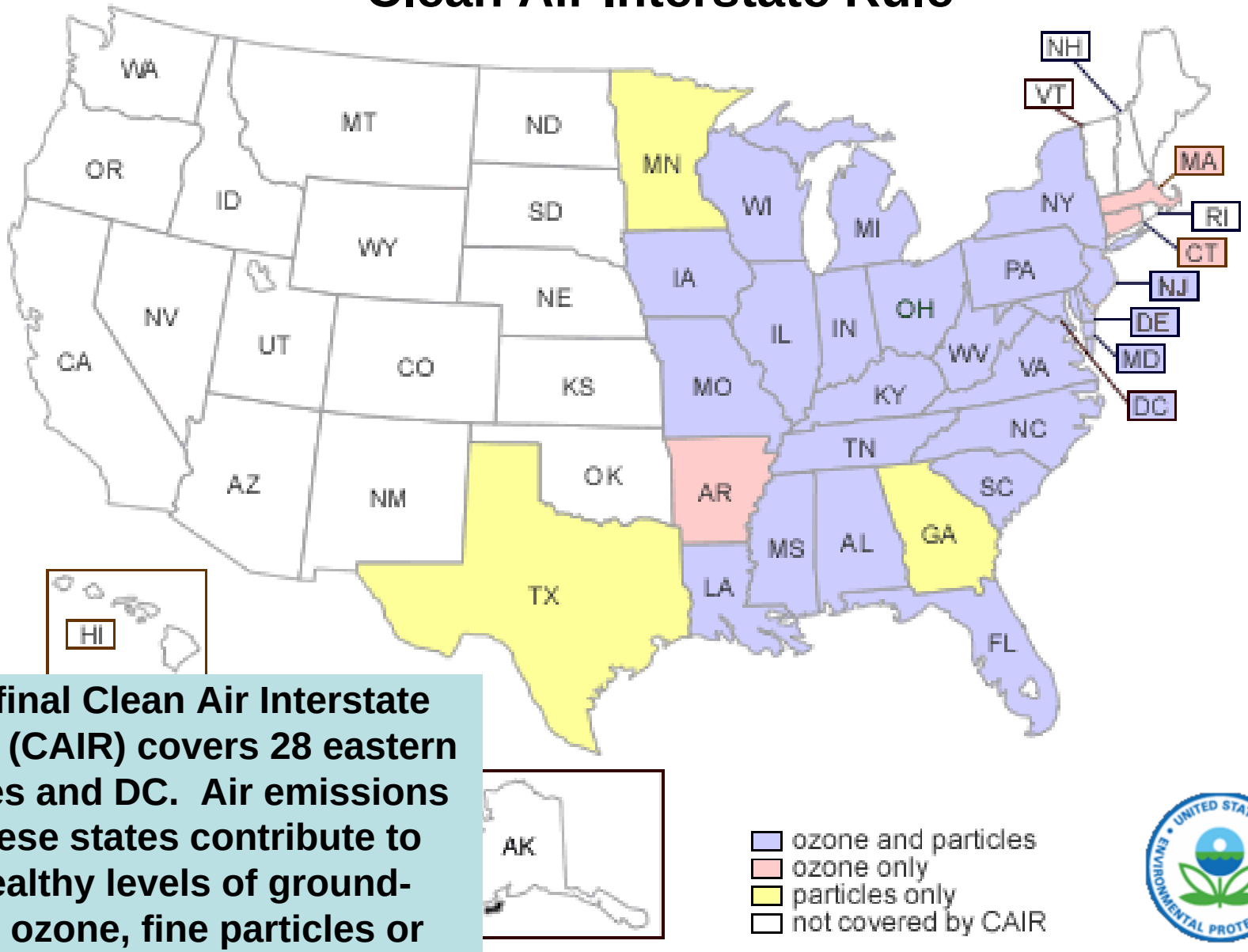
(From National Renewable Energy Laboratory, DOE: http://www.nrel.gov/analysis/winds)

2005 Electricity Generation by State according to Fuel Source



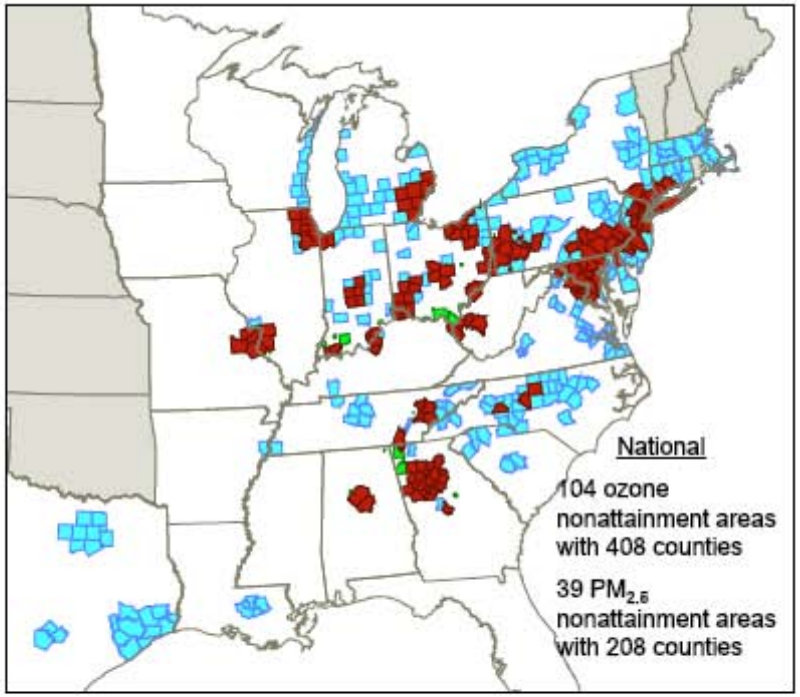
Source: eGRID2007 Version 1.0 Year 2005 data, www.epa.gov/egrid (created Sept 2008)

States regulated by EPA under the Clean Air Interstate Rule



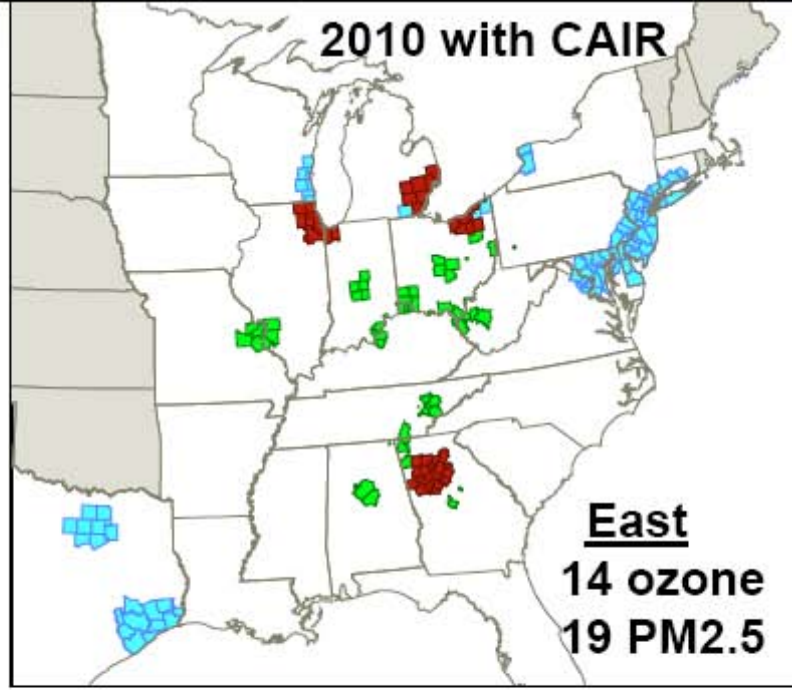
The final Clean Air Interstate Rule (CAIR) covers 28 eastern states and DC. Air emissions in these states contribute to unhealthy levels of ground-level ozone, fine particles or both in downwind states.

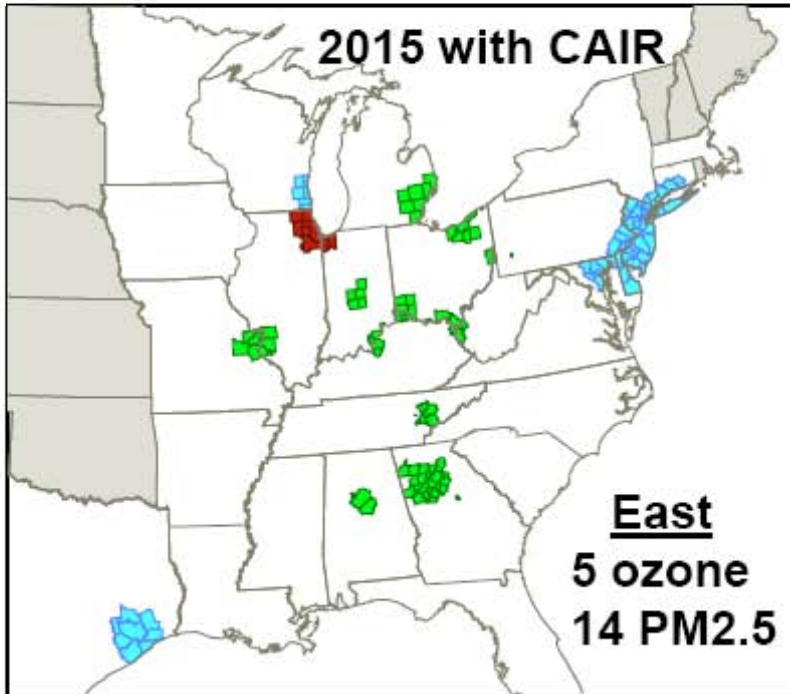
http://www.epa.gov/interstateairquality/where.html



Ozone & Fine Particle Nonattainment (Apr. 05)

Projected Non-attainment Areas in 2010 & 2015 after reductions from Clean Air Interstate Rule (CAIR) and existing Clean Air Act (CAA) programs





CAIR and Other CAA Programs Will Help Bring Many Eastern Areas into Attainment - However, a number of areas are projected to not attain through 2010 and 2015

- Nonattainment areas for 8-hour ozone pollution only
- Nonattainment areas for fine particle pollution only
- Nonattainment areas for both 8-hour ozone and fine particle pollution

Projections concerning future levels of air pollution in specific geographic locations were estimated using the best scientific models available. They are estimations, however, and should be characterized as such in any description. Actual results may vary significantly if any of the factors that influence air quality differ from the assumed values used in the projections shown here.

SOURCE:
http://cleanairinfo.com/modelingworkshop/presentations/PM2_5_Damberg.pdf

CAP&TRADE PROGRAMS MAKE SO2 AND NOx A ZERO-SUM GAME

Any reduction in SO2 and NOx emissions associated with development of wind energy will occur against a background of substantial emission reductions obtained through the Clean Air Act and other regulatory programs. Examination of U.S. emissions data for 1970–2003 indicates that emissions of SO2 from electrical generating units declined 37% while emissions of NOx from power plants declined by 9%.*

Current regulatory programs mandate either national or regional caps on emissions of SO2 and NOx from power plants, and additional reductions of both pollutants are scheduled even though demand for electricity is projected to increase (e.g., Clean Air Interstate Rule). However, any offset of emissions from those fossil-fueled power plants whose generation would be displaced by wind turbines' output likely results in the affected power plant owners selling or trading to other power plants their "unused" pollution allowances (which are doled out by EPA under auspices of "Cap & Trade" programs of the Clean Air Act) – or they also could decide to burn cheaper but "dirtier" fuels (e.g., higher sulfur coal). A ZERO-SUM GAME!**

See: *http://epa.gov/airtrends/2005/pdfs/detailedtable.xls and
http://www.windaction.org/opinions/11517 & http://www.epa.gov/airmarkt/cap-trade/index.html

Environmental Concerns

- Direct wildlife mortality – esp. bats
- Indirect wildlife impacts –
  e.g.,displacement and noise effects
- Habitat Loss and Fragmentation

Photos by Ed Arnett,
Bat Conservation International

Shell/NedPower Windplant Mount Storm, WV Sept. 29, 2008

See also: http://www.windaction.org/documents/18575

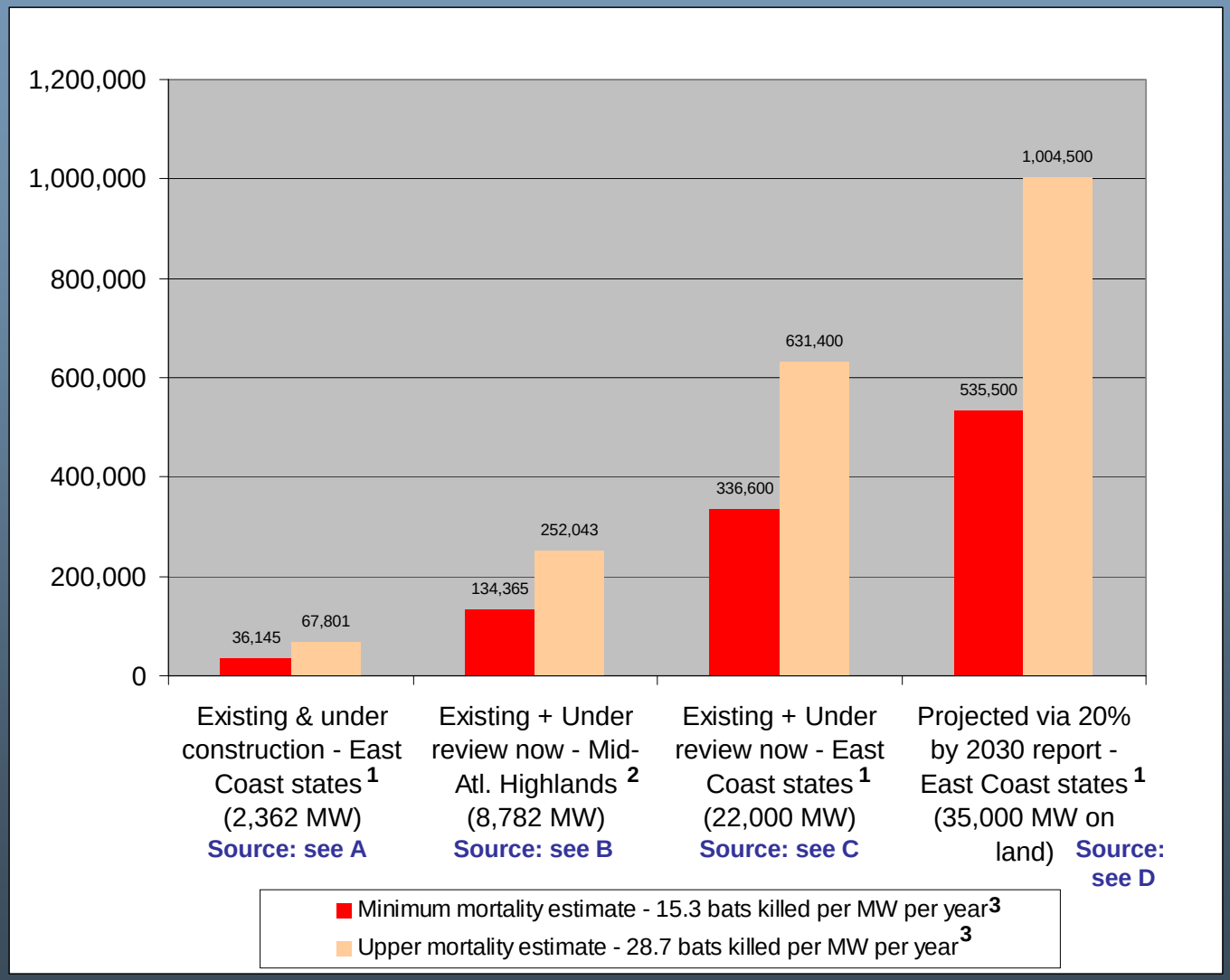
Up to
4,000 birds
and bats
were
killed in
collisions
with 44
wind turbines
in WV
during 2003

Photos of bats by Merlin Tuttle,
Bat Conservation International

Bat experts recently estimated that <u>over 110,000 bats may be killed per year</u> if less than 4,000 MW of industrial wind turbines are installed within the Mid-Atlantic Highlands Region

Source: http://www.vawind.org/#Kunz

Projections of Cumulative Annual Bat Mortality Resulting From Various Future Wind Energy Development Scenarios In the Eastern United States

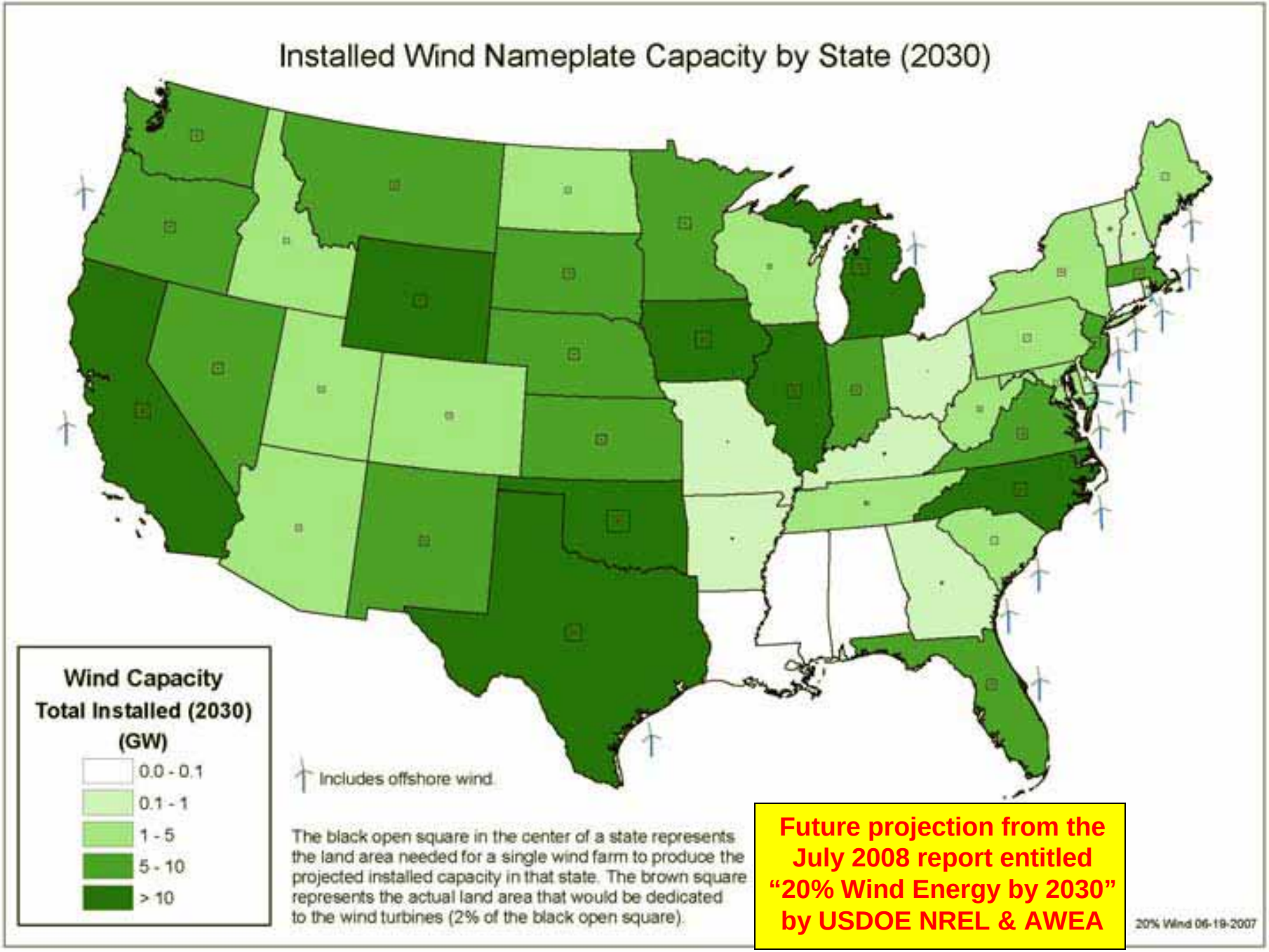


1 – East Coast States include New England, NY, PA, WV, MD, VA, TN & NC

2 – Mid-Atlantic Highlands include non-coastal portions of PA, WV, MD and VA

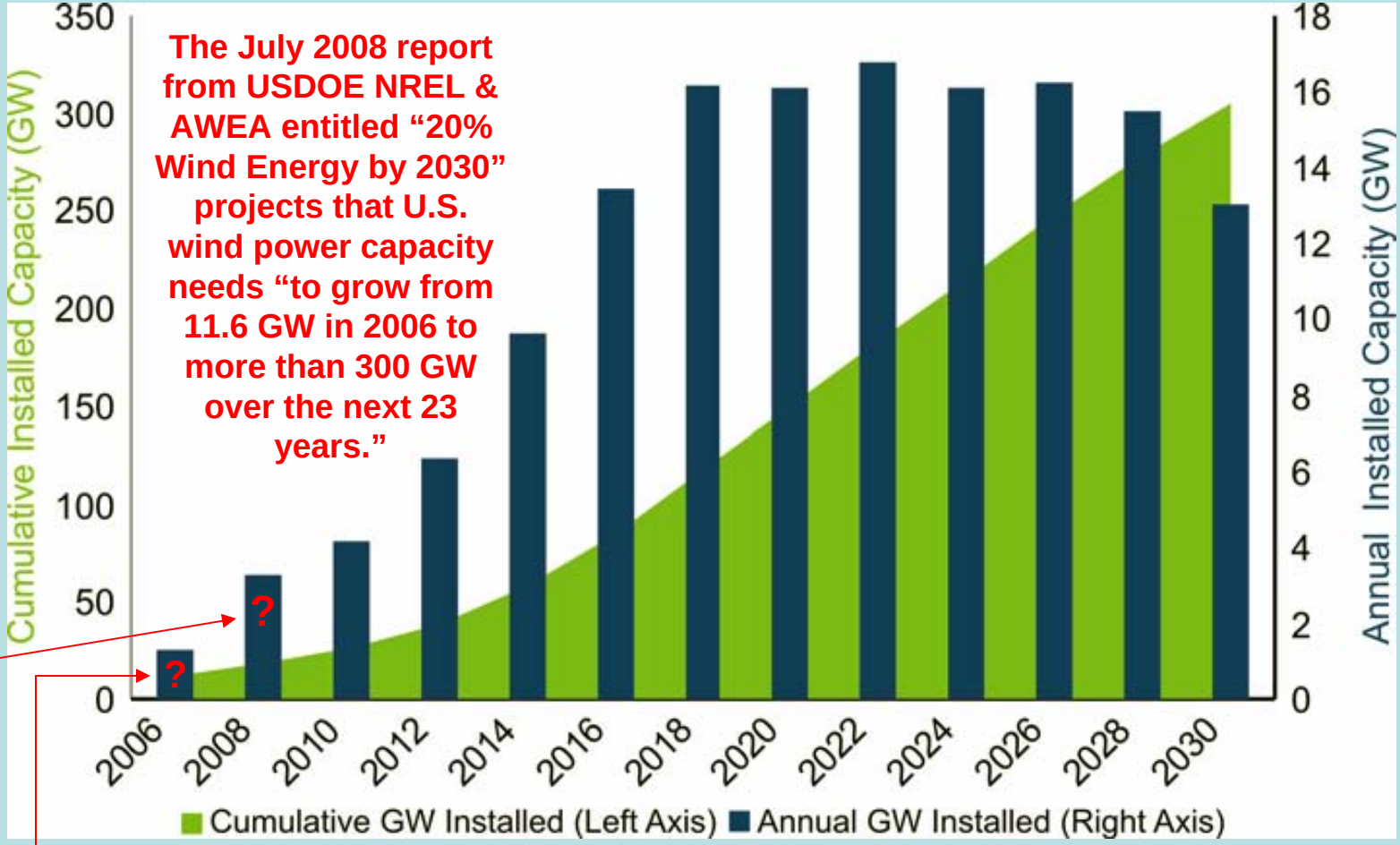
3 – estimate range from Kunz et al. 2007; see: www.vawind.org/#Kunz

Sources for MW estimates: A - www.awea.org/projects B - www.pjm.com/planning/project-queues/queue-gen-active.jsp
C - see generator interconnection queues for PJM, NY-ISO and ISO-NE (checked Oct. 23, 2008)
D – http://www1.eere.energy.gov/windandhydro/pdfs/41869.pdf (extrapolated from Fig. 1-8)



Source: Fig. 1-8 in: http://www1.eere.energy.gov/windandhydro/pdfs/41869.pdf

Annual and cumulative wind installations in the US by 2030



The July 2008 report from USDOE NREL & AWEA entitled "20% Wind Energy by 2030" projects that U.S. wind power capacity needs "to grow from 11.6 GW in 2006 to more than 300 GW over the next 23 years."

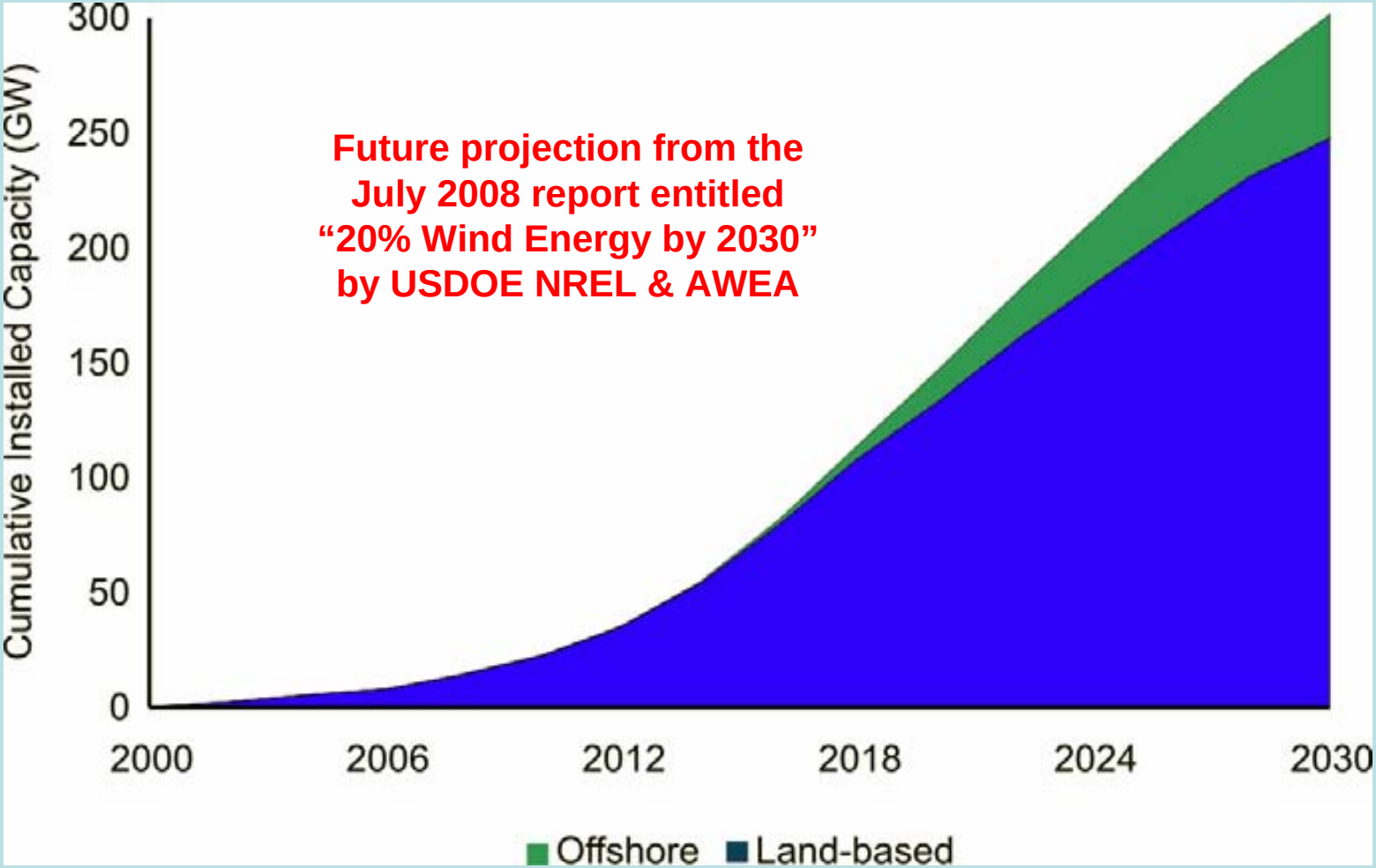
"The 20% Wind Scenario would require an installation rate of 16 GW per year after 2018"

Source: Fig. 1-4 in: http://www1.eere.energy.gov/windandhydro/pdfs/41869.pdf

2006 – 2,454 MW of wind turbines installed within USA
2007 – 5,249 MW of wind turbines installed
2008 – projection of 7,500 MW of wind turbines installed

Sources: http://www.awea.org/newsroom/releases/Wind_Power_Capacity_012307.html & http://www.awea.org/pubs/documents/Outlook_2008.pdf & http://www.awea.org/newsroom/releases/AWEA_Quarterly_Report_102208.html

Projected cumulative installed wind power capacity to supply 20% of the US electricity demand by 2030



Source: Fig. 1-7 in: http://www1.eere.energy.gov/windandhydro/pdfs/41869.pdf

Forest Fragmentation

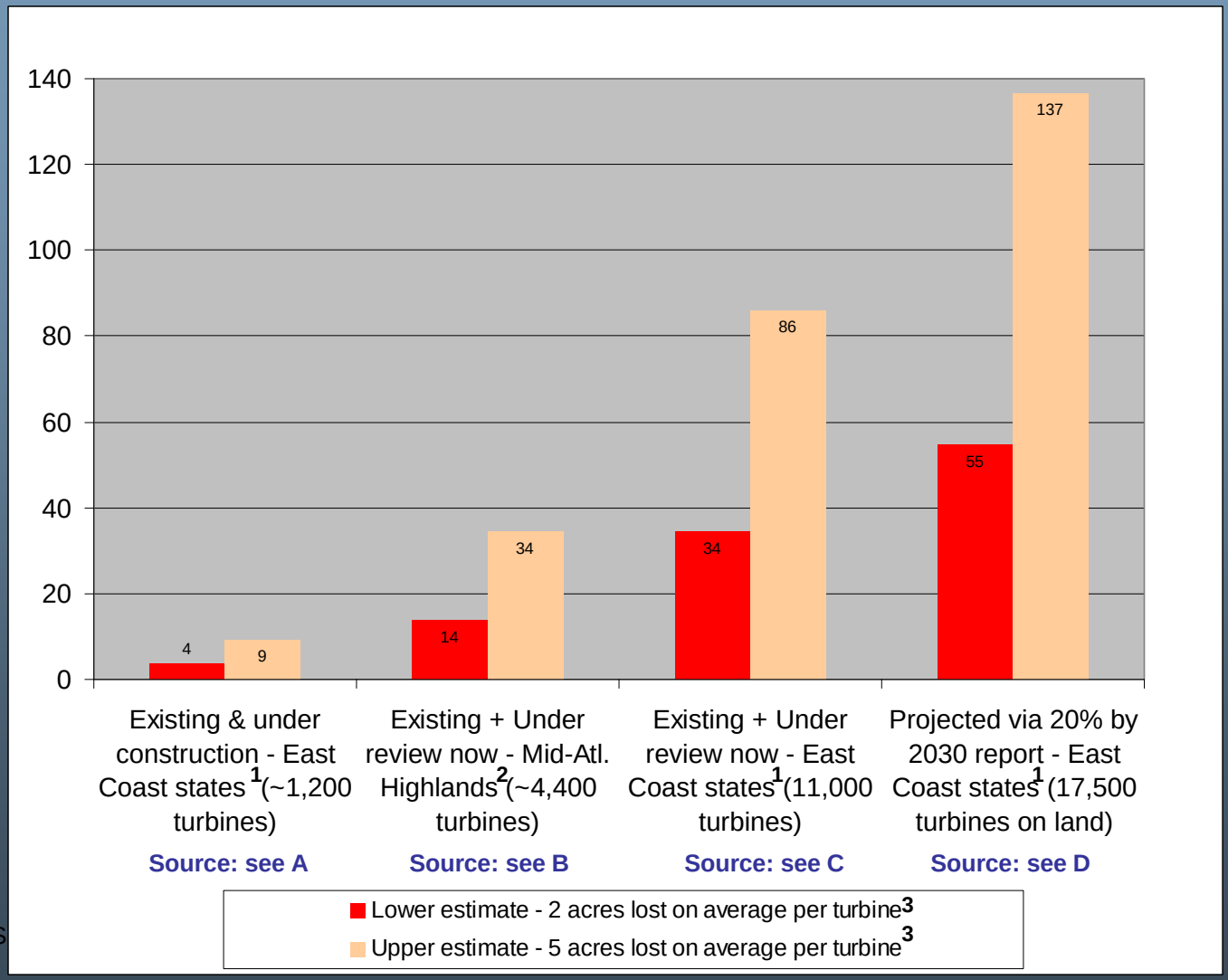
3-5 acres cleared and 15-20 acres of interior forest lost per turbine*

* http://www.kutztown.edu/acad/geography/wildlife&windconf/Speaker_Presentations/Boone_GIS.pdf

Projections of Cumulative Forest Habitat Loss Resulting From Various Future Wind Energy Development Scenarios In the Eastern United States

Square mile = 640 acres

Estimated Number of Square Miles of Forest Loss



1 – East Coast States include New England, NY, PA, WV, MD, VA, TN & NC

2 – Mid-Atlantic Highlands include non-coastal portions of PA, WV, MD and VA

3 – estimate range based on GIS analysis of existing wind projects (total forest loss **/** # turbines) - see: http://www.kutztown.edu/acad/geography/wildlife&windconf/Speaker_Presentations/Boone_GIS.pdf

Sources for # turbine estimates: A - www.awea.org/projects B - www.pjm.com/planning/project-queues/queue-gen-active.jsp
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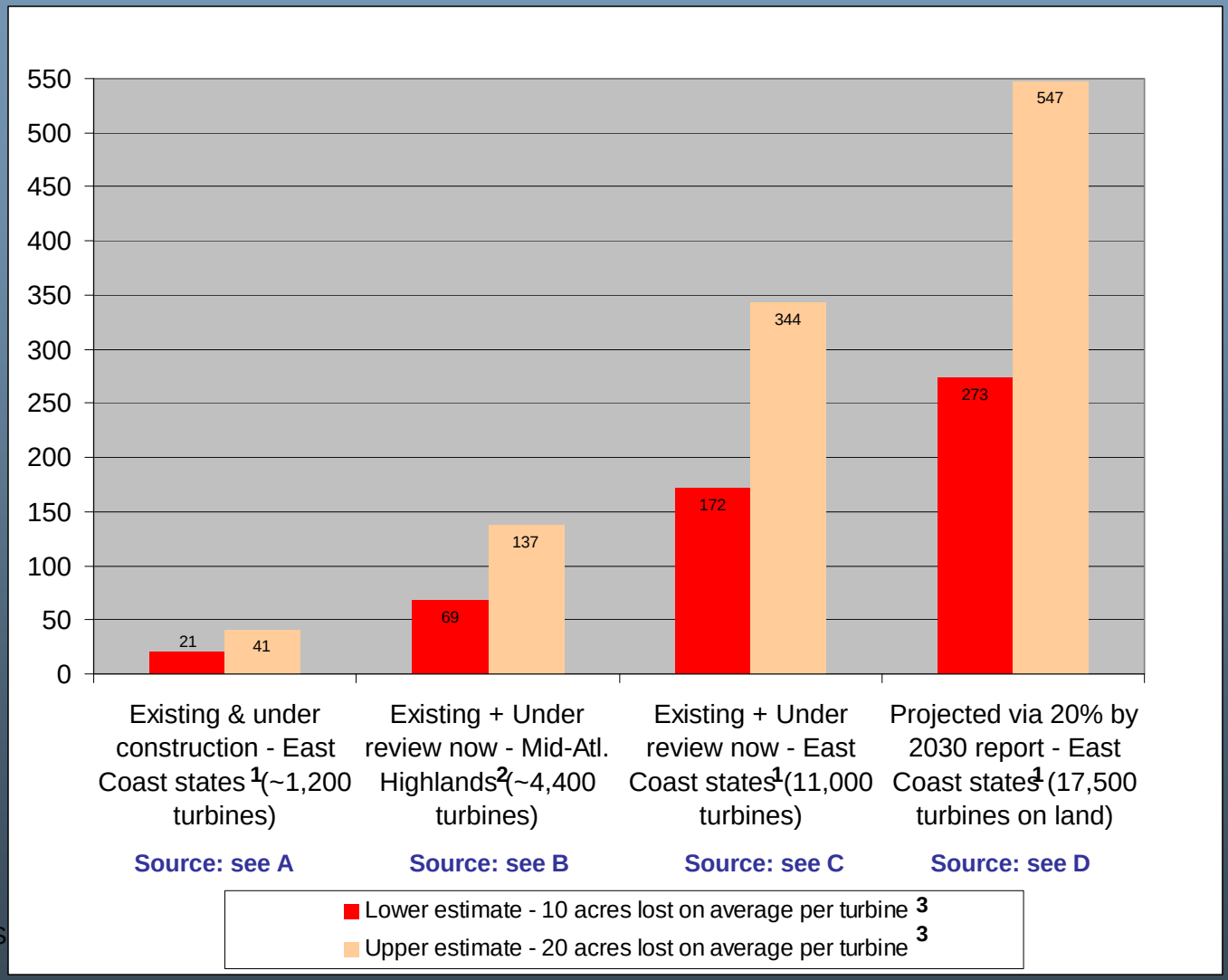
D - http://www1.eere.energy.gov/windandhydro/pdfs/41869.pdf (extrapolated from Fig. 1-8). **All scenarios assume turbines = 2MW**

Projections of Cumulative Forest "Interior" Habitat Loss Resulting From Various Future Wind Energy Development Scenarios In the Eastern United States

Forest "interior" occurs >100 m from edge of non-forest area or a linear break of canopy that is >30 feet in width

Square mile = 640 acres

Estimated Number of Square Miles of Forest Interior Loss



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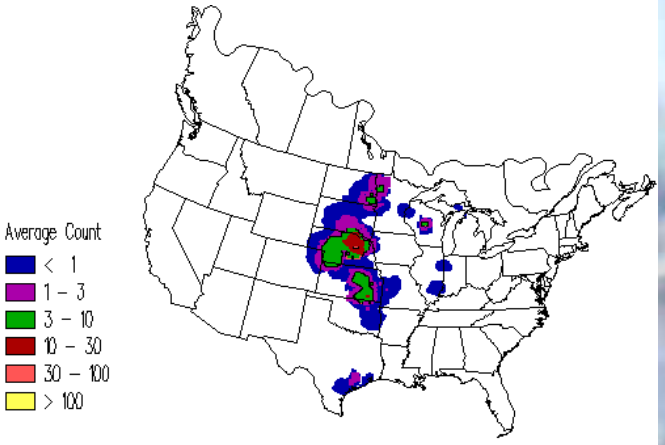


Greater Prairie-chicken range map

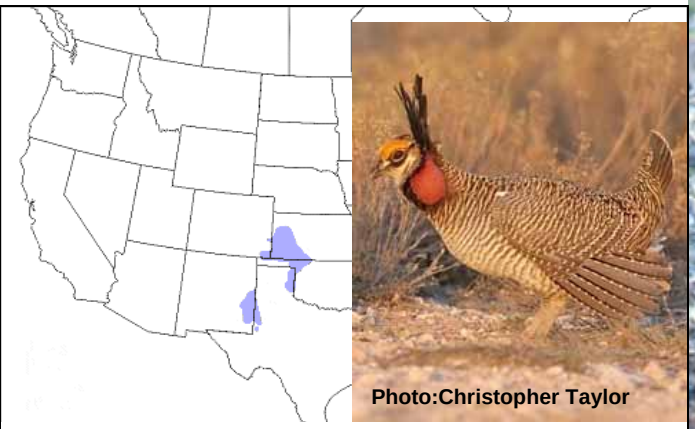


Photo:Christopher Taylor

Lesser Prairie-chicken range map

Greater Prairie-chicken

The behavioral response of the Greater Prairie-chicken is similar to that of the Lesser Prairie-chicken, and it is predicted that nesting and brood-rearing hens of both species will avoid large wind turbines (1.5 MW models; 350 feet tall) by at least a one-mile radius (Robel et al., 2004). In its Briefing Paper regarding prairie grouse leks and wind turbines, the U.S. Fish and Wildlife Service recommends a five-mile buffer between occupied prairie grouse leks and wind power facilities (Manville, 2004).

Source: Position of the Kansas Department of Wildlife and Parks Regarding Wind Power and Wildlife Issues - http://www.dnr.state.ak.us/mlw/wslca/appendix_b/kansas_dwp_wind_power_position.pdf

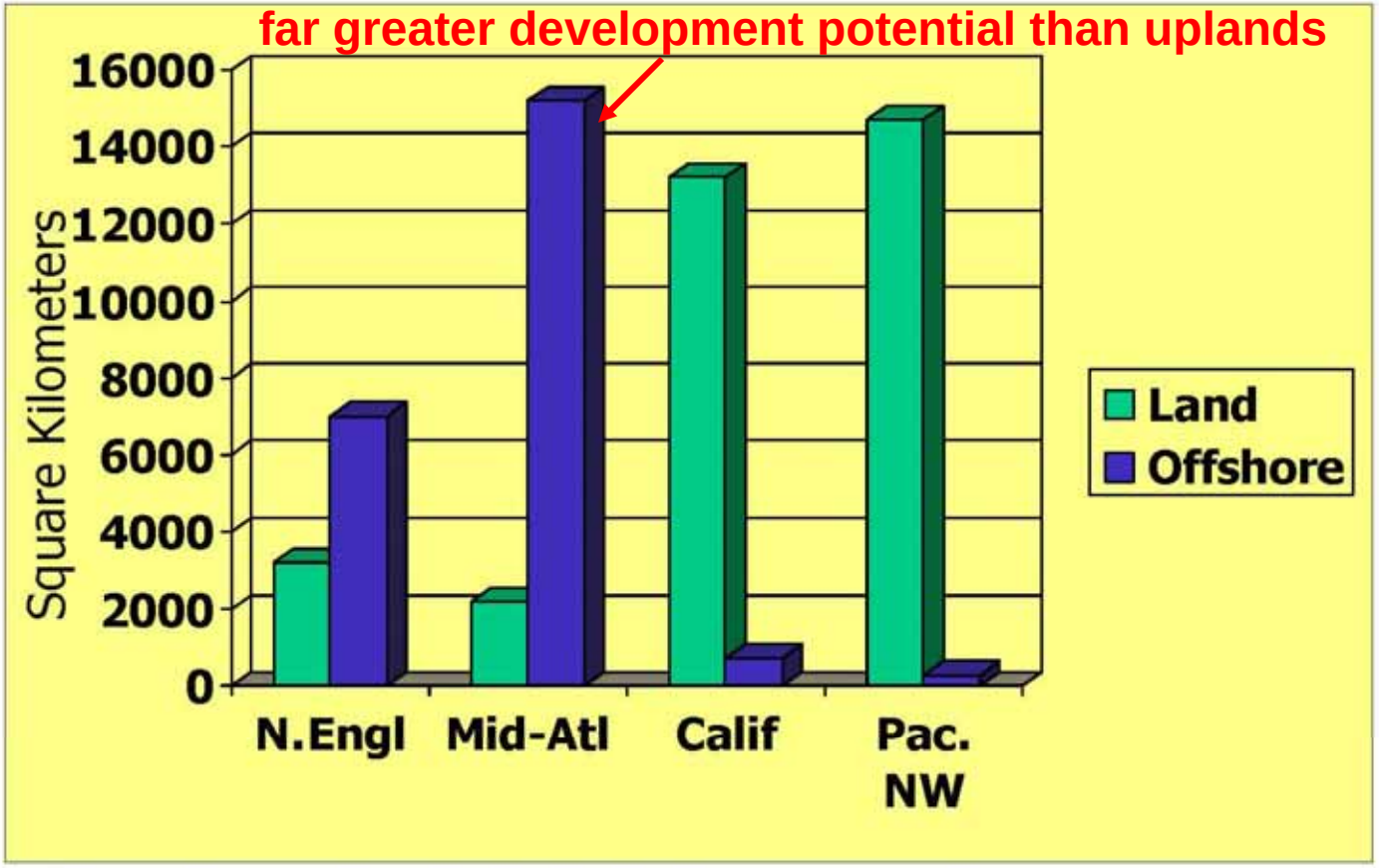
Summary

. . . wind energy development on central Appalachian ridges carries great risk of environmental harm and very little potential for benefits.

1. The wind energy capacity of the central Appalachian region is substantially less than in other regions of the U.S.
2. The areas with sufficient wind for commercial projects are the ecologically fragile areas that represent our remnant wild landscape.
3. Wind energy development in the region cannot make a significant contribution to solving our energy and environmental problems.
4. Promotion of wind energy development in the region hinders our ability to achieve real solutions for real problems.

Available Windy Area

Offshore wind areas in Mid-Atlantic Region have far greater development potential than uplands



*Class 4+ on Land; Class 5+ Offshore and Water Depths <70 ft; No land use exclusions

AWS Truewind

SOURCE: Bruce Bailey - http://gcep.stanford.edu/pdfs/energy_workshops_04_04/wind_bailey.pdf

Golden Eagle in Highland County, Virginia

www.VaWind.org