



# Wind Turbines for K-12 Education

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**ASA, August 2008**  
**Sponsored by DOE/NREL**  
**Wind Powering America**  
(All charts through NREL)



# What is Wind for Schools?

- Renewable Energy
- Education-students and community
- Excitement
- Understanding



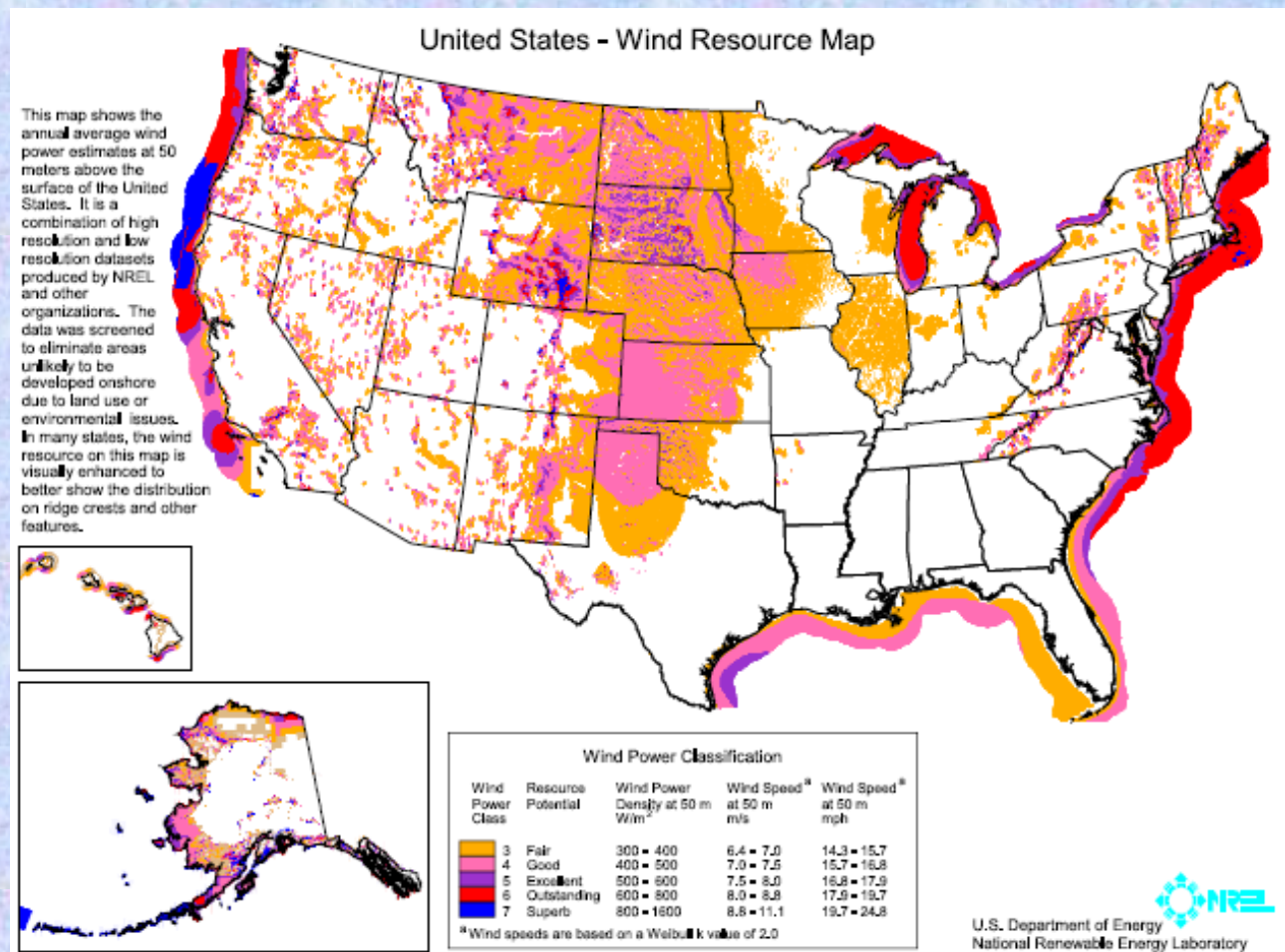
# Small Turbines at Schools

- NREL-funded
- Up to 5 per year per state
- Rural schools in 6 states
- Math, physics, engineering
- Energy, environment, stewardship
- Marketing



# States Involved

- Colorado
- Idaho
- Kansas
- Montana
- Nebraska
- South Dakota
- Next year...



# Skystream Wind Turbine

- Southwest WindPower
- 1.9 kW rated
- Wind class 3: 14 mph avg.
- 300-400 kWh/mo
- 8¢/kWh => \$30/mo
- Average-sized house fall/spring consumption



# Sight and Sound

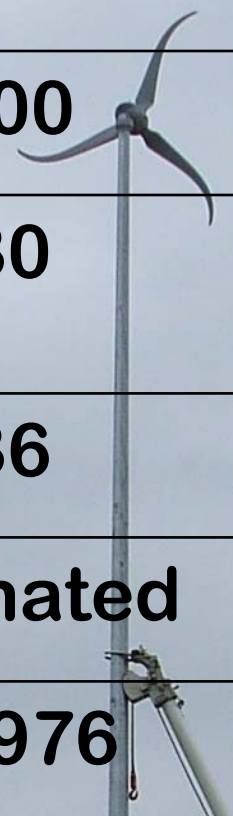


Skystream and 2<sup>nd</sup>, taller turbine at NREL NWTC (Boulder); spinning appears much slower than actual because of aliasing.



# Cost

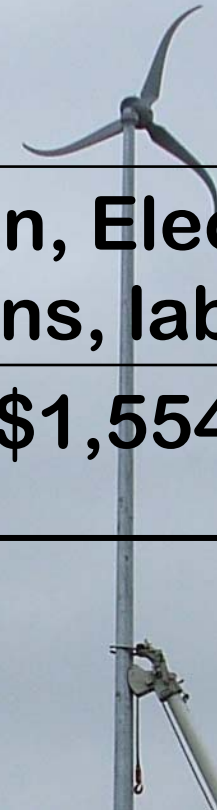
	Maximum	Minimum
<b>Turbine</b>	<b>\$3,510</b>	<b>\$3,510</b>
<b>Tower</b>	<b>\$6,945</b>	<b>2,000</b>
<b>Foundation Materials</b>	<b>\$1,275</b>	<b>\$630</b>
<b>Elec Connect</b>	<b>\$4,713</b>	<b>\$836</b>
<b>Installation</b>	<b>Donated</b>	<b>Donated</b>
<b>Total</b>	<b>\$16,443</b>	<b>\$6,976</b>



# Financing

<b>Green donations</b>	<b>\$2,000</b>
<b>State support</b>	<b>\$1,000</b>
<b>Utility/community</b>	<b>Foundation, Elec connections, labor</b>
<b>School</b>	<b>\$7,455 to \$1,554</b>

**Southwest WindPower donates part of turbine by selling at cost.**





# School Commitment

- Integrate into curriculum (NEED, KidWind)
- Cooperate with other schools
- Send students to WAC schools
- Send workers into wind industry



# Community Benefit

- **Positive attitudes toward wind**
- **Familiarity, comfort level**
- **Increased environmental awareness**
- **Support for green regulation**
- **Utility familiarity, enthusiasm**



# Utility Benefit

- **Most rural electric cooperatives do not understand wind energy and are afraid of it**
- **Assisting schools is positive PR.**
- **Experience with small-scale parallel generation may help encourage net-metering**



# University Benefit

- More wind engineering students
- Increased potential for research funds
- Significant outreach to interested citizens
- Increased interest in renewable energy on campus



# Vision

- **Excited children comparing turbines**
- **Communities understanding renewable energy**
- **Utilities understanding renewables**
- **Increasing workforce for renewables**
- **Less carbon, less NO<sub>x</sub>, SO<sub>x</sub>**
- **Less human impact**
- **Better tomorrow!**



# Creation Benefit

- Increased interest/investment in renewable energy
- Lower greenhouse gas emissions
- Lower water demand
- Better stewardship
- Glory to God--with our minds, hearts and actions.



# Going Bigger

- Entegriy 50kW turbine
- \$200,000 installed
- 36,000 kWh/month
- \$2,900/month
- 6-10-yr payoff



# Even Bigger

- **Northwind 100**
- **100-kW upwind turbine**
- **\$400-500,000 installed**
- **6-10-yr payoff**





# Going Smaller

- Skystreams for individuals
- Homeowner-sized
- \$12-15,000 installed
- Same cost as new windows
- Similar savings
- Good wind a must
- Bergey, other options



# Future of Wind Energy

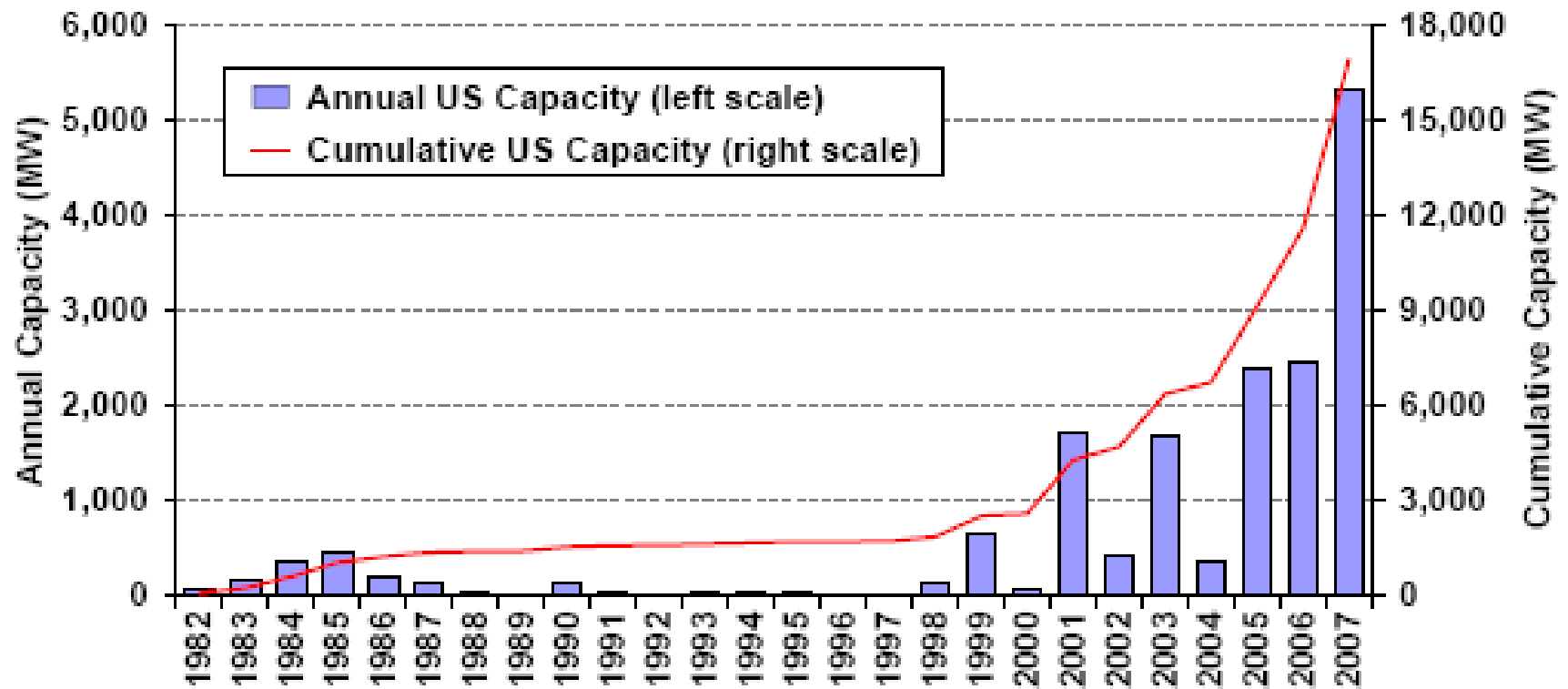
- **Lowest-cost renewable**
- **Most rapidly growing nationwide**
- **Works at a variety of scales**
- **Benefits rural economies**
- **No water needed!**



# Installed Wind, end 2007

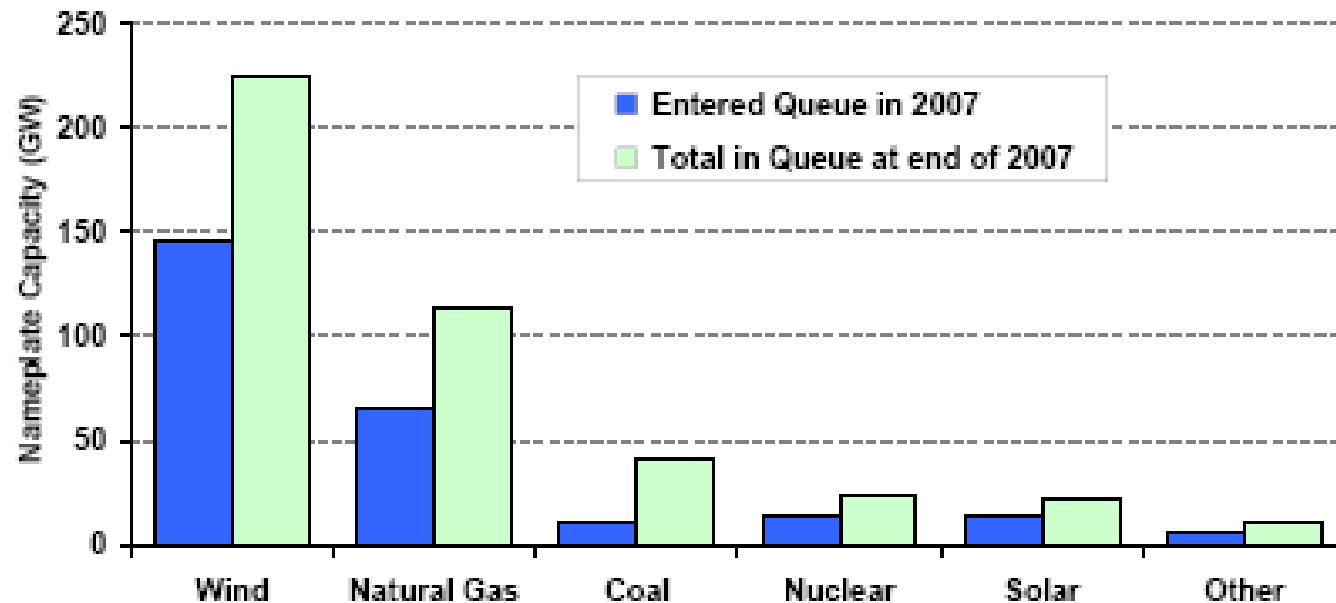
Ryan Wiser, Lawrence Berkeley Lab, July 2008

## U.S. Wind Power Capacity Up 46% in 2007



Source: AWEA

# Current Growth Predictions



Note: Figure includes data from 11 wind-relevant interconnection queues, so does not represent a truly national picture

Source: Eater Associates review of interconnection queues

- MISO (66 GW), ERCOT (41 GW), and PJM (35 GW) make up 2/3 of total
- Twice as much wind as next largest resource (natural gas) in these queues
- ***Not all of the capacity will be built, but demonstrates enormous interest***

## Applications for Grid Interconnection: an indication of planned construction.

Ryan Wiser, LBLab, July 2008.

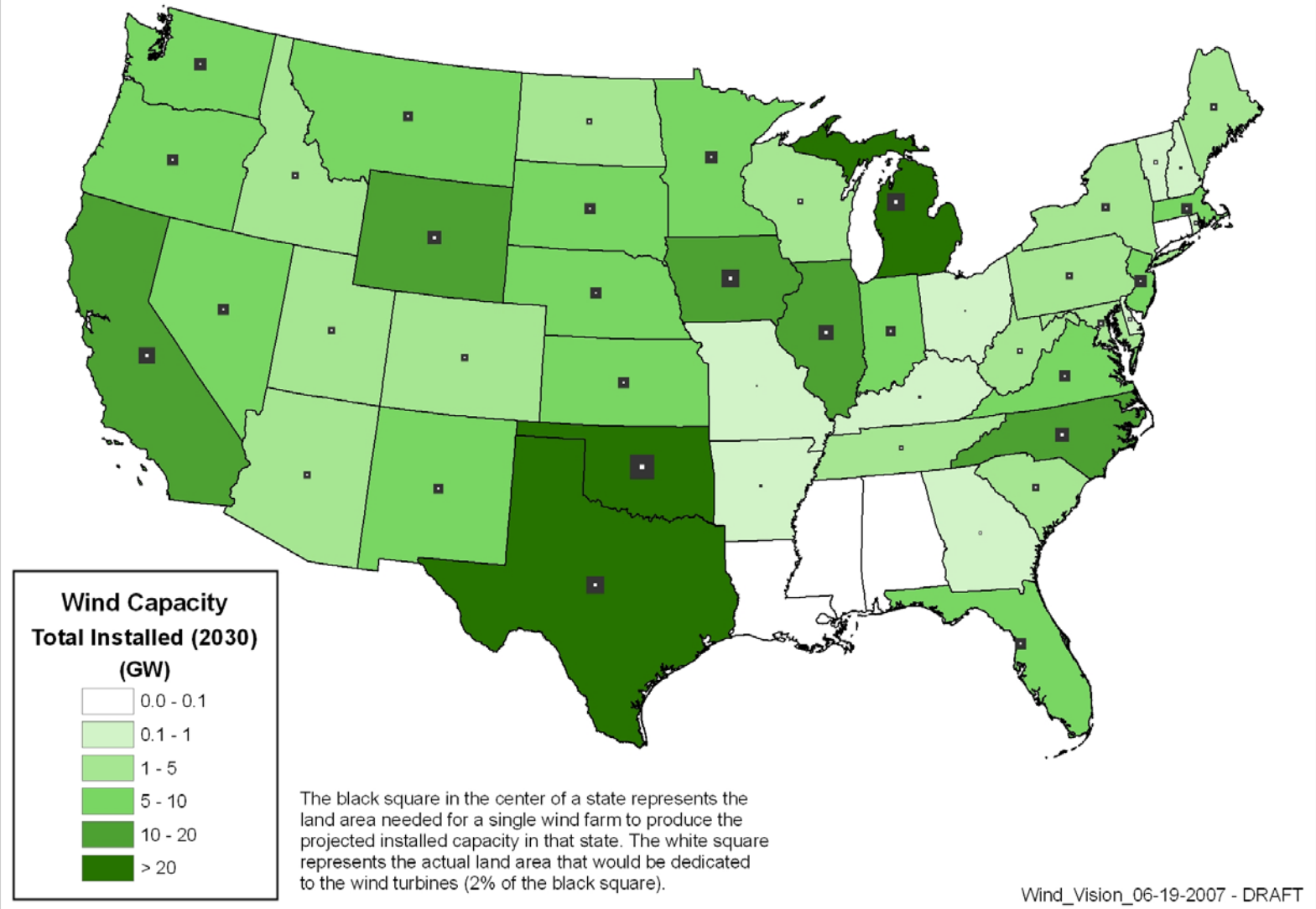


# Comparative Costs

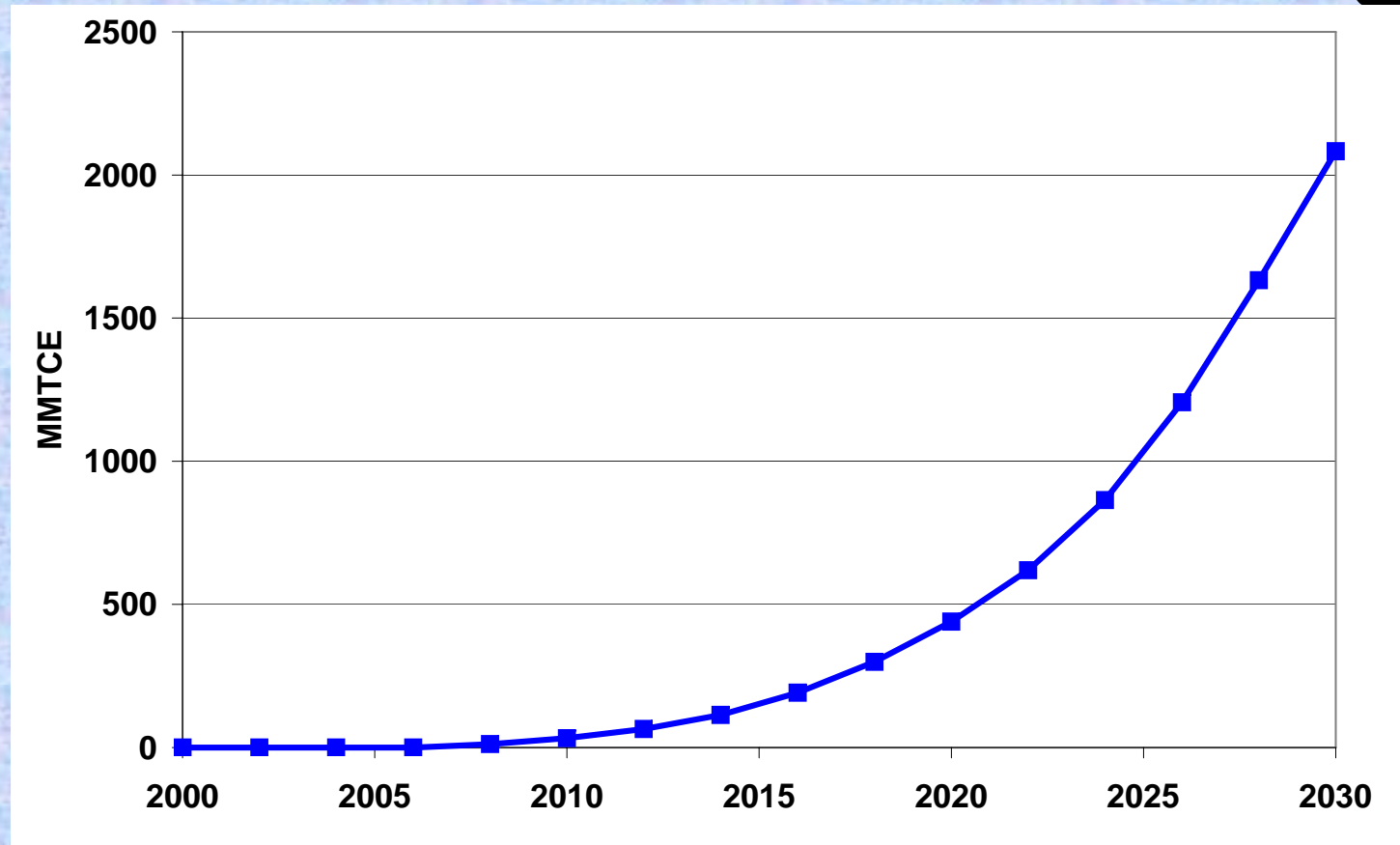
- New wind: 5-6¢/kWh (with PTC)
- Natural gas: 5-6¢/kWh
- New coal: 4-8¢/kWh (no carbon tax)
- Old coal: 2-3¢/kWh
- Old wind: <1¢/kWh?
- New Solar: 10¢/kWh lowest



### Installed Wind Nameplate Capacity by State (2030)



# Cumulative Carbon Savings



Cumulative Carbon Savings (2007-2050, MMTCE)	Present Value Benefits (billion 2006\$)	Levelized Benefit of Wind (\$/MWh-wind)
4,182 MMTCE	\$ 50 - \$145	\$ 9.7/MWh - \$ 28.2/MWh

# Community Wind: a Necessary Part

- One or few turbines per city/farm/business/town
- Lower costs, reduce carbon, increase independence
- Requires net-metering
- Lowers tax burden
- Approx 10% rate increase?





# What about Solar?

- Production peaks with demand
- Still expensive (10¢/kWh)
- Long-lasting, low maintenance
- Solar thermal costs less
- Future in low-cost amorphous CdTe



# Where the Future?

- Lots more wind plants
- Carbon tax -> renewable incentive
- Diverse mix of electric generation
- Community wind and biomass
- Smaller, lighter electric cars
- A cleaner, warmer, more expensive future

