Community-Scale Wind Energy

A Presentation to the communities of Aquidneck Island

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Supported by the

The US Department of Energy

Community-Scale Wind Power:
Agenda

- Why Wind Power?
- Community-scale wind
  - Technology
  - Economics
  - Process / Next Steps
  - Impacts


Spirit Lake Schools, Iowa

Point of view:

the community -
needs factual support for important decisions

Why Renewables?
Impacts of Fossil Fuels

- NOx, SO_2, CO_2
- Mercury, Dioxin, Particulates, CO
- Oil Spills, mountain top removal, ash, sludge, …

Why Renewables?
Impacts of Fossil Fuels

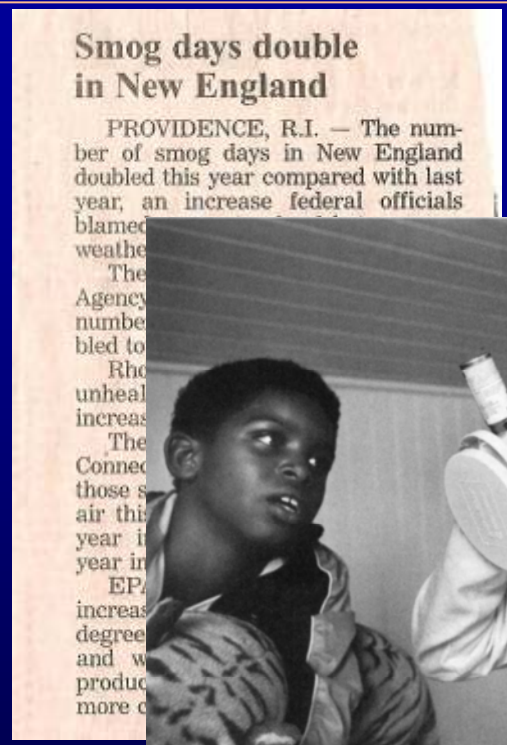
- Electricity: Largest industrial source of air pollution.
  - 2/3 SO_x
  - 1/4 NO_x
  - 2/5 CO_2
  - 1/3 Mercury

Impacts of Fossil Fuels:
Sulphur Dioxide – SO_2 – Acid Rain

- Where it comes from:
  - 67 % of SO_2 emissions in US from fossil-fuel power plants
- Effects:
  - acid rain
  - smog
- Health impacts:
  - smog triggers asthma attacks
- Environmental Impacts:
  - acid rain harms lakes & streams, depletes soil nutrients,
  - damages trees, crops, historic buildings

Impacts of Fossil Fuels:
Nitrogen Oxides – NO_X – Smog

- Where it comes from:
  - 23% of NO_X emissions in US from fossil fuel power plants.
- Effects:
  - ground-level ozone (smog)
  - acid rain
- Health impacts:
  - smog triggers asthma attacks
- Environmental Impacts:
  - acid rain, reduced visibility


Smog days double in New England

PROVIDENCE, R.I. — The number of smog days in New England doubled this year compared with last year, an increase federal officials blamed

Want more info? Try-
http://www.epa.gov/air/concerns/

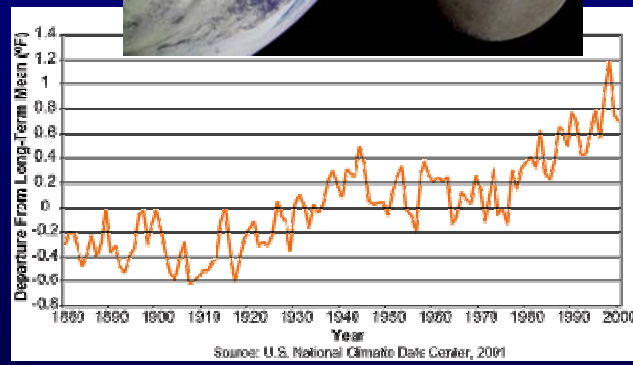
Impacts of Fossil Fuels:
Poisons & other emissions

- Mercury
  - brain damage, fetal damage
- Dioxin
  - Liver damage, immune deficiency
- Carbon monoxide
  - poisonous; greenhouse gas
- Particulates, arsenic, lead, cadmium
- Cooling water heats rivers & lakes
- Oil Spills, mountain top removal, ash, sludge, etc.

Anchorage Daily News

Impacts of Fossil Fuels:
Carbon Dioxide – CO_2 – Climate Change

- Where it comes from:
  - 40% of man-made US CO_2 emissions from fossil fuel-fired power plants
- Effects:
  - Predominant greenhouse gas
  - Disrupts earth's carbon cycles - more CO_2 than normal into atmosphere
  - Warming
- Environmental Impacts:
  - Global climate disruption:
  - Sea level rise, Glacier melt, intensifying weather
  - Impacts on: health, agriculture, water resources, forests, wildlife, coastline



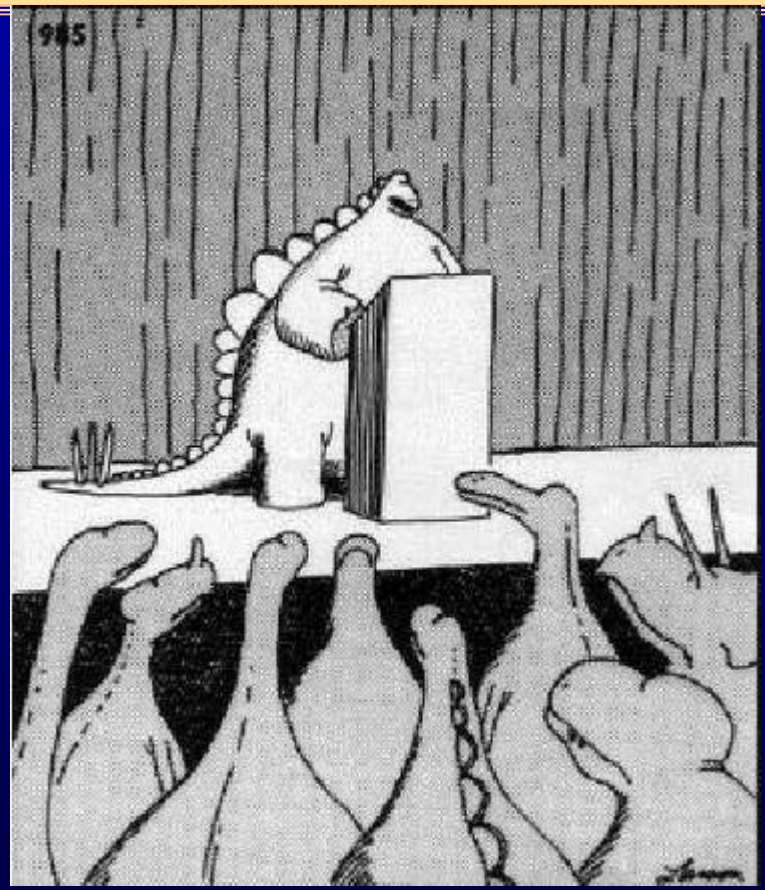
Want more info? Try- www.epa.gov/globalwarming

Impacts of Fossil Fuels:
Climate Change – No longer conjecture

- All scientists believe in the greenhouse effect.
- All scientists accept that putting more greenhouse gases into the atmosphere will warm the planet.
- The only disagreement is over precisely how much the warming will be amplified by planetary feedbacks

Want more info? Try -
http://www.newscientist.com/channel/earth/climate-change

Impacts of Fossil Fuels - The Far Side:
At least our brains are the size of a cantaloupe



United States: 5 % of world population, but emits ~ 25 % of world's greenhouse gases.

Energy from low/zero emissions sources is the core of the strategy.

- conclusion of US Climate Change Technology Program, Sept '05

The picture's pretty bleak, gentlemen.
The world's climates are changing, the mammals are taking over, and we all have a brain about the size of a walnut.

Beyond emissions - More Impacts of Fossil Fuels: *Extraction*

- Coal & Mountain-top removal

- Oil drilling

Impacts of Fossil Fuels: *Environmental Impacts*

- Major environmental groups support wind power

  as one of the tools to reduce our energy's impacts.

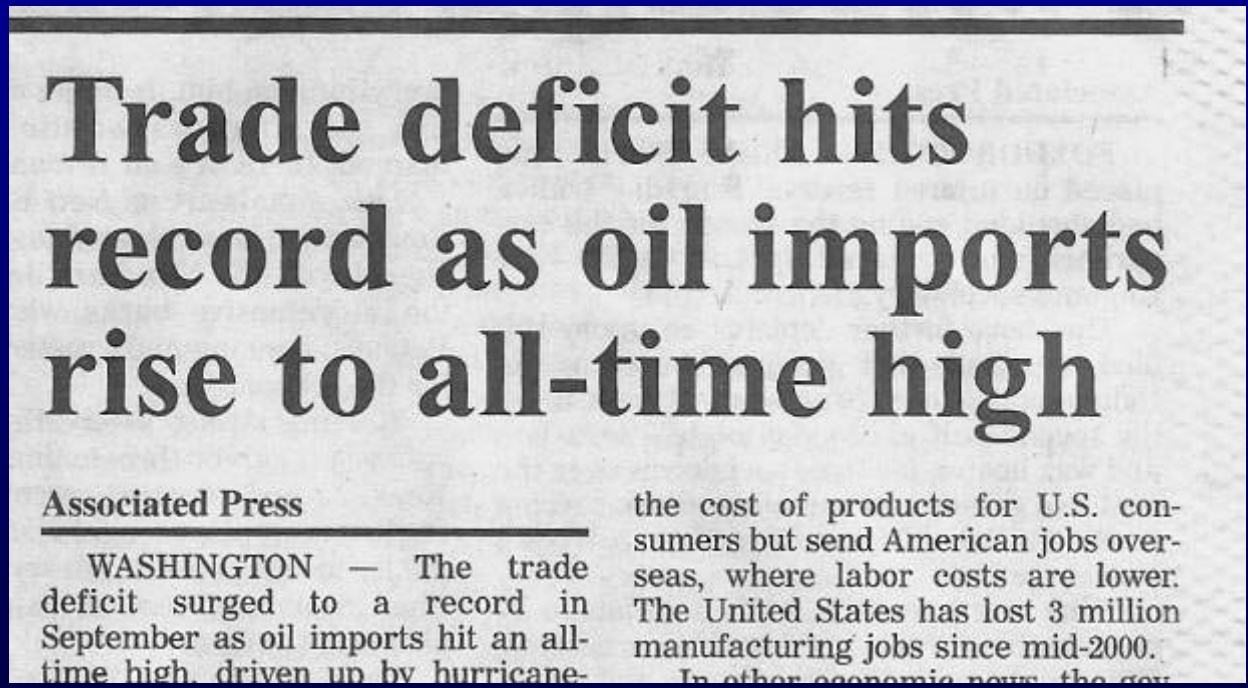
Electric power generation produces more pollution than any other single industry in the US

- Sierra Club
- Union of Concerned Scientists:
- Conservation Law Foundation
- National Audubon Society
- Green Peace
- Friends of the Earth
- Environmental Defense Fund
- Clean Water Action
- Natural Resources Defense Council
- Climate Action Network
- National Environmental Trust

etc.

Why Renewables?
Economic Reasons -

- Reduce dependence on foreign oil



Trade deficit hits record as oil imports rise to all-time high

Associated Press

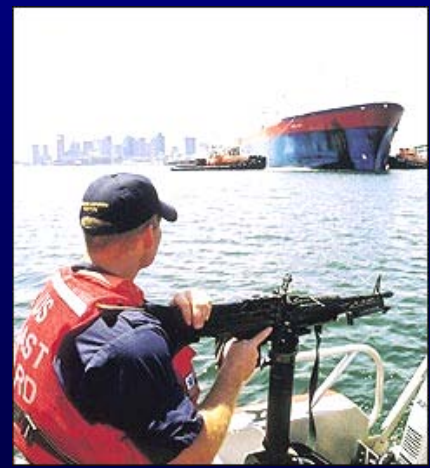
WASHINGTON — The trade deficit surged to a record in September as oil imports hit an all-time high, driven up by hurricane-

the cost of products for U.S. consumers but send American jobs overseas, where labor costs are lower. The United States has lost 3 million manufacturing jobs since mid-2000.

In other economic news, the gov

Why Renewables?
Economic Reasons -

- Renewable
  - No fuel-price volatility
  - US oil production is declining / “Peak Oil”
- Diversify energy portfolio
  - Over-dependence on Natural gas
- Reduce fossil fuel dependence
  - Security & foreign policy
    - Fossil fuels from unstable regions
  - Economic
    - Trade Deficit
- Domestic, local power
  - RI $ & jobs leaving the state

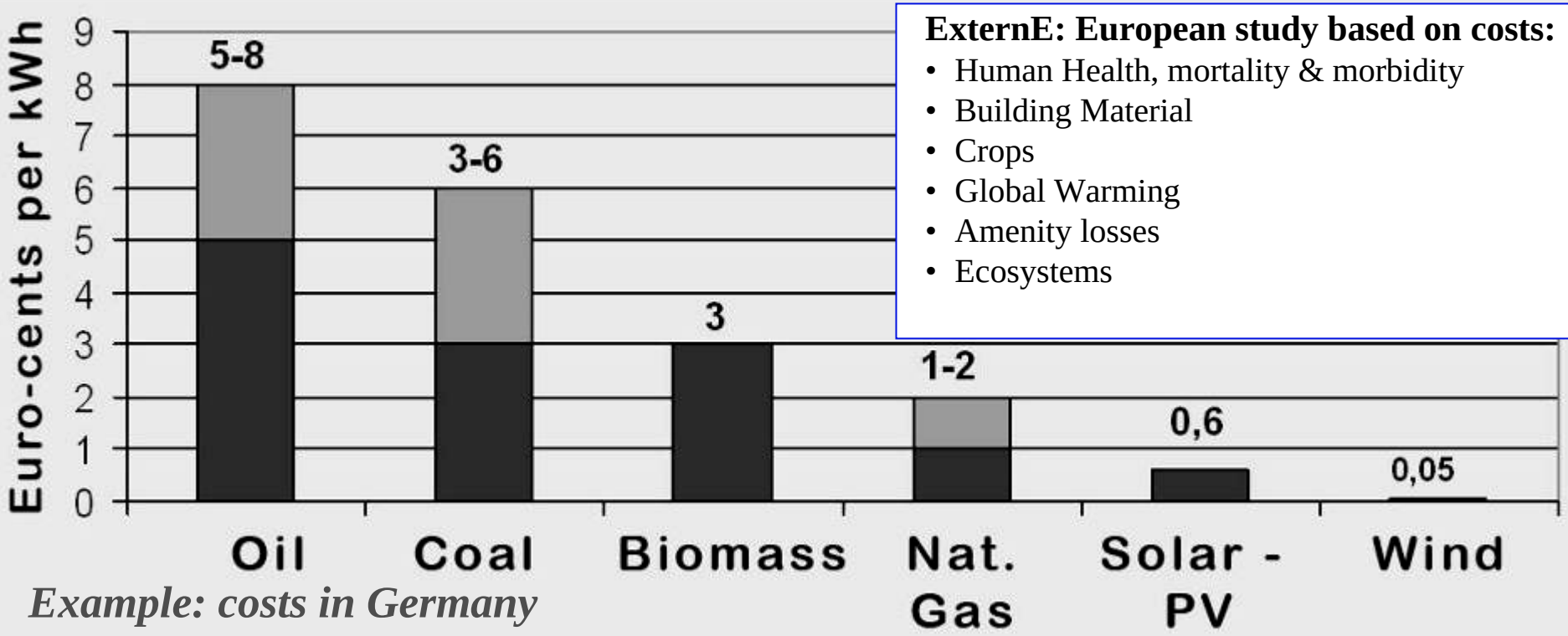


Armed escorts of LNG tanker into Boston Harbor. Source: Globe.

Impacts of our Energy Use & Production

- All energy choices have impacts
  - Health
  - Economics
  - Security
  - Environmental
    - Air, water, radiation, strip-mining, habitat, wildlife …
  - Global climate change, etc. …
- How can you compare them?

External Costs of Electricity



ExternE: European study based on costs:

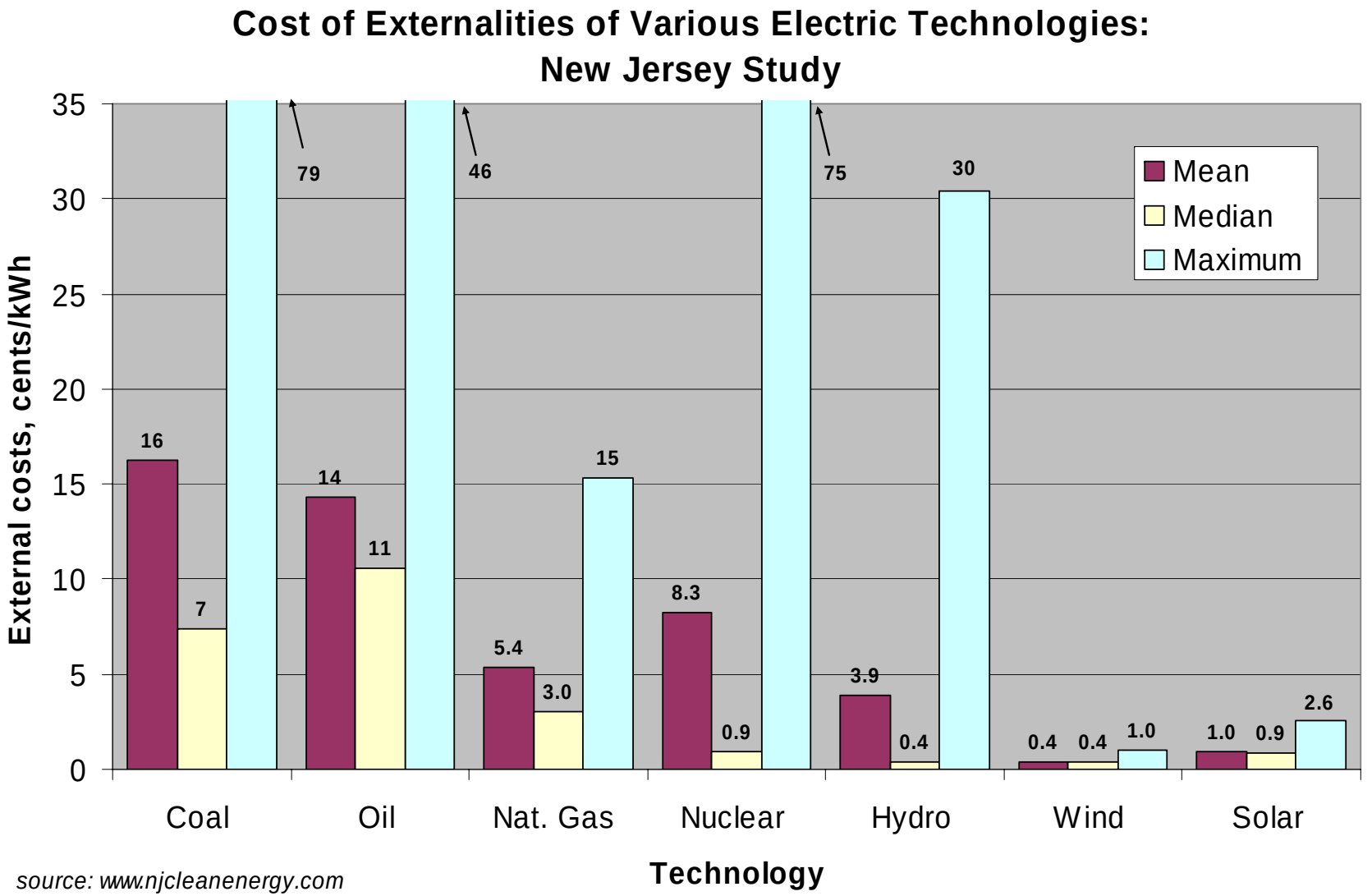
- Human Health, mortality & morbidity
- Building Material
- Crops
- Global Warming
- Amenity losses
- Ecosystems

Example: costs in Germany

Source: ExternE - European Community study, 2003

Want more info? http://www.externe.info/

External Costs of Electricity



source: www.njcleanenergy.com

Want more info?
http://www.njcleanenergy.com/media/base_line_studies_pdfs/CEEEP_Impacts_of_Environmen.pdf

Why Renewables?

- Environmental & Economical
  - Energy Status quo:
    - Not acceptable
    - Not sustainable - it *will* change
- Solutions

  …. No one solution is sufficient
  - Conservation & efficiency
  - Renewable energy

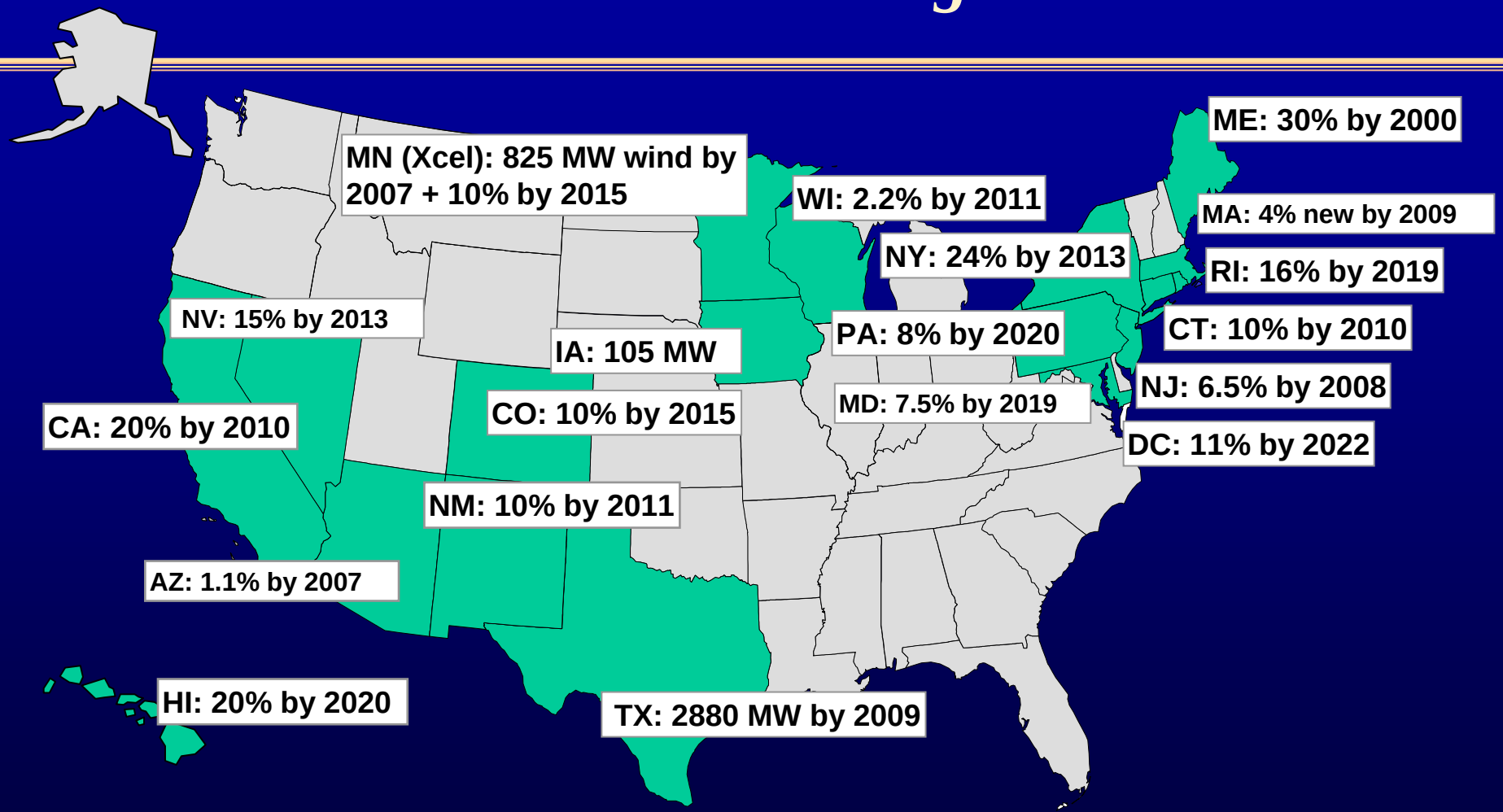
States respond: Rhode Island et al. Require Renewables

- RI Renewable Portfolio Standard (RPS)
  - 1% new in 2007 … 14% new in 2019
- Massachusetts RPS
  - Renewable Energy Certificates ("REC 's")
  - Anywhere on New England Grid
- ~18 states have an "RPS"

Want more info? www.evomarkets.com lists current REC prices

Existing State Renewable Portfolios

18 States and Washington D.C.



Renewable Energy Source

- Ultimately derived from the sun*
- Capable of being replenished on a reasonable time-scale

**Or moon, in case of tides*

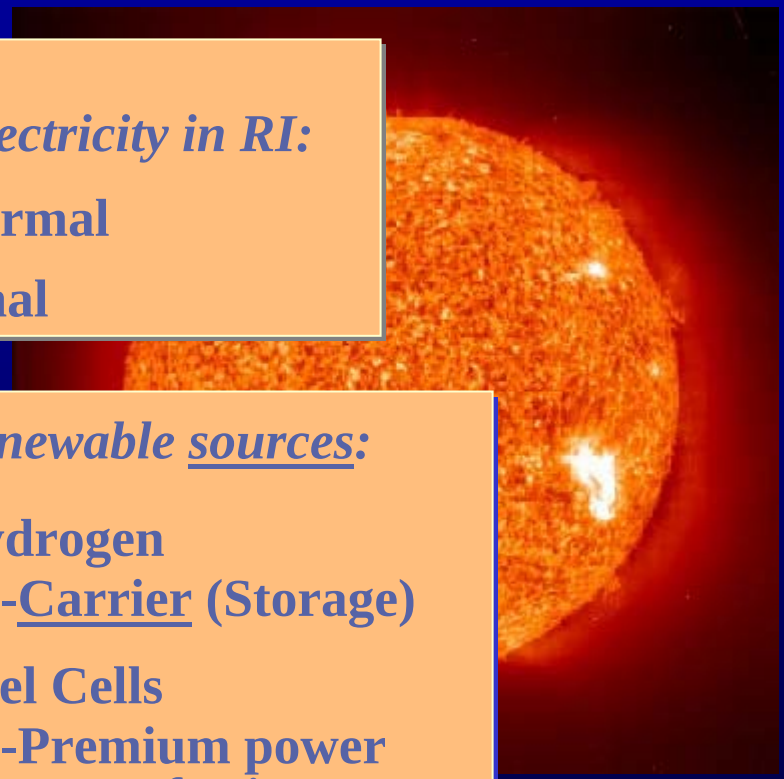
No one energy source can deliver all the electricity we need to fuel our economy

Renewable Energy: Sources for *Electricity*

- **Sunlight: PV**
- **Wind**
- **Biomass**
- **Landfill gas**
- **Hydro**
- **Ocean:**
  - **Waves**
  - **Ocean currents**
  - **Tides**

Renewable,
but not for Electricity in RI:

- **Solar Thermal**
- **Geothermal**

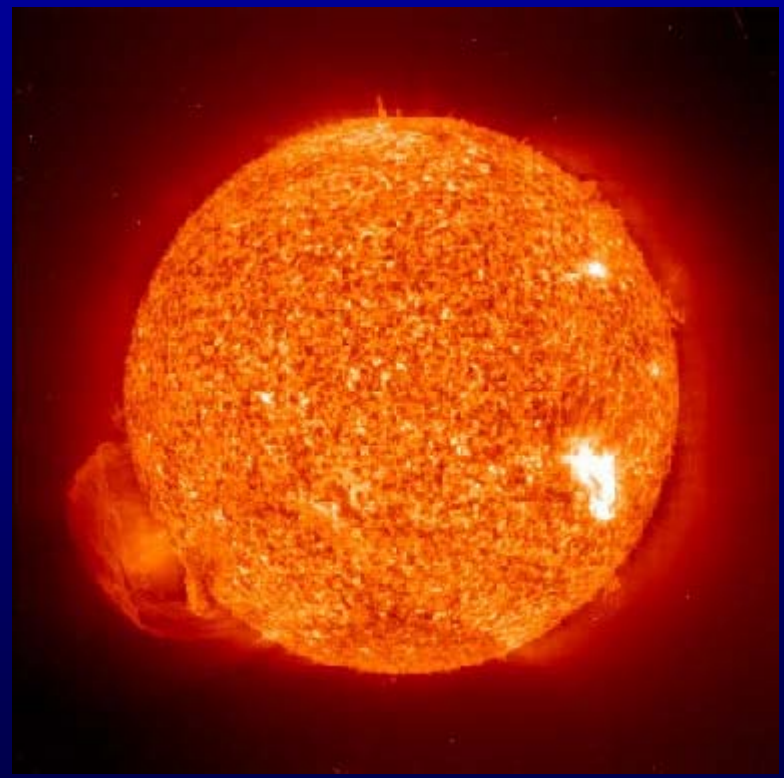


Not renewable <u>sources</u>:

- **Hydrogen**
  -<u>Carrier</u> (Storage)
- **Fuel Cells**
  -Premium power
  -Way of using H_2

Renewable Energy:
Electricity Options for New England

- Hydro: sites are taken in NE
- Ocean: Not yet feasible in N.E.
- Landfill: important
  - But limited resource
- Biomass: important
  - emissions
- PV: 5-25 x cost of wind
- → Wind

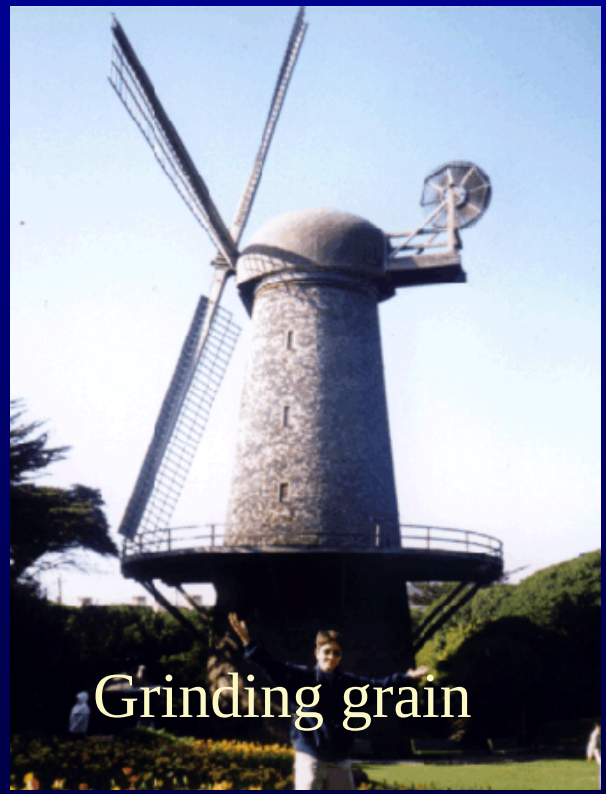


Wind Power Today

Our primary renewable energy resource

Wind Power Today
(& yesterday): Wind Mills

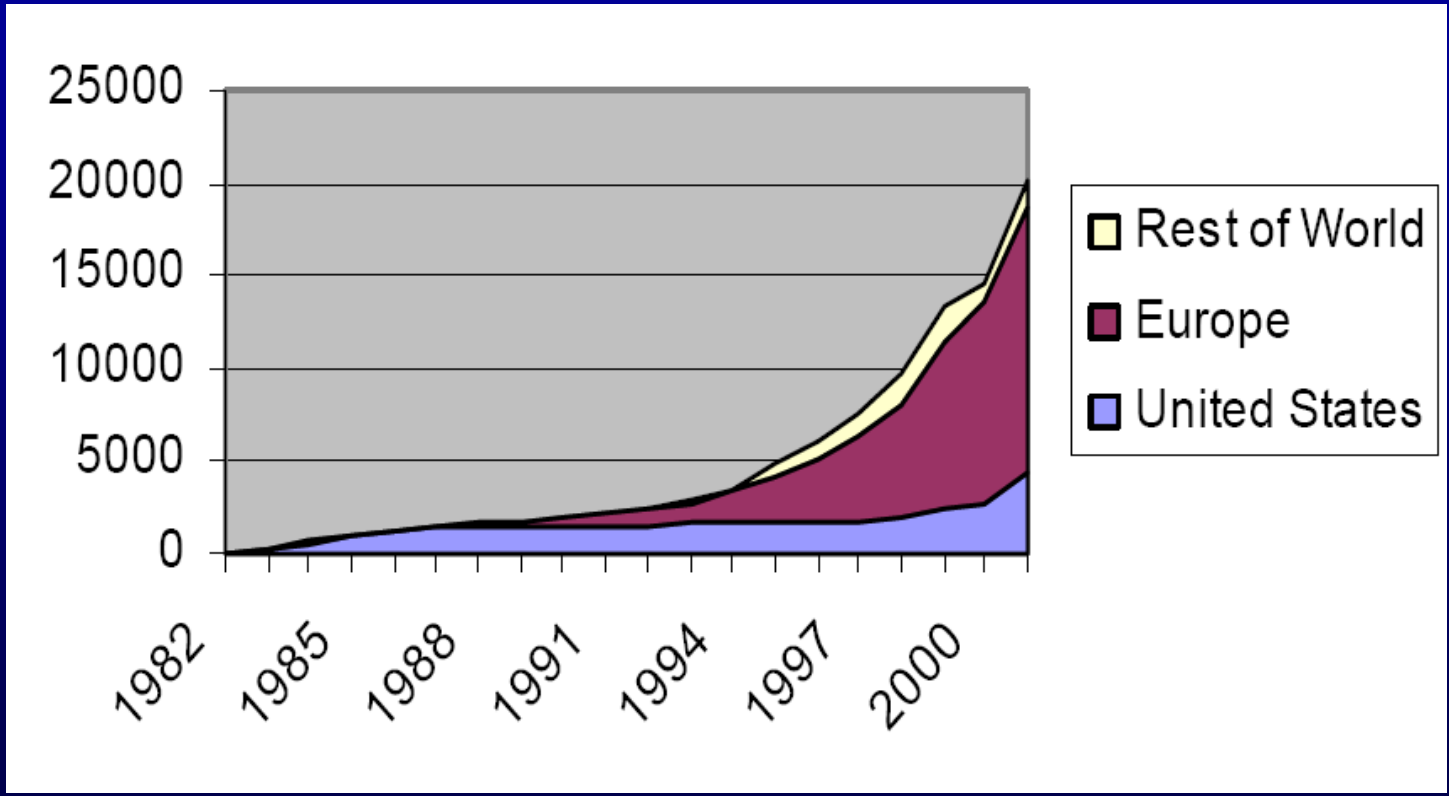
Wind mills do *mechanical* work



Wind Power Today:
Wind Turbines or *Wind Generators*

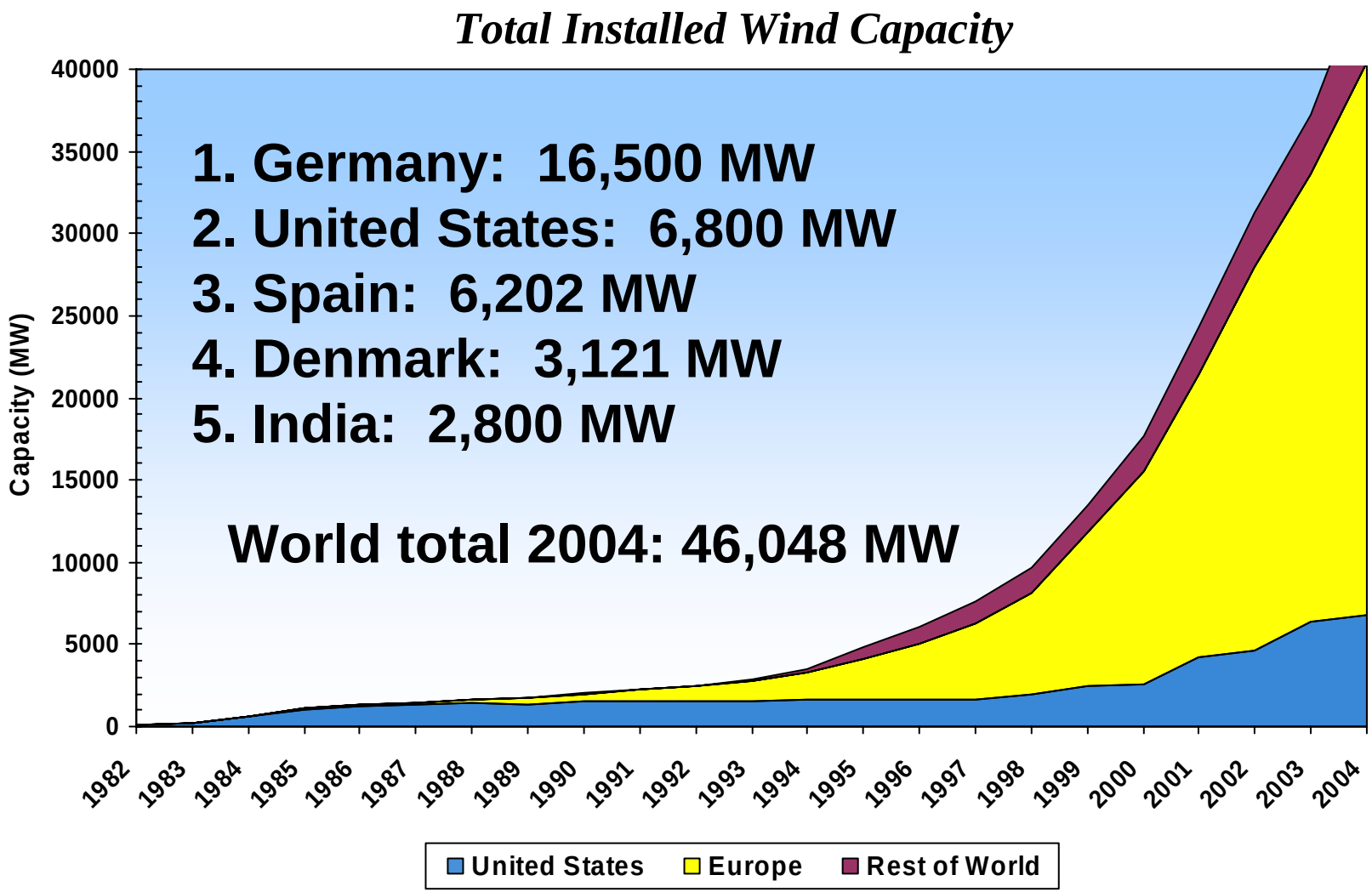
Generating *electricity*

Growth of Wind Energy
*Quick: 32% per year**



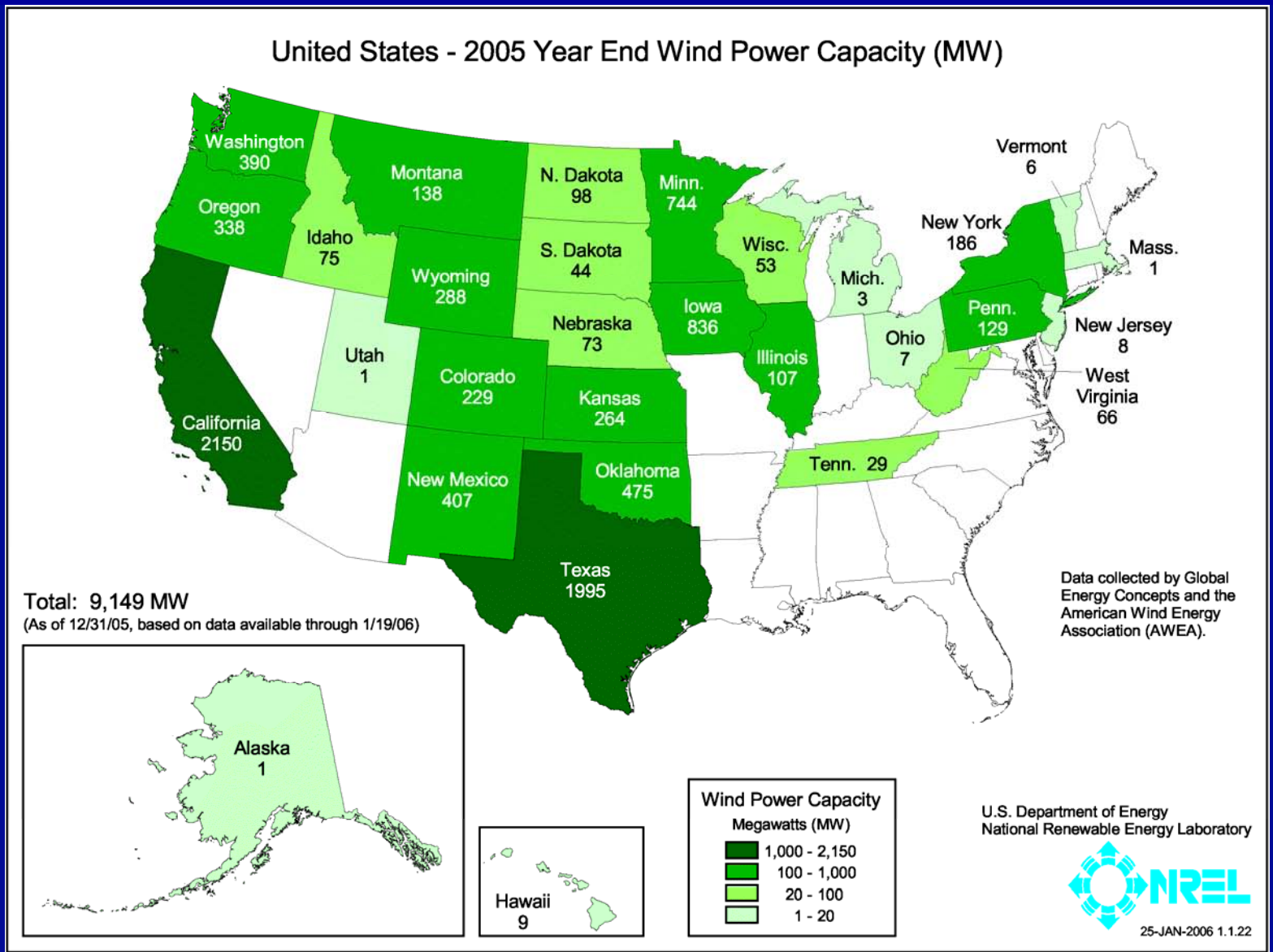
**5-year average*

Growth of Wind Energy
Worldwide

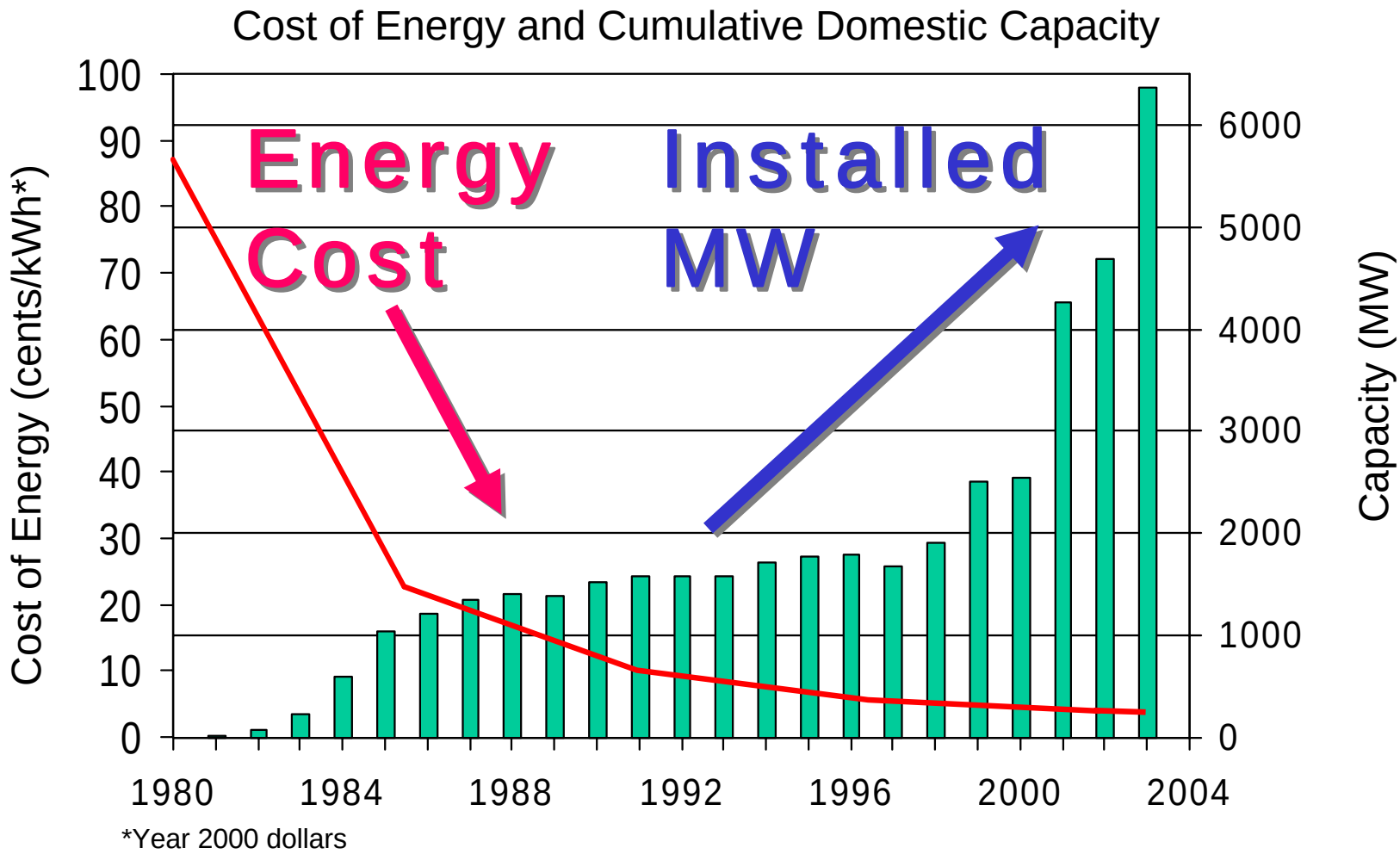


Source: WindPower Monthly

Growth of Wind Energy
Nationwide



Growth of Wind Energy
Spurred by lowering costs



Increased Turbine Size - R&D Advances - Manufacturing Improvements

Wind Power Today:
Scale

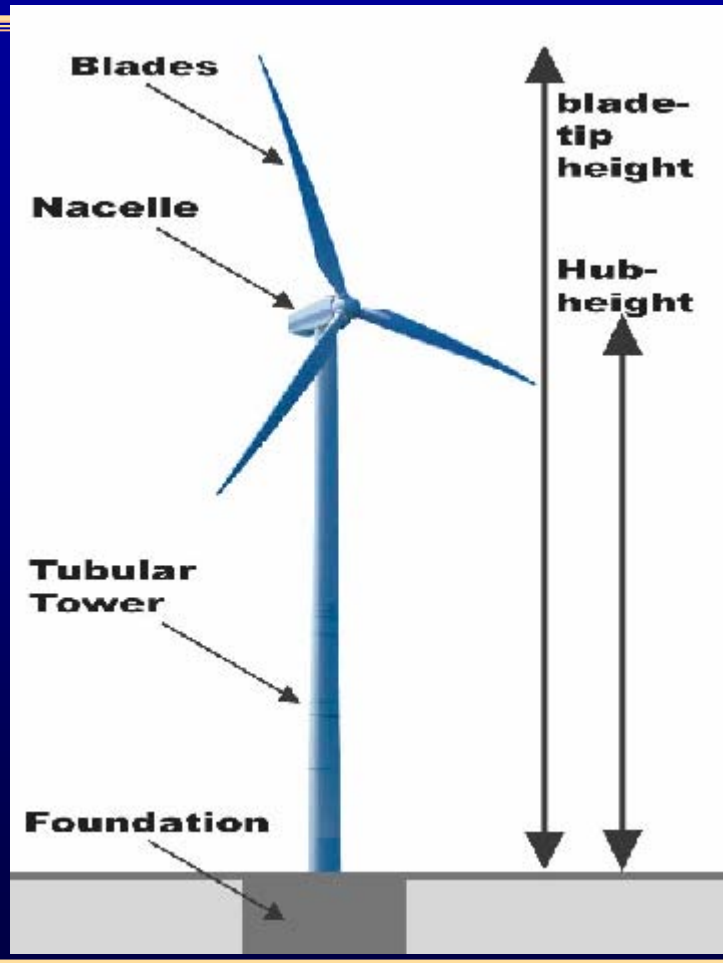
- "Small" Wind
  - 1-30 kW
  - Net-metered
    - Sized for the load

- Large
  - 660 kW – 2 MW +
  - Grid- connected
    - Normally *not* sized to a load
- Medium
  - Usually matched to a large load

Wind Power Today:
Scale - Height

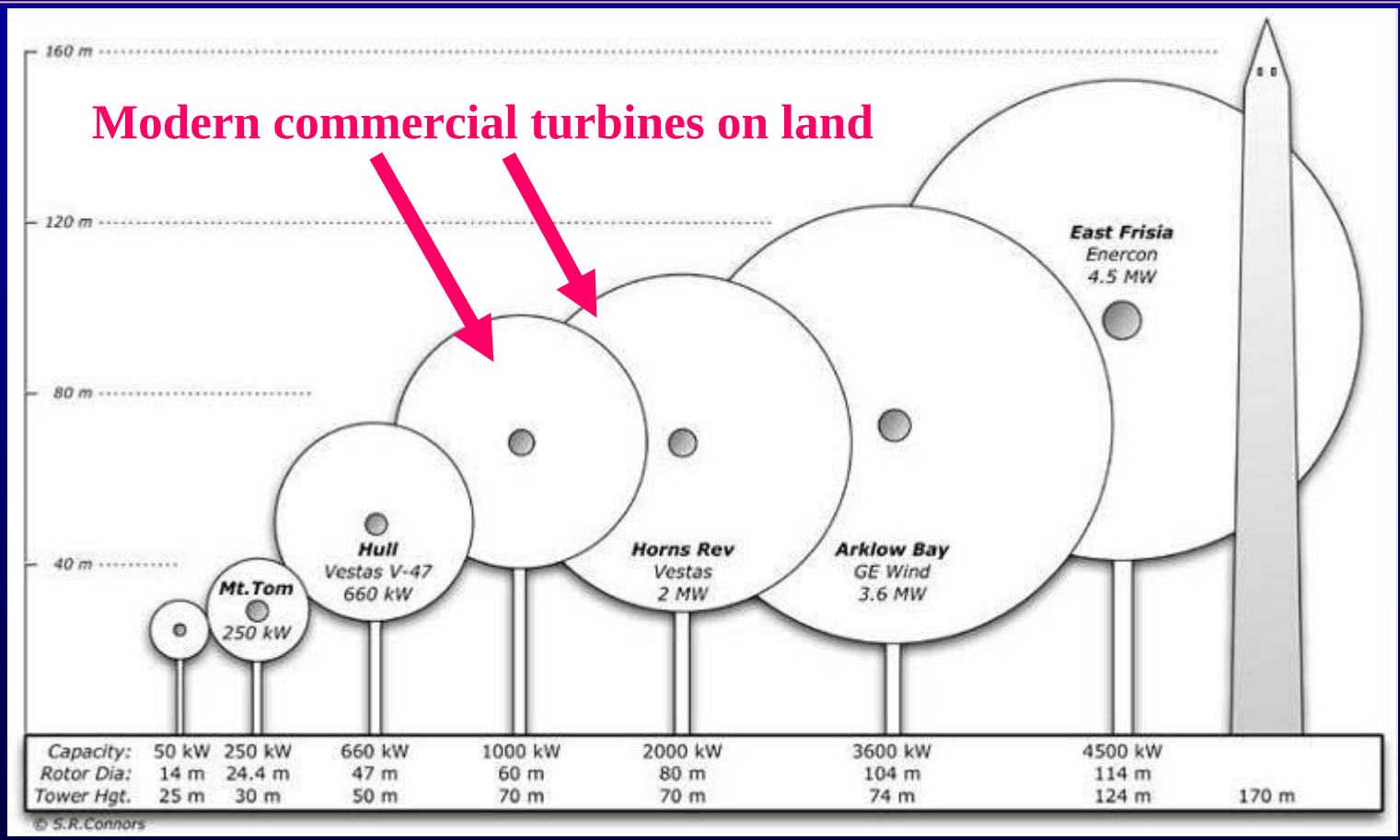
- Hub height : 160’ - 260’
  (50 – 80 meters)

- Blade tip : 240’ - 390’
  (74 – 119 meters)



Three warmest years on record have all occurred since 1998; 19 of the warmest 20 since 1980.

Wind Power Today:
Scale - Height



Wind Power Today:
Scale - Length

- *Transportation– tower sections*
- *~50’ long*

Wind Power Today:
Scale - Length

- *Transportation – blades*
- *75-130’ long*

Wind Power Today:
Scale – Footprint

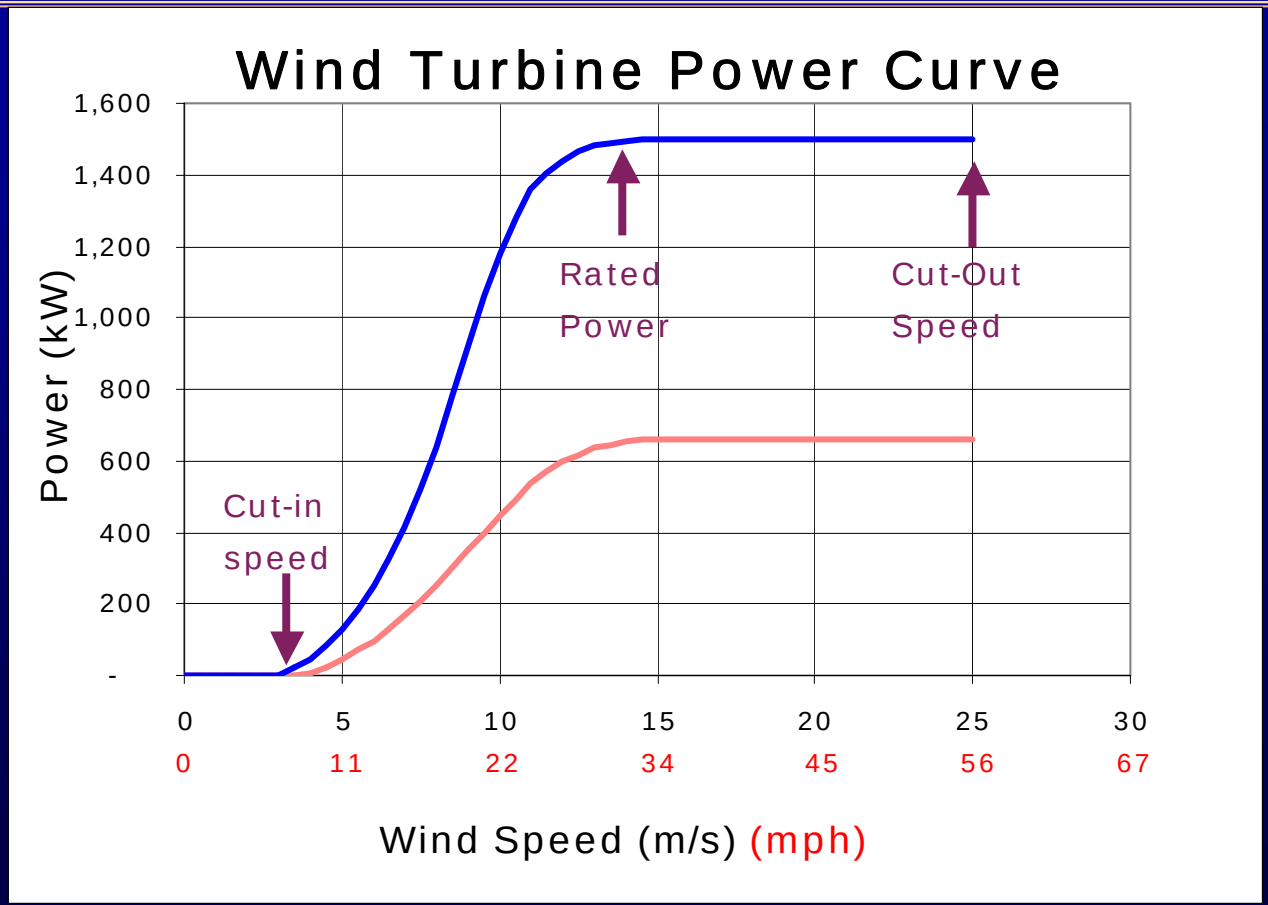
Diameter ~10-15’

Wind Power Today:
Technology

- *Power curves*

tell us:

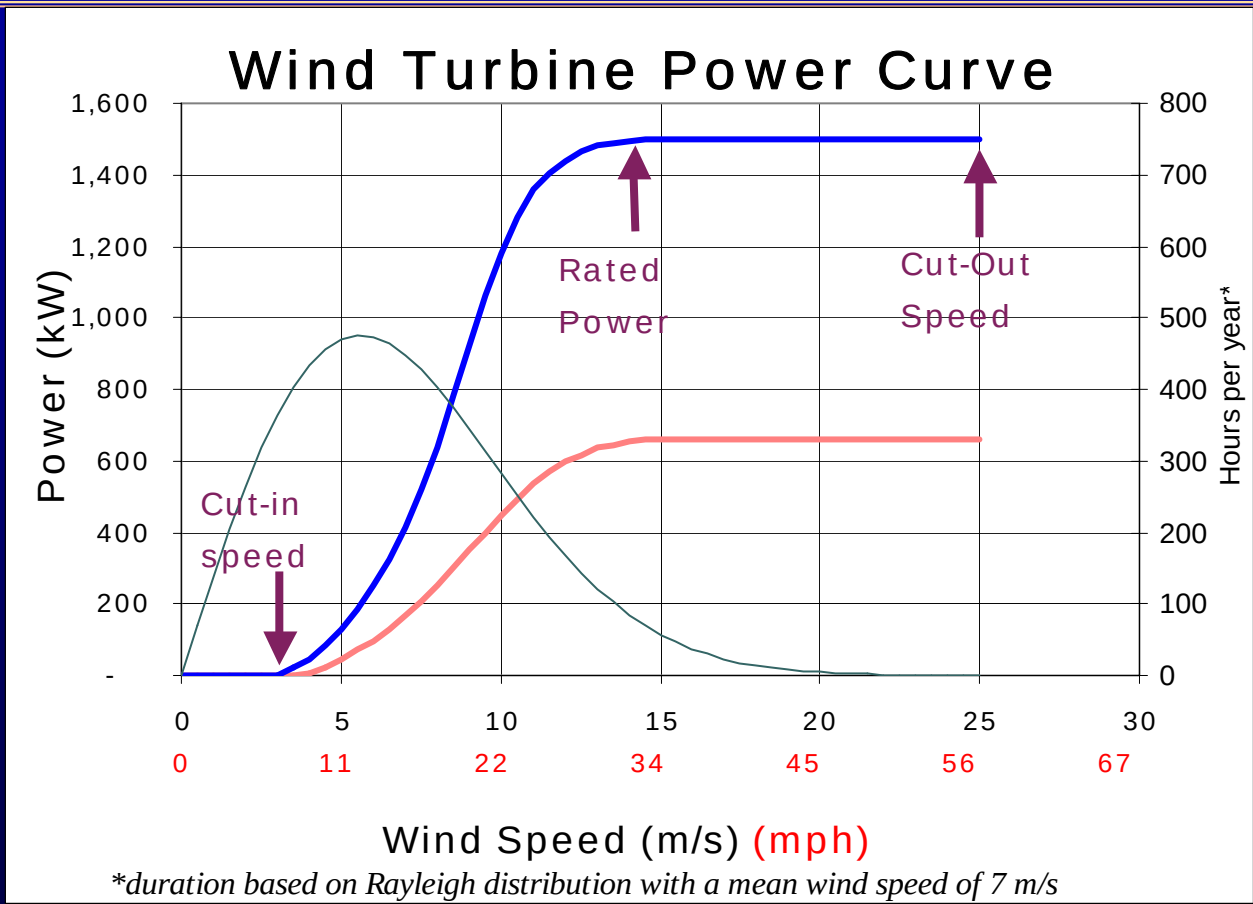
how much power can we make, at a given wind speed?



Wind Power Today: *Technology*

- *Power curves*

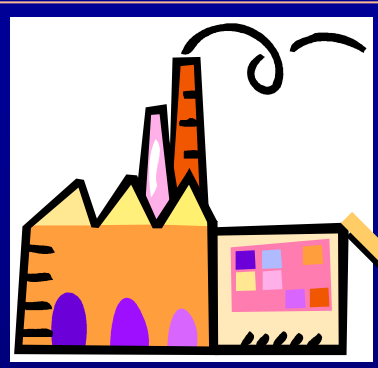
are designed to make the best of the available wind

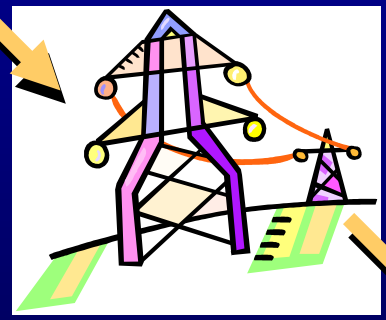


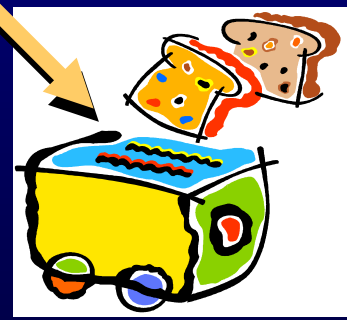
*duration based on Rayleigh distribution with a mean wind speed of 7 m/s

Energy Basics
Talking Power

- Power
- Energy
- Capacity factor
- The Grid



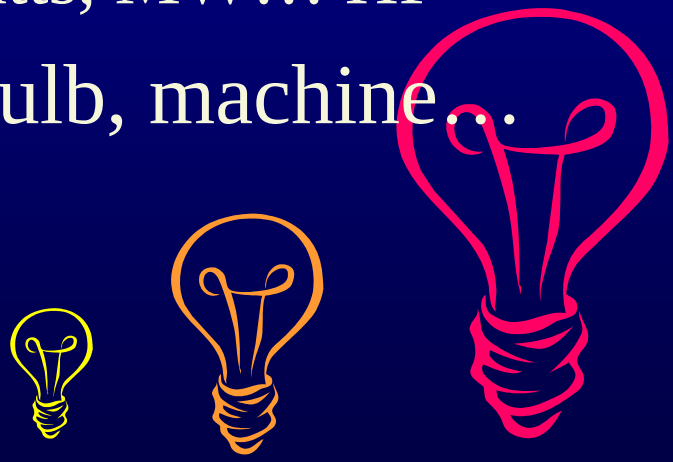




- *… And what happens when the wind doesn't blow*

Energy Basics
Talking Power

- Power is:
  - The rate of using / making energy
- Units:
  - Watts, kilowatts, MW… HP
- Size of light-bulb, machine…



How **big** is that?

1000 Watts = 1 kilowatt:

Ten 100 watt light bulbs

1000 kW = Megawatt:

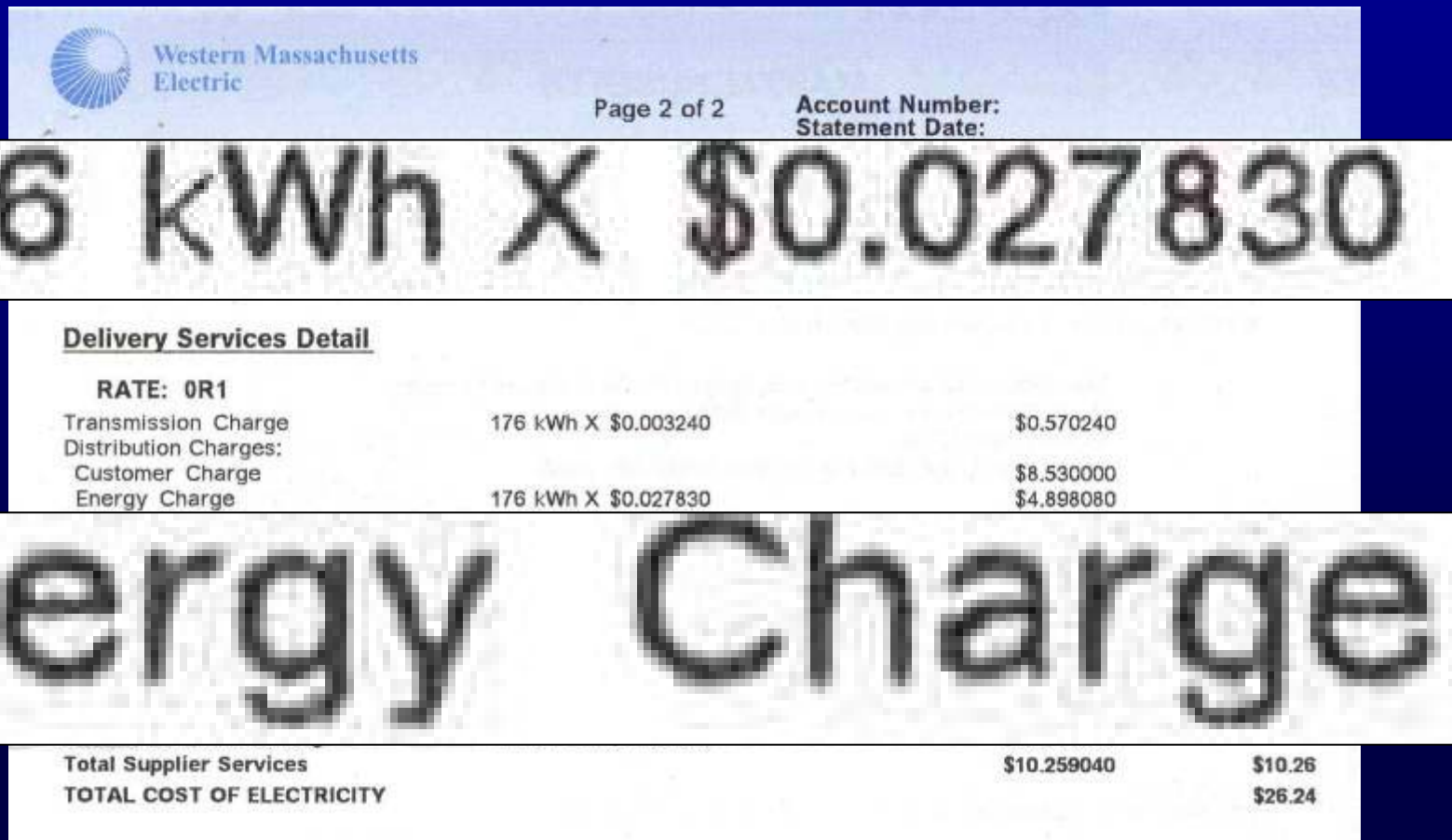
A wind turbine

1000 MW = Gigawatt:

One nuclear plant

Energy Basics
Talking Energy

kW? kilowatt-hours??



Energy Basics
Talking Energy

- Energy is:
  - the ability to change oneself or one's surroundings
- Units:
  - Kilowatt-hours, kWh, MWh
  - Size x time
- Focus on the Energy – the kWh:
  - Cost & savings based on *energy*
  - Emissions based on *energy*
  - Wind is an *energy* resource
    - not a power resource

How **much** is that?

1 kilowatt-hour (kWh)

One 100-watt light bulb on for 10 hours

600 kWh:

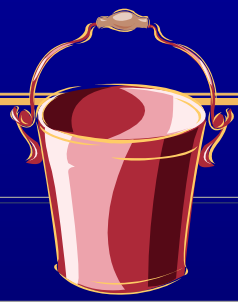
one household in one month

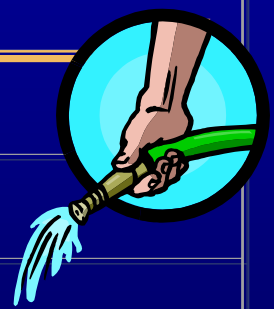
1 or 2 GWh:

Portsmouth Abbey's Wind Turbine for one year

Energy Basics

Talking about Energy & Power





	Energy	**Power**
	Quantity	*Rate*
Unit	kWh	kW, MW
Water analogy	Gallons	Gal / Min
Car analogy-	- How far? - Gallon of gas	Engine HP
Cost example	12 ¢/kWh	$1,500,000/MW
Grid	Cost & emissions	Installed capacity

Describing Energy:
Capacity Factor
or, "What happens when the wind doesn't blow?"

- Hypothetical year @ 100%:
  660 kW generator size
  x 24 x 365 hours/year
  = 5,765,760 kW-hours/Year
  – ~ 1,600,000 kWh in Hull in 2003
    - 28% capacity factor
  – Typical CF: 20 - 40%
- → the Grid

Capacity Factor
is not unique to wind power

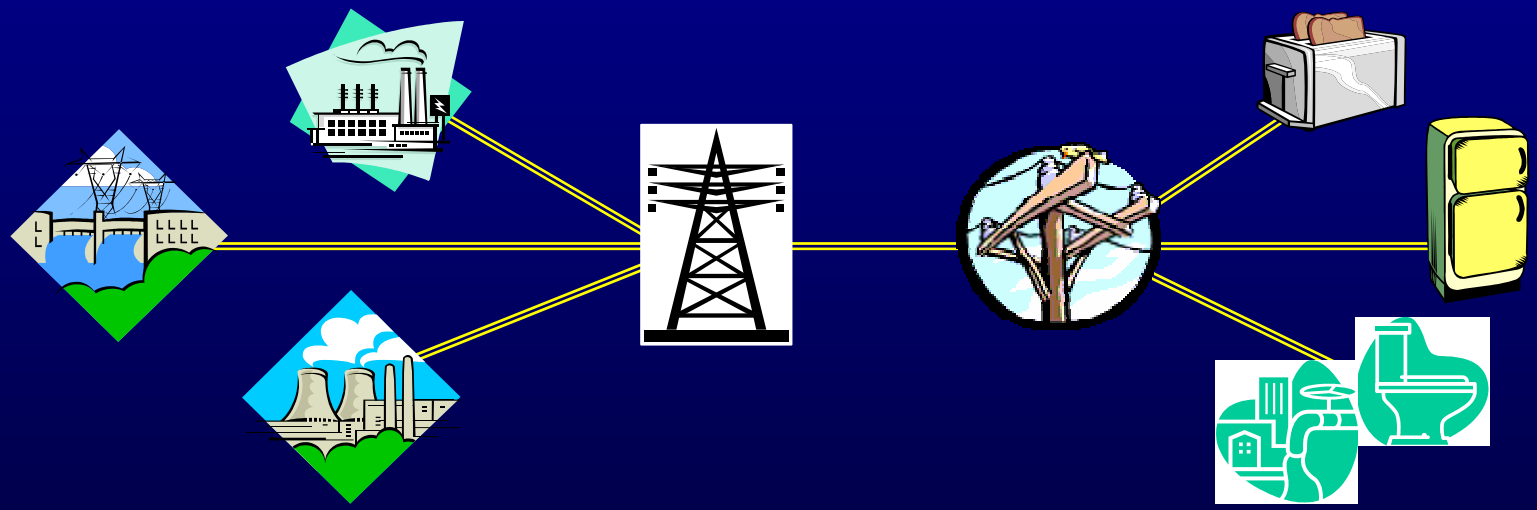
- All generators have capacity factors
- Depending on purpose, resource, and technology
  - Thermal plants
    - base-loaded (e.g. large coal): 70-90%,
    - combined cycle natural gas, e.g.: 60% (depending on gas prices)
  - Hydro: 30-80%
    - US average toward the low end of that range
    - Hoover Dam: 25%
  - PV in New England: 12-15%.
  - Nuclear 60% -100% or more
    - 2002 average: 92%

Talking about Energy
The first important question:

"How many kWh does it make per year?"

The Grid in New England:
What is a Grid?

- All the Generators
- All the Loads (Everything that uses electricity)
- Distribution &Transmission lines connecting them



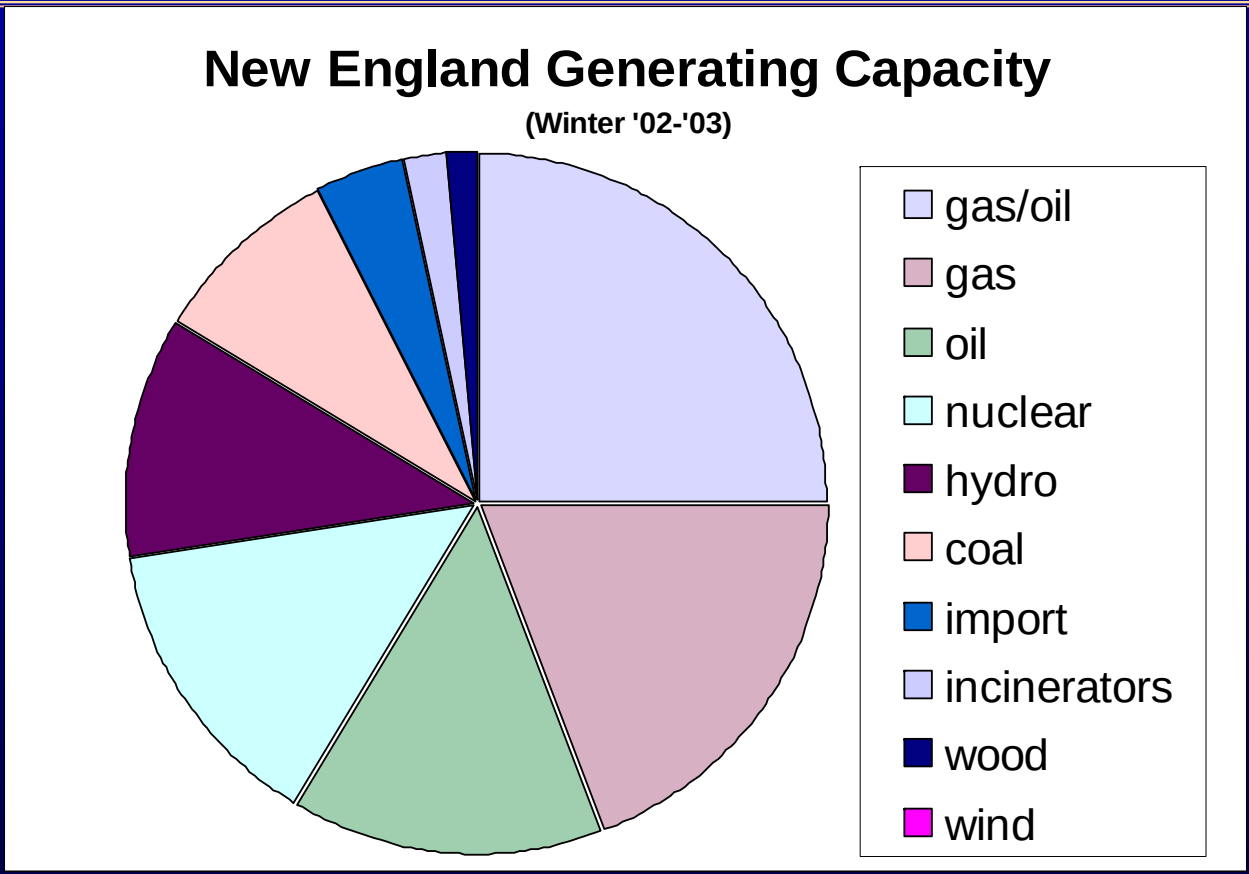
Half a million Massachusetts children live within 30 miles of a power plant, where the greatest health impacts are felt.

The Grid in New England:
Who is it?

- ISO New England operates our grid
- Control room in Holyoke, western MA:

(ISO = “Independent System Operator”)

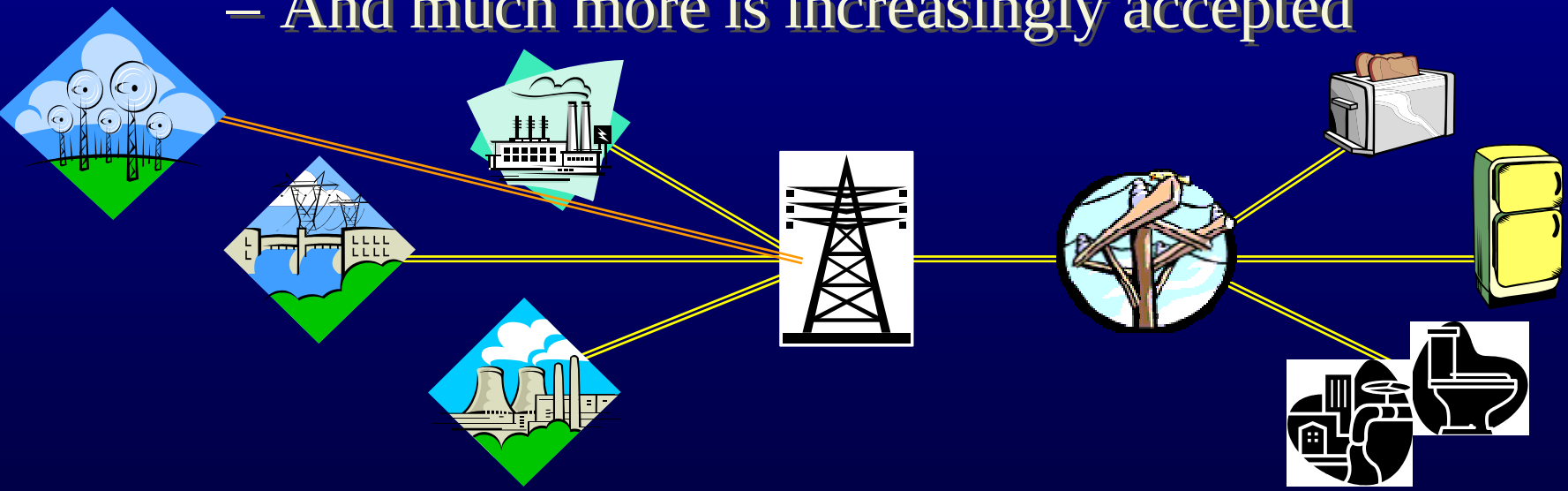
The Grid in New England:
Generators



Source: ISO-New England 2003 CELT Section I Summaries

The Grid
& Wind's intermittency & variability

- Loads are already quite variable
- Adding 10% wind:
  - very little effect on cost or reliability
  - And much more is increasingly accepted



Want more info? Try www.uwig.org, *or* www.nyserda.org/publications/wind_integration_report.pdf

The Grid
& Wind's intermittency

- Intermittency ≠ Reliability
  - Wind turbines have comparable availability as other generation
- Avoided emissions is the point:
  - For every kWh made by wind, a kWh is not made with fossil fuel *

**primarily. Other types of plants offset to a lesser degree*

Want more info? See http://www.iso-ne.com/Planning_Reports/Emissions/

Describing Energy:
Marginal Emissions Rate
another "unit of energy"

- By New England Power Pool (NE-ISO)
- Tells us the emissions change for RE & EE
- Annual marginal average, 2002
  - SO_2: 3.27 lbs/MWh
  - NO_x: 1.12 lbs/MWh
  - CO_2: 1337.8 lbs/MWh
- E.g. Hull, 660 kW @ 28% CF
  - SO_2: 5,300 lbs
  - NO_x: 1,800 lbs
  - CO_2: 1,100 tons.

Want more info? See http://www.iso-ne.com/Planning_Reports/Emissions/

The Wind Resource – *Is there enough wind to bother?*

Yes, very significant:

- World
  - Denmark: ~20% from wind
  - Schleswig-Holstein, Germany, 30% of demand
  - Navarra, Spain, 50%
- US Resource
  - North Dakota, Kansas and Texas could power the US
    (Department of Energy 1991)
- New England's indigenous energy resource
  - On-land
  - Offshore – much more than our consumption

The Grid:
Summary: Wind Works

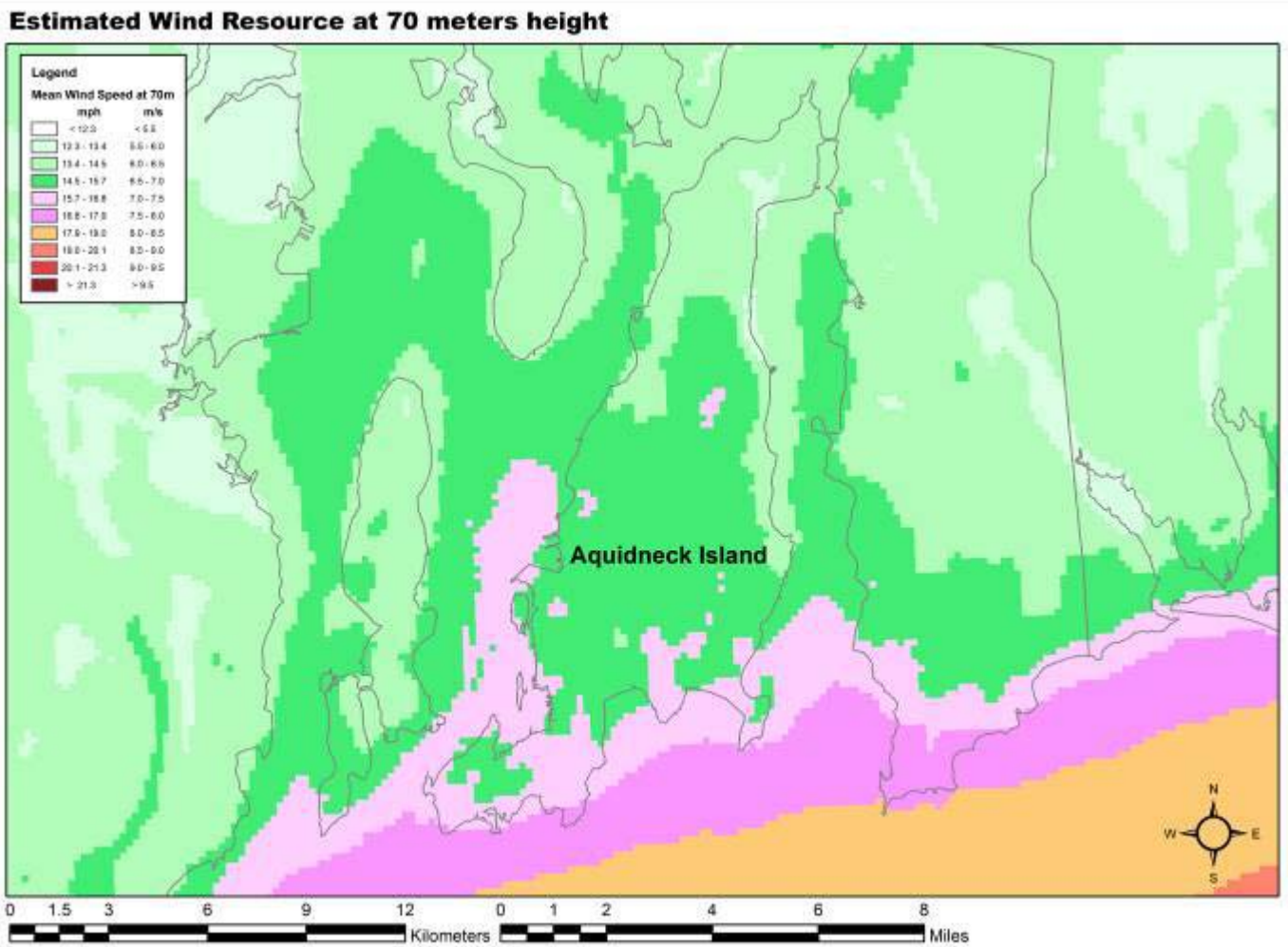
- For every kWh made by wind, a kWh is not made with fossil fuel *
- Wind power -
  - reduces emissions
  - can make a significant amount of our energy
  - has been successfully integrated into power grids

**primarily. Other types of plants offset to a lesser degree*

Want more info? See http://www.iso-ne.com/Planning_Reports/Emissions/

The Wind Resource –
Where is Rhode Island's Resource?

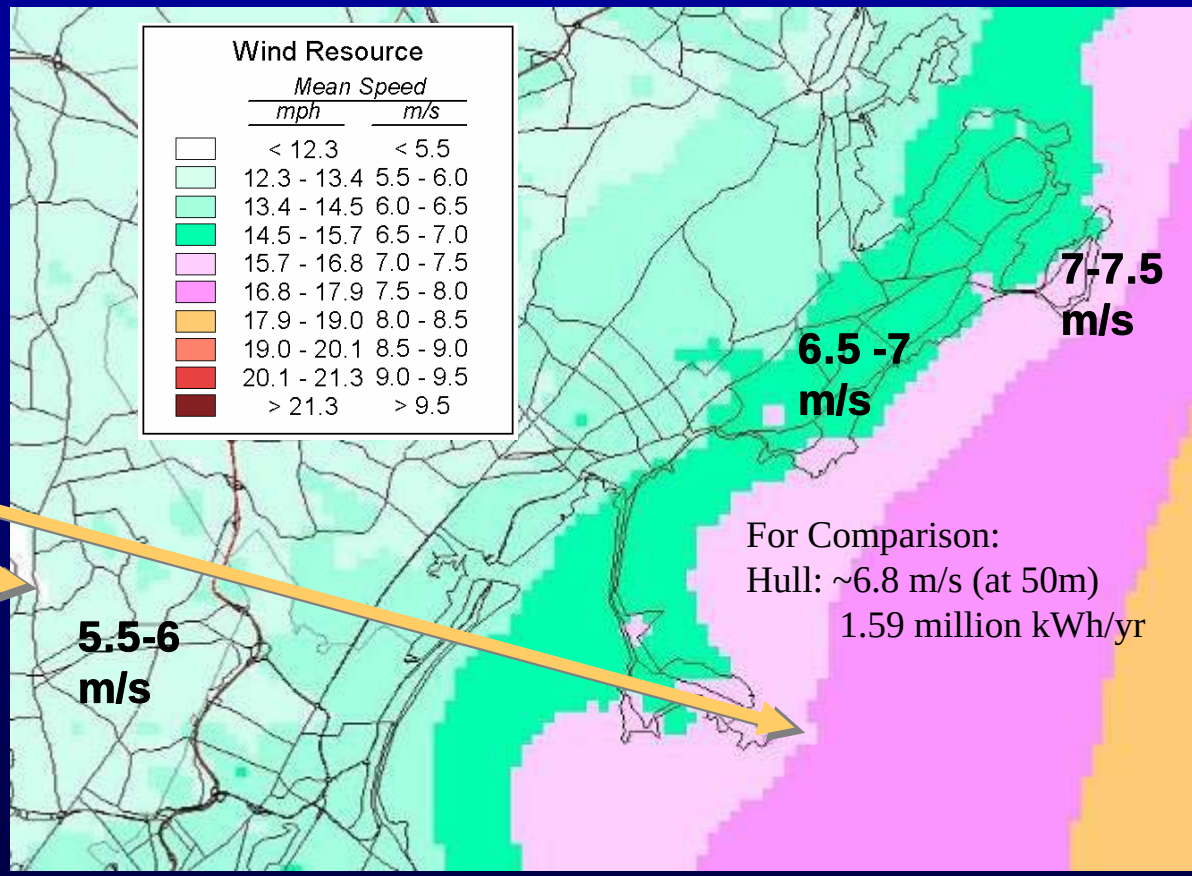
- Coast
- Hills
- Offshore



Mean wind speeds are AWS-TrueWind's estimates for New England, 2003. For more information, see TrueWind Solutions, truewind.teamcamelot.com/ne/ . Sites of primary interest for megawatt-scale wind power have a mean wind speed of 6.5 m/s or over, i.e. shown in dark green, pink or above.

The Wind Resource – *Does Wind Speed Really Matter?*

- Yes!
  - Expect ~75% more energy here than here
  - → Siting



Community Wind

Community Wind Examples:
Municipal Electric Co. - owned

- Hull, MA
- Vestas V47, 660 kW
- 262’ to high school
- 788’ feet to nearest home
- 1.5 million kWh/year
  (→ ~28 % capacity factor)

www.hullwind.org/ or http://www.ceere.org/rerl/publications/published/communityWindFactSheets/RERL_Case_Study_Hull_Wind_One.pdf

Community Wind Examples: *Co-op owned*

- Toronto Renewable Energy Co-operative
  - Citizen environmental group
- 50/50 partnership: WindShare & Toronto Hydro
- Lagerwey 750 kW
  - 1.8 GWh/yr (~250 homes)
  - 94m tall
  - 200 meters to nearest household

http://www.windshare.ca/

Community Wind Examples: *School-owned*

- Eldora, IA, High School
- 750-kW turbine
- Purchased with no- & low-interest loans
- Offsets the school's electricity use; excess energy sold to local utility
- When the loans are paid off, revenue will be used for school programs.

See www.windustry.com/community/projects.htm for other community wind profiles

Community Wind Examples: *Farmer-owned*

- MinWind Model
  - 11 turbines (NEG Micon/Vestas)
  - 9 LLC's
- Co-op based By-laws
  - 85% Farmer-owned
  - No one can own more than 15%
- Hired a lawyer for LLC
  - Cost $198,000
- Hired a consultant for PPA
  - "hardest part"

See http://www.windustry.com/newsletter/2002FallNews.htm for more on MinWind I & II

Community Wind Examples: *Town Sponsored*

- Example
  - On town land
  - Turbine owner
  - Pays lease to town
- MA law: hard for town to own any generator
  - Unless municipal utility
- RI:

Community Wind Economics:
Siting matters

- Siting affects:
  - Wind speeds
    - Capacity factor
    - Energy production
  - Installed cost
    - road building
    - site access costs
    - foundation costs
  - Maintenance costs

Community Wind Economics:
How do you make money with electricity?

- Example: a Vestas V47, 6.8 m/s

1. Make energy	1,600,000	kWh/year
2. Sell the energy Per your Power Purchase Agreement (PPA):	4	¢/kWh
3. Sell your REC's (Massachusetts RPS):	2.5	¢/kWh
4. Federal tax credit (PTC)	1.8	¢/kWh
Gross income per kWh	8.3	¢/kWh
Gross annual income	$ 132,800	$/Year

- Then pay for maintenance, operation & insurance - and equipment
- If cost was $770,000 ➔ about 6 years *simple* payback

Community Wind Economics:
Your mileage will vary!

- Can be a Revenue Source
  - Pay back
- Three "income streams"
  - Sell kWh
  - Sell REC's
  - Fed. Tax credit (PTC)
    - or REPI - Renewable Energy Production Incentive
- Siting & financing matter
- Weigh risks & benefits of community ownership

Community Wind:
Steps to siting a wind turbine

1.Measure resource

– Why? To compare *value* (kWh) with costs

– How? 40^{+}m tower for one year

2.Community involvement

3.Evaluate sites

– Land use & environmental concerns

– Land rights & access; Transmission access

4.Financial

– Raise Capital

– Plan to market the power: PPA

5. Permitting, Zoning, FAA

6. EPC, O&M: Select turbine / go out to bid; negotiate contract

Wind Resource Monitoring:
Why

- Understand potential benefits
  - Energy production
  - Environmental benefit
  - Economic benefit
- i.e Reduce risk
- Community focus
- Spec & order equipment

Wind Resource Monitoring: *Equipment*

- Met tower:
  - Anemometers & Vanes
  - 134 foot (40 m) tower
    - Guy wires
    - Temporary
    - No foundation
  - Logger

Wind Resource Monitoring: *How*

- Equipment
  - Owned by RERL
  - Supported by DOE
  - Loaned to towns

- Installation by RERL
  - Equipment fits in a pickup
  - Constructed on site
  - Lifted with a battery powered winch
  - Typically 2 days

Wind Resource Monitoring:

Does the met tower have to be in the same place as the wind turbine?

- Ideally yes, but…
- Wind turbines have different siting requirements than met towers.

Questions?

- Community Wind
- Economics
- Siting
- Technology

Wind Power:
Impacts & Issues

- Property Values
- Visual
- Noise
- Birds
- Net Environmental Impact

- Communities need facts to make important decisions
- Hold wind power to comparable standards as other human activities
- Compare wind with what it replaces: fossil fuels

Impacts of Wind Power: *Property Values*

- In-depth study
  - "The Effect of Wind Development on Local Property Values"
  - 25,000 property transactions
    - In view shed of wind projects
    - Compared to similar sites
  - No evidence of reduced value
    - full report: www.repp.org

(http://www.repp.org/articles/static/1/binaries/wind_online_final.pdf)

Impacts of Wind Power: *Visual*

- *Not* aesthetics
- Local input / control / ownership

  → local support

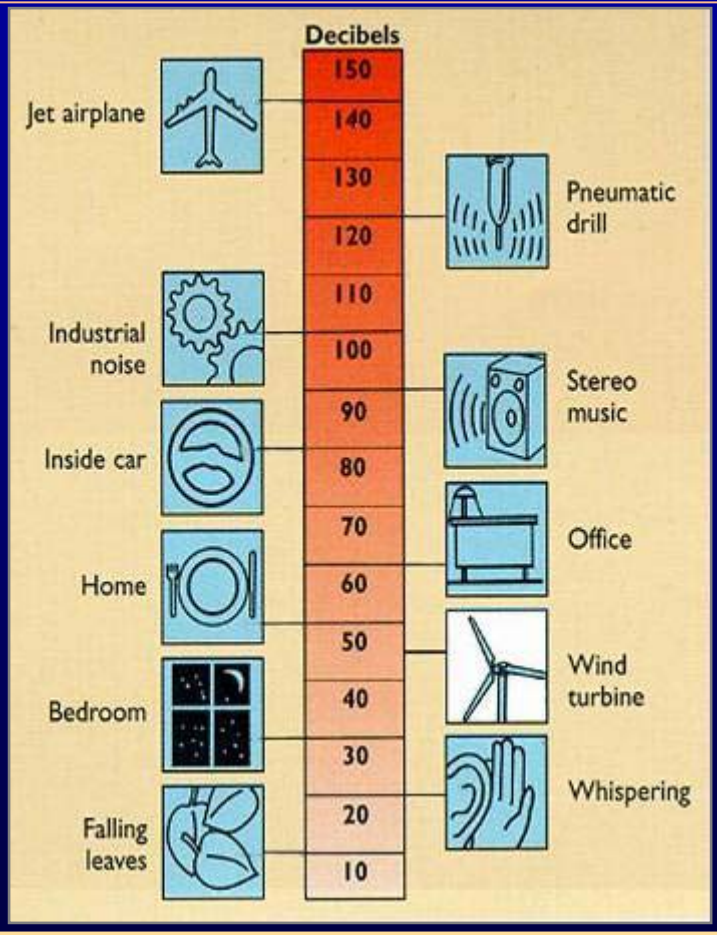
15% of babies born in the US had a dangerous level of prenatal exposure to mercury.

Impacts of Wind Power: *Visual*

- Visualizations

Weather-related disasters – floods, droughts, windstorms – are growing in frequency & intensity.

Impacts of Wind Power:
Noise



- Modern turbines are relatively quiet
- Rule of thumb – stay about 3x hub-height away from houses

Go to Portsmouth Abbey & listen!

Impacts of Wind Power:
Birds, Overview

US national average for *modern* turbines:

Two-three birds

per turbine, per year

Impacts of Wind Power: *Birds, Comparative*

- Wind's impact is lower than what it replaces
  - Reduces impacts of fossil fuel power
- Small relative to accepted human activities
  - Much smaller than bird mortality by cars *(per household)*
  - E.g. If *all* our power was from wind, would be 10% of the impact of house cats

Impacts of Wind Power:
Birds: What has changed since Altamont?

2 Decades & Millions of $ of research
Have led to changes
in design and siting:

- Slower
  - birds can avoid blades, as they do cars
- Tubular towers
  - birds roosted on old truss towers
- Upwind
- Fewer & Taller turbines
  - out of flight paths

Birds & Wind Power:
Audubon supports wind

The Boston Globe

WEDNESDAY, MARCH 29, 2006

RISING EXPECTATIONS

TODAY: *Sunny and warm. High 56-61. Low 38-43.*
TOMORROW: *Sunny and warmer. High 62-67. Low 41-46.*
HIGH TIDE: *10:52 a.m. 11:15 p.m.*
SUNRISE: *5:32 a.m.* SUNSET: *6:06 p.m.*
FULL REPORT: PAGE A20

Audubon review supports wind farm

Threat to birds is less than feared, group finds

By Beth Daley
GLOBE STAFF

The Massachusetts Audubon Society gave its preliminary blessing yesterday to a large-scale wind

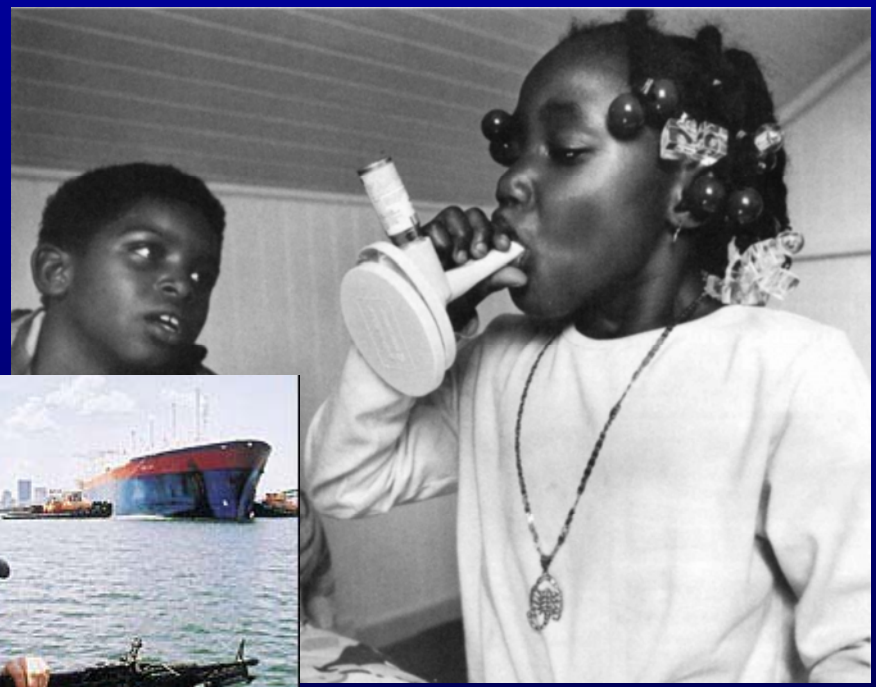
Impacts of Wind Power: *Birds, Summary*

- One-three birds per turbine, per year
- Net positive environmental impact - Supported by all major environmental groups

> *"Audubon appreciates and supports responsible wind project development."*
>
> *– Dan Beard, National Audubon Society*

Net Impacts,
Avoided Impacts & Environmental Justice

- Environmental
- Health
- Security



Sources:
Armed escorts of LNG tanker into Boston harbor: Globe.
Asthma inhaler: Sierra Club.
Oiled water fowl: Anchorage Daily News.

Mass. has an environmental justice policy - http://www.mass.gov/envir/ej/EJ_Policy_English.pdf

Impacts of Wind Power
Land Use & Planning

- Land conservation
  - Planning: which areas are off-limits to roads/logging/wind turbines
- Primary impact is visual

Impacts of Wind Power
Net Impact

- Primary impact is visual
  - All other impacts dwarfed by benefits
- Balancing local impacts, global/regional benefits

87% of Americans support the expansion of windfarms
(national survey by Yale University's Center of Environmental Law and Policy)

Wind 101
Recap

- U.S. Energy status quo – must change / will change
- Wind is good for the Environment
  - All energy forms have environmental consequences
  - Wind power – one of lowest-impact energy forms
  - Wind replaces fossil fuels *
    - Every kWh made with wind is a kWh not made with fossil *
    - Reduces emissions
  - Can make a significant amount of our energy
- Wind is good for the Economy
  - Jobs, trace deficit, price hedges, diversity

**primarily. Other types of plants to a lesser degree*

Tour a Wind Facility

- Portsmouth Abbey
- Hull, MA
  - 2 turbines
  - East of Boston
- Mass Maritime Academy
  - At base of the Cape Cod Canal

For More Information

- Renewable Energy Research Laboratory
  - www.ceere.org/rerl/
  - Community Wind Fact sheets: www.ceere.org/rerl/about_wind/
  - 413-545-4359
- www.windpower.org
  - Lots of accessible, technical information
- Others:
  - AWEA: www.awea.org
  - Wind Power America: www. windpoweringamerica.gov
  - Utility Wind Interest Group : http://www.uwig.org
  - Links: www.me3.org
  - Database of State Incentives for R.E. www.dsireusa.org

Community-Scale Wind Energy for Aquidneck Island

Thanks to:

- Tina Dolen & the Aquidneck Island Planning Commission
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and for providing some of these slides & graphics

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Questions

Technology

1,600,000	Wh/year
4	¢/kWh
2.5	¢/kWh
1.8	¢/kWh
8.3	¢/kWh
$ 132,800	$/Year

Economics

Resource

Community - "Wind Power can fund schools"

Impacts