79th Annual Montana 4H Congress

WIND ENERGY Workshop

Schedule

Wednesday

- 1:30- 1:45 Introduction and overview
- 1:45 – 2:05 Presentation: Wind Energy
- 2:05 – 2:45 Tour of MSU Facilities
- 2:45 – 4:00 Wind Turbine Design, Build and Test
- 4:00 – 4:30 Wrap-up

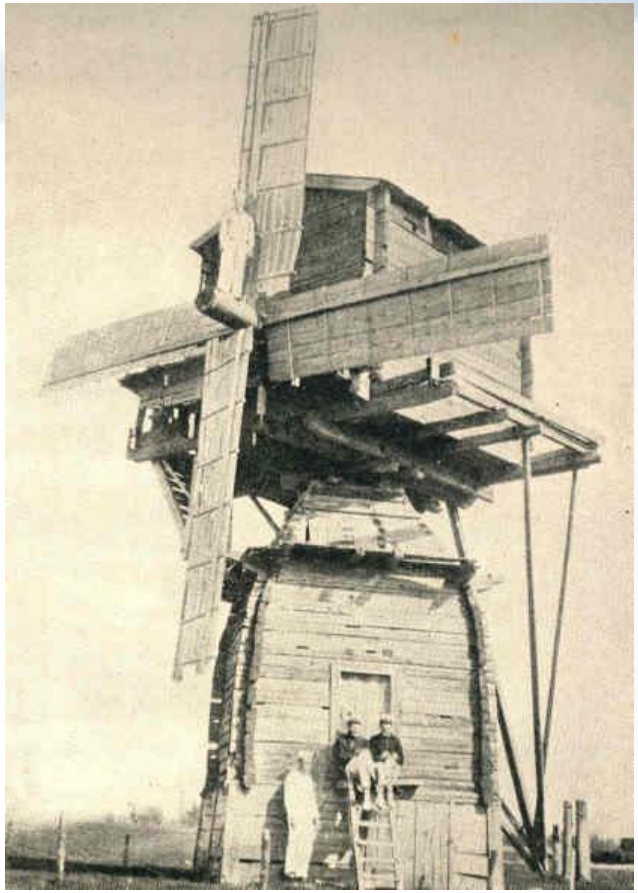
Schedule

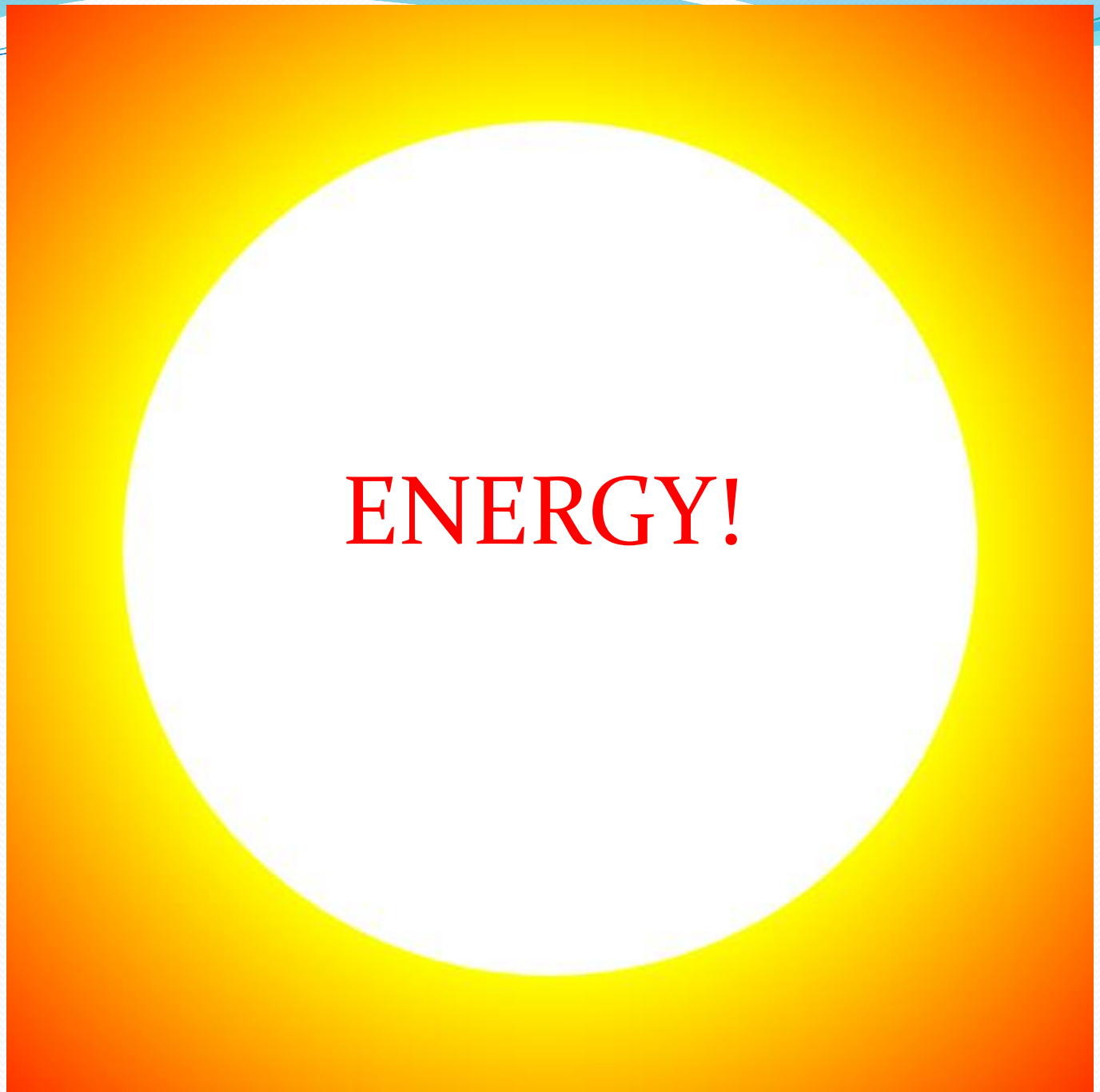
Thursday

- 10:30- 10:45 Introduction and Overview
- 10:45 – 11:05 Social, Environmental and Economic Issues
- 11:05 – 12:05 Group Discussions and Debate
- 12:05 – 12:20 Share Group Results with Participants
- 12:20 – 12:30 Wrap-up

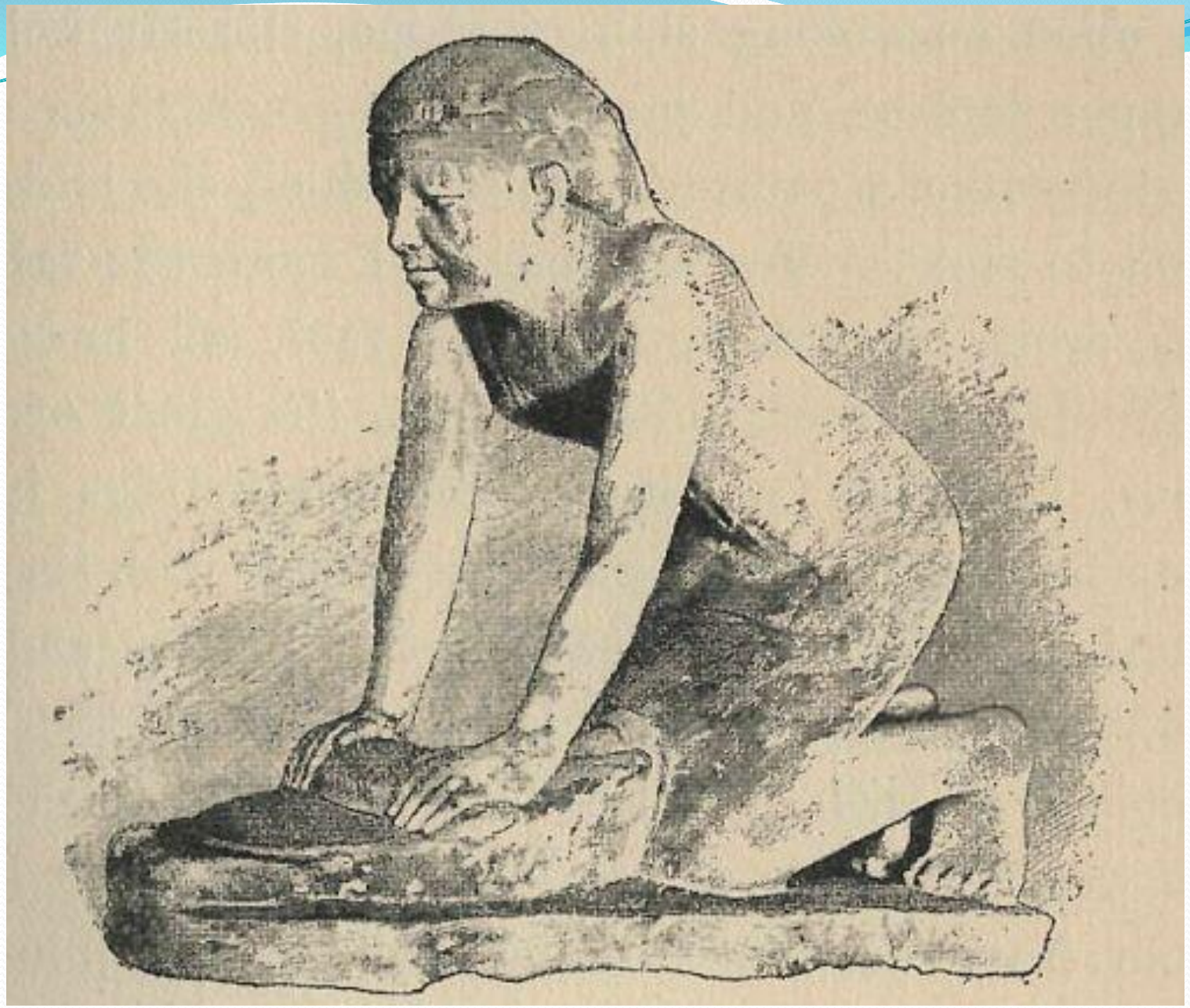
Presentation Topics

- Energy and Electrical Power Generation
- Why Wind?
- Wind Turbine Blades – Designs, Aerodynamics, Function
  - How do we get energy from the air?
- Future Trends in Wind




ENERGY!

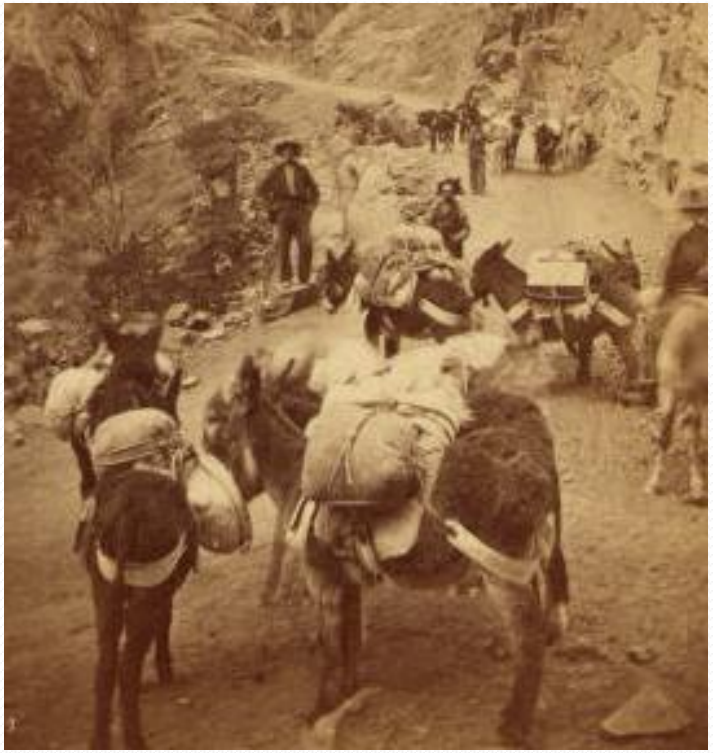
Human Power

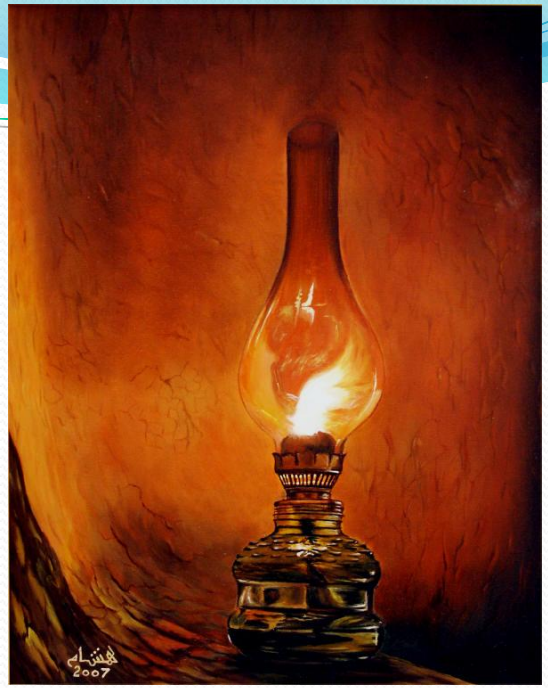


FIRE!


参观由此去
PLEASE COME THIS WAY

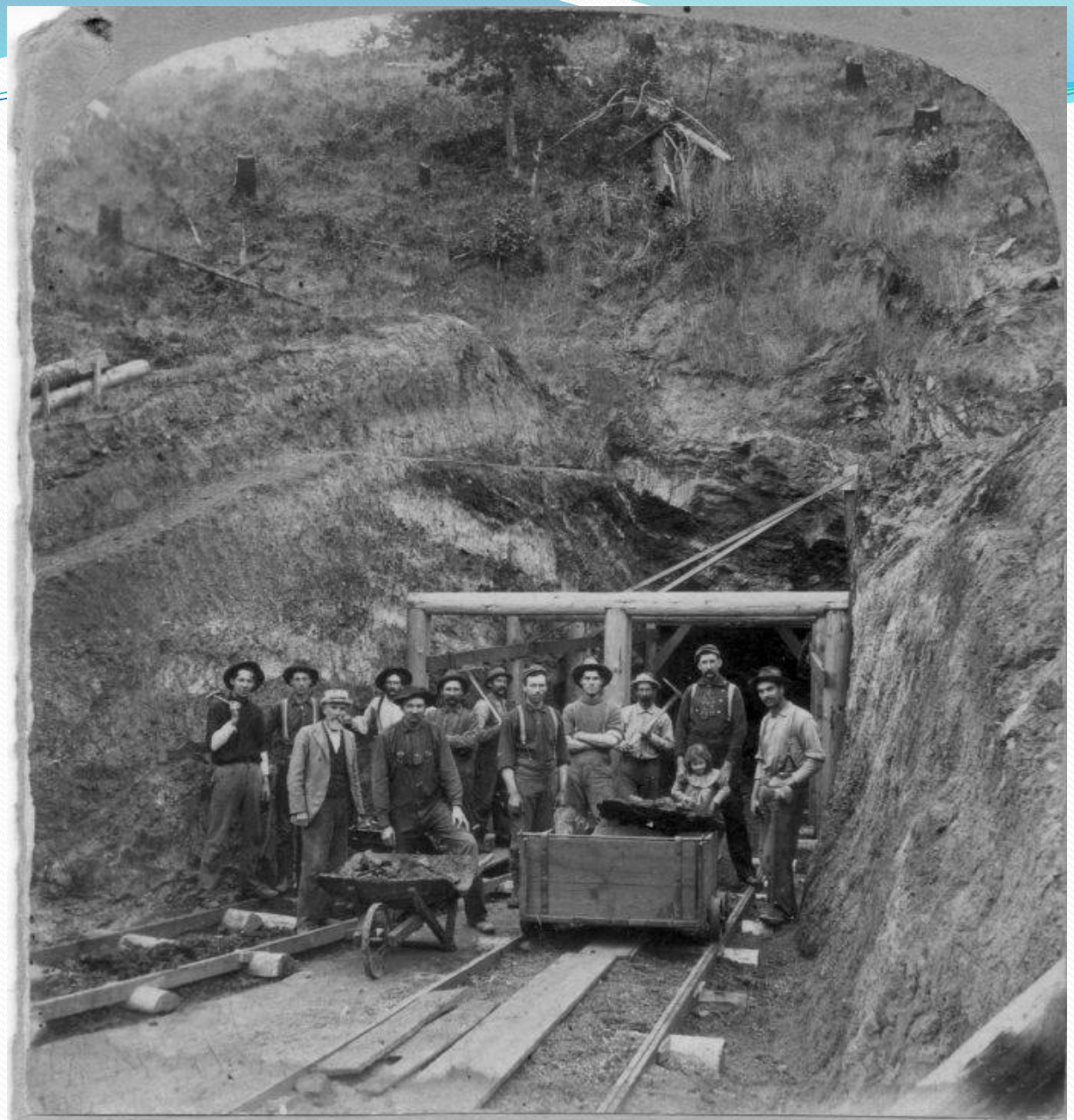
ANIMAL POWER





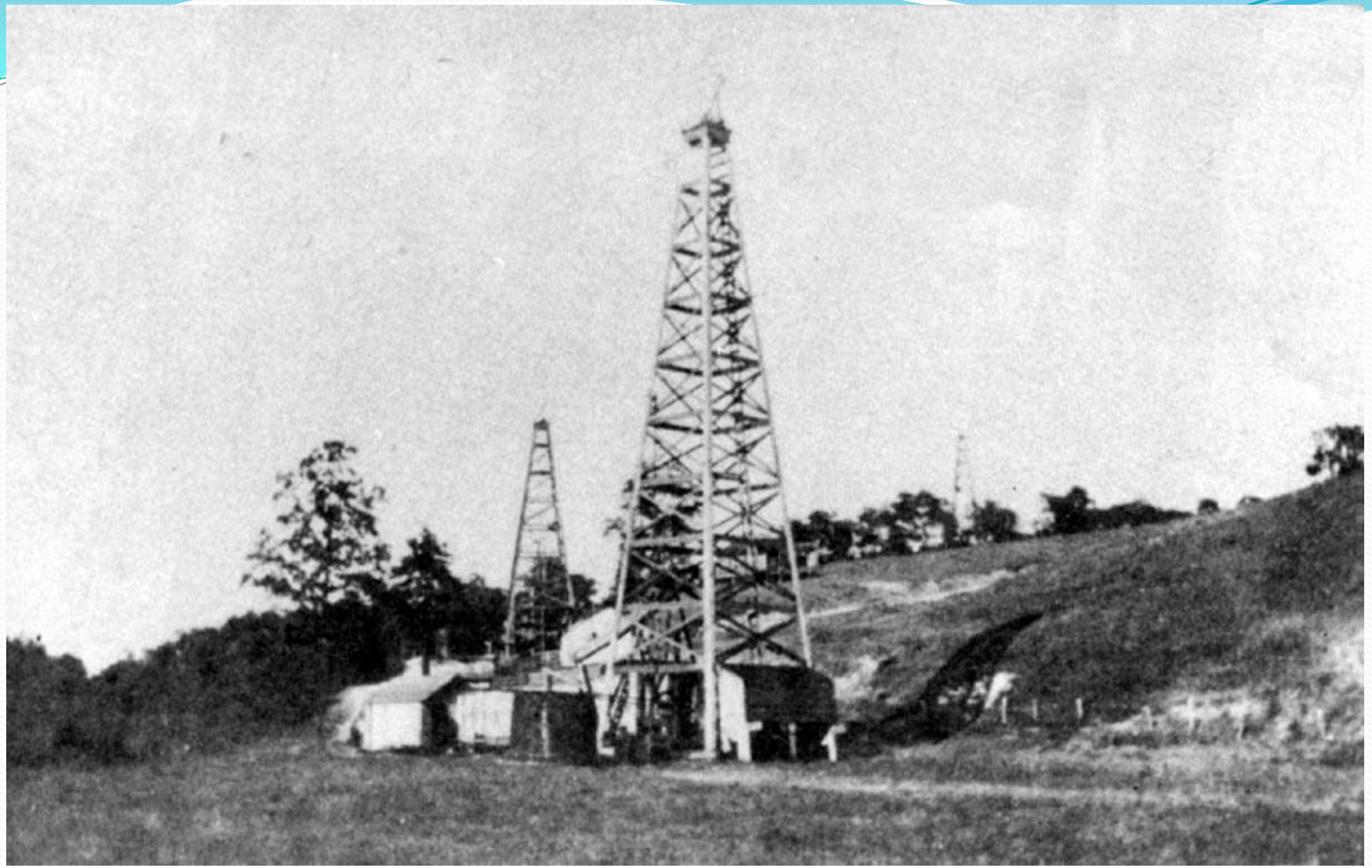
FOSSIL ENERGY:

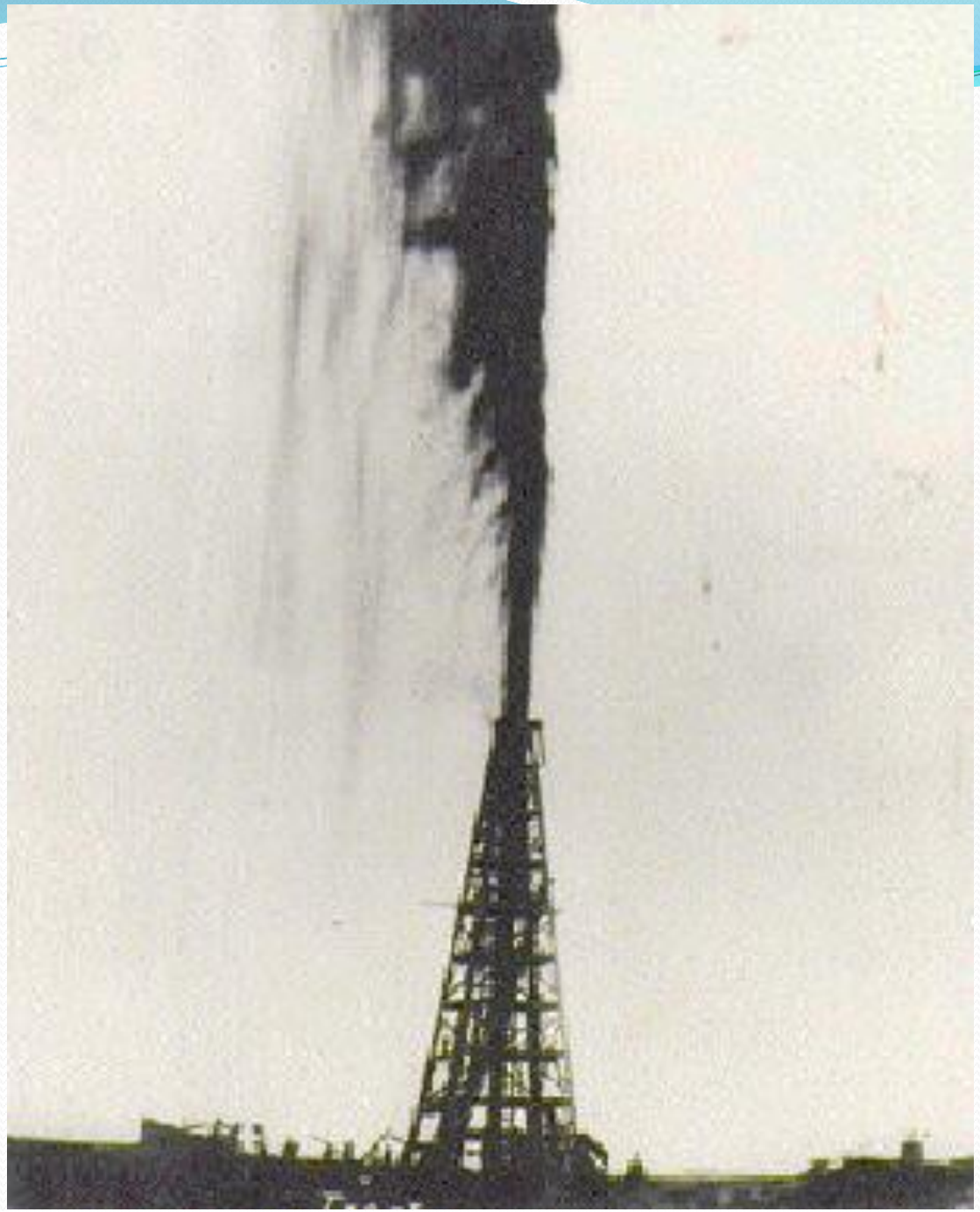
COAL, OIL, GAS



Coal Mines; Yamhill County, Oregon.

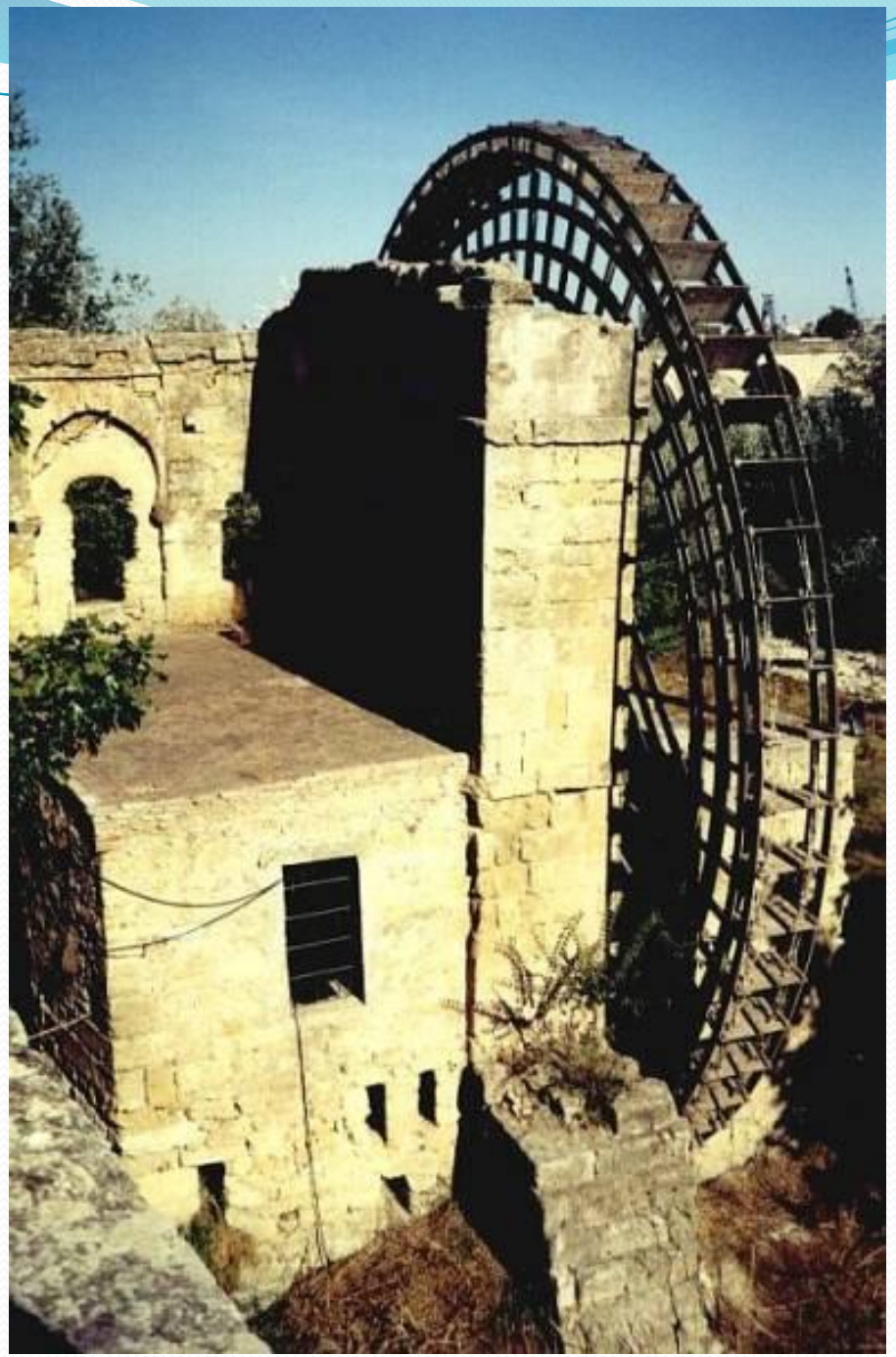

corbis
FIAT-ALLIS



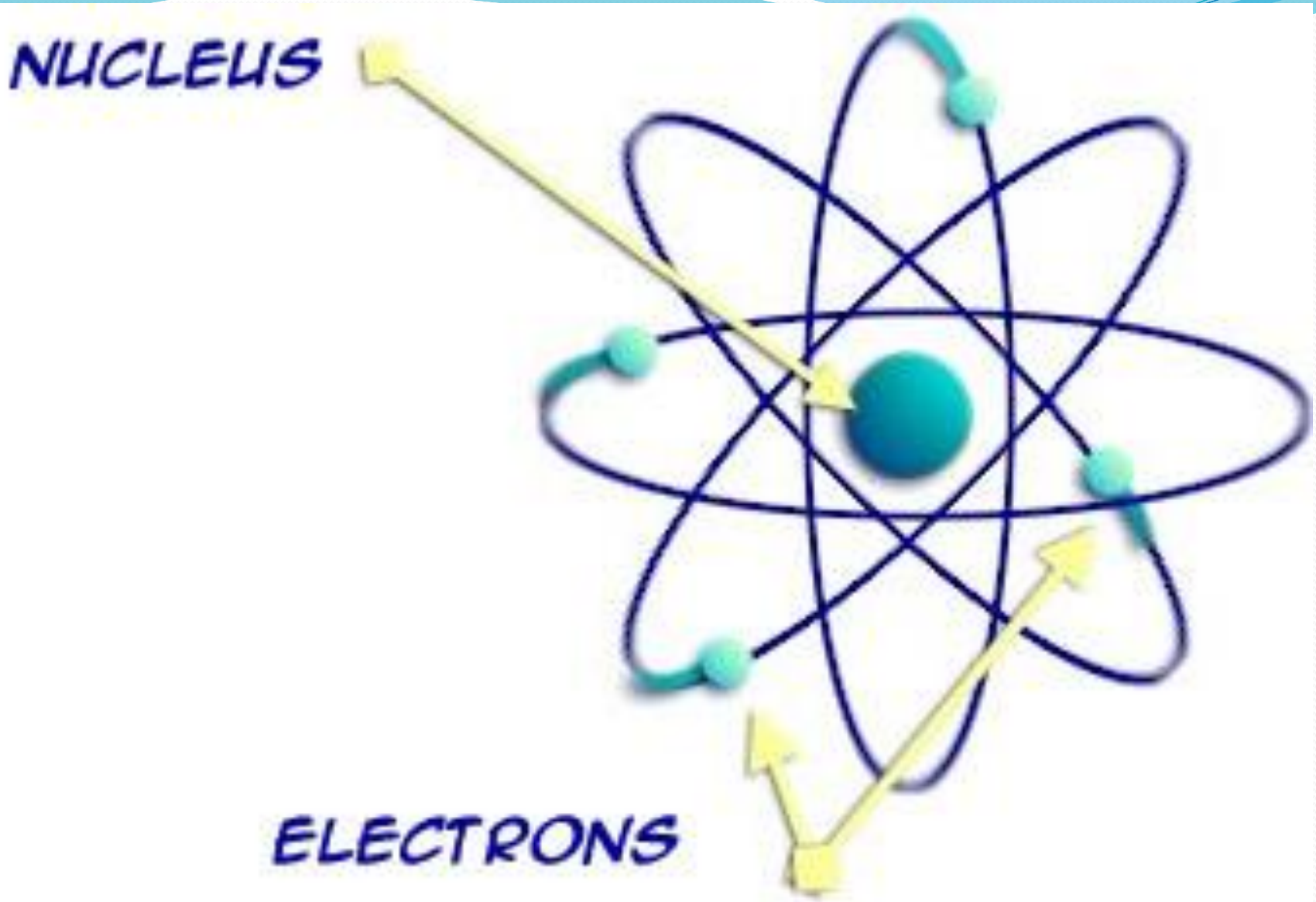



ARCTIC PRINCESS

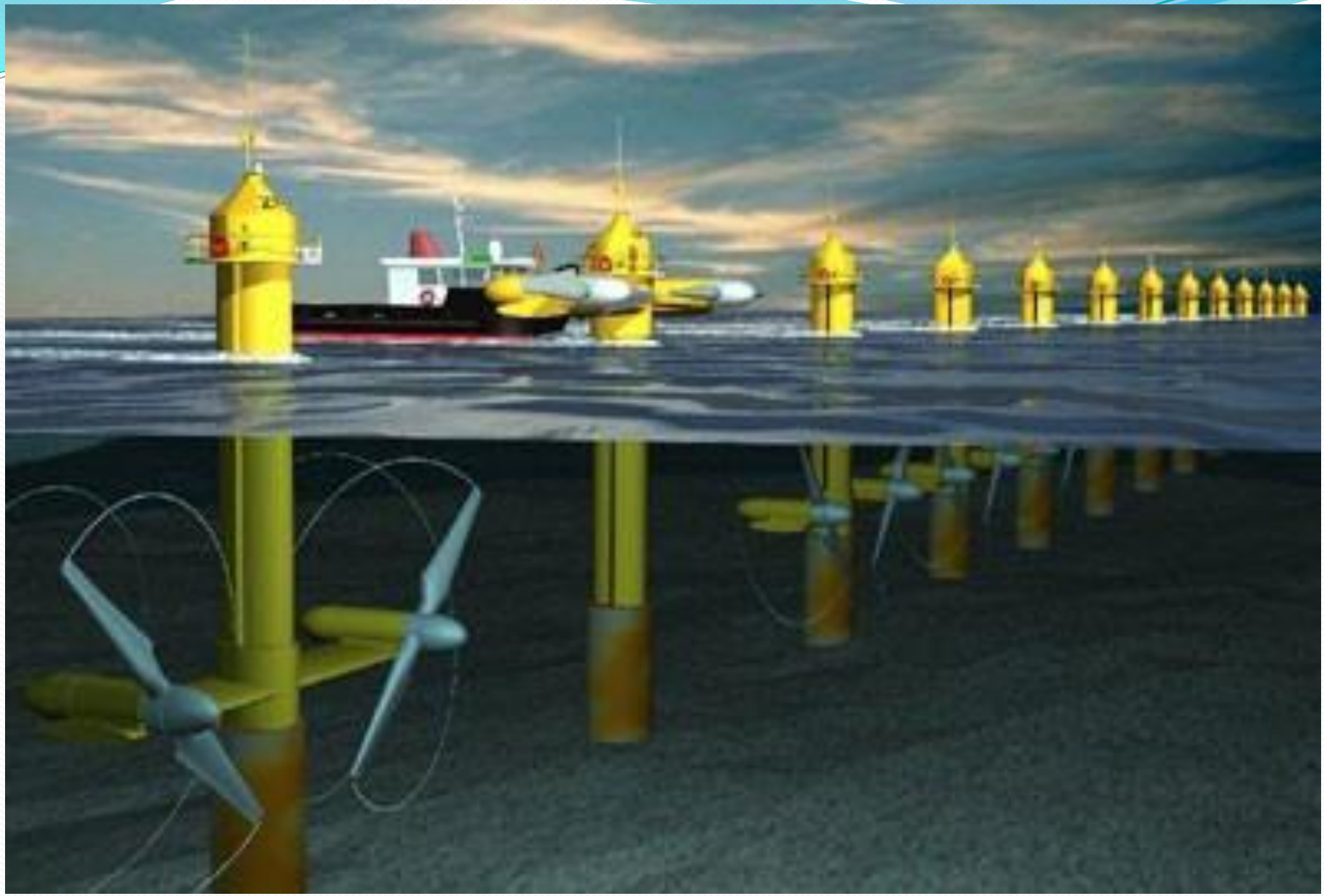
WATER (HYDRO) ENERGY…

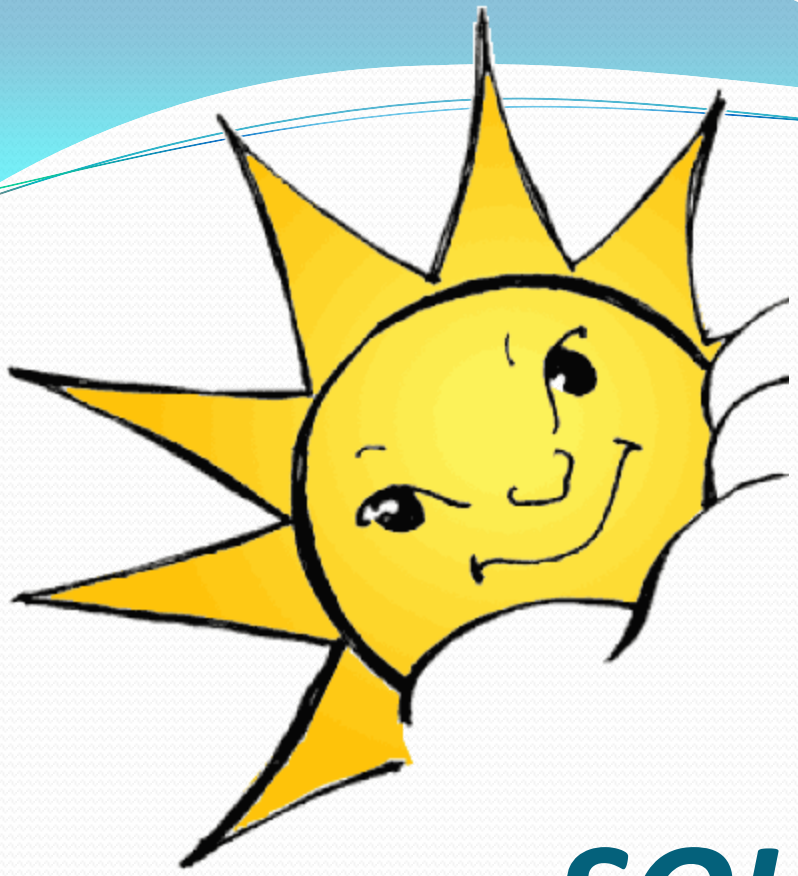


NUCLEAR ENERGY…

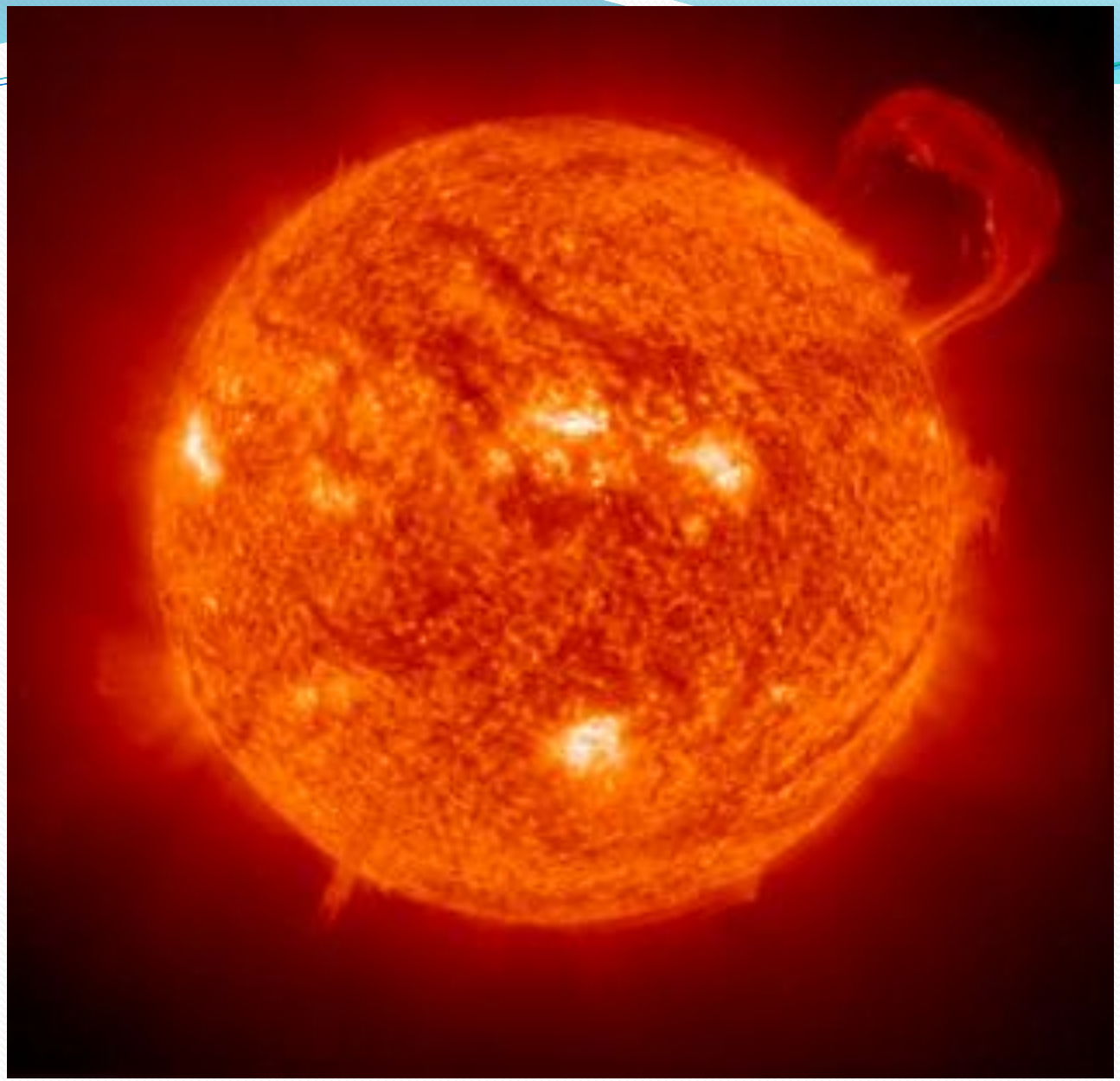

NUCLEUS
ELECTRONS

OCEAN ENERGY…

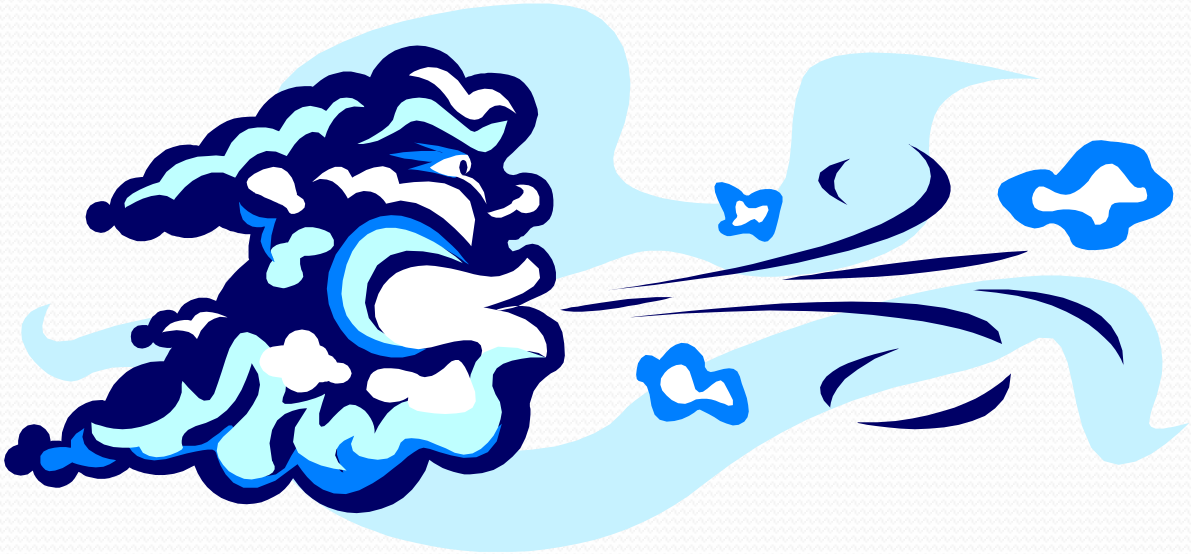




SOLAR ENERGY…

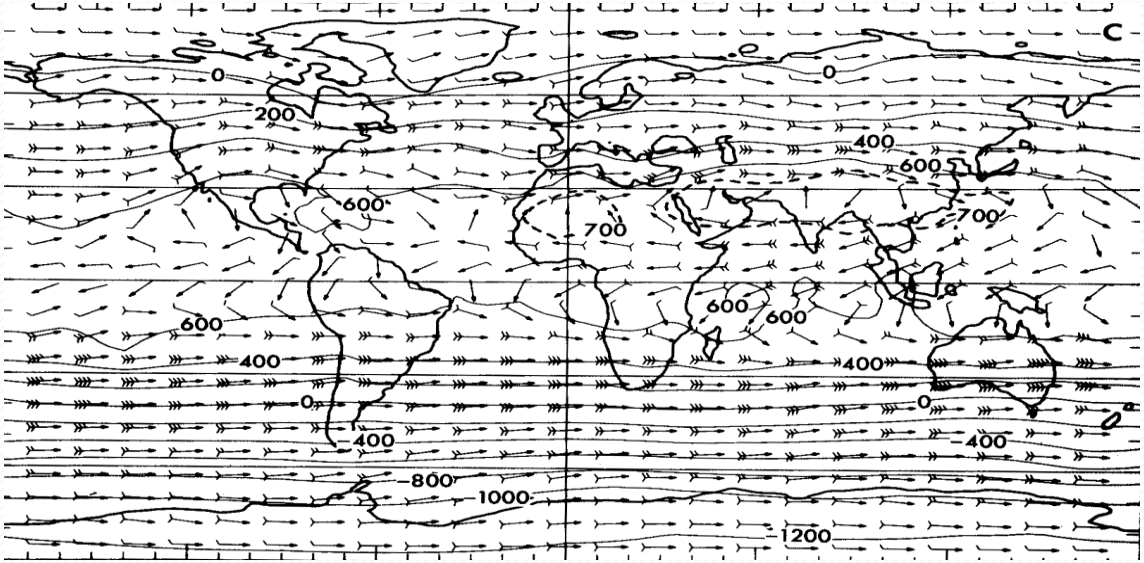


WIND ENERGY…



Wind …

- ~0.25% of incident sunlight converted to wind energy
- That energy is lost primarily to surface friction and is therefore available to harness



Available power ~1W/m² in surface winds.
Global resource estimated to be 30-300 TW.

MSE at Illinois

Slide Courtesy of Dr. Angus Rocket, University of Illinois at Urbana-Champaign

Some Windmill History

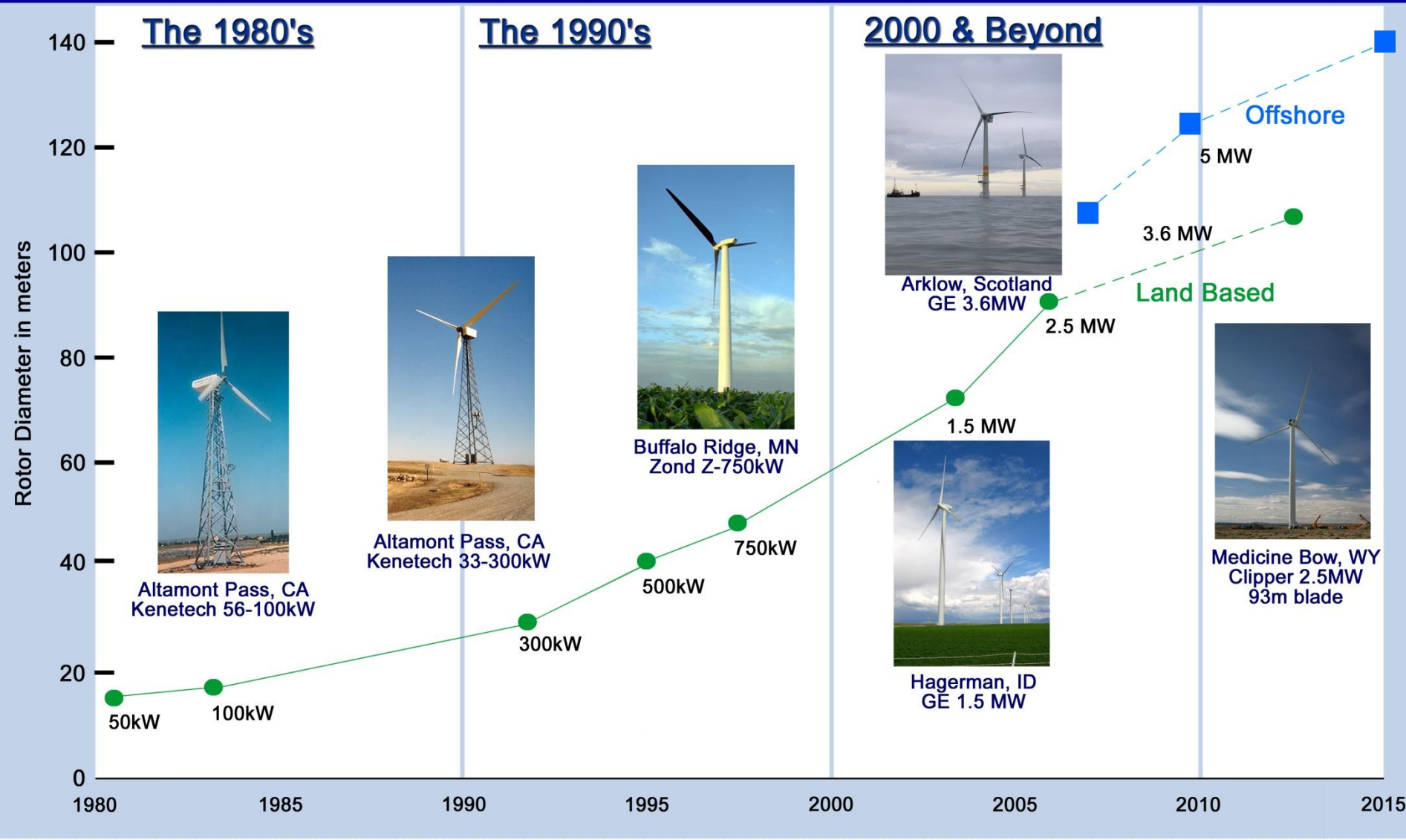
Courtesy of Mr. Michael Horneman, Clipper Wind Inc.

- **Wind machines used in Persia in 200 B.C. & in the Roman Empire in 250 A.D.**
- **First practical windmills, built in Afghanistan in the 7th century, were vertical axle windmills, with long vertical driveshafts with rectangle shaped blades. Made of 6 to 12 sails covered in cloth, these windmills were used to grind corn and draw up water.**
- **14th century Dutch windmills were in use to drain areas of the Rhine River delta.**
- **In Denmark by 1900 there were ~ 2500 windmills for mechanical loads such as pumps and mills, producing an estimated combined peak power of about 30 MW.**

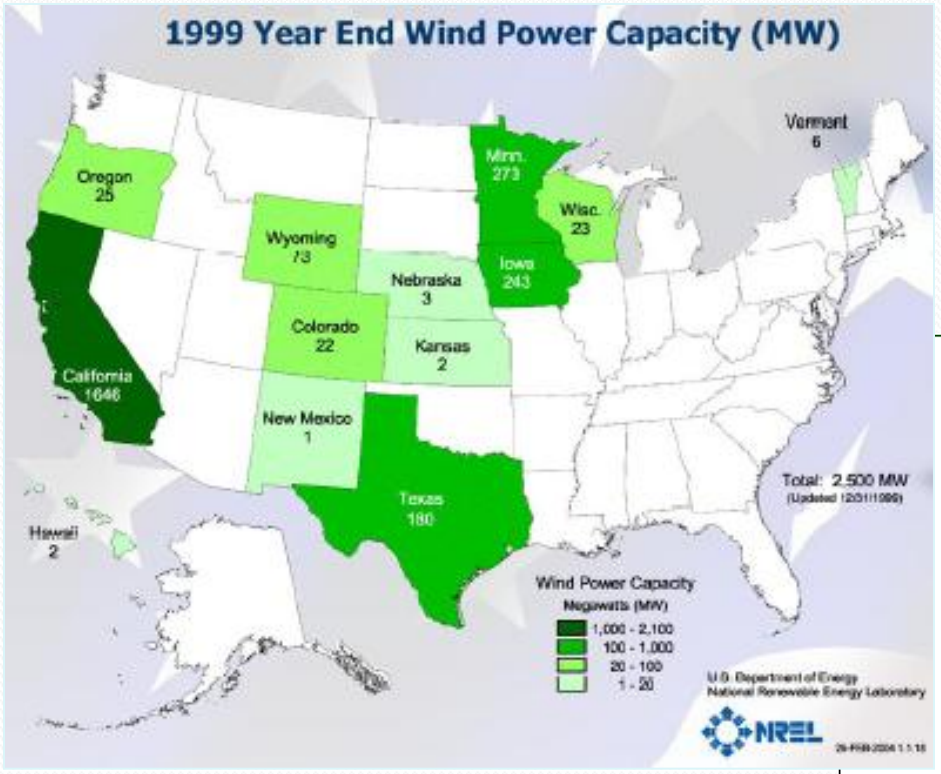
Some Wind History (continued…)

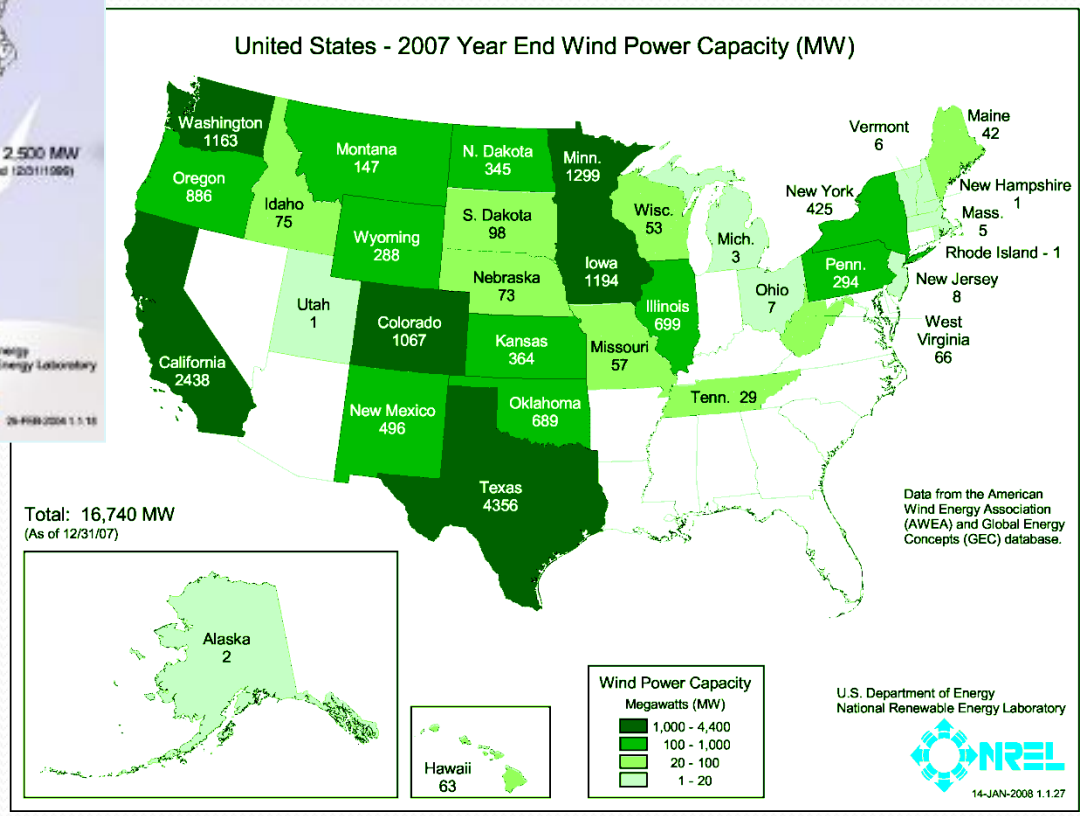
- **Around the time of World War I, American windmill makers were producing 100,000 farm windmills each year, most for water-pumping.**
- **By the 1930s windmills for electricity were common on farms, mostly in the United States where distribution systems had not yet been installed. In this period, high-tensile steel was cheap, and windmills were placed atop prefabricated open steel lattice towers.**
- **-A forerunner of modern horizontal-axis wind generators was in service at Yalta, USSR in 1931. This was a 100 kW generator on a 30 m tower.**
- **The first windmill for U.S. electricity production was built in Cleveland, Ohio in 1888. By 1908 there were 72 wind-driven electric generators from 5 kW to 25 kW. The largest machines were on 24 m towers with four-bladed 23 m diameter rotors.**

Evolution of U.S. Commercial Wind Technology



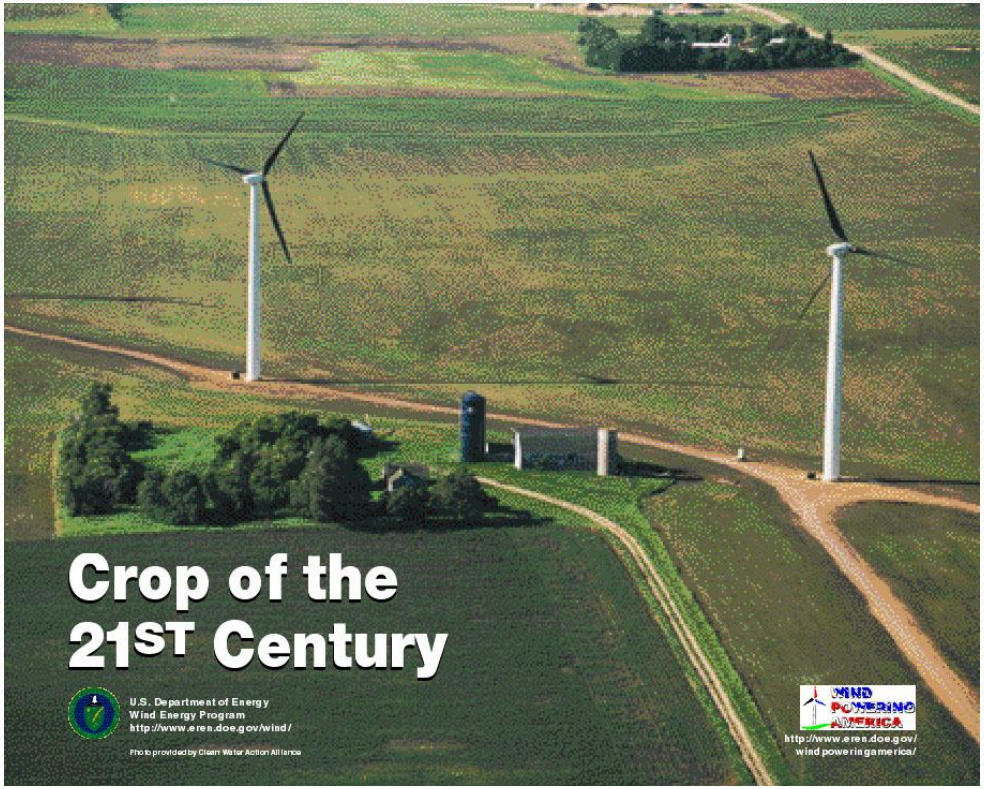
Installed Wind Capacities ('99 – Dec '07*)



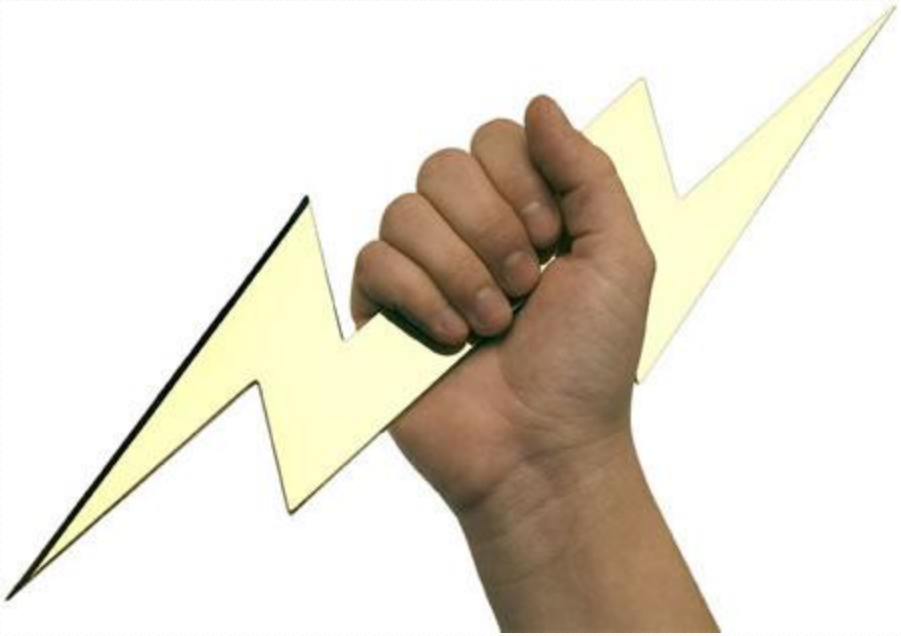


Drivers for Wind Power

- Declining Wind Costs
- Fuel Price Uncertainty
- Federal and State Policies
- Economic Development
- Public Support
- Green Power
- Energy Security
- Carbon Risk

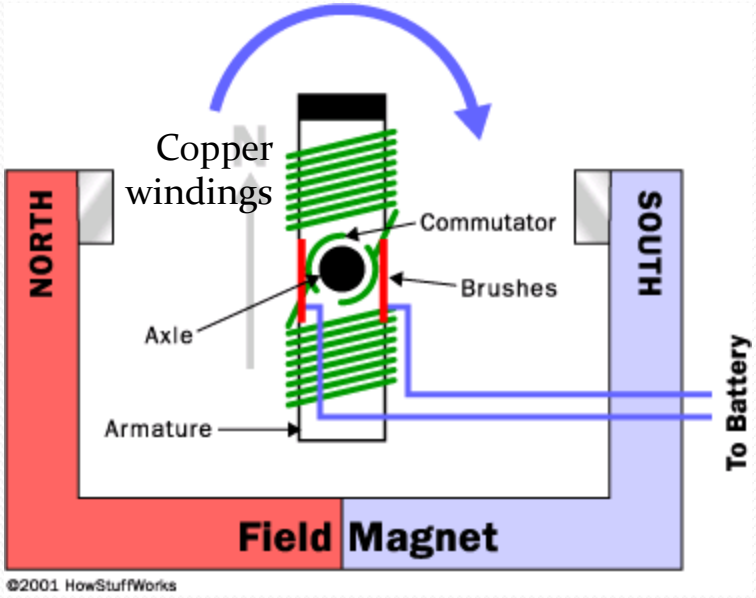


Electrical Power Generation



Electrical Power Generation

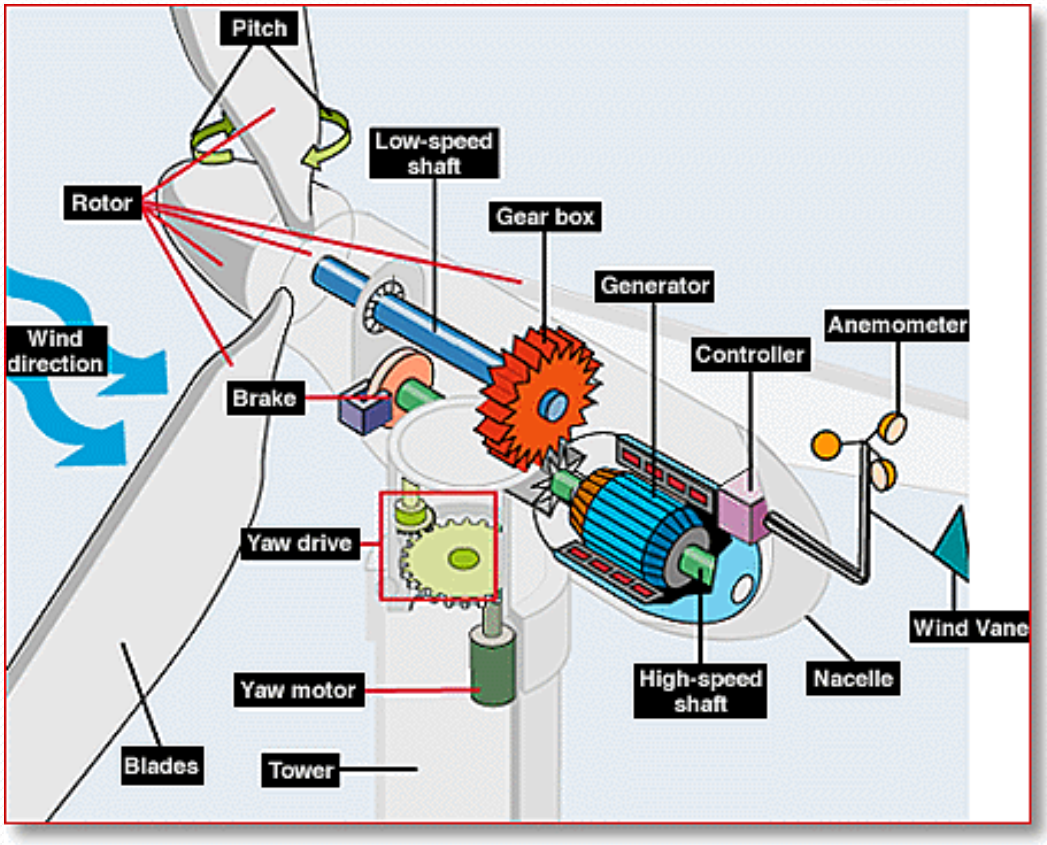
Most power used in the world is generated by converting rotational torque into electricity by using copper and magnets.



When the copper windings pass through the magnetic fields created by the magnets, electrical current is generated and sent to the battery

This concept is the basis for most electrical generators, including modern wind turbines.

TURNING WIND ENERGY INTO ELECTRICITY



WIND

TURBINE BLADES

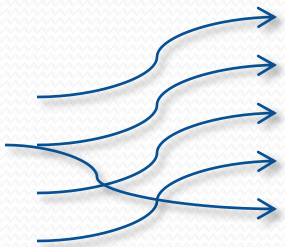
SHAFT & GEARBOX

GENERATOR

WIRES & DISTRIBUTION SYSTEM (GRID!)

ELECTRICAL LOAD (USER)

Wind is ENERGY



Wind is the flow of air or other gases that make up the atmosphere. Air flow is driven by solar heating and earth's rotation.

Since air contains mass (molecules of oxygen, nitrogen, argon, carbon dioxide, etc) and wind possesses velocity (movement) the wind has ENERGY!

Much of this ENERGY can be extracted by a wind turbine and turned into electrical energy!
So…HOW MUCH ENERGY IS IN THE WIND?

$$E=(.5)\ (rho)\ (A)\ (V)^3$$

That is,

ENERGY=(1/2)X(AIR DENSITY)X(SWEPT AREA OF BLADES)X(WINDVELOCITY)^3

>> This is the TOTAL energy, but only about 2/3 of it can actually be extracted <<

Wind Resource Analysis

The first step to establishing a potential wind site is to analyze the wind quality

The basic tools used for analysis are:

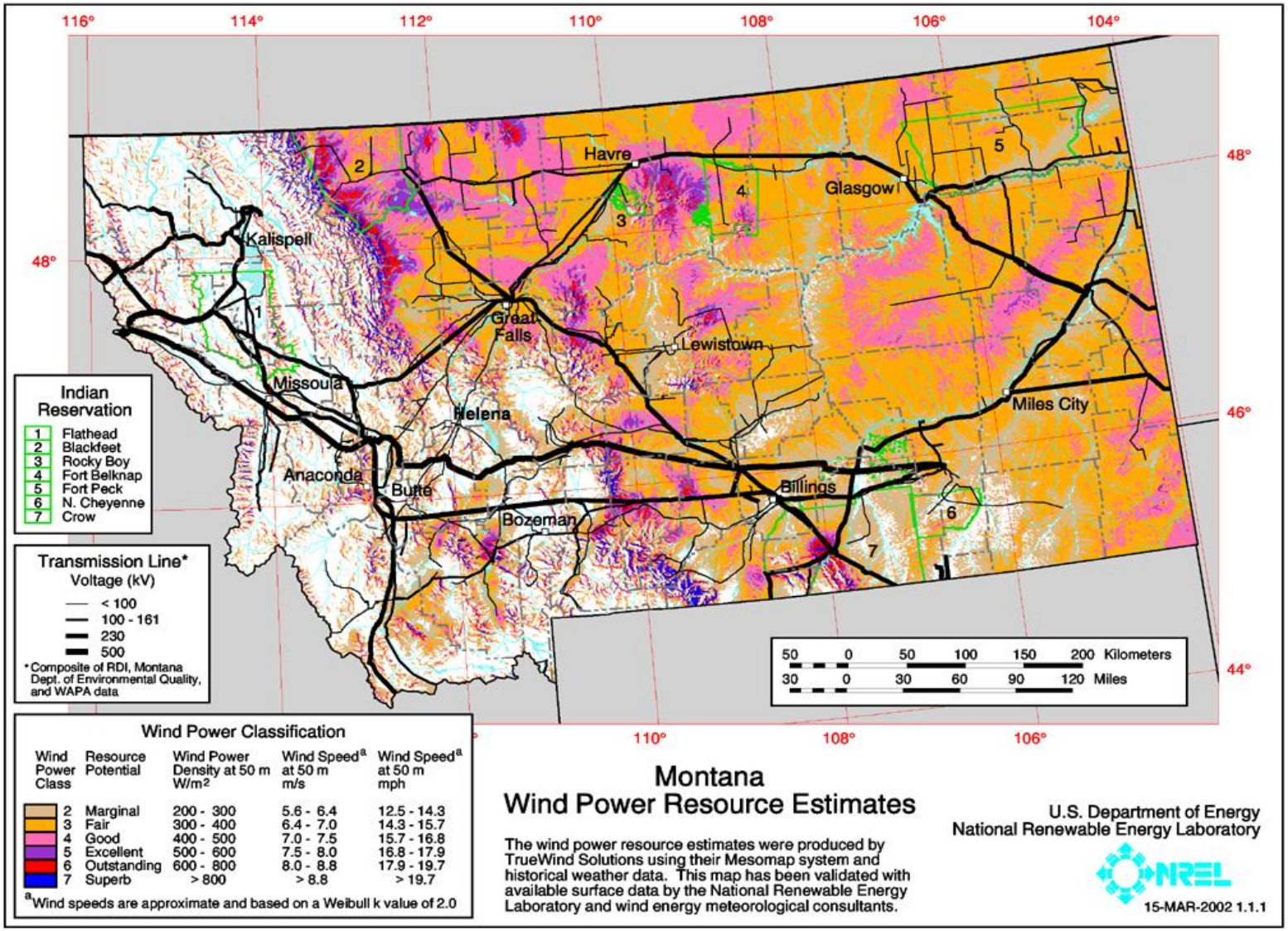
Anemometer

Direction vane

Data logger.

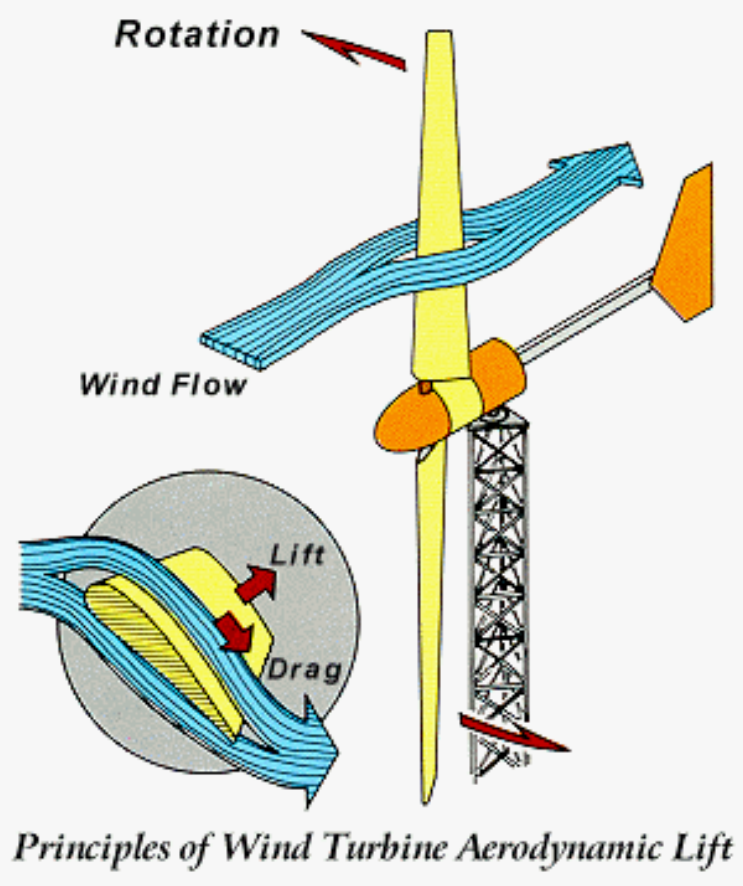
Computer modeling software

Wind Resource Mapping



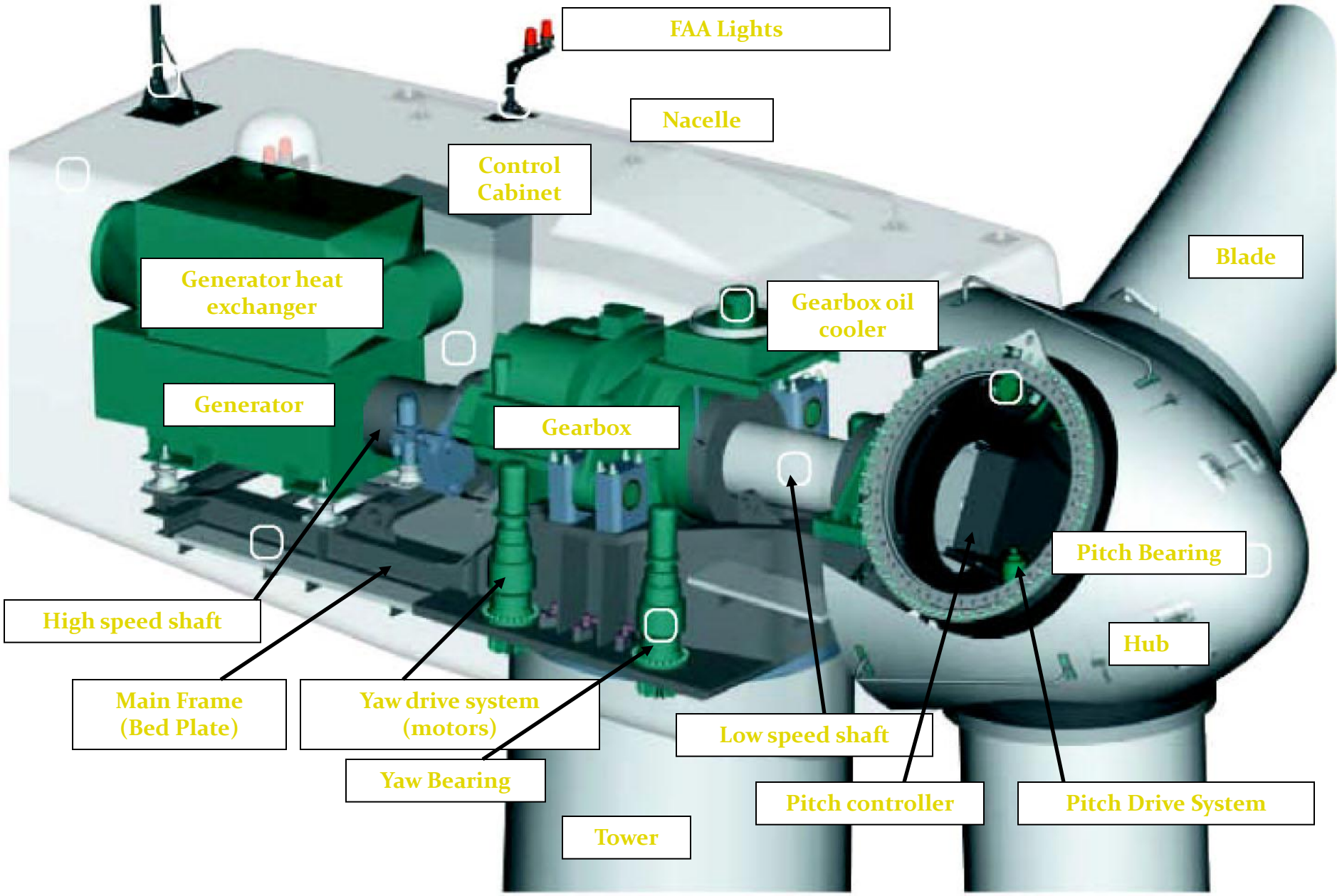
Wind Turbines and Blades

Horizontal Axis Wind Turbines = HAWT



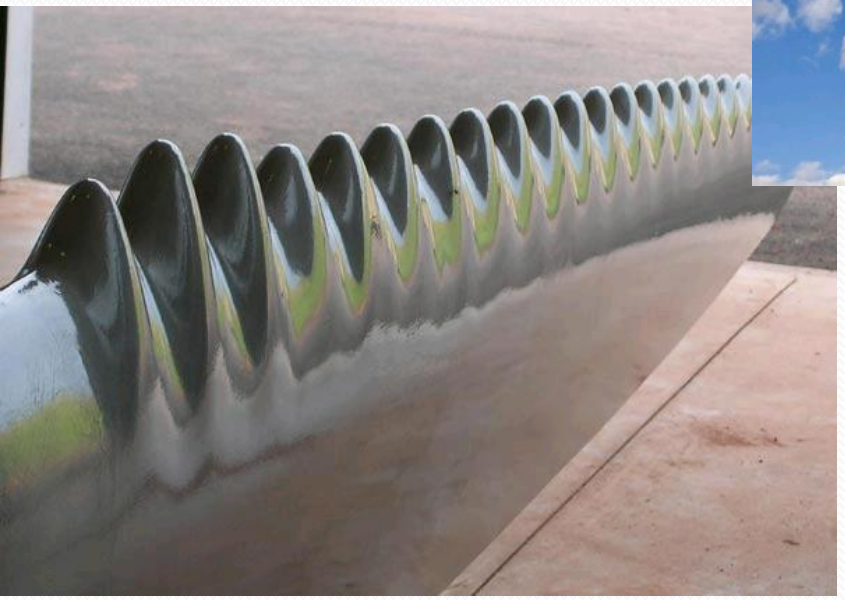
Principles of Wind Turbine Aerodynamic Lift

From the inside:



HAWT Designs

WhalePower
http://www.whalepower.com/drupal/?q=node/3



Airbreeze
http://airbreeze.com/

Skystream 3.7

Industrial-Scale HAWT Designs

Enercon E-126

The World's Largest Wind Turbine
Rotor Diameter 126 meters (413 feet)
Rated at 6 MW
Hub Height 135 meters (450feet)

http://www.newlaunches.com/archives/enercon_e126_worlds_largest_wind_turbine.php

VIDEO 1

Vertical Axis Wind Turbines = VAWT

Giromill
http://www.symscape.com/node/407

Darrieus
http://www.symscape.com/node/406

Windspire

http://www.popsci.com/files/imagecache/photogallery_image/files/articles/mariah-power-windspire_pg-1.jpg

Quietrevolution 5

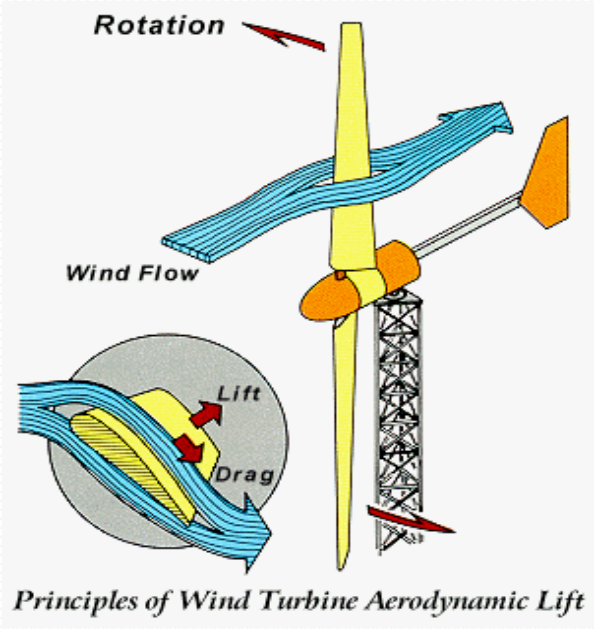
http://www.quietrevolution.co.uk

Savonius

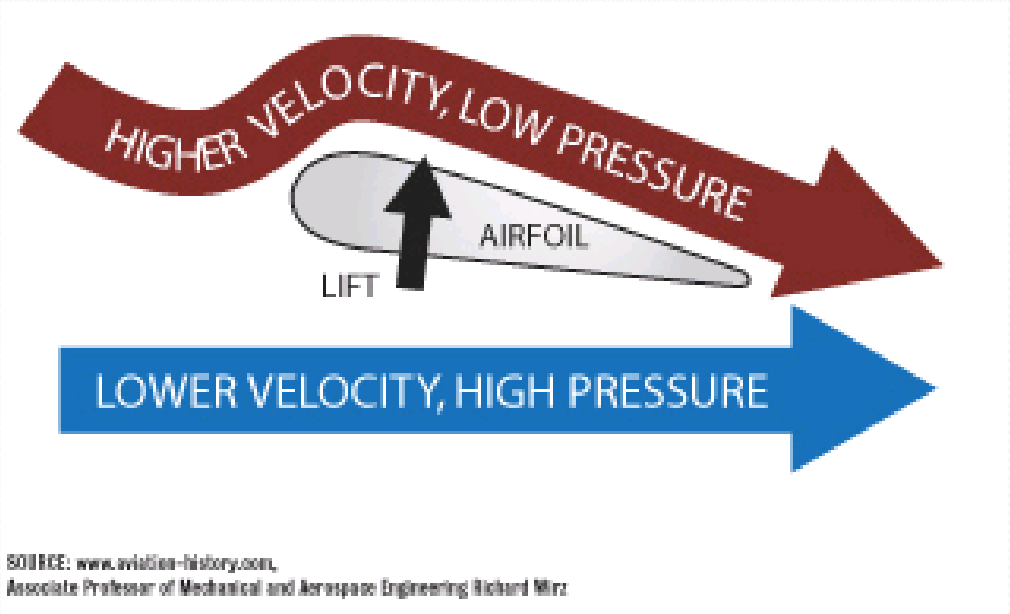
http://www.symscape.com/blog/vertical_axis_wind_turbine

Turbine Blades

- Aerodynamics are used to produce lift just like an airplane wing.
- Blades are light weight but very strong.

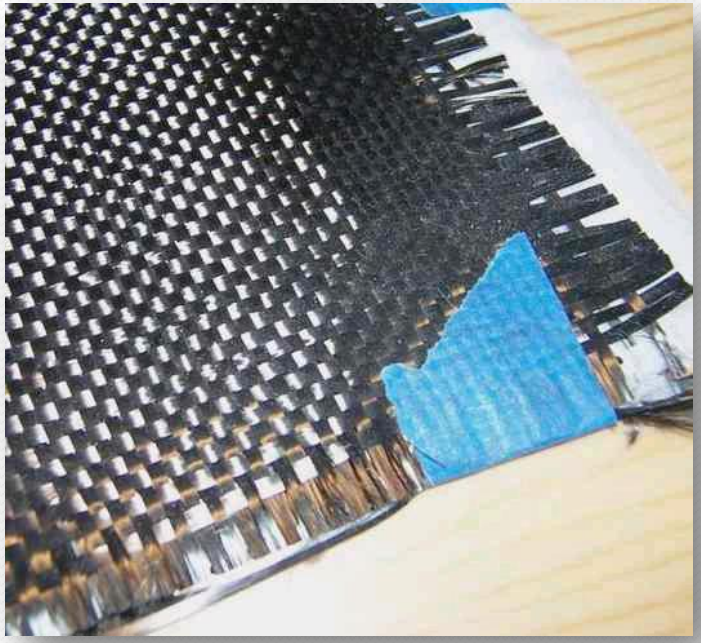


Principles of Wind Turbine Aerodynamic Lift



SOURCE: www.aviation-history.com,
Associate Professor of Mechanical and Aerospace Engineering Richard Mirz

Fabricating BIG Turbine Blades



COMPOSITE MATERIALS =
COMBINATIONS OF SEVERAL MATERIALS

The main materials for modern turbine and epoxy resin.

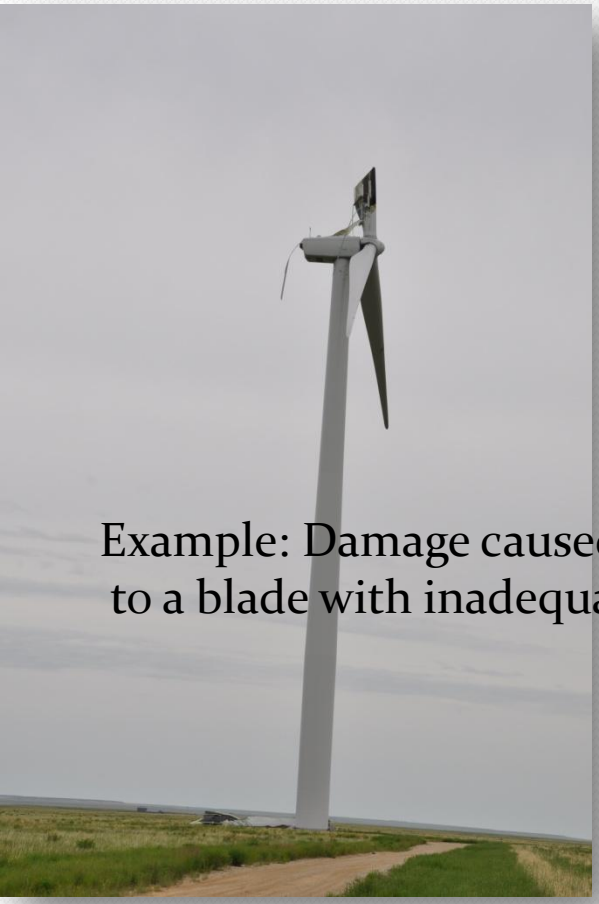
The fiberglass cloth is laid in large molds while epoxy is injected into the molds under pressure.

Static and Dynamic Blade Testing

Blades are tested to ensure performance and reliability in the field.

http://environmentalresearchweb.org/cws/article/opinion/37719/1/ERWbend_1009_09

Even Rigorous Testing Cannot Prevent Occasional Problems



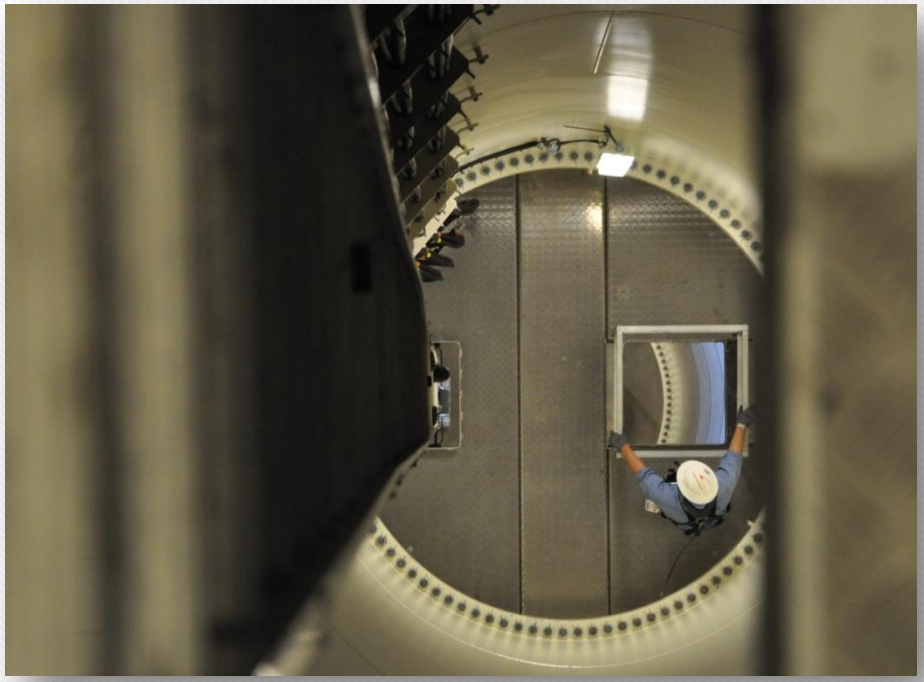
Example: Damage caused by lightning strike to a blade with inadequate grounding.

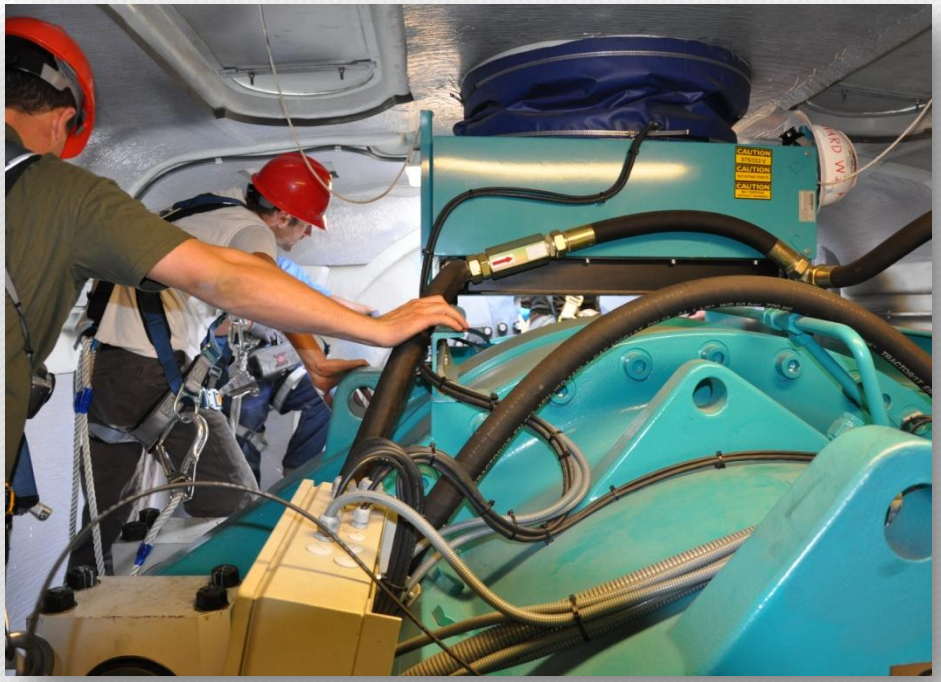
Internal Burn Marks

Internal Spar Burned Down the Length

VIDEO 2

Inside a turbine…

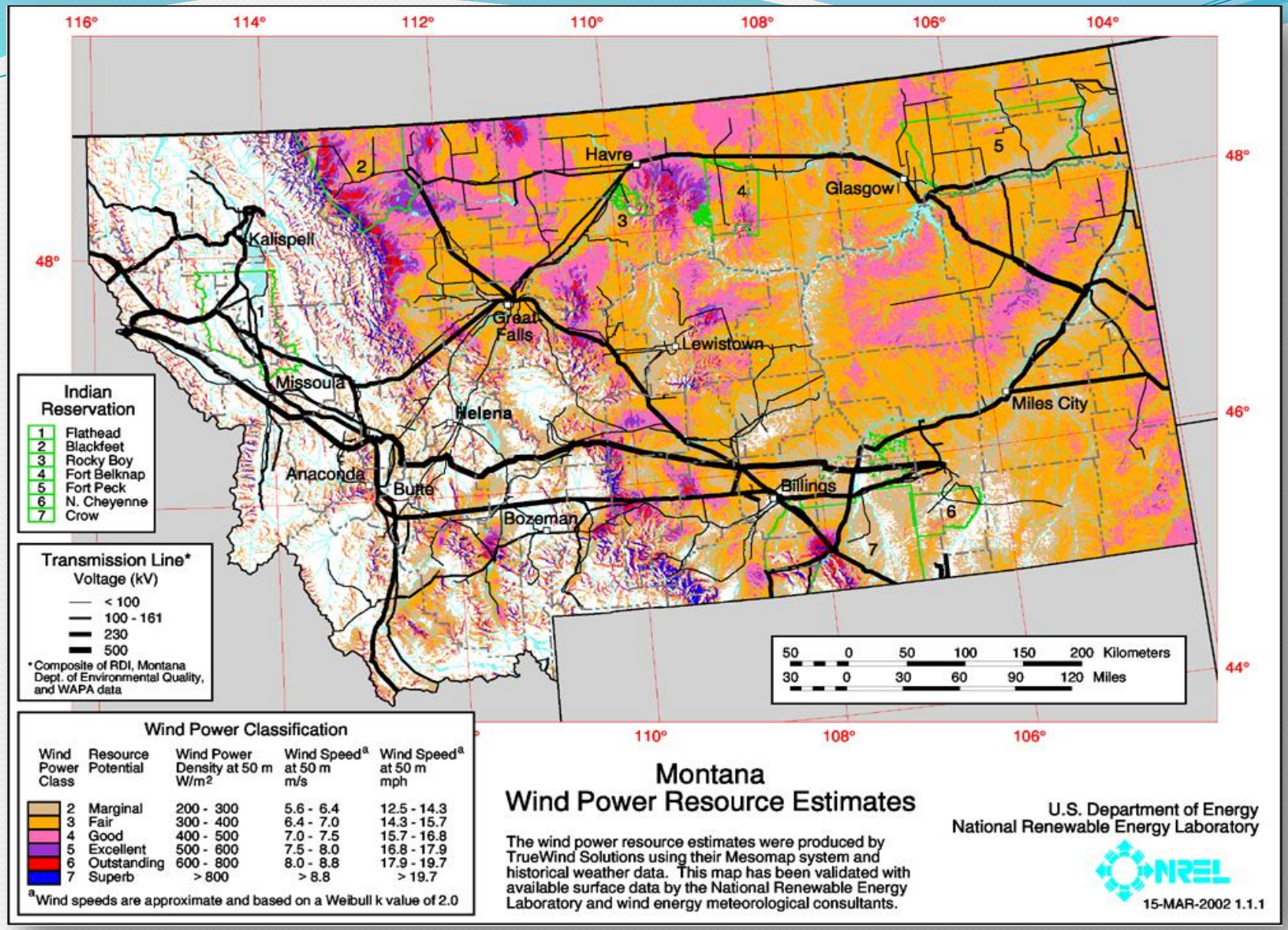




Some Limitations

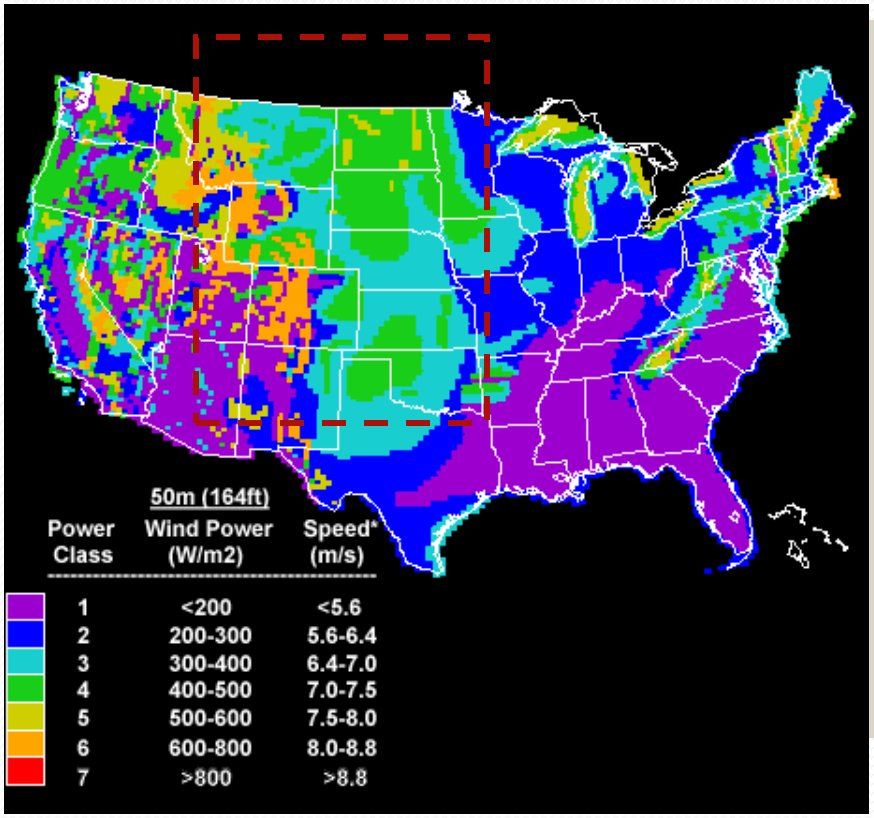
- Turbines must be located at the wind resource
- Transmission: Power lines from resource to load site
- Durability and Lifespan of turbines
- Blade design and construction
- Wind doesn't blow all the time!
  - How to provide power to users when wind doesn't blow?
  - Load Balancing, Power Firming, Smart Grid Issues

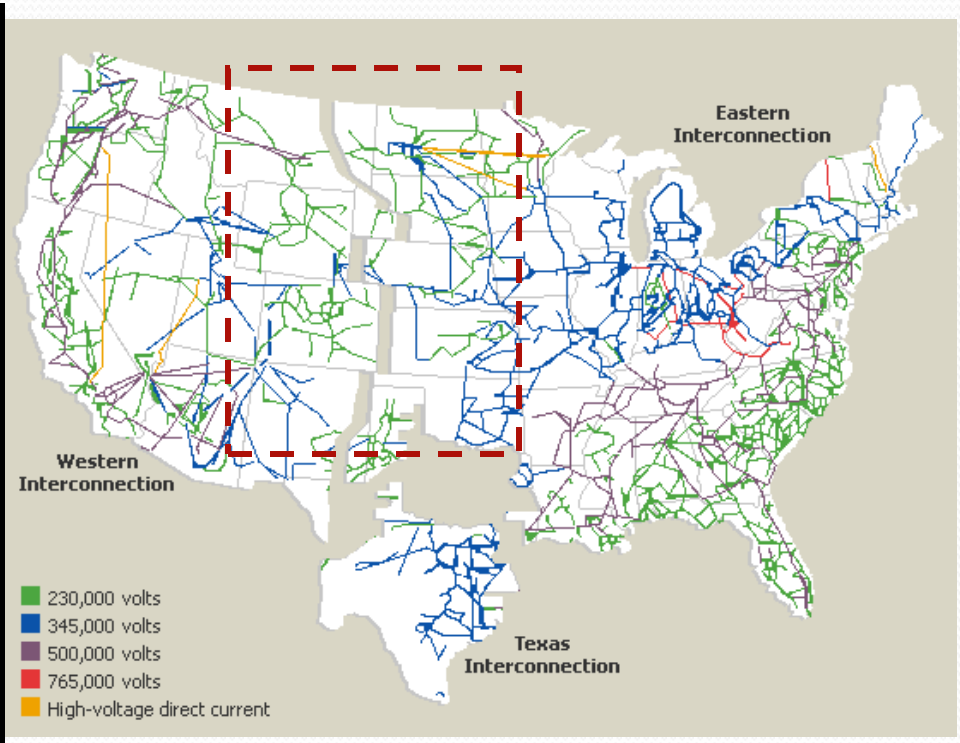
A lot of wind resources are NOT located near transmission lines (black lines on MAP)



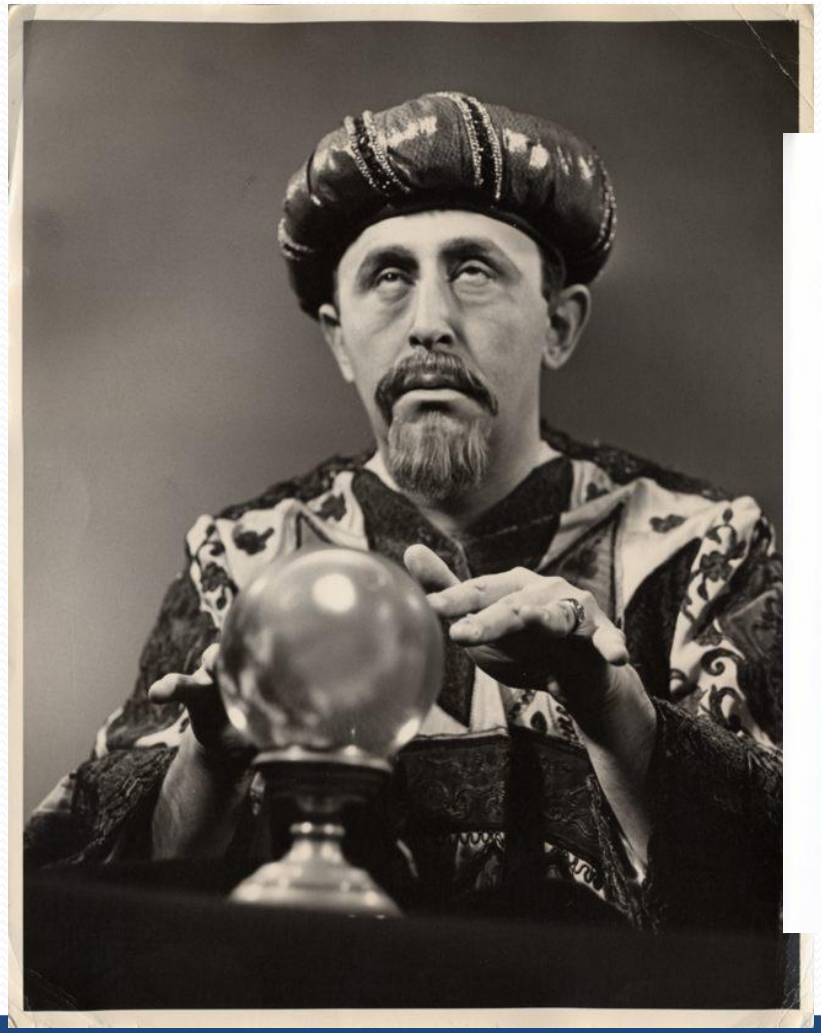
Wind power and the grid

Wind power is generally not produced where it is used: A transmission system is required to bring power to the user. The U.S. Electrical Distribution grid evolved to deliver power primarily from coal, hydro, oil, and natural gas sources - and does not necessarily support wind development.



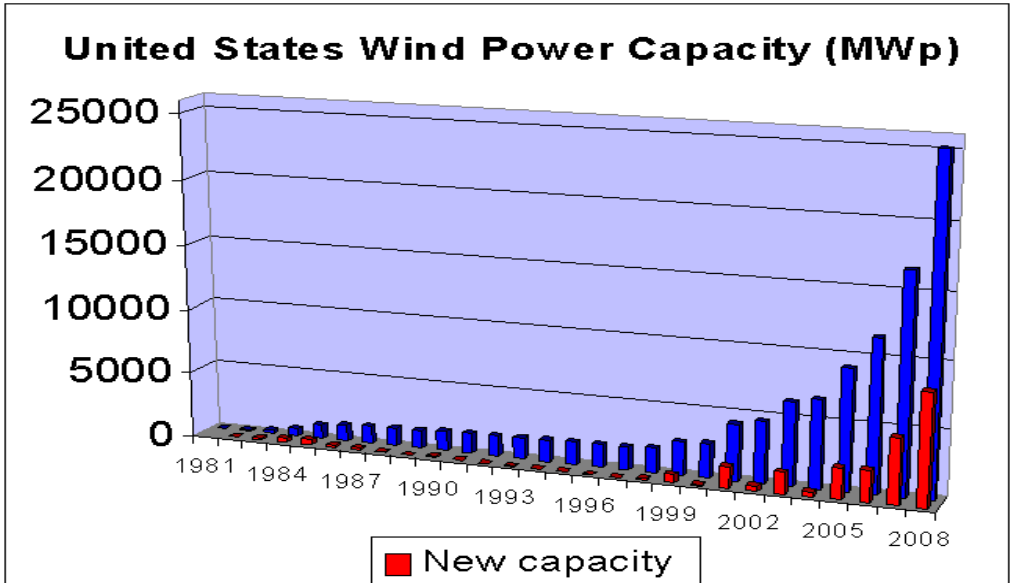


What does the future hold?



What does the future hold?

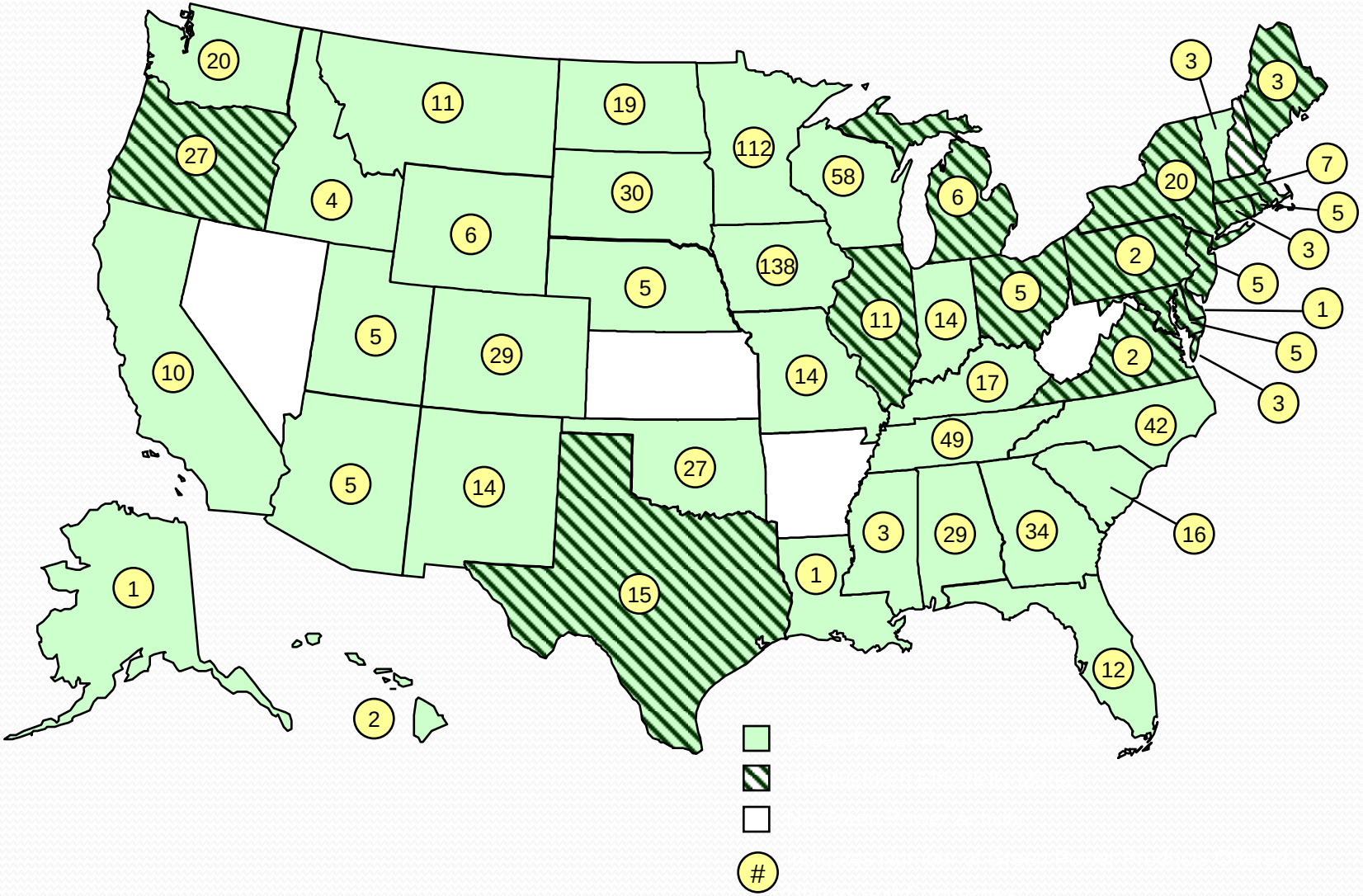
- Advances in turbine technology will lengthen the lifespan of the machines
- More power generated by wind means less pollution in the air



Environmental Benefits

- No SOx or NOx
- No particulates
- No mercury
- No CO_2
- No water used!

States with Green Power Programs

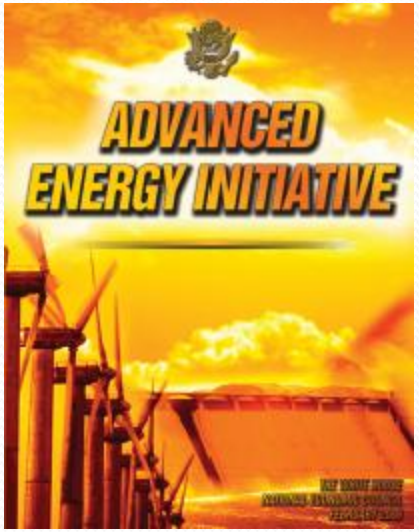


A New Vision *For Wind Energy in the U.S.*


White House photo by Eric Draper

Bush "…We will invest more in … **revolutionary** and…**wind technologies**"

Obama. "*Wind* farms are an important part of our ongoing efforts to make the United States more *energy* independent…



“The future ain’t what it used to be.”

- Yogi Berra

MSU Wind Applications Center

- Wind For Schools
- Public Outreach
- Anemometer Loan & Installation
- Wind Resource Evaluation
- Technical Assistance

Website:
http://www.coe.montana.edu/wind/