Renewable Energy and Conservation

Renewable = replaced within a reasonable amount of time by natural processes

Types of renewable energy

- Direct Solar → heat or electricity
- Ex: passive solar heating, solar hot water, pv cells, solar thermal electric

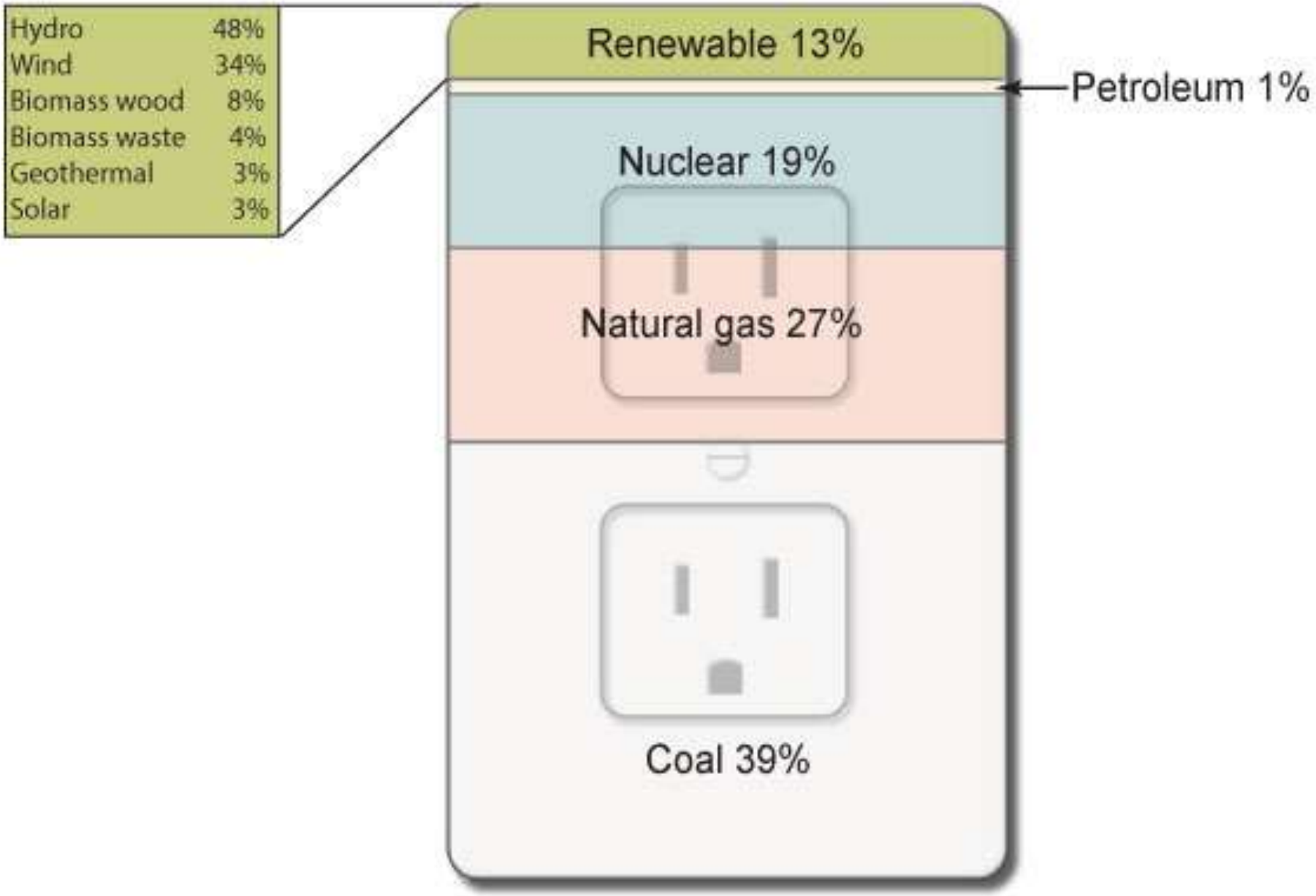
Indirect solar

- Examples:
  - Wind
  - Biomass (living matter) can regrow
  - Hydrological cycle → hydro power, ocean thermal energy, tidal energy

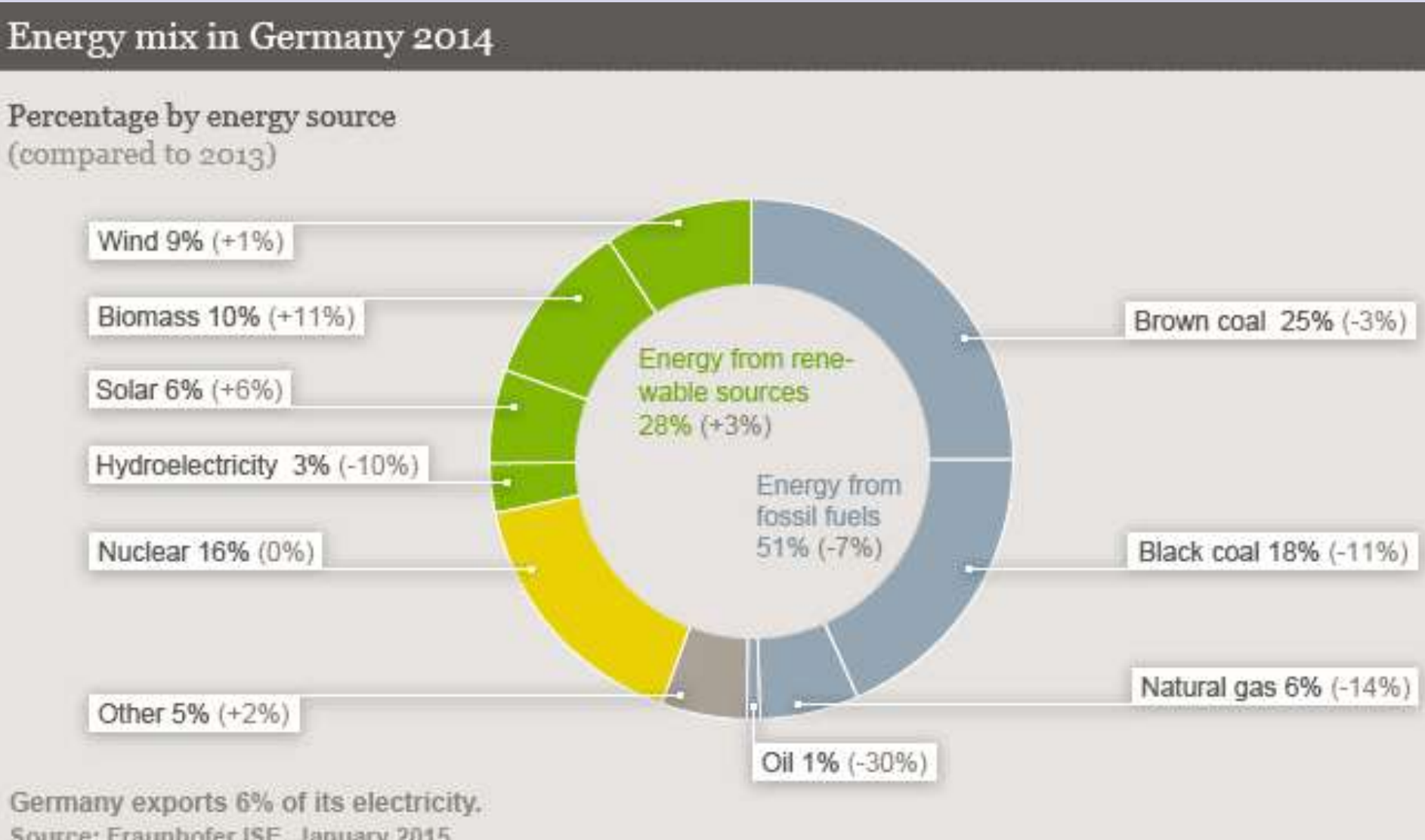
Geothermal energy is constantly being supplied by heated areas of the Earth's crust

Note: as of 2014 only about 13% of electricity is generated from renewable sources of energy (mostly hydro(48%))

Sources of U.S. electricity generation, 2014



Renewables → 28% Germany's electricity (2014)



Part 1: Solar Energy

- Lots of possibilities

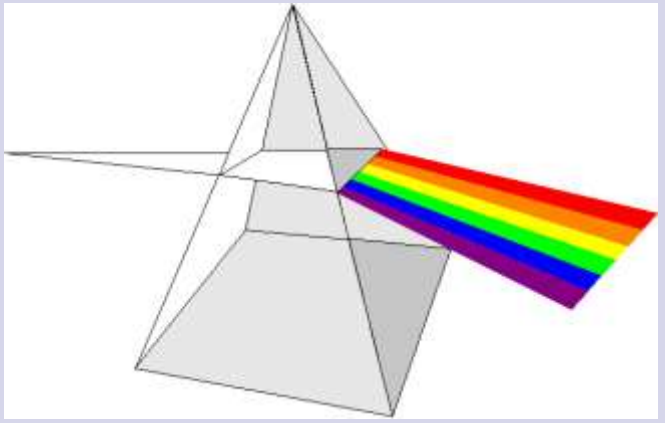
Part 1: Solar Energy

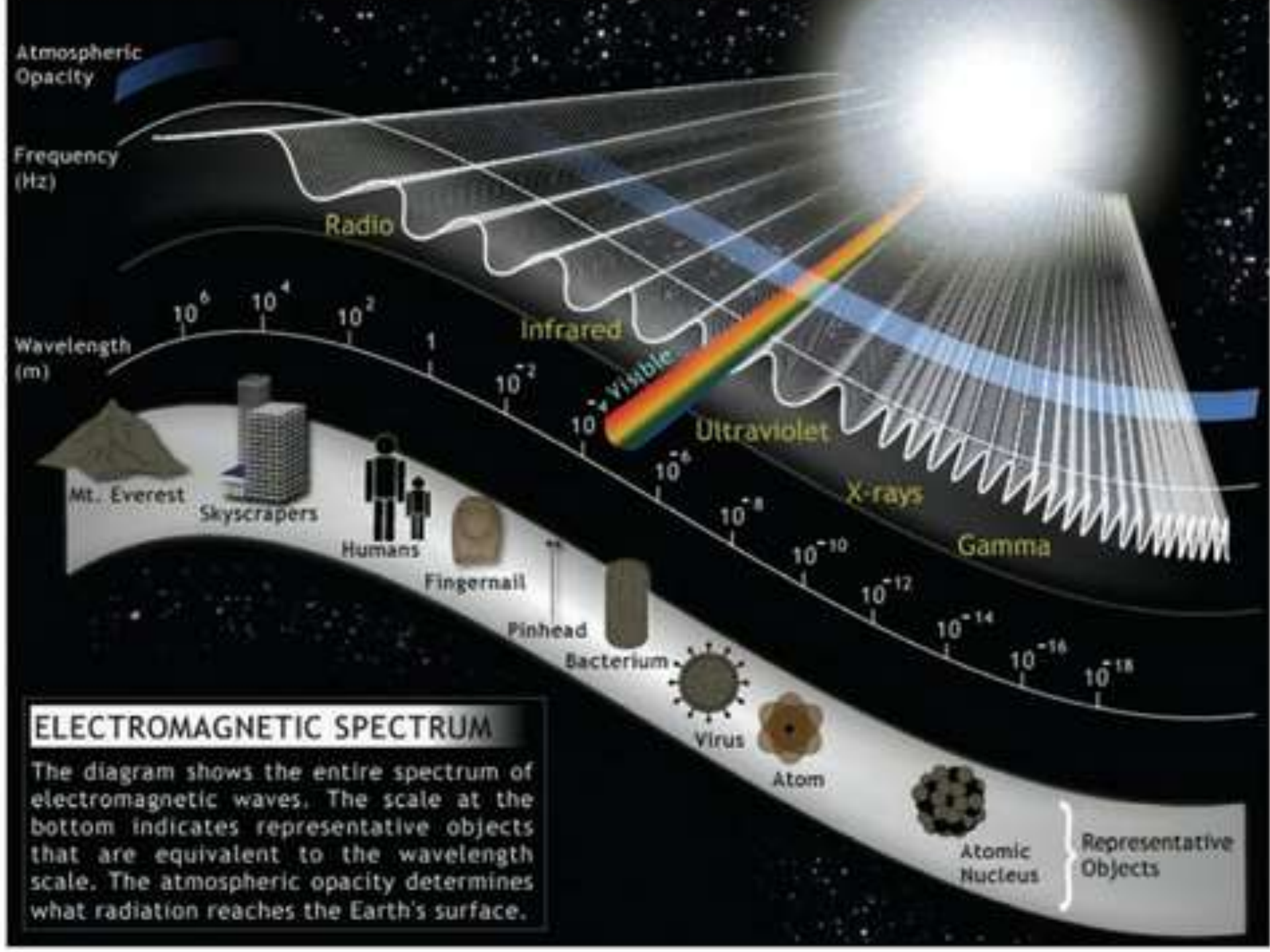
- Energy comes from thermonuclear reactions on sun
- What kind???
- Fusion

http://www.wright.edu/~william.wagner/prism.gif

Sun → energy in form of

- Electromagnetic radiation
  - Visible light
  - Infrared = heat
  - UV = Ultraviolet radiation





ELECTROMAGNETIC SPECTRUM

The diagram shows the entire spectrum of electromagnetic waves. The scale at the bottom indicates representative objects that are equivalent to the wavelength scale. The atmospheric opacity determines what radiation reaches the Earth's surface.

Uneven distribution of Solar radiation

- Uneven heating → temp. differences → winds, weather and ocean currents
- Amount of sunlight reaching surface depends on:

- Latitude

- Season (time of year)
- Time of day
- Cloud cover

http://www.spacesciencegroup.nsula.edu/sotw/newlessons/graphics/latitude.jpg

http://astronomy.swin.edu.au/~pbourke/geometry/sphere/latitude.gif

Direct Solar Energy

- Transfer of energy direct from the sun can be used to :

- Heat water
- Heat buildings
- Generate electricity

- Note: technologies to use direct solar exist but the initial start up costs can be expensive.

www.eren.doe.gov/.../projects/ images/pueblo_laguna.jpg

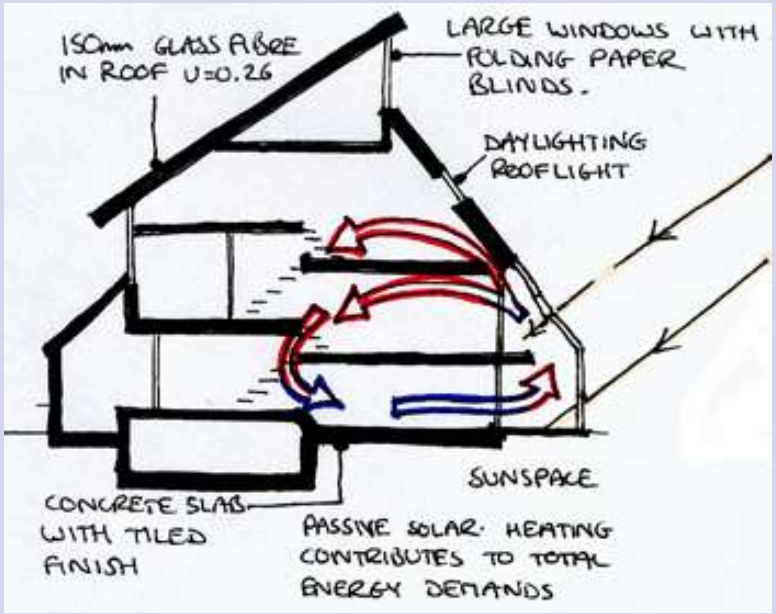
Direct solar heating

- Glass is transparent to visible light but impenetrable to heat,
  - Visible light → warms objects → they radiate heat

- The darker the object absorb more energy
  - *dark = low albedo*

- **Convection = Heat moves from hi → low**

Passive solar design



- Windows on South side of building
- Concrete or stone floors radiate heat at night
- Lots of insulation to prevent heat loss

http://www.russellbridge.co.uk/week5/06_02.gifPassive

Five Elements of Passive Solar Design

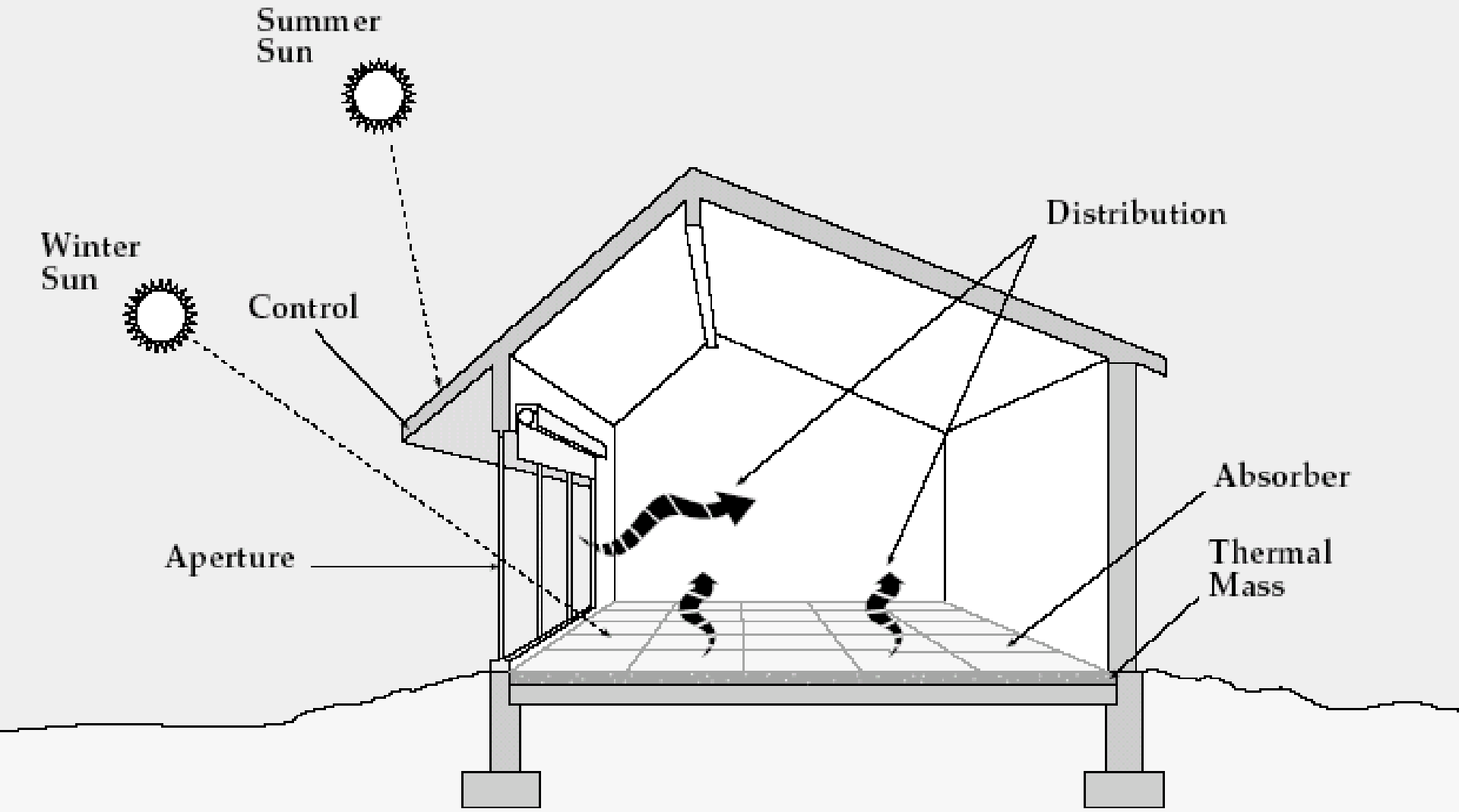
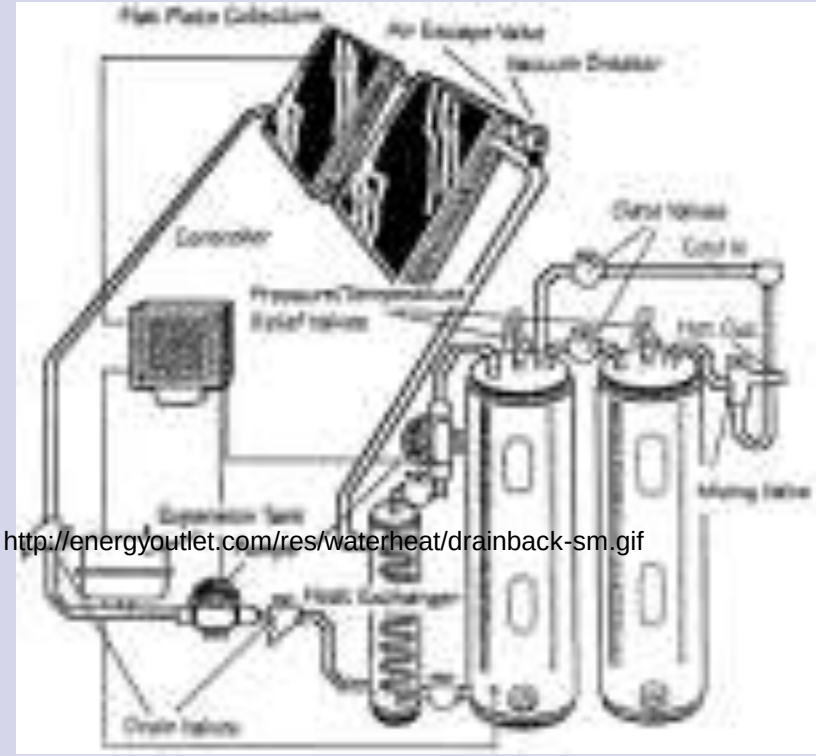


Fig. 1 Direct Gain

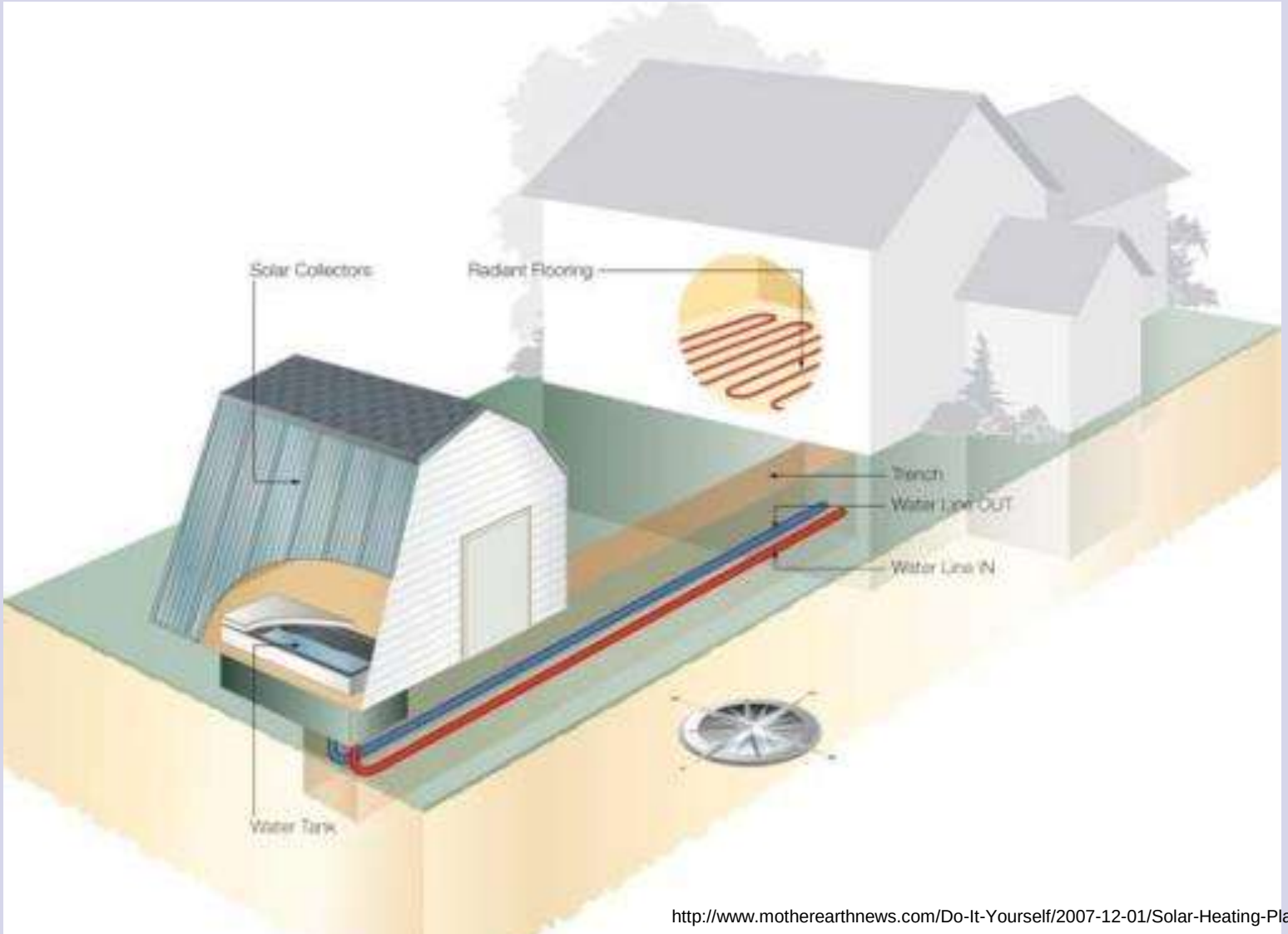
Active Solar heating

- Collection devices on roof →
- Heat transfer liquid →
- Heat exchanger where heat is transferred to water
- Used to heat water for homes and swimming pools



http://energyoutlet.com/res/waterheat/drainback-sm.gif

Gary Reysa's solar heating system (Montana)



http://www.motherearthnews.com/Do-It-Yourself/2007-12-01/Solar-Heating-Plan-for-Any-Home.aspx

http://mariasurmamanka.greenoptions.com/files/images/SolShed2.jpg

Your Turn Lab Next Week

- Build a solar hot water heater (groups of 2 or 3)
- Your system must be designed to
  - Heat one liter of cold water
  - minimum of 10º above the starting temp after about 30 minutes of sunlight
- Determine heat energy gained by the water using the formula:
  - Heat (Joules) = m c ΔT
    - Mass = mass of 1l of water (note: 1ml water = 1g)
    - C = specific heat of water (4.18J)
    - ΔT = change in water temp
- Best one wins ($5.00/person prize)

Solar thermal electric generation

- 2 Ways to turn direct sunlight into electricity
  - Solar Electric Generation plant
  - Photovoltaic cells
- Only accounts for about 3% of renewable energy use in the US

Solar Electric Generation plants

- Mirrors and lenses concentrate the sunlight
- Sun heats molten salt or water to high temps → steam turns generater → electricity
- Used in industrial processes, desalination plants and water purification

Solar Thermal Electric plant

- There are a total of nine SEGS plants in Southern California (Mojave Desert) with a total generating capacity of 354 MW

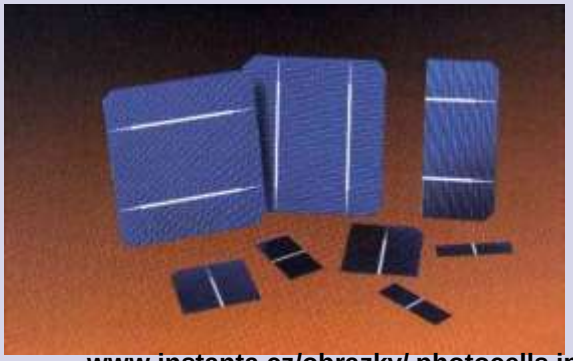
http://sol.crest.org/renewables/re-kiosk/solar/solar-thermal/case-studies/trough-power.shtml

Solar Energy Generating Systems

- Disadvantages =
  - Need backup power or storage
  - Takes up space

- Advantage =
  - More efficient than other solar technologies because heat is concentrated
  - No air or water pollution
  - No fuel costs

View: History Channel Video solar technologies



www.instanta.cz/obrazky/ photocells.jpg

Photovoltaic Solar Cells

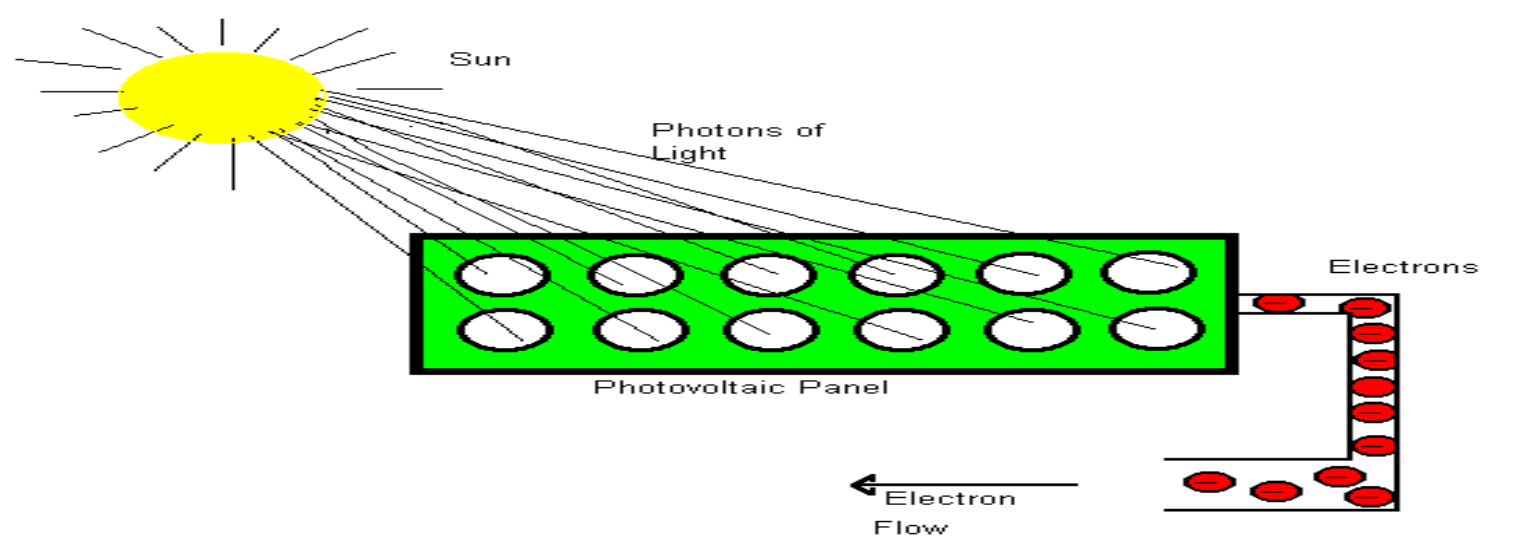
- Convert sunlight directly into electricity
- PV's are wafers or thin films of a semiconductor (ex: silicon, or galium arsenide) coated with metals
- Solar energy hits the film → a flow of electrons
- Many cells must be wired together in panels to produce electricity

http://www.thefutureschannel.com/dockets/science_technology/solar_power/index.php

Photovoltaics

Photovoltaics

- Requires a semi-conductor (Si)
- Creates a direct current (DC) which can
  - Be stored in batteries
  - Or converted to a conventional alternating current (AC)
  - Or used to split water (electrolysis) → Hydrogen gas (stored fuel for fuel cells)
- Typical PV cell has a 15-20% efficiency



Read how to connect solar panel article in notes

- Series → increased voltage. Same amps
  - Problem if one panel goes down they all cut off
- Parallel → same voltage but increased amps
  - Advantage = multiple ways for current to flow = still get power if one panel is damaged

Lake Placid System

- Consists of 9 panels
- Size of system=1.575 kW(Direct Current)
- 1 panel:
  - Width=51 inches
  - Length=40 inches
  - ~ 1,341.8 kwh / year

Triangle Electrical Systems, Inc.

- Company Information
  - Located 126 Idaho Avenue Plattsburgh,NY
  - Phone#(518)-562-5425
  - Fax#(518) 566-9583
  - Email-lbrienza@trianglesystems.com
  - Website-http://trianglesystems.com
- http://view2.fatspaniel.net/FST/Portal/TriangleElectricalSys/lakePlacidHS/HostedAdminView.html

Electrical Energy Consumption

- 2014 electricity consumption for average US household =

- 10,932 kWh/yr

- According to eia.gov (energy information administration

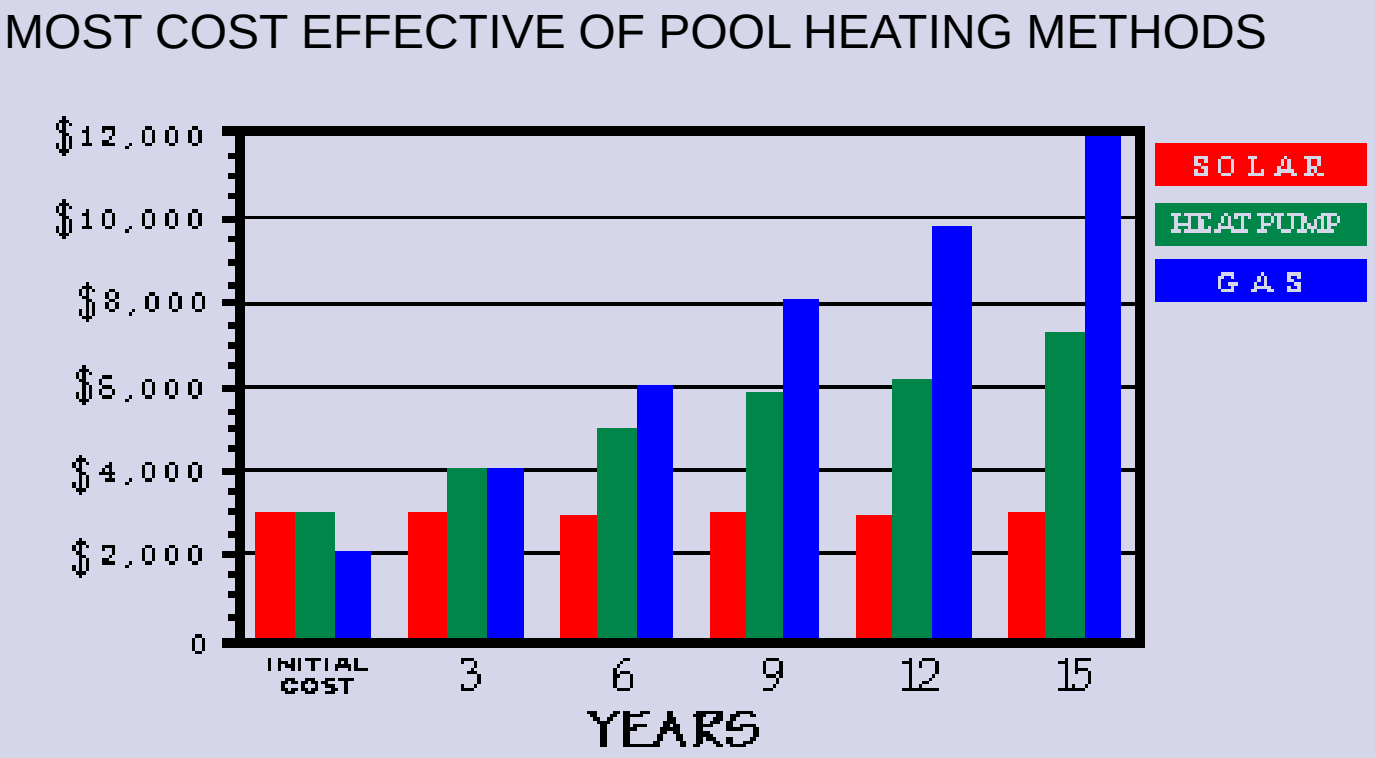
Energy use per household

- U.S. Department of Energy (2006) estimate: the average electricity use for a house is about 31kWh daily
- How many kwh / house / yr?
- = 31kwh/day * 365days =
- 11,315kwh /yr
- This is = How many megawatt hours/yr?
- 11
- How much does a typical household spend on electricity /year if the cost to consumer is $0.13 / kwh
- $0.13 * 11,315kwh =
- $1470.95 / year

Lake Placid Central School 2013-14 kwh usage per location	
Bus Garage	180,350
Annex	83,916
Middle/High School	549,200
Elementary School	845,600
Total usage in kwh	1,659,066

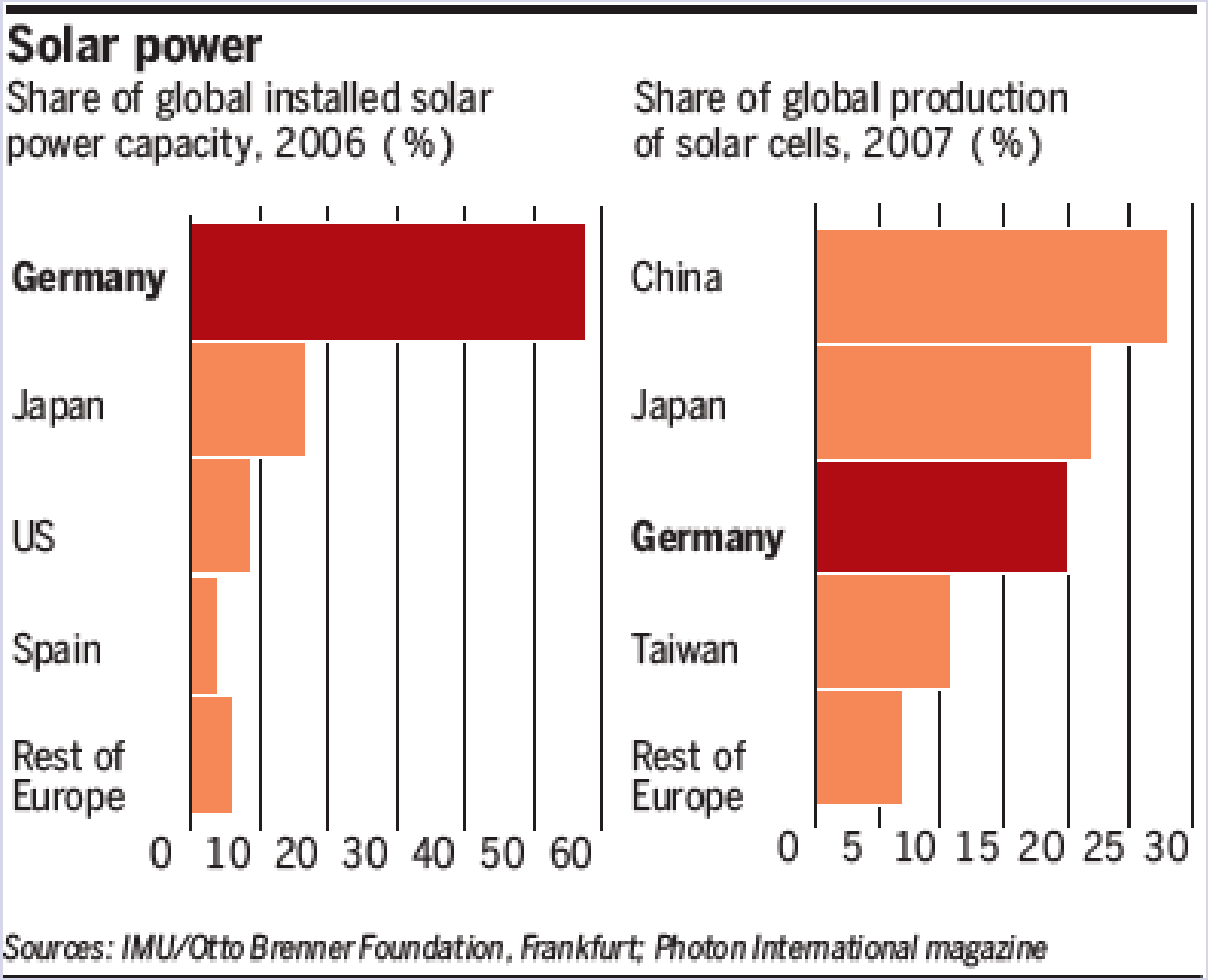
Startup cost of inserting solar technologies is higher but can be cheaper then alternatives in the long run

Example:



www.suntrek.net/images/ budge.gif

Germany and Japan = world leaders in solar industry



Future for Solar?

- Research → better efficiency and cost effective technologies
  - Ex: thinner films use less Si
  - (currently ~ 20% efficient)
- Federal support
  - Renewable energy tax credit (30% of installation costs can be given back in form of a tax credit)
- State support (NY)
  - Solar thermal incentive program ($1.50/kwh displaced by solar heating) up to $4,000/yr
  - Pv incentive program (offers rebates of up to 40% of costs $1.30/watt installed)
  - Residential solar sales tax exemption – exepts all solar energy systems from state sales taxes
  - https://www.nyserda.ny.gov/All-Programs/Programs/NY-Sun/Communities/Solarize

Net Metering Article in notes

- Explain how net metering can apply to solar pv sytems
- What are the advantages and disadvantages?
- Explain the advantages and disadvantages of a stand-alone solar pv system

Disadvantages of Solar

- High initial start up costs
  - Can be offset by Net metering = receiving credit for excess power sent to the grid
- Large scale operations require lots of space
- Need for backup (better batteries)

Advantages of Solar

- Can produce electric power → no air or water pollution
- Low operating costs
- Widely available

Fossil Fuels are not getting any cheaper..

Environmental impacts of fossil fuels

- CO_2
- → global warming → rising sea levels and climate change
- NO_x and SO_x
- → acid rain → impact aquatic and forest ecosystems
- Particulate matter
- → smog → decreased photosynthesis and respiratory problems in animals

https://www.startsomegood.com/shiriki-hub

Wind Power

Can → mechanical energy to do work or electricity

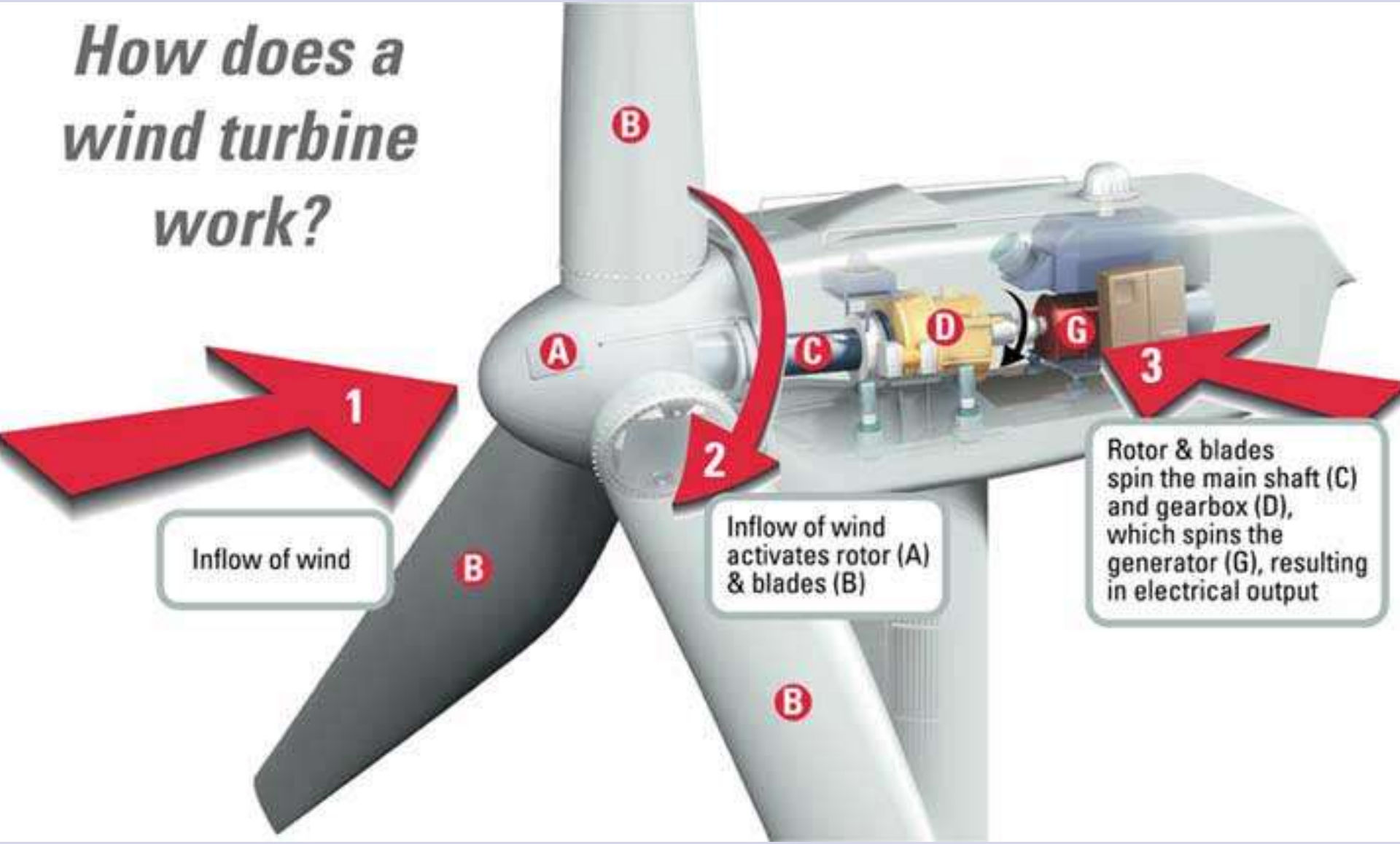
Wind = Indirect form of solar

- Sun → uneven heating of earths surface → movement of air from warm to cold → wind

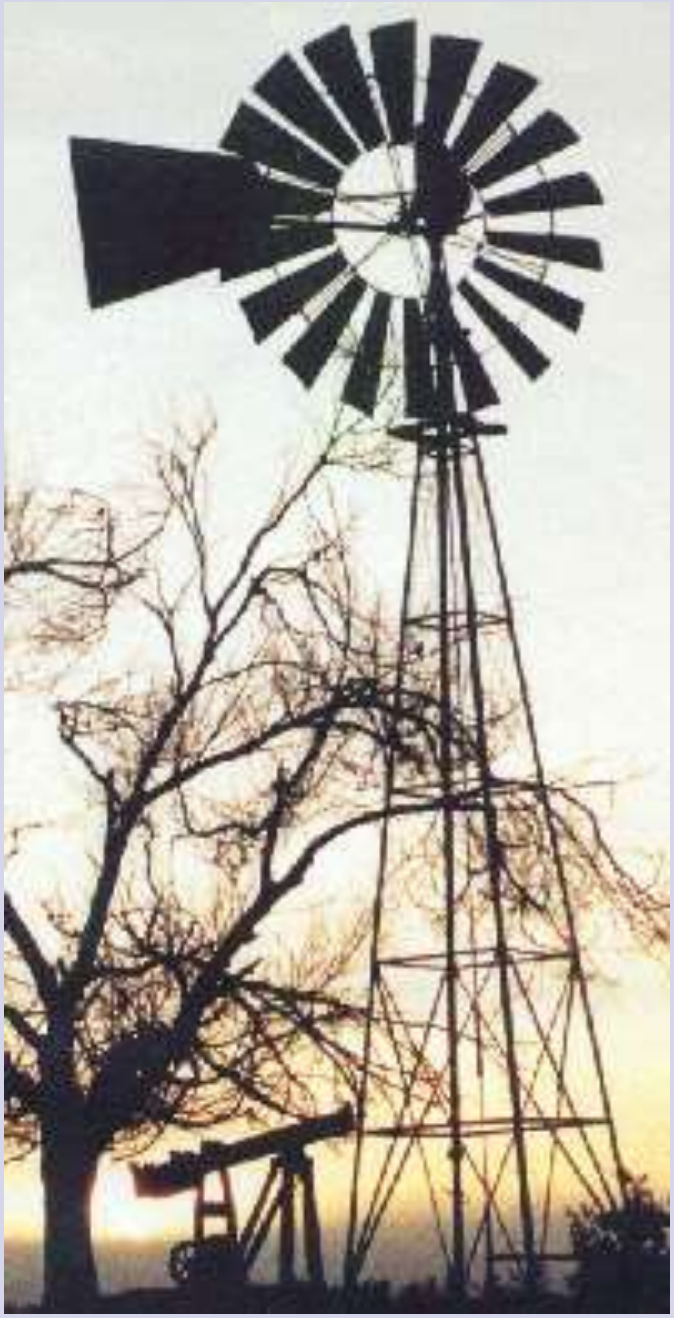
- Coriolis effect = swerving of winds due to the rotation of the earth

Converting Wind Energy to Electricity

- Wind turns a rotor blade which powers a generator creating a flow of electrons (electricity)
- As turbines have become larger and more efficient and subsidies have increased, costs have declined rapidly
- Wind = most cost competitive form of renewable energy


How does a wind turbine work?
B
A
C
D
G
1
2
3
B
B
Inflow of wind
Inflow of wind activates rotor (A) & blades (B)
Rotor & blades spin the main shaft (C) and gearbox (D), which spins the generator (G), resulting in electrical output

Early “WINDMILL” in Afghanistan (900AD) used to grind grains and seeds



Part of our history

Common in the midwest → pump water

One of the first commercial windmills → electricity

Smith-Putnam Turbine

Vermont, 1940's built in response to fuel shortages → 1,250kw

Modern Windmills

Types of Electricity Generating Windmills

Small (≤10 kW)

- Homes
- Farms
- Remote Applications

(e.g. water pumping, telecom sites, icemaking)

Intermediate (10-250 kW)

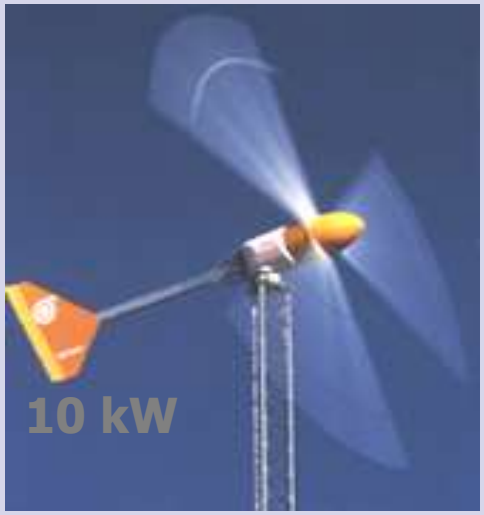
- Village Power
- Hybrid Systems
- Distributed Power

Large (250 kW - 2+MW)

- Central Station Wind Farms
- Distributed Power

Modern Wind Turbines:

- Reliable
- Only 2-3 Moving Parts
- Very Low Maintenance

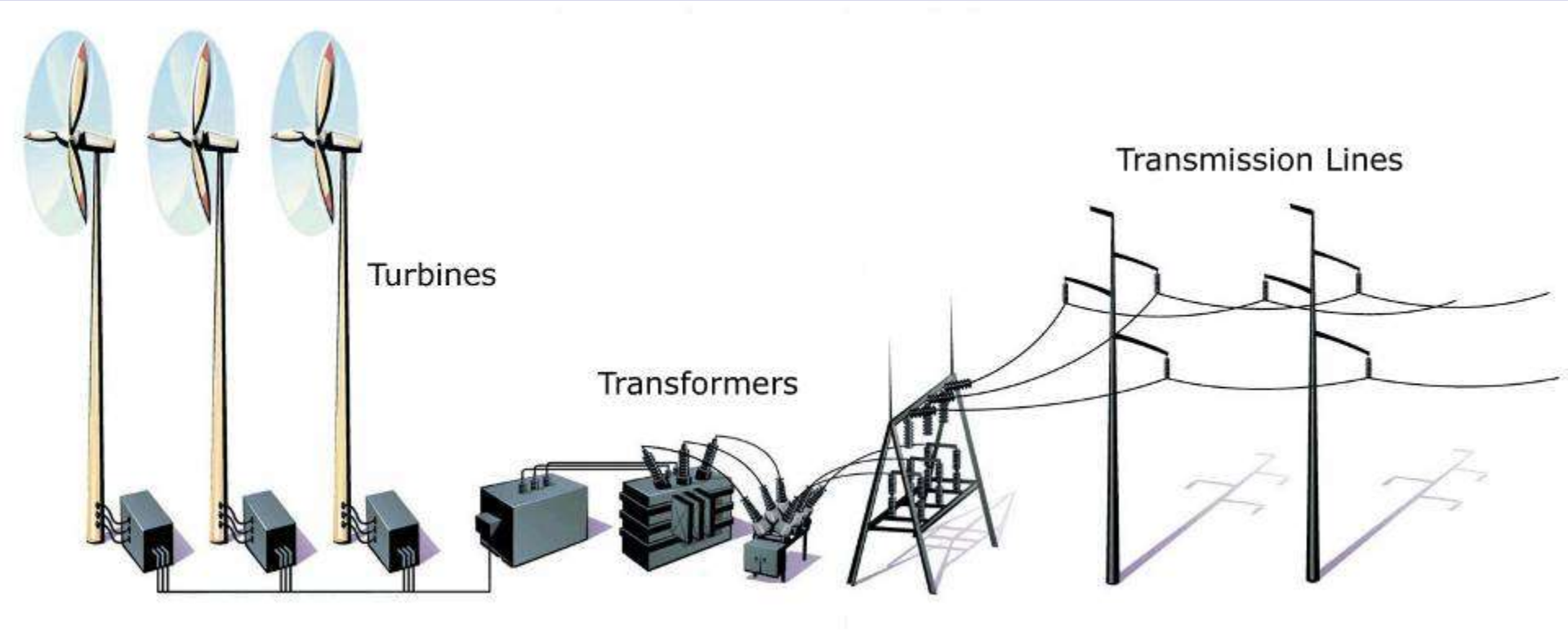


(Not to scale)

Large Commercial Wind Farms

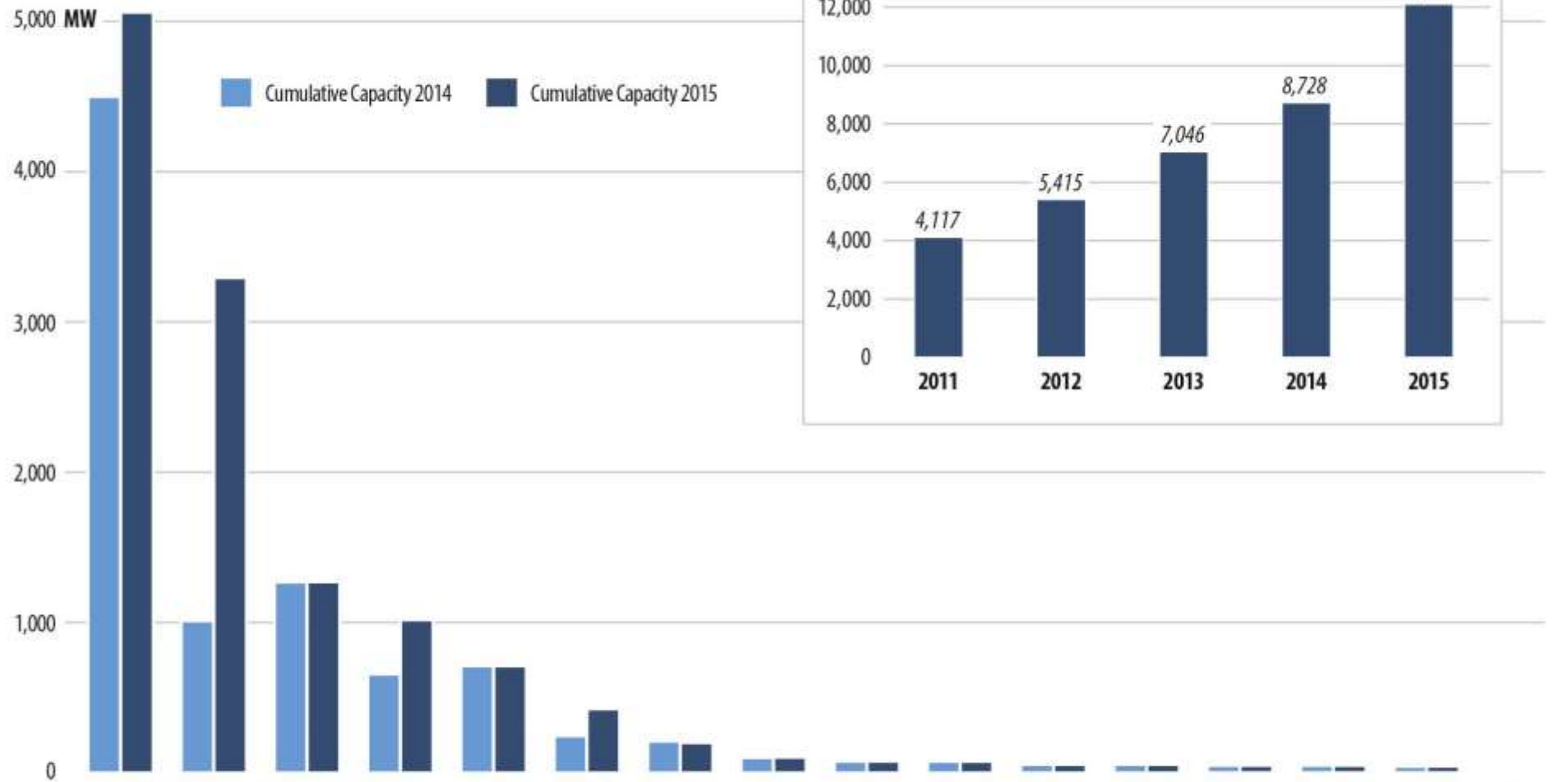
- **Germany and Denmark are the technology leaders**

Connected and tied into the grid



Off-Shore Windfarms (popular in Europe but not US)

GLOBAL CUMULATIVE OFFSHORE WIND CAPACITY IN 2015



	UK	Germany	Denmark	PR China	Belgium	Netherlands	Sweden	Japan	Finland	Ireland	S Korea	Spain	Norway	Portugal	US	Total
Total 2014	4,500	1,012	1,271	658	712	247	212	50	26	25	5	5	2	2	0.02	**8,728**
New 2015	566	2,282	0	361	0	180	0	3	0	0	0	0	0	0	0	**3,392**
Total 2015	5,061	3,295	1,271	1,018	712	427	202	53	26	25	5	5	2	2	0.02	**12,105**

Source: GWEC

ANNUAL CUMULATIVE CAPACITY (2011-2015)

ote: Sweden and UK had decommissioning of 10MW and 6MW offshore capacity respectively
unding affects the final sums

The London Array, England

The world's largest offshore wind farm, the London Array, can power 470,000 homes

Middelgrunden (Germany)

Why Not the US?

- Concern about views, bird kills, noise… →
- NIMBY
- Not In My Backyard

NIMBY (Not in my backyard) Syndrome

- Cape Wind Offshore windfarm…this was a very contested project…about half the people on the cape supported the other half opposed.

New projects near us

https://www.northcountrypublicradio.org/news/story/33597/20170317/under-new-energy-law-will-it-matter-if-these-slc-towns-say-no-to-wind-farms

Need to Change Perceptions…

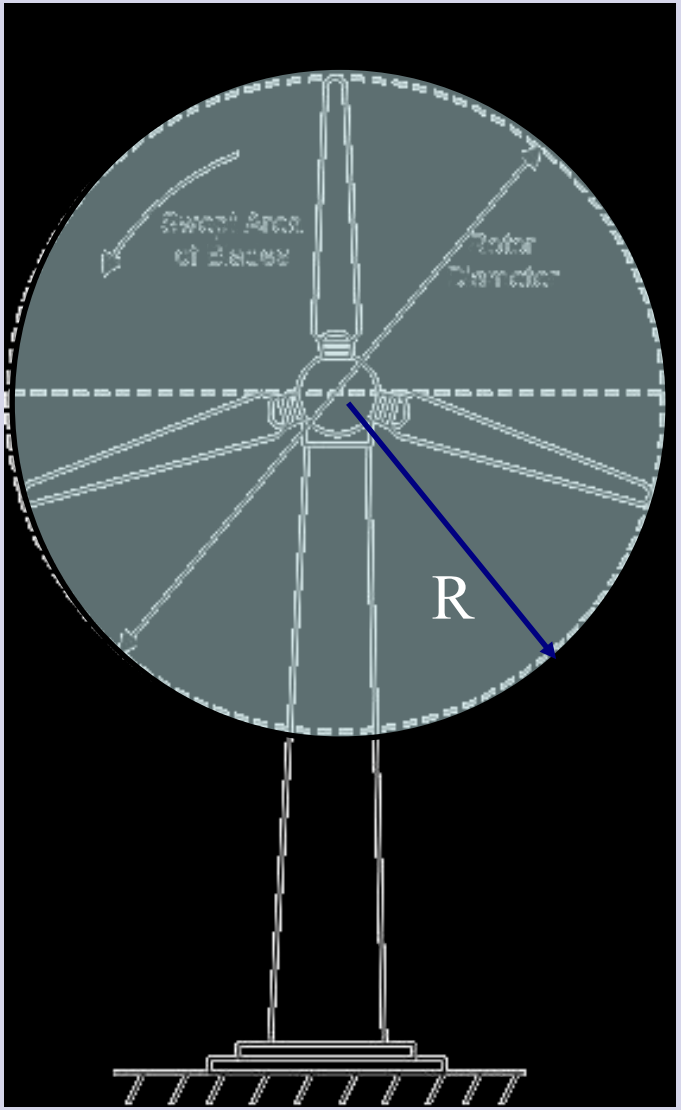
Large Wind Turbines

- 450’ base to blade
- Each blade 112’
- Span greater than 747
- 163+ tons total
- Foundation 20+ feet deep
- Rated at 1.5 – 5 megawatt
- Supply at least 350 homes

Why so big?

Power in the Wind = $\frac{1}{2}\rho A V^3$

- Effect of air density, ρ
- Effect of swept area, A
- Effect of wind speed, V



Swept Area: $A = \pi R^2$
Area of the circle swept by the rotor (m^2).

Why do windmills need to be high in the sky??

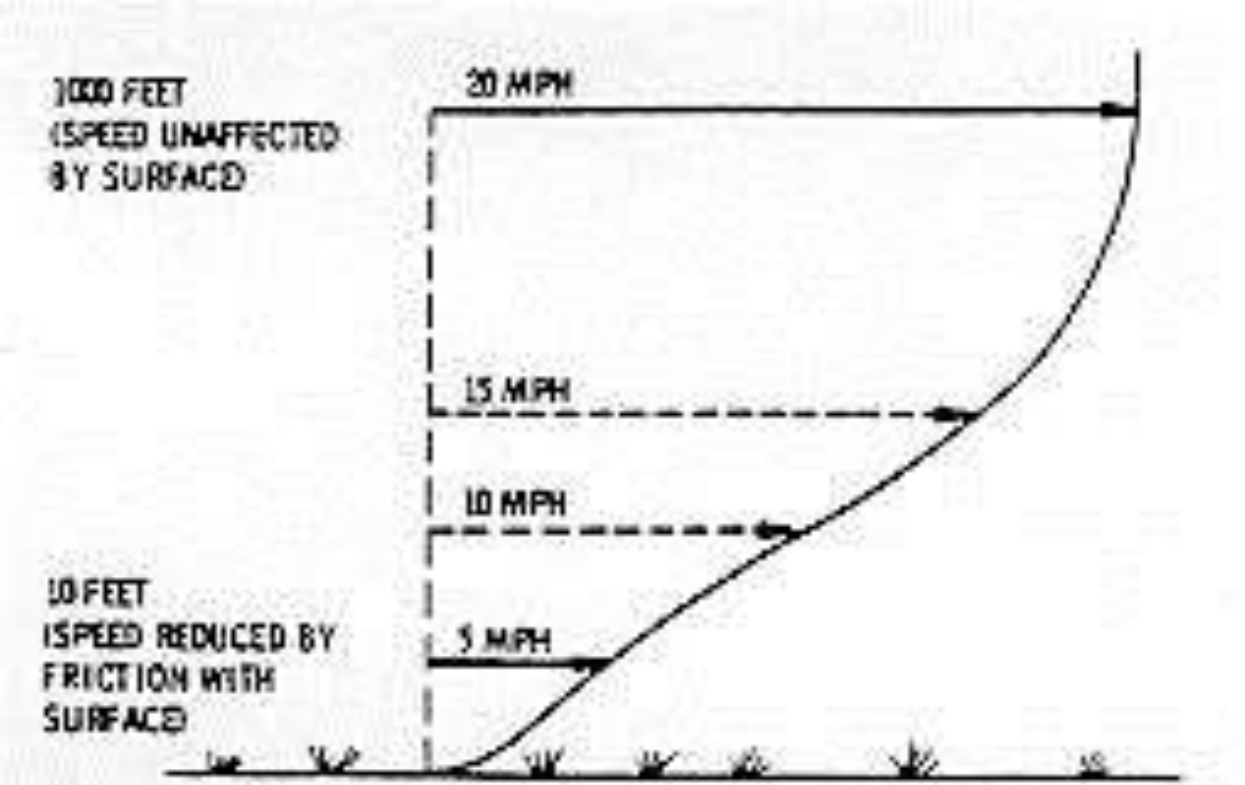


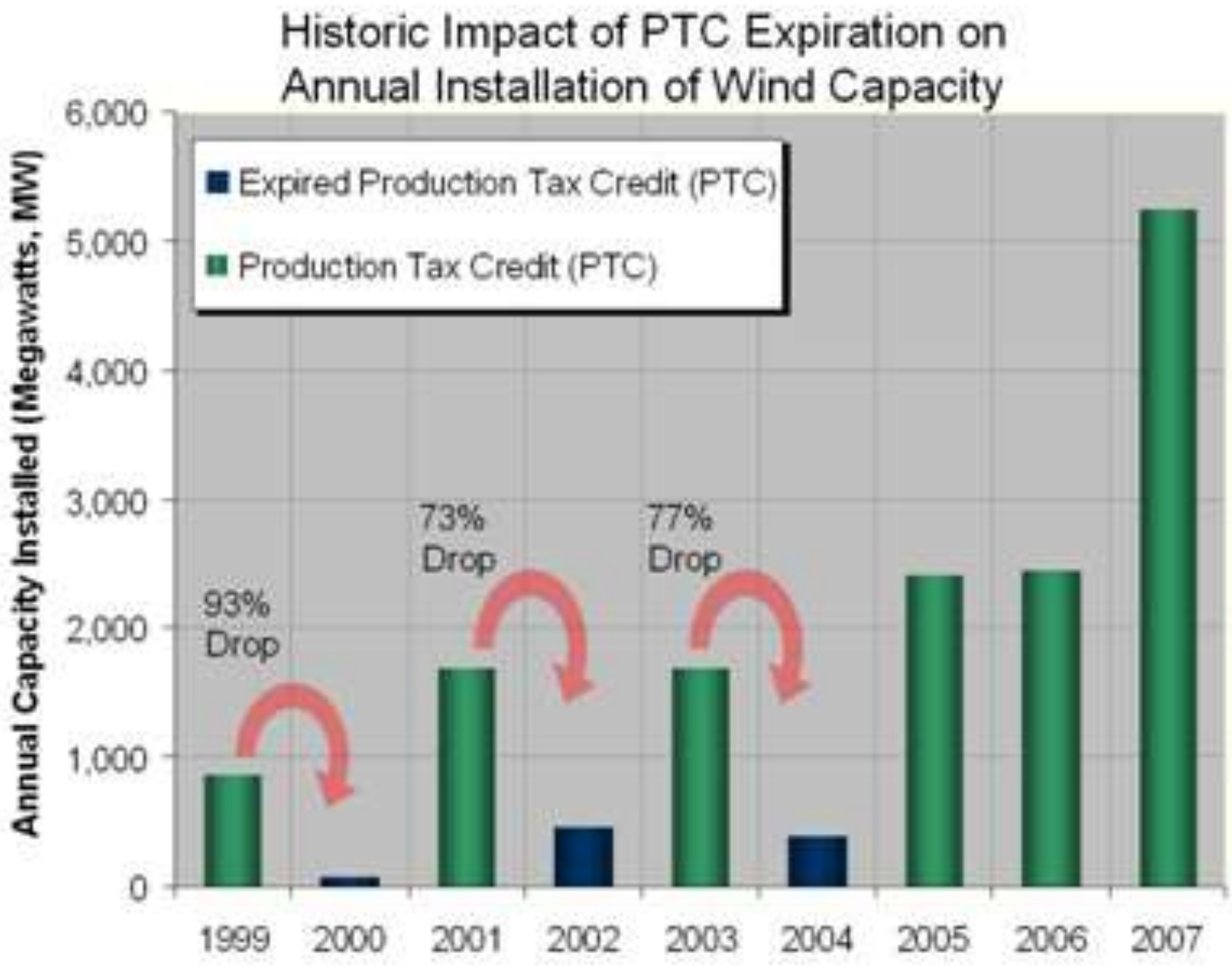
FIGURE 2. Effect of Surface Friction on Low-Level Wind

Tax Credits

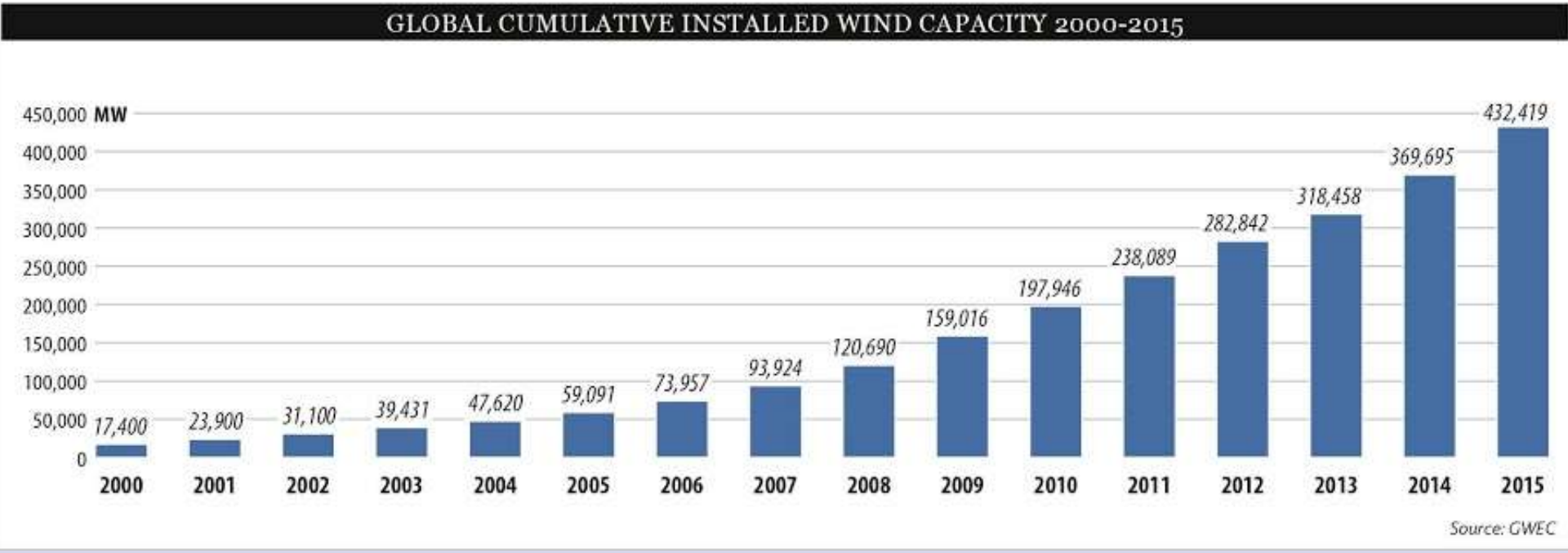
- No Federal Incentives for Small Wind Since 1985
- Large Wind Supported with Production Tax Credit
- State have varying levels of support
  - NY 50%-75% Support
  - ME 0%
  - MA 20%-50%

Production Tax Credits

- RECs = renewable energy credits
- Part of the Energy Policy Act of 1992
- Covers Wind, Hydro, Geothermal, Biomass, Landfill and Municipal Solid Waste Gas projects

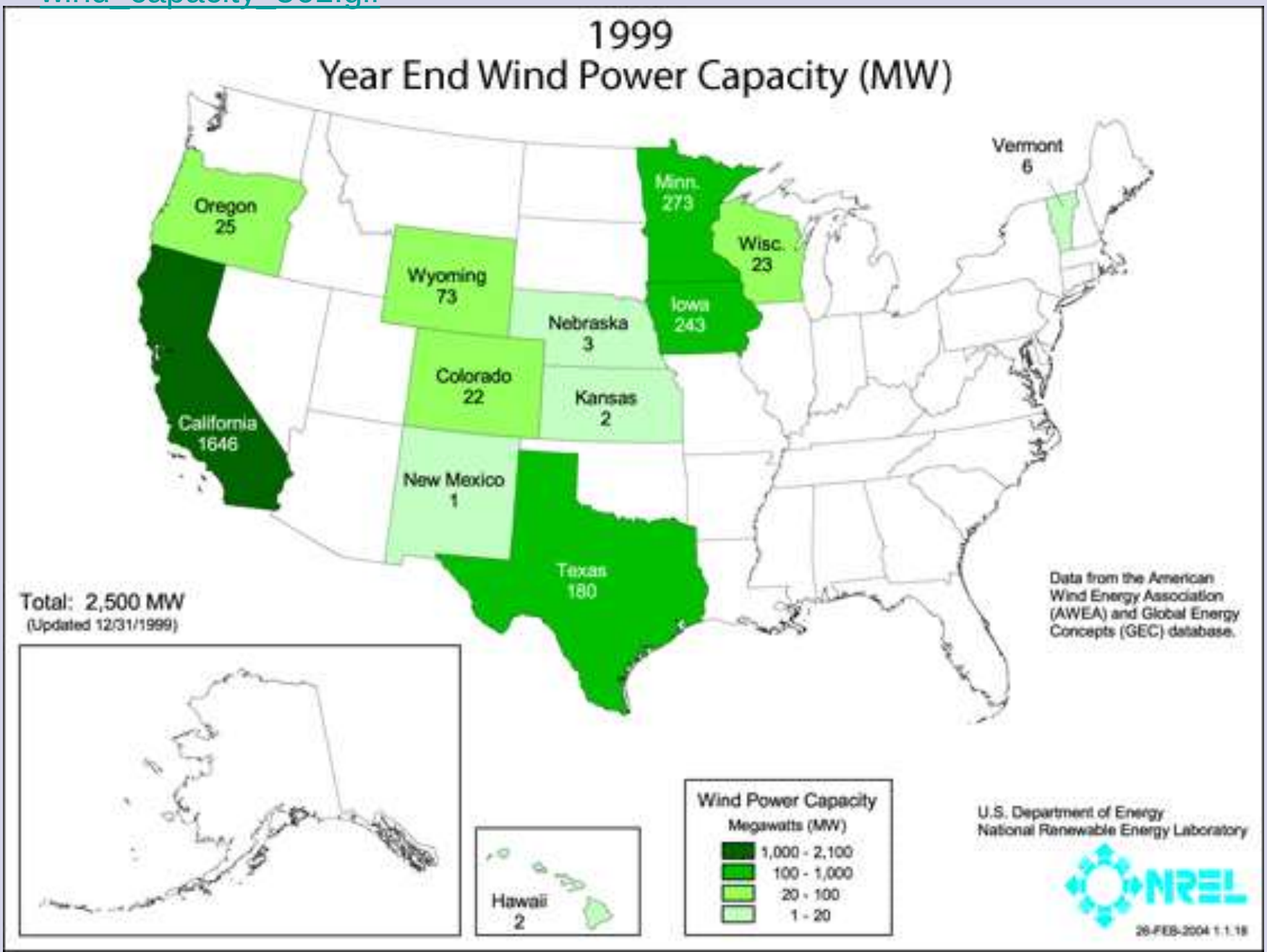

Historic Impact of PTC Expiration on Annual Installation of Wind Capacity
Annual Capacity Installed (Megawatts, MW)
6,000
5,000
4,000
3,000
2,000
1,000
0
Expired Production Tax Credit (PTC)
Production Tax Credit (PTC)
93% Drop
73% Drop
77% Drop
1999
2000
2001
2002
2003
2004
2005
2006
2007

Wind Energy is the Fastest Growing Energy Source in the World

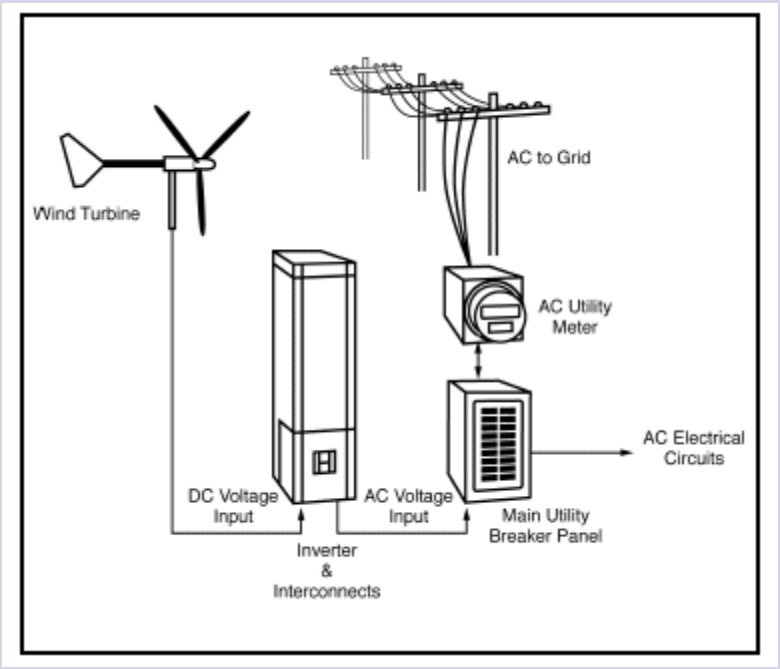


http://www.gwec.net/wp-content/uploads/vip/Global-Cumulative-installed-wind-capacity-2000-2015_corrected-file_22.02.2016.jpg

http://apps2.eere.energy.gov/wind/windexchange/images/windmaps/installed_wind_capacity_561.gif



Net Metering



- Grid connected
- Adv:
- → backup system,
- get credit for power produced
- Disadv:
- requires more infrastructure and power lines and
- still have an electric bill

Stand-alone

- Advantage =
- can bring power to remote locations,
- no electric bill
- Disadvantage =
- Requires backup (ex: battery storage, combined solar…)

Advantages of wind generated power

- Produces no waste, air or water pollution
- Requires no fuel source
- Easily assembled and disassembled

Two wind turbines in the UK's Blyth Offshore Wind Project.

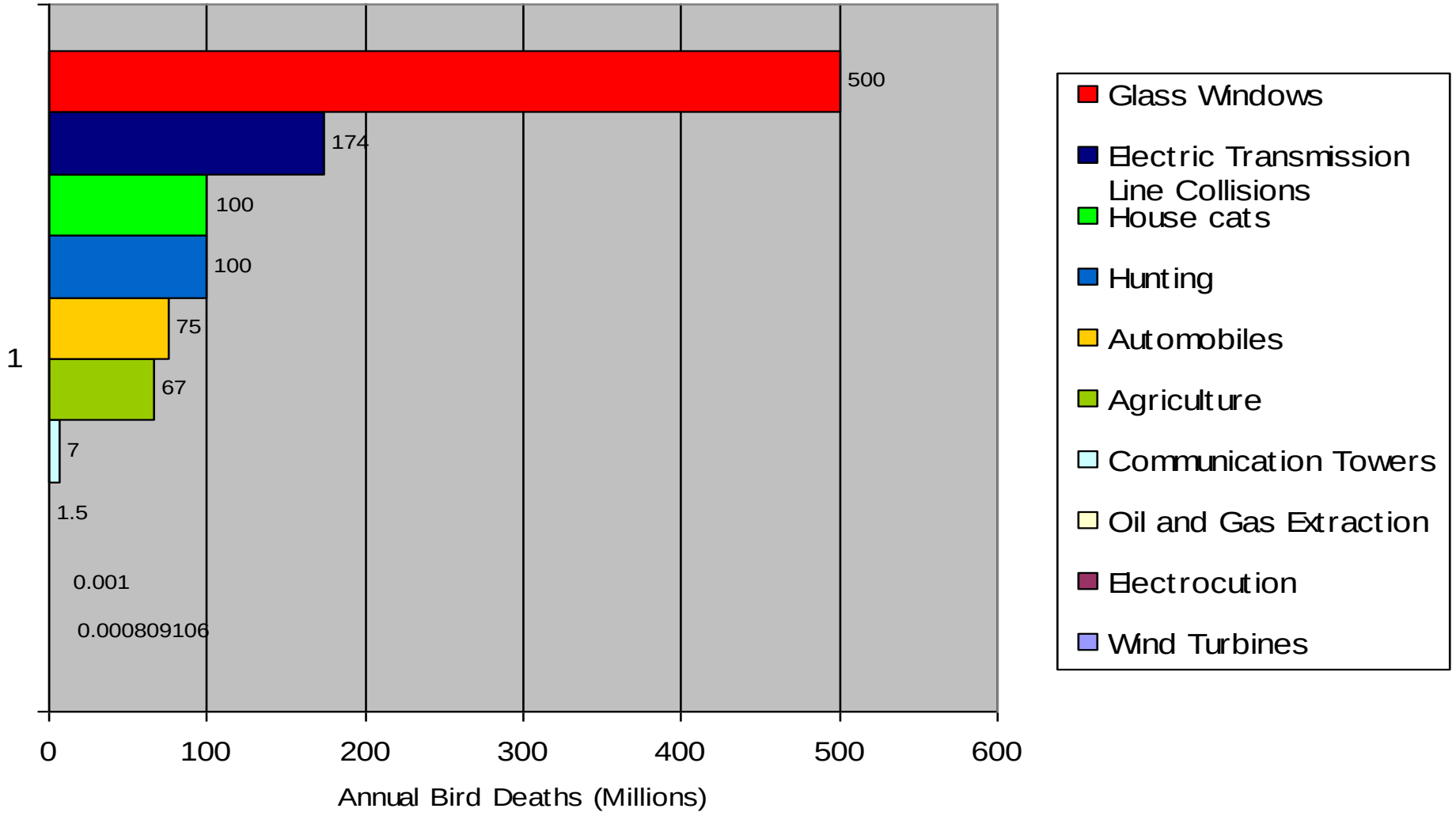
Disadvantages

- <u>Some concern over reported bird kills</u>
- Example: California's Altamont Pass wind farm was located in a major bird migration pathway→ death of several hundred birds (many raptors (birds of prey))

1980's California Wind Farm

Older Technology
+ Higher RPMs
+ Lower Elevations
+ Poorly Sited
= Bad News!

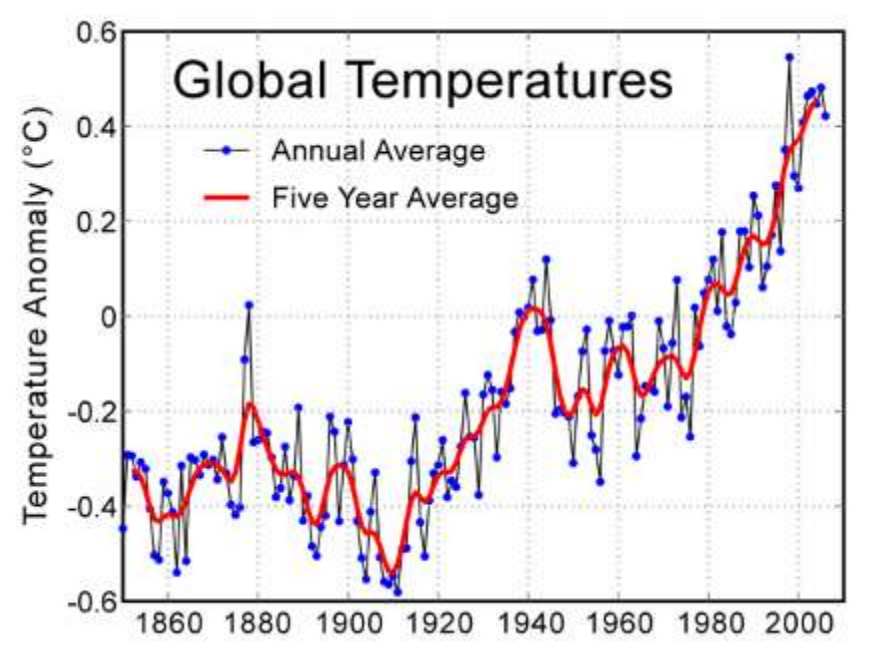
Avian Deaths Per Year



DIRTY ENERGY

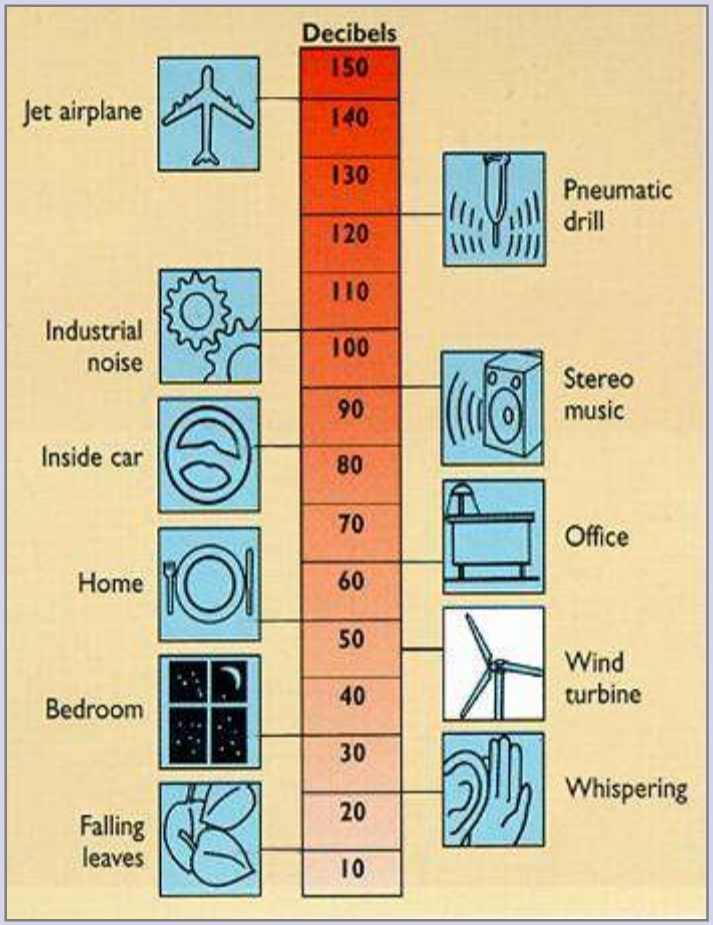
CLEAN ENERGY

- In the November-December Audubon Magazine, John Flicker, President of National Audubon Society, wrote a column stating that Audubon "strongly supports wind power as a clean alternative energy source," pointing to the link between global warming and the birds and other wildlife that scientist say it will kill.



Read Audobon's Position on Wind Power

Other disadvantages:
Noise Impacts of Wind Power



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

Go to Hull or Searsburg & listen!

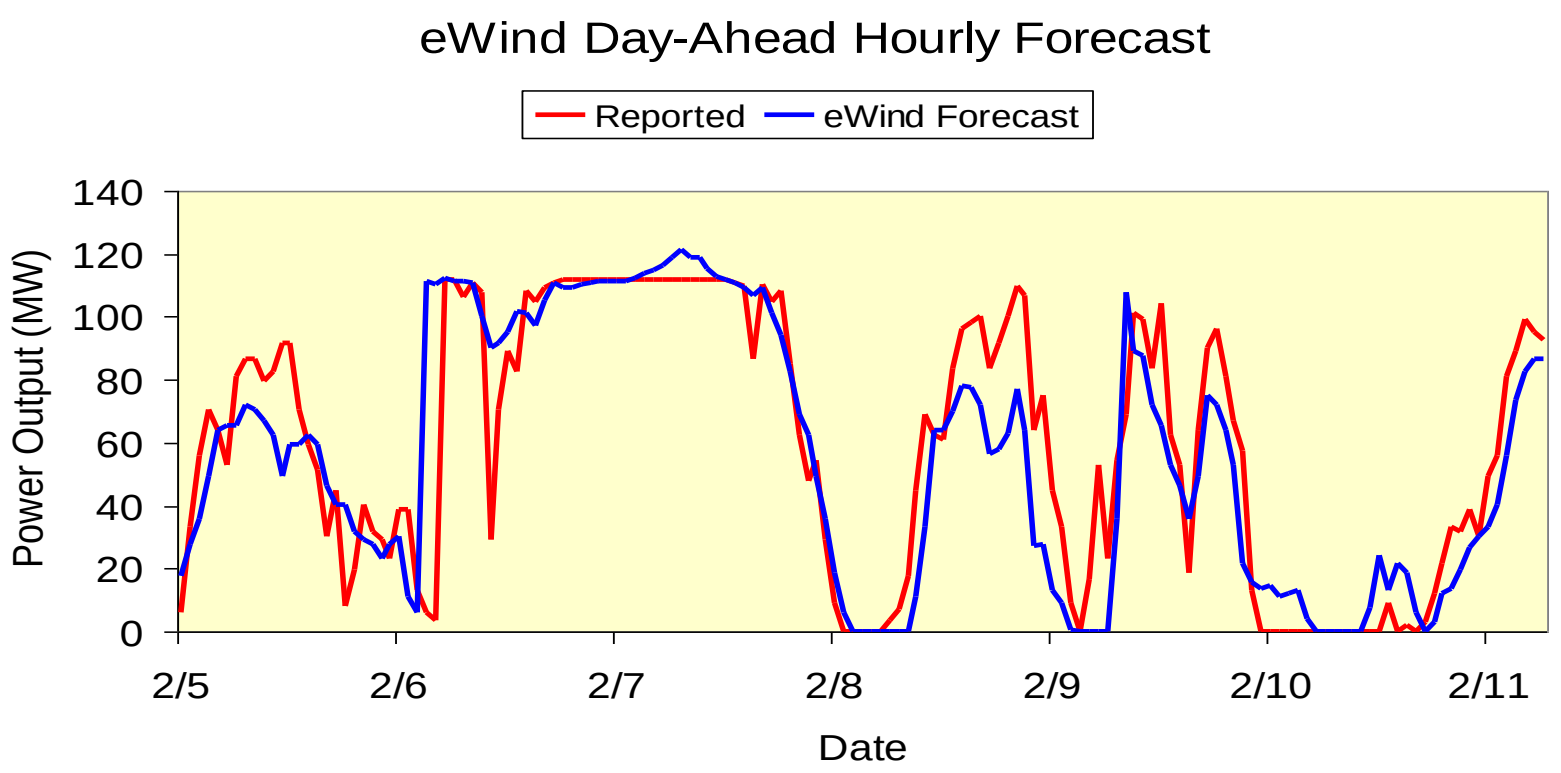
Note: Searsburg turbines are older & a bit louder than many modern turbines

http://www.youtube.com/watch?v=JD0v9_zV2uk

http://www.youtube.com/watch?v=YCEgRTYmrNQ&feature=fvw

Wind is sporadic → **Destabilization of the grid**

(Requires backup system)



wind engineers have teamed up with meteorologists to help improve the accuracy of predicting the windspeed

Compare and Contrast Articles

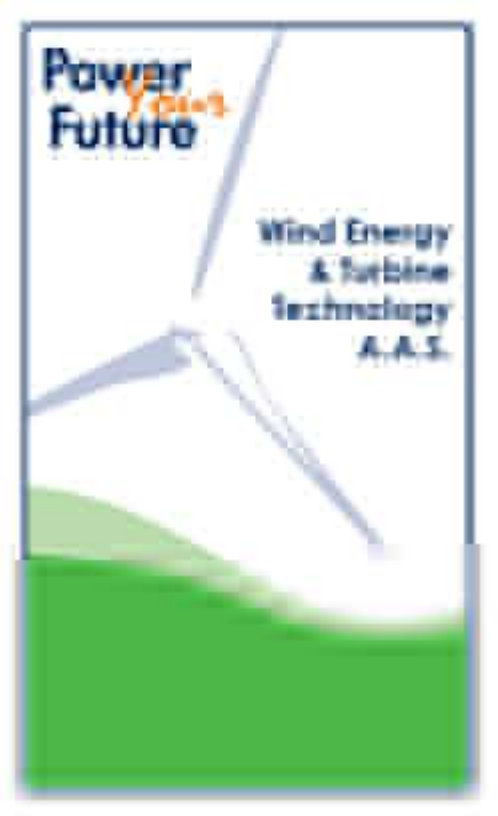
Impact of Wind and Solar on the Electric Grid

Best sites for wind

- Rural
- Not necessarily high winds but constant winds
  - islands,
  - mountain passes and plateaus,
  - coastal regions, and
  - grasslands

Clinton Community College

SUNY Plattsburgh



- Wind Enery and Turbine Technology Program
- For people with :

  - Mechanical aptitude
  - Physical ability to climb the tower (260'), work at that height, and in close quarters
  - Reasonable math skills
  - Desire to work outside
  - Interest in renewable energy technology

https://www.youtube.com/watch?v=J6GykrpzQ

https://www.youtube.com/watch?v=vfUhBKZR4sU

https://www.indeed.com/q-Wind-Technician-l-New-York-State-jobs.html

- **Salary Estimate**
- **Entry level**
- $30,000+ (17)
- $35,000+ (15)
- Experienced
- $40,000+ (12)
- $45,000+ (8)
- $55,000+ (5)


Questions???

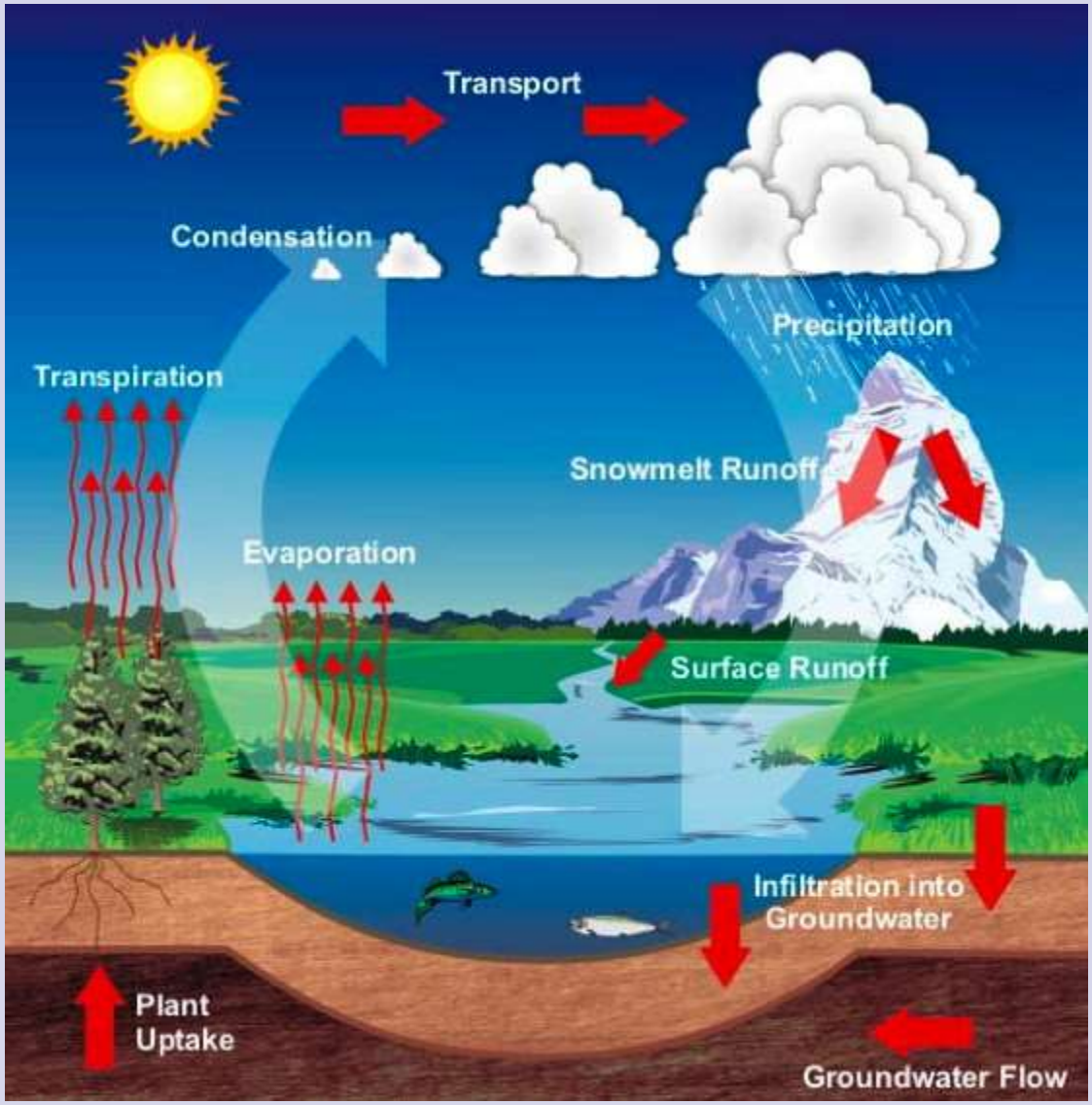
Hydroelectric Power

Watch hydropower video clips → notes

Hydropower

- Hydro = indirect form of solar energy because

- <u>Sun's energy → hydrologic cycle</u>



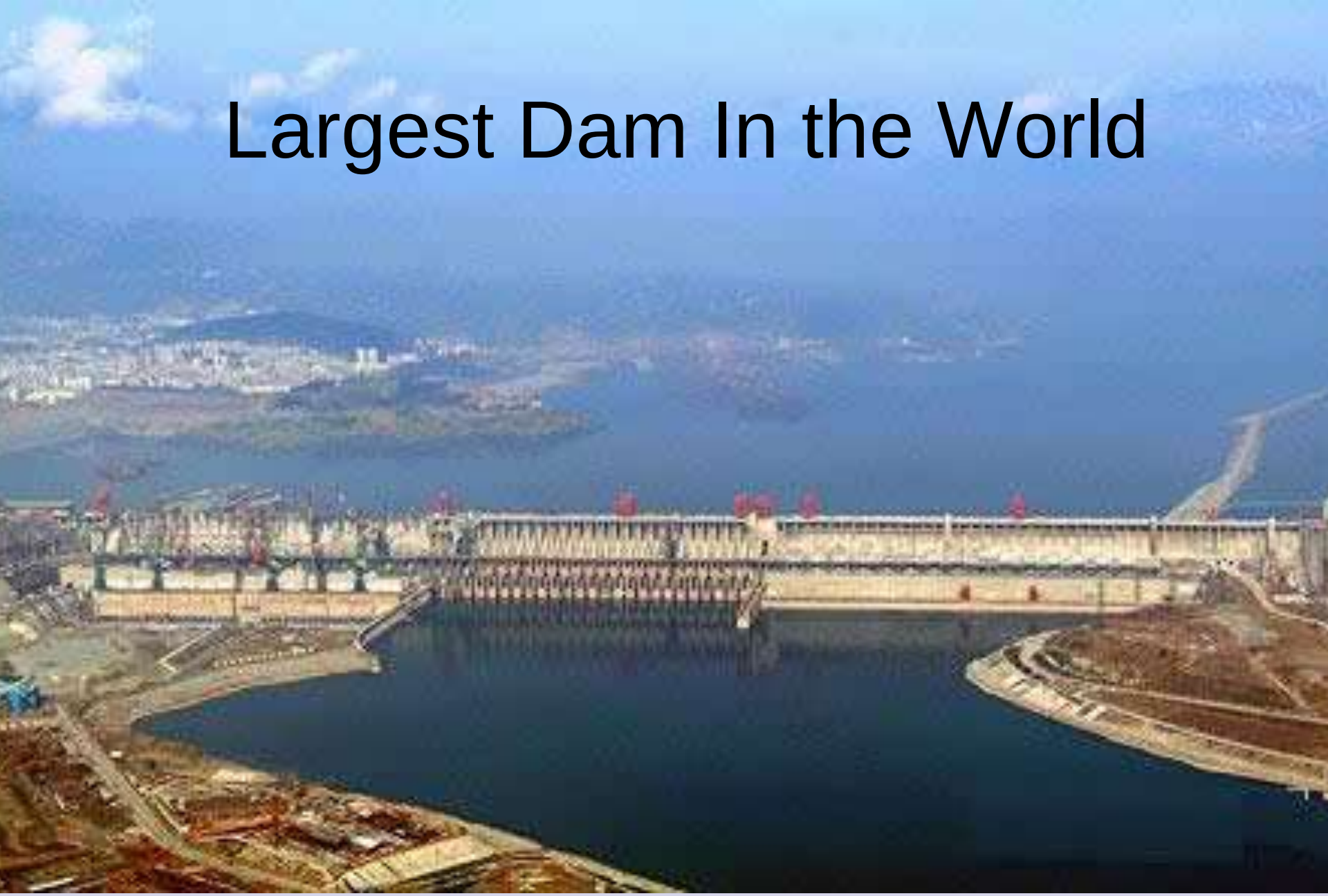
Advantages of Hydro

- Power without wastes or air pollution
- Downstream flood control
- Recreation/navigation (lake vs stream)
- Water supply
- Economics (construction, facility operating jobs)

Disadvantages of Hydro

- Filling in of the reservoir can cause:
- Seismic disturbances
- Involuntary displacement of people
- Habitat destruction
- In arid regions building a reservoir may increase evaporation rates
- Sediment can build up behind the dam *(read Dam Breech Spills Sediment)*

Largest Dam In the World



3 Gorges Dam in China

Impacts of constructing the 3 Gorges Dam

- 22,500 MW
- Displaced more than 1.2 million people
- 13 cities
- 140 towns
- 1,350 villages
- World heritage sites

Disadvantages of Hydro-Dams

- Building a dam changes the natural flow of a river disrupting ecosystems
  - Impact native species
  - Alter aquatic env.
  - Dams → habitat fragmentation
  - (Lotic → lentic) (temp changes)

Running water flows down

- Standing water – LENTIC systems

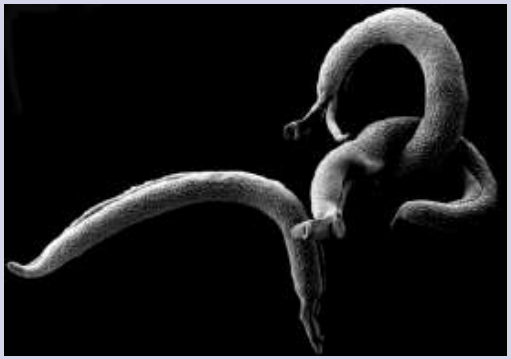
- Flowing water – LOTIC systems

Decreased river based recreation (ex: rafting, salmon fishing…)

- Dams interfere fish migration (fish ladders help)

Dams → increase in water borne disease

- Reservoirs → breeding grounds for **cholera, typhoid fever, and schistosomiasis…**



Among parasitic diseases, schistosomiasis = second behind malaria in global importance. Infects more than 200 million people in 74 countries.

Schistosomiasis worms, parasite in water.

www.med.sc.edu:85/parasitology/ schis7.jpg

Dams → decrease in water downstream

- Read Mideast Water Wars article
- What is the best way to prevent the tragedy of the commons????
- Legislation

Legislation

- The Wild and Scenic Rivers Act (1968) prevents → new dams on certain rivers,
- # of rivers protected < 1% of the nations total river systems.
  - (ex. Missouri and Delaware Rivers are protected)

www.chattoogariver.org/Articles/ 2002S/Images/rob.jpg

Wild and Scenic Rivers

- New York has approximately 51,790 miles of river
- Only 73.4 miles are designated as wild & scenic—
- a bit more than 1/10th of 1% of the state's river miles.

APES FR 2002 Colorado River

a) Describe and discuss 2 environmental problems with water diversion (4pts)

APES FR 2002 Colorado River

b) If there is a shortage of water, choices will have to be made as to whether water should be diverted to urban, agricultural or natural ecosystems. Make an argument for diverting water for urban consumption and an argument for permitting the flow of water to natural areas

- (4pts) one for each argument and 1 for supporting each argument

APES FR 2002 Colorado River

c) Identify another example of a **large scale** water diversion project. Discuss two environmental problems that have resulted or might result from this project

- (3pts) one for identifying a project, one for each environmental problem resulting from the project

James Bay Hydro Quebec

- 1970 Project includes 600dams and dikes and blocks 19 different rivers

Problems associated with James Bay Hydro Project

- 10,000 caribou were drowned in 1984 while migrating,
- coastal marshes and estuaries were degraded →
- decline of eel grass (a keystone species), and salmon

Aswan Dam (Nile River)

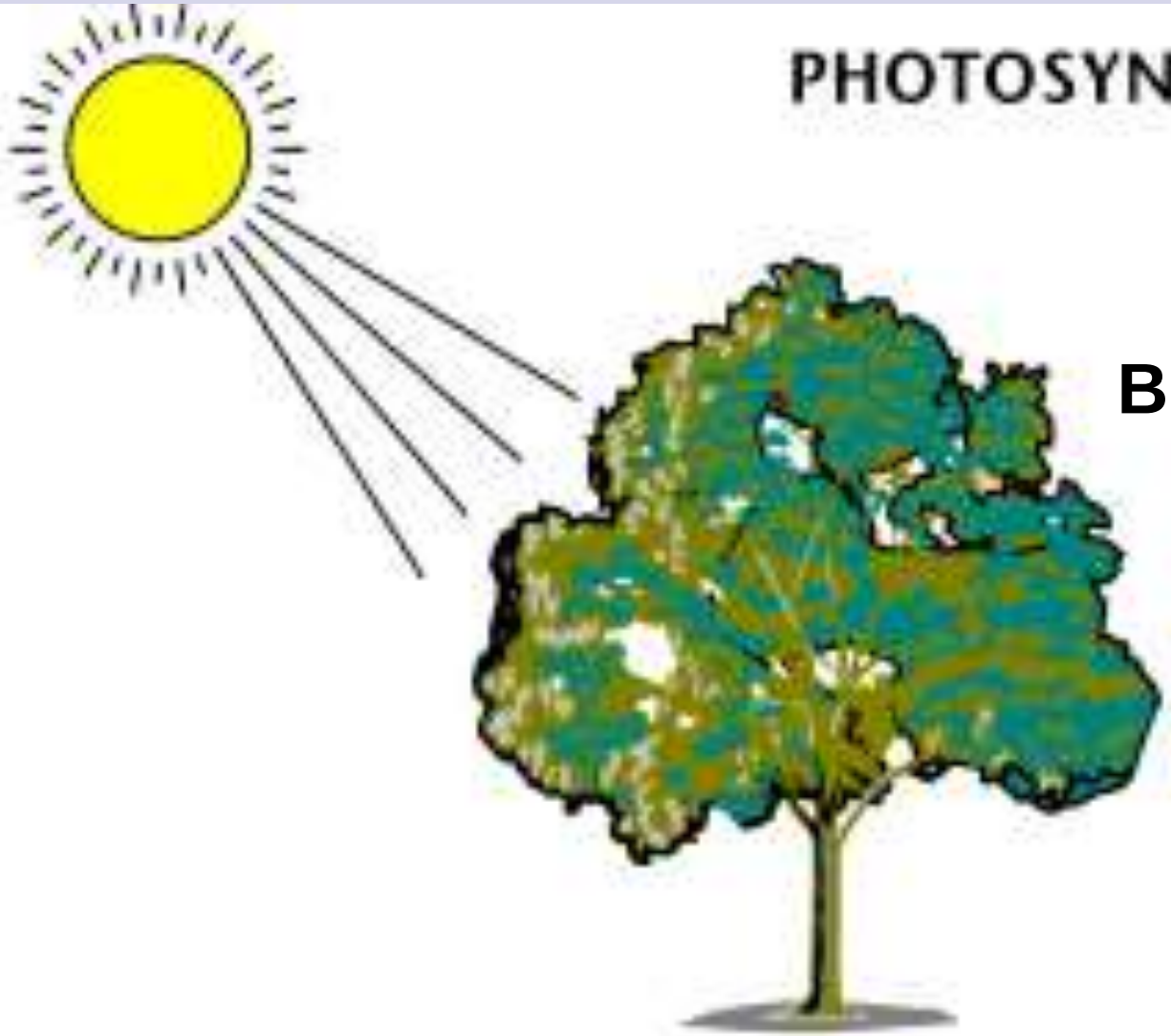
- Annual floods used to deposit silt and fertilizers naturally
- This no longer occurs → decreased primary productivity → decreased diversity and decreased stability of riparian zone ecosystems

3 Gorges Dam / Yangtze River, China (largest in world)

- Largest dam in world → 22,500 MW

Part 4: Biomass and Biofuels

PHOTOSYNTHESIS



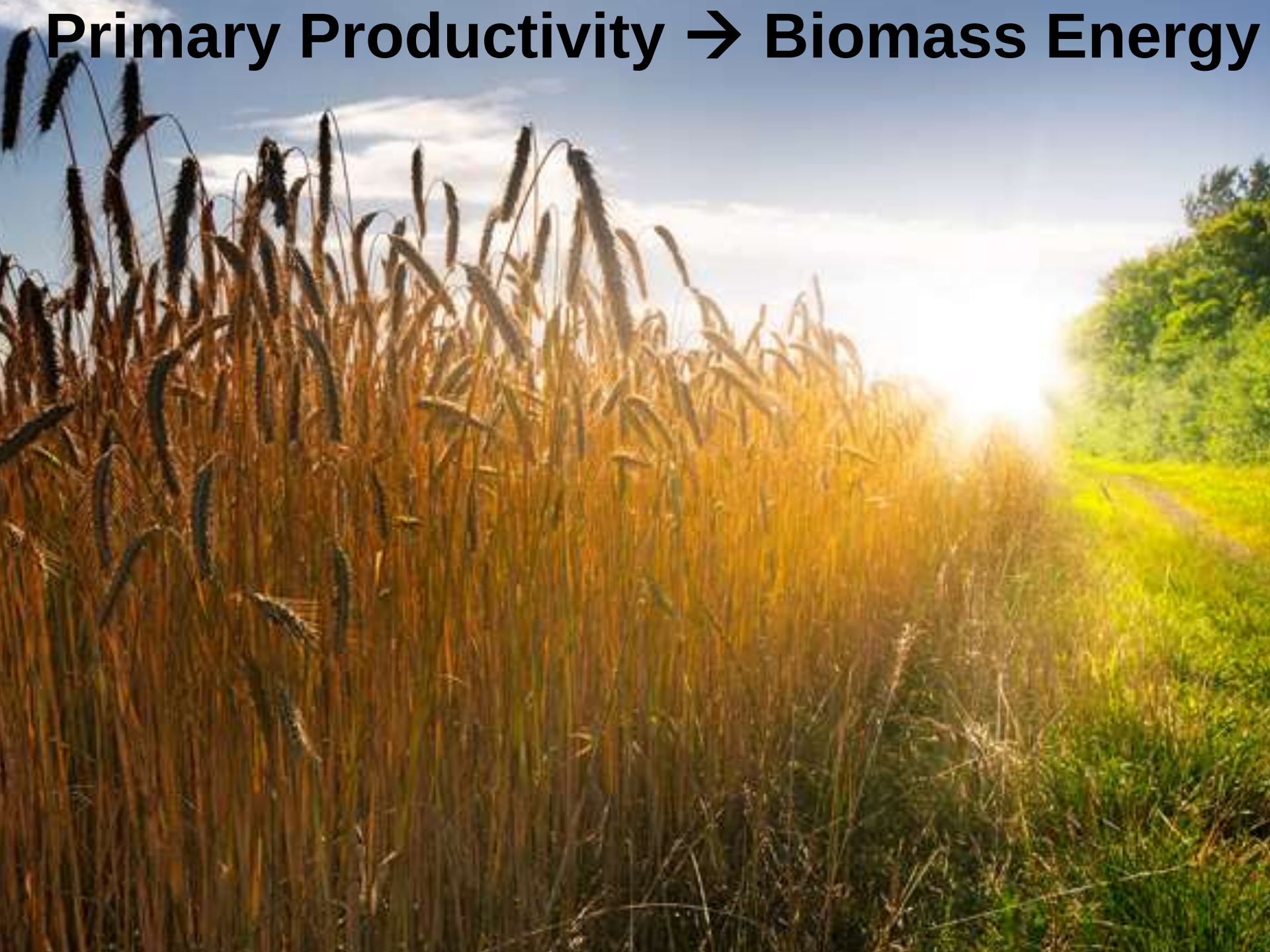
Biomass

In the process of photosynthesis, plants convert radiant energy from the sun into chemical energy in the form of glucose - or sugar.

water + carbon dioxide + sunlight → glucose + oxygen

$6\ H_2O + 6\ CO_2 + \text{radiant energy} \rightarrow C_6H_{12}O_6 + 6\ O_2$

Primary Productivity → Biomass Energy



Biomass (a form of indirect solar)

- Biomass energy = break chemical bonds that hold living organic material together → energy

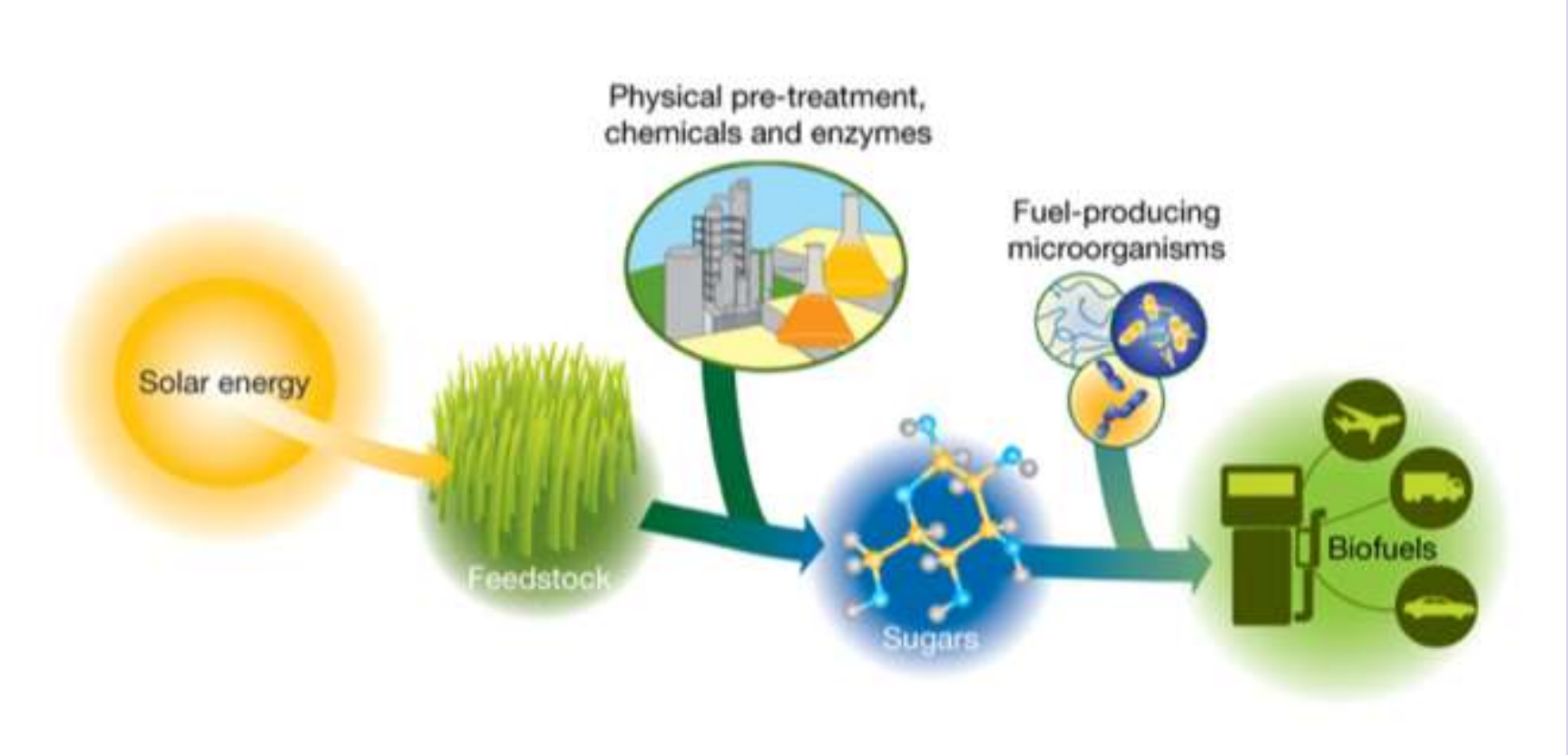
Examples:

- wood,
- fast growing plant and algal crops,
- crop wastes,
- animal dung,
- food wastes,
- Peat
- Charcoal

www.eia.doe.gov/kids/renewable/ images/photosynthesis1.gif

Biofuels come from biomass
Examples of biofuels:

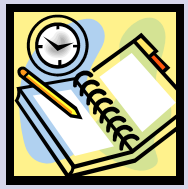
- Biomass
- Bioethanol
- Biodiesel
- Biogas



Biofuels → Transportation or Electricity

http://www.china.org.cn/business/2012-05/25/content_25472345.htm

Biomass = living matter



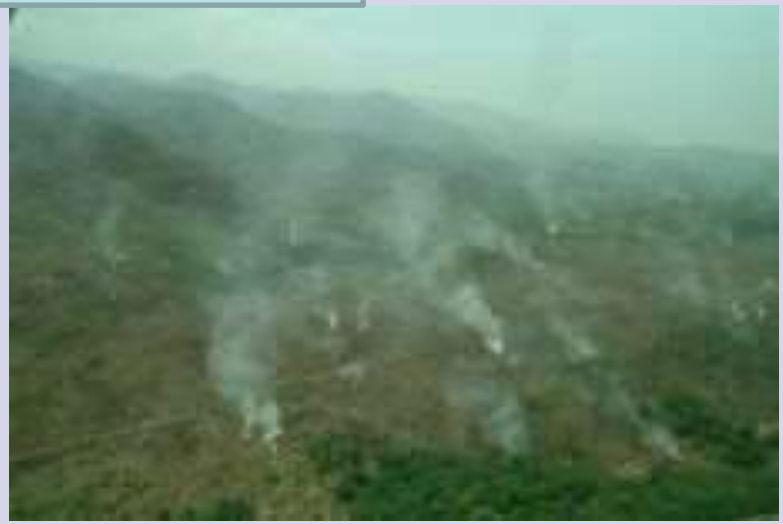
- Burned → heat, electricity
- or converted to biofuels

Examples of Biomass

- Charcoal = wood that has been partially burned
- Wood and charcoal are main sources of fuel for cooking in most African countries
  → 68% of energy consumption in Kenya, 94% in Ethiopia, 70% in Zambia and 92% in Uganda.
- Current bans on charcoal trade have failed to reduce deforestation
- Little enforcement → illegal trade widely used
- Tree planting incentives and alternatives are needed to enforce charcoal bans

Charcoal trade →

- #1 cause of high extinction rates
- Ex: Mountain gorillas of the Congo
- Share home with millions of refugees of civil war who rely on charcoal for cooking and heating



Peat = partially decayed plant matter from bogs and swamps

- Over 90% of peat lands are in the temperate and cold belt in the Northern Hemisphere.
- Peat used to heat homes
- Ecosystem services of peat bogs
  - →biogeochemical cycling
  - Sequester carbon
  - hydrological dynamics and water quality,
  - and provide habitats

- Due to slow regeneration rates peat bogs are often considered nonrenewable

- But when you harvest sphagnum it does re-grow and research aims at increasing growth rates

Bioenergy: An Overview

Introduction to

Biogas

Bioethanol &

Biodiesel

Biogas

- Anaerobic digestion of Biomass → renewable biogas
- Mixture of gases (60-70% methane some H_2S and H_2O)
  - Burned as a gas (→ heat, electricity, or transportation fuel (CNG vehicles run on gas)
  - Converted to liquid fuels - ex: methanol and ethanol → mixed with gasoline → gasohol (cleaner version of gas)

Feedstocks for anaerobic digesters

- Food Processing wastes
- Municipal food wastes
- Sewage
- Manure
- Landfills

Cow power at Blue Spruce Farm (Vermont)

- 1300 cows
- 30 mil lbs of milk
- 1.6 mil kWh of electricity

1300 cows → Lot of poop = environmental disaster

- Nitrogen and phosporus
- Contaminates water supplies
- Eutrophication
- Pathogens

List the environmental benefits of building digesters

- Recycles organic materials
- Decrease wastes
- Produces renewable energy
- Decreases greenhouse gas emissions from landfills

Solution

- Underground anaerobic digester
- Takes 21 days for feces to circulate through
- Anaerobic digestion → biogas (mix)
- Generators burn the dirty gas → electricity → grid

Solids → compost (can be used for bedding or gardens)

Excess heat from generators

- Used to heat water for the farm
- Used to heat a greenhouse
  - Experimenting with using heat to grow algae → biodiesel for farm equipment

Microalgae → 15,000 oil yield gallons per acre
corn → 20 gallons/acre.

Co-generation

- One fuel → heat and power
- More efficient
- Ex: SUNY at Stonybrook
  - Natural gas → electricity
  - Waste heat → used for heating and cooling systems within the university

http://www.eserc.stonybrook.edu/brentwood/1998/cogeneration/home.html

District Heating in Finland

- District heating warms 44% of the buildings in Finland,
- 72% of district heat was produced by CHP (cogeneration electrical plant) in 1993.
- Other industries produce heat that is fed into the system (computer networks, sewage treatment plants, paper industry…)

Advantages of biogas

- Burns cleaner than fossil fuels
- Decreases solid wastes

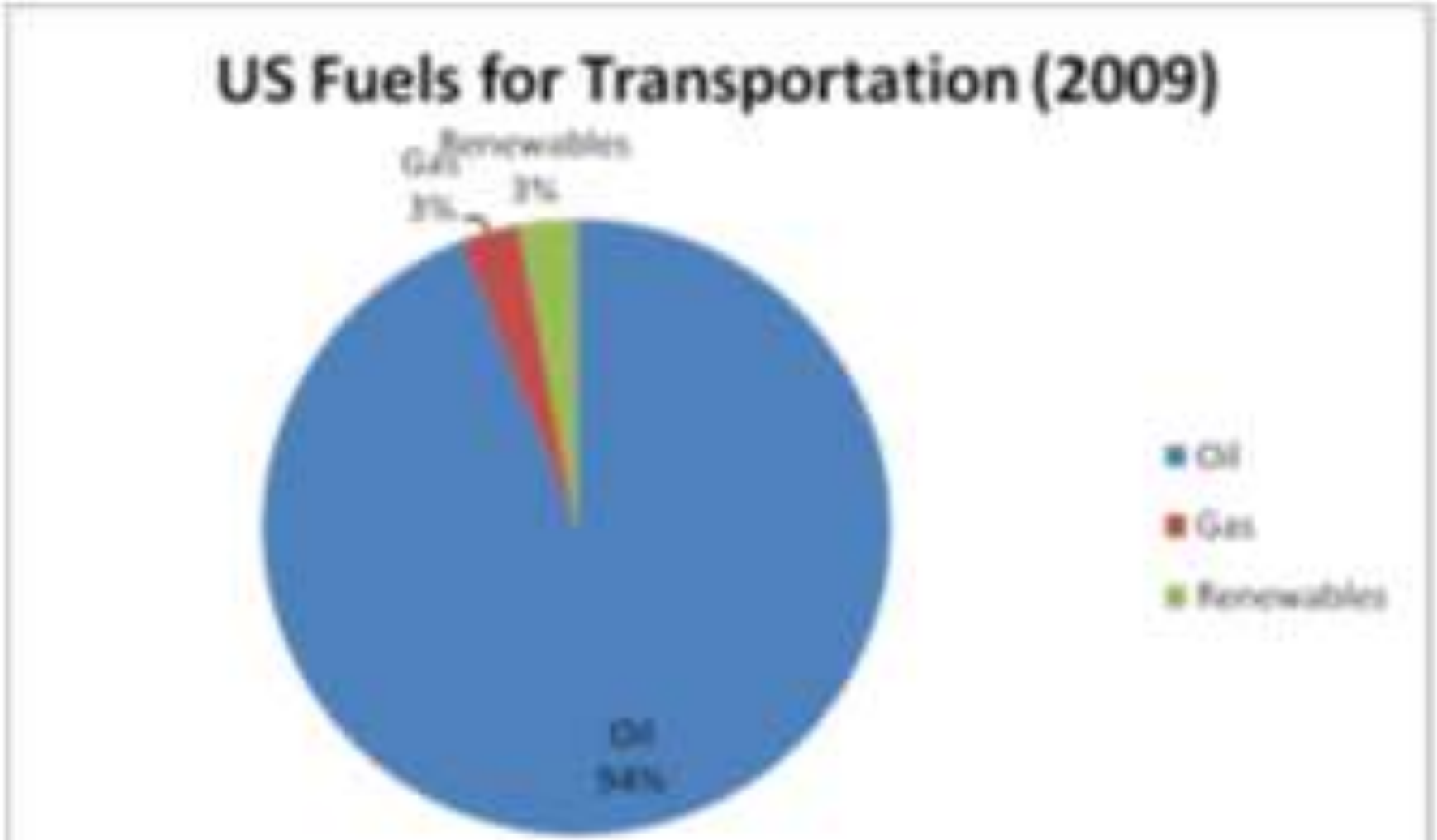
Disadvantages of biogas

- Overall efficiency is very low
- 30-40% of the energy in the starting material is lost in the conversion (because bacteria use energy)
- Both CO_2 and CH_4 are greenhouse gases
- Biogas is a mixture of many gases

Biofuels: Bioethanol & Biodiesel

- Bioethanol
  - From starch / sugar
  - From lignocellulosics
  - Sustainability depends on feedstocks and processing
- Biodiesel
  - From seed crops, microalgae and from wastes
  - Sustainability depends on feedstocks and processing

Most of our oil consumed → transportation



So far, biomass is the only renewable to generate liquid fuels!

Sustainable Options for Transportation Fuels

1. Build More Efficient Cars

- How can engines and vehicles be improved
  - Decrease friction
  - Decrease weight

Renewable options for transportation fuels

2) Hybrid and Electric vehicles http://www.pbs.org/wgbh/nova/education/video/ht/q-3507-car-04-300.html

- Definition of Hybrid =
- combination electric and gas =
- more efficient, why?

Hybrids and Electrics

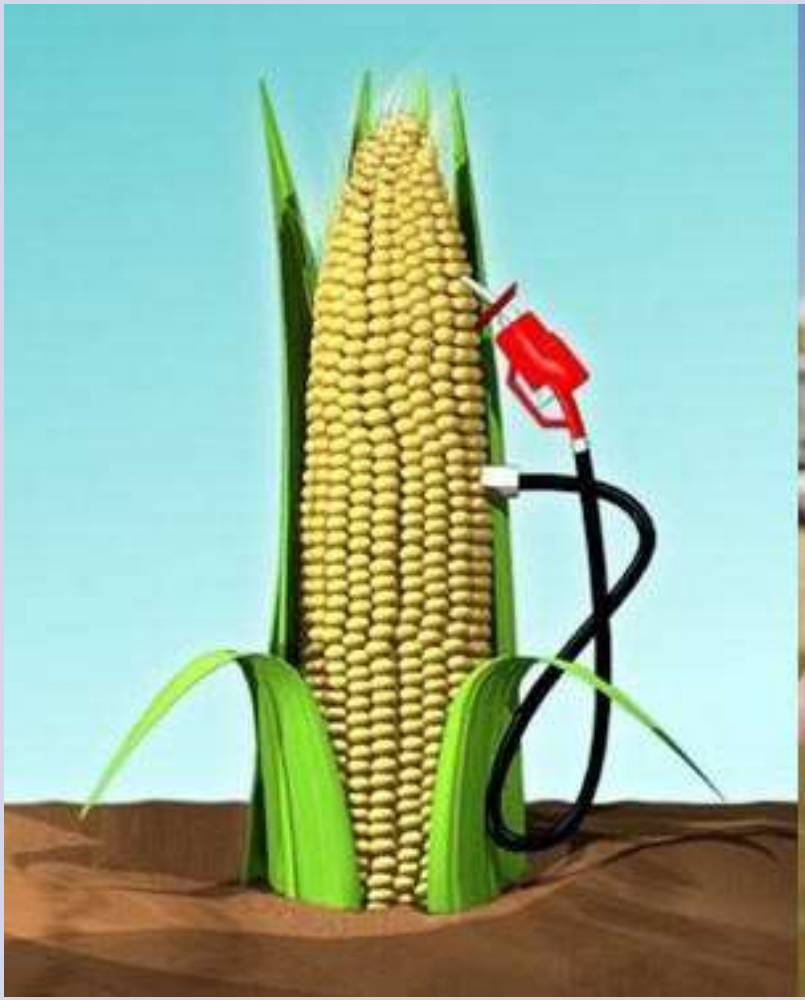
- Why are hybrids more efficient?
  - Only use gas when battery power is not enough
  - Charge battery when breaking
- Pros for Electric
  - No air pollution from tailpipe
  - Decreases use of foreign oil
- Cons for Electric
  - Need for more powerplants that might pollute
  - Takes long time to charge
  - Batteries are expensive and heavy

3) Hydrogen can be used in cars or for electricity. H_2 Fuel can come from water, oil, gas, or biomass

Hydrogen fuel cell vehicles

Pros	Cons

4) Fermentation of Biomass → Bioethanol can be added to gasoline engines



Note: ethanol = drinkable

Problem: methanol often formed in the reaction as well

→ lead to blindness and death

Big problem with moonshine production during prohibition

Bioethanol can be added to gasoline engines

Fermentation → Alcohols (ex: ethanol)

Examples:

We can ferment Starches and Sugars

We can ferment Cellulosics

https://www.youtube.com/watch?v=a0g3MB8HMdA&t=352s

Cellulosics

- Advantages
  - Can grow where corn can't
  - Can use waste products from food processing plants
- Disadvantages
  - Have to break down cellulose using enzymes = extra step = less efficient

Biofuels: The Big Picture

- 2007 Energy Independence and Security Act (EISA) → renewable fuel standard
- Increased minimum annual renewable fuels for US transportation
- Increased advanced biofuel requirements

1st Generation Feedstocks

Sugar Beet

Corn Grain

Sugar Cane

Bioethanol from Starch & Sugar

A mature technology that is currently in use (E10, E85, E100)

Corn

Sugar beets

Cane Sugar

Fermentation

* Microorganisms (bacteria, yeast, algae)

Ethanol

2nd Generation Feedstocks

Hybrid Poplar

Hybrid Willow

Switchgrass

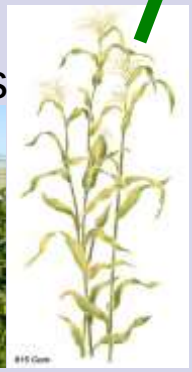
Miscanthus

Corn Stalks

Bioethanol from cellulosics (2 steps)

Hybrid Poplar

Corn Stalks



Cellulose hydrolysis

Enzymes breakdown cellulose

Fermentation

* Microorganisms (bacteria, yeast, algae)

Ethanol

Ethanol fuels

- Alternative to MTBE (methyl tertiary butyl ether = gas additive)
- leaked into water supplies → bad tasting water)
- → less CO and ozone
- Can reduce total CO_2 emissions
  - comes from crops that absorb CO_2
- Decreases use of fossil fuels

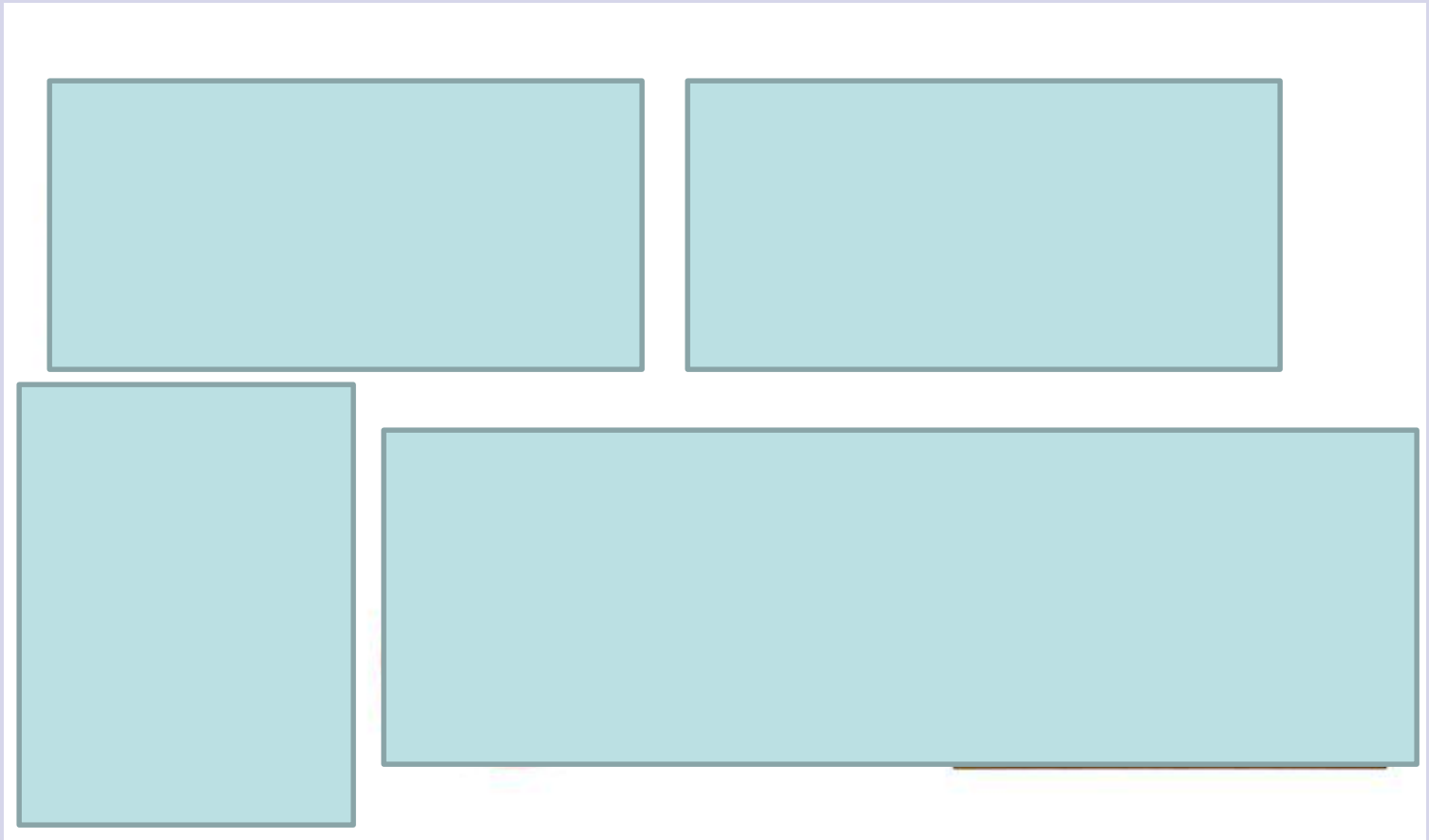
Disadvantages

- Land and water for fuel vs food
- 10% Rule → decreased efficiency (bacteria use up most of the energy originally stored in plants)

5) Biodiesel

Biodiesel can go into diesel cars / buses

- Need oil (from beans or seeds) → biodiesel
- Can use waste oil from restaurants → biodiesel



Pros and cons of biodiesel

- Advantage
  - More efficient → more miles / gal than gasoline
- Disadvantage
  - More polluting → increased air pollution

Biomass sources

- Wood and wood chips → heat
- Sugars → ethanol for gasoline vehicles
- Fats and oils → biodiesel for diesel vehicles

Summary notes

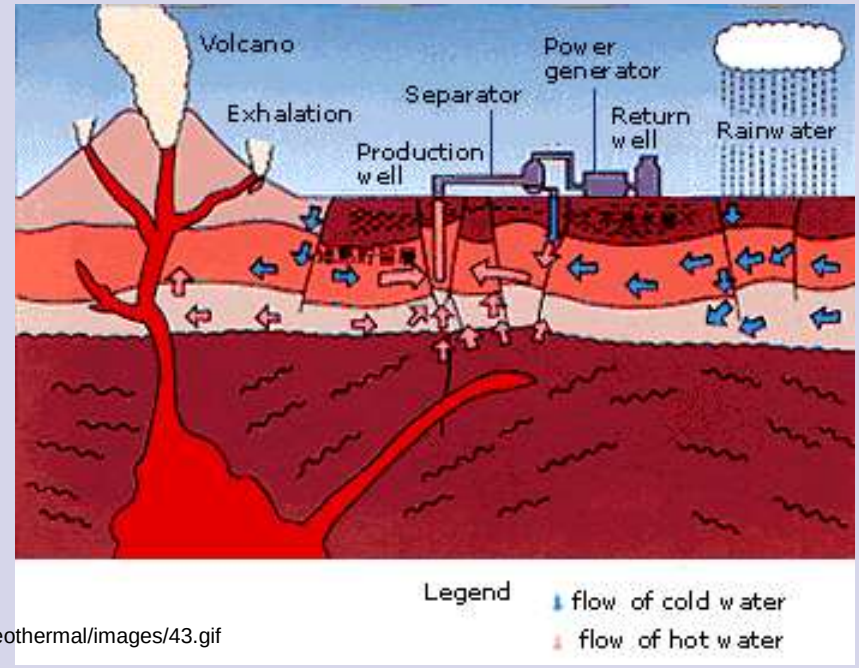
- Direct solar
  - Pv cells
  - Passive solar
  - Solar thermal electric
- Indirect solar
  - Hydro
  - Wind
  - biomass

Non solar energy sources

- Tidal
- Geothermal

Geothermal energy sources

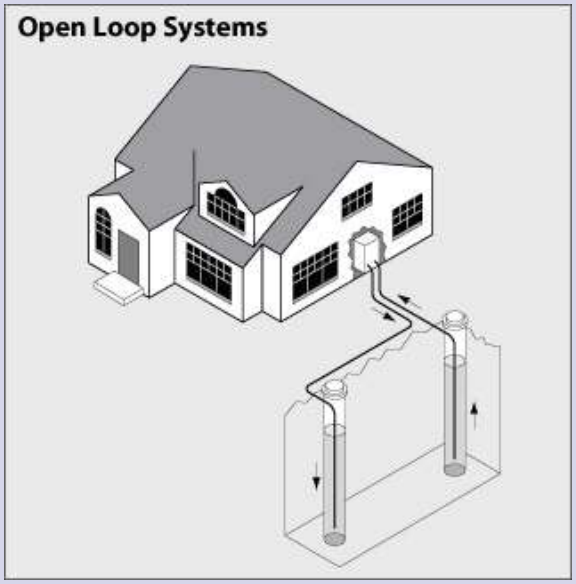
- Earth's interior → heat as magma rises toward the surface
- Magma heats nearby rocks and groundwater in crust (up to 700ºF) → <u>geothermal reservoirs</u>



http://www.enecho.meti.go.jp/english/energy/geothermal/images/43.gif

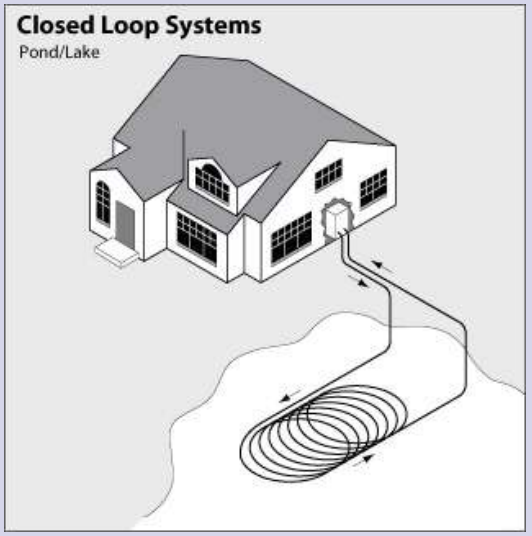
Uses of geothermal

- **Heating and cooling**



Closed units = loops of antifreeze run through underground coils picking up geothermal heat

Open loops = well water filtered through geothermal unit then returned to groundwater reservoir *(more efficient in NE and no chance of antifreeze leak but requires more maintenance)*



http://www.freedomenergysystems.com/Geothermal/HowItWorks.html

Geothermal Heat Pumps

- Rely on the fact that earth's crust remains at a constant temp (48-58ºF)
- Fluid warmed by earth is pumped through a heat exchanger and compressor circulated through building then returned
- Can be used to heat and cool homes economically
- Available worldwide

Practical for the Adirondacks?

- Frost = 4-6 feet → cooling effect → 15ft
- To avoid freezing only vertical loops that are at least 15ft below the surface are efficient here
- **80% of their energy dollars → heating and cooling**
  - Expensive to install but with geothermal 70 – 75% of energy source is free = no fuel cost
- For more information contact:

  Smart-Energy
  Queensbury, NY 12804
  Phone: (518) 744-8220

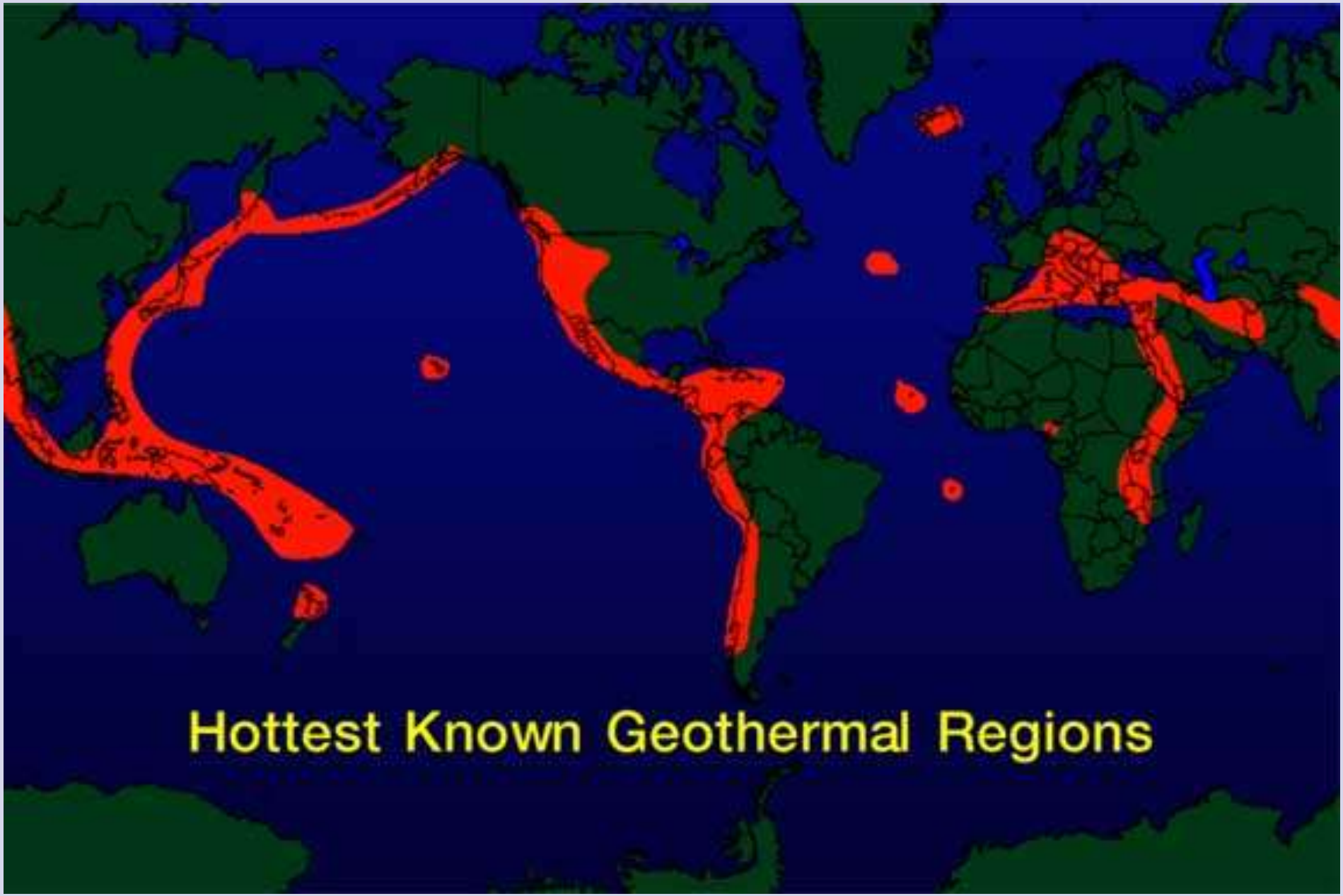
Advantages =

- Requires minimal land
- Renewable and Reliable
- Produces no air pollution

Thermal energy at plate boundaries and hot spots → electricity

- Where this occurs

- Subduction zones (crusts collide)
- Spreading centers (plates pull apart)
- Transform boundaries
- Hot spots (volcanoes and hot springs)


Hottest Known Geothermal Regions

What uses most of the energy in a home

- Heating and cooling

Heating systems need:

1. Fuel source –
   - Nonrenewable: Coal, oil, natural gas
   - Renewable: biomass,
   - Most sustainable: geothermal, passive solar
2. Heat conversion unit - furnace, boiler, woodstove, or geothermal unit

   Note: geothermal gets 70-75% of its energy from the earth and 25-30% from electrical heat exchangers
3. Distribution = steam, hot water, forced air, radiant floor or fans

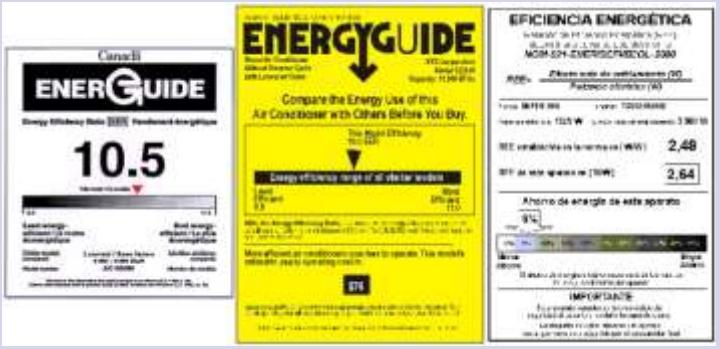
What decreases efficiency

- 2nd law of thermodynamics

National Appliance Energy Conservation Act

- 1990
- DOE sets strict efficiency standards for appliances

Energy efficiency



- Efficient appliances → reduce amt of energy lost during energy conversions
- EER (energy efficiency rating)→ operating costs

Ex: front loading washing machines (40% less water and 60% less energy

- Energy Star Program = government program → identifies products that are significantly more efficient than standard models
- Combination heating/hot water systems = more efficient

Efficiency continued

- Compact fluorescent bulbs = last longer and much more efficient however contain trace amounts of Hg
- incandescent bulbs = only 5% efficient (95%→ heat not light)
- LED lighting = more efficient

Energy Conservation

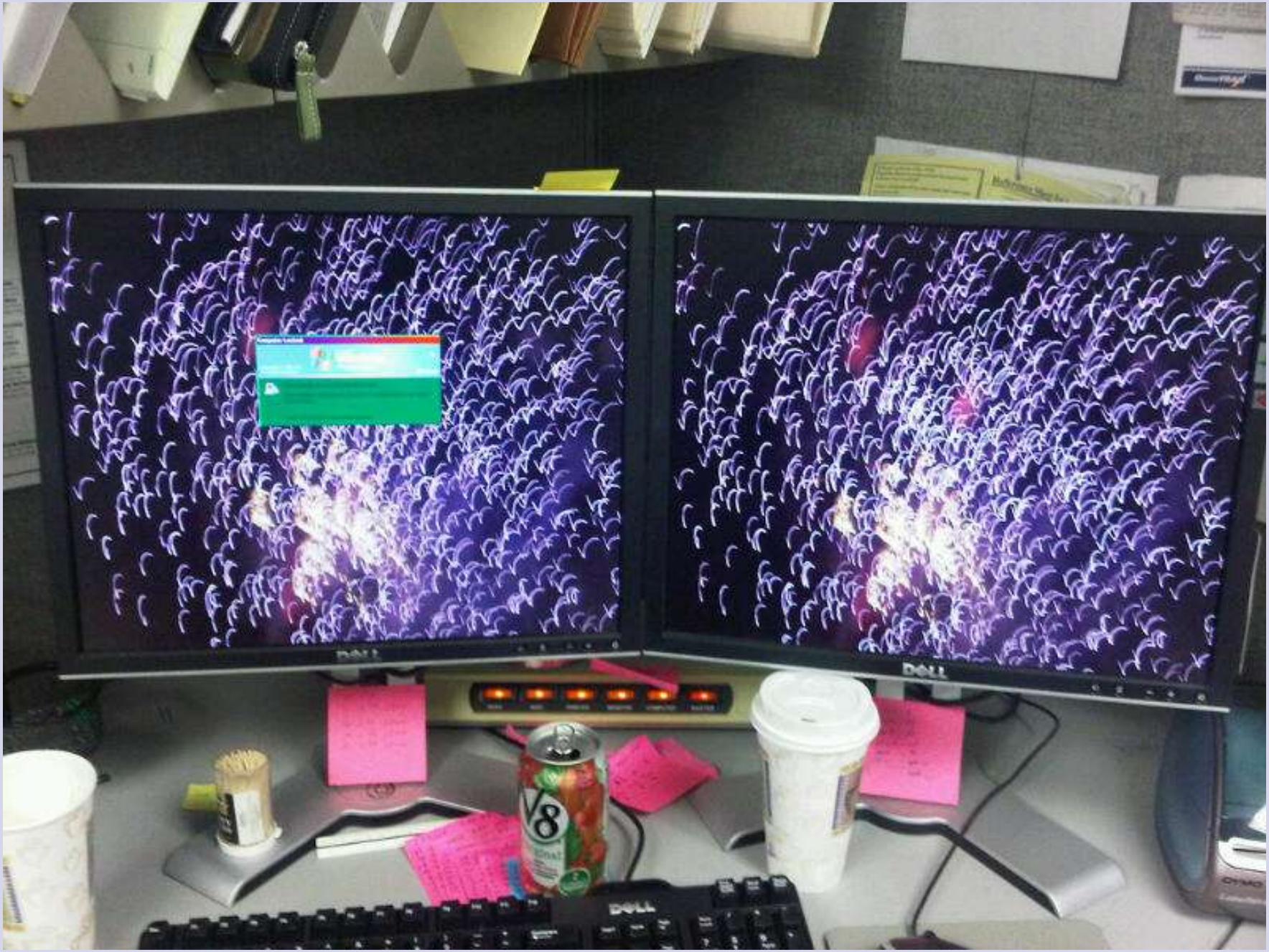
- Weatherization programs offer low income families help in permanently reducing energy bills by weatherizing
- Low flow shower heads cut down on hot water consumption
- Recycling can decrease energy consumption
  - Bauxite → Al (requires 20x's more energy than recycling)
  - (recycling Al → 95% less air pollution Iron ore → steel
  - Recycled steel uses 33% less energy

Decrease Phantom Loads (appliances that stay on even when you think they are off)


The Islands
The 6th Day
Enemy of the State


Haier


ADVERTENCIA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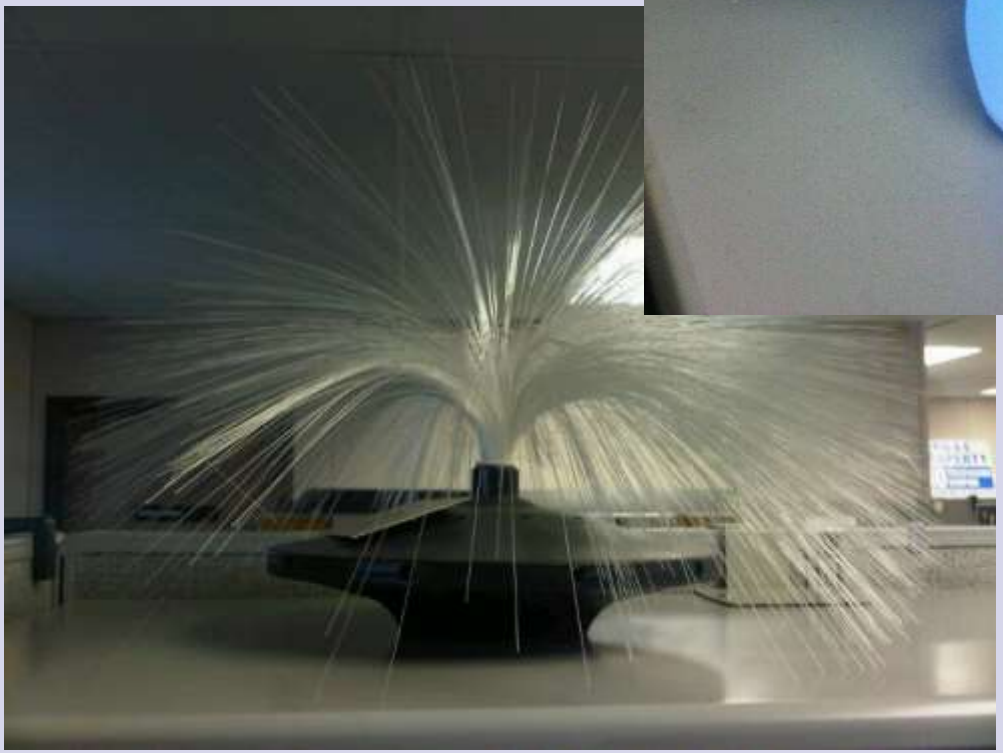

How to Reduce Phantom Loads to Lower Your Electric Bill

- Unplug Electronic Device
- Use Power Steps
  - Smart Strip Surge Protectors
- Use Sleep Mode
- Choose to purchase “Energy Star” appliances