Renewable Energy Resources

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•To cover the basics of renewable energy for NRCS personnel.

US Energy Usage by Source

Renewables

BIOMASS — 3.5%
renewable
Heating, electricity, transportation

HYDROPOWER — 2.9%
renewable
Electricity

GEOTHERMAL — .3%
renewable
Heating, electricity

WIND — .2%
renewable
Electricity

SOLAR & OTHER — .1%
renewable
Light, heating, electricity

Nonrenewables

PETROLEUM — 38.1%
nonrenewable
Transportation, manufacturing

NATURAL GAS — 22.9%
nonrenewable
Heating, manufacturing, electricity

COAL — 23.2%
nonrenewable
Electricity, manufacturing

URANIUM — 8.1%
nonrenewable
Electricity

PROPANE — 1.7%
nonrenewable
Manufacturing, heating

Source: DOE, Energy Information Administration

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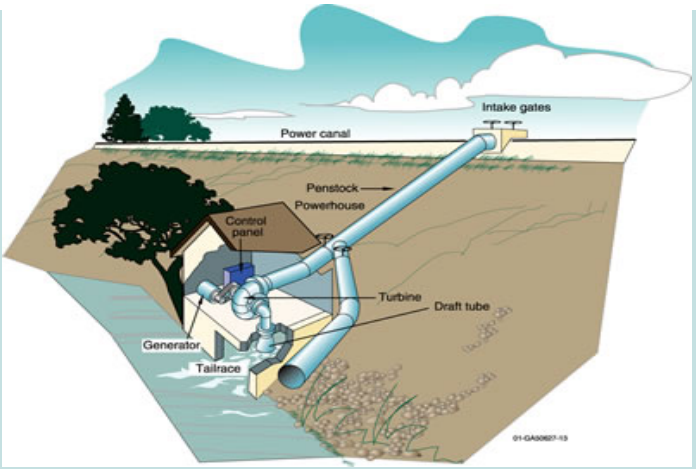
Small Hydro Turbines



Courtesy: U.S. Department of Energy

http://www1.eere.energy.gov/windandhydro/hydro_turbine_types.html

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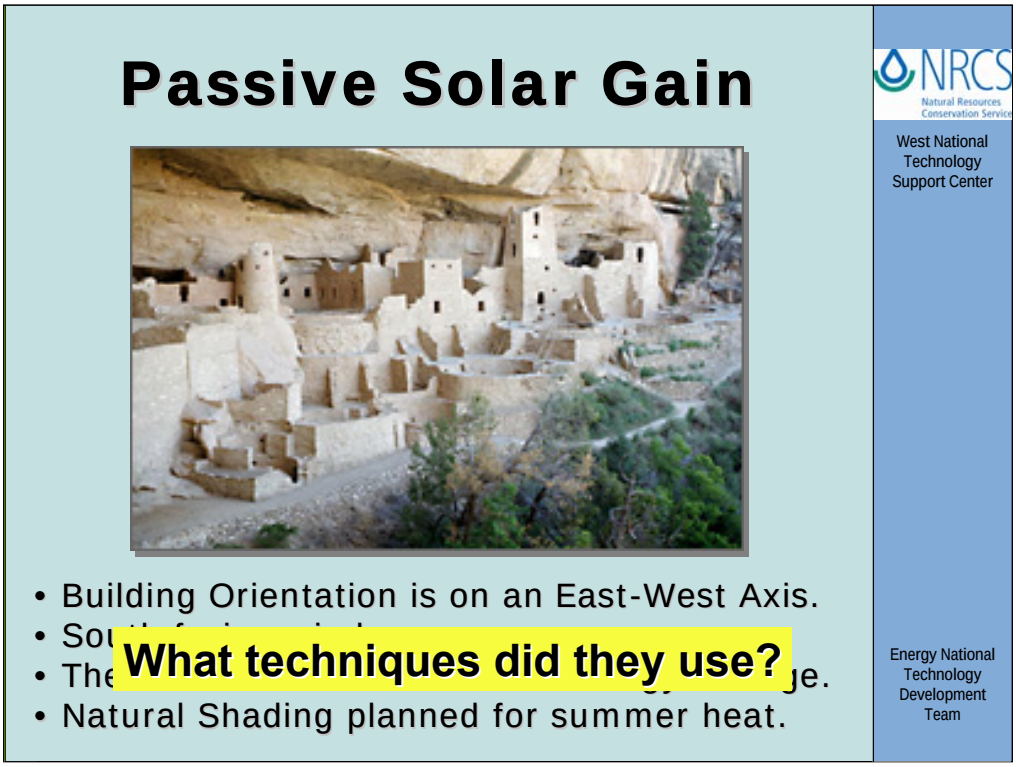
Considered a renewable resource, click on link if time permits. Most sites in the U. S. are used or not eligible for permitting.

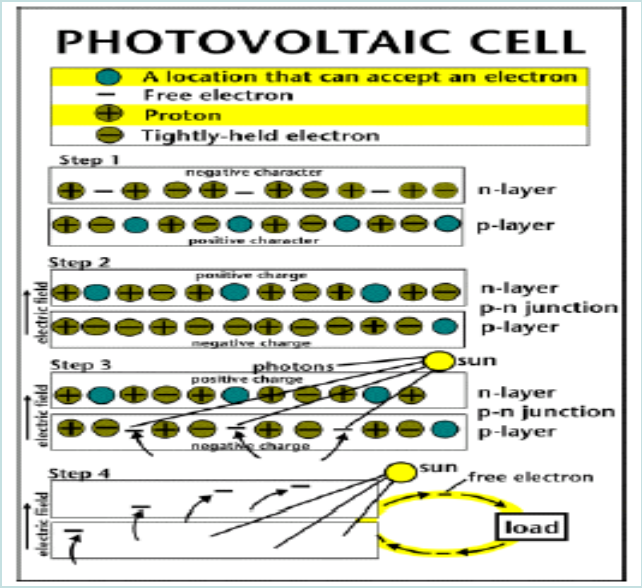


•If you are looking for the low cost solution to assist with heating in the winter and help with cooling in the winter then what can you do.

•Thousands of years ago, the Anasazi Indians in Colorado incorporated passive solar design in their cliff dwellings. Today we use the same kinds of techniques to take advantage of the sun's free energy.

•Daylighting features include building orientation, window orientation, exterior shading, sawtooth roofs, clerestory windows, light shelves, skylights and light tubes. These features may be incorporated in existing structures but are most effective when integrated in a solar design package which accounts for factors such as glare, heat gain, heat loss and time-of-use. Architectural trends increasingly recognize daylighting as a cornerstone of sustainable design.

Photovoltaic



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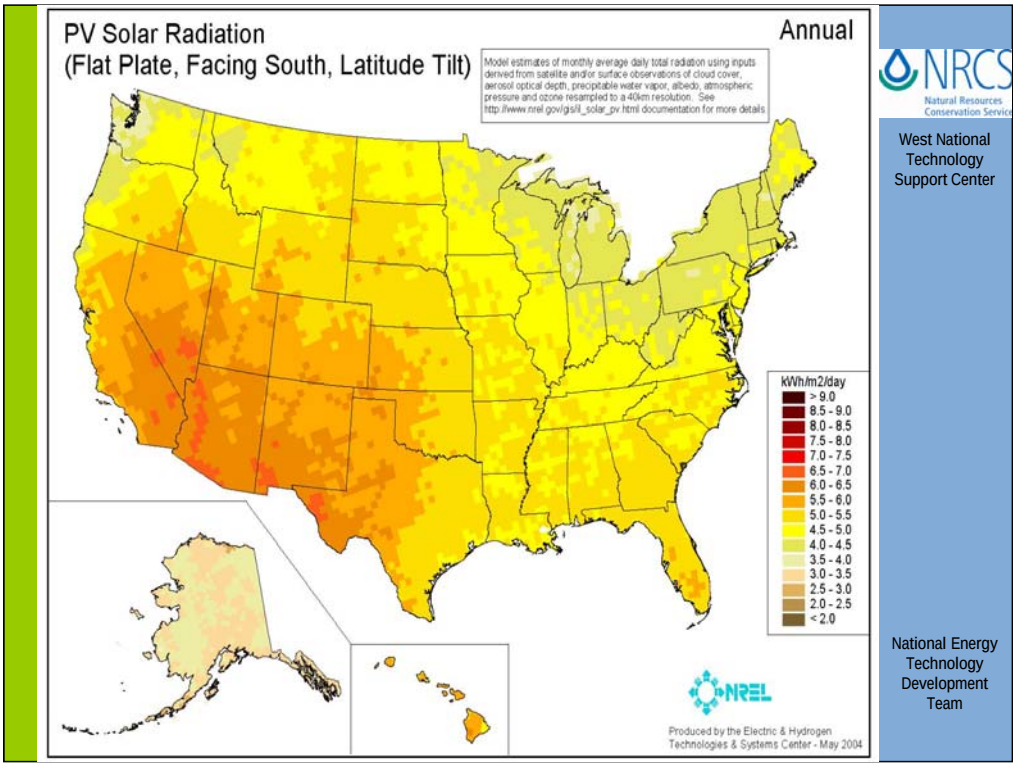
•Sunlight is composed of photons, or particles of solar energy. These photons contain various amounts of energy corresponding to the different wavelengths of the solar spectrum. When photons strike a photovoltaic cell, they may be reflected, pass right through, or be absorbed. Only the absorbed photons provide energy to generate electricity. When enough sunlight (energy) is absorbed by the material (a semiconductor), electrons are dislodged from the material's atoms. Special treatment of the material surface during manufacturing makes the front surface of the cell more receptive to free electrons, so the electrons naturally migrate to the surface.

•When the electrons leave their position, holes are formed. When many electrons, each carrying a negative charge, travel toward the front surface of the cell, the resulting imbalance of charge between the cell's front and back surfaces creates a voltage potential like the negative and positive terminals of a battery. When the two surfaces are connected through an external load, electricity flows.

•The photovoltaic cell is the basic building block of a PV system. Individual cells can vary in size from about 1 cm (1/2 inch) to about 10 cm (4 inches) across. However, one cell only produces 1 or 2 watts, which isn't enough power for most applications. To increase power output, cells are electrically connected into a packaged weather-tight module. Modules can be further connected to form an array. The term array refers to the entire generating plant, whether it is made up of one or several thousand modules. As many modules as needed can be connected to form the array size (power output) needed.

• Photovoltaic cells, like batteries, generate direct current (DC) which is generally used for small loads (electronic equipment). When DC from photovoltaic cells is used for commercial applications or sold to electric utilities using the electric grid, it must be converted to alternating current (AC) using inverters, solid state devices that convert DC power to AC.

•<u>The environmental impact of a photovoltaic system is minimal, requiring no water for system cooling and generating no by-products</u>.



•The performance of a photovoltaic array is dependent upon sunlight. Climate conditions (e.g., clouds, fog) have a significant effect on the amount of solar energy received by a PV array and, in turn, its performance. Most current technology photovoltaic modules are about 10 percent efficient in converting sunlight with further research being conducted to raise this efficiency to 20 percent.

•This figure varies by location and weather patterns. Deserts, with very dry air and little cloud cover, receive the most sun—more than six kilowatt-hours per day per square meter. Northern climes, such as that of Boston, get closer to 3.6 kilowatt-hours. Sunlight varies by season as well, with some areas receiving very little sunshine in the winter. Seattle in December, for example, gets only about 0.7 kilowatt-hours per day.

•A 1 kilowatt peak Solar System will generate around 1,600 kilowatt hours per year in a sunny climate and about 750 kilowatt hours per year in a cloudy climate.

PVs and Agriculture

http://rredc.nrel.gov/solar/old_data/nsrdb/redbook/atlas

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•The cost for one mile of power line ranges between $10,000 and $30,000.

•Solar pumping equipment has a high initial cost when compared with alternatives. A small sized solar pumping system will cost at least $2500 not including well costs. Operation and maintenance costs will be lower then alternative water pumping systems. The National Center for Appropriate Technology conducted six demonstrations and costs per cow ranged from $.03-.15 per day with costs of pumping one gallon ranging between $.002 and $.007.

•These two arrays may produce 50-100 watts, enough for a small pump.

•1 Horsepower pump equals 748 watts, so this array should power a pump of about 1/10 HorsePower.

•Small solar water pumps are 1/25th HP in size.

•Direct Current (DC) pumps are best suited for PV water pumping systems as they use one-third less energy than conventional AC pumps and does not require an inverter. There are two types of DC pumps, displacement or centrifugal. Displacement pumps seal water in a chamber through either diaphragms, vanes or pistons and then force the water through a discharge outlet.

•Electric fencing on farms can easily be powered from PV panels. SPRAYING CATTLE with insecticide can help control flies. Every time a cow goes for mineral, this device sprays insecticide on her back. When the cow puts her head inside, a magnetic switch activates a timer. After seven seconds, a 12-volt electric pump runs for three-quarters of a second. This releases about 10 cubic centimeters of dilute fly spray in an 8-foot spread across her back. The 120-milliamp, 6-inch by 12-inch PV panel keeps a battery charged to run the pump anytime. If a calf is standing beside her, it gets a spray, too.

•Fish pond oxygenator

What is Wind?

- Wind is a byproduct of solar energy
- Approximately 2% of solar energy reaching the earth is converted to wind
- Wind results from
  - Uneven heating and cooling of the earth
  - Creates atmospheric pressure gradients
  - Gradients force air movement from areas of high pressure to low pressure

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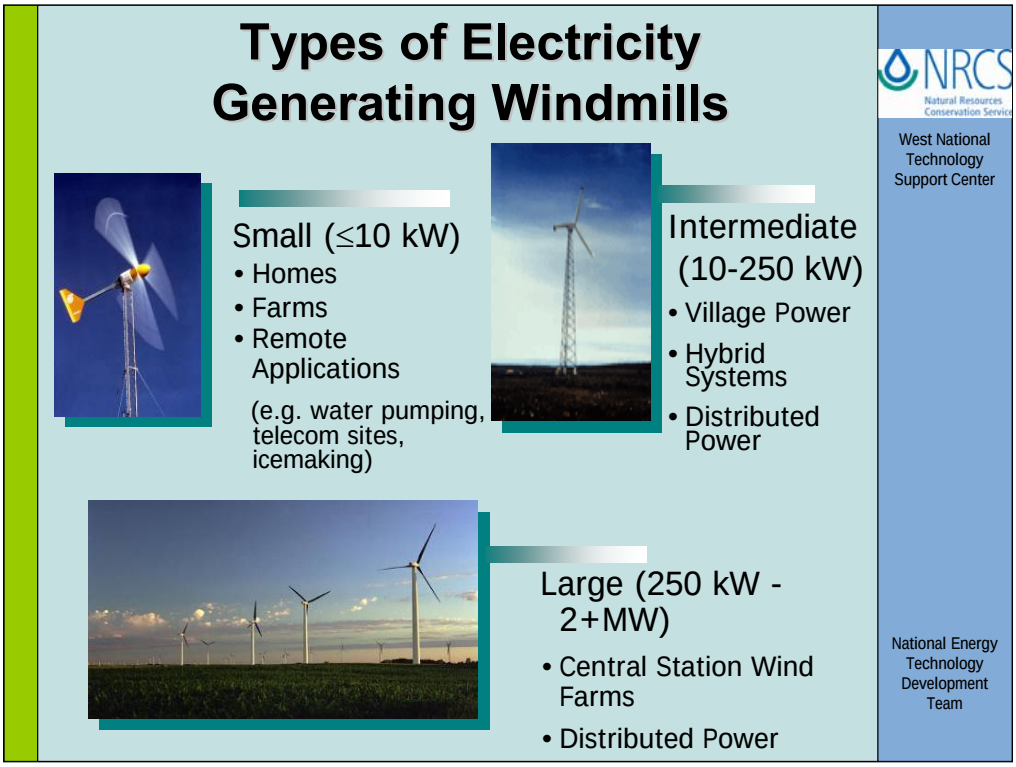
•Wind power is the fastest-growing energy source in the world,with annual average growth of 32 percent between 1998 and 2002. In the United States alone, nearly two billion dollars' worth of wind turbines are projected to come on line in 2003—enough to power 800,000 homes.

•The U.S. Department of Energy's (DOE) "Wind Powering America" initiative has set a goal of producing five percent of the nation's electricity from wind by 2020. While the negative effects of intermittency have to be considered in the economics of power generation, wind is unlikely to suffer momentary failure of large amounts of generation, which may be a concern with some traditional power plants. In this sense, it may be more reliable (albeit variable) due to the distributed nature of generation.



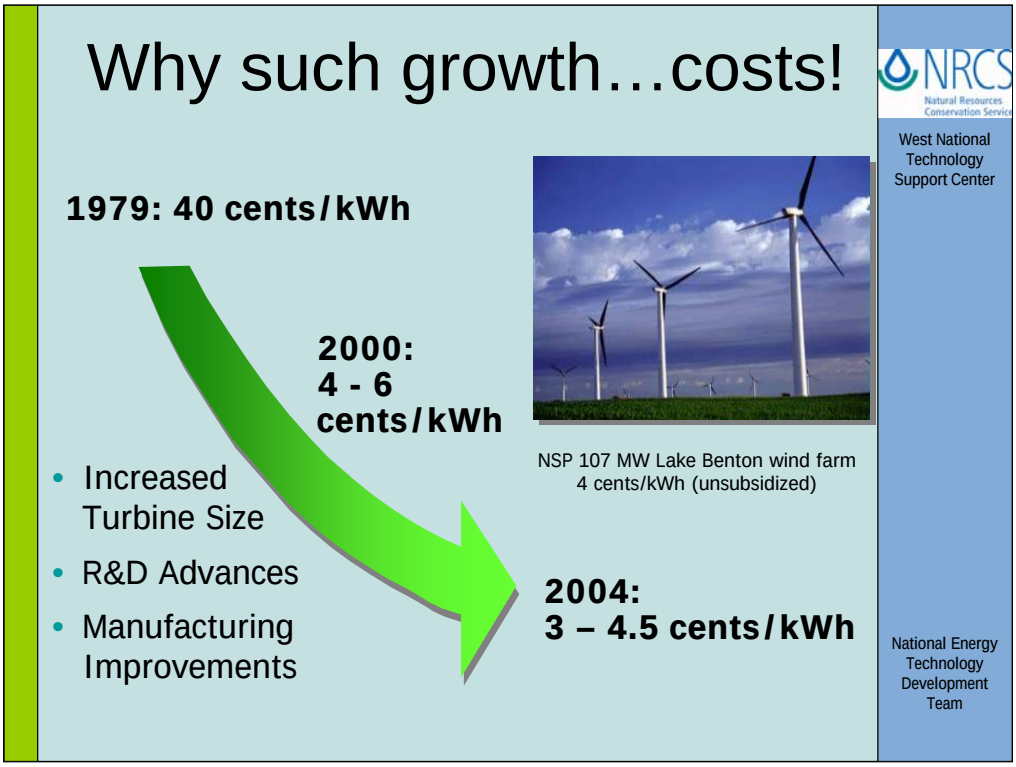
•The output of a wind turbine depends on the turbine's size or power rating, and the wind's speed through the rotor. Wind turbines being manufactured now have power ratings ranging from 250 watts (for battery charging) to 10-kW (which can generate about 15,000 kWh annually, more than enough to power a typical household) to 1.8 megawatts (MW) or more—enough to power some 500 households.

•For a small turbine (about 10-kW), it is recommended that the location have a wind speed average of 5 meters per second (m/s) (11 miles per hour) or more. For large turbines (750 kW, or more), it is recommended that average wind speeds exceed 6 m/s (13 mph).

•The amount of power generated is proportional to the cube of the wind's speed. If P/a is the power per unit area (P/a), and V is the wind speed, or velocity, then the relation of power to wind speed can be expressed by the following equation: P/a = α V3

•Large wind turbines typically use less than half an acre of land, including access roads, so farmers can continue to plant crops and graze livestock right up to the base of the turbines.

•Small wind generators, ranging from 400 watts to 40 kilowatts or more, can meet the needs of an entire farm or can be targeted to specific applications.



•Maintenance costs depend on the age of the turbine but generally run $.005 to $.01/kWh

•"Net metering" enables farmers to get the most out of their wind turbines. Net metering rules and laws are in place in most states.

•A third opportunity for a farmer or group of farmers is to become a wind developer who produces power to sell to others. Electric companies increasingly buy their power from independent power producers rather than generating it themselves.

Wind Turbine Site Conditions

- Highest general elevation
- On a ridge line perpendicular to prevailing winds
- Flat or gently rolling ground
- Low height ground cover
- No significant wind breaks/obstructions
- Proximity to airport(s) and utility grid
- Zoning and safety issues

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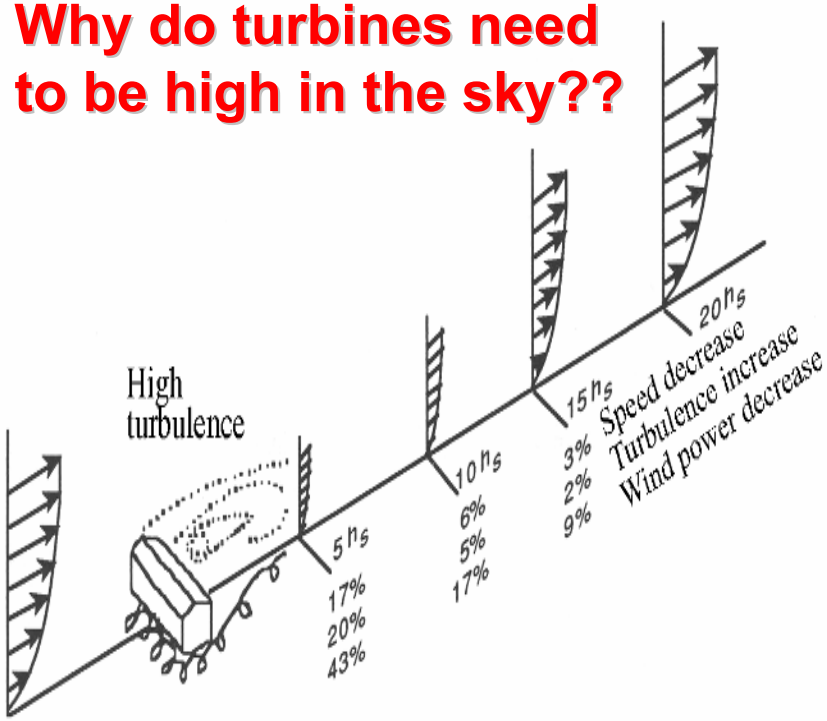
Why do turbines need to be high in the sky??



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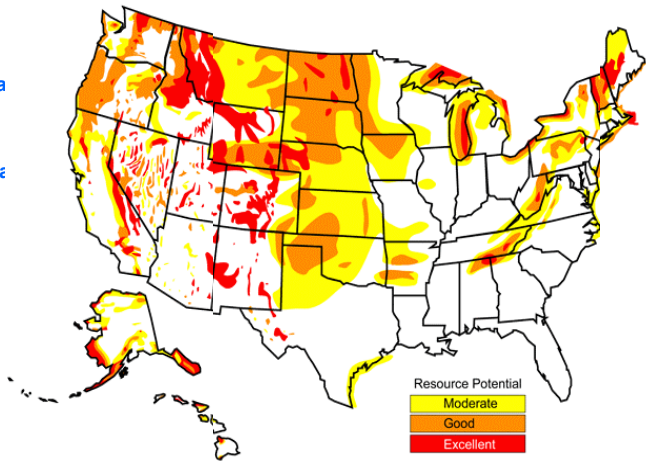
Wind Resource Potential

Rank	State
1	North Dakota
2	Texas
3	Kansas
4	South Dakota
5	Montana
6	Nebraska
7	Wyoming
8	Oklahoma
9	Minnesota
10	Iowa
11	Colorado
12	New Mexico
13	Idaho
14	Michigan
15	New York
16	Illinois
17	California



North Dakota's Potential: 250 GW
Germany's Potential: 100 GW

Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

NRCS
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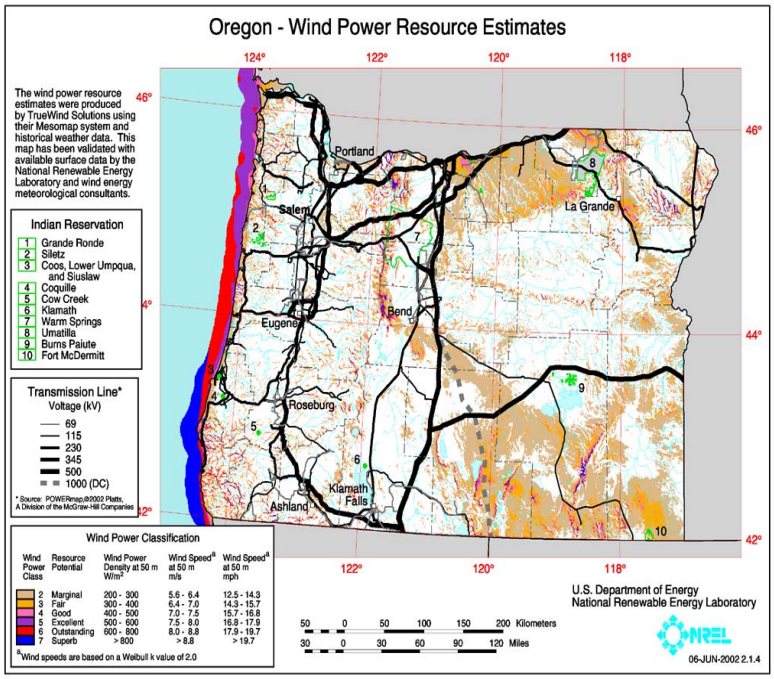

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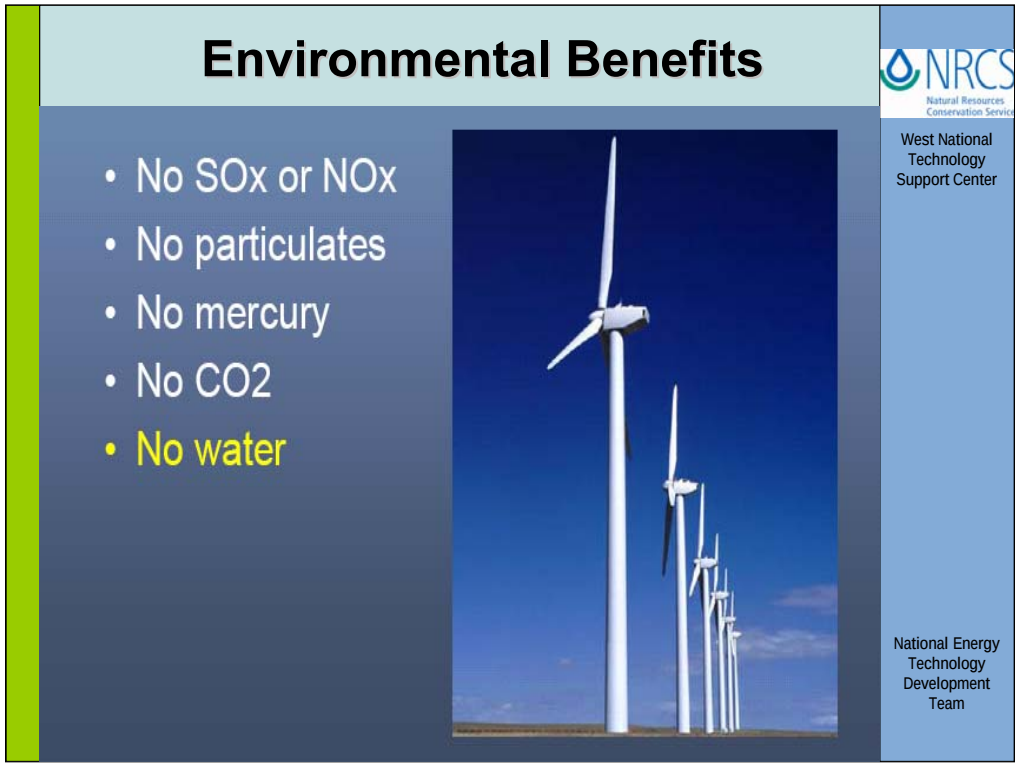


•Wind power consumes no fuel for continuing operation, and has no emissions directly related to electricity production. Wind power stations, however, consume resources in manufacturing and construction, as do most other power production facilities.

•Wind power may also have an indirect effect on pollution at other production facilities, due to the need for reserve and regulation, and may affect the efficiency profile of plants used to balance demand and supply, particularly if those facilities use fossil fuel sources

•Compared to other power sources, however, wind energy's direct emissions are low, and the materials used in construction (concrete, steel, fiberglass, generation components) and transportation are straightforward. Wind power's ability to reduce pollution and greenhouse gas emissions will depend on the amount of wind energy produced, and hence scalability, as well as the profile of other generating capacity

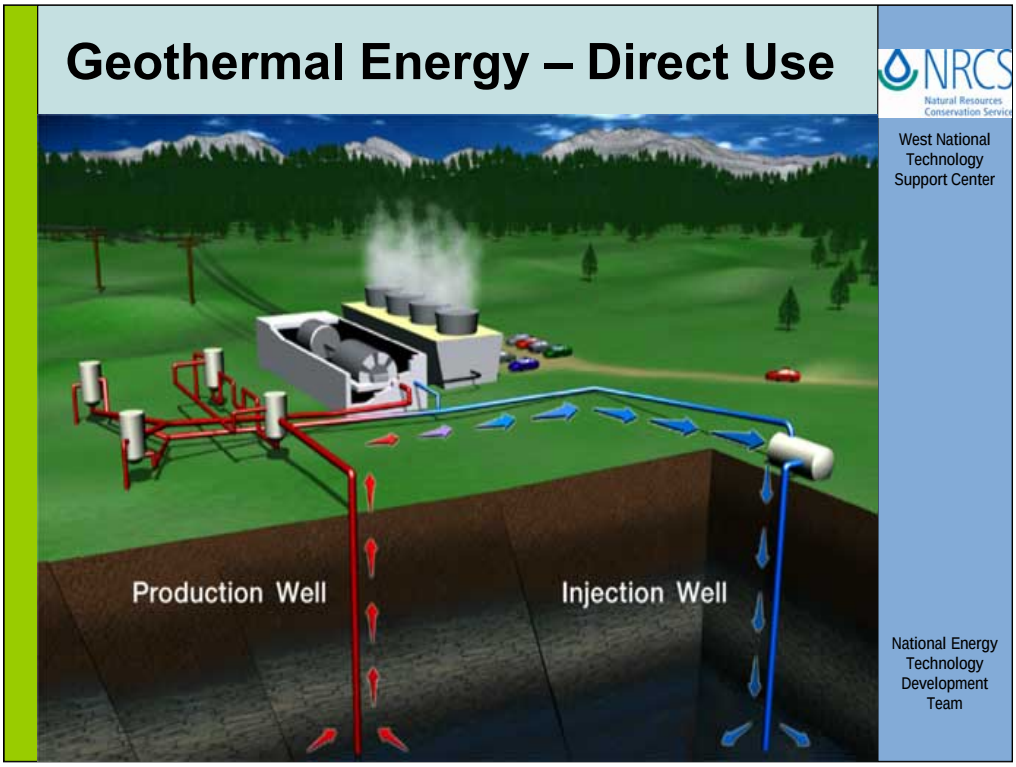
•A study by the Irish national grid stated clearly that "Producing electricity from wind reduces the consumption of fossil fuels and therefore leads to emissions savings", and found reductions in CO2 emissions ranging from 0.59 tonnes of CO2 per MWh to 0.33 tonnes per MWh

•Net energy gain for wind turbines has been estimated in one report to be between 17 and 39 (i.e. over its life-time a wind turbine produces 17-39 times as much energy as is needed for its manufacture, construction, operation and decommissioning)

•Onshore and near-shore studies show that the number of birds killed by wind turbines is negligible compared to the number that die as a result of other human activities such as traffic, hunting, power lines and high-rise buildings and especially the environmental impacts of using non-clean power sources. For example, in the UK, where there are several hundred turbines, about one bird is killed per turbine per year; 10 million per year are killed by cars alone.[56] In the United States, onshore and near-shore turbines kill 70,000 birds per year, compared to 57 million killed by cars and 97.5 million killed by collisions with plate glass

•"...wind energy is one of the safest energy technologies, and enjoys an outstanding health & safety record. In over 20 years of operating experience and with more than 50,000 machines installed around the world, no member of the public has ever been harmed by operating wind turbines. High standards exist for the design and operation of wind energy projects as well as close industry co-operation with the certification and regulatory bodies in those countries where wind energy is deployed

•Improvements in blade design and gearing have quietened modern turbines to the point where a normal conversation can be held underneath one

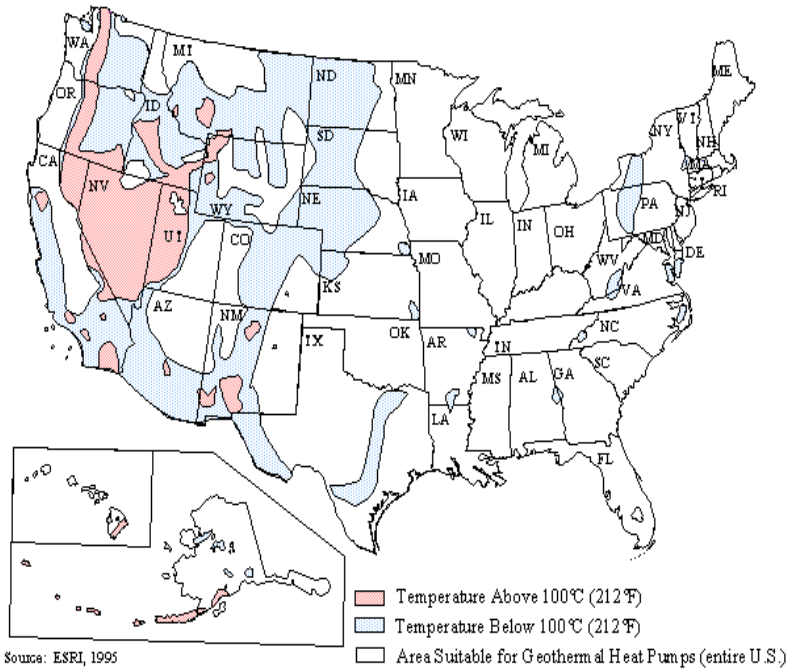


Geothermal energy is produced by drilling a well into the ground and attaching a well head. The steam is separated from the water, and the water is diverted through a turbine engine which turns a generator. Usually the water is injected back into the ground to resupply the geothermal source.

Geothermal power plants work continuously, day and night. From an economic view, geothermal energy is extremely price competitive.

Geothermal power plants release about 1 to 3 percent of the carbon dioxide emissions of a fossil fuel plant plus they create less waste and have a longer life span.

Common agriculture applications for direct use geothermal include operations which require higher and somewhat constant heating loads such as greenhouses, aquaculture and produce drying operations.



Source: ESRI, 1995

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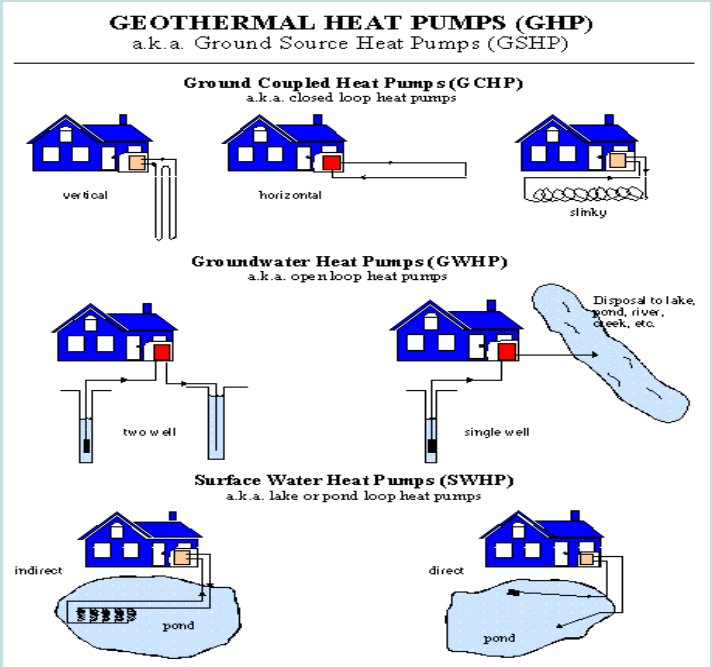

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•Definition- Ground source heat pumps (GSHP) are electrically powered systems that tap the Earth's stored energy.

•This is a display of a variety of loop layouts, featuring ground and water sources.

•The radiator system, in this case the ground loop,absorbs heat from the Earth and transfers it to a plenum where cooler indoor air is blown through a heat exchanger inside the plenum, warmed up, and distributed through duct work or a hydronic systemto a home, office, or agricultural application.

•For every watt of electrical input you use you may extract twice as much energy from the ground. Add to this the heat gained from the compressor (located within the plenum) you may receive a 1:3 input/output ratio. Leaky furnace ducts will decrease your system's efficiency. They should be well sealed.

•Pros

- Crop Drying Applications may be a great match-up.
- The net energy transfer can improve profitability.
- Preheating air or water, in the field or underground,may be quite cost-effective.
- Greenhouses and Aquaculture heating needs can be supplemented by geothermal heat.

•Cons

- Proper design may require reliable field studies.
- Water chemistry should be analyzed for direct use.

Electricity Estimated Wholesale Costs for Various Fuel Sources

Resource	Cost (cents per kilowatt-hour)
Hydroelectric	1.1 to 7.0
Chemical recovery boilers	2.6
Natural gas	2.7
Industrial cogeneration (natural gas)	2.7 to 6.4
Landfill gas	3.1
Wood residue	4.3 to 5.4
Geothermal	5.2 to 6.5
Wind	3.0 to 8.1
Forest biomass	5.5 to 6.6
Solar thermal	8.6
Solar photovoltaic (large-scale)	19.4
Solar photovoltaic (small-scale)	21.5 to 23.6

Renewable Resources Estimating the Cost of Generating Electricity

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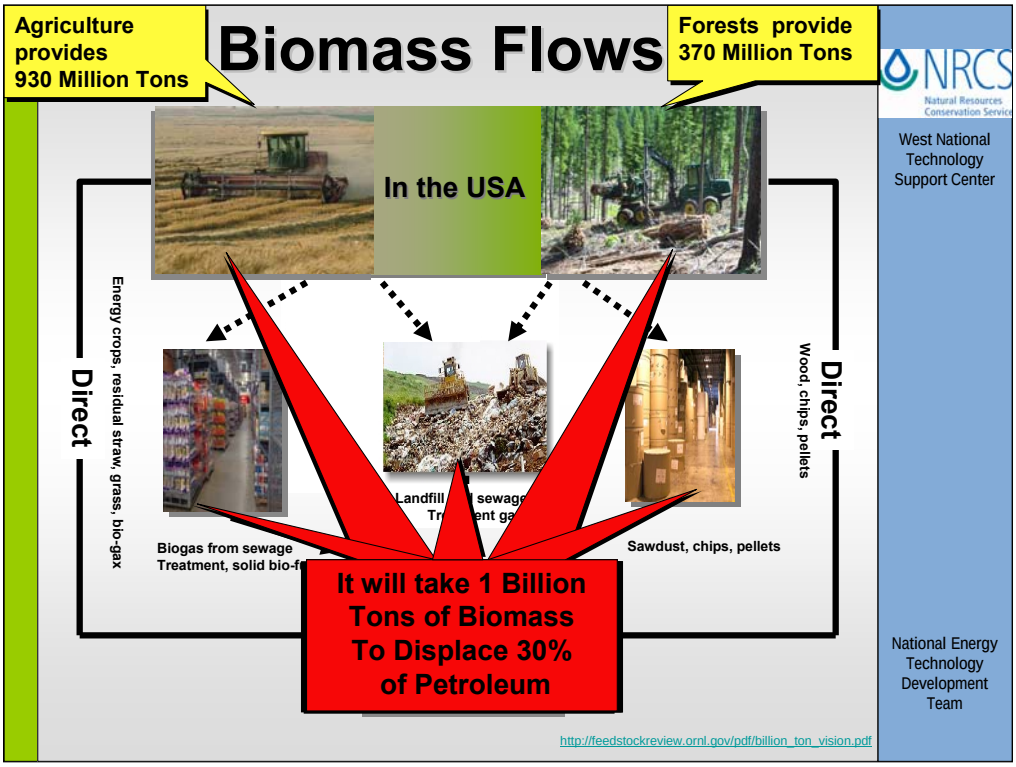

•Biomass available for energy on a sustainable basis includes herbaceous and woody energy crops, agricultural food and feed crops, agricultural crop wastes and residues, wood wastes and residues, aquatic plants, and other waste materials including some municipal wastes.

•Much of the electricity generated by biomass is used by the industries making the waste; it is not distributed by utilities, it is co-generated.

•Nearly three-fourths of the biomass used today comes from burning wood and wood scraps such as saw dust. The rest comes from crops, garbage, landfill gas, and alcohol fuels.

•In this joint report done by DOE and USDA in 2005 it was determined the land resources of the US are capable of producing a sustainable supply of biomass sufficient to displace 30% or more of the country's present petroleum consumption. To do this would require approximately 1 billion tons of biomass feedstock per year.

•Looking at just forestland and agricultural land the U.S. is capable of producing 1.3 billion dry tons of biomass annually (about 930 million dry tons from agricultural lands and about 368 million dry tons from forestland).

•Of the approximately 900 million dry tons from agricultural land 425 mil dry tons and annual crop residues, 377 mil dry tons of perennial crops, 56 mdt of grains, and 75 mdt of animal manures, process residues, and other miscellaneous feedstocks.

Typical Biomass Composition

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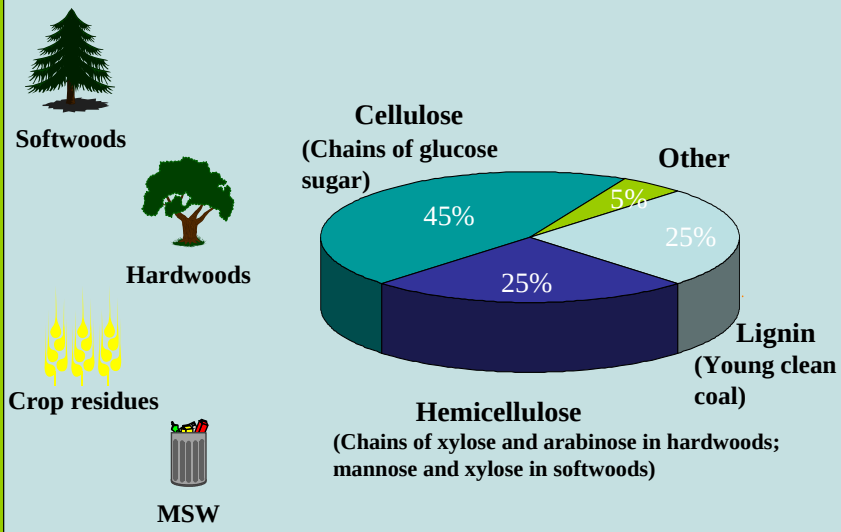

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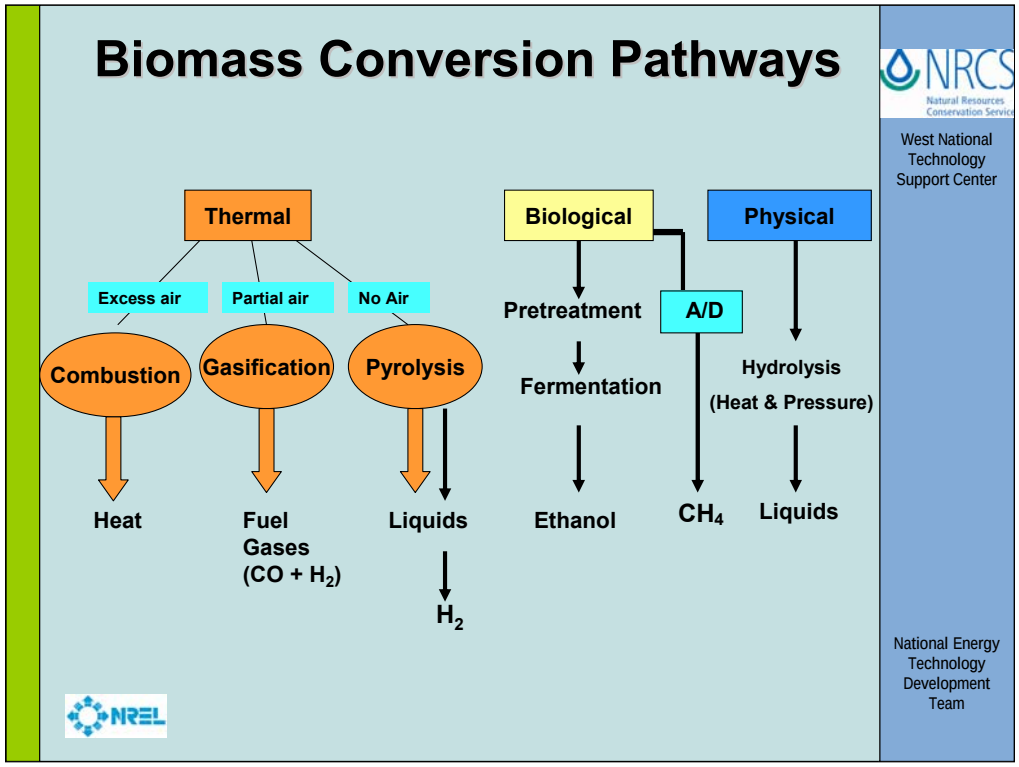


•And from these many sources of available forest and agricultural biobased feedstocks, there are a wide variety of conversion processes, and a wide range of potential bio-based products involved.

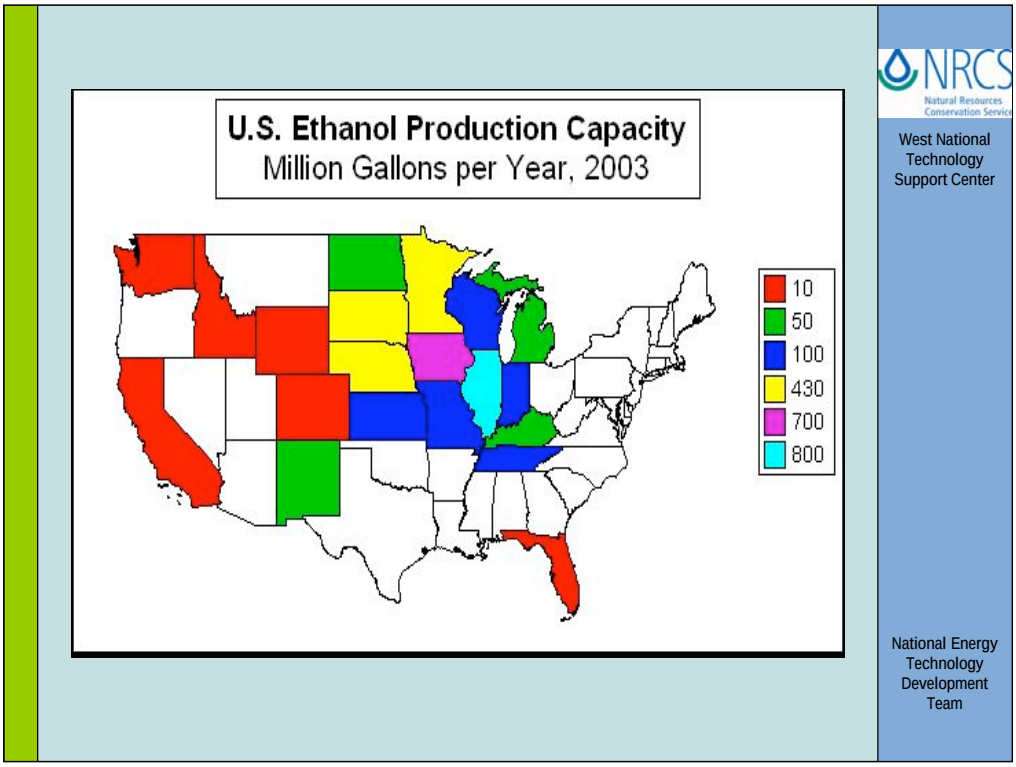
•From the forestry standpoint, in addition to meeting our energy, fire and healthy forest goals, using biomass, instead of burning it or disposing of it, has numerous indirect benefits:

▪reduces land managers' costs for removing waste materials

▪saves landfill space

▪reduces the emissions of wildfire and prescribed burning, and

▪can provide substantial socio-economic benefits to the rural communities whose economies are tied to Federal lands and Federal land management.



Ethanol Quick Facts

•In 2005, the U.S. produced about 4 billion gallons of ethanol from corn grain, equaling approximately 2% of the 140 billion gallons of gasoline consumed.

•Ethanol is widely used as a fuel additive. The oxygen contained in ethanol improves gasoline combustibility.

•The Energy Policy Act of 2005 has established a renewable fuels standard which requires using 7.5 billion gallons of ethanol by 2012.

•E85 (85% ethanol and 15% gasoline blend) can be used as a substitute for gasoline in vehicles that have been modified to use E85.

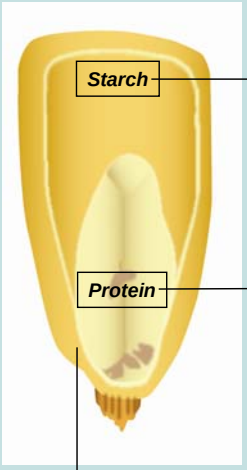
•Energy content of E85 is 70% that of gasoline, so about 1.4 gallons of E85 are needed to displace one gallon of gasoline.

•Starch in corn grain is readily degraded into glucose sugar molecules that are fermented to ethanol. The complex structural carbohydrates in cellulosic biomass are more difficult to break down, and they yield a mix of glucose and other sugar molecules that are not as efficiently converted to ethanol.

•An acre of corn generates about 4.5 tons of grain; 66% (3 tons) is starch that can be converted to 400 gallons of ethanol. Ethanol yield could be increased to roughly 700 gallons per acre by using corn stover (stalks and leaves) in addition to corn grain.

•Potential energy crops include perennial grasses like switchgrass or woody crops such as fast growing poplar. For these crops, average annual yield per acre is about 5 dry tons of cellulosic biomass; at a current conversion rate of 65 gallons per dry ton, an acre generates about 325 of gallons of ethanol. Goals include increasing biomass yield to 10-15 dry tons per acre and ethanol yields to 80-100 gallons per acre.

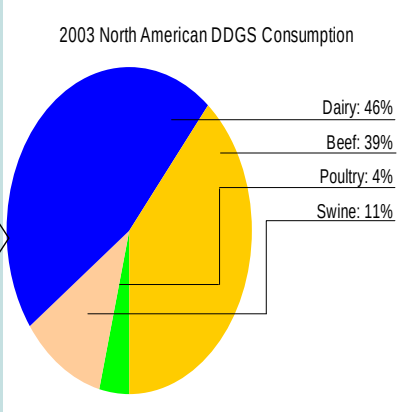
One-Third of Corn Kernel Mass Ends as Animal Feed (a Co-Product) in Ethanol Plants



Ethanol

Distillers Dry Grains and Solubles (DDGS)

Carbon Dioxide



Source: Commodity Specialist Co. (in RFA, 2005)

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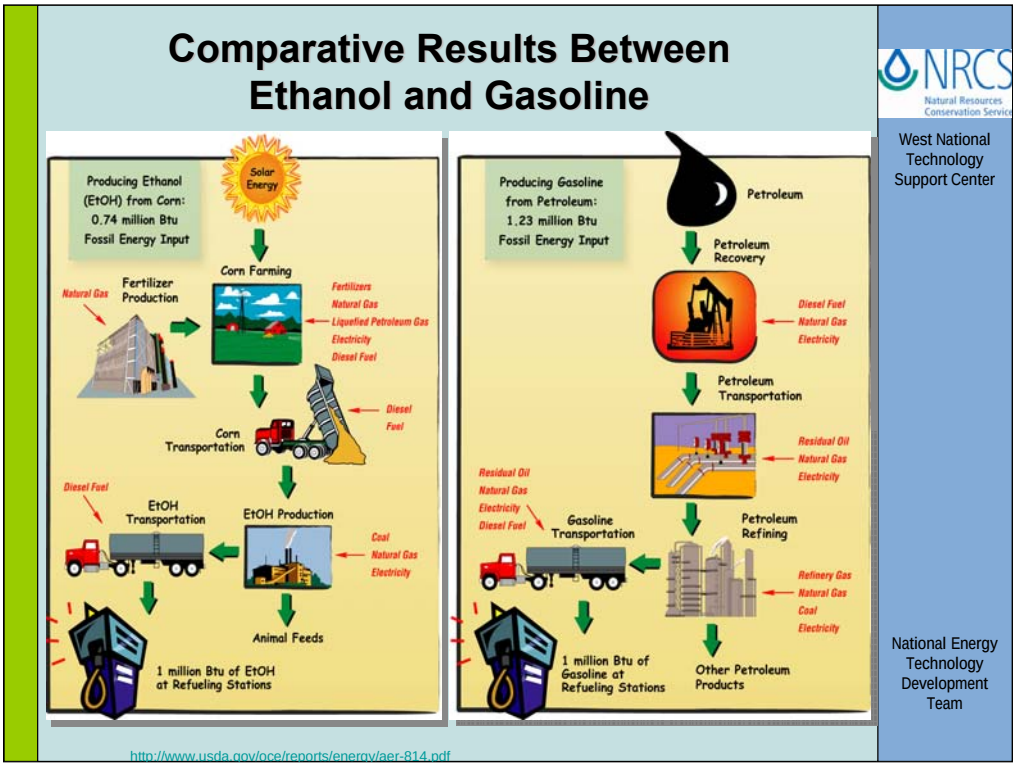
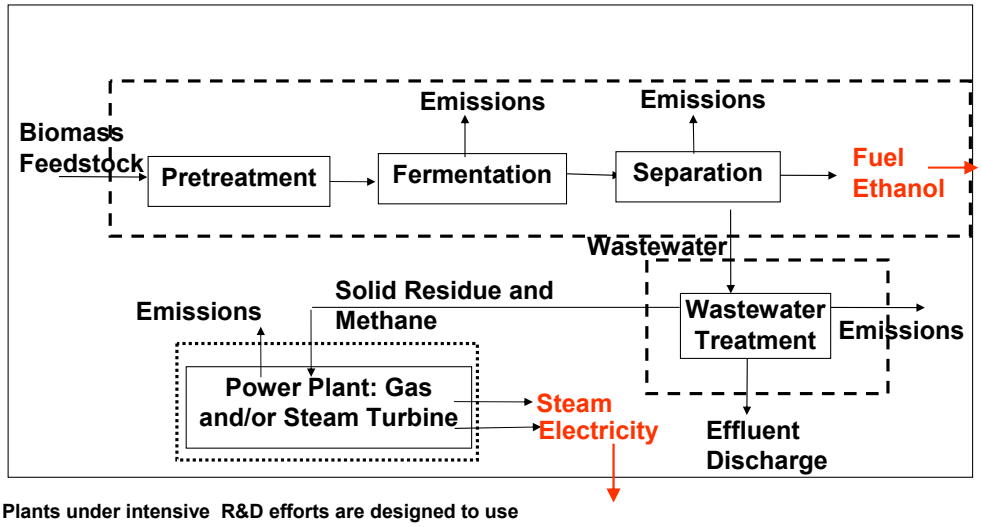


•A United States Department of Agriculture (USDA), Economic Research Service Report number 814 titled "Estimating The Net Energy Balance Of Corn Ethanol: An Update " was published in July of 2002. The Conclusion states in part: "Corn ethanol is energy efficient, as indicated by an energy ratio of 1.34; that is, for every Btu dedicated to producing ethanol, there is a 34-percent energy gain." A similar study done in 1995 indicated only a 1.24 energy ratio. The increase is accounted for by an increase in corn yields and greater efficiencies in the ethanol production process. As a result, energy efficiency in the production of ethanol is increasing.

•**Biodiesel versus Petroleum Diesel Fuel*** Energy yield**Net Energy (loss) or gain**Gasoline0.805(19.5 percent) Diesel0.843(15.7 percent) Ethanol1.3434 percent Biodiesel3.20220 percent * Life cycle yield in liquid fuel Btus for each Btu of fossil fuel energy consumed.

•"Only about 17 percent of the energy used to produce ethanol comes from liquid fuels such as gasoline and diesel fuel. For every 1 Btu of liquid fuel used to produce ethanol, there is a 6.34 Btu gain.

Cellulosic Ethanol Plants Will Be Significantly More Efficient than Corn Ethanol Plants



Plants under intensive R&D efforts are designed to use the unfermentable portion of biomass to generate steam and electricity.

Oilseed Biodiesel Production

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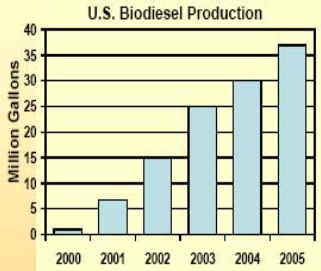
- The majority of bio-diesel produced uses waste grease and soybean oil



Soybean

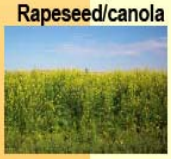
Mustard

Safflower

Other oilseed crops such as mustard, rapeseed, safflower, sunflower and canola produce 1.2 – 2.5 times more oil/acre than soybeans. The result will be lower feedstock costs thru improved production efficiencies.

The PNW crop production potentials are among the highest in the nation.

Rapeseed/canola



Sunflowers

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BioDiesel Production

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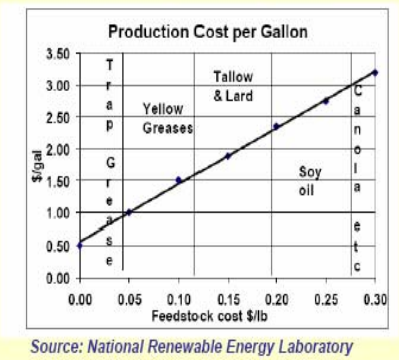
- The major economic factor to consider for input costs of bio-diesel production is the feedstock, which is about 80% of the total operating cost.



Source: National Renewable Energy Laboratory

To bring down costs value added products are needed:

- animal feed
- glycerin
- biofumigants
- other

- It takes around 7.5 pounds of fat or oil to produce a gallon of bio-diesel.

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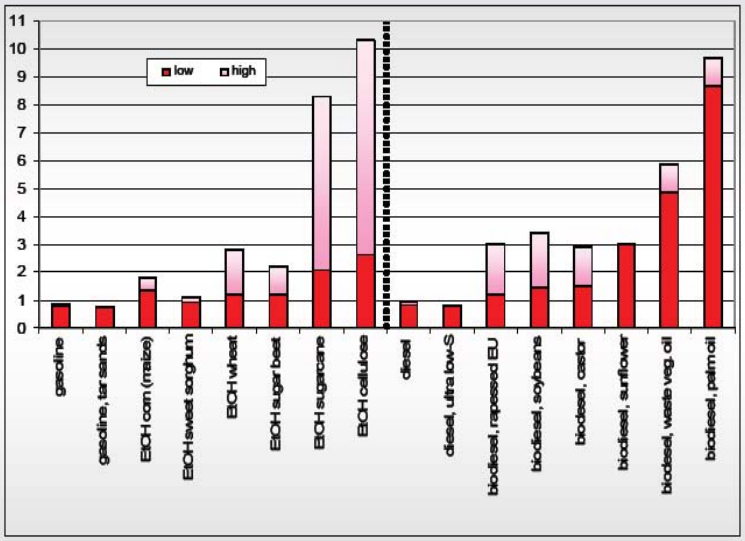
Energy Balance

Sustainable Biomass



Fossil Energy Balance of Transport Fuels, data from WWI/gtz (2006)

*Data given as ratio of energy output per **fossil** energy input*

www.oeko.de

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Life-cycle Carbon Dioxide Emissions for Various Transportation Fuels

Fuel	CO2 Emissions (lbs/ Gallon)
Biodiesel	5.84
Ethanol	14.60
Gasoline	24.30
Petrodiesel	26.55

DOE - Fossil Energy: DOE's Carbon Sequestration Research Program

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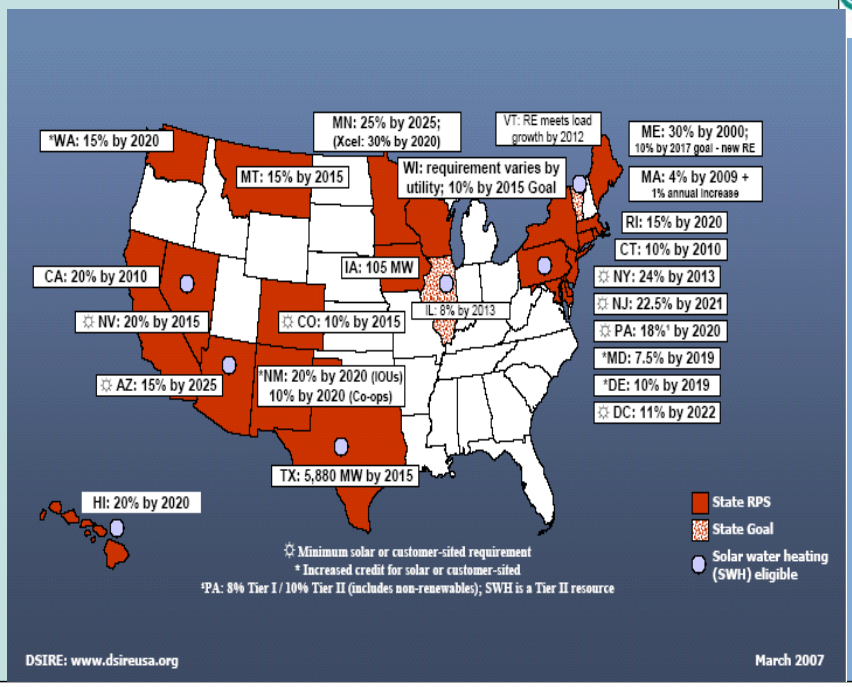
•Another study, by the US Department of Energy, reveals a similar hierarchy of fuels, as ranked by their life-cycle carbon dioxide emissions.

Renewables Portfolio Standards



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Excellent Web Site for Renewable Standards And Possible Sources of Funding and Incentives

http://attra.ncat.org/farm_energy/farm_energy_main.php

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Conclusions

- We have not made energy choice decisions on the basis of total energy balance values
- Energy balance value for a given energy product alone is not meaningful in evaluating its benefit
- Issues of concern, such as petroleum consumption and GHG emissions, should be analyzed directly for energy source alternative
- A complete, robust way of evaluating a energy source effects is to compare that source (e.g., wind) with the comparable source to be displaced (e.g., coal)

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All Btus are valuable.

Some Btus are just more valuable than others.

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