**Energy Resource Attributes**

**A. major fossil fuels**

1. **Coal:** the dirtiest burning of fossil fuels – very high carbon (greenhouse) and sulfur dioxide (acid rain). Newer “clean coal” emissions technologies are cleaner than conventional ones, but still coal is the **dirtiest burning**. **Coal supplies about ~~50~~ 44% of US electricity**. In spite of associated declining employment base and pollution, coal has received much **more government subsidies** than natural gas - coal’s largest direct competitor for generating electricity, and wind and solar, its likely successors in the 21st century. Coal can be traded internationally although shipping costs per unit of energy are greater than those of oil. In the US: **coal production increased ~40% percent from 1980 to 2008, but employment declined from 242,000 to 87,000**. Coal is the most plentiful fossil fuel in the US.

**Coal utilization is increasing rapidly in the high growth economies of Asia, particularly China and India**. Coal can be made into gasoline using the Fischer-Tropsch process, originated in Germany in WWII, and is cost-competitive with oil at oil prices exceeding $**~**60 per barrel.

For more info. **on our most abundant fossil fuel:**  <http://www.ucsusa.org/security/> and

<http://www.eia.doe.gov/cneaf/coal/page/special/feature.pdf>

**2. Natural gas:** **cleanest burning** (just 38-50% as much carbon dioxide as coal) and most rapidly growing source of the big three fossil fuels, **mostly used as a heating and electricity generating fuel.** Pipeline infrastructure suitable for natural gas could be adapted for hydrogen in the future. Natural gas is much more expensive to transport via pipeline and tanker than oil because it has 5 times higher volume relative to energy content. **Due to high transportation costs, natural gas is geographically more variable in price than oil**. The US currently imports a significant amount from Canada. Low ground level pollution (NOX, SO2) from natural gas means that highly efficient combined heat and power (**co-generation) plants** can be used. The price of natural gas is related to coal more than oil because of significance of both in electricity markets. Liquid natural gas (LNG) can be shipped by ship, which has recently opened up imports into regions where natural gas is not produced. LNG (US case). **The horizontal fracturing technology “fracking” has vastly expanded production and reserves of North American natural gas, raising the possibility of the region exporting natural gas abroad.**

3. **Oil:** **provides about 95% of the fuel used in transport worldwide**. Transport uses about 49 percent of today’s worldwide oil supply. Most of the balance competes with electricity, which is also generated by coal, hydroelectricity, nuclear, natural gas, and renewables. **Oil is clearly the major source of strategic energy insecurity for the US**, as most of our consumption is imported and our transportation sector is almost entirely reliant on it. OPEC holds 77% of world oil reserves, the US 3%, while we consume about a quarter of world production. Unconventional oil such as Alberta’s tar sands and Venezuela’s extra heavy oils are more carbon polluting but vast, suggesting world oil might last more than a century with current growth rates in demand.

**B. selected renewables** see: http://www.eia.doe.gov/

**Solar:** Global solar cell (photovoltaic) electricity generation growth averaged 20% per year in the 1990s, and then has annually increased 40+% since 2000. Globally about 2/3 of all homes with solar cells are rural and in developing countries. For remote “off the grid” locations, it is often cheaper to install solar cells than to get hooked up to a distant power source. Wholesale panel Costs have fallen from $70 per watt (1970s) to about $~~2.50~~ (2009) to 1.25 per watt today. In better sites, solar electricity is generated at less than 20 cents per kw-hr. Historically, for every doubling of solar cell manufactured output, price per kw. has dropped by about 15-20%. Some analysts believe that in the long term solar cells **may become the cheapest mode** of electricity generation. (know solar energy class notes )

**Wind:** among the fastest growing of renewable energy sources globally, is generally considered by analysts to be the most rapidly growing source of grid power in the foreseeable future. The United States has some of the most impressive wind resources anywhere in the world, and is sometimes referred to as the Saudi Arabia of wind. **Cost** **per kilowatt hour is already** **competitive with coal** in the best generation sites, with **no emissions pollution**. Electricity from some of the new U.S. projects has been contracted at ~ 3 cents per kWh—establishing wind energy as a power source that is now more affordable than natural gas.

 Economies of scale and improving generation technology are likely to bring down the price a bit more in the near future. Industry analysts have consistently underestimated in the past the degree to which cost per Kilowatt-hr. will drop. **Coal, nonetheless, has received much more government financial support. US wind resources are vast** – some 3-5 times the current electricity production at current levels of technology. **Wind mfg. and installation employs** **more people per kilowatt hr**. than any of the fossil fuels: European studies show 3 to 4 times more employment.

 **California kick started the modern global wind industry in the 1980s with generous investment incentives combined with federal tax incentives, and currently produces enough electricity for the city of San Francisco. The Reagan administration, however, cut renewable incentive budgets by nearly 80% by 1988, and the US lost its industrial leadership. Tiny Denmark currently manufactures nearly half of the wind turbines, and installed more Megawatts in the late 1990s than the entire United States.** New government support brought back wind energy installations in the US by 2000, however, and 2001 data show an expansion of 60%.

 From 1995 to 2000, the **global wind industry grew by nearly fourfold, a growth rate comparable to the computer industry**. While 1980s and continued US government investment in microprocessors and the Internet now pay handsome dividends to corporations and the general public, support for wind and other renewables has been relatively minor and irregular.

 Wind is variable in velocity in time, but this is not currently a major technical problem given the wind generates less than 1% of the US electricity supply. In some regions as generation capacity expands, wind generated energy could be stored in the form of hydrogen at times when grid demand is low. In this case hydrogen would be produced by electrolysis (splitting the water molecule). Hydrogen can then be used in fuel cell-driven cars, which are planned by Toyota and DaimlerChrysler to be on the market by 2003 or soon thereafter. What the US lacks at present is an infrastructure to transport large quantities of hydrogen. There are already plans to place hydrogen refueling stations in densely populated Southern California, where the infrastructure needs would be limited. Hydrogen produced by wind energy in today’s market conditions would not be cost competitive with oil to run automobiles.

 Using current technology, wind (and solar) could drive a large plug-in hybrid electric vehicle fleet in the US and perhaps completely eliminate oil imports.

 Problem: NIMBY

 The states with the most wind potential are in the Midwest, and rural areas are where most installations are taking place.

See American Wind Energy Association website: <http://www.awea.org/>

Geothermal: Perhaps the “**sleeper**” of alternative energy, geothermal grew at 4 percent per year from 1990-2000. Geothermal resources - generated by radioactive decay and gravitational pressure of the Earth’s interior, are **vast**. **It is most abundant in areas near volcanic activity such as continental margins like** the Pacific Ring of Fire and tectonic spreading centers. Electricity serves as **baseload.**

**C. Nuclear** waste, cost, and risk issues

Currently no private insurer will insure plants, meaning the US gov’t underwrites the cost – through the Price-Anderson Act.

Unresolved problems:

-Waste disposal issues not solved

-Nuclear enrichment from electricity plants is how countries develop nuclear weapons

-centralized and toxic nature of plants makes them high risk

-cost higher than coal and natural gas, per kilowatt-hour.

-cost overruns and inability to finish plants on time was big problem in 1970s (no plants built in US since then)

-**but carbon neutral**