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Alternative and Renewable Energy

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ALTERNATIVE AND RENEWABLE ENERGY

By: Emil Opitz

A Thesis Submitted to the
Department of Geology
in Partial Requirement of the
Fulfillments for the Bachelor
of Science Degree

December 13, 2007

Abstract

The world is going to run out of fossil fuels in the near future. An estimated one to two trillion barrels of oil is believed recoverable using today's technologies. This amount of oil will last the world no more than 70 years, and perhaps only half that long. A system of alternative and renewable fuels is our only solution to this problem. With proper action and development, a worldwide energy crisis will be avoided.

We have an abundance of renewable and alternative energy sources that are not currently being used, enough to supply almost all of our energy needs. Wind can provide over 10 trillion kWh of electricity annually; three times the electricity that we currently use. Corn crops produce about 330 gallons per acre of ethanol, which will ease the change of fuel from gasoline to some other source. Transitioning to these clean sources requires time and money to develop them, and needs to begin now.

We not only risk loosing a constant supply of energy, but also further degradation to our environment due to global climate change. CO_2 levels are over 375 parts per million, and on track to pass 700 parts per million by the end of this century; over twice as high as ever recorded in the last 400,000 years. By taking steps today, we will prevent a crisis from happening tomorrow.

We need energy to power our everyday lives. As our nation expands in both population and technology, so does the demand for energy to meet our needs.

Introduction

Life in the United States has relied upon cheap and abundant energy resources for so long that being without low-cost energy has never really occurred to anyone. As our lives became easier to live because of technological advancements, we required more energy to operate these innovations. Our homes all have lighting. Heating and air conditioning keeps our houses' climates at comfort levels we prefer. Refrigerators, microwaves, ovens, computers, and washing machines are a few examples of energy dependant appliances that are available today. All these modernizations are possible because of inexpensive energy. As the demand for energy continues to rise, the supply of electricity continues to meet these rising demands, which translates to increased coal, natural gas, and nuclear consumption.

The last fifty years have seen more than a 200% increase in the number of vehicles per person in the United States (Statistico, 2007). We have affordable air travel and water travel, which allows people and goods to be transported anywhere. These modes of transportation, coupled with the population nearly doubling during the same time (U.S. Census Bureau, 2000), are major contributors to increased oil consumption. Figure 1 illustrates the steady decline in wood as the main energy source over the last century and a half, and a heavier dependence on fossil fuels. As the industrial era began, so did a need for more reliable, cheaper, and abundant energy sources. Coal was the first solution to this problem, and we can see during the 1880's that coal eventually became the primary source of energy. With the sudden increase in coal usage, we quickly noticed many damaging effects. Soot from factories covered many cities in black, and deadly elements such as mercury and antimony were released into the environment. Near the turn of the twentieth century, oil and natural gas began replacing many of coals' uses as cleaner options. We are still building most transportation advancements, such as ships or submarines for example, using finite fuels as their primary energy source. They have become more efficient and cleaner burning, as ships have gone from coal to diesel, but are still reliant on fossil fuels. Alternative fuels and renewable fuels need to be the next big change in the transportation industry. If no other source of energy is found and consumption continues to rise, we will use all of the remaining fuel in the near future and have nothing to replace it. Nothing mechanical will be useful anymore, and life will be quite primitive again.

Current proven reserves

There are currently 3.5 trillion barrels of proven oil in the world, and between one and two trillion of which are believed recoverable using current technologies (Leggett, 2005). At the current consumption rate of just more than twenty-nine billion barrels per year, we have between thirty-five and seventy years of oil left. However, consumption is increasing worldwide with forecasted rates of thirty-six billion barrels per year in 2015, and forty-three billion barrels per year by 2025. We will only have twenty-seven to fifty years of oil left. Usable oil for the public will be affordable for another decade or two at most if these predictions are correct.

Proven natural gas reserves were 5,000 trillion cubic feet in 2000 (Berinstein, 2001), and 6,183 trillion cubic feet in 2006 (Murray, 2006). World consumption is currently at 100 trillion cubic feet per year (Department of Energy-Energy Information Administration, 2004). The world has only about sixty years of natural gas usage left.

Coal reserves worldwide are more abundant, proven at just more than 900 billion short tons (British Petroleum, 2007). Current consumption is 5.5 billion tons per year, giving 160 years of coal usage, assuming steady consumption rates. By 2030 coal use is expected to double, leaving us with less than 100 years of coal.

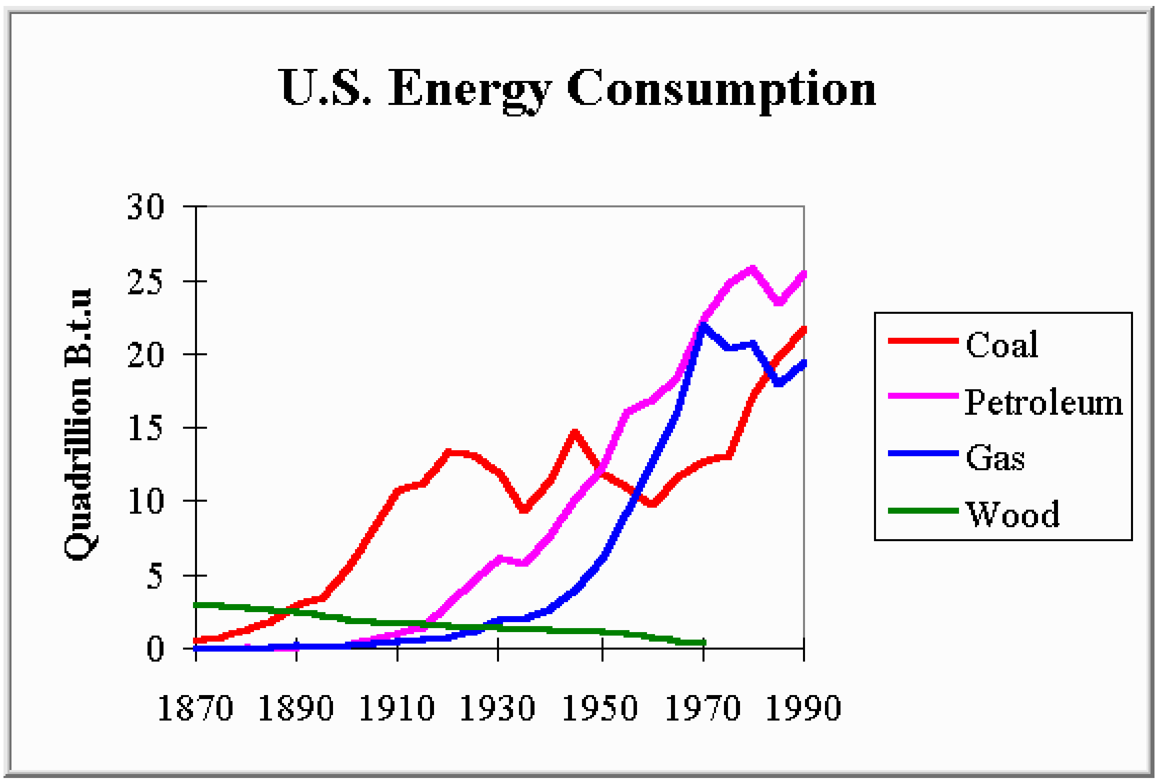


Figure 1

Energy Shortage

The scenario is set for an energy crisis within the next fifty years. We will, of course, have oil around for the next few centuries, but it will either be far too expensive for everyday use or set aside for various world governments. The same applies to the other fossil fuels. What is going to replace these energy sources? Without any natural gas or fuel oil, homes will be without heat. Shortages of oil will create chaos in the workforce on all levels. Locally to worldwide, people may not be able to afford transportation to and from their jobs, nor will the companies be able to afford shipping their products.

The United States has an enormous problem to overcome if it wishes to continue into the future as a world power. The energy crisis is imminent, people are just beginning to talk about it, and yet nothing is being done. Two previous crisis scares that the U.S. experienced were in 1973 and 1979. The 1973 scare occurred because the Arab members of the Organization of the Petroleum Exporting Countries, OPEC, wanted to punish supporters of Israel during the Yom Kippur War. This mostly affected western countries, specifically the United States and the Netherlands. In preparation for the Yom Kippur War, Saudi King Faisal and Egyptian president Anwar Sadat met in Riyadh and secretly negotiated an accord whereby the Arabs would use the "oil weapon" as part of the upcoming military conflict (Yergin, 1991). In October of 1973, OPEC exercised their “oil weapon” and announced an embargo against the United States that lasted until March of 1974.

The oil crisis in 1979 occurred because of instability in Iran. The Iranian revolution marked the beginning of this oil crisis. The Shah of Iran fled his country in 1979, and the new power of the country was inconsistent in its oil production. This caused instability within the market. Then in 1980 following the Iraqi invasion of Iran, Iranian oil production nearly came to a stop, and Iraqi oil production diminished as well.

If we look at the two energy crises of 1973 and 1979, we can observe some commonalities. According to Williams and Alhajji, both events:

1. Started with political turmoil in some oil producing countries
2. Were associated with low oil stocks
3. Were associated with high import concentration from a small number of suppliers
4. Were associated with declining US petroleum production
5. Were associated with high dependency on oil imports
6. Were associated with low level of oil industry spending
7. Led to speculation
8. Caused an economic downturn
9. Limited United States policy options in the Middle East

We could have done some things to prevent the crises from happening. The United States could have backed the Arab nations during the Yom Kippur War, supplying them with munitions and supplies, instead of backing the nation of Israel. The United States could also have been more careful and efficient in using petroleum and its products. There are many preventive measures that we could have taken, but we did not take any. We depended on OPEC for oil, and discovered that any problems they have can affect our oil supplies very quickly. Similar situations exist today, as they did thirty years ago, allowing for another crisis to occur. This time the crisis will not be a scare, but a shortage of extraordinary proportions.

There are currently ninety-eight oil producing countries in the world. Sixty-four are thought to have passed their production peak, and of those, sixty are in terminal production decline (Strahan, 2007). These sixty countries are very steadily producing less oil in each consecutive year, and many more countries are soon to follow that trend. The worldwide downward trend in recoverable oil began decades ago, and with our skyrocketing demand, supplies will start to drop drastically in the future. They have predicted this in figure 3 to the year 2050. The decreasing supplies have been apparent over the past few decades. The United States hit peak production in 1970. Our imports surpassed our own production in the early 1990's, as shown in figure 2. This curve was predicted fourteen years before we hit our peak production by the late Dr. M. King Hubbert, a Geophysicist, in 1956. His prediction was that U.S. oil production would peak in about 1970 (Hubbert, 1949). At the time, his prediction was scoffed at, but it proved to be remarkably accurate. Our increasing dependence on foreign oil and decreased production of indigenous oil will play a major role in the approaching years. If we do have an energy crisis, we can expect a recession, inflation, and high unemployment rates (Williams and Alhajji, 2003). The shock to our country could result in chaos as our way of life becomes disrupted. We need bold leadership at the highest level in our country; otherwise we can expect an energy crisis unlike any before. The President must enable us to take the urgent steps that are needed. Offering tax breaks for installing renewable energy generators, and punishing those who use fossil fuels with excessive fees and taxes will help the transition to alternative energy solutions. Without incentives that only the government can offer, and only the President can require, this transition will be extremely slow and much more difficult.

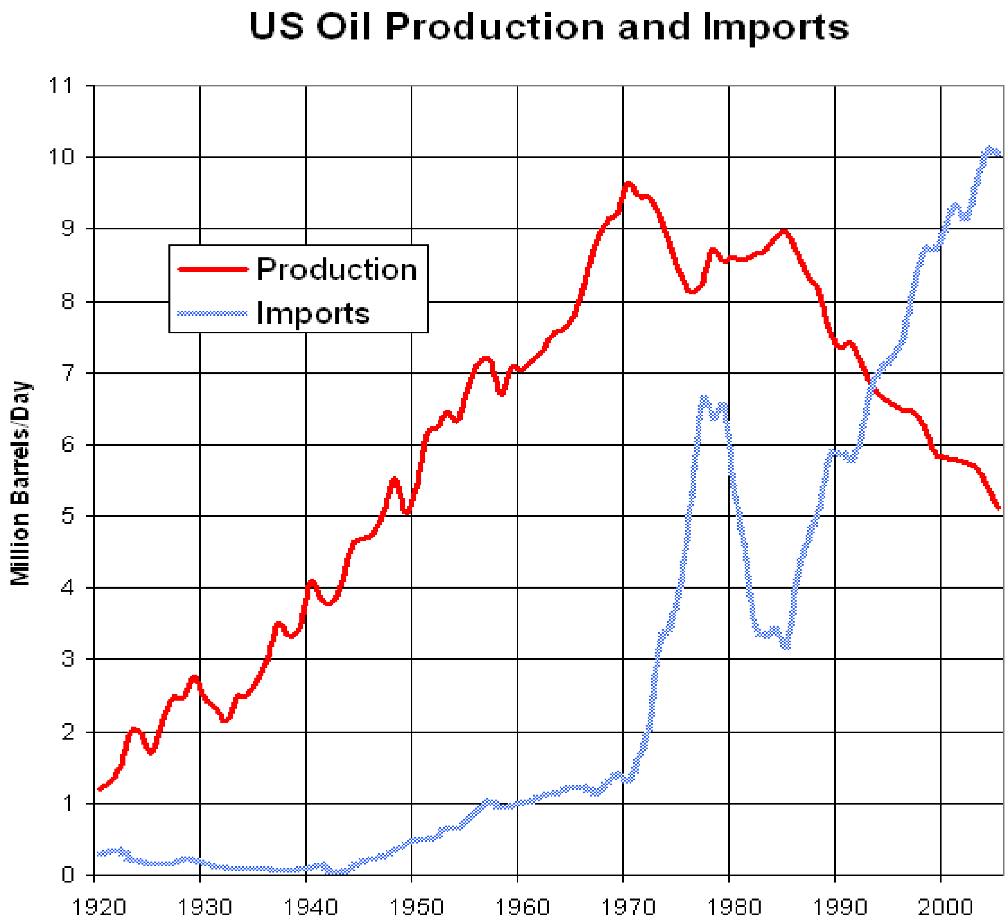


Figure 2

Alternative Energy

Current potential alternatives to fossil fuels are extremely limited and underdeveloped, and technology cannot save us without time and money to develop and scale them up. Alternative energy sources for transportation are still in the beginning stages. Solar cars have been around since the early 1980's, but are still not much more than projects for college engineering teams to compete in solar car races. They are extremely small, very slow, and high priced. They would also not be very practical, for families or on cloudy days, for example. Hydrogen fuel cells are the newest hype in alternative fueled vehicles. There is still much research and development to be done, and once the cars are affordable and efficient enough to use, a hydrogen fuel station infrastructure would need to be put in place. If we are going to pursue this option, we must start soon, as there is much to be done. Ethanol is also another alternative fuel, and it is currently being used. Recently automobile manufacturers have begun to make cars that accept 85% ethanol fuel, commonly called E85, in the United States. Gas stations are slowly beginning to carry this fuel, and although E85 is an alternative fuel, it cannot fully replace oil, and we will discuss why later.

We are currently using some alternative sources for electricity, but not nearly to their full potential. There is enough potential clean renewable energy in the United States to supply at least five times the electricity we use today. Wind energy alone, if only used in the top three windiest states, could supply all of the electricity we currently use. We have hydroelectric dams in place across the nation, many of which have been in place for decades now. There are also solar and geothermal alternatives. These four alternative energy sources are renewable and do not emit any CO_2.

We can also burn biomass, like wood or garbage, to generate electricity. This practice is already in place to a small degree in the United States. The problem with burning biomass is that it creates CO_2.

Figure 3 outlines the necessity of alternative fuels. This graph shows the major oil producers and their volumes of production in A Billion Barrels per Year. When United States production peaked in the early 1970's, other producers increased their output to keep up with rising global demand. Today, most oil producing countries have already hit their peak production, or are very close. The area following the red arrow, near 2010, is one of the many projected world peak production years. Although the exact year of world peak production is unknown, the future oil shortage portrayed on this figure is. When we hit the peak, whether it is in 2009 or 2020, the production seen on the right portion of figure 3 will follow. The oil market will become more strained due to higher demands and lower supplies, and prices will rise to extraordinary levels. The only solution to this coming crisis is the development and use of renewable and alternative fuels.

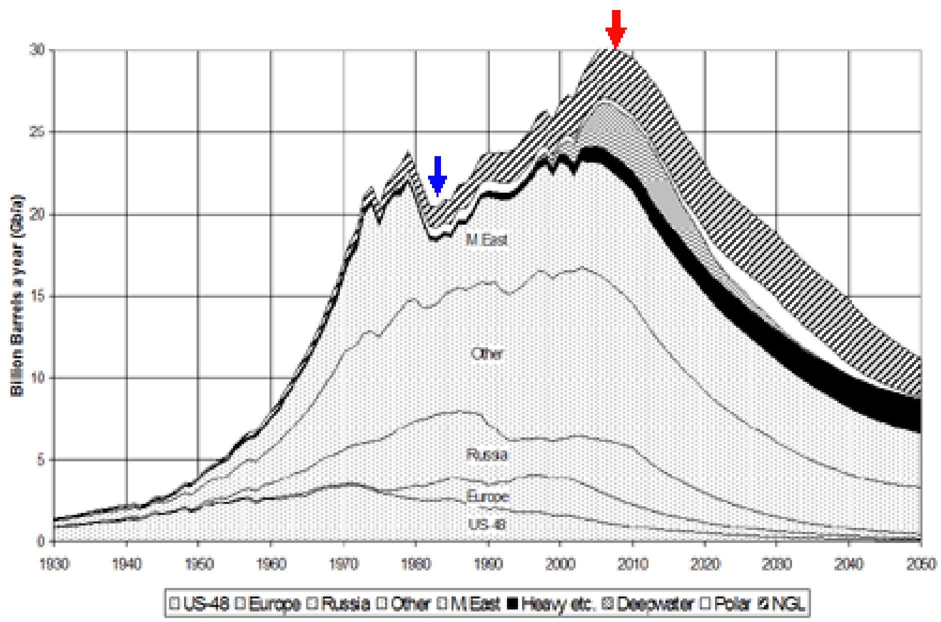


Figure 3

Ethanol

Ethanol is an alcohol fuel that we can make from any cellulose containing source such as corn, sugar cane, switch grass, and even straw or saw dust. The raw materials used to produce ethanol typically reflect upon the region where it is made.

Brazil supports their large population of ethanol-burning automobiles with a well-established national infrastructure that produces ethanol from domestically grown sugar cane. Today, almost half of Brazil's cars use ethanol as fuel. This includes ethanol-only engines and flex-fuel engines. Flex-fuel engines are able to work with pure ethanol, pure gasoline, or any mixture of both. The sucrose concentration in sugar cane is greater than corn, by about 30 percent, and is much easier to extract. The bagasse, which is biomass remaining after sugarcane stalks are crushed to extract their juice, generated by the process is then utilized in power plants as an efficient fuel to produce electricity.

The United States ethanol industry is currently based largely on corn. Other crops, such as switch grass, can also be utilized. Corn is currently used because an infrastructure is already in place in the United States. Corn growers have a large lobby and receive huge government subsidies, and there are no incentives for farmers to start growing grasses instead (Lewin, 2006). Corn is very nutrient dependant, and removes nutrients, especially nitrogen, from the soil in just a few years of being grown. This requires the corn fields to be rotated with other crops every two or three years so the depleted nutrients can be reintroduced into the soil. Switch grass does not remove nutrients from the soil like corn does. Switch grass is much easier to grow and will grow in less desirable conditions than corn, because it does not have the nutrient and water requirements of corn. It is also a perennial grass, so once planted, it will grow on its own in the following years. Not having to cultivate fields and plant seeds every year, as corn farmers do, will save tremendous amounts of time and energy. For these reasons, switch grass is looking to be a promising alternative to corn in the production of ethanol, and may replace corn as the main ethanol producer in the future.

Ethanol produced from corn requires a large amount of fuel. David Pimentel, a professor from Cornell, has done the analysis. An acre of United States corn can be processed into about 328 gallons of ethanol. But planting, growing and harvesting that much corn requires about 140 gallons of fossil fuels and costs $347 per acre, according to Pimentel. That is $1.05 per gallon of ethanol before the corn even moves off the farm. The energy economics get worse at the processing plants, where the grain is crushed and fermented. As many as three distillation steps and other treatments are needed to separate the ethanol from the water. All these need energy. Adding up the energy costs of corn production and its conversion to ethanol, 131,000 BTU are needed to make 1 gallon of ethanol which has an energy value of only 77,000 BTU. "Put another way," Pimentel says, "about 70 percent more energy is required to produce ethanol than the energy that actually is in ethanol. Every time you make 1 gallon of ethanol, there is a net energy loss of 54,000 BTU." Some reports have been published claiming ethanol made from corn to be a net energy gain. Marland and Turhollow conducted a study in 1991 and found a net energy gain of 18,324 BTU. A study was also conducted by Morris and Ahmed in 1992 finding a net energy gain of 25,653 BTU. Differences among these studies are related to various assumptions about corn yields, ethanol conversion technologies, fertilizer manufacturing efficiency, fertilizer application rates, and the number of energy inputs included in the calculations.

According to the Renewable Fuels Association, as of November 2006, 107 grain ethanol bio refineries in the United States have the capacity to produce 5.1 billion gallons of ethanol per year. An additional 56 construction projects are underway in the United States that will add 3.8 billion gallons of new capacity in the next 18 months. Over time, it is believed that a material portion of the 150 billion gallon per year market for gasoline will begin to be replaced with fuel ethanol (Renewable Fuels Association, 2006).

Ethanol production using corn requires 29% more fossil energy than the ethanol fuel produced (Lang, 2005), and that is currently the most common method of ethanol production. Currently, corn produces approximately 330 gallons of ethanol per acre, and is forecasted to produce 530 gallons per acre in the next ten years. The United States uses about 150 billion gallons of gasoline per year. So, to fulfill demand, we must plant over 500 million acres, or 780,000 square miles of corn. This is equivalent to the area of Texas, Montana, California, Arizona, and Nevada. Because farming that much corn is not practical, ethanol from corn will not solve our upcoming shortage of oil.

. As a possible partial solution, or at least a transitional solution to filling the upcoming transportation gap that the absence of oil will create, ethanol does have the positive side of being a mostly carbon neutral alternative, as shown in Figure 4. The ethanol begins as corn, which uses CO_2 as it grows. Then the corn is processed into ethanol and used in a vehicle as fuel. The vehicle releases the CO_2 that the corn retained during its growing stages back into the atmosphere. The next crop of corn will then reabsorb the carbon dioxide, and start the carbon cycle shown in figure 4. Corn ethanol is only “mostly” carbon neutral because there are outside energy sources needed. Tractors farm the corn and distilling plants produce the ethanol, and both use energy that is not derived from the corn.   There are also other toxins released. The emissions of nitrogen oxides by the burning of ethanol and methanol are similar to those of burning petroleum (Berinstein, 2001).

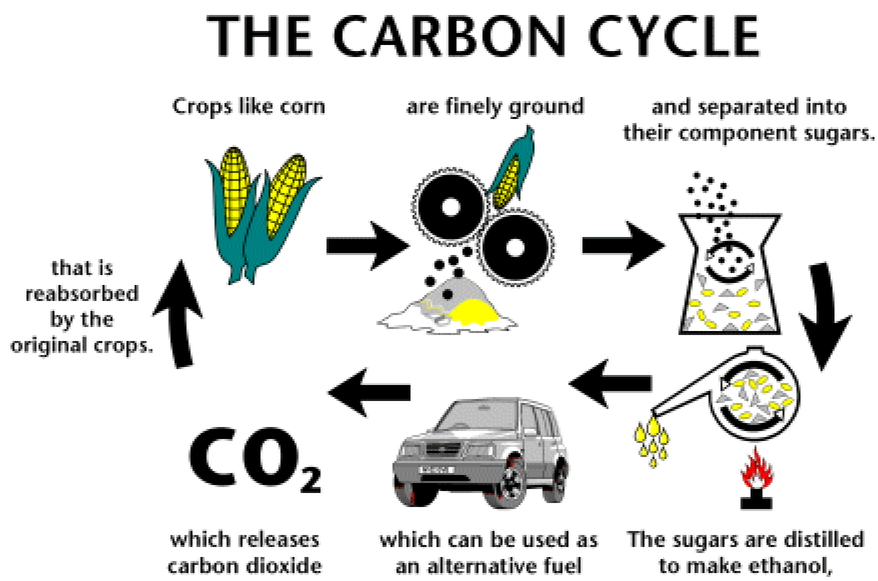


Figure 4

Hydro power

We list hydro power under alternative energy, although many will argue it is a conventional energy source. This is due to its longstanding use, developed infrastructure, and technological maturity (Berinstein, 2001). Hydroelectric generation is very efficient with low environmental risks. The energy can be produced twenty-four hours a day, and creates minimal pollution. The cost of Hydroelectricity is between five and eleven cents per kilowatt hour. In 1997, Hydroelectricity made up roughly 10% of all electricity generated in the United States, having 79,795 megawatts of generating capacity (Berinstein, 2001). The generating capacity is not likely to grow in the future for the United States, because we have developed nearly all possible dam sites already. The few remaining sites have been untouched yet, mostly due to regulatory issues, environmental considerations, economics, and public opposition. Although the cost of this energy is low, the damming of rivers required to harness the energy is extremely disruptive of animal and plant habitats. We must typically flood millions of acres of land, often completely altering the surrounding habitat from a shallow fast moving river to an extremely deep reservoir. The dams also cause problems for fish that move upstream for breeding and migration purposes. This problem has been remedied by creating side channels for the fish to be able to continue past the dams. Evaporation from the reservoirs also concentrates minerals and changes the overall composition of the water. Another major issue with hydroelectricity is not building the dam, but decommissioning the dam. Lake Mead, the reservoir behind the Hoover Dam, has a volume of just over 35 km^2 (Bureau of Reclamation, 2006). This is about two years flow of the Colorado River, which fills the reservoir. If some major problem was found and the dam needed to be removed, doing so without flooding everything downstream would be extremely difficult. Although this is a clean source of energy, it will decline through 2020, as regulation limits generation at the existing sites, and there are no large new sites available for development (Berinstein, 2001).

Wind Power

Wind energy is an extremely efficient, cheap, and clean alternative. We can only build wind farms in certain regions of the country where the average wind speed is above 10 mph, for practical purposes, in areas shown in Figure 6. Wind speeds that are below that average would not be economically beneficial, because the generators would not create very much electricity. The windiest regions are in the nations interior in the Great Plains regions, and along the east and west coasts. This is a limitation on how much wind energy that we can produce.

The installed wind energy generating capacity of the United States totaled 9,149 MW in 2006, and was expected to generate about 24.8 billion kWh of electricity. Wind Power currently supplies 1% of the nation's electricity. The total amount of electricity that wind power could potentially generate from wind in the United States has been estimated at 10,777 billion kWh annually—three times the electricity generated in the United States today. Although we know that wind energy has great potential, many experts believe that only 6% of our energy demands will be met through these means by the year 2020 (AWEA, 2005). The top three states alone could potentially supply all the electricity that this nation uses every year. North Dakota alone can provide one-third of the electricity that this nation currently uses (AWEA, 2007). Using wind farms as a large portion of electrical supply can work, as Denmark creates 20 percent of their electrical power by using wind energy (AWEA, 2007). Worldwide wind harnessing created 73.9 GW of electricity in 2006, and is expected to be up to at least 160 GW by the year 2010 (WWEA, 2007). Although the numbers are doubling, they are still much too small to make the difference that they can.

Wind energy costs between four and six cents per kWh without production tax credit, and between three and five cents per kWh with production tax credit (Berinstein, 2001). As technology advances, we expect the price for wind energy to drop below three cents per kWh, without tax credit, by the year 2013. This would make it much more cost competitive with coal and natural gas in the electricity production sector. When state and local governments introduce more tax incentives, and technology continues to lower prices of equipment, wind energy will soon replace coal and natural gas plants, using them only as back-up during peak demand for electricity.

The environmental considerations that may be of importance are disrupting wildlife and possibly erosion (Berinstein, 2001). Large wind farms will also produce noise, although the noise would be noticeable only to near by homes. The wildlife at risk would be airborne animals, and the possibilities that they may fly into these 30+ story wind machines. There is also the possibility for erosion to take place, if there is nothing planted around the wind farm. Areas most susceptible to this would be in the desert, where erosion happens continually every day.

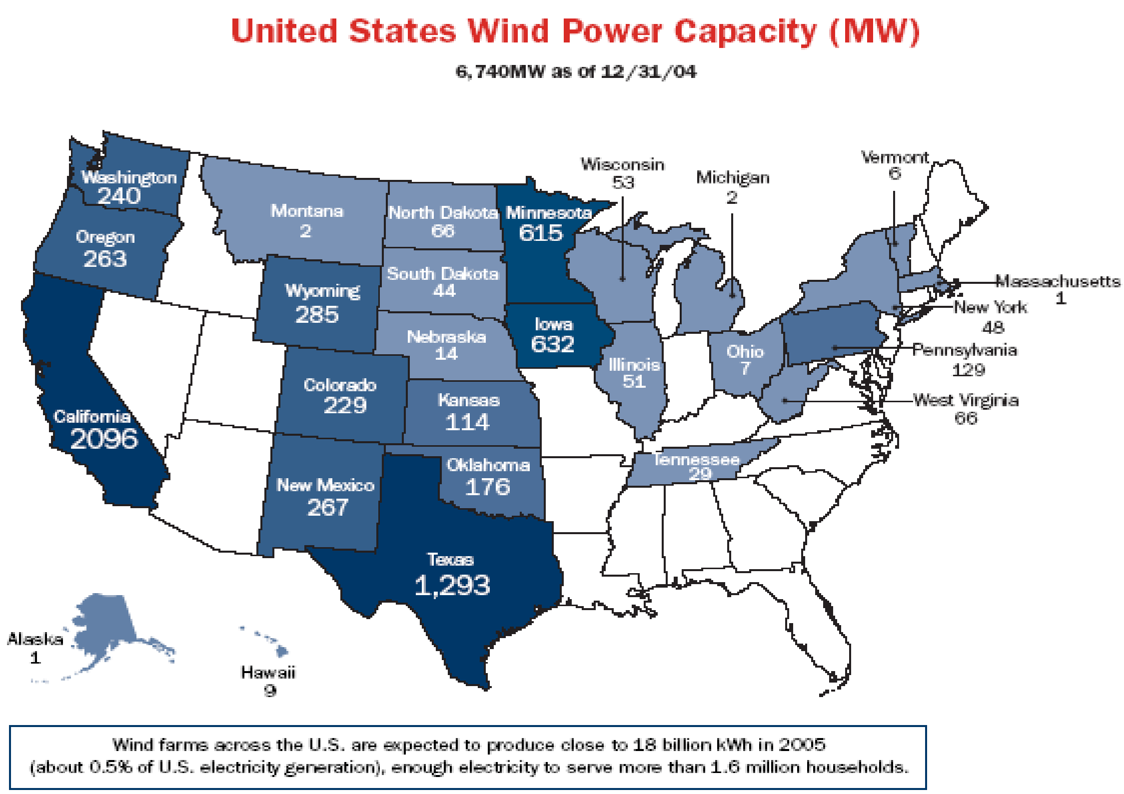


Figure 5

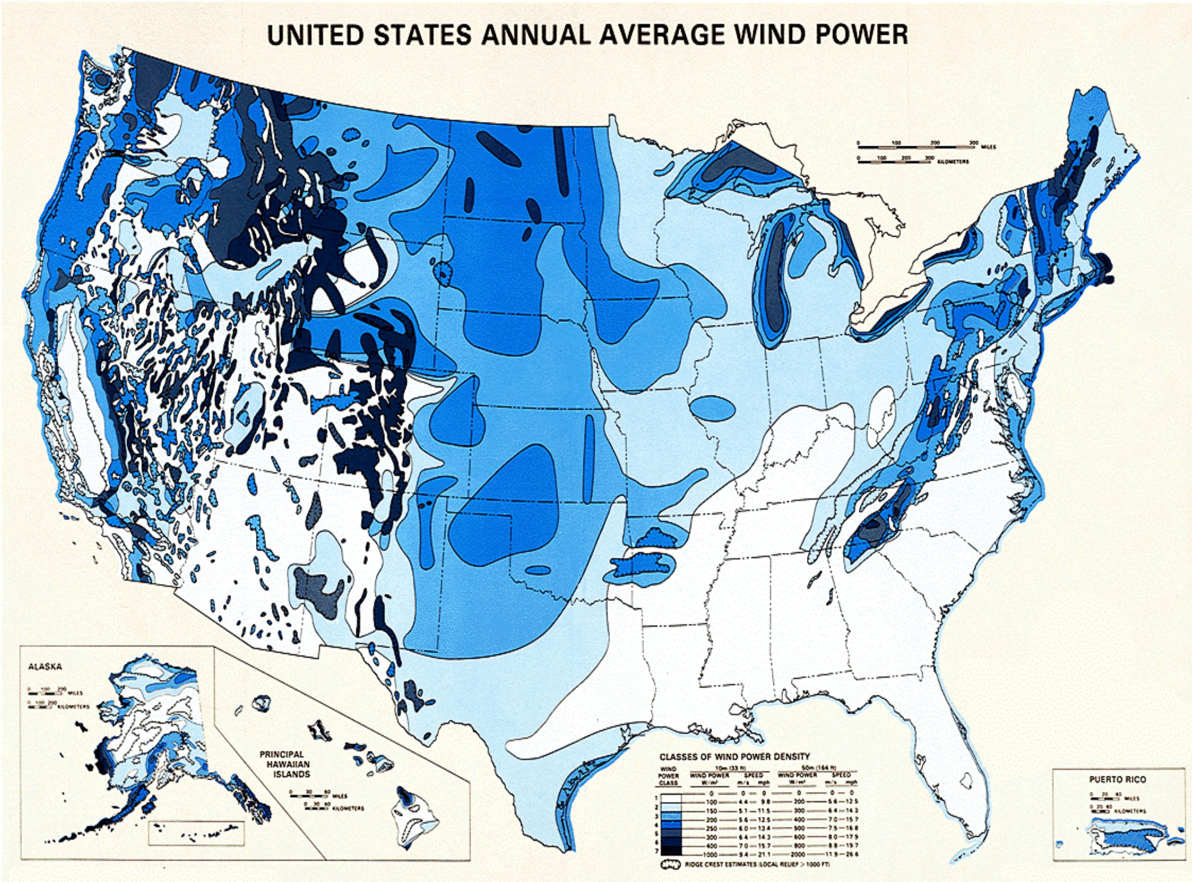


Figure 6

THE TOP TEN STATES for wind energy potential, as measured by annual energy potential in the billions of kWhs, factoring in environmental and land use exclusions for wind class of 3 and higher.

1 North Dakota 1,210
2 Texas 1,190
3 Kansas 1,070
4 South Dakota 1,030
5 Montana 1,020
6 Nebraska 868
7 Wyoming 747
8 Oklahoma 725
9 Minnesota 657
10 Iowa 551

Source*: An Assessment of the Available Windy Land Area and Wind Energy Potential in the Contiguous United States, Pacific Northwest Laboratory, 1991.*

Solar power

Solar power can be broken into a few different categories. They are passive, active, and photovoltaic. Passive solar power is something that everyone can harness virtually for free. Simply defined, passive solar is energy that we can harness without any mechanical means. Typically passive energy is used in housing and buildings to keep them warmer in winters and cooler in summers. Placing windows properly in a house or building can significantly decrease the heating required by a furnace during the winter. When building a new house, if placement, shape, and building materials are considered when planning, the house can be virtually independent of a heating and cooling system.

Active solar systems use solar collectors and additional electricity to power pumps or fans to distribute the sun's energy. The solar collector is a black absorber that converts the sun's energy into heat. This heat is then transferred to another location for either immediate heating, or stored for later use. The heat is transported by circulating water, antifreeze, or sometimes air. Applications for active solar energy include heating swimming pools, domestic hot water use, ventilation and industrial air and water needs for commercial facilities such as Laundromats, car washes, and fitness centers. This application alone could save nearly 20 percent of the energy that goes into a private houses' hot water heater (Natural Resources Canada, 1987). Energy saved at a house that has a heated pool or spa could potentially double if solar water heaters replaced natural gas or electric water heaters.

Photovoltaic (PV) solar power is perhaps the most commonly thought of kind of solar energy. PV solar cells convert the sun's radiation directly into electricity. PV solar power is currently available at an efficiency of 12-18%. Just recently the Department of Energy funded a newly developed concentrator solar cell produced by Boeing-Spectrolab, which has achieved a world-record conversion efficiency of 40.7 percent, establishing a new milestone in sunlight-to-electricity performance. This breakthrough may lead to systems with an installation cost of less than the current $3 per watt, producing electricity at a cost of 8-10 cents per kilowatt/hour, making solar electricity a cost-competitive and integral part of our nation's energy mix (United States Department of Energy, 2006). This new technology will also become an integral part of the alternative energy conversion to come. In 1997, solar power was responsible for 334 MW out of the 95,303 MW of renewable energy generated during that year (Berinstein, 2001). This amount is a minuscule fraction of the electricity that wind or hydroelectric dams are creating. Most of the solar electricity harnessing is currently taking place in Europe and Asia, and oddly enough, most of the products are from American companies. (NESEA, 2001).

There are some disadvantages to using PV systems. PV solar power only works when the sun is shining. This means that the electricity needs to be stored somewhere to be used during the nighttime or cloudy days. PV systems usually store the energy in batteries. The electricity generated by PV systems is also in direct current (DC), whereas power from utility companies is alternating current (AC). This requires a converter, which is another component that must be purchased. These many components quickly increase the price for installing a complete PV system. Companies are working on this obstacle. Many opponents to solar electricity argue that more energy is used to produce solar cells than they will produce during their lifetime. A study by Fthenakis and Alsema in 2006 showed that systems will typically produce at least ten times the energy required to produce the system, as shown in figure 7. A 5,000 watt system with storage batteries, which is sufficient to run a typical suburban home with air conditioning, is rated to last for twenty-five years. At an installation cost of $4 per watt, the consumer would end up paying between twenty and thirty cents per kWh over that time (Berinstein, 2001). Now installation costs are near $3 per watt, dropping the cost per kWh to between fifteen and twenty-two cents. As PV technology advances, costs will continue to drop, making it a much more affordable option.

System Energy Payback Times for Several Different Photovoltaic Module Technologies

(1700 kWh/m^2/yr insolation and 75% performance ratio for the system compared to the module.)

Cell Technology	**Energy Payback Time (EPBT)[1] (yr)**	**Energy Used to Produce System Compared to Total Generated Energy [2] (%)**	**Total Energy Generated by System Divided by Amount of Energy Used to Produce System[2]**
Single-crystal silicon	2.7	10.0	10
Non-ribbon multicrystalline silicon	2.2	8.1	12
Ribbon multicrystalline silicon	1.7	6.3	16
Cadmium telluride	1.0	3.7	27

(Fthenakis and Alsema, 2006)

Figure 7

Biomass

Biomass is another alternative source of energy. The term biomass refers to any organic material, living or recently living, which can be used to create energy. Trees and plants constitute a large portion of this category, although garbage waste and sometimes animal waste is also used. These are a renewable source of energy, although they still emit CO_2 and other harmful gasses that fossil fuels do. The burning of trees, for example, will still emit carbon dioxide. The difference is that the tree is part of the "CO_2 Cycle," shown in figure 4.

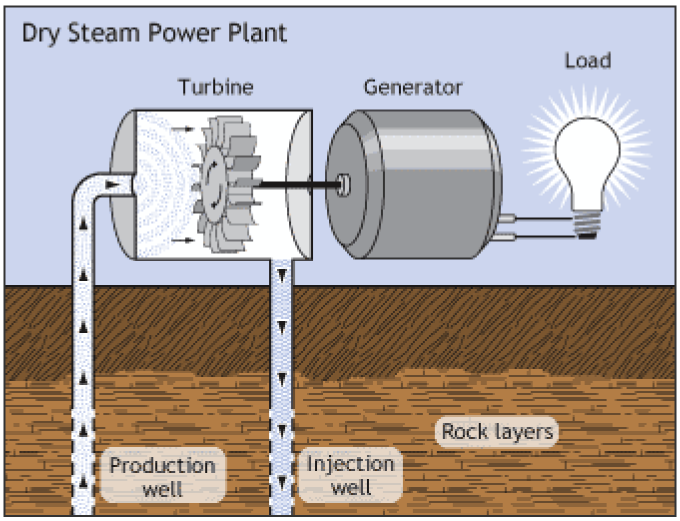
Biomass burning accounted for about 10,700 MW of generating capacity in 1997, which was about 10 percent of all renewable energy capacity for that year. The cost ranged from six to eleven cents per kWh. More than 500 facilities used wood or wood waste to generate electricity that year. In that same year, 112 waste to energy combustion power plants in the United States burned thirty-seven million tons, or about 17% of the country's municipal solid waste, to create electricity (Berinstein, 2001).

There are toxic metals and chlorinated compounds that municipal solid waste can produce when burned. Overall though, biomass is less harmful than fossil fuels, and can be another helpful transitional solution to get away from our fossil fuel dependency.

Geothermal

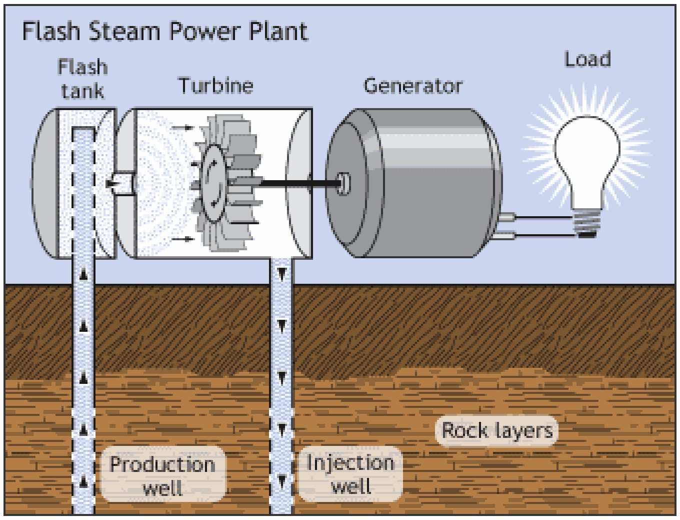
Geothermal energy is a form of alternative energy that uses heat stored under Earth's surface to provide energy. This makes geothermal systems efficient because the energy is not being converted. There are three different types of power plants; dry steam, flash, and binary, which are used to generate electricity. The type of plant depends on the temperature, depth, and quality of the water and steam in the area (United States Department of Energy, Energy Efficiency and Renewable Energy, 2006). In all cases the condensed steam and remaining geothermal fluid is injected back into the ground to pick up more heat. In some locations, the natural supply of water producing steam from the hot underground magma deposits has been exhausted, so processed waste water is injected underground to continue the supply of steam.

Dry Steam Power Plants



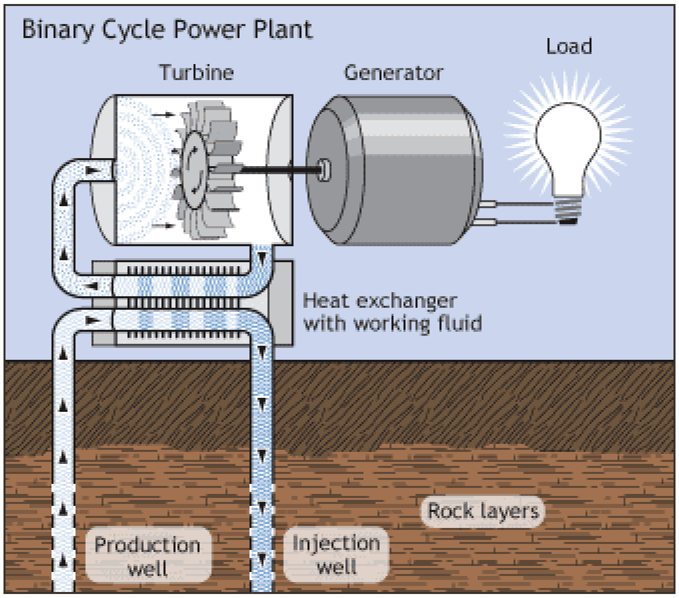
Steam plants use hydrothermal fluids that are already primarily steam. The steam goes directly to a turbine, which drives a generator that produces electricity. This is the oldest type of geothermal power plant. It was first used at Lardarello in Italy in 1904. Steam technology is used today at The Geysers in northern California, the world's largest single source of geothermal power. These plants emit only excess steam and very minor amounts of gases.

Flash steam Power Plants



Flash steam power plants use hot water, above 182 °C (360 °F), from geothermal reservoirs. The high pressure underground keeps the water in the liquid state, even though it is well above the boiling point. As the water is pumped from the reservoir to the power plant, the drop in pressure causes the water to convert, or "flash", into steam to power the turbine. Any water not flashed into steam is injected back into the reservoir for reuse. Flash steam plants, like dry steam plants, emit small amounts of gases and steam. Flash steam plants are the most common type of geothermal power generation plant in operation today. An example of an area using the flash steam operation is the CalEnergy Navy I flash geothermal power plant at the Coso geothermal field.

Binary-cycle Power Plants



The water used in binary-cycle power plants is cooler than that of flash steam plants, ranging from 107 to 182 °C (225-360 °F). The hot fluid from geothermal reservoirs is passed through a heat exchanger, transferring heat to a separate pipe that contains fluids with lower boiling points. These fluids, usually Iso-butane or Iso-pentane, are vaporized to power the turbine. The advantage to binary-cycle power plants is their lower cost and increased efficiency. Another advantage is that these plants do not emit any excess gas. Since they use fluids with a lower boiling point than water, binary cycle plants are able to utilize lower temperature geothermal reservoirs, which are much more common. Most geothermal power plants planned for construction are binary-cycle.

Geothermal energy also has smaller scale applications, such as heating and cooling homes. Geothermal systems are much simpler than the conventional natural gas furnaces that most houses have today. They are also much more efficient, granting payback generally within 5-7 years. These systems have a life expectancy of about 25 years, which means that homeowners essentially make money during that time. The most advantageous place to install a geothermal system is where temperatures reach both hot and cold, such as the northern United States and southern Canada. An enormous potential exists for heating and cooling houses and buildings throughout these countries, and other countries along the same latitudes. Geothermal heating and cooling systems do, however, work best in moderate climates. Their capabilities are less practical when temperatures reach the extremes found in the southern United States and northern Canada, for example. Residential and commercial applications of geothermal systems reduce the demand for electricity by approximately 50 percent, and reduce the demand for fossil fuels such as fuel oil, propane, and natural gas, by 100 percent. These systems are a more reliable and much cheaper alternative, and they benefit the environment, the energy crisis, and the consumer.

Geothermal electricity costs between two and eight cents per kWh. It was responsible for 2,854 MW of generating capacity in 1997, of a total renewable capacity of 95,303 MW, and a total capacity of 778,513 MW (Berinstein, 2001). This translates to about 3% of renewable capacity, and less than half of 1 percent of total capacity in the United States.

We can get large amounts of geothermal energy from Earth, but it is only reachable in certain locales around the globe. A concern is the mantle not being able to replenish the heat fast enough due to overuse, consequently cooling the reservoirs. This could lead to fewer magnificent eruptions of old faithful in Yellowstone, for example.

Current Environmental Concerns

Fossil fuel burning has many environmental impacts. Large amounts of gasses are emitted, such as carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_x), and sulfur oxides (SO_x). Nitrogen oxides and hydrocarbons can combine in the atmosphere to form tropospheric ozone, the major constituent of smog (UCS, 2005). Fossil fuels also emit suspended particulates. These byproducts of fossil fuel burning are harmful both to the environment and to humans. Using coal and oil causes health and environmental problems. Miners may get black lung disease. Mining and drilling damages land. Global climate change, acid rain, and water pollution cause environmental degradation. Security costs, such as protecting foreign sources of oil, increase.

The harmful emissions of gasses and particulates have been steadily increasing over the past century, even more so during the last few decades, and there are no signs of them slowing anytime soon. Scientists worldwide have linked the increase of CO_2 to the rise in global temperature, as shown in Figure 8. Atmospheric CO_2 never reached levels much more than 300 ppm over the last 400,000 years. During the Ice ages, the CO_2 levels hovered around 200 ppm. As Figure 8 shows, we are currently over 375 ppm, and at current levels of burning oil, gas, and coal, we will approach 700 ppm by the end of this century (Leggett, 2005).

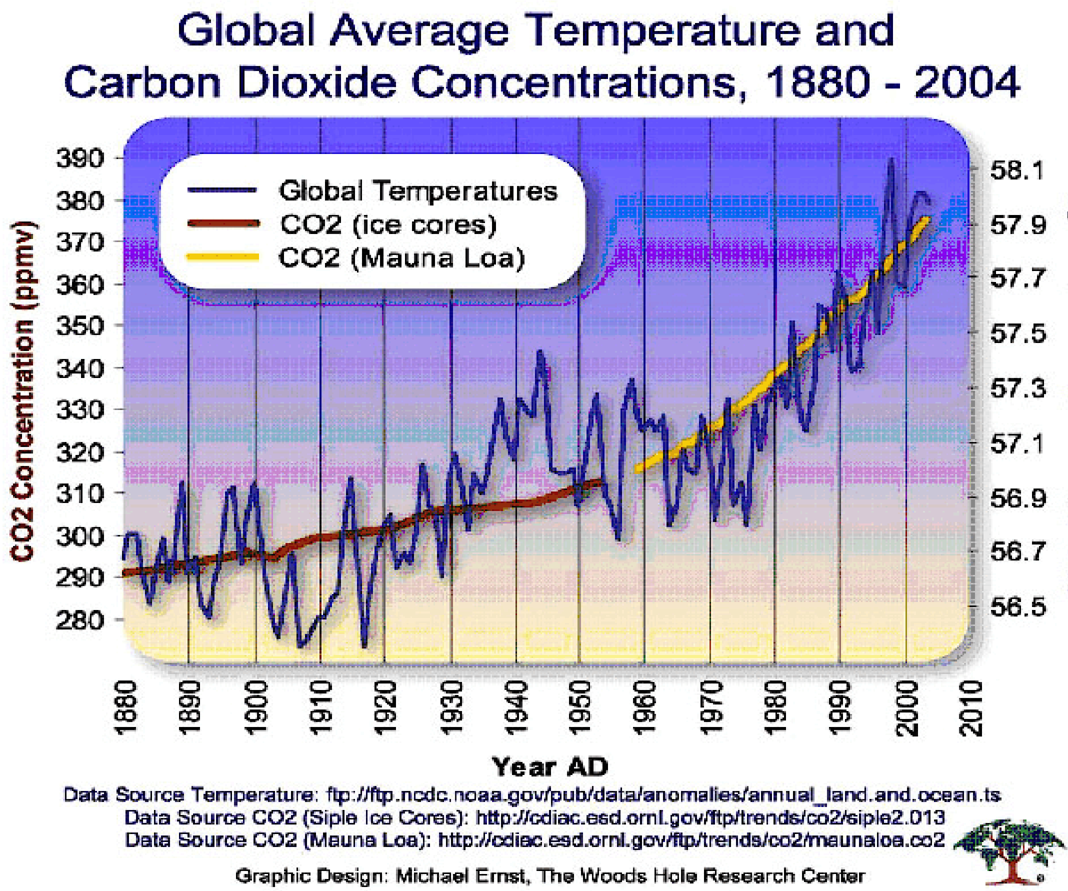


Figure 8

Since reliable records began in the late 1800s, the global average surface temperature has raised 0.5-1.1 degrees Fahrenheit (0.3-0.6 degrees Celsius). Scientists with the Intergovernmental Panel on Climate Change concluded in a 1995 report that the observed increase in global average temperature over the last century "is unlikely to be entirely natural in origin" and that "the balance of evidence suggests that there is a discernible human influence on global climate" (UCS, 2005). Climate scientists predict that if carbon dioxide levels continue to increase, the planet will continue warming during the next century. The current projected temperature increases will result in a variety of impacts. In coastal areas, sea-level rise due to the warming of the oceans and the melting of glaciers will lead to the inundation of wetlands, river deltas, and populated coastal areas. Altered weather patterns will result in more extreme weather events, as we have seen lately with stronger and more recurrent hurricanes. Inland agricultural zones will likely suffer an increase in the frequency of droughts. This scenario presents a plethora of problems for the world in the future. We will see decreasing food supplies, habitable areas, energy and electricity sources, and ultimately stability. Finding cleaner energy sources is a necessity in avoiding the worst of these circumstances. By using renewable and cleaner energy sources, we cannot only avert global pandemonium, but also allow Earth to try to reach its atmospheric equilibrium again.

Solutions

A single solution will not solve these imminent crises, but instead many different methods need to be implemented. This will be one of the largest obstacles to overcome, as everybody will need to change their current lifestyles. We only have a small amount of time to make these adjustments, so we need to start now. Failure to act quickly will result in a complete shock to the population and our economy. If we take steps to begin converting to more renewable and cleaner sources of energy and electricity, the conversion will be more widely accepted. Our energy needs to come from cleaner and renewable sources, and consumers need to modify their lifestyles. Simple actions such as recycling, installing more efficient light bulbs, walking and biking instead of driving, and keeping thermostats down during the winter can be taken by everyone. This will be very difficult for Americans, because we consume one fourth of the eighty billion barrels per day of oil produced worldwide (Eberhart, 2007), and 3,675 billion kilowatt hours of electricity, which is also about one fourth of the world total (Berinstein, 2001). We can also take other actions, such as using geothermal heating and cooling systems in housing and buildings, installing on-demand electric water heaters, re insulating houses, and installing better windows. Some of these suggestions may seem a bit insignificant, but these small steps are necessary now more than ever. United States citizens have greatly misinterpreted the size of the obstacle that our nation needs to overcome. We have been spoiled with uninterrupted energy supplies for our relentless demands. The public becomes outraged when the prices for our energy raise even the slightest amount, yet we still pay these increases, and our demand continues to grow. If we continue as we have been, we will run out of resources. If we make some changes, we will postpone the fossil fuel shortage, and will ease the transition to alternative energy sources. This needs to be a collective effort, from the highest levels of government down to the individuals of this country. Unbiased literature and media need to be made available to the public, from sources not associated with and paid by the large energy companies. Incentives need to be given to businesses and home owners to make the transition to more renewable and cleaner energy sources more appealing and affordable. Government needs to allocate more money to be used for research and development in renewable technologies and other alternatives. These are just some possibilities to get the change to happen.

Conclusion

Careful planning and prompt action can avert an unmatched national crisis. Waiting to take any action leaves us approaching the critical moment of no return, if we have not already passed it. We must find ways to educate the people of this nation, and the world, and overhaul the current energy system. We are very close to or possibly at peak oil production, and the decline of crude oil supplies will be a reality in the next decade. Natural gas reserves are not very far behind, and coal, although more abundant, will not last forever. Without any alternative options, people will either be forced to spend most of their income on energy, or perhaps may not be able to afford energy. This situation could be partially, if not wholly, avoided with an alternative energy system in place. Given enough time and will, we can develop alternative and renewable systems to replace hydrocarbon energy generation. Time, of course, is one thing of which we are desperately short.

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