ENERGY - Part One – EMM

INTRODUCTION

In this century our nation will face choices as we try to find new, cleaner, energy sources and learn ways to create or extract them. Over the next two unit meetings, we will examine all sources of energy—explaining and simplifying their effective output, costs, delivery system, environmental and human impacts, and suitability for use. The first session will focus on "old" technologies: coal, oil, gas, nuclear power and hydroelectric. The second will include newer technologies: wind, solar, ocean, biomass (including ethanol), and geo-thermal power. We will expand into new processes not viable on the commercial market at this time. In addition, the current American electric grid will also be explored.

LWVUS last studied energy and developed positions in 1978-79. Over the last 30 years many changes in science and technology have occurred dictating new ideas, concepts and policies. There is a possible need for LWVUS to restudy our energy position(s) to take into account advances made in these interim years.

COAL

Coal, a fossil fuel, is the largest source of energy for the generation of electricity world-wide. Coal is not only abundant, but is also wide-spread, occurring in many countries around the world. Twenty-seven countries have notable quantities of coal. The United States, China and India have immense coal resources: the US has 27.1% of the world's coal, followed by Russia 17.3%, China 12.6%, and India 10.2%. Today coal is used in the United States to produce nearly 50% of its electricity, and it is much cheaper than other fossil fuels such as gas and oil. Coal will continue to be used to meet the world's energy needs in significant quantities during the foreseeable future. China is currently constructing the equivalent of two 500-megawatt coal-fired power plants per week. The United States, as of June, 2009, had 36 coal-fired power plants under construction with a capacity of 19,421 megawatts.

The increased use of coal in countries like China and continued use in countries such as the United States puts a tremendous amount of CO^2 into the atmosphere and increases the threat of global warming. Much attention is being paid to the reduction of the amount of CO^2 being released. The only method that offers the prospect of preventing releases is carbon capture and sequestering (CCS) in which CO^2 is compressed into a liquid, pumped into naturally sealed geologic formations at depths of approximately 8,000 feet and stored forever. Suitably sealed geologic formations may be found in oil fields from which the oil has been extracted or in unexplored terrain--after careful study to assure suitability for a storage site.

Sequestering (CCS) could be used as a bridge to a sustainable energy future because it would successfully reduce CO^2 as a greenhouse gas from our atmosphere. Coal, used with CCS, then would become a clean fuel. However, in order to sequester the CO^2, it must be transported to a suitable site. To give some idea of the amount of CO^2 emissions that would have to be transported, consider that the United States produces about 1.5 billion tons of CO^2 per year. This quantity is equivalent to one third of the annual volume of natural gas transported by the U.S. gas pipeline system. Therefore, if all this CO^2 is to be transported for sequestration, an additional pipeline system, equivalent to one-third of the current U.S. gas pipeline system would be required.

COAL (continued)

Carbon capture and sequestration, at this point, is not feasible for political, economic and technical reasons. The technology is expensive and still unproved. Overcoming this problem would require a large investment of the federal government in research and development and determination of the cost of such an operation. Motivation to cause a coal-fired power plant to spend the money to build a CCS installation facility would have to be created by federal political activity. The government would have to impose laws to make it more expensive for a company to operate without a CCS installation through the payment of a carbon tax, fees, cap and trade regulations or other penalties, rather than installing a CCS facility. It has yet to be shown that a coal-fired power industry, operating under news laws and economic conditions would be able to compete successfully against renewable and nuclear energy power sources on a cost basis.

The long term future world supply of coal is also problematic. The United States Energy Information Administration gives world reserves (technically recoverable) of 930 billion short tons (equal to 843 gigatons) as of 2006. At the current extraction rate, this would last 132 years. However, the rate of coal consumption is annually increasing at 2.3% per year and setting the growth rate to 2.5% yields an exponential depletion time of 56 years or the year 2065.

PETROLEUM (OIL)

Since the invention of motor vehicles, gasoline has been our major source of energy for transportation, (99%), and oil is accountable for 40% of our overall energy use. Oil reserves in the U.S. peaked in the 1970’s, and the world’s oil supply is estimated to peak in 2020-2050. The national peak meant that the U.S. had to import more oil to meet demand. According to the Energy and Information Agency, the United Sates imported 58% of its oil in 2007, mostly from the Western Hemisphere: Canada 18%, Mexico 11.4%, Venezuela 10.9%, Saudi Arabia 11%, and Nigeria 8.4%. Of the 42% of oil produced here, fields are located primarily in Texas, Alaska, California, Oklahoma, and Louisiana, one-fourth of Louisiana’s is from off-shore. The U.S. consumes 24% of the world’s total production, 20.7 million barrels per day. New discoveries continue to be made, but at an ever decreasing rate, so production continues to go down. Even new production from the potential opening of Alaska’s Arctic National Refuge or off-shore areas will not reverse the trend.

OIL SHALE

The United States has the largest known deposit of oil shale in the world, according to the Bureau of Land Management. America’s oil shale reserves are enormous, totaling at least 1.5 trillion barrels of oil. That’s five times the reserves of Saudi Arabia. At present, there is no commercial production of oil from oil shale in the U.S. because the price of oil is not high enough or stable enough to justify the investment to develop it. Oil shale does not contain oil, but rather a waxy substance called kerogen. Sometimes the name oil shale is confused with the shale rock, a source of natural gas. In December 2008, Shell Oil Company filed for 375 cubic feet per second water rights on the Yampa River to fill a proposed reservoir for future use in production of oil shale.

NATURAL GAS

Natural gas, a fossil fuel, is abundant and readily available in most homes and businesses in the United States and produces about one half the CO^2 of coal when burned. Gas production has increased in the last few years due to higher prices and improved technology in horizontal drilling and hydraulic fracturing (fracking). Fracking forces water, sand, and chemicals at high pressure into rock formations, fracturing the rocks to allow the gas to be pumped out. Horizontal drilling inserts pipes and pumps into the producing formation at distances of thousands of feet and sometimes miles to give greater access to the producing areas. Many horizontal drill holes directed to many different areas are sited on a single drill pad, reducing the environmental impact compared to a separate drill pad for each hole. The combination of horizontal drilling and fracking has greatly increased the production of natural gas formations formerly considered to be nonproductive, thereby increasing reserves—technically recoverable resources.

Natural gas stockpiles in the United States are at an all time high at 3,589 trillion cubic feet. This increase in production comes from across the United States including Colorado's western slope. According to 2007-2008 records, growth in Texas is 15%, Wyoming 9%, Oklahoma 6%, Louisiana 4% and even a 2% growth in the Gulf of Mexico, which has been declining for years. The rest of the lower 48 states, as a group,

increased by 8%. Recent investigations show that natural gas distributed throughout the Marcellus black shale in northern Appalachia could, conservatively, boost proven U.S. reserves by trillions of cubic feet. The abundance of natural gas has prompted T. Boone Pickens to propose that this domestic fuel be made easily available for use in transportation to replace the importation of oil and increase energy independence.

Tremendous amounts of natural gas deposits are also located in oceans 500-1000 meters down. Methane hydrate, "burnable ice", a solid when kept cold and under pressure, is on top of this gas and acts as a shield. This hydrate is very unstable and when exposed to higher temperatures will give off 160 cubic cm. of methane for every cubic cm. of hydrate. Releasing this gas into the atmosphere would be very bad for the environment. This is similar to what is happening in the Arctic today as the permafrost melts.

Technology has not yet been developed that will allow us to capture this natural gas without CO^2 emission damage. Recently Japan National Oil Corporation has obtained successful results in experimental production of methane gas by injecting hot water into a borehole in the Mackenzie Delta in the Artic region of Canada. Methane is a principal component of natural gas, which although harmful if released into the atmosphere is useful if captured. Japan's intention is to develop the Nankai Trough that would give Japan a 100 year supply of gas. Our own continental shelves have some of this same kind of formation.

NUCLEAR ENERGY NOTE: An asterisk* indicates that a definition is given below

An atomic nuclear bomb (a clean one) was dropped on Hiroshima killing 140,000 people. Within two years, other people were living on the site, and it is now a city of 1.1 million people. Chernobyl (a Russian nuclear power plant) exploded, and people will not be able to get near the area for 125,000 years. This is the difference between a clean bomb and a dirty one. The point is that not all nuclear is alike.

Worldwide there are 435 reactors producing 370 gigawatts (GW) of power. Currently in the US, we have 104 licensed nuclear power plants (66 active) producing 20% of our electric power. Most of these plants, located in the east, are 30+ years old. The St.Vrain nuclear plant in Colorado has been closed for about 25 years. Twelve days after the movie “China Syndrome” was released, the Three Mile Island incident occurred, and the U.S. public reaction to the dangers of nuclear energy has prevented the building of nuclear plants here for the past 30 years.

Nuclear power plants emit no CO^2 into the air, making it a clean fuel in regard to global warming. As a result, they are being examined again by many (26 new applications), including the current administration, as a future energy source. “Existing nuclear power plants prevent the release of nearly as much carbon as American cars now release.”(*Time*, 1/12/2009) Over the course of 30 years, new developments have taken place in nuclear energy. France has built many new recycle-type nuclear power plants, and 77% of its electricity comes from this energy source. According to *Time* the demand for electricity will increase an additional 30% by 2030, and many feel that nuclear power has to be part of the mix in a new energy package. The U.S. Department of Energy (DOE) would like us to consider three choices on nuclear energy.

The first is to do nothing: just keep the plants we have, maintain them the best we can, and find more on-site fuel storage sites. This would be the cheapest method. Our present systems are called “once-through fuel cycle.” Uranium ore is first enriched.* Then the fuel rods are fabricated* and are placed into a light water reactor.* After about three months the rods are taken out, and stored. At present these rods (Spent Nuclear Fuel – SNF) are stored on site, above ground. This waste has a half life* of 125,000 years. The waste is set into a pool of water to cool, then incased in casks, then into 100 ton air-conditioned steel containers. After

30 years of on-site storage, these plants are running out of waste storage space. The waste storage issue must be solved if these sites are to continue. Buying more land adjacent to the present site or transporting waste elsewhere are the two options.

Yucca Mountain in Nevada was designated for nuclear waster storage. Eight billion dollars have been spent on developing this site for nuclear waste, but, so far, politics stand in the way of ever having this site used. Besides Nevada saying “no,” restrictions as to the radiotoxicity* of the proposed stored waste and the problems involved with transporting the SNF across state lines are issues.

Although the DOE supports continuing with the “old” reactors, it would like to see the U.S. move to one of the following two nuclear power methods below:

NUCLEAR ENERGY (continued)

One method would create a new nuclear power plant system --"a closed fuel cycle"-- with the ratio of regular light water plants to fast reactors of 60 to 40. Fast reactors would be built as SNF recycling centers. These reactors would recycle spent fuel from our existing light water reactor plants creating new fuel made of uranium waste with its other transuranic* elements. These plants could even use up some current nuclear waste, making more room for on-site storage at present sites. The end product would still create waste, but its half-life would be under 1000 years, and after separations of certain elements some of the waste would decay even faster -- 375 to 400 years. After a first recycle, this new SNF can be recycled several times. This system would require huge amounts of money for the building of fast reactors. Furthermore, SNF would have to be transported to the recycle reactor. Storage would remain a problem, but because of its lower half-life, decay would happen much quicker.

Another option is called Thermal/Fast Reactor Recycle. It differs mainly from the one above by being able to use our present thermal reactors for the first recycle process. Then, this new SNF would go on to a fast reactor. As a result it would be less expensive (fewer fast reactors required) and quicker to implement. Both options would require the licensing of the new fuel type and reprocessing. Reprocessing entails separating plutonium from SNF which has been banned in the US since the 1970's. DOE states that these reactors would be designed to avoid the separation of pure weapons grade plutonium.

Others have suggested a different option. This one would use thorium, an ore that is plentiful in many developing countries. The plus side of this system is that it does not produce plutonium (which could be used for a nuclear bomb) as a by-product. Its negative side is that its waste (SNF) would take 525,000 years to decay.

Opposition to nuclear power plants rests mainly on five things: 1) fear of a blow-up as in Chernobyl; 2) exposure of workers to high levels of radiation; 3. exposure of citizens in case of an accident when SNF was being transported; 4) fear that SNF could be stolen by terrorists and used to make bombs; 5) the financial cost of building nuclear plants.

The following are some of the answers to these concerns. 1) The Chernobyl reactor was very different from the ones used in America. The reactor at Three Mile Island (which did have an incident) worked properly and shut down with no deaths unlike Chernobyl. We use light water reactors in the U. S. 2) Workers are monitored for radiation levels. Greenpeace estimates that until 2007 at least 4,100 people have died from nuclear power accidents. However, not including falls, truck crashes, and other ordinary accidents, but only radiation exposure accidents, the number is four fatalities and 66 exposures (from 1945-1970). 3) Since all nuclear waste is stored on site, exposure due to SNF transportation is currently unknown. The DOE using mathematical probability charts estimates 130-280 deaths over 131 years, mainly due to transportation crashes. 5) Regarding stealing SNF and producing plutonium, the logistics of loading this nuclear waste (in 100 ton containers) without anyone noticing theft is unlikely. Moreover, terrorists would need a processing plant to separate out the plutonium. 5) The estimated cost to build one plant would be as high as $7-$13 billion and take up to 10 years to build.

NUCLEAR ENERGY (continued)

Two more objections to nuclear plants have been raised by David Fleming, environmental activist, author of <u>*The Lean Guide to Nuclear Energy*</u>*. First, he states that although nuclear only produces 16% of the* CO^2 *emissions that a gas–powered electric plant would emit (and gas -powered plants emit about 50% less than coal-powered plants), if the total life cycle of a nuclear power plant were taken into consideration, the* CO^2 *emissions levels would be much higher. The life cycle of nuclear begins with mining, either by "in-situ", wherein leaching also occurs, or open pit wherein many trucks, bulldozers, cranes and grinding equipment are in use and producing* CO^2*; and then the enriching of the "yellowcake"* uranium, and eventually the decommissioning of the plant when it ages and is disposal of, he concludes that nuclear is not carbon free.*

His second argument is that uranium, although found everywhere throughout the world in phosphates and even seawater, does not give a PREI (practical return on energy invested) to get it into the state that can be useable for a nuclear reactor. Sixty-five thousand tons of uranium are now consumed in a year; 40,000 from mines, 10,000 from salvaged nuclear weapons (bought from Russia), 15,000 stored or recycled from tailings. He projects that the world's uranium supply is between 70 and 270 years and toward the end of this time we will be using very poor grade uranium, and thus using more energy to get to the 3.5% purity required for reactors. He concludes that between 2010-2019 some nuclear reactors will close for lack of fuel.

France in the 70's made a decision to come up with their own energy source so that they would not be held hostage to the coal and oil supplies coming from Russia and the Middle East. France's decision was based on national policy. If U.S were to build more nuclear capacity, it is clear that our federal government would need to provide funds for the project, enforce federal eminent domain over state's rights, and provide government-issued liability insurance. Thirty countries currently operate nuclear reactors; 35 plants are now under construction outside the U.S. There is talk of creating a Nuclear Fuel Bank. Only a dozen nations have enrichment plants. This "bank" would supply enriched uranium, free of plutonium, "so that countries could access peaceful power without increasing the risks of proliferation." (Obama)

NUCLEAR ENERGY DEFINITIONS:

Enriched uranium - Uranium needs to be enriched in order to make it easier to fission in light water reactors. Uranium ore contains only .7% uranium. It needs to reach a concentration of 3.5% in order to be usable in a reactor.

Fabrication – creation of ceramic-like pellets from enriched uranium and placing them to 12' rods

Half-life – the time it takes for the material to decay to 50%. Then the next half-life is another 50% of the remaining 50%, etc., until fully decayed. The half-life of Chernobyl's curie release was 5 to 8 days. Half-life of U-238 = 4.5 B years: half-life of thorium = 4.5 B years x 3

Radiotoxity – measures the radiation level remaining in a mineral.

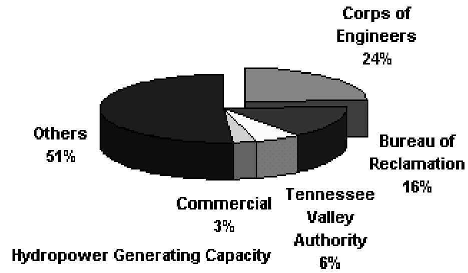
Reactors work when enriched or non-enriched (need heavy water, D_20) uranium is bombarded with neutrons, causing fission. The rods are pulled in and out of the reactor to control the speed of the reaction. Water cools the system so that it does not overheat and cause a meltdown. The heat from the fission heats a secondary water system which creates the steam which is used to turn the generators that create electricity much like a coal plant's steam does. A **breeder reactor** is a reactor that has the ability to create plutonium. Plutonium must be extra pure to be used in a bomb.

Transuranic elements – during the fission process about 20 new elements are created from uranium; neptunium, americium, curium, etc; some with very long half-lifes.

"Yellowcake" is 80% uranium oxide, used in the intermediate step in the processing of the ore to enrichment. 1000 tons of uranium ore needs to be ground in order to produce one ton of "yellowcake". The remaining 999 tons of waste are low radioactivity waste.

HYDROPOWER (hydroelectric power)

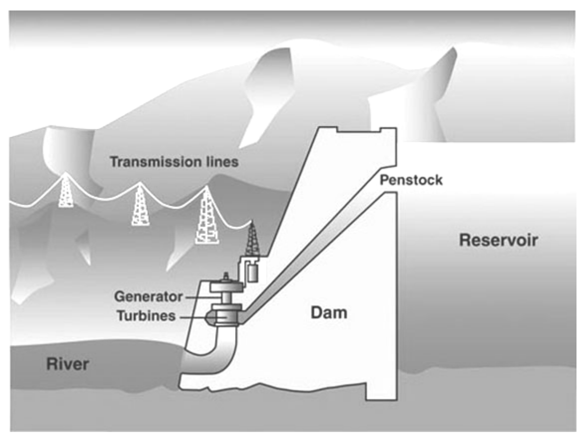
Hydropower facility operation costs are 2 to 4 cents per kilowatt-hour (kWh). In 2004, hydropower dams produced 270 billion kWh, which was about 7% of total U.S. electricity production and accounted for about 45% of total renewable energy consumption in the U.S. hydroelectric facilities can generate an average of 65 percent of their operating capacity—compared to about 25 percent for wind and 10 percent for solar. Only about 3 percent of the roughly 79,000 dams in the United States have hydropower plants and can generate electricity. Most dams are used for flood control and recreation, like the Chatfield Reservoir instead of power generation.



Most hydropower is produced at large facilities built by the Federal Government, such as Grand Coulee Dam on the Columbia River in Washington State - the largest single electric power facility in the United States. Most of the largest dams are located on rivers in the western United States, but there are numerous smaller facilities operating around the country. The US Corps of Engineers is the single largest owner and operator of hydropower in the United States. They have 75 power projects with a total of 349 generator units. The pie-chart to the right indicates the distribution of hydropower generating capacity in the U.S. The US Corps has a total capacity of 20.7 million kilowatts. The sale of hydroelectric power generated from units operated by the Corps of Engineers returns an amazing amount of revenue to the US Treasury each year. Worldwide China is the largest producer of hydroelectricity, followed by Canada, Brazil, and the United States. Canada is a major hydroelectric supplier to New York, New England, the Upper Midwest, the Pacific Northwest, and California.

<u>**Types of Hydropower Facilities**</u>

Impoundment Hydropower uses a dam to store water. Water may be released either to meet changing electricity needs or to maintain a constant water level.



Run-of-River Projects utilize the flow of water within the natural range of the river, requiring little or no impoundment. Run-of-river plants can be designed using large flow rates with low head or small flow rates with high head. Low or high head is the difference in elevation between the intake of the hydro system penstock and downhill to the input side of the water turbine.

Microhydropower Projects produce 100 kilowatts (kW) or less. Microhydro plants can utilize low heads or high heads.

Diversion Hydropower channels a portion of the river through a canal or penstock, but may require a dam. The Tazimina project in Alaska is an example that does not require a dam.

Pumped storage projects, using their own generated electricity, pump water from a lower reservoir to an upper reservoir at times when demand for electricity is low. During periods of high electrical demand, the water is released back to the lower reservoir to generate electricity for community needs. This type of hydropower facility is operated five miles south of Georgetown, CO at the Xcel Cabin Creek Station. This station has the ability to respond to increases in customer demand quicker than any other plant in the Xcel system.

HYDROPOWER (continued)

Hydropower is a renewable, efficient, and reliable source of energy that does not directly emit CO^2 gases or other air pollutants and that can be scheduled to produce power as needed. Problems with power generation do occur during the summer months when the natural water flow gets too small for hydro electric's functioning. In that case the dam must be sealed to maintain a water level at a biological minimum. It is predicted that the global climate change will cause a loss or reduction in production of electric power from hydroelectric plants due to low water/loss of snow pack. Like other energy sources, the use of water for generation has limitations, including environmental impacts caused by damming rivers and streams, which affects the habitats of the local plant, fish, and animal life. For example, this fish ladder (pictured to the left) on the Ice Harbor Dam on the lower Snake River provides safe passage for migrating fish. Another concern when accumulating water is earthquake protection. Long term problems include silt accumulation in the river bed or reservoirs and stress fractures that can lead to seepage through the dam.

Hydropower facilities in the United States can generate enough power to supply 28 million households with electricity, the equivalent of nearly 500 million barrels of oil. The total U.S. hydropower capacity—including pumped storage facilities—is about 95,000 megawatts. Researchers are working on advanced turbine technologies that will not only help maximize the use of hydropower, but also minimize adverse environmental effects.

Submitted by LWV Jeffco Energy Committee-
Cath Perrone, Ruth Wells, Jackie Busch, Brook Wilson, Gari Westkott, chair

EVERY MEMBER MATERIAL SOURCES:

Coal
World Coal Reserves, United States Energy Information, 2006, British Petroleum annual report, 2007
Carbon capture and Sequestration (CCS) World Resource Institute, 2009
The Future of Coal – An Interdisciplinary MIT Study, 2007, Massachusetts Institute Of Technology.
Petroleum
US News and World Report 4/2009 and Denver Post 7/11/09, 3/19,09
Energy Information Administration - Oil imports; How dependent are we on foreign oil?, 2007
Colorado Independent; David O. Williams 2/11/09, Jeff Ekert, Exxon Petroleum engineer
Natural Gas
U.S.News 4/09, Denver Post 6/12/09, 7/16/09, 4/22/09, 6/10/09, 9/2/09, 10/23/09, Progressive Populist 6/09
Department of Energy, Gas Hydrates, Japan Oil, Gas and Metals National Corporation
Wikipedia, LNG, shale gas
Energy Information Agency energy brief, 6/11/08, Earthworks – Hydraulic Fracturing 101
Nuclear Energy
US News and World Report 4/09, Time 1//12/09, Science magazine 6/13/08,
Parade Magazine World Nuclear Ass. –"Nuclear Power in the U.S.", Denver Post 5/20/09
Nuclear Lean Company   by David Fleming
NPR 3/28/09
Department of Energy," Global Nuclear Energy Partnership Impact Statement"/ kids page
Greenpeace.org/nuclear-reaction/2008
cddc.vt.edu/host/atomic/accident/redexpos.html (Trinity Atomic Web Site)
Hydropower
The Federal Energy Regulatory Commission, or FERC, is an independent agency that regulates the interstate transmission of natural gas, oil, and electricity. , National Hydropower Association, US Department of Energy, NewsNet.com / New Energy World Network

In this century our nation will face choices as we try to find new, cleaner, energy sources and learn ways to create or extract them. During the last unit meeting, we examined sources of energy ("old" technologies: coal, oil, gas, nuclear power and hydroelectric) -explaining and simplifying their effective output, costs, delivery system, environmental and human impacts, and suitability for use. Now, we continue that discussion to include newer technologies: wind, solar, ocean, geo-thermal and biomass (including transportation energy sources). We will expand into new processes not viable on the commercial market at this time. In addition, the current American electric grid will also be explored.

LWVUS last studied energy and developed positions in 1978-79. Over the last 30 years many changes in science and technology have occurred dictating new ideas, concepts and policies. There is a possible need for LWVUS to restudy our energy position(s) to take into account advances made in these interim years.

WIND ENERGY

Winds are created by the sun's uneven heating of the atmosphere, irregularities of the Earth's surface, and its rotation. Local terrain, bodies of water, weather patterns, vegetative cover, and other factors also contribute to wind flow. Wind is renewable and produces no greenhouse gases. Like water, wind can run turbines. Modern wind turbines range from 600 kW (thousand watts) to 5 MW (million watts) of power. Wind turbines with rated outputs of 1.5 to 3 MW have become the most common for commercial use. The power output of a turbine is a function of the cube of the wind speed. As wind speed increases, power output increases. Since wind speed is not constant, the capacity factor for actual energy production is 20%-40% of the theoretical maximum. The wind speed needed for a small wind turbine is 9 mph, while a utility scale wind turbine needs a minimum of 13 mph. Off shore or higher altitude sites are preferred locations for wind farms. Wind turbines also generate alternating current which is suitable for efficient transmission.

The average U.S. household uses about 10,000 kilowatt hours (kWh) of electricity each year. A kWh is 1000 watts of electricity produced or consumed in one hour. One MW of wind energy can generate 2.4-3.0 kWh annually (depending on the size of the turbine). Therefore, a MW of wind energy generates enough electricity to supply 240-300 households. In many parts of the US, a state of the art wind power plant can generate electricity for little more than five cents per kWh. In 2008, wind turbines in the US produced 48 billion kWh of electricity, enough energy to power 4.5 million homes for one year. If the equivalent electricity were produced using conventional fuel supplies, (largely coal and natural gas), 44 million tons of CO_2 would have been released into the atmosphere. Colorado wind farms generate 1,060 MW of power, enough to power 850,000 homes. The world's largest wind farm, Horse Hollow Wind Energy Center in Texas, has 735.5 MW capacities.

Globally, the technical potential of wind energy is believed to be five times the total current global energy production, or 40 times the current electrical demand. Wind power is growing at the rate of 30% annually, with a worldwide installed capacity of over 100 GW (100 billion watts) and 1.3% of global electricity consumption in 2008. Wind power accounts for approximately 19% of electricity in Denmark, 9% in Spain and Portugal, 6% in both Germany and the Republic of Ireland and 1% in the U.S.

A wind farm, installed on agricultural land, has one of the lowest environmental impacts of all energy sources. It occupies less land area per kWh of electricity generated than any other conversion system. It generates the energy used in its construction in three months operation, yet its operational lifetime is 20 to 25 years. Greenhouse gas emissions and air pollution produced by its construction are low and declining. There are no emissions or pollution produced by its operation. Modern wind turbines are almost silent. Improvements in their design, including much slower rate of blade rotation and a smooth tower base, instead of lattice towers upon which birds can perch, have helped reduce bird mortality.

WIND ENERGY (cont'd)

There are downsides to some wind farms, unintended consequences to landscape and wildlife. An example is the Elk River wind farm in Kansas. It will generate enough electricity to power 42,000 homes annually, but its towers have been built on some of the last remaining tall grass prairie, one of the most threatened habitats in the world. These grasslands also make up much of the habitat for ground-nesting birds, including imperiled species such as the lesser prairie chicken. The site is now sliced by 20 miles of road, 100 towers, transmission lines and a sizeable electric substation. Conservationists hope to steer wind farms into crop lands near developed areas.

Unlike coal-burning power plants and other sources of electricity, wind farms generally do not require federal permits. In states where rural areas have few zoning laws, it could be possible for a wind developer to sign a lease with a landowner and start raising turbines the next day. The Nature Conservancy and 21 other organizations from industry, government, and other conservation groups have been meeting to set up guidelines for siting wind farms. The group is discussing incentives for compliance ranging from a green power certification to a bonus on production tax credits, and although the final recommendations will be voluntary, it hopes that these guidelines might someday become law. A national set of maps overlapping wind and wildlife resources is crucial to correct siting. Maps have been created for Colorado, Kansas, Oklahoma, and Montana. The Conservancy has been awarded a contract by the American Wind and Wildlife Institute to create a wind and wildlife resource map for the entire country.

SOLAR ENERGY

Solar Thermal Energy devices use direct heat from the sun, concentrating it in some manner to produce heat and power. The amount of solar energy intercepted by the Earth every minute is greater than the amount of energy the world uses in fossil fuels each year. The solar energy industry began with the oil embargo of 1973-74 and was strengthened by another embargo in 1979. The growth of the industry during this period soared from 45 collector manufacturing firms to 225 firms. The solar industry was helped by both federal and state government assistance. As of 2009, there are six operational solar thermal power stations in the U.S. with overall operational capacity of 430 MW (million watts). This figure does not include any photovoltaic installations.

Solar energy can be applied in many ways to generate electricity. These various systems include: **Photovoltaics** or one of the **Concentrated Solar Power Systems**.

Photovoltaics (PV) is the field of technology and research involving the use of PV cells to convert sunlight (including ultra violet radiation) directly into electricity. A PV cell is made of a semi conducting material, usually crystalline silicone, with wires running through it. The heat of the sun excites the electrons within layers of the cell and the excited electrons jump back and forth creating electricity. While a single PV cell can power an emergency telephone, for the cells to power a home or power plant they must be combined into modules which then can be arranged in multiples as an array. The electricity generated by PV cells is direct current, the type used in batteries. To be used on the electric grid, the direct current must pass through an inverter which turns it into alternating current. The first practical application of PV modules was to power orbiting satellites and other spacecraft, but today the majority of PV modules are used in grid connected power generation. Although the selling price of PV module electricity is too high to compete favorably with currently generated grid electricity, financial incentives in Japan, Germany, Italy and France have triggered a growth in demand and increased production has, followed. A significant market has emerged in off-grid locations for solar power charged storage battery based solutions. These have the advantage of matching end-use energy needs, in terms of scale, close to where it is needed.

SOLAR ENERGY (cont'd)
Photovoltaics production has been doubling every two years since 2002. It is the world's fastest growing energy technology. At the end of 2008, global PV installations reached 15,100 MW, a 94% annual increase. Ninety percent of this capacity consists of grid-tied electrical systems. As of 2009, the largest PV power plants in the world are in Spain, 60 MW, Portugal, 46 MW, and Germany, 40 MW.

Concentrated Solar Systems are advanced systems that collect solar radiation and use it to heat water and other fluids to much higher temperatures appropriate for industrial needs. These include: Linear Concentrator, Dish/Engine and Power Tower.

- **Linear Concentrator Systems** collect the sun's energy by using long rectangular, curved mirrors which focus sunlight on tubes than run the length of the mirrors. The reflected sunlight heats a fluid flowing through the tubes. This fluid is then used to boil water in a conventional steam generator to produce electricity. There are two types of linear concentrator systems: parabolic trough and linear Fresnel. Their main differences are their mirror types and their relationship to the collector tubes. Overall efficiency of these systems from collector to grid, i.e. (electrical output) is about 15%. In the U.S., there are four operational parabolic trough thermal power stations, and two using the Fresnel reflector design. There are nineteen parabolic trough solar thermal power stations under construction in Spain.
- **Dish/ Engine System** uses a mirrored dish similar to a very large satellite dish. The surface directs and concentrates sunlight onto a thermal receiver which absorbs and collects the fluid heated by the receiver to move pistons and create mechanical power. The mechanical power is then used to run a generator or alternator to produce electricity.
- **Solar Power Towers** are used to create solar thermal power plants. These systems consist of a large field of sun tracking heliostats, (mirrored panels connected to clock works), which follow the sun and reflect the radiation they receive to the top of a very tall tower. A heat transfer fluid is heated in the receiver on the tower and is used to generate steam that is converted to electricity in a turbine generator. There is one operational solar thermal power tower plant in America. It is located in Lancaster, California and has a 5 MW capacity. There are three operating in Spain and one, the PS20 in Seville, is the largest in the world. It generates 20 MW of electricity and is powering 10,000 homes.

Solar Thermal Collectors are devices which collect direct rays from the sun to produce heat at useful temperatures for personal use only. They do not produce electric power. Some of the different solar thermal collectors are explained below.

- **Solar Domestic Hot Water Systems** are defined as either active or passive. Active systems use pumps and other controls to manage water circulation within the system, passive systems depend on thermodynamics to circulate the hot water. These systems can also be direct or indirect. In a direct system the solar heated water is transferred directly to a storage tank for use in the home. In an indirect system, solar energy heats an antifreeze fluid in a closed system that includes a heat exchanger. The heat exchanger then heats the domestic water in the storage tank. Direct systems can be subject to freezing in cold climates, indirect systems are not.
- **Solar Chimneys** improve cooling and ventilation in buildings by using convection of air heated by solar energy. The chimney is painted black to absorb the sun's heat during the day. The heated air in the chimney rises and pulls cooler air from underground heat exchange tubes to cool the building. On hot windless days the chimney can also provide ventilation. Solar chimneys have been in use for centuries, particularly in the Middle East and by the Romans.

SOLAR ENERGY (cont'd)

Solar Thermal Collectors (cont'd):

- **Solar Cookers** convert sunlight to heat energy which can then be used for cooking. The three most common types of solar cookers are heat-trap boxes, curved concentrators (parabolics) and panel cookers. 1- A box cooker is a dark insulated box with a lid and a glass or plastic window. It cooks at moderate to high temperatures and can use multiple pots. This stove is the most widespread in the world. There are thousands in India alone. 2- Curved concentrated cookers, or parabolics, cook fast at high temperatures, but require frequent adjustment and supervision. The pot sits in a parabolic reflector and doesn't need a heat trap. 3- Panel cookers incorporate elements of the box and curved concentrated cookers. A transparent heat trap around the dark pot lets in the sunlight, but keeps in the heat. The trap is a clear heat resistant plastic bag or large inverted glass bowl. The panel cookers are simple and relatively inexpensive to buy or produce.

Passive Solar Building Design (PSBD) uses a structure's windows, walls, and floors to collect store and distribute the sun's heat in the winter and reject solar heat in the summer, no pumps fans or electrical controls are used. During daylight hours, sunlight enters the building to warm it. At night, as temperatures drop, the stored heat warms the rooms. This is called direct gain. Buildings designed for passive solar must have these five elements: 1 - Large south-facing windows, collectors. 2 - Dark surfaces which attract sunlight, absorbers. 3 - Materials that store and slowly release heat, thermal mass. 4 - Conduction, convection and radiation to move heat from warmer spaces to cooler ones, distribution. 5 - Window shades and roof overhangs to adjust the amount of sunlight entering the building, regulation. A sunspace, a room or solarium with thermal mass, is required to store solar heat.

Unlike large electricity producing power plants, solar thermal hot water heaters, solar chimneys, solar cookers and passive solar building designs lend themselves to individual buildings and homes. This is a truly sustainable concept that, if used, would decrease our overall demand for electricity.

OCEAN ENERGY: TIDAL, THERMAL, and WAVE

Ocean energy is a form of renewable energy that uses the ocean's tides, waves, winds, currents and thermal elements to generate energy. Ocean energy has the potential to deliver ten million terra-watt hours of electricity per year. Here is a breakdown of these three energy forms gathered from the ocean:

TIDAL ENERGY

Tidal energy is the utilization of the sun and moon's gravitational forces. Tidal energy is a direct result of tide shifting from low to high and it's one of the oldest forms of energy. Today, tidal energy is exploited in two ways: (1) By building semi-permeable barrages across estuaries that have with a high tidal range (2) By allowing tidal waters to fill an estuary via sluices (pictured to the right) and to empty through turbines. Tidal streams can be harnessed using offshore underwater devices similar to wind turbines.

The technology required to convert tidal energy into electricity is very similar to the technology used in traditional hydroelectric power plants - dam, gates and turbines. There are three prototypes of tidal energy devices: horizontal axis turbine, vertical axis turbine, and oscillating devices.

The major advantage of tidal energy is its economical benefits. For example, tidal energy does not require any fuel. Tides rise and fall every day in a very consistent pattern. It has an efficiency of 80% in converting the potential energy of the water into electricity. Tidal power is non-polluting, reliable and predictable.

TIDAL ENERGY (cont'd)
Although the technology required to harness tidal energy is well established, tidal power is expensive, the cost of tidal energy is very site specific, and influenced by geography, distance to grid, and speed and volume of the current. Another disadvantage of tidal power is that it changes the sedimentation and turbidity (how clear the water is) of the water system. The altering of the ecosystem at the bay is the biggest drawback of tidal power. Damages like reduced flushing, winter icing and erosion can change the vegetation of the area and disrupt the balance.

There is only one major tidal generating station in operation. This is a 240-megawatt station at the mouth of the La Rance river estuary in France. At this location the difference between high and low tides averages 26 feet,, peaking at 44 feet during the equinox. Tidal barrages, undersea tidal turbines - like wind turbines but driven by the sea - and a variety of machines harnessing undersea currents are under development. Unlike wind and waves, tidal currents are entirely predictable.

OCEAN THERMAL ENERGY CONVERSION (OTEC)
A great amount of thermal energy (heat) is stored in the world's oceans. Each day, the oceans absorb enough heat from the sun to equal the thermal energy contained in 250 billion barrels of oil. Ocean Thermal Energy Conversion Systems (OTEC) systems convert this thermal energy into electricity — often while producing desalinated water. OTEC systems are envisioned as being land-based (or "inshore"), near-shore (mounted on the ocean shelf), or offshore (floating). All three types of OTEC use warm seawater to create steam which in turn moves a turbine. The main obstacle that hinders the OTEC implementation is the cost. Bringing down the cost to a more reasonable level is not that easy because of the method, which is used to drive OTEC.

The United States became involved in OTEC research in 1974 with the establishment of the Natural Energy Laboratory of Hawaii Authority. There is no OTEC facility currently producing electricity at Keahole Point. In September 2009, a new project on Kauai to generate clean, sustainable alternative energy from the ocean will receive $600,000 federal funds for ocean thermal energy conversion.

OTEC has important benefits other than power production. For example, air conditioning can be a byproduct. Spent cold seawater from an OTEC plant can chill fresh water in a heat exchanger or flow directly into a cooling system. Simple systems of this type have air conditioned buildings at the Natural Energy Laboratory for several years. The seawater provides about 50 tons of air conditioning, offsetting the equivalent of 200 kW of peak electrical demand. Using the cold seawater for air conditioning saves nearly $4000 per month in electricity cost - and the system requires much less maintenance than traditional compressor systems.

Chilled-soil agriculture is also supported by OTEC technology. When cold seawater flows through underground pipes, it chills the surrounding soil. The temperature difference between plant roots in the cool soil and plant leaves in the warm air allows many plants that evolved in temperate climates to be grown in the subtropics. The Natural Energy Laboratory maintains a demonstration garden near its OTEC plant with more than 100 different fruits and vegetables, many of which would not normally survive in Hawaii.

Aquaculture is perhaps the most well-known byproduct of OTEC. Cold-water delicacies, such as salmon and lobster, thrive in the nutrient-rich, deep seawater from the OTEC process. Microalgae such as Spirulina, a health food supplement, also can be cultivated in the deep-ocean water.

As mentioned earlier, another advantage of open or hybrid-cycle OTEC plants is the production of fresh water from seawater. Theoretically, an OTEC plant that generates 2-MW of net electricity could produce about 4,300 cubic meters (14,118.3 cubic feet) of desalinated water each day.

WAVE ENERGY

Wave energy is an irregular and oscillating low-frequency energy source that can be converted and can then be added to the electric utility grid. The energy in waves comes from the movement of the ocean and the changing heights and speed of the swells. Kinetic energy, the energy of motion, in waves is tremendous.

The total power of waves breaking on the world's coastlines is estimated at 2 to 3 million megawatts. An average 4-foot, 10-second wave striking a coast puts out more than 35,000 horsepower (this converts to a wave energy density of about 65 megawatts) per mile of coast. Three approaches to capturing wave energy are:

- Floats or Pitching Devices generate electricity from the bobbing or pitching action of a floating object. The object can be mounted to a floating raft or to a device fixed on the ocean floor.
- Oscillating Water Columns (OWC) generate electricity from the wave-driven rise and fall of water in a cylindrical shaft. The rising and falling water column drives air into and out of the top of the shaft, powering an air-driven turbine.
- Wave Surge or Focusing Devices, also called "tapered channel" or "tapchan" systems, rely on a shore-mounted structure to channel and concentrate the waves, driving them into an elevated reservoir. Water flow out of this reservoir is used to generate electricity, using standard hydropower technologies.

It is estimated that if 142 mile-long wave energy converters were installed all over the world's oceans, 2 terawatts of power would be harnessed — twice the consumption of the entire world. Portugal has built Agucadoura, the world's first wave farm off its coast. This wave farm has three wave energy converters which are producing a total of 2.25MW for 1,500 homes and saving 60,000 tons of CO_2 per year compared to a conventional fossil fuel plant.

GEOTHERMAL ENERGY

Geothermal Energy has been exploited for power generation since at least 1904. However, the last few years have witnessed a conspicuous revival in interest in geothermal technologies both old and new. In fact, 2008 was a watershed year for the industry. The U.S. Department of Energy (DOE) revived its Geothermal Technologies Program (GTP) with new funding that made possible substantial new investments in geothermal research, development and technology demonstration. The U.S. Department of the Interior's (DOI) and the Bureau of Land Management (BLM) also significantly increased the amount of Federal land available for geothermal exploration and development and worked to streamline the complex permitting and leasing process.

Geothermal Energy is defined as heat (thermal) from the Earth (geo). It is a clean, renewable resource that provides energy in the U.S. and around the world in a variety of applications and resources. Although areas with telltale signs like hot springs are more obvious and are often the first places geothermal resources are used, the heat of the earth is available everywhere. It is considered a renewable resource because the heat emanating from the interior of the Earth is essentially limitless. The current production of geothermal energy from all uses places third among renewables, following hydroelectricity and biomass, and ahead of solar and wind. Despite these impressive statistics, the current level of geothermal use pales in comparison to its potential. Geothermal energy can be used for electricity production, for commercial, industrial, and residential direct heating purposes, and for efficient home heating and cooling through geothermal heat pumps.

Geothermal Electricity: To develop electricity from geothermal resources, wells are drilled into a geothermal reservoir. The wells bring the geothermal water to the surface, where its heat energy is converted into electricity at a geothermal power plant. With an endless supply of heat from the earth, a plant can run 24/7, that makes it about five times as valuable as wind or solar.

GEOTHERMAL ENERGY (cont'd)

Current U.S. geothermal electric power generation totals approximately 2200 MW or about the same as four large nuclear power plants. The BLM estimates Colorado could produce 50 megawatts of geothermal electricity by 2025 – enough for about 50,000 households.

There are three types of geothermal power plants: dry steam, flash steam, and binary cycle.

Dry steam power plants- The steam is piped from underground wells to the power plant, where it is directed into a turbine/generator unit. There are only two known underground resources of steam in the United States: The Geysers in northern California and Yellowstone National Park in Wyoming, where there's a well-known geyser called Old Faithful. Since Yellowstone is protected from development, the only dry steam plants in the country are at The Geysers.

Flash steam power plants are the most common. They use geothermal reservoirs of water with temperatures greater than 360°F. The water flows up through wells in the ground under its own pressure. As it flows upward, the pressure decreases and some of the hot water boils into steam. The steam is then separated from the water and used to power a turbine/generator. Any leftover water and condensed steam are injected back into the reservoir, making this a sustainable resource.

Binary cycle power plants operate on water at lower temperatures of about 225°- 360°F. These plants use the heat from the hot water to boil a working fluid, usually an organic compound with a low boiling point. The working fluid is vaporized in a heat exchanger and used to turn a turbine. The water is then injected back into the ground to be reheated. The water and the working fluid are kept separated during the whole process, so there are little or no air emissions.

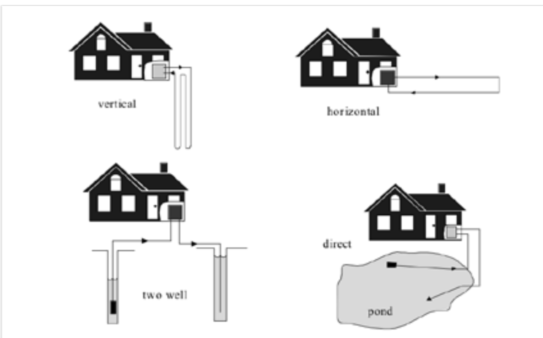
Air Quality / Emissions: No smoke is emitted from geothermal power plants, because no burning takes place; only steam is emitted from geothermal facilities. Emissions of nitrous oxide, hydrogen sulfide, sulfur dioxide, particulate matter, and carbon dioxide are extremely low, especially when compared to fossil fuel emissions. Even dry steam plants, which are considered to have the highest levels of air emissions, are considered environmentally benign compared with fossil fuels. For example, Lake County, California, downwind of the 21 power plants at The Geysers, has met all federal and state ambient air quality standards for almost 25 years. The air quality has been improved because hydrogen sulfide, which would ordinarily be released naturally into the atmosphere by hot springs and fumaroles, instead now passes through an abatement system that reduces hydrogen sulfide emissions by 99.9%.

Direct Geothermal: Geothermal heat can be used directly, without involving a power plant or a heat pump, for a variety of applications that include heating buildings (either individually or whole towns), raising plants in greenhouses, drying crops, heating water at fish farms, and several industrial processes, such as pasteurizing milk. Uses for heating and bathing are traced back to ancient Roman times. In modern direct-use systems, a well is drilled into a geothermal reservoir to provide a steady stream of hot water. The water is brought up through the well, and a mechanical system—piping, a heat exchanger, and controls—delivers the heat directly for its intended use. A disposal system then either injects the cooled water underground or disposes of it on the surface.

Currently, in the United States geothermal is being used for direct heating purposes in 26 states with a capacity that totals 470 MW or enough to heat 40,000 average-sized houses. New direct use projects are encouraged by the provisions of the Geothermal Steam Act Amendments passed by Congress in 2005. There is interest in new direct use projects in numerous states and on various Indian reservations within several states.

GEOTHERMAL ENERGY (cont'd)

Geothermal Heat Pump (GHP): The geothermal heat pump takes advantage of the shallow ground, the upper 10 feet of the Earth, constant temperature between 50° and 60°F. Like a cave, this ground temperature is warmer than the air above it in the winter and cooler than the air in the summer. The GHP can be used almost everywhere in the world, as it does not share the requirements of fractured rock and water as are needed for a geothermal plants. The Environmental Protection Agency considers them to be one of the most efficient heating and cooling systems available. GHPs reduce electricity use 30 - 60% compared with traditional heating and cooling systems, because the electricity which powers them is used only to collect, concentrate, and deliver heat, not to produce it.



The GHP circulates water or other liquids through pipes buried in a continuous loop, either horizontally or vertically, under a landscaped area, parking lot, or any number of areas around the building. Geothermal heat pump systems consist of basically three parts: the ground heat exchanger, the heat pump unit, and the air delivery system (ductwork). The heat exchanger is basically a system of pipes called a loop, which is buried in the shallow ground near the building. A fluid (usually water or a mixture of water and antifreeze) circulates through the pipes to absorb or relinquish heat within the ground.

The GHP delivery system distributes heat energy or cooling indoors via forced air; hydronic (water) or both air and water. In the winter, the heat pump removes heat from the heat exchanger and pumps it into the indoor air delivery system. In the summer, the process is reversed, and the heat pump moves heat from the indoor air into the heat exchanger. The heat removed from the indoor air during the summer can also be used to heat water, providing a free source of hot water.

The Air-Conditioning, Heating and Refrigeration Institute (AHRI) reported 2008 shipments of more than 71,000 units, indicating continued strong demand. The heat pump market still faces significant barriers, however, including: high installation and capital costs; a pervasive lack of consumer awareness; and insufficient market delivery infrastructure. In order for heat pumps to reach their full market potential, these barriers must be addressed through effective market conditioning strategies.

BIOMASS ENERGY

Biomass energy -the energy from plants and plant-derived materials- has been used since people began burning wood to cook food and keep warm. Wood is still the largest biomass energy resource today. Other sources include food crops, grassy and woody plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes. Even the fumes from landfills can be used as a biomass energy source.

The natural decay of biomass produces methane, which can be captured and used for power production. In landfills, wells can be drilled to release the methane from decaying organic matter. Then pipes from each well carry the methane to a central point, where it is filtered and cleaned before burning. This produces electricity and reduces the release of methane (a very potent greenhouse gas) into the atmosphere. Methane can also be produced from biomass through a process called anaerobic digestion. Natural consortia of bacteria are used to decompose organic matter in the absence of oxygen in closed reactors. Gas suitable for power production is produced, and possibly troublesome wastes (such as those at sewage treatment plants or feedlots) are turned to usable compost.

BIOMASS ENERGY (cont'd)

Biomass Power is the use of biomass to generate electricity. The United States is currently the largest producer of electricity from biomass having more than half of the world's installed capacity. Biomass represents 1.5% of the total electricity supply compared to 0.1% for wind and solar combined. More than 7800 MW of power is produced in biomass power plants installed at more than 350 locations in the U.S., which represent about 1% of the total electricity generation capacity. According to the International Energy Agency, approximately 11% of the energy is derived from biomass throughout the world.

Biomass energy is CO_2 neutral, which means the CO_2 produced is the amount ingested during the plants lifetime. A key attribute of biomass is its availability upon demand - the energy is stored within the biomass until it is needed.

Environmental concern about harvesting biomass for energy is that soil nutrients, organic matter and moisture-holding capacity may be depleted by intensive harvesting methods. Another concern is that deforesting will increase the global excess carbon dioxide problem because forests remove carbon dioxide from the atmosphere.

ENERGY SOURCES FOR TRANSPORTATION USE

The transportation sources have been placed together because unlike other sources, they must be portable and not connected to transmission lines (with the exception of the electric car, depending upon its recharging source). At present we are using gasoline, diesel fuel, and ethanol; all of which emit CO_2. We will include, in order, electric vehicles, hydrogen, fuel cells, and hybrid electric vehicles.

ALL-ELECTRIC VEHICLES (EV's)

All-electric vehicles (EV's) use a rechargeable battery to furnish all of the energy to power the vehicle's electric motor. The electric motor moves the car down the road and furnishes all the power needs (e.g. lights, computer, radio, GPS) for the vehicle. A typical EV requires up to 350 volts of electrical energy. These electric vehicles have a typical 100 to 150 mile range without needing a recharge for the battery. The mileage range is limited by the size of the battery and by the technology used to construct the battery. The EV operating on the road does not generate any CO_2; it does not even have a tail pipe. This zero emissions feature is one of the most desirable aspects of the electric car. . However, the electricity that is used to the charge EV's currently comes from the local electric power grid, and this electricity is generated almost exclusively from coal-fired electric power plants. Further, manufacturing the EV also creates emissions. Still, EV's will significantly reduce CO_2 compared to internal combustion engines, and when natural gas is used to make electricity, CO_2 emissions will be even less. Alternatively, if electricity comes from solar or wind power, EV's can eliminate all emissions.

The first company to successfully build and market an all-electric car is the Tesla Company located in California. Tesla has developed an electric roadster that uses new lithium ion battery technology that extends the mileage range to 310 miles and enables the vehicle to charge in less than 5 hours. For $109,000 one can own the sporty version. This car can compete in high speed, short distance automotive races with Ferraris, Porsches and Corvettes.

In the 1990's Chevrolet produced an experimental electric car. Their version, the Volt -1, was distributed to more than a 1000 participants in southern California for a multi-year test period that recently expired in 2005. It was a very successful program that many owners enjoyed. Chevrolet, however, collected all of the leased vehicles in March 2005 and sent them to the wrecking yard to end the program. At the time Chevrolet felt that the future lay with hydrogen fueled vehicles that had a greater mileage range.

ALL-ELECTRIC VEHICLES (cont'd)
A primary benefit of electric vehicles is that they are environmentally sustainable. However, there are other benefits, as well. EV's are easy to drive. They use only one speed control and a brake pedal. EV's are very quiet at all speeds; they don't idle and waste fuel; the power and drive train require much less maintenance and their tires are smaller and more efficient. They have a lower driving cost per mile (Tesla says 15,000 miles of driving costs $300.) Plug in versions of EV's can be recharged at home or at remote recharging stations located within a Smart Grid electric infrastructure. EV batteries can easily be removed and replaced with new fully charged batteries. The new lithium battery technology allows a battery to be recharged within a few minutes.

The main disadvantages are as follows: 1)--Cost.. The Lithium-ion battery is the heaviest and costliest item. Lithium is a metal that occurs naturally in nature and is easily extractable, but in limited quantities. So the EV may be trading one limitation for another. EV's are costly to produce under current manufacturing scenarios. EV's are costly to produce under current manufacturing scenarios. As more EV's are manufactured costs will diminish. 2)--Safety. EV's collision safety records are a big concern because the weight of a typical EV is less than half that for a standard internal combustion vehicle. 3)--Convenience. At present service stations are not set up to handle the recharging or replacement of the batteries for EV's.

These vehicles seem suitable only for site–based businesses where the vehicle can return to a recharging station or residential-local use where one can plug into one's own home electrical source. Recharging infrastructure is just beginning to be addressed here in Colorado and elsewhere in the U.S.

HYBRID ELECTRIC VEHICLE (HEV)
The Hybrid Electric Vehicle is an electromechanical system that uses two sources of energy, liquid hydrocarbon, i.e. gasoline, ethanol or diesel, and electricity from a battery. A typical HEV is expensive ($26,000 to $80,000) primarily because of its lithium ion battery and elaborate drive trains.

The HEV's prime power source is the standard internal combustion engine (ICE). If the HEV is flex-fueled, both gasoline and E-85 fuel can be used. The ICE is used to mechanically turn a generator that creates the electrical current to recharge the batteries that in turn furnish electrical power to the car's electric motor(s). Electrical energy is also created through the rotation of the wheels of the car. This happens when the vehicle slows down and/or brakes. The electric motor switches to reverse mode and electrical energy is created and returned to the battery. These electric motors create the high torque that makes the HEV move.

HEV Drive Train- Three types of HEV's exist based on their drive train configurations. The drive train is essential for recharging the batteries.

- The **series drive train** uses an electric motor to furnish torque, i.e. movement, while the ICE provides power <u>only</u> for recharging the batteries. This type of drive train is most used where high torque power is needed for busses and trucks. This first generation HEV type operates solely as an electric vehicle with a typical range of less than 100 miles.
- The **parallel drive train** uses one electric motor and one ICE to provide torque. They alternate with each other as needed. Examples of HEV's that use parallel drive trains are the Honda Civic, Honda Insight, Honda Accord, Ford Escape, Mercedes Benz S400 Blue Hybrid, and BMW 7-Series. In these vehicles batteries are recharged while the HEV is in motion. This type of HEV cannot operate solely as an electric vehicle (EV).

HYBRID ELECTRIC VEHICLE (cont'd)

HEV Drive Train (cont'd)

- The **series/parallel drive train** consists of two electric motors and one ICE. One electric motor (smaller) is used only to recharge the battery. Examples of HEV's that use series/parallel drive trains include Toyota Prius, Lexus Gs450, and the Lexus LS600. The combined series/parallel drive train extends the electric motor's capacity to drive the car at normal speeds while also recharging the battery. This allows the hybrid to operate solely as a battery-electric vehicle (EV) for as many as 20-60 miles, thus providing a more flexible driving option and improving environmental performance before the ICE takes over.

HEV Batteries- The single most expensive and heaviest item in the HEV is the battery. Batteries used in vehicles contain either nickel-metal hydride (NiMh), lithium ion (Li Ion), or lead acid, if the vehicle is very large. . Li-ion batteries can be recharged in minutes compared to taking many hours for most other batteries. The typical automotive battery can be recharged about a thousand times and lasts between 3 and 5 years before being replaced. This is true also of the lithium battery, however, the cost of the lithium battery is around $15,000 compared to our present day lead-acid batteries that cost less than $100. In HEV's a computerized control system is required to safely coordinate the recharging processes and to control the discharge of electricity to the electric motor and various on board electrical devices in an efficient manner.

Plug-In Hybird (PHEV) operates as a typical full hybrid but have the ability to be recharged from the electric grid. The current PHEV and HEV's ranges are limited only by the quantity of gas or diesel in their fuel tanks. In the future fuel cells could be added to the HEV as an alternative electrical power source.

HYDROGEN FUEL

Hydrogen can be used as a non-carbon energy source for electric vehicles (EVs) or hybrid electric vehicles (HEVs) and as direct augmentation in internal combustion engine (ICE) vehicles. In addition, it can be used for transportation systems, industrial uses, building power supplies, and for furnishing independent power for items in remote locations.

A **fuel cell** produces electricity from an electrochemical reaction called catalysis. The fuel cell is constructed to receive two flowing gases, hydrogen and air or oxygen, that combine chemically to form electricity as a stream of electrons and water as a waste product. An average fuel cell can produce a voltage of about 0.6 Volts +/-.

Fuel cells and batteries are similar in that both have anodes and cathodes and use chemical reactions to produce electrons that form a current. However, they differ in how they furnish fuel and oxidant to the cell. A battery is a closed and self-contained fuel and oxidant system. The fuel cell is an open system wherein both the hydrogen and the oxidant (air or oxygen) are stored in a tank and then piped into the cell on a continuous basis. Fuel cells are considered to be a steady and long-lived supplier of electricity under varying load conditions. Batteries will furnish electricity usually for shorter durations then they will abruptly drop off and need to be recharged.

In 2007 MIT researchers discovered how to generate hydrogen by using a cobalt-phosphorus catalyst to split water at room temperature. Water that is split produces the hydrogen and oxygen needed for the fuel cell process. Cobalt and phosphorus are cheap, earth-abundant materials that can be easily mass-manufactured. This inexpensive process, still experimental, will have major economic implications for the future development of fuel cells and renewable energy storage.

HYDROGEN FUEL (cont'd)
Augmentation/Direct Injection - Hydrogen in the form of Brown's gas (HHO)* is injected into the carburetor system to mix with air and gasoline. HHO gas is generated from water by electrolysis using a low voltage current. This process is occurring onboard the ICE vehicle as it is being driven. The HHO then forms as a gas that flows to the ICE injector system thereby boosting power and improving mileage in the internal combustion engine. Over 6,000 augmented vehicles are currently in use in India and the Philippines. Mileage per gallon improved by 11%.

Safety Concerns - The two prime safety concerns from the use of fuel cells and hydrogen-powered vehicles include electrical shock and flammability. ICE vehicles use a standard 14-V voltage system which causes minimal shock to humans. The new EV and HEV vehicles will have electrical systems that range from 42 to 350 volts. Any voltage greater than 50 volts can stop the human heart. The second area of concern is flammability. Hydrogen gas has three times more energy, i.e., is more explosive, than gasoline. Therefore, storage of hydrogen within the vehicle is problematic. However, because this gas is lighter than air, it dissipates quickly and create less harm overall. U>S> Department of transportation specifications have been met for theses vehicles to operate on the highway.

Future hydrogen sources include the use of cellulose as a source. Urine is also an excellent source of hydrogen that could also be used in fuel cells. Research at Ohio University is developing urine technology that generates hydrogen gas using a nickel-based electrode. Urine-powered vehicles could obtain 90 mpg. Soldiers could have easy access to this fuel in the battlefield.

*Brown's gas (HHO) consists of two hydrogen atoms loosely bonded with one oxygen atom. This arrangement differs from water H_20 in that water has a much stronger bind. Brown's gas is produced by electrolysis of water.

AMERICA'S ELECTRIC GRID

Electric power is essential to modern society. The lack of electric power, even for short periods, causes communities to have trouble meeting their basic needs for food, shelter, water, law and order. Electricity, as a source of energy consumption use in America, has grown from l0% in 1940 to 40% today. It is unique in its ability to convey both energy and information, thus serving an increasing supply of services and products. Electricity is one of the largest and most capital-intensive sectors of the economy; its asset value is estimated to exceed $800 billion. This represents investments of 60 % in power plants, 30% in distribution facilities and 10 % in transmission facilities. America's 131 million electricity customers paid an "electric bill" of about $247 billion in annual revenue. These customers include nearly every business and household in the U.S. Of the more than 3,100 electric utilities that share the grid and supply electricity to their customers, 213 are stockholder owned, 2,000 are public, run by state and local government and 930 are cooperatives. Additionally there are nearly 2,100 non-utility power producers, independent power companies and customer owned energy facilities. There are three independent networks, called the bulk power system: Eastern Interconnection, Western Interconnection, and the Texas Interconnection. These networks incorporate international connections with Canada and Mexico. Overall reliability planning and coordination is provided by the North American Electric Reliability Council, a voluntary organization formed in 1968 in response to the Northeast blackout of 1965.

America's Electric Grid System is composed of electric generation - about 10,000 power plants, electric transmission - 157,000 miles of high voltage (>230kV) electric transmission lines, and electric distribution - a fleet of substations and lower voltage distribution lines.

AMERICA'S ELECTRIC GRID (cont'd)

Electric Generation-The average thermal efficiency of the power plants in America is about 33%, it has not changed much since 1960 because of the inherent inefficiency of central power generation that cannot recycle heat. Power plants are generally long-lived investments; the majority of the existing capacity is 30 or more years old. Some distributed energy facilities combine heat and power generation and achieve higher efficiencies, as much as 90%. The electric power generation industry is experiencing a change in ownership as it shifts from regulated utilities to competitive suppliers. The share of installed capacity provided by competitive suppliers has increased from 10% in 1997 to 35% today. More fuel-efficient and cleaner power generation technologies are becoming available. These include combined cycle combustion turbines, wind energy systems, advanced nuclear power plant designs, clean coal power systems and distributed energy technologies such as photovoltaic and combined heat and power systems. America faces a need for new electric power generation. Many aging plants in the existing fleet are approaching retirement. The growth of the information economy and the forecasted rise in electricity demand has all contributed to this situation.

Electric Transmission- These high voltage lines can experience bottlenecks that interfere with reliable, efficient and affordable delivery of electric power. While electricity demand increased by about 25% since l990, construction of transmission facilities decreased about 30%. Investment of new facilities has also declined. Grid congestion caused by heavily used systems, line losses and congested transmission paths now affect many of the parts of the grid across the U.S. It is estimated that power outages and disturbances cost the economy $25 to $180 billion annually. These costs could soar if outages or disturbances become more frequent or longer in duration. There are also operational problems in maintaining voltage levels. The very competitive bulk power market can also affect these problems. It has been increasing its transactions substantially. Annual contracts on the Tennessee Valley Authority's transmission system numbered less than 20,000 in l966, they exceed 250,000 today. This is a volume that the system was not designed to handle. Actions by transmission operators to curtail transactions for economic reasons and to maintain reliability (according to procedures developed by the North American Electric Reliability Council) grew from 300 in 1998 to over 1,000 in the year 2000. Significant impediments interfere with solving America's electric problems. These include: opposition and litigation against the construction of new facilities, cost recovery for investors, confusion over whose responsibility it is to build, and jurisdiction and government agency overlap for siting and permitting.

Electric Distribution- America's fleet of substations takes power from transmission-level voltages and distributes it to hundreds of thousands of miles of lower voltage distribution lines. The distribution system is generally considered to begin at the substation and end at the customer's meter. Beyond the meter lies the customer's electric system - wires, equipment, appliances, computerized controls and electronics. State and local governments are involved in the electric distribution business, regulating prices and rates-of-return for shareholder-owned distribution utilities. In 2,000 localities across the country, state and local government agencies operate their own distribution utilities, as do over 900 rural electric cooperative utilities. All of the distribution systems operate as franchise monopolies as established by state law. Increased use of information technologies, computers and consumer electronics has raised the possibility for outages, fluctuations in voltages and frequency levels and other power quality disturbances. Also interest in other forms of generation - solar, wind, photovoltaic, and electric storage devices is adding new requirements for interconnection and safe operation of electric distribution. Information technology can also change the distribution business.

AMERICA'S ELECTRIC GRID (cont'd)

The ability to monitor and influence each customer's usage, in real time, could enable distribution operators to better match supply and demand, thus boosting utilization, improving service quality, and lowering costs. Renewable power energy sources can be integrated into the grid system quite well. The problem of variable power supplies may be alleviated by grid energy storage. Available storage options include pumped-storage hydro systems, batteries, hydrogen fuel cells, thermal mass and compressed air. Initial investments of these storage systems can be high, but recovered over the life of the system.

In conclusion, America's electric system is facing questions about its ability to continue providing citizens and businesses with clean, reliable and affordable services. The grid congestions in numerous locations across the country could interfere with regional economic development. There is a need for substantial amounts of capital to be invested over the next several decades, in new generation, transmission and distribution facilities. Without new investments, service quality can degrade and costs may rise. With new investments, new technologies could revolutionize the electric grid.

OVERALL ENERGY CONCLUSIONS

Based upon the research, the LWV Jeffco Energy Committee has concluded the following:

1. Cost, convenience and safety drive energy choice decisions today.
2. Future energy decisions must take into account the true costs of social, economic and environmental impacts.
3. Natural gas will be the alternative to oil and coal as an interim energy source for the near future.
4. Solar and wind are considered to be the answer, but the sun does not always shine and the wind does not always blow.
5. It will be necessary to expand and modernize our grid infrastructure.
6. The key to managing any energy source is its storage.
7. More energy will be needed even with every conservation method in use.
8. Every energy source, including nuclear, will be needed even though all energy sources have disadvantages.
9. There is a need for LWVUS to restudy our energy position to take into account advances made in the last 30 years since it was written.

Jeffco League Energy Committee: Gari Westkott, Chair, Ruth Wells, Cath Perrone, Brook Wilson and Jackie Busch

Please Note: Material Source Information will be available upon request from the Discussion Leader or a request may be emailed to the Jeffco League office at jeffcolwv@netzero.net.

ENERGY RESOURCES PART II SOURCES:

Auto News, 2009
Ballard Power Systems, www.ballard.com
BBC, 10 September 2008
Better World 2008, Charging Stations

Boulder Electric Vehicle, 2009, http://boulderev.com/vehiclespecs.html
Brian Harper, May 01, 2009, Motor Mouth
Cadex Electronics Inc., Vancouver BC. www.cadex.com.
California Energy Commission 1993
Car Companies: TESLA Company, 2010, Roadster , General Motors, Nissan , Porsche, Honda Motors Inc, Ford Motor, Toyota Motor
City of Boulder Colorado/ SmartGridCity Design Plan for Boulder, Colo.
City of Franklin Tennessee
Colorado School of Mines Research Foundation
Daily Camera, Ryan Morgan, 03/12/2008 , Boulder picked by Xcel for first smart grid
Denver Council of Regional Governments DRCOG
Denver Post
Dr. Paul De Vadder, Belgium.2003
EV World
EVWorld 01/182003, Hydrogen Car Fire Sunrise
Geo-Heat Center, Oregon Institute of Technology geoheat.oit.edu/
Geothermal Heat Pump Consortium www.geoexchange.org/
Geothermal Resource Council (GRC) www.geothermal.org/
Good News India, 2003,
Hybrid Cars, SEPT. 16, 2009, http://www.hybridcars.com
Isidor Buchmann, November
Kettering Fuel Cells www.Kettering.edu, 2009
Lawrence Berkeley National Laboratory Geothermal Program esd.lbl.gov/ER/geolbnl.html
Lithium One, A123 Inc
National Bridges National Monument
National Renewable Energy Labv (NREL)
Norway Hidrogen Road Project
NOVA | ScienceNOW | Point-Counterpoint | PBS , 8/4/09, Hydrogen Fuel Cells
OCS Alternative Energy and Alternate Use Programmatic EIS Information Center
Oak Ridge National Laboratory www.ornl.gov
Pelamis Wave
Running_on_alcohol.tripod.com
Sandia National Laboratories Geothermal Research Department

Solar Cooking

South Face Solar Energy
Treehugger.com
US Bureau of Land Management (BLM) Geothermal Program
US Department of Energy
Warren, Nanda Warren 2004
Wikipedia Encyclopedia
XCEL Energy , 2008