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Green Energy

Abstract

Energy resources are crucial for maintaining our high standard of living. Development of new and conventional energy resources is now essential for industry, agriculture, transportation, and communication. Unfortunately, however, the dramatic increase in our use of energy since the Industrial Revolution has increasingly damaged our environment.

To relieve environmental damage, we must either reduce our use of energy or improve our methods for producing energy to become more environmentally friendly. Reducing energy is difficult because such reduction has direct negative impact on our economy and our daily lives. Energy conservation is not easily achieved because it requires public cooperation as well as political action. However, through improvement in our efficiency of energy use and energy generation, we may reduce environmental damage to an acceptable level.

Green energy refers to sources of energy that are environmentally friendly. Green energy sources include biofuels for transportation and geothermal, hydroelectric, solar, wind, and nuclear energy for generation of electricity. Environmentally friendly energy can relieve environmental pollution and, in addition, relieve our nation's strong dependence on foreign oil. As of 2006, about 18% of global energy consumption comes from green or renewable energy sources. These green energy sources are mostly replenishable. But 18% is not enough. Unless that percentage is significantly raised, the world will exhaust its supply of readily-available oil within one or two generations.

Introduction

Contemporary energy sources largely depend on fossil fuels, especially oil. While fossil fuels generate abundant energy, they also generate pollutants such as carbon dioxide (greenhouse gas), and sulfur dioxide, and nitrogen oxide that can cause acid rain and smog. The greenhouse effect increases global warming, which can bring potentially devastating climatic changes. Global warming has already produced some noticeable effects on our environment such as glaciers melt-down in the Arctic/Antarctic regions. Burning fossil fuels also generates some polluting trace metals. Coal combustion, for example, releases thousands of tons of radioactive uranium and thorium into the atmosphere every year according to ORNL review. (Gabbard)

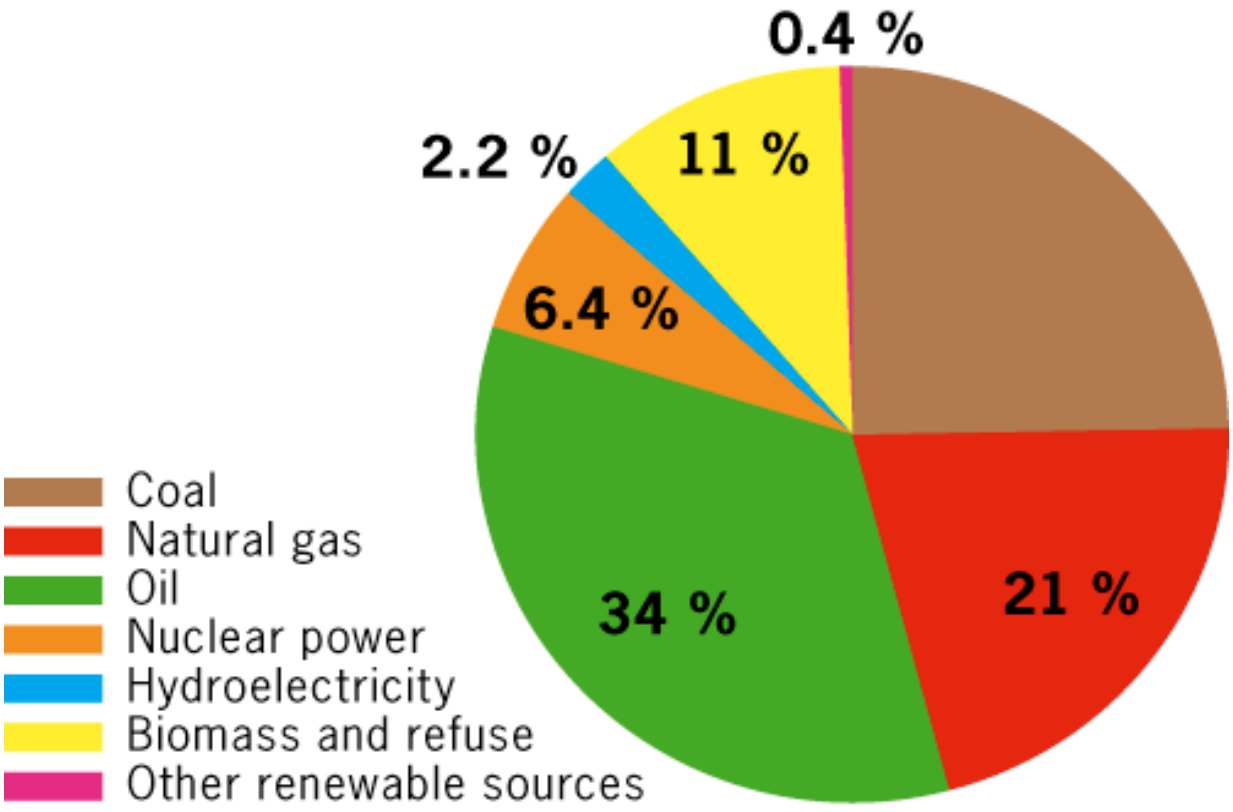


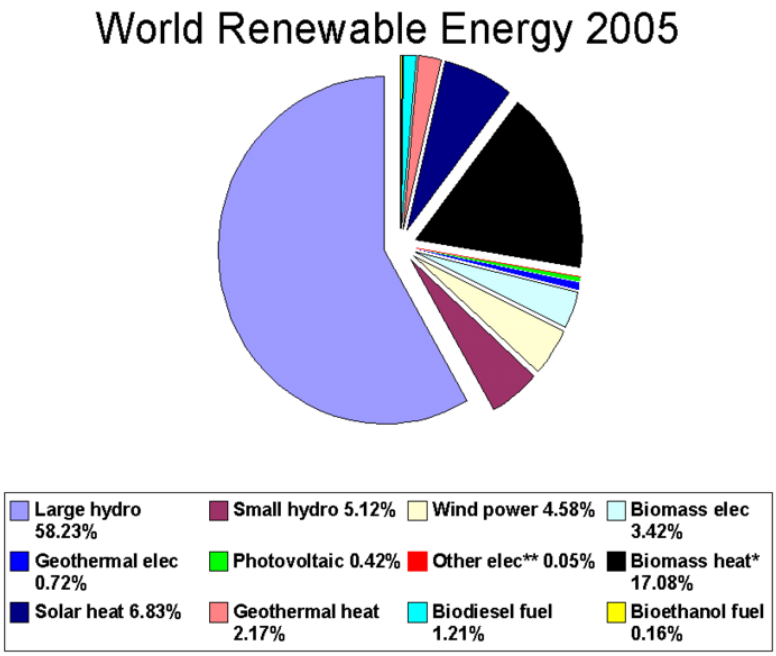
Figure 1: **World energy consumption** from different sources. (The Resource Report 2007)

Figure 1 shows consumption of world energy sources. Coal, natural gas, and oil are fossil fuels that are not replenishable.

Fossil fuels were formed long ago from living remains (plants and animals) that were buried in Earth for countless years. Due to large energy consumption, the readily-available fossil fuels (oil and gas) in the U.S. do not suffice to satisfy the nation's need. This energy imbalance creates a U.S. dependence on foreign oil. With rising world energy consumption, deposits of readily-available fossil fuel are rapidly disappearing.

Nuclear energy provides an alternative energy source. However, the radioactive waste products from nuclear reactors are difficult to dispose safely. Further, nuclear power can produce radioactive contamination, and availability of nuclear fuel may lead to the spread of nuclear weapons and terrorism.

Green Energy Resources/Application



Green energy includes natural energy sources: water (hydro), wind, sunlight (solar), geothermal, and biofuels. Figure 2 shows the distribution of renewable energy sources in 2005.

Figure 2: **World Renewable Energy**. Nuclear is not included due to political controversy (global stature)

Biofuels

Biofuels refer to bioorganic fuel, that is, any plant that can burn to produce heat. Biofuels can, to some degree, replace gasoline although biofuels usually have lower energy density than petroleum, typically by 50 to 80%. A common biofuel is wood that has been used as a fuel for centuries.

Biofuels reduce net greenhouse gas emission when replacing fossil fuels because biofuels are plants that derive energy from photosynthesis, a process that takes carbon dioxide, a major greenhouse gas, from the atmosphere. These biofuels can be derived from any carbon-based living substance including waste e.g. domestic garbage. Bioenergy derived from waste can also contribute to reduction of global warming. Landfill gas, generated from buried waste, can serve as a biofuel. This gas (mostly methane), if not collected and burned, can escape into the atmosphere where it contributes to global warming.

For use in transportation, biofuel must be in liquid form. Vegetable oil, biodiesel, and bioalcohol are all excellent sources of renewable, less-polluting energy sources. Biodiesel is produced from vegetable oil or animal fat using transesterification. In the U.S., because 80% of commercial trucks and city buses run on diesel, these engines could also function with biodiesel in the near future. Bioalcohol is produced from microorganisms and enzymes through fermentation of sugars and starches. Bioalcohol fuels are relatively high in energy density compared to other biofuels. The ethanol-fuel program in Brazil reduced oil imports in that country by 50 billion dollars in the period 1975-2002.

Most biofuels are biodegradable. However, as yet, biofuels are not cost-effective, relative to gasoline from petroleum. As petroleum prices continue to rise, biofuels are likely to become more economically attractive.

Water Power

Hydroelectric, tidal and wave power can provide a significant energy source. A desirable feature of these energy sources is that they produce no waste. Figure 3 shows a schematic of a hydroelectric power plant.

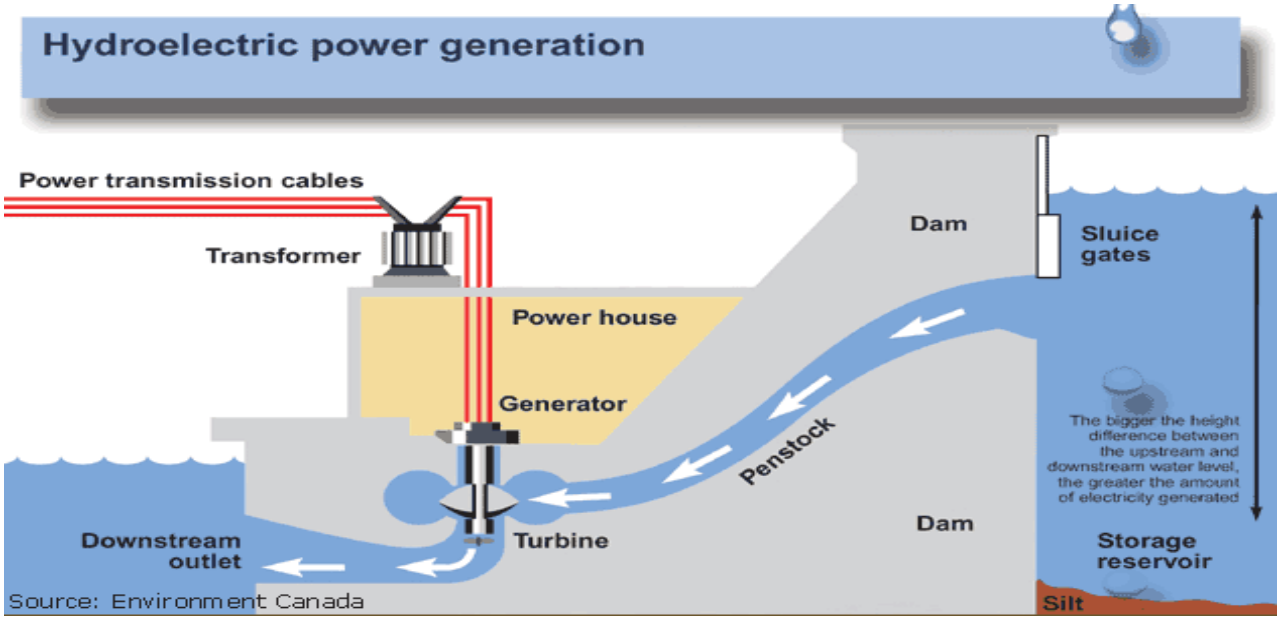


Figure 3: Hydroelectric power plant. (Environment Canada)

Hydroelectricity supplies 19% of world electricity, and accounts for 63% of total electricity from renewable sources in 2005. A hydroelectric power plant generates electricity from the potential energy of dammed water driving a turbine. Usually, a hydroelectric power plant is associated with a water reservoir that provides water for fishing, farming, or tourism. A water-power plant does not have any waste production; it simply converts the potential energy of falling water to electricity. Similarly, a tidal-power plant generates electricity through energy captured during changes in water level caused by the tide. A wave power plant generates electricity through energy captured from the movement of ocean surface waves.

Although water power is environmentally friendly and energy efficient, it is generally limited by available water resources; further, water-power plants may disrupt aquatic ecosystems. Only some geographic areas with high tides or a high waterfall are suitable for hydroelectric power. A man-made dam will eventually deteriorate and require extensive maintenance. Equipment exposed to salt water is likely to suffer severe corrosion.

Wind Power

Wind energy provides a renewable and clean energy source. Commercially viable wind energy is estimated to be 72×10^{12} watt world-wide. By 2010, the World Wind Energy Association expects that installed wind-power energy will be 160×10^{9} watt. Wind-power generation increased more than fivefold from 2000 to 2007. Although, at present, wind power only accounts for 1% of world electricity generation, in Denmark, it accounts for 20% of the nation's electricity production.

A modern windmill uses a three-bladed wind turbine to minimize fatigue losses and to maximize wind-energy conversion while minimizing windmill damage. Wind power is a relatively unpredictable power source because the wind velocity and direction can vary greatly in time. Wind power poses some environmental risk to birds.

Solar Power

The earth receives 174×10^{15} watts of solar radiation at its upper atmosphere (50% is reflected or re-radiated into space). Solar power provides an abundant available energy source. Currently, photovoltaic panels convert about 15% of incident sunlight into electricity. Solar

panels are widely used in good sunlight locations. Although in its infancy, there is some effort to develop a solar-powered car.

Some heating systems derive their energy from solar radiation. Solar heating systems can provide heat for a water tank or a swimming pool. Greenhouses use incident sunlight to provide heat for growing crops. The largest greenhouse complex in the world is in Wilcox, Arizona where the agricultural farm comprises 106 hectares (one hectare is 10,000 square meters).

Solar heat provides a huge potential energy source; solar heat can generate high-pressure steam to drive a turbine. However, the current efficiency for solar-powered turbines to generate electricity is relatively low (~17%). In the U.S. and elsewhere, the government promotes development of solar-power technology through incentives such as rebates, tax credits, and research funding. If the efficiency can be increased, solar power could become a major energy source for electricity.

Geothermal Power

Geothermal power is energy generated by collection of heat from below the earth's surface, or from oceans. The geothermal energy harvesting process is clean and safe. Geothermal energy is also cost-effective and sustainable because it comes from a large natural heat reservoir. Geothermal energy is harvested by a steam engine that is powered by hot steam. Liquid water is returned from the steam engine to below the earth where it is heated to steam. These power plants are unaffected by weather; they can work steadily as a base-load power plant because they can convert stable geothermal heat to electricity around the clock. Total potential power stored in geothermal fields in Iceland can yield about 15×10^{12} watt for about 100 years.

The largest geothermal field is "The Geysers" field in Northern California. Since 1960, "The Geysers" has been producing about 750×10^6 watt. At present, geothermal power supplies less than 1% of the world's energy but in some countries (e.g., Iceland) that percentage is much higher.

Green Energy Commercialization

Green energy sources must be converted to fuels or to electricity for daily use. Green energy conversion development uses a diverse range of technologies. Mature renewable energy conversion (e.g. hydroelectric and geothermal power plants) does not require much government subsidy. However, less-mature methods for renewable energy conversion, (e.g. solar and wind power) need considerable government assistance.

Solar-powered generators depend on government subsidies to attain higher efficiency. Windmills also require subsidies. Although solar and wind power are less cost-effective than other renewable energies, they generally require only a one-time investment to yield reliable energy for many years. California's Million Solar Roofs Program set a goal for solar panels to provide electric power capacity of $3{,}000 \times 10^{15}$ watt by 2017. For many more years, government must play a key role to develop use of renewable energies.

Future Development and Conclusion

Table 1 shows the world's renewable energy potential. Table 1 indicates that nature provides a variety of green-energy resources for the future. Unlike fossil fuels, green energy is environmentally friendly and often sustainable. Although at present, green energy supplies only a small fraction of total energy use, the world provides much potential green energy for future

development. According to some estimates (similar to Table 1), potentially we can increase current renewable energy use by a factor of 10^3.

The Renewable Energy Resource Base ($\times 10^{18}$ joules per year)

	Used (2001)	Technical potential	Theoretical potential
Hydropower	9	50	147
Biomass energy	50	>276	2,900
Wind energy	0.12	640	6,000
Solar energy	0.1	>1,575	3,900,000
Geothermal energy	0.6	5,000	140,000,000
Ocean energy	not estimated	not estimated	7,400
Total	60	>7,600	>144,000,000

Table 1: **renewable energy resources**. Theoretical potential refers to the total available energy on Earth or potentials of the sun (solar). Technical potential refers to the total available energy that can be harvested with current technologies while not disturbing the environment significantly. (World Energy Assessment 2001)

At present, energy conservation provides the most effective way to reduce oil dependence, environmental damage, and to improve energy security. However, in the future, development of green energy is required for further reduction in environmental damage and oil dependence. Green energy can improve energy security. With sufficient political will and investment, green energy can provide a cleaner and sustainable energy economy.

References

Darling, David “Hydroelectric Power”, The Encyclopedia of Alternative and Sustainable Energy, The California Energy Commission, 2008 <http://www.daviddarling.info/encyclopedia/H/AE_hydroelectric_power.html>

Gabbard, Alex “Coal Combustion: Nuclear Resource or Danger”, Oak Ridge National Laboratory (ORNL), Feb 2008<http://www.ornl.gov/info/ornlreview/rev26-34/text/colmain.html>

Guey-Lee, Louise “Renewable Energy Annual 2006”, Energy Information Administration, 2006 <http://www.elsevier.com/wps/find/journaldescription.cws_home/969/description#description>

Groce, Pam “Renewable Energy Fact Sheets”, Texas State Energy Conservation Office, 2008 <http://www.infinitepower.org/factsheets.htm>

Hanssens, Olav “Scenarios for development on the Norwegian continental shelf”, The Resource Report 2007, Norwegian Petroleum Directorate, 2007 <http://www.npd.no/English/Produkter+og+tjenester/Publikasjoner/Ressursrapporter/2007/ress_kap6.htm?tip=true>

Rognor, Hans “Energy and the Challenge of Sustainability”, World Energy Assessment, 2008 <http://www.undp.org/energy/activities/wea/drafts-frame.html>

Sayigh, A.A.M. “Renewable Energy”, The World Renewable Energy Network, Elsevier, 2008 <http://www.elsevier.com/wps/find/journaldescription.cws_home/969/description#description>