EENS 1110	Physical Geology
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Energy Resources	

This page last updated on 29-Feb-2012

Energy

Energy is the capacity to do work and is required for life processes. An energy resource is something that can produce heat, power life, move objects, or produce electricity. Matter that stores energy is called a fuel. Human energy consumption has grown steadily .throughout human history. Early humans had modest energy requirements, mostly food and fuel for fires to cook and keep warm. In today's society, humans consume as much as 110 times as much energy per person as early humans. Most of the energy we use today come from fossil fuels (stored solar energy). But fossils fuels have a disadvantage in that they are non-renewable on a human time scale, and cause other potentially harmful effects on the environment. In any event, the exploitation of all energy sources (with the possible exception of direct solar energy used for heating), ultimately rely on materials on planet Earth.

Some of the questions we want to answer in this discussion are:

1. What sources of Energy are available?
2. How do the energy sources rely on resources available on Earth?
3. Which energy sources are renewable on a human time scale?
4. Since fossil fuels (oil, natural gas, coal) are our main source of energy, how are they formed, how do we find them and exploit them?
5. What is the future for our energy needs?

Energy Sources

There are 5 fundamental sources of energy:

1. Nuclear fusion in the Sun (solar energy)
2. Gravity generated by the Earth & Moon.
3. Nuclear fission reactions.
4. Energy in the interior of the Earth.
5. Energy stored in chemical bonds.

Solar Energy

Solar Energy arrives from the Sun by electromagnetic radiation. It can be used directly for heat and converted to electricity for other uses. It is a nearly unlimited source, it is renewable, and largely, non-polluting.

Gravity Generated by the Earth & Moon.

Gravitational pull of the Moon on the Earth causes tides. Tidal flow can be harnessed to drive turbines. This is also a nearly unlimited source of energy and is largely non-polluting.

Combining both both solar energy and gravity provides other useful sources of energy. Solar radiation heats air and evaporates water. Gravity causes cooler air to sink and condense water vapor. Gravity then pulls condensed water back to Earth, where it flows downhill. The circulation of the atmosphere by the process is what we call the wind. Energy can be extracted from the wind using windmills. Water flowing downhill has a result of gravity can also be harnessed for energy to drive turbines and generate electricity. This is called hydroelectric energy. This sources of energy are mostly renewable, but only locally, and are generally non-polluting.

Nuclear Fission Reactions

Radioactive Uranium is concentrated and made into fuel rods that generate large amounts of heat as a result of radioactive decay. This heat is used to turn water into steam. Expansion of the steam can then be used to drive a turbine and generate electricity. Once proposed as a cheap, clean, and safe way to generate energy, Nuclear power has come under some disfavor. Costs of making sure nuclear power plants are clean and safe and the problem of disposing of radioactive wastes, which are unsafe, as well as questions about the safety of the plants under human care, have contributed to this disfavor.

Energy in the Interior of the Earth

Decay of radioactive elements has produced heat throughout Earth history. It is this heat that causes the temperature to increase with depth in the Earth and is responsible for melting of mantle rocks to form magmas. Magmas can carry the heat upward into the crust. Groundwater circulating in the vicinity of igneous intrusions carries the heat back toward the surface. If this hot water can be tapped, it can be used directly to heat homes, or if trapped at great depth under pressure it can be turned into steam which will expand and drive a turbine to generate electricity.

Energy Stored in Chemical Bonds

Energy stored in chemical bonds drives chemical reactions. When the reactions take place this energy is either released or absorbed. If it is absorbed, it is stored in the chemical bond for later use. If it is released, it can produce useful heat energy. electricity, and light.

Hydrogen Fuel Cells are one example: A chemical reaction occurs wherein Hydrogen reacts with Oxygen in an electrolyte bath to produce H_2O, and releases electricity and heat. The reaction is non-polluting, but currently has problems, such as safely storing and distributing compressed hydrogen gas, and producing hydrogen efficiently.

Biomass Energy is an other example. It involves burning (a chemical reaction) of wood, or other organic byproducts. Such organic material is produced by photosynthesis, a chemical process which derives energy from the Sun and stores that energy until the material is burned.

Fossil Fuels - Biomass energy that is buried within the Earth where it is stored until humans extract and burn it to release the energy. Among these sources are petroleum (Oil & natural gas), oil shale, tar sands, and coal. All of which will be one of the primary topics of our discussion here.

Geology and Energy Resources

Exploitation for human use of nearly all of the energy sources listed above, requires geologic knowledge.

While using direct solar energy to heat water and homes does not require geologic knowledge, the making of solar cells does, because the material to make such cells requires knowledge of specific mineral deposits. Chemicals to produce wires (iron, copper, gold), batteries, (Li, Cd, Ni), and electric motors (Fe, Cu, Rare Earth Elements) all must be extracted from the Earth using geologic knowledge.

Hydroelectric energy requires geologic knowledge in order to make sure that dams are built in areas where they will not collapse and harm human populations.

Finding fossil fuels and geothermal energy certainly requires geologic knowledge.

Nuclear energy requires geologists to find deposits of uranium to generate the fuels, geologists to find sites for nuclear power plants that will not fall apart due to such things as earthquakes, landslides, floods, or volcanic eruptions, and requires geologists to help determine safe storage sites for nuclear waste products.

Again, here will concentrate on the fossil fuels.

Fossil Fuels

The origin of fossil fuels, and biomass energy in general, starts with ***photosynthesis***. Photosynthesis is the most important chemical reaction to us as human beings, because without it, we could not exist. Photosynthesis is the reaction that combines water and carbon dioxide from the Earth and its atmosphere with solar energy to form organic molecules that make up plants and oxygen essential for respiration. Because all life forms depend on plants for nourishment, either directly or indirectly, photosynthesis is the basis for life on Earth. The chemical reaction is so important, that everyone should know it (**Hint**).

$$nCO_2 + nH_2O + \text{Energy} \longrightarrow C_nH_{2n}O_n + nO_2$$

Carbon Dioxide, Water (from atmosphere) — Solar Energy — Simple Sugar (Plant matter) — Oxygen to atmosphere

Note that if the reaction runs in reverse, it produces energy. Thus when oxygen is added to organic material, either through decay by reaction with oxygen in the atmosphere, or by adding oxygen directly by burning, energy is produced, and water and carbon dioxide return to the Earth or its atmosphere.

Petroleum

To produce a fossil fuel, the organic matter must be rapidly buried in the Earth so that it does not oxidize (react with oxygen in the atmosphere). Then a series of slow chemical reactions occur which turn the organic molecules into hydrocarbons- Oil and Natural Gas, together called Petroleum. ***Hydrocarbons*** are complex organic molecules that consist of chains of hydrogen and carbon.

Petroleum (oil and natural gas) consists of many different such hydrocarbons, but the most