Human Impact on Natural Systems

Energy is the ability to do work. While energy surrounds us in all aspects of life, the ability to harness it and use it as constructively and as economically as possible continues to be a great challenge for humankind. For as long as there have been humans living on the Earth, their actions where for survival or development has been leaving a tremendous impact on the Earth (see Table 1).

As populations grow and civilization progresses, man is constantly in the need for more and more energy to meet his growing needs. Despite the fact that this energy may be found in numerous sources the fossil fuel combustion has been, for quite some time, the preferred source. However, this widespread use of fossil-based energy has and continues to leave a negative footprint on our environment (see Table).

Time Zone	Global Population	Daily Energy Use per person (kcals)	Energy Source	Technological Discoveries	Environmental Impacts
1 million to 5000 years BC	< 10 million	1,000-5,000	Food, human muscle	Tool production, fire	Local and short-term; animal kills and vegetation change
5000 BC to AD 1800	10 million - 1 billion	12,000-26,000	Animals, agricultural crops, wind, water, coal	Cultivation, building, transport, irrigation	Local and longer-term; natural vegetation removal, soil erosion, urban air pollution
AD 1800 to 1950	1 billion - 4 billion	50,000	Fossil fuels, electricity, steam	Industry	Local, regional and permanent; major landscape changes, air and water pollution common
1950 to present	> 4 billion	300,000	Internal combustion engine, electricity, nuclear, fossil fuel	Industry, cultural globalization	Local, regional, global; permanent and perhaps irreversible; acid rain, global warming

Table 1: Energy, Technology and Environmental Impact Timeline

ALTERNATIVE ENERGY

Alternative energy is defined as any fuel sources that are other than those derived from traditional fuel sources. These traditional sources include fossil fuels, coal, oil and natural gas. Formed from plants and animals that lived up to 300 million years ago, fossil fuels are found in deposits beneath the earth. The fuels are burned to release the chemical energy that is stored within this resource. Traditional fuels are also non-renewable source of energy. That means that they are taken from finite sources that will eventually run out. Over 85% of our energy demands are met by the combustion of fossil fuels.

Fortunately, they are also renewable sources of energy. These sources have a comparatively smaller negative impact on the environment and, as opposed to the traditional fuels, these sources will not run out despite the fact that its intensity and availability will change from time to time. They are naturally replenished in a much short period of time than the traditional sources. These alternative sources of energy include:

- ⇨ Solar
- ⇨ Wind
- ⇨ Geothermal
- ⇨ Wave & Tidal
- ⇨ Ocean thermal
- ⇨ Hydroelectric
- ⇨ Biomass

SOLAR ENERGY

The Sun is the source of all of the energy on Earth. Plants absorb the suns energy to grow and produce food which we eat for energy. The sun's light and heat gives the atmosphere and oceans the energy it needs to produce winds and waves. None of this would exist without the sun. The amount of sun that reaches the earth's surface is enormous. Solar (sun) energy is therefore one the most resourceful sources of energy. One of the reasons for this is that the total energy we receive each year from the sun is around 35,000 times the total energy used by man. Two weeks of sunlight over the whole earth is equal to all of the energy stored in coal, oil and natural gas. Bearing in mind that 1/3 of this energy is absorbed, scattered or reflected by the outer and inner atmosphere, that fact is pretty impressive. The problem is to harness and store it. For one thing, solar energy is not constant through the day or, over the surface of the Earth.

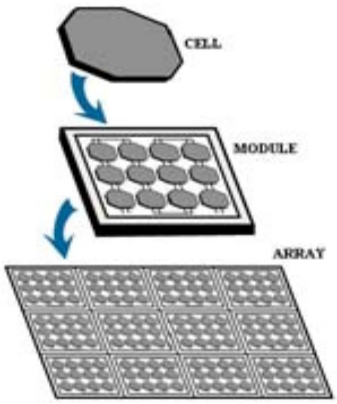
If there were only solar energy, what would we do during the night or on a cloudy day?

Solar Thermal Energy

Solar thermal energy refers to the energy given off by the Sun in the form of heat. It is often used for heating swimming pools, heating water used in homes, and space heating of buildings. Solar space heating systems can be classified as passive or active. Passive space heating is what happens to your car on a hot summer day. In buildings, the air is circulated past a solar heat surface and through the building by convection (i.e. less dense warm air tends to rise while more dense cooler air moves downward). No mechanical equipment is needed for passive solar heating. Active heating systems require a collector to absorb and collect solar radiation. Fans or pumps are used to circulate the heated air or heat absorbing fluid. Active systems often include some type of energy storage system.

Photovoltaic (PV)

In addition to using the Sun's heat for energy, technology has also enabled us to use sunlight for energy. This energy, converted from sunlight into electricity is known as photovoltaic energy. A photovoltaic cell, commonly called a solar cell or PV, is the technology used to convert solar energy directly into electrical power. These cells are connected to form a module and, the modules connected to form an array.



The performance of a photovoltaic array is dependent upon sunlight. Climate conditions (e.g., clouds, fog) have a significant effect on the amount of solar energy received by a photovoltaic array and, in turn, its performance. Most current technology photovoltaic modules are about 10 percent efficient in converting sunlight.

Wind Energy

Wind is a form of solar energy. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind power is another alternative energy source that could be used without producing by-products that are harmful to nature. Like solar power, harnessing the wind is highly dependent upon weather and location (terrain, bodies of water, vegetative cover). This wind flow, or motion energy, when "harvested" by modern wind turbines, can be used to generate electricity. The average wind velocity of Earth is around 9 m/sec. And the power that could be produced when a windmill is facing the wind of 10 m/hr is around 50 watts.

The terms "wind energy" or "wind power" describe the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity to power homes, businesses, schools, and the like.

Advantages	Disadvantages
Clean, free, non-polluting, renewable resource, 'life-cycle' (construction and maintenance) cost of the wind farm is much more competitive with other generating technologies	Noise produced from wind turbines, aesthetic (visual) impacts, and birds and bats having been killed by flying into the rotating blades, good spacious sites are often far from the population hence there is a high transportation cost

Geothermal Energy

Geothermal energy is an alternative energy source, although it is not resourceful enough to replace more than a minor amount of the future's energy needs. Geothermal energy is obtained from the internal heat of the planet and can be used to generate steam to run a steam turbine. This in turn generates electricity, which is a very useful form of energy. The radius of the Earth is about 4000 miles, with an internal core temperature of about 4000^{o}C at the centre. The mantle surrounds the outer core and is only about 45 miles below the surface, depending on location. The temperature at the mantle-surface crust boundary is about 375^{o}C.

It turns out that if we drill down only three miles we can reach temperatures of 1000C, which is enough to boil water to run a steam-powered electric power plant. Drilling three miles through the earth is possible, but not easy, so luckily there are easier routes to access this power source, known as geothermal hotspots. Hotspots are simply areas of reduced thickness in the mantle which transmits excess internal heat from the interior of the earth to the outer crust. These hotspots are well known for their unique effects on the surface, such as the volcanic islands of Hawaii, the mineral deposits and geysers in Yellowstone National Park, or the hot springs in Iceland. These geothermal hotspots can easily be used to generate electricity.

Most geothermal reservoirs are deep underground with no visible clues showing above ground. Geothermal energy can sometimes find its way to the surface in the form of volcanoes and fumaroles (holes where volcanic gases are released), hot springs and geysers. The most active geothermal resources are usually found along major plate boundaries where earthquakes and volcanoes are concentrated. Most of the geothermal activity in the world occurs in an area called the Ring of Fire.

Wave Energy

Waves are caused by the wind blowing over the surface of the ocean. There is tremendous energy in the ocean waves. The total power of waves breaking around the world's coastlines is estimated at 2-3 million megawatts. The west coasts of the US and Europe and the coasts of Japan and New Zealand are good sites for harnessing wave energy.

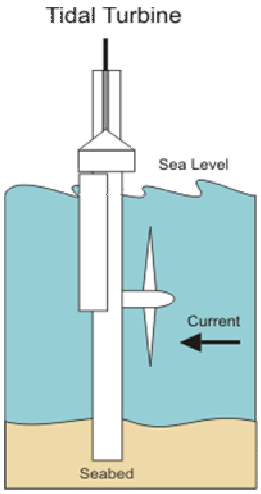
One way to harness wave energy is to bend or focus the waves into a narrow channel, increasing their power and size. The waves can then be channelled into a catch basin or used directly to spin turbines. There are no big commercial wave energy plants, but there are a few small ones. Small, on-shore sites have the best potential for the immediate future; they could produce enough energy to power local communities. Japan, which imports almost all of its fuel, has an active wave-energy program.

Title: The Soup Bowl Barbados Compliments

Tidal Energy

Tides are caused by the gravitational pull of the moon and sun, and the rotation of the earth. Near shore, water levels can vary up to 40 feet. Only about 20 locations have good inlets and a large enough tidal range- about 10 feet- to produce energy economically. The simplest generation system for tidal plants involves a dam, known as a barrage, across an inlet. Sluice gates on the barrage allow the tidal basin to fill on the incoming high tides and to empty through the turbine system on the outgoing tide, also known as the ebb tide. There are two-way systems that generate electricity on both the incoming and outgoing tides.

Tidal barrages can change the tidal level in the basin and increase turbidity in the water. They can also affect navigation and recreation. Potentially the largest disadvantage of tidal power is the effect a tidal station can have on plants and animals in the estuaries. There are currently two commercial sized barrages in operations. One is located in La Rance, France; the other is in Annapolis Royal, Nova Scotia, Canada.



Tidal fences can also harness the energy of tides. A tidal fence has vertical axis turbines mounted in a fence. All the water that passes is forced through the turbines. Tidal fences have less impact on the environment than tidal barrages although they can disrupt the movement of large marine animals. They are cheaper to install than tidal barrages too. A tidal fence is planned for the San Bernardino Strait in the Philippines.

Tidal turbines are a new technology that can be used in many tidal areas. They are basically wind turbines that can be located anywhere there is strong tidal flow. Because water is about 800 times denser than air, tidal turbines will have to be much sturdier than wind turbines. They will be heavier and more expensive to build but will be able to capture more energy.

Ocean Thermal Energy (OTEC)

The energy from the sun heats the surface water of the ocean. In tropical regions, the surface water can be 40 or more degrees warmer than the deep water. This temperature difference can be used to produce electricity. The OTEC system must have a temperature difference of at least 25 degrees Celsius to operate, limiting use to tropical regions. Hawaii has experimented with OTEC since the 1970's. There is no large-scale operation of OTEC today. There are many challenges. First, the OTEC systems are not very energy efficient. Pumping water is a giant engineering challenge. Electricity must also be transported to land. It will probably be 10 to 20 years before the technology is available to produce and transmit electricity economically from OTEC systems.

The first closed cycle Mini-OTEC plant to produce net power (15 kilowatts) at Keahole Point, Hawaii, in 1979

Advantages	Disadvantages
clean, abundant, renewable, natural resources	OTEC electricity at present is considerably more expensive than fossil fuel electricity
the intensity of the source is relatively constant	
Produce little or no emissions or waste	The plants must be located where a difference of about 5° C occurs year round.
can produce fresh water as well as electricity	
The solar energy incident on the Caribbean ocean is enough to satisfy most if not all present human energy needs	Some additional development of key components is essential to the success of future OTEC plants (e.g., less-costly large diameter, deep-sea water pipelines; low-pressure turbines and condensers for open-cycle systems; etc.)
The cold sea water may be used for air-conditioning, agriculture, and fish growing	

Hydroelectricity

Hydro electricity is another term for power generated by harnessing the power of moving water. Not necessarily falling water, just moving water. By either using the free movement of the water or by having to dam (trap the water like in a reservoir) it, the pressure created by the movement of the waster is channelled to turbines. The turning turbines change the moving energy into electricity. Hydroelectric systems have huge upfront costs, but have relatively low maintenance costs and provide power quite cheaply. In the United States approximately 180,000 MW of hydroelectric power potential is available, and about a third of that is currently being harnessed.

Title: Chalillo Hydroelectric Station, Belize

Advantages	**Disadvantages**
Dams can act as a flood control mechanism.	Flood and flood related damage can ensue as a result in the case of a dam failure.
There are no carbon dioxide emissions during the operation phase.	Dammed water can produce methane emissions due to the break down of bacteria.
There is no fuel cost.	Large population may need to be relocated where reservoirs are planned in the creation of a floodplain.
Reservoirs facilitate - water sport activities, tourist attractions, fish farming.	Hydroelectric projects can disturb and destroy the surrounding aquatic ecosystems
Dammed water can be available for boat transportation in cases where a rapid previously existed.	Recreational users must exercise extreme care when near hydroelectric dams

Biomass

Biomass is energy produced from organic substances. The key to the power of biomass lies in the energy of the sun. All plants undergo a process called photosynthesis, whereby the plants use clorophyll to convert the energy in the sun's rays into stored energy in the plants. Photosynthesis, water, and nutrients in the soil are the ingredients of plant growth. Biomass is simply the conversion of stored energy in plants into energy that we can use.

Methods of Converting Biomass to Energy

- ⇨ Burning – This is the most straight forward and long lived method. Mankind has burned wood and other forms of biomass for thousands of years, to keep warm, to cook food, and eventually to forge weapons and other tools. This method however pollutions and releases greenhouse gasses.

- ⇨ Pyrolysis – This involves the heating of biomass in the absence of oxygen. The biomass is heated to around 1000°F allowed to decompose into gas and charcoal (carbon). A major advantage of this method is that carbon dioxide is not produced. A disadvantage, however, is that the biomass must be heated to relatively high temperatures, a process that in and of itself requires significant amounts of energy.

- ⇨ Anaerobic Digestion - Anaerobic digestion converts biomass, especially waste products, into methane (a major component of natural gas) and carbon dioxide by mixing the waste with water and then storing in an airtight container. The process is quite costly and relatively efficient.

- ⇨ Alcohol Fermentation – With this method, the starch in organic matter is converted to sugar by heating. The sugar is then fermented using yeast to form ethanol. The ethanol is then mixed another fuel. The drawback to this method of biomass energy conversion is that the process itself requires the use of fossil fuels, and is therefore somewhat inefficient.

Advantages

- Theoretically inexhaustible fuel source
- When direct combustion of plant mass is not used to generate energy (i.e. fermentation, pyrolysis, etc. are used instead), there is minimal environmental impact
- Alcohols and other fuels produced by biomass are efficient, viable, and relatively clean-burning
- Available throughout the world

Disadvantages

- Could contribute a great deal to global warming and particulate pollution if directly burned
- Still an expensive source, both in terms of producing the biomass and converting it to alcohols
- On a small scale there is most likely a net loss of energy--energy must be put in to grow the plant mass.