Lesson 1

INTRODUCTION: THE PROBLEMS & ENERGY SOURCES

Aim
Describe the nature and scope of alternative energy.

ALTERNATIVE ENERGY

Alternative energy is energy that is not popularly used and is *usually* environmentally sound. The energy is derived from non-traditional, *renewable* sources (e.g. Solar, wind) as opposed to fossil fuels that are *not renewable*. Renewable sources can be readily replaced or replenished, either by the earth's natural processes or by human action.

Energy for human activity is obtained from a variety of sources:

- Fossil Fuels (i.e. Oil, Gas, and Coal).
- Nuclear Fuels (i.e. Uranium, Plutonium).
- Renewable Fuels - Geothermal, Solar, Water (Tides, Waves), Wind Power, and Bio-fuels (Firewood and fuel distilled from crops)

Some quick definitions

Alternative Energy: is commonly defined as energy that is generated from non-fossil fuel resources and that does not harm the environment. Generally speaking nuclear energy is not included.

Renewable Energy: is energy from sources that are naturally replenished such as solar, wind, wave/tidal, hydroelectric, biofuels and geothermal energy.

Solar Energy: is energy from the sun's solar radiation and can be divided into passive (no mechanical devices) and active solar energy (such as photovoltaic).

Wind Energy: is energy from the conversion of wind to electricity by a wind turbine.

Hydropower Energy: is energy generated by moving water, commonly from waterwheels, hydroelectric dams but also from tides and more.

Biofuels: are fuels generated from plant biomass, including bio-diesel and ethanol.

Geothermal Energy: is energy derived from the heat of the Earth's core.

WHY ALTERNATIVE ENERGY?

When discussing why we need alternative energy it is important to understand the history of energy consumption and its historical link to civilisation. The production, storage and consumption of energy have been and still are essential for our survival. The very structure of our social groups from families to corporations, have focused on this very need. Our need for alternative energy which is renewable and non-polluting is underpinned by our very requirements for survival. It is most likely that our need for energy is not going to change, if anything it is only going to keep increasing.

"*However imprecise it may be, most people still accept the steadfast formula: energy=progress=civilization.*" Williams (2006)

A Brief History of Energy Consumption

BC
1 Million - Discovery of Fire
11,000 - Domestication of large animals
7,000 - Development of agriculture and farming in China and the Middle East.
5,000 - First small cities – development of wheels, pottery, bronze, weapons, farming tools.
5,000 - Wind used to power boats on the Nile
3,500 - Bronze Age
1,500 - Iron Age
200 - Windmills used to pump water in China and grind grain in Middle East
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AD
1100 - Windmills used extensively in Middle East, spreading to Europe
1700 - A solar heater used to melt platinum
1708 - Jethro Tull invents the mechanical seed sower leading to large scale cropping
1709 - Iron smelted with coke by Abraham Darby
1712 - First steam engine
1779 - First steam powered cloth mills
1800 - More households using coal for heat/cooking
1800 – Voltaic Pile (literally a pile of simple galvanic cells) discovered by Alessandro
1807 - Steamboat
1821 - Faraday shows electro magnetic rotation which is the basis for the motor
1838 - Morse develops the telegraph and morse code
1859 - First oil well in Pennsylvania
1867 - Dynamite
1876 - Bell invents the telephone
1879 - Edison invents the incandescent lamp
1886 - First automobile with an internal combustion engine
1890 - First wind turbines in Denmark
1896 - Marconi develops the wireless telegraph
1903 - Wright brothers develop the airplane
1904 - Larderello Fields steam was used to generate power
1908 - Model T Ford
1920 - 25 - The Persian Gulf and Texan oil fields are opened.
1922 - First geothermal power plant in the US
1928 - TV signals
1941 - Russell Ohl developed the first silicon solar cell
1945 - First computer
1954 - First silicon photovoltaic cell
1959 - First computer chip
1968 - Silicon Chip
1976 - Apple II first home computer
1983 - First mobile phones
1991 - World Wide Web

THE INDUSTRIAL REVOLUTION

Possibly the period of time which has had the largest and longest environmental impact is the *Industrial Revolution* which came into being in the UK during the mid 1800's. It gave us unprecedented access to energy and with this came increasing wealth and prosperity and, with improvements to nutrition and sanitation, came a huge surge in population growth. It has been estimated that in the first two decades of the twentieth century mankind consumed more energy than it had used, in total, over all the previous centuries of its existence. The Industrial Revolution initially relied to a large extend upon *wood, coal, horses and water power* especially to drive factories, it was not until the discovery of the *steam engine* that an increased reliance upon non *renewable fossil fuels* such as coal started. Along with this came new levels of *air and water pollution*. Since the industrial revolution society has increasingly relied upon fossil fuels but has since realised that these fuels are limited in supply and that these fuels create many associated environmental problems such as pollution, climate change and associated health problems.

Climate Change

One of the most important environmental impacts to arise from the Industrial Revolution is climate change.

> It is important to understand that the *greenhouse effect* and *climate change* are two different things. Without the greenhouse effect, Earth would be uninhabitable for humans as it keeps the Earth at a warm temperature, however, there is mounting evidence that *anthropogenic (human) carbon dioxide* and other human activities are affecting the world's climate. In effect human activity appears to be responsible for increasing the greenhouse effect to a point causing increasing global temperature rises, this is known as climate change.

The earth's atmosphere is composed of 78% nitrogen, 21% oxygen, and only about 1% of greenhouse gases (water vapour, carbon dioxide, methane and nitrous oxide). Since the Industrial Revolution atmospheric concentrations of CO_2 have risen from under 1 billion metric ton/year in the early 1800's to over 8 billion metric tons/year in 2000.

There are two main sources of anthropogenic (man made) greenhouse gasses. These are: burning of fossil fuels such as coal, natural gasses and petroleum; and deforestation causing CO_2 to be released through both decaying vegetation and burning vegetation.

Many scientists believe that increases in greenhouse gasses are causing the earth's temperature to rise, resulting in global warming. Other scientists believe that these changes are just part of the natural cycles of change that continuously occur on earth. While most agree that earth's temperature is rising, they disagree about how much it will rise, how fast it will rise, and what the effects will be on earth and on living thing.

From table 1 below, it is possible to see how reliant the world still is upon fossil fuels compared to renewable energy. With that in mind, if there is not a concerted effort by all energy consumers to switch their primary fuel source to renewable sources (from fossil fuels say), the overall predicted usage outlined in the graph is unlike to vary.

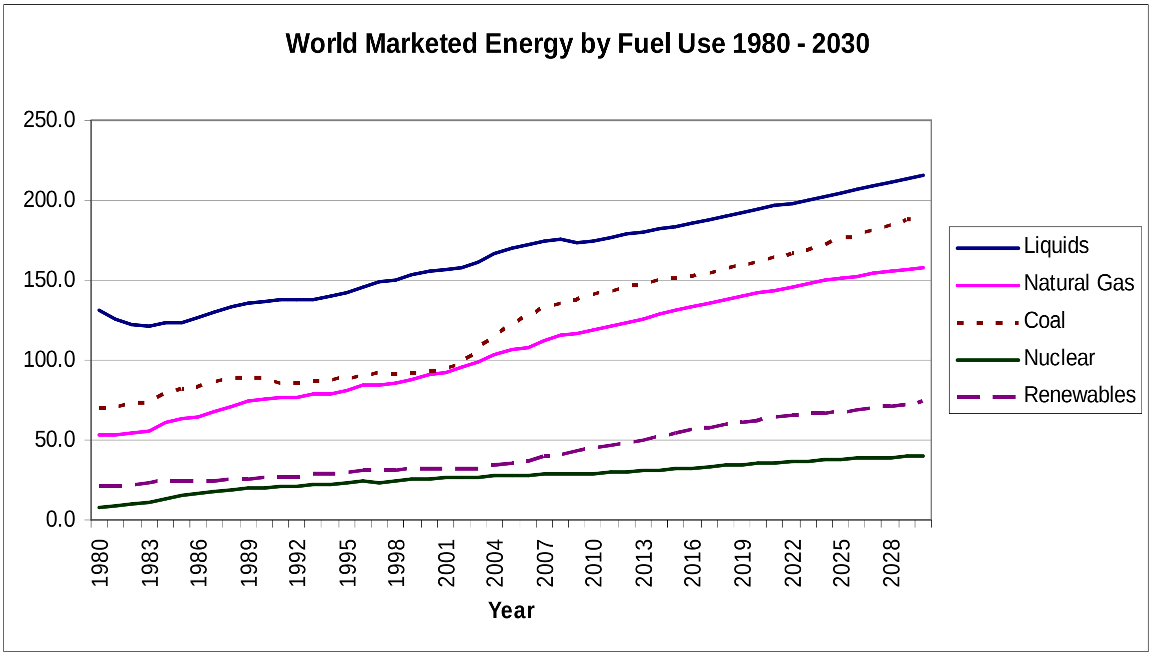


Table 1: World Fuel Use by type 1980 – 2006, projected from 2006 -2030.
Source: Adapted from: Energy Information Administration (EIA), 2009, International Energy Statistics, accessed 3 November 2009 from http://www.eia.doe.gov/oiaf/ieo/graphic_data_world.html

ENERGY UNITS

When comparing energy consumption, the British Thermal Units, which is a measure of heat energy, is frequently used. Below are some conversions:

- 1 barrel (42 gallons) of crude oil = 5,800,000 Btu
- 1 gallon of gasoline = 124,000 Btu (based on U.S. consumption, 2008)
- 1 gallon of diesel fuel = 139,000 Btu
- 1 gallon of heating oil = 139,000 Btu
- 1 barrel of residual fuel oil = 6,287,000 Btu
- 1 cubic foot of natural gas = 1,028 Btu (based on U.S. consumption, 2008)
- 1 gallon of propane = 91,000 Btu
- 1 short ton of coal = 19,988,000 Btu (based on U.S. consumption, 2008)
- 1 kilowatt hour of electricity = 3,412 Btu

SOME PROBLEMS BY ENERGY SOURCE

All energy supplies have problems. The current trend for alternative energy sources is driven by a host of long-range ubiquitous problems associated with fossil fuels. Below are outlined briefly some problems of different fuel sources *including* alternative energy sources!

Problems with Fossil Fuels - Coal, Gas and Petroleum
Common environmental issues include contribution to climate change via greenhouse gasses, atmospheric sulphur dioxide (SO_2) which is also known as acid rain; Smog and airborne particulates which contribute to lung diseases; nitrous oxide (N_2O) which contributes to ozone formation at low altitudes; carbon monoxide (CO) and heavy metals. Aside from environmental issues, one of the biggest issues is the fact that fossil fuels are not renewable, they are finite.

While Natural Gas is considered the cleanest of the fossil fuels there are still many associated issues. One of the main concerns is '*fracking*' where new deep drilling technologies break up rock formations leaving toxic fluids available to pollute groundwater.

The actual extraction of these types of fuels is as problematic and environmentally damaging as their actual consumption. Some risks associated with the production of these fuels includes: oil spills; heavy metal contamination and habitat disturbance.

Problems with Hydroelectricity
While hydroelectricity is often considered green due to the fact that it is renewable and relatively non-polluting, it does come with some fairly significant environmental costs. Hydroelectricity is generally the production of electricity from the movement of water; traditionally this is from the damming of a river to create a reservoir of water which via controlled release is used to drive turbines. Problems associated with damming and channelling water through a turbine include: reservoir stratification leading to a decline in the amount of dissolved water; habitat loss through dam construction; changing water levels in reservoir; sedimentation of the reservoir which can also lead to nutrient loading; erosion; dramatic changes in habitat for wildlife and fish.

Problems with Nuclear Energy
While much is discussed in the media regarding the dangers of nuclear energy, it is worth actually understanding a little about why it is dangerous.

Radioactivity
An atom has at its core the nucleus. The nucleus is made up of protons (positively (+ve) charged) and neutrons (electrically neutral – no charge). Around the nucleus is a cloud of electrons (negatively (-ve) charged). Normally the number of electrons will equal the number of protons plus neutrons, thus balancing the charges and creating a neutrally charged atom.

An isotope however is an atom that has the same number of protons but a different number of neutrons. The isotope therefore has an unbalanced charge and an unstable nucleus. Due to this instability the nucleus can 'decay' spontaneously.

This is called radioactivity. When a nucleus decays, it breaks apart and emits radiation and particles (parts of an atom). Below three types of radioactivity are outlines, note that there are actually more than this;

- *Alpha:* Alpha particles are emitted from the nucleus. Alpha particles consist of two protons and two neutrons bound together into a particle. This type of particle radiation has low penetration.
- *Beta:* An electron is emitted. This is a high speed and high energy particle with medium penetration.
- *Electron Capture*: This occurs when there are too many protons in the nucleus and one of the electrons is captured by a proton to form an extra neutron in the nucleus.

Half life
As mentioned above, a half life of an isotope is the amount of time it takes for one half of the nuclei in the sample to decay. This is the common way of expressing the time for radioactive decay. Half lives of known radionuclides vary widely, with highly radioactive substances decaying much faster than those that are weak. Additionally rates of decay can and are measured precisely nor does the rate of decay vary in differing conditions. This means that it is an excellent technique for determining geological ages. If the half life is known, the parent/daughter ratio can be measured. It is this ratio that allows the calculation of the samples age. Note that the ratio refers to the percentage of atoms that decay during a half life (50%).

However the actual numbers of parent isotopes will decline continuously while the number of daughter atoms will rise in proportion. For example: If there are 100 parent isotopes and 0 daughter atoms the half life will be equal to zero. If there are 50 parent isotopes and 50 daughter atoms the half-life is 1. If there are 25 parent atoms and 75 daughter atoms, then the half life is equal to 2.

Parent Isotope	**Daughter atom (stable)**	**Half Life Value**
Rubidium 87	Strontium 87	50 billion years (error of 30-50 million years)
Uranium 235	Lead 207	700 million years
Uranium 238	Lead 206	4.5 billion years
Potassium 40	Argon 40	1.3 billion years

Table 2: Half life of some common isotopes

Radioactive Waste Disposal
Despite the horrors of a nuclear accident, the disposal of radioactive material is possibly one of the greatest problems with this type of energy production. This is due to the extremely long half life of the materials used (table 2). It is estimated that one reactor can produce up to 30-40 tonnes annually of waste. Currently technology has not found a way to safely store waste nuclear material. Generally, it is stockpiled in repository sites around the world.

Accidents and Safety
Nuclear fuels have been adopted in some countries however there remains a question of safety associated with that energy source. For example, storage of nuclear waste and it's very long half-life, and risks of nuclear accidents and spills causing catastrophic damage. One very well-known nuclear disaster was Chernobyl nuclear power station disaster in the Ukraine in 1986.

It happened largely because normal reactor operations were suspended; an experiment was to take place in the reactor. Normal safety guidelines were disregarded and the accident occurred.

Several fuel rods within the reactor shattered and two explosions occurred as a result of liquid uranium reacting with steam. A fire within the plant emitted extremely radioactive smoke into the area surrounding the reactor. The effects of the disaster at Chernobyl were very widespread. The World Health Organization (WHO) found that the radiation release from the Chernobyl accident was 200 times that of the Hiroshima and Nagasaki nuclear bombs combined. The fallout was also far-reaching travelling as far as Scotland. Thirty lives were directly lost during the accident or within a few months after it. Many of these lives were those of the workers trying to put out the graphite fire and were lost from radiation poisoning. The radiation released has also had long-term effects on the cancer incidence rate of the surrounding population.

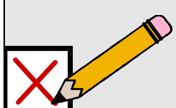
According to the Ukrainian Radiological Institute over 2500 deaths resulted from the Chernobyl incident. The rate of thyroid cancer is particularly high after the Chernobyl accident because much of the radiation was emitted in the form iodine-131, which collects in the thyroid gland, especially in young children.

Wind Turbines
Most of the complaints levelled against wind turbines is that they are visually unappealing as they can be very tall and dominate the landscape particularly when they are grouped; and noise produced by some turbines. They can also impact upon birds when they try and fly through them and they are also prone to being hit by lightening. The energy produced by wind is not stored easily and if often generated far from population centres.

Solar Photovoltaics
To date one of main drawbacks to common usage of solar energy is the cost involved with photovoltaic cells. Other problems include the fact that they only work during sunlight hours, they can be affected by pollution (reduction in solar energy reaching the cell).

SET READING

Spend some time researching textbooks, references or the internet to find out more about our history of energy production and consumption. If using the internet please be mindful of the credibility of the sites you are looking at.



SELF ASSESSMENT
Complete Self Assessment Test 1.1.
If you answer incorrectly, review the notes and try the test again.

SET TASK

1. Do a thorough inspection of your home. Look at the different ways you use energy. How do you think you could minimise energy usage in your home. Take notes.

2. If possible contact and visit any display homes set up to demonstrate the practical use of alternative energy systems. Such houses/displays can be found in most states. Contact your local energy supply company or State Department of Energy (or similar body) to see if they can recommend such a place in your area.

Keep a note of the places you visit to compile a resource file which you can continue to build throughout the duration of the course.

ASSIGNMENT
Complete Assignment 1.