SUSTAINABLE SOURCE OF ENERGY(phys3101)

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CHAPTER ONE
ENERGY IN CONTEXT

- What is sustainable sources of energy?
- List the benefits and limitations of sustainable sources of energy?
- How global is changed due to energy usage?
- Explain the difference between renewable, non-renewable and sustainable source of energy?
- What are the methods used to estimate energy resources?
- What are the of causes of air pollution?

Overview of energy use and related issues

- Energy is a very broad concept and is defined as the potential of materials and systems to perform useful work.
- Energy is measured in the same unit as work and comes in several forms. Energy is all around us.
- You can hear energy as sound.
- You can see energy as light.
- And you can feel it as wind.
- The five main forms of energy are:

1. Heat
2. Chemical
3. Electromagnetic
4. Nuclear
5. Mechanical

Heat Energy

▶ The internal motion of the atoms is called heat energy, because moving particles produce heat.

▶ Heat energy can be produced by friction.

▶ Heat energy causes changes in temperature and phase of any form of matter.

Chemical Energy

▶Chemical Energy is energy required to bond atoms together.

▶ And when bonds are broken, energy is released.

▶ Fuel and food are forms of stored chemical energy.

Electromagnetic energy

▶a type of energy that is given off in the form of transverse waves from all matter not at absolute zero.

▶ Power lines carry electromagnetic energy into your home in the form of electricity.

▶ Light is a form of electromagnetic energy (ROYGBV), x-ray, radio wave, laser light, etc.

Nuclear Energy

▶ The nucleus of an atom is the source of nuclear energy.

▶ When the nucleus splits (fission), nuclear energy is released in the form of heat energy and light energy.

▶ Nuclear energy is also released when nuclei collide at high speeds and join (fuse).

Mechanical Energy

▶When work is done to an object, it acquires energy.

▶ The energy it acquires is known as mechanical energy.

Energy Conversion

▶ Energy can be changed from one form to another.

▶ Changes in the form of energy are called energy conversions.

▶The suns energy through solar cells can be converted directly into electricity.

▶Green plants convert the suns energy (electromagnetic) into starches and sugars (chemical energy).

▶In an electric motor, electromagnetic energy is converted to mechanical energy.

▶ In a battery, chemical energy is converted into electromagnetic energy.
▶ The mechanical energy of a waterfall is converted to electrical energy in a generator.
▶ The most common energy conversion is the conversion between potential and kinetic energy.
▶ All forms of energy can be in either of two states:

1. Potential
2. Kinetic

▶ Macro Potential Energy : Gravitational Energy or Strain energy.
▶ Micro Potential Energy : Chemical energy and Nuclear energy.
▶ Kinetic energy is due to motion (Motive Energy) - the motion of waves, electrons, atoms, molecules and system.
▶ When the nucleus splits (fission), nuclear energy is released in the form of heat energy and light energy.
▶ Nuclear energy is also released when nuclei collide at high speeds and join (fuse).

Units of energy

- The units of energy in the systeme internationale(SI)is the joule(J) and is the work done when a constant force of 1N moves its point of application by 1m.
- In the British system of units the British thermal unit (1 Btu)is commonly used in the heating and air-conditioning industries and

$$1Btu = 1055J$$

- An extremely large amount of energy is the Quard (1Q) i.e

$$1Q = 10^{15}Btu = 10^{18}J$$

- Fossil fuel(crude oil) represents large fraction of total energy sometimes quoted in terms of "tonnes of oil equivalent(toe)".

$$1toe = 41.87GJ$$

▶ Crude oil can be measured both in terms of mass(tonnes) or volume(cubic metres or barrels).

$$1 barrel = 42 USgallons$$

$$1 USgallons = 3.78 litres$$

$$1 barrel = 158.76 litres$$

▶ Humans use energy in several different forms in order to run machinery and accomplish different tasks:

- An air-conditioner unit uses electric energy to drive its compressor and provide cool air in a building.
- A stove uses natural gas to prepare food in homes.
- Cars, trucks and buses use gasoline or diesel fuel in their internal combustion engines to transport people and goods.
- Airplanes use kerosene to transport people and goods.

▶ Energy is demanded in different forms, the most important of which are: electricity, gaseous fuels, liquid fuels and solid fuels.

▶ Global energy demand has been constantly growing due to the industrial revolution and is affected by two factors:

- The increase of the global population.
- The increasing energy demand per capita as agrarian and less affluent societies transform to industrial and more affluent societies.

▶ It is apparent that the global energy demand more doubled in these 40 years.

▶ This growth is accounted by two factors:

- The improved economic prosperity in the entire world, and
- The increase of the worlds population.

▶These factors are driving the global energy demand continuously to higher levels.

▶ And the world will need more energy to produce and to consume in the near future.

▶ Natural laws indicate that energy may neither be created nor destroyed, all the energy that is consumed must be produced from energy sources, which exist in the natural environment.

▶ These natural energy sources are:

- Fossil fuels, such as coal, crude oil and natural gas.
- Renewable energy.

▶ The first form of energy is essentially formed several millennia ago.

▶ Its formation process takes place over very long period of time, and will be exhausted at some point in the future.

- Fossil energy sources have problems of:
  - Security of supply/price stability (esp. petroleum)
  - Depletion
  - Climate impacts from greenhouse gas emissions
- Second are reproduced and are inexhaustible and will continue to supply energy to the humans in the foreseeable and far future.
- Due to above mentioned problems we have to change our present energy to renewable sources of energy and clean technology (wind, solar, bio, geothermal)

FOSSIL FUELS

FOSSIL FUELS

COAL

NATURAL GAS

OIL

FOSSIL FUEL

▶ Fossil fuels are formed from prehistoric plants and other living things formed underground millions year ago.

▶ This organic matter (matter that comes from a life form and contains mainly the element carbon) was crushed, heated and deprived of oxygen.

▶ Under the right conditions an over millions of years, this treatment turns dead plants into fossil fuels.

▶ Nearly 90 perecent of the worlds energy comes from fossil fuels. Because fossil fuels are the main source, they are not alternative energy sources.

▶Fossil fuels are nonrenewable energy source since they take millions years to form.

▶ Fossil fuels ultimately get their energy from the sun. The plants that turned into fossils stored energy from the sun by photosynthesis.

▶ The three main types of fossil fuels corresponds to the three states of matter :- solids, liquids and gas;

▲ a. coal is a solid

▲ b. petroleum is a liquid

▲ c. natural gas is a gas

A. COAL

▶ Supplies about one-fourth of the worlds energy needs.

▶It is a solid hydrocarbon made primarily of carbon and hydrogen with small amounts of other elements such as sulfur and nitrogen.

▶It looks like black rock, and it leaves black dust on things that it touches.

▶ How coal is formed?(step)

▶ There are two ways to mine coal: surface mining and underground mining.

1. Subsurface mining

▶ If a coal seam (or deposit) is deep below the surface of the earth, miners use subsurface mining.

▶ They dig vertical tunnels into the ground to reach the seam and then dig horizontal tunnels at the level of the seam.

2. surface mining (strip mining)

▶ It is a process of taking coal from the surface of the Earth without going underground.

▶ Miners use giant (huge) shovels to remove dirt, called overburden, from the coal seam and then use explosives to blast the coal out of the rock.

▶ Strip mining is much safer than subsurface mining, but it leaves huge scars on the land and can contribute to water pollution.

B. PETROLEUM (OIL)

▶ It is the most widely used fossil fuel supplying about 40 percent of the worlds energy.
▶ One of the most important uses of petroleum is as fuel for motor vehicles.
▶It can be also be used to pave(overlay) roads, to make other chemicals, and to moisturize skin.
▶It is made up mostly of molecules that contains only carbon and hydrogen atoms. It also contains some oxygen, nitrogen, sulfur and metal salts.
▶The ingredients in petroleum include microscopic plants and bacteria that lived in the ocean millions years ago.
▶ When they died, these plants and bacteria fell to the bottom of the ocean and mixed with the sand and mud there.
▶ This process continued for millions of year and gradually the layers at the bottom were crushed by the layers above them.

- The mud became hotter and the pressure and heat slowly transformed it.
- The minerals turned into a kind of stone called shale, or mudstone, and the organic matter turned into petroleum and natural gas.
- Because they are not solid, petroleum and natural gas can move around.
- They seep(escape) into holes in undersea rocks such as limestone and sandstone, called reservoir rocks.
- These rocks are porous, meaning they have tiny holes in them that allow liquids and gases to pass through and function as sponges.
- The largest fields in the world are in the middle east, especially in Saudi Arabia, Qatar, and Kuwait and in North Africa.
- There are also large fields in Indonesia, Nigeria, Mexico, Venezuela, Kazakhstan, and several U.S states.

C. NATURAL GAS

▶ Natural gas is gaseous hydrocarbon. It is colorless, odorless, and lighter than air.

▶ Natural gas is made up of 75 percent methane, 15 percent ethane, and small amounts of other hydrocarbons such as propane and butane.

▶ Natural gas produces much less pollution than petroleum.

▶ It is used for heating, electrical power and other purposes.

▶ Natural gas formed from underwater plants and bacteria.

▶ These microscopic organisms fell to the bottom of the ocean when they died and over millions of years were crushed and heated by the pressure of layers of sand, dirt and other organic matter that accumulated on top of them.

▶ The mineral components of the undersea mud gradually turned into shale and some of the organic components turned into natural gas.
▶ Natural gas can move around within porous reservoir rocks.
▶ It can also be trapped in underground reservoirs, or geologic traps.
▶ Natural gas is lighter than petroleum, so it usually sits on top of the petroleum in a reservoir.
▶ Natural gas sometimes seeps up through Earths crust and appears on the surface.
Natural gas is usually found with petroleum.
▶ When geologists search for underground oil, they find natural gas along with it.

1.Advantages

✓ very high energy density

✓ fossil fuels are relatively easy to transport

✓ cheap when compared to other sources of energy

✓ can be built easily if there transportation links and water availability

2.Disadvantages

✓ combustion $\longrightarrow$ pollution (acid rains)

✓ combustion products contains green house gases

✓ getting fossil fuels damages environment

✓ nonrenewable

3.Environmental

✓ oil spills( )

✓ pollution

✓ green house gases

✓ acid rain

✓ mining destroys large areas of the landscape

Sustainable Energy and clean technologies in context

▶What is sustainable energy?

▶ Sustainable Energy means energy sources that will allow the Earth to sustain (keep up) balanced, healthy ecosystems and human life.

▶ It has minimal negative impacts both in its production and consumption.

▶ Primarily those are inexhaustible in nature, and which are ultimately derived from the radiant energy of the sun reaching the earth.

▶ The term sustainable energy is most of the time applied to the energy that is not associated with significant environmental damage (and climate change).

▶ Generation does not compromise on the potential of future generations to meet their energy needs.

▶ Sustainable sources of energy available in Ethiopia: - Hydropower, Biomass energy, Wind energy, Solar energy and Geothermal energy,.

Advantages of Renewable Energy:

- They are fairly reliable resources, and renewable.
  - Non depletable on a short time scale.
  - Low impacts on natural resources (land, water, etc.,)
  - Accessible and well distributed.
  - Emissions free of NO_x, SO_x, $CO2$, particulates, etc.
  - Scalable from 1 kW to 1000 MW.
  - Flexible -applications for electricity, heat.
- Disadvantage of renewable energy are variability and low density, which in general results in higher initial cost.
- They are not finite like coal, oil, natural gas.
- Renewable energies such as wind and solar are not available 24, unlike fossil fuels.

▶ It can be seen that almost 80 percent of all of our primary energy needs are supplied from conventional fossil fuels.
▶ The largest fossil fuel component of the overall supplied to be oil, followed by coal, and finally natural gas.
▶ But these fossil fuels are available only in limited years.
▶ The ways of estimating energy resources are:
♦ Monte Carlo Method
♦ Hubbert Method and
♦ Delphi Method
▶ From these methods it is observed that:
▶ Present oil reserves would last around 90 yr at the 2009 rate of consumption.
▶ Present coal reserves would last around 200 yr at the 2009 rate of consumption.
▶ Present natural gas reserves would last around 100 yr at the 2009 rate of consumption.

Global change and response issue

- Change in climate of the Earth leads to global warming.
- Global warming is gradual increases in over all of the temperature of the Earths atmosphere due to increased levels of CO_2 and other pollutants.
- It primarily due to human activities such as deforestation and burning of fossil fuel, which increases the concentration of GHG (CO_2, CH_4, SO_2).

Since 1979, the land temperatures have increased about twice as fast as ocean temperatures.

- This due to heat capacity of oceans.
- Studies by the United nations intergovernmental panel on climate change (IPCC) have shown that the atmospheric concentration of CO_2, has risen from 280 ppm (part per millions) in pre-industrial times to nearly 370 ppm today.

▶ The average global temperature over the period appears to have risen by about 1^0c.

▶ IPCC suggested that over the next 100 years the concentration of CO_2 in the atmosphere may increase to a level between 540 ppm and 970 ppm with a resultant rise in the global average temperature of 1.4^0c to a level of 5.8^0c.

Response issues: (Mitigation of climate change)

▲ Reducing the amount of future climate change is called mitigation of climate change.

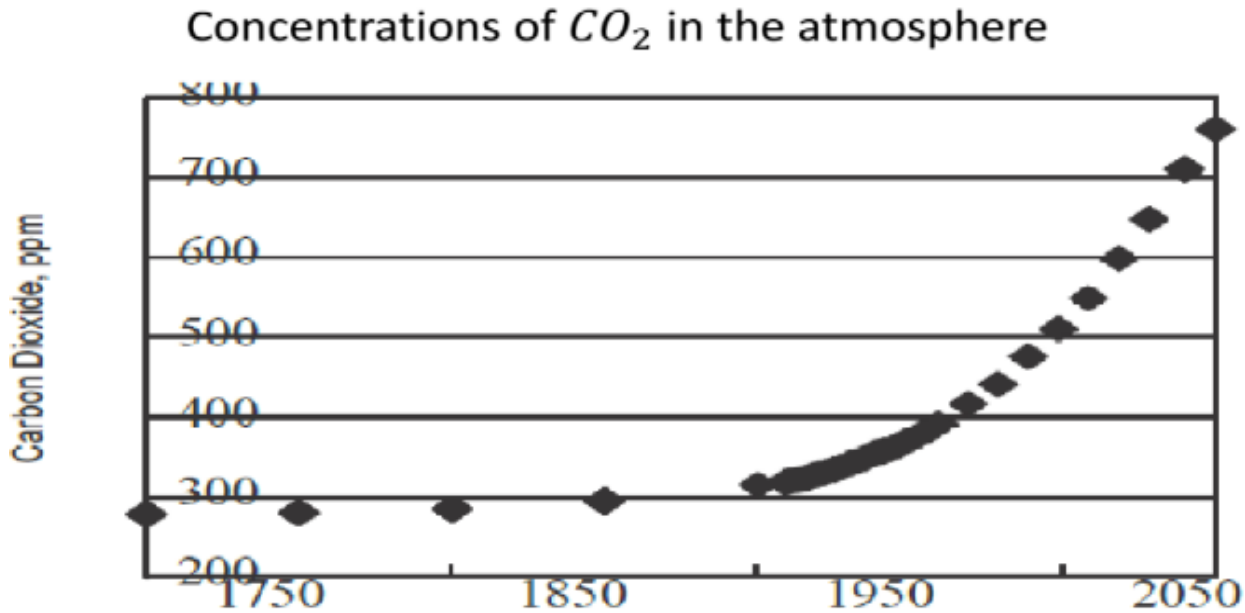
▲ The IPCC defines mitigation as activities that reduce greenhouse gas (GHG) emissions, or enhance the capacity of carbon sinks to absorb GHGs from the atmosphere.

▲ Many countries, both developing and developed, are aiming to use cleaner, less polluting technologies.

▲ Use of these technologies aids mitigation and could result in substantial reductions in CO_2 emissions.

▲ Most countries are Parties to the United Nations Framework Convention on Climate Change (UNFCCC).
▲ The ultimate objective of the Convention is to prevent "dangerous" human interference of the climate system.
▲ As is stated in the Convention, this requires that GHG concentrations are stabilized in the atmosphere at a level where ecosystems can adapt naturally to climate change, food production is not threatened, and economic development can proceed in a sustainable fashion.
▲ The Kyoto Protocol of 1996 to reduce GHG emissions became effective in 2005 as Russia became the 55^{th} country to ratify the agreement.
▲ The goal was for the participants collectively to reduce emissions of greenhouse gases by 5.2 percent below the emission levels of 1990 by 2012.

▲ At the 15^{th} UNFCCC Conference of the Parties, held in 2009 at Copenhagen, several UNFCCC Parties produced the Copenhagen Accord. Parties associated with the Accord (140 countries, as of November 2010) aim to limit the future increase in global mean temperature to below $2^0 C$.



▲ The 16^{th} Conference of the Parties (COP16) was held at Cancun in 2010.

▲ It produced an agreement, that the Parties should take urgent action to reduce greenhouse gas emissions to meet a goal of limiting global warming to 2^0C above pre-industrial temperatures.
▲ It also recognized the need to consider strengthening the goal to a global average rise of 1.5^0C and keeping CO_2 concentrations below 500 ppm.
▲ Global warming causes the polar ice sheets melt.
▲ It increases the sea-level. It will possibly rise 18 cm by 2030 and 58 cm by 2090.
▲ Flooding will probably occur in lowlands.
▲ Many cities along the coast may be under sea water.

Regional Air Poluution

▲ Air pollution is the introduction of chemicals, particulate matter, or biological materials into the atmosphere that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment.

▲ A substance in the air that can cause harm to humans, living organisms and the environment is known as an air pollutant.

▲ Pollutants can be classified as primary or secondary.

▲ Primary pollutants are substances that are directly emitted into the atmosphere from sources.

▲ The main primary pollutants known to cause harm in high enough concentrations are:

a) Carbon compounds, such as CO, CO_2, CH_4, and volatile organic compound.

b) Nitrogen compounds, such as NO, N_2O, and NH_3

c) Sulfur compounds, such as H_2S and SO_2
d) Halogen compounds, such as chlorides, fluorides, and bromides
Secondary pollutants are not directly emitted from sources, but instead formed in the atmosphere from primary pollutants.
The main secondary pollutants known to cause harm in high enough concentrations are the following:
a) Ozone (O_3) formed from photochemical reactions of nitrogen oxides and Volatile organic compounds (VOCs)
b) Sulfuric acid droplets formed from SO_2, and nitric acid droplets formed from NO_2.
▲Some secondary pollutants sulfates, nitrates, and organic particles can be transported over large distances, such as hundreds and even thousands of miles.
▲Wet and dry deposition of these pollutants contributes to the acid deposition problem (often called acid rain), with possible damage to soils, vegetation, and susceptible lakes.

Over view of Energy Supply portfolio

▲ Energy supply portfolio mainly depends on energy consumption or demand, reserves, production and reserves-to-production ratio,(R/P).

▲ The world energy continues to be dominated by fossil fuels, accounting for nearly 80 percent of total global energy supply.

▲These fossil fuels are not evenly distributed around the world and so there is a large international trading and transportation system to move oil supplies from the principal producing regions, like the Middle East, to the principal consuming regions, like North America, Europe, and Asia.

▲The major oil producing region in the world is the Middle East, which has a relatively small population, and therefore low demand, so that oil is transported from there to the major consuming regions.

▲ Energy is useful only if available when and where it is wanted.
▲ Carrying energy to where it is wanted is called distribution or transmission or transportation; keeping it available until when it is wanted is called storage.

Energy Storage

A) Electromechanical Storage

▲ Electromechanical energy storage systems store energy as potential energy, kinetic energy, or electric energy.

▲ Chief among them are above and below ground water pumping, compressed air, mechanical springs, flywheels, superconducting coils, and capacitors.

B) Thermal Storage

▲ Thermal storage may be accomplished for two purposes:

a) To store energy in the form of sensible or latent heat for later use, and

b) To store coolness, that is to produce materials at lower temperatures, which will be used at a later time for refrigeration or air-conditioning.

C) Chemical Storage

▲ Chemical storage is by batteries, photosynthesis, production of methane and hydrogen, fertilizer, and other types.

Energy Transportation:

▲ Energy transportation modes are travel by land, sea, and air.

▲Energy transportation can be classified in to two methods.

▲ Continuous flow transportation: For long and medium distances oil and gas in pipelines, Electricity in wires.

▲ Batch transportation: For long distances oil in tankers and coal in ships.

▲ For medium distances ethanol in vehicle as cargo, Coal in trains.

▲ For short distances Wood by hands.