UNIT – 1

Introduction

- Important Repeated Questions

1.1 Man and Energy

1.2 Classification of energy sources

1.3 World's and India's production and reserves of energy

1.4 Non-Convectional Sources

1.5 Need for Alternate sources

Important Repeated Questions:

1. **Explain the need for renewable energy.**
    - Appeared in: W25 (Q1a, 03 marks), W22 (Q1a, 03 marks)
2. **Explain advantages and limitations of renewable energy.**
    - Appeared in: W25 (Q1b, 04 marks), S24 (Q1a, 03 marks), S25 (Q1a & Q1b combined, 03+04 marks)
3. **Explain present scenario of conventional and renewable energy sources in India.**
    - Appeared in: W23 (Q1a, 03 marks), W24 (Q1a, 03 marks), S22 (Q1a, 03 marks)

Legends: W- Winter, S- Summer, Q- Question and 03/04/07- Marks of Question

1.1 MAN AND ENERGY:

- ENERGY is the ability to do work.
- ENERGY is the primary and most universal measure of all kind of work by human beings and nature.
- Energy: It is the capability to produce motion, force, work, change in shape, change in form etc.

Energy exists in several forms such as:

- Chemical energy
- Nuclear energy
- Mechanical energy
- Electrical energy
- Internal energy
- Bio-energy in vegetables and animal bodies
- Thermal energy etc.

- Man has needed and used energy at an increasing rate for his sustenance and well-being ever since he came on the earth a few million years ago.
- Primitive man required energy primarily in the form of food. He derived this by eating plants or animals which he hunted. Subsequently he discovered fire and his energy needs increased as he started to make use of wood and other biomass to supply the energy needs for cooking as well as for keeping himself warm.
- With the passage of time man started to cultivate land for agriculture. He added a new dimension to the use of energy by domesticating and training animals to work for him. With further demand for energy, man began to harness the wind for sailing ships and for driving windmills, and the force of falling water to turn water wheels.
- Till this time, it would not be wrong to say that the sun was supplying all the energy needs of man either directly or indirectly and that man was using only renewable sources of energy.

1.2 CLASSIFICATION OF ENERGY SOURCES:

1. **BASED ON USABILITY**
   a) PRIMARY SOURCES
      - These sources are obtained from environment.
      - Example: fossil fuels, solar energy, hydro energy and tidal energy.

   b) SECONDARY SOURCES
      - These resources do not occur in nature but are derived from primary energy resources.

   c) SUPPLY MENTRY SOURCES
      - It is define as those whose net energy yield is zero and those requiring highest investment in terms of energy insulation (thermal) is an example of this source.

2. **BASED ON TRADITIONAL**
   a) CONVECTION
      - The sources of energy which have been in use for a long time, e.g., coal, petroleum, natural gas and water power.
   b) NON CONVECTION
      - The resources which are yet in the process of development over the past few years. It includes solar, wind, tidal, biogas, and biomass, geothermal.
3. **BASED ON LONG TERM AVAILABILITY**
   a) RENEWABLE
      - These sources are being continuously produced in nature and are inexhaustible.
      - Wood, wind energy, biomass, biogas, solar energy etc.
   b) NON RENEWABLE
      - These are finite and exhaustible.
      - Coal, petroleum etc.
4. **BASED ON COMMERCIAL APPLICATION**
   a) COMMERCIAL
      - The commercial energy has great economic value. This energy pollutes the environment badly. These types of energy are limited in nature. High capital investment is required in the purification. It is used in urban as well as rural areas. Coal, petroleum, natural gas and nuclear energy.
   b) NON COMMERCIAL
      - The non-commercial energy is cheaper. This is pure and keeps the environment clean. Abundant in nature. It can be used in raw form. It is dominantly used in rural areas. Cow dung, charcoal, firewood and agricultural waste.

1.3 WORLD'S AND INDIA'S PRODUCTION AND RESERVES OF ENERGY

- Today, every country draws its energy needs from a variety of sources.
- We can broadly categorize these sources as
  a) Commercial/Conventional
  b) Non-commercial/Non-conventional
- The commercial source include the fossil fuels, nuclear, Hydro-electric power, while the non-commercial source include wood ,animal waste and agricultural wastes.

GLOBAL ENERGY CONSUMPTION

- The global primary energy consumption at present was equivalent to 9741 million tons of oil equivalent (Mtoe)

Coal	32.5	
Oil	38.3	
Gas	19	**92%**
Uranium	0.13	
Hydro	2	
Wood	6.6	
Dung	1.2	**8%**
Waste	0.3	

1.3.1 CONVECTIONAL/NON RENEWABLE ENERGY SOURCES

Convectional sources are as follow:

FOSSIL FUEL: Coal
Oil
Gas
Uranium/ Nuclear
Hydro-electric

COAL

- It has been estimated that there are over 847 billion tones of proven coal reserve worldwide. This means that there is enough coal to last us around 118 years at current rate of production (2011). In contrast, proven oil and gas reserves are equivalent to around 46 and 59 years at current production levels respectively.
- Coal reserves are available in almost every country worldwide, with recoverable reserves in around 70 countries. The biggest reserves are in the USA, Russia, China, and India.
- Coal provides 30.3% of global primary energy needs and generates 42% of the world's electricity. In 2011 coal was the fastest growing form of energy outside renewable. Its share in global primary energy consumption increased to 30.3% - the highest since 1969.
- Total world coal production reached a record level of7,678 Mt in year 2011, increasing by 6.6% over 2010. The average annual growth rate of coal since 1999 was 4.4%.

India's scenario

- The coal reserves in India up to depth of 1200 meters have been estimated by the geological survey of India is 285.86 billion tones as on 1st April, 2011,
- Coal deposits are chiefly located in Jharkhand, Odessa, Chhattisgarh, west Bengal, Madhya Pradesh, Andhra Pradesh, and Maharashtra.
- The coal production all over India during the year 2011 was 588.5 million tones
  = 5.6% of world's production.
- The production of coal by country and year is shown in Table 1.1:

Table 1.1

Country	Production Year		% share	Reserve life (years)
	2010	2011		
China	3235	3520	49.5	35
USA	983.7	992.8	14.1	239
India	573.8	588.5	5.6	103
European Union	535.7	576.1	4.2	97
Australia	424	415.5	5.8	184

OIL

- World's proven oil reserves in 2012 are estimated to be about 1324 billion barrels; it is equivalent to 210.5 x 109 m3. The most of the world's oil reserves (56%) are in the Middle East.
- Oil began to be used in significant quantities around 1900 and that there was an almost steady increase in its production all through and even during the world wars. The production increased at the average rate of over 7% per year from 1945 to 1973 and reached a value of 19.96 billion barrels in 1973. Thereafter with the beginning of the oil crisis, the annual production fluctuated up and down for 12 years from 1973 to 1985 before starting to increase more or less steadily from 1985 onwards.

India's scenario

- In 1951, the consumption of petroleum products was only 3.89 Mt, most of which were imported; while in 2011 it was increase to 141.785 Mt.
- Crude oil production during 2010-11 at 37.71 Mt. The refining capacity in country was 187.686 Mt per annum as on 1st April 2011.
- India has total reserves (proved and indicated) of 757 Mt of crude oil 1 as on 1st April 2011.

NATURAL GAS

- Natural gas is a mixture of various compounds of hydrocarbons and small quantities of non-hydrocarbons.
- The world's proven natural gas reserves are estimated to be 196,163 billion m3 in the year 2011. They were 192,549 billion m3 in the year 2010. Associated gas will last for approximately the same time as crude oil. However, the presence of non-associated gas should help. Thus, the peak in the production of natural gas may occur around 2025, about 10 years after the peak in oil production.
- The world's marketed production of natural gas is about 2,636,611 million m3 in the year 2011. It is seen that the production has been increasing more or less continuously at the rate of about 5% per year.
- India has total reserves (proved and indicated) of 1241 billion m3 of natural gas as on 1st April 2011.Gross production of natural gas in the country at 52.22 billion m3 during 2010-11

HYDRO-ELECTRIC POWER

- Hydro-electric power (water power) is developed by allowing water to fall under the force of gravity. Hydroelectricity accounted for 16% of global electricity consumption and 3,644 terawatt hours of electricity production in 2011.
- Hydroelectric power is produced in 150 countries with the Asia-Pacific region generated 32% of global hydropower in 2010. China is the largest hydroelectricity producer, with 721 terawatt-hours of production in 2010, representing around 17% of domestic electricity use.

- Brazil, Canada, New Zealand, Norway, Paraguay, Australia, Switzerland, and Venezuela have a majority of the internal electric energy production from hydroelectric power. Paraguay produces 100% of its electricity from hydroelectric dams, and exports 90% of its production to Brazil and to Argentina. Norway produces 98-99% of its electricity from hydroelectric sources.
- Out of the total power generation installed capacity in India of 1, 76,990 MW (June, 2011), hydro power contributes about 21.5%, i.e. 38,106 MW.
- The public sector has a predominant share of 97% in this sector.
- National Hydroelectric Power Corporation (NHPC), Northeast Electric Power company (NEEPCO), Satluj Jal Vidyut Nigam ltd.(SJVNL), Tehri Hydro Development Corporation, NTPC-Hydro are a few public sector companies engaged in development of Hydro electric power in India.

NUCLEAR POWER

- Nuclear power is developed by fission reactions of nuclear fuel in nuclear reactor.
- Common nuclear fuel used is uranium. Nuclear power plants provided 12.3% of the world's electricity production in 2011. In total, 13 countries relied on nuclear energy to supply at least one-quarter of their total electricity.
- As of August 2012, 30 countries worldwide are operating 435 nuclear reactors for electricity generation and 66 new nuclear plats are under construction in 14 countries.
- The world's resources of uranium are estimated to be 8.8 Mt.
- As of 2011, India had 4.8 GW of installed electricity generation capacity using nuclear fuels. Nuclear power plants generated 32455 million units or 3.75% of total electricity produced in India.
- India’s nuclear power plant development began in 1964. India signed an agreement with general electric of the United States for the construction and commissioning of two boiling water reactors at Tarapur. In 1967, this effort was placed under India's Department of atomic energy. In, 1971, India set up its first pressurized heavy water reactors with Canadian collaboration in Rajasthan. In 1987, India created Nuclear Power Corporation of India Limited (NPCIL) to commercialize nuclear power.
- India’s Kakrapar-I reactor is the world's first reactor which uses thorium rather than Depleted uranium to achieve power flattening across the reactor core. India, which has about 25% of the world’s thorium reserves; is developing a 300 MW prototype of a thorium-based Advanced Heavy Water Reactor (AHWR). The prototype is expected to be fully operational by 2013, after which five more reactors will be constructed. India currently envisages meeting 30% of its electricity demand through thorium based reactors by 2050.
- India’s resources of uranium are not extensive. It is estimated that reserves available are about 61,000 t. It is easy to show that the reserves would only be adequate for providing

- The requirements of an installed capacity of 10,000 MW for about 30 years.

Advantages of convectional/non renewable energy sources

- The advantage of non renewable energy is it's easy and cheap to use.
- There is no better way to store transfer and use energy than gasoline for powering motor vehicles.
- It's quick to pump fossil fuel into a car. It's stable in the tank and a gas tank hold quite a bit, and a gasoline powered car is cheap to manufacture.
- Coal is a ready-made fuel. It is relatively cheap to mine and to convert into energy. Coal supplies will last longer than oil or gas Oil is a ready-made fuel. Relatively cheap to mine and to convert into energy It is a relatively cheap form of energy.
- Natural Gas is a ready-made fuel. It's a slightly cleaner fuel than coal or oil, emitting less carbon dioxide.
- Nuclear has a small amount of radioactive material produces a lot of energy. And raw materials are relatively cheap and can last quite a long time. It doesn't give off atmospheric pollutants.

Disadvantages of convectional/non renewable energy sources

- Non-renewable energy comes from fossil fuels (coal, oil, natural gas, uranium): they are non-renewable and fast depleting.
- They leave behind harmful by-products upon combustion, thereby causing a lot of pollution; mining of such fuels leads to irreversible damage to the adjoining environment.
- Fossil fuels pollute the environment. They will eventually run out. Prices for fossil fuels are rising, especially if the real cost of their carbon is included. Burning fossil fuels produces carbon dioxide, a major cause of global warming.

1.3.2 NON CONVENTIONAL/ RENEWABLE ENERGY SOURCE PRODUCTION & RESERVE

- These sources include wind energy, solar energy, biomass and biofuel, small hydro resources, geothermal energy etc.
- The mankinds have started the use of these sources recently, hence they are known as non-conventional energy sources. The share of these sources in world’s electricity generation is around 3% in 2011.
- The use of wind power is increasing at an annual rate of 20% with a worldwide installed capacity of 238,000 MW at the end of 2011, and is widely used in Europe, Asia, and the United States. Since 2004, photovoltaics passed. Wind as the fastest growing energy source, and since 2007 has more than doubled every two years.
- At the end of 2011 the photovoltaic (PV) capacity worldwide was 67,000 MW, and PV power stations are popular in Germany and Italy.

- Solar thermal power stations operate in the USA and Spain, and the largest of these is the 354 MW SEGS power plant in the Mojave Desert.
- The world's largest geothermal power installation is the Geysers in California; with aerated capacity of 750 MW Brazil has one of the largest renewable energy programs in the world, involving production of ethanol fuel from sugarcane, and ethanol now provide 18% of the country's automotive fuel. Ethanol fuel is also widely available in the USA.
- Top ten wind power generating countries are given in table 1.2

Table 1.2

COUNTRY	TOTAL CAPACITY IN 2011(MW)	COUNTRY	TOTAL CAPACITY IN 2011(MW)
China	62,733	France	6,800
USA	46,919	Italy	6,747
Germany	29,060	U.K.	6,540
Spain	21,674	Canada	5,265
India	16,084	Portugal	4,083

India's non-conventional sources

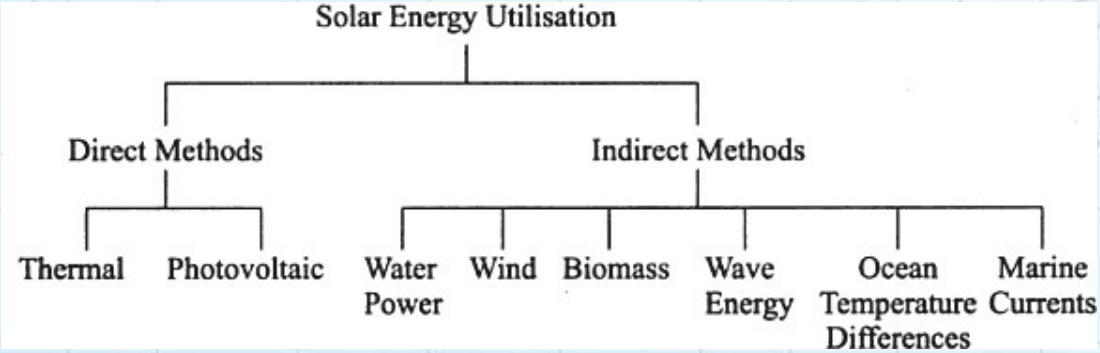
1. **Grid based:** As of June 2011, the Government of India was successful in deploying a total of 2051.05 MW capacity of grid based renewable energy 14550.68 MW of which was from wind power, 3105.63 MW from small hydro power, 1742.53 MW from bagasse cogeneration, 1045.10 MW from biomass power, 39.66 MW from solar power (SPV), and the rest from waste to power.

2. **Off-grid:** As of June 2011, the total deployment total deployment of off-grid based renewable energy capacity was 601.23 MW Of these, biomass (non-bagasse) cogeneration consisted of 316.76 MW, biomass gasifier was 133.63 MW; waste to energy was 73.72 MW. SPV systems (less than 1 kW) capacity was 69 MW, and the rest from micro-hydro and wind power.
   As was the case for the world, in India also, wind energy is the main contributor. India has the fifth largest installed wind power capacity in the world. In 2011, wind power accounted for 6% of India's total installed power capacity, and 1.6% of the country's power output. Suzlon is the leading Indian company, in wind power, with an installed generation capacity of 6.2 GW in India.

1.4 NON-CONVENTIONAL SOURCES/RENEWABLE ENERGY SOURCES

- A plenty of energy is needed to sustain industrial growth and agricultural production. The existing sources of energy such as coal, oil, uranium etc. may not be adequate to meet the ever increasing energy demands. These conventional sources of energy are also depleting and may be exhausted at the end of the century or beginning of the next century.
- Consequently sincere and untiring efforts shall have to be made by the scientists and engineers in exploring the possibilities of harnessing energy from several non-conventional energy sources.

– The various non-conventional energy sources are as follows:
    1. Solar energy
    2. Wind energy
    3. Energy from biomass and biogas
    4. Ocean thermal energy conversion
    5. Tidal energy
    6. Geothermal energy
    7. Hydrogen energy
    8. Fuel cells
    9. Magneto-hydro-dynamic generator
    10. Thermionic converter
    11. Thermo-electric power.



1. Direct application of solar energy
1. Solar Space heating and cooling of residential buildings
2. Solar water heating
3. Solar drying of agricultural and animal products
4. Solar distillation
5. Salt production by evaporation of seawater or inland brines
6. Solar cookers
7. Solar pumping
8. Food refrigeration
9. Solar green houses
10. Solar furnaces
11. Solar electric Power generation
12. Solar photovoltaic cells

2. Indirect application of solar energy

1. Wind energy

– A small portion of solar radiation reaches on earth surface causes wind due to:
    a) Heating up of earth surface due to absorption of solar radiation and cooling at night.
    b) Rotation of earth and its motion around sun.

Fig1.1 Horizontal Axis Wind Turbine

2. Tidal energy

- Tides are generated due to gravitational pull between the earth and the moon and sun.
- The difference between high tide & low tide could be utilized to operate hydraulic turbine.

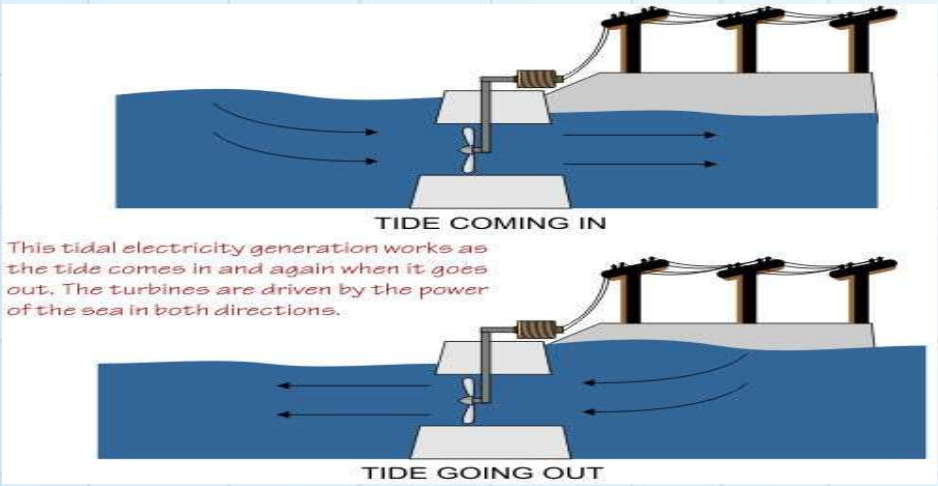


Fig1.2

3. Wave energy

- The wave energy is developed due to wind interacting with the surface of the ocean .wind get 1 to 5% of sun energy and part of this is transfer to wave this can be used for power generating.

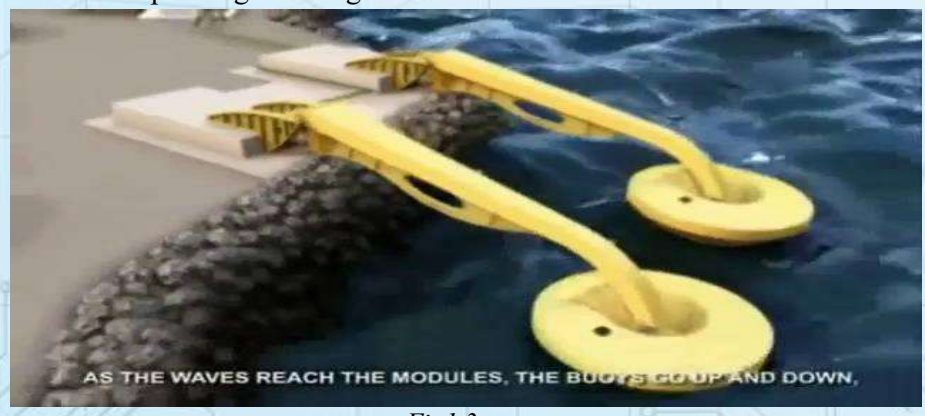


Fig1.3

4. **Geo thermal energy**

- Geo thermal energy itself on earth's surface in the form of geyster, hot spring, furnarhole& boingMud
- By drilling hole 3 km deep in the field the steam and water comes out from surface at temperature Up to 500°c
- It can be used for power generating.

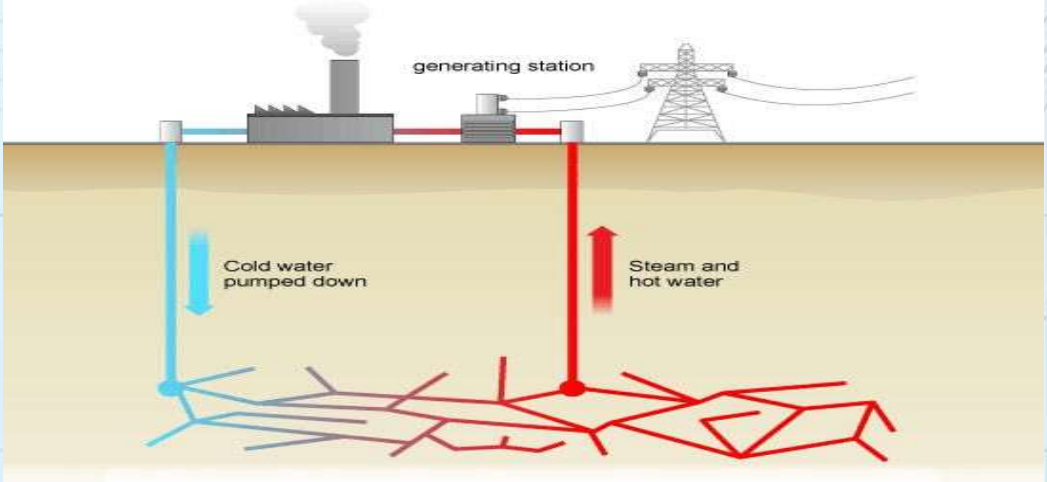


Fig1.4

5. **Ocean thermal energy**

- Ocean serves a big store house of solar energy
- At water surface 23°c-source ,while temperature at depth of 100m is 5°c-sink
- Temperature differential can be used to run heat engine & power can be produce using working fluids NH3,R-12, propane gas .

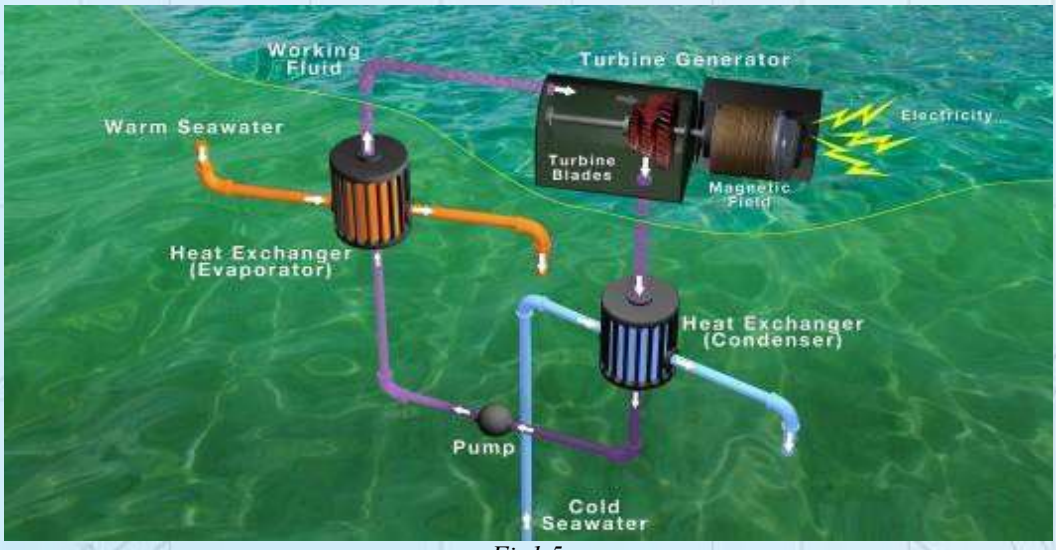


Fig1.5

6. **Biomass & biogas**

- Bio mass is an organic matter produced by plant both grown on land and in water and their derivatives and animal manure .

- Biomass is in indirect application because it grows by photo synthesis.
- Bio-gas is a gaseous fuel which is obtained by fermenting the biomass anderobically in absence of oxygen.
- It contains
  - Methane (55 to 65%)
  - CO2 (30 to 40%)
  - Rest impurities N2, H2S, H2 etc.
- Used for power generation, cooking etc.

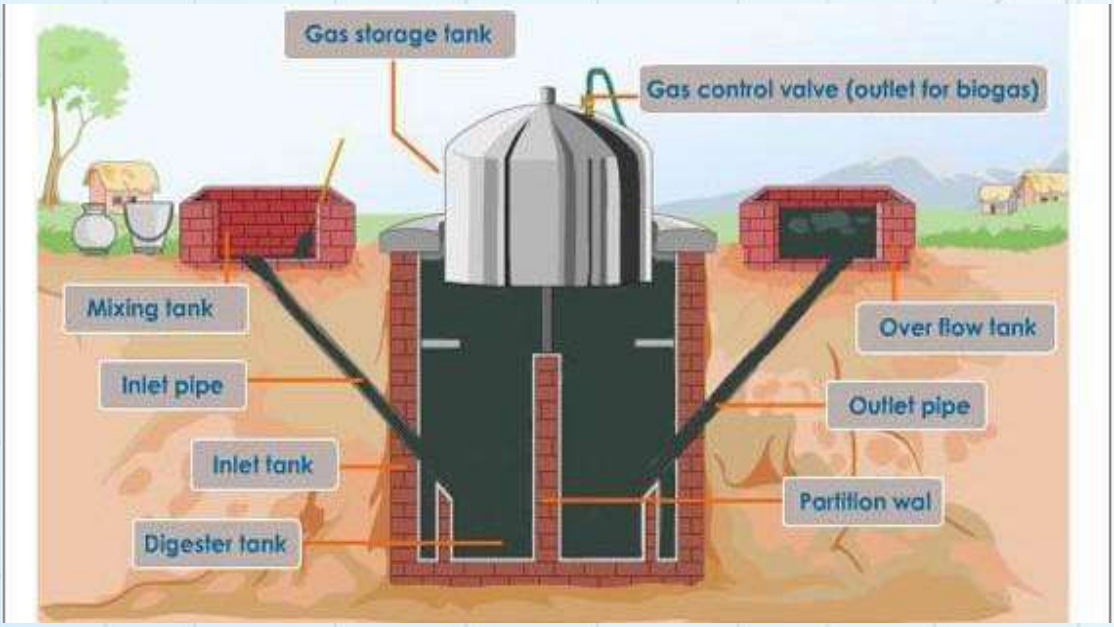


Fig1.6

Advantages of non-conventional sources/renewable energy sources

- The main advantage is the fact that they are renewable.
- We will never run out of sources of renewable energy (at least in our lifetimes, as long as humans will exist) solar energy - the sun will always be there, and in abundance.
- The amount of solar energy intercepted by the Earth every minute is greater than the amount of energy the world uses in fossil fuels each year.
- wind energy - the wind will always exist - The energy in the winds that blow across the United States each year could produce more than 16 billion GJ of electricity - more than one and one-half times the electricity consumed in the United States in 2000.
- Tidal energy - the moon which provides the forces that causes the tides will always be there hydroelectric energy - unless there is a drastic change in rain patterns, it will always be there On the other hand, non-renewable resources such as fossil fuels are finite - our resources of them will run out eventually.

- A second advantage, renewable resources are seen as being 'green', or environmentally friendly. This is because they do not emit carbon dioxide (the biggest contributor to global warming) into the atmosphere. Non-renewable resources such as petroleum release CO2 into the environment when they are combusted for energy.
- Other renewables such as biofuels are carbon neutral - producing them consumes about as much CO2 as using them produces.

Disadvantages of non-conventional sources/renewable energy sources

- Renewable energy is energy derived from sources that will not run out. Some of the present disadvantages are:
- Solar panels are expensive. Governments are not all willing to buy home generated electricity. Not all climates are suitable for solar panels.
- Wind -- turbines are expensive. Wind doesn't blow all the time, so they have to be part of a larger plan.
- Waves -- different technologies are being tried around the world. Scientists are still waiting for the killer product.
- Tides -- barrages (dams) across river mouths are expensive to build and disrupt shipping. Smaller turbines are cheaper and easier to install. rivers -- Dams are expensive to build and disrupt the environment. They have also caused earthquakes. Smaller turbines are cheaper and easier to install.
- Geothermal -- Difficult to drill two or three kilometers down into the earth.
- Biofuel -- Often uses crop lands and crops (like corn) to produce the bio-alcohol. This means that more land has to be cleared to grow crops, or there is not enough food, or that food becomes more expensive.

Electrical power generation

- It has been widely recognized that the fossil fuels and other conventional resources, presently used in generation of electrical energy, may not be either sufficient or suitable to keep pace with the ever increasing world demand for electrical energy. The prospects for meeting this demand and avoiding a crisis in supply would be improved if new and alternative energy sources could be developed.
- The present total installed capacity of electrical power generation in India is 1,10,000 MW, produced from various resources as given in Table 1.3:

Table 1.3

RESOURCE	%
THERMAL	68.8
HYDRO	24
NUCLEAR	2.7
NON CONVENTIONAL	4.5

1.5 Need for alternate sources

- Due to increasing use of fossil fuels and environmental concern and rapid depletion of natural resources have led to development of alternative source of energy which are renewable and environment friendly. In this connection, the following points may be considered.
    - Due to rapid industrialization and population growth the demand of energy is increasing very rapidly. Hence the conventional source of energy will not be sufficient to meet the growing demand.
    - Conventional sources except hydropower are non-renewable and are bound to finish up one day.
    - Conventional sources also cause pollution; thereby their use degrades the environment.
    - Large hydro resources affect wildlife, cause deforestation and pose various social problems.
    - Fossil fuels can also be used extensively as feed stock materials for the manufacture of organic chemicals.
- Now, it has become important to explore and develop non-conventional energy resources to reduce too much dependence on conventional resources due to above reasons.