LECTURE 5

WIND ENERGY:

Energy of wind can be used for generating electrical energy. Winds are caused from 2 main factors:

1) Heating and cooling of the atmosphere which generates convection currents. Heating is caused by the absorption of solar energy on the earth's surface and in the atmosphere.
2) The rotation of the earth with respect to atmosphere and its motion around the Sun.

The potential of wind energy as an energy source is large of the order of $1.6*10^7$ MW. Wind energy is an indirect source of solar energy conversion utilized to run wind mill, which in turn drives a generator to produce electricity. Wind energy can be used to provide mechanical power such as for water pumping. In India, since wind speeds obtainable are in the lower ranges, it is used for the development of low cost, low speed mills for irrigation of small and marginal farms for providing drinking water in rural areas. Water pumping wind mills are suitable for operation in a wind speed range of 8-36 km/h. High wind speeds are obtained in coastal areas of Saurashtra, Western Rajasthan, and some parts of Central India where medium and large sized wind mills can be used for generation of electricity. Some common wind mills designed, developed and found practically suitable and useful are:

1) Multiblade type wind mill
2) Sail type wind mill
3) Propeller type wind mill
4) Savonius type wind mill
5) Darrieus type wind mill

Vertical axis machine are simple in design.
Characteristics of wind energy are:

1) It is a renewable source of energy.
2) It is non-polluting.
3) Wind energy systems avoid fuel provision and transport.
4) Production on a small scale is less costly and costs are competitive with electricity generated conventional.

Problems associated with wind energy are:

1) Wind energy available is dilute and fluctuating in nature and requires conversion machines.
2) Wind energy needs storage options because it is irregular.
3) Noisy during operation, heard many kilometers away.
4) Large areas are needed to install wind farms for electrical power generation.

Wind velocities in India are relatively low (5-20km/h) and fluctuating appreciably with the seasons. These low and seasonal winds imply high cost. Electric power will not be available in many areas due to the high cost of generation and distribution to small dispersed users. There is possibility of reducing the cost of the wind mills to suitable design. Following are some projects on the wind mill system for water pumping and for production of small amount of electrical power:

1) CAZRI wind mill at Jodhpur(Rajasthan)
2) WP-2 water pumping wind mill at NAL(Bangalore)
3) MP-1 sail wind mill at Madurai
4) Tayabji wind mill at Tilonia(Rajasthan)
5) Sholapur wind mill at Sholapur.

12 PU 500 wind mill can pump at the rate of about 5000 to 6000 l/h over a total head of 5m when the wind speed is in the range of 12 to 14km/h. It can develop more power at higher wind speeds.

The simple MP-1 sail type wind mill has same output as that of 12 PU 500. The Dept. of Non-Convention Energy Sources(DNES), Govt. of India. Commisioned 4 wind farms at Mamdavi(Gujarat) 550KW ,Puri(Orissa) 550KW, Okha(Gujarat) 550KW and Deogarh(Maharashtra) 550KW.

During the 7^{th} plan, nine wind-farm projects of aggregate capacity of 10.10 MW have been commissioned at Okha, Mandvi and Okha-Mandhvi in Gujarat, Tuticorin and Kayattar in Tamilnadu; Puri in Orissa; Deogarh in Maharashtra; Tala Cauvery in Karnataka and Tirumala in Andhra Pradesh and about 2500 water pumping wind mills have been installed. Wind pump technology has been upgraded to cover the deep-well wind pumping applications. India has a potential of 20,000 MW of wind power. DNES plans to harness 400 MW of wind energy during 8^{th} plan period.

3) ENERGY FROM BIO-MASS AND BIO-GAS:

The potential for bio-mass as an alternate source of energy in India is very great since plenty of agricultural and forest resources are available for production of bio-mass. Bio-mass is produced through photosynthesis achieved by solar energy conversion. Bio-mass

means organic matter. The reaction is the process of photosynthesis in the presence of solar radiation given by

$$H_2O + CO_2 \xrightarrow{\text{Solar Energy}} CH_2O + O_2$$

Water and CO_2 are converted into organic material, i.e., CH_2O, which is the basic molecule of forming carbohydrates stable at low temp., it breaks at high temp., releasing an amount of heat = 112,000 cal/mole or 469 kJ /mole.

$$CH_2O + O_2 \longrightarrow CO_2 + H_2O + 112 \text{ K cal /mole}$$

It is possible to produce large amount of Carbohydrate by growing, For example: algae under optimum conditions in plastic tubes or in ponds. The algae could be harvested, dried and burnt for production of heat that could be converted into electricity by conventional methods. The bio-mass is used directly by burning or is further processed to produce more convenient liquid and gaseous fuels.

Bio-mass resources fall into 3 categories :

1.) Bio-mass in its traditional solid mass (wood and agricultural residue) when burnt gives the energy directly.
2.) Bio-mass in non-traditional form (converted into liquid fuels) which is converted into ethanol and methanol to be used as liquid fuels in engines.

The third category is to ferment the bio-mass anaerobically to obtain a gaseous fuel called bio-gas containing 55 --- 65% methane, 30 – 40% CO_2 and the rest impurities such as H_2, H_2S and N_2.

Bio-mass resources include :

a.) Concentrated waste – municipal solids, sewage wood products, industrial waste, manure of large lots.
b.) Dispersed waste residue – crop residue, disposed manure.

Harvested bio-mass, standby bio-mass, bio-mass energy plantation.

Energy Plantation :

For large scale production of selected power, fire wood is used as a fuel for the bodies of a conventional power plant. In energy plantation scheme, selected species of trees would be planted and harvested over regular time period on a large area of land near the power plant. In India, eucalyptus, casuarina and babool are the selected trees planted.

Bio-gas :

The main source for production of bio-gas is wet cow dung or wet livestock and human waste, to produce bio-gas. The production of bio-gas is important in India because of its large cattle population of about 250 million.

Other sources of bio-gas are :

i) Sewage
ii) Crop residue
iii) Vegetable waste
iv) Algae
v) Poultry droppings
vi) Pig manures etc.,

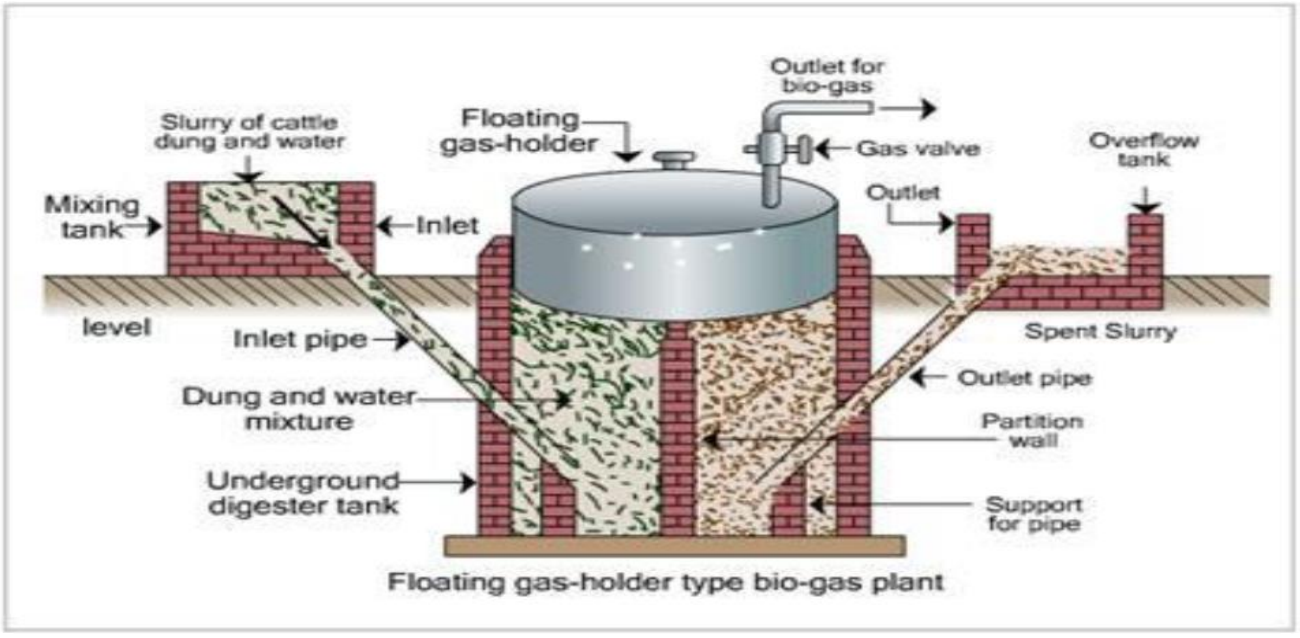
In cities, sewage is the main source for production of bio-gas. Bio-gas thus obtained can be used to run pumps to pump out the sewage water itself. Pilot plants have already been developed for handling sewage. The sewage bio-gas is high quality fuel containing 84% CH_4. CH_4 could be economically used to run engines to drive electric generators.

In the rural areas, bio-gas finds great applications in cooking, lighting, mechanical power and generation of small electricity. The gas can be used with advantage to improve sanitary conditions and also to control environmental pollution. Bio-gas can be used independently or with diesel in I.C. engines for production of power. For converting I.C. engines of diesel, or petrol/kerosene type to gas engines, a special attachment is required. Ruston and Hornsby have developed 5 HP engine to work on bio-gas. Remarkable progress has been made in India in respect of bio-gas plants. Many bio-gas plants were installed during the Seventh Plan Period. Some successful bio-gas plants commissioned by DNES during 1985-86 are at Muradnagar (U.P.), Rishikesh (U.P.) , Sanganer and Sihar (Rajasthan), Pondicherry, Bhopal (M.P.), etc. About 70 community / institutional type bio-gas plants are set during the year 1985-86.

BIOGAS

A combustible gas (composed primarily of methane) produced when Organic waste, sewage or manure is fermented in the absence of oxygen. The solid material that remains in the digester after fermentation can be used as an organic fertilizer.

Biogas - a gas mixture of methane, carbon dioxide and small quantities of hydrogen and hydrogen sulphide - is created under air exclusion through the fermentation of organic substances with microorganism assistance. Biogas is a gas mixture, consisting of approximately 40 to 75 % methane (CH4), 25 to 60 % carbon dioxide (CO2), and approx. 2 % of other gases (hydrogen, hydrogen sulphide and carbon monoxide).



Floating gas-holder type bio-gas plant

THE PROCESS

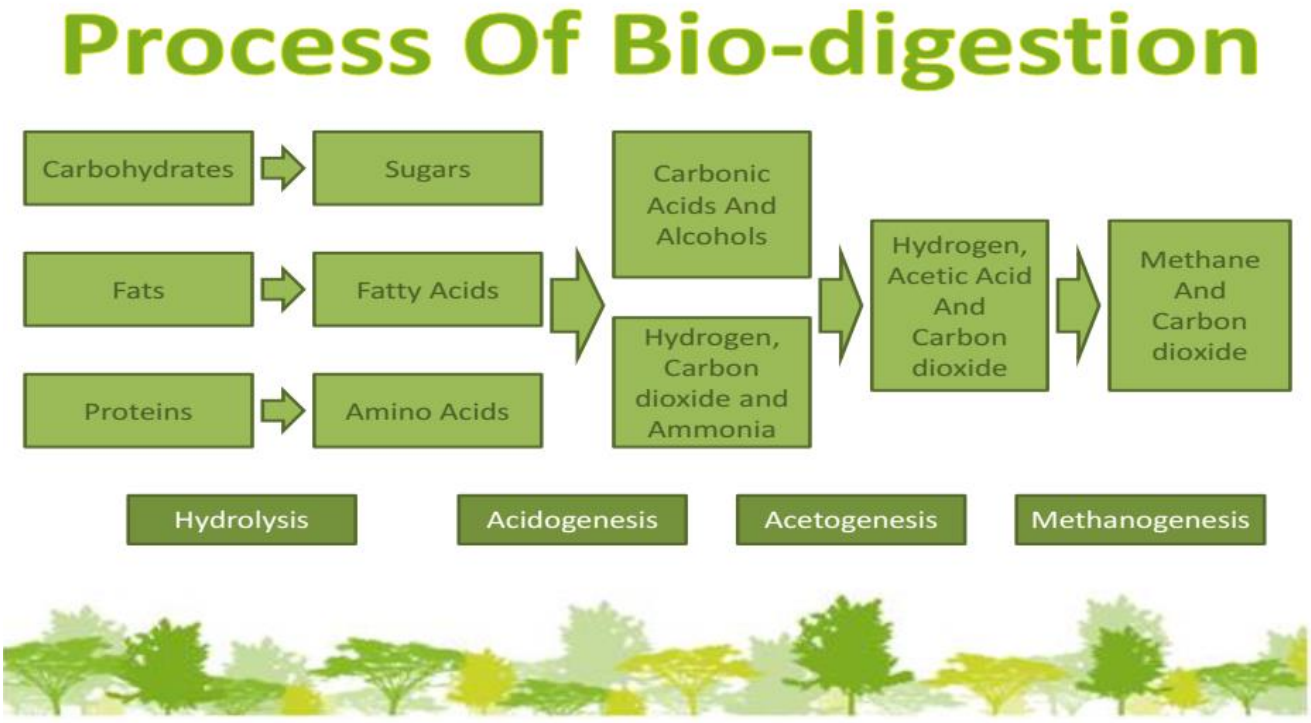
The feed materials are collected in the Anaerobic Digester through re routed ***pipe line.***

The slurry is fermented inside the ***digester*** and biogas is produced by bacterial action.

The biogas then gets collected into the ***Dome***. The Dome holds the gas until the time of consumption.

The digested slurry is Collected into the ***outlet tank*** as a water condition discharged through outlet pipe for irrigation.

The ***gas pipe line*** carries the gas to the point of utilization.



Benefits Of Biogas

- Availability of power at affordable rates
- Reduces pollution
- Reduces time wastage while collecting firewood
- Reduces reliance on fossil fuels
- Saves on the environment (Reduces deforestation)
- Improves living standards in rural areas
- Reduces global warming
- Produces good quality enriched manure to improve soil fertility.
- Effective and convenient way for sanitary disposal of organinc wastes, improving the hygienic conditions.
- As a smokeless domestic fuel it reduces the incidence of eye and lung diseases.

Ocean Thermal Energy Conversion (OTEC)

Ocean thermal energy conversion is also indirect method of utilizing solar energy. A large amount of solar energy is collected and stored in tropical oceans. The surface of the water acts as the collector for solar heat, while the upper layer of the sea constitutes infinite heat storage reservoir. Thus, the heat contained in the oceans, could be converted into electricity by utilizing the temp. difference between the warm surface waters of the tropical oceans and the colder waters in the depths is about 20—25°K. Utilization of this energy with its associated temp. difference and its conversion into work, forms the basis of OTEC systems. The surface water which is at higher temp. could be used to heat some low boiling oraganic fluid, the vapours of which could run a heat engine. The exit vapour would be condensed by pumping cold water from deeper regions. The amount of energy available for ocean thermal power generation is enormous. France has several such plants, the largest of which has a capacity of 7.5 MW

All the systems for OTEC method work on closed Ramkine cycle and use low boiling organic fluids like NH_3, propane, R-12, R-22, etc.

The warm surface water is used for supplying the heat input in boiler, while the cold water brought up from the ocean depths is used for extracting the heat in the condenser. In India, DNES has proposed to install a 1 MW OTEC plant in Lakshadweep island at Kavaratti and Minicoy. The proposed OTEC plant will bring up the water from 1000m depth which has high nutrient value. The sea water provides the cooling effect in the condenser.

TIDAL ENERGY

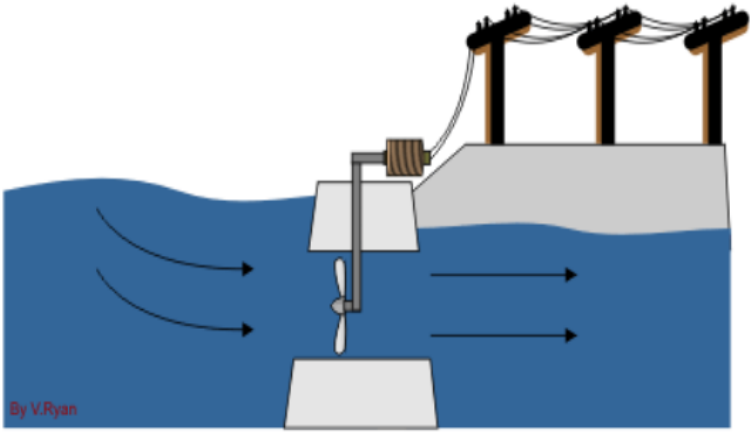
The tides in the sea are the result of the universal gravitational effect of sun and moon on the Earth. Due to fluidity of water mass, the effect of gravitational force becomes apparent in the motion of water, which shows a periodic rise and fall in levels in rhythm with the daily cycle of rising and setting of sun and moon. This periodic rise and fall of the water level of the sea is called tide. These tides can be used to produce electrical power which is known as tidal power. When the water is above the mean sea level, it is called flood tide and when the level is below the mean sea level, it is called ebb tide . The use of tides for electrical power generation is practically possible in a few sites where the geography of an inlet or bay favours the construction of a large scale hydroelectric plant. To harness the tides, a dam should be built across the mouth of the bay. It will have large gates in it and also low head hydraulic reversible turbines are installed in it. A tidal basin is formed by the dam, separating the basin from the sea. The constructed basin is filled during high tide and emptied during low tide, passing through sluices turbine respectively. This principle is explained in fig.4. By using reversible water turbines, turbine can be run continuously during high tide and low tide. The turbine is coupled to generator. Potential energy of the water stored in the basin as well as energy during high tide is used to drive the turbine to generate electricity.

TIDES & TIDAL POWER:-

- Rise and fall in sea levels
- Caused by the combined effect of moon and sun.
- Tides are quite predictable.

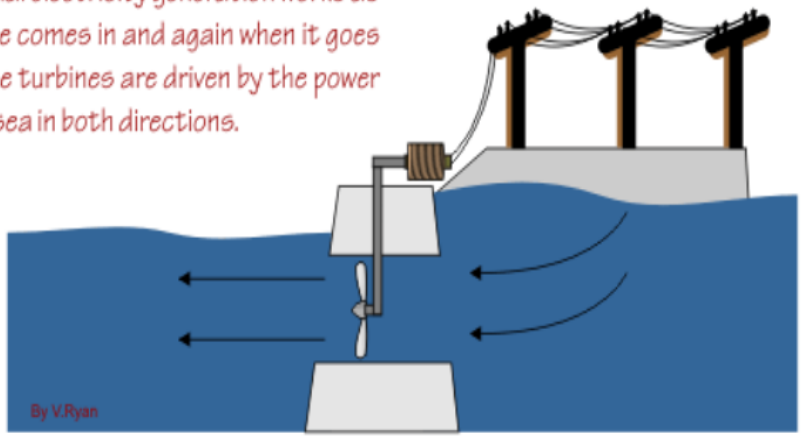
WORKING PRINCIPLE:-

- Consists of a turbine & an electrical generator(alternator).
- Turbines/**windmill like blades** are installed on the ocean floor.
- Turbine and generator are connected directly or by a gearbox.
- Due to kinetic or potential energy of sea water the turbine rotates.
- Generator rotates and produces electricity.
- At shore, electricity can be distributed.



TIDE COMING IN

This tidal electricity generation works as the tide comes in and again when it goes out. The turbines are driven by the power of the sea in both directions.



TIDE GOING OUT

A tidal power plant at Rance in France with a capacity of 240 MW works on single basin, two way system with pumping. The possible sites for tidal power plants in India are at Gulf of Cambay, Gulf or Kutch in Gujarat and Sunderban area in West Bengal.

Geothermal Energy

Geothermal energy is the energy which lies embedded within the earth. The earth has a molten core. The fact that volcanic action takes place in many places confirms this theory. The steam and hot water comes naturally to the surface of the earth in some locations of the earth. For large scale use bore holes are normally sunk with depth upto 1000 m, releasing steam and water at temps. upto 200 or 300^0 C and pressures upto 30 kgf/cm^2. Two ways of electric power production from geothermal energy is transferred to a working fluid which operates the power cycle. This may be particularly useful at places of fresh volcanic activity. Fig.5 is a schematic diagram of Geothermal power plant (wet steam).

By embedding coil of pipes and sending water through them, high temp. can be obtained. In the other, the hot geothermal water and/or steam is used to operate the turbines directly. From the well head, the steam is transmitted by pipe lines upto 1 m in diameter over distances upto about 3 Km to the power station. At present, only steam coming out of the ground is used to generate electricity, the hot water is discarded because it contains as much as 30% dissolved salts and minerals, and these cause serious rust damage to the turbine. The water however contains more than 1/3 of the available thermal energy. Research is being carried out to build turbines which can withstand the corrosive effects of hot water coming our of the wells. Geothermal energy is abundantly available in USA, Japan New Zealand, Iceland, USSR, Italy and Mexico. In India, Himachal Pradesh possesses geothermal energy in exploitable amounts. World's first geothermal power station was established at Lardarello in Italy in 1905 which currently produces more than 460 MW of power. Other chief installation of geothermal energy is at Wairaki in New Zealand (250 MW). A 7.5 Tonne capacity cold storage pilot plant based on geothermal energy is installed by DNES at Manikarah in Himachal Pradesh.

HYDROGEN ENERGY

Hydrogen energy can play an important role as an alternative to conventional fuels provided its technical problems of production, storage, and transportation can be resolved satisfactorily and the cost could be brought down to acceptable limits. Hydrogen can be produced from water which is abundantly available in nature. It has the highest energy content per unit mass of any chemical fuel and it can be substituted for hydrocarbons in various applications with high combustion efficiency. Its burning is non-polluting and it can be used in fuel cells to produce both electricity and useful heat.

Renewable Energy Resources :

Renewable energy resources include direct solar radiation intercepted by collectors (e.g. solar and flat plate thermal cells) and indirect solar energy such as wind, hydropower, ocean energy and bio mass resources. Traditional methods of using biomass and derivatives such as wood and charcoal are highly inefficient. Modern techniques use proper forest management, fuel wood plantations and efficient production. Economic and financial analyses help to improve the efficiency of conventional energy use.

Advantages of Renewable Energy :

Renewable energy is an indigenous resource available in considerable quantities and help to conserve foreign exchange and generate local employment if conversion technologies are designed, manufactured, assembled and installed locally.

Conversion technology of renewable energy flexible and modular ; It can be rapidly deployed; It is easy in adding new capacity with less risk; lower interest on borrowed capital and reduced transmission and distribution costs for dispersed rural locations.

Prospects of renewable energy sources:

Solar energy could be captured using solar collectors, wind water turbines, wave energy converters, etc. to supply more useful energy. Renewable energy resources cannot be exhausted and they already supply a major part of the world's energy needs. Biomass accounts for about 1/7 of all fuel consumed ; Hydro-generators ¼ of the world's electricity. The sun contributes directly to space heating in virtually all buildings.

Resource	Application	Comment
Solar Total solar radiation absorbed by earth is about 3.8×10^{24} J/yr	Space heating, Water heating and Electricity	Millions of solar water heaters and solar cookers in use. Solar cells and power towers are in operation.
Wind KE available = 7.5×10^{24} J in atmosphere	Electricity and pumping transport.	No. of small wind turbines and wind pump in use
Biomass Total solar radiation absorbed by plants is 1.3×10^{21} J/yr. Its world potential is about 1.5×10^{22} J.	Cooling, smelting, mechanical power	It provides over 80% of the energy needs of man developing countries. Millions of biogas plants in operation in China.
Biomass (continued)	Alcohol for transport	Production of alcohol is increasing rapidly in Brazil and the U.S. Many countries have launched liquid biofuel programmes
Geothermal: (a) Geothermal energy from earth's crust through surface is 9.5×10^{20} J/yr.	Bathing, space and water heating	It supplies about 5350 MW of heat for use in bathing, in Japan, Italy, Hungary, Iceland. More than a lakh houses are supplied with heat and geothermal walls.
(b) Total amount of water or stream to a depth of 10 km is = 4×10^{21} J. That stored in the first 10 km of dry rock is around = 10^{27}J.	Electricity	Installed capacity is >2500 MW and expect to increase sevenfold.
Resource	Application	Comment
Tidal :- Energy dissipated in connection with slowing down the rotation of earth as	Electricity	Only 1 largetidal barrage is in operation at La Rance in France and small schemes in Russia and China.

a result of tidal action is around 10^{26}J/yr.		Total installed capacity =240MW output=0.5 JWh/yr. China has several small tidal pumping station
Wave :- The amount of energy stored as kinetic energy in waves = 10^{18} J.	Electricity	Japanese wave energy research vessel, the Kaimu, has an installed capacity of about 1 MW. There are several hundred wave powered navigating buoys for wave energy
Hydroelectric Power :- Assuming average elevation of land as 840m the annually accumulated potential energy would be $9x10^{20}$ J.	Electricity	Large hydroschemes provide ¼ of the world's total electric supply and more than 40% of the electricity used in developing countries. The installed capacity is more than 363 GW.

The requirements of oil are expected to increase from about 30 - 92 million tonnes and coal from 100 - 530 million tonnes.

In India, coal reserves = 11,700 million tonnes
oil reserves = 300 million tonnes
natural gas reserves = 73 million m^3 .

India has modest reserves of U and substantial reserves of T_h . India's thorium reserves can support a very large programme of nuclear power development based on breeder reactor technology.

The use of electrical energy in India has steadily increased. But it is essential to keep transmission and distribution losses and consumption of energy by auxiliaries in the power station to a minimum. In India, hydroelectric power is the most economical source of power generation. Due to the limited oil reserves, India has to depend on importing for meeting its future requirements. Transport sector consumes the most.

Biogas and solar energy offer the greatest scope for the development of new energy sources.