

# ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY

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Department of Mechanical Engineering



ADD-ON COURSE ON RENEWABLE ENERGY RESOURCES  
(RCETMECHAC04)

## **UNIT IV**

### **ENERGY SOURCES**

#### **1.1. Introduction to energy**

The energy of a body is its capacity to do work. It is measured the total amount of work that the body can do. Energy is the primary and most universal measure of all kinds work by human beings and nature. Every thing what happens the world is the expression of flow of energy in one of its forms.

#### **1.2. Different forms of energy**

The different forms of energy are:

1. Mechanical energy (kinetic and potential)
2. Thermal (or) Heat energy
3. Chemical energy
4. Electrical energy

5. Nuclear energy

6. Electromagnetic energy

7. Gravitational energy

The S.I unit of energy is Joule or KJ or Watt.h.

### **1.Primary Energy Sources**

Primary energy sources can be defined as sources which provide a net supply of energy

Coal, Oil, Uranium etc., are examples of this type. The energy required to obtain these fuels

is much use than what they can produce by combustion or nuclear reaction. The supply of

primary fuels is limited. It becomes very essential to use these fuels sparingly.

### **Examples**

Coal, natural gas, oil and nuclear energy.

## **2.Secondary Energy sources**

Secondary fuels produce no net energy. Though it may be necessary for the economy, these may not yield net energy. Secondary sources are like sun, wind, water (tides), etc.

Solar energy can be used through plants, solar cells, solar heaters and solar collectors.

3. **Supplementary sources** are defined as those whose net energy yield is zero and those requiring highest investment in terms of energy. Insulation (thermal) is an example for this source.

## **Energy Consumption as a Measure of Prosperity :**

Energy is an important input in all sectors of any country's economy. The standard of living of a given country can be directly related to per capita energy consumption. The per capita energy consumption in U.S.A. is 8000 kWh per year, whereas the per capita energy consumption in India is 150 kWh U.S.A. with 7% of world's population consumes 32% of the total energy consumed in the world, whereas India, a developing country with 20% of the world's population consumes only 1% of the total energy consumed in the world. Therefore one might conclude that to be materially prosperous, a human being needs to consume more and more energy than his own.

## **What Constitutes an Energy Crisis ?**

Energy crisis is a situation in which the nation suffers from a disruption of energy supplies (in our case, Oil) accompanied by rapidly increasing energy prices that threaten economic and national security.

With the international crude oil prices hovering around \$ 125 per barrel and the oil import bill set for a jump of over Rs. 537 billion to reach over Rs. 2727 billion this year, India is heading for a major energy crisis. With a population of around 113 corer, we cannot afford to follow the high-energy consumption pattern of the West that has resulted in an indiscriminate exploitation of fossil fuels and high pollution levels. The situation will aggravate if necessary steps are not taken in time. According to Dr. Rajendra K Pachauri, Director-General, The Energy and Resources Institute (TERI) ‘The lack of any comprehensive national energy policy, inadequate public transport system and disregard of domestic renewable energy resources has led to the present energy crisis’.

### **3. Energy sources and their availability**

#### **Introduction**

Today every country draws its energy needs from a variety of sources. We can broadly categorize these sources as commercial and noncommercial. The commercial sources include the fossil fuels (coal, oil and natural gas), hydro-electric power and nuclear power, while the noncommercial sources include wood, animal waste and agricultural wastes. In

an Industrialized country like U.S.A. most of the energy requirements are met from commercial sources, while in an Industrially less developed country like India, the use of commercial and non-commercial sources are about equal.

#### **1.4. Conventional and non-conventional sources energy**

##### **1.4.1. Conventional energy sources**

Conventional energy sources are:

(a) Fossil fuel energy

(b) Hydraulic energy

(c) Nuclear energy

### **(a) Fossil fuel energy**

Coal, petroleum, and natural gas are called Fossil fuel as these are formed by the decomposition of the remains of dead plants and animals buried under the earth for a long time. These are non-renewable sources of energy, which, if exhausted, can not be replenished in a short time. Their reserves are limited and are considered very precious. These should be used with care and caution to let them last long. These are also contributing to the global environmental pollution.

Wood was dominant source of energy in the pre-industrialization era. It gave way to coal and coke. Use of coal reached a peak in the early part of the twentieth century. Oil get introduced at that time and has taken a substantial share from wood and coal. Wood is no more regarded as a conventional source. Hydroelectricity has already growth to a stable level in most of the developed countries.



A brief account of the various important sources of energy and their future possibilities is given below. The percentage use of various sources for the total energy consumption in the world is given in Table. 1

**Table 1.4.1.**

Coal	32.5%	}	→ 92%
Oil	38.3%		
Gas	19.0%		
Uranium	0.13%		
Hydro			2.0%
Wood	6.6%	}	→ 8%
Dung	1.2%		
Waste	0.3%		

**(i) Coal**

India now ranks third amongst the coal-producing countries in the world. Coal is the most abundant fossil fuel in India till date and coal has been the mainstay of India's energy supply for many years. Production of coal has increased from about 71 MT (million tones) in the early 1970s to 407 MT in 2005-06 (MOC 2007). Indian coal is of poor quality and has high ash content

Since the advent of industrialization coal has been most common source of energy. In the last three decades, the world switched over from coal to oil as a Major source of energy because it is simpler and cleaner to obtain useful energy from oil. Coal is a complex mixture of compounds of carbon, hydrogen and oxygen. Small amounts of nitrogen and Sulphur compounds are also present in coal. It is mainly available in Bihar, West Bengal, Orissa and Madhya Pradesh. The big coal mines in our country are at Jharia and Bokaro in Bihar and at Raniganj in West Bengal. It is considered as the backbone of the energy sector for its use in industry, transportation and electric power generation.

According to estimates coal is abundant. It is enough to last for 200 years. However, it is low in calorific value and its transportation is expensive. Coal is pollutant and when burnt it produces CO<sub>2</sub> and CO. Extensive use of coal as a source of energy is likely to disturb the ecological balance of CO<sub>2</sub> since global warming will take place due to large proportions of carbon dioxide produced by burning large quantities of coal.

Coal : Proved reserves at end of 2005 in MT.

	Total	Share of Total	R/P Ratio.
India	92445	20.2%	237
World	909064	100.0%	155.

## **(ii). Petroleum**

**Oil:** The 40% of the energy needs of the world are fed by oil

It is a dark coloured, viscous and foul smelling crude oil. The petroleum means rock oil. It is normally found under the crust of earth trapped in rocks. The crude oil is a complex mixture of several solid liquid gaseous hydrocarbons mixed with water, salt and earth particles. It is a natural product obtained from oil wells.

With today's consumption and a resource amount of 250,000 million tones of oil, it would suffice for about 100 years unless more oil is discovered. Some of the crude oil producing locations in our country are:

(i) Ankleshwar and Kalol in Gujarat

(ii) Rudrasagar and Lakwa in Assam; and

(iii) Bombay high (off-shore area)

The oil wells of Bombay high are producing about 22 million tons of crude petroleum oil per year, which is little less than half of the total requirement of the country. The efforts are also being made to search oil well in off-shore deltas to Godavari, Kaveri, and Rajasthan.

The indigenous production of crude oil has increased from 6.82 MT in 1970/71 to 34.227 MT in 2007-08 (MoPNG 2008). However, during the last 15 years, domestic production of crude oil has remained almost stagnant, thereby leading to increased import of crude oil. During 2007-08, the country's crude oil import was 122.67 MT, valued at Rs. 2727 billion, resulting in an import dependency of about 75%.

Oil : Proved reserves at end of 2005 in TMB

India	5.9	0.5%	20.7
World	1200.7	100.0%	40.6%

### **(iii) Natural gas**

It consists about 95% Methane and rest ethane and propane. It occurs deep under the crust of the earth either alone or along with oil above the petroleum deposits. It is a product of petroleum mining. The gas is available in Tripura, Jaisalmer, off-shore areas of Bombay High and in the Krishna – Godavari delta. It is used as a domestic and industrial fuel. The natural gas is now also available as CNG (Compressed Natural Gas) a substitution of petrol in automobiles.

Gas is incompletely utilized at present and huge quantities are burnt off in the oil production process because of the non-availability of ready market. The reason may be the high transportation cost of the gas. To transport gas is costlier than transporting oil.

The production of natural gas increased from 1.4 B.C.M. (billion cubic meters) in 1970/71 to 32.274 BCM in 2007-08. The demand for natural gas is more than the demand hence to bridge this gap, India is importing natural gas in liquefied form, commonly referred to as LNG(liquefied natural gas).

Natural Gas : proved reserves at end of 2005 in TCM.

India	1.10	0.6%	36.2
World	179.83	100.0%	65.1

**(b) Hydraulic energy (or) Water power**

Water power is developed by allowing water to fall under the force of gravity. It is used almost exclusively for electric power generation, in fact, the generation of water power on a large scale became possible around the beginning of the twentieth century only with the development of electrical power plants or Hydro electric plants were usually of small capacities usually less than 100 KW. Potential energy of water is converted into Mechanical energy by using prime moves known as hydraulic turbines. Water power is quite cheap where water is available in abundance. Although capital cost of hydro electric power plants is higher as compared to other types of power plants but their operating Costs are quite low,

as no fuel is required in this case. The development rate of hydropower is still low, due to the following problems:

1. In developing a project, it will take about 6-10 years time for planning, investigation and construction.
2. High capital investment is needed, and some parts of the investment have to be designed from foreign sources.
3. There are growing problems on relocation of villages, involved, compensation for damage, selecting the suitable resettlement area and environmental impact.

Because of long transmission line to the villages with low load factor, the electric power will be available to the people in rural areas may not be economical. This leads to the development of Mini or Micro hydroelectric projects to supply the electric power to remote areas. The Importance of Micro hydroelectric projects have been observed in some parts of

the country with availability of river flow through out the year. In order to reduce the cost of development several Measures have been considered as follows:

(a) Development of low cost turbines and generators.

(b) Participation of villages in the development and operation of the project.

(c) Using the appropriate technology and tolerable substandard requirement and project civil work component at the beginning stage.

Dehar power house of Beas Sutlej link located on the right bank of Sutlej river is equipped with 6 units of 165 MW each, which is the largest size in country.

Hydro-electric power is one of the indirect ways in which solar energy is being used. Thus, the main factor in its favour is that it is the only renewable non-depleting source of the present commercial sources. In addition it does not create any pollution problem.

As on 31<sup>st</sup> May 2008, the total installed capacity of the utilities in India was 1,44,565.97 MW(megawatts). This includes 92,216.64 MW of thermal (coal, gas and diesel), 36,033.76 MW of hydro, 4,120.00 MW of nuclear and 12,194.57 MW



of wind and other renewable. The availability of power and been continually falling short of the demand, resulting in power shortages of varying degree in different parts of the country

### **(c) Nuclear energy**

According to modern theories of atomic structure, matter consists of minute particles known as atoms. Heavier unstable atoms such as  $U_{235}$ ,  $Th_{239}$ , liberate large amount of heat energy.

The energy released by the complete fission of one Kg of Uranium ( $U_{235}$ ), is equal to the heat energy obtained by burning 4500 tones of coal (or) 220 tons of oil. The heat produced by nuclear fission of the atoms of fissionable material is utilized in special heat exchangers for the production of steam which is then used to drive turbo generators as in the conventional power plants. However there are some limitations in the use of nuclear energy namely high capital cost of nuclear power plants, limited availability of raw materials, difficulties associated with disposal of radio active waste and shortage of well trained personnel to handle the nuclear power plants. The Uranium reserves in the world at present are small. These reserves are recoverable but are expensive.

Nuclear energy has the potential to meet the future needs of electricity in the country. The capacity of nuclear power in India currently stands at 4120 MW (NPCIL 2007). There are in total 17 nuclear reactors. Of these, the 220 MW Kaiga-3 is the latest addition, which began operation in May, 2007. Another 2660 MW reactor is expected to become commercially operational by December, 2008.

India has limited availability of uranium, but has one of the largest resources of thorium in the world.

The presently working power plants are:

1. Tarapur atomic power station in Maharashtra
2. Ranapratap sagar atomic power station near Tota, Rajasthan
3. Kalpakkam atomic power station near Madras, Tamilnadu.
4. Narora atomic power station in U.P.

About 3% of the energy produced in India is obtained from nuclear power plants.

## 1.4.2. Non-Conventional Energy Sources

### Introduction

The sources of energy which are being produced continuously in nature and are inexhaustible are called renewable sources of energy (or) non-conventional energy.

Some of these sources are:

(a) Solar energy

(b) Wind energy

(c) Tidal energy

(d) Geothermal energy

(e) Energy from seas can be utilized as wave, tidal or ocean thermal energy.

*Non-Conventional Energy Sources*

### **(a) Solar energy**

Solar energy can be a major source of power. Its potential is 178 billion MW which is about 20,000 times the world's demand. Sun's energy can be utilized as thermal and photovoltaic.

Brief history of solar energy (or) Importance of solar energy: Energy from the sun is called solar energy. The Sun's energy comes from nuclear fusion reaction that take place deep in the Sun. Hydrogen nucleus fuse into helium nucleus. The energy from these reactions flow out from the sun and escape into space.

### **(b) Wind energy**

Winds are caused because of two factors.

1. The absorption of solar energy on the earth's surface and in the atmosphere.
2. The rotation of the earth about its axis and its motion around the Sun. A wind mill converts the kinetic energy of moving air into Mechanical energy that can be either used directly to run the Machine or to run the generator to produce electricity.

Wind energy uses the high wind velocity available in certain parts, California State in USA is generating 500 MW from 900 wind turbines based on wind mills.

A minimum wind speed of 3 m/s is needed. This is considered to have a high efficiency. Coastal, hilly and valley areas are suitable for this process.

### **(c) Geothermal energy**

Geothermal energy derives the heat in the centre of the earth.

Energy from seas can be utilized as wave, tidal or ocean thermal energy. U.K. and Japan are pioneers in this area.

. Ocean thermal energy conversion utilizes the temperature difference between warm surface seawater at about 28<sup>0</sup>c and the cold deep sea water at 5-7<sup>0</sup>c at a depth of 800-1000 m in tropical areas.

#### **(d) Tidal energy**

Tidal energy is energy that can be trapped from sea. Tides are generated primarily by the gravitational attraction between the earth and the Moon. They arise twice a day in Mid-Ocean. The tidal range is only a Meter. Basically in a tidal power station water at high tide is first trapped in a artificial basin and then allowed to escape at low tide. The escaping water is used to drive water turbines, which in turn drive electrical generators.

#### **(e) Biomass Energy**

Biomass is another renewable source of energy in the form of wood, agricultural residues, etc. The potential for agricultural residues alone is estimated as 480 mt with residues from food grains contributing about 100mt. These can be burnt directly to generate steam for use in steam turbine for power generation or they can be gasified and the gas used in an internal combustion engine for agricultural pumping or power generation. Power generation is being tried on a small scale upto 1 MW. Biomass may prove a useful fuel for localised power generation in rural areas where electric transmission lines have not reached.

(1) **Solar Energy:** It has the greatest potential of all the sources of renewable energy. Energy comes to the earth from the sun. This energy keeps the temperature of the earth above that in colder space, causes current in the atmosphere and in ocean, causes the water cycle and generate photosynthesis in plants.

The solar power where sun hits atmosphere is  $10^{17}$  watts, whereas the solar power on earth's surface is  $10^{16}$  watts. The total world wide power demand of all needs of civilization is  $10^{13}$  watts. Therefore, the sun gives us 1000 times more power than we need. If we can use 5% of this energy, it will be 50 times what the world will require

India receives solar energy in the region of 5 to 7 kWh/m<sup>2</sup> for 300 to 330 days in a year. This energy is sufficient to set up 20 MW solar power plant per square kilometre land area.

The basic research in solar energy is being carried in universities and educational and research institutions, public sector institution, Bharat Heavy Electricals Limited and Central Electronic Limited are carrying out a co-ordinated programme of research in solar energy.

The applications of solar energy are:

- (1) Heating and cooling of residential building
- (2) Solar water heating
- (3) Solar drying of agricultural and animal products.
- (4) Solar distillation on a small community scale.
- (5) Salt production by evaporation of seawater or inland brines.
- (6) Solar cookers.
- (7) Solar engines for water pumping.
- (8) Food refrigeration.
- (9) Bio conversion and wind energy, which are indirect source of solar energy
- (10) Solar furnaces.
- (11) Solar electric power generation by –
  - (i) Solar ponds



- (ii) Steam generators heated by rotating reflectors (heliostat mirrors), or by tower concept.
- (iii) Reflectors with lenses and pipes for fluid circulation (cylindrical parabolic reflectors)
- (12) Solar photovoltaic cells, which can be used for conversion of solar energy directly into electricity or for water pumping in rural agricultural purposes.

#### Solar Energy Utilization :

Direct methods ---- Thermal and Photovoltaic.  
 Indirect methods ----- Water power generation, Wind power, Biomass and Ocean temperature differences.

Photo-voltaic (PV) solar energy conversion is one of the most attractive non-conventional energy sources of proven reliability from micro watts to mega watts level. The PV system performs direct conversion of Sunlight to electricity, providing a non-polluting conversion process, not depending on fossil or nuclear fuels.

#### 1.2 Overview of Photo-Voltaic System :

The most useful way of harnessing solar energy is by directly converting into electricity by means of solar photovoltaic cells, when Sunshine is incident on solar cells, they generate DC electricity without the involvement of any mechanical generators i.e. there is direct conversion of solar radiation into electricity. In this system stage of conversion into thermo dynamic form is absent. The Photovoltaic effect is defined as the generation of electromotive forces as a result of the absorption of ionizing radiation. Energy conversion devices, which are useful to convert Sun, light to electricity by use of the photovoltaic effect. Photovoltaic systems employ energy conversion devices called solar cells.

#### 1.3 Advantages / Disadvantages of Photovoltaic System :

##### A) Advantages :

- Direct room temperature conversion of light to electricity through simple solid state devices.

- Absence of moving parts, Ability to function unattended for long periods as evidence in space program.
- Power levels voltage/current can be achieved by more integration.
- Maintenance cost is low, as they are easy to operate.
- They do create pollution, they have a effective life.
- They are highly reliable.
- They consume no fuel to operate, as the Sun's energy is free.
- Rapid response in output to input radiation.
- Wider power handling capabilities. And Easy to fabricate.
- Amenable to on site installation.
- They can be used with or without sun tracking making possible wide range of applications possibilities.
- It is an environmentally clean source of energy.
- Free and available in adequate quantities in almost all parts of the world where people live.
- Non-availability of conventional source of energy.

B. Disadvantages :

- The solar radian flux availability is a low value 1 KW/m<sup>2</sup> for technological utilization.
- Large collecting area required and Availability varies with time.
- In many applications, energy storage is required because of insolation at night.

The relatively poor conversion efficiency and cost is more

**Wind Energy :**

Energy of wind can be economically used for the generation of electrical energy. Winds are caused from two 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 ratio of the earth with respect to atmosphere, and its motion around the sun.

The energy available in the winds over the earth's surface is estimated to be  $1.6 \times 10^7$  MW, which is of the same order of magnitude as the present energy consumption on the earth

Some characteristics of wind energy are stated below :-

- (i) It is a renewable source of energy.
- (ii) Like all forms of solar energy, wind power systems are non polluting, so it has no adverse influence on the environment.
- (iii) Wind energy systems avoid fuel provision and transport.
- (iv) On a small scale, upto a few kilowatt system, is less costly. On a large scale, costs be competitive with conventional electricity and and lower costs could be achieved by mass production.

Disadvantages :

1. Wind energy available is dilute and fluctuating in nature. Because of the dilute form, conversion machines have to be necessarily large.
2. Unlike water energy, wind energy need storage means because of its irregularity.

3. Wind energy systems are noisy in operation; a large unit can be heard many kilometers away.

4. Large areas are needed to install wind farms for electrical power generation.

. Coastal, hilly and valley areas are suitable for this process. Potential in India is estimated between 20,000 and 25,000 MW. Coastal areas of Gujarat, Maharashtra and Tamil Nadu are considered as favorable. The maximum power generator, from any single unit is about 1 MW.

Installed wind power capacity on global scale exceeds 93,000 MW's and India is about 8500 MW's, out of 75000 MW wind power potential. In Kanrataka is 1073 MW's of wind power installed capacity, out of 13236 MW wind power potential.

**Following are some of the developments.**

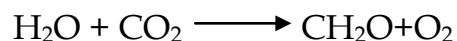
1. CAZRI wind mill at Jodhpur (Rajasthan)
2. WP-2 water pumping wind mill by NAL Bangalore
3. MP-1 sail wind mill at NAL Bangalore
4. Wind mills at Central Salt and Marine Chemicals Research Institute Bhavnagar (Gujarat).
5. 12 PU 500 wind mill at NAL Bangalore
6. Madurai wind mill at Madurai (Tamil Nadu)
7. Tayabji wind mill at Tilonia near Ajmer (Rajasthan)
8. Sholapur wind mill at Sholapur (MS)

India has potential of 20,000 MW of wind power, DNES plans to harness 400 MW of wind energy during eighth plan period.

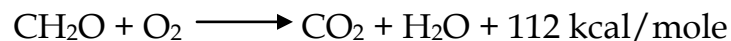
### **Energy from Bio-mass and Bio-gas:**

**Bio-Mass:** . Bio-mass means organic matter. The potential for application of bio-mass as an alternate source of energy in India is very great. We have plenty of agricultural and forest resources for production of bio-mass. Bio-mass is produced in nature through photosynthesis achieved by solar energy conversion. In simplest form the reaction is the process of photosynthesis in the presence of solar radiation, can be represented as follows

### **Solar energy**



In the reaction, water and carbon dioxide are converted into organic material i.e.  $\text{CH}_2\text{O}$ , which is the basic molecule of forming carbohydrate stable at low temperature, it breaks at high temperature, releasing an amount of heat equal to 112,000 cal/mole (469 kJ/mole)



The absorbed energy of photons should be at least equal to this amount. It is therefore, possible to produce large amount of carbohydrate by growing say, algae, under optimum conditions in plastic tubes or in ponds. The algae could be

harvested, dried and burned for production of heat that could be converted into electricity by conventional methods.

Bio-mass resources fall into three categories.

1. Bio-mass in its traditional solid mass (wood and agricultural residue) and
2. Bio-mass in non-traditional form (converted into liquid fuels).

The first category is to burn the bio mass directly and get the energy. In the second category the bio-mass is converted into ethanol and methanol to be used as liquid fuels in engines.

3. The third category is to ferment the bio-mass anaerobically to obtain a gaseous fuel called bio-gas (Bio gas- 55 to 65% Methane, 30-40% CO<sub>2</sub> and rest impurities i.e. H<sub>2</sub>, H<sub>2</sub>S and some N<sub>2</sub>)

Bio-mass resources include the following :

- (i) Concentrated waste municipal solids, sewage wood products, industrial waste, manure of large lots.
- (ii) Dispersed waste residue - crop residue, logging residue, disposed manure.
- (iv) Harvested bio-mass, standby bio-mass, bio-mass energy plantation.

More than 350 million tons of agricultural wastes are generated in India every year. Biomass available for power generation in the state from agricultural residues. By using the Bio-gas produced from animal waste, fisheries waste, and other organic waste, the power generation potential is roughly estimate to be around 1500 MW

Biomass gasification based power generation systems upto 500 kW rating are being set up in states like Gujarat, Karnataka. Further foreign technologies based plant can yield several MW of power.

### **Bio-Gas:**

The main source for production of bio-gas is wet cow dung or wet livestock (and even human) waste, to produce bio-gas. The production of bio-gas is of particular significance for India because of its large cattle population. The total cattle population in the country is about 250 million. Some of the other sources of bio-gas are :

(i) Sewage, (ii) crop residue, (iii) vegetable wastes (iv) water hyacinth, (v) poultry droppings, (vi) pig-manures, (vii) Algae, (viii) Ocean-kelp.

In big cities, sewage source is the main source for production of bio-gas thus obtained can be used to run pumps to pumpout the sewage water itself. Pilot plants for such purpose, capable of handling sewage, have already been developed and installed in some areas. The sewage bio-gas is found to contain 84 per cent Methane, which is already pointed out, is a high quality fuel Methane could be economically used to run engines to drive electric generators.

Bio-gas plants commissioned by DNES during the year 1985-86 are at Muradnagar (U.P.), Rishikesh (U.P.), Sanganer (Raj.), Pondicheri, Bhopal (M.P.) etc. About 70 community / Institutional type bio-gas plants are set during the year 1985-86.

In India, Department of Non-conventional energy sources (DNES) has proposed to install a 1MW OTEC plant in Lakshadweep Island at Kavaratti and Minicoy

#### **4. OCEANTHERMAL ENERGY :**

Utilization of the temperature difference which exist naturally between the upper and lower levels of water in the ocean. Utilization of this energy with its associated temperature difference and its conversion into work form the basis of ocean thermal energy conversion (OTEC) systems.

Likely 10 MW, pilot plant will begin to function in Hawaii, USA within a couple of year. In Cuba attempt to build 40 KW OTEC system of the coast of CUBA was made by CLAUDE in the twenties. The system worked and delivered power for some time. The first was the use of an open thermo-dynamic cycle with sea-water as the working fluid and the second factor was the use of a land based power plant. This required the use of a very long cold water pipe from the ocean depth. The temperature is around 20°C and occurs a few hundred meters.

#### **5. Tidal Energy :**

The tides in the sea are the result of the universal gravitational effect of heavenly bodies like sun and moon on the earth. Due to fluidity of water mass, the effect of this force becomes apparent in the motion of water, which shows a periodic rise and fall in levels which is in rhythms with the daily cycle of rising and setting of sun and moon. This periodic rise and fall of the water level of sea is called tide. These tides can be used to produce electrical power which is known as tidal power.

To harness the tides, a dam would 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, which gets separated from the sea, by



dam. The difference in water level is obtained between the basin and 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. By using reversible water turbines, turbine can be run continuously, both 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, which is coupled to generating electricity. This arrangement of harnessing tidal energy, is known as single basin plant.

An estimate of the rate of tidal energy dissipation for the world is about  $3 \times 10^6$  MW. The first commercial tidal power station in the world was constructed in France in 1965 across the mouth of the LA RANCE estuary. It has a capacity of 240 MW. In India, tidal power could probably be generated in KUTCH and in the HOOGHLY River.

A tidal power plant has been completed at Rance in France with rating of 240 MW in 1966. It works on single basin, two way system with pumping. Substantial sources of this form of energy are known to exist in U.S.A., Japan, USSR, New Zealand, Italy and Mexico & India.

## **6. GEO-THERMAL ENERGY :**

Geo thermal energy is energy coming out of the molten interior of the earth towards the surface. The average rate at which this heat emerges is about  $0.05 \text{ w/m}^2$ , while the radial temperature gradient which causes this heat flow is about  $0.03^\circ \text{ C}$  per meter. Thus on an average, the temperature of the earth increases by  $30^\circ \text{ C}$  per kilometer as one moves inwards.

Geothermal energy derives the heat in the centre of the earth and it is stated that potential to the extent of 3400 MW exists in New Zealand, USA, Japan and Iceland. 700 MW of power is generated in Phillipines and China.

## **Renewable Energy Resources:**

**Renewable** energy sources also called non-conventional energy, are sources that are continuously replenished by natural processes. For example, solar energy, wind energy, bio-energy - bio-fuels (grown sustainably), hydropower etc., are some of the examples of renewable energy sources

A renewable energy system converts the energy found in sunlight, wind, falling-water, sea-waves, geothermal heat, or biomass into a form, we can use such as heat or electricity. Most of the renewable energy comes either directly or indirectly from sun and wind and can never be exhausted, and therefore they are called renewable.

Renewable energy sources include both 'direct' solar radiation intercepted by collectors (e.g. solar and flat-plate thermal cells) and indirect solar energy such as wind, hydropower, and ocean energy and biomass resources that can be managed in a sustainable manner.

The definition of renewable resources also includes the chemical energy stored in food and nonfuel plant products and even the energy in air used to dry materials or to cool, heat and ventilate the interiors of buildings. From an operational view point, the correct way to treat renewable energy is as a means to reduce the demand for conventional energy forms.

**TO DEVELOP NEW GENERATION TECHNOLOGIES & RENEWABLE ENERGY SOURCES :**

- Ever-increasing energy demand.
- Reduced environmental damages and increased safety.
- Conversion of energy and inexhaustible sources.
- Received greater attention to develop efficient energy conversion and utilization Techniques.
- The realization of enormous need to electrify and energize remote rural areas.
- Adequately available, least impact on environment and ecology.
- Ideally suited for decentralized variety of applications.
- The future of fossil fuels has a limited time for their availability i.e. estimated that it could be around 70 to 100 years.
- Inaccessible areas and hilly terrain's, renewable energy becomes very handy.
- The cost of generation goes on decreasing as time passes.
- Environmental friendly projects.

No.	RE Sector	Potential available	Project allotted by Government		Projects commissioned	
			No.	MW	No.	MW
1.	Wind	13236	393	8002	511	1073
2.	Small Hydro	2500	307	2011	57	411
3.	Cogeneration	1000	476	861	18	339
4.	Biomass	650	65	478	11	81
	<b>Total</b>	<b>17386</b>	<b>812</b>	<b>11352</b>	<b>597</b>	<b>1905</b>

**3. LIMITATIONS OF RENEWABLE ENERGY SOURCES:**

- SOLAR – SEASONAL NATURE AND USEFULNESS IS SOMEWHAT LIMITED.
- BIOMASS-COST OF RAW MATERIAL INCREASES EVERY YEAR.
- CO-GENERATION – ONLY IN SUGAR FACTORIES.

- MINI / MICRO HYDEL – SEASONAL NATURE AND CANAL BASED SITES.
  - WIND – SEASONAL NATURE AND REQUIREMENT OF WINDY SITES.
4. RENEWABLE PROGRESS IN KARNATAKA :
- a. Renewable energy contribution in the national level is 7.7% (11125 MW) and State Level is at 10.45% (1905 MW)
  - b. Karnataka is No. 1 in Co-Generation and No. 3 in Wind Energy exploitation.
  - c. Renewable Energy in Karnataka.

RE Power Sources	Installed capacity upto 30 <sup>th</sup> June, 2008	RE Power scenario by end of year 2011.
Solar Energy		
Home Light	23038 Nos.	46038 Nos.
Street Light	2271 Nos.	7771 Nos.
Water Heating	23,00,000 Sq.Mt.	26,00,000 Sq.Mt.
Rural Electrification	27.5 kW	103.1 kW
Hybrid Systems (Wind, Solar)	65 Nos.	265 Nos.

