RES

(22ETC15E)

Notes.

[Module- 1]

* principles of renewable energy.

The aim of this text is to analyse the full range of renewable energy supplies available for modern economies
- Such renewables are recognised as vital inputs for sustainability hence encouraging their growth is significant.

Analysis has to be done on following point
- How much energy is available in the immediate environment - what is resource
- For what purposes can this energy be used - what is the end-use ?
- What is the environmental impact of the technology - is it sustainable ?
- What is the cost of the energy - is it cost-effective.

* Energy and Sustainable development

Sustainable development can be broadly defined as living, producing and consuming in a manner that meets the needs of the present without compromising the ability of future generations to meet their own needs.

- Renewable energy supplies are much more compatible with sustainable development than are fossil & nuclear fuels
- Almost all national energy plans include four vital factors for improving social benifit from energy
  - → increased harnessing of renewable supplies
  - → increased efficiency of supply & end-use
  - → Reduction in pollution
  - → Consideration of lifestyle

Renewable Energy Sources.

Module-1 : Introduction

- **Renewable Energy:**
  Energy obtained from the sources that do not deplete or can be replenished within a human's life time.
- **Non-Renewable Energy:**
  Energy obtained from the Conventional fuels which are exhaustible today or tomorrow with time.

Energy Sources. Classification

Based on Traditional Use
- Conventional (obtained from fixed reserves like oil, gas, coal)
- Non conventional (like bioenergy, tidal, solar, wind)

Based on long term Availability
- Non Renewable Energy sources
- Renewable Energy sources

→ Renewable Energy
- Solar
- Wind
- Tide
- Geothermal
- Biomass

Non-Renewable Energy
- Coal
- petroleum
- Natural Gas
- Nuclear Energy.

Energy sources & their availability.

Energy sources broadly classified into two categories
→ Commercial and non commercial.

- Commercial sources include the fossil fuels (Coal, oil and natural gas), hydro electric power and nuclear power.
- Non-commercial sources include - wood, animal waste and agricultural waste.
- The percentage use of various sources for the total energy consumption in the world is

Coal - 32.5%
Oil - 38.3%
Gas - 19.0%
Uranium - 0.13%
Hydro - 2.0%
} 92%

Wood - 6.6%
Dung - 1.2%
Waste 0.3%
} 8%.

Coal: Modern steam boilers burn coal in any of its forms as a primary fuel.

Coal developed vegetable matter which grew in past geological ages., trees and plants falling into water decayed and produced peat bogs.

These buried bogs under layers of silt, with soil pressure, heat & movement of the earth crust distilled off some of the bogs gaseous matter to form a brown coal or lignite, continuing subterranean activity reduce the coal's gaseous content

progressively to form different ranks : peat, lignite, bituminous & anthracite.

The Vindyachal thermal power station in Singrauli of MP with installed Capacity of 4760MW is currently the biggest thermal power plant in India.

- According to estimates coal is abundant. It is enough to last for 200 years, but causes more pollution when burns as it produces CO_2 & CO

*Oil Almost 40% of the energy needs of the world are fed by oil.

The rising prices of oil has brought a Considerable strain to the economy of the world more, with today's consumption & a resource amount of 2,50,000 million tones of oil it would suffice for about 100 years unless more oil is discovered.

- India is not particularly rich in petroleum reserves. The potential oil bearing areas are located in Assam, Tripura, Manipur, west bengal etc.
- Diesel power plants in India are installed in isolated places & the total installed capacity is estimated as 0.35 million KW. less than 2% of total installed capacity in the Country.

Gas: It is now known clearly that any organic waste can be employed for the production of biogas.

The earlier concept of simply burning away the natural gas at the oil well head itself has now changed

It has become economical to even long distance pipe lines for the gas to be transported several hundred kilometers to the place where it can be used.

Incidentally the Natural gas ~~be~~ can be more profitable employed as a raw material to produce several important chemicals

- Biogas from rural, urban & industrial waste is another area presently under development.

Water power:

- Water power is developed by allowing water to fall under the force of gravity
- potential energy of water is converted into mechanical energy by using prime moves known as hydraulic turbines
- does not create any pollution problem.
- In developing a project, it will take about 6-10 years time for planning, investigation & construction.
- High capital investment is needed
- selecting the suitable resettlement area & environmental impact.

Nuclear Power:

According to Modern theories of atomic structure; Atoms represent enormous concentration of binding energy Controlled fission of heavier unstable atoms such as U^{235}, Th^{232} & artificial element Pu^{239}, liberate huge amount of heat energy

- The energy released by the Complete fission of one kg of U^{235}, is equal to the heat energy obtained by burning 4500 tonnes of high grade Coal or 2200 tons of oil.
- high Capital Cost, limited availability of raw materials, difficulties associated with disposal of radioactive waste ..

* World Renewable Energy Resources

Resource	Form of delivered Energy	Comment
# Solar Total solar radiation absorbed by the earth & its atmosphere is 3.8×10^{24} J/yr.	low temp heat (Space heating, water heating & Electricity)	solar water heater, cookers are in use. Solar cells & power towers in application
# Wind The kinetic energy available in the atmosphere circulation is 7.5×10^{20} J	Electricity	Multi mega watt wind turbines.

3) Biomass

Total solar radiation absorbed by plants is 1.3×10^{21} J/yr

Biomass has energy content of about 1.5×10^{22} J

High temp heat

Bio gas (Cooking, Mechanical power etc)

It provides over 80% of the energy needs of many developing Countries.

4) Geothermal

The heat flux from the Earth's Interior through the surface is 9.5×10^{20} J/yr

Low temperature heat

installed Capacity is more than 2650 MW

5) Tidal

Tidal action is around 10^{26} J/yr

Electricity

Total installed Capacity is 240W. (China, Russia & France)

6) Wave

The amount of energy stored as kinetic energy in waves is order 10^{18} J

Electricity

Installed Capacity 1MW in Japan

7) Hydro

Taking the average elevation of land area as 840m, the annually accumulated potential energy would be 9×10^{20} J

Electricity

more than 40% of electricity produced by Hydro power in developed Countries.

- Renewable energy availability in India
India ranks 3rd in Renewable energy country attractive index in 2021 & 3rd largest energy consuming country in the world.
- The country has set an ambitious target to achieve capacity of 175 GW worth of renewable energy by the end of 2022, which expands to 500 GW by 2030.
India - Got the position
- 3rd Globally for total renewable power capacity additions.
- 4th largest installed capacity of wind power in the world.
- 3rd largest market in the world for new solar photovoltaics (PV) capacity.
- Following is the installed capacity for Renewables
  - → Wind power : 41.2 GW
  - → Solar power : 59.34 GW
  - → Biomass / Co-generation : 10.2 GW.
  - → Small Hydro power : 4.88 GW.
  - → Waste to Energy : 0.47 GW.
  - → Large Hydro : 46.85 GW.
- India has been ranked amongst top 5 countries in the world based on its Climate change performance.
- India has set a target to reduce the carbon intensity of its nation's economy by less than 45% by the end of the decade, achieve 50% cumulative electric power installed by 2030, & achieve net-zero carbon emission by 2070.

Solar Energy: Solar energy has the greatest potential of all the sources of renewable energy & if only a small amount of this form of energy could be used, it will be one of the most important supplies of energy specially when other sources in the country have depleted.

- 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 & generate photosynthesis in plants.

* If we can use 5% of this energy, it will be 50 times what the world will require

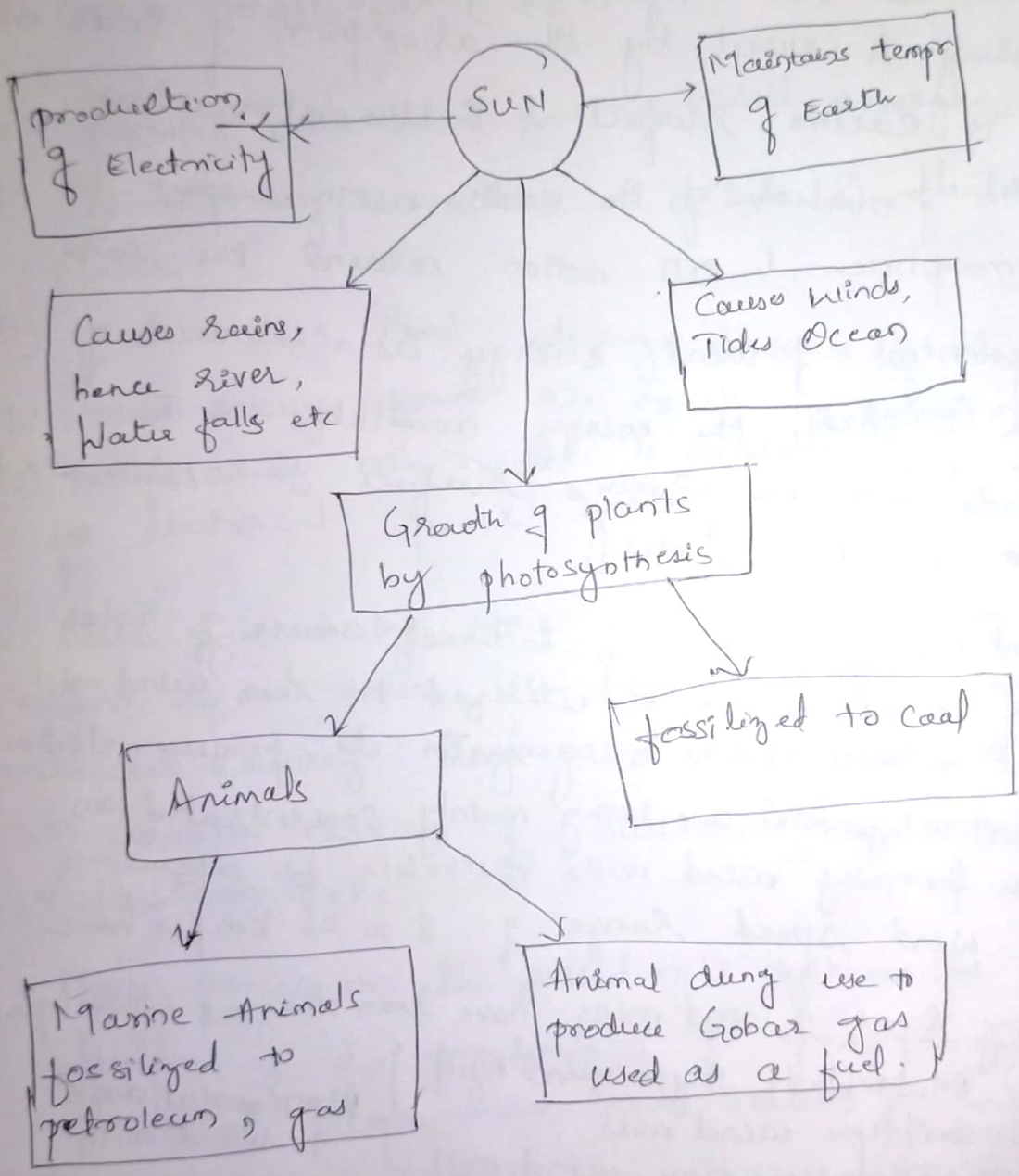
(Solar power - hits Earth atmosphere is 10^{17} watts.
solar power on earth - 10^{16} watts,
Total demand of all human needs of Civilization is 10^{13} watts

* The energy radiated by the sun on a bright sunny day is approximately $1 kw/m^2$
* attempts have been made to make use of this energy in raising steam which may be used in driving the prime movers for generation of electrical energy

. Applications of Solar Energy

(i) Heating and cooling of residential building
(ii) Solar water heating
(iii) Solar drying of agricultural & animal products
(iv) Solar distillation on a small community scale
(v) Salt production, Solar cookes.

(vi) Solar furnaces, Solar ponds
(vii) Solar photovoltaic Cells.
(viii) Solar furnaces
(ix) Food refrigeration
(x) Bio Conversion & Wind Energy which are indirect source of solar energy



* ## Wind Energy :

Energy of wind can be economically used for the generation of electrical energy. Winds are caused from two main factors :

(i) Heating and cooling of the atmosphere which generate convection currents.
Heating is caused by the absorption of solar energy on the earth's surface & in the atmosphere.

(ii) The rotation of the earth with respect to atmosphere. & its motion around the sun.

The potential of wind energy as a source of power is large, the energy available in the winds over the Earth's surface is estimated to be 1.6×10^7 MW.

- Wind energy which is an indirect source of solar energy conversion can be utilized to run wind mill, which in turn drives a generator to produce electricity.
- The developments are being mainly concentrated on water pumping wind mills suitable for operation in a wind speed range of 8 to 36 km per hour.
- Many types of wind mills have been designed & developed,
  - (i) Multiblade type wind mill
  - (ii) Sail type wind mill
  - (iii) Propeller type wind mill

  } Horizontal axis wind mills

  - (iv) Savonius type wind mill
  - (v) Darrius type wind mill

  } Vertical axis wind mills.

* Some characteristics of Wind Energy.

(i) It is a renewable source of energy

(ii) Like all forms of Solar energy these are non-polluting

(iii) Wind energy systems avoid fuel provision & transport.

(iv) On a small scale (upto few KW) is less costly

* probles associated with wind energy

(i) Wind energy available is dilute & fluctuating in Nature.

(ii) Wind energy need storage because of its irregularity

(iii) Wind energy systems are noisy in operation

(iv) Large areas are needed to install wind farms for electrical power generation.

* Data quoted by some scientists that for India wind speed value lies between 5Km/hr to 20 km/hr

• In our country, high wind speeds are obtained in Coastal areas of Saurashtra, Western Rajasthan. etc

• Many projects on the wind mill systems for water pumping & for production of small amount of electrical power have been taken, Some are

(i) CAZRI wind mill at Jodhpur (Rajasthan)

(ii) WP-2 water pumping wind mill by NAL Pune

(iii) MP-1 sail wind mill at NAL Bangalore

(iv) Madurai wind mill (Tamil Nadu)

(v) Wind mills at Central Salt (Gujarat) etc

Energy from Bio-mass & Bio-gas

- Bio-mass is produced in nature through photosynthesis achieved by solar energy conversion, we have plenty of agricultural & forest resources for production of bio-mass.
- process of photosynthesis in presences of solar radiation can be represented as follows.

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

Water & Carbon dioxide are converted into organic material i.e, CH_2O (basic molecule of Carbohydrate) Stable at low temp^r, it breaks at high temperature releasing an amount of heat equal to 112,000 Cal/mole (469 kJ/mole)

$$CH_2O + O_2 \longrightarrow CO_2 + H_2O + 112\ kcal/mole$$

- large amount of carbohydrates produced by growing say, algae.
- Under optimum condition in plastic tubes or in ponds the algae could be harvested, dried & burned for production of heat that could be converted into electricity by conventional methods
- Bio mass resources fall into 3 categories
1. Bio-mass in its traditional solid mass (wood & agricultural residue)
2. Burn the bio-mass directly to get the energy.
2. Bio mass in non-traditional form (converted into liquid fuels such as

Ethanol & methanol to be used as liquid fuels for engines.

3. ferment the bio-mass anaerobically to obtain a gaseous fuel - called Bio-gas
[Bio-gas - 55 to 65% Methane, 30-40% CO_2 & rest impurities i.e., H_2, H_2S & N_2).

Energy plantation:

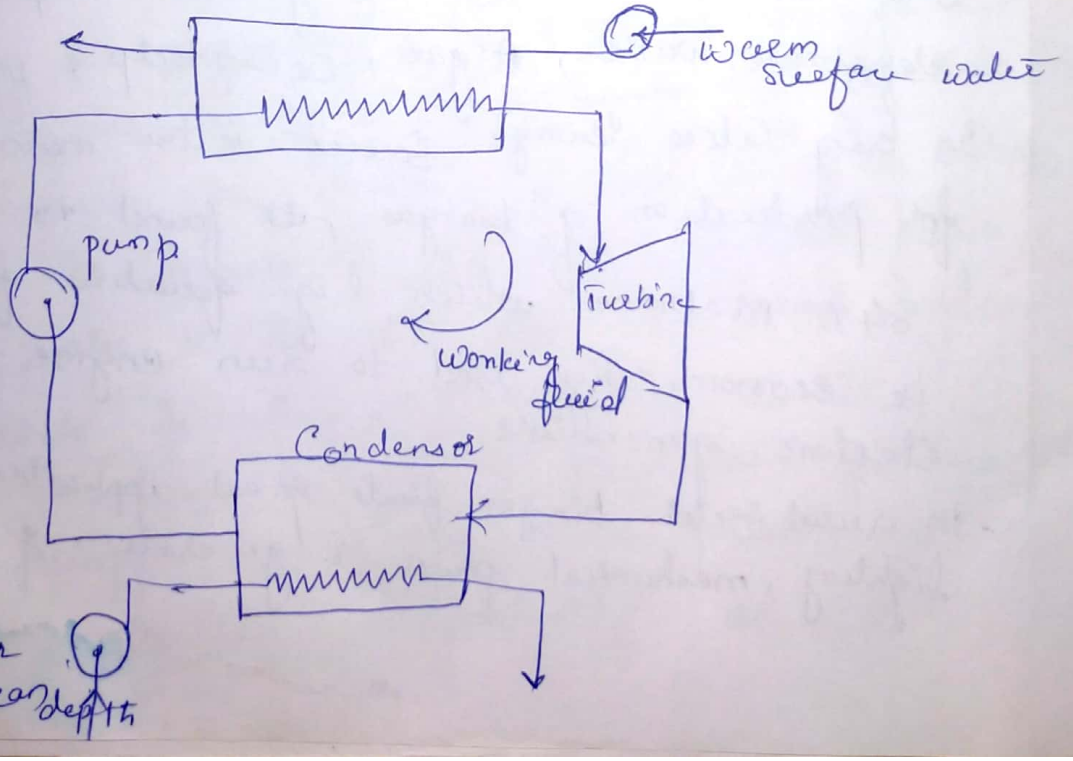
For large scale production of electrical power, the use of fire wood as a fuel for the boilers of a conventional power plant is suggested. this approach is called the "energy plantation".

Bio-Gas:

- The main source for production of bio-gas is wet Cow dung & wet livestock (and even human) waste to produce the Bio-Gas
other sources are (i) Sewage (ii) crop residue, vegetable waste, Algae, Ocean kelp, poultry droppings
- In big Cities Sewage Source is the main source for production of bio-gas, it found to contain 84% Methane which high quality fuel, could be economically used to run engine to drive electric generators.
- In rural sector bio-gas finds great application in cooking, lighting, mechanical power & generation of small electricity.

Ocean Thermal Energy Conversion:

- This is also an indirect method of utilizing Solar energy. the large amount of solar energy is collected & stored in tropical oceans.
- The surface of the water acts as the collecto for solar heat, while upper layer of the sea constitute infinite heat storage reservoir.
- Thus the heat contained in the oceans, & could be converted into electricity by utilizing the fact that the temperature difference between the warm surface waters of the tropical oceans & colder waters in the depths is about 20-25°k
- The surface water which is at higher temp^r could be used to heat some low boiling organic fluids The vapours of which would run a heat engine.
- All the systems for OTEC method work on a closed Rankine cycle & use low boiling organic fluids like ammonia, propane, R42, 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 depth is used for extracting the heat in the condenser.
- In India Dept of Non-conventional energy sources has proposed to install 1 MW OTEC plant in Lakshadweep Island at Kavaratti & Minicoy.

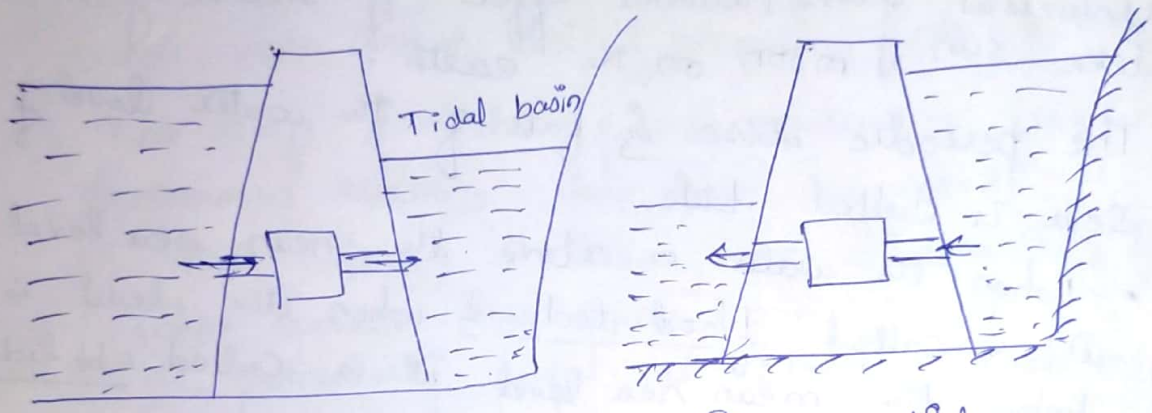
Tidal Energy :

The tides in the sea are the result of the universal gravitational effect of heavenly bodies like sun & moon on the earth.

The periodic rise & fall of the water level of sea is called tide.

- When the water is above the mean sea level, it is called flood tide & when the level is below the mean sea level it is called ebb tide.
- The use of tides for electrical power generation is practical in a few favourably situated sites where the geography of an inlet or bay favours the construction of a large scale hydroelectric plant.
- 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.
- The constructed basin is filled during high tide and emptied during low tide passing through sluices turbine respectively as shown in figure

- By using reversible water turbine, turbine can be run continuously, both during high tide & 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 generator, generating electricity



(a) High tide

(b) low tide

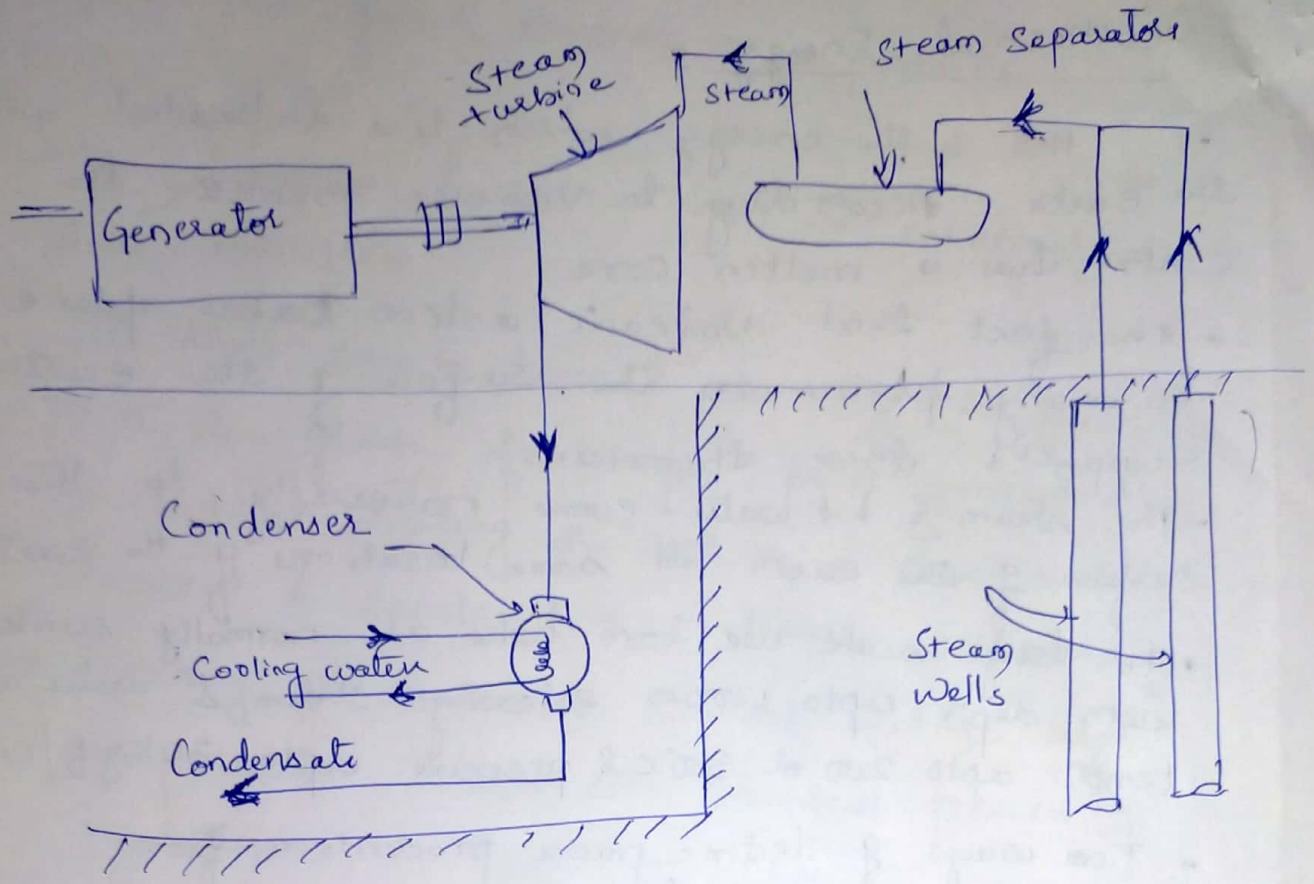
Single basin plant

- A tidal power plant has been completed at Rance in France with rating of 240MW in 1996.

Geothermal Energy :

- This is the energy which lies embedded within the earth. According to various theories the earth has a molten core
- The fact that Volcanic action takes place in many places on the surface of the earth, supports these theories.
- The steam & 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 1000m releasing steam & water at temp upto 200 or 300°C & pressure upto 30 kgf/cm^2
- Two ways of electric power production from Geothermal energy has been suggested.
  1. heat energy is transferred to a working fluid which operates the power cycle. (particularly useful at places of fresh Volcanic activity).
  2. The molten interior mass of earth vents to the surface through fissures & substantially high temperature (450 to 550°C), by embedding Coil of pipes & sending water through them Can be raised.

- Substantial sources of this form of energy are known to exist in U.S.A, Japan, USSR, New Zland, Italy & Mexico.
- In India State of Himachal Pradesh is reported to possess geothermal energy in Exploitable amount.



schematic of Geothermal power plant.

Oil shale :

- Oil shale is an organic-rich fine grained sedimentary rock containing kerogen (a solid mixture of organic chemical compounds) from which liquid hydrocarbons can be produced.
- In addition to kerogen, general composition of oil shales consistutes inorganic substance and bitumens.
- Based on their deposition environment, oil shales are classified as marine, lacustrine and terrestrial oil shales.
- Major deposits are found in United States estimated around 6.05 trillion barrels.

Oil shale has gained attention as a potential abundant source of oil

- only Estonia & China have well established oil shale industries
- Oil shale can be burned directly in furnaces as a low-grade fuel for power generation & district heating or used as a raw material in chemical & construction-materials processing.
- Heating oil shale to a sufficiently high temperature causes the chemical process of pyrolysis to yield a vapour.
- Upon cooling a vapour, the liquid unconventional oil called shale oil is separated from combustible oil-shale gas.
- Shale oil is a substitute for conventional crude oil.
- Oil-shale mining & processing raise a number of environmental concerns such as land use, waste disposal, water use, waste-water management, greenhouse-gas emissions & air pollution.

Wave Energy :

- Wave power is the capture of energy of wind waves to do useful work - for example electricity generation, water desalination or pumping water.
- A machine that exploits wave power is a wave energy converter (WEC)
- Wave power converts the periodic up & down movement of the oceans waves into electricity by placing equipment on the surface of the oceans that captures the energy produced by wave movement & converts this mechanical energy into electrical power.
- No matter the size of a wave or the weather conditions wave energy will be harvested.
- An A-shaped floating wave energy converter that is designed to extract wave energy input in a fresh & innovative way built with a floating angular construction.
- The wave energy converter is adaptive to sea conditions. By adjusting its opening angle it can regulate the wave energy input & reduce the impact during harsh weather conditions.
- In 2000 the world's first commercial wave power Device, was installed on the Coast of Islay in Scotland.

- Internet of Energy (IoE): a technological term that refers to the upgrading & automating of electricity infrastructures for energy producers and manufacturers.
- This allows energy production to move forward more efficiently & cleanly with the least amount of waste.
- If internet is a cyber universe, then the Internet of Energy is a corner of that universe. dedicated to all things energy-related.
- The IoE allows for the exchange of energy information called big data. Big data analytics provide grid operators, energy producers & distribution utilities with real-time energy consumption trends
- allowing them to forecast where & when energy demand & energy consumption will peak.
- Grid operators, who manage & track energy production & delivery, can direct adjustments in the energy supply as needed with that data
- The IoE includes energy infrastructure in energy production and delivery by using artificial intelligence (AI) at power plants & power delivery systems.

- So within the IoE, we have smart grid technology, IoT (Internet of things) which helps power producers & distributors monitor & deliver power on a more efficient basis
- Each segment can 'talk' to others about the most energy-efficient ways to provide power from the point of power generation to your home.