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Unit 4 notes energy science

B.tech (Dr. A.P.J. Abdul Kalam Technical University)

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Unit - IV

Conventional and Non-conventional Energy Sources :-

Conventional source of energy is also called Non-renewable source of energy " that sources of energy which have accumulated in nature over a long time and can not be quickly replaced when exhausted. Such as fossil fuel, Nuclear fuel, are used long time but produced enviromental pollution.

Non-conventional source of energy is also called renewable sources of energy " that sources of energy can be reused and does not exhaust. (Alternative sources of energy). Such as Tidal energy, Solar energy, Bio-gas, are recently discovered. The renewable sources of energy does not effect on enviromental pollution.

Biological Energy Sources :- Bio-energy is a renewable energy created from natural biological sources. Many sources such as Plants, animals and their byproduct can be valuable resources. Most of Bio-energy comes from forests, Agriculture farms and waste. The feed stocks are grown by farms specially for use their use as an energy source. Common crap include starch or sugar-based plants like corn or sugar cane.

Organic materials containing bio-energy are known as bio-mass. there are two main form of Bio-mass -

(i) **Raw Bio-mass :-** It is constists of forestary products such as gases, craps and animals manuare etc.

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(ii) Secondary Bio-mass :- It is a material that comes from raw Bio-mass but has undergone the significant changes eg. papers, card board, cotton, natural rubber plant products and used cooking oils.

Bio-Mass (Grower Gas)

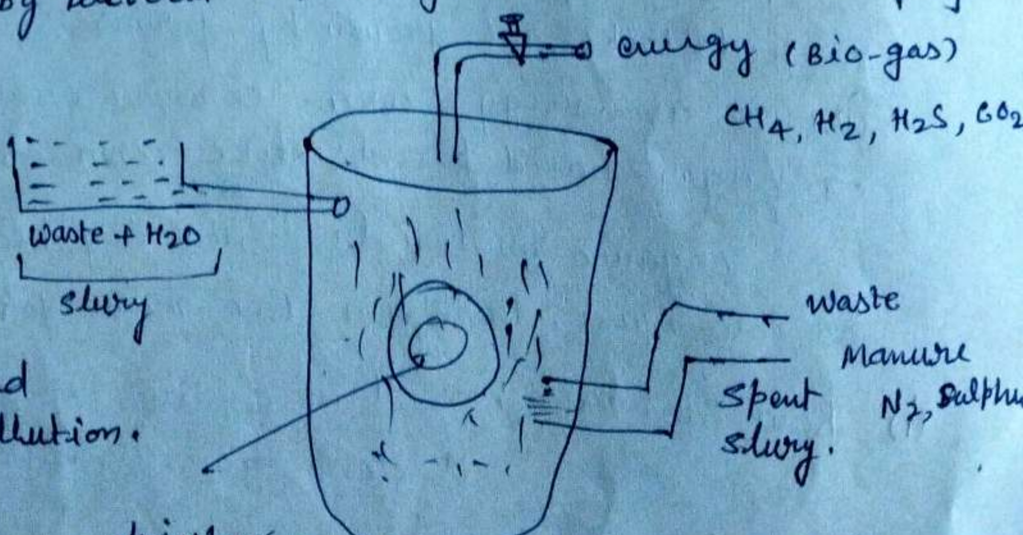
The dead part of plants and tree and the waste material of animals are called Bio-mass. Bio-mass is renewable source of energy. It is a mixture of methane, carbon dioxide, Hydrogen and hydrogen sulphide.

mixture → CH_4] → 75%
CO_2, H_2, H_2S] – 25%

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$$

The formantation is anerobic (absence of oxygen O_2)

waste material → cow dug cake → Bacteria → [Carbohydrote + protein + fat]
decomposed by bakteria → Bio gas.



Excellent quality and 0% environment pollution.

Bio-mass is used for cooking, heating, transportation (ethanol) and electric power production.

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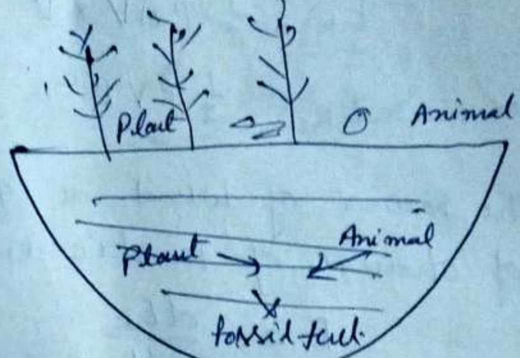
Fossil fuel :- Fossil fuel are the fuel formed by natural processes in a long time period such as decomposition of dead and buried organism. such as coal Petroleum and Natural gas. fossil fuels are not renewable source of energy.



High temperature & Pressure.

Fluid Dynamics and Power in wind :- Fluid dynamics is the branch of applied science that is concerned with the movement of liquids and gases. It has several sub-disciplines including aerodynamics and hydrodynamics.

Winds are essentially caused by the solar heating of the atmosphere causing unequal expansion and therefore unequal densities of the air of various regions.

Winds speed increases with height. In many contries wind is used to generate electricity. wind turbines are used forgenerate of electricity. wind turbines can be used singly or in cluster called wind forms.

A wind turbines converts the kinetic energy of wind to rotary mechanical energy.

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Power in wind :- Wind energy is the kinetic energy of the moving air, the kinetic energy of mass m and velocity v of air

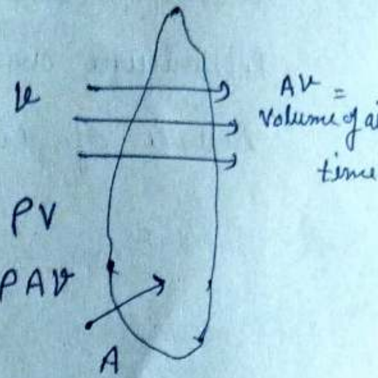
$$E_K = \frac{1}{2} m v^2$$

$$E_K = \frac{1}{2} \rho A v \times v^2$$

$$E_K = \frac{1}{2} \rho V v^2 \quad \text{———} \quad (1)$$

$m = \rho V$

$m = \rho A v$



The power of wind is given by the rate of change of kinetic energy.

$$P = \frac{dE_K}{dt}$$

$$= \frac{d}{dt}\left(\frac{1}{2} \rho V v^2\right)$$

$$= \frac{1}{2} \rho \frac{dV}{dt} v^2$$

$$= \frac{1}{2} \rho (A v) v^2$$

$$= \frac{1}{2} \rho A v^3 \quad \text{———} \quad (2)$$

Hence, power available in the wind is directly proportional to the cube of velocity of the wind. At lower speed, very large turbine rotor is required and at higher wind speed the stresses on turbine blades and shaft are very high.

Normally, the Area is circular (swept area of turbine) with Diameter D. then

$$A = \pi r^2 = \frac{\pi D^2}{4}$$

from equation (2)

$$P = \frac{1}{2} \rho \frac{\pi D^2}{4} v^3$$

$$P = \frac{1}{8} \rho \pi D^2 v^3 \quad \text{———} \quad (3)$$

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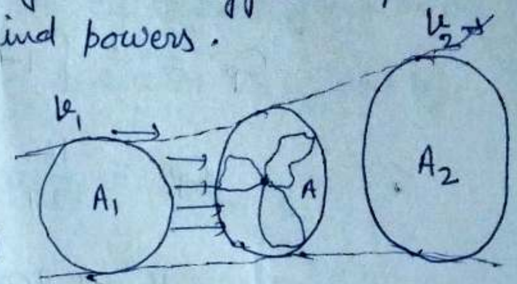
Maximum Power of Wind :-

The wind speed before the wind turbine is larger than after. Because the mass flow must be continuous, the area A_2 after the wind turbine is bigger than the area A_1 before. The effective power is the difference between the two wind powers.



$$P_{out} = P_{eff.} = \frac{1}{2} m v_1^2 - \frac{1}{2} m v_2^2$$

$$= \frac{1}{2} m (v_1^2 - v_2^2) \quad \text{—— (1)}$$

The Average velocity $v = \frac{v_1 + v_2}{2}$

$$m = A v \rho$$

$$= \left(\frac{v_1 + v_2}{2}\right) A \rho \quad \text{—— (2)}$$

for maximum output

$$P_{eff} = \frac{1}{2}\left(\frac{v_1 + v_2}{2}\right) A \rho \left(v_1^2 - v_2^2\right)$$

$$= \frac{1}{4} A \rho \, (v_1 + v_2)(v_1^2 - v_2^2)$$

$$= \frac{1}{4} A \rho \left[v_1^3 - v_1 v_2^2 + v_2 v_1^2 - v_2^3\right]$$

$$= \frac{1}{4} A \rho v_1^3 \left[1 - \left(\frac{v_2}{v_1}\right)^2 + \left(\frac{v_2}{v_1}\right) - \left(\frac{v_2}{v_1}\right)^3\right]$$

let $\frac{v_2}{v_1} = x$, $P_{eff} = \frac{1}{4} A \rho v_1^3 \left[1 + x - x^2 - x^3\right]$

$$P_{eff} = \frac{1}{4} A \rho v_1^3 \left[1 + x - x^2 - x^3\right]$$

$$P_{eff} = \frac{1}{2} P_W \left[1 + x - x^2 - x^3\right] \quad \text{—— (3)}$$

The Power coefficient C_p characterizes the relative drawing power (ideal power coefficient)

$$C_p = \frac{P_{eff}}{P_W} = \frac{1}{2}\left[1 + x - x^2 - x^3\right]$$

for maximum output $\frac{\partial C_p}{\partial x} = 0$

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$$\frac{1}{2}[0+1-2x-3x^2] = 0$$

$$3x^2+2x-1=0$$

$$x = \frac{1}{3}$$

$$C_p = \frac{1}{2}\left[1+\frac{1}{3}-\left(\frac{1}{3}\right)^2-\left(\frac{1}{3}\right)^3\right]$$

$$C_p = \frac{16}{27} = 0.593 \approx 59\%$$

For normally, a good system the power coefficient 0.4 ~ 0.5 or 40% ~ 50%.

Viscocity of a fluid :- It describes the internal friction of moving fluid. Viscocity is the quantity that describes a fluid resistance to flow. Fluid resists the relative motion of layers with differing velocities within them. The viscocity represented by η and defined " viscocity is the ratio of the shearing stress to the velocity gradient in a fluid.

$$\eta = \frac{F/A}{\Delta u_x/\Delta Z}$$

$$\frac{F}{A} = \eta \frac{\Delta u_x}{\Delta Z}$$

The SI unit of viscocity is the Pascal Second. (Pa.s) the most common unit of viscocity is the dyne sec per square centimeter (dyne s/cm^2).

$$1 \text{ Pa.S} = 10 \text{ P}$$

$$1 \text{ mPa.S} = 0.01 \text{ P}$$

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Equation of continuity :- The continuity equation is defined as the product of cross sectional area A of the pipe and the velocity of fluid (v) at any point along the pipe is constant. This product is equal to the volume flow per second or flow rate. The continuity equation is given by

$$R = A_1 v_1 = A_2 v_2 = A_3 v_3 = \cdots = A_n v_n$$

$$R = Av = \text{constant.}$$

where R is the volume flow rate.

Bernoulli Equation :- The total mechanical energy of the moving fluid comprising the gravitational potential energy of elevation, the energy associated with the fluid pressure and the kinetic energy of the fluid motion, remains constant.

Bernoulli Equation formula is a relation between pressure kinetic energy and gravitational potential energy of a fluid in a container.

$$P + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$$

where P is the pressure of the exerted by the fluid, v is the velocity of fluid, ρ is the density of the fluid, h is the height of the container. The various terms are

P = Pressure energy.

$\frac{1}{2}\rho v^2$ = Kinetic energy per unit volume.

$\rho g h$ = Potential energy per unit volume.

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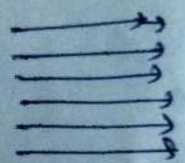
Types of flow of fluid :- (1) Steady and unsteady flow.

$\frac{\partial v}{\partial t} = 0$, $\frac{\partial v}{\partial t} \neq 0$, velocity, Pressure, density not chan

(2) uniform and Non-uniform flow.

$\frac{\partial v}{\partial x} = 0$, $\frac{\partial v}{\partial x} \neq 0$ velocity gradient, Pressure gradient not change.

(3) Laminar & Turbulent flow.



Parallel stream line.

$R \leq 2000 \Rightarrow$ Laminar flow.

$2000 < R < 4000$ Transition.

Zigzag

$R \geq 4000 \Rightarrow$ Turbulant flow.

Turbulent flow

(4) Compressible and Incompressible flow.

$\rho = $ Constant

$d\rho = 0$, Incompressible flow.

$d\rho \neq 0$ compressible flow.

(5) 1-D, 2-D, and 3-D flow.

(i) $u \neq 0$, $v = 0$, $w = 0$, $v = f(x)$ 1-D

(ii) $u \neq 0$, $v \neq 0$, $w = 0$. $v = f(x, y)$ 2-D

(iii) $u \neq 0$, $v \neq 0$, $w \neq 0$ $v = f(x, y, z)$ 3-D

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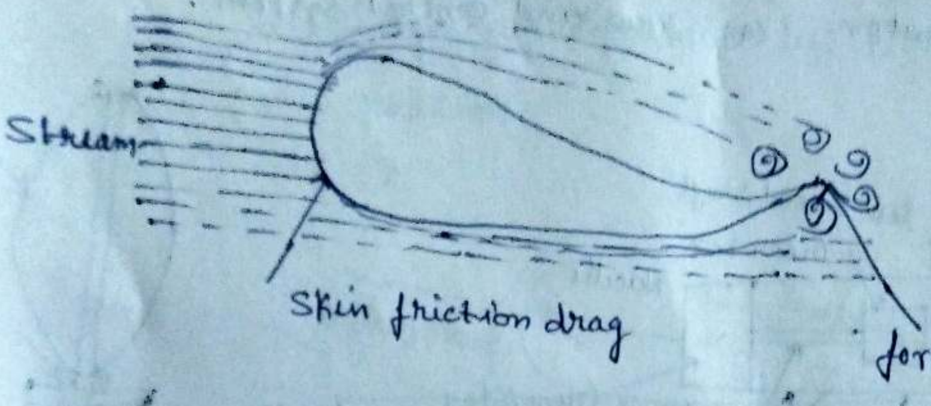
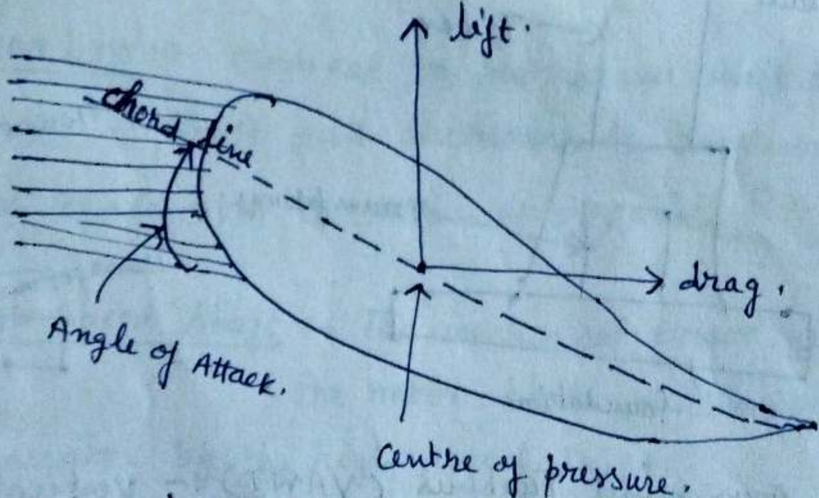
Drag and lift force :- A drag force is the resistance force caused by motion of body through fluid.



The lift force is the component of drag force, perpendicular to flow direction.



Wind turbines dynamics and design :- wind turbine design is the process of defining the form and specifications of a wind turbine to extract energy from the wind. A wind turbines installation consists of the necessary system needed to capture the wind energy. Point the turbine into the wind covert mechanical rotation into electrical power and other system to start, stop and control the turbine

Wind turbine generators are different types.

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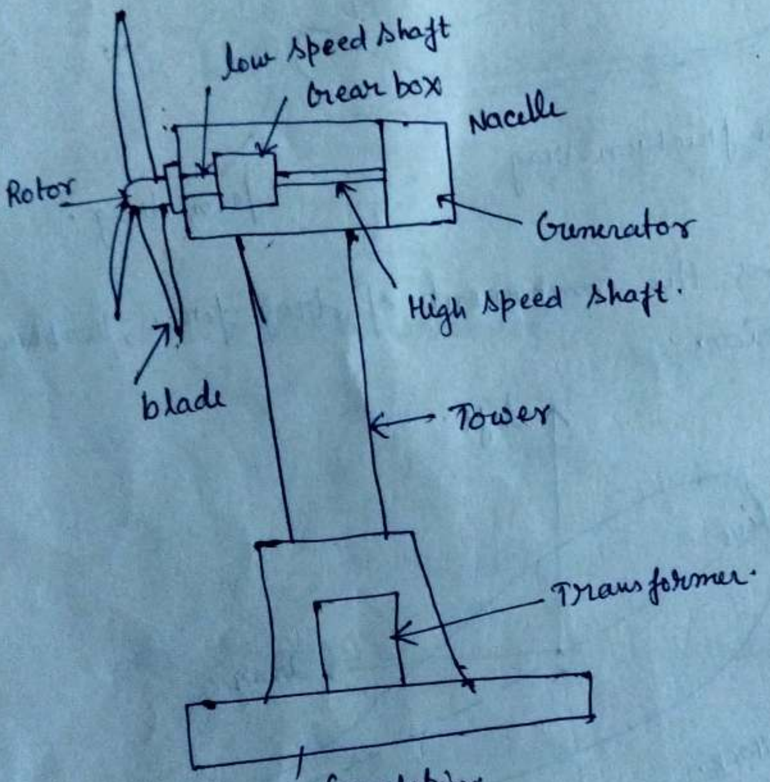
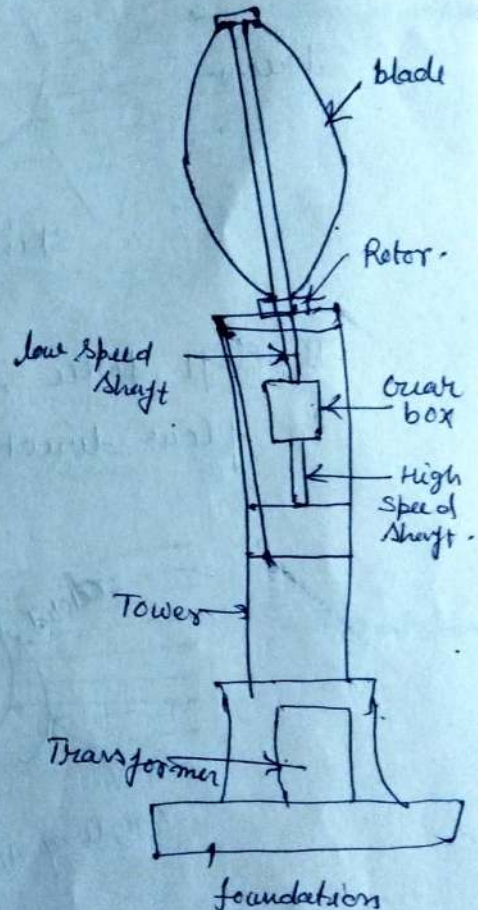
Horizental Axis Wind Turbines (HAWT) :- Wind turbines consists of four main components. (1) The rotor. (2) transmission system. (3) Generator (4) yaw and control system.





Vertical Axis Wind Turbines (VAWT) :- Vertical axis wind turbines shown in figure. In this rotor mechanism are vertical. The details of wind turbines are following.

1. **Tower** :- Made from tubular steel, concrete or steel lattice. supports the structure of the turbine.

2. **Nacelle** :- It is placed on top of tower and contains the Gear box, low and high speed shafts, generator controller and brake.

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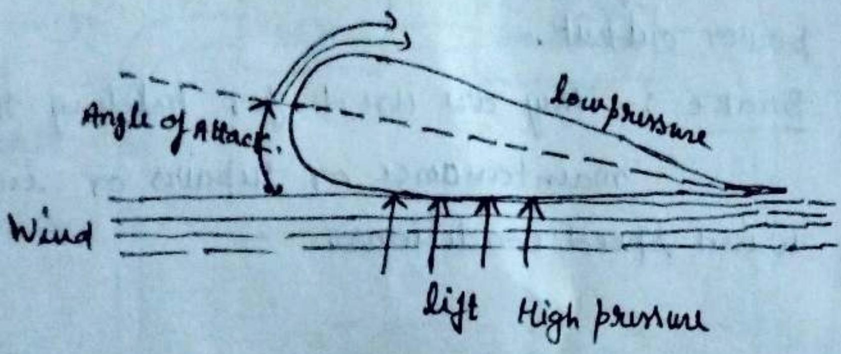
3. Rotor :- The rotor consists of the hub, three blades and a Pitch regulation system.

4. Blades :- The blades are made of air foils design, which depend on aerodynamic lift to move the blades and cause rotation.



5. Gear box :- Connect to low speed shaft to high speed shaft and increases the rotational speeds from 30-60 rpm to 1000-1800 rpm.

6. High speed shaft :- The mechanical power generated by the rotor blade is transmitted to the generator by the high speed shaft.

7. Generator :- The generator converts the mechanical energy to into electrical energy.

8. Yaw and Control System :- The yaw system turns the Nacelle into the actual wind direction using a rotary actuator and gear mechanism at the top of the tower.

9. Anemometer :- measures the wind speed and transmits wind speed data to the controller

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10. Wind vane :- Measures wind direction and communicates with yaw drive to orient the turbine properly with respect to the wind.

11. Pitch System :- Pitch system adjust the blade angle by rotating them so that they use the right amount of the available wind energy to get the most power output.

12. Brake :- They are used for holding the turbine for maintanance or repairs or incase of extreme wind speed conditions.

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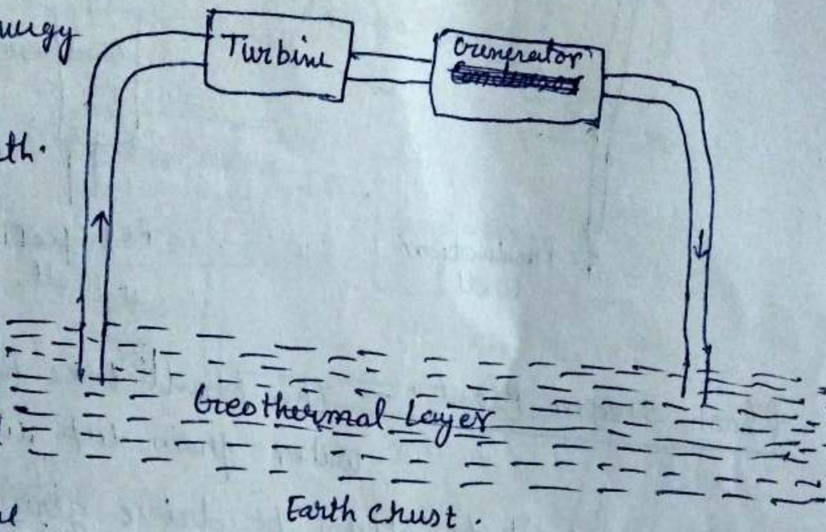
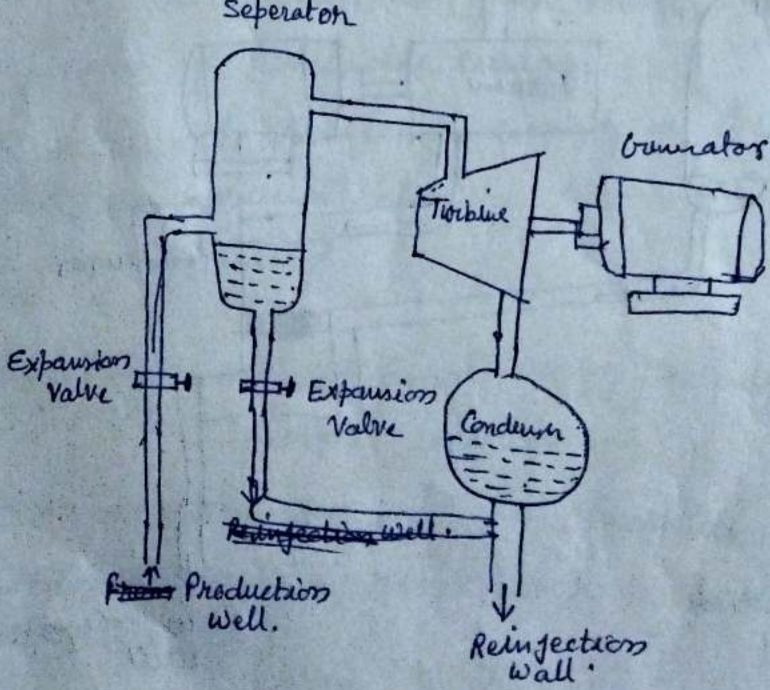
Geothermal Power Plant :- Geothermal Power Plant is used to generate electricity by the use of geotherm energy (the Earth internal thermal energy). They essentially work the same as coal or nuclear power plant, the main difference being the heat source.

Geothermal energy is the thermal energy generated and stored in Earth. The geothermal energy of the Earth's originates from the original formation of the



planet and from radioactive decays of materials.



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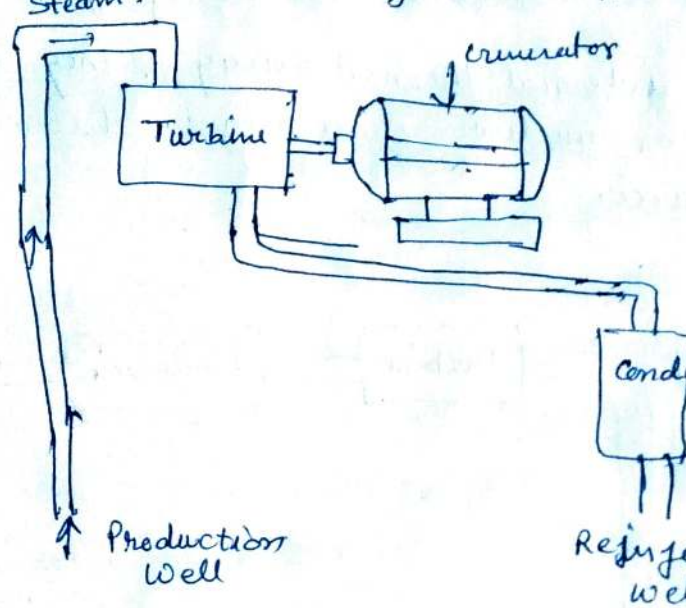
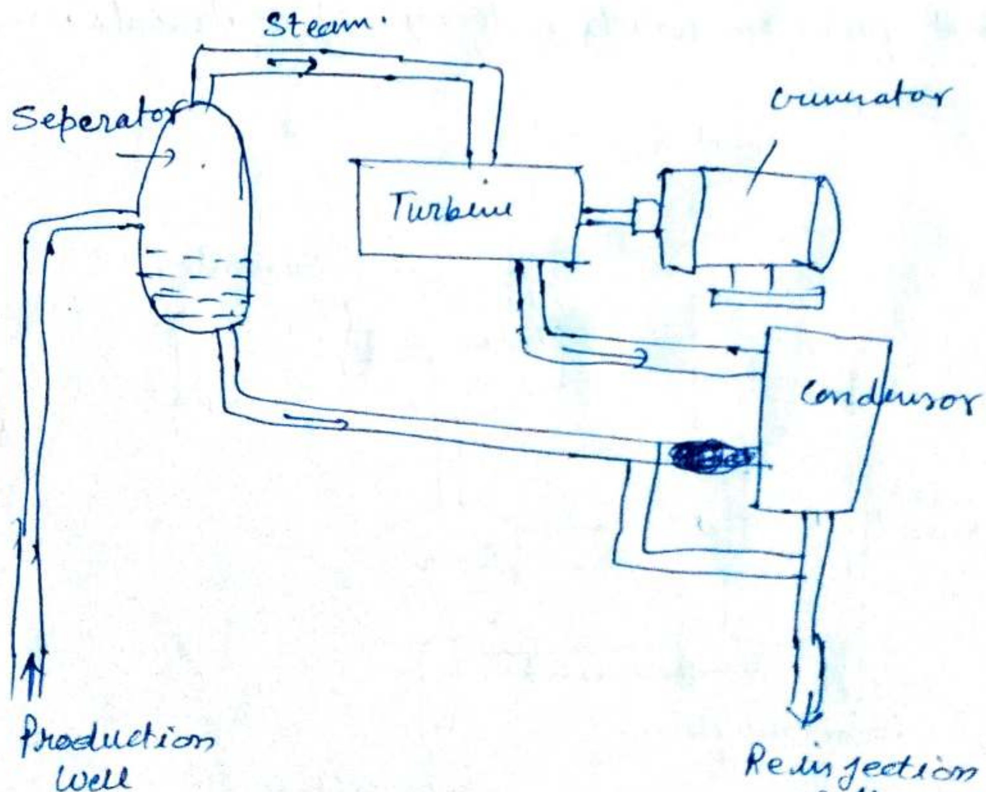
Types of Geothermal Power Plant :- (1) Dry Stream Plant :- This plant use steam directly from a geothermal reservoir to turn generator turbines.



(2) Flash Steam Plant :- This plant take high-pressure hot water from deep inside the earth and convert it to steam to drive generator turbines.



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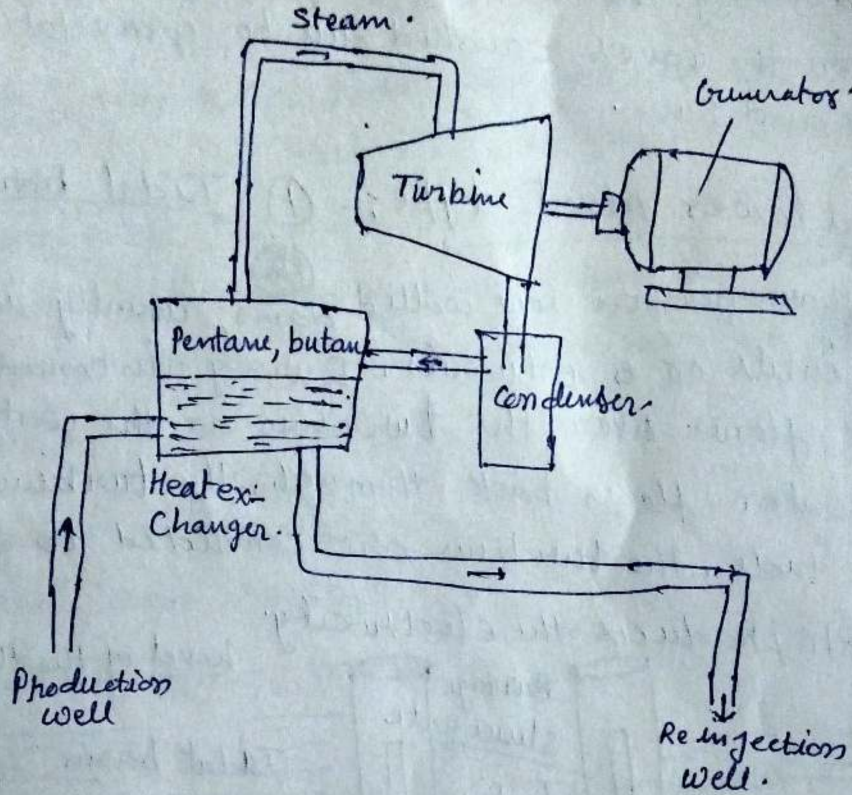
(3) Binary cycle power plant :- This plant transfer the heat from geothermal hot water to another liquid. the heat causes the second liquid to turn to steam which is used to drive a generator turbine.



Advantages :- ① this energy source is more environmentally friendly the conventional fuel sources.

② A source of renewable energy.

③ A sustainable source of energy as its always available unlike wind and solar.

④ No fuel is required

Disadvantage : ① Geothermal energy is only available at specific location.

② Gases are released into the atmosphere during digging

③ Geothermal energy runs the risk of triggering ~~earthquake~~ earthquakes.

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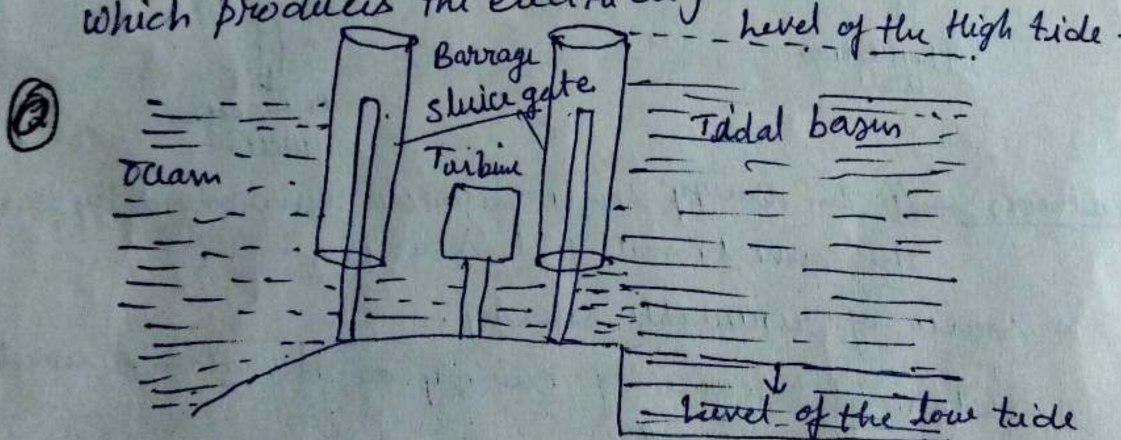
Tidal Power Plant :- Tidal Power plant is a plant which converts the energy of tides into the useful form of power, mainly in electricity. Tidal energy is created using the movement of tidals and currents of oceans- Tides are the waves caushed due to gravitational pull of the moon and Sun.

Tidal Power plant type :- ① Tidal barrage

Tidal barrages are low walled dams, usually installed at tidal inlets or estuaries. During incoming high tide, water flows over the turbines as the water rises, then the water flows back through the turbines as it becomes low tide. The turbines are connected to a generator which produces the electricity.



Main Parts of Tidal Barrage :- ① **Barrage :-** A tidal Barrage is a dam-like structure used to capture the energy from masses of water moving in and out of a bay or river due to tidal force.

② **sluice gates :--** The sluice gates are left open during high tide and closed during low tide to create a water level differential, creating a potential difference that powers the turbine when the water is released

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③ <u>Tidal Stream Generator</u> :- Tidal stream generators are very similar to wind turbines except their below the ~~waste~~ water surface instead of above or on land.

② <u>Tidal Turbines</u> :- Tidal turbines are similar to wind turbines. They can be placed on the sea floor where there is strong tidal flow. Because water is about 800 times denser than air, tidal turbines have to be much sturdier and heavier then wind turbines.

① Horizontal axis turbine
② Vertical axis turbine
③ Enclosed tips (venturi)

<u>Advantages</u> :- ① Tidal energy is environmentally friendly. energy and doesn't produced green house gases.

② As 71%. of Earth surface is covered by water, there is scope to generate this energy on large scale.
③ The life of tidal energy power plant is very long.
④ Tidal energy does't require any kind of fuel to run.

<u>Disadvantages</u> :- ① Cost of construction of tidal power plant is high.
② There are very few ideal locations for construction of plant and they too are localized to coastal regions only.
③ Intensity of sea waves is unpredictable and there can be damage to power generation unit.
④ The actual generation is for a short period of time.

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