CBCS SCHEME

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21EE652

Sixth Semester B.E. Degree Examination, June/July 2024
Renewable Energy Resources

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Briefly discuss the causes of energy scarcity and possible solution to energy scarcity. **(06 Marks)**

b. Classify the various types of energy resources and explain briefly. **(08 Marks)**

c. Discuss the worldwide renewable energy availability briefly. **(06 Marks)**

OR

2 a. With neat sketch, explain the layers of Sun. **(06 Marks)**

b. Define the following :
i) Hour Angle ii) Declination angle iii) Latitude angle iv) Surface Azimuth angle **(08 Marks)**

c. Write brief notes on applications of solar thermal energy. **(06 Marks)**

Module-2

3 a. With neat sketch, explain flat plate solar collector. **(07 Marks)**

b. Write short notes on Solar pond. **(06 Marks)**

c. Write brief notes on Stirling Engine system. **(07 Marks)**

OR

4 a. Explain the components of a solar cell. **(06 Marks)**

b. Draw and brief out the V-I characteristics of solar cell. **(06 Marks)**

c. Write detailed notes on photovoltaic panels with necessary diagrams. **(08 Marks)**

Module-3

5 a. List the benefits of hydrogen energy. **(04 Marks)**

b. Explain the hydrogen production techniques in detail. **(08 Marks)**

c. Briefly explain the problems associated with hydrogen energy. List the advantages and disadvantages of hydrogen energy. **(08 Marks)**

OR

6 a. Explain the parameters to be considered while choosing a site for wind mills. **(05 Marks)**

b. Explain in detail, the geothermal based power generation and its associated problems. **(08 Marks)**

c. Elaborate the waste recovery management scheme briefly. **(07 Marks)**

Module-4

7 a. Define gasification. Explain the various types of gasifier with neat sketches. **(10 Marks)**

b. Write short notes on characteristics of biomass feed. **(05 Marks)**

c. Briefly bring out the applications of biomass gasifier. **(05 Marks)**

OR

8	a.	Write brief notes on biogas and its composition.	**(06 Marks)**
	b.	Explain in detail, the process of anaerobic digestion with neat sketch.	**(10 Marks)**
	c.	List the benefits of biogas.	**(04 Marks)**

Module-5

9	a.	With neat sketches, explain the devices for harnessing wave energy.	**(08 Marks)**
	b.	Write short notes on power associated with sea waves.	**(06 Marks)**
	c.	Enumerate the advantages and disadvantages of wave power.	**(06 Marks)**

OR

10	a.	Discuss the principle of Ocean Thermal Energy Conversion (OTEC).	**(06 Marks)**
	b.	Explain Rankin cycle and its working.	**(08 Marks)**
	c.	Bring out the advantages, disadvantages and applications of OTEC.	**(06 Marks)**

* * * * *

Renewable Energy Resources.

June/July 2024.

1 @. Causes of Energy Scarcity.

- Increasing population.
- Increasing energy usage on consumption.

Energy is constantly used at home, at work, & for leisure period of enjoyment.

- Uneven distribution of energy resources.

Uneven distribution of energy and resource trade among countries is of paramount importance to environmental & political stability.

Possible solution to energy scarcity.

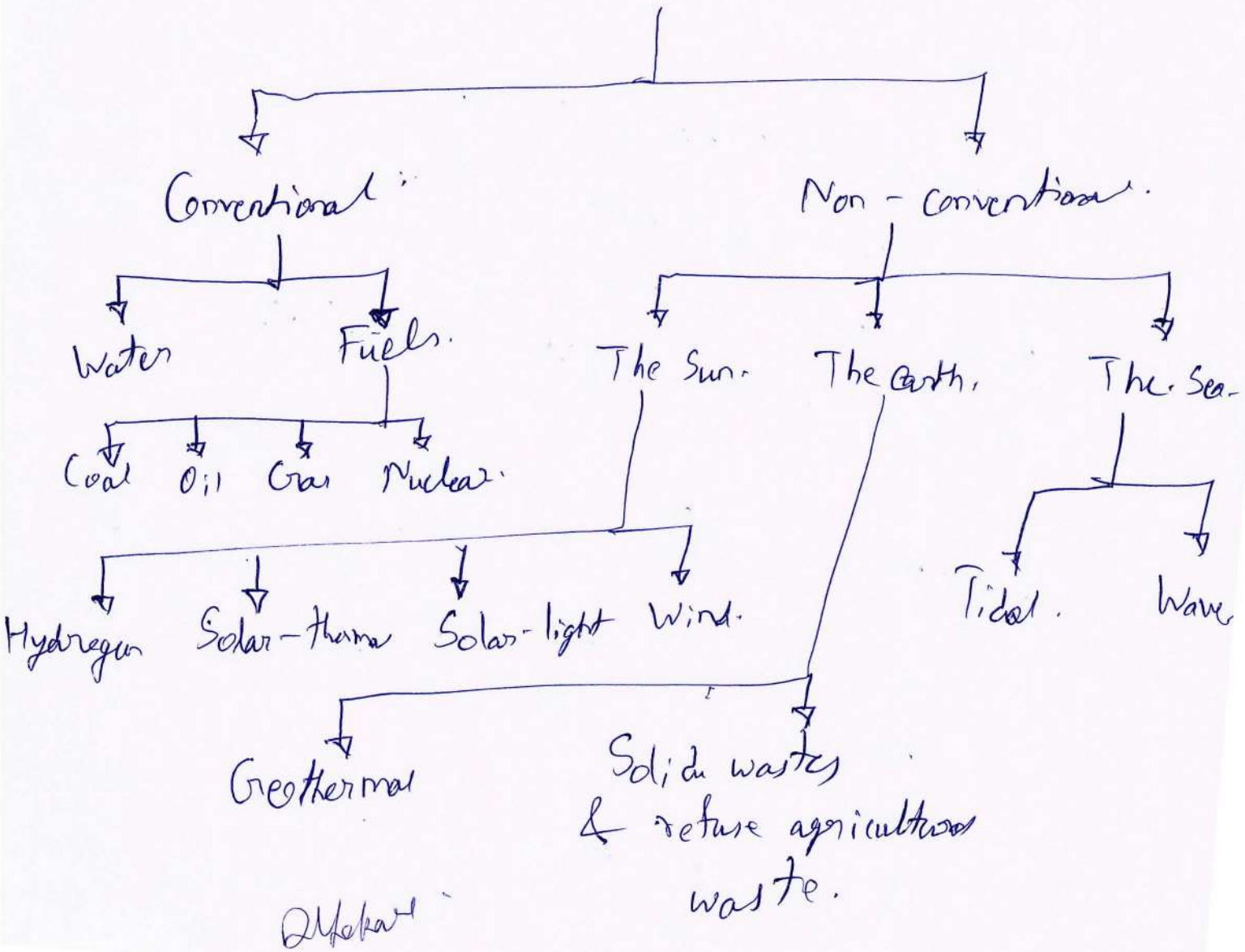
- Minimizing population growth exploitation & harnessing the large utilization of energy reservior.
- Development of energy conversion techniques to convert basic energy available from.

energy resources to usable form of energy.

- Keep the new energy system pollution free as far as possible
- Energy management.
- The development of cheap & reliable energy storage system.

1 (5)

Classification of energy resources.



Mahesh

Conventional energy resources are energy stored within the earth & the sea. They include both fossil fuels & nuclear energy.

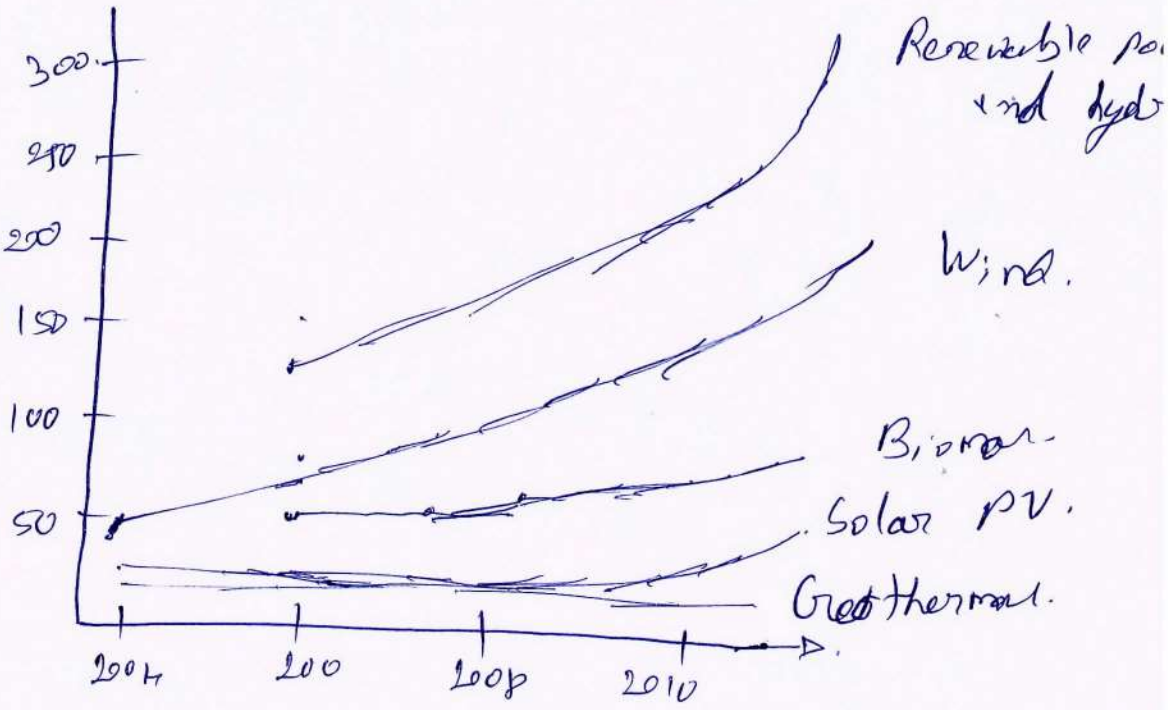
Non-conventional energy resources are obtained from the energy flowing through the natural environment.

Renewable energy resources are continuously restored by nature. Ex:- Solar, water, wind etc.

renewable.
Non-renewable energy resources are the reserve that is once accumulated in nature has practically ceased to form under new geological conditions. Ex:- coal, oil, gas, nuclear etc.

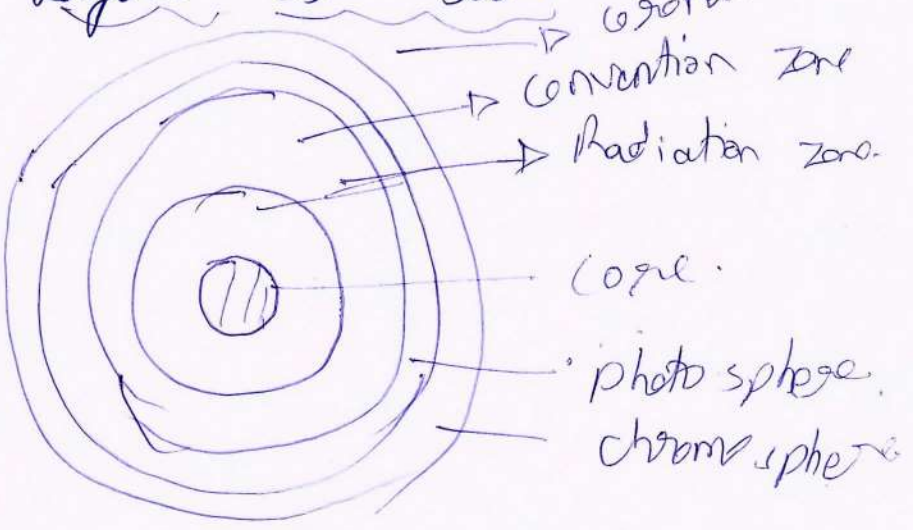
1© Worldwide renewable energy availability.

About 16% of global final energy consumption comes from from renewable. with 10% coming from traditional biomass, which is mainly used for heating & 3.4% from hydroelectricity.



The share of renewable energy in electricity is around 19% with 16% of global electricity coming from hydroelectricity, & 3% from new renewable energy.

Q: Layers of sun.



Core :-

The innermost layer of the sun is called the core. With a density of 160 g/cm³, the core might be expected to be solid.

Solar envelope :-

Outside of the core is the radiative envelope which is surrounded by the convective envelope. The temp is 4 million Kelvin.

Photosphere :-

The photosphere is the zone from which the sunlight is both sun & emitted. The photosphere is a comparatively thin layer of low-pressure gases surrounding the envelope.

Chromosphere :-

During an eclipse, a red circle can sometimes be seen outside the sun. This circle is called the chromosphere.

D. Thakare.

Corona :-

The outermost layer of the sun is called corona. The corona is very thin & faint & is therefore, very difficult to observe the earth.

2 (b). i) Hour angle :-

The hour angle is the angular distance between the meridian of the observer & the meridian whose plane contains the sun.

ii) Declination angle :-

The declination angle (δ) is the angle between the rays of the sun & the plane of the earth's equator.

iii) Latitude Angle (ϕ).

It is the angle between a line drawn from a point on the earths surface to the centre of the earth & the earths equatorial plane.

Ajekar.

iv) Solar Azimuth angle:

It is the angle betn the central ray of from the sun & horizontal plane containing the observer.

2 (c) Applications of Solar Thermal Energy:

The energy from the sun can be converted into usable form of energy for multi-purpose utilization for the applications based on the controlled technology. These technologies includ.

Passive Systems:

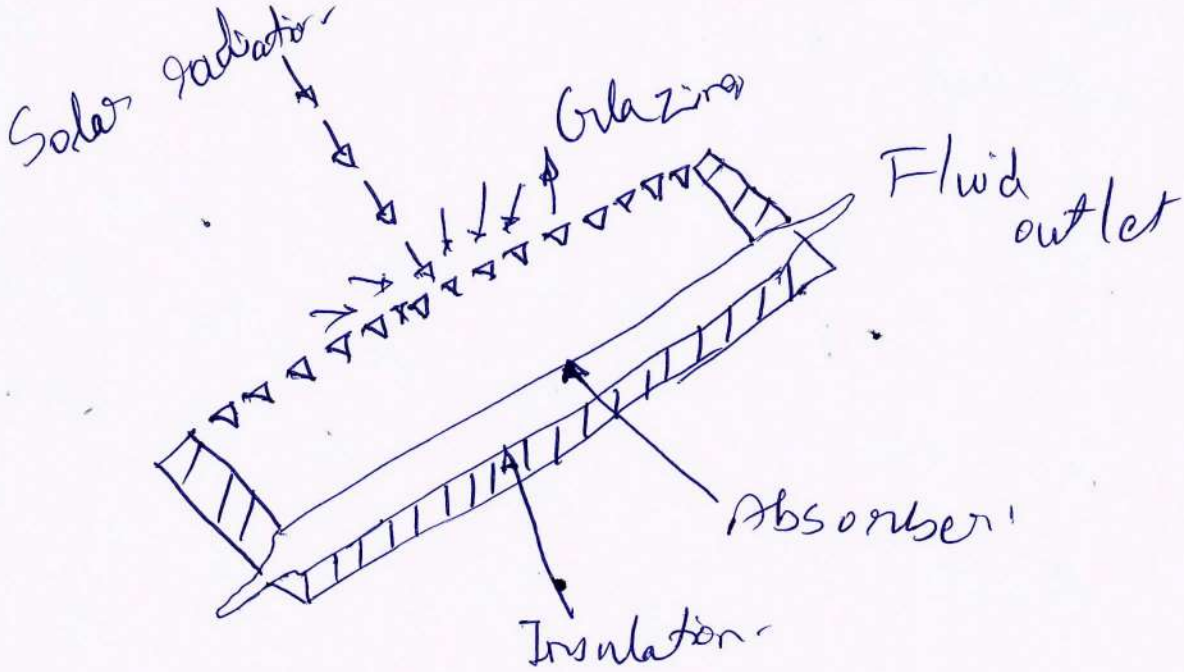
This system collects energy, without the need for pumps or motors, generally through the orientation, materials, & construction of a collector. These properties allow the collector to absorb, store & use solar radiation. Suited for the design of buildings & Thermo siphoning solar hot water systems.

D Mokare.

Active Systems

The most common active systems use pumps to circulate water or another heat absorbing fluid through solar collectors. These collectors are most commonly made of copper tubes bonded to a metal plate, painted black & encapsulated within an insulated by a glass panel.

3@ Flat plate solar collector.



It has five important parts :-

→ 1. Dark flat plate of absorber of Solar energy.

The absorber consists of a thin absorber sheet because of the flat and the metal is

good heat conductor. Sized approximately 0.5 to 1 square foot per gallon of daily hot water use.

→ Transparent cover :-

This allows solar energy to pass thro but reduces heat losses.

→ Heat - transport fluid :-

To remove heat from the absorber, fluid is usually circulated through tubing to transfer heat from the absorber to an insulated water tank

→ Heat insulation backing.

often backed by a grid or coil of fluid tubing.

→ Insulated casing :-

It is made of a glass or polycarbonate cover.

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3 (b) Solar Pond :-

One of the best ways of harnessing solar energy is through solar ponds. It is basically a pool of water that collects & also stores solar energy. The solar pond is a low cost approach for harvesting solar energy. To develop a solar pond, pond is filled with three layers of water.

1) The top layer is cold & has relatively little salt content.

(2) Next is the intermediate insulating layer that has a salt gradient that maintains a density gradient.

(3) The bottom layer is hot upto 100°C & has a high salt content.

D Mokare.

3) Stirling Engine System.

After the array of mirrors focuses the sunlight, the concentrated sunlight then heats the working fluid to temperatures around 750°C within the receiver. The heated high temp working fluid is then used in either a stirling cycle to produce mechanical power via rotational K.E and then electricity for utility use with an electric generator.

In the cycle, the concentrated sunlight focused on the solar fluid heats up the compressed working fluid of the cycle i.e air, replacing altogether or lowering the amount of fuel needed to heat up the air in the combustion chamber for power generation. A recuperator is also utilized to capture waste heat from the turbine to preheat the compressed air & make the cycle more efficient.

D.Mokare

4 @ Components of solar cell.

i) Substrate:- It is an unpolished p-type wafer referred to as p-region base material The typical thickness of wafers used for sola cells is 180 - 300 μm, resistivity 1 - 2 Ω cm.

ii) Emitter:-

The emitter formation involves the doping of silicon with pentavalent impurities such as phosphorus, arsenic, & antimony. The doping is done by the process of diffusion. The commonly used diffusion technique makes use of POCl3 as the phosphorus source.

iii) Electrical contacts:-

These are essential to a photovoltaic cell since they bridge the connection bet" the semiconductor material & the external electrical load. It includes.

→ Back contact
→ Front "
→ Antireflective coating.

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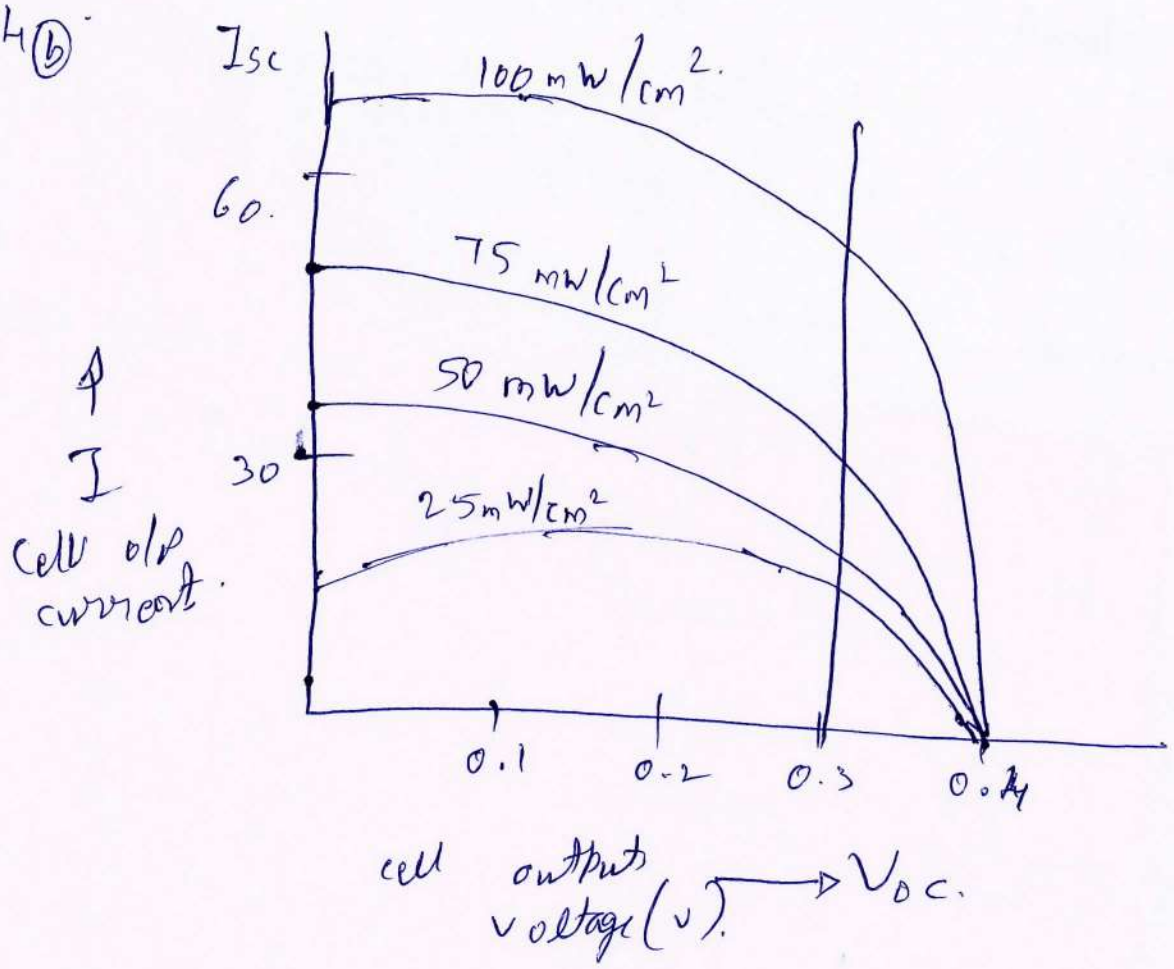
4(b)



The voltage output of the cell (V) is.

$$V = (kT/e) \log_e [1 + (I_s - I)/I_0]$$

eqn represents the I-V characteristic of solar cell. under different illumination levels.

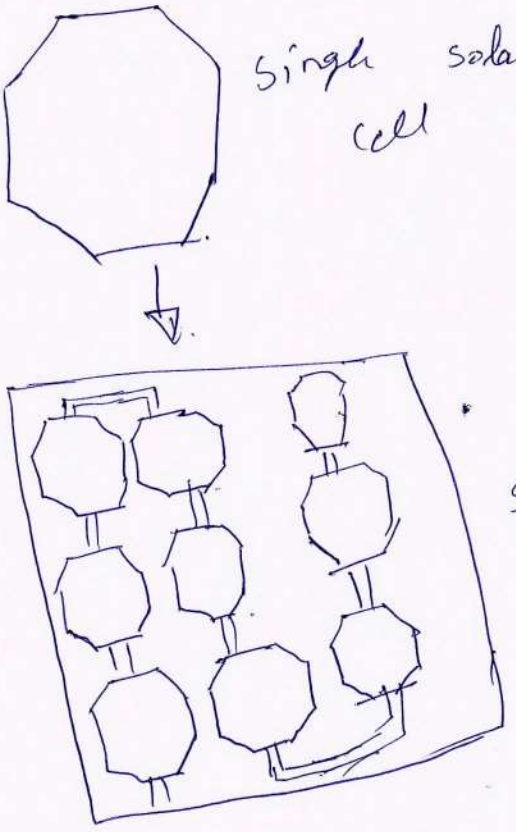
On an I-V characteristic, the vertical axis refers to the current (I) & the horizontal axis refers to voltage (V). The actual I-V curve typically passes through two significant points.

D Mokare.

→ The short-circuit current (I_{sc}) is the curre produced when the positive and negative terminal of the cell are short circuited & the voltage bet the terminals is zero.

→ The open circuit voltage (V_{oc}) is the voltage acr the positive & negative terminals under open-circuit conditions when the current is zero.

4 (c) Photovoltaic panels.



P Kolar

Photovoltaic panels are made in a wide range of si for different purposes. Low voltage or low powe panels are made by connecting bet^n 3 & 12 smal segments of amorphous silicon photovoltaic with a total area of a few sq cm for voltages bet^n 1.5 & 6 V. and o/p of a few milliwatts.

They are used in watches, clocks & calculators, cameras & devices for sensing light & dark, such as night lights.

Small panels of 1-10W & 3-12V, with areas from 100 cm^2 to 1,000 cm^2 are made by either cutting 100 cm^2 single or polycrystalline cells into pieces & joining them in series. or by using amorphous silicon panels.

Large panels, ranging from 10 to 60W, & either 6 or 12V, with areas of 1000 cm^2 to 5000 cm^2 are made by connecting from 10 to 36 full sized cells in series. They are used either separately for small pumps & caravan power. or in arrays to provide power for houses, communi-cation, pumping, & remote area power supplies.

5 @ Benefits of Hydrogen energy :-

- Use of hydrogen greatly reduces pollution : When hydrogen is combined with oxygen in a fuel cell energy in the form of electricity is produced

- Hydrogen can be produced locally from numerous sources : Hydrogen can be produced either centrally & then distributed, or onsite where it will be used. Hydrogen gas can be produced from methane, gasoline, biomass, coal or water.

- A suistainable production system if hydrogen is produced from electrolysis of water : Using renewable energy provides a sustainable system that is independent of petroleum products. It is non-polluting. Some of the renewable sources used to power electrolysis are wind, hydro, solar & tidal energy.

Dhokavi

5 (b). Hydrogen Production Technologies.

1) Thermochemical production technologies.

Hydrogen bound in organic matter & in water makes up 70% of the earth's surface. Breaking up these bonds in water allows us produce hydrogen, & then, to use it as a fuel. There are numerous processes that can be used to break these bonds. Most of the hydrogen now produced on an industrial scale by the proce of steam reforming, or as a by product of petroleum refining & chemical production.

→ Steam reforming.

Steam reforming uses thermal energy to separate hydrogen from the carbon components in methane & methanol & involves the reaction of these fuels with steam on catalytic surfaces. The first step of the reaction decomposes the fuel into hydrogen & carbon monoxide. These reactions occur at temp of 200°c or greater.

The endothermic reforming reaction is.

Where: $CH_4 + H_2O + 206\,(kJ/kg) \rightarrow CO + 3H_2$.

Exothermic shift reaction

$$CO + H_2O \longrightarrow CO_2 + H_2 + 41\ (kJ/kg)$$

The overall reaction is:

$$CH_4 + 2H_2O + 165\ (kJ/kg) \rightarrow CO_2 + 4H_2.$$

⇒ Electrolytic Production Technologies

Electrolysis separates the elements of water H_2 & oxygen (o) - by charging water with an electrical current. An alkaline electrolyser immerses the two electrodes, the cathode & the anode, into an aqueous alkaline electrolyte, typically a solution of sodium or potassium hydroxide & a voltage is applied across the electrodes. The resulting migration of ions in soln results in the production of hydrogen at the cathode & oxygen at the anode as follow.

Cathode reaction $4H_2O + 4e^- \rightarrow 2H_2 + 4OH^-$

Anode reaction $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

D Hodare.

In a PEM electrolyzer, the mobile ion is a proton in an electrolyte that is a proton conducting polymer membrane. Reactions are as follows.

Cathode reaction $4H^+ + 4e^- \rightarrow 2H_2$

anode reaction. $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

5 (c). Advantages of Hydrogen energy.

1) Uncoupling of primary energy source & utilization

2) Hydrogen is a gas; thus it is easier to ~~reduce~~ store than to store electricity.

3) Hydrogen can be obtained from any primary energy source, including RES.

(4) Decentralized production is possible.

(5) Very efficient when used in fuel cells.

(6) Very good experience hydrogen as a chemical reactant

(7) Very good safety records.

R Mokare.

Disadvantages of hydrogen energy

→ ① Poor overall energy efficiency when produced from electricity made with fossil fuels.

② Very low density & poor specific volume energy density

③ Need for high pressures & very low temperat if stored in the liquid phase

④ Specific safety problems and poor public acceptance.

⑤ No existing infrastructures for transport, distribution & storage.

⑥ Rather high cost.

Problems associated with hydrogen energy

1> Hydrogen storage.

2> High reactivity of hydrogen

③ Cost & methods of hydrogen fuel productio

④ Consumer demand

⑤ Cost of changing the infrastructure.

D Nakare.

6 @ Parameters to be selected (considered) for choosing a sites for wind mill. (11)

→ High annual average wind speed.
→ availability of anemometry data.
→ No tall obstruction for some distance in the upwind direction.
→ A wide and open view. i.e open plain, open shoreline or offshore location.
→ An island in a lake or the sea.
→ A narrow mountain gap through which wind is channelled.
→ Site reasonably close to power grid.
→ soil conditions.
→ Production results of existing wind turbine in the area so act as a guide to local wind conditions.
→ Favourable land cost
→ other conditions such as icing problem, salt spray or blowing dust should not present at the site.

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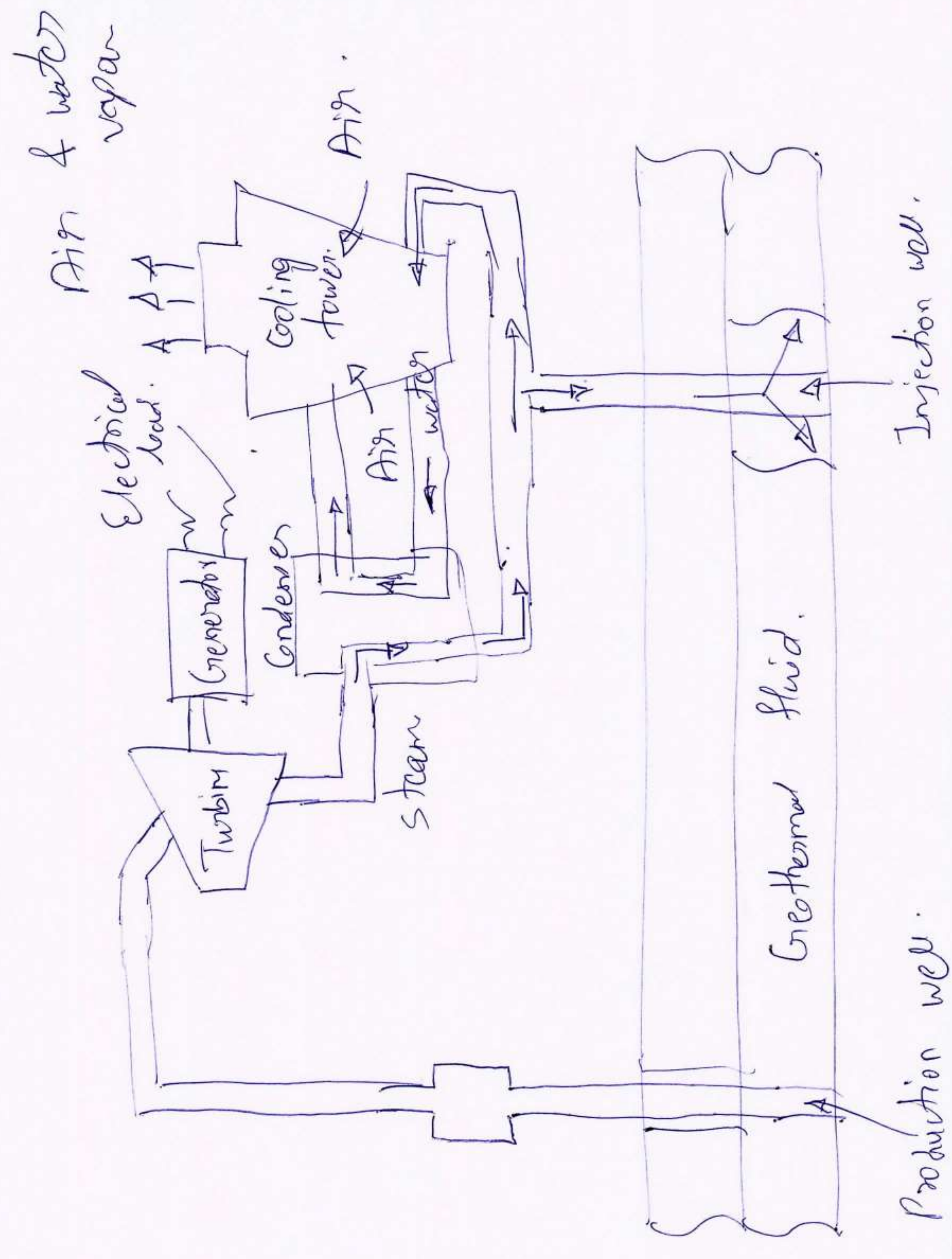
6 (b) Geothermal based power generation.



Dry steam plants have been operating for over 100 years., though these reservoirs are rare

In a dry steam plant like those at the geysers in california, steam produced directly from the geothermal reservoir runs the turbines that pow the generator. Dry steam systems are relatively simple, requiring only steam & condensate injection piping & minimal steam cleaning devices. A dry steam system requires a rock catcher to remove large solids, a centrifugal separator to remove condensate and small solid particulates, condensat drains along the pipeline & a final scrubber to remove small particulates & dissolved ~~solids~~ solids.

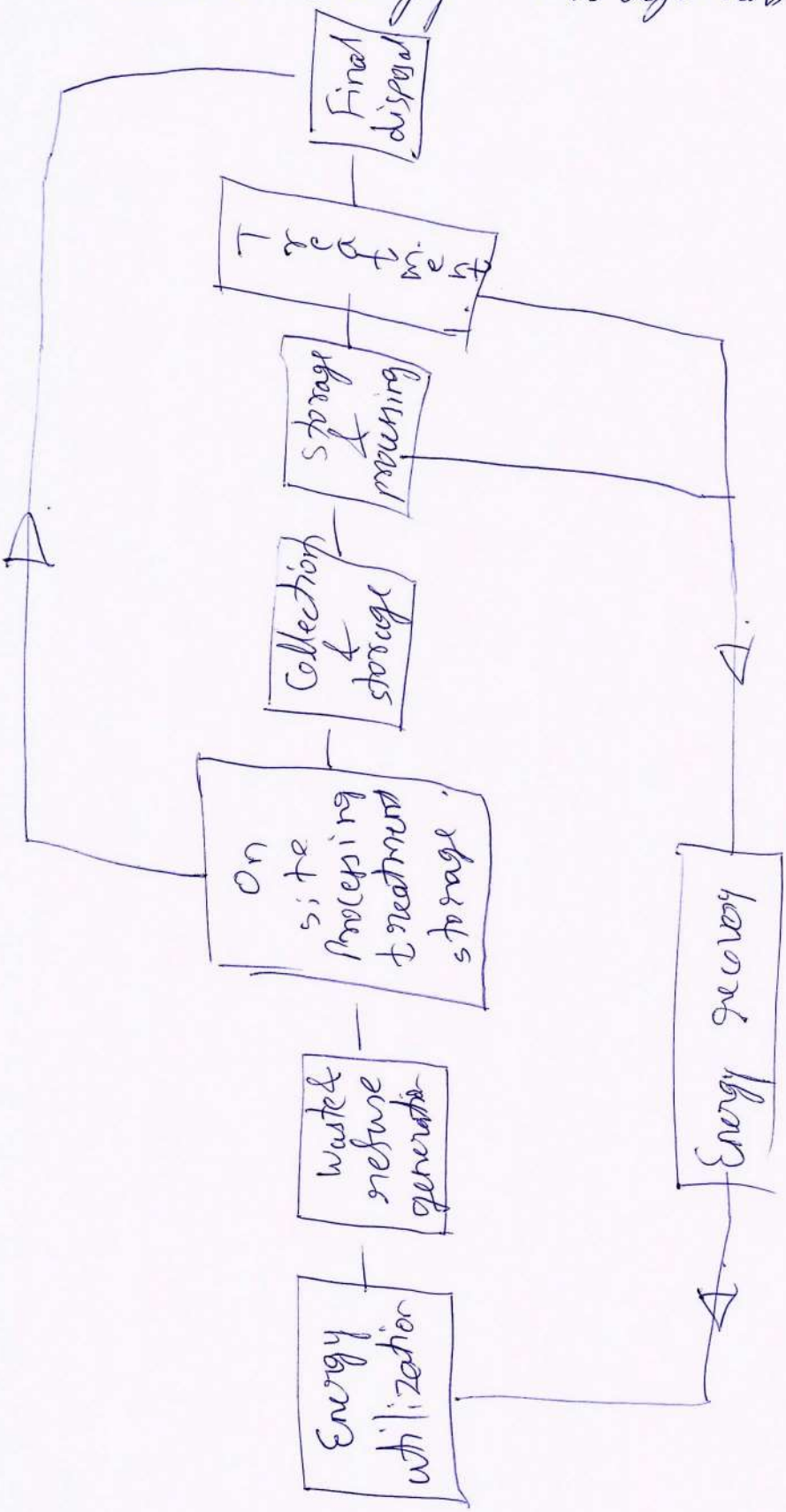
Associated problems

→ The estimation of the power life of the reservoir to make a reasonably accurate decision on the size of station to be built.

→ The separation of steam from the steam wate mixtures at the well heads & transmission of steam only through a long pipeline to the power house.

→ The selection of materials that are suitable for geothermal systems & plants.

6(c). Waste recovery management system (scheme)



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The major part of waste obtained after the energy utilization are non organic that have diversified nature & characteristics, & thus, their identification & separation from the main waste stre by improved techniques are an essential parameter of any energy recovery scheme. On-site processing of waste for the reduction of in-house compactors and industrial shredders through impro technology should be employed. A careful cost analysis & implementation of this vital component will minimize the running cost of the scheme. The storage of waste for resource recovery & final disposal after suitable treatment is another component of scheme & selection of t storage station & other associated problems invite careful attention.

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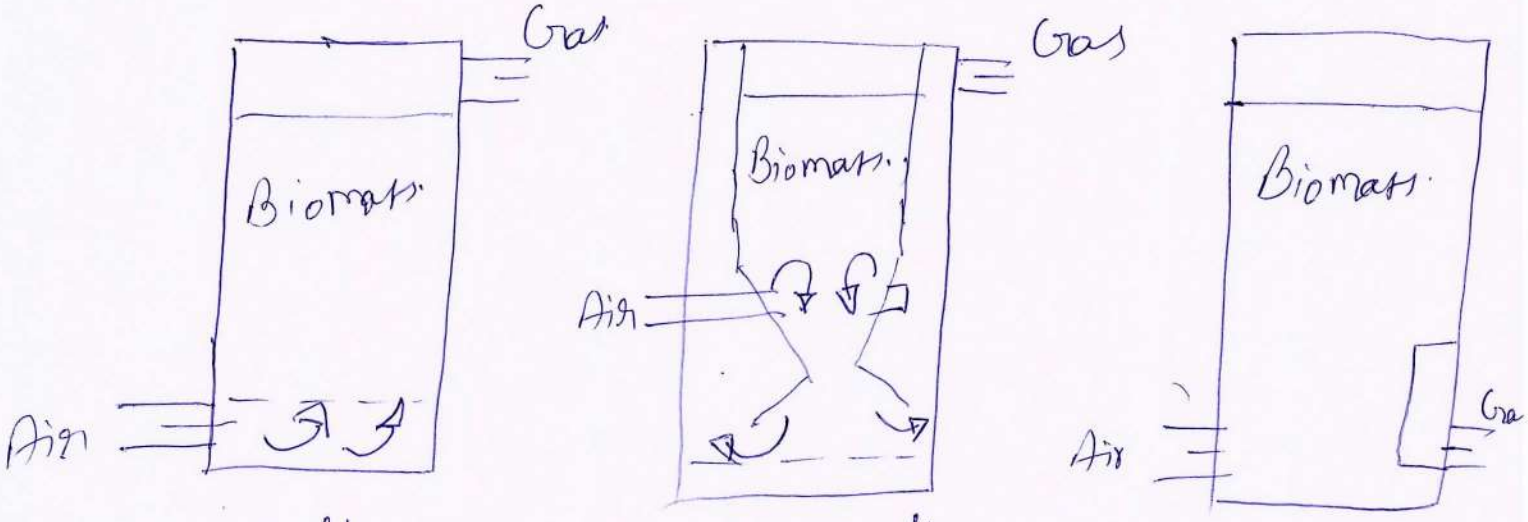
7@ Gasification :-

Biomass gasification is a process of partial combustion in which solid biomass usually in the form of pieces of wood or agriculture residue is converted into a combustible gas mixture.



Updraft gasifier

Downdraft gasifier.

Cross draft gasifier.

Fixed draft gasifier :-

In this gasifier, biomass fuels move either countercurrent or concurrent to the flow of gasification medium as the fuel is converted to fuel gas.

D Kokare.

(a) Down draft gasifier :-

In this, the air is passed from the layers in the downdraft direction.

(b) Updraft gasifiers :- In this, air passing through the biomass from bottom & the combustible gas come out from the top of the gasifier.

(c) Cross draft gasifier :- It is a very simple gasifier and is highly suitable for small outputs. With slight variation, almost all the gasifiers fall in the abovementioned categories.

(2) Fluidized bed gasifier :-

In this, an inert material is utilized to make bed & that acts as a heat transfer medium.

7 (b) Characteristics of biomass feed.

1> Energy content of the fuel.

The higher the energy content & bulk density of fuel, the similar is the gasifier volume, as for one biomass fuel charge, power can be obtained for longer time duration.

Volume.

② Moisture content :-

It is defined by the type of fuel, its origi & treatment. It is desirable to use fuel with lo moisture content to minimize heat loss due to its evaporation.

③ Dust content :-

The gasifier design should be such that it should not produce dust beyond certain limits.

④ Tar content :-

It is a product of highly irreversible proc taking place in the pyrolysis zone.

⑤ Ash and slagging characteristic.

The mineral content in the fuel that remains in oxidized form after complete combustion is usually called ash. The ash content of a fuel & the ash composition has major impact on trouble free operation of gasifier.

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7(c) Applications of biomass gasifier.

1) Motive power :- Gasifier products are used to provide shaft power to industrial & agriculture machinery such as.

- Diesel engine operation on dual or 100% modes
- water pumps
- Tractors, harvesters etc.

(2) Direct heat applications :-

- Drying of agricultural crop & food products such as large cardamom, ginger, rubber & tea.
- Baking of tiles & potteries in the moderate temp. range.
- For melting metals & alloys

(3) Electrical power generation :-

" " " from few kW to hundreds of kW either for local consumption or for grid power is being installed based on gasifier products

(4) Chemical production :-

Production of chemicals such as methanol & formic acid from producer gas.

8@. Biogas :-

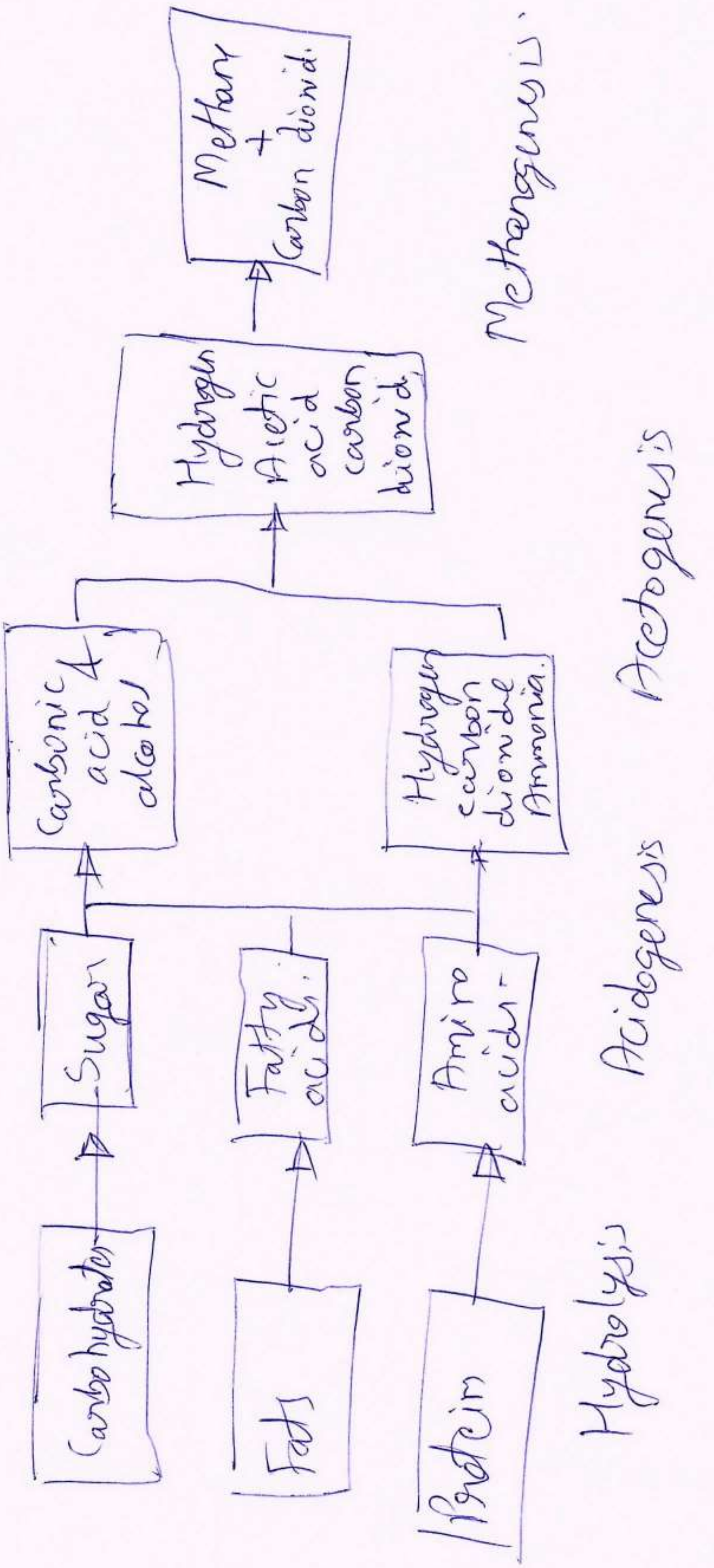
Biogas is a clean, non-polluting, & low-cost fuel. It contains about 50-70% methane, which is inflammable. A methane gas molecule has one atom of carbon & four atoms of hydrogen (CH_4) & is popularly known as biogas.

Composition of biogas.

Sl No	Substances.	Symbol	%
1	Methane	CH_4	50-70
2	Carbon dioxide.	CO_2	30-40
3	Hydrogen.	H_2	5-10
4	Nitrogen.	N_2	1-2
5	Water vapour.	H_2O.	0.2-0.3
6	Hydrogen sulphide.	H_2S	Minute traces.

D Mahare

8(b) Process of anaerobic digestion.



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Hydrolysis :-

It is the process of breaking large bio organic chains into their smaller constituent pa such as sugar, fatty acids & amino acids & dissol the smaller molecules into soln is called hydroly

Acidogenesis :-

In this process the remaining components are broken down by acidogenetic bacteria.

Acetogenesis :-

Simple molecules created through the acidogenesis phase are further digested to produce more acetic acid, CO_2 & H_2.

Methanogenesis :-

In this stage the methanogen use intermediate products of the preceding stages & convert them into CH_4, CO_2 & water

$$C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4.$$

DMokare

8 ©. Benefits of biogas.

1) Transformation of organic wastes into high-qual organic fertilizer

2) Production of energy (heat, light and electricity)

3) Health benefits of biogas and the improvement of hygienic conditions.

4) Reduction of workload, mainly for women, in firewood collection and cooking.

5) Environmental advantages through protection of forests, soil, water and air.

6) Global environmental benefits of biogas technology.

9 @ Devices for harnessing wave energy :-

1) Terminator devices :-

It is a wave energy device oriented perpendicular to the direction of the wave & has one stationary & one moving part. An oscillating water column (owc) converter is an example of terminator device. Power ratings of 500 kW to 2 MW.

R Mahajan

② Attenuator devices :-

These devices are oriented parallel to the of the waves & are long-multi-segment floating structures. It has a series of long cylindrical floatin devices connected to each other with hinges and anchored to the seabed. Pelamis wave energy conver is an example.

③ Point absorber :-

It is a floating structure with parts movin relative to each other owing to wave action. bu it has no orientation in any defined way towards th waves. instead absorbs the wave energy coming from any direction. Aqua Buoy WEC is an example.

④ Overtopping devices :-

These devices have reservoirs like a dam that are filled by incoming waves, causing a slight build-up of water pressure. Gravity causes released water from reservoir to flow back into the ocean through turbine coupled to an electrical generator. Salter Duck WEC is the example of overtopping devices.

Unkare

9 (b) Power associated with sea waves. (18)

Linear wave motion theory that the K.E of a wave per meter of crest & unit of surface can be approximated as

$$E = \rho g a^2 / 2.$$

$\rho \rightarrow$ density of water
$g \rightarrow$ acc^n.
$a \rightarrow$ amplitude of wave

The power that a meter of crest holds can be obtained by multiplying the amount of energy transported by the group velocity.

In deep water, dispersion relation (k) is given as

$$k = \omega^2 / g.$$

group velocity $(V_g) = \omega / 2k = g / 2\omega.$

Total power $P = E V_g = [\rho g a^2 / 2](g / 2\omega)$

$$= \rho g^2 a^2 / 4\omega.$$

wave period $T = \frac{2\pi}{\omega}$ or $\omega = \frac{2\pi}{T}$ & $a = H/2$

$$\therefore P = \rho g^2 a^2 / 4\omega = \rho g^2 H^2 T / 32\pi.$$

Dhokare.

9 (c) Advantages of wave power.

1) Sea waves have high energy densities & provide a consistent stream of electricity (capaci

(2) Wave energy is clean source of renewable ene with limited negative environmental impacts.

(3) It has no greenhouse gas emissions or water pollutants

(4) Operating cost is low & operating efficiency is optimal.

(5) Damage to ocean shoreline is reduced.

Disadvantages.

1) High construction costs.

(2) Marine life is disrupted & displaced.

(3) Damage to the devices from strong storms. & corrosion create problems.

(4) Wave energy devices could have an effect on marine & recreation environment.

Offshore

10 @ Principle of OTEC

The warm water from the ocean surface is collected and pumped through the heat exchange to heat & vapourize a working fluid, & it develo pressure in a secondary cycle. Then, the vapourized working fluid expands through a heat engine coupl to an electric generator that generates electrical pow Working fluid vapour coming out of heat engine is condensed back into liquid by a condenser. Cold deep ocean water is pumped through condenser where the vapour is cooled and returns to liquid state. The liquid is pumped again through heat exchanger & cycle repeats.

10 (b) Rankine cycle and working.

The basic rankine cycle consists of

→ An evaporator
→ A turbine expander
→ A condenser
→ A pump
→ A working fluid.

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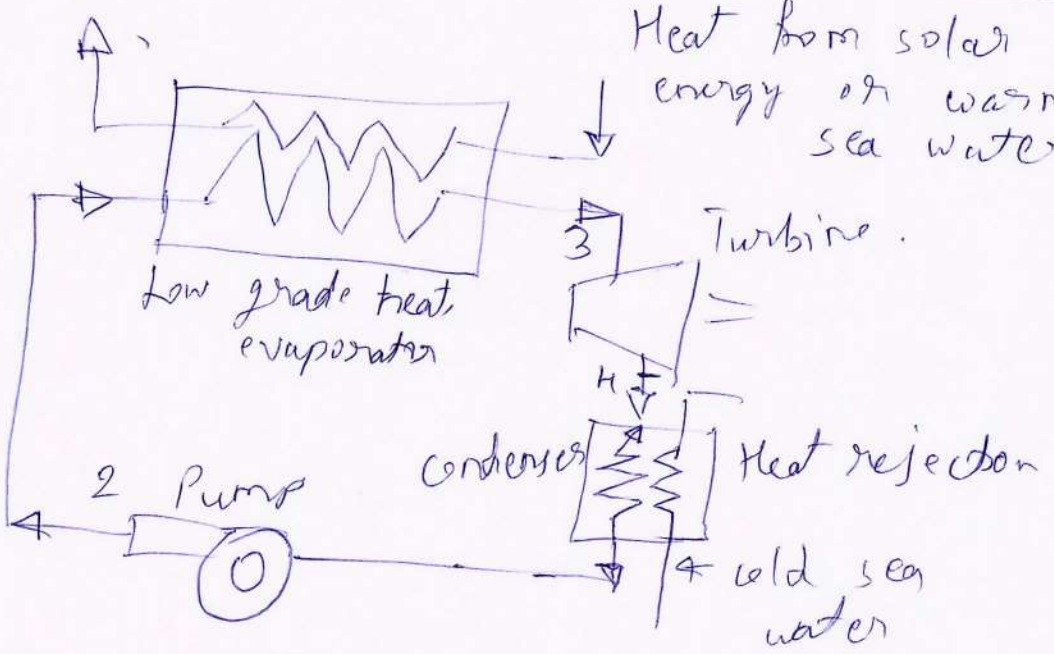

Warm ocean surface water flows into the evapora which is the high temperature heat source. A fluid pump is utilized to force the fluid in a heat evaporator where liquid fluid vaporizes. Then, the vapour of boiling fluid enters the turbine expander coupled with an electrical generator to generate electrical power. The vapour released from the turbin enters into condenser where it condenses. The cold deep sea water is pumped through the condenser for heat rejection from vapour fluid & condenses it as liquid fluid. The liquid fluid is again pumped through evaporator & cycle repeats.

D Mokare.

(20) Advantages of OTEC.

(2)

1> OTEC is a renewable, clean natural resour. available in abundance.

(2) It is pollution-free & has no greenhouse of

(3) It is a good source of freshwater & portable water

Disadvantages :-

(1) Electricity generated by OTEC plants is more expensi

(2) Complexity. OTEC plants must be located where a difference of about 20°C occurs year round.

(3) Acceptability: For the large scale production of electricity and other products, OTEC plants are poorly acceptable due to their high costs.

(4) Ecosystem damage :- It is obvious by setting OTEC plants.

(5) Lower efficiency : A higher temp difference betn. ocean surface warm water & cold deep ocean water is required for highly efficient operation of plant.

Dilshare.

Applications of OTEC.

1> Electricity: Electrical energy is the primary product of OTEC plants.

(2) Hydrogen production:- Electricity produced from OTEC plants is used for separating water in hydrogen & oxygen by the method of electrolysis of water.

(3). Ammonia and methanol production:-
OTEC electricity can be used to obtain by-products, such as ammonia and methanol.

(4) Desalinated water:-
It is freshwater & widely used as water resource for drinking, agriculture & industry.

(5). Aqua culture:- provides sufficient environment for fish farming.

(6) Air conditioning:- cold water can be used as a fluid in air condition systems.

Reference.

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