MODULE-03

(a) Hydrogen energy.

I. Benefits of Hydrogen Energy:

The three basic benefits of hydrogen energy are as follows:

(i) Use of hydrogen greatly reduces pollution.

(ii) Hydrogen can be produced locally from numerous resources

(iii) A sustainable production system if hydrogen is produced from electrolysis of water.

Electrolysis is a method of separating water into hydrogen & oxygen.

II Hydrogen production Technologies ※※ VVImp.

Researchers are developing a wide range of processes for producing hydrogen economically & in an environmental friendly way.

There are three major Hydrogen production technologies, They are

1. Thermo chemical production technologies.
2. Electrolytic production technologies.
3. Photolytic production technologies.

1. Thermo chemical production Technogies:

Now a days hydrogen is produced on an industrial scale by the process of

(a) Steam Reforming

(b) Partial oxidation or Ceramic Membrane reactor

(c) Biomass gassification and pyrolysis.

(a) Steam Reforming: Steam reforming uses thermal energy to separate hydrogen from the carbon components in methane and methanol.

It involves following reaction, They are

(i) Endothermic reforming reaction

$$CH_4 + H_2O + 206\ (kJ/kg) \Rightarrow CO + 3H_2$$

(ii) Exothermic shift reaction

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

** Heating not required in exothermic

(iii) Overall reaction is:

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

Steam reforming is a least expensive method & more than 90% of hydrogen production worldwide.

(b) Partial oxidation ~~or~~ Ceramic Membrane reactor:

* Developing a ceramic membrane reactor for the simultaneous separation of oxygen from air & the partial oxidation of methance.
* In partial oxidation process, natural gas & oxygen are injected into a high-pressure reactor.
* The partial oxidation reaction for natural gas is

$$CH_4 + \frac{1}{2}O_2 \Rightarrow CO + 2H_2$$

* partial oxidation is typically less energy efficient than steam reforming.

2. Electrolytic production Technologies:-

* Another way to produce hydrogen is by electrolysis.
* Electrolysis separates the elements of water - H_2 & oxygen (O) by changing water with an electric current.

* Adding an electrolyte like salt improves the conductivity of the water & increases the efficiency of the process which results in the production of hydrogen at the cathode and oxygen at the anode according to the following equation.

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

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

* Following types of electrolysis are commonly used for hydrogen production
  (a) Water electrolysis
  (b) Steam electrolysis
  (c) photo electrolysis
  (d) Thermochemical Water splitting:- It takes several high-temperature thermochemical reactions, which have high efficiency & practical applicability with nuclear heat sources.

The chemical reaction of sulphur-iodine cycle

$$I_2 + SO_2 + 2H_2O \Rightarrow 2HI + H_2SO_4 \; (120^\circ C)$$

$$H_2SO_4 \Rightarrow SO_2 + H_2O + \tfrac{1}{2}O_2 \; (830^\circ - 900^\circ C)$$

$$2HI \Rightarrow I_2 + H_2 \; (300 - 450^\circ C)$$

The overall reaction $H_2O \Rightarrow H_2 + \tfrac{1}{2}O_2$.

(e) By product of Sodium or Potassium Chloride electrolysis:- Hydrogen is a by product of sodium or potassium chloride electrolysis that produces chlorine & caustic soda or potash:

$$NaCl + H_2O + \text{electricity} \Rightarrow \tfrac{1}{2}Cl_2 + NaOH + \tfrac{1}{2}H_2$$

$$KCl + H_2O + \text{electricity} \Rightarrow \tfrac{1}{2}Cl_2 + KOH + \tfrac{1}{2}H_2$$

Chlorine is one of the most common chemicals in the world.

(f) Reversible Fuel cells or Electrolysers.

3. Photolytic production Technologies:

Hydrogen production can be achieved by using either i) photochemical process
ii) photo-biological process

photochemical process use two types
(a) uses soluble metal complexes as a catalyst
(b) uses semiconductor surfaces.

Certain photosynthetic microbes produce hydrogen in their metabolic activities using light energy.

III. Hydrogen energy storage:-

Storage of hydrogen is difficult in large quantities without taking up a significant amount of space.

(i) Compressed gas & liquid Hydrogen Storage tank:-

Hydrogen has a very high energy content by weight, but it has a very low energy content by volume. [liquid hydrogen is about four times less than gasoline]. This makes hydrogen a challenge to store.

(ii) Materials-based storage:- It can be stored on the surface of solids (by absorption process) or within solids (by absorption process).

In absorption process, hydrogen attaches to the surface of a material either as hydrogen molecules (H_2) or hydrogen atoms (H) also called surface absorption storage.

(iii) Methods of Hydrogen energy storage:-

Hydrogen energy storage may be classified as follows

(i) Compression:- Hydrogen can be compressed into containers or underground reserviours. It is relatively simple technology, but the energy desity & efficiency (65% - 70%) are low. The energy required for compression is a major drawback.

(ii) Liquefied Hydrogen:- The Hydrogen can be liquefied by pressurising & cooling. Further, keeping the hydrogen liquified is very energy intensive, as it must be kept below 20.27K.

(iii) Metal Hydrides:- Certain materials absorb molecular hydrogen such as nano structured carbons & clathrate hydrate. By absorbing the hydrogen in these materials, it can be easily transported & stored.

There is no optimum method to store hydrogen energy at present.

IV Use of Hydrogen Energy:-

Hydrogen can be used as a mobile source of power for transportation by being compressed & stored is small tanks for application similar to gasoline or propane.

The following are the two superior ways of using hydrogen energy.

1. Internal combustion engine (ICE): It is expected that the ICE will act as a ~~transition~~ transition technology while fuel cells are improving, because the modification required to convert an ICE to operate on hydrogen are not very significantly.

2. Fuel cell (FC):- A fuel cell converts stored chemical energy, in this case hydrogen, directly into electrical energy.

V. Advantages & Disadvantages of Hydrogen Energy.

Advantages:-

(i) Uncoupling of primary energy sources & utilization.

(ii) Hydrogen is a gas; thus, it is easier to store than to store electricity.

(iii) Hydrogen can be obtained from any primary energy source, including renewable energy source.

(iv) Decentralized production is possible.

(v) Very efficient when used in fuel cells.

(vi) very good experience of hydrogen as a chemical reactant (ammonia, methanol & oil refining).

(vii) Very good safety records [for a specific range of applications].

Disadvantages:-

(i) Poor overall energy efficiency when produced from electricity made with fossil fuels.

(ii) Very low density & poor specific volume energy density.

(iii) Need for high pressures & very low temperatures if stored in the liquid phase.

(iv) Specific safety problems & poor public acceptance

(v) No existing infrastructures for transport, distribution & storage.

(vi) Rather high cost (till today).

VI. Problems associated with Hydrogen energy:-

The serious problems that are affecting the development of hydrogen for household & transport applications are as follows.

1. Hydrogen storage
2. High reactivity of hydrogen
3. It is combustible & flammable
4. cost & methods of hydrogen fuel production.
5. Consumer Demand
6. Cost of charging the infrastructure to accomodate hydrogen equipment & appliances.

(b) Wind Energy.

I. Wind mills:

If the mechanical energy is used directly by machinery, such as for a pump or grinding stones the machine is usally called a windmill.

A windmill is a mill that converts the energy of wind into rotational energy by means of vanes called sails or blades.

There are two types of windmill

1. Horizontal windmill
2. Vertical windmill

II. Wind Turbines:

Wind turbines deliver their power through a revealing shaft & in this respect, they are similar to other prime movers such as diesel engines & steam turbines

Wind turbines are of two types

1. Vertical axis wind turbine
   (a) Darrieus type
   (b) Savonious type
2. Horizontal axis wind turbine
   (a) Dutch type
   (b) Multi blade type
   (c) High speed propeller type.

III. Wind Resources:-

The availability and reliability of wind speed data is extremely poor in many regions of the world. Large areas of the world appear to have average annual wind speed below 3m/s & are unsuitable for wind power systems.

(i) Worldwide wind energy scenario in 2010.

As per the world wind energy Report 2010, wind energy scenario is summarized as follows.

(a) Worldwide capacity reached 196,630 MW, out of which 37,642 MW were added in 2010, slightly less than the capacity in 2009.

(b) Wind power showed a growth rate of 23.6%, the lowest growth since 2004 & second lowest growth of the past decade.

(c) China became No.1 in total installed capacity & the centre of the international wind industry. & it added 18,928 MW with in one year, accounting for more than 50% of the world market for new wind turbines

(d) Many western european countries are showing stagnation, whereas there is strong growth in the number of eastern European countries.

(e) Germany keeps its number one position in Europe with 27,215 MW, followed by Spain with 20676 MW

(f) The highest shares of wind power can be found in three european countries. Denmark (21%), Spain (16%) & portugal (18%).

(g) Asia accounted for the Largest share of new installations (54.6%) followed by europe (27%) & North America (16.7%).

(h) WWEA sees a global capacity of 600,000 MW as possible by 2015 & more than 1,500,000 MW by 2020.

(ii) Wind energy in India:

* The India wind energy sector has an installed capacity of 14,158 MW as on March 31, 2011.
* India is ranked fifth in the world in terms of wind power installed capacity.
* Indian wind energy association has estimated that with the current level of technology, the on-shore potential for utilization of wind energy for electricity generation is of the order of 65000 MW.
* Wind in India are influenced by the strong south-west summer monsoon, which starts in May-June, when cool, humid air moves towards the land.
  Further, the weak north-east winter monsoon, which starts in October, when cool, dry air moves towards the ocean.
* The implemented project in prominent wind potential states as on 31 March 2011 is given in table 1.

State	Gross potential MW	Total Capacity MW till 31.03.2011
Andra pradesh	8968	200.2
Gujarath	10,645	2175.6
Karnataka	11,531	1730.1
Kerala	1,171	32.8
Madhya pradesh	1019	275.5
Maharashtra	4584	2310.7
Orissa	255	—
Rajasthan	4858	1524.7
Tamil Nadu	5530	5904.4
others	—	4
Total (All India)	48,561	14,158

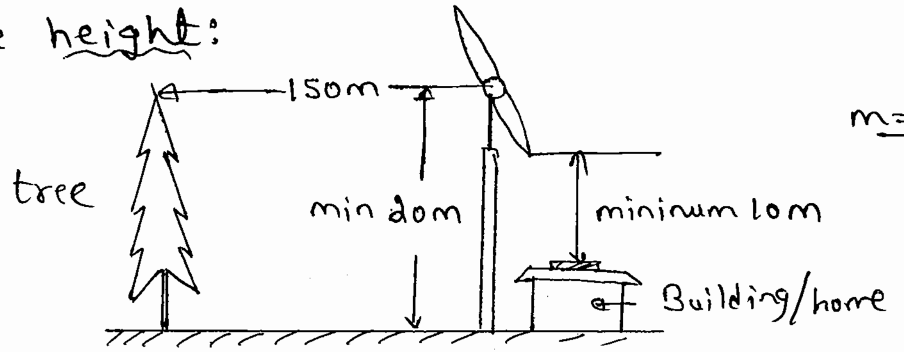
Table 1. State-wise Wind power installed Capacity in India.

IV WIND TURBINE SITE SELECTON: ※※ vvImp.

The selection of a wind farm site is complex & time consuming, and also it involves multiple disciplines such as financing, government permits, meteorological studies, land use restrictions & design have to be completed well along before site is approved & before the construction can begin.

The following important factors needed for wind site selection.

1. Turbine height:



2. Hill effect: The installation of wind turbines on hilltops takes advantage of increase in speed, bcz The compressed air rises & gains speed as it approaches at top of the hill.

3. Roughness or the amount of friction that earth's surface exerts on wind.

4. Tunnel effect: placing wind turbine between two mountains can be a good way to take advantage of wind speeds that are higher than those of the surrounding air.

5. Turbulence: Rapid changes in the speed & direction of the wind caused by natural or artificial barries is called turbulence.

Turbulence causes not only fluctuations in the speed of the wind but also wear & tear on the turbine. Turbines are mounted on tall towers to avoid turbulence caused by ground obstacles.

6. Variations in wind speed.

7. Wake: The abrupt change in the speed makes the wind turbulent, a phenomenon called wake. Because of wake, wind turbines in a wind farm are generally placed about three rotor diameters away from one another in the direction of the wind, so that the wake from one turbine does not interfere with the operation of the one behind it.

8. Wind obstacles: Trees, buildings & rock formations are the main, obstacles in the installation of wind turbines, which cause wind shade, can considerably reduce the speed of the wind & therefore the power output of a turbine.

9. Wind shear: It is differences in wind speeds at different heights.
When a turbine blade is pointed straight upward, the speed of the wind hitting the tip can be, for example 9 mile or 14 km/hour, but when the blade is pointing straight downward, the speee of the wind hitting its tip can be 7 miles or 11 km/hour. This difference places stress on the blade. Further, too much wind shear can cause the turbine to fail.

(C) Geothermal Energy:

I. Geothermal Systems:

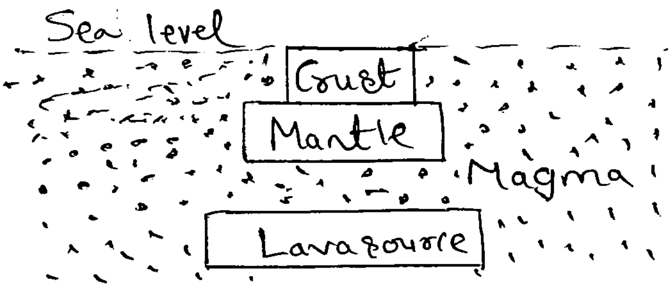


Figure 1. Interior of earth

* Under the earth's crust, there is a layer of hot &

molten rock called magma.

* The amount of heat within 10,000 m of the earth's surface contains 50,000 times more energy than that of all oil & natural gas resources in the world.

* The geothermal resource base is defined as total heat greater than 15°C in the earth's crust; but only a small portion of this storage of heat base can properly be considered as a resource.

* Geothermal energy is the earliest branch of power generation and these energy resources utilize the earth's deep heat to provide a significant contribution to the power budget of every country.

II Classifications.

Geothermal systems are classified into two categories

(i) Vapour-dominated / Dry steam geothermal systems:-

* This system are uncommon & poorly understood when compared to liquid-dominated system.

* It requires relatively potent heat supplies and Low initial permeability.

* Vapour-dominated reservoir actually is a very deep water table, but some may be swept out with steam in channels of principal upflow.

* Steam greatly dominates the Larger channels and discharge from the wells.

(ii) Liquid-dominated / Hot water geothermal systems:-

* It is comparatievly modest temperatures & low entalpies.

* Used for direct heat applications

New zealand first demonstrated the generation of geothermal power.

III Geothermal Resource Utilization;

Geothermal Resource utilization are extensively used in the following ways,

1. **Direct use of Low Grade Geothermal energy:**
   - (i) Aquaculture and horticulture
   - (ii) Industry & agriculture
   - (iii) Food processing
   - (iv) Providing heat for residential use.
   - (v) Hot water
   - (vi) Crop & Lumber drying.

2. **Electricity generation:-** Geothermal power generation is completely clean & releases no harmfull gas emissions whatsover. Conversion technology for electricity generation is as follows

   (i) **Flashed steam plants:** The water 'flash' boils & the steam is used to turn turbines

   (ii) **Dry steam plants:** These plants rely on the natural steam that comes from the underground reservoirs to generate electricity.

   (iii) **Binary power plants:** These plants use the water to heat a 'secondary liquid' that vaporizes & turns the turbines. The vaporized liquid is then condensed & reused.

   (iv) **Hybrid power plants:** In these plants, binary & flash techniques are utilized simultaneously.

3. Geothermal Heat pumps:

4. Geothermal resource are classified into temperature range (i) High temperature $>220°C$ (ii) Intemediate temp $(100-220°C)$ (iii) Low temperature $30-150°C$.

IV Resource Exploration:-

* Geothermal exploration involves outlining broad regions where the heat flow is significantly greater than 1.5×10^{-6} cal cm^{-2} s^{-1}.
* Most of regions with high heat flow are in zones of early volcanic and tectonic activity. which are characterized by hot springs.
* The following tehniques play major role in geothermal exploration, they are geological, geochemical, electrical seismic, gravitional, magnetic & thermal methods/techniques.
* Aerial surveys with infrared scanners have great future in the detection of geothermal resources.
* Seismic methods are proving usefull in locating fractured & permeable zones in geothermal areas.
* anomalies are used as indicators of the internal surface temperature.
* India also has vast potential for geothermal energy scattered all over the country. There are more than 300 hot springs scattered all over the country.
* These thermal springs are mostly in Bihar, Bombay, Ratnagiri, Himachal pradesh & Ladakh.
* puga valley ranging 50°C to 110°C, manikaran thermal spring 69°C to 93°C, Rajgir ranging from 35.5°C to 42.5°C.
* Further, oil & Natural gas commission has detected hot water & steam at depth of 1500 to 2000 m during oil exploration in cambay region of gujarath.

V Geothermal based Electric power generation.

1. Dry-steam based Geothermal power plant.

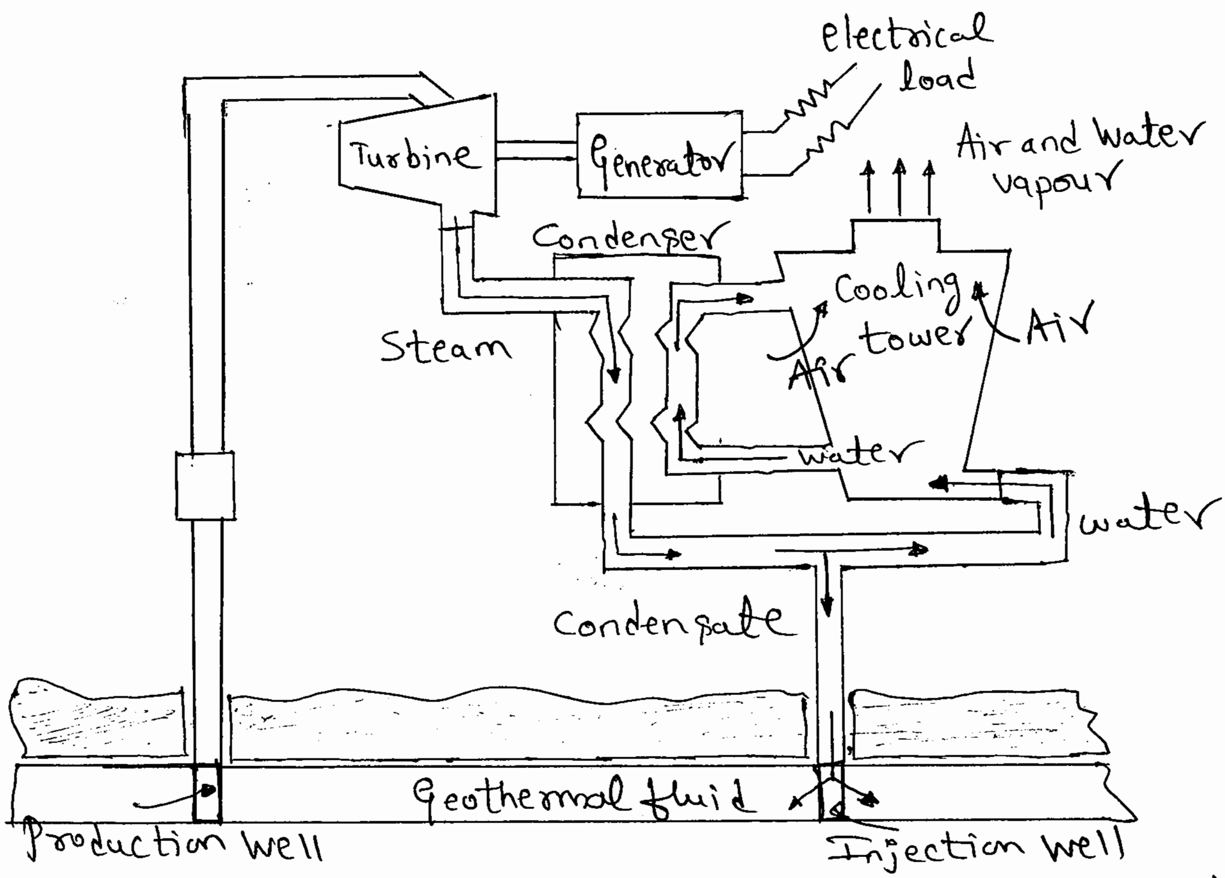


Figure 2. Dry steam geothermal electric power plant.

* Figure 2 shows a dry steam plant. it was first operated in 1904 in Larderello, Italy. Even so. it operating for over 100 years longer than any other geothermal conversion technology.
* In a dry steam plant like those at the geysers in california, steam produced directly from the geothermal reservoir runs the turbines that power the generator.
* Dry steam systems are relatively simple, requiring only steam and 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 & small solid particulates, condensate drains along the pipeline, and a final scrubber to remove small particulates & dissolved solids.
* Today, steam power plants make up a little less than 40% of U.S. geothermal electricity production, all located at the Geysers in California.

2. Flash Geothermal power plants.

(i) Single flash geothermal steam-electric power plant.

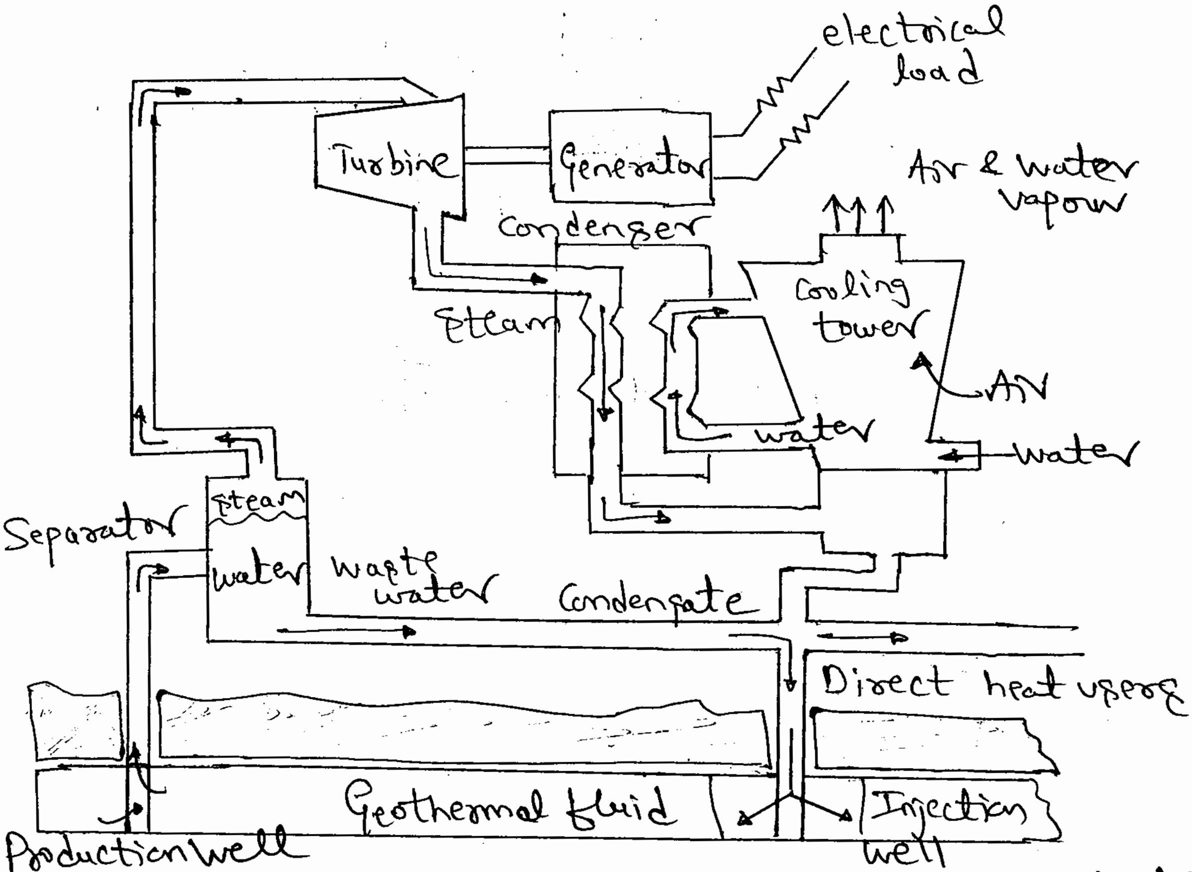


Figure 3. Single flash geothermal steam-electric plant

* The term flash steam refers to the process where high-pressure hot water is flashed (vaporized) into steam inside a flash tank by lowering the pressure.
* Flash steam is today's most common power plant type.

* First Flash steam technology was the Wairakei Power station in New Zealand which was built in 1958.
* Pipeline is installed to tap the resource, when the compressed liquid reaches the surface at atmospheric pressure then, a portion of it immediately flashes a steam.
* The exhaust steam is then piped to a condenser where it is returned to liquid. This hot liquid water can then be used ~~for~~ further heating applications prior to the reinjection into the rock.

(ii) Double flash geothermal steam - electric powerplant.

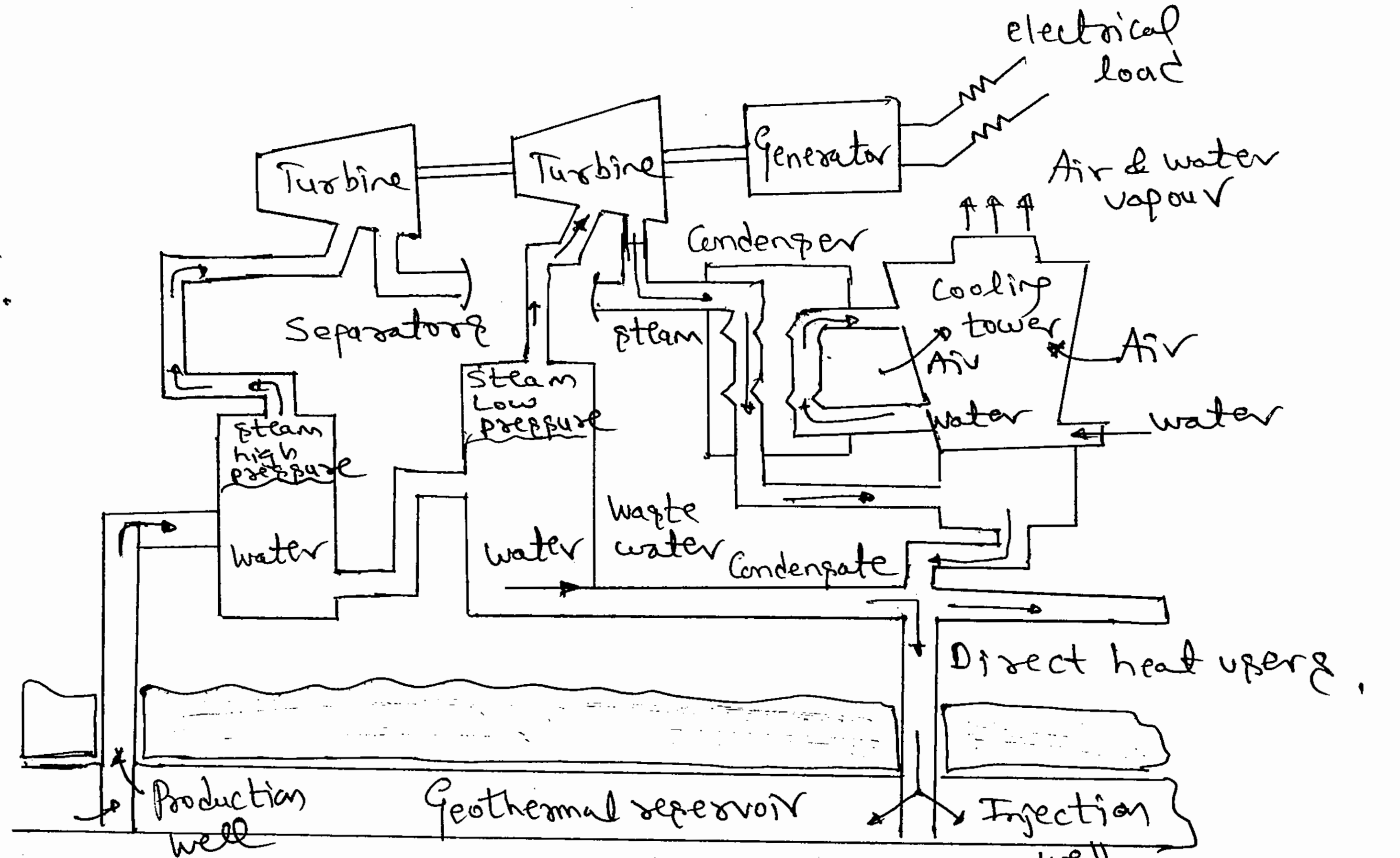


Figure 4. Double flash plant.

* Flash steam plants are the most common type of geothermal power generation plants in operation today.
* Fluid at temperature greater than 182°C is pumped under high pressure into a tank at the surface held at a much low pressure, causing some of the

fluid to rapidly vaporize.

* The vapour then drives a turbine, which drives a generator. If any liquid remains in the tank, it can be flashed again in the second tank to extract more energy.
* Hot liquid water from deep in the earth under pressure to shallower levels, it quickly loses pressure, boils & flashes to steam.
* The steam is separated from the liquid in a surface vessel & is used to turn the turbine & thus power a generator.
* About 45% of geothermal electricity production in USA comes from flash technology.
* It typically require resource temperatures in the range of 177°C – 260°C.

Merits

1. Very low emissions
2. Safe & reliable
3. Immune to varying weather conditions
4. Cost effective over life of plant
5. sustainable
6. Small footprint
7. No fuel cost.

Demerits

1. High Initial cost
2. Increased risk of seismic activity
3. Location sensitive
4. Risk of overexploiting resources.

3. Binary cycle-based geothermal plants.

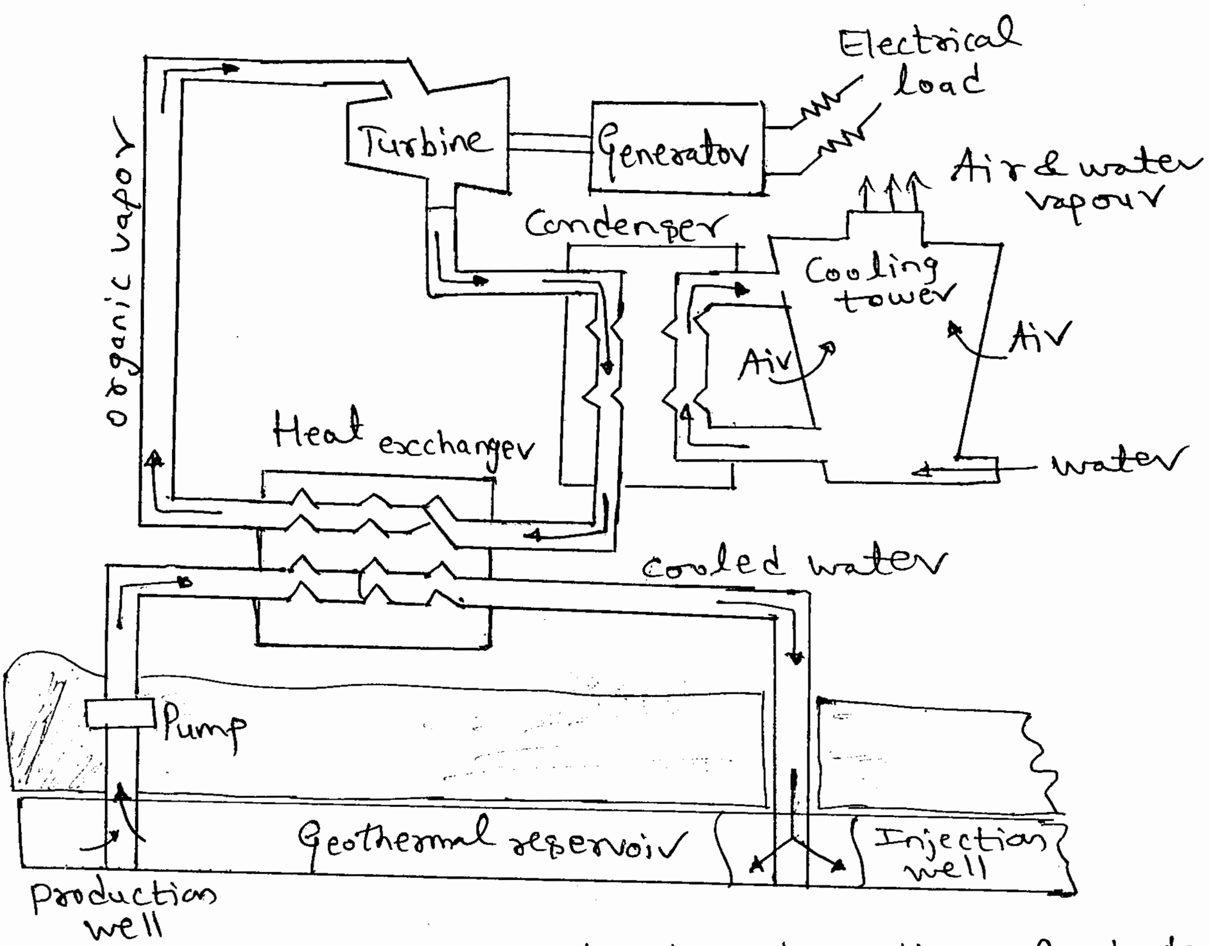


Figure 5 Binary cycle-based geothermal electric power plant.

* In the binary process, the geothermal fluid, which can be either hot water, steam or a mixture of the two.
* The geothermal working fluid may be isopentane or isobutane that boils at a lower temperature than water
* The two fluids are kept completely separate through the use of a heat exchanger that is used to transfer heat energy from the geothermal water to the working fluid.
* The working fluid vaporizes into gas when heated & the force (steam) of expanding gas turns the turbines that power the generators.

* Low temperature geothermal plant also known as binary cycle-based Geothermal plant, today make use of resource temperatures as low as 74°C & as high as 177°C.
* Approximately 15% of all geothermal power plants utilize binary conversion technology. It is shown schematically in Figure 5.

VI. Associated problems [Geothermal].

The major problem associated with geothermal plant are.

i) Estimation of the life of the reservoir fluid to make a reasonably accurate decision on the size of station to be built.

ii) Financial life such as station should be sufficiently long, in which predicting unique feature of reservoir is challenging.

iii) Separation of steam from the steam-water mixtures is difficicult.

iv) transmission of steam require long pipeline to the power house

v) Another important problem is the selection of materials are suitable for geothermal system & plants, Materials should have large resistance to corrosion for the gaseous products & properties to fulfil the electromechanical & other requirement

vi) Automatic start control is rather expensive requires investigation at the plant to trip the unit during operating condition before the unit is restarted.

VII Environmental effects: [Geothermal]

As we know geothermal energy clean, but there are some undesirable effects can extend for several kilometers from the geothermal field itself, thus introduce environmental problems into the surrounding regions. The effects are as follows.

i) Gaseous & Particulate emission

(a) Carbon dioxide (CO_2) (b) hydrogen sulphide (H_2S (c) Methane (CH_4) (d) ammonia (NH_3) these pollutants contribute to global warming, acid rain & noxious smells if released.

ii) Land pollution: Degradation of usable soil, reduce soil sterility & may adversely effect on food chains.

iii) Subsidence effect.

iv) Seismic Hazards: Mostly, the geothermal resource areas are closely associated with the regions of high geologic activity, which is manifested most commonly as earthquakes.

v) Water pollution.

vi) Biological effects

vii) Social effects. in the form of strikes, noise land issues.

viii) Long term alteration in humidity.

(d) Solid waste & Agricultural refuse.

I. Waste is Wealth.

Globally, the focus is to modify all resources from waste to wealth or from trash to cash. The following are some of the driving forces of change (waste to wealth).

(i) Growing concern about the hazards of waste disposal.

(ii) Broad environmental concerns, especially global warming & resource depletion.

(iii) Economic opportunities created by new waste regulations & technological innovation.

(iv) Fuel shortage.

(v) Heat energy generation: waste is used as supplemental boiler fuel & heat energy is obtained by the direct combustion of the waste to heat energy.

(vi) Bioenergy generation: It is a modern method of hazards control of waste disposal & for the recovery of fuels & energy.

vii) Eco-modification through recycling

viii) Fuel & energy generation from forest & agricultural & municipal waste

II. Key Issues.

The following are the key Issues that must be investigated before the economic viability of a refuse-derived fuel (RDF) scheme.

i) Collection of waste from doorsteps, commercial places, community dump & final disposal sites.

ii) The volume & nature of refuse to be processed

iii) The type of efficient RFD process required & market for fuel products.

iv) The required potential users & the revenue obtainable.

v) The economy of the alternative method of disposal of the refuse.

vi) The utilization of solar thermal energy for increasing the temperatures of digesters.

III. Waste Recovery Management scheme.

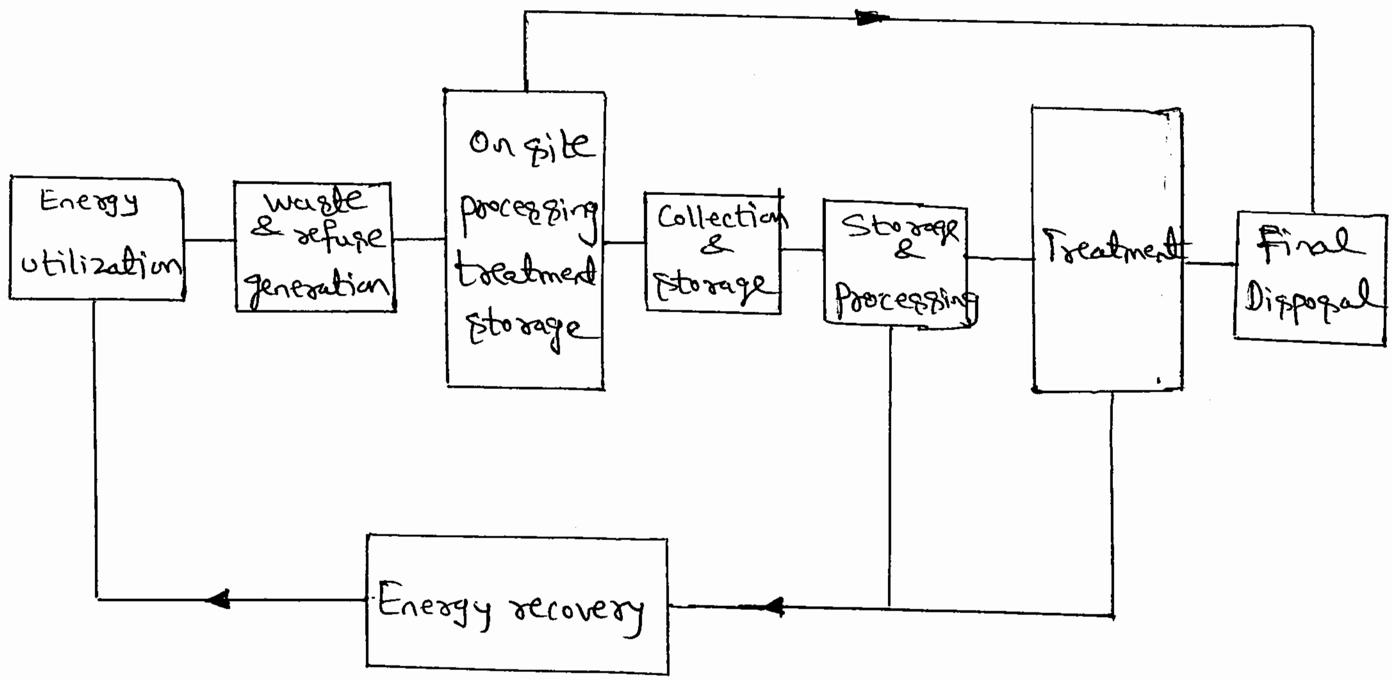


Figure 1. Schematic representation of waste refuse energy management.

* A simple waste, refuse resource recovery scheme can be understood from Figure 1. which represents the various important scheme components as energy use & solid waste generation, transportation, storage, energy recovery, treatment & final disposal of the waste.
* 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 stream by improved techniques are an essential parameter of any energy recovery scheme.
* The storage of waste for resource recovery & final disposal after suitable treatment is another component of scheme & selection of storage station & other associated problems invite carefull attention.
* Normally two types of energy recovery systems are used

1) Separation of metals, paper & glass from the remaining waste through the process such as size reduction, screening, vibrating sorting & electronic scanning, however inexpensive separation system will provide competitive input to waste energy utilization.

2) Conversion of the remaining waste product to usable form of energy and energy conversion may include the following

i) Generation of methane gas
ii) Generation of electricity either form (i) or through thermo-mechanical process
iii) Composting of fertilizers.

* Treatment: Treatment means that those process

designed to reduce waste to innocuous forms without or after energy recovery. The most familiar techniques are the burning of waste at high temperature is called incineration.

IV Advantages & Disadvantages of waste recycling.

Advantages:

(i) Reduced damage to environment
(ii) Reduced consumption of energy.
(iii) Reduced environmental impact & pollution
(iv) Mitigate global warming
(v) Promotes sustainable utilization of resources

Disadvantages:

(i) High cost of recycling
(ii) Durability & small life span of recycled items
(iii) Unsafe & unhygienic process
(iv) might pose dangers/illness to our health.

V Sources & Types of Wastes.

1. Residential wastes: These are single family or multi family dwellings. It constitute kitchen waste, paper & cardboards, clothes & leather materials, plastics & rubber materials, glass, wood & metal crockery & furniture, gadgets etc,

2. Muncipal service wastes: They include general waste collected from street sweeping, park, recreational places, sludge, Landscapping & tree trimming.

3. Industrial & commercial wastes: These are house-keeping & food wastes, packaging & demolition wastes, scraps, hazardous wastes, wood material wastes, cardboard paper, plastics etc.,.

4. Building construction & demolition: wood, concrete, steel & dust.

5. Agriculture: It consists of diary & agriculture farm crop waste, hazardous pesticides etc.,

VI Recycling of plastics:-

plastics play an important role in almost every aspect of our lives. plastics are durable, their toughness & inertness are what make them so usefull.

→ The recycling rate of different types of plastic varies greatly, plastics are of two types

(i) Thermosets
(ii) Thermoplastics.

→ According to estimates, 80% of post-consumer plastic waste is sent to landfill, 8% incinerated & only 7% is recycled.

→ plastic come in variety of colours & chemical formulations, all with different recycling needs. The plastic resin identification code is a set of symbols placed on plastics to identify the polymer type which was developed by SPI (soceity of plastic Industry) in 1988 & is used internationally.

→ The following are benefits of plastic recycling

1. Energy & natural resource conservation
2. Envirommental protection
3. Reducing the dumping (landfill) spaces
4. Energy conservation.
5. It is good for practicing green living
6. It saves resource, energy & some money.

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