EE02

Hall Ticket Number:

IV/IV B.Tech (Regular/Supplementary) DEGREE EXAMINATION

Jan/Feb, 2021 — **Common to CE, , ECE and ME**

Seventh Semester — **Non-Conventional Energy Sources**

Time: Three Hours — **Maximum :** 60 Marks

Answer ALL Questions from PART-A. (1X12 = 12 Marks)
*Answer **ANY FOUR** questions from PART-B.* (4X12=48 Marks)

Part - A

1 Answer all questions (1X12=12 Marks)

a) What are the drawbacks of nonconventional energy sources?
b) What is green energy?
c) What are the ill effects of electrical energy generated using Fossil fuel?
d) What is Solar cell?
e) Define solar constant?
f) What is Direct & Diffuse radiation?
g) Define cut-out velocity.
h) What are the disadvantages of vertical axis wind turbine?
i) What is Pitch control?
j) Which kind geothermal plant is most common type?
k) What are the causes of tides?
l) What is biogas digester?

Part - B

2	a)	Explain in detail about ultimate energy sources on the earth?	6M
	b)	Explain about Primary Energy Supply &End Use Requirements using Spaghetti &Pie Diagram?	6M
3	a)	Classify Energy sources into Commercial &Non- Commercial energy sources?	6M
	b)	What is the importance of energy management in improving energy efficiency? Explain.	6M
4	a)	Briefly explain about Solar Pond with a neat sketch?	6M
	b)	Explain how solar radiation is measured.	6M
5	a)	Explain about working of Solar Thermal Central Receiver System with neat diagram?	6M
	b)	Explain about non concentrating collectors with neat sketches?	6M
6	a)	With a neat block diagram explain about basic components of wind energy conversion system?	6M
	b)	What are the types &causes of winds? Derive the expression for Total power in wind stream?	6M
7	a)	Briefly explain about Horizontal axis & Vertical axis wind mills with diagrams?	6M
	b)	Derive expression for Maximum power in wind stream.	6M
8	a)	Explain the concept of geothermal energy with a diagram?	6M
	b)	What are biomass conversion technologies? Draw a schematic diagram to explain various conversion technologies and products.	6M
9	a)	With a diagram explain about Open cycle &closed cycle OTEC power plant?	6M
	b)	Explain the constructional details & working of biogas digester.	6M

PART - A

I.

a) The Electricity Generation Capacity is Still Not Large Enough.

Renewable Energy Can be Unreliable

Low-efficiency Levels

Takes a Lot of Space to Install

Expensive Storage Costs

b) Green energy is any energy type that is generated from natural resources, such as sunlight, wind or water.

c) Depending on the particular fossil fuel and the method of burning, other emissions may be produced as well. Ozone, sulfur dioxide, NO2 and other gases are often released, as well as particulate matter. Sulfur and nitrogen oxides contribute to smog and acid rain.

d) A solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon.

e) Solar constant, the total radiation energy received from the Sun per unit of time per unit of area on a theoretical surface perpendicular to the Sun's rays and at Earth's mean distance from the Sun.The value of the constant is approximately 1.366 kilowatts per square metre.

f) Direct radiation is also sometimes called beam radiation or direct beam radiation. It is used to describe solar radiation travelling in a straight line from the sun down to the surface of the earth.

Diffuse radiation is solar radiation reaching the Earth's surface after having been scattered from the direct solar beam by molecules or particulates in the atmosphere.

g) The cut-out speed is the point at which the turbine must be shut down to avoid damage to the equipment.

h) Less Rotation Efficiency.

Lower Available Wind Speed.

Component Wear-down.

Less Efficiency.

i) Pitch control is the technology used to operate and control the angle of the blades in a wind turbine.

j) Flash steam power plants are the most common.

k) Tides are caused by the gravitational interaction between the Earth and the Moon.

l) biogas digesters are the systems that process waste into biogas, and then channel that biogas so that the energy can be productively used.

Part - B

2.

a. There are five ultimate primary sources of useful energy:

1 The Sun.

2 The motion and gravitational potential of the Sun, Moon and Earth.

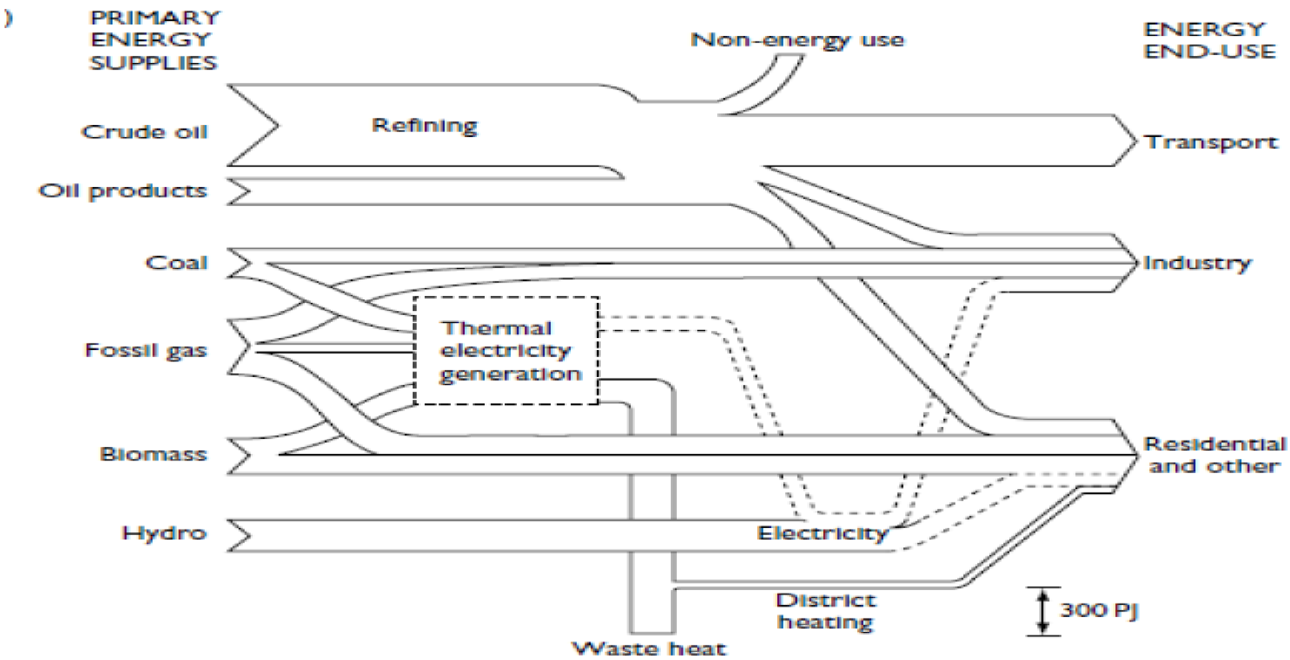
3 Geothermal energy from cooling, chemical reactions and radioactive decay in the Earth.

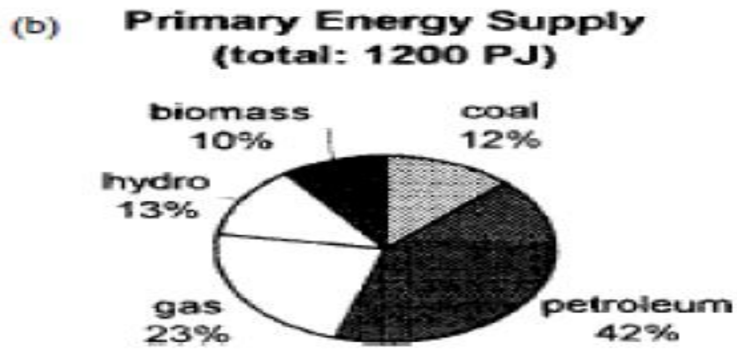
4 Human-induced nuclear reactions.

5 Chemical reactions from mineral sources.

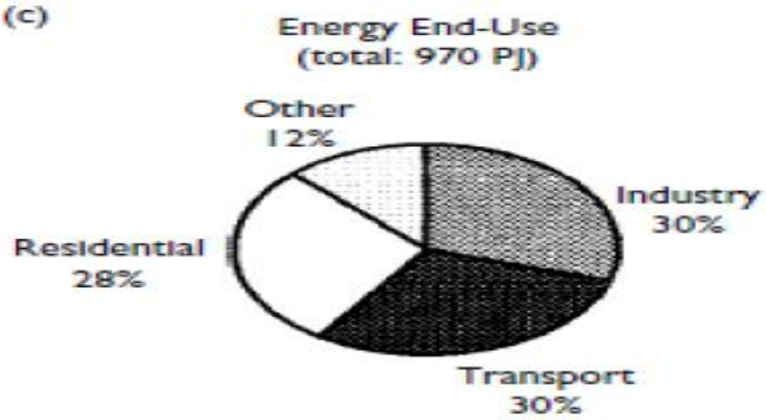
Renewable energy derives continuously from sources 1, 2 and 3 (aquifers). Finite energy derives from sources 1 (fossil fuels), 3 (hot rocks), 4 and 5. The sources of most significance for global energy supplies are 1 and 4. The fifth category is relatively minor, but useful for primary batteries, e.g. dry cells.

b. All energy systems can be visualised as a series of pipes or circuits through which the energy currents are channelled and transformed to become useful in domestic, industrial and agricultural circumstances. Figure 1.3(a) is a Sankey diagram of energy supply, which shows the energy flows through a national energy system (sometimes called a 'spaghetti diagram' because of its appearance). Sections across such a diagram can be drawn as pie charts showing primary energy supply and energy supply to end-use.





The total energy end use is less then the primary supply because of losses in the transformation processnotably the generation of electricity from the fossil fuels.



3.

a. Commercial energy sources:

(i) Coal and Lignite:

It has been considered as the major source of energy in India. It can be easily converted into other forms of energy such as electricity, gas and oil. The total estimate resources of coal are now placed at 1, 48, 79 million tonnes, but the mineable reserves are estimated to be 60,000 million tonnes i.e. on 40% of the total coal reserves. Lignite is brown coal with lesser amount of energy than black coal. In 1950-51, production of coal and lignite in India was 32.3 million tonnes which increased to 413 million tonnes in 2004-05.

(ii) Oil and Gas:

Demand for fossil fuels grew rapidly with the growth of the industrial sector and transport services. Crude oil production has constantly, been increasing since the beginning of economic plans in India. After Independence, the Government of India felt the need for oil exploration on an extensive scale, and therefore, the Oil and Natural Gas Commission (ONGC) was set up in 1956, an(in 1959, Oil India Limited (OIL) was established.

(iii) Hydroelectric power:

It plays an important role in the filed of power development in country, our country has made considerable progress in the field of hydroelectricity power generation.

(iv) Atomic or Nuclear Power:

India has also developed nuclear power. Uranium and thorium are both sources of nuclear power generation. India's uranium reserves have been estimated to be of the order of about 70,000 tonnes, which is equal to 120 billion tonnes of coal. Similarly, our thorium reserves of 3, 60,000 tonnes would be equivalent to 600 billion tonnes of coal.

(b) Non-commercial Energy Sources:

(i) Fuelwood:

It is required for cooking purpose. The total fuel wood consumption has been estimated at about 223 million tonnes in 2001- 02.

(ii) Agricultural wastes:

It is also used how for cooing purpose. Agriculture waste are also used as feed and fodder for animals, roofing materials in Katcha houses. It has been estimated that for fuel alone, the consumption of agricultural wastes was around 65 million tonnes in 2001.

(iii) Animal dung:

Dried dung of animals is commonly used as fuel in our rural India, out of the total estimated production of 324 million tonnes of animal dung, nearly 73 million tonnes (22.5%) is burnt as fuel every year.

b.

"Energy management" is a term that has a number of meanings, but we're mainly concerned with the one that relates to saving energy in businesses, public-sector/government organizations, and homes:

The energy-saving meaning

When it comes to energy saving, **energy management is the process of monitoring, controlling, and conserving energy in a building or organization**. Typically this involves the following steps:

1. Metering your energy consumption and collecting the data.
2. Finding opportunities to save energy, and estimating *how much* energy each opportunity could save. You would typically analyze your meter data to find and quantify routine energy waste, and you might also investigate the energy savings that you could make by replacing equipment (e.g. lighting) or by upgrading your building's insulation.
3. Taking action to target the opportunities to save energy (i.e. tackling the routine waste and replacing or upgrading the inefficient equipment). Typically you'd start with the best opportunities first.
4. Tracking your progress by analyzing your meter data to see how well your energy-saving efforts have worked.

Why is it important?

Energy management is the key to saving energy in your organization. Much of the importance of energy saving stems from the global need to save energy - this global need affects energy prices, emissions targets, and legislation, all of which lead to several compelling reasons why you should save energy at your organization specifically.

The global need to save energy

If it wasn't for the global need to save energy, the term "energy management" might never have even been coined... Globally we need to save energy in order to:

- Reduce the damage that we're doing to our planet, Earth. As a human race we would probably find things rather difficult without the Earth, so it makes good sense to try to make it last.
- Reduce our dependence on the fossil fuels that are becoming increasingly limited in supply.

Controlling and reducing energy consumption at your organization

Energy management is the means to controlling and reducing your organization's energy consumption... And controlling and reducing your organization's energy consumption is important because it enables you to:

- Reduce costs – this is becoming increasingly important as energy costs rise.
- Reduce carbon emissions and the environmental damage that they cause - as well as the cost-related implications of carbon taxes and the like, your organization may be keen to reduce its carbon footprint to promote a green, sustainable image. Not least because promoting such an image is often good for the bottom line.
- Reduce risk – the more energy you consume, the greater the risk that energy price increases or supply shortages could seriously affect your profitability, or even make it impossible for your business/organization to continue. With energy management you can reduce this risk by reducing your demand for energy and by controlling it so as to make it more predictable.

On top of these reasons, it's quite likely that you have some rather aggressive energy-consumption-reduction targets that you're supposed to be meeting at some worrying point in the near future.

4.

a. A solar pond is a solar energy collector, generally fairly large in size, that looks like a pond. This type of solar energy collector uses a large, salty lake as a kind of a flat plate collector that absorbs and stores energy from the Sun in the warm, lower layers of the pond.These ponds can be natural or man-made, but generally speaking the solar ponds that are in operation today are artificial.

How they Work

The key characteristic of solar ponds that allow them to function effectively as a solar energy collector is a salt-concentration gradient of the water. This gradient results in water that is heavily salinated collecting at the bottom of the pond, with concentration decreasing towards the surface resulting in cool, fresh water on top of the pond. This collection of salty water at the bottom of the lake is known as the "storage zone", while the freshwater top layer is known as the "surface zone". The overall pond is several meters deep, with the "storage zone" being one or two meters thick.

These ponds must be clear for them to operate properly, as sunlight cannot penetrate to the bottom of the pond if the water is murky. When sunlight is incident on these ponds, most of the incoming sunlight reaches the bottom and thus the "storage zone" heats up. However, this newly heated water cannot rise and thus heat loss upwards is prevented. The salty water cannot rise because it is heavier than the fresh water that is on top of the pond, and thus the upper layer prevents convection currents from forming. Because of this, the top layer of the pond acts as a type of insulating blanket, and the main heat loss process from the storage zone is stopped. Without a loss of heat, the bottom of the pond is warmed to extremely high temperatures - it can reach about 90°C.If the pond is being used to generate electricity this temperature is high enough to initiate and run an organic Rankine cycle engine.

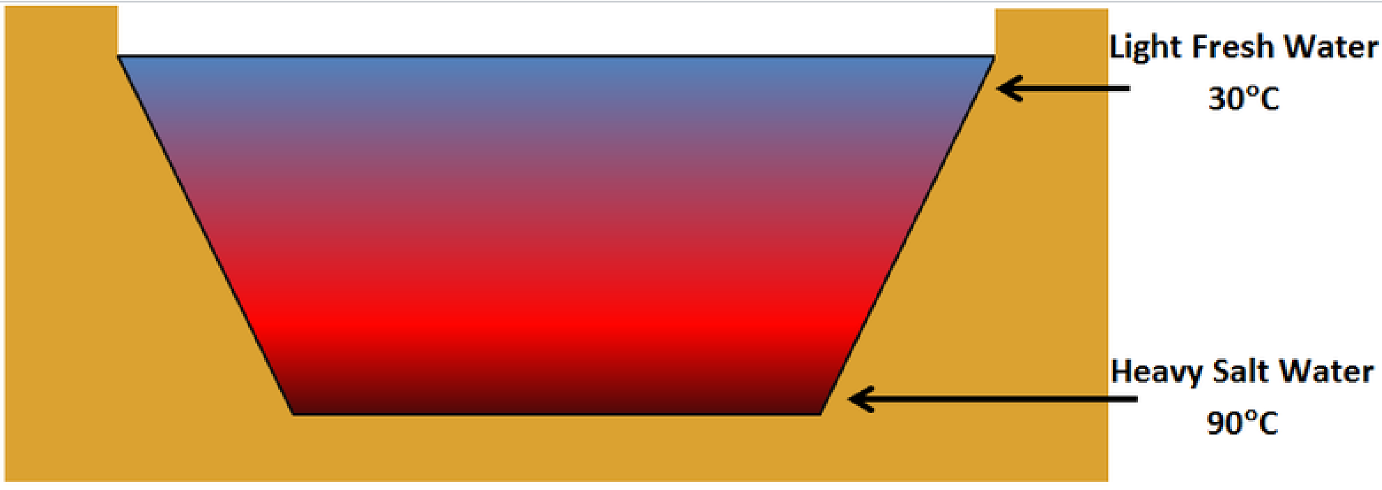


Figure 1. Diagram of a solar pond showing the temperature and saline gradient.[3]

It is vital that the salt concentrations and cool temperature of the top layer are maintained in order for these ponds to work. The surface zone is mixed and kept cool by winds and heat loss by evaporation. This top zone must also be flushed continuously with fresh water to ensure that there is no accumulation of salt in the top layer, since the salt from the bottom layer diffuses through the saline gradient over time.Additionally, a solid salt or brine mixture must be added to the pond frequently to make up for any upwards salt loses.

Applications

The heat from solar ponds can be used in a variety of different ways. First, since the heat storing abilities of solar ponds are so great they are ideal for use in heating and cooling buildings as they can maintain a fairly stable temperature.These ponds can also be used to generate electricity either by driving a thermo-electric device or some organic Rankine engine cycle - simply a turbine powered by evaporating a fluid (in this case a fluid with a lower boiling point). Finally, solar ponds can be used for desalination purposes as the low cost of this thermal energy can be used to remove the salt from water for drinking or irrigation purposes.

Benefits and Drawbacks

One benefit of using these ponds is that they have an extremely large thermal mass. Since these ponds can store heat energy very well, they can generate electricity during the day when the Sun is shining as well as at night. Despite being a source of energy, there are numerous thermodynamic limitations as a result of the relatively low temperatures achieved in these ponds. Because of this, the solar-to-electricity conversion is fairly inefficient - generally less than 2%. As well, large amounts of fresh water are necessary to maintain the right salt concentrations all through the pond. This is an issue in places where fresh water is hard to come by, especially in desert environments. These ponds also do not work well at high latitudes as the collection surface is horizontal and cannot be tilted to collect more sunlight.

b. There are two important types of instruments to measure solar radiation:

1. Pyrheliometer is used to measure direct beam radiation at normal incidence. There are different types of pyrheliometers. According to Duffie and Beckman (2013), Abbot silver disc pyrheliometer and Angstrom

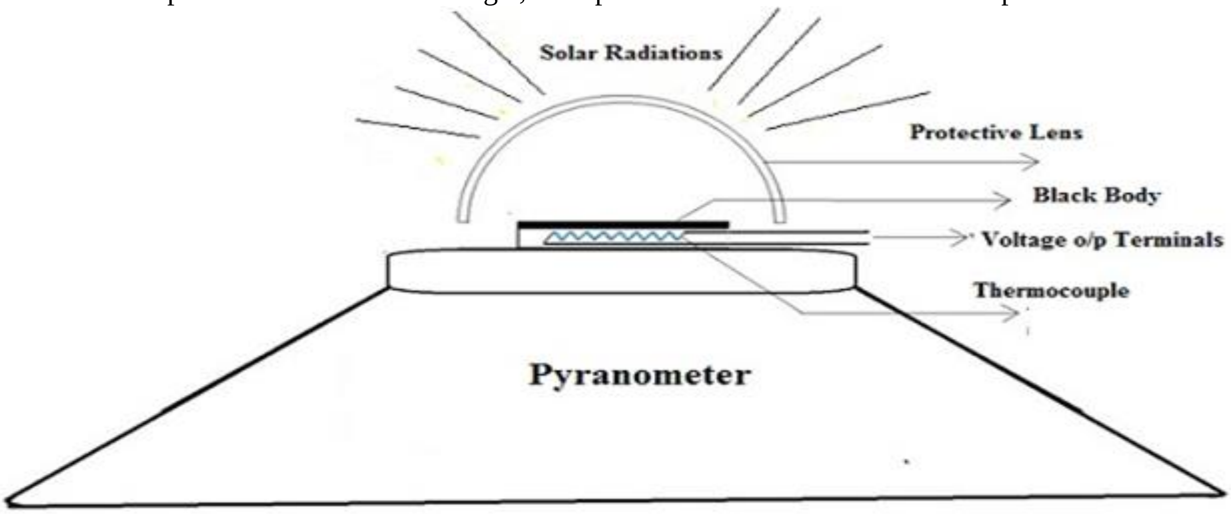
compensation pyrheliometer are important primary standard instruments. Eppley normal incidence pyrheliometer (NIP) is a common instrument used for practical measurements in the US, and Kipp and Zonen actinometer is widely used in Europe. Both of these instruments are calibrated against the primary standard methods.

Based on their design, the above listed instruments measure the beam radiation coming from the sun and a small portion of the sky around the sun. Based on the experimental studies involving various pyrheliometer design, the contribution of the circumsolar sky to the beam is relatively negligible on a sunny day with clear skies. However, a hazy sky or a uniform thin cloud cover redistributes the radiation so that contribution of the circumsolar sky to the measurement may become more significant.

2. Pyranometer is used to measure total hemispherical radiation - beam plus diffuse - on a horizontal surface. If shaded, a pyranometer measures diffuse radiation. Most of solar resource data come from pyranometers. The total irradiance (W/m2) measured on a horizontal surface by a pyranometer is expressed as follows:

   $I_{tot} = I_{beam} \cos\theta + I_{diffuse}$

   where θ is the zenith angle. These instruments are usually calibrated against standard pyrheliometers. There are pyranometers with thermocouple detectors and with photovoltaic detectors. The detectors ideally should be independent on the wavelength of the solar spectrum and angle of incidence. Pyranometers are also used to measure solar radiation on inclined surfaces, which is important for estimating input to collectors. Calibration of pyranometers depends on the inclination angle, so experimental data are needed to interpret the measurements.



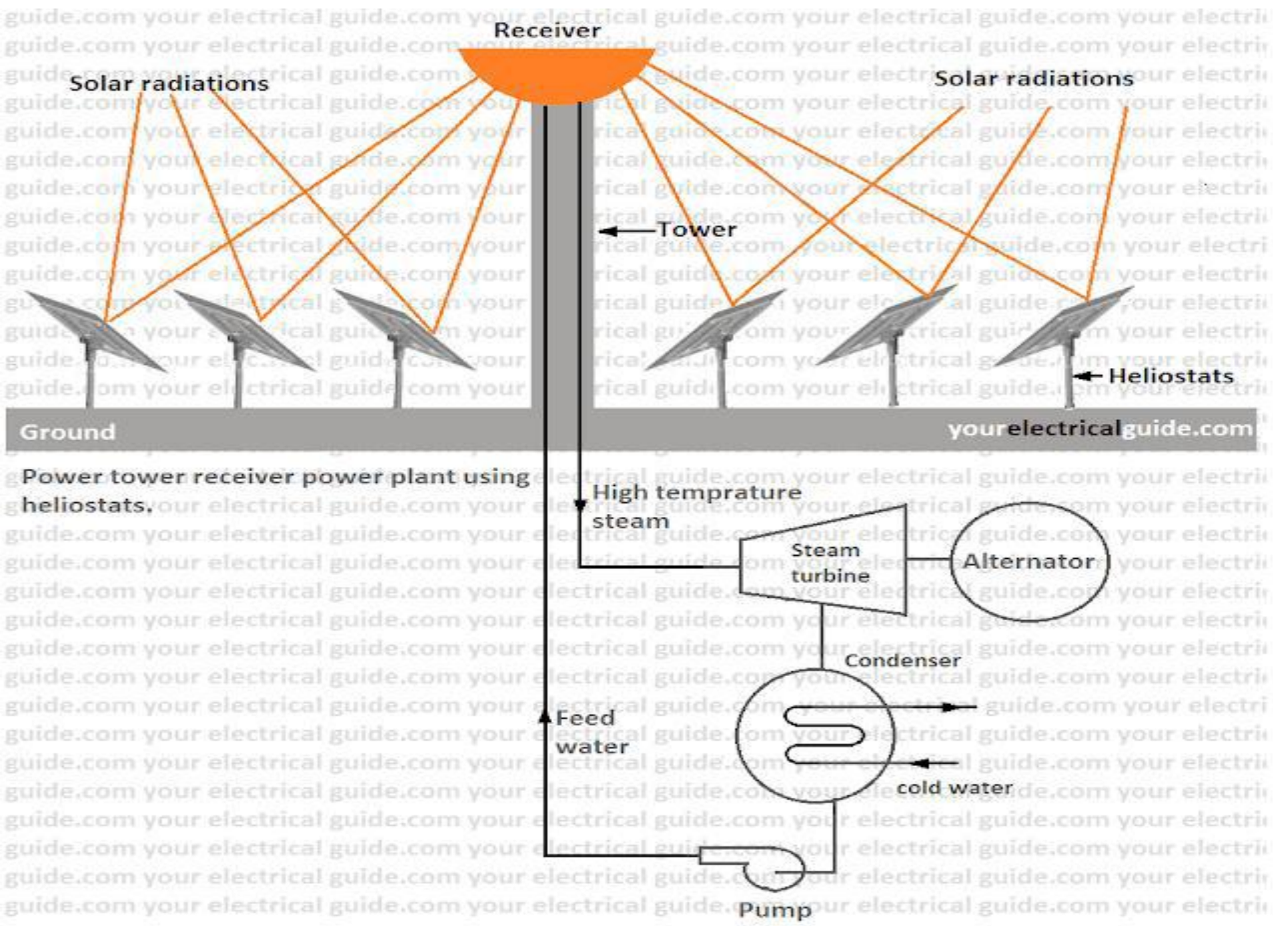
3. Photoelectric sunshine recorder. The natural solar radiation is notoriously intermittent and varying in intensity. The most potent radiation that creates the highest potential for concentration and conversion is the bright sunshine, which has a large beam component. The duration of the bright sunshine at a locale is measured, for example, by a photoelectric sunshine recorder. The device has two selenium photovoltaic cells, one of which is shaded, and the other is exposed to the available solar radiation. When there is no beam radiation, the signal output from both cells is similar, while in bright sunshine, signal difference between the two cells is maximized. This technique can be used to monitor the bright sunshine hours.

5.

a.

In this collector, the receiver is located at the top of the tower. It has a large number of independently-moving flat mirrors (heliostats) spread over a large area of ground to focus the reflected solar radiations on the receiver. The heliostats are installed all around the central tower.

Each heliostat is rotated into two directions so as to track the sun. The solar radiations reflected from heliostats are absorbed by the receiver mounted on a tower of about 500 m height. Each heliostat is continuously rotating around two axes to follow the sun as it moves so that solar rays are always reflected to the central receiver. This means that the tilt and the orientation angles of each heliostat are continuously adjusted. The reflected radiation from the heliostat field is absorbed by the receiver surface. The tower supports a bundle of vertical tubes containing the working fluid. The working fluid in the absorber receiver is converted into the high-temperature steam of about 600oC – 700oC. This steam is supplied to a conventional steam power plant coupled to an electric generator to generate electric power.



b. The flat-plate solar collectors are probably the most fundamental and most studied technology for solar-powered domestic hot water systems. The overall idea behind this technology is pretty simple. The Sun heats a dark flat surface, which collect as much energy as possible, and then the energy is transferred to water, air, or other fluid for further use. These are the main components of a typical flat-plate solar collector:

- Black surface - absorbent of the incident solar energy
- Glazing cover - a transparent layer that transmits radiation to the absorber, but prevents radiative and convective heat loss from the surface
- Tubes containing heating fluid to transfer the heat from the collector
- Support structure to protect the components and hold them in place
- Insulation covering sides and bottom of the collector to reduce heat losses

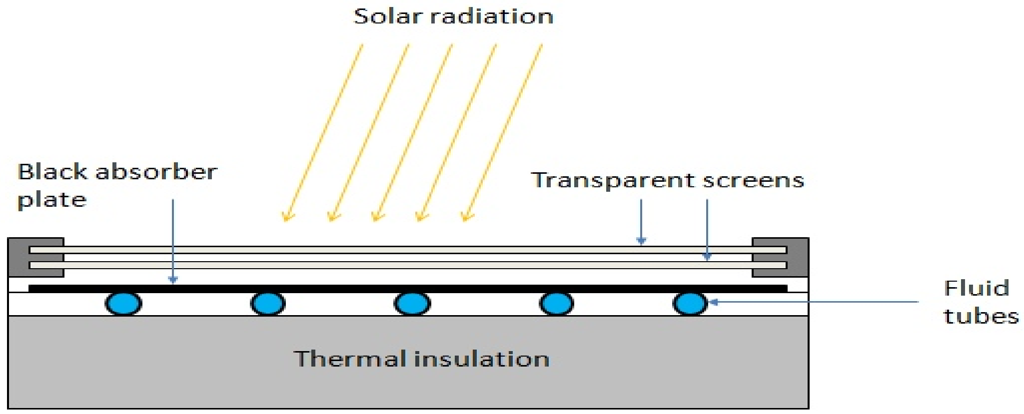


Figure 3.1: Schematic of a flat plate solar collector with liquid transport medium. The solar radiation is absorbed by the black plate and transfers heat to the fluid in the tubes. The thermal insulation prevents heat loss during fluid transfer; the screens reduce the heat loss due to convection and radiation to the atmosphere

The flat-plate systems normally operate and reach the maximum efficiency within the temperature range from 30 to 80 oC (Kalogirou, 2009), however, some new types of collectors that employ vacuum insulation can achieve higher temperatures (up to 100 oC). Due to the introduction of selective coatings, the stagnant fluid temperature in flat-plate collectors has been shown to reach 200 oC. Some advantages of the flat-plate collectors are that they are:

 Easy to manufacture

 Low cost

 Collect both beam and diffuse radiation

 Permanently fixed (no sophisticated positioning or tracking equipment is required)

 Little maintenance

Flat-plate collectors are installed facing the equator (i.e. South oriented in the Northern hemisphere and North oriented in the Southern hemisphere). The optimal tilt of the collector plate is close to the latitude of the location (+/- 15o). If the application is solar cooling, the optimum installation angle is Latitude - 10o, so that the solar beam is perpendicular to the collector during summertime. If the application is solar heating, the optimum installation angle is Latitude + 10o. It was found however, that for year-round hot water application, the optimum angle is Latitude + 5o, which provides somewhat better performance during winter, when the hot water is more needed (Kalogirou, 2009) Transport fluid options The flat plate collectors can involve liquid or air heat transport. Water is one of the common options as liquid fluid due to its accessibility and good thermal properties:

 It has a relatively high volumetric heat capacity

 It is incompressible (or almost incompressible)

 It has a high mass density (which allows using small tubes and pipes for transport)

One disadvantage of water is that it freezes during winter, which can damage the collector or piping system. This can be managed by draining down the collector at low solar inputs (below a critical insolation threshold). Drain down sensors are often employed to monitor the system and to ensure complete draining, as pocket water freezing can cause damage. Refilling the system with water on the next morning also is not perfect. Possible air pockets in the collector can be a problem, blocking water flow and decreasing system efficiency (Vanek and Albright, 2008). Antifreeze mixtures can be used instead of pure water to alleviate the above-said problems. The common antifreeze components are ethylene glycol or propylene glycol. Those chemicals are mixed with water require closed-loop systems and proper disposal due to toxicity. Nominal antifreeze service like is about 5 years, after which it needs to be replaced. Air can be used as transport fluid in some designs of flat -plate collectors. This option is better suited to space heating applications or crop drying. A fan is usually required to facilitate air flow in the system and efficient heat transport. Certain designs can provide passive (no fan) movement of air due to thermal buoyancy. Phase-change liquids can also be used with flat-plate collectors. Some refrigerants are included in this group of fluids. They do not freeze, which eliminates troubles explained above for water, and, due to their low boiling point can change from liquid to gas as temperature increases. Those fluids can be practical in settings where quick response to rapid temperature fluctuation is needed.

Collector construction

The key considerations in flat plate collector design are maximizing absorption, minimizing reflection and radiation losses, and effective heat transfer from the collector plate to the fluids. One of the important issues is obtaining a good thermal bond between the absorber plate and changes (tubes or ducts containing the heat-transfer fluids). Different construction designs (shown below) try to address this issue. The plate - channel assembly may use a variety of methods of component attachment - thermal cement, solder, clips, clamps, brazing, mechanical pressure applicators. One of the considerations in choosing the assembly method is cost of labour and materials.

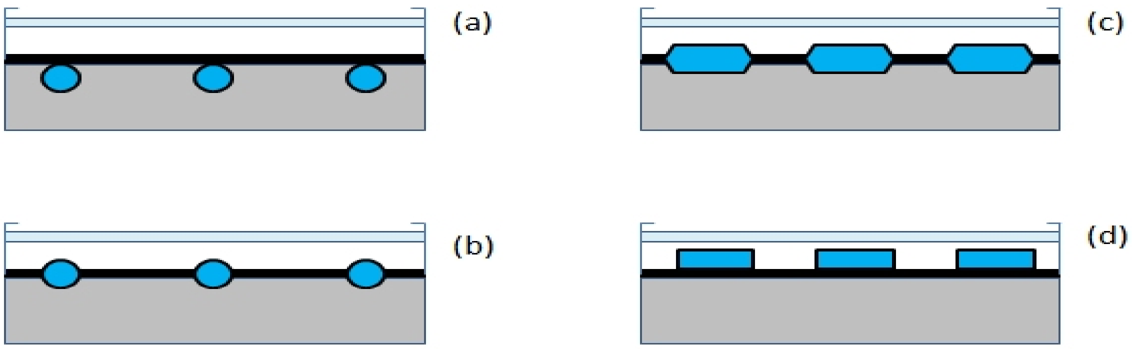
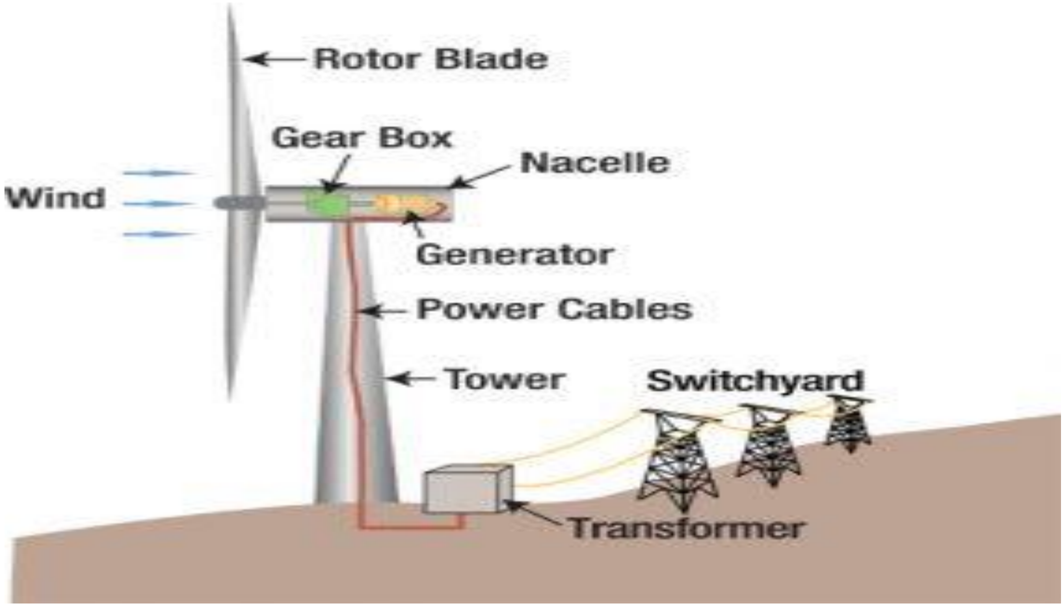


Figure 3.2: Various designs of flat-plate collector assembly. Color codes: light blue - glass cover, dark blue - fluid channels, black - absorber material, gray - insulation. Some constructions (b, c) include fluid channels in the absorber plate structure to maximize thermal conductance between the components. Other modifications (a, d) include tubes and channels soldered or cemented to the plate.

6.

a. Wind turbines harness the power of the wind and use it to generate electricity. Simply stated, wind turbines work the opposite of a fan. Instead of using electricity to make wind—like a fan—wind turbines use wind to make electricity. The wind turns the blades, which in turn spins a generator to create electricity. This illustration provides a detailed view of the inside of a wind turbine, its components, and their functionality.



Anemometer: Measures the wind speed and transmits wind speed data to the controller.
Blades: Lifts and rotates when wind is blown over them, causing the rotor to spin. Most turbines have either two or three blades.
Brake: Stops the rotor mechanically, electrically, or hydraulically, in emergencies.
Controller: Starts up the machine at wind speeds of about 8 to 16 miles per hour (mph) and shuts off the machine at about 55 mph. Turbines do not operate at wind speeds above about 55 mph because they may be damaged by the high winds.
Gear box: Connects the low-speed shaft to the high-speed shaft and increases the rotational speeds from about 30-60 rotations per minute (rpm), to about 1,000-1,800 rpm; this is the rotational speed required by most generators to produce electricity. The gear box is a costly (and heavy) part of the wind turbine and engineers are exploring "direct-drive" generators that operate at lower rotational speeds and don't need gear boxes.
Generator: Produces 60-cycle AC electricity; it is usually an off-the-shelf induction generator.
High-speed shaft: Drives the generator.
Low-speed shaft: Turns the low-speed shaft at about 30-60 rpm.
Nacelle: Sits atop the tower and contains the gear box, low- and high-speed shafts, generator, controller, and brake. Some nacelles are large enough for a helicopter to land on.
Pitch: Turns (or pitches) blades out of the wind to control the rotor speed, and to keep the rotor from turning in winds that are too high or too low to produce electricity.
Rotor: Blades and hub together form the rotor.
Tower: Made from tubular steel (shown here), concrete, or steel lattice. Supports the structure of the turbine. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.
Wind direction: Determines the design of the turbine. Upwind turbines—like the one shown here—face into the wind while downwind turbines face away.
Wind vane: Measures wind direction and communicates with the yaw drive to orient the turbine properly with respect to the wind.
Yaw drive: Orients upwind turbines to keep them facing the wind when the direction changes. Downwind turbines don't require a yaw drive because the wind manually blows the rotor away from it.
Yaw motor: Powers the yaw drive.

b.

Planetary Winds:

The winds blowing throughout the year from one latitude to another in response to latitudinal differences in air pressure are called “planetary or prevailing winds”. They involve large areas of the globe.

Local Winds:

Local winds are the ordinary winds. They are influenced by various landforms such as vegetation, hill, plains, water bodies, mountains and so on. The blow variedly and the changes are because of different temperatures and pressure regions during the night and day. Local winds are the kind of winds that are focused as part of daily weather by the meteorological department on broadcast media such as radio and TV. The speeds of local winds range from mild to strong but just for a few hours, and they only blow over short distances. Common examples of local winds are the land and sea breezes, and valley and mountain breezes.

Under constant acceleration, the kinetic energy of an object having mass m and velocity v is equal to the work done W in displacing that object from rest to a distance s under a force F, i.e.:

$$E = W = Fs$$

According to Newton's Law, we have:

$$F = ma$$

Hence,

$$E = mas \quad \dots (1)$$

Using the third equation of motion:

$$v^2 = u^2 + 2as$$

we get:

$$a = \frac{(v^2 - u^2)}{2s}$$

Since the initial velocity of the object is zero, i.e. $u = 0$, we get:

$$a = \frac{v^2}{2s}$$

Substituting it in equation (1), we get that the kinetic energy of a mass in motions is:

$$E = \frac{1}{2}mv^2 \quad \dots (2)$$

The power in the wind is given by the rate of change of energy:

$$P = \frac{dE}{dt} = \frac{1}{2}v^2\frac{dm}{dt} \quad \dots (3)$$

As mass flow rate is given by:

$$\frac{dm}{dt} = \rho A\frac{dx}{dt}$$

and the rate of change of distance is given by:

$$\frac{dx}{dt} = v$$

we get:

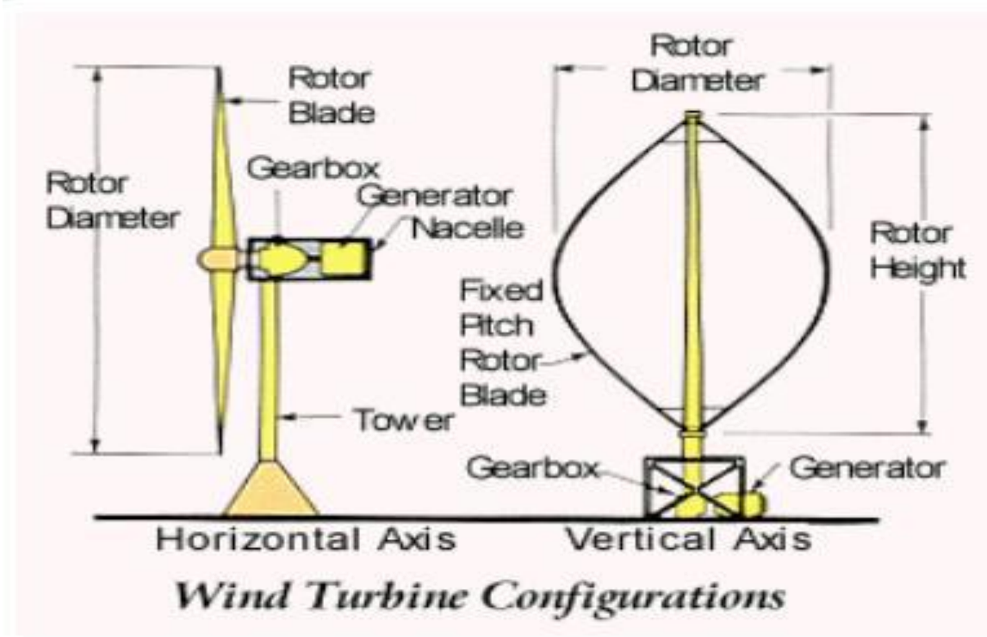
$$\frac{dm}{dt} = \rho Av$$

Hence, from equation (3), the power can be defined as:

$$P = \frac{1}{2}\rho Av^3 \quad \dots (4)$$

7.

a. It is a mechanical machine that converts kinetic energy of the fast moving winds into electrical energy. On the basis of axis of rotation of the blades, it is divided into two parts.
1. Horizontal axis wind turbine (HAWT)
2. Vertical axis wind turbine (VAWT)



1. Horizontal Axis Wind Turbine (HAWT)
It is a turbine in which the axis of rotation of rotor is parallel to the ground and also parallel to wind direction. They are further divided into two types (i) Upwind turbine (ii) Downwind turbine
(i) Upwind Turbine
The turbine in which the rotor faces the wind first are called upwind turbine.
- Today most of the HAWT is manufactured with this design.
- This turbine must be inflexible and placed at some distance from the tower.
- The basic advantage of this turbine is that, it is capable of avoiding wind shade behind the tower.
- It requires yaw mechanism, so that its rotor always faces the wind.

(ii) Downwind Turbine
The turbine in which the rotor is present at the downside of the tower is called downwind turbine. In these types of wind turbines, the wind first faces the tower and after that it faces the rotor blades.
- Yaw mechanism is absent in this turbine. The rotors and nacelles are designed in such a way that the nacelle allows the wind to flow in a controlled manner.
- It receives some fluctuation in wind power because here the rotor passes through the wind shade of the tower. In other words the rotor is present after nacelle of the tower and this create fluctuation in the wind power.

2. Vertical Axis Wind Turbine (VAWT)
It is a turbine in which the axis of rotation of the rotor is perpendicular to the ground and also perpendicular to the wind direction.
- It can operates in low wind situation.
- It is easier to build and transport.
- These types of Wind turbines are mounted close to the ground and are capable of handling turbulence in far better way as compared with the HAWT.
- Because of its less efficiency, it is used only for the private purpose.

VAWTs are further classified as (i) Darrieus turbine (ii). Giromill turbine (iii) Savonius turbine
(i) Darrieus Turbine
Darrieus turbine is type of HAWT. It was first discovered and patented in 1931 by French aeronautical engineer, Georges Jean Marie Darrieus. It is also known as egg beater turbine because of its egg beater shaped rotor blades.
- It consists of vertically oriented blades which are mounted on a vertical rotor. It is not a self-starting turbine and hence a small powered motor is required to start its rotation.

 First the Darrieus turbine is rotated by using a small powered motor. Once it attains sufficient speed, the wind flowing across its blades generates lift forces and this lift forces provides the necessary torque for the rotation. As the rotor rotates, it also rotates the generator and electricity is produced.

(ii) Giromill Turbine:
It is similar to the Darrieus turbine but the difference is that, it has H-shaped rotor. It works on the same principle of Darrieus turbine.
 This turbine has H- shaped rotor. Here Darrieus design which has egg beater shaped rotor blades are replaced by straight vertical blades attached with central tower with horizontal supports. It may consists of 2-3 rotor blades.
 Giromill turbine is cheap and easy to build as compared with Darrieus turbine. It is less efficient turbine and requires strong wind to start. Same as darrieus types of wind turbines, it is also not self- starting and requires small powered motor to start. It is capable of working in turbulent wind conditions.

(iii) Savonius Turbine
Savonius turbine is HAWT.It was first discovered in 1922 by a Finnish Engineer Sigurd Johannes Savonius. It is one of the simplest turbine among all known turbines.
 It is a drag-type device and consists of two or three scoops. If we look it from above than it looks „S" shape in cross section. The scoops of these turbines have curvature shape and because of that, it experiences less drag when it moves against the wind instead of moving with the wind.
 Since it is a drag-type machine, it is capable of extracting very less amount of wind power as compared with other similar sized lift-type turbines.

b.

We first show that for all wind turbines, wind power is proportional to wind speed cubed. Wind energy is the kinetic energy of the moving air. The kinetic energy of a mass *m* with the velocity *v* is

$$E_{kin} = ½\ m\ v^2$$

The air mass m can be determined from the air density ρ and the air volume V according to

$$m = \rho\ V$$

Then,

$$E_{kin,\ wind} = ½\ V\ \rho\ v^2$$

Power is energy divided by time. We consider a small time, Δt, in which the air particles travel a distance $s = v\,\Delta t$ to flow through. We multiply the distance with the rotor area of the wind turbine, *A*, resulting in a volume of

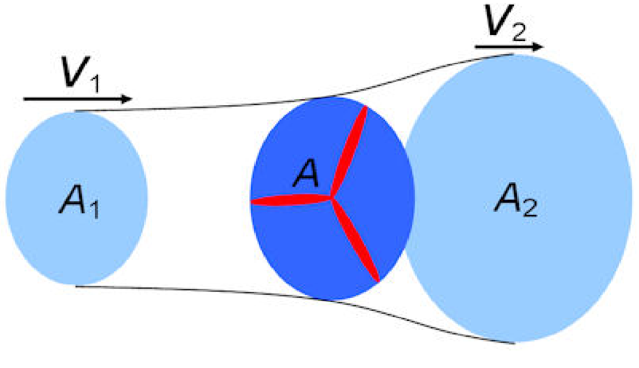
$$\Delta V = A\ v\,\Delta t$$

which drives the wind turbine for the small period of time. Then the wind power is given as

$$P_{wind} = \frac{E_{kin,\ wind}}{\Delta t} = \frac{\Delta V\ \rho\ v^2}{2\ \Delta t} = \frac{\rho\ A v^3}{2}$$

The wind power increases with the cube of the wind speed. In other words: doubling the wind speed gives eight times the wind power. Therefore, the selection of a "windy" location is very important for a wind turbine.

The effective usable wind power is less than indicated by the above equation. The wind speed behind the wind turbine can not be zero, since no air could follow. Therefore, only a part of the kinetic energy can be extracted. Consider the following picture:



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:

$$P_{eff} = P_1 - P_2 = \frac{\Delta V \rho}{2 \Delta t}\left(v_1^2 - v_2^2\right) = \frac{\rho A}{4}\left(v_1 + v_2\right)\left(v_1^2 - v_2^2\right)$$

If the difference of both speeds is zero, we have no net efficiency. If the difference is too big, the air flow through the rotor is hindered too much. The power coefficient c_p characterizes the relative drawing power:

$$c_P = \frac{P_{eff}}{P_{wind}} = \frac{\left(v_1 + v_2\right)\left(v_1^2 - v_2^2\right)}{2 v_1^3} = \frac{\left(1 + x\right)\left(1 - x^2\right)}{2}$$

To derive the above equation, the following was assumed: $A_1 v_1 = A_2 v_2 = A\,(v1+v2)\,/\,2$. We designate the ratio $v2/v1$ on the right side of the equation with x. To find the value of x that gives the maximum value of C_P, we take the derivative with respect to x and set it to zero. This gives a maximum when $x = 1/3$. Maximum drawing power is then obtained for $v_2 = v_1 / 3$, and the ideal power coefficient is given by

$$c_P = \frac{P_{eff}}{P_{wind}} = \frac{16}{27} \approx 59\%$$

8.

a. Geothermal Energy

If you were to dig a big hole straight down into the Earth, you would notice the temperature getting warmer the deeper you go. That's because the inside of the Earth is full of heat. This heat is called geothermal energy.

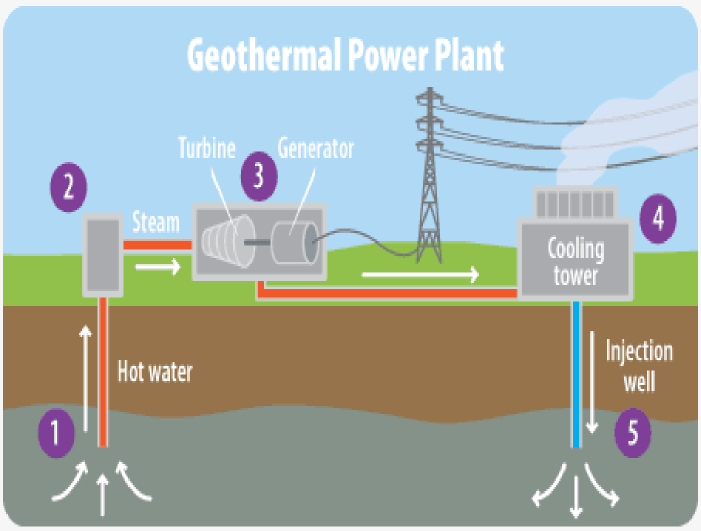
People can capture geothermal energy through:

- Geothermal power plants, which use heat from deep inside the Earth to generate steam to make electricity.
- Geothermal heat pumps, which tap into heat close to the Earth's surface to heat water or provide heat for buildings.

Geothermal Power Plants

At a geothermal power plant, wells are drilled 1 or 2 miles deep into the Earth to pump steam or hot water to the surface. You're most likely to find one of these power plants in an area that has a lot of hot springs, geysers, or volcanic activity, because these are places where the Earth is particularly hot just below the surface.

How It Works



1. Hot water is pumped from deep underground through a well under high pressure.
2. When the water reaches the surface, the pressure is dropped, which causes the water to turn into steam.
3. The steam spins a turbine, which is connected to a generator that produces electricity.
4. The steam cools off in a cooling tower and condenses back to water.
5. The cooled water is pumped back into the Earth to begin the process again.

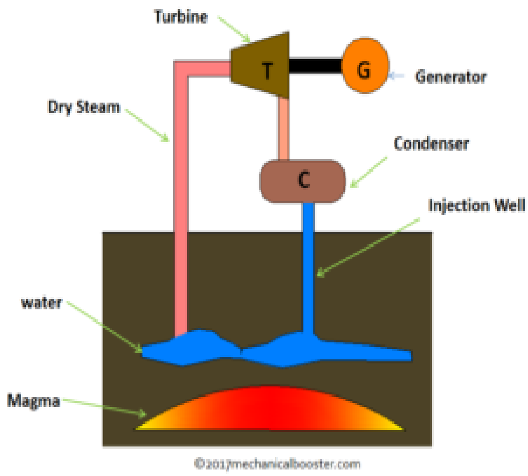
Types

The Geothermal power plant which is in working is of three types

1. Dry steam power plant
2. Flash steam power plant
3. Binary cycle power plant

1. Dry Steam Power Plant

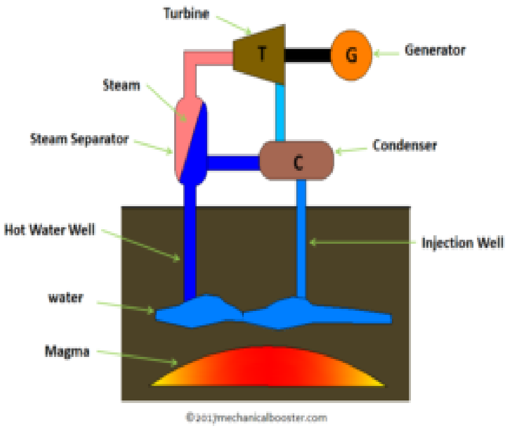
In dry steam power plant, direct steam from the geothermal reservoir is used to turn the turbine and generator to produce electricity. The temperature of the geothermal steam needed in this plant is atleast 150 degreee Celsius.



Dry steam Geothermal Power plant

2. Flash Steam Power Plant

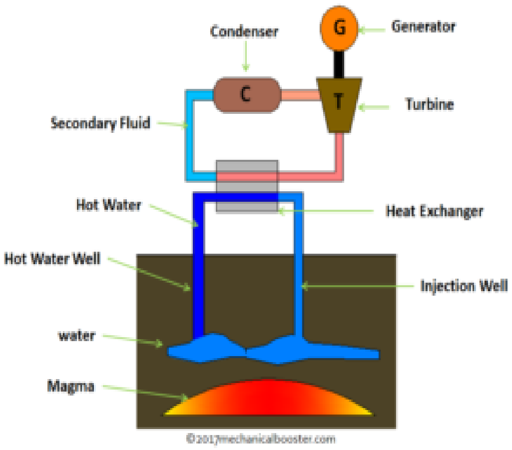
In flash steam power plant, high pressure hot water from deep inside the earth is taken out and collected in a steam separator. This high pressure hot water comes to the surface by its own and its pressure keeps on decreases as it moves upward, this allows hot water to gets converter into steam. Steam gets separated in steam separator, and allowed to turn the turbine generator. When the steam cools, it is again injected back into the earth surface to be used again. Nowadays most of the geothermal power plants used are of flash steam plants. This power plant requires a temperature of atleast 180 degree Celsius for its operation.



Flash Steam Geothermal Power plant

3. Binary Cycle Power plant

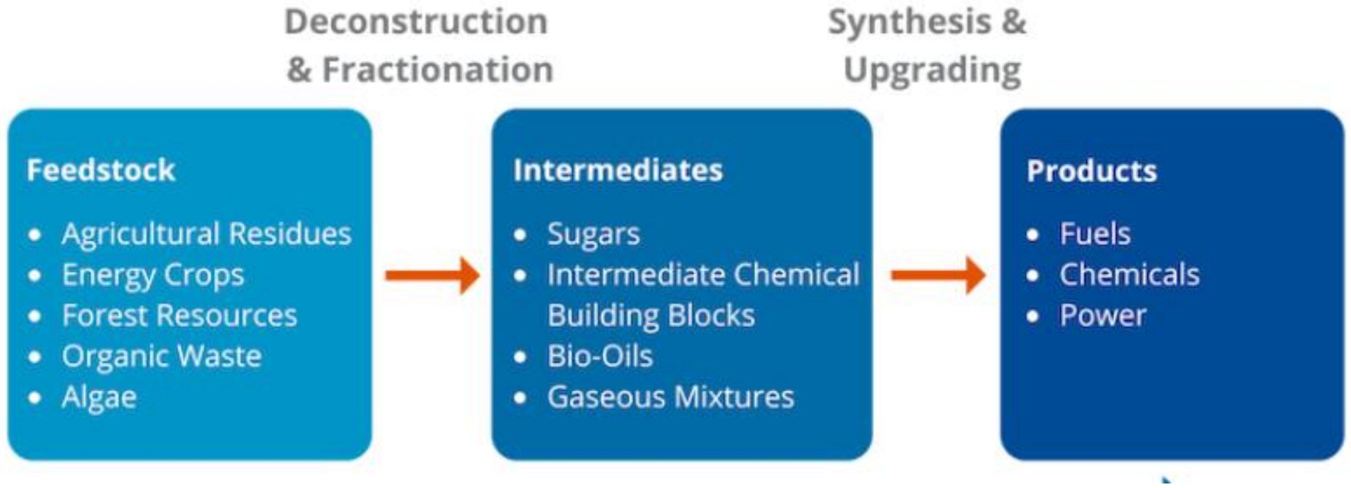
In binary cycle power plant, the heat of hot water is transferred to another liquid (called as secondary liquid). The heat of hot water causes another liquid to change into steam and then this steam is used to rotate turbine. It is the most recent developed power plant which may be operated at lowest temperature of atleast 57 degree Celsius. The secondary fluid (i.e. another liquid) used in this binary cycle geothermal power plant has much lower boiling point than water. It works on both Rankine and Kalina cycle. The thermal efficiency of this power station is expected to be lie in between 10-13%. This power plant is called as binary, since here we are using two liquids (hot water and secondary liquid) for its working.



Binary Cycle Geothermal Power plant

b. There are many different types of biomass that include crop wastes, forestry residues, purpose-grown grasses, woody energy crops, algae, industrial and municipal organic wastewaters and sludges, non-recyclable municipal solid waste, urban wood waste, and food waste. Biomass is considered renewable as either a feedstock or waste and due to government incentives, corporate sustainability goals and climate change initiatives, a majority of the conversion technologies use biomass to produce various forms of renewable energy. The type of energy includes electrical power, thermal energy, renewable natural gas, biodiesel, jet fuel, and ethanol.

Biomass also can be used as a substitute for fossil fuels in the manufacturing of high value products including plastics, lubricants, industrial chemicals, and many other products derived from petroleum or natural gas. The US Department of Energy's Bioenergy Technologies Office also is promoting the existing "petroleum refinery" model, where these "bioproducts" can be produced alongside biofuels at an integrated "biorefinery." This co-production strategy offers a more efficient, cost-effective, and integrated approach to the utilization of our nation's biomass resources. Revenue generated from bioproducts provides added value, improving the economics of biorefinery operations and creating more cost-competitive biofuels.



There are four types of conversion technologies currently available that may result in specific energy and potential renewable products:

Thermal conversion is the use of heat, with or without the presence of oxygen, to convert biomass into other forms of energy and products. These include direct combustion, pyrolysis, and torrefaction.

- Combustion is the burning of biomass in the presence of oxygen. The waste heat is used to for hot water, heat, or with a waste heat boiler to operate a steam turbine to produce electricity. Biomass also can be co-fired with existing fossil fuel power stations.
- Pyrolysis convert biomass feedstocks under controlled temperature and absent oxygen into gas, oil and biochar (used as valuable soil conditioner and also to make graphene). The gases and oil can be used to power a generator and some technologies can also make diesel and chemicals from the gases.
- Torrefaction is similar to pyrolysis but in a lower operating temperature range. The final product is an energy dense solid fuel often referred to as "bio-coal".

Thermochemical conversion is commonly referred to as gasification. This technology uses high temperatures in a controlled partial combustion to form a producer gas and charcoal followed by chemical reduction. A major use for biomass is for agriculture residues with gas turbines. Advanced uses include production of diesel, jet fuel and chemicals.

Biochemical Conversion involves the use of enzymes, bacteria or other microbes to break down biomass into liquids and gaseous feedstocks and includes anaerobic digestion and fermentation. These feedstocks can be converted to energy, transportation fuels and renewable chemicals.

Chemical Conversion involves the use of chemical agents to convert biomass into liquid fuels which mostly is converted to biodiesel.

9.

a. OTEC:

OTEC or ocean thermal energy thermal conversion is a technology which converts solar radiation absorbed by the oceans to electric energy. The ocean‟s can be considered as the world‟s largest solar energy collector as it covers two third of the earth surface.

OCEAN TEMPRATURE DIFFRENCE:

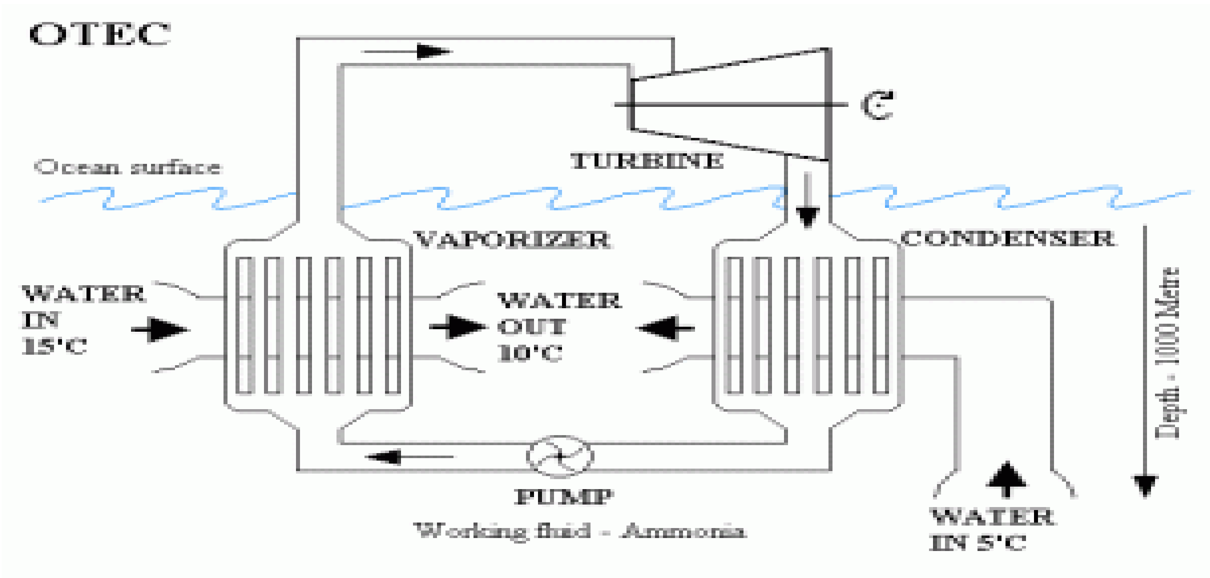
There is different temperature in the different layers of the oceans. This is because of the heat input from the sun at the surface of ocean. The surface at the top of the oceans are warmest and gradually the temperature decreases with in depth. But in the polar regions the temperature at the surface of ocean is low,so there is no gradual change in temperature.

PRINCIPLES OF OTEC PLANT OPERATION:

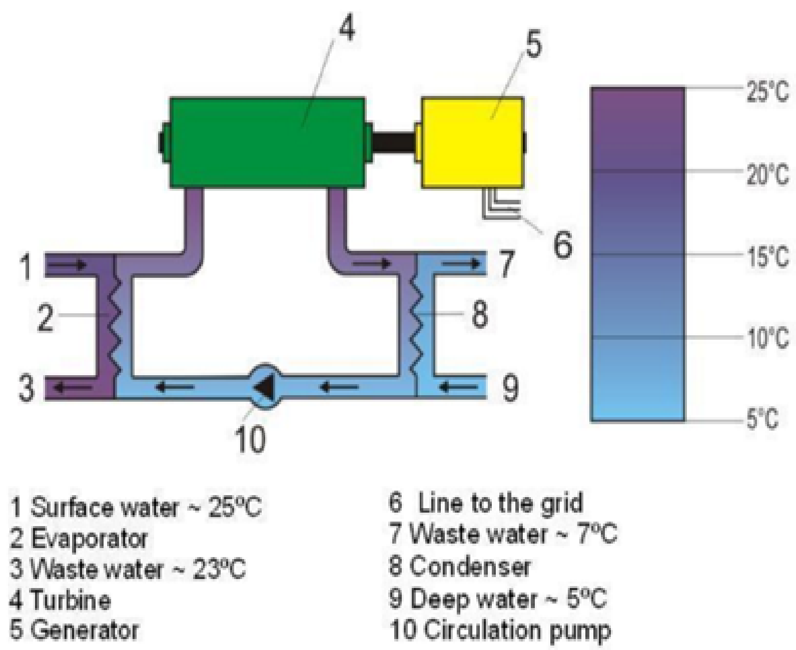
The working principle of an OTEC plant is that it uses the warm water to heat and vaporize a liquid (working fluid).And this working fluid develops pressure which forces it to evaporate.and the expanding vapour runs through a heat engine like turbine, generator, and it is condensed back into a liquid by cold water brought up from depth and the cycle is repeated.

As we know that water is not perfectly transparent nearly all sunlight is absorbed in the surface layer which heats up. As warm water raises and cold water sinks so this warm water stays near the ocean‟s surface. Now Wind and waves circulate the water in the surface layer distributing the heat within it to some extend, and the temperature may remain quite uniform for the first hundred metres, but below the mixed layer the temperature drops very rapidly, perhaps 20

degrees Celsius with an additional of 150 m depth. This area of rapid transition is called thermocline and below it the temperature continues to drop with depth but very gradually.
Genrally thermocline varies with latitude and season but it is permanent in the tropics, variable in the temperate climates is strongest during the summer and is weak to nonexistent in the polar regions where the water is cold from the surface to the bottom.

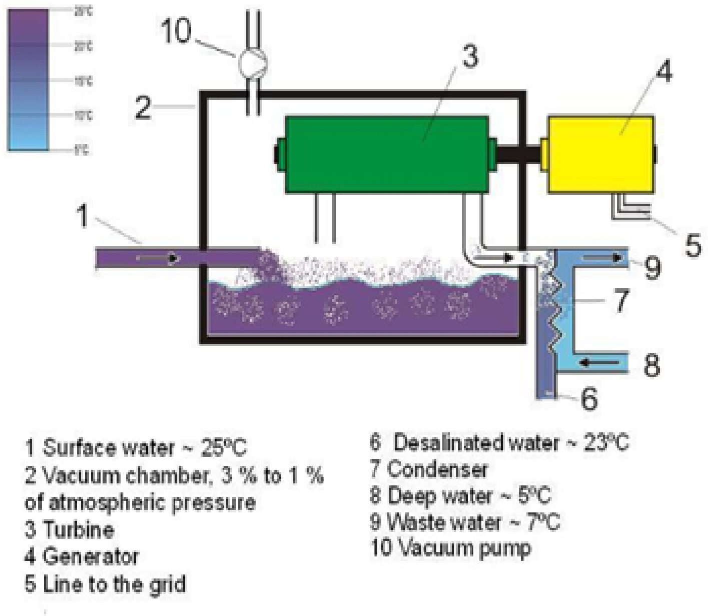


There are basically two types of OTEC power plant:



Closed Cycle OTEC system

- **Closed Cycle:** Closed cycle Ocean Thermal Energy Conversion systems use a working fluid with a low boiling point, Ammonia for example, and use it to power a turbine to generate electricity. Warm seawater is taken in from the surface of the oceans and cold water from the deep at 5°. The warm seawater vaporizes the fluid in the heat exchanger which then turns the turbines of the generator. The fluid now in the vapour state is brought in contact with cold water which turns it back into a liquid. The fluid is recycled in the system which is why it is called a closed system.



Open System OTEC system

- **Open Cycle:** Open cycle OTEC directly uses the warm water from the surface to make electricity. The warm seawater is first pumped in a low-pressure chamber where due to the drop in pressure, it undergoes a drop in boiling point as well. This causes the water to boil. This steam drives a low-pressure turbine which is attached to an electrical generator. The advantage this system has over a closed system is that, in open cycle, desalinated water in the form of steam is obtained. Since it is steam, it is free from all impurities. This water can be used for domestic, industrial or agricultural purposes.

Ocean Thermal Energy (OTEC) is a real candidate as one of the future sources of energy. Its environmental impact is negligible, in fact, the mixing of deep and shallow seawater brings up nutrients from the seafloor. The deepwater is rich in nitrates and this can also be used in agriculture.

b. The secret to understanding the most common biogas plant construction and working stages, is explained here for the most common Anaerobic Digestion plant type. By far the most common biogas plants are those based upon one single anaerobic digestion tank, and they are often known as "Continuous Stirred Tank Reactors" (CSTRS).

They are often called single stage biogas plants, which can be confusing, because to the onlooker there would seem to be many more tanks and "stages". Tanks are added to increase the amount of biogas produced, and for other uses.

Step 1 – Feeding The Bacteria That Make Biogas

Organic input materials such as silage, foodstuff remnants, fats or sludge, are fed into the biogas plant as what is called "substrate" – that"s food for the biogas making bugs, to you and me!

Renewable resources such as corn, beet, or grass, can serve as feed both for animals such as cows and pigs as well as for the micro-organisms in the biogas plant.

Not only those foods work, so do farm wastes such as manure, dung, and chicken litter, plus increasingly biogas is being made from supermarket and household food waste.

Step 2 – Fermentation in the Large Tank (Digester Tank)- where the bacteria make the biogas.

In the fermenter, heated to approx. 38-40 °C, the substrate is decomposed by the micro organisms under exclusion of light and oxygen. The final product of this fermentation process is biogas with methane as the main ingredient. But, at the same time some other unwanted compounds form a small part of the biogas. Pure biogas is just methane alone. But the raw biogas that emerges can be bad smelling from corrosive hydrogen sulphide. Carbon dioxide is also produced and a percentage is contained in the biogas.

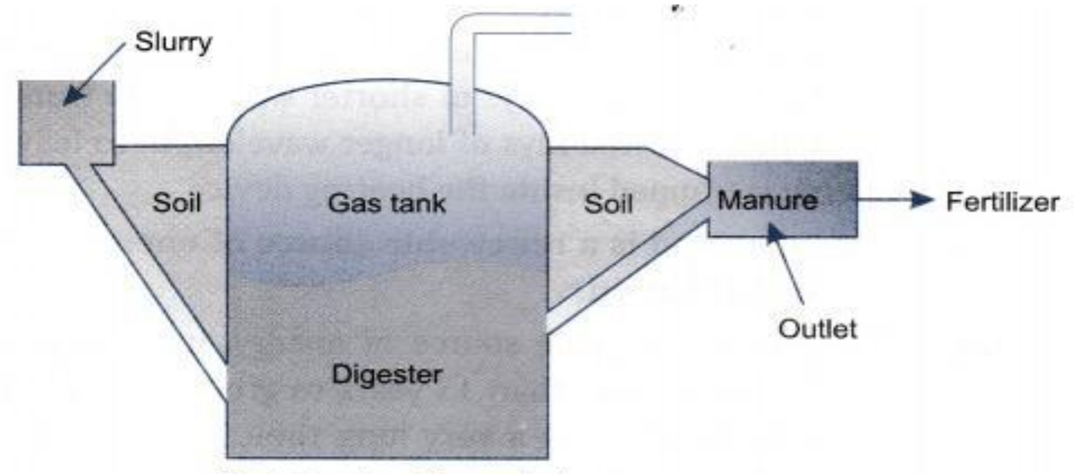
Step 3 – Fermentation Residues Storage Tank

Once the substrate has been fermented, it is pumped to the fermentation residues end storage tank and is retrieved from there for making useful products.

The residues, are called “digestate” and these comprise both a fibrous solid part and a liquid part, and these can be utilised as high quality fertiliser, and a soil conditioner respectively. The advantage of digestate is that it has a lower viscosity than farmyard manure, and it therefore penetrates into the ground more quickly than liquid manure slurry. Furthermore, the fermentation residue usually has a higher fertiliser value than manure, and is less odorous.
Further treating the fibrous part, by leaving it to mature in wind-rows, and subsequently using it as dry fertiliser is also common.

Step 4 – Using the Biogas

The biogas part of the output is usually stored in the plastic roof of the tank. From there it is most often burned in a combined heat and power (CHP) plant to generate electricity and heat.
The electric power is fed directly into the power grid.
The heat generated can be utilized to heat buildings, to dry firewood, or to dry harvest products such as grain.
At an increasing number of biogas plants the quality of the raw biogas is upgraded to purify it. The carbon dioxide, hydrogen sulphide, and other impurities are removed, and it is compressed and used as a clean renewable transport fuel.



Fixed dome type biogas plant

Step 5 – Delivery of Biogas to Users

The biogas power which is not used in running the biogas plant, is exported as either a supply to the national grid or to gas filling stations.
Every tonne of food waste recycled by anaerobic digestion as an alternative to landfill prevents between 0.5 and 1.0 tonne of CO_2 entering the atmosphere, one of the many benefits of anaerobic digestion.