MODULE 5 : BIO MASS AND GEO THERMAL ENERGY

Introduction:

The energy obtained from organic matter, derived from biological organisms (Plants and animals) is known as biomass energy. Animals feed on plants, and plants grow through the photosynthesis process using solar energy. Thus, photosynthesis process is primarily responsible for the generation of biomass energy. A small portion of the solar radiation is captured and stored in the plants during photosynthesis process. Therefore, it is an indirect form of solar into biomass energy is estimated to be 0.5 – 1.0%. To use biomass energy, the initial biomass may be transformed by chemical or biological processes to produce intermediate bio-fuels such as methane, producer gas, ethanol and charcoal etc. On combustion it reacts with oxygen to release heat, but the elements of the material remain available for recycling in natural ecological or agricultural processes. Thus, the use of industrial bio-fuels, when linked carefully to natural ecological cycle, may be non-polluting and sustainable. It is estimated that the biomass, which is 90% in trees, is equivalent to the proven current extractable fossil fuels reserves in the world. The dry matter mass of biological material cycling in biosphere is about 250×10^9 tons/y. The associated energy bound in photosynthesis is 2×10^{21} J/y (0.7×10^{14} W of power).

Biomass mainly in the form of wood, is mankind's oldest form of energy. It has traditionally been used both in domestic as well as industrial activities, basically by direct combustion. As industrial activities increased, the growing demand for energy depleted the biomass natural reserves. The development of new, more concentrated and more convenient sources of energy has led to its replacement to a large extent by other sources. Though biomass energy share in primary energy supply for the industrialized countries is not more than 3%, a number of developing countries still use a substantial amount of it, mostly in the form of non-commercial energy.

Main advantages of biomass energy are:

- It is a renewable source.
- The energy storage is an in-built feature of it.
- It is an indigenous source requiring little or no foreign exchange.
- The pollutant emissions from combustion of biomass are usually lower than those from fossil fuels.
- Commercial use of biomass may avoid or reduce the problems of waste disposal in other industries, particularly municipal solid waste in urban centers.

Main disadvantages are:

- It is a dispersed and land intensive source.
- It is often of low energy density.
- It is also labor intensive, and the cost of collecting large quantities for commercial application is significant.

Most current commercial applications of biomass energy use material that has been collected for other reasons, such as timber and food processing residues and urban waste.

Photosynthesis Process:

Solar radiation incident on green plants and other photosynthetic organisms performs two basic functions: (i) temperature control for chemical reactions to proceed, and (ii) Photosynthesis process. The fundamental conversion process in green plants is photosynthesis, which is the process of combining CO2 from the atmosphere with water plus light energy to produce oxygen and carbohydrates (sugars, starches, celluloses and hemicelluloses). They are the ultimate source of most of our foods and other necessities of daily life such as clothes (in the form of cotton), furniture (in the form of wood), etc.

More complex hydrocarbons (sucrose, starch, cellulose, etc.) are formed by a chain of these simple structures. The reverse of thisprocess is called respiration, in which CO2, H2O and energy are produced using carbohydrate and oxygen. In green plants, both photosynthesis and respiration occur during the day and only respiration at night. There is a net overall gain of energy in the process, as the rate of energy loss in respiration is much less as compared to rate of energy gain during photosynthesis process. The process also results in net gain of oxygen and fixation of carbon in the form of biomass. The net energy absorbed from solar radiation during photosynthesis can be measured from its combustion.
ΔQ is enthalpy change of the combustion process, equal to the energy absorbed from photons of solar radiation, less the energy of respiration during growth. The value of ΔQ is 4.8eV per carbon atom, 470kJ per mole of carbon or 16 MJ/kg of dry carbohydrate material. It is to be noted that the combustion requires the temperature of approximately 4000C, whereas respiration occurs at 200C through catalytic enzyme reactions.

Bio gas

Biomass is converted to biogas by the process of digestion or fermentation in the presence of micro-organisms. This biogas mainly contains methane which is a good combustible gas.

Biogas consists of 50-55% of methane, 30-35% of CO2 and remaining waste gases like H2, N2, H2S etc. since it contains a hydrocarbon gas it is a very good fuel and hence can be used in IC engines. It is a slow burning gas with calorific value of 5000-5500 Kcal/kg. the raw material used to generate this are algae, crop residue, garbage, kitchen waste, paper waste,

waste from sugar cane refinery, water hyacinth etc. apart from the above-mentioned raw materials excreta of cattle, piggery waste and poultry droppings are also used as raw materials.

Biogas is generated by fermentation or digestion of organic matter in the presence of aerobic and anaerobic micro-organisms. Fermentation is the process of breaking down the complex organic structure of the biomass to simple structures by the action of micro-organisms either in the presence of O2 or in the absence of O2. The container in which the digestion takes place is known as the digester.

Factors Affecting on Bio gas Generation

PH value: It is an index of hydrogen ion concentration in the mixture which also predicts acidity or alkalinity of the mixture. For effective gas generation the required PH value is 6.5 to 7.6. If this value decreases to 4-6, the mixture becomes acidic and if the value becomes 9-10 then it becomes alkaline. Both for acidic and alkaline conditions the methane forming bacteria becomes inactive and the gas generation is reduced. Thus, for effective gas generation the required PH value is 6.5-7.5.

Temperature: The effect of temp on gas generation is as shown in graph. The two curves represent two types of bacteria which are sensitive to two different temp levels. Mesophilic type of bacteria will effectively generate gas at a temp of about 35º C. Thermophilic type of bacteria will generate gas effectively at a temp of about 55º C. As the temperature decreases or increases from the above values the period of gas generation will be increased. Since it is easy to maintain a temp of 35º C, it is advisable to select mesophilic type of bacteria for digestion.

Total solid content: The raw material added to the digester contains both solid and liquid in the ratio of 20:80 by weight. From the experience it is found that the gas generation is improved by maintaining the solid content of the mixture at about 8 to 10% by weight. This is done by adding water to the mixture.

Loading rate: It is the addition of the raw material to the digester/day/unit volume. The effective load rating is found to be 0.5 to 1.6 kg of solid material/day/m^3

Seeding: During digestion the methane forming bacteria are consumed rapidly and their number will decrease affecting the gas generation. In order to maintain the quantity of methane forming bacteria, digested slurry from the previous batch is added to the digestor. The digested slurry is rich in methane forming bacteria and the process is known as seeding.

Uniform feeding: this is one of the prerequisites of good digestion. The digester must be fed at the same time every day with a balanced feed of the same quality and quantity.

Dia to depth ratio: from the experiments it is seen that the gas generation is improved by maintaining a dia to depth ratio of 0.66 to 1. This provides uniform temp distribution throughout the digester resulting in increased gas generation.

Carbon to nitrogen ratio: The bacteria in the digester utilize carbon for energy generation (as food) while nitrogen is used for cell building. Hence a carbon to nitrogen ratio of 30:1 is maintained for effective gas generation. If the ratio is not maintained the availability of carbon and nitrogen will vary resulting in reduced gas generation.

Nutrients: The nutrients required by the bacteria for food digestion are hydrogen, nitrogen, oxygen, carbon, phosphorous and sulphur. of this nitrogen and phosphorous have to be provided externally while the others are contained in the raw material itself. Nitrogen is provided by adding 'leguminous plants' (plants with seeds enclosed in casings, eg: Maize) which are rich in nitrogen content. Phosphorous is provided by adding 'night soil' (soil mixed with excreta of animals and humans) to the digester.

Biochemical reactions in anaerobic digestion

There are four key biological and chemical stages of anaerobic digestion:

- Hydrolysis
- Acido genesis
- Aceto genesis
- Methano genesis.

In most cases biomass is made up of large organic compounds. In order for the microorganisms in anaerobic digesters to access the chemical energy potential of the organic material, the organic matter macromolecular chains must first be broken down in to their smaller constituent parts. These constituent parts or monomers such as sugars are readily available to microorganisms for further processing.The process of breaking these chain sand dissolving the smaller molecules in to solution is called hydrolysis. Therefore, hydrolysis of high molecular weight molecules is the necessary first step in an aerobic digestion. It may be enhanced by mechanical, thermal or chemical pretreatment of the waste. Hydrolysis step can be merely biological (using hydrolytic microorganisms) or combined: bio-chemical (using extra cellular enzymes), chemical (using catalytic reactions) as well as physical (using thermal energy and pressure) in nature.

CLASSIFICATION OF THE BIOGAS PLANTS

1) Continuous and Batch type
   - Single stage
   - Double stage

2) Dome and drum type
   - Floating gas holder or KVIC model
   - Fixed dome type or Chainese model or Janatha

Single stage continuous plant

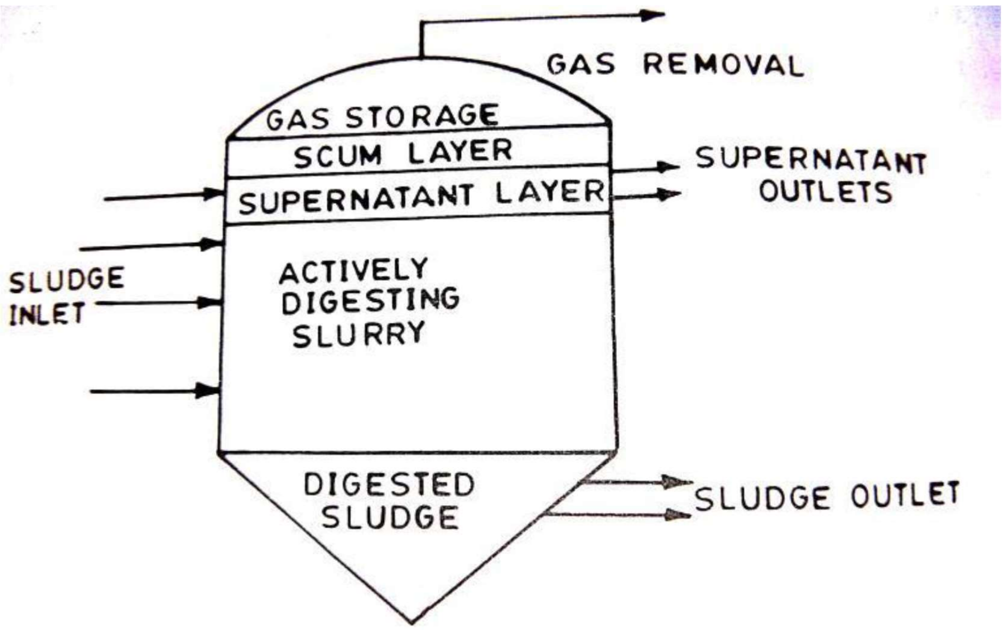


Fig. 7.6.1. Schematic of single process conventional digester.

The entire process of conversion of complex organic compounds into biogas in completed in a single chamber. This chamber is regularly fed with the raw materials while the spent residue keeps moving out. Serious problems are encountered with agricultural residues when fermented in a single stage continuous process.

Two stage continuous plant: (i)Acid & ii) Methane forming

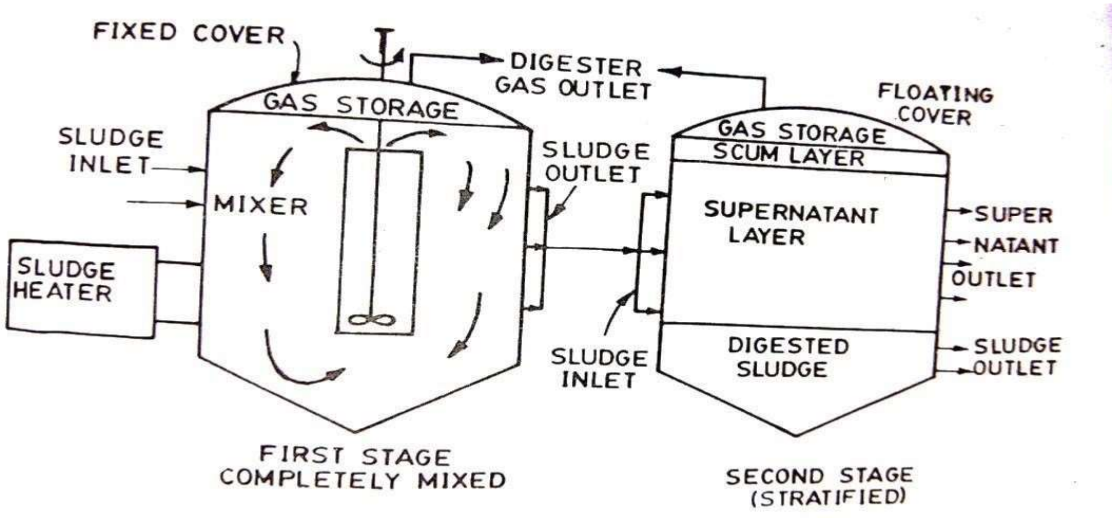


Fig. 7.6.2. Schematic of two-stage digestion process.

The acidogenic stage and methanogenic stage are physically separated into two chambers. Thus, the first stage of acid production is carried out in a separate chamber and only the diluted acids are fed into the second chamber where bio-methanation takes place and the biogas can be collected from the second chamber. Considering the problems encountered in fermenting fibrous plant waste materials the two stage process may offer higher potential of success. However, appropriate technology suiting to rural India is needed to be developed based on the bauble stage process.

The main features of continuous plant are that:

1. It will produce gas continuously;
2. It requires small digestion chambers;
3. It needs lesser period for digestion;
4. It has fewer problems compared to batch type and it is easier in operation

INDIAN DIGESTER

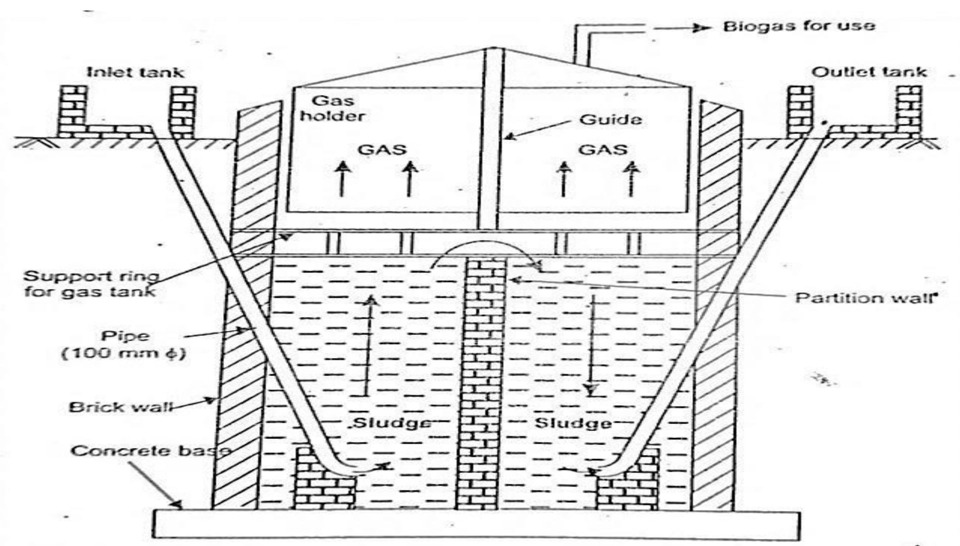


Fig. 8-6. Indian Design Digestor

This mainly consists of a digester or pit for fermentation and a floating drum for the collection of gas. Digester is 3.5-6.5 m in depth and 1.2 to 1.6 m in diameter. There is a partition wall in the center, which divides the digester vertically and submerges in the slurry when it is full. The digester is connected to the inlet and outlet by two pipes. Through the inlet, the dung is mixed with water (4:5) and loaded into the digester. The fermented material will flow out through outlet pipe. The outlet is generally connected to a compost pit. The gas generation takes place slowly and in two stages. In the first stage, the complex, organic substances contained in the waste are acted upon by a certain kind of bacteria, called acid formers and broken up into small-chain simple acids. In the second stage, these acids are acted upon by another kind of bacteria, called methane formers and produce methane and carbon dioxide.

Gas Holder: The gas holder is a drum constructed of mild steel sheets. This is cylindrical in shape with concave top. The top is supported radially with angular iron stripes. The holder fits into the digester like a stopper. It sinks into the slurry due to its own weight and rests upon the ring constructed for this purpose. When gas is generated, the holder rises and floats freely on the surface of slurry. A central guide pipe is provided to prevent the holder from tilting. The holder also acts as a seal for the gas. The gas pressure varies between 7 and 9 cm of water column. Under shallow water table conditions, the adopted diameter of digester is more and depth is reduced. The cost of drum is about 40% of total cost of plant. It requires periodical maintenance. The unit cost of KVIC model with a capacity of 2 m3/day costs approximately Rs.14, 000/.

Janata type biogas plant (Chinese):

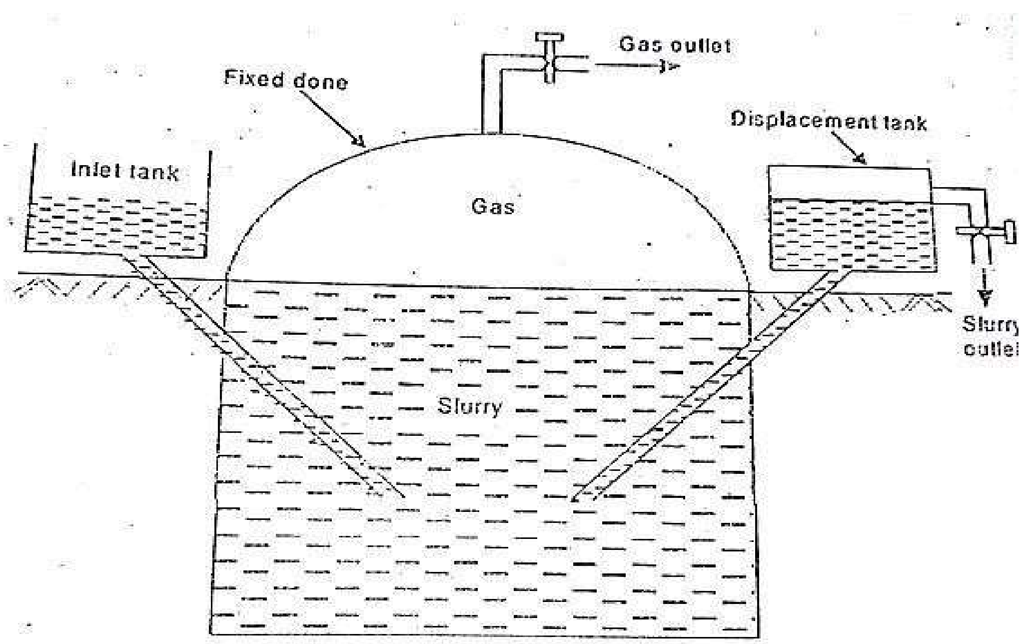
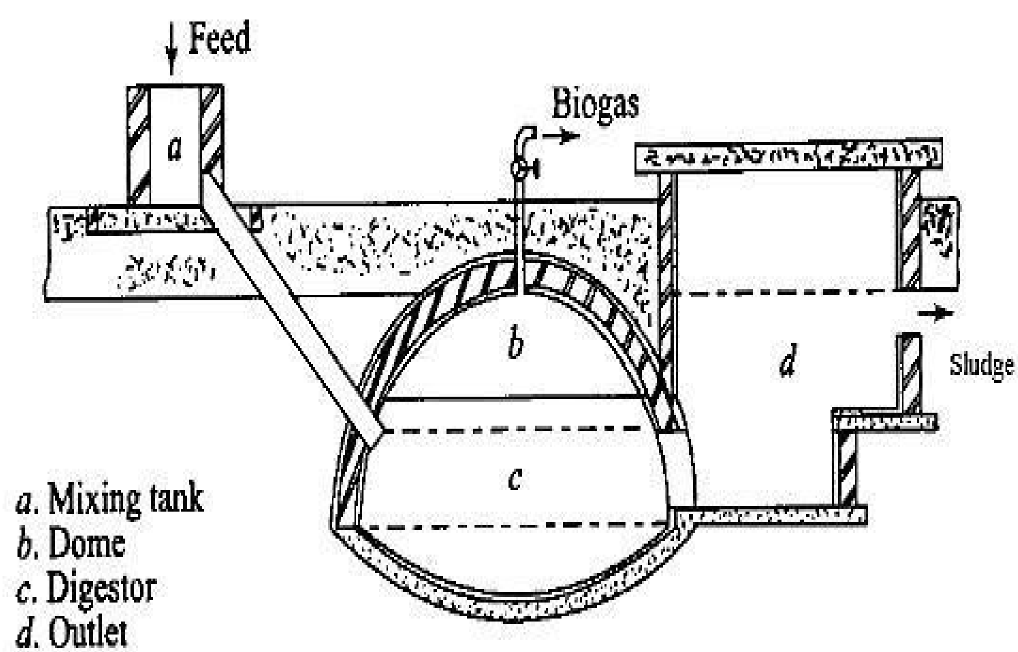


Fig. 8-7. Chinese design biogas plant

The design of this plant is of Chinese origin but it has been introduced under the name Janata biogas plant" by Gobar Gas Research Station, Ajitmal in view of its reduced cost. This is a plant where no steel is used, there is no moving part in it and maintenance cost is low. The plant can be constructed by village mason taking some pre-explained precautions and using all the indigenously available building materials. Good quality of bricks and cement should be used to avoid the afterward structural problems like cracking of the dome and leakage of gas. This model has a higher capacity when compared with KVIC model, hence it can be used as a community biogas plant. This design has longer life than KVIC models. Substrates other than cattle dung such as municipal waste and plant residues can also be used in janata type plants. The plant consists of an underground well sort of digester made of bricks and cement having a dome shaped roof which remains below the ground level is shown in figure. At almost middle of the digester, thereare two rectangular openings facing each other and coming up to a little above the ground level, act as an inlet and outlet of the plant. Dome shaped roof is fitted with a pipe at its top which is the gas outlet of the plant. The principle of gas production is same as that of KVIC model. The biogas is collected in the restricted space of the fixed dome; hence the pressure of gas is much higher, which is around 90 cm of water column.

Deenbandhu biogas plant:



Deenbandhu model was developed in 1984, by Action for Food Production (AFPRO), a voluntary organization based in New Delhi. Schematic diagram of a Deenabandhu biogas plant entire biogas programme of India as it reduced the cost of the plant half of that of KVIC model and brought biogas technology within the reach of even the poorer sections of the population. The cost reduction has been achieved by minimizing the surface area through joining the segments of two spheres of different diameters at their bases. The cost of a Deenbandhu plant having a capacity of 2 m3/day is about Rs.8000/. The Deenbandhu biogas plant has a hemispherical fixed-dome type of gas holder, unlike the floating dome of the KVIC-design is shown. The dome is made from pre-fabricated Ferro cement or reinforced concrete and attached to the digester, which has a curved bottom. The slurry is fed from a mixing tank through an inlet pipe connected to the digester. After fermentation, the biogas collects in the space under the dome. It is taken out for use through a pipe connected to the top of the dome, while the sludge, which is a by-product, comes out through an opening in the side of the digester. About 90% of the biogas plants in India are of the Deenbandhu type.

Problems related to bio-gas plants

Some problems are natural and some are created by the persons biogas plants owners but all are controllable.

- Handling of effluent slurry is major problem if the person is not having sufficient open space or compost pits to get the slurry dry. Use of press filters and transportation is expensive and out of reach of poor farmers.
- The gas forming-methanogenic bacteria are very sensitive towards the temperature compared to those of non-methanogenic. During winter as the temperature falls, there is decrease in the activity of methanogenic bacteria and subsequently fall in gas production rate.
- Due to lack of proper training to the bio-gas plant owners for the operation of plant, a lot of problems arises. It has been noticed that many persons increase the loading rate and some also do not try to mix the cattle dung with water, keeping in mind more gas production.
- Some persons add urea-fertilizer in large quantities due to which toxicity of ammonia nitrogen may cause a decrease in gas production.
- pH and volatile fatty acids play an important role in anaerobic digestion and should remain under optimum range otherwise this may cause upsetting of digester and even its failure.
- Leakage of gas from gas holder especially in case of Janta type biogas plants is a major and very common problem. When there is quite enough gas in a gas holder, the leakage should be checked by using water and the points marked and then get repaired.

Advantages of Biogas

1. Biogas is an energy carrier which can be used for several energy applications (eg. electricity generation, heat production, combine heat and power production, transport fuel, injection to the natural gas grid).

2. Biogas can contribute to several sectors:
Environment
(eg. Fight against Climate change)
Energy
(eg. Energy security, local source)
Agriculture
(eg. Sustainable cultivation and animal breeding)
3. Some Environmental benefits of biogas:

- Reduced emissions of greenhouse gases, direct and indirect (eg. CO_2, CH_4 and nitrous oxide –N_2O).
- Water and Waste management (Reduced consumption of resources and increased recycling, reduced water environment pollution from leaching of nutrients, environmentally friendly solution to the waste disposal problem).
- Reduced odor and flies nuisances.
- Soil and landscape

4. Water and Waste management

- Compared to other biofuels, biogas needs the lowest amount of process water. This aspect is very important since many regions of the world face huge water problems
- One of the main advantages of biogas production is the ability to transform waste material into a valuable resource, by using it as feedstock for AD.
- Biogas technologies contribute to reduce the volume of wastes and the costs for waste disposal (transportation, disposal).

Application of bio-gas in engines:

Biogas in Diesel Engine applications:

Biogas generally has a high self-ignition temperature hence; it cannot be directly used in a CI engine. So, it is useful in dual fuel engines. The dual fuel engine is a modified diesel engine in which usually a gaseous fuel called the primary fuel is inducted with air into the engine cylinder. This fuel and air mixture does not auto ignite due to high octane number. A small amount of diesel, usually called pilot fuel is injected for promoting combustion. The primary fuel in dual fuelling system is homogeneously mixed with air that leads to very low level of smoke. Dual fuel engine can use a wide variety of primary and pilot fuels. The pilot fuels are generally of high cetane fuel. Biogas can also be used in dual fuel mode with vegetable oils as pilot fuels in diesel engines. Introduction of biogas normally leads to deterioration in performance and emission characteristics. The performance of engine depends on the amount of biogas and the pilot fuel used. Measures like addition of hydrogen, LPG, removal of CO_2 etc. have shown significant improvements in the performance of biogas dual fuel engines. The ignition delay of the pilot fuel generally increases with the introduction of biogas and this will lead to advance the injection timing. Injectors opening pressure and rate of injection also are found to play important role in the case of biogas fuelled engine, where vegetables oil is used as a pilot fuel. The CO_2 percentage in biogas acts as diluents to slow down the combustion process in Homogenous charged compression ignition (HCCI) engines. However, it also affects ignition. Thus a fuel with low self-ignition temperature could be used along with biogas to help its ignition. This kind of engine has shown a superior performance as compared to a dual fuel mode of operation.

Biogas in Dual Fuel Engine applications:

In this case, the normal diesel fuel injection system still supplies a certain amount of diesel fuel. The engine however sucks and compresses a mixture of air and biogas fuel which has been prepared in external mixing device. The mixture is then ignited by and together with the diesel fuel sprayed in. The amount of diesel fuel needed for sufficient ignition is between 10% and 20% of the amount needed for operation on diesel fuel alone. Operation of the engine at partial load requires reduction of the biogas supply by means of a gas control valve. A simultaneous reduction of airflow would reduce power and efficiency because of reduction of compression pressure and main effective pressure. So, the air/fuel ratio is changed by different amounts of injected biogas. All other parameters and elements of diesel engine remain unchanged.

Biogas in HCCI Engine applications:

The Homogeneous Charge Compression Ignition (HCCI) concept is a potential for achieving a high thermal efficiency and low Nitrogen Oxide (NO) emission. The HCCI engine with 50 % biogas as a primary fuel and 50% diesel as pilot fuel gives a maximum NO of 20 ppm is a major advantage over biogas diesel dual fuel mode. In biogas diesel dual fuel mode, the presence of CO_2 in biogas lowers the thermal efficiency however, in biogas diesel HCCI (BDHCCI) mode CO_2 reduces high heat release rate. The break mean effective pressure (BMEP) in BDHCCI mode is in the range of 2.5 bar to 4 bar. The smoke and Hydro Carbon (HC) level were also low when the biogas is used as a primary fuel for BDHCCI mode. For HCCI operation the inducted charge temperature is required to be maintained at 80-135°C, which can be obtained from the exhaust heat. Thus, biogas with HCCI engine gives high efficiency and low emission.

Geothermal Energy

Geothermal energy, form of energy conversion in which heat energy from within Earth is captured and harnessed for cooking, bathing, space heating, electrical power generation, and other uses.

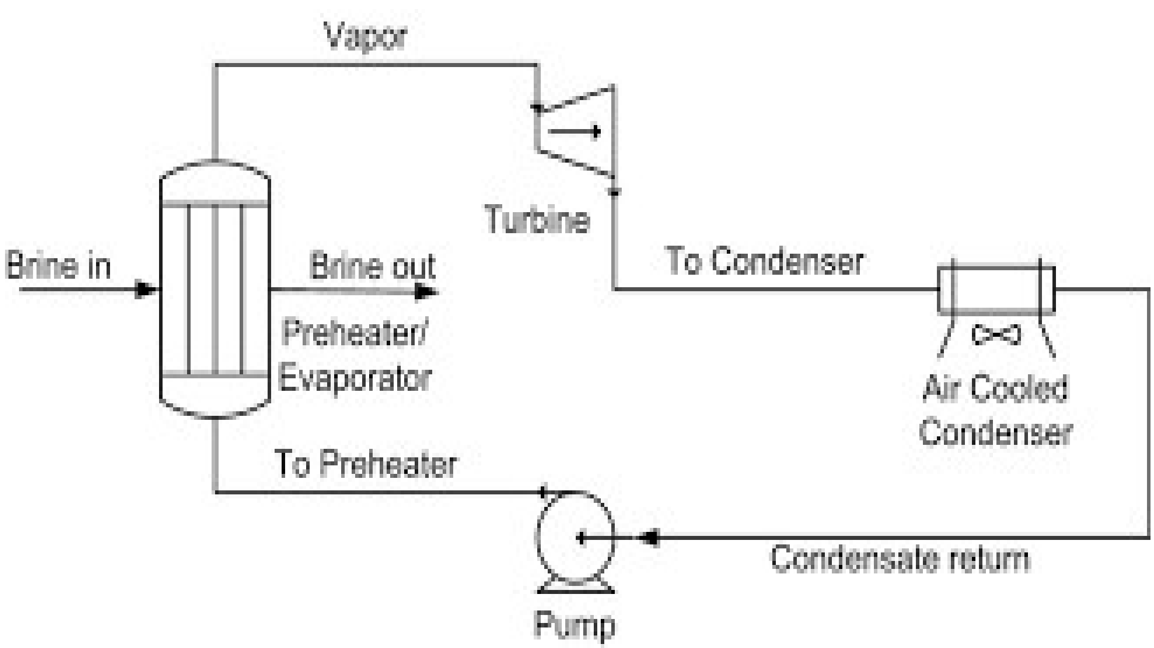
Geothermal energy from natural pools and hot springs has long been used for cooking, bathing, and warmth. There is evidence that Native Americans used geothermal energy for cooking as early as 10,000 years ago. In ancient times, baths heated by hot springs were used by the Greeks and Romans, and examples of geothermal space heating date at least as far back as the Roman city of Pompeii during the 1st century. Such uses of geothermal energy were initially limited to sites where hot water and steam were accessible.

Types of geo thermal power plant

There are three geothermal power plant technologies being used to convert hydrothermal fluids to electricity—dry steam, flash steam and binary cycle. The type of conversion used (selected in development) depends on the state of the fluid (steam or water) and its temperature.

Geothermal power plants use steam to produce electricity. The steam comes from reservoirs of hot water found a few miles or more below the earth's surface. The steam rotates a turbine that activates a generator, which produces electricity.

Binary cycle geo thermal power plant

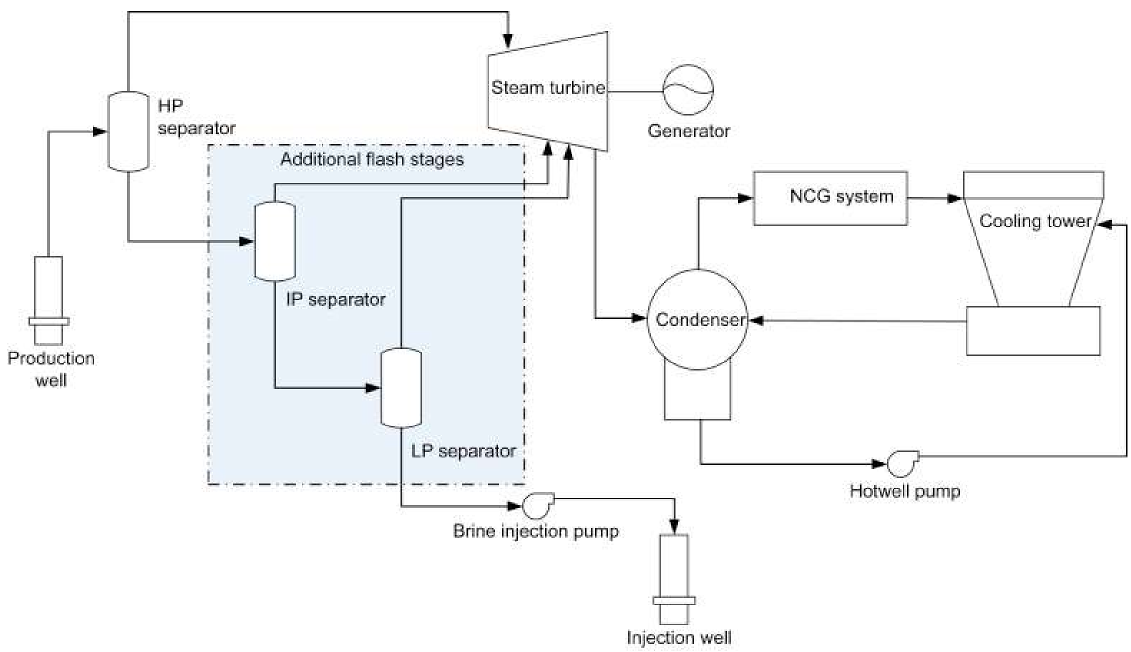


A binary cycle is a method for generating electrical power from geothermal resources and employs two separate fluid cycles, hence binary cycle. The primary cycle extracts the geothermal energy from the reservoir, and secondary cycle converts the heat into work to drive the generator and generate electricity.

In the binary cycle, heat is transferred from the geothermal fluid to a secondary working fluid. During this heat transfer process, the pressurized working fluid is vaporized. The working fluid leaving the geothermal heat exchangers is subsequently expanded through a turbine producing work, or electrical power.

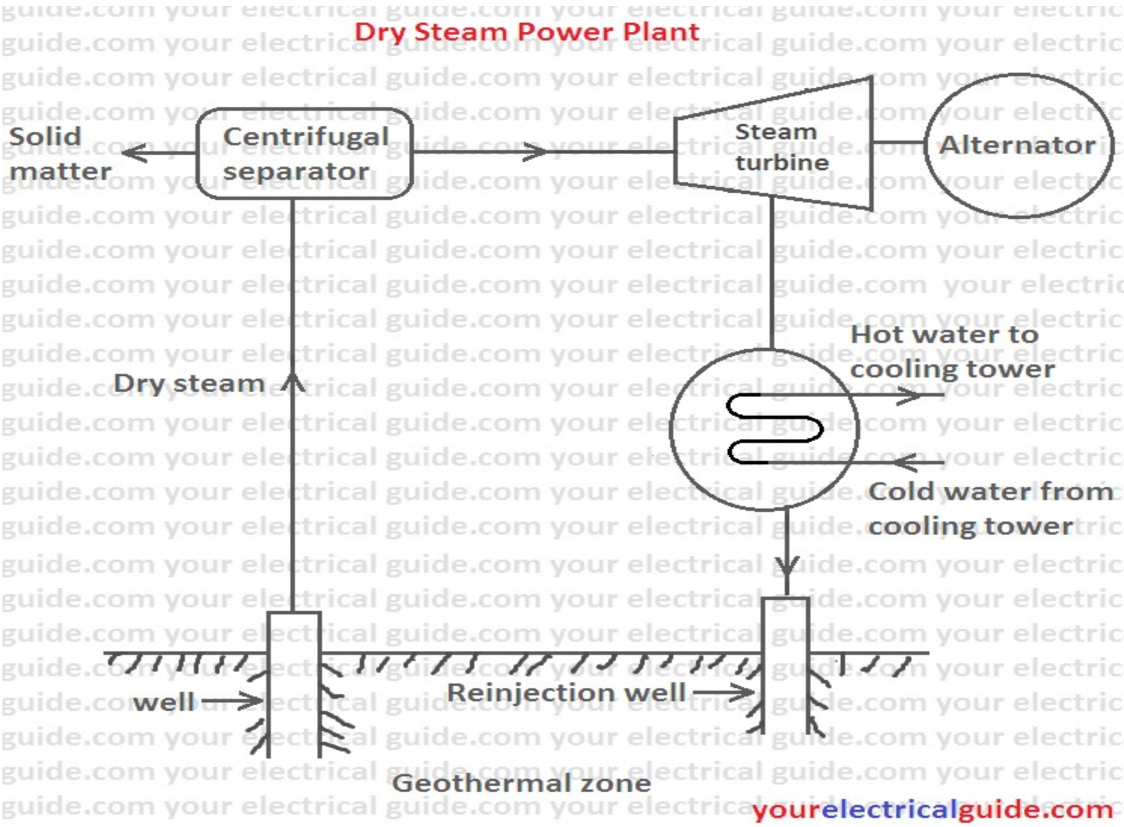
A binary power plant has several advantages such as **reservoir sustainability, high reliability operation, and environmental friendliness**. In our study, we used Isopentane as the secondary working fluid.

Flash steam Geo thermal power plant



Flash steam plants **take high-pressure hot water from deep inside the earth and convert it to steam to drive generator turbines**. When the steam cools, it condenses to water and is injected back into the ground to be used again. Most geothermal power plants are flash steam plants. Flash steam power plants are relatively a common method used to convert the geothermal energy into electricity when production wells produce a mixture of steam and liquid in a geothermal system. In comparison to the single flash system, the double flash steam power plant generates more power from geothermal fluid at the same conditions. A single-flash geothermal power plant **uses hot geothermal water at 230ºC as the heat source**. The mass flow rate of steam through the turbine, the isentropic efficiency of the turbine, the power output from the turbine, and the thermal efficiency of the plant are to be determined.

Dry Steam Geo thermal power plant



Dry steam plants use hydrothermal fluids that are primarily steam. **The steam travels directly to a turbine, which drives a generator that produces electricity**. The steam eliminates the need to burn fossil fuels to run the turbine (also eliminating the need to transport and store fuels). In the Geysers Geothermal area, **dry steam from below ground is used directly in the steam turbines**. In other areas of the state, super-hot water is "flashed" into steam within the power plant, and that steam turns the turbine. Expand All. Direct Dry Steam. Steam plants use hydrothermal fluids that are primarily steam. The direct dry steam cycle **uses a working fluid in the saturated or superheated vapor phase that is directly produced in the Earth's interior**. After flowing into a separator that removes solid particles, the working fluid is used to directly run a turbine and generate electricity.

Advantages of Geothermal

1. Environmentally Friendly

Geothermal energy is more environmentally friendly than conventional fuel sources such as coal and other fossil fuels. In addition, the carbon footprint of a geothermal power plant is low. While there is some pollution associated with geothermal energy, this is relatively minimal when compared to fossil fuels.

2. Renewable

Geothermal energy is a source of renewable energy that will last until the Earth is destroyed by the sun in around 5 billion years. The hot reservoirs within the Earth are naturally replenished, making it both renewable and sustainable.

3. Huge Potential

Worldwide energy consumption is currently around 15 terawatts, which is far from the total potential energy available from geothermal sources. While we can't currently use most reservoirs there is a hope that the number of exploitable geothermal resources will increase with ongoing research and development in the industry. It is currently estimated that geothermal power plants could provide between 0.0035 and 2 terawatts of power.

4. Sustainable / Stable

Geothermal provides a reliable source of energy as compared to other renewable resources such as wind and solar power. This is because the resource is always available to be tapped into, unlike with wind or solar energy.

5. Heating and Cooling

Effective use of geothermal for electricity generation requires water temperatures of over 150°C to drive turbines. Alternatively, the temperature difference between the surface and a ground source can be used. Due to the ground being more resistant to seasonal heat changes than the air, it can act as a heat sink/ source with a geothermal heat pump just two meters below the surface.

6. Reliable

Energy generated from this resource is easy to calculate since it does not fluctuate in the same way as other energy sources, such as solar and wind. This means we can predict the power output from a geothermal plant with a high degree of accuracy.

7. No Fuel Required

Since geothermal energy is a naturally occurring resource there is no fuel required, such as with fossil fuels that are a finite resource which needs mining or otherwise extracting from the earth.

8. Rapid Evolution

There is a great deal of exploration into geothermal energy at the moment, meaning that new technologies are being created to improve the energy process. There are an increasing number of projects to improve and grow this area of industry. With this rapid evolution many of the current cons of geothermal energy will be mitigated against.

Disadvantages of Geothermal Energy

1. Location Restricted

The largest single disadvantage of geothermal energy is that it is location specific. Geothermal plants need to be built in places where the energy is accessible, which means that some areas are not able to exploit this resource. Of course, this is not a problem if you live in a place where geothermal energy is readily accessible, such as Iceland.

2. Environmental Side Effects

Although geothermal energy does not typically release greenhouse gases, there are many of these gases stored under the Earth's surface which are released into the atmosphere during digging. While these gases are also released into the atmosphere naturally, the rate increases near geothermal plants. However, these gas emissions are still far lower than those associated with fossil fuels.

3. Earthquakes

Geothermal energy also runs the risk of triggering earthquakes. This is due to alterations in the Earth's structure as a result of digging. This problem is more prevalent with enhanced geothermal power plants, which force water into the Earth's crust to open up fissures to greater exploitation of the resource. However, since most geothermal plants are away from population centers, the implications of these earthquakes are relatively minor.

4. High Costs

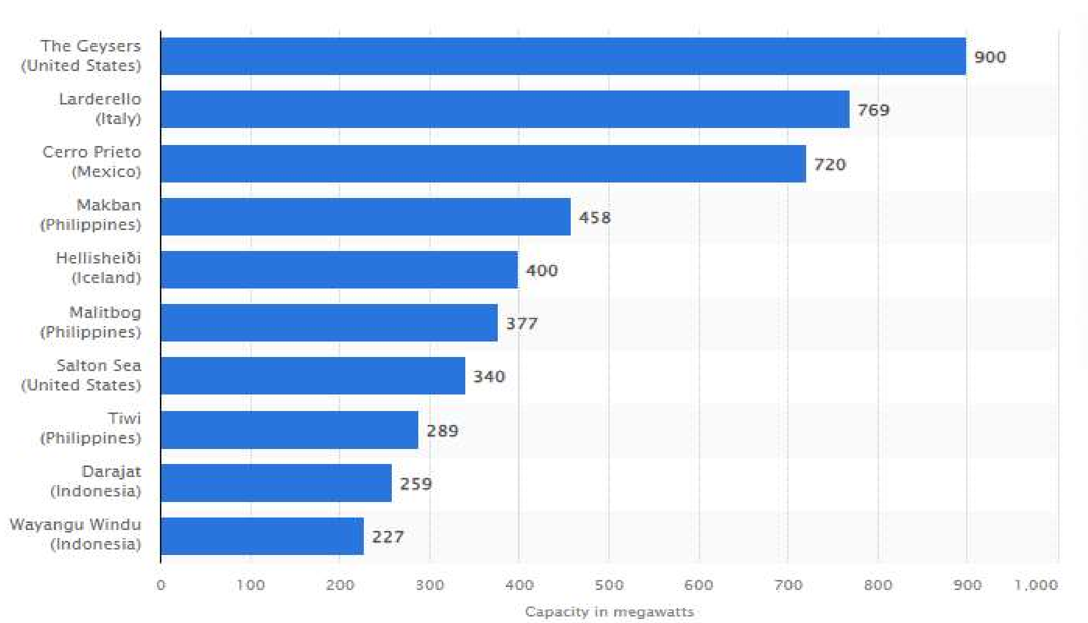
Geothermal energy is an expensive resource to tap into, with price tags ranging from around \$2-\$7 million for a plant with a 1-megawatt capacity. However, where the upfront costs are high, the outlay can be recouped as part of a long-term investment.

5. Sustainability

In order to maintain the sustainability of geothermal energy fluid needs to be pumped back into the underground reservoirs faster than it is depleted. This means that geothermal energy needs to be properly managed to maintain its sustainability.

It is important for industry to assess the geothermal energy pros and cons in order to take account of the advantages while mitigating against any potential problems.

Geothermal Power Plants in the world



Problems associated with geo thermal

The environmental effects of geothermal development and power generation include the changes in land use associated with exploration and plant construction, noise and sight pollution, the discharge of water and gases, the production of foul odors, and soil subsidence.

Geothermal power plants can have impacts on both water quality and consumption. Hot water pumped from underground reservoirs often contains high levels of sulfur, salt, and other minerals. Most geothermal facilities have closed-loop water systems, in which extracted water is pumped directly back into the geothermal reservoir after it has been used for heat or electricity production. In such systems, the water is contained within steel well casings cemented to the surrounding rock. There have been no reported cases of water contamination from geothermal sites in the United States.

Scope of geo thermal energy

Geothermal Energy is the thermal energy generated by the radioactive decay of materials in the earth's interior, it can be harnessed virtually anywhere on the Earth's but viable methods are possible only at the surface or near-surface manifestations. These manifestations are only limited to some parts of the world. It is a very nascent renewable source of energy. Even though surface manifestation like hot springs have been used by humans since ancient times, the first geothermal pumps were used in the 1940's and the first geothermal electric plant became operational only in 1960. Many countries since then have been investing in geothermal energy as a clean and renewable energy source, it is more relevant now that ever.