How is geothermal energy generated?

The thermal energy contained in the interior of the earth is called geothermal energy. Volcanoes, geysers, and hot springs are visible evidence of a large amount of heat lying in Earth's interior. The geothermal is enormous and last for several millions of years. Hence, it is called renewable energy.

Energy presents as heat (i.e. thermal energy) in the earth's crust. The more readily accessible heat is in the uppermost part (10 km) or crust constitutes a potentially useful and almost the inexhaustible source of energy. This heat is apparent from the increase in temperature of the earth with an increase in depth below the surface. Although higher and lower temperatures or cross the average temperatures occur, the average temperature at the depth of 10 kilometers is 200 degrees celsius.

The molten rock within the earth is called magma. It is commonly presented at a depth of about 32 km on an average with a temperature of about 3000 degrees C. In some places, anomalous geologic conditions cause the magma to be pushed up towards the surface where the heat of the magma is being conducted upward through an overlying rock layer. The figure shows a typical geothermal field.

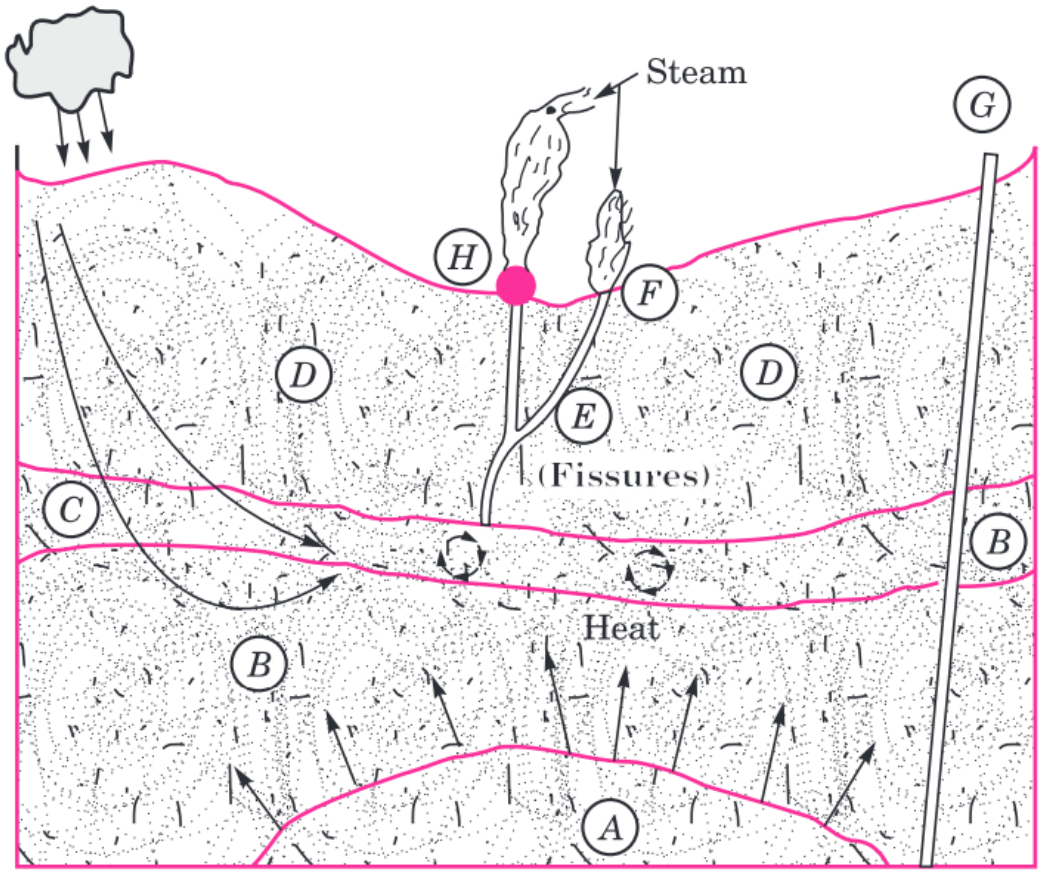

Fig. 8.1. A typical geothermal field.

The hot magma near the surface (A) solidifies into igneous rock (D). The heal of the magma is conducted upward to this igneous rock. Ground waler which finds its way down to this rock through cracks is healed by the heat of the rock or by mixing with hot gases and steam coming from magma. Then the heated water convectively rises upward and into a porous and permeable reservoir (C) above flit igneous rock. The reservoir is capped by a layer of the impermeable solid rock (D) which traps the hot water in the reservoir. The solid rock has fissures (E) which act as vents of the giant underground boiler. The

vents show up at the surface as geysers fumaroles (I) or hot spring (G). A well (H) traps steam from fissures for the use in a geothermal power plant.

At any place on the planet, there is a normal temperature gradient of 30 degrees C. per km dug into the earth. Therefore, if in one dig 20000 feet the temperature will be about 190-degree c above the surface temperature, this difference will be enough to produce electricity. However, no useful and economical technologies have been developed to extract this large source of energy.

Geothermal Energy Sources

The basic kinds of geothermal sources are as follows.

1. Hydrothermal
(a) Vapour-dominated or dry steam fields
(b) Liquid dominated system
(c) Hot-water fields

2. Geopressured
3. Hot dry rock or Petrothermal
4. Magma resources
5. Volcanoes

Hydrothermal resources contain superheated water, steam, or both in fractures or porous rock but further trapped by a layer of impermeable rock.

Hot dry rock or petrothermal resources consist of high-temperature rocks ranging from 90°C to 65O degree C. The rocks can be fractured and water may be circulated through the rocks to extract thermal energy.

Direct Uses of Geothermal Energy

It is more appropriate for sources below 150 degrees C. It is used for.

1. Space heating
2. Air conditioning
3. Industrial processes
4. Drying
5. Greenhouses
6. Aquaculture
7. Hot water
8. Resorts and pools
9. melting snow.

Types of Geothermal Power Plants :

1. Dry steam or Vapor -Dominated geothermal power plant.
2. Liquid -dominated geothermal power plant.

Liquid -dominated geothermal power plant is further classified as

- Flashed-steam system
- Binary-cycle system.

Working Of Geothermal Energy – Working Of Geothermal Power Plants

Dry steam Or Vapour-dominated geothermal power plant

The figure shows a schematic and T-s diagram of a vapor-dominated power system. Dry steam from wells is collected, filtered to remove abrasive particles, and passed through turbines that drive electric generators in the usual manner. The essential difference between this system and a conventional steam turbine-generator system using fossil or unclear fuel is that the geothermal steam is supplied at much lower temperature and pressure.

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The dry steam from the well at (1) perhaps 200°C is used. It is nearly saturated at the bottom of the well and it may have o shut off pressure about 35 bar. The pressure drop through the well is slightly the superheat at well head (2).

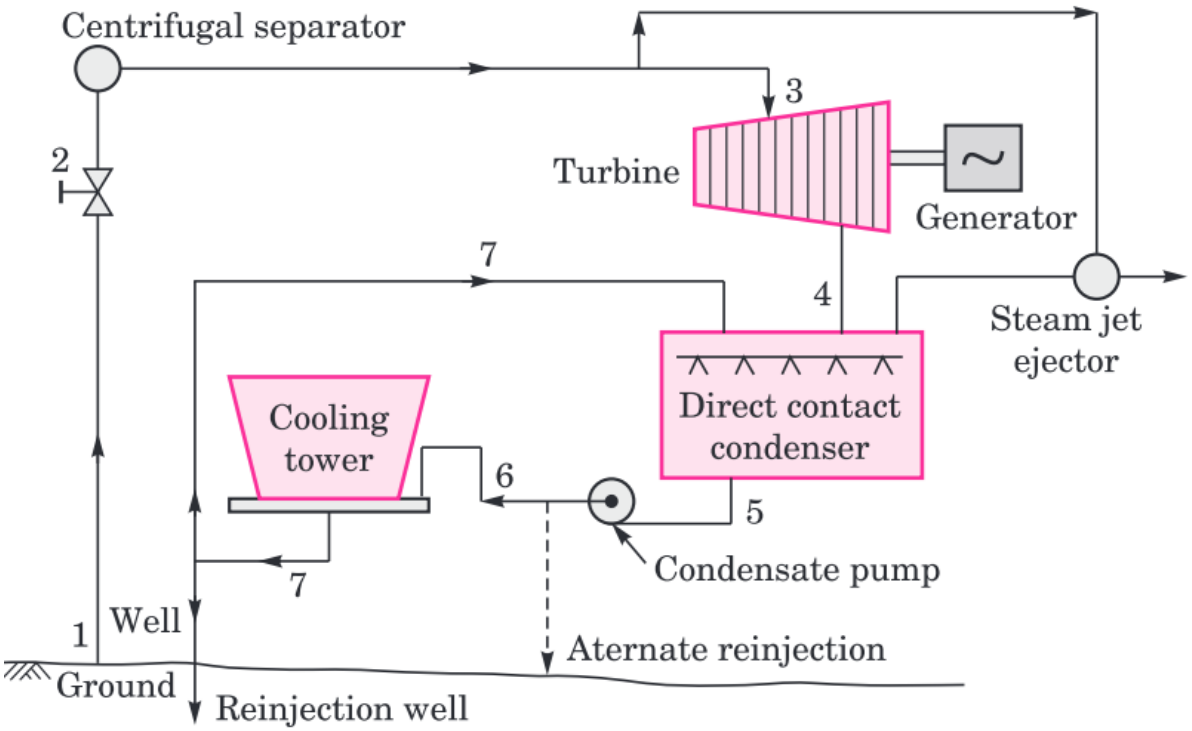
The steam after expansion in the turbine (3) enters the condenser at 4.

The condensation of steam continuously increases the volume of the cooling water.

A part of this heat is lost by evaporation in the cooling tower (6) and the remaining heat is injected deep into the ground (7) for disposal.

The turbine exhaust steam at (4) mixes with the cooling water (7) coming from the cooling tower. The mixture of cooling water coming from the cooling tower and turbine exhaust is saturated vapor at (5) and it is pumped to the cooling tower (6).

Geothermal Power plant Diagram :



(*a*) Scheme of a vapour dominated power plant

2. Liquid-dominated geothermal power plant

In the liquid dominated reservoir, the water temperature is above the normal boiling point 100 degrees C. However, it does not boil but it remains in a liquid state because the water in the reservoir is under pressure. When the water comes to the surface, the pressure is reduced, then rapid boiling occurs and the liquid water "flashes" into a mixture of hot water and steam. The steam can be separated and used to generate electric power or to provide space and process heat or it may be distilled to yield the purified water.

There are two important methods of liquid-dominated systems as follows,

- Flashed – steam system
- Binary-cycle system

Prime Movers for geothermal energy Conversion :

The prime movers can be classified used in geothermal power plants are,

1.Impulse/Reaction machines:

- Axial flow – Curtis, Rateau steam
- Radial inflow – Francis turbine, multiple disk drag turbine
- Radial outflow – Rotating nozzle, Hero's turbine
- Multiple disc turbine – Bladeless impulse or reaction drag turbine.

2. Positive displacement machines :

- Helical screw expander
- Rotating oscillating vane machine.

3. Impulse machines :

- Tangential flow – Pelton wheel, Re-entry type turbine.
- Arial Flow, De-laval turbine, and Curtis turbine.

Advantage and Disadvantage of geothermal energy :

Advantages of Geothermal energy :

1. It is versatile in its use and a reliable source of energy.
2. It is cheaper compared to energies obtained from other sources both zero fuels and fossil fuels.
3. Geothermal plants require little land area.
4. Using geothermal energy directly for heating applications can be up to 70% more efficient.
5. Its availability is independent of the weather.
6. It has an inherent storage feature and hence no extra storage systems are necessary.
7. It delivers a greater amount of net energy from its system than other alternative or conventional systems.
8. It has the highest annual load factor of 85 % to 90 % compared to 45% to 50% for fossil fuel plants.
9. It leads to minimum pollution compared to other conventional energy sources.
10. Using geothermal energy directly for heating applications can be up to 70 % more efficient.
11. Once built, geothermal power station operating costs are small making geothermal generated electricity much cheaper.
12. Ground-based geothermal heat pumps for heating and cooling can be used almost anywhere.

Disadvantages of geothermal energy :

1. Overall efficiency for power production is low about 15% when compared to 35-40% for fossil fuel plants.
2. The steam and hot water gushing out of the earth may contain H_2S , CO_2 ,NH_3, and radon gas, etc. These gases are to be removed by chemical action before they are discharged.
3. Drilling operation is noisy
4. Large area is required for the exploitation of geothermal energy as much diffused.
5. Continuous extraction of heated groundwater may lead to subsidence of land.
6. The corrosive and abrasive geothermal fluid reduces the life of plants.
7. Thermal energy cannot be distributed easily over a long distance (longer than 30 km)

8. Initial capital and installation costs are high.

Applications of Geothermal Energy:

- It is used in generating electric power.
- It is used in industrial process heat.
- It is used in space heating for various kinds of buildings.
- It is used in agricultural and related applications.