GOVERNMENT POLYTECHNIC, AURANGABAD

GOVERNMENT POLYTECHNIC, AURANGABAD

(An Autonomous Institute of Government of Maharashtra)

"PERSUIT FOR EXCELLENCE"

DEPARTMENT OF ELECTRICAL ENGINEERING

Seminar Report On

"Geothermal Power Plant"

SUBMITTED BY,

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GUIDED BY,

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GOVERNMENT POLYTECHNIC, AURANGABAD

(An Autonomous Institute of Govt. of Maharashtra)

DEPARTMENT OF ELECTRICAL ENGINEERING

CERTIFICATE

This is to certify that **Rajput Dinesh Dilip (193049)** Student of 3rd year diploma in electrical engineering has completed seminar report on **"Geothermal Power Plant"** which is being submitted here with in partial fulfilment for the award of the "Diploma in electrical engineering" of Government Polytechnic Aurangabad. The seminar has been successfully completed under the guidance of **Prof. B. S. SANAP** academic year 2021-22.

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It is a great pleasure for me on bringing out the Report of Seminar. I express my great regards to my guide **S. J. GHORPADE SIR**, whose guidance and friendly discussion inspired and supported me in selecting the topic of Seminar and also the completion of my Report. I am also thankful to the honorable **Principal Prof. M. M. Ganorkar Sir** and **Prof. B. S. Sanap Sir (HOD of Electrical Department) for** introducing course "Seminar" and encouraged and supported us for the completion.

Yours Sincerely,

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ABSTRACT

Geothermal energy is the heat energy generated from radioactive decay of minerals and stored in the Earth. Theoretically, total geothermal resources are more than adequate to supply all human energy needs for many years. However, so far only a small portion of geothermal energy has been extracted and used either directly as a heat source or converted to electricity. Often significant drilling and exploitation costs make the energy conversion process unfeasible.

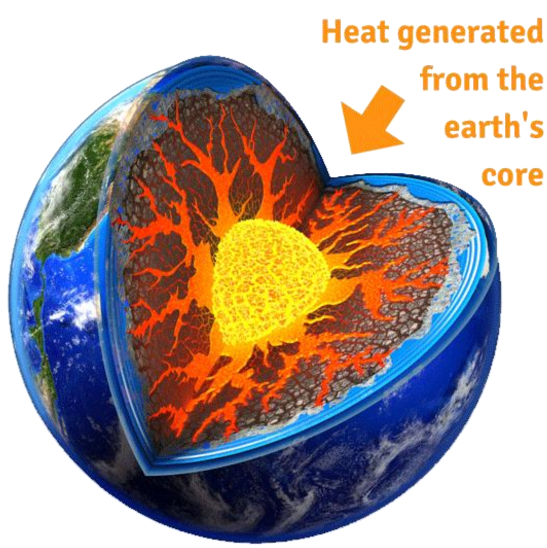
Geothermal industry has been significantly developed since the first commercial geothermal plant was built in 1904 in Italy. Geothermal sources are in different forms including dry hot steam, hot water, and hot rock. Depending on the characteristics of each geothermal resource, different types of geothermal plants have been designed and installed. Single- or double-flash power plants are the most common plants for hot water geothermal resources.

As the technology develops and more renewable energy policies are introduced, the levelized cost of geothermal power decreases. Future technology developments, renewable energy initiatives, and availability of other sources of energy are expected to further reduce the cost of geothermal power.

Introduction

Geothermal energy is type of renewable energy which is generated within the earth and can be used directly for heating or transformed into electricity .An advantage of geothermal energy over some other renewable energy sources is that it is available year-long (whereas solar and wind energy present higher variability and intermittence) and can be found around the globe . However, for electricity generation , medium to high-temeperature resources, which are usually close to volcanic active regions,are needed.

Geothermal Power has considerable potential for growth. The amount of heat within 10,000 metres of the earth's surface is estimated to contain 50,000 times more energy than all oil and gas resources world-wide. Moreover ,there is a strong economic case for the deployment of geothermal energy . The cost for electricity generation from geothermal technologies are becoming increasingly competitive ,and they are expected to continue to drop through 2050.



Deep inside the Earth, at depths near 150 kilometers, the temperature and pressure is sufficient to melt rock into magma. As it becomes less dense, the magma begins to flow toward the surface. Once it breaks through the crust it is referred to as lava. Lava is extremely hot; up to 1,250 °C. Average lava temperatures are about 750°C. A normal household oven only reaches temperatures near 260°C (500°F)!

The rock located just above the magma is also very hot but remains solid. What if we could harness this thermal energy and use it to generate electricity or heat homes and businesses? We would have a domestic, clean, and nearly inexhaustible energy supply. Geothermal energy is one of the components of the National Energy Policy.

Today, due to the explorations and calculations of many scientists and engineers, we've realized that only 1% of the geothermal energy contained in the uppermost ten kilometers of the Earth's crust is 500 times that contained in all the oil and gas resources of the world! The next step is designing technology that can harness this immense, renewable, and low to no - emission energy reservoir. Geothermal energy can be usefully extracted from four different types of geologic formations. These include hydrothermal, geopressurized, hot dry rock, and magma.

Hydrothermal reservoirs have been the most common source of geothermal energy production worldwide. They contain hot water and/or steam trapped in fractured or porous rock formations by a layer of impermeable rock on top. Hydrothermal fluids can be used directly to heat buildings, greenhouses, and swimming pools, or they can be used to produce steam for electrical power generation. These power plants typically operate with fluid temperatures greater than 130oC.

Geopressurized resources are from formations where moderately high temperature brines are trapped in a permeable layer of rock under high pressures. These brines are found deeper underground than hydrothermal fluids and have high concentrations of salt, minerals, and dissolved methane gas. In addition to producing steam for electrical power generation, minerals can be extracted from brines and used as supplementary revenue for a power plant. This process is known as co□ production. Hot dry rock reservoirs are generally hot impermeable rocks at depths shallow enough to be accessible(<3,000 m). Although hot dry rock resources are virtually unlimited in magnitude around the world, only those at shallow depths are currently economical. To extract heat from such formations, the rock must be fractured and a fluid circulation system developed. This is known as an enhanced geothermal system (EGS). The water is then heated by way of conduction as the it passes through the fractures in the rock, thus becoming a hydrothermal fluid.

Geothermal power is already an important energy resource for our nation and the world. Hydrothermal plants in the western states now provide about 2,500 megawatts of constant, reliable electricity, which meets the residential power needs for a city of 6 million people. Over 8,000 megawatts are currently being produced worldwide. A variety of industries, including food processing, aquaculture farming, lumber drying, and greenhouse operations, now benefit from direct geothermal heating.

LAYERS OF EARTH

•The Crust-

The Crust is the outermost layer of the Earth. The crust is completely solid and made up of rocks and various kinds of minerals. It is actually much thinner than you might expect it to be, as it only makes up roughly 1% of the Earth's total volume. With a depth of 40 kilometers (or 25 miles) it can generally be broken down into two distinct types. The first type of crust is a thicker, continental crust and the second being a thinner oceanic crust.

•Continental Crust-

The continental crust is primarily composed of many different types of granites. Aluminum and silicon are the most abundant elements found in this type of crust, hence, geologists also refer to the continental crust as "sial". Sial stands for silicates and aluminum respectively. In comparison to the oceanic crust, the continental crust is much older in age.

•Oceanic Crust-

The oceanic crust extends beneath the ocean floors by approximately 5-10 kilometers (3-6 miles). This sort of crust is mainly composed of different types of basalts. The most abundant elements that make up the oceanic crust are silicon and magnesium; as a result, geologists refer to the oceanic crust as "sima". Sima stands for silicates and magnesium respectively. The oceanic crust is much younger in age in comparison to continental crust because of the process of subduction. Due to plate tectonics, many areas where two or more oceanic plates can cause one plate to sink beneath the other; grinding away at both plates. As a result, the oceanic plates tend to erode and recycle often leading them to always be much younger in age.

•The Mantle-

Venturing further down into the Earth, after the crust, we have the mantle. The mantle is a mostly-solid portion of the subsurface of the Earth which has a depth of about 2,900 kilometers (1,802 miles). In comparison to the measly 1% of Earth's volume that the crust makes up for, the mantle accounts for a staggering 82% of the Earth's total volume. The rocks that commonly make up the mantle are silicates. Some silicates (which are compounds that have both silicon and oxygen molecules) that can be found in the mantle are; olivine, garnet, and pyroxene. Another common type of compounds/elements found in the mantle are; magnesium oxide, iron, aluminum, calcium, sodium, etc. The expected temperature in the mantle falls between the range of 1000°C (1832°F) to 3700°C (6692°F).

•The Core-

Finally, we've arrived at the Core. The core can be broken down into two sections; the Outer Core and the Inner Core.

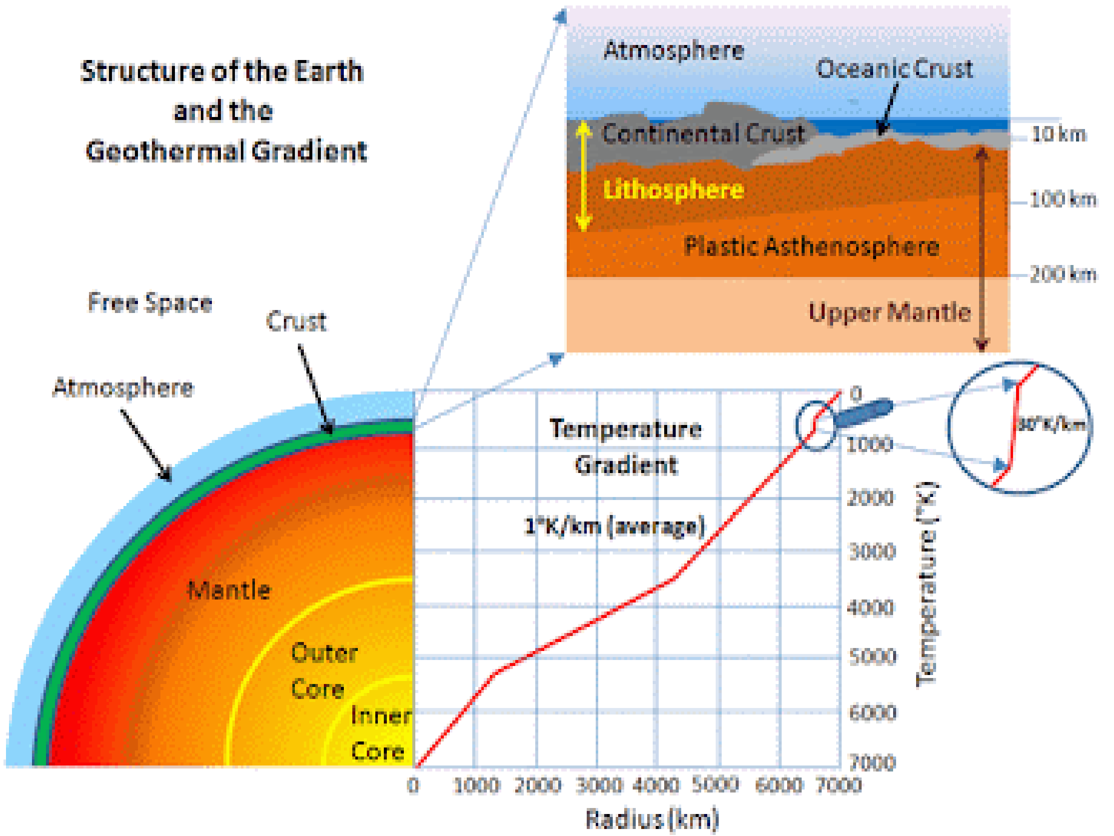
•The Outer Core-

The outer core is the portion of the core that is the closest to the mantle of the Earth. The outer core has a thickness of 2,200 kilometers (1,367 miles) and is composed of liquid iron and nickel. The alloy that is formed, NiFe, has a very high temperature. The outer core has a temperature range of 4,500°C (8,132°F) to 5,500°C (9,932°F). The liquid metal of the outer core has a very low viscosity, meaning that it deforms very easily and is malleable.

•The Inner Core-

The inner core is a hot, dense sphere composed of iron. The sphere has a radius of about 1,220 kilometers (758 miles) in size.The temperature of the inner core is approximately 5,200°C (9,392°F). In comparison to the outer core, on average the inner core is much hotter than the outer core. 5,200°C (9,392°F) is far beyond the melting point of iron. Despite that, you might expect the inner core to be liquid like the outer core but due to the inner core's intense pressure (and the entire rest of the planet and its atmosphere) the iron is prevented from melting. In short, the pressure and density are simply too great for the iron atoms to change state to a liquid. Because of these uncommon characteristics, most scientists prefer to interpret and understand the inner core not to be solide by as plasma.

Another unique characteristic of the inner core is that it rotates eastward, like the surface. The inner core makes a rotation about every 1,000 years. The Earth's magnetic field is also theorized to be as a result of the inner cores rotation.



Geothermal Gradient and temperature vs depth graph of earth

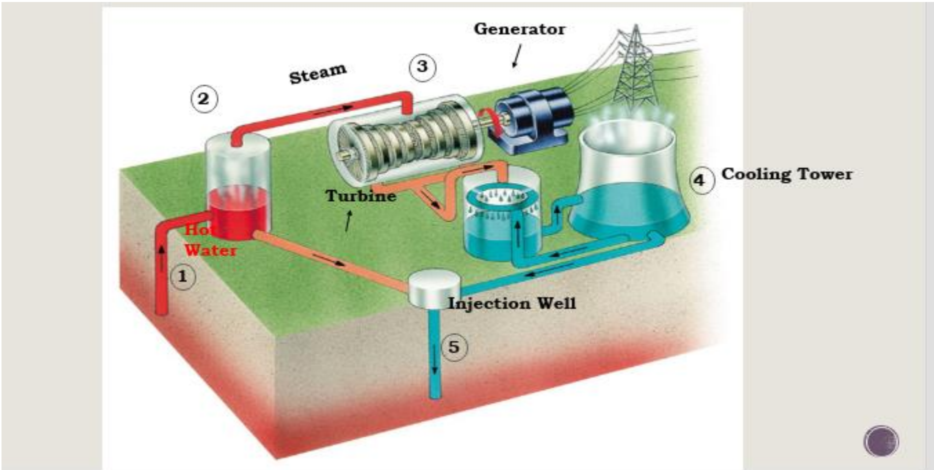
HISTORY OF GEOTHERMAL POWER PLANT

- Prince Piero Ginori Conti tested the first geothermal power generator on 4 July 1904 in Larderello, Italy. It successfully lit four light bulbs.
- Later, in 1911, the world's first commercial geothermal power plant was built there
- Italy was the world's only industrial producer of geothermal electricity until 1958.
- In 1958,Newzealnd became the second major industrial producer of geothermal electricity.
- In 1960, Pacific Gas and Electric began operation of the first successful geothermal electric power plant in the United States at The Geysers in California.
- The binary cycle power plant was first demonstrated in 1967 in Russia and later introduced to the USA in 1981.
- Worldwide, 11,400 megawatts (MW) of geothermal power is online in 24 countries in 2012

Prince Piero Ginori Conti with first geothermal power plant in 1904

The world's first geothermal power station in Laederello Southern Tuscany ,Italy 1911

Geothermal Power Plants



A geothermal power plant uses steam obtained from these geothermal reservoirs to generate electricity. Wells are drilled at the appropriate locations to bring this geothermal energy up to the surface. A mixture of steam and water is collected from the production well. Steam separators are employed to separate the steam and use it to operate turbines. The further process is quite similar to a thermal power plant - steam turbines run the generators and, hence, electricity is generated. The condensed steam and the water collected from the production well are injected back into the reservoir through the injection well.

This is, however, a general working principle of a geothermal power plant. The particular working of the plant depends upon the type of the plant.

Construction of Geothermal Power Plant-

1.Geothermal Vents-The geothermal vent is the first component of a geothermal plant. A geothermal vent is a deep well drilled into the Earth that the power plant uses to tap into the Earth's heat. A geothermal plant may have two goals for its vent; most current geothermal plants draw superheated, pressurized water upward; these are called flash steam plants. Geothermal plants may also simply dig far enough underground, as many as three kilometers, to reach a point where the Earth is warm enough to boil water, these are called dry steam vents.

2.Steam Generator-

Another key component of a geothermal plant is the steam production unit, which can take multiple forms. In a flash steam vent, superheated pressurized water is drawn from its place underground to low-pressure tanks. The pressure of the Earth kept the water in liquid form despite its high temperature, and by removing that pressure the hot water instantly turns to steam, hence the term flash steam. In a dry steam plant, the plant technicians pump water to the bottom of the vent where the Earth’s heat boils the water and turns it into steam.

3.Turbine-

Regardless of the plant type, both flash steam and dry steam plants pump the steam from the geothermal vent to a large turbine. The steam passes this turbine, turning it in the process. This turbine is attached to an electric generator, and as the turbine turns the generator turns the mechanical energy into electric energy, thus converting the heat from the Earth into usable electricity.

4.Condenser-

After the steam passes through the turbine, it continues to a condenser chamber. This chamber condenses the steam back into liquid water by cooling it. The excess heat lost as the steam turns to liquid water may be used for other applications, such as heating or greenhouse farming. The cooled liquid water is then typically pumped back into the ground to either restart the boiling process for dry steam or to replenish the natural heated aquifer for flash steam plants.

Working of geothermal power plant-

WELLS ARE DRILLED-

A production well is driiled into a known geothermal reservoir .Typically an injection well is also drilled to return used geothermal fluids to the geothermal reservoir .Hot geothermal fluids flow through pipes to a power plant for use in generating electricity.

STEAM TURNS THE TURBINE-

Hot, pressurized geothermal fluid, or a secondary working fluid, is allowed to expand rapidly and provide rotational or mechanical energy to turn the turbine blades on a shaft.

THE TURBINE DRIVES THE ELECTRIC GENERATOR-

Rotational energy from the turning turbine shaft is used directly to spin magnets inside a large coil and create electrical current. The turbine and generator are the primary pieces of equipment used to convert geothermal energy to electrical energy.

TRANSMISSION - POWER LINES DELIVER ELECTRICITY-

Electrical current from the generator is sent to a step-up transformer outside the power plant. Voltage is increased in the transformer and electrical current is transmitted over power lines to homes, buildings, and businesses.

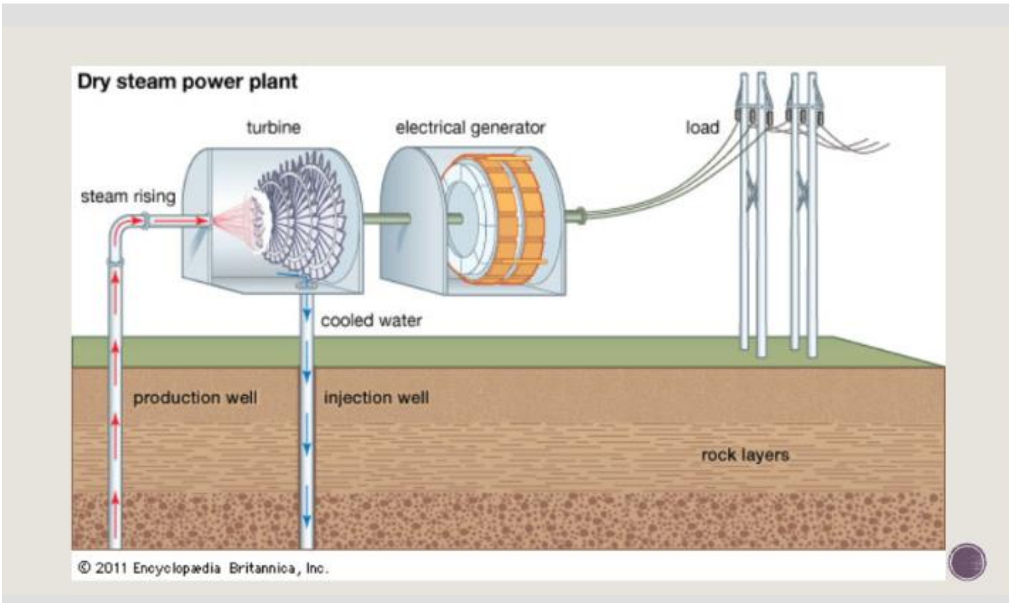
There are three types of geothermal power plant-

1.Dry steam power plant

2.Flash steam power plant

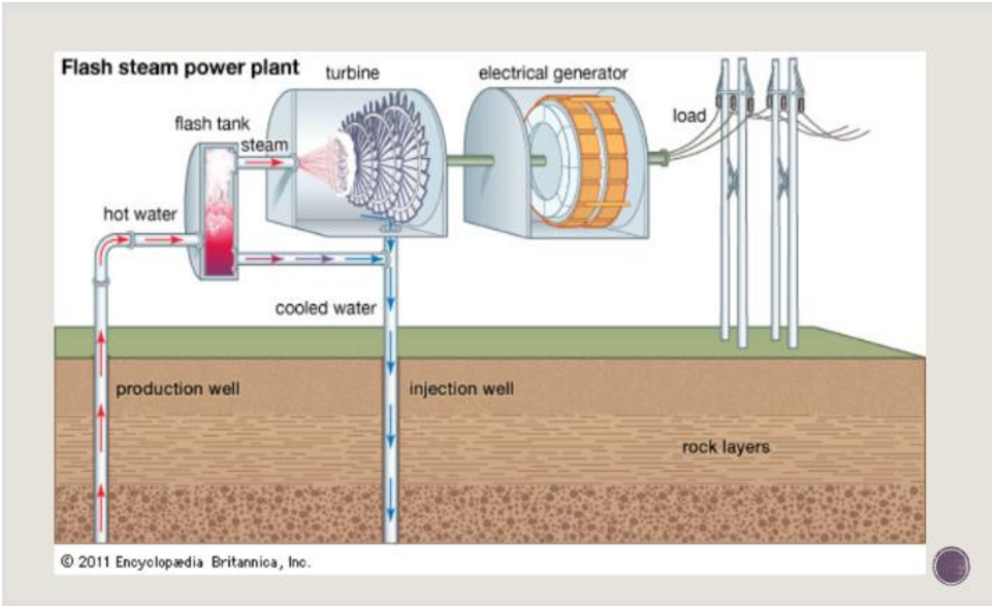
3.Binary-cycle power plant

1.Dry steam power plant-



Dry steam stations are the simplest and oldest design. This type of power station is not found very often, because it requires a resource that produces dry steam, but is the most efficient, with the simplest facilities. In these sites, there may be liquid water present in the reservoir, but no water is produced to the surface, only steam.Dry Steam Power directly uses geothermal steam of 150 °C or greater to turn turbines. As the turbine rotates it powers a generator which then produces electricity and adds to the power field.Then, the steam is emitted to a condenser. Here the steam turns back into a liquid which then cools the water.After the water is cooled it flows down a pipe that conducts the condensate back into deep wells, where it can be reheated and produced again. At The Geysers in California, after the first 30 years of power production, the steam supply had depleted and generation was substantially reduced. To restore some of the former capacity, supplemental water injection was developed during the 1990s and 2000s, including utilization of effluent from nearby municipal sewage treatment facilities.

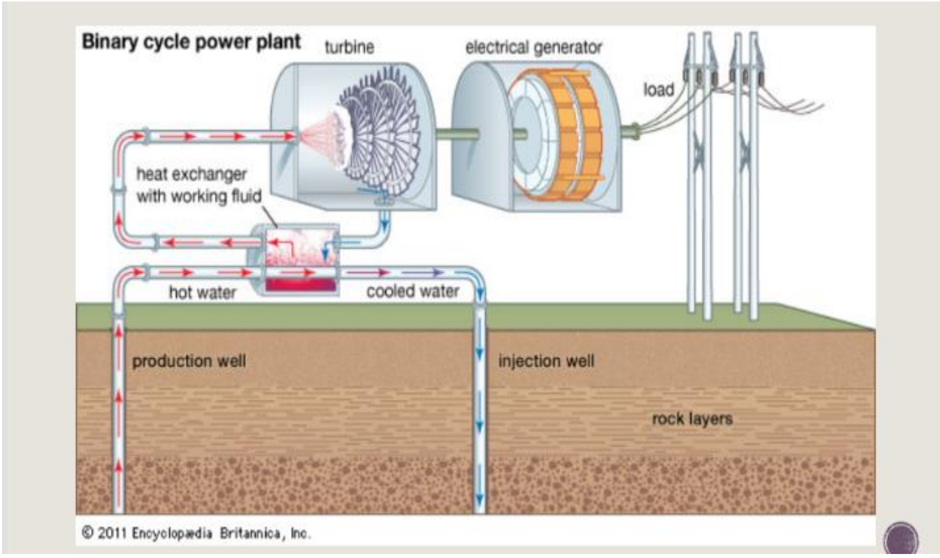
2. Flash steam power plant-



Flash steam power plants - These are the most common type of geothermal electricity plants in operation today. They are similar to dry steam plants; however, the steam is obtained from a separation process called flashing. The steam is then directed to the turbines, and the resulting condensate is sent for re8 Geothermal Power Technology Brief

injection or further flashing at lower pressure (IEA-ETSAP, 2010) (Figure 5). The temperature of the fluid drops if the pressure is lowered, so flash power plants work best with well temperatures greater than 180°C. The fluid fraction exiting the separators, as well as the steam condensate (except for condensate evaporated in a wet cooling system), are usually re-injected. Flash plants vary in size depending on whether they are single- (0.2-80 MW), double - (2-110 MW) or triple-flash (60150 MW) plants (S&P Global Platts, 2016).

3.Binary-cylce power plant-



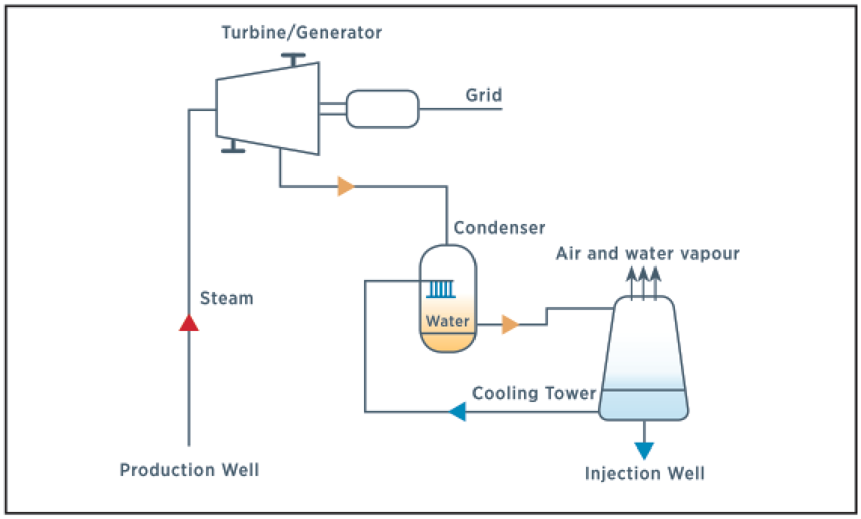
Binary cycle geothermal power generation plants differ from Dry Steam and Flash Steam systems in that the water or steam from the geothermal reservoir never comes in contact with the turbine/generator units. Low to moderately heated (below 400°F) geothermal fluid and a secondary (hence, "binary") fluid with a much lower boiling point that water pass through a heat exchanger. Heat from the geothermal fluid causes the secondary fluid to flash to vapor, which then drives the turbines and subsequently, the generators.

Binary cycle power plants are closed-loop systems, and virtually nothing (except water vapor) is emitted to the atmosphere. Because resources below 300°F represent the most common geothermal resource, a significant proportion of geothermal electricity in the future could come from binary-cycle plants.

There are also other power plants which are given with their diagrams-

1.Direct steam plant-

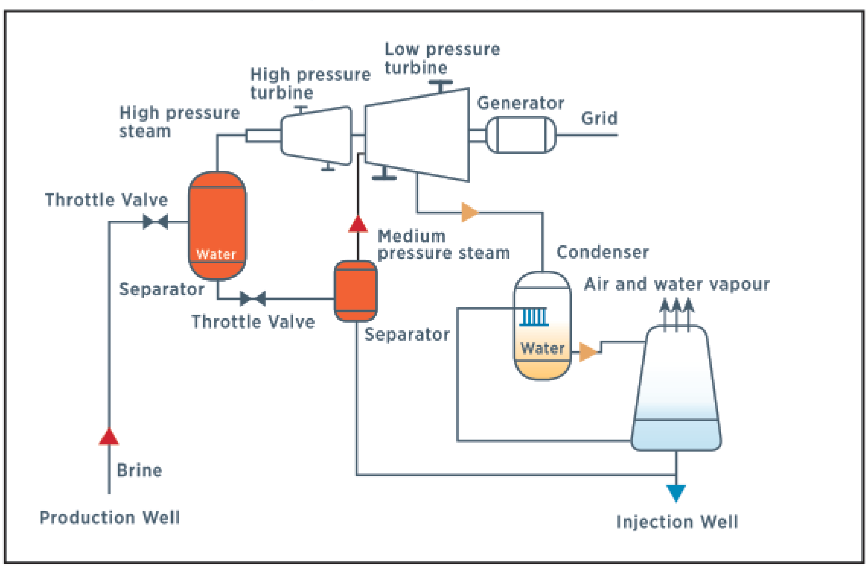
Figure 4: Direct steam plant



Source: IRENA, 2017c

2.Double flash Plant-

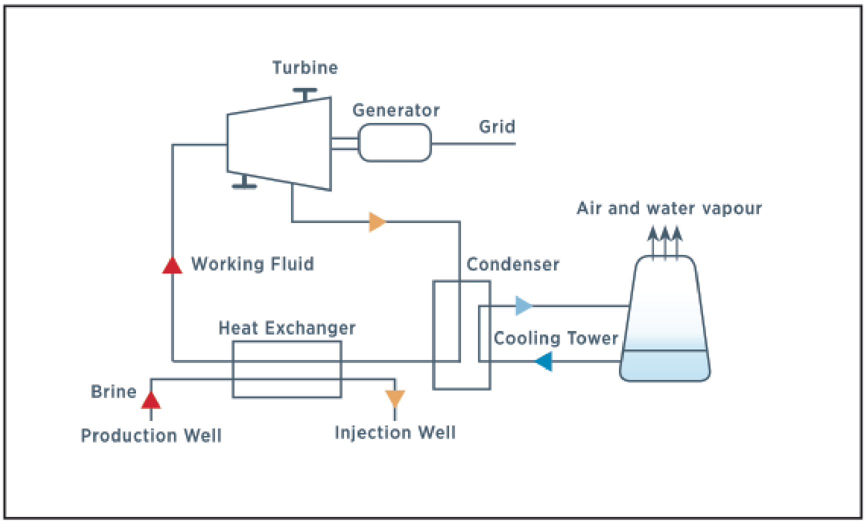
Figure 5: Double flash plant



Source: IRENA, 2017c

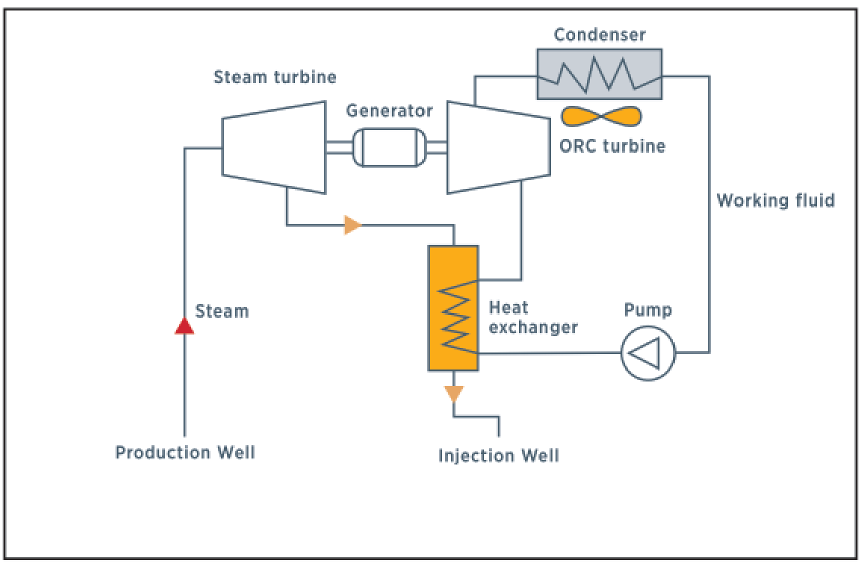
3.Binary Plant-

Figure 6: Binary plant



4.Geothermal combined-cycle plant

Figure 7: Geothermal combined-cycle plant



Adapted from: ORMAT, 2017

Advantages

Geothermal power plants have lots of advantages-

- **Comparatively ecologically clean**- Unlike coal-fired power plants, geothermal ones use a renewable heat source with a constant supply. Studies have shown that only 6.5% of the total world potential is involved in the industry, which means that energy will last for many years in advance. In addition, the amount of greenhouse gas from geothermal power plants is only 5% in the contrary with coal-fired power plants.
- **More energy**- Geothermal power stations have great capacity – they can gravely help in meeting the demand for energy that grows every year, both in developed and developing countries.
- **Stable prices-** Simple power plants depend on fuel, so the cost of their electricity is varying, based on the market price of fuel. Since geothermal power plants do not use fuel, they do not need to take into account its cost, and they can offer their customers stable electricity costs.
- **Low operating costs-** Geothermal installations require minimal maintenance compared to conventional power plants. As a result, they are reliable and cheap in operation.
- **Renewable and sustainable source-** Geothermal energy will never end, unlike non-renewable energy sources. As long as the earth supports our lives, geothermal energy will exist and geothermal power will work.
- **Permanent power supply-** Unlike other renewable energy sources, geothermal one can provide a constant supply of energy – 24 hours a day, 7 days a week, 365 days a year, regardless of external factors. For example, solar panels can produce electricity only during the day, and wind turbines produce energy only with sufficient wind.
- **Small area-** They occupy less space than their coal, oil and gas equivalents. Although they will reach far below the earth's surface, their area will be negligible.
- **Low noise work-** There is a little noise in the production of geothermal energy. The main source of noise is the fans that are in the cooling systems. To reduce its level, engineers can install in the generator shops materials with high damping properties. It helps to reduce noise pollution.
- **Energy security-** Using local geothermal resources, the need to supply sources from other countries reduces, which, in turn, lowers dependence on external influences and helps to increase our energy security.

Disadvantages

As it often happens, some advantages can smoothly go into disadvantages, everything will depend from which side to consider a particular question. No wonder that there are two sides of the same coin.So, the disadvantages of geothermal power plants are-

- **Ecological problem-** High environmental consumption of fresh water can be a loss for the environment, which will ultimately lead to its deficit. Liquids extracted from the earth during drilling contain a large number of toxic chemicals (including arsenic and mercury), as well as greenhouse gases (such as hydrogen sulfide, carbon dioxide, methane, ammonia and radon). If they are incorrectly disposed or treated, they can get into the atmosphere or leak into groundwater and damage the environment and human health.
- **Geographical limits-** Geothermal activity is the highest along the tectonic fault lines in the earth's crust. Exactly in these places the geothermal energy has the greatest potential. The drawback is that only few countries can use geothermal resources. Therefore, while having a look at their geographical peculiarities, such countries are the main producers of geothermal energy: the USA, Iceland, Kenya, Indonesia.
- **Seismic instability-** There are reasons to believe that geothermal structures have caused underground shakings in different parts of the world. Despite the fact that seismic activity is often insignificant, it can lead to building damage, injuries and death. In 2006, scientists blamed the geothermal exploration project in Basel (Switzerland) for causing a series of earthquakes. Some of these earthquakes were estimated in 3.4 points on a Richter scale. Further research in 2011 revealed a strong correlation between geothermal exploration and seismic activity.
- **Expensive construction-** Geothermal power plants require significant investments. Although they have low operating costs, the cost of their construction may be much higher than coal, oil and gas plants. Much of these expences concerns the exploration and drilling of geothermal energy resources. Traditional power plants do not require exploration and / or drilling. What is more, geothermal power plants require specially developed heating and cooling systems, as well as other equipment that can withstand high temperatures.
- **Possible exhaustion-** Studies show that without careful management, geothermal tanks can be exhausted. In such cases, the geothermal power plant will become unnecessary until the tank is restored. The only inexhaustible option is to get geothermal energy directly from the magma, but this technology is still in the process of development. This option is worth investing at least because the magma will exist billions of years.

CONCLUSION

In the case of geothermal energy, several topics are identified as being key to its advancement in the Indian context. These are related to cost reduction, sustainable use, expansion of use into new geographical regions, and new applications. The priorities are categorized as “general” or specific to RD&D.

General priorities:

 Life-cycle analysis of geothermal power generation and direct use systems.

 Sustainable production from geothermal resources.

 Power generation through improved conversion efficiency cycles.

 Use of shallow geothermal resources for small-scale individual users.

 Studies of induced seismicity related to geothermal power generation (conventional systems and enhanced geothermal systems).

Specific R&D priorities:

 Commercial development of EGS.

 Development of better exploration, resource confirmation and management tools. Development of deep (>3 000 m) geothermal resources.

 Geothermal co-generation (power and heat).

Geothermal electricity has already proven itself to be a clean, reliable, and comparatively inexpensive alternative to fossil fuels. Continued government-funded research in exploration and reservoirs, drilling, and energy conversion, performed in close collaboration with industry, offers considerable promise for significantly lowering the cost of geothermal power production. Combined with deployment programs and environmentally sensitive energy policies, geothermal can become a major energy contributor throughout the Indian States and in many countries around the world. There ca be the Potential Applications of geothermal power in India as Power generation , Cooking , Space heating Use in greenhouse cultivation, Crop drying etc

Future Prospects

Currently, two main trends are evident: 1) thedevelopment of conventional geothermal power plants in geologically favourableregions, mainly in developing like Indonesia and the Philippines, 2)dissemination of geothermal heat pumps systems in countriesnot yet applying this technology. Futuretechnologies like Enhanced Geothermal Systems (EGS, [10]) for co-generation will see rapid and wide-scale distribution worldwide, provided their establishment and operational experience confirm the expected results.Quantitative development trends for coming decades can only be estimated. Figure 1 is from a recent study prepared for the Intergovernmental Panel on Climate Change, IPCC [8]. It is considered possible to increase the installed world geothermal electricity capacity from the current 10 GW to 70 GW in 2050 with present technology, and to 140 GW with enhanced technology. The potential may be estimated orders of magnitude higher based on enhanced geothermal systems (EGS) technology.

Some Of the major companies planning to enterThe geothermal energy in India are given below:

1.Tata Power-Tata power holds an 11.4 percent stake in Geodynamics Ltd.,., which is building a geothermalPlant with Origin Energy Ltd. In Australia. The Company plans to set up two 5 MW plants in the western state of Gujarat.

2.Thermax – It is a major publicly listed power equipment company. The company is deciding to explore Geothermal plant in Ratnagiri Region in western Maharashtra state. A 3 MW Project is slated to be set up in Puga Valley in Ladak.

3.Panax Geothermal – Panax is an Australian company which has tied up with Geosyndicate to develop a 60 MW plant in Puga, Himachal Pradesh. However the project is still inThe Very initial stage With permits .

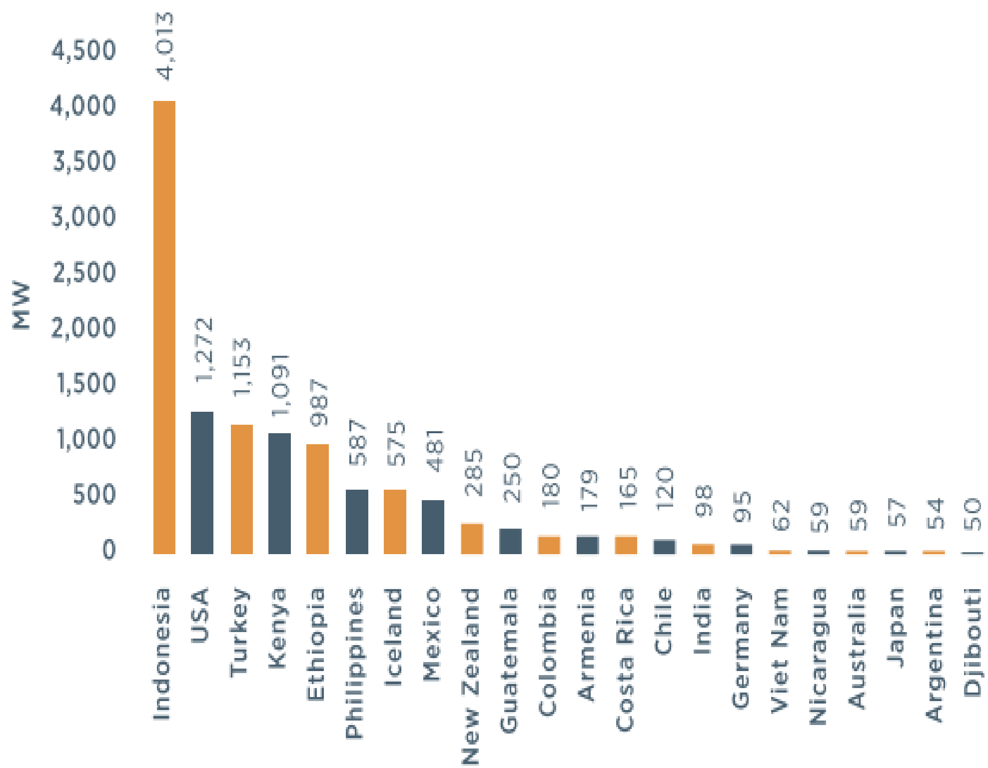
4.Avin Energy – This is a small Company which Plans To Develop a 5 MW plant in Gujarat. However it seems to Being having difficulty in finding financing and Seems to have changed its focus to solar energy.

5.NTPC– The government owned power utility has its fingers in all the energy pies in the country. The company Had tied up with National Geophysical Research Institute (NGRI) to identify potential sites for geothermal power projects in the country but nothing has come up as of now.

*Table 2: Projected geothermal capacity (MW)**

Country	2016	2025	>2025**
Australia	0.8	0.8	462.5
Chile	-	98	298
China	28.4	28.43	98.4
Costa Rica	213.5	368.5	368.5
Croatia	-	16.5	36.5
El Salvador	204.4	204.2	304.4
Ethiopia	8.5	178.5	278.5
Germany	13.2	13.2	66.1
Guatemala	54.2	54.2	134.2
Iceland	612.4	752.4	1 322.4
Indonesia	1 468.9	3 410.7	4 270.2
Italy	946.4	946.4	1 142.4
Japan	545.5	612.0	935.7
Kenya	617.16	932.16	1 247.2
Mexico	882.9	957.9	1 252.9
New Zealand	1 058.8	1 128.8	1 483.8
Nicaragua	133.2	190.2	412.2
Papua New Guinea	56	56	166
Philippines	1 943.4	2 104.4	2 834.4
Portugal	27.8	27.8	53.8
Russian Federation	95.2	95.2	150.2
Turkey	409.3	721.6	997.6
USA	3 490.3	3 874.3	5 425.3

Figure 12: Planned capacity additions for geothermal power by country



Source: GEA, 2016

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