

# An Overview of Geothermal Energy for Future Electricity Generation

Savitha R, Dr.P. Pradeepa

Department of Electrical and Electronics Engineering, Faculty of Engineering and Technology, Jain (Deemed-to-be University), Bengaluru, India

Email Id- savi.msrit@gmail.com

**ABSTRACT:** *Geothermal energy is a promising technology for the electricity generation in the future. Rapid growth in the climate change and global warming due to generation of the power based on the non-renewable energy resources such as fossil fuels and coal promotes the utilization of renewable energy resources for the electricity generation in the future. Geothermal energy is a renewable energy resource that has been associated with the heat generation by the core of the earth. By using this heat, the electricity has been generated in cleaner manner. The main benefits of the geothermal energy are availability, capacity and efficiency. This review paper discussed about the importance of the geothermal energy in the future prospects of electricity generation. In the near future, the development of technology based on geothermal energy will reduce the cost and increase the productivity of the geothermal based reservoirs. It will have huge positive socio-economic impact in the future.*

**KEYWORDS:** *Energy, Electricity Generation, Renewable Energy Resources, Geothermal Energy, Power Plant.*

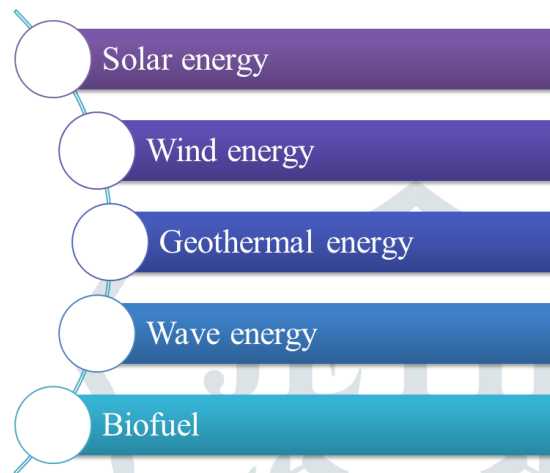
## INTRODUCTION

Renewable energy resources are well known for its availability in the nature. There are mainly five types are renewable resources such as wind energy, solar energy, wave energy and biofuels present in the nature. These energy resources are available in the nature in unlimited quantity that has been utilized for different purposes such as electricity generation and heat generation. The main benefit of the consumption of the renewable energy resources is that it doesn't produce any hazardous products or any harmful gases that has adverse impact on the environment[1]. Commercial technologies for the generation of electricity generally utilize non-renewable energy resources such as fossil fuels and coal. The energy generated by using coal and fossil fuels produce wastes and greenhouse gases at large scale that misbalances the nature of ecosystem. Since, the wildlife, health of the humans as well as animals depends on the ecosystem that is why it must be ensure the conservation of the environment.

As the population increases the demand of the energy consumption also increases significantly. The dependency only on the non-renewable energy resources for the electricity generation continuously damages the environment that has to be minimized or eliminate in order to conserve our ecosystem. Among all the renewable energy resources, geothermal energy has its own advantages such as availability, capability to produce electricity on large scale and inexpensiveness etc[2]. It mainly depends on the heat produced by the core of the earth. The temperature of the core of the earth is very high as similar as temperature of the sun. High temperature of the earth's core is the main source of the geothermal energy. Currently, the utilization of the geothermal energy in terms of production of the electricity is continuously increases. Developed and developing nation shows an interest to establish the geothermal power plants for the production of the electricity. Since it has huge positive socio-economic as well as environmental impact, the adaptation of this technology has been increase in recent years. USA is the biggest producer of the electricity generation by using the electro thermal energy followed by the Indonesia, Philippines, Turkey, New Zealand and Mexico[3]. This review article provides an overview of electricity generation by utilizing the geothermal energy. It will cover every aspect associated with the geothermal energy including how electricity generated by using the geothermal energy, different types of geothermal plants, merits and demerits followed by the future prospects of the geothermal energy.

## RENEWABLE ENERGY RESOURCES AND ITS SIGNIFICANT

The renewable energy resource is well known for its sustainability that means this energy will never run out or present in the nature in endless quantity. Since, the raw material present on the earth is in limited quantity and heavy use of this material can make things more difficult. Renewable energy resources are best alternative for the production of the electricity at large scale in order to fulfill the demand by the society[4]. It reduces generation of the wastes significantly that will help in minimizing the pollution level. There are mainly five types of the renewable energy resources that are shown in the Figure 1.

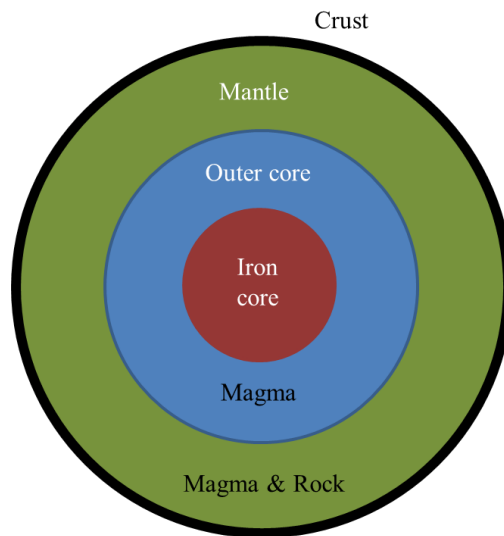


**Figure 1: Schematic Illustration of the Renewable Energy Resources for Electricity Generation**

The renewable energy resources are completely different from the non-renewable energy resources such as fossil fuels and coal in terms of availability, diversity and potential applications. These energy resources can be utilize from anywhere on the earth because these are natural resources. Among the all advantages, the most important significance is it doesn't produce greenhouse gases such as carbon dioxide (CO<sub>2</sub>) and other harmful gases. The primary objective of the utilization of the renewable energy resource is to conserve the ecosystem because it was heavily damaged by the consumption of the non-renewable energy resources. It also ensures the energy security for long term[5]. The major issue is implementation of these technologies for the production of the electricity. It requires proper regulatory so that the process of implementation can be easier. For instance, solar energy offers various advantages and technologies based on the solar energy has been already matured. Since, solar energy based technology has been already known to the most of the people that is why it is there is chance for the development of the technology. Like that other renewable energy resources that are in emerging stage needs to be funded for Research & Development(R&D) so that each technology can take up to the next level[6].

### GEOTHERMAL ENERGY

Geothermal energy generally referred to the energy provided by earth. It is generated by the heat present inside the earth. As we go inside the earth, the temperature continuously increases. The inner core temperature is very high as temperature of the surface of the earth[7]. The internal structure of the earth has been shown in the Figure 2. Geothermal energy generally utilizes for the different purposes including in order to heat houses as well as buildings, bathing and for the electrical energy generation.



**Figure 2: Schematic Representation of the Internal Structure of the Earth**

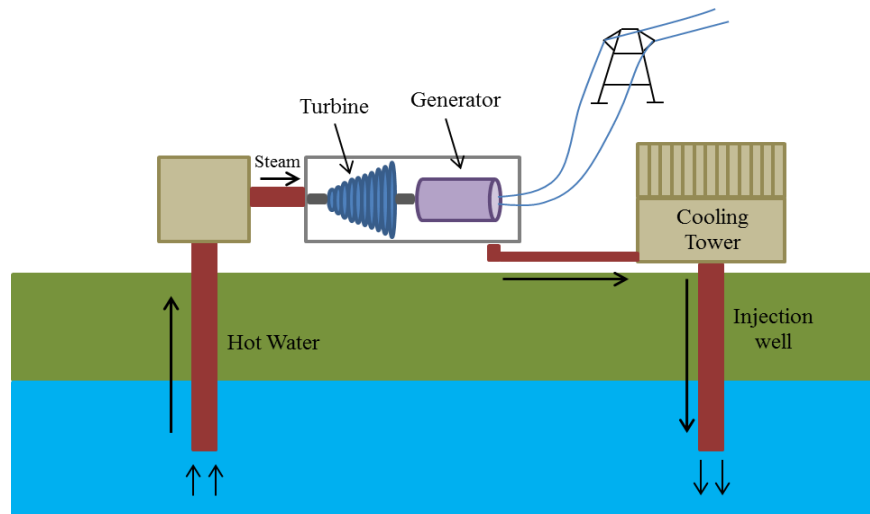
The generation of the geothermal energy is based on the decaying of the radioactive elements in the core of the earth. The process of the decaying of the radioactive elements occurs in the rock present in the core of the earth. As shown in the Figure 2, the earth consists of four different structures or parts: iron core, outer core, mantle and crust.

- The diameter of the iron core is approximately 2414 Km.
- The thickness of the outer core is about 2414Km.
- The outer core of the earth covered by the mantle and the thickness is approximately 2897 Km
- The crust is the upper part of the earth which consists of oceans and continents and the thickness of the crust is approximately 5 to 8 Km.

Different studies have been done for the measurement of the temperature of the inner core. But earlier it was very difficult for the scientist to evaluate the temperature because as we go inside the earth, the temperature increase to the extreme level. Some researchers and scientists have been reported that the temperature of the inner core of the earth is approximately 6000 degree centigrade. When the crust of the earth breaks, it cracked down and converts into different pieces that are usually known as tectonic plates. When magma present in the outer core comes near the edges of tectonic plates leads to the volcanoes. Volcano is the major source of the lava that comes out from the occurring of the volcanoes and very less amount of the magma is present. In the deep, when the magma comes in contact with the water as well as rocks, it produces steam.

### **ELECTRICITY GENERATION UTILIZING GEOTHERMAL ENERGY**

Geothermal energy mainly utilizes for the generation of the electricity. Under the crust (i.e. upper or top layer) of the earth, there is a layer called magma layer that continuously produces heat due to the decay of the radioactive element (i.e. Uranium etc.). The thermal energy inside the earth is far greater than that has been produced by the natural gases or any other fossil fuels. The electricity generation principle through the geothermal energy is very simple, the design of the electricity generation power plant based on geothermal energy is shown in the Figure 3.



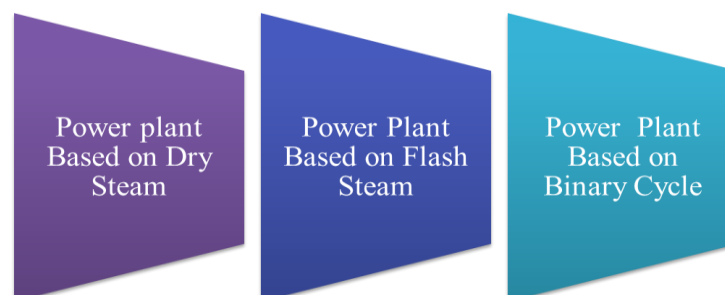
**Figure 3: Schematic Illustration of the Design of the Electricity Generation Power Plant Based on the Geothermal Energy**

In order to produce electricity through the geothermal energy, hydrothermal fluids or water is pumped inside the earth through the injection wells. When these liquids interact with the magma present inside the earth, the water transforms into steam. This steam travels through the pipe and reaches the power plants. A chamber is associated with the steam pipes; this chamber contains a turbine and a generator. When steam interacts with the turbines, the high flow of the steam rotates the turbine, which subsequently rotates the generator to produce electricity based on the electromagnetic induction principle. Turbines are the devices that convert the kinetic energy of fluids such as gases, water, and air into rotational energy. The size of the turbines depends on the application area. The pressure from the steam is very high, which is why it rotates the turbines in a more efficient way. Rapid development in the field of turbine designs has shown the direction to the advanced energy generation power plant based on the geothermal energy.

The chamber that consists of turbine and generator flows the steam to the cooling tower that stores the water that has been converted from the steam after cooling down. The stored water is again pumped down to the earth. The flow of the water continuously takes place in a cycle for the generation of electricity through the geothermal energy [8]. In order to establish the geothermal power plant, a specific place is needed to be found because it can be set up at any place. This is the basic requirement for setting up the geothermal power plant. Efficiency of the power generation through the geothermal energy heavily depends on the processing of the steam.

### TYPES OF PLANTS OF GEOTHERMAL ENERGY

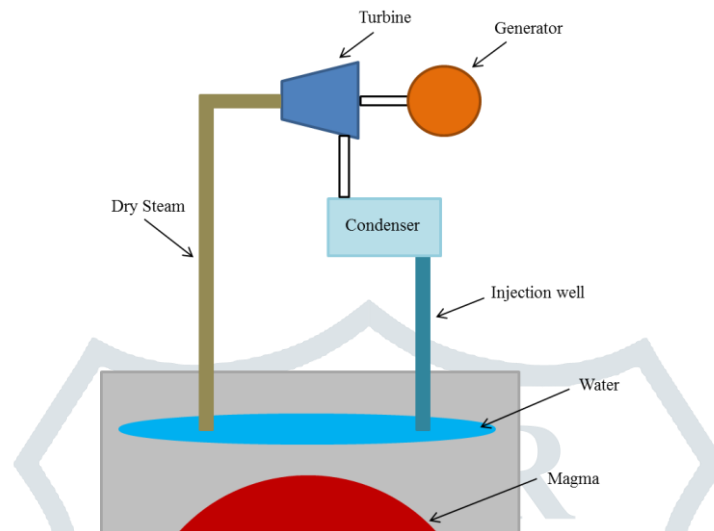
For the production of electricity through the geothermal energy, it has been categorized into three types as shown in Figure 4. These technologies have been developed in order to expand their geographical area. Since, geothermal energy greatly depends on the geographical conditions, that is why it must be expanded to various technologies for the establishment of the geothermal power plants on various geographical locations.



**Figure 4: Types of the Power Plant for the Generation of the Electricity based on the Geothermal Energy**

### 1. Geothermal Power Plant based on the Dry Steam:

The primary source of this technology is dry steam; the geothermal power plant based on the geothermal energy is shown in the Figure 5. It consists of various parts in order to utilize the geothermal energy for the production of the electricity. In this technology, hydrothermal fluids have been utilized for the production of the electricity. When hydrothermal fluids injected through the injection wells, it collected to the reservoirs.

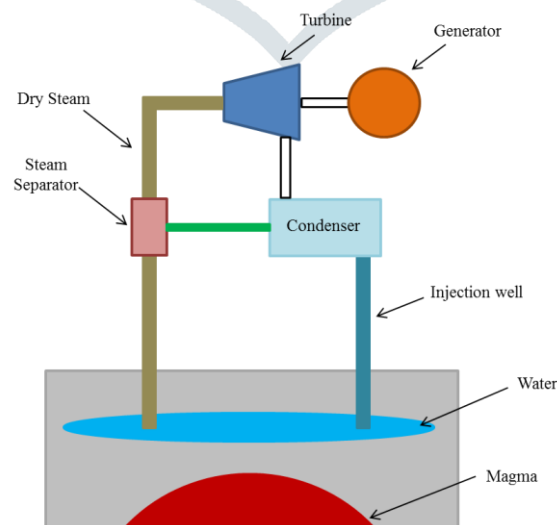


**Figure 5: Schematic Illustration of the Geothermal Power Plant based on the Dry Steam**

When it comes in the contact of the magma, it directly converts to the steam and high pressure of steam when interacts with the turbines, they start converting the flow kinetic energy of the steam to the rotational energy. Since the turbines are connected to the electric generator subsequently starts producing the electricity. The processed steams by the turbines are now passing through the condenser chamber for converting the steam back in the form of hydrothermal fluid and inject once gain to the hydrothermal reservoirs.

### 2. Geothermal Power Plant based on the Flash Steam:

The technology based on the steam separation technique as shown in the Figure 6. In this technology, the hot water collected from the hydrothermal reservoirs. In the steam separator, the hot water comes inside the separator with very high pressure and the hot water keep moves in the up direction and the pressure reduces significantly as it moves up direction. Based on the decreasing in pressure of hot water starts converting the hot water to the steam and the separator make sure to separate these two components.



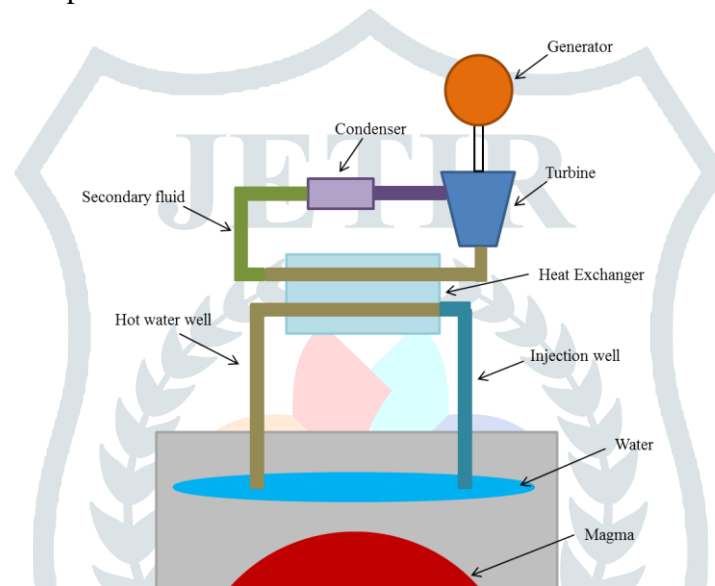
**Figure 6: Schematic Representation of the Geothermal Power Plant based on the Steam Separator**



The rest of the design of the thermal power plant as same as for the based on the dry steam. After generating the steam by the steam separator, it transfers to the turbines. Because of high pressure of the steam, the turbines start rotating and converts to the rotational energy from the flow kinetic energy of the steam. The main advantage of this technology is minimizing the wastage of the hydrothermal fluids such as water. This technology requires the temperature greater than  $185^{\circ}\text{C}$  for the generation of the electricity based on the flash steam.

### 3. Geothermal Power Plant based on the Binary Cycle:

This is the last one geothermal energy based electricity generation. The basic configuration of the geothermal energy power plant based on the binary cycle is shown in the Figure 7. It utilizes two fluids; first one is called as primary fluid. Primary fluid is hot water that has been extracted from the hydrothermal reservoirs. When primary fluid (i.e. hot water) interact with the secondary fluid (i.e. liquid having the boiling point less than water), it starts producing high pressure steam due to the conversion of the secondary fluid to the steam. The remaining operational mechanism as same as earlier two technologies. The main advantage of this technology is to reduce the operational temperature.



**Figure 7: Schematic Illustration of the Geothermal Energy Power Plant based on the Binary Cycle**

### MERITS AND DEMERITS OF GEOTHERMAL ENERGY

Since, geothermal energy belong to the renewable energy resources that is why it offers various benefits that can be utilized for the generation of the electricity in order to fulfill the demand of the electricity by growing population. Geothermal energy is an emerging technology that is why it has some drawback also because every technology in the beginning facing difficulties in the implementation. The merits and demerits associated with the geothermal energy are listed in the Table 1.

**Table 1: Merits and Demerits Associated with the Geothermal Energy for the Production of the Electricity**

Merits	Demerits
Geothermal energy is friendly to the environment as compared to the non-renewable energy resources. It produces carbon in minimal amount.	The main disadvantage of this technology is that it is highly depend on the geographical location. The power plant based on the geothermal energy has been established only where it is available or accessible.
It is a renewable energy resources that means it will never run out in the quantity and cover maximum geographical area.	Geothermal energy doesn't generate any kind of harmful gases that affects the health of the environment but while making holes for the establishment of the geothermal power plants

	inside the earth, there are various harmful gases present inside the earth release out to the atmosphere.
Has huge potential to generate the electricity as large scale in order to fulfill the requirement of the electricity by the growing population.	It creates the chances of earthquakes because it is dealing with the internal structure of the earth.
Due to the large capital investment in the R&D, energy generation based on the geothermal energy evolve continuously. It has been open up the path to develop advanced technologies based geothermal energy for the production of the electricity	The power plants establishment based on the geothermal energy needs heavy financial capital. It requires generally \$3-\$8 million for the generation of 1MW electricity. Initial investment is very high in the geothermal energy based electricity generation.
Geothermal energy is highly reliable, and the electricity generation output can be easily measured because it doesn't fluctuate much like other renewable energy resources such as wave energy or solar energy etc.	In order to maintain the flow cycle of the water to the reservoirs, proper management is necessary that increase the capital load on the geothermal power plant.

### FUTURE PROSPECTS OF GEOTHERMAL ENERGY

Electricity generation based on the geothermal energy has huge potential in order to fulfill the requirement of the electricity by growing population. Availability is the major advantage of the geothermal energy that makes it for long term player for the generation of the electricity. Since the electricity generation based on the geothermal energy is highly depend on the geographical location that makes this technology to restrict in some places. The recent advancement in the geothermal thermal based technologies has been focused on this issue efficiently and solves this problem in more effective manner. Since, continuous investment put in the R&D of geothermal energy that leads to the inexpensive electricity generation with the technology evolvment. Since, every new technology in the beginning is expensive due to the lack of skilled workers in that field, poor regulations, lack of resources and less investment in the R&D. Many countries are now providing heavy investment in the geothermal energy sector in order to make this technology to be mature. Government support and effective regulation and initiative will open the pathways in order to take this technology to next level.

### DISCUSSION

Non-renewable energy resources are usually utilized at the commercial level for the production of the electricity. But the main drawback associated with the non-renewable energy resource based electricity generation is the emission of greenhouse gases and hazardous wastes. In contrast, the renewable energy resources best alternative of the other energy resources because it doesn't produce any kind of wastes and it is available in the nature in unlimited quantity. There are mainly five types of the renewable energy resources including wind energy, wave energy, solar energy, biogas and geothermal energy. Among all the renewable energy resources, geothermal energy has its own advantages as compared to the others. The first advantage is that the electricity production based on the geothermal energy can be predict easily because it doesn't fluctuate as other renewable energy resources. It is highly reliable energy resources for the production of the electricity. The other advantage is that it has huge potential to generate the electricity at the large scale for the fulfilling the electricity requirement by the growing population.

### CONCLUSION

Geothermal energy is the best alternative for the generation of the electricity at large scale. Recent advancement in the geothermal energy expands it area of establishment to the various geographical locations. Geothermal energy is highly reliable, ecofriendly and sustainable energy resources. Developed as well developing countries are now focusing on the geothermal energy for the electricity generation because there are fewer fluctuations that make this technology more reliable so that the capacity of the electricity generation can be easily predicted. There are some drawbacks are also associated with the geothermal energy such as earthquake risks, location

specific and releases some harmful gases from the earth during the establishment of the geothermal energy power plant. In order to tackle these challenges more R&D and regulations need to be implement so that this technology can take up to the next level. It is recommended that, government authorities as well industries must invest in the R&D because this is only way to make this technology more accessible. The effective regulation and implementation framework needs to apply properly and revise alternatively in required for the proper development of the geothermal energy sector.

#### REFERENCES

- [1] J. Twidell and T. Weir, *Renewable energy resources*. Routledge, 2015.
- [2] J. W. Tester *et al.*, "The future of geothermal energy," *Massachusetts Institute of Technology*, vol. 358, 2006.
- [3] J. W. Lund, D. H. Freeston, and T. L. Boyd, "Direct utilization of geothermal energy 2010 worldwide review," *Geothermics*, vol. 40, no. 3, pp. 159–180, 2011.
- [4] A. Kagel, D. Bates, and K. Gawell, "A guide to geothermal energy and the environment," 2005.
- [5] H. C. H. Armstead, "Geothermal energy: its past, present and future contributions to the energy needs of man," *London*, 1978.
- [6] J. W. Lund, D. H. Freeston, and T. L. Boyd, "Direct application of geothermal energy: 2005 worldwide review," *Geothermics*, vol. 34, no. 6, pp. 691–727, 2005.
- [7] J. Zhu, K. Hu, X. Lu, X. Huang, K. Liu, and X. Wu, "A review of geothermal energy resources, development, and applications in China: Current status and prospects," *Energy*, vol. 93, pp. 466–483, 2015.
- [8] E. Barbier, "Geothermal energy technology and current status: an overview," *Renewable and sustainable energy reviews*, vol. 6, no. 1–2, pp. 3–65, 2002.

