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Geothermal Energy: An Overview

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***Abstract*—** Geothermal Energy can contribute towards the power production to great extent if the thermal energy enclosed in it is profitably exploited. Geothermal Energy is, literally, the heat contained within the Earth's crust that can be used directly or indirectly. The thermal energy in the form of heat can be used either directly in the space heating or indirectly in the generation of electricity. Geothermal resources are easily available and thus the generation of electricity is possibly achieved at low cost and with high efficiency. It can be a pond or a volcano or a hot spring, however, the thermal energy available in these resources alters. Some resources have huge thermal energy such as volcanoes and some others have low amount of thermal energy such as hot springs. As we go down from the Earth's crust to the inner core, the heat content rises probably reaching up to the temperature of 4000°C. The Geothermal Energy of the Earth's crust originates from the formation of the planet and from the decaying of the radioactive elements. The Geothermal Gradient drives the conduction of the thermal energy in the form of heat from the core of the earth to the surface of the earth. Geothermal is one of the renewable energy that can provide 'base load power' as it gives a constant rate of supply which are not affected by the weather conditions or seasonal changes. In addition to this, there is no need of storage as the source of energy is available all the time. Geothermal Energy is reliable power source due to its all-time availability as compared to other sources of energy either conventional as well as non-conventional. Geothermal Energy can become the great source of energy to fulfil the needs of the present era if exploited in a lucrative manner.

***Keywords*—** Earth's crust; geothermal energy; power generation; thermal energy.

I. INTRODUCTION

Geothermal Energy is defined as the thermal energy that is present in the earth's crust, which is exploited by the man for its use to fulfil the power needs. The thermal energy is the amount of heat contained in the geothermal resource which can be used for the generation of electricity or for various other applications like space heating, water heating systems, air dryers, and many more [11]. The decaying of the radioactive elements present in the inner surface of the earth and the continuous heat losses from the formation of earth are mainly responsible for the generation of thermal energy [2]. Thermal Energy present in the form of heat in geothermal resources like hot springs are available all the time and thus there is no need of storage as it is already available in the form of stored energy which can be used at any instant of time [15]. Hence we can set up a power plant without any storage structure which reduces the cost factor and consequently increases its economy.

Since conventional sources of energy have been used by the people from ancient period of time and day by day, the demand of the energy is increasing and Consequently more and more usage of the conventional sources are taking place. Unfortunately, at some time in future, these resources will get extinct and hence, there will be a shortage of the energy sources. Moreover, with the continuous use of these conventional sources, the pollution level goes on rising drastically. There are a never ending emissions of 'Green House Gases' which ultimately leads to the 'Global Warming' and also contributes towards the pollution of the earth's atmosphere [11]. To surmount these adverse effects and to control the pollution, the concept of 'Renewable Energy' came into existence and has provided the pollution free energy sources. Geothermal Energy is one of them and we can use this source of energy without affecting the atmosphere and hence can bring some reduction in the emission of 'Green House Gases' [11].

II. HISTORY OF GEOTHERMAL ENERGY

Geothermal energy has been used by the people since ancient times. Hot springs and hot water ponds have been used by the people for personal as well as domestic purposes since Palaeolithic era [4]. People take baths in them and also cook their food.

In earlier times these sites of thermal energy were considered as sacred and people took baths on the specific occasions. Romans were the first who used a hot spring to feed the hot water in public baths and also in under floor heating. America's first district heating system was developed in 1892. The first geothermal power plant was set up in Larderello, Italy in 1904. After the success of the plant, many countries tried to follow the example.

In 1919, first geothermal well was drilled at Beppu, in Japan and then at Geysers in California. Gradually, more and more power plants were developed by many countries. After the Second World War, many countries were in favour of geothermal source of energy and considered it to be economically competitive with others sources of energy and began to exploit it [3-5].

III. GEOTHERMAL POTENTIAL IN INDIA

Geothermal Energy has a power potential of about 10,600 MW in India but unfortunately, this potential has not been developed completely yet. The 'Geological Survey of India' (GSI) has been prepared by the 'Geothermal Atlas of India' in 1991 [6a]. This survey describes almost 340 hot springs resources and more than 300 sites having geothermal energy. Nearly half of the hot springs are present in the Himalayan region. In Jammu and Kashmir, there are about 20 hot springs out of which 12 are present in the Chenab valley, 6 are present

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in the Kashmir valley and rest are present in the Ladakh region. Puga valley, in Ladakh region is observed as the excellent source of Geothermal Energy [7].

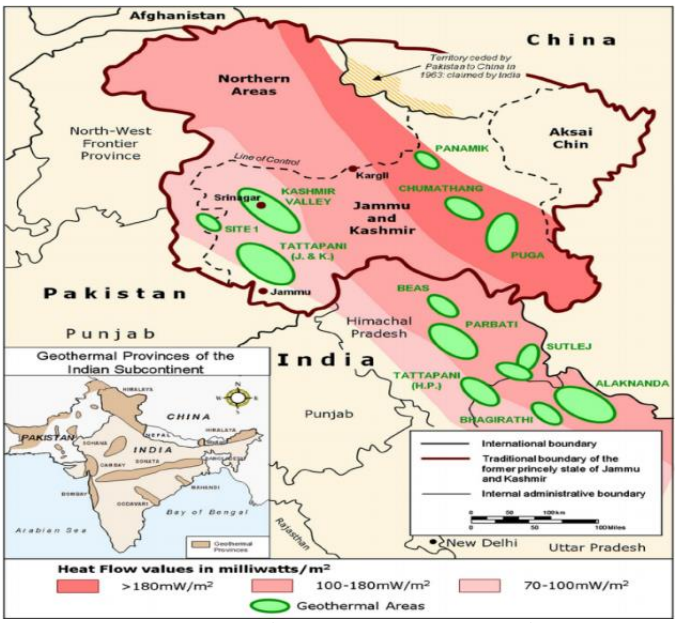

Fig. 1. Geothermal areas of India and Geothermal sites of Jammu and Kashmir [6b].

IV. GEOTHERMAL RESOURCES

Geothermal Resources can be categorised according to different terminologies. The most common criterion for the classification of resources is the temperature of the geothermal fluid that carry heat from the inner core of the earth to its outer surface. The heat transfer is mostly achieved by the convection phenomenon [3]. We have low temperature resources, the temperature of which ranges from 90°C to 190°C and high temperature resources with a temperature greater than 225°C. The low temperature resources may include hot water ponds or thermal springs while high temperature resources may include the areas close the volcanoes.

Fig. 2. A resource of a geothermal energy in the form of a hot spring [10].

Geothermal resources can also be classified according to the 'accessible resource base' which is defined as the stored thermal energy between the outer surface of the earth and a specified depth in the earth's crust [3]. Accessible resource base consists of two parts; one is useful accessible resource base (resource) and the other one is identified economic resource base (reservoir).

Further, the geothermal systems can be classified as 'water or liquid-dominated geothermal systems' and 'vapour-dominated geothermal systems' [3]. In the water-dominated system, fluid that carry heat is the liquid (water), which is continuous and pressure-controlling phase. In addition, there are some vapours present in the form of bubbles. This system can produce hot water, water and steam mixture, wet steam and sometimes dry steam. In vapour-dominated system, there is a coexistence of liquid water and vapours, the latter is the pressure-controlling phase.

TABLE I. Types of geothermal resources on the basis of temperature [9].

S. No.	Geothermal Resources on basis of temperature		
	Resource	Min. Temp. (°C)	Max. Temp.(°C)
1	Low temperature resource	90	190
2	Intermediate temperature resource	90	225
3	High temperature resource	>150	>225

This system normally can produce dry steam and super-heated steam. The steam so produced from the systems can be used in the geothermal power plants. Geothermal resources ranges from the shallow hot water ponds to the hot rocks found beneath the earth's crust and even more deeper to intensely high temperature of molten rocks (magma). This heat content of the hot rocks and molten magma filled the pores and fractures present in the Earth's crust, which can be exploited and used for many applications [8].

V. POWER GENERATION FROM GEOTHERMAL ENERGY

Geothermal energy can be used for a wide variety of applications like space heating (indoor heating), food drying, spa heating, and many more but the major application is the generation of electricity [11].

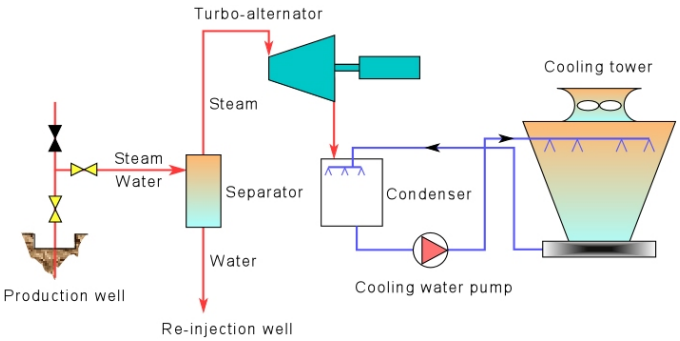

Fig. 3. Schematic diagram of a geothermal power production [12].

The basic schematic diagram of the power production from a source of a geothermal energy is shown in the [Fig 3].

The main principle behind this is the conversion of the thermal energy stored in the geothermal resource into the mechanical work which in turn produces electricity.

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As shown in the sketch, the production well is a source of geothermal energy, from which either hot water or steam can be extracted. The steam so obtained is passed through the turbines. It is to be noted that the steam can be either wet or dry based on the resource we are taking into consideration. If the resource is high enthalpy resource, then the superheated steam is obtained. The high intensity steam rotates the turbine and hence generators will work to produce electricity. The waste in the form of low intensity steam is then passed through the condenser and finally the water is re-injected to the well. As we have seen from the above that there is no requirement of storage structure and also there is a continuous supply of thermal energy for the running of generators, hence it can achieve high economic power production. The power so produced is much cost efficient and reliable. Most of the geothermal places are found in the remote areas of the country, so it can be used as remote energy security programmes.

VI. Environmental Impacts of Geothermal Energy

Geothermal source of energy is considered as 'clean energy'. Geothermal energy is one of the renewable energy which is considered as environment friendly as it emits negligible amount of 'Green House Gases' and hence does not contribute towards the 'Global Warming' unlike conventional sources of energy. It has almost no negative impact on environment. However there are few harmful impacts on environment which are listed below:

- As in the production of electricity, hot water is continuously extracted from the resource which leads to the land subsidence. This can cause increase in seismic activities. To avoid this the cooled water must be injected back into the resource [13].
- If we do not inject cooled water back into the resource, then Hydrogen sulphide gas (H_2S) is released which has a smell of 'rotten eggs'. This gas can be fatal if inhaled in large amount. Hence re-injection of waste cooled water is necessary [14].

VII. Conclusion

Geothermal Energy is a favourable and satisfactory source of energy for the production of electricity. It is a sustainable and reliable source of energy. It can fulfil the increasing energy needs of the people efficiently and without polluting the environment. We should make progress in this beautiful field and develop new technologies to exploit its unlimited source of energy.

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