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Geothermal Energy : An Alternative Source of Energy

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Abstract:
Nowadays renewable sources are preferred over the non renewable source to generate the energy. The rapid rates of exhausting non-renewable resources have completed us to look out for new avenues in energy generation. According to global energy scenario, developed countries are adopting renewable resources as major source of energy. Geothermal energy originates from the original formation of the planet, from radioactive decay of minerals, and from solar energy absorbed at the surface. Geothermal energy is derived from the hot interior of the earth. The earth is a reservoir of heat energy, most of which is buried and is observed during episodes of volcanic eruption at the surfaces. Geothermal is one of the most promising renewable source of energy which is plentiful, eco-friendly, reliable and clean source of energy available in earth crust. In our country there is wide scope for the utilization of geothermal energy with proper strategically approach to meet the energy requirement. The future prospects of this heat energy as a sustainable source of renewable energy are indeed promising. Today India is the fifth largest consumer of electricity and by 2030 it will become third largest overtaking Japan and Russia according to statistical data available by Energy Planning Commission, Government of India.
Keywords: *Non-renewable Energy, Geothermal energy.*

I. INTRODUCTION

Energy is the key input for the socioeconomic development of any nation. Industrialization urbanization and mechanical agriculture technology have generated a high demand of energy in all forms i.e. thermal mechanical and electrical. In December 2012 total capacity of energy source in India is 210950 MW out of them 83% energy utilized for industrial, domestic and agriculture as per Energy Statistics 2012. Most of the developing nations have a huge difference between demand and supply due to this reason the government think about the alternate source of energy. Due to limitation of solar energy, bio mass energy and wind energy to should go for some other alternate source of energy. In recent years the Ministry of New and Renewable Energy (MNRE), government of India has shown renewed interest in geothermal exploration and different geothermal area of the country besides creating a framework for nation policy on exploitation of geothermal energy resources.

Renewable energy sources occur in nature in the form of energy flows of indefinite duration as opposed to non-renewable convectional fuels of finite values. India is the 4th largest country with regard to installed power generation capacity in the field of renewable energy sources and much is waiting to be discovered by it. India, considered as one of the ideal investment destinations for renewable energy equipment manufacturers and service providers, has tremendous potentialities to harness the much-needed energy from renewable sources and has one of the largest possibilities in the world for deploying renewable energy products and systems.

Geothermal energy is the earth's natural heat available beneath the earth. This thermal energy contained in the rock and fluid that filled up fractures and pores in the earth's crust can profitably be used for various purposes. Heat from the Earth, or geothermal — Geo (Earth) + thermal (heat) — energy can be and is accessed by drilling water or steam wells in a process similar to drilling for oil. Geothermal energy is an enormous, underused heat and power resource that is clean (emits little or no greenhouse gases), reliable (average system availability of 95%), and can be made available in our own country (making us less dependent on foreign oil).

India has reasonably good potential for geothermal. The potential geothermal provinces can produce 10,600 MW of power. But yet geothermal power projects has not been exploited at all, owing to a number of reasons, the main being the availability of plentiful coal. However, with increasing environmental problems with coal based projects, India has to think to start depending on clean and eco-friendly energy sources in future; one of which could be geothermal.

II. GEOTHERMAL ENERGY

The major sources of commercial energy in India are coal and oil. The natural resources for commercial energy are limited in the country. It needs no emphasis that energy is an important component of rural development also and needs proper consideration in the renewable energy sector policy of the country. The geothermal potential of high-temperature resources suitable for electricity generation with conventional technologies (steam turbines, binary turbines) is not systematically utilized as it depends on the volcanic zones. Geothermal power plants are in operation in 24 countries. The worldwide utilization of geothermal energy has increased rapidly during the last three decades. Here is the list of top 10 countries with the already installed capacities in MW.

Rank	Countries	Installed Capacity (MW)
1	United States	3086
2	Philippines	1904
3	Indonesia	1197
4	Mexico	958
5	Italy	843
6	New Zealand	628
7	Iceland	577
8	Japan	536
9	El Salvador	204
10	Kenya	167

Table 1: List of top 10 countries with Installed capacity of GPP
Source : Akshay Urja, MNRE

The centre of the Earth is around 6000 ^{o}C - hot enough to melt the rock. Even a few kilometers under the earth, the temperature can be over 250 ^{o}C if the Earth's crust is thin. In general, the temperature rises one degree Celsius for every 30 - 50 meters you go down, but this does vary depending on location in volcanic areas, molten rock can be very close to the surface. Geothermal energy, that is the long term availability and the large extent of heat contained in the earth’s interior, usually considered as clean and renewable sources on the timescales of technological system is most extensively used worldwide as an effective source for a sustainable supply of energy, because the recovery of high-enthalpy reservoirs would fully recover to its pre-exploitation state after an extended shutdown period or even at the same site from which the fluid or heat is extracted in almost all geothermal projects worldwide. Moreover, the environmental impacts of geothermal power generation and direct use are generally minor, controllable, or negligible.

Geothermal resources include dry steam, hot water, hot dry rock, magma, and ambient ground heat. Steam and water resources have been developed commercially for power generation and ambient ground heat is used commercially in geothermal heat pumps; methods of tapping the other resources are being studied. The Geysers steam power plant in California is the oldest and largest geothermal power plant in the world, with a capacity of 2000 MW. Hot-water plants have been developed more recently and are now the major source of geothermal power in the world.

Hot water from geothermal resources is also used directly to provide heat for industrial processes, dry crops, or heat buildings, for a total U.S. capacity of about 500 thermal MW. Many developing countries have geothermal resources, and continue to be an attractive market. Geothermal heat pumps do not generate electricity, but they reduce the consumption of electricity by using heat exchangers and the constant temperature of the earth several feet under the ground to heat or cool indoor air. The market for geothermal heat pumps has been growing rapidly and expectations are that they will soon reach the level of installation on more than 400 000 homes and commercial buildings per year.

III. TECHNOLOGY OF GEOTHERMAL POWER PLANTS

Mile-or-more-deep wells can be drilled into underground reservoirs to tap steam and very hot water that drive turbines that drive electricity generators

Four types of power plants are operating today:

- *Flashed steam plant*: The extremely hot water from drill holes when released from the deep reservoirs high pressure steam (termed as flashed steam) is released. This force of steam is used to rotate turbines. The steam gets condensed and is converted into water again, which is returned to the reservoir. Flashed steam plants are widely distributed throughout the world.

- *Dry steam plant*: Usually geysers are the main source of dry steam. Those geothermal reservoirs which mostly produce steam and little water are used in electricity production systems. As steam from the reservoir shoots out, it is used to rotate a turbine, after sending the steam through a rock-catcher. The rock-catcher protects the turbine from rocks which come along with the steam.
- *Binary power plant*: In this type of power plant, the geothermal water is passed through a heat exchanger where its heat is transferred to a secondary liquid, namely isobutene, isopentane or ammonia–water mixture present in an adjacent, separate pipe.

Due to this double-liquid heat exchanger system, it is called a binary power plant. The secondary liquid which is also called as working fluid should have lower boiling point than water. It turns into vapour on getting required heat from the hot water. The vapour from the working fluid is used to rotate turbines. The binary system is therefore useful in geothermal reservoirs which are relatively low in temperature gradient. Since the system is a completely closed one, there is minimum chance of heat loss. Hot water is immediately recycled back into the reservoir. The working fluid is also condensed back to the liquid and used over and over again. A 700 KW plant on 80 ^{o} C brine and F-12 as a secondary working fluid is used at paratunkin south eastern Kamchatka.

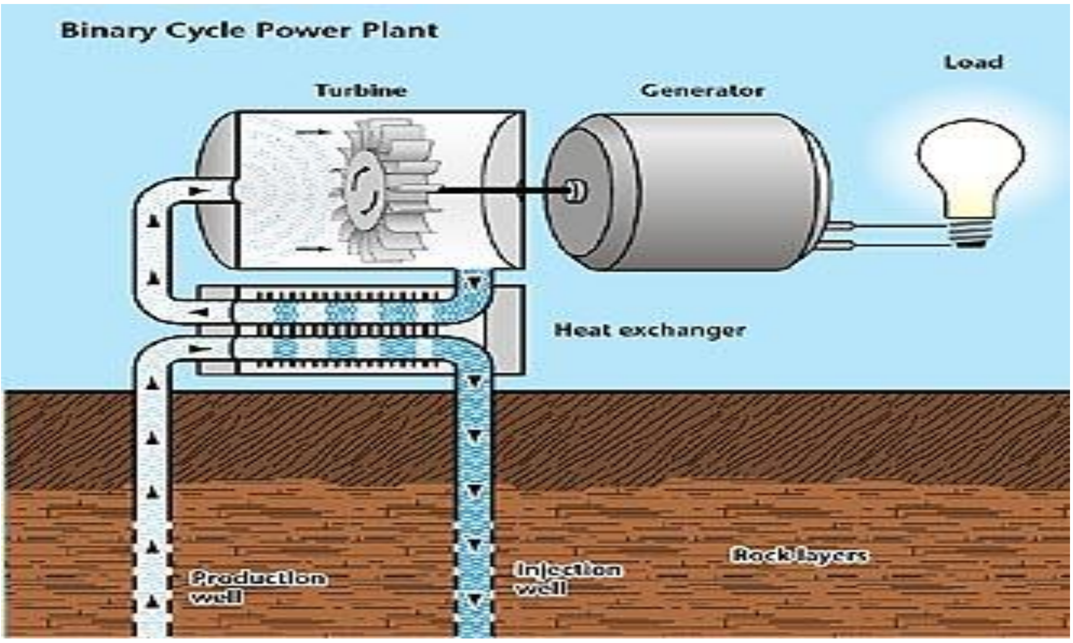

Figure 1: Schematic diagram of Binary Cycle Power Plant
Source: EERE, US Dept. Of Energy

In India the temperature of thermal spring between 80 to 150 ^{o} C, it means low enthalpy geothermal fluid used as an indirect energy utilization with the help of binary system.

- *Hybrid power plant*: Some geothermal fields produce boiling water as well as steam, which are also used in power generation. In this system of power generation, the flashed and binary systems are combined to make use of both steam and hot water. Efficiency of hybrid power plants is however less than that of the dry steam plants.
- *Enhanced geothermal system*: The term enhanced geothermal systems (EGS), also known as engineered geothermal systems (formerly hot dry rock geothermal), refers to a variety of engineering techniques used to artificially create hydrothermal resources (underground steam and hot water) that can be used to generate electricity. Traditional geothermal plants exploit naturally occurring hydrothermal reservoirs and are limited by

the size and location of such natural reservoirs. EGS reduces these constraints by allowing for the creation of hydrothermal reservoirs in deep, hot but naturally dry geological formations. EGS techniques can also extend the lifespan of naturally occurring hydrothermal resources. Given the costs and limited full-scale system research to date, EGS remains in its infancy, with only a few research and pilot projects existing around the world and no commercial-scale EGS plants to date. The technology is so promising, however, that a number of studies have found that EGS could quickly become widespread.

In developing a program to use geothermal energy following factors need to be analyzed-
1. Variation of temperature with depths in different parts of the world.
2. Identification of location at convenient depths from which it is possible to approach water bearing rocks having water temperature higher than 50C.
3. Identification of rocks those are sufficiently hot and impermeable which render extraction of heat and economically viable proposition.

IV. DIRECT USE OF GEOTHERMAL ENERGY:

With regard to direct use applications, a large increase in the number of Geothermal Heat Pump installations for space heating (presently estimated to exceed 500 000) has put this category in first place in terms of global capacity and third in terms of output. Other geothermal space heating systems are second in capacity but first in output. Third in capacity (but second in output) are spa uses followed by greenhouse heating. Other applications include fish farm heating and industrial process heat. The outstanding rise in world direct use capacity since 1996 is due to the more than two-fold increase in North America and a 45% addition in Asia.

Sr.No.	Use of Geothermal Energy	Temperature range of geothermal fluid in ^oC
1.	Soil warming & fish farming	15-45
2.	Heat Pump	15-55
3.	Swimming Pool	25-55
4.	Green houses	30-80
5.	Spa treatment	40 -60
6.	Copper Processing	40-50
7.	Cloth drying & wool Washing	45-75
8.	Food Processing	40-80
9.	Snow melting Process	40-80
10.	Domestic Hot Water	50-70
11.	Concrete blocks curing	60-75
12.	Oil recovery	60-90
13.	Pulp & Paper mill	70-110
14.	Vegetable Dehydration	100-125

Table 2 : List of direct application of low enthalpy geothermal energy (Lindal diagram)

In India geothermal fluid temperature between 50 to 180 ^oC. Above Table 2 given use of direct application of the geothermal energy instead of conventional energy and save conventional source and also reduce the emission.

V. SCOPE FOR GEOTHERMAL ENERGY IN INDIA

India has about 340 hot springs spread over the country, of this, 62 are distributed along the northwest Himalaya, in the States of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. They are found concentrated along a 30-50-km wide thermal band mostly along the river valleys. Naga-Lusai and West Coast Provinces manifest a series of thermal springs. Andaman and Nicobar arc is the only place in India where volcanic activity, a continuation of the Indonesian geothermal fields, and can be good potential sites for geothermal energy. Cambay graben geothermal belt is 200 km long and 50 km wide with Tertiary sediments. Thermal springs have been reported from the belt although they are not of very high temperature and discharge. During oil and gas drilling in this area, in recent times, high subsurface temperature and thermal fluid have been reported in deep drill wells in depth ranges of 1.7 to 1.9 km.

Steam blowout have also been reported in the drill holes in depth range of 1.5 to 3.4 km. The thermal springs in India's peninsular region are more related to the faults, which allow down circulation of meteoric water to considerable depths.

The circulating water acquires heat from the normal thermal gradient in the area, and depending upon local condition, emerges out at suitable localities. The area includes Aravalli range, Son-Narmada-Tapti lineament, Godavari and Mahanadi valleys and South Cratonic belts.

In recent years, the ministry of New and Renewable energy (MNRE), government of India has shown renewed interest in geothermal exploration in different geothermal areas of the country besides creating the framework for a national policy on exploration of geothermal energy resources. The geothermal fields in India are in the form of hot water springs (40 ^{0}C to 98 ^{o}C) and shallow water reservoir temperatures are less than 160 ^{o}C.

Promising geothermal sites for the development of geothermal energy in India.

Geothermal Field	**Estimated(min.) reservoir Temp (Approx)**	**Status**
Puga geothermal field, (J & K)	240^{o}C at 2000m	From geochemical and deep geophysical studies (MT)
Tattapani Sarguja (Chhattisgarh)	120^{o}C - 150^{o}C at 500 meter and 200 Cat 2000 m	Magneto telluric survey done by NGRI
Tapoban Chamoli (Uttarakhand)	100^{o}C at 430 meter	Magneto telluric survey done by NGRI
Cambay Garben (Gujarat)	160^{o}C at 1900 meter (From Oil exploration borehole)	Steam discharge was estimated 3000 cu meter/ day with high temperature gradient.
BadrinathChamoli (Uttarakhand)	150^{o}C estimated	Magneto-telluric study was done by NGRI Deep drilling required to ascertain geothermal field

Table 3: Current projects in India
Source: NGRI

The National Geophysical Research Institute (NGRI), Hyderabad, has conducted magneto-telluric investigations in Tattapani Geothermal fields in Chhatisgarh to identify subsurface geological structures to evaluate its energy and thermal potential. Based on the promising results obtained during the investigations, it is planned to develop the site for power generation. A similar study has been carried out through NGRI in Puga Geothermal fields in Ladakh region of Jammu & Kashmir and the site is planned to be developed for power generation. There are other organizations working on those development. The viability of geothermal heat pumps for heating inside building should explored in the states of Jammu and Kashmir, Himachal Pradesh and parts of Uttarakhand which experience severe winter conditions for long periods.

VI. CONCLUSION

Now more than 24 countries generate more than 10,000 MW electricity generated by geothermal energy. The total world use of geothermal power is giving a contribution both to energy saving (around 26 million tons of oil per year) and to CO_2 emission reduction (80 million tons/year if compared with equivalent oil-fuelled production). Geothermal power could serve the 100% need of 39 countries in Africa, central/South America and the pacific. Entire world resource base of geothermal energy calculated to be larger than those of coal, oil, gas and uranium combined. Further research and experience will improve the geothermal resource base.

India is yet to produce the electric power from geothermal energy except for nominal 5 KW binary power plants at manikaran that was operational for very short time. India has high scope in utilizing its geothermal resources. India’s ministry of non-renewable energy and other geo research centers may pay their attentions towards these renewable resources of clean energy. There is enormous scope for developing the capabilities in geothermal cooling of buildings by modifying existing technologies to suit Indian conditions. Geothermal power can become a valuable source of energy if properly harnessed. Continued energy shortages have created added interest in geothermal energy for both power generation and direct applications. The technology is expensive and it is necessary that for real breakthrough the cost to be reduced substantially. Environmental problems associated geothermal development is physical disturbance of site, noise, brine disposal and ground water contamination by geothermal fluids and air pollution especially by hydrogen sulphide. Manageable problems relate to serious social, economic and institutional impacts that generally accompany large scale geothermal development.

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