A Review on Geothermal Energy

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Abstract: Today most of the energy is drawn from conventional non-renewable energy resources, like coal, biomass and petroleum products in India. The culprit behind conventional non-renewable energy resources is the uncontrolled emission of CO_2 which leads to global climate change. To reduce environmental problems, India has to depend on clean, cheap, rural based and eco-friendly power in future. Therefore energy efficiency and renewable energy are becoming important in India to achieve energy security and to reduce the emission of greenhouse gasses. Geothermal energy is one of the renewable energy resources which are still unexplored. In this paper an attempt has been made to describe the utilization of geothermal energy in India.

KEYWORDS: conventional, renewable energy, geothermal energy, eco-friendly power.

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I.INTRODUCTION

The word Geothermal comes from the Greek words geo (earth) and thermal (heat), so geothermal means earth heat. Geothermal energy is very clean source of power which comes from radioactive decay in the core of earth. India is third largest consumer of energy in the world. The current energy demand is increasing day by day. After the oil crisis in 1970s, the Geological Survey of India conducted survey and reported the results in their records. These investigations have identified that Indian geothermal provinces have the capacity to produce 10,600 mw of power which is five times greater than the combined power being produced from non-conventional energy sources.

II. HISTORY:

From earliest times, people used geothermal water that flows freely from the earth's surface as hot springs. Native Americans used hot water springs for cooking and medicine. The Romans used geothermal water for treatment of eye and skin disease. For centuries the New Zealand people have cooked geothermally. The world's first geothermal district heating system was started in the fourteenth century at France, and the first geothermal well was drilled near Reykjavik, Iceland, in 1755. Since 1960s, France has been heating up 200,000 homes using geothermal water.

III. GEOTHERMAL ENERGY IN INDIA:

India's geothermal energy installed capacity is experimental, and commercial use is insignificant. Availability of large recoverable coal reserves in India is preventing healthy growth of non-conventional energy sector, including geothermal energy. However, with the growing environmental problems associated with thermal power, future for geothermal power appears to be bright in India. According to some researches, India has 10,600 MW of geothermal energy available. India has about 300 hot springs, clustered in seven provinces spread over the country. Of these, Puga and Chumathang area in Ladakh are deemed as the most promising geothermal fields in India. These areas were discovered in 1970s and initial efforts were made in the 1980s by Geological Survey of India (GSI).On 6th February 2021, the ONGC Energy Center signed a Memorandum of Understanding with Ladakh and Ladakh Autonomous Hill Development Council, Leh in the presence of Lieutenant governor Radha Krishna Mathur.

Indian Geothermal Provinces:

Indian has about 300 medium to high enthalpy geothermal springs, clustered in seven provinces. The geothermal provinces of India are located in places with high heat flow and geothermal gradients. The most promising provinces are The Himalaya province, The SONATA province, The Godavari province, The West coast province, The Cambay province, The Bakreswar province, The Barren Island. Most of them are liquid dominated systems and with one or two having both liquid and gas dominated systems. Let us examine the geothermal characteristics of the above provinces.

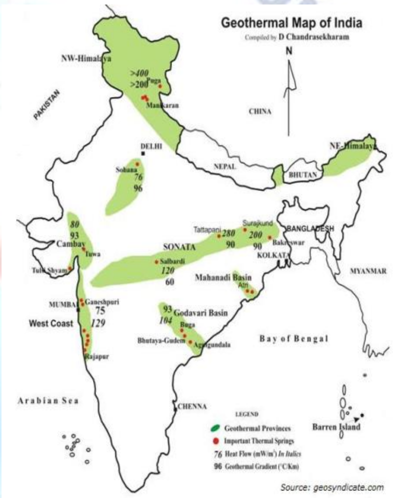

Fig: Geothermal map of India

The Himalaya Geothermal Province:

The Himalaya is the one of the most promising provinces in coldest part of the country comprises of approximately 1,500 km²area with an occurrence of about 100 geothermal springs. The estimated temperature of the geothermal reservoir is higher than 260⁰C. The area show the highest geothermal gradient in India: more than 100⁰ C /km and a heat flow of 100 MW/m².The geothermal potential in Puga Valley seem to be sufficient for room heating, geothermal power supply and the heating of green houses as well giving the population the opportunity for growth of vegetables which are imported from southern regions today. The first pilot binary 5 kW power plant using R113 binary fluid was successfully operated by the GSI at Manikaran which proved the power producing capability of this province.

Sonata Geothermal Province:

The Son-Narmada-Tapi rift (SONATA) extending from Combay in the west to Bakreswar in the east. This geothermal province is spread across approximately more than 8000 km^2 and encloses well known Tattapani province. Tattapani province encloses 23 thermal springs with surface temperature varying between 60 to 95^0 C and flow rate greater than 4000 l/min. Based on thermal gradient and experimental results, the estimated reservoir temperature are as high as 217^0 C at 3km depth. According to GSI, the thermal gradient in these province exceed 100^0 C/km. A pilot power plant of 3.17 MW was drilled by GSI. According to some sources the pressure of the thermal discharge from the thermal springs is 5 kg/cm^2 and the estimated life of the reservoir is about 20 years.

Godavari Geothermal Province:

The Krishna-Godavari delta in Andhra Pradesh is a northwest-southeast trending graben filled with Gondwana sedimentary rock formations. The lower Gondwana group of rocks consists of sandstone, shale and clays and is exposed towards the southwestern part of the graben and contains 13 thermal discharges with surface temperature varying from 50 to 60^0 C and geothermal gradient of 60^0 C/km. The estimated temperatures are expected between 173 for Manuguru and 250 for Bugga geothermal springs. These two thermal springs can discharge 100 l/m of water and it has been estimated that 38 MW power can be generated from this province.

West Coast Geothermal Province:

This province is located within the world famous Deccan flood basalts of Cretaceous age. This province has a thin lithosphere of 18 km thickness thereby rendering this province as one of the most promising sites for exploitation. The thermal discharges are with saline content varying from 800 ppm to 1500 ppm. The reservoir temperatures calculated, after making necessary correction for 1% saline component, are between 102 and 137^0 C. The thermal discharge, located at Rajapur, within the Deccan basalts along the coast is an exception to the other thermal discharges mentioned above. The thermal reservoir of this discharge is located in the Precambrian formation, like the Puttur thermal waters, with reservoir temperatures varying between 120 and 200^0 C.

Cambay Geothermal Province:

The Cambay geothermal province is spread across an area with a length of 200 km and a width of 50 km with more than 15 geothermal provinces whose surface temperature varies from 40 to 90^{0}C. This province shows a heat flow of 80 MW/m^{2}and geothermal gradient of 60^{0}C/km. Steam discharge in certain oil wells were recorded with rates exceeding 3000 m^3/d. The reservoir temperatures estimated at two sites Tuwa and Tulsi Shyam are greater than 150^{0}C.

Bakreswar Geothermal Province:

The Bakreswar-Tantloi thermal province falls in Bengal and Bihar districts and marks the junction between SONATA and Singbhum shear zone. High Helium (He) gas is encountered in all the geothermal discharges and it is proposed to install a pilot plant to recover Helium (He) from the thermal discharges of this region.

The Barren Island Geothermal Province:

The Barren island forms a part of the Andaman - Nicobar island chain in the Bay of Bengal and is located 116 km NE of Port Blair. The recent volcanic activity was recorded in the year 1991 which resulted in the appearance of high temperature steaming ground and thermal discharges. Fumarolic discharge recorded temperatures varying between 100 and 500^0 C. detailed exploration works need to be commissioned in this province.

IV. GEOTHERMAL POWER PLANTS

The geothermal power plant uses steam obtained from the geothermal reservoir to generate electricity. Wells are drilled at the locations to bring this geothermal energy up to the surface. A mixture of steam and water is collected from the wells drilled. Steam separators are used to separate the steam and use it to operate turbines. The further process is similar to thermal power plant. Steam turbines run the generators and, electricity is generated. The condensed steam and the water collected from the production well are used and injected back into the reservoir through the injection well. The particular working of the plant depends upon the type of the plant.

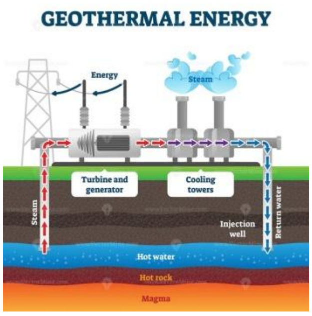

Fig: Geothermal power plant

Types of Geothermal Power Plants:

Dry Steam Plant:

This is the oldest type of geothermal plant. It directly uses steam from the reservoir to run the turbine. The steam used is collected from the production well and used to operate low-pressure turbines. Hence, the fluid is steam. The used steam is injected back through the injection well. It is only suitable in the site where steam is available in the reservoir. The installation cost of dry steam plant is low when compared to other type of plants.

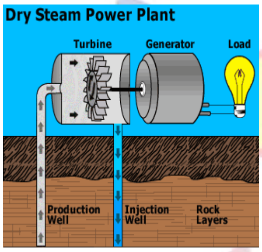

Fig: dry steam geothermal plant

Flash cycle Plant:

Flash cycle power plants are the most commonly employed geothermal plants today. They operate the geothermal reservoirs having water temperature greater than 180^{0}C. The high-pressures water from the reservoir flows up through the production well due to its own pressure. The pressure decreases as the water flows upwards and, some of it gets converted into steam. The steam is separated from the water by steam separator and sent to the steam turbine. The unused water as well as the condensed steam is injected back through the injection well. Further the flash cycle plants are divided into two types they are single-flash cycle and multi-flash cycle.

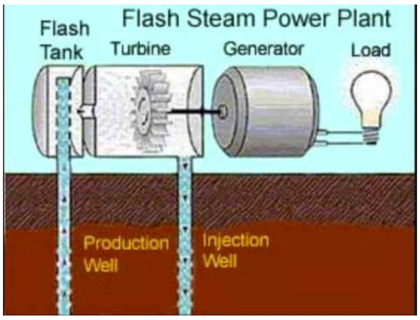

Fig: flash cycle geothermal plant

Single-flash cycle: If the geothermal fluid is in compressed liquid state, it flashes into steam in the well as it rises to the surface. Additional steam is then separated in the flash tanks and feed to the steam turbine. The remaining fluid is disposed on the surface or injected back into the reservoir.

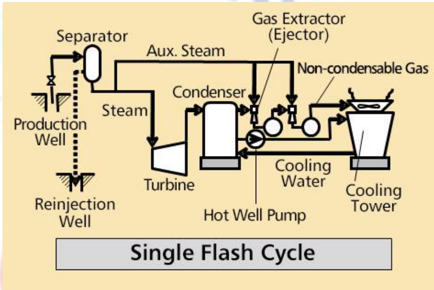

Fig: single flash cycle

Multi-flash cycle: if the resource temperatures are high the fluid can be flashed twice or more. Flashing occurs in the well and in the separators on the surface. The liquid from the first separator is flashed again in the second (low pressure) separator. The addition of the second flash stage increases the plant efficiency by 20% compared to the single flash system.

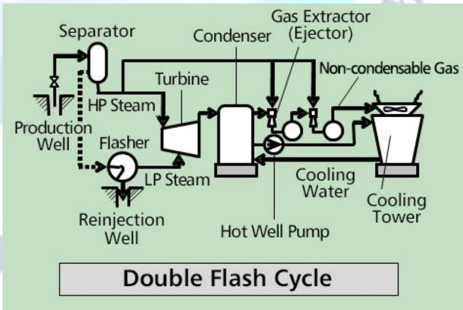

Fig: multi flash cycle

Binary Steam Plant:

Binary power plants are the recent development. They made it possible to produce electricity from geothermal reservoirs with temperatures lower than 150^{0}C. In these plants, hot water from geothermal reservoir is used to heat up another organic fluid having a lower boiling point. Thus, the working fluid is the secondary organic fluid and not the water from reservoir. The heat energy from the water is transferred to the working fluid in the heat exchanger. As a result, the working fluid vaporizes, and then drives the turbines. The used fluid passes through the condenser and the cycle repeats. The water is injected back into the reservoir through the injection well.

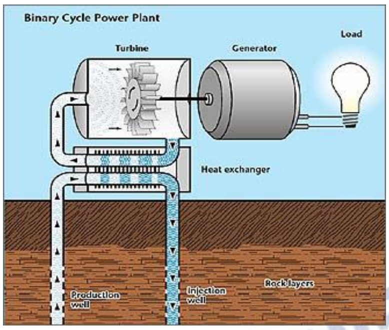

Fig: binary steam power plant

Types of ground source geothermal systems:

There are two main types of ground source geothermal systems classified according to the loop used they are:

- Open-loop systems.
- Closed-loop systems.

Open loop system:

Open loop systems use water source (groundwater or a surface body of water) as the source of heat exchange. This is most appropriate only when there is a sufficient source of clean water and water codes and regulations related to groundwater discharge are met. The water moves through the geothermal heat pump system and then returns through a well or surface discharge. Open loop systems can have negative environmental impacts such as warming surface waters and lowering water oxygen levels.

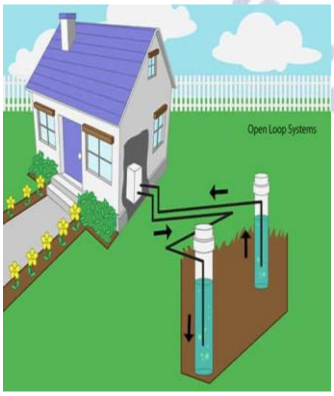

Fig: open loop system

Closed loop system:

Closed loop systems can be further divided into horizontal, vertical and pond based loop system.

Horizontal closed loop system: A horizontal closed loop system is the most common set up and generally the most economical option for residential applications. These systems include high-density polyethylene piping that is buried in trenches 4-6 feet underground in a horizontal pattern. The pipes are filled with an antifreeze and water mixture that acts as a heat exchanger that extracts heat from the ground to the building in the winter, and it takes heat from the building and transfers it to the cooler ground in the summer.

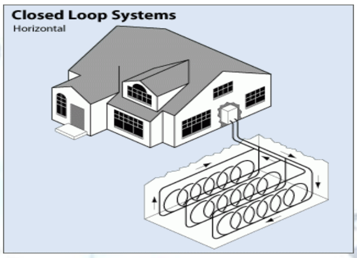

Fig: horizontal closed loop system

Vertical closed loop system:

Vertical closed loop systems are most appropriate for commercial buildings or other large buildings where land space is limited or areas where soil is too shallow to dig trenches. Vertical systems are made of piping that extend 100-400 feet deep underground and are combined with a U-bend to form a loop, so they are called as the vertical closed loop system. This vertical closed loop system uses less space so it is more suitable for residential buildings

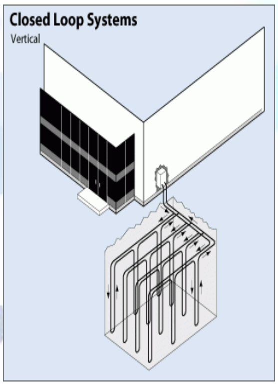

Fig: vertical closed loop system

Pond based closed loop system:

Closed loop systems that are connected to a pond or lake can be the most economically viable option when the site has a sufficient body of water. This system is suitable only if there is a nearby the construction site. This system involves running a pipe-system underground between the building and under the water in a coiled pattern that helps prevent freezing during the winter.

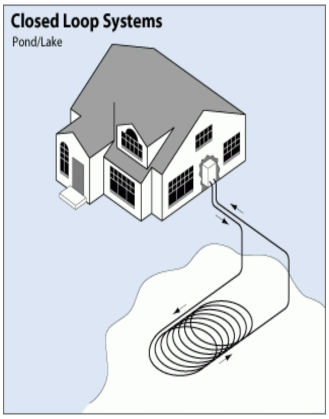

Fig: pond or lake geothermal power

Procedure for setting up a geothermal power plant:

The development of a successful geothermal power plant depends upon the specialized technologies and cost effective processes used for the construction. The following are the steps followed to establish the geothermal power plant.

Exploration: The first step of construction of geothermal power plant begins with exploration to find the location of the reservoir. Collecting data from wide variety of sources to identify the site is important.

Well drilling and testing: Drilling of wells is done to measure subsurface temperatures, flow rates and other subsurface conditions to produce and re-inject the fluid from the reservoir. After each well is completed production and injection tests are done. Reservoir characteristics like temperature, pressure and permeability are measured and further used to plan the resource utilization.

Reservoir engineering: Information gathered from the subsurface measurements and well drilling and testing are used to construct the model of the plant. These models are used to decrease the energy extraction and maximize the life time of the resources. Reservoir engineering also helps us to determine the major design considerations such as location, depth of flow and number of production and injection wells.

Power plant design: geothermal power plant design depends on the physical properties of the geothermal fluid. Capacity to control the fluid pressure, enthalpy and gaseous content may take place in later part of system. Life span of geothermal power plant is also important.

Fluid handling: chemical constituents in some geothermal fluids can cause corrosion and mechanical erosion of wells, production and injection systems and surface plant equipment. Injection of carbonate compounds into production wells and use of CO_2 resistant cements for production wells have helped to overcome the problems.

Environmental control: H_2S emissions to atmosphere and land use are the major environmental problems. Although the intensity of these hazards varies from site to site, development of suitable control technologies should be implemented in the site to control the emissions of harmful gases.

V. LIMITATIONS OF GEOTHERMAL ENERGY:

- Energy Sources like wind, solar and hydro are more popular and well established. These factors could make developers decided against geothermal energy.
- Finding a suitable location. Main disadvantage of building a geothermal plant mainly lies in exploration stage. Areas are located in harsh areas of the world (near poles), or high up in mountains.
- Harmful gases can escape from deep of the earth, through the holes drilled by the constructors and investigation agencies.
- High installation cost required.

ADVANTAGES OF GEOTHERMAL ENERGY:

- **Clean and Reliable:** Geothermal power plants produce only a small amount of air emissions. Compared to conventional fossil fuel plants, they emit very small amounts of carbon monoxide, particulate matter, carbon dioxide, and typical nitrogen oxides.
- **Sustainable:** Geothermal power is considered to be sustainable because water can be recycled back into the earth and reused and also no other fuel mixture required producing electricity.
- **Land Conservative:** For energy production and development geothermal power plants do not use much land compared to coal and nuclear power plants.
- **Flexible:** Geothermal power plants can have modular design, with additional unit installed in increments when needed to fit growing demand in the electricity.

VI. CONCLUSION

It is found that India has no geothermal power plant yet but according to GSI (Geological Survey of India), geothermal resources in India are able to contribute to the country's energy supply by more than 10,600 MW of sustainable power. According to Chandrasekharam (IIT Bombay), the estimated power shortage in India in the next five year is about 43,000 MW. This demand will increase in the coming year due to economic globalization. This gap between demand and power supply can overcome with the help and utilization of renewable power like geothermal energy resources.

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