AN OVERVIEW OF GEOTHERMAL ENERGY IN INDIA

[1]Illinda Pranav,[2]Kola Leleedhar Rao
[1,2]Assistant Professor, [1,2]Department of EEE
[1]Chiatanya Bharathi Institute of Technology (Autonomous), Hyderabad, India
[2]Sree Vidyanikethan Engineering College (Autonomous), Tirupati, India

Abstract: Geothermal energy is heat within the earth that can be used either as steam or hot water to heat buildings or generate electricity. As the earth interior will be hotter than sun surface and continuously heat is produced inside the earth which is inexhaustible, geothermal energy comes under a class of renewable energy sources. As fossil fuels are depleting day-by-day particularly in highly populated countries like India, geothermal energy is gaining importance as an alternate source of energy. This paper emphasizes interior topology of the earth, electricity production from geothermal energy, different types of geothermal power plants and various geothermal provinces located in India.

Index Terms **-Geothermal energy, geothermal power plant, geothermal province.**

I. INTRODUCTION

The word "geothermal" is originated from the Greek words "geo" means earth and "therme" means heat. This energy comes from deep inside the earth. Due to the abundant availability of coal reserves in the country, Coal is used as a major fuel in India's Power Production Industry contributing to a massive share of nearly 70%. These coal reserves are prone to be extinct one day and further it affects the environment thereby affecting human life. So we need to switch over to non-conventional energy sources wherein geothermal energy is one among them which has the potential to replace fossil fuels completely and help mitigate global warming. Further geothermal energy is cleaner because neither fuel transporting equipment nor huge boiler equipment set up is not required. The slow decay of radioactive particles in the earth's core produces geothermal energy. This process happens in all rocks.

The earth's interior topology has a double layered core almost 4000 miles beneath the earth's surface. Earth has a number of layers. The innermost layer consists of Earth's core made of solid iron and is surrounded by an outer core of hot molten rock called magma. The next layer is mantle which is made up of magma and rock. The mantle surrounds the core and is about 1800 miles thick. The next layer is the outermost layer called crust which is like a shell of an egg. This crust forms the continents and ocean floors. It can be 3-5 miles thick under the oceans and 15-35 miles thick on the continents [1].

When the earth's crust breaks into pieces called tectonic plates, Magma comes close to earth's surface near the edges of these plates, which is where many volcanoes occur. The lava that erupts from volcanoes is partly magma. Rocks and water absorb heat from magma deep underground and attain the highest temperatures. People around the world use geothermal energy to heat their homes and to produce electricity by drilling deep wells and pumping the hot underground water or steam to the earth's surface.

Fig.1: The earth's interior (Courtesy: U.S. Energy Information Administration [1])

II. GEOTHERMAL POWER

Geothermal power generation requires hot water or steam at a high temperature (300^{O}F to 700^{O}F) that is to be drawn from deep inside the earth. This requires deep well to be drilled which may act as a reservoir of energy. All the geothermal power plants use naturally available hot water and steam from the earth to turn turbine generators for producing electricity. India has an estimated geothermal potential of 10,000MW. The various countries which produce geothermal power particularly in Asia are the Philippines,

Indonesia and Thailand [2]. China and Taiwan have direct use of geothermal applications and to a lesser extent electricity production. Apart from countries in Asia, Iceland, the United States of America, Italy, Costa Rica, Russia, Mexico, Australia and New Zealand are some of the countries which are notable producers of geothermal power. Among all the countries in the world, Iceland is a country with one of the highest development of geothermal energy. Iceland is also called as "geothermal country" in the international arena because there is a tremendous growth of geothermal electricity in the past two decades or so.[14]. Most of the geothermal activity in the world occurs around the Pacific Ocean in an area called the 'Ring of Fire' [2].

III. FINDING GEOTHERMAL ENERGY

Some naturally occurring phenomena like volcanoes, hot springs, geysers and fumaroles indicate the presence of geothermal energy in that particular area [2]. Geologists use different methods to find geothermal energy reservoirs, but the only way to be sure there is a reservoir is to drill a well and test the temperature deep underground [2]. A geyser is a vent in the earth's surface from which there will be periodical eruptions of steam and hot water columns. A fumarole is a crack in the earth's surface from which steam and volcanic gases are emitted. Geothermal reservoirs located near the earth's surface are mostly in the western United States of America, Alaska and Hawaii. India is yet to produce electric power from geothermal energy, except for a nominal, 5kW, binary plant at Manikaran in the Himalayan geothermal province that was operational for a very short time. [13]. There are 3 types of geothermal power plants namely: dry steam power plants, flash steam power plants and binary cycle power plants.

a) Dry Steam Power Plants

These Plants use steam directly from a geothermal reservoir to turn generator turbines. Wells are drilled deep into the earth and water is pumped into it, where the heat turns the water into steam. The pressurized steam (180˚C-350^{O}C) is brought to the surface at high speeds and passed through a steam turbine to generate electricity. This method relies on natural seams and fractures in the rock or completely man-made boreholes to pass water from the earth's surface to the depths and back to the surface. These types of power plants are the simplest and economical in terms of technology.

b) Flash Steam Power Plants

These power plants take high-pressure hot water from deep inside the earth and convert it to steam to drive generator turbines. The return fluid is in the form of water with a temperature of over 360˚F. A flash chamber is installed before the steam turbine and the super-heated water is sprayed into the flash chamber, which is at a lower pressure than water. It gets vaporized(or flash) rapidly to steam [3]. Most of the geothermal plants are flash steam type.

c) Binary Cycle Power Plants

In these Plants, heat is transferred from geothermal hot water to another liquid. The liquids used can be pentane, butane or isopropane which are organic fluids [10]. The heat causes the second liquid to turn to steam, which is in turn used to drive a generator turbine. A heat exchanger transfers the energy from the hot water to a secondary fluid with a lower boiling point. In organic fluids, the critical point is reached at lower pressures and temperatures compared with water [10]. In this type of power plant, hot water is not directly used in the process of power generation [2].

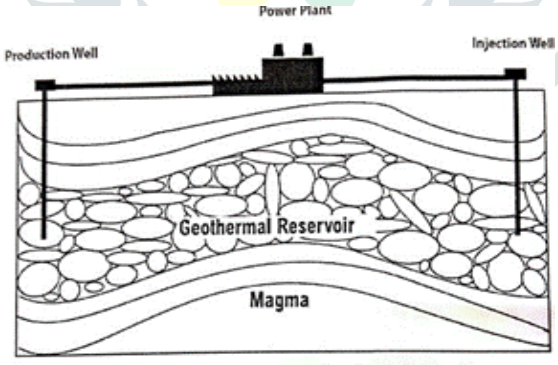

Fig.2 Geothermal Power Plant; (Courtesy: [2])

The simplified diagram of a geothermal power plant is shown in Fig.2. The different components of a geothermal power plant can be briefed as follows:

Production Well: It is a well that is drilled to extract the geothermal fluids, such as hot water and steam. The hot water and steam are brought to the surface and piped into the power plant. The well can extend up to a few kilometers underneath the earth surface. The pipes are designed with certain technology so that they do not burst due to high temperatures.

Power Plant: It comprises of turbine mechanically coupled to the generator as the main machinery. The turbine is used as a prime mover to run the generator. The geothermal fluid turns the turbine blades, as soon as the fluid strikes the blades. The potential energy of the fluid is converted to kinetic energy, which also spins a shaft that spins magnets inside a large coil of wire to generate electricity [2].

Injection Well: It is drilled to inject back the used geothermal fluid and later fed into the reservoir again without evacuating the earth's interior crust [4].

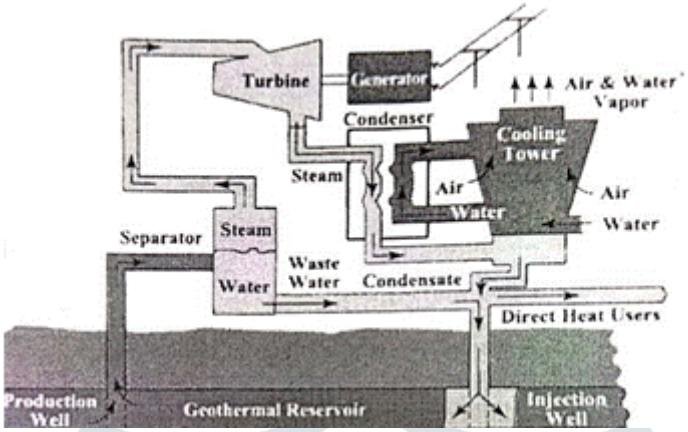

Fig. 3 Typical layout of a Geothermal Power Plant (Courtesy: [4])

4. GEOTHERMAL PROVINCES IN INDIA

There are 7 provinces in India which are classified by the Geological Survey of India [4 & 7].

The North-Eastern Himalayan Region: It is situated in the coldest part of the country where there are about 100 thermal springs with surface temperatures as high as 90^{O}C.The localities are Puga, Ladakh, Manikaran and Tapoban. 27 boreholes are drilled and the average reservoir temperature in these areas vary from 155^{O}C to 204^{O}C [7].

SONATA Province (Son-Narmada-Tapi): This area is located from Cambay in the west to Bakreswar in the east. There are 23 Thermal springs located with surface temperatures varying from 50^{O}C to 97^{O}C. The localities are Tatapani and Anhoni-Samoni.8 boreholes are drilled and the reservoir temperature is around 125^{O}C[11]. This province has got a well-known Tatapani Geothermal field in the Suguja district of Chhattisgarh state [10].

West Coast Province: This is located near the Arabian Sea in Maharashtra and it is a worthy site for exploitation. The thermal waters are found to have a temperature in the range of 120OC to 200OC. 6 boreholes are drilled and the reservoir temperature is from 125^{O}C to 170^{O}C.

Chhota Nagpur Gneissic complex: It is located in Bakreshwar in West Bengal. Hot springs are found to have a temperature of 40^{O}C to 70^{O}C and 2 boreholes are drilled. In all these thermal discharges, high helium gas is emitted. Reservoir temperature is in the range of 120^{O}C to 140^{O}C.

Godavari Province: This is located in a locality called Manuguru near the banks of river Godavari in the state of Telangana. There are around 13 thermal discharges with surface temperatures varying from 50^{O}C to 60^{O}C. Hot springs of 36^{O}C to 44^{O}C found with reservoir temperature ranging from 100^{O}C to 150^{O}C.

North-Eastern Region: This is located in the Assam-Meghalaya States. Hot springs with temperatures of 46^{O}C are identified at Jakrem in Meghalaya and at Garampani (54^{O}C) in Assam. The reservoir temperature is approximately 120^{O}C.

The Barren Island: This forms part of the Andaman & Nicobar Islands in the Bay of Bengal. The thermal discharges have temperatures varying between 100^{O}C to 500^{O}C.

Apart from producing electricity from geothermal energy, there are multiple areas where geothermal resources can be utilized. The important criteria for direct usage of geothermal energy is that the resources should have a temperature range of approximately 20^{O}C to 150^{O}C [9]. Geothermal resources above 150^{O}C are generally used for the generation of electricity. Direct use applications include space heating, spa, swimming pool, food processing, milk pasteurizing, drying of vegetables, fruit products, etc. A large number of geothermal heat pumps are being installed globally for space heating mainly in cold countries where the temperatures are too low for a larger part of the year [12]. Iceland is one nation which is best known for the usage of 90% of geothermal resources for direct use and this island nation also takes advantage of the resources for use in agriculture and industrial processing.

5. CONCLUSIONS

Geothermal energy is clean energy and is available 24x7, unlike solar and wind energies, generating very little in the way of by-products or emissions [10]. As geothermal energy is independent of climatic conditions, the Ministry of New and Renewable Energy (MNRE) under the Government of India may explore more geothermal areas for the possibilities of tapping the geothermal energy

for electricity production. The government of India may encourage foreign funding and technology transfer so that India can gradually install geothermal power plants in the future and use it efficiently [11]. The development of geothermal energy in India has been hampered due to the non-availability of proper machinery and the lack of incentives for those organizations that can explore and develop geothermal resources [11]. Geothermal energy can be regarded as the hidden wealth underneath the earth's surface for the sustainability of mankind. So it's time to look for clean environment-friendly energy for.

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