GEOTHERMAL ENERGY: NEW PROSPECTS

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ABSTRACT

This paper discusses the use of geothermal energy in our electrical power systems. The paper emphasis the resource in conjunction with the ways in which geothermal energy is converted into electrical energy. The paper also reviews a few geothermal projects in world. Finally a comparative review of renewable energy sources is presented. This paper suggested short comes and future prospects for geothermal energy in

KEYWORDS: *geothermal energy, electricity, EGS Technology, geothermal power*.

I. INTRODUCTION

Geothermal is named comes from two Greek letter "thermal" that means 'heat' and "geo" have means 'earth'. Renewable energies are provided by natural resources (sunlight, wind, water, and geothermal heat) through the use of engineering technologies able to collect the energy and to convert it in a more usable form. Geothermal power is extracted from heat stored in the earth. This geothermal energy originates from the original formation of the planet, from radioactive decay of minerals, and from solar energy absorbed at the surface. Almost everywhere, the shallow ground or upper 3 m of the Earth's surface maintains a nearly constant temperature between 10°C and 20°C. Geothermal heat pumps can tap into this resource to heat and cool buildings. A geothermal heat pump system consists of a heat pump, an air delivery system (ductwork), and a heat exchanger-a system of pipes buried in the shallow ground near the building. In the winter, the heat pump removes heat from the heat exchanger and pumps it into the indoor air delivery system. In the summer, the process is reversed, and the heat pump moves heat from the indoor air into the heat exchanger. The heat removed from the indoor air during the summer can also be used to provide a free source of hot water.

II. BACKGROUND

Geothermal energy is a well established renewable energy subsector. In 2008, geothermal power production exceeded three times that of solar photovoltaics. Current growth is steady, but rather slow. While wind and solar photovoltaic are going through periods of accelerating growth, geothermal power is developing rather linearly. So far, its deployment has relied mainly on hydrothermal resources (hot rock and water) located in special geological settings. There are two main utilization categories: power generation and direct use.

Direct use of geothermal energy means that the thermal energy from underground is used directly as heat (or cold), rather than being used to generate electricity. There are significant advantages to geothermal energy. Geothermal energy is available around the clock, independent of the time of day and night, or of the current climatic conditions. When used to generate electricity, this means that geothermal energy is base-load, suited to producing energy at a constant level, in contrast to the variable output of wind and solar power, and the peaking output of hydropower and some bio-power.

Geothermal energy’s potential is ubiquitous, environmentally friendly and only marginally developed [1].

Geothermal Power

The geothermal potential of high-temperature resources suitable for electricity generation with conventional technologies (steam turbines, binary turbines) is spread rather irregularly and depends on the volcanic zones. Geothermal power plants are in operation in 24 countries. This number is expected to increase to 35 by 2015. The main producers of geothermal energy are the United States (3.1 GW), the Philippines (1.9 GW), Indonesia (1.2 GW) and Mexico (1 GW) (Bertani, 2010). Employment trends point of view, geothermal power plants can be operated by a relatively small number of full time human resources but require continued involvement by geothermal professionals and technicians to maintain the supply of fluid to the surface plant. Many of these people may not be employed full time on one project, but may have input into a number of projects as consultants. March 12th, 2010, the range in capacities for geothermal power as a renewable energy resource is drastic. The United States has roughly 3000 more MWe of geothermal energy available than the Russian Federation, which ranks tenth shown on the table 1.

Table I: Geothermal Power [2].

Sr. No.	Country	Power
1	United States	3153.0 MW
2	Philippines	2195.3 MW
3	Indonesia	1132.0 MW
4	Mexico	965.0 MW
5	Italy	810.0 MW
6	New Zealand	577.0 MW
7	Japan	535.0 MW
8	Kenya	169.0 MW
9	Turkey	83.0 MW
10	Russian Federation	81.0 MW

Studies of the renewable resource potential indicate an enormous capacity of wind, solar, geothermal, tidal, biomass and hydropower. Several renewable technologies have matured in the past decade, and growth rates of solar and wind is now at 17% and 24% respectively. The leading companies in these two areas today are Shell, BP, Enron and Siemens-- indicating recognition by the energy providers of a growing market opportunity.

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 rural energy is an important component of rural development programme and needs proper consideration in the renewable energy sector policy of the country. It is in this context, international cooperation for the purposes of survey, formulation, installation, monitoring & evaluation is called for, to take up the renewable energy programmes in a systematic manner in India. It is also required that energy data/ information which are not being collected at present, may be planned in the next census or alternatively special energy survey can be undertaken even by creating a separate agency in this regard. For this Govemment of India’s approval will be required. There is no doubt that we should first be clear about the availability of various resources for practical utilization to the feasible extent within our own limited financial ability to execute the same and do some service to the human kind in a manner most acceptable to them for their own good [3].

III. GEOTHERMAL ENERGY

The centre of the Earth is around 6000 degrees Celsius - easily hot enough to melt rock. Even a few kilometres down, the temperature can be over 250 degrees Celsius 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. Sometimes we can use that heat. Geothermal energy has been used for thousands of years in some countries for cooking and heating [4].

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 [15]. Moreover, the environmental impacts of geothermal power generation and direct use are generally minor, controllable, or negligible [16].

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. Research centers on lowering costs, improving methods for finding and characterizing reservoirs, and tapping broader resources [5], [6]. 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. Total U.S. capacity is about 2800 MW, enough electricity for 3 million people, at a cost of $0.05–$0.08/kW h. 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 [7]. 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 [8], [9].

Available energy resources in the world are large, and energy shortage is not expected in the foreseen future. On the other hand, most (86 %) of the energy used in the world at present is coming from finite energy resources, whereas renewable energy sources are more
suitable for sustainable development. The highest share of the use of renewable energy resources is in Iceland, where renewable energy resources comprise 70% of the primary energy resources and 30% is coming from fossil fuels. This unique position has been achieved by an extensive and advanced use of geothermal energy in Iceland. On the worldwide basis, geothermal energy is considered to have the largest technical potential of the renewable energy sources. Furthermore, the production price of geothermal energy is favorable as compared to all other energy sources [10].

India's geothermal energy installed capacity is experimental. Commercial use is insignificant. India has potential resources to harvest geothermal energy. The resource map for India has been grouped into six geothermal provinces [11].

Himalayan Province – Tertiary Orogenic belt with Tertiary magmatism

Areas of Faulted blocks – Aravalli belt, Naga-Lushi, West coast regions and Son-Narmada lineament.

Volcanic arc – Andaman and Nicobar arc.

Deep sedimentary basin of Tertiary age such as Cambay basin in Gujarat.

Radioactive Province – Surajkund, Hazaribagh, Jharkhand.

Cratonic province – Peninsular 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 [12].

In a December 2011 report, India identified six most promising geothermal sites for the development of geothermal energy. These are, in decreasing order of potential:

- Tattapani in Chhattisgarh
- Puga in Jammu & Kashmir
- Cambay Graben in Gujarat
- Manikaran in Himachal Pradesh
- Surajkund in Jharkhand
- Chhumathang in Jammu & Kashmir

India plans to set up its first geothermal power plant, with 2–5 MW capacity at Puga in Jammu and Kashmir [12].

Geothermal energy resources

There are four major types of geothermal energy resources.

- Hydrothermal
- Geopressurised brines
- Hot dry rocks
- Magma [20]

IV. ELECTRICITY FROM GEOTHERMAL

Geothermal power projects convert the energy contained in hot rock into electricity by using water to absorb heat from the rock and transport it to the earth's surface, where it is converted to electrical energy through turbine-generators. Water from high-temperature (>240 °C) reservoirs is partially flashed to steam, and heat is converted to mechanical energy by passing steam through low-pressure steam turbines. A small fraction of geothermal generation worldwide is generated using a heat exchanger and secondary working fluid to drive the turbine. The geothermal process diagram in Figure 11 shows the production wells, separator, scrubber, turbine, condenser, and cooling tower. After being separated from steam, brine is injected back into the reservoir. Steam is piped to the plant where it passes through a scrubber before entering the turbine, and it is then condensed. Condensed steam is used in the cooling towers, where roughly 80% evaporates and the remainder is injected back into the reservoir. Exploitable geothermal reservoirs exist in high- temperature, highly permeable, fluid-filled rock within the earth's upper crust, typically in areas associated with young volcanic rocks. Driven by heat loss from underlying magma, hot fluids rise along pre-existing zones of high permeability. The buoyant up-flowing fluids enhance the permeability of the rocks through which they are flowing by chemical leaching and by explosive boiling.

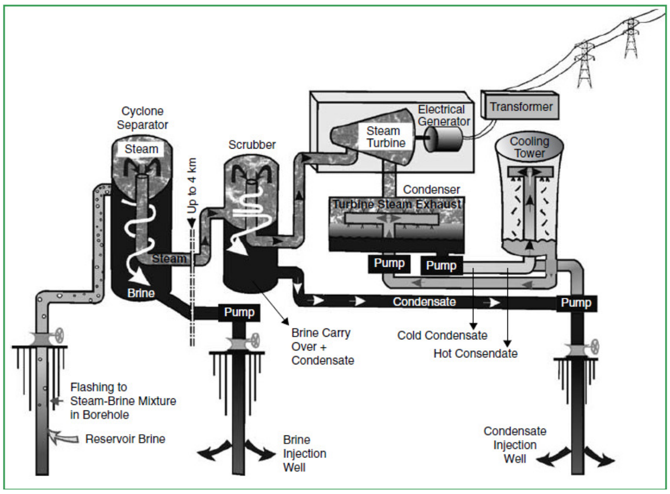

Fig.1: Geothermal Process

If the system becomes large enough and has high enough permeability, it has the potential to be a commercial grade geothermal reservoir with temperatures typically in the range of 240 to 320 ºC. The current drilling technology can exploit geothermal reservoirs economically in the depth range of 500 to 3,000 m. [13].

Renewable Energy Sources Scenario

In this scenario, a geographic mapping of renewable energy sources, as solar, wind, geothermal, hydro, ocean and bioenergy, is mandatory in order to understand and manage the potential exploitation of these resources. Deserts can provide solar energy on an enormous scale, while coasts in the temperate zones offer huge potential for wind energy. On the other hand, great geothermal energy resources are located along the circum-Pacific "Ring of Fire", while mountainous countries with sufficient rainfall offer high potential for hydropower. Subtropical regions instead represent a great potential for bioenergy. The technical potential for the utilization of renewable energy is nearly 20 times greater than current global energy demand. Yet, today renewable energy only provides 17% of the world's primary energy needs and traditional renewable energy use (biomass and large hydro) make up the greater share (9% and 5.7%, respectively). New renewable such as wind and solar provide only 2% of total global primary energy consumption. In particular, in the last years, many wind farms have been built in complex terrains, offshore, forests, and at high levels in the atmosphere. Marketing of large, multi-MW wind turbines is in continued growth. At the same time our basic knowledge on winds in these challenging environments is inadequate [14].

Indian Scenario

India has reasonably good potential for geothermal; the potential geothermal provinces can produce 10,600 MW of power.

Though India has been one of the earliest countries to begin geothermal projects way back in the 1970s, but at present there are no operational geothermal plants in India. There is also no installed geothermal electricity generating capacity as of now and only direct uses (eg.Drying) have been detailed.

Thermax, a capital goods manufacturer based in Pune, has entered an agreement with Icelandic firm Reykjavík Geothermal. Thermax is planning to set up a 3 MW pilot project in Puga Valley, Ladakh (Jammu & Kashmir). Reykjavík Geothermal will assist Thermax in exploration and drilling of the site.

India's Gujarat state is drafting a policy to promote geothermal energy [20]

Potential Geothermal regions/sources in India

With India's geothermal power potential of 10,600 MW, the following are the potential sources/ regions where geothermal energy can be harnessed in India shown in table 2.

Table II : Potential Sources/Regions [20].

Province	**Surface Temp ^{0}C**	**Reservoir Temp ^{0}C**	**Heat Flow**	**Thermal gradient**
Himalaya	>90	260	468	100
Cambay	40-90	150-175	80-93	70
West Coast	46-72	102-137	75-129	47-59
Sonata	60-95	105-217	120-290	60-90
Godavari	50-60	175-215	93-104	60

List of Geothermal Energy Companies in India –

- Panx Geothermal
- LNJ Bhilwara
- Tata Power
- Thermax
- NTPC
- Avin Energy Systems
- GeoSyndicate Power Private Limited [17].

Alternative Geothermal Energy Uses

Besides power resources, geothermal energy can be harnessed for other means as well. Thanks to geothermal water, there are natural hot springs all over the world and many people enjoy the warm waters and its restorative effects. Geothermal water can also be beneficial for growing agricultural products in a greenhouse within a cold or icy climate. Geothermal waters can be harnessed to create space heating in buildings or even to keep streets and sidewalks warm enough to prevent icing over. Several cities have actually used geothermal energy in this unique manner.

Future of Geothermal Energy

Because geothermal energy is reliable and renewable, this alternative power source will start to enjoy more growth. However, just remember that geothermal energy will not necessarily be available in many areas due to its volatile needs. Areas like California, Iceland, Hawaii and Japan are just a few places where geothermal energy is being used, many due to earthquakes and the underground volcanic activity[18],[19]. From the long-term perspective, it is necessary for Japan to start studying electricity generation with enhanced geothermal systems (EGS), which the United States and Australia have already started researching. In the end, there are high expectations that geothermal energy will again come into the spotlight.

EGS Technology

The EGS concept is to extract heat by creating a subsurface fracture system in the hot constituent rock to which water can be added through injection wells. Rocks are permeable due to minute fractures and pore spaces between mineral grains. EGS are reservoirs created to improve the economics of resources without adequate water and permeability. Enhanced geothermal system (EGS) reservoir performance is controlled by the interplay of a complex set of parameters: reservoir, geologic, drilling, well completion, plant design, and operation.

Some of the EGS resource resides in the sedimentary section, however. In general, as depth and temperature increase, the permeability and porosity of the rocks decreases. So, at depths of 3+ km and temperatures of 150+°C, the rocks are similar to basement in permeability and porosity. In many areas of the country, there is extensive drilling for gas at depths where temperatures are well within the EGS range because the gas deadline is on the order of 200+°C. In many of these areas, the rocks are “tight” and must be fractured to produce commercial quantities of gas (Holditch, 2006). In fact, much of the gas resource remaining in the United States is related to these types of formations. Examples are the Cretaceous sandstones in the Pieance Basin, Colorado (Mesa Verde and Wasatch Formations), and the East Texas Jurassic section (Bossier, etc.). These sandstones are “granitic” in bulk composition but still have some intrinsic porosity and permeability. Modeling by Nalla and Shook (2004) indicated that even a small amount of intrinsic porosity and permeability increases the efficiency of heat extraction, so that these types of rocks may be better EGS hosts than true granite. Thus, there is a natural progression path from the deep hot gas reservoir stimulation and production to EGS reservoir development in both technology and location. It seems likely that these areas might be developed early in the EGS history, because of the lower reservoir risk than in unknown or poorly known basement settings. To extract thermal energy, it is required to drill to depths where the rock temperatures are sufficiently high to justify investment in the heat-mining project. With the impending commercialization of Enhanced Geothermal System (EGS), geothermal energy could be harnessed everywhere in the world and no longer be limited to a few selected areas [21].

V. CONCLUSION

Renewable energy technologies offer the promise of clean, abundant energy gathered from self-renewing resources such as the sun, wind, earth, and plants. Virtually all regions of the United States and the world have renewable resources of one type or another. Each of the renewable energy technologies is in a different stage of research, development, and commercialization and all have differences in current and future expected costs, current industrial base, resource availability, and potential impact on greenhouse gas emissions. At present, the scale of geothermal power industry is small because of the limitation of easily exploitable high temperature geothermal resources, therefore, the development of geothermal resources have to be primarily focused on utilization of ground source heat pumps which can make good use of the enormous low temperature geothermal resources.

Though the quality cannot compete with other kinds of renewable energy, geothermal energy would still have strong competition, if the utilization efficiency and cost could be made great progress. In view of the future development trends, geothermal energy will remain a higher growth rate than that of fossil energy for a long time, and the proportion in energy consumption will further increase, but it would not be of reality looking forward to alternate fossil energy in large scale. Geothermal energy is a kind of "heat-embedded" energy, and can be used directly without conversion, better than other types of renewable energy in some extent. In certain cases, geothermal energy is more convenient to use, and would become an effective "compliment" energy for other types of energy. When renewable energy sources are used, the demand for fossil fuels is reduced.
There is significant scope for developing geothermal energy resources in India and other renewable energy has the potential to provide sufficient electricity to meet all of India's domestic electricity requirements. As to support the green technology programmed, the government has plan many incentives to the development by implemented the project by geothermal based energy. The improvement of developing the geothermal energy can encourage the energy sectors of economy in this country. According to this study, there are still have a limit that are could be improved for further study. Therefore, there are several recommendations that can be performed to enhance renewable energy development. Firstly, Analyze widely about the potential of other renewable energy such as hydro, geothermal and etc. so that there will be a lot of data and information would be gathered for the future used. Finally, latest policies and funding mechanisms will be required to sustain and promote renewable energy investment.

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