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Geothermal Energy Resource of North-western Himalayas

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ABSTRACT

Geothermal energy came into the picture after the oil crisis in the 1970s, with proper research and exploration took place in 1973. India's geothermal potential is entirely undeveloped with a power potential of 10,600 MWe. The capital cost of generating energy from geothermal sources in India is estimated to be US$1.6–2.0 million per MW, but the operating cost is minimal. This paper discusses geothermal heat source of different provinces of Jammu & Kashmir and Himachal Pradesh, with its direct use for production of electricity.

Keywords: *Geothermal; Energy; Himalaya; Environment*.

1.0 Introduction

Importance of geothermal energy came into the picture after the oil crisis in the year 1970s, with research and exploration started in 1973. In 1991 Geological Survey of India (GSI) prepared the 'Geothermal Atlas of India' describes 340 hot springs sites and identifies more than 300 sites with geothermal energy potential.

The great Himalayas represents one of the best areas for geothermal energy and a detailed study of several thermal provinces [1] with geochemical characteristics of the thermal discharges and reservoir temperature has been estimated (Giggenabch, 1976; Giggenbach et. al., 1983; Nevada and Rao, 1991; Chandrasekharam et. al., 1989; 1992; 1996; Chandrasekharam and Antu, 1995; Chandrasekharam and Jayaprakash, 1996; Chandrasekharam et. al., 1997). These provinces are capable of generating 10,600 MW of power [1] with heat flow (>100 mW/m^2). Mixed magmatic fluids make the discharge saline (Alam et. al., 2004) with surface temperature varies 47 - 87^{o}C.

These resources can be used for the direct application like space heating, drying crops, several industrial processes like pasteurizing milk and also for electricity production.

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2.0 Geothermal Heat Source

Himalayan region is one of the main sources of geothermal energy in India. It extends from the north-western part of India (Ladakh) to its north-eastern part (Assam) covering an area greater than 1500 km^2 and encloses over 150 thermal areas.

The heat source available in Himalaya Geothermal Province is best suited for direct use as well as electricity generation [13].

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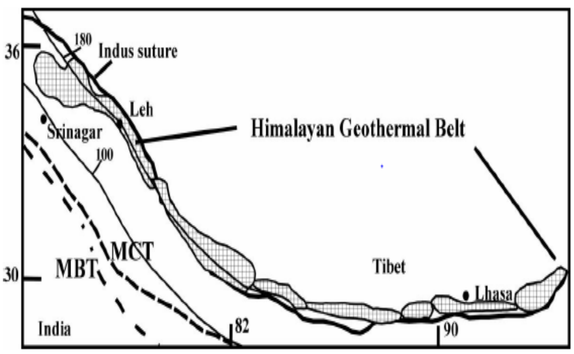
2.1 Jammu and kashmir

2.1.1 Puga and chumathang

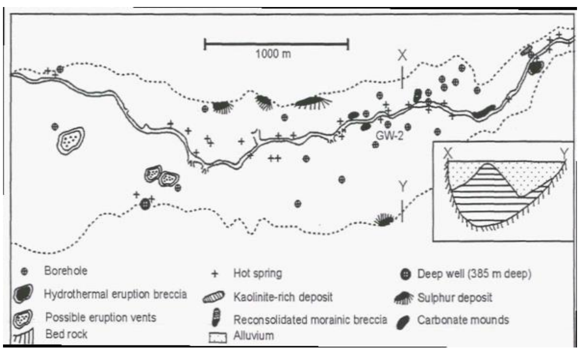
Located at an altitude of about 4400m above m.s.l., Puga Valley has more than a hundred of hot springs of temperatures range 28^{o}C to 84^{o}C [2] with the cumulative discharge of 30 l/s. It is the most promising and relatively high potential geothermal field in India located in the Indus Valley in eastern Ladakh. Geothermal resources are concentrated in an east-west elongated area of some 4 km^2, near the mouth of the 15 km long and 1 km wide Puga Valley. The area isat high altitude with snow desert during the winter season for about 4-5 months.

Fig 1: Regional Structure and Heat Flow Values (Varun Chandrasekhar and Chandrasekharam, 2007)



The surface temperature of the discharges at Puga ranges from 30^{o}C to 84^{o}C [2] with the boiling point of 84^{o}C at the altitude of (4400 m). More than 100 hot springs in an area of c. 5 km^2 with individual discharge rates of hot springs range from 30 to 40 l/s and an accumulative discharge of 300 l/s [3].

Fig 2: Map Showing Surface Alteration Features Of Puga Valley Geothermal System.



A pH range from 6.4 to 8.6 from the thermal water of the Puga geothermal field making thermal water neutral to weakly alkaline. Around 34 wells have been drilled in Puga geothermal field, with depths ranging from 28.5m to 384.7m [4] with 17 of 35 wells results in blow-outs. For 8 out of 17 flowing wells, wellhead measurements were taken with the discharge temperature of more than 120^{o}C. Discharge from a single a borehole was 1800 to 2400 l/min at Puga and 900 l/min at Chumanthang. Thermal studies and chemical thermometry suggest that at a depth of about 2.5 km below the Puga Valley temperature is more than 220^{o}C [6]. While a reservoir modelling studies suggest that a temperature of up to 160^{o}C at a depth of 450m [7].

Discharge surface temperature of Chumanthang range from 85 to 87^{o}C and a boiling point of 87^{o}C at an altitude of 3950m. The max recorded discharge is 90 l/min with the cumulative discharge of all the springs is 200 l/min [3]. 4 out of 6 wells blew out at Chumanthang with depths range 20 to 221m.

The maximum temperature recorded is 110^{o}C with reservoir temperature is expected to have at least 130^{o}C. Around 73 hot springs have been identified with the max discharge of 90 l/min and 200 l/min of cumulative discharge [3]. The thermal water extracted from Chumathang has a slightly higher pH and a higher sulfate level. A geothermal power of 500MWt is considered to be available at Puga[5].

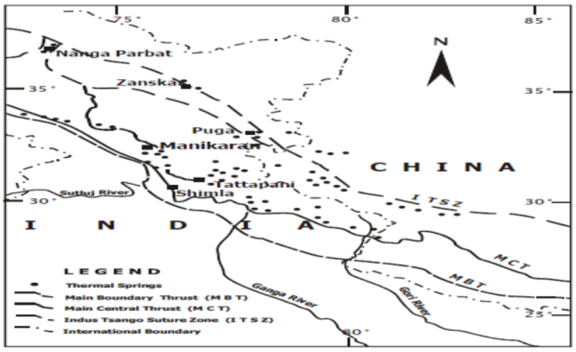
2.1.2 Shyok valley

Shyok valley has hot springs at Panamik, Changlung, and Pulthang. Around 65 to 76^{o}C of surface temperature with a discharge of 600 l/min were located at Panamik ranges. Two hot spring at Changlung has a discharge temperature of 61 and 66^{o}C respectively with a cumulative discharge of 180 l/min, while the hot spring at Pulthang has a discharge of 180 l/min with a surface temperature of 28^{o}C. Based on a subsurface temperature range of 130-150^{o}C are considered at Panamik and Changlung with an installed capacity of 3-5 MWe at Panamik is considered feasible.

2.2 Himachal pradesh

Himachal Pradesh geothermal provinces fall between Main Boundary Thrust (MBT) and Indo-Tsangpo Suture Zone (ITSZ) at an altitude of 1160 to 3660 m above the sea level [8] (Fig 3).

Fig 3: Northwest Part of Himalayas [9].



The Manikaran Quartzite inserted between the layers of phyllite constitutes the formation of the Rampur Group [10].Grey and green phyllite, with layers of carbonaceous schist and meta basics, are basal of Manikaran Quartzite [8]. Schist and gneiss of the Chail Group lie on the top of the Manikaran Quartzite [11].

Himachal Pradesh provinces reach a high geothermal gradient of about 260^{o}C/km with a heat flow value ranges from 70 - 180 mW/m^2 [1]. The thermal springs of surface temperature vary from 57 to 98^{o}C [12]. Thermal water from Manikaran was investigated and shows that it is considered as a mixture of two end members, one represented by calcium carbonate rich water and another by paleo-brine rich in NaCl [12]. It is a region with high altitudes and uneven surfaces, so it difficult to transmit power using conventional coal or hydropower grid. Though transmission cables are installed in rural areas, proper power demand is not fulfilled. Himachal Pradesh is also famous for apple cultivation with more than 40% of total area and about 88% of total fruit production [9]. Processing of these fruits requires a high amount of energy which can be extracted from geothermal energy. Himachal Pradesh can become one of the major food producing and processing regions in the country with the proper use of geothermal energy [13-14]. For agribusiness industry, greenhouses, dehydration of fruits and vegetables and aquaculture are three primary uses of geothermal energy [15].

4.0 Conclusions

A great potential of geothermal energy lies within northern part of India, the Himalayas. The existing data on the geothermal resources indicates that direct application and power production is possible. It's a clean and renewable energy, hence development can occur without any hazardous effect on the environment.

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