Geothermal Resource Exertion: Indian Scenario

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Abstract. Geothermal energy is an enormous in extent, obviously renewable and truly green, sustainable resource of heat energy stored in the earth’s core and manifested as volcanoes, hot springs, fumaroles, steaming ground and geysers. Nearly 340 thermal springs are known to pre-exist throughout India, mostly in Himalayan province and some are in Peninsular (non-orogenic) provinces. If the geothermal energy potential is properly developed, then India may have surplus to the requirements of total annual electrical power demand. Potential sites for developing hot dry rock projects in the orogenic provinces and in central India and food processing industries in North India may bring up India a global player using geothermal source in the near future. This paper briefly exemplifies the challenges and potential benefits are those leading in India towards the exercise of Geothermal resources.

1. Introduction
Energy is the major issue of the socioeconomic evolution of any nationhood. All the developing countries have a massive disparity between demand and supply by the time being due to the extravagant exercise of fossil fuels increasing the Greenhouse emission into the ambient and fabricates a layer which in sequence incites an incessant rise in the atmospheric temperature; and by the reason the government has started contriving use of the alternate source of energy. Due to limitation of solar, biomass and wind energy, in recent times, the Ministry of New and Renewable Energy (MNRE), Government of India has refurbished a big interest in geothermal resource exploration at several geothermal provinces of the country and created an agenda of national policy on the utilization of these energy resources. Growth in geothermal energy use recorded the maximum rate of 22.5% per 5 years in between 1980 and 1990 and a slightly lower rate of 16.7% between 1990 and 2000 [1].

Geothermal energy supply differs extensively from one position to another, depending on the enthalpy content (indicating by temperature) and depth of the source, the rock alchemy and the abundance of underground fluid. Geothermal resources of low temperatures (50-200ºC) are originated extensively in continental provinces, whereas high temperature (larger than 200ºC) resources are found in island chains and volcanic regions. The type of resource decides the process of its exploitation. The most extensive direct use of low temperature geothermal resources is in space heating of individual buildings in cold regions. In places like north-east region in India, where no fossil fuels are available readily, the high temperature geothermal field affords a useful energy supply to local residents. In large countries like India, geothermal energy may not replace all fossil fuels demand, but contributes considerably to the requirements of the nation. A study has been accomplished here considering the aforementioned objective with the data available from assorted sources to evaluate the potency of exploiting the geothermal resources in India.

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2. Principal Provinces
The geographical districts in India are sorted of seven geothermal provinces (figure 1) by the Geological Survey of India and are illustrated below in brief:

2.1. The North-East Himalaya
About 100 hot springs of surface temperature as high as 90°C with depth varying from 1 and 3 km are spread in the coldest region (figure 1) of this nation with expulsion ability of hot water above 190 tones/hr. according to magneto-telluric recordings [3]. This prefecture has been expressed into three belts by the reason of re-occurrence of the springs as at Chhumathang and Puga of altitudes of 4000 m to 4400 m in Trans-Himalayan belt; while in central-Himalayan belt, the altitude ranges from 1300 m to 3000 m in Parbati, and 1000 m altitude Satluj and Beas Valleys of outer-Himalayan belts in Himachal Pradesh.

The Hot spring region of Puga district (figure 2) is placed at about 180 km from Leh in Ladakh region of Jammu and Kashmir along the collided junction of two crustal plates of the Himalayan Orogeny of an aerial extent of 4 km with temperatures varying from 30°C to 84°C (boiling point at Puga area) and discharge up to 300 litres/min. Chhumathang geofield is thermally irregular area stretched for about 700 m along the right bank of Indus River in the form of hot springs, travertine deposits and stained ground, located about 40 km north of Puga on Leh-Chushul road at an altitude of 4300 m., 150 km distant from Leh. The maximum temperature of the thermal spring recorded is 87°C (boiling point at Chhumathang) with a cumulative discharge of all the springs of 200 lit/min. Manikaran geothermal ground is traced at an altitude of about 1700 m about 50 km east of Kulu, Himachal Pradesh. Geo-thermal commotion in the temperature range of 34°C-96°C at Manikaran occurs in the form of hot springs, about 1.25 km distant from the right bank of Parbati river. Tapoban Geothermal area (figure 3) in Dhauli river valley, 15 km from Joshimath, in Chamoli district, Uttarakhand at an altitude of about 1800 m, has the surface manifestation in the form of five hot springs.
between 0.83-9.22 lit/sec spread over a distance of one km along with the highest temperature of 65°C. Five thermal springs located in Yumthang, Yumesamdong, Borong, Polot and Rishi, in Sikkim have surface temperatures of 38°-59°C with moderate discharge and have therapeutic values because of the content of sulfur and boron, currently being utilized locally for bathing and drinking purposes only.

2.2. West Coast
One of the most potential sites in Deccan flood basalts of an emaciated lithosphere of 18 km width [4] where 60 thermal springs at 18 zones are found in the range of 120-200°C. This belt spreads along the west coast for a distance of about 350 km falls in Thane, Raigad and Ratnagiri districts of Maharashtra. The boundary is bloated by Western Ghats to the coastline of the Indian Ocean. The thermal spring zones have been subdivided into three distinct bunches in the West Coast as:
- Northern zone consists of Paduspada, Koknere, Haloli, Ganeshpuri, Sativli and Akloli.
- Central zone consists of Pali, Sov, Tamhane and Vadavli.
- Southern zone consisting of Unhavre, Khed, Rajawadi, Tural, Rajapur, Math, Sangameshwar and Aravli.

2.3. Cambay
The Cambay basin, Gujarat geothermal provinces characterized by about 22 springs (35-93°C), extending up to mantle depth, appeared during the late cretaceous and has been turned anticlockwise into post northward glide of the Indian plate [5]. This basin is a focus of major alkaline magmatism and a few bore-wells capitulate steam at depths greater than 1500 m with a discharge rate of 125 m³/hr.

2.4. Godavari
The Mahanadi and Godavari valleys are grabens of dead faults with post Gondwana formations. Average temperature of 39±5°C/km slope and 13 thermal discharges of heat flow 80±15 MW/ m² have been traced in this Valley. It has been approximated that 38±8 MW can be generated from this province [6]. The graben is a tectonically progressive region of hydrocarbon and coal-bearing Gondwana reactivations.

2.5. Sonata
An area of about 80,000 m² of Tattapani, the most promising geothermal field in the Peninsular India geothermal province, ranging from Cambay in the west to Bakreswar in the east, known as Sonata,
comprises of 23 springs with surface temperatures varying from 60 to 95°C with very high heat flow and geothermal gradient of 60°C/km. It was found that reservoir temperatures are as high as 217°C at a depth of 3 km from the ground surface [7]. Two distinct lithological sequences belonging to Proterozoic and Gondwana Supergroup exist in Tattapani geothermal field (figure 4). Deep seismic sounding silhouettes along the south of Tattapani across the Sonata, suggest that the fault system reaches the mantle [8].

2.6. Barren Island
High temperature searing ground and hot discharges of temperature 100-500°C of volcanic activity (recorded in 1991) exists on the Barren Island, a zone of the Andaman-Nicobar Island in the Bay of Bengal. This province is geotectonically similar to the Taupo Volcanic area of New Zealand. Heating effect of persistent subduction of the Indian Plate use to be seen as many lively volcanism.

2.7. Bakreswar
The Bakreswar-Tantloi geothermal province exists in Bengal and Bihar districts. The measured cumulative flow of three springs in Bakreshwar is 800 lit/m fluid and 20 lit/m gas. Based on the radioactive element content, the area occupied and heat flow values of these high helium emitting granites, the power generation capacity has been approximated as 3.13 x 10^10 BTU saving about 10^6 kg CO_2 [9].

3. Potential and Utilization
India should not ignore the huge potential of 10,600 MW geothermal energy if has to depend on clean, rural based and cheap energy sources in near future [10]. Geothermal possessions fluctuate widely with the enthalpy and the depth of the resource in locations, the amount of groundwater, and the rock chemistry. A heat flow characteristics of different provinces given by Roy and Rao [11] heat flow map with heat flow sites in filling triangles for the Indian shield are shown in figure 5. Heat flow has been determined by the temperatures in boreholes and rock thermal conductivity. Major study comprises reporting pockets of large heat generation i.e. in Tattapani region, and young granite invasive in northwestern zone of India; the Gondwana basins have usually large, but variable heat flow of 46-107 MW/m²; Cambay basin confirms steady, high heat flow, 75-96 MW/m² in northern parts and a lesser flow of 55-67 MW/m² in the southern parts.

The warm water emerging from hot springs in the country is utilized for several direct uses like bathing and balneology, redeveloping tourist spas, removal of borax and cesium, greenhouse agriculture and aquaculture in cold season, growth of mushrooms in closed hut and hatching poultry. 1 MW potential of Tattapani geothermal field has been employed in setting up a binary cycle power plant. The thermal water flowing at other areas, in Maharashtra, Himachal Pradesh, Haryana and Uttar Pradesh, classified as medium-enthalpy geothermal resource, can be used for non-electrical purposes besides power production; Himalayan geothermal resources are best fitted to prop up food industries, apposite for growing varieties of fruits like pear, peach, apple, plum, walnut, grapes, citrus, raisin etc. The area under fruit cultivation is about 2000 sq. km in Himachal Pradesh alone of annual production more than 5000 MT.

Steam tapped from geothermal springs or drill holes (usually 121-371°C) are used for electricity production by rotating turbines. The first 5 kW bi-nary pilot power plants were successfully built and activated in India by the GSI. A 3.17 MW pilot power plant by commissioning 6 inches diameter
production wells also have been drilled by the GSI at Tattapani, Sonata province. The geo-reservoir has been reported to produce 38 MW at Bugga and Manuguru areas in Godavari province. Three drill holes have been managed at a distance 3 km upstream along the Dhauliganga River near Tapoban. A dis-charge at Yamnotri shrine is ejecting about 90°C hot water which can be used in a binary power plant here. There is no commission of other power plant reported till date by any private sector or the government. Heating suburban or business complex is also exercised throughout the world, but it is not trendy in India.

4. Developments

Geothermal resources at Chhumathang and Puga will be expanded for power production and direct use. According to the chief executive councilor of the hill development council of Ladakh, the energy demand of Leh is growing from 94 MW in 2010 [10] and generating power from the existing geothermal resources may relieve the situation of scarcity in supply, especially in winter. More than 5000 MW at Puga can be developed for heating and originating greenhouse cultivation as the vegetables are flown from either Chandigarh or Delhi and the army uses to negotiate for the rural Leh population at a practically low cost. Solar power supply was the only ray of hope for the children in Puga valley one time and those systems lost no longer than 2 years due to inherent problems of maintenance and low success rates (World Bank, 1999). A project has been initiated jointly by IIT Bombay, The Hill Development Council of Ladakh, Ladakh ecological Development Group (LeDEG) and Ladakh Renewable Energy Development Agency realizes the problem and potential of geothermal energy in Leh. Under this initiative, the thermal releases from the living bore-wells in Puga valley were planned to develop in two phases. During the first phase, two HPs, each capable of recovering 50-75 kW of heat for space heating, greenhouse cultivation, aquaculture, ice-melting applications and water heating were developed and the second phase integrated the 50-75 kW heat pipes with sealed turbo-generators for cogenerating about 10-15 kW and 75 kW of heat for space heating. Puga resources were utilized for maintaining a number of Tibetan residential schools. After success, similar systems were started installing at Chhumathang.

5. Summary

The geothermal development in India is poised to take a lead in the near future. It is essential to provide guidelines for exploration and development of geothermal resources, similar to oil and gas
resources. The basic database on selected geothermal areas may be prepared for the benefit of entrepreneurs. The geothermal exploration may be expedited by providing financial incentives for power generation. In India, the ground water is a state subject and is the property of the State Government; while the surface mineral resources are the property of the individual. Besides, the need to exploit the geothermal resources judiciously, for sustainable development, require that the geothermal energy sources may be declared as “national energy sources”, controlled by common policy issued by the Central Government.

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