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Geothermal Energy in India: Poised For Development

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ABSTRACT

The investigation over last two decades for geothermal resources in India, spread over 340 hot spring locations, has set the field ready for utilization. The investigation for geothermal resources in India was carried out mostly to shallow level of 300m to 500m depth. Exploration for geothermal resources at Puga, Leh district, and Tatapani, Chhattisgarh state have yielded free flowing water of 123°C and 112.5°C, respectively. The geothermal resources at West Coast of India, hot springs of Himalayan belt viz. Manikaran and Tapoban yield hot water useful for power generation. The estimated reservoir temperature at Puga and Tatapani ranges from 180°C to 230°C, while in other geothermal prospects the estimated reservoir temperature is around 150°C. These geothermal resources are useful for power generation by binary cycle method. Besides power generation, direct uses like spa, hot water bath, refrigeration, green house cultivation, skin cure centre can be implemented for effluent water.

The development of geothermal resources in India was lagging behind due to non- availability of roper machinery and lack of incentive. The government of India has taken major initiative to boost alternate energy sources and proposed incentives for development of geothermal resources in India. The proposals include scope for foreign direct investment, assistance in processing the papers and incentive for exploration and development of geothermal resources. Besides, the cooperation of National and International agencies responsible for geothermal development is also encouraged. These measures may help in attracting the private entrepreneurs to take up exploration for geothermal resources in India.

1. INTRODUCTION

Assessment of Geothermal resources was initiated in India, at the proposal of UNDP in 1973 for development of non-conventional energy resources. The investigation for geothermal resources in India was completed almost two decades before, which now requires appraisal to decide further follow up. Geological Survey of India is the prime organisation involved in investigation of geothermal resource while National Geophysical Research Institute, Oil & Natural Gas Corporation, Regional Research Laboratory, Bhabha Atomic Research Centre, and university departments were engaged in the study of specific aspects e.g. heat flow, direct heat uses, isotope studies. During the course of investigation GSI reported 340 hot springs in India, varying in surface temperature from 32° to 97°C.

The Geothermal resource assessment in India is mainly based on the pioneer work of Krishnaswamy and Ravishanker (1982) who prepared an inventory 340 hot springs in India. Out of this 113 hot springs were found suitable for exploitation and utilisation. The total resource potential of all the 113 hot springs was estimated to be 10,600 MW (Krishnaswamy & Ravishanker, 1982). Geothermal resources in India, have been grouped into 10 provinces (Pitale & Padhi, 1995) based on geographical location and heat flow pattern. The stored heat potential of these 113 hot springs was estimated to be 40.91×10^{18} calories (Pandey & Negi, 1995).

Geological Survey of India and National Geophysical Research Institute carried out investigation of geothermal resources in India, preparing database on geology, discharge and temperature parameters, heat flow pattern, water quality and shallow level resource potential. Development of geothermal resources in India remained stagnant due to availability of cheap power from coal based plants, non- availability of deep drilling machinery locally and funding. Considering the need to encourage the alternate energy resources, various measures are proposed to the Government of India for development of the geothermal resources in India. The constrains in development of geothermal resources in India and proposed incentive are discussed here.

2. GEOTHERMAL SCENARIO IN INDIA:

Occurrence of the geothermal resources in India is mostly controlled by tectonic features. The main zone of geothermal resources is located in the Himalayas stretching from Puga in Jammu & Kashmir (Mandal 2003), Manikaran in Uttar Pradesh to Takshing in Arunachal Pradesh. Geothermal resources along Son-Narmada lineament at Anhoni-Samoni, Madhya Pradesh and Tatapani, Chhattisgarh form a most promising resource base in Central India. A linear stretch from Koknere in north to Ganeshpuri, Unhavare, Tural and Rajapur in south hosts 18 hot springs along the West Coast of India. The other geothermal springs are located at Bakreshwar in West Bengal, Tarabola in Odisha, Manuguru in Telangana, Unai in Gujarat, Garampani in Assam, Takshing in Arunachal Pradesh, Rajgir in Bihar, mostly formed due to local geological conditions (Thussu 2003).

The basic data of geothermal fields in India are summarized below indicating possible areas for development in India.

Sr. No.	Geothermal Province	Locality	Temp. gradient Heat flow
1.	**Himalayan Geothermal Province**	**i. Puga Chumthang, Ladakh**	Hot springs of 30 to 84°C. Granite is reservoir rock. Reservoir temperature 160°C to 220°C. 13 boreholes drilled have total flow 3000 lpm, of 83°C to 123°C. Calcite, Sulphur, Borax deposits observed, Cs in water.
		ii. Manikaran	Hot springs of 34°C to 96°C discharge of 420 lpm. Springs in Quartzite, thermal gradient 100°C±10/ km, 8 boreholes show temperature of 83°C to 93°C. Maximum borehole temperature is 100°C. Reservoir temperature 186°C to 202°C.
		iii. Tapoban	Hot springs of 30°C to 65°C with flow of 50 lpm to 560 lpm. Quartzite with schistose bands, thermal gradient from 44 to 68°C/ km. 5 boreholes drilled show max temperature of 92°C. Reservoir temperature 120°C to 190°C.
2.	**Son- Narmada Lineament Province**	**i. Tatapani**	Hot springs of 52°C to 97°C, reservoir temperature 160°C to 200°C, 5 boreholes (depth 350m) discharge 1800 lpm water with max temperature of 112.5°C. Thermal gradient 60 to 100°C/km. Deposit of arsenic and sulphur. (Pitale et al, 1995)
		ii. Anhoni- Samoni	Hot springs show temperature of 32°C to 45°C with gas emission. Dolerite dykes at the contact with Gondwana sediments, 3 boreholes drilled yield 130 lpm water of max 54°C and methane. Thermal gradient 59°C/km, reservoir temperature ≈125°C.
3.	**West Coast Province**	**West Coast in Maharashtra.**	Unhavre (Khed) hot spring has temperature of 72°C with discharge 730 lpm. Deccan basalt with marshy ground. Six boreholes yield 300 lpm water of 54°C. Reservoir temp ≈145°C. Tural hot springs has temperature of 62°C with 330 lpm flow. Marshy ground. Max temperature in borehole is 59°C. Thermal gradient is 60°C/ km. Reservoir temperature 125°C to 170°C.
4.	**Chhota Nagpur Gneissic complex**	**Bakreshwar**	Hot springs of 40°C to 70°C with discharge of 420 lpm. Gneissic rocks at contact with Gondwana sediments. Gas emission. Two boreholes drilled show max temperature of 65°C. Reservoir temperature 120°C to 140 °C. Helium gas flow.
5.	**Godavari valley**	**Manuguru**	Hot springs of 36°C to 44°C, water of 50-60°C found in boreholes drilled for coal exploration. Gondwana sediments. Coal mines encounter hot water. Reservoir temperature 100°C to 150°C.
6.	**North Eastern Region**	**Assam- Meghalaya**	Hot spring are reported at Jakrem (46°C) in Meghalaya, Garampani (54°C) in Assam, Takshin (52°C) in Arunachal Pradesh. Discharge varies from 30 lpm to 90 lpm. Reservoir temperature ≈120°C (Thussu 2002).

3. SCOPE FOR DEVELOPMENT

The demand for power is increasing manifold due to rapid urbanization and industrial growth. The Government of India proposes to replace all thermal based power plants by renewable energy till 2030. Considering the need to reduce the coal based power by alternate sources of energy, it is pertinent to develop new energy sources like geothermal energy. The geothermal energy can be used as main power source as well as substitute to electricity as a source of heat, depending on geothermal parameters and local geographical conditions. Hence, the geothermal resources in India may be utilized for following developmental schemes.

3.1 Power plant and direct heat uses: Binary cycle Power Plant (Temperature required, 100°C-180°C at pressure of 2-3 bars): The hot water upto 180°C can be used for electricity generation by binary cycle method. The resources in remote areas and hilly terrain can be used for electricity generation to cater need of local population. In India, the geothermal resources at Puga – Chhumathang Geothermal field, Jammu & Kashmir; Tatapani Geothermal field, Chhattisgarh; Tapoban and Manikaran in Himalayan belt, Bakreshwar in West Bengal are useful for binary cycle power generation.

3.2 Refrigeration for preservation of fruits and vegetables (Temperature required, 70°-100°C): The effluent water from proposed power plant can be utilized for refrigeration by evaporation in refrigeration plant of ammonia absorption type.

3.3 Greenhouse (Temperature required, 60-80°C): Green house cultivation can be done by using hot water in cold weather conditions for growing vegetable and flowers in all seasons under controlled temperature and humidity. Green house cultivation is possible in Manikaran, Tapoban, Parbati valley, Puga-Chhumthang field, Tatapani, West Coast area, Anhoni- Samoni, and Surajkund.

3.4 Food processing- Fruits and see-weed drying, drying of vegetables, onions and fishes, food processing (Temperature required, <100°C): Hot water can be used for drying of fishes, vegetables and pulp preparation by using the heat radiation and heat exchangers. Useful for food industry in Ladakh, Tapoban, Parbati valley, Manikaran, West Coast, and Surajkund.

3.5 Snow melting (Temperature required, <80°C): The hot water can be used for snow melting and soil warming by circulation of water through subsurface pipes in places of extreme cold weather conditions like Puga-Chhumthang, Tapoban, Parbati valley, Manikaran.

3.6 Space Heating (Temperature required, >60°C): The hot water can be used for maintaining warmth in houses during extreme cold weather in Himalayan belt like Puga-Chhumthang, Tapoban, Parbati valley, Manikaran and Tatapani.

3.7 Industrial uses, paper and pulp, cement block curing, metal parts washing, timber washing, wool drying (Temperature required, 80-100°C): Various industrial uses to substitute heat component of electricity is possible by use of geothermal water at Puga, Manikaran, Parbati valley, Tatapani, West Coast, Bakreshwar, Surajkund and NE Region.

3.8 Aquaculture and agriculture, crocodile farming etc. (Temperature required, <60°C): Low temperature geothermal water can be sued for aquaculture and fish farming in controlled conditions at Manikaran, Tapoban, Parbati valley, NE Region, Anhoni-Samoni, Tatapani, Puga-Chhumthang, Bakreshwar, Surajkund, and Munuguru.

3.9 Soil Warming (Temperature required, >40°C): Low temperature water is used for soil warming in cold weather conditions. Useful at Puga-Chhumthang, Parbati valley, Manikaran, Tapoban, Tatapani in Chhattisgarh, Surajkund, NE Region.

3.10 Tourism, Spa, Swimming pool etc. (Temperature required, >40°C): This is most popular use of geothermal water of low enthalpy almost in all geothermal localities.

3.11 Coal Washing (Temperature required, >30°C): Low temperature water is used for cleaning coal and separation of shale from mine Manuguru in Khammam, Tatapani in Surguja, Anhoni-Samoni in Hoshangabad districts.

3.12 Industrial uses, washing of metal parts, furniture industry etc. (Temperature required, >50°C): Low to medium enthalpy hot water can be used for small scale industry in West Coast, Cambay basin, Manikaran, Sohna Valley, Agnigundala, Manuguru.

3.13 Extraction of rare metals, Extraction of helium, Mineral water industry (Temperature required, 30°C): Extraction of dissolved heavy metals, rare gases and native elements like sulphur are noticed in geothermal areas. It is profusely found in Puga (Cs), Tatapani, dist. Surguja (Ag, He), West Coast (Hg?), Bakreshwar (He), Anhoni-Samoni (CH_4). Deposition of silver is recorded in the scaling on discharge pipes of boreholes at Tatapani, dist. Surguja (Pitale et al 1995). Extraction of valuable minerals / metals from the geothermal processes help in bringing down the cost of geothermal power and makes it more attractive (Clutter 2000). Presence of Helium is reported at Bakreshwar hot springs (Mukhopadhyay 1996). Helium content of 1% to 2.2% is reported from steam discharge of borehole from Tatapani Geothermal field, dist. Surguja (Minissale et al, 2000).

4. DEVELOPMENT OF GEOTHERMAL RESOURCES

The above data indicate that there are active geothermal fields in India which are useful for utilization purpose. The geothermal resources in Himalayan belt need attention for power generation which may help in economic development of the region. The West Coast area has ample scope for developing direct heat uses for the benefit of existing industries. The main constraint in exploration is non-availability of machinery for deep drilling in India and related technical studies as most of these are engaged in oil exploration. The initial high cost of exploration and power plant installation as compared to thermal power plant or wind energy also restricts decision making. The geothermal energy development involves initial high investment as exploration cost is included in power plant installation but the cost of fuel supply (steam supply) is less as compared to fossil fuels, improving the economics of geothermal power generation. Geothermal is a capital intensive power project as the cost of exploration is included in the plant cost, but the cost of fuel in geothermal plant reduces steadily, hence, geothermal power is economical over life period of plant. The CEC, USA has estimated the levelised generation costs for a 50 MW geothermal binary plant at $92 per megawatt hour and for a 50 MW dual flash geothermal plant at $88 per megawatt hour (geo-energy.org).

The investigation for geothermal resources in India is carried out mostly to shallow level i.e. <500 m depth, hence deep drilling is essential to know the deep reservoir parameters for assessing power generation potential in selected fields. The deep level assessment of potential will help in planning and development of geothermal resources in India.

The following measures need to be initiated for possible utilization of geothermal energy in India.

- The investigation carried out so far is mostly at shallow level creating a gap of data for planning power project. It is proposed that concerned authorities may drill deep boreholes at Puga, Tatapani, Parbati valley and West Coast hot spring area; to decipher characters of deep reservoir which will be useful to assess feasibility of the resources for power production (Sarolkar 2015).
- Simultaneously, MT survey may be conducted to support the observations of geological and drilling data and study the reservoir structure at levels >1000 m, which will be useful for precise exploration planning.
- Private parties consider geothermal exploration as capital intensive activity, hence, financial incentives may be announced to promote exploration for geothermal resources. Funding at exploration stage will motivate exploration agencies to take up geothermal energy projects for power generation and direct heat uses.
- Government of India may encourage installation of demonstration geothermal plant at Puga and Tatapani, for establishing the geothermal power generation technology in India. Successful installation of power plant will attract the local entrepreneurs to take up more projects. The government has also proposed to encourage the use of geothermal energy for low temperature commercial applications and direct heat utilization. Government of India has formulated policy for development of geothermal energy and for

streamlining of procedure for participation of Foreign Entrepreneurs in development of geothermal resources in India. It is suggested that government may offer financial incentives for use of geothermal energy, to reduce the emission of green house gases.

- Government of India, MNRE, is planning for Geothermal capacity of 1000 MWth in the initial phase till 2022. The government is planning to encourage installation of demonstration projects to assess the technical viability. Government of India, Ministry of New and Renewable Energy (MNRE) contemplate initiatives in RDD&D of Geothermal technology specifically for the purpose of cooling, drying, Space heating, Greenhouse cultivation, Industrial processes, Cold Storage, Poultry & Fish Farming, Mushroom Farming, Horticulture. (http://mnre.gov.in/schemes/new-technologies, 2016).

5. CONCLUSION

The available data base suggest that shallow reservoir potential has been estimated in Puga-Chhumathang, Tapoban, Manikaran, Tatapani, and West Coast geothermal prospects. However, exploration for deep geothermal resources need to be taken up to establish feasibility for installation of power plant. Government shall promote exploration to deeper level to establish resource potential in selected fields for power plant installation. Government is encouraging installation of demonstration power plant and direct heat uses of geothermal energy as an alternative energy. Foreign funding and technology transfer may be encouraged along with suitable financial incentives to attract private parties for development of geothermal energy in India. The geothermal energy may prove to be a good substitute to fossil fuels in low to moderate temperature uses.

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