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GEOTHERMAL ENERGY IN INDIA - A PERSPECTIVE VIEW

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ABSTRACT

Among the various new and renewable energy sources, geothermal is known to be one of the clean energy without smoke and also without environmental hazards. Indian geothermal provinces have the capacity to produce 10,600MW of power-a figure which is five times greater than the combined power being produced from non-conventional energy sources such as wind, solar and biomass. With escalating environmental problems with coal based projects. Indian has to depend on clean, cheap, rural based and eco-friendly geothermal power in future. Due to technical and logistic problems with other non-conventional energy sources, present industrialists' mood is upbeat are showing keen interest in developing geothermal based power projects.India's first geothermal power plant with an initial capacity of 25MW was in Telangana State, of Khammam district by 2012. India's first power purchase agreement (PPA) between Geosyndicate Power Private Limited (an incubated company) of Indian Institute of Technology, Bombay and Northern Power Distribution Company of Andhra Pradesh Limited (APNPDCL) was signed recently in this connection. Dr.D.Chandrasekharam, founder and chairman of Geo-syndicate Power Private Limited. Geo-syndicate is an incubated company of Indian Institute of Technology, Bombay with corefocus on exploration and production of geothermal energy, Dr.D.Chandrasekharam is a well known geothermal expert and faculty member at Department of Earth Sciences, Indian Institute of Technology, Bombay. The signing of the agreement was done under the aegis of the Non-Conventional Energy Development Corporation of Andhra Pradesh Limited (NEDCAP).

TelanganaState, was the first state in the country has to executed this Power Production Agreement (PPA) with India's one and only Indian geothermal company with scientists and technocrats on its board. Global warming and climate change is and will continue to be one of

the key challenges the world has to face in the coming decades and geothermal energy could play a vital role in mitigating 'these challenges by reducing dependence on fossil fuels and provide clean energy. India looks forward to play a significant role in reducing the country's carbon foot print by setting up the geothermal plant. And one more company Tata Power exploring geothermal energy sources in India. India's Tata Power is looking to tap into geothermal power sources in the country, as the company believes growth in the renewable energy sector will continue.In the present paper I discussed the details of geothermal energy provinces in India and India's first geothermal power plant was came in Telangana State by 2012, and one more Tata Power company looking to tap into geothermal power sources in the country.

Key Words: Geothermalenergy, renewable energy, PPA, GSPPL, APNPDCL, NEDCAP, Tata Power.

INTRODUCTION

Several geothermal provinces in India characterized by high heat and thermal gradients (47-100o C/km) discharge about 400 thermal springs. The Geological Survey of India conducted reconnoiters survey on them in collaboration with UN organization and reported the results in several of their records and special publications (G.S.I., 1987; G.S.I., 1991). Subsequently, detailed geological, geophysical and tectonic studies on several thermal provinces (Kaila and Krishna, 1992; Gupta, 1981; Ravi Shanker, 1988) geochemical characteristics of the thermal discharges and reservoir temperature estimations have been carried out by several workers (Giggenbach, 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 and Chandrasekharam, 2000) These investigations have identified several sites which are suitable for power generations well as for direct use. These provinces are capable of generating 10,600 MW of power (Rani Shanker, 1996). Though geothermal power production in Asian countries like Indonesia, Philippines has gone up by 1800 MW in 1998, India with its 10,600 MW geothermal power potential is yet appear on the geothermal power map of the world! The growing environmental problems associated with thermal power plants, future for geothermal power in India appears to be bright. India's first geothermal power plant with an initial capacity of 25 MW was came in the Telangana State's Khammam district by 2012. India's first power purchase agreement (PPA) between Geosyndicate power private limited (an incubated company of Indian Institute of Technology, Bombay and Northern Power Distribution

Company of Andhra Pradesh Limited (APNPDCL) was signed recently in this connection. Dr.D.Chandrasekharam, founder and chairman of Geosyndicate power private limited. In the present paper, the details of geothermal energy provinces in India and India's first geothermal power plant was came in Telanagna by 2012 and one more Tat Power company looking to tap into geothermal power sources in the country in discussed.

PRESENT STATUS OF NON-CONVENTIONAL ENERGY RESOURCES

The power shortage in demand will increase in the. coming years due to economic globalization and increasing population. Though India boasts of generating eco-friendly energysources during the coming years. The present power generated through non-conventional sources is less than the installed capacity of the power plants,

Capital subsidy and financial incentives are given by the Government of India, non-conventional energy sources are not able to bridge the gap between demand and supply of power. Geothermal energy, a non-conventional energy source, has not so far put to use though its power generating capacity is of the order of 10,600MW. Neither the Government bodies nor the Independent power Produces (IPPs) are aware this vast resource in the country in previous years. The Indian is not keen in developing this source in bridging supply-demand power gap. The 192 billion tones of recoverable coal! reserves which is encouraging coal based power projects and hampering the healthy growth of non-conventional energy programs. Ina addition to coal availability at naphtha in the world is adding fossil fuel to the fire!

TABLE 1. POWER PRODUCTION STATUS OF NON-CONVENTIONAL ENERGY IN INDIA

Renewable Power	Potential	Achieved
Wind Power	45,000 MW	1,507 MW
Small Hydro Power	15,000 MW	1,663 MW
Biomass	19,500 MW	343 MW
Solar photo- voltaic Power	47 MW/sq.km	810 KW

POWER GENERATING CAPACITY OF INDIAN GEOTHERMAL PROVINCES

Indian has 400 medium to high enthalpy geothermal springs, clustered in seven

province shown in Figure 1. The most promising provinces are:

i) The Himalaya,

ii) Sohana,

iii) Cambay,

iv) Son-Narmada-Tapi (SONATA) and

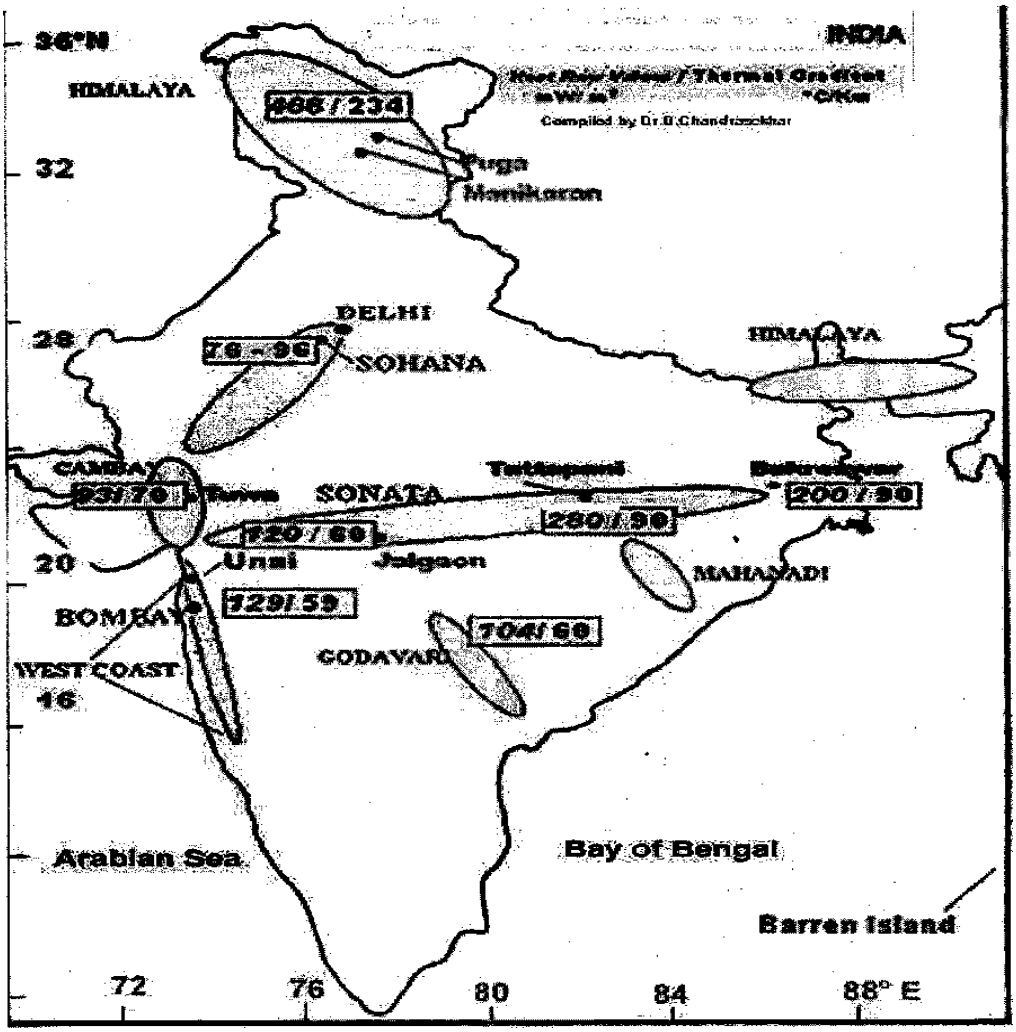
v) The Godavari.

vi) With the recent volcanic eruption, the Barren Island, and

vii) A part of the Andaman-Nicobar chain of islands.

Most of them are liquid dominated systems with one or two having both liquid and gas dominated systems. Let us examine the geothermal characteristics of some of the provinces.

G.S.I.. 1991. "Geothermal Atlas of India". Geol. Sury. India Spe.Pub., 19,144 p.



THE HIMAYALA PROVINCE

This is one of the most promising provinces in the coldest part of the country and contains about 100 thermal springs with surface temperatures as high as 90° C discharging > than 190 tones /h of thermal water. This province falls in one of the most tectonically active zones- the Indo-Eurasian plate boundary (Fig. 1) which experiences a large number of earthquakes (Chamoli experienced 6.8 magnitude earthquake on 29, March 1999). Post Tertiary granite intrusives are responsible for the high temperature gradient (> 100° C/km) and heat flow (> 468 mW/m^2) recorded in the 500 m drill-hole in this province. Geothermal reservoir between depths 1 and 3 km was delineated from magneto-telluric recordings (Singh and Nabetani, 1995). The first and the last (!) pilot binary 5 kW power plant using R 113 binary fluid was successfully operated by the Geological Survey of India at Manikaran which proved the power producing capability of this province. Presence of epidote in drill-cuttings recovered from 500 m drill-holes support estimated reservoir temperature of 260° C. Space heating experiments were also successfully conducted using thermal discharge by the Geological Survey of India.

CAl^IBAY PROVINCE

! Situated in a failed arm of a rift (Sheth and Chandrasekharam, 1997), this province forms a part of the Cambay basin with > 500 m of post Cretaceous sedimentary formation overlying the well known Deccan flood basalts. Besides deep seated faults, which brackets the basin, older granite intrusive(~ 955 Ma; Gopalan et. al., 1979), such as those at Tuwa and Miocene-Pliocene basic intrusive, contribute. partly to the high thermal gradient (> 60° C) and heat flow value (>80 mW/m^2) of this basin. More than 15 thermal discharge sites are located in this province with surface temperatures varying from 40 to 90° C. Steam discharge in certain oil wells were recorded with rates exceeding 3000 m^3 /d. Reservoir temperatures estimated at two sites (Tuwa and TulsiShyam) are greater than 150°C(Kamble, 1994).

WEST COAST PROVINCE

This province is located within the world famous Deccan flood basalts of Cretaceous age. Attenuation and foundering of the continental crust prior to the outpouring of the large volume of lavas along the coast (Chandrasekharam and Parthasarathy, 1978) resulted in the development of several faults and graben structures (Chandrasekharam, 1985) which are channeling thermal waters. This province enjoys a thin lithosphere of 18 km thickness (Pande et.al., 1984) thereby rendering this province as one of the most, promising sites for

exploitation. The thermal discharges are saline with Cl content varying from 800 ppm to little over 1500 ppm (Ramanathan, 1993). Hence, geo-thermometers may not indicate the true reservoir temperatures. About 1% saline component has beenestimated in these thermal discharges. The reservoir temperatures calculated, after making necessary correction for 1% saline component, are between 102 and 137° C (Chandrasekharam et.al., 1989). One thermal discharge, located at Rajapur, within the Deccan basalts along the coast is an exception to the other thermal discharges mentioned above. The thermal reservoir of this discharge is located within the Precambrian formation, like the Puttur thermal waters, with reservoir temperatures varying between 120 and 200° C (Ramanatha and Chandrasekharam, 1997).

SONATA PROVINCE

This province extending from Cambay in the west to Bakreswar in the east is an area with very high heat flow and geothermal gradient (Fig. 1) and encloses the well known Tattapani geothermal province spreading over an area of about 80,000 sq.m. The Tattapani province encloses 23 thermal discharge sites with surface temperatures varying between 60 and 95° C and flow rate greater than 4000 1/m.. Nine thermal springs are discharging waters at 90° C. These waters, compared to those of west coast, are low in Cl content (60 -70 ppm) and the chemical composition of the thermal discharge is controlled by water-rock interaction. Based on thermal gradient and experimental results, estimated reservoir temperatures are as high as 217° C at 3 km depth. (Chandrasekharam and Antu, 1995). In certain bore holes drilled by the Geological Survey of India, thermal discharge was not encountered but the recorded thermal gradient in these bore holes exceed 100° C/km (K. Muthuraman, G.S.I., personal communication). Such sites are best suited for experimenting HDR projects (Chandrasekharam, 1996). Five 6 inches diameter production wells to commission a pilot power plant of 3.17 MW were drilled by the GSI. The pressure of the thermal discharge is 5 kg/cm^2 and the estimated life of the reservoir is about 20 years (Pitale et.al., 1995). It is unfortunate that a power plant is yet to be commissioned at Tattapani.

Unapdeo and Nazardeo, the two thermal provinces located between Tattapani and Cambay and enclosed by the Tapi rift within the SONATA, discharge 59^P C thermal waters. Though these springs issue through Deccan basalts, chemical signature of the springs indicate that they are in chemical equilibrium with underlying Na-rich granites, recorded through magneto-telluric surveys (Rao, et.al., 1995). Estimated reservoir temperatures are 105 and 133°C respectively. (Chandrasekharam and Prasad, 1998).

BAKRESWAR PROVINCE

The Bakreswar-Tantloi thermal province falls in Bengal and Bihar districts and marks the junction between SONATA and Singbhum shear zone (Fig. 1). High He gas is encountered in all the thermal discharges (water and gases) and it is proposed to install a pilot plant to recover He from the thermal manifestation of this region. The He discharge is 4 l//h(Nagar et.al., 1996).

GODAVARI PROVINCE

Godavari valley in Andhra Pradesh is a northwest-southeast trending graben filled with Gondwana sedimentary formations. The lower Gondwanagroup of roks consist ofsandstone, shale and clays and are exposed towards the southwestern part of the graben and hosts 13 thermal discharges with surface temperature varying from 50 to 60° C. This graben falls within zone II (100 - 180 mWm^2) on the heat flow map of India and has a thermal gradient of 60° C/km (Ravi Shanker, 1988). Two thermal springs, Bugga and Manuguru, discharging 1000 l//m of water, were studied in detail. Talchir sandstone, which forms a unit in the lower Gondwana group, is the reservoir rock with an effective porosity of 35%. The storage capcity of the sandstone is 35 x 10^6 m^3 which is expected to yield thermal discharge for about 75 years.

Geochemical thermometers indicate reservoir temperatures in the range of 175 and 215° C. The reservoir is reported to be at a depth of 2.5 km. It has been estimated that 38 MW power can be generated from this province (Chandrasekharam and Jayaprakash, 1996). A 1-6 shell and tube heat exchanger to suite the thermal discharge conditions has been designed to dehydrate 10,000 Ib/hr of onions with an air volume of 20,000 m^3 (Chandrsekharam et.al., 1996).

THE BARREN ISLAND

The Barren island forms a part of the Andaman - Nicobar island chain in the Bay of Bengal and is located 116 km ENE of Port Blair. Recent volcanic activity was recorded in 1991 which resulted in the appearance of high temperature steaming ground and thermal discharges. Fumarolic discharge recorded temperatures varying between 100 and 500° C. Detailed exploration work needs to be commissioned in this province.

Table 2.summarizes the temperatures, heat flow values and geothermal gradients of the provinces discussed above.

TABLE 2. POTENTIAL GEOTHERMAL PROVINCES OF INDIA

Province	Surface T°C	Reservoir T° 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

Heat flow: mW/m^2; Thermal gradient: °C/km

Thus, it is apparent that, with the available technology all the above thermal provinces can be exploited for power generation as well for direct use.

Though coal based and naphtha based power project are riding over other non-conventional energy sources, environmental problems associated with such mega-projects are many. The existence of a very strong coal and naphtha lobby which is hampering the healthy growth of non-conventional energy sources.

INDIA'S FIRST GEOTHERMAL POWER PLANT TO COME UP INANDHRA PRADESH

India's first Geothermal power plan t with an intital capacity of 25 MW was came in Telangana State's Khammam district by 2012. India's first geothermal Power Purchase Agreement (PPA) between Geosyndicate Power Private Limited (an incubated company of Indian Institution of Technology, Bombay) and Northern Power Distribution Company of Andhra Pradesh Limited (APNPDC) was signed recently in this connection, Dr.D.Chandrasekharam, Founder and Chairman of Geosyndicate. The signing of the agreement was done under the aegis of the Non-Conventional Energy Development Corporation of Andhra Pradesh Limited (NEDCAP) (formerly Andhra Pradesh). Telangana State is the first state in the country to have executed this power purchase agreement with India's one and only Indian geothermal company with eminent Scientists and technocrats on in board. Global warming and climate change is and will continue to be one of the key challenges the world has to face in coming decades and "Geothermal energy could play a vital role in

mitigating these challenges by reducing dependence on fossil fuels and provide clean energy. Geosyndicate looks forward to play a significant role in reducing the country's carbon foot print by setting up the geothermal plant (Dr.D.Chandrasekharam, founder and chairman of Geosyndicate told PTI).

A power plant based on geothermal energy basically harnesses the heat from the Earth's inner layers to produce electricity. Advancement of drilling and heat exchanger technology is making it increasingly easier for developing countries to utilise their enormous untapped geothermal energy resources, according to Dr.D.Chandrasekharam, Chairman, Geosyndicate and a well known geothermal expert and faculty member at Department of Earth Sciences, Indian Institute of Technology, Bombay. Per unit cost of electricity would be below Rs.10/-, which would be cheaper than electricity rates from solar farms. The project has not received any financial aid from the Government institution and all the required funds would be raised from the private sector. The company is in the process of raising funds for the project and therefore the debt equity ratio cannot be disclosed.

Geosyndicate power private limited a Mumbai-based energy company, will set up the country's first geothermal power plant of 25 MW in the Khammam district of Telangana State at an investment of Rs.300 crore. The Khammam site has a total potentialof about 60MW which would be exploited over a period of time. The land required for the 25 MW plant would be just about an acre. Since, geothermal power is produced by non-polluting sources. The country which had earlier been lagging behind in the geothermal sector is now making headway. (Sep 28th, 2010 PM News Beaurau). And one more company Tata Power exploring geothermal energy sources in India. India's Tata Power is looking to tap into geothermal power sources in the country, as the company believes growth in the renewable energy sector will continue.

CONCLUSIONS

; Indian Power Producers involved in non-conventional energy sources, are showing keen interest in Geothermal energy exploration and production by those organisations working in this field such as Indian Institution of Technologies (IIT) (Dr.D.Chandrasekharam, 2010), Geological Survey of India(GSI), and National Geophysical Research Institution(NGRI). One time investment and low maintenance, low cost, low area requirement, and incentives given by the Government for non-conventional energy sector is attracting many Independent Power Producers in India like geo-syndicate.

India with its 10,600 MW geothermal power potential is yet appears on the geothermal power map of the world! India's first Geothermal power plan t with an initial capacity of 25 MW was came in Telangana State's Khammam district by 2012.

This is the stepping stone in the coming decades and geothermal energy could play a thumb role in mitigating these challenges by reducing dependence on fossil fuels and provide clean energy. India's Tata Power is looking to tap into geothermal power sources in the country, as the company believes growth in the renewable energy sector will continue. No, doubt this one only geosyndicate power private limited (an incubated company of Indian Institute of Technology, Bombay) would change the entire future power scenario in India.

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