Proceedings World Geothermal Congress 2015
Melbourne, Australia, 19-25 April 2015

Potential of Geothermal Resources in Power Generation in India

Shanmugasundaram Manikandan

Milltex Engineers P Ltd., 8/68-69, Sundaresa layout, Trichy road, Coimbatore 641 018, India

milltex@vsnl.com

Keywords: India, Power Generation, Direct use

ABSTRACT

India has a reasonable quantum of geothermal resources and with the National Power Grid completed in early January, connecting the North and the South, creating an increased need to look at geothermal resources to augment the current generation. The growing opposition against Nuclear power generation and the delay in privatisation of coal mining has resulted in darkness in some parts of the country. The lack of regulated power supply has had its impact on the economic prospects of the country and therefore creating an immediate need to exploit the existing geothermal resources of the country. It is estimated to augment supply between 10,000 to 15,000 Mw of power production. The geothermal belts have been identified by the geologists and a study to understand the potential has gained momentum.

1. INTRODUCTION

The Energy sector is India (conventional or renewable) has seen an erratic since the days of Independence and even with the baton of faster development being moved to private enterprises with the change of Government policy, the impetus has been meek.

The sentiment in the private sector is not meek because of the collapse of private sector ventures or the lower efficiency of existing power plants but the lack of clear energy policy in India. While my attempt is not detail the policy paralysis in India for the last 4-5 years but to highlight the reasons for lack of growth in all the forms of energy generation though renewable energy alternate in the form of geothermal sources were evaluated in India in 1950s. The lack of consistency in India's policies is very critically to the lack of "greater" interest in the energy sector in India. While I am reviewing this, the people of India have cast their mandate in favour of Mr. Narendra Modi with the hope of providing a stable and progressive government especially in the renewable energy sector. The Government of Gujarat has already cleared the feasibility to establish a geothermal plant in Gujarat but with the UPA – II at the centre the paralysis impacted the move.

2. THE POWER SITUATION IN INDIA – NATIONAL ELECTRICITY POLICY 2003

The Government of India notified National Electricity Policy in 2004 with an objective to enhancing our power production capability and by 2012 the demand would be met with adequate spinning reserve but this policy failed in all aspects as evolution of the policy lacked holistic thought. This was compounded by the policy paralysis that began towards the end of United Progressive Alliance – 1 and the industry has since been almost dormant. The fuels that were deliberated or focused were coal, natural gas, nuclear substances or materials, hydro and renewable sources of energy and there was no essence in any of the areas. Infact, the Ministry of New and Renewable Energy could not even fall back on its own records on Geothermal being not just a renewable energy but one of the cleanest in its class.

Fuel	MW	Percentage
Coal	1,34,388.39	58.75
Gas	20,380.85	8.91
Oil	1,199.75	0.52
Total Thermal	1,55,968.99	68.19
Hydro (renewable)	39,788.40	17.39
Nuclear	4,780.00	2.08
Renewable Energy Source*	28,184.35	12.32
Total Installed Capacity	2,28,721.73	100

* Renewable energy sources includes Small Hydro Project, Solar Photovoltaic Power, Wind Energy, Biomass Gasifier, Biomass Power & Urban and Industrial Waste Power and sadly it does not include Geothermal Energy.

Table 1: Installed capacity in India (as on 30.09.2013).

3. RENEWABLE ENERGY SOURCES IN INDIAN POWER SCENE

The estimated power shortage in India at the moment is 50,000 MW while the potential of non-conventional energy is about 50,000 MW without considering geothermal energy sources in India. The development of renewable power energy plants is capital intensive and cross-subsidies in conventional sources of power generation has made the Government of India averse to greater support to the renewable power industry and this has increased the cost of power per unit compared to conventional sources. The malice in the Indian power generation industry can be attributed to the inefficiency in state-run conventional power generation plants and private power generation companies more keen on Governments assurance for low cost – long term fuel supply for easy profits not just by producing power but by sale of assigned fuel for other industries.

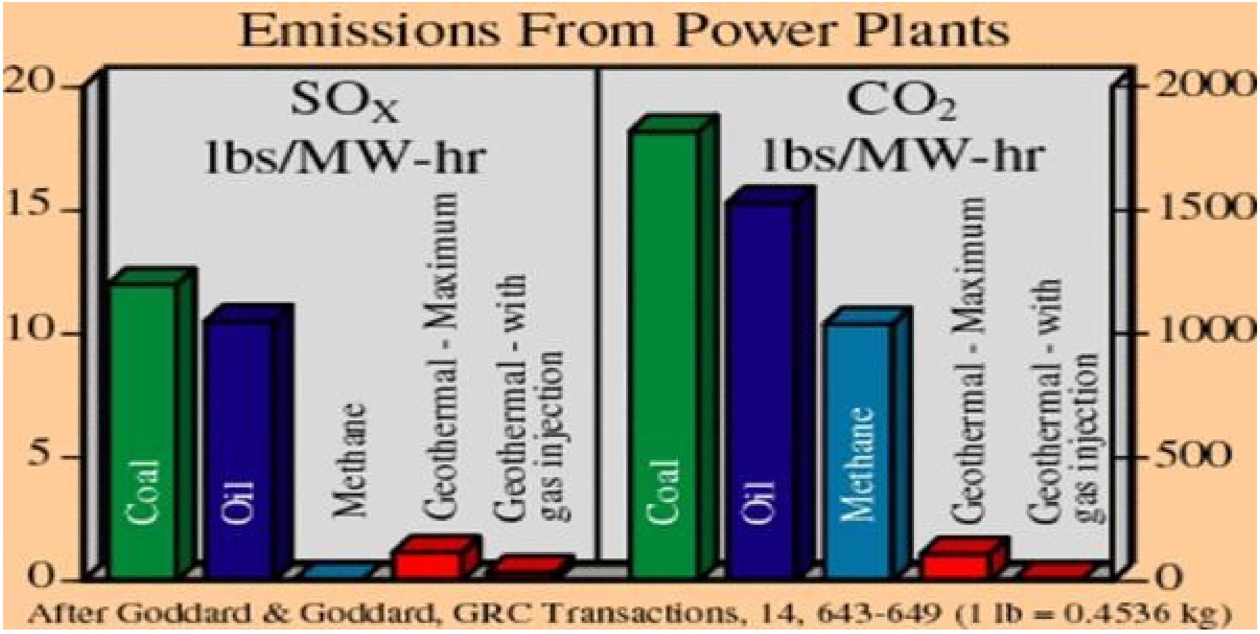

Figure 1: Table indicates emissions from power plants, conventional and geothermal (Source: IBC Conference Geothermal Power Asia 2000, Manila, Philipines, Feb 2000 by D. Chandrasekaram)

The already existing renewable energy sources are still at the mercy of the Indian Government as power distribution is still mostly controlled by state run institutions mainly the major grids that connect the entire country. Power production, conventional or renewable source driven, need over 90% evacuation of the energy generated by them to maintain profitability and overall interest in the industry.

4. GEOTHERMAL ENERGY ALTERNATIVE

The geothermal energy potential in India is estimated to be about 10,000 MW (Ravi Shankar, 1996) and independent power producers are not keen on this form of energy and the reasons for the lack of interest is attributed to the 190 billion tonnes of recoverable coal resources in India. The exploitation of the geothermal resources that exist in India needs just a change in mind-set and this would create a sea change in not just energy production but also help in 1) reducing foreign exchange out-flow 2) reducing carbon foot-print and 3) enhanced use of geothermal energy for direct application reduces use of electricity from the current grid.

This effort is to re-introduce several attempts made by scientists of India and rest of the world in studying India's geothermal resources and make a concentrated attempt to push the newly elected Mr. Narendra Modi led government to look at geothermal as an attractive source to help reduce the ever growing energy demand in India. No great attempt will be made to draw parallels between the conventional fuels or competing renewable fuel options but focus on the heat sources available to exploit it to serve multiple objectives in India's renewed plan for development; a) increased energy production b) rural electrification (as most sources are in rural areas or non-industrialised areas) and c) direct applications (heating or cooling), either directly or in cascade methods.

Geothermal energy can be harnessed from domestic sources with greater reliability and environmental advantages over conventional energy sources and it can contribute to energy supply with electricity power generation and direct-heat use.

The process of production of electricity or direct use of geothermal sources have been well documented and need not be elaborated further. However the emission table illustrated earlier needs to be highlighted and the indicators would prove critical whenever India signs the Kyoto protocol. The excessive use of coal or other fossil fuels will have serious irreversible damage to the quality of human life and the power producers just calculate the direct cost involved in cost of power production and do not include the cost of reversing the damage caused by dumping of fly-ash or the emissions released into the environment.

The high cost of power from solar photo-voltaic or solar thermal and the seasonal supply of wind velocity would make geothermal sources as a viable and reliable alternate and its high time that India falls in line with the changing environment and depend on cheap, independence of weather and season and environment friendly clean geothermal energy resources.

5. CURRENT GEOTHERMAL SITUATION IN THE WORLD

Geothermal power plants produce electricity in about 25 countries and over 78 countries use geothermal energy for direct applications (India uses geothermal energy for direct applications). Over 88% of the total capacity of 10.7 GW (as of 2010) is produced in only seven countries; USA, Philippines, Indonesia, Mexico, Italy, New Zealand and Italy. The United States of America leads with the production and use of geothermal resources for energy production but Iceland raised almost 25% of its total electricity requirement from geothermal resources. Currently there are over 800 geothermal power projects totalling 23,313 megawatts in various stages of development around the world the balance is likely to tilt towards Asia with over 10,100 megawatts.

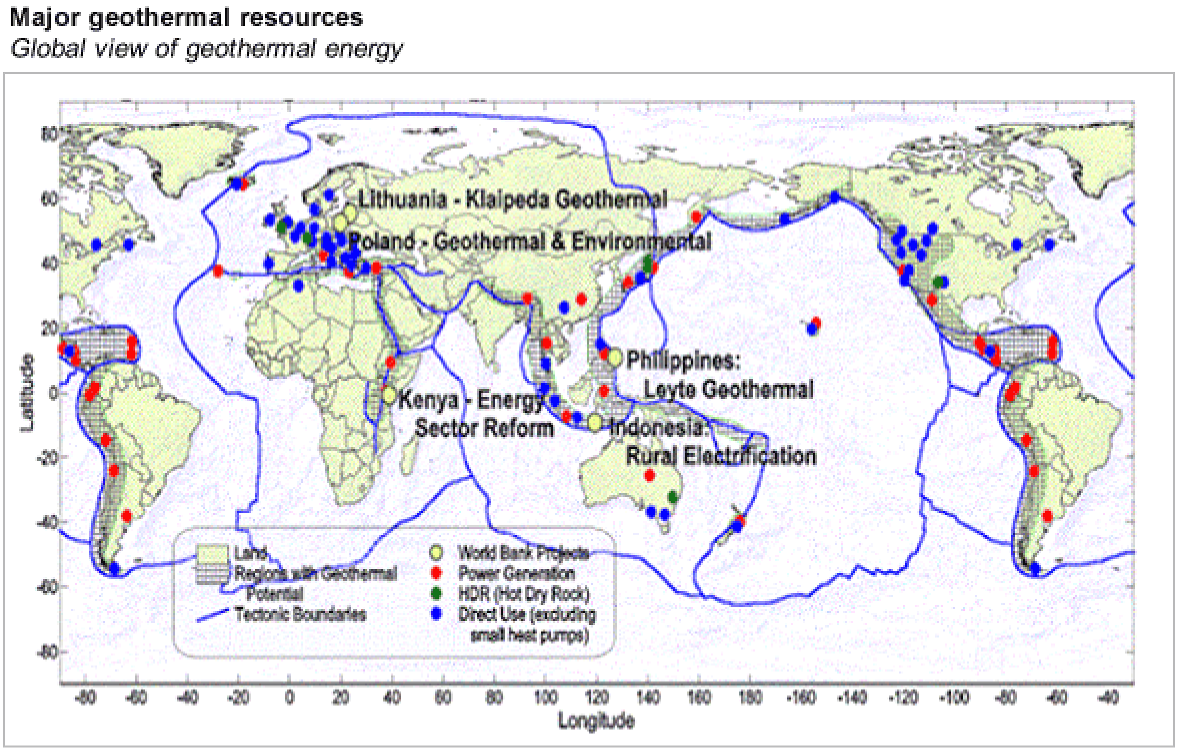

Figure 2: Major geothermal resources in the world (Source: IBC Conference Geothermal Power Asia 2000, Manila, Philipines, Feb 2000 by D. Chandrasekaram)

The increased impetus to geothermal resources has only been due to the awareness of its potential in not only being renewable and much safer to the environment, extensive research and development in new generation geothermal power systems have reduced capital costs by almost 50% and energy is produced with lower temperatures. In addition to this cascade methodology also helps in better utilisation of the drilled well by increased power production from the same number of wells.

6. GEOTHERMAL RESORUCES IN INDIA

India has reasonably good potential for geothermal; the potential geothermal provinces can produce over 10,000 Mw of power. But the exploitation has been rather slow. The state Governments of Gujarat and Chattisgarh have initiated in-principal approvals while Panax Geothermal along with Geosyndicate Power have been able to re-start exploration at Puga, Jammu & Kashmir in collaboration with Raya as operator and the project is high on viability as its close to 30 kms from the nearest transmission line.

India like most other countries joined the geothermal exploration during the oil crisis in 1970s and considerable progress was made in not just research but also commenced exploration and the details of the work is briefed below in the classification of geothermal resources in India.

In India nearly 400 thermal springs occur, distributed in seven geothermal provinces. These provinces include

1. The Himalaya province
2. Cambay province
3. West coast province
4. SONATA province
5. Bakreshwar province
6. Godavari province
7. The Barren Island (added after the volcanic eruption)

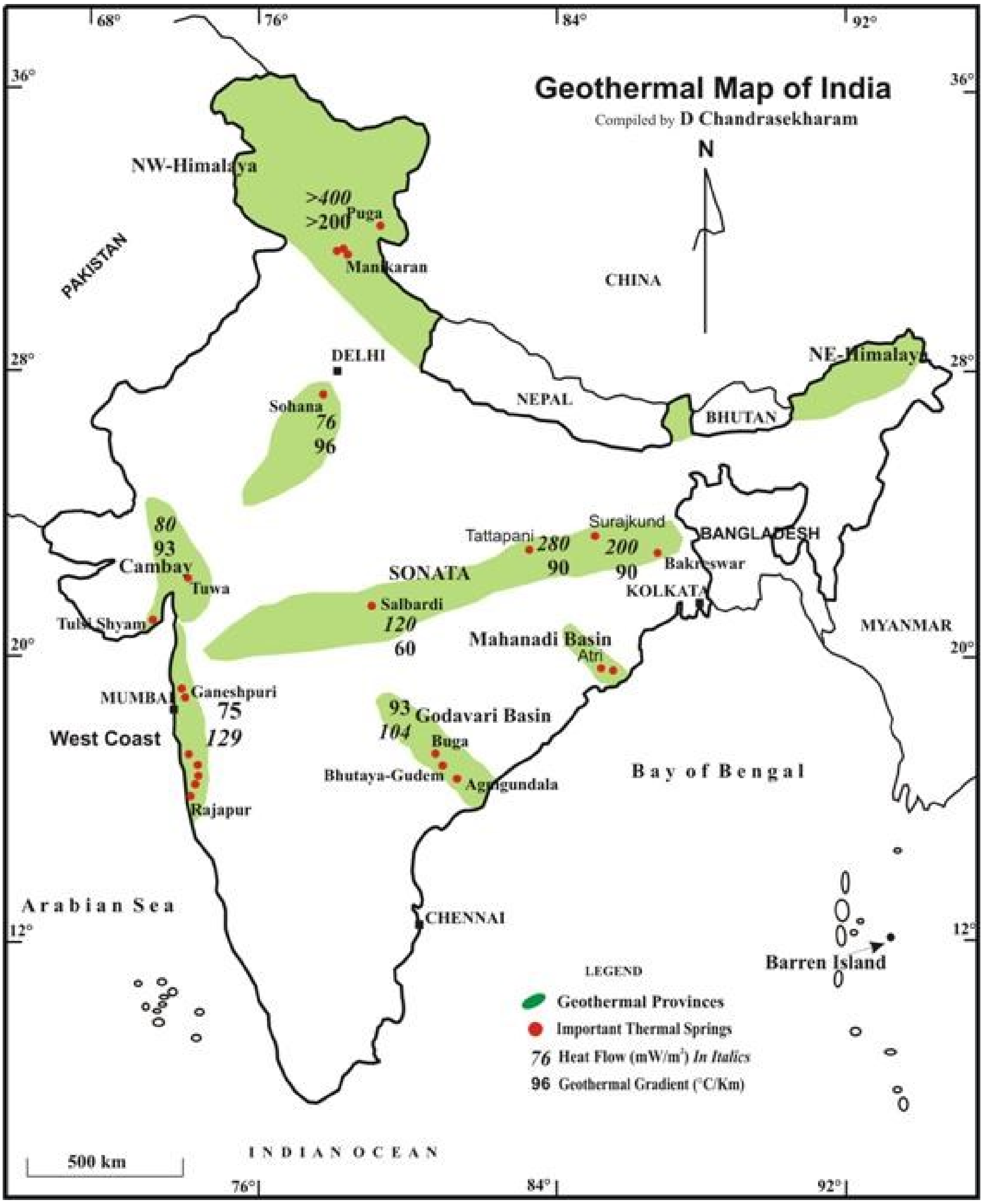

Figure 3: Geothermal map of India (Source: IBC Conference Geothermal Power Asia 2000, Manila, Philipines, Feb 2000 by D. Chandrasekaram)

6.1 The Himalaya Province

This is one of the most promising provinces in the India and is one of the coldest part of the country and has over 100 thermal springs with surface temperatures as high as 90°C discharging more than 190 tonnes/hour of thermal fluid. The province falls in the most tectonically active zones of the Indo-Eurasian plate and is subject to number of earthquakes.

Puga, which is located at a distance of about 180 kms from Leh has seen a lot of interest. A total of 34 boreholes ranging in depths from 28.5m to 500m have been drilled in the valley by the Geological Survey of India (GSI) and results of the fluid pumped showed promise. The hottest thermal spring showing a temperature of 84°C with a maximum discharge of 5 litres / second have also been recorded and manifestations in the form of hot springs, hot pools, sulphur condensates and borax evaporates have been recorded. This province is under next stage of exploration (as mentioned earlier) by the Raya group in collaboration with Geosyndicate Power and is expected to produce 60 Mw in the next few years. However, in terms of direct usage there has been reasonable success in this province with fluids being used for heating spaces, processing of borax and sulphate, poultry farming and green house cultivation.

Close to Puga, Chhumathang spring has been identified and the fluid is similar to Puga except the presence of relatively higher pH and sulphate. Geothermal activity at Parvati area in Manikaran (Himachal Pradesh) has seen a lot of activity with GSI installing a pilot 5 Kw power plan using R 113 binary fluid but was never operated beyond the testing phase. Temperatures between 65° and

96°C have been recorded in the area and scope of enhanced geothermal system is high. But the area has shown a lot of promise in direct applications with a 7.5 tonne cold storage based on ammonia absorption system.

6.2 The Cambay Province

This province forms a part of the Cambay basin with post cretaceous sedimentary formation overlaying the well-known Deccan flood basalts. More than 15 thermal sites are located in this province with surface temperatures varying from 40 to 90°C and the potential of this province is visible with steam discharge in certain oil well exceeding 3000 m3/d and reservoir temperatrues in two sites – Tuwa and Tulsi Shyam - are greater than 150°C. The Government of Gujarat has initiated discussions to setup a pilot 1 Mw plant in the state and selection of appropriate site will commence any time.

6.3 West Coast Province

This province is located within the world famous Deccan flood basalts of Cretaceous age and large outpouring of large amounts of lavas along with coast resulted in the development of several faults and structures which are channelling thermal fluids. The west coast line of India stretching to nearly 300 kms is numerous hot springs dot along the narrow coast line with Satvili, Ganeshpuri (107°C), Akloli, Unhvre (Khed - 127°C), Tural (170°)-Rajwadi (113°C) and Rajapur. The hot springs of West Coast geothermal province forms part of active geothermal systems having low to medium enthalpy. The fluids from these springs are alkali type except for the one in Rajapur which recorded high sulphate content. Further results after adjusting 1% saline content in the fluid indicate temperatures between 102 and 137°C and higher viability has been recorded in the Puttur thermal waters were temperatures between 120 to 200°C after adjustments. However, the presence of saline with CI content in the thermal discharges may not indicate the true reservoir temperature and therefore ideal for exploration to understand the potential.

There has been luke warm response in exploration in this belt though there are more than 18 recorded thermal springs in this province as the potential for electricity generation is low in this belt but and a few of them have the potential for direct use and this can reduce the stress on the grid.

6.4 Sonata Province

This province extends from the Cambay region in the west to Bakreshwar in the east has recorded high heat flow and geothermal gradient and encloses the well known Tattapani geothermal province spreading over an area of about 80,000 sq.m. This province encloses 23 thermal discharge sites with surface temperatures varying between 60 to 95°C and flow greater than 4000 litres/min and 9 thermal springs discharge fluids consistently at 90°C or more and these fluids compared to the West are low in CI content.

Thermal gradient experiments estimate reservoir temperatures are high as 217°C and GSI drilled bore wells have not been utilised. However, the Chattisgarh government has decided to establish a geothermal power plant and MoU has been signed between National Thermal Power Corp. (NTPC) and Chattisgarh Renewable Energy Development Agency (CREDA) and detailed project report is under preparation.

6.5 Bakreswar Province

This province falls in Bengal and Bihar districts and marks the junction between SONATA and Singbhum shear zone. Presence of helium gas has been noticed in all reported thermal discharges and steps had been initiated to tap the helium gas but the progress has been very slow. However, recently the government of West Bengal has shown some interest in the setting of a pilot geothermal plant in Bakreshwar, where a state run-thermal power plant has not been working in full capacity. The tapping of geothermal resources in the Atri region (in Bihar), Tantoli (Jharkhand) needs further study as part of the rural electrification plan proposed.

The thermal fluids in this province needs further exploration to identify areas for power production but the temperatures recorded are appropriate for direct heat use in refrigeration, green-housing, aquaculture, sericulture, concrete curing, coal washing and spa / therapeutic use.

6.6 Godavari Province

The lower Gondwana group of rocks in the Godavari province hosts 13 thermal discharges with surface temperature as low as 50°C. Two thermal springs, Bugga and Manuguru, discharging about 1000 litres/min. were studied in detail and thermal discharge is expected in the longer run and geochemical tests indicate reservoir temperatures in the range of 175-215°C at depth of 2.5 kms or more and estimated that about 35-38 Mw power can be produced from this province.

Further exploration in this province is critical to understand power generation capability but the direct use alternative is ready for exploitation and the agricultural and aqua-culture business of the area can surely utilise this potential to de-stress the current grid.

6.7 The Barren Island

The Barren Island forms a part of the Andaman – Nicobar chain of islands and is located 116kms north east of Port Blair and results indicate appearance of high temperature steaming ground and thermal discharges and detailed work has to be commissioned in this province. The island was believed to be uninhabited but an Indo-Italian joint study in 2003 recorded the existence of goats and the presence of two natural springs and the water was found potable after chemical analysis. But access to the area is highly restricted and under monitoring by the Coast Guard of India due to the high level of the sea near the island and recorded volcanic activity.

It lies on the Neogene Inner Volcanic Arc extending from the extinct volcanoes like Mt. Popa, Mt. Wuntho of Myanmar in the north to the active volcanoes of Sumatra and Java in the south. The volcano consists of a caldera, which opens towards the west, with a central polygenetic vent enclosing at least five nested tuff cones. Two spatter cones exist - one on the western flank of the central cinder cone and the other one on the southeastern flank of the central cone.

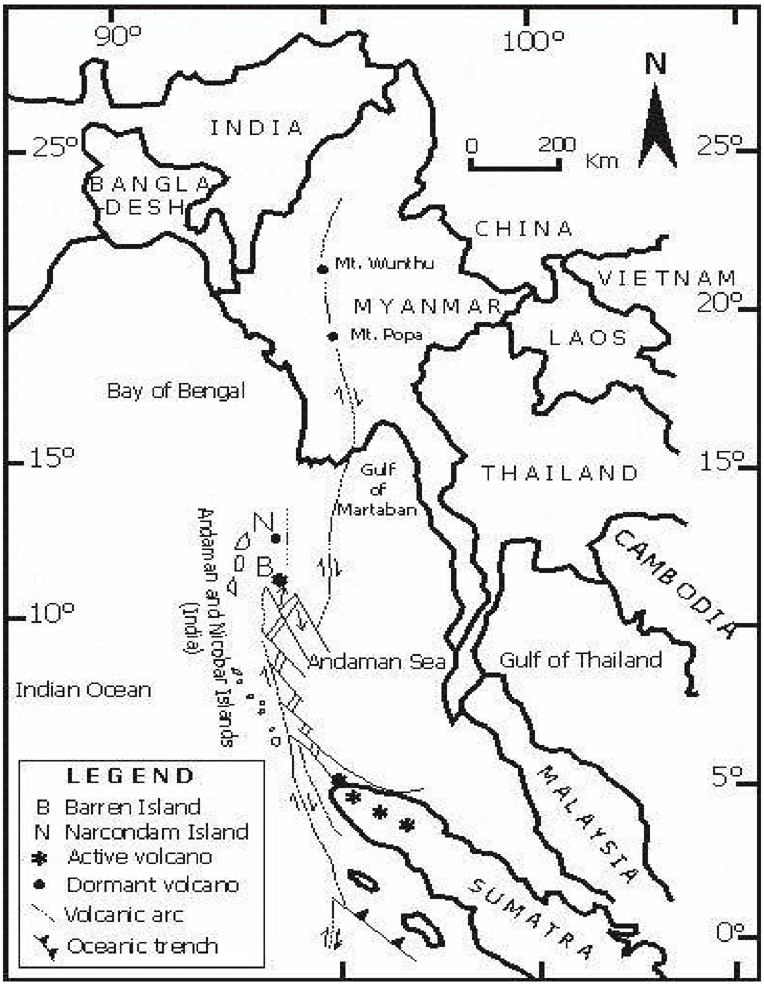

Figure 4: Location of Barren Island over the volcanic arc (Modified after Rodolfo, 1969; Source: www.dchandra.geosyndicate.com/geothermal - D. Chandrasekaram)

7. STEP AHEAD

The above referred provinces hold high potential for electricity production and direct use, which can be reduce the strain as power that is not drawn from the grid can be deployed in other areas.

The studies done till date have not been extended to the north eastern states; especially the states of Sikkim and Arunachal Pradesh have presence of hot springs and study teams to these two states in particular along with The Barren Islands will have to be initiated to understand its potential and work towards development. The North Eastern states have already been subject to a lot of deliberation for their hydel power generation capabilities but their integration with the rest of India, culturally and economically look much slower than the integration of the newly created states in India.

Apart from the above provinces, the potential in Ocean Thermal Energy Conversion (OTEC) for India needs special mention. India is geographically well placed to exploit the OTEC potential with coast length of 2000 kms along the south Indian coast and temperature difference of 20°C persists between the surface water and water at a depth of one km, around the year. This amounts to about 1.5 X 10 (power 6) square kilometres of tropical water in the Exclusive Economic Zone around India with a power density of 0.2Mw km (power – 2). Additionally, attractive OTEC plant locations are available around Lakshadweep and Andaman & Nicobar Islands and the total potential is estimated to be whopping 1,80,000 Mw considering 40% of gross power for parasitic losses.

It is envisaged that most of the future commercial OTEC plants shall use closed-cycle technology floating plants of 10-50 Mw ranges over open-cycle as they are more effective. However, hybrid plants will have to be developed to get the advantages of both.

8. CONCLUSION – OPPORTUNITY FOR INDIA

I have tried to discuss the possibilities of utilising the geothermal sources in India for either power production or direct use of the resources to reduce the strain on the grid and also work towards better quality of human life. The geothermal power generation scene in India has finally evolved with the Puga valley project being initiated and I am sure that the Governments of Chattisgarh and Himachal Pradesh would be closely following the situation and coordinating with National Thermal Power Corporation (NTPC) to harness the geothermal sources in their respective states.

A Geothermal Policy has to be instituted by the Government of India with a nodal agency created for developing the geothermal resources of the country for power generation, direct use and tourism potential (as volcanic / geothermal tourism needs special care to exploit the potential). The policy should also work a mechanism to deploy Government funding for research & development in this area to establish necessary laboratory and develop new generation drilling equipment that can be manufactured in India. The OTEC alternative too needs a lot of study and the geothermal policy can be comprehensive to include this potential too.

The other bigger opportunity that needs to be debated is drilling skill-set that Indian business can develop to not only make developing our geothermal field viable but also work in the global geothermal fields in making this potential as the next big energy thought.

REFERENCES

D. Chandrasekaram : Geothermal Power – Asia 2000 at IBC Conference in Manila, Feb. 2000

www.dchandra.geosyndicate.com/geoenergy.html

www.powermin.nic.in

National Electricity Policy notified under Section 3 of Electricity Act 2003 (No. 23/40/2004-R&R (Vol.II))

Akshaya Urja – April 2012 : Pages 16-18

Akshaya Urja – August 2013 : Pages 14 – 18

www.greentechmedia.com/articles/read/the-status-geothermal-power-development

P.B. Sarolkar: Geochemical Characteristics of Hot Springs of West Coast, Maharashtra State, India

D. K. Mukhopadhyay and B. Sarolkar: Geochemical Appraisal of Bakreshwar-Tantloi Hot Springs, West Bengal and Jharkhand, India

Article on Live Mint newspaper 18.2.2013.