7th International Conference & Exposition on Petroleum Geophysics

"HYDERABAD 2008"

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Utilization of Geothermal Energy Resources for Power Generation in India: A Review

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Summary

In this review we look into the possibilities of utilization of geothermal energy for power generation in India. Geothermal energy is a non-conventional source of energy and it is very cost efficient in comparison to conventional sources. India has a vast potential of geothermal energy sources constituted from its seven geothermal provinces which can be tapped to various uses and can meet the ever increasing demand for power in developing countries like India.

Introduction

Geothermal Energy is the manifestation of heat from within the Earth. Temperature hotter than the Sun's surface are continuously produced inside the Earth by the slow decay of radioactive particles and this is responsible factor for geothermal energy. Geothermal energy finds its way to the surface in the form of volcanoes, hot springs and geysers. India has 400 medium to high enthalpy geothermal springs mainly present in seven geothermal provinces. All the geothermal provinces of India are located in areas with high heat flow and geothermal gradients. The heat flow and thermal gradient values vary from 75–468 mW/m^2 and 59– 234°C respectively. These provinces are capable of generating 10,600 MW of power. Just like any other developing country, India is also suffering from power shortage and this will increase in the coming years due to economic globalization. Though country is boosting the generation of eco-friendly energy sources but still the present power generated through non-conventional source is far less than the installed capacity of the power plant. Geothermal energy, a non-conventional energy source has not so far put to use though its huge power generating capacity. This is because of 192 billion tones of recoverable coal reserves which are encouraging coal based power projects and hampering the healthy growth of non-conventional energy programs, but environmental problems associated with such mega-projects are many. India is already the sixth largest and second fastest growing contributor to greenhouse gases. The greatest unsolved problems with coal bases power plant is the fly-ash. Indian coal has an ash content of 45%, which is highly problematic. But geothermal energy is much advantageous over other non-renewable source of energy (coal, petroleum) because its use does not produce any pollution, no fuel is needed and once a geothermal power station is built, the energy is almost free. With escalating in environmental problems with coal based project in future, India has to depend on clean rural based, cheap energy sources like geothermal energy.

Utilization of Geothermal Energy Geothermal energy is used to heat homes, commercial greenhouses, fish farms, food processing facilities, gold mining, pulp making and in paper mills. Lindal's diagram (Figure 1.) lists the uses of geothermal energy according the temperatures available in the fields.

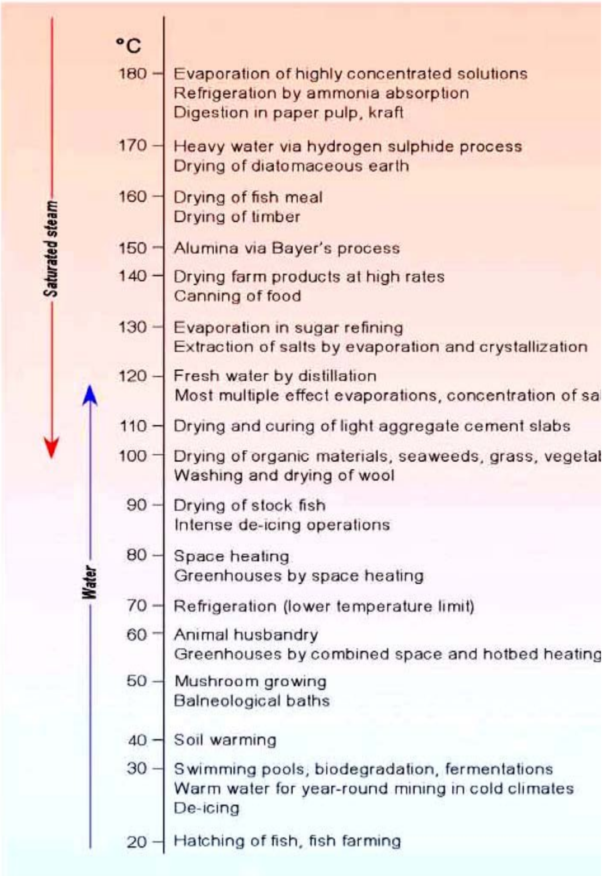

Figure 1: Lindal Diagram: Temperature requirements of geothermal fluids for various applications

Geothermal Energy Resources

There are four major types of geothermal energy resources.
(i) Hydrothermal
(ii) Geopressurised brines
(iii) Hot dry rocks
(iv) Magma

After an eruptive cycle, when a volcano falls into dormancy, magma and hot rocks may remain at relatively shallow crustal depths for hundreds or thousands of years. Groundwater seeping through faults, joints and porous rocks encounter these high temperature regions and are they heated. The hot water ascends and denser, cooler waters take their place. Vigorous convective system can thereby be established and maintained. The rising water in such a hydrothermal system may reach the surface as hot springs or, if temperatures are high enough, convert low pressures to steam.

In some subterranean plumbing systems, retained water heats up until the temperature is reached at which it 'flashes' and converts to stream. In the ensuing volume change, cooler water in the conduits above may be violently blown out at the surface as a **geyser.** After such an event, time elapses as new water enter the system, become heated and the cycle is repeated.

Geothermal Provinces

Geothermal energy resources in India (Figure 2.) are associated with, 1) Indo-China plate margins in Himalayan region; 2) Intraplate tectonic zones along western coast of India; 3) Cambay graben; 4) Along Son-Narmada Tapti basin; 5) along Godavari Rift areas. The provinces are:

(i) North-West Himalayan Geothermal Province :
It has surface temperature manifestation ranging from 21°-96 °C; and estimated reservoir temperatures are of the order of 110 ° -200 °C. Temperature of 125 ° C at a shallow depth of 180 m has been proved at Puga.

(ii) North-East Himalayan Geothermal Province:
Surface temperature of 38 °-52 °C is recorded in this area.

(iii) North Indian Precambrian and Cambay Graben Geothermal Province: Surface temperature of 39 °C and 24 °-46 °C are recorded and reservoir temperature upto 100 ° has been estimated for these areas**.**

(iv) Son-Naramada-Tapti and Damodar vallery graben Geothermal Provinces:

Surface temperature of 35°C-88°C (Damodar Valley) and 32°C-98°C (Son-Narmada-Tapti) are recorded and reservoir temperatures of 110°C-150°C (Damodar valley) and 81°C-161°C (Son-Narmada-Tapti) have been important for this East west trending geothermal province along the intraplate tectonic zone. It is vast area with very high potential for extensive power generation.

(v) West Coast Geothermal Province: It is 350 km long north-south trending coastal geothermal belt with surface geothermal manifestation ranging in temperature from 35° C to 71°C in 18 localities. Reservoir temperatures of the order of 84°C to 130°C are estimated for this area. In the explored depth of 500m, temperature of 55°C with heavy discharge of geofluid has been established.

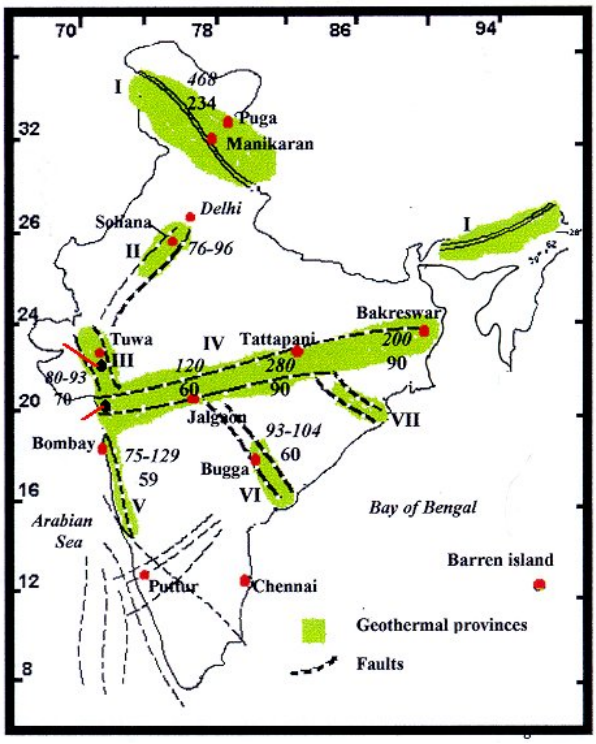

Figure 2: Map of India showing the geothermal provinces, heat flow values (mW/m^2: *in italics*) and geothermal gradients (^{o}C/km). I: Himalaya; II: Sohana; III: Cambay; IV: SONATA; V: West coast; VI: Godavari; VII: Mahanadi. M: Mehmadabad; B: Billimora.

(vi) Godavari and Mahanadi Graben Geothermal Province: Surface temperature of 47^{o}C to 85^{o}C and 29^{o}C to 62^{o}C have been recorded in Mahanadi and Godavari graben areas, respectively. Reservoir temperature of 130^{o}C is expected in both the areas.

(vii) Tamilnadu-Pondicherry Geothermal Province:
It has a favorable geological setting for the possible presence of good geothermal reservoir at depth. Existing surface temperatures is 62^{o}C, and estimated reservoir temperature is 90^{o}C.

Electric Power Generation

There are two types of the plants.

1. Flash steam plants:
When the geothermal energy is available at 150 °C and above temperature, the fluids can be used directly to generate electricity. In some cases, direct steam is available from the geothermal reservoir; otherwise the steam is separated and turbines are used for power generation.

Schematic of flash steam geothermal power plant

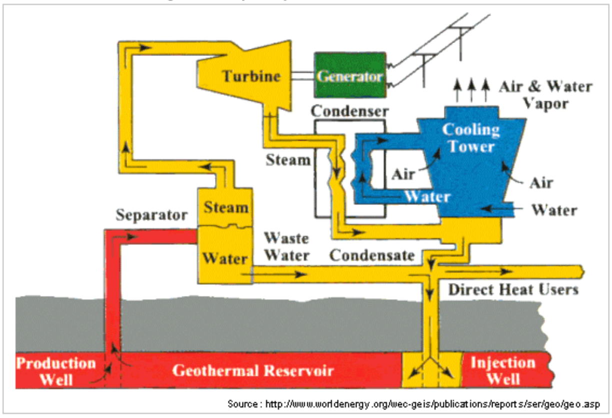

Figure 3(a): Flash steam plant

2. Binary plant:
These plants are used when geothermal temperature is between 100 °C and 150 °C. The fluid is extracted and circulated through a heat exchanger where the heat is transferred to the low boiling point organic liquid. This gets converted into high pressure vapour, which drives organic fluid turbines (Figure 3b).

Projects in India

A systematic geothermal survey in India began in 1973 undertaken by Geological Survey of India and the existence of 340 potential sites was reported. Eleven geothermally prospective districts have been identified till date. Most of them appear to have resources at temperatures of about 100-120^{0}C, but some appear to have reservoirs at 1-3 km depth with calculated geothermometry temperatures of 200-250^{0}C. The most promising geothermal fields as on date are:

- NW Himalayas: Puga-Chumathang (Ladakh district, J&K) where a 1MWe plant is planned and Parbati Valley with the Manikaran field in Himachal Pradesh where in 1992 a 5kWe geothermal binary cycle plant was successfully run.

- Central India: Tattapani region (Madhya Pradesh) where the installation of a 20MWe binary plant has been planned.

No deep geothermal well has been drilled to date. Large- scale availability of cheaper energy sources like coal apparently has hampered the growth of geothermal energy exploitation.

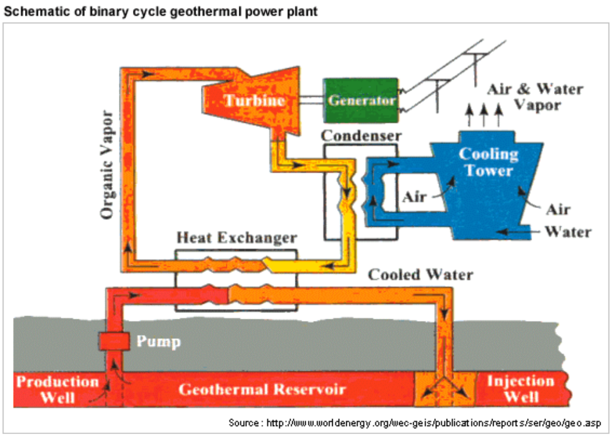

Figure 3(b): Binary plant

Conclusions

Geothermal energy has many advantages over most other forms of electricity generation. Geothermal energy does not produce any pollution, and does not contribute to the greenhouse effect and the power stations do not take up much area, so there is not much impact on the environment. The advantages of geothermal energy utilization vastly override its disadvantages which conclude that it would be an effective way of preserving our Earth and environment.

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Acknowledgements

The authors are grateful to Prof. (Dr.) D.C. Singhal, Dept. of Hydrology, IIT, Roorkee, for his support and encouragement sought in completion of this work.