GEOTHERMAL POWER GENERATION IN MAHARASHTRA: A PRACTICAL ASSESSMENT

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ABSTRACT

The subject of “Geothermal Power Generation” has recently evoked keen interest among energy conscious inquisitive minds. Ideally, we should not get high temperature at earth surface. However, the presence of local faults, joint fractures act as channel ways for release of heat. Geothermal potential site is defined as the place where natural heat from the earth can be extracted from a depth “not exceeding the limit of economic exploitation”. The geothermal mapping of the world indicates that potential sites are mostly concentrated in Italy, Japan, USA, Philippines and South American countries. As a result, thousands of MW geothermal power projects are installed in these areas. Basically, these resources are found in those areas where two lithospheric plates either collide or one plate is subducted beneath another. None of these criteria fit to Indian subcontinent except the Himalayan region and therefore, India lacks high quality geothermal resources. In Maharashtra, there are 60 hot springs clustered around 18 localities in Thane, Ratnagiri, Dhule, Jalgaon, Yeotmal and Amravati districts. The surface temperature ranges from 34 ^{0}C to 71 ^{0}C, which are low temperature ranges. As per GSI surveys the best site with highest available temperature of 71 ^{0}C and maximum flow of 43,920 litres per hour is available at Unhaware (Khed) followed by Tural, with 61 ^{0}C and 20,160 liters per hour both in Ratnagiri districts. To commercially exploit the sites, deep drilling ranging 1.0 to 3.0 km depth needs to be done. Mainly there are two types: Dry Hot Rock Technology and Geothermal fluid wet technology. In India and also Maharashtra, no magmatic heat sources are available in the crust. Hence, hot rock technology appears to be remote possibility. As regards thermal springs, it has been well proven that high temperature springs are available only in Himalayan region or in Chattisgarh. All the springs in Maharashtra are low temperature maximum up to 71^{0}C surface temperature. Reported cost of geothermal power projects are Rs. 15-20 crores/MW with energy generation cost of Rs. 7-10 per kWh. Such costs are under favorable conditions only. However, under unfavourable conditions, the cost can be very high. Compared to coal based, gas based and even wind power projects, the existing cost appears to be very high and project commercially non-viable. Based on above observations, geothermal power generation in the state of Mahrashtra does not seem to be commercially viable as on today. Deep drillings at few kms are required to ascertain highly feasible sites having high temperature with sufficient sustainable reservoir. Instead of power generation, direct thermal or non-electrical applications are advisable such as space heating / cooling, refrigeration, tourism (hot water bath), green house for horticulture, milk pasteurization, and dehydration of fruits and vegetable.

1.0 INTRODUCTION

The subject of "Geothermal Power Generation" has recently evoked keen interest among energy conscious inquisitive minds. Maharashtra, being the most industrialized state in India, is ever power hungry and therefore, there is demand that Govt. of Maharashtra must take giant leap in this direction. As regards geothermal potential, large volume of data already exists supported by surveys carried out by Geological Survey of India and National Geophysical Research Institute. We need to analyze them first before taking any techno economic step and more so to avoid reinventing the wheel. Objective of this paper is to put up facts and findings based on available information without claiming any originality. Much of the facts are reproduction of "Feasibility Report For Geothermal Energy Applications" got prepared by Maharashtra Energy Development Agency through M/s Auro Consultant Pvt. Ltd., Pune in May 1988.

2.0 HEAT OF THE EARTH:

At the depth of around 5000 km from surface, the earth has huge ball known as "Core of Earth" made of hardest material with temperature of around 5000 ^{0}C. Between 3000 km to 5000 km lies the layer of "Lower Mantle" having molten rock known as "Magma" with more than 1200 ^{0}C temperature. From the depth of 50 km to 3000 km is "Upper Mantle" which is relatively cooler. However, this is the layer, which causes movements of plates on earth's surface. The movement of plates makes the oceans wider, builds mountains and causes volcanoes to erupt and earthquakes to happen. The topmost layer of 15 km to 50 km known as "Crust", is the coolest part also called as "Lithosphere".

Earth's crust has two layers. The upper layer is made up of "Granite". Under the layer of "Granite" is a thick layer of hard rock called "Basalt".

Ideally, we should not get high temperature at earth surface. However, the presence of local faults, joint fractures act as channel ways for release of heat. The high enthalpy zones occur within the belts of geologically young volcanism, crustal deformation and rifting connected with plate tectonic movements. On regional scale, geothermal sites are localized with active magmatic rifting, faulting and orogeny. Such belts are called geothermal belts.

Geothermally potential site is defined as the place where natural heat from the earth can be extracted from a depth "not exceeding the limit of economic exploitation". Such sites can be exploited for power generation at high temperature location while the low temperature locations can be put to non electrical uses like space heating, air conditioning, refrigeration, green house farming, mushroom cultivation and other industrial applications.

The temperature of earth in general rises 2 ^{0}C to 3 ^{0}C per 100 meter depth beyond ambient temperature. Such a low heat flow in earth crust in primarily due to radioactive reactions by uranium, thorium and potassium elements. However, in the potential geothermal areas the temperature rises from 7 ^{0}C to 10 ^{0}C per 100 meter depth.

3.0 POTENTIAL SITES:

Geothermal fields are noticed in all the continents of the world. They are mostly located in seismic belts, which are prone to earthquake. In such areas, high temperatures are obtained at relatively lesser depth. The geothermal mapping of the world indicates that potential sites are mostly concentrated in Italy, Japan, USA, Philippines and South American countries. As a result, many thousand MW of geothermal power projects are installed in these areas.

Basically, these resources are found in those areas where two lithospheric plates either collide or one plate is subducted beneath another. In the latter case, the quality of geothermal resources is very high due to its being closer to young volcanic chain. Apart from these, they also occur in areas where (I) a new crust is being created, (II) a new rift is formed or (III) the hot spots become very active. None of these criteria fit to Indian subcontinent except the Himalayan region and therefore, it lacks high quality geothermal resources.

Geodynamically, Indian subcontinent has been extremely active and mobile since its break up from Antarctica 130 million years ago. This has resulted in substantial thinning of its lithosphere, which is now much warmer. In some places like western margin, even crust has thinned with thickness ranging from 18 to 30 km. This is reflected by more than 300 thermal springs which occur scattered along weak tectonic zones and rifted garbens all over the country. The springs are of mainly non-volcanic types, with temperature ranging from 30 ^{0}C to 100 ^{0}C and thus hot springs themselves form low to inetermediate temperature exploitable resources.

Geothermal sites in India with hot springs are mainly concentrated in three areas.

a) NW and NE Himalaya and Andaman Nicobar where some potential sites are

Place	Surface Temperature ^{0}C	Estimated reservoir temperature ^{0}C
Puga, Ladakh	123	180-260
Chhumathang, Ladakh	109	180-260
Manikaran, H. P.	110	186-200
Tapoban, H. P.	90	180 ± 20

b) Son – Narmada – Tapi Rift

Place	Surface Temperature	Estimated reservoir temperature
Tattaparri, Chhattisgarth	98	160 ± 20
North Cambay	-	175 ± 25

c) West – Coast Margin

Place	Surface Temperature	Estimated reservoir temperature
NE offshore, Mumbai	--	196 ± 63 (3 km depth)
Kokan Province	71	202 (3 km depth)

In Maharashtra, there are 60 hot springs clustered around 18 localities in Thane, Ratnagiri, Dhule, Jalgaon, Yeotmal and Amravati districts. The surface temperature ranges from 34 ^{0}C to 71^{0}C, which are low temperature ranges.

As per GSI surveys the best site with highest available temperature of 71 ^{0}C and maximum flow of 43,920 litres per hour is available at Unhaware (Khed) followed by Tural, with 61 ^{0}C and 20,160 liters per hour both in Ratnagiri districts. To commercially exploit the sites, deep drilling ranging 1.0 to 3.0 km depth needs to be done.

4.0 TECHNOLOGY OPTIONS:

Geothermal power technology depends upon the type of site available. Mainly there are two types.

A) Dry Hot Rock Technology
B) Geothermal fluid wet technology.

A. Dry Hot Rock Technology:

Dry hot rock technology essentially uses the heat of hot dry rock with long term sustainable heat source situated deep inside earth (1-3 km). Two parallel bores are dug at feasible site; first bore called “injection well” and second one “production well”. Water is pumped through injection well and hot steam is obtained from production well at high pressure, which is used to directly run steam turbine under closed cycle. Cooled steam is again pumped to injection well. Such sites are available mostly at the places where “magma” is available close to “Crust” i.e. volcano prone areas. Very sensitive earthquake prone areas are also suitable for hot rock technology. Another important condition is that the “hot rock” at the given depth of earth must be hard enough to sustain the artificially created steam chamber. Availability of heat source for unlimited time is must, at temperature 250^0 - 400 ^{0}C.

In India and also Maharashtra, no such magmatic heat sources are available in the crust. Hence, hot rock technology appears to be remote possibility.

B. Geothermal Fluid Wet Technology:

Such technology is applied mostly at the sites with hot fluid/water or steam discharge with temperature ranging 90 ^{0}C to 200 ^{0}C. Mainly two technologies (a) Flash steam and (b) Binary cycle are used.

In a flash steam plant the two phase (water + steam) flow from well is directed to a steam separator, where the steam is separated from water phase and directed to inlet to turbine. The hot water phase is used for direct thermal applications of drying, heating etc. The flash technology is used only at sites where temperature of 150-200 ^{0}C is attained.

In a binary plant, the thermal energy of geothermal fluid is transferred to a secondary working fluid via heat exchanger to use in conventional Rankine cycle or alternatively Kalina cycle. The vaporized secondary working fluid (e.g. isopentane propane, freon or ammonia) drives the turbine before being condensed and returned to heat exchanger in closed loop. This is basically low temperature technology with temperature range of 105 ^{0}C to 150 ^{0}C. Typically it has efficiency of 5-10% and availability over 90%. A potential site must have regular sources of water (large reservoir) at required temperature. As a conservative estimate, for 1 MW of power plant, hot water at 100^{0}C is required with regular flow of minimum 2.5 lakh liters per hour.

5.0 CONDITION FOR COMMERCIAL EXPLOITATION:

Successful commercial exploitation depends upon following major counts:

(a) Getting large heat reservoir

(b) High net energy return.

(c) Low investment / unit output

(d) Almost nil pollution

(e) Versatility of application at site.

6.0 PRELIMINARY GEOLOGICAL SURVEY:

The primary geological data have clearly shown that high temperature hot rocks are not possible to get in Maharashtra. Although nothing can be ruled out in science, it would be highly costly affair to find the hot rocks through drilling. Even magnetotelluric (MT) technology can not confidently identify hot rock sites since MT is mainly electrical conductivity measurement study and not that of thermal conductivity.

As regards thermal springs, it has been well proven that high temperature springs are available only in Himalayan region or in Chattisgarh. All the springs in Maharashtra are low temperature maximum up to 71^{0}C surface temperature. It needs to be found out through deep boring whether high temperature large reservoirs are available at these sites. Thermal gradient expected is 5 ^{0}C per 100 meter depth. That means 1 km drilling will provide temperature of maximum 120 ^{0}C. It is also unknown whether reservoir is large enough to sustain commercial exploitation.

7.0 DRILLING TIME AND COST

After successful experimental application trials, it may be feasible to drill wells for enhancing yield. The estimated time in geothermal areas under favorable condition is as follows:

Depth in meters	Actual drilling days
500	15 – 30
1000	25 – 45
1500	35 – 55
2000	50 - 70

The prospecting and drilling cost varies very much and it depends upon rock strata. However, based on available experience, the cost is around Rs. 10,000/- per meter .i.e .Rs. 10 million per km.

8.0 THE PROJECT COST AND ENERGY GENERATION COST

The project cost has following components:

a. Exploration cost
b. Drilling cost
c. Well head equipment cost
d. Power Generation system cost
e. Collection and distribution pipe work

Percentage wise the cost break-up is as follows: Fixed cost 20%, depth dependent cost 30%, time dependent cost 40%, engineering 10%.

Feasibility of plant depends upon.

a. Interest on capital
b. Depreciation of capital equipment
c. Maintenance and repairs of pipe work
d. Bore maintenance
e. Salaries and wages.

Reported cost of geothermal power projects are Rs. 15-20 crores/MW with energy generation cost of Rs. 7 – 10 per kWh. Such costs are under favorable conditions only which can rise to unimaginable extent for less feasible sites. Compared to coal based, gas based and even wind power projects, the existing cost appears to be very high and project commercially non-viable.

Direct Thermal or non-electrical applications are advisable such as pulp treatment, water desalination space heating / cooling, refrigeration, tourism (hot water bath), green house for horticulture, milk pasteurization, and dehydration of fruits and vegetable.

9.0 CONCLUSION:

Based on above observations, geothermal power generation in the state of Mahrashtra does not seem to be commercially viable as on today. Deep drillings at few kms are required to ascertain highly feasible sites having high temperature with sufficient sustainable reservoir.

It is worth mentioning here that personal interactions with some agencies have given following views:

(a) NGRI - Although nothing can be ruled out at first instance, it is advisable not to venture into power generation in India, and especially in Mahrashtra.

(b) ONGC - There is no drilling device available in India for medium range of 1-3 kms, which is commercially exploitable depth for geothermal projects. ONGC is mainly involved in offshore drilling. On shore drilling is rare. Even on shore drilling platform, machinery is so huge that it is difficult to transport easily. Moreover, they are meant for deep drillings 5-10 kms deep. Also the drilling cost with such a machine will be very costly, which will make the project non-viable.

We might get favorable data in future and feasible site for power generation using geothermal energy in Mahrashtra. Till then, let us pragmatically wait and hope for the best. However, non-electric applications are also good options.

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Suggested Readings:

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