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Roadmap to Geothermal Energy

(An Assessment of the Geothermal Potential of Bangladesh)

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Abstract— In the context of geothermal energy utilization, Bangladesh is still at a very early stage. Though there is one project ongoing at Thakurgain for establishing the first geothermal plant of the country, no systematic study has been done to evaluate the geothermal resources of Bangladesh. However, in a few research have stressed the potential of geothermal energy resources in Bangladesh. Geothermal energy exploration involves cash incentives in the early stages of exploration, but good planning minimizes risks and saves money. In Bangladesh many deep abandoned wells, originally drilled for oil and gas exploration, have been used to extract valuable information about the subsurface geology and temperature of areas of interest. Analysis of the temperature data of these wells indicates that the average geothermal gradient along the southeast part of the Bengal Foredeep region varies from 19.8 to 29.5°C/km and along the northwest stable shelf from 20.8 to 48.7°C/km. For assessment of the geothermal potential of Bangladesh, it is recommended that preliminary surface geological and geochemical studies be done followed by geophysical investigations (resistivity (MT), seismic, gravity, etc.) and drilling of shallow gradient wells to make a conceptual model of any geothermal systems before proceeding with the most expensive, as well as the most risky part, i.e. drilling of a deep well.

Index Terms—Deep Well, Fossil Fuel, Geothermal Energy, Indigenous Energy, Resources, Temperature gradient, Transmission Grid

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1 INTRODUCTION

INDIGENOUS energy sources are urgently needed in developing countries and geothermal energy is ideally suited to provide the required thousands of megawatts of electric power with the least environmental impact. High temperature hydrothermal systems occur throughout the world, and are notably abundant in many developing countries, where the judicious utilization of these resources can displace construction of power plants requiring more traditional fuel sources. Readily available in these countries for large scale, base load electric power generation, geothermal energy shows great promise for supplying small amounts of power to local transmission grid or rural electrification.[1]

1.1 Geothermal energy

Geothermal energy is the energy contained in the heated rocks and fluid that fills the fractures and pores within the earth's crust. It originates from radioactive decay deep within the Earth and can exist as hot water, steam, or hot dry rocks.

Geothermal (meaning "earth heat") energy involves using the high temperatures produced beneath the earth to generate electricity from heated water, as well as for various direct uses (such as hot springs spas, lumber drying or aquaculture). The term geothermal is also applied to the temperatures of the Earth near the surface which are used as a source of consistent temperatures for heating and cooling of buildings. Geothermal applications that involve water heated within the earth are also called hydrothermal processes. [1]

1.2 Advantages of Geothermal power plant

Geothermal power plants have no smoky emissions. What is coming out of a geothermal plant cooling tower is steam (water vapor). Flash and dry steam plants produce only a small fraction of air emissions compared to fossil fuel plants. Binary power plants have virtually no polluting emissions. [1]

Geothermal power plants use very little land compared to conventional energy resources and can share the land with wildlife or grazing herds of cattle. They operate successfully and safely in sensitive habitats, in the middle of crops, and in forested recreation areas. However, they must be built at the site of the geothermal reservoir, so there is not much flexibility in choosing a plant location. Some locales may also have competing recreational or other uses.[1]

Geothermal wells are sealed with steel casing cemented to the sides of the well along their length. The casing protects shallow cold groundwater aquifers from mixing with geothermal reservoir waters. This way the cold groundwater does not get into the hot geothermal reservoir and the geothermal water does not mix with potential sources of drinking water.[1]

Geothermal power plants provide very reliable base load electricity. Some plants can increase production to supply peaking power. But geothermal plants cannot be used solely as peaking plants; if geothermal wells were turned off and on repeatedly, expansion and contraction (caused by heating and cooling) would damage the well.[1]

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1.3 Current projects on geothermal energy in Bangladesh

Plants for 200 MW are in the pipeline in the district of Thakurgain. Already it has secured favorable opinions from the Geological Survey of Bangladesh, the Ministry of Water Resources and the Ministry of Environment. Soon to be constructed the first geothermal power plant for electricity generation in Bangladesh, which will thus become the twenty-sixth country in the world to use this source of renewable energy. The project is being developed by Anglo MGH Energy, a Dhaka-based private company, which aannounced the construction of plants for a total of 200 MW, using steam from a hydrothermal basin close to Saland, in the Thakurgain district, in the northern border with India. Anglo MGH Energy conducted preliminary feasibility studies on an area of over 3,500 hectares, in order to identify the best site for the construction of the plant. The Geological Survey of Bangladesh and the Ministry of Water Resources and Environment have given favorable advice regarding the project. According to Energy Anglo MGH, several northern districts of Bangladesh show favorable conditions for the exploitation of geothermal resources. The latter can therefore play a significant role as regards energy supply for these populated areas (among the poorest in Bangladesh), where there is a severe shortage of energy in general and specifically of electricity. It must be noted that 200 MW are not insignificant considering the situation in Bangladesh where, with a population of over 156 million inhabitants, the total installed power capacity is currently about 6,000 MW.

1.4 Prospects of Geothermal energy in Bangladesh

1. 4. 1 Geothermal resources of Bangladesh

Geothermal resources of Bangladesh have yet to be explored in detail. Current knowledge about these resources and their utilization is very limited compared to other renewable energy sources available in the country. Thus far no systematic field investigation has been done to evaluate the prospects of these resources and their utilization. Only few authors have discussed the potential of geothermal resources of Bangladesh. It is therefore of utmost importance to evaluate the geothermal resources of the country and how they can play a part in the renewable energy scenario of Bangladesh. The geothermal energy resources are considered environmentally friendly, local and sustainable, independent of wind and sun variations. The electricity production cost using geothermal resources (steam/hot water system) is still very low compared to other available energy sources. Due to the different geo-tectonic setups in Bangladesh, geothermal resources of the country may be broadly classified into two different geothermal provinces: the northwest part of Bangladesh known as the shield areas of the country and, to the southeast, the deep sedimentary basin known as the Bengal Foredeep region which consists of several basement highs and lows as well as the hill ranges of the Chittagong-Tripura folded belt, where a few thermal springs are known to occur. In the northwest part of the country, in the Thakurgaon district, thermal manifestations and related evidence in some shallow aquifers tend to suggest the presence of a geothermal resource. Recent work shows the potential of a geothermal resource in that area. The reported high-temperature water wells show a much higher geothermal gradient compared to the surroundings. In the Bogra shelf region, the Singra-Kuchma-Bogra areas offer potential zones for geothermal exploration . The Madhyapara hard rock mine area and the Barapukuria coal basin are also zones of interest for geothermal exploration. In the northwest shield, the underlying basement complex is intensely faulted and highly fractured. Some of these major deep seated faults can be delicately identified from gravity and magnetic surveys. These fault systems are thought to act as conduits for transferring heat through the fluid within the pore spaces from beneath to the overlying sedimentary aquifer. The prevailing geological features, including the hydrogeological settings, clustering of basement faults, seismicity and earthquakes, and surface thermal anomalies all point to the existence of possible heat sources at a few km depth beneath the earth's surface. In the Bengal Foredeep region along the tertiary hill ranges, the Sitakund hilly area, with a few thermal springs, may also be considered an area with geothermal prospects.

1.4. 2 Geothermal Gradient of Bangladesh

The geothermal gradient of Bangladesh is mostly controlled by the tectonic-stratigraphic setup of the Bengal Basin. It is, therefore, necessary to evaluate the geothermal gradient of Bangladesh in order to understand individual tectonic elements with respect to the regional tectonic history. The tectonic framework has been discussed by a number of authors. The Bengal Basin of Bangladesh can be subdivided into two parts, namely the Northwest Stable platform and the Southeast Deep Geosynclinals basin known as the Bengal Foredeep. The BengalBasin is traditionally a cool sedimentary basin with an average temperature gradient of 20°C/km in the southeast deep basin area and 30°C/km in the northwest stable shelf area. The rate of subsidence and sedimentary thickness in the southern part is higher than in the northern part. The available information about the geothermal gradient of the country is based mostly on deep hydrocarbon exploratory well data. In the present study, data

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has been compiled from previous studies of subsurface temperature and the thermal gradient of Bangladesh. Figure 1 shows the subsurface temperature distributions that were recorded in deep exploratory wells in the two different tectonic-stratigraphic regions of Bangladesh. Geothermal gradients were calculated from corrected BHT (Bottom hole temperature) using Horner´s plot or by simply adding 10°C to the maximum recorded BHTs. Surface temperature is assumed to be 24°C (75°F) for onshore wells, and 15°C (59°F) for offshore wells. Geothermal gradients were computed on the assumption of a linear increase in temperature with depth. With this assumption, the temperature of any depth can be expressed by the following equation:

$$T_z = T_0 + T_g Z/100 \quad (1)$$

where T_z is the wellbore temperature (°C) at depth Z (m);

T_o is the mean surface temperature (°C); and

T_g is the geothermal gradient in (°C/km).

The isogeothermal map of Bangladesh shows that the geothermal gradient in the portion of the Bengal Foredeep region ranges from about 20 to 30°C/km. It is also observed that there is a trend of increasing geothermal gradients from north to south (i.e. from Sylhet trough to Hatiya trough) and also from east to west (i.e. from folded flank to platform flank). In the Southeast Bengal Foredeep region, the maximum geothermal gradient was found in the deep basin part at Hatiya trough (Shahbajpur 1, 29.5°C/km), and the minimum in the folded flank of the Sylhet trough (Beani Bazar 1 well, 19.8°C/km). A single value of the geothermal gradient for each well was recorded and expressed in units of °C/km for the presentation.

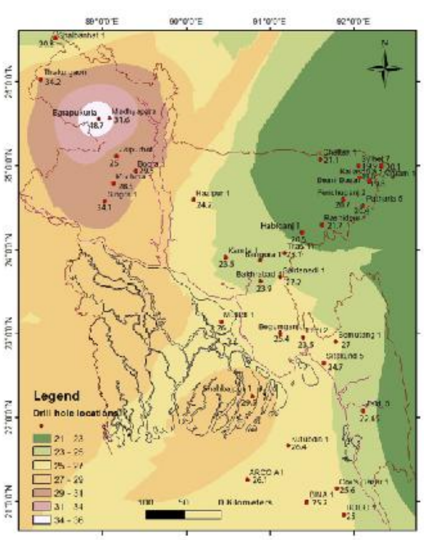

Fig. 1. Overall geothermal gradient (°C/km) of Bangladesh with individual well gradient

TABLE 1
GEOTHERMAL GRADIENTS (°C/KM) FOR THE DEEP WELLS ALONG THE BENGAL FOREDEEP REGION

Sl/No.	Well name	Gradient (°C/km)
1	Kuchma 1	28.5
2	Shalbanhat 1	20.8
3	Jaipurhat	25
4	Bogra 1	29.5
5	Singra 1	34.1
6	Madhyapara	31.6
7	Thakurgaon	34.2
8	Barapukuria	48.7

TABLE 2
GEOTHERMAL GRADIENTS FOR THE DEEP WELLS ON THE NORTHWEST STABLE SHELF REGION

Sl/No.	Name	Temperat. (°C)	Depth (m)	Gradient (°C/km)
1	T-278	35	87	126
2	T-277	30	56	107
3	HTW-1	29	27	182
4	HTW-2	27	26	115
5	HTW-3	29	26	192
6	STW	33	36	250

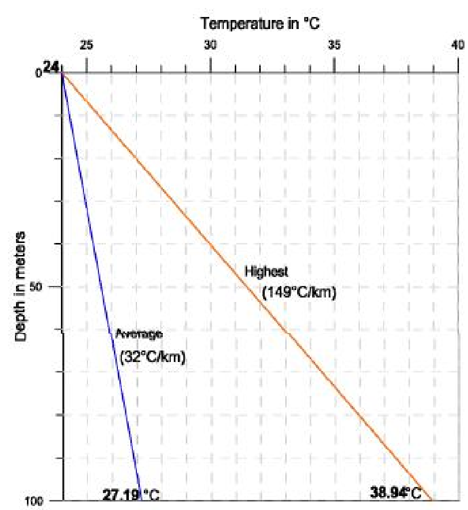

Fig. 2. Anomalous geothermal gradient at the Madhyapara hard rock mine area

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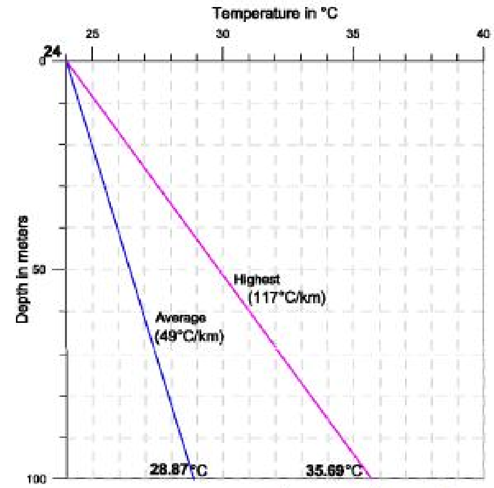

Fig. 3. Anomalous geothermal gradient at the Barapukuria coal basin.

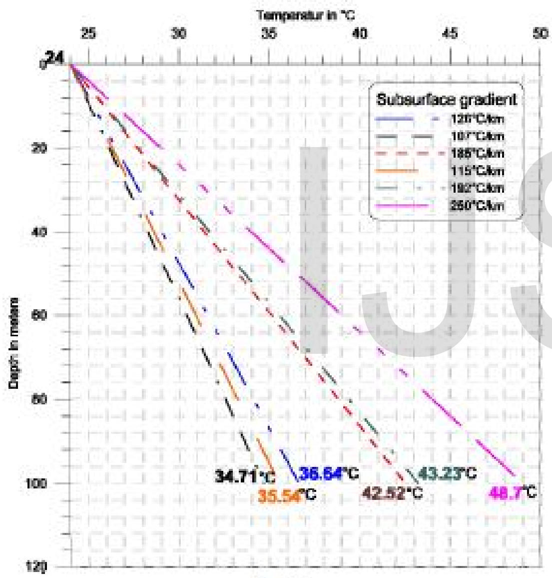

Fig.4. Variable temperatures at 100m depth and thermal gradient (°C/km) at Thakurgaoi area Suitable Suites for Geothermal Energy Exploration in Bangladesh

As it can be seen from the above findings Thakurgain's temperature gradient is most suitable for exploration of geothermal energy in Bangladesh. As we already mentioned earlier in this paper there is already one project going on there to explore the geothermal energy from there. But Thakurgain is not the only place, from where we can explore the geothermal energy in our country. The Temperature gradient profile suggests that Madhyapara and Barapukuria are the other two potential location of exploring the geothermal energy in Bangladesh. Similar plants like Thakurgain can be constructed in those two locations to explore the geothermal energy. Another observation is that the other locations such as Singra, Bogra and Jaipurhat can also be used for this purpose but the size of the plant may be medium and can be used to meet the local demand of these regions.

The assessment of an area in the context of subsurface geothermal exploration requires a detailed study of all surface exploration methods such as geological, geochemical and geophysical methods as well as drilling data. Afterward, integrating all the available information needs to be done for a better understanding on the subsurface geothermal condition, including the likely temperature of the reservoir fluids, heat sources, flow pattern of reservoir fluids and geological structure of the reservoir, the volume of the hot rocks, and the natural heat loss. A conceptual model of the geothermal system has to be drawn which will comply with all results of the surface exploration before proceeding further. The drilling of a deep exploration/production well in a geothermal system is considered the most expensive part of the programme as well as the most risky part of a geothermal exploration.

2 Conclusion

In this paper the potential locations for geothermal energy exploration is discussed. The feasibility study of implementing geothermal power plant can be done and also detail calculation of geothermal energy generation is needed. The challenges and environmental impact was also not discussed in this paper, which can be the topic for further study. Another observation is that, geothermal power plant is not the only the way to explore the geothermal energy. Other alternative ways can be found to explore and use the geothermal energy.

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