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A Study on the Prospect of Geothermal Energy in Bangladesh

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Abstract- Energy plays a vital role in ensuring sustainable development of a country. At present, Bangladesh is experiencing a lot of drawbacks as power demands are increasing at a rate greater than that of production. The country depends mainly on its natural gas reserve for power production, which is predicted to exhaust soon. As conventional sources of energy are finite and have negative impacts on environment, countries around the world are putting greater emphasis on harnessing electricity from renewable sources. In this context, geothermal energy can provide a viable solution for Bangladesh to ameliorate power crisis scenario and ensure a secured future. The Ganges-Brahmaputra Delta, world's largest one has formed the most parts of Bangladesh, which also has a large sedimentary basin. Different studies carried out by geologists in abandoned deep wells of northwest region found suitable temperatures of more than 100°C (in the depth of 3 to 4 kilometers) for geothermal plants. This paper recapitulates the fundamental concepts of geothermal energy, observes the potential geothermal resources of Bangladesh based on previous geological studies, also considers prevailing scenario in energy sector and government policy to provide suggestion for utilizing the resources in future.

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I. Introduction

The thermal energy generated and stored inside the earth is known as 'Geothermal Energy'. This kind of energy is extracted from hot water or steam found a few kilometers underneath the earth's surface and further deeper to the level of magma which is molten rock of exceedingly high temperature. Geothermal energy from hot springs has been used for bathing purpose since Paleolithic ages and also for space heating since the times of ancient Roman Empire [1]. In modern day world, this energy is utilized as a clean and sustainable source of electricity production. Currently, 24 countries are producing electricity from geothermal resources. In January 2015, the global market was about 12.8 GW and highly anticipated to extend between 14.5 GW and 17.6 GW by 2020 [2].

Bangladesh is in dire crisis of electricity; the per capita energy consumption is only 371 KWh as of January 2016 [3], among the lowest in the world. Major share of the total generation is based on natural gas [4], but the country's gas reserve is in an alarming situation with the possibilities of dying out within 2020 [5]. Other plants are mainly dependent on petroleum and coal, but the additional amount spent in those imports are disrupting GDP as much as 2% annually [5]. For tackling the prevailing energy crisis to some limit, Ruppur Nuclear Plant – first of its kind in the country – is expected to start operating in 2021; however, it will include higher probability of disastrous consequences like environmental and health hazards. In such a situation, geothermal energy, a renewable one, has been proposed to meet the challenges of increasing power demand in a safe, sustainable and environmentally friendly way.

II. Background of Geothermal Energy

Two Greek words – Geo and Therme, meaning the earth and the heat respectively [7] are combined to derive the word Geothermal. So, it means the heat within the earth.

Earth's core with temperature of approximately 6000^0 C is the source of geothermal energy. Fundamentally, five layers form the earth - inner core, outer core, mantle, upper mantle and the crust. Temperature increases about 17° to 30°C per every kilometer in case of going downwards from the earth's surface [8]. This energy inside the earth is produced from the primordial heat and radioactive decay. Immense amount of heat produced during the formation of earth about 4.5 billion years ago is known as primordial heat. Radioactive decay is from substances that were radioactive during the earth's early days, and the decay is still occurring deep within the earth, releasing enormous heat [8].

From the earth's core, the heat consistently moves upwards to reach mantle which is a layer of rock. Some of the mantle melts to become magma as temperature and pressure reaches a certain value. Because of being lighter than the rock nearby, the magma moves slowly upwards the earth's crust, carrying the heat along with it. Sometimes the hot magma finds a way to reach the earth's surface, then it is called lava. But on most occasions, the magma stays beneath the earth's crust, heats surrounding rocks and water. Some of the hot geothermal water moves upwards through faults and cracks which is referred to as hot spring or geyser. Usually, it remains trapped in cracks and porous rocks deep underground to form a geothermal reservoir [9]. Production wells are used to lead hot water/steam from the reservoir to the power plant.

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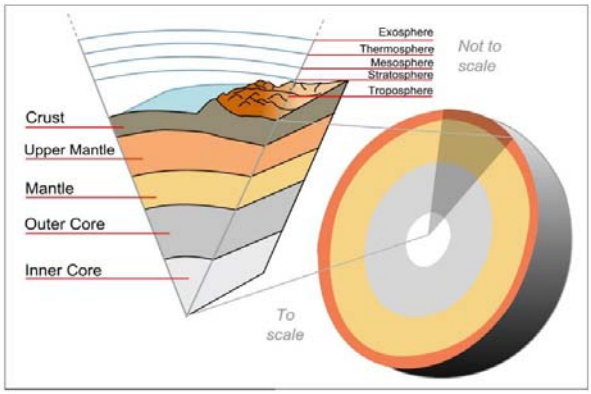

Fig.1: The earth layers [8]

III. Prospective Areas in Bangladesh with Geothermal Resources

Studies performed by geologists in various abandoned deep wells excavated for finding natural gas and oil indicated possibilities of geothermal reservoirs in Bangladesh. Because of varying geo-tectonic patterns of the country, probable resources of geothermal energy are basically divided into two regions- i) Northwest, known as 'Shield areas of the country' and ii) Southeast, referred to as 'Bengal foredeep region' existing in the deep sedimentary basin [13].

Different geological aspects of the northwest, such as the hydrogeological settings, seismicity and earthquakes, clustering of basement faults, and surface thermal anomalies indicate possible existence of geothermal reservoirs at a depth of few kilometers below the earth's surface. In this region, the geothermal gradient ranges from 20.8° to 48.7°C/km [13]. Study carried out by Mizanur Rahman exhibited the potential of a geothermal resource in Thakurgao district [12]. Singra-Kuchma-Bogra are promising areas of inspection in the Bogra shelf region; the Singra well with over 150° C bottom hole temperature is the most propitious among the three areas [10]. Two other zones of interest are the Barapukuria coal basin area and the Madhyapara hard rock mine area [11]. Using geochemical information from water samples of the Madhyapara hard rock mine area's basement aquifer, temperature was found to be varying in the range of 67° to 153°C, referring to a probable low-temperature geothermal reservoir in this area [13].

In the southeast region, geothermal gradient varies from 19.8° to 29.5°C/km. Sitakund hilly area is a place of interest because of having few thermal springs. Elsewhere Hatiya trough at Shahbajpur 1 well has the highest gradient of 29.5°C/km followed by Saldanadi 1 with gradient of 27.2°C/km in this region [13].

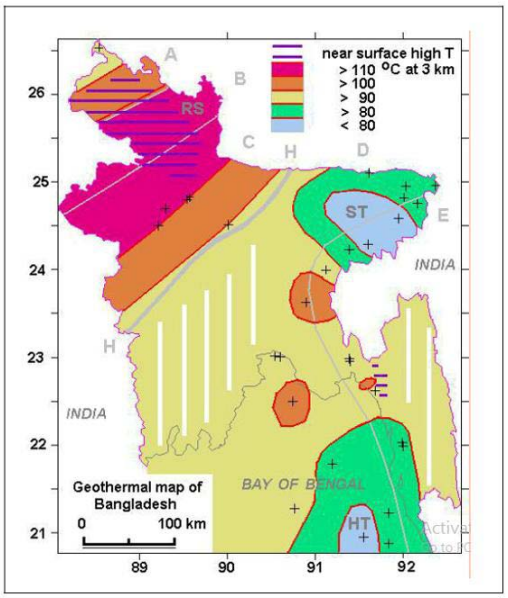

Fig.2: Geothermal Map of Bangladesh showing temperatures at 3 km [10]

IV. Available Methods of Geothermal Energy Extraction

Geothermal power plants work on the same principle as other thermal power plants using steam driven turbines – heat derived from a fuel source (Earth's core for this case) is applied to heat water or any other working fluid to produce steam or vapor which rotates a turbine to activate a generator, ultimately generating electricity. Afterwards, the fluid is cooled and brought back to the original heat source to reuse. Based on working principle, geothermal plants can be divided into three types- dry steam, flash steam, and binary cycle [14].

Dry Steam: In a dry steam power plant, steam is drawn from reservoir located underground and piped directly to a turbine generator unit. Underground source of steam is necessary here [14]. It is the oldest among the various types of plants.

Flash Steam: For a flash steam plant, hot water of high-pressure is pulled into lower-pressure tanks, and the resultant flashed (vaporized) steam is used to operate turbines. It necessitates fluid of more than 182°C temperature. It is the most usual type of plant operating in present day world [14].

Binary Cycle: Binary cycle plant is the latest advancement in this field. It uses water of lower temperatures, between 107^0 to 182^0 C [14]. The hot water is utilized to vaporize a working fluid, commonly a hydrocarbon; for instance, isopentane or a refrigerant of lower boiling point [15]. In a heat exchanger, the working fluid is then vaporized to turn a turbine. Finally, the water is fed back into the reservoir to be reutilized. Currently, binary cycle plants exploit two distinct geothermal resources: enhanced geothermal systems (EGS) and low-temperature or co-produced resources [14].

Along with the three types of geothermal plants discussed above, hybrid systems are also in use, which are actually combined systems consisting of more than two of the basic types connected in series and/or in parallel.

Table I: Uses and Technologies for Various Reservoir Temperatures

Temperature of Reservoir	Available Fluid	Technologies Used
High Temperature (>220^0C) [1]	Steam, Water	Dry Steam, Flash Steam, Combined Cycle (Flash and Binary)
Intermediate Temperature (100^0 – 220^0 C) [1]	Water	Flash Steam, Binary Cycle
Low Temperature (30^0 – 150^0 C) [1]	Water	Binary Cycle

V. Present Scenario of Energy Sector, Renewable Energy Policy and Geothermal Resources of Bangladesh

a) *Energy Sector In Bangladesh And Dependence On Coal For Future Development*

Bangladesh's installed electric power generation capacity was 15351 MW in January, 2017, which included 2200 MW of captive power. Among the installed capacities, sources of power generation were- natural gas (62.78%), furnace oil (21.19%), diesel (7.82%), coal (1.9%), hydro power (1.75%), and imported power from India constituted rest of 4.56% [16]. By 2030, the country's peak demand has been predicted to reach 33,708 MW [17]. Present government of Bangladesh has primarily identified coal based plants as the major solution of the energy crisis, but given their adverse effects on agricultural land, livelihood, and environment, people often become dissatisfied with such projects; consequently, making the conundrum even more difficult for the government to solve. Environmentalists have expressed concerns over government's plan to construct a thermal power station (1320 MW) at Rampal, Bagerhat – demonstrating protests against the project ever since its inception. According to them – being situated in close proximity to Sundarbans—the coal-fired power station will adversely affect the bio-diversity of the world's largest mangrove forest, which is also a UNESCO world heritage site [18]. Meanwhile, in another incident last year, government's decision to build two Chinese financed coal-fired plants were violently protested in Chittagong [19]. Previously in 2006, government's initiative to build open pit coal mining project at Phulbari, Dinajpur was also protested by local communities, human rights activists, and environmentalists, ultimately forcing the government to postpone further development [20].

b) *Renewable Energy policy of Bangladesh*

Government of Bangladesh formulated a renewable energy policy in 2008 to attain specific national goals. The policy mainly focused on developing solar, wind, bio-mass, bio-gas, and hydropower resources. It mentioned geothermal energy twice, but very implicitly, with no specific goals or guidelines [21].

c) *Current condition of geothermal resources*

Research for utilizing geothermal resources of Bangladesh has been largely restricted within few works carried out by geologists. In 2011, Anglo MGH Energy, a Dhaka based private company announced the construction of 200 MW geothermal plant, first ever of such kind, in Thakurgaon district [22]. But for some unknown reasons, this project never commenced, and

no development in this field has been announced afterwards.

VI. Observation of Geothermal Resources and Suggestion for Future Development

Based on the geological studies done in various parts of Bangladesh, it appears that some of the prospective sites in the northwest region, such as Singra-Kuchma-Bogra area, Barapukuria coal basin area, and the Madhyapara hard rock mine area- with temperature gradient above 30°C/km and bottom hole temperature in excess of 100°C– meet the requirements of binary cycle power plants. But to reach a forgone conclusion on exploiting the resources in a viable, feasible, and economically profitable way, extensive research is required. The process can only begin if the government realizes the prospect of this abundant natural resources indicated by geological works and takes necessary initiatives to develop it.

The research work must go through several steps. First of all, estimation of the geothermal energy potential of Bangladesh is required. To estimate the value, detailed geological, geochemical, shallow geophysical and shallow drilling data are required. After estimating and assessing geothermal potential, a revised policy should be formulated to develop the resources within a time frame. Additionally, Bangladesh can take into account India's effort in this relevant field, as the two neighboring nations are in close proximity with many geological similarities. Indian government has been patronizing efforts in geothermal research for over two decades. Methodical approach to explore geothermal potential began back in 1976 and some prospective areas were proposed after the initial study. A draft policy of "Indian geothermal energy development framework" was issued on 6 June, 2016 by the government's Ministry of New and Renewable Energy (MNRE). It mentioned the government's target to develop 1,000 MW geothermal energy capacity in the primary stage till 2022 and 10,000 MW by 2030 with active international collaboration with countries such as the US, Philippines, Mexico and New Zealand [23].

One of the main barriers in geothermal energy exploitation is that its profitability in countries unexposed to active volcanos is still not convincing, mostly because of extremely capital intensive and risky exploration stage. That is probably the reason why countries around the world prefer more established renewable energy resources like solar, wind, and hydropower at present. But interest on geothermal energy among many countries has gained momentum over the last few decades as technology has vastly improved with the introduction of binary cycle plants and enhanced geothermal systems (EGS).

Although right now Bangladesh has better alternatives like coal, nuclear, and solar energy for electricity production, geothermal energy utilization can help the nation's energy sector in the long run as it provides a virtually inexhaustible source of energy, available throughout the day, round the year. But for that to happen, interdisciplinary research and development projects should be carried out. Prominent universities and institutes should be encouraged and funded to research not only on the geological aspects, but also on the engineering side of the geothermal energy extraction, for example, generating electricity through enhanced conversion efficiency cycles, utilizing shallow resources for small scale use, and ensuring sustainable production from geothermal resources.

VII. Conclusion

Besides solar, wind, hydropower, and other renewable resources, geothermal energy can help Bangladesh in tackling issues like energy scarcity and variation in fuel prices in a self-sustained and environmentally safe process. Extensive studies and field surveys are required to harness this energy, which is accessible in abundance but stays predominantly unexploited. Energy crisis is no more an issue based on a single country or two, but a far greater phenomenon concerning the whole of human race. So, all the countries including Bangladesh have immense responsibility to contribute in the ongoing research and development of geothermal energy, as technological advancement will benefit every nation and ensure a habitable planet for generations to come.

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