A Proposal for Introduction of Geothermal Energy to the Energy Sector of Bangladesh

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Abstract—Due to the rapid industrialization over the last two decades, Bangladesh has witnessed a high demand for uninterrupted electricity, which keeps on increasing every day. With the power sector in Bangladesh beset by many infrastructural problems such as an inefficient transmission system, overdependence on natural gas reserves and a cumbersome decision making process for expansion of current power system to name a few, it has become the imperative to seek new energy sources that are relatively cheap, quick to set up and operate and have a low overall loss. The current energy demand stands at around 5,500 MW against a backdrop of an average supply of 3,800 MW. This demand rises to 6,000 MW in the harvesting and irrigation season. In this regard, geothermal energy can be a viable and useful alternative and this paper proposes the prospects of its introduction to the power sector of Bangladesh. Geothermal power systems produce no polluting emissions, can be set up utilizing local resources and are relatively inexpensive compared to solar, wind or hydropower plants. In this paper, a study is presented that shows the suitable locations in Bangladesh where geothermal power plants can be set up easily. A total of approximately 1000 MW can be added into the energy grid of Bangladesh through geothermal power systems. Therefore, it poses both a short term solution and assists in long term planning for expansion of the power system in Bangladesh.

Keywords- geothermal power systems; reservoir; surface temperatures; tectonic-structural regions

I. 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 for rural electrification.

II. 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.

III. HISTORY
Man has taken advantage of geothermal energy for purposes such as cooking and bathing for many centuries; the Romans used waters heated by the earth in bathhouses, for instance [1]. An early example of commercial geothermal energy use took place in Idaho in 1890, where the Boise Water Works Company drilled wells to create a geothermal radiant heating system for the city. Hot water from the geothermal wells was piped into more than 200 homes and businesses; this system, as well as three newer versions, is still in use today [2]. Geothermal energy was first used to generate electricity in Larderello, Italy in 1904. The site had hot springs and steam outlets that had been used for Roman baths. In 1904, a turbine there lit five light bulbs, and by 1913 the first geothermal power plant was built in an area that continues to provide about 10 percent of the entire world’s geothermal electricity [3].

IV. PROCESS AND TECHNOLOGY STATUS
The capacity of geothermal power plants in the world totals approximately 9 GWₑ with an annual electricity generation of about 60 TWhₑ, equivalent to less than 1% of the global electricity demand. Geothermal heating plants have a global capacity of approximately 18,000 MWₜ and produce some 63 TWhₜ per year. In general, technologies for the exploitation of what is called ‘conventional and shallow’ geothermal energy resources are commercially available. These technologies include [4]:

- Dry steam plants.
- Flash plants.
- Binary plants.
- Combined-cycle or hybrid plants.
- Combined Heat and Power based on geothermal energy.
- Heating based on geothermal energy.

However, these resources are rather limited. The challenge is currently the development of Enhanced Geothermal Systems (EGS)–also called “Hot Dry Rocks” to exploit deep geothermal resources, which could expand considerably the potential of geothermal energy.

V. COMPONENTS OF GEOTHERMAL SYSTEMS
Geothermal systems are made up of four main components: a heat source, a reservoir, a fluid (the carrier that transfers the heat) and a recharge area. When defining a geothermal system, the principal consideration is the practicality of how much power can actually be produced. In most instances, electric power generation is the reason for developing geothermal energy and the typical geothermal system must yield 10 kg of steam to produce one unit (kWh) of electricity [5]. Therefore, a geothermal system must contain great volumes of fluid at high temperatures or a reservoir that can be recharged with fluids heated by the hot rocks. Geothermal fields are found in rocks such as shale, limestone and granite, with the most common rock type being volcanic. Areas where thick blankets of thermally insulated sediment cover basement rock having relatively normal heat flow also house geothermal energy. The combination of these elements represents targets for the application of geophysical, geological and geochemical exploration techniques. The basic forms of geothermal energy are:

- Hydrothermal Fluids.
- Hot Dry Rock.
- Geo-pressured Brines Magma.
- Ambient Ground Heat.
VI. SIZES OF GEOTHERMAL POWER PLANTS

Geothermal power plants come in small (300 kW to 10 MW), medium (10 MW to 50 MW), and large (50 MW to 100 MW and higher) capacities. A geothermal power plant usually consists of two or more turbine-generator “modules” in one plant. Extra modules can be added as more power is needed. Binary plants are especially versatile because they use relatively low reservoir temperatures. Small binary modules can be built quickly and transported easily. These little power plants are great for use in remote parts of the world, far from transmission lines. One interesting plant is installed in the rugged mountains of Tibet (People’s Republic of China). At a soaring 14,850 feet (4,526 meters), it is the highest geothermal power plant in the world. Small binary plants are also popular for hot spring spas and health resorts. They add the convenience of electricity while maintaining an environmental and healthful appeal. For example, an artistically designed hot springs resort in Austria is using a small binary geothermal power plant for its power.

VII. COSTS AND BENEFITS

Geothermal heat pumps have a higher initial installation cost than conventional heating and air conditioning systems, but can recover those costs in two to 10 years through energy savings. The actual cost of a geothermal system will depend not only on the size requirements for the building but also the location, size and configuration of its lot, and even the proximity of contractors familiar with them.

The systems have an overall cost of roughly $2,500 to $5,000 per ton of capacity [7]. Conventional geothermal-generated electricity generally is sold for five cents to eight cents per kWh [8].

Establishing a steam geothermal power plant costs $1,400 to $1,500 per kW, including exploration and drilling. For a binary plant, the total cost is about $2,100 per kW [9]. In the case of systems that use existing oil and gas wells, however, exploration and drilling costs could be greatly reduced. Since geothermal electric production can have a 90 percent to 95 percent capacity factor (the ratio of actual electricity production to the total capacity of the energy source), compared to, for example, a factor of 20 percent to 30 percent for wind farms, this source has the potential to be very profitable.

VIII. ENVIRONMENTAL IMPACT

Geothermal energy produces no air emissions other than steam, and the water used in the conventional hydrothermal process often is injected back into the source reservoir. Because available water can be depleted, as can the heat, if too much cooler water is injected, there has been some discussion as to whether geothermal is truly “renewable”. The heat in the Earth, however, is for all practical purposes inexhaustible, if people can figure out how to access it sustainably. And geothermal electricity has a very high capacity factor in that it can be generated practically continuously, 24 hours a day. Heat rejection (cooling and condensing the geo-thermal resource), if accomplished through water cooling towers, can require considerable amounts of water. Engineered reservoirs, as noted above, also require large amounts of water.

IX. ADVANTAGES OF GEOTHERMAL POWER PLANTS

1. Geothermal power plants have no smoky emissions. What is seen 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.

2. 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.

3. 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.

4. 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.

X. GEOGRAPHICAL ANALYSIS FOR SUITABLE GEOTHERMAL POWER PLANT SITES IN BANGLADESH

Bangladesh located at the head of the Bay of Bengal, is formed by the successive delta systems developed by the two great rivers of the Ganges (Padma) and the Brahmaputra (Jamuna). The Himalayan mountain ranges were uplifted as a result of the collision with the northward drifting Indian Plate after the break-up of the Gondwana Continent starting in Upper Jurassic / Lower Cretaceous time.

Places called hot spots are fixed points in the mantle that continually produce magma to the surface. Because the plate is continually moving across the hot spot, strings of volcanoes
are formed, such as the chain of Hawaiian Islands. There is a known hot salt water spring, known as Labanakhy, in Bangladesh at 5 kilometer to the north of Sitakunda (40 kilometer from Chittagong). Possibility of extracting energy from this site or any other unknown sites can be investigated by Satellite Remote Sensing or Physical Surveys.

The Bengal Foredeep is one of the world's largest exogeosynclines. It runs parallel to the hinge zone of the Sub-Himalayan Foredeep. It is about 450 kilometers wide in southern Bangladesh, narrowing towards the northeast. A folded belt of the Burmese alpine mobile belt marks its eastern boundary. It can be divided into further sub-zones - (1) the Faridpur Trough; (2) the Barisal High; (3) the Hatiya Trough; (4) the Sylhet Trough; and (5) the Madhupur High.

The Bengal Foredeep occupies the vast area between the Hinge Line and the Arakan Yoma Folded System and plays the most important role in the tectonic history of Bengal Basin. The Bengal Foredeep can be divided into two major regions: a Western Platform Flank and an Eastern Folded Flank. The Western Platform flank is further subdivided into the Faridpur Trough, the Barisal-Chandpur High, the Hatiya Trough, the Madhupur High and Sylhet Trough.

The Folded Belt (or the folded eastern flank of Bengal Foredeep) represents the most prominent tectonic element of the Bengal Foredeep, with general sub-meridional trending hills parallel to the Arakan Yoma Folded System. The Folded belt extends S-N within Bangladesh for 450 km.

The Folded Belt is sub-divided into a Western Zone and an Eastern Zone according to the intensity of folding and other structural features. The Western Zone consists of a large number of relatively simple anticline structures with 27 known structures in Bangladesh, 10 in adjacent regions of India and 3 in Myanmar. The Western Zone is the most important and prospective oil and gas province of Bangladesh with 12 fields from Kailas Tila in the north to Semutang in the south. [9]

<table>
<thead>
<tr>
<th>Group</th>
<th>Formation</th>
<th>Rock Types</th>
<th>Thickness(m)</th>
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<tbody>
<tr>
<td>Dupi Tila</td>
<td>Dupi Tila</td>
<td>Sandstone(SSt.) and Clay</td>
<td>150 - 1000</td>
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<tr>
<td>Tipam</td>
<td>Girujain Clays</td>
<td>Clays with SSt.</td>
<td>100 – 300</td>
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<td></td>
<td>Tipam Sandstones</td>
<td>SSt. with shales (Sh.)</td>
<td>400 – 1200</td>
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<tr>
<td>Surma</td>
<td>Upper Boka Bil</td>
<td>Shales</td>
<td>300 – 400</td>
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<td></td>
<td>Middle Boka Bil</td>
<td>SSt. and Sh. Alternation</td>
<td>700 – 900</td>
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<td></td>
<td>Lower Boka Bil</td>
<td>Shales</td>
<td>300 – 400</td>
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<tr>
<td>Surma</td>
<td>Upper Bhuban</td>
<td>SSt. and Sh. Alternation</td>
<td>1200 – 1500</td>
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<td></td>
<td>Middle Bhuban</td>
<td>Shales</td>
<td>800 - 1000</td>
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<td></td>
<td>Lower Bhuban</td>
<td>Sh. and SSt. alternation</td>
<td>1000-1200</td>
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The geothermal energy resource should be given emphasis now, as geothermal energy is green, local and continuously available, independent of wind and sun variations. The high cost of drilling a well can be reduced by using the existing abandoned on-shore dry wells where the geothermal gradient is sufficiently high (like over 30 K/km) and where porous and permeable reservoir sandstones are penetrated. The study of geothermal conditions in Bangladesh has now resulted in clearer patterns for the geothermal energy potential [10], related to the major tectonic-structural regions, illustrated in Fig. 3.

The Sub-Himalayan foredeep in Northwestern Bangladesh, where relatively low thermal gradients and only one deep drill
hole occurs, is barely feasible to explore geothermal energy with present technology of electricity generation.

The Rangpur saddle, where relatively high surface temperatures have been observed in connection with some irrigation wells, in coal bearing structures and underground hard rock’s mine. The geothermal resource is likely located within the uplifted basement and would require hydraulic fracturing methods to create permeability at depth with sufficient high temperature for present technology of electricity generation. As fairly high temperatures may be reached at reasonable drilling depth, further study of the region is recommended. By pilot drill holes a depth of 1 km if dug, can establish a proper geothermal gradient.

The Bogra Shelf, with the deep wells at Singra, Kuchma and Bogra potentially offers such favorable conditions for geothermal energy. The Singra well with over 150°C bottom whole temperatures is the most promising of the three areas and a feasibility study is part of the ongoing project. The porosity of Bhurban sandstone, Sylhet limestone, Cherra sandstone and Gondwana sandstone varies from 7-20%. The permeability needs to be ascertained from cores of the Singra well regarding the Lower Bhurban to Gondwana sandstones. Similar studies should also be done for the cores of the Kutchma and Bogra wells. Additional reflection seismic lines may also needed in the Singra and Kuchma areas for the assessment of available volumes for geothermal energy.

The Deep Basin areas are continuously loaded with cool sediments and the geothermal gradients are very low. Despite some deep drill holes, they are barely feasible to explore for geothermal energy with present technology for electricity generation.

The margin of the Folded Belt, where hot springs occur in connection with local tectonic structures, the geothermal gradients are relatively high. Further mapping of conditions for geothermal energy may be rewarding in the area.

XI. CONCLUSION

With the demand for electricity in Bangladesh increasing every day, potential energy sources need to be sought out in order to alleviate the ensuing energy crisis. As Bangladesh is also a developing country, it has to be borne in mind that these energy sources have to be inexpensive, preferably local and can be quickly setup for power generation. Although solar, wind and hydropower offer interesting alternatives they require huge funding, which would strain the economy and take a longer time to recover the costs. This paper looks into the prospect of geothermal energy in Bangladesh and where in the country, there is suitable infrastructure for its implementation. Geothermal power systems satisfy the criteria for a suitable energy systems for Bangladesh, and if the suggestions given in this paper are implemented, it would be a giant leap forward in solving the present energy crisis of the nation.

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REFERENCES


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