GEOTHERMAL SCOPE IN BANGLADESH

A Thesis submitted in partial fulfillment of the requirements for the award of Degree of
Bachelor of Science in Electrical and Electronic Engineering

by
Tarekul Islam
ID: 153-33-219

Sabbir Ahmed
ID: 153-33-217

Co-supervised by
Md. Didarul Alam
Lecturer of the Department of EEE

Supervised by
Prof. Dr. Md. Shahid Ullah
Head of the Department of EEE

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FACULTY OF ENGINEERING

DAFFODIL INTERNATIONAL UNIVERSITY

January 2020

Certification

This is to certify that this thesis entitled "**GEOTHERMAL SCOPE IN BANGLADESH**" is done by the following students under my direct supervision and this work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering. The presentation of the work was held on **06-01-2020.**

Signature of the candidates

Name: Sabbir Ahmed

Student ID: 153-33-217

Name: Tarekul Islam

Student ID: 153-33-219

Countersigned

Md. Didarul Alam
Lecturer
Department of Electrical and
Electronic Engineering
Faculty of Engineering
Daffodil International University.

Prof. Dr. Md. Shahid Ullah
Head of the Department
Department of Electrical and
Electronic Engineering
Faculty of Engineering
Daffodil International University.

The project and thesis entitled **"GEOTHERMAL SCOPE IN BANGLADESH"** submitted by **Tarekul Islam, ID No: 153-33-219 & Sabbir Ahmed, ID No: 153-33-217,**Session: Fall 2019 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical and Electronic Engineering**.

BOARD OF EXAMINERS

Dr. Engr. … **Chairman**
Professor
Department of EEE, DIU

Dr. Engr. --- Internal Member

Professor
Department of EEE, DIU

Dr. Engr. --- Internal Member

Professor
Department of EEE, DIU

CONTENTS

List of Figures

List of Tables

ACKNOWLEDGEMENTS

We are deeply grateful and indebted to the thesis supervisor Prof. Dr. Md. Shahid Ullah, Head of the Department of Electrical and Electronic Engineering, Daffodil International University (DIU), Dhaka, Bangladesh for his cordial encouragement, guidance and valuable suggestions at all stages of this thesis work.

We would like to express our gratitude to MD. Didarul Alam, lecturer at Daffodil International University, Department of Electrical and Electronic Engineering.

We would like to express our appreciation to Prof. Dr. M. Shamsul Alam, Honorable Dean of the Faculty of Engineering, Daffodil International University (DIU) for providing us with the best department facilities and timely suggestions.

We would like to thank Md as well. For his valuable guidance and suggestions in our research, Ashraful Haque, Assistant Professor, Department of Electrical and Electronic Engineering, Daffodil International University (DIU), Dhaka, Bangladesh

Last but not least, we would like to thank all our friends and well-wishers who have been directly or indirectly involved in the successful completion of this work.

ABSTRACT

With only 510 kWh per capita of electricity generation, Bangladesh is one of the world's energy-affected countries and only 94 percent of its population has access to that electricity. Bangladesh is still very early in the sense of geothermal water use. To date, there has been no systematic study to assess Bangladesh's geothermal potential. However, authors in a few articles have highlighted the potential of Bangladesh's geothermal energy resources. Exploration of geothermal energy involves early exploration cash incentives, Yet good planning reduces risks and saves money. Many deep abandoned wells were used in Bangladesh, initially drilled for oil and gas exploration, to collect valuable information on the underground geology and temperature of interesting areas. Analysis of the temperature data for these wells shows that the average geothermal gradient along the south-eastern part of Bengal Foredeep varies from 19.8 ° C to 29.5 ° C / km and from 20.8 ° C to 48.7 ° C / km along the stable north-western shelf. An attempt was made to recalculate different temperatures of the geothermometer using the geochemical data from water samples from the basement aquifer of the Madhyapara hard rock mine region and using the knowledge gained from this training program. The predicted temperature ranges from 67 to 153 ° C, which can relate to a potential low-temperature geothermal field in the region of Madhyapara. After geophysical investigations (resistivity (MT), seismic, gravity, etc.) preliminary geological and geochemical surface studies are recommended, Drilling of shallow gradient wells to create a conceptual model of any geothermal system before continuing with the most expensive and hazardous part, i.e. deep well drilling.

Keywords —— Geothermal Energy (GE), Renewable Energy (RE)

CHAPTER 1

INTRODUCTION

The word geo-thermal originates from the Greek words 'geo' and 'thermos'. 'Geo' means earth and 'thermos' means heat. 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.

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.

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.

1.1 Bangladesh's renewable energy scenario

Efficient use of renewable energy resources in Bangladesh is not yet commercial and can not be an alternative to conventional energy resources. Although Bangladesh has enormous potential for renewable energy, due to lack of proper planning and value, it can’t be used. Renewable energy is again available and there is no waste of its energy source Sun, Wind, water flow, biomass are the major natural sources of renewable energy. Many renewable energy sources include earthquakes, seabed, seawater, tidal waters, coastal waste, hydrogen fuel cells, nuclear power, etc. Experts estimate that Bangladesh will run out of natural gas by 2021.A country's growth is largely dependent on improved power management. . Innovation in the world does not stop at generating electricity. The country whose electricity is better, the better it is. Renewable energy is currently the country's most important source of energy to address the power crisis. Different countries around the world are turning to this green power generation system. Because it doesn't suffer damage to the environment. However, they will help to significantly add to Bangladesh's long-term energy needs. Using these services seems to be a possible way to boost rural villagers' quality of life.

The market share of renewable energy is about 6%. Actually, renewable energy-based national efficiency, with the exception of hydropower, is about 50 MW. The country has constructed a 242 MW capacity hydro-electric power plant in 1962 that now produces 224 MW of electricity. Nonetheless, in Bangladesh, There is limited potential for micro-hydro and mini-hydro.

The government has taken a number of steps to encourage energy conservation and the use of renewable sources in view of the fuel crisis and the discovery of modern, secure and sustainable energy resources GoB has declared Bangladesh's Renewable Energy Policy successful since 2009 (MEMR, 2008). According to this strategy, the government is committed to promoting investment in renewable energy projects by both the public and private sectors to raise contributions from existing renewable energy generated electricity production. The strategy calls for 10% (at least 500 MW) of overall renewable energy generation by 2020 and 15% by 2025. Under the 1994 Companies Act, an independent agency, the Sustainable Energy Development Agency (SEDA), will be formed as a focal point for sustainable energy development and ' sustainable energy ' including renewable energy.

1.2 Bangladesh's geothermal wealth

Bangladesh's geothermal potential are yet to be investigated in depth. Bangladesh recently announced its decision to generate electricity from the warm ground water stream. This is a natural water stream in Barunagaon, Thakurgaon district. This power generation will be the first in the history of Bangladesh through geothermal energy.

Because of the different geotectonic configurations in Bangladesh, the country's geothermal resources can be broadly classified into two different geothermal provinces: the northwestern part of Bangladesh, known as the country's shields and the southeastern, deep sedimentary basin known as the Bengal Foredeep zone consisting of several basement heights and lows as well as the hills of the Chittagong-Tripura folded belt where some thermal springs are known to occur. Thermal manifestations and related evidence in some shallow aquifers tend to suggest the presence of a geothermal resource in the northwest part of the country, in the Thakurgaon district. Recent work done by Mizanur Rahman also shows the potential of a geothermal resource in that area (Rahman, 2006). The reported water wells of high temperature show a much higher geothermal gradient compared to the surrounding area. The Singra-Kuchma-Bogra regions offer possible geothermal discovery zones in the Bogra shelf area (Guha et al., 2010). There are also areas of interest for geothermal exploration in the Madhyapara hard rock mine field and the Barapukuria coal basin

(Kabir, 2008). The underlying basement structure is strongly faulted and extremely fragmented in the northwest shield. Some of these major deep-seated faults can be delicately detected from magnetic surveys and gravity. Such fault systems are thought to serve as conduits to transfer heat from below to the overlying sedimentary aquifer through the fluid within the pore spaces. The prevailing geological characteristics, including hydrogeological settings, clustering of basement faults, seismicity and earthquakes, and surface thermal anomalies all point to the existence of potential heat sources a few kilometers below the surface of the earth. The hilly area of Sitakund with a few thermal springs can also be found in the Bengal Foredeep zone along the tertiary hills.

CHAPTER 2

Bangladesh's geological landscape

2.1 Bangladesh's tectonic system

Our earth's surface is wrapped in multiple sheets or plates, called tectonic plates. Because of its geographical location, the promise of geothermal energy in Bangladesh is very strong. Bangladesh is at the top of the Bay of Bengal. An island has emerged here as two large rivers, the Ganges (Padma) and the Brahmaputra (Jamuna), collide with their coals. The collapse of the Gondwana continent at the beginning of the Jurassic Period or the end of the Cretaceous Period caused the collision with the Indian tectonic plate to the north, elevating the Himalayan mountain range. From here came river chronology. And in some of these places, the moving plate has created hotspots (folded over the plate). Only when excavating from the top to the bottom can a minor temperature difference be found in these areas. Around 5 km north of Sitakunda, a salt hot water reservoir, "Saltaksha," was discovered. There is also a naturally heated water stream in Barungaon of Thakurgaon district bordering Bangladesh. The average temperature of Kuchma, Joypurhat, is 145 ° C below 4,000 feet. And at this temperature, electricity can be easily produced from the steam collected from a liquid. In Bangladesh, to reach the surface, 5000 meters (in some cases even less) may need to be excavated to reach the heated liquid in the ground.

Fig 2.1: Tectonic framework of Bangladesh

The Bengal Basin is the world's largest fluvio-deltaic sedimentary system that occupies most of Bangladesh, India's West Bengal, and part of Bengal Bay. Sediments are accumulated in the GBM basin and dispersed into the Bay of Bengal making up the world's largest deep-sea fan. Bangladesh's major tectonic elements (Figure 4) are discussed briefly in the following.

The safe shelf in the northwest

A shelf covers the Bengal Basin's western and northwestern sections, the margin of which has a northeastern-southwesterly trend along which the basement slopes down to form a hinge line. Where in graben formations the continental Gondwana sequences are preserved, the shallowest deposits of which can be seen in the Barapukuria graben at depths of only 117 m. The shelf area is characterized by a series of buried ridges and natural gravity errors. The cellar slopes northwest and forms a prominent hill, Rangpur's Saddle.

Rangpur saddle

The Rangpur saddle and the so-called Garo-Rajmahal gap constitute the country's most elevated portion of the basement, covered under a thin alluvium veneer. The Rangpur saddle represents an Indian shield block that connects the Southwest Indian Shield with the Shillong massif and the Mikir Hills. Seismic data indicates that the northern and southern slopes of the Rangpur saddle are relatively gentle. The basement slopes gently from Madhyapara's southeast to the southern slope of the Hinge zone, a region known as the Bogra shelf.

Sub-Himalayan Foredeep

The Sub-Himalayan Foredeep lies south of the Main Boundary Thrust (MBT) along the Himalayan foothills. The Neocene Siwaliks are well formed in this area, reaching a thickness of 3-4,5 km with mostly sandstones, subordinate shales and clay and gravel beds. The northern margin of this foredeep is strongly folded and faulty. The Salbanhat 1 well reached the basement at a depth of 2500 m to the northwestern tip of the country (BPSD, 1988).

Deep sedimentary basin

It is known as the Bengal Foredeep region, which comprises the deeper part of the Bengal Basin, the vast area between the Hinge Line and the folded ArakanYoma network. It is a narrow area from Sylhet-Mymensingh-Panba-Calcutta, 25 km wide SSW-NNE and further southwest along the coastline of Orissa. The Hinge region is linked to the north-eastern Dauki fault of the Sylhet trough, which is aligned with a sequence of west-eastern spreading faults. The Indo-Burmese mobile belt's folded belt marks its eastern boundary. The Foredeep of Bengal is made up of several pits and structural peaks, known as

1. The trough of Faridpur, according to the results of gravity surveys and drilling

2. The strongest Barisal-Chadpur

3. The Hatiya trough

4. The trough of Sylhet and

5. The Tall Tangail Tripura or Madhupur.

Folded belt

The folded belt (or the folded eastern flank of Bengal Foredeep) represents the most prominent tectonic element of the Bengal Foredeep, consisting of general north-south folds parallel to Arakan Yoma's folded system. The folds are characterized by ridges with an elevation in Bangladesh ranging from 100 to 1000 m, box-shaped, echelon-oriented. The rate of tectonic deformation in the east is relatively high, slowly declining to the west at Bangladesh's eastern folding belt (Guha, 1978).

2.2 Stratigraphy of Bangladesh

The stratigraphic structure of the Bengal Basin was originally founded solely in lithostratigraphic association with the type parts in Assam, the northeastern province of India, based on exposures along the eastern folding belts (Evans, 1932). A thick alluvium mantle covers most parts of the country and almost all strata are without any marker fossils. Bangladesh stratigraphy is discussed in two broad facies:

(1) The facies of the Shelf

(2) The facies of the Geosynclinal.

There are no outcrops on the floor and the walls are lined by drill holes. Burgess (1959) first reported the existence of a drill hole in Bogra in an Achaean basement in Bangladesh, Similar rocks were later found at different depths in drill holes in the shelf area, the shallowest of which was found in Madhyapara, Rangpur saddle 128160 m below the surface. The basement complex is inconsistently overlapped during the Permo Carboniferous in intracratonic, fault-bound basins by the coal-bearing lower formations Gondwana Kuchma and Paharpur (Ahmed and Zaher, 1965). Paharpur's formation is inconsistently overlaid by the basaltic Rajmahal Trap of the Upper Gondwana group, which is illustrated by Sibganj's formation.

The Jainta group that surpasses the formation of Sibganj is divided into

i)Tura sandstone

ii) Calcareous Sylhet and

iii) Formation of kopili.

The Bogra formation which resembles the Kopili formation is inconsistent with the equivalents of Central and Lower Assam Barail (Khan and Muminullah, 1980).

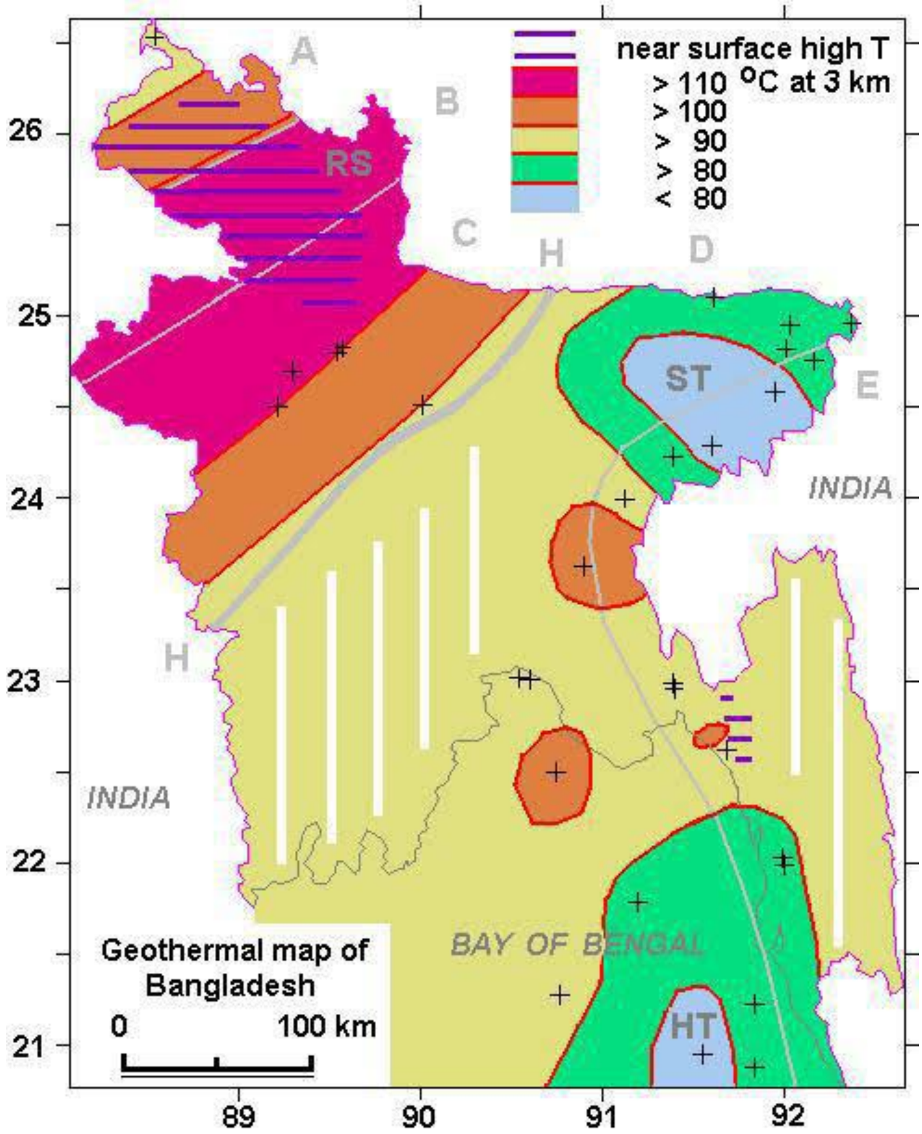


Fig 2.2: Geothermal map of Bangladesh

Geo-synclinal facies stratigraphy

The Barail group is reported to be the oldest rock formation found in geo-synclinal facies on the northern fringe of the Sylhet trough, intersected along the folded belt in drill holes, In the drill holes, Chittagong and Chittagong Hill Tracks are also included. The party's bringing water. It is divided into the following formations:

(1) Bhuban and

(2) Boka Bil.

The following groups are categorized into:

(1) Bhuban and

(2) Boka Bil. Tipam group rocks are in line with the shape of Boka Bil. Tipam's group is again divided into

(1) Tipam sandstone and

(2) Girujan clay.

The Girujan clay lies in harmony with the sandstone of Tipam and is underpinned by the formation of Dupi Tila, followed by the formation of Madhupur and the top of Alluvium.

CHAPTER 3

Working Principle of Geothermal Power Plant

Heated fluid begins to rise above the surface of the earth under the pressure of intense pressure in the centre of the earth. Upon reaching the earth's surface, a pipe line will enter a cylinder where heated liquid and high pressure vapour will be separated. Through the pipe line, the extracted fluid is pumped into another cylinder where the normal pressure vapour (proof pressure vapour) is removed from that fluid and the separated fluid is re-entered into a cylinder where the fluid is low pressure vapour is split. Subsequently, steam is introduced into a turbine in these three categories of high-pressure, standard and low-pressure steam, rotating the turbine, connecting the turbine to a generator, generating electric charge. Such power is transmitted through copper wire to a step-up transformer, where it is transformed by increasing the voltage into a usable power for commercial and domestic use. On the other hand, heated liquid is re-filtered through another tube to the centre of the earth, so that the fluid is balanced.

3.1 The Geothermal power plant which is in working is of three types:

Dry steam power plant

Flash steam power plant

Binary cycle power plant

Dry Steam Power Plant

Direct steam from the geothermal reservoir is used in the dry steam power plant to turn the turbine and generator into electricity generation. The temperature of the geothermal steam needed at least 150 degree Celsius in this power plant.

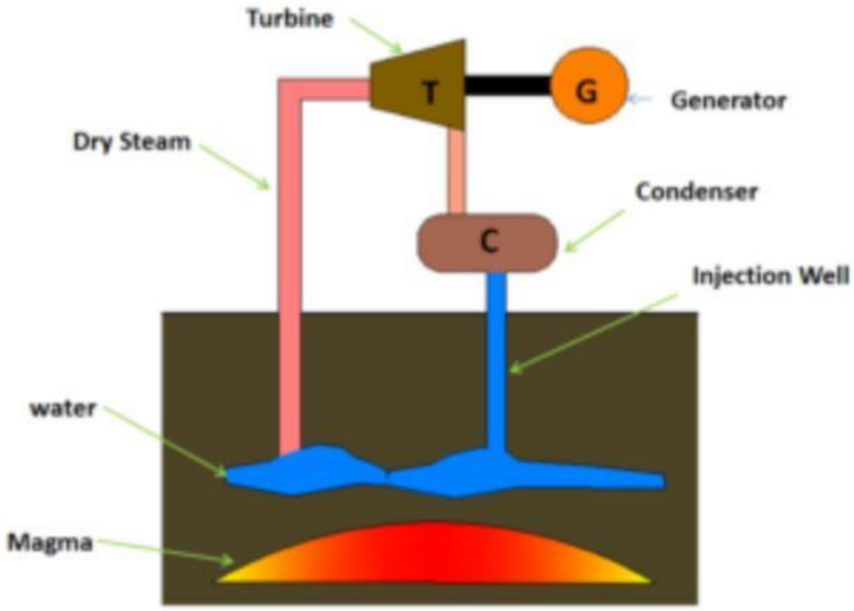


Fig 3.1: Dry Steam Geothermal Power Plant

Flash Steam Power Plant

High pressure hot water from deep inside the earth is drained from the flash steam power plant. Then it was collected in a separator for steam. The high pressure hot water comes to the surface on its own and the pressure continues to decrease as it travels upward, making it possible to turn hot water into steam. Steam is collected in a steam separator and the turbine generator can be switched. When the steam cools, it is injected back into the surface of the earth to be reused. Most of the geothermal power plants that are used today are flash steam plants. The power plant requires a minimum operating temperature of 180 degrees Celsius.

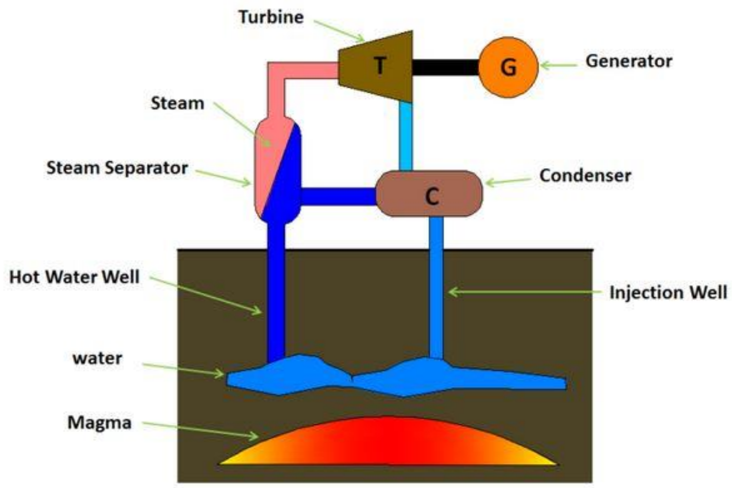


Fig 3.2: Flash Steam Power Plant

The most common type of power plant today is flash steam. The first geothermal power plant to use flash steam technology was New Zealand's Wairakei Power Station, built as early as 1958.

Binary Cycle Power plant

The heat of hot water is transferred to another liquid (called secondary liquid) in the binary cycle power plant. Hot water heat causes another liquid to turn to steam and then this steam is used for turbine rotation. It is the newly built power plant that can be run at at least 57 degrees Celsius at the lowest temperature.

In this binary cycle geothermal power station, the secondary fluid used has a much lower boiling point than water. It works both on the cycle of Rankine and Kalina. The thermal efficiency of this power station is expected to be lie in between 10-13%. This power plant is called as binary, since here we are using two liquids (hot water and secondary liquid) for its working. First successful geothermal binary cycle project took place in Russia in 1967.

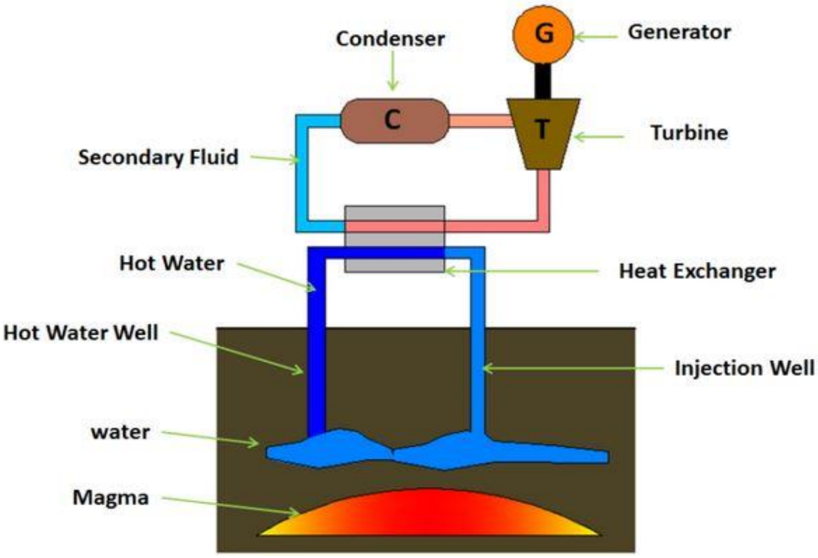


Fig 3.3: Binary Cycle Power Plant

3.2 Cogeneration (Combined Heat and Power)

The thermal efficiency range does not exceed 10-23 percent, Depending on the size, location and other factors of the geothermal power plant. Technically, low efficiency levels do not impacts on it's operating costs, like heating a working fluid with fuel-based power plants.

Electricity generation does suffer from low thermal efficiency levels, Nonetheless, there are many useful applications for by-products, waste heat and hot water. By not only generating power, but also taking advantage of the by-products ' thermal energy, overall energy efficiency is increasing. This is what we call the combined heat and power (CHP) or geothermal cogeneration.

Here are some good examples of this:

- District heating
- Greenhouses
- Timber mills
- Hot springs and bathing facilities
- Agriculture
- Snow and ice melting
- Desalination (processes that remove salt and other minerals from saline water)
- Various other industrial processes.

CHAPTER 4

EXPLORATION GEOTHERMAL

4.1 General Discussion

Bangladesh has always been noted for its acute power shortage, mainly due to insufficient power generation capacity compared with the increasing demand for energy in the country. Bangladesh's per capita energy consumption is one with the world's lowest. Potential geothermal energy with favorable geotectonic conditions and suitable petrophysical properties could be explored in regions with higher geothermal gradients. Some of them are of great interest, including the Singra-Kuchma-Bogra district, the Barapukuria coal mine area, the Madhyapara hard rock mine area and the Thakurgaon thermal area in northwestern Bangladesh, And the hilly Sitakund area along the folded belt in south-east Bangladesh, where warm springs can be found. The most important physical parameters in a geothermal system are: temperature, porosity, permeability, amount of fluid chemicals and pressure. Not all these parameters can be measured directly using conventional methods of geophysical surface; Nevertheless, It is possible to calculate or estimate other significant parameters such as temperature, electrical resistivity, magnetization, density, seismic velocity, thermal conductivity, etc.

The most widely used geothermal exploration tools are geological mapping, geochemical sampling and analysis, geophysical approaches and geological drilling. The most commonly used geothermal exploration techniques are geological mapping, geochemical sampling and analysis, geophysical methods and geological drilling. It has been shown that the integrated method using various datasets is a very effective way of identifying the most suitable geothermal exploitation areas in Hungary. Therefore, an integrated approach is suggested using all the above methods to assess the geothermal potential of Bangladesh. The present report does not have much data to concentrate on for each of the suggested methods, but will highlight the importance of the individual research methods for geothermal exploration in a brief overview.

4.2 Surface investigation

Once a prospect area has been selected for geothermal studies, complete surface exploration will be carried out. Although a detailed research plan is always specific to the site, most of the following components will normally be included. Though not all of them, necessarily. The first step is often to gather all available information from previous work on the area of interest, including geological, geothermal and tectonic maps, topographic information and other infrastructural data. Taking into account the following steps:

The Geology of This:

• A comprehensive geological map of the geothermal structure & climate.

• Visual study of tectonic features such as faults, cracks and fractures.

• Advanced analysis of minerals for surface change.

• Geothermal events map, including temperature, flow rate, conductivity, etc.

• Tectonic thermal manifestations and volcanism (if present) to gain insight into the heat sources, hydrology, and flow paths of the reservoir.

• Advanced groundwater mapping, cold springs, lake and groundwater depth.

Geochemistry:

• Comprehensive hot water, steam and gas sampling.

• Clear analyzes of chemical elements, chemical products and gases (both main and trace elements). In general, geothermometers are used to measure the temperatures of the reservoir and the existence of the heat source.

• Sampling for studies with stable isotopes. Stable isotope analysis. To evaluate the origins of the geothermal fluid of the reservoir, isotope ratios and concentrations are used.

Geophysics:

Thermal techniques provide direct measurements of temperature and/or heat as well as geothermal system properties. When understanding thermal methods, heat exchange processes in the Earth, i.e. conduction, convection and radiation, are considered important. Despite several limitations, thermal methods are important in geothermal exploration. These are included:

• Detailed map of the geothermal surface (GPS).

• Measurements of the soil temperature in the uppermost meter or so.

• Temperature measurements in wells with a gradient of 20-100 m to assess national or local gradient anomalies.

• Airborne Infrared Survey (IR).

• Regional flow heat analysis.

Electrical Process: Most important geophysical process for geothermal exploration are the electrical resistivity methods, temperature and surface alteration and pore fluid salinity can be associated with rock electrical resistivity. A full resistivity survey is a shallow (< 1 km deep) survey and a deep resistivity survey (0.5-10 km deep). The shallow survey is typically conducted using central loop

TEM soundings or audio magneto telluric (AMT) soundings, but DC methods (Schlumberger) can also be used and Magneto telluric (MT) soundings generally conduct the deep survey.

Transient Electro Magnetic (TEM) Process:

The TEM approach has now become a standard tool in the geothermal exploration of the uppermost km of the earth to replace Schlumberger soundings. The current is then shut down and the decreasing magnetic field generates a secondary current in the ground. In turn, a secondary magnetic field that decreases over time is caused by the current distribution in the ground. The decay rate of the secondary magnetic field is determined by measuring the induced voltage in the center of the large current loop in another small loop. These measures determine apparent resistivity. The Magneto telluric (MT) process is a natural-source, geophysical electromagnetic method of imaging structures from depths of a few 100 meters to several 100 kilometers below the earth's surface. The signal frequency corresponds to its range of sampling, with low frequencies reaching higher levels. Natural variations in the Earth's magnetic field cause under the Earth's surface electrical currents (or telluric currents). The system is portable and the collection of data is simple, requiring measurement of the components of the magnetic field B and the induced electrical field E at each location, both as multiple hours operation. MT measurements, however, are sensitive to environmental noise (power lines, etc.). More recently, the method has been routinely used in combination with TEM or AMT, with the TEM or AMT measurements used to map the uppermost kilometer in detail to improve the interpretation of the MT measurements, resulting in better information at deeper levels. In this way, good knowledge about the distribution of resistivity can be obtained in the deeper parts of the geothermal system, reaching a depth of 5-10 km. Magnetic telluric measurements are often made at audio frequencies using energy from spherics; then the method is called the audiomagnetotellurics (AMT) method.

Gravity tests are used to measure geological formations in different densities. The density difference results in a different gravitational force measured, typically in 10-3 cm / s2 mgal. The rock density depends primarily on rock structure and porosity, but the values may also be influenced by partial rock saturation. By general, sedimentary rocks are lighter than crystalline rocks. The rock density mainly depends on the rock's composition and porosity, but partial saturation of the material can also influence the values. Generally, sedimentary rocks are thinner than crystalline rocks. Gravity survey techniques are useful to locate underground fault systems. Gravity data can be used to calculate the volcanic rock distribution and then help identify the heat source.

Throughout geothermal research, magnetic measurements are widely used to measure geological structures, often in conjunction with gravity and seismic refraction. A magnetic anomaly is a local or regional phenomenon caused by a change in magnetization. It is characterized by the effective direction and magnitude of magnetization and the form, position, properties, and history of the anomalous body. Throughout geothermal research, magnetic measurements aim to locate concealed intrusive and likely estimate their size, or track individual buried dykes and flaws. Seismic methods measure earth's distribution of sound velocity and anomalies as well as sound wave attenuation. Through different rocks, these waves propagate at varying speeds. Two important wave types are generated. P waves are usually faster moving in the same direction as the wave, and S waves traveling perpendicular to the wave path are slower than the P waves. The seismic methods are classified, whether active or passive. For geothermal exploration, active methods are not commonly used, but are widely used in oil exploration and are very costly. The two types of active seismic approaches are reflexion and refraction. These are suitable for well packed sedimentary rocks instead of volcanic formations. Passive methods are used mostly as earthquakes or micro-earthquakes are reported in geothermal exploration. Natural seismicity is used to delineate active faults and permeable areas (shear wave splitting) or to locate the boundary between brittle and ductile crust, which may imply the depth of the source of heat. Integrating geological and geophysical data by integrating all available survey data (geological, thermal, seismic, resistivity, gravity, etc.) will lead to a clearer and more transparent. The things shown below.:

• Like reservoir fluid temperature;

• Position of sources of heat;

• Reservoir fluid flow pattern;

• Geological composition and form of rocks of the reservoir;

• Estimated abnormally hot rock volume; and

• Total natural heat loss calculated.

CHAPTER 5

BANGLADESH GEOTHERMAL GRADIENT

The Bangladesh's geothermal gradient is largely regulated by the Bengal Basin's tectono-stratigraphic setup.Therefore, it is important to analyze Bangladesh's geothermal gradient to understa nd individual tectonic elements in terms of regional tectonic history.A variety of scholarshave addres sed the tectonic framework. Bangladesh's Bengal Basin can be divided by two sections:

1) The platform of Northwest Stable and

2) The synclinal basin of The Southeast Deep Geo known as the Bengal Foredeep

The Bengal Basin is historically a cool sedimentary basin with an average temperature gradient of 20 ° C / km in the deep basin region of the South East and 30 ° C / km in the stable shelf area of the No rth West (Rahman, 2006).For the southern part, the subsidence rate and sedimentary thickness are hi gher than for the northern part.The information available on the country's geothermal gradient is pri marily based on deep hydrocarbon exploratory well data.Data from previousstudiesof subsurface tem perature and thermal gradient were collected in this report.Data from previous studies of sub-surface temperature and thermal gradient were collected in this report.Offshore wells are thought to h ave a surface temperature of 24°C (75°F) and offshore wells of 15°C (59°F) (Ismail and Shamsudd in, 1991).On the assumption of a linear rise in temperature with depth,geothermal gradientsweredeter mined.The following equation can be used to express the temperature of any depth with this assumpti on:

$$Tz = To + TgZ/100$$

Where,

The wellbore temperature are Tz (°C) at depth Z (m);

The mean surface temperature are To (°C); and

The geothermal gradient is Tg in (°C/km)

Well name	Depth (km)	Gradient (K/km)
Hazipur	3816	30.9
Bakhrabad	12,837	25.0
Titas	13,758	30.1
Habigonj	13,509	31.6
Rashidpur	13,861	26.8
Biani Bazar	14,107	28.7
Kailas Tila	14,139	27.8
Sylhet	12,377	31.1
Chhatak	12,133	33.8
Semutang	14,088	30.3
Begamganj	13,656	31.7

Table 1: Bangladesh's deep well situated

Bangladesh's isogeothermal map shows that the geothermal gradient in the Bengal Foredeep area var ies between about 20 ° C and 30 ° C / km. Also observed is the pattern of growing geothermal gradients from north to south (i.e. from Sylhet to Hatiya trough) and from east to west (i.e. from folded flank to platform flank). The highest geothermal gradient was found in the Hatiya trough deep basin (Shahbajpur 1, 29.5 ° C / km) in the Foredeep region of Southeast Bengal, and the lowest was found in the Sylhet trough folded flank (Beani Bazar 1 well, 19.8 ° C / km). A single value of the geothermal gradient was recorded for each well and expressed in units of ° C / km for presentation. Temperatures were taken from the plotted average curve at different depths (at km intervals) to create an isothermic geothermal gradient. Due to Bangladesh's specific geological structure as well as the distribution of deep exploratory wells, the geothermal gradients are discussed as follows under two broad headings.

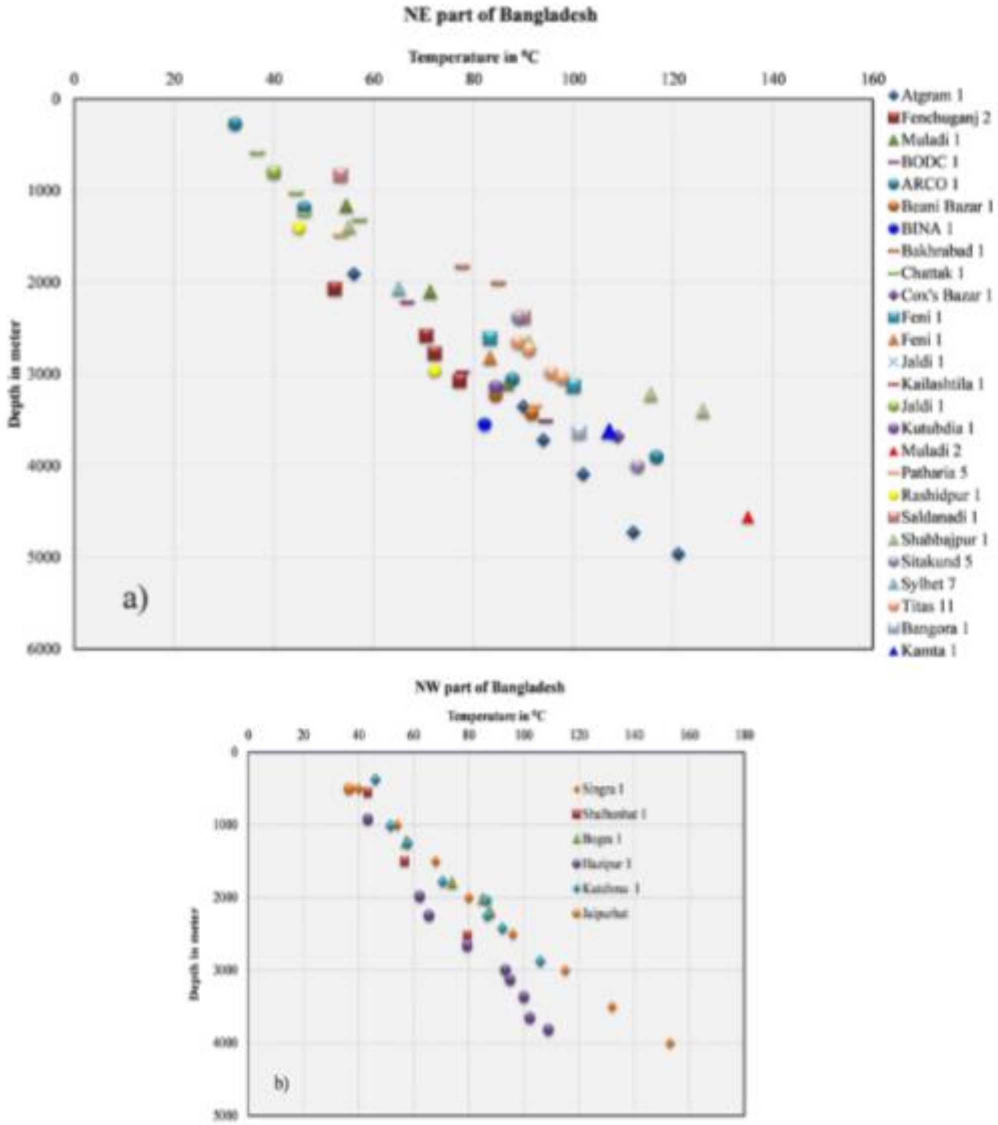


Fig 5.1: Sub-surface temperature distribution in

a) Bangladesh's southeast basin;

b) Bangladesh's stable northwest portion

5.1 Bangladesh's southeast basin

The Bengal Foredeep, which occupies the southeastern part of Bangladesh, is a zone of great subsidence of the Earth's crust, occupying the vast area between the Hinge line and Arakan Yoma's folded network, and plays a major role in the tectonic history of the Bengal Basin. Based on its geotectonic nature, Bengal's Foredeep is again divided into the unfolded western or deep basin area and the folded eastern region known as Chittagong-Tripura's folded belt extending parallel from north to south. As seen from gravity and magnetic surveys, there are several highs and lows in the unfolded western part. Sylhet's northeastern trough is also known as Sylhet's basin, And the southwestern Faridpur trough is separated by a prominent high known as the Tangail-Tripura high and the Hatiya trough in the southernmost depression of the basin; north of it is the Barisal-Chadpur high gravity.

Folded belt

The folded belt (or the folded eastern flank of Bengal Foredeep) is the most prominent and recent tectonic feature on the western flank of the Indo-Burman Ranges. The hydrocarbons identified so far in the country are included in the reservoir sands of the Neogene Surma group. The wells were drilled to approximately 21004977 m below the surface. Thirty temperature data from exploratory wells have been used to map the thermal gradients of the area. A high sedimentation rate is likely to affect the low geothermal gradient in the deep basin area in the majority of the Tertiary sedimentary sequence.

The geothermal gradient for sedimentary sequences consisting mainly of shale is 22.5 ° C / km. The geothermal gradient for the Hatiya trough at Shahbajpur 1 well, 29.5 ° C / km,is the highest followed by Saldanadi 1, at 27.2 ° C / km, along the folded belt region of Bangladesh. Which is shown by Table 2.

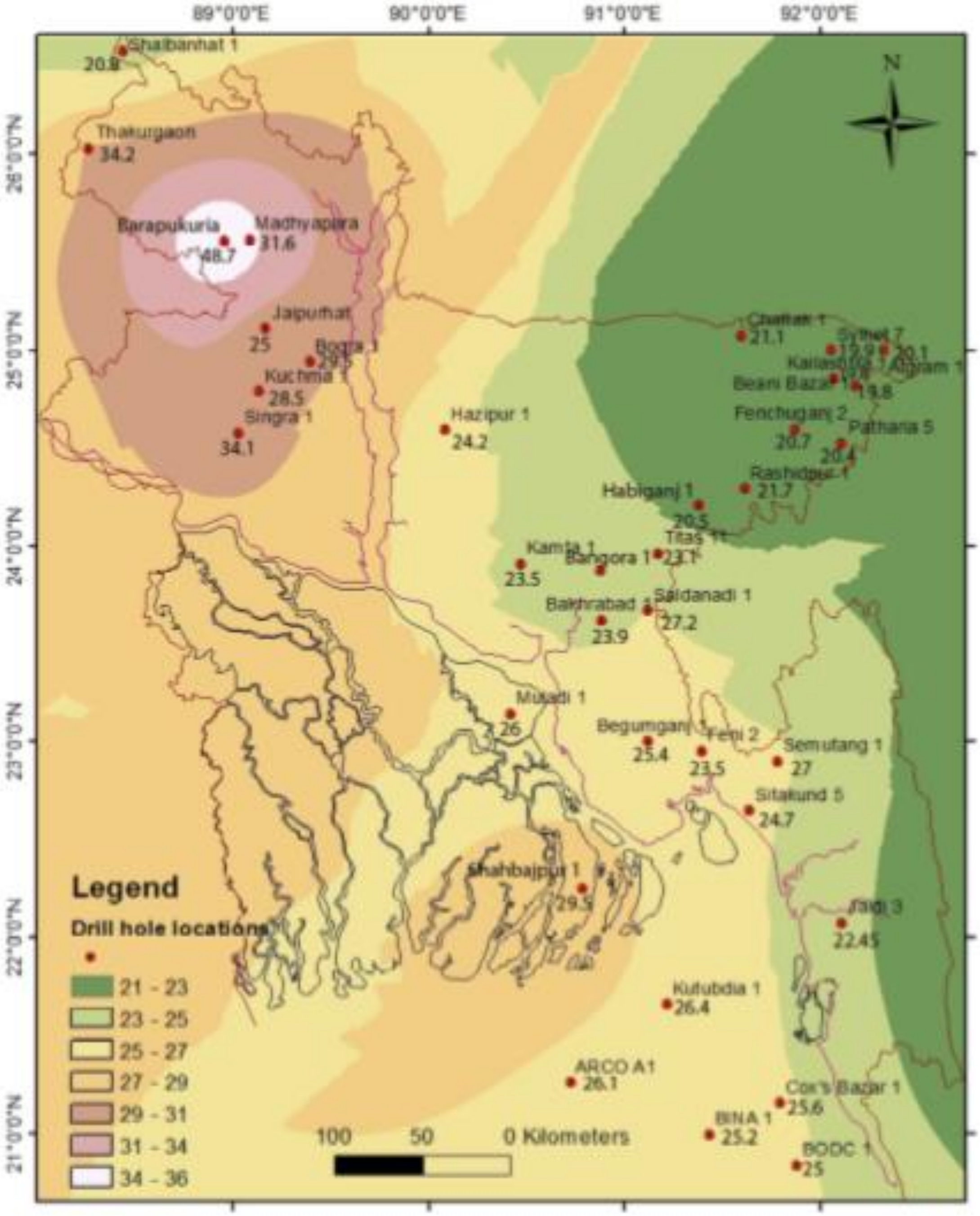


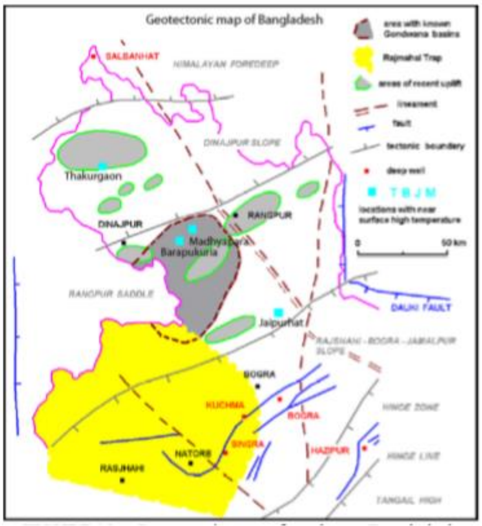
Fig 5.2: Bangladesh's overall geothermal gradient (° C / km) with individual well gradient

Sl/No.	Well Name	°C/km	Sl/No.	Well Name	°C/km	Sl/No.	Well Name	°C/km
1	ARCO A1	26.2	11	Fenchuganj 2	20.8	21	Muladi 2	24.3
2	Atgram 1	20.2	12	Feni 1	23.9	22	Patharia 5	20.5
3	Bakhrabad 1	23.8	13	Feni 2	23.6	23	Rashidpur 1	21.8
4	Bangora 1	21.3	14	Habiganj 1	20.6	24	Saldanadi 1	27.3
5	Beani Bazar 1	19.7	15	Jaldi 1	20.1	25	Semutang 1	27.1
6	Begumganj 1	25.5	16	Jaldi 3	22.6	26	Shabajpur 1	29.6
7	BINA 1	25.3	17	Kailashtila 1	19.9	27	Sitakund 5	24.8
8	BODC 1	25.1	18	Kamta 1	23.6	28	Sylhet 7	19.8
9	Chattak 1	21.2	19	Kutubdia 1	26.5	29	Titas 11	23.2
10	Cox`s Bazar 1	25.5	20	Muladi 1	26.1	30	Hazipur 1	24.3

Table 2: Geothermal gradients (° C / km) for deep wells in the Foredeep area of Bengal

5.2 Northwest stable shelf part of Bangladesh

The stable shelf area of the northwest is characterized by a minimal to moderate sediment thickness over the igneous and metamorphic basements of Precambria. Interpretation of Bangladesh's aeromagnetic map showed several well-defined faults in the stable platform. These faults are thought to be controlled in the basement with a mechanism for the formation of the associated fracture system to transfer heat to the surrounding rocks. Some of these faults, containing Gondwana coal, are surrounded by intracratonic grabens. The field has a sedimentary minimum thickness of 130 m. Temperature data from the deep exploratory wells of hydrocarbons as well as many shallow wells helped identify four prominent zones, including three very high anomalous thermal zones in the stable zone; these zones are discussed below.



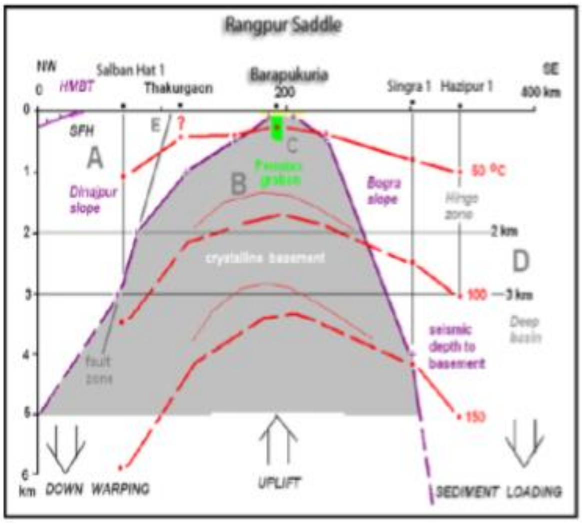


Fig 5.3: Northwestern geotectonic view

Fig 5.4: NW-SE Bangladesh regional map

The Bogra shelf (Bogra slope) represents the Rangpur Saddle's southern slope, a regional monocline gently plunging south-east into the Hinge district. The width of the Bogra shelf ranges from 60 to 125 km up to the Hinge zone and the thickness of the sedimentary sequence rises to the south-east Four deep wells were drilled on the Bogra plateau, namely the Singra 1, Bogra 1 and 2 and Kuchma 1 with the highest drilling depth of 4100 m at Singra 1 in the north-west area. The field of Singra-Kuchma Bogra is distinguished by a 400 m vertical throw between the wells of Singra and Kuchma and 700 m between the wells of Kuchma and Bogra (Guha et al., 2010). The Singra 1 well has a bottom hole temperature of more than 150 ° C, making this region look promising for geothermal exploration.

Madhyapara hard rock mine area

Madhyapara granite mine is situated in the northwestern part of Bangladesh, in Madhyapara, Dinajpur district. This area is situated within the Rangpur saddle, which is the most elevated basement rock block in the stable shelf area of the northwest. The area has a minimum sedimentary thickness of as low as 130 m, while Bangladesh has not found any Precambrian exposed rock. The basement is extremely unstable and broken, releasing large amounts of water when mined. The upper DupiTila aquifer and the lower aquifer of the basement are two distinct aquifer systems that prevail in the area. The aquifer is about 125 m deep and in most of the region is 6 m below ground level (Reza, 1988). The aquifer in the basement lies below the upper aquifer. Water occurs in the intergranular pores of the weathered portion of the basement complex and is responsible for performing heat flow through the rocks along with the fissures and fractures of fresh basement rocks. Madhyapara's basement aquifer groundwater is characterized by a higher temperature (40.4 ° C) than the average annual surface temperature of about 24.7 ° C (CMC, 1994). A high head with artesian water flow characterizes the aquifer in the basement. A recent study of some shallow wells found a very high anomalous thermal gradient from 32°C/km to 149.4°C/km, as shown in Figure 13 (Rahman, 2006). Another research work revealed that the average thermal gradient for overlying sediments was 26.8 ° C / km and the underlying Precambrian basement complex was 32 ° C / km (Kabir, 2008).

Coal Basin Of Barapukuria

The coal basin of Barapukuria is situated in Parbatipur thana of Bangladesh's Dinajpur district. Gondwana coal deposits were found in the graben system of the stable shelf at the lowest depth (118 m). The Precambrian basement is covered by a sedimentary crust of around 1200 m of predominantly Permian Gondwana rocks (Figure 14). At Barapukuria, at a depth of 380 m (Wardell Armstrong, 1991) 40.5°C and 440 m (IMC, 1998) 52°C were encountered.

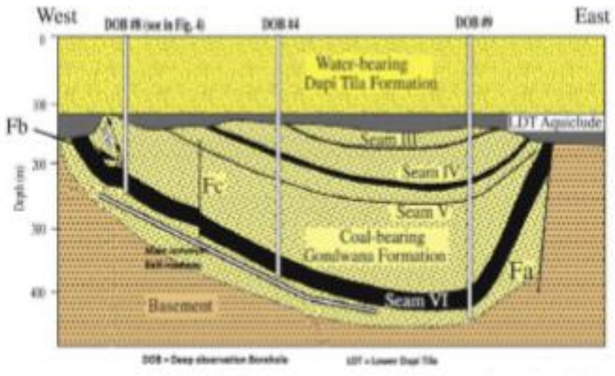


Fig 5.5: West East Barapukuria coal cross-section

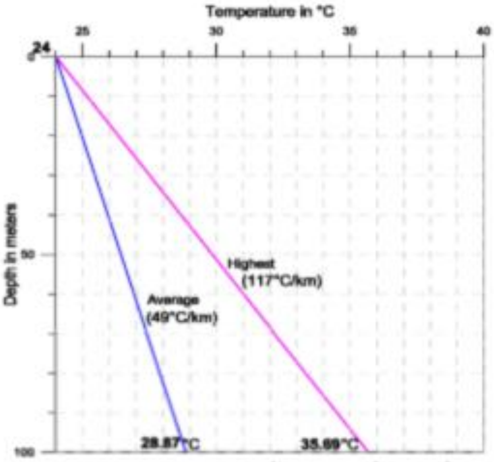


Fig 5.6: Anomalous geothermal mine field

A high temperature gradient at an average temperature of 48.7 ° C / km was reported in the coal mine, whereas the thermal anomaly was documented at 116.9 ° C / km in the deeper part of the Gondwana basin (CMC, 1994). Faulting is associated with high temperatures; spontaneous combustion and the passage through the coal seams of an igneous dyke triggered the region's high heat flow (Kabir, 2008). Higher heat flow characterizes the southern part of the coal basin than the north. The northern part of the basin is comparatively cooler and the Lower Dupi Tila clay unit above the Gondwana coal is absent. Higher heat flow characterizes the southern part of the coal basin than the north. The northern part of the basin is comparatively cooler and the Lower Dupi Tila clay unit above the Gondwana coal is absent. The low geothermal gradient may be caused by cool meteoric water's downward vertical movement.

Thakurgaon high-temperature area

The high-temperature area of Thakurgaon, situated northwest of Barapukuria, is part of the Tista flood plain and is part of the Himalayan Foredeep zone of Bangladesh. The basement only occurs to the southeast at a depth of 150 m in the Phulbari coal basin (GSB, 1990). During groundwater pumping, high temperature groundwater was observed in the Thakurgaon district village of Barunagaon (well 278) (Bashar and Karim, 2001). In some parts of the Thakurgaon area, subsequent research revealed a high anomalous temperature gradient in certain groundwater wells (Rahman, 2006; Kabir, 2008). Recently, the Bangladesh Geological Survey also drilled a thermal well there and found a temperature gradient of 34.2 ° C / km at a depth of 550 m.

SI/No.	Name	Temperat. (°C)	Depth (m)	Gradient (°C/km)
1	T-278	35.1	87.5	126.5
2	T-277	30.2	56.5	107.5
3	HTW-1	29.1	27.5	182.5
4	HTW-2	27.2	26.2	115.5
5	HTW-3	29.1	26.2	192.5
6	STW	33.1	36.2	250.5

Table 3: Wellhead temperatures in the Thakurgaon district at shallow wells (Kabir, 2008)

CHAPTER 6

GEOCHEMICAL METHOD

6.1 Methods of geochemical discovery

Geochemical methods are an integral part of geothermal exploration techniques, particularly during pre-drilling. Geochemical methods are relatively cheap and can provide valuable information about the temperature conditions in a geothermal reservoir and the source of the geothermal fluid that can not be provided through geological or geophysical techniques. This is a rather straightforward and simple approach for initial evaluation of a possible geothermal field. The use of geochemistry in geothermal exploration has a deep significance in inferring subsurface conditions by researching the chemistry of surface manifestations or discharge fluids that bear the deep geothermal system's signature. Chemically inert materials that are retained and not changed by chemical reactions provide information about the fluid sources. Those sources are known as tracers. On the other hand, reactive components such as SiO2, CO2, H2S etc. react with minerals and other reactive components and can thus provide information in the form of geo-indicators on the sub-surface conditions (Giggenbach, 1991). Geo thermometers are geo-indicators that use the chemical and isotopic compositions of discharges to measure sub-surface temperatures.

6.2 Geothermometers

Chemical and isotope geothermometers are important geothermal indicators for geothermal resource exploration and development. They are also very important in monitoring the response of a geothermal reservoir to the load of production during exploitation and in elucidating chemical reactions that occur in depressurization zones around wells resulting from boiling and/or cooling by recharging cold water. Care must be taken in the application of geothermometers, otherwise serious errors can result from the tests and interpretations. Comparing temperatures suggested by various geothermometers is a good practice.

There are three classes of geothermometers.

1. Geothermometers of water or gas

2. Geothermometers of steam or gas

3. Geothermometers of isotpe

The geothermometers of water and steam are collectively known as chemical geothermometers. As geothermal waters rise from a deep reservoir to the surface, they can cool by conductive heat loss while moving through cooler rocks or boiling due to reduced hydrostatic head. Nevertheless, cooling will affect the degree of saturation of both primary and secondary minerals. As a result, conductive cooling may result in some modification by mineral dissolution or precipitation in the chemical composition of the ascending waters. Boiling induces frequent changes in the composition of rising geothermal waters.

Geothermometers of Water

The Silica, Na-K ratio and Na-KCa geothermometers are the most common water geothermometers. As a function of temperature and pressure, the silica geothermometer is based on experimentally determined variations in the solubility of different species of silica in water. In the majority of geothermal systems. Deep fluids are in equilibrium with quartz at temperatures > 180 ° C; quartz is stable up to 870 ° C and has the lowest solubility relative to other silica polymorphs. Quartz is popular as a rock forming mineral, primary and secondary (hydrothermal). At cooler temperatures of <180°C, silica polymorphs with a less ordered crystalline structure have higher solubility than quartz and form. The geothermometer of quartz is suitable for conditions of reservoir >150°C.

Geothermometers of steam:

For most geothermal fields, surface manifestations consist primarily of fumaroles, springs, and hot sites. Water supplies can not be available where the groundwater is deep. If this is the case, it is not possible to use water geothermometers to determine the temperature on the air.

• Balance of gas-gas.

• Mineral-gas equilibrium involving H_2S, H_2 and CH_4 but assuming that CO_2 is set by empirical methods externally.

• Relationship between mineral and gas.

Geothermometers of isotope:

The fractionation between compounds of the isotopes of light elements is quite important and depends on temperature. The distribution of the stable H, C and O isotope between aqueous and gaseous compounds was used as geothermometers. Reactions to the exchange of isotopes may be between gases and steam phase, mineral and gas phase, water and a solvent or a liquid and a solvent. And though there are several mechanisms of exchange of isotopes. Which are based on the simplicity of collection and preparation of samples, ease of isotopic calculation, an adequate rate of isotopic equilibrium achievement and knowledge of the constants of equilibrium. The following was used:

• Isotopes of oxygen

• Geothermometer of carbon dioxide and methane isotopes;

• Isotopic geothermometer for water-hydrogen gas;

• Geothermometer for sulfate-water oxygen isotopes;

• Geothermometer of sulphate-hydrogen sulfide

6.3 Scaling:

The formation or scaling of minerals is a very common phenomenon observed in almost all fields of exploration of geothermal energy. All geothermal fluids contain minerals dissolved. Such minerals are collected at different processing points, adversely influencing the process by limiting the movement of fluids. Scale formation has always been a problem for the geothermal industry. Changes in water temperature, pressure, pH and mineral saturation are inevitable when fluid is drilled into a reservoir from geothermal reservoirs by manufacturing wells. Scaling is the most important part of the geothermal power plant, in these case scaling is helped out to change the water temperature and also its pressure. The term of scaling is used about geothermal systems.

6.4 Corrosion

The term corrosion is used for chemical material destruction. Iron and common unalloyed steels easily corrode into rust. Wet corrosion is the most common case. The corrosive processes are very complex and are carried out under very different conditions. Various types of corrosion such as pitting, crevice corrosion, stress corrosion cracking (SCC), sulfide stress cracking, while galvanic corrosion, corrosion fatigue and exfoliation are less common in geothermal systems. Hydrogen ion, chloride ion, hydrogen sulfide, carbon dioxide, oxygen and iron are the most common corrosive species in geothermal fluids.

6.5 Use of geochemical methods

The present work is an achievement of the latest information gained on the geochemical exploration method. The reuse of 17 previously studied water samples from the basement aquifer of the Madhyapara granite mine area has been considered for the current study. The samples were taken from an aquifer in the basement where the water flow was artesian and fissured at different levels of mining from the hard rock mine area. Samples were tested in the Bangladesh Atomic Energy Commission's chemical laboratory at the Institute of Nuclear Science and Technology (INST).

Sample no.	[1]Na-K-Ca	[2]Na-K	[3]Na-K	[4]Na-K	[4]K-Mg
1	74	95	58	116	84
2	94	127	93	147	95
3	88	118	83	139	52
4	82	106	70	126	89
5	88	114	78	134	76
6	81	103	67	124	81
7	89	110	74	131	101
8	62	82	45	104	57
9	65	76	39	98	37
10	67	76	39	98	64
11	97	81	43	102	76
12	123	120	85	140	77
13	88	79	41	100	53
14	124	110	74	131	84
15	134	133	99	153	79
16	95	90	52	111	59
17	100	84	47	105	71

[1]Fournier and Truesdell,1973; [2]Fournier,1979; [3]Arnórsson et al., 1983; [4]Giggenbach, 1988;

Table 4: Various geometric temperature (° C) for Bangladesh's water samples

6.6 Study of the geothermometer

A broad variety of sub-surface temperature was observed using different geothermometers based on the relative abundance of Na, K and Ca as suggested by various authors. The measured temperatures of the subsurface are summarized as follows:

- The temperatures of the Na-K geothermometer are 76-133 ° C, 39-99 ° C and 98-153 ° C.
- The temperatures of the K-Mg geothermometer are 37-79 ° C.
- The geothermometer Na-K-Ca offers temperatures between 65 and 134 ° C.

Calculated temperatures are quite variable for the water samples studied. With the rise in silica content, temperature rises and disparities slowly decrease. Even interestingly variable are the tests of the three Na-K geothermometers.

CHAPTER 7

GEOTHERMAL POWER PLANT IN BANGLADESH

7.1 BANGLADESH AND POWER DEMAND:

Power crisis has become one of Bangladesh's vital problems, even though it faces so many major problems such as poverty, population, terrorism. In 2006-07, the nominal gross electricity demand in 2010-2011 was 5112 MW, 6765 MW, and the demand in 2011-2012 was estimated as 7518 MW, with an average annual rise of 481 MW. About 8916 MW of demand will be reached by 2015.

The average generation, on the other hand, was 3717. 80 MW in 2006-2007, which increased to 4890 MW in 2010-2011 and 2011-2012. It reaches 6066 with an average annual increase of 213 MW[3] and an average generation of 6705 MW by 2015, with our vision of generating 11500 MW by 2015Across addition, across 2011-12, the cumulative annual shedding of load is 1058MW. Again, the market varies from east to west. In the eastern zone, the demand for electricity is much higher (more than double) than in the western zone. Electricity demand has increased in the eastern zone at a rate of 18.3 percent per year. In the western region, however, this increase was 9.1 percent over the same period.

Various types of power plants are now available in Bangladesh. Many operate on natural gas or other fuels. In manufacturing, these are very costly. Everyone is aware of global warming in this modern life and wants to create effective regulation that won't harm the environment. Today, there is a lot of information and excitement about the growth and increased production from alternative energy sources of our global energy needs.

We found various types of power plants in renewable energy. Wind power plants, solar power plants, hydroelectric power plants, geothermal power plants, etc. The most efficient geothermal power plant is by all the renewable plants. We can get electricity from there at all times.

7.2 Comparison of Geothermal Power Plant & other Renewable Power Plants:

Uses of Land:

As a solar power plant takes a huge place for solar, a hydro power plant takes a huge place for dam, a wind power plant takes a huge place for Turbine, but a geo thermal power plant takes a very small place of land only where a maximum geothermal temperature is available. Bangladesh is a country of huge population density, so this type of power plant will be more helpful to the country.

Continues Power Supply:

If we think about Wind Power Plant, we can only get electricity from there when there is sufficient air & it get expected electricity from there. In Solar Power Plant, it only works at day & it not works at night. But if it a cloudy sky there and in rainy day it can’t produce expected amount of electricity. So it only works properly on a Sunny day. If we think about Hydroelectric Power Plant, it only works properly when there is a sufficient water in the dam or River. In Summer & Winter it can’t produce expected amount of electricity due to lack of water. But, In Geothermal Power Plant we will use only the hot water which will comes from the Ground. So we can get electricity from there at day & night, or at summer or winter. We can get a continuous supply of electricity from there.

Low cost:

Cost Comparison between Renewable Energy Sources:

Power Plant Type	Cost tk/KW-hr
Geothermal	2.88
Biomass	7.36
Hydro	3.12
Wind onshore	2.96
Wind offshore	8.48
Solar PV	3.04
Solar Thermal	13.2

While the raw forms of energy are both free and practically Infinite, the equipment and materials needed to collect, process and transport the energy to the users.

From the above table we found that, Geothermal power plant is most cost effective than any other renewable Power plant.

Operation and Maintenance:

Geothermal plants are high in energy, but they are fairly cheap to run. Costs range from 0.88tk to 2.64tk per kilowatt-hour, and may be available at 90% or more. Maintenance costs increase if the availability of a geothermal power plant exceeds 90%.

7.3 Assumed Calculation and Cost of Geothermal Energy:

A formula to produce energy at binary cycle is shown below:

$$W=MCT$$

Where, M=Mass of the working liquid

C=Specific heat of the fluid

T=Temp.

Say 1 hour we getting, T=57 degree Celsius = 330.15K

M=1kg

C=water vapor specific steam=1996kj/kg/k

Therefore W=330.15*1996*1=658.9794KWh

Therefore for 1 year is

W=658.9794*365*24=5772.65MWh

Maximum cost is=5772.65*80=4000 crore.

7.4 Geothermal Power Plant Effect on Environment:

The emissions of geothermal power plants are low. Geothermal power plants do not burn fuel for electricity generation, so they emit low levels of air pollutants. Geothermal power plants emit 97% less acidic rain-causing sulfur compounds and about 99% less carbon dioxide than similar-sized fossil-fuel power plants. Geothermal power plants are using scrubbers to extract the naturally occurring hydrogen sulfide in geothermal reservoirs. Some geothermal power plants pump back into the earth the geothermal steam and water they use. This recycling helps regenerate the ability of geothermal energy.

7.5 Top 10 Geothermal Countries:

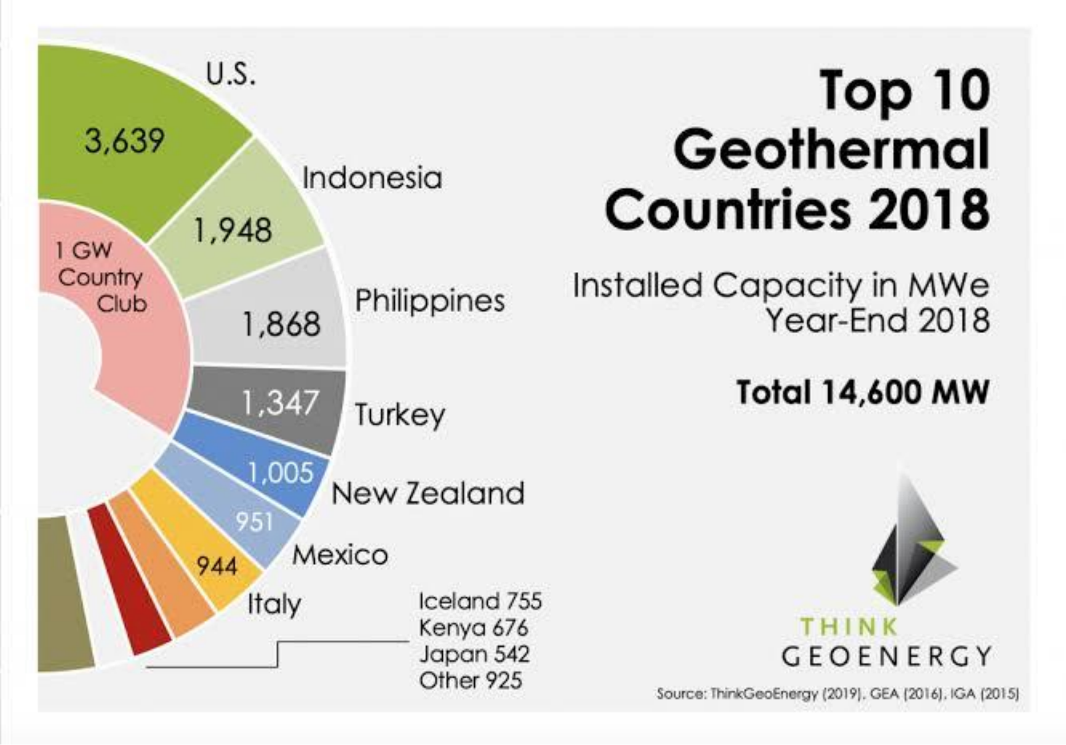


Fig 7.1: Top 10 Geothermal Countries

7.6 Geothermal Power Plant future in Bangladesh:

In Bangladesh we found very high geothermal temperature in northern part of Bangladesh. In Madhyapara & Barapukuria coal Basin area we found a very high geothermal temperature, Which is suitable for geothermal power plant. In Bangladesh, Anglo Power is constructing a geothermal power plant in Thakurgaon.

7.7 ANGLO MGH

A private company is planning to set up the first geothermal power plant in Bangladesh with a production capacity of 200MW. The company based in Dhaka is preparing to dig 28 deep tube wells to raise hot steam. The temperature of which must be 120 degrees Celsius or more. The steam that is lifted and pressed is channeled into a turbine. Which is connected to a generator to turn it into electricity.3555 hectares of land to select Thakurgaon's spot. The cost of 200MW (150-200) is one-third of the cost. The organization has received favorable views from the Bangladesh Geological Survey.

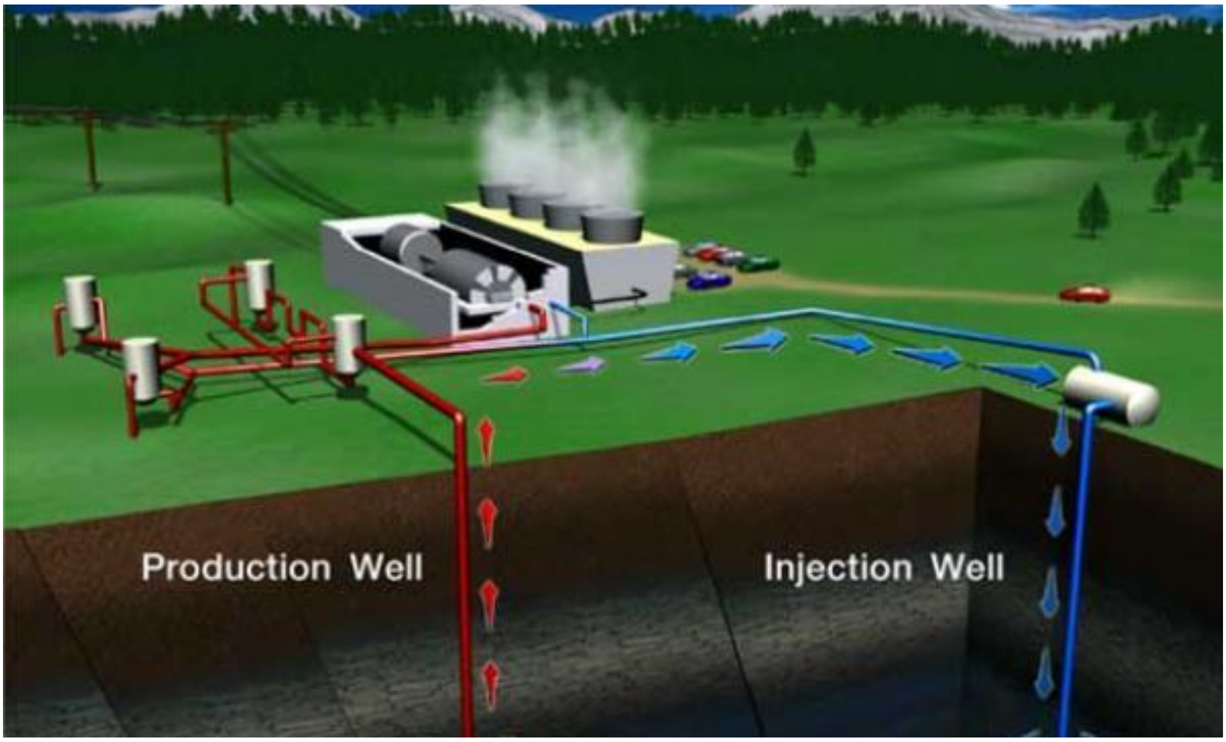


Fig 7.2: ANGLO MGH

Fig 7.3: Salandar,Thakurgaon

7.8 Our Proposed 100MW Geothermal Energy in Barapukuria, Dinajpur:

We proposed 100MW geothermal energy program for raising hot steam by drilling at least 14-15 deep tube wells. What temperature is a minimum of 120 degrees Celsius. The steam that is raised and pushed is channeled into a turbine. Which will be connected to a generator to generate electricity. At least 1750-1800 hectors of land to select the spot in Barapukuria, Dinajpur. 100MW cost is probably $75M-100M which is compare to the third of the cost. This is secured for environment which is cleared about our geological survey of Bangladesh. High temperature in the coal faces in part of the mining area has been one of major factors that has made the Barapukuria underground mining difficult. The high temperature, high humidity and hot water flow have created major obstacles in smooth working in the southern part of the coal mine. So this is the right place to plant geothermal energy because in coal mine 450m we found 35-36 degree Celsius temperature and 620m-720m average temperature was found 46-52 degree Celsius. So we saying in deeper temperature is increasing constantly to high. Geothermal installations produce electricity from geothermal water (>120◦C). We already found 50 degree Celsius up near about 700m so we can say up to near 2000m we found our exactly temperature which is needed to geothermal plant. That’s why Barapukuria and near at Barapukuria is the best place to installation our geothermal plant.

CHAPTER 8

CONCLUSIONS

Power and energy are prerequisites for increased economic growth, poverty alleviation and social development in a least developed country like Bangladesh. Bangladesh's per capita energy consumption is one of the world`s lowest. At present electricity access is available to only 51 percent of its population. The current capacity of Bangladesh is about approximately 7000 MW. Currently, electricity generation is highly dependent on natural gas, which accounts for 73.5% of the total installed capacity of electricity generation. Yet with growing demands for more gas, the current electricity reserves will only last another 10 years. The established supply cannot satisfy the current demand for gas. Indigenous coal also has no significant impact on the energy scenario. In our countries solar, wind, biomass, hydro, geothermal, tidal wave etc. renewable energy used for energy but it is very slow compare to other country. Yet to achieve commercial proportions and can not operate as alternates to conventional energy tools. Bangladesh's recently adopted renewable energy policy has mandated a contribution of 10% of renewable energy resources by 2020 and 15% of total power demand by 2025. This technology is very new in Bangladesh. On the other hand some of Asian country liked Indonesia is upgrading day by day their geothermal energy with also renewable energy. This is quit challenging work but if we success on our research it was very effective and reasonable to all of them. So far, no systematic work has been done to determine Bangladesh's geothermal prospects.

Exploration of geothermal energy involves initial cash investments in order to minimize risks and save money. Our environment department have done a great job to this energy otherwise it was not certified. It is very important to know that geothermal energy is very effected our nature and nearest people. Our society is also used this energy to applied their home. Geothermal energy is both renewable and one of the cleanest sources of energy and its use has the potential to greatly reduce greenhouse gas emissions by displacing fossil fuels. It is important to prioritize the areas to be explored in the early stages. The typical geothermal gradient along Bangladesh's southeastern portion of Bengal Foredeep. In Bangladesh, several deep abandoned wells that were originally drilled for oil and gas exploration could provide valuable information on underground geology and temperatures in areas of interest. All areas previously explored were seismically surveyed along with other established geophysical methods. In the north west zone like Bogra, Dinajpur, Rangpur, Thakurgaon is stable to produce geothermal energy because here founded high temperature. So this area fulfill the requirements to our condition which we are shown in up. All areas previously explored were seismically surveyed along with other established geophysical methods. The region of the Barapukuria coal mine, the area of the Madhyapara hard rock mine and the Thakurgaon thermal areas in the northwest part of Bangladesh are also known as high anomalous thermal zones, so further analysis is stressed for them. Another promising area for geothermal exploration is the Sitakund area along the folded belt of southeastern Bengal Foredeep district, where local warm springs occur. An attempt was made to calculate different geothermometer temperatures using the geochemical data from the basement aquifer water samples of the Madhyapara hard rock mine area and the knowledge gained from this training. In the previously analyzed data, some of the data required for the standard practice in geochemical geothermal exploration research are relatively absent. The cation plot reveals that most waters are in partial equilibrium with a few samples showing young waters, while the plot of anions implies peripheral waters. Specific geothermometers were used to measure the water sample temperatures. The expected temperature ranges from 67 to 153 ° C were considered very variable.

An area assessment in the context of underground geothermal exploration requires a detailed study of all surface exploration methods such as geological, geochemical and geophysical methods and drilling data. Subsequently, for a better understanding of the subsurface geothermal environment, including the possible temperature of the reservoir fluids, heat sources, reservoir fluid flow pattern and geological structure of the reservoir, hot rock thickness, and natural heat loss, it is important to incorporate all available information. A conceptual model of the geothermal system must be drawn that complies with all surface exploration results before proceeding. In a geothermal environment, drilling a deep exploration / production well is considered the most costly part of the plan as well as the most dangerous aspect of a geothermal project.

REFFERENCES

[1] Ahmed, W., and Zaher, M.A., 1965: Paharpur Gondwana coal field and subsurface geology of Rajshahi division. Geological Survey of Bangladesh, unpublished report.

[2] Alam, M., 1989: Geology and depositional history of the Cenozoic sediments of the Bengal Basin of Bangladesh. Palaeogeogr. Palaeoclimatol. Palaeoecol., 69, 125-139.

[3] www.yourelectricalguide.com%2F2018%2F08%2Fgeothermal-energy-power-plants-working-advantages-disadvantages.html%3Ffbclid%3DIwAR0Kh61v9ksI_ENiqWm2CYj9VykDmHcLnPYwA35sBIlnvGdDnscXqjRzFTw&h=AT2JukABop8OZiS3G7kxggbROBNNDhuVi0JZDDBqT_lsR2WsuVO2y7Pg4jisKeC3NYlZwDdlxOdyE-jAuIFlYgiLTXYWw96ALsXaCQxCO3O60D7SE9OPNi3k8RKyGUFV1h4mBA

[4] Bashar, K., and Karim, M.R., 2001: Geochemical evaluation and source of thermal groundwater of Madhyapara granite mine, Dinajpur, Bangladesh. Bangladesh J. Geology, 20, 1-16.

[5] BOGMC, 1997: Petroleum exploration opportunities in Bangladesh. Bangladesh Oil, Gas and Mineral Corporation (Petrobangla), Dhaka.

[6] BPSD, 1988: Well resume, Salbanhat-1, geological report, part B. Bangladesh Shell Petroleum Development, Dhaka.

[7] D'Amore, F., and Panichi, C., 1980: Evaluation of deep temperatures in geothermal systems by a new gas geothermometer. Geochim. Cosmochim. Acta, 44, 549-556.

[8] Fournier, R.O., 1977: Chemical geothermometers and mixing model for geothermal systems. Geothermics, 5, 41-50.

[9] Giggenbach, W.F., 1991: Chemical techniques in geothermal exploration. In D‘Amore,F. (coordinator), Applications of geochemistry in geothermal reservoir development. UNITAR/UNDP publication, Rome, 119-142.

[10] GSB, 1990: Geological map of Bangladesh. Geological Survey of Bangladesh, Dhaka, Bangladesh.

[11] Guha, D.K., 1978: Tectonic framework and oil and gas prospects of Bangladesh. Proceedings of the 4th Annual Conference of the Bangladesh Geological Society, 65-75.

[12] Hayashi, Y., 1988: Fundamentals of corrosion. IGTCGE, textbook 29, Kyushu, Japan.

[13] Hossain, I., Tsunogae, T., Rajesh, H.M., Chen, B., and Arakawa, Y., 2007: Palaeoproterozoic U–Pb SHRIMP zircon age from basement rocks in Bangladesh: a possible remnant of Columbia supercontinent. Comptes Rendus Geosciences, 339, 979-986.

[14] Hunting Geology and Geophysics Ltd., 1981: Report of an aeromagnetic survey of Bangladesh. Petrobangla and Geological Survey of Bangladesh, report, 25 pp.

[15] Iler, R.K., 1979: The chemistry of silica-solubility, polymerization, colloid and surface properties, and biochemistry. John Wiley and Sons, Inc., NY, 866 pp.

[16] Ismail, M., and Shamsuddin, A.H.M., 1991: Organic matter maturity and its relation to time, temperature and depth in the Bengal Foredeep, Bangladesh. J. Southeast Asia Earth Sci., 5, 381-390.

[17] Kabir, S.M., 2008: Subsurface temperature and geothermal gradient in Bangladesh. Dhaka University, Department of Geology, MS thesis (unpubl.), roll no. CH 3202, (2003-4).

[18] Khan, M.R., and Muminullah, M., 1988: Stratigraphic lexicon of Bangladesh. Rec. Geol. Surv. Bangladesh 5-1, 70 pp.

[19] Petrobangla, 2011: Petrobangla achievements and roadmap. Bangladesh Oil, Gas and Mineral Corporation (Petrobangla), Power Division, Ministry of Power, Energy and Mineral Resources.

[20] Rahman, M., 2006: Geothermal potential resources in Thakurgaon district, northern Bangladesh. Bangladesh J. Geology, 25, 13-30.

[21] Reza, J.M., 1988: Hydrogeology of Maddhapara Hardrock mining area and environs in relation to mining geology. Dhaka University, Dhaka, MSc thesis (unpubl.).

[22] Sikder, A.M., and Alam, M.M., 2003: 2-D modelling of the anticlinal structures and structural development of the eastern fold belt of the Bengal Basin, Bangladesh. Sedimentary Geology, 155-3/4, 209-226.

[23] Tulinius, H., Thorbergsdóttir, I.M., Ádám, L., Zuzhin Hu Z., and Yu G., 2010: Geothermal evaluation in Hungary using integrated interpretation of well, seismic and MT data. Proceedings of the World Geothermal Congress 2010, Bali, Indonesia, 8 pp.

[24] Wardell Armstrong, 1991: Techno-economic feasibility study of Barapukuria coal project, Dinajpur, Bangladesh. Wardell Armstrong, internal report, v.1-12, Dhaka.

[25] Zaher, M.A., and Rahman, A., 1980: Prospects and investigations for minerals in the northwestern part of Bangladesh. Petroleum and Mineral Resources of Bangladesh, Seminar and Exhibition, Dhaka, 9-18.

[26] https://www.power-eng.com/2011/03/07/anglo-mgh-energy-plans/#gref

[27] https://asian-power.com/project/news/bangladeshs-first-geothermal-plant-now-in-works

[28] http://www.thinkgeoenergy.com/private-company-exploring-200mw-project-in-bangladesh/

[29] https://www.power-eng.com/2011/03/07/anglo-mgh-energy-plans/

[30] https://renewablesnow.com/news/anglo-mgh-energy-proposes-200-mw-geothermal-plant-in-bangladesh-report-16939/

[31] https://www.sciencedirect.com/science/article/pii/S1876610219313104

[32] http://article.sapub.org/10.5923.j.ep.20180801.01.html

[33] https://www.worldfuturecouncil.org/100-renewable-energy-bangladesh/

[34] https://www.sciencedirect.com/science/article/pii/S1876610219313104

[35] https://www.thedailystar.net/development-of-renewable-energy-in-bangladesh-49670