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# DRILLING TECHNOLOGY SYSTEM: A WIN-WIN SOLUTION FOR JUST TRANSITION, LEAPFROG AND INTERNATIONAL PARTNERSHIP: CASE STUDY OF BANGLADESH

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**ABSTRACT**
IPCC special report on Global Warming of 1.5°C presents the assessment based on available scientific literature that accelerated deep decarbonization is at the core of global mitigation strategy consistent with 1.5°C warming compared to pre-industrial level. The same report also presents the high agreement and robust evidence of risks evaluated by the scientific community in faster and deeper mitigation strategies through possible threats to multiple social and economic dimensions of sustainable development for countries with high dependency on fossil fuels for revenue, economic development and employment generation. The same concerns are coming from literature on just transition which are representing voices around possible job loss, loss of investment flow despite new resource identification, high risks of stranded assets, lower revenue earning with fluctuating oil and gas prices, dwindling resources. Another set of literature on policy instruments talk of need for diversification of economy and energy sector to ease these adverse consequences of transition and need for creating enabling conditions. The diversification discourse is mostly dominated by focus on new investment opportunities limited to wind and solar energy sectors. Also, the countries at risk discussion get dominated by GCC (Gulf Countries Council) countries. All these discourses ignore multiple challenges and realities in many small but fast emerging developing country perspectives. So, the research question for this paper is how can accelerated global transition address the 'trio': 'just, sustainable and peaceful transition' through cooperation for oil and gas dependent developing countries and what is the potential for leapfrog.

We refer this 'trio' with reference to oil and gas based fossil fuel energy systems which is caught up in a complex combination of problems due to likely uncertainty and redundancy of human resource currently engaged in the sector, stranded asset due to prospective early retirement of infrastructure and projected reduction in investment and need for finding substitute of fossil based energy carrier to cleaner, renewable energy carrier. Our hypothesis is that for Bangladesh endowed with gas resources and drilling infrastructure one of the transition path can be through geothermal energy system. The policy can encompass objectives of scaling up contributions of renewable energy to electricity production, promoting appropriate, efficient and environment friendly use of renewable energy and promoting clean energy as the country is facing risk of natural gas depletion. However, currently policies make no reference to geothermal potential as a part of the solution. So this study will make a novel and unique contribution in the subject and discourse.

**Keywords:** Geothermal energy, Just Energy transition, Bangladesh, Sustainable transition, Peaceful transition, Stranded asset

## 1. INTRODUCTION

In 2015 world has achieved consensus in the declaration of few global agenda. Interestingly wide variety of scientific efforts started at various contexts, levels and scale to give shape to these agenda in reality. This article sits in the intersection of two such agenda. First one is the adoption of Paris Agreement at the COP21 and the other is adoption of Sustainable Development Goals (SDG) framework. Three years later in 2018 IPCC special report (IPCC 2018) [14] on Global Warming of 1.5°C presents the assessment based on available scientific literature that, accelerated deep decarbonization is at the core of mitigation strategy consistent with 1.5°C warming compared to pre-industrial level. The same report also presents the high agreement and robust evidence of risks evaluated by the scientific community in faster and deeper mitigation strategies through possible threats to multiple social and economic dimensions of sustainable development for countries currently having high dependency on fossil fuels for income generation, national income contribution, economic development and generation of employment. The same concerns are coming from literature on just transition which are representing voices around possible job loss, loss of investment flow despite new resource identification, high risks of stranded assets, lower revenue earning with fluctuating oil and gas prices, dwindling resources. Another set of literature on policy instruments talk of need for diversification of economy and energy sector to ease these adverse consequences of transition and need for creating enabling conditions. The diversification discourse is mostly dominated by focus on new investment opportunities limited to wind and solar energy sectors. Also, the countries at risk discussion get dominated by GCC (Gulf Countries Council) countries. All these discourses ignores multiple challenges and realities in many small but fast emerging developing countries' perspectives. Our example is Bangladesh which is growing at more than 7% and is aiming for developed country status before middle of the century.

So, the research question for this paper is how can accelerated global transition address the 'trio': just, sustainable and peaceful transition through international cooperation Sustainable developmental goal (SDG 17) for oil and gas dependent developing countries and what is the potential for leapfrog. So, this study presents the basic hypothesis within an analytical frame in section 2. Section 3 presents the current and future challenges for sustainability of Bangladesh energy sector. Section 4 presents how technologically geothermal can use gas/oil infrastructure and how is it happening in other countries to justify technical feasibility globally. What is the resource potential global/for some countries. Where is the technology in terms of commercialization/demonstration scale, will make a novel and unique contribution in the subject and discourse.

## 2. ANALYTICAL FRAMEWORK

This is mostly a sustainable development narrative based on review of past efforts within Bangladesh and in other country context and raises future research questions. We argue that to be consistent with 'trio' (sustainable, just and peaceful transition through international cooperation) solution space need to be broader than solar and wind for energy sector to be guided by national circumstances and international cooperation. IPCC special report also talks about benefits of portfolio approach in mitigation options and technology and strategy selection. Multiple technologies, policies and subsystem transitions need to be searched for instead of one size fits all kind of solution. Solar and wind can also be part of the solution but need not be the only solutions if 'trio' of complex challenge is to be addressed. We refer this 'trio' with reference to oil and gas based fossil fuel energy systems, which is caught up in a complex combination of problems due to likely uncertainty and redundancy of human resource currently engaged in the sector, stranded asset due to prospective early retirement of infrastructure and projected reduction in investment and need for finding substitute of fossil based energy carrier to cleaner, renewable energy carrier (Roy et. al. 2018) [15].

Our premise is energy system transition needs to be guided and requires large scale investment and long period of time with long term developmental goal. So, any transition plan need early action to start conceptualising innovation plan, piloting the same to understand feasibility and challenges to overcome them gradually in a demonstration project. Commercialisation stage takes much more challenges as enablers need to be in place to guarantee commercial success, such as: policy, finance, human resource with new skill and public acceptance. History of energy system transition has seen many failures, slow down, trapped in valley of death in innovation chain in the absence of systems approach and enablers.

We hypothesize that for countries like Bangladesh currently endowed with oil and gas resources and with high domestic human skill existing for drilling with appropriate infrastructure one of the important transition path can be the geothermal energy resource based system. Geothermal energy resource base system can use the drilling infrastructure, wells, human skill and help in leapfrog in renewable energy path with strategic international partners.

The Government of Bangladesh adopted the Renewable Energy Policy in 2008 and subsequent Power sector master plan in 2010 and 2016 have objectives of developing renewable energy resources to harness the existing potential and adoption of the renewable energy technologies where ever possible. The policy also aims at scaling up renewable energy share in electricity generation as the country is depleting natural gas however, currently makes no reference to geothermal in renewable energy potential portfolio as a part of the solution.

## 3. BANGLADESH ENERGY SECTOR: CURRENT AND FUTURE CHALLENGES

Bangladesh economy is growing currently with 7.86% annual growth in GDP with per capita income moving up to USD 1751 in 2017-18 from USD 843 in year 2009-10 (BSS, 2018; BSS, 2018). Success story of Bangladesh is unique. Studies show that, the larger part of this economic transformation has been supported by the growth of the power sector, social changes, especially women empowerment, girls' education, children's health improvements (life expectancy is now 72years), population growth reduction, NGO participation in development sector and microcredit program stimulating social interactions and involvement of rural women in economic activity (Basu, 2018; [16] Mahmud, Asadullah, & Savoia, 2013[17]). Now maintaining and advancing this decade long remarkable success in a sustainable and equitable manner is an opportunity as well as challenge and the focus should be given to the removal of the bottlenecks in infrastructure and urbanization and challenges in energy sector, and response to climate change.

In Bangladesh power installed capacity is around 20 GW, but actual generation is less than 12 GW, which falls short of current demand. The government projects demand to reach at least 52 GW by 2041. World Bank surveys indicate outages are major obstacle, with businesses experiencing several hours of outages per day. Bangladesh is overwhelmingly reliant on heavily-subsidized domestic sources of natural gas (61% of total generation). Lack of reliability and intermittency of grid supply is another major obstacle for development in Bangladesh. Domestic gas reserves are slowly being depleted, which means imports of much more expensive LNG will be needed, requiring either significant new subsidies or price increases. The majority of new power supplies coming online include coal, imported LNG, nuclear, and regional trading. Due to seasonal water flows and limited land area, conventional renewables are not seen as a primary contributor. Gas production is still government-controlled. Bangladesh intends to import power from India, Bhutan, Nepal, and Thailand (via Myanmar). Progress on this front is already underway: Bangladesh is doubling the capacity of its interconnection with India to 1 GW, and the government has begun exploring with neighbors' potential co-investments in hydroelectric power plants. But these are not going to be sufficient for securing energy supply going forward. So, search for new energy sources which can provide long term sustainable source and security of supply are the major criteria for Bangladesh energy sector.

## 4. GEOTHERMAL DRILLING TECHNOLOGY: OPPORTUNITIES AND CHALLENGES

This section deals with the geothermal energy technology and presents how technologically geothermal can use existing gas/oil infrastructure and how is it happening in other countries to justify technical feasibility globally. What is the resource potential global /for some countries. Where is the technology in terms of commercialization/ demonstration scale.

The share of intermittent renewable energy from solar and wind has increased rapidly in the grid during the last decades. Technology development, cost reduction and supportive policy decisions have made this transition possible. However, the issue of intermittency of the renewable power already cause difficulties for grid stability and grid control. Different from solar and wind, the geothermal energy is dispatchable and therefore, it could be a strong contributor to full transition to decarbonized energy system by supporting the grid thanks to its dispatchability.

Geothermal energy has been utilized for heat and power generation for many years, but its share of total global energy generation is marginal. The main reason for the limited utilization of geothermal energy has been the high cost of installation of such plants, where the drilling and well construction stands for the major part of the total investment. Therefore, reducing the drilling and well construction costs for geothermal installations have been discussed for years, without a major breakthrough.

Utilization of exploration wells and depleted oil and gas wells for generation of geothermal heat and power has gained attention recently, since this would result in reduced cost of installation of geothermal plants. There are some obvious advantages with reusing the existing wells, such as reduced cost, but there are also challenges related to use of depleted wells for geothermal production, which need to be understood and handled accordingly to enhance growth of this dispatchable renewable energy source.

There has been several studies reported by researchers over the globe where the potential of geothermal energy generation from depleted wells have been investigated experimentally and theoretically [1-13]. These studies have demonstrated the potential as well as the readiness level of the technologies needed for utilization of geothermal energy from depleted wells. To better understand the possibilities and challenges of reusing the existing depleted wells, the readers need to have a general understanding of the physical well construction and the legislative framework concerning ownership, use and finally plug and abandonment (P&A) of the wells. The following section is aimed at sorting out various factors impacting the energy generation potential from depleted wells (technical, economic, legislation) to illuminate some of the opportunities and the challenges:

- From an energy generation point of view, the main parameters impacting the energy generation capacity of the wells are the available temperature and the flow rate of the working fluid at the well head (at the surface). Higher flowrate means higher energy generation capacity, which requires wells with large diameters. However, keeping the diameter large to the target depth would result in very high cost of drilling and well construction. It could be mentioned here that the wells drilled for oil and gas production are usually ending with a diameters between four and seven inches at the final section of the well, which is not exactly the optimum size from the geothermal energy generation point of view.
- From the remaining lifetime and well integrity aspect, one need to understand the construction of the petroleum wells, which at each section and depth is presented by the following layers from outside in; the formation, the cement layer and the casing (steel piping inside the well). Utilizing existing wells for geothermal energy production requires sufficient remaining lifetime of the well, which motivates additional investments in geothermal energy. The well casing might have been exposed to erosion and corrosion at different sections of the well, which will limit the useful remaining life of the well. The quality of cementing job and the condition of the cement in place are also important factors for the remaining lifetime of the well. An important step in utilization of the existing wells for geothermal production is assessment and qualification of the wells for geothermal production. Programs for systematic analysis and evaluation of the existing wells, as well as identification of measures that provides safe and secure operation of the geothermal plants will be necessary for an affordable and large scale utilization of existing wells for geothermal energy production.
- From a legislation point of view, one should consider the responsibility for plugging and abandonment of the wells (P&A), since P&A stands for considerable capital costs followed by the long-term responsibility associated with well monitoring. When the allowances for exploration and production of petroleum is given to a company, the P&A responsibility for the wells is also given to the petroleum producing company. Thereby, the petroleum company is responsible for closing and monitoring of the wells so that no unexpected events take place even after the P&A. However, if another company/organization would take over the depleted wells for geothermal energy generation the issue related to P&A will assume a new dimension. It might become a problem if the petroleum company is not ready to accept the responsibility for P&A after the years of geothermal production. Therefore, one of the major showstoppers for using existing wells for geothermal energy production in some countries are around the P&A and the responsibility issues related to it. However, they need deeper and newer attention as challenges are new.
- There are plenty of depleted and exploration wells over the globe, but the legal and economic issues for the abandoned wells need to revised in new paradigm of sustainable development and climate action to enable geothermal production from these wells. The rules and regulations concerning wells to will be operated by more than one company/organization in not clear today. Therefore, there is a need for clarification of technical, economic, legal responsibilities for the involved companies when

using existing wells for geothermal energy generation and social and political issues for the country under consideration.

The use of existing infrastructure for transport of equipment and distribution of the energy from the wells is a major advantage of the existing wells, which further reduces the total cost of the geothermal energy from abandoned wells. Several pilot studies have been carried out in various countries to evaluate the energy generation potential of the depleted wells. The results show that between 3 and 5 MW electricity can be produced from one depleted and sealed well with electrical efficiencies of about 10-15%, when using double pipe heat exchanger (coaxial tubing in the well with injection between existing well and outer pipe and production from the inner pipe with sufficient isolation between the inner and outer pipes). However, the amount of energy generated and the cost of it will be different depending on location, depth and other circumstances. Beside heat and power, which has been in focus for energy generation, there are also examples where the geothermal heat has been utilized for poly-generation with several useful products as outcome (e.g. desalinated water, etc.) [12, 13]. The economic viability of the geothermal energy needs to be investigated for different markets and locations before the optimal solution can be selected.

Assuming electrical efficiency between 10 and 20%, a temperature difference of 30 to 60°C between inlet and outlet, and a mass flowrate of 10 to 60 kg/s, one can estimate the power output [kW], using water as working fluid (see figure 1 and 2). For more detailed mathematical calculations, the readers are referred to the publications in the reference list.

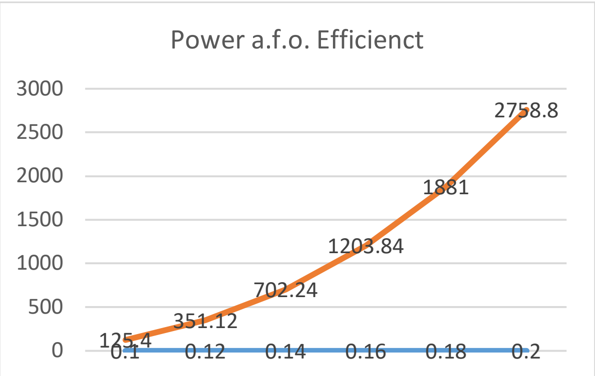


Fig 1 : Power output as function of electrical efficiency

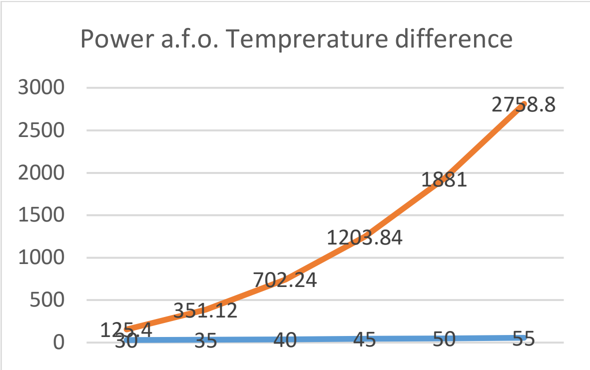


Fig 2 : Power output as function of temperature difference

## 5. GEOTHERMAL EXPLORATION STATUS IN BANGLADESH

Several studies [18-32] (Das, 2017; Guha, Henkel, & Imam, 2010; Akbar, 2011; Masum, 2015; Khan, Ahmed, Parvez, & Hossain, 2015; Monne, 2015) identify the prospects of geothermal energy and concluded that there are several potential site for the geothermal energy extraction in Bangladesh but more detailed systematic studies including detailed calculation of geothermal energy generation potential with feasibility assessment are necessary to fully explore the geothermal potential in this area. Although, Geological survey of Bangladesh drilled an exploratory well for geothermal resource at Thakurgaon districts in 2011 and the recorded normal temperature gradient was 44.75◦ C at a depth of 560 m (Masum, 2015). In 2011, a private company, Anglo MGH Energy, was declared to build the first geothermal plant in Thakurgaon district with a capacity of 200 MW (Power Engineering, 2011), but the project did not commence finally.

### *5.1 Potential Geothermal Area In Bangladesh*

Based on the geo-tectonic setup, the potential area for geothermal energy is divided into two different sections: (1) Northwest shield area (2) southeast deep sedimentary basin (Akbar, 2011). The northwest area has an average temperature gradient of 30 °C /km, whereas the southeast deep sedimentary area is 20 oC /km (Rahman, 2006). Tectonically, northwest shield area is subdivided as (a) Sub-Himalayan Foredeep (b) Rangpur Saddle (c) Bogra shelf and the southeast deep sedimentary basin is subdivided as (a) Deep Sedimentary Basin (b) folted belt (Guha, Henkel, & Imam, 2010).

The southern part of Bangladesh lies on Sub-Himalayan foredeep area. The average thermal gradient is only 22.5 ◦ C. One well (Salbanhat-1) was drilled in

Tetulia and obtained 79 ◦ C at a depth of 2500m (Guha, Henkel, & Imam, 2010) and projected 110 ◦ C at a depth of 4000 m (Masum, 2015).

Concerning the Rangpur Saddle area, currently hard rock has been collected from Madhyapara and coal from Barapukuria. High temperature was detected at these coal bearing zone and hard rock structure. Below the coal seams of Barapukuria mine, there is a sandstone called Gondwana sandstone where 50 ◦ C was observed at a depth of 400 m. The coal seams works as an insulator for increasing the temperature of the basement. Besides, in this area, warm water with a temperature of 36 ◦ C was observed in irrigation wells at a depth of 80 m at Thakurgaon (Guha, Henkel, & Imam, 2010). In coal mine temperature obtained was 50◦ C at 400 m, 40.5◦ C at 380m, 52◦ C @440m. The author conclude that if a well is drilled in this area, there might have a chance to get enough temperature for electricity production at a depth (Might be dipper). As hard rock and coal mine are in the same geological structure then there might be a need for fracturing to penetrate into the low permeability region. (Guha, Henkel, & Imam, 2010)

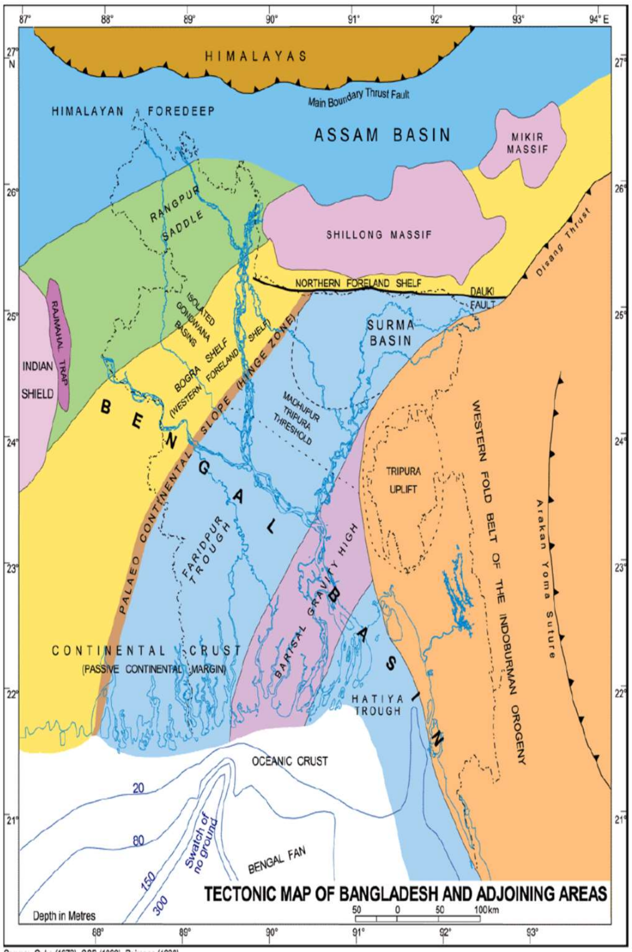


Fig 3 : Tectonic Map of Bangladesh
Source: (Guha D., 1978)

Bogra Shelf is the transition zone of Rangpur saddle and Bengle foredeep. Magnetic and seismic survey of these zones were done by Stanvac Oil Company in the mid-fifties. Four deep wells have been drilled in this area (Singra, Kuchma and Bogra). Similar temperature gradient at a value of 35 ◦C /km were obtained in these three wells. For the most promising one, Singra-1, temperature higher than 150 ◦C was recorded at the bottom of the well. Thus, the deep wells at Singra, Kuchma and bogra have high potential for geothermal energy generation (Guha, Henkel, & Imam, 2010; Masum, 2015).

Deep Sedimentary Basin consist of the area between hinge line tending SSW-NNE from Sylhet-Mymensing-Pabna and Arakan Yoma Folded System called Bengal Foredeep region. The area has several troughs and highs namely Faridpur Trough, Hatiya Trough, Sylhet Trough, Modhupur high (Guha D. , 1978). In the Hatiya trough, shahbajpur 1, well has a significant temperature gradient of 29.5◦C/km that might be a potential location for geothermal energy extraction (Das, 2017). But, cool sediments are continuously loaded in this deep sedimentary basin and very low hermal gradient (average 20K/km) was observed. Thus, although there are some deep abandoned wells, the area has limited potential for electricity production (Guha, Henkel, & Imam, 2010; Akbar, 2011).

The most prominent tectonic element, parallel to Arakan Yoma Fold, is the folted belt. The western part of the folted belt is the most prospective Oil and gas area of Bangladesh with 12 gas fields. Several hot springs was observed in Sitakund anticline structure at Barapkundo and gobindachara with a temperature gradient of 35 k/km. Besides, wells at Bakhrabad and Saldanadi have the thermal gradient of 30 ◦C/km and 27.2 ◦C/km respectively (Guha, Henkel, & Imam, 2010; Masum, 2015). As there are many high depth, dry and abandoned

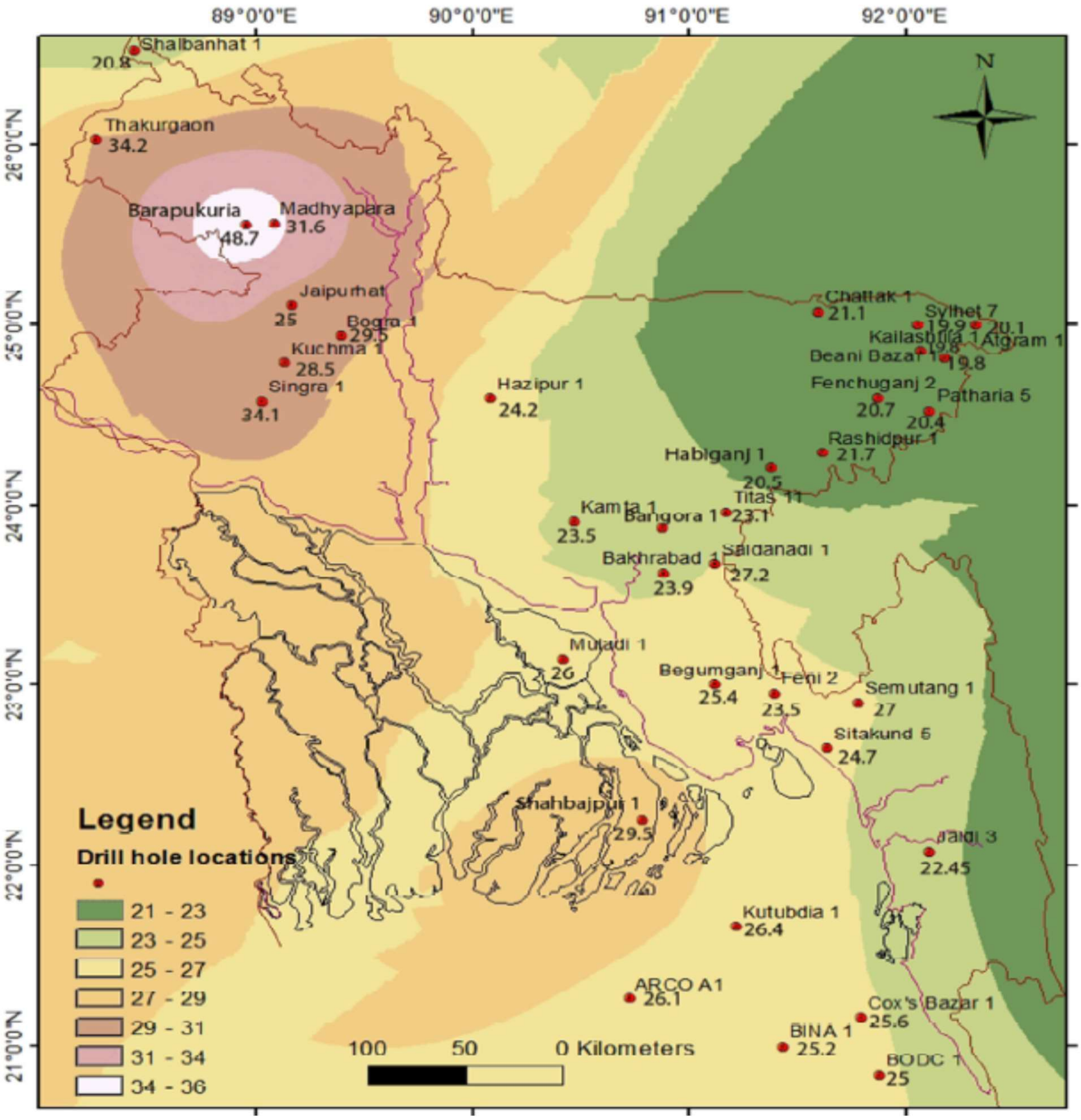


Fig 4 : Well wise temperature gradient of Bangladesh, Source: (Akbar, 2011).

wells available in this area with significant thermal gradient, these could be prospective geothermal energy source.

### *5.2 Thermal Gradient of Deep Exploratory Wells*

In order to explore and develop oil and gas reserves, a number of wells were drilled over the years in the in the eastern part of Bangladesh. These wells with the measured subsurface temperature are also available (SAARC Energy Center, 2011; Hossain, 2009; Akbar, 2011). The drilling depth of these wells ranges from 2100m to 4977m. Using the temperature data, a thermal gradient map of Bangladesh was developed as shown in figure 2.The most prominent zone for geothermal energy was obtained at Singra 1 well location in northwest shield area with more than 150 °C bottom hole temperature. Whereas, in the Southeast deep sedimentary basin area, potential thermal gradient was obtained at Shahbajpur 1 well at a rate of 29.5°C/km located in Hatiya trough followed by Saldanadi 1 well at a rate of 27.2°C/km.

## 6. SCOPE FOR GLOBAL COOPERATION AND CONCLUDING REMARKS

Norway is a petroleum producing country with considerable export of oil and gas to Europe. The mature petroleum fields on the Norwegian continental shelf are reaching the end of their economic lifetime in the North Sea and will soon be subject to P&A. Utilizing the depleted fields for energy generation and energy storage have been reviewed carefully in Norway lately and there are certain opportunities identified for reuse of the existing wells. However, the Norwegian petroleum fields are mostly at deep water area and thereby the costs related to reuse of the existing wells might be considerably higher than e.g. for the countries where all or a majority of the wells are drilled onshore. In comparison, Bangladesh used domestically the drilling activity and gas withdrawal for early phase of economic development of the economy. This is still acting as a major source of energy for the country's economic development. But as the country grows towards targeted middle income by 2021 and by 2041 towards high income status as envisaged by political leaders of the country, new innovation is getting into the developmental action agenda very fast. Moreover, our observation is that Bangladesh with all on shore wells have scope for exploring the possibility of geothermal technology rather easily compared to Norway. Norway has been very successful concerning development of petroleum exploration and production technologies. Therefore, the accumulated Norwegian knowledge, supported by the modern and state of the art technologies available could enhance further utilization of the existing depleted wells for energy generation in Bangladesh. This will not only alleviate the uncertainty arising from depleting gas reserves and employment of the skilled manpower but will also help in leapfrogging the renewable energy ladder beyond conventional solar and wind technologies which have already limited expansion possibility given the expected growth of demand of electricity in Bangladesh and scarcity of land mass. Therefore, a careful socio-technical and economic-environmental assessment would be required to evaluate the energy production and storage capability, by reusing existing wells. Since gas sector is still government controlled it may be easier for Bangladesh to overcome well ownership and closer deal for used up wells. If we follow the various criteria for successful transition [18] then political, social, environmental feasibility indicators are compatible with geothermal energy pathway for Bangladesh. However, a demonstration stage pilot project for feasibility assessment in all it's dimension need an immediate global cooperation. Urgency of action match with urgency of global climate change mitigation response need (SDG 13). There is need for enhanced focus on geothermal energy generation and use strategically in Bangladesh in it's fast economic growth phase (SDG 8) and need to be undertaken now to make a smooth and peaceful transition in the longer run (SDG 16). This will not only build a sustainable energy future for Bangladesh (SDG7)with justice in transition assured but will also act an energy sector development model for many developing economies with necessary global partnership development (SDG 17) in innovation (SDG 9) and knowledge transfer.


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