

## PAPER 15 – REVIEW of Geothermal Electricity Generation and its Environmental Impacts in Nigeria

F.U Ilo

Department of Electrical and Electronic Engineering, Enugu State University of Science and Technology  
Email: ude.ilo@esut.edu.ng

### **ABSTRACT**

This paper discusses the technologies involved in generating electricity through geothermal energy and its environmental impacts. The inability of the federal government of Nigeria to maintain steady power supply for the populace has necessitated the need to research into alternative sources of power supply. The focus of this work is on geothermal energy as one of the renewable energy source. In this work, the technology of geothermal was analyzed. The details of how electricity can be generated from geothermal technology were explained. A review of recent previous works by others researchers and the major components of geothermal energy system were discussed. Effort was made in this report to discuss the classifications of geothermal energy and the merits of using geothermal energy as source for electricity generation. The environmental impacts of using geothermal technology to generate electricity were also highlighted. The geological features and subsurface temperature data of oil and shallow water wells from both Northern and Southern part of this country shows the possible presence of geothermal energy due to the thermal gradient. If tapped, this will serve as alternative energy, as being utilized by several other countries since it can produce base load electricity which is reliable and sustainable unlike many other renewable energy sources that are affected by weather and seasonal variations.

**KEYWORDS:** geothermal energy, renewable energy, electricity generation, alternative energy and environmental impacts

### **1. INTRODUCTION**

This study focuses on technologies of geothermal electricity generation and its environmental impacts in Nigeria. Geothermal energy refers to the production of energy using the internal heat of the earth's crust. This heat comes from the radioactive decay of minerals and continual heat loss from the earth's original formation. Nigeria is blessed with many abundant natural mineral resources such as gypsum, iron ore, gold, bitumen, coal, among others. All the natural minerals resources are as a result of the decayed plants and animal residues. The epileptic electricity power supply has become a fundamental issue affecting the economic development of Nigeria. Geothermal energy, which results from the radioactive decay of minerals within the Earth's core and solar energy systems have been discovered and utilized by several countries. Nigeria is still far behind in tapping the abundance of geothermal energy resources (Dorcas, et al. 2016). Figure 1 show the geological setting and location of the major structural units in Nigeria where geothermal energy can be utilized. Classification systems used for classifying geothermal resources are based mainly on their temperatures, geologic settings and intrinsic properties of reservoirs. This work treats geothermal energy resources as renewable, alternative and sustainable energy resources with capabilities of generating electricity and heat for direct use applications and commercial purposes. The earth possesses vast underground stores of energy supply in form of heat, whose potentials are yet to be fully realized. The earth is divided into shells; the crust, the mantle and the core. Its interiors where this heat energy occurs, reach temperatures greater than 4,000°C. The heat generated and stored in the earth is known as geothermal energy. Geothermal energy is generated from the earth's core, almost 6,400km beneath the earth's surface. The double-layered core is made up of hot melted rock (magma) surrounding a solid iron center. Very high temperatures are continuously produced inside the earth by the slow decay of radioactive materials, a natural process in all rocks. Surrounding the outer core is the mantle, which is about 2,900km thick and made up of magma and rock (Colin, et al. 2011). The outermost layer of the earth, the land forming the continents and ocean floors, is called the crust. The crust is not a solid plate; it is divided or broken into pieces called plates. Magma from deep within the earth gets to the earth's surface through openings at the edges of these plates and volcanic processes are very common at these edges. Deep underground, rocks and water trapped in the earth absorb heat from this magma.

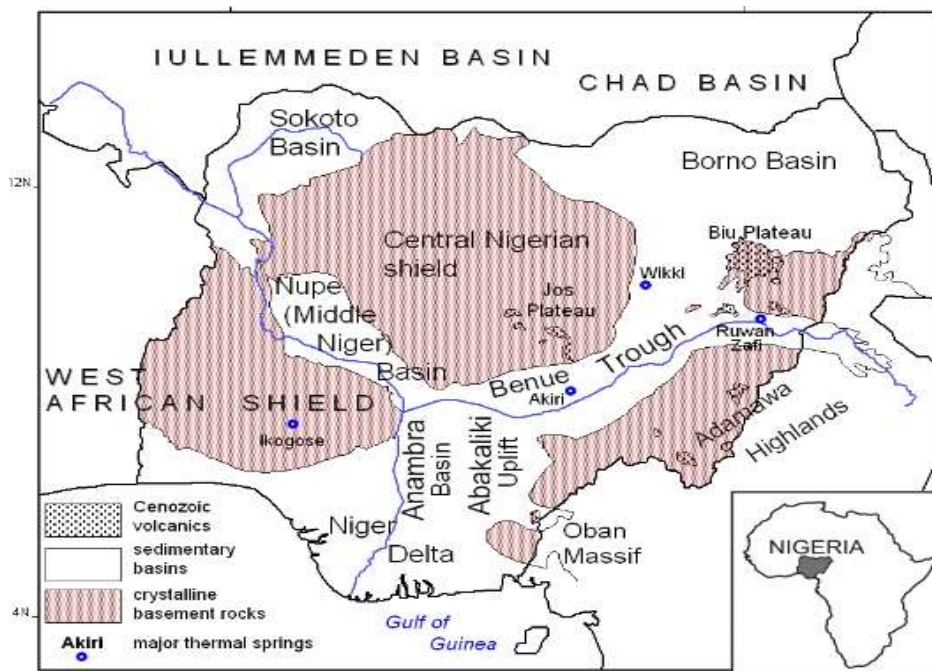


Figure 1: Geological setting and location of the major structural units in Nigeria. Source: (Kurowska, E, and Schoeneich, K , 2010)

## 2. REVIEW OF PREVIOUS WORKS

Geothermal resources are created and put away in the earth (Garba, et al., 2022). This review focuses on the geothermal energy investigations in Nigeria with focus on researches that have been conducted so far, their outcome, challenges and the future through the geo-scientific oculus. The author made effort to cover notable geo-scientific researches' from geological, geophysical and geochemical perspective, which also focused on geothermal electricity generation. This review is made to stimulate interest in geothermal energy in Nigeria and also invigorate the geo-scientific community toward extensive research in the field. This review should eventually lead to understanding of the technologies involved during conversion of geothermal energy into electricity. A warm spring location in Nigeria that has received geophysical examination is the Wikki Warm Spring (WWS) located in Bauchi State, northeastern Nigeria. Preliminary geophysical investigation of the source of heat of the WWS was conducted by Omanga, (1998). He used the electrical resistivity, radiometric methods and gamma ray spectrometry around the WWS area. The ultimate aim was to investigate the source of heat at the WWS region. Within the WWS, fourteen (14) sounding were conducted using vertical electrical sounding (VES) method and measurements of the concentrations of radioactive elements such as uranium (U), thorium (Th) and an isotope of potassium (K) in the area were estimated. The resistivity results showed that low resistivity values exist around the WWS area while the radiometric survey measurements revealed high gamma activity in that region. This high radioactivity in the area is an indication of the importance of radiogenic heat activities within the WWS area and a pointer to the heat source probably due to radioactivity. So far, there is probably the only one (direct) geothermal energy utilization site in Nigeria, a swimming pool where water from Ikogosi warm spring (37°C) is used. It is located in south-western part of the country, in Ekiti State. Other possible sources of geothermal energy in Nigeria are Kerang Springs in Plateau State, Rafin Rewa Warm Spring in Jos Plateau, Nike Lake in Enugu state and Wikki Warm Springs in Abuja Nigeria.

Steps needed to generate electricity from geothermal energy

If you dig a big hole straight down into the Earth, you would notice that temperature increases as the dept increases. That is because the inside of the Earth is full of heat (Kurowska and Schoeneich, 2017). That heat is called geothermal energy. Below are steps of generating electricity from the geothermal energy

- a) Hot water is pumped from deep underground through a well under high pressure,
- b) when the water reaches the surface, the pressure is dropped, which causes the water to turn into steam,

- c) the steam spins a turbine, which is connected to a generator that produces electricity,
- d) the steam cools off in a cooling tower and condenses back to water and
- e) the cooled water is pumped back into the Earth to begin the process again.

#### Component of Geothermal Energy System

The major components of geothermal energy system are the:

- a) Heat source
- b) Reservoir and
- c) Carrier (fluid)

### 3. MATERIALS AND METHODS

Materials and Devices used:

Methods Adopted:

The methods adopted for the realization of this work are descriptive and analytical techniques. The technique enables the author to give a clear description of the technology of geothermal and also do analysis on environmental impacts in Nigeria.

#### Technologies of Geothermal Electricity Generation

Geothermal power plants draw fluids from underground reservoirs to the surface to produce steam. This steam then drives turbines that generate electricity. There are three main types of geothermal power plant technologies namely: dry steam, flash steam, and binary cycle.

#### Dry Steam Power Plant

This type of power plants uses hydrothermal fluids that are mostly steam and which is relatively natural occurrence. The steam is drawn directly to a turbine, which drives a generator that produces electricity. After the steam condenses, it is frequently re-injected into the reservoir. Figure 2 is a diagram showing the processes involved in dry steam power plant.

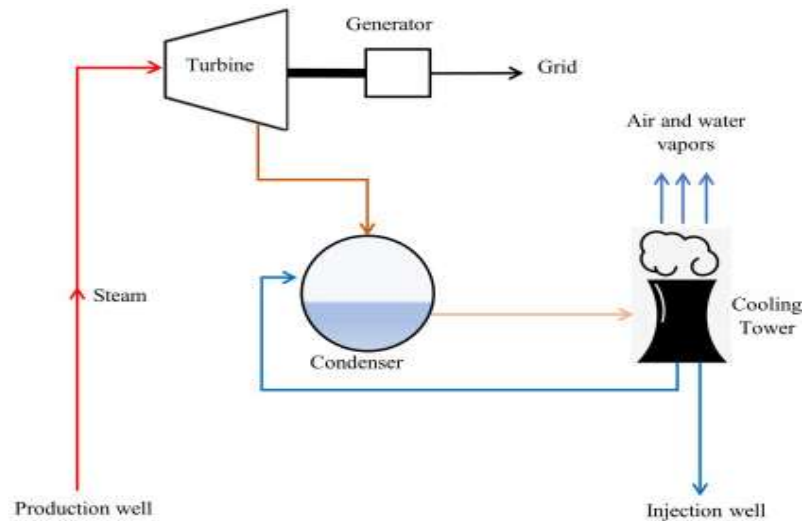


Figure 2: dry steam power plant. (Kurowska, and Schoeneich, 2017)

Since steam is directly used to run a steam turbine, it eliminates the need for burning of coal or other fossil fuels to generate electricity. Figure 2 shows a schematic diagram of a dry steam power plant. When the steam cools, it condenses to water and is injected back into the ground to be used again.

### Flash Steam Power Plant

Flash steam plants take high-pressure hot water from deep inside the earth and convert it to steam that drives generator turbines. When the steam cools, it condenses to water and is injected back into the ground to be used again. Single flash power plants are usually considered as the most economical alternative for available geothermal resources temperature above 190 °C. Higher temperature resources will produce more liquid and steam for natural pressure conditions. Figure 3 is a typical example of flash steam power plant. It illustrates the stages of flash steam power plant from production well to Load.

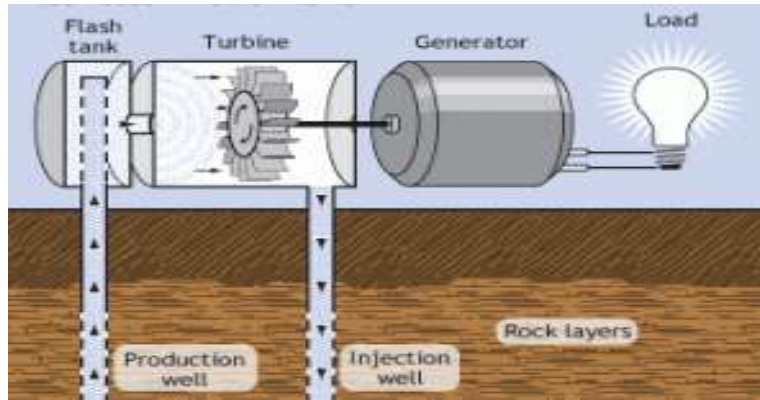


Figure 3: flash steam power plant. (Kurowska, and Schoeneich, 2017).

### Binary-Cycle Power Plant

Binary cycle plants use the heat from the hot water to boil a working fluid, usually an organic compound with a low boiling point. The working fluid is vaporized in a heat exchanger and used to turn a turbine. The water is then injected back into the ground to be reheated. In this first unit, the organic Rankine cycle was used to generate electricity using Iso-pentane as a working fluid. Figure 4 is a sketch showing step by step processes involved in binary cycle power plant.

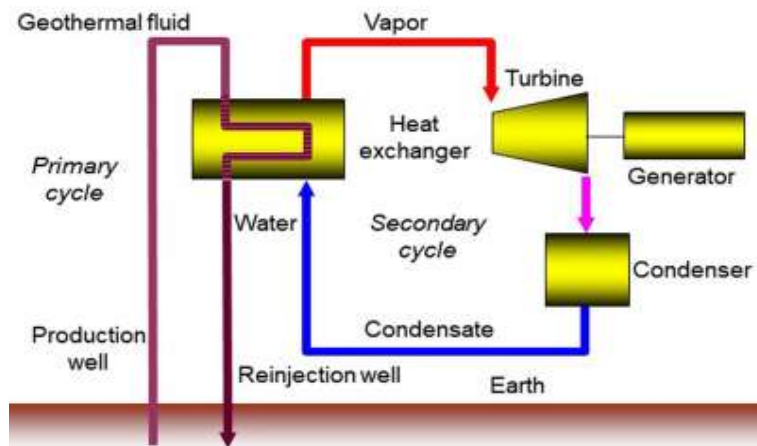


Figure 4: binary cycle power plant. (Kagel, 2007)

Environmental impacts of using geothermal technology to generate electricity in Nigeria

The environmental impacts of electricity generation using geothermal as it affect Nigeria were discussed. The three major affected areas are water quality, air pollution and land use. The environmental effects of geothermal energy depend on how geothermal energy is used or how it is converted to useful energy. There are positive and negative effects of using geothermal technology in generating electricity.

#### Positive effects

1. Reduced energy costs: Geothermal energy systems provide consistent and stable energy at lower costs, leading to significant savings for consumers.
2. Job creation: Geothermal energy installation and maintenance requires skilled labor, creating job opportunities for locals and boosting the economy.
3. Increased tax revenue: Geothermal energy projects generate tax revenue for the government, leading to an increase in funds available for public services and infrastructure development.
4. Improved energy security: Geothermal energy is a local and indigenous source of energy, reducing reliance on foreign sources and promoting energy security.
5. Reduced greenhouse gas emissions: Geothermal energy produces almost no emissions, leading to a reduction in air pollution and greenhouse gas emissions.
6. Increased electricity reliability: Geothermal energy systems are highly reliable, providing consistent and stable electricity supply with minimal disruptions.
7. Potential for export: Nigeria has significant geothermal energy potential, providing opportunities for exporting excess electricity to neighboring countries.
8. Increased tourism: Geothermal energy installations can attract tourists and visitors to the region, boosting the local economy and creating additional job opportunities.
9. Improved public health: Reduced air pollution from geothermal energy can lead to improved public health outcomes, including reduced respiratory illnesses and related healthcare costs.
10. Increased property values: Properties with geothermal energy systems have higher resale values, leading to increased property tax revenue for local governments.

#### Negative Effect

##### Water quality and use

Geothermal power plants have impacts on both water quality and consumption. Hot water pumped from underground reservoirs often contain high levels of sulfur, salt, and other minerals. So it is not the best for consumption.

##### Air emissions

The distinction between open- and closed-loop systems is important with respect to air emissions. In closed-loop systems, gases removed from the well are not exposed to the atmosphere and are injected back into the ground after giving up their heat, so air emissions are minimal. In contrast, open-loop systems emit hydrogen sulfide, carbon dioxide, ammonia, methane, and boron. Hydrogen sulfide, which has a distinctive “rotten egg” smell, is the most common emission (Kagel, 2007).

##### Land use

The amount of land required by a geothermal plant varies depending on the properties of the resource reservoir, the amount of power capacity, the type of energy conversion system, the type of cooling system, the arrangement of wells and piping systems, and the substation and auxiliary building needs (Kagel, 2008).

#### Merits of Geothermal Energy

The merits of geothermal energy are:

1. They are natural source.
2. Due to the near limitless ability of the earth to produce magma, and the continuous transfer of heat between subsurface rock and water, geothermal energy is considered a renewable resource (Rybach, 2007).

3. Geothermal energy produces base load electricity as it is available 24 hours a day, 365 days a year, unlike many other renewable energy resources that are affected by weather and seasonal variations.
4. They are cost effective
5. The energy source is reliable, sustainable, and environmentally friendly
6. Geothermal power has the potential to help mitigate global warming if widely deployed in place of fossil fuels.

## 1. CONCLUSION

The technologies of geothermal electricity generation were discussed. From the discussion, it is clear that, federal government of Nigeria should focus attention on geothermal electricity generation as an alternative power source. This is because of the benefits it has over the currently used conventional power sources. The environmental impact of geothermal electricity generation is almost zero. There is need to encourage Nigerian's to invest on geothermal electricity generation as alternative source for power generation

## REFERENCES

- Dorcas S. Eyinla, Michael A. Oladunjoye, Thompson H.T. Ogunribido and Olumuyiwa A. Odundun (2016). An Overview of Geothermal Energy Resources in Nigeria. *Environtropica – An International Journal of the Tropical Environment*. Pages61-71, ISSN 1597-815X
- Colin, F.W, Reed, J.R and Anderson A.F.,( 2011). Updating the Classification of Geothermal Resources. U.S Geological Survey (USGS), Menlo Park, CA 94025, Department ofEnergy, Geothermal Technologies Program Washington, DC.
- Garba M . L, Kurowska E, Schoeneich K and Abdullahi I (2022) Rafin rewa warm spring, a new geothermal discovery. *American International Journal of Contemporary Research* 2: 231-236.
- Omanga USA, (1998) Preliminary geophysical investigation of the source of heat of the wikki warm spring, Bauchi, Nigeria. A Thesis Submitted to the Department of Physics, Ahmadu Bello University, Zaria, in Partial Fulfilment for the Award of the Degree of Master of Science in Applied Geophysics, 1-93.
- Kurowska E and Schoeneich K, (2017) Geothermal exploration in Nigeria. *Proceedings of World Geothermal Congress, Indonesia*, 25-29.
- Kagel, A, (2007). *A Guide to Geothermal Energy and the Environment*. Washington, DC: Geothermal Energy Association.
- Kagel, A. (2008). *The State of Geothermal Technology. Part II: Surface Technology*. Washington, DC: Geothermal Energy Association.
- Rybach, L. (2007). "Geothermal Sustainability". *Proceedings European Geothermal Congress*, Unterhaching, Germany, 5 p.
- Kurowska E. and Schoeneich K. (2010). *Proceedings World Geothermal Congress 2010 Bali, Indonesia*, 25-29 April 2010.