

## Harnessing Earth's Energy: The Geothermal Marvel of Tiwi, Albay

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**Abstract:** This paper explores the potential and benefits of geothermal energy, focusing on the Geothermal Power Plant of Tiwi, Philippines. Geothermal energy is derived from the inner core of the Earth and from radioactive decay, and it is a reliable and clean source of electricity, particularly well-suited for a country like the Philippines. The paper discusses the Tiwi Geothermal Power Plant's history, its regional contributions, and recent developments, including a proposed 17-MW binary geothermal power plant.

Despite its success, the geothermal industry in the Philippines faces challenges such as a privatized energy sector, permitting processes, and a lack of investors. To address these challenges, collaboration between the government and industry stakeholders is crucial. Streamlining processes, offering incentives, and supporting research and development efforts can unlock the full potential of geothermal energy in the country.

It is suggested that more research be conducted in the field of geothermal energy, particularly by engineering students and professionals. Increased research can attract scientists and investors, leading to greater recognition and utilization of geothermal resources. Overall, investing in geothermal energy can contribute to a more sustainable and environmentally-friendly energy landscape in the Philippines, especially in rural areas like Tiwi.

**Key Words:** Geothermal energy; Tiwi Geothermal Power Plant; Mayon Volcano; renewable energy; research and development.

## I. INTRODUCTION

The earth's inner core is solid iron and it has a diameter of 1,500 miles, and the outer core of magma is 1,500 miles thick. As a result, the Earth's inner core's temperature is around 10,800 °F, almost equivalent to the heat of the sun's surface (*Geothermal Explained*, 2022). This heat or thermal energy is contained within the fluids and rocks at the Earth's core and is also contained within the radioactive decay of materials, thus leading to the recognition of geothermal energy as a form of renewable energy (*What Is Geothermal Energy? How Does It Work?*, n.d.). In a warm-climate country such as the Philippines, geothermal energy is reliable to use, as it can operate 24/7 and can produce electricity close to its maximum capacity, since it is not dependent on weather conditions (para. 32). It is also considered as "clean energy" because it extracts energy without burning fossil fuels that can cause damage to the environment (*Geothermal FAQs*, n.d.).

Geothermal energy is the ongoing transfer of heat from the Earth's core to its surface, a process that has been occurring for 4.5 billion years now. This heat is constantly being renewed by the decay of naturally occurring radioactive elements in the Earth's interior, guaranteeing an essentially limitless supply of energy for billions of years to come (para. 15). In lieu of this, the Philippines has experienced a persistent power shortage since the latter half of the 1980s, reaching its peak during the power crisis of 1992-1993. Furthermore, the Philippines is prone to typhoons, because the country is within the Pacific Ring of Fire (*Philippines Typhoon Facts and Figures*, n.d.). This was another cause of the power shortages. The power shortages, the typhoons—all of these were pressing matters, hence the need for a stable power supply in the country. It required the development of new power sources, the restoration of output, and the upgrading of outdated power generation facilities (*Tiwi Geothermal Power Plant Complex Rehabilitation Project*, n.d.). This is when the adoption of geothermal energy was introduced in Tiwi, Albay. Advancing geothermal energy is possible because the Philippines is known as a "geothermal hotspot" (Bank, 2024). While establishing a power plant costs a lot of time, effort, and money, the geothermal field should not be put to waste because it is for cleaner and sustainable energy in Tiwi, for the advancement of the geothermal sector in the region, and for a more livable Albay.

## II. HISTORY

Tiwi, formerly known as one of Albay's poorest towns in Region 5, has been forever changed since the birth of the geothermal field. It all started in 1962, when a team from PHIVOLCS or the Philippine Institute of Volcanology and Seismology (previously known as "Commission on Volcanology"), led an excursion to Mount Malinao. Their goal was to make use of the area's plentiful geothermal energy for electricity generation (Barcia, 2023). The *Geothermal Energy, Natural Gas and Methane Gas Law*, which is known as the *Republic Act No. 5092*, was then enacted in 1967 in preparation for the rise of the geothermal power plant (*Republic Act No. 5092 - Geothermal, Natural Gas, Methane Law*, n.d.). In 1979, commercial geothermal operations in Tiwi began, and it now boasts an installed capacity of 234 MW, hence ranking as the third-largest geothermal facility in the Philippines and the third oldest in Asia (Barcia, 2023, para. 15).

The first turbine-generator, which had a power capacity of 55MWe, had started commercial operations in June, 1979. The capacity was then increased to 330 MWe in 6 power generator units over the course of three years. Table 1 shows the outline of the rated output from the study, "*Tiwi Geothermal Power Plant Complex Rehabilitation Project*" (n.d.).

TABLE I. OUTLINE OF THE RATED OUTPUT OF THE POWER PLANT

Plant	Power generator	Start of operation	Rated output
Plant A	Unit 1	January 1979	55MW
	Unit 2	May 1979	55MW
Plant B	Unit 3	January 1980	55MW
	Unit 4	April 1980	55MW
Plant C	Unit 5	December 1981	55MW
	Unit 6	March 1982	55MW
Total	MW	330	

Note: From *Tiwi Geothermal Power Plant Complex Rehabilitation Project*, n.d.

It is important to note that this was a hasty and heavy advancement due to the oil price shocks of the 70's and the country's dependence on imported oil

(Menzies et al., 2010). But because of this development, Tiwi's geothermal power plant has averaged a gross generation of 157MWe and has provided 40.6TWe-hrs worth of electricity to the region of Luzon. This has prevented the Philippines from needing to import 80.6 million barrels worth of oil. (para. 2).

### III. POWER PLANT DEVELOPMENTS

In 2023, the "Tiwi Binary Geothermal Power Plant Project" was proposed. A 17-MW binary geothermal power facility was scheduled to be constructed on 1.5 hectares of land, since the generated electricity of the power plant had a significant decline from 330 MW to 115 MW after 50 years of operation (Barcia, 2023, para. 31). This development is being handled by Aboitiz Power Corporation, also known as AboitizPower, and is expected to be fully operational in 2024 (Mioten, 2023). The project will start from scratch; constructing a brand-new binary plant system, transmission lines, and pipes.

According to Jeffrey Estrella, the AboitizPower Renewables Inc (APRI) President and the COO of AboitizPower, the power plant is designed in a closed-loop system where there is no emission of harmful gases or liquids, and no waste products are released into the atmosphere. This upholds their "Cleanergy portfolio," wherein their facilities are utilized to clean and zero-emissions energy to communities (*AboitizPower Holds Groundbreaking Ceremony for New 17MW Binary Geothermal Plant in Tiwi, Albay*, 2023).

### IV. LIMITATIONS AND CHALLENGES

Managing the Tiwi Geothermal Power Plant over the past three decades has posed several challenges due to various resource-related issues. Challenges such as meteoric water influx, injection breakthrough, and reservoir pressure decline are commonly encountered in geothermal energy extraction. These factors can lead to non-condensable gas concentrations, enthalpy changes, and the production of sulfuric and hydrochloric corrosive fluids (Menzies et al., 2010, para. 3).

From 1996-2004, the power plant underwent a decrease in steam production and electricity generation caused by a decline in base steam supply, insufficient drilling of make-up wells, and reduced steam productivity due to power plant deterioration. Not to mention, there were incidents of plant shut-downs due

to rehabilitation activities and natural calamities such as typhoon damage (para. 25).

In June 2023, the province of Albay was at Alert Level 3 because of the volcanic eruptions of the Mayon Volcano. Despite being in a state of calamity, the APRI president did not stop the power facility operations, as the power plant remained fully functional. The volcanic activity did not pose any notable impacts on geothermal electricity production or other related issues from temperature changes and fluid flow (*AboitizPower: Tiwi Geothermal Plant Ops Unaffected by Mayon Unrest*, 2023).

### V. ANALYSIS AND EVALUATION

Given the pronounced impact of climate change on the Philippines, which faces a number of typhoons yearly, the demand for transitioning to cleaner energy sources becomes more urgent. The heightened risk of natural disasters, including earthquakes, floods, and typhoons, has prompted numerous organizations and experts to advocate for a greener future powered by cleaner energy sources (Richter, 2020). It is about time that experts maximize Tiwi's potential in the geothermal field, especially that the Bicol region is more prone to typhoons, due to it being located within the typhoon belt in the Philippines (*Why Is Bicol Prone to Typhoons?*, n.d.). In the Bicol Region, the cyclone hazard, also known as a hurricane or typhoon, is categorized as high, with a probability exceeding 20% of experiencing potentially damaging wind speeds in the project area over the next decade (*Think Hazard - Region V (Bicol Region) - Cyclone*, n.d.). In response to this pressing need for cleaner energy and non-weather-dependent solutions, Tiwi has made notable advancements in its geothermal sector, but there are still several factors that hinders a sustainable and better future for the citizens of the Bicol Region.

In 2018, the Philippines positioned third to Indonesia in geothermal energy production. (Richter, 2020, para. 5). The Department of Energy or DOE aims for the Philippines to reclaim its status of second place in the global rankings of largest geothermal energy producers (Mercurio, 2023). AboitizPower's addition of a 17-MW binary geothermal power facility in Tiwi is an important development in the geothermal field, as there had been a decline in the renewable energy capacity in the Philippines. A 29.1% capacity in 2015, followed by a slow and fluctuating decline over the years, which then led to a mere 26.6% capacity in the

year 2023 (*Renewable Energy Electricity Capacity Philippines 2013-2023, 2024*).

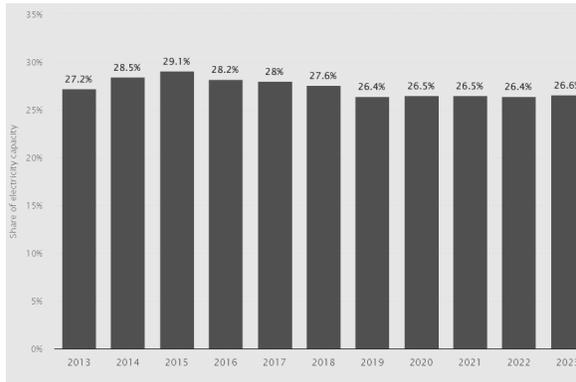


Fig. 1. Electricity capacity of renewable energy in the Philippines (from 2013 to 2023)

## VI. CONCLUSION

The Tiwi Geothermal Power Plant has been in operation for four decades, and it is a place that is full of potential for further growth and development in the geothermal sector. Over the years, Tiwi has contributed significantly to the country's energy mix, providing clean and renewable electricity to the Luzon region. The Philippines is said to be “outperforming” in the geothermal sector, according to a Financial information services company called Fitch Solutions (Cariaga, 2022). They forecasted that in 10 years time, geothermal power will become the principal source of renewable electricity output in the country; it is forecasted to achieve an average growth rate of 1.1% from 2022 to 2032. However, despite its success and “outperforming” status, more needs to be done in order to fully maximize the potential of geothermal energy in the country, particularly in the Bicol Region. While Tiwi is a shining example of geothermal power generation, there remain several factors that contribute to the decline in investors. According to Richter, para. 9, these include: “a privatized energy sector, tedious permitting processes, unattractive incentives package, and a lack of potential investors who are willing to take the risk.” But the fact that AboitizPower did not stop power plant operations despite volcanic activity as mentioned in Part IV: Limitations and Challenges, proves that geothermal energy is worth investing in.

To address these challenges, the government and industry stakeholders must work together to create a more favorable environment for geothermal

development. This includes streamlining permitting processes, offering attractive incentives to investors, and providing support for research and development efforts. By doing so, the Philippines can unlock the full potential of its geothermal resources, paving the way for a more sustainable energy future, especially in a rural place like Tiwi.

It is also suggested that engineering students and engineers in the Mechanical Engineering field do more research on this topic. Increased research and development in geothermal energy can help attract future scientists and investors to the sector. By demonstrating the potential and benefits of geothermal energy through research, more individuals and organizations may be inclined to invest in its development. This, in turn, can lead to greater recognition and utilization of geothermal resources in the Tiwi, ultimately contributing to a more sustainable and environmentally-friendly energy landscape.

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