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CHALLENGES IN GEOTHERMAL

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INTRODUCTION (BACKGROUND)

Geothermal energy stands as one of the most dependable and sustainable renewable energy sources, harnessing the Earth's internal heat to produce constant, base-load power. Unlike solar and wind energy, geothermal systems provide uninterrupted supply, making them a crucial component of a resilient, low-carbon energy future. Globally, this resource remains underutilized despite its vast potential, with geothermal contributing less than 1% to total electricity generation.

In Africa, Kenya has emerged as a continental leader in geothermal development, accounting for more than 47% of the nation's electricity generation and ranking among the top ten producers worldwide. The country's success demonstrates the region's immense geothermal promise particularly within the East African Rift System yet many nations continue to face challenges in resource exploration, financing, technology, and policy implementation.

This paper examines the key technical, economic, environmental, and regulatory barriers hindering geothermal growth, drawing insights from Kenya's experience as a model for sustainable development in Africa. By addressing these challenges through innovation, collaboration,

METHOD

This study used a desk-based research approach to collect and analyse information about geothermal energy. Data were gathered from books, research journals, government reports, and international energy databases such as the International Renewable Energy Agency (IRENA), the International Energy Agency (IEA), and the Geothermal Development Company (GDC) in Kenya.

Information was reviewed to identify the main challenges affecting geothermal energy development — including technical, financial, environmental, and policy issues. The study also looked at case studies from Kenya and other African countries such as Ethiopia, Djibouti, and Tanzania to compare their experiences and progress.

To make the findings more reliable, data from different sources were cross-checked and compared. This helped to build a clear picture of the key problems and possible solutions for improving geothermal development in Africa and around the world..

RESULTS

The results show clear patterns in geothermal energy development across Africa, with Kenya leading in installed capacity and utilization. Data collected from IRENA (2024), IEA (2023), and GDC reports indicate that geothermal power in Africa is concentrated mainly in the East African Rift Valley, which stretches from Djibouti to Malawi.

Growth in Geothermal Capacity (2010–2024)

Kenya's capacity grew from **150 MW in 2010** to **950 MW in 2024**, driven by major projects such as Olkaria I–V and Menengai. Ethiopia and Djibouti have shown slower growth due to financing and exploration barriers.

Cost and Economic Trends

- Average drilling cost per well in Africa: USD 5–7 million, compared to USD 3–4 million in mature geothermal markets like Iceland or the USA.
- The exploration phase accounts for about 40–50% of total project costs.
- Financing risk remains high due to uncertainty in resource viability.

Environmental Observations

- Geothermal fields show limited CO_2 emissions (90–95% lower than coal-based plants).
- Minor land subsidence and induced seismic events recorded in Menengai and Olkaria, but within safe thresholds.
- Reinjection of geothermal fluids has reduced contamination and improved sustainability.

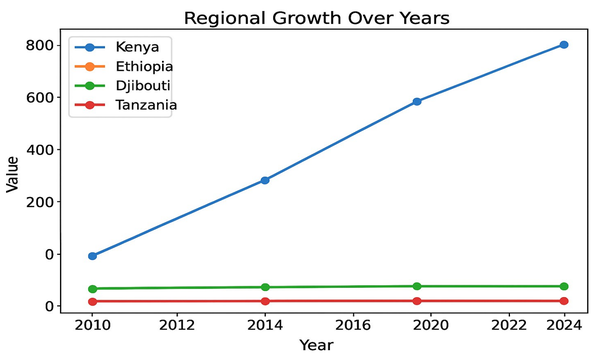


Figure 1: Comparing geothermal installed capacity by country (Kenya, Ethiopia, Djibouti, Tanzania, Others).

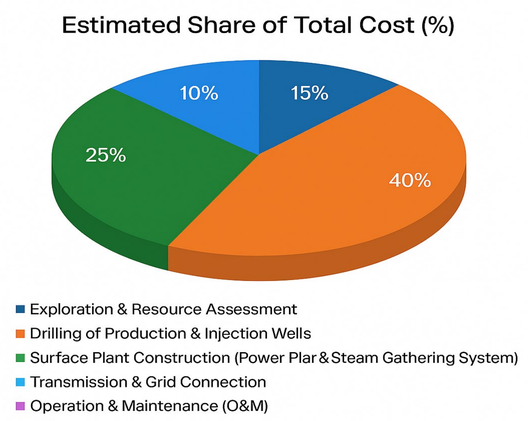


Figure 2: distribution of project costs (exploration, drilling, power plant construction, operation & maintenance).

DISCUSSION

The discussion highlights that Kenya's geothermal success provides a strong model for other African nations seeking sustainable energy solutions. Through effective government leadership, supportive policies, and investment in research and innovation, Kenya has managed to overcome many of the barriers that limit geothermal development elsewhere. However, most African countries still face challenges such as limited technical skills, high drilling costs, and inadequate infrastructure for exploration and energy distribution.

Economic and financial barriers remain a major concern across the continent. Geothermal projects require large upfront investments with uncertain returns during the exploration phase, making them less attractive to private investors. Kenya's approach — through public–private partnerships and risk-sharing funds led by the Geothermal Development Company (GDC) — shows that well-structured financing and government involvement can reduce risks and encourage investment. Expanding similar models to other countries could significantly boost geothermal growth in the region.

Policy, environmental, and social factors also play a key role in geothermal development. Countries with clear legal frameworks and incentives, like Kenya, progress faster than those without. At the same time, community engagement and environmental management are vital to ensure public acceptance and sustainability. Overall, the discussion emphasizes that stronger policies, regional collaboration, and technological innovation are essential for Africa to fully harness its geothermal potential and support its clean energy goals.

CONCLUSION

Geothermal energy offers a sustainable, reliable, and clean solution to Africa's growing energy needs. The findings of this study show that while the region—particularly along the East African Rift System—holds vast geothermal potential, development remains uneven and limited by technical, financial, environmental, and policy-related barriers.

Kenya's success in harnessing geothermal power demonstrates that progress is achievable when there is strong government commitment, clear policies, and targeted investment in exploration and innovation. By integrating lessons from Kenya with regional cooperation and technology transfer, other African nations can accelerate their geothermal programs.

To fully unlock geothermal potential across Africa, stakeholders must focus on:

- Reducing exploration risks through early-stage public funding and insurance schemes.
- Building technical capacity through training, research, and regional partnerships.
- Streamlining regulations and incentives to attract private investment.
- Strengthening environmental safeguards and community engagement for long-term sustainability.

If these actions are taken, geothermal energy could become a cornerstone of Africa's low-carbon transition — contributing to energy security, industrial growth, and climate resilience. The future of Africa's geothermal development depends on collaboration, innovation, and inclusive policy support, paving the way toward a cleaner and more sustainable energy future.

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REFERENCES

DiPippo, R. (2012). Geothermal Power Plants: Principles, Applications, Case Studies and Environmental Impact. Butterworth-Heinemann.
Lund, J. W., & Boyd, T. L. (2016). Direct utilization of geothermal energy 2015 worldwide review. Geothermics, 60, 66–93.
Majer, E. L., Baria, R., & Stark, M. (2007). Induced seismicity associated with Enhanced Geothermal Systems. Geothermics, 36(3), 185–222.
International Renewable Energy Agency (IRENA). (2017). Geothermal Power: Technology Brief. IRENA.
International Energy Agency (IEA). (2021). Geothermal Energy Technology Report. IEA Publications.
Geothermal Development Company (GDC). (2023). Annual Geothermal Development Report: Progress and Prospects in Kenya. Nairobi: GDC Publications.
Ministry of Energy and Petroleum, Kenya. (2019). Energy Act No. 1 of 2019. Government Printer, Nairobi.
African Development Bank (AfDB). (2022). Geothermal Development in Africa: Opportunities and Challenges. AfDB Energy Sector Report.