

CONFERENCE PRE-PRINT**ESTABLISHING AFRICAN FUSION ENERGY RESEARCH
CONSORTIUM: CAPACITY BUILDING AND INNOVATION PATHWAY**

U.F. AHMAD

Centre for Renewable Energy and Sustainability Transitions, Bayero University, Kano, Nigeria

Email: ufahmad.crest@buk.edu.ng

A.S. ALIYU

Centre for Renewable Energy and Sustainability Transitions, Bayero University, Kano, Nigeria

N.F. ISA

Department of Physics, Bayero University, Kano, Nigeria

Abstract

Africa is experiencing a growing demand for sustainable and clean energy solutions. Nuclear fusion, with its potential for limitless and low-carbon power generation, represents a transformative opportunity. However, Africa currently lacks a structured framework for fusion research, education, and workforce development. This paper advocates for the establishment of the African Fusion Energy Research Consortium (AFERC)—a collaborative initiative aimed at fostering education, training, and research capacity across the continent. AFERC will empower African institutions and researchers to contribute meaningfully to global fusion energy development by bridging the knowledge gap. The Centre for Renewable Energy and Sustainability Transitions (CREST) at Bayero University, Kano, is proposed to be the leading center for AFERC, serving as a hub for research coordination, training, and international partnerships. This study outlines AFERC's objectives, proposed structure, roadmap, challenges, and expected impact, highlighting the need for Africa to take proactive steps towards integration into the global fusion energy landscape.

1. INTRODUCTION

The 21st century is defined by a pressing demand for sustainable and reliable energy. Africa, with its rapidly growing population and industrialization, faces unique challenges in meeting its energy needs. While renewable sources such as solar and wind are being increasingly deployed, these alone cannot meet the long-term requirements for energy security, industrialization, and climate commitments. Fusion energy, often described as the 'holy grail' of clean power, offers Africa a chance to leapfrog into a future of sustainable and large-scale power generation. Globally, major initiatives such as ITER, EUROfusion, and national fusion programs in China, the USA, and Japan are advancing the science and technology of fusion. Yet, Africa remains absent from this global race, lacking the necessary institutions, funding, and technical expertise to contribute meaningfully. The establishment of the African Fusion Energy Research Consortium (AFERC) is a timely response to bridge this gap. By fostering education, research, and international collaboration, AFERC seeks to integrate Africa into the global fusion energy community, while simultaneously building local capacity for science, innovation, and sustainable energy futures.

2. BACKGROUND AND RATIONALE

Fusion energy involves the combination of light atomic nuclei, such as isotopes of hydrogen, to release enormous amounts of energy. Unlike fission, fusion produces minimal radioactive waste and carries no risk of large-scale nuclear accidents. Research in this domain requires cutting-edge infrastructure such as tokamaks, stellarators, and advanced plasma physics laboratories. Africa, however, has historically lagged in nuclear science development. Current nuclear efforts are largely focused on fission power plants (e.g., South Africa's Koeberg station), medical applications, and research reactors. While pockets of plasma research exist in Nigeria, Egypt, and South Africa, there is no continental framework for fusion research. This absence threatens to exclude Africa from the economic, scientific, and industrial benefits of the ongoing fusion revolution. The rationale for AFERC is thus clear: without a strategic, coordinated, and well-funded effort, Africa risks being left behind in a future where fusion energy could dominate the global energy mix.

3. OBJECTIVES OF AFERC

- The African Fusion Energy Research Consortium is envisioned to achieve the following objectives:

- Developing Educational Programs: Creating specialized curricula and training programs in plasma physics, nuclear engineering, and computational modeling.
- Enhancing Research Capacity: Establishing research laboratories, simulation centers, and collaborative projects among African institutions.
- Fostering International Collaboration: Building partnerships with ITER, EUROfusion, IAEA, and other global fusion research bodies for technology transfer and joint research.
- Encouraging Industry Participation: Engaging African industries and energy stakeholders in fusion-related innovations and applications.
- Training the Next Generation: Providing scholarships, workshops, and professional training opportunities for students and researchers

4. PROPOSED STRUCTURE OF AFERC

AFERC will adopt a multi-tiered organizational framework to ensure sustainability and inclusivity across the continent. The structure will include:

- Core Members: African universities, national research institutes, and nuclear regulatory bodies.
- Affiliated Partners: International laboratories, funding agencies, and private sector entities.
- Programs and Initiatives: MSc and PhD programs, joint projects, faculty/student exchanges, and industry engagement.

5. ROADMAP FOR IMPLEMENTATION

The establishment of AFERC will be pursued through a phased roadmap:

- Phase 1 (2025–2027): Formation of partnerships, securing funding, and launching pilot educational programs.
- Phase 2 (2027–2030): Development of research facilities, simulation platforms, and regional collaborations.
- Phase 3 (2030–2035): Initiation of experimental fusion projects, with integration into global fusion efforts.

This roadmap will require a combination of domestic government funding, international donor support, and public-private partnerships. Evaluation metrics will include number of trained personnel, research outputs, publications, and participation in international fusion programs.

6. EXPECTED IMPACT

AFERC is expected to transform Africa's scientific, technological, and energy landscapes in several ways:

- Capacity Building: Cultivating a generation of African fusion scientists and engineers.
- Scientific Contributions: Increasing African representation in international fusion collaborations.
- Energy Security: Establishing the foundations for future integration of fusion into Africa's energy grid.
- Technological Advancement: Driving innovation in plasma physics, materials science, and computational modeling.

7. POLICY RECOMMENDATION

To ensure AFERC's success, several policy actions are recommended:

- Governments: Provide funding, establish enabling policies, and integrate fusion research into national energy strategies.
- Universities: Develop curricula, promote interdisciplinary research, and strengthen postgraduate programs.
- Industry: Invest in fusion-related R&D and support workforce development.
- African Union and AFCONE: Coordinate continental strategy, foster regional collaboration, and represent Africa in global forums.

8. CONCLUSION

The African Fusion Energy Research Consortium represents a bold step towards positioning Africa in the global fusion energy landscape. By establishing AFERC, Africa will not only build the scientific and technological

foundations needed for future fusion power but also create a skilled workforce, foster innovation, and enhance energy security. This initiative calls upon African policymakers, academia, and industry to support and invest in the continent's fusion energy future. With strategic collaborations and sustained commitment, Africa can become a key contributor to the global clean energy revolution.

9. BUDGET

A critical aspect of establishing the African Fusion Energy Research Consortium (AFERC) is the allocation of adequate financial resources. Fusion research is inherently capital-intensive, requiring advanced infrastructure, specialized equipment, and long-term investment in human capital. The budget for AFERC should be structured around phased implementation and supported by contributions from African governments, international donors, multilateral agencies, and private sector partners.

The proposed budgetary allocations for the first 10 years (2025–2035) are as follows:

- Infrastructure Development (Laboratories, Simulation Centers, and Training Facilities): USD 250 million. This includes the construction of plasma research labs, supercomputing centers, and specialized classrooms across regional hubs.
- Human Capacity Development (Scholarships, Fellowships, Training, and Workshops): USD 100 million. This will provide postgraduate scholarships, faculty exchange programs, and professional training for early-career researchers.
- Research and Development (Pilot Projects, Materials Research, Computational Modeling, and Plasma Diagnostics): USD 150 million. Funding will be directed to joint research projects among African institutions and collaboration with international partners.
- Governance and Coordination (AFERC Secretariat, Policy Development, and Monitoring & Evaluation): USD 25 million. This will support administration, policy harmonization, and continental coordination.
- International Collaboration (Partnerships with ITER, EUROfusion, and IAEA; Conferences and Exchange Programs): USD 50 million. This will cover participation in global programs, travel grants, and hosting of international conferences in Africa.

The estimated total budget for the first decade is approximately USD 575 million. This cost, while substantial, is modest compared to global fusion projects like ITER (with an estimated budget exceeding USD 10 billion). The goal is not to replicate ITER, but to build Africa's entry point into fusion science through education, simulation, and incremental experimental capability. By leveraging partnerships and phased investments, AFERC can achieve maximum impact with efficient use of resources.

10. REGIONAL HUB AND THEMES

To ensure balanced participation across the continent, AFERC will establish regional hubs, each focusing on a specific research theme based on local strengths and opportunities. This distributed structure ensures specialization while promoting continental integration. The proposed hubs and their themes are as follows:

- North Africa (Egypt): Plasma Physics and Magnetic Confinement
- West Africa (Nigeria): Computational Modeling and Fusion Materials
- East Africa (Kenya): Fusion Energy Policy and Innovation
- Central Africa (Cameroon): Diagnostics and Instrumentation
- Southern Africa (South Africa): Inertial Confinement and Experimental Reactors
- Northwest Africa (Morocco): Renewable–Fusion Hybrid Systems

Figure 1 below illustrates

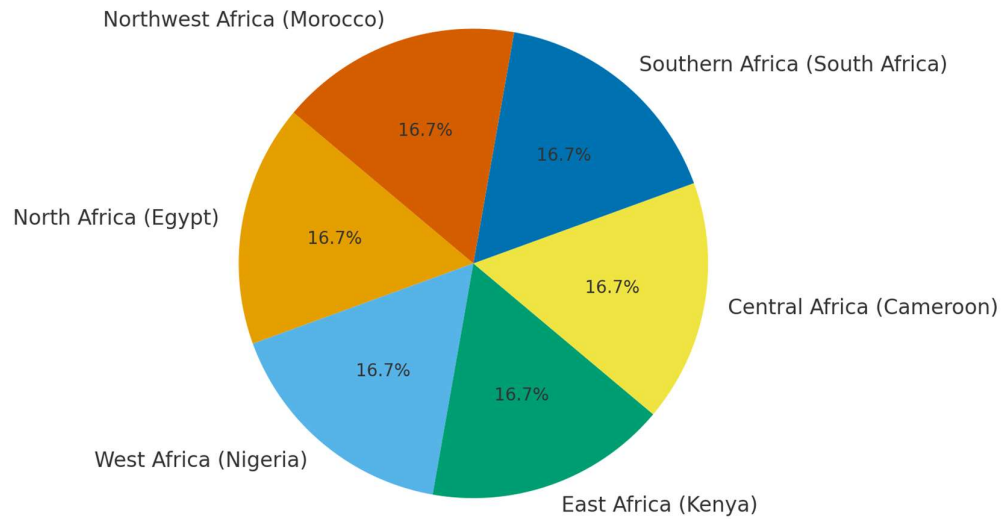


FIG. 1. The distribution of AFERC hubs across African regions and their assigned research themes.

REFERENCES

- [1] W. S. Ebhota and P. Y. Tabakov, "A Retrospect of Energy Demand and Potential of Sub-Saharan Africa: Leveraging Energy Deficit to Attain Clean Energy Hub Region," *Arid Zo. J. Eng. Technol. Environ.*, vol. 20, no. 1, pp. 261–294, 2024.
- [2] M. Mohamed, N. D. Zakuan, T. N. A. Tengku Hassan, S. S. M. Lock, and A. Mohd Shariff, "Global development and readiness of nuclear fusion technology as the alternative source for clean energy supply," *Sustainability*, vol. 16, no. 10, p. 4089, 2024.
- [3] ITER Organization, "ITER: The Way to New Energy," 2023. [Online]. Available: <https://www.iter.org>
- [4] EUROfusion, "European Fusion Programme," 2023. [Online]. Available: <https://www.euro-fusion.org>