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ENHANCING WEST AFRICA'S ENERGY SOVEREIGNTY THROUGH SMALL MODULAR REACTORS, INSTITUTIONAL INTEGRATION AND STRATEGIC DEPLOYMENT

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A B S T R A C T

This paper explores the strategic deployment of Small Modular Reactors (SMRs) as a catalyst for enhancing energy sovereignty in West Africa, with a focus on institutional integration under regional frameworks such as ECOWAS, WAPP, ECREEE, and ERERA. Against a backdrop of acute energy poverty and overreliance on imported fossil fuels, the study argues that SMRs if embedded within coherent regional governance mechanisms can address both technological and geopolitical deficits in West Africa's energy transition. Drawing on the author's direct involvement over a four-year period as a volunteer with Rosatom-led initiatives to promote nuclear education and scientific exchange between Russia and African countries, the research provides a unique practitioner perspective on the soft-power dimensions of nuclear cooperation. It analyzes how Russian foreign policy strategies anchored in technical assistance, regulatory capacity building, and education diplomacy can serve as enablers of institutional readiness for nuclear technology adoption in Africa. Through a mixed-methods approach combining geospatial analysis, regulatory mapping, and scenario planning, the study assesses the nuclear readiness of Ghana, Nigeria, Mali, and Burkina Faso. It highlights how regional harmonization of nuclear policy, underpinned by Russia–Africa energy diplomacy, can foster a resilient, autonomous energy architecture in the ECOWAS bloc. The findings suggest that SMRs present not only a technical solution but also a platform for advancing regional integration, industrial transformation, and geopolitical autonomy in West Africa.

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1. INTRODUCTION

Energy access remains one of the most critical development challenges facing Sub-Saharan Africa. According to the International Energy Agency, more than half of the population in West Africa lacks reliable access to electricity, severely limiting industrial development and economic competitiveness (Agoundedemba et al., 2023). These structural energy deficits undermine the broader development ambitions outlined in the African Union's Agenda 2063 and ECOWAS Vision 2050, both of which emphasize sustainable infrastructure and economic integration as pillars of regional development (African Union, 2024; ECOWAS 2022; ECOWAS, 2025). Although West Africa possesses significant renewable energy potential, reliance on hydropower and intermittent renewable sources has proven insufficient for sustaining large-scale industrial growth. Consequently, policymakers are increasingly exploring diversified energy portfolios that include nuclear energy

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technologies alongside renewables and natural gas (Miah & Karekezi, 2020). Small Modular Reactors (SMRs) have emerged as a particularly promising nuclear technology for developing regions (Ghimire & Waller, 2023). Unlike conventional nuclear reactors, SMRs are designed with modular components that can be manufactured in factories and assembled on site, significantly reducing construction time and capital requirements (Vujić et al., 2012). Their smaller capacity and enhanced safety features make them suitable for countries with limited grid infrastructure and constrained financial resources. However, the successful deployment of SMRs depends not only on technological feasibility but also on institutional readiness, regulatory capacity, and regional policy coordination.

However, the literature on SMRs in Africa remains limited, particularly with regard to policy implementation and institutional readiness.

2. LITERATURE REVIEW

2.1 Literature overview

This literature review synthesizes scholarly and policy-oriented sources related to the deployment of Small Modular Reactors (SMRs) in developing regions, particularly West Africa, in the context of energy sovereignty and institutional governance. It critically assesses three key thematic areas: (1) the technical and policy dimensions of SMRs in developing countries, (2) the role of regional governance frameworks in shaping energy transitions, and (3) the identified gaps in scholarship that this study aims to address. The review also incorporates emerging literature on nuclear fusion in developing contexts to situate SMR deployment within a broader innovation trajectory.

2.2 SMRs and the African Energy Transition

Small Modular Reactors have increasingly gained global traction as scalable, safer alternatives to conventional large nuclear plants (Figure 1).

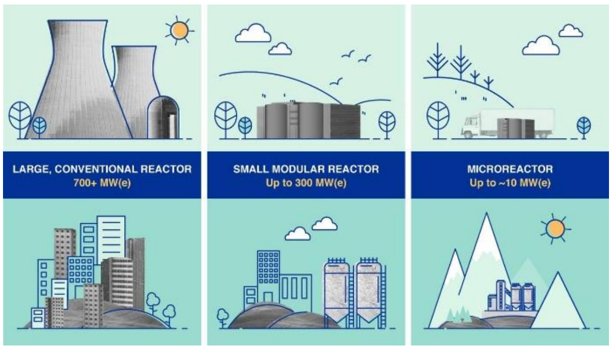

Figure 1. Small modular reactors
Source: *International Atomic Energy Agency*

Their modular design, reduced initial capital outlay, and flexible siting make them especially suitable for developing regions with limited grid capacity or constrained financial resources (Atlantic Council, 2023; Coelho, 2023). In the African context, SMRs are often portrayed as a "leapfrogging" opportunity, enabling nations to bypass large-scale infrastructural limitations (Fabricius, 2023; IAEA, 2025).

Pilot partnerships such as Rwanda's test reactor agreement with Dual Fluid Energy, Ghana's discussions with NuScale, and Nigeria's engagement with Rosatom—illustrate growing regional interest (Emmanuel, 2024; IAEA, 2025). These developments are underpinned by the recognition that intermittent renewables alone are insufficient for sustaining industrialization or supporting grid stability, especially in landlocked and under-electrified areas.

Despite this optimism, the literature often lacks in-depth analyses of deployment constraints, including regulatory gaps, institutional misalignment, and public trust in nuclear governance (Charnley-Parry et al., 2024). Furthermore, scholarly engagement remains centered on technical viability and less on region-specific implementation models that align with existing energy institutions.

2.3 The Role of Regional Governance Frameworks in Shaping Energy Transitions

Regional governance frameworks are critical in managing energy transitions in developing countries. These frameworks spearhead collaborative efforts among nations to streamline energy strategies and standards, which is increasingly vital in a globalized world facing shared challenges like climate change and energy poverty (Tariq, 2026). By promoting cooperation, regional frameworks facilitate the adoption of technologies such as Small Modular Reactors (SMRs), empowering countries to reach their energy transition goals more efficiently (Zarębski & Katarzyński, 2023).

Existing regional groups, such as the African Union (AU) and the Association of Southeast Asian Nations (ASEAN), are crucial in shaping energy policies that promote renewable energy integration and nuclear options (African Union, 2024). In West Africa, for example, the Economic Community of West African States (ECOWAS) has developed a multi-institutional framework to enhance transnational energy access and coordination. Key components of this framework include the West African Power Pool (WAPP), which facilitates cross-border electricity trade and regional infrastructure planning; the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE, 2023), which promotes sustainable energy innovations and capacity building; and the ECOWAS Regional Electricity Regulatory Authority (ERERA, 2023), which harmonizes electricity regulation across member states. These institutions play a vital role in integrating energy solutions, lowering costs, and reducing bureaucratic barriers associated with SMR deployment (Avordeh et al., 2025).

Additionally, the African Energy Commission (AFREC) supports continental coordination in alignment with the African Union's Agenda 2063 (Raza & Khan, 2024). The literature highlights the potential of these regional bodies to serve as platforms for joint nuclear governance, regulatory standardization, and financing of SMR projects (ECOWAS, 2022). Harmonization of regulations across borders can facilitate the movement of ideas, technologies, and investments, maximizing the potential benefits of SMRs. A regional regulatory body could oversee safety standards and provide unified guidelines for construction and operation. This collaborative approach can enhance the competitiveness of member states in attracting global investments in SMR technology.

These frameworks are not only pivotal for sustained energy security but also for addressing the intertwined challenges of sustainable development and climate change. The 2030 Agenda for Sustainable Development emphasizes the need for affordable and clean energy for all; thus, regional governance can directly contribute to achieving these goals (Raszkowski & Bartniczak, 2019). By incorporating renewable energy sources alongside SMRs within a structured framework, developing countries can move toward a diversified energy portfolio that reduces dependency on fossil fuels (Black et al., 2025).

However, it is important to recognize that most studies have primarily focused on renewables and conventional energy sectors, with limited exploration of how regional institutions can accommodate disruptive or advanced technologies such as SMRs (An et al., 2025). This gap is significant, given the centrality of institutional harmonization in ensuring the safe, equitable, and efficient deployment of nuclear assets. Enhancing our understanding of these dynamics will be crucial for developing energy strategies that successfully integrate SMRs into national and regional energy ecosystems. Emphasizing the role of regional frameworks in fostering innovation and cooperation will be essential for realizing the potential of SMRs in advancing Africa's energy transition (Karikari et al., 2026).

2.4 SMRs and Energy Sovereignty

Energy sovereignty refers to a nation's ability to control and manage its energy resources, technologies, and policies independently (Schelly et al., 2020). In West Africa, dependence on imported fossil fuels and donor-driven electrification programs has historically constrained national energy autonomy (Okojokwu-du et al., 2025). SMRs have the potential to strengthen energy sovereignty by enabling localized electricity generation and reducing reliance on external energy imports. According to El-Emam et al. (2024) decentralized nuclear systems could provide stable baseload electricity for industrial zones and emerging urban centers. However, achieving these benefits requires strong regulatory institutions, technical expertise, and diplomatic cooperation.

2.5 Research Gap

Despite growing interest in SMR technology, three major gaps remain in the literature: Limited integration of geospatial analysis in SMR deployment planning. Insufficient examination of regional institutions in nuclear energy governance. Lack of research linking SMR deployment to broader questions of energy sovereignty and diplomacy. This study addresses these gaps through an integrated analysis combining spatial assessment, institutional evaluation, and policy analysis

3. METHODOLOGY

This study adopts a mixed-methods research design based primarily on desk-based analysis.

3.1 Case Study Selection Four ECOWAS member states were selected for analysis: Ghana Nigeria Mali Burkina Faso These countries represent varying levels of nuclear development and energy infrastructure capacity (ECOWAS, 2022; ECOWAS, 2025).

3.2 Data Sources Data were collected from multiple sources including: National energy strategies and nuclear roadmaps ECOWAS institutional reports International Atomic Energy Agency publications Academic literature on nuclear energy and regional governance This approach enables a comprehensive analysis of both national and regional policy frameworks.

3.3 Analytical Framework The study employs two complementary analytical frameworks. PESTLE Suitability Model A PESTLE framework evaluates SMR feasibility based on: Political stability Economic capacity Social acceptance Technological infrastructure Legal frameworks Environmental conditions (Barbieri & Capoani, 2025). Institutional Comparative Analysis Regional and national institutions are assessed according to: existence of nuclear regulatory authorities compliance with IAEA standards participation in regional energy platforms alignment with continental development strategies (Jaloliddin, 2026).

4. DISCUSSION AND ANALYSIS

Geospatial and Institutional Analysis of selected African countries is presented on Figure 2 as part of the research.

Figure 2. Geospatial and Institutional Analysis of selected African countries
Source: *Authors own work*

Who in Africa is ready for Nuclear Power is presented on Figure 3.

4.2 Country-Level Readiness for SMRs

4.2.1 Ghana

Ghana is considered one of the most advanced countries in West Africa in terms of nuclear energy development. Through the Ghana Atomic Energy Commission (GAEC, 2021), the country has implemented a nuclear power roadmap and completed Phase 1 of the IAEA Milestones Approach, indicating its political commitment and infrastructural baseline for hosting a nuclear facility (IAEA, 2019l IAEA, 2023). Ghana has entered into memoranda of understanding with international vendors such as Rosatom and NuScale, and has recently partnered with the United States Trade and Development Agency (USTDA) to explore feasibility studies for deploying the NuScale VOYGR-12 SMR system (Boadi et al., 2019; GMC, 2021).
Geospatially, Ghana's middle belt is suitable for SMR deployment due to its grid connectivity through the West African Power Pool (WAPP), stable geology, access to water bodies for cooling, and growing industrial corridors (GEC 2021: GWC 2021). This region is particularly conducive to distributed power solutions for agro-processing zones and emerging industrial enclaves (Prah & Adu, 2024).

4.2.2 Nigeria

Nigeria possesses significant nuclear development ambitions and institutional infrastructure, spearheaded by the Nigeria Atomic Energy Commission (NAEC) (Abdulkadir et al., 2019; Inyada, 2021). The country has expressed its intent to integrate nuclear power into its national energy mix and has received technical support from the IAEA for regulatory and human resource development (IAEA, 2023). Nigeria's North-Central geopolitical zone, including Abuja and Niger State, has been identified as a suitable SMR deployment region due to its high demand, grid infrastructure, and central location relative to power evacuation routes (Ilesanmi et al., 2020).
Despite these developments, Nigeria faces challenges related to political stability, energy market fragmentation, and funding constraints, all of which may affect the viability of SMR projects in the short to medium term (Dinneya-Onuoha, 2025).

4.2.3 Mali and Burkina Faso

Both Mali and Burkina Faso are energy-poor and landlocked, heavily reliant on imported electricity from neighboring countries (BFCC, 2021; BFME, 2021). However, their strategic locations in the Sahel make them key potential beneficiaries of regional SMR deployment. Cross-border deployment strategies where SMRs are constructed in Ghana or Nigeria but supply power via WAPP to Sahelian countries can address their energy insecurity. For this to materialize, however, regional governance structures must guarantee shared regulatory oversight, equitable tariff mechanisms, and transboundary security protocols (Bourouni et al., 2019; Brou et al., 2019).

Ready by 2030	Potentially Ready by 2030	Potentially Ready by 2050	No ranking due to conflict
Egypt South Africa	Ghana Uganda Morocco Kenya Algeria Tunisia	Rwanda +12 more	Nigeria Sudan Burkina Faso +8 more

Figure 3. Who in Africa is ready for Nuclear Power?
Source: *Global Market for Advanced Nuclear Map, Energy for Growth Hub Third Way, 2024*

Both countries are members of ECOWAS and active participants in regional electricity harmonization programs but lack national nuclear energy frameworks or regulatory commissions, requiring significant institutional support for SMR inclusion (Kouadio et al., 2019).

4.3 Economic Governance, Innovation, and Sustainability Implications of SMR Deployment in West Africa

4.3.1 Financial Systems and Economic Governance

The economic viability of Small Modular Reactors (SMRs) in West Africa depends on the interaction between financing mechanisms, institutional governance, and long-term electricity demand. Nuclear infrastructure is traditionally capital intensive; however, SMR technology is specifically designed to reduce financial barriers through modular construction, smaller unit capacity, and phased deployment. According to the International Atomic Energy Agency (IAEA), capital costs for large conventional nuclear power plants often exceed USD 6–10 billion per project, whereas SMR installations typically range between USD 3,000 and USD 6,000 per kilowatt of installed capacity depending on reactor design and local construction conditions (IAEA, 2023). This lower upfront capital requirement makes SMRs more accessible for emerging economies with limited fiscal capacity.
In West Africa, the economic rationale for SMR deployment is closely linked to the high costs of unreliable electricity supply. The World Bank estimates that energy shortages and power outages reduce economic productivity in Sub-Saharan Africa by approximately 2–4 percent of GDP annually, largely due to industrial disruptions and the widespread use of costly diesel generators (Farquharson et al., 2018). In many ECOWAS countries, industrial electricity tariffs range between USD 0.18 and USD 0.25 per kWh, significantly higher than global industrial averages (IAEA, 2023).
The introduction of nuclear baseload generation through SMRs could stabilize electricity prices and reduce production costs for energy-intensive sectors such as mining, manufacturing, and agro-processing. Estimates from the International Energy Agency suggest that nuclear-based electricity systems typically operate within a long-term cost range of USD 0.10–0.14 per kWh,

depending on financing structures and operational efficiency (IAEA, 2023). Lower electricity costs could enhance industrial competitiveness and stimulate regional economic growth.

Several financing models may support SMR deployment in West African economies: Public–Private Partnerships (PPP). Governments collaborate with private investors and reactor vendors to share capital costs, operational risks, and long-term revenues. Vendor Financing Arrangements. Reactor suppliers, including companies such as Rosatom and NuScale Power, have proposed build-own-operate models in which vendors provide long-term financing and technical expertise. Multilateral Development Financing. Regional institutions such as the African Development Bank and international financial institutions may support nuclear energy projects through blended finance instruments, infrastructure loans, and sovereign guarantees. Regional Infrastructure Funds. Energy integration initiatives under Economic Community of West African States (ECOWAS) could create joint infrastructure funds for cross-border nuclear energy projects linked to the West African Power Pool (WAPP). By combining these financing models, West African countries could mitigate fiscal risks while expanding regional energy infrastructure.

4.3.2 Innovation Systems and Human Capital Development Beyond energy generation, SMR deployment has significant implications for technological innovation and human capital formation. Nuclear energy programs require highly specialized skills in engineering, safety regulation, radiation protection, digital instrumentation, and environmental monitoring. The International Atomic Energy Agency emphasizes that nuclear infrastructure development often stimulates the creation of national innovation ecosystems by strengthening research institutions, technical universities, and industrial supply chains (IAEA, 2023).

For West African countries, participation in SMR projects could therefore support the emergence of knowledge-based energy sectors. Technology transfer can occur through several mechanisms:

1) joint research programs between universities and nuclear laboratories;
2) training programs for nuclear engineers and safety regulators;
3) international scholarships and scientific exchanges;
4) local participation in manufacturing and maintenance supply chains .

Countries such as Ghana and Nigeria have already begun developing nuclear expertise through institutions such as the Ghana Atomic Energy Commission and the Nigeria Atomic Energy Commission. These institutions are responsible for developing nuclear regulatory frameworks, training technical personnel, and coordinating international cooperation in nuclear science.

The employment impacts of nuclear infrastructure are also substantial. According to the Nuclear Energy Institute, the construction phase of a nuclear power facility can generate 2,000–4,000 temporary jobs, while plant operation requires 400–700 permanent high-skilled employees, including engineers, technicians, and safety specialists. In addition to direct employment, nuclear projects stimulate broader economic activity in sectors such as engineering services, construction, environmental monitoring, and digital control systems. Over time, these developments contribute to the formation of knowledge-intensive industries and enhance technological capacity within national economies.

4.3.3 Environmental Sustainability and Regional Development

From an environmental perspective, SMRs offer significant advantages compared to fossil fuel-based electricity generation. Many West African power systems rely heavily on diesel generators and heavy fuel oil plants, which produce approximately 700–900 grams of CO_2 per kilowatt-hour of electricity generated (IAEA, 2023).

In contrast, nuclear power generates extremely low lifecycle emissions. According to the Intergovernmental Panel on Climate Change, nuclear electricity has lifecycle emissions of approximately 12 grams of CO_2 per kilowatt-hour, comparable to wind energy and substantially lower than fossil fuel alternatives (Mathew, 2022).

If a 300-megawatt SMR were deployed to replace diesel generation capacity in West Africa, annual emissions reductions could reach 1.5–2 million metric tons of CO_2, depending on capacity factors and grid integration patterns.

Beyond climate mitigation, SMRs may also contribute to broader sustainability and regional development objectives:

1) reliable electricity supply for industrial zones and mining operations
2) integration with desalination technologies for water security
3) heat generation for industrial processes
4) support for agro-processing and manufacturing sectors

These applications demonstrate the potential for SMRs to serve as multifunctional infrastructure supporting both economic development and environmental sustainability.

4.3.4 Global and Development Economics: Transformation Scenarios

Energy infrastructure plays a fundamental role in economic development by enabling industrial production, technological innovation, and regional trade integration. In the case of West Africa, electricity demand is projected to increase significantly in the coming decades due to population growth, urbanization, and expanding industrial activity.

The International Energy Agency projects that electricity demand in Sub-Saharan Africa could increase by more than 75 percent by 2040, requiring large-scale investments in generation capacity and transmission infrastructure. Scenario analysis suggests that the integration of SMRs into the regional energy mix could generate substantial macroeconomic benefits. If SMRs were to provide approximately 10–15 percent of West Africa's electricity supply by 2040, several structural economic effects could emerge:

1) improved reliability of electricity supply;
2) increased productivity in manufacturing and extractive industries;
3) reduced dependence on imported fossil fuels;
4) expansion of regional electricity trade through the West African Power Pool.

Reliable baseload electricity is particularly critical for energy-intensive industries such as mineral processing, cement production, steel manufacturing, and digital infrastructure development. The availability of stable electricity could enable the development of industrial clusters and special economic zones across the ECOWAS region. Furthermore, cross-border electricity trade enabled by SMR-based generation could allow countries with nuclear capacity, such as Ghana or Nigeria, to export electricity to energy-deficient neighbors including Mali and Burkina Faso. This regional approach would strengthen economic integration while improving energy security across the Sahel and coastal West African states.

4.3.5 Implications for Regional Economic Stability

The integration of SMRs within the regional energy architecture could strengthen the institutional role of ECOWAS energy organizations, including the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) and the ECOWAS Regional Electricity Regulatory Authority (ERERA). These institutions could coordinate regulatory harmonization, cross-border infrastructure planning, and safety standards for nuclear energy deployment. A coordinated regional strategy would reduce investment risks, attract international capital, and improve long-term energy security. Ultimately, the deployment of SMRs within the ECOWAS framework could support a more diversified and resilient energy system capable of sustaining industrial development and economic transformation in West Africa.

The responsibilities of this body would encompass harmonizing nuclear energy policy frameworks, establishing standardized siting criteria, developing shared safety and liability mechanisms, and facilitating access to funding and technology. Such institutional integration would significantly reduce transaction costs, bolster investor confidence, and facilitate joint SMR pilot projects benefiting multiple member states.

Despite the promising technical attributes of SMRs, their adoption is impeded by several institutional gaps. These include the absence of national nuclear legal frameworks in the majority of ECOWAS states, a shortage of trained personnel in nuclear engineering and safety regulation, minimal public engagement strategies that lead to knowledge deficits and sociopolitical resistance, and limited financing pathways, particularly for landlocked and low-income member states. Addressing these challenges necessitates a coordinated multilateral approach centered on capacity development and policy harmonization at the regional level, strongly supported by strategic partnerships with countries that have advanced SMR technology, such as Russia, China, the USA, and Canada.

In conclusion, West Africa possesses considerable geospatial and institutional potential for the deployment of SMRs. However, realizing this potential necessitates deliberate policy realignment, regional regulatory harmonization, and sustained capacity development. While nations like Ghana and Nigeria are positioned to take the lead in this transition, regional governance bodies namely ECOWAS, WAPP, ERERA, and ECREEE must evolve to support the integration of nuclear energy. The deployment of SMRs presents a unique opportunity not only to enhance energy sovereignty but also to catalyze industrial transformation and foster regional cooperation, provided that the necessary institutional foundations are strategically reinforced

5. MAJOR FINDINGS AND OUTCOMES

This study has examined the potential for enhancing West Africa's energy sovereignty through the strategic deployment of Small Modular Reactors (SMRs), framed within the region's institutional and policy architecture. Drawing on geospatial analysis and regional energy governance frameworks, the research finds that SMRs offer a viable, scalable, and regionally integratable solution for addressing West Africa's chronic electricity deficits and dependence on external energy imports.

The analysis has shown that Ghana and Nigeria are relatively advanced in terms of nuclear energy readiness, due to their established atomic energy commissions, regulatory progress, and partnerships with international SMR vendors (IAEA, 2023). These countries could serve as pioneers in regional nuclear energy cooperation. However, landlocked and energy-insecure nations such as Mali and Burkina Faso will require cross-border infrastructure, regulatory harmonization, and cooperative financing schemes to benefit from SMR-generated electricity.

At the regional level, the institutions of ECOWAS namely the West African Power Pool (WAPP), the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE), and the ECOWAS Regional Electricity Regulatory Authority (ERERA) present the foundational architecture necessary to support a harmonized approach to SMR deployment. However, the current energy integration strategies lack explicit consideration of nuclear energy, indicating a policy and strategic planning gap (ECOWAS, 2022).

Establishing regional mechanisms for waste management, environmental licensing, and public consultation will further solidify a comprehensive framework for SMR deployment.

5.1 External Partnerships and SMR Deployment: Russia's foreign policy.

While institutional integration in West Africa primarily involves the alignment of regional and national frameworks to support Small Modular Reactor (SMR) deployment, the influence of external actors remains pivotal in shaping this process. Among these actors, the Russian Federation stands out as a key partner through its strategic promotion of nuclear energy cooperation on the continent.

Russia's foreign policy leverages state-owned enterprises, notably Rosatom, to foster bilateral and multilateral engagements that extend beyond technology transfer, encompassing regulatory capacity building, financing, and governance reforms (Wang, 2025). This external involvement is not merely transactional but instrumental in advancing the institutional architecture required for effective SMR integration within West African energy systems.

5.2 Contributions to Scholarship and Policy

This study makes significant contributions to the existing body of literature by establishing a crucial link between Small Modular Reactor (SMR) technology and regional energy governance frameworks in Africa. While much of the current scholarship primarily concentrates on the technical and environmental aspects of nuclear energy, this research emphasizes the strategic importance of institutional integration, regional planning, and regulatory convergence as critical enablers for the successful deployment of SMRs. Furthermore, it offers an Africa-centered perspective that positions SMRs not merely as foreign innovations imported from the West, but as potentially indigenous solutions to the continent's pervasive energy challenges, provided they are strategically adapted to fit regional governance structures.

6. CONCLUSION

In conclusion, the strategic deployment of SMRs, when bolstered by institutional integration and regional governance reforms, has the potential to significantly enhance energy sovereignty in West Africa. The region stands at a unique crossroads, presenting an unparalleled opportunity to leapfrog traditional fossil-fuel-based development models in favor of a technologically advanced, climate-resilient, and geopolitically autonomous energy future. However, achieving this vision necessitates visionary policymaking, robust multilateral cooperation, and a committed political will to embed nuclear innovation within Africa's broader development trajectory. By addressing these dimensions, West Africa can pave the way for a sustainable energy landscape that aligns with its aspirations for economic growth and regional stability

7. RECOMMENDATIONS FOR FUTURE WORKS

The analysis has predominantly relied on desk-based research, which has constrained the inclusion of field interviews and real-time stakeholder engagement. While this approach is sufficient for policy analysis, future studies could benefit from incorporating a variety of methodologies, such as multi-criteria decision analysis for site selection, geospatial risk modeling to assess seismic and hydrological constraints, and field-based surveys focused on the public's acceptance of nuclear energy.

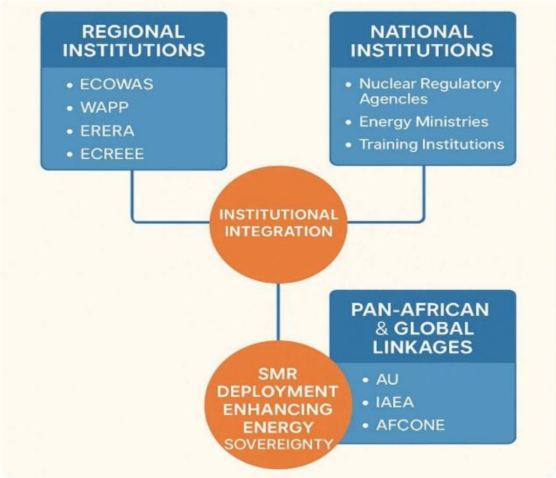

Figure 4. Institutional Integration Framework

The Figure 4 is the institutional Integration Framework. Additionally, comparative case studies with regions undertaking similar nuclear initiatives, such as ASEAN or Mercosur, would provide valuable insights into the applicability of SMR strategies across different contexts.

8. SUGGESTIONS

Analysis and design in this study yielded the following conclusions:

This study set out to examine the potential of Small Modular Reactors (SMRs) to enhance energy sovereignty in West Africa through strategic deployment and institutional integration. Drawing on a mixed-methods design combining geospatial assessment, policy analysis, and institutional evaluation, several important conclusions emerge regarding the feasibility and developmental implications of SMR adoption in the region.

First, the analysis confirms that West Africa possesses significant structural potential for the deployment of SMRs, particularly in countries with relatively advanced institutional and regulatory frameworks. Among the case studies examined, Ghana and Nigeria demonstrate the highest level of readiness due to the presence of established nuclear governance institutions such as the Ghana Atomic Energy Commission and the Nigeria

Atomic Energy Commission. These institutions provide foundational regulatory capacity and policy direction necessary for the safe development of nuclear energy infrastructure. In contrast, countries such as Mali and Burkina Faso exhibit limited institutional readiness but could benefit from regional energy integration mechanisms.

Second, the study demonstrates that regional governance structures play a critical role in enabling the practical deployment of SMRs. Institutions operating under the Economic Community of West African States, particularly the West African Power Pool, the ECOWAS Centre for Renewable Energy and Energy Efficiency, and the ECOWAS Regional Electricity Regulatory Authority, provide an institutional framework capable of supporting cross-border electricity trade, regulatory harmonization, and coordinated infrastructure planning. The research findings suggest that strengthening these institutions and integrating nuclear energy into their strategic planning could facilitate the creation of a regionally coordinated nuclear energy ecosystem.

Third, the study highlights that SMRs offer important economic advantages compared to conventional nuclear infrastructure. Their modular design, smaller generation capacity, and flexible siting requirements reduce initial capital costs and construction timelines, making them more suitable for developing economies with constrained financial resources. By providing stable baseload electricity, SMRs could reduce dependence on imported fossil fuels, lower industrial energy costs, and improve productivity in energy-intensive sectors such as mining, manufacturing, and agro-processing. In this context, the deployment of SMRs could contribute to broader economic transformation by strengthening regional industrial competitiveness.

Fourth, the analysis underscores the strategic importance of international partnerships in supporting nuclear energy development in West Africa. External actors with advanced nuclear technology capabilities play an essential role in providing technical expertise, financing mechanisms, and regulatory capacity building. Strategic cooperation with international technology vendors and multilateral institutions can therefore accelerate the development of domestic nuclear governance systems while ensuring compliance with global safety standards.

Fifth, the study finds that SMR deployment could generate significant environmental and sustainability benefits. Nuclear power produces extremely low greenhouse gas emissions during operation and can serve as a reliable complement to intermittent renewable energy sources. By replacing diesel-based electricity generation, SMRs could substantially reduce carbon emissions while providing reliable electricity for industrial development and urban expansion.

Finally, the research concludes that the successful integration of SMRs in West Africa depends primarily on institutional coordination, regulatory preparedness, and regional cooperation rather than technological constraints. While the technology itself is increasingly mature, effective governance structures, workforce development programs, and financing mechanisms remain critical prerequisites for successful implementation.

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Any remaining errors or omissions are solely the responsibility of the author.

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