ANL/NSE-26/3

Feasibility and strategic implications of deploying nuclear power reactors in Africa

Nuclear Science and Engineering Division

About Argonne National Laboratory

Argonne is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC under contract DE-AC02-06CH11357. The Laboratory's main facility is outside Chicago, at 9700 South Cass Avenue, Argonne, Illinois 60439. For information about Argonne and its pioneering science and technology programs, see www.anl.gov.

DOCUMENT AVAILABILITY

Online Access: U.S. Department of Energy (DOE) reports produced after 1991 and a growing number of pre-1991 documents are available free via DOE's SciTech Connect (http://www.osti.gov/scitech/)

Reports not in digital format may be purchased by the public from the National Technical Information Service (NTIS):

U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Rd
Alexandra, VA 22312
www.ntis.gov
Phone: (800) 553-NTIS (6847) or (703) 605-6000
Fax: (703) 605-6900
Email: **orders@ntis.gov**

Reports not in digital format are available to DOE and DOE contractors from the Office of Scientific and Technical Information (OSTI):

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
www.osti.gov
Phone: (865) 576-8401
Fax: (865) 576-5728

ANL/NSE-26/3

Feasibility and strategic implications of deploying nuclear power reactors in Africa

prepared by
Iyabo Usman, Nicolas Stauff, Temitope Taiwo
Nuclear Science and Engineering Division, Argonne National Laboratory

January 30, 2026

Executive Summary

This report assesses the feasibility and strategic implications of deploying nuclear power reactors, including large-scale plants, advanced small modular reactors (SMRs), and microreactors, in African countries. Case studies focus on South Africa, Egypt, Kenya, Ghana, and Nigeria, examining nuclear energy's role in Africa's rapidly evolving energy landscape, marked by fast-growing demand, significant electricity access gaps, increasing renewable penetration, and strong policy commitments to industrialization and energy security.

Several U.S. reactor technologies and designs are considered based on their development status and readiness for deployment. The analysis finds that nuclear power can provide reliable, clean baseload and flexible generation, as well as high-temperature process heat for desalination, hydrogen production, and industrial applications. However, suitability is highly country-specific, depending on grid size and stability, transmission capacity, cooling water availability, regulatory readiness, and fuel supply chains.

Near-term deployment opportunities are strongest for light-water reactors (such as NuScale, BWRX-300, AP300, and SMR-300) that use low-enriched uranium and build on proven technology. More advanced concepts, including gas-cooled, sodium-cooled, molten-salt cooled reactors, and microreactors, will likely be relevant for African deployment in the 2030s or later, contingent on demonstration projects, high-assay low-enriched uranium (HALEU) fuel availability, and mature international licensing frameworks.

Economic analysis shows that SMRs are capital-intensive, with projected overnight costs for 300 MWe units in 2025 ranging from approximately 1.4 to 2.6 billion USD per module. The levelized cost of electricity (LCOE) is highly sensitive to the weighted average cost of capital (WACC). Given typically higher financing costs and utility balance-sheet weaknesses in many African countries, bankable project structures will require sovereign guarantees, robust offtake arrangements, and layered financing from export credit agencies, development finance institutions, and vendor nations. Comparisons with recent large nuclear projects in the United Arab Emirates (UAE) and Egypt underscore the central role of state-backed loans, long tenors, and concessional terms.

Country case studies illustrate a spectrum of readiness and opportunity. South Africa operates two 920 MWe pressurized light water reactors (totaling 1,840 MWe) at Koeberg and has the most mature regulatory and industrial base, positioning it as a prime candidate for both large reactors and SMRs to replace coal, support desalination, and anchor industrial hubs. Egypt is constructing four VVER-1200 units at El Dabaa with strong state leadership and could later complement this fleet with SMRs for coastal and industrial applications. Kenya and Ghana are advancing through IAEA Milestones with growing institutional capacity and clear interest in SMRs that match their smaller grids and industrialization plans. Nigeria has the largest demand potential but faces acute constraints in grid reliability, project bankability, and regulatory capacity; targeted deployments of large reactors and SMRs near coastal or industrial sites could have high impact if accompanied by major grid upgrades and institutional reforms.

The report identifies cross-cutting challenges such as financing, political continuity, public acceptance, nonproliferation and security, waste and back-end management, regulatory capacity, grid adequacy, and long deployment timelines for first-of-a-kind designs, and proposes broad directions for resolution. These include stronger multifaceted financing for nuclear, long-term national energy strategies that transcend electoral cycles, proactive stakeholder engagement, strengthened regional and national regulators, and systematic workforce development through centers of excellence and expanded training.

The United States should develop partnerships with African countries and offer end-to-end nuclear package similar to those used effectively by competitors: coordinated project development, state-backed financing, long-term fuel services, and durable in-country support through regional offices and sustained workforce/regulatory training.

With timely planning, sustained political commitment, and appropriate financing and institutional support, nuclear energy, both large reactors and advanced SMRs, can become a meaningful, though not dominant, pillar of Africa's future power mix, enhancing energy security, enabling industrial growth, and supporting climate goals.

Acknowledgements

The authors would like to thank Dr. Taek K. Kim and Dr. John Stevens for their thoughtful review of this report and for their constructive feedback and insights, which helped strengthen the final document.

Table of Contents

EXECUTIVE SUMMARY I
ACKNOWLEDGEMENTS III
TABLE OF CONTENTS IV
FIGURES V
TABLES V
ACRONYMS 6
1. INTRODUCTION 9
2. SUITABILITY OF ADVANCED NUCLEAR POWER REACTOR TECHNOLOGIES IN AFRICA 12
2.1 TECHNOLOGY REVIEW AND DEVELOPMENT STATUS 13
2.2 EXPECTED SMR COSTS 13
3. ASSESSMENTS OF NUCLEAR POWER REACTOR MARKET POTENTIALS IN DIFFERENT CASE STUDY COUNTRIES 17
3.1 NUCLEAR POWER REACTOR STRATEGIC ASSESSMENT FACTORS 17
3.1.1 Drivers and needs assessment 17
3.1.2 Energy markets 18
3.1.3 National grids 18
3.1.4 Economics and funding models 19
3.2 COUNTRY CASE STUDIES 20
3.2.1 South Africa 22
3.2.2 Egypt 23
3.2.3 Kenya 23
3.2.4 Ghana 24
3.2.5 Nigeria 25
3.3 ENGAGEMENT BETWEEN AFRICAN COUNTRIES AND INTERNATIONAL SMR VENDORS 26
3.4 INTERNATIONAL ENGAGEMENT STRATEGIES IN AFRICAN COUNTRIES 27
3.5 MATCHING NUCLEAR REACTORS TO AFRICAN CONTEXTS 29
4. CHALLENGES AND POTENTIAL RESOLUTIONS 34
5. CONCLUSIONS AND RECOMMENDATIONS 37
BIBLIOGRAPHY 39

Figures

Figure 1. Share of global nuclear energy generation measured in terawatt-hours of annual total electricity produced in the region. 10

Figure 2. Estimated overnight capital costs and levelized cost of energy for 1, 2, and 4-unit plants based on a 300 MWe unit size of SMR for Nigeria in 2025 USD terms 15

Tables

Table 1. Design and status of U.S. large reactor, SMR and microreactor technologies 14

Table 2. Estimated total overnight capital costs for 1, 2, 3 and 4-unit plants based on a 300 MWe unit size of SMR for Nigeria (2025 USD).. 16

Table 3. Selected African countries: population, GDP, annual electricity production and IAEA milestone phase.. 21

Table 4. International engagement strategies in African countries... 30

Table 5. Suitability and readiness of advanced nuclear reactor technologies for African countries... 32

Acronyms

AfCFTA	African Continental Free Trade Area
AFCONE	African Commission on Nuclear Energy
AMR	Advanced Micro Reactor
BRI	Belt and Road Initiatives
BOO	Build, Own, and Operate
BOT	Build, Operate, and Transfer
CERT	Center for Energy Research and Training
CfD	Contract for Differences
CGN	China General Nuclear Power Group
CNNC	China National Nuclear Corporation
DFI	Development Finance Institution
EAPP	Eastern African Power Pool
ECA	Export Credit Agency
ENEC	Emirates Nuclear Energy Corporation
ENRRA	Egyptian Nuclear and Radiological Regulatory Authority
EPC	Engineering, Procurement, and Construction
FIRST	Foundational Infrastructure for Responsible Use of SMR Technology
FOAK	First-of-a-kind
FNRBA	Forum of Nuclear Regulatory Bodies in Africa
GAEC	Ghana Atomic Energy Commission
GDP	Gross Domestic Product
Gen-IV	Generation-IV
HALEU	High-Assay Low Enriched Uranium

HTGR	High-Temperature Gas-cooled Reactor
IAEA	International Atomic Energy Agency
IFNEDA	Integrated Framework for Nuclear Energy Development in Africa
INIR	Integrated Nuclear Infrastructure Review
IPP	Independent Power Producer
IRRS	Integrated Regulatory Review Service
KEPCO	Korea Electric Power Corporation
KHNP	Korea Hydro & Nuclear Power
KNRA	Kenya Nuclear Regulatory Authority
LCOE	Levelized Cost of Energy
LEU	Low Enriched Uranium
LMFR	Liquid Metal Fast Reactor
LWR	Light Water Reactor
MSR	Molten Salt Reactor
NAEC	Nigerian Atomic Energy Commission
NBP	Nuclear Business Platform
NECSA	South African Nuclear Energy Corporation
NEPIO	Nuclear Energy Program Implementing Organization
NEXT	Nuclear Expediting the Energy Transition
NIRR-1	Nigeria Research Reactor
NNR	National Nuclear Regulator
NuPEA	Nuclear Power and Energy Agency
NZW	Net Zero World
OCC	Overnight Capital Cost
OECD-NEA	Nuclear Energy Agency
OPG	Ontario Power Generation

PBMR	Pebble Bed Modular Reactor
PPA	Power Purchase Agreement
PPP	Public Private Partnership
PWR	Pressurized Water Reactor
SAPP	Southern African Power Pool
SMR	Small Modular Reactor
TRISO	Tri-Structural Isotropic
UAE	United Arab Emirates
UCO	Uranium Oxycarbide
UO_2	Uranium Dioxide
USANES	US-Africa Nuclear Energy Summit
U.S. DOE	U.S. Department of Energy
U.S. DOS	U.S. Department of States
U.S. EXIM	U.S. Export Import Bank
U.S. NRC	U.S. Nuclear Regulatory Commission
VVER	Water-Water Energetic Reactor
WACC	Weighted Average Cost of Capital
WAPP	Western African Power Pool

1. Introduction

Africa's energy landscape is defined by rapid growth, persistent gaps in energy access, and increasing commitments to decarbonization and industrialization. Many countries are pursuing diversified power mixes to meet development goals while reducing reliance on fossil fuels, thereby enhancing resilience to supply risks and climate variability [[1] [2] [3] [4]]. In this context, nuclear power is attracting renewed attention as a source of electricity and process heat that can complement variable renewables and strengthen energy security, with the aim of reducing pollution and improving quality of life.

A robust analysis of the feasibility and strategic implications of deploying nuclear power reactors in Africa must be grounded in the continent's diverse starting points. These range from countries with nascent nuclear programs and advanced planning, to those focused primarily on expanding renewables and natural gas, alongside regional integration through power pools and continental development agendas [[5] [6] [7]].

Feasibility spans multiple dimensions. Technical readiness involves grid adequacy and stability, transmission expansion, water availability and siting, and the compatibility of large-scale reactors or small modular reactors (SMRs) with existing system characteristics and demand profiles [[1], [3]]. Institutional and regulatory preparedness is typically assessed against the International Atomic Energy Agency's (IAEA) Milestones approach for newcomer countries, which defines phased development across nineteen nuclear infrastructure issues. IAEA Integrated Nuclear Infrastructure Review (INIR) missions provide peer-reviewed evaluations and guidance [[8], [9]].

Financial viability hinges on cost of capital, risk allocation, sovereign borrowing capacity, the availability of vendor financing, and the chosen financing model: Build, Own, and Operate (BOO); Build, Operate, Transfer (BOT); or Public Private Partnership (PPP). System effects and costs are identified using the broader levelized cost of energy (LCOE) value-adjusted metric in international benchmarks [1] [10]. Safety, security, safeguards, waste management, and public engagement are foundational and supported by adherence to international conventions and regional treaties [[3] [11] [12]].

Strategically, nuclear deployment in Africa has implications for energy security, industrialization, and geopolitics. Stable, reliable, and flexible nuclear generation can reduce dependence on imported fuels, stabilize grids with growing shares of renewables, and enable high-temperature applications such as desalination and hydrogen production, supporting water security and green industrial strategies [[3] [13]]. Regional power pools such as Southern (SAPP), Western (WAPP), and Eastern (EAPP), create opportunities for cross-border trade and optimization of capacity investments, but also require coordinated planning, harmonized regulatory frameworks, and robust transmission infrastructure to realize economies of series and manage system reliability[[5] [6] [7]]. Choices of technology vendors and financing partners influence long-term industrial localization, workforce development, and strategic alignments. Continental priorities articulated in the African Union's Agenda 2063 and initiatives like the African Development Bank's New Deal on Energy for Africa provide relevant policy anchors and development frameworks [[14] [15]].

This study expands on the current state of advanced nuclear technology readiness for deployment in African countries, providing a holistic overview of national commitments, preparedness, and drivers, including challenges to overcome for successful long-term nuclear energy development and realization of energy security and growth on the continent. Recommendations will depend on country-specific conditions and support from both local stakeholders and international organizations.

While traditional large-scale nuclear power plant technologies have operated internationally for more than seven decades, South Africa is the only African country with commercial nuclear power, operating two units of 920 MWe each (totaling 1,840 MWe) at Koeberg near Cape Town since 1984 [16].

Figure 1 illustrates the share of global nuclear energy generation capacity, with Africa accounting for only 0.31% share, mainly from South Africa, based on data from Ember (2025) Energy Institute [17]. However, this narrative is expected to change as Egypt's ongoing construction projects come online, despite some of the challenges detailed in Section 4 of this report.

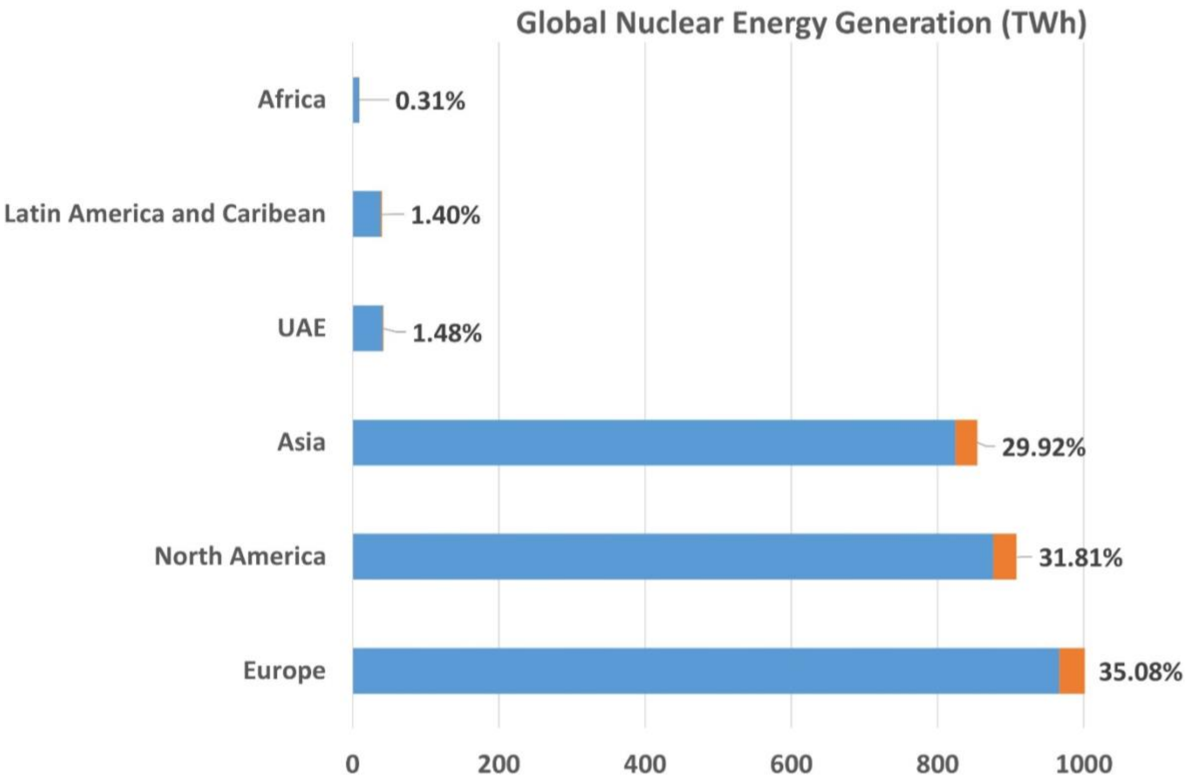

Figure 1. Share of global nuclear energy generation measured in terawatt-hours of annual total electricity produced in the region.

The choice of reactor technology is critical for nuclear power deployment in Africa. Recently, small modular reactor (SMR) technologies have attracted global interest, developing rapidly and drawing significant private and government funding. This momentum has accelerated following the recent U.S. Government Executive Order mandating the accelerated deployment of advanced nuclear reactor technologies within the U.S. and worldwide [18]. In August 2025, the IAEA released the Outlook for Nuclear Energy in Africa as part of its collaboration with South Africa's G20 Presidency. The report outlines nuclear power prospects on the continent and what is needed for nuclear energy to meet Africa's growing demand.

SMRs are increasingly seen as a viable nuclear energy solution for both newcomer and expanding countries in Africa. Of more than 80 global SMR designs under development, nearly one-third originated in the United States [19]. African countries have shifted from reluctance to a more positive stance on adopting nuclear reactors for future energy programs [1]. The Nuclear Business Platform (NBP) reported in its Africa SMR Survey (2022) [20] that Africa is the leading recipient region of the IAEA's INIR, training, and integrated workshops. The survey aims to bridge the gap between SMR developers and end users, accelerate SMR deployment in emerging markets, and help African countries understand regional priorities while providing feedback to refine SMR offerings tailored to the continent's needs. Projected nuclear capacity growth in Africa could expand from a doubling to more than a tenfold increase by 2050 depending on scenarios, with the high case requiring over US$100 billion in investment; nonetheless, nuclear would still represent a modest share of Africa's power mix [20].

This report is organized as follows. Section 2 discusses the suitability of advanced nuclear reactor technologies in Africa, focusing on technology reviews, development status, and expected SMR costs. Section 3 assesses the market potential for nuclear power reactors in selected case-study countries, presenting the status in South Africa, Egypt, Kenya, Ghana, and Nigeria. It also provides information on potential strategies, international engagements, and reactor selection (or alignment). Section 4 discusses challenges and potential solutions for nuclear deployment in Africa. Section 5 presents the report's conclusion.

2. Suitability of Advanced Nuclear Power Reactor Technologies in Africa

Deploying nuclear power in Africa requires careful consideration of reactor size and technology. Options include large-scale reactors, small modular reactors (SMRs), and microreactors. SMRs and microreactors encompass a wide range of technologies, from proven light-water designs to advanced high-temperature gas, molten-salt, or liquid-metal cooled systems. These offer flexible power blocks (e.g., ~120 MWe microreactors, 50–345+ MWe SMRs), enhanced passive safety, and the ability to provide process heat for industrial applications such as desalination, district heating, and hydrogen production.

Selecting the appropriate technology for each African country depends on several factors:

- Grid size and stability
- Cooling water availability
- Industrial heat demand
- Site location and remoteness
- Regulatory capacity
- Fuel supply chains (e.g., Low Enriched Uranium [LEU] at ≤ 5% enrichment versus High-Assay LEU [HALEU] at 5–20% enrichment)
- Financing models
- Deployment timelines

Currently, large reactor units similar to the AP1000 are operational and compatible with South Africa's national grid, while Egypt's VVER units are under construction. Most other African countries are considering SMRs due to their smaller grid sizes and financial constraints.

The 2024 edition of the IAEA Small Modular Reactor (SMR) Technology Catalogue [19] provides a comprehensive overview of advanced SMR designs under development worldwide. It covers key reactor types, including land-based and marine-based light-water reactors (LWRs), high-temperature gas-cooled reactors (HTGRs), liquid metal fast reactors (LMFRs), molten salt reactors (MSRs), microreactors, and floating nuclear power plants.

Recent developments show promise for international collaboration. For example, at the 2024 US-Africa Nuclear Energy Summit in Kenya, an agreement was reached to deploy a NuScale VOYGR-12 SMR plant, and a new Africa-focused nuclear training hub was launched in Ghana [21], signaling strong U.S. partnership in the continent's energy transition. NuScale, the first and only SMR to have its design certified by the U.S. Nuclear Regulatory Commission, is positioning itself to serve diverse customers worldwide, supplying nuclear energy for electricity generation, data centers, district heating, desalination, commercial-scale hydrogen production, and other process heat applications.

This section focuses on U.S. large reactor, SMR, and microreactor technologies and their feasibility for deployment in African countries. Table 1 presents selected technologies from the United States, categorized by reactor type and development status. Apart from NuScale, there has been no recent information about other U.S. SMR designers or vendors actively pursuing African markets.

Therefore, increased international awareness and engagement should be considered for African countries.

2.1 Technology review and development status

Based on the recently available technologies, Table 1 derived from information from [22] and [23], summarizes the choices of advanced large reactors, SMRs, and microreactors suitable for African countries and their development status. This list is not exhaustive and is not meant to exclude specific designs. It includes projects recently selected under the U.S. Department of Energy (DOE) Reactor Pilot Program, authorized by Presidential Executive Order 14301 on the American Nuclear Renaissance [18], which aims to expedite testing of advanced reactor designs for national and international deployment.

With the recent surge in interest in SMRs and the race toward commercialization, near-term deployable candidates within the next 5 to 10 years could be light-water-based SMRs such as NuScale, BWRX-300, and SMR-300, as well as large reactors like the AP1000. Due to the lower readiness of the international supply chain for Gen-IV SMRs compared to LWRs, their deployment in Africa may lag behind light-water-based SMRs. However, ongoing progress in U.S. demonstration projects and associated supply chain development will accelerate deployment.

Gen-IV reactors offer benefits such as inherent safety, higher fuel utilization, and reduced high-level waste volumes, making them attractive options. They are likely to be ready for their first African deployments by the 2030s, with pilot demonstrations occurring earlier where partnerships and supply chains are secured. For countries like South Africa, which already have an established nuclear industry, there may be greater interest in deploying SFR or HTGR technologies rather than PWRs, since the workforce and supply chain are better prepared for such technologies. However, a detailed country feasibility assessment is needed to quantify grid constraints, siting/cooling requirements, fuel logistics, regulatory pathways, and project finance specific to the proposed technology and site. In addition, all 19 infrastructure mandates required by the IAEA to achieve Phase 2 and 3 of the Milestones should be considered essential.

2.2 Expected SMR costs

Based on the approach in [24], projected Overnight Capital Costs (OCC) and Levelized Costs of Energy (LCOE) for SMR projects (300 MWe units) in selected African countries, considering different Weighted Average Costs of Capital (WACC), were modeled. The report provided a range for OCC, the cost of delivering a nuclear power reactor overnight, considering all costs prior to the start of operations, excluding financing costs. For SMRs in modeled countries (including those in Africa), OCC was estimated at $2,750/kWe to $6,250/kWe in 2022 USD terms. These cost ranges are expected for a first commercial offering (following a demonstration project).

Consequently, for a 300 MWe SMR unit, the capital cost per plant would range from a Low-End cost of $825 million (300,000 kWe x $2,750/kWe) to a High-End cost of $1.88 billion (300,000 kWe x $6,250/kWe). These projected costs use U.S. OCC as a reference to estimate cost projections for nuclear energy in different countries and predict that costs can decrease with subsequent additional units or modules due to learning effects (estimated at 8%) and multi-unit deployment savings (associated with shared workforce and infrastructure).

Table 1. Design and status of U.S. large reactor, SMR and microreactor technologies

Design	Output MW(e) (Net unless specified)	Type	Designer	Development Status
Large Reactor				
AP1000	1100	PWR	Westinghouse Electric Company	Commercially deployed
SMRs				
AP300	330	PWR	Westinghouse Electric Company	Basic design
BWRX-300	300	BWR	GE Vernova Hitachi Nuclear Energy	Under construction in Canada
NuScale Power Module	77 (gross)/module up to 12 modules	iPWR	NuScale Power Inc	Standard Design Approval Complete
PWR-100	100	PWR	Last Energy	Detailed design
SMR-300	300	PWR	Holtec International	Conceptual design
Xe-100	80	HTGR	X-Energy LLC	Basic design
IMSR	195	MSR	Terrestrial Energy	Basic design
Natrium	345 (baseload) flexed up to 500	SFR	TerraPower	Final Safety Evaluation for Construction and Environmental Impact Statement Completed
KP-FHR	140	FHR	Kairos Power LLC	HERMES test reactor under construction
Aurora	75	SFR	Oklo Inc	Basic design
Microreactors				
Hadron	2	LWR	Hadron Energy	Principal design
Kaleidos	1	HTGR	Radiant	Conceptual design
DFBR-1	15	PWR	Deep Fission	Basic design
Aalo-1	10	Sodium cooled	Aalo Atomics	Basic design
R1	500 kWt	SFR	Antares Nuclear	Basic design
VIPR	15 MWt	PWR	Atomic Alchemy	Basic design
MSRR	1 MWt	MSR	Natura Resources	Basic design
Ward 250	100 (kWt)	HTGR	Valar Atomics	Basic design

LCOE is heavily influenced by WACC, which is typically higher in emerging economies than in advanced ones. LCOE includes OCC, operation and maintenance (O&M, both fixed and variable), fuel, and decommissioning costs, all levelized over the plant's lifetime. Higher WACC increases financing costs, which form a major part of the LCOE for capital-intensive projects like nuclear plants. SMR LCOEs can vary significantly, with some optimistic manufacturer estimates around $58/MWh (which is low), while other studies suggest median LCOEs starting at $116/MWh, or even higher for specific designs. The specific LCOE depends on the chosen WACC, capacity factor, operational costs, and the plant's economic life.

Figure 2 and Table 2 illustrate the estimated total overnight capital costs for 1, 2, and 4-unit plants in Nigeria, with a projection for the escalation factor from 2022 to 2025, based on a 300 MWe unit size. There is a significant cost reduction for deploying 4 units of the same SMR, with base-case LCOE (and 9% WACC) reduced from $125/MWh for 1 unit to $87/MWh for 4 units.

While these values represent costs for a first commercial offering (also referenced as "between of a kind" in [24]) for OCC and LCOE only, total project costs do not include a detailed cost estimate for any specific reactor type listed in Table 1. Including financing and O&M costs can significantly increase total costs, especially with longer construction times, inflation rates, and high WACC (those effects are captured as part of the LCOE estimate).

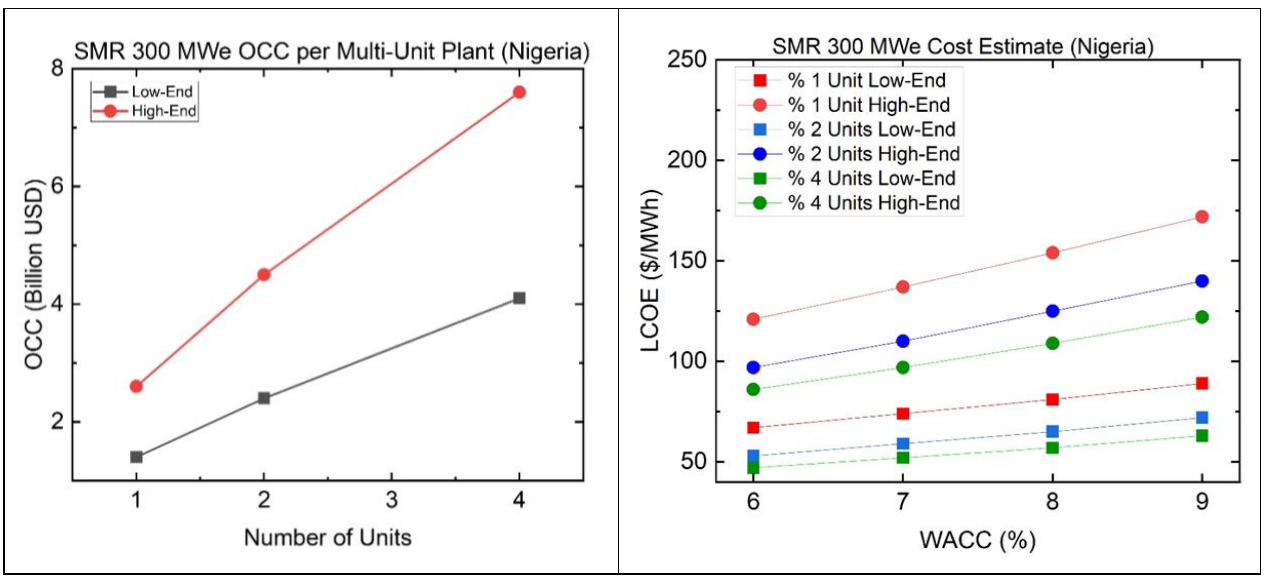

Figure 2. Estimated overnight capital costs and levelized cost of energy for 1, 2, and 4-unit plants based on a 300 MWe unit size of SMR for Nigeria in 2025 USD terms

Table 2. Estimated total overnight capital costs for 1, 2, 3 and 4-unit plants based on a 300 MWe unit size of SMR for Nigeria (2025 USD)

Number of Units / Modules in the Plant	Total Capacity (MWe)	Low-End Total OCC (approx. USD billions)	High-End Total OCC (approx. USD billions)
1 unit	300	1.4	2.6
2 units	600	2.4	4.5
3 units	900	3.5	6.6
4 units	1200	4.1	7.6

As an indication of reactor cost and financing, we reference here two recently completed and ongoing projects. The UAE's Barakah Nuclear Energy Plant project, with four units of APR1400 (totaling 5.6 GW) that costs approximately 24.4 billion USD [25] (OCC of $4,350/kWe), was financed through a combination of debt and equity commitments by the Barakah One Project Joint Venture Company (shared between ENEC and KEPCO), direct loans from the Government of Abu Dhabi and Korea EXIM, and five local and international commercial banks. The recent experience in Africa comes from the ongoing construction of four VVER 1,200 MW units (totaling 4.8 GW) at El Dabaa, Egypt, which costs approximately 30 billion USD (OCC of $6,250/kWe), and is financed through a unique arrangement of a 25 billion USD Russian loan, with the remainder covered by the Egyptian government.

3. Assessments of Nuclear Power Reactor Market Potentials in Different Case Study Countries

Momentum is building worldwide as nations recognize the potential of nuclear energy for energy security and industrial competitiveness. African countries are not left out of this trend, but when can we expect nuclear energy deployment to peak on the continent? This is a billion-dollar question that requires energy forecasting, infrastructure development, and long-term government commitment and implementation. Several African countries have shown growing interest in developing nuclear energy to diversify the continent's energy mix and support sustainable economic development. The list includes Ghana, Kenya, Nigeria, Senegal, Niger, Ethiopia, Morocco, Algeria, Tunisia, Namibia, Rwanda, Uganda, Zambia, Egypt, and South Africa, as well as more than 13 countries in the pre-phase 1 stage of the IAEA Milestone Approach [26]. The International Atomic Energy Agency (IAEA) has pledged support to help African countries develop safe and sustainable nuclear programs, emphasizing Africa's critical role in the global clean energy future [26].

3.1 Nuclear power reactor strategic assessment factors

Energy is the backbone of development in all sectors, including agriculture, health, socio-economics, and livelihoods. Thus, adding nuclear power to a country's energy system offers many potential economic benefits. Beyond providing a stable baseload electricity supply, nuclear energy can drive industrial and infrastructure development, job creation, and increases in gross domestic product (GDP). This section highlights the foundational features necessary for the realization of nuclear power.

3.1.1 Drivers and needs assessment

As part of the IAEA's pre-feasibility study to assess the suitability of nuclear energy for aspiring countries, components that can be incorporated into a country's comprehensive report include technological assessments, needs assessments, and energy analyses. Here are the main motivating factors for nuclear energy, whether large reactors, SMRs, or microreactors, across Africa, depending on the robustness of each country's national grid system.

Rapid demand growth and reliability needs, driven by fast population growth and urbanization, are pushing up power demand as countries strive to close large electricity access gaps. Therefore, a reliable, round-the-clock energy supply is required to support modern services and reduce reliance on costly diesel backup due to frequent outages and blackouts. According to the African Union's Agenda 2063, economic development and industrialization goals require national policies that focus on sustainable power for manufacturing, mining, mineral processing, metals refining, oil and gas production, fertilizer production, and heavy transport electrification. Nuclear energy can provide both electricity and high-temperature process heat to support energy-intensive industries and special economic zones.

In terms of energy security and price volatility, exposure to imported fuel price shocks and supply disruptions, even for countries with domestic gas or oil, has heightened interest in diversifying the power mix. Nuclear energy offers stable fuel costs over long operating lifetimes. While large reactors could be a favorable option for some African countries, as currently seen in Egypt and in response to growing demand in Nigeria, SMRs are also attractive. SMRs are well-suited to smaller grids, as they come in modular units with small capacities that better match many African grids and can serve remote or off-grid applications (such as mines, islands, petrochemicals, agriculture, and industrial parks) where diesel use is prevalent. SMRs and microreactors can also complement renewables by providing stable capacity that reduces curtailment and integrates variable solar and wind. Efficient application of large-scale nuclear energy, beyond electricity, with co-generation enables desalination and industrial steam, valuable in water-stressed regions and urbanizing corridors, potentially improving overall system efficiency and resilience.

3.1.2 Energy markets

African power systems are growing steadily but remain capital-constrained, fragmented, and challenged by reliability issues, with many national grids below 5–10 GW peak and heavy dependence on diesel for both backup and remote supply. A large power reactor such as an AP1000 may be suitable for some African countries. However, due to initial capital cost considerations, SMRs might be more attractive and have been selected by some countries. Their smaller unit sizes and modular build-out can better match limited grid absorption and reliability criteria. They can provide a firm baseload that complements the increasing penetration of solar and wind. In regions linked by the Southern, Eastern, and West African Power Pools, SMRs could be sited near demand centers or resource projects and sell surplus energy into cross-border markets via Power Purchase Agreements (PPAs). Designs that offer load-following, high-temperature process heat, or microreactor-scale outputs could displace costly diesel use in mines (e.g., Ghana, Nigeria), support coastal desalination (e.g., Egypt, South Africa, Ghana, Nigeria), or underpin green hydrogen and ammonia hubs, provided water use and cooling constraints are managed (including by dry or hybrid cooling options).

3.1.3 National grids

African electricity grids are characterized by rapid demand growth alongside persistent access and reliability gaps. Apart from a few large systems in the north and south of the continent, most national grids are small (often below a few gigawatts peak), with constrained transmission backbones and high technical and commercial losses. Generation mixes vary widely: coal-heavy in South Africa, gas-dominant in parts of North and West Africa, and hydro-reliant in several East and Central African countries, while many systems still depend on costly diesel or heavy fuel oil. Utility finances are typically fragile due to non-cost-reflective tariffs, arrears, and high losses, which in turn limit maintenance and expansion. Reliability challenges manifest as recurring load shedding, grid collapse, and voltage instability, prompting extensive use of behind-the-meter diesel generators and captive power by industries and commercial customers. Climate variability adds further stress, with droughts reducing hydro output and heatwaves elevating demand and derating thermal plants and lines.

At the same time, the grids are steadily evolving. Large-scale solar and wind are expanding through competitive procurement in countries like South Africa, Morocco, Egypt, and beyond, while commercial and industrial rooftop solar and mini-grids expand access in weak-grid and off-grid areas.

Grid integration and infrastructure readiness are prominent topics in vendor–country engagement. Many African grids are relatively small and must consider system adequacy, stability, and transmission and distribution planning when adding a large reactor (on the order of 1.0 GW) or a 300 MWe unit of SMR. This might lead to interest in diversified deployment concepts such as clustering multiple SMR modules near industrial hubs, pairing nuclear with renewables to stabilize variable output, and exploring microreactors or smaller advanced units for remote mining or desalination where grid connections are limited.

Here are the typical electricity capacity ranges found across African systems:

- South Africa: installed capacity 60–70 GW, peak demand 28–35 GW.
- Egypt: installed capacity 60–70 GW, peak demand 30–35 GW.
- Kenya: installed capacity 3–4 GW, peak demand 2.1–2.5 GW.
- Ghana: installed capacity 5–6 GW, peak demand roughly 3.5–4 GW in recent years.
- Nigeria: installed capacity 13–14 GW, available generation typically 4–6 GW (varies with gas supply and outages).

3.1.4 Economics and funding models

For African countries to move from pledges to implementation in the deployment of large reactors and SMRs, concrete funding models must be in place with international lenders such as the World Bank, Export-Import Banks, and International Development Banks. The core bankability challenges are high upfront capital, utility creditworthiness, currency risk, and back-end liabilities. Mitigation typically requires sovereign guarantees, take-or-pay Power Purchase Agreements (PPAs), and multilayered political risk cover. Such financing models could be in the form of structured Build-Own-Operate (BOO), Build-Operate-Transfer (BOT), or Public Private Partnership (PPP) with Export Credit Agency (ECA) support (e.g., US EXIM).

PPP is becoming increasingly viable with international development finance institutions such as the World Bank [27] and the European Bank for Reconstruction and Development, which are more willing to fund nuclear energy projects, as announced through the IAEA G20 and OECD-Nuclear Energy Agency (NEA) meetings held recently [28]. In addition, an Engineering, Procurement, and Construction (EPC) project integrates financing from Export Credit Agencies (ECAs) to support the export of goods and services from a country. ECAs provide loans, credit insurance, or guarantees to reduce the risks for the exporter or foreign buyer, enabling large, capital-intensive projects by bridging financing gaps and making projects more competitive. This support can involve direct loans, refinancing, or interest-rate support for the projects.

Contract for Differences (CfDs) or regulated asset base models can also be used where appropriate. A CfD is a derivative financial agreement between a buyer and seller in which they exchange the difference in the price of an underlying asset between the time the contract is opened and closed. Traders speculate on price movements, aiming to profit from price increases (going long) or decreases (going short), without owning the asset itself.

In any case, financing remains a key issue, and joint funding arrangements for both Western developers and African buyers should be a focal point. To enter the African nuclear reactor market, the United States could work with its allies to help co-develop and co-finance nuclear energy project deployments in Africa by providing attractive financing vehicles similar to those provided by Russia to Egypt for the El Dabaa construction.

3.2 Country case studies

While many African countries have indicated their interest in adding nuclear power to their energy mix, this report focuses on five countries as case studies, based on progress made in achieving IAEA Phase 2 and 3 milestones, where preparatory work for the contracting, construction, and operation of a nuclear power plant has been fulfilled. These countries are South Africa, Egypt, Kenya, Ghana, and Nigeria. For comparison, Table 3 lists selected African countries with their approximate population, gross domestic product (GDP, nominal), and electricity production capacity, using data primarily from 2022–2024 sources [27], [29].

A recent suggestion from [30] presents the Integrated Framework for Nuclear Energy Development in Africa (IFNEDA), designed to make nuclear power feasible, safe, and context-appropriate across the continent. Its financing mixes could lower the initial capital needs of SMRs by 30% to 40% via risk-sharing and hybrid funding.

South Africa recently announced plans to expand its nuclear energy capacity to 12 GW by 2050, in addition to reviving the PBMR project, as indicated in the 2025 Integrated Resource Plan (IRP 2025), to stabilize the grid, reduce coal dependence, and meet growing electricity demand [31]. This proactive plan will support South Africa's industrial sectors, such as mining, which relies heavily on coal, by providing access to clean energy from nuclear power plants.

In Egypt, there is a theoretical surplus of generation capacity; however, challenges with fuel supply (natural gas) and aging transmission infrastructure have historically led to power cuts, particularly during peak summer months when demand for air conditioning surges. Once the ongoing construction at El Dabaa is completed, together with the expansion of grid interconnections, more energy will be available for export to neighboring countries.

Kenya has significant reserve capacity when all plants are operational, but the actual available capacity can be lower due to maintenance and transmission losses. The country has indicated a national priority for projected nuclear energy expansion up to 10 GW by 2038.

Ghana has a substantial installed capacity that theoretically exceeds its current peak demand, but operational capacity is often limited by challenges such as fuel supply issues, transmission bottlenecks, and seasonal variation in water levels for hydropower.

Nigeria's highest recorded peak electricity generation stands at approximately 5.8 GW, achieved in March 2025. The total installed capacity is higher, at approximately 13.4 GW, though only a fraction is typically available for dispatch due to operational constraints. The Transmission Company of Nigeria (TCN) has a transmission potential of approximately 8.1 GW, indicating that infrastructure upgrades are needed to handle higher loads.

Based on reported energy per capita and the country's population growth, it is suggested that South Africa, Ghana, and Nigeria may require up to 20 GW of added nuclear capacity (which could be met with large reactors or many SMRs) to overcome severe energy poverty that impedes the continent's economic growth and industrial development [32].

Table 3. Selected African countries: population, GDP, annual electricity production and IAEA milestone phase

Country	Population (Millions, 2024 est.)	Gross Domestic Product (GDP) Nominal 2024 est. USD Billion)	Annual Electricity Generation (TWh 2024)	Average Electricity Generation per Year (GW, 2024)	Energy Per Capita Electricity (kWh/Year, 2024)	Peak Energy Demand (GW)	Largest existing power plant on the grid (MW)	Grid Capacity (GW)	Industrial Energy Use (TWh/yr) & (% of Total Energy)	Estimated Nuclear Power Growth by 2050 (GWe) [1]	IAEA Milestone Phase
South Africa	64	6,253	244.8	27.9	3,835	34.7	4,800 (Coal)	58	250 (40%)	10	Operating
Egypt	116	3,338	235.4	26.9	2,020	39.4	4,800 (Natural Gas)	59	170 (26.5%)	2	Under Construction
Kenya	53	2,206	12.8	1.5	228	2.41	310 (Wind)	3.3	~3.4 (12%)	2	Phase 2
Ghana	35	2,406	24.3	2.8	718	4.13	1,020 (Hydro)	5.1	8.2 (18.6%)	4	Phase 2
Nigeria	237	807	40.1	4.6	172	5.8	1,320 (Natural Gas)	13.4	26 (14.5%)	8	Phase 2

[1] Based on the Africa Energy Chamber report on the State of African Energy 2025 Growth forecast [32].

3.2.1 South Africa

Currently, South Africa is the only African country with an operational commercial nuclear power plant, centered at the Koeberg Nuclear Power Station near Cape Town. Koeberg consists of two pressurized water reactors (PWRs) supplying about 3% of the country's electricity, with a total capacity of 1,840 MWe, and is operated by ESKOM Holdings. The nation has a well-established nuclear regulatory framework, overseen by the National Nuclear Regulator (NNR), and infrastructure managed by the South African Nuclear Energy Corporation (NECSA). The country aims to expand its nuclear capacity to support energy security and foster industrial development, while balancing economic and environmental considerations. However, progress on new large-scale nuclear plants has been delayed by financial, political, and policy challenges, leading to increased interest in small modular reactors (SMRs) as flexible, scalable options for future deployment. South Africa is also seeking international partnerships with BRICS countries to enhance its nuclear capabilities.

South Africa's ambitious plans include expanding its nuclear energy capacity by 10 GW over the next 10 to 15 years, restarting its pebble bed modular reactor (PBMR) program, which was closed by the government in September 2010, and re-establishing a full domestic nuclear fuel cycle [31].

The country has recently extended the life of the existing Koeberg plant to 60 years (i.e., through 2044) and its 20 MW Safari research reactor, while developing new multi-purpose research reactors for medical isotope production.

On the technical side, South Africa is developing a 10 MW(t)/3 MW(e) modular reactor called the Advanced Micro Reactor (AMR), which falls under the category of High-Temperature Gas-Cooled Reactors (HTGRs). The AMR uses helium as the coolant and graphite as the moderator, with fuel assemblies containing TRISO-coated particles using uranium dioxide (UO_2) or uranium oxycarbide (UCO) ceramic fuel kernels enriched between 10 wt% and 19.9 wt%. The AMR aims for inherent safety without requiring active safety systems or operator intervention to prevent fuel damage. This design supports passive decay heat removal and xenon oscillation damping, contributing to operational stability. The development involves collaboration between STL Nuclear (Pty) Ltd., the University of Pretoria, North-West University, and NECSA. Another design by Stratek Global in South Africa is the High Temperature Modular Reactor (HTMR-100) SMR, which was initiated in 2012, with the basic design phase completed in 2022 [33]. Licensing and demonstration phases are ongoing, though exact dates and timelines are undisclosed. Overall, South Africa's SMR projects are progressing steadily from early design stages toward licensing and demonstration, with a strong emphasis on passive safety and modularity to support flexible deployment.

<u>Country Assessment:</u> High feasibility (mid-2030s onward)

- Drivers: Coal retirements, reliability needs with a large, relatively strong grid (~45–60 GW installed), strong National Nuclear Regulator (NNR), and operating experience (Koeberg).
- Economics: Strongest case in Africa for advanced passive AP1000 and 100–300+ MWe SMRs at sites for coal plant replacements and coastal desalination or industrial hubs. Potential to leverage domestic manufacturing and series build to drive costs down. Financing via sovereign-backed PPP/CfD and export credit risk cover is plausible given institutional capacity.

- Risks: Eskom's electricity balance sheet, policy consistency, and procurement governance, though reforms are ongoing.

3.2.2 Egypt

Egypt has been actively developing its nuclear energy program primarily through the construction of the El Dabaa Nuclear Power Plant, a large-scale Gen-III nuclear power reactor supplied by Russia's Rosatom. The El Dabaa plant, located on the Mediterranean coast, is planned to have four VVER-1200 pressurized water reactors with a total capacity of about 4,800 MW. This project marks Egypt's first foray into commercial nuclear power generation, aimed at diversifying its energy mix and meeting growing electricity demand. Construction officially began in 2021 after years of preparatory work, including site selection, environmental assessments, and regulatory approvals. The plant is expected to contribute significantly to Egypt's electricity grid once operational, with the first unit anticipated to come online in the late 2020s or early 2030s [34]. The project also includes the development of local nuclear infrastructure, workforce training, and regulatory framework enhancement to support safe and sustainable nuclear operations.

Beyond El Dabaa, Egypt has expressed interest in exploring advanced nuclear technologies such as small modular reactors (SMRs) for future applications, particularly for remote areas or industrial uses, but no concrete SMR projects or deployments have been publicly reported yet.

Egypt's nuclear regulatory framework is overseen by the Egyptian Nuclear and Radiological Regulatory Authority (ENRRA), which ensures compliance with international safety standards set by the International Atomic Energy Agency (IAEA). ENRRA is responsible for licensing, inspection, and enforcement related to nuclear facilities, including El Dabaa. The country has been strengthening its regulatory capabilities through training and collaboration with international partners to support safe nuclear power deployment. Egypt is also investing in physical infrastructure such as research reactors, fuel cycle facilities, and waste management systems to support the full lifecycle of nuclear power generation.

Country Assessment: High feasibility (complementary SMRs post-El Dabaa)

- Drivers: Ongoing large nuclear build (El Dabaa 4x1200 MWe), strong state capacity, coastal desalination potential, and industrial growth.
- Economics: Large, advanced reactors such as AP1000, as well as SMRs (100–300 MWe), could economically support desalination/hydrogen clusters, free domestic gas for export, and diversify supply. Sovereign credit and state-led procurement enhance bankability through familiar vendor financing models.
- Risks: Opportunity cost versus cheap domestic gas in the near term.

3.2.3 Kenya

Based on the recently concluded Integrated Regulatory Review Service (IRRS) mission in October 2025, an International Atomic Energy Agency (IAEA) team of experts observed a strong commitment to nuclear and radiation safety in Kenya, reflected in its legal and regulatory framework upheld by the Kenya Nuclear Regulatory Authority (KNRA) [35]. The team also encouraged further enhancements, including the development of a national policy and strategy for safety to align more closely with IAEA safety standards.

Kenya has been exploring the development of nuclear energy to diversify its energy mix and support growing electricity demand. The country has shown interest in SMRs as potentially suitable technology due to their scalability and lower upfront costs compared to large reactors. Kenya's nuclear energy ambitions are part of broader efforts in East Africa to develop peaceful nuclear energy capabilities for power generation, industrial use, and regional energy security. The government has engaged with international partners and regulatory bodies to build capacity, establish regulatory frameworks, and assess feasibility, but commercial deployment is still in early stages with no operational nuclear plants yet. However, Kenya has establishments that use radiation sources across medical, research and industrial sectors. Kenya is also preparing to establish its first nuclear research reactor which was reviewed by the IAEA in 2024 and is envisaged to serve as a key facility for nuclear science education, training and research.

Country Assessment: Medium feasibility (late-2030s)

- Drivers: Industrialization, data centers, and coastal desalination, with an established Independent Power Producer (IPP) market and active nuclear newcomer program through Kenya's Nuclear Power and Energy Agency (NuPEA) and Kenya Nuclear Regulatory Authority (KNRA).
- Economics: Funding is feasible with national government backing together with reasonable international loan agreements with financial institutions such as the World Bank. Phased SMR modules less than or equal to 300 MWe to respect grid constraints. Geothermal remains the least cost, while SMRs would target firm capacity for industrial parks/coastal water and provide system flexibility with renewables.
- Risks: Tariff affordability, newcomer regulatory capacity, and project bankability versus cheaper geothermal/renewable energies for competitiveness.

3.2.4 Ghana

Ghana's nuclear energy development is primarily driven by the need to diversify its energy sources, enhance energy security, and support economic growth. The Ghana Atomic Energy Commission (GAEC) spearheads the country's nuclear program, focusing on establishing a regulatory framework, building technical capacity, and developing infrastructure necessary for safe nuclear power deployment. Ghana has engaged with international organizations like the International Atomic Energy Agency (IAEA) to receive guidance on best practices, safety standards, and training. The country signed a commercial agreement in 2024 [21] based on its particular interest in small modular reactors (SMRs), as their smaller size and modular nature align well with Ghana's grid capacity and financial resources compared to large traditional reactors. SMRs offer flexibility for incremental capacity additions and can be deployed in remote or off-grid areas, which suits some of Ghana's regional energy needs. Ghana has also been active in signing bilateral agreements and participating in international cooperation initiatives to facilitate technology transfer, financing, and knowledge sharing. These efforts include exploring partnerships with countries experienced in nuclear technology to accelerate project readiness.

While Ghana is considered an emerging nuclear newcomer, it has no commercial nuclear power plant but has operated a research reactor since 1994 which is used for medical, agricultural and environmental radiation research. The existing Graduate School of Nuclear and Allied Sciences, devoted to training both undergraduate and postgraduate students in nuclear techniques and applications, has been very successful over the years with students from other African countries enrolled in the program. Ghana is progressing through the IAEA milestones with preparatory phases such as feasibility studies, site selection, and workforce development. The government recognizes that successful nuclear deployment will require sustained investment, public engagement, and adherence to stringent safety and environmental standards.

Ghana's energy needs continue to grow. In 2025, projected electricity consumption is estimated to reach 25,836 GWh, representing a 4.7% increase in demand year-on-year. Hydro, thermal, and renewables constitute Ghana's electricity generation mix. Installed generation capacity, excluding embedded capacity as of November 2024, was 5,260 MW, with a total dependable capacity of 4,856 MW. Thermal generation accounts for 66% of Ghana's power generation, and hydro accounts for 33%. Ghana's thermal power generation is fueled largely by natural gas but occasionally uses light crude oil and diesel. Ghana exports power to neighboring countries such as Togo, Benin, and Burkina Faso.

Country Assessment: Medium feasibility (late-2030s–2040s)

- Drivers: Energy transition to support industrialization, energy security, and contribution to national GDP. Interregional access through the power pool to neighboring countries. The United States supports and engages through the establishment of the NuScale Energy and Exploration (E2) Centre and related services at the Ghana Atomic Energy Commission (GAEC) to drive workforce training and development in nuclear power plant operations.
- Economics: 80–300 MWe modules can anchor industrial parks/desalination with sovereign PPAs and multilateral financing.
- Risks: Grid size (limiting the size of its largest load), utility finances, and exchange rate risk.

3.2.5 Nigeria

The Nigerian Atomic Energy Commission (NAEC) oversees nuclear energy development. The commission was established in 1976 and funds the Center for Energy Research and Training (CERT) in Zaria, which hosts the Nigeria Research Reactor (NIRR-1). This is a miniature neutron source reactor with a thermal power of 30 kilowatts which has been in operation since February 2004 primarily for nuclear activation analysis, geochronology and postgraduate training. The country aims to build its first nuclear power plant to address chronic power shortages and reduce reliance on fossil fuels. However, challenges include financing, infrastructure development, regulatory capacity, and public acceptance. Nigeria is also focused on developing human capital and regulatory frameworks aligned with international safety standards to support safe and sustainable nuclear energy deployment.

Nigeria's energy crisis remains one of the most pressing constraints on its economic growth. Despite an installed generation capacity of about 13 gigawatts, the national grid delivers barely 4 gigawatts to more than 200 million citizens. Frequent blackouts and outdated infrastructure have pushed many factories, businesses, and households to rely on self-generated power from diesel and gas generators. The resulting operational costs have constrained productivity, raised inflationary pressures, and diminished competitiveness in the manufacturing sector. Most recently, Nigeria is in discussions with the Export-Import Bank of China (EximBank) for funding a $2 billion super grid project to address its ongoing grid collapse [36]. This initiative aims to expand Nigeria's electricity capacity and reliability.

To achieve its future energy plans, Nigeria's proactive efforts need to include massive, large-scale nuclear reactor deployment as a strategic component of its long-term energy policy aimed at diversifying the national electricity generation mix, enhancing energy security, and supporting sustainable economic growth. Meanwhile, an announcement made during the 2022 Nigerian International Energy Summit in Abuja [37] proposed the addition of four large reactors (up to 4.0 GWe) into the energy mix, but the newly elected government cancelled the process later in 2024.

Country Assessment: Mixed feasibility, with advanced large reactor units such as AP1000 as well as SMRs in medium-term deployment for limited applications.

- Drivers: Nigeria has a large market but chronic generation shortfalls affecting industrial loads with opportunities for coastal desalination and industrial hubs such as refineries.
- Economics: Bankability is challenging due to utility creditworthiness, exchange rate risk, and grid constraints. SMR modules around 300 MWe could be feasible in shorter term at coastal industrial hubs with government guarantees and PPP or ECA financing. Large reactors should be an attractive power addition in the longer-term.
- Risks: Grid reliability, regulatory capacity, security, and instability in the Naira foreign exchange rate undermine nuclear economics unless mitigated.

3.3 Engagement between African countries and international SMR vendors

Engagements between African countries, foreign governments, and international vendors on small modular reactor (SMR) deployment are active but remain largely in exploratory and preparatory phases. In 2024, the United States built on ongoing nuclear cooperation and signed an agreement with Ghana under the Department of State's Foundational Infrastructure for the Responsible Use of Small Modular Reactor Technology (FIRST) Program. This initiative is helping Ghana establish itself as an SMR regional hub and center of excellence in Africa.

Many African governments see SMRs as a potential complement to renewables and hydropower. Interest is driven by industrialization goals and reliability needs, alongside the recognition that large gigawatt-scale nuclear plants may be challenging for smaller grid systems or remote regions. Vendors from the United States, South Korea, Europe, Russia, and China are engaging African counterparts with technology briefings, feasibility studies, and training offers, while multilateral bodies such as the IAEA support capacity building and the Milestones Approach for newcomer countries.

The level of engagement varies widely across the continent. Countries with established nuclear institutions, such as South Africa, which has long experience through the Koeberg power plants and prior modular reactor work, are examining SMRs for grid support, industrial loads, and mining operations. Nations developing first-time nuclear programs (e.g., Ghana, Kenya, Nigeria, Morocco, and others) are advancing policy frameworks, regulatory capacity, and workforce development, often under IAEA guidance, and using vendor dialogue to understand technology options, siting constraints, and lifecycle responsibilities.

Egypt's current construction of a large-scale plant with Rosatom underscores that conventional large nuclear power plants remain part of Africa's energy mix. Although SMRs are being considered in parallel by several countries, most engagements remain at the memorandum of understanding (MOU), scoping study, and institutional strengthening stages, rather than near-term deployment commitments.

International vendors are keen to position their offerings for African contexts by highlighting modular construction, the potential for phased additions, and co-generation uses. However, the pathway to first-of-a-kind (FOAK) SMR projects in Africa is shaped by financing and risk allocation, regulatory readiness, and the maturity of the technology. Securing bankable structures is a central hurdle, as multilateral development banks have generally been cautious about nuclear power, placing greater emphasis on export credit agencies, vendor-backed models (e.g., BOO/BOT), sovereign guarantees, and industrial offtakers as potential anchors.

Regulatory frameworks will need to evolve to license SMRs efficiently, drawing on international experience, harmonized standards, and collaboration through networks such as the Forum of Nuclear Regulatory Bodies in Africa (FNRBA). Engagement often includes discussions on fuel leasing, waste management strategies, and long-term stewardship that align with nonproliferation obligations under the Pelindaba Treaty and oversight by AFCONE and the IAEA.

Workforce development and supply-chain localization are integral to these discussions, with vendors and partner governments offering scholarships, training programs, and technical exchanges to build operational, regulatory, and safety competencies.

Overall, engagement is accelerating but remains cautious, paced by the global commercialization of SMRs and the need for demonstrator plants to operate successfully and de-risk the technology. Over the next five to ten years, progress on licensing and first deployments in vendor countries and early adopters will strongly influence African timelines, financing appetite, and regulatory confidence. In the interim, African governments and international vendors are laying the groundwork through policy design, institutional capacity building, feasibility analyses, and partnership frameworks. They are positioning SMRs as a potential tool within broader national strategies for reliable, resilient, and low-carbon energy growth.

3.4 International engagement strategies in African countries

Africa’s only active nuclear power plant at Koeberg was built by the French group Areva (now Framatome) in the early 1980s with government financial backing. In recent years, however, South Africa has sought partnerships with other countries in its quest for additional nuclear power.

Russia’s state nuclear corporation, Rosatom, already has active nuclear sector agreements with at least twenty-three African countries and holds about half of the global export market for new nuclear plants [38].

Its primary focus is on large-scale nuclear power plants and floating power units. As part of its strategic approach, Russia often provides sales packages that include high-percentage state-backed loans—up to 85% of nuclear reactor construction financing. In addition, Russia offers long-term fuel supply, nuclear waste repatriation, and focused nuclear technology training programs, securing decades of influence with African countries. Headquartered in Moscow, Rosatom has an international footprint with offices and projects close to its customers, including locations in Cape Town (South Africa), Cairo (Egypt), Dubai (UAE), Rio de Janeiro (Brazil), Central Asia, and Europe.

China’s engagement in African countries, primarily through the China National Nuclear Corporation (CNNC) and China General Nuclear Power Group (CGN), focuses on SMRs and pebble bed modular reactors (PBMRs). These state-owned nuclear power companies are aggressively expanding their “green” Belt and Road Initiatives in many African countries, emphasizing training and infrastructure development for nuclear-related projects. China’s influence extends to large-scale student scholarship programs, particularly for training African personnel at Chinese nuclear universities and technical institutions. CNNC and CGN merged their separate Gen-III reactor designs (ACPR1000 and ACP1000) into the standardized Hualong One, creating a joint venture (Hualong International) to market it globally [39]. While both Chinese companies focus on domestic power generation, they also compete and collaborate on global expansion, forming alliances to export their advanced nuclear technology and secure international projects in Africa. As of today, China has exported a total of six nuclear power units, five research reactors, and subcritical facilities to seven countries worldwide [40]. To further build global market influence, CNNC has seven global offices: Vienna, Austria for the European market, Riyadh, Saudi Arabia for the Middle East market, Moscow, for Russia and the Central Asian market, Abuja, Nigeria for the African market, Buenos Aires, Argentina for the Americas, Islamabad, Pakistan for Asia, and Perth for Australia and New Zealand. China's export policy now emphasizes high-tech products, including nuclear technology, using direct investment and diplomatic platforms such as the Belt and Road Initiative (BRI), BRICS, ASEAN-China, and the China-Africa summit [39].

South Korea's engagements under the Korea Electric Power Corporation (KEPCO) and Korea Hydro & Nuclear Power) (KHNP) oversees major nuclear projects, including the recent UAE's Barakah nuclear power plant. Their primary focus is on advanced large reactors (APR1400), iSMRs, and technical training as part of strategic international expansion. South Korea is positioned as a "democratic alternative" to Russian and Chinese influences. They offer financial support through a $14 billion pledge of export financing to support its businesses, including nuclear firms, operating across Africa [41]. A significant portion of Africa's nuclear regulatory and engineering staff has been trained in South Korea, creating long-term connections that Seoul leverages to win future contracts [42].

The United States, through the Department of Energy (DOE) and Department of State (DOS), has focused primarily on SMRs in Africa. In 2025, the U.S. positioned itself as a strategic alternative by championing SMR technology and strengthening regulatory frameworks across Africa. Rather than funding massive construction projects, the U.S. approach emphasizes private-sector commercial deals, supported by capacity-building programs like FIRST (Foundational Infrastructure for Responsible Use of SMR Technology) and the Nuclear Expediting the Energy Transition (NEXT) programs in Ghana, Kenya, Nigeria, and Rwanda [43]. The U.S. DOE organized the first US-Africa Nuclear Energy Summit (USANES) in 2024 in Accra, Ghana, signaling the country's interest in nuclear technology partnerships with African countries.

Although Russia and China have an early presence and greater visibility in Africa, African nations increasingly recognize the importance of long-term, reliable partnerships to achieve energy security. This environment is favorable to the U.S., especially if U.S. technologies can be deployed in a timely manner. However, growing Chinese presence and geopolitical competition with Russia and South Korea may make it more difficult for the U.S. to expand its nuclear technology footprint in Africa if U.S. engagement is perceived as inconsistent. For example, the U.S.–South Africa agreement for nuclear fuel and equipment, which Koeberg Unit 1 relied on, expired in 2022 without renewal [44].

The U.S. government and vendors should take action to compete in global nuclear markets by promoting cooperation in the U.S.–Africa nuclear power sector. U.S. vendors should collaborate to develop business strategies tailored to Africa. The U.S. government should work with allied development banks to co-develop and co-finance nuclear reactor exports to Africa. Additionally, the U.S. and its African partners should make better use of existing tools, such as the African Continental Free Trade Area (AfCFTA) and Power Africa. Flexibility in U.S. nuclear export control and policy would help enable more nuclear business agreements with African countries. U.S.

partnerships should emphasize systematic nuclear engineering training to build local expertise and foster future collaborations.

A summary of international engagement strategies, trade-offs, perceived strengths, and weaknesses is presented in Table 4.

3.5 *Matching nuclear reactors to African contexts*

With the current grid systems in Africa, the deployment of nuclear reactors may require upgrades to grid infrastructure, including transmission and distribution capacity, to mitigate the risks associated with power loss due to transmission and the impact of unplanned reactor outages on the grid. One important consideration for deploying nuclear reactors in African countries is the availability of cooling water, especially in the Sub-Saharan region, where water can be scarce throughout much of the year. In such cases, technologies like the Xe-100 and other dry-cooling reactor designs could be suitable (most SMR technologies can be deployed with various cooling methods, each with different water requirements and environmental impacts). These technologies can also be adapted for use in industrial parks, particularly in the cement, fertilizer, hydrogen, and oil and gas industries.

In addition, most African countries are endowed with critical mineral resources such as gold, uranium, diamonds, phosphates, platinum, lithium, and rare earth elements used for high-technology storage batteries, which can be mined off-grid in many remote areas. In these cases, the deployment of microreactors such as the eVinci, which can be shipped by cargo vessel and installed on-site, could be considered. Regarding fuel supply, many advanced nuclear technologies require High-Assay Low Enriched Uranium (HALEU), which necessitates a high level of IAEA nuclear security and safeguards. In this context, light water reactors (LWRs) such as NuScale, which have demonstrated regulatory advancement in Africa, could be considered for near-term deployment.

Based on the country information summarized in Table 3, for example, in Nigeria, the industrial sector consumes approximately 14.5% of total energy, with about 7,278 GWh (26,200 terajoules) of electricity annually. The residential sector is the largest overall energy consumer, mainly due to the use of traditional biomass. However, out of the 13.4 GW installed capacity, only about 5.8 GW, roughly 38%, is available for dispatch due to grid constraints, maintenance issues, gas supply shortages, and transmission bottlenecks. The actual unserved electricity demand in Nigeria is widely considered to be substantially higher than the current peak generation value, as many large industries and citizens rely on private, off-grid generators (estimated at an additional 6.5 GW capacity) to meet their needs due to the weak grid. If these concurrent problems are to be solved nationally, the deployment of large nuclear power plants (NPPs), such as eight units of the AP1000, would be the best option for integrated nuclear power, to be followed by further expansions. Such deployment of large nuclear units, however, would require significant upgrades to the national grid.

The nuclear generating capacity envisaged in Africa is expected to increase from the current 0.95% to 3.5% of total electricity by 2050. In this scenario, South Africa and Egypt are projected to jointly lead the continent's power generation mix, each with a nuclear share of nearly 20% by 2050 [32]. This will include a combination of large power reactor units of approximately 1.0 GWe and SMRs. Table 5 provides a summary of most of the United States designs forecasted for deployment in Africa, along with their potential suitability and matching market needs in the country case studies.

Table 4. International engagement strategies in African countries

Country (Key Actors)	Nuclear tech offer in Africa	Engagement tools	Financing approach	Capacity building	Notable presence	African country preference	Trade-offs for African countries	Perceived strengths	Weaknesses for Africa
Russia (Rosatom)	Large-scale NPPs; floating power units	Bundled offering: build + fuel + waste repatriation + training	Often offers high-percentage state-backed loans	Training programs aligned with long-term operations/ support	Agreements with ~23 African countries; international offices include Cape Town, Cairo, Dubai	Ability to proceed without waiting for deep domestic capital, markets "single counterparty" turnkey delivery; long-term fuel/services commitments	Potential long-term debt exposure; reliance on a single vendor for fuel/services; less flexibility to diversify suppliers over plant lifetime	Integrated, end-to-end package; strong export experience and project delivery model; financing as a strategic enabler	Vendor dependence/lock-in (fuel, services, waste arrangements); heightened geopolitical sensitivity and potential exposure to external shocks (sanctions/ finance access)
China (CNNC, CGN)	SMRs and PBMRs; export of Hualong One (large PWR)	Infrastructure-linked engagement; Belt-and-Road-style platforms; diplomacy (BRI/BRICS/ China-Africa summit)	Leans on direct investment + state-linked financing mechanisms	Scholarships /training in Chinese institutions	CNNC offices in Abuja, Vienna, Riyadh, Moscow, etc.; exports 6 power units, 5 research reactors, globally	Package can align nuclear with broader infrastructure development; large-scale training pipeline; multiple engagement channels beyond energy ministry	Risk of projects being tied to broader geopolitical/ economic packages; technology/ standards alignment and long-term O&M arrangements may reduce multi-vendor flexibility	Strong scaling capacity; coordinated state support; ability to couple technology export with workforce development	Potential dependency on Chinese supply chains and financing; competition/ overlap between CNNC/CGN can complicate counterpart selection; geopolitical competition may affect perceptions

Country (Key Actors)	Nuclear tech offer in Africa	Engagement tools	Financing approach	Capacity building	Notable presence	African country preference	Trade-offs for African countries	Perceived strengths	Weaknesses for Africa
South Korea (KEPCO, KHNP)	APR1400 large reactors; iSMRs; training-heavy partnerships	Export-oriented partnerships framed as “democratic alternative”	~$14B export financing pledge to support Korean businesses including nuclear	Training of African regulatory/ engineering staff	Credibility example cited: Barakah (UAE)	Preference for a partner perceived as lower geopolitical risk; proven recent delivery reference; strong emphasis on skills transfer	Financing scale may be smaller than Russia/China for some projects; fewer entrenched Africa nuclear supply-chain links	Reputation for project execution and standardization; training as a relationship-builder	Potential limited local ecosystem initially (parts, experienced local contractors); may still require strong host-country readiness for procurement, QA, and regulation
United States (private vendors)	Primarily SMRs and AP1000; regulatory frameworks and enabling environment	Capacity-building + convening; support for private-sector commercial deals; programs FIRST and NEXT	Less emphasis on state-funded megaprojects; more on enabling investment and deals	Training/ technical assistance embedded in FIRST/ NEXT-style efforts	USANES 2024 (Accra); example continuity issue: U.S.–South Africa fuel/ equipment agreement expired in 2022	Appeal of strong regulatory/ governance approach; potential access to advanced SMR ecosystem and high assurance standards; diversification away from Russia/China	Deal pace may be slower if reliant on private finance; host countries may need higher readiness (regulatory, bankability, grid/off-taker strength)	Strong institutional capacity-building; emphasis on safety/security/ regulatory alignment; potential technology leadership if deployments mature	Perceived inconsistency/ continuity risk; policy/export-control constraints; may offer less “turnkey” financing than competitors, increasing burden on host-country project finance and risk allocation

Table 5. Suitability and readiness of advanced nuclear reactor technologies for African countries

SMR Design	Deployment target	Attributes	Mapping and suitability	Considerations
AP1000	Already constructed in several countries	In operation in the U.S. and China, and projects planned in Europe and India; LEU fuel	South Africa, Egypt and Nigeria scale based on needs assessment, population and demand growth	Vogtle NPP is operating in Georgia, USA
NuScale Power Module **(iPWR,77 MWe/module)**	Near term (not specified) Up to Twelve Units per site	NRC-certified design; passive safety; flexible multi-module sizing; LEU fuel.	Good for 300–900+ MWe in 4–12 modules; grid-friendly blocks for South Africa, Egypt, Ghana, Kenya and Nigeria.	Vendor pursuing new deployments studies in Romania and USA. Received NRC design certification.
GE Vernova Hitachi BWRX-300 (BWR~300 MWe)	2029-2033 (Canada or TVA) With Four Units per site	Simplified BWR leveraging ESBWR; first-of-a-kind at OPG Darlington; passive features; LEU;	Suitable for larger grids in 2-4 modules for South Africa, Egypt, Kenya, Ghana and Nigeria, noting that single 300 MWe may be greater than 10% of smaller grids.	On track for FOAK operation in early 2030 in Canada and USA
Holtec SMR 300 (iPWR, 300 MWe)	2030 (Palisades) With Two Units per site	Option for dry/air cooling , LEU fuel;	Similar to BWRX-300	Pre-licensing in multiple jurisdictions underway; deployment expected by early 2030s in USA.
Westinghouse AP300 (PWR, 300 MWe)	2033 (Community Nuclear Power, UK) Up to Four Units per site	Downscaled AP1000 technology; a proven passive safety system; LEU fuel; construction/operating experience basis	Similar to BWRX-300	FOAK targeted early 2030s; standard large reactor systems adapted to smaller block
X-energy Xe 100 (80 MWe/module)	2030 (Texas)	Process heat/hydrogen; air cooled heat rejection options; inherent safety via TRISO fuel; load flexibility; high	Similar to NuScale. May also be especially suitable to provide process heat to industrial	Requires HALEU TRISO; FOAK under US DOE

SMR Design	Deployment target	Attributes	Mapping and suitability	Considerations
	With Four Units per site	temperature process heat (565ºC); HALEU fuel	clusters (cement, steel, fertilizer) in Nigeria, Ghana and South Africa.	ARDP; early 2030s operation
KP-FHR 100 (FHR, Hermes demo leading to 140 MWe	2028 (Hermes, Oak Ridge) With Dual-unit configuration per site	Fluoride-Salt-cooled high temperature with HALEU TRISO fuel; high temperature process heat (650ºC)	Same as Xe-100.	Demo under construction
TerraPower Natrium (SFR with thermal storage, 345 MWe)	2031 (Kemmerer) With Single Units per site	Coupled molten salt storage for flexible output; high temperature process heat (540ºC); HALEU fuel	Same as Xe-100.	FOAK under construction, early 2030s operation
Westinghouse eVinci (heat pipe microreactor, 5–13+ MWe)	2029 (Saskatchewan, Canada) With Single Units per site	Factory built, rapid deployment, minimal balance of plant, transportable; off grid operations; long refueling.	Remote mining and industrial parks isolated towns, disaster resilience in Nigeria, Ghana, Kenya	NRC pre application; demonstration targets by late 2020s
Oklo (sodium fast microreactor, 15MWe /75 MWe)	2028 (Idaho National Laboratory) With Single Units per site	Micro scale, long core life; off grid loads	Remote industrial sites and smart microgrids in Nigeria, Ghana, Kenya	Licensing pathway evolving; HALEU; schedule subject to regulatory progress

4. Challenges and Potential Resolutions

Africa faces a substantial energy gap, with approximately 600 million of its 1.5 billion people lacking access to electricity, and the continent remains heavily dependent on fossil fuels. Despite recent ambitions and growing interest among African countries to deploy nuclear energy, using both large reactors and SMR technologies, this transition is expected to face significant challenges. From the vendor or designer's perspective, the leap from prototype to commercialization carries enormous execution risks, particularly regarding deployment timelines and budgets. The U.S. nuclear industry would thrive with strong state support, rather than leaving private vendors to compete against international vendors with state-backed financing. While SMRs promise to overcome many hurdles through standardization and modular manufacturing, their effectiveness remains to be demonstrated.

Broadly, the following challenges and potential resolutions are anticipated for the deployment of nuclear power reactors in Africa:

a) **Financing**
Challenge: Based on the recently concluded COP30 climate conference in Brazil, the OECD/NEA organized a webinar on unlocking climate finance for nuclear energy in emerging economies. Senior executives from African institutions stated that the missing link for nuclear projects in developing countries is access to affordable financing. Thus, financing new nuclear facilities remains one of the toughest challenges.
Potential Resolution: Multilateral cooperation with institutions such as the World Bank, African regional banks, and credible financing models will be essential to bridge financial gaps. This can be achieved through collective learning, public trust, and equitable access to finance. Africa also needs energy off-takers to reduce nuclear project financing risks.

b) Political Risks
Challenge: Key questions remain: What is the plan if there is a change in political leadership or party after a 4- to 5-year government term? What are the next steps for vendor companies or operators regarding legal backing for financial arrangements made before a leadership change? Are there influences from the country's colonial history affecting vendor or bid consideration? Honest answers and long-term commitments are needed for nuclear power deployment to be achievable.
Potential Resolution: A solid long-term project commitment, backed by sound energy policy, should be implemented to ensure continuity. Political stability measures should be a component of any credible policy.

c) Social Acceptance
Challenge: Most African countries have limited public information and awareness about the beneficial applications of nuclear technology, while local opposition groups often amplify concerns about nuclear waste and safety.
Potential Resolution: For successful nuclear deployment, governments should establish active stakeholder engagement with municipal leaders and councils in areas being considered for nuclear reactor siting. Participation in spatial planning, local radio programs, and demystification of nuclear fears through public debate, especially involving youth, would help the Nuclear Energy Program Implementing Organization (NEPIO) gain support through transparency and openness.

d) Nonproliferation, Security, and Safeguards
Challenge: Although major African member states have implemented the Pelindaba Treaty, enforcing these treaties during cross-border conflicts remains challenging and increases risks for nuclear nations. Examples include incidents following the collapse of the Soviet Union and, more recently, the Zaporizhzhia NPP in Ukraine, where the United Nations' seven indispensable pillars for nuclear safety, security, and safeguards during armed conflict were not upheld. What are the

implications for neighboring countries experiencing civil unrest, insurgency, or conflict in terms of nuclear plant safety and security?

Potential Resolution: Nations with high-risk facilities, their neighbors, and the international community should uphold international agreements regarding the safety and security of nuclear facilities.

e) **Workforce Development**

Challenge: Nuclear energy is a long-term endeavor; even with the BOO approach, a domestic workforce is required for knowledge transfer and eventual operator independence. This brings socio-economic benefits to local communities, increasing social expectations and improving the country's economic outlook.

Potential Resolution: Skill transfer agreements for local scientists, engineers, and technicians are critical. Joint efforts among governments, utilities, industry, academia, and international partners should focus on creating centers of excellence in nuclear science education and training as part of talent development.

f) **Back-End Risk (Waste Management)**

Challenge: The risk of managing nuclear waste is a major factor used against nuclear energy worldwide, including in emerging African countries.

Potential Resolution: If implemented, Russia's offer to take back spent nuclear fuel from African countries for reprocessing would mitigate this risk for purchasers of nuclear technology. The United States could also consider revising its SMR technology export policy to offer attractive waste management solutions to interested African countries. Once the back-end risk is managed by the vendor, technology importers will have less difficulty convincing their citizens.

g) **Regulatory and Institutional Capacity**

Challenge: Most emerging countries still need to develop skilled regulatory capacity to support streamlined regulatory policy for the protection of people and the environment.
Potential Resolution: Expertise from Egypt and South Africa's nuclear regulatory commissions, as well as the IAEA, should be shared among African nuclear newcomers. International collaboration between the U.S. NRC and African regulatory organizations, through training, MOUs, and sharing best practices, should be encouraged.

h) **Continuous Research and Development**

Challenge: Nuclear energy cooperation is long-term, requiring collaboration from licensing to construction, operation, and decommissioning. Each stage requires ongoing research and development for sustainability.

Potential Resolution: Governments, utilities, industry, academia, international organizations (such as the IAEA), and advanced nuclear vendors should work together to create centers of excellence in nuclear science education and training. This will build institutional capacity and workforce expertise in areas such as physical security, cybersecurity, nuclear material accounting and control, operational safety and performance, decontamination technologies, and environmental protection. Multinational partnerships, often facilitated by the IAEA, can effectively address these needs.

i) **Deployment Timelines (FOAK Schedules and Costs)**

Challenge: Currently, the overnight capital cost per power level for a first-of-a-kind (FOAK) advanced SMR is higher than for large reactors. This may delay deployment in Africa, as countries may wait for demonstrated cost reductions before committing to SMR projects.
Potential Resolution: Demonstration projects for advanced reactors should be an immediate action item for U.S. SMR technologies to reduce technology risks and aid African countries in design selection. Deploying multiple SMRs in Africa can reduce average NPP costs through learning effects, as discussed in Section 2.2.

j) **Stable Grids with Transmission and Distribution Efficiency**

Challenge: As highlighted in Section 3, most country case studies face grid constraints and uneven reliability in electricity distribution.

Potential Resolution: Infrastructure upgrades to national grids, including suitable transmission and distribution lines, are essential before adding nuclear to the energy mix.

While these challenges are generic, detailed analysis should be conducted on a country-by-country and regional basis in future studies.

Lessons learned from South Africa's PBMR project, where government funding for R&D was halted in 2010, should be shared with other countries. Priority should be given to public-private partnerships to ensure successful project completion. Within Africa, South Africa has the most mature regulator (NNR), supply chain experience, and an IRP that contemplates 5.2 GW of new nuclear capacity alongside Koeberg's life extension. Other newcomer countries like Kenya, Ghana, and Nigeria should leverage this expertise. In line with a recent announcement [31], South Africa is seeking to participate in the entire nuclear fuel cycle and is considering partnerships with neighboring countries for uranium enrichment as reactor fuel.

Based on ongoing large-scale nuclear power construction in Egypt, continuous dedication, long-term commitment, and determination should be considered as key lessons from Egypt's successful entry into nuclear power. Egypt has invested heavily in grid upgrades and workforce development, including established nuclear research and development centers.

5. Conclusions and Recommendations

This study has evaluated the feasibility and strategic implications of deploying nuclear power plants in Africa. The report discussed advanced nuclear reactor technologies that may be suitable for emerging nuclear countries on the continent. Technology timelines and estimated costs were also addressed. An assessment of nuclear reactor market potential was conducted, focusing on drivers and needs assessment, energy markets, national grids, economics and funding models, and international engagements. Five countries, South Africa, Egypt, Kenya, Ghana, and Nigeria, were presented as case studies. The challenges and resolution pathways for nuclear deployment were also discussed.

It was found that the most crucial challenges hindering the deployment of nuclear power reactors are funding, the availability of a skilled workforce, the presence of fully developed national regulators, and weak national grid systems across African regions. Based on these identified challenges, suitable resolution pathways were suggested. It is important to note that this was a cursory study of the topic, and a more in-depth study could be conducted in the future for country-specific strategies.

Regarding U.S. international engagement with African countries, perceived policy variability and continuity risks, along with constraints related to policy and export controls and less "turnkey" financing compared with some competitors, may increase the burden on host-country project financing and complicate risk allocation.

Recommendations

The ability to match nuclear reactors to each country's market requires detailed analysis, including information about the expected energy capacity each country needs to deploy in the coming decades (for example, projections or forecasts for 2050), as well as the percentage of this capacity expected to come from nuclear power generation. Such detailed analysis is recommended for future studies to capture countries' short- and long-term goals for growth, development, and deployment of nuclear reactors.

As interest and commitment grow in African countries for the deployment of nuclear energy, both large reactors and small modular reactors, it is important that decision-makers and policymakers learn from both delays and success stories in other African countries, such as South Africa and Egypt, as well as from international key players in nuclear technology. Countries that export nuclear technology should collaborate with importing countries to identify components that can be manufactured locally and to train the workforce. For example, local steel manufacturing companies, uranium suppliers, and other local civil, manufacturing, ceramic, and mining industries needed for the construction of new nuclear builds should work together with the vendor company to support the domestic workforce.

Although some countries' energy demand favors SMRs in the near term, especially when cost is considered, long-term growth in population, industry, and interconnectors could justify larger reactors. Above all, the potential for nuclear reactors, large NPPs, SMRs, and microreactors, as promising technologies for the continent's energy transition in the coming years should be considered a promising venture.

The United States could benefit from drawing on approaches used by other countries to develop partnerships anchored in an end-to-end "nuclear offer" that competitors have deployed effectively, such as coordinated project development, state-backed financing, long-term fuel services, and durable in-country support through regional offices and sustained workforce and regulatory training. To remain competitive with Russia, China, and South Korea, this package could be delivered through multi-decade agreements and a more predictable, streamlined export policy, leveraging U.S. vendors alongside development banks and platforms such as Power Africa and the African Continental Free Trade Area (AfCFTA) to help move from capacity-building toward timely, bankable deployments.

The nuclear renaissance has ushered in the development of various advanced reactor designs with inherent safety, new fuel designs, innovations in the supply chain, and advanced manufacturing such as 3D printing, as well as powerful hyperscale computing for high-order magnitude simulation. All these aspects work together to enable a new nuclear era and achieve energy abundance in Africa.

Bibliography

[1] International Energy Agency (IEA), "Africa Energy Outlook," 2022. [Online]. Available: https://www.iea.org/reports/africa-energy-outlook-2022.

[2] IEA, IRENA, UNSD, World Bank, WHO, "Tracking SDG7: The Energy Progress Report 2024," https://www.irena.org/Publications/2024/May/Tracking-SDG7-The-Energy-Progress-Report-2024, 2024.

[3] International Atomic Energy Agency (IAEA), "Climate Change and Nuclear Power," https://www.iaea.org/publications, 2023.

[4] World Nuclear Association (WNA) , "Emerging nuclear energy countries: Africa," https://world-nuclear.org/information-library/country-profiles/others/emerging-nuclear-energy-countries#africax, 2025.

[5] Southern African Power Pool (SAPP), [Online]. Available: https://www.sapp.co.zw.

[6] West African Power Pool (WAPP), [Online]. Available: https://www.ecowapp.org.

[7] Eastern Africa Power Pool (EAPP), [Online]. Available: https://www.eappool.org.

[8] IAEA Nuclear Energy Series NG-G-3.1 (Rev. 1), " Milestones in the Development of a National Infrastructure for Nuclear Power," 2015.

[9] IAEA, "Integrated Nuclear Infrastructure Review (INIR)," IAEA, Vienna, 2020.

[10] IEA and OECD Nuclear Energy Agency (NEA), "Projected Costs of Generating Electricity," https://www.iea.org/reports/projected-costs-of-generating-electricity-2020, 2020.

[11] IAEA, "Convention on Nuclear Safety; Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Managementt," https://www.iaea.org/topics/nuclear-safety, 2001.

[12] African Union, African Nuclear Weapon Free Zone Treaty (Treaty of Pelindaba), https://au.int/en/treaties/african-nuclear-weapon-free-zone-treaty, 2009.

[13] IAEA,, "Nonelectric Applications of Nuclear Energy (process heat, hydrogen, desalination)," [Online]. Available: https://www.iaea.org/topics/non-electric-applications.

[14] African Union, "Agenda 2063: The Africa We Want.," https://au.int/en/agenda2063, 2013.

[15] African Development Bank (AfDB), "Sustainable energy fund for Africa," https://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/sustainable-energy-fund-for-africa, 2013.

[16] World Nuclear Association, [Online]. Available: https://world-nuclear.org/information-library/country-profiles/countries-o-s/south-africa.

[17] Data sources: Ember (2025) Energy Institute - Statistical Review of World Energy (2025) – with major processing by Our World in Data Via Our World In Data (OWID), [Online]. Available: https://ourworldindata.org/nuclear-energy.

[18] M. Goff, "9 Key Takeaways from President Trump's Executive Orders on Nuclear Energy," Department of Energy, [Online]. Available: https://www.energy.gov/ne/articles/9-key-takeaways-president-trumps-executive-orders-nuclear-energy.

[19] IAEA Small Modular Reactors Catalogue 2024, IAEA, 2025.

[20] Nuclear Business Platform, "Nuclear's Next Big Play: Early Investment in Africa and Newcomer Markets," [Online]. Available: https://www.nuclearbusiness-platform.com/media/insights/early-investment-in-nuclear-africa.

[21] 2024, US-Africa Nuclear Energy Summit, August 2024. [Online]. Available: https://usanes.org/.

[22] U.S. NRC, "Pre-Application Activities for Advanced Reactors," [Online]. Available: https://www.nrc.gov/reactors/new-reactors/advanced/who-were-working-with/pre-application-activities.

[23] U.S. DOE, "U.S. Department of Energy Reactor Pilot Program," [Online]. Available: https://www.energy.gov/ne/us-department-energy-reactor-pilot-program.

[24] L. M. Larsen, N. Guaita, I. Lantgios, J. Zhou, A. Abou-Jaoude and N. Stauff, "Nuclear Energy Cost Estimates for Net Zero World Initiative - 2024 update," Idaho National Laboratory. INL/RPT-24-80552, 2024.

[25] World Nuclear Association, [Online]. Available: https://world-nuclear.org/information-library/country-profiles/countries-t-z/united-arab-emirates.

[26] IAEA, "legal-support-to-nuclear-newcomer-countries-in-africa," [Online]. Available: https://www.iaea.org/newscenter/news/legal-support-to-nuclear-newcomer-countries-in-africa.

[27] World Bank, "The 2024 GDP per capital (in USD) for selected African countries," [Online]. Available:

https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=A9&most_recent_year_desc=false.

[28] IAEA, Nuclear Energy in Focus at the G20 in South Africa, [Online]. Available: https://www.iaea.org/newscenter/news/nuclear-energy-in-focus-at-the-g20-in-south-africa.

[29] IEA, "Total electricity production in Africa 2023," [Online]. Available: https://www.iea.org/regions/africa/energy-mix. [Accessed 30 November 2025].

[30] S. Gawusu, S. K. Debrah, S. T. Moomin, S. A. Jamatutu, E. D. Miensah, . R. A. Mensah, O. Das, M. Abubakar, X. Zhang, I. Ackah, S. J. Adams and A. A. Amadu, "Nuclear energy in Africa: Challenges and pathways to sustainable development," *Sustainable Energy Technologies and Assessments,* vol. 82, no. 104489, 2025.

[31] South African Department of Electricity and Energy, "Integrated Resource Plan (IRP-2025)," Johannesburg, 2025.

[32] African Energy Chanber, "The State of African Energy: 2025 Outlook Report," 2025.

[33] Stratek Global Advanced Energy Solutions, [Online]. Available: https://stratekglobal.com/htmr-100/.

[34] World Nuclear News, "Presidents launch El Dabaa reactor pressure vessel installation," 19 November 2025. [Online]. Available: https://www.world-nuclear-news.org/articles/presidents-launch-installation-of-el-dabaa-reactor-pressure-vessel.

[35] IAEA, IAEA Mission Finds Comprehensive Regulatory Framework for Nuclear and Radiation Safety in Kenya, October 2025. [Online]. Available: https://www.iaea.org/newscenter/pressreleases/iaea-mission-finds-comprehensive-regulatory-framework-for-nuclear-and-radiation-safety-in-kenya.

[36] Business Insider Africa, "Nigeria turns to China for a new $2 billion loan to rebuild ailing power grid," October 2025. [Online]. Available: https://africa.businessinsider.com/local/markets/nigeria-turns-to-china-for-a-new-dollar2-billion-loan-to-rebuild-ailing-power-grid/b84t1hr.

[37] World Nuclear News, 18 March 2022. [Online]. Available: https://www.world-nuclear-news.org/articles/nigeria-moving-ahead-on%C2%A0nuclear-power-plant-plan.

[38] World Nuclear Association, [Online]. Available: https://world-nuclear.org/Information-Library/Country-Profiles/Countries-O-S/Russia-Nuclear-Power.

[39] Nuclear Engineering International, 11 December 2025. [Online]. Available: https://www.neimagazine.com/analysis/chinas-step-onto-the-global-stage/?cf-view.

[40] World Nuclear Association, [Online]. Available: https://world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.

[41] Ministry of Foreign Affairs, Republic of Korea, "Joint Declaration 2024 Korea-Africa Summit," 2024.

[42] ANS Nuclear Newwire, 8 April 2014. [Online]. Available: https://www.ans.org/news/article-1545/kenyas-studied-approach-to-a-nuclear-future/.

[43] America Enterprise Institute, "Unleashing US Nuclear Energy in Africa Is Good for Business, Bad for China and Russia," 2025.

[44] U.S. DOE, [Online]. Available: https://www.energy.gov/node/4812839#:~:text=The%20Agreement%20for%20Cooperation%20between%20the%20United,control%20*%20Nuclear%20safeguards%20*%20Nuclear%20security.

[45] IPCC, AR6 Working Group III, "Mitigation of Climate Change (Summary for Policymakers)," https://www.ipcc.ch/report/ar6/wg3/.

[46] NECSA, [Online]. Available: https://www.necsa.co.za/2025/02/17/south-africa-seeks-new-nuclear-allies-in-russia-and-iran-as-u-s-influence-fades/.

Nuclear Science and Engineering Division
Argonne National Laboratory
9700 South Cass Avenue, Bldg. 208
Argonne, IL 60439