Sustainable Nuclear Energy in Nigeria: Addressing Challenges and Bridging Knowledge Gaps

Dennis Solomon BALAMI*
Department of Physics, University of Maiduguri
Email: dennisbalami@unimaid.edu.ng

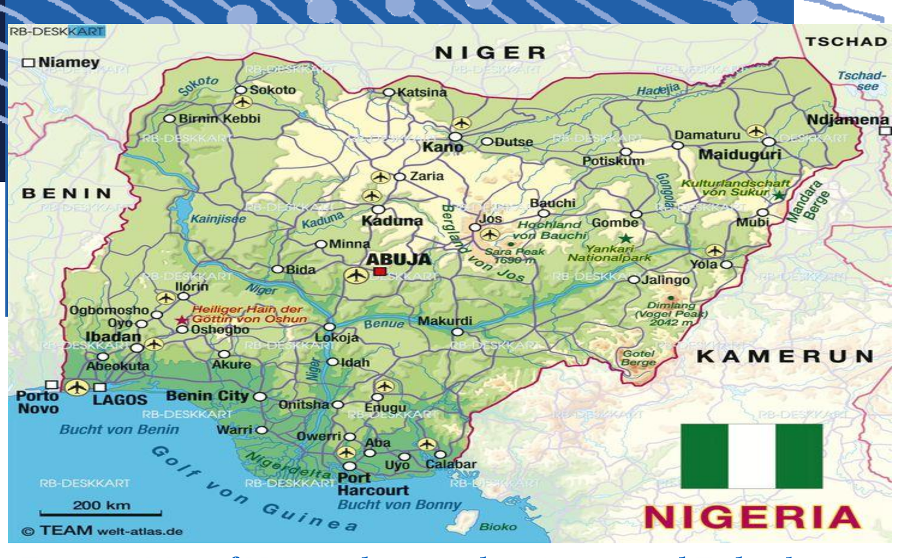


Figure 1., Map of Nigeria showing the 36 states and Federal Capital

Introduction

Nigeria faces a significant energy deficit hindering its economic growth. Nuclear energy offers a potential solution for clean and reliable electricity generation.

Energy Situation in Nigeria

- Current Energy Deficit: Major obstacle to development.
- Hydropower: Provides some baseload generation.
- Need for Diversified Energy Mix: High power density, low greenhouse gas emissions, and fuel security of nuclear energy.

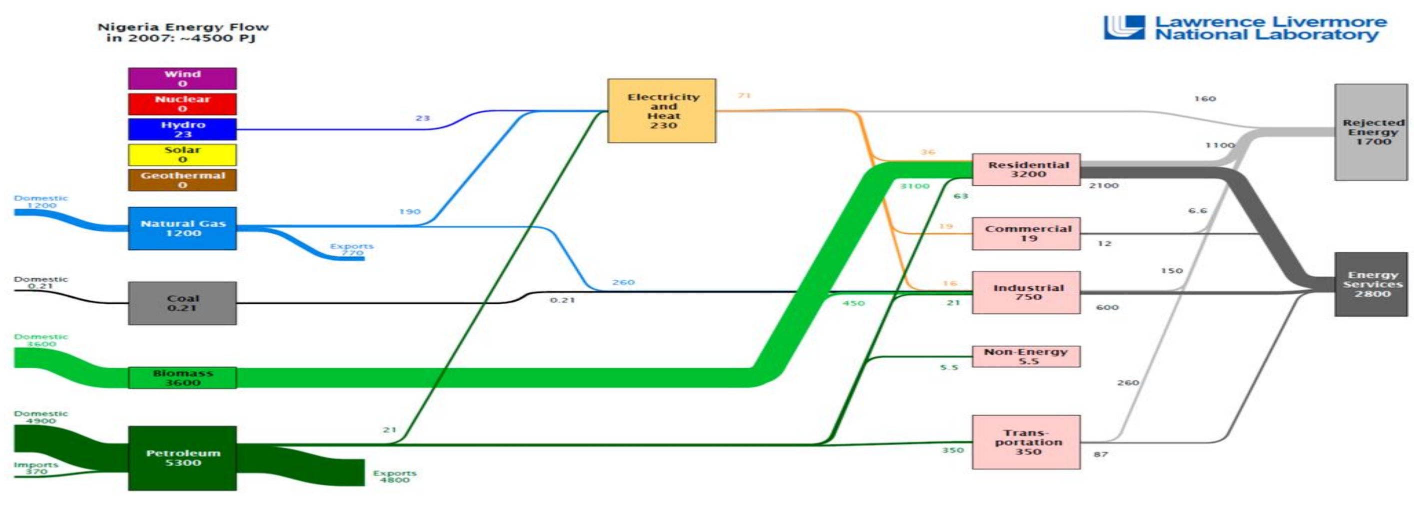


Figure 2. The Nigerian energy flow

Nigerian Energy Flow

- Petroleum (Crude Oil): Most extracted and exported energy resource.
- Biomass: Most commonly used energy source in rural homes.
- Natural Gas: Primarily used for electricity generation.

Need for Nuclear Energy

- Energy Security: Nuclear energy offers a stable and reliable energy source with fewer supply density.
- Environmental Benefits: Low greenhouse gas emissions compared to fossil fuels.
- Fuel Security: Nuclear fuel provides a long-term energy solution with fewer supply chain disruptions.

Edomah *et al.*, 2016 and Smith *et al.*, 2011

SWOT Analysis of Nigeria's Nuclear Energy Preparedness (Ishola *et al.*, 2019)

- Objective: Evaluate Nigeria's readiness for nuclear energy to ensure a sustainable regime.
- Method: Conducted strategic interviews to identify Key Performance Indicators (KPIs) and militating factors. A SWOT analysis was performed using global standards and best practices.

Ishola *et al.*, 2019

Action Points

- Regular evaluation and improvement of nuclear policies.
- Invest in research and development.
- Enhance border monitoring and intelligence security operations.
- Focus on capacity building to overcome technological and safety challenges.

By leveraging strengths and opportunities while addressing weaknesses and threats, Nigeria can pave the way for a sustainable nuclear energy future.

Figure 3: SWOT Analysis of Nigeria's Nuclear Energy Preparedness (Ishola *et al.*, 2019)

Human Resource Development and Needs Analysis for Nuclear Power Plant Deployment in Nigeria (Egieya *et al.*, 2022)

- Context: Nigeria aims to integrate electricity generation from nuclear power plants (NPP) by 2027 to combat its severe electricity shortages.
- Importance: A sustainable electricity supply is essential for economic development, and robust human resource development (HRD) programs are critical for NPP implementation.

Description of the NPHR Tool

- The Nuclear Power Human Resource (NPHR) model is a tool provided by the International Atomic Energy Agency (IAEA) to assist member states in planning human resource development for nuclear power plants (NPP).
- The NPHR modeling tool thus provides a comprehensive framework for assessing and planning the human resource needs critical for the successful implementation and operation of nuclear power plants.

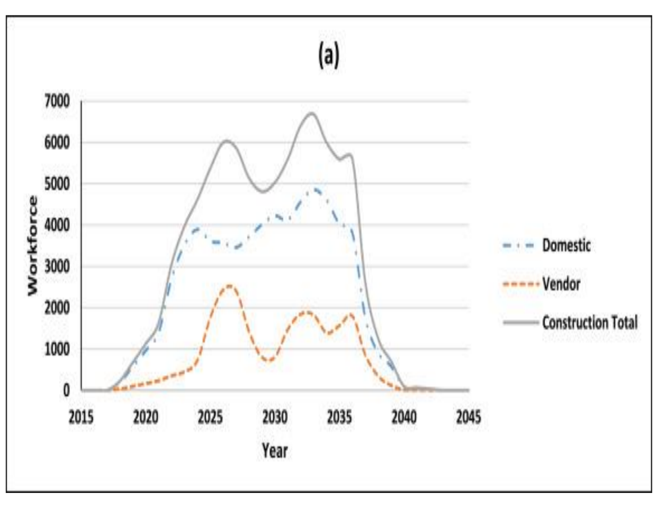
Key Assumptions

1. Plant Life and Licensing:
   - A Pressurized Water Reactor (PWR) plant with a 60-year life span is considered, with an option for a 20-year extension.
2. Population and Growth:
   - Based on Nigeria's 2019 population of approximately 200 million, growing at an annual rate of 2.64%.
3. Contracting Option:
   - The Build-Own-Operate-Transfer (BOOT) model, allowing the vendor flexibility in recruiting personnel.
   - Possibility for a workforce split between vendor and local personnel.
4. Energy Demand:
   - The starting point is Nigeria's current energy demand of 24.37 GWh.

Human Resource Development (HRD)

- Critical Requirement: HRD is essential before NPP construction and operation.
- Challenges for Developing Countries:
  - Specialized skills for nuclear reactors are scarce and often take over 10 years to develop.
  - NPPs require a highly technical and competent workforce to ensure functionality and sustainability.

Figure 4. Proposed sites for Nuclear Power Plants (Egieya *et al.*, 2022)



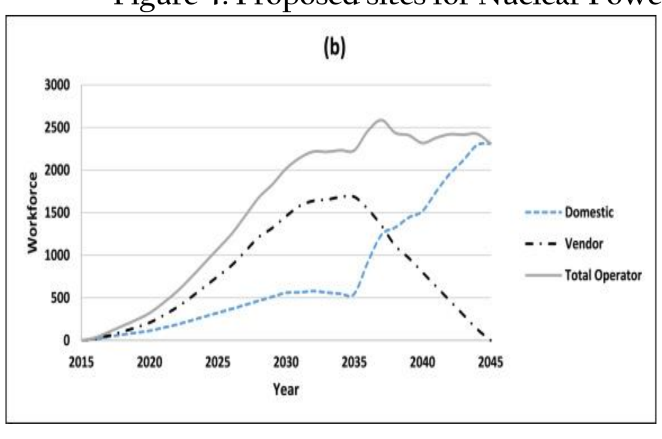
Peak Construction Workforce: Peaks at approximately 6678 personnel during the construction of the third unit in the third quarter of 2032.

- Effective Workforce Management: The data shows efficient allocation of personnel during peak construction periods, followed by a planned reduction towards project completion.
- Strategic Planning: The phased decrease in workforce aligns with project milestones, demonstrating optimized deployment of vendor and domestic staff.
- Operational Efficiency: This approach highlights effective workforce planning, ensuring cost-efficiency and timely project delivery.

Figure 5a Proposed construction workforce (Egieya *et al.*, 2022)

- Vendor Contribution About 27% (estimated at 1803 personnel).
- Domestic Contribution: Comprises the remaining 73%.

Decrease in Construction Workforce: Declines to about 2606 personnel by the completion of the fourth unit around 2037.

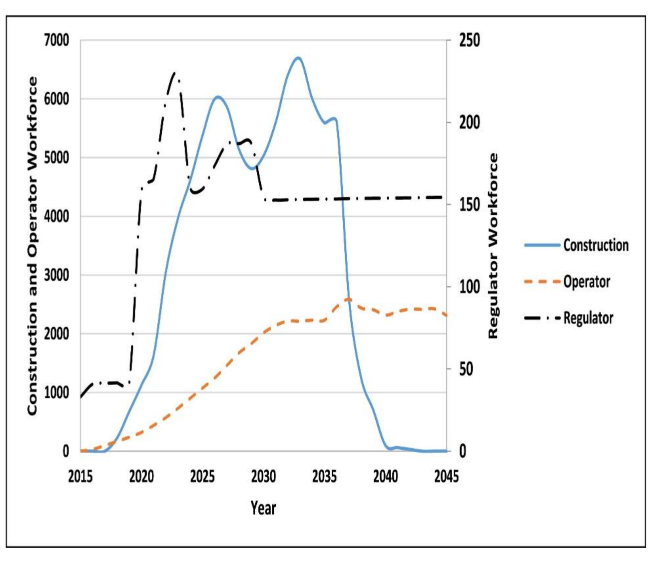


Operating Staff Trends (Figure 5b):2027: Approximately 1461 personnel during commissioning of the first plant.

- Strategic Workforce Management: The study emphasizes efficient workforce distribution between vendor and domestic staff, optimizing construction and operational phases.
- Contracting Strategy: Vendor personnel gradually decrease under the BOOT model, ensuring a smooth transition to entirely domestic staffing by 2045.
- Sustainability Focus: This approach supports long-term operational sustainability and local employment, crucial for project continuity beyond construction.

Figure 5b Proposed operator workforce (Egieya *et al.*, 2022)

- 2037: Peak of around 2586 staff after commissioning of the last unit.
- Vendor Contribution: Peaks at 52% (1346 personnel) of workforce.
- Domestic Contribution: Makes up 48% of workforce at peak.
- Contract Type: BOOT (Build-Own-Operate-Transfer).
- Transition Period: 10 years.
- Vendor Workforce Decline: Gradually diminishes to zero by 2045.



- Peak Workforce (2033): Demand peaks post-third unit commissioning, exceeding similar case studies by about 16%, influenced by contracts, technology choices, and local skill availability.
- Factors Affecting Workforce: Workforce needs fluctuate based on contractual terms, technology, and local skills, crucial for operational efficiency.
- Long-term Stability (2045): Workforce stabilizes with a focus on operational roles (operators and regulators), ensuring sustainable plant management beyond construction.

Peak Workforce Projection (2033):

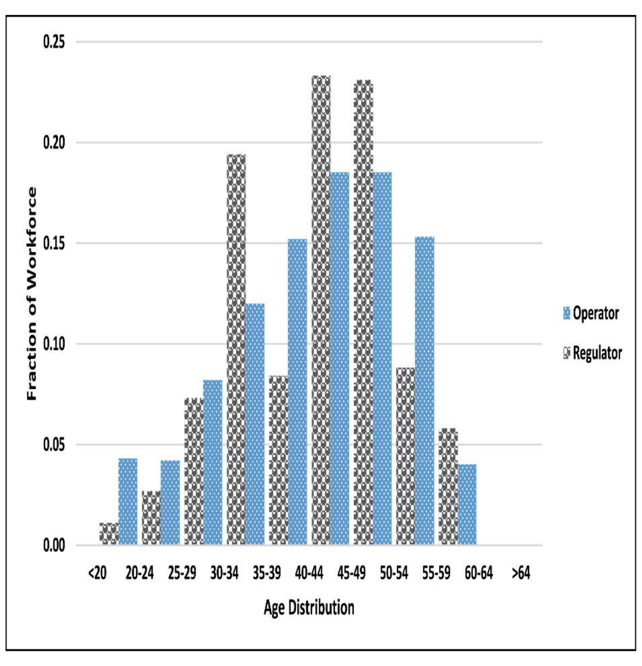
- Total Personnel: Approximately 9045
  - Construction: 73%
  - Operators: 24%
  - Regulators: 3%

Figure 6: Proposed overall workforce. (Egieya *et al.*, 2022)

- Comparison: 16% higher than the Morocco case study due to factors like contractual agreements, technology adoption, and local skill availability.

Steady State Workforce (2045):

- Total Personnel: Approximately 2465
  - Operators: 94%
  - Regulators: 6%



- Age Distribution Discrepancy: The observed median age ranges for operators and regulators in 2045 (45–49 years and 40–44 years, respectively) differ notably from the originally proposed median age range (35–39 years in Fig. 3).

This indicates a shift in the expected age demographics over time within the operator and regulator organizations, possibly influenced by factors such as workforce retention, recruitment patterns, and demographic changes. Understanding these shifts is crucial for workforce planning and ensuring continuity in operational expertise within the nuclear power sector.

Figure 7: Age distribution of operator and regulatory staff in the year 2045. (Egieya *et al.*, 2022)

Age Distribution Differences (2045):

- Operator Organization: Median age range is 45–49 years.
- Regulator Organization: Median age range is 40–44 years

Comparison with Proposed Age Distribution (Figure 7):

- Proposed Age Distribution: Median age range is 35–39 years.

This indicates a discrepancy between the age profiles projected at the end of the model period (2045) and the originally proposed age distribution assumptions (Figure 7).

- Construction Phase Dominance: In the initial 15 years (2015-2030), the workforce is predominantly focused on construction activities, peaking at approximately 73% (6678 personnel) just before the planned commissioning of Nigeria's third nuclear power plant in 2033.
- Shift to Operational Phase: Subsequently, there is a gradual transition towards owner/operators, stabilizing at about 2400 personnel shortly after the anticipated commissioning of the fourth nuclear power plant.
- Role of Regulatory Body: The regulatory workforce in Nigeria's nuclear sector remains consistent, contributing a minor proportion (less than 10%) to the overall workforce across key nuclear organizations.
- Utility of NPHR Tool: The NPHR modeling tool proves valuable for anticipating and planning workforce needs specific to Nigeria's nuclear energy ambitions. Future scenarios could explore different vendor contributions and contracting types (e.g., turnkey, build-own-operate), aligning with Nigeria's policy objectives.
- Economic Perspective: Integrating an economic analysis is crucial for Nigeria, given that salaries constitute a significant portion (at least 25%) of the operational and maintenance costs of nuclear power plants. This highlights the need for cost-effective workforce management strategies.

These conclusions underscore the strategic importance of the NPHR modeling tool in Nigeria's nuclear energy planning, emphasizing tailored workforce planning, regulatory oversight, and economic considerations for sustainable nuclear energy development. (Egieya *et al.*, 2022)

Advocacy and Outreach Programs

AFRA-NEST

- Facilitates education, training, research, and outreach in nuclear science and technology.

NGA-NEST-UNIMAID

- Introduced nuclear science and technology in secondary schools in Maiduguri.
- "CATCH THEM YOUNG" initiative targeting ten schools.

Impact of Nuclear Education Outreach

- Impact on Students and Teachers:
  - Increased understanding and interest in nuclear science and technology.
  - Encouraged pursuit of further studies in the field.
- Impact on Nigeria:
  - Advocacy for a new economic paradigm based on knowledge and creativity.
  - Raising public awareness of nuclear technology's applications and significance.

The Way Forward

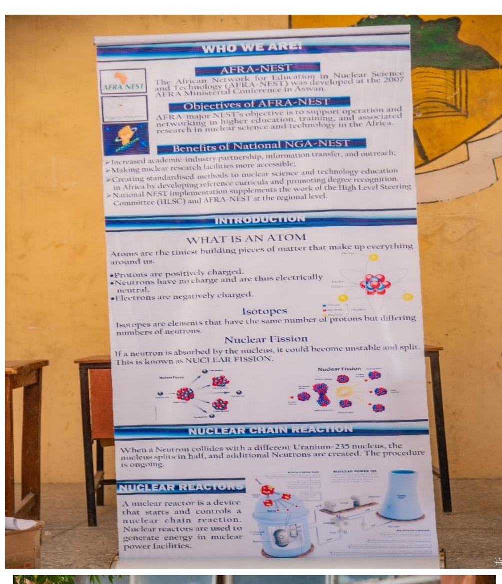
- E-Learning and Technological Advancements:
  - Utilize information technology to enhance outreach programs.

Maiduguri Nuclear Advocacy Timeline

- Details of school visits, interaction sessions, and book distributions conducted in Maiduguri.
- Federal Government College, Yerwa Government Girls Secondary School, Capital School, Maiduguri International School, Abande Memorial School, Ruby Model School, Pearl's Comprehensive School, Shallara Secondary School, and Namu Model Secondary Schools (two campuses).

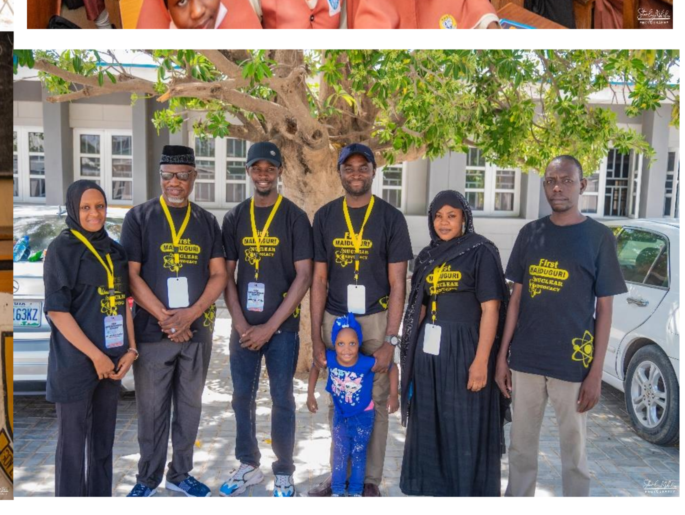
Team Members

- Dennis Solomon Balami: Lecturer, University of Maiduguri.
- Professor Muhammad Hassan: Director, CNERT, University of Maiduguri.
- Samaila Hassan: Lecturer, University of Maiduguri.
- Mohammed Bukar: Lecturer, University of Maiduguri.
- Hajiya Salamatu Hassan: Staff, Nigerian Atomic Energy Commission (NAEC).
- Hajiya Aisha Abubakar: Yobe State University.
- Emmanuel I. Moses: Technical Crew, University of Maiduguri.









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Dennis Solomon BALAMI
Department of Physics, University of Maiduguri
Email: dennisbalami@unimaid.edu.ng