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Cross-Regional Energy Strategies: Evaluating Japan's Power Blueprint for Nigeria's Needs

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Abstract

The urgent need for sustainable, secure, and diversified energy sources remains a pressing concern for both developed and developing economies. Japan, an advanced economy with limited domestic energy resources, has adopted a power generation strategy centered around nuclear energy, liquefied natural gas (LNG), and wind. Conversely, Nigeria, a resource-rich yet energy-deficient country, continues to struggle with energy access and sustainability. This paper conducts a comparative assessment of Japan's proposed power generation strategy and evaluates its viability and applicability in the Nigerian context. Using criteria such as economic feasibility, environmental sustainability, energy security, and socio-political acceptability, the study finds that adapting elements of Japan's strategy, particularly its emphasis on LNG, nuclear, and wind, could significantly enhance Nigeria's energy mix. However, key contextual differences such as geography, regulatory maturity, infrastructure, and public perception must be carefully considered for successful policy transfer.

Keywords: *Energy strategy, renewable energy, nuclear power, Nigeria, Japan energy mix.*

1.0 Introduction

Electricity generation lies at the heart of modern civilization, serving as a foundational pillar for socio-economic development, industrialization, and technological innovation [1]. Access to reliable and affordable electricity is a key determinant of national prosperity, enabling the functionality of critical infrastructure such as education, healthcare, transportation, water supply, and communication systems. Countries with resilient and well-managed power sectors tend to demonstrate higher indices of human development, economic competitiveness, and social inclusion. Conversely, energy poverty, marked by inadequate electricity access and supply unreliability, remains a significant barrier to progress in many developing nations, exacerbating issues such as unemployment, poor health outcomes, and low productivity [2].

Despite its importance, the task of building and maintaining a secure, affordable, and sustainable electricity generation system is inherently complex [2]. It is influenced by a host of interdependent factors, including geographical endowment, resource availability, economic capacity, technological readiness, political stability, and environmental commitments. In recent decades, climate change imperatives have intensified the global push toward cleaner energy solutions, prompting a paradigm shift from fossil-based systems to renewable and low-carbon alternatives [3]. This has led to the development of diversified national energy strategies aimed at achieving net-zero emissions while ensuring energy access and affordability. International institutions such as the International Energy Agency (IEA), the United States Energy Information Administration (EIA), and the World Energy Council (WEC) have played key roles in facilitating cross-border collaboration, data transparency, and policy benchmarking [4].

Table 1: Key Comparative Indicators [5]

Indicator	Japan	Nigeria
Population (2024 est.)	~124 million	~220 million
Electrification Rate	100%	~55%
Primary Energy Import Dependence	High (>90%)	Low (net exporter)
Nuclear Power Capacity	~33 GW (9 active reactors)	Planned 4 GW by 2030
LNG Usage	Largest global importer	Significant domestic potential
Wind Power Capacity	>4 GW (growing)	Negligible (potential in north)

Against this backdrop, Japan and Nigeria serve as valuable yet contrasting case studies in energy strategy formulation, with key comparative indicators summarized in Table 1. Japan, an industrialized and resource-constrained island nation, is highly dependent on imported energy and has invested heavily in advanced power technologies, including nuclear, liquefied natural gas (LNG), offshore wind, and hydrogen energy. Its energy policy has evolved significantly, particularly in the aftermath of the 2011 Fukushima disaster, to prioritize safety,

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decarbonization, and technological innovation [6]. Nigeria, on the other hand, is endowed with abundant natural resources, including crude oil, natural gas, solar, wind, and hydropower potential. However, systemic issues such as inadequate infrastructure, poor governance, underinvestment, and policy inconsistency have impeded the effective harnessing of these resources [7]. The result is a paradoxical scenario of energy abundance amidst widespread energy poverty.

Given the urgent need for both countries to transition toward cleaner and more resilient energy systems, this study investigates the feasibility of applying aspects of Japan's proposed power generation strategy to the Nigerian context. The Japanese model, with its emphasis on a balanced mix of nuclear, wind, and LNG power generation supported by smart grid infrastructure and strong regulatory frameworks, provides a potential blueprint for energy transition. This paper aims to evaluate the degree to which elements of this strategy are transferable to Nigeria and to identify the contextual constraints, adaptation requirements, and policy lessons that could inform Nigeria's pathway to sustainable energy development. Through this comparative exploration, the study contributes to the broader discourse on global energy transition, highlighting how country-specific innovations can offer valuable insights, even across vastly different geopolitical, economic, and environmental settings.

This paper is structured as follows: Section I introduces the context and motivation behind the comparative energy policy analysis between Japan and Nigeria. Section II provides an overview of Japan's proposed power generation strategy, detailing its focus on nuclear energy, wind power, and liquefied natural gas (LNG), along with the rationale behind these choices. Section III presents an in-depth review of Nigeria's energy landscape, including its resource endowments, current generation mix, and national energy transition goals. Section IV evaluates the applicability of Japan's energy strategy within the Nigerian context, considering geographic, economic, infrastructural, and policy-related factors including a comparative analysis between Japan and Nigeria energy strategies. Section V and VI offers a set of tailored recommendations for Nigeria and concludes with key findings from the comparative analysis respectively.

2.0 Japan's Energy Strategy: Overview and Rationale

2.1 Country Energy Profile

Japan is a highly industrialized island nation located in the Pacific Ring of Fire, with a population of about 124 million and limited indigenous energy resources as shown in Table 1. Its mountainous terrain and seismic activity limit the potential for large-scale fossil fuel exploitation, making the country one of the most energy import-dependent nations in the world. Japan is the largest importer of liquefied natural gas (LNG), the third-largest importer of coal, and among the top oil-consuming countries globally [4], [8]. This heavy reliance on foreign energy supplies makes Japan vulnerable to external price shocks, geopolitical tensions, and supply chain disruptions.

The 2011 Fukushima Daiichi nuclear disaster marked a major turning point in Japan's energy policy, triggering the shutdown of all nuclear reactors and a nationwide reassessment of energy safety, security, and sustainability. The immediate aftermath saw a significant increase in fossil fuel imports to compensate for the loss of nuclear capacity, leading to rising energy costs and carbon emissions [4]. Since then, Japan has taken a measured approach to reintroducing nuclear power while accelerating investments in cleaner and more diversified energy sources.

In response to these complex challenges, Japan's energy policy framework, guided by the Strategic Energy Plan, now emphasizes three interlinked priorities: resilience, diversification, and affordability [9, 10, 11]. These goals reflect a broader commitment to ensure energy security, meet international climate obligations, and maintain economic competitiveness. Central to this strategy are three focus areas: nuclear power, wind energy, and liquefied natural gas (LNG), each playing a distinct role in enabling a balanced and low-carbon energy mix.

2.2 Nuclear Power

Nuclear energy is a cornerstone of Japan's long-term decarbonization strategy due to its high energy density, zero direct carbon emissions, and potential to deliver stable base load power [12]. Despite significant public concern and regulatory scrutiny following the Fukushima incident, the Japanese government has maintained that nuclear power is essential for achieving a secure, low-carbon future. This is especially critical as Japan aims to fulfil its commitments under the Paris Agreement and contribute to global climate mitigation efforts [13].

As of early 2025, Japan has 33 operable nuclear reactors, of which 14 have been restarted after meeting the stringent safety standards introduced by the Nuclear Regulation Authority (NRA) following the 2011 Fukushima Daiichi disaster [14]. Despite public apprehension, the gradual restart process underscores Japan's strategy to reintegrate nuclear power into its energy mix as a stable, low-carbon base load option in alignment with its greenhouse gas reduction targets and energy security goals. The reactivation process is governed by the Nuclear Regulation Authority (NRA), which has instituted some of the world's most stringent safety standards. Additionally, the establishment of the Japan Nuclear Safety Institute (JANSI) has further strengthened industry oversight and public accountability.

The government has also invested in public engagement campaigns and technical innovation to address societal concerns around nuclear energy. The plan moving forward includes not only the restart of more reactors

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but also research into next-generation reactors with passive safety features and reduced waste output. In this regard, nuclear power is expected to provide approximately 20-22% of Japan's electricity generation by 2030, supporting both emissions targets and energy security goals [15].

2.3 Wind

Japan's pursuit of renewable energy is heavily focused on wind power, which is seen as a scalable and increasingly cost-competitive option for decarbonizing the electricity sector [16]. While hydropower remains the most mature renewable source in Japan, its potential for expansion is limited due to topographical and environmental constraints. In contrast, offshore wind, particularly in Japan's exclusive economic zone, offers vast untapped potential.

Government initiatives have designated offshore wind as a "main power source", leading to regulatory reforms, tendering frameworks, and investment incentives aimed at accelerating deployment. Several demonstration projects and commercial-scale installations are underway, with the goal of achieving 10 GW of offshore wind capacity by 2030 and up to 30-45 GW by 2040 [9, 17, 18].

Nevertheless, challenges persist. The country's fragmented grid infrastructure, weak interregional connectivity, and complex permitting processes hinder rapid deployment. Additionally, onshore wind faces competition for land use and community opposition in densely populated areas sector [16]. Addressing these barriers will require continued investment in grid modernization, energy storage solutions, and policy harmonization across local and national levels.

2.4 Liquefied Natural Gas (LNG)

LNG plays a critical transitional role in Japan's energy strategy. It serves as a reliable and flexible energy source capable of balancing fluctuations from intermittent renewables such as wind and solar [19]. With lower carbon intensity compared to coal and oil, LNG supports Japan's medium-term decarbonization targets while offering operational advantages in grid stability and peak load management.

Japan has developed one of the world's most advanced LNG supply chains, featuring state-of-the-art import terminals, regasification infrastructure, and diversified procurement strategies [20]. The country's commitment to long-term LNG contracts, along with investments in LNG bunkering and storage, ensures price stability and supply continuity. In addition, Japan has been promoting the concept of "carbon-neutral LNG", where upstream emissions are offset through mechanisms such as carbon credits and methane abatement technologies [20].

LNG is also being positioned as a key enabler of hydrogen production, particularly blue hydrogen derived from natural gas with carbon capture and storage (CCS). This dual role enhances LNG's value proposition in Japan's evolving low-carbon economy.

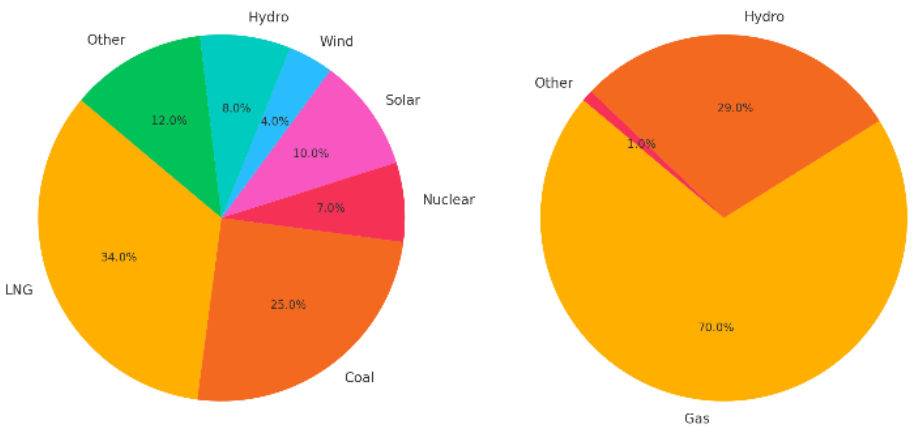

Figure 1: Comparative electricity generation mix of Japan (left) and Nigeria (right) [16], [17].

3.0 Nigeria's Energy Landscape

Nigeria, Africa's most populous country with over 200 million people, is endowed with a vast array of energy resources, including crude oil, natural gas, solar, wind, hydro, and biomass [21]. Despite its immense resource wealth, Nigeria faces acute energy challenges, particularly in electricity access and supply reliability. Over 85 million Nigerians, approximately 38% of the population, still live without access to grid electricity [22], making Nigeria home to the largest energy access deficit in sub-Saharan Africa.

The current national energy mix is dominated by natural gas-fired power plants, which account for approximately 70% of grid-connected electricity generation as shown in Figure 1. Hydropower constitutes 29%, primarily from large dams such as Kainji, Jebba, and Shiroro [22], [21]. However, even this existing capacity is

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often underutilized due to infrastructural inefficiencies, transmission constraints, and frequent gas supply disruptions. Figure 1 provides a comparative electricity generation mix of Japan and Nigeria. Japan's energy mix reflects a diversified portfolio including LNG (34%), coal (25%), renewables (wind, solar, hydro), and nuclear (7%) [23]. In contrast, Nigeria's generation mix is dominated by gas (70%) and hydro (29%), with minimal contribution from other sources [22].

Paradoxically, Nigeria is the largest holder of natural gas reserves in Africa, estimated at over 200 trillion cubic feet, and ranks ninth globally [24]. Yet, its domestic energy landscape suffers from persistent underinvestment, poor maintenance of refineries, and heavy reliance on petroleum imports, largely due to the inefficiency and low-capacity utilization of its four state-owned refineries [25, 26]. These disconnects between energy resource abundance and chronic energy poverty have far-reaching impacts. It stifles industrial productivity, undermines healthcare and educational services, limits ICT and digital inclusion, and hampers socio-economic development.

Recognizing the urgent need for reform, the Nigerian government has outlined a bold Energy Transition Plan (ETP) aimed at achieving universal access to electricity by 2030 and net-zero emissions by 2060 [27]. A central pillar of this plan involves diversifying the energy mix, increasing investments in renewable energy technologies, scaling up local refining capacity, and modernizing the electricity transmission and distribution networks.

The ETP projects that renewables (including wind, solar, hydro, and nuclear) will supply up to 42% of the country's total power generation capacity by 2030 [21]. Achieving these targets will require addressing systemic challenges such as poor regulatory enforcement, financing bottlenecks, grid unreliability, and land acquisition barriers.

4.0 Applicability of Japan's Strategy to Nigeria

Given the structural differences in geography, economy, and technological maturity, wholesale adoption of Japan's energy strategy in Nigeria would be impractical. However, certain elements, particularly nuclear power, LNG, and wind energy, offer valuable insights and potential pathways for adaptation. This section explores the contextual feasibility of these three pillars in the Nigerian setting.

4.1 Nuclear Energy in Nigeria

Nuclear power represents a promising long-term solution to Nigeria's base-load power and low-carbon development ambitions. The country has expressed its intent to integrate nuclear into the national grid, targeting up to 4,000 MW of nuclear capacity by 2030 [28]. The Nigeria Atomic Energy Commission (NAEC) has spearheaded efforts in partnership with the International Atomic Energy Agency (IAEA) to develop a roadmap for nuclear infrastructure and safety regulation.

Nigeria's experience with large-scale hydroelectric and thermal power plants provides a foundational basis for the kind of institutional and engineering capacity required for nuclear development. Furthermore, nuclear energy could serve as a consistent power source to stabilize an increasingly renewable-dependent grid. However, several critical challenges need to be addressed:

- Regulatory preparedness: The Nuclear Regulatory Authority is still evolving, and gaps in safety enforcement and licensing frameworks persist.
- Public perception and awareness: Concerns about nuclear safety, radiological risks, and environmental impacts could trigger resistance without extensive public education.
- Financing and technology partnerships: Nuclear projects are capital-intensive and require long-term international collaboration, especially with experienced nuclear nations.
- Nuclear waste management: Establishing a viable, long-term waste disposal strategy remains a key unresolved issue.

Despite these challenges, the inclusion of nuclear energy in Nigeria's energy portfolio aligns well with both decarbonization and industrialization goals.

4.2 Wind Energy Potential

Wind energy in Nigeria has substantial untapped potential, particularly in the northern regions such as Sokoto, Katsina, Kano, and Maiduguri, where wind speeds exceed 5-7 m/s, sufficient for commercial wind power generation [29, 30, 31]. Pilot projects such as the 10 MW Katsina Wind Farm demonstrate technical feasibility, but operational issues and inconsistent policy support have limited further scale-up.

Japan's approach to wind energy, especially its focus on offshore development and long-term tendering strategies, provides valuable lessons. However, Nigeria's wind strategy must be tailored to its land-based resources, demographic realities, and infrastructure limitations. To unlock the full potential of wind energy, Nigeria must address the following:

- Policy and regulatory consistency: Frequent policy reversals have undermined investor confidence. A stable framework for procurement and tariffs is essential.

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- Feed-in tariffs and incentives: Clear, bankable power purchase agreements (PPAs), and attractive feed-in tariffs are necessary to catalyse private investment.
- Grid upgrades and storage integration: Improved transmission capacity and the integration of storage systems are critical to accommodate wind variability.
- Land and community engagement: Transparent land acquisition processes and benefit-sharing mechanisms can help mitigate local opposition.

If supported by appropriate reforms, wind energy could play a growing role in Nigeria's decentralized energy systems, especially in rural and off-grid communities.

4.2 Liquefied Natural Gas (LNG)

Nigeria, as one of the world's top 10 LNG exporters, is in a strong position to scale up domestic LNG-based power generation and deepen its role in the global gas economy. The country's flagship Nigeria LNG (NLNG) project, operated by a consortium including the Nigerian National Petroleum Corporation (NNPC) and major international oil companies, has been operational since 1999 and continues to expand [19].

Domestically, gas-fired power generation is set to increase from 5,600 MW to 13,600 MW by 2030, aligning with the country's Energy Transition Plan [21]. However, supply reliability remains a major challenge due to gas pipeline vandalism, theft, and flaring. To harness LNG for broader national benefit, Nigeria must pursue the following:

- Expand gas processing and distribution infrastructure, including mini-LNG plants to serve rural and industrial clusters.
- Reduce gas flaring, which wastes valuable resources and contributes to emissions. Nigeria's Gas Flare Commercialization Program (NGFCP) aims to convert flare sites into useful energy hubs [32].
- Take advantage of gas-to-power projects in industrial zones and free trade areas to stimulate local manufacturing and create jobs.
- Adopt carbon-neutral LNG models, following Japan's lead, by incorporating emission offsets and clean technologies.

Table 2: Comparative analysis: Japan and Nigeria's energy strategies

Dimension	Japan	Nigeria	Comparison
Energy Security Priorities	Energy security is a top priority due to lack of domestic fossil fuels.	Energy abundance exists, but poor infrastructure limits supply.	Nigeria must translate energy abundance into security through infrastructure upgrades.
Nuclear Energy	Mature nuclear industry with 30+ reactors; disrupted post-Fukushima.	Plans to deploy 4,000 MW nuclear by 2030; no reactors operational yet.	Nigeria can learn from Japan's safety reforms, regulatory practices, and waste handling.
Liquefied Natural Gas (LNG)	Global LNG leader in imports; has carbon-neutral LNG initiatives.	LNG exporter; domestic use constrained by infrastructure and gas flaring.	Nigeria can emulate Japan's use of LNG in power and industry with environmental foresight.
Wind Energy	Aggressive offshore wind targets; stable feed-in tariff system.	High onshore wind potential, especially in the north; limited contribution.	Nigeria must develop incentive mechanisms and grid upgrades to harness wind potential.
Energy Efficiency	Embedded across sectors; high-tech solutions drive efficiency gains.	Energy inefficiency due to outdated appliances, poor grid, and policy gaps.	Japan's efficiency standards can inform Nigeria's industrial and residential reforms.
Public Perception	High awareness of energy policy; strong civil oversight post-Fukushima.	Limited public awareness and engagement in energy discourse.	Nigeria needs to improve transparency and public education on energy issues.

Nigeria can significantly enhance energy access, reduce reliance on imported fuels, and improve environmental outcomes by modernizing its gas sector and linking it more directly to domestic electricity needs. Table 2 presents a comparative analysis outlining key areas of convergence, divergence, and potential lessons that Nigeria can draw from Japan's energy strategy. Furthermore, Table 3 presents a SWOT analysis evaluating the applicability of Japan's energy strategy within the Nigerian context. It identifies the strengths and opportunities that could support

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successful adoption, while also highlighting potential weaknesses and threats that must be addressed. This strategic assessment provides a structured framework for understanding the feasibility and risks associated with implementing similar policies in Nigeria.

Table 3: SWOT analysis of applying Japan's strategy in Nigeria

Factor	Nuclear Energy	LNG-Based Strategy	Wind Energy
Strengths	Low carbon; scalable	Abundant domestic gas	Northern region potential
Weaknesses	High setup cost; safety concerns	Infrastructure gaps	Low current investment
Opportunities	International partnerships	Reduce flaring; export value	Job creation, off-grid use
Threats	Public skepticism; security	Corruption; policy inconsistency	Grid limitations; land use

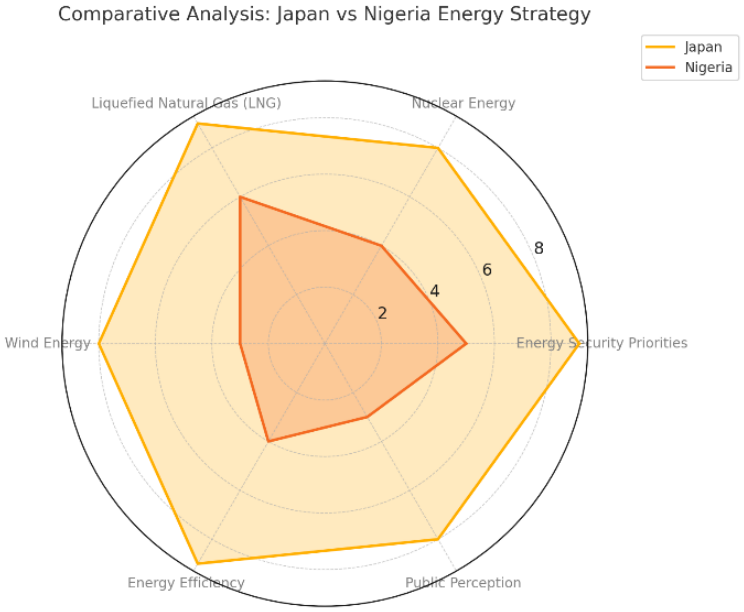

Figure 2: Comparative analysis of Japan Vs Nigeria energy strategy

Figure 2 shows a comparative radar chart that visually contrasts Japan and Nigeria's energy strategies across six key dimensions:

- ✓ Energy Security Priorities: Japan scores high due to its strategic diversification; Nigeria is still evolving.
- ✓ Nuclear Energy: Japan has existing infrastructure and strategic policies, while Nigeria is in early planning stages.
- ✓ LNG: Japan is the largest LNG importer with advanced infrastructure; Nigeria, though a top producer, needs to expand domestic utilization.
- ✓ Wind Energy: Japan is scaling up; Nigeria has potential but lacks enabling policy and infrastructure.
- ✓ Energy Efficiency: Japan leads in innovation and demand-side management; Nigeria is yet to prioritize efficiency strongly.
- ✓ Public Perception: Japan has cautious public support post-Fukushima; Nigeria's public awareness and acceptance are relatively low.

5.0 Policy Recommendation for Nigeria

Drawing from Japan's experience and adapting to Nigeria's unique context, the following policy recommendations are proposed to enhance the feasibility and effectiveness of adopting nuclear, wind, and LNG energy strategies.

5.1 Strengthen Institutional and Regulatory Frameworks

The development of a comprehensive National Wind Energy Policy is essential. This policy should articulate clear goals for wind energy deployment, outline attractive and consistent tariff structures, and include land-use regulations that facilitate project development and encourage private sector investment. Additionally, Nigeria must fully enforce the Gas Flare Reduction (Prevention of Waste and Pollution) Regulations by imposing strict penalties

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on non-compliant operators. The government should also introduce incentives that promote the monetization of flared gas, thereby reducing environmental impact while boosting energy availability.

5.2 Promote Public-Private Partnerships (PPPs)

To drive nuclear power development, Nigeria should actively promote public-private partnerships that include technology transfer agreements and capacity-building initiatives with countries experienced in nuclear energy, such as Russia, South Korea, or Japan. In the wind sector, joint ventures between local and international developers should be encouraged, particularly for projects in the wind-rich northern regions of Nigeria. These partnerships can benefit from blended finance models that reduce investment risk. For LNG, the government should expand infrastructure through concession-based approaches, enabling private investors to develop mini-LNG plants and localized power clusters to enhance energy access and economic growth.

5.3 Enhance Grid and Transmission Infrastructure

Investment in smart grid technologies is essential to enable the integration of variable renewable energy sources, such as wind and solar, while improving load management and system reliability. The rehabilitation plan of the Transmission Company of Nigeria (TCN) should be fast-tracked, with a focus on high-loss transmission corridors and underserved regions with significant wind energy potential. Furthermore, promoting regional electricity interconnections, in line with the goals of the West African Power Pool (WAPP), can facilitate energy exports and enhance overall grid stability across the sub region [33].

5.4 Improve Public Engagement and Awareness

A nationwide campaign on nuclear energy literacy should be launched, incorporating educational content into school curricula, conducting media outreach, and facilitating community engagement through open dialogues. To ensure inclusive policy-making, energy stakeholder forums should be established to bring together civil society, academia, industry experts, and local communities. Additionally, pilot projects such as the Katsina Wind Farm can be leveraged as demonstration hubs for community education, technical training, and job creation [34].

5.5 Incentivize Local Manufacturing and Job Creation

Local content policies should be developed to mandate domestic assembly of wind turbines, production of nuclear components, and construction of LNG infrastructure. To attract renewable energy Original Equipment Manufacturers (OEMs), the government can offer tax breaks, training subsidies, and access to dedicated industrial parks. Collaborations with technical and vocational institutions are vital to launch a national skills development program, focused on preparing the workforce for jobs in the emerging green energy sector.

5.6 Align with Climate and Development Goals

Nigeria's energy strategies must be closely aligned with its Nationally Determined Contributions (NDCs) under the Paris Agreement to ensure environmental sustainability [35]. Nuclear and wind energy projects should be positioned to qualify for international climate finance mechanisms, including the Green Climate Fund (GCF) [36], to mobilize additional investment. Moreover, energy access initiatives should be designed to deliver co-benefits across health, education, and economic empowerment, ensuring that the transition contributes to broader national development objectives.

6.0 Conclusion

This paper has explored the contrast between Japan's structured, technologically advanced energy strategy and Nigeria's evolving energy landscape, highlighting the potential for knowledge transfer and strategic adaptation. While Japan's prioritization of nuclear power, LNG, and wind energy reflects its need for resilience and decarbonization amid resource scarcity, Nigeria's abundant natural resources and underutilized energy potential present both challenges and opportunities.

The assessment reveals that while wholesale adoption of Japan's strategy is impractical due to contextual differences in infrastructure, governance, and socio-political realities, selective integration of core elements, such as small modular nuclear reactors, decentralized wind generation in the north, and LNG-based grid stabilization, and could significantly improve Nigeria's energy security and access.

Critical success factors for Nigeria include strengthening institutional and regulatory frameworks, promoting public awareness and acceptance, and investing in grid modernization. Moreover, international partnerships and south-south cooperation could facilitate technology transfer, capacity building, and sustainable financing mechanisms.

Ultimately, Nigeria's path to energy sustainability must be rooted in its unique geographical, socio-economic, and political context, yet informed by adaptable global best practices such as those exemplified by Japan. The

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interplay between ambition and pragmatism will determine the country's success in building a resilient, inclusive, and low-carbon energy future.

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