ZIBELINE INTERNATIONAL PUBLISHING
ISSN: 2521-0904 (Print)
ISSN: 2521-0440 (Online)
CODEN: EHJNA9

Engineering Heritage Journal (GWK)

DOI: http://doi.org/10.26480/gwk.02.2024.71.78

CrossMark

RESEARCH ARTICLE

RENEWABLE ENERGY POTENTIALS AND NIGERIA'S INDUSTRIALIZATION DRIVE: PROSPECTS, CHALLENGES AND WAY FORWARD

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ARTICLE DETAILS

Article History:

Received 20 February 2024
Revised 04 March 2024
Accepted 25 April 2024
Available online 29 April 2024

ABSTRACT

Industrialization had been a major driver of the global socio-economic development and its ecosystems but rest on energy security for its sustainable process. Nigeria's industrialization drive has largely been challenged with inadequate supply of energy due to poor implementation of energy frameworks and infrastructural challenges in the energy sector among others. More than 70% of the industries in Nigeria operate on self-generated power which had always been via fossil-based system that is both finite in supply and environmentally unfriendly. This also affect the competitiveness of light industries resulting in their closure. According to the Nigerian Association of Chambers of Commerce, Industry, Mines, and Agriculture (NACCIMA), more than 800 small and medium scale industries closed down between 2009 and 2011 due to energy related issues (PremiumTimes 2012). Meanwhile, Nigeria has a high renewable energy potential which could be harnessed to close the energy supply gap for the industrialization drive. This study assesses the potentials and prospect of renewable energy exploitation for industrialization in Nigeria with focus on the applicability of the current frameworks on renewable energy and industrialization process. Despite the huge renewable energy potential and a number of policy and institutional frameworks on renewable energy, the study found poor implementation of the policy due to no clear leadership in the implementation, hence it recommends energy commission of Nigeria to take a coordinating role. The current industrial policy is also found to be obsolete and recommended to be reviewed while there should be development of home-grown advanced manufacturing technology (AMT) system to utilize low-to-medium density energy obtainable from renewable sources for industrialization in Nigeria

KEYWORDS

Renewable energy technology; Socio-economic development; Energy security; Industrial energy supply; Environmental sustainability

1. INTRODUCTION

1.1 Background

Nation's socio-economic development is hinged on increased productivity which is brought about by increase in industrial activities that aids the transformation of raw materials into value added products thereby creating more wealth. Industrialization is instrumental to paradigm shift from the conventional primary work and production systems to mass production and division of labour/specialization. This is accompanied by similar socio-economic change across the globe which equally led to change in the primary energy use to other sources of energy with higher densities (Demirbas, 2002). These energy sources include coal and oil to power the increased production level through industrialization in order to meet up with the need of growing population, increasing living standard, and growing urbanization. Furthermore, today's world population is about 8 billion from 3 billion in the 1950s and it projected to reach 9 billion in 2050 (Figure 1). This means addition of another 1 billion people to the planet earth who will have to eat food, drink water, live somewhere, and engage in other daily activities (iea, 2021). There must be increase in production infrastructure to meet the associated demands and energy to power the increased production. (Rapu et al., 2015).

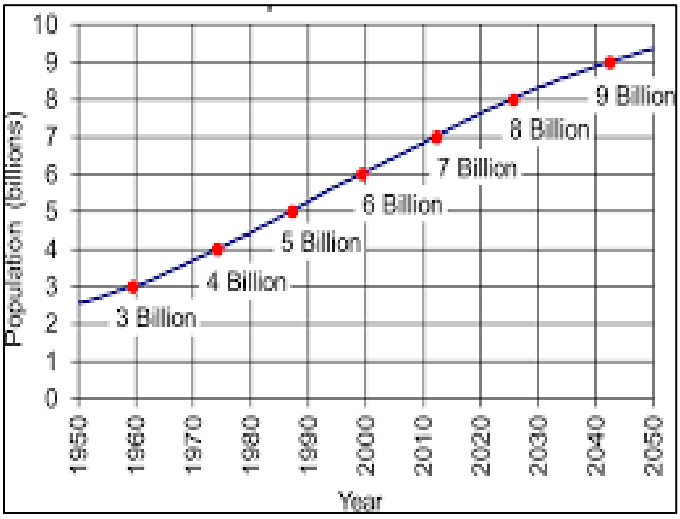

Figure 1: World Population 1950 – 2050 (eia, 2021)

Quick Response Code	Access this article online	
	Website: www.enggheritage.com	**DOI:** 10.26480/gwk.02.2024.71.78

Cite The Article: Rasaq Adekunle Olabomi (2024). Renewable Energy Potentials and Nigeria's Industrialization Drive: Prospects, Challenges and Way Forward. *Engineering Heritage Journal, 5(2): 71-78.*

This also requires the need for increase in energy exploitation to power the industrialization employing heavy equipment requiring high intensity energy. Hence, for sustainable industrialization, there must be equivalent total energy consumption (Li et al., 2019). Meanwhile, exploitation of conventional energy resources is both unsustainable (due to their finite supply) and source of environmental concern. According to the United Nations Industrial Development Organization, "sustainable industrial development must promote economic, social, and environmental sustainability as well as poverty reduction" (UNIDO 2014). Furthermore, World Energy Council also noted that nation's energy performance is ranked on the global Energy Trilemma Index (ETI), which are; energy security, energy equity, and environmental sustainability as shown in Figure 2 (WEC 2022). Renewable energy offers these sustainability conditions.

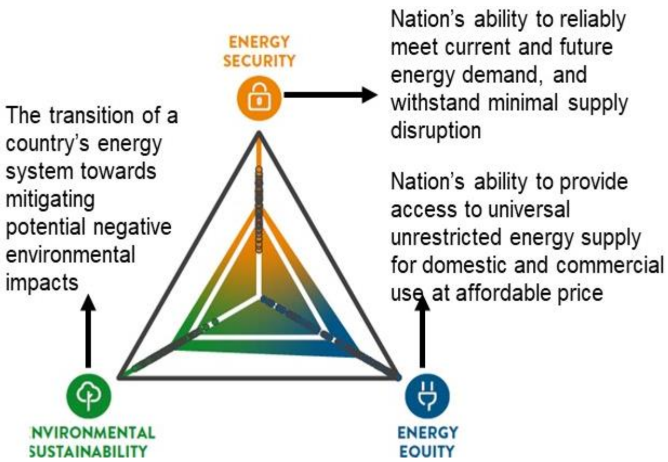

Figure 2: Global Energy Trilemma Index (WEC 2022)

As a developing country, Nigeria must handle the Energy Trilemma with care and industrialize responsibly. This could be achieved by optimally harnessing the ample renewable energy resources in the country for sustainable industrialization process. Hence the objectives of this paper include to; 1) assess the current situation of energy security and industrialization in Nigeria; 2) analyze the existing frameworks on energy security and industrialization, and their interconnectedness and applicability in the contemporary period; 3) analyze Nigeria energy situation in comparison with the newly industrialized nations; 4) analyze Nigeria's renewable energy technology potential and its suitability for the nation's industrialization development; and 5) make appropriate recommendations for responsible industrialization in Nigeria

1.2 Conceptual Clarifications

1.2.1 Energy Sources

Sources from which useful energy is extracted either directly or by means of a conversion or transformation process. With the exception of geothermal energy and nuclear energy (fusion and fission), nearly every known energy source on earth can be traced back to the sun (Verma 2022). However, the main primary sources of energy include Solar, Biomass, Wind, Hydro, Geothermal, Tidal, Nuclear, Offshore wind, and Fossil energy. There are also energy carriers such as electricity, natural gas, hydrogen and biofuels among others that can be used either directly or as sources for other forms of energy

1.2.2 Renewable and Sustainable energy

Renewable energy is energy derived from natural sources that are replenished at a higher rate than they are consumed (Kutscher et al., 2019). E.g, Sunlight (solar), Wind, Geothermal heat, Biomass, and water bodies (running water and ocean). While most of the renewable sources are sustainable, some are not necessarily sustainable. Biomass at the current rate of exploitation in Nigeria is considered unsustainable (Owusu and Samuel, 2016). Energy source is considered sustainable if it is able to meet the present needs without compromising the ability to meet the needs of future generation including the ecosystem. Hence, renewable and sustainable energy resource must take care of economy, social and environment within which it being exploited.

1.3 Clean Energy

In line with the United Nations Sustainable Development Goal 7 (SDG7), to ensure access to clean, affordable, reliable, sustainable and modern energy for all, clean energy sources and technology becomes paramount. That is, sources and technology that result in zero or minimum carbon dioxide (CO_2) emission. A number of non-renewable energy technology can however be regarded as clean technology due to their low-carbon emission. Examples of these include nuclear power, and hydrogen derived from low-carbon sources (iea, 2021).

1.4 Energy Security

Generally, energy security can best be understood as robustness against (sudden) disruptions of energy supply. Dorian defined energy security as guaranteeing the sustainable supply of energy at a reasonable price to support the normal operation of industry and economy (Dorian, 2006). According to Benjamin and Ishani, energy security comprises of five dimensions related to availability, affordability, technology development, environmental sustainability, and regulation as shown in Table 1 (Benjamin and Ishani, 2011)

Table 1: Energy Security Dimensions

	Availability	Affordability	Technology Efficiency	Environmental & Social Sustainability	Regulation & Governance
Energy Security Dimension	Sufficient in supply. Promote diversified collection of different energy technologies. Able to harness domestically available fuels and energy resources. Ensure prudent reserves-to-production ratio	Produce energy services at lowest cost. Have predictable prices Enable equitable access to energy services	Capacity to adapt and respond to the challenges from disruption, Room for developing new and innovative energy technologies, Deliver high quality and reliable energy services	Ensure minimum deforestation and land degradation, Ensure sufficient quantity and suitable quality of water, Minimize pollution and mitigate GHG emissions associated with climate change.	Have stable, transparent and participatory modes of energy policy making. Promote trade of energy technology and fuels, and enhance social and community knowledge about education and energy use
Underlying Values of energy security	Self- sufficiency, resource availability, security of supply, independence, imports, variety, balance, disparity.	Cost, stability, predictability, equity, justice, reducing energy poverty, improving energy per-capital	Investment, employment, technology development and diffusion, energy efficiency, stockholding, safety and quality	Stewardship, aesthetics, natural habitats conservation, water quality and availability, human health, climate change mitigation, change adaptation	Transparency, accountability, legitimacy, integrity, stability, resource curse, geopolitics, free trade, competition, profitability, interconnectedness, security of demands, exports
Components of energy security	Security of supply and production dependency diversification	Price stability, Access and Equity decentralization, Affordability	Innovation and research, Safety and Reliability Resilience Efficiency and Energy Intensity Investment and Employment	Land use Water Climate change Pollution	Governance Trade and Regulation Interconnectivity Competitive and market knowledge Access to information

1.5 Industrialization

Industrialization refers to the transformation from a manual labor-based economy to a machine labor-driven industrial society. It involves a systematic change of the agrarian economic system to a complex mechanized mass manufacturing process. The adoption of machine-based production methods leads to creation of job opportunities, boosts in productivity, acceleration of economic growth, and higher living standards (Dheeraj, 2023). Industrialization represents a shift from agriculture-based economy to an economy in which manufacturing represents the principal means of subsistence (Ndiaya and Lv, 2018). According to them, the dimensions of industrialization include economic activities, organization, and economic output as shown in Fig 3. The industrial sector includes refining, mining, manufacturing, agriculture, construction, and energy industry

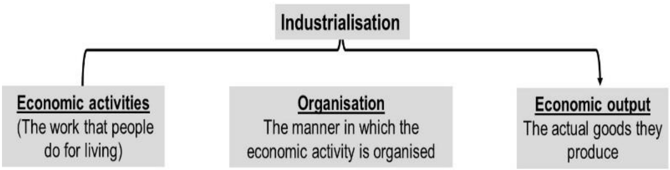

Figure 3: Dimensions of Industrialization (Ndiaya and Lv, 2018)

Industrialization has its positive and negative impacts (as shown in Table 2) and balancing the impacts of industrialization is related to its sustainability. Most importantly, increased productivity and economic expansion respectively lead to increased use of fossil fuels, and global warming and climate change. Hence to industrialize responsibly, the negative impacts must be balanced with the positive ones.

Table 2: Impacts of Industrialization

S/N	Positive impacts	Negative impacts
1	Urbanization	Overcrowding
2	Wealth creation	Income inequality for top 0.1%
3	Employment growth	Child labor
4	Higher living standards	Poor factory staff living conditions
5	Increased productivity	More use of fossil fuels
6	Economic expansion	Global warming and climate change

2. Historical Trend of Energy and Industrialization

Prior to the Industrial Revolution, wood and dried manure were burnt to heat homes and cook food, muscle power, wind, and water mills were relied upon to grind grains, while transportation was aided by carts driven by horses or other animals. The advent of industrialization from the UK (in the early 19th century) led to first energy transition to coal as the then new and cheaper source of energy. This led to further fall in the cost of energy due to economies of scale (Govind Bhutada, 2022). The use of coal stimulated technological advances and adaptations; steam engine was developed to use coal and homeowners used coal to heat their homes and cook food. This led to share of coal in global energy mix rising from 1.7% in 1800 to 47.2% in 1900. This was followed by oil the era; another fossil fuel, to power automobile industries

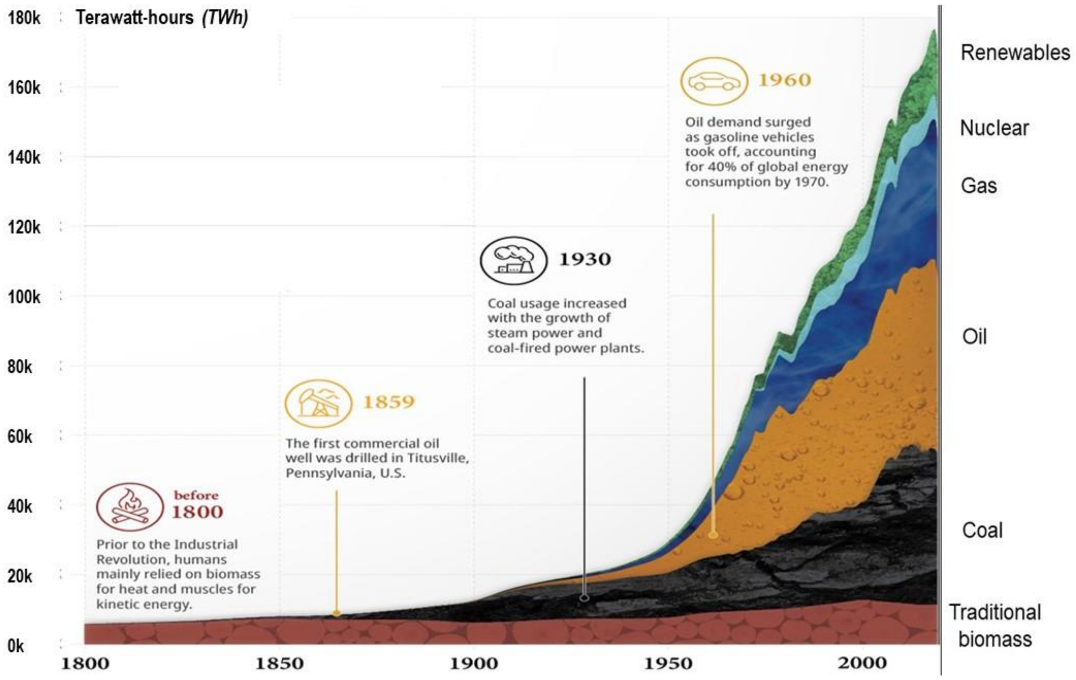

Figure 4: Trend in Industrialization and Energy Exploitation (Govind Bhutada, 2022)

2.1 Energy Crisis and its Fallout

The search for renewable energy sources was propelled by the energy crises between Arab countries and the Western World in the 1967 and 1973 and its global economic discomfort (Haqeem and Zulkifli, 2022; Nwaezeigwe, 2021). As ways forward, series of measures were taken by the affected countries; U.S embarked on fuel rationing, reduced driving habits, and focused on geothermal, wind, nuclear, and solar sources of energy (Krutakov, 2021; Van e Graaf, 2014; Tobal-Cupul et al., 2022). European Energy Policy was formulated to increase the shear of renewable energy in the supply mix and to mitigate the environmental impacts of conventional energy sources (Tang, 2012; Solangi et al., 2011). In the Asia region, there was provision of incentives such as tax exemptions and concession agreement between government and investors in order to improve renewable energy and significantly reduce the associated market risk (Wang and Qiang, 2010; Shing and Tick, 2012).

A major turning point in the development of renewable energy was the formation of the International Renewable Energy Agency (IRENA) in 2009 with 154 member countries and with the objective of mitigating climate change and increase economic growth, creating employment, and guaranteeing clean energy security to achieve sustainable industrialization among the member countries (Harjanne and Korhonen, 2018). Nigerian government established the Energy Commission of Nigeria (ECN) in 1979 with the mandate to conduct research and development (R&D) on renewable energy technologies and to popularize its applications all over the country (Sambo, 2009). Through this, Nigeria aims to achieve sustainable industrialization via climate friendly energy resources exploitation

3. Frameworks on Renewable Energy and Industrialization in Nigeria

3.1 Current Policy and Institutional Framework on Renewable Energy

There are a number of institutional and policy frameworks on renewable energy exploitation for socio-economic and industrial development in Nigeria. Some of the frameworks with their related objectives are presented in Table 4

Table 4: Frameworks on Energy in Nigeria and Renewable Energy Related Objectives

National Policy (Institution)	Related Objectives
National Energy Policy (NEP) 2003, 2006, 2013, 2022 (ECN)	• To ensure energy security via robust energy supply mix, using the principle of "an energy economy from which the share of renewable energy will be increased at affordable cost throughout Nigeria
Renewable Energy Master Plan (REMP), 2005 and 2012 (ECN)	• To set out the roadmap for increasing the role of renewable energy in achieving sustainable development in Nigeria. • To set out modality for achieving the targets of R.E contribution of 13%, 23%, and 36% in the Nigeria energy mix by the year, 2015, 2025, and 2030 respectively.
Nigerian Biofuel Policy and Incentives (NBPI), 2007 (NNPC)	• To develop and promote domestic ethanol industry through utilization of agricultural products.
National Renewable Energy and Energy Efficiency Policy (NREEEP 2015 (FMP)	• For promotion of renewable energy and energy efficiency
Nigerian Energy Transition Plan (ETP 2022) (Energy Transition Working Group)	To serve as a blueprint to Nigeria's commitment and ambition to achieving carbon neutrality, through the following strategies; • Expansion of generation capacity via renewable sources, primarily solar. • Deployment of decentralized renewable energy (RE). • An initial ramp-up of gas generation prior to 2030, to facilitate the integration of renewables. • Post 2030, deployment of centralized RE - solar PV and corresponding storage with hydrogen starting in 2040 • Shifting to lower carbon processes such as the application of bioenergy with carbon capture and storage (BECCS) in cement production, the replacement of grey hydrogen with green and blue hydrogen in ammonia production
Nigeria Electricity Act 2023 (NERC and states counterparts)	• Provides for states to issue licenses to private investors (or industries) who can operate mini-grids and power plants within the state. • Obligates industries to generate electricity from renewable sources or purchase renewable power or equipment for renewable energy generation

3.2 Current Policy and Institutional Framework on Industrialization

3.2.1 Nigeria Industrial Revolution Plan (NIRP)

The Nigeria's current industrial policy, NIRP was developed by the Federal Ministry of Industry, Trade, and Investment in year 2014 as a comprehensive and integrated roadmap to Nigeria's industrialization. With the aim of increasing the manufacturing's contribution to GDP from 4% to 10% by 2017, the Plan had the following objectives amongst others;

i. To make Nigeria a preferred manufacturing hub in west Africa

ii. To make Nigeria a preferred source for supply of low and medium industrial goods, and

iii. To diversify and improve government income and export

The Plan was designed for a five-year accelerated industrial capacity building by recognizing the impacts of insufficient energy supply on the manufacturing sectors and making provision for deliberate intervention, and making provision for Industrial Cities in each of Nigeria's geo-political zones with plans to ensure infrastructure could be shared to lower the operating costs. However, the plan though has reached its expiration, but did not consider renewable energy for Nigeria industrial sector nor planned for energy efficient industrialization in the country, rather it focused majorly on the supply of fossil-based fuels to power the industries. Additionally, the plan did not envisage the emergence of the African Continental Free Trade Area (AfCFTA). The AfCFTA's aim of gradual elimination of tariffs on more than 90% of goods and services produced and traded within the continent further calls for necessity of the review of NIRP.

4. Industrial Energy and Supply

4.1 Outlook of Newly Industrialized Countries (NIC)

The newly industrialized countries (China, Malaysia, India, Brazil, Indonesia, Thailand, etc) recognize the importance of energy security in the short term which encompasses their continuous access to energy at affordable prices to meet the emerging demand. However, many of these countries (China and India) rely heavily on fossil-based energy supply to avoid the risk of energy insecurity. This calls for understanding the nexus between the energy security for sustaining their industrialization drive and global call for environmental sustainability. According to Fernandes and Karen, industrialization is one of the causes of increased energy consumption in most of newly industrialized nations, hence their study recommends the need for the NIC to invest in the discovery of renewable sources of energy to sustain their economic development while giving consideration for environmental sustainability (Fernandes and Karen, 2021).

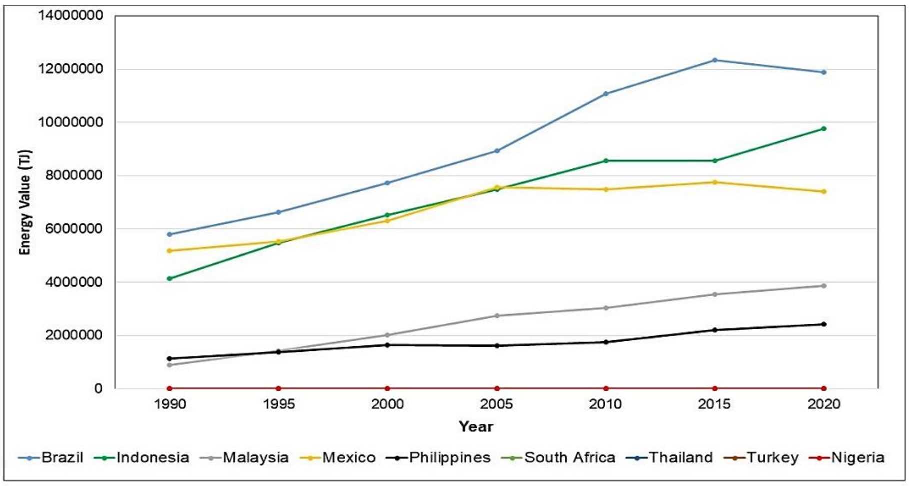

Figure 5: Per Capita Energy Consumption of NIC and Nigeria (iea, 2021)

4.2 Energy Demand and Supply in Nigeria

Nigeria energy sector faces a number of challenges right from the generation through transmission and distribution to metering system, making it difficult to satisfy both domestic and industrial energy needs. As shown in Table 5, while peak demand from 2014 to 2022 is about 20,000MW, Nigeria has peak generation capacity of 7,851 MW and could only produce a maximum of about 6,000 MW (all-time peak) for both domestic and industrial use.

Table 5: Nigeria Power Generation

Generation profile: national statistics			
Details	MW	Time	Date
Peak demand forecast (connected + suppressed load)	19,798.0	1900	08/09/2022
Daily available generation	4,480.0	-do-	-do-
Units on bar capability at peak	4,480.0	-do-	-do-
Peak generation	4,451.1	-do-	-do-
Lowest generation	3,884.8	0300	08/09/2022
All-time peak generation ever attained	5,801.6	21:30	01/03/2021
Maximum available capacity to date	7,851.2	06:00	14/04/2014
Maximum peak generation capability to date	7,099	07:00	13/04/2014
Maximum daily energy ever attained	119,471.15 MW-h	0000-2400	05/03/2021

Source: TCN (2022)

However, while the daily maximum of grid electricity supply in Nigeria over the selected period is 119,471.15 MW-h, industrial sector alone in Nigeria, consumed an average of 3,172,951 MW-h electricity as shown in Figure 6 (Statista, 2023). This indicates that Industries in Nigeria mostly depend on other sources (including coal) to bridge the wide energy supply gap. For instance, industrial sector consumes 32% of total gas production and 0.1 Mt (100%) of coal in 2021 (Enerdata, 2023).

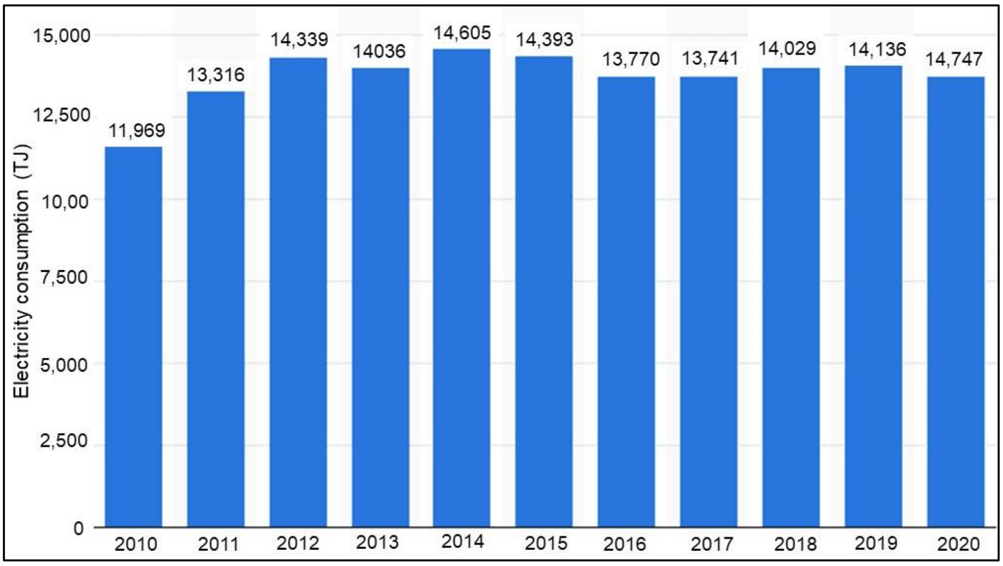

Figure 6: Industrial Electricity Consumption in Nigeria (Statista (2023)

4.3 Renewable Energy Status in Nigeria

There exists abundance of renewable and non-renewable energy resources in Nigeria out of which non-renewable is mostly explored apart from biomass in its unprocessed form as shown in Figure 7 (IEA, 2022). Whereas, there are renewable energy technologies at various level of development (as shown in Table 6). The Nigeria industrial sector could take the advantage of the renewable energy potential to bridge the energy supply gap.

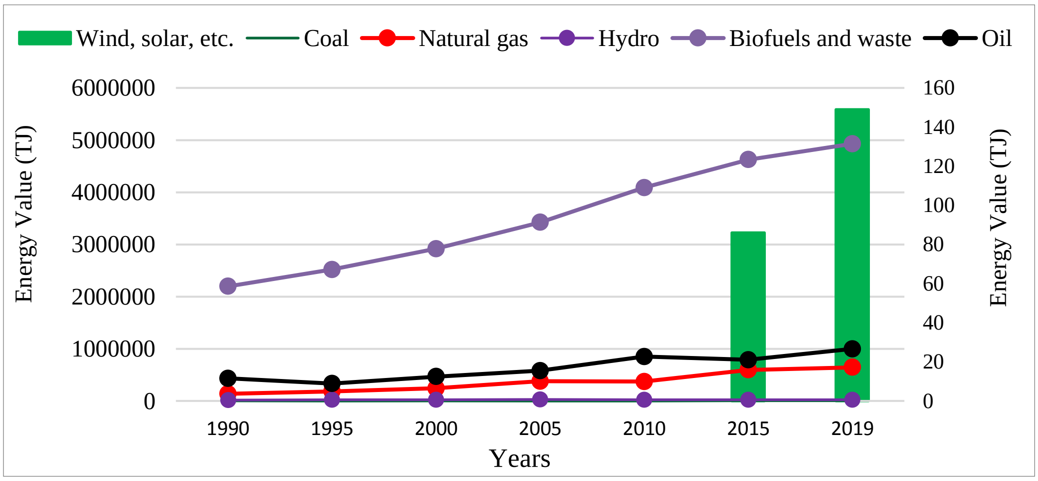

Figure 7: Nigeria total energy potential (IEA 2022)

4.3.1 Renewable Energy Application Potentials

Although exploitation of renewable energy is capital intensive, but this can partly be offset by the carbon credit window and other environmental benefits. Olayinka Oyedepo noted that for Nigeria to ensure sustainable economic development, policy direction must be focused on implementation of renewable and energy efficiency technologies (Olayinka Oyedepo, 2012). Renewable energy technologies have been developed to various level of technology maturity (as shown in Table 6), advantage of which the Nigerian government could take to advance its industrialization process. Nigerian government however did power sector reform and came up with the Renewable Energy Master Plan in 2005, to increase the proportion of renewables in the nation's electricity supply by 13%, 23%, and 36% in the year 2015, 2025, and 2030 respectively. Achieving this will probably propel Nigeria electricity coverage to about 80% general coverage.

Table 6: Areas of Potential Utilization of Renewable Energy

RE Source	Technology	Output	Technology maturity
Solar	Solar Thermal	Concentrated Solar Power; Sorption cooling systems; Solar driers; Domestic hot water; Process heating systems	Up to commercial stage
	Solar PV	Lightings; Light electrical load	Up to commercial stage
Hydro	Mini/small hydro	Electricity	Up to commercial stage
Ocean	Salinity gradient	Electricity	Development stage
	Tidal		Up to large scale in France and South Korea
	Wave energy		Development stage
	OTEC	Electricity; District cooling; Aquaculture; Other spin off activities	Pilot stage, nearing full scale
Bio energy	Solid biomass	Electricity; Process heat	Up to commercial stage
	Bio fuels	Electricity; Liquid and gaseous fuels	Up to commercial stage

With daily solar irradiance of 3.5kWh/m^2 in the south and 7kW-h/m^2 in the north, it is estimated that covering 1% of Nigeria's land area with solar module, it is possible to generate 1850×10^{3}GWh of solar electricity per year (Sambo, 2009.) Solar hot water system also presents an excellent cost saving; an energy savings equivalent to 50-80 percent of residential and industrial hot water bills can be achieved thereby aiding energy security for industrial and domestic usage in Nigeria (Azhar et al., 2021).

Nigeria has small hydro (SHP) estimated potential of 3,500 MW from which the National Development Plan (2021-2025) sets a target 1,000 MW on short-term. In addition to existing schemes in Kura, Tiga, and Oyan amongst others with a total capacity of 64.2 MW, there exist a number of potential sites for SHP across Nigeria to give additional capacities (O Fagbohun and Omotoso, 2018; Ugwu et al., 2022).

OTEC is a marine renewable energy technology that harnesses the solar energy absorbed by the oceans to generate electric power. This is achieved by using the thermal gradient between the warmer (surface) and colder (deep) sea to run a heat engine to produce electricity. To exploit OTEC, Federal Government of Nigeria has (in April 2012) approved the initiatives to exploit the Ocean Energy Resources in Nigeria, and with the signing of ocean renewable energy memorandum of understanding (MOU) between the Nigerian Institute for Oceanography & Marine Research (NIOMR) and FOT-K Consortium (NIOMR, 2023). The preliminary studies conducted indicate that Nigeria can develop over 10 Nos of multi-product OTEC plants, each generating 100-500MW, along the coastal shores of the country on incremental basis

Nigeria has 13,071,464 hectares of woody forest, produced about 83 million tons of crop residue and 61 million tones of animal waste per year (REMP, 2005). The availability of green technologies for the production of biofuels presents an excellent opportunity for the country to increase its energy mix towards achieving sustainable industrialization. Furthermore, in addition to viability of renewable energy when considered based on its levelized cost, continuous research and development on renewable energy technologies have also led to increase in its competitiveness as shown in Table 7.

Table 7: Global Average Installation Cost, Capacity Factor and Levelized cost of RE Technologies (IRENA, 2014, IRENA, 2021, Tobal-Cupul, Garduño-Ruiz et al., 2022)

R.E Technology	Total Installed costs (USD/kW)			Capacity factor (%)			Levelized cost (USD/kWh)		
	2010	2021	Change	2010	2021	Change	2010	2021	Change
Bioenergy	2,714	2,353	-13 %	72	68	-6 %	0.078	0.067	-14 %
Hydropower	1,315	2,135	62 %	44	45	2 %	0.039	0.048	24 %
Solar PV	4,808	857	-82 %	14	17	25 %	0.417	0.048	-88 %
CSP	9,422	9,091	-4 %	30	80	167 %	0.358	0.114	-68 %
OTEC	5,000	1,240	-75 %	90	95	5.6 %	0.180	0.029	-84%

4.4 Challenges against R.E for Industrialization

4.4.1 Technical

While some of the renewable energy technologies are at full maturity stage, a number of them are at development stage, hence requiring technical capacity development (including R&D) for their optimal utilization. Manny of the industrial infrastructures in Nigeria are also obsolete and require high energy density to power them. Changing to energy efficient facility requires technical and financial intensity

4.4.2 Economic/ Financial

The investment (initial) cost of R.E project is usually high with low rate of return unless incentivized (Saygin et al., 2015). Challenges such as lack of financial relief on renewable energy and energy efficiency appliances, poor support to R & D, and low incentives to encourage renewable energy entrepreneurs and local manufacturers are some of the challenges against its significant contribution to energy supply mix in Nigeria. Light industries with low financial muscles need incentives to exploit renewable energy and clean technology instead of their current unsustainable use of biomass due to constraint of lack of affordable energy supply.

4.4.3 Political

Due to its relatively high initial cost, renewable energy technology and application require strong political will to rally technical, financial, regulatory and social assistance towards sustainable development of renewable energy technology; thanks to the recent subsidy removal on fossil fuels and approval of Electricity Act 2023. There are so many institutions working at cross mandates with no coordinating institution/agency on R.E activity including those of private sectors. This makes it difficult to ascertain the R.E utilization status of Nigeria

5. Conclusion

The abundance of energy resources in Nigeria could stimulate the country's industrialization drive if the resources are optimally exploited, however, there is persistent inability to optimally utilize the resources to power the industrialization process. The persistent power problem is not unconnected with the array of issues on Nigeria central grid system and the resultant power problem has led to large number of Industries closing down. Renewable energy presents an alternative and sustainable solution if its potential is optimally harnessed. This could lead to R.E making a significant contribution to Nigeria energy mix in addition to satisfying the industrial energy needs. Even though its expiration has passed, Nigerian Industrial Revolution Plan did not consider R.E and other emerging issues like AfCFTA and thereby should be reviewed. Meanwhile, there are adequate policies and institutional frameworks to harness R.E for industrialization. However, many of the agencies and R.E service providers in the country are working in silos, making it difficult to ascertain the R.E status in Nigeria. Strong political will could be an overriding factor to overcome issues and challenges against optimal utilization of renewable energy potential in Nigeria. This could be applied by giving required financial reliefs to encourage R.E utilization. Renewable energy technologies require high initial cost, but have better levelized cost and other social benefits than the conventional types. The following are therefore recommended: Federal government of Nigeria should mainstream R.E department in all relevant institutions and MDAs, and make the Energy Commission of Nigeria the coordinating agency for policy formulation and implementation on renewable energy and its technologies. Federal Ministry of Industry, Trade and Investment should review the Industrial Revolution Plan to accommodate emerging realities. Federal Government of Nigeria should strengthen the implementation of Nigeria Startup Act (NSA) 2022 towards development of home-grown technologies for sustainable industrialization including training on advanced manufacturing Technologies (AMT) suitable for renewable energy.

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