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The Use of Nuclear Energy to Solve Nigeria's Energy Crisis and Help the Country Achieve its SDGs.

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Abstract: Nuclear energy is often viewed as a clean, renewable energy source capable of producing a significant amount of energy without disrupting a vast amount of land, thereby preserving the environment for agriculture and preventing pollution. The achievement of almost all sustainable development goals requires energy, and Nigeria is far from meeting even the basic energy needs for domestic and corporate functions, let alone for industrialization and the increased energy requirements for a seamless transition to smart cities, the internet of things, artificial intelligence, smart agriculture, and the revival of industries. During discussions on renewable energy generation, policy makers and scientists often place inappropriate emphasis on nuclear energy due to inherent nuclear phobia, cost, and other factors. Despite these challenges, nuclear energy seems to be the only available renewable and clean energy generation method that can provide a solution to the energy crisis affecting rural and urban areas in Nigeria, in line with the attainment of sustainable development goals and the associated urgency. Although other renewable energy generation methods such as solar, wind, geothermal, and biomass are available, they can only provide relatively low energy, which cannot ensure a smooth transition to clean and renewable energy without disrupting normal day-to-day energy utilization. This paper utilized a desk review method to critically assess the contribution that nuclear energy can make in achieving SDGs in Nigeria, compared to other renewable energy generation methods.

Keywords: Nuclear energy, Renewable energy, Sustainable Development Goals (SDGs).

1 Introduction

According to Internet World Statistics, Nigeria is the most populous country in Africa with over 200 million citizens, the majority of whom live below the poverty level of $1.0 per day [1]. Unfortunately, only 40% of the population is connected to the national electricity grid, and even those who are connected experience power problems 60% of the time [2,3]. The current energy supply is insufficient to meet the high demand, resulting in frequent power outages, limited access to electricity, and an overreliance on fossil fuels, which has negative impacts on the economy, environment, and society. Nigeria has announced a transition plan to become a country of low-carbon, climate-resilient, and high-growth circular economy with an emissions reduction of 50% compared to the current levels by 2060.

To achieve this goal, Nigeria needs reliable, affordable, and clean sources of electricity that will play an increasingly important role in meeting the global energy and climate challenge. At present, it is difficult for Nigeria to achieve clean and sustainable energy, as on-grid generation is dominated by natural gas power stations (86%) and large hydropower plants (14%), which are prone to gas unavailability, machine breakdowns, seasonal water shortages, and limited grid capacity [4]. This has led to severe electricity shortages across the country, with blackouts lasting for several hours in a day. In response, many households and businesses have resorted to self-generation of off-grid electricity using diesel and gasoline generator sets as back-up. As of 2015, it is estimated that around 15-30.5 GW of diesel and petrol-based generation capacity was available in the country [5,6].

Fig 1 presents the power generation capacity of Nigeria

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from different sources as at 2015. Currently, there are about 440 nuclear power reactors operating in 31 countries, which represent over 60 per cent of the global population. A further 55 reactors are under construction in 15 countries. In developed nations, nuclear energy is well-established and already makes a significant contribution to electricity supply (averaging roughly 20 per cent of electricity supply across the OECD countries). Several countries have successfully implemented nuclear energy programs and have benefited from this technology. For instance, South Korea has developed a robust nuclear energy program that has provided a reliable source of electricity and contributed to the country's economic growth [5,6].

Despite the challenges and concerns associated with nuclear energy, it is the only available renewable and clean energy generation method that is capable of providing a solution to the energy crisis affecting both rural and urban areas of Nigeria, and that can contribute to the attainment of SDGs. The other available energy generation methods such as solar, wind, geothermal, and biomass can only provide relatively low energy, which cannot guarantee a smooth transition to clean and renewable energy without disrupting normal day-to-day energy utilization. Therefore, this paper employs a desk review method to critically evaluate the contribution that nuclear energy can make in the attainment of SDGs in Nigeria in comparison to other renewable energy generation methods. The aim is to examine the role that nuclear energy will play in combating the energy crisis for the attainment of SDGs in Nigeria, and to draw lessons from countries with successful nuclear energy programs that could be applicable to Nigeria's nuclear energy program [5,6].

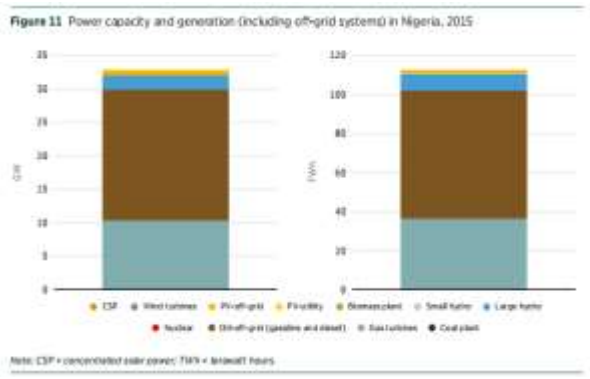


Fig 1: Power capacity and generation in Nigeria.

2 Energy Crisis in Nigeria

Nigeria's energy crisis is caused by several factors and is multi-dimensional. The country's power generation capacity is insufficient, and the majority of electricity is generated from fossil fuels. Inefficient transmission and distribution networks lead to losses and blackouts. Furthermore, the lack of access to electricity in rural areas and low-income households restricts economic growth and development. The consequences of Nigeria's energy crisis include high business costs, increased carbon emissions, and health issues caused by indoor air pollution from the use of inefficient fuels like kerosene lamps [5,6].

Presently, about 84% of urban households in Nigeria rely on backup power supply systems like diesel/gasoline generators and solar-based systems. Additionally, approximately 86% of Nigerian companies either own or share a generator [7,8]. With several million captive generators imported into the country, Nigeria is Africa's leading generator importer and one of the largest globally. The unstable power supply system and expensive captive generation negatively affect the economy, from residential to industrial sectors. The high cost of captive generation causes households and small-medium enterprises to spend two to three times more on kerosene, diesel, and petrol than on electricity from the grid [9]. Moreover, self-generating power makes Nigerian products approximately one-third more expensive than imports [10].

To reduce the use of captive diesel and gasoline generators, Nigeria needs to improve the provision of reliable electricity access throughout the country.

2.1 Sustainable Development Goals

The World Commission of Environment and Development defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs, including energy requirements [11]. The Sustainable Development Goals (SDGs) consist of 17 goals and 169 targets that were established to be achieved by 2030 (Figure 2) as a blueprint for sustainable development worldwide. In Nigeria, the SDGs provide a framework for addressing the country's development challenges, such as the energy crisis. The energy sector is crucial to achieving many of the SDGs, including SDG 7, which aims to ensure universal access to affordable, reliable, sustainable, and modern energy. The alignment of the energy sector with the SDGs is critical for Nigeria's economic, social, and environmental development.

The sustainable development concept was adopted by 193 UN member states at the Sustainable Development Summit in September 2015. The United Nations member states adopted the Program for Sustainable Development, which covers the period until 2030, in order to find a common solution for many social and environmental issues. The Program consists of 17 SDGs, which address the main challenges of today. The Sustainable Development Goals represent an upgrade and expansion of the eight Millennium Goals that the UN member states aimed to achieve by 2015. Energy is considered a key factor in achieving the Millennium Goals in the future [12].

Therefore, energy is viewed through the lens of sustainable development, with attention directed toward energy supply, availability, economic viability, and environmental impact.

During the development of national strategies, countries must decide on various energy sources, including fossil fuels such as oil, gas, and coal, as well as renewable energy sources like solar, wind, hydro energy, biomass, and nuclear power. Due to the limited global oil reserves, many countries are investing in the development of alternative energy sources based on their economies, knowledge, and availability of renewable resources in their territories [12].

Fig 2: The sustainable development goals.

2.2 Role of nuclear energy towards achieving SDGs in Nigeria

According to the Nigerian Atomic Energy Commission (NAEC), Nigeria intends to have 1,000 MWe of nuclear power installed by 2017 and 4,000 MWe by 2027. In 2009, cooperation agreements were signed with Russia on the peaceful use of nuclear energy, including the construction of nuclear power plants (WEC, 2013) [11,12]. The proposed sites for hosting 4,000 MW nuclear power projects in Nigeria are Geregu in Kogi State and Itu in Akwa Ibom State [13]. The country has established a National Atomic Energy Commission to supervise the development of nuclear energy programs. To tackle the energy crisis, Nigeria is presently constructing a 1,200 MW nuclear power plant in Akwa Ibom State, which is projected to be completed by 2025. The adoption of nuclear energy has the potential to offer a dependable and sustainable source of electricity to meet Nigeria's escalating energy demand. Additionally, the use of nuclear energy could diminish the country's dependence on fossil fuels, thereby contributing to the reduction of climate change effects. The acquisition of nuclear energy in Nigeria would aid in accomplishing all other SDGs since all the SDGs are interconnected. SDG 7 explicitly acknowledges that energy is “central to nearly every major challenge and opportunity the world faces today”. Access to energy supports all of the SDGs and is a significant pillar of the UN sustainable development agenda. As the world continues to urbanize, people's aspirations will increase, including better education, stable jobs, nutritious diets, better healthcare, and access to cultural and leisure activities that enable a higher quality of living. Increasing energy access will be critical to fulfilling these aspirations. Furthermore, access to electricity is closely linked to economic development, as shown in Figure 3. Economic growth will be significantly impeded without a substantial increase in power consumption. Countries with electrification rates of less than 80% of the population (such as Nigeria and other African countries) consistently have lower GDP per capita. Therefore, the government should hasten the process of nuclear energy generation to achieve the SDGs [12].

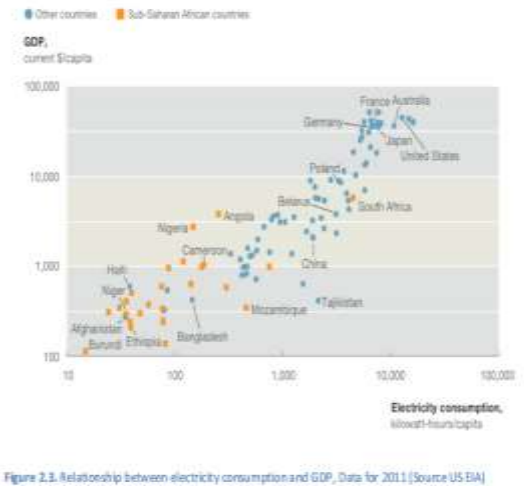


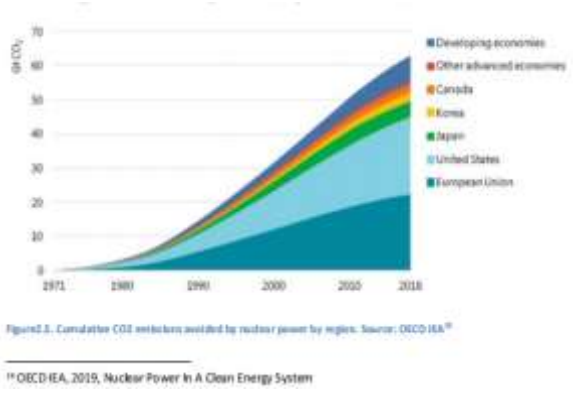
Figure 2.3. Relationship between electricity consumption and GDP, Data for 2011 (Source US EIA)

Fig 3: Relationship between electricity consumption and GDP.

2.3 Mapping nuclear energy/technology to SDGs

Currently, there are around 440 nuclear power reactors in operation in 30 countries, contributing about 10% of the world's electricity supply. The use of nuclear power over the past half-century has resulted in a reduction of approximately 60 giga tonnes of CO2 emissions, equivalent to nearly two years' worth of total global energy-related emissions, as depicted in Figure 4. Nuclear reactors have various applications in addition to electricity generation, such as providing high temperature process heat and district heating. They can also generate hydrogen and synthetic fuel. Furthermore, nuclear reactors can produce radioisotopes used in a broad range of medical, environmental, and industrial applications worldwide. Every year, approximately 30 million individuals receive diagnosis and treatment for illnesses using nuclear medicine. Radioisotopes and radiation employed in food and agriculture help combat world hunger by reducing the use of pesticides, improving water management and conservation, and tracing underground water resources and contamination sources. Although nuclear energy is most

relevant to SDG7, it has a significant impact on economic growth, which is critical to achieving many other SDGs. The nuclear industry is a significant industrial employer that requires high standards, competencies, international cooperation, and ongoing research and development. The cost-effective and stable electricity supplied by nuclear power plants attracts energy-intensive industries, creating more jobs. Additionally, nuclear energy can power the development of small and medium enterprises, contributing to local economic activity in terms of jobs, revenue, and spending. Since nuclear energy is mostly immune to weather fluctuations, it also helps build climate resilience for the economy [13].



[14] OECD IEA, 2019, Nuclear Power In A Clean Energy System

Fig 4: Cumulative CO_2 emissions avoided by nuclear power.

Fig 5: Mapping nuclear energy to SDGs.

2.4 Nuclear energy when viewed from the lens of three pillars of sustainability

The extraction of Uranium is the primary step in the nuclear fuel cycle from an economic standpoint. Phosphates are the current source of uranium extraction, with uraninite, coffinite, and brannerite being the primary resources, while autunite, carnotite, and uranophane are secondary minerals. Uranium deposits are also found in sandstones, quartz, lignite, shale, and breccia, and are extracted through open-pit mining, underground mining, or chemical treatments, depending on the region. Presently, the annual consumption of Uranium is around 65 000 tons, and it is one of the few fuels used in nuclear plants. Thorium, which is four times more abundant than uranium, can serve as an alternative. Nuclear plants are like other renewable energy sources in that they require high capital investments. However, uranium's lower price, ease of storage, and lack of degradation compared to coal make it a more advantageous option [14]. Uranium's price has a small impact on total costs, accounting for only 7-10%, which leads to greater stability. Even if the uranium price were to rise tenfold, the total cost increase would only be between 18-36%. By comparison, for power plants that run on natural gas, fuel prices make up 70% of the total costs, and a doubling in gas prices would increase the total costs by 80% [15].

Public attitudes towards nuclear power plants, especially regarding risk perception, can have a significant impact on energy planning requirements. Negative attitudes towards nuclear power persist due to the memories of nuclear disasters in Chernobyl and Fukushima, despite extensive research on mortality prevention through nuclear energy [16]. Public perception is the key factor in the consideration of nuclear energy [17]. Negative attitudes are linked to radioactivity, nuclear disasters, and even nuclear wars. Renewable energy plants are potentially impacted by volcanic eruptions, erosion, floods, and winds, with coal sources causing the highest mortality rates (particularly in China) while hydro and nuclear energy have the lowest mortality rates. Other renewable energy sources also have a low mortality rate and impact on human health [18]. Nuclear energy has prevented 1.84 million deaths and 64 Gt of greenhouse gas emissions, according to Kharecha & Hansen. Their projections show that nuclear energy can save between 420,000 and 704 million lives and between 80 and 240 Gt of CO2 emissions [16,19].

The environment is most affected by the release of radioactive isotopes, and their negative impact on the environment. Nevertheless, due to its high capacity, nuclear power is considered a potentially powerful tool in reducing fossil fuel consumption in the global energy mix [19]. Nuclear power plants emit small quantities of fine dust and gases, such as SOx and NOx, which cannot create acid rains or damage the ozone layer. Although small amounts of carbon components are produced by all processes [20], nuclear energy and other low-carbon technologies have prevented more than 157 Gt of CO_2 emissions from 1970 to 2012, for the same energy quantity obtained from fossil fuels such as coal, oil, or gas. The Intergovernmental Panel on Climate Changes (IPCC) Working Group III in its fifth report confirms the potential of nuclear energy in the global de carbonization of the economy and the energy sector. Scenarios predict an increase in nuclear energy from 383

GW in 2015 to 930 GW in 2050

[15,20]. The advantages of nuclear energy will disappear if the radioactive isotopes leave the reactor in uncontrolled conditions. Waste disposal, defined in SDG 12 is based on responsible consumption and production of fuel for energy use. Energy density plays an important role in the evaluation of fuel extraction, transport and quantity of the generated waste which is disposed in the environment. The densities of fuels according to [15,20] are as follows:

-1 kg coal = 8.2 кWh; (1)

-1 m3 gas = 1.1 kg coal = 9.0 кWh; (2)

-1 kg oil = 1.4 kg coal = 12.0 кWh; (3)

-1 kg uranium = 2.7 millions kg coal = 50 000 кWh (4)

It is important to note that the amount of waste generated by nuclear power plants is relatively small compared to the waste generated by other industries such as mining, manufacturing, and agriculture. However, nuclear waste is more hazardous and requires special handling and storage due to its radioactivity [20].

The majority of nuclear waste generated by power plants is low and intermediate level waste, which includes items such as contaminated tools, clothing, and equipment. This waste can often be safely disposed of in near-surface facilities [20].

High-level nuclear waste, which includes spent nuclear fuel and other highly radioactive materials, requires special handling and long-term storage. Currently, many countries store their high-level waste in deep geological repositories, where it is stored in containers designed to prevent the release of radioactive materials into the environment [21].

Proper management and disposal of nuclear waste is crucial for the safety of both human health and the environment. Efforts are continually being made to improve waste management technologies and find innovative solutions for the safe disposal of nuclear waste [22].

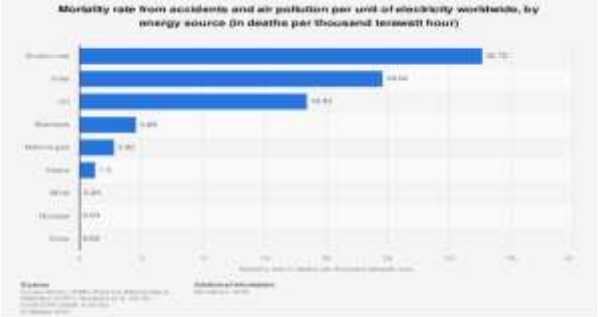


Fig 6: Mortality rate per unit of electricity.

3 Conclusions

Nigeria's energy crisis is a significant challenge that requires urgent action. The adoption of the SDGs provides a framework for addressing the energy crisis and achieving sustainable development in Nigeria. Nuclear energy has the potential to provide a reliable and sustainable source of electricity that could support the achievement of SDGs in Nigeria. However, the challenges associated with nuclear energy require careful consideration and management. Policymakers, stakeholders, and the public need to collaborate and make informed decisions to ensure the successful implementation of nuclear energy programs in Nigeria.

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