A Brief Study into Renewable Energy Technologies

Omolayo M. Ikumapayi[1,3,5*], *Temitayo S.* Ogedengbe[2], Opeyeolu T. Laseinde[3], *Rasaq A. Kazeem*[4], *Sunday A.* Afolalu[1], Stephen A. Akinlabi[6], Esther T. Akinlabi[6]

[1]Mechanical and Mechatronics Engineering Department, Afe Babalola University, Ado-Ekiti, Nigeria
[2]Nile University of Nigeria, Mechanical Engineering Department, FCT Abuja, Nigeria
[3]Department of Mechanical and Industrial Engineering Technology, University of Johannesburg, South Africa.
[4]Department of Mechanical Engineering, University of Ibadan, Ibadan 200281, Nigeria.
[5]Department of Mechanical Engineering, INTI International University, Malaysia
[6]Department of Mechanical and Construction Engineering, Northumbria University, Newcastle, NE7 7XA, United Kingdom

Abstract. The massive increase in energy consumption, especially over the past several years, has raised fears that the world's fuel and other resource reserves would be drained in the coming years. Over the years, low-cost, long-term energy has been viewed as the foundation of any country's social and economic success. Nonetheless, in recent decades, a bigger section of the population of developing economies has had limited access to inexpensive and sustainable energy, contributing greatly to these countries' poor economic and social growth. This study was therefore a review of the various sources of energy and their applications.

1 Introduction

Energy can be seen as the amount of power or strength that, when applied, may propel anything from one location to another, or it might represent a system's ability to perform labour. Potential, electromagnetic, light, kinetic, sound, nuclear or photo-energy, and gravitational energy are all types of energy. The ability to convert one type of energy to some other types is the most important attribute of energy. This can be performed either naturally (using chemical processes) or by employing man-made energy equipment (for example, hydropower plants). Further energy transformations convert a naturally existing source of energy, (such as electricity or heat) into the desired form [1-2].

Global growth has risen significantly since the Industrial Revolution, notably after the second world war, fueling the rise in energy demand. As a result, worldwide energy use has risen consistently over the previous 50 years. Oil has the largest share, followed

* Corresponding author : ikumapayi.omolayo@abuad.edu.ng

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closely by gas and coal, all of which have climbed by over 280%. At the same time, hydroelectric energy increased by 500% [3]. Yet, its percentage remains significantly smaller than those of fossil fuels. Nuclear energy has also grown dramatically, but has plateaued recently, owing to increased public understanding of the hazards associated with this technology in the wake of nuclear electricity plant mishaps such as the one that occurred in Fukushima in 2011 [3]. It is commonly acknowledged that a region's economic and industrial progress is focused on its ability to construct clean, efficient, and long-term energy systems. Adequate access to alternative fuels can improve not just the financial and cultural well-being of people, but also allow towns and human settlements to evolve and operate in more open, secure, adaptable, lesser polluted, and more lasting ways [4]. The availability of a safe, reliable, and cost effective energy supply, particularly in emerging economies like Nigeria, has shown to be a tremendous job across the corporate and energy industries. Not only does it have an impact on people's living standards and reduces industrial production capacity, but it is also a major contributor to developing countries' slow GDP growth. In light of this, the UN agreed in 2016 on a common framework to solve 17 major global challenges by 2030, with access to an affordable and efficient energy system (Fig 1) recognized as SDG 7 [5].

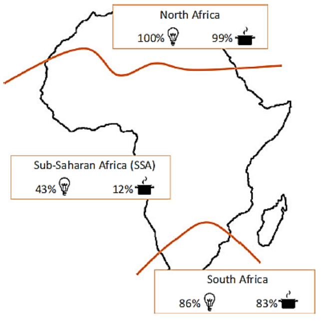


Fig 1. Energy (power) supply and clean cooking gas availability per zone in Africa [5].

2 Energy Sources

The earth is endowed with huge energy resources that can be used to address the energy shortages that both the commercial and public sectors are currently experiencing. These resources are roughly classified as renewable energy, which includes energy from sun, wind, biomass, and hydro, and nonrenewable energy, which includes energy from crude oil, natural gas, and coal [6-7]. The next subsection discusses energy resources.

2.1 Renewable energy sources

Renewable energy (RE) supplies are many types of energies received naturally from the earth, notably geothermal energy. There are different types of renewable resources accessible, comprising hydrothermal, thermal, sunlight, wind power, aquatic and biogenic energy, which provide the ability to create constant power. North Africa's topography and climatic characteristics allow it to generate a substantial measure of 0.25 TWh/km^2 [8]. Furthermore, a vast amount of clean water may be created and distributed to nearby regions in need of water with the correct technologies. Wind energy is another important asset in the territory, with Egypt exhibiting the highest production level, followed by Morocco [1,8].

Nigeria is endowed with an abundance of renewable energy resources, giving her enormous capacity to build an effective national energy plan. The incorporation of sources of clean energy into reservoir of the country's energy mix can significantly impact on the budget of the country on energy [8]. Unfortunately, over the years, the tremendous promise of renewable energy, particularly solar energy, wind energy, and geothermal, remains unrealized [9].
According to Ezugwu [10], Nigeria is a country endowed with big rivers and a few natural falls, as well as tiny rivers and streams in each of the country's eight

hydrological basins. A number of these rivers sustain minimum discharges all year, and hydropower potential currently contributes for around 29% of total electrical power supply. Approximately 20 percent of the the nation's technically accessible hydropower potential, estimated to be 11,000 MW, is already being tapped and fed to the National grid. [7]. Table 1 show the top 15 nations in terms of overall wind power gadget installations. The worldwide expansion of 17.2% in 2015 is clearly noteworthy, and it represents a substantial pattern toward the use of clean energy [1,11].

Table 1. Largest Nations in terms of total wind energy installations [11]

Place	Nation	2015 Cumulative Capacity (MegaWatts)	Improved Capacity (MegaWatts)	Rate of Growth (%)
1	Germany	45, 192	4919	11.7
2	China	148,000	32,970	29.0
3	Canada	11,205	1511	15.6
4	Spain	22,987	0	0.0
5	India	24,759	2294	10.2
6	USA	74,347	8598	13.1
7	UK	13,614	1174	9.4
8	Sweden	6025	615	11.1
9	Italy	8958	295	3.4
10	France	10,293	997	10.7
11	Brazil	8715	2754	46.2
12	Portugal	5079	126	2.5
13	Poland	5100	1266	33.0
14	Turkey	4718	955	25.4
15	Denmark	5064	217	3.7
Other Nations		40,800	5000	14.0
		Cummulative:		Average Value
		434,856	63,690	17.2

2.2 Renewable energy sources

Nigeria has an abundance of various energy resources. Nonrenewable energy is derived from petroleum and petroleum products such as crude oil, coal, nuclear powerpropane, . As of 2011, Nigeria's estimated coal resource was 27 billion tons [9], with the vast majority of the coal deposit lying in the cretaceous Anambra region and expanding to Dekina in the basin's northern part [12]. Coal mining areas are scattered unevenly throughout countries, with each having a varied production capacity, kind, and depth of coal. According to Osueke and Ezugwu [12], after full privatization and rehabilitation, the production abilities of significant mining sites in Nigeria can be increased to the extent that Onyeama and Okpara can achieve 150,000-400,000 tonnes/year, Owukpa (2500 tonnes/year), and Okaba (15,000-300,000 tonnes/year). Nigeria also has the world's sixth biggest crude oil reserve, with an estimated 36.2 billion barrels of oil and a petroleum product deposit of roughly 187 trillion cubic feet [5]. Oil and gas deposits are concentrated in the Niger Delta, Gulf of Guinea, and Bight of Bonny [5]. Other energy production that is buried underground in reservoirs is natural gas. It is largely methane-based and cheaper than crude oil. As of January 2006, Nigeria's gas reserves were projected to be 182 TCF (trillion cubic feet), with a pace of growth of more than 70% expected by 2025 [6]. The capacity places the country seventh in the world and first in Africa in terms of natural gas reserves [13]. Current crude oil and natural reserve estimations are 35 billion barrels and 185 trillion cubic feet, accordingly. These fossil fuel reserves have the potential to supply Sub-Saharan Africa's energy demands for several decades [14] (Fig. 2).

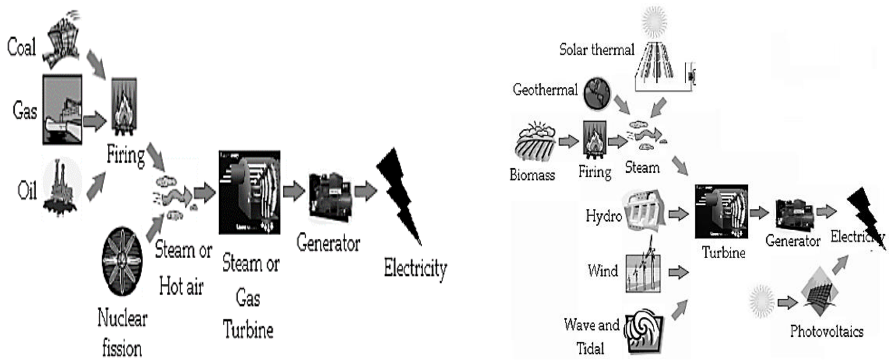


Fig 2. Energy technologies that are generic. (a) Non-renewable (b) Renewable [1]

2.3 Energy generation and its challenges

2.3.1 Africa's generation capacity

The African energy sector is better divided into three distinct regions. North Africa relies significantly on natural gas and oil, South Africa depends on coal, while all other African nations mostly depend on biomass [15]. Statistics for Eastern and Southern African countries show that biomass energy accounts for a significant share of overall national energy supply (Fig. 3) [15].

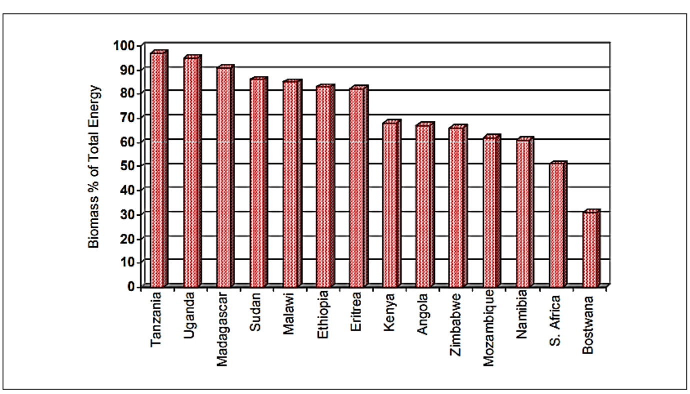


Fig. 3. Percentage Biomass Energy from total energy for some selected African countries [15]

Even oil-rich countries in sub-Saharan Africa rely on biomass energy to meet the vast majority of their family's electricity requirements: in Nigeria, biomass is projected to supply 97% of domestic energy needs [15]. Conventional biomass energy has major environmental consequences. Indoor air pollution from enclosed biofuel burners is an important factor contributing to respiratory ailments in Sub-Saharan Africa's highlands. Biomass usage (particularly charcoal use) contributes to land degradation. In certain locations, the demand for charcoal appears to be adding to the deterioration of neighboring woods and forests, notably around urban centers such as Lusaka, Tanzania, Zambia, Dar-es-Salaam, Kenya, and Nairobi [15-16]. Sub-Saharan Africa (excluding South Africa) uses almost no modern energy. East and southern Africa's per capita usage of modern energy remained low and stagnant between 1980 and 2000, dropping from 317kgoe (kilograms of oil equivalent) on average to 292kgoe [17]. When power utilization is analyzed, it becomes clear that Sub-Saharan Africa has very low levels of contemporary energy use. Without South Africa, per capita power consumption reduces from 431kWh to 112kWh [17]. Sub-Saharan Africa's overall energy demand is roughly 267 Mtoe, includes 54% classic energy (80% without South Africa), 14% solid fuel, 27% oil, 3% hydroelectric power, and 2% gas (Fig. 4a).

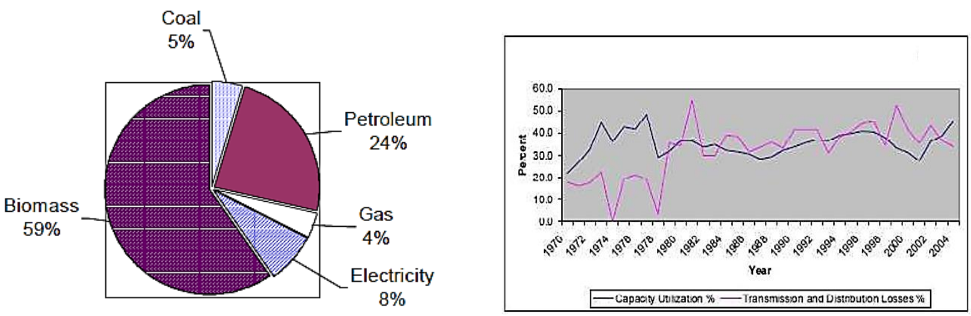


Fig 4. (a) Africa's cumulatives energy need in 1999 (b) Indicator for Electricity Shortage [14-15]

The Nigerian power system, like other power systems, is divided into three hierarchical subsystems: generation, transmission, and distribution. The state-controlled Power Holding Corporation of Nigeria (PHCN), formerly named as the National Electrical Power Authority (NEPA), has proven unable to meet minimum acceptable international standards of power service reliability, accessibility, and availability over the past thirty years. The pattern of transmission and distribution losses depicted in Figure 4b illustrates the nature of the power supply's poor performance [15].

2.4 Solving energy generation challenges

2.4.1 Enhancing energy effectiveness and lowering energy intensity

It is possible to reduce energy usage through boosting energy efficiency. This can be realized through properly developing equipment, motors, and, in particular, buildings, where energy consumption is high [18]. Reducing the use of electricity in lighting and heating and cooling systems, using more recycled materials, collecting local water and energy for self-consumption, and other measures are all feasible ways to enhance energy effectiveness and move toward near zero-energy buildings (NZEB) or even zero energy buildings (ZEB).The phrase "smart city" refers to the place where a person lives [3]. The term "smart city" relates to an area in which an individual lives. The term "smart city" relates to the city in which a person lives. Merchandise creation must be properly connected, with a reduction in the distance between production and consumption, resulting in less energy for movement and more efficient manufacturing processes [3]. This drop in power use will be reflected in lower energy inclusion in goods, i.e. lower energy intensity. In order to boost energy efficiency and minimize energy intensity, efficient waste management [19], as well as resource and energy retrieval, are required [3].

2.4.2 Improving the long-term viability of energy systems

The development of biorefineries, which are equivalent to petrochemical compounds but rely on recyclable energy and raw materials, is now considered as more realistic in the medium to long term [20-21]. They are an excellent alternative for sustainability since they allow for the substitution of non-renewable sources with renewable ones, reducing the total negative environmental consequences of commodities over their entire life cycle. Furthermore, the prospective uses of RES may be expanded, boosting their efficiency, durability, and economic potential in comparison to current energy sources, particularly fossil fuels [22].

2.5 Sustainable energy generation techniques

Natural resources utilized to create energy and power for nations worldwide are finite and may run out before they can meet demand. At the same time, global renewable energy output climbed by 2.9% between 2013 and 2014 [1]. As a consequence, if the total global energy supply is 13.700 Mtoe (Figure 2), clean energy contributes for 13.8% of total primary energy supply (1.894 Mtoe) [23]. This is a considerable quantity given that global energy demand is expected to reach 599 Exajoule20 (EJ) by 2020 and 657 EJ by 2025 [1]. Since the 1990s, renewable energy output has expanded at a rate of roughly 2.2% per year, exceeding the total supply of primary energy growth of 1.9% (Fig. 5).

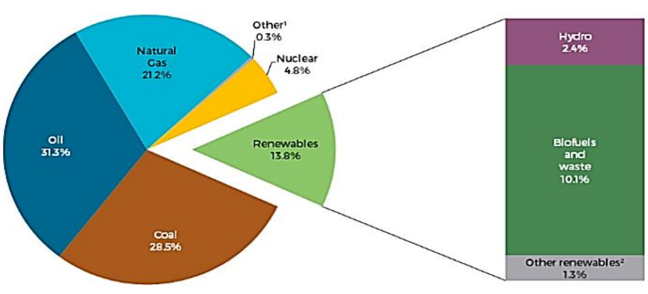


Fig 5. Total Basic Energy Supply for 2014 Fuel Sharing Across the Globe [1]

Notwithstanding the above, photovoltaic solar and wind energy have grown at a rate of 46.2% and 24.3%, respectively, in the Organisation for Economic Cooperation and Development (OECD) area and China. At the same time, hydro and solid biofuels remain the most popular kinds of renewable energy, with yearly growth rates of 2.5% and 1.5%, respectively. As seen in Figs. 5–7, non-OECD regions utilize about 75% of all sustainable energy when bioenergy is used. Materials such as wood are used by the general people. Similarly, renewable energies account for over 50% of total energy consumption in Africa, but just a quarter of total energy consumption in Asia (excluding China) and the Non-OECD Americas [24-25].

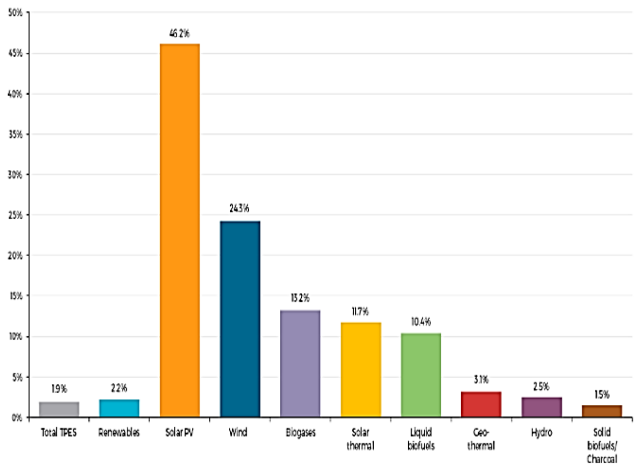


Fig 6. Annual growth rates of worldwide renewable energy output from 1990 to 2014. [1,11].

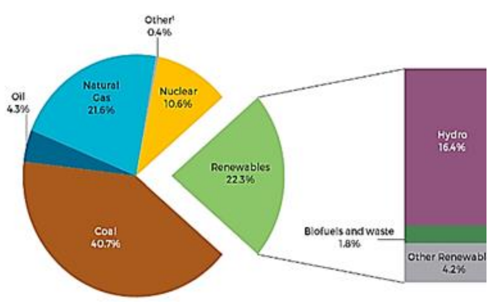
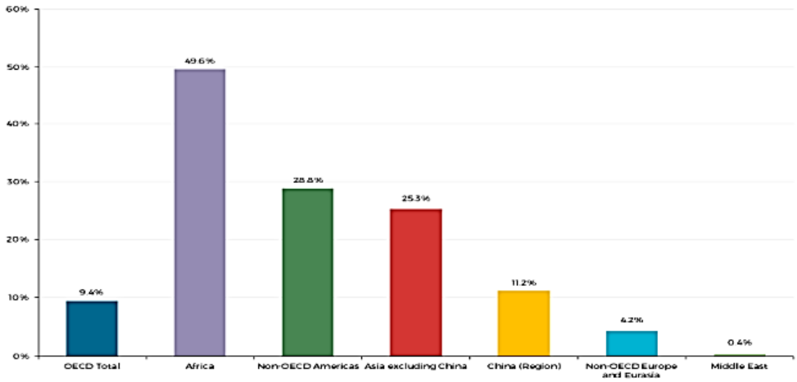


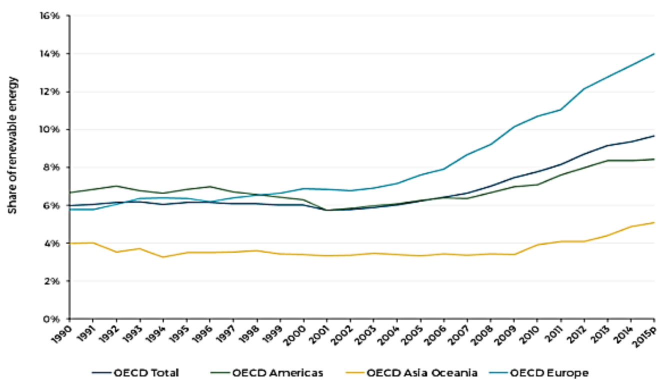
Fig 7. Fuel Shares in World Energy Production in 2014 [1].

Almost 73% of renewable electricity is supplied by hydroelectricity, accounting for more than 16% of global electricity generation. Furthermore, alternative resources such as solar, wind, geothermal, and tidal power, that collectively account for over 4 percent of total, are continually growing. Renewable energy contributed for around 19% of total electricity generation in 2014. Global renewable power output increased by 3.6% per year after the 1990s, slightly faster than the overall increase in power generation of 2.9% [1].

Africa, as seen in Fig. 8, has a particularly rapid pace of development when contrasted with the rest of the globe. In contrast, it appears that the Middle East has witnessed the least amount of renewables deployment and increase throughout the years. This might be owing to an excess of natural resources like oil and gas, an absence of technological advances, or governments' unwillingness to invest in such areas. As shown in Fig. 7, renewable energy is the second biggest source of worldwide electricity generation, contributing to more than 22% of global output in 2014, following only coal (more than 40%) and slightly ahead of has (more than 21%), followed by nuclear (more than 10%) and oil (more than 4%) [1,3].



(a)



(b)

Fig 8. OCED countries: (a) Annual Power Generation Growth Rates from 1990 to 2015; (b) Renewable Electricity Generation Proportion from 1990 to 2015 [1].

To counteract last year's decline in progress, the African progress Bank established strong international and regional ties with all key stakeholders, with the objective of resolving the continent's major energy issue and eliminating energy poverty by 2025 [1].

As a result, a new, collaborative, and coordinated set of critical primary actions emerged. For the 2017 agenda, Morocco, the nation of the Congo Republic (DRC), Kenya, South Africa, Algeria, Ethiopia, Tanzania and Egypt plan significant growth in terms of renewable energy impact, developed power production in remote communities, and assistance in connecting and generating power in agrarian regions, all with the goal of revolutionizing the Continent's Renewable Energy evolution [26-27]. A new beginning at the Paris Climate Conference, the African Renewable Energy Initiative was formed with the purpose of deploying at least 10 GW of extra renewable energy potential by 2020, with the ultimate goal of generating at least 300 GW by 2030 [28-29].

3 Conclusion

The various energy sources, prospects and challenges as well as possible solutions to these highlighted challenges have been reviewed in this study. The following conclusion has been reached based on the findings of this review;

(i) Ability to key into the use of renewable energy is a vital determinant of growth rate in Africa and other developing countries.

(ii) To fix energy shortfall in Africa, renewable generation policies must be reviewed and adopted.

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