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Renewable and Green Energy, Africa's Pathway to Sustainable Development; Harnessing the Continent's Natural Energy Sources

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Abstract

Renewable energy includes all forms of energy produced from renewable sources in a sustainable manner, including bioenergy, geothermal energy, hydropower, ocean energy, solar energy, and wind energy. Less than one quarter of Africa's renewable power generation potential is utilized. Africa's natural endowments are enormous, yet the continent experiences high energy shortage. Amongst the classifications of energy sources, renewable and green energy sources are increasingly gaining popularity due to their sustainable nature and environmental concerns. This paper explores the continent's natural energy sources and identifies pathways to sustainable development. The paper also narrows the renewable and green energy sources obtainable on the continent and presents their contribution to the development of the continent. The awareness level of Africans towards renewable energy is discussed and the challenges of renewable and green energy sources are highlighted. Finally, the roles to be played by the government and private organizations in the development of renewable and green energy sources in Africa are discussed.

Keywords

Green, Renewable, Continent, Harness, Sustainable, Environmental

1. Introduction & Literature Review

Africa possesses great natural endowments in all forms. It has the advantage of an abundance of natural hydrocarbons. Africa has a significant percentage of the world's oil production as well as large quantities of coal and gas [1]. Africa has abundant sunlight, wind as well as abundant land. Africa's land includes the tropical rain forest which has carbon sequestration implications. The continent also has arable and affable land with a potential for biofuels. In terms of utilization, fossil fuels, biomass and hydro make up Africa's most predominant energy sources [2]. There is however a different mix of resource endowments in the different regions and countries of Africa; almost all the geothermal resources in Africa are in East Africa, a big percentage of the hydro resources are in central Africa, significant wind resources are in the North and East as well as solar resources located in North and West [2]. There is more dependence on renewable energy sources by Eastern Africa and Central Africa than other regions [3]. Africa contains great energy options and is truly blessed with all the resources needed, both conventional and renewable energy sources. **Tables 1-6** show the power projects in Africa in terms of the ones operating, in construction and

Table 1. Africa [4].

OPERATING	CONSTRUCTION	PLANNED
227,586 MW	51,805 MW	296,270 MW
2765 projects	210 projects	2036 projects

Table 2. Centre Africa [4].

OPERATING	CONSTRUCTION	PLANNED
6014 MW	1003 MW	23,585 MW
269 projects	7 projects	101 projects

Table 3. East Africa [5].

OPERATING	CONSTRUCTION	PLANNED
16,987 MW	10,539 MW	44,924 MW
660 projects	61 projects	511 projects

Table 4. North Africa [4].

OPERATING	CONSTRUCTION	PLANNED
104,069 MW	20,601 MW	56,204 MW
397 projects	51 projects	154 projects

Table 5. Southern Africa [4].

OPERATING	CONSTRUCTION	PLANNED
72,111 MW	12,765 MW	83,617 MW
547 projects	41 projects	682 projects

Table 6. West Africa [4].

OPERATING	CONSTRUCTION	PLANNED
28,405 MW	6897 MW	87,941 MW
892 projects	50 projects	588 projects

planned.

From the above tables, we see that West Africa has the most projects in operation with 892 projects. The region, however, lacks behind East Africa in the number of projects undergoing construction (61) and Southern Africa in the number of planned projects (682). We can see generally from the tables that Africa is making intentional progress as regards making energy available as the number of planned projects in all regions is comparable to the number of already existing projects as should be for the second most populous continent.

2. Conventional, Renewable and Green Energy

According to the United States environmental protection agency, Conventional energy sources typically refer to fossil fuels combined with nuclear fission involving uranium (3). Fossil fuels include crude oil, natural gas, coal etc. Nuclear energy may be differentiated in the sense that it does not involve emission of greenhouse gases. However just like fossil fuels, it involves mining, extraction as well as the storage of the long-term radioactive wastes. Renewable energy sources refer to sources that do not diminish but are restored by themselves between short periods. They occur freely in nature and are infinite supply. Examples include the wind, sun, waste material, heat (geothermal), organic plants etc. Green energy is a constituent of renewable energy sources. They reflect the sources that promote a lot of benefits to the environment. The Environmental Protection Agency (EPA) classifies green power as power generated from the sun, wind, geothermal, biomass, biogas, and hydroelectric sources that have low impact. The difference between all renewable energy sources and the subset that constitutes green power lies in the effects transmitted to the environment. Large hydroelectric resources for instance have trade-offs that relate to the environment like the effect on fisheries and land use. Another example of a renewable energy source not classified as green power by EPA is municipal solid waste. It is important to note that renewable energy sources are not the only class that occurs naturally. Non-renewable sources are also naturally occurring as they are within the surface of the earth. The difference is in the duration at which the sources replenish. Non-renewable sources are only available in finite amounts and thus can produce energy shortages in the near future [4]. It is then very clear to see why renewable energy sources are preferred to non-renewable sources. **Figure 1** shows the total renewable energy consumption globally in terms of terawatt-hours per year while **Figure 2** shows that for Africa alone.

Despite being heavily blessed with these natural endowments, research carried out in [1] and [2] showed that awareness of these resources and their utilization

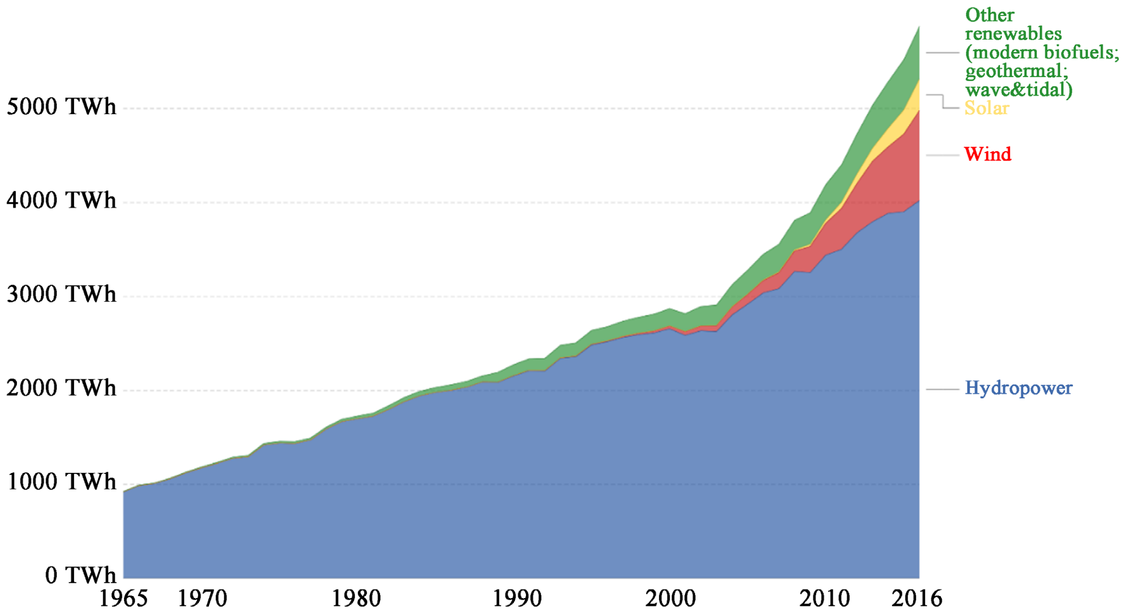

Figure 1. Global renewable energy sources [5].

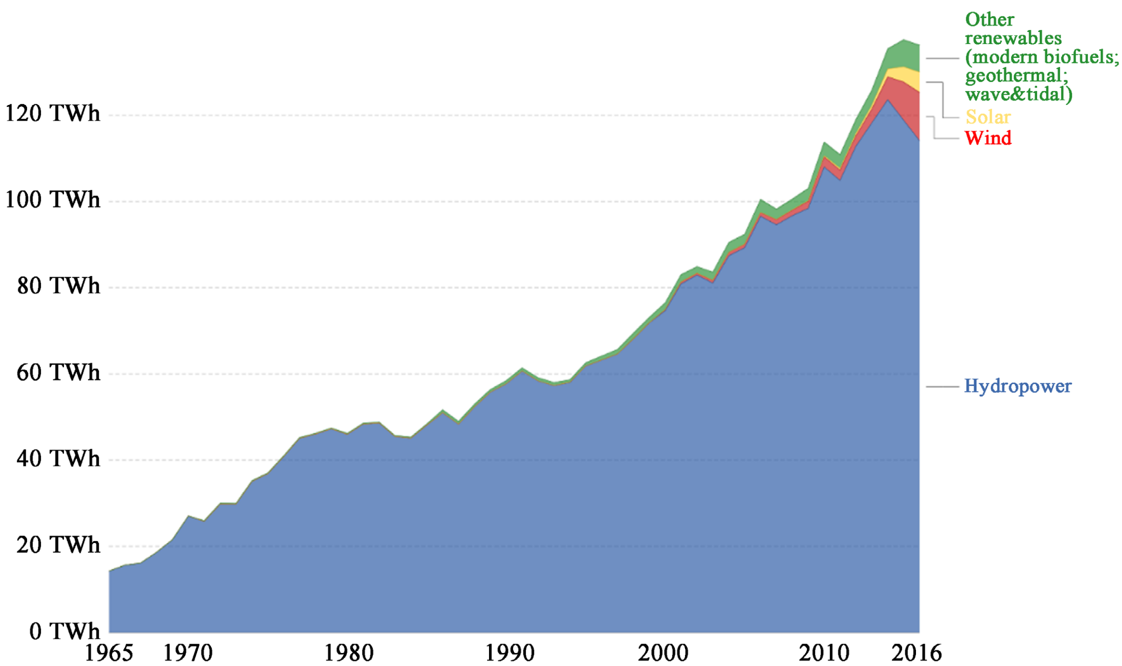

Figure 2. Renewable energy consumption in Africa [5].

is low. In [5] the utilization of renewable energy resources was explored for the purpose of achieving sustainable development in Nigeria. They adopted a survey approach by distributing questionnaires across Abuja, Nigeria. The results obtained from the data collation revealed that a large number of the respondents lacked knowledge of renewable energy resources and its utilization and adoption. The authors recommend the political commitment of the government towards renewable energy and developing an energy-efficient environment for the private sectors, which will in turn enhance the achievement of sustainable development goals. In [6] the application of renewable energy technologies was analyzed for the reduction of electricity poverty in the Southwestern region of Nigeria. To examine this application, data was collected by reviewing the opinions of 143 respondents with the aid of questionnaires. This was carried out in order to examine the knowledge of the residents towards the substitution of the national grid system with renewable energy. From the obtained results, it was discovered that a reasonable percentage of the population (38%) were unaware of renewable energy derived from biomass, wind, and solar heating. However, they possessed knowledge of energies from firewood, solar and large hydro. In addition, the bulk of the population was open to the introduction of renewable energy Technology, provided the government funds the operation. The authors urge the local and state governments in setting up plants, providing a sustainable environment for implementation, as well as educating both rural and urban dwellers about the advantages of such technology and how sustainable development can be achieved. Currently, there is perhaps no greater need for energy than in sub-Saharan Africa.

In sub-Saharan Africa, it is noted that just 42.8% of the population can access electricity [7]. This should not be as Africa is the continent with the highest renewable reserves in the world. The sub-Saharan Africa region is also the region that depends most on available natural resources in order to meet the region's social and economic needs. Africa can also benefit from her status as a "latecomer". The African Development Bank (AFDB) has put the spotlight on green growth to actively encourage a more sustainable and resource efficient development [8]. Research shows that a bi-directional positive relationship exists between energy and economic growth [3]. Wesseh & Lin [9], showed that for every unit increase in capital, labor, renewable and non-renewable energy, Africa's economic growth is boosted by 15%, 21%, 12% and 5%. Renewable energy in particular was also shown to have a significant role in Africa's economic activities as it had an average estimated output elasicity gap of 0.41 to nonrenewable energy [10]. Health and education are improved in areas where there is electricity access [3]. While developing countries have poured in huge investments in their power supply and other infrastructures, Africa will be making her investments at a time when new technologies are readily available leading to more efficiency [11]. The continent should however not wait for technological change and should invest quickly as it is experiencing grave energy shortages. Renewable energy also largely contributes to the reduction of pollution locally and globally. Climate change constitutes a serious problem in our world today. Renewable energy sources produce little or no carbon dioxide or Sulphur dioxide as well as particulates which pollute the environment. In the present world, there are control measures to limit the effects of carbon emission in operations that involve it. Carbon Capture and Storage (CCS) is one of those measures. However, the cost of implementation of CCS is very high especially for a continent like Africa. The engagement of Renewable energy sources also reduces the pressure on the use of fossil fuels. This means that mining activities can also be reduced. Mining activities constitute environmental factors such as oil spillage. These have an effect on the surrounding environment. Oil spillage is a direct threat to life below water. The protection of life below water is one of the present world's sustainable development goals.

Figure 3 and Figure 4 show the renewable energy electricity share globally and in sub-Saharan Africa.

3. Renewable and Green Energy in Africa

Table 7 shows the progression of different renewable energy sources

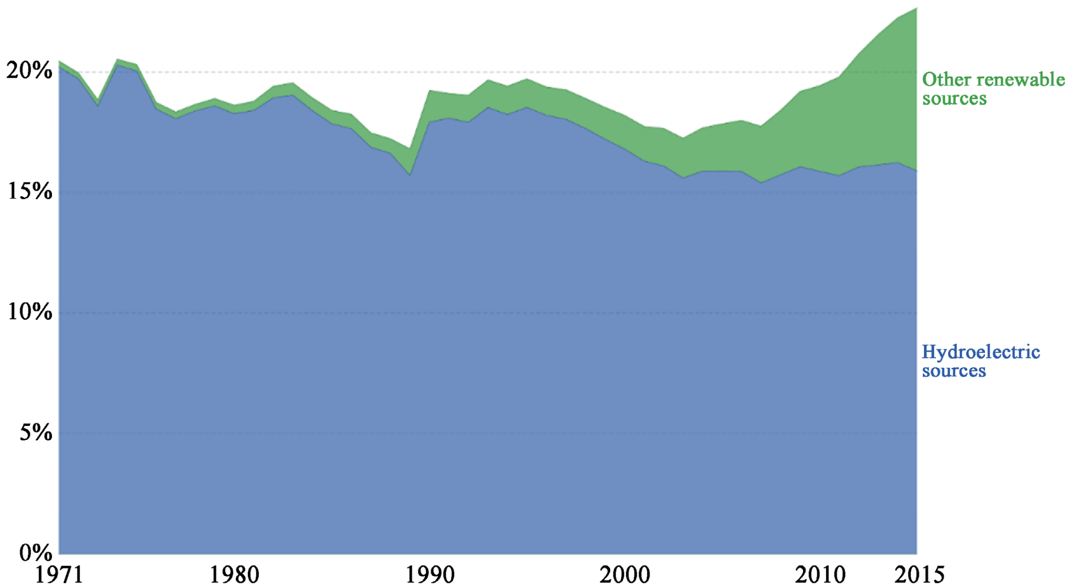

Figure 3. Global renewable energy source electricity share [11].

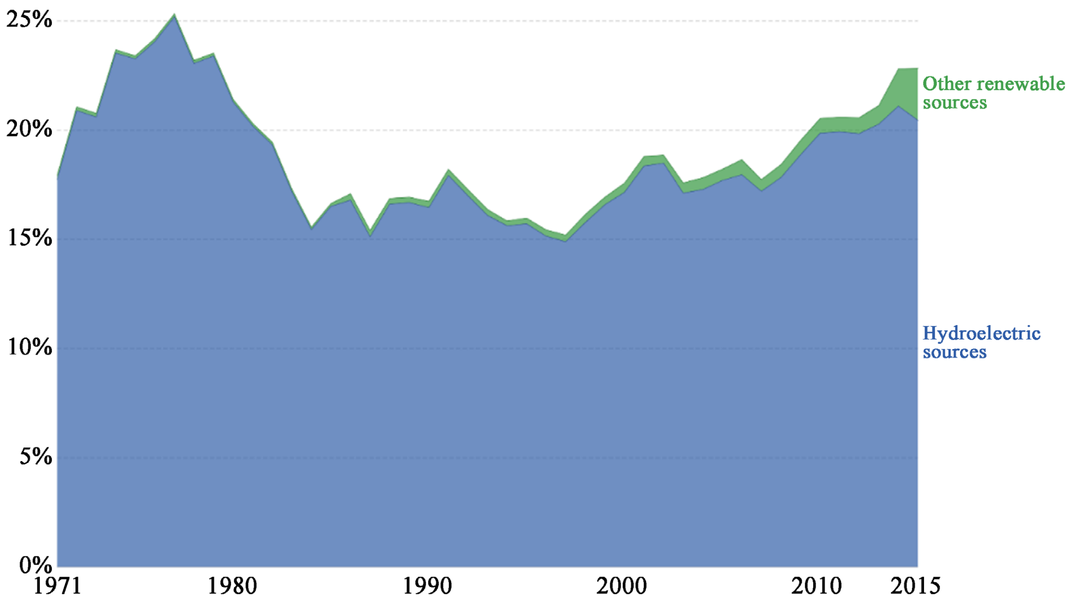

Figure 4. Renewable energy source electricity share in sub-Saharan Africa [12].

Table 7. Modern renewable energy sources in Africa in terawatt hours [12].

Year	Hydropower	Wind	Solar	Other renewables (modern biofuels; geothermal; wave & tidal)
1965	14.27881	0	0	0
1966	15.64905	0	0	0
1967	16.15833	0	0	0
1968	18.62298	0	0	0
1969	21.5829	0	0	0
1970	27.07629	0	0	0
1971	25.83661	0	0	0.164
1972	29.83688	0	0	0.165
1973	29.80374	0	0	0.17
1974	35.08919	0	0	0.175
1975	36.87905	0	0	0.172
1976	40.86118	0	0	0.185
1977	45.08335	0	0	0.189
1978	46.08508	0	0	0.195
1979	47.28021	0	0	0.201
1980	46.03017	0	0	0.207
1981	48.37745	0	0	0.218
1982	48.63271	0	0	0.236
1983	45.50891	0	0	0.23
1984	45.12596	0	0	0.234
1985	48.12639	0	0	0.269
1986	51.03188	0	0	0.659
1987	48.35234	0	0	0.658
1988	52.38957	0	0	0.626
1989	55.79135	0	0	0.617
1990	57.7303	0	0	0.732158
1991	60.70288	0	0	0.738421
1992	58.41492	0	0	0.730421
1993	57.3304	0.002	0	0.715421
1994	58.0541	0.0054	0	0.600474
1995	61.85884	0.0063	0	0.745474
1996	63.22384	0.0071	0	0.948462
1997	64.65638	0.0072	0	1.033462

Continued

1998	68.17048	0.0076	0	1.33387
1999	71.86766	0.0318	0	1.266555
2000	74.7062	0.2325	0.002	1.619632
2001	80.91176	0.45808	0.002	1.709421
2002	82.94512	0.435064	0.023313	1.536368
2003	81.10015	0.621187	0.023313	1.914
2004	87.43447	0.786267	0.025323	2.292
2005	89.30455	0.822299	0.028323	2.2827
2006	96.57064	0.86144	0.031933	3.08399
2007	94.6426	1.182661	0.033858	2.41415
2008	96.72956	1.291401	0.089115	2.519322
2009	98.43312	1.681591	0.126766	2.854122
2010	108.0391	2.368697	0.245571	3.207342
2011	104.933	2.411056	0.400934	3.172857
2012	112.8685	2.431426	0.545924	3.272924
2013	118.2414	3.28258	0.812731	3.550538
2014	123.6531	5.323815	1.806518	4.712818
2015	118.8991	8.852924	3.534706	6.303893
2016	114.1265	11.21308	4.712726	6.277311

consumption in Africa from 1965 to 2016.

It can be seen from the table that hydropower constitutes the majority of the renewable energy consumption in Africa with a large margin. Wind comes second. However, amongst the new green technologies in Africa, Solar power can be regarded as the most promising. This is because Africa has intense sunlight that is evenly distributed all though the year [13]. Another advantage is that solar power does not require a grid. Collier & Venables likened solar power to mobile phones which conquered Africa because the existing landline networks were inadequate [14]. Solar power, however, is both expensive to implement and skill-intensive. The maintenance needed by solar panels requires technicians to be distributed around. Thus the life span of solar panels is reduced and costs increased when these technicians are scarce. [15]. At the current stage, solar power is only realizable for houses and firms that are small in nature with conditions of grave energy shortage and high shadow price of energy. Solar power may be very useful in making power available to outlying villages but not very much for urban areas. Solar also requires storage if it is to serve all through the day. Storage cost for solar power system is high.

Solar energy however is continually making steady progress in the continent. Aderemi, *et al.* [16] explored the implementation of solar energy for supplying power to mobile cellular base stations in South Africa. They believe that the proposed approach would greatly contribute to the eradication of harmful gas emissions, improve power supply, while also minimizing energy cost. Thus, they provide an insight into the ability of South Africa to transition to Solar PV Powered Base Station from the conventional Base Station. Through the study, they suggest investments towards the development of Solar PV Powered BS rather than other power sources to enhance cellular network operations.

The presence of many high-altitude 1 areas in Africa presents a great advantage for hydropower as the water vapor from the Atlantic falls comes around it. Many of the renewable projects in Africa are hydro and of all of them, Hydro is presently the most promising for large-scale development [17]. The capital costs per MWh of Hydro power are the cheapest among the renewable energy sources.

Another advantage Africa can utilize is her large landmass. The population density of sub-Saharan Africa is low and thus much of the land mass is idle [18]. Azouma, *et al.* [4] introduce the production of biogas with the aid of agricultural waste for sustainable supply of energy in developing countries (in this case, the Republic of Togo). They investigated the conversion of solid wastes from pineapple into biogas through anaerobic digestion carried out in a laboratory. From the experiments carried out, it was deduced that the pineapple waste was highly compliant for producing biogas. A high percentage of methane content (41.0 vol. % - 70.5 vol. %) was derived from the conversion, thus resulting in a successful implementation, as the goal of obtaining high methane yield was achieved. As future work, they plan to construct a pilot plant and employ the laboratory results for sealed biogas production. Amigun, *et al.* [19] also present an outlook towards biofuel development in Africa as well as the environmental, social and economic issues prevalent in the countries. In their work, they propose the combination of policy incentives with advanced technologies in order to reduce hazards caused by biofuels production and as a result, contributing to sustainable development. They recommend gender equity for sustainable biofuels assessments and urge governments to develop regulations, programs and policies regarding biofuels development.

Uduma and Arciszewski [20] recommend solar and biomass-based sustainable energy systems for solving problems of water shortages and utility challenges in rural and urban environments in Nigeria. They propose the adoption of these two Renewable Energy Technologies (RETs) for sustainable energy development. They also specify various strategies in which sustainable energy sources can be developed including NGO partnerships, creative lending strategies, shifting energy-distribution and renewable energy business incubators. The authors believe that the implementation of sustainable energy would result in stability (political stability and social order) in Nigeria, while stimulating economic development and curbing social vices.

Gebretsadik, *et al.* [7] propose a model for maximizing generation of wind and hydropower. This model was applied on the hydropower system and reservoir storages located in the Zambezi river basin. The outcome of the experimentation depicted a reasonable increase in the wind penetration level in South Africa's power system and a decrease in utilization of coal power. With these results, the authors believe that developing this model would play a great role in South Africa's goal by reducing the emission of greenhouse gases.

Kuang, *et al.* [8] review the utilization of renewable energy for power generation in Islands. They were able to identify wind energy, solar power and hydropower as the major sources of electricity in most islands, while the remaining few generated electricity from geo-thermal, ocean energy and modern biomass. They also brought an insight into the percentage of electricity produced by these islands, with 100% generated from renewable energy in some islands and 10% in some others. They identified major barriers of the utilization of renewable energy in the islands including randomness and variability of renewable sources dependent on weather. The authors encourage the inculcation of advanced information and communication structures in smart grids for efficiently conserving energy in islands.

Hassan, *et al.* [9] provide a survey of already existing works and required principles needed for enhancing understanding based on the implementation of renewable energy in mobile cellular networks. In addition, they propose a reference model for Renewable Energy Base Stations (REBS) while completely analyzing its components. This model was evaluated with several performance metrics, which include; economical, environmental, technical, feasibility, and quality and energy metrics. They derived positive results, ensuring promising advancements when considering future developments. As future work, the authors plan to carry out investigations on the integration of REBS to the power grid system.

4. Challenges of Renewable and Green Energy in Africa

Like wind and solar, most renewable systems have low energy content, sitting problems as well as capacity factors thus needing significant inputs of conventional fuels to maintain stability of supply [20]. Different fuel types need different amounts of space, and renewable energies generally need more space than fossil fuels. One way to compare them is to use the concept of power density, measured in watt/m^2 defined as the average electrical power produced in one horizontal square meter of infrastructure. In terms of scale, wind and solar for instance have a far lower energy content than conventional energy. While conventional sources have 85% to 90% capacity factors, wind and solar have between 21.7% and 34.4% meaning they will not supply 65.6% - 78.3% of the time in a year [21]. Also, wind has a power density of 1 watt/m^2 which is low in comparison to coal and gas-fired generation which have a power density of 550 W/m^2 and 1100 W/m^2 respectively. 300,000 km^2 of land would be used in order to reach Africa's 300 GW potential with maximum power factor. This is the same as half of Eastern Africa. This may be bound to experience delays as it would require huge capital investment in land leading to social acceptability issues. Solar on the other hand has a power density of 6.5 W/m^2 and only converts 20% - 30% to electricity [20].

Apart from the natural assets, Africa also needs other inputs. Capital endowment (physical capital, human capitals and skills) is a great need as Africa has a low savings rates and poorly developed financial markets [21]. Governance endowment, which involves the institutional capacity towards the implementation and regulation of economic activities, are an important part of the energy sector's growth. Africa greatly lacks capacity in this area and there are politically economy obstacles that preclude the making of some policies.

In terms of economics, renewable energy sources do not incur fuel cost. Two things, however, challenge its competitiveness: high capital cost and value of generation. It can be shown that we do not always derive the same electricity value at all times. Power at peak demand has more value than off peak generation. For instance, in wind energy, wind velocities blow well at night and are inversely related to the daily hours of peak demand. Also, renewable energy sources are not always available at periods when they can be most economical. This makes dispatching or scheduling not possible and thus the need for backup capacity becomes essential for system reliability [20]. The backup capacity then adds to the costs of the renewable energy source and increases the operation costs of the system. Energy production, especially in relation to green energy, requires capital, high skilled labor as well as regulatory and governance capacity [21].

Azimoh, *et al.* [12] evaluate the financial barriers hindering implementation of renewable energy technology in Sub-Saharan Africa, regardless of the declining cost of RETs. They view this reduction in cost as an avenue for increasing access to electricity in the region. However, they have been able to point out several factors inhibiting the development of RETs despite the price reduction. The following factors are presented as the barriers towards RET development: lack of renewable energy policy, existence of weak institutions, lack of skills for the operation and management of off-grid electrification in the region. They observed that the two phase; capital and operational expenditure phases are points where the most failed projects occur. Therefore, more research is required to address these challenges. Pegels [10] and Sebitosi and Pillay [11] in their works, identified the potentials and barriers for renewable energy in Southern Africa, while providing policy recommendations. They were able to recognize the major barriers involved in implementing the system, which comprised two investment-planning factors: risk structures and cost.

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In terms of sitting, traditional power plants can be easily placed anywhere. The required fuels can be transported to the generation utility. Renewables such as wind or solar must be located at certain places (where the wind blows or sun shines). This means we have a limited number of optimal sites and as the ones with the lowest costs get utilized first, there results an increase in the successive costs of utilizing these sites.

In [13] the authors analyzed the energy situation in the African Island states and recommend the use of renewable energy to improve such situations. However they discovered that some of these countries possessed barriers for access to energy including lack of political commitment, poor investment in energy sector and technical hindrances.

Collier & Venables, argued that Africa's need to address its energy shortage is a priority and can be helped by creating much of her energy production on energy resources (oil, gas, coal) that she is endowed with [21]. (Wesseh and Lin, 2016) claimed that Africa would have a higher chance of reducing the effects of climate change if they make use of stable production recipe (like fossil) to accelerate wealth creation [20]. They argued that Africa should prioritize ending energy poverty and boosting real GDP while making environmental concerns on the long run; protection of the environment shouldn't be at the expense of growth [20]. There is therefore the challenge of depending on renewable energy in the process of industrialization and urbanization. China for example used its cheap energy resources such as coal to alleviate poverty and achieve close to 100% electrification rate. They are now making progress towards renewable energy but this is after eradicating poverty and reaching a certain economic growth level [20].

5. Leading the Pathway

For renewable and green energy to develop in the continent, various participations are required from different sects of the nations in Africa. The key participants and the corresponding actions required are identified:

5.1. Government

The role of the government in power generation is unavoidable and more pronounced in Africa [21]. The handling of power generation purely by private entities would quickly tend to monopoly if there is no regulation in place [21]. Collier & Venables stated that Africa inherited this system from their colonial periods where the most frequent way the monopoly problem was solved was by placing power generation in the public sector [22]. They argued that this approach has proved to be dysfunctional because of grievous capacity and political economy issues that the African governments face. The grave and persistent nature of the power shortages, lack of maintenance and under-investments have been some of the results of this system. If power generation is to improve, then the government has to be heavily involved and committed.

From [10] and [11] in a bid to solve these issues, the South African government introduced renewable energy support measures. Some of these measures involved: collaborating with other countries to share experiences and learn, supporting independent producers of power, encouraging the discovery of renewable energies, incorporating energy efficiency measures and several others. The authors believe that these approaches would aid in eliminating potential barriers involved in developing renewable energy systems in the country.

The authors, Surroop and Raghoo [13] recommend renewable energy as the solution to the above listed problems thereby improving sustainable development, mitigating climate change, improving the standard of living and in turn, enhancing livelihood. From the study, it is evident that these states possess the required potential for exploiting renewable energy sources. Thus, through their work, the authors bring into focus the need for adequate energy governance to overcome the barriers and proffer solutions for the implementation of renewable energy systems.

In [14] [15] [16] [17] and [18] analysis were carried out to understand the challenges facing the RE in African countries. Ackah and Asomani [14] analyze the demand for renewable energy in Ghana through autometrics (*i.e.* automatic variable selection model). From the findings obtained in the experimentation, it is evident that the demand for Renewable Energy (RE) is affected by both economic and non-economic factors. They recommend the development of a public education platform by the Ghana Energy Commission to encourage energy efficiency mostly in periods of power crises. Keser, *et al.* [15] analyze the relationship between energy environment and education in the Turkish policy. They suggest the economical use of energy sources as the cheapest energy and the implementation of policies towards creating education programs and raising awareness of the public towards energy consumption. They highly recommend the development of energy education programs to serve as a foundation for effectively dealing with energy before it becomes late. Oyedepo [16] evaluates the consumption of electricity in Nigeria, while encouraging the implementation of an energy-efficient policy and strategy for addressing the energy crisis being faced by the country. The author evaluates the contribution of the utilization of industrial energy in Nigeria's sustainable development as well as addresses various to engender an increase in energy efficiency. His work is posed as a review of the achievement of efficiency of industrial energy in the nation, while achieving cost-effective measures and good energy management practices. The author believes that the work will aid industrial policy makers and the government in developing a sustainable energy system. Ackah and Kizys [17] study the drivers of demand in renewable energy in oil-producing countries in Africa. In order to estimate the demand in renewable energy, three panel data models are considered, which include: a fixed effects model, a dynamic panel data model, and a random effect model. The acquired results show that energy-related carbon emissions and energy resource depletion are the main drivers of demand in renewable energy. The authors suggest the development of policies for encouraging consumption of commercial sources of renewable energy. Selosse, *et al.* [18] analyzed renewable energy techniques for securing a sustainable energy future in Reunion Island. The authors use this research work as an example for formulating energy policies that would foster renewable energy technologies for the provision of electricity. The TIMES model was used to analyze the case of the island in obtaining 100% renewable energy-based form of electricity generation. From the study, it can be seen that both financial and political support from government would play a vital role in harnessing RETs, which would in turn, foster sustainable development. In conclusion the government has a vital role to play in the development of policies, educational programs and so on to improve the utilization of renewable energy across the continent Africa.

5.1.1. Pricing Control

Collier & Venables categorized the political economy games of energy policies in Africa into two; One involving the government and the citizens and the other involving the government and investors [21]. The first category has to do with the pricing of energy. In Africa, urban electorates hold the government responsible for the pricing [21]. This is both due to energy generation and distribution being publicly owned as well as the control of prices with policies. Collier & Venables argued that under-pricing is a contributor to the low generating capacity [22], this is because both public and private investments are only viable with substantial increase in price. The energy shortage is so severe that virtually all citizens would benefit from the improved supply even with the increase in price. The drawback of this approach is the possibility of protests by the citizens. Such protests do not end with change promises [23] especially in countries that have a record of bad governance and UN kept promises. The African government faces the issue of providing an assurance to the citizens that increase in supply would follow a corresponding increase in price [21]. Oyedepo [16] recommends the placement of subsidies or incentives on investments towards energy efficiency in Nigeria.

5.1.2. Security

Concerning investors, the government needs to take serious steps towards attracting serious investments. There are social factors that affect the decisions of investors in a location. Security and the presence of social amenities are some of those factors. Investors would be less likely to invest in areas where the rule of law does not seem to prevail. Foreign investments would likely be accompanied with foreign employees. The safety of such employees is also of great concern to investors as kidnapping can be pronounced in such areas. The governments of African countries should enhance security in their respective countries in order to provide investors and private power plant owners the peace they need to make further investments and inputs.

5.1.3. Training and Skill Development

The energy sector definitely requires highly skilled labor. Africa faces the issue of skill scarcity [24]. The quality of the tertiary education is low, Inadequate on-the-job training has contributed to the persistent low power generation. The existing skilled workforce transit seeks other regions that can offer a much better quality of life [21]. There needs to be concentrated efforts in developing indigenous skilled labor. Serious investments can be done by the government both in encouraging the improvements of standards in tertiary education and also sending out indigenous engineers to developed countries for further trainings. The second part which involves sending out engineers to be trained and returned would greatly improve both the power sector and the standard of engineers that would be produced in the long run in the country.

5.2. Private and Foreign Involvement

Power generation is really capital intensive. Renewable energy systems might even be more expensive to deploy in Africa [21]. Collier & Venables showed that on shore wind and solar (which are two major renewable alternatives were the two most expensive technologies to implement in Africa. This reflects the high costs needed for renewable systems to work as wind and solar are amongst the most popular systems currently. They claimed that just few countries receive substantial funds from natural resources, and even then the revenues are expended for current consumption as against investments; this leaves African power generation dependent on private commercial power generation by foreign direct investments. The impact of private and foreign involvement in any sector is tremendous. Private involvements create a reason for improvements. This is because competition would begin to exist with the increasing numbers of private power plants who would have to ensure excellence in order to outdo similar competition. Power plants committed to excellence and improvements would gradually fade out the occurrence of power shortages in the country Collier & Venables also claimed that Foreign owned private enterprises that are regulated would be more effective in power generation in Africa since the government have failed [21]. One limitation involves the concern for investments safety. Since it is not possible to fully specify regulation in contracts, investors would fear that these foreign private companies would have to battle with corruption and bias especially from a government that can't assure credible regulation [21]. Once investments are made, they become subject to government decisions. Generally, Participation of the private sector in the generation of electricity is far lower in Africa than in other regions [22].

Figure 5 shows the investments levels by Countries in renewable energy. Just as in any other country or continent, growth, and development of green renewable energy in Africa would demand financial investments and would definitely pay off dividends in the future.

6. Commitments of African Countries to Climate Change

Renewable green energy has one major distinction; it has a very positive effect on the environment. Table below shows the "Intended nationality determined contributions" (INDC) commitments made by African countries. These show or reflect the plans that the countries propose and plan to execute concerning climate change actions.

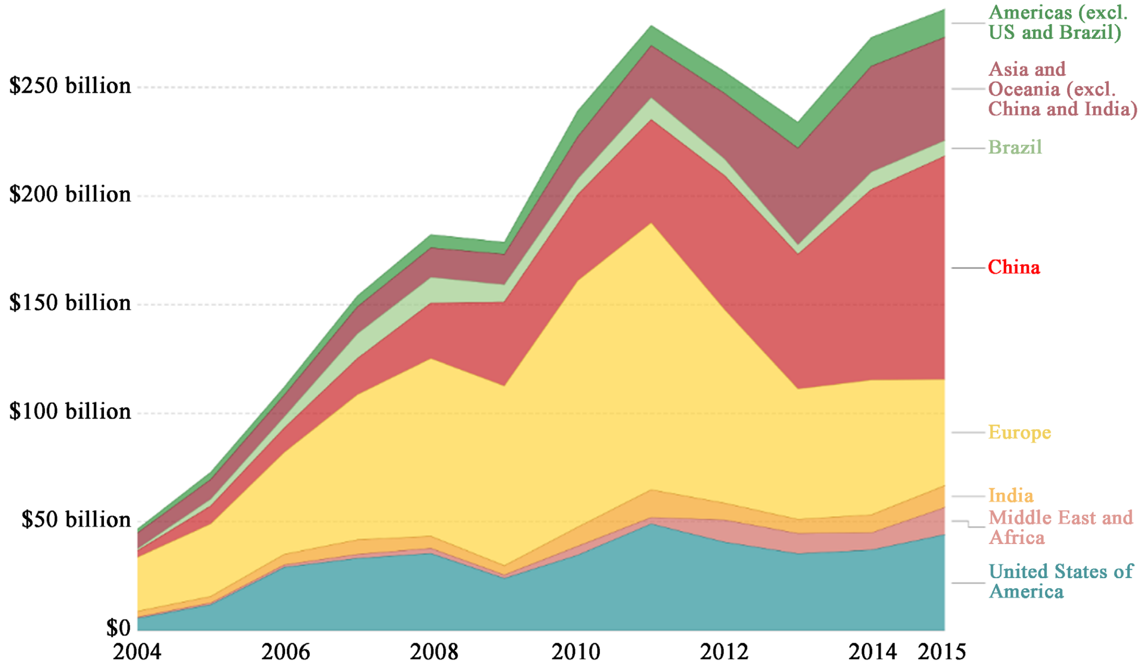

Figure 5. Global investments in renewable energy over the years [25].

Table 8. Intended nationality determined contributions by African countries [25].

Country	GHG	INDC Summary	MCT	GTT
Algeria	201.69	By 2030, reduce greenhouse gas emissions by 7-22%, compared to a baseline scenario (Business as Usual: BAU), Conditional on support for external financing, capacity building, technology transfer and development	GHGT	BST
Angola	252.09	Reduce greenhouse gas emissions up to 35% unconditionally by 2030". Also an additional 15% below BAU emission levels by the same time is possible with a conditional mitigation scenario. Over 14.7billion USD.	GHGT	BST
Benin	23.54	"In comparison to the status quo scenario, reduction of overall cumulative greenhouse gas emissions without the inclusion of the forestry sector. Featuring about 49.49 Mt E-CO_2, a reduction of 16.17 percent. Over the period 2021 to 2030.	GHGT	BST
Botswana	36.56	15% reduction by 2030 in terms of overall emissions, with 2010 as the base year."	GHGT	BYT
Burkina Faso	32.6	Three scenarios. reduce greenhouse gas emissions by 7808 Gg/yr in 2030, Unconditional (annex 1), reduce greenhouse gas emissions by (11.6%),13.766 Gg/yr in 2030, A Hybrid Conditional scenario (annex 1), to restore and develop 5,055,000 ha of degraded lands hence feeding an additional 6,000,000 persons at the 2030 horizon.	GHGT and NGHGT	BST
Burundi	5.56	In comparison to the BAU Scenario, reduce greenhouse gas emissions by 3% for 2030 Conditional contribution: Reduce greenhouse gas emissions by 20%, beginning in 2016, for 2030.	GHGT	BST

Continued

Cameroon	196.56	In comparison to a baseline scenario, reduce greenhouse gas emissions by 32% for (2035). conditional on support from the international community in the form of financing, capacity building and transfer actions technologies.	GHGT	BST
Cape Verde	0.48	Renewable Energy (RE) and Energy Efficiency (EE) Targets with other mitigation actions that are nationally appropriate.	NGHGT and A	NA
Central African Republic	61.89	In comparison to the BAU reference, reduce emissions by 5% and 25%, respectively, in the 2030 and 2050 horizons.	GHGT	BST
Chad	52.67	In comparison to the baseline scenario, reduce 18.2% of the country's emissions by 2030. Reduction (Conditional) of 71% of the country's emissions by 2030.	GHGT	BST
Comoros	0.46	Reduce greenhouse gas emissions by 84% by 2030.	GHGT	BST
Democratic Republic of the Congo	206.75	Reduce emissions by 17% by 2030 against emissions under the status quo emissions scenario.	GHGT	BST
Djibouti	1.51	avoid future emissions of 1.8 $MtCO_2$, reducing greenhouse emissions by 40% An additional reduction of (20%) 0.9 $MtCO_2$ of GHG emissions in 2030 by implementing conditional measures.	GHGT	BST
Egypt	272.47	National conditions that address general economic conditions or efforts made to reduce GHG emissions in different sectors funding, capacity building, and technology transfer as implementation mechanisms.	A	NA
Equatorial Guinea	25.94	To reduce emissions by 20% in relation to the levels at to 2010, in a bid to achieve a 50% reduction by 2050.	GHGT	BYT
Eritrea	7.42	To reduce CO_2 emissions from fossil fuels by 23.1% in 2020, 30.2% by 2025 and 39.2% by 2030. Further reduction by 36.4% in 2020, 61.1% by 2025 and 80.6% by 2030.	GHGT	BST
Ethiopia	147.73	Reduce by 64% in comparison to the BAU scenario in 2030.	GHGT	Fixed level target
Gabon	−86.9	In comparison to baseline scenario, reduce greenhouse gas emissions by at least 50% emissions in 2025.	GHGT and NGHGT	BST
Gambia	7.44	Reduction by about 44.4% in 2025 and 45.4% in 2030.	A	NA
Ghana	38.57	In comparison to BAU, reduction by 15%.	GHGT	BST
Guinea	30.18	13% greenhouse gas emissions in 2030.	GHGT	BYT
Guinea Bissau	3.5	Implementation of policies and planned actions in forestry and energy sectors.	A	NA
Ivory Coast	39.21	In comparison to BAU, reduce by 28% greenhouse gas emissions (2030).	GHGT	BST
Kenya	29.29	In comparison to BAU scenario, abate greenhouse gas emissions by 30% by 2030.	GHGT	BST
Lesotho	4.17	In comparison to BAU, to reduce the emissions frequency with a conditional target of 35% by 2030	GHGT	BST
Liberia	3.51	Reduce total greenhouse gas emissions by 15% below a Business-As-Usual trajectory by 2030.	GHGT and NGHGT	BST
Libya	133.67			
Madagascar	48.5	In comparison to BAU scenario, 2030, reduce approximately 30 $MtCO_2$ (14%).	GHGT	BST

Continued

Malawi	14.54	Mitigation and adaptation actions implemented unconditionally using domestic sources including some conditional on external support in terms of capacity building, technology development and transfer, and financial resources.	A	NA
Mali	38.7	Reduce greenhouse gas emissions to 29% for agriculture, 31% for energy and 21% for land use change and forestry.	GHGT	BST
Mauritania	9.68	Reduce GHG emissions by 22.3% by 2030.	GHGT	BST
Mauritius	5.83	Abate its greenhouse gas emissions by 30%, by the year 2030.	GHGT	BST
Morocco	80.22	In comparison to BAU, reduce greenhouse gas emissions by 42% in 2030.	GHGT	BST
Mozambique	68.1	Actions (policies/programs).	A	NA
Namibia	19.66	In comparison to the BAU scenario, reduce 89% of its greenhouse gas emissions at 2030.	GHGT	BST
Niger	29.52	In comparison to BAU 2020, reduce (unconditional) of 2.5% and 3.5% by 2030 and conditional of 25% and 34.6% 2030.	GHGT	BST
Nigeria	492.44	Energy efficiency improvement by 20 percent, 13 GW of renewable electricity to rural off grid communities and gas flaring ending 45 percent below BAU.	GHGT	BST
Republic of Congo	19.29	Reduce greenhouse emissions by 48% in 2025 and 54% in 2035.	GHGT	BST
Rwanda	7.59	"Emission reductions for the 2030 year based on policies/actions which are conditional on availability of international support.	GHGT	BST
Sao Tome and Principe	0.19	In comparison to BAU, reduce 24% of national emission reduction by 2030.	GHGT	BST
Senegal	30.45	Reduce emissions (unconditional) 3%, 4% and 5% respectively in 2020, 2025 and 2030. With the conditional reductions, 7%, 15% and 21%.	GHGT	BST
Seychelles	0.56	In comparison to baseline emissions, reduce greenhouse gas emissions by 21.4% in 2025 and 29% in 2030.	GHGT	BST
Sierra Leone	12.85	Implement specific emissions-reduction actions including policies or mitigation actions such as advancing a feed-in tariff for renewable energy technologies maintain relatively low emission levels about 7.58 $MtCO_2$.	A	NA
Somalia	36.46	Communication with INDCs projects.	A	NA
South Africa	527.22	Emissions range of 398 - 614 Mt CO_2 by 2025 and 2030.	GHGT	Trajectory target
South Sudan		Policies and actions in energy generation and use, policies, and standards for financial support for investing in low carbon options.	A	NA
Sudan	234.55	Low carbon development interventions in energy, forestry and waste. Mitigation and adaptation relevant to national development priorities.	NGHGT and actions	NA
Swaziland	3.21	(Conditional) mitigation and adaptation actions. As its (unconditional contribution) human capital on mitigation and adaptation of climate change.	A	NA
Togo	13.57	In comparison to the baseline scenario, reduce by 11.14% greenhouse gas emissions.(unconditional) by 31.14% (conditional).	GHGT	BST
Tunisia	37.88	In relation to 2010, reduce its greenhouse gas emissions across energy, industrial processes, agriculture, forestry and other land use; waste lower carbon intensity by 41% in 2030.	GHGT	Intensity target

Continued

Uganda	59.92	BAU scenario, mitigation of energy-saving in 2030 will be 7,730,000 tons of carbon illustrate. Adaptation is priority.	A	NA
United Republic of Tanzania	286.49	BAU scenario of 138 - 153 million tonnes of carbon dioxide equivalent ($MtCO_2$ e). A climate resilient development pathway.	GHGT	BST
Zambia	379.89	Mitigation and adaptation components. 1/CP.19 and 1/CP.20 reduce emission of 38,000 $GgCO_2$ (47%).	GHGT	BST
Zimbabwe	63.79	Mitigation Contribution including full implementation of the draft articles of the European Commission on the subject of finance, technology and capacity adaptation visions, goals and targets.	GHGT	BST

GHG = Green house gas; MCT = Mitigation contribution type; GTT = Greenhouse gas target type; BST = Baseline scenario target; BYT = Base year target; GHGT = Green house gas target; NGHGT = Non green house gas target; NA = Not applicable; A = actions.

7. Conclusion

Energy drives all socio-economic activities and in it lies the battle for Africa's long term development and economic prosperity [20]. The increase in the number of policy makers talking and strategizing around renewable energy technologies would provide a sustainable growth path that is cost-effective for Africa [25]. This paper demonstrated the impact of renewable energy to the sustainable development of Africa. Renewable energy is increasingly promising in Africa and has received a lot of spotlights over the years. While most renewable energy sources are more expensive to implement than non-renewable energy sources, it is expected that renewable energy sources would become increasingly cost-effective with more technological advances. While the world drives green energy, some researchers claim that Africa should temporarily put a delay on environmental concerns and prioritize solving their energy shortage with cheaper non-renewable sources [20]. Some researchers advocated for a mix of both sources, Müller-Steinhagen and Nitsch [19] proposed the use of renewable energies for sustainable development. They suggest the combination of renewable energy with conventional energy carriers, which would lead to the achievement of the necessary sustainability criteria. They believe that the conventional methods of energy conversion for electricity supply (*i.e.*, heat and chemical energies) would be able to supply reliable energy at reduced costs, when adequate technological development is employed. To achieve such development, they suggested the acceleration of the growth rate for timely achievement of energy goals.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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