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Prospect and Challenges of Renewable Energy Resources Exploration, Exploitation and Development in Africa

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ABSTRACT: This paper enumerates the status and challenges of exploration, exploitation and development of renewable energy resources and its roles in sustainable development in Africa. A brief review of energy and renewable energy resources in Africa was succinctly done. The concept of sustainable development as it borders on the Renewable Energy Technologies and their roles were also discussed. The challenges facing the acceptance, deployment and promotion of Renewable Energy Technologies in Africa were also highlighted. The barriers were classified as; policy, regulation and institutional; information and technical capacity and financial. Recommendations were made towards solving problems peculiar to exploration, exploitation and development of Renewable Energy in entirety in Africa.

Keywords: Energy, Renewable, Exploration, Exploitation, Development.

I. INTRODUCTION

The continent of Africa is endowed with abundant energy resources much of which have not been exploited as a result of numerous challenges hindering the development and full scale harnessing of the essential energy resources across the continent. The major barriers are political conflicts and conventional challenges (technical, technological, economic, and institutional weaknesses). The political instability in the continent has adverse impacts on sustainable development, making the environment unsafe for both exploration and exploitation of energy and other economic resources. Energy is the inevitable necessity for enhancing economic activity and improving sustainable growth in all human endeavours. Use of energy in Agricultural and industrial production processes efficiently increase the productivity of the sectors. Households need energy for purposes such as cooking, lighting, refrigeration, study and home-based economic activities. Africa currently has 147 GW of installed power capacity, a level comparable to the China installed capacity in one or two years. Average per capita electricity consumption in sub-Saharan Africa (excluding South Africa) is 153 kWh/year. This is one-fourth of the consumption in India and 6% of the global average. Nearly 600 million people in Africa lack access to electricity, while electricity blackouts occur on a daily basis in many African countries. Faced with this situation, people and enterprises often have to rely on expensive diesel power generation to meet their electricity needs thereby costing some African economies between 1% and 5% of GDP annually. There is need to explore and exploit other energy resources not withstanding their countless challenges for sustainable development. This paper enumerates the status and challenges of exploration, exploitation and development of renewable energy resources and its roles in sustainable development in Africa.

II. ENERGY RESOURCES IN AFRICA

Africa has the population of about 1,220,136,243 with the landmass of over 30.3million km^2 area equivalent to the put together of United State of America, Europe, Australia, Brazil and Japan (worldometer, 2016). According to BP statistics, there are about 9.5%, 5.6% and 8% of worlds proven global economic energy resources of oil, coal and gas reserves respectively, most of which are not yet exploited and hence, this becomes a contributing factor to energy poverty in Africa. The majority of the conventional energy reserves (oil and gas) are found in few countries from northern and western Africa and Angola, if not for the recent discoveries in eastern and southern Africa. Coal reserve is in South Africa, and it uses about 95% of the coal produced on the continent. Geothermal reserves exist along the Rift valley in eastern Djibouti, Eritrea, Kenya, Malawi, Mozambique, Tanzania and Zambia and it is estimated to be in the range of 2.5-6.5GW. However, only Kenya exploited this resource, with the installed capacity of 129MW. Africa's technically exploitable hydropower capacity is estimated to be over 1917TWh/year, which is 13% of the global hydropower potential (WEC, 2005). The economically exploitable capacity is estimated to be at least 1100TWh/year for both large and small hydropower systems. Africa has the estimated wind power potential of 10600TWh/year, if only 10% of the land area with an average wind speed exceeding 5.1m/s at the height of 10m is used for wind power farm. However, the useable wind energy mostly occurs in highly localized area and therefore, requires detailed assessment (Davison *et al*, 2007). Across the continent, there is a general acceptance that modern energy is an indispensable ingredient of the growth and progress that Africa needs to bring prosperity to every citizen – women and men, rural and urban, of every ethnicity and every origin. The Sustainable Development Goals will only succeed if they succeed in Africa) (APP 2015).

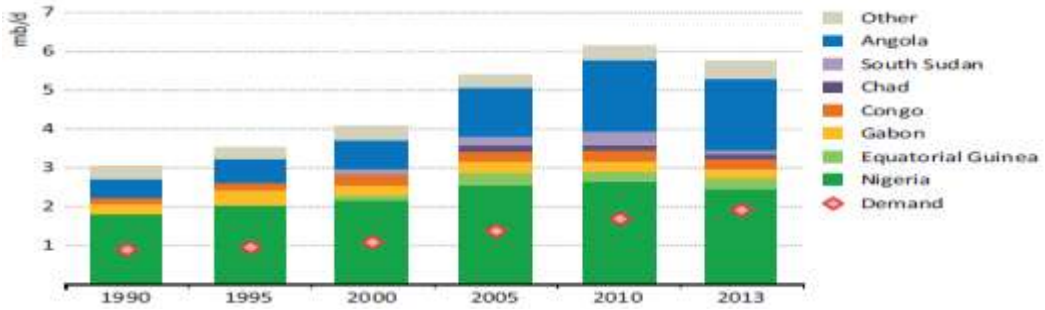

Figure 1: Sub-Saharan Africa oil production by country and total demand

Source: IEA 2014

The most widely used source of energy in Africa for household is biomass; firewood and charcoal. According to IEA, (World Energy Outlook 2015) about 68% population of Africa rely on biomass for cooking and other heat energy requirement. About 67% of the Nigerian population uses 'dirty' fuels like fuel wood for cooking. Unfortunately, continued reliance on these energy sources has negative effects on the people and the environment, thus violating the principles of sustainability (Oyekale 2012). Firewood satisfies over 80% of the energy needs of rural people and urban poor (Bala 2013). Ethanol from sugar cane is also produced as an additives to gasoline in some African countries, there is potential for biodiesel production and use. Despite the continent having about 14% of the world's population and producing 7% of the world's conventional energy, it consumes only 3% and exports more than half of its production (Davidson and Sokona, 2002). If South Africa is excluded, the average residential electricity consumption in sub-Saharan Africa is the same as electricity consumption in New York State (See figure 2) (IEA 2014). That is to say, the 19.5 million people in New York consume the same amount of electricity, approximately 40 terawatt-hours (TWh), as is shared between the 791 million people of sub-Saharan Africa. Universal access to electricity is widely believed to be the region's greatest energy challenge.

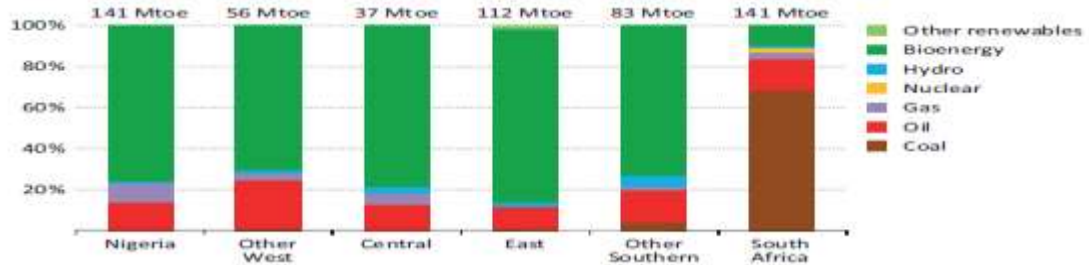

Figure 2: Average electricity consumption per household in sub-Saharan Africa 2012 and indicative consumption levels by appliance.

Source: IEA, 2014

III. Africa's Estimated Renewable Energy Potential and Critical Issues

At a capacity factor (c.f) of 25%, Africa with a total landmass of 30,370,000 km square can generate with her 1% landmass each, solar electricity of 5,433,996.024MWp at 18% efficiency, wind power of 1,695,046.579MWp at 85% efficiency, 50m tower height with 6m/s average wind speed and 84,367,860 MWp/h using the biomass at 75% efficiency. For Nigeria, the Table1 and Table 2 give the estimated potential of renewable energy in Megawatt value at 1% landmass;

S/N	Capacity Factor (C.F) %	Efficiency (Eff) %	Available Power (MWP)	Energy (GWh/day)
1	100	15	550,955	1,652.9
2	50	15	275,478	826.4
3	25	15	137,739	412.2

Average sunshine hour: 6hrs, Average Irradiation: 500W/m2

Table 1: Solar Power Estimate of Nigeria

S/N	Capacity Factor (C.F) %	Efficiency (Eff) %	Available Power (MWP)
1	100	90	218,365

2	75	75	136,478.25
3	50	75	90,985.5
4	50	50	60,657
5	25	50	30,328.5

Table 2: Wind Power Estimate of Nigeria

These Renewable Energy (RE) technologies can be integrated to buildings, thus, the competition between energy production and human shelter does not arise. Of all these, solar photovoltaic system enjoys easiest integration into African buildings. Energy is multi-dimensional in nature, therefore, diverse issues such as renewable energy supply, exploration, exploitation, development and utilization can best be addressed by appropriate policy measures. Inadequate energy supply restricts socio-political development, limits economic growth, inclusive growth in particular, and can adversely affect the quality of life of citizens of a nation. Financing is critical to achieving sustainable renewable energy development, exploration and exploitation; therefore, both domestic and foreign funding is required for RE development in Africa.

IV. THE CONCEPT OF SUSTAINABLE DEVELOPMENT

Sustainable development emerged in the political, public and academic arena in 1972 and 1987; these reports were published by the World Commission on Environment and Development (WCED). This Special Report on Renewable Energy Sources and Climate Change Mitigation defines sustainable development as the ability to meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987; Bojö et al, 1992). The sustainable development concept has links sustainable development to renewable energy; however, sustainable development was tightly coupled with climate change at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil in 1992. Sustainability was built upon three pillar models such as economy, ecology and society which are considered to be interconnected and relevant for sustainability. The three-pillar model explicitly acknowledges the encompassing nature of the sustainability concept and allows a schematic categorization of sustainability issues. Though, Brand and Jochum, in 2000 criticized the three-pillar model for diluting a strong normative concept with vague categorization and replacing the need to protect natural capital with a methodological notion of trans-sectoral integration. United Nation General Assembly aims for action to promote the integration of the three pillars of sustainable development; economy development, social development and environmental protection to strengthen the interdependent and mutually reinforcing pillars (UN, 2005a). This line of action is substitution of fossil fuels with renewable energy sources to achieve all the three developmental goals simultaneously. For sustainable development, an energy transition from fossil fuels to cleaner alternatives is needed both in developed and developing countries. Whilst the former already have large established energy systems that require a profound system transformation, the latter have the potential for 'leapfrogging', i.e. for moving from their current, inadequate energy systems to systems that use the most advanced technologies. Starting with a 'clean slate' thus offers developing countries the potential to contrive energy systems that do not solely rely on fossil fuels, but rather incorporate other technologies more in tune with the aim of sustainable development, such as renewable energy sources (Janosch O. 2014).

4.1 Roles of Renewable Energy Technologies (RETs) in Sustainable Development

Renewable energy has an important role to play in meeting the future energy needs in both rural and urban areas. The development and utilization of renewable energy should be given a high priority, especially in the light of increased awareness of the adverse environmental impacts of fossil-based generation. The need for sustainable energy is rapidly increasing in the world. A widespread use of renewable energy is important for achieving sustainability in the energy sectors in both developing and industrialized countries.

4.2. Renewable to sustainability

The design of effective strategies or policies is not achievable without proper understanding of the links between energy, socio-economic development, environment, and security, hence, it will give options for chosen energy system compatible with sustainable development. Perhaps, the following factors have to be considered; economic, technical, social and environmental factors.

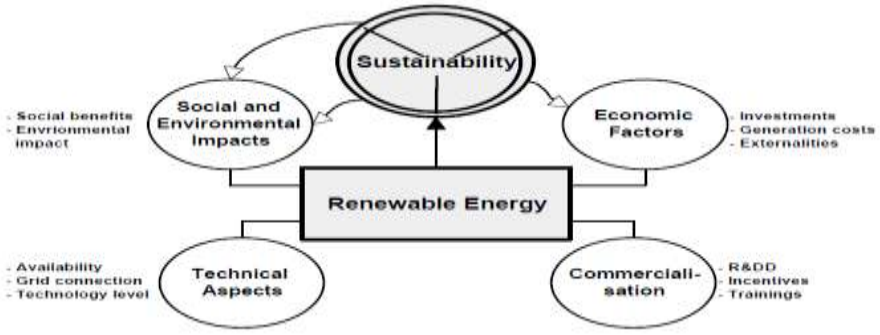

Figure 3: Major considerations for developing renewable energy technologies
Source: Hui, 1997

However, renewable energy is indispensable prerequisite to the attainment of the sustainable energy and development even with slow exploitation of the resources across Africa due to the low price of fossil fuel. Rigorous application of relevant theory and technologies will boost the development and utilization of renewable energy and also increases its contribution to the current energy mix agenda. Renewable Energy is projected to play a central role in mitigation of dangerous anthropogenic climate change. This role will be one strong driving force behind increased use of Renewable Energy technologies worldwide. Various studies have found that solar PV and other solar energy technologies are generally expected to contribute an increasing share to electricity generation in the coming decades in Africa. However, their contributions will probably be constrained by their high current costs, which render them uncompetitive without subsidies. Therefore, it is expected that the role of solar PV in Africa will remain mostly limited to off-grid electrification for years to come (Janosch O. 2013).

V. CHALLENGES OF RENEWABLE ENERGY TECHNOLOGY IN AFRICA

The persistent energy challenges in Africa have serious negative impacts on the overall performance of the region's social and economic developments. This has also resulted to the food insecurity, energy poverty and overall hindrance of sustainable development in the region. Therefore, renewable energy seems to be the source of energy to address the present situation of energy in Africa but the effort has been undermined by bad experiences, misinformation, technology push, and consequent negative perceptions. The balance between energy services for meaningful economic growth and general welfare gains has been the source of conflict among stakeholders, as both are indispensable and complementary. The promotion of renewable energy becomes so difficult because of the high capital investment and re-payment of services (tariff). However, the contribution of renewable energy in Africa can be increased through market-based approaches. The barriers are classified as; policy, regulation and institutional; information and technical capacity; and financial.

4.1 Policy, regulatory, and institutional frameworks

Policy and regulatory frameworks are the essentials for the dissemination of renewable energy technologies in Africa, regardless of all energy departments or agencies in various African countries yet there is no substantial consistent and conducive renewable energy policies and regulations to create safe ground for private and industrial sector to operate effectively and expand their investments in the development and use of renewable energy in the continent, if for the countries like Nigeria, Kenya and Zimbabwe came out with ad hoc policies on renewable energy such as giving incentive or removal of excise tax on PV system components importation. Recently, some countries have instituted some ad hoc policies on renewable energy; for instance, Kenya and Zimbabwe removed excise tax on PV systems. Though these efforts are not consistent, widespread and well coordinated, a recent review of the World Bank's Poverty Reduction Strategy Papers (PRSPs) for countries in Africa shows that only very few countries mentioned the energy sector, let alone the renewable energy sector, as their priorities. Despite the importance of this sector to the economic and social development, however, majority of renewable energy projects are externally financed, and even the above mentioned countries dedicated less than 3% of the total public expenditure for renewable energy, despite the existence of suitable policies for promoting renewable energy, their impact is weakened by lack of enforcement mechanisms.

Deficiencies of ancillary of technical institutions for testing, operation and maintenance of technologies also affect development of renewable energy markets. One area in which Africa suffers the most in technology development and transfer is the absence of National Systems of Innovation (NSI). Such systems have proven to be crucial in increasing technological receptivity in most developed and emerging economies. Only few African countries have attempted to put systems that foster technology incubation and commercialization into place.

4.2 Information and technical capacity

The major challenges faced on deployment of renewable energy in Africa are lack of technical-know-how and inadequacy of sophisticated instruments for collection of energy data. Africa relied on the already made data collected by the developed nation which are mostly not accurate. Some selected countries with data on solar, wind, geothermal, hydro and land lack the links such as space satellites to disseminate the information to the world. More so, the poor technical skills in the continent affect the sustainable development of renewable energy technologies, hence, there is need for high and middle level technical manpower in business development, manufacturing and overall management of renewable energy technologies. The public sector also lacks adequate personnel to undertake effective monitoring and evaluation of the technologies. Renewable energy depends on institutional and human capacities as well as business and market capabilities.

4.3 Financing and investments

The African Development Bank has estimated at US$ 547 billion as the total investment required to implement its scenario of universal access to reliable and increasingly cleaner electric power in all the 53 countries in Africa by 2030, yet total funding to the energy sector in Sub-Saharan African has averaged only about US$ 2 billion every year. Therefore, the energy sector in general faces serious challenges with respect to mobilizing finances. Many economies in Africa are performing badly and this only makes the situation more difficult when seen in the context of ongoing financial crisis. Due to weak government support, the private sector, banks and lending facilities are not yet interested in enhancing their investments in renewable energy systems. The following are major financial barriers to the development of renewable energy technologies; high initial capital, low pay back period, lack of foreign direct investment, misconception of incentives, bank liquidity and unwillingness of banks to grant loans,

VI. Conclusion

Africa is well-endowed with high levels of renewable energy resources. The existing level of utilization of renewable energy, using modern technologies, is low, it is for this reason that all stakeholders in the energy sector should as

a matter of urgency rise up and engage in advocacy programmes to create awareness on the enormous potential of the technology. African youths should adopt Renewable Energy production as a vocation in the future. While there is need for governments and wealthy individuals to fund pilot projects, fresh graduates wishing to establish RET business should be provided soft loans, a mechanism therefore needs to be established for this. Well managed alternative energy sources can turn around the economy of this great Africa continent.

5.1 Recommendations

African governments should endeavour to: ensure quick approval of the energy and renewable energy policy documents in those countries where existing, set up Renewable Energy Fund for R&D; facilitate partnerships between the local energy institutions and International Donor Agencies, International Finance Institutions and Development Partners, etc for R&D. Micro-finance institutions and facilities should be put in place to empower rural and peri-urban dwellers, especially women, to establish small scale energy service companies based on renewable energy resources and technologies; Intensive public awareness activities should be embarked upon to educate rural and peri-urban communities on energy efficient methods through NGOs, CBOs, community leaders and the mass media. This will encourage Research and Development.

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