Critical Factors Affecting The Development And Diffusion Of Renewable Energy Technologies (RETS) In Nigeria

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***Abstract*—The paper examines the barriers, policies, prospects as well as the factors affecting the development and diffusion of Renewable Energy Technologies (RETs) in Nigeria. The study identified weak institutional framework, poor policy implementation, inadequate financing, and lack of awareness of the socioeconomic, technological and environmental merits of RETs as the major barriers hindering its development and diffusion. Furthermore, the authors affirm that a paradigm shift is required to alter the current sociopolitical and techno-economic dynamics of current energy climate of fossil based fuels in the country. This will require the adoption a fossil fuels complementary approach as opposed to the dominant substitution approach recurrently described by academics in literature. The study concludes by highlighting the future prospects RETs development and diffusion in Nigeria.**

Keywords— Renewables; Energy; Development; Sociopolitical; Nigeria; Technovation.

I. INTRODUCTION

The global drive for future socioeconomic growth and sustainable development will require low cost, clean and renewable sources of energy [1, 2]. Hence a comprehensive and complete divestment from the current status of fossil fuel energy dependency towards renewable energy technologies (RETs) such as biomass, solar, wind, and hydropower is required. For decades, the world has relied on fossil fuels for its energy needs notably in transport, heating, and industry at the expense of the environment. This has resulted in environmental degradation due to widespread pollution and increased greenhouse (GHG) emissions. In addition, the overreliance on fossil fuels has presented geopolitical and socioeconomic challenges particularly in oil producing regions of the world. In spite of the widely acceptable benefits of clean energy, the proposed transition from fossil based fuels to renewable sources has been low or unexplored notably in developing countries like Nigeria [3].

Nigeria is a resource rich nation with an estimated 35 billion barrels of crude oil, 180 trillion cubic feet of natural gas, 40 billion metric tonnes of coal as well as tar sands, precious metals, ores which account for over 90 % of GDP annually [4]. Furthermore, Nigeria possesses vast hydropower potential amounting to 11,000 MW, fuel-wood 13 million hectares, animal wastes and crop residues [5]. Other renewable sources of energy in Nigerian include solar, wind and ocean tidal energy. However, Nigeria is plagued by widespread socioeconomic poverty and an energy crises despite its position as the largest producer and exporter of crude oil in Africa [6, 7]. Consequently, it is estimated that 60% of the public lacks access to reliable modern energy and electricity services culminating in the “energy poverty” scenario in Nigeria. In general, energy poverty in Nigeria encompasses inadequate quantity, poor quality and low access to energy [7, 8].

Consequently, fuel-wood and other traditional biomass sources have become the principal sources of energy for domestic and industrial applications in the country [9]. Currently, fuel-wood utilization accounts for 70–90% of domestic energy use which equates to per a capita consumption of 393.43 kg/yr and 255.75 kg/yr in rural and urban areas, respectively [10]. This high rate of fuel-wood consumption has led to high rates of deforestation, desertification, erosion and soil infertility over the years [11]. Furthermore, the overdependence on traditional biomass sources, dwindling fossil fuel reserves, and adverse effects of increased greenhouse gas emissions particularly in developing countries like Nigeria. This has increased the calls for the adoption of an energy economy based on renewable energy technologies in the country. However numerous efforts by governments in developing countries have failed to materialize into a sustainable energy economy based on renewable energy technologies (RETs).

According to *Tsoutsos and Stamboulis* (2005), the fundamental difference between RETs and conventional energy systems requires an innovative and sustainable development, diffusion and management process for incorporation into future

energy systems. The group also posits that the successful integration of RETs will require a re-evaluation of the dominant substitution approach of individual technologies that all too often discounts the interaction of technology diffusion, system restructuring and technology development. Furthermore, policies aimed at stimulating RETs development and diffusion will needs consider the socioeconomic and environmental impacts of RETs from generation to transmission and finally to consumption [12].

Ultimately, the development and diffusion of RETs in Nigeria will require a paradigm shift in the technological, sociopolitical and economic dynamics of current energy climate of fossil based fuels. This will require a shift in dominant substitution approach described by *Tsoutsos and Stamboulis* (2005) to a complementary approach whereby RETs supplement energy derived from fossil fuels systems. Therefore, this paper aims to assess the critical factors affecting the effective development and diffusion of renewable energy in Nigeria. It will examine the current policies, implementation barriers and future potentials of renewable energy technologies in the country.

II. DISCUSSION

A. Current RETs policies in Nigeria

The actions and policies of national governments can significantly influence the development and diffusion of novel technologies such as RETs. According to Hekkert *et al.,* (2007), new technologies such as RETs experience difficulties competing and conquering conventional technologies such as fossil fuels for potential markets [13]. This scenario known as carbon lock-in effectively prevents RETs from the cost advantages, financial subsidies and trading markets benefits enjoyed by established or regime technologies based on Fossil Fuels (FFs) [14]. Hence these technologies require government support through the creation of protected spaces or the formation of provisional niche markets for their development [15]. Furthermore, governments can protect and promote novel niche technologies like RETs by enacting favorable policies, and the mobilization of resources through tax breaks, grants and incentives and provision of requisite infrastructure for growth and development.

Consequently the Federal Government of Nigeria (FGN) has enacted a number of key energy policies to guide and direct the development and diffusion of RETs in the country. The umbrella policy for energy development in Nigeria is the National Energy Policy (NEP) enacted in 2003 [16]. The policy is aimed at highlighting the relationship dynamics between energy and socio-economic growth and sustainable development in Nigeria. In general, the core objectives of NEP include to develop and diversify Nigeria's energy resources in order to safeguard national energy security, promote sustained investments and encourage private enterprise participation in the development of future energy systems in the country. Lastly, the policy aims stimulate innovative technologies and companies working towards the providing reliable, adequate and cost effective energy supplies to the citizenry.

However due to the broad nature of NEP and lack of emphasis on renewables sources of energy in Nigeria, the FGN in 2005 adopted the Renewable Energy Master Plan (REMP) [17]. The policy was promulgated to synchronize the visions, targets and roadmap for tackling the challenges of energy supply in the country. Furthermore, REMP is aimed at addressing the key developmental challenges of reliable and sustainable supply of energy in Nigeria from RETs such as solar, wind, biomass, and ocean tidal energy. The FGN envisages that REMP will accelerate the development and diffusion of RETs in Nigeria through the adoption of policy guidelines through the implementation of renewable portfolio standards; formation of innovative economic and market incentives for the future growth of firms in the renewable energy industry. It is also envisioned that the provision of financial incentives such as tax breaks, feed-in-tariffs and importation waivers for RETs equipment will stimulate growth with the energy sector [17, 18].

The National Energy Master Plan of Nigeria (NEMP) is also a key RETs policy in the Nigerian energy economy. Enacted in 2006, NEMP highlights the prospects and potentials of hydropower as a major source of renewable energy in the country. Currently, Nigeria can reportedly generate 11,250 MW from large and 3,500 MW from small hydroelectric power [7, 19]. On the other hand, the Nigerian Biofuel Policy provides a policy framework for the development and diffusion of biofuels in Nigeria [20, 21]. The policy aims to emulate the policies of nations like Brazil and Malaysia which have successful developed biofuels and biodiesel industry [22, 23]. Other notable RET policies in Nigeria include Vision 2020, the National Policy in Environment in Nigeria (NPE) and the National Policy and Guidelines on Renewable Electricity (NPRE) of 2006 [7]. However, despite the noble intentions of the outlined energy policies energy poverty, production and transmission remains a key issue in Nigeria.

B. Barriers to RETs Implementation in Nigeria

The development and diffusion of RETs into the Nigerian Energy Economy (NEE) is plagued by numerous challenges. As highlighted by Hekkert et al., (2007), novel technologies such as RETs encounter problems competing with conventional technologies [13]. In the Nigerian context, these challenges can be broadly categorized into; *sociopolitical and techno-economic* factors. This section of the paper will examine the crucial barriers and challenges hindering RETs in Nigeria.

Sociopolitical factors

The sociopolitical factors hampering RETs development and diffusion in Nigeria are largely centered on policy enaction, execution and monitoring. Despite the numerous RETs policies, energy generation and power distribution in Nigeria remains dismally low. According to Eleri *et al.,* (2011, 2012), the poor integration of RETs into the Nigerian power mix can be attributed to weak institutional framework, poor policy implementation, and lack of awareness [7, 24]. The group posits that poor government commitment and unsupportive regulatory framework have stifled the development and diffusion of RETs in Nigeria. In addition, the low integration of RETs into Nigeria Energy Economy may also be due to the perennial dominance of petroleum based energy products which are readily available in the country at subsidized prices in Nigeria.

To curb the sociopolitical challenges, the FGN must harmonize RET laws, policies and guidelines and re-direct national efforts towards RETs by focusing on high potential sources such as solar, biomass and hydropower. Furthermore, policy implementation must be prioritized and monitored by all the ministries and government agencies charged with RETs in the country. The proposed reforms should involve the ministries of Energy, Agriculture, Environment, Science and Technology; and agencies such as National Orientation Agency (NOA) working hand in hand with the Energy Commission of Nigeria (ECN). The NOA, ECN and the media in Nigeria can improve awareness and stimulate meaningful debates on the merits of RETs and their underlying importance on socioeconomic growth and sustainable development in the country. By so doing, the government can effectively create the favorable environment required for the formation of markets, mobilization of resources and creation of legitimacy [25] for RETs in the Nigerian Energy Economy.

Techno-economic factors

The techno-economic factors of RETs diffusion in Nigeria are centered on the technology and economics aspects of development. According to Innovation system theories, the development and diffusion of novel technologies require the participation of stakeholders within the technovation climate [25]. These strategic stakeholders can be broadly categorized into technology producers (TP) and technology regulators (TR). The TP comprise technology entrepreneurs, utility companies, power equipment manufacturers, and power distribution companies. The regulators include; government regulatory and supervisor agencies charged with implementing and monitoring energy policies. The role of TP and TRs is to design, develop and execute innovative technologies and processes for RETs.

Despite Nigeria's potentials, the fraction of energy generated from RETs in the country remains low. This may be attributed to poor financial commitments, low infrastructure investments and access to financing for RETs development in Nigeria. According to Eleri *et al.,* (2011), low RETs development could also be due to lack of local manufacturing capacity, and barriers to financing for technologies [7].

Furthermore, the poor state of the educational sector in Nigeria particularly post primary and tertiary institutions has prevented the development of innovative technologies and ideas like RETs in the country. Educational institutions can provide trained professionals, skilled labor and knowledge based hubs required for RETs to thrive. As a result, the RETs sector in Nigeria lacks the strategic network linking R&D, Academia and Industry required for knowledge development, diffusion and guidance of search required in a novel technovation system [13, 25].

Other techno-economic factors hindering RETs in Nigeria include the presence of subsidies petroleum energy products in the country. As with competing technologies, the presence of petroleum subsidies effectively crowds out RETs out of the energy market thereby presenting RETs as expensive alternatives. This will ultimately discourage future investments in R&D, equipment manufacture and clean energy production.

Hence the government can address the status quo by phasing out subsidies and investing more funds in RETs development and diffusion to encourage socioeconomic growth, sustainable development and environmental remediation. Furthermore, the accrued funds can be invested in the Nigerian educational sector to stimulate the development of Innovation Hubs, Technology centers and fund Feed-in-Tariffs for the future development of RETs in Nigeria.

C. Future prospects of RETs in Nigeria

The development and diffusion of RETs in Nigeria has numerous prospects for the nation. Furthermore, RETs can theoretically address issues related to rapidly depleting fossil fuels, concerns about global warming, climate change and environmental sustainability. Consequently, these possibilities will be examined under the broad categories; *sociopolitical, techno-economic* and *environmental prospects* in the Nigerian Energy Economy (NEE).

The sociopolitical prospects of RETs stem from the establishment of sound policies, laws and institutional framework aimed at repositioning the nation as world leader in promoting the principles of sustainability. The result of this objective will be increased international cooperation of matters of sustainability, R&D collaboration and partnerships with international funding bodies and NGOs.

The techno-economic prospects include increased investments in social infrastructure, and sustainable energy supply. The ripple effect will be evident in increased job opportunities, disposable income and improved standards of living for the citizenry. Furthermore, the successful implementation of RETs will stimulate the knowledge development, knowledge diffusion networks such as technological

hubs, clusters and centers and promote future investments in the technological base of the country.

The deployment of RETs will help reduce the government's recurrent expenditure and colossal loss of revenue due to the importation of petroleum products under the highly controversial regime of fuel subsidies. The saved funds can be ploughed back for future investments in social infrastructure, health, education and technology development.

The environmental prospects of RETs implementation will increase awareness on the importance of reducing carbon footprint, protecting mankind and safeguarding the planet. This will discourage the high rate of deforestation, desertification and loss of biodiversity in the country.

Furthermore, RETs will reduce the nation's dependence on fossil fuels thereby decreasing the high rate of oil spills and environmental degradation due to oil production in the Niger Delta region of the country.

III. CONCLUSION

The current policies, implementation barriers, future potentials and factors affecting the development and diffusion of RETs in Nigeria were examined in this paper. The findings of the study indicates that RETs development and diffusion in Nigeria requires a paradigm shift in the current sociopolitical and techno-economic dynamics of current energy climate of fossil based fuels in the country. Furthermore, the authors conclude that the development and diffusion of RETs in Nigeria must adopt a complementary approach as opposed to the dominant substitution approach regularly described by academics in literature.

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