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Research paper

The status quo of rural and renewable energy development in Liberia: policy and implementation

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Abstract

Energy is the key for development and is indispensable for human and its society's sustenance. Likewise, without electricity and access to modern information technologies it would be quite difficult to provide quality education and health care. For the least developing countries with rural populations such as Liberia, a working financing mechanism for renewable energy (RE) applications is of extreme importance. This is because Liberia has failed to implement a sound rural and RE development policy due to uncertainty regarding the financial costs as with many least developing countries. It is therefore, crucial that the use of the available RE resources should be intensified to meet the energy needs of the country, particularly, in the rural and remote areas. This paper examined and discussed the current and potential of RE exploitation and development in Liberia from the viewpoint of sustainable development. The status of the various RE sources and their applications including details of the few existing RE projects in the country are carefully explored and discussed before elucidating the major barriers and challenges faced by the energy sector as regards the implementation of Liberia's rural and RE policy. Measures and policies that are required to facilitate the deployment of RE in Liberia are proposed while the existing government policies are assessed. These evidence-based policies could guide the future design, delivery and development of affordable and sustainable energy solutions in Liberia.

Keywords: *RE; RETs; Biomass; Solar; Hydropower; Wind; Rural and RE Policy; Liberia.*

1. Introduction

Energy is an essential driving force for the development and sustainability of any country's economy [1-2]. Without a doubt, it is fundamental to the fulfilment of basic individual and community needs such as lighting, transportation, education, health, food and provision of water [3, 4]. Since all these services are indicators that guide/measure the progress and development of a nation, it follows that energy is a key determining factor of the socio-economic development of any nation [3-4]. In addition, the future economic development of any country is said to be guaranteed when there is an uninterrupted energy supply that is accessible, affordable, eco-friendly and sustainable [1-4]. However, the quality of life (health, education, security etc) of the citizens of any nation closely depends on the sufficiency of the available energy supply [4].

Currently, fossil fuels (coal, oil and natural gas) have been the major source of energy, meeting three-quarters of total world energy needs (See Figure 1) [5]. Nevertheless, increasing concerns as regards the security of such energy supplies have led to a global search for alternative energy sources [6]. The drive for sustainable energy is not motivated by concerns over energy security alone but also by the fact that fossil fuels have been the main cause of unpleasant environmental and social consequences such as air pollution, climate change, and mining accidents [6]. Since sustainability is a key factor that influences the long-term feasibility of any energy resource, it comes as no surprise that it is at the vanguard of the global campaign to abandon the use of fossil fuels [7-8].

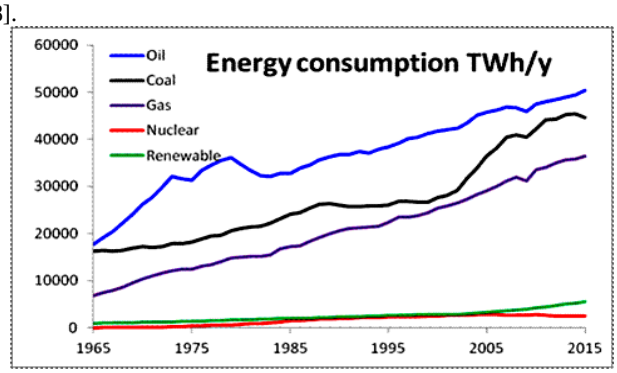

Fig. 1: The World is Increasing Demand for Energy [5].

RE offers solutions to the problems faced by conventional energy sources [9, 10]. They are perceived to be safe, clean, unlimited, and satisfy the standard for sustainability as prescribed by the World Bank [11]. RE sources include solar energy, wind energy, biomass, hydropower, geothermal energy and tidal energy. Several definitions of RE have been offered. Twidell et. al. [12] defined RE as the energy obtained from the continuous or repetitive currents of energy recurring in the natural environment [12]. In another work, Sorenson [13] described RE as the energy flows, which are replenished at the same rate as they are used [13]. How-

ever, no matter what the definition is, the concept remains the same. Contrary to fossil fuels, RE sources are eco-friendly, ever-present, self-replenishing, unlimited, and as a result are considered globally as the way for the future [12, 13]. This implies that a boost in the accessibility to affordable and clean energy in most part of Liberia is vital to the political and socio-economy growth of the country.

Energy consumption in Liberia is dominated by biomass with a share of over 90% of the used primary energy sources [14]. Liberia is naturally rich in fuel wood, but excessive wood-gathering activity has caused critical depletion of this resource. The data of the Forest area (percentage of land area) of Liberia which is the case study here has shown continuous reduction for some time now [14]. The Forest area (percentage of land area) for the year 1990 was approximately 51.17%, 2000 was 48.06% and 2010 was 48.06% while 2015 was 43.39% [14]. Nevertheless, the sustainability of bioenergy in terms of greenhouse gas emissions lifecycle, is determined by biomass and land resource management and practices [15] The implication for the environment is that woodlands run the risk of deforestation, which in turn increases the risk of other hazards such as erosion and flood [14, 15]. Most important is woody biomass being used for domestic cooking and heating [15-17]. It is presently the major source of fuel for over 70 percent of the Liberian population, particularly in the rural communities [18]. This is because these people live on less than $ 2.00 per day and cannot afford to pay for commercial cooking fuels such as kerosene and gas [18, 19]. However, vigorous research efforts have been made globally to develop improved woodstoves to replace the traditional three-stone open fires normally used for cooking in rural areas [18]. Asides the environmental hazards posed by wood gathering, traditional three-stone open fires are very inefficient and the fumes cause rigorous health hazards [20] to the women and children who normally make use of them [18, 20]. In spite of these breakthroughs internationally and an unwavering 40% increase in access to improved stove in remote and isolated areas as depicted in the 2009 national energy policy [21], the widespread, development and dissemination of improved woodstoves is still not a reality in Liberia.

Prior works on the development of RE resources in quite a number of African countries [22-33] indicate that most countries have an huge potential for the production of RE. However, for different reasons, the present RE applications in these countries is insignificant when compared to their potential [25]. A number of these works reviewed the status of energy in these countries and proposed the feasible measures that can facilitate the utilization of RE in the countries [25, 28-32]. Mohammed et al [25] in one of the studies reviewed the utilization of RE resources in Sub-Saharan African. These RE sources include hydropower, solar, geothermal, biomass, and wind [25]. The authors revealed that there is a need to integrate power generated from RE to the traditional power generation in order to advance the energy access in most of these countries [25].

The potential of forest and agricultural residue-based bioenergy has also been studied by Okello et al. [23] in the Ugandan context. In the study, the authors disclosed that bioenergy can offer a major contribution to the energy diversification in Uganda. The study also suggested that there is a need for the utilization of improved bioenergy technologies if sustainable biomass energy production is to be guaranteed besides reducing its harmful environmental impacts [23, 34]. However, in spite of the efforts made towards improving the biomass sector, there is a need to change the present technology used for biomass consumption [35]. The authors also believe that this is a potential solution that can fortify bioenergy production in Uganda and most African countries. Hensley et al. [36] in another study reviewed the potential of the available biomass energy and bioenergy resources that can be used for rural electrification in Ghana [36]. The authors suggested that an increased investment in RE resources could improve the national grid supply, enhance energy security and advance sustainable development of the country in the long run [36]. Suberu et al. [29] on the other hand, indicated that there is an increase in wood-based bioenergy exploitation in the West African region, particularly in Ghana and Nigeria [29]. They revealed that the huge increase in the utilization of bioenergy in the form of wood fuel has led to deforestation, which in turn, impinges the environment [29]. These challenges as regards sustainable development can be traceable to several technological constraints. These constraints are mostly related to local food systems and environmental protection issues as identified in a study by Osei [37]. Kiplagat et al. [38], in one of the prominent studies identified that out of all the RE sources in Kenya, biomass energy have a huge potential to help meet the country's increasing energy demand as compared to the others [38]. In concluding, the authors suggested that the energy obtained from biowaste residues could play a crucial role as an alternative to fossil fuel-based generated electricity in Kenya [38]. Furthermore, prior studies have also investigated the status and potential of RE technologies in Sub-Saharan Africa. Twaha et al. [39], investigated the potential and status of the utilization of renewable-based generation in Uganda that include biomass, hydropower, solar, wind, and geothermal energy resources [39], but did not identify the current or possible drivers of RE in Uganda as it relates to their proposed policies that could help overcome the identified RE challenges. Fashina et. al. [40] in a more recent study, explored the current situation and potential of RE exploitation and development in Uganda before explaining the drivers and barriers associated with development of RE applications in the country [40]. The authors also provided a significant analysis of the policy instruments and measures that can efficiently contribute to the incredible growth of RETs in Uganda [40]. Kihwele et al. [31] also presented visions toward future Tanzanian power grid. The study investigated the planning and regulation of rural electrification and the generation power system in Tanzania [31]. The authors further developed scenarios to support the planning and integration of different components of the Smart Grid that can be envisioned to be a policy framework for the Government of Tanzania at all levels of action [31].

In addition, a survey assessment was conducted in Mpala village in the Laikipia district of Kenya between 2010 and 2012 by Tong et al. [19, 40] to determine the factors that affected the adoption of solar lanterns in the rural community and assess their impact on the villager's socio-economic, health, and education levels [19, 40]. Prior to the two year questionnaire study that identified the key factors that resulted in the adoption rate of 96% and a decrease of 14.7% in annual family expenditures, the authors had developed ways of converting old kerosene lanterns to solar powered lanterns at a cost of about US$ 25 per lamp [19-40]. The results of the study offered new insights that are now employed in formulating business strategies that could improve energy access in rural/urban communities of Africa [19, 40]. In a similar work on photovoltaic (PV) system, Fashina et al. [41] reported a study on the performance and reliability of solar powered street lighting systems in Nigeria taking the African University of Science and Technology as a case study [41]. The authors revealed that the use of substandard components, particularly, the charge controller can destroy other components of the solar powered street lighting system which in turn reduce the life cycle of the PV system [41].This they ascribed to the problem of standardization and regulation of importation of goods in the country [41]. The authors also noted that the reliability of PV systems is a key contributing factor to cost effectiveness, and vital to continued investor confidence [41].

Presently, much work has not been carried on the status and potentials of RE utilization and development in Liberia due to the 14 years long conflict/war that ended in 2003 [42-43]. The few works recorded were carried out mostly by Non-governmental Organisations (NGO) and the World Bank [43]. Among these works is a study by Wesseh et al. in 2015 [44]. The authors developed various scenarios that were used to quantify benefits derived from research and development funding for RE power generation in Liberia [44]. The result from the study indicated that RE may have intrinsic limitations such as seasonality of supply, low energy content and capacity factor which underscores the need for exter-

nal costs-related policies [44]. In another work, Krishnan [45] reported a study on the simulation of rural electrification in Liberia using biomass residues from the country's major rubber and oil palm plantations [45]. The study utilized an Agent-Based Model that indicated that change in residential power consumption patterns would not be necessarily impact land use and that less than 2% of a plantation's producing area is sufficient to support this system over a project lifetime of 30 years [45]. The author however recommended a decentralized power structure to effectively implement and sustain the system [45]. In a recent work by Alfaro et. al. [43], the authors reported the outcomes and opportunities from a stakeholder workshop on rural renewable electrification in Liberia [43]. The authors noted that Liberia is poised to have a strong decentralized rural electrification sector as claimed by most research presentations at the workshop [43]. They also highlighted six specific objectives that are recommended for follow up. A detailed of this can be found in Ref. [43]. There is a need to therefore review the present and potential of RETs, and analyze the related RE policy instruments and measures required to overpower the existing and potential barriers of RE in Liberia.

This paper aims at providing the current situation and potential of RE utilization and development in Liberia before elucidating the barriers and challenges linked with RE development in the country. The paper further provides an important analysis of the policy tools and measures that can efficiently contribute to the enormous growth of RETs in Liberia.

2. Energy in the Liberian context

Considering energy utilization patterns, the Liberian economy can be divided into five different sectors that include household, transportation, industrial, commercial, and agriculture sectors [43-45]. The household sector represents the major share of energy consumption in the country. This can be attributed to the poor state of development in all the other sectors. The main energy-consuming activities in Liberian households include lighting, use of electrical appliances and cooking. Cooking represents an astounding 85 percent of household energy consumption, lighting consumes six percent and the remaining nine percent can be ascribed to the use of basic electrical appliances such as television sets, refrigerator and charging of phones [42]. The key household energy movers are electricity, kerosene, fuel-wood and liquefied petroleum gas (LPG). Fuel-wood (charcoal and firewood) is the most broadly used energy, accounting for over 85 percent of household energy, while less than 15 percent is provided by the other energy sources [42, 44].

Energy consumption per capita in Liberia is 8.45 kWh [46] which is relatively small when compared with energy consumed in developed countries. This can be directly correlated to the level of poverty in the country. With 2018 GDP of about $ 352 billion and per capita income of only about $753, Liberia is one of the poorest countries in the world [46]. The World Bank has estimated that about 50.5 percent of the Liberian population is presently living below the poverty line (People living on less than $2.00) [47]. This percentage translates into about 2.4 million Liberians. Over the past decade, Liberia's population has been on the increase alongside a demand for modern and sustainable energy services. Presently, only 19.8 percent of the citizens have access to electricity according to the 2016 access to electricity data by the World Bank (See Figure 2) [48]. This implies that an increase in the access to cost-effective and sustainable energy services is needed urgently to re-launching the nation's economy while improving human development and livelihoods [47]. Although most of the country's pre-existing infrastructures were destroyed during the 14 years of war, Liberia still possesses a huge potential for the development of RETs such as biomass, wind, solar, and hydroelectric energy [43, 44]. Nevertheless, intensifying access to reliable and affordable electricity, predominantly in the rural areas, should be one of the highest priorities of the GoL. Moreover, several approaches can be helpful in achieving a vivacious and secure energy future for Liberia, one of which is a practical or evidence-based energy policy.

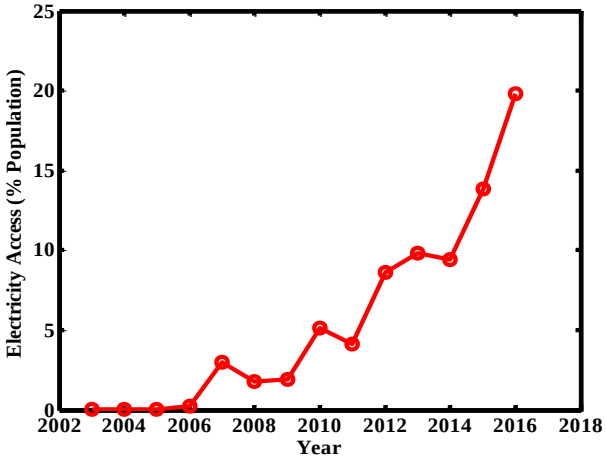

Fig. 2: Total Electricity Access to Electricity (percentage Population) In Liberia from 2003 to 2016. Data Obtained From Ref. [48].

3. The Liberian national energy policy

A broad and rational energy policy is vital in guiding a country towards efficient exploitation of its energy resources [44, 49]. However, the existence of an energy policy may be essential, but that does not guarantee a liable management of the energy resources of a country [44, 49]. The Liberian National Energy Policy was instituted in May 2009. Prior to 2009, the country had no ample energy policy and there was no consideration whatsoever for the inclusion of RE sources in the national energy mix. The 2009 National Energy Policy document however, incorporated elements of renewable energy planning [21]. The overall driving force of the Liberian National Energy Policy (NEP) is the best possible utilization of the country's energy resources for sustainable development [21, 50]. The policy identifies RE as one of the sub-sectors of the nation's energy sector. This is an important indicator which shows that the policy recognizes the fact that RE is positioned within the context of a greater representation as regards the nation's energy sector. However, for a RE plans to be absolutely effectual, it must be steeped in a uniformly efficient national energy policy.

The National Energy Policy also admits that in spite of the abundant energy resources available in Liberia, they have not been properly managed to satisfy the nation's energy needs. The Liberian economy is predominantly agriculture-driven, but the contribution of agriculture to GDP is very small indeed [43, 49]. The GoL's over-dependence and excessive obsession on oil for electricity has slowed down the growth of RE as an alternative sources, even when the need is obvious. Lack of funds, coupled with casual management of available resources has incapacitated the nation's energy sector. The consequence of this negligence is insufficient and undependable supply of electricity nationwide. However, the Liberian government has to realise that energy is the driving factor that powers all other sectors.

Furthermore, through the provision of the Energy Policy, the Energy Regulatory Board (ERB) is the government body in charge of the management of activities within the energy sector. It is also responsible for supervision of the implementation of the objectives spelt out by the Energy Policy. However, interaction and collaboration between the ERB and other relevant government organisations is very pathetic. Even within individual organisations, processes and systems are incompetent and inadequately coordinated. Presently, the participation of private sector in the Liberian energy sector is negligible. However, recognizing the need for a dynamic private sector investment by both foreign and local companies the National Energy Policy included this as a necessity for effectual reform of the energy sector.

It is therefore, useful to be aware of the objectives of the National Energy Policy, for it provides the context out of which the nation's RE ambitions have emerged. The awareness of these objectives will thus provide a genuine platform on which future RE efforts can thrive effortlessly. The following indicators summarise the objectives stated by the Liberian National Energy Policy:

a) Access: Guarantee availability of modern energy services for all Liberians
b) Quality: Ensure acceptability of energy products and services by adopting standards that are consistent with international best practice
c) Cost: Guarantee affordability through least-cost production and utilization of energy services.
d) Institutional framework: Establish an adequate delivery process for energy products and services through public and private partnership

4. Renewable energy resources potentials in Liberia

RE resources is one of the most promising and significant assets that can have a multiplier effect on the development of any country [51-53]. It is a well-known fact that the extent of industrialization is a function of the amount of energy available and the degree to which that energy is used [54]. RE resources has contributed to Liberia's energy mix in the past years. Fuel-wood (usually referred to as woody biomass) is the most durable primary energy source for rural Liberia and the African continent at large. Hydropower has also contributed substantially to Liberia's national electric grid supply. Other new RETs adoption includes solar, small hydropower, wind, and efficient biomass. Liberia is endowed with abundant RE resources that are evenly distributed across the nation. In spite of this enormous potential, the existing RE projects in Liberia is very few and is mainly funded and implemented by international agencies or non-government organisations. The means of financing is usually via grants, resulting in a deformed market situation that can neither be persistent over time nor replicated all over the country. These funded projects are usually executed in the rural areas of the nation, where there is a greater need. A few of the wealthy folks and businesses have installed standalone RE systems such as solar PV systems to complement the unreliable power supply from the national grid, although there is no official estimate of the figure. Consequently, the rate of diffusion of RE in Liberia is almost negligible which does not correspond to that of the global RE industry. It is thus importance to examine the present state of each RE technology in the country.

4.1. Solar energy

Solar energy is one of the most promising RE sources, with apparently unlimited potential [55]. It is the primary energy resource that drives other RE sources such as biomass, hydropower, wind etc. [25, 56-58]. Solar energy is also an alternative source of energy in rural and remote areas where connectivity to the national grid is not economical [24, 58-60]. This assists in the reduction of rural-urban drift and supplements the rapid growth of small-scale industries [40], [61], [62]. The radiation from the sun is transmitted as electromagnetic wave/energy at the rate of about 3.8×10^{24} kW/second, and with an average solar radiation level of about 5.08×10^{12} kWh/day [63].The current solar data [46] clearly reveal that the solar energy resource in Liberia lies above the equator in the northern and western hemispheres and this allows Liberia to obtain a high level of solar insolation of about eight hours of sunshine daily, all through the year [64]. The electromagnetic radiation from the sun is estimated to be 4-6 kWh/m^2/day in the country (See Figure 3) [64].

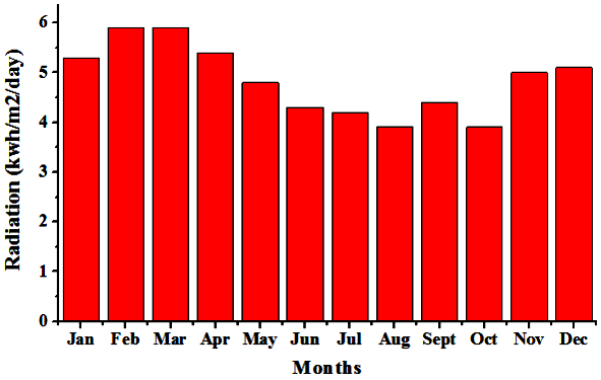

Fig. 3: The Monthly Average Daily Irradiation in Liberia All Through the Year. Data Obtained from Ref. [64].

Furthermore, solar energy is obtained using some solar energy technologies that are broadly categorised into two groups, namely, solar-thermal and solar photovoltaic (PV) [63]. For solar thermal applications, the electromagnetic waves from the sun are converted into heat energy [63]. The heat energy can then be used either directly as heat, or transformed into other forms of energy. In general, these applications are use for heating, drying, cooking, cooling, electricity generation in thermal power plants and so on. On the other hand, for solar photovoltaic applications, the solar radiation for the sun is converted directly into electricity [63]. This is achieved through the use of solar cells such as silicon-based solar cells [65], [66], organic solar cells [67, 68-69] and hybrid solar cells [70], [71].

4.1.1. Solar photovoltaic (PV)

Solar PV system converts solar radiation from the sun to electricity using solar cell [72], [73] that are usually made from crystalline silicon substrates [74]. Its energy source is free and is considered to produce no greenhouse gas emission (Carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) after installation [63]. It basically comprises of solar panels (arrays), battery (ies), charge controller(s), and inverter (ies). The typical lifetime of the panels is mostly 20 to 25 years and this is considered the lifetime of the total system [63]. The solar radiation data depicted in Figure 3 shows that solar photovoltaic (PV) technologies have good prospects in Liberia. Due to inadequate power supply in Liberia, solar photovoltaic electricity has become a thing of choice for homes, private projects and government projects that include lighting, healthcare, satellites, water supply, agriculture, transportation and communications [42-45]. Furthermore, these projects are categorized into two types; domestic and community based projects. An example of the domestic based projects is the solar powered lanterns that are used to provide enough energy of about 5-10 hours of lighting and/or cell phone charging and an hour of radio listening each night [19]. Similarly, several government projects in Liberia at all level are now been integrated with solar based technology to provide its citizens with continuous services for a longer period of time [42-45]. They are also used to supply power to remote villages and locations that are not connected to the national grid [43]. This project approach is referred to as the community based solar projects.

Liberia is far behind other African country such as Nigeria, Egypt, Morocco, Algeria and South Africa in the application and development solar photovoltaic technology [25]. The few photovoltaic installations in the country are all imported and as a result, acquisition costs are excessive. This is the single greatest challenge that needs to be conquered to achieve widespread diffusion of solar photovoltaics technology in the country.

4.1.2. Solar thermal

Unlike the solar photovoltaic systems, solar thermal technology generates non-electricity energy from solar radiation. Much ad-

vancement has been recorded globally in the area of solar thermal technology and some of these applications include solar cooker, solar water heater, solar refrigeration and solar dryer. Many of these appliances are locally developed in most part of Africa such Nigeria [49], Ghana [49] and Uganda [40]. Although these appliances are functional, most of them have not yet been developed to international standards. However, this is not yet visible in Liberia as compared to other neighbouring countries where most of appliances are now advancing from research and development stages to commercial stage. Likewise, public awareness of the potential and advantages of solar thermal systems particularly in the agriculture sector is still very limited in Liberia [45]. As a result there is very little or no demand for the systems. Also, the failure of decision-makers at all levels of government to identify solar thermal energy as a suitable energy option for agriculture is another challenge. These limitations on both the demand and supply sides have for a long time prevented solar thermal technology from reaching its full potential in many African countries.

4.2. Wind energy

The production of wind energy is one of the fastest emerging RE markets in the world today [75]. The global cumulative installed wind energy capacity has increased gradually from 6100 MW in 1996 to approximately 540 GW in 2017 [76]. It is therefore, projected that wind energy will play an imperative role in the mitigation of future Greenhouse Gas emission [76]. The utilization of wind energy in Liberia is almost nominal and relatively insignificant [43].

Liberia generally lies in a low wind region so potential for wind energy exploitation may be considered moderate or low. Notwithstanding, observations along coastal and mountainous areas show some good prospects for the development of wind power in the country [77]. It follows therefore that these will be the most resourcefully feasible sites for wind energy development in Liberia. Currently, there is no reliable national wind resource data for Liberia. The low level of technological development in Liberia is probably the major reason why wind data are yet to be available in the country. There is currently no effort toward obtaining wind data from potential sites along the coastal areas and hilly regions of Liberia. None of the Universities in Liberia has an appreciable wind research programme due to inadequate funding and personnel. There is therefore lack of capacity and experience in the country on wind power development.

4.3. Large hydropower energy

Liberia has its rainy season between April and November, different rivers and a lengthy sea coast [43]. Yearly rainfall is around 510 cm (200 in) on the coast, 200 cm (80 in) inland. Average relative humidity is approximately 82% in the coastal area during the rainy season, and 50% to 78% in the dry season [43], [77]. According to the Rural Energy Strategy and Master plan, hydropower potential is estimated to be about 2 300 MW in Liberia [43]. This potential is mostly on large rivers with high mean annual flow and low heads. Among these rivers, there are six major ones that have a high potential for hydroelectricity generation. These include the Cavalla, Cestos, Lofa, Mano, Saint John and the Saint Paul rivers [43], [77]. These rivers drain two-thirds (66 %) of the country's water [77]. The intensive drainage blueprint demonstrate that a considerable potential for hydroelectric power in Liberia to be approximately 1,000 MW. Moreover, Liberia's hydrological resources for power generation may differ considerably between seasons. This implies that large-scale hydropower generation will require a combination of upstream reservoirs alongside with a thermal power generation.

Between 1976 and 1983, feasibility studies carried out identified over 11 medium hydropower sites with six main rivers having a potential of 20 MW and eight other with the potential of 10–20 MW [43]. Four of these sites have further been analyzed at prefeasibility level although they will require an in-depth analysis to measure the potential environmental and social impact, in particular the Via Reservoir, which puts forward a more even distribution of water all through the year [43]. The rehabilitation of the Mount Coffee hydropower plant with installed capacity of 88 MW was initiated in May 2012 with a series of surveying and engineering assessments of the feasibility of revitalizing the plant [43]. Although the project was expected to be commissioned by 2015, the first turbine-generator unit out of four 22 MW units waited until December 2016, before it was dedicated and commissioned [77]. The other three turbine-generators failed to meet up with the August 2017 deadline but are expected to be functional in 2018. The cost of the rehabilitation is estimated to be about $3830 million with support from the Liberian government, the European Investment Bank, Kreditanstalt für Wiederaufbau (KfW) and the Norwegian government [43]. Also, with the support of the European Commission, the Ministry of Lands, Mines and Energy of Liberia (MLME) a prefeasibility study of the Via Reservoir was approved in 2013 but was later cancelled [78]. Nevertheless, the development of large hydropower has been particularly challenging due to financial and capacity constraints, despite its potential for energy trade via the West African Power Pool.

4.4. Small hydropower energy

Liberia has an abundant supply of rainfall, rivers and streams that is well distributed across the country. Small hydropower schemes are mostly useful because they can be developed independently off the national grid. It is a feature that is particularly desirable for rural and remote electrification. However, it is a bit surprising that small hydropower technology is still lagging behind in the country, despite the identification of 31 sites for small hydro plants between 1938 and 1998 by DECON and Geoscience respectively [77]. Although it is proven to be locally realistic, small hydropower still confronts large scale implementation in Liberia. This signifies that there is a fundamental problem that may need to be identified and tackled.

Prior to the civil war in the country, only two out of the 31 identified sites were developed. These are the Firestone Plantation with a capacity of 4 MW hydropower plant that provided electricity to its factories and several other villages, and the 60 kW Yandohun micro-hydro in Bong County. The two plants were destroyed during the war. However, in May 2013, the Yandohun micro-hydro was rehabilitated and commissioned to serve over 240 households. The project was financed by the World Bank and implemented by the Rural Renewable Energy Agency (RREA). This is the country's first community-owned power system. Other projects that are either in the feasibility or construction stage include the Mein River Hydropower Project in Suakoko District which is financed by USAID through the Liberia Energy Sector Support Project (LESSP), and the Nimba County project which is supported by UNIDO [43, 77]. These projects aim at installing multipurpose mini-hydro infrastructures.

4.5. Geothermal energy

Geothermal energy is one of the feasible alternative RE sources that can complement the existing sources of energy [79]. It is an eco-friendly and versatile RE resource that can support the different developmental activities, ranging from raw materials production and processing to minerals and agricultural production [80]. There is no comprehensive assessment of the potential of geothermal energy nor does any policy framework exist to encourage public-private participation in Liberia [77]. Scouting surveys on Liberia geyser is yet to be accomplished by any geological survey [77] despite the potential sites in Nimba County. The possible geothermal sites in Nimba county need to be studied to explore potential parameters/tectonic and volcanic features such as the reservoir temperature, chemistry of reservoir, ground permeability, and natural heat transfer. Although high heat flow values have been recorded for offshore to the south and west in the Guinea and Sierra Leone Basins [43], [77] which are ascribed to possible tec-

tonic activity, the activity's thermal effects are not thought to extend inland to the Liberian Shield.

4.6. Biomass energy

In the context of energy, biomass can be seen as products containing partial/full vegetable matter that are obtained from agriculture or forestry [23], [81], [82]. Biomass is the organic material produced by photosynthesis, a process that converts solar energy into stored chemical energy [83].They can be used as fuel with the intent of improving its energy content. Biomass includes but not limited to animal dung, crop residues, grasses, forest waste, sawmill residues, shrubs, and agro-industrial residues. Currently, biomass is the leading type of energy used in Liberia, meeting about 90 percent of the energy need of Liberian populace and is therefore crucial to the nation's fundamental needs and economic activity [34]. Biomass is the major source of energy for rural industries and its trading contributes to the rural economy, in terms of employment, rural incomes and tax revenue [83-85]. It could also open opportunities for agriculture and rural development and provide other socioeconomic and environmental benefits [83-85].
Conventional biomass products, such as firewood and charcoal, are the prime energy sources used for household cooking. Charcoal is mostly used in the urban settings while firewood, agro-residues, crop residues and wood wastes are broadly used in the rural areas [34], [84], [86]. On the other hand, wood is presently the major source of fuel for over 70 percent of the Liberian population, particularly in the rural communities. In spite of the enormous biomass resources in Liberia, there is currently no consensus on the quantity of power that can be generated sustainably. Theoretically, the energy production potential that can be derived from biomass in Liberia is about 27,452 GWh per year [14]. Other independent assessments carried out in five sites of rubber plantations reported that 2,500 hectares of rubber trees per year has the potential to support 80 MW of biomass-fired power plants [14]. However, the economic and financial feasibility of biomass power in Liberia is yet to be assessed and is mostly dependent on the type of technology required, the size of the power plant and cost of the fuel-transport.
In 2004, a survey carried out by the Center for Sustainable Energy Technologies pointed out that most parts of Liberia is seriously experiencing the problem of firewood scarcity/shortage [43]. However, in 2005, the production of charcoal stood at about 36, 500 tonnes while firewood consumption in the country presently has no firm data [43]. It is also estimated that about 960,000 trees are cut down annually for charcoal production that is expected to supply the Monrovia area alone [43]. In spite of all these, the impact of firewood shortages needs to be explored in order to be able to formulate an evidence-based policy that will protect the resource in the nearest future. Consequently, failure to meet this demand sustainably will ultimately lead to environmental degradation, deforestation and desertification. This implies that as Liberia's reliance on its biomass resources increases, policies and measures must be put in place for future sustainable harvesting and replanting practices, as well as for efficient consumption.
Furthermore, there are various biomass energy technologies that are applicable to different end users. These include biofuels, biogas, improved wood/charcoal stoves and biomass briquetting. Biomass briquetting is the process of refining raw biomass materials (charcoal, crop residues, animal dung etc.) into standard mini-brick units with enhanced efficiency [81]. Biogas and biofuel technologies are technologies used for the conversion of organic biomass matter to gaseous and liquid states respectively. Biogas is mostly used for household cooking, heating, and lighting, beside the production of energy for agricultural and industrial processes [81]. Biofuels on the other hand are gradually being used to replace traditional petrol and diesel. This is geared towards reducing the quantity of carbon-dioxide emitted by vehicles. Improved wood/charcoal stoves are new technology that is now replacing traditional three-stone open fires commonly used for cooking in rural areas in Liberia but yet to be disseminated widely [86], [87].

5. Major barriers and challenges associated with RE development and policy implementation in Liberia

Presently like in most African countries, Liberia suffers a slow development rate due to little/no access to RETs. This is as a result of the high levels of drawbacks from poor energy policies, insufficient funds, deficient infrastructures, as well as the absence of technological advances [30]. Moreover, rapid growth in population and succeeding increase in energy demand in the least developing countries like Liberia has led to rising energy crisis which in turn increases the citizen's reliance on fossil fuel energy sources [88].
Furthermore, regardless of the precise RE technology, the barriers associated with RE implementation have proven to be the same across board, with very few exceptions. Scaling up RE resources in Liberia would therefore require certain barriers to be overcome, possibly via mitigation options drawn from experiences in other countries as well as Liberia itself. These barriers and challenges include:

a) Political and regulatory barriers
b) Institutional barriers
c) Financial and market-related barriers
d) Technological barriers
e) Public awareness and information barriers
f) Socio-cultural barriers

5.1. Political and regulatory barriers

Well-rounded policies are important for the successful implementation of any technology in a country [89]. Many countries in the Sub-Saharan Africa region possess typical national renewable energy policies while regional policies are not fully formed because of incompatible implementation approach as reported in a study by Mohammed et al. [25]. This implies that, in spite of the numerous RE policies developed in most of these countries, there are difficulties implementing them primarily because they are underdeveloped.
For instance, Liberia does not have comprehensive RE Policy, although there is short declaration for rural and renewable energy in the 2009 National Energy Policy and this does not give the appropriate guidance for implementing a national renewable energy agenda [21]. The deficiency in favourable policies and regulations for the development of RETs can hamper the adoption of these technologies [89]. This is because of the features of RE structures and market requires clear policies and legal actions to increase investors' interest [89]. Moreover, rejuvenating policies generate steady and predictable investment environments, assist in overcoming barriers and guarantee an expected project income streams [90].
Furthermore, private sector participation in RE projects in Liberia is hampered by insufficiency of distinct policies on private investment and delays in the approval of private sector projects [88]. Consequently, progress toward RE development in the country is deprived by policymakers' failure to implement measures that would attract private investors, since large-scale RE, projects necessitate huge amounts of capital to run [89].

5.2. Institutional barriers

The implementation of RET is affected by policies and regulations at the national level as regards to rural electrification and poverty eradication goals. Presently, Liberia lacks strong institutional leadership for RE [42]. The institutional structure of the energy sector in most developing/least developed countries like Liberia is still under government monopoly, with the accountability for energy generation and distribution allocated among a number of government departments, hence excluding other stakeholders [42], [43]. Consequently, inadequate coordination that is as a result of an array of government bodies with energy authority, and the limi-

tation of institutional capacity constituent critical institutional hindrances to the development of RETs in Liberia [42], [44]. This in turn generates a wavering macro-economic environment which augments risks and dampens investments. This barrier exists not only because Liberia is still a low-income country, but also as a result of the insufficient attention of the government to R&D and the government's failure to facilitate science and engineering activities while building human capacity.

A strong legal regulatory framework governing intellectual property rights, financial policy and support mechanisms is a key requirement for RET development. Without this commitment from the GoL, investors, suppliers alongside developers will want to be quite sure that not only will the existing government meets up its obligations but also that the decision of a future legislature or RE management will not impinge on their investment in any way [44], [91]. A well-organized institutional framework with the components that will provide direction and coordination for all RE activities, can therefore, champion the continuous development of RE in Liberia. It is thus essential that sufficient institutional infrastructure exists to serve as the implementing instrument for all public and technological innovation in RETs. In addition, the Liberian National energy policy calls for the establishment of a Rural and Renewable Energy Agency that is expected to encourage energy efficiency, improve the quality of management and training on energy efficiency, increase public awareness of energy-related matters, support local institutional reforms that could assist in achieving policy goals and reduce environmental risks [21]. Although this is an admirable initiative, it is much more vital to understand how the agency should works; the reason for its establishment; the blueprint and trends that can help specify the degree of success or failure; and the required efforts necessary for them to function effectively. However, the GoL needs to realize that at the institutional level the centralized energy model is becoming gradually more redundant in developed countries [39]. Liberia needs to focus more on the development of a decentralized energy structure that would better match its current capital resources and management capability as suggested by many researchers [43], [45]. This could help position the country to adapt future energy technologies and systems.

5.3. Financial and market-related barriers

According to the belief of RE experts, financing is the major barrier for rural and renewable energy development projects [92, 93]. A key barrier to the RE exploitation in Liberia as a least developing country resides in the high initial investment and installation costs of RE equipment [93], [94]. The high initial cost may also be a vital contributing factor to an unrelenting investor confidence and an overall insufficiency of financing tool as well as uneven financial sectors [40], [93], and [94]. In general, RE technologies have higher initial capital costs than the traditional energy technologies. Nevertheless, RETs are seen to have elongated life spans and low maintenance costs, leading to much lower life cycle costs compared to traditional technologies. The problem associated with this is that most investors do not care about the life cycle costs but rather are mostly concerned with the initial cost of the technology. They prefer to keep the initial cost low than to reduce the operating costs which exceeds a longer period of time [94]. This sort of initial cost preconception is mostly evident in rural Liberia where the potential consumers are low income earners. Extensive implementation of RE in Liberia would therefore require substantial financial investment by both the public and private sectors. Furthermore, banks and other financial institutions are also required to play a vital role in the exploitation of RE in the country. Innovative and affordable financial plans/supports can be made readily available to individuals both in the rural and urban areas for the procurement of RE technologies such as solar PV systems [92]. The need for the participation of private sector in the national rural and renewable energy implementation cannot be overemphasized. It is only then that an affordable, sustainable, and realistic RE market can be shaped, as a complementary to the distorted market that is so frequently created by solely government and international aid-driven projects [92-94]. However, the achievement of these targets would require the active participation of stakeholders at all levels.

Additionally, there are little or no incentives on local manufacturing and importation of RE technology such as solar devices in Liberia. This has in turn increased the investment cost of RE equipment and devices above the conventional energy technologies. Consequently, some RE projects like solar are executed using sub-standard or fake solar PV system components. For instance, some solar street lighting project contractors mostly have a preference to save cost by arranging for device components that are of low standard, and as a result, many solar PV projects fail within a short period after they are installed or commissioned [41]. It is therefore, very difficult for an average Liberian or a company to invest in RE technology system.

5.4. Technological barriers

This is the sum total of a range of issues that include substandard product quality, inadequate resource data, inadequate human and mechanized capacities, and insufficient R&D activity. As previously discussed, there are no accurate records of solar, wind, hydro, biomass and geothermal resource accessibility in Liberia. There are few or no data collection stations in the country. The few that may exist are equipped with outdated measuring equipment which must have been acquired prior to the war. Also, the manufacturing industry in Liberia is not well developed due to the destruction of most of the facilities during the war. Consequently, majority of the finished goods and services consumed by the citizens are mainly imported from neighbouring countries, Asia and Europe.

Increasing a trained workforce to operate and maintain RET equipment is very crucial for a successful exploitation and growth of RE projects in Liberia, particularly in the rural areas. However, most engineers do not have the basic technical skills and training in RE technology and thus are not familiar with the best applications and limitations associated with the various RE technologies. Currently in Liberia, there are limited trained personnel and training facilities for the installation, operation, and maintenance of RE technologies, which make it very difficult for the country to achieve a sustainable RE market [95]. Training such engineers and ensuring that they have complete access to spare parts requires the establishment of new infrastructure that can provide a quality training platform for technical and engineering personnel [95], [96]. This is highly crucial for the rural and remote areas with restricted access, where frequent repair and maintenance is often required. Failure to provide the expected maintenance of the equipment when it is needed could lead to the total breakdown of the system, thus overwhelming the purpose of the initial investment. RE education is yet to be included in the academic curriculum of most universities and tertiary institutions in Liberia. Currently, there is no institution in the country offering RE as a course at any level of higher degree. This implies that relevant application of RE to fields such as engineering, environmental science, geography and architecture is not being taught adequately or at all, and as such, the graduates produced from the Liberian universities system are not aware of the value that RE can add to their work professionally.

Presently, the GoL has not given proper attention to R&D in the area of science and engineering not to talk of RE. There is no visible plan/budget for universities and institutions of higher learning to precisely carry out research on RE technologies [91] neither is there any working systems put in place for quality international research and development collaborations that can easily accelerate transferable skills and technologies [91].

Consequently, domestic technical knowledge concerning RE products like solar PV (solar lanterns, solar chargers etc.) is inadequate and as such, related technologies are imported at very high cost. Yet, with an indigenous skilled and averaged-skilled workforce, a sustainable RE industry could be easily attained in Libe-

ria. This means that skilled personnel from multidisciplinary academic and research institutions are mandatory for R&D activities in the country to sufficiently engender widespread diffusion of solutions to precise energy needs of the citizens. Also, a lot of work still needs to be done in creating a sustainable framework for the scale-up of energy solutions from the laboratories to the market place. This will therefore require a lot of efforts for the GoL.

5.5. Public awareness and information barriers

The lack of public awareness has been identified by prior work as a major barrier in the utilization of RE technologies in many countries [97], [99]. There is little/no-general public awareness regarding the use, importance, acceptable quality and standards of RETs, socio-economic and environmental benefits that are derivable from RETs [97-99]. Since RETs are quite new in Liberia, a large number of the public sector knows little or nothing about them [100]. The public sector is not offered with sufficient training required to make informed choices (i.e. there is a shortage of technical information). This means that both end users and implementing personnel are likely not to be able to distinguish between quality and counterfeit equipment. Thus, making informed choices becomes quite difficult and this translates into high rate of substandard installations.
Furthermore, the nonexistence of vital information and proper awareness has generated a disparity in the RE technology market that has given rise to a higher risk perception for potential RE prospects [101]. However, the accessibility of such vital information could increase investors' interest and thus RE project development.

5.6. Socio-cultural barriers

To most of the Liberia populace, RETs are completely new and this is a fundamental issue, as there is no way RETs can be excellently functional in the country if the potential customers are ignorant of their existence and benefits as previously discussed [102]. This is because the decisions to adopt RETs are normally influenced by consumer perceptions on the quality and usefulness of the technologies when compared to traditional technologies [102]. For instance, Liberia system operates a cash economy in which citizens do not depend on credit as in developed countries. It will therefore require several efforts to convince a rural farmer in the rural community who has programmed his living strictly within his income to accept a technology that is outside of his budget and thus may oblige him to obtain a short or long term loan.
In other words, social acceptance of RETs is very significant and influential for the dissemination of these technologies. For instance, biogas produced from metropolitan waste for cooking may not be acceptable to some portion of the society. Moreover, the local culture, superstitions, religion, practices and beliefs of diverse communities need to be understood when RE projects are planned in order to avoid unexpected challenges later in the development phase of such projects. These are bound to influence the view of the communities of the benefits to be derived from any new technology introduced to them [95]. Also, since both the assembling and utilization of most of the energy used in households in rural communities are mainly carried out by women, it is imperative that suppliers and developers of RET must recognize its relationship with gender technology [96, 102].
Furthermore, the social framework of a community, the existing hierarchy and decision-making process are required to be given appropriate attention during the planning process of RETs projects. Confrontations faced by RETs could also occur in cases where neighboring communities are displaced from their ancestral land or denied access to grazing land due to the development of large RETs such as solar PV arrays and hydropower plants [14, 102]. Other barriers are majorly connected to lack of assessment of environmental externalities [102].

6. Resourceful measures and policies requisite in overcoming barriers to RE deployment in Liberia

To overcome the aforementioned barriers and accelerate RE deployment in Liberia, there is a need for the GoL to set up favourable policies at the diverse levels of the government. These policy frameworks are basic premises required by the GoL to apply, extend and assess its policies and successive actions that may include regulation, implementation, decision-making etc. This would efficiently confront major RE concerns that are depicted in the policy framework and others which are yet to be captured. The following effective measures and policies are thereby suggested, in order to hasten RE development in Liberia:

6.1. Mitigation of regulatory and political investment risk

Investment risk can be ascribed to numerous factors but the most noticeable one is regulatory and political risk [103-104]. It poses a major restriction on investment decisions and it is considered as the greatest constraint for any investment into emerging markets [103-104]. Consequently, some investors, even when in search for urgent investment opportunities, would rather not put into consideration an RE infrastructure asset in emerging and developing nation. Indeed, a cultured system of regulation is valuable to the society, and RE infrastructure investors typically do not have any problem with them [90]. Rather, their main concern is mostly associated with the unforeseen variation in the laws and regulation. RE investors crave to be quite sure that not only that the current government consolidates its obligations but also that the decision of a future legislature or RE management will not intrude on their investment in a cruel way [89]. This means that the RE sector of Liberia would obviously require a considerate regulation that can prevent the cruelty of pricing power.
In addition, by paying attention to the impacts of the RE development in Liberia, the government should perhaps establish a particular body that would be accountable for the management of all the activities related to RE projects across the country. This would be of great assistance in reforming the crucial but significant needs in the RE sector as it is in some developing and developed countries [105]. As such, compulsory reputable laws will be essential steps required to reduce the fundamental hindrances of the political and regulatory risk in Liberia. The development of critical reform processes in social, political, economic planning can also help control corrupt practices while ascertaining transparency ethics in public administration. Moreover, regulatory measures such as standards and codes can increase the implementation of RETs while reducing the technological and regulatory risk that unfolds with investments in these types of projects [90].

6.2. Energy subsidy and cost reduction measures

Presently, the GoL have made available economic incentives that include tariffs waivers, subsidies etc. to promote investments on energy through fossil fuel sources. One of the main reasons for subsidizing fossil fuels is to protect domestic prices from the erratic global market [40, 106]. Besides, subsidies drive the prices of fossil fuel energy down, while positioning the already capital-demanding RE technologies at more disadvantages [40]. Most of these incentives are not opened to RE technology projects and these are factors that play major roles in the impediment of RE expansion in Liberia [40]. Nevertheless, shifting these subsidies on fossil fuels to support the necessary incentive methods for RE development will certainly accelerate the development of RE resources in Liberia, particularly, solar energy. For instance, the GoL can approve a non-refundable subsidization for the implementation of solar PV technology in which about 50% of the activity/action cost can be funded.

Conversely, despite the continuous efforts from the government to subsidize electricity, the schemes have failed to meet the electricity needs in the country. This may be ascribed to the conducts and approaches utilized by the authorities for subsidization. The country has suffered the rising burden of subsidizing electricity in the midst of a devaluing Liberian dollar. However, this kind of financial support is durable for a short period and not cost-effective as it leads to additional pollution [93]. So, the establishment of incentives for households and rural communities to install small-scale RE systems in their proximity will be a long-term solution. Another challenge is that there is an inadequate funding for RE projects in Liberia, particularly for small-scale projects. Part of this complexity comes from a lack of awareness of RETs, and the ambiguity as regards the steadiness of energy resource assessments. Moreover, the capital cost of RETs is somewhat high and this discourages funding agencies/investors.

6.3. Favourable feed-in-tariffs (FITs) policies

A RE policy like the FITs is one of the best political mechanism that can provide investment security and broaden the decentralized/production of RE [107]. This policy has to be appropriately managed with the aim of attracting potential investors and concurrently their activities should be closely checked. Nevertheless, to achieve an efficient process of renewable energy Feed-in-Tariffs (REFITs), the government would have to hire skilled personnel that will be accountable for the handling of the process. This is because favorable policies are principal requirements for long-term sustainability of RE development [107-108]. Thus, ensuring that laws are established and obligatory is very important as prospective investors would require a realistic assurance that the legislative provisions put in place for RE activities will remain steady, perspicuous and compulsory, thus promoting future stability of investment.

Furthermore, REFITs in Liberia can also be a valuable policy avenue for a growing RET deployment, just as FITs have been profitably engaged in some developed and developing countries [105]. The implementation of REFITs will be a significant policy mechanism that can be used to enhance the RET deployment as well as improve affordability. It also guarantees payment to RE investors at a set fee for electricity production over a period of about 20 years [91], [93], [94]. These tariff charges can be programmed based on the cost of power generation of precise technologies but usually reduced over time [108]. Moreover, for meaningful investment in RE power generation, the electricity tariff must be market reflective irrespective of the accessibility of fossil fuel energy sources. This will convince probable stakeholders to invest in RE applications. Conversely, an increase in the tariff routine could be counter-productive, taking into account that a larger portion of the populace belongs to the low-income class and that costs are distributed among electricity consumers as part of their recurring bill [107]. Liberia must thus take a bold step to follow after the FIT pioneering African countries such as Uganda, Egypt, Rwanda, South Africa etc.

6.4. Quality and standardization policies

Standardization is a vital component that can make significant impact on RET development and deployment [109]. It is a process that is necessary for the support of small-scale RE industries such as briquette and improved stove making industries [110]. A lot of impediments as a result of poor-quality of RE technologies such as solar systems have deteriorated some solar energy projects in the country. As a result, standardization of RE manufacturing procedure is essential in fortifying small-scale RE industries. For instance, the National Standards Laboratory (NSL) and other government agencies need to establish and firmly enforce suitable manufacturing standards and specifications. This can be accomplished through the introduction of standardized policy instruments and incentives that can encourage local assembling of RE devices, particularly, solar energy applications. Similarly, for the purpose of sustainability, the GoL have to also make efforts to introduce domestic manufacturing industry for RE technologies, thus reducing the dependence on imported products. This is particularly applicable to solar energy technology. With the implementation of these standard production procedures, the quality and quantity of RE output will yield increase. This will be a step in a right direction that would entirely empower the RE industries in Liberia.

7. Conclusions

The current and potential of RE exploitation and development in Liberia is explored and discussed in this study from the perspective of sustainability. RE resources such as biomass, hydro, solar, wind etc. are in abundance in Liberia and they display considerable potential that can meet up with the country's energy needs. Nevertheless, the development of RETs in Liberia is hindered by factors that include political and regulatory, institutional, financial and market-related, technological, public awareness and information, and socio-cultural barriers. Basically, all these factors are seen to work in cycle to limit the development and utilization of RE sources. For example, Liberia presently has not been able to adapt and develop most of the RETs due to huge initial cost that is required to set up the systems. Consequently, because there is a cheaper alternative like coal, most populace would prefer not to utilize RE sources in spite of their enormous benefits. Likewise, incoherent government policies and poor communication between the various governments departments involved in RETs and the general public have proved to be a widespread barrier upsetting a successful development and exploitation of these RETs in the country. In our opinion, we suggest that the GoL would have to take bold steps regarding the reform and implementation of its rural and RE policy with the aim of increasing energy security and making headway towards a sustainable energy future. In order to energize the Liberian economy, the GoL need to avoid grand RE projects that will takes 7-12 years to be accomplished rather, the GoL should solicit for investment for mini RE power projects (off-grid: 20-70 MW) that can be accomplished in a year. These are quick wins that the young Liberians are expecting from the new government. However, the key to strengthening the subsistence of RETs in Liberia does not lie just in the individual solutions to the policy challenges but rather, a comprehensive practice must be engaged. Apparently, the path towards a sustainable energy future in Liberia is in no way simple, nevertheless a solution certainly exists at the same time. In spite of the numbers of approaches that may have been suggested in this study to promote the growth of RE in Liberia, these solutions will certainly require meaningful efforts and commitment on the part of the GoL. The country thus needs to take into account the long-term benefits of RE power generation for its citizens and as a result, Liberia's investment on the sustainability of RETs today would lead to a safe energy future for tomorrow. However, it is clear that further work needs to be done on the status of the utilization and development of RETs in Liberia. This may include but not limited to rigorous data collection for wind energy, geothermal energy and solar energy; an empirical model can be developed to elucidate on the citizen's concerns with acceptability issues of RETs and the impact of RE policy and development in Liberia can also be explored.

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