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The Renewables' Development Constraints in Cameroon: Challenges and Future Prospects

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Abstract: ***Sub-Saharan Africa is in the midst of an energy crisis. The region's power generation capacity is lower than that any other world region, and capacity growth has stagnated compared with other developing regions. The Cameroon's case is even more problematic since the sector suffers from many other evils and shortcomings justifying the current and future energy deficit if nothing is done. Although the country enjoys huge renewables' resources, actual exploitation is threatened by a range of institutional, financial, technical and/or technological problems. Our study analyzes these constraints and proposes some development prospects. We found that overall energy sector is characterized by a plethora of administrations without coordination's structure and clear responsibilities, which leads to mixed outcomes. In addition, there is no institutional framework for renewables and no promotion program. Cameroon equally faces inadequate number of renewables experts which considerably stands as barrier. Unreliable infrastructures, insufficient distribution networks, corruption, administrative bottlenecks as well as financial insecurity are the most significant risks and barriers. As it has done for fossil fuels and large hydropower, Cameroon must clearly define its policy on other abundant renewables resources. It must also improve the overall business environment in order to reassure and attract more interested investors.***

Keywords: Business environment; Cameroon; energy policy; renewable energies; sustainable development.

1. Introduction

Renewable energies supply is of ever increasing environmental and economic importance in all countries. A wide range of Renewable Energy Technologies (RETs) are established commercially and recognized as growth industries by most governments [1]. Renewable energy is advancing rapidly to close the gap between the energy haves and have-nots. Providing a basic level of electricity access with renewable technologies is increasingly economically feasible (e.g. kerosene lighting systems at USD 4–15 per month cost households significantly more than the USD 2 per month to run a solar lighting systems) [2, 3]. Also, renewables'-based solutions to improve cooking practices such as improved cook stoves or biogas-based technologies among others are effective in reducing polluting fumes [4-6]. However, the lack of modern energy services is a major impediment to the socio-economic development and widening access is limited by several factors particularly in the least developed countries like Cameroon.

Renewables are now the most economical and competitive solution for off-grid and mini-grid electrification in remote areas, as well as for grid extension in some cases of centralized grid supply with good renewable resources [5]. They are now established around the world as main-stream sources of energy. In 2015, an estimated 147 gigawatts (GW) of renewable power capacity was added, the largest annual increase ever, while renewable heat capacity increased by around 38 gigawatts-thermal (GWth), and total biofuels production also rose [7]. This growth occurred despite tumbling global prices for all fossil fuels, ongoing fossil fuel subsidies and other challenges facing renewables, including the integration of rising shares of renewable generation, policy and political instability, regulatory barriers and fiscal constraints. Renewables-based energy growth is both viable and desirable for all three major energy sectors: electricity, heat, and transport. In addition, it can enable access to modern energy services for all.

In December 2010, the United Nations General Assembly (UNGA) declared 2012 the International Year of Sustainable Energy for All (SE4ALL), recognizing the importance of access to modern and affordable energy services in developing countries [2]. The initiative seeks to engage governments, the private sector, and civil society partners worldwide, to achieve three major objectives by 2030: First, ensuring universal access to modern energy services; second, doubling the global rate of improvement in energy efficiency, and; third, doubling the share of renewable energy in the global energy mix [8]. IRENA developed REmap 2030 [9] to explore in more detail the feasibility of the third objective, including the interconnectivity between

renewable energies and energy efficiency strategies. REmap 2030 is a roadmap to double the share of renewable energy by 2030. It is the first global study to provide renewable energy options based on a bottom-up analysis of official national sources.

In 2012, the United Nations General Assembly (UNGA) declared 2014-2024 to be the Decade of Sustainable Energy for All, underscoring the importance of energy issues for sustainable development and for the elaboration of the post-2015 development agenda [10]. IRENA Members expressed strong support for the Agency to be the "Hub for Renewable Energy" within the SE4ALL initiative.

This paper is a literature review of Cameroon's energy sector (with a particular focus on renewables' sub-sector) and as such, it is based on a desk review of available literature. Its main objective is to analyze the possibility of using renewable sources in order to optimize the energy production of the country. It also seeks to examine the renewables sub-sector and the possibility to revitalize the whole energy sector in an environmentally friendly way.

After the introductory section, the remainder of the study is structured as follows: the ensuing section presents the context and the problematic of the study. In section 3, we analyze the country's energy situation by presenting the legal and institutional framework of energy sector, studying the current practices and presenting the market actors. Section 4 puts a focus on renewable resources while sections 5 and 6 respectively, examine the barriers and drivers to renewables' deployment in the country. The last section followed by references concludes the study by setting out some development prospects.

2. Context and problematic

Today, an estimated 1.2 billion people (17% of the global population) remain without electricity, and 2.7 billion people (38% of the global population) still lack access to clean cooking fuels. More than 95% of those living without electricity are in sub-Saharan Africa countries and developing Asia, and they are predominantly (around 80% of the world total) in rural areas [7, 11]. Many more suffer from supply that is of poor quality.

In 2010, about 590 million African people (57% of the global population) had no access to electricity, and 700 million (68% of the global population) were living without clean cooking facilities, although the situation differs significantly between urban and rural areas. If these current energy access trends continue, in 2030 there will still be 655 million people (42% of the population) without access to power, and 866 million (56% of the population) without clean cooking facilities, depriving the majority of the population of the opportunity to pursue a healthy and productive life [2].

In Cameroon, until now, despite its huge renewables potential, energy demand remains unsatisfied. Of the 13,104 identified localities in the last census, only about 2,400 (18.32%) are electrified. Access to modern energy is very low, on a national average rate of 15% for electricity and 18% for domestic gas. Access to electricity is less than 10% in rural areas against about 50% in urban areas, which is a significant threat to the economy and populations' life [12]. The regions that suffer the most from a lack of electrification are mainly those with large rural concentrations, notably, the Adamaoua, East, Extreme North, North, North-West, and South-West, where the average rate of electricity access is 10% among the poor and 33% among non-poor populations [13].

The widespread issue of using fossil fuels and inefficient traditional fuel for cooking requires urgent solutions to avoid serious health and environmental implications (i.e. indoor air pollution, deforestation, fossil fuels exhaustion, global warming and climate change). In Cameroon, about 19% of electricity generated comes from the combustion of fossil fuels in thermal power plants and more than 80% of populations still rely on traditional biomass [12, 14]. This combustion pollutes the atmosphere and emits greenhouse gases responsible for today's climate change [15]. This sad fact is distressing and incompatible with any hope of Sustainable Development.

The current global challenge is to meet the growing energy demand while fighting against global warming and ensuring the safety of the energy supply. The best way to meet this threefold challenge is an energy transition mainly based on renewable energy technologies. But, the fundamental question is to know how this energy transition must be made? Within which institutional framework and which environment? With which actors? Which resources? And, which energy pattern?

3. Cameroon's Energy Situation

3.1. Institutional framework

The institutional framework of the energy sector in Cameroon includes several institutions [12]:

- The Presidency of the Republic which defines and guides the sector's overall policy;
- The Prime Ministry which coordinates the action of the whole government;
- The Ministry in charge of finance which ensures the financial supervision of the sector;
- The Ministry of Energy and Water Resources (MINEE) which ensures the technical supervision of the sector and which is charged, consequently of the design, implementation and monitoring of the governmental policy in the energy sector.
- Electricity Development Corporation (EDC); created in 2006, the EDC is a state company that plays a strategic role in the development of the electricity sector while ensuring conservation of the public heritage in the sector. The EDC is also in charge of construction and development of all hydroelectric projects in the country.
- Electricity Regulatory Board (ARSEL); the second institutional arm of the electricity sector. ARSEL is responsible for regulating the electricity sector as well as setting electricity rates and determining electrical standards. It is also in charge of protection of electricity consumers.

- Rural Electrification Agency (AER); created in 1999, the AER is responsible for promoting and implementing rural electrification in Cameroon. It manages the Rural Energy Fund (REF).

Several other government agencies including the Ministry of Environment, Protection of Nature and Sustainable Development (MINEPDED), the Ministry of Agriculture and Rural development (MINADER), the Ministry of Mines, Industries and Technological Development (MINMIDT), the Ministry of Economy, Planning and land Use (MINEPAT) and the Ministry of Scientific Research and Innovation (MINRESI) are also involved in the energy sector. According to the organic texts instituting the government [50], the ministry in charge of energy as technical supervisor of energy sector is responsible for ensuring the coordination of all activities in this field.

3.2. The Current Status

Since a few decades, energy supply in Cameroon suffers from a lot of insufficiencies. Even for those with relatively high rates of electricity access (e.g. urban households), quality of supply continues to be an issue that holds back consumers and the economy from realizing the full benefits of electricity access. The underlying reasons for outages include insufficient generation capacity, fuel shortages (for thermal power plants operation), excess strain on the system and shutdowns for repairs and maintenance [11]. In the same time, the maintenance quality of hydropower dams is below average and the production plant operates with performance rate inferior to 55% [16]. In addition, there is a high rate of production losses of about 25 % [17]. Whatever the reason, the result is essentially the same: an economy that is unable to operate at its full potential. Figure 1 below shows the monthly and average duration of outages of some countries.

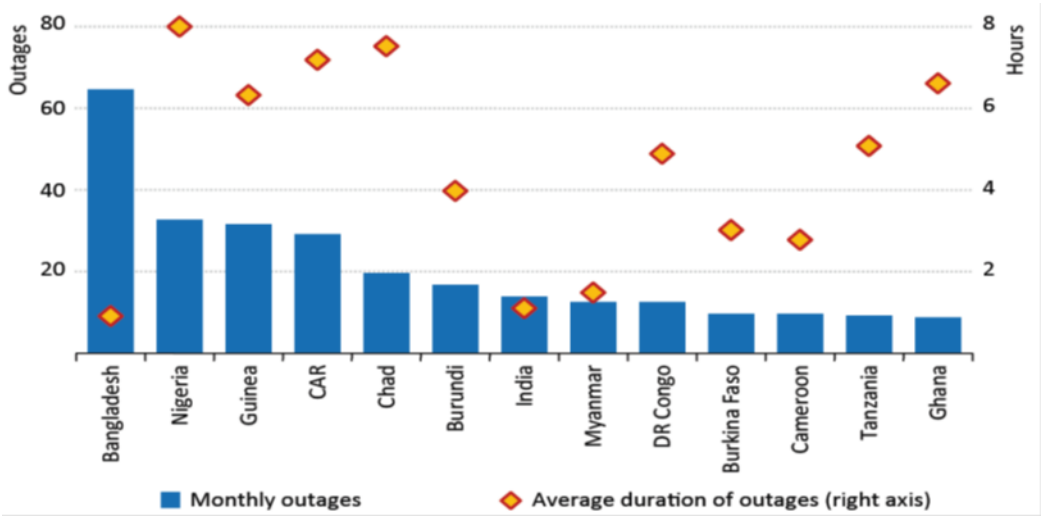

Figure 1: Number and duration of monthly electrical outages by selected countries [11]

Currently, no commercial production of biofuels is taking place in Cameroon. Only some isolated trials have been undertaken by agro-industries such as Sodecoton, Socapalm, Cameroon Development Corporation, Maiscam, Ferme Suisse and Sosucam in the cotton, palm-oil and sugar sectors [18]. They use residues for self-cogeneration with a total power output of approximately 88 GWh per year. About 3.8% of households also have gensets for self-generation. The share of gensets amongst rural households increases up to 6.1% compared to only 1.7 of urban households [17]. Overall, kerosene lamps are used for lighting by over two-thirds of the rural population and 10 % of the urban population. Household consumption of kerosene is estimated at 1.9 liters per month in rural areas and 0.8 liters per month in urban areas. The primary factor affecting consumption, especially among the poor is the high price of oil products, approximately 350 CFA per liter [13]. In addition, more than 85% of the populations (rural in majority) use fuelwood and/or charcoal for heating or cooking purpose [12, 14].

Investigation of modern technologies (off-grid lighting such as PV products and cook-stoves) found that they are largely absent from the market in Cameroon [13, 19]. This is due to the weak development of the market, in both rural and urban areas, where there exists greater purchasing power. Most of the modern renewable's products are imported from Asia, especially from China but also from Nigeria. Energy consumption in the rural areas is therefore essentially structured around solid biomass with inefficient technologies and risks on people's health [20-22]. Overall, the current energy pattern of Cameroon is characterized by social and spatial inequity both in access than consumption. Moreover, intergenerational equity is not either ensured. Therefore, Cameroon's energy system is judge unsustainable [23].

A close examination of the official documents intended for the implementation of energy policy in Cameroon does not clearly indicate the provisions promoting renewable energies development [12, 24-27]. The legal and regulatory framework for renewable energies is essentially apprehended through the different texts of legislation relating to the electricity sector and their implementation decrees [28-30]. All these texts, furthermore their tendency to reduce energy to the exclusive notion of electricity, do not include the profound regulations of the renewables sector. Despite the evolution contained in the 2011 law governing the electricity sector (which devotes one section to renewable energies), the implementing legislation is still expected. This law provides in the conditional tense the

creation of an agency in charge of renewable energies promotion. Overall, the country's energy policy does not take into consideration the use of biomass and other abundant renewable energies [31]. A lack of coordination among Cameroon's regulating bodies is the main obstacle concerning decisions and actions in this sector [12, 32].

3.3. Market actors and regulation structures

The main institutional players in the Cameroonian energy (especially electricity) sector are the Government of Cameroon, multilateral financial institutions, regulatory agencies, as well as the national operator, Eneo-Cameroon S.A. There are respectively:

- The Ministry of Energy and Water Resources (MINEE) which defines policies in the overall energy sector and grants concessions and licenses to market actors. Other tasks include the development of the energy sector, the planning of rural electrification and the promotion of renewable energies. But, the main focus of activities is on the electricity sector.
- The Ministry of Environment, Protection of Nature and Sustainable Development;
- ARSEL, the Electricity Regulatory Board;
- AER, the Rural Electrification Board;
- Eneo-Cameroon S.A, the current operator and the main electricity producer in the country.
- SONATREL, the National Company of Electricity's Transport, the new operator recently created in 2015. It is exclusively in charge of electricity transportation all over the country. This supposes that from this date, Eneo-Cameroon S.A. which was previously responsible for generation, transportation and distribution of electricity will henceforth be responsible of production side only.

The petroleum sector of Cameroon is dominated by the National Hydrocarbon Corporation (SNH) in charge of the oil and gas sector, the National Refinery Corporation (SONARA), the Cameroon Petroleum Depots Corporation (SCDP) and the Stabilization Fund of Hydrocarbons' Prices (CSPH). The distribution sub-sector has been liberalized, and activities are being shared between multinational companies like OiLybia, Total and Texaco. On top of that, several approved multinational and national companies are active in the petroleum sector of the country. While government put a focus on electricity and petroleum sectors, renewables' sector (especially biomass, solar and wind) is not regulated at all. Activities in this sector are in disorder and total anarchy.

The following developmental players are relevant to energy access and renewables:

- SNV, the Netherlands development organization is helping Cameroon in the development of the renewable energy sector in order to increase the living standards of the rural and the urban populations in domestic biogas and other renewable energy technologies. It equally has as objective to promote and supply solar energy and other available technologies;
- Pro-Climate International and Atmosfair in partnership with United Nations Development Programme are helping to put in place a program entitled `Improve Cook Stoves for Rwanda and Cameroon`;
- EX-IM Bank of China, which provides solar energy in certain areas of Cameroon (Centre, North, West and south regions);
- European Union; in connection with the Rumpi project, the European Union is carrying out mini hydro and solar projects in the Rumpi area of Cameroon.
- Action for an Equitable, Integrated and Sustainable Development (ADEID) a local Non-Governmental Organization which develops some micro and pico-hydropower projects in the country.

The main multilateral financial institutions lending money to Cameroon are the World Bank group, the International Monetary Fund (IMF) and the African Development Bank. These institutions take the lead in setting up Cameroon's reimbursement and development strategies. Other creditors usually require indebted countries to work in collaboration with the World Bank and IMF, as a condition for their loans [33]. Consequently, this gives the World Bank and the IMF a crucial and decisive role as lenders and multilateral coordinators in shaping Cameroonian economic and development policies.

The market for solar lighting products is just starting to develop and is still small. Primarily, it offers lamps that operate with rechargeable batteries. But, the market is dominated by low quality and low price lighting products sold by informal actors who acquire goods from wholesalers supporting the informal market (primarily from China and Nigeria). Official suppliers of photovoltaic equipment and materials are listed by the Inter-Patronal Groupment of Cameroon (GICAM) and the Chamber of Commerce, Industry, Mines and Crafts. Companies sometime offer more specialized services which include installation of photovoltaic systems. Improve cook-stoves are also found at different prices and points of sale.

3.4. Some implemented renewables projects

In Cameroon, access to data is a major concern for researchers. This is also valid for renewable energies domain, a field in full gestation in the country. It is partly due to the lack of data but also, when available, to the strong culture of data's retention because of corruption and bureaucracy. It therefore becomes difficult to analyze the activities carried out and to make a comprehensive assessment of the total installed capacity across the country.

In the large hydroelectricity, some hydropower plants are planned by the Government in the short term to improve generating capacity with currently, the building of the Lom-Pangar storage dam (30 MW) and the development of hydroelectric schemes at Nachtigal (250 MW), Mekin (15 MW) and the Memv'ele (201 MW) which is going to raise the capacity of the power plants by 75 MW [24]. Besides these projects currently under completion for some, several other hydropower plants are awaiting construction or are under study, they are: Menchum, (84 MW), Birni à Warak (60 MW), Song-Dong (280 MW) and Kpep (550 MW) [34].

Small hydroelectricity however, is not a concern of the government in spite the great potential. Despite the difficult environment, some private projects have fortunately been

realized. Thanks to the initiators! A number of micro and pico-hydropower projects with a total installed capacity of 515.5 kW have been developed since 2004 by a local Non-Governmental Organization (NGO) namely, Action for an Equitable, Integrated and Sustainable Development (ADEID). Table 1 below shows the achievements of this NGO.

Table 1: Projects realized by ADEID

Location	Installedcapacity (KW)	Region
Mamamram	7,5	West
Tongou	5	West
Nefolem	6,5	West
Bellah	7,5	South-West
Wabane	30	South-West
Quibeku	10	South-West
Bamunkumbit	10	North-West
Tchouandeng	20	West
Nkah	48	North-West
Jakiri	23	North-West
Famtchuet	15	West
Foumbot	46	West
Koutaba	93	West
Massagam	116	West
Schungou	78	West
Total	515.5	

Source: ADEID

Concerning solar energy, some projects have been realized. The first solar rural electrification project in Cameroon was inaugurated on March 30, 2012 in the Muyengue village, situated in the Southwestern region. Henceforth, 98 rural households have a fixed unit comprising a solar panel, 20 Wp and 12 V batteries, a mobile lamp and 3 transmission fluorescent bulbs [35].

In May 2015, the Bolloré Africa Logistics Group officially inaugurated a solar power plant dedicated to power two 100 % electric buses (baptized Blues bus) on the University of Yaoundé 1 campus. The first electric buses ever used in Cameroon, to facilitate student transportation. This solar power plant covering an area of 1000 m^2 consists of 288 photovoltaic panels of 240 Wp each for a total installed capacity of 69.12 KWp. In August 2015, another solar power plant built by the Chinese company Huawei Technologies was officially inaugurated at Mvomeka'a, in the Southern region by the Minister of Energy and Water Resources. This solar power plant with an installed capacity of 73 kWp with 293 photovoltaic panels serves to power 93 street lamps. Global Village Cameroon, a local NGO has also developed a mini-solar power plant in the rural area of Ngan-ha with an installed capacity of 9.5 KWp to electrify 75 households as well as some public buildings [36].

Cameroon has a few areas where wind can be exploited at a commercial level. A locally manufactured small wind turbine has been installed at Bandzeng, a village located in the Bui department, Northwestern region [36]. Increasingly, solar street lights are used in some cities for public lighting. There are also on the local markets some gadgets such as calculators, watches, flashlights, etc., all powered by solar energy.

4. Renewables resources in Cameroon

Cameroon enjoys a rich and diversified natural resources base with enormous potentials. However, according to the 2011 law governing the electricity sector in the country, the following resources shall be considered as renewable energies [30]:

- Solar, thermal and photovoltaic energy;
- Wind energy;
- less than or equal to 5 MW river hydroelectric energy;
- Biomass energy;
- Geothermal energy;
- Marine energy.

This law excluded from the field of renewable energies all hydraulic installations that can deliver a power more than 5 MW, which nonetheless raises the problem of the definition of renewable energies as adopted by international scientific community.

4.1. Hydropower

Cameroon has the second largest hydroelectric potential in sub-Saharan Africa. Total potential is estimated at 20 GW, with a production potential of 115 TWh per year [12]. There are three main facilities in the country: Edea (263 MW); Songloulou (387 MW) and Lagdo (72 MW). The potential for small Hydro Power installations (up to 1 MW) is estimated at 1,115 TWh, mainly in the eastern and western regions of the country, however this potential is yet to be properly exploited.

4.2. Solar energy

Cameroon has good potential for solar energy exploitation. In National average, the solar radiation received in the country along the Year is 4.2824 $kWh.m^{-2}.d^{-1}$. This allows us to estimate the solar potential of Cameroon to $7.431x10^{8}$GWh per year, representing 128,988 times the total electric production of Cameroon estimated in 2014 at 5.761 billion kWh [22]. Solar power is currently used in distributed generation systems, particularly for powering the cellular telecommunications network.

4.3. Wind energy

Most of the country has insufficient wind speed for power production with an average of 2-4 m/s at the height of 100 meter. According to available study, wind energy potential exists in the northern, western and the littoral regions. Northern areas have average wind speed of 5-7 m/s. The department of Bamboutos (Western region) registers wind speeds of 6.65 m/s and would have the capacity to host three wind fields with a total cumulative installed capacity of 14 MW [25].

4.4. Biomass energy

Cameroon has the second largest biomass potential in sub-Saharan Africa, with 21 million hectares of forest covering three-quarters of its territory [37]. However, the unsustainable use of this resource has led to significant

deforestation throughout the country, with an annual clearance rate of 100,000 hectares/year and regeneration of only 3,000 hectares/year [14, 25]. The primary use of biomass residues in the country includes heating and lighting for the majority of the rural populations. Cameroon's potential to produce electricity from biomass residues is enormous and estimated at 1,200 GWh [38]. There is also a big potential to produce biofuel.

4.5. Geothermal energy

Cameroon's potential is unknown but hot springs are found in extensive areas: Ngaoundéré region (Laopanga sources, katipFoulbé, Voludé and Bazao), Mount Cameroon region and Manengoumba area with Lake Monoun [12, 25].

5. Barriers to renewables' development in Cameroon

There are significant barriers to the further implementation of renewable energies that need to be addressed. They include:

5.1. Institutional and administrative barriers

In Cameroon, the institutional framework [12] of the energy sector is made up of a multiplicity of institutional actors, which leads to conflicts of jurisdiction and intervention. This plethora is one of the main barriers; the lack of coordination body, the lack of clear responsibilities, the lack of coherence in the actions, complicated, slow or non-transparent procedures constitute impediments [36, 39]. In reality, this situation is due to non-respect of official texts governing institutions. In the energy sector, the ministry in charge of energy ensures technical supervision and as such, it should be the coordinator of all energy projects. In their operation, this provision is not always applied, each actor works in an isolated fashion without any global vision. Also, there is no research program promoting renewable energies, no official renewables policy [40, 41]. The 2011 Law governing the electricity sector [30] gives a little attribution to renewable energy but with a lot of insufficiency. Until now, the implementation texts are still awaited.

5.2. Corruption and administrative bottlenecks

It also exists in the country a plethora of administrations fighting against these evils, but with mixed outcomes. Indeed, one of the greatest impediments to doing business (in general) and to renewables' development (especially) in Cameroon is the corruption, which is at **all levels** [39] of the civil and public service. Cameroon has regularly been cited among the most corrupt countries in the world. Accusations of corruption were frequent in the past and are still common [42-44]. In 2015 Corruption Perceptions Index, Cameroon is ranked 130 out of 168 countries on the list of corrupt Countries [44]. A detail look at the reports on Cameroon is very telling about the individual reports that add up to give the general ranking. Concerning the business environment, the situation of the country is not either encouraging. In Doing Business 2016 Report, Cameroon is ranked 172 out of 189 economies [45]. In addition to corruption, bureaucracy and administrative red tape are also identified as significant barriers.

In 1990, Cameroon was one of the first African countries to enact an investment code confirming basic guarantees to investors such as free repatriation of capital and property ownership and providing various incentives such as tax reductions. However, this act was only good on paper: few years later, the tax regime changed superseding the tax advantages of the investment code. Also, corruption, high bureaucracy and the arbitrary application of the code provisions often revoked the benefits of the investment law. This resulted in Cameroon ranking amongst the bottom 25 countries when it comes to ease of doing business and even bottom 10 in relation to paying taxes in a World Bank's survey [46].

In order to attract foreign investors, revamping the 1990 investment code had become a priority for State and so the new Cameroonian investment code became law in 2013. This new law is very attractive and different to most African investment codes. Firstly, there is no discrimination between local and foreign investors. Secondly, no minimum investment is required. Thirdly, there are numerous incentives [47]. Once more, corruption and big bureaucracy have hindered the implementation of this law. For example, the process to qualify for the various benefits of the investment law still requires three different approvals: the one-stop shop body, the Minister of Finance and the Minister of private investment. Also, during the operation phase, the benefits are not automatic; all import and local purchase requests must obtain the visa of the body in charge of incentives promotion first. Finally, the new law provides for the setting-up of two other authorities: the Control Committee and a Joint Monitoring Committee [46].

5.3. Financial barriers

Presently, there are no fiscal measures specifically designed to foster the uptake of modern renewable technologies. Consequently, private enterprises interested in investing in the distribution of lighting products and other technologies will not benefit from subsidies, which create a substantial obstacle for large scale investment.

In order to promote private investment in general, Cameroon's investment code offers a set of fiscal and tax incentives to investors. They include the following [13]:

- Exemption of all taxes during a period of 10 years (followed by a 15 % tax on profits starting on the 11th year but exempted for life from all other taxes);
- Life-long exemption of all imports and exports from all duty and other taxes;
- Right to open accounts in foreign currency in the local banking system;
- Right to transfer abroad any profits made on capital investments.

Conditions of eligibility include social and economic development, creation of employment, and an investment of 500 million FCFA for small or medium sized companies or 5 billion FCFA for large corporations during a five year investment period. The investments must also be made in

priority sectors, such as the energy sector, which includes renewable technologies. But due to bureaucracy and corruption, these provisions are by no means applied, which contributes to discourage potential investors.

On the other hand, despite a comparably better economic case, obtaining financing for renewable energy technologies is currently more difficult than for fossil-fuel. In part, this is due to the relative lack of knowledge of RETs and a lack of project experience [5, 6]. Because of this, banks are often either reluctant to finance projects, or agree to finance but at premium rates. And while renewable energy projects are often cheaper in levelised terms, they tend to have higher up-front capital costs, requiring more specific financing schemes.

5.4. Technological barriers

Apart from a few small private structures producing the improved cook-stoves with local materials, it almost does not exist currently in Cameroon, renewable technology manufacturing industries. This issue needs to be addressed.

5.5. Technical barriers

Cameroon equally faces insufficient awareness on the environmental benefits of renewable energy as well as the inadequate skilled personnel and number of trained renewable energy experts which considerably stands as a barrier. An analysis of the energy situation in Cameroon focusing on the development of local expertise in renewable energies, revealed that of 29,206 graduates identified (degrees and engineers combined) during the 2007/2008 academic year, only 5,440 graduates (18.6%) may develop technical expertise including renewables [12]. This percentage is even more insignificant when compared to Cameroon total population to understand that it is equivalent to 0.00029 graduates per million people. This fact reflects the very low intellectual capacity of Cameroon's energy policy to adapt to the conditions of a changing climate, the annual proportion of graduates that can significantly condition the mental structures of the Cameroonian society and contribute to a change of attitude and thinking of the population. However, some institutions and organizations carryout good appropriation experiences of technologies related to renewable energies. There are:

- The University of Dschang, precisely the Department of Agricultural Engineering of the Faculty of Agronomy and Agricultural Sciences (FASA);
- The University of Ngaoundéré through its two high schools, the University Institute of Technology (IUT) and the National Advance School of Agro-Industries (ENSAI);
- The National Advance School of Polytechnic (ENSP) of Yaoundé with its energy Laboratory and four series/branches: Drying, Decentralized energy production, Energy audits, Heat the building;
- Higher Institute of Sahel (ISS) through its branch "Renewable Energy" in its training program;
- Energy Research Laboratory (LRE);
- Civil Society Organizations.

At the lowest level of education, there is no unfortunately any training program concerning renewable energies and its socio-economic and environmental benefits. Policy makers have therefore an essential role to play in addressing all these challenges. This would boost the economy by developing an enabling environment for all those interested in renewable energies.

6. Overcoming the Barriers

6.1. Institutional and administrative barriers

The Cameroonian authorities must absolutely reduce the plethora of administrations in charge of energy. Secondly, they must clarify the role and responsibility of each actor and designate a coordination structure. They must also organize and structure the renewable energy sub-sector by taking appropriate legislation, but especially by ensuring their implementation. Pro-active and long-term policy-oriented renewable energy programs aimed at senior decision-makers in both Government and the private sector should be initiated. The policy programs should be designed to demonstrate the economic and environmental benefits of renewables technologies. Priority should be given to highlighting the real and tangible economic benefits (such as job creation and income generation) that renewable energy programs can deliver to the country at both the micro and macro levels.

6.2. Corruption and administrative bottlenecks

The authorities must **systematically** and **vigorously** fight against these scourges in all its forms and at every scale. Such cleaning should start with the judiciary corps that is not free from reproaches although in charge of this sector. Because they proved to be ineffective, decision makers must reduce the plethora of administrations fighting against corruption. This plethora is problematic since instead of reducing the phenomenon, it is rather amplified and unfortunately still goes better than before the creation of these institutions. Must therefore be strengthened with material, financial and human resources the capacity of the judiciary corps normally in charge of regulating the behaviors in the society.

6.3. Financial barriers

To overcome this barrier, priority should be given to the establishment of innovative and sustainable financing programs for RETs. This may range from the creation of a National Fund for renewable energy projects financed by a modest tax on fossil fuels (e.g. carbon tax) to credit schemes specifically aimed at developing renewable energy industries and endowment funding of renewable energy agencies. The Rural Energy Fund already created can also enable the private sector and cooperatives to benefit from its financing in rural areas.

In order to increase access to loans, banks should find alternatives to stringent requirements e.g. the collateral requirements. But since bank policy is unlikely to change in the near future, one possibility is to encourage potential consumers to form self-help groups or cooperatives so that

they can acquire loans through cooperative banks, most of which do not have stringent collateral requirements. In addition, small credit institutions such as micro-finance institutions could provide financing for RETs investors and users at affordable and accessible terms. Small-credit institutions are crucial in ensuring continuity when external support ceases. Many have a nationwide network in place and are able to provide service even to remote rural areas.

Another untapped financing source by Cameroon is funding in favor of the environment set up by the United Nations through the Kyoto Protocol, namely the Clean Development Mechanism (CDM). Indeed, the CDM presents a useful financing opportunity for Cameroon. This mechanism allows industrialized countries to meet part of their commitment to reduce emissions by investing in projects of developing countries that reduce Green House Gas (GHG) emissions. The rationale is that emissions reduction is less costly in developing countries. The CDM could solve the financing barrier of RETs in Cameroon in several ways. Mainly, one of the basic requirements of the CDM is that the projects that industrialized countries invest in should meet the host country's development priorities. The range of technologies being considered under the CDM project is wide, and includes renewable energy technologies.

For the implementation of the CDM, Cameroon has ratified the United Nations Framework Convention on Climate Change in October 1994 and the Kyoto Protocol in July 2002. Moreover, Cameroon has created a designated national authority for CDM in 2006 while the Ministry of Environment and Nature Protection established a national committee for the implementation of CDM projects [19]. Until now, only HYSACAM, the national company in charge of collection, transportation and treatment of municipal solid wastes has benefited from this funding source.

6.4. Technological barriers

Technological mastery is one of prerequisite for the development of renewable energies. For technologies that can be manufactured locally, the State should establish or facilitate the establishment of companies for local manufacture. Mechanical and thermal technologies such as wind pumps, small hydro and improved cook-stoves can thus be built on local knowledge and skills. Consequently, maintenance is a less of problem, which results in greater and more sustainable dissemination. This leads to employment opportunities and local enterprises creation. With increased financial support at national and international levels for such technologies, it may be possible for Cameroon to become a significant player in the global renewable energy industry. For instance, with the exception of solar PV technologies, over 60% of the components required in many RETs can be produced locally.

Experience has shown that most RETs (especially those that can be locally manufactured) require subsidies only in the initial stages, and can become financially sustainable in the short to medium term after a certain level of technology dissemination has been attained [48]. After attaining this stage, the renewables industry can become self-sustaining and subsidies can be gradually withdrawn without any adverse effects on continued dissemination of RETs.

For technologies that cannot be manufactured locally, the authorities should undertake negotiations with developed countries for technology transfer in order to build at the local level the manufacturing industries. But since this cannot be done in the short or medium term, other solutions can be considered. In Europe for example, many countries have adopted different approaches such as feed in tariff, certificates and fixed tariff. In order to overcome the initial high capital cost, the allocation funding is required. It could be done through government bodies, private institutions sustained by government or simply through dedicated funds (budgetary allocation, subsidies, incentives, etc.). The process should be stopped as soon as the renewable technologies become competitive and are driven by market forces alone. Finally, awareness-raising and education of key stakeholders is fundamental to creating an enabling environment for rapid and modern technologies market development.

6.5. Technical barriers

The choice of RETs for dissemination and development in Cameroon should take into account the existing technical knowledge and local workforce. Trained manpower capable of designing, developing, manufacturing, installing and maintaining renewable energy systems is a prerequisite for their successful deployment. Technical knowledge is important in order to build over the long term, a critical mass of professional policy analysts, economic managers and engineers who will be able to manage all aspects of the RETs development process and to ensure effective utilization of already trained analysts and managers [49].

Long-term renewable energy training programs designed to develop a critical mass of locally trained manpower with the requisite technical, economic and socio-cultural skills are urgently needed. These programs should imply all the education system (from the lowest to higher level) and even the whole society through the communication media. At the higher level, many of the engineering and technical courses that are currently taught provide little exposure to renewable energy technologies. Modest changes in curricula could significantly increase the supply of skilled engineers, policy analysts and technicians in renewable energies. Finally, in order to increase the training offer, the creation of other training schools specifically dedicated to renewable energies and energy efficiency is needed.

7. Conclusion and Policy Implications

This study analyzes the general environment of renewable energies in Cameroun and the possibilities of their full deployment. It presents the available resources, examines the constraints limiting their exploitation and proposes some ways to overcome them. We found that Cameroon owns an important renewable potential which is still suffering from poor development. The main cause is the poor commitment and dedication of decision makers who have not taken the necessary measures. Because of this, the renewables' sub-sector lacks a legal and institutional framework. It is also

characterized by a weak distribution network and poor structuring. Several institutional actors are involved in the energy field without any coordination structure. Other more important constraints are financial, technological, technical and behavioral (especially corruption and high bureaucracy). All these constraints are closely linked; they need to be addressed absolutely if Cameroon wants to embark on the path of clean and sustainable growth. Nowadays, renewable energies have become ordinary energies around the world. Their modularity and complementarity make them an important development tool and Cameroon has every interest in taking advantage of its potential. With small decentralized systems, renewable energies are likely to solve the current energy crisis in a sustainable way and especially at lower cost compared to classical solutions. Decision makers have therefore the responsibility to undertake the necessary reforms and appropriate measures in order to improve the sector and enable the private to significantly contribute.

The government has made 2035 as a target of becoming an emerging country. Apart from energy, the country is faced with other challenges such as infrastructures, education, communications, health, water, transportation and so on. Of all these challenges, that of energy is the most pressing because energy is in the heart of all development process. It will help to address all others. In order to reach its goal, the government must undertake deep transformations in the concerned sectors. Such unprecedented transformations will not happen all by itself. It can only be made possible by a concerted effort and close cooperation of all stakeholders including decision makers, universities, NGOs, professionals, providers of RETs and banks that will be providing loans. Once more, government intervention to level the playing field is therefore needed to start this process. If all this is done, the lives of all will be profoundly improved, the overall society will be transformed for the better, Cameroon will certainly become an energy 'Hub' of the sub-region and ultimately, an emerging economy.

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References

[1] Twidell John and Weir Tony, 2006. Renewable energy resources. 2nded.. Taylor & Francis.
[2] IRENA, 2013. Africa's Renewable Future: The Path to Sustainable Growth. International Renewable Energy Agency, United Arab Emirates; 2013.
[3] Lighting Africa. The True Cost of Kerosene in Rural Africa. International Finance Corporation/World Bank, Washington, DC, 2012b.
[4] IIASA. Global energy assessment, deliverable: summary report access to modern energy forms and technologies for developing and emerging regions, IIASA; September 2011.
[5] David Newbery, 2018. Evaluating the case for supporting renewable electricity, Energy Policy 120 (2018) 684–696.
[6] Global Network on Energy for Sustainable Development. Renewable energy technologies and poverty alleviation: overcoming barriers and unlocking potentials; 2007.
[7] REN21. 2016. Renewables 2016 Global Status Report (Paris: REN21 Secretariat).
[8] SE4ALL, 2012. "A Global Action Agenda: Pathways for Concerted Action towards Sustainable Energy for All", The Secretary-General's High-Level Group on Sustainable Energy for All, United Nations, New York.
[9] IRENA, 2014. REmap 2030: A Renewable Energy Roadmap, June 2014. IRENA, Abu Dhabi. Available at: www.irena.org/remap. [accessed on 02/07/2016].
[10] UNGA, 2012. "Decade of Sustainability for All 2014-2024". United Nations General Assembly, GA/11333 EN/274, United Nations, New York, 2012. Available at: www.un.org/News/Press/docs/2012/ga11333.doc.htm. [accessed on 15/09/2016].
[11] WEO, 2015. Chapter 2 Extract: Energy Access, World Energy Outlook, 2015.
[12] SIE-Cameroun. Système d'Information Energétique du Cameroun. Rapport; 2010.
[13] Lighting Africa. Lighting Africa Policy Report Note – Cameroon. IFC and WB; 2012a.
[14] Nkutchet M., 2004. L'Energie au Cameroun. Edition l'Harmattan, 2004.
[15] GIEC-IPCC, 2007. Changements climatiques 2007: Rapport de synthèse; 2007.
[16] Tamo T.T., Kemajou A., Diboma B.S., 2010. Electricity self-generation costs for industrial companies in Cameroon. Energies 2010;3:1353–68.
[17] Africa-EU Energy Partnership. Country Power Market Brief: Cameroon. Workshop Report, Yaounde; December 2013.
[18] Eisentraut Anselm. Sustainable production of second-generation biofuels: potential and perspectives in major economies and developing countries. International Energy Agency; February 2010.
[19] Ngnikam Emmanuel, 2009. Renewable Energies in West Africa: Cameroon country chapter. gtz regional report.
[20] WHO, 2006. Fuel for life, household energy and health. Geneva: World Health Organization (WHO); 2006.
[21] WHO, 2011. Indoor Air Pollution: Multiple Links between Household Energy and the MDGs. 2011.
[22] E. Mboumboue and D. Njomo, 2016. Potential contribution of renewables to the improvement of living conditions of poor rural households in developing countries: Cameroon's case study. RenewSustainEnergyRev2016; 61: 266–279.
[23] Njomo et Nkue, 2009. Analyse du système énergétique camerounais dans une Perspective de développement soutenable. Revue de l'Energie, vol. 588; 2009. p.102–16.
[24] MINEE. Long-term Development Plan of the Electricity Sector; 2006.
[25] Ministère des Mines, de l'Eau et de l'Energie, Plan Energétique National, Janvier 1990.
[26] MINEE. Plan d'Action National Energie pour la Réduction de la Pauvreté. Yaoundé; 2005.
[27] République du Cameroun, 2006. Assistance au Ministère de l'Energie et de l'Eau dans l'élaboration du

Plan de Développement à long terme du Secteur de l'Électricité Horizon 2030 (PDSE 2030). Rapport Final. Volume 1: Présentation et conclusions du PDSE, Juillet 2006.
[28] Loi N° 20 du 26 Novembre 1983 portant régime de l'électricité; 1983.
[29] Loi N° 98/022 du 24 décembre 1998 régissant le secteur de l'électricité; 1998.
[30] Law N° 2011/022 of December 14, 2011 governing the electricity sector in Cameroon; 2011.
[31] Asan VernyuyWirba, et al., 2015. Renewable energy potentials in Cameroon: prospects and challenges. Renew Energy 2015; 76:560–5.
[32] REN21. 2014. Renewables 2014 Global Status Report (Paris: REN21 Secretariat).
[33] Pierre-Olivier Pineau, 2004. Transparency in the Dark – An Assessment of the Cameroonian Electricity Sector Reform. August 12, 2004.
[34] Commission économique des Nations Unies pour l'Afrique. «Profil de pays-Cameroun», Mars 2015.
[35] Yasmine Bahri-Domon, 2014. Business in Cameroon. November 2014.
[36] GVC, 2012. État des lieux du cadre réglementaire du secteur des énergies renouvelables au Cameroun. Global Village Cameroon, Rapport d'analyse, 2012.
[37] MINFOF et FAO, 2005. Evaluation des ressources forestières du Cameroun; 2005.
[38] Tchouate H. P., 2003. Contribution des énergies renouvelables au développement durable du secteur électrique: le cas du Cameroun. Thèse de Doctorat, Université Catholique de Louvain, Décembre 2003.
[39] British High Commission Yaoundé. The power and energy sector in Cameroon, [Undated]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/237129/Cameroon_Doing_Business_Guides_Pt.1.pdf. [Accessed on 14/09/2016]
[40] Maximilian Engelken, et al., 2016. Comparing drivers, barriers, and opportunities of business models for renewable energies: a review. Renew Sustain Energy Rev 2016;60:795–809.
[41] Abanda F.H., 2012. Renewable energy sources in Cameroon: potentials, benefits and enabling environment. Renew Sustain Energy Rev 2012; 16:4557–62.
[42] Transparency International 2003. Transparency International Corruption Perceptions Index 2003. Transparency International Secretariat, Berlin, 2003.
[43] Transparency International 2004. Global Corruption Report 2004. Transparency International, Pluto Press, London-Sterling, VA 2004.
[44] Transparency International 2016. Corruption Perceptions Index 2015. Transparency International, 2016.
[45] World Bank Group. Doing Business 2016: Measuring Regulatory Quality and Efficiency. The World Bank Group Flagship Report. 13th edition, Washington-DC, 2016.
[46] Camille Astier and Alex BebeEpale, 2013. The new Cameroonian investment code. Hogan Lovells International LLP, May 2013.
[47] Law N° 2013/004 of 18 April 2013 to lay down private investment incentives in the Republic of Cameroon; 2013.
[48] Stephen Karekezi and WaeniKithyoma. Renewable Energy in Africa: Prospects and Limits. Workshop for African Energy Experts on Operationalizing the NEPAD Energy Initiative, AFREPREN, Dakar-Senegal, 2-4 June, 2003.
[49] World Bank, 1996. Rural Energy and Development-Improving Energy Supplies for Two Billion People, World Bank, Washington DC, 1996.
[50] *https://www.spm.gov.cm/* [Accessed on 10/04/2020].