Global Scientific JOURNALS

GSJ: Volume 8, Issue 4, April 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

DEVELOPMENT OF A RENEWABLE ENERGY MAP OF THE SOUTH WEST REGION OF CAMEROON: IMPLICATIONS FOR THE RURAL ELECTRIFICATION OF VILLAGES OF THE REGION

Fuhneh Lewis

ABSTRACT

Cameroon known as Africa in miniature is endowed with huge renewable energy potentials, with the South West Region inclusive. The entire country has a hydropower potential of about 55,200MW, second only to the Democratic Republic of Congo in Africa. So far, its energy needs are met by 4.8% hydropower, no wind and solar. This energy capacity is insufficient to cover the entire country, the situation is even more deteriorating when narrowed down to the south west region, as a cross section of the region most especially rural areas have no access to electricity and even when they do, it is always accompanied with frequent power cuts. This power shortage worsens during the heart of the dry season when water level reduces, but alternatively, other sources of energy like solar power, wind and even Biomass are at their peak during this season and could conveniently supplement or completely substitute the hydro plant during such a period. Secondly, localities which are not connected to the grid can find solace in the implementation of this other sources of renewables. In order to assess and quantify these renewable resources, models where designed for the different resources for some locations (14 localities) which were carefully chosen making sure all the six divisions of the region were represented. To obtain meteorological data for the locations and further analyze them, the Homer Pro software tool, RETscreen Expert software and LabVIEW tool were used. By doing this, the dominant renewable resources for the south west region were identified and a renewable energy map drawn. Results show that, only three localities have a little wind potential and Akwaya has the highest solar potential with irradiance of ≈5kWh/m^2/d while Buea the lowest with irradiance of 4.08kWh/m^2/d. Hydro potentials was also identified and quantified in some locations not leaving out Biomass potential. Financial and Emission (GHG) analyses were done as well. This thesis ended with a conclusion and some recommendations.

Keywords

Renewable, Energy, Map, Electrification, Villages, Region

1.0. INTRODUCTION

Cameroon has a tropical climate which is humid in the south and dry towards the north. The entire country has an average annual rainfall of about 4060mm, main annual hours of sunshine a year of over 3000hours and an average solar radiation intensity of 240W/m^2 [1]. Solar irradiance in the sunny part of Cameroon is estimated at 5.8kwh/day/m^2 and in the rest of the country, it is 4.9kwh/day/m^2[2].This statistics are from meteorological center of the country, but most part of Cameroon including the South West region have not been assessed deeply and so lack such data. However, in this work we will be developing a renewable energy map of the south west region of Cameroon: implications for the rural electrification of villages of the region.

Cameroon has ten region. Our research will be focused on one of these regions known as the South west region.

The South West region of Cameroon with a surface area of 25,410km^2 has a population of over 1,481,433[3] and its capital isBuea. It is one of the two English speaking regions of Cameroon. The region is divided into six divisions namely; Fako, KupeManenguba, Lebialem, Meme, Manyu and Ndian. These are in turn broken down into sub divisions. Some of the major towns in this region include; Buea, Limbe, Kumba, Tiko, Mamfe. The South West region is an important economic center, it consist of a petroleum refinery (SONARA), a sea port, a university, and various plantations for rubber, cocoa and banana. It is also a great center for touristic attractions as it carries one of Africa’s largest volcanoes – Mount Cameroon. It also harbors fine beaches and Korup national park.

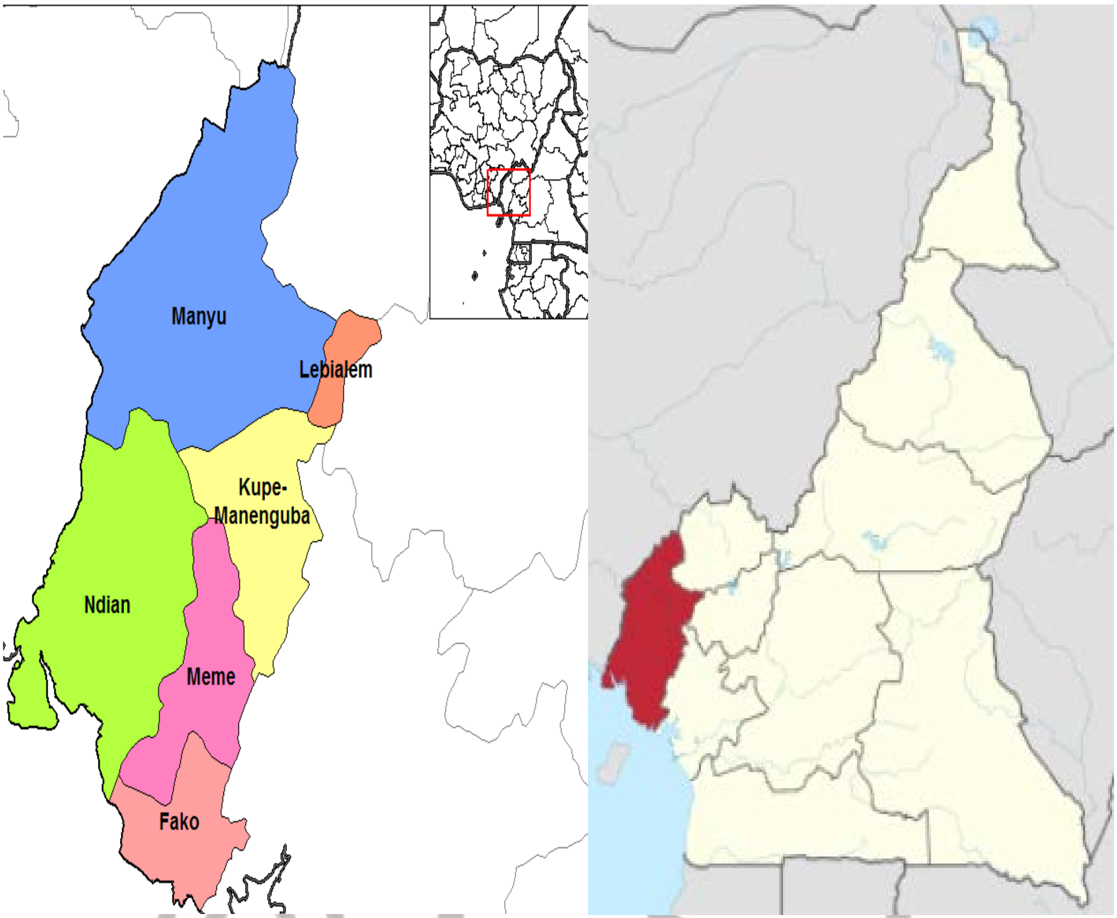


Figure 1 Map of south west region from that of Cameroon (Reproduced: Wikimedia commons)

1.1. State of Energy in Cameroon

Electrical energy in Cameroon is very important and plays a pivotal role in the economy of the country. Cameroon is following new policies to improve and develop its sources of energy which remains the main factor in achieving emergence in 2035. A rise in the global competition has led to the urge for expansion of her energy sector. The major energy sources of Cameroon include wood, hydro power and petroleum. The energy sector of Cameroon is presently undergoing a smooth and steady development that helps to attract foreign investors but frequent power outages remain a major threat. Out of over 14000 localities, just about 3000 are electrified. Giving a national electrification rate of 22% and in which just 3.5% of rural areas are electrified as well.

1.2. Problem statement

Cameroon has a total installed electricity production capacity of 935MW, but the country is only able at present to produce 450MW [4]. Due to this small energy capacity, the country is unable to electrify all its localities. One of the reasons for which just 22% of the entire country is electrified. Out of which only 3.5% of rural areas have access to electricity. Most parts of the South West region have no access to electricity and even when they do, the problem of frequent power outages is a key constrain. These don't only deprive the rural population from household energy facilities but also go a long way to deprive the region from industrialize activities or companies which would have been established but for the energy problem and that has a negative effect to the region's economy. Therefore there is a need to develop other sources of energy most especially renewables since greenhouse gases emission problems have contributed greatly to global warming. Also, due to energy related threats such as lack of sustainable secure and affordable energy supplies, environmental damage incurred in producing, transporting and consuming energy is one of the principal reasons for which renewable energy development is highly appreciated. The world has a population of over 6billion which increases with time and therefore causes a rise in fuel cost, climate change and a growing demand for more electrical energy. This therefore makes renewable energy an increasingly valuable solution for the world's energy problem at large and the south west region in particular. Though Cameroon has a vast renewable energy potential, the performance of the energy sector in Cameroon since 2001 has been a problem to our economy because of fluctuations and insufficient power generations. The sole dependence on hydroelectric power in the country as a whole has significantly contributed to her energy problems. Majority of people in Cameroon in general and the South West region in particular use biomass as their primary energysource due to a lack of accessibility to electricity. It is due to all the above reasons and more that in this research, we will be accessing the dominant renewable energy potential of the different localities of the South West region.After all understanding which renewable energy resource exist where, and to what extent, is critical to scaling up commercial development.

1.3 Aims and objectives of the research

The main objective of this piece of work is to assess the renewable energy potentials of the South West region such as wind, solar, hydro, bioenergy and even geothermal. It also tries to quantify these potentials.

The specific objectives of this study are as follows;

- ✓ To assess thoroughly the dominant renewable energy potential and the state of its development in the South West Region,
- ✓ Simulate Small scale solar, hydro and wind technologies for short and long term rural energy supply in the region,
- ✓ To analyze the economic and sustainable benefits in developing renewable energy in the region,
- ✓ To determine the environmental benefits that renewable energy will enforce over the amount of greenhouse gas emissions that will be avoided.

1.4Advantages of renewable energy

Renewable energy has the following advantages;

- ➢ They help to reduce negative health impact from airborne emissions and climate impacts since they have close to zero greenhouse gas emissions.
- ➢ They contribute to energy security

- They provide a more sustainable alternative to the use of finite sources of energy
- Renewable energy technologies are relative cheap though considered as higher cost technologies.
- Renewable energy can help our countries meet her sustainable development goals through provision of access to clean, secure, reliable and affordable energy.

1.5 Structure of the thesis

For us to successfully present findings as a means of providing adequate solutions for the aforementioned problems and in order to facilitate easy digestion of this piece of work, it is structured as follows;

. Chapter one, being an introductory chapter, it gives a vivid view of the country and the south west region in particular, the major problem of the research, the objective, and the advantages of renewable energy is also presented here.

Chapter two provides a review of related literature on solar, hydro, wind, biomass and geothermal energy.

Chapter three presents the methodology of the study and the software used for analyses.

Chapter four which is the major part of this research, introduces the locations chosen for the analyses. It contents the technical analysis where in analyses are done on renewable energy potentials of the chosen locations of the south west region. Simulations in attempt to quantify these energies are also done. This chapter ends with the results and discussion of each energy resource at every location and the renewable energy map of the south west region.

Chapter five explains the economic (cost) and benefits of renewable sources especially to the rural communities. And finally chapter six is the conclusion and recommendation.

2.0 LITERATURE REVIEW

2.1 Renewable energy

This is energy generated from natural resources such as sunlight, wind, rain, tides and geothermal heat which are naturally replenished [5]. statistics taken in 2006 shows that close to 18% of global energy consumption was from renewables, with 13% coming from traditional biomass such as wood burning meanwhile just 3% comes from hydroelectricity [6]. New renewables such as small hydro, modern biomass, wind, solar, geothermal and biofuels accounts for 2.4% and are growing very rapidly. In Cameroon over 78.6% of energy used is from Biomass, 4.8% hydro and 16.6% oil as seen in the chart below.

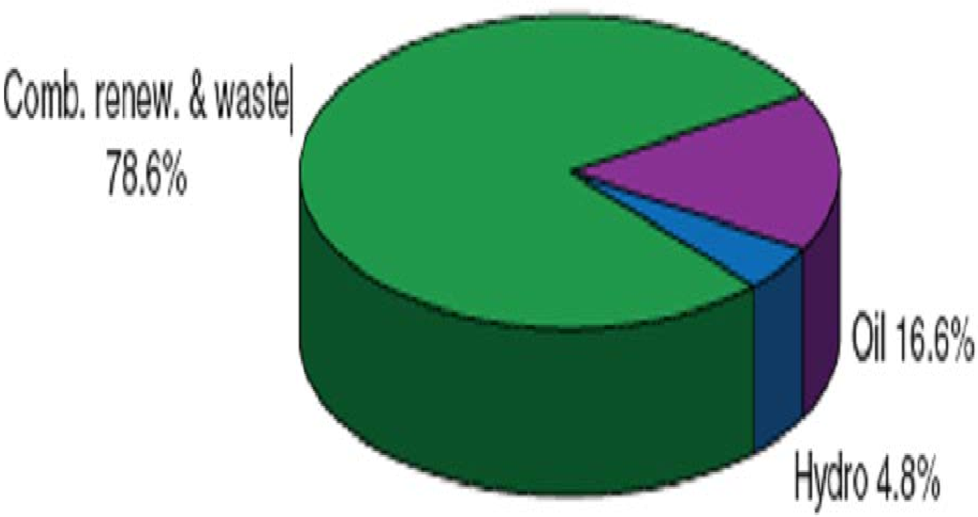


Figure 2 Share of Total Primary Energy Supply in Cameroon 2009[1]

Abanda reported that very little research has been done to evaluate the potential of renewable energy in Cameroon as a whole. Literature on different types of renewables, their benefits and potentials is therefore very limited resulting to an information gap for researchers, potential investors and policy makers.

2.2 Overview of renewable energy in Cameroon

Renewable energy resources are diverse and vary from country to country. In Cameroon in general and the South West region in particular, the known renewable energy resources are solar, wind hydro, biomass and geothermal.

2.2.1 Solar Energy

It is worth noting that less than 1billion of the sun's energy is received on earth. In spite this huge potential, solar energy provides only a tiny proportion of the world's energy need. Cameroon being Africa in miniature is endowed with vast solar energy potential with about 900 trillion KWH of solar energy reaching the land area per annum. Solar energy is very clean and abundant in supply hence, there's no doubt it will play a role in contributing to the future energy need of the South West region. In most sunny parts of the country like the North, the average solar radiance is estimated at 5.8KWH/day/m^2 meanwhile it is 4.9KWH/day/m^2 in the rest of the country with the Littoral region (Douala) recording the least while Garoua has the maximum followed by Maroua [2].

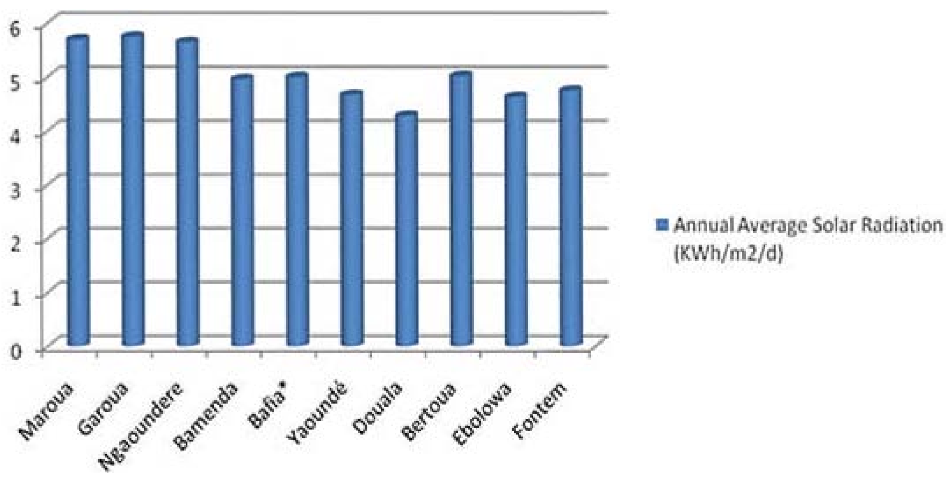


Figure 3 Average annual solar radiation for locations used [2]

Solar energy is at present already making substantial contributions to the nation's energy supply though unquantified with its traditional application being through sun drying of agricultural produce, fish, wood and cloth. There exist different types of technologies used to tap energy from the sun some of which include;

Solar photovoltaic, Solar thermal electricity, Solar heating, artificial photosynthesis and solar architecture. The development of affordable, inexhaustible and clean solar energy technologies has a huge and long term benefits. It will go a long way to increase the country's energy security since it is inexhaustible and an independent resource enhancing sustainability, reducing pollution, bringing down the cost of mitigating climate change and keeping fossil fuel prices lower than otherwise [7]. The nation Cameroon offers an ideal condition for exploiting the solar energy resource through any of the above technologies.

2.2.1.1 PV system energy requirements

We shall look at the crystalline silicon, thin-film and other system component modules.

a. Crystalline silicon module:

Energy conversion is about 13% for multi crystalline silicon and around 14% for mono crystalline silicon modules [8].

b. Thin-film module:

These models are made by depositing a thin (0.5-10UM) layer of semiconductor material on a substrate (usually a glass plate) [8].

As earlier mentioned, Cameroon has a huge solar potential but the cost of solar panels remain a major hindrance. Though the solar panel prices have significantly been reduced over the years, the cost still remains high especially for most rural inhabitants who are basically peasant farmers. This problem can be solved if only the government or other non-governmental organizations could help make available the solar technology systems in the rural areas. Some governments of a few developing countries however have supported the solar technology programs so as to meet up with the energy needs of their rural poor.

2.2.1.2**Solar thermal**

Sun's infrared rays are concentrated through reflecting mirrors on a heating fluid (normally liquid salt) medium, which in turn generates steam to propel turbines.

2.2.2 Wind Energy

Wind energy though being an important renewable source has never been studied thoroughly in Cameroon most especially in the South West region. However, a few attempts have been made using wind speed data published by the Cameroonian meteorological services. These assessments could not give a concrete conclusion as to the possibility of wind energy exploitation in the northern regions but none the less, these results reveal that the far northern regions of Cameroon are favorable for the use of wind energy [9]. Meteorological data from NASA confirms that the Northern regions of Cameroon have an annual wind speed that are equal to or more than 3m/s for over 80% of the time, and the Adamawa region has annual wind speed that are equal to or exceed 2m/s for over 60% of the time, while the rest of the country greater than or equal to 1m/s for over 50% of the time. Some favorable sites have however been identified in the North and some few coastal regions in the country. So far few multi-blade wind power pumping stations are found in the Northern part of Cameroon [2], this findings agrees with that of Nchinda [9]which gives us a 95% assurance of its potency.Tansi, 2011 had the following results for wind potentials in Cameroon;

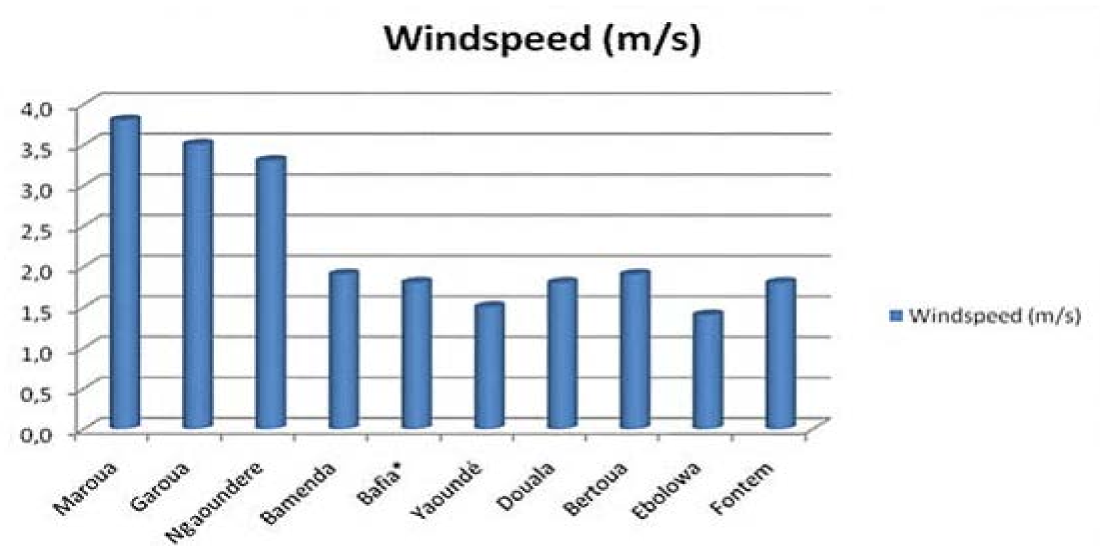


Figure 4 Graph of Average Annual wind speeds for various locations used [2]

Though research has been done in some of the localities in Cameroon especially in the North, little or no research has been done yet on the available wind potential of the South West region of Cameroon.

3.0 METHODOLOGY

3.1. Introduction

Methodology, in a broad perspective, refers to the process, principles and procedures, by which we approach problems and seek answers [13]. Methodology comprises data collection, organization and interpretation [14]it applies to how research is being conducted. The methodology employed in this research is mainly through literature reviews, the use of the RETScreen, homer and lab view software tools for analysis not leaving out field surveys with visits undertaken to a few places.

For the realization of this research work, information and necessary literature was gotten from textbooks, international scientific journals, internet websites, and reports by governmental agencies and NGO's). Substantial knowledge was gathered from field work as well and a review of what other scientists have written on issues concurring with the research topic was made.

It is evident that our assumptions, interest and goals will influence methodological choices [13], and thereby the results. It is extremely important to present how the different studies have been conducted.

Njomo [15] measured solar Irradiation in ten meteorological stations in Cameroon between1982 and 1987. In another study Njomo and Wald [16] compared ground measurements for Yaoundé and Garoua against satellite derived solar irradiation using the Heliosat_2method.Their analysis showed that there was good agreement between the measured and satellite derived data for Garoua (with semi-arid surface and Uniformly dry atmosphere) while there was large variability in Yaoundé (forest type surface with a humid and persistently cloudy atmosphere).

It is therefore evident that data obtained from ground measurements in Cameroon is either non-existent or available for short intervals and unreliable because of maintenance issues with malfunctioning devices which were poorly attended. In such cases, calculating site-specific solar irradiance values using satellite derived data has become an accepted alternative.

3.2 Software

This research work is aimed at developing a model for assessing the practicality of using renewable resources for electricity production in the south west region of Cameroon. In order to achieve this, wind speed and solar irradiance data for major locations in the region from the NASA Langley Research Centre Atmospheric Science Data center and NRELwere used. This was to be estimated using complicated calculations involving assumptions and complex equations in understanding and constructing wind turbine generators, solar modules and even hydro power stations. This could cause errors and produce false results. In order to minimize the error margin and obtain a more precise resultant value which will be as close to the true value that would be obtained on the ground, it was important to employ standardized tools which are internationally accepted. Such tools should have access to a rich database, be able to provide detailed information on equipment suppliers and service providers around the globe and should be user friendly and flexible without compromising on the technical details. There exist many energy software such as Hybrid2, ViPOR, RET Finance, HOMER, and PV WATTS to name a few. To meet the objectives of this research, The RETScreen expert tool, Homer pro and Labviewsoftware were selected. Though HOMER, is muchmore technical and less user friendly than the RETScreen software tool it has a broader data base as it contents data from both NASA and NREL.

3.2.1RETScreen expert

RETScreen expert is a comprehensive **clean Energy management Software** platform which enables energy professionals and decision-makers to identify, assess and optimize the technical and financial viability of potential clean energy projects and cogeneration projects; and to measure and verify the actual and ongoing energy performance of buildings, factories and power plants around the world. The software is developed by the Government of Canada in collaboration with notable international partners and is used by over **525,000 people** in every country and territory of the world. RETScreen is also used as a teaching and research tool by well-over 900 universities and colleges worldwide, and is frequently cited in academic literature.

Before we had Retscreen 4 internationall which used to runs five-step standard analysis under Microsoft Excel, which provides a familiar interface (Figure 3-1). Behind Excel, RETScreen contains over 70,000 lines of code, making it powerful and flexible.

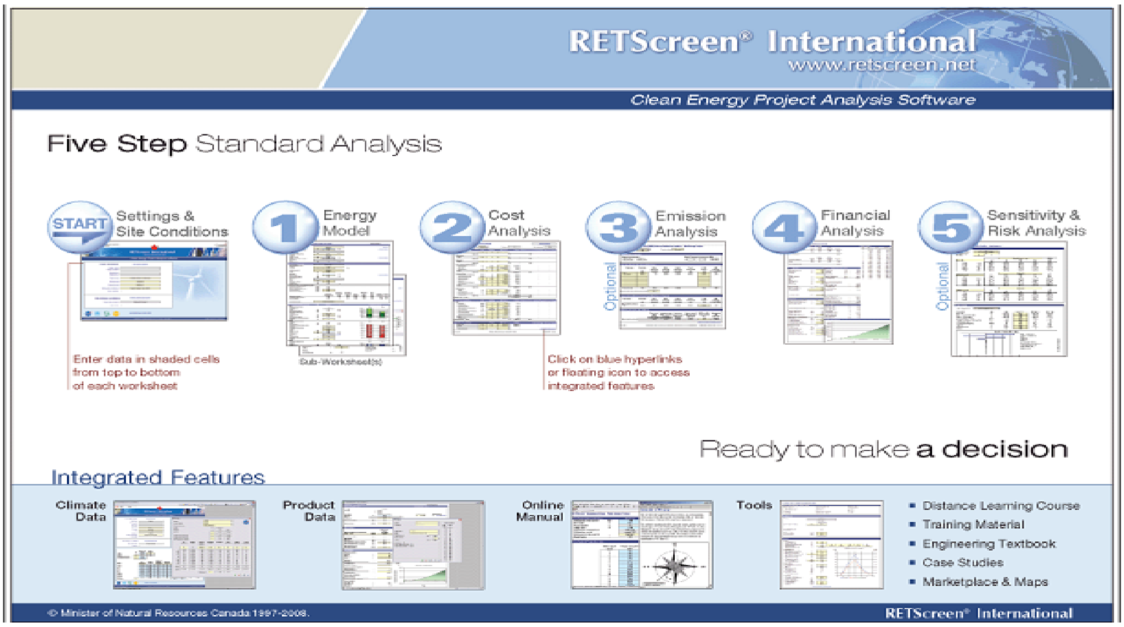


Figure 5: RETScreen's Five Step Analysis.

(Reproduced from: RETScreen, 2009)

But this version has been upgraded to **Retscreen expert** which now has its own in buit interface capable of running the same five steps analyses without the help of excel. These five steps fall under well designed captions (representing different types of analyses) created in the Retscreen start page in the form of a circle as seen below;

Figure 6: Reproduced from: RETscreen Expert

4.0. TECHNICAL ANALYSIS

4.1 Introduction

Cameroon and most especially the South West Region like most developing countries does nothave a reliable network of surface observation stations for collecting weather data. This has been a major drawback for accurate assessment of the energy generation potential.

However a comprehensive analysis of the renewable energy potential of the south west region for the following major sources of renewable energy has been done; solar, wind, hydro, and biomass. Because of time constraint, the unavailability of meteorological data for some parts of the region and the scope of a master thesis, our study may not exhaust all parts of the south west region and we may have some limitations on the analysis of some of the renewable energy sources. Meteorological data for the locations chosen in the south west region for this research were obtained through the RETScreen software from NASA, and National renewable energy laboratory through the Homer Pro software, meteorological centers and field work data collection.

The Homer Pro software was then used to evaluate the energy generated by PV systems with optimally inclined PV modules. Because meteorological data and information on some hydro and biomass sources were not readily available for some locations, a few places were visited in which generic data was taken and later analyzed. We also visited some waterfalls in other to assess its characteristics.

Table 1 : Locations chosen for the research

DIVISION	LOCATION/TOWN
FAKO	BUEA
	LIMBE
	TIKO
	MUYUKA
	IDENAU
KUPE MANENGUBA	NGUTI
LEBIALEM	FONTEM
	WABANE
MANYU	AKWAYA
	MAMFE
MEME	KUMBA
	KONYE
NDIAN	BAMUSSO
	MUNDEMBA

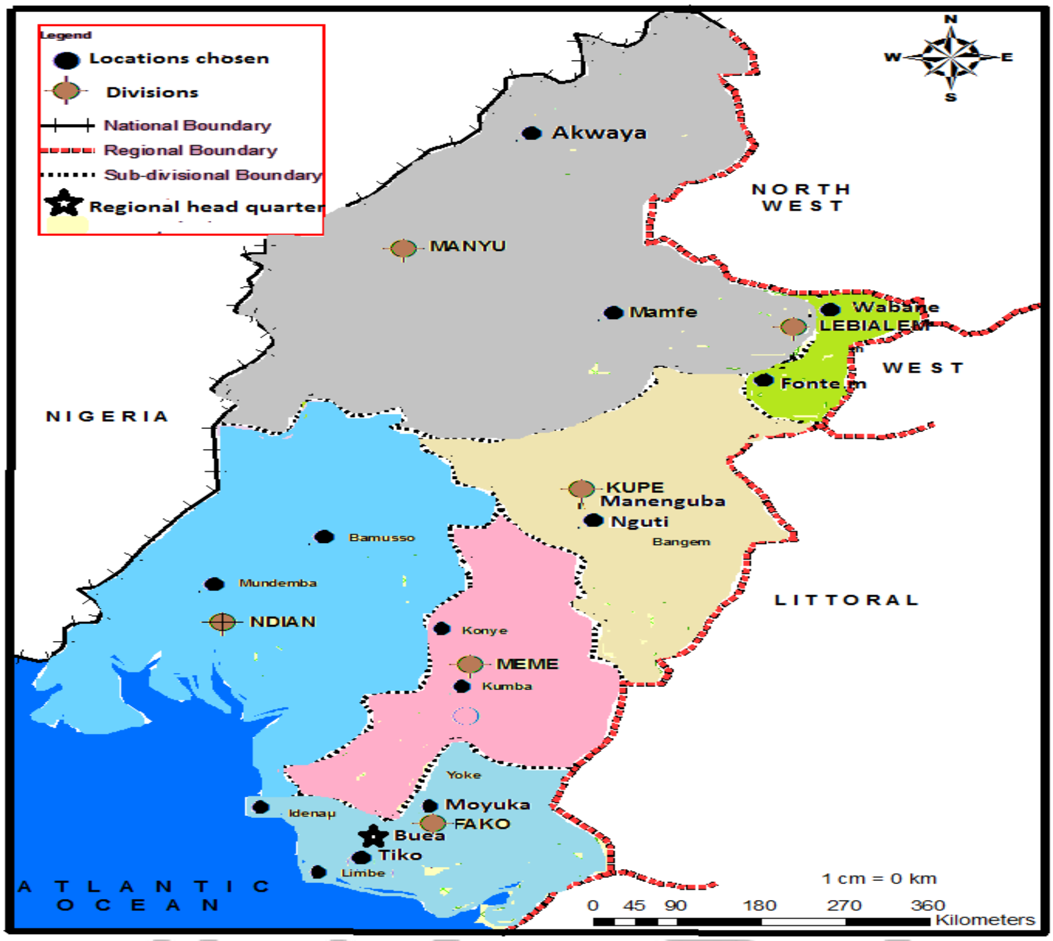


Figure 7: Map View of Locations of the south west region of Cameroon used for the analyses.

4.1.1. FAKO DIVISION

1. Buea

Buea is the Sub Divisional headquarter of Buea and the South West Regional head quarter of Cameroon. The Bueahas a surface area of 870.km^2, 67 villages, four distinct identified urban spaces as per outlined criteria (Buea station, Soppo, Molyko/Mile 17 and Muea). With an equatorial climate, temperatures are moderate with a slight seasonal variation (rainy and dry season). Buea is one of the fastest growing towns in Cameroon today with a mix cosmopolitan setting. Agriculture (plantations, small holders, local farmers) due to its rich volcanic soils. Plantations include CTE tea Farms, CDC banana as well as small holders' palms and tea farms. In effect it has an equatorial climate with 2 major seasons. Rainy season which runs from March to October and Dry season, from November to May). Temperature ranges between 20^{o}C to 28^o C while, annual rainfall ranges between 3000mm to 5000mm. However, average monthly High/Low Temperature for these urban spaces ranges from 23^o C low to 32^{o}C high. (CVUC-UCCC, 2014).

Solar and Wind data

Thedata gotten for solar is the irradiance measured in Kwh/m^2/d and for Wind, the wind speeds was gotten**.**

Monthly average solar irradiance (GHI) data for Buea

This data is collected from NASA and the National Renewable Energy Laboratory through the HOMER software tool.

Project location;

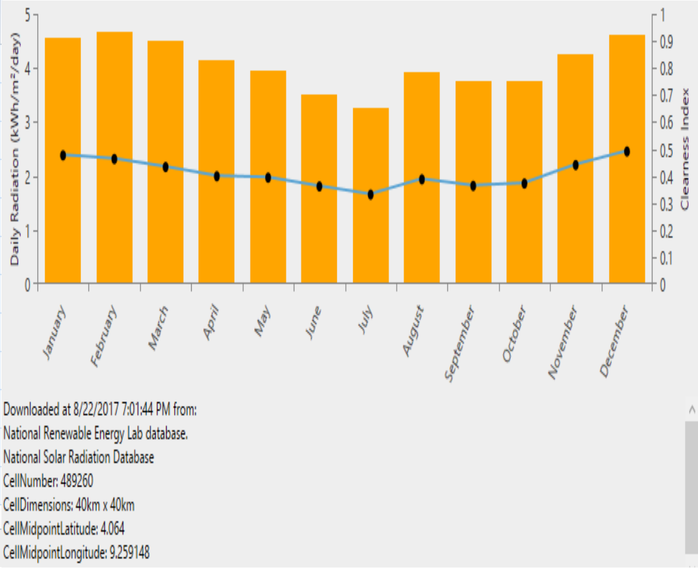
Latitude 4.06^o N

Longitude 9.25^o E

Table 2: Monthly average solar irradiance (GHI) data for Buea

Month	Clearness Index	Daily Radiation (kWh/m²/day)
January	0.476	4.571
February	0.463	4.664
March	0.433	4.516
April	0.399	4.134
May	0.393	3.937
June	0.361	3.515
July	0.331	3.250
August	0.387	3.932
September	0.363	3.756
October	0.372	3.766
November	0.440	4.259
December	0.490	4.613

Annual Average (kWh/m²/day): 4.08



- **Monthly average wind speed data for Buea**

This data is gotten from NASA surface meteorology and solar Energy database through Homer software tool, at a height of about 50m above the earth surface (anemometer height) and for a period of over ten years.

Table 3: Monthly average wind speed data for Buea

Month	Average (m/s)
January	2.470
February	2.580
March	2.220
April	1.860
May	1.850
June	2.330
July	2.680
August	2.820
September	2.560
October	1.960
November	1.840
December	1.970

Annual Average (m/s): 2.26

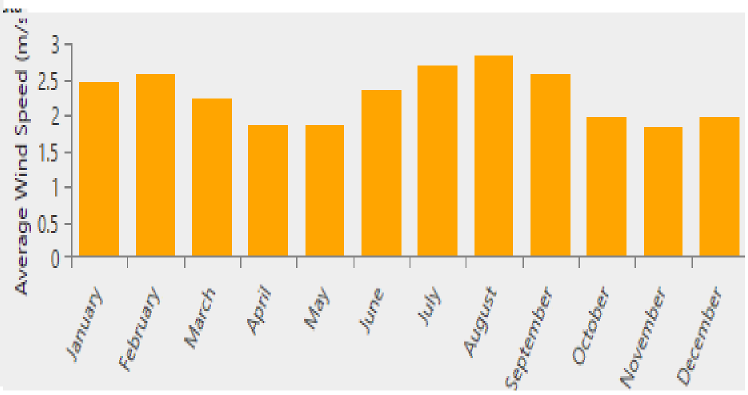
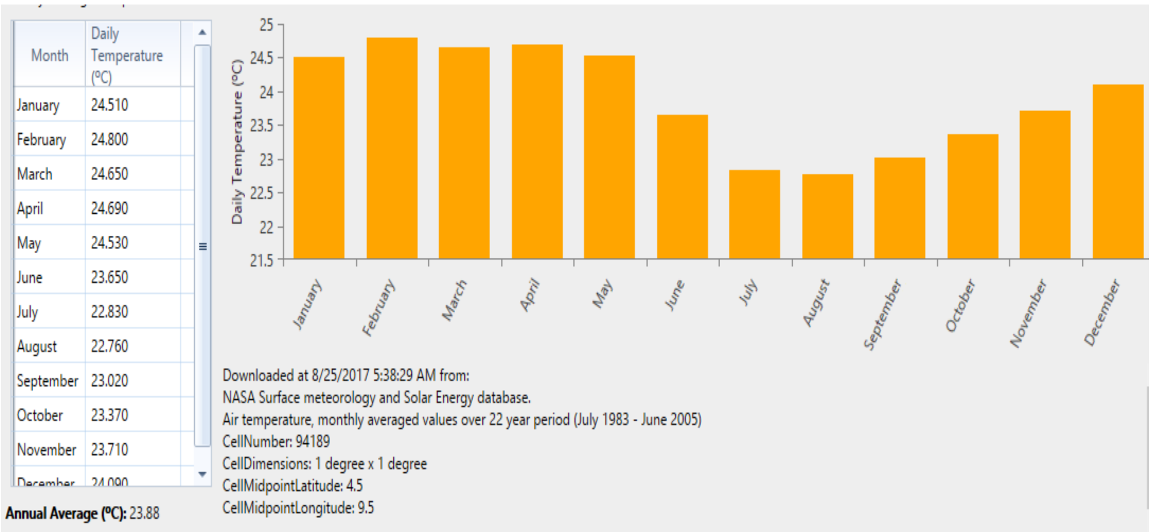


Table 4: Monthly average temperature data of Buea



Month	Daily Temperature (ºC)
January	24.510
February	24.800
March	24.650
April	24.690
May	24.530
June	23.650
July	22.830
August	22.760
September	23.020
October	23.370
November	23.710
December	24.090

Annual Average (ºC): 23.88

HOT 1 MOUNT CAMEROON- BUEA WIND DATA

In this research, a generic data for wind speed was also collected around hot 1(at 1015m above sea level) at the mountain area which is still in the Buea locality.

Wind speed around this area was taken at 4m height and had an average wind speed of 2.9m/s, and to have the equivalent wind speed at the required height of say 50m, we used the Power law equation as seen below;

$$\frac{V}{Vo} = \left(\frac{H}{Ho}\right)^{\alpha} \text{(Power law equation)}$$

Where;

V= the estimated wind speed at height H

V_0= the known wind speed at height Ho and α is the wind shear exponent which for our case we assumed 0.14.

We then had a wind speed of 4.13m/s (average wind speed for August)and after further extrapolations, we obtained an annual average speed at the said Hot 1 of 3.57m/s as seen below;

Table 4-5: Monthly average wind speed data.

Month	Average (m/s)
January	3.780
February	3.890
March	3.530
April	3.170
May	3.160
June	3.640
July	3.990
August	4.130
September	3.870
October	3.270
November	3.150
December	3.280

Annual Average (m/s): 3.57

2. **Idenau**

Idenau is the headquarters of the West Coast Sub division located in Fako Division of the South West Region of Cameroon. It is located some 29km from Limbe city. It is located between latitude 4.233333^{o} N and longitude 8.9833333^{o}E with an altitude of about 300m above sea level in the mainland area and 5m in the maritime area. Generally, Idenau is found on the North of Atlantic Ocean and the windward side of Mount Cameroon. It has altitudes of about 5m to 20m. Rainfall is unimodal and spreads from March to November with a temperature range of about 25-28˚C. The rainfall rises up to 4000 mm with its peak being in July, August and September. The peak of the dry season falls in December and January. Average annual temperature is 27°C. The mean annual relative humidity ranges between 80% and 95% (CDC weather records). It has a waterfall that we visited at Bibunde.

Hydro potential data

1. **Bibundefall**

Figure 8: Bibunde waterfall.

5.1 Cost analyses

In order to better present the potentials of the renewable energies of the south west region and attract energy investors, it is imperative that a good analysis be done as to how much is required to guarantee the complete installation, running and functioning of the wind, solar and even hydro power stations analyzed in this research. In this section, the costs presented were obtained from various sources. The cost for solar was obtained already calculated by the Homer pro software as seen below,

5.1.1. Solarcost

Table 5 net cost of the solar model for a location

Component	Capital	Replacement	O&M	Fuel	Salvage	Total
Generic flat plate PV	$312,783	$0.00	$13,328	$0.00	$0.00	$326,111
Generic 1kWh Lead Acid	$149,400	$108,846	$63,661	$0.00	-$9,692	$312,214
Generic system converter	$10,131	$4,227	$0.00	$0.00	-$786.82	$13,571
System	$472,313	$113,073	$76,989	$0.00	-$10,479	$651,896

Note that this cost include feasibility cost, purchasing of required equipment, transportation, installation, labour and maintenance cost over a number of years (project life). Considering $1=600FCFA, implies the net cost of the system over the projects life which is **$651,896 = 391,137,600FCFA**

Table 6 annual cost of the solar model for a location

Component	Capital	Replacement	O&M	Fuel	Salvage	Total
Generic flat plate PV	$24,468	$0.00	$1,043	$0.00	$0.00	$25,511
Generic 1kWh Lead Acid	$11,687	$8,515	$4,980	$0.00	-$758.21	$24,423
Generic system converter	$792.49	$330.68	$0.00	$0.00	-$61.55	$1,062
System	$36,948	$8,845	$6,023	$0.00	-$819.76	$50,996

The cost of the project installation and maintenance for a year which is **$50996 = 30,597,600FCFA.**

Meanwhile the cost for wind and hydro was calculated using a table of installation cost gotten from other research works. This table as seen below is actually a collection of empirical data from a large number of existing projects.

Table 7 estimated initial costs of different technologies (types of power plant) [2]

Technology	Typical total initial costs (€/kW)					
	Average		Minimum		Maximum	
	€/kW	FCFA/kW	€/kW	FCFA/kW	€/kW	FCFA/kW
Fuel cell	8,712	579,348	6,552	4,357,080	1,123	7,356,960
Gas turbine	1.224	813,960	432	287,280	2,016	1,320,480
Gas turbine(combined	864	574,560	504	335,160	1,224	801,720
Geothermal power	2.592	1,723,680	936	622,440	3,816	2,499,480
Hydro turbine	1.584	1,053,360	288	191,520	3,384	2,216,520
Ocean current power	0	0	0	0	0	0
Photovoltaic	**6,552**	**4,357,080**	**5,472**	**3,638,880**	**1,648**	**10,799,640**
Reciprocating engine	1,008	670,320	504	335,160	1,512	990,360
Solar thermal power	4,968	3,303,720	3,384	2,250,360	6,336	4,150,080
Steam turbine	792	526,680	360	239,400	1,224	801,720
Tidal power	2,952	1,963,080	2,520	1,675,800	3,312	2,169,360
Wave power	0	0	0	0	0	0
Wind turbine	**1,368**	**909,720**	**792**	**526,680**	**2,232**	**1,461,960**

5.1.2. Wind project cost for the 50kW turbine used in this research.

From the table above, the average initial cost for installing a wind turbine per KW is given as €1,368/KW (909,720FCFA/kW). Therefore the average cost for installing the 50kW power wind turbine used in this research is **45,486,000FCFA** (909720 × 50).

5.1.3. Hydro project cost for the different falls

From the table above, the minimum cost of installing a hydro power station is €288/KW (191520FCFA/kW), hence the various costs are presented in the table below;

Table 8 Summary of the potential power of the falls detected and the estimate of the cost of each

NAME OF FALL (HYDRO RESOURCE)	POWER IN kW	INSTALLATION COST IN FCFA
OMBE FALL	538.8	103,190,976
YOKE	565.21	108,249,019
BIBUNDE	826.5	158,291,280
LEBIALEM	2641.1	505,823,472
MOBOMBE	3169.3	606,984,336
MBONGE	5666.4	1,085,228,928

5.2Environmental analyses

In this section of the research we looked at the possible emissions from the renewable sources that could be of harm to humanity and the environment as a whole comparing it to that emitted from nonrenewable resources. These emissions are mostly GHG (greenhouse gases) which could be water vapour, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), ozone (O3) and or several classes of halo carbons. These emissions could cause the ozone depletion and possible global warming. A study by the Intergovernmental Panel on Climate Change presented the following results; natural gas emitting rate is between 0.6 and 2 pounds of CO2 equivalent per kilowatt-hour (CO2E/kWh), and coal, emits between 1.4 and 3.6 pounds of CO2E/kWh, solar emits 0.07 to 0.2, more is illustrated in the table below;

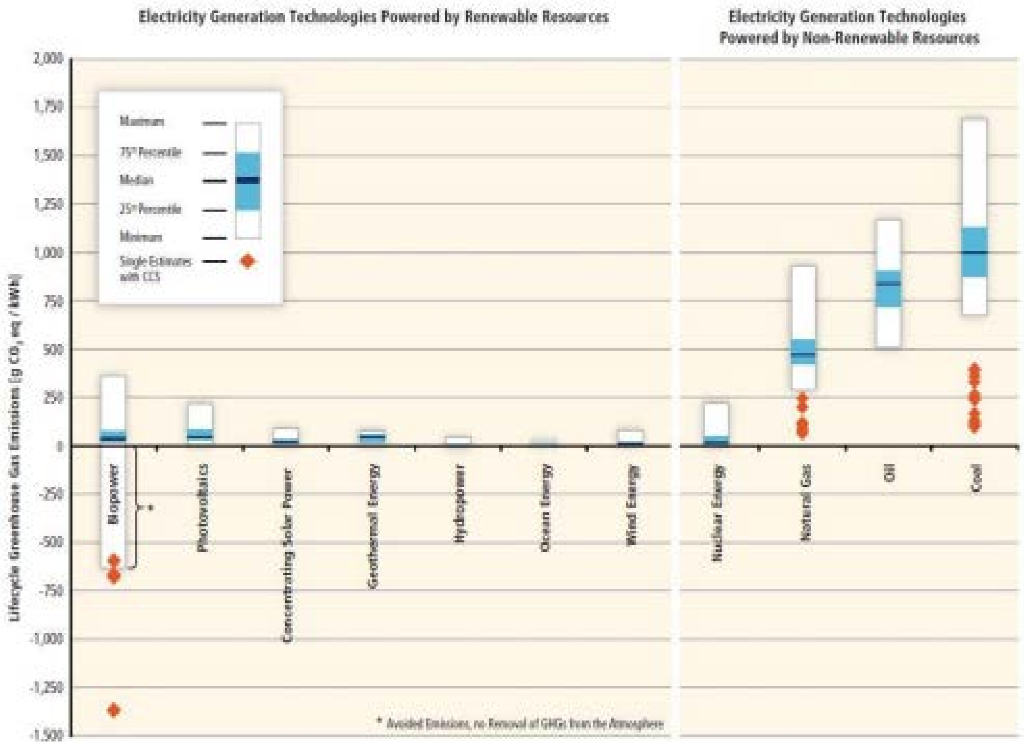


Figure 9 chart to showing the level of GHG emission from both RE and non-RE resources[20]

6.1. Conclusion

Energy is a back bone to the development of every economy and gives the possibility for us humans to live a comfortable and stress free lives. Energy is a resource which man cannot live without. Though very important and readily available, it still appears to be relatively very expensive as only the privilege gets access to it.Assessing and mapping renewable energy resources should be seen as a classic public good becauseunderstanding which renewable energy resources exist where, and to what extent, is critical to scaling up commercial development. In this research, we had acknowledged that majority of the places in the south west region which is where we are concerned are not electrified, since the main grid is unable to assess all the localities and even when they do the amount of power cuts are just so alarming.This is because the whole country depend on electricity from mainly hydro power stations, and the electricity capacity of the country is not enough to sufficiently satisfy the entire country talk less of south west region. So in this research we have assessed different renewable energy potentials as a way of solving the energy problem of the region. In the cause of our findings we discovered that the dominant renewable energy potential which is at least averagely present everywhere is solar energy, it is closely followed by hydro as the region is rich in water sources with water falls almost evenly distributed all over the region. Biomass potential too is available due to the richness of the region in forest species, and agricultural products of almost all forms there by making available residues of every form. The wind potential was noticed only in a few parts of the region like around Mt. Cameroon area, the Limbe onshore and Debuncha. This research has also provided analyses of the electrification of locations (Rural areas) in this region with the dominant renewable energy of most of the locations identified and quantified with the financial cost installation calculated as well. The cause of installation may look high but it is relatively very cheap since the resource is natural and renewable on like conventional source which may need constant financial inputs. The challenge faced in the cause of this research was the fact that meteorological data was not readily available despite fact that such centers was visited (that of the south west and Littoral) yet data like wind speed and irradiance of the region was not found, so we had to rely on data from NASA and NREL alongside field work which was very stressful but good because the goal was finally achieved.

6.2. Recommendations

This research work has the following recommendations to make;

- ✓ The government or nongovernmental organizations even community associations should help with the installation of the small scale renewable power stations be it solar, or micro hydro power plans as already analyzed and simulated in chapter four of this work, by this rural communities can be electrified.
- ✓ The public and investors should be sensitized about the dominant renewable energy available in the different areas of the region and its advantages clearly stated just as it has been done by this piece of work.
- ✓ Renewable energy resource assessment and mapping should not be seen as an end in itself, but as an input into a broader and ongoing process of policy development, by this, the government is called upon to develop a straight forward and more favorable renewable energy policy for our country as a whole.

REFERENCES

[1] IEA (2009), Share of total primary energy supply in 2009. http://www.iea.org/stats/pdf_graphs/CMTPESPI.pdf.

[2] Tansi, B. N., (2011). An assessment of Cameroons wind and solar energy potential: a guide for a sustainable economic development. Hamburg,Diplomicavalary GmbH.

[3] Alumnieeni, 2009. Economic information about CAMEROON: Investment, Population, GDP, Household income, Economie, Economia online, available at

[4] Fbo, 2008: Cameroon: Limbé Gas to Electricity Technical Assistance. Available at https://www.fbo.gov/index?s=opportunity and mode=formandid

[5] Wikipedia, 2009: Renewable Energy. Available online at http://en.wikipedia.org/wiki/Renewable.

[6] REN21. Renewables 2016 Global Status Report; Technical Report; Renewable Energy Policy Network (REN21): Paris, France, 2016.

[7] IAE (2011), Solar Energy Perspectives, www.iea.org/Textbase/npsum/solar2011SUM.pdf.

[8] Alsema E.A. and Nieuwlaar. E (2000). Energy viability of photovoltaic systems, Department of Science, Technology and Society, Utrecht University, Padualaan 14, NL-3584 CH Utrecht, The Netherlands.

[9] Tchinda, R.; Kaptouom, E. Wind energy in Adamaoua and North Cameroon provinces. Energy Convers. Manag. 2003, 44,845–857.

[10] Belda Pascal, 2007. Cameroon Energy and Mining. Ebizguides Cameroon p116.

[11] GTZ. Renewable energies in West Africa. Regional report on potentials and markets 17 country analyses, energy-policy framework papers. Germany: GTZ; 2009.

[12] Laurea University of Applied Sciences. Cameroon report. Laurea University of Applied Sciences; 2012. Available from: http://www.laurea.fi/en/connect/results/Documents/Cameroon%20Country%20 Report.pdf

[13] Bogdan, R. and Taylor, S.J; 1975. Introduction to qualitative research methods. A phenomenological approach to the social science sciences. Wiley, New York.

[14] Riley, M.W; (Ed.) 1963. Sociological Research. Harcourt, Brace and World,

New York.

[15] Njomo D. Analyse desensibilitédessystèmes hélio thermiques dans un climat Solaire tropica [Thèse d'Habilitation à Dirigerdes Recherches].France: Energétique et Géniedes Procédés, Université de Perpignan;2003

[16] Njomo D, Wald L. Solar radiation retrievalin Cameroon from Meteosat satellite Imagery using the Heliosat_2 method.SciTechnolVis2006;2 (1):19–24

[17] NkonghoAyuketangArreyndip and Ebobenow Joseph (Journal of Renewable Energy,) (2016), Generalized Extreme Value Distribution Models for the Assessment of Seasonal Wind Energy Potential of Debuncha, Cameroon.

[18] Mas'ud, A.A.;VernyuyWirba, A.;Muhammad-Sukki,F.; Mas'ud, I.A.; Munir, A.B.; MdYunus,N. An assessment of renewable energy readiness in Africa: Case study of Nigeria and Cameroon. Renew. Sustain. Energy Rev. 2015, 51,775–784

[19] Ngnikam,E., and Tolole, E.,(2009) Energy Systems: Vulnerability –Adaptation Resilience .Available online at http://www.heliointernational.org/uploads/VARCameroun.En.pdf.

[20] Inter governmental Panel on Climate Change. (2011). IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. Prepared by Working Group III of the Inter-governmental Panel on Climate Change. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1075 pp. (Chapter 9).

[21] Aston University and DK Teknik, (1993). An Assessment of Thermochemical

Conversion Systems for Processing Biomass and Wastes.ETSU,

B/T1/00207/Rep.

[22] Amigun, B., Parawira W., Musango J.K., Aboyade, A.O, (2012). Anaerobic Biogas Generation for Rural Area Energy Provision in Africa, ISBN: 978-953-51-0204-5,

[23] InTech. Available online at:http://www.intechopen.com/books/biogas/anaerobic-biogas-generation-for-rural-areaenergy provision-in-africa.

[24] Barbara, J.S. (2007). The false promises of biofuels. The International Forum on Globalization and the Institution of Policy Studies. Available at: http://www.ifg.org/pdf/biofuels.pdf.

[25] Mitsui Babcock Ltd., (1997). Studies on the Thermal Processing of Biomass and Waste Materials. ETSU, B/T1/00358/Rep.

[26] Warren Spring Laboratory, (1993a). Fundamental Research on the Thermal Treatment of Wastes and Biomass: Literature Review of Part Research on Thermal Treatment of Biomass and Waste. ETSU, B/T1/00208/Rep/1.

[27] Gerhard Oelert, Falk Auer, and KlausPertz, 1988: Economic Issues of Renewable Energy Systems. Greven and Bechtold GmbH, D-5000 Cologne.

[28] IERN, 2009: Country statistics – Cameroon. Available online at http://www.iern.net/portal/page/portal/IERN_HOME/IERN_ARCHIV/Country_Factshets/Country%20Factsheet? PId=3062009 and pPath1=AfricaandpPath2=Cameroon.

[29] World Bank, 2009: Projects and Programs – Cameroon. Available online at http://web.worldbank.org/external/default/main?menuPK=343845&pagePK=141155&piPK=141124&theSitePK=343813.

[30] WRI, 2009: Report reveals threats to Cameroon's growing timber industry, available online at http://archive.wri.org/news.cfm?id=71.

[31] Encyclopedia of Nations, 2009, Energy and power - Cameroon - annual available at: http://www.nationsencyclopedia.com/Africa/Cameroon-ENERGY-AND-POWER.html#ixzz0bNRVbIOo