

Enhancing Urban Energy Security Through Renewable Energy Solutions

Case Study- Douala, Cameroon

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ABSTRACT

The Purpose of this research is to examine the potentials of renewable energy (RE) and to enhance energy security (ES) within the present Douala metropolis. The production and use of renewable energy has been identified as part of the solution to be adopted and to improve the current energy crisis, and as a necessary inclusive contrivance towards creating a sustainable city. Most cities in Cameroon are faced with energy problem. The constant energy shortage has result in the deterioration of Douala urban environment. The main focus of this thesis is to create a sustainable Douala city by utilizing the energy potentials identified.

Urban population growth is unavoidable around the world. Therefore, the demand and supply of energy use will defiantly increase. An explicit and proactive method to enhance the preserved concept to energy security (ES) is suggested in this thesis. By applying, producing, and maintaining such phenomenon, this will benefit the Douala environment and its urban slums.

In order to achieve this, the present energy production and management methods were analysed; three Interviews were carried out, books, articles, journals and online sources were examined. Also, a specific indicator such as technology was identified to examine the vulnerability and less effectiveness to energy security (ES). Thus, measuring the current energy situation within this predefined urban area, the indicators measure a very poor urban energy security (ES). Herein, some solutions were proposed which constituted the recommendations for this study.

Key Words: Renewable Energy (RE), Energy Security (ES), Urban Energy (UE), Greenhouse Gas (GHG)

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LIST OF ABBREVIATIONS

RE	(Renewable Energy)
ES	(Energy Security)
UE	(Urban Energy)
GHS	(Greenhouse Gas)
IEA	(international energy Agency)
LPG	(liquefied petroleum gas)
IPCC	(Intergovernmental Panel on Climate Change)
M.O.S.E.S	Model of Short-term Energy Security (MOSES)
S.W.O.T	strengths, weaknesses, opportunities and threats
CEMAC	(Economic Community of Central African States)
SSA	(Sub-Saharan Africa)
IEO	(International Energy Outlook)
OECD	(Organization of Economic Cooperation and Development)
countries	
REMP	(Renewable Energy Market Potentials)

1. INTRODUCTION

In developing nations nowadays, urban energy security is not just essential for enhancing a good quality of life for the urban dwellers, this also increases the effects of creating sustainable urban development and poverty eradication within the urban areas. Nowadays, energy crisis is subjected to climate change and non-sustainable future which also causes degradation of our environment and makes it vulnerable. One of the most challenging task in recent urban areas is the comparative evaluation of energy security and climate change alongside modern approaches and policies which actually occurs under certain conditions of socio-economic and demographical change.

This piece of work proves that, urban energy security, if managed, planned and implemented well, creates an essential benefit for urban dwellers and this aspect will enhance the day to day life of people and the environment. People have come to understand that all these factors together with the protection of our environment make nature liveable, healthier and above all sustainable. Within the twenty-first century, sustainability has become the main challenge in cities and arguable the major focus in present-day science and research. (Lakala & Vehmas 2011)

Urbanization is seen as an important universal inclination regarding energy crisis as urban areas are the world's most habitat places. Energy security and renewables thus play a critical role in providing valuable ecosystems within our ever-growing urban environments which in effect makes it sustainable.

Though this research basically focuses on urban energy security in a developing country, a brief over view on the development history of urban energy security in western countries will be mentioned. This is due to the fact that Cameroon anticipates in planning and regulating its guidelines in

urban energy security. Hence it will be important to understand the main principle in energy security and its developmental principles from its origin.

Cities of today have to be competitive and at the same time sustainable. Looking at the concept of sustainability it is almost certain that most developing countries might get a bad reputation with regards to sustainability, renewable energy and energy security is convenience as often prioritized over environmental awareness. (Liveable Cities 2007)

The problem is not the lack of the necessary legislation, but rather the fact that the implementation thereof seems far more complex than anticipated. On the other hand, in some cases, it is often argued that a few developing countries are "over planning" in regards to energy and green spaces and are therefore wasting valuable land to be used for development.

The challenges and obstacles of achieving Energy security through renewable energy was regarded as an internal affair. But recently, research has shown that some of the major energy security challenges have become global. Stated by the executive director of IEA Maria Van der Hoeven, "energy security was seen primarily as a concern of industrialized countries", but today "the challenge has become global". The recent geopolitical instability and conflict in some of the world's main oil and gas countries has been a global debate on energy security most especially in Eastern Europe, North Africa and West Africa regions. (Karel 2014)

During the 60s, energy security was engulfing just around oil which today the whole definition has changes in the last 40 years, since the creation of IEA. The whole concept of energy security has also change with respect to the working direction to achieve it changes. This has almost come to conclusion that, energy security has no unified solution as to handle it rather, each country should find its own solution as the challenges is now a global issue and thus needs new ways of exploring to develop a solid multilateral corporation. (Anthony 2009, 104)

Some of the obstacle of energy security is also regarding as a result of large scale electricity generation which should be transmitted to other areas and thus required a huge project which may requires billions of dollars and will also attract more public attention to it large effect on local budget and environment (Flyvbjerg 2003).

Such mega-projects are especially threatened by the risk of overruns because of their vulnerability to sunk cost of investment and high transaction cost due to complex contractual situation and their unique character at assets (Globerman 1996). Some activists stated campaigns that most energy producing companies should enhance in climate change and decarbonize the future global greenhouse gas emission path, while maintaining energy security in other to be able to address climate change (Nadejda et al 2009, 104).

This thesis therefore intends to explore what value(s) is attached to renewable energy and the various schemes set up for conserving it in Cameroon with respect to its energy security as a resilient mechanism in the Douala urban setup, what are the possible ways to renounce in case of crisis and a comprehensive picture (scenario) of its future snap short (Resilient aspect as it sustainable concern), in practicing climate justice by reducing climate change.

1.1 Statement of the Problem

Energy uses have contributed to a lot of environmental mutations in the Douala region with subsequent changes in the environment and have brought forth issues like environmental destructions that have led to climate change and related problems. The continuous degradation of the environment by energy use has actually exposed our natural habitat and its livelihood to suffer in the process of global warming, poor energy use causes high basic electricity bills, reduces the value of our infrastructures

and also increases the negative impact on the environment. Poor energy produced methods such as Kerosene and Charcoal which is derived from carbonize wood and LPG creates high percentage of carbon and thereby destroys the environment and the livelihood, is what is commonly used in the Douala region.

Barriers to renewable energy technologies in Cameroon (Douala) include the fact that Douala has varieties of energy means which could be produced through affordable cost and means. Thus, many issues obstruct this development such as Politics, economic, experience and technology points to substantial market barriers and also market failure which on the other hand prevents the development of renewables in this region of the country.

Douala urban area over the past years has suffered from rapid transformation caused mainly by energy and environmental degradation. As the economic capital of Cameroon, most of the main activities constitute of businesses both industrial and small scale with the major backbone to be energy. Today, the story is different as Douala has experienced a rapid transformation in both its infrastructures and environment. These problems are more evident in Douala urban area that in recent days has witness a huge migrant population than over the years.

The Douala area is composed of fairly undulating energy sources associated with great potentials, thus, proving an additional advantage that has necessitated the establishment of renewable energy. This area with such location advantages is exposed to considerable population pressure, energy shortage, housing and economic issues. Health care has also been a major concern with a high level of illnesses in this area of the country which is mostly cause by pollution and gives ways for human to cut down trees for burning to provide a source of energy for cooking and other household requirements. Given the advantages plants have over our

environment and further increase its rate of degradation. More wild life and biodiversity's have emerged and aquatic ecosystems are now affected.

Hence, the combination of these factors has influence the various stages of energy use and energy production evolution that has brought about problems and changes in environmental degradation.

1.2 Purpose of this thesis

With the challenges in energy security in Douala regions the goal of the study is to examine opportunities to utilize more renewable energy in providing energy security

The study of existing literature in order to preview a comprehensive solution while identifying and describing the nature, diversity and values of renewables in an urban setup initiated within the allocated study area.

In line with cost benefits and effects of renewable energy, renewable energy such as wind, geothermal, hydroelectric, solar and biomass are seen as potential providers and substantial benefits for human with respect to health, economy and climate.

2015 has been rated as the world's warmest year for history which has urge the need for human activities to reduce or stop the high emission of CO₂ to the atmosphere and other global warming emissions. This aspect will reduce the trap heat, increased the temperature and will improve human impact on our health, our climate and our environment and this will be known as the global warming emissions reduction. (Benefits of Renewable Energy use 2016)

Douala Region in Cameroon has had the most rapid growth in public health and environmental issues and this effect has caused significant amount of health issues which is believed to be as a result of lack or poor electricity generation. Air and water pollution emitted by fossil fuel is often

as a result linked to breathing problems, neurological damage, heart attacks, and cancer. Therefore, replacing fossil fuel with renewables will act as health benefits to the environment.

Encouraging the use of renewable energy, we can clearly note that Economic benefits are seen as one of the major development. Comparing renewable energy with fossil fuel technologies, the renewable industries are considered a resilient mechanism when looking at enhancing the country's economic growth due to its labour intensiveness. In this view, more jobs are created in each renewable area of production which the fore gives a boost to the economy. Economics have suggested that every consumer's happiness, is the reduction of price in a said commodity, renewable energy is also said to be the main actor of stable energy price which make it affordable to all consumers across the country.

1.3 Research questions and purpose

The following research questions will be answered as part of this research:

- How great are the potentials for using Renewable Energy Security to achieve Energy Security?

- What are Douala urban area current renewable energy indicators?

- What are the current renewable energy indicators in the Douala urban area as compared to other cities?

- How is renewable energy, a resilient mechanism to enhance energy security in the Douala urban area?

1.4 Research phases

This thesis was done in three different phases. The first phase involved the period in which a field reconnaissance survey of the study area was carried out. This was for the purpose of identifying the various potentials of Renewable Energy and to determine how the data was to be collected. On the field, specific sampling method was employed to administer questionnaires to administrative authorities and other stakeholders were interviewed. This helped to provide information about the past energy characteristics of the study area.

1.5 Significance of the Studies and Limitations

This research will be relevant to the general public of Cameroon and Douala. Actually, very little research has been done in this city on the said topic which is believed that, policy makers will adopt some controversial point that will be discovered in energy security such as,

- Importance of renewable energy as a resilient mechanism to energy security
- Economic growth
- Mechanization
- Industrialization
- Health and education

The direct physical impacts of climate change, such as increased frequency and severity of storms, heat waves, and droughts are likely to impact energy security in a number of ways. Issues at the nexus of water and energy and power grid resilience have gained substantial and growing

attention in the literature, indicating that policymakers are focusing on these issues. Previous reports on the physical impacts of climate change, such as the Intergovernmental Panel on Climate Change (IPCC) global climate assessments, have focused more on the impacts of climate change on natural systems and human health. Even in developed countries, energy infrastructure is susceptible to disruption by weather conditions.

Climate policies may be compatible, or may work at cross-purposes with energy security. Policies designed to mitigate climate change and promote energy security can also be mutually reinforcing. Energy conservation is seen as a “no regrets” strategy for enhancing energy security while reducing climate change—at least in developed nations. (Marcus & Jay 2013)

However, the risks associated with energy security affect national economies on a daily basis. Climate policies can undermine energy security by limiting near term energy supply options. Consequently, greenhouse gas emissions reductions would be less disruptive to energy security if they were implemented only after key technological solutions—such as carbon capture and sequestration—become available for large-scale deployment. (Marcus & Jay 2013, 33, 35)

This thesis hopes contribute to the understanding of the dynamism of Renewable energy and energy security that changing patterns over time, which is an issue that is of interest to economist, Ecologist and Environmental Scientist.

Hence, it will contribute to creating awareness about the irrational exploitation of lots of renewable that will cause a subsequent migration and extinction of some fauna and flora due to the destruction of their habitats. These are valuable resources needed by man for his own survival. If we destroy the forest for energy use or other reasons, then we

destroy our own means of surviving. It will cover the scope as starting point the year 1960 for the following reasons as its limitations: This was the year that Cameroon gained its political independence. The period in which most Rural and Urban areas were created, a lot of transformation took place during this period.

Therefore, it is important to create awareness of public attention to the importance for maintaining the state of the natural environment for recreation of industries and tourism and also provide baseline data for further academic research.

2. REVIEW OF RELATED LITERATURE

According to IEA. 2011, ensuring energy security has been central to the mission of the International Energy Agency (IEA) since its inception. Founded in response to the oil crisis of 1973, the IEA initially focused on oil supply security. While security of oil supplies remains an important concern, contemporary energy security policies must address a broader range of risks. Threats to energy security come from a variety of natural, economic and political factors, and affect all energy sources and infrastructure.

Badcock. 2000, states that, more often in the process of building cities, nature has been overtaken by the built environment and that urban development usually reduces biomass and biodiversity by building over land and displacing animal and plant populations (Expert Group on the Urban Environment 1996, 45). Cities need to be viewed as ecosystems “since they build themselves by destroying nature”. In the past, cities were never thought of as ecosystems but opportunities exist for city builders of the future to redeem themselves by seeing to it that the built environment is more completely in harmony with nature. Today, projects are conceived to help “revegetate” wastelands, protect remnants of native bush and create wildlife sanctuaries and natural wetlands.

Regarding this research, a quantitative research method will enable the findings from a primary source in other to make sure it is accurate but will not be limited just to that. Some qualitative findings will be examine as well.

- Chapters within the literature study identifies both the potentials of renewable energy and the specific roles each government sphere has in regards to policies and legislation guiding green spaces within Cameroon.

- The empirical investigation identified Douala Urban area`s current guiding policies, legislations and green space indicators in order to compare those to standard indicators.
- M.O.S.E.S analysis was conducted, identifying the Long term and short term of energy security.
- S.W.O.T analysis was also conducted to identify the vulnerabilities of energy security.
- The conclusion and recommendations regarding Douala Urban area, development and policies within the City will be discussed.

2.1. Energy Framework and Energy Policy in Cameroon

The government of Cameroon said to have certain policy which according to its view will eradicate the country`s under development energy crisis. This development is considered to happen by grating and implementing a good energy plan underneath the long-term sector development plan (PDSE 2030) and the poverty reduction strategy paper (PRSP) (Reeep Cameroon 2012).

The government of Cameroon views the energy sector as a tool for attracting investment and strengthening growth with more emphasis given to the country`s hydroelectric potentials which is being considered the second highest in the region of the central Africa after the Democratic Republic of Congo (DRC).

Moreover, one of Cameroon government 2035 developmental objective is to enrich the energy sector, this is said to be done by increasing the present GPD of 17% to 47% by the year 2035. Regarding these objectives, increase in electricity production is the country`s main priority. Oil and gas delivery is also one of the country`s prime objectives to bust the economy though by environmental point of view this is considered none renewable.

Cameroon's energy policy is known as a "no overt energy policy". The energy policy in Cameroon was introduced way back in the 1990 and it is known to be the most recent energy policy in the country energy history. Though this energy policy was introduced, it was not implemented until the 1998 whereby another energy policy was introduced, this was said to concentrate on the hydroelectric power generation in the country. (Abdullahi. A, Wirba. A, Muhammad-Sukki.F & Munir. A 2015)

The Cameroon ministry of Energy and water in 2005 said to have a plan to develop new energy plan by 2035. This developmental initiative 2035 by the government is focused on investing in RE which is believed to enhance energy independence and economic growth. Though with this objectives, there is literally no direct policy or guideline regarding RE development in Cameroon. There are many laws have been put in place by the ministry of energy and water to deal with energy solutions which will involve renewable energy both mini and micro hydro production. As indicated above, Cameroon strongly focused on hydro power production though having a lots of other RE sources that could be produced. This RE potentials could basically seen in few area in mostly big city's like the Douala urban area and the capital city Yaoundé where installation of solar panels is placed on electric poles in the streets for powering and illumination of the localities.

Despite having numerous potentials of RE productions in Cameroon, there are lots of prohibitions facing this development. One of these challenges is the political unrest in the northern part of the country which threatens the security stability in this part of the country. Some of the reason for lack of RE potential in the country is the lack of technological development and also unskilled expatriate in this sector. Lately, research has proven that, the major problem in the RE production in Cameroon is known to be the political holdback.

Unlike many developed nations which have adequate policy on development, there is always the policy of maintenance in every installation after a specific period of time, in Cameroon, even with its solar PV installed on street lighting pool in some parts of the country, there is no proper policy in maintenance which eventually course or wipe out any development to that aspect. Therefore, for any sustainable development, there must be proper policies which will definitely attract both local and foreign investors to improve this sector.

2.2. Over view of urban energy security through renewable energy solutions.

Definition

Renewable energy: this is energy generated from natural resources such as sunlight, rain, wind, tides and geothermal heat which are renewable (naturally replenished). Renewable energy technologies range from solar power, wind power, hydroelectricity/ micro hydro, biomass and bio fuels for transportation. Energy Security: With respect to climate change, the International Energy Agency (2011) has tried to accommodate such concerns within its own definition of energy security: the uninterrupted physical availability at a price which is affordable, while respecting environment concerns.

More than 50% of the global population lives in urban settlements and urban areas are projected to absorb all population growth by 2050, amounting to some additional three billion people. With respect to energy, the world is already predominantly urban. It is estimated that 60 - 80% of final energy use globally is urban.

Modern urban cities eventually have the scope to rebound from the biggest destruction. In this concern, it could be seen that the resilient cycle engulfs an attempt to create an exact time and measurement to react with

disasters and security related issues. According to UN's Rio+20 conferences, resilience was said to be one of the pillars of sustainable development. Thus, sustainability could be seen as a tool which includes environmental, economic and social dimension and gives the concept of scenarios to be able to predict the future.

In Africa, a billion of its current population lives in urban areas and by 2030, half of the population of Africa will be inhabited in urban areas. The United Nations agency for human settlements opine that, the population of some cities is set to swell by up to 85% in the next 15 years. With respect to the urban worries in the Douala municipality, it was clearly observed that food and water shortages, poor infrastructure are some of the problems faced by Douala city government including lack of housing during such rapid urbanization.

Some progress in attending to these challenges for example, the fall in the proportion of slum-dwellers, who currently account for up to 70% of urban inhabitants. Majority of world issues and worries today could attribute to energy usage, concerns about greenhouse-gas emissions to loss of productivity, from oil supplies and output stemming from shortages and black out.

Nowadays, 1.3 billion inhabitants do have no access to electricity while some 2.6 billion people uses modern cooking facilities and 95% of the inhabitants with no access to electricity lives in sub-Saharan Africa. Approximately, two billion inhabitant's lives in rural areas in developing countries have no access to electric energy. A lot of the consumed energy is produced via traditional sources. Some of the widely used energy is produced through human and animal muscle power, animal waste, and kerosene. One of the world's most pressing worries could be seen as environmental destruction which courses global warming resulting from the heavy consumption of fossil energy. These fast changes have drawn the attention to many around the world. (UN-HABITAT 2015).

Renewable energy is assumed to be an appropriate replacement of energy used with respect to it safe and highly contributing to enhance the current hazard caused by fossil fuel around the sphere due to its friendliness. Evidently, energy is a problem in most of African countries and Cameroon in particular. The International Energy Agency recently stated that, improvements to the energy sector could provide the equivalent of a decade of growth in some of the poorest parts of the world. Global energy crisis has actually been aggravated by a lack of innovation. (Abanda 2012).

The United States government Lawrence Livermore National Laboratory found that 60% of the energy we use is lost between the time it is generated and the time it is consumed just as in Douala, such consumption loss happens via inefficiency in converting fossil fuel to electricity more to it. Wasteful consumer behaviour in public, private and basic house hood thirdly, losses during poor transmission and lastly the need to maintain a reserve to avoid issues such as power cut.

The need for security is seen as a tool to enhance such effects. "Energy security is a state in which consumers and their governments believe, and have reason to believe, that there are adequate reserves and production and distribution facilities available to meet their requirements in the foreseeable future, from sources at home or abroad, at costs which do not put them at a competitive disadvantage or otherwise threaten their well-being." (Raphael & Gordon 2008; Belgrave, Ebinger et al 1987, 2)

Scenarios are carefully constructed snapshots of the future and possible ways a sector might develop. Scenarios help focus thinking on the most important factors driving change in any particular field. In environment, the future is unpredictable, full of changes and complexities as a result; leads of organizations ought to have insights regarding this. This will be able to guide them in decision making for a greater success of their company. The

future of energy production cannot be planned without the use of strategies and scenario thinking which will help explore strategic questions.

Scenario thinking is regarded as the best approach when thinking about the future of an environment as well as when planning to start up its security thoughts. However, it has its own weakness as it does not always result in entirely satisfied strategists; specifically, when an analysis of the business world or environment has been made and taken to the company for strategic action, the people it is intended to inform become lukewarm about it resulting in decisions not being taken at all or taken when its already late. (Security strategy for society 2010).

Even though this research is primarily focused on urban energy security in developing countries, an executive summary will be made on the consolidation of Finland's energy security. The reason being, Cameroon is planning and regulating guidelines to mostly adopt from those used within the European cities.

2.3. Geographical Location and Percentage Energy Sources in Cameroon



Fig 1. Map of Cameroon

Cameroon as pictured in the map above, lies along the Gulf of Guinea and its boundaries with Chad, Central African Republic, Nigeria, Republic of Congo, Gabon and Equatorial Guinea. Cameroon is seen by many researchers as Africa in miniature in its highly diversified minerals and agricultural products. The country is the most populated within the Economic Community of Central African States (CEMAC) region. With respect to the 2014 data, Cameroon had a population of about 23 million with an annual growth of 2% yearly. Some 20% of Cameroons population lives in its two major cities namely Douala and Yaoundé which are its Economic Capital and Capital respectively. Cameroon when compared to most of its neighbours enjoys relatively high social and political stability.

The country which is known for its bilingual nature with French and English as its two main official languages with French approximately 80% of the country's population and English 20% of its population. Regarding the history of the country, French Cameroon got her independent in 1960 and was merged with southern British Cameroon in 1961 whereby the two separate entities has made up the Republic of Cameroon.

Cameroon with respect to natural resources has been pictured with high potentials of renewable energy (RE) sources but with its lack of technological enhancement, most of it has not been harnessed.

Cameroon's large population in the 60s on till present date still depends on conventional solid fuel such as charcoal which basically used for cooking and also for domestic electrification.

The country's main energy sources are petroleum, coal, hydropower, biofuels and waste with their percentages as could be seen in figure 1 with respect to electricity. 75% of Cameroons Electricity is produced from hydropower schemes. Recently, due to some changes in the development on energy production, other renewable sources cover about 25%. The hydro power schemes are actually estimated at 721MW scheme.

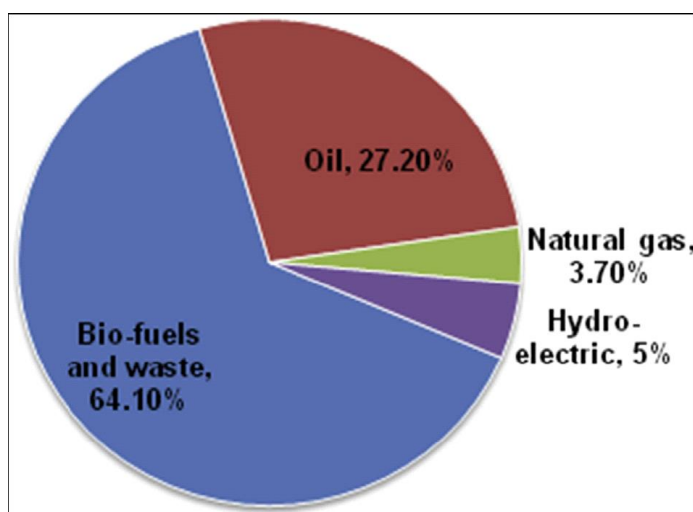


Fig 2. Energy sources in Cameroon. Developing renewables (2006)

In Cameroon, there are three major hydroelectric power stations whereby in the 60s just one of these station was operational and more became operational during the 80s namely, Song Loulou, Edea, and Lagdo. The creation of all these power stations made Cameroon to be regarded as the second largest hydro station within the region. Though Cameroon has a huge arena of hydro power scheme, its electricity is still not shared properly. Only 20% of the country's population enjoys the national grid while most of the country's inhabitants who deal with electricity are the urban dwellers with very little improvement focused in the rural electrification schemes. One other source of energy production apart of the hydro is fuel. Fuel thus makes up 11% of the country's energy production. (Asan et al 2014, 560).

2.4. Status quo, energy demand and potentials of renewable energy in Cameroon

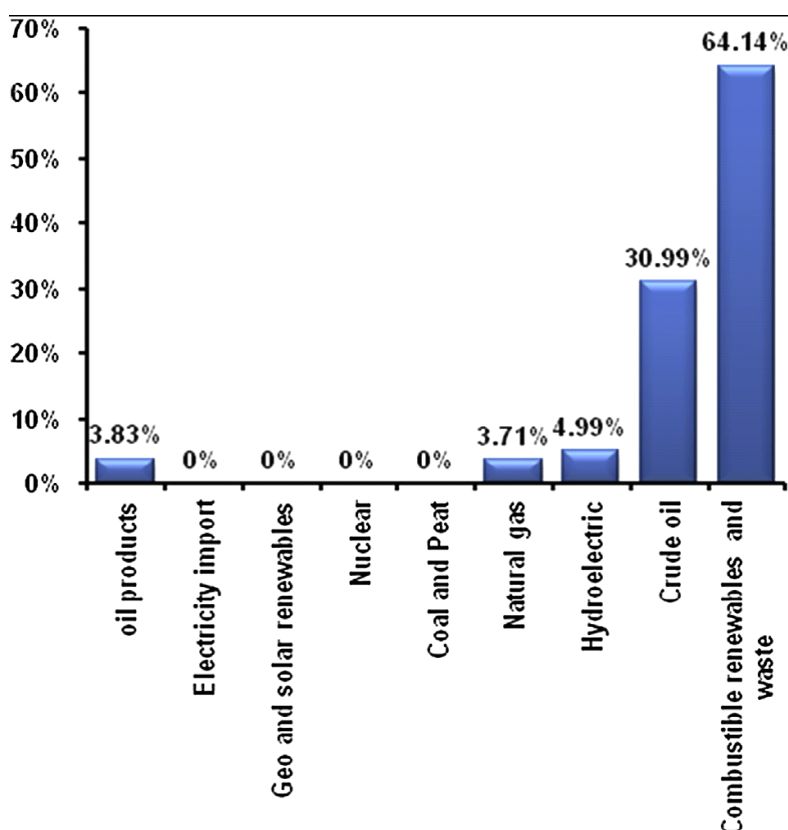


Fig 3. Energy supply scenario for Cameroon. Developing renewables 2006.

The figure above indicates the energy demand and supply scenario in Cameroon. This clearly shows that most of the huge area of energy which is at 70.63 percent of energy is consumed by household. This energy is mainly used for heating, cooking and lighting. About 14.49% of Cameroon energy is used in the transport areas both for fuelling and powering vehicles and the rest of some major sectors such as healthcare, education, business and administration being estimated to use just 8.24%. 6.16% of the country's energy is used by industries and mainly for heating, cooling and powering equipment. Some 0.07% is been used by Agricultural sector. (Asan.V et al 2014, 560)

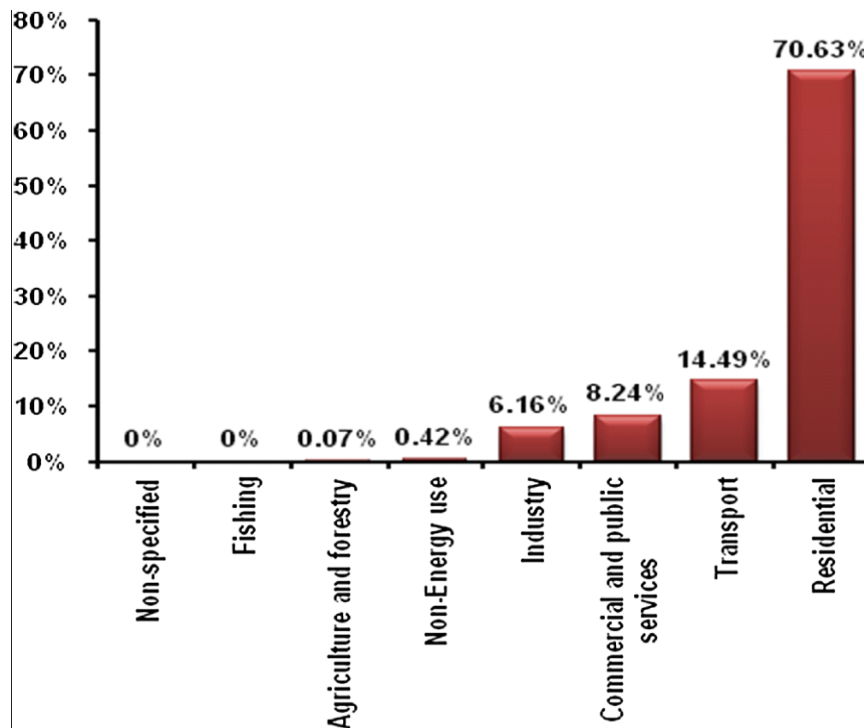


Fig 4. Energy consumption by sector in Cameroon. Developing renewables (2006)

According to 2015 statistics, Cameroon electricity capacity was at 817MW where by hydroelectricity makes up some 88% with rest from thermal power generation. Now our days, the demand for electricity use in Cameroon is as high as 1455MW with respect to 2014 statistics. This

amount is said to rise to about 5000 MW by 2010. According to Ayompe and Duffy, the Cameroon government planned to install 2500MW of hydroelectric power between 2012 and 2020 and 298MW from thermal power plant by the year 2013, but this has not been fully implemented to date. With this implementation remain undone, the country's main electricity still hugely depends on it hydroelectric power which as mentioned in the write-up, is not evenly distributed nationwide.

Regarding the above analysis, it is seen that Cameroon is facing some major challenges regarding its electricity sector. This could be concluded that the demand of energy and electricity in particular exceeds the supply. Although several measures have been put in place to enhance the needed situation, as of now, there have been no tangible answer to this. Therefore, this gives us the reason why there should be an indication that renewable energy (RE) will play as major contributor in combating the country and it future energy demand if the full utility of the abundant RE potentials is consume. (Abdullahi, Wirba, Muhammad-Sukkim & Munir 2015)

Environmental degradation, global warming and the continuous energy demand in the globe at large and it markets together with the huge increase in energy prices mostly affecting developing nations has called for the need of renewable energy (RE) resources. With natural resources and great energy potentials in the African continent, the inappropriate scale of electricity production and generation is still pine pointed as a major concern in sub-Sahara Africa (SSA). Based on the International Energy Agency (IEA) information, the Sub-Saharan Africa has mass Population without access to adequate electricity.

These are due to disparities in the energy development across the whole continent. In examining Africa modern energy consumption with regions such as Middle East, North America, Latin America and Europe, it is obvious that Africa has one of the lowest per capital consumption rate of

energy. This among other things is due to the fact that Africa relies mostly on traditional biomass and hydropower energy. Africa as a continent has abundant RE potential, but has not been fully harnessed. Amongst the reason for the slow uptake in RE are high capital cost of initial financial investment as well as lack of adequate Knowledge regarding the benefits of RE. Cameroon is among the African countries that are slowly striving to include RE in their future energy development. (Abdullahi, Wirba, Muhammad-Sukki & Munir 2015)

Based on the International Energy Outlook (IEO 2013) report, the world energy growth will be 56% between 2010 and 2040, with an increment of 1.5% per annum. In the reference case (see Table 1 and Fig. 4), the total energy demand in non-OECD (Organization of Economic Cooperation and Development) countries – in which Cameroon belong to – had increased by 90% compared with a rise of only 18% in OECD countries.

Table 1, shows that the total energy in the world rises from 524 to 820 quadrillion British thermal units (Btu) between 2010 and 2040. This is driven by strong economic and population growth in Non-OECD contrasting OECD countries with slow economic growth and population expansion.

World marketed energy consumption based on country grouping, in quadrillion Btu, from 2010 to 2040.

Table 1 Total energy in the world

Region	2010	2015	2020	2025	2030	2035	2040	Mean annual Percent change
OECD	242	244	255	263	269	276	285	0.5
Americas	120	121	126	130	133	137	144	0.6
Europe	82	82	85	89	91	93	95	0.5
Asia	40	41	43	44	45	46	46	0.5

Non-OECD	282	328	375	418	460	501	535	2.2
Europe and Eurasia	47	50	53	57	61	65	67	1.2
Asia	159	194	230	262	290	317	337	2.5
Middle East	28	33	37	39	43	46	49	1.9
Africa	19	20	22	24	27	31	35	2.1
Central and South America	29	31	33	35	39	42	47	1.6
America								
World	524	572	630	680	729	777	820	1.5

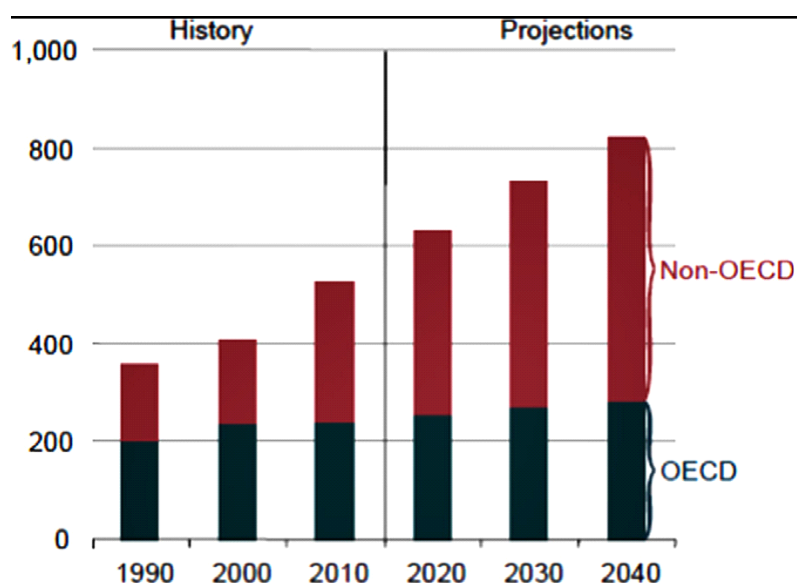


Fig 5. World energy consumption, in quadrillion Btu for the period from 1990 to 2040

Regarding finding means to enhance energy issues around the world and Cameroon in particular, RE can be considered the most effective way in battling the energy crisis and will be a fast growing energy source of electricity than Coal fired generation which is the leading source of the world's electricity generation.

Apart from coal, other non renewable energy sources such as nuclear and natural gas are amongst the rapid growing energy sources in the world. Though there is an increasing concern on RE in the globe today, non OECD countries like Cameroon is still left underneath the development of such technology. However, research has proven that net electricity generation in non-OECD countries rises at an average rate of 3.1% annually. This is led by India and China. As the world battles with security concern with environmental consequences, many governments around the world are designing policies which support the development of RE sources. (Abdullahi, Wirba, Muhammad-Sukki & Munir 2015).

During the cop 21 in Paris 2015, after reviewing the proposed solution for clean future, some solutions were made concerning our environment and the climate such as, saving energy by implementing the most energy efficient devices existing today that will promote renewable energy resources and will give stakeholders efficient energy devices. This will push the transition to renewable energy resources. Also, further explanations were related to the rapid changes in the climate which is been rated as the highest in human history with a significant part of it that is created by the use of fossil fuels. Never the less, increase in the future fuelled by renewable energy is the only and most reliable means to reduce catastrophic climate change.

With the use of available technologies many countries have already put this in practice. The aim of this RE solutions does not just end there, rather; it creates economic advantages such as jobs than those being lost in fossil industries. On this note, it was noticed that renewable energy is

good for the climate, good for the economy and good for business. Lastly, on the picture of the cop21 solutions, was on Focus on education, new generation of committed experts needs to emerge from international and local institution.

Potential and Characteristic

Cameroon has PV systems, solar thermal installations for hot water preparation and small hydro. The system utilized only by small number of inhabitants in the rural areas. In recent years, a number of technical studies have shown that a geographically very large power system design, such as Deserted, leading to 100% renewable electricity by 2050 is technically possible and economically feasible, but politically very challenging. (Czisch 2005; SRU 2010).

Cameroon is considered in the CEMAC region (central Africa) as an energy exporter, presently, its energy situation has been described as bad with respect to the fact that more than 70% of its energy consumption is derived from traditional biomass with hug effect on the environment and also a contributing factor to climate change. Cameroon in Africa is known to be one of the countries with approximately >95% of its electricity generated from hydropower plants.

Underneath, the figures shows list of hydropower production in Africa where Cameroon is seen as the third in the continent with its country's second in the list of central African countries.

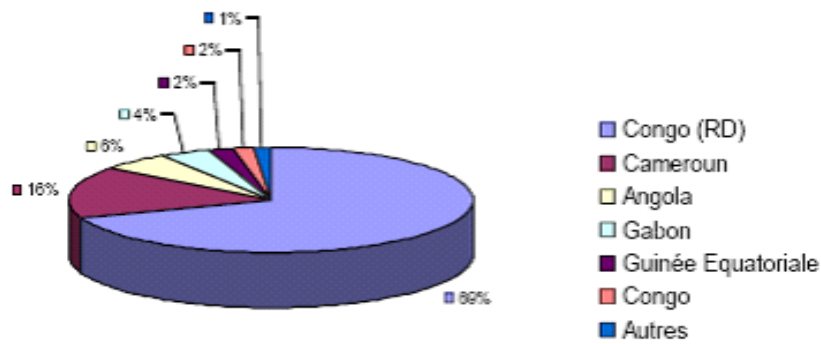


Fig 6. Central African Power Pool (CAPP)

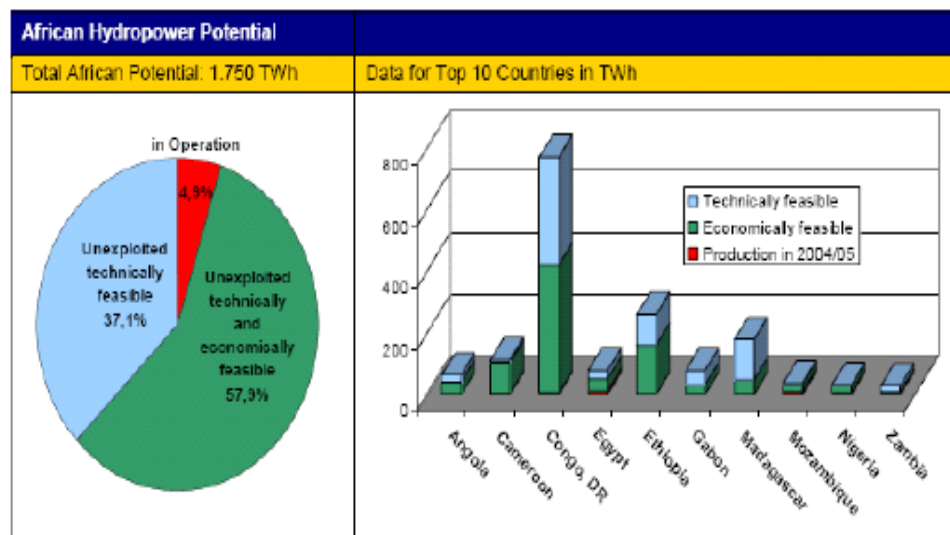


Fig 7. Hydropower Resources Assessment of Africa

Despite some largely ideological criticism from the decentralized renewable energy community the feasibility of deserted is questioned by surprisingly few, although there are numerous questions that indeed require thorough investigation. Among these are questions that may be severe enough to make the implementation of the entire idea unfeasible. (Hollain 2009; Johan & Saskia 2010)

Cameroon ranks second in the central Africa region as shown above, with potentials of energy rated as 55.2GW per a producible potential of 294TWH/ year after the Republic of Congo in hydropower production.

Though the country holds huge product ability of hydro, only 20% of its population has access to grid network. Majority of its population with connection to the grid are urban dwellers while rural electrification in the country remains on a poorly low rate of just 15%.

Generally, such approaches appear to navigate the problem of not knowing the future by either creating dimensionless indices with subjective weights, or they by declare the future a state of ignorance in which it is impossible to know both the probability and the impact of events. Most approaches see supply diverse in citation as the only available tool to ensure energy security. The method to assess this is typically a dual-concept diversity index, often coupled with a measurement of the current general political stability of the exporter (e.g. Frondel et al 2009; Jansen et al 2004; Lefevre 2010; Stirling 1994

Market implementation in Cameroon.

Renewable energy (RE) potentials simultaneously appeared to be in line with market implementation. On this note, reference scenario is said to examine the future development of the respective market technology in the country as picture in the table below. Carefully looking at the table below, the scenario thus explains the output per technology by 2020.

Table 2. Cameroon energy market implementation

	Present	2020	
		Reference scenario	Maximum scenario
Total primary energy supply			
RE % including large hydro	4.5%	4.8%	7.7%
RE % excluding large hydro	pm	<0.01%	0.02%
Electricity			
RE % including large hydro	97%	65%	95%
RE % excluding large hydro	pm	<0.01%	0.04%

Renewable energy potential and market implementation, it is important to look at ways to improve energy sustainability in the urban areas in Cameroon by means of generating attractive ways to distribute renewable energy. Niemi. R opin that, a reliable means to increase urban renewable energy production is to produce and convert lots of electricity into thermal energy. The multi carrier urban energy system enables the means to analyzed spatial energy demand and supply together with spatial energy flow through the urban community. (Niemi et al 2012, 524).

In Cameroon, the existing systems for PV, solar hot water production and mini and micro hydro power is calculated under the maximum scenario and in any consequences to RE contribution in the total energy used. With the country's huge nature of hydro power growth, Cameroon is evenly noted for a huge potential of wind energy, geothermal power are said to be less suitable but the country's waste, biomass and its huge arena of hydro can contribute to some 7.7% of RE contribution by 2020.

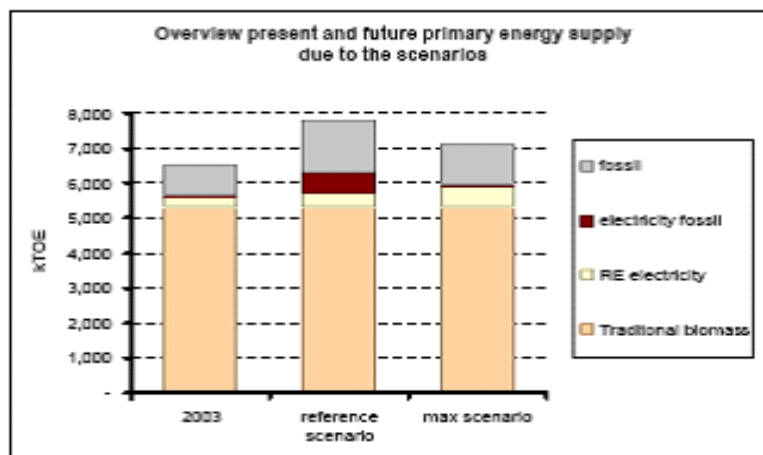


Fig 8. Overall Energy supply till 2020

The above figure 7 shows the overall picture of energy supply till 2020. The large amount of traditional biomass is assumed to remain at the present level, due to more efficient use of this source. In the reference scenario the total primary energy use is larger than in the maximum

scenario due to the use of more fossil energy in electricity demand. (Developing Renewable 2006, 6).

2.5. Ecosystem, geography and economics of Douala

The following two figures below respectively, illustrates the urban edge of Douala and the delineated study area which represents most of the urban development found inside the mother city of Douala municipality. It is therefore very important to note that the delineated study area is actually the total area of the urban edge of the Douala municipality. Douala is one of Cameroon ancient cities and is also known as the country's economic capital.

The Douala municipality is currently home to about two million inhabitants approximately 20%. Cameroons urban population is estimated to be 11% of the country's total population and 5% annual growth rate in the country's average 2.3 %. The city of Douala is divided into six communes and its headquarter as listed, Douala 1 (Bonandjo), Douala 2 (Newbell), Douala 3 (Logbaba), Douala 4 (Bonassama), Douala 5 (Kotto), Douala 6 (Monako). The first five communes are urban areas while the sixth one is a rural zone. The city is led by a community council of 37 members and two government representatives.

Douala is a major port and industrial center, but there is also a significant urban agricultural activity within the metropolitan area. Self-medication and recourse to traditional practitioners are frequent because of the difficulties in reaching healthcare facilities. The positive notation of the economic rate of the Douala city thus has no prohibition of long term challenges. Douala city margin has a high risk of energy crisis couple with its complex marine and aquatic ecosystem that contributes to its present degradation of the environment. (CLUVA 2010).

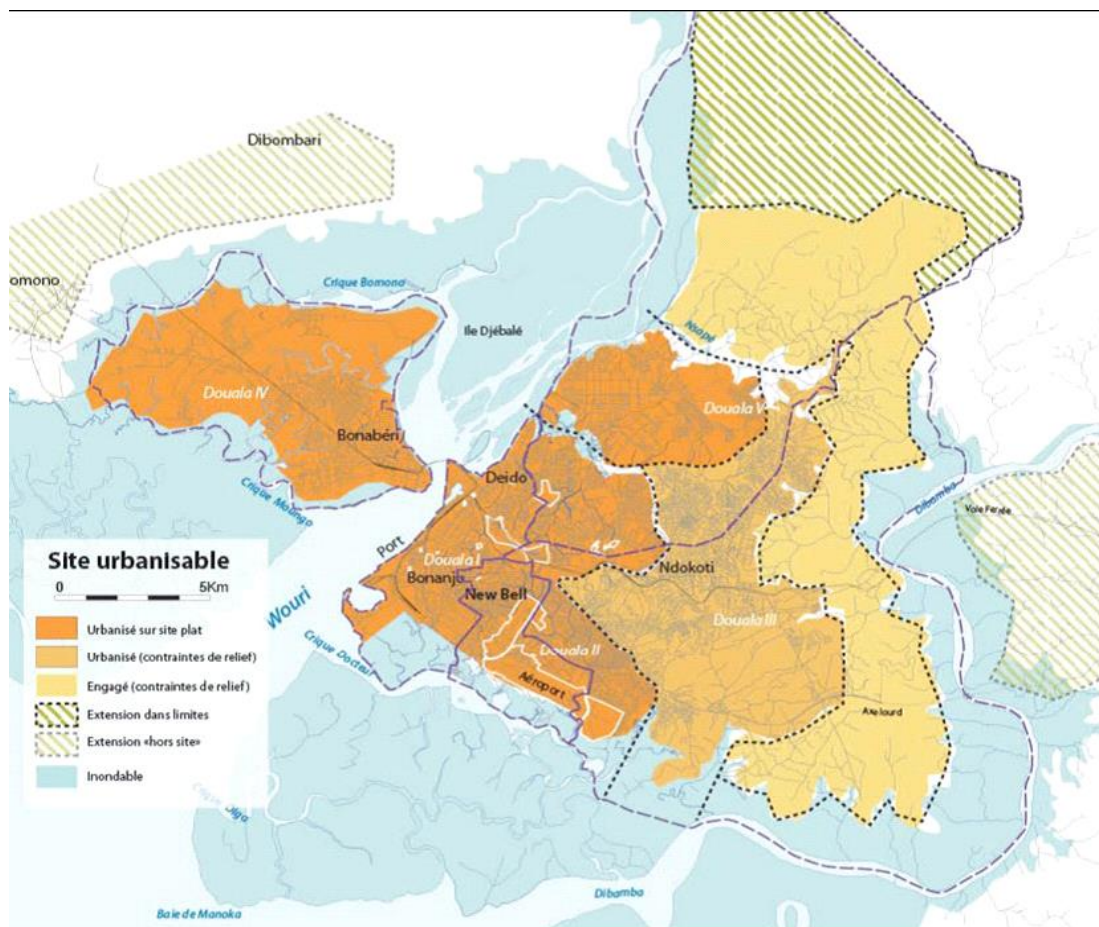


Fig 9. Douala Urban Community / Groupe Huit / November 2011

This figure shows the national planning and an extract from urban development strategy for the city and metropolitan area of Douala.



Fig 10. Cameroon National Planning, Douala Urban Community / Urban Plan / December 2009

The massive extensive growth within Douala municipality is witnessing great significant environmental problems to the surrounding lagoon complex and also to its wetlands. The fragile wetland ecosystem of tidal mud flats, estuaries, mangroves, wetlands, and inlets where creeks flow into lagoons, all this provide a critical coastal habitat for socio-economic activities and now face destruction due to the rapid expansion of the Douala metropolitan area. The destruction takes the form of land reclamation for urban growth as well as wetland conversion for industrial infrastructure and development, and is accompanied by increases in the discharge of effluents (sewage). The consequences include impaired water quality, the contamination of surface and ground water sources, public health hazards, wetland loss, subsidence, and flooding (Ideals 2009).

Other challenges of Douala urban municipality are due to the overloading which results to the deterioration of existing infrastructure such as power, drinking water, sanitation and transportation where by some areas in the community lack such infrastructure. The urban area suffers a severe shortage of affordable low cost housing with extreme poverty affecting about 13% of the city's household.

The climatic condition of Douala is not different from some of Cameroon regions though with the huge industries in the region, there is a significant change in its climate. Douala experiences a wet, tropical monsoonal climate. The region actually has an average annual rainfall that exceeding 3000 mm. The rainfall peaks during the boreal summer and autumn (June-November), during the monsoonal circulation dynamics are said to be in good development with a monthly temperature of 20s via the whole year. The figures below indicate that Douala's annual rain fall could increase by 35% with respect to the current state and will as well have an increase in its annual temperature by 2 degrees Celsius.

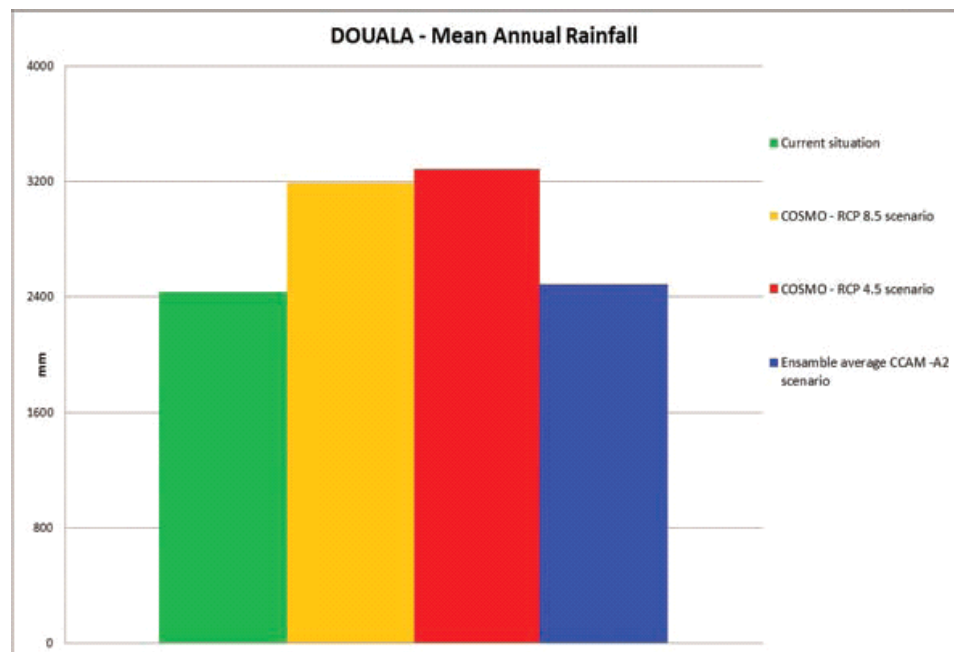


Fig 11. Douala Annual rainfall CLUVA (2010)

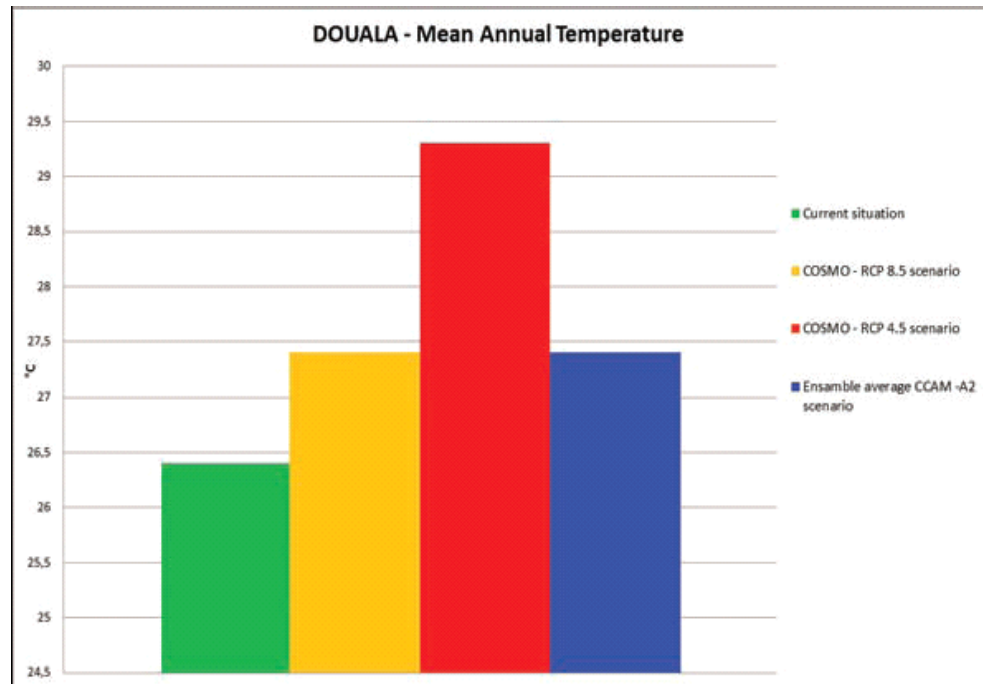


Fig 12. Douala annual Temperature (CLUVA 2010)

Douala climate projections have a strict correlation between heat wave duration and number of hot days. The heat wave length episodes indicate an increase of 3 to 15 (RCP4.5)-17(RCP8.5) days.

The frequency distribution plot of hot days duration for four separate bi-decadal periods, according to the legend (see figure), shows the temporal change of heat wave characteristics. For example the number of events with maximum length lasting 5 days could increase from 3 to 34 (42 for RCP8.5) over 100 years (from 1950-70 to 2030-2050).

The expected persistence of long-lived heat waves lasting approximately 1.5-2 weeks is clearly longer to the climatological period (1961-1990). During the past one hundred years, short duration but more intense waves are more than doubled and this brought the needs for the national health services to develop strategies for the mitigation of the hot wave effects, to enhance the resilience of the population, particularly the elder people. (Tchangang 2012; CLUVA 2010).

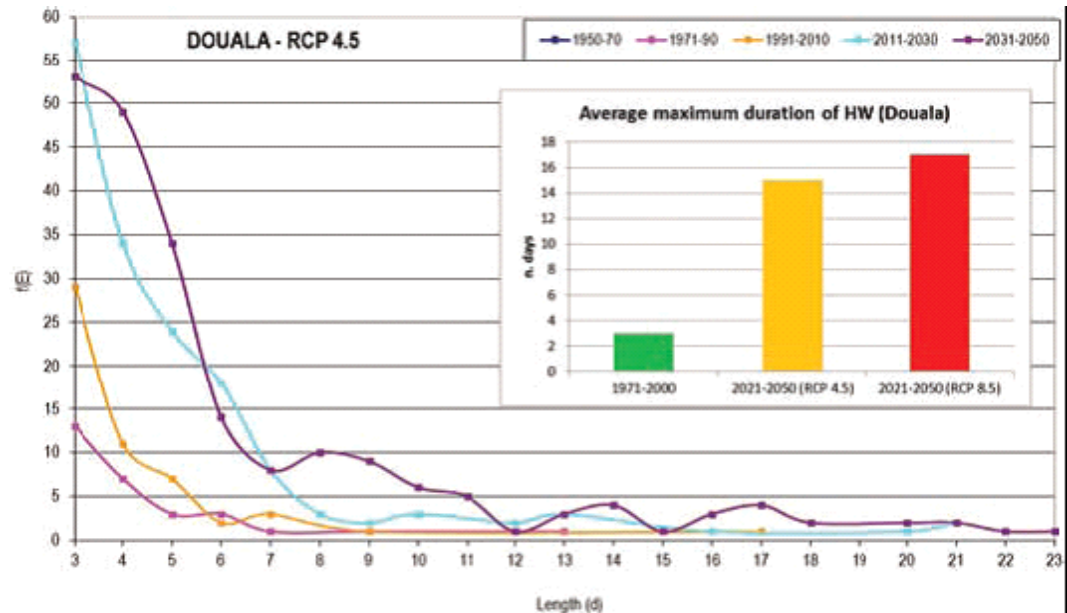


Fig 13. Average maximum duration of Heat Wave phenomena and frequency distribution plot of hot days' duration for four separate bi-decadal periods.

With the above data of Douala extreme rain fall event which is stated by projection until 2050, this shows the intensity of this rain full with definitely decrease, though an increase of frequency is pictured ahead. The Douala region also has a coastal nature with a significant present of water and mangroves. This is mostly seen around the bang of River Worri estuary. As shown below, it is usually not a surprise to experience dwellings surrounding by standing water from rain fall. The city of Douala has very little planning with few sustainable buildings, this indicates a very poor population and hence a high pressure on natural resources and vegetation. Plantations, parks, and agriculture cover only a little part of the area (CLUVA 2010)



Fig 14. Dwellings surrounded by 'scanty water' in Mambana, Douala (photo by Rodrigue Aimé Feumba).

2.6. Douala Pattern of energy use

As energy is said to be located at the center of every economy in a country. Douala urban city has had a sharp increase in construction industry since the 70s with public building experiencing a huge surface area. Energy efficiency in such huge building as public building has been a key concern affecting the environment and its development.

Within Douala urban city, housing and industry remain two areas of high energy consumption. The most important objective of a building is to provide its inhabitants with a comfortable indoor climate in the respect of energy efficiency. On the other hand, the industrial decision-makers are always in search of techniques allowing them to produce more, while consuming less energy. Many works proved that more than 2.3 billion people count on wood or charcoal for cooking and heating of buildings (Goldemberg 2000; IEA 2010).

The use of such means for heating and cooking has made the Douala urban area less environmental friendly and less urban planning constructed (Modeste, Kameni et al. 2015). Environmentally friendly urban planning should determine the optimal amount of energy production through compact demand forecasting and construct an energy saving structure through energy supply planning using clean energy resources in

the urban planning stage. It would not be wrong in the first step to energy efficient and energy saving supply planning to deduce a compact energy demand by considering the safety ratio as well as consumption closer to the actual consumption through precise energy demand forecasting in the urban planning stage (In-Ae Yeo et al 2013)

Douala urban energy demand fluctuation hugely depends on its consumed energy in relation to its urban town planning and also on the city climate and geographical condition.

According to Kameni 2015, Degree-day methods are simple yet efficient and fairly reliable for quantifying the heating and cooling energy demands in a building. Estimations are accurate if the internal temperature, thermal gains, and building properties are relatively constant. The severity of a climate can be characterized concisely in terms of degree-days. According to a recent survey carried out in Douala by Kameni 2014, it has been found that the temperature of human comfort varies following the seasons. The threshold temperatures vary for different conditions and as a general rule, the range of 19°C –25°C is proposed for human comfort. In order to estimate the amount of cooling needed in an N-day definite period, equation (1) was used.

$$CDD = (T - \theta_2), \theta_2 = 25. (1)$$

In equation (1), the CDD is the required amount of cooling and T, the daily mean temperature. The temperature threshold θ_2 considered for Douala is 25°C.

In order to calculate the need of θ_2 to heating, equation (2) must be employed.

$$HDD = (\theta_1 - T), \theta_1 = 19. (2)$$

In this equation, HDD is the need for heating on the basis of degree-day; T and θ_1 have the same concept as in the

previous equation and regarding Douala's conditions 19°C has been chosen as the temperature threshold.

The heating degree-days (HDD) and cooling degree-days (CDD) can be defined in accordance with (SIA Standard 1982; McCarthy et al. 2001; ASHRAE 2009) the equations (3) and (5):

$$\text{HDD}(\theta_i, \theta_{th}) = \sum_{k=1}^n (\theta_i - \theta_{e,k}) \quad (3)$$

Where θ_i is the internal temperature, $\theta_{e,k}$ the daily mean external temperature, θ_{th} the threshold temperature for heating, and k is the day number in the year.

In this sense, the annual heating demand of a building Q_h may be written as equation (4):

$$Q_h = K_{tot} \text{HDD} - \eta Q_s \quad (4)$$

Where K_{tot} is the total thermal loss due to transmission and infiltration, Q_s is the internal heat source and solar gain and η is an efficiency to factor in the share of Q_s that serves to reduce heating demand.

In equation (5), θ_{tc} is the threshold temperature for cooling:

$$\text{CDD}(\theta_{tc}) = \sum_{k=1}^n (\theta_{e,k} - \theta_{tc}) \quad (5)$$

Finally, it is interesting to note that, if building properties are assumed to be constant, the cooling energy demand is proportional to the number of CDD.

Hydroelectric production contributes to 88% of energy production with an average capacity of 817 MW while thermal power generation makes up the rest of Cameroon energy production. With the above rate of power, central electricity generation company (AES SONEL) has three major

hydroelectric plants, two of them feed the South network (RIS) and 9 thermal plants connected to the grid, including eight (8) debiting on the RIS. At the end of 2011, one could count 26 isolated plants, which 12 built in the regions supplied by the RIS, 8 in the northern areas served by the north network (RIN) and the 6 remaining others were established in the area of East network (eastern region); by analogy to RIN and RIS, the latter will be designated by RIE, especially as it is expected to have a supply of 90 kV from the Lom Pangar dam as from 2016. Over 56% of the electric energy use is concentrated in the large area of the South (RIS area), with 83% of the main stations connected to the network and 44% of isolated plants; this therefore should reflect a relative importance of the electricity demands in the great south network.(Metegam et al 2014)

Douala uses relatively more energy per unit of economic output than the rest of the regions, regarding social and economic framework, the primary energy supply is mainly from the state runs hydropower station which is being transported to various sectors within the urban city. Though, Douala city fails to use many of its energy potential which could enable the efficient use of energy.

2.7. Legislation, policy and regulation guiding use in Douala

The government of Cameroon said to have certain policy which will improve the countrys poor energy situation. This development is considered to happen by creating and implementing a good energy plan underneath the long-term sector development plan (PDSE 2030) and the poverty reduction strategy paper (PRSP) Reep Cameroon (2012).

The government of Cameroon views the energy sector as a tool for attracting investment and strengthening growth with more emphasis given to the country's hydroelectric potentials which is being considered the second highest in the region of the central Africa after the Democratic Republic of Congo (DRC).

One of Cameroon's government 2035 developmental objective is to enrich the energy sector by increasing the present GDP of 17% to 47% by the year 2035. Regarding these objectives, increase in electricity production is the country's main priority. Oil and gas delivery is also one of the country's prime objectives to bust the economy though by environmental point of view this is considered non-renewable.

The ministry of energy and water in Cameroon commented in 2005 the development of a new energy plan by 2035. This developmental initiative by the government is focused on investing in RE and is believed to enhance energy independence and economic growth. Though with these objectives, there is literally no direct policy or guideline regarding RE development in Cameroon. Though many laws have been enacted by the ministry of Energy and Water to deal with aspects which will increase RE both mini and micro hydro production. The government of Cameroon is strongly focused on hydro power production though having several potentials of other RE sources that could be explored. These RE potentials could basically be seen in cities such as Douala urban area and the capital city Yaoundé where installation of solar panels is placed on electric poles on the street for powering and illumination of the localities.

Despite having many renewable energy potentials in Cameroon, there are lots of odds facing this development. One of these challenges is the political unrest in the northern part of the country which threatens the security stability in this part of the country. Some of the reasons for lack of RE potential in the country is the lack of technological development and also unskilled experts in this sector. Lately, the major problem with RE production in Cameroon is known to be the political hold back.

Unlike many developed nations which have adequate policy on developmental framework, there is always the policy of maintenance in

every installation after a specific period of time, in Cameroon, even with its solar PV installed on street lighting poles in some parts of the country yet there is no proper policy in maintenance which eventually erodes or wipes out any development to that aspect.

Regarding legislation of Cameroon regulatory framework, Reep Cameroon (2012) opines that “Instead of specific legislation to promote renewable energy in general or specific clean technologies, there is rather a general legislation concerning the electricity sector. In its title IV, Chapter I, the law n°98/022 of 24 December 1998 governing the electricity sector, ARSEL and the REA are in charge of the promotion and the follow-up of the use of the primary sources of energy, in particular renewable sources.”

According to Kameni (2013), the Cameroon government commented in its new law on energy production that, a chapter has been dedicated to renewable energies. Notably for the facilitation and the guarantee of acquisition of productions. Cameroon is the second-most forest occupied region in Africa with an area of about 21 million hectares as estimated in 2006 (MINFOR ET FAO 2005). 98% of the poor households still use firewood as their main source of energy (MINEE 2004).

The reserve of natural gas in Cameroon is estimated to be about 186 billion m³. Second hydroelectric potential in sub-Saharan Africa with an amount of 19.7 GW is attributed to Cameroon. Sunshine average is of 4.9 kWh/m²/j, but its exploitation remains weak.

The law number 2011/022 of December 14, 2011 governing the electricity sector in Cameroon dedicates the support of the state to the promoters of renewable energies, notably in its articles 63–67 (ARSEL 2013). Douala is the most industrialized city in central Africa and at the same time the city most affected by the climatic change in Cameroon. The methodology used in this research is described in detail in the survey of Christenson (2006).

The AER known as (Agence d'Electrification Rurale) create and govern energy regulations in Cameroon. It is also responsible for formulating policy and provides recommendations for rural electrification for the Ministry of Energy, as well as producing management schemes for rural communities in relation to electricity access.

The institutional environment of Cameroon does not encourage private investment. Insufficient investment regulations and a lack of standards and quality control mechanisms make it almost impossible to collaborate with traditional financial institutes.

It is therefore very difficult to establish a national market for renewable energy. Unreliable infrastructure, insufficient distribution networks, anticompetitive commercial framework as well as administrative bottlenecks and financial insecurity are the most significant risks and barriers. (REEEP Cameroon 2012)

3. RESEARCH FRAMEWORK

3.1. Case Study – Douala Cameroon

This research used the case study approach, a chosen urban area to examine the potentials and its effectiveness of the said current urban area, its policies, frameworks and barriers. This chapter will give the study approach of the case.

The case study approach will also give the possibility to engulf the rural and urban energy production and electrification with concentration on urban energy production i.e. Douala urban municipality of Cameroon. This will give a good understanding to the renewable energy potentials of the case area also, the challenges and the sustainable mechanism attributes to the urban energy.

Charles Schell (1992) stated, once a body of research evidence has been accumulated, particular issues can be focused upon using selective case studies - other data, provided by other forms of research such as surveys, can be corroborated and illustrated through more richly detailed and precise accounts. The value of the case study is measured by the degree to which the incidents discussed can be regarded to other situations. Moreover, this method gives a clear understanding of the present factors and barriers in relation to renewable energy and energy security. Whilst on same note, this illustrates the current energy market state within the Douala urban area

3.2. Renewable energy potentials

- Hydropower

Hydropower remains the main energy source in Cameroon with some energy potentials in the Douala region. The total energy production is estimated to approximately 23GW, the production power per annum is approximately 103TWh. The major hydro generation in Cameroon is located within the Littoral region where Douala remains the capital. In the

Douala Urban area, Hydropower account to significant energy supply which could enforce the already existing energy Wirba (2015) opine that, there is lack of good governance in developing dams. Tariffs are not well defined to attract investors.

There lack of accountability from the government making it difficult to enforce certain rules and regulations. The quality of maintenance of hydropower dams is below average and the production plant operates with performance rate inferior to 55% [20]. Though hydro power remains the largest means of production in Cameroon and to the Douala region in particular, the government is required to embark in good ways and more updated technical, economic and environmental aspect to enhance this source of production.

- Solar Energy

Solar energy is the main renewable energy means in Douala due to its high rate of sunlight. This area could also play a key role in the development of energy. Douala is estimated to have approximately 5.8kwh/m²/day. This energy source is partially being use with the Douala urban area with just 50PV installation presently. With the solar energy production, the major setback remains the lack of technology.

- Biomass Energy

The Douala urban area is also known for its huge forest reserve where many forest and timber companies are said to locate for wood process and exportation. Biomass is seen as having great potentials that could help the energy sector and thus, maximize the use of urban waste in wood processing.

Wirba (2014) opine that biomass is mostly use in all sector of the economy in Cameroon i.e. industrial and residential. Biomass provides around 75%

and up to 90% of the energy requirement in residential and in the industry sectors respectively. There is also huge utilization of palm oil for production of biodiesel mainly used for agricultural purposes. Furthermore, Abanda (2014) argues that firewood in remote area is being depleted without being replenished and that had led to many challenges of energy affordability and environmental impact. Therefore, other RE sources would have enormous environmental and energy potential.

- Wind Energy

Regarding wind energy, Douala has a fringe with approximately 2-4m/s at 100m height. This urban area is known to have some very excellent sites where wind turbines can be installed.

- Geothermal Energy

Geothermal energy is one of the many potential in the Douala urban area though this energy production has not be harvested. Komendantova (2012) argues that, in developing countries the state-owned electricity enterprises are characterized by low labor productivity, inadequate investment, and an inability to provide services to large groups of the population (World Bank, 1994). Several state owned electricity utilities have suffered from huge financial losses, and have experienced frequent supply interruptions, with resulting major losses to the economy (Boardman & Vining 1989).

Politically motivated interference by the government in enterprise management has caused losses from inefficiencies, under-pricing policies, a lack of maintenance, and poor operational performance (World Bank, 1994). For this reason, during the period 1990–97 more than sixty developing and transition countries engaged in some sort of privatization of their electricity sectors.

3.3. Scenarios to enhance renewable energy in Douala

Energy Systems Scenarios

Scenarios is referred to RE and ES concept as an approach which gives a view to the future and its environment, scenarios also pave the way forward to future planning for better development. Though this seemed to be a preview to certain vulnerability, it does not always result in entirely satisfied strategists and specific details as seen in this research above. Different scenarios were also investigated.

Regarding energy systems scenarios, WEC's (2013) stated, to better understand and ultimately cope better with this increasing complexity, integrated system modeling will deserve more attention in the future to provide a more holistic view and lead to a better understanding of complex energy systems. Oil and natural gas remain a dominating means of energy to the Douala community with huge critics to this fossil fuel impact, it is ideal to anticipate an increase in renewable energy to meet the demand for energy in this region and to reduce the growing effect to climate change.

Energy Efficiency and Technology Scenarios

Energy efficiency scenario is a major concern in dealing with demand and supply in the Douala region. This scenario indicates that energy efficiency and energy conservation should stick simultaneously to solve the energy efficiency problems in the Douala region.

In this scenario, there must be some changes with the end users' needs and also in cost efficiency. This scenario also provides possibilities to greenhouse gas reduction (GHG), Douala region being an industrial zone within Cameroon, the government of Cameroon needs to play a major role in meeting the country's 2035 climate target by implementing actions and given the right incentives and technological solutions to major industries where energy is their prime need in order to achieve an emission target.

WEC (2013) argued that, governments should be aware that promoting new technologies through subsidies such as feed-in tariffs can also lead to 'energy market bubbles'.

Re Market Scenarios

According to Cameroon county report (2006), the increase in electricity consumption will have a sharp positive curve of about 7TWh by 2020, the report went further to explain that, "This is an extrapolation of the electricity consumption of 2003 and the expected energy growth as explained in paragraph"

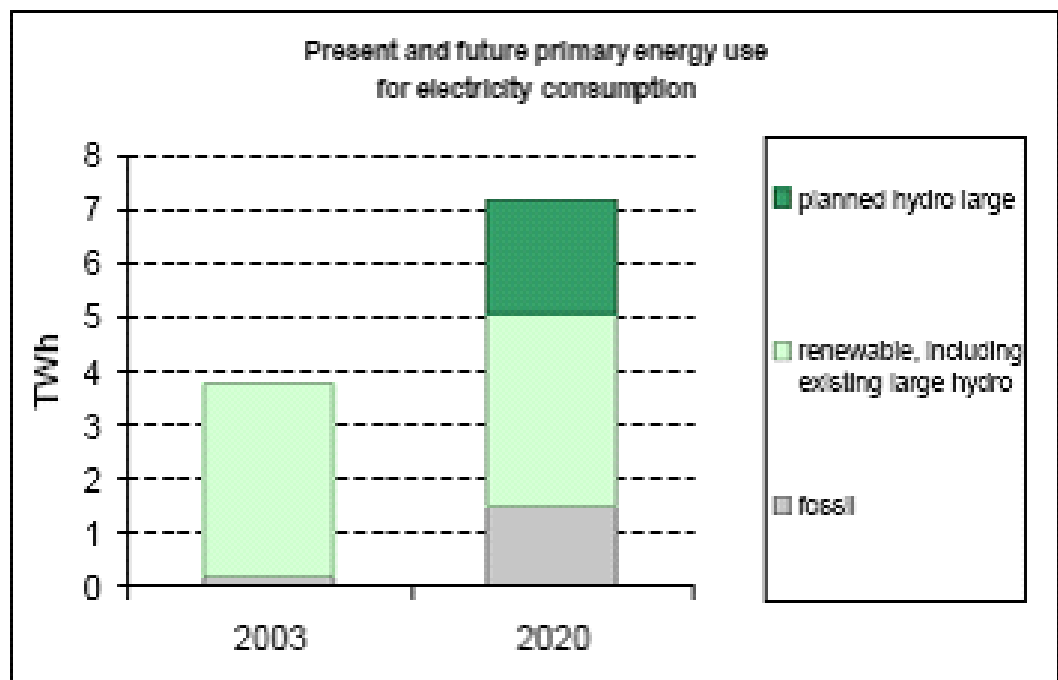


Fig 15. Primary energy used for the electricity consumption and the RE part

These scenarios examine each market technology combination and market drivers which seem to be a future key component for development within Cameroon and Douala region in particular. The Market technology

scenarios will assess the effect of a reference scenario which actually examines the future development if the present situation remains unchanged.

The renewable energy potentials country report (2006) explained that, since mid-2005 there is no consensus about the expected increase of energy cost. The impact of high energy cost on cost-effectiveness of renewable energy will of course be high. However, the influence on finance availability in developing countries will mostly be negative. Because this study does not consider oil price scenarios it is not taken into account that the energy prices will remain at the high level of end 2005 and rise from there.

The curve beneath, explains the RE yearly increase rate which states as a significant parameter to oversee the REMP.

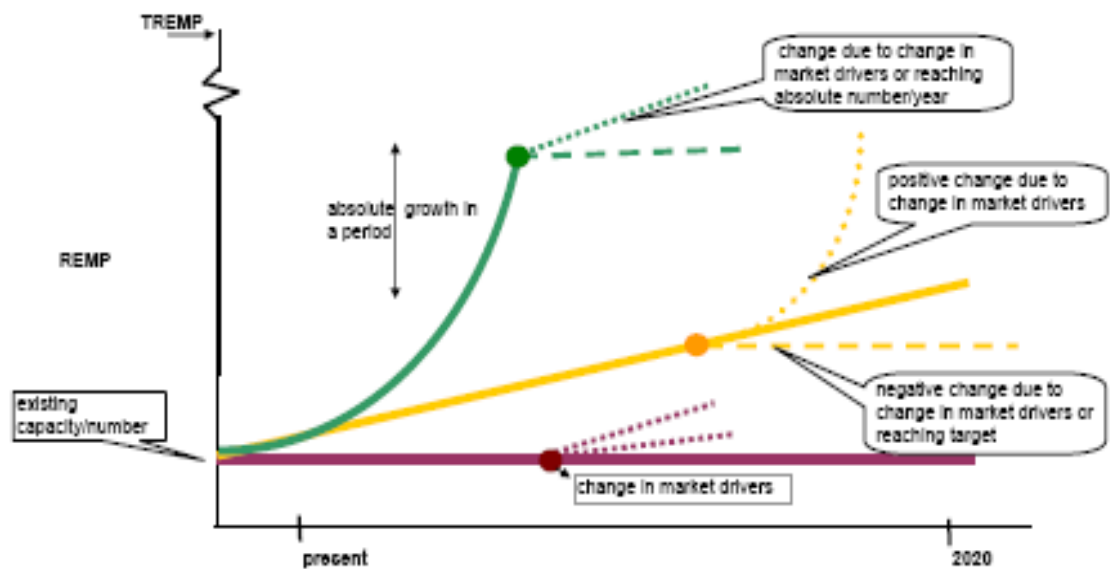


Fig 16 Curves of the market growth

The yearly growth rate of RE technology is based on the market drivers as seen above in account to the present capacity.

3.4. Carbon footprint in Douala urban Area

Carbon footprint in Douala urban area is seen as an increase in the increase in population growth. This also causes the high consumption of fuel wood, charcoal, gas and kerosene used in domestic cooking and lighting. Carbon emission in Douala is as a result to inappropriate technologies in some main manufacturing or distribution of primary energy within the slums in Douala urban area. Within this area, slum dwellers mainly woman headed households utilize high carbonize product for electric use which is not sustainable energy. This generates an immeasurable increase in carbon emission. This carbon emission can only be reduced by the establishment of a local green energy market by the slum dwellers.

3.5. Enhancing energy security and address climate change in Douala

Energy security and climate change has a cross cutting edge in between which needs a common solution in addressing it. Within the Douala urban area, the lack of energy or power generation to the urban dwellers is seen as the core cause of high carbon emitted fuel supply chain where by a total dependence in states own energy supply could not be a factor to the climate change and energy security equation with this area of research.

RE generating technologies which is believed to combat the high increase in climate change is seen as just one means in fighting greenhouse gas (GHG) emission and increase energy security. Climate mitigation aspects such as creating awareness and encouraging low carbon domestic sources in within the urban dweller in Douala will give a significant boost in enhancing Energy Security and Addressing Climate Change.

Raphael (2008) argued that, a broader view of energy security concept can be explained by some major setbacks as could be seen in the table

underneath. The table below shows the interaction between climate change, adaptation policies and energy security.

Table 3. Elaboration, adaptation policies based

Adaptation policies	Interaction with energy security
<i>Water resources</i>	
River basin planning and coordination	Flooding of nuclear reactors
Contingency planning for drought	Cooling for thermal power plants
Marginal changes in construction of infrastructure	Energy infrastructure / flexibility
Options for new dam sites	Protection of nuclear reactors
<i>Sea-level rise</i>	
Plan urban growth	Energy infrastructure / flexibility
<i>Forests</i>	
Diverse management practices	Biomass
<i>Agriculture</i>	
New crops and seed banks	2 nd generation biofuels
Increase irrigation efficiency	Biomass/biofuels
Liberalize agricultural trade	Free trade of bio-energy products
Drought management	Biomass

(Smith and Lenhart 1996, 200)

3.6. Renewable energy, a resilient mechanism for Douala urban area

With the high price in hydro energy in Douala urban electric use, the use of fuel wood and other none renewable sources of energy has increased. This none GHG energy consumptions in its enormous use has a negative impact to Douala urban dwellers and its environment. Though RE sources seem challenging, however it is the best resilient mechanism to Douala urban area with its many potentials. RE if exploited with good technology will enhance the already energy supply in the urban slum whereby, they

will benefit economically with increase in employment, positive edge in market potentials and will definitely attract other stakeholders to invest and design good policies to enable the continuous and sufficient flow of energy to the area.

4. RESULTS

4.1. Interviews

Hirsjarvi and Hurme stated that, Interviewing is a flexible research method and especially when it is carried out orally it gives opportunities for interaction and directing the data collecting. It enables a chance for repeating questions if necessary, correcting possible misunderstandings and making conversation with the interviewee openly. (Hirsjärvi & Hurme 2000, 34-37, 73.)

During this research, interview was carried out. The respective interviewed individuals choose to remain unnamed due to personal reasons. Three interviews where carried out in three sectors, the Ministry of Energy and water (MINFE), The Cameroon energy producer (AES-SONEL) and the Ministry of Public health.

Ministry of Energy and Water (MINEE)

Cameroon Ministry of Energy and Water Resources (MINEE) is the ministry in charge of the country's energy and water sector. This ministry work towards a sustainable developing and diverse way. Minee operates all the country's natural resources such as hydro potentials, petroleum, downstream refineries, and natural gas reserves.

Cameroon and the world energy partners are working on ways to improve various means regarding energy in the country and particularly in urban areas. Most of this projects will act in a sustainable way of enhancing in the country's energy crisis both in long and short term respectively. These sustainable means of energy will involve the building of some dams in a major river such as Sanaga river which is situated at Lom Panger along the Eastern part of the Country. The construction of this dam will cost the state some 1.3 billion US dollars and will enable the production of some 170 MW of electricity and will boost the energy output in the Littoral region with Douala as its capital.

The Government is in the process of building a dam at Memvele with a production capacity of 200 MW along the Ntem river. In line with these sustainable initiatives to enhance energy in Cameroon, the government also aimed at increasing the access of social services and industries to improve in the sustainable energy approach

- This will improve the regional grid inter-connection.

- Enactment of development in new hydropower electric generation while still aiming at having the following diversity of sources in ratio of 25 – 30 % thermal and 70 – 75 % hydro.

- Providing adequate materials and means to speed up modern energy services mostly in rural areas.

- The government of Cameroon also has a goal by 2018 to Re-develop the transmission grid of 225KV and MW substation through the Edea – Douala and Baffoussam -Yaounde -Edea loop. (MINEE 2016).

AES–SONEL

The energy production company in Cameroon is known as AES-SONEL S.A (American Energy Supply Company). This company engages in in the generation, transmission, and distribution of electrical energy in the country. AES-SONEL operates energy plants in Cameroon which involves hydro, thermal, and isolated plants.

AES-SONEL was founded in 2001 by the American AES with its headquarters in Douala. Recently, AES-SONEL has officially been named as Eneo Cameroon SA (Energy of Cameroon) This name change follows a British private equity investment firm, Actis which has officially taken over the electricity sector in Cameroon.Cliffs. (AES-SONEL S.A 2016)

At the Cameroon energy production headquarters in Douala an interview was carried out with one of its product management staffs who agreed to remain un named. The primary intention of this interview was to

understand the various methods used to improve energy security in the Douala region. During this process, some plans were noted as to improve the main generating capacity of the regions hydro plant in Edea and to build several energy plants in other locations in the country namely, Lom pangar storage dam with capacity of 170MW, Song Dong with capacity of 280MW and Memvele with capacity of 200MW.

The Cameroon energy management plans to generate about 20 MW of energy through the Littoral and the south west region of the country. With the country's energy consumption of about 0.4 toe, this energy in addition will add to the existing energy. This 20 MW energy will be generated through heavy oil fire plants namely in Kribi with capacity of 150 MW, Limbe with 85 MW and in Logbaba Douala with about 17.6 MW capacity.

The Government under the ministry of energy and water is already in the process of a 50 MW thermal gas plant in the Douala region situated at Logbaba which began in April 28, 2015. The pressing need for this energy production is to have the electricity supply and its demand in an equal scale during the dry season where the rivers suffer from very low flow of water with a negative impact to the electricity output.

Ministry of Public Health (MINSANTE)

The Ministry of Public Health in Cameroon is responsible for the maintenance of all public health services. The ministry of public health ensures a universal access to modern energy services in the country's health facilities in order to improve health and well-being. While conducting an interview with one of the directors of the Reference hospital in Douala who spoke on condition of anonymity said, it is evident that Cameroons health care institutions lack energy access. He noted that the government of Cameroon needs to multiply the rate of energy efficiency with the renewable energy.

Commenting on the energy statistic in Cameroon, electricity access data in health care facilities are rarely measured in both the public and private

sectors. Thus, health care facilities are unable to power laboratory equipment's and machines such as ultrasound, incubators, and X-ray machines. However, electricity shortage is evident such that, reliable, and rapid diagnostic testing cannot be carried out which could prevent most of the medical emergencies. The lack of sufficient electric supply has caused a negative impact on child survival rates also, the lack of good storage capacity of vaccines, blood work.

An unprofessional way of carrying and protecting blood test due to poor electricity supply in hospitals refrigerators can cause loss of effectiveness. Mostly in other private health centers, refrigerators are thought to have an unreliable power supply of electricity.

4.2. Description of analysis Methods

For a better energy future in Douala urban area, some major setbacks need to be identified for long term.

- Identify the elements that could strengthen ES provision,
- Identify weaknesses that hampered ES provision process.
- Identify elements with huge opportunity to improve ES.
- Identify elements that pose possible threat to ES

The S.W.O.T Analysis is used to clarify the above mentioned identification.

The S.W.O.T analysis on Renewable energy and Energy security



Fig 17. SWOT analysis (own creation)

Figure 17 shows a stronger competition with state run energy firms and possible urban town planning restructuring are the visible threats in the Douala urban area. Increased in RE by individuals and other stake holders will definitely create an atmosphere for competitiveness with the major energy sources. The great energy potentials with excellent capability and possible tourism potentials is identified as the strength to RE with the urban area.

On the other hand, many opportunities are seen with RE and this gives ways to sufficient energy flow to the Douala urban dwellers. It will generate new market possibilities and will definitely open doors to employments. However, there are also negative weaknesses which may hindered these such as development, lack of technologies, poor expertise, lack of harmonized and policies and financial setback are possible weaknesses to this effect. In addition, certain issues however, can be adapted which may help in improving the possible threat and weaknesses.

Interpretation of M.O.S.E.S analysis

The international Energy Agency (IEA) has taken energy security to be it's opt most concern of assurance. The different threats posed to energy

security from natural, economic and political factors. These negative factors affect every energy source and infrastructure IEA (2011). With the difficult state in which energy security appears to be in recent days, IEA created a comprehensive analysis which will enable the swift responds to the challenges. The model analysis of this short term security of energy is known as MOSES. This model acts as a tool that combines and interprets energy security indicators in a more chronological manner.

Though MOSES analysis is created to enhance short term energy security solutions in IEA countries, other countries internationally (developing nations) have been adapting this model for understanding the challenges faced by energy security as related to the case of Douala urban area.

Douala urban area energy production suffers significant negative effects in almost all areas in it energy framework. MOSES analysis explained a system approach on how to deal with the various parts of vulnerable energy system. Mostly, energy system in urban and rural areas is well known for some weaknesses as seen in the first analysis in Douala urban area. This system includes transformation, distribution and end user energy service such as lighting and cooking. The figure below explains the energy system approach analysis by MOSES where it assessed effect on security of production, security of electricity and also that of the end user.

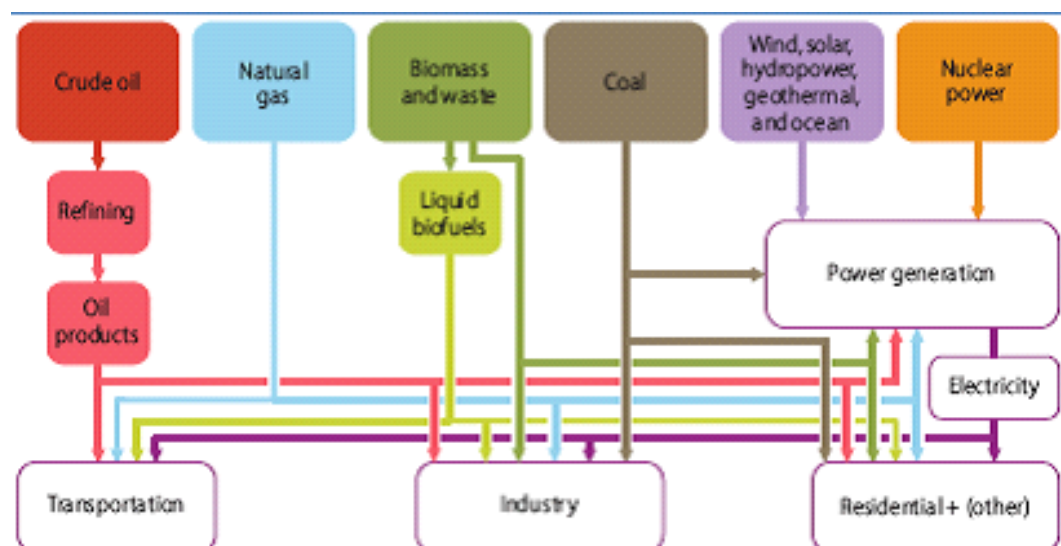


Fig 18 Energy system approach

By helping policy makers identify and understand strengths and weaknesses of a particular energy system, this systematic approach can be used to formulate strategies and policies for decreasing vulnerabilities and increasing resilience, targeting different elements of energy systems or their interconnections. (IEA 2011).

Moses analysis was designed to enable the vulnerabilities of short term energy security, it went further to restrain the edges of other energy systems to increase the responds to energy security. Douala urban energy system will enhance in the design and policies together with possible insights to avoid the risk to its energy system in a short term. This framework will act as a resilient mechanism to provide system control for Douala urban energy disruptions. MOSES also examine different energy security as in the table below.

Table 4. Dimensions of energy security addressed in MOSES

	Risk	Resilience
External	External risks: risks associated with potential disruptions of energy imports.	External Resilience: ability to respond to disruptions of energy imports by substituting with other suppliers and supply routes.
Domestic	Domestic risks: risks arising in connection with domestic production and transformation of energy.	Domestic Resilience: domestic ability to respond to disruptions in energy supply such as fuel stocks.

External and domestic factors analyses in MOSES reflect both risk exposure and resilience, the ability of energy systems to adapt to or withstand disruptions.

4.3. Importance of energy security in Douala

According to IEA, energy security has proven to be an important global issue, this problem have troubled the globe since the 70s.

Energy security, urban electrification and sustainable development remained a key issue to Cameroon's concern to the nation. One of the biggest vulnerability of Douala urban area today is its energy insecurity. Okeke, argued that, every developed economy is built with the realization that a sustained availability of affordable energy in its various forms is fundamental to the provision of jobs, food, health services, education, housing, clean water and good sanitation. The truth, argues that, energy security is the foundation stone and the pillar, upon which every advanced world economy is built. (Okeke 2014; Orazulike 2012 ; Adisianya 2010)

One cannot expect to succeed in creating jobs without first solving energy problems. In fact, energy security is the main catalyst to job creation. All economic activities: the industries, the factories, the schools, the businesses, the markets, the hospitals, the service companies, the hotels, tourism and all the public and private sectors need constant energy to function effectively (Adisianya 2010).

Energy plays a significant role to the economy of Douala and its industries where majority of the country's employment is centered. According to Oyedepo (2012), energy plays the most vital role in the economic growth, progress, and development, as well as poverty eradication and security of any nation. Uninterrupted energy supply is a vital issue for all countries today. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible, and environmentally friendly (Oyedepo 2012).

Energy security is an important factor to the Douala urban area, it acts as a tool to enhance many of the Municipality's vulnerabilities due to the lack of constant energy supply. A robust and a more secure energy and

strategic planning is required within the Douala urban area for both short and long term need. This frame work will guarantee the present and future energy and urban development to this area. Presently, Douala economy suffers a huge problem with the energy sector of its economy and has severely affected the general output of the economy.

Looking at the energy warfare in Douala, apart from the community's high financial loss, energy crisis has been an underlined issue to health hazards due to the exposure to co2 emissions which is generated from local energy use. Oyedepo (2012) state that in different households and business enterprises, unemployment and high cost of living leading to a deterioration of living conditions.

With consistent supply cuts in Douala, the reason to adapt an energy security planning will be a considerable motivation to all area of the urban area at large. Raphael 2008 states that "Energy security is a state in which consumers and their governments believe, and have reason to believe, that there are adequate reserves and production and distribution facilities available to meet their requirements in the foreseeable future, from sources at home or abroad, at costs which do not put them at a competitive disadvantage or other wise threaten their well-being." (Belgrave 1987, 2).

4.4. Challenges related to energy security in Douala urban area

Most related challenges regarding energy security in Douala urban area has often been the case of lacking in major exploitation of other possible potentials derivatives that are necessary for supporting both domestic and industrial consumption of energy use. It is also recognized as one of the main hindrance to energy security in the Douala region, this has also affected all or most of the sectors with huge effect on local businesses

area the region. Such issue needs to be tackled in other for the inhabitants to pave a significant way forward to energy security.

An effect to the energy security ideology within the Douala region has often been the issue of state energy company having monopolized the energy sector and do not give any room for growth and build up of other mini or mega sources of energy production. In Cameroon and Douala in concern, energy power generation is strictly under the control of the national energy producer (AES SONEL). To break through the energy security challenges, such rigid policies need to be change and reformed.

Renewable Energy Related Challenges in Douala

According to Nadejda (2009) in face of the relatively high costs of renewable energy technologies, several decision-makers were not sure about whether renewable energy expansion would be a positive influence on the local economy and society. Governance and administrative factors were often seen as barriers to investment. The Douala urban area has huge renewable energy potentials, there are lots of challenges which face these prospects such as lack of technology and stakeholder's interest in investment is seen as a major setback in the renewable energy development.

Mas'ud (2015) stated that, there is high capital cost for the initial implementation, lack of adequate skills in the sector and lack of political will from the government. Though, solar PV has been applied for street lighting in some part of Cameroon, poor maintenance has crippled the process.

With the vast potentials of renewable energy which is still about to be produced in the Douala urban area, this will definitely be a positive advantage to the regions energy mix if investment is concentrated to this area. In addition, Douala has significant potentials of geothermal and solar

potentials but is currently faced by issues related to land acquisition and evacuation infrastructure.

All the energy thus generated, should be fed into the national grid, creating adequate mix of energy, from the different sources and having a compact energy development process, which will be suitable, sustainable, constantly available, environmentally friendly and economically viable in the long term national energy plan. Cameroon electricity is mostly depended on hydroelectric power stations which is not evenly distributed, with only 20% of the population having access to the national grid.

It is obvious that Nigeria and Cameroon are facing challenges regarding the electricity sector, whereby the demand for electricity exceeds the supply. Several measures are put in place to improve the situation, so far there is no tangible result. It is a clear indication that RE can play a role in meeting the future energy demands of these two countries if both governments can fully utilize the abundant RE potentials.

A major challenge to RE in Douala urban community is the lack of full government contribution to major investment in RE projects while locals and other stake holders continue to rely on state investment which has so far proven to be unsustainable and less attractive to private investors. Also, the lack of policies and financial investments has proven to be a major setback for RE development in the Douala urban area.

Policy implementation is seen as one of the many hindrances to these developments which has limited the enhancement to the business prospects of RE in this urban area. Most developmental projects around the world have been successful due to the implementation of standards and quality control mechanism in every sector. In the case of Douala urban area, there has been the absence of the above concept.

Douala metropolitan area also suffer less availability of reliable infrastructure in the energy sector which could stimulate the development of RE potential in this area, though RE have a lot of potentials in the Douala Urban area, this area may contribute a significant amount of renewable energy.

5. DISCUSSION AND CONCLUSION

5.1. Conclusion

In conclusion to this research, a wider knowledge and concept of energy security is needed to incorporate the tangible relationship between energy security and climate change. It was noticed that energy security is about financial ability and consistent frame work which include good technology. Climate change and related issues have been a point of focus, energy has appeared to be one major concern linked to this conceptual discussion with Douala urban area. It is clear that, Douala urban area has great potentials of RE which have not been fully exploited while most concentration is based on hydro energy production. From the view point of this research, RE can contribute significant urban energy demand and supply.

Though policy makers in the country at large have not produced any frame work in improving RE, one main setback to RE production in Douala urban area is financial ability and also technical knowhow. Douala is an area which is well equipped with sufficient materials for biomass whereby, if developed, managed and maintained will have significant impact to Douala Urban electrification. IEA (2011) stated that, 21 century needs a vital, adequate and affordable energy mix which is a means to achieve energy security. However, the leaders in Douala region needs to solve issues such as corruption before establishing any adequate policy framework and reforms to enable a concrete energy build up in Douala urban area.

In order to measure the potential of RE in Douala Urban area this study found out that some basic problems needs to be evaluated. In addition, these thresholds are used to indicate the specific access to exploit RE. Though from a strategic point of view, no concrete policies and planning framework are designed to enhance ES with RE in this area. Furthermore,

this studies provide means to analysis some perception for long and short term RE and ES in urban areas.

5.2. Recommendations

As urban areas in mostly developing countries faces rapid growth in population, a significant increase in energy consumption is seen in the supply and demand phases of energy production. Regarding the demand phase of management process of energy potentials and production of sufficient and efficient energy, proper and holistic manner is needed to address this aspect, there is urgent need to take into consideration proper ways to enhance ES, mostly in developing countries as the case of Douala urban energy production which suffers great deficiency to this regards, as proposed energy exploit potentials are concern. With the help of good policies, innovation in technology, skilled manpower will make Douala energy sector economically as well as environmentally sustainable.

To enhance urban energy security through renewable energy solutions in Douala urban area, adequate assurance need to be taken regarding a sustainable energy production which will meet the desired requirements for its urban dwellers as specify in this recommendation. A holistic relationship needs to be established between the energy stakeholders and the local community in other to identify the publics need regarding energy services in the locality. The public should be given the audience to address negative practices executed by some urban energy practitioners while grating awareness of GHG usage.

As a result of rapid urban growth, Douala urban town planning suffers a negative effect in developing energy within its slums. Community authorities should be able to ensure a proper urban town planning which will enable energy development to be improved in those areas in a more coherent approach. The authorities should have a constant review on the supply and demand phases of energy production and end user's needs, in other to address immediate possible problems. Douala urban area needs

a long term energy production goal, within the urban planning phases such as ES enhance by RE solutions, this solution will address both the short term and long term energy crisis within the urban dwellers.

Lastly, funds need to be allocated to improve the energy sector. Thus locals or residents can aid in maintaining urban energy and electrification within the urban vicinity with local methods such as small scale energy generated from solar system or biomass. Local authorities need to implement legislative framework to enable good strategies in addressing ES in the urban vicinity.

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APPENDIX

Interview questions

IDENTIFICATION

- 1) Code and Age of respondent.....
- 2) Sex.....
.....
- 3) Quarter/ Village in which you reside.....
- 4) Place of origin (Province and Division).....
- 5) Marital status.....
- 6) Family size / company size 6-10 > 10
- 7) Occupation.....
.....

- How effective is the usage of renewable sources the Douala urban area?
- What is the impact of renewable energy sources in the Douala region?
- What are the effects of energy security in the health sector in this region of Cameroon?
- What can be done to balance the demand for energy and electricity in Douala Cameroon to meet supply?

- What plan could be done to disseminate energy knowledge to the Cameroon population?