

Sustainable Energy Policy for Africa (Nigeria) and Europe: A Comparative Study

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Abstract—The purpose of this paper was to develop a policy and associated regulatory actions together with legislations that could help in sustainable energy development in Africa and Nigeria in particular. As a result of depletion of fossil fuels in most African countries, renewable energy options such as solar, wind and hydropower biomass are considered to be alternative sources in sustaining the energy security in the continent and particularly Nigeria. Corruption level is another factor that hinders economic growth and development in Nigeria. A review of the past literature on sustainable energy policy from Europe has been carried out. The countries investigated include: The United Kingdom, Germany, Norway and Finland. Their policies have been examined, and this helps suggest new policies on sustainable energy for Nigeria and Africa as a continent. The policies analyzed focused on incentives such as Feed-in-Tariff (FiT). Renewable energy sources potential and renewable have been investigated in Nigeria and that could help in formulating new sustainable energy policy for the country. Some of the proposed policies includes: Renewable Obligation (RO), Cogeneration, FiT, Carbon Capture and Storage (CCS), Renewable Integration, and Heat Entrepreneurship. These are some of the new policies that could help sustain the energy security, reduce the level of poverty and corruption in Nigeria as well as Africa in general. If these policies are well designed and properly implemented as observed in this research, Nigeria can achieve sustainable energy and economic growth and development in the near future. Each proposed policy was assigned a timeframe for it to be achieved.

Keywords—Sustainability, renewable energy, energy policies, Africa, Nigeria, Europe, United Kingdom, Germany, Norway, Finland.

I. INTRODUCTION

THE purpose of this research was to develop ways in which new energy policies could be formulated for Nigeria and Africa as a whole. This could be achieved through a comparative assessment of other energy policies from some selected European Countries in order to have sustainable energy development for Africa and Nigeria in particular [1].

To achieve sustainable energy development in some region of Sub-Saharan Africa, intelligent use of energy and their resources with a good and careful technological expansion in

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the energy sector needs to be remodified. In addition, appropriate policies must be in place with a proper implementation of them [2]. Promotion and development of sustainable energy policies as well as protecting the environment against pollution and degradation involves a lot of effort especially from the government side [3]. These efforts may include proper and well-modified legislation and policies in energy sector for most of the developing African countries [4]. The policies must focus on enterprises such as low/interest, free credit and other incentives in order to finance and support renewable energy technologies. Good subsidies may play an important role too, as well as encouraging private investors to invest in energy sector [5].

Most of the Sub-Saharan African countries face economic challenges mainly due to inadequate supply of electricity [6]. The shortage of electricity in African developing countries poses a serious problem especially in economic growth and development. For any country to grow economically there must be stable and adequate power supply [3].

In 2009, European Union (EU) formulated binding policies which targeted on 20% renewable energy production, 20% energy efficiency increase and 20% reduced greenhouse gases emission by 2020 [7].

The continuous consumption of fossil fuels is a great concern to our environment together with climate change issue [5]. This has brought about the idea of policy change and amendment in most Europe. These issues have driven them to look for alternative ways to generate energy that is sustainable for the future [8].

II. METHODOLOGY ADOPTED

The research methodology adopted in this research was based on the secondary data obtained from the review of the past literature. Energy policies from Germany, UK, Norway and Finland are being reviewed and examined on how significantly these policies could have an impact on Africa and Nigerian energy sector. The idea was to have insight into the current situation of the energy sector in Africa and Nigeria in particular.

A general overview of previous literature from selected countries in Europe which include Germany, UK, Norway and Finland was also carried out. In this case, their policies are reviewed and how significantly could these policies have an impact on Nigeria and Africa in general.

As a result of ever-increasing in population in Africa, there is also an increase in demand for sustainable energy. This research would try to figure out how could new policies on energy and sustainability helps to integrate both conventional

energy sources (fossil fuels) and unconventional energy sources (renewable energy) for the attainment of sustainable energy development in Africa and Nigeria in particular [9].

Previous researches have shown that Nigerian government will continue to struggle in energy sector unless if something necessary is done in the current policies. The country is running out of petroleum derivatives, therefore, striving to harness all the available renewable resources such as solar, wind, biomass and hydropower is necessary [10]. The technical aspects of the energy production need to improve and the policy strategies needs to be reviewed and amended [11].

There is also a Renewable Energy Master-Plan (REMP) which has both short and long-term target for the sustainable energy in Nigeria. The target of the country is to generate electricity from renewable energy sources for up to 30-35% by 2050 [7].

III. NIGERIAN ENERGY POLICY

The energy policy is a tool which the country used to address the issues concerning energy development of the country. This includes how the energy is produced, distributed and the level of consumption [8]. The major challenge in energy sector of Nigeria is the imbalance between urban and rural areas [12]. The supply of energy is centered only on urban and industrialized areas leaving rural areas isolated. This situation has caused energy disparity in Nigeria and other African countries [13].

The rural dwellers in Nigeria depend solely on firewood as their source of energy which has caused a lot of destruction to wildlife species and deforestation activities within the country [14]. Environmental issues such as pollution and deforestation are of great concern and if proper measures are not taken it will lead to deterioration of the environment [15]. The country is at risk of increasing climate change and global warming due to the deforestation activity and increasing use of conventional sources of energy in the urban centers [9].

Nigerian energy policy comes top effect in the year 2003 when it was first introduced in order to be used as a roadmap for the enhancement of the country's energy future. In 2005, the policies were redeveloped into renewable energy master plan. This development was achieved out by Energy Commission of Nigeria and United Nations Development Programme (ECN-UNDP) [2]. Renewable Energy Master Plan (REMP) was created through a series of meetings with group consultants which was organized by Energy Commission of Nigeria (ECN) with effort from United Nation Development Programme (UNDP). The aim was to look into the energy situation in Nigeria and what are the proper solutions to those problems which could help enhance new energy policy [2].

The ability to create and formulate new sustainable energy policy for Nigeria is of paramount important. This could help balance the situation of the energy crisis in the country from rural to urban areas [2]. The establishment of sustainable energy policy does not mean the country is safe in terms of energy security rather than implying for the way forward. It is

also necessary after establishing new policies to implement them. Most of the world issues relating to climate change and global warming comes from African developing countries. Gas flaring was another issue for environmental concern; this is very common in Niger-Delta or South-Southern region of Nigeria. This situation has made Nigeria to look for other alternative policies in order to protect the environment.

IV. SUSTAINABLE ENERGY POLICY FROM EUROPE

There is increase in demand for electricity in most European countries. As a result of this demand in electricity, most countries have to look for alternative energy sources in order to achieve a sustainable energy development. Most of the developed countries like UK and Germany have progressed rapidly through their policies in the energy sector [17]. Countries like Germany, Norway, UK and Finland are all amongst the leading countries in sustainable energy development in Europe with Germany leading the way.

The interconnection between challenges of global warming, energy security and sustainable and efficient use of the natural resources are among the issues which need to be addressed in a tactical perspective in order to ensure global sustainability in the energy sector [18]. Renewable energy has help these four countries Germany, UK, Norway and Finland to save up to 110 million of greenhouse gases emissions. In the whole continent of Europe, it was recorded that around 220 million tons of greenhouse gases was saved in 2007 [19].

V. SUSTAINABLE ENERGY DEVELOPMENT POLICY FROM GERMANY

Germany is amongst the current leading countries in Europe for energy security and sustainable development. The country has a record of proven reserves of fossil fuels with a hard and brown coal enriched. Germany is well known for their little oil reserves of about 35 million tons as of 2001 and natural gas of about 320 Gm³ as of 2003. The country is endowed with many natural resources in terms of renewable energy potential and they have proven reserves of 66 billion tones (Gt) in 2002 which is equals to 6.7 % of the global reserves [13].

There is a strong and positive shift from conventional sources of energy to unconventional renewable energy. The growth in electricity generation increases from 4.7% to 16.1% which occurs between 1998 and 2009. In the case of biofuels, Germany has excelled too, there is great improvement in transport from 0.2% to 7.0% of transport fuel is coming from biofuels mainly bioethanol and biodiesel [12].

Sustainable development scenario in Germany aimed at achieving certain goals. The target goals include; greenhouse gases reduction of 80% by 2050. This requires a proper policy that support the maximum utilization of all renewable energy sources on both demand and supply. As a result of increasing fraction of the intermittency in renewable energy sources such as wind, hydropower, and solar photovoltaics, Germany wants their energy system to be very flexible in order to ensure stable and reliable energy production [14].

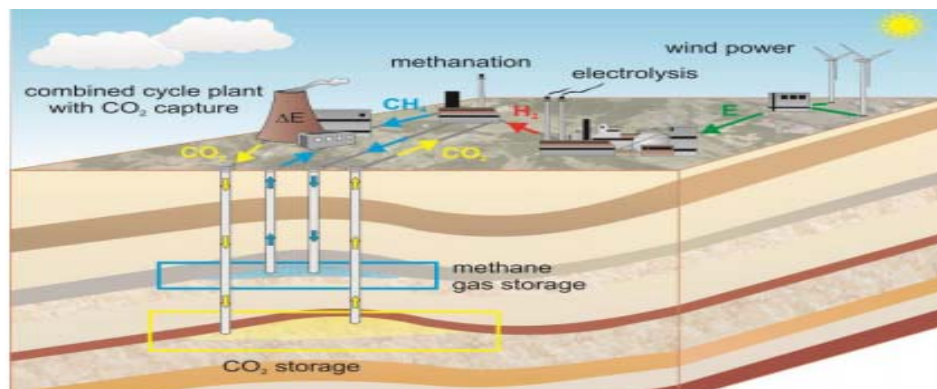


Fig. 1 Integrated underground storage of CO₂ and CH₄ [14]

The Fig. 1 shows the schematic representation of CO₂ and CH₄ to decarbonize the “power-to-gas-power” technology.

The FiT model was established by Germany Act called Renewable Energy Sources Act in 2000. This model has been used by many countries in Europe. The purpose of the Act is to determine how much electricity is generated per kilowatt hour. In 2012, renewable energy has contributed about 12% to the total energy supply and 23% to the supply of the electricity in Germany [15].

VI. ENERGY AND SUSTAINABLE DEVELOPMENT POLICY FROM NORWAY

Persistent and steady public policy administrations are always critical to dynamic changes in the energy production and consumption [5]. The most critical concerns to the environment are pollution, global warming, and energy security [11]. It is therefore important for the public and commercial sectors to make the shift towards greener forms of energy production and that industries stakeholders must take part and responsibility towards that moves [16]. This shift was done with priority given to new innovations and investments for the purpose of attainment of sustainable and secured energy in Norway [16].

Norwegian electricity system has been dominated by renewable hydroelectricity, this is because it is cheap and clean energy from unconventional energy sources [5], [16]. CCS is another option to mitigate greenhouse gases emissions thereby curtailing the effect of climate change. Norway is amongst the countries in Europe with a clear policy to encourage CCS at both national and international levels [16].

VII. SUSTAINABLE ENERGY DEVELOPMENT POLICY FROM UNITED KINGDOM

According to Hafez, 2014, UK has established energy policies which solely focuses on providing sustainable energy that can also curtail greenhouse gas emissions [17]. The aim is to a develop policy that could provide clean, efficient and affordable energy (sustainable energy) to the UK citizens. There are other policies integrated together such as Carbon Floor Price (CFP), Vehicle Excise Duty (VED), Industrial Energy Tax (IET), Landfill Tax and Climate Change Levy (CCL). This is to reduce greenhouse gas emissions and

encourage development in sustainable energy in the UK [17].

The sustainable transitions include green economy and low carbon futures. While sustainable economic growth and development includes expanded access to credit and tax cuts. Each one stands alone in a political position in the UK. But still, they share the same interest in the energy policy of the country [18].

VIII. SUSTAINABLE ENERGY DEVELOPMENT POLICY FROM FINLAND

The idea of moving into the renewable energy production is based on the established EU and national policy in Finland [19]. The notion is to substitute conventional energy sources (fossil fuels) to unconventional renewable energy sources which was considered to be an option for mitigation against climate change [20]. The country new Long-Term Climate and Energy Strategy, completed in 2008, have set out comprehensive procedures for the target 2030 and plans for the period up to 2050 [20]. Global warming is the biggest concern for the Finland municipal decision-makers. The country energy structure has been conventionally based on strong state control. In Finland, due to the urgent need of sustainable energy, the country developed new approach to sustain the energy security of the country by harnessing all the available renewable energy sources within the country [20].

IX. PROPOSED ENERGY POLICY FOR AFRICA

According to Nigerian roadmap for the power sector reform which was held in August 2013, the current energy generation capacity in Nigeria was in the region of 6,000MW as of 2012, all of which 4,730MW which is equivalent to 79% comes from fossil fuels sources and only 1,270MW which account for 21% comes from hydropower which is the only current and existing renewable energy source in operation in Nigeria [21].

Benin, Senegal and Sierra Leone have current energy consumption of fossil fuels that double the figures in renewable energy consumption. Though, the three above mentioned countries are all endowed with renewable sources. South Africa is the most industrialized country in the Sub-Saharan Africa; they are one ratio 3 in consumption of fossil fuel and renewable energy sources. The Botswana is the most

successful country in terms of sustainable energy with the ratio of 22:4 in favor of renewable energy. Their grid is now connected to South Africa due to the excess energy produced more than what the citizens consumed and the countries are close to each other which makes it easy for connection [21].

TABLE I
POTENTIAL ANNUAL RENEWABLE ENERGY PRODUCTION/CONSUMPTION IN
SUB-SAHARAN AFRICAN COUNTRIES [21]

Country	Total
Namibia	100.5
Central African Republic	90.9
Mauritania	86.2
Chad	77.3
Mali	58.4
Niger	50.4
Congo	43.6
Angola	27.9
Sudan	27.6
Zambia	25.2
Congo Dem. Republic	24.7
Mozambique	23.4
Botswana	22.4
Gabon	20.3
Burkina Faso	15.9
Madagascar	14.6
Guinea-Bissau	14.2
Tanzania	14.1
Cameroon	12.7
Senegal	12.5
Benin	12.5
Sierra Leone	10.1
Cote d'Ivoire	9.6
Eritrea	9.5
Guinea	9.0
Togo	8.9
Ethiopia	8.5
Zimbabwe	8.0
Kenya	6.5
Malawi	6.4
Ghana	5.7
Uganda	3.1
Gambia	2.3
Burundi	2.2
Nigeria	2.0
Swaziland	1.6
Lesotho	1.4
South Africa	1.3
Equatorial Guinea	0.9
Cape Verde	0.9
Rwanda	0.7
Comoros	0.2

X. RENEWABLE ENERGY OBLIGATION

RO is a policy developed and used in the UK. The obligation was first introduced in the UK in order to achieve its aim on the renewable energy generation for up to 10% by 2010. This is a mechanism used in supporting sustainable energy development in the UK. In theory, the obligation has been introduced in order to support customers to have a

certain percentage of the electricity produced from renewable sources. This is done in order to increase competitiveness in the renewable energy market [22].

Renewables obligation (RO) is an imposed policy of action in the UK which is designed without any direct intervention. The root of this obligation is to lower the price of electricity thereby increasing maximization of renewable energy production which also in turn increases competition in energy market [22]. This policy could also be applied to most African countries especially Nigeria. This policy can help boost competitiveness in renewable energy market within the continent and lower down the price of electricity since the intervention is not direct it is just an action by the government [23].

XI. STABLE FRAMEWORK TO SUPPORT SMALL AND MEDIUM ENTERPRISES

Germany provides support mechanisms in their policy framework which are essential for both small and medium enterprises to invest in renewable energy sector and this could help in the initiation development in the renewable energy sector. Provision of incentives to reduce the cost of electricity might also play another significant role in accelerating competitiveness in the energy market [12]. The German government, citizens and parliament come into agreement for the German Feed-in law which guarantee grid access of electricity from renewable sources as a masterpiece empowering legislation so as to trigger the development of renewable energy market. The Feed-in law will help in integration of renewable energy produced into the national grid. The helps in electricity price reduction [12].

XII. LEGAL FRAMEWORK TO SUPPORT RENEWABLE ENERGY AND COGENERATION

There are several policies in Germany that could be applied to African countries like legal framework to encourage renewable energy and cogeneration [23]. For instance, Renewable Energy Heat Act, this is a policy that help in improving the share of renewable energy in the heating and buildings. There is also Combined Heat and Power Act which support energy efficient buildings (smart buildings), construction and cogeneration plant. Another Act is the Renewable Energy Act in the electricity sector. This is the current Act in Germany which was established in 2000 and introduces FiT system with the aim to bolster renewable energy development and provide background or base for further research in renewable energy technology that could be profitable to the country [23]. In the case of FiT, there is incentive given to renewable energy power plants operators which are fixed tariff for each kWh that is fed into the grid for guaranteed duration of 20 years [23].

XIII. NIGERIAN ENERGY CALCULATOR (NECAL 2050)

The Nigerian National Energy Policy under Energy Commission of Nigeria (ECN) has launched Nigeria Energy Calculator (NECAL 2050) on 28th October 2015 which was

held at the Transcorp Hilton Hotel, Abuja, Nigeria [8]. NECAL 2050 was established by the Energy Commission of Nigeria before it was formulated into current energy policy in conjunction with the United Kingdom Department of Energy and Climate Change (UK-DECC) and British High Commission in Nigeria. This calculator 2050 was similar to the first calculator initiated in the UK, but now it was modified in Nigeria to NECAL 2050 [8]. The calculator serves as a significant tool for the future target of renewable energy for the country. This is an energy development planning tool that could be used to relate the long-term energy demand and supply pathways to greenhouse gas emissions up to the target year 2050 [24].

XIV. CCS MANAGEMENT

CCS engagement is a policy introduced in Norway in order to protect the environment from the harmful effects of carbon monoxide and carbon dioxide emission [25]. This is a very costly technology which is difficult to adopt even in most European countries. In Norway, they refined their climate policy to cost-effective CCS as a mitigation option for

greenhouse gas emissions [16]. CCS is mostly for the gas-fired power plants, the Norwegian government has made an effort with important ownership and participation in the CCS technology projects as a crucial mitigation option for climate change. Norway is leading the way in Europe for CCS technology development as greenhouse gases mitigation option [26].

XV. HEAT ENTREPRENEURSHIP

Heat entrepreneurship is a system in which local farm producers provides heat to rural communities or local buildings such as school or market [27], [28]. This was introduced as energy policy in Finland and Germany due to prospect of depletion of fossil fuels and projected consequences that global climate change can cause [28], [29]. In Finland, the agricultural sector of the country has undergone into structural manipulation as another development of farming renewable energy crops. It was one of the most diversified sectors to provide the country option in both liquid fuels and electricity from farming of energy crops [24].

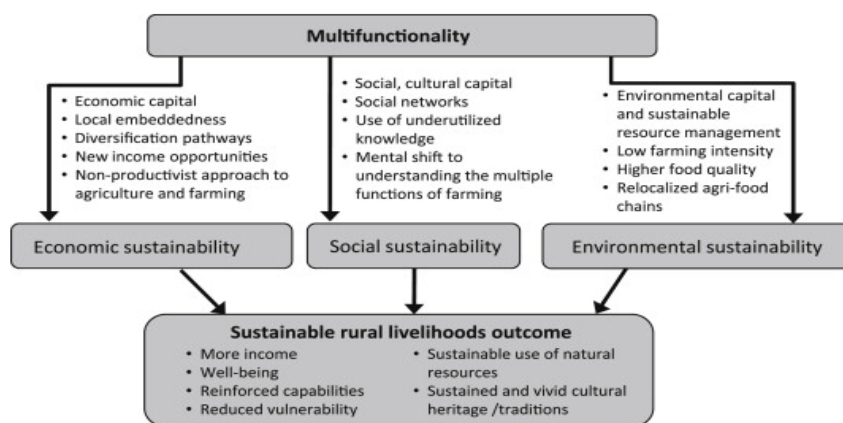


Fig. 2 Multi-functionality for sustainable rural livelihood outcome [24]

TABLE II
 RANKING OF THE PROPOSED POLICIES

S/No	Policy	Number of Challenges	Rank	Comment
1	Nigerian Energy Calculator (NECAL 2050)	1. Technical expertise	1	Very low challenge
2	RO	1. Imposed policy of action	1	Very low challenge
3	Small and Medium Enterprises	1. Monopoly in the market. 2. Loan from the Banks. 3. Incentives to reduce cost of electricity. 4. Feed-in-Law legislation	4	High Challenges
4	Renewal energy and cogeneration	1. Payment of incentives from the government. 2. FiT for each kWh produced.	2	Low challenges
5	CCS	1. Technology cost. 2. Mainly for gas-fired plant. 3. Government and Non-Governmental Organization consensus.	3	High Challenge
6	Heat Entrepreneurship	1. Farming of Energy crops. 2. Deforestation.	2	Low Challenge

The Fig. 2 above shows how multifunctional is sustainability and how it connects environmental, social and economic sustainability altogether into sustainable rural livelihoods outcome.

Table II above shows some of the selected/proposed policies for Africa and particularly Nigeria with their number of challenges in terms of their implementation. The challenges are given ranking number based on the number of challenges

they could pose. Some are having higher challenges, while others are having lower challenges in their implementation [30].

XVI. RANKING PROCEDURE OF THE PROPOSED POLICIES

The policies with only one challenge were identified and ranked as the first, they are; Nigerian Energy Calculator (NECAL 2050), and RO. Those with two challenges were ranked as the second, they include; Renewable Energy and Cogeneration and Heat Entrepreneurship. While CCS with three challenge is ranked third. The final and fourth ranking goes to Small and Medium Enterprises with four challenges.

TABLE III
 PROPOSED TIMESCALE FOR THE IMPLEMENTATION OF THE PROPOSED POLICIES

S/No	Policy	Rank	Timescale
1	Nigerian Energy Calculator (NECAL 2050).	1	5 Years
2	RO	1	5 Years
3	Renewable Energy and Cogeneration.	2	10 Years
4	Heat Entrepreneurship.	2	10 Years
5	Small and Medium Enterprises.	3	15 Years
6	CCS	4	20 Years

The proposed policies are ranked based on the challenges and timescale for their implementation in Nigeria and Africa in general. The Nigerian Energy Calculator (NECAL 2050) was aimed to be achieved in 2050. But the modelling of the tool could take up to five years before it is achieved. RO could take same years with energy calculator since it is an imposed action of plan.

Renewable Energy and Cogeneration could take approximately 10 years to be implemented due FiT as incentives. This is also challenging because it involves deforestation in some aspects, it could be achieved in 10 years' time.

The CCS are extremely difficult to Implement due to the cost involve in the technology. Although, some African countries like Nigeria have the funds to support the implementation of this policy. This could be expected in the next twenty years.

The Small and Medium Enterprises is a policy that supports the reduction of monopoly in the energy market thereby encouraging small and medium enterprise to invest in the energy sector. This could be implemented in Nigeria and most African countries within 20 years or less. The monopoly in the energy industries is very hard to abolish at once.

XVII. DISCUSSION

All the proposed energy policies could play a significant role in securing our environment against global climate change and greenhouse gases emissions thereby providing African countries with sustainable energy and Nigeria in particular. Social and economic development can improve in any country if there is stable, adequate and accessible electricity.

According to Hinrichs 2013, around 300, 000 people across the Europe have gotten jobs created through sustainable energy policy in most countries within the continent which was between the year 2000 and 2009. This could also be applied to most African countries where the level of unemployment and poverty is significantly high. Nigeria has abundant natural resources but to explore them is the main problem. This is as a result of unstable policies and lack of implementation. For instance, most African countries lack technical expertise in the renewable energy exploitation that makes it even harder to progress in the renewable sector. In comparison to Europe where they boast a high number of technological expertise's in renewable energy sector, around 33.4 billion Euros has been spent on machine operation to the installation of equipment's [12].

XVIII. CONCLUSION

The main aim of this research which is to find new policy and associated regulatory and legislative proposals that could help bring sustainable energy development to the African countries with the special focus on Nigeria as a case study in Africa.

- Firstly, an in-depth and thorough review of the past literature from some selected countries in Europe has been carried out based on their policies on how could their policies have impact on securing sustainable energy for Africa and Nigeria in particular. This start with the analysis of RO policy in the UK, provision of a supportive mechanism by the government in the policy framework which gives way for small and medium firm marketers of electricity to invest in the power sector. The Combined Heat and Power Act which support building for energy efficient buildings. The aim of the policy is to move the country from fossil fuels consumption to more sustainable renewable energy. The CCS in Norway is also a good policy even though its costly. And finally there is renewable energy integration which is a policy designed to support local farmers that produces energy crops.
- Secondly, investigating the obstacles to each proposed policy development and implementation in energy sector in most African countries and Nigeria in particular is very high. This is because most of the policy requires provision of high technical expertise. The level of corruption in Nigeria was identified as one of the elements that hinder the country's economic development. This also makes it hard to implement policies in Nigeria.
- Thirdly, review of the existing policies on energy in Nigeria and evaluation of the extent to which these policies help in harnessing renewable energy sources such as (Solar, Wind, Biomass and Hydropower) and integrating the energy produced into the national grid is also required. This lead to the identification of the Nigeria's government intention to expand its energy sector through Electric Power Reform Act thereby carrying out significant changes within energy sector for both short-term and long-term future.

In conclusion, if the current launched Energy Calculator

could be used appropriately, there is possibility Nigerian economy will rise again. This is because no country could develop economically without adequate access to electricity. Inadequate electricity has contributed greatly to the poverty and downfall of the economic sector in most African countries. A proper policy in the energy sector with good implementation is the only solution that could help solve Nigeria and African current energy problems.

XIX.RECOMMENDATIONS

There is a great challenge for Nigeria and some developing African countries in formulating these proposed policies that could provide sustainable energy to their countries. The problems and challenges may include:

- Funding: If at all the country wants to develop economically, there must be funding for further research in renewable energy sector together with incentives.
- Policies need to be reviewed regularly each time with a proper amendment.
- The legal framework must be put in place like that of RO in the UK.
- Corruption: The level of corruption has to be reduced, because it is part of the element that hinders Nigerian economic development together with other countries in Africa. This also makes it hard to implement policies in Nigeria due the level of corruption within the country.

Privatization of energy sector should be encouraged as this could bring competition in the energy market. The funding should be both from the government and private sectors in the energy industry.

Companies that are involved in the privatization of the energy sector should be encouraged and regulations in the energy policy need to be readjusted by the policy makers of the country.

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