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NIGERIA ELECTRICITY CRISIS RESCUE PLATFORM: RENEWABLE ENERGY TECHNOLOGIES OPTION

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Abstract

Development in modern time is closely linked to energy supply in whatever form. It is clearly evident that the level of access to energy by individuals and industries is sine quanon to measuring the standard /quality of the life of people. As with most infrastructures Africa in general and Nigeria in particular have very poor rating in energy provision, an average of 6GW to a population of more than 160 million in Nigeria. There are several reasons for the abysmal energy provision performances. The main causes being poor energy policy, capital resources leakages, and know how deficiency. This problem has affected Nigerians socially and economically, as they lack adequate energy supply to power their household and businesses. The negative impacts of this situation to the nation are; relocation of manufacturing companies to neighboring countries, unemployment, and an endemic rural-urban migration. More than 65% of the population is deficient in commercial electricity. Nigeria planning Act has been reviewed with a view to identified position of peri-urban/ urban fringes in the development strategy in the country. Peri-urban electricity potential has been assessed and it was identified to be in the best position to augment electricity access in the country. Systemic review method is used to assess viability of numerous RETs in Nigeria; this is in addition to sustainable check analysis, policy instrument and Whole Life Costs (WLC) concept that are used to determine renewable energy technologies appropriate for different categories of people/users in Nigeria. Policy Instruments and Nigeria energy policies have been reviewed. It has become apparent that solution to these can be found in the 'mushrooming' of energy generation and usage points; thereby making it possible for people in the peri-urban areas to generate their electricity; this is to be made possible by the adoption of appropriate renewable energy technology. These papers seek to highlight the effectiveness of renewable energy technologies (RETs) in solving the energy limitations in Nigeria.

Keywords: Nigeria, Electricity crisis, Renewable energy and Technologies

Background to the Study

Discourse on Nigeria's energy crises has been on for a very long time, but the translation of the outcome of same to tangible change has been the challenge. This is traceable to the ensuing recommendations being "White Elephant" in nature, hence the need for solutions which implementations are simplistic and within the reach of an average person or group of Nigerians for implementations. Nigeria has being experiencing electricity shortage for over three decades now, resulting from failure of the utility company (Power Holding Company of Nigeria) and utilisation of centralised electricity system mostly operated with fossil fuel system in the country. Suffice it to say that the following contextual background to the prevailing situation will do well to provide base for discourse inspired change. Only approximately one-third of the country's population has access to commercial electricity, with around 10% in the rural areas (Ikeme & Ebohon 2005). This deficiency in core urban and peril-urban centres has cause relocation of many multi-nationals companies to neighbouring countries for their production and a lot of local manufacturers have turn to traders, with resulting effect of job losses and business closure. While the effect in the rural areas is endemic rural-urban migration, increasing poverty level, unemployment, health deterioration and depleting of forestry biomass.

This paper is focused within the realm of the adaptation of Renewable Energy Technologies (RETs) for electricity provision especially for people living in urban fringes/peril-urban settlements. This has been motivated by the strategic value of RETs in identifying when and where electricity is actually required thereby eliminating/reducing high cost of gridline network and their associated infrastructure (transformer). More so, considering the population size and economic buoyancy of these communities over the rural people and their energy requirements, they can provide sustainable electricity from RETs sources that will augment electricity supply in the country. Electricity energy is a key factor for any form of socio-economic development and sustenance. There is connection between accessibility to electricity and socio-economic growth of a nation (Ikeme & Ebohon 2005; Ohunakin et. al. 2011) and is among factors that are utilized in controlling national growth in relation to population explosion and rural-urban migration (Ajayi et. al 2011). Nigeria has plentiful of fossil fuel and renewable energy resources (ECN 2005). The country is rated nr.7th among OPEC countries. Despite its energy resources, it is still unable to meet electricity needs of its citizens and even over 85% of its secondary energy is being imported (Oseni 2012). Nigeria power generation installed capacity was approximately 6500 MW in 2005 but 3959 MW was the only capacity available (Ibitoye & Adenikinju 2007) and this circumstance is yet unchanged till date. Although, electricity access of peri-urban/urban fringes settlements are much better than the rural communities but is not as core urban centres. This scenario has giving them (peri-urban settlers) opportunity to access their electricity privately considering the on-going privatization of energy sector in Nigeria and proximity to the national grid. The benefit of this case is that they can provide electricity for themselves through RETs and at the same time sell excess to the grid at much better price.

According to Sambo (2009) “between 1989-2000 fuel wood and charcoal (FWC) usage constituted between 32%-40% of total primary energy consumption with approximately annual consumption of 50 million metric tons of fuel wood only”. The major reasons for electricity deficiency in Nigeria are as follows: investment pattern and limitation, economy of extending and vandalizing of gridline network, increasing attack on the energy infrastructure (761 cases of pipeline vandalism between January – September, 2013), and climate change effect affecting hydropower dams in the country (Iwayemi 1994; Nnaji 2011; Sambo 2010). Several energy policies in Nigeria have being demonstrated in order to avail citizens of access to sustainable electricity. Among these policies- government had previously being the main provider of electricity in the country, with tariff system subsidized. This system had failed and has cause concomitant set back to development process in the country. Similarly, rural energy policy targeting rural inhabitants in order to improve their energy access-typical of this case is subsidizing of petroleum products (kerosene) unfortunately this policy didn't attain its goals due to terrain of some locations, diversion of the products by selfish marketers, rural areas far from cities and poor road network and this have made rural dwellers to pay for these products over 200% of the pump price per litre. This policy had cost federal government of Nigeria in excess of US$20 billion over the last three years without meaningful result (Garba & Kishk 2014). In an attempt to fix this problem, Nigeria government privatized the utility company in 2005 through an act Electric Power Sector Reform Act (EPSRA) 2005. According to Ikeme & Ebohon (2005) the aim of EPSRA 2005 “is to attract private sector, stimulate investments, promote competition and efficiency, in such a way as to sustain the development of the power sector and meet social goals”. Five years after the reform (EPSRA 2005), worrisome challenges persist in the power sector with little or no increase in the power generation, and the generation available was equal or less than 4,000 MW which was same figure in 2005 for a population of over 160 million (Mohiuddin 2011).

Nigerian electricity sector problems may be mitigated by utilization of peril-urban/urban fringes energy resources through adoption of alternative sources of electricity provision such as RETs (decentralized) in order to improve electricity access in the country. Hence, the aim of this paper is the assessment of sustainable electricity provision through Renewable Energy technologies (RETs) by the peril-urban/urban fringes settlements.

Nigeria Planning Act and Peril-Urban Energy Development Strategy

Urban and regional development is composed of several matrices in terms of lateral and vertical dimensions. Laterally we often categorised the matrices into urban and regional, while the third one is often refer to as the rural. However, another important matrix that is not traditionally categorised is the peril-urban settlements. This is the city slums or fringes of most beautifully planned urban centres. Today they have become a reality in planning challenges of urban centres. Even though there seems not to be a generally acceptable definition of the peril-urban interface, it's reality of urban -rural coexistence is indisputable; after all activities in these interface zones affect both urban and rural areas (Ogbonna,

Onazi and Datong, 2011). According to Allen (2003), environmental perspective considers peril urban as an interface that is characteristically a heterogeneous mosaic of natural ecosystem that is "productive" or "agro". In this respect therefore it can be construe that peril urban interface are those areas that energy infrastructure are neither completely absent nor are being adequately provided. They are urban areas lacking in terms of low density in some instances, lack accessibility or services and infrastructures (Tacoli, 1998; Iaquita and Axel, 2001).

Deeply ingrained dichotomy of urban and rural planning is clearly inadequate. This is particularly so with respect to infrastructural planning and development. The current option of extrapolation for infrastructural requirements of such critical segment of the population demands more careful study for fruitful results. This paper essentially focuses on the peril urban areas, which are the links between the urban and rural areas aside the regional development strategy. The paper further argues that once properly identified, they could indeed play quite an important role in the bridging of renewable energy provision for the vast unaccounted urban population and the Nigerian economy at large.

Plan preparation and administration are often done base on the various levels of physical and development plan status. According to Nigeria Urban and Regional Planning Act of 1992 the types and levels of Physical Development Plans are as shown here below;

Table 1: Physical Development Planning Levels in Nigeria

Levels	Federal Level	State Level	Local Level	Remarks
Physical Development Plans	National Physical Development Plan	regional plan	-	These are the highest planning options at state and national levels.
	regional plan	sub-regional plan	town plan	The planning level in a way varies the scope of planning development
	sub-regional plan	urban plan	rural area plan	
	urban plan	Local Plan	local plan	Could place the peril-urban as an intersection between urban and local plan for development.
	subject plan	subject plan	subject plan	This is essentially for any definite plan in this case could include the peril urban as a specific component.

Source: (Adapted from FGN, 1992).

The urban centers are mostly the reference points for most physical planning development strategies, the rural areas are often considered, as the case may be; for the peril urban it is scarcely an issues for serious discuss and much less for development plan. As can be seen in Table 1 above, peril urban settlements has no actual place in the Nigeria Urban and regional planning and development strategy. It is estimated by UN-HABITAT that nearly one billion people live in slums in the cities of the world. That is one-sixth of humanity. Most of these slums are in the cities of the developing countries of the world (Tumashie, 2011). Slums are the precarious, environmentally degraded, and unplanned areas of cities. With good planning and a political will to make land available for housing, these problems should not need to exist. These slums are the peril-urban regions of our great cities that even planners do not specifically acknowledge and thus do give minimal consideration at best. Development in whatever form must give careful considerations to all segments of the society. On electricity energy the desire for renewable energy generation and distribution, for peril urban areas are a major linkage node that cannot be ignored.In developing nations of sub-Saharan African, energy access is often understood

in the context of two distinct policy target zones, which is the urban areas characterized by a high population density and the proximity of the energy infrastructure and, the rural zones that are less populated and mostly are not easily accessible (Sarr et. al. 2008). It is further assert that due to the specialized approach to energy policy, these peril-urban zones are integrated in the urban energy policy even though they possess strikingly different features than traditional cities. This has the detrimental effect of leaving an energy policy vacuum in these peril-urban areas that tends to exacerbate the already existing level of poverty. The peril-urban zones are strikingly different compare to traditional urban zones and it is important to understand its true nature to develop an effective plan to boost energy access for their population. Another important feature of the debate is the necessity to delineate the peri-urban zone to have a clear understanding of their location relative to the urban centres and their actual size. Alabi and Akimbode (2010) established that the local government system in Nigeria needs reconfiguration for effective physical development, especially in the area of financing. The option of RETs for small scale energy generation, utilization and contribution to national grid from urban fringes is here advocated as a worthy option to guarantee physical development of this critical environment.

Peril-urban Electricity and Energy Issues in Nigeria

Urban centres world over symbolize the measure of both economic and social property. There is nothing that announces the level of prosperity in urban centres than building and associated civil infrastructures. Buildings on all forms serve one basic human purpose-shelter or dwelling. The Spatial land distribution only account for use delineation hence you have CBD, industrial layouts and residential layouts. Apart from the physical structure of these living places, services and its quality of life is a practical measure of the quality of life in each settlement. Like what air is to human, energy (electricity, fuel etc.) is the livewire of modern day living. A settlement can also be classified based on the quality availability of energy services. There are indicators that the quality of energy supply is synonymous to the economic well-being of a country, a state, a settlement and/or a people. Settlement challenges are experience in most parts of the world; peripheral parts of urban centres are usually homes to people of lower economic means, who are thorn between the rural areas/settlement and the core urban centres. Hierarchically their economic capacity can be located in the middle, not poor and not rich. These peril-urban settlers usually have access to services, especially energy, in their compromised form. This scenario has giving them opportunity to access energy (electricity) privately considering the on-going privatization of energy sector in the country. The benefit of this case is that they can provide electricity for themselves through RETs and at the same time sell excess to the grid at much better price. The energy crises in Nigeria can be fitted into the foregoing context. As posited by Obadote (2009) and Ikeme & Ebohon (2005) only approximately 10% of rural households and 40% of the country's total population have access to electricity. Several issues have been attributed to the poor energy supply state, poor stable state of energy infrastructure (operating below installed capacity because of the need to rehabilitate existing facilities). Oscillatory outputs as a result of water level, lack of gas supply, vandalism of transmission towers and general poor network administration.

Ogbonna, Onazi and Datong (2011) aver that in peril-urban as in urban setting domestic energy demand is affected by house type, income, household size and occupancy pattern. Also they establish that there is a strong correlation that exists between house types, number of appliances and household energy consumption. In Dakar Senegal the peril-urban energy profile as established by Sarr, et'al (2008) is characterized by a transition from traditional sources of energy (wood and charcoal) to more modern energy type (LPG etc.). The extent of this transition is a function of many variables namely: the adequacy of the energy access policies and socio-economical parameters. Ogbonna (ibid) adduced that most peril-urban settlements are able to afford the basic energy consumption gadgets, however their usage are generally not so intense. It therefore means that if these settlement areas are thoroughly analysed and investment made particularly on RETs, they could contribute greatly to National grid towards enhancing the energy available for other sectors of the nation's economy. It has been noted that there is need for a holistic understanding of the role of energy services in sustainable urban livelihoods, as well as form a basis for making policies that addresses the associated issues. Recent concerns about the urban poor are the result of the realization that majority of the world population in the next two decades would be living in urban areas. The rapid rate of urbanization will generate a large percentage of urban poor whose quality of life will depend on many factors including access to sustainable and efficient energy services. Unless efforts are made to put in place policies that would stem the negative impact of energy on urban poor, the world faces a major challenge of attaining the Millennium Development Goals (MDGs) (Friends of the Environment, 2005).

Solution to energy crisis

In urban fringes attentive have been touted as the best way out of the general energy shortages, more specifically RETs are considered most appropriate: This has become attractive because of the existence of the core source of the energy in the area needing the energy most and the large population of these settlements; ranging from biogas, biomass, solar, and other similar sources. It is estimated that the energy crisis can be solved by researching, harvesting and utilizing these various sources of energy; not only for personal use, but also the sharing excesses through the national grid.

The economic benefits inherent in these small-scale energy generations are many:

(a) Providing own energy needs
(b) Connecting excess to the grid through NET metering system
(c) Enhancing economic buoyancy.

The overall effect of the harnessed locally generated energy can be awesome. Thus, emancipating those at the urban fringes from deprivations and also serving as reference point, to copy from, for people in the rural areas. Because of the fair economic status of living in peril-urban settlements they are best suited for pivotal energy generation decentralization. They thus serve as alternative energy hubs using RETs pilot initiators/implementers. They become cardinal stakeholders in the use of RETs.

Nigeria RETs Potential for Electricity Generation

Nigeria has abound RET sources, with only two sources currently exploited and they are hydropower and biomass. Lack of exploitation of RET sources may not connected to plentiful of fossil fuel energy sources in the country. The following session will assess prospect of major RETs in Nigeria for utilization in peril-urban areas.

Wind Energy

Wind energy technology has experienced significant growth globally in the last decade, with its installed capacity doubling every three years (WWEA 2013). Unfortunately, this is not the case in Nigeria. The country is categorised under poor-moderate wind regime and consequently, wind energy cannot be applied on bigger scale except for irrigation and village electrification. Nigeria wind speed between 2-4 m/s is at 10m height (ECN 2005) but feasible speed of average 5 m/s at 10m height from ground level is required for wind energy exploitation (Sambo 2009). According to Ajayi (2007) wind energy resource is very poor in onshore of the southern region particularly south west and south-south regions of the country; but offshore areas of the same zones bound by the Gulf of Guinea have excellent wind energy resources. However, a lot of authors recommended its application for specific locations particularly in the Northern region (Ojosu & Salawu 1990; Ohunakin et. al. 2011; Fagbenle et. al. 2011). Nigeria has not official record of wind energy utilisation presently but Sopian et. al. (2011) reported that 2.2MW of electricity has been generated from wind energy in Nigeria but the reality suggests that they have been abandoned due to lack of maintenance culture in the country.

Solar Energy in Nigeria

Nigeria average annual total solar radiation ranges from 3.5 and 7 KW/m2 /day from the south coastal areas to semi-arid areas in the far northern Nigeria respectively (Sambo, 2009). Solar energy that falls on Nigeria daily is approximately 16.7 EJ (Akinbami et. al. 2003), with average sunshine of 6.5 hr/day (Shaaban & Petinrin, 2014). It is feasible to produce electricity of around 1850 x 103 GWh/year if only 1% of the Nigeria land area (923,773 Km2) is used with current efficiency of silicon based solar PV in the market (Sambo, 2009). The country's solar capacity is far more than current electricity generation and 27 times more than the nation's fossil fuel sources (Augustine & Nnabuchi 2009; Sambo 2009). Nigeria has commenced solar panel manufacturing in Abuja with annual capacity of around 7.5 MW. This will solve high cost of imported PV module and technical knowhow deficiency previously experienced in the country .According to Adeoti et.al. (2001), it is possible to generate electricity to meet the needs of people throughout the year in all locations in the country. Currently, solar energy system is use in Nigeria for small and medium power applications which include: street lighting, domestic/offices powering, water pumping, rural electrification, rural health centres, powering of telecommunication boaster stations and Banks ATM machines.

Hydropower Energy in Nigeria

Nigeria has hydropower potential of approximately 14,735 MW with 11,235 MW and 3,500MW for large and small hydropower sources respectively; with waterways in excess of 3,000KM. Only 1,960 MW have so far been exploited, representing 14% of total capacity-i.e 1930MW (Large hydro) and 30MW (Small hydropower) (Sambo 2009; ECN 2005). Currently 150 MW of small and medium hydropower project is on-going in the country but more potential need to be developed considering its potential. Since the 1960s hydropower technology has been developed and utilised in Nigeria; with good local skills and experience. If small hydropower technology is utilised the distribution system does not requires high tension cables, transformer and reservoirs. Inhabitants' displacement, however, is a major side effect. This can be mitigated through informed consent from local communities with some financial reward.

Biomass Energy in Nigeria

Nigeria is located in the tropical zone and that gives her opportunity to biomass resources; these resources include agricultural residues, forestry biomass, and animal dung. The country's vegetation pattern dictates the availability of these resources. Typical case in this respect is the northern part of the country where substantial land areas are cultivatable and majority of the people in the region earn their livelihood through farming. Hence, the region produces large agricultural products, animal dung and modest quantities of fuel wood; while large quantities of wooden biomass are produce in the south. The major form of vegetation patterns in Nigeria are savannahs (Guinea and Sahel) and forests with the former occupying approximately 80% of Nigeria's area (Sambo 2009; Akinbami et. al. 2003) and good for cereal plantation. Nigeria has biomass potential of approximately 1.2 Petajoule (PJ) as at 1990 (Akinbami 2001) but this estimate does not include MSW, biogas and other few sources. According to ECN (2005), Nigeria biomass energy resource was projected to be around 144 million tonnes per annum. These resources can generate electricity up to 68,000 GWh/year at 30% availability. This source can significantly generate electricity. However, biomass effective supply chain and priced affordability would decide its viability for electricity generation; this is mainly because of procurement of the resources. Also, residues particularly forestry biomass have low density and low value where transportation cost are high/energy unit (Evans et. al. 2010). Nigeria is currently not generating electricity from this source but, biomass resources are generally available in the country that can support sustainable electricity generation without supply chain difficulties.

Geothermal Energy in Nigeria

There are two locations of geothermal energy that exist in Nigeria and include Ikogosi warm spring and Wikki warm spring in Ondo state and Bauchi state respectively. Similarly, tendencies of high geothermal gradient are identified in the Lagos sub-basin, Auchi-Agbede, Okitipupa ridge and also the Abakaliki anticlinorium (ECN 2005). The Wikki source above was further confirmed through empirical study of Obande et. al. (2014) The

source of the heat in the region may not be unconnected with radioactive decay of various isotopes . The problems of this energy source are lack of discovering of commercial proportion in the country and perhaps lack of record. However, situation may change if commercial quantities from this source are establishing (ECN 2005).

Ocean Energy in Nigeria

Nigeria is bordered by Atlantic Ocean in the southern part of the country, with the coastline extending from Bakassi to Badagry with distance in excess of 850 km. This gives Nigeria opportunity to produce energy from ocean energy technologies if the resources availability is confirmed.

The wave energy potential of West Africa coast (Nigeria inclusive) has the poorest resources in Africa with energy regime of 10 KW/m. ECN (2005) "Nigeria does not seem to have significant tidal energy resource". However, OPEC (2004) estimated that Nigeria has 150,000 TJ/annum of wave and tidal energy resources.

Challenges of RETs in Nigeria

The major obstacles of RETs in Nigeria include among others: inadequate policy framework (lack of incentive instruments), insufficient budgetary allocation, lack of education and awareness, long-term financing inaccessibility, lack of technological knowhow, government apathy in development of RETs, uses of sub-standard components, monopolising of fossil fuel uses, poor maintenance culture (Oyedepo 2012; Mohammed et. al. 2013; Shaaban & Petinrin 2014).

Sustainability Assessment of RETs in Nigeria Rural Areas

From the evaluation exercise in table 2 above, biomass energy scores the highest mark of 23 and closely followed by hydropower, solar and wind sources with 22, 21 and 20 marks respectively. The least technologies were geothermal and ocean energy with 18 marks each. Currently Nigeria has no official record of electricity generation from biomass but recently biomass projects were initiated for energy crops. Demonstration farms for energy crops are available in the country particularly in southern part see details from (Mohammed et. al. 2013; Ajayi & Ajayi 2013); likewise, a farm in Katsina state is being used for the same purpose. However, despite lack of electricity generation from this source, Nigeria is producing biofuel from biomass resources with current capacity in excess of 120 million/year (Mohammed et. al. 2013) and there are promising steps in improving the capacity; this depicts high possibilities of electricity generation from this source with adequate policy support. Also, there are about 30 biogas pilot projects in the country for cooking application with capacities between 10–30 m3. Hydropower energy is the next energy source in term of sustainable electricity provision in Nigeria. Hydropower energy have being the largest RET both globally and Nigeria, contributing approximately 18% and 25% respectively. In Nigeria this source has been tested, evenly distributed and with huge potential for further utilization (Manohar & Adeyanju 2009); it can provide base load and peak load, and flexibility of operation (can start operation and capacity addition

within seconds).. The next sustainable electricity source is solar. This source has the largest potential and generally found in all locations in the country. This source is already in used in the country; therefore there is a utilization experience.

Whole Life Costing (WLC) & Applications

WLC is describe as a systematic consideration of all costs, revenues and performance associated with the acquisition, operation and maintenance and disposal of an asset over its economic life (Kishk et. al. 2003). WLC concept is applicable in many industries, ranging from construction, power energy, transport etc and apparently it's being used by management as a tool assisting in optimal selection among RETs competing options and in determining the exact maintenance and operating cost of an asset before acquisition or ownership (Ferry & Flanagan 1991). Thus, WLC technique determined initial and future cost surrounding the asset and reduce them to their present worth by applying discounting technique principle (Kirk & Dell'isola 1995).

WLC and RET Economic Evaluation

Considering the privatization of power sector in Nigeria, investors may be worried over electricity provision to rural areas using centralised system. Hence, application of RET is inevitable bearing in mind its strategy benefits of identifying when and where electricity is actually required. More so, considering the profit driving attitude of investors, the economy of electricity provision using RETs has to be evaluated for the purpose of cost benefit analysis. WLC will serve as a better tool for economy analysis of subsets of RETs identified above suitable for Nigeria rural areas electricity application (comparative analysis) with a view to select best options having considered all the significant costs rather than only initial capital cost. Furthermore, the major barriers of RETs is high capital cost (reason mostly used to disqualified it); WLC will not only assist in preventing spending more at the initial stage to save sufficiently in the future but it helps in making rightful decision at the beginning or during the operation of the physical asset/investment for every household or the entire rural communities thereby reducing electricity cost/Kwh (Flanagan & Jewell 2005). The major obstacles of WLC are Lack of reliable and effective cost data, high cost of data collection, insufficient time for data collection, complex problem of time value of money, Clients lack of understanding of the benefit of WLC, uncertainty associated with events projection in to the future over the life of a physical asset (Flanagan & Jewell 2005). Mahapatra & Dasappa (2012) identified WLC framework suitable for calculating different RETs and capacities by using the following relations. The difference between the two formulas is mainlyin the operation and maintenance cost.

Table 2: Sustainability Indicators of RET in Nigeria Rural Areas

	CRITERIA	WIND	SOLAR	HYDRO	GEOTHERMAL	BIOMASS	OCEAN (Tidal)
1	ENVIRONMENT						
	Green house emission (g/kwh)	25 (3)	90 (2)	41 (3)	170 (1)	70 (2)	41 (3)
2	ECONOMY						
	Price -cost/kwh (US$)	0.07 (3)	0.24 (1)	0.05 (3)	0.07 (3)	0.06-0.08 (3)	0.12 (2)
	Energy Efficiency (%)	24-54 (2)	4-22 (1)	>90 (3)	10-20 (1)	60-70 (2)	55-75 (2)
3	SOCIAL						
	Visual, displacement, Noise, Pollution, Seismic etc.	Visual, Noise & Bird strike (3)	Toxins & Visual (3)	Displacement health, Agric & Earthquake (1)	Seismic, Noise, pollution, odour (1)	Food shortage, biodiversity loss, more labour used (2)	Effect on marine life, visual (2)
4	RESOURCES						
	Water consumption(Kg/KWh)	1 (3)	10 (3)	36 (2)	12-300 (1)	150-260 (1)	28-40 (2)
	Land use/TWh	72Km^2 (2)	28-64Km^2 (3)	73-750Km^2 (1)	18-72Km^2 (3)	462Km^2 (1)	73-750Km^2(1)
	Continuity of resources	Intermittent (1)	Intermittent (1)	Partly Intermittent (2)	Continuous (3)	Continuous (3)	Continuous (3)
	Resources availability type	Location specific (1)	General (3)	Partly Location specific (2)	Location specific (1)	General (3)	Location specific (1)
5	OTHERS						
	Nigeria potential (TWh/year)	1 (2)	17,702 (3)	58 (3)	NER (1)	225 (3)	41.7 (1)
	Capacity factor (%)	21 (1)	19 (1)	20-70 (2)	>70 (3)	60-70 (3)	23 (1)
	TOTAL	21	21	22	18	23	18

Coal -GHG emission = 850-900g/kwh, Cost $0.042; NER-No Existing Record
Legend- Numbers in the brackets represent (scores), other numbers/statements are raw data
Adopted from: Garba & Kishk (2014)

ET with little/no maintenance cost (Wind, Solar PV)

$$WLC_{PV} = C_{PV} + C_B + (C_{PV} + C_B) \times \beta \times P(d,n) + C_R \times P(d, n_1) - C_C \times P(d,n)$$

- Where $C_C = (L \times h \times n \times C)$ $\qquad L \times h \times n$

RET with operation & maintenance cost (Biomass gasifier)

$$WLC_{BG} = C_G + C_E + (C_F + C_M) \times P(d, n) + C_R \times P(d, n_1) - C_C \times P(d, n)$$

$$L \times h \times n$$

- Where $C_F = (S_C \times f_{con} \times h \times f_C)$, $C_M = (S_C \times f \times M_C)$, $C_C = (L \times h \times n \times C)$

Nomenclature	
SOLAR PV	BIOMASS GASIFIER
C_{PV} capital cost of photovoltaic system C_B capital cost of batteries ß Operation and maintenance cost P present worth factor d discount rate n life of the project n_1 life of each component C_R component replacement cost C_C annual carbon benefit C carbon emission benefit h annual operation hours L load (Kw	C_G capital cost of gasifier C_E capital cost of engine C_F annual fuel cost C_M annual maintenance cost S_C gasifier rating (kg) f_{con} fuel consumption (kg/h) f_C unit fuel cost M_C maintenance cost of the system

Policy Instruments (PI)

The major problem of RETs is high capital cost; this is as results of RETs still at developmental stage and failure of engineering in delivery the technology to the market at reasonable price. Although, the prices of some technologies are reducing- particularly capital cost of PV modules has reduced between 20-30% in recent time (Wiese et. al. 2010). This cost problem is inhibiting RETs diffusion into the market. The essential means of speeding promotion of RETs is Policy Instrument. According to Harmelink et. al. (2006) Policy Instruments (PI) is defined as "any concrete activity initiated by the government in order to enlarge the market implementation of renewable energy sources". In line with the above problem without policy support RETs will continued to face market access obstacles. However, alternative view suggest that it is not necessarily that PI can bring about cost reduction, but some instruments such as quota obligation and certification system perhaps may bring forth this cost reduction (Ackerman et. al. 2001). Afolabi (2010) identified three major key implementation PI among EU countries as follow; feed-in-tariff, quota system and tender system.

Nigeria Energy Policies

Nigeria Energy Policy (NEP) and Energy Power Sector Reform Act (EPSRA) 2005 were both produced and approved by government in 2003 and 2005 respectively. The aims of the two policies are the same i.e. promoting increased participation of private sector for optimal usage of the country's energy resources. In addition, EPSRA 2005 breaks the monopoly of the utility company in to three sections of companies (transmission, 11 distribution and 6 generations). The act also expected the growth of rural electricity access through a decentralised pattern in a sustainable manner from Rural Electrification Fund. Furthermore, this act provided license incentive (electricity licence exemption for producers) to organisations interested in decentralised power generation business not exceeding 1MW. The major problems of energy policies in Nigeria are inadequate policy framework (lack of market-oriented incentives), insufficient budgetary allocation and apathy in developing RETs in Nigeria. The way forward is the need for policies review with a vision of providing economic and fiscal incentives to potential RETs investors such as Renewable Obligation (RO), Feed-in-Tariff (FIT), tax holiday, low/non- interest loans as witnessed in developed countries. Considering the benefits of these incentives particularly FIT driving 64% and 87% of global wind and solar PV installation respectively (Shaaban & Petinrin 2014). Nigeria has recently established its FIT system for sustainable electricity development. Table (3) below is the Renewable Energy FIT system for operation in the country.

Table (3): Renewable Energy FIT Model in Nigeria

	Wholesale contract prices (N/KWh)				
	2012	2013	2014	2015	2016
SHP	23.56	25.43	27.46	29.64	32.00
Wind	24.54	26.51	28.64	30.94	33.43
Solar	67.92	73.30	79.12	85.40	92.19
Biomass	27.43	29.62	32.00	34.57	37.36

Source: National Electricity Regulatory Commission (2012)

Conclusion/Recommendation

Approximately only one-third of the country's total population and 10% of Nigerians rural communities have access to commercial electricity and this is affecting the socio-economic activities of the citizens following failure of utility company and centralized energy system that uses fossil fuel sources in provision of electricity. The major reasons for electricity deficiency in Nigeria are investment pattern and limitation, economy and vandalism of gridline network, energy infrastructure insecurity. Decentralized RET is recognized to be the solution because of its strategic benefits in identifying when and where electricity is actually required. Considering the population size of the peri-urbans/urban fringes settlements and their economy buoyancy it's recognised they are in the best position to provide sustainable RETs, with a view to augment the electricity crisis in Nigeria. Nigeria RETs sustainability has been assessed using sustainable development objectives and resource constraints. Nigeria has abundant renewable energy resources particularly biomass, hydro and solar energy sources for electricity provision. The level of RET utilization in the country is low and the causes of RET diffusion are lack of implementable policy framework, vested interest (monopolizing uses of fossil fuel), low purchasing power of majority of citizens. Nigeria energy policies have been reviewed and their major problem is lack of market-oriented incentive and policy instruments that will support promotion of RETs in the country has been established. WLC has been recognized as a best tool for economic evaluation of subset of RETs for the purpose of optimal selection among competing alternatives. Hence, through appropriate technology selection, systematic economic evaluation with WLC and support through consistent and reliable policy framework with emphasis on economic and fiscal incentives, RETs can provide sustainable electricity to Nigerian and augment fossil fuel sources for application in the country.

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