



Solar Power as Unparalleled Alternative, Renewable Energy for Self-Reliant and Sustainable Economy in Nigeria

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Abstract Nigeria is a greatly endowed nation as far as nature is concerned. In human resources, she is equally blessed with industrious people. Unfortunately, colonial penetration deeply subjected her to a whopping 100 years of slavery which affected her creativity and self-discovery as a people. After decolonization, the case was exacerbated by the type of political leadership that midwived the transition from colonization to independence subjecting her to neocolonialism and underdevelopment. Despite the poverty of leadership, Nigerians are not deficient of wonderful ideas; in fact, all known development strategies had been employed to turn around the nation's developmental predicament but to no avail. This paper strongly believes that Nigeria should for once solve one of the greatest problems besetting her development which is energy, pointing out that the country has abundant renewable energy particularly, solar energy. In fact, Nigeria has great comparative advantage in solar energy production that can make her a giant exporter like gas. Considering the capacity of photovoltaic in Nigeria, it has been proven that at any given location produces above 1,000 kW – h / kWh, of solar power, a huge electricity generation potential that is more than sufficient for Nigeria to take care of her energy requirements. This paper while adopting qualitative and comparative methodology, vehemently canvassed for exemplary shift from non-renewable, insufficient cumbersome energy to renewable, nature endowed, cheap energy and superabundant, the solar energy for self-reliant and sustainable economy in Nigeria.

Keywords technology, underdevelopment, colonization, leadership, renewable energy, non-renewable energy, solar energy, photovoltaic, electricity

1. Introduction

The current socio-economic challenges besetting the country which has deepened to recession is not only worrisome but calls for dramatic solutions before it escalated to depression. While the causes have been adequately diagnosed, the current leadership must muster the political will to confront the monster headlong. Contrary to popular opinion, the nation's major problem is not lack of diversification of the economy but that of power. I mean energy to power the resources and until Nigerian leadership and policy makers begin to understand that the amount of energy available to a community dictates its level of development, they may not be able to critically proffer radical solutions to Nigeria's persistent underdevelopment. Going by the economic indices for 2014 as released by the Central Bank of Nigeria (CBN) and Nigerian Bureau of Statistics (NBS) the gross external reserve which stood at US 42, 85 billion dollars by 31st December, 2013 has decreased by US 0.98 billion dollars or 2.23 percent when compared to the figures recorded as at the end of December, 2012 which stood at US 43, 83 billion dollars [1-2]. The entire picture can be captured going by the decrease of oil revenue in the first quarter of 2014 to the gross domestic product estimated at about 14.75 percent compared to 15.80 percent as against same period in 2013. The decline in revenue from the oil sector has remained



unresolved due to instability in crude oil production compounded by the vagaries in the international oil commodity price [1-2].

From the foregoing statistics, the major problem of this country is the over-reliance on non-renewable petroleum products for revenue sources to the detriment of renewable superabundant energy and other non-oil sector. The leadership is so comfortable and complacent with the providential rent from oil export; otherwise *free money* from oil which forms the bulk of revenue for the government. As a result, and despite calls from every quarter for diversification of the resource base, the leadership being the product of the status quo ante wants to remain conservative even with the harsh economic realities. Otherwise, why should the government commit huge sums of money for prospecting for oil in the Chad basin and other locations in the northern part of Nigeria especially at this period of recession? I think this is unacceptably a misplaced priority. After all, oil as a non-renewable energy has been projected to last for a maximum of 50 – 56 years to go into extinction all over the world and so the policy makers have not taken the most economically rational decision. That money now invested in the Chad basin can still be invested in the Northern part of Nigeria, but for other sources of energy- preferably renewable energy sources which is also in superabundance in that part of country. The entire North and Middle Belt regions are profusely well endowed with abundant solar radiation, hence solar energy which must be tapped now. This is the focus of this paper to advance a total shift from how we use to do it, to breaking new grounds and challenge the problem of energy being the greatest problem of this nation and direct massive investment to renewable energy sources with particular reference to solar energy. Investing therefore in solar energy which is an everlasting, renewable energy is at the same time investing in poverty eradication, unemployment and youth restiveness. To present this paper, the structure was, following this introduction was section one devoted to conceptual framework and theoretical investigation. Section two was statement of the problem: the comatose of energy sector, section three was exploiting, the superabundance energy resources: the solar energy: while section four was the revolutionary potential of solar energy in the rural area and its abundance usage in homes.. Section five was concluding remarks: the ideal energy for all times and recommendations: Nigerian leadership to make the exploitation and application of solar energy a matter of national priority and urgency.

2. Conceptual Framework and Theoretical Investigation

The economics of the sun is demonstrated by its huge potential as the most readily and extensively available renewable energy resources with overwhelming capacity to satisfy the needs of the human race. This ability is astoundingly evident by the enormous energy output of the sun, the solar constant which is equivalent to 3.8×10^{33} ergs / see, being the amount of energy emitted within forty minutes of its radiation on the planet earth. This quantity discharged by the sun is proven to be adequate to meet energy requirement of the entire world for a whole year. Paradoxically, less than one percent of this amount of energy discharged by the sun is effectively exploited and transformed for the benefit of humanity [3]. Interestingly, the sun is an enduring and everlasting star, forming the solar system which the earth orbits. The sun and other stars in the solar system are called the galaxies. The earth as one of the planets of the solar system is also a galaxy. It is referred to as the Milky Way galaxy, being the only planet conducive to living organisms, human beings, animals, plants and what have you [4].

The aspect of its replenishment and continuous sources of energy as a stable, clean, renewable and conducive power took scientists centuries to unveil which made humanity to turn to non-renewable fossil sources of energy which is now reaching extinction. The discovery of sun's energy radiating the earth as a stable sunlight, emitting the right amount of energy and the ideal size all the year round has made scientists refer to it as the power House [3,5]. This energy reaching the earth is steady and constant which has also been referred to as solar constant. It is renewable, intangible and unending energy supply accessible to man depending on geographical location, time and season. Along the equatorial axis, sunlight is of high intensity while elsewhere outside this axis, sun's energy concentration is low. Generally, solar energy can be obtained wherever sun shines and all over the world, lots of development has been made in the utilization of solar energy resources but at varying degree. While in some parts of the world, it is highly developed, and in other climes, it is the contrary. At this point in the evolution of the world where effort is towards diversification in energy supply with particular reference to renewable energy resources, some countries remain dependent on perishable, non-renewable fossil energy.



Considering a country like Nigeria, what are the implications of remaining a consuming and not a creative nation, is interrogating on the theoretical exegesis of the country, not much as an underdeveloped country, rather as a country with superabundance of natural resources including solar energy but remains pathetically underdeveloped, plagued with poverty, unemployment and the declining or collapsing of manufacturing sector. All over the world, the engine of growth, infact, development is the manufacturing sector and agriculture which is also the highest employer of labour. In countries with superabundance of natural resources there is tendency for the leadership to abandon the slightest effort to develop real economic sectors but to concentrate on rent from natural resources such as oil. The Nigerian scenario is typical of this theoretical analysis depicted by *resource curse or Dutch disease*. One argument of resource curse devastatingly affecting Nigeria is the penchant for rent-seeking dependence on oil by the policy makers to the extent that the entire economy, policy formulation, budget, revenue allocation or sharing to the three tiers of governments are all tied to revenue from oil. The centre has been so conceived as a pool for sharing of revenue of non-productive sector, hence the neglect of productive sector such as manufacturing and agriculture. In Nigeria, the theory of resource curse has practically changed to resource corruption as if the Federal Government only exist for sharing the rent from oil, hence the entire political elite scheme to always belong to where the action is, that is, the party in power; when it was PDP, they were there and now APC, they are still the same politician changing camp without apology. And with all the poverty and joblessness in the land, the APC government knowing fully well the uniqueness of energy with particular reference to renewable energy to wipe out poverty and despite the abundance of solar energy, cheap, clean and easy to install, the authorities have not deemed it important to invest in it.

3. Statement of the Problem: The Comatose of the Energy Sector

The problem of Nigeria has been well captured by the twin theories of resource abundance/ curse and Dutch Disease; but with the economic recession and the much talked about diversification, the interrogation for further probing is; what diversification? From the economic standpoint, there is relationship between the discovery oil for export and decrease in manufacturing. There is also relationship between lack of energy supply and poverty, if we marry the two economic statements, the problem of Nigeria can adequately be situated, bordering fundamentally on crude oil dependence, underdevelopment, capacity underutilization, unemployment and poverty. But how did Nigeria get here.

Nigeria is a country abundantly endowed with virtually all types of natural resources. As a colonial state, her technological progress was interrupted by colonial hegemony as depicted by the advancement the Yoruba made in cloth manufacturing [6], such that 95 percent of the cloth was consumed locally. It was an affront to the British textile industry, denying Britain 30 million yards of cloth per year. The colonial master forthwith legislated against this competition, thereby put paid to Yoruba technological prowess.

Britain however allowed Africans to thrive in cash crops production such as cocoa, palm kernel, oil palm, cotton, groundnut among others. At the exit of Britain in 1960, Nigeria had comparative advantage in export of cash crop products. It was from the revenue accruing from this source that the First Development Plan 1962 – 1968 was financed. Nigeria was making her mark on the international commodity market when it was interrupted by oil exportation.

The discovery of oil in 1956 gradually replaced the agricultural cash products such that by 1970's have completely displaced these products as the major source of revenue for the country. The rest is history but painfully marked the genesis of the nation's underdevelopment. The oil boom of those years led to total abandonment of key sectors, the agricultural and manufacturing consequently, employment generation. Nigeria a growing population put at over 170 million with 53 per cent living in rural areas and 47 per cent in urban agglomeration, is a country with abundant sunshine being located a little above the equatorial between longitudes 3 degrees and 14 degrees and latitudes 4 degrees and 140 degrees (Nigeria Embassy: 2013). In other words, the country is superabundantly endowed in both non-renewable energy the fossil fuel, crude oil, gas, coal among others as well as renewable energy. For instance, less than 20 per cent of Nigerians are connected to national grid and over 80% are not connected. This percentage of Nigerians not connected is more of rural dwellers and they belong to the household sector. According to a report by partitioning the economy into industry, transport, commercial, household and agricultural sector, the household sector was by far the highest



consumer of energy. Analyzing further the sources of the energy, wood and others topped the list with 82 per cent; kerosene 13 per cent; electricity 4 per cent and LPG 1 per cent [7-8]. The deepened problem of the country can thus be appreciated from the abysmal and erratic power supply. It is the singular problem with multiplying factor resulting into a vicious circle of underdevelopment and poverty. This can best be understood when we revert to economic law which states that the amount of energy available to a community dictates the level of development and well-being of such people which aptly describe the Nigerian problem as not economic but socio/ political with economic implications. This is a country amply blessed in both non-renewable and renewable energy but still lack energy for development. Therefore to alleviate rapidly the unacceptable poverty and unemployment ravaging the country is to deploy all energies to bring to materialization renewable energy with particular attention to solar energy for the benefit of the vast rural dwellers in particular and the generality of Nigerians.

The irrevocability of this policy is timely and with the recession which the country has plunged into, caused by over-reliance on non-renewable oil export, and as the country is stridently and laboriously looking for alternative solutions, caution must be taken not to fall back investing the scarce resources developing non-renewable energy for various reasons. Fundamentally, Nigerian policy makers and the executive arm of the government must be prevailed upon to divert to renewable sources of energy. Extant scholarly predictions have posited the unavoidable exhaustion of non-renewable energy, the fossil fuel within the next 8 – 20 years in the global production [9-11]. And already petroleum oil has become highly expensive, with dwindling reserve and enormous pressure arising from population explosion, high demand in urban agglomeration and rural dwellers [8]. This is particularly evident in Nigeria where there is no reliable population data but where energy demand is increasing astronomically due to uncontrollable and accelerated urban growth. Available statistic [12] showed that Nigeria consumed 8.41 million tonnes of petroleum products in 2007; with over 93 per cent imported with the implication that though Nigeria is a major producer and exporter of fossil fuel (oil & gas) yet a higher percentage of her internal energy needs are filled by expensive imports for lack of functioning refineries. Coupled with insufficient energy to meet her needs is the problem caused by oil spillage and gas flaring on the environment. The amount of carbon dioxide emitted into the atmosphere through fossil fuel combustion and flaring is put at about 20×10^{12} kg [11]. Presently the plants cannot absorb the huge amount of excess carbon dioxide which continue to accumulate in the atmosphere resulting in global warming, ozone layer depletion and other harmful atmospheric hazards. As a result, the ultimate alternative is to revert to renewable, clean and environmental friendly energy with particular focus on solar energy.

4. Exploiting Superabundant Solar Energy Resources for Development

The current world energy projections are emphatic on the decline of non-renewable fossil fuel (oil, gas, coal etc.), coupled with its harmful effects to the inhabitants of this planet, calls for a proactive and urgent action to find alternative energy, a solution already pursued by some developed countries. The strategy is based on energy mix or energy utilization balance between non-renewable and renewable energy potentials. While some countries are already investing substantial resources towards its prosecution, others are still scouting or prospecting for non-renewable crude oil. Be that as it may, the hard truth is that the current fossil fuel can only meet the world's requirement for a few more decades and so the answer is to research and develop the renewable energy being a constant source of energy for humanity.

Energy from the above explanation can be categorized into non-renewable fossil fuel stored beneath the earth as crude oil, natural gas and coal. The renewable energy is energy derived from natural resources that can be regenerated without end. The sun that emits solar energy can be adjudged the catalyst of all other types of renewable energy such as wind, tides and rain. In other words, electrical energy, heat, kinetic and chemical energy are products of solar energy conversion [13-14]. The energy generated from sun is clean, non-polluting, ideal and infinite. Its source is nuclear fusion which uses high temperatures and densities to produce radiant and thermal energies for ages and has enough hydrogen for reproduction for the next hundred billion years ad infinitum [3].

Solar energy can be exploited in two forms: directly by converting sunlight into electricity using silicon cells, also referred to as photovoltaic (PV). The technology of solar-electric conversion of sunlight into electricity is



achieved through a balance of system (BOS) of photovoltaic. The process consists of erecting structures for modules; power conditioning equipment, tracking structures, concentrator systems and storage devices. Photovoltaic so converted could be on a small scale for individuals or on a large scale connected to national grid. The energy so generated is used for lighting, water pumping, drying and other electrical applications. The United Nations commission on sustainable development has canvassed for global access to solar energy as a means to increase energy supply worldwide, create jobs and drastically reduce poverty. The rationale of this advocacy is inherent in the advantage and ease of installation, application and deployment. Individuals have easy access to acquisition, utilization and transportation. According to Akinboro *et al* [7], there is no transformer required, only PV (panels) which can be easily carried, deployed and installed on individual basis at a minimum cost anywhere and at any time throughout Nigeria.

Solar thermal which is also a direct application of solar energy to generate heat is the commonest and has been a source of energy for drying for generations all over the world, though more profoundly and widely used in Africa. Solar thermal also referred to as concentrated solar power (CSP) can be converted into electricity indirectly by the use of lenses or mirrors and tracking systems to focus a large area of sunlight into a receiver that heats a liquid; the excessively heated liquid is used to make steam to produce electricity exactly the same process coal plants do [8]. This technique is by far a less complex and more adaptable method of generating electricity. It is equally a great opportunity for a country like Nigeria that lags behind in energy production to acquire renewable energy at a minimal cost as well as overcome the embarrassing condition of dependence on fossil fuels. Particularly for a country like Nigeria, solar panels and other devices have the capacity to store energy and after sunset to generate power which makes ideal for street lighting and house utilization.

This should be a great challenge to Nigeria or any country with abundant sunshine; if a country like Poland in the cold region could develop a technology capable of storing solar energy in the ground during summer season when there is abundant sunlight and making use of it in winter should spur African countries to invest in such technology. The technology is such that the heat (energy) from the sunshine is stored under the ground through a fluid heat converter system. During the winter season the stored energy is to be discharged to heat household, churches, shopping malls, public establishments etc.

The potentiality of solar energy technologies is quite unique as not just a renewable energy but one that in the long run has a payback period that is quite cost effective and ideal for a continent like Africa devastated by poverty. The potentiality is inherent in the enormous opportunity for research in the technology to produce materials to harness its energy resources. According to Charters [15] solar energy can be obtained directly or indirectly which ever technology is applied as highlighted below:

Table 1

Solar Direct	Solar Indirect
(a) Photovoltaic	Hydropower
(b) Photochemical	Wind power
(c) Photo galvanic	Biomass power
(d) Solar thermal	Solar thermal power

For instance if we consider evolving technologies in the production of PV, according to Lorenz *et al* [16], three technologies are competing for cost of production. These are silicon-wafer-based photovoltaic, thin-film photovoltaic and concentrated solar thermal power.

On global scale, silicon-wafer-based photovoltaic is more popular and constitute up to 90 per cent of installed capacity of solar panels, though costlier to produce. The other one is the thin-film photovoltaic, just recently being produced for commercial purpose; the cost structure is half of silicon-wafer-based silicon. The third significant solar technology is the concentrated solar thermal power being the cheapest available PV in use today [16].

The need for production of solar cells becomes a matter of policy as highlighted by Swami [11] which include low maintenance process and unhindered sources of electricity for all times, very appropriate for those living in far remote places and from national electricity grid, highly cost effective for rural dwellers; noiseless and non-polluting, clean sources of energy, very ideal for tourist sites, caravans and campers; particularly environment



and flexible sources of small quantity of power for laptop, calculators, cameras, high pad, watches and lamps; very timely and renewable sources of energy, appropriate and providential for mitigating global warning. The inexhaustibility, non-polluting, and environmental friendly nature of solar energy made it world's ideal substitutable energy for non-renewable fossil fuels. Some countries far from the Equatorial Belt have made spectacular advancement in tapping into the immense resources provided by its exploitation, in particular, countries in the European Union such as Germany, Spain, Italy and France. There is also United States of America and Japan that have made outstanding progress in the production and marketing of solar PV. Based on the material used different types of solar cell are

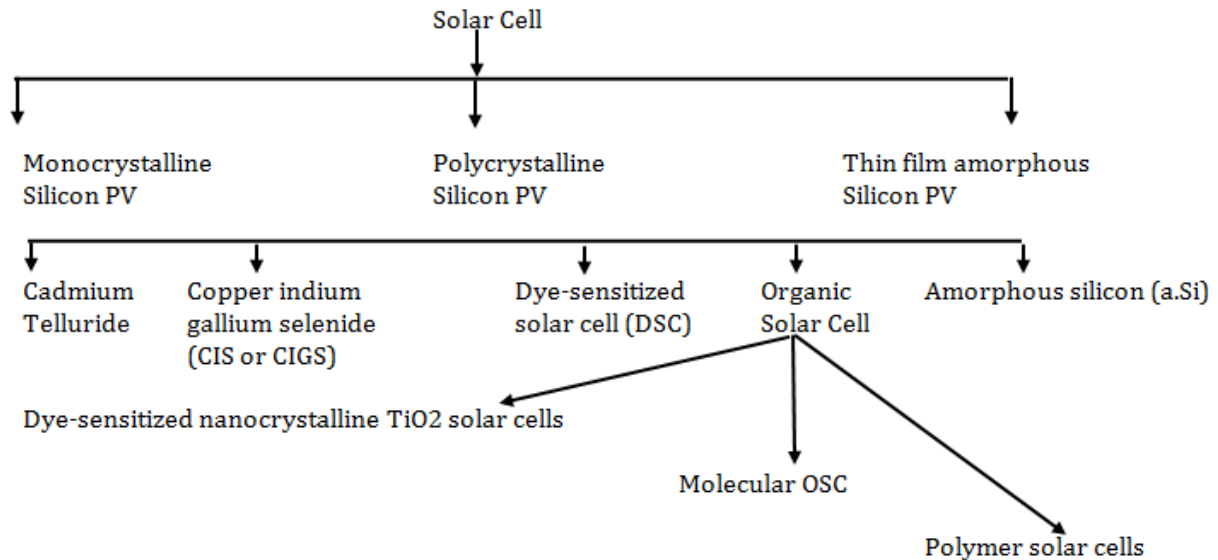


Figure 1: Types of Solar Cell

Table 2 shows world photovoltaic installation as at 2001. From the installed capacity Japan could be seen as far ahead all other countries, followed by United States of America and Germany in that order [17].

Table 2: Global Photovoltaic Installation Distribution, 2001

S/N	Continent	Country	Installed Capacity KWp.
1	Africa	Morocco	3,000
		Egypt	2,000
		South Africa	1,160
		Senegal	1,000
		Botswana	600
		Ghana	196
		Switzerland	60
		2	Asia
India	44,000		
China	8,800		
Indonesia	5,000		
Thailand	4,600		
Korea Rep.	3,459		
Nepal	1,122		
Philippines	217		
Turkey	150		
3	Europe		
		Italy	18,475
		Switzerland	13,400



		France	9121
		Netherland	9,105
		Spain	9,080
		Norway	5,670
		Austria	3,672
		Sweden	2,584
		Finland	2,302
		United Kingdom	1,131
		Denmark	1,070
		Portugal	503
		Slovenia	50
		Croatia	10
		Czeh. Rep.	10
		Romania	6
4	North America	United States	117,300
		Mexico	12,922
		Canada	5,826
5	South America	Argentina	5,000
		Bolivia	470
6	Oceania	Australia	25,320

The distribution of photovoltaic installations is meeting with high competition from developing countries with India recording a leading position in the industrial production of solar equipment which according to Chinnammai [3] has reached 7 MW/years. There are other countries such as China, Malaysia, Taiwan and Bangladesh. Bangladesh for instance, has designed various household programmes based on solar energy; one of such was the solar home system (SHS) with a total installed capacity of 32.586KWP. Another project under Renewable Energy Technologies (RET) have cumulative installed capacity of 40.5KWp based on solar systems among others such that 30 per cent of household works can be effected through SHS [18] pointing to steady advancement of solar energy application in Bangladesh. In the worldwide development of PV panels, China has taken the lead in solar PV production due to government policy which encourages investment with subsidy in the production of solar panels. As for installations, European countries have advantage [13-14].

Africa which supposed to be in the forefront in solar energy acquisition and application based on her strategic location within the Equatorial Belt has been handicapped by low technology. However, some countries are making inroad in solar energy development and application; countries such as Morocco, Egypt, South Africa, Senegal [17] and Kenya. Infact Kenya awakening to solar energy resources is commendable. As noted by Ikponwonsa [14] over 30,000 small solar panels are sold annually in Kenya. Accordingly, more Kenyans are reverting to solar system of power supply. In the referenced table above, even though Nigeria was not featured, the story has gradually changed as the country is now adopting the technology from the number of solar panels mounted in cities like Lagos for street lighting. Since 2014 or thereabout, small solar panels are being sold in Nigeria, imported though, they are mainly for households; for lighting and charging small appliances such as handsets, high pads, watches among others, but given the energy situation of Nigeria, the impact of solar energy to the overall energy consumption is highly infinitesimal. This is an area Nigerian policy makers will have to beam their searchlight and direct investment given the level of poverty and the potentialities of energy to reduce poverty and engineer development.

5. Harnessing Solar Energy Resources to Revolutionise Nigeria's Rural Sector

The Nigeria's current economic situation which has slide into recession is a result of years of lackadaisical handling of public policies. The effect of non-implementation of various policies has turned Nigeria into a mono-dependent economy with the resultant deepened trade imbalance, against major international partners, a devastation of the manufacturing and agricultural sectors being the engine of growth and general praetorian state



of the economy. A situation compounded by unstable monetary and fiscal policies that has plunged the naira into all-time low against major international currencies, making businesses highly uncompetitive and a host of other challenges in particular, mounting unemployment and poverty biting terribly hard in the rural areas. These challenges can be traced to epileptic energy supply as supported by most economic theories and reached by the UNDP [19] to poverty. In Nigeria the lack of adequate energy supply is the greatest bane and as it is, there is no immediate solution in sight. Going by the population that is increasing astronomically ahead of energy provision something drastically must be evolved. Instead of the government committing stupendous resources to prospecting for oil in Lake Chad Basin, such money should as a matter of policy reversal be invested in developing solar energy as most appropriate, superabundant and renewable energy. The government does not need to spend money prospecting for it. It is a ubiquitous energy available wherever sunshines. In Nigeria, it is everywhere all year round. All over the world, lots of solar energy technologies have been developed to supply energy for household consumption, factories, street lighting, automobile and a host of other things. It has become a perfect alternative for non-renewable fossil fuels which is becoming expensive with unstable price in the world commodity market. More so, the rapidly growing world population coupled with the concomitant climate change due to excessive emission of CO_2 on the environment and other societal and economic factors have made the switch to renewable energy with particular attention to solar energy imminent. The availability of renewable energy sources to supply the whole world is possible in the next 10 – 15 years. According to a research anchored by Jacobson & Delucchi (2011 p. 1154) quoted by Timmons, Harris & Roach [20] that renewable energy sources based on wind, water and sunlight (abbreviated as WWS; excluding biomass) is capable of producing renewable energy worldwide by 2030 and replace current non-renewable energy source by 2050.

Table 3: Availability of Global Renewable Energy [20]

Energy source	Total global availability (trillion watts)	Availability in Like-Developable Locations (trillion watts)
Wind	1700	40 – 85
Wave	> 2.7	0.5
Geothermal	45	0.07 – 0.14
Hydroelectric	1.9	1.6
Tidal	3.7	0.02
Solar photovoltaic	6500	340
Concentrated	4600	240

Table 4: Infrastructure Requirements for Supply All Global Energy in 2030 from Renewable Sources [20]

Energy source	Percent of 2030 Global Power Supply	Number of Plants/Devices Needed Worldwide
Wind turbines	50	3,800,000
Wave power plants	1	720,000
Geothermal plants	4	5,350
Hydroelectric plants	4	900
Tidal turbines	1	490,000
Rooftop Solar PV Systems	6	1.7 billion
Solar PV power plants	14	40,000
Concentrated solar power plants	20	49,000
Total	100	

Table 3 shows estimate of the potential energy from various renewable energy sources, converted into trillions of watts. Projected world energy demand is 17 trillion watts. It can be seen in Table 3 that the availability of energy from wind and solar alone is more than sufficient to meet global energy requirements [20].

The estimate of the infrastructure that would be needed to supply the global energy from WWS in 2030 based on the assumption that 90 per cent world energy come from wind and solar and the remaining 10 per cent from other renewable sources was presented in Table 4. Land requirement for the infrastructure was considered. Total land requirement amount to about 2 per cent of the total global land [20] associated with non-renewable, fossil



fuels. In this energy revolution, where stand Nigeria? And for how long will the country continue to wait. These are germane questions posed at the right time and at the right confabulation. This forum being the National Conference of Nigerian Institute of Physics and at a time when Nigeria is faced with overwhelming economic challenges where scholars are already hammering on diversification.

The emphasis of this paper is diversification in energy production, supply and distribution to meet absolute requirements of every Nigerian with a focus on renewable energy sources. Nigeria is greatly endowed in virtually all sources of renewable energy be it, geothermal plants hydroelectric plants and solar PV power plant among others. From the analysis given above in this section, if Nigeria can devote substantial resources to the development of wind and solar energies will be enough to satisfy energy demand of the country and poverty would be greatly alleviated. However, the emphasis is on solar energy in all its application.

Solar energy revolution is strongly canvassed to bail the country out of energy doldrums, power epileptics and the near comatose of the productive sector. The ongoing plan to revive the economy from depression must focus on renewable energy sector with particular reference to solar energy to cater for household, manufacturing and the agricultural sector. The three sectors are vital to revamping the economy. While manufacturing and agriculture have the capacity to provide jobs and mop up the rising unemployment. It must be borne in mind that household is equally critical to reviving the economy; this is because most small scale businesses are household based. Talking of tailor, fashion designer, electrician, computer, ICT, businesses, mechanics among others, are categorized as household and draw their energy requirements from household structure. Renewable Energy Technologies (RET) based on solar system can be deployed to communities, estates, by installing solar based energy system as developed in Bangladesh called Solar Home System (SHS). Rural homes can be flooded though this solar programme. The beauty of solar energy equipment is the adaptability. That is to say, it can be fabricated in varying degrees of sophistication and in a broad range of sizes and costs. In other words, as it can be used in homes for various purposes so can it be used on a large scale by farmers to dry grains or to pump water for irrigation?

In respect to agricultural sector, it has been discovered that the application of solar energy in automobile, in the same way, tractors can be powered through solar energy technology. Infact, in the agricultural sector, Nigeria has no business with non-renewable energy. While the country's engineers and scientists in partnership with manufacturing companies locally or partnership with foreign manufacturers of PV panels, government owe a duty to subsidize the solar energy equipment needed by farmers. The issue of epileptic power supply should be a thing of the past.

Another refreshing characteristic of solar energy is that it can be connected to national grid. And as we have seen, solar energy is a complete and comprehensive energy that can be harnessed directly or indirectly. As such, the dormant manufacturing industry can be profoundly revived and let the technology of solar energy be deployed appropriately to all manufacturing industries all over the countries – all the comatose textile industries great employer of labour, the iron and steel should be connected to solar energy powered grid. Nigeria is so blessed that solar energy can be complemented by wind energy and devices installed in such companies. Solar energy can also be stored under the ground through the technique developed in Poland. In this respect, Nigeria has no reason not to be self-sufficient in power generation. This proactive policy will save manufacturing and industrial sector from exorbitant money spent on generators, the servicing and environmental pollution emitted there from would be eliminated.

In the 21st century, it is a breach of faith and imprudence on the part of the government to allow any hospital for that matter to operate without adequate electricity supply. The advent of solar energy, its ubiquity and unflinching supply makes it inadmissible for any government or its agents not to deploy this type of energy to power the nation's hospitals and public institutions generally.

Table 5: Top Ten Largest Installed Solar Power Capacity Country in the World

Rank	Country Name	Installed (GW)
1	Germany	35. 736
2	China	18. 528
3	Italy	17. 861
4	Japan	13. 947
5	USA	12. 035



6	Spain	5.375
7	France	4.639
8	Australia	3.524
9	Belgium	3.470
10	United Kingdom	3.316

If we consider the ten (10) largest installed solar energy capacity, countries in the world, as depicted in Table 5; a part from China and Australia, the rest are in Europe and America. It is very clear that Germany takes the lead as the biggest solar power producer but interestingly as mentioned above, China has taken the lead in the production of PV panel as a result of government energetic and purposeful policy which granted generous subsidy to PV panel manufacturers, coupled with relatively cheap labour, they have been able to overtake Europe in the production of PV panel; although Germany still has an edge in respect to actual number installed (Table 5). This should be a great challenge to Nigerian policy makers who have to approach critical issues of development in a different way. Various strategies could be adopted ranging from collaboration, partnership, training, subsidized plant location, tax holiday and many more to acquire the technology. Nigeria cannot afford not to be a major player in the production of PV panels and all the new solar energy technologies. It should be a sustainable policy for the basic truth is that renewable energy with particular reference to solar energy never runs out. It is everlasting energy of the future rapidly displacing non-renewable and polluting energy.

At this juncture, it must be asked why it has been impossible for government to engineer a white paper on renewable energy and a sound policy on solar energy. Despite the nation's technological backwardness, the solar energy technology cannot be said to be an extremely complicated or complex one that Nigeria scientists, physicists and engineers cannot develop. What happened to Nigeria with non-renewable energy, the petroleum industry where the nation has remained a rentier state ever since. At this point, all possible strategies must be designed to be on top of solar energy technology.

The search for development of renewable energy technology with special focus on solar energy is a must, given the potentialities of the energy to transform the rural areas and very adequate to reach remote villages and riverine water logged terrain. It is indeed ideal for Nigeria that has suffered untold disgrace from the hands of electricity corporations because of its low cost, uncomplicated installation and easy transportability. It is pollution free and can be stored in the ground and in the battery. An inexhaustible energy appropriate to turn life around for rural dwellers and the vast households condemned to permanent darkness by supplying lighting for cooking, pumping water for general household use, poultry and horticultural farms and a host of other uses.

At this point, the interrogation is what will it take for the grand take-off of full development of this highly profitable, ideal and easy to master solar energy technology? The singular, major problem of all times is the political will which is anchored on lack of visionary leadership. Nigerian nation which is looked to, to lead the continent to industrial and technological breakthrough remain a sleeping giant. Despite this assertion and great expectation, the nation's opportunistic leaders remain dwarf, unambitious and defective in taking *hard* decisions that will turn the nation around not to talk of leading the entire Africa.

Closely related to the above is lack of neither institutional mechanism nor comprehensive energy policy well-articulated proactively formulated to take care of non-renewable finite energy and the renewable energy of the future? The issue may at the end of the day not to do with policy but conscientious and dogged implementation. The third, which is equally critical is the lack of technological adaptability, capability and businesslike. Since Nigerians are used to easy life, developing indigenous technology is culturally resisted; even when individuals have made breakthroughs, it will not be encouraged but frustrated by comprador bourgeoisie; importer/exporter of finished goods in collusion with multinational companies (partners) will not allow such engineering feat to thrive. All the same, there must be synergy between engineering research institutes and manufacturing companies to make inroad in solar energy technology, especially in the manufacturing of PV and other solar equipment. In furtherance to the above is lack of engineering or technical culture. Though some people may look at it as financial handicap but the truth is that Nigerian, generally want quick solution to issues, the same mentality as in business; in short, Nigerian investors do not like investing in long-term business which may not be good enough for developing indigenous solar energy technology in the country. The failure of mastering petroleum technology must teach Nigerians lesson not to lack behind in developing appropriate solar energy technology. Nigeria as a nation must take bold step to move from consuming, or ready-made to creating,



developing and manufacturing for domestic consumption before thinking of exporting. The money realized from The Single Account (TSA) must be deployed to finance solar energy technology. Candidly speaking, this is a technology Nigeria can conveniently master and become proficient in.

There is also overwhelming ignorance of the public on the various sources of available energy which has translated into lack of adequate information and awareness on the potentials of solar energy, its everlasting availability and all-purpose usage to address current energy shortage and epileptic energy supply, have not been sufficiently disseminated. The public awareness must also take cognizance of educating the public on the safety, the non-polluting characteristic of solar energy which makes it an ideal energy for a developing country as Nigeria.

There is the question of affordability. But in the present circumstances where awareness is very low and where few companies engage in importing few components, final word cannot be said, rather to say that issue of energy is central to development and policy on reversing government unchallenging attitude to transforming the nation, energy wise should be uppermost. What, infact should be the government and policy makers do to turn around the fortunes of Nigeria for so long underdeveloped despite abundant resources?

6. Concluding Remarks: Solar Power as Ideal Energy for All Times

This paper has undeniably established from revolutionary perspective having laid bare the unquantifiable potentialities of renewable energy resources in Nigeria, an irrevocable stand for a policy shift from lack or insufficiency energy supply to abundant supply from solar energy resources. Nigeria as a world player cannot sit on the fence waiting for others to work and reap. The whole gamut of the nation's research outfit must be deployed to begin an unrelenting development in the area of renewable energy technologies with particular reference to solar energy.

The ICT revolution has so much simplified research that Nigerian scientists simply need to synergize with other advanced, semi-advanced technologies in solar energy and produce its own variation. The fundamental science for the design, building and creating solar equipment such as solar panels among others are not what our scientists even manufacturers cannot handle. It needs to be localized or customized and turn Nigeria into a technological haven. The various engineering, industrial companies need to network with countless polytechnics, universities of technology, engineering research institutes and develop capacity building such that products of these institutions highly excited to be productive will be gainfully engaged and there would be no room for unemployment. Nigeria must join the group of creative, original, imaginative, innovative and inventive countries. The people must move from dependent, consumer of finished goods from all nooks and cranny of the world and be inventive, producer and exporter of manufactured finished goods. Nigeria must in the next 10 years become a leader in the production and manufacturing of various sizes and models of PV and other solar energy materials and equipment. Definitely, the future of this world is dependent on renewable energy resources with sun at the centre of all the renewable energies. Nigeria is a master in the generation of solar energy by virtue of its location; it must also be a master in its development, application and export of solar as a commodity. The geometric increase of the nation's population should be thought-provoking for the government and its leadership to continually seek for solution to meet their needs. If a party or a president knows that he cannot meet up with the demands of the great people of this country, such person or group should give room for dynamic, visionary set of leadership. The world is exceedingly dynamic, fast-changing with competing technological innovations that need creative, innovative and intellectual sound minds to keep up with the tempo. Nigeria of the 21st century, well-endowed and robustly positioned from all humanly and materially perspective must take all the advantages inherent in solar energy to benefit her people and also be beneficial to the world. (Renewable sources like bio-fuel, biogas, wind energy, tidal energy, hydropower, geothermal, solar energy.)

7. Recommendations: Nigerian leadership to make the exploitation and application of solar energy a matter of national priority and urgency.

Nigeria is a well-positioned country to benefit maximally from sun radiation; the power that produces the solar energy. The country must as a matter of national policy take an unyielding stance for its immediate application. This means that the leadership must commit substantial financial resources for its actualization. As already



canvassed by Solar Energy Society of Nigeria [21]. The government should perfect the details for a National Energy master plan with a distinguished package of Renewable Energy Master as the ultimate energy of the future, which its exploitation must be pursued now. The government therefore owes the people of this country a sacred duty to move her from poverty and unemployment to wealth by paying revolutionary attention to solar energy exploitation.

The government must concurrently propagate the policy of technology of energy mix with focus on renewable energy as the energy of the present and future. The importance of energy mix is critical for positioning the industrial and manufacturing sector of the economy in such a way that iron and steel industry can be fully established with abundant renewable solar energy [22].

The government should backup research and the research institutes for renewable energy – the solar energy. In particular, government must fund companies manufacturing PV cells or materials for making it. Such as silicon wafers among others. With ICT, solar technology is quick to adapt. The environment must be tailored to respond to technology development.

In this period of recession, government must educate the citizen on alternative renewable sources of energy with particular focus on solar energy and its application. Solar equipment such as solar panels of different sizes can be exhibited and the advantages associated with its usage such as cleanness, easy installation, easy transportation, no transformer, no high tension, and no low tension - just sunshine.

This awareness must be complemented by legislation to rid the country of generators which is a source of great impediment to viable energy policy. Its proliferation in Nigeria was a major cause of government energy policy. Now, that non-renewable energy is on the way to extinction and the focus is on renewable energy resources, anything that could be a hindrance must be outrightly removed.

As a matter of national sensitization and global awareness, all new settlements should be totally planned on solar energy resources. All energy to be supplied to such communities or agglomerations must be based on solar energy. The length and breadth of Nigeria's rural areas, settlements and villages must be dotted with Nigerian PV panels to power the solar energy as well as wind energy plants to beautify the landscape.

Government must show pragmatic example of total commitment to renewable, clean and pollution free energy by legislating the replication and application of solar energy resources to power the nation's railway transportation system; the underground metropolitan light train planned for Abuja and Lagos to be totally powered by solar energy. Also government institutions such as Hospitals, Universities, Airports, Ministries, Estates, and Prisons among others must rely on solar energy.

Government should create via local governments solar energy equipment demonstration points to practically create the on-the-spot awareness for the citizens on the unending power derivable from solar energy and its every day ideal application. The present precarious state of Nigerian economy, forced into recession should serve as a motivating factor to wriggle out of it by taking a look at some countries in temperate region benefitting maximally from solar energy. Countries like Germany, Japan, USA, Italy and China to mention a few. Nigeria must not seat on the fence, she must galvanize all resources humanly and materially abundantly at her disposal and launch herself to the forefront, as a model of African economy powered by indigenously designed and developed solar energy technology.

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