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Renewable Energy Resources in Nigeria as Panacea to Electricity Inadequacy: A Review

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Abstract:
Energy is vital to the economic growth of every nation of the world. It is universally believed that per energy consumption of electrical energy of nations of the world determines the prosperity of such nations. In Nigeria, power supply to the citizens is inadequate and this is not farfetched from the fact that the growing population cannot withstand the dwindling generated power. The power required by the blotted population outweighs the power generation and this has created a huge gap between power generation and power demand. This paper reviewed the per capita consumption of the developing and the developed nations of the world and the potentials of the available renewable energy in Nigeria with the view of harnessing the resources to make Nigerians have access to electricity. The renewable energy will enhance affordable, available and adequate power supply to consumers as long as the full potentials of renewable energy sources in the country is maximally harnessed. The paper reviewed the sources of renewable energy, average consumption rate and its impact on the economic growth. The methodology used in this paper was the review of existing literature and collection of relevant secondary data for analysis. The paper posited that electricity inadequacy in Nigeria would become history as long as the available resources of renewable energy is fully harnessed which in turn make power supply available for electricity consumers.

Keywords: *energy, electricity, renewable, resources, panacea*

Introduction:

Energy is required for any activity to be successful in life. It is defined as capacity or abilityto perform any activity. Energy is vital in driving the growth and development of anyeconomy and it serves as an input in growth and developmental processes of any country ofthe world (Akinbami, 2009, Akinyemi et al, 2014). Energy is critical to any modern andgrowing society. Energy heats, cools, and lights our homes and business, powers ourfactories, fuels our cars, and increasingly underpins the fabric of societal communicationthrough modern technology. Sequel to the increased population of the world to be about 9billion people by 2050 as estimated by United Nations, the struggle to provide continuedaccess to affordable energy and increase access to those who lack energy becomes moreintense (Ladislaw, 2011). Energy access is a full requirement for achieving sustainabledevelopment. Energy produced must be environmentally friendly and sustainable for thefuture generations (Oyedepo, 2012, Akinyemi et al, 2014). 20 % of world population of

approximately 1.3 billion people lack access to electricity. 40 % of the world population relies on traditional biomass to meet their daily energy needs such as cooking, lighting and heating. 84 % of the people in the rural areas are without access to electricity. The magnitude of reliance on traditional biomass is estimated to lead to 1.5 million deaths that are 4000 deaths per day by 2030 (Ladislaw, 2011, IEA/OECD, 2011). The power demand and generation in Nigeria is challenged with a mis-match thereby leading to power imbalance which further propels underdevelopment and incessant power failure (Adeoye et al, 2011, Adeoye and Adebayo, 2018). A mathematical model that determines power demand – generation gap was set up to determine the energy gap to be filled by renewable energy potentials as 9160 MW (Adeoye and Oladimeji, 2020). Population of 140 million people in 2006 with per capita demand of fully urbanized city was 0.094 kW (Melodi and Ajeigbe, 2012; IEA Energy Statistics, 2007). Switching to renewable energy produced from naturally replenished resources promotes energy security, likewise addressing issues such as global warming and climate change. Renewable energy contributes to energy resilience through its decentralized structure that lessens the effect caused by potential technical failures or extremist assaults which might significantly damage the national electricity grid (Valentine, 2011). Nigeria is estimated to be about 90 percent deficiency in electricity supply, with some off-grid areas where about 50% of Nigerians living do not have access to electricity (Egila, et al, 2017). Furthermore, in 2013, Nigeria could only provide access to electricity to about 42% of the population (85 million people) dwelling in both the urban and rural areas (Nnaji et al, 2010). Nigeria's energy crisis has paralyzed industrial and commercial activities, with power outages leading to a loss of about 126 billion naira (US$ 984.38 million) annually (Oyedepo , 2012) . The restricted access to fuel for conventional generation in Nigeria requires that alternative sources of power generation, mostly renewable energy sources, be explored (ECN and UNDP, 2005). However, in order to reposition renewable energy as a key driver for sustainable economic development and to make access to electricity for every citizen of the country, there is a need to change the future energy mix towards more sustainable and renewable sources of energy (UNCTD, 2010).

Literature Review:

Energy and Poverty in Nigeria:

The energy dimension of poverty may be defined as the absence of sufficient choice in accessing adequate, affordable, reliable, high quality and environmentally benign energy services to support economic and human development. In Nigeria, about 70 million people (54.4% of Nigerians) are without clean, safe cooking fuels and electricity and depend on traditional biomass sources (Nnaji et al, 2010). Increased access to such energy services will not, in itself, result in economic or social development but lack of adequate energy inputs can be a severe constraint on development.

Renewable Energy Potentials in Nigeria:

HYDROPOWER:

Hydro energy is the only renewable energy currently used commercially for power generation in Nigeria. Nigeria is endowed with large waterfalls, rivers and dams. The total potential of hydro power in Nigeria is about 14,750 MW. Approximately 14 % of the hydro power potentials, that is, 1930 MW which is currently being generated at Shiroro, Kainji and Jebba representing 30 % of gross installed grid –connected electricity generation capacity of

Nigeria (Shaaban and Petinrin, 2014). Artificial dams and hydropower sources can be built due to the large amount of water in some areas in Nigeria. The high hydropower potential in Nigeria is appreciable with an exploitable capacity of 18,600 MW. Unfortunately, only 19% of this exploitable capacity is currently used (Ohunakin et al., 2014). Hydropower, although currently a major source of electricity generation in Nigeria, can play a larger role in the generation and supply of electricity (GENI, 2004). Hydro-power is derived from the potential energy available from water due to height difference between its storage level and the tail water to which it is discharged. Power is generated by mechanical conversion of the energy into electricity through a turbine at a usually high efficiency rate. The overall large scale potential is in excess of 18,600 MW. Small hydro power potentials in Nigeria are distributed in 12 sites and in river basin. There are 278 unexploited sites with potentials of 734.3 MW. Eight small hydro power Stations with aggregate capacity of 39.0 MW have been installed by private company and government. Small hydro power at Jos, Plateau has a capacity of 2MW, 8 MW Station at Kurre fall (Charles, 2014).

SOLAR POWER:

This involves technologies of generating electricity from the energy of the sun. Solar systems provide electricity for rural dwellers, homes, hospitals, schools and businesses among others. Globally, solar energy is abundant and has a huge potential for cleaner climate environment (Tsilingiridis et al., 2004). Consequently, the country enjoys abundant amounts of sunshine. It has been well documented in the past relevant studies that the potential and viability of solar energy sources in Nigeria show that the country has nearly 290 days of sunlight in a year. The average solar insolation in Nigeria is estimated to vary between 4.0 kWh / m^2/ day at the Southern coasts and 7.0 kWh / m^2/ day at the northern coasts of the country (Freling and Lahl, 2005). The daily average is estimated at 5.5 kWh /m^2 / day which shows that availability of abundant sunshine is a positive indicator that Nigeria is an ideal candidate for investment in solar energy resource development. Africa has the potential to expand the continental economy in four folds with energy demands expanding by only 50 % according to report. The International Energy Agency (IEA) unveiled its report on the first day of the second African Investment Forum in Johannesburg, South Africa. Africa Energy Outlook 2019 found that the continents' future energy prospects look bright but only if governments can make the shift to more renewable energy sources. The report says there are three factors that will determine the continent's future energy consumption-its growing population, the rapid increase in urbanization and industrialization (afdb.org/en/news and events/ press releases posted on 14th November, 2019 and retrieved on 16th November, 2019). SUNGAS project is to catalyze development of Nigeria's natural gas and renewable energy markets through innovation, demonstration, policy dialogue and advocacy. Renewable energy has considered potentials in Nigeria and could bridge the major energy gaps in rural areas particularly in Northern Nigeria. New grid technologies such as concentrated solar power are emerging as in competitors with conventional power generation. The scale of renewable energy potential is much larger than the public or policy makers realize. Recent studies credibly put concentrated solar thermal power potential in Nigeria at over 427,000 MW. Present levels of power generation of around 5,000 MW meet only a fraction of demand and

renewable energy power generation could play an escalating role (Newsome, 2012). For Nigeria to meet its energy needs which requires per capita of 1000 W or a power generation / handling capacity of 140, 000 MW compared with the current deliverable capacity of just 5,000 MW which has hampered socio-economic development in Nigeria. Nigeria's renewable energy master plan of 2005 posited that the country should endeavor to increase the energy generation capacity from 5,000 MW to 16,000 MW by 2015 through the exploration of renewable energy sources and in 2020, the country is yet to reach half of power generation target for 2015 (ECN-UNDP, 2005). There are two ways by which solar energy can generate power via thermal conversion and photo voltaic conversion. Solar thermal is the heating of fluids to produce steam to drive turbines for large scale centralized generation. Solar thermal system is called concentrated solar power. Solar thermal system uses a solar collector with a mirrored surface to focus sunlight into a receiver that heats a liquid. The super heated liquid is used to make steam to produce electricity through a photo cell. It could be in a centralized or decentralized form. Photo voltaic technologies convert sunlight directly into electrical power. Nigerian government has started operation "Light up Rural Nigeria" in year 2014 with the aim of providing constant electricity supply to the rural areas through an off-grid system. The first phase is to extend the solar-powered initiative to remote parts of the country that are yet to be connected to the national grid. More people especially the rural dwellers that do not have access to electricity are expected to benefit from this. This is still at the infancy stage in Nigeria but it is expected to reduce poverty by ensuring a high quality service that guarantees the realization of sustainable development goals in Nigeria (www.premiumtimesng.com posted on the 24th January, 2014 and retrieved on the 10th June, 2020).

WIND:

Wind energy is not in use for commercial electricity production in Nigeria, the passion to seek a lasting solution to the poor energy / power situation in the country prompted some research into Nigeria's wind energy potential (Ajayi, 2009). The area has a mean wind speed of 5.36 m / s according to data collected from 1994 - 2003 (Asiegbu and Iwuoha, 2007). The renewable energy potential in Ibadan (an ancient city in Southwestern Nigeria) had a mean wind speed of 2.947m/s and a solar power density of 15.484 W / m^2 (GENI, 2014). The prospect of wind power has been researched in many locations in Nigeria. There are disparities in values of wind speed due to year difference and height of wind data collection for different sites in Nigeria. A set of wind speeds across Nigeria into four different regimes: 1.0 - 2.0 m/s (Osogbo, Minna and Yola), 2.1 - 3.0 m/s (Lagos, Makurdi and PortHarcourt), 3.1 - 4.0 m/s (Enugu, Kano and Maiduguri) and above 4.1 m/s. An average wind speed in Nigeria is from 2.1 to 4 m/s with highest average speed of about 3.5 and 7.5m/s in the south and north areas (Jos, Nguru and Sokoto) (Oyewole and Aro, 2018, Fagbenle and Karayiannis, 19

BIOMASS:

It is usually a plant-derived organic matter as well as animal wastes available for energy generation. It can be used as solid fuel and can also be converted to liquid or gaseous forms

for electric power generation, heat or fuel using different technologies. The use of biomass for energy production is on the rise worldwide. In Nigeria, the biomass resources consist of wood, forage grasses and shrubs, animal wastes arising from forestry, agricultural, municipal and industrial activities as well as aquatic biomass. The total land available in Nigeria for agriculture and under vegetation is a measure of biomass potential (Rahman, et al, 2011). The biomass energy resources of the nation have been estimated to be 144 million tones / year. It is estimated that Nigeria consumes about 43.4 × 109 kg of fuel wood annually. Over 60% of Nigeria's population depends on fuel wood for cooking and other domestic uses. This traditional method is not sustainable as the rate of consumption of fuel wood far exceeds the replenishing rate thus resulting in desert encroachment, soil erosion and loss of soil fertility (National Bureau of Statistics, 2016). The rural dwellers should be enlightened so as to use an improved wood-burning stove which could reduce fuel wood consumption for a particular process by 50%. Also, the government should work towards providing the modern high-efficiency bio energy which uses more convenient solids, liquids and gases as secondary energy carriers to generate heat, electricity, combined heat and power and transport fuels for various sectors (Chum et al., 2011). Biomass is the plant derived from water and bio mass resources of Nigeria are crops, forage and shrubs, animal wastes and wastes arising from forestry, agriculture, municipal and industrial activities and aquatic bio mass. It was estimated that Nigeria produces about 227, 500 tons of fresh animal wastes daily. 1kg of fresh animal waste produces about 0.03 m^3 of biogas. Nigeria can potentially produce 6.8 million m^3 of bio-gas everyday from animal waste only. The estimated range of global bio-energy potentials for the year 2050 is between 32 and 1130 EJ/year (Audu and Aluyor, 2012).

Benefits of Renewable Energy:

The benefits of adopting renewable energy are multifarious. It is renewable, sustainable and will never run out. It is constantly being renewed from natural. They have security of supply, unlike fossil fuels, which are negotiated on the international market and subjected to international competition, sometimes even resulting in wars and shortages. Renewable energy needs less maintenance than traditional generators. Their fuel being gathered from natural and available resources reduces the costs of operation (Agbongiarhuoyi, 2015).

The Role of Renewable Energy Technologies in Nigeria's Sustainable Development:

Renewable energy has an important role to play in meeting the future energy needs in both rural and urban areas. The development and utilization of renewable energy should be given a high priority, especially in the light of increased awareness of the adverse environmental impacts of fossil-based generation. The need for sustainable energy is rapidly increasing in the world. A widespread use of renewable energy is important for achieving sustainability in the energy sectors in both developing and industrialized countries. Nigeria is blessed with a large amount of renewable natural resources, which, when fully developed and utilized, will lead to poverty reduction and sustainable development.

Limitations to the Development of Renewable Alternative Energy Resources in Nigeria:

The development of renewable energy resources in Nigeria has been limited by a number of factors, which include:

(i) Cultural Religious and Traditional Issues:

Rejection of new energy may sometimes arise from cultural taboos. Certain new energy involves known taboos in certain part of the world e.g. the use of human excreta in biogas production in some parts of Africa.

(ii) Technology:

Apart from solar thermal and biogas technology, the required technology to develop and tap other forms of renewable energy technologies is lacking in Nigeria. Most of the technologies are being imported thereby escalating the already high investment cost.

(iii) Inadequate Funds:

Lack of funds thwarts the development of new energy resources. Public funds are limited and the absence of any serious private sector participation in the development and dissemination of the technology poses a serious barrier to renewable energy technologies.

(iv) High Cost of Energy Infrastructure:

Small scale hydropower, central and residential solar photovoltaic technologies, etc have not penetrated Nigeria's energy supply systems because of their relatively high investment cost.

(v) Political Factor:

Centralization is a problem for new fuels which are usually scattered and produced on a relatively small scale. There is also the preference for advanced technology in developing countries. Also political zeal to implement desirable energy options is a major limitation, because of political interest.

Methodology:

This paper discusses different types of renewable resources with the view of suggesting how to derive efficient and constant power supply in Nigeria and the potentials of them were carefully reviewed. Information was collected from secondary data, such as journals, internets with respect to energy resources in Nigeria and per capita energy consumption. This present circumstances made the point of relation to the state of renewable energy in Nigeria.

Data Analysis:

The per capita energy consumption in Nigeria is one of the lowest in the world, about one-sixth of the energy consumed in developed countries. This is directly linked to the level of poverty in the country. Table 1 is presented to illustrate the per capita energy consumption in Nigeria from 2002 to 2011. The falling trend of energy consumption from 0.754 toe / capita in 2002 to 0.703 toe / capita in 2009 before stabilizing at 0.721 toe / capita in 2011 was observed. These values may be compared with a value of 1.253 toe / capita obtained in Gabon, 2.186 toe /capita in Libya and 2.795 toe / capita in South Africa for the year 2011. Fig. 1 shows the graphical expression of per capita energy consumption of Nigeria from 2002 to 2011 as shown in Table 1.The scenario in the chart could be linked to a steady increase in population without a corresponding increase in energy production and consumption. It is a fact that no country can develop any significant growth without proportional growth in its primary energy exploration for secondary energy production like electricity as mostly required by the industries and consumers. Fig.2 expresses the behavioral pattern of per capita

energy consumption with the highest in 2005 at 0.760 Toe/cap. Evidently, Nigeria provides a classic example. Table 2 represents the per capita electricity consumption for African countries. The per capita electricity consumption per annum in Nigeria is plotted and shown in Figure 2 along with few other African countries. As shown in the figure, the per capita electric energy consumption in Nigeria for an average household of five people was 149 kilowatt-hours (kWh) per annum for the year 2011. This value is among the lowest ten in the world. Incidentally, studies have shown that there is a strong correlation between energy consumption and economic growth; access to modern electric energy directly contributes to economic growth and poverty reduction of a country through creation of wealth. The abysmal low annual per capita electricity consumption in Nigeria obviously constitutes a major roadblock to economic progress and social wellbeing of the citizenry. Table 3 represents different countries with their population and electricity consumption per capita. U.S.A has a population of 250 million with power generation of 813, 000 MW and per capita consumption of 3.3 kW. South Africa has a population of 44.3 million with per capita consumption of 1.02 kW. Nigeria has a population of 140 million with power generation of less than 4000 MW and per capita consumption of 0.03 kW.

Table 1: Per capital energy consumption in Nigeria for 2002 – 2011

year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Toe/cap	0.755	0.745	0.750	0.760	0.750	0.732	0.737	0.705	0.720	0.722

Source: Akorede et al, 2017.

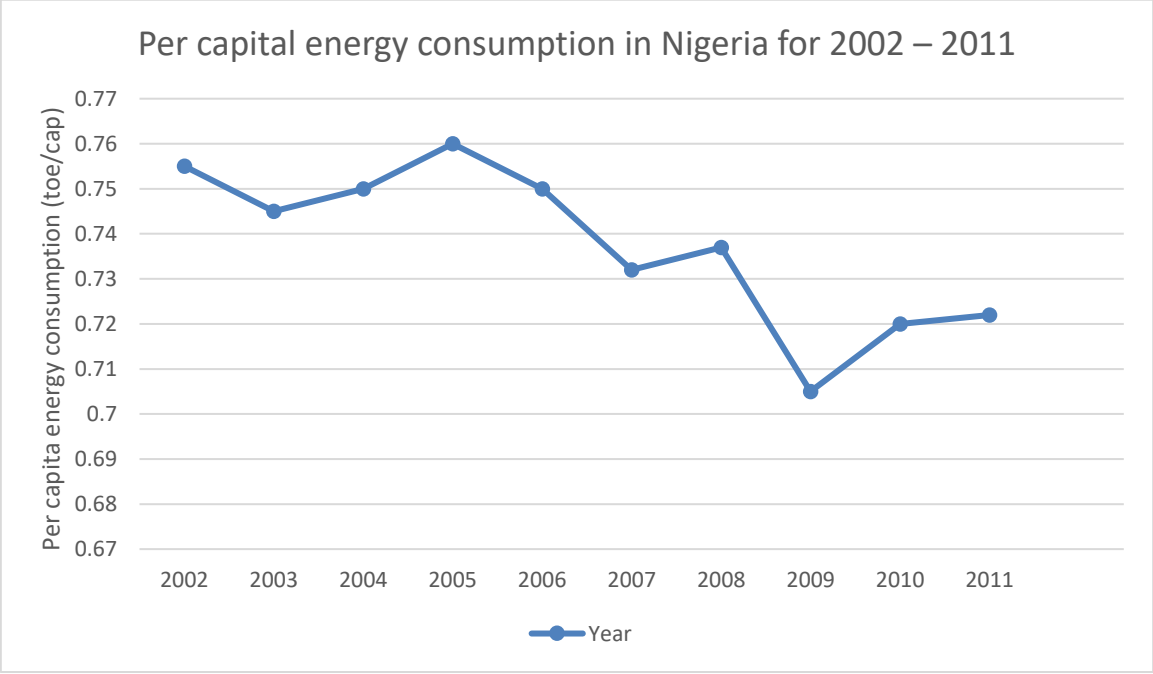

Figure 1: Per capital energy consumption in Nigeria for 2002 – 2011

Table 2: Per capita electricity of a few African countries

Countries	Nigeria	Kenya	Senegal	Ghana	Gabon	Egypt	Libya	South Africa
kWh/cap	100	150	200	300	800	1700	3800	4700

Source: Oseni M.O, 2012

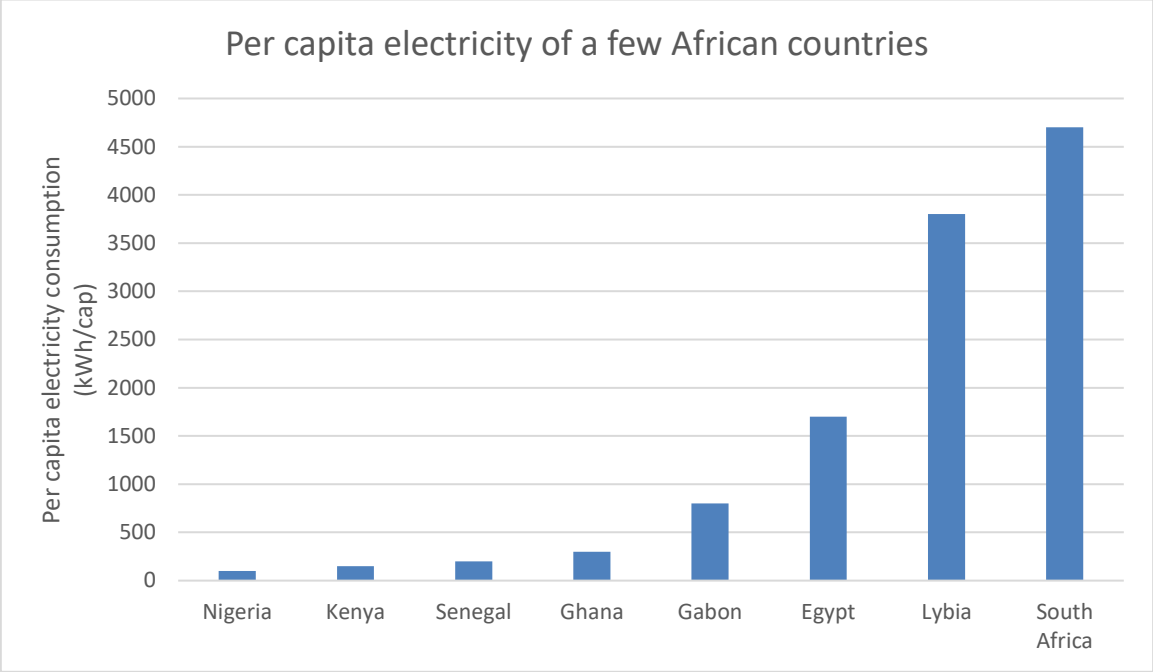

Figure 2: Per capita electricity of a few African countries

Table 3: Country Statistics of Electricity Generation and Per Capita Consumption

Continent	Country	Population (Million)	Generation Capacity (MW)	Per Capita Consumption (kW)
North America	USA	250	813,000	3.2
South America	Cuba	10.54	4,000	0.38
Europe (Central)	UK	57.5	76,000	1.1
Europe (Eastern)	Ukraine	49	54,000	1.33
Middle East	Iraq	23.6	10,000	0.42
Far East	South Korea	47	52,000	1.1
Africa	Nigeria	140	< 4,000	0.03
	Egypt	67.9	18,000	0.27
	South Africa	44.3	45,000	1.02

Source: IEA Energy Statistics, 2007

Conclusion:

Fossil fuels, whose supply is limited, and their extraction, conversion and transport cause severe pollution which is responsible for global warming. The paper has explicitly reviewed the need to make use of the abundant resources of renewable energy that are limitless and the risk of climate alteration is reduced, while they also contribute to job creation. The renewable energy resources in Nigeria such as hydropower, biomass, solar, wind geothermal and others are in abundance and should be maximally harnessed to fill the gap created by the conventional power generation which is grossly inadequate for the growing population of the country. This will help the country to move on the part of development and later joint the comity of the developed nations of the world in the nearest future.

Recommendation:

1. One of the major factors militating against the deployment of renewable energy in Nigeria is lack of clear government policies. The government should provide adequate legal framework for renewable energy development.
2. To ensure long term development of renewable energy and energy efficiency, there must be human resource development at high level and manufacturing capacity building. Critical knowledge and technical know-how transfer should be the focus for project development and management.
3. Renewable energy is the solution to increasing cost of producing conventional energy.
4. Renewable energy sources such as solar and wind energy (both of which are grossly unexploited) provide very good sources (opportunities) to increase energy generation in Nigeria.
5. There is need to review and strengthen the energy policy of Nigeria to make it more responsive.
6. Energy based economic development in rural community is recommended in order to achieve 100% prospect of renewable energy.

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