

## The Utilisation of Renewable Energies in the Modern Tropical Cities of Nigeria

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### Abstract

This study which examines the utilisation of renewable energies in the modern tropical cities of Nigeria in the West African Region benefits from the renewable energy specialists' views, authentic facts in texts, and the top-geomorphic exploration of the Nigerian environment. The study identifies and analyses the four most suitable types of renewable energies in the country as hydro, solar, wind, and biomass. It argues strongly that widespread beneficial development is possible in Nigeria where adequately viable and reliable energies are established and transmitted to the diverse areas of need through the public-private efforts. On this premise, the study analyses the diverse contributions of renewable energies to Nigeria's development in the vital areas of agro-production, construction, manufacturing, communications, transportation, aesthetic tourism, human health sustenance, rural-urban business, crime reduction, research and innovations. Based on its findings, the study suggests realistic measures, which include, inter-alia, the deployment of specialists, adequate funding of energy projects, provision of effective security in the work sites, improvisation of suitable tropical technology, and improved research and innovations to sustain the continuous utilisation of modern renewable energies in Nigeria.

### Introduction and Research Problem

Contemporary planned cities characterised with hydro-geomorphic resources, potent green surfaces, climatic essentials, and viable socio-economic and political facilities immune from persistent fossil pollutants spurred by agro-industrial, automobile, and electrical engines are the most desirable habitats for city residents across the diverse climates of the world. In addition, a pristine political system, which fosters adequate housing, stable food production, secure transport networks, healthy healthcare system, efficient communications, and the safety of people in the city, becomes the second most desired quest of the current city dwellers. Prudent utilisation of the facilities established in the modern cities by the residents and the collective sustenance of the amenities by the urban authorities become the decisive options in making the cities suitably healthy for human habitation and fruitful socio-economic activities. The built urban facilities in the modern universe require permanent surveillance and sustenance, which must be realised through the integrated cooperation of government agencies, business organisations, corporate entities, and the private interests. Similarly, durably viable, adequately reliable, and efficiently functional clean energies, which are relatively noiseless in operations, are needed to sustain these complex, built-up, and high-tech facilities in the modern cities. The most suitable among these modern clean energies in the humid tropical Nigeria based on its hydro-geomorphic nature, climatic traits, human-capital capacities, location and site, the government's preference for impactful development, acquired specialties, and personal selection are the hydro, solar, wind, and biomass powers. These four important renewable energies would elicit our profound scientific assessment in the current study. The realistic contention of the modern urban climatologists in the 21st Century is how to nurture and facilitate the authentic functionality and impactful development of the global city system. This specific option suggests the urgent integration of the simple environmental ethics and designs, which can be used with suitable specialists' techniques to ward-off hazardous pollution and destructive city forces. The aim is to make the global city environment realistically sustainable towards improving the living standards of the residents at all the levels of habitation [1]. The use of renewable energies in the modern cities of the world has a number of merits. First, reliable abundant energy in diverse forms is provided for the people's consumption in their residences at the exact time. These modern energies are practically habitat friendly, pollutant-immune, safe, noiseless, and viable across the seasons. Third, these energies interact mutually with the green urban surfaces thus stimulating diverse private and public operations in the cities. These renewable powers provide healthy breezes in most private and official residences for safe human respiration. The use of renewable energies ensures the formation and occurrence of abundant meteoric rains in the city environment, which alleviate the heat wave crises. Renewable energies usage promotes the life span of the city residents in both low and high elevations, agro-insects that enhance surplus harvests production in diverse farm settlements, and microorganisms which serve as catalysts in soil formation and crops fertilization. Finally, these energies stabilize atmospheric temperatures, facilitate even clouds spread, stimulate rainfall, accelerate ozone production, and mitigate the severe impacts of global heat circulation. In the tropical cities of Nigeria, the processes of exploration, a retinue of challenges confronts exploitation, generation, and transmission of renewable stable energies to diverse users. Poor national planning and governance, inadequate private-public funding of viable energy projects, terrorist and bandit attacks on the worksites, dearth of technology, the brain-drain overseas, sporadic hydro-geomorphic and atmospheric surveys, and poor workers' mobilisation are the frontline limitations. Others are delays in projects execution, misuse of energy projects funds, and applications of substandard exotic materials for facilities installation, generation, and transmission. As of the current period in Nigeria, water, crude oil, natural gas, coal, and solar powers are utilised but these energies are generated far below the required satisfaction of the private-industrial sectors owing to the setbacks itemized. It is against this background of realistic setbacks that this current study examines the major sources and types of possible renewable energies and their contributions to impactful development in Nigeria. The realistic measures to sustain the utilisation of these new energies in Nigeria are also discussed in the study.

### Research Methods

A general topo-geomorphic exploration of Nigeria using the contemporary Collins' (2010) Atlas for Nigeria and Iloeje's (1982) [2]. A New Geography of Nigeria was carried out. Major hydro-climatic elements of Nigeria were observed and physically identified as radiation, rainfall, humidity, temperature, and wind. These major factors blend with the vegetative resources were assessed as mandatory for the inception, generation, and provision of adequately renewable energies to the diverse areas of need in Nigeria. In addition, suitable texts and recent articles in reputable journals were reviewed and the relevant facts derived for applications in the study. The specialists' responses in orderly verbal discussions on the types of renewable energies needed in Nigeria were utilised in the study. To these experts, eight preferred major types of energies listed as coal, crude oil, hydro,



solar, gas, nuclear, wind, and biomass should be developed in Nigeria for impactful diverse uses. From these identified energies, four most suitable and stable renewable powers which are hydro, solar, wind, and biomass were selected for scientific assessment premised on environmental intricacies, innovation selective approach, skilled human resources, capital availability, technological capacities, workers' security, and personal reflections. These holistic facts formed the primary data and documented information used in the current study. Overall, the positivist scientific approach, which relates valid theories to observations, was applied in the analysis and discussion of findings. No doubt, the study suggests suitable measures to sustain the renewable energy sector of Nigeria in the West African Region.

## Results and Discussion

### The major sources and types of renewable energies in Nigeria

This part of the study examines the sources and possible types of renewable energies in the modern cities in Nigeria. The hydro, solar, wind and biomass energies are selected based on both physical and human factors. These factors are locations, suitable sites, hydro-geomorphic features, climate and vegetal resources, human safety, adequate capital, expertise, political stability, skilled management, and technical potency of the tiers of authorities in existence in Nigeria.

#### Hydro-energy

The hydro-energy is derived from the natural water body. Specifically, the river water in motion is required to generate this renewable energy. The headwaters of the choice flowing river must plunge down from either a natural highland or manufactured dam via the penstocks into some durably devised turbines. The turbines link up the fixed dynamos, which generate the electricity. High-voltage transmission cables derived from the step-up transformers are connected to the step-down transformers. From the built sub-stations, underground electric cables take their sources. These electric cables are finally stepped down by other viable transformers, which distribute the electricity through the over-headlines to the diverse areas of needs within and beyond the cities. In Nigeria, the widespread use of hydro-energy accompanied the construction of the Kainji Dam at the River Niger in Minna in 1969. This laudable effort was expanded with the inception of the Shiroro Dam Project also in Niger State. Currently, there are several human-made dams across Nigeria. Some of these dams serve as sources of water, energy, vegetables, and fish for private and industrial uses. Others serve as tourist grounds for domestic revenue generation, students' explorations and surveys, research and invention, and aesthetic benefits to many workers and visitors. The Kainji Lake serves as a veritable site for anxious visitors. It enables the divers, tourists appreciate the norms, and ethics of the local people, feed on their fruits and meals, and assess the microclimate of the site. The extensive impact of the Lake's refreshing cool breezes on the tourists' health is also great to observe in the area. As its merits, this energy is characteristically clean, noiseless, reliable, pollution-free, distributable, and cost-friendly. However, the seasonal variations in meteoric rainfall, frequency, intensity, and distribution across Nigeria have had serious negative impacts on the energy generation and supply to users. Inadequate funding by the private-public authorities, shortage of modern technical facilities, brain-drain overseas, misuse of funds by the contractors, and poor facilities maintenance have obstructed the full viability of the hydro-energy sector in Nigeria. Despite these visible setbacks, the hydro-electricity remains one of the most reliably functional, clean, affordable, and renewable energies for domestic-industrial utilisation in the modern tropical cities of Nigeria. As it is currently, the hydroelectricity can be generated in almost every State in Nigeria. This is practically possible owing to the torrential rainfall and presence of fast-flowing seasonal rivers in all the States. Adequate capital provision, improvised tropical technology, skilful management, supply of viable electrical inputs, security of workers, routine maintenance of energy facilities, and occurrence of high rainfall amounts are the mandatory requirements to realise the generation and distribution of hydro-energy in Nigeria to its fullest.

#### Solar energy

The solar energy is a truly recent renewable clean energy being generated by modern experts in the Nigerian Energy Sector. It is vastly suitable and available for development in every State in Nigeria owing to sustained radiation of natural sunlight from the earth's atmosphere. Effectively receptive solar panels skilfully devised by specialists in the energy industry are mounted on the outside fields and rooftops of buildings where they are exposed to sunrays for storage and transmission. Insulated and transmissible cables are connected to link these solar panels with high duration storage and energy providing batteries in the built high-voltage stations. The generated solar electricity is finally distributed to the areas of need. This is one version of its production. The solar energy is the conversion of energy

from the natural sunlight into usable electricity. This is done directly either by using the photovoltaic (PV) technique or indirectly by applying the concentrated solar power method; or a combination of both methods. On the one hand, the photovoltaic cells are able to convert sunlight into electric currents using the photovoltaic effects. On the other hand, the concentrated solar energy systems use mirrors or lenses and tracking systems to focus a large area of solar radiation into viable small beam as solar power. The suitable factors for the installation and development of the solar energy exist in abundant state in Nigeria as of the period. Based on its pristine location coordinates within Latitudes 40N-140N and Longitudes 30E-150E [2-4]. Nigeria receives its daily mean temperature which enhances from 270C in the coastal Sub-Equatorial South to 330C and above in the expansive Continental North. This air temperature is markedly adequate to derive the required energy in terms of distribution, intensity, reception, and storage for solar energy inception across Nigeria. Other factors include clear skies for natural solar energy penetration and passage, extensively absorptive rural-urban surfaces, adequate funds and technology, ready market, and proven human expertise in the new breed solar energy sector. In the USA, the Solar Energy Industry there has installed the double-digit gigawatts (GW) of solar PV capacity with 10.6 GW. In Abu Dhabi recently, the world's largest solar power plant was commissioned for use owing to the abundant presence of high solar radiation and suitably receptive urban surfaces as in physical and human-built solar facilities and digital technologies. In Nigeria currently, there are huge benefits to derive when this energy type is vastly developed. First, the energy would guarantee secure investments in agriculture, industry, trade, education, transportation, recreation, and other related socio-economic activities. Second, the use of solar energy would save human lives and ensure a pollution-immune environment in Nigeria. Third, being simple to install, generate and maintain, it implies that it would be largely available for use and cost-effective to afford by the rural-urban Nigerians. It would provide great values to built residential houses when placed for sale in Nigeria. Finally, the solar energy would ensure the functionality of all the relevant operations and guarantee sustained development in modern tropical settlements in Nigeria. The seasonal rampant fire outbursts in private homes, public facilities, and agro-industrial sectors would be put at bay in Nigeria.

#### Wind energy

A scientific analysis of circulating winds is deeply grasped from the close assessment of the global atmospheric circulation. In the global circulation, it is observed that the primary, secondary, and tertiary levels exist. These winds could be used as significant requirements for wind energy development in any place in the world. In fact, for sustainable global wind electricity to be generated, these levels of winds must be sufficiently captured by the wind turbines, stored, and distributed to the diverse areas of power needs. Permanent wind circulation across the world is induced by some viable physical factors. These are solar energy, radiation disparity, earth's rotation, angular momentum, and the pressure gradient force. These factors are operational in Nigeria based on its latitudinal position in the world. As Iloje (1982) [2]. observes, there are seven major tropical types of winds in operation in Nigeria. These are tropical maritime, tropical continental, equatorial easterlies, land and sea breezes, and the anabatic and katabatic winds. These winds are adequately suitable for wind energy development on the land, water, and mountainous surfaces. Adequate capital, specialized workforce, exotic technology, suitable environment, market, and pristine climate are needed in Nigeria. Improved private-public support, security, and motivational work remunerations should be added up to the former factors to make the wind energy inception plan a huge reality in Nigeria. The wind energy has some vital merits. It requires moderate capital, viable technology, and specialized workforce to establish. It is of high efficiency in the areas of need. It is carbon emissions free. In terms of kilowatt, it is easily adjustable to meet the people's needs. It is quick and easy to construct on the land surface. It can also be set up at the sea. The land below the wind turbines can be used to grow crops and raise livestock for human consumption. It has become one of the cheapest sources of power for man's use in the modern world. Based on these relevant merits, it is fundamental for Nigeria to invest greatly in this sector in order to accelerate and realise its vital development goals without polluting its complex environment.

#### Biomass energy

Biomass consists of plant materials and animal waste. These products are burnt directly to produce solid fuels or converted into gaseous and liquid biofuels through the industrial refining processes. Most biomass is burnt directly for heating and cooking, or indirectly to drive turbines and produce electricity. As Tyler (2005) puts it, the burning of woods and manures for heating and cooking supplies almost 10% of the world's energy and 30% of the energy used in the developing countries such as Bangladesh, Ethiopia, Burundi, and Bhutan. The production of biomass energy for man's use requires a number of factors. First, fast-growing trees should be cultivated in large numbers of plantations. These trees include cottonwoods, sycamores, willows, shrubs, poplars, water hyacinths,



and perennial grasses. Large numbers of these trees should be harvested and burnt in the select biomass plantations. Third, in some prominent agro-areas of the world, plant waste, animal manures and countless crop residues, which are derived from sugarcane, rice, millet, cotton, maize, oil palm, cocoa, and coconut, should be gathered, burned, and converted to industrial biofuels for diverse human uses. Particularly in Nigeria, adequate capital, resourceful expertise, pristine climate, viable remunerations, political stability, and life security are needed to sustain this biomass energy sector. In addition, large areas of flora and crop production as well as animal husbandry should be set apart to create vital avenues for adequate biomass collection, storage, processing, and distribution within Nigeria. Effective means of transport networks coupled with adequate material sustenance are needed in the sector to achieve the anticipated successes in energy production and distribution to the users. There is argument that the production of biomass energy creates and increases CO<sub>2</sub> emission into the world's natural atmosphere. However, there is a counter argument that where the rate of use of biomass does not exceed the rate at which it is replenished by new plant growth, which consumes the CO<sub>2</sub> in the air, there would be lucid absence of net increase in CO<sub>2</sub> emissions [5,6]. Nigeria exists as a prominent sedentary agro-country in West Africa. Its soils are suitably fertile in the Forest South, Grassland Middle Belt, and Sudan-Sahel North. In addition, vast hectares of useful forests and disposed animal waste products are available in the country. Adequate capital is available, and experts needed in the sector could be deployed from the Western World to Nigeria based on mutual multilateral negotiations and ratified agreements. The transfer of exotic industrial technology for use in Nigeria would be easy as long as the government provides the required funds for its acquisition. Finally, evenly suitable biomass electricity production points on large-scale would have to be determined in Nigeria for smooth energy transmission to the utilization points. Biomass energy experts of prominent traits would help determine these points in Nigeria.

### The Contributions of Renewable Energies to Nigerian Development

The inception and transmission of renewable energies to diverse users would activate and promote countless private businesses within Nigeria. In the rural regions, rice, millet, groundnut, and corn milling factories would spring up. The rural people would set up Cocoa, coffee, and palm oil factories, brick firms, cassava grating mills, hair dressing salons, and bike repair worksites. In the cities, modern malls for the sale of computers and cell phones, cement and block factories, and fashion design schools would be established. Miscellaneous firms, which produce snacks, textiles, shoes, food, pharmaceuticals, electronics, and electrical materials, would also start operations in the cities. Immense sales of products would be recorded which would generate revenues for the business owners. As jobs and revenues accelerate in figures, so would rural-urban penury decrease with its attendant socio-economic and political crimes in Nigeria. The results would be realistically seen in a lucidly sane and healthy society of responsible people. The provision of regularly stable, viable, and reliably noiseless energies to diverse users would result to generation of huge sums of revenues and funds to both the private interests and public agencies in Nigeria. In addition, the supply of reliably stable energies would activate the inception of adequate rural-urban water and waste treatment factories across Nigeria. In this regard, human's health would improve immensely as water-borne diseases such as dysentery, cholera, and typhoid would cease to exist. In Nigeria, its environment would be rendered virtually clean and healthy for human habitation and numerous investments owing to effective sanitation and regular waste treatment operations. As observed using computer internet explorations of the world, stable energies are used for operating tourism, recreation, banking, transport, and communication facilities in the developed western world. Of these energies, the hydro, solar, wind, geothermal, and biomass types are the most utilised in the latitude. Nigeria should emulate these developed countries and generate her own renewable energies to accelerate impactful realistic developments in these vital sectors itemized. In the vast agro-sector of the Nigerian economy, reliable energy supplies are needed for the processing, storage, preservation, and distribution of agro-produce to the consuming areas. Significant intensive researches and modern inventions in tropical agriculture are realised using computer and internet facilities. Stable energy provisions are mandatorily required to activate and operate these facilities. The impacts of these inventions, by inference, would be evident in adequate food, cash crops, and livestock production against the old traditions of produce destruction by insects and diseases, and shortage of foodstuff for human consumption in Nigeria. As of today in Nigeria, consistently inventive researches into the diverse sectors of its economy geared towards meaningful and impactful developments are urgently required. The sectors concerned are agriculture, forestry, lumbering, fishing, mining, and quarrying. The others are building and construction, manufacturing, refinement, communications, transportation, banking, pharmaceuticals, health, distribution, and marketing. In these aspects, adequately stable and renewable energies become the salient mandatory requirements for the inception, activation, and operation of these facilities installed in the diverse sectors of the Nigerian economy. Adequate sectoral production of the diverse human needs and healthy human safety are mandatory in Nigeria to accelerate her

current development objectives. Sufficiently functional and stable energies are essential to achieving these laudable feats.

Effective safety and operations of airports, seaports, train stations and motor parks in Nigeria depend, largely, on adequately stable, functional, and ready power supplies of diverse grades. The renewable energies assessed in the study could offer these possibilities and help achieve other significant goals such as the perennial safety of facilities and passengers, production of aesthetic and nutritious satisfactions, generation of local revenues and foreign currencies, foreign business promotions, and exchange of specialized services and products among the countries involved. Pollution free and renewable stable energies have become the unique operational means on which the current global socio-economic and political systems are suitably anchored. In the rural and urban healthcare systems, reliably viable energies are required to carry out vital clinical tests and diagnoses as well as perform significant life-saving operations on admitted patients in the hospitals. Stable and functional energies are needed to expedite satisfactory production of industrial technologies, electronics, pharmaceuticals, standard construction materials, educational apparatuses, consumable goods, defensive weapons, and human clothing. More so, important office documents and classified policy decisions of governments are stored in modern computers. The successful operations of these socio-economic activities and political affairs within Nigeria and beyond depend on the inception, viability, and provision of adequately stable and reliable renewable energies. Domestic house activities would also benefit immensely from the use of renewable stable energies in Nigeria. The preparation of hot clean water for bathing, consistent electrification of buildings, and the cooking of diverse meals for human consumption and healthy living are possible owing to viable renewable energies. In addition, the heating of cool indoor habitats to ensure warm microclimatic human acclimatization, regular sanitation of kitchens, living rooms and bedrooms within the buildings, and intermittent washing of human clothing would become lucid possibilities owing to availability of stable clean energies. Finally, the utilisation of renewable energies would result to prevention and mitigation of incessant injections of greenhouse gases into the rural-urban atmosphere in Nigeria. In essence, the huge green surface would sprout thereby producing abundant flora produce for human consumption while the human devised world would be largely healthy in the aspects of physical respiration, building ventilation, human procreation, meteoric water utilisation, sports, aesthetic tourism, advanced research, and impactful innovations.

### The Measures to Sustain the Utilisation of Renewable Energies in Nigeria

The hydro, solar, wind, and biomass energies are selected, assessed, and suggested for urgent inception and transmission to the diverse areas of need in Nigeria. In this part of the study, the effective measures to sustain the perennial utilisation of these four renewable energies in Nigeria are discussed. First, adequate funding of renewable energy projects and continuous provisions of viable electrical and mechanical materials are suggested for immediate realisation in the new renewable energy sector of Nigeria. The sustained cooperation of the private-public authorities is most necessary in these areas. More so, suitably functional energy technologies with sustainable spare parts of exotic characteristics should be imported from Sweden, Germany, Spain, Canada, United Arab Emirate, England, and the USA into Nigeria for timely installation and utilization. The dynamos, turbines, transformers, solar panels, underground pipes, batteries, diverse cables and wires, air-conditioners, serviceable computers and digital phones that are adjustable to tropical climates are the most required. Locally similar technologies would have to be devised by the Nigerian experts based on the perfect energy training received from the foreign specialists. The patriotic development paradigm should be instituted within the Nigerian development system as it concerns suitably qualified human workforce. This paradigm specifies that the Nigerian specialists in renewable energy inception, installation and transmission trained overseas and currently serving in other parts of the world should be sought after and invited to redeploy home for a certain period to resuscitate, renew, and develop the energy sector for the vast Nigerian Economy. Their functions, already itemized, should span a five-year period within the Nigerian territorial energy space after which the locally mentored specialists would take-over their duties in the renewable energy sector. Adequate remunerations, hazard allowances, safe security, and suitably stable accommodation should be provided for these overseas specialists during their work habitation in Nigeria. Generally, effective security of the renewable energy producing and transmission workers should be strengthened across the entire Nigerian geomorphic landscape using the civil defence, policemen, soldiers, and the naval and air force officers. The essence is to ensure adequate safety of the renewable energy-producing workers as well as secure the diverse energy resources established in Nigeria from reckless vandalism, burglary, fire outbreaks, and terrorist attacks. More so, the enlistment of the local community vigilantes to monitor and provide close security at the sites of functional renewable energy resources is necessary. To this end, specially built remotely sensitive monitoring stations in camouflage are required in the four cardinal



locations in Nigeria to provide continuous and sufficient sites feedback to the National Security Headquarters established for this security purpose. Intensive researches matched with pragmatic innovations are necessary in the renewable energy sector in Nigeria. The positive findings of these studies, which must be properly documented as essential data banks in functional computers, should be utilised to strengthen and maintain the energy sector, prevent frequent fire outbreaks, and facilitate holistic efficiency in the provision of adequate energy to the diverse users in Nigeria. Overall, timely and satisfactory monthly remunerations lucidly backed with gainful allowances, leave bonuses, routine workplace nourishment, and leisure grants should be given to all the local experts and related workers in the renewable electricity sector in Nigeria. These measures are orderly as the inception, generation and provision of reliable adequate energies should be the mandatory concern of the Federal-State Governments while the Local Authorities should monitor and provide feedback on the state of normalcy and performance of established facilities within their geomorphic constituencies across the country [7].

## Conclusion

This study, which benefited from energy experts' responses and documented facts in some select texts, examined the utilisation of renewable energies in the modern tropical cities of Nigeria. As its objectives, the study lucidly identified and assessed the main sources and suitable types of renewable energies in Nigeria as hydro, solar, wind, and biomass. The characteristics of these energies and their contributions to sustainable development in Nigeria were analysed. The realistic measures required to sustain the utilisation of these renewable functional energies in Nigeria such as adequate funding of projects, importation of viable modern technology, deployment of western specialists,

robust security provisions to workers and facilities, effective research, training of local energy workers and innovations, workers' mobilisations, inter-alia, were suggested in the study.

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