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# A Review of the Feasibility of Selected Renewable Energy Technologies in Delta State of Nigeria

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## Abstract

The significance of Renewable Energy Technologies (RETs) to sustainable development, although largely undisputed is often categorized by inherent 'implementation-related' challenges. Such challenges are largely associated with conflicts in establishing the suitability of each technology to specific regions based on the unique peculiarities of each region. Therefore, in an attempt to facilitate the resolution of these 'suitability-based conflicts' this investigation sought to explore common RETs as obtained from literature via a combination of interpretive, discourse and synthesis analysis. The study sought to establish the most viable RETs for Delta State of Nigeria based on the theoretical exploration of the peculiarities of the state as obtained from literature. This analysis was subsequently able to establish the viability of all RETs considered with the exception of the liquid bio fuels due to identified possible impacts. These negative impacts include the possible increase in cassava prices, suggested significant Life Cycle Accounting (LCA) of the entire production process as well as the relatively poorer technological competence within the region for the production of 3rd generation bio fuels. Indeed this study attempted to summarize the unique peculiarities of each technology considered to aid the analysis while simultaneously considering the hydrogeology as well as the climate of Delta State of Nigerian as a conduit for establishing the validity of the conclusion of this analysis.

**Keywords:** Renewable energy technologies, Life cycle accounting, Sustainable development, Delta State, Hydrogeology, Biofuels.



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# 1. Introduction

Delta State is a state located in the South-South geopolitical zone of Nigeria having a common boundary with Edo and Ondo States to the north-west, Imo and Anambra to the north east, Rivers and Bayelsa States to the southeast. The state which has a Capital city of Asaba is also characterized by a 160 kilometer coastline bounded by the is the Bight of Benin on the Atlantic ocean (Nigeriagalleria, 2014).

According to Inoni (2007), the State, which is predominantly rural, is well traversed by flowing streams and rivers that ultimately empty into the western coast of the Niger Delta. The state is characterized by a cocktail of vegetation ranging from mangrove swamps along the coast to freshwater swamp forests as well as a savannah in the northern extremities.

According to Online Nigeria (2003a) since Delta State is situated in the tropics it experiences a climate that ranges from the humid tropical in the south, to the sub humid in the northeast. The state also experiences an average rainfall of about 266.5mm with a daily temperature average ranging from 30°C to 44°C. Indeed the prevailing climatic and hydrographic conditions promotes fishery and agriculture related activities within the state. Figure 1 clearly illustrates the basic geography of the Delta State of Nigeria.

However according to Shaad and Wilson (2009) although the region is characterized by numerous natural resources that should encourage economic activity, poverty in the Niger Delta remains significantly higher than the national average, with over 70 per cent of the residents having no access to basic services. Idemudia (2006) further emphasizes an underlying anomaly of the prevailing situation since the region accounts for about 70 per cent of government revenue via oil and gas exports. Indeed the deteriorating economic conditions as well as the significant environmental degradation due to crude oil exploration activities suggests the need for the identification of energy sources that will facilitate sustainable development of the region (O'Rourke and Connolly, 2003).


**Figure-1.** Niger Delta region of Nigeria (Urobo, 2012)

# 2. Viability of Renewable Energy Technology in Delta State

In recognition of the dire energy condition of Delta state as well as the need for alternative and sustainable energy, this section will therefore explore the most common Renewable Energy Technologies (RETs) to establish viability based on the fundamental peculiarities of the state.

These common RETs, which utilize energy sources such as solar energy, geothermal, biomass, energy from water (hydro energy) and wind energy (motion) will be explored and logical conclusions reached from literature (Michaelides, 2012; New Energy Technologies (NET), 2014).

## 2.1. Wind Energy

In exploring the validity of wind power in Delta State, it is logical to suggest that the feasibility of wind power will be dependent on the availability of a minimum wind velocity. Level (2013) insists that wind velocity remains a fundamental consideration for wind electricity generation capacity with wind velocities of 2 m/s being the minimum required to initiate rotation in most small wind turbines. Dike (2011) subsequently stated that mean wind velocities of 2.1 $ms^{-1}$ to 3.0 $ms^{-1}$ are obtainable in the Niger Delta region suggesting that sites in Delta State are low wind speed regions with wind-power density values of less than 100 $Wm^{-2}$. However, according to Chineke and Nwofor (2007) while the wind power available in the sites can be used for small stand-alone wind power systems, it can also be scaled up using modern wind energy technologies, thus promoting the integration with other energy systems.

*[Wind energy: Selected for Delta state]*

## 2.2. Geothermal Energy

In establishing, the viability of geothermal energy for Delta state Huddlestone-Holmes and Hayward (2011) suggested that for the selected working fluid, it is critical for the temperature difference between the temperature of the reservoir and the rejection ($\Delta T$) also called the sensible heat extractable from the production hole is optimized. Indeed optimizing sensible heat ($\Delta T$) improves the overall economics since the capital cost is by far the largest component of Levelised Cost of Electricity (LCOE) of geothermal systems. Helston (2012) therefore suggests that although energy can be tapped anywhere on the earth's surface, volcanically active regions are much more practical for convenient access points to geothermal energy. However for regions of no volcanic activity Helston stated that an average geothermal gradient of about 2.5-3°C/100m will be sufficient for low-intensity applications such as direct space heating and cooling systems, agricultural drying as well as low wattage power generation. Having considered

the minimum requirement for geothermal energy generation Olumide (2013) further stated that the availability of boreholes utilized in exhausted oil extraction sites eliminates the drilling cost while also emphasizing that the mean geothermal value is 3.29$^{O}$C/100m within the Niger Delta region supports the consideration of 'low temperature' geothermal energy as an alternative energy source.
*[Geothermal energy: Selected for Delta state]*

## 2.3. Solar Energy

According to Okolocha (2010) the climate of Nigeria and indeed Delta state is perhaps the major reason why direct solar radiation (sunlight) constitutes one of the two most prominent of sources of renewable energy, the other being biomass. According to OnlineNigeria (2003b), this observation is due to the location, with the state lying roughly between longitudes 5°00 and 6°45'E and latitudes 5°00 and 6°30'N, very close to the equator. Indeed as a general rule a greater amount of solar radiation is received nearer the equator than near the poles where the angle of incidence of radiance is greater with up to an average of 12 hours of sunlight daily as illustrated in Figure 2 (Columbia University Department of Earth and Environmental Sciences (CUDEES), 2007)

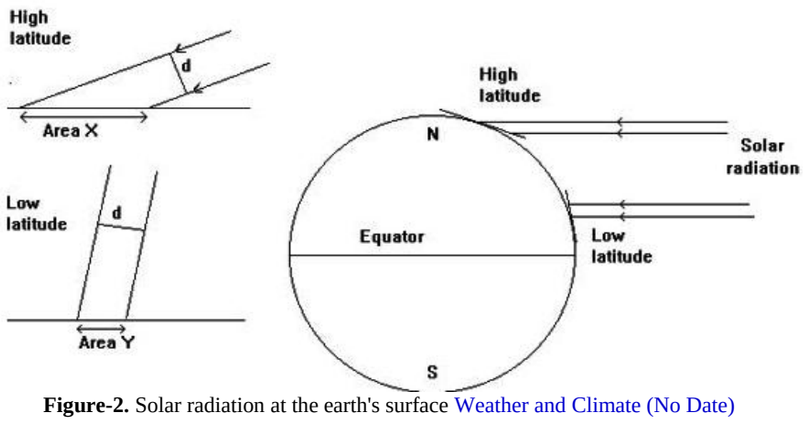


**Figure-2.** Solar radiation at the earth's surface Weather and Climate (No Date)

Since according to Hoyt (2008), the total daily peak sun hours approximately equals the value in kWh of the total amount of direct and diffuse solar radiation incident on a square meter in a day, a 12 hour daily sunlight suggests the availability of approximately 216600 x $10^{6}$kWh. A value obtained by virtue of the available total land area of the state (18,050 sq. Km) (Egun, 2012). Indeed literature suggests the feasibility of solar energy use in Delta State by virtue of its sub equatorial location.
*[Solar energy: Selected for Delta state]*

## 2.4. Biomass

As suggested earlier, the abundance of biomass as a renewable energy source is largely undisputed, indeed according to Omuta (2011) in the absence of sustainable and functional energy alternatives, the significant proportion of individuals in the Delta already depend on biomass fuel sources for their domestic energy. The challenge is therefore not the availability of the resource but the selection of the appropriate conversion technology. McKendry (2002) therefore suggested that the energy conversion process is largely selected based on the nature of biomass available with biogas technologies requiring regular organic waste and liquid bio fuels requiring specific feedstock. In exploring the viability of Anaerobic Digestion for the conversion of biomass to Biogas, it is important to consider the biogas generation parameters such as temperature regime and pH, which according to Cioabla (2012) are the two most important parameters that have a direct impact on biogas production with Monnet (2003b) subsequently suggesting two major temperature ranges for on-site application:
- Mesophilic conditions, between 20-45°C, usually 35°C
- Thermophilic conditions, between 50-65° C, usually 55°C
Figure 3 therefore summarizes the biogas generation variation for different temperature ranges.

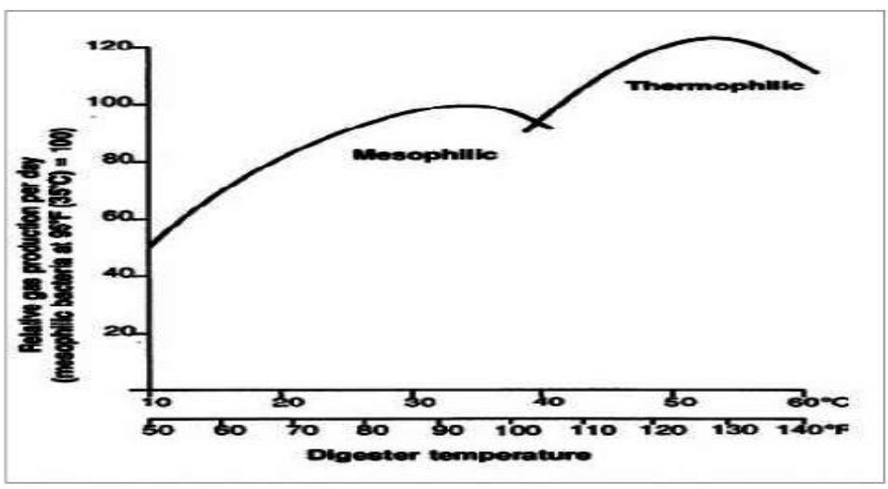


**Figure-3.** The variation of biogas generation with temperature (Roediger, 1967)

As established previously, the location of the state suggests that consistent heat energy will be available thus encouraging Anaerobic Digestion feasibility within the Mesophilic and indeed the Thermophilic temperature range, depending on the prevailing seasonal condition. Indeed the need for external heating for the digester as well as complex pre-treatment of the feedstock does not exist. Perhaps it is the recognition of this that led Okoro (2014) to suggest the suitability of the technology for the Delta since the process would guarantee a steady supply of biogas, generating power to meet base and peak load requirements of the region. This assertion is however valid provided the pH and other parameters are well monitored.

While the abundance of cassava, agricultural waste as well as sea weed in the Delta may present a scenario that promotes the production of 1st, 2nd and 3rd generation liquid bio fuels the resultant impact on the state must be considered to establish feasibility (Ogwo, 2012). Indeed the possible negative impact on cassava prices, as well as suggestions that the environmental impact of some liquid bio fuels may actually be significant if the Life Cycle Accounting (LCA) of the entire production process is investigated supports the selection of AD as the sole biomass conversion technology that will be explored in the Delta (Phipps, 2007).
*[Biomass energy via Anaerobic Digestion Conversion: Selected for Delta state]*

### 2.5. Hydroelectric Energy

As earlier established Delta State is a region that is not only well traversed by flowing streams and rivers, but also shares its coastal boundary with the Atlantic Ocean. According to Otutu (2010) some of the important Rivers in the region include the Niger, Ethiope, Adofi and Umu rivers with the Ase Creek being a major creek within the region. Indeed the abundance of inland rivers as well as the closeness to the Atlantic Ocean suggests the feasibility of undertaking small hydroelectric power projects as well as tidal and wave power projects respectively. Perhaps the realization of this feasibility of hydro energy was the driver that prompted the National Council on Niger Delta (NCND) to encourage investment in small run off river hydro energy projects to boost rural electricity in the region (Aminu, 2013). *[Hydro energy via small hydro, wave and tidal technologies: Selected for Delta state]*

## 3. Synopsis of Selected Technologies

This analysis was therefore able to establish the viability of all RETs identified with the exception of the liquid bio fuels (Biodiesel and Bio ethanol) mainly due to possible competition with existing food sources within the state. Indeed, the unfavorable LCA that characterizes liquid bio fuel production as well as the poor technology maturity of the 3rd generation liquid bio fuel suggests that the utilization of the RET within the context of Delta State may not guarantee sustainable practice.

## 4. Conclusion

Having recognized the significance of RETs as one possible and realistic alternative to the existing non-sustainable power systems operating in Nigeria and indeed Delta State this investigation sought to establish the most suitable RET for Delta State of Nigeria based on the unique peculiarities of the state without compromising the need for sustainable development. The research study therefore incorporated a comprehensive analysis of the most common RETs as obtained from literature while simultaneously investigating the basic characteristic hydro geological structure of the State in an attempt to establish a logical selection of viable RETs for the state. This investigation was therefore able to identify the most appropriate technologies, with all RETs considered practical with the exception of ethanol and biodiesel, mainly due to the competition of food sources as well as the less than satisfactory knowledge of the conversion processes

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