Waste to Energy Technologies and Its Energy Generation in Nigeria

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Abstract
The need for efficient and sufficient power supply in Nigeria has really brought about an increasing interest in renewable energy generation particularly from solar, wind, biomass, hydro and municipal solid waste (MSW). Energy recovered by waste raise unique interest because of its enormous benefits to the environment and social and economic advancement. For clean operation of waste to energy (WTE) facilities requires frequent supply of MSW in Nigeria. This study has really presented the implications of recovery energy from waste using incineration system of WTE technologies. It shows also the variations of electricity generation in states in Nigeria as between 31-205MW depending on the state's waste generation capacity. The outcome supports situating of WTE facilities in Nigeria. It also presented a policy recommendation that show the strength from adopting WTE technologies.

Keywords: *municipal solid waste, Renewable Energy, Electricity generation.*

1. INTRODUCTION

Global warming issue is a global challenge. The environment has been endangered in many ways by producing energy from non- renewable sources. The non renewable energy sources as fossil fuels (natural gas, oil and coal) will in due course get depleted (Ramos *et al*, 2018). Carbon (iv) oxide release is predicted to be 8.6 billion metric tons in 2035.This carbon (iv) oxide released to atmosphere stays there since not all are absorbed by plants or oceans. (Othman *et al*, 2017). Basically, it is not surprising that the fossil fuels are the major cause of the effect of greenhouse which necessitates global warming and the climatic changes (Othman *et al*, 2017). Energy demand is expected to be 9.7% by 2030; therefore Nigeria requires all support available towards increasing the energy production while mitigating pollution (*Oh et al*, 2018). Nigeria has RE resources: solar, wing, biomass, and hydropower which have the capacity of producing clean and environmental-friendly energy. Besides, the demand rate is expected to rise; therefore, serious efforts and investments are required to meet the needs, hence this work. This work is based on energy recovery from municipal solid waste (MSW) using incineration method, a type of thermal treatment process. Waste treatments systems are categorized into two types; biological treatment (aerobic composting and anaerobic digestion) and thermal treatment (incineration, gasification and pyrolysis) (Tan*et al*, 2014).

The composition and also the quantity of MSW is being influenced, according to the World Bank facts, by the economic development level, cultural believes ,geographical site, sources of energy , and climate change (Pan *et al*, 2015). In Nigeria, the amount of waste generated ranges from about 0.2-0.4 kg per person per day in the rural areas to 0.66 kg per person per day in the urban cities (Emem *et al*, 2019). The reasons behind the increment are related to the population growth, the rising of the economic productions, urbanization process (Fazeli *et al*, 2016).

The primary category of waste is considered to be organic matter representing 49.78% of the collected waste in Nigeria (Harir, Ksaim, & Ishiyaku, 2015). Organic wastes are capable of being transformed into methane gas, CH_4 (50%-55%) utilizable as a fuel (Johari *et al*, 2012).

This paper is aimed at highlighting energy impacts of WTE in this Nigeria using incineration system. Biomass and organic waste is considered which is reported to be dominance in the overall wastes in Nigeria 49.78%. Biomass is basically agricultural residues. These create a positive renewable source of energy capable of being utilized in the production of fuels and electric energy (Ramos*et al*, 2018). Efficient process reduces carbon (iv) oxide emissions thus mitigates greenhouse gas effects. For that reason, biomass is undoubtedly a carbon reducing fuel that lessens carbon (iv) oxide emissions and methane emissions from land fill (McKendry, 2002.).

2. ENERGY IMPACT

As a result of growth in economy and technological advancement, it is forecasted that in 2030, the electricity demand will reach 1.9×10^3 MWh respectively in Nigeria (Ezennaya *et al*, 2014). By 2030, renewable energy (RE) sources are targeted to contribute about 10% of energy requirements in Nigeria (NREEEP, 2014). This will encourage the development of RE sources. Therefore, as a result of waste abundance in Nigeria, WTE is courageous.

2.1. Electricity generation potential from MSW in Nigeria

In Nigeria the average MSW generation rate is of 0.49 to 0.56 kg MSW/cap/day (Hoornweg andBhada-Tata, 2012; Solomon, 2009; Bichi and Amatobi, 2013). It is projected however by 2025 to produce about 100,000 tonnes of MSW/day of waste generation in the urban at rate of 0.80 kg MSW/cap/day (Hoornweg and Bhada-Tata, 2012). Thus, the potential for electricity generation per hour of having WTE incineration facilities in Nigeria can vary from different states from 31 to 205 MW at 0.53 kg/cap/day. At MSW generation projection rate of 0.80 kg/cap/day, the individual states potentials for electricity generation varies from 47 to 312MW. It is estimated that the country's electricity generation potential varies from 26,744 GWh/year (0.53 kg/cap/day) and 40,753 GWh/year (0.80 kg/cap/day), resulting to 0.78 MWh/tonne of MSW (Tosin *et al.*, 2017). According to World Bank (1999), 0.68 MWh of electricity can be recovered per ton of incinerated waste. According to Amber *et al* (2012) estimate, a WTE potential of 0.70 MWh/ton MSW and a report by Amoo and Fagbenle (2013) a range of 0.75-1.59 MWh/ton MSW for electricity produced through incineration and for the overall waste generated. According to Ogwueleka (2009), in urban cities, MSW generation rates varied between 0.44 and 0.66 kg/cap/day. The MSW generation rate according to (Nnaji, 2015) can vary broadly inside and among states from 0.13 to 0.71 kg/cap/day. Hence, MSW can generate energy which can contribute significantly to energy supply in Nigeria. Urban cities have high generation capacity waste with non-organic fractions, whereas the rural communities generate high amount of organic waste having relatively small quantity of inorganic waste (Amber *et al.*, 2012).

2.2. Exploitable electricity generation capacity at various states

According to report by (Tosin *et al.*, 2017) MSW generation rate of 0.30 kg/cap/day and waste collection efficiency (WCE) of 30-50%, states in Nigeria have the potential of electricity generation as low as 50 MW. Tosin *et al.*, *(*2017) also reported that 2-15 states have up to 50MW at high MSW generation rate of 0.80 kg/cap/day, at 30-50% of WCE. Hence, Nigeria has the potential to generate electricity from MSW and is varies between 3768 and 26,082 GWh/year, with a capacity factor of 80% of the plant. This is suggesting that 0.60 kg/cap/day of MSW generation and 70% waste collection efficiency; WCE is enough to have half of the states to possess a WTE facility connectible to the national grid. According to the Nigerian Electricity Supply Industry (NESI, 2015), in Nigeria, the installed plants for electricity generation from gas and hydro-electric power plants in 2015 was12,522MW, but the capacity available was 7141MW as a result of constraints for repair and maintenance. The available

capacity was further reduced in 2015 to 3879MW due to inadequate gas and supply of water, reduction in the capacity of transmission and imbalances in the demand. The Nigerian Energy Support Programme (NESP,2014), reported that the demand for electricity was estimated at between 8664 to 12,800 MW in 2014, but projections by different authors suggested the rise in the demand of electricity from 28,261to 88,698MW by 2030. In order to meet with the present and projected demands for energy, the Energy Commission of Nigeria anticipate from renewable energy sources contributions to be 14,970 MW from Solar energy ,47 MW, 12,132 MW and 1660 MW from large and small-hydro respectively. Others are 65 MW from biomass crops with an investigative annual consumption of electricity of 99,590 GWh in 2025. Taking into account the exploitable electricity production potential at 0.80 kg/cap/dayMSW,at 30 to 80% WCE, predicted WTE potential has the capacity of providing up to 10% of the renewable supply of energy that was projected, 0.7-1.7% of the overall projected supply of energy in 2025, and meet up with 9.8- 26.2% of the indicative consumption of energy in 2025.
According to Mohammed *et al*. (2013), the collective energy potential from micro-, small-, and large hydropower plants in Nigeria is estimated at 12,220 MWand 1900 MW of large hydropower is presently being exploited. Recently, Akuru *et al.* (2017) estimate was that the utilizable energy from hydropower stations will be 36,000 GWh/year, amounting to one-third of the reported value reported by Mohammed *et al.* (2013). The solar energy potential is reported to vary from 4 kWh/m^2/day in the south to 6.5 kWh/m^2/day in the north (NESP, 2014). The energy potential of wind is estimated at 50,046 MWh per annum (Shaaban and Petinrin, 2014), although Mohammed *et al.* (2013)reported a higher range of 120 - 790 MW at average wind speed of1.6- 4.4 m/s and 10- 25 m height.

3 POLICY RECOMMENDATIONS

The following recommendations are proposed towards maximizing the potential of waste-to-energy in Nigeria. Looking at the disengagement between policy-makers and stakeholders in the management of solid waste, it is important that proper arrangement for the operation of WTE projects in Nigeria. Appropriate framework is recommended to promote current and better sustainable energy recovery alternatives from wastes. Opportunities are abound to be explored among formal and informal sectors in the states through strategic partnership towards promoting sustainable waste management system as well as secure adequate quantities of waste. There should be waste management policies that will integrate waste pickers and scavengers, create jobs, lessen damage to the environmental caused by increasing use of not reusable goods, and lower fiscal costs of operating landfill. There should be an organization where the informal waste pickers form cooperative societies and have direct engagement with government and private sector. This will enhance the productivity of waste pickers and encourage higher income, contribute substantially to energy recovery and increase firms' proceeds by removing the role of agent's process of transfer (Aljaradin *et al.*, 2015).

4 CONCLUSIONS

This study presented waste to energy technologies and its energy implications in Nigeria. The study also presented an investigation on the available WTE potential in Nigeria at various MSW generation rates, efficiency of collection and energy conversion technologies. The study showed that the potential for generating electricity varies between states in Nigeria from 31 to 205 MW at waste production capacity of 0.53 kg/cap/day, using incineration with energy recovery as the preferred alternative of thermal treatment. This add up to the nation's annual potential generation of electricity from MSW to be 26,744 GWh/year, and could go below to 3768 GWh/year at reduced capacity of 0.30 kg/cap/day and the efficiency of collection of 30%.There is need for adequate feasibility investigation of rate of waste generation before citing a WTE facility, to ensure economic possibility.

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