

ANALYSIS AND PROSPECT ON WASTE TO ENERGY FOR ELECTRICITY GENERATION, (STUDY OF ABA ABIA STATE, NIGERIA).

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ABSTRACT

Analysis and prospect on Waste to Energy for electricity generation conducted within Aba metropolis establishes a knowledge that about 173.3million kg of waste per annum can effectively generate about 426.07GWhr to 883.32GWhr electricity per annum dependent on type of waste used for Waste to Energy plant. The project considers different kind of wastes, and energy generated from them jointly, in order to develop a framework for sustainable waste-to-energy power plant. The aim of this paper is to take advantage of poorly disposed waste on our streets diverted to landfill and some wastes that are indiscriminately degraded by heating and turn it to techno-economic asset of waste to energy plant(to produce electricity).The set objective is to analyze the quantity of waste and its type in Aba city and turn it to” waste to energy” (electricity). The literature review examines briefly the efforts of different researchers and technologies used for waste to energy plant. The method used for this work summarily review the mathematical model for calculating gross electricity generated from waste and the research diagram for the proposed waste to energy plant. The analysis and results from the methods used for calculating energy generated from waste shows that much energy can be generated from the waste of low heating value. Besides the areas with greater population produces more waste than areas with lesser population of people.

Keywords: Analysis, Prospect, Waste To Energy.

1.0 INTRODUCTION:

Recent findings have shown that “about 400 Waste- to- Energy Plants are operating in the European Union (EU). None the less, only 20% are disposed by incineration and more than 42% of Waste produced in EU is still land filled” (Jiri Kropce). There is a large potential for new up-to-date technologies for energy recovery of waste. Waste becomes valuable source of clean and reliable energy; and in this way it contributes to reduce of primary energy sources consumption. Power – from – waste plants are combustion plants designed to destroy or reduce in volume municipal and in some cases industrial waste. Even though there are no Waste-to-Energy (WTE) plants in Nigeria within the period of this research, but much studies have been carried out to study the potential of this technology. Three study cases (i.e. Toluca; Valpariso, and Buenos Aires were presented by (Themelis 2013). Results show that, for the city of Toluca (Mexico); it is possible to produce 96 GWh yearly based in a capacity of 160,000 tons of waste per year; for the case of Valpariso in Chili, a plant with a capacity of 336,000 tons of waste per year is projected. The generation capacity in this case is 182GWh per year. Results from the technical and environmental evaluation show the benefits of the plant. Finally; a plant with a processing capacity of 1 million tons per year for the city of Buenos Aires (Argentina) is also considered. The electricity generation is estimated – 605GWh per year.

The problems of poor waste management, deteriorating supply of electricity cum occasional load shedding has affected the economic growth and performance of manufacturing industries that depends on electricity. Different types of waste in our environment are recklessly diverted to landfill, some are thermally degraded without taking due advantage of the heat energy for co-generation.

The aim of this paper is to take advantage of poorly disposed waste on our streets diverted to landfill and some indiscriminately degraded waste by heating and turn it to techno-economic asset of waste to energy plant(to produce electricity). The set objective is to analyze the quantity of waste generated in Aba city and it’s types that can generate more energy (electricity).

2.0 LITERATURE REVIEW

The level of exploitation of Waste-to-Energy Plant varies from Country to Country. The composition of waste varies from place to place. There are different types of waste suitable for disposal in a Power – Waste – Plant, which can be classified under:- hazardous waste, Industrial Waste, Municipal Solid Waste (MSW) Biomass waste and Refuse derived Fuel (RDF).

2.1 Biomass Waste

Biomass waste can be divided into four categories urban, agricultural, livestock and wood wastes. Urban biomass waste is a special category available in relatively small quantities. It usually comprises timber waste from construction sites, some arsenic house hold refuse a special category available in relatively small quantities. It usually comprises timber waste from construction sites. Some organic house hold refuse and wood and other materials from urban. Most of this is cycled through an urban refuse collection. The waste from Timber sites at Ariaria market, the waste from leather at Bakassi site in same Ariaria and other areas like Nkwo ngwa and Uratta market generate preponderance of waste that can be massively collected in an enclosure and conveyed to waste to energy plant where it can be thermally degraded to generate heat or be converted to residual derive fuel (RDF).

2.2 Municipal Solid Waste (MSW)

The nature of Municipal Solid Waste (MSW) mainly includes physical; chemical and sensory properties. The nature of municipal Solid Waste is closely related to its composition where they are employed, these plants generally burn domestic and urban refuse – called in this context municipal Solid Waste (MSW) – using the resulting heat to generate steam to drive a conventional steam turbine. Municipal Solid Waste (MSW) can also be sorted and treated to produce a compacted fuel called ‘refuse – derived fuel’ (RDF) which can be burned in a power station. Knowledge of the calorific value of post-recycling Municipal Solid Waste (MSW) is necessary since its part that is not Land filled can be the fuel of Waste to Energy (WTE) furnace.

2.3 Industrial Waste

This has two components hazardous which is toxics, corrosive, flammable, a strong sensitizer or irritant and may pose a substantial present or potential danger to human health or the environment when improperly processed, stored, or transported, or disposed of or otherwise managed. Non-hazardous which includes inert and essentially insoluble industrial solid waste; usually including, but not limited to; materials such as rock, brick, glass, dirt and certain plastics and rubber etc, that are not readily decomposable.

2.4 Refuse Derived Fuel (RDF)

Refuse Derived Fuel (RDF) is the product of the treatment of municipal solid waste (MSW) to create fuel that can be burnt easily in a combustion boiler. In order to produce Refuse Derived Fuel (RDF); waste must first be shredded and then carefully sorted to remove all non-combustible material such as glass, metal and stone. Shredding and separating is carried out using a series of mechanical process which are energy intensive”. The world Bank has estimated that it requires 80 – 100kwh to process 1 tone of MSW and a further 110 – 130kwh to dry the waste. After the waste has been shredded and separated, the combustible portion is converted into pellets which can be sold as fuel. The original intention of this process was to generate a fuel suitable for mixing with coal in a coal fired power plant. This however led to a system problems and the modern strategy is to burn the fuel in a specially designed power plants. An alternative is to mix the Refuse Derived Fuel (RDF) with biomass waste and then burn the mixture in a pure plant.

3.0 METHODOLOGY

3.1 Design Approach

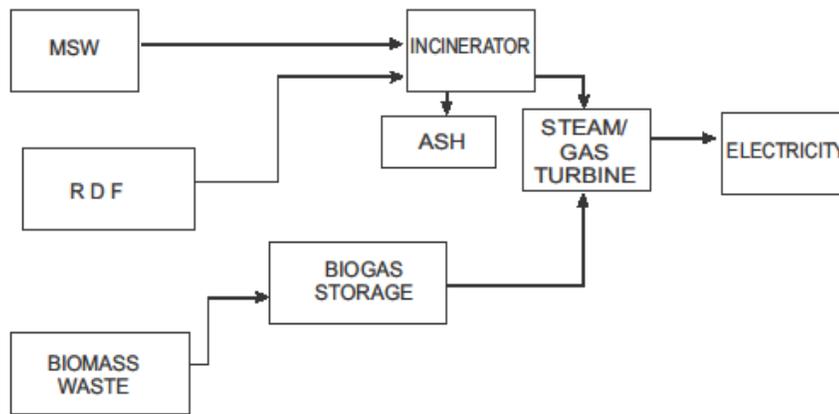
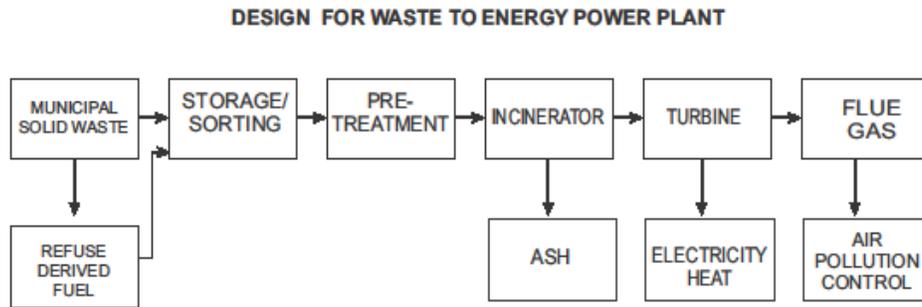
The main approach employed for this study is a qualitative case – study of Aba municipality, Abia State Nigeria. A traditional mathematical model for calculating energy from waste and the electrical power systems parameter was used.

The following steps were undertaken to perform analysis in this study to be used.

- Collect performance information on relevant technologies for the systems under evaluation.
- Perform down – selection process with developed criteria to identify most appropriate scenarios.

The model that provides gross electricity generated from waste was used.

3.2 System Diagram



FOR A TYPICAL COMBINED CYCLE POWER PLANT

3.3 The energy to be realized from waste is calculated as:

$$Th_{energy} = LHV \times M_{waste}$$

$$Ge_{lect} = (Th_{energy} + Fuel) \times \eta_{boiler} \times \eta_{turbine} \times \eta_{generator} \times \delta$$

$$\eta_{elect} = \frac{Net\ electricity}{Th_{energy} + Fuel} \times 100\% \quad (1)$$

Th_{energy} = theoretical energy content of the waste (MJ), M_{waste} = the mass of waste fed to the plant in (kg), Ge_{lect} = gross electricity production, η_i = the efficiencies of boiler, turbine, generator, η_{elect} = the net electrical efficiency, $Fuel$ = the energy of additional fuel (MJ), δ = unit conversion factor, LHV = Low Heating Value.

3.4 Data Analysis of Waste Processing In Nigeria

In Nigeria, there have been many initiatives and attempts at Solid Waste processing through resource recovery. However not much is being done on waste energy. Solid waste generation rates vary across the cities and states.

Table 1: The per capita solid waste generation rates in some cities across the nation (ACEN, 2019).

City	Rate (Kg person/day)	Source	Year
Abuja	0.55 – 0.58	Imam <i>et al</i>	2007
Lagos	0.44	Balicon / LAWMA	2006
Markurdi	0.54	Sha’Ato <i>et al</i>	2006
Abeokuta	0.60	Adewunmi <i>et al</i>	2005
Ado-Ekiti	0.71	Adewunmi <i>et al</i>	2005
Akure	0.54	Adewunmi <i>et al</i>	2005
Ibadan	0.71	Adewunmi <i>et al</i>	2005
Ilorin	0.43	Yusuf and Onyewunmi	2005
Nsukka	0.44	I, Amber, D. M. Kulla	2008
		N. Gukop / T.C. Ogwuelela	2012/2009
Onitsha	0.53	Ditto	2012/2009
Aba	0.46	Ditto	2012/2009
Port-Harcourt	0.60	Ditto	2012/2009
Kano	0.56	Ditto	2012/2009
Kaduna	0.58	Ditto	2012/2009

It is reported that apart from solar energy’ MSW constitutes the most abundant available energy reservoir on the earth. This is because it consists of about 90% of biomass and plastics; which are materials with high calorific values. The energy content per kilogram of major component of Municipal Solid Waste (MSW) has been derived as follows:

- Organic - 5.2KW/Kg
- Paper / Cardboard - 4.1KWh/Kg
- Plastics - 8.5KWh/Kg
- Rags and leather - 4.1KW/Kg (ACEN, 2019).

The primary goal of municipal solid waste incineration is to reduce MSW Volume and Mass and also to make it chemically inert in a combustion process without the need of additional fuel (autothermic combustion). The analysis on per capita solid waste generation for: Aba South, Aba North, Osisoma, Oningwa and Ugwunagbo are shown in Appendix 1.

Table 2: Summary of Total per capital solid waste generation per annum (for Aba south, Aba North, Osisoma, Ugwunagbo , Obingwa) [per ton equivalent]. 1kg = 0.001102 tons

Per capital solid waste generation .	Kg waste per annum	Per ton equivalent per annum
Aba south	71.2 million Kg waste	78,462.4
Aba north	18.2 million Kg waste	20,056.4
Osisoma	36.9 million Kg waste	40,663.8
Ugwunagbo	16.4 million kg waste	18,072.8
Obingwa	30.5 million kg waste	33,611.0
TOTAL	173.2 million kg waste	190,830.4

The waste per annum is 190,830.4 tons (approximately: 200,000 tons)

4. RESULTS AND ANALYSIS

4.1 Energy content municipal solid waste (Heat value) was summarized as:

- (i) Organic 5.2Kwh/Kg
- (ii) Paper/cardboard 4.1Kwh/Kg
- (iii) Plastics 8.5kwh/Kg
- (iv) Rags and leather 4.1Kwh/Kg

(ACEN Journal, 2019)

Table 3: Analysis and Results on Theoretical energy content of waste with their respective Heat value (HV) and Gross electricity Produced.($\eta = 0.6, \delta = 1$)

Mwaste per annum.	Types of Waste	Heat Value (HV)	$T_{energy} = M_{waste} \times HV$	$G_{elect} = (T_{energy} + Fuel) \times \eta_{boiler} \times \eta_{turbine} \times \eta_{generator} \times \delta$
173.3million Kg	Organic	5.2kwh/kg	900.64GWhr	540.34GWhr
173.3million Kg	Paper/Cardboard	4.1kwh/kg	710.12GWhr	426.07GWhr
173.3million Kg	Plastics.	8.5kwh/kg	1472.2GWhr	883.32GWhr

The area with the highest population produced the greatest waste. Hence the aggregate waste is proportional to the number of people that lives in the geographical area. The waste from plastic produces the highest energy and gross electricity,

The waste-to-energy plant is a power station fuelled with urban waste. According to the International Renewable Energy Agency (IREA), “the capacity for power generation from municipal wastes in the world was around 11,540MW in 2018 (IRENA 2018). Energy recovery from waste could be carried out by two main routs (i.e. biological and Thermal)”. “The biological route is based on biogas production as energy source from organic waste on the other hand; during the thermal route; the waste is prepared as refuse – derived – fuel (RDF) for combustion; gasification or pyrolysis to produce electricity, heating or both” (ROUSTA 2015, Nordi 2017).

The abundant of waste in the city of Aba can be treated as RDF and preserved to be used in waste to energy plant. RDF can be mixed with biomass waste and then burn the mixture in a power plant. The waste from Timber sites at Ariaria market, the waste from leather at Bakassi site in same Ariaria and other areas like Nkwo ngwa and Uratta market generate preponderance of waste that can be massively collected in an enclosure and conveyed to waste to energy plant where it can be thermally degraded to generate heat or be converted to residual derive fuel (RDF).

The proposed system is an improvement upon the existing system of electricity supply to the city of Aba, Nigeria and has reliable strength, but it does not address the whole issue. The Federal Government of Nigeria in its electricity reform has approved the exploit of Distributed Generation. The Distributed Generation base on waste-to-energy power plant is a renewable energy. This will provide adequate electricity supply, with clean environment free from pollutions. This will boost the economy of the state; revive the small scale and medium scale industries that has been plagued by inadequate supply of electricity.

Conclusion

Conclusively about 173.2 million Kg waste generated per annum in the city of Aba, Abia state Nigeria can generate about 426.07GWhr to 883.32GWhr of energy per annum if Waste to Energy plant is considered for Distributed Generation. The area with the highest population produced the greatest waste. Hence the aggregate waste is proportional to the number of people that lives in the geographical area. The waste from plastic produces the highest energy and gross electricity, Hence Waste to Energy plant will serve the joint purpose of waste management and energy for electricity.

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Appendix:

(a) Per Capita Solid Waste Generation Rate For Aba South (with a population 423,852 persons).

One person produces 0.46kg per day.

One person will produce a total of (0.46kg x 365 days i.e. for a period of one year)

= 167.9Kg waste per annum.

A population of 423,856 persons will produce $167.9 \times 423,856$

= 71,165,422.4 (approximately 71.2 million Kg waste per annum).

(b) Per Capita Solid Waste Generation Rate For Aba North (with a population 107,488 persons)

One person produces 0.46kg per day.

One person will produce a total of $0.46 \text{kg} \times 365 \text{ days}$ i.e. for a period of one year)

= 167.9kg waste per annum.

A population of 107,488 persons will produce $= 167.9 \times 107,488$

= 18,047,235.2 (approximately 18.2 million kg waste per annum)

(c) Per Capita Solid Waste Generation Rate For Osisioma (with a population of 219,632 persons)

One person produces 0.46kg per day.

One person will produce a total of $0.46 \text{kg} \times 365 \text{ days}$ i. e for a period of one year)

= 167.9kg waste per annum.

A population of 219,632 persons will produce $= 167.9 \times 219,632$

= 36,876,212.8 (approximately 36.9 million kg waste per annum)

(d) Per Capita Solid Waste Generation Rate For Ugwunagbo (with a population of 97,710)

One person produces 0.46 kg waste per day.

One person will produce $0.46 \text{kg per day} \times 365 \text{ days}$ i.e. for a period of one year)

= 167.9kg waste per annum.

A population of 97 710 will produce a total of $167.9 \times 97,710$ (i,e for a period of one year)

= 16,405,509. (approximately 16.4 million kg waste per annum)

(e) Per Capita Solid Waste Generation Rate For Obingwa (with a population of 181,439)

One person produces 0.46kg waste per day.

One person will produce a total of $0.46 \text{ kg} \times 365 \text{ days}$ (for a period of one year)

= 167.9kg waste per annum.

A population of 181,439 persons will produce $= 167.9 \times 181,439$

= 30,463,608.1 (approximately 30.5 million kg waste per year)