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DETERMINATION OF ELECTRIC POWER GENERATION POTENTIAL OF ABUJA'S MUNICIPAL SOLID WASTES

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Abstract

Electric Power Generation Potential of Municipal Solid Wastes (MSW) in Abuja, the capital city of Nigeria has been studied in this work. A pilot study on waste generation activities in Galadimawa District of Abuja was carried out and the results were applied to the metropolis as a whole due to the observed similarities in the demographics of Galadimawa and other Districts in the metropolis. The city of Abuja presently has an annual MSW generation rate of 973,557 tons with a per capita generation of 0.77 kg/day. Waste fractions for the metropolis were also analysed and discounting materials that have recycling value, energy bearing fractions of organic and textile wastes were found to be 59.5%. This translates to 579266.42 tons per annum and with an aggregate higher heating value (HHV) of 15.84 MJ/kg for this fraction, this approximates to about 9.2 x 10^9 MJ/annum of realisable energy. Using a typical waste-to-energy (WTE) plant efficiency of 44% it is seen that Abuja's MSW can support a power generating plant with a capacity of 128 MW. This potential far exceeds the energy being presently delivered to Abuja city from the national grid which is about 80 MW.

Keywords: Municipal solid waste, Waste to energy, Energy potential, Higher heating value, National grid.

1.0 INTRODUCTION

There is an ever-growing challenge of municipal solid waste (MSW) management in many developing cities of the world including Abuja, Nigeria's capital city. This is amidst the perennial inadequacy of public power supply in Nigeria. This combined scenario of poor waste management and very low access to public power supply necessitates–investigation of Abuja's MSW for generation of electricity. The purpose is to seek for possible implementation of such strategy within our own socio-economic setting. This strategy has been proved effective in other parts of the world in the management of MSW. This is especially so, given the persistent negative economic outlook of the nation, which is being compounded by global warming and climate change. It is a known fact that alternatives such as incineration for energy, biogas and harvest of energy from landfills have not taken firm roots in Nigeria. The desire of 'killing two birds with one stone' in contributing to efforts in finding solution to the burgeoning problem of MSW and the epileptic power supply situation is the driving motivation for this study. In Nigeria and many parts of Sub-Saharan Africa (SSA), the combined influence of poverty, population growth and rapid urbanization has tended to worsen the situation, with solid waste collection and disposal rates being abysmally very low in many cities [1].

Access to public electric power in Nigeria is also reported to be only 144.53 kWh per capita as at 2019 which is very poor when compared to values for other African countries such as South Africa 3,739.6 kWh per capita, Botswana 1,616.64 kWh per capita, Namibia 1,535.99 kWh per capita and Ghana 333.17 kWh per capita [2]. Abuja is reported to be the most rapidly growing city in Africa [3], with some of its suburbs growing in population by as much as 20 -30% per annum [3, 4], driven mainly by migration from other states of the country. MSW management in Abuja is yet to be fully developed and practices are far from global best standards. In developing an efficient waste management scheme for Abuja city, it will be necessary to take advantage of processes of waste conversion to electricity among other strategies. This will help to create more value and wealth from the waste, while minimizing quantity of waste that goes for final disposal. To do this, it is observed that required technical data such as waste collection rate, percentage of collected waste that can be converted to energy and energy content of the MSW necessary for achieving a waste to wealth model with respect to generating electric power will be required for Abuja, among other relevant parameters.

Waste to energy conversion has been found to be another effective strategy in MSW management. This is being achieved through application of various energy conversion technologies such as biomass fermentation, gasification of the waste or direct incineration for energy recovery, especially electricity and heat energy production.

Waste generation has been observed to be on a steady increase, consistent with the proven correlation with increase in population and economic earning power. The World Bank projects that within the next 30 years, due to rapid urbanisation, population growth and economic development, global waste generation will increase by 70% to about 3.4 billion tonnes annually from the present annual value of 2.01 billion tonnes [5]. Presently, the more advanced countries with much higher socio-economic power have higher MSW generation rate per capita than in the poorer developing counties. It has been observed that in the developing world, waste collection rates range from about 44% in sub-Saharan Africa, 58% in the developing Asian countries to 84% in Latin American countries, unlike the 90 – 100% collection rates achieved in Europe and North America [1]. The situation is even worse for Nigerian cities with most wastes uncollected, and where collected, they are not disposed according to standard best practices.

Compared with other cities in Nigeria, municipal solid waste generation in Abuja is estimated to be high due to the economic status and population density of the metropolis. Waste generation from households is mainly organic with high quantities of food and yard wastes. Moderate amount of plastic waste is generated within the study area especially from single-use plastics for food and drink packaging. Studies have shown a high correlation between income level and waste generation quantities, [6, 7]. Table 1 shows the waste generation estimates for Abuja and other urban cities within Nigeria, with Abuja having the highest estimate of 0.66 kg/capita/day as at 2013. This present work found that there has been a marginal increase in waste generation rate per capita for Abuja. The Abuja Metropolis now has a per capita MSW generation rate of 0.77 kg/day.

Table 1: Typical MSW generation rates for some urban centres in Nigeria [4]

S/N	CITY	POPULATION	TONNAGE PER MONTH	MSW Density (Kg/m^3)	Kg/capita/day of MSW
1.	Lagos	8,029,200	255,556	296	0.63
2.	Kano	3,248,700	156,676	290	0.56
3.	Ibadan	307,840	135,391	330	0.51
4.	Kaduna	1,458,900	114,433	320	0.58
5.	Port Harcourt	1,053,900	117,485	300	0.6
6.	Makurdi	249,000	24,242	340	0.48
7.	Onitsha	509,500	84,137	310	0.53
8.	Nsukka	100,700	12,000	370	0.44
9.	Abuja	159,900	14,785	280	0.66

The waste composition in Abuja metropolis is quite similar to results obtained in many other Nigerian cities, as can be seen from Table 2, with organic and plastic wastes making up the highest composition in term of quantity in the waste stream. The waste composition data for some districts of Abuja metropolis are shown in Table 3

Table 2: MSW Characteristion for some Cities in Nigeria [4, 6, 11]

S/N	Waste Component	Onitsha	Lagos	Makurdi	Kano	Maiduguri	Ibadan	Abuja
1.	Food and organic %	30.7	60	52.2	43	25.8	76	43
2.	Paper %	23.1	14	12.3	17	7.5	6.6	25.3
3.	Glass and Ceramics %	9.2	3	3.6	2	4.3	0.6	3
4.	Metals %	6.2	4	7.1	5	9.1	2.5	3.6
5.	Plastics %	9.2	4	8.2	4	18.1	4.0	18
6.	Textiles %	6.2	--	2.5	7	3.9	1.4	3
7.	Others %	15.4	16	14	22	31.3	8.1	4.1
	Total	100	100	99.9	100	100	100	100

Table 3: MSW Composition Data for Some Selected Districts of Abuja Metropolis [6, 7]

S/N	Waste Type	Percentage by Weights for Various Districts							
		Garki	Wuse	Galadimawa	Maitama	Asokoro	Gwarimpa	Apo	Average
1	Paper	13.0	12.0	10.32	13.0	13.6	6.9	10.1	**11.28**
2	Metal	5.6	3.3	12.73	5.3	6.7	5.4	4.9	**6.28**
3	Glass	5.5	4.4	-	5.3	4.1	4.1	-	**3.34**
4	Plastic	16.2	17.3	25.06	20.0	15.1	21.3	18.7	**19.09**
5	Food waste	52.0	54.3	47.39	54.8	53.0	61.2	65.3	**55.43**
6	Textile	2.2	4.7	4.51	0.10	3.1	-	-	**2.09**
7	Rubber	3.4	1.5	-	0.19	0.7	-	0.9	**0.96**
8	Others	1.8	2.4	-	0.6	2.8	1.1	-	**1.24**

	Total	**99.7**	**99.9**	**100**	**99.3**	**99.1**	**100**	**99.9**	**99.7**
9	Persons per household	8	8	5	6	6	13	6	8

Waste collection practice in Abuja metropolis, especially in the densely populated districts is poor, with road sides and drainages littered with uncollected wastes indiscriminately dumped. Aggregate waste collection rate for the metropolis has not been properly documented in literature and this poses a challenge in evaluating the performance of the waste management system for the city.

Coordination and documentation of the waste management activities for the Federal Capital City (FCC) are done by Abuja Environmental Protection Board (AEPB). A sample of collection data for the FCC for the period 2015 to 2019 is as shown in Table 4.

Table 4: Annual MSW collection (tons) for Abuja FCC [8]

Quantity of Solid Waste (Tons) Collected by AEPB (2015-2019)					
MONTH	**2015**	**2016**	**2017**	**2018**	**2019**
January	22229.06	21814.18	17966.754	20560.644	20615.868
February	22388.18	22539.58	17597.268	17310.852	17694.378
March	20354.06	23885.78	19286.28	20513.142	19974.942
April	23042.45	23342.90	18756.504	19995.3	21037.77
May	15306.5	22582.87	19975.176	21540.402	21046.194
June	21553.72	21682.91	19523.79	20218.068	19050.642
July	20998.22	21304.06	20676.24	21067.254	19895.85
August	23091.12	20951.66	20811.258	22201.218	21147.984
September	22674.6	21137.69	20316.582	20385.208	17216.55
October	24431.47	23867.06	20307.69	20645.352	24634.116
November	23811.84	22856.18	21255.156	20082.816	24955.164
December	23568.48	19308.74	20175.948	20223.684	24233.508
Total (tons)	**263449.7**	**265273.63**	**236,648.65**	**244,743.94**	**251,502.97**

Waste segregation at source is hardly practised in Abuja hence the waste collected is mixed. The little segregation or sorting observed is done by itinerant scavengers seen at dumpsites and along the city streets. Waste collection has been a challenge for several years in Abuja with increasing generation rates, urban development and expansion, changes in road networks, illegal structures and settlements, traffic conditions, insufficient collection machinery and resources.

2.0 MATERIALS AND METHODS

2.1 Materials

2.1.1 Study area

Abuja is Nigeria's capital City and is located at latitude 9◦ 12' North of the equator and along longitude 7◦ 11' East of the Greenwich Meridian. Abuja has an estimated population of 3.3 million people (urban population) [9]. The Federal Capital Territory (FCT) has a total land area of approximately 713 km^2 which is divided into six area councils i.e. Abuja Municipal, Abaji, Bwari, Gwagwalada, Kuje and Kwali. Abuja Metropolis which is the focal area of this study constitutes the Abuja Municipal Area Council, (AMAC). The map of AMAC within the FCT is shown in Figure 1. Abuja has a central government institution responsible for solid waste management in the City known as the Abuja Environmental Protection Board (AEPB). The Board's solid waste management portfolio has the following components: City cleaning, street sweeping, litter control, solid waste collection and transfer and vegetation control [10].

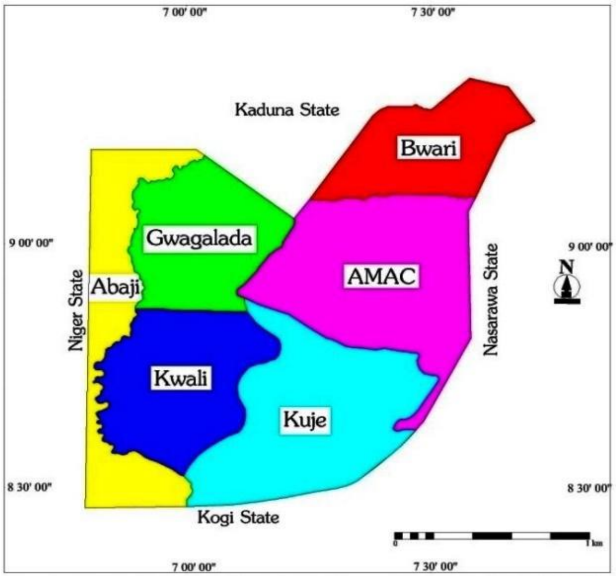

Figure 1: Map of FCT showing Abuja Municipal Area Council

F.C.T has waste landfill sites located in all the area councils including those located at Mpape, Gosa, Ajata, Karshi and Kubwa to serve the municipal area. The Mpape dumpsite which was opened in 1989 was closed in 2005 due to complaints of odour and air pollution. It panned 16 hectares with a waste depth of about 15-30 metres at the time of closure [6]. Ajata dumpsite was opened in 1999 while the Kubwa dumpsite which was opened in 2004 has been forced to close in 2005 due to odour and random fire outbreaks.

2.2 Methods

The process of quantifying total energy realisable from Abuja's MSW involves knowledge of the study area's population and the calorific value of the MSW. It is a known fact that waste generation is greatly dependent on population [11] and the calorific value is obtained from laboratory analysis.

2.2.1 Abuja municipal solid waste generation data

Primary data collection and analysis for municipal waste generation rate for Abuja were carried out using the selected zone of Galadimawa for a pilot study and the results reported in subsequent sections. Galadimawa district which is a good microcosm of Abuja because almost all the population strata found in Abuja are represented in Galadimawa, ranging from the very high income earners living in the exclusive luxury estates to the very low income earners found in the suburbs of the district. The selection of Galadimawa as representative of Abuja followed observation of demographic distribution and settlement patterns from the field survey. Galadimawa consists of estates for the very high class, middle class and rural suburban housing for the lower class of the population. This is observed to be unlike districts such as Asokoro, Maitama or Garki that appear to be exclusively for the upper class and cannot be taken to represent the whole metropolis for the purpose of studying waste generation and collection rates. The selection of Galadimawa is the therefore on purposive sampling, reflecting the reality in carrying out a pilot study. The MSW generation per capita per day obtained for Galadimawa can therefore be applied to the whole city with minimal error.

The methodology for obtaining the waste generation data is described here for Galadimawa District.

Household survey

For the purpose of obtaining relevant information, it became necessary to carry out a household survey of the Galadimawa district. This phase of study included:

a. Questionnaire design and Administration Population information for Abuja on district basis was not accessible for the purpose of this study, as it is only available on local government basis. Appropriate questionnaire was therefore developed and administered on selected 200 households in the different zones of Galadimawa to represent the number of households estimated in the field survey to be six thousand five hundred and fifty (6050), in order to obtain the relevant population details such as total number of persons living in each house hold, earning capacity of household and total population in the district, all being factors that affect waste generation in a community. Sample size of 200 is a slight departure from standard value available in published tables for sample size determination due to cost consideration in collecting wastes from large number of houses for 7 days for sorting and recording [12]. Number of questionnaires successfully returned by respondents was 189.
b. Visitation to various selected households ranging from the low income to the high-income earners within this part of the study area consisting of 7 out 8 zones. A total of one hundred and eighty nine (189) households were used for this study, distributed among the seven out of eight zones of the area.
c. Distribution of polythene bags for periodic collection of generated wastes from 189 households.
d. Collection of wastes from 189 households and sorting of same with results shown in section 3, below. Weighing and documentation of sorted wastes according to waste.

The solid wastes were gathered from from the same household to which refuse bags were distributed. which randomly received and returned the questionnaires within the district.

The following steps were taken to conduct the household survey and determine the relevant waste management parameters:

i. Determination of the Total Number of Households in Galadimawa District: For the purpose of this study, the district was divided into eight discrete zones consisting of the seven estates (Sun City, Ammsco, Aldenco, Brains Hammers, Sam Ujouma, and Harmony) and Galadimawa suburbs. The determination of the total number of households was obtained using physical counting and official requests to the various town planning authorities in charge of the district. Table 6 below shows the estimated number of households in the study area.
ii. Estimation of Average Number of Persons per Household: The number of individuals in each household was obtained from the responses to questionnaires administered on the selected population sample. The average number of persons per household for each zone of the study area was then obtained.
iii. Estimation of Total Population of the Galadimawa District: From the knowledge of the total number of households and the average number of persons per household in the district, the total population in Galadimawa was estimated.

$$P_e = A_p * H_n \tag{1}$$

Where; P_e is the estimated population, A_p is the average number of person per house, H_n is estimate number of houses in Galadimawa.

$$P_e = \frac{T_p}{H_{ns}} * H_{nz} \tag{1}$$

Where; T_p is the total number of person per household, H_{ns} is the number of household surveyed, H_{nz} is the estimate number of households in the zone.

iv. Estimation of MSW Generation Rate in the Galadimawa District: Total waste generated per week, in the district was obtained from the responses to the questionnaires. From the estimated total waste generation per week for each zone of the district, the waste generation per day per capital was calculated as

$$r = \frac{\text{Total waste Generated}}{\text{Total no.of people}} \tag{2}$$

v. Estimation of obtainable Energy from MSW Generated in Galadimawa District: To determine the obtainable energy that can be achieved, the energy content of a unit mass of the waste material must be determined together with the MSW quantity with inherent energy obtainable in the study area. This information was obtained and used together with results as shown in Section 3. Energy obtainable from MSW is calculated as a product of the mass M, of MSW generated per annum and the aggregate higher heating value HHV, of the MSW.

$$Energy = M \ x \ HHV \tag{3}$$

vi. Estimation of Obtainable Energy from MSW in Abuja Metropolis: The waste generation per day per capital as calculated for Galadimawa is applied to the Abuja metropolis to quantify the total MSW generation for Abuja and also the renewable energy available in Abuja's MSW, relying on the similarity of demographics in Galadimawa and the whole Abuja Metropolis. Values obtained are reported in Section 3.1, below.

3.0 RESULTS AND DISCUSSION

3.1 Results

Waste generation and collection in any area of interest are a direct function of human population in that location. Population of Abuja metropolis is estimated to be three million, four hundred and sixty four thousand as at 2021 (3,464,000) [13]. To obtain up to date information on data for waste generation per capita for Abuja, primary data for Galadimawa that has been observed as a microcosm of Abuja in terms of demographic distribution were obtained and applied to the whole metropolis. This approach was justified necessary since the most recent estimates available for Abuja in literature were published in 2009 [4].

3.1.1 Waste generation in Galadimawa

With the aid of questionnaires administered, the estimated waste generated per day per capita was calculated in steps as shown below.

Population of Galadimawa district could not be obtained from relevant authorities, therefore an estimate was obtained as shown below. Results of average weekly household waste quantification survey carried out in the Galadimawa district are also presented. The results are then aggregated for the Abuja study area.

a. Determination of the Total Number of Households in Galadimawa:

The determination of the total number of households was obtained using physical counting and official requests to the various town planning authorities. Table 5 below shows the estimated number of households in Galadimawa, according to zones within the district.

b. Estimated Average Number of Persons per Household:

The number of individuals in each household was obtained from the responses to questionnaires administered on the selected population sample. Table 5 below shows the number of persons per household for each region of the study area. The total population of the Galadimawa district was estimated to be twenty one thousand, five hundred and twenty (21,520).

Table 5: Number of persons per household in Galadimawa by Zones

S/N	Zone	Number of Household	Average no. of persons per household	Population	Waste Generation per week (Kg)
1.	Sun City	1700	5	8,500	1019
2.	AMMSCO	310	4	1,240	593
3.	Sam Nujoma	400	5	2,000	538
4.	Harmony	200	6	1,012	590
5.	Aldenco	300	5	1,356	549
6.	Brains & Hammer	700	7	4,340	465
7.	Galadimawa Suburbs	800	4	3,080	1079
	Total	5910	Ave = 6	21,520	4833

c. Estimation of the amount of waste generated in Galadimawa District:
Total waste generated per day, in the district was obtained from the responses to the questionnaires. Total waste generation per week estimated for each zone of the district are as shown in Table 5 above.

d. Estimation of Waste Generation per Capita:
From the responses to questionnaires total waste generation per day was 690 kg for a population of 893 in the households that responded to the questionnaires. Therefore, the average waste generation per capita was calculated from Equation 2 as $r = \frac{\text{Total waste Generated}}{\text{Total no.of people}} = \frac{690\text{ kg}}{893} = \frac{0.77\frac{\text{kg}}{\text{man}}}{\text{day}}$, population from households surveyed being 893 persons and the recorded waste generated per week in households surveyed being 4833 kg. The total estimated population for Galadimawa district was 21,520; hence the daily municipal solid waste generation for Galadimawa is estimated to be 16,570.4 kg. This results to a value of 6,048tons/annum for the district.

e. Determination of Waste Constituent Amounts:
Waste collected during the study were sorted and weighed according to constituents. Table 6 below shows the resulting quantity for each waste component obtained as primary data from Galadimawa.

Table 6: Waste Composition per Zone

Waste Composition per Zone in Galadimawa							
Waste Component	**Waste Quantity per week (kg)**						
	Sun City	**AMMSCO**	**Sam Nujoma**	**Harmony**	**Aldenco**	**Brains & Hammer**	**Galadimawa Suburbs**
Food Waste	381	177	152	180	183	171	393
Plastic waste	212	115	115	135	105	77	178
Paper wastes	52	34	39	34	35	26	72
Metallic wastes	105	75	75	85	75	50	150
Cardboards	42	23	25	23	22	25	47
Textiles	46	41	28	27	28	20	28
Polythene wastes	71	33	24	18	22	15	91
Garden wastes	110	95	80	88	79	81	120
Total	1019	593	538	590	549	465	1079

Table 8 below shows the resulting quantity per annum for each waste component obtained as primary data from the study area.

f. Estimation of Obtainable Energy from MSW in Galadimawa District:
To determine the obtainable energy that can be achieved, the energy content of a unit mass of the waste material must be determined together with the MSW quantity with inherent energy obtainable in the study area. The quantity of MSW with inherent energy content generated in the district is estimated to be 4218 kg per week. This is as shown in Table 8 below. Table 7 shows the energy content per kg for the various waste components, in Nigeria as studied by Igoni et al [14].

Table 7: Energy content for waste components (Igoni et al. 2005) [14]

Waste components	Energy content (MJ/kg)
Food and garden wastes	22.40
Paper	10.14
Cardboard	11.033
Plastics	14.89
Polythene	46.5
Textile	9.27

Using Table 7 and the tonnage of MSW generated from Galadimawa district, energy realisable from MSW generated in that district was calculated. Table 8 shows the estimated energy that can be obtained from MSW generated in the Galadimawa district.

Table 8: Estimated MSW generation quantity and obtainable energy in Galadimawa district

Component	Quantity (kg per annum)	% Wt.	Energy content HHV (MJ/kg)	Energy Obtainable (MJ/Annum)
Organic waste items	119,080	54.3	22.40	2,667,392.00
Paper	15184	6.9	10.14	153,965.76
Cardboard	10764	4.9	11.03	118,726.92
Plastics	48724	22.2	14.89	725,500.36
Polythene	14248	6.5	46.50	662,532.00
Textile	11336	5.2	9.27	105,084.72
Total	219336	100	Aggregate: 19.04	Total: 4,433,201.76

Noting that paper, cardboard, plastic and polythene wastes have recycling value, only organic and textile waste items should be considered for conversion to energy. Giving this allowance, this fraction will have a total generation tonnage of 130,416 kg/annum and an aggregate heating value of 15.84 MJ/kg. This will give an estimated energy realisable from Galadimawa's MSW to be 2,065,789.44 MJ/annum.

g. Estimation of Waste Generation in Abuja:
With the per capita waste generation rate of 0.77 kg per day and estimated population of Abuja being 3,464,000, the daily waste generation for the metropolis is calculated to be 2,667,280 kg. This gives an annual rate of 973,557 tons of MSW generated in the study area. The organic fraction of this waste at 59.5% (Table 8) will be 579266.42 tons per annum.

h. Estimation of Obtainable Energy from Organic fraction of MSW in Abuja Metropolis:
From the MSW data for Abuja in the Sections above, the organic and textile fraction of MSW generated will be 579266.42 tons per annum with an aggregate HHV of 15.84 MJ/kg (22.4 MJ/kg for organic waste and 9.27 MJ/kg for textile waste, Table 8). Hence the realisable energy from Abuja's MSW is estimated to be $9.2\ x\ 10^9\ MJ/annum$, applying Equation 3 above.

3.2 Discussion

The results obtained in this study are discussed in the subsequent sub-sections.

From the results reported in the sections above, it is seen that Abuja with a per capita MSW generation of 0.77 kg/day and an estimated population of 3,464,000, has capacity to generate 2,667,280 kg, daily, amounting to 973,557 tons of MSW per annum. The organic and textile fractions of these wastes amount to 59.5% (Table 8) which is 579266.42 tons per annum. The obtainable energy from Abuja's MSW after discounting fractions that can be recycled is estimated to be 9.2 x 10^9 MJ/annum. Assuming a typical WTE plant (incineration with energy recovery) efficiency of about 44% [15], this energy resource can support a plant with capacity of 128 MW. Electrical energy delivery to Abuja FCC at its peak is presently estimated to be 80 MW [16]. Using the African average annual per capita electric energy consumption of 792.93 kWh (144.53 kWh for Nigeria [16]) and the present population estimate, Abuja's electric power demand estimate is calculated to be 313.55 MW. With the city's population projected to be 5,119,000 by 2030 [17], Abuja's power demand forecast for that near future will be 463.36 MW.

Therefore an effort to convert the MSW generated within only the metropolis alone to electrical energy will provide more electric power to the city than what is presently being delivered from the grid, and will be adequate for almost 50% of the present electric demand forecast. The estimate WTE capacity will be able to account for about 28% of the projected demand of 463.36 MW for the city by 2030 in the given scenario. In addition, energy from MSW will be green and more economical than from fossil fuel sources. This will also bring a great relief to the national power grid, while at the same time solving the problem of city's municipal solid waste management. The electric energy forecast scenario is depicted in Figure 2.

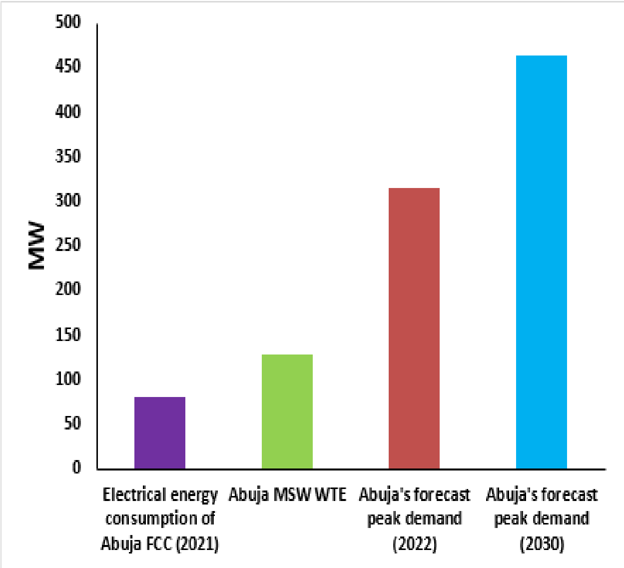

Figure 2: Abuja Electric Power Forecast Scenario (2021 – 2030)

4.0 CONCLUSION

The total MSW generation for Abuja metropolis is estimated at about 973,557 tons/annum with the fraction for energy generation being 579,266.42 ton (59.5%). The daily per capita MSW generation for the city was found to be 0.77 kg/capita/day. The overall MSW composition for Abuja was found to be: organic waste, 54.3%; Paper, 6.9%; Cardboard, 4.9%; Plastics, 22.2%; Polythene, 6.5%; Textile, 5.2%. The aggregate higher heating value (HHV) for the MSW, using laboratory procedure was determined to be 19.04 MJ/kg. The annual quantity of MSW generation in Abuja has the energy potential of 9.2 x 10^9 MJ/annum. This resource can sustain a WTE plant with a capacity of 128MW at 44% efficiency. This is found to be more than the energy being presently delivered to the city from the national power grid.

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