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Renewable Power Generation Opportunity from Municipal Solid Waste: A Case Study of Lagos Metropolis (Nigeria)

Mohammed Yekini Suberu[1*], Ahmad Safawi Mokhtar[1], Nouruddeen Bashir[2]

1. Dept. of Electrical Power Engineering, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malsysia
2. Institute of High Voltage and High Current, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malsysia

* E-mail of the corresponding author: engryek88@yahoo.com

Abstract

Renewable power generation is increasingly becoming a well-known phenomenon in our modern society. Various research efforts have been rationalized to prove the benefits that could be derived from the utilization of renewable energy resources for electricity. Though, environmental benefits have been the major focal advantage but in the case of municipal solid waste (MSW), socio-economic impact on the society is possible in the form of saving in land allocation for waste management and income generation. Therefore, this study discusses the concept of waste-to-energy (WTE) management in Lagos metropolis as a case study. Lagos state has 20 administrative Local Government Areas with 16 of them forming the Lagos metropolis. The study also significantly accesssed the potential of MSW for power generation considering the route of thermo-chemical conversion as an alternative measure to landfilling and open dumping of waste commonly practice in the metropolis. It was found that approximately 442MWe is possible to be achieved using a population benchmark of over 16 million recorded in the metropolis in 2006.Three major techniques for energy generation from MSW are also discussed.Finally the study was concluded on possible investment issues to enhance the resources utilization for energy purpose.

Keywords: Renewable energy, power generation, Municipal Solid Waste, Lagos metropolis

1. Introduction

Globalization of modern economy, technologies and other human related activities has been attributed to the dynamic and sophisticated nature of modern electricity supply structures. The rapidly changing structure of these phenomena is responsible for the tremendous increase in the level of energy demand around the globe. There have been rigorous efforts to meet the global energy demand challenges but relying on the traditional fossil fuels alone is synonymous to taken a great risk of backward trend in modern developmental strategies. The main reason behind this assertion is that fossil fuels and other conventional energy resources are not only limited but their global reserves is declining as each day closes. Excessive combustion of fossil fuel for energy has potential contribution to negative environmental consequences such as global warming. To this regard, renewable energy has attracted a very realistic global interest being the only viable option available to man for providing solution to energy. Development of renewable energy from biomass is one of the major promising alternative energy resources because of its presence in almost every part of the world. Hamzeh et al. (2011) acknowledged that about 10% of global energy supply is generated from biomass with the remaining 90% obtainable from fossil and other conventional energy resources. This development is a clear indication that the entire world is vulnerable to serious environmental hazard if the trend is allowed to persist for a longer period of time.

The environmental mitigating potential of bioenergy resources utilization has been seen as one of the premeditated solutions adopted for climatic hazards reduction measures globally supported. Moreover, several international energy policies have rendered unambiguous hold up for biomass as an integral part of clean development mechanism (CDM). To achieve the pursuit for effective development, all forms of sustainable energy resources must not be allowed to be underutilized. There are different types of bioenergy resources with potential capabilities for electrical power generation in Nigeria. Biomass from agricultural crops and its residue, animal manure, forest base resources and municipal solid waste are very common type of bioenergy resources in the country. The frequency of generation of these bioenergy resources may be daily or periodically. On daily basis, municipal solid waste and animal manure are generated unlike other biomass from agricultural resources.

In cities, daily human activities within domestic homes, commercial centers and industrial sites generate municipal solid waste (MSW). Lagos, a densely populated commercial city of Nigeria produces a lot of MSW. The burden of municipal solid waste management can certainly not be ignored in such a heavily populated metropolis. An effective way of managing the waste is to apply a logic that will provide economic and environmental advantages.

1.1 Lagos in Brief

Lagos is the most developed city in Nigeria with population of about 18 million. It was the first place used by the defunct British government as their administrative centre in Nigeria with the name of Lagos Colony dated back to 1861. In 1914 when the British colonial power merged Lagos Colony and the Protectorate, the city of Lagos still retain its administrative role. The Federal Government of Nigeria under the military leadership of General Ibrahim Badamasiu Babangida relocated the administrative base of the country from Lagos to a new Federal Capital Territory, Abuja in 1991. This relocation became necessary due to the high level of urbanization and migration into the state whereas the state is the smallest in land mass among the 36 states of the country. The state border Atlantic Ocean to the south which makes it play a very significant role in import and export operations in the country. The city has also been distinguished for its greater attraction for investors and tourists from within and outside the country. Lagos State has 20 Local Government with 16 of them formed the metropolitan city of the state (Figure 1). Within the metropolis, there is heavy concentration of commercial and industrial activities that give rise to bulk waste generation.

The large volume of solid wastes generated in various local government areas of the state have been a major problem to every successive government. From time to time waste management strategies tend to change for effective disposal. Before 2003, municipal solid waste management in Lagos metropolis did not attract well organized response from the government. The present government adopted the method of landfilling of waste in three major designated landfill areas. Among the 36 states in Nigeria, Lagos state has demonstrated the necessary political will and business initiatives for effective waste management. In other states of the federation with the exception of the nation's capital territory, waste management is only practice in state capital cities. In most cases, the waste materials are collected and transported to open dump areas located some kilometers away from the capital cities. In areas where waste are dump in open space there is very high incidence of disease contraction as well as environmental pollution.

2. Structure of Waste Generation and Characterization in Lagos Metropolis

Municipal solid waste (MSW) is a composition of both organic and inorganic materials generated from series of human activities in industrial sites, domestic households, commercial centers and other institutional workshops. The presence of MSW in a society is a great problem if not well managed due to its ability to induce environmental degradation. In the past few years, Lagos metropolis witnessed rapid industrialization and demographic expansion. These twin developments have been responsible for the increase in volume of waste generations in the city. The high quantity of waste generation in Lagos metropolis symbolizes a greater opportunity for electricity generation in the form of alternative energy from bio-waste resource.

Organic fraction of municipal solid waste (OFMSW) is the most useful component of municipal solid waste.

Like other bioenergy resources, OFMSW is biodegradable. The composition of MSW generated in a Lagos include but not limited to putrescibles, paper, plastic, textile waste, vegetables, metal glass and hospital waste (Figure 2). Solid wastes is one of the new source of energy (Lino et. al, 2010) called renewable energy. Wastes from different sources have different description as activities generating the wastes are differing. The content of industrial waste shows some variation from that of household and commercial wastes. Table 1 illustrates wastes from different sources in Lagos metropolis and their description base on the authors' survey. Major waste production in the metropolis comes from household activities, commercial, institutional and industrial operations. However, street sweeping is also another sources of municipal solid waste even though is not included in the table classification.

The reason behind the exclusion of street sweeping as a major category in the Table 1 is that it is consider as one of the activities that take place in households, commercial centers, institutional places and industries to maintain healthy environmental living or working conditions

3. Current waste management practice in Lagos metropolis

In advance nations, waste management is basically by landfilling and combustion for energy in modern incineration or gasification systems. Among the industrialized nations, some countries developed policy framework for integrated waste management. An integrated waste management system (Figure 3) is a management system which ensured that all benefits that can be derived from MSW are effectively utilized. In some countries, the organic fraction of the waste is treated by anaerobic digestion to produce biogas for fuel consumption. The traditional method of waste management in most developing countries is landfilling and dumping in open areas. In majority of Sub-Sahara Africa (SSA) countries, waste dumping in open areas is more prevalent. Waste management authorities of some organized cities in the region are more accustomed to landfilling techniques for disposing their wastes while little is used for energy generation purpose. Due to high level of poverty in the region, human scavengers sometimes search for recyclables waste components in some open dump areas to make a living.

Landfilling of municipal solid waste has two major setbacks: environmental consequences and space allocation. In landfill areas, there is greater possibility of methane formation by spontaneous reactions. Excessive release of methane gas and other hazardous gases such hydrogen sulphide (H2S), ammonia (NH3), and oxides of sulphur and carbon has greater environmental consequences which may not be immediate. Methane and carbon dioxide are the most important gases that can rapidly influence the phenomenon of global warming. According to Scheehle et al. (2006), an estimated 12% of methane emissions are caused by landfilling of wastes. Another study by (Melack et al. 2004 and Ramos et al. 2006) noted that about 4% of global warming scenario is being induced by methane emissions from man-made waste dams. Susu et al. (2003) proclaimed that many techniques especially landfill are used in environmental waste management in Nigeria but there still exist a need for effective waste control to provide a platform for sustainable development.

Landfilling of waste management strategy also has associated space allocation challenges as reported in several major cities of the world. Some designated areas for landfill have run short of accommodating space. The case of China in 2011 is such that two-third of the country's landfill areas are swamped with garbage and millions of tonnes of waste are sent to non-sanitary landfills with one-quarter of cities having no place to dispose-of trash (Jianhong, 2011 and Curry et al. 2012). In a similar outlook, world biggest economies and technologies are not spare in the landfill space constraint scenario. It was reported that presently London convey about 20 million tonnes of annual waste to 18 different landfills located outside the city that are also running short of space (Reducing, reusing and recycling London's waste, 2011). Advanced city of New York is also caught in the web of the problem as the last designated landfill area in the city closed in 2001 and an estimated waste of 12,500 tonnes are transported daily outside the city (United Nations Population Division, 2011). In the case of Lagos metropolis, of waste generation is high but land availability for the waste disposal is limited. Lagos state has the smallest land mass in the country. Most of the land areas put for commercial enterprises therefore the tendency for shortage in space allocation for landfilling in nearby future is very likely. The need to reduce the wastes and exploit the advantage for power generation has to be advocated.

3.1 Waste Collection and Transportation System

Nigeria is a developing country with inadequate technologies of waste management. The recycling and reuse potential of the country is underdeveloped and limited. Waste collection and transportation play a very significant role in any complete waste management practice. Efforts to stimulate effective collection of waste were favorably channeled towards the establishment of multiple collection strategies in Lagos metropolis. The methods are house-to-house, communal depots, curbside bin, bulk loading and industrial collection system. In most area, Lagos State Waste Management Authority (LAWMA) installed waste collection container (Figure 4) to avoid indiscriminate dumping of waste on the street.

In the metropolis of Lagos, collection and transportation of MSW is totally on division of labor. LAWMA collects from commercial and industrial centers while private sector participation (PSP) is actively involved in domestic wastes collection. On a large-scale situation, LAWMA and other well established private sector participants use trucks and compactors for transportation. In some cases where the landfill or dumping site is not far, some private individuals render collection services to various households and receive their pay directly from their customers. The wastes are transported in this case with the aid of their pulling open bed cart.

4. Why power generation from municipal solid waste in Lagos metropolis?

There is increasing interest in Electric power generation from MSW throughout the world. Power generation from MSW is one of the stringent measures adopted by international communities to prevent escalation of harsh environmental conditions. Application of bio-waste resources for electricity has positive mitigation impact on atmospheric pollutions. Overdependence on fossil fuels combustion for energy raised serious concerns about the health of living organisms and their immediate environment.

Moreover, Nigeria is largely accustomed to power generation from gas-fired power plant due to the country's natural gas resources potential. The national power generation mix comprises hydro and gas-fired power plant but predominantly natural gas power plant. Besides, there has been a situation in the Nigeria power sector where the current power system infrastructures can no longer deliver half of the total national power demand. The total installed capacity of the country is over 8000MW but available capacity has never reach 4000MW at any time in the history of the nation's power sector. Phenomenon of sporadic power failures and energy crisis has prevailed over efforts to bridge the gap between power demand and supply scenario. This ugly development is not peculiar to Nigeria alone. Turkson and Wohlgemuth (2001) noted that in the entire region of Sub-Sahara Africa (SSA), provision of reliable power supply is a daunting task taken into account that most of the region is without electricity. According to (Agboola, 2011) the continent's power sector is in backward situation in the comity of world standard, particularly in West Africa states like Nigeria.

The Nigerian power sector started in 1962 as Electricity Corporation of Nigeria (ECN). Niger Dam Authority (NDA) was created later to harness the country's hydropower resources. The name of the power sector was changed to National Electric Power Authority (NEPA) after the merger of NDA and ECN in 1972. Operating under the name of NEPA, the power sector was granted the monopoly of generation, transmission and distribution of electric power in the country. As a result of general poor performance indices of NEPA, a major reform in the sector known as Electric Power Sector Reform (EPSR) Act was carried-out in 2005.

The foremost objective of the reform was to liberate the marketing policy in the sector by breaking the long-time monopoly being enjoyed by the NEPA. The reform led to the establishment of a statutory regulatory commission, Nigerian Electricity Regulatory Commission (NERC) enthrusted with the mandate to monitor all power generation, transmission and distribution related activities in the nation's power sector. Independent Power Producer (IPP) participation was supported as part of the reform measures. The reform also endeavors to segregate the entire power system operations into three independent companies comprising six generation, one transmission and eleven distribution companies implemented in 2007. The collection of these independent companies is now called Power Holding Company of Nigeria (PHCN). The reforms are yet to bring any fruitful changes to the situation in the energy sector of the country.

Possible exploitation of renewable energy resources particularly from MSW will help to provides primary energy needs of people at household level and for some commercial services. In the region of SSA, Nigerian is well known for bulk importation of commercial diesel based generators. A development that became inevitable as a result of recurrent energy crisis situation. Besides, the concept of biomass for energy application has been growing with wide-range acceptability throughout the world. The situation has been on the contrary in Nigeria as there seems to be no single power plant running on biomass based fuel even on experimental basis. Figure 5 illustrates progressive growth in net power generation from various bioenergy resources in European Union countries. The unveiling trend signifies that within an interval period of five years, utilization of biomass for energy increases. The net power generations from MSW and solid based biomass have well pronounced increasing status compare to others.

4.1 Technological approach to electric power generation from municipal solid waste

There are several technological approaches available for exploitation of electric power from organic fraction of municipal solid waste (OFMSW). Base on general perspective, the technologies are categorized into thermo-chemical and bio-chemical conversion. In ideal situation, the choice of technology depends on economic viability and technical know-how. Different bioenergy technologies have been studied to different level of success and efficiency because some conversion techniques are known for their technical challenges such as low energy net yield, water pollution, conversion efficiency and capital investment (Rittmann, 2008 and Rao et al., 2010). However, the most three famous waste-to-energy (WTE) technology in the world today is gasification, anaerobic digestion and combustion. The phenomenon of WTE is a complex process that must be accomplished in stages as illustrated in Figure 6 (Budzianoskwi, 2012). To achieve energy production from MSW, sorting of the organic and inorganic component of the waste is usually at the foremost stage. This is done to separate the heavy component that is usually difficult to be burnt and to ease recycle process. The heavy components are mostly the inorganic substances in the waste which are preferably disposed by landfilling in most cases. Sometimes, non-organic substances such as stones, concrete pieces, glass, and poisonous chemical among others are present in the waste. The organic component is consumed for energy mainly by bio-chemical conversion route. In thermo-chemical process, the whole waste may be burnt for energy as all the organic and inorganic fraction can donate to the energy delivery. More also, inorganic fraction of municipal solid waste can be burnt directly as refuse derived fuel (RDF) in an incineration energy production plant for heat or electricity generation.

4.1.1 Gasification of municipal solid waste

Gasification of waste to produce energy involves thermo-chemical conversion reactions. The process is used to induce production of varieties of gases such as carbon dioxide, steam, methane and other byproducts like ash and tar under the conditions of high temperature and low concentration of pure oxygen or air. Methane is the basic product gas from gasification process and after being allowed to pass through some cleaning processes, then it can be applied directly to run an Internal combustion engine (IC) for electricity generation (Figure 7). Gasification has been used in many part of the world for effective WTE management with positive environmental and economic impacts. It is a very fast growing technology with promising nature in area of bioenergy applications.

It has the tendency to reduce the mass of the waste by 70-80% and volume 80-90% while preserving the land area for waste land filing (Consonni et al., 2005 and Arena, 2011). It is important to point out here that since gasification process is view as a modification of pyrolysis (Figure 8), therefore special discussions of waste pyrolysis is not given priority in this study.

Generation capacity of gasification system depends on the utility scale of demand, availability of feedstock and other necessary logistics. Gasification system can be designed for either centralized or distributed power generation. The entire process involves waste collection, transportation, sorting, and conversion process, then electricity generation via a generator.

4.1.2 Anaerobic digestion

Anaerobic digestion is purely a bio-chemical conversion process used to produce a fuel for energy in a well-controlled enclosure called digester. As a well-known dynamic process, it is currently in used in developed and developing countries for treatment of both wet and dry biomass resources. It involves the application of microbial actions on bio-waste in absence of oxygen for biogas production. The complete process of anaerobic digestion is complex involving series of heterogeneous chemical reactions such as hydrolysis, acidogenesis, acetogenesis and methanogenesis (Figure 9). These are integrated process that becomes feasible with microbial influence to degrade organic waste, which results to the production of biogas and other energy-rich organic compounds (Lastella et al, 2002 and Lata et al, 2002). The process is applicable for conversion of wide-range of material such as MSW, agricultural and industrial wastes and plant residues (Chen et al., 2008; Kalra et al., 1986; Khalid et al., 2011; Gallert et al., 1998).

Anaerobic digestion has been found to be technically productive on small and large scale basis. It has been used successfully for small scale electricity generation in rural and remote areas of developing countries with difficult access to electricity by grid extension. To this development, anaerobic digestion of municipal solid waste has recorded reasonable breakthrough in the past few years. It was also declared by (De Baere, 2006 and Jingura and Matengaifa, 2009) to be considered as a workable technology for treatment of organic waste with simultaneous renewable energy production effects.

Biogas yield from different type of municipal solid waste can vary significantly due to variation in the chemical composition as shown in Table 2. Different kind of biomass waste are used as feedstock for anaerobic digestion: various type of kitchen waste, organic fraction of municipal solid waste, animal manure, waste oil and fat products, waste water, agricultural crop residues and latrine wastes. Therefore, the chemical composition disparities of these different substances accounted for the variation in the quantity of methane yield.

4.1.3 Incineration

This is another thermo-chemical conversion process for energy generation from waste either in the form of heat or electricity. In this method of energy extraction from municipal solid waste, no pre-treatment of the waste is required. The whole mass of the waste is burn in incineration, hence the name mass burn. It is one of the oldest methods used for handling waste-to-energy management in many industrialized nations of the world before the feasibility of other technologies was proved. Incineration of MSW has the ability to drastically reduce the volume of MSW as much as 80-90%.

Waste incineration technology has three basic components: incineration, energy recovery and air pollution control system (Incineration of Municipal waste, 1990 and Lee et al., 2007). The combustion process of waste in incineration plant release gaseous pollutants from oxides of sulphur, carbon, nitrogen and possibly little ash particles. This is the major reason why it is necessary to incorporate pollution control system in a complete set-up of the plant to avoid environmental polution. An incineration plant operates within a temperature range of 800-1000^{o}C. With appropriate energy system connections heat and electricity can be generated. On the account of economic point of view, this technology is seen to be cost ineffective but is one of the mainly used WTE technology in Island countries like Singapore and Taiwan with limited space for landfilling. In current practice, the choice for gasification is becoming more popular than incineration.

5. Estimated energy and electric power generation potential in the metropolis

Table 3 presents estimated values of energy and power generation potential from the municipal solid waste in the case study areas. The assessment was carried out through thermo-chemical conversion route. Singh et al. (2011) stated that waste generated in developing countries have almost the same chemical composition since the variation between regions is being determined by climatic, cultural, industrial, infrastructural and legal factors. Previous studies conducted by Rao et al. (2010) on the calorific value of MSW in a developing country like India indicated that it varies from 800.70-1009.89kcal/kg. The average value is approximately 905kcal/kg.The thermo-chemical conversion is preferably used due to its ability to ensure the contribution of both biodegradable and non-biodegradable components of the waste to the energy output.

Bamgbose et al. (2000) reported that Word Bank sponsored studies indicated that per capita waste generation in Lagos metropolis is 0.21kg. This value was thoroughly disputed by many researchers as underestimated. Moreover, the basis of their argument is that before 2003; about 30-40% of waste generation in the metropolis never gets to waste disposal point due to logistic problems. This claim is undisputed when considering different mountains of waste dumps indiscriminately at unapproved open places in the metropolis. Government stringent measures against indiscriminate dumping in 2007 have indeed positively altered collection factor and the per capita generation figure. A more recent study conducted by (Ogwueleka, 2009) in conjunction with LAWMA revealed that 0.63kg/capita/day is estimated for Lagos metropolis. This value is preferably used for this study based on the fact that many recent studies on municipal solid waste (MSW) evaluated figures between 0.6-0.8kg as capita/person/day. The energy and power potential was estimated as follows:

$$E_p = HV \times W \times 0.0011628 \quad (1)$$

$$P_{gp} = {E_p}/{24} \quad (2)$$

Where E_p = Energy potential (kWh)

P_{gp} = Power generation potential

HV = Calorific value of the waste ($kcalkg^{-1}$)

W = Weight of the waste (ton)

Calorific value (Higher heating value) used for the purpose of this calculation = 905kcal/kg

Generally, energy recovery potential from MSW through the route of thermo-chemical conversion depends on the quantity, physical and chemical characteristics of the waste. Application of bio-chemical conversion route for energy generation from MSW is subject to the biodegradable component of the waste. In bio-chemical conversion process, only the organic components of the waste have the ability to constitute to energy production.

6. Discussion and concluding remarks

Lagos metropolis has a share of 16 Local governments out of 20 in the state. The estimated waste generation in the state has an overall electrical power potential of 483MW with approximately 442MW from the metropolis alone. The bold characters in the table 4 indicated the administrative Local Government Areas that are not part of the metropolis under consideration. This study has possibly presented electrical power potential of MSW in the metropolis of Lagos. It also discusses some reasons why power generation from such renewable resources is necessary. Metropolis of Lagos harbors about 70% of Nigerian industrial sector but in recent time many of these industries manufacturing basic consumer goods were closed down due to present situation of severe power supply constraints. The atmosphere of profitable business enterprise operations is no longer sustainable to some of these local industries relying on private generators for power supply. In addition to this fact, power allocation to the state is below 300MW in 2011 as against the backdrop of 800MW in the last decade. This experience shows that with power generation potential of 442MW estimated from MSW can improve the power supply in the state drastically.

Furthermore, there is need for radical policy framework in the Nigerian power sector to ensure power supply reliability, availability and accessibility. The concept of waste-to-energy is very new to the people of SSA especially Nigeria. To this regard there is necessity for proper orientation of the general public and feasibility studies on MSW for energy in the metropolitan of Lagos should be conducted. The government has to take the risk to initiate experimental project on waste-to-energy while also craving for vertical and horizontal partnership with organized private sectors for possible investment. This will help in the efforts to improve power generation in the country. Development of compressive waste-to-energy management legislation is inevitable to attract private sector investment. Since power generation from MSW has environmental benefits, then incentive provisioning to intended private investors should be another welcome development from the government.

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Figure 1. Metropolitan city of Lagos (Motherland Nigeria, 2011)

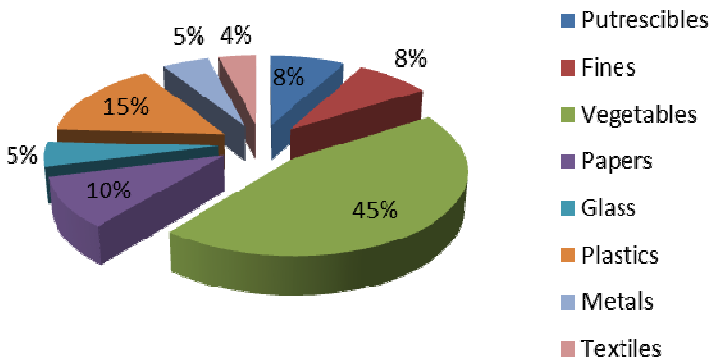

Figure 2: Waste characterization in Lagos metropolis (Jeleel, 2011)

Table 1. Classification of MSW in Lagos metropolis [Source: Authors' construct]

Source of waste	**Description**
Households	Vegetables, biodegradable kitchen waste, rags, animal bones, sweeping refuse, package papers.
Commercial centers	Vegetable wastes, fruit wastes, plastics, metals, polythene bag waste, package papers, textiles, cardboard, waste tyres, food waste, papers, slaughter waste, animal bones, sweeping refuse.
Institutions	Printed papers, cardboards, packaging wastes, hospital wastes, flower trim waste, office sweeping refuse.
Industries	Agro-processing waste, plastics, discarded metals, packaging waste, chemical waste, wood waste, food processing waste.

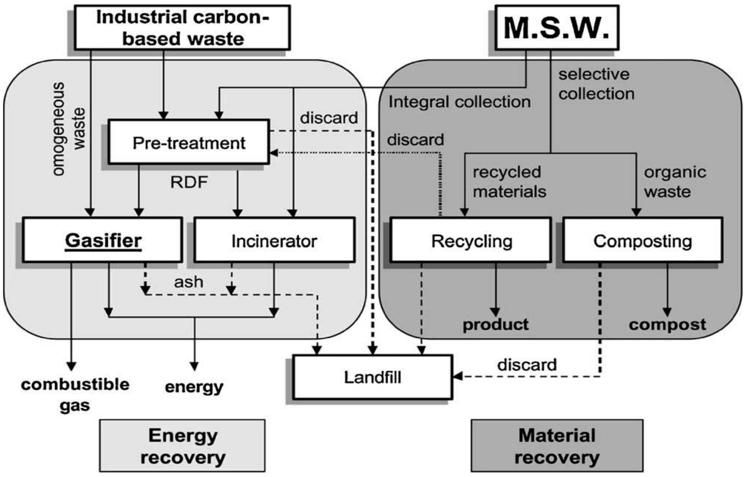

Figure 3. An integrated waste management system (Belgiorno, 2003)

Figure 4: LAWMA street trash containers

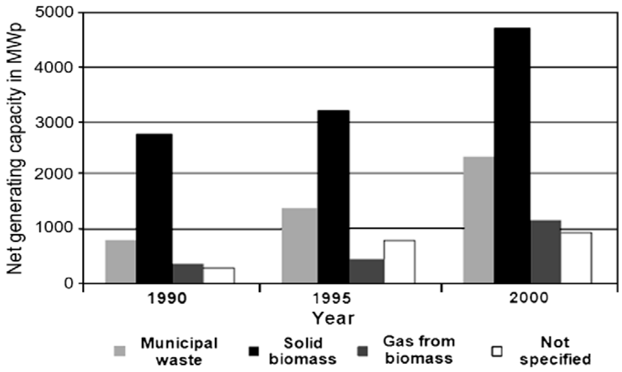

Figure 5: Progress in net power generating capacity from MSW and solid biomass in European Union countries (IEA, 2009 and Zhang et al 2010)

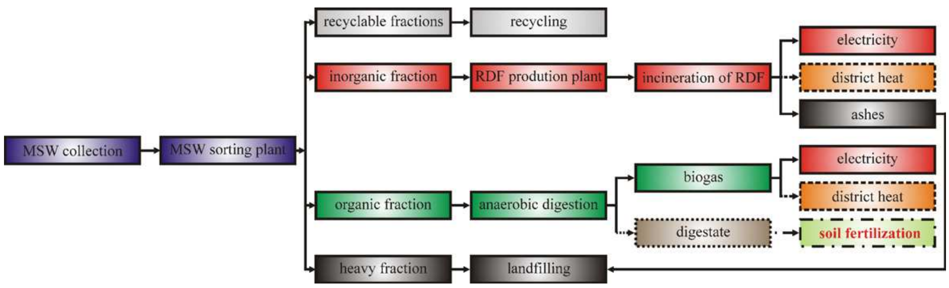

Figure 6: The sustainable strategy for MSW management for energy production (Budzianowski, 2012)

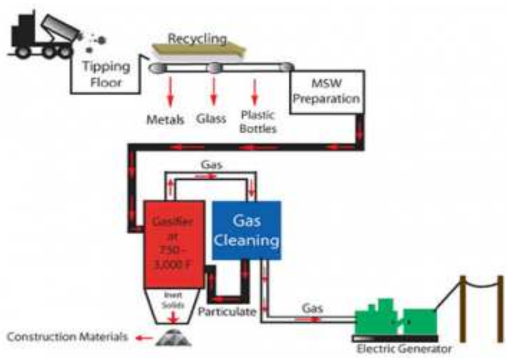

Figure 7: A complete set-up of WTE gasification system (Distributed waste to energy conversion, 2011)

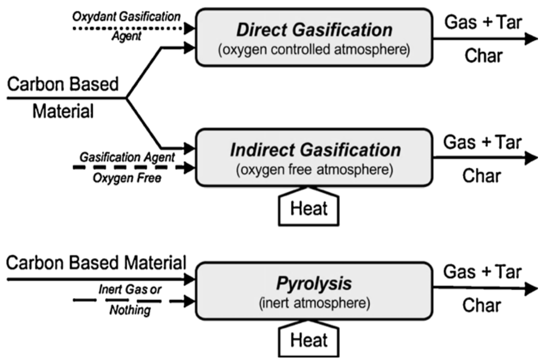

Figure 8: Gasification and pyrolysis process (Belgiorno et al, 2003)

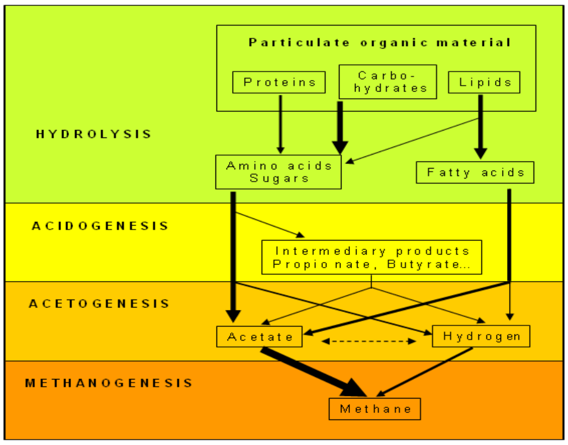

Figure 9: Biodegradable stages of complex organic matters in anaerobic digestion (Mata-Alvarez, 2003)

Table 2. Methane yield from anaerobic digestion of different MSW (Owens and Chynoweth, 1993)

Category of MSW	Methane yield (m^3/Kg organic dry solid)
Mechanically sorted (fresh)	0.22
Mechanically sorted (dried)	0.22
Hand sorted	0.21
Grass	0.21
Leaves	0.12
Branches	0.13
Mixed yard waste	0.14
Office paper	0.37
Corrugated paper	0.28
Printed newspaper	0.10

Table 3. Estimated power generation potential from MSW in Lagos Metropolis

Local Government Area	Population (2006)[a]	MSW Generation (ton/year)	Energy Recovery Potential (MWh)	Power Generation potential (MW)
Agege	1,033,064	650.83	685	28.5
Ajeromi-Ifelodun	1,435,295	904.24	953	37.7
Alimosho	2,047,026	1,289.63	1357	56.5
Amuwo-Odofin	524,971	330.73	348	14.5
Apapa	522,384	330.73	348	14.5
Badagry	**380,420**	**239.66**	**252**	**10.5**
Epe	**323,634**	**203.89**	**215**	**9.0**
Eti-Osa	983,515	619.61	652	27.2
Ibeju-Lekki	**99,540**	**62.71**	**66**	**2.8**
Ifako-Ijaiye	744,323	468.92	494	20.6
Ikeja	648,720	408.69	430	17.9
Ikorodu	**689,045**	**434.10**	**457**	**19.0**
Kosofe	934,614	588.81	620	25.8
Lagos Island	859,849	541.70	570	23.8
Lagos Mainland	629,469	396.57	417	17.4
Mushin	1,321,517	832.56	876	36.5
Ojo	941,523	593.16	624	26.0
Oshodi-Isolo	1,134,548	714.77	752	31.3
Somolu	1,025,123	645.84	680	28.3
Surulere	1,274,362	802.85	845	35.2
Total	**17,552,942**	**11,058.35**	**11614**	**483**

[a]Census population result of 2006 (The authentic census, 2011)