Reflecting on Waste Management Strategies for South Africa

Edison Muzenda, *Member, IAENG,* Mohamed Belaid, Mansoor Mollagee, Ntemi Motampane, Freeman Ntuli, *Member, IAENG,*

Abstract— The energy crisis, global warming and a cleaner environment are arguably amongst the most pressing issues at present facing modern society. Before devising a suitable strategy to convert a proportion of the waste into useful product, categorization of waste types is of great significance to any more detailed study. The population of the world continues to grow, as does the average standard of living, increasing demand for food, water and energy which places increasing pressure on the environment. This paper attempts to parameterize waste generation within a South African context in order provide a theoretical foundation for such work to take place. Organic materials, which includes wood, leaves, grass, food, paper, plastic, cotton, synthetic fabrics, sewage sludge, animal remains, bacteria, any carbohydrates or hydrocarbons. These are all materials sent to landfills (with the exception of metal, ceramics and glass). The Gauteng province was chosen for this preliminary study as it constituted 42% of SA's waste in 2010 making it by far the country's biggest waste generator. The types of waste that were particularly targeted in lieu of the downstream research endeavoured were medical waste, plastics, tyres and sewage sludge.

Keywords— landfills, waste generation, cleaner environment, organic materials

I. INTRODUCTION

Energy is the life blood of modern civilization. Today, most energy is generated through the combustion of fossil fuels. The production thereof is approaching the saturation levels worldwide. The world is in dire need alternative sources of energy. The energy crisis, global warming and a cleaner environment are arguably the most pressing issues at facing civilization today, as a natural consequence of production and manufacturing within an industrialized context. If sufficient energy is available the human race will enjoy a dynamic future with high standards of living. Sources of unconventional oil are; extra heavy oil and oil sands, tight sands, oil shale, biofuels, thermal depolymerization and coal and gas conversion.

The first three sources are not relevant to the South African circumstance. Coal and gas conversion though are fully developed processes in South Africa (SASOL and PetroSA). This paper seeks to provide a foundation for addressing some of South Africa's energy and environmental needs through processes that could develop alternatives to our current sources of energy. The population of the world doubled from 3.2 billion in 1962 to 6.4 billion in 2005 and is forecast to grow to 9.2 billion in 2050. The world's primary sources of energy are the sun, geothermal activity, water, nuclear reactions and hydrocarbons including oil, natural gas, coal and biomass. Secondary energy sources include petroleum products refined from crude oil and gas, biofuels derived from biomass and electricity generated from coal. According to the IEA (International Energy Agency), fossil fuels provided 80% of world energy demand in 2004, while renewable energies, mostly biomass, met 13.2% of world energy demand and could rise to 13.7% by 2030. The depletion of fossil fuels has put many countries, including South Africa, in a desperate position. According to SAPIA (South African Petroleum Industry Analysis), the latest energy consumption of conventional diesel and petrol for the year 2009 was 9116 and 11313 billion litres respectively, with an annual total consumption of approximately 21 billion litres. This makes South Africa the continent's biggest oil guzzler alongside Egypt.

The future could depend on the following technologies and processes:

- Thermal Depolymerization
- Nuclear fusion reactors
- Use of thorium as nuclear fuel
- Biofuels derived from algae
- Cellulosic biofuels
- Next generation solar technology

The first method (TDP), which when applied to wastes of an organic nature yields a suite of products currently only satisfied by oil. Examples of these would be natural gas, propane, kerosene, gasoline, diesel fuel, jet fuel, home heating oil and lubricating oil. With further processing

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E. Muzenda is with the Department of Chemical Engineering, University of Johannesburg, Doornfontein, Johannesburg 2028 (corresponding author phone: +27 11 5596817; fax: +27 11 5596430; email: emuzenda@ uj.ac.za).

M. Belaid is with the Department of Chemical Engineering, University of Johannesburg, Doornfontein, Johannesburg, South Africa, 2028 (email: mbelaid@ uj.ac.za).

M. Mollagee is with the Department of Chemical Engineering, University of Johannesburg, Doornfontein, Johannesburg, South Africa, 2028 (email: mmollagee@ uj.ac.za)

N. Motampane is with the Department of Chemical Engineering, University of Johannesburg, Doornfontein, Johannesburg, South Africa, 2028.

F. Ntuli is with the Department of Chemical Engineering, University of Johannesburg, Doornfontein, Johannesburg, South Africa, 2028 (email: fntuli@ uj.ac.za).

plastics, paints, refrigerants and thousands of other chemicals used in industry can also be produced. TDP will convert our landfill and agricultural waste into the same products which are currently produced from fossil oil. Carbon is the major chemical constituent of most organic matter- plants take it in; animals eat plants, die, and decompose; and plants take it back in. Since the industrial revolution, boosted concentrations of atmospheric carbon in the form of carbon dioxide have been accumulating in the atmosphere and as a result disrupted this cycle.

To alleviate this environmental hazard, TDP would mean the accoutrements of the civilized world, domestic animals and plants, buildings, artificial objects of all kinds, would then be regarded as temporary carbon sinks. At the end of their lives, they would be converted into short-chain fuels, fertilizers, and industrial raw materials. This means that belowground carbon would remain there. As a result the balance of nature would be preserved. This is a process using hydrous pyrolysis for the reduction of complex organic materials (variety of waste products), into crude oil. This means that where once plastic was considered a bad and environmentally unfriendly product it can now be considered as a valuable resource, a source of energy. Considering the amount of waste modern societies produce TDP could make lots of cities and other urban areas self-sufficient in energy terms. By conducting a feasibility study on the state of waste in South Africa and the implementation of TDP as a solution, the above could be achieved.

II. OBJECTIVES

The objectives of this study are to:

- Quantify the amount of waste produced in South Africa.
- Demonstrate the potential that exists for waste reduction and the prospect for energy applications

III. SIGNIFICANCE

Waste management and utilization in South Africa is in a bad state. Municipal solid waste management constitutes one of the most crucial health and environmental problems facing our three levels of government. Severe backlogs still remain in providing universal access to adequate municipal solid waste collection services (DEAT, 2002). Residents of core urban areas have relatively good access to refuse removal services while those in peri-urban and rural areas have limited access to formal services. The General Household Survey of 2007 (Stats SA, 2007) revealed that 39% of households, or 50% of the South African population [1], is not receiving a regular municipal waste collection service, with municipal waste collection having only improved by 2.7% between 1996 and 2001 [1]. Waste infrastructure includes landfill sites, waste storage facilities, recycling facilities, materials recovery facilities and waste transfer facilities. A 2005 census of available information on these facilities revealed a need for addressing the backlog in the permitting of these sites. A total of 1 336 waste facilities were included in the census (DEAT, 2005). The 2007 capacity assessment estimated the number of waste handling facilities to be more than 2 000, of which 530 were licensed (DEAT, 2007). The remaining backlog in facility permits can therefore be calculated as being in the order of 82% of the total. An additional concern in terms of waste handling facilities is the available capacity of these facilities to deal with the waste volumes.

The main energy-related challenges facing the world today are:

- Achieving an affordable, secure, reliable supply of energy to meet the immediate and long-term needs of a population growing in numbers and standards
- Depletion of non-renewable energy reserves in years are crude oil (known reserves - 40), natural gas (66), uranium (84) and coal (164))
- Meeting increasing demand for energy while, at the same time, significantly reducing carbon dioxide emissions
- Conversion to renewable energy, including nuclear, restricted by the pace of technological innovation
- Sustainable biofuels competition for resources with agriculture, food supply and security forestry and natural habitats
- Political stability of oil and gas producing regions
- Increased competition for energy resources; “increasing nationalization of energy and mineral resources”. Greater international regulation and setting of standards
- Safety of communities located close to energy facilities
- Energy saving/reduction
- Worldwide shortage of qualified managers, professionals and technical staff to tackle these challenges

IV. EFFECT OF GLOBALISATION ON SOLID WASTE MANAGEMENT

Globalization, which according to Ref [2] implies a strong cultural, technological and especially economic interconnection between people and countries has been widely promoted as a process, which will improve the wellbeing of both the developed and developing worlds. For the developing world in particular, globalization is seen as an economic transformation, a breakthrough to poverty alleviation, and inflation reduction thus expected to help narrow the gap between the two worlds as well as between and within individual nations. It is rightfully argued that globalization brings opportunities for many cities, especially those that can be key centres for production, distribution and services for liberalizing economies. However, increasing evidence suggests that globalization is also creating an increasingly unequal world in terms of distribution of incomes, assets and economic power. While some few countries and their cities are incorporated into it, others are bypassed or excluded. Some are incorporated but at huge social costs. Globalization has raised some troubling concerns for the developing world, including Africa. One such concern is its impact on urbanization and the ramifications that accompany it. Cities are traditionally engines of social modernization and economic growth and at

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the same time the theatres in which globalization stages its actions. For Africa this has meant fueling the already unprecedented urban growth phenomenon and increasing the challenges that go with it. One key challenge is the management of municipal solid waste.

According to recent sources, thirty-eight percent of Africa is urbanized, making the region the least urbanized in the world. It is however, fast catching up with the worlds' most rapid urban growth rate of nearly 4 percent per annum.

Municipal solid waste management constitutes one of the most crucial health and environmental problems facing governments of African cities. This is because even though these cities are using 20-50 percent of their budget on solid waste management, only 20-80 percent of the waste is collected. The uncollected or illegally dumped wastes constitute a disaster for human health leading to environmental degradation. Not only are the quantities of waste increasing but also the variety, both as a consequence of increasing urbanization, incomes changing and changing consumption habits fuelled by globalization. This scenario places already-distressed urban councils in a difficult situation especially as they have to develop new strategies to deal with increasing volumes as well as odd varieties of waste.

South Africa is faced with waste management problems left by years of inequitable development and service delivery under Apartheid rule. The White Paper on Integrated Pollution and Waste Management for South Africa (RSA, 2000) emphasizes a significant shift in waste management strategy from control to prevention. This shift will:

- Minimize and/or avoid the creation of pollutants and waste;
- Minimize and/or avoid the transfer of pollutants from one medium to another;
- Accelerate the reduction and/or the elimination of pollutants;
- Minimize health risks and impact;
- Promote the development of pollution prevention technologies;
- Use energy, materials and resources more efficiently;
- Minimize the need for costly enforcement;
- Limit future liability with greater certainty;
- Limit costly clean-up practices;
- Promote a more competitive economy;
- Reduce human impact on the environment;
- Enhance the quality of life, and
- Ensure intergenerational equity (RSA, 2000). [3]

V. DELIVERY SHORTFALLS

Attempts to fast track service delivery in South Africa has led to Cabinet directing that sector departments should account for all service backlog. On the basis of this information, sector plans were developed to address the deficit. The Pollution and Waste Management Directorate of the National Department of Environmental Affairs commissioned a study in 2007, which assessed the status of waste service delivery at local government level, including the availability of capacity to deliver this service. In addition the Department of Cooperative Governance and Traditional Affairs set out to determine the root causes of poor performance, distress and dysfunctionality in municipalities and responded to these challenges with the development of the Local Government Turnaround Strategy.

Severe backlogs still remain in providing universal access to adequate municipal solid waste collection services (DEAT, 2002). Residents of core urban areas have relatively good access to refuse removal services while those in peri-urban and rural areas have limited access to formal services. The General Household Survey of 2007 (Stats SA, 2007) revealed that 39% of households, or 50% of the South African population [1], is not receiving regular municipal waste collection service, with municipal waste collection having only improved by 2.7% between 1996 and 2001[3]. The status of waste removal services in 2007 is depicted in Fig. 1.

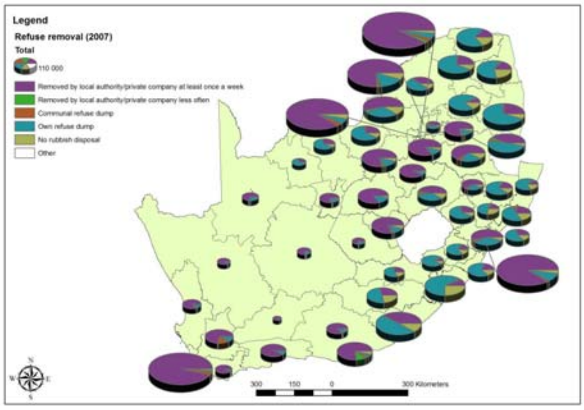

Fig. 1 Status of refuse removal per district municipality IN 2007 [3]

Key findings from the capacity assessment (DEA, 2007) were:

- The waste service function is often not accounted for in rural towns;
- Staffing in these areas is skewed towards laborers with fewer middle and top managers;
- There is a shift towards outsourcing of the recycling function to small community contractors;
- A total of 87% of municipalities do not have the capacity or infrastructure to pursue waste minimisation;
- More than 80% of municipalities are initiating recycling but projects are struggling due to a lack of capacity;
- Metros and secondary municipalities provide the highest percentage of weekly collection services within their areas of jurisdiction; and
- Metros and secondary municipalities have to deal with 54% of the national waste management service backlogs.

Waste infrastructure includes landfill sites, waste storage facilities, recycling facilities, materials recovery facilities and waste transfer facilities. A 2005 census of available information on these facilities revealed a need for addressing the backlog in the permitting of these sites. A total of 1 336 waste facilities were included in the census (DEAT, 2005). The results of the census data is summarised in Table 1 below. The 2007 capacity assessment estimated the number of waste handling facilities to be more than 2 000, of which 530 were licensed (DEAT, 2007). The remaining backlog in facility permits can therefore be calculated as being in the order of 82% of the total. An additional concern in terms of waste handling facilities is the available capacity of these facilities to deal with the waste volumes. Accurate figures on available national landfill airspace and other general waste handling facilities, including recycling facilities, are not available.

TABLE I
WASTE MANAGEMENT FACILITIES – PERMIT STATUS

Facility Type	No. of facilities	No. of facilities Permitted	% Backlog in permits
General Landfill sites	1203	524	56.40%
Hazardous waste Sites	77	41	46.80%
Medical waste Facilities	12	4	66.70%

It should be noted that addressing the backlog in waste service delivery will lead to an increase in waste entering the formal waste stream, which in turn will result in pressure on the available recycling, treatment and disposal capacity to deal with the waste volumes. An assessment of available waste treatment and disposal capacity for all waste streams should be considered. The information should be available from the integrated waste management plans (IWMPs) from local municipalities since the development of IWMPs is a legal requirement in terms of the National Environmental Management: Waste Act, 2008. [3], [5], [6].

VI. WASTE GENERATION

The Department of Water Affairs and Forestry are responsible for availing waste generation figures. However, the last document to be published was as far back as 1998. A projection is made using a growth rate of 2- 3% is shown in Table 2 below. The amount of waste generated in South Africa is tremendous particularly the Gauteng province which amongst other factors is the reason it has been chosen as the sample province. The Gauteng province constituted 42% of SA's waste generation in the year 2010 making it by far the country's biggest generator. The last figures to be released on the state of waste by the Department of Water Affairs and Forestry (DWAF) were in 1998. According to Fiehn& Ball waste generation growth rate has been 2-3% per annum since 1999 as a result of population and economic growth. Utilizing this rate the waste generation figures have been extrapolated and are indicated below. Focusing on the waste that will have been generated by the end of the current year, the figures for 2010 can be analyzed. The standard form of expressing waste generation is per capita, the latter in this study being per person. This obtained by dividing the waste generated per annum by the population. The estimated population figures were obtained from Stats SA. [3], [5].

TABLE II
EXTRAPOLATED WASTE FIGURES PER PROVINCE

	1998	2008	2009	2010
Mpumalanga	3831000	5148544	5303000	5462090
Eastern Cape	2281000	3065473	3157437	3252161
Free State	1675000	2251060	2318592	2388149
Gauteng	17899000	24054759	24776402	25519694
KwaZulu-Natal	4174000	5609507	5777792	5951126
North West	1625000	2183864	2249380	2316861
Northern Cape	733000	985091	1014643	1045083
Limpopo	1470000	1975557	2034824	2095869
Western Cape	8543000	11481078	11825510	12180275
TOTAL	42231000	56754933	58457581	60211308

Table 3 below represents the amount of waste generated per Province for 2010.

TABLE III
WASTE GENERATION FIGURES PER PROVINCE

	General waste (m^3/yr, 2010)	Percentage per province	Population (2010 estimates)	Per capita waste generation (m^3/ yr)
Mpumalanga	5 462 090	9.1	3 617 600	1.51
Eastern Cape	3 252 161	5.4	6 743 800	0.48
Free State	2 388 149	4.0	2 824 500	0.85
Gauteng	2 5519 694	42.4	11 191 700	2.28
KZN	5 951 126	9.9	10 645 400	0.56
North West	2 316 861	3.8	3 200 900	0.72
N Cape	1 045 083	1.7	1 103 900	0.95
Limpopo	2 095 869	3.5	5 439 600	0.39
W Cape	12 180 275	20.2	5 223 900	2.33
TOTAL	60 211 308	100	49 991 300	1.2

As expected the Gauteng province has the highest per capita waste generation as it has the largest population and economic growth rate. The typical waste stream composition in the Gauteng province is broken down into non-recyclables (40% of total waste stream), organic materials (15%), main line recyclables (25%) and building rubble (20%). In this study the waste materials of interest are medical waste which forms part of the organic stream as well as plastic (PET) and tyres which constitutes part of the main line recyclable stream.

The producer of bottle grade PET in South Africa is HOSAF with 120 000 tons per annum, of which 70% is used in the manufacture of beverage bottles. In South Africa more than 85- 90% of post-consumer PET bottles are collected from landfill sites. Utilizing the above-mentioned figures this works out to 71 400 tons of PET bottles collected from landfills every year which is equivalent to 8 tons per hour.

VII. WASTE MANAGEMENT STRATEGIES

Now that it is known how much waste is generated in South Africa currently, the methods of disposing of this waste will be examined. The conceptual approach to waste management is underpinned by the waste hierarchy, introduced into South African Waste Management Policy in the White Paper on Integrated Pollution and Waste Management. Implementation of the waste hierarchy (Table 4) requires changes in the way products are designed and manufactured in order to promote their re-use and recycling, giving effect to the concept of "cradle-to-cradle" waste management.

TABLE IV
WASTE MANAGEMENT HIERARCHY

Cleaner production	Avoidance or prevention
	Minimization and reduction
Recycling and Reprocessing	Re-use
	Recovery
	Composting
Treatment	Physical
	Chemical
	Destruction
Disposal	Landfill

A. *Waste Reduction*

Waste avoidance and reduction is the foundation of the waste hierarchy and is the preferred choice for waste management measures. The aim of waste avoidance and reduction is to achieve waste minimization and therefore reduce the amount of waste entering the waste stream. This is especially pertinent for some waste streams where the recycling, recovery, treatment or disposal of the waste is problematic. While waste minimization is difficult to quantify, available figures indicate that waste generation per capita and per GDP (as a proxy for waste minimization) are on the increase.

B. *Recycling / Re -processing*

Recovery, re-use and recycling comprise the second step in the waste hierarchy. Recovery, reuse and recycling are very different physical processes, but have the same aim of reclaiming material from the waste stream and reducing the volume of waste generated that moves up the waste hierarchy. Recycling rates within South Africa are relatively well established, driven primarily by industry-led, voluntary initiatives with funds managed independently of government via nonprofit associations, which oversee recovery/recycling processes and facilities.

Approximately one and a half billion tons of packaging and paper waste (40% of the consumption of packaging and paper products) is recycled per annum [7]. Whilst this is still slightly behind developed country statistics, this provides an established base upon which to build and set future targets for the recycling industry. [3], [6]

TABLE V
RECYCLING RATES IN SOUTH AFRICA, 2007 [6]

Example of recyclable	% recyclable in 2007
Metal beverages cans	70
Paper	54.5
Glass	25
Plastic	22

Treatment and Disposal: Treatment is any process that is designed to minimize the environmental impact of waste by changing the physical properties of waste or separating out and destroying toxic components of waste. Disposal refers specifically to the depositing or burial of waste onto, or into land. The term 'land filling' refers to the deposition of waste on land, whether it is the filling in of excavations or the creation of a landfill above grade, where the term 'fill' is used in the engineering sense. Historically, wastes have been disposed of on land. This is because land filling is the cheapest and most convenient method of waste disposal. It is estimated that in excess of 95% of the waste generated in South Africa is disposed of in landfills, while the world figure is believed to be in excess of 85%. No matter what waste minimisation technologies are implemented, whether volume reduction or resource recovery, some form of residue will always remain and waste will continue to be generated. This is ultimately disposed of in a landfill, the most commonly used method for ultimate disposal. Land filling is environmentally acceptable if properly carried out. Unfortunately, if not carried out to sufficiently high standards, land filling has the potential to have an adverse impact on the environment.

VII. CONCLUSION

South African municipalities should embark on energy and other resources recovery from the biodegradable part of both fresh and mined waste. This will assist the country in moving away from landfills as the automatic choice when dealing with rubbish and in the reduction of greenhouse gases resulting from fossil fuel combustion. Climate change is one of the biggest environmental challenges facing the world today. South African authorities in particular the Gauteng Provincial Government can achieve low carbon economy without nuclear power by waste utilization. The waste currently buried in the South African landfills pollutes soil and water, as well as producing methane. Future work will focus on the diversion of the biodegradable fraction of municipal waste from landfill sites into energy and useful materials.

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