Recycling Economics: Savings vs Prices

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ABSTRACT

Plastic, paper, and glass waste is packaging waste that is regarded as general waste. It therefore falls under Municipal duties and is disposed of in general landfill site mostly run by Municipalities. Municipal waste is currently the focus of recycling especially its packaging fraction. The industry for making glass, paper, and plastic are very different and each poses unique dynamics that affects their ability to be recycled. Poor aggression from certain role players in the respective industries to pursue recycling is threatening the viability of recycling operations in spite of the environmental and perceived financial benefits. This half-hearted approach to recycling is evident in the recovered volumes and prices of recyclables. PET has the most attractive prices followed by paper then glass. In a free economy when industry economics are not yielding desired results, governments - as the last hope - need to step in and inspire progress through legislative means.

1 INTRODUCTION

Recycling is as old as the history of mankind. There is evidence of recycling dating back as far as 400 BC. This practice has changed forms and sizes but has always been obedient to the law of supply and demand. With the onset of the industrial revolution, recycling graduated from being a household practice to industrial scale. With this development came three sources of recyclable material along the life of a product, namely factory production line, factory dispatch operations, and post-consumer activities.

It is widely accepted that there are generally three levels of recycling. At the top is upcycling which refers to creation of a useful product from recycled material that is of higher quality or has more value than the original product. The second type of recycling is called recycling (also known as closed loop recycling) and refers to making of new products with the same/equivalent quality or value as the original product. The last type of recycling is called downcycling (open loop recycling); it means that a product with less quality or value is created from a recycled product. Although different in the quality or value of the new product formed from waste material, it is general understanding that all recycling efforts should produce products of better environmental value. In most cases than not better environmental value means savings realised due to recycling with respect to resource consumption, energy usage, air water and land pollution and water usage.

It is a long known fact and therefore no debate that recycling of metals (most commonly steel, aluminium, and copper) gives good returns to both the collectors and reprocessors. This is evident from the fact that metal is the longest recycled material and even today many informal recyclers burn items made of other recyclable materials to get to metals. It is for his reason that this paper focuses on other household waste that is commonly recycled (paper, plastic, and glass) to the exclusion of metals.

This paper is an attempt to look at the merits and demerits of the plastic, paper and glass making industry to determine the possible factors affecting their recycling performance in the country. It also suggests remedial action that can be taken by stakeholders, especially government, to increase demand of recyclable material in the country and hopefully help move the prices of recovered material upwards.

2 PLASTIC MAKING INDUSTRY

2.1 Introduction

Plastic is made from chemicals products, called monomers and mainly derived from fossil carbon sources such as oil, gas and coal, which are linked through polymerisation reaction to form polymers. Polymers have a variety of properties such as flexible, transparent, rigid, etc. and it is their thermal properties that gave birth to the four different types of plastic namely thermoplastics, thermosets, rubber or elastomers, and thermoplastic elastomers. Thermo plastics are more or less rigid at room temperature and can be melted by heating e.g. PE, PET, HDPE, LDPE, etc. It is this group of plastic that dominates the plastic industry and as a result they are the one that are most recycled.

2.2 Production Process

The plastic making process has a number of role players starting from it being oil, gas or coal to being a finished product sold to final customers. The role players and their examples are indicated in Figure 1 below.

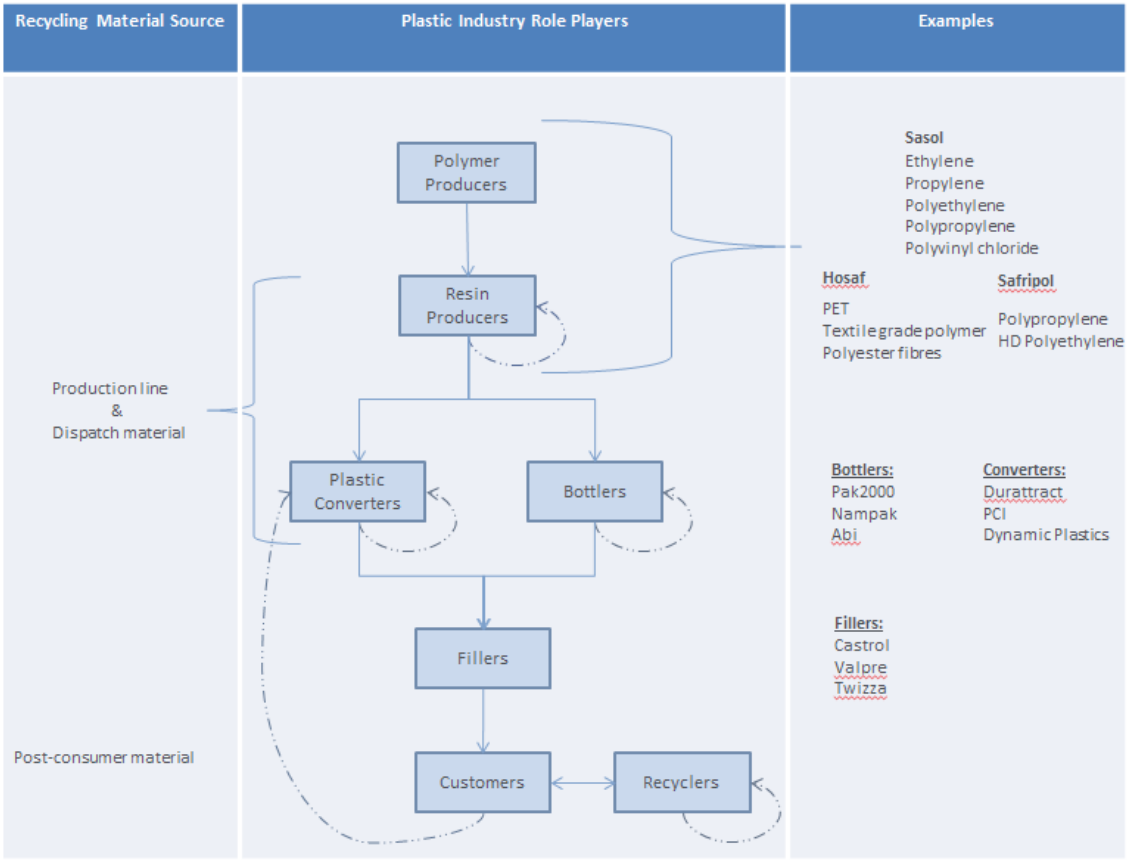


Figure 1. Plastic life cycle indicating role payers and stages of recycling material

The making of plastic begins with production of monomer from refinery processes. The monomers are reacted by petrochemical industry during a polymerisation reaction to produce polymers (about 100 units of polymers). The polymerisation process can occur through an additional (use in making PE, PS, PVC, etc) or condensation (used in making polyester and nylons) reaction. The produced polymers are mixed with additives to obtain polymer resins with desirable properties. Polymer resin is then converted through blow-molding or inject-molding to produce pre-forms. Bottlers use preforms and blow them into plastic bottle according to the specifications required by fillers. Fillers brand the empty bottles then fill them with products before selling the finished product to customers.

The well-known plastic resins all belong to thermoplastic group of plastic. The resins are 1) PET, 2) PE-HD, 3) PVC, 4) PE-LD, 5) PP, 6) PS, and 7) Other (PC/ABS/HIPS); mainly used for container packaging; and their identification codes are usually indicated inside the universal recycling logo at the base of a container.

2.3 SA Supply vs Demand

South Africa consumes about 1,370 million tons of plastic per year (Plastic SA, 2014). About 850 000 tons of this demand is derived from locally produced monomers while the rest is imported (Ndaba, 2007). The per capital rating of the South African plastic market is small at about 27 kg/person compared to Australia - 55kg/person, Western Europe - 80kg/person, and US - 110kg/person (Engineering News, 2007). Its small size relative to the world makes the sector vulnerable to international market forces.

2.4 Plastic Recycling

The sources of recycling material can be found inside or outside the factory. The out-of-factory waste is also called post-consumer waste and forms a bigger portion of recovered plastic waste.

More than 50% of polymers produced in South Africa make polyolefins (PE and PP) and go to making packaging materials (Plastic SA). Plastic packaging material is the most recycled plastic and its recycling in 2012 was sitting at 33.5% (216,932 tpa out of 647,244 tpa sold). A close look into the details showed that PET led the recycling rates of plastic packaging with 32.5% followed by PE-LD (28.75%), PP (28%), PE-HD (23%), and PVC (Plastics SA, 2012). Although comparable to globally trends, the indicated low plastic packaging recycling figures are as a result of poor material recovery rather than lack of recycling capacity as indicated by higher recycling rate targets set by recycling organisations such as PETCO (50% Pet recycling by 2015).

In the same breath, it is a fact that plastic packaging manufacturers cannot use recovered plastic as feed stock in their processes. This is due to high purity requirements (material purity as high as 99.99% is sometimes not good enough for polymer production) and polymer grade variations. This drives plastic recycling costs upward as separate recycling factories have to be set up for handling recovered material (PETCO, 2010). South Africa has about 210 plastic recycling companies employing about 5,000 people (Plastic SA, 2012). The high running costs for these operations keeps the prices of recovered plastic material down and this situation is also exacerbated by the new products made from recovered plastic having to compete in the market with products made from virgin resin. In the case of downcycled plastics (PET to polyester fibre) new products are sold on other markets and the demand and supply dynamics of that new market impact on the prices of the recovered plastic as well. It is in an effort to ease these market dynamics that lead to the voluntary establishment of PETCO by the industry players. PETCO collects a levy from the industry and uses it to promote plastic recycling and stabilise market prices of recovered plastics more specifically PET. POLYCO, a polyolefins recycling company which is in fact a not-for-profit industry body formed by polyolefins convertors, does similar work to PETCO for plastic with resin identification codes 2,4, and 5.

3 PAPER MAKING INDUSTRY

3.1 Introduction

While nowadays paper is mainly made from wood/timber paper can be made from any cellulose containing material such as cotton, straw, grass, hemp, etc (Pulp and Paper BREF, 2001). Paper is made in two stages namely production of pulp from wood and making of paper from pulp. Wood pulp is taken from trees like spruce, larch, fir, hemlock, and pine - main softwood of South Africa and hardwoods such as birch, aspen, and eucalyptus - main hardwood of South Africa (NALEDI).

There are many grades of paper used to make an endless number of products. An attempt to categorise paper grades is better approached by arranging them based on their functional uses. The uses can be categorised as follows (Pulp and Paper BREF, 2001):

1. **Information:** This refers to newsprint, coated and uncoated magazine, and coated and uncoated woodfree printing and writing grades. The grades are used to make products like newspaper, books, computer printouts, etc.
2. **Packaging:** This refers to corrugating medium, folding box boards, and wrapping grades. The grades are used to make products like bags, boxes, wrappings, etc.
3. **Hygiene:** This refers to dry crepe and wet crepe grades. The grades are used to make products like toilet paper, kitchen towels, facial tissue, napkins, wipes, etc.
4. **Specialised:** This group covers official paper, filter paper, and fire resistant paper grades. The grades are used to make products like notes, stamps, air filters, coffee filters, banking paper, etc.

3.2 Production Process

Wood is made up of three materials namely cellulose, hemi-cellulose, and lignin apart from water, which makes up about 50% of the wood/timber mass. The first step to paper making is removal of lignin and hemi-cellulose (delignification) to obtain cellulose fibres. This takes place in a pulp mill and the resulting material is called fibreboard or pulp. The pulp is cleaned, thickened, and dried before being moved to a paper mill for further processing to make different grades of paper.

Pulp production can be performed in three ways namely a) chemical pulping which uses chemicals to separate cellulose fibres, b) mechanical pulping which uses various mechanical energy means, and c) use of recycled fibres which uses fibres from recovered pulp products. Below in Figure 2 is the summary of the paper making industry.

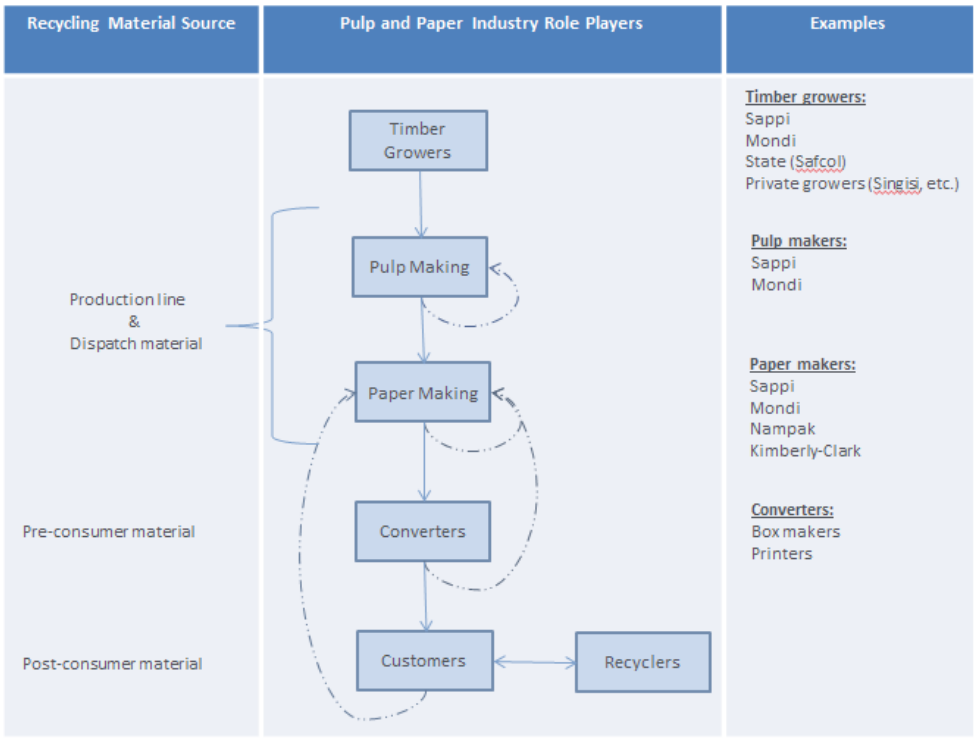


Figure 2: Life cycle of paper indicating role payers and stages of recycling material

The South Africa pulp and paper making industry is dominated by the same role players from start to end namely Mondi and Sappi. Sappi concentrates on fine coated paper that makes magazines while Mondi focuses on fine uncoated paper for computer printouts (Cartel, 2011). They together make up 100% of the domestic pulp making market. Together with Kimberley Clark and Nampak, Sappi and Mondi account for 90% of the domestic paper (Timbetwatch coalition).

3.3 Supply and Demand

South Africa is the biggest producer of pulp and paper in Africa followed by Swaziland and they are together the only pulp and paper producers in the continent. South Africa produces about 2.4 million tons of pulp and 2.7 million tons of paper for consumption by both the country (60% and 75% respectively) and the world (WFB).

South Africa is ranked the 11th largest producer of pulp in the world and 21st largest in paper and paperboard production. In 1996 South Africa exported about 507,000 tons of paper and paperboard. Even with all its pulp and paper production capabilities South Africa still imports significant amounts of all types of paper products. The African per capita paper consumption is standing at 7kg/yr which is far below the compared to the global average of 55kg/yr. South African on the other hands finds itself just below this average at about 52kg/yr per capita. The US has the highest per capita paper and paperboard consumption at 300kg/yr.

3.4 Pulp and Paper Recycling

When we talk of recycling in the pulp and paper industry focus is placed on only pre-consumer (from converter factories) and post-consumer paper (households and offices) and not paper mill waste -known as mill-broke (Timberwatch coalition).

Paper can be only recycled between six and eight times as the fibres get shorter and weaker every time it's recycled. It is for this reason that virgin fibre cannot be completely avoided in pulp and paper recycling as it helps strengthen the recycled fibres. Recycled paper is mainly used to produce tissue paper, corrugated box paper, newsprint, and various other grades of paper with proportions varying from 100% to a few percent (NALEDI, 2005). Some grades of paper cannot take recovered fibres and this is often due to health reasons. Examples of these grades include liquid packaging paper, and photocopy papers. Tissue paper is now growingly made from recovered fibre by small paper recycling mills like Unicell, Jacaranda, Genpak, Green tissue, etc (NALEDI, 2005). About 65% of recovered fibre in South Africa is used as raw material in paper mills. South Africa consumed 2,532,244 tons of paper in 2013 and collected 62.1% of the 1,882,480 tons of recoverable paper. Consumption of recycled paper stood at 1,112,219 tons in 2013 which was 43.9% of the total paper consumption (PRASA, 2013).

Unlike PETCO Paper Recycling Association of South Africa (PRASA) does not impose levies on industry role players as the market is highly dominated and less constrained with respect to the use of recovered material as feed stock. The use of recovered paper is the highest and recycled products compared have an established market.

4 GLASS MAKING INDUSTRY

4.1 Introduction

There are more than seven different types of glass namely,

a) **Container glass:** *hollow glass for packaging of food and beverages, household chemicals, cosmetics etc.*
b) **Flat glass:** *glass for commercial and residential construction, automotive applications, mirrors etc*
c) **Domestic glass:** *glass tableware, cookware and decorative items such as drinking glasses, bowls, plates, cookware, vases and ornaments*
d) **Special glass:** *pressed and blown glass for tableware, cookware, television, lighting, laboratory equipment s etc*
e) **Continuous filament glass fibre:** *mainly used for the production of composite materials as weight-lightening reinforcement component*
f) **Mineral wool:** *main products are low density insulation rolls, medium and high density slabs, loose wool for blowing, and pipe insulation*
g) **Glass frit and enamel frit:** *glass ceramic particle that fuses into the glass area making it an exceedingly durable and scratch resistant.*
h) **Other**

By far the most consumed glass in the world is container, flat, domestic, and special glass (Glass Bref, 2013).

4.2 Production Process

Glass is generally made from eight industrial steps where sand, soda ash, lime and other chemicals are reacted in furnaces at temperatures in excess of 1500^{o}C. The first step is designing of the looks of the glass required followed by mixing of all the required ingredients in the exact quantities. The ingredients are then reacted in the glass furnace to produce molten glass. The molten glass is then carefully cooled (to form gobs) and moulded (forming process) into the desired glass bottle shapes. Various tests are carried out on the finished bottles to verify conformation with specifications. The bottles then go for printing and decoration before being packed for distribution. Figure 3 shows the role players in the glass making industry.

The South African glass smelting sector is made up of only Consol and Nampak. The fillers consist of all the different uses of packaging glass. The main type of glass recycling takes place at the smelters for making glass bottles and very little recovered glass is used to make other products.

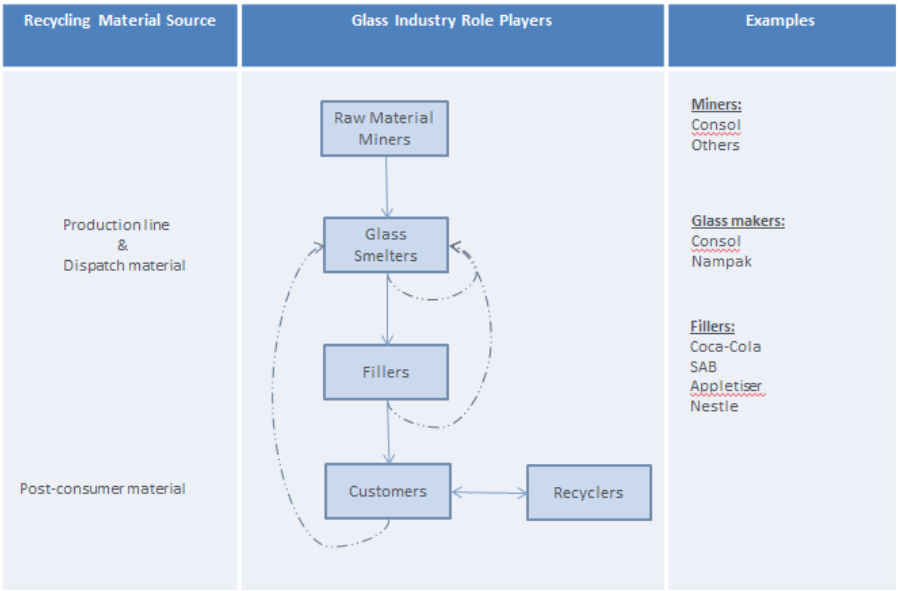


Figure 3: Life cycle of glass indicating role payers and stages of recycling material

4.3 Supply and Demand

South Africa produces a little over 1 million tons of glass per annum (Borralho, 2013). In South Africa the glass making industry is dominated by Consol and Nampak. Together they have five factories and four out of five are in Gauteng. Consol is much bigger than Nampak holding about 80% of the market with its one million plus tons per annual (tpa) production. On the other hand Nampak has a production capacity of 200 000 tpa and commands 15% of the domestic glass market (Ingham, 2011). The country consumes over 3.1 million tons of glass per year, with 68% (2.1 million tons) of this being returnable glass (Barralho, 2013).

4.4 Glass Recycling

The beautiful thing about glass is that it is inert and can be recycled infinite times. Container glass is by far the highest sold glass and also the highest recycled glass in South Africa and the world. Domestic container glass can contain up to 40% cullets while higher percentages (up to 90%) are recorded in other parts of the world. South Africa uses two schemes of container glass collection namely returnable (deposit scheme – 2.1 million tons annual consumption) and non-returnable glass (non-deposit scheme – 1 million tons annual consumption). The deposit payment drives recycling of returnable glass while recycling of non-returnable glass is driven by the glass recycling company (TGRC) formed by Consol and Nampak. Domestic glass recycling is sitting at 40.1% and very comparable with the rest of the world while South Africa is only 15 years into recycling (TGRC, 2012).

Not all types of glass accept cullets as raw material. The degrees to which cullets can be used in the glass making process depend on the required quality of the product and the technology used. Container glass, flat glass, and special glass sectors are by far the most users of cullets while frit does not take cullets as feed stock at all. While the use of cullets greatly reduced the raw materials and energy usage, glass recycling is hamstringed by other technical considerations. The main limit in the recycling of glass lies in the fact that glass furnaces are machines that have to run continuously for their life span which is about 10 to 12 years. The limited opportunity (only at the start-up stage) for setting the machines therefore demands high batch consistency which is hard to ensure when dealing with cullets as feed stock due to inconsistent recovery (EPA, 1992). This fact also makes the gains that came from the introduction of the glass colour separation technology by Consol (2006) and Nampak (2009) less spectacular (Barralho, 2013).

5 RECYCLING THEORY VS REALITY

It is reported that making aluminium cans from recovered aluminium cans uses 95% less energy than it does making them from virgin material. Recycling of glass uses 30% less energy and 17% less raw material (silica) than virgin glass. Making plastic bottles from recycled material use only 70% of the energy needed when using virgin materials while recycled paper uses 40% less energy (The Economist, 2007). All of these savings are not inclusive of further savings related to reduced emission problems due to the use of recovered material.

In spite of all these benefits, official 2012 recycling statistics put recycling at 19.9% for plastic, 57.3% for paper, and 40.1% for glass. Given that the above listed recycling benefits should lead to better profits, it is mind boggling why companies do not pursue this new found recycling attitude to increase their bottom line and in the process help save the environment through savings on energy, water and air emissions at the very least. The half-hearted adoption of recycling attitude into the business model of companies is rather intriguing and renders recycling a far less profitable business venture in the world right now in spite of all its environmental and perceived financial glory. Contained in Table 1 is a collection of some of the facts and factors that affect recycling from various sources.

Table 1: Summary of recycling information pertaining to plastic, paper and glass (Source: Various)

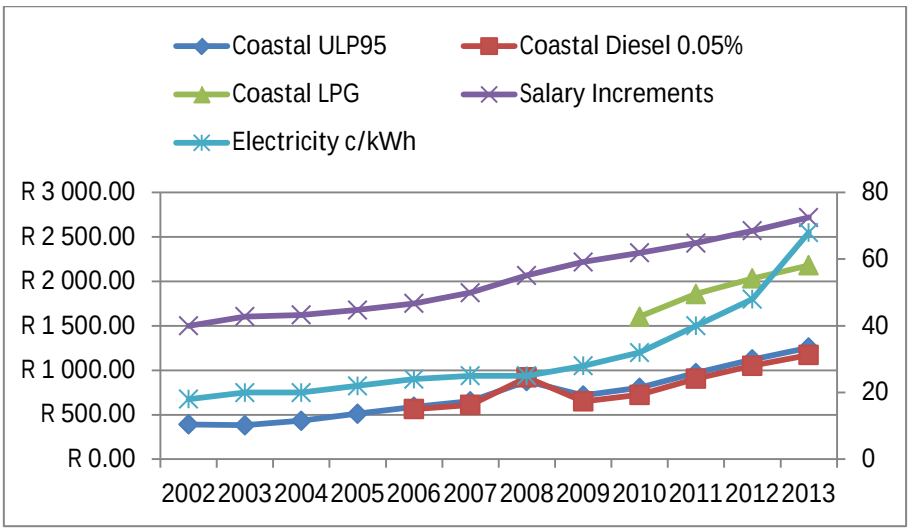
Topic	Plastic	Paper	Glass
Production	2 step process: *Polymer resin production and *Plastic conversion/making	2 step process: *Pulp making and *Paper making	One step process: *melting and forming
Recyclability	Infinitely for some types	Paper recycled 7 to 8 times before it is worthless	*Infinitely (Cullet % can go up to 90%)
Process limits	Some plastic making processes do not take recovered material, e.g. food packaging	None	*None (continuous process of between 10 & 12 years) * Frit does not recycle
Industry commitment	Industry pays self-imposed levies to run PETCO that creates a market for recovered plastic (PET to Polyester conversion); POLYCO recently established on same model for PE, PP	*Mpact Recycling formed by Mondi (40% share in recovered pulp) *Some paper making mills use recovered fibre (including bagasse) as the only fibre source *65% of recovered paper used in paper mills as raw material	*TGRC *All glass made in SA has about 40% cullets makeup
Where recycling happens	Recycling of post-consumer plastic happens at converter level	Paper making level	Glass smelting level
Competition environment	South Africa has more than 1,800 converters	Mondi Sappi Nampak	Consol vs Nampak
Recycling rates	Plastic recycling was about 19.9% (packaging was 34.2%) in 2012	Paper recycling was about 57.3% in 2012	Recycling of non-returnable glass was about 40.1% in 2012
Energy	*Around 250^{0}C melting point *depends on plastic type	*Pulping happens at around 150^{0}C *the process needs 14.4GJ/ton of paper	*Around 1500^{0}C melting point *the process needs 7.5GJ/ton of glass
Savings from Recycling	*30% energy *	*40% energy *	* 70% energy and *17% raw material
Water	*	*Paper manufacturing uses 37.1kLof water per ton	*
Savings from Recycling	*	*60% water	*
Market forces	*Recovered plastic products in the market competes with virgin plastic (polyester vs cotton) *International buyers of recovered plastic *Currency Exchange rates	*International buyers of recovered plastic *Currency Exchange rates	*International buyers of recovered plastic *Currency Exchange rates
Recycling Agent	*PETCO *Plastic SA	*PRASA *PAMSA	The Glass Recycling Company

* Still many gaps to be filled in the table to allow for a better comparison

6 PRICES OF COMMODITIES VS SAVING FROM RECYCLING

In South Africa, with its open market economy, prices of recovered materials (just like many others except for gas, petrol, etc) are set by the market based on the supply and demand pressures. While this may sound fair, in an environment where monopolies exist this model may be less than desirable. An in-depth understanding of these forces is therefore critical if one wants to sway the scales towards fair trade.

Businesses are started with a primary goal of making a profit above any other. Among other things it then becomes critical for them to keep their expenses to a minimum in order to realise greater profit margins. The expenses list for all businesses includes universal things like transport (petrol/diesel), power (electricity/gas), salaries etc. In the last couple of years South Africa has had a more than steady escalation of these expenses and the trend is depicted in Figure 4 below.



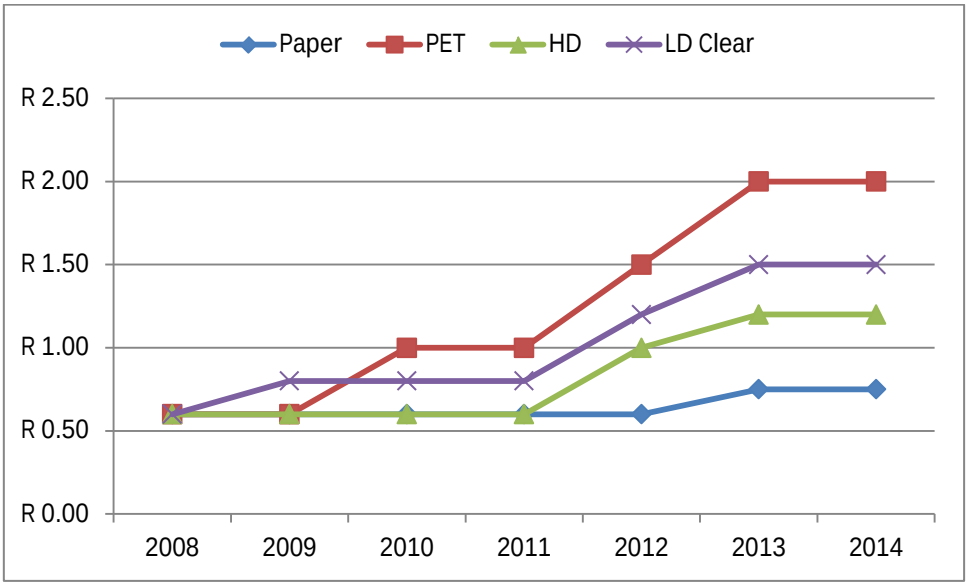
*Salaries start from R1500 per year and increase by inflation year in year

*SA government only started regulating 0.05% diesel and LPG from 2006 and 2010 respectively

Figure 4: Prices of important commodities in the past 10 years (Dept. of Energy)

It can be seen from Figure 4 that average costs of transport and power costs were increasing year on year. It follows that prices of revenue generating operations should track these trends if a business is to maintain its profitability.

A look at the prices of recovered material in South Africa shows concerning trends as shown by Figure 5 below.



*Price records only start from 2008

*Company does not collect glass and therefore does not have prices

Figure 5: Prices per kg of recovered material in the past 06 years (KZN buyback company)

Judging from Figure 5 the prices of recyclables seemed to increase only from about 2009 which could be linked to increased drive around recycling. Year 2012 also saw another marked increase across the board. Although being the one with most recycling limitation PET has the highest price and this can only be attributed to PETCO efforts. From Figure 5, paper prices are the lowest even though it has the lowest limitations when it comes to recycling. It is well known that glass generally has the lowest prices at about R0.30 per kilogram and therefore would have the lowest if it was represented in Figure 5. This in spite of its well accepted 3% savings in energy for every 10% increase in cullets used as raw material.

7 INTERVENTION OPPORTUNITIES FOR ROLE PLAYERS

The main challenge facing recycling worldwide is low prices of recovered material and price fluctuations experienced by the recycling markets. These two makes recycling less attractive to investors and this section seeks to identify possible solutions to these teething problems.

7.1 Collection, transport, cleaning, separation costs

The involvement of communities in the product use stage further complicates the problem by inclusion of socio-economic and political aspects into the discussions of who should be held responsible for recycling. The global acceptance of the polluter pay principle allowed for the blame for pollution caused by manufactured goods, and therefore recycling, to be laid squarely on the manufacturers.

As such the use of the extended producer responsibility (EPR) which places significant responsibility (financial or otherwise) for post-consumer management of products at the producers themselves can be used to pay for these costs. EPR levies can be industry or government posed but in cases where they fail or do not exists then government can be expected to subsidise these costs through its fiscus.

7.2 Creation of market for recycled goods

Some of the factors to be considered, in addition to the above mentioned, include the price of competing raw material, price of products competing with product made from recycled material, import-export controls, value of trading currency, supply and demand environment, energy costs, etc.

A number of various intervention opportunities (punitive steps and enticing steps) exists with respect to creating demand for recovered material and these include:

- *Waste Management or Recycling Policies:* This is where government uses bylaws to mandate waste management/recycling policies for high occupancy properties like a block of flats, schools, businesses, etc. This will increase waste separation and therefore recycling and prices paid for the clean recyclables.
- *Preferential procurement:* This is where preference is given to goods made from recycled materials so that they go on demand.
- *Mandated Recycled Content on Products:* In this case government legislates that certain goods must have a set percentage of recycled material in them. This will create recovered material demand from manufacturers.

Creation of market for commodities is not a straight forward task and needs input from of economic experts to analyse both its intended and possible unintended consequences.

7.3 Cost of alternatives (landfilling)

Another important aspect to consider at this stage is the cost of alternatives to recycling. While this might not be relevant when one looks at the environmental issues but producers are in business for the primary goal of profit making and so positive economic benefits are crucial to whether they commit to something or not. As a way of maximising profits all avenues are investigated during the economic feasibility studies with a view of choosing the least expensive.

Apart from operational cost associated with recycling low landfill disposal fees can also discourage recycling. Low landfill disposal fees are common in developing countries and they come about because plastic, paper and glass form part of the municipal waste of which governments are generally responsible for managing. In the interest of its people, governments find themselves relaxing gate charges at landfill sites in an effort to avoid illegal dumping and this practice is mostly blamed for stagnating levels of recycling by households.

It then becomes critical for government to make disposal costs reflect the true accounting costs of landfill disposal so that recycling costs receive a fair comparison.

8 CONCLUSION

PET prices demonstrate rewarding efforts from the most constrained industry while those with fewer constraints prove to be much relaxed and therefore exhibit lesser prices. These prices do not compare favourably with the ever increasing expenses of running a recycling business and point to a need for an in-depth study of the forces at play in order to determine the intervention strategies required. The lack of readily available information with respect to certain aspects of recycling in the country points to a need for better information gathering for both industry and government. It also seems that government has various methods at their disposal to try and influence the recycling momentum.

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