GLOBAL TRENDS IN WASTE MANAGEMENT:
SOME POINTERS FOR SOUTH AFRICA
Saliem FAKIR

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Global trends in waste management: Some pointers for South Africa

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### Acronyms

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<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>ABS</td>
<td>acrylonitrile butadiene styrene</td>
</tr>
<tr>
<td>ALM</td>
<td>Advanced Locality Management</td>
</tr>
<tr>
<td>ARF</td>
<td>advance recovery fee</td>
</tr>
<tr>
<td>ASPO</td>
<td>Association for Peak Oil</td>
</tr>
<tr>
<td>ASR</td>
<td>automobile shredder residue</td>
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<tr>
<td>ATT</td>
<td>advanced thermal treatment</td>
</tr>
<tr>
<td>C&amp;D</td>
<td>construction and development</td>
</tr>
<tr>
<td>CBO</td>
<td>community-based organisation</td>
</tr>
<tr>
<td>CRT</td>
<td>cathode ray tube</td>
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<tr>
<td>DEAT</td>
<td>Department of Environmental Affairs and Tourism</td>
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<tr>
<td>DiE</td>
<td>Design for Environment</td>
</tr>
<tr>
<td>DSF</td>
<td>Global Digital Solidarity Fund</td>
</tr>
<tr>
<td>DST</td>
<td>Department of Science and Technology</td>
</tr>
<tr>
<td>EC</td>
<td>European Community</td>
</tr>
<tr>
<td>ELV</td>
<td>End-of-Life Programme for Vehicles</td>
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<tr>
<td>EoL</td>
<td>end-of-life</td>
</tr>
<tr>
<td>EPR</td>
<td>extended producer responsibility</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>EUR</td>
<td>estimated ultimately recoverable</td>
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<tr>
<td>GDP</td>
<td>gross domestic product</td>
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<tr>
<td>HDPE</td>
<td>high-density polyethylene</td>
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<tr>
<td>HIPS</td>
<td>high-impact polystyrene</td>
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<tr>
<td>HSRC</td>
<td>Human Science Research Council</td>
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<tr>
<td>IEA</td>
<td>International Energy Agency</td>
</tr>
<tr>
<td>IP</td>
<td>Intellectual property</td>
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<tr>
<td>LDPE</td>
<td>low-density polyethylene</td>
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<tr>
<td>MCGM</td>
<td>Municipal Corporation of Greater Mumbai</td>
</tr>
<tr>
<td>MHT</td>
<td>mechanical heat treatment</td>
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<tr>
<td>MRF</td>
<td>materials recovery facilities</td>
</tr>
<tr>
<td>MSW</td>
<td>Municipal Solid Waste</td>
</tr>
<tr>
<td>NA</td>
<td>neighbourhood association</td>
</tr>
<tr>
<td>NCV</td>
<td>net caloric value</td>
</tr>
<tr>
<td>NGO</td>
<td>non-government organisation</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>PCB</td>
<td>polychlorinated biphenyl</td>
</tr>
<tr>
<td>PET</td>
<td>polyethylene terephthalate</td>
</tr>
<tr>
<td>PPP</td>
<td>public-private partnership</td>
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<tr>
<td>PVC</td>
<td>polyvinyl chloride</td>
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PWB     printed wiring board
RCF     recycled cellulose fibre
UK      United Kingdom
UNEP    United Nations Environment Programme
US      United States
USA     United States of America
US EPA  United States Environmental Protection Agency
WEEE    waste electrical and electronic equipment
WPC     wood/plastic composite
WRAP    Waste and Resources Action Programme
Executive summary

Introduction

This report is an overview of global trends in recycling, defined as the recovery and use of waste. It seeks to identify innovations and explore how these innovations can be used in South Africa.

It goes on to investigate the economic benefits of, and current thinking on, recycling, and suggests that waste should be seen as a national resource. The life-cycle of materials is examined in order to explore how the end use of components can be incorporated into designs to minimise waste. In order that less waste ends up on landfills it is imperative that there be a growing awareness of recycling possibilities among users, and that government encourage the process through regulation and incentives.

Reasons

The benefits of recycling go beyond reduction in landfill and in costs to the environment and to health. There are savings to be made on energy expenditure while reducing the burden on mineral ore reserves. In developing countries in particular, recycling is a means of job creation, where there are particular challenges related to the reuse of waste. There is a large informal sector, a diverse composition of waste, low levels of education and inadequate infrastructure. In this environment there are opportunities for low-tech solutions. The global market in recycled materials is shifting towards developing economies. There is a need to deal with a broader range of recyclates and higher levels of electronic waste.

Economic drivers

The economics of recycling are embedded in the industry it affects. The simple costs are collection, separation, cleansing and transportation. Connected to these are the location of recycling centres and the quality of the recyclates. The ability to cover costs determines, to a large extent, what is ultimately recycled. The less waste that ends in landfills, the greater the saving for municipalities.

As a result of the commodities boom there has been an increase in demand for primary materials. This has been followed by a growing demand for secondary materials. Much of this growth has been driven by developing economies such as China. In an environment where primary metal supply has lagged behind demand, secondary materials shadow the primary material both in demand and in pricing. These secondary materials can function as a backup that ensures constant supply.

Energy input is a critical factor when comparing the costs of primary and reused materials. This is another way of factoring the viability of recycled materials. Recyclables, particularly certain plastics, can be converted to types of low-grade oils.

Recycling as a global trend is overtaking the national waste markets. India and China are leading the way in the cost-effective recovery of waste. China leads the way by paying competitive prices. At the same time laws permitting the export of waste have encouraged many developed economies to ship out their waste. The reasons for this global trend towards developing economies include cheap
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labour, lower energy inputs required, the demand for materials in manufacturing, and policies that push recycling so that economies of scale can be reached.

Provided the current economic drivers continue, recycling will be more cost-effective than disposal. High volatility in the market can create uncertainty that might be a disincentive to investments. In the field of plastics, if there is a constant supply of primary materials then the secondary material will fill the residual demand. It is a very varied market that is limited to well-developed recyclates. They can only compete if they can match the quality and price of the primary materials. Peaks in the commodities market can often prompt hasty investment, while mandatory recycling can create an oversupply. To ensure the survival of recyclers, long-term contracts are needed to counter market volatility. Web exchanges are tools that would further assist in tracking prices.

As seen in the South African paper industry, monopolies can drive prices down as dictated by market fluctuation. When government has imposed price caps on materials, or in cases where the industry has resorted to long-term contracts, these have been seen as interventions that have helped stabilise the market.

A variety of factors affect the volatility of the market for recyclates. There is a lack of information that makes operators reliant on general commodity prices. Prices are determined by supply-and-demand patterns. The heterogeneity of certain products creates a demand for quality processing. Undersupply of virgin materials creates spikes in the demand for recyclates. Lags in plant capacity can lead to oversupply. The competitiveness of user markets will determine price levels – meaning that the more integrated and monopolistic the markets are, the less the collector will receive. Domestic markets are affected by global supply and demand. Speculation can also have an effect on supply and demand.

A case study from China illustrates how the Chinese have managed to sustain a high price for plastics due to their high demand for the material. They have cheap labour and low duties, and they have developed an economy of scale. Added to this they have low freight costs. Due to manual processing they have been able to reduce the major cost involved in sorting of the product. To compete, other countries would need to improve their separation and collection practices on the downstream side. On the upstream side of operations there is a need for better integration between the recyclers and the manufacturers. Prices of recycled plastics are expected to increase with the need for virgin materials. There is a need for plastic products that are more recyclable.

Driving recycling domestically

It is important to focus on generating local economic benefits. This is dependent on the volume of recyclable materials, the market for these materials and push factors like incentives and technology. Value can be recouped from waste, since recycling adds value to waste and it creates jobs and secondary industries. To maintain a healthy market there is a need to look into better collection systems of waste while creating new uses for it. This entails investment in research and development. It is necessary to build better supply-and-demand chains. Closed-loop systems can also ensure a constant flow within an industry.

Policies and incentives are important elements of the process of driving recycling domestically. To address environmental concerns a system of extended producer responsibility (EPR) can be introduced. This often entails an extra charge linked to the cost of a product. This is a way of
incentivising waste reduction. It promotes product reuse and encourages the increased use of recycled materials. It is a way of internalising environmental cost within industries. Industries have different ways of recouping the money. It requires a level of administration, and needs awareness on the part of the end users as well as systems that are easy to use. It should encourage greater participation and should be consensus-driven. The US model of project stewardship involves looking at waste streams, the selection of materials, product design, production and methods of disposal. Implementation of EPRs has shown increased recovery rates and improved innovations in design and production.

In a case study of a Portuguese end-of-life (EoL) programme for tyres, it is shown how the Portuguese government set up the Valorpneu Society, a non-profit organisation that acts as an intermediary in the collection and reuse of tyres. It is jointly owned by the stakeholders. It manages the collection and fees system relating to the return of tyres. The collected tyres are then distributed to be retreaded or for the rubber to be reused. The organisation has resulted in a significant rate of financial stability for the recyclers.

There is considerable scope for innovation within waste collection in developing countries. Recycling has been seen as a way of employing people in these countries. There is a need to incentivise kerbside systems. This will contribute to improving efficiency and quality. The establishment of recycling co-operatives ensures economies of scale while at the same time creating the opportunity to provide training and equipment to the members. Waste collection can be better organised, along with improvements to transport and facilities. It has been shown that there is a need for regulations, monitored agreements and incentives. These rely on thorough planning, fairness, transparency and participation of all the stakeholders.

A case study into cheap labour and the global e-waste industry concludes that e-waste is the fastest growing component of municipal waste. India is at present the largest importer of e-waste. The nature of the e-waste entails an elaborate dismantling process, since this type of waste consists of a variety of materials that can be reclaimed. Sixty-six per cent of the weight consists of metals, while another 21% comprises various plastics. Certain parts can be salvaged, while others need to be recycled. Often the plastics in the products are used as fuel to extract the metals in the other parts. Recycling of e-waste requires specific knowledge of the various streams of recyclable components.

The recycling of aluminium is of growing importance. Because of its light weight it is seen as an energy-efficient material for use in construction and transport. In terms of recycling it is seen as an energy bank, since the secondary processing of aluminium requires considerably less energy than the primary production of the metal. There are also opportunities for closed-loop systems, such as used cans being made into new cans.

The role of technology

The role of technology is to increase the rate of recovery while maintaining the quality of the secondary materials, and to develop new products. This entails considerable research and development. Tax incentives can be a tool to encourage this development.

Plastics pose particular challenges. Plastics fit roughly into two categories: thermosets that cannot be remoulded; and thermoplastics that can be reused but need sorting and cleaning. Currently new uses for plastics are being investigated, such as using plastic as a substitute for wood. Research is
being done into new plastics that are more easily recyclable. Quantity and quality are more important than plastic types. While manual sorting is still the most cost-effective, technological solutions are being sought for this part of the process, as well.

Advanced thermal treatment (ATT) is a method of extracting materials from waste. Pyrolysis and gasification are the two treatments used. The former is the degradation of waste without oxygen while the latter employs limited amounts of oxygen. Both systems can generate heat for industry as well as providing power for the electrical grid. Syngas, a mix of useable gases, is another by-product. While gasification also produces some low-value recyclates, pyrolysis produces solid residues. Portions of the syngas can be condensed to produce waxes, tars and oils.

Mechanical heat treatment of solid waste is intended to enhance the recyclates that are recovered. Rotating kilns and autoclaves are the most commonly used technologies. They are commonly used for destroying bacteria and drying out the waste. They are also often used for reclaiming ferrous metals. Other mechanical waste separation techniques employ screens, magnets, water and air, along with manual separation, to sort materials. All these techniques can be optimised to recover specific by-products.

Lessons and recommendations for South Africa

Should South Africa recycle? The report concludes that South Africa should recycle as recycling has overall economic benefits. A sustainable policy needs to be designed that ensures consumer participation. Along with international trends, the numbers of materials that are to be recycled need to be expanded. The recommendation is that there be a clear policy on recycling, one that is supported by incentives to consumers at household and municipal levels.

What are the prospects for the recycling sector? The prospects for recycling seem to be good as the global demand is likely to be sustained. Domestic uses for waste need to be found. It is important to recognise that recycling has economic as well as environmental advantages. It provides a viable substitute for virgin materials. Closed-loop systems need to be established to control the reuse of materials. There is a strategic need for a national inventory of materials. In order to improve the prospects of recycling, the report recommends that market trends and prices should be easily available, to create a symmetry between buyers and sellers.

How can South Africa improve recycling rates? There are several ways in which South Africa can improve recycling rates: use manual labour to expand the collection and control of recyclables; decentralise disposal and separation systems; separate recyclates to obtain a higher price; facilitate the establishment of innovative organisations; and create incentives to participate in the process. The report recommends that entrepreneurship be encouraged in relation to the collection and processing of recycled materials, and that this process should be led by the municipalities. It recommends that materials recovery facilities (MRFs) are placed strategically to lower transport costs. These should be able to house inventories that can drive supply and demand depending on available market information. The report also recommends that international technology is mapped to see what technologies are appropriate to South African conditions. What this requires is an improved economic strategy that takes into account policy, incentives, markets (low- and high-end) and appropriate technology for different phases of recycling, types of recycling material and end use products for the material.
Introduction

This paper is part of a broader study conducted by the Human Sciences Research Council (HSRC) on behalf of the Department of Environmental Affairs and Tourism (DEAT) and the Department of Science and Technology (DST) on the growth potential of the recycling industry in South Africa, and the industry’s contribution to job creation. The first two components of the HSRC study have included an industry overview and tracking of recycling industry growth trends internationally, as well as a detailed study of the economic dynamics of recycling in South Africa with respect to paper, plastic and glass. This third component focusing on technology aims to offer an overview of emerging technology trends in recycling and how to realise the industry’s potential through innovation, technology and appropriate policy levers.

The foundation of this think-piece is a scan of global trends to identify innovations in the recycling business and the potential for their promotion in South Africa in order to achieve greater value creation. If innovations are taking place elsewhere, then questions arise as to why they are not being adopted in South Africa, and what could be done to improve innovation within the waste management system. These questions in turn raise broader questions about the size of the market and whether there are sufficient economies of scale to warrant the investment in upstream innovation. Getting rid of waste is a costly business. Rich countries spend about US$120 billion per annum disposing of their municipal waste and US$150 billion per annum dealing with industrial waste. The amount of waste generated depends entirely on the growth patterns of different economies and the rate of urbanisation in each case. Nobody really knows the true size of this industry, nor the scale of the waste problem (Economist, 28 February 2009).

The paper’s approach is to investigate a global selection of recycling industries and provide some generic understanding of the drivers within these, and the different aspects of the value chain involved. Factors such as where the greatest economic benefit can be generated, the role of technology, and secondary markets that are dependent on recyclable materials are reviewed. The paper goes on to investigate some of the conditions that suggest recycling and reuse can significantly spur downstream investment in manufacturing by the private sector.

Brief overview of the sector

2.1 Terminology and conceptions of recycling

The word ‘recycle’ is being used here to connote two intentions simultaneously: recovery of waste material; and the utilisation of the waste material that has been procured from this recovery in the manufacture of new materials and products. The old recycling paradigm focused on what to do with the product after it had been disposed of. The new paradigm, however, involves looking at the entire life-cycle and engineering of a product before it is even produced, so as to increase reusability and recyclability of the product and/or its components. There are essentially three inter-related components in the recycling value chain: recovery, post-recovery utilisation and product engineering for recovery.

International literature suggests that thinking has moved away from conceiving of waste as ‘waste’ and towards seeing it rather in terms of resources. Technological design and recovery logic is
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shifting from the conception of general materials usage to thinking of recycling and reuse of a whole product within closed-loop systems. In this instance, a closed-loop system would encompass consideration of an end use for a product or its components.

Some literature refers to this as Design for Environment (DfE). It is often combined with extended producer responsibility (EPR) schemes (Calcott & Walls 2005) or other similar schemes. One increasing trend is to design products with cognisance of their future dismantling or demanufacturing. This is particularly true for complex and composite products such as computers and cars, which are produced from an array of different types of materials ranging from plastics to metals to glass.

Growing environmental awareness and increasing government specifications have resulted in a trend towards ensuring that once a product has completed its life-cycle, part or all of the product should avoid ending up as waste being disposed of at a landfill. This has encouraged design innovation to remove particular materials from products or minimise their use, to ensure that those materials used can be recycled or reused. This would include advance planning for the disposal of materials recovered from a product. An example of this is the manufacturing of mobile phones from modular units, which enables easy dismantling and facilitating of the reuse of parts and materials (Nishino, Oda & Ueda 2007).

The limitations on this approach may be not the ability to design for retirement, but uncertainty related to the economics of recovered material or the availability of certain technologies for economical separation and reprocessing of the material (Ishii, Eubanks & Di Marco n.d.).

2.2 Reasons for recycling

There are a variety of logical arguments for recycling, including ways in which it benefits economies. Some of the cost-benefits of recycling have been identified as the following:

- saving energy by reducing the need to process new material;
- saving valuable landfill space and associated costs;
- reduction of an environmental and health externality cost by taking waste out of the system;
- a source of local job creation;
- saving on the use of increasingly scarce and expensive mineral ores and other virgin materials (timber, oil).

The economic logic of recycling differs for developed and developing countries. The logic driving investment in recycling in developing countries involves changing supposed barriers into challenges and entrepreneurial opportunities. Most of the investment focus in developing countries is on the

1 Composite materials are a mixture of different materials – polymer, fibrous reinforcements (glass or carbon fibre) and in many cases fillers (these may be cheap mineral powders to extend the resin).
side of collection and separation, because of the cost advantages. This is partly because, when an industry is still developing and hasn’t reached full maturity, entrepreneurs will take advantage of whatever opportunity arises so long as there are some profits to be made.

However, a broad generalisation in this regard would be hard to establish. It is better to suggest that as manufacturing capacity and the demand for virgin material grow, there will be a demand for recycling of material. Good government policy and stimulation of investment in research and upstream business opportunities vary. Public policy is critical in determining how extensively the value chain can be spread, and the degree to which it matures in the development of new business opportunities, expansion of markets and generation of high-value products. Managing waste in general is an expensive business and this may partially explain why rich countries have a more developed waste management sector, as they can spend more on public awareness, infrastructure, incentivisation of industry, and research and development.

Some of the key characteristics that define the waste sector in developing countries are (UNEP 2005):

- low labour costs and shortage of capital, which usually drive the approach towards more low-tech solutions;
- waste streams that are usually dominated by organic waste, making incineration difficult;
- a complex informal sector involved in collection, separation and recycling of waste;
- significant mixing of industrial waste with municipal solid waste (MSW);
- low levels of education and awareness about recycling;
- inadequate physical infrastructure in urban areas that forms a barrier to the collection of waste.

The objects available for or requiring recycling are becoming increasingly complex. Traditional materials that have developed mature recycling markets include paper, plastics, aluminium, glass, iron/steel scrap, tyres and batteries. A review of the literature points to the fact that recycling is now clearly a globalised market, with the centre of trade shifting away from developed economies to emerging economies where the demand for raw and secondary material is high. However, with the increase in hi-tech products, the levels of waste that require complex dismantling and reprocessing are increasingly developing markets of their own. These products are universally classified as e-waste, or waste electrical and electronic equipment (WEEE) (televisions, computers, video recorders etc.) and with the EU (2005) End-of-Life Vehicle (ELV) Directives, targets have been set for motor vehicle retirement.

According to the ELV Directives, by 2006, 85% of the weight of all ELVs should have been reused, recycled or subjected to energy recovery, and only 15% should have been sent to landfill. From 2015, the target is to have a further 10% of the ELVs subject to energy recovery and 5% sent to landfill (Pickering 2006). WEEE is one of the fastest growing municipal waste categories worldwide, at an average of 3–5% per annum (WRAP 2006).

Case study – ELV recycling and automobile shredder residue management in Japan
The people of Japan own about 80 million cars. Annually about 6 million cars are sold and 5 million cars are retired. The duty to recycle is imposed on the manufacturers, whereas costs are borne by the owner. Recovery and recycle rates are further increased by the government placing a ban on heavy metals such as lead, mercury, cadmium and hexavalent chromium. About 5 000 disassembly plants take apart car engines, batteries and tyres, and the remaining 60% of the weight of the car is delivered to shredders. The shredders use magnetic tools to separate the iron and sell it off as scrap. The remaining automobile shredder residue (ASR) – which is about 20–25% of the weight of the car – has to be processed under Japan’s new ELV law (enacted in 2002). The target recycling rate is 70% by 2015. ASR is subjected to both material and thermal recovery. ASR contains both useful and harmful substances and therefore proper management during the recycling process is needed. Combustible material is gasified and completely burnt in a combustion chamber, while non-combustible material is melted in the coke-bed of a furnace at very high temperatures. The slag is then cooled and the metals recovered (Sakai, Noma & Kida 2007).

As the landscape of materials used for various products grows as a result of changes in technology, so does the complexity of the types of waste – most new products rely on composite materials that require advanced or sophisticated technologies for separation and processing of the waste. The WEEE and ELVs are good examples – in the latter case there is going to be increased electrification of cars, and use of lighter and lighter material that is composite in nature.

2.3 Economic drivers for recycling

2.3.1 Some basics of the economics of recycling

The economics of recycling is embedded in the different industries and processes that recycling affects, or is affected by, in order to achieve a targeted amount of recyclable material. An example drawn from the context of municipal management can illustrate how this works. In a municipality that has a waste management programme and has inhabitants in the millions, each household generates a relatively small amount of waste. Assuming that the municipality has a recycling programme that requires the participation of each household, the recycling process will require that each unit of waste be collected from each household, taken to a recycling centre, the recyclates separated and cleaned, and the remaining waste taken to a landfill site. As a result the main costs are labour, transportation and sorting costs. The critical factors that affect the economic optimality of recycling are sorting costs per unit of waste, transportation costs per unit of waste, and the size and geographical spread of the municipality. Finally, restrictions (such as zoning laws) on where recycling centres may be located can also affect the economics of recycling (Highfill, McAsey & Weinstein 1994).

Increased volumes of recyclable material per collection vehicle, and more en route sorting and cleaning, will mean that the recycling operation becomes more economical and a higher profit is made on the material. The less pure the recyclates, the lower the price obtained for them will be. However, the cost-effectiveness of different recyclable materials is affected by market conditions – income from various materials depends on market prices and varies greatly. This means that costs are only recovered in some instances. Since recycling is predominantly driven by the private sector, especially in developed economies, it is only those materials where the market price covers collection and processing costs that are likely to be collected or recovered. Those materials that are
not covered by market prices are usually disposed of rather than taken to buy-back centres. Studies in the USA have shown that there is a great degree of willingness-to-pay on the part of a municipality for the disposal of all waste – this factor alone should make recycling feasible (Beatty, Berck & Shimshack 2007). In other words, this should not preclude municipalities from investing in recycling programmes and infrastructure, as some costs associated with paying both the collection and landfill costs can be offset. These saved costs can potentially be diverted towards increasing the incentive for recycling those materials that have a low market value. The long-term avoided costs of energy, land filling, preventing environmental externalities and secondary and tertiary economic benefits can lead to the industry paying for itself.

2.3.2 The impact of the commodities boom

The increased demand for primary material by the global economy has also changed the economics of secondary material production and trade. This trend has been demonstrated for the last 20 years and is expected to be sustained and to accelerate. Until now the developed economies, which account for a fraction of the world’s population, have consumed 30–50% of the world’s mineral ore, fossil fuels and other raw materials. Without a change in the raw material reserves, the increased demand from high-population countries such as China and India has resulted in a shortage. This demand is coupled with the associated increased demand for goods globally, and changes in lifestyle choices within emerging economies, as the size of the global middle class increases. This has implications for global resource acquisition, usage and innovation.

These countries also do not have the full capacity to process raw materials to meet their entire demand, so the parallel importation of secondary materials has been found to be economical. Global demand for primary materials serves also to drive the demand for secondary materials. So long as there is growth in demand for primary materials, there will be concomitant demand for secondary materials. This may be true only for some materials. For example, high oil prices may boost plastics recovery and recycling as it becomes more profitable, and companies want to reduce input costs in order to ensure that their products remain competitive. Secondary material demand comes in cycles and depends on the degree to which there is recovery of material, and the extent to which virgin material becomes so scarce that it necessitates replacement with recyclates. For example, in the case of electronic goods there are peaks in disposal of these goods, followed by lags, and then peaks again as these goods become disused. However, demand for virgin material is likely to outstrip supply, making the economy of secondary material more promising. There could be two reasons for this: 1) in certain cases the supply of virgin material has reached a natural peak, for example in the case of oil, and hence global demand will outstrip availability; and 2) investment in expansion or opening of new supply lines is likely to lag demand.

Much of this growth has been driven by emerging economies and, in particular, demand from China. As the developed economies shift towards more stringent recycling and reuse targets, more material will be available in the market. However, in the last decade emerging economies have played a big role in the demand for secondary material. Their cheaper cost structures and the expansion of their manufacturing base have seen emerging economies’ markets for recyclable material grow.

The commodity markets exhibit high long-term demand, and longer-term scarcity of supply. For instance, China’s import of metals has grown from a factor of 4 to 10 over the last decade (Tolle 2007). In 2003 China produced 23% of the world’s steel, compared to 2% in 1950; it also produced
19% of the world’s aluminium compared to 3% in 1980; and its imports of recycled scrap and non-ferrous metals for the same period jumped from 15% to 30% in 2004 (Veolia Environmental Services 2007). Trends in demand for various commodities have driven the global demand for these materials, pushing demand for virgin and secondary materials simultaneously as some of these figures show.

Countries such as China, the Ukraine and Russia impose high taxes and quota restrictions on the export of metals such as copper, tin, bauxite and steel scrap, as well as other secondary materials. This is an indication of expansion of demand for these material locally, and of governments wanting to ensure that strategic industries do not lose market share because of supply constraints in essential metals.

The 2008 World Bank Global Economic Prospects Report notes that the price of metals has increased in the last four years, as depicted in Figure 1.

**Figure 1 – Commodity prices, 2000–2007**

![Commodity prices continued gains through 2007 led by metals](image1)

*Source: World Bank 2008*

The biggest spike in commodity prices has been in copper. This is largely driven by China, which imports most of its copper, with slight spikes in zinc and aluminium largely due to the fact that China also imports these metals. These spikes are a result of the combined world demand for these metals, while the increased demand from fast developing economies like China has ensured that supply has lagged demand.

Other contributing factors on the supply side are underinvestment in mining infrastructure and numerous supply problems – for example supply interruptions as a result of conflict. Shortages in capacity such as skills and equipment have also significantly increased development costs. Prices are likely to be high because ore grades are deteriorating. The market price of metals peaked in 2007
and was expected to decline by 5% in 2008, and continue lower in the 2009 period because rising capacity is pushing more surpluses onto the markets.

The World Bank Report also projects that oil prices are likely to hover at or remain above the US$75/barrel mark for the coming two years. The volatility in commodities prices is likely to continue and will have a similar effect on the pricing for secondary material. While the long-term prospects are uncertain, the demand for primary and secondary materials in the medium term is unlikely to subside (WRAP 2006).

2.3.3 The role of energy in the recycling industry

The cost of primary materials and the energy costs for processing them also serve as primary drivers of change in the recycling and reuse sectors. The higher the costs of primary materials, the more economical it is to recover and produce secondary materials. Energy inputs are a critical factor and are driven by demand and supply of predominantly fossil fuels. Alternatives such as nuclear and renewable energy are unlikely to make significant differences to the demand for these energy sources. Future energy costs are expected to be high. Coal and oil prices have already doubled in the last year (Engineering News, 16–22 May 2008).

The International Energy Agency’s (IEA) 2007 overview of global energy demand projected that if unfettered growth remained, by 2030 global energy needs would be well over 50% higher than the current demand (IEA 2007). China and India together are expected to account for 45% of the increase in demand. Fossil fuels are likely to remain the dominant source of primary energy, accounting for 84% of the overall increase in demand between 2005 and 2030. Oil should remain the single largest fuel, with demand reaching 116 million barrels/day in 2030, up 36% from 2006. Coal could also show spectacular demand growth rates – 73% between 2005 and 2030 (IEA 2007).

High energy costs as a result of the demand for coal and oil have also helped to improve the economic viability of certain secondary materials such as plastics, tyres and other materials. Recycled material becomes valuable as it obviates the need to produce virgin material, given high energy costs.

The energy intensity of producing primary raw materials like aluminium and copper offers advantages for the recycling industry – 95% of energy is saved over primary production of aluminium and 85% in the case of copper (Richards 2007). Approximately 40% of the world’s copper, for instance, is now supplied by recycling. The abundance of low-cost metals is directly related to the availability of low-cost energy – this will change in the future as fossil fuels become scarcer and the global demand for energy grows.
Case study – trends in aluminium demand and reasons for growth

Aluminium is of growing importance and is the world’s most recycled material. About 45 million tons of fabricated aluminium and 14 million tons of aluminium are recycled annually. The aluminium recycling industry employs about 1 million people worldwide (International Aluminium Institute 2006).

The nature of the global market is changing, with many of the activities shifting towards China. In 1991, China produced 0.96 million tons of aluminium. By 2004 the demand had grown by 600%. The biggest demand was for electrolysed aluminium. Due to the high energy intensity involved in the production of electrolysed aluminium, 90% of electrolysed aluminium companies closed in Japan and there was a 67% drop in output in the USA. In China, the opposite is happening – production is rising. This occurs at a great cost – 4% of the GDP’s energy costs in return for 1% economic return to GDP, with an unaccounted-for environmental externality cost due to China’s reliance on coal for its energy production (Xiao-wu, Li-rong & Ben 2008).

The top markets for aluminium are transportation, packaging, building and construction (Figure 2). Transportation continues to be the largest market. Its importance will grow as the transport sector is faced with demands for higher fuel efficiency and low gas emissions. An example of aluminium use in transportation is in measures taken to increase fuel efficiency in aircraft, where 80% of the weight is aluminium; it is also used in aircraft because it is corrosion-resistant and does not need painting. The demand for commercial aircraft is expected to increase by approximately 60% in the next decade (Das & Yin 2007).

Figure 2 – Global aluminium flow, 2004

![Diagram of global aluminium flow, 2004](image)

*Source: International Aluminium Institute 2006*
Another example is the automotive industry, where aluminium usage had already quadrupled between 1991 and 2005. In 2004, up to 30% of wrought and casting alloys used in cars, aircraft, trains, ships etc. were made of aluminium. Annual global vehicle production is expected to increase by 3%. Aluminium is preferred because it is durable and lightweight. It is mostly used in engine blocks, cylinder heads and manifolds. The diagram in Figure 3 illustrates the life-cycle of aluminium in vehicles and the associated technologies needed for its recycling (International Aluminium Institute 2006).

**Figure 3 – Aluminium life-cycle in vehicles**

*Source: International Aluminium Institute 2006*
Aluminium is also regarded as an energy bank because it takes 45 kWh to make 1 kg of primary aluminium, and only 2.8 kWh to make the same amount of secondary aluminium from recyclable material. According to the International Bureau of Recycling, recycling of metal materials such as lead, steel etc. is good for reduction of emissions. Countries where aluminium consumption is growing exponentially are China and Russia, at 11% and 6% respectively. Global primary production of aluminium is expected to reach about 60 million tons in 2020. In the automotive industry, aluminium fetches four or five times the price of steel.

Aluminium, in general, has always been recycled at a higher rate than most other raw materials. Given the necessary infrastructure, it is possible to recycle all aluminium used in construction industry applications for several reasons. Firstly, there is a relatively high level of scrap aluminium available. Secondly, aluminium has a high scrap value, which can contribute significantly towards covering demolition costs. Finally, the infrastructure required for the collection of scrap metals is already well established and will continue to grow on its own economic merit, as it has done in the past, to provide an increasingly efficient recycling system. A third or more of all the aluminium currently produced globally originates from recycled metal. The aluminium recycling industry has effectively tripled its output from 5 million tons in 1980 to over 16 million tons in 2006. During the same period, primary metal use has grown from 15 to 30 million tons. The proportion of recycled aluminium to the global demand for the metal has grown from less than 20% in 1950 to approximately 33% in 2006 (Global Aluminium Recycling Committee 2006).

The metal from recycled aluminium cans is usually made into new aluminium cans. This is called closed-loop recycling because the old cans are turned into the same products again. Using recycled aluminium beverage cans to produce new cans allows the aluminium can industry to make up to 20 times more cans for the same amount of energy (International Aluminium Institute 2006).

If high energy costs are sustained, the demand for secondary materials is likely to grow. This is all dependent on the determinants of the oil, gas and coal prices in the future. In the case of oil, the following two key factors are driving up prices up: 1) peak oil, in which estimated ultimately recoverable (EUR) oil is on the decline; and 2) refining capacity, which is not keeping pace with demand. Improved refining capacity is needed because increasingly supply is shifting from sweet crude to sour crude – an indication that peak oil has been reached.

The Association for Peak Oil (ASPO), in its last update of September 2007, put the global EUR at 1 900 billion barrels. It estimated the peak date to have been 2005, when 1 001 billion barrels were already recovered (Hicks & Nelder 2008). The IEA, in its Medium Term Oil Market Report of July 2007, also pointed to an oil supply crunch by 2012 (House of Commons All Party Parliamentary Group on Peak Oil 2008).

So critical has energy become that even some recyclables are being considered as sources of fuel, rather than just as material for the production of goods. In China, research and innovation are
focusing on the conversion of plastics into oil. The principle technology being used to convert plastic waste to oil is pyrolysis; the recovery rate is around 55% but can be pushed to 75% with an upgrade of the technology. The upgrade essentially involves adding a silica-alumina catalyst within the pyrolysis reactor. The small-scale systems being used in China have a capacity of 1 000 tons per annum per plant (where 1.92 tons of plastic produce 1 ton of oil). A plant with a capacity of 3 tons per day will need 1 728 tons of plastic waste annually. The products are a low-octane fuel and paraffin.

However, the biggest barrier to success in this process has been the need to provide a reliable and continuous supply of sufficient volumes of plastic waste to ensure that the capital investments in technology can be recouped with short payback periods (Zhang, Zhu & Okuwaki 2006). This development is likely to make China a preferred destination for the export of waste plastic material. It is likely that waste-to-energy initiatives could become a growing new stream of business. In Europe, there are numerous waste-to-energy projects which are very expensive to develop. There are also very high emission reduction standards set by the EU and this increases the capital and operating expenses of these technologies as they are forced to incorporate externality costs.

The implications are that so long as there is sustained global economic growth and a shortage of supply of primary material sources, the economics of secondary materials will be favourable. However, the 2008 period showed a slight decline in demand for oil and primary commodities, but this was largely due to the fact that the global economy had slowed down as a result of inflationary pressure and the global financial crisis. The World Bank predicts a modest slowdown, with sustained growth after 2009 (World Bank 2008).

A number of factors will drive energy costs up in the future: demand for primary energy resources (coal, gas and oil) is expected to increase; global generating capacity will require extensive capital investment as the demand for global energy is expected to double, and with the current financial crisis the availability of this capital is not assured; the rate of deployment of new generating capacity is likely to be constrained by the shortage of skills (this is already being experienced for new nuclear plants); and externality costs are increasingly being factored into energy generation (for example South Africa is likely to introduce a carbon tax, and new coal-fired power stations will not be permitted without carbon-capture and storage technology).

### 2.3.4 The global nature of the recycling market

The recycling industry is no longer a national market but a global business, as the diagram in Figure 4 illustrates. China, and gradually India, are likely to have the biggest influence on the market for recycling material. The result is that domestic prices for recyclable material will be influenced by global trends as trade in these materials is part of the global trade in commodities. Increasingly, source countries, as Figure 4 shows, are exporting their waste to countries which have lower recycling costs. This material is then reused in the manufacturing of goods and exported back again to the source countries as part of the finished goods. In some cases, the recycled raw material is processed, for example into plastic pellets, and exported back to the source country for use as material in production within that country.
While trade statistics show that developed countries (OECD countries) are the biggest traders in waste, China remains the world’s largest importer of waste, importing more than 4 billion tons of plastic, 12 billion tons of waste paper and 10 billion tons of scrap iron and steel per annum (Willen 2008). Some of the reasons why China is benefiting from this are that high recovery and disposal costs in the USA and Japan make it more feasible to export the waste to China – China also pays favourable prices for recyclable material. Disposal costs in developing countries are estimated to be between US$2.50 and US$50 per ton, whereas in OECD countries the costs are between US$100 and US$2 000 per ton (1988 figures).

Recycling laws in developed economies facilitate exports – as in Japan, where the law of ‘Containers and Packaging Recycling’ obligates recycling companies to process polyethylene terephthalate (PET) waste into plastic flakes or pellets for reuse in textiles. Given that these costs are high, recyclers prefer to export PET waste to China, where it is then turned into plastic fibre for reuse in the textile industry in Japan – through a re-export scheme closing the loop between waste and high-value product (Willen 2008).

As a result of the recycling industry’s globalisation and two-way trade, rates of recovery have improved notably. Recovery rates for paper increased from 29% to 49% in 1991 and for aluminium from 20% to 30% between 1972 and 1988. China is now the biggest importer of recycled cellulose fibre (RCF). It imported half of the 41 million tons of RCF being traded worldwide in 2005. From 2000 to 2006, China’s RCF imports increased fivefold; the main beneficiaries of waste exports to China are the USA (constituting 46.4% of Chinese imports in 2006) and Europe (28.1%) (Veolia Environmental Services 2007). Comparative trends are being observed for plastics and other materials because of the growth in demand for primary commodities such as metals and energy, and in particular oil.
The market for secondary materials is being globalised for several reasons:

- Cheap labour in developing countries makes it attractive for developed economies to export recyclable material.
- Demand for material for the manufacturing of goods in developing countries, especially in Asia, is increasing rapidly.
- Increasing fuel prices make secondary materials preferable because of the lower energy input required.
- Public policies and laws for recycling in developing countries are helping to push recycling volumes so that economies of scale are being reached.

The fear of supply bottlenecks for primary raw material, as demand can exceed extractive capacity, seems to be another major factor. Countries like China have more of a strategic focus due to their emphasis on the security of supply. Some of these raw materials have to be procured from volatile regions or countries in the world that can lead to supply disruptions – oil is a good example of this. Disruptions can lead to production cuts, which lead to increases in the prices of commodities, and these then have a knock-on effect on the costs of other production sectors, thus affecting the overall economy. Recycling can therefore be an important strategy for countries to pursue in order to reduce their import dependency for raw materials.

2.3.5 Price volatility and future implications for recycling

Provided the market drivers remain, recycling can be more cost-effective than the disposal of waste. This would be true for countries where disposal costs are already so high that finding other economic uses for the waste will increasingly become a preferred option (Bogert & Morris 1993). A 2006 OECD study pointed out that market efficiency is influenced by factors such as information failures and technological externalities. In addition market power can affect the prices, quantity and quality of materials traded (OECD 2006). Table 1 offers some insight into how these factors influence market inefficiency.

Issues that affect industry performance and the price volatility of secondary material are nicely summarised in Table 1. Some of these issues will be picked up in the commentary below. However, a couple of things stand out very clearly: transaction costs associated with the recovery of recyclates, price margins associated with the quality of the material, and competitiveness in the market which also influences demand and supply conditions.

High levels of price volatility can create uncertainty in the market, often leading to a disincentive for further investment in the sector. In the case of plastics, price volatility has been shown to be more significant for recycled plastics than virgin plastic, as it varies due to the different grades and quality of plastics that are recovered by recyclers. The recycled plastic market is closely tied to the virgin plastic market. When there is a supply constraint in the virgin market, recycled plastics usually take up the residual demand for plastic, which temporarily increases the price. For instance, the downturn in the US economy has encouraged greater exports of plastics to China, where the economic growth rate has been higher and the price of recycled plastics more favourable.
Table 1 – Potential sources of market inefficiency

<table>
<thead>
<tr>
<th>Causes of market inefficiency</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transaction costs in secondary material markets</td>
<td>Arises from the diffuse and irregular nature of waste generation. May also arise from the heterogeneous nature of secondary materials.</td>
</tr>
<tr>
<td>Information failures related to waste quality</td>
<td>Arises from the difficulty for buyers of detecting waste quality, and the relative ease with which sellers can conceal inferior-quality waste.</td>
</tr>
<tr>
<td>Consumption externalities and risk aversion</td>
<td>Perceived costs associated with the quality of final goods derived from secondary materials relative to those derived from virgin materials.</td>
</tr>
<tr>
<td>Technological externalities related to products</td>
<td>Complexity of recycling due to the technical characteristics of the recyclable material and products from which secondary materials are derived.</td>
</tr>
<tr>
<td>Market power in primary and secondary markets</td>
<td>Substitution between primary and recyclable materials may be restricted due to imperfect competition and strategic behaviour on the part of firms.</td>
</tr>
</tbody>
</table>

Source: OECD 2006

When there is excess virgin material, recycled plastics will only compete if they can match the same quality and/or come at a lower price (OECD 2006). However, the review of international literature suggests that little can be done to reduce levels of price volatility as they are dependent on market conditions. Some recyclers enter into long-term contracts with buyers as a way of offsetting the negative effects of price volatility. A study in the USA has shown that recycled materials prices depict a high degree of ‘co-movement’. Trade up or down in a range of commodities can influence the relative price of recycled material as well (Ackerman & Gallagher 2002).

A growing international phenomenon is the establishment of web-exchanges for secondary materials where the prices and grades of secondary materials can be tracked. The purpose is to ensure a closer connection between demand and supply information, as there can often be asymmetries. A good example of a web-exchange system is the Chicago Board of Trade Recyclables Exchange (which received support from the United States Environmental Protection Agency (US EPA)). The impact of such internet-based trade systems is to reduce transaction and search costs by creating a virtual centralised market. It is only for well developed recyclates that this market system has proven to be invaluable. However, for products that have a high level of heterogeneity in terms of mix of material content, physical inspection is still needed in order to grade and price the material. In waste oil, for example, heterogeneity factors such as the presence of water in the oil, the viscosity of the oil and the presence of pollutants, such as polychlorinated biphenyls (PCBs), all affect the buyer’s preferences and price. These factors of quality cannot be determined virtually, but require special tests for quality.

South Africa is also not immune to price volatility, as Table 2 shows for recycling in Durban. The profitability of recycling is dependent on price fluctuations and these can drive recycling rates beyond mandatory recycling activities. However, mandatory systems are no guarantee of a viable
and sustainable recycling sector, as they can drive prices down if there is an oversupply of material and a general slump in global demand.

Table 2 – Average selling prices for recyclables in Durban, 2001–2005

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Price (US$/ton)</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>Mean</th>
<th>Min.</th>
<th>SD</th>
<th>Co. of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardboard</td>
<td></td>
<td>37</td>
<td>44</td>
<td>52</td>
<td>66</td>
<td>22</td>
<td>44</td>
<td>22</td>
<td>16</td>
<td>0.37</td>
</tr>
<tr>
<td>Magazines &amp; newspaper</td>
<td></td>
<td>15</td>
<td>22</td>
<td>29</td>
<td>29</td>
<td>7</td>
<td>21</td>
<td>7</td>
<td>10</td>
<td>0.47</td>
</tr>
<tr>
<td>Computer paper</td>
<td></td>
<td>88</td>
<td>96</td>
<td>96</td>
<td>118</td>
<td>15</td>
<td>83</td>
<td>15</td>
<td>40</td>
<td>0.48</td>
</tr>
<tr>
<td>Low-density plastic</td>
<td></td>
<td>74</td>
<td>88</td>
<td>96</td>
<td>118</td>
<td>118</td>
<td>99</td>
<td>74</td>
<td>19</td>
<td>0.19</td>
</tr>
<tr>
<td>High-density plastic</td>
<td></td>
<td>No market for HDP in Durban</td>
<td>74</td>
<td>74</td>
<td>74</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Ferrous metals</td>
<td></td>
<td>44</td>
<td>52</td>
<td>59</td>
<td>74</td>
<td>111</td>
<td>68</td>
<td>44</td>
<td>26</td>
<td>0.39</td>
</tr>
<tr>
<td>Glass</td>
<td></td>
<td>7</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>13</td>
<td>7</td>
<td>3</td>
<td>0.25</td>
</tr>
</tbody>
</table>

*Source: Matete & Trois 2008*

Matete and Trois (2008) do not offer explanations for the price fluctuations between 2001 and 2005. It can only be assumed that they are a result of changes in supply and demand in the market. A paper written by Langenhoven and Dyssel (2007) corroborates this assumption. However, prices in the paper market could be a result of the fact that often pulp and paper production are vertically integrated businesses, and because there is limited competition in the paper and milling industry they exercise a de facto price monopoly.

Differential prices may explain why less profitable organisations sometimes opt out, waiting for the markets to turn before they are willing to trade again. The effect is erratic volumes of material entering the market – this in turn having an effect on price. It is not ideal for long-term business planning and investment. Where there is no culture of separation and collectors’ transport costs are not covered, volume and market price are critical to the success of collectors’ business.

Some government intervention in the market, in terms of price caps for materials, can instigate stability and efficiency in the market (Ackerman & Gallagher 2002). In other instances, private actors themselves have resorted to long-term contracts where supply and demand are fairly consistent.

Sudden price peaks can also give a misleading impression of the long-term market prospects, resulting in overinvestment in capital or plant expansion. The industry’s ups and downs do not make for efficient allocation of investment capital.

The price of one recyclate can also affect the incentive to continue business in cases where collectors are sources of multiple material supply and revenue streams. Operators usually offset high transport costs by collecting multiple materials. For example, low-value recyclates like plastics and paper will be collected in high volume, while high-value recyclates like metals will be collected in low volume. However, transport costs are not the sole factors: price volatility and access to waste suppliers will also determine the choice of material. Table 3 provides a summary of factors influencing price volatility.
Table 3 – **Summary of factors that can influence price volatility**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Lack of information makes operators reliant on general commodity prices to determine price and value of material – the ‘co-movement’ phenomenon.</td>
</tr>
<tr>
<td>2.</td>
<td>Prices are determined by normal supply-and-demand patterns – these, in turn, are influenced by the rate of collection of materials, and from the demand side, by general economic growth and demand for goods.</td>
</tr>
<tr>
<td>3.</td>
<td>The <strong>heterogeneity</strong> of the product creates a premium on quality. However, quality is not always consistent when materials are produced manually, although technology could increase consistency.</td>
</tr>
<tr>
<td>4.</td>
<td>The undersupply of virgin materials can also cause sudden demand spikes for recyclates.</td>
</tr>
<tr>
<td>5.</td>
<td>Lags in plant capacity for processing can lead to ‘oversupply’ and therefore reduce prices or increase the export of surplus from the domestic market to the global market.</td>
</tr>
<tr>
<td>6.</td>
<td>The competitiveness of the user market can also determine price levels – the more integrated and monopolistic markets are, the lower the prices collectors will receive.</td>
</tr>
<tr>
<td>7.</td>
<td>Domestic prices are affected by global supply and demand – the globalisation of trade introduces greater volatility, and increases the need for information and secure channels of supply and demand to ensure stability in the market.</td>
</tr>
<tr>
<td>8.</td>
<td>Speculation can also affect supply and demand – suppliers of recyclates can hold back sales in anticipation of higher prices.</td>
</tr>
</tbody>
</table>

Research which supports the findings from Durban indicates that market price volatility in the recycling industry in Delhi, India, is usually caused by the demand for material versus the levels of supply (Agarwal, Singhmar, Kulshrestha & Mittal 2005). The authors point to the following key factors influencing prices for recyclable material:

- If there is an excess of material, the users of the material usually have more influence over the price.
- If the material is scarce, the dealers have more influence.
- If these influences are balanced, it is a neutral market.
- Often the market price for virgin material influences the price for recycled material.
- Suppliers with the ability to maintain high stock levels can impact on the prices by releasing material as demand exceeds supply.
Case study – China and the prices of plastic

This case study is merely a way to expand understanding of how price fluctuations as a result of supply and demand of the material influence the global situation. Since China is a big importer of various types of plastics, the case study draws from the Chinese example.

Plastics are a global commodity and subject to the volatility of world economic prices. The price of plastics is not expected to decline in the near future because of strong demand in China, and the relatively higher prices China is prepared to pay. The biggest demand is for PET, high-density polyethylene (HDPE) and low-density polyethylene (LDPE) plastics. China’s demand is affecting the economics of recycled plastics in source countries. China is able to take advantage of cheap labour, low customs duties, economies of scale and low freight costs relative to the high cost ratios for plastic recycling in developed economies. Without subsidies, the average collection and processing costs exceed scrap values by more than two-and-half times in developed economies (California Integrated Waste Management Board 2003). This is because multiple plastic resin types require sorting, which adds to the cost. Plastics are also difficult to clean because of their low melting point, when there is a need to remove dirt, contaminants, colouring, labels etc.

Figure 5 shows price fluctuations for various types of plastics over a four-year period, indicating volatility and how price changes follow trends in the oil price. Over the same period the world oil price also spiked dramatically. The higher prices China is prepared to pay make it preferable for countries to export recycled plastic rather than use it domestically. The result is that plastic recyclers are becoming less competitive in source countries. Consequently these countries are trying to find solutions in both downstream and upstream parts of the value chain. In the downstream parts of the chain increased collection rates and better technology to deal with the separation of plastic materials are being sought. At the upstream level, better integration of recyclers with manufacturers, or the development of new high-value products from plastics that have global markets, are being pursued. One market, for example, is the development of plastic film for composite lumber producers. Recycling plastics from ASR that can be reused in automobiles is another potential growth area for recycled plastics. In this way, the domestic market for plastic recycling can be sustained, rather than having the waste material exported because of the lack of domestic use further up the value chain.

The prices of individual types of recycled plastics are dependent on the markets for products made from these plastics (see Figure 5 for the different types of plastics and price shifts since 2002). The future growth in the market for recyclable plastics is expected to increase because of the growth in demand for virgin plastics. The use of plastics in electronic goods and vehicles is expected to increase, and these will be future sources of recycled plastics. In vehicles, especially, the need for a

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4 PET is clear and tough, provides a barrier to gas and moisture, and is heat-resistant. It is used in drinking bottles, injection-moulded consumer products and fibre applications. HDPE is stiff and resistant to chemicals and moisture, but is permeable to gas. It is easy to process and mould, and is used in a wide range of products including bottles, tubs and bags. LDPE is used predominantly in film applications. It is useful because it is tough, flexible and relatively transparent. LDPE is also used in wire and cable applications.
variety of plastic material will grow as designs shift. The manufacturing of many of these goods is likely to experience exponential growth in Asia, especially China and India, where a significant relocation of electronics and car assembly plants has taken place in the last decade (WRAP 2006). As a consequence, imports of virgin and secondary plastics are expected to grow.

**Figure 5 – Price per ton for different recovered packaging plastics, 2002–2005**

In the future, it is possible that the switch to new types of materials, such as substitutes for polyester instead of PET flakes, could affect the market value for PET bottles. Additionally, the increased use of biopolymers may also have some effect. The impacts of new types of material or technologies on the plastics market as a whole are still uncertain. The increasing costs of prime resin and freight will affect the cost of plastic in the future. Another important factor affecting the global price of plastic could be that if the rate of recycling of plastics in China increases, the demand for imports may decline (WRAP 2006).

One recurring feature in the recycling industry is the existence of what is termed a consumption externality. The lack of information about the end use of a product, and the lack of relative stability and continuity of usage of secondary material, can hamper long-term investment decisions in the recycling sector. This can be regarded as a market barrier; it affects the optimal recycling rates for various recyclable materials, and even hinders the development of new recycling streams and adoption of technologies to process these. One way to overcome this is for the public sector to develop or influence market uptake through demonstration projects and provide information about the different ways in which existing recyclable material can be used. An issue arises in some cases where products derived from secondary materials are not received favourably by consumers, and therefore markets for these products see no growth potential (OECD 2006).
Driving recycling domestically

3.1 Generating local economic benefits

The economics of recycling is very dependent on three things: the volume of the material that can be reused or recycled; the market for these materials, driven by commodity prices and goods that can be manufactured from them; and finally, push factors for the market such as incentives, technology and regulation. The collection of solid waste or recyclables constitutes the largest percentage of municipal waste management budgets. Cost-effective ways of handling waste or their reuse within a particular system help to recoup value.

It is estimated that in OECD countries the recycling industry employs 1.5 million people with an annual turnover of US$160 billion, in which the physical amount of recycled waste is greater than 500 million tons (OECD 2006).

Research from the USA concludes that the ability to provide continuity from collection-processing-to-manufacturing can bring substantial economic spinoffs (National Recycling Coalition 2001). About 50% of all people employed by the recycling and reuse industries in the USA in 1997 were in paper and paperboard pulp mills, steel mills, plastic converters, and iron and steel foundries (see Figure 6). Plastic and non-ferrous metals were the highest-valued commodities, ferrous metals and paper of middle value, and glass and compost were of the lowest value as shown in the figure.

Figure 6 – Recycling manufacturing industry employment, by major material group

![Graph showing recycling manufacturing industry employment by major material group]

*Source: National Recycling Coalition 2001, using data is from a 1997 US economic census*

Notably, the recycling and reuse industries combined were larger than the waste management industry as a whole, because more value was derived from the materials than from their disposal into landfill sites (as shown by the graph in Figure 7). Recycling and reuse can be inherently value-adding, and value-adding activities, in turn, can create jobs and promote economic activity. This is
largely dependent on the extent to which labour intensity is consciously built into the operations of the recycling business.

**Figure 7 – Potential employment numbers in the recycling industry compared to other sectors**

![就业人数图表](image)

*Source: National Recycling Coalition 2001, using data is from a 1997 US economic census*

The National Recycling Coalition study further showed that a range of secondary industries and services are also supported as a result of the recycling and reuse industry. In addition, the diversification of the waste industry increases government’s tax revenue from better waste management. Investments made by local government, in collection and processing of recyclables, and public policies that favour recycling, encourage private sector investment in downstream processing and manufacturing (National Recycling Coalition 2001). One of the key factors that has promoted growth in recycling rates in the USA has been residents having access to kerbside recycling facilities and recycling centres (Beaty, Berck & Shimshack, 2007).

It is generally accepted that recycling is of value to the national economy. The challenge is how to make it viable, given the nature of the economics of recycling and the globalised nature of the market. There are downstream challenges in terms of collection and upstream challenges in terms of maintaining market value by stabilising demand and creating new uses for material. There are numerous examples of sustaining the market for recyclables within the domestic economy by building upstream demand for the material. However, a sudden downturn in the domestic economy, as seen in the USA, can lead to the forced export of material because of lower demand from the manufacturing sector within the domestic economy. To avoid this, many countries are developing alternative use systems for recyclable material.

For example, the recycling of glass as aggregate material for the construction industry has been found to be economical because it can be obtained in large quantities and has low quality requirements. Its usage is in the form of partial replacement of aggregate in asphalt concrete, pipe bedding, landfill gas venting systems and gravel backfill for drains. In the past ten years, the use of glass aggregate has been revived because of environmental regulations and the high cost of the
disposal of glass. The glass is obtained from a variety of sources, including e-waste. In China, especially, this is a growing industry (Shi & Zheng 2007).

Studies have been done on the use of recycled hot-mix asphalt for the rehabilitation of pavements and roads, which has been shown to reduce the eco-burden by up to 23%. This is due to the avoidance of extraction and transport of virgin materials (Chiu, Hsu & Yang 2008).

It is thought that building strong supply-and-demand chains for recyclable material can be mutually reinforcing. A key focus area is developing the recycling industry, i.e. finding new uses within the domestic manufacturing sector instead of having to export raw secondary material. This will require more long-term investments in scientific research and development, in partnership with the private sector. International studies show that recycling, in general, is not economical unless there is societal awareness, clear government policy and regulation as well as the right incentive and growth in markets for secondary material. Good domestic policy should drive recycling rates and help build the foundations of the industry and the market.

3.2 Importance of domestic policy and incentives

In the European economies, the drivers for recycling are environmental concerns and the shrinkage of landfill space. For example, in the UK 62% of waste ends up in landfill sites (Harder & Woodard 2007). Various policy instruments have been devised, with the primary form of intervention being obligatory targets.

For example, waste electrical and electronic equipment (WEEE) is dealt with, in most cases, through policies and legislation based on the principle of extended producer responsibility (EPR) – it is a different version of the ‘polluter-pays principle’ – a tool for integrating sustainability criteria into waste management systems throughout the life-cycle of the product. EPR conditions stipulate that the producer is responsible for the disposal and recycling of the good or managing the product’s environmental impact. The idea of EPR is to incentivise changes in the design of a product, or what is referred to as the introduction of Design for Environment features (DfE), or to ensure that at the end of a product’s life, somebody takes responsibility for it (Greenpeace 2007).

In Australia, for instance, EPR is achieved by the producer charging a fee on the sale of the good to cover disposal costs, but the consumers get a rebate if they return the product after it has completed its lifespan. EPRs have been applied to a range of products such as packaging, batteries, automobiles, solvents, paper, plastics, tyres, carpets and electrical and electronic equipment. The primary focus is on brown goods (computers, mobile phones etc.), white goods (refrigerators, air conditioners etc.), automobiles and batteries, which require special handling facilities.

EPRs, as a result, are meant to facilitate the ‘designing out’ of environmental problems associated with particular materials used in production. One example of this method is to set an energy efficiency target and force the producers to design an energy-efficient product. In summary, the main objectives of an EPR are:

- waste prevention and reduction;
- product reuse;
- increased use of recycled materials in production;
internalisation of environmental costs (Nnorum & Osibanjo 2008).

Different tools can be applied to give effect to an EPR, such as advanced recycling fees, product take-back mandates, virgin material taxes and others. These instruments are some of the innovative ways in which different costs associated with recycling can be recouped. Systems vary from shifting the cost to consumers, to spreading the cost along different parts of the value chain, or loading all costs onto producers. Some of these incentive schemes are described below:

- **An advance recovery fee** (ARF) is paid by the consumer at the point-of-sale when purchasing a new product and used to finance some or all of the recycling processes. One advantage of an ARF is that it is immediately available and can pay for all aspects of recycling, including dealing with orphan products. Another advantage is that the ARF can be adapted to cover only transport costs, and encourages people to act as collectors through a collection incentive payment. The disadvantages are that the fee has to be relatively high, and that it can be avoided through internet sales. In the USA, the State of California launched its own ARF on all new computers and television sets in January 2005. Depending on the size of the product, the ARF ranges from US$6–10. This is used to reimburse recyclers at around 48 cents per pound by weight, the recyclers in turn paying the collectors about 20 cents per pound (Herat 2007). In Japan the Law for Recycling of Specified Kinds of Home Appliances requires that the producer retrieve the appliance once it has been used. The consumer is expected to pay a fee for the disposal of the appliance by the producer (Nishino et al. 2007).

- **End-of-life (EoL) fees** are the cost paid by the end user to have the material discarded. The big advantage of these fees is that they provide immediate finance for the disposal of the waste. There is potential for producers to start competing with recyclers. The downside of the EoL fee is that it could discourage consumers and lead to illegal dumping of e-waste. This system can also lend itself to new institutional models – joint consortia initiatives between different producers, or the use of a third-party organisation such as a non-profit entity (see the case study in this paper of EoL for tyres in Portugal).

- **Deposit and refund payments** as used in the beverage industry. This has proven to show an 80% recovery rate in many countries. This may not be ideal for e-goods as they are held in possession for a long time by users.

- **Product stewardship** is aimed at encouraging those in the product life-cycle – manufacturers, retailers, users and disposers – to take common responsibility for the environmental impacts of their products. The concept embraces the idea that products contain material of value and this value should be captured, preserved and returned for use in commerce.

- **The UK voucher system.** In the UK recycling rates have increased significantly, from 8% in 1996/97 to 27% in 2005/06. A key factor in the rise is increased accessibility to recycling services. The Household Waste Recycling Act requires that all households have access to kerbside schemes by 2010. The challenge was to increase public participation in recycling. Pilot

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5 The consumer pays a deposit to the retailer and when the consumer returns a used container, such as a bottle, he or she is refunded. The deposit serves as an incentive for the consumer to return used containers.

6 The vouchers were designed to encourage greater participation from households in four pilot districts. The vouchers had different levels of monetary value in terms of the quantity of material submitted for redemption.
schemes were set up with the support of local authorities in which shop owners distributed vouchers. Different vouchers had different colour schemes and redeemable values, so as to improve performance by each household (Harder & Woodard 2007).

Each system requires fairness, administration and enforcement for successful implementation. EPRs should not work in isolation from other factors such as administrative implementation costs, post-consumer sorting costs, and the structure of primary and secondary markets, and most importantly, public willingness to participate in the systems. Studies have shown that awareness is often not matched by practice. As noted, the more informed citizens are, and the more they have access to easily located ecopoints to support the drive for recycling, the more recycling rates increase (Vicente & Reis 2008).

Close to fifty US states now have e-waste laws and advanced recycling fee systems to finance recycling. The predominant form of EPR in the USA is the product stewardship model. This model is a stakeholder consensus-driven one, in which costs are shared between producer, retailer and consumer. In the USA the system is voluntary, whereas in the EU it is mandatory and driven by government.

The US model of product stewardship involves identification and classification of different waste streams at the onset of manufacturing – from selection of raw materials, to design and production processes, to use and disposal of the product. It takes into account the product’s entire life-cycle and identifies materials of value that can be returned through recycling to the production process. The US government, for instance, is promoting the product stewardship model in automobiles, packaging and electronics.

An OECD evaluation of EPR implementation for various EU countries showed significant recovery rates for different types of recyclables – varying from low bases of 30% to 70% and even higher for some countries. Costs have been difficult to determine, but in three countries where the recycling of 0.33 l aluminium cans was evaluated, the costs for the respective countries were as follows: US$0.0161 (Germany), US$0.0105 (Sweden) and US$0.0345 (Switzerland) – all three having different systems of collection, and recycling rates of 85–90%.

In Germany, the EPRs have also stimulated innovation within industry; the packaging sector is an example of this. There has been significant use of reusable packaging, reduction in the use of composite and plastic packaging, and changes in the design of packaging. At the upper end of the waste stream, improvements have been made by the introduction of new technologies for sorting and recycling of plastics in order to meet the recycling mandate (Tojo, Lindhqvist & Davis 2001).

**Case study – The Portuguese EoL for tyres**

In Portugal, prior to the implementation of the EoL system, 29% of tyres were retreaded, 29% recycled, and 10% incinerated. The whereabouts or disposal of the remaining 32% was unknown. It is assumed that they were landfilled. Discarded tyres are usually a hazard in a number of ways – they are breeding grounds for mosquitoes, they are a fire hazard, and the resultant fires can lead to other environmental problems like pollution and soil contamination. The long-term problem also comes from the way tyres are designed – the cross-linked structure of the rubber and the inclusion of stabilisers and additives slows the process of tyre degradation. Tyres in landfills occupy valuable airspace and can be a source of chemical leachates. Tyres are used generally as a fuel source in
Global trends in waste management: Some pointers for South Africa

cement kilns, resulting in by-products such as gas, oil and char. However, the study on which this case study is based shows that energy recovery is costly if one uses tyres in pyrolysis systems – the study concluded that tyre pyrolysis projects have proven not to be commercially viable.

It proposed recycling as an alternative, as a variety of products can be generated from tyres. Recycled tyres can be used as vulcanised rubber in sports facilities and floors, as construction and filling material, and as an additive to bitumen in road surfaces. Retreading is also cost-effective from the point of view of the amount of energy saved in the making of new tyres. The Portuguese government instituted a decree to give effect to an EoL so as to promote recycling, waste prevention, and enhancement of collection. In order to support the implementation of the EoL programme, the Portuguese government established a non-profit organisation, Volorpneu, which acts on behalf of government and other parties as the third-party entity by collecting fees and distributing these to recyclers to cover various costs associated with the recycling of tyres. Figure 8 indicates the different parts of the tyre recycling value chain and the flow of finances from the third-party agencies to pay for different aspects of the process as described in this case study.

The third-party system works on the basis that each of the key stakeholders ‘owns’ a share in the organisation depending on the size of their market; the producers/distributors and importers pay a fee for each tyre they put in the market. The fees cover the set-up of the tyre collection network and logistics, and are managed through contracts with distributors, municipal waste systems and other waste operators; contracts are also established with retreaders, recyclers and others.

The fees are calculated on the basis of the cost of the EoL management system – the costs of storage and sorting, transportation and recovery as well as other costs such as investment depreciation, marketing and the establishment of research and development capacity. Tyre collection centres are rewarded by the third party entity, Valorpneu, at about €23/ton. The tyres are then distributed from the centres to the retreaders and recyclers. The transport costs for recycling are covered by Valorpneu (see Figure 8). Retreaders pay their own transport costs. Retreaders usually pay for the tyres, while recyclers and incinerators receive a fee. The ‘gate-fee’ depends on market conditions and contracts negotiated with each EoL recovery company, and averages about €60/ton.

To establish the market profile, producers and importers submitted data to an academic institution that consolidated the data and developed a national profile of tyres used, disused etc. There are two tyre recycling firms that produce rubber granules which are exported to the rest of Europe.

Table 4 shows that since the programme’s implementation in 2003, recycling and incineration numbers have increased. The 2004 period shows higher figures for tyres because it was the year in which most tyres were entering the end of their natural cycle before new ones were required. One key impact of the establishment of the Volorpneu Society is that it brought significant rates of financial stability to recyclers, because of a more reliable flow of tyres (Ferrao, Ribeiro & Silva 2008).
Figure 8 – The Portuguese EOL system, with financial flows

Table 4 – End-of-life options before and after the Valorpneu Society programme

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>%</th>
<th>2003</th>
<th>%</th>
<th>2004</th>
<th>%</th>
<th>2005</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retreading</td>
<td>21 091</td>
<td>29</td>
<td>18 429</td>
<td>27</td>
<td>20 538</td>
<td>26</td>
<td>19 808</td>
<td>25</td>
</tr>
<tr>
<td>Reuse (except retreading)</td>
<td>–</td>
<td>–</td>
<td>0</td>
<td>0</td>
<td>1 588</td>
<td>2</td>
<td>1 623</td>
<td>2</td>
</tr>
<tr>
<td>Recycling</td>
<td>216</td>
<td>29</td>
<td>30 633</td>
<td>45</td>
<td>3 347</td>
<td>42</td>
<td>38 641</td>
<td>49</td>
</tr>
<tr>
<td>Incineration (cement kilns)</td>
<td>7634</td>
<td>10</td>
<td>9287</td>
<td>14</td>
<td>16 554</td>
<td>21</td>
<td>16 165</td>
<td>20</td>
</tr>
<tr>
<td>Landfill</td>
<td>–</td>
<td>–</td>
<td>0.720</td>
<td>1</td>
<td>4 531</td>
<td>6</td>
<td>1 591</td>
<td>2</td>
</tr>
<tr>
<td>Unknown</td>
<td>23 441</td>
<td>32</td>
<td>9 284</td>
<td>14</td>
<td>2 12</td>
<td>3</td>
<td>1.37</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>73 766</td>
<td>100</td>
<td>68 353</td>
<td>100</td>
<td>78 801</td>
<td>100</td>
<td>79 198</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Ferrao, Ribeiro & Silva 2008
3.3 Waste collection innovations in developing countries

In countries with high rates of unemployment, recycling has also been seen as a way of creating employment. In the recycling sector in India, it is estimated to involve about 300 workers per kiloton of plastics, throughout the entire process (Mutha, Patel & Premnath 2006).

Waste management and increasingly limited landfill space in cities have also influenced municipalities to consider recycling as a solution, creating a push factor. A pull factor is the growing market for secondary material. In the future, domestic waste in developed and developing countries is expected to increase because the per capita income is growing, with concomitant growth in the consumption of goods.

The South African situation is expected to be in line with that of other emerging economies—in the sense that it has a well developed waste management sector side-by-side with informal collection and scavenging. The waste sector will be more reliant on informal waste collection, which is currently already being handled by informal pickers and house-to-house collectors who can derive any sort of income or material from waste, than on the highly industrialised and capital-intensive operations in developed economies. The informal sector has low fixed capital costs and operates under the radar of the tax system. However, trends in South Africa may be changing as the economics of recycling improves, and there is growth in the market for recycling material collection which may well become more formalised.

Cities that have contracts with collectors can positively incentivise recycling if they combine a favourable fee for the collection of kerbside waste per ton with introduction of a flexible price based on market conditions for the recovered material itself. This will improve handling efficiency and the quality of the material recovered.

In Brazil all the major municipalities’ recycling is done by informal collectors – there are about 45 000 informal recyclers on landfills and 30 000 in streets. In a few countries in Latin America, such as Mexico and Colombia, recycling co-operatives have formal recognition and status. Many of them have developed regional networks and markets (Gutberlet 2008). This allows collectors and recyclers alike to both source and sell material on a much wider scale.

The profitability of the industry seems to lie in questions of economy of scale, as well as consistency and quality of supply. The integration of the informal and formal systems into a comprehensive and complete system will require government intervention and the stimulation of the market. In China, for instance, where rapid urbanisation has led to greater informalisation, the informal system exists harmoniously with the formal system (Wang, Han & Li 2008). In higher-labour-cost countries such as the UK, it has been shown that the manual removal of selective parts of vehicles in the new EC-mandated ELV programme for vehicles improves the profitability of recycling. Each actor in the ELV system needs to optimise their rate of activity (Reuter, Schaik, Ignatenko & De Haan 2006).

In developing countries, the real innovation is not in technology but in waste collection organisation. Even where recycling technologies are available, it is thought that ‘no recycling technology is useful unless products are actually collected in the market’ (Nishino et al. 2007: 844). Therefore the challenge in recycling becomes an institutional one.
Different approaches have been taken to optimising waste collection and separation at the level of collection. Collection constitutes by far the largest cost in waste management. In developed countries it ranges from 60–70% of the total cost, while in developing countries it can be anywhere between 70% and 90%. This can be attributed to issues of distance, volumes, weight, value, price of petrol, as well as general inefficiencies due to lack of equipment, sub-optimal equipment, and in some cases poorly motivated municipal workers and other factors. For some types of waste, lack of equipment can be a barrier to entry for small collectors. In the case of construction and demolition waste (C&D), the biggest barrier in terms of cost is access to portable equipment, which can be used and set up close to demolition sites. The transport of C&D over very long distances is uneconomical; collection should occur in close proximity to crusher units. The barrier to entry for small operators is high because of the capital and transport costs associated with the recycling of C&D. In South Africa C&D is expected to grow because of the general growth in construction in the country (Rao, Kumar & Misra 2006). There are opportunities for entry for small recycling operators if the government levies high costs on the construction industry for the disposal of waste, forcing them to divert material for recycling. In addition, the establishment of a crusher plant close to construction sites, and the financing of mobile equipment through a co-operative business model, may reduce barriers to entry for new operators.

Improvements in waste collection in the informal sector can be made. The best examples are from Latin America (particularly Colombia and Peru) where enterprising NGOs have formed a relationship with waste pickers (Ortiz & Piedrafita n.d.; UNEP 2005). The co-operatives pay households that have recycled their waste. Co-operatives have proven to be effective because they have managed to scale up operations and negotiate better terms from industry than individuals are able to. As a result their profits tend to be higher. They are able to better train their workers who, in turn, are also able to obtain better health benefits. They are reviving the traditions of recycling and separation. The pickers are no longer seen as ‘scavengers’ but are deemed to be doing acceptable work. The materials they sell to industry are much cleaner and of a better quality. They make use of human-driven or semi-motorised front-end loaded vehicles to cart the material around. The administrative costs have proven to be lower than municipal costs (UNEP 2005). Similar initiatives are reported in Asia and Africa. Most are run by NGOs and pickers are very dependent on the financial viability of the NGOs.

Improvements in collection and separation of recyclable material were shown to improve the economics of recycling in Lahore, Pakistan (Batool, Chaudhry & Majeed 2008). Lahore generates about 1.97 million tons of waste per annum. Of this, about 30% is not collected each year. Of the remaining amount, one-fifth is recyclable. In a survey conducted by researchers in Lahore, it was found that 15% of recyclable waste is sold directly to industry, and households also reuse 20% of the recyclables. The rest of the waste is then separated by scavengers. The total recyclable industry in Lahore has been valued at US$4.5 million per year. Scavengers are estimated to make a profit of 15% and junkshop owners about 14%. If recycling were adopted as an industry, it is estimated that the recycling revenue stream could be doubled (Batool et al. 2008).

In the Chinese district of Haidian, Beijing, the participation of residents in a community-based collection scheme is highly dependent on their satisfaction with the conduct and practices of the community-based recycling services. Each buyer, or group of recycling buyers, operates a recycling services site. They are usually poorly educated rural immigrants who become itinerant buyers. This was unorganised until the government intervened in 2002 and worked with waste management companies to create an open market for recycling waste. The companies employed the buyers,
providing them with uniforms, measuring tools, tricycles and other essential equipment to be able to handle the waste in a proper manner. Once the buyers have purchased the material from the residents, they sort the waste into fifteen different types. Having collected enough material, they sell the recycled material to distribution centres – usually at a profit. The companies do not pay a wage to the buyers, but charge a small administration fee for the set-up of the recycling service sites. Field usage is agreed on through resident committees and property companies. However, community-based buyers are occasionally in competition with itinerant buyers. This is dealt with through community co-operation. Only companies that are licensed by government are allowed to operate this system.

The recycling distribution centres are an intermediary where the material is usually further separated and then distributed to factories as raw or processed material. The key to the Chinese system, because of low awareness of recycling and environmental issues, is the commercial exchange that happens between residents and the recycling buyers – this is unlike the Western system in which households do this voluntarily. The second key factor is that the waste management system for recyclables is based on creating jobs and thus keeping the labour intensity of the collection side. The system is new, but requires three key things: government intervention, market forces and low-paid workers (Wang et al. 2008).

In Indonesia, waste management has also taken the form of community-based projects. However, the establishment of voluntary neighbourhood associations (NAs) has not worked as intended, largely due to the lack of government support and lack of a good policy environment where source separation is taken seriously by the local authorities. Several recycling schemes undertaken by NGOs or CBOs have failed in Indonesia because of the lack of regulations and incentives.

Many of the problems in Indonesia have involved collection, separation and finding appropriate ways to dispose of the recyclable waste. Recycling has not worked in general in Indonesia as yet, despite 15% of the waste reaching Jakarta’s disposal sites being reduced by scavengers, and the existence of an active market for plastics, glass, bottles, scrap paper and scrap metal. In the NA systems where recycling did work, there was good community participation and the workers received a fee for their collection, although sometimes these fees were too low. Usually, workers would combine collection with security services as part of the work allocated under the NAs. All collected materials were transported by wooden handcarts. The typical capacity of a handcart is about 1.5 m$^3$ and the waste is taken to a collection truck, communal collection site or transfer station. The NAs in Jakarta are usually formal structures linked to a local municipality.

The authors of the Indonesia case study draw an interesting conclusion that may be of relevance to South Africa. They state that problems with the system of recycling ‘are not so much related to financial and technical aspects, but rather to vision, commitment and policy initiatives such as long-term planning, revenue collection, sharing disposal facilities, level of stockholder participation, and transparency in decision-making’ (Pasang, Moore & Sitorius 2007: 1936). Some of the problems associated with waste collection in Indonesia are summarised in Table 5.
Table 5 – Problems and constraints of municipal solid waste management in Jakarta

<table>
<thead>
<tr>
<th>Waste management aspect</th>
<th>Problem</th>
<th>Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Technical</td>
<td>• Existing landfill congested and new sites not yet prepared&lt;br&gt;• Inoperative monitoring facilities (e.g. landfill weighbridge inoperative)&lt;br&gt;• Uncontrolled scavenging both within the city and at landfill site</td>
<td>• Lack of trained staff at all levels&lt;br&gt;• Poorly maintained and designed infrastructure, transport and collection system&lt;br&gt;• Limited research and development causes limited information and technology option for Jakarta</td>
</tr>
<tr>
<td>2. Institutional</td>
<td>• Some agencies have both operational and regulatory roles</td>
<td>• Lack of strong legal system to prosecute laws&lt;br&gt;• Lack of co-ordination among relevant agencies</td>
</tr>
<tr>
<td>3. Financial</td>
<td>• Revenue from waste fees too low to cover the costs of a complete waste management service&lt;br&gt;• Potentially valuable resources going to landfill</td>
<td>• No mechanism of revenue collection&lt;br&gt;• No concept of producers’ responsibility or polluter pays&lt;br&gt;• Cost of environmental and health damage not accounted in monetary value</td>
</tr>
<tr>
<td>4. Political</td>
<td>• Arbitrary decisions made by a few staff based on expertise and experience without sufficient data and information</td>
<td>• Public participation in decision-making does not exist&lt;br&gt;• No transparency in political processes&lt;br&gt;• Waste is not a fashionable political problem&lt;br&gt;• Corruption</td>
</tr>
<tr>
<td>5. Socio-economic</td>
<td>• Health and safety of scavengers&lt;br&gt;• Salary supplementation by workers through scavenging&lt;br&gt;• Health impact</td>
<td>• Low awareness of health and safety issues</td>
</tr>
<tr>
<td>6. Environmental</td>
<td>• Illegal dumping causes health impact&lt;br&gt;• Open incineration causes smoke pollution&lt;br&gt;• Non-renewable resources going to landfill</td>
<td>• No proper control of hazardous wastes&lt;br&gt;• Valuable resources (renewable and non-renewable) going to landfill</td>
</tr>
</tbody>
</table>

Source: Pasang, Moore & Sitorius 2007

In Mumbai, India, a localised system of community-based waste management has been tested. It is a decentralised system of waste management called Advanced Locality Management (ALM) and was introduced in 1997. The basis of it is a partnership between CBOs, NGOs and the Municipal Corporation of Greater Mumbai (MCGM). The primary objective is to ensure segregation of waste at-
source into biodegradable and recyclable materials. The biodegradable material is processed locally, and recyclables are sold. The system works by the establishment of a local committee, which has links with the MCGM. The MCGM undertakes awareness programmes and provides training for rag-pickers, who can also be trained by NGOs/CBOs. The MCGM has established compost pits in certain areas. In total, 360 ALMs have been formed, servicing about 0.2 million people who generate 69 tons/day of waste. The scheme is financed by the residents, with the MCGM providing funds to cover set-up costs. A study that carried out cost evaluations comparing community-based approaches, a public-private partnership (PPP), and the municipality doing the collection and separation found the community-based system to be cheaper (Rathi 2006). The cost varied, at US$35, US$41 and US$44 respectively. However, there are some barriers to success, such as lack of participation by some members of the community and inability to recover full revenue from composting.

Case study – Cheap labour and the global e-waste industry

Globally e-waste is the fastest growing component of municipal solid waste. In the USA, for instance, it accounted for 2.63 million tons of waste in 2005 (or 1.1% of the waste stream), an 8.8% increase from 2004. Of this, 87.5% was disposed of rather than recycled. Most e-waste lifespans are declining. For example, a computer’s lifespan has declined from five years to two years.

In the USA, e-waste already constitutes 2–5% of the municipal solid waste stream (Kang & Schoenung 2005). It is also one of the most complex waste streams to deal with because of the variety of materials that go into making it. About 66% of WEEE by weight consists of metals such as iron, copper, aluminium and gold, and non-metals with other pollutants make up the other 34%. Plastics are the second-largest component of WEEE, by weight about 21%. The recovery of metals occurs mainly manually, or using other methods such as incineration and chemical processes. Obsolete electronic devices can be cleaned and made functional for reuse. Figure 9 illustrates the different ways in which plastics can be recovered and made into new end products. Each product in turn has its own market value and use.

Figure 9 – Recycling options for managing end-of-life plastics from e-waste

Source: Kang & Schoenung 2005
The International Association of Electronic Recyclers estimates that various kinds of consumer electronic products will become untenable. A staggering number of 4 billion units, or 400 million units per annum, will have to be scrapped in the next decade.\(^7\)

Many developing countries have taken the recycling challenge as an opportunity. Most of these countries do not have well established systems for separation, storage, collection, transportation and disposal of e-waste; nor do they have proper enforcement mechanisms. They possess neither state-of-the-art technologies nor facilities (Nnorom & Osibanjo 2008a, 2008b). Asian countries are fast becoming major global producers of e-goods, disposers and users of e-waste, and importers of e-waste; Asia’s e-waste stream is the fastest growing in the world. The global e-waste stream is estimated to be between 20 and 50 million metric tons per annum. India is the largest receiver of e-waste in the world. It receives 70% of e-waste generated by the developed world. Total revenue for e-waste has been estimated at approximately US$2.7 billion, and is expected to grow at 8.8% annually to approximately US$11 billion by 2009 (Babu, Parande & Basha 2007).

E-waste management involves sorting out those components or parts that can reused, before other components of the waste are cleaned and processed for recycling. Waste that cannot be reused or refurbished is sent for demanufacturing into component parts – such as ferrous metals, non-ferrous metals, plastics and glass. The different types of waste that are recoverable, in terms of their volume proportions, are indicated in Figure 10 and Table 6.

Often the plastic in the e-waste is used as fuel when smelting the metal in the electronic circuitry boards. However, thermoplastics used in electronic goods are classified as ‘engineering thermoplastics’, which have a high intrinsic value. In the USA, plastic retrieved from e-goods is used as plastic lumber, outdoor furniture and road materials. Used plastic can also be reused in new equipment.

Acrylonitrile butadiene styrene (ABS) and high impact polystyrene (HIPS) – which are resins used for protection in television sets – can be recycled. ABS, for instance, can be used for battery boxes, compact disc trays and camera casings. ABS and HIPS can also be substituted for stone and gravel – the resins can be used as binding to improve bond strength. Much research in the USA is being done to find alternative uses for e-waste plastic and to expand the markets for this waste (Kang & Schoenung 2005).

The residue of precious metals in the recycling process is declining because manufacturers are using substitutes in new e-goods. There is also diminishing use of lead and mercury, because of their health impacts.

\(^7\) See [http://www.iaer.org](http://www.iaer.org).
Figure 10 – Materials found in electronic equipment

Source: Zhang & Forsberg 1997

Table 6 – Summary of material types in demanufactured TVs and computers, by percentage weight

<table>
<thead>
<tr>
<th>Materials</th>
<th>TV</th>
<th>Computer*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>47.6</td>
<td>24.80</td>
</tr>
<tr>
<td>Plastic</td>
<td>14.7</td>
<td>23.00</td>
</tr>
<tr>
<td>Printed wiring board</td>
<td>5.6</td>
<td>– **</td>
</tr>
<tr>
<td>Precious metals</td>
<td>27.1</td>
<td>0.02</td>
</tr>
<tr>
<td>Iron</td>
<td>–</td>
<td>20.47</td>
</tr>
<tr>
<td>Lead</td>
<td>–</td>
<td>6.30</td>
</tr>
<tr>
<td>Aluminium</td>
<td>–</td>
<td>14.17</td>
</tr>
<tr>
<td>Copper</td>
<td>4.8</td>
<td>6.93</td>
</tr>
<tr>
<td>Others</td>
<td>–</td>
<td>4.30</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Source: Kang and Schoenung 2005

Notes: * CPU and monitor
       ** Disassembled to plastics, metals and other parts

E-waste management research in the USA has identified the following areas as key in the value chain of waste management:

- Defining what needs to be included in the recycling programme. For example, some states ban cathode ray tubes (CRTs) from landfills. Studies have shown that television sets constitute about 25% of the bulk of the e-waste, and 69% of the weight.
It is also important to distinguish between commercial and residential e-waste. The former has proven to be more economical. Residential e-waste is often older, as products are used for longer before being discarded. Old waste can have low value because of the orphan product syndrome, and may have little recycling value. Television sets are difficult to recycle. They have larger CRTs than computers, and have less recyclable metals. A large quantity of the US e-waste is now exported.

Identifying where the waste is to be collected from and transported to for recycling (Office of Technology Policy 2006).

Different approaches have been taken to the collection of e-waste, such as kerbside drop-off centres, local government drop-off centres, special one-day drop-off events, one-for-one take-back by retailers, and producer-established drop-off centres. It was found that kerbside disposal often allows for more private operators or government services to make regular pick-ups. In rural areas, one-day drop-off events seem to work best. The problem is cost – e-waste is relatively low-volume, with high transport cost. Collection and transport costs can constitute up to 80% of the total cost (Kang & Schoenung 2005). Some countries use retailers as drop-off centres as they already have a system in place for sending back defective electronic goods. The schematic diagrams in Figures 11 and 12 illustrate the different parts of a value chain for e-waste. The diagram in Figure 11 is generic and that in Figure 12 is specific to India.

In some developing countries, there are substantial markets for the reuse of CRTs. This involves an elaborate process of dismantling the parts of the television set, dismantling the CRT unit, transporting and cleaning the glass casing, and removing the CRT. If there is no market for the CRT glass, the glass can be sent to a smelter or reprocessed. In the USA, glass-to-lead recycling has been found to be expensive. The low-cost alternative is to export CRTs overseas, where the process costs one-tenth of the US cost (Kang & Schoenung 2005). In the USA, MRFs are critical in the way in which e-waste is disposed of. Collected equipment is divided into two categories: reusable or recyclable. Used equipment is sorted into three secondary markets: the first market is for refurbished systems that can be sold or donated to secondary users; the second market is for components that can be reclaimed, resold and reused, and the third market is for salvaged or recycled material. Identifying material for reuse can be time-consuming, but a simple plug-and-play test is applied. If the equipment is not working it is dismantled. The recovery process requires some knowledge on the part of the employee as to which components are valuable, how to dismantle them, and which components require special handling care to prevent damage.

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8 A MRF is a dedicated facility for the sorting/separation of recyclable materials.
For example, CRTs require the careful removal of the casing, and the tubes need to be depressurised; thereafter the metals are separated and plastics shredded. CRT dismantling can be costly in developed economies because it is quite labour-intensive. The CRTs can enter what is called a glass-to-glass recycling process, as the glass is used as raw material for new CRTs. The advantages of CRTs that have been converted to recyclable cullet (shredded glass fragments) are that recycled cullet can replace virgin material at lower or equal cost, and it can improve the efficiency of the furnace, lowering energy consumption in making new CRT glass. The quality of
the output glass can be improved because of the process, and there would be lower emissions from the glass-making as recycled glass already has high levels of purity.\(^9\)

**Figure 12 – Typical WEEE take-back and recycling system, India**

For example, CRTs require the careful removal of the casing, and the tubes need to be depressurised; thereafter the metals are separated and plastics shredded. CRT dismantling can be costly in developed economies because it is quite labour-intensive. The CRTs can enter what is called a glass-to-glass recycling process, as the glass is used as raw material for new CRTs. The advantages of CRTs that have been converted to recyclable cullet (shredded glass fragments) are that recycled cullet can replace virgin material at lower or equal cost, and it can improve the efficiency of the furnace, lowering energy consumption in making new CRT glass. The quality of

\(^9\) While this can be a good business there are barriers, including the identification of glass composition, the cost of CRT demanufacturing, the cost and complexity involved in the set-up of collection infrastructure, and insufficient supply of recycled cullet.
the output glass can be improved because of the process, and there would be lower emissions from the glass-making as recycled glass already has high levels of purity.10

Usually, the process of disassembling starts with high-end parts, which are more valuable, and then ends with low-end parts which are of less value. The rate of material recovery from e-waste depends on the size of the facility and the targeted electronic products (Kang & Schoenung, 2005).

E-waste challenges in developing countries are:
1) significant dispersed rural populations, thereby increasing the cost of the collection process;
2) the fact that recycling is undertaken by the informal sector; and
3) problems with identifying producers, as many e-goods are cloned or are second-hand.

E-waste has potential for exploitation in South Africa because it can be transformed into a labour-intensive industry, and there are numerous recyclables that can be processed as shown in the Indian example. E-waste organisation and processing can be done within one facility, with the benefits of multiple streams of a variety of recyclates with different market values. Since e-waste is complex, different parties and technologies need to be involved.

As the US example shows, the successful diversion of e-waste relies on it being economically sustainable and technically feasible, and on the existence of strong social support for the programme (see the Appendix for discussion of a pilot programme established by HP in South Africa). In the USA there has been strong reliance on consumer awareness about e-waste recycling through extensive advertising, in order to increase recycling rates and to prevent continued individual storing of obsolete electronic goods.

WEEE will be a growing problem in developing countries, given the increased consumption of television sets, computers and mobile phones. Disposal of WEEE will be a challenge, as will the low economic value of the material composition, and the high rate of material mixing that can discourage recycling. However, there are also some advances occurring, such as low levels of toxic materials used in the production of WEEE goods.

Role of technology in recycling

4.1 Introduction

Off-the-shelf technology tends to get adopted quickly because companies are concerned about market position and competitiveness. Remaining within the cycle of the technology innovation loop should be part of normal business planning and capital investments.

10 While this can be a good business there are barriers, including the identification of glass composition, the cost of CRT demanufacturing, the cost and complexity involved in the set-up of collection infrastructure, and insufficient supply of recycled cullet.
In areas where the market is not mature and new technology is still to take off, adoption takes longer. There will be a few early adopters who are willing to take the initial risk; as the markets mature and there are profits to be made more and more late adopters come on board until market conditions are saturated. The next phase is a period of consolidation as market growth is also saturated; market players cannot grow profits any longer unless they become more competitive and innovative in terms of product lines, services, and quality of goods and services they offer. Or they simply move on to the next technology cycle within the sector, to improve their profit margins by enhancing production capacity, reducing costs or introducing new product lines in order to expand their market range.

The commercialisation of any new recycling technology, from mere laboratory demonstration to wider dispersal in the economy, is largely dependent on how investors make decisions about competing technologies and options. Decisions to invest depend on market opportunity and risk/return features of a particular investment. There are also psychological, social and institutional factors that influence the adoption of new technology, and not just financial ones.

If one scrutinises the issue further, shifts to new technologies and approaches may have to do with the degree to which existing ways of doing things have been so embedded that there is a greater inclination to protect the existing system than to opt for the new. The new may entail risks. These risks may have to do with the performance of the new technology, the lack of operating experience, and uncertainty about who should bear any further development costs associated with improvements in the technology.

Where market growth can push higher profit expectations, adoption of new technology is likely to occur faster. Where market growth is uncertain, and profit opportunities marginal, private operators are more likely to stick to what they know than opt for the new.

Cost factors can play a role, as can the availability of other competing technology clusters, such as substitutes for existing materials, that may be of an equivalent critical mass and could shift the techno-economy paradigm in another direction, away from a specific technology as the preferred choice. They could also result in what Carlota Perez calls the creation of ‘induced branches’ – when infrastructure is developed a cluster of services are created around them, and keep on expanding until they reach a critical mass (Perez 2002).

Perez’s theory of the link between technological revolution and the behaviour of financial markets is an interesting framework within which to assess the overall viability of the use and development of technology, or to provide indications of factors that will contribute to the financial markets responding favourably to this technology push. As we know, there is a thin line between favourable and unfavourable responses – promising technologies only become cost-effective if they reach a critical mass which leads to economies of scale. Perez writes:

For approximately the first half of the surge, financial capital drives the diffusion process, forcefully pushing the revolution forward. During the second half, it is usually production capital that conducts the growth process propagating the paradigm across the economy. Throughout the successive phases of diffusion, deep and widespread transformation must occur, which demand[s] adequate innovations not only in the production sphere – in products, processes and modes of organisation – but also in finance and institutions. These innovations condition the
extent to which a technological revolution will deliver its potential and the distribution of its economic and social benefits. (Perez 2002: 138)

Perez talks of a technological revolution in which a cluster of technologies, products and services has the effect of changing the techno-economic paradigm.

*Each technological revolution, then, is an explosion of new products, industries and infrastructures that gradually gives rise to a new techno-economic paradigm, which guides entrepreneurs, managers, innovators, investors and consumers, both in their individual decisions and in their interactions, for the whole period of propagation of that set of technologies.* (Perez 2002: 9)

And then, referring to economist Simon Kuznet, Perez points out that major technological change or revolutions often occur as epochal innovations – sustaining economic growth over several centuries (Perez 2002: 9). She continues:

*When each technological revolution irrupts, the logic and the effects of its predecessor are still fully dominant and exert powerful resistance. The generalised shift into ‘the logic of the new’ requires two or three turbulent decades of transition from one to the other, when the successful installation of the new superior capabilities accentuates the decline of the old. By the time the process has fully taken place, the end of the previous revolution is little more than a whimper.* (Perez 2002: 12)

Perez has described major shifts brought about by technological revolutions as bringing about great surges of development, which are characterised by a turbulent process of diffusion that can last a half-century or more (Perez 2002: 23). These also involve an interaction between the economy and social institutions – usually profound and intense in nature. The underlying cause of the tension is psychological – each new revolution changes the status quo, and often this is resisted. She writes:

*Thus, each technological revolution brings with it, not only a full revamping of the productive structure but eventually also a transformation of the institutions of governance, of society and even of ideologies and culture, so deep that one can speak about the construction of successive and different models of growth in the history of capitalism.* (Perez 2002: 25)

Each technological revolution also introduces another tension: the new techno-economic paradigm inevitably leads to a mismatch between social and regulatory systems, as the old generally suits the previous techno-economic paradigm and the new always lags behind the needs of the latest technological revolution (Perez 2002: 26–27). Perez’s thesis further points out that technological revolution leads to new requirements: a new network of interlinked services and, more profoundly, cultural accommodation of the new technology – there is a process of socialisation that takes some time to work the change (Perez 2002: 41). Revolutions in the techno-economic paradigm do not happen overnight. She summarises the process as being characterised by three things:

1) *Technological innovation occurs in clusters that produce a revolution and that change the production system;*

2) *Financial and production capital have an interrelationship but also act separately pursuing profits for different reasons and therefore depict different behaviour;*
Perez’s thesis extends to the behaviour and inter-relationship between financial capital and productive capital. When new innovations appear on the horizon financial capital has already exhausted the opportunities of old technologies. It is hungry for new ideas and better margins on its investments.

A second theory that explains how technology adoption may occur comes from the theoretical work of Paul Ormerod (1998), as set out in his book *Butterfly Economics*. The theory has relevance in that it illuminates our thinking about market dynamics and how technological choices are made, and why some technologies succeed while others do not.

The new economics that Ormerod speaks of is a developing science, and relies on psychological and sociological evidence to describe economic behaviour. Its main achievement is to explain economic anomalies that go against the dominant economic paradigm, which states that economic choices are rational and follow the logic of maximising individual benefit. It is a shift from a mechanistic approach to economics to a systems approach. It allows for economic theory to build into its predictions the effects of interactive agency on the behaviour of consumer/investor choice – in other words, group think and individual psychology.

The central thesis of the new economics is premised on the view that economic choices are dictated by social patterns, just as in the case of ants. We are creatures of fads or fashion. This has implications for how consumers make choices about products and technologies. It helps to predict which technologies are more likely to reach greater market penetration than others. The new economic studies show that these are often determined not by price, nor by product quality, but by group choices. The theory argues that economic choices are decided by three processes:

1) Choices are determined by what has already been entrenched or dictated by the prevailing conditions.

2) Consumers can change their choices or paths at their own volition and choose an entirely new outcome.

3) Choices are influenced by the persuasion of others.

In such a systems approach there is complexity and unpredictability, but over time a level of regularity can be reached that cannot be shifted. This has been proven, for instance, with technologies. The great example is the competition between VHS and Betamax video machines. Betamax, being the much superior machine, lost market share because VHS had far better ways of persuading consumers to choose VHS above Betamax. In the end VHS gained such momentum in the market that it was difficult to erode or replace its market dominance (Ormerod 1998: 22–23).

As Ormerod writes, ‘In terms of two rival new products, the choice of one of them by a consumer shifts the chances, ever so slightly, in favour of the next person making the same choice’ (1998: 28). The problem with technology is that once a choice is made to incur the fixed capital cost, it is not like sugar or bread where one can change one’s mind overnight and switch to a new brand. Ormerod notes, ‘ Whoever gains an early lead will set-up the process of self-reinforcement, and will probably obtain control of the entire market’ (1998: 24).
The key insight of this theory relies on an assessment of which technologies have gained first-mover advantage and market share – or putting it differently, which countries have secured the market and will most likely dominate that market in the future. Such an assessment guides public investment and intervention. It suggests that funding technologies in which other countries already have first-mover advantage will most likely reap little rewards for new investors, and it may be better to focus on other aspects of the supply chain for such technologies, or to invest in different technologies where better market advantages can be gained. It can also suggest that certain tactical alliances and partnership strategies with likely or existing dominant market players may need to be secured, in order to gain some share of the market and ensure that investments made in certain technology choices will result in benefits.

Technology plays three key roles in the recycling sector: assistance in the quantity and quality of collection; assistance in the processing of recyclates; and finally, development of new products and markets for recyclates.

Many of the international technological developments in the recycling sector have focused on improving recovery rates and processing of recyclable material, with the aim of maintaining essential qualities of the secondary material for their reuse. This is because new environmental or recycling legislation, in particular in the EU, is focused on preventing the disposal of used material by entering landfill. There are pressures to meet recycling targets; hence the focus on collection, separation and processing.

Some technological development has also taken place in the use of recycling materials for purposes other than their original intended use. However, some of these developments still require considerable investment in research and development. Non-conventional uses have to be identified, primarily in the form of substitutes for conventional materials in the production of goods. An example of this is the use of plastics as a substitute for wood in certain types of construction; another is the use of a recyclate as a mixer with conventional material, such as glass aggregates used in the construction industry as fillers or reinforcement for conventional construction material. Table 7 provides an overview of available technologies for recycling. The table was developed specifically for the recycling of material in concrete and demolition waste, but gives a sense of what could be involved more generally, in terms of technology, when materials are recycled.
### Table 7 – Overview of recycling materials, applicable technology and products

<table>
<thead>
<tr>
<th>C&amp;D materials</th>
<th>Recycling technology</th>
<th>Recycled product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt</td>
<td>Cold recycling</td>
<td>Recycled asphalt</td>
</tr>
<tr>
<td></td>
<td>Heat generation</td>
<td>Asphalt aggregate</td>
</tr>
<tr>
<td></td>
<td>Minnesota process</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parallel drum process</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elongated drum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Microwave asphalt recycling system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Finfalt</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Surface regeneration</td>
<td></td>
</tr>
<tr>
<td>Brick</td>
<td>Burn to ash</td>
<td>Slime burnt ash</td>
</tr>
<tr>
<td></td>
<td>Crush into aggregate</td>
<td>Filling material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hardcore</td>
</tr>
<tr>
<td>Concrete</td>
<td>Crush into aggregate</td>
<td>Recycled aggregate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cement replacement (replace the cement by the fine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>portion of demolished concrete)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Protection of levee</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Back filling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Filler</td>
</tr>
<tr>
<td>Ferrous metal</td>
<td>Melt</td>
<td>Recycled steel scrap</td>
</tr>
<tr>
<td></td>
<td>Reuse directly</td>
<td></td>
</tr>
<tr>
<td>Glass</td>
<td>Reuse directly</td>
<td>Recycled window unit</td>
</tr>
<tr>
<td></td>
<td>Grind to powder</td>
<td>Glass fibre</td>
</tr>
<tr>
<td></td>
<td>Polishing</td>
<td>Filling material</td>
</tr>
<tr>
<td></td>
<td>Crush into aggregate</td>
<td>Tile</td>
</tr>
<tr>
<td></td>
<td>Burn to ash</td>
<td>Paving block</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asphalt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recycled aggregate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cement replacement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Man-made soil</td>
</tr>
<tr>
<td>Masonry</td>
<td>Crush into aggregate</td>
<td>Thermal insulating concrete</td>
</tr>
<tr>
<td></td>
<td>Heat to 900 °C to ash</td>
<td>Traditional clay brick</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sodium silicate brick</td>
</tr>
<tr>
<td>Non-ferrous metal</td>
<td>Melt</td>
<td>Recycled metal</td>
</tr>
<tr>
<td>Paper and cardboard</td>
<td>Purification</td>
<td>Recycled paper</td>
</tr>
<tr>
<td>Plastic</td>
<td>Convert to powder by cryogenic milling</td>
<td>Panel</td>
</tr>
<tr>
<td></td>
<td>Clipping</td>
<td>Recycled plastic</td>
</tr>
<tr>
<td></td>
<td>Crush into aggregate</td>
<td>Plastic lumber</td>
</tr>
<tr>
<td></td>
<td>Burn to ash</td>
<td>Recycled aggregate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Landfill drainage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asphalt</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Man-made soil</td>
</tr>
<tr>
<td>Timber</td>
<td>Reuse directly</td>
<td>Whole timber</td>
</tr>
<tr>
<td></td>
<td>Cut into aggregate</td>
<td>Furniture and kitchen utensils</td>
</tr>
<tr>
<td></td>
<td>Blast furnace deoxidization</td>
<td>Lightweight recycled aggregate</td>
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<tr>
<td></td>
<td>Gasification or pyrolysis</td>
<td>Source of energy</td>
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<tr>
<td></td>
<td>Chipping</td>
<td>Chemical production</td>
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<tr>
<td></td>
<td>Moulding by pressurising timber chip under steam and</td>
<td>Wood-based panel</td>
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<tr>
<td></td>
<td>water</td>
<td>Plastic lumber</td>
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<tr>
<td></td>
<td></td>
<td>Geofibre</td>
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<tr>
<td></td>
<td></td>
<td>Insulation board</td>
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</table>

*Source: Tam & Tam 2006*

If atypical uses are identified, markets have to be assured or developed in order to maintain the viability of the economics and the downstream materials recovery and processing. The latter part of
the value chain is the hardest to accomplish as it takes time and considerable public or private sector investment. It involves essentially innovations that carry the same commercial risks associated with any innovation – good innovations or new products are not always assured of success in the market. The point to reiterate here is that technology is only part of the solution; products need to be sold and their markets developed and matured to ensure success.

The following sections survey some of the new technologies and approaches being taken to increase recycling rates, the quality of recyclates, and the development of new upstream products and markets to boost the domestic value for recyclates. The emerging theme from the research is that both stable supply and stable demand are critical for the success of the industry and its long-term financial viability. The first section has a quick synopsis of some of the technological challenges associated with the plastics industry by way of illustration. Plastics pose a problem because there are different grades, and upstream market development requires considerable research and development to produce products that have market impact and penetration.

4.2 The challenges associated with plastics

There are two broad categories of plastics: thermoplastics and thermosets. Thermoplastics can be heated and reformed many times and so are ideal for recycling. Thermosets cannot be remelted. Thermoset plastics are particularly difficult to handle as they cannot be remoulded, even after separation and isolation from scrap mixtures. They are also associated with fibrous mixtures such as glass fibres, which are equally difficult to separate and reuse.

Thermoplastics, in turn, can be classified into different categories of plastics with different melting points, and thus have to be separated prior to reuse. The most common plastics are PET, used for soda bottles, and HDPE. PET and HDPE are the most frequently recycled plastic materials. The biggest alternative use of PET and HDPE is in the creation of fibres for duvets, pillows, textiles and carpets – this is a huge and well established market. The example, discussed below, of posts and poles is merely an attempt to point to other innovations that make it possible for additional uses and markets to be developed.

Many agencies and private companies have been experimenting with the use of recycled plastic for items such as guardrail posts and block-outs, delineator posts, fence posts, noise barriers, sign posts and snow poles. Although the product’s initial cost is currently higher than for conventional block material, it is believed that the post will resist damage and deterioration better than conventional materials, thereby resulting in reduced overall life-cycle cost.

In addition to this, a new industry is beginning to evolve involving wood/plastic composites. Recycled wood/plastic composite (WPC) lumber is one of the prime uses for recycled plastic trash bags and waste wood fibres. The composite material is used to produce building products such as decking, door and window frames, and exterior mouldings. Manufacturers claim that products produced with recycled WPC lumber are more durable than conventional preservative-treated lumber (Clemons 2001).

Furthermore, these products contain no toxic chemicals such as those used in conventional treated lumber. Recycled WPC lumber typically consists of a 50:50 mix of wood fibres from recovered sawdust and waste plastics that include high-density polyethylene and polyvinyl chloride (PVC). The material is formed into both solid and hollow profiles. Recycled WPCs are typically more rigid
than 100% recycled plastic lumber because the wood fibres act as reinforcement. In addition, the plastic encapsulates and binds the wood together to resist moisture penetration and degradation from fungal rot. Some recycled WPC lumber products can weigh considerably more than standard lumber products. Like other plastic products, recycled WPC lumber can become more flexible in hot weather and more rigid in cold weather than other decking materials.

The WPC industry is still small. Market surveys estimate that the WPC market was 320 000 tons in 2001, and the volume was expected to have doubled in 2005 (Clemons 2001).

A high proportion of plastics is derived from packaging waste generated by commerce, industry and households. Plastics used in electrical and electronic waste are very difficult to recycle. A very small portion of the 230 million tons of plastic produced annually in the world gets recycled. In Europe, for instance, only 4 million tons of plastic was recycled in 2005 of the 18% that was recovered. The volume of recyclable plastics is said to increase by 10% each year.

Europe produces about 21 million tons of plastic annually although only 16.5% is recyclable. The biggest user of plastics in Europe is the packing industry – it consumes 37% of the plastics produced by the plastics market. The EU launched a research initiative called NOVPOL, which aimed to create a recycling technology that could use a mixture of at least five different polymers. The initiative was completed in 2007, and resulted in greater efficiency of the recycling of plastics and on a more economical basis. The aim was to increase the efficiency and reduce the cost of recycling plastics, as they require manual sorting and separation into different polymers. The recycling of mixed plastic waste produces a homogenised thermoplastic, which has enhanced properties. The project’s objective was to provide a cost-effective recycling route for mixed polymer waste that produces recyclate with enhanced mechanical properties suitable for engineering applications, that can demand a selling price of at least 80% of virgin polymers. The technological objective was to have a homogeniser able to operate continually with output of at least 500 kg/hour, based on a 100 kW drive motor.11

In a Delphi study (Boks & Tempelman 1998) it was shown that new technology would make it possible to deal with mixed plastics; that manual sorting would still be cost-effective; and that economic attractiveness is linked to well defined waste streams and/or certain types of plastics. The technologies identified by the researchers for facilitating sorting varied from infrared spectroscopy to electrostatical sorting and using spectral analysis. It was also shown that these were the top three technologies identified for the future. One of the findings of the study was that the logistics of collecting and the market price of the recyclates are key to the recycling business. The quality and quantity of the plastic waste stream is more important than the plastic types it contains (Boks & Tempelman 1998).

Collection rates for plastics are growing in South Africa as a result of the plastic regulations and the demand for secondary material resulting from the increase in oil prices. China is clearly the dominant player in this sector and receives most of the world’s recyclable plastic waste. There may be opportunities for South Africa to develop new product lines that require recycled plastic – both as source material for the making of conventional products (like plastic containers or in packaging)

11 Refer to the product website at www.ist-world.org for further information.
and for the creation of new products. These opportunities need to be investigated, and their market potential explored as well as the technology options identified.

4.3 Advanced thermal treatment

Advanced thermal treatment (ATT) includes technologies such as pyrolysis and gasification, rather than incineration. Incineration technologies are already well developed and mature. Pyrolysis itself is not new – it has been used to churn wood into charcoal and produce gas from coke. However, its application in MSW is in its infancy. Pyrolysis is the thermal degradation of MSW in the absence of oxygen, with temperatures varying from 300–850 °C. The products resulting from the combustion are solid residues and syngas (Figure 13). The syngas is a mix of gases – hydrogen, carbon monoxide, methane and others. A portion of these can be condensed out to produce waxes, tars and oils.

Figure 13 – Advanced Thermal Treatment recycling

Source: DEFRA 2007a

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12 Pyrolysis and gasification both involve the heating rather than burning of waste. This is done until the waste material is broken down into a flammable mixture of carbon monoxide and hydrogen, in what is called syngas, with residuals of char, ash or slag remaining. The syngas itself can be converted into different chemicals or liquid fuel, like biodiesel. Those who are promoting gasification and pyrolysis technology argue that they are better and cleaner than waste-to-energy projects. Syngas itself can be used to power turbines and generate electricity.
Gasification involves the partial oxidation of a substance. The main product of gasification is syngas. The caloric values of syngas are lower than natural gas. The net caloric value (NCV) of syngas from pyrolysis is between 10 and 20 MJ/NM$^3$; from gasification the NCV is between 4 and 10 MJ/NM$^3$ where the NCV of natural gas is about 38 MJ/NM$^3$. This is one of the reasons why waste-to-energy projects in general have high capital costs with low energy value.

An ATT plant will typically have the following components:

- waste reception, handling and pre-treatment;
- a thermal treatment reactor;
- a gas and residue treatment plant;
- an energy recovery plant;
- an emissions clean-up plant.

The ATT plant has to be cleared of non-combustible material such as metals and glass, and uses the remaining paper, card, putrescible waste, green waste and wood as sources for combustion. Solid residues usually contain ash and metals. These can be further processed for recovery of the metals and recycled. The syngas can be used to boil water in a boiler, to generate steam and then electricity. Recyclates that are recovered from the ATT process – either front-end or back-end – are of low quality and value. Materials that are recoverable inevitably contain ferrous and non-ferrous metals (DEFRA 2007a, 2007b).

4.4 Mechanical heat treatment technologies

Mechanical heat treatment (MHT) is a new term used to describe heat-based methods of treating and separating waste. The different types of waste that can be processed and recovered by different current MHT technologies are illustrated in Figure 14. Table 8 lists other, conventional mechanical waste separation techniques. The MHT method is designed to enhance the amount of recyclates that are available for recycling, and the heat treatment sanitises the material by destroying bacteria and lowering the moisture content. The most common device is an autoclave.$^{13}$ It has commonly been used to treat medical waste. The alternative to autoclaves is a rotating kiln system in which heat treatment occurs in a non-pressurised environment.

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$^{13}$ This is a device used to expose items to steam at high pressure in order to decontaminate the materials or render them sterile.
Global trends in waste management: Some pointers for South Africa

Figure 14 – Mechanical heat treatment of waste

Source: DEFRA 2007b

Table 8 – Conventional mechanical waste separation techniques

<table>
<thead>
<tr>
<th>Separation technique</th>
<th>Separation property</th>
<th>Materials targeted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trommels and screens</td>
<td>Size</td>
<td>Oversize – paper, plastic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Small – kitchen waste, glass, fines</td>
</tr>
<tr>
<td>Manual separation</td>
<td>Visual examination</td>
<td>Plastics, contaminants, oversize</td>
</tr>
<tr>
<td>Magnetic separation</td>
<td>Magnetic properties</td>
<td>Ferrous metals</td>
</tr>
<tr>
<td>Eddy current separation</td>
<td>Electrical conductivity</td>
<td>Non-ferrous metals</td>
</tr>
<tr>
<td>Air classification</td>
<td>Weight</td>
<td>Light – plastics, paper</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heavy – stones, glass</td>
</tr>
<tr>
<td>Ballistic separation</td>
<td>Density and elasticity</td>
<td>Light – plastics, paper</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heavy – stones, glass</td>
</tr>
<tr>
<td>Optical separation</td>
<td>Diffraction</td>
<td>Specific plastic polymers</td>
</tr>
</tbody>
</table>

Source: DEFRA 2007b

In the UK, where MHT is being promoted, the markets for most of the products or outputs resulting from an MHT process are still to be proven. The net output of a heat/steam processing
system is relatively clean recyclables (tin, glass and plastics), with a fibrous material generated from
the breakdown of card, paper and green/kitchen waste and a reject fraction. One of the other
benefits is that there is usually a high-quality ferrous and non-ferrous metal stream that is
recyclable. Another important benefit is that labels and foodstuff are removed during this process,
rendering the cleaned material with a higher value, especially in the case of metals.

Sometimes plastics are rendered too deformed from the heat, and this reduces their recyclable
value. However, such plastics could be used as fuel to generate energy. The fibre is the main
product generated by a MHT system. Studies are still being done to find the most commercially
optimal use of the fibres, but it is thought that they could be used with crushed shale and a resin to
make tiles. Other uses being considered are fibre board, door and wall panelling and the production
of briquettes. However, the market for MHT fibre is not yet well developed, with more research
required. Most of the refuse-derived fuel generated in the UK becomes usable as a fuel source for
cement kilns or power companies generating renewable energy (DEFRA 2007a, 2007b).

Case study – The ArrowBio Process – a new waste-sorting technology

The ArrowBio Process is an innovation developed by an Israeli company, which recently signed a
deal to introduce their intellectual property (IP) in Australia. The technology is novel in the sense
that it uses water to separate waste. The following types of waste can be treated as-received:

- MSW;
- unsorted industrial waste from the paper (including recycled paper) and food processing
  industries;
- manures and agricultural residues;
- slaughterhouse wastes;
- sludge from sewage and water treatment plants;
- industrial settling tank sludge;
- garden waste with or without other household discards.

One of the key areas in which the technology is quite useful is MSW, which is unsorted and mixed.
The company states that MSW can be treated directly once it is tipped from a truck. In the primary
state of separation inorganic and organic waste are separated using the liquid-based separation
method. One end product of the process is clean recyclables such as glass, metals and plastics. The
next end product is an organic stream which is ready for the biological stage.

The organic matter comes in slurry form, rich with organic suspensions and high chemical oxygen
demand. This leads to high rates of methane gas generation. The company claims that the technology
allows for high levels of biogas production. Excess biomass is used as compost. This sludge contains
many plant nutrients, such as ammonia and phosphorus, in a readily available form for the plants.
This fraction, called ArrowBio compost, can be dewatered and sold as a high-value soil-conditioning
agent. Further processing, such as pelletisation of this product, will increase the market potential and
value of the ArrowBio compost. (See the company’s website, www.arrowbio.com, for further
information.)
Lessons and recommendations for South Africa

The environmental movement has been characterised by three waves: that of the 1900s, which involved conservation and protection of environmental resources; that of the 1960s and 1970s, characterised by regulation and compliance; and that of the 1990s, which is the wave we continue to experience now, characterised by commitment to green investments.

Recycling, like clean technology, fits within the ambit of the third wave. There is growing awareness of the value of recycling in terms of three areas of concern: reduction of the environmental impact of waste; acceptance of the need to do something about waste because of the growing global population and related consumption; and recognition that waste itself is both a cost and a value. In terms of cost, there are both direct costs, related to the need to dispose of the waste, and costs associated with externalities like pollution, which is borne by society and not accounted for in the life-cycle of the product. On the issue of value, entrepreneurs have sought to extract more value from waste through recycling that has in turn necessitated new technologies, new products and markets, and the development of business models to increase the profitability of waste recycling.

For instance, a UK-based company called Closed Loop Recycling has found that investing in expensive and new sorting technology, including enhanced plastics separation (with which it is experimenting), is profitable because there is a high demand for its recyclates from British retailers who are increasingly using recyclable plastics in their packaging and containers. For the British retailers in turn, using recycling material is cheaper, as the cost of virgin material is higher. The British company Tesco has also developed a product line, in this case school uniforms, made out of recycled polyester, and is experimenting with new uses to increase benefits from recycled material (Economist, 28 February 2009).

The prospects for the recycling industry on the whole look promising. There are several reasons why growth can be expected:

- Recycling rates in South Africa can be improved substantially with greater government and industry collaboration on policy, organisation of the market and location of appropriate infrastructure.

- If the global economy grows, resource demand for virgin material is likely to peak again and there should be concomitant demand for secondary material.

- Secondary demand will also be influenced by the relative prices of metals, energy cost (such as the cost of electricity and oil) and landfilling costs, making recycling a better option.

- Increasingly, governments all over the world are having to factor in the externality costs associated with the pollution and environmental damage that result from the production of virgin material. This will no doubt also have a positive impact on the viability of recycling, as these costs get incorporated into the manufacturing of products.

- Upfront investments in recycling at the lower end of the value chain are likely to push the development of upstream innovation to improve the increased use of recycling material.

- The world’s population and rate of urbanisation are expanding, especially in developing countries. This means more waste will be generated and there will be no shortage of workload in the waste sector.
In the case of landfill sites there are increasingly stringent laws, especially in developed economies, that specify the ways in which municipal wastes need to be dealt with. European law, for instance, prohibits the mingling of solid and liquid waste, and requires the separation of hazardous from non-hazardous waste. There are also standards regarding the lining of landfill floors with waterproofing and other material to prevent leachate. All of these contribute to the increased cost of landfills, besides the costs associated with the purchasing of land or the use of landfills.

With regard to oil, even though the price has come down of late, global projections – especially by the IEA – forecast that oil consumption will increase by 45% by 2030. Demand is likely to outstrip supply. Supply constraint is envisaged as a result of oil peak, and also of lag in oil production due to infrastructure investment backlogs related to the opening of new wells, to increasing recovery rates from old wells, and to investment in new refining capacity. Higher oil prices will be felt as higher input costs in transport energy, affecting production costs, including costs associated with the transport and extraction of metal ore as well as transport of waste. Secondary material production can offset some of the input energy costs, as the case study of aluminium in this report illustrates. This is one of the reasons why the secondary material market is growing in developing economies.

In the case of global waste generation, the OECD forecasts that waste generation in rich countries will grow by 1.3% per year up to 2030, but growth in emerging economies like India and China will be substantially higher: in India it is predicted that urban-dwellers will generate 130% more waste, and in China the prediction is over 200%. This growth in general is accompanied by growth in environmental awareness, and pressure on governments to do something about the waste problem (Economist, 28 February 2009). Governments, in turn, will have to introduce laws that will impose obligations on individuals, firms and municipalities to embark on recycling programmes. The public policy directives will assist in improving recycling rates (as has been shown in OECD countries); industry in turn will put pressure on governments to introduce incentives to cover costs associated with recycling; and this in turn can stimulate identification of new business opportunities. But a coherent public policy regime, that links pressure to recycle with incentives to industry and support for infrastructure and technology investments, can help strengthen and mature the recycling market.

Capitalising on these potential growth opportunities will require a value chain analysis for each of the different types of recyclates – including technology options for optimisation of collection, processing of the waste, reuse and development of new product lines, and development of markets where the recyclates can be used.

5.1 Should South Africa prioritise the growth of the recycling industry?

Designing good public policy, developing supply and demand markets, and creating incentives and tools to assist with respect to market failure will all assist in driving growth in the sector. Currently, recycling is driven by market conditions and regulations. Improving recycling rates can increase employment and income rates generated from recycling. In South Africa there is much focus on the mature markets such as glass, plastics, paper and aluminium cans. South African recycling has further potential if expanded to include other materials, such as batteries, tyres, electronic waste, and the recycling and reuse of materials from obsolete cars. These areas of recycling are growing internationally; however, South Africa still lags considerably. E-waste and the recovery of waste
from cars require specialised technologies, facilities and training. Whilst recovery of materials can be done manually, recovery from shredded composite parts requires special technologies so as to improve the volume of recoverable material. The benefit of dealing with e-waste is that it produces multiple streams of waste with revenue options.

Recycling is very dependent on consumer participation and compliance. Laws are not enough; strong levels of public awareness are needed. Financing each part of the system is key, as is creating the market for recycled materials. In the South African situation it is doubtful that the simple creation of a market for secondary materials will increase rates of recycling; the problem needs to be approached across the entire value chain. There is already a good market for certain secondary materials such as paper, glass and plastic, but their volumes can be increased through improved collection and local reuse. As has been proven in Asia, there needs to be a robust collection system. Even in countries where new technologies are being introduced to produce recyclates through automation, there is still a need to increase participation in recycling at the front-end. In China, it has been shown that an economic exchange between residents and buyers can be a useful incentive to drive increases in recycling rates.

Recommendation

- Rates of recycling, in terms of the volume collected and the recovery of usable material, will need to be improved, and this can only be done through clear policy and incentives that will drive collection rates and volumes at household and municipal levels. For example, the policy to place a levy on tyres that was introduced in South Africa in 2008 has already increased the volume of tyres collected by tyre retailers and manufacturers. The economies of scale in supply are already influencing downstream investment decisions concerning new technology to produce higher-value products from recycled tyres. This should be expanded in the future to other waste areas such as e-waste and vehicle waste. South Africa will have to consider ways in which to increase labour intensity in these areas, and/or make investments in facilities and technology to dismantle and process waste from these products. South Africa’s car market is expanding. There is an opportunity to look at this market and enhance the recycling segment so that more material can be generated. Investigation of market opportunities, with an analysis of different technology options for different waste streams in different parts of the chain, will be a useful exercise to undertake.

5.2 What are the prospects for the recycling sector?

Global demand for recycled material is considered to be healthy, and in the medium term looks likely to be sustained. It is difficult to predict the market conditions over a 10–20-year period, because much of the demand forecast for secondary material is difficult to predict. The prospects look positive, though, for reasons outlined earlier in this section. In the long term, domestic uses for waste need to be found to offset the importation of materials or to increase the use of secondary material in manufacturing. In the latter case, a more closed loop needs to be developed between improved systems of collection, processing of recyclable materials and their use in manufacturing. The entire notion of recycling has to be changed from being seen as purely an environmental issue. The country has to recognise that recycling provides materials that are substitutes for virgin materials, thus having a tremendous impact on our balance of payments and creating alternative sources of supply for metals, glass, plastics etc. It should be seen as strategic to building our national inventory of key materials as a supplement to the commodities trade.
Recommendation

- Analysing future market opportunities and growth will be critical to identifying where in the value chain strategic investments need to be made. These could be aimed at the better organisation of the waste industry, improving collection volumes, introduction of technology to improve the quality of those recyclates recovered, and finding markets and products for expanding the end use possibilities for recyclates. None of this will happen, as the British example discussed above shows, without the support of the government. The British government, for instance, financed and supported, by various means, the testing of new technologies, bringing different market players together (such as the waste company, a waste engineering firm, retailers and the banks) and helping to expand the end use market. In this way the British government avoided having recycling companies export raw plastic bottles to China by finding domestic uses for the material. It introduced a programme called the Waste and Resources Action Programme (WRAP) – a special agency tasked to help improve market conditions and use market forces to drive change in the waste management sector. In a global market where waste streams are increasingly being prioritised as part of the secondary market trade, innovation will have to be promoted and developed in ways that retain the use of the waste stream within the domestic economy. For this new end uses will have to be found, perhaps by replacing virgin material with existing product lines or through the development of new products. In this way future investments can be justified and encouraged. And, hopefully, this will lead to an improvement in the value-add and competitiveness of the waste sector within the global market.

5.3 How can South Africa improve recycling rates?

In developed economies, innovation in recycling practices has been identified as serving two purposes: firstly, reducing the amount of material that can have an environmental impact; secondly, introducing economic and technological innovations as instruments to increase the amount of recyclable material. In developing countries, the innovation has been to find ways of using manual labour to expand the level of collection and control of recyclables. In Asia, resource constraints are the key drivers for recycling. The net impact of recycling is also reflected as a hidden saving in energy usage, transport costs and purchase of primary raw materials where there is a likelihood of import inflation due to shifts in global commodity prices. So well organised has the sector become that Asia is now a net importer of recyclable material from major economies. Chinese companies, for example Nine Dragon, which specialises in recycling material, have established offices in Europe to facilitate growth.

Another area of innovation is the move away from centralised systems of disposal and separation to developing temporary disposal sites in which recycling is taken as close as possible to source. The location of MRFs may also play a role in changing some of the economics of recycling, from the point of view of collection, separation and disposal. The MRF facility itself can be fully mechanised such that raw waste is brought in and sorted on site, or it can be designed to undertake labour-intensive separation, cleaning and processing before disposing of remaining waste to landfill sites.

The decision to centralise or decentralise MRFs (close to landfill sites) is dependent on the peculiarities of the recycling system within a city or country. Decentralised systems may be cheaper if landfill sites are too far away. In the case of centralised systems, the MRFs receive the waste, recyclates are separated, cleaned and processed, and then they are taken directly to factories or
users. The MRFs can serve two systems: receiving mixed recyclates where the amounts paid are lower, or receiving separated recyclates where the amounts paid could be higher. Unrecyclable material is collected, stored and then sent to landfill sites.

The international studies clearly point out that while there are standard off-the-shelf technologies that can improve separation at MRFs or other facilities, they are not the only solution. Vast improvements can be made at the level of collection. This requires innovative organisation – both in terms of ways in which collectors can work more efficiently, and in identifying incentives for consumers to have a greater willingness to participate in recycling activities.

**Recommendations**

- **Policies to obligate recycling should be expanded into other waste streams so as to increase recycling rates for these wastes – this should include batteries, cars and e-waste streams.** Increased rates of recovery in these waste streams should be combined with incentives for upstream investments for the processing of this waste, or the use of material from the waste for other high-value purposes.

- **Given what Asian and Latin American countries are doing at the low end of the value chain there should be further investigations into, and encouragement of, different models of organisation and entrepreneurship related to collection and processing of recyclable material.** South Africa can do a lot more than it is currently doing. Such innovation should be driven by municipalities, and can be done through procurement policies aimed at small and medium enterprises already involved in the waste management industry.

- **MRFs can play an important role, but they need to be located strategically in ways that facilitate lower transport costs for collectors, serving as recycling depots in which large inventories of recycling material can be stored and then sent off to manufacturers or other users.** MRFs can also drive both the supply and demand sides of the process, through information exchange on volumes, prices and links to direct users of recycling material. A more innovative approach can be taken on MRFs as intermediary facilities and agencies between sellers and buyers to improve market conditions.

- **South Africa should do a local and international mapping of technologies for different recyclable materials – this should be done in relation to collection, processing, and end use technologies.** There are so many technologies – some may be more appropriate than others, given South African conditions. Some technologies may still be in an incubation phase and will require further development in order to make them commercially viable. It would seem that there are many technologies that can be imported to improve recycling rates and quality. However, there has been no exercise to date to determine their appropriateness, cost/benefits and likely uptake by industry. All of this requires a better economic strategy for the recycling industry that takes into account policy, incentives, markets (low- and high-end) and appropriate technology for different phases of recycling, types of recycling material and the end use products of the material.
Appendix

Case study – E-waste pilot in South Africa

The following text was taken directly from the HP (Hewlett-Packard) website in November 2008, www.hp.com/eur/environment:

HP today unveiled a pilot project in South Africa which will be a key component of the company’s strategy to tackle the growing amount of electronic waste in Africa and around the world. The project aims to create new jobs in disadvantaged communities by equipping people with the relevant training and equipment to dismantle electronic waste both safely and responsibly.

HP is working together with the Global Digital Solidarity Fund (DSF), the Swiss Institute for Materials Science and Technology (Empa) and Recover-e-Alliance, Wasteplan and the Salesian Institute locally in South Africa to assess the current conditions for electronic recycling and test methods to improve recycling processes and equipment.

The pilot project in Cape Town will represent the main focus of an African-wide project to tackle e-waste, which aims to develop a blueprint for electronic waste management across the continent. HP, DSF and Empa in cooperation with local organisations are also conducting studies in Kenya and Morocco.

‘HP has a responsibility that starts with the design of a product and goes right through to its disposal and we take that responsibility very seriously,’ commented Thoko Mokgosi-Mwantembe, managing director of HP South Africa. ‘We see this project as a way to help develop a sustainable infrastructure to safely deal with electronic waste based on local practices that will benefit local communities. Once fully operational, this pilot project will process up to 150 tonnes of equipment per year and create around 20 jobs.’

The pilot project in South Africa will concentrate on a low-tech and labour-intensive material dismantling and recovery facility (MRF) in Cape Town. The aim is to maximise the potential for refurbishment, repair and reuse of ICT equipment, with environmentally responsible dismantling and recycling only as a last resort. The project also seeks to incorporate informal e-waste processing activities that have proved highly effective in dealing with waste, by transforming them into sustainable and environmentally sound operations.

‘We have seen some very inventive and entrepreneurial people making a living out of dismantling old electronic equipment in South Africa,’ said Gerry Newson, Recover-e-Alliance. ‘This equipment is being refurbished to be used by the community and people are making everything from toys to art out of it. We are looking to develop effective methods of dealing with waste that will allow this sector to flourish in a safe and sustainable manner.’

For decades HP has worked to manage its environmental impact by adopting environmentally responsible practices in product development, operations and supply chain. The company strives to be a global leader in reducing its carbon footprint, limiting waste and recycling responsibly. HP South Africa recently received the ISO 14001 certification, an international standard that provides a framework for organisations to manage, control and demonstrate their environmental conservation practices.

More information about the company’s environmental programmes is available at www.hp.com/eur/environment.
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