Plastics Recycling: an Australian Overview

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INTRODUCTION

Although Australia has a relatively small population of some 17 million in a continent whose area is approximately the same as mainland USA or continental Europe, it has a highly urbanised society. In fact, if city nations such as Singapore are discounted, Australia is one of the most urbanised nations in the world with a large percentage of the population living in the major cities, Sydney, Melbourne, Brisbane, Adelaide and Perth. In terms of waste management, this provides both advantages and disadvantages. With a degree of concentration of the population, options such as kerbside collection of recyclables become possible. However, there is the natural reluctance of communities to have waste management centres and landfill in their locality which has led to the so called "NIMBY" syndrome (Not In My Back Yard). This in turn leads to extra costs for waste disposal in terms of transport and greater environmental controls.

In Australia, waste collection is predominantly the responsibility of local government who dispose of waste almost entirely by landfill. The cost and availability of landfill sites has lead a number of councils to implement strategies to reduce the volume of waste going to landfill. As an example, the Brisbane City Council which serves the greater Brisbane area with a population

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of around 1million people has a target of reducing landfill by 50% by th year 2000. To achieve this, they have adopted such measures as promoting composting of garden and kitchen wastes by providing low cost composting bins and the provision of recycle bins to every householder to collect recyclables specified as newspapers, metal cans, glass and plastic bottles. The contents of the recycle bins are then collected separately and taken to recycle stations where the individual materials are separated. The provision of the recycle bins has also been adopted by numerous other local governments and follow from trials of such schemes in selected areas in the early 1990's. In addition, there are a number of community based recycling programmes to collect specific products such as aluminium cans, PET bottles and Telephone Directories. Many of these programmes have been driven by the manufacturers effectively subsidising the collection process so that it becomes attractive as a fund raising exercise for community groups.

The public perception and awareness of the need to recycle has grown enormously in the last five years in Australia. The high profile that these issues have in Australia is epitomised by the Sydney bid for the year 2000 Olympic Games which were billed as the 'Environmentally Friendly Games'. This has already affected many areas of planning for this event ranging from the choice of building materials to the developing of biodegradable packaging materials, crockery and cutlery. Although plastics are only a small proportion of the municipal waste stream (approximately 7% by weight), their high visibility and long lifetime has given plastics a prominent position in the recycling debate. Unfortunately, some of this debate has been ill informed and often neglects the beneficial aspects of plastics, such as their ability to protect the quality of food in packaging or their use as light weight structural materials, that have a positive influence on lifestyle and the environment.

RESPONSE OF THE PLASTICS INDUSTRY IN AUSTRALIA

The community perception of plastics being environmentally unfriendly led the plastics industry under the umbrella of the then Plastic Industry Association, PIA (currently the Plastics and Chemical Industry Association, PACIA) to set up an Environment Action Group. This group embarked on a campaign to improve the industry's environmental record supported by a credible well researched communications programme. Initiatives included the developing of a National Recycling Plan, the adoption of the international coding system to aid in the identification and sorting of plastics, and the sponsoring of recycling trials in Sydney and Melbourne and at major sporting events to establish the viability of recycling programmes. Communications activities included the publication of a Plastics Recycling Register [1], which provided information on recycled products and companies involved in recycling, the sponsorship of a 'Design for Recycling Competition', and the funding of a Plastics Recycling Kit [2] for use by teachers in schools. In addition a number of market sectors such as the polystyrene producers and the PET bottle manufacturers and soft drink bottlers have initiated specific programmes for recycling. These have involved levees to support research and development activities and, in the case of PET, to maintain a minimum price for recycled PET.

BIODEGRADABLE PLASTICS FROM RENEWABLE RESOURCES

The awareness of the impact plastics have on the environment has also led to an interest in some quarters in biologically produced polymers such as polyhydroxybutyrate and starch based polymers. Australia has a strong agricultural industry and is a low cost producer of sugar and maize. It would seem logical, for example, to exploit the status as a low cost producer of sugar to produce polymers via fermentation. The biodegradable polymers may have some effect on waste management in the long term but the fact that there is some doubt as to the rate at which

they will degrade in landfill suggests that their main attractiveness to the community at large will be that they are made from renewable resources rather than their inherent biodegradability.

WASTE MANAGEMENT STRATEGIES

Figure 1 shows a typical waste management strategy. It is of course preferable to reduce the amount of waste produced in the first place. This can often be achieved in the plastics converting industry by good design, total quality management and modern processing equipment. In addition, careful design and material selection may allow lower weight objects to be produced which in turn means lower waste when these objects finally make their way into

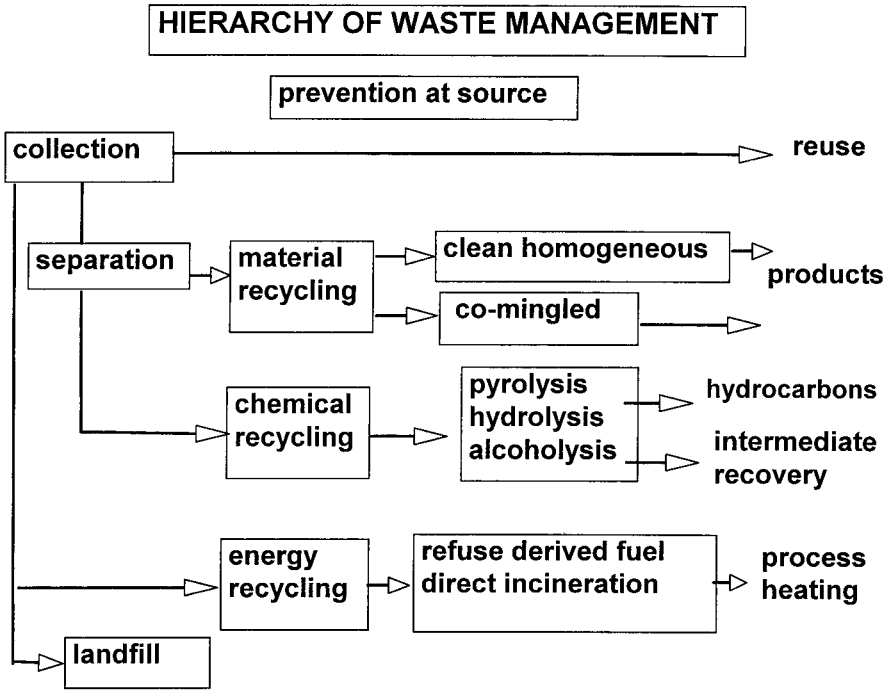

Figure 1 Typical waste management strategies

the waste stream. Design is also important when it comes to separating plastics from manufactured goods and a number of initiatives have been taken by the plastics industry in Australia to improved design for recycling[3].

Inevitably in most processes to manufacture plastic articles, a degree of waste is produced. However, since this is a relatively clean source of waste of known origin and history, it can usually be recycled directly into the same product or related products often via closed loop systems within the same factory. In keeping with world best practice, the Australian plastic converters practice a high level of recycling of this industrial waste.

Once the plastic product leaves the factory, the problems of recycling become more difficult. If the post consumer waste can be collected and separated economically into its component plastics, then a useable recycled granulate can be produced. In Australia to date, this form of recycling has been restricted largely to PET soft drink bottles and HDPE milk bottles since these constitute large and readily recognisable product streams. However, if the component plastics cannot be readily separated from each other, it then becomes quite difficult to make acceptable products from the mixed waste due to the inherent incompatibility of most polymers.

Although it is preferable to reuse the polymers, the plastics can be used as an energy source since they still retain high calorific value or in some cases, the plastic can be converted back to the monomer and these monomers used to reform the polymer. The final option is to place the plastics in landfill sites.

In Australia, except in a number of specific cases, land fill remains the predominant waste management strategy. This has been for a number of reasons. Traditionally the cost of landfill in

Australia has been under valued. According to a Bureau of Industry Economics report[4], factors that have traditional not been included in the cost of landfill have included:

-deterioration in environmental amenity due to landfills

- environment contingency costs

- closure and post closure monitoring costs and

- the cost of the land used for the landfill

The cost of labour and equipment used in the land fill were also often undervalued. In many remote areas, the cost of land used for landfill is very low and the low volumes of recyclables and the cost of transport of these to recycling facilities will make landfilling the preferred option.

According to a recent report[5], Australia has no precise data on municipal waste incineration but the rate of incineration is very low by international standards. Australia possesses only a small number of incinerators, most of which are used for specific wastes such as hospital waste, with only one incinerator reported to be burning waste at a reasonably large scale. The reason for the under-utilisation of incineration for waste management in Australia is probably twofold. Firstly, the costing of the landfill option mentioned above has been generally under-valued. Secondly, there is a strong community resistance to incineration which has not only persuaded local authorities away from the option but has also constrained informed debate on the issue. Community perception of incineration in general may be influenced by a recent unsuccessful attempt to establish a toxic waste incineration industry.

AUSTRALIAN PLASTICS MARKET

The market for plastics in Australia is approximately 1 million tonnes per annum of which approximately 70 % is consumed in long life products. These include applications such as the automotive industry, building and construction, electrical goods and those items that have a useful life over 5 years. The remaining 30 % of plastics used each year in Australia goes into packaging and appears in the waste stream.

Table 1 gives capacity and demand for the common packaging plastics in use in Australia in 1992.

Table 1 Capacity, Demand and Imports of Packaging plastics (tpa) in Australia in 1992 [5]

Product	Capacity	Demand	Imports
LDPE	125,000	120,000	13,000
LLDPE	100,000	55,000	47,000
HDPE	150,000	125,000	22,000
PP	255,000	125,000	13,000
PS	65,000	46,000	n.a.
PVC	175,000	150,000	25,900
PET	Nil	26,000	21,000

The majority of the Low Density Polyethylene (LDPE) and High Density Polyethylene (HDPE) consumed in Australia is locally produced. While significant amounts of Linear Low Density Polyethylene (LLDPE) were imported in 1992, these imports have been reduced by ICI Australia's new LLDPE production facility in Botany, Sydney. Australia is a net exporter of Polypropylene (PP) and is reasonably self sufficient in PVC. However, there is no producer of Polyethylene terephthalate (PET) and this is all imported.

In packaging applications, LDPE is used in such areas as shopping bags and film, while HDPE is used in milk bottles and other general bottle applications. PP is also used in bottle

applications but also in such items as margarine and fast food containers and ice cream containers. PET is the predominant material used for carbonated soft drinks and is also gaining popularity in other fruit juice areas. In the area of pasteurised fruit juice, this is largely at the expense of PVC since both PVC and PET make excellent clear bottles. PS is used in expanded form in meat packaging trays, disposable cups for hot beverages and produce boxes and trays. Some styrenic based materials also find their way into small food containers.

RECYCLING

A recent Strategic Industry Research and Analysis report[6] split plastic waste into three categories, industrial waste where plastics are recycled within an industrial process, post consumer industrial waste where the waste is generated from within industry and post consumer domestic waste. The report indicated that approximately 47,000 tpa of plastic waste is recycled in Australia from industrial and commercial sources and a further 12,000 tpa comes from post consumer domestic waste. Figure 2 indicates that the rate of recycling of plastics from industrial sources has remained relatively stable through the 1990's suggesting that this process has been

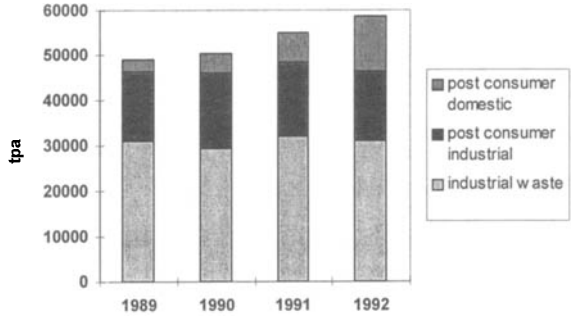

Figure 2 Plastic waste collection by source
(Source SIRA, Australian Plastics Materials Survey,1994

well established for a long time. The rate of post consumer waste collection has however increased markedly in the last five years.

Table 2 shows the amount of each type of plastic collected in1992. The market sectors that show significant recycling rates are the PET soft drink bottles and the HDPE milk bottles with

Table 2 shows the amount (tpa) of each type of plastic collected in 1992. [5,6]

Plastic Type	Amount Consumed	amount recovered/collected	% recovered
PET	28000	5435	20
HDPE	140000	4612	3.3
PS	46000	652	1.4
PVC	170000	400	.2
LDPE	121000	713	.6
PP	160000	385	.2

over 80% of all recycled post consumer recycled plastics being PET and HDPE. This reflects the relatively well established collection infrastructure for the easily identifiable products, milk bottles and soft drink bottles, but does not correspond to the relative ranking of the resins as they would most likely appear in the waste stream. In the order of tonnages of these plastic used in packaging, the order would be: LDPE, HDPE, PP, PET, PS, PVC.

Although public perception is that plastics compose a large volume of the waste stream going to landfill, the typical composition of municipal waste in Australia contains only ~ 7% by weight of plastics. Table 3 shows the typical composition of waste. These figures are very similar to other developed western nations. These figures also support the approach of a number of municipalities, such as the Brisbane city council, who have attempted to reduce the amount of landfill by encouraging composting by local residents since the single largest component of the municipal waste stream is compostable materials.

Table 3 Typical composition of municipal waste[5]

material	% by weight
paper/cardboard	21
putrescibles	48
plastic	7
inert solids	4
glass	9
ferrous metals	5
non-ferrous metals	1
cloth/fibre/wood/other	5

Over 40 companies in Australia are involved in the plastics recycling industry. A register of these companies has been produced by the PIA[1]. Most of these companies are relatively small operations with low employment levels and low tonnages handled and specialise in a specific processing method or polymer type.

RECYCLING OF SPECIFIC PLASTICS

HDPE

HDPE milk, cream and fruit juice bottles are currently recycled at a rate of ~ 20 % in 1993 [5]. This rate has been growing strongly over the last few years probably reflecting the growing rate of kerbside collection and the relatively uniformity of the collected material. The majority of recycling of HDPE is undertaken by Full Cycle Plastics in Melbourne and Plastics Recyclers (Queensland) who recycle the HDPE into products such as mobile garbage bins, crates, compost bins, inspection pits and covers, garden products and the like. Currently there is a surplus of milk bottle feedstock due to a lack of end-use markets. A stockpile of some 2,000 tonnes existed in 1993 and it is expected that this will increase by a further 2,000 tonnes in 1994. The problem of developing end-use applications has been exacerbated by the low cost of virgin materials through the recession of the early 1990's.

A national waste reduction plan is being developed for HDPE supermarket bags A joint effort between bag manufacturers and retailers is being established to collect bags for recycling.

PET

Over 20 % of all PET bottles produced are currently being recycled. A number of processes are being used for the recycling of PET. The most innovative is the development of a process to make multi-layer oriented PET bottles which has been developed by ACI Petalite. This allows the use of up to 30 % recycled material in a sandwich layer between two layers of virgin PET. The injection moulded preform is made by a sequential co-injection of recycled and virgin polymer which results in a laminated preform with recycled material coated with virgin material. Virgin material is also used at the closure end of the preform. The preform is then stretched into the final bottle with the oriented virgin PET in the body of the bottle giving a good barrier between the bottles contents and the recycled layer. This is an important innovation as it allows the use of recycled plastic in a food contact application.

A second PET recycling process (Smorgon) uses a cryrogenic process to granulate PET and separate contaminants such as PVC via gravity separation. Washed flakes are then processed into pellets which can then be made into bottles, sheet or other moulded forms. the flake material is also exported. Smorgon plastics has also announced the adoption of a chemical recycling process for PET. Southam [7] described the process as one in which the flaked PET is separated from paper and polyolefins in a water wash process after which the PET is partially depolymerised to make the PET brittle. This material is crushed which allows separation of uncrushed paper, PVC aluminium etc. After hydrolysis the terephthalic acid is recovered from boiling water. this material after further purification can be repolymerised to PET.

PVC

A recycling rate of ~ 6% of PVC fruit juice and cordial bottles was reported in 1993 and ~ 15% for container applications. PVC bottles have been recycled by Cryogrind under an agreement with Geon Australia using a process of cyrogenic grinding. The ground material can be mixed with virgin PVC and moulded into non-pressure pipe and flooring. A process for making non food bottles has also been developed by ICI Australia.

PS

Both PS and expanded polystyrene EPS are used in packaging as small containers and trays for meat and other foods. Due to their relatively low usage, they tend to be uneconomic to collect via kerbside recycling schemes. Since most Ps and EPS used in packaging also has had food contact (eg. yoghurt for PS and meat for EPS) these materials tend to have a high level of contamination and cannot be recycled into food contact applications.

In common with the PET users, the two major suppliers of PS in Australia together with a number of importers have formed a Polystyrene Producers council that has placed a small levy on sales of PS resin which has been used to fund various recycle and reuse schemes.

Mixed Plastics

A number of companies operate mixed plastics recycling plants and the majority of these plastics are sourced from kerbside recycling schemes. These mixed plastics face the problem of the incompatibility of the component plastics. Smorgon Plastics Recycling (Victoria) recycle mixed plastics into a lumber substitute which has been used for park benches, posts and poles, garden goods and other outdoor lumber applications.

An innovative product has recently been developed by the Polymer Technology Centre at RMIT were mixed PET and HDPE have been processed into a tough, strong product that can be

injection moulded. The controlled processing of this blend produces a fibrous PET inside the HDPE matrix.

RESEARCH AND DEVELOPMENT

Projects to increase the recycling of plastic materials involving researchers from universities, government laboratories, such as the Commonwealth Scientific Research Organisation (CSIRO), and industry have been encouraged by the Australian government particularly through its Generic Industry Research and Development (GIRD) scheme.

An example of this cooperation is a project at the Royal Melbourne Institute of Technology (RMIT) in conjunction with CSIRO, Division of Building Construction and Engineering, and Encore Rubber Technologies, a subsidiary of the large conglomerate Pacific Dunlop, to recycle waste automotive tyres into a rubber-polymer blend for use in other products. Discarded car tyres are a major environmental problem in Australia, as in other developed countries, with over 10 million tyres being disposed of in Australia each year. The aim is to recycle more than 3 million tyres per year.

The Polymer Technology Centre at RMIT also have a number of other active recycling projects such as developing useful blends of PET and HDPE. The Centre for Design at RMIT is involved in both teaching and research into the design of products for recycling. One such programme involved a local electrical goods manufacturer, Kambrook, and was again supported with government funds through an Australian Research Council (ARC) Industry Collaborative research grant.

The Cooperative Research Centre for Polymer Blends, which combines research groups from CSIRO, Monash University, RMIT and DSTO with ICI Australia and Huntsman as industrial participants, has been working on a number of blend projects that have relevance to recycling such as polyolefin blends and blends of engineering polymers. They have also been investigating the recycling of painted toughened PP automotive bumpers.

Numerous polymer groups around Australia are involved in work relevant to polymer recycling. The polymer group at the University of Queensland has long been involved in the degradation of polymers and also has activities in rheology and mechanical property of blends.

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