Q7

Issue 7

quickstart

Design for Sustainability with Plastics

Specifying recycled plastics

This is the seventh in a series of Quickstarts on Design for Sustainability (D4S) with Plastics. It includes information and guidelines on the use of recycled plastics in the manufacture of new products. There are a number of recovery options for plastics (discussed in Quickstart 5) including mechanical, biological and energy recovery. This Quickstart only focuses on plastics recovered through mechanical recycling processes.

The Quickstart covers:

- Sustainable design principles for recycled plastics
- Recycled plastics in the supply chain
- Benefits and applications of recycled plastics
- Checklist for using recycled plastics in design and manufacture
- Marketing and recycled content in products
- Regulations and standards

Lampshade made from recycled polypropylene (image supplied by Eco Depot)

Footwear manufactured from recycled polyvinyl chloride (PVC) (image supplied by Vinyl Council Australia)

Three principles for D4S were identified in Quickstart 1 Some of the implications of these for the use of recycled plastics in design are listed in Figure 1.

Design principles

Figure 1: Sustainable design principles and recycled plastics

Sustainable design principle	Implications for recycled plastics
Triple bottom line sustainability – considering the long term benefits and impacts on human health and quality of life, commercial feasibility, and the natural environment	• Recycled plastics are suitable for a wide range of product applications and are often competitive with virgin polymers in both cost and quality. • Recycled plastics can provide a marketing advantage if promoted accurately and effectively to consumers. • The use of recycled plastics reduces waste and landfill burden by providing an end-market for reprocessed materials.
Life cycle approach – considering the benefits and impacts of a product within the context of its total life cycle	• Recycled plastics generally have a smaller environmental footprint than virgin plastics over their life cycle[1]. They use less energy to manufacture and generate less pollution because they avoid the resource extraction and polymerisation stages. • Plastic products should utilise recycled material where suitable, but they should also be designed for recycling. This helps to provide an ongoing supply of high quality recycled material to the market.
Step-change transformations – developing new and innovative ways to deliver product value with significantly less environmental impact	• Advances in reprocessing technologies are opening up new applications for recycled plastics, particularly for food contact.

The aim of the Quickstart series is to promote the design of products and services that are sustainable - that is, products and services that contribute to social progress and economic growth, as well as providing ecological benefit, throughout their life cycle. The sustainability of a product is largely locked in at the design phase, which is why D4S is so important.

The Quickstarts are written for practitioners at every stage of the plastics product chain, including designers, polymer suppliers, product manufacturers, brand owners, specifiers and recyclers. The series also supports the implementation of PACIA's Sustainability Leadership Framework (2008), which promotes a whole-of-life approach to product innovation and stewardship and the need for step-change 'transformations' in material and resource use.

Outdoor furniture manufactured from a mix of pre-consumer and post-consumer HDPE and PP plastic. Post-consumer material includes packaging from kerbside collections, plastic bags from supermarkets and sterilised wrap from hospitals (image supplied by Replas)

The supply chain for recycled plastics

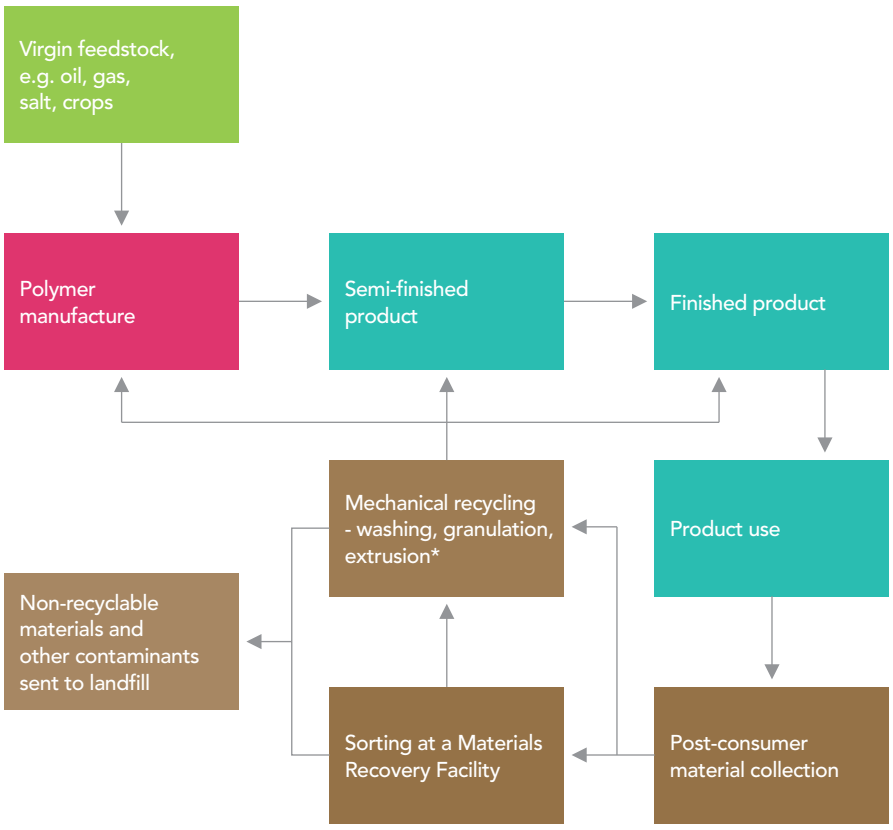
Recycled plastic products are manufactured from:

- material generated by the end-users of products that have fulfilled their intended purpose or can no longer be used ('post-consumer'); and
- material diverted during a manufacturing process ('pre-consumer')[2].

These materials are collected, sorted, washed (if necessary), reprocessed and used in the manufacture of new plastic products (see Figure 2). Pre-consumer waste is often preferred as a source of raw material because it is cleaner, more homogenous and available in more concentrated locations than post-consumer waste.

Post-consumer material from households is sorted at a Materials Recovery Facility (MRF) into individual polymers and/or mixed streams, depending on market requirements. Non-recyclable materials and other contaminants are sent to landfill. Further sorting is undertaken during the mechanical recycling process. For example, non-compatible polymers and paper labels are separated during the washing of the flake. The quality of the new product will depend on the condition of the recycled materials, contaminants, and the effectiveness of sorting processes at the MRF and during reprocessing.

Figure 2: The life cycle of post-consumer recycled plastics



* Washing and extrusion are not always undertaken depending on market requirements.

Tubs made from recycled plastic and rubber (image supplied by Eco Depot)

If used effectively, recycled plastics can provide financial, marketing and environmental benefits for product manufacturers, retailers and users. Recycling also generates economic and social benefits such as income and employment within local communities.

The benefits of recycled plastics

Using a recycled plastic is beneficial because it avoids the much larger environmental impacts associated with the manufacture of a virgin material. For example, there are significant benefits when recycled polyethylene terephthalate (PET) is used to replace a percentage of the virgin PET in a soft drink bottle, or when recycled polypropylene (PP) from old battery cases is used in new battery cases. This is often called 'closed loop recycling'.

Closed loop recycling is not always possible, such as when recycled materials are not available in sufficient quantities or when they do not meet the necessary performance standards (e.g. for food contact applications). However, recycling generates similar environmental benefits if the recycled material replaces a virgin polymer in another application.

This is the case, for example, when recycled PET replaces virgin polyester in clothing and textiles and when recycled PP is used in materials handling pallets or crates.

The energy savings generated by recycled plastics over their life cycle are shown in Figure 3. These savings assume that the recycled material replaces virgin polymer.

Some mixed recycled polymers are not suitable as a replacement for virgin polymer in applications with tight performance specifications. However, mixed polymers are used to replace timber or concrete in many different products (see Figure 4). These applications divert material from landfill and avoid the significant environmental impacts associated with forestry or cement production.

Figure 3: Energy savings of recycled plastics compared to virgin plastics[3]

Plastics Identification Code	Material	Energy saving
1	Polyethylene terephthalate (PET)	76%
2	High density polyethylene (HDPE)	79%
3	Polyvinyl chloride (PVC)	80%

Note: High energy savings are partly due to the feedstock energy in virgin material (i.e. the use of oil or gas as a raw material for polymer manufacture as well as energy production).

Applications for recycled plastics

Designers need to match the material specifications for their product with the performance characteristics of a recycled material.

Plastics may degrade during the recycling process due to:

- mixing of different polymers and polymer grades;
- the presence of additives such as pigments, fillers, stabilisers and flame retardants; and
- contamination with other materials, such as aluminium or paper, from closures, labels, coatings etc.

It is therefore very important to design plastic products for recycling (see Quickstart 5) and to ensure that materials collected for recycling are as clean and homogenous as possible.

There may also be some thermal degradation of plastics during reprocessing which can reduce its environmental stress crack resistance (ESCR).

Reprocessors can modify recycled resins to meet customer requirements, for example by adding UV stabilisers, colour or fillers. The resins can also be blended with virgin plastics to improve characteristics such as melt flow index (MFI), toughness or ESCR[4].

While they may not have exactly the same properties as virgin resin, recycled plastics can be used in a wide range of applications (see Figure 4). Some sources of recycled material, such as PET bottles, HDPE milk bottles and PP crates, are particularly valuable as a raw material for new products because they have consistent properties. A new process developed in the UK produces HDPE milk bottles with 30% recycled content from recovered milk bottles, and these perform in an identical way to virgin bottles[5].

The variable performance qualities of some other recycled materials mean that they are better suited to applications which do not have tight performance specifications. Popular applications include outdoor furniture, traffic management products, pallets, decking and vineyard posts. These recycled materials may not be suitable for:

- thin-walled products;
- products with tight material specifications;
- food contact packaging (unless they meet stringent regulatory standards); and
- packaging for products covered by Dangerous Goods regulations.

Another factor which may limit the use of recycled plastics in some applications is availability. For example, while recycled low density polyethylene (LDPE), HDPE and PP are widely available, some engineering resins are only available in limited quantities. A list of polymer recyclers/ recycled resin suppliers is available on PACIA's web site at www.pacia.org.au.

Figure 4: Applications for recycled plastics[6]

Plastics Identification Code	Polymer	Applications
1	Polyethylene terephthalate (PET)	Beverage bottles, clothing, geotextiles, yarn, strapping, pallets, fence posts.
2	High density polyethylene (HDPE)	Film, blow moulded containers, storm and agricultural pipes, irrigation tubes, mobile garbage bins, shopping and garbage bags, building and industrial film, wood substitutes, water tanks, mixed plastic products (e.g. fence posts, kerbing etc), materials handling products.
3	Polyvinyl chloride (PVC)	Pipe, floor coverings, hoses, profiles, electrical conduit, clothing, bags, shoes.
4	Low density polyethylene (LDPE) / Linear low density polyethylene (LLDPE)	Builders and agricultural film, shopping and garbage bags, shrink wrap, agricultural pipes, trickle irrigation tubes, vine cover, slip sheets, fence posts, timber replacement products.
5	Polypropylene (PP)	Crates, boxes, plant pots, electrical cable covers, building panels, bar stools (for concrete reinforcing), furniture, automotive parts, agricultural and garden pipe, tanks, builders film, worm farms, kerbing, bollards.
6	Polystyrene (PS)	Bar chairs, industrial spools, office accessories, coat hangers, industrial packing trays, wire spools.
6	Expanded polystyrene (EPS)	Waffle pods for buildings (used in concrete slabs), synthetic timber products (including photo frames, decorative architraves and fence posts), insulation sheeting, lightweight concrete.
7	Acrylonitrile butadiene styrene (ABS)	Injection moulded products, sheet extrusion, coffin handles, drainage covers, automotive components.
7	Polyurethane (PU)	Carpet underlay, mattresses.
7	Nylon	Furniture fittings, wheels and castors.
7	Mixed polymers	Agricultural pipe, fence posts, bollards, garden stakes, kerbing, marine structures, outdoor furniture, sheet extrusion, post and rail systems, shipping dunnage, rail bridge transoms, bottle blowing, sheet extrusion.

Bollards made from recycled plastics (image supplied by Replas)

Checklist for specifying recycled plastics

To successfully use recycled plastics in the design and manufacture of a new product:

- be clear about the material specifications for the product and ensure that the specifications are performance-based rather than material-specific;
- it may be necessary to adjust the design of the product to accommodate recycled material[7];
- choose a reputable plastics recycler who can provide detailed technical data sheets and good customer support;
- develop a long term relationship with recyclers – the benefits are likely to include guaranteed supply, a more stable price and technical support;
- make sure that the recycled material is available in sufficient volume for the product; and
- design the product for recycling to support the supply of high quality raw materials for the recycling process.

Marketing recycled plastic products

Marketing claims about recycled content in products need to be accurate and verifiable in accordance with the Trade Practices Act 1974 and Australian Standard 14021[8].

'Recycled content' is defined as the proportion, by mass, of recycled material in a product or packaging. This definition only refers to pre-consumer and post-consumer material – it specifically excludes scrap or regrind that is generated in a manufacturing process and can be reclaimed in the same process that generated it[9].

The 'mobius loop', accompanied by information on the percentage of recycled content, is recommended for claims about recycled content (Figure 5). If recycled content varies, then a minimum amount or range can be specified.

Figure 5: The mobius loop with recycled content claim[10]

Chair with recycled polyethylene terephthalate (PET) upholstery (image supplied by Formway)

The Quickstart series is part of the 'Design for Sustainability with Plastics' program managed by a collaborative partnership between Sustainability Victoria and PACIA. The Quickstart series can be downloaded from www.pacia.org.au.

Regulations and Standards

Recycled plastics intended for food contact applications must meet the requirements of Australian Standard 2070 (*Plastic materials for food contact use*). The test Standard normally applied is the US Food and Drug Administration's (FDA's) standard for recyclates in direct food contact[11]. Recycled products that are exported may also need to meet other specific requirements[12].

Further information

PACIA (to download the D4S toolbox and Quickstart series and to find plastic recyclers/ recycled resin suppliers): www.pacia.org.au

Sustainability Victoria
(to download D4S resources):
http://www.resourcesmart.vic.gov.au/for_businesses/3526.html

Publication details

Quickstart: Design for Sustainability with Plastics was prepared by Helen Lewis Research for Sustainability Victoria and the Plastics and Chemicals Industries Association (PACIA) with input and advice from practitioners and others involved in the sector.

Footnotes

1 Grant, T., James, K., Lundie, S. and Sonneveld, K. 2001, *Stage 2 report for life cycle assessment for paper and packaging waste management scenarios for Victoria,* January 2001, EcoRecycle Victoria, Melbourne.

2 ISO 2008, ISO 15270: *Plastics - guidelines for the recovery and recycling of plastics waste,* Geneva, p. 4.

3 Grant. *et al,* Ibid.

4 CRC for Polymers 1999, *Reconstituting PET for sustainable recycling,* Final report to EcoRecycle Victoria.

5 Recycled HDPE milk bottles are a desirable source of raw materials for recycling because they are available in large volumes, are unpigmented and have a consistent melt flow index (MFI). For the results of the trial see WRAP 2007, *Large scale HDPE recycling trial,* www.wrap.org.uk/downloads/WRAP_Large_Scale_HDPE_Recycling_Trial_Report.4cb6e1dc.3769.pdf.

6 Based on PACIA 2008, *2008 Plastics recycling survey,* www.pacia.org.au/_uploaditems/docs/Recycling%20Survey%202008%20Report.pdf, p. 45.

7 For example, geotextiles made from 100% recycled PET achieve physical properties equal to virgin material if the fabric is around 5% heavier (Kosior and Kegel 2000, *Geotextiles from recycled PET,* Report to EcoRecycle Victoria).

8 For more information see ACCC 2008, *Green marketing and the Trade Practices Act,* www.accc.gov.au/content/index.phtml/itemId/815763; and Standards Australia 1999, *AS/NZS ISO 14021: 1999, Environmental labels and declarations - Self-declared environmental claims (Type II environmental labelling).*

9 Standards Australia, Ibid, p. 13-14.

10 Standards Australia, Ibid, p. 15.

11 Food and Drug Administration (FDA) 2006, *Use of recycled plastics in food packaging: chemistry considerations,* www.cfsan.fda.gov/~dms/opa2cg3b.html.

12 For example the European Commission has introduced the Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) (http://ec.europa.eu/enterprise/reach/reach_more_info_en.htm) and Regulation 1935/2004/EC on the use of post-consumer recycled plastics for contact with food (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:338:0004:0017:EN:PDF).