PLASTICS NEW ZEALAND

best practice programme

Design for the Environment Guidelines 2006

Ministry for the Environment
Manatu Mō Te Taiao

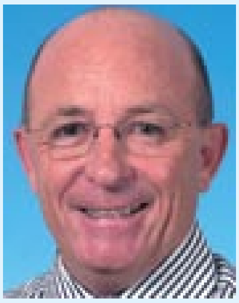
Sustainable Management Fund

Over the last three years the Plastics Environmental Best Practice Programme has found simple and effective ways of encouraging companies within the New Zealand Plastics Industry to take a good look at the way they manage their businesses from an environmental perspective. The focus is on cleaner production, extended producer responsibility, resource recovery, and design for the environment.

Dr Shashi Vohora, Best Practice F acilitator and Ket Bradshaw, the Environmental Manager for Plastics New Zealand have worked with the companies within the Best Practice Programme to prepare these Design for the Environment Guidelines. Simon Wilkinson, the current facilitator, helped to complete them. The production of these Design for the Environment guidelines is a first for New Zealand. We wanted guidelines that reflect plastic manufacture and use in New Zealand as well as assisting our companies to meet the requirements of their export markets.

This project was generously supported by the Minister for the Environment's Sustainable Management Fund. The Minister has supported us over the last three years, and we appreciate his continuing support of the fourth year of this successful programme.

I encourage all those involved in the New Zealand Plastics Industry to use these guidelines. This includes plastic raw material suppliers, plastic manufactures and their suppliers and customers, toolmakers, designers, brand owners, retailers, recyclers and local authorities. We look forward to profiling your Design for the Environment successes in the future.



Terry Mischefski
Chair Environmental Committee
Plastics New Zealand

The Six Design for the Enviroment Guidelines cover:

1. General Guidelines for all plastic products
2. Managing Design for the Enviroment Projects and four specific guidelines for the
3. Electronics, 4. Packaging, 5. Construction and 6. Agricultural Sectors

September 2006.

For more information go to www.plastics.org.nz

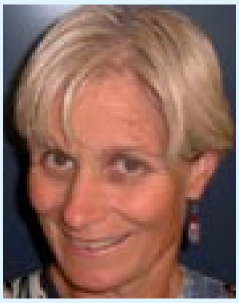
This document has been printed on 100% recycled TCF paper using water soluble vegetable dyes.

Since 2003 Plastics New Zealand has been offering the Plastics Best Practice Programme to its members. During 2005–2006 the Best Practice Programme companies have addressed Design for the Environment.

Design for the Environment is about developing products in a way that minimises their environmental impact. By using Design for the Environment principles, a good quality, desirable and cost-effective product can be developed that also has a reduced impact on the environment.

We would like to congratulate all our Plastics Best Practice companies. These guidelines profile some of their exciting design projects, clearly demonstrating that good design improves performance and is good news for business and the environment. We profiled their case studies in our 2005 report entitled: 'Good News for the Environment from the New Zealand Plastics Industry' http://www.plastics.org.nz/attachments/docs/best-practice-prog-v2-e-final-draft-1.pdf.

Our focus in the next year is on all aspects of the previous three years – Product Design, Environme ntal Management Systems, Cleaner Production and Resource Stewardship – with an initial emphasis on energy efficiency. We are also preparing case studies on the environmental performance of selected iconic New Zealand plastic products. These products will demonstrate 'Kiwi' ingenuity and innovation, a hallmark of the New Zealand plastics industry.



Ket Bradshaw
Environmental Manager
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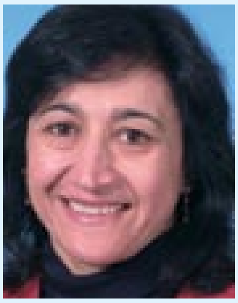

Dr. Shashi Vohora
Best Practice Facilitator
Plastics New Zealand
July 2004 to July 2006

Simon Wilkinson
Best Practice Facilitator
Plastics New Zealand
August 2006 to date

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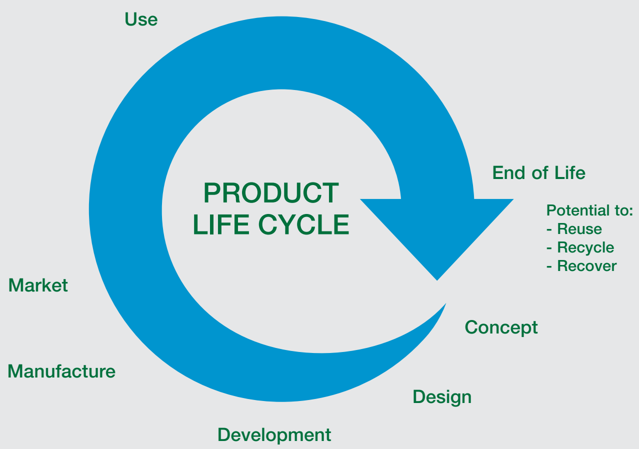
Plastics Design for the Environment Guidelines

Design for the Environment is about developing products in a way that minimises their environmental impact.

By using Design for the Environment principles a good quality, desirable and cost-effective product can be developed that also has a reduced impact on the environment.

Design for the Environment considers the impacts of a product over that product's entire life cycle: from raw material extraction to manufacturing, to use and, finally, to its end of life.



By thinking about the life-cycle impacts of a product at the design stage, product developers can identify opportunities for changes that will reduce the environmental impacts of the product they are creating.

These Design for the Environment Guidelines have been developed by Plastics New Zealand to give anyone involved in the development of plastic products an easy-to-use method. Users of the Guidelines might include marketers, product designers, raw material suppliers, toolmakers, manufacturers, distributors and brand owners.

Early intervention in product development and design is important. It is vital to have senior management commitment and a design team that considers Design for the Environment from the very start of a project, in the same way as any other technical or economic factor.

How to Use These Guidelines

Start by reading through Guideline 1. It gives a good general introduction to the principles of Design for the Environment and tells you how benefits can come from adopting a Design for the Environment strategy.

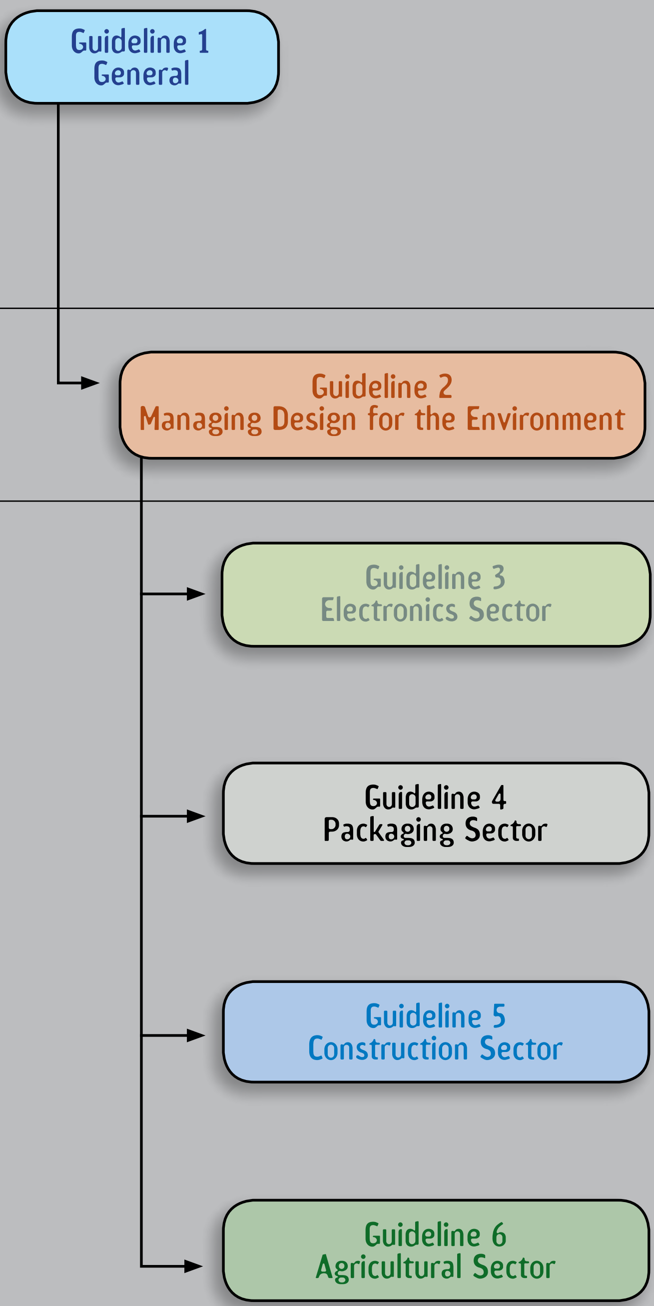
Once you have made a decision that Design for the Environment is something you are interested in and you want to start using it in your company, Guideline 2 will give you some ideas on how to start an in-house Design for the Environment project.

Once you have started a project, Guidelines 3 to 6 will give you more detailed strategies relevant to particular sectors. If your project does not fit into one of these sectors, use the more general strategies and the checklist from Guideline 1.

Design for the Environment (DfE) is sometimes also known as EcoDesign. In these guidelines we use Design for the Environment throughout.

'It is estimated that approximately 80% of environmental costs are predetermined during the product concept and specification stage. By addressing the environmental aspects throughout the complete product or service life cycle, the environmental costs can be greatly reduced.'

AT&T Technical Journal, Nov-Dec 1995



- Gives you an introduction to Design for the Environment
- Tells you how Design for the Environment might benefit your company
- Identifies strategies for Design for the Environment in plastic products
- Provides a simple checklist you can use to begin Design for the Environment on any plastic product

- A practical guide to actually running a Design for the Environment project within your company

- Simple, practical advice for product developers in these particular sectors
- Identifies Design for the Environment strategies particular to products from these sectors

Guideline 1 – General

Design for the Environment is about developing products in a way that minimises their environmental impact.

By using Design for the Environment principles a good quality, desirable and cost-effective product can be developed that also has a reduced impact on the environment.

Plastics Design for the Environment General Checklist

Use this checklist as a prompt as you work through the design of a particular product. Work your way down the list and identify the areas in which you can incorporate the Design for the Environment aspect in your product design. Ask yourself, 'Can we do this for this product?' and, 'Will this improve the product's environmental performance?' for each aspect.

There is more detail on each aspect, including practical design ideas and case studies, in the pages that follow the checklist.

If you tick 'Yes' because you think there is an opportunity to make an improvement in the product design, make a note of the measure you are going to take and the actions needed to implement the change.

Each of the Design for the Environment elements in the checklist below has more detailed information in section 3 of this guideline.

Design for the Enviroment Element	Yes	No	ACTION (e.g. investigate further, change from LDPE to HDPE, use fastener instead of adhesive)
3.1 Material Selection			
Lightweighting			
Avoiding toxic and hazardous substances			
Avoiding ozone-depleting substances			
Avoiding or minimising the production of greenhouse gases			
Types of flame retardant			
Reducing material variety			
Using recyclable materials			
Using compatible plastics			
Reducing the use of composites			
Considering the type of fibre used for material reinforc			
Minimising the use of additives			
Use of biodegradable materials			
3.2 Product Design			
Minimising material use			
Avoiding the use of unnecessary components			
Designing for disassembly			
Using appropriate fastening and joining technology			
Looking at potential for modularisation			
Considering biodegradability			
3.3 Process Design			
Reducing energy consumption			
Minimising solid waste			
3.4 Communication			
Labelling			
Environmental marketing and eco-labelling			
3.5 Distribution			
Reducing and reusing packaging			
Modes of transport			
3.6 Reduction of Impacts During Production Use			
Energy efficiency			
Water efficiency			
3.7 End of life Options			
Reusability			
Remanufacture			
Recyclability			

Why Design for the Environment?

There is a growing demand for cleaner, greener products. This demand highlights the commercial potential of Design for the Environment. Growing sophistication among consumers provides the 'market pull' for products with lower environmental impacts.

Design for the Environment can also provide a method of compliance with increasingly stringent environmental regulations (both present and future) for products. Market entry can now be explicitly dictated by the regulation of environmental performance. New Zealand manufacturers exporting to Europe are already faced with this issue, due to explicit regulations concerning packaging, electronics and restricted substances. Non-compliant products can now be denied access to the valuable European market. As a result, manufacturers and brand owners can gain commercial advantage by addressing compliance issues through Design for the Environment.

1. Design for the Environment Internal and External Drivers

Motivation to implement Design for the Environment can come from within the company itself (**internal drivers**) and, increasingly, it will come from the immediate and global marketplace (**external drivers**).

1.1 Internal Drivers

(a) Need for increased product quality — A high level of environmental quality may also raise product quality in terms of functionality, reliability in operation, durability and/or repairability.

(b) Image improvement — Communicating a product's environmental quality to users through an environmental 'seal of quality', such as the Environmental Choice Label or a good report in consumer tests, can improve a company's image significantly.

(c) Need to stimulate innovation — Design for the Environment can lead to radical changes at the product system level – the combination of product, market and technology. Such innovations can provide entry into new markets.

(d) Need to reduce costs — Companies can use Design for the Environment strategies to deliver financial benefits by:

- purchasing fewer materials for each of its products;
- using energy and auxiliary materials more efficiently during production;
- generating less waste and lowering disposal costs; and
- reducing the need to dispose of hazardous waste.

(e) Employee motivation — Morale generally increases when employees are empowered to help reduce the environmental impact of the company's products and processes. Design for the Environment can also boost employee motivation by improving occupational health and safety.

(f) A sense of responsibility — There is a growing awareness that business plays an important role in working towards sustainable development.

1.2 External Drivers

(g) Government policies — Product-oriented environmental policy is growing rapidly in New Zealand, Australia, Europe, the United States and Japan. The following are some examples and trends:

- Development of a product stewardship policy by the New Zealand government. This policy may result in legislation requiring producers to take more responsibility for their products when they reach the end of their life. More detail can be found on the Ministry for the Environment website: http://www.mfe.govt.nz/issues/sustainable-industry/initiatives/product-stewardship/index.html. The New Zealand Packaging Accord was a direct result of the government's push towards product stewardship

- Extended producer responsibility legislation passed by the European Union that includes a take-back obligation for all electronic and electrical goods, and others such as cars and packaging
- Introduction of mandatory eco-labelling programmes for products or product groups
- Requirement to provide environmental information on products and processes, requiring business to pursue more pro-active environmental communication policies
- Development of industrial subsidy programmes to stimulate Design for the Environment activities and encourage companies to carry out research into potential environmental improvements.

(h) Market demand/competition — The needs/wants of suppliers, distributors and end-users are powerful drivers for environmental improvement. The following are some examples and trends:

- Some companies are systematically reviewing their entire supply chain and imposing new environmental standards or other measures of environmental performance.
- Increased implementation of environmental management programmes in many industries, has resulted in more companies experiencing cleaner production. In cases where intense competition exists for a particular product, companies with a good environmental profile can create an 'edge' by promoting their environmental point-of-difference.
- The development of a more environmentally-friendly product may give a company access to new markets. There is strong growth in environmentally conscious consumerism worldwide and Design for the Environment may provide an opportunity to tap into this market.

(i) Trade/industrial organisations — These organisations often encourage member companies to take action towards environmental improvement.

MORE INFORMATION ABOUT ISO 14000

www.iso.org the international standards organisation
http://www.plastics.org.nz/env-bestpractice.asp?id=650 for case studies of Plastics NZ Best Practice Programme companies involved in ISO projects

Most organisations are supporting and encouraging the introduction of more environmentally focused programmes, initiatives and standards. The International Organization for Standardization (ISO) 14 000 series is an example of international standards for environmental management systems, life-cycle assessment, environmental auditing of processes, environmental labelling and environmental performance evaluation.

(j) Waste charges — Waste processing charges such as landfill costs are constantly increasing. The prevention of waste and emissions and re-use and recycling will consequently become more attractive and make economic sense.

(k) Environmental requirements for design awards — Several respected design competitions have now stipulated that contestants must provide specific environmental information on their products.

National design competitions pro-active with regard to the environment are:

- New Zealand Plastics Industry Awards

  One category in the New Zealand Plastics Industry Awards is the Environmental Achievement Award which takes into account materials, products, concepts, processes and methods. All other Awards also include environmental criteria.
  http://www.plastics.org.nz/page.asp?id=567

- NZ Packaging Council Environmental Awards

  The intent of the Awards programme, first introduced in 1999, is to recognise and reward those companies and individuals who are making a significant contribution to improve the environmental performance of packaging, packaging systems and environmental education, or the operation of their manufacturing facilities.
  http://www.packaging.org.nz/awards.php

- Design Institute of New Zealand Best Design Awards

  The Best Design Awards are the annual awards programme presented by The Designers Institute of New Zealand (DINZ) to showcase and celebrate the best work the design industry has to offer. The Best Design Awards encompass the disciplines of Graphic, Interior and Product Design. The Sustainable Product Design award will be made separately from the existing Best Design Awards product categories. This award will also highlight the contribution sustainability and awareness of the environment can make to best practice design.
  http://www.bestawards.co.nz/home/index.html

- Institute of Professional Engineers (IPENZ) Student Design Awards

  The IPENZ Student Design Award sponsored by Meridian Energy, is an annual award that recognises engineering excellence at the student level, and rewards innovation and entrepreneurial potential. It is designed to encourage students to combine and stretch their knowledge and skills in innovative and entrepreneurial ways and apply them to their design work in an enterprising context. Student Design Awards can be an opportunity for industry to have research projects undertaken for them; this in turn can also enable the students to have a more practical insight to industry product development.
  http://www.ipenz.org.nz/ipenz/who_we_are/Awards_Events/StudentDesign.cfm

- Pride In Print Awards

  The Pride In Print Awards are a forum for recognising the achievement of excellence in New Zealand Print. Entries are invited that utilise any printing process and are welcomed from any person or company associated with the production or purchase of print.
  http://www.prideinprintawards.co.nz/home/

- Industrial Design Excellence Awards (IDA)

  The Industrial Design Excellence Awards, (run through the Industrial Designers Society of America) are dedicated to fostering business and public understanding of the importance of industrial design excellence to the quality of life and the economy. Categories include: Furniture, Packaging & Graphics, Computer Equipment, and Design for the Enviroment
  http://www.idsa.org/idea2006/

2. Design for the Environment Benefits

Companies that apply Design for the Environment find that it has a number of business benefits:

- **The bottom line** — Cuts costs of raw materials and waste disposal
- **Customer expectations** — Meets user needs/wants by exceeding current expectations for price, performance and quality
- **Environmental marketing** — Many customers now include Design for the Environment issues in tender documentation and a 'greener' image can increase market share
- **Enhanced reputation** — Demonstrating good environmental performance can enhance the company's standing with shareholders, investors and other stakeholders
- **Improvements in workplace health and safety** — Through reduced waste and emissions
- **Increased staff morale** — There is a growing awareness among staff that businesses play an important role in working towards sustainable development. This can provide a strong personal incentive to pursue Design for the Environment

- **Environmental performance of products** — Reduces the environmental impact of products throughout their life cycle
- **Efficiency** — Optimises raw material consumption and energy use
- **Environmental performance of processes** — Improves waste management/pollution prevention systems
- **Innovation** — Encourages good design and drives innovation.

3. Design for the Environment Elements

In the past, product responsibility meant that producers and distributors had to assume responsibility for the safety and serviceability of their products. To remain cost competitive, manufacturers, processors and distributors strive to design products to minimise the waste incurred during their production. The Design for the Environment approach means this is extended to the whole life of products.

The environmental performance of a product is basically determined at the design stage. Decisions on the material used, the shaping and joining technology selected, and overall functionality all influence the impact of the product throughout its life cycle.

3.1 Material Selection

One of the key phases in product development is the choice of the right materials. As well as technical performance and price, environmental performance is becoming increasingly important.

Design for the Environment opportunities include:

- using the minimum amount of material consistent with functionality (lightweighting);
- avoidance of toxic or hazardous materials; and
- designing for recovery at end of life, for example, through recycling or composting systems.

There are a number of elements that should be taken into account when selecting materials to improve the environmental performance of a product. Each of these issues is detailed below.

3.1.1 Lightweighting

Reducing the weight of a product delivers environmental benefits throughout the entire product life cycle. Using less material has obvious resource and cost saving benefits. A lighter, smaller product reduces transport demands and therefore impacts through fuel consumption.

Reductions in the weight of a product are often restricted by the functional requirements of that product. However, product developers should consider the potential to reduce the weight of products by:

- making the product smaller;
- reducing the quantity of material;
- using lighter weight materials; and
- reducing the requirements of the product.

Opportunities for making a product lighter by using less material are discussed further in section 3.2.1 below.

3.1.2 Avoiding toxic and hazardous substances

Toxic and hazardous materials can be a risk to the health of workers who make the heavy metal-based pigments and stabilisers and certain plasticisers.

Hazardous Substances & New Organisms Act 1996

Under the Hazardous Substances and New Organisms Act a hazardous substance is defined as… any substance with one or more of the following properties: explosiveness, flammability, a capacity to oxidise, corrosiveness, toxicity (including chronic toxicity) and ecotoxicity with or without bioaccumulation.

Plastic polymers with hazardous properties will be subject to management controls as set out in the Group Standards. For more information go to the website http://www.ermanz.govt.nz/hs/groupstandards/standards/polymers.html

Substances of particular environmental concern include lead, mercury, cadmium, arsenic, chromium, nickel, selenium, fluoride, tin, copper, cobalt, phenols, endocrine-disrupting chemicals and chlorinated organic solvents.

Designers should strive to avoid toxic or hazardous materials when this is practicable. Wherever possible, products should be designed that avoid pigments, inks and dyes that utilise heavy metals such as cadmium or chrome. In many cases these substances are already being phased out and replaced by less hazardous alternatives. For example, the use of lead stabilisers in PVC products (e.g. pipes) has largely been phased out.

Cadmium has historically been used in pigments, coatings and stabilisers. Calcium zinc stabilisers are being used as replacements for cadmium stabilisers.

Alternatives to cadmium pigments are able to be produced from more environmentally friendly materials. Manufacturers should discuss the availability of alternatives with their suppliers.

There has been some concern about the migration of plasticisers (phthalates) from flexible PVC products such as cable. There have been particular concerns about diethylhexle phthalate (DEHP) because it may migrate into the environment at various stages of the product life cycle. DEHP has been detected in water, soil and food. DEHP has been largely replaced in New Zealand with diisononyl phthalate (DINP), diisodecyl phthalate (DIDP) and diisooctyl phthalate (DIOP) which have lower environmental risk. Other plasticisers are already replacing phthalates, including adipates, citrates and cyclohexyl-based plasticisers.

The use of three specific hazardous substances in products is considered in the sections below.

WANT TO LOOK INTO THIS FURTHER?

Take a look at more specific information on hazardous substances in the Electronics and Packaging Design for the Environment Guidelines in this series.

Phthalates Information Centre Europe
www.phthalates.com
Excellent information on the different phthalates in use.

3.1.3 Avoiding ozone-depleting substances

Some substances cause depletion of the ozone layer. The ozone layer is important because it screens us from harmful radiation from the sun. Compounds that cause ozone depletion include hydrochlorofluorocarbons (HCFCs) and chlorofluorocarbons (CFCs). HCFCs and HFCs have replaced CFCs because they have a much lower ozone-depletion potential than CFCs. Hydrofluorocarbons (HFCs) and hydrocarbons (such as propane and pentane) are now the preferred refrigerants.

3.1.4 Avoiding or minimising the production of greenhouse gases

When some gases are present in the atmosphere they absorb radiation from the sun and cause the temperature of the planet to rise. This is known as the 'greenhouse effect'. Increasing quantities of greenhouse gases are being discharged into the atmosphere from human sources. Most scientists believe this is causing the temperature of the Earth to rise at an unsustainable rate.

Greenhouse gases include carbon dioxide, methane, nitrous oxides, carbon monoxide, non-methane volatile organic compounds, perfluorocarbons and HFCs. Plastics do not degrade in landfill and therefore have a low greenhouse impact at end of life.

WANT TO LOOK INTO THIS FURTHER?

http://www.climatechange.govt.nz/
Ministry for the Environment climate change office.

3.1.5 Types of flame retardant

Flame retardants are used to inhibit or resist fire. They play an important role in the safety of some products. Some halogenated flame retardants (containing chlorine or bromine) such as polybrominated diphenyl ethers (PDBEs) and polybrominated biphenyls (PBBs) can be environmentally hazardous. There is some evidence that these types of flame retardant release hazardous substances into the environment in the incineration process and may leach in landfill conditions. More details on these flame retardants and their restrictions can be found in the Electronics Design for the Environment Guideline.

If a product or component has flame retardancy requirements, then the first step should generally be to consider inherently (naturally) flame retardant materials, such as polycarbonate. If this is not possible, then preference should be given to halogen-free flame retardants which do not pose any problems for recycling or disposal.

WANT TO LOOK INTO THIS FURTHER?

Take a look at the Electronics Design for the Environment Guideline in this series.

Or these websites:
http://www.ebfrip.org European Brominated Flame Retardant Industry Panel.
http://www.lenape.com/retard.html A chemical company that offers alternative flame retardants
http://www.mst.dk/udgiv/Publications/1999/87-7909-416-3/html/kap08_eng.htm
Danish study of alternative, non-halogenated flame retardants.

3.1.6 Reducing material variety

Most products contain several different types of materials such as, for example, polypropylene housing, metal fasteners and foil laminates. Reducing the variety of materials used in a product will generally mean easier and more efficient disassembly and improvement in the recyclability of that product.

Whenever possible, the designer should reduce the range of incompatible material types employed in component assemblies and final products. This makes it easier to either recycle the product as a whole, or to disassemble it into its constituent materials.

> 'Any time a designer uses dissimilar materials together, she or he should picture whether and how they can eventually be easily separated...'
>
> (Graedel & Allenby, 1995)

For example, if designing a product such as a deodorant that has a tube, ball and lid, it would be preferable that all these components are made of one material, or materials that are compatible for recycling together.

Adhesive labels can contaminate plastic products.
Consider moulded-in labels, laser etching, or hot stamping.

It is difficult to remove metallisation or paint when recycling plastic. If the designer specifies the required surface finish when moulding plastic parts, there is no need for a separate process stage to produce the surface finish (Bergendahl et al, 1995[1]). This has the advantage of avoiding an added process stage in the manufacture of the item, as well as ensuring the part is free of coatings that will contaminate the recycled plastic.

Labels that are difficult to remove also create problems when recycling plastics. Labels and their adhesives can contaminate and affect the physical, chemical and mechanical properties of the recycled plastic. Alternatives should be considered, including moulded-in labels, laser etching, or hot stamping.

Where incompatible materials are used in a product it is preferable for those materials to have densities that differ by at least 0.05 specific gravity units per material[2]. These differences in density can help with the separating of materials for recycling.

WANT TO LOOK INTO THIS FURTHER?

BOOKS:

- Graedel, T.E. and Allenby, B.R. (1995) Industrial Ecology Prentice Hall, New Jersey
- Bergendahl, C.G.; Hedemalm, P; Segerberg, T. (1995) Handbook for Design of Environmentally Compatible Electronic Products. Swedish Institute of Production Engineering Research (IVF)
- American Plastics Council (2000) A Design Guide for Information and Technology Equipment

3.1.7 Using recyclable materials

Thermoplastics[3], by their very nature, are ideally suited to mechanical recycling. These materials can be re-melted several times over at relatively low temperatures (220 – 350 °C), without suffering any major loss of properties, and moulded into new parts. An alternative is the use of biodegradable resins which can be composted at the end of their life.

If a product is to be recycled at the end of its life then it is important that materials that can be recycled are used. Designers should consider current recycling technologies and infrastructure in the locations where the product will be used. Many manufacturers claim their materials are recyclable, but these claims need to be verified against the existing recycling technologies and the infrastructure used to collect and process the material.

For more information on plastics recycled in New Zealand visit http://www.plastics.org.nz/page.asp?id=634 or Recycling Operators of New Zealand (RONZ) at www.ronz.org.nz.

Recycled and spun in an innovative way, the 2-litre plastic PET bottle works brilliantly as the base material for Synchilla®, a signature Patagonia fleece. More than 150 Synchilla garments are made from 3,700 recycled 2-litre bottles. This saves a barrel of oil (42 gallons) and avoids approximately half of a ton of toxic air emissions. http://www.patagonia.com

3.1.8 Using compatible plastics

This toothbrush has been co-injection moulded. Two incompatible materials that cannot be recycled together are now permanently bonded, making disassembly nearly impossible.The designer might have considered using different coloured components that could slot together, or using different colours of the same material (from: Sustainable Design Awards www.sda-uk.org).

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1 Berg, T. (1995) Handbook for Design of Environmentally Compatible Electronic Products. Swedish Institute of Production Engineering Research (IVF), Research Publication 95851. Göteborg, Sweden

2 American Plastics Council (2000) A Design Guide for Information and Technology Equipment

3 See http://www.plastics.org.nz/page.asp?section=about-plastics for a definition of thermoplastics

If more than one polymer is used in a product, problems can be caused at the recycling stage because the polymers may be incompatible for recycling together.

Try to select materials that are compatible in the recycling process. This means that they can either be processed together with an acceptable drop in quality, or can be easily separated in the recycling process (e.g. during washing). Further detail on the compatibility of different resins for recycling can be found in Guideline 3 – Electronics, of this Design for the Environment series.

Advice on compatibility of materials in the design of PET and HDPE packaging is available from the Recycling Operators of New Zealand (RONZ) and discussions with suppliers and recyclers are recommended.

WANT TO LOOK INTO THIS FURTHER?

Take a look at the Australian Council of Recyclers (ACOR) Manufacturers Recycling Guides for PET and HDPE, downloadable from http://www.acor.org.au/materials.html

Talk to the Recycling Operators of New Zealand (RONZ) about the recycling compatibility of plastics http://www.ronz.org.nz/

3.1.9 Reducing the use of composites

Composites are materials that have been mixed together to achieve a particular blend of properties. Polymer and plastic composites are strengthened with fibres, fillers, particulates, powders and other matrix reinforcements to provide improved properties. This can be beneficial in certain applications, such as weight saving in vehicles, but can cause problems for the recycling of the material.

One of the important rules in 'designing for recycling' is to select the smallest possible number of different constituents in a material system or selecting compatible polymers. This assists in the ease of material recovery. Wherever possible, mono-materials should be used.

WANT TO LOOK INTO THIS FURTHER?

http://www.polymers.nl/PRO1/general/next_content.asp?itemnummer=233

Dutch Polymer Institute article on "Green Composites".

3.1.10 Considering the type of fibre used for material reinforcement

Composites are commonly used in both thermoplastic and thermoset matrices. Glass fibre is the most common, although other reinforcements are synthetic, such as carbon and aramid; or natural, such as wood, hemp, and flax. Composites can be in a variety of forms from: cloths/mats, continuous strands, chopped strands; and in random, linear, or even multi-directional orientation.

Fibres used to reinforce plastics may adversely affect the recyclability of a product. Before choosing a fibre to reinforce a plastic it is recommended that its impact on recyclability is discussed with plastic recyclers. Recyclability includes the ability to process the material and the appropriate end uses of the recycled material.

IMPACT OF ADDITIVES ON RECYCLED PRODUCTS
Slip sheets are used in place of pallets, for loading cargo and transporting. In making the slip sheets, a variety of recycled materials are used. One material in particular is HDPE milk bottles (and caps) that have been flaked. The colouring pigments in the milk bottle caps mean that when recycled, more pigment has to be added to get the product to one colour. This is why many products made of recycled material are usually black e.g. slip sheet, rubbish bins, and pipe, etc.

3.1.11 Minimising the use of additives

Most materials used in plastic products are not in a pure state. They often contain a range of other substances such as colourings, fillers, UV stabilisers, fire retardants and surface treatments. Some of these substances, or additives, can cause difficulties when recycling a product. Other additives may even improve the recyclability of a plastic (for example talc, in polyester is an aid to recycling).

Additives within a material/product are often impossible to separate from the material during recycling and so become mixed with other materials. The result is that every time the material is recycled, its quality is reduced (down-cycled) due to the unwanted mixing and increasing ratio of contaminants.

Not all additives are completely necessary and designers should aim to keep additives to a minimum. Where additives are used, their environmental properties should be researched and discussions with recyclers should be held to identify how an additive might affect recycling.

WANT TO LOOK INTO THIS FURTHER?

British Plastics Federation
http://www.bpf.co.uk/bpfindustry/Plastics_Additives.cfm

List of common additives used in plastics and their properties.European Council for Plasticisers and Intermediaries
http://www.ecpi.org/

Special Chem
http://www.specialchem4polymers.com/index.aspx
Knowledge centre for polymer additives and colours.

3.1.12 Using biodegradable materials

Mechanical recycling is not always the most effective method of recovering materials. It is possible for many renewable materials to be composted. However, the benefits of composting biodegradable materials are dependent on effective systems being in place to ensure that the materials are treated correctly. If these systems are not in place then biodegradable materials can have negative impacts, such as contaminating plastics recycling or increasing the amount of biomaterial in landfill.

Discussions on the future of degradable plastics in New Zealand are currently underway. Product designers should acquaint themselves with the key issues and the state of industry discussions before using degradable plastics in a new product. This information will be available through Plastics New Zealand _.

3.2 Product Design

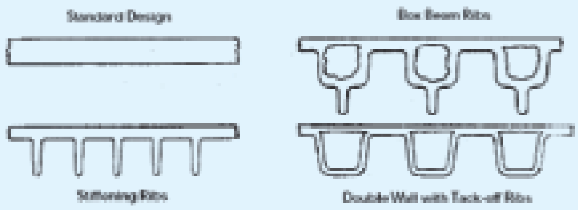
When considering the design of a product it is important to consider:

- minimising material use;
- combining functions in a product;
- avoiding any unnecessary components; and
- designing for recovery (cyclic design).

3.2.1 Minimising material use

Using less material to make a new product is desirable because it reduces the use of natural resources. Reducing the amount of material needed to make a product will often result in cost benefits as well.

Whenever possible, only the minimum amount of material should be used in the product being designed. The design or shaping of a part is dictated, first and foremost, by the functions that it is required to fulfil, including the aesthetic requirements. However, there are some techniques that can be used to reduce the amount of material needed.



Designs requiring less materials than a standard design to achieve the same strength.
(Source: American Plastics Council, 2000[4])

In some cases, for example, it may be possible to increase plastic stiffness by using engineering techniques, instead of increasing the amount of plastic used. Examples of these techniques are shown above.

By employing materials with an optimised flowability it is frequently possible to avoid increases in wall thickness that are required purely on flow engineering grounds, as well as the associated increase in the amount of material required. Care must, of course, be taken to ensure that the type of material selected also satisfies the requirements placed on the part in respect of all other properties.

It can make sense to apply more sophisticated, computer-aided optimised-dimensioning methods (such as the familiar finite element method) to components which have not justified the high cost of these calculation methods so far and which have therefore been dimensioned on an empirical basis or with simple aids. A twofold benefit is then derived from the potential for material savings revealed by these calculations – in the immediate costs of the part and in the subsequent cost of recycling.

WANT TO LOOK INTO THIS FURTHER?

American Plastics Council (2000) A Design Guide for Information & Technology Equipment
Downloadable from http://www.plasticsresource.com/s_plasticsresource/doc.asp?TRACKID=&CID=174&DID=383

4 American Plastics Council (2000) A Design Guide for Information & Technology Equipment

3.2.2 Avoiding the use of unnecessary components

Minimising the number of parts in a product has clear benefits in material saving, disassembly efficiency and ease of repair. When analysing a product's primary and secondary functions, designers may discover that some components are superfluous.

It is important to ask questions that lead to a better understanding of end-users' purchase decisions.

- What are the product's primary functions for users?
- What are its secondary functions?
- Are the functions utilitarian or aesthetic in nature?

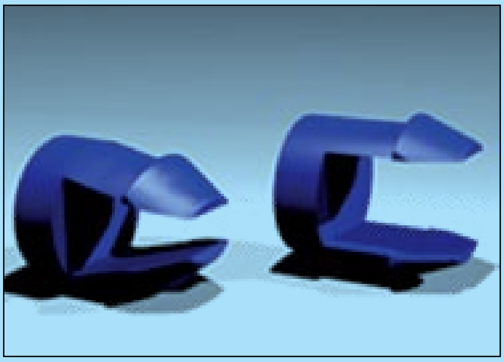
Reducing the number of parts can be achieved in a number of ways such as integrating many functions into one component or assembly, or simplifying the way in which the product is assembled. Reducing the number of components is not only environmentally attractive but also reduces tooling and material costs and the amount of processing energy required. The standardisation of components so they are easy to replace has similar benefits.

3.2.3 Designing for disassembly

When developing a product with multiple parts or components it is important to consider how easy the product will be to disassemble for end-of-life recycling. Multiple-material and multiple-component products need to be disassembled so that the different materials can be separated for recycling, reuse, repair, or re-manufacture. Products that are easy to disassemble, are also easy to assemble and this can deliver production savings.

Designers can choose assembly procedures that help to make disassembly easier. Design options include:

- minimising the number of separate components and materials;
- avoiding glues, metal clamps and screws in favour of 'push, hook and click' assembly methods;
- use of a simple component orientation;
- if using screws, use of standard screw heads to aid assembly and disassembly;
- making fasteners from a material compatible with the parts connected;
- designing interconnection points and joints so that they are easily accessible;
- use of active disassembly technology such as smart materials (see sidebar);
- designing the product as a series of blocks or modules;
- use of in-mould identification symbols for plastic resins based on the Polymer Identification Codes for packaging or ISO 1043 (see section 3.4.1 on labelling for more information);
- making fastening points accessible, visible and clearly marked. Consider using colour coding to aid assembly and disassembly, e.g. for upgrade or repair;
- locating unrecyclable parts in one area so they can be quickly removed and discarded.



Active Disassembly & Smart Materials: The future?

Active disassembly uses techniques such as 'smart materials' to allow for the quick and easy non-destructive disassembly of products, subassemblies and constituent components.

The technology uses shape memory and smart polymer components in products.

A shape memory material is manufactured to hold a set shape, until it is taken to a trigger temperature, at which point it adopts a second set shape.

For example a 'snap-fit' connector can be made of a shape memory polymer. During assembly of a product, a snap-fit holds its shape. When the product needs to be disassembled, it can be heated or cooled (usually) to the trigger temperature. At this point the snap-fit will automatically transform, allowing the component to easily be removed.

Read more about active disassembly and smart materials at www.activedisassembly.com including videos of the technology in action.

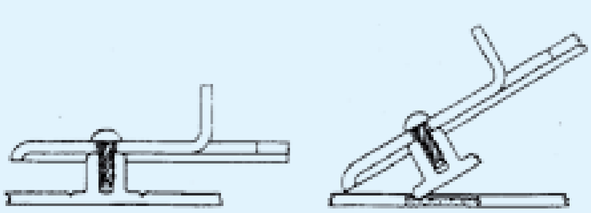
3.2.4 Using appropriate fastening and joining technology

The choice of fastening and joining method can significantly affect the recyclability of a product. The cost-effectiveness of plastics recycling decreases when different plastics or plastic and non-plastic parts are joined together.

Wherever possible, designers should avoid the intimate attachment of plastic and non-plastic parts as this will reduce the ability to recycle a product.

When determining the type of joining technology it is important to consider not only the assembly and production technology but also the subsequent dismantling of the component and the material separation/recovery processes that are available.

If using metal fasteners, these should be designed to be easily separated from the plastic as they might need to be removed in the recycling process. Carbon or stainless steel fasteners should be chosen over brass or aluminium to allow for magnetic separation of metal and plastic parts in the recycling process. When metal hinges are used in plastic products, break points can be designed into parts so that the hinge can be easily snapped off.

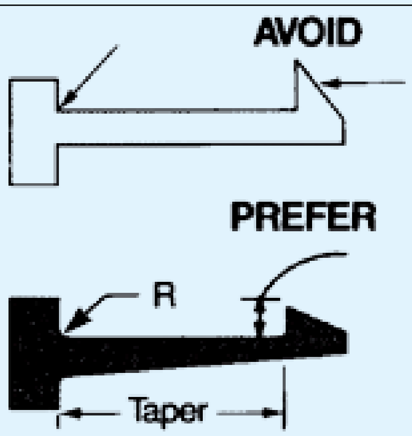


Break-off metal inserts (from American Plastics Council, 2000)

Snap joints and screw connections are considered to be particularly suitable for non-destructive dismantling. It is important to remember that the dismantling operation for recycling is not necessarily just the assembly operation in reverse, since different constraints apply here.

Preferable methods for joining are:

- **Snap connectors and fittings** — The most preferable method from both an environmental and economic viewpoint. Avoids the use of metals, adhesives or solvents.



Example of plastic snap fits (American Plastics Council, 2000)

- **Ultrasonic bonding** — Can be used to join thermoplastics with other materials. Recycling is much easier if the two parts being joined are both of the same material.
- **Hot riveting** — Also used to join thermoplastics with other materials. As with ultrasonic bonding, preferable if the parts are the same material.
- **Solvent bonding** — Two similar solvent-bonded plastics can be recycled as a unit. Only a small amount of solvent is needed. Some solvents, however, can be environmentally damaging.

In order to ensure straightforward dismantling it is best to aim for a uniform and readily visible joining technique which does not require any special tooling. It can also be worthwhile, on cost grounds, employing techniques which do not destroy or damage the component.

Press fitting, bonding, welding and riveting will continue to retain their importance. These should be employed preferentially for compatible material combinations.

The use of metal inserts for screw connections must be examined carefully because, unlike thin-walled metal sheet, these elements can cause damage to blades when the plastics are shredded and granulated in conventional shredders. If it is impossible to get by without metal inserts, then these should be clearly recognisable so that the plastics components are not fed to an unsuitable shredding unit.

WANT TO LOOK INTO THIS FURTHER?

American Plastics Council (2000) A Design Guide for Information & Technology Equipment

Downloadable from http://www.plasticsresource.com/s_plasticsresource/doc.asp?TRACKID=&CID=174&DID=383

3.2.5 Looking at potential for modularisation

Products can often be designed as a set of modules that can be fitted together to provide a combination of functions. This allows customised products to be created from a set of standard modules, products to be altered or upgraded to meet the users' changing needs, and for products to be easily repaired or remanufactured.

3.2.6 Considering biodegradability

If a product is being designed for degradation — for example, a biodegradable bag or food service item which will be collected for composting after use — a number of issues need to be considered:

- selecting the most appropriate material for both application (functionality) and the disposal environment (soil, water, landfill etc);
- ensuring that the wall thickness will enable the product to degrade within the required time period; and
- avoiding additives which will contaminate the end-product (compost), e.g. pigments or inks containing heavy metals.

Discussions on the future of degradable plastics in New Zealand are currently underway. Product designers should acquaint themselves with the key issues and the state of industry discussions before using degradable plastics in a new product. This information will be available through Plastics New Zealand www.plastics.org.nz.

3.3 Process Design

Production processes should be investigated to identify opportunities to improve environmental performance and reduce operating costs. Improvements can often be made through good housekeeping, water and energy conservation, waste minimisation and on-site recycling.

The target should be to make your processes as environmentally benign as possible. Production techniques should:

- minimise the use of ancillary materials and energy;
- avoid the generation of hazardous compounds such as Volatile Organic Compounds (VOCs);
- provide high efficiency production with low material losses; and
- generate as little waste as possible.

VOCs are generated by solvent-based printing processes. Alternative processes (e.g. water-based printing) should be used wherever possible. Avoid finishing processes that produce toxic wastes in production (e.g. chrome plating).

Process improvements are an effective strategy to reduce pollution and can provide many cost-benefits by:

- improving efficiency and reducing costly production downtime; and
- increasing regulatory compliance and reducing fines.

Look at the wastage associated with production. Use a structured approach that allows your company to:

- assess the cost of its waste, either using existing company records or by running an audit;
- identify the points in a process where waste is arising, assess the specific costs in each case and present the findings in a format that will encourage action;
- construct and use simple diagrams to prioritise those process components that are most in need of attention and, perhaps, change;
- identify the possible causes of waste, using tools and techniques such as brainstorming, tally sheets, scattergrams, process maps and cause and effect diagrams;
- carry out a capability study that provides a numerical assessment of how consistent a process is and how well it is meeting the company's target specifications;
- identify actions that will improve the process and its capability;
- use control charts to maintain control once a process is operating satisfactorily.

Improving production processes is a key component of Environmental Management Systems like ISO 14001 that encourage organisations to make specific commitments to preventing pollution. For more information go to http://www.plastics.org.nz/env-bestpractice.asp?id=646

3.3.1 Reducing energy consumption

Reducing the amount of energy used in the production process has economic and environmental benefits. Energy efficiencies can be obtained by:

- changing production technology;
- optimising process design; and
- reviewing company-wide practices.

The type of production technology can have a major influence on the energy consumed in the manufacture of a product. Energy demand can be minimised by selecting adapted production technologies. The objective should be to analyse the energy consumed at each of the individual stages of production. On the basis of this analysis you can make the manufacture of the product as efficient as possible. This should be taken into account when deciding for or against a certain production technology.

In addition to using energy efficient technologies, an optimised process design will contribute to a reduction in energy consumption. Savings can be found through constant monitoring and optimisation of the process parameters (e.g. temperature, quantity of secondary material used) through computerised process control.

The starting point for a reduction in overall energy consumption at a production site should be an analysis of energy flows and the resulting costs. This will give an assessment of the savings potential that can be used to target priorities. In many cases the Energy Efficiency and Conservation Authority (EECA) will provide grants to businesses to help them conduct an energy audit as a first step towards energy efficiency.

WANT TO LOOK INTO THIS FURTHER?

http://www.emprove.org.nz/
online resources for businesses from the Energy Efficiency & Conservation Authority (EECA) to help you review energy efficiency in your operations. Includes a downloadable guideline and the Energy Challenger online tool for assessing energy efficiency opportunities. Also has a directory of local energy experts.

3.3.2 Minimising solid waste

The goal of each production process consists of the transformation of raw materials into products. Process waste can be considered an indicator of inefficient use of materials. Apart from the environmental impact caused by the disposal of waste, the consumption of raw materials extracted from the environment has to be taken into account.

There are often simple measures that can be taken to minimise waste and increase recycling at the production phase. The goal should be to prevent waste being created in the first place. Production processes should be reviewed to assess the reasons for waste being created. This may reveal opportunities for simple changes in processes that will avoid waste.

An important strategy to prevent waste and reduce costs comes from closing material cycles in the production process. Recycling waste materials and returning them into the production process reduces consumption of primary raw materials as well as the cost of waste disposal.

Where it is not possible to avoid process waste altogether, or to return these materials in the production process, there may be opportunities for others to re-use or recycle them. This may require separation and sorting, and thought should go into establishing in-house recycling systems.

WANT TO LOOK INTO THIS FURTHER?

http://www.plastics.org.nz/env-bestpractice.asp?id=645 Plastics NZ Best Practice Guide to Reducing Waste

http://www.zerowaste.co.nz/default,187.sm has a brief guide to conducting a waste audit and a DIY waste audit manual for small businesses.

http://www.mfe.govt.nz/issues/sustainable-industry/tools-services/subjects.php?id=15
Ministry for the Environment link to resources on waste minimisation tools.

3.4 Communication

It is important to provide good information to those who are buying and using your products. Design for the Environment needs to be supported by appropriate behaviour by consumers 'doing the right thing' — for example, recycling.

Product-related environmental communication needs to be accurate, relevant, informative and verifiable. Responsible purchasing and consumer behaviour can be encouraged by:

- designing the consumer interface on the product or packaging to encourage the selection of efficient options;
- providing information on appropriate reuse or recycling options as well as disposal; and
- using appropriate logos and labels (e.g. plastic identification codes, recycling logos, information on the product label).

You can assist recyclers by informing them when a new product comes onto the market or there are changes to an existing product. Wherever possible, provide recyclers with technical information about the product and any available examples of how it might be recycled. In New Zealand you can contact the Recycling Operators of NZ (RONZ) http://www.ronz.org.nz/ to discuss material selection and options for recycling.

Consumers can visit the Reduce Your Rubbish site to find out the reuse and recycling options in their area.
Go to http://www.reducerubbish.govt.nz/ and look for the regional links.

Material Type Acronym	Plastic Identification Code	Full Polymer Name(s)	Examples of Common Products
PET	1	Polyethylene Terephthalate	Soft-drink and water bottles, food packaging such as salad domes and biscuit trays
HDPE	2	High Density Polyethylene	Milk bottles, ice-cream containers, detergent bottles, and shopping bags
PVC	3	Polyvinyl Chloride Unplasticised: PVC-U Plasticised: PVC-P	Cosmetic containers, pipes, films, wire coatings, and garden hoses
LDPE	4	Low Density Polyethylene	Film for protection of pallets during transportation, squeezable bottles, rubbish bags, plastic food wrap
PP	5	Polypropylene	Lunch boxes, microwave containers, straws, packaging film, and dairy food containers
PS	6	Polystyrene	Plastic cutlery, CD cases, stationery parts, toy parts and plastic 'glassware'
EPS	6	Expanded Polystyrene	Protective packaging for fragile goods, insulation, clamshell food take-away containers and cups
Other	7	Acronyms normally specified underneath the Identified code e.g. ABS (Acrylonitrile butadiene styrene) or SAN (Santoprene)	Car parts, appliance parts, computers, electronics, water cooler bottles, and other packaging

Plastics New Zealand introduced its plastic identification coding system in the early 1990s. The code is not intended to be a recycling logo. A growing number of New Zealand towns and cities are implementing recycling schemes in an effort to reduce waste to landfills. Because these recycling schemes target packaging, the coding system focuses on the six most common plastics.
Refer to Appendix 3.

3.4.1 Labelling

It is very important that plastic components are labelled so they can be easily identified. Proper end-of-life treatment of materials relies on the users and waste collection services recognising the type of material.

Many plastics are difficult or impossible to distinguish from others without clear identification (usually in the form of labelling), and some, such as potentially hazardous materials, need to be very clearly labelled if the material is to be disposed of in the correct way.

There are industry standards for the labelling of plastics. The appropriate labels for identification of plastics can be found in:

- the Plastics Identification Code for packaging (http://www.plastics.org.nz/_attachments/docs/plasticscode.pdf); and
- ISO 1043 and ISO 11469 for more detailed and internationally accepted labelling.

Use of the Plastics Identification Code is a target in the 2003 Plastics NZ Sustainability Initiative (http://www.plastics.org.nz/page.asp?id=506). The target is to label all rigid plastic products and all printed plastic code 1 to 6 films.

Advice on environmental claims and logos (including recycling logos) is provided in AS/NZS 14021: 2000.

3.4.2 Environmental marketing and eco-labelling

Design for the Environment can also help companies to increase their market share by tapping into the growing number of 'green' consumers.

The public sector (e.g. government agencies) are increasingly requiring suppliers to address environmental issues in tendering exercises. Commercial customers, particularly for large business-to-business contracts, have also indicated that they want producers to demonstrate adequate control over future end-of-life product costs.

Many producers, particularly in consumer supply chains, have published environmental policy commitments. To comply with these commitments, they are exerting pressure on their supply chains by:

- dealing only with suppliers that have a certified environmental management system (EMS) such as EnviroMark or ISO 14001; and/or
- asking their suppliers to demonstrate that they manufacture their products, components or materials in an environmentally responsible manner.

Eco-labelling can provide marketing benefits by highlighting that the product is designed specifically to reduce its overall environmental impact, compared to other similar products. The International Standards Organisation (ISO) distinguishes three main approaches to eco-labelling and these are outlined in Appendix 2.

WANT TO LOOK INTO THIS FURTHER?

http://www.landcareresearch.co.nz/research/sustain_business/trade/documents/eco_labels.pdf

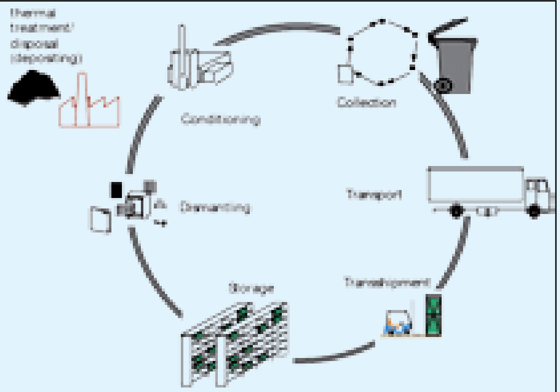
Landcare Research publication that summarises the implications of ecolabels for NZ manufacturers – Eco-labels: a short guide for New Zealand producers.

www.enviro-choice.org.nz home of New Zealand's Environmental Choice ecolabel

www.plastics.org.nz for plastics-specific labelling

3.5 Distribution

Logistics and distribution during the whole life cycle of a product have a significant impact on the environment. There are opportunities to reduce this impact by optimising logistics and this can result in significant economic as well as environmental benefits.



Logistic stages in the life cycle of a product (from ECOLIFE 2002[5])

A designer, or product developer can make changes to a product that will ensure that the product is transported in the most efficient manner possible. The factors involved in optimisation include packaging and mode of transport. Opportunities for logistics optimisation might also include reverse logistics (backloading) or modelling to identify efficiencies.

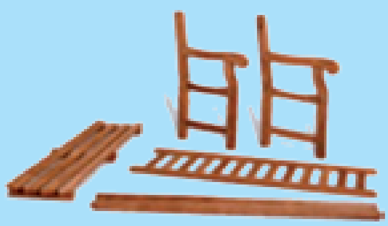
5 ECOLIFE (2002) Environmentally Improved Product Design Case Studies of the European Electrical and Electronics Industry

3.5.1 Reducing and reusing packaging

Reducing the weight of the load being transported will reduce fuel consumption. Reducing the number of components or the overall size of the product, by using alternative solutions to using thicker material for added strength, and reducing the amount and weight of the packaging used, can all reduce the overall load weight.

Reusable packaging is desirable where there are short distribution distances, frequent deliveries, and a small number of parties involved and when companies own their own distribution vehicles. Recyclable packaging should be clearly labelled and made from only one material (or compatible or easily separable materials), and those materials should have an established recycling system.

Efficiency of packaging can be improved by: reducing the amount of material required to contain a given shape; dismantling or collapsing the product; packing products in their concentrated form; and using flexible rather than rigid packaging. Standardised transport packaging, and the use of bulk packaging will help with transport efficiency.



Flat-pack furniture requires less packaging and allows many more units to be contained in a transport vehicle than would be possible in the product's assembled state. This enables more products to be transported at once, reducing the number of fuel consuming journeys that have to be made.

3.5.2 Modes of transport

Use the most efficient mode of transport wherever possible. This will decrease energy demand and reduce harmful emissions. Optimise efficiency transport modes following these rules: transport by container ship or train is preferable to transport by truck. Transport by air has a greater environmental impact.

3.6 Reduction Of Impacts During Product Use

For many products the most substantial environmental performance improvements can be made during the use of the product. There is often a gap between the manufacturer's intended use and maintenance of a product and what actually happens when it is in the hands of end-users. This gap can result in wasted energy, water or materials.

Many products consume energy, water and/or other consumables during their life span. The following principles should be considered by product developers when trying to improve the efficiency of use of a product.

- Design for ease of use and provide clear instructions.
- Design to reduce the risk of wasting auxiliary materials, e.g., funnel-shaped filling inlets, and spring return or auto-off power switches.
- Place calibration marks so that users know exactly how much auxiliary/consumable material, e.g., detergent or lubricant oil, is required.
- Make the default position or state-of-the-product the one that is most desirable environmentally, e.g., power-down or stand-by modes.

3.6.1 Energy efficiency

Some products need electricity to function. Reducing the energy consumed by a product will result in savings to the consumer and the environment.

The goal of this Design for the Environment element is to achieve energy efficiency and/or the use of more environmentally responsible energy sources during product use. Energy efficiency leads to reduced fossil fuel consumption, thereby lowering emissions of greenhouse gases and chemical contributors to acid rain.

Environmental analyses of durable products such as refrigerators and washing machines show that the largest environmental impacts can come during the use-phase of a product's life cycle. As a result, the operational costs over the product's lifetime can often exceed the initial purchase price. When users are made aware of the importance of these then energy efficiency becomes a strong marketing feature.

When considering potential energy efficiency improvements in product development, the following principles can act as a guide :

- Clarify core functions — energy efficiency should not come at the expense of a product's core function.
- Look for synergies — improvements in energy efficiency may yield additional benefits in the product (e.g. reduced insulation requirements).
- Look for waste — in the form of leaks, standby usage, or components working against each other.
- Design for part-load operation.

- Optimise system efficiency — ensure that savings in one part of the product do not result in losses elsewhere.
- Design for a range of conditions.
- Plan for ongoing efficiency improvement — technology development may allow improvements not possible today.

The 5 watts often required to run the digital displays of a microwave oven can, over its life, exceed the amount of electricity used for cooking with the appliance

WANT TO LOOK INTO THIS FURTHER?

BOOKS: Gertsakis,J; Lewis, H.; and Ryan, C. (1997) A Guide to EcoReDesign; Centre for Design, RMIT, Melbourne

WEBSITE: NZ Energy Efficiency Conservation Authority www.eeca.govt.nz
A wide range of excellent information about energy efficiency in New Zealand. Has a searchable online library.
Minimum Energy Performance Standards (MEPS) http://www.eeca.govt.nz/labelling-and-standards/meps.html Information about energy efficiency standards for certain products.

3.6.2 Water efficiency

Some products consume water during their use phase. High levels of water use impact on water supplies and put pressure on wastewater systems.

The principles used for considering energy efficiency during use (above) can also be applied to water efficiency. Wherever possible, water efficiency should be improved by reducing the water requirements of a product. Where reduction in demand is not possible, recovering and reusing water should be considered.

It is also possible to encourage water-efficient behaviour in consumers by providing good information on performance. On 1 July 2006 Australia introduced a mandatory Water Efficiency Labelling scheme for certain products, including: clothes washing machines, dishwashers, flow controllers, toilet equipment, showers, tap equipment, and urinal equipment. The New Zealand government is considering the same approach.

WANT TO LOOK INTO THIS FURTHER?

http://www.mfe.govt.nz/publications/waste/product-stewardship-water-labelling-jul05/html/page10.html Ministry for the Environment Consideration of a Water Efficiency Labelling Scheme (WELS) for New Zealand.

http://www.waterrating.gov.au/index.html Australian Water Efficiency Labelling Scheme

3.7 End-of-Life Options

Options that avoid the product becoming waste in the first place will generate the greatest economic and environmental benefits.

It is important to consider whether:

- the product is intrinsically suited to a particular end-of-life option. For example, if a product's commercial value lies in the packaged technology it contains, then product re-use, upgrading or refurbishment may be better end-of-life options;
- the end-of-life option makes good business sense and can be integrated into the overall marketing strategy for the product;
- suitable collection, transport and storage arrangements exist or can be put in place for getting equipment back in sufficient quantities and condition for the end-of-life option; and
- degradable, biodegradable and bio-based polymers will impact on existing material recycling and composting systems.

3.7.1 Reusability

Many products are designed to be disposable or have limited cycles of use. Sometimes these products are actually in excellent condition when they are discarded. Designers should seek ways of extending the life of products and avoid their disposal until the time that they actually fail to function. This saves material and reduces pressure on landfill. Designing products for longer lifetimes can result in significant long term savings, as in the case of reusable packaging systems, for example.

Reuse and Remanufacture at Xerox

90% of all Xerox-designed product models introduced in 2004 were developed with remanufacturing in mind.

Machines are designed for easy disassembly and contain fewer parts. Parts are designed for durability over multiple product life cycles. Parts are also easy to reuse or recycle, and are coded with disposition instructions. As a result, equipment returned to Xerox at end-of-life can be remanufactured — rebuilt — to as-new performance specifications, reusing 70 to 90% by weight of machine components, while meeting performance specifications for equipment with all new parts.

Xerox has further extended its ability to reuse parts by designing product families around modular product architectures and a common set of core components. These advances offer Xerox multiple options for giving new life to old equipment. A returned machine can be rebuilt as the same model through remanufacture, converted to a new model within the same product family, or used as a source of parts for next-generation models.

Machines with reused/recycled parts are built on the same manufacturing lines as newly manufactured equipment, and they undergo the same rigorous quality assurance tests. As a result, products with reused/recycled parts carry the same Xerox guarantees, warranties, and service agreements as Xerox equipment made from all new parts.

3.7.2 Remanufacture/repairability

Most products are disposed of when they fail to function correctly, but the fault is usually only in one small part of the product. If carefully designed, it is often possible for products to be repaired so that faulty or worn parts are replaced or repaired. This saves material and extends the life of the original product.

3.7.3 Recyclability

If a product is to be recycled at the end of its life then it must be produced from materials that can be recycled. Certain combinations of plastic types are compatible for recycling together, and the designer needs to consider this in the selection of materials. To find out if a material can be recycled, you are encouraged to contact recyclers during the design phase for new products and product innovations when important decisions are being made about material selection and design. This can be done through the Recycling Operators of New Zealand (RONZ) (www.ronz.org.nz). Further information on plastics recycling in New Zealand can be found in Appendix 4 of this Guideline.

Contamination of the materials must also be minimised in order to assist with the viability of recycling. Labelling of polymer types according to standard practice is vitally important to improve the recyclability of a product.

Further information on compatibility of materials, minimisation of contaminants and labelling of plastic types can be found in previous sections of this Guide.

For more statistics and information about Sustainable End-of-Life Options for Plastics in NZ, please visit: http://www.plastics.org.nz/page.asp?id=6&newsid=132

4. Next Steps

The majority of Design for the Environment elements presented here will improve the sustainability of a product over its lifetime. Now use the techniques you will find in Guideline 2 to map the product life cycle in order to understand where environmental impacts occur and begin to implement the Design for the Environment strategies from Guideline 1.

Guideline 2 - Managing Design for the Enviroment Projects

Design for the Environment is about developing products in a way that minimises their environmental impact.
By using Design for the Environment principles a good quality, desirable and cost-effective product can be developed that also has a reduced impact on the environment.

If your company is involved in developing new products or seeking ways to improve existing products this is a chance for your company to:

- integrate Design for the Environment into your design/ development process;
- use Design for the Environment to achieve your goals of creativity and cost-cutting; and
- apply Design for the Environment to turn the environment into an opportunity for innovation.

You might be asking yourself, 'How do I start a Design for the Environment project?'. This Guideline will help you to implement a Design for the Environment project by taking you through each stage of the process and giving you some simple decision-making techniques.

These guidelines are designed to be used by all those involved in the plastics industry e.g. production engineers and toolmakers as well as designers.

Design for the Enviroment Tip: Start small!

It's not necessary to apply Design for the Enviroment to everything at once - you can start in a small way and apply Design for the Enviroment in increments to meet your needs. For example:

- You may find it beneficial to focus on environmental improvements that have a short implementation time. If there is considerable internal or external pressure to improve the environmental performance of your company's products, implementing Design for the Enviroment can improve employee morale and have market benefits. In such cases, you might focus on packaging which generally allows for rapid improvement.
- You may find it more cost-effective to apply Design for the Enviroment on a component-by-component basis. This allows your company to benefit from incremental product improvement while developing Design for the Enviroment experience.

Design for the Environment Project

It is not easy to consider every aspect of a product's design while also taking environmental impacts into account, and many decisions have to be made. Ideally Design for the Environment and development should be a step-by-step process that takes place alongside, and interacts with, overall product design.

A Design for the Environment project involves the following stages:

1. Selecting the product or component
2. Gathering information
3. Creating a design brief
4. Forming a project team
5. Analysing the product's environmental profile
6. Identifying Design for the Environment elements
7. Evaluating feasibility
8. Refining design brief
9. Monitoring and review.

1. Selecting the Product or Component

Usually selection of a product or component to be considered for Design for the Environment will be determined by market pressure, but you can run a simple screening exercise on your product by asking yourself:

- [ ] Could you save money by making the product more efficient?
- [ ] Do any of your products have significant environmental impacts?
- [ ] Are any of your products non-compliant with local and international regulations?
- [ ] Are you under pressure from regulators or non government organisations (NGOs) to change any of your products?
- [ ] Are any of your products / markets at risk from future regulations or NGO campaigns?
- [ ] Are you likely to increase sales of one of your products by appealing to environmentally aware consumers?
- [ ] What are your competitors doing? Are you going to lose market share for one of your products if you do nothing?

2. Gathering Information

In consultation with your supply chain, gather information that will inform the development of the design brief. For example:

- Customers, e.g. supplier guidelines, questionnaires
- Government, e.g. voluntary programmes, regulations (now and in the future)
- Environment groups, e.g. campaigns against your product
- Consumers, e.g. interest in greener products
- Suppliers
- Retailers
- Internal teams
- Manufacturer, e.g. identification code, tool costs.

Information to pull together in the initial stages of your Design for the Environment project might include:

Market

- key attributes of the product – function, aesthetic, quality, cost, etc.;
- current size of the market, including trends, past and future predictions;
- other factors affecting market — costs, regulations and standards, consumer interests; and
- any environmental issues identified within the market.

Competing products

- identification of a competing product (in the global market) with the best environmental profile.

Pressures or potential for change of product

- environmental issues, new materials, new technology; and
- new customer demands or niches.

Product information

- a broad description of the product (function and components), key design/production features, its history, a listing of material used and current patterns of disposal of the product at end of life;
- a list of all production processes involved in fabricating the product and all the components of the product and the source of those; and
- data on the use of the product, resources consumed (if any), frequency of use (if relevant), emissions generated, expected average life-time.

3. Creating a Design Brief

The next step is to develop a design brief. The design brief might include:

- general analysis of the existing product, as in traditional design briefs
- reasons for the selection of the specific product or component for Design for the Environment
- particular Design for the Environment strategies chosen as a focus
- a statement about the project team's latitude, i.e., how radically the existing product concept can be changed
- indication of the environmental and financial objectives
- how the project is to be managed
- how the results will be documented and measured
- final composition of the project team, plus any outside experts, and a description of members' responsibilities
- project plan and time frames
- project budget and its allocation to subsequent activities.

4. Forming a Project Team

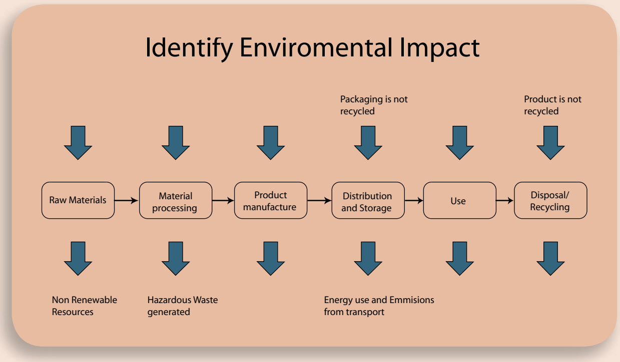
As Design for the Environment considers the full product life cycle, input is needed from different parts of the organisation. In effect, Design for the Environment promotes a holistic look at your business operations, but with a focus on a specific product. Form a project team that is able to address issues related to:

- design
- production
- marketing
- finance
- suppliers
- environment
- engineering
- quality assurance
- logistics
- purchasing
- sales

5. Analysing the Product's Environmental Profile

It is important to develop a good understanding of the product's main environmental impacts throughout its total life cycle. This will enable you to identify opportunities to improve the environmental performance of the product. At this stage, analytical tools are used to gain this insight into the life-cycle environmental impacts of the product.

Your project team should decide the scope of the environmental profile by considering not only the physical product but also the whole system required for the product's proper functioning.



5.1 Qualitative Analysis Versus Quantitative Analysis

The project team needs to decide how to analyse the environmental profile of the existing product. This analysis can be qualitative or quantitative and there are tools available for both options. Life-cycle assessment (LCA) is a tool, or methodology, for analysing these impacts. An LCA allows a designer to consider and design around the broader environmental implications of the product[1]. Two options are:

i. a semi-quantitative life-cycle review; and

ii. a quantitative life-cycle assessment (LCA).

1 Lewis, H. and Gertsakis, J. (2001) Design + Environment: A Global Guide to Designing Greener Goods.

A life-cycle review does involve some data collection but it is not as detailed as a fully quantitative LCA approach. A life-cycle review is much easier to undertake in-house and is therefore more cost effective.

However, if more detailed information is required – for example, if it is required by one of your customers, it may be better to allocate more time and money to an extensive quantitative life-cycle analysis.

5.2 Life-cycle Review

The life cycle of a product covers the complete cycle from concept to design; development to manufacturing; marketing and use; through to product end of life.

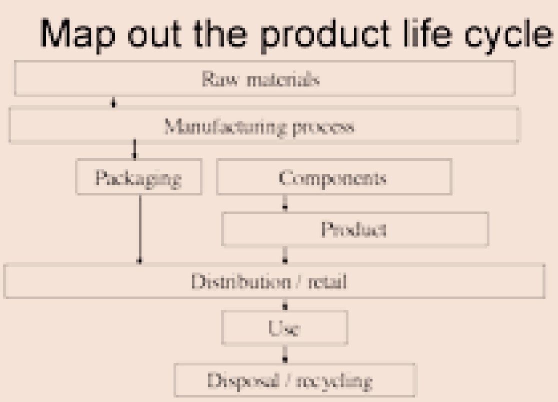
Start a life-cycle review by mapping out the product life cycle – product flows and all of the inputs and outputs along the life cycle.

Identify all of the components – what they are made from, where they are made and how they are transported (truck, ship etc.).

Identify the disposal or recycling routes for products and packaging when they are discarded, including transport and secondary packaging disposed of by distribution centres, retailers and consumers.

Identify any 'hot spots', i.e. issues that you think should be addressed in the design process. Collect more information on relevant areas, for example;

- quantify the amount of waste generated by your product at end of life;
- find out the recycling rates for relevant materials, such as LDPE (shrink / stretch wrap) or packaging materials at kerbside (PET, HDPE etc);
- investigate the amounts and potential toxicity of specific additives used in manufacturing the product; or
- find out how much energy is used and greenhouse gas generated in manufacturing or transport.



Adapted from Helen Lewis, Plastics New Zealand Presentation Nov 2005

5.3 Life-cycle Analysis

Life-Cycle Analysis (LCA) is the investigation into the amount of impact a product may have on the environment through all stages of its 'life'. Using this method, the environmental costs and benefits of a product or service can be quantitatively measured and evaluated. There is an international standard for conducting LCA (ISO14040) and there is a wide range of software programs available for those companies who want to conduct a thorough analysis.

WANT TO LOOK INTO THIS FURTHER?

http://www.setac.org/htdocs/who_intgrp_lca.html
Society of Environmental Toxicology and Chemistry (SETAC) provides international support to LCA practitioners worldwide.

http://www.pre.nl/simapro/default.htm
SimaPro is one of the leading pieces of LCA software. Developed by Pré Consultants in the Netherlands, who also have useful information on Design for the Environment and LCA throughout their website.

http://www.uneptie.org/pc/sustain/lcinitiative/home.htm United Nations Environment Programme has a Life Cycle Initiative with useful international resources and links.

http://reports.eea.europa.eu/GH-07-97-595-EN-C/en European Environment Agency report: Life Cycle Assessment (LCA) - A guide to approaches, experiences and information sources

6. Identifying Design for the Environment Elements

Generating ideas and assessing them is vital to the Design for the Environment process. Ideas will flow from the use of the Design for the Environment checklists and from brainstorming or ideas workshops.

Use the Design for the Environment checklist from Guideline 1 to evaluate the product or component against each of the Design for the Environment elements:

- Material selection
- Product design
- Process design
- Communication
- Distribution
- Impact during use
- End of Life options.

For electronic, packaging, construction or agricultural products, use the more detailed and specific guidelines 3 to 6.

After you have worked through the checklist and identified the elements that are relevant to your product, and you have reviewed some of the supporting information and case studies, use the checklist as the basis for a brainstorming session, or workshop.

Set a simple agenda for the session (see below). Identify ideas for making environmental improvements in your product design. You might consider pulling in your suppliers' customers, as their input to the process can be valuable. Some outside design assistance and a neutral facilitator may also help.

The next stage is to evaluate the ideas from the workshop and translate them into a design brief.

Those ideas that fall into Category 1 are the highest priority for implementation as they are technically and economically feasible and they deliver good environmental gains. Category 2 ideas should also be pursued as a priority because they are highly feasible, despite the reduced environmental benefits. Ideas in Category 3 should be reviewed to determine the worth of their adoption. Ideas in Category 4 should generally be discarded.

Possible Agenda for an Ideas Workshop

(adapted from Lewis & Gertsakis, 2001)

General product information

Present results
Invite questions and discussion
Identify opportunities and threats

Environmental profile

Present results
Invite questions and discussion
Identify key impacts

Design for the Enviroment strategies

Brainstorm creatively with no constraints
List ideas and strategies (on a whiteboard perhaps)

Review ideas

Hold a critical reflection on the ideas generated
Identify priorities

Example of priority setting for a hypothetical product

CATEGORY 1 – highest priority

Lightweight the product by using 2 widgets instead of 4
Reduce the amount of packaging we use for distribution
Use plastic identification labelling on all plastic types

CATEGORY 2 – medium priority

Reduce the use of cadmium as a pigment

CATEGORY 3 – medium priority

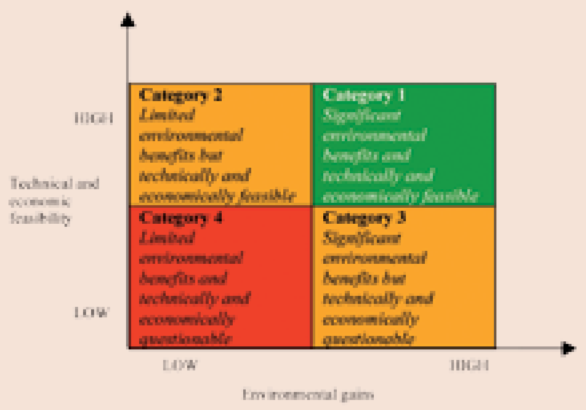
Minimise material use by changing housing wall design
Use plastic fasteners rather than metal

CATEGORY 4 – low priority

Use sea distribution rather than air
Restrict use of glass fibre as an additive in the plastic housing

7. Evaluating Feasibility and Prioritising

Evaluation could take place as part of the workshop or may be done following the workshop. The team categorises each improvement option identified in the checklist. Each option is categorised according to the significance of its technical and economic benefits, as shown in the matrix below.



8. Refining the Design Brief

Drawing on the original design brief and the ideas that have come from working through the checklist and conducting a workshop, it is time to refine the design brief. Design for the Environment objectives and elements can now be incorporated into the design brief according to their priority ranking.

9. Monitoring and Review

As you apply Design for the Environment elements to a number of products/components there will be opportunities to streamline the Design for the Environment process within your company. It's important to monitor project implementation and plan to review and report on how the product is performing over the whole life cycle.

Guideline 3 – Electronics

Design for the Environment is about developing products in a way that minimises their environmental impact.

By using Design for the Environment principles a good quality, desirable and cost-effective product can be developed that also has a reduced impact on the environment.

This guideline is number 3 in a series of six that have been created to provide practical Design for the Environment assistance to anyone involved in the design of products that contain plastics. This guideline will give you practical advice and guidance on implementing Design for the Environment in electronic product design projects.

Plastics Design for the Environment Electronics Checklist

Use this checklist as a prompt as you work through the design of a particular product. Work your way down the list and identify the areas in which you can incorporate the Design for the Environment aspect in your product design. Ask yourself, 'Can we do this for this product?' and, 'Will this improve the product's environmental performance?' for each aspect.

There is more detail on each aspect, including practical design ideas and case studies, in the pages that follow the checklist.

If you tick 'Yes' because you think there is an opportunity to make an improvement in the product design, make a note of the measure you are going to take and the actions needed to implement the change.

Each of the Design for the Environment elements in the checklist below has more detailed information in section 3 of this guideline.

Design for the Enviroment Element	Yes	No	ACTION (e.g. investigate further, change from LDPE to HDPE, use fastener instead of adhesive)
3.1 Material Selection			
Avoiding toxic and hazardous substances			
Using recyclable material			
3.2 Product Design			
Minimising material use			
Avoiding the use of unnecessary components			
Designing for disassembly			
Using appropriate fastening and joining technology			
Designing for repairability			
Looking for functionality innovation			
Considering component design			
3.3 Communication			
Labelling			
Ensuring compliance information for overseas markets			
3.4 Impacts During Product Use			
Energy efficiency			

Electronics in New Zealand

Electronics is a catch-all description for a range of products that need electricity to operate. Think of it as 'anything that has a plug or battery'. Examples include domestic appliances, computers, telecommunications systems, GPS, marine electronics, and agricultural electronics.

Profile of the New Zealand Electronics Industry

A study of 68 electronics companies (estimated to cover 90% of the industry) showed that exports of electronics products and services reached $800 million by the beginning of 2000.

Total employment in the companies surveyed was 4600, with around 18% of staff deployed in research and development and 44% in production.

The companies in the study had around 1200 staff qualified in electronics and software at professional and technicial engineer levels.

Eighty per cent of production from the companies surveyed was exported, and around 10% of revenue from sales was channelled back into R&D.

From www.marketnewzealand.com

Plastic is the second largest component of electronics after iron/steel. Studies have estimated that plastics make up around 20% of electronic products by weight.

There are many types of plastics used in electronic equipment. The proportion and types of plastics used vary, not only from one product type to another, but also among similar products manufactured in different years. Styrenes (ABS, ASA, SAN, PS, HIPS) and polypropylene (PP) are the most common of the plastics used, accounting for around 70%.

1. Drivers for Design for the Environment in Electronics

The key driver for environmental design in the New Zealand electronics industry has been the introduction of legislation in overseas markets. Many New Zealand export manufacturers have already been affected by the introduction of product stewardship regulation overseas.

Electronics legislation now exists in many significant export markets, including the European Union, Japan, South Korea, and California. Legislation is also being developed in China and Australia. The EU legislation is probably the best known and consists of:

1. a Directive on Waste Electrical and Electronic Equipment (WEEE); and
2. a Directive on the Restriction of Use of Certain Hazardous Substances (ROHS) in electrical and electronic equipment.

The WEEE Directive requires producers to pay for at least the collection of their products at end of life and to meet targets for re-use, recycling and recovery. The ROHS Directive means that products containing restricted substances have not been allowed to be placed on the European market since 1 July 2006.
Refer to Appendix 5.

As far as component suppliers and distributors are concerned, EuP is going to mean a continuing pressure to remove restricted substances, and to reduce power consumption and weight. There will also be a growing demand for more comprehensive data on energy use, composition and compatibility of materials, weight, disassembly and recyclability, identification and in some cases a move towards more modular designs which can be upgraded more easily.

Premier Farnell PLC
Summary of EuP Directive, downloadable from
http://www.electronicsyorkshire.org.uk/uploads/documents/eup_directive_indd1.pdf

Of even more significance could be the proposed European Union legislation that will require the adoption of Design for the Environment principles in electronic products. The EU Directive on the eco-design of Energy-using Products (The EuP Directive) aims to establish a framework that will allow the Design for the Environment requirements to be imposed on electronic products. These requirements will be specific, quantified and measurable relating to a particular environmental aspect of a product, for example, the amount of energy it consumes during its working life.

Crucially, a product will not be subject to the Directive requirements unless it

- sells more than 200,000 units per year in the EU
- has a significant environmental impact
- presents significant potential for improvement.

And, any measures must not have a 'significant negative impact' on

- a product's price or performance, or
- on the competitiveness of EU industry.

WANT TO LOOK INTO THIS FURTHER?

http://ec.europa.eu/environment/waste/weee_index.htm Official European Union website for the WEEE and RoHS Directives. Includes downloadable copies of the Directives and FAQs.

http://ec.europa.eu/enterprise/eco_design/index_en.htm Official European Union website for the EuP Directive.

http://www.plasticsresource.com/s_plasticsresource/sec_electronics.asp?TRACKID=&CID=272&DID=823 American Plastics Council resource on plastics in electronics.

The New Zealand government is also in the process of developing a product stewardship approach to electronic products and this could include a RoHS-type restriction on substances. This may have significant impacts on the electronics industry.

WANT TO LOOK INTO THIS FURTHER?

http://www.mfe.govt.nz/issues/sustainable-industry/initiatives/product-stewardship/index.html
to follow the development of product stewardship by the Ministry for the Environment.

http://www.mfe.govt.nz/publications/waste/product-stewardship-water-labelling-jul05/index.html
2005 discussion document on product stewardship policy in New Zealand.

http://www.canz.org.nz/E-waste%20in%20NZ,%20CANZ%20report,%20July%202006%20-%20Web%20version.pdf
2006 report into computer and television waste in New Zealand.

2. Design for the Environment Benefits

Companies that apply Design for the Environment find that it has a number of business benefits. These are discussed in Guideline 1.

3. Design for the Environment Elements

There is a wide range of Design for the Environment elements that can be applied to a product, or products, to improve environmental performance. Guideline 1 in this series has detailed some of the more general Design for the Environment elements applicable to plastic products. The following sections contain ideas more specifically focused on electronic products.

3.1 Material Selection

One of the key phases in product development is the choice of the right materials. As well as technical performance and price, environmental performance is becoming increasingly important. Opportunities to design improved environmental performance through material selection in electronic products include:

- avoiding toxic or hazardous materials; and
- using materials that maximise recyclability.

There are a number of elements that should be taken into account when selecting materials to improve the environmental performance of a product. Each of these issues is detailed below.

3.1.1 Avoiding toxic and hazardous substances

Toxic and hazardous materials can be a risk to the health of workers who make the product, to the consumer who uses it, and to the natural environment that must deal with airborne, waterborne or solid wastes during the lifetime of the product.

It is recommended that the use of hazardous substances be avoided where possible. Where this is not practical, the substances or materials should be clearly marked and easy to separate and must comply with current hazardous substances regulations. In New Zealand, plastic polymers with hazardous properties will be subject to management controls as set out in the Polymer Group Standards. These came into force on 1 July 2006. Plastics New Zealand will provide guidance for the manufacturers or importers of plastic polymers to determine which group standard, if any, applies to the polymers. For more information go to the website: http://www.ermanz.govt.nz/hs/groupstandards/standards/polymers.html

There are a number of hazardous substances commonly found in electronic products.

Substance	Example of use
Lead	• tin-lead coatings • low temperature brazing alloys (SnPb) • thermal stabilisers of PVC (lead stearate) • pigments for polymers (lead chromate)
Mercury	• mercury whetted relay
Cadmium	• coatings (with hexavalent chromium passivation) • high temperature brazing alloys (ex Ag-Cu-Zn-Cd) • thermal stabilisers of PVC (cadmium stearate) • pigments for polymers
Hexavalent Chromium	• passivations of zinc, copper, alloys of aluminium, silver, galvanized sheet steel
Polybrominated biphenyls (PBB)	• flame retardant, cables, plastics
Polybrominated diphenyl ethers (PBDE)	• flame retardant, cables, plastics, ABS

Examples of common uses for hazardous substances in electronics (from www.raws.co.nz)

Substances restricted by the EU RoHS Directive since 1 July 2006

Lead
Mercury
Cadmium
Hexavalent chromium
Polybrominated biphenyls (PBB)
Polybrominated diphenyl ethers (PBDE)

Significant exemptions

Lead in cathode ray tube glass
Mercury in compact fluorescent lamps, not exceeding 5 mg per lamp
Lead in high melting temperature type solders

Refer to the Directive and Electronics South for more detail on exemptions.

These substances have already been the subject of restrictions, or 'bans', in Europe. Hazardous substances restrictions in electronics are also being developed in China, California, Korea and Australia.

Products, or components of products, that are being designed for the EU market (and others in the near future) must not contain these hazardous substances. If a product is found to contain restricted substances there is the very real risk that the product will not be allowed onto the market.

Other hazardous materials used in electrical and electronic equipment are also under scrutiny and may be subject to voluntary or regulatory restrictions in the future. Product developers should use the links below to keep themselves updated on changes to RoHS Directive exemptions and developments in other countries.

WANT TO LOOK INTO THIS FURTHER?

http://ec.europa.eu/environment/waste/weee_index.htm Official European Union website for the WEEE and RoHS Directives. Includes downloadable copies of the
Directives and FAQs.

http://www.electronicssouth.com/index.cfm/RoHS%20and%20WEEE New Zealand online support for the RoHS & WEEE Directives. Funded by NZTE, Electronics South and the Canterbury Electronics Group. Site managed by RoHS & WEEE Specialists Ltd (http://www.raws.co.nz/).

http://www.eiatrack.com/ Subscription based web service that delivers information on product-oriented environmental compliance for the electronics sector.

Lead

Lead is commonly found in electronic products. It is used in solder, and as a plasticiser and pigment in plastics.

Lead has been widely used in solder to attach components to printed circuit boards. Due to legislative pressures (see above) there has been a move to alternative solders. For most mainstream soldering applications, alloys based on tin-silver-copper (Sn-Ag-Cu) will probably be the first choice to replace lead solder.

Compatibility of lead-free solders with existing components and coatings must also be considered. A range of components — from plastic encapsulated devices to capacitors, electromechanical components and connectors — may not be able to withstand the higher process temperatures required for lead-free solders. Although thermal stress on components is being addressed through soldering flux and equipment developments, some components will need to be requalified to withstand higher temperatures, which is time-consuming and expensive. There may also be some impact on component lifetimes.

WANT TO LOOK INTO THIS FURTHER?

http://www.envirowise.gov.uk/page.aspx?o=electronics UK site offering advice for businesses. Includes simple guidance on complying with RoHS and WEEE Directives.

http://www.electronicssouth.com/index cfm/RoHS%20and%20WEEE/RoHS/Lead%20Free%20Soldering New Zealand website. Excellent technical information on alternatives to lead solder and links to lead-free resources.

http://www.leadfree.org/ technical website of the IPC (Association Connecting Electronics Industries) with a lot of good resources on alternatives to lead solder.

Halogenated flame retardants

Some halogenated flame retardants (containing chlorine or bromine) such as polybrominated diphenyl ethers (PBDEs) and polybrominated biphenyls (PBBs) can be environmentally hazardous. There is some evidence that these types of flame retardant release hazardous substances into the environment when incinerated and may leach in landfill conditions.

If a product or component has flame retardancy requirements, then the first step should be to consider inherently (naturally) flame retardant materials, such as polycarbonate. If this is not possible, then preference should be given to halogen-free flame retardants that do not pose any problems for recycling or disposal.

A number of halogen-free flame retardants are now commercially available. Some of the main alternatives which are applicable to different polymer types used in the electronics industry are summarised in the following table.

Halogen-free flame retardant	Applicable polymer types
Aluminium trioxide Epoxy	ABS, HIPS, PC, EVA, XLPE
Magnesium hydroxide Epoxy	ABS, HIPS, PC, nylons, PVC, EVA, XLPE
Magnesium carbonate	ABS, HIPS, PC, PVC, EVA, XLPE
Zinc borate Epoxy	nylons, PVC, EVA
Zinc hydroxystannate	PVC, EVA
Zinc stannate Epoxy, nylons	PVC
Red phosphorus Epoxy	phenolic, nylons
Ammonium polyphosphate	Epoxy
Phosphate esters Phenolic	ABS, HIPS, PC, PVC, EVA
Melamine derivatives	ABS, HIPS, PC, nylons
Reactive P-N	Epoxy

Some alternative, halogen-free flame retardants

A comprehensive analysis carried out by the Electronic Industries Association of Japan in 1999 estimated that about 3% of global printed circuit board manufacturers had switched to using halogen-free materials. However, it expects this to increase rapidly to 80% by 2010.

WANT TO LOOK INTO THIS FURTHER?

http://www.lenape.com/flameretard.html A chemical company that offers alternative flame retardants

http://www.e1.greatlakes.com/fr/common/jsp/index.jsp Great Lakes Chemical Corporation. Major US supplier of flame retardants.

http://www.mst.dk/udgiv/Publications/1999/87-7909-416-3/html/kap08_eng.htm Danish study of alternative, non-halogenated flame retardants.

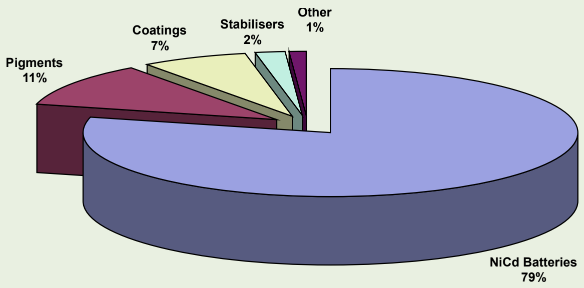
www.halogenfree.org website maintained by the IPC ("Association Connecting Electronics Industries") with a lot of good resources on flame retardants.

http://www.ebfrip.org European Brominated Flame Retardant Industry Panel.

Cadmium

Cadmium is used by industry for a number of purposes, including:

- as an anti-binding agent (cadmium-plated parts have good lubricity);
- as an anti-corrosive agent (particularly to protect connectors and fixings in salt-spray);
- conditions where electromagnetic compatibility (EMC) is a critical issue;
- as pigments and stabilisers in paints and plastics;
- as solders; and
- in batteries.



Use of cadmium in 2003 (from www.cadmium.org)

Cadmium sulphide and cadmium sulphoselenide are utilised as bright yellow to deep red pigments in plastics, ceramics, glasses, enamels and artists colours. They are well known for their ability to withstand high temperature and high pressure.

Cadmium-bearing stabilisers retard the degradation processes in polyvinylchloride (PVC) which occur upon exposure to heat and ultraviolet light. These stabilisers contain organic cadmium salts, usually carboxylates such as cadmium laurate or cadmium stearate, which are incorporated into PVC before processing and which arrest any degradation reactions during subsequent processing and ensure a long service life.

Cadmium coatings are also employed in many electrical or electronic applications where a good combination of corrosion resistance and low electrical resistivity is required.

In many cases, design changes could remove the need for cadmium coatings altogether. Where coatings are required, alternatives to cadmium are available for most applications and include:

- tin and its alloys;
- zinc and its alloys (e.g. zinc/cobalt);
- ion vapour deposition (aluminium coatings);
- nickel;
- epoxide; and
- plasticised coatings that have been developed for specialised use.

Where weight is not an issue, nickel/aluminium/bronze alloys can be used for corrosion resistant connectors. These alloys may increase the weight of each connector by a factor of 2 – 3 or greater in comparison with cadmium-plated aluminium connectors. New materials continue to be developed, many of which exceed the performance of existing cadmium coatings.

WANT TO LOOK INTO THIS FURTHER?

www.cadmium.org basic information on cadmium use from the International Cadmium Association.

http://www.epa.gov/reg5rcra/wptdiv/wastemin/cd.pdf
US EPA factsheet on cadmium and alternatives to cadmium.

Hexavalent chromium (chrome VI)

Hexavalent chrome is used extensively in the electronics metal finishing industry in the form of a passivation for zinc and aluminium to prevent oxidisation. Hexavalent chrome is also used in electronics as:

- chrome-based alloys or chrome plating to provide hard wearing surfaces;
- corrosion resistant surface treatments;
- pigments and stabilisers in paints — lead chromate pigments are used to achieve bright yellows, oranges and reds.

Where coatings are required, alternatives to chrome VI that may be considered, including:

- zinc-based coatings and compounds, e.g. zincate;
- nickel-based coatings, e.g. electroless nickel, boron nickel;
- copper;
- silver; and
- modified primer/paint technologies.

WANT TO LOOK INTO THIS FURTHER?

http://www.electronicssouth.com/index.cfm/RoHS%20and%20WEEE/RoHS/Hexavalent%20Chromium%2C%20Mercury%2C%20Cadmium
Gives details on chrome uses and alternatives being developed in New Zealand.

Mercury

Mercury has traditionally been used in electronics as:

- thermostat switches (e.g. in domestic heating systems);
- tilt switches (e.g. for convenience lighting in car boots and chest freezers, and for pilot lights on gas ovens); and
- in fluorescent lamps (including LCD backlights).

Most manufacturers phased out the use of mercury in these applications in the early 1990s. The use of mercury in fluorescent lamps is still permitted by the European RoHS Directive up to a specific threshold level.

WANT TO LOOK INTO THIS FURTHER?

http://ec.europa.eu/environment/waste/weee_index.htm Official European Union website for the WEEE and RoHS Directives. Includes downloadable copies of the Directives and FAQs.
http://www.p2pays.org/ref/07/06743.pdf
US EPA study on Mercury Usage and Alternatives in the Electrical and Electronics Industries.

3.1.2 Using recyclable material

Selecting the best choice of plastics for your product involves considering downstream end-of-life issues with recyclers as well as upstream material flows with suppliers. Each of the main polymer types has different strengths and weaknesses in environmental and performance terms.

It is important to consider the design of the injection moulding process. For example, some design features (e.g. sharp corners) and process steps (e.g. heating profiles) can degrade polymers and so reduce the quality of the plastic for recycling.

Ideally, the same plastic polymer should be used throughout the product. This will increase opportunities for end-of-life recycling. In some cases, there may be opportunities to use both virgin polymer and the same type of recycled polymer for different parts of the product. If this is not possible, it may be preferable to select polymers which are easier to separate at end-of-life for individual recycling. This will depend on the recycling process (e.g. granulation followed by air filtration) and require consultation with the recycling industry.

Alternatively, select combinations of polymers that can be recycled together to form a usable alloy. For example, polycarbonate (PC) and ABS can be recycled together to form PC/ABS. The compatibility of different combinations of polymers for recycling is compared in Appendix 6.

> Compatibilty of different polymer combinations for potential recycling is compared in Appendix 6

To assist with the material selection process there are key questions that can be put to your suppliers and to the recycling industry:

Questions for polymer suppliers

- Can polymers be selected which are more robust to the recycling process?
- Can polymers be selected which are easier to separate for individual recycling?
- Can polymers be selected which are more compatible for mixed recycling?
- Do the additives used in these polymers comply with EU RoHS retrictions?

Questions for recyclers

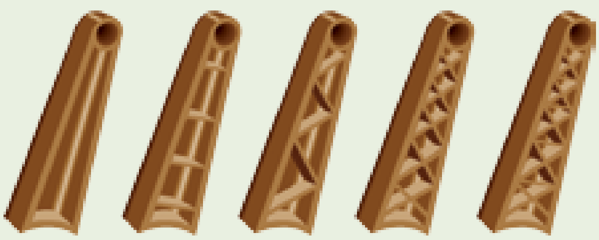
- What is the market demand for the recycled polymers?
- Can the recycler separate polymers from this type of product for individual recycling?
- Can the recycler recycle polymers together to produce a mixed polymer?
- Will the coatings or fixings be a barrier to recycling?

3.2 Product Design

3.2.1 Minimising material use

Material use in plastic parts for electronics can be minimised by designing stiffer and thinner walls[1]. When plastic parts are designed with thin walls, part stiffness can be reinforced using one of several environmentally preferred design features. Increasing stiffness in this way will reduce the raw material required. Design features include:

- narrow ribs used to stiffen a flat surface area – a larger number of narrow ribs is preferable to a smaller number of large and heavy ribs;
- bosses (protruding studs or pads used to reinforce holes or for mounting an assembly); and/or
- gussets (supporting members used to provide added strength to features such as bosses or walls).



Examples of ribs used to increase stiffness and minimise material use (from Plastics New Zealand Diploma in Plastics Design http://www.plastics.org.nz/page.asp?id=660

3.2.2 Avoiding the use of unnecessary components

Minimising the number of parts in a product has clear benefits in material saving, disassembly efficiency and ease of repair. Lowering the number of separate parts required in a design can reduce the need for disassembly of a product. Multiple parts can be designed into one part, reducing the number of fasteners and thus reducing the time required for disassembly, sorting and recycling.

Using a smaller number of higher function components will reduce the number of components to be joined and the complexity of the fixings. As well as reducing manufacturing costs, this will reduce failure rates in assembly and use.

1 American Plastics Council (2000) A Design Guide for Information & Technology Equipment

‘Recycling is made more difficult by the ever greater complexity of products, increased use of composite materials and the trend towards miniaturisation, as is the case, for example, in the electronics industry’
(Braunmiller & Wörle, 2000).

3.2.3 Designing for disassembly

It is important to consider how easy the product will be to disassemble for end-of-life recycling when developing a product with multiple parts or components.

By having standard connections that are readily accessible and easy to disconnect, the recyclability of the product is improved, because components and material fractions of the product are easily separated.

Disassembly may even be eliminated by joining parts made of the same material through alternative joining methods that do not require the use of hinges, fasteners, inserts or other attachment devices.

The Apple G4 computer enclosure was designed as two components: a metal chassis with a polycarbonate plastic skin. This allows for easy separation of materials for recycling. The previous G3 model used 11 screws to secure the motherboard to the unit, while the G4 uses just 2 screws, facilitating easier and faster removal. Only common screws were used (Torx or Philips head screws) reducing the tools required for dismantling.

The lithium battery was placed on top of the circuit board and held in place with a plastic snap-fit holder to enable easy removal without the use of tools.

3.2.4 Using appropriate fastening and joining technology

There is a wide range of attachment techniques and these greatly affect the disassembly of a product and therefore the economics of recycling. The choice of attachment type depends on assembly cost and required performance parameters during the product’s lifetime.

For example, will the attachment be permanent during the product’s lifetime or will it need to be reversible for servicing, repair or upgrade? The choice will affect the purity of recycled materials and hence their value. Reversible attachments need to be accessible, easy to remove and durable, and will give more pure materials after disassembly.

Where fasteners are used, it is important to:

- make fastening points accessible, visible and clearly marked. Consider colour coding to aid assembly and disassembly, e.g. for upgrade or repair;
- use a simple component orientation;
- use screws in place of rivets for easier disassembly at end of life;
- standardise screw heads to aid assembly and disassembly with as few tools as possible;
- avoid assemblies that require power tools to take them apart; and
- consider using fasteners of the same material as the parts to be joined to optimise materials recycling opportunities at end of life.

Snap-fits can be designed to allow rapid and efficient disassembly of the product, for example, by ensuring that the tines are easily accessible. However, in some cases they may not provide adequate pressure on connecting parts, for example, to ensure adequate conductive continuity in products requiring shielding from electromagnetic interference, and in areas with high levels of vibration.

Joining of dissimilar materials using adhesives or welding should be avoided. Staking techniques for joining thermoplastic parts to other materials can provide a low-cost approach, but reduce opportunities for end-of-life materials and component recycling.

WANT TO LOOK INTO THIS FURTHER?

Take a look at Guideline 1 in this Design for the Environment series.

American Plastics Council (2000) A Design Guide for Information & Technology Equipment

Downloadable from http://www.plasticsresource.com/s_plasticsresource/doc.asp?TRACKID=&CID=174&DID=383

3

3.2.5 Designing for repairability

Designing a product so that it can be easily serviced and upgraded to extend the product's lifetime can also provide marketing benefits and enhance brand value. It will also reduce the cost of repairing products that fail quality control inspections or are returned under warranty.

This involves:

- considering higher specification components, sub-assemblies and PCBs to improve reliability;
- designing parts for equal lifetime, since failure of a single part often means that the whole product is discarded;
- designing for disassembly to ensure that products can be taken apart efficiently;
- modularisation to enable product upgrade and repair;
- ensuring replaceable and upgradable components are easily accessible; and
- considering how best to supply spares. Providing spares in kits may result in waste of unwanted parts. However, having each part available separately may increase packaging requirements.

3.2.6 Looking for functionality innovation

Design for the Environment can stimulate innovation and lead to radical changes in the product itself. Focusing on the service that the customer gains from the product and how the customer uses the product's functions can provide a fresh insight into new ways of delivering these.

Reviewing how the customer uses the product's function can identify opportunities to design products to gain functional leadership in the marketplace. For example, a multifunctional product such as a combined printer, scanner and copier machine can increase market share by meeting customer requirements in a more cost-effective manner. A combined printer, fax, scanner and copier:

- uses fewer materials and is cheaper to manufacture than three or four separate machines;
- uses less energy in stand-by mode;
- takes up much less space; and
- costs less to transport.

Design for Disassembly and Upgrade: Electrolux Chameleon

Commercial cooling displays typically consume most of the energy used in supermarkets. They also require periodic styling updates even though many of the parts of the unit may still be fully functional. Through the use of Design for the Environment principles the disassembly time of this Electrolux product was reduced by 40%, with 96% of the materials recycled at end of life, and energy use reduced by about 10%.

Savings were made in the following ways:

- Silicon insulating strips were replaced with foam strips that can be peeled off during assembly (Electrolux also found this to be more aesthetic).
- Larger copper evaporators improved energy efficiency.
- Alternative materials were used to increase recyclability. For example, the polyester bin sections, traditionally filled with polyurethane, were replaced with a combination of recyclable surface, foam, and adhesive.
- The amount of copper and aluminum used in large parts was decreased, while the use of recycled materials was increased.
- A new support construction for the glass and lighting allows for rapid disassembly and conversion between serve-over and selfservice displays.
- To address the need to upgrade the style of an otherwise functioning refrigerated display, designers use modular subassemblies to ease disassembly and replacement.

For more information:
www.dfma.com/news/Electrolux.htm

A multifunction printer/copier/scanner/fax

3.2.7 Considering component design

For electrical and electronic design, the starting point is component specification because this has knock-on effects on other production issues.

The packaging of components has a major impact on the design of printed circuit boards and their ease of assembly. Some components are available with a range of packaging options. Where design constraints allow, maximising the feature geometry will make the PCB easier to manufacture and assemble, thus reducing costs.

Reprogrammable components can keep the product design more flexible and enable design upgrades without needing to change hardware requirements. This can be particularly cost-effective for low volume products where hardware set-up costs are a major component of product cost. Reprogrammable components can improve time to market by allowing for programming changes at the last minute or in the field. Reprogrammable components also offer greater opportunities for re-use at end of life.

3.3 Communication

3.3.1 Labelling

It is very important that plastic components are labelled so they can be easily identified. Proper end-of-life treatment of materials relies on the users and waste disposal services recognising the type of material.

Plastic polymers should be marked with the material category and date of manufacture to optimise opportunities for materials recycling at end of life.

ISO 11469 specifies a system of uniform marking of plastic products and the symbols and abbreviations to be used are given in ISO 1043.

Flexible tooling using tool inserts allows in-mould marking to be changed if the polymer material is changed.

For example:

>ABS< identifies an ABS polymer;

>PC+ABS< identifies a blend where PC is the main polymer;

>PVC-P(DBP)< identifies a PVC containing dibutyl phthalate as plasticiser.

The marking should be clearly visible on each separate component. This will facilitate the identification and sorting of different polymers after disassembly of the product.

Generally, marking by tooling is preferable to marking by labels, pad printing, bar coding or laser inscribing. Moulded-in markings are one of the most environmentally conscious marking methods because they require no use of other chemicals or materials, reducing the likelihood of contaminating recyclable material.

Labels can introduce an incompatible contaminant to the recycling process. Wherever possible labels made from the same plastic type as the part to be labelled should be used. It is also preferable to attach the label using methods that leave no contamination, such as ultrasonic welding, heat staking and spin welding, hot-plate or hot-gas welding.

Once again, it is important to check with recyclers to make sure that these treatments will not inhibit recycling, i.e. by contaminating the recyclate.

WANT TO LOOK INTO THIS FURTHER?

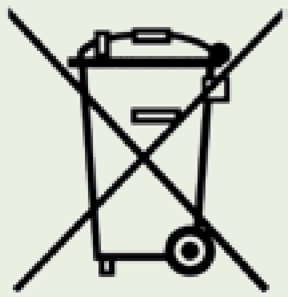
http://www.iso.org/iso/en/ISOOnline.frontpage
to buy a copy of ISO 11469.

Take a look at section 3.4 of Design for the Environment Guideline 1 in this series.

3.3.2 Ensuring compliance information for overseas markets

It is important to note that all electronic products placed on the European Union market must meet particular marking requirements (see Appendix 5). Every product must be labelled with a crossed out wheelie bin (or if the marking on the label will be less than 5mm then the label can be placed on the instruction manual).

Producers are also required to provide information on components and materials used in their products to enable treatment facilities, re-use centres and recycling facilities to disassemble, re-use and recycle them.



Crossed-out wheelie bin symbol must be placed on every electronic product being placed on the EU market.

While the marking and information requirements of the WEEE Directive apply only to final products, component suppliers will also increasingly find their customers requesting information about the composition of components and evidence that components meet the restrictions of such overseas legislation.

Legislation is also being developed elsewhere in the world that will have very similar information and marking requirements on products. It is recommended that designers stay abreast of legislation changes through sources such as those suggested below.

WANT TO LOOK INTO THIS FURTHER?

http://www.electronicssouth.com/index.cfm/RoHS%20and%20WEEE
New Zealand online support for the RoHS & WEEE Directives. Funded by NZTE, Electronics South and the Canterbury Electronics Group. Site managed by RoHS
& WEEE Specialists Ltd (http://www.raws.co.nz/).

http://www.eiatrack.com/
Subscription-based web service that delivers information on product-oriented environmental compliance for the electronics sector.

3.4 Impacts During Product Use

3.4.1 Energy efficiency

For many electronic products, the energy consumed during the product's lifetime represents a significant proportion of the overall environmental and financial costs of the product. Designing products with lower energy consumption provides tangible cost savings to customers and can be exploited as a valuable marketing tool. Where the product has energy-efficient operating modes, consumers can be encouraged to use these by providing 'user friendly' controls and easy-to-follow user instructions.

ENERGY STAR®
New Zealand recently adopted the ENERGY STAR programme. ENERGY STAR is the global mark of energy efficiency. It is awarded to the most energy-efficient appliances and products.

ENERGY STAR is being phased into New Zealand, with new products added each year. The first phase, from July 2005 to June 2006, covered home electronics and office equipment.

For more information:
http://www.eeca.govt.nz/labelling-and-standards/endorsement-labels.html and http://www.energystar.gov/

Collectively, hot water systems, heaters, cooking equipment, fridges, lights, air conditioners and washing and drying machines use 95% of the energy in an average house[2].

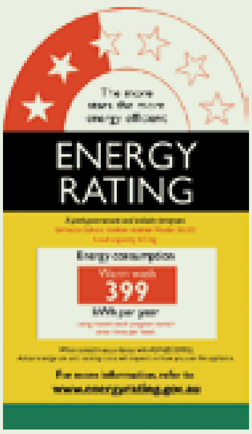
Electronic products can be designed to minimise energy consumption and costs during use by:

- using low voltage logic;
- using thermostats, timers and sensors;
- designing an energy efficient 'stand-by mode';
- making the product compatible with other energy efficient devices;
- increasing the thermal tolerance of the design to avoid the use of cooling fans or air conditioning;
- improving the insulation of hot or cold elements;
- looking at recovery of excess heat output. If a product is used in an air-conditioned building between 1.2 and 1.6 times the heat output of the device will be used to remove that heat from the building.

2 Australian Consumers Association (1992) Why waste energy? Choice, May 1992

In New Zealand and Australia there are minimum energy performance standards for certain electronic products. These products include:

- fridges and freezers
- electric hot water cylinders
- air conditioners
- three-phase electric motors
- refrigerated display cabinets
- fluorescent lamps
- ballasts for fluorescent lamps
- distribution transformers.



Example of an energy rating label

Since 2002, all fridges, freezers, and single-phase domestic air conditioners must also display an Energy Rating Label. This rating system has been harmonised with the Australian system that has been in place since 1989.

Where batteries are required, batteries with greater energy efficiency and lower environmental impact should be used. Nickel metal hydride (NiMH) is a well-established technology that offers more than twice the volumetric energy density (energy stored within a given volume) of cheaper nickel cadmium (NiCd) batteries. NiMH batteries are smaller, lighter and contain less heavy metal content. Lithium ion (LiON) batteries offer still higher energy density, using a newer technology.

Product developers for European markets also need to be aware that the Batteries and Accumulators Regulations were implemented in response to EC Directives and apply to batteries containing specified amounts of mercury, cadmium or lead. The regulations:

- banned the marketing of batteries with over 0.0005% of mercury by weight, with the exception of button cells or batteries containing button cells, where the limit is 2% of mercury by weight;
- require that appliances using batteries must be designed to ensure that the batteries can be easily removed;
- introduced a marking system for batteries to specify mercury, cadmium or lead content; and
- indicate separate collection for disposal as hazardous waste at end of life.

WANT TO LOOK INTO THIS FURTHER?

www.eeca.govt.nz Energy Efficiency and Conservation Authority has excellent resources on energy efficiency and energy labelling.

http://www.energyrating.gov.au/ Australian website for Energy Rating system that has been harmonised with New Zealand.

3.4.2 Water efficiency

Some electronic products are high users of water – for example: washing machines and dishwashers. The principles used for considering energy efficiency during use (above) can also be applied to water efficiency. Wherever possible, water efficiency should be improved by reducing the water requirements of a product. Where reduction in demand is not possible, recovering and reusing water should be considered.

It is also possible to encourage water-efficient behaviour in consumers by providing good information on performance. On 1 July 2006 Australia introduced a mandatory Water Efficiency Labelling scheme for certain products, including: clothes washing machines, dishwashers, flow controllers, toilet equipment, showers, tap equipment and urinal equipment. The New Zealand government is considering the same approach.

Example of Australian water rating label for a washing machine

WANT TO LOOK INTO THIS FURTHER?

http://www.mfe.govt.nz/publications/waste/product-stewardship-water-labelling-jul05/html/page10.html Ministry for the Environment Consideration of a Water Efficiency Labelling Scheme (WELS) for New Zealand.

http://www.waterrating.gov.au/index.html Australian Water Efficiency Labelling Scheme.

Guideline 4 – Packaging

Design for the Environment is about developing products in a way that minimises their environmental impact.

By using Design for the Environment principles a good quality, desirable and cost-effective product can be developed that also has a reduced impact on the environment.

This guideline is number 4 in a series of six that have been created to provide practical Design for the Environment assistance to anyone involved in the design of products that contain plastics. This guideline will give you practical advice and guidance on implementing Design for the Environment in packaging product design projects.

Plastics Design for the Environment Packaging Checklist

Use this checklist as a prompt as you work through the design of a particular packaging product. Work your way down the list and identify the areas in which you can incorporate the Design for the Environment aspect in your product design. Ask yourself, ‘Can we do this for this product?’ and ‘Will this improve the product’s environmental performance?’ for each aspect.

There is more detail on each aspect, including practical design ideas and case studies, in the pages that follow the checklist.

If you tick ‘Yes’ because you think there is an opportunity to make an improvement in the product design, make a note of the measure you are going to take and the actions needed to implement the change.

Each of the Design for the Environment elements in the checklist below has more detailed information in section 3 of this guideline.

Design for the Enviroment Element	Yes	No	ACTION (e.g. investigate further, change from LDPE to HDPE, use fastener instead of adhesive)
3.1 Material Selection			
Lightweighting			
Avoiding toxic and hazardous substances			
Using biodegradeable materials			
3.2 Product Design			
Reducing void space and fillers			
Ensuring the packaging is fit for its purpose			
Avoiding unnecessary packaging			
Considering standardisation			
Designing for re-use			
Designing for recycling and composting			
Minimising contamination			
3.3 Process Design			
Reducing production losses			
Reducing energy use			
3.4 Communication			
Using plastics identification labelling			
Communicating with suppliers, customers and recyclers			
3.5 Distribution			

Packaging in New Zealand

The New Zealand plastics industry produces a higher proportion of packaging products in comparison to other developed nations. Over 53% of New Zealand's plastic product manufacture is in the packaging field.

A significant amount of plastic manufactured in New Zealand is exported as packaging for New Zealand dairy, meat and horticultural products.

Packaging in the environment gets a lot of attention. This attention comes because packaging is one of the most visible components of the waste stream.

Packaging is designed to contain, protect and promote a product.

The most obvious benefit of packaging is to preserve foodstuffs and protect other consumer goods from damage. One international study found that the loss of foodstuffs between grower and consumer is about 2% in the developed world and up to 33% in the developing world. The difference is largely due to packaging.

1. Drivers for Design for the Environment in Packaging

There are several factors driving companies to implement Design for the Environment when developing new products. The general drivers for Design for the Environment are described in Guideline 1 of this series.

The single most important driver for the packaging industry in New Zealand has been the **2004 New Zealand Packaging Accord**. The Accord is a voluntary 5-year agreement between industry and government and has four key parties, representing nine sectors:

- Packaging Council – representing six of the sectors: brand owners and retailers, glass, plastics, paper, steel and aluminium
- Local Government New Zealand
- Recycling Operators of New Zealand
- Ministry for the Environment.

The Packaging Accord has a 23% target recycling rate (by 2008) for plastic packaging consumed in New Zealand. The Accord adopts the principle of Extended Producer Responsibility: that those who make products and sell them, the producers, should be responsible for the lifecycle impacts of those products throughout the production process and supply chain, and especially at the point where consumers generate packaging as waste.

An integral part of the Accord is the Packaging Code of Practice and manufacturers and users of packaging in New Zealand are required to follow the Code of Practice in design and procurement. For more information on the Packaging Accord and the Code of Practice refer to the Packaging Council www.packaging.org.nz and Plastics NZ website http://www.plastics.org.nz/page.asp?id=637

As well as the New Zealand Packaging Accord there are other specific reasons for packaging companies to start considering Design for the Environment.

- The Australian National Packaging Covenant and various State-based policies also act as incentives and drivers for industry to address environmental concerns associated with packaging.
- NZ exporters must conform to stricter overseas legislation in order to compete in foreign markets.
- Increased public awareness and participation in recycling food and beverage containers through kerbside recycling is also educating people about resource conservation and effective waste management.
- Potential financial savings from source reduction, lightweighting and re-use of packaging.
- Customers (particularly large retailers) and consumers, while demanding high quality packaging, are becoming increasingly interested in its environmental profile.

Many New Zealand companies export products and packaging to the Australian market. These companies must comply with Australian regulations.

The main consideration for packaging suppliers into the Australian market is the National Packaging Covenant (NPC). The NPC is a self-regulatory agreement between industries in the packaging chain and all parts of government.

The agreement is applied throughout the chain: from raw material suppliers to retailers, and the ultimate disposal
of waste packaging.

More detailed information about the NPC can be found on Environment Australia's web site http://www.environment.gov.au/epg/covenant/index.html .

2. Design for the Environment Benefits

The specific benefits of applying Design for the Environment to packaging can include:

- a reduction in cost of compliance with proposed Producer Stewardship legislation for New Zealand and existing legislation overseas;
- a reduction in direct packaging and material costs;
- reduced supplier and customer costs;
- an improvement in company reputation and brand image, particularly in the eyes of an increasing number of 'green' customers;
- an improvement in market share; and
- a reduction in product damage and costly customer returns.

3. Design for the Environment Elements

There is a wide range of Design for the Environment elements that can be applied to a product, or products, to improve environmental performance. Guideline 1 in this series has detailed some of the more general Design for the Environment elements applicable to plastic products. The following sections contain ideas more specifically focused on packaging products.

3.1 Material Selection

One of the key phases in product development is the choice of the right materials. As well as technical performance and price, environmental performance is becoming increasingly important. Opportunities to design improved environmental performance through material selection in packaging include:

- lightweighting;
- avoiding toxic or hazardous materials; and
- using materials that maximise recyclability.

3.1.1 Lightweighting

Like all products, packaging has environmental impacts at every stage of its life cycle. The most effective way of reducing these impacts is to produce less packaging in the first place[1]. There are various different strategies that can be used to lightweight packaging, including:

- eliminating one or more packaging layers to reduce the weight of packaging used;
- eliminating plastic film 'windows' in packaging. Instead use a cut-out or a scaled photograph of the product on a smaller pack;
- not using hollow, double-walled containers (e.g. plastic tubs) unless these are specifically needed for strength/insulation;
- using double-walled rather than triple-walled corrugated board where the extra strength given by the latter is not necessary;
- strengthening materials locally to allow an overall reduction in material use;
- reducing the average thickness of the material used wherever possible;
- using CAD/CAM[2] and associated tools such as finite element analysis (FEA) (for stress analysis) and mould flow analysis (MFA) to help reduce/optimise packaging weight;
- avoiding putting strength into secondary/transit packaging if the primary/secondary packaging already provides that strength;
- considering reducing the main packaging material and using adhesive; and
- minimising the size of labels and ensuring that the same material or a compatible material is used for these.

1 Lewis & Gertsakis (2001) Design + Environment: A Global Guide to Designing Greener Goods
2 CAD – computer aided design; CAM – computer aided manufacture

Light-weight materials and improved designs have led to big reductions in the weight of product packages over the past 10 years. The Packaging Council estimates that the packaging industry has reduced the unit weight of packages by more than 20 percent in the past 12 years. www.packaging.org.nz

Bonson Container Redesign

Bonson Industrial Company Ltd redesigned one of their portion containers using the principles of Design for the Environment. Lightweighting and improved distribution were the key elements the company looked at.

Bonson redesigned the product to have the same functionality (i.e. holding capacity) but they also:

- reduced product weight by 15% from 5.9g to 5.2g;
- reduced the stack height by almost half; and
- reduced carton box size by 60% (Original size = 0.05m3, new size = 0.02m3).

These changes have resulted in material savings and transport savings.

Stack of old containers beside new containers

Old product packaging requirements next to new

For more information: www.bonson.co.nz

3.1.2 Avoiding toxic and hazardous substances

There are four key areas of concern regarding hazardous substances and packaging:

- heavy metals (lead, cadmium, hexavalent chrome, mercury);
- industrial solvents in inks;
- coatings and adhesives; and
- plasticisers.

The main sources of heavy metals in packaging are colour pigments and recycled materials.

There has been some concern about migration of plasticisers out of flexible PVC products. The use of PVC in food-grade packaging has largely been phased out. Where PVC is used in flexible packaging, care should be taken to use plasticisers that have a low environmental impact. Examples of lower risk plasticisers are: diisononyl phthalate (DINP), diisodecyl phthalate (DIDP), adipates, citrates and cyclohexyl-based plasticisers.

Key points to note when designing packaging to minimise the use of hazardous substances are as follows:

- If the packaging is destined for overseas markets, ensure that any hazardous materials limits are adhered to. For example, the European Union Packaging Directive (1996) requires that lead, cadmium, mercury and hexavalent chromium present in packaging or packaging components must not exceed 100ppm (combined).
- Use paperboard that is unbleached or that uses a totally chlorine-free (TCF) or elemental chlorine-free (ECF) bleaching process.
- Try to use inks that have the least overall environmental impact. Possible alternatives to organic solvent-borne inks which contribute towards environmental damage, include water-borne, ultraviolet (UV) curable and litho inks.
- Consider using water-based adhesives and hot-melts instead of solvent-based products. Be aware, however, that water-based adhesives can have longer drying times/higher energy use.
- Use the information in material safety data sheets (MSDS) that suppliers are obliged to provide to assist in your decision making.

WANT TO LOOK INTO THIS FURTHER?

http://ec.europa.eu/environment/waste/packaging_index.htm

Official EU site on packaging waste, including full text of the EU Packaging Directive.

3.1.3 Using biodegradable materials

Mechanical recycling is not always the most effective method of recovering materials. It is possible for many renewable materials to be composted. However, the benefits of composting biodegradable materials are dependent on effective systems being in place to ensure that the materials are treated correctly. If these systems are not in place then biodegradable materials can have negative impacts, such as contaminating plastics recycling or increasing the amount of biomaterial in landfill.

Discussions on the future of degradable plastics in New Zealand are currently underway. Product designers should acquaint themselves with the key issues and the state of industry discussions before using degradable plastics in a new product. This information will be available through Plastics New Zealand www.plastics.org.nz

3.2. Product Design

3.2.1 Reducing void space and fillers

- Reduce unnecessary void space in containers.
- Avoid using fillers and padding in containers wherever possible, by using better designed, smaller containers.
- Consider using air as the packing medium where the product is fragile.

3.2.2 Ensuring the packaging is fit for its purpose

It is obviously very important that packaging must be able to fulfil the functions required of it.

These functions are to:

- protect, contain and preserve the product while at the same time allowing efficient manufacturing, handling and distribution methods;
- provide commercial and consumer information;
- present and market the product;
- ensure tamper evidence and to facilitate product use (ergonomics);
- ensure safe use and handling by consumers.

Factors to be considered:

- Will the load be palletised? If so, what size of pallet will be used?
- Will the product be stacked? If so, will layer pads be necessary?
- Will stretch/shrink wrap be used?
- Will the customer break the pack into smaller units for onward distribution?
- Will the packaging be re-used?
- Is it compatible with customer handling systems?

While packaging is being optimised with environmental concerns in mind, it is essential to undertake constant checks on performance criteria.

4

3.2.3 Avoiding unnecessary packaging

Look for opportunities to reduce the amount of packaging, for example, by:

- eliminating packaging altogether;
- eliminating unnecessary layers;
- eliminating the use of adhesives and tapes by using only interlocking tabs; and/or
- eliminating the need for labels by using in-mould embossing or direct printing wherever possible.

In some cases, the need for packaging can be avoided by a change in product design, working practices or through the introduction of a new item of equipment.

- Just-in-time delivery — Just-in-time (JIT) delivery can mean that the product spends less time in the warehouse and therefore is not subjected to the same level of risk in terms of contamination and physical damage.
- Bulk delivery — In many cases, materials can be delivered in bulk, thereby avoiding the need for packaging.
- Change the product itself — In some cases, a minor redesign of a product may allow significant gains in terms of the packaging used to protect it.
- Alternative on-site handling and distribution — Liquids and powders can be pumped around a site, while certain light objects can be moved around a site pneumatically.
- Alternatives to pallets — Quite heavy loads can be handled using slip sheets and push-pull units.

3.2.4 Considering standardisation

One of the problems facing New Zealand plastic recyclers is the lack of consistency in the use of materials across similar products and even within the same brand. Any brand owners considering a change of material should consult the Recycling Operators of New Zealand (www.ronz.org.nz) to ensure that our plastics recyclers are aware of changes and do not encounter contamination issues. Sticking to the most common plastics ensures recyclability.

Standardisation of packaging and material selection offers various benefits, including:

- economies of scale;
- flexibility;
- reduced recycling costs; and
- reduced warehousing needs.

3.2.5 Designing for re-use

Packaging designed for re-use as part of a closed-loop system (e.g. plastic totes) can last for at least 30 trips and often 100 or more. Where this is the case, the best environmental option may be to encourage greater re-use by, for example, increasing material thickness slightly, rather than opting for an ultra-lightweight one-trip design.

Returnable systems offer the best economic and environmental solution where a closed-loop distribution system exists and/or where transportation distances are relatively short. The more standardised your packaging, the more readily reusable it will be.

Design factors to consider for the re-use of packaging:

- Consider second/multi-purpose use rather than conventional re-use. Some transit cases and secondary packaging can be used directly as point-of-sale display cases or shelf-ready packaging.
- Consider novel re-use systems. Re-usable air bags can be used, for example, in electronics packaging.
- Whatever the type of re-use, make sure the appropriate arrangements are in place and available to make re-use possible in practice.
- Consider reinforcing existing designs. Material changes (e.g. the use of kraft fibres in corrugated cases), ribs, internal separators, edge strengthening, lamination etc. can help to turn a one-trip box into a reusable system.
- Consider ‘finish’ and other factors as well as strength. Will the packaging maintain all aspects of its performance or will one aspect make it unusable after a few trips?
- Make the packaging lightweight as well as durable. Corrugated plastic and double/tri-wall coated board offer possible alternatives to solid plastic or even steel crates and offer the added advantage of being collapsible and hence easy to transport.
- Design the package so that the product can be discharged/unloaded without any significant damage to the packaging.
- Make the packaging readily collapsible or design it for easy stacking/nesting to minimise the impact of storage and transportation. Provide clear markings to indicate how the packaging should be collapsed/stacked/nested.
- Ensure easy opening and secure closure to facilitate handling and use. For example, overlapping/interlocking box lids are useful.
- Ensure easy label removal/attachment. Using label pouches on returnable boxes, for example, will ensure that the boxes do not become covered in unsightly sticky labels that make recycling more difficult once the box has ended its useful life.
- Design the packaging so that it is easy to clean/wash where this is likely to be necessary, for example, for food safety/hygiene reasons.
- Make the packaging modular and repairable. If sections of a plastic box, for example, can be replaced when damaged, the overall life of the packaging will be significantly extended. Wooden pallets and crates are, of course, quite easy to repair.
- Make sure that any cleaning/reconditioning process has minimum impact on the environment. Using excessive amounts of water and detergent after each use, for example, will reduce the benefits of re-use.

Design for the Environment of Packaging for Re-use Boosts Profits

Polaroid, UK changed to the use of returnable component trays within reusable plastic boxes. Operator workstations were modified to enable components to be taken directly from transit boxes without decanting

	Original packaging (0.54kg)	New packaging (0.22kg)	Benefits of new packaging
Inner packaging	One-trip plastic component trays. Use EPS and other filler material	More substantial, moulded plastic tray shaped to match the component	Parts better protected from transit damage Eliminated need for filler material No longer needed to pay suppliers for expensive packaging
Outer packaging	One-trip corrugated cardboard boxes	Plastic corrugated material boxes suitable for more than 30 trips	Plastic box is light and collapsible, reducing return transport costs and associated energy use Box material can also be recycled after multiple use

Results of the changes were:

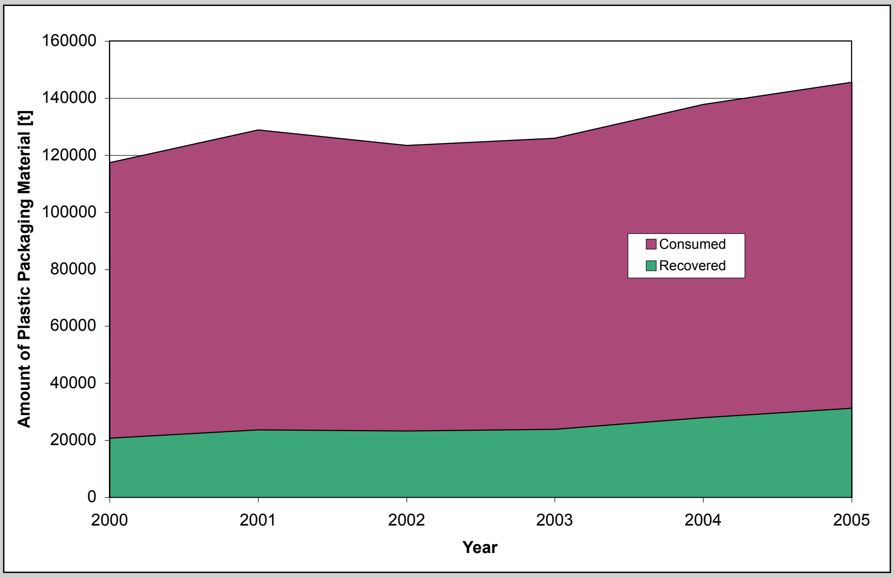
- reduction of almost 60% in solid waste disposal per camera produced;
- net savings of at least NZ$9 million per year; and
- payback on capital costs in under 2 months.

Plastic Packaging Recycling in New Zealand

In 2005, plastic packaging consumption from both locally produced and imported product was 145,650 tonnes and approximately 31,310 tonnes or 21% was recovered. This recovery was slightly higher than the 20% of plastic packaging recovered in 2004 and indicates we are on track to reach our 2008 Packaging Accord target of 23% recovery.

Total Amount of Packaging...	2004	2005	2008 (estimated)
Consumed	137,909t	145,650t	150,000t
Recycled	28,004t	31,310t	34,500t
Proportion Recycled from Consumed	20%	21%	23%

Total amount of packaging consumed and recycled in New Zealand in 2004 and 2005



Total amount of plastic packaging consumed and recovered in (2000-2005)

Source: Plastics NZ

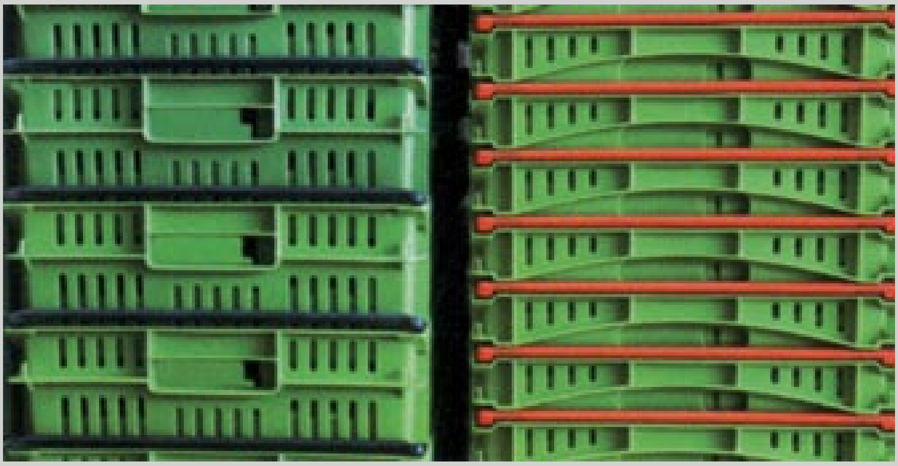
Fuel-saving Crate Design Reaps Huge Savings for Customers

An environmentally-friendly plastic crate developed in New Zealand as a solution to rising oil prices is helping the fruit growing industry significantly reduce freight costs.

Viscount Plastics developed the 47-litre deep nest crate for New Zealand's largest crate hirer, The Fruit Case Company (FCC), in response to concerns over rising freight costs hurting fruit growers' ability to earn a living.

The RECRATE 47 Deep Nest crate has given a 95% increase in load capacity. What was two truck loads is now down to one for the grower hiring the new crate. This means crate hire and transport companies are more able to hold costs against oil price rises.

Compared with the standard RECRATE 47, the Deep Nest requires 4% less material and 27% less energy in its manufacture.



Before After

Viscount Plastics also worked with KFC and Inghams to develop a 23-litre deep nesting stacking bar crate to replace KFC's previous off-the-shelf crate.

Deep nesting to a quarter of its height achieves an impressive 200 crates per pallet – twice as many as the previous supplier's. Costs for Cook Strait crossings are dramatically cut, along with the elimination of 220 trucking movements annually. This equates to significant reductions in fuel usage and other operating expenses, and exhaust emissions.

The new 23-litre chicken crate carries the same 16 kg as the previous supplier's 32-litre crate. So that represents more crates of product per pallet and the equivalent of 9 litres of fresh air per crate removed from the supply chain.

Positive Impact:

KFC and Inghams report high levels of satisfaction with the deep nesting 23-litre chicken crate. In KFC outlets it achieves a 25% increase in product stored in chillers. When empty it also makes more efficient use of available storage space.

Inghams' Plant Manager Adrian Revell says the crate's base makes life easier for him through being specifically designed for conveyor transfers. Distribution Manager Brian Tolson describes the crate as a quantum leap for assembling orders and stacking on pallets, relative to cardboard packaging.

For more information: http://www.viscountplastics.co.nz/

3.2.6 Designing for recycling and composting

Packaging design for recycling and composting should take into account how the packaging will be handled after use. Designers need to consider the ways in which:

- segregation, collection and sorting will take place; and
- reprocessing will take place.

Find out more about plastics recycling in New Zealand:

- Take a look at section 3.7 of Guideline 1 in this Design for the Environment series
- Read about plastics recycling in New Zealand at http://www.plastics.org.nz/page.asp?section=recycling
- Communicate with the Recycling Operators of New Zealand (RONZ) www.ronz.org.nz or email admin@ronz.org.nz
- Use the Australian Council of Recyclers (ACOR) Manufacturers Recycling Guides for PET and HDPE, downloadable from http://www.acor.org.au/materials.html

Other considerations include:

- Design plastic packaging using a single polymer wherever possible. Alternatively, use compatible polymers that are easy to deal with during sorting and reprocessing. Further information on the compatibility of different plastic resins for recycling can be found in Appendix 6
- Use a recyclable material, i.e. one which is collected through kerbside recycling programmes in New Zealand (see Design for the Environment Guideline 1 for more information).
- Use labels materials that are resin compatible with the packaging they are applied to. Select adhesives that can be processed in New Zealand (talk to RONZ about this). For example, avoid using PVC labels on HDPE containers as automatic recognition or density separation systems used for HDPE/PET mixed streams may not be able to separate out the PVC. As a result, PVC would be incorporated in the PET stream.
- Identify polymer components with the Plastics Identification Code. Refer to Appendix 3

3.2.7 Minimising contamination

Contaminants within a material/product are often impossible to separate from the material during recycling and so become mixed with other materials. The result is that every time the material is recycled, its quality is reduced (down-cycled) due to the unwanted mixing and increasing quantity of contaminants.

Contaminants include:

- additives
- labels
- fasteners
- adhesives
- laminates.

Not all contaminants are necessary and so designers should aim to keep contaminants to a minimum. To minimise contaminants in plastic packaging you should:

- avoid using colorants in plastic packaging wherever possible. Where they are necessary, use them sparingly to minimise colour contamination. Avoid mixing coloured and clear plastics in the same design, even when the polymer is the same, as this can limit potential uses for the recycled material;
- minimise the use of inks, adhesives and other coatings as these will usually need to be removed or dispersed during recycling;
- minimise the use of labels as these will usually need to be removed or dispersed during recycling. If possible, mould/emboss (e.g. as often done for polymer ID codes on plastic bottles) or print information directly onto the packaging;
- consider making greater use of integrally moulded press-studs on plastic packaging, avoiding the need for adhesives;
- use easy-to-remove fasteners rather than tape. Staples can be used where it is appropriate, although not in packaging for food and toys because of the safety considerations; and
- avoid plastic and foil laminates and UV varnishes on paper packaging (e.g. cartons) unless these are absolutely necessary, as they can inhibit recycling in certain paper mills.

3.3 Process Design

Production processes should be investigated to identify opportunities to improve environmental performance. Improvements can often be made through good housekeeping, water and energy conservation, waste minimisation and on-site recycling.

Detailed engineering designs will generally be based on the detailed specifications that follow initial concept development.

- Computerised stress analysis (often using finite element analysis (FEA) methods) can be used to optimise the packaging structure.

- In the case of plastic and glass packaging, mould flow analysis (MFA) can be used to gain a better understanding of how the material will move in the mould and hence where thicker and thinner wall thickness and stress concentrations will occur. It can also be used to improve the flow and reduce the moulding time, thereby reducing energy use.
- Finally, it is worth noting the role of rapid prototyping. Real packaging prototypes can be made very quickly using stereo lithography/laser techniques to produce a layered resin model from a CAD design.

3.3.1 Reducing production losses

- Choose a shape that minimises material wastage in pack production.
- Maximise material yield by using a CAD/CAM system to plan pack/component layout.

3.3.2 Reducing energy use

Reducing the amount of energy used in the production process has economic and environmental benefits.

- Use adhesives with a low melting point where possible.
- When considering a change to alternative inks, coatings or adhesives, determine what opportunities there are for energy savings per unit of production as well as any impact on recyclability.
- Consider the sealing temperature (and hence energy use) needed for films. Ionomers, for example, can initiate sealing at temperatures as low as 75°C, while linear low-density polyethylene (LLDPE) requires a temperature of around 100°C.

WANT TO LOOK INTO THIS FURTHER?

http://www.emprove.org.nz/

Online resources for businesses from the Energy Efficiency & Conservation Authority (EECA) to help you review energy efficiency in your operations. Includes a downloadable guideline and the Energy Challenger online tool for assessing energy efficiency opportunities. Also has a directory of local energy experts.

3.4 Communication

It is important to provide good information to those who are buying and using your products. Design for the Environment needs to be supported by appropriate behaviour by consumers 'doing the right thing'.

3.4.1 Using plastics identification labelling

Plastic packaging should be identified using the Plastics Identification Code. This will help the consumer to know if the package is recyclable in their kerbside system, and assist recyclers in the segregation of plastic types. You will need to follow industry guidelines on its appropriate use.

Refer to Appendix 3 for the Plastics Identification Code. It can also be downloaded from http://www.plastics.org.nz/_attachments/docs/plasticscode.pdf

3.4.2 Communicating with suppliers, customers and recyclers

Supply chain management – working with customers and suppliers – is particularly important to ensuring successful Design for the Environment packaging. Obtaining packaging data from suppliers is crucial, both to the design process and to meeting obligations under the packaging Code of Practice (http://www.packaging.org.nz/packaging_code.php).

It is important to consider the practical effects of design changes on other parts of the packaging chain. For example, a change to the ink or varnish specification could significantly affect the converter's production process, while a change in adhesive could affect a packer/filler's production line.

It is also important to understand the final destination of the packaging, as this can influence the design. Questions that need to be answered include:

- Can the packaging be returned or can it be re-used by the customer?
- Will the packaging always be used for the same purpose?
- Are plastic identification codes clearly visible to enable ease of sorting?
- Will the packaging be recycled, composted, recovered for energy, or just put in a landfill site? What collection systems and processing facilities are available?

3.5 Distribution

Logistics and distribution during the whole life cycle of a product have a significant impact on the environment. There are opportunities to reduce this impact by optimising logistics and this can result in significant economic as well as environmental benefits

3.5.1 Improving transport efficiency

The packaging of a product can have a major influence over the cost and environmental impact of transporting that product. In order to minimise transport impacts:

- choose packaging shapes that will maximise case and pallet utilisation and transport efficiency;
- choose distribution pack sizes that maximise palletisation/transport efficiency;
- consider producing a concentrated product and/or lightweight refill packs; and
- use packaging that is able to compress, allowing lower transportation costs after use.

Guideline 5 – Construction

Design for the Environment is about developing products in a way that minimises their environmental impact.
By using Design for the Environment principles a good quality, desirable and cost-effective product can be developed that also has a reduced impact on the environment.

This guideline is number 5 in a series of six that have been created to provide practical Design for the Environment assistance to anyone involved in the design of products that contain plastics. This guideline will give you practical advice and guidance on implementing Design for the Environment in construction product design projects.

Plastics Design for the Environment Construction Checklist

Use this checklist as a prompt as you work through the design of a particular construction product. Work your way down the list and identify the areas in which you can incorporate the Design for the Environment aspect in your product design. Ask yourself, 'Can we do this for this product?' and 'Will this improve the products environmental performance?' for each aspect.

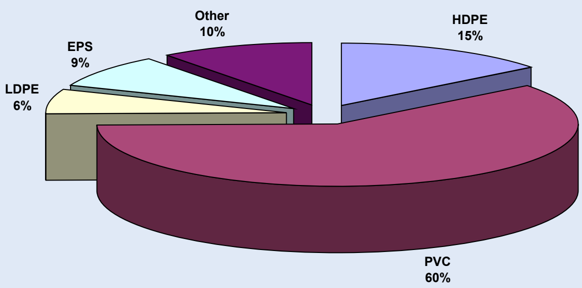
There is more detail on each aspect, including practical design ideas and case studies, in the pages that follow the checklist.

If you tick 'Yes' because you think there is an opportunity to make an improvement in the product design, make a note of the measure you are going to take and the actions needed to implement the change.

Design for the Enviroment Element	Yes	No	ACTION (e.g. investigate further, change from LDPE to HDPE, use fastener instead of adhesive)
3.1 Material Selection			
Lightweighting			
Avoiding toxic and hazardous substances			
Reducing the use of composites			
Using recycled materials			
Minimising the use of additives			
3.2 Product Design			
Minimising material use			
3.3 Communication			
Considering eco-labelling			
3.4 Impacts During Product Use			
Water efficiency			
3.5 End-of-Life Options			
Considering recycling			

Plastics and Construction

In New Zealand the construction sector is the second highest user of plastics after packaging. In 2005 approximately 47,900 tonnes of plastic were used in the construction sector.



Polymer types used in the New Zealand construction sector

Plastics are used in a growing range of applications in the construction industry. They have great versatility and combine excellent strength-to-weight ratio, durability, cost effectiveness, low maintenance and corrosion resistance which make plastics an economically attractive choice throughout the construction sector.

Plastics in construction are mainly used to make products such as:

- roofing
- pipe and fittings
- wall and roof insulation
- window frames
- house wrap
- siding
- concrete forms
- sealants
- electrical products (wire and cable, outlet boxes)
- decking
- fencing/railings
- wall coverings and entry doors.

Potentially, plastics have further uses as they do not rot, rust or need regular re-painting. Plastics also have strength with lack of weight, they are easily formed, and their light weight enables them to be easily transported and moved on site.

The construction and demolition (C&D) industry is one of the largest waste producing industries in New Zealand. C&D waste may represent up to 50% of waste being disposed of in New Zealand. For this reason there is a strong emphasis in this guideline to consider ways to recover and recycle C&D plastic waste.

1. Drivers for Design for the Environment in Construction

There are several factors driving companies to implement Design for the Environment when developing new products. The general drivers for Design for the Environment are described in Guideline 1 of this series.

A key driver for Design for the Environment in the construction sector is the growth in 'green building'. A green building, also known as a sustainable building, is a structure that is designed, built, renovated, operated, or reused in an ecological and resource-efficient manner. Green buildings are designed to meet certain objectives such as:

- protecting occupant health;
- improving employee productivity;
- using energy, water, and other resources more efficiently; and
- reducing the overall imp act on the environment.

There is currently a global trend to include environmental criteria in tenders for the design and construction of new buildings. Evidence of this is the recent establishment of the New Zealand Green Building Council and the increasing use of green building rating tools for commercial and residential buildings (see links at the end of the document). This has implications for the design of plastic materials and products used in the construction of buildings as well as products used in the fit-out, such as floor coverings and office furniture.

A number of Government policies, and legislation, support sustainable building in New Zealand. All new building work in New Zealand must comply with the New Zealand Building Act (2004), which requires, through both its purpose and principles, that 'buildings are designed, constructed, and able to be used in ways that promote sustainable development'. The Building Code prescribes functional requirements for buildings and the performance criteria with which buildings must comply.

The Government's Sustainable Development Programme of Action (SDPOA) requires government agencies to consider implementing the Government's sustainable development policies such as the Energy Efficiency and Conservation Strategy 2001 (NEECS), and the New Zealand Waste Strategy 2002. A number of these same agencies are also signatories to the New Zealand Urban Design Protocol which commits them to consider and use good urban design principles when undertaking a new building project.

In Building the Green Way (Harvard Business Review, June 2006), Charles Lockwood writes the owners of standard buildings are facing massive obsolescence. 'Green is not simply getting more respect; it is rapidly becoming a necessity as corporations - as well as home builders, retailers, health care institutions, governments, and others - push green buildings fully into the mainstream over the next five to 10 years.'

In New Zealand, this is being led by government, universities and others who want good buildings with economical running costs.

Govt3 is a sustainability programme for government departments. All 48 core government agencies are now formally signed up and other government agencies such as Crown-owned entities are welcome to sign up. One of its key planks is a sustainable procurement policy, which applies to its accommodation.

The core agencies with a combined budget of $5 billion wield market clout, particularly in Wellington, which accommodates 17,000 office-based public servants.

Extract from 'NZ gets set to ride the green wave' EECA News item, August 2006; http://www.eeca.govt.nz/news/energywise-news/august-2006/features/green-wave-1.html

WANT TO LOOK INTO THIS FURTHER ?

New Zealand Green Building Council
http://www.nzgbcservices.org.nz/

Australian Green Building Council
http://www.gbcaus.org/

World Green Building Council
http://www.worldgbc.org/

Govt3 http://www.mfe.govt.nz/issues/sustainable-industry/govt3/index.html Ministry for the Environment programme for sustainable government agencies.

Beacon http://www.beaconpathway.co.nz/home.aspx New Zealand consortium researching affordable, attractive ways of making homes more sustainable. Includes trials in live projects. Funded by industry and government.

2. Design for the Environment Benefits

Companies that apply Design for the Environment find that it has a number of business benefits. These are discussed in Guideline 1.

3. Design for the Environment Elements

There is a wide range of Design for the Environment elements that can be applied to a product, or products, to improve environmental performance. Guideline 1 in this series has detailed some of the more general Design for the Environment elements applicable to plastic products. The following sections contain ideas more specifically focused on construction products.

It is important to note that most environmental gains in a building are to be found during the use of the building throughout its lifetime. Opportunities exist in the design of a building to maximise energy efficiency, increase natural lighting, and incorporate recycled materials. Plastics can enhance the environmental performance of a building. PVC windows and expanded polystyrene insulation are just two examples of plastic products that can deliver environmental benefits when used in construction.

Plastic materials offer significant advantages to reducing the environmental impact of a building. They are:

- source reduced, with low energy and material consumption;
- lightweight, needing lower transportation costs;
- easy to install, conserving resources and manpower and reducing injuries;
- low maintenance, with long-life products in use for decades;
- durable, with low replacement frequency;
- used in energy efficient insulation, conserving heating and fuel and reducing sound;
- air and moisture barriers, minimising mould and improving insulation effectiveness;
- corrosion and rot resistant; and
- most are technically recyclable and may contain recycled content.

While plastic materials and products can contribute to environmental performance by improving energy efficiency, there are some important issues that need to be considered in the design process. These include the use of additives, impacts on indoor air quality (e.g. through the use of hazardous substances) and recyclability at end of life.

3.1 Material Selection

The concept of sustainable building incorporates and integrates a variety of strategies during the design, construction and operation of building projects. The use of Design for the Environment building materials and products represents one important strategy in the design of a building. Design for the Environment building products are environmentally responsible because impacts are considered over the life of the product. Affordability can be ensured when building product life-cycle costs are comparable to conventional materials or, as a whole, are within a project-defined percentage of the overall budget.

Design for the Environment building materials offer specific benefits to the building owner and building occupants through:

- reduced maintenance/replacement costs over the life of the building;
- energy conservation;
- improved occupant health and productivity;
- lower costs associated with changing space configurations; and
- greater design flexibility.

Opportunities to design improved environmental performance through material selection in plastic construction products include:

- lightweighting;
- avoiding hazardous substances;
- using recycled materials; and
- using materials that are easily recycled.

3.1.1 Lightweighting

The use of plastics in buildings provides opportunities for lightweighting at the same time as improving durability. Opportunities for lightweighting products are discussed in Guideline 1 of this Design for the Environment series.

Opportunities for lightweighting products in the construction sector are more limited than in other sectors. There are strict requirements placed on the performance and reliability of products to be used in buildings. These requirements are specified in Australia New Zealand Standards (e.g. ANZS 1260 for PVC pipes) and referenced by the Building Code.

3.1.2 Avoiding toxic/hazardous substances

Wherever possible, select materials that avoid the use of toxic or hazardous substances. This is particularly the case for those substances that may cause problems in the case of fire or which contribute to poor indoor air quality.

The use of many hazardous substances is being reduced voluntarily by the industry to meet growing consumer demand. For example, lead has traditionally been used as a stabiliser in some plastic products such as PVC pipe. Lead stabiliser is being phased out of use in PVC pipe and is being replaced by calcium tin and calcium zinc.

3.1.3 Reducing the use of composites

Fibre-reinforced polymers (FRPs) are increasingly being used in construction due to their light weight, ease of installation, low maintenance, tailor made properties, and corrosion resistance. By adding fibre reinforcement, a high strength, high modulus composite can be produced.

A wide range of amorphous and crystalline materials can be used as the fibre. In the construction industry the most common fibre used is glass fibre. Carbon fibre can be used separately or in conjunction with the glass fibre as a hybrid to increase the stiffness of a structural member or the area within a structure, so that the stiffness exceeds the value possible using only glass fibre. Aramid fibres can be used instead of glass fibres to give increased stiffness to the composite. Further information on the use of composites and their implications can be found in the General Guideline in this Design for the Environment series.

WANT TO LOOK FURTHER INTO THIS?

Network Group for Composites in Construction www.ngcc.org.uk Useful resource including links to online tools and materials calculators.

Green Guide to Composites, published by NetComposites http://www.netcomposites.com/composites-green-guide.asp An environmental profiling system for composite materials and products created to allow the composites industry to understand the environmental and social impacts of different composite materials and manufacturing processes.

UK Building Research Establishment http://cig.bre.co.uk/composites/selectcomponent.jsp Online tool enables user to select component, different process designs, and materials and simply assess their environmental and social impacts using life-cycle analysis.

3.1.4 Using recycled materials

Incorporating recycled content into new products can offer financial as well as environmental benefits. The use of recycled material (sometimes referred to as 'toll' in the plastics industry) means less virgin material has to be purchased and less waste has to be disposed of to landfill.

Construction products often have strict functional requirements and performance standards, sometimes set out in the Building Code. This can restrict the use of recycled material to only that material over which the manufacturer has good control.

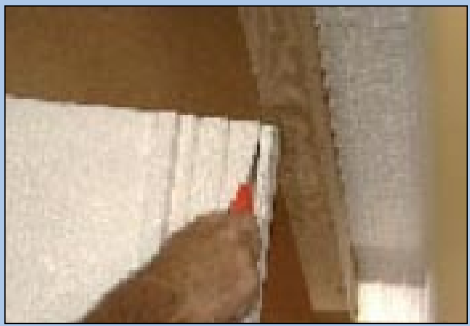
Plastic construction products are often sold directly to building contractors for use. This can provide an opportunity for companies to offer product takeback from customers and enables material to be recycled and incorporated back into new products.

One of the biggest difficulties in using recycled materials in new products is knowing what potential contaminants they might contain. By taking back your own product there is certainty over the quality of material and any additives that might have been used.

Offering recycled content in construction products can provide opportunities to access growing markets for sustainable building and government purchasing (see section 3, above).

Expol EPS Recycling

Expol manufacture and sell expanded polystyrene underfloor insulation. A large volume of sales are made direct to building contractors. Expol will accept unwanted or offcut EPS insulation from its direct customers at its plant in Onehunga. Approximately 60-80m^3 of collected material is reprocessed into new underfl°or insulation every week.



3.1.5 Minimising the use of additives

For building applications it is mandatory for many plastic products to achieve some degree of flame retardance. Fire retardants are usually incorporated in the resin itself or as an applied gel-coat. Fillers and pigments are also used in resins for a variety of purposes, the former principally to improve mechanical properties and the latter for appearance and protective action.

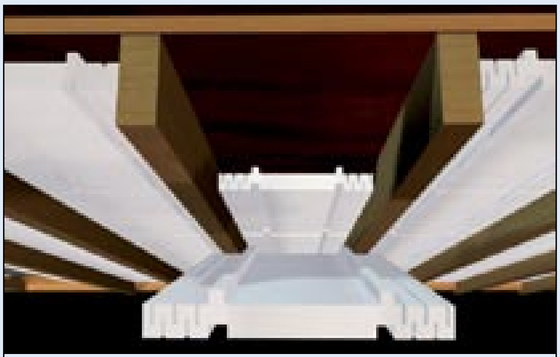
Additives in plastics can inhibit recyclability at end of life or contribute to poor indoor air quality. Specific issues for the plastics industry include:

- Lead – lead has traditionally been used as a stabliser in PVC pipes and cable but is in the process of being phased out;
- Plasticisers – there are concerns that phthalate plasticisers in flexible PVC products can migrate out of products. In the building industry, the primary application is for cable covers, but they are also used in other products such as flooring tiles. Phthalates can make up 10 – 50% by weight of a PVC product.

3.2 Product Design

3.2.1 Minimising material use

Minimising the amount of material used in a product has economic as well as environmental benefits.



Expol underfloor insulation includes an 'air gap' between the product and the floor above it. This layer of air offers an added thermal insulation benefit. The air gap also reduces the total amount of material required for the product.

Consider opportunities for reducing the amount of material used in a product through innovative design. This might include alternative strengthening methods such as those detailed in Guideline 1 – General and Guideline 3 – Electronics, of this Design for the Environment Guideline series.

You might also consider providing special manufacturing runs for clients to their specification, or designing your product range to suit standard sizes of other building products (to reduce the need for resizing on site).

3.3 Communication

With the growth in demand for green building products there need to be clear and informative communications about the environmental aspects of your products.

3.3.1 Considering eco-labelling

Find out whether your product is covered by an eco-labelling standard (check the Environmental Choice New Zealand website). Eco-labels can be a valuable marketing tool.

Building specifiers working on green building initiatives will look to gather technical information in order to evaluate the environmental performance of products they might use in the project. Information they would require includes:

- manufacturers' information such as Material Safety Data Sheets (MSDS);
- Indoor Air Quality (IAQ) test data;
- product warranties;
- source material characteristics;
- recycled content data;
- environmental statements; and
- durability information.

In addition, they would be looking for information on how the product fits with:

- building codes;
- government regulations;
- building industry articles;
- model green building product specifications; and
- other sources of product data.

It is therefore important that suppliers of products provide relevant information to help ensure their use.

Environmental Choice licence criteria for receiving eco-label

http://www.enviro-choice.org.nz/specifications/EC-28-05%20Floor%20coverings.pdf

http://www.enviro-choice.org.nz/specifications/EC-25-04%20Thermal(resistant-type)Insulant.pdf

3.4 Impacts During Use

3.4.1 Water efficiency

Plastic products may also offer opportunities for water efficiencies in buildings.

- Design for dual plumbing to use recycled water for toilet flushing or a gray water system that recovers rainwater or other nonpotable water for site irrigation.
- Wastewater can be minimised by using ultra low-flush toilets, low-flow shower heads, and other water conserving fixtures.
- Use recirculating systems for centralised hot water distribution.
- Meter the landscape separately from buildings. Use micro-irrigation (which excludes sprinklers and high-pressure sprayers) to supply water in nonturf areas.
- Use state-of-the-art irrigation controllers and self-closing nozzles on hoses.

3.4.2 Energy efficiency

Research shows that older, uninsulated homes lose 42% of heat through the ceiling and roof, 24% through walls, 12% from ventilation, 12% from windows and 10% through the floor.

A fully insulated home will almost halve the heating requirements compared to an uninsulated home.

From: www.consumerbuild.org.nz and www.energywise.org.nz

Plastic products can be used to improve the energy efficiency of buildings.

- Expanded polystyrene can be used as an efficient insulation material. The use of EPS as an insulation material has the potential to save large amounts of energy in buildings. One kilogram of oil used in the manufacture of EPS insulation board will save the equivalent of about 200 kilograms of heating fuel over the average life of a house.

- PVC can be used to improve the performance of solar panels (see sidebar).

- PVC windows have been shown to require only one-third as much energy as aluminium windows in manufacture.

- Although many factors impact overall energy efficiency, measurements of typical 'U-values' – which represent the rate of heat flow through a window or glass door – show that vinyl performs as well or better than alternative framing materials. For example, the typical U-value of vinyl window frames ranges from 0.3 to 0.5, with lower numbers meaning less heat flow and better thermal performance. The U-values of wood window frames fall in the same range, while aluminium-stet and vinyl-stet windows range from 0.4 to 0.6 and aluminium windows range from 1.0 to 2.2.

- Increasing natural lighting is an important way of minimising energy use in a building. In many cases plastic windows or skylights can be used to maximise natural light and light sensors can be used to adjust artificial lighting levels according to weather conditions.

Insulation helps to improve the health and well-being of New Zealanders and has been mandatory in New Zealand since 1978, supported by standards. Standards for home and commercial building insulation, hot water cylinders and piping and the lighting of commercial buildings are now cited in the Building Code, Clause H1: Energy Efficiency:

- Requirements for roof, wall, window and floor insulation levels are specified for houses and small commercial buildings in the Standard for Energy efficiency – Small building envelope, NZS 4218:1996 (the 2004 revision is still under consideration for referencing in the Building Code).

- Guidance on choosing roof, wall, window and floor insulation levels to improve the energy efficiency of houses beyond the minimum required by the Building Code is covered in SNZ/PAS 4244:2003, Insulation of lightweight-framed and solid-timber houses. Designers, builders and homeowners can use the 'better' and 'best' options included in the document to install above the minimum insulation levels. By voluntarily installing more than the minimum insulation levels, houses will be warmer, less costly to heat and healthier to live in.

- The thermal performance of domestic scale electric hot water cylinders (less than 300 litres) is covered by the Standard for Energy efficiency – Domestic type hot water systems, NZS 4305:1996.

- The Standard for Energy efficiency – Large buildings, NZS 4243:1996, is referenced by the Building Code. It sets out the adequate levels of thermal insulation for commercial buildings over 300 square metres in floor area and also covers lighting energy use.

When you laminate photovoltaic cells to a highly reflective PVC roofing membrane, you get an ecological one-two punch: Solar energy is harnessed to generate electricity, and unwanted heat is reflected away from buildings. This patented solar integrated roof system is topping buildings in California and in Europe.

Find out more: http://www.sarnafilus.com/

3.5 End-of-Life Options

Plastic products make up a small percentage of the waste from building demolition but many contractors are starting to recover as much demolition waste as possible for re-use or recycling. This normally involves on-site source separation of different materials and transport to recyclers.

The plastics industry could support these efforts by taking back waste plastics for reprocessing or by supporting R&D efforts to improve collection and reprocessing of plastic building products.

3.5.1 Considering recycling

Please refer to the Recycling Operators of New Zealand (RONZ) directory for a fully searchable database of businesses that can accept C&D wastes for recycling and reuse in Auckland and Christchurch/Canterbury. This directory is found at http://www.ronz.org.nz/directory/index.php. Their waste minimisation resources directory that is searchable by resource type and market can also be accessed from their website.

For downloadable pdf documents of Auckland, Hamilton and Christchurch recycling and reuse operators, listing those businesses which are not on the RONZ directory as at April 2005, click the required region; Auckland, Hamilton and Christchurch. Details include: a description of services, minimum quantities taken, what processing is carried out and the destination of the resource.

The national waste exchange database, sponsored by WasteMINZ, is a free service available as a website portal. It lists waste quantities and availability for each region in New Zealand to help businesses find alternative disposal methods. The service is confidential and is updated frequently.

WANT TO LOOK INTO THIS FURTHER?

Resource Efficiency in the Building and Related Industries (REBRI) http://www.rebri.org.nz includes Guidelines on reducing waste and sustainable building products.

Waitakere City Council www.waitakere.govt.nz/AbtCit/ec/bldsus/betterbuilding.asp

Waitakere City Council Better Building Site sets minimum standards for its own buildings, but is equally applicable to other public buildings and private commercial buildings.

Building Research Association in New Zealand (BRANZ) http://www.branz.co.nz/main.php?page=Sustainable%20Construction

Information on sustainable construction Victoria University www.vuw.ac.nz/cbpr/ Centre for Building Performance Research.

Guideline 6 – Agriculture

Design for the Environment is about developing products in a way that minimises their environmental impact.
By using Design for the Environment principles a good quality, desirable and cost-effective product can be developed that also has a reduced impact on the environment.

This guideline is number 6 in a series of six that has been created to provide practical Design for the Environment assistance to anyone involved in the design of products that contain plastics. This guideline will give you practical advice and guidance on implementing Design for the Environment in agricultural product design projects.

Agricultural Plastics Design for the Environment Checklist

Use this checklist as a prompt as you work through the design of a particular agricultural product. Work your way down the list and identify the areas in which you can incorporate the Design for the Environment aspect in your product design. Ask yourself, 'Can we do this for this product?' and 'Will this improve the products environmental performance?' for each aspect.

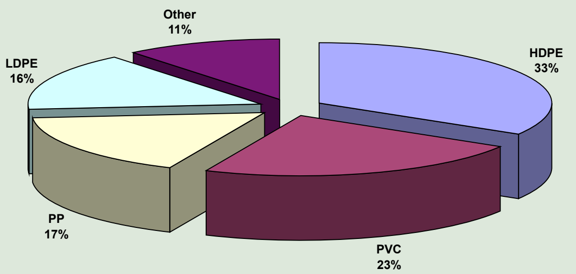
There is more detail on each aspect, including practical design ideas and case studies, in the pages that follow the checklist.
If you tick 'Yes' because you think there is an opportunity to make an improvement in the product design, make a note of the measure you are going to take and the actions needed to implement the change.

Design for the Enviroment Element	Yes	No	ACTION (e.g. investigate further, change from LDPE to HDPE, use fastener instead of adhesive)
3.1 Material Selection			
Avoiding toxic and hazardous substances			
Reducing material variety			
Using recyclable material			
Using recycled material			
Minimising the use of additives			
Considering the use of biodegradable materials			
3.2 Product Design			
Minimising material use			
3.4 Distribution			
Considering the mode of transport			
3.5 End-of-Life Options			
Considering re-use			
Considering recycling			
Considering energy recovery			

Plastics and Agriculture in New Zealand

New Zealand's temperate climate and fertile soil make the country ideal for sheep and cattle farming, cropping, and production in horticulture and forestry. The agriculture and forestry sector is one of the largest sectors in the New Zealand economy.[1] As agriculture becomes an increasingly technical industry, the use of plastics in agriculture, or 'plasticulture', is growing globally.[2]

Roughly 40,790 tonnes of plastic was used in 2005 in New Zealand to manufacture plastic agricultural products.



Polymer types used in New Zealand to manufacture plastic agricultural products.

Plastic films are used in greenhouses, as tunnels over crop rows, as silage covers, as bale-wrap films, and as mulch films to cover rows. Other uses for plastics include twines for bale wraps, irrigation tapes and tubing, pots, trays and seedling containers.

Many plastic agricultural products tend to be large in size, for long-term, outdoor use. UV stability, strength and durability are therefore key design requirements. Many of the larger products, such as water tanks, silage films and pipe, need to be manufactured in New Zealand, largely due to transportation costs. New Zealand also has a very innovative field in the development of high-tech products such as milking equipment, animal hygiene gear, and plant cultivation apparatus.

The Ministry of Agriculture and Forestry (MAF) estimates that gross revenue from the agricultural sector is $16.8 billion[3]. At current prices it is estimated that agriculture, horticulture and forestry contributes approximately 20% to GDP and accounts for 65% of our export earnings.

1 http://www.maf.govt.nz/mafnet/rural-nz/overview/nzoverview005.htm
2 http://www.addcomp.com/features/archive/janfeb05/janfeb05.htm
3 MAF Situation and Outlook for NZ Agriculture and Forestry, July 2006

1. Drivers for Design for the Environment in Agricultural Products

There are several factors driving companies to implement Design for the Environment when developing new products. The general drivers for Design for the Environment are described in Guideline 1 of this series.

The main driver for Design for the Environment consideration in agricultural plastics is the marketing of New Zealand fresh produce as 'clean and green'.

2. Design for the Environment Benefits

Companies that apply Design for the Environment principals find that it has a number of business benefits. These are discussed in Guideline 1.

3. Design for the Environment Elements

There is a wide range of Design for the Environment elements that can be applied to a product, or products, to improve environmental performance. Guideline 1 in this series has detailed some of the more general Design for the Environment elements applicable to plastic products. The following sections contain ideas more specifically focused on plastic agricultural products.

3.1 Material Selection

One of the key phases in product development is the choice of the right materials. As well as technical performance and price, environmental performance is becoming increasingly important.

3.1.1 Avoiding toxic and hazardous substances

Toxic and hazardous materials can be a risk to the health of workers who make the product, to the consumer who uses it, and to the natural environment that must deal with airborne, waterborne or solid wastes during the lifetime of the product. With agricultural products, it is important to avoid toxic/hazardous substances, especially when they may be in contact with animals, plants, and marine-life, during use; e.g. feeding equipment.

Most manufacturers rely on the raw material suppliers to provide test results and certification on materials, particularly if they are compounds and contain additives such as pigments, UV stabilisers or fire retardants. Potentially toxic and hazardous ingredients in these can include: lead (e.g. as a plasticiser in PVC), flame retardants (containing chlorine and bromine), and cadmium in bright/deep coloured pigments that can withstand high temperatures and pressures. The use of plasticisers and stabilisers in agricultural plastics is relatively high, and it is important to work with raw material suppliers, in determining what additives are incorporated within the resin mix.

For more information on toxic and hazardous substances refer to the Electronics Guidelines; which are especially relevant in the design of electronic agricultural plastic products such as electric fence testers, 'hot-tape', and motorised tooling.

3.1.2 Reducing material variety

Reduce material variety for easier end-of-life processing and for improved economics of manufacturing.

Agricultural products generally tend to have less material variety than other product categories. They tend to be more robust and cost effective. This should mean that products can simply be one layer, unlabelled, and manufactured from one material type rather than with layers of laminated materials or with large amounts of printing.

Where more mechanical strength is needed, wall thickness, for example, can be increased, instead of using composites.

Incorporating other materials can significantly impact on the overall cost of manufacturing. If products do have to be labelled, either print on the product or label it, with the same material type.

The more additives that are included, the less ability there is to recycle the polymer product.

AGRECOVERY

An estimated 10 million 20-litre equivalent plastic agrichemical containers are disposed of every year in New Zealand.

Agrecovery is a product stewardship programme for the sustainable recovery of triple-rinsed agriculture and forestry sector plastic containers.

The Agrecovery Programme will take Agrecovery branded, triple-rinsed HDPE plastic agrichemical containers (30 litres/kilograms or smaller) from farmers/growers in New Zealand.

Farmers and growers will be able to deliver eligible containers free-of-charge to specific collection sites located at a set number of local authority transfer stations.

The mixed-colour HDPE containers will be shredded and reprocessed into a variety of new applications.

The programme is scheduled to start in March 2007.

For more information: www.agrecovery.co.nz

3.1.3 Using recyclable material

If a product isn't being designed to have a long life, the next ideal option is to use material types that enable the product to be recycled at the end of its life. Agricultural plastics generally have the advantage of being large and are usually made from one material type. Selecting materials such as the main 6 (PET, HDPE, PVC, L/LDPE, PS, and EPS) recyclable plastics and not including contaminants, such as fillers, pigments and other additives, can be a great help with recyclability.

Further information on the compatibility of different plastic resins for recycling can be found in Guideline 3 – Electronics, of this Design for the Environment series.

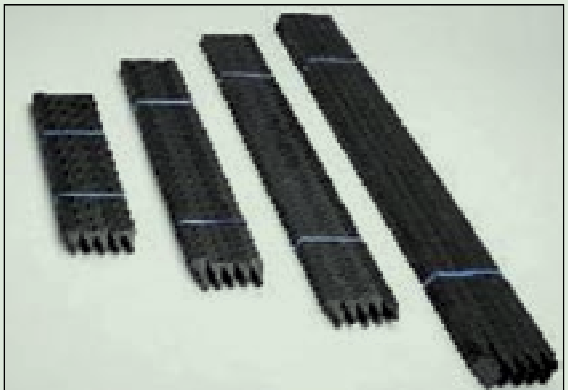
Because of their application and contact with contaminants such as grass and dirt, agricultural plastics usually need to be 'down-cycled' into lower-end products such as plant pots and plastic lumber.

Designers should familiarise themselves with programmes for the recycling of agricultural plastics in New Zealand. Programmes such as the Agrecovery product stewardship system are set up and financed by manufacturers. It is therefore advantageous for designers to liaise closely with these programmes about the recyclability of materials selected for products.

3.1.4 Using recycled material

If the product cannot be made out of 100% recycled material, try to incorporate as much as possible within mechanical property specifications and heath/safety requirements.

Compared to the likes of packaging and electronic goods, agricultural products can generally contain more recycled content than many other products. Mainly because they tend to be bulkier products, restriction on size and wall thickness isn't as critical in some cases, and appearance usually doesn't matter as much.



Plant stakes made from recycled plastic.


Garden edging made from recycled plastic.

3.1.5 Minimising the use of additives

Product types that are becoming more recyclable, such as:

- silage cover / bale wrap;
- agrichemical containers;
- plant pots; and
- plastic reels;

are contaminated if other materials and additives are included.

To assist with recycling it is important to minimise the use of additives in the design of a product. However, a trend towards thinner-gauged films results in a greater reliance on additive technology to protect films in harsh environments.

Generally speaking, the main additives in agricultural products are UV stabilisers, some colourants (primarily white and black), and antioxidants that provide stability during processing. Lead-based stabilisers are tending to be replaced now with non-heavy metal-based stabilisers.

3.1.6 Considering the use of biodegradable materials

Although there are many agricultural products that need to be made to 'last forever', products such as silage cover and bale wrap could be made from biodegradable plastics.

Depending on product specifications, such as mechanical functionality, and health/safety requirements, other applications for degradables could include: breeding equipment, plant pots, and the likes of castration rings.

As discussed in Guideline 1, there are many different types of degradable plastics, ranging from homogenous renewable-resource-based material, to petrochemical plastics with pro-degradant additives.

In New Zealand's harsh UV conditions it is important that degradable plastics do not degrade before they are supposed to. In the worst case scenario, product functional properties could fail or the product may only break down to small, non-degradable plastic particles. Work with your suppliers to ensure you're getting 100% degradable material that will degrade in a certain period of time, within certain atmospheric conditions; get them to advise you on the best way to use and (if applicable) label the plastic product so the consumer knows how to use and dispose of the material at end of its useful life.

Discussions on the future of degradable plastics in New Zealand are currently underway. Product designers should acquaint themselves with the key issues and the state of industry discussions before using degradable plastics in a new product. This information will be available through Plastics New Zealand www.plastics.org.nz.


Film farm plastics could be made from biodegradable material.

Examples of biodegradable agricultural plastics:


EcoCover fertiliser enriched weed mats.

Plastic mulch film.

3.2 Product Design

3.2.1 Minimising material use

Depending on the application, material use can be minimised and material strength can be maximised. This can be done by using design features such as corrugation, ribbing, bracing and down-sizing.

In some agricultural applications, it is difficult to reduce wall thickness, e.g. silage cover and greenhouse films. However in other products, such as bins/crates, it may even be worthwhile designing to minimise material use for health and safety reasons; e.g. with agrichemical containers, the trend now is for product to come in smaller sizes.

WANT TO LOOK INTO THIS FURTHER?

Crop Life Australia (2006) Container Design and Performance Guidelines for Liquid Animal Health and Crop Protection Products
www.croplifeaustralia.org.au/files/stewardship/Container%20Design%20and%20Performance%20Guidelines.pdf

Simple checklist guidance for the design of chemical containers

3.3 Distribution

RX Plastics had the deck of a truck completely modified to be able to handle the transportation of their water tanks. They have maximised loading potential and ensured their product gets delivered safely and securely.

3.3.1 Considering the mode of transport

It is important to consider not only the mode of transport, but how that product will fit in/on the distribution vehicle, particularly for larger agricultural products.

In most cases, the cost of freight is included in the overall cost of the product; so, economically, it makes sense to try and get the best transportation method available.

Other products are specifically designed to fit within the boundaries of trailer/container/decking dimensions, or simply, made to stack/ fit in with as much other product as possible.

3.4 End-of-Life Options

End-of-life disposal methods for agricultural plastic products can include:

- random burning in uncontrolled conditions, causing smoke/ pollution;
- accumulation of products used on farms, which can be an eyesore for the community;
- dumping either in landfill or on the farm.

Unlike for some other product categories, there is a wide number of potential end-of-life options for agricultural plastics. This potential could flourish if an infrastructure was established economically for recycling (for low-end product such as wood fibre-reinforced fence posts) and energy recovery programmes.

3.4.1 Considering re-use

The re-use of agricultural plastics is very common for most products of shorter life span – such as fertiliser containers, plant pots and baling twine. But there is some difficulty with more toxic, short-life products such as pesticide and herbicide containers.

However, most agricultural plastics have longer life spans, being larger in size, more durable, and UV resistant, etc., so re-use doesn't really come into the equation very often.

So, for all plastic products, depending on the application and the life-span of the product, designing for reuse needs to be a priority, followed by the option of recycling and possible energy recovery in the future (unless of course the product is biodegradable).

3.4.2 Considering recycling

Agrichemical containers ready for baling

One of the issues with recycling agricultural products is contamination from additives within the plastics and dirt/organic matter and chemicals that may have been in contact with the product. A further complication is the widespread distribution of farm plastics and the transportation costs associated with their collection. For these reasons recycling infrastructure for these products is currently not established throughout New Zealand.

Programmes are being developed to try and increase the recovery of agricultural plastics, particularly silage cover/bale wrap and agrichemical containers. These programmes are attempting to establish product stewardship systems for the sustainable nationwide recovery of farm plastics. By developing coordinated, long-term programmes economies of scale can be used to make the collection and recycling of plastics economically viable.

It is important for product developers to not only liaise with recyclers on design ideas but also to keep up to date with developments in the recycling industry. Particularly, there needs to be strong communication between product developers and product stewardship programme co-ordinators.

Some of the companies/organisations involved in developing agricultural plastics recovery programmes throughout New Zealand include:

- Agpac
- Agrecovery - www.agrecovery.co.nz
- Growsafe - www.growsafe.co.nz
- New Zealand Agrichemical Education Trust
- Agcarm.

3.4.3 Considering energy recovery

Energy recovery for plastics is only in trial stages in New Zealand. Potentially, energy recovery could be a viable end-of-life option because of the bulk quantities of material available (mainly silage cover and bale wrap), as long as the transportation and collection costs are economical.

Energy recovery doesn't rely so much on cleanliness of product, so some level of dirt, grasses and other organic matter could potentially be included.

Plastics New Zealand is currently involved in some energy recovery research that, if successful, could prove to be an option for some farm plastics.

3.4.4 Considering composting

As mentioned in section 3.1.6, there is the potential for products such as silage cover and bale wrap to be made from biodegradable plastics. However, both non-degradable and degradable plastics can be contaminants to recycling and composting streams.

The reason for this is that there is no way of identifying what material it could be, or how long it could take to degrade – if at all. This is because one of the first steps in some composting processes is the shredding of all material. The separation of plastics after this shredding is virtually impossible.

Discussions on the future of degradable plastics in New Zealand are currently underway. Product designers should acquaint themselves with the key issues and the state of industry discussions before using degradable plastics in a new product. This information will be available through Plastics New Zealand www.plastics.org.nz.

FOR FURTHER INFORMATION ON PLASTICS IN AGRICULTURE

American Society for Plasticulture, http://www.plasticulture.org/what_description.htm 'The term plasticulture is defined as the use of plastics in agriculture.'

Growsafe http://www.growsafe.co.nz/gs_2005/doormouse/main/gs_2005_main.php

Joint website for both The NZ Agrichemical Education Trust and Total Business Training (Australasia) Ltd.

Agrecovery www.agrecovery.co.nz A New Zealand product stewardship programme for the sustainable recovery of triple rinsed agriculture and forestry sector plastic containers.

drumMUSTER www.Drummuster.com.au Australian farm plastic container collection programme.

Appendix 1

Links to More Information

Plastics New Zealand Inc.
www.plastics.org.nz

Ministry for the Environment
www.mfe.govt.nz

Packaging Council of New Zealand
http://www.packaging.org.nz/

Recycling Operators of New Zealand Inc.
www.ronz.org.nz

WasteMINZ, Waste Management Institute of New Zealand
http://www.wasteminz.org.nz/

Centre for Design at Melbourne's RMIT University
http://www.cfd.rmit.edu.au
or http://www.rmit.edu.au/browse?SIMID=fx3cmtoxlapp

Design for Sustainability Guide, from The Design for the Enviroment Foundation, Sydney, Australia
http://www.edf.edu.au/DfSGuideWebsite/IntroBackg/IntroFrameset.htm

MBDC a product and process design firm that offers 'Cradle-to-Cradle' consultancy
http://www.mbdc.com

Product Ecology Consultants
http://www.pre.nl/Design for the Enviroment/default.htm

Loughborough University, Information Inspiration web-resource for industrial designers
http://www.lboro.ac.uk/research/susdesign/InfoInsp/setup.htm

DEMI guide to sustainability, web-resource
http://www.demi.org.uk/

Envirowise, Practical Environmental Advice for Business
http://www.envirowise.gov.uk

Product Ecology, consultancy group
http://www.productecology.com.au/

BioThinking, web-resource and consultancy service
http://www.biothinking.com

Rocky Mountain Institute, a non-profit organisation providing economical design integrative solutions
http://www.rmi.org/

Information on Plastics & the Environment, through The American Plastics Council
www.plasticsresource.com/

PACIA - Plastics and Chemicals Industries Association (Australia)
www.pacia.org.au

Plastics Europe, Association of Plastics Manufacturers
www.plasticseurope.org

British Plastics Association
http://www.bpf.co.uk/bpfissues/Electrical.cfm

Sustainability Victoria
http://www.ecorecycle.vic.gov.au/

Environment Agency, UK consultancy organisation
http://www.environment-agency.gov.uk/subjects/waste/1019330/?lang=_e

Australian Council of Recyclers, HDPE containers, and LDPE film specifications
www.acor.org.au/pdfs/ACOR%20HDPE%20spec.pdf

Environmental Choice New Zealand, ecolabel
http://www.enviro-choice.org.nz/

Energy Efficiency and Conservation Authority
www.eeca.govt.nz

New Zealand Climate Change
www.climatechange.govt.nz

Standards New Zealand
www.standards.co.nz

BOOKS

Cradle to Cradle: Remaking the Way We Make Things, (2002), William McDonough and Michael Braungart, North Point Press, New York.

The Eco-Design Handbook: A Complete Sourcebook for the Home and Office, (2002), Alastair Fuad-Luke, Thames and Hudson, London.

Design + Environment: A Global Guide to Designing Greener Goods, (2002), Helen Lewis and John Gertsakis with Andrew Sweatman, Tim Grant and Nicola Morelli, Greenleaf Publishing, UK.

Appendix 2

Overview of Eco-labelling Schemes

The International Standards Organisation (ISO) distinguishes three main approaches to eco-labelling that a company could adopt:

Type I A third party determines whether or not a product meets certain standards and approves the use of an environmental mark for those that do. Principles and procedures for establishing and operating third party schemes such as these are defined in ISO 14024.

Type II Companies and groups can make 'self-declared' environmental claims for products and services, based on their own standards. Although these claims have less market credibility, this is a popular option for manufacturers as it provides more flexibility for them to differentiate their products by focusing attention on particular environmental features.

ISO 14021 provides guidance on suitable evaluation methodologies and definitions of terms used in environmental claims on labelling, including:

- designed for disassembly;
- extended product life;
- recyclable;
- recycled content;
- reduced energy consumption;
- reduced resource use;
- reduced water consumption.

Type III Life-cycle assessment (LCA) labels provide quantitative environmental information on all stages in a product's life-cycle. ISO Technical Report 14025 is the first step towards developing a certifiable eco-label in this area, and requires a life-cycle assessment to be carried out in accordance with the ISO 14040 series of standards.

Appendix 3

The Plastic Identification Code

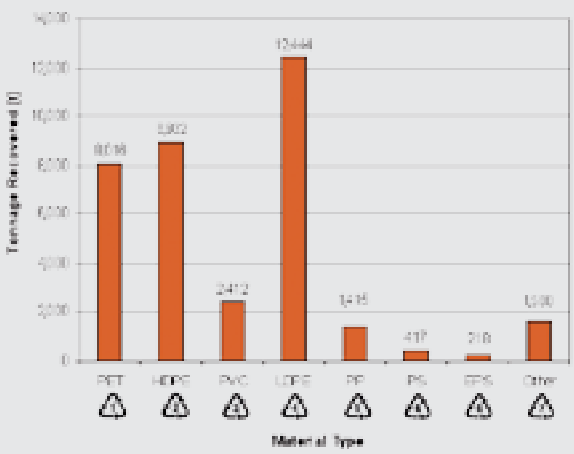
Symbol	Type of Plastic	Properties	Common Uses	Recycled In
1 PET	**PET** Polyethylene Terephthalate	Clear, tough, solvent resistant, barrier to gas and moisture, softens at 80°C	Soft drink and water bottles, salad domes, biscuit trays, salad dressing and peanut butter containers	Pillow and sleeping bag filling, cloth-ing, soft drink bottles, carpet
2 PE-HD	**PE-HD** High Density Polyethylene	Hard to semi-flexible, resistant to chemicals and moisture, waxy surface, opaque, softens at 75°C, easily coloured, processed and formed	Crinkly shopping bags, freezer bags, milk bottles, ice cream containers, juice bottles, shampoo, chemical and detergent bottles, buckets, rigid agricultural pipe, milk crates	Recycling bins, compost bins, buckets, detergent containers, posts, fencing, pipes
3 PVC	**PVC** Unplasticised Polyvinyl Chloride PVC-U Plasticised Polyvinyl Chloride PVC-P	Strong, tough, can be clear, can be solvent welded, softens at 80°C Flexible, clear, elastic, can be solvent welded	Cosmetic containers, electrical conduit, plumbing pipes and fittings, blister packs, wall cladding, roof sheeting, bottles Garden hose, shoe soles, cable sheathing, blood bags and tubing, watch straps	Flooring, film and sheets, cables, speed bumps, packaging, binders, mud flaps and mats
4 PE-LD	**PE-LD** Low density Polyethylene	Soft, flexible, waxy surface, translucent, softens at 70°C, scratches easily	Glad wrap, garbage bags, squeeze bottles, black irrigation tube, black mulch film, garbage bins	Rubbish bin liners, pallet sheets
5 PP	**PP** Polypropylene	Hard but still flexible, waxy surface, softens at 140°C, translucent, withstands solvents, versatile	Dip pottles and ice cream tubs, potato chip bags, straws, microwave dishes, kettles, garden furniture, lunch boxes, blue packing tape	Pegs, bins, pipes, pallet sheets, oil funnels, car battery cases, trays
6 PS 6 PS-E	**PS** Polystyrene **PS-E** Expanded Polystyrene	Clear, glassy, rigid, brittle, opaque, semi-tough, softens at 95°C. Affected by fats and solvents Foamed, light weight, energy absorbing, heat insulating	CD cases, plastic cutlery, imitation 'crystal glassware', low cost brittle toys, video cases Foamed polystyrene hot drink cups, hamburger take-away clamshells, foamed meat trays, pro-tective packaging for frag-ile items	Coat hangers, coasters, white ware components, stationery trays and accessories
7 OTHER	**OTHER** Letters below indicate ISO code for plastic type e.g. SAN, ABS, PC, Nylon	Includes all other resins and multi materials (e.g. laminates) Properties dependent on plastic or combination of plastics	Car parts, appliance parts, computers, electronics, water cooler bottles, packaging	Car parts, concrete aggregate, plastic timber

Appendix 4

Overview of Plastics Recycling in New Zealand

A survey conducted by Plastics NZ on plastics recovery, showed that 35,442 tonnes of plastics were recovered in 2004. The graph below shows the breakdown of quantities of each main material type collected.

The largest quantity collected, 12,444 tonnes, is shown in the LDPE column, (which included LLDPE, and other films). The second highest tonnage was HDPE with 8,932 tonnes, followed by PET with 8,016 tonnes.



Tonnage of Plastic Recovered in 2004 by Material Type

New Zealand's Plastic Recycling Infrastructure (2005)

New Zealand's current recycling infrastructure is largely made up of recycling companies and organisations (including community groups) collecting, visually sorting and processing plastics from industrial and domestic sources. Smaller organisations generally on-sell their product to trading companies. Collection of plastics occurs in a variety of ways throughout New Zealand, depending on the company and their contract with other businesses, organisations, and councils. Approximately 35% of the recovered plastic is collected from consumers, with the remainder collected from industries and businesses.

Once material is collected and sorted, 55% of the plastics recovered in NZ is sent off-shore, most commonly in bales to end-market customers in Asia. The material that remains in New Zealand for reprocessing is predominantly HDPE and some LDPE.

Plastic manufacturers recycle in-house and/or send their scrap/reject to a recycler to granulate or repelletise the material for reuse back at the manufacturing plant. This is called 'tolling'. Some of this material is also sold to a recycler.

Forms of Recovered Plastics — Bales of recovered product include: PET soft-drink bottles (in non-coloured, individual colours, and mixed colours); Baled HDPE milk bottles (if they are not on-sold to NZ markets) and pallet shrink/shroud film.

Appendix 5

Waste Electrical and Electronic Equipment Directive

The WEEE Directive encourages the design and production of electrical and electronic equipment to facilitate its repair, possible upgrading, re-use, disassembly and recycling at end of life. From August 2005, it made producers in ten broad product categories responsible for financing the collection of their own products at end of life and meeting targets for re-use, recycling and recovery.

- New products must be marked clearly with the producer's name, together with a symbol (crossed-out wheelie bin) to indicate that they must not be disposed of in municipal waste collection.
- Producers are required to provide information on components and materials used in their products to enable treatment facilities, re-use centres and recycling facilities to disassemble, re-use and recycle them.

Producers are required to provide information to treatment facilities to identify specific components and materials in the equipment that must be removed, including:

- capacitors containing polychlorinated biphenyls;
- components containing mercury (e.g. switches, backlighting lamps);
- batteries;
- printed circuit boards (PCBs) in mobile phones;
- brominated flame retardants (will be banned from use after July 2006 by the ROHS Directive);
- cathode ray tubes (fluorescent coating must be removed);
- gas discharge lamps (mercury must be removed); and
- liquid crystal displays.

Restriction of Use of Certain Hazardous Substances Directive

The ROHS Directive is complementary to the WEEE Directive and seeks to reduce the environmental impact of WEEE by restricting the amount of certain hazardous substances that may be present in products to certain maximum concentration levels. It applies to the same categories of products defined by the WEEE Directive, with the exception of medical equipment systems and monitoring and control equipment. From July 2006, producers will need to demonstrate that their products do not contain more than the maximum permitted levels of

- lead;
- mercury;
- cadmium;
- hexavalent chromium; or
- polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE), which are currently used as flame retardants.

It is proposed that the levels are 0.01% by weight for cadmium in any individual homogenous material and 0.1% for the other substances.

Where restricted substances are currently in use, the greatest costs could arise from the need to develop, test and re-qualify products, components and sub-assemblies to meet performance specifications and standards. This will have a considerable impact on supplier contracts throughout these supply chains and will require extensive awareness-raising and communication.

Appendix 6

Compatibility of different polymer combinations for potential recycling

	LDPE	LLDPE	ULDPE/VLDPE	Ethylene copolymers	HDPE	PP	EPM/EPDM	PS (gen purpose, high impact)	SAN	ABS	PVC	PA	PC	PMMA	PBT	PET	SBS
LDPE																	
LLDPE	1																
ULDPE/VLDPE	1	1															
Ethylene copolymers	1	1	1														
HDPE	1	1	1	1													
PP	4	2	(1)	2	4												
EPM/EPDM	4	4	(1)	3	4	1											
PS (gen purpose, high impact)	4	4	4	4	4	4	4										
SAN	4	4	4	4	4	4	4	4									
ABS	4	4	4	4	4	4	4	4	1								
PVC	4	4	4	(2)	4	4	4	4	2	3							
PA	4	4	4	(1)	4	4	(1)	4	4	4	4						
PC	4	4	4	4	4	4	4	4	2	2	4	4					
PMMA	4	4	4	(3)	4	4	4	4	2	2	2	4	2				
PBT	4	4	4	(2)	4	4	4	4	4	4	4	4	1	4			
PET	4	4	4	(3)	4	4	4	4	4	4	4	3	1	4	3		
SBS	4	4	4	4	4	4	4	1	3	2	3	3	4	4	4	4	

Key: 1 excellent; 2 good; 3 fair; 4 incompatible; (n) dependent on composition

Source: Envirowise Good Practice Guide: Sustainable design of electrical and electronic products to control costs and comply with legislation

Important note: This compatibility table was developed in the UK and should therefore be used as a rough guide. Recycling compatibility will vary for the local NZ market. Consultation with recyclers is recommended in all cases.

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