Q3

quickstart

Issue 3

Design for Sustainability with Plastics

Life cycle design tools

This is the third in a series of Quickstarts on Design for Sustainability (D4S) with Plastics. It provides an overview of some of the tools which can help designers and other practitioners to understand the impacts and benefits of plastic products over their entire life cycle.

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

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

Bench seat made from recycled plastics (image supplied by Replas)

There are a number of different tools that can be used to evaluate the sustainability benefits and impacts of a product. The most appropriate tool or tools will depend on the objective. For example, particular tools may be used to quickly compare the environmental impacts of several different design concepts over the product life cycle. Other tools allow practitioners to gather more rigorous and peer-reviewed information on an existing product.

Understanding which tools to use

Figure 1 lists some of the reasons for using a life cycle design tool, and indicates which ones might be able to assist. Each tool is then briefly discussed. The methodology and tools for LCA are discussed further in Quickstart 8.

Figure 1: Life cycle design tools

Objective	Life cycle map	Sustainability matrix	LCA*	Streamlined evaluation tools
Quickly compare the environmental impacts and benefits of alternative design concepts	✓	✓	✗	✓
Quickly evaluate the sustainability impacts and benefits of a product	✓	✓	✗	✗
Understand, with a high level of accuracy, the environmental impacts and benefits of a product	✗	✗	✓	✗
Publicly promote the environmental benefits of your product relative to competing products	✗	✗	✓	✗

* LCA = Life Cycle Assessment

Compost bins help reduce waste to landfill

The life cycle map is a qualitative tool that can provide insights into the product life cycle and some of the sustainability benefits and impacts associated with each stage. A process tree, or 'map', of the product life cycle is drawn up by asking a series of questions.

Life cycle map

An example of a life cycle map is shown in Figure 2, in this case for a hypothetical packaged food product. The food product, processed fruit, is sold in a multi-pack which consists of 3 polystyrene cups with aluminium foil lids, wrapped in a cardboard sleeve.

The value of this type of exercise is that it can identify sustainability issues that need to be considered in the design process, but which may not have been immediately obvious. For example, when designing food packaging, it is important to consider how design can minimise stock damage and the associated environmental and commercial impacts.

The next step is to highlight any opportunities to reduce environmental impacts or improve efficiency through better design.

The following questions may be useful when drawing up a life cycle map:

- What components or materials are used to make the product, and where are they manufactured?
- How and where are the raw materials sourced, and how are they transported to the manufacturing facility (e.g. truck, ship, air)?
- Where are the components made and how are they transported to the manufacturing facility?
- What types of materials are used for packaging the product (e.g., retail packaging, shipper, pallets etc)?
- Is any refrigeration used in transport or retail display, or by the consumer?
- Does the product require energy, water or any other consumables during use?
- What proportion of the product and its packaging is recovered at end-of-life, or disposed to landfill?
- Are there any social impacts associated with the product, such as litter?
- Is there any product waste in the supply chain, which represents inefficiency and an unnecessary loss of resources and energy?

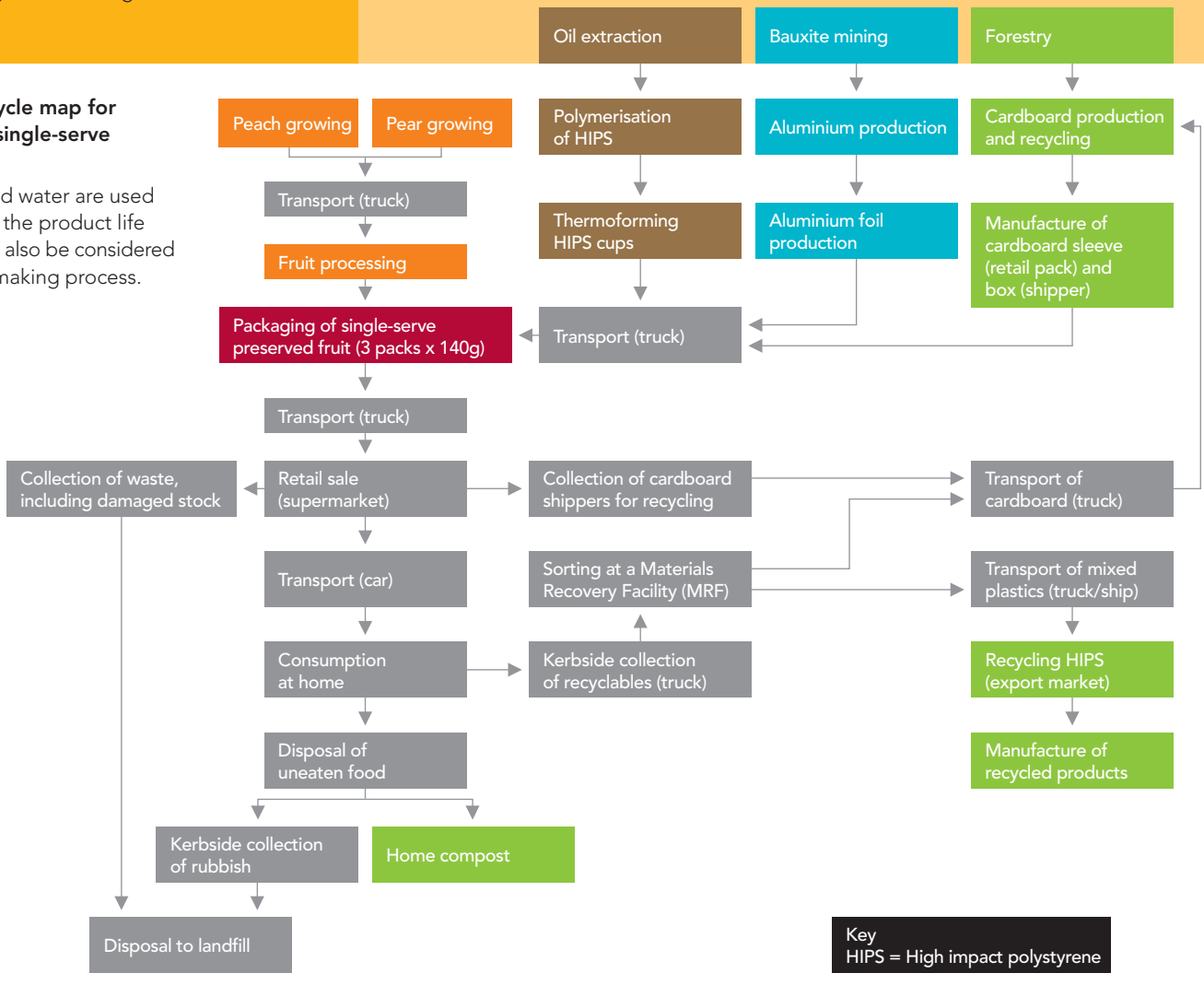

Figure 2: Life cycle map for a hypothetical single-serve food product

Note: Energy and water are used at each stage of the product life cycle and should also be considered in the decision-making process.

Another tool that can be used in conjunction with the life cycle map is a multi-criteria sustainability matrix (see Figure 3). This extends the 'design for environment' assessment tool which was originally developed by engineers at the AT&T Corporation[1], to include social and economic criteria.

Bridge planks made from recycled plastics (image supplied by Replas)

Sustainability matrix

The sustainability matrix involves:

- identifying relevant evaluation criteria and life cycle stages;
- using expert knowledge, supplier surveys, checklists and other sources of information to fill out each box in the matrix with a mix of qualitative information, quantitative information and questions which need to be followed up.

The aim of the matrix is to help the user to think through the sustainability impacts and benefits at each stage of the life cycle[2]. It can be used in conjunction with the life cycle map to build knowledge about the life cycle impacts and benefits of a product, as well as identifying opportunities to enhance sustainability through better design. Figure 3 shows how the matrix might be completed for a plastic bread bag and closure. Some of the data have been quantified from readily available sources but there are also gaps or questions which the user would need to follow up.

Figure 3: Sustainability product assessment matrix for a hypothetical plastic bread bag

	Input of materials	Energy use	Water use	Emissions	Solid wastes	Economic benefit/impact	Social benefit/impact
Production of basic materials	LDPE: Crude oil or gas HIPS: oil	LDPE: 81.6MJ/kg HIPS: 88.4 MJ/kg	Water used in process cooling	Greenhouse gas emissions – CO_2, other?	Minimal	Manufactured in Australia	Local employment
Manufacturing	Each bag: LDPE 0.4g Each closure: HIPS 5.2g	Energy used in film blowing (LDPE) and injection moulding (closure)	Water used in process cooling	Emissions of VOCs from printing process?	Waste LDPE sent to recycler HIPS recycled in-house	Manufactured in Australia	Local employment
Distribution	Reusable plastic crates – PP?	Transport by truck (diesel) Lightweight bag/ square shape of bread – efficient to transport	How often are crates washed?	Emissions from transport: CO_2, NO_X and ozone	Bread past use-by date thrown away by retailer – landfill Damaged unserviceable crates sent to recycler	Any opportunities to improve efficiency of distribution?	Packaging enables wide-spread, timely distribution of undamaged goods
Product use	Nil	Nil – unless consumer puts bread in fridge / freezer / toaster	Nil	Nil – unless consumer puts bread in fridge / freezer / toaster	Bread past use-by date thrown away by consumer - landfill	Bread in plastic keeps longer than paper – less waste	Bag keeps bread fresh, can be frozen, can be re-sealed after use
End of product life	Nil	Minimal due to light weight (kerbside collection – garbage trucks)	Nil	Minimal due to light weight (kerbside collection – garbage trucks)	Bag and closure technically recyclable but not collected at present – disposed to landfill	Recycling bags would be more expensive than disposal to landfill	Some consumer interest in a recycling program for bags and closures; no recycling logo or PIC on bags

Sources: Packaging weights are for a loaf of wholemeal sliced bread (retailer own brand). General information on the plastics manufacturing process is from Plastics Industry Association (1992), *Manufacturing plastics*. Embodied energy data is from Sustainable Packaging Alliance (2004), *Materials Selector* (average Australian data from SimaPro LCA software).

Abbreviations:

CO_2 = carbon dioxide

HIPS = high impact polystyrene

LDPE = low density polyethylene

NO_X = nitrous oxide

PIC = Plastics Identification Code

PP = polypropylene

VOC = volatile organic compound

Baled PET bottles ready for recycling

LCA is an internationally recognised technique (ISO 14040 series) for assessing the environmental aspects and potential impacts associated with a product over its total life cycle.

Life Cycle Assessment (LCA)

LCA involves four stages[3]:

1. Goal and scope development—the reason for conducting the study, its intended audience, and the scope of the study.
2. Inventory development—the compilation and quantification of inputs (e.g. oil, salt, coal) and outputs (e.g. carbon dioxide, solid waste) to and from the product system.
3. Impact assessment—evaluating the magnitude and significance of these inputs and outputs by linking them to environmental issues of concern (e.g. global warming, eco-toxicity).
4. Interpretation—interpreting the inventory and impact assessment results to draw conclusions and make recommendations to help inform decision making.

A full LCA is particularly useful if the environmental impacts of a product or system need to be evaluated with a high level of accuracy. However, it can be a time-consuming and expensive exercise because of the need to collect detailed inventory data for each stage of the life cycle. A project is currently underway in Australia, supported by PACIA and other stakeholders, to improve the availability and quality of Australian inventory data[4].

There are a number of LCA software tools which are available to assist practitioners. These tools include publicly available inventory data on the most common materials and processes, and they also allow the user to add their own product-specific data. The two which are most commonly used in Australia are:

- SimaPro, developed in the Netherlands as a tool for designers. It is relatively straightforward to use and incorporates both Australian and international data.
- GaBi, developed in Germany, with applications specifically tailored for beginners and practitioners of design for sustainability. A new version of the software integrates social and economic impacts over the product life cycle. Like SimaPro it includes Australian data when sold locally.

Streamlined life cycle evaluation tools

It is not feasible to use LCA as a routine diagnostic tool because of the time and effort required. To overcome this problem, a number of streamlined tools have been developed to help designers evaluate design options at the concept stage. These have a more user-friendly interface than LCA software and have been tailored for specific purposes, such as the evaluation of packaging systems or the specification of building materials and assemblies.

The disadvantage of streamlined tools is that they use 'average' life cycle inventory data which may not be directly relevant to a particular product or process. Their value is in highlighting important issues which need to be considered during the design or procurement process, rather than in providing quantitative estimates of environmental impact.

Streamlined life cycle evaluation tools that are being developed in Australia include:

Packaging Impact Quick Evaluation Tool (PIQET)™ – PIQET is an on-line life cycle evaluation tool specifically designed for packaging systems. Like SimaPro and GaBi, it is based on publicly available inventory data, but also allows the user to add product-specific information to improve the accuracy of the analysis. The first commercial version of PIQET is being used by food and beverage manufacturers and packaging manufacturers to support the packaging development process.

Greenfly – Greenfly is an on-line life cycle modelling and ecodesign tool. Unlike other streamlined LCA tools, it provides the user with suggestions for reducing the environmental impacts of a product. The first version of Greenfly is currently available on-line for a limited trial period.

Building Assemblies and Materials Scorecard (BAMS) – BAMS is a life cycle decision support tool for building designers and specifiers. It allows the user to evaluate the life cycle impact of assemblies such as flooring systems, windows and walls. BAMS is currently under development.

LCADesign™ – LCADesign estimates the environmental impacts of a building at the design stage by linking information from a CAD file with life cycle inventory data. These impacts include resource consumption and emissions generated during the manufacture of building materials and water and energy used in building operation.

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

Recycled PVC flake and powder (image supplied by Vinyl Council Australia)

Standards

The methodology for a full LCA is governed by a series of international Standards (ISO 14040 series). These are listed in PACIA's D4S toolbox at www.pacia.org.au.

Further information

Australian LCA Society (ALCAS) (membership and events): www.alcas.asn.au

Australian Life Cycle Inventory project (AusLCI): www.auslci.com

Building Assemblies and Materials Scorecard (BAMS): www.cfd.rmit.edu.au/programs/sustainable_materials/building_assembly_materials_scorecard

Centre for Design at RMIT University (LCA consulting services and training courses): www.cfd.rmit.edu.au/programs/life_cycle_assessment

Centre for Water and Waste Technology, University of UNSW (LCA consulting services and GaBi software licenses for Australia): www.cwwt.unsw.edu.au/sustainability-assessment.html

CRC for Construction Innovation (information on LCADesign): www.construction-innovation.info/index.php?id=780

Greenfly (access to the on-line tool): www.greenflyonline.org

EPA Victoria (for information on life cycle management and various tools, including LCA): www.epa.vic.gov.au/Lifecycle/default.asp

Life Cycle Strategies (SimaPro demo, SimaPro software licenses for Australia and LCA training): http://simapro.lifecycles.com.au

PE International (GaBi demo and software licenses): www.gabi-software.com

PACIA (for information on D4S, plastics recycling and sustainability): www.pacia.org.au

Sustainable Packaging Alliance (for a demonstration, licenses or training for PIQET): www.sustainablepack.org/research/subpage.aspx?id=30&PageID=0

Sustainability Victoria (to download a range of D4S resources): www.sustainability.vic.gov.au

Publication details

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

Footnotes

1 For more information, see Graedel, T. E. and Allenby, B. R. 1995, *Industrial ecology*, Prentice Hall, New Jersey, Ch. 20.

2 For more information on this type of approach, see Ch. 3 'Environmental assessment tools' in Lewis and Gertsakis et al (2001), *Design + environment*, Greenleaf, Sheffield.

3 ISO 14040: 1997, *Environmental management - life cycle assessment - principles and framework*

4 PACIA and other stakeholders from industry, government and research institutions are developing more accurate data for LCA studies through the Australian Life Cycle Inventory (AusLCI) project. This will provide a national, publicly-accessible database with easy access to authoritative, comprehensive and transparent environmental information on a wide range of Australian products and services over their entire life cycle.