Design Smart Material Guide No.2

Australian Packaging Covenant

Fibre-Based Packaging

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Purpose of this Guide

This Design Smart Material Guide for fibre-based packaging is the second in a series of ten guides published by the Australian Packaging Covenant (APC).

This guide considers packaging primarily based on wood fibre. Throughout the guide the general term 'fibre packaging' is used to cover packaging material types such as boxboard, cartonboard, corrugated board, paper bags, and other wood fibre-based packaging. Where necessary the specific type of fibre-based packaging is identified.

The purpose of this guide is to help you improve the environmental performance of your packaging system, without compromising on cost or functionality. It provides a 'checklist' of sustainability issues to keep in mind when designing and/or specifying your next fibre-based package.

The guide will also support your packaging reviews against the Sustainable Packaging Guidelines (SPG), as required by the APC. To facilitate this, the design considerations are grouped under the four principles of the guidelines.

The information contained in this guide is based on 'life cycle thinking', which considers the sustainability impacts of packaging throughout its supply chain, during use, and at end-of-life. It considers the impacts of the whole packaging system, including primary, secondary and tertiary packaging[1], as well as its performance in delivering the product to the consumer.

You are probably designing your packaging to fulfil a particular function, rather than an intrinsic need to use wood fibre as the primary packaging material. If this is the case, then we encourage you to read the first of the guides, which provides information on the comparative environmental and functional performance of the many different packaging material types that are available. Maybe there is another packaging format that will better fulfil your need to optimise cost, function, and environmental performance. Maybe now is the time to consider a bigger change?

[1]Primary packaging contains the sales unit product (e.g. a high recycled content box-board container for cereal, with a plastic film liner), secondary packaging contains the sales units (e.g. a corrugated board box holding 8 cereal boxes), and tertiary packaging is the freight/distribution related packaging (e.g. a pallet, with pallet wrap and a cardboard 'slip').

If you have any questions about theses guides, would like to make comments regarding the guidance provided, or just like to better understand sustainable packaging assessments in general, please contact the APC at apc@packagingcovenant.org.au.

The Life Cycle of Fibre-Based Packaging

Fibre-based paper and board is the most common form of packaging used in Australia (by weight), accounting for over 60% of all packaging.

Paper and cardboard in Australia is made almost entirely from cellulose-based fibres sourced from wood. The fibre can be sourced from other plants, such as hemp and kenaf, however the focus of this guide is on packaging manufactured from either trees (virgin fibre) or recycled wood fibre. It doesn't directly consider non-packaging forms of paper products, such as newspapers, magazines and office paper.

In Australia, packaging paper and paperboard (and newspaper) are generally based on recycled wood fibre, and printing and communication papers on virgin wood fibre.

Recovered fibre (i.e. paper and cardboard recyclate) is a very important source of raw material in Australia, with over 60% of fibre used in Australia sourced from recycled products. Without paper recycling, significantly larger areas of arable land would be required for (virgin) fibre production, and much greater quantities of fibre would be disposed to landfill. Increased waste would result in the loss of this resource and increased generation of methane (a strong greenhouse gas).

Paper must be strong enough to provide the strength requirements for its intended application. It must provide the required level of 'barrier' protection, often through the addition of coatings or non-paper layers. Finally, it needs to perform aesthetically, usually by offering an adequate surface for printing. Typically, packaging papers (on a dry basis) are 80% cellulose (wood fibre) and 20% fillers (such as chalk or kaolin clay). Cardboard is approximately 65% cellulose, 10% filler and 25% lignin (the natural 'glue' that holds wood fibres together).

The Life Cycle of Fibre-Based Packaging

Fibre packaging types

There are many different variations of fibre-based packaging, which mostly fall into the following five categories:

Kraft paper (10–120 g/m2)

Kraft paper is usually manufactured using virgin wood fibre, but might have some recycled fibre content. It can be used as a barrier layer to prevent food contact with another packaging component, such as recycled fibre in the corrugated core of corrugated containerboard. The strength and barrier properties of kraft paper can be improved through the use of coatings (e.g. resins or waxes) or laminated layers (e.g. polyethylene or aluminium). Kraft paper can be either natural brown or bleached.

Boxboard (120–800 g/m2)

Boxboards are thick paper grades used as the base material for many packaging applications, particularly folding cartons for dry food and non-food primary packaging applications. Boxboard usually consists of four or five layers of pulp laminated together during the paper making process, with an outer coating of clay (e.g. kaolin) and varnish to provide a smooth surface suitable for printing or other finishes. Depending on the functional requirement, boxboards can have a recycled content of 0–100%.

Corrugated board (250–1,500 g/m2)

Corrugated board (commonly called corrugated cardboard) is typically constructed with a high recycled content fluted core or 'medium' (the wavy centre), which is glued between two linerboard sheets of kraft or recycled paper, using starch. Corrugated containerboard is commonly used for secondary and tertiary packaging applications. Two and three layer corrugated boards can be bonded together to construct heavier duty packaging if required.

Liquid paperboard (250–500 g/m2)

Liquid paperboard (LPB) is a multi-layer composite material. It comes in two common forms: gable top LPB (e.g. fresh milk cartons) and aseptic LPB (e.g. long-life milk cartons). Gable top LPB usually has a typical structure of: printing (exterior surface), polyethylene, fibreboard, polyethylene (interior surface). Aseptic LPB usually has a layer of aluminium, with a typical structure of: printing (exterior surface), polyethylene, fibreboard, polyethylene, aluminium foil, polyethylene (interior surface). The fibreboard makes up about 75% of the weight of the packaging. Usually 100% of the fibre in LPB is from virgin sources.

Moulded fibreboard (>500 g/m2)

Moulded fibreboard packaging (e.g. egg cartons) is usually made with a high proportion (up to 100%) of recycled fibre. Due to the manufacturing technique and the fairly low strength requirements, moulded fibreboard packaging can use shorter fibres than is feasible with most other paper packaging applications (e.g. from newsprint). Moulded fibreboard can still be recycled at end-of-life; however less reusable fibre will be recovered.

The Life Cycle of Fibre-Based Packaging

Figure 1

Life cycle of paper packaging

Adapted from diagrams developed by GreenBlue (2011)

The Life Cycle of Fibre-Based Packaging

In favour

Life cycle-related considerations in favour of fibre-based packaging

- Paper and board packaging is highly recyclable and recovered at a high rate.
- While recovered paper does not have a high value (compared to aluminium, PET or HDPE recyclate), there is strong demand for it both locally and in international markets.
- Paper and board recycling is a robust process, which can tolerate reasonable levels of contamination.
- Paper is theoretically 100% recyclable, although there are unavoidable reprocessing losses due to fibre deterioration. Virgin wood fibre is a necessary input into the fibre pool, and can be harvested from sustainable sources.
- The production of paper and board packaging using recovered fibre requires significantly less energy, chemicals and trees than using 100% virgin materials.
- Paper is manufactured from renewable natural resources (wood and recovered paper or board).
- In general, life cycle studies comparing the use of fibre-based beverage containers with plastic, glass or metal alternatives, have found that the fibre containers perform as well or better across most areas of environmental impact.
- A recycled content of up to 100% is common. While a high recycled content may reduce functional performance compared to kraft paper, this can be offset by increases in paper or board thickness and by surface modification of the recycled paper or board.
- Paper packaging is versatile, relatively inexpensive and provides good product protection. With the addition of coatings or non-paper layers it can also be moisture/grease proof or resistant.
- Fibre-based packaging is biodegradable (excluding some inks and adhesives), reducing the potential hazard of littered items to wildlife as well as litter-related amenity issues.
- Fibre-based packaging is potentially compostable (depending on the packaging material and format, and excluding some inks and adhesives), making it compatible with food waste in recovery processes.
- Fibre-based packaging can be formed into a wide variety of shapes, and empty packaging can be delivered flat to packaging lines, reducing transport impacts.
- There is a low risk of migration of chemicals from packaging into food contents, which means there is a low risk of contamination. Recycled fibre that has been tested and approved for food contact can be used in many applications, however bleached virgin fibre is often used for some odour-sensitive foods.
- Virgin fibre pulping wastes and fibre reprocessing wastes have high energy values and can be used to generate energy (both steam and electricity).
- Corrugated board usually contains a significant proportion of recycled fibre, and is recyclable.
- Dedicated collections of corrugated board from commercial sites can produce large quantities of recyclate with very low contamination rates.
- Fibre-based materials are fairly straightforward to sort from commingled kerbside recycling streams at Materials Recovery Facilities (MRFs).
- Wood fibre and lignin are biodegradable, and adding fibre to composted products can improve the compost structure and carbon levels, which is particularly useful for balancing the high nitrogen content of composted food.

The Life Cycle of Fibre-Based Packaging

Against

Life cycle-related considerations against fibre-based packaging

- Pulp and paper making use a lot of water, energy and chemicals. The manufacture of pulp from virgin fibre sources is particularly energy intensive.
- Fibre-based packaging production is relatively emissions intensive, including greenhouse gases, when compared to other packaging materials. This is particularly the case for production using virgin fibre sources.
- Poorly managed forestry operations may lead to unsustainable rates of deforestation, soil erosion and degradation, habitat destruction and fragmentation, loss of high value forests and loss of biodiversity.
- Regrowth following logging can result in significant reductions in rainwater run-off. Plantations can also have other local and water system impacts due to fertiliser and herbicide use.
- Pulp and paper mills (in particular virgin fibre mills) are significant sources of emissions including particulates, carbon dioxide (CO_2), sulphur dioxide (SO_2), carbon monoxide (CO), and nitrogen dioxides (NO_x).
- The harvesting and combustion of wood fibre results in the emission of 'biogenic' CO_2, and is generally defined as carbon neutral. That said, if the biomass is sourced from native forest, there can be significant CO_2 emissions associated with the land use change (e.g. a permanent reduction in sequestered carbon due to land use changes and losses in soil carbon levels).
- Pulp and paper mills use large quantities of water, although many mills have water recycling systems.
- Some pulp and paper mills (particularly virgin fibre pulping mills) generate large quantities of wastewater containing many different natural and synthetic chemicals. While all paper mills operate wastewater treatment systems, the industry is one of the major emitters of many chemicals into the environment both here in Australia and overseas.
- Wood fibre bleaching can generate significant quantities of water and air pollution, including chlorinated chemicals (e.g. dioxins) from some bleaching processes.
- Pulp and paper mills generate large quantities of solid wastes. Sometimes this is burnt for energy recovery, however it can also be stockpiled or disposed to landfill, if unsuitable for energy recovery or if an energy recovery capability is lacking at a mill.
- Paper and board, if disposed to landfill, tend to decompose anaerobically. This will result in the generation of methane, which is a strong greenhouse gas if released into the atmosphere.

The Key Manufacturing Processes

There are many different processes used by pulp and/or paper mills. No two mills are exactly the same, with the specific processes at a site determined by the nature of the fibre source and the products being manufactured. However, there are two general process stages that can be identified:

Pulping

Pulping processes generate the separated wood fibres that are later formed in the paper or board. The nature of these processes is determined by the type of wood fibre feedstock, i.e. wood chips, pre-processed pulp, recovered fibre (from different paper types and with different contamination levels), or a mixture of these.

Pulping can be undertaken at stand-alone pulp making sites, which on-sell dried pulp to paper making mills located elsewhere, or at integrated pulp and paper mills, where wet pulp is used immediately. Following pulping, fibres can also be bleached.

Paper making

Paper making processes are determined by the wood fibre source and the products being manufactured (e.g. packaging papers, newsprint, printing and writing papers, etc.). The paper is produced on paper/board machines from a mixture of fibres, plus other chemicals. These chemicals include sizing agents (e.g. rosin), wet-strength resins (assorted synthetic polymers), dry strength resins (e.g. starch), colouring and whitening agents and fillers (e.g. clay or calcium carbonate).

During the pulping of virgin woodchips, the fibres are separated from each other, and unbleached (brown) wood fibres are produced.

Pulping can be done either mechanically (mechanical pulp), where the lignin polymer 'glue' holding the fibres together is physically broken. The lignin remains attached to the fibres and is subsequently incorporated into the paper. This type of fibre is not bleached.

Alternatively, the lignin can be chemically dissolved (chemical pulp), producing cellulose fibres with much less lignin still attached. This pulp type makes stronger papers than those made from mechanical pulps, on a weight-for-weight basis. Following chemical pulping the fibre can then be used directly in paper making, or bleached.

Cellulose by itself is white, so bleaching involves the removal of a number of residual wood components (lignin included) that colour the fibre. A typical bleaching process used in Australia is based on hydrogen peroxide (H_2O_2) and chlorine dioxide (ClO_2). The bleached fibre is then most commonly used in bleached boxboard grades. However, most wood fibre used in packaging in Australia is unbleached.

The Key Manufacturing Processes

There are also other virgin fibre pulping processes that are combinations of and variants on mechanical and chemical pulping. A process commonly used in Australia is a form of 'semi-chemical pulping', which is used to process wood chips from hardwoods, such as Tasmanian Blue Gum. This process softens the lignin, allowing the fibres to separate with less damage than mechanical pulping, but most of the lignin is still left on the fibres. Major applications of this type of pulp in Australia are boxboard and corrugated board.

During the pulping of recovered fibre (from either packaging or non-packaging applications) the recyclate is placed into a massive and powerfully agitated pulping vessel. The material is broken up into a slurry, which is then passed through a series of clean-up and filtration steps to remove contaminates. Contaminating materials typically include adhesives, waxes, plastics, metals, unpulped fibre masses, glass fragments, coatings and inks. Following pulping and decontamination, the recycled fibres can be separated into short, medium and long fibres, depending on the requirement. Usually, the recovered fibres are not bleached or de-inked.

In terms of wood fibre supply, paper making mills can be defined as:

- **Virgin pulp and paper mills using <20% recycled content**
- **Recycled mills using >80% recycled content**
- **Swing mills using 20–80% recycled content**

In general, the paper production process for virgin fibres is the same as for recycled fibre.

The reprocessing of recovered paper packaging (or other paper products) gradually shortens and weakens the fibres due to the impact of the mechanical and/or chemical processes that take place. It is generally estimated that wood fibre can be recycled about 4–7 times before the fibres can no longer be recovered back into the paper matrix during paper making. So it is important to note that the continuous addition of new virgin fibre is a necessary input into the fibre 'pool'.

Virgin fibre-based pulp and paper mills can generate significant quantities of energy (both electricity and steam) onsite by burning waste biomass (e.g. 'black liquor' residues); sometimes they can even export surplus heat and electricity, whereas mills based on recycled paper are typically reliant on imported energy sources instead of biomass. However, the picture is more complicated as the production of virgin chemical (kraft) pulp generally requires twice compared with recycled pulp (3.0 GJ/tonne versus 1.5 GJ/tonne of pulp respectively). Bleaching requires another 2.7 GJ/tonne of pulp, and papermaking typically requires around 5.9 GJ/tonne of finished paperboard (which is about equivalent to 1 tonne of pulp).

APC data shows that in 2011, 2.6 million tonnes of fibre-based packaging was sold in Australia. This represented around 60% of all packaging sold (by weight) in Australia. Of this 2.6 million tonnes, nearly 2.0 million tonnes was recycled (75%). The recycling rate for fibre-based packaging increased significantly over the period from 2003 to 2011, from 49% to 75%.

Design Considerations for Fibre-Based Packaging

Packaging design should be guided by the resource efficiency design hierarchy[1]. The hierarchy of preferred packaging design changes is: avoid, minimise, reuse, recycle, recover (energy) and dispose. The robustness of this general hierarchy is backed by a very significant body of evidence, based on packaging life cycle assessments (LCAs).

Embedded across the resource efficiency design hierarchy are the requirements to maintain or improve the packaging system functionality (fitness for purpose), and to minimise product losses.

More specifically, the key design aspects to keep in mind to minimise the environmental impacts of fibre-based packaging are:

- Minimise the impacts of virgin fibre sourcing. The fibre source is generally the most significant environmental issue for paper and board packaging.
- Minimise the impacts of virgin or recovered fibre pulping and preparation. Virgin wood fibre production, in particular, can be energy, chemicals and water intensive. Fibre bleaching (for either virgin or recovered fibre) is energy and chemicals intensive, and can be a potential source of toxic effluent into water systems.
- Maximise the ‘pulpability’ of the recovered wood fibre. Packaging that doesn’t pulp quickly enough is likely to be filtered from the pulp slurry, and be disposed to landfill or burnt for energy recovery. Avoid the use of additives or coatings that may significantly reduce the pulpability of the fibre in your packaging.

As with all other packaging materials, fibre-based packaging systems have specific design constraints which may limit the application of the resource efficiency design hierarchy. With this in mind, we have outlined the general design considerations for fibre-based packaging in Figure 2. During material selection and packaging system design all of the aspects in Figure 2 should be considered.

Each of these design considerations is then discussed in more detail in Table 1.

[1]The resource efficiency design hierarchy is also often referred to as the waste hierarchy.

Design Considerations for Fibre-Based Packaging

Figure 2

Summary of design considerations for fibre-based packaging

Design to be fit-for-purpose
SPG principle 1

Design to:
- Improve accessibility
- Withstand loads from stacking
- Manage the trade-offs between primary, secondary and tertiary packaging

Design for resource efficiency
SPG principle 2

Design to:
- Minimise primary packaging
- Minimise secondary packaging
- Consider reusable/ returnable secondary packaging
- Recover filling line packaging losses
- Maximise product to packaging weight/ volume ratios
- Maximise transport efficiencies

Design with low-impact materials
SPG principle 3

Design to:
- Source sustainable fibre
- Optimise recycled content in primary packaging
- Minimise manufacturing inputs
- Maximise recycled content in secondary packaging
- Minimise the use of problematic chemicals during packaging manufacture
- Minimise the use of problematic chemicals in the packaging

Design for resource recovery
SPG principle 4

Design to/for:
- Maximise the pulpsbility and recyclability of recovered fibre packaging
- Minimise the impact of adhesives and waxes on fibre recycling
- Minimise the use of inks, lacquers and coatings
- Minimise the number of material types and/or design for disassembly
- Provide clear consumer information
- Improve the recyclability of multi-laminate/poly-laminate cartons, and polymer coated board grades

Design Considerations for Fibre-Based Packaging

Table 1

SPG Principle	Design to	Design Considerations	Life Cycle Importance
1 - Design to be Fit-for-Purpose	Improve accessibility	Tear strips on cardboard packaging allow quick and easy opening of the pack. To improve accessibility make sure that the tear strip is highly visible and big enough to be held easily between the fingers, and that notches on the tear strip are aligned, and that it gives way completely and easily. The force required for opening packaging should not exceed 22 newtons of linear force. If using closures or seals (e.g. aseptic LPB), ensure that the force required to pull open or puncture the seal does not exceed 22 newtons. Avoid seals that require a tool to puncture. Check Arthritis Australia's Food Packaging Design Accessibility Guidelines (see Useful Further Reading list) for more suggestions to improve the accessibility of your packaging.	HIGH
	Withstand loads from stacking	When considering down-gauging of your packaging, confirm with suppliers that the finished packaging will be sufficiently robust to tolerate the required stacking loads for your product. Transit test thinner/lighter weight packaging to prevent product loss through packaging failure.	HIGH
	Manage the trade-offs between primary, secondary and tertiary packaging	Consider primary, secondary and tertiary packaging as a total system. In particular avoid functional overlap between the primary and secondary packaging levels. For example, many packaging formats are weight-bearing (e.g. steel cans and glass jars), so secondary packaging is required to provide less load-bearing functionality. Consider possibilities for minimising the tertiary packaging components that are required to secure loaded pallets, e.g. through the use of strapping, down-gauged and/or perforated stretch films, sleeves, 'lock-'n-pop' low residue adhesives, returnable plastic crates that lock into place on pallets with minimal strapping, or pallet boxes/bulk bins.	MEDIUM
2 - Design for Resource Efficiency	Minimise primary packaging	Down-gauge your packaging as much as possible but not at the expense of recycled content. Down-gauging usually provides an overall reduction in environmental impacts, but there is one exception. Increasing the recycled content of paperboard, with a modest related increase in board weight to maintain the required packaging strength, could provide a better environmental outcome than down-gauging (e.g. by shifting to a stronger solid bleached sulphate (SBS) fibre-based board, or a coated unbleached kraft board, both containing high levels or 100% virgin fibre). In many applications the recycled board can be up to 20% heavier and still be the environmentally preferable option. See the Introductory Guide for more on the comparative environmental impacts of virgin versus recycled content for a number of packaging material types, including fibre-based packaging. More packaging is often used to signal a premium product. Consider alternative approaches to indicate product quality, e.g. cut-out windows to display the product. It may even be beneficial to replace paperboard with lightweight plastic films in applications where packaging recovery rates are low.	HIGH

Design Considerations for Fibre-Based Packaging

2 - Design for Resource Efficiency		Enhance the benefits of shelf-ready secondary packaging by using it to reduce or eliminate primary packaging, particularly if the board is high wet-strength. Shelf-ready packaging (SRP) can assume some of the marketing and communication functions traditionally performed by primary packaging, e.g. through the use of external and internal printing to aid brand recognition. If designed effectively, these changes can also help to reduce manufacturing and supply chain costs, as well as labour costs at the retail level. Depending on the specific design, more printing may be required on SRP; however this can potentially be offset by a reduction in printing on the primary packaging. For example, categories such as breakfast cereals and powdered detergents are dominated by large rectangular cartons. There may be an opportunity to switch to significantly lighter flexible film packaging. The SRP can then be used to provide distribution protection and enhanced presentation in-store. Design your packaging to reduce packaging surface area per unit volume, as compact cubes use less material than flat 'display' formats. This may also reduce the amount of secondary packaging that is required. Minimise the overlap on flaps as much as possible, and put the flaps on the smallest face to reduce material overlap. Discuss the possible options with your supplier.	
	Minimise secondary packaging	Down-gauge secondary packaging as much as possible, while ensuring that the integrity of the primary pack is not compromised. The exception to this rule is if you are considering moving to a higher level of recycled content, in which case a degree of 'up-gauging' could well be justified. Reduce the amount of corrugated board in secondary packaging by minimising flap overlaps (even to the point that the box contents are visible). Move the flaps to the smallest end of the box so that there is less overlapping material. You might be using a double-walled corrugated container (with two corrugated medium layers) to fulfil a structural strength requirement. Consider if adequate strength can be achieved with a single-walled corrugated container through the use of thicker gauge liners, while still achieving a reduction in overall weight. Ask your supplier to identify the lightest weight corrugated board that will fulfil your functional requirements. Moving from traditional shippers to shelf-ready packaging may increase the packaging-to-product ratio in some circumstances; always look for opportunities to minimise material use wherever possible.	HIGH
	Consider reusable/ returnable secondary packaging	Consider whether your product could be supplied in returnable plastic crates/trays (RPCs) that are collapsible or nested, and whether this is likely to have environmental benefits. RPCs are becoming more widely used, particularly by the major supermarket chains. The life cycle and cost benefits of using returnable plastic crate systems instead of corrugated board boxes can be significant depending on a range of factors including the supply chain and the number of returns. Supply chain product losses are also reported to be lower when using RPCs for some fruit and vegetables due to better product protection and ventilation.	MEDIUM

Design Considerations for Fibre-Based Packaging

2 - Design for Resource Efficiency	Recover filling line packaging losses	While paper and board packaging losses in the filling line tend to be very low, confirm with the line operators that they have paper and board recycling systems in place.	LOW
	Maximise product-to-packaging weight/volume ratios	Many products packaged in fibre-based packaging already have close to ideal product-to-packaging weight and volumetric ratios. However, do some 'back of the envelope' calculations on these ratios as part of your packaging design process to see if the ratio can be improved. Investigate the feasibility of pre-settling or vacuum packing loose fill product, particularly for less dense products. Reducing the product volume reduces the primary, secondary and tertiary packaging requirement, and also reduces the transport requirements.	LOW
	Maximise transport efficiencies	Look for opportunities to improve palletisation (volumetric) efficiencies; improving these can significantly reduce the costs associated with product storage and distribution.	LOW

3 - Design with Low-Impact Materials	Source sustainable fibre	Ask your supplier about the source of all virgin wood fibre to ensure that it is from a sustainable source. Look for credible, third-party certification of claims. Numerous independent certification schemes exist, of which the Forest Stewardship Council (FSC) is one of the best known, independent and most reputable.	HIGH
	Optimise recycled content in primary packaging	Specify the use of high recycled content and unbleached fibre-based packaging where possible. The production of fibre from virgin sources usually has greater environmental impacts than sourcing recycled fibre. The strength of the paper or board will probably be reduced as a result of a shift to higher recycled content, so a thicker gauge may be required. However, even a 20% increase in weight due to the use of recycled fibre will generate a net environmental gain. Ask your supplier for information on the post-consumer recycled content percentage of your packaging and find out if it can be increased. See if you can make a feature of the unique characteristics of recycled paper. Care must be taken in the use of recycled fibre in direct food contact applications, as recycled fibre may increase the risk of problematic chemicals migrating from packaging to food. This is particularly the case for recycled fibre from overseas sources. Discuss this potential issue with your packaging supplier, and ensure that recycled materials have been tested to relevant food contact standards.	HIGH

Design Considerations for Fibre-Based Packaging

3 - Design with Low-Impact Materials	Minimise manufacturing inputs	Minimise or avoid the use of bleached wood fibre in your packaging if possible. Alternatively, seek to specify the use of fibre that has been bleached using a chlorine-free process. Fibre can be bleached using a number of different processes, based on 'elemental' chlorine, chloride dioxide, ozone or hydrogen peroxide. The use of elemental chlorine results in the production of organo-chloride compounds that are toxic to the environment. Contact your supplier to find out about the bleaching method used. Fibre production is very water intensive, particularly production from virgin fibre sources. Ask your suppliers for information on their water consumption per tonne of finished paper/board production, and if they use recycled water during processing.	HIGH
	Maximise recycled content in secondary packaging	Specify the highest possible level of post-consumer content in corrugated board or polyethylene over-wraps and shelf-ready packaging, while maintaining the required functional and strength performance of the secondary packaging.	MEDIUM
	Minimise the use of problematic chemicals during packaging manufacture	Inks and lacquers are applied to many different paper and board grades, and these coatings often involve the use of high VOC (volatile organic compounds) chemicals, particularly in the solvents. These chemicals can be locally toxic to the environment and human health (e.g. for factory workers), and their use requires the operation of significant (and expensive) pollution control measures. Inks also lead to discolouration of recovered fibre during pulping (this aspect is discussed in more detail in the Design for resource recovery section). Ask your packaging material supplier whether there are low-VOC or water-based inks and lacquers that will fulfil your printing requirements. Consider the use of ultraviolet (UV) curable inks. UV curing is compatible with lithographic printing techniques, and could potentially speed up the drying process. Water-based inks generally take more time and energy to dry than organic solvent-based inks, and can be more difficult to remove during de-inking (if it takes place) after pulping at end-of-life. Consider using inks based on vegetable oils rather than synthetic chemicals and organic solvents (e.g. toluene). Minimise the amount of printing, e.g. through the use of techniques such as embossing. Minimise the amount of dark printing, as light pigments will generally discolour recovered pulp less than dark pigments. There have been some reports overseas of mineral oil hydrocarbons in recycled fibre (primarily from newspaper and magazine inks) migrating into food, from recycled content boxboard, where no functional barrier was present. This is probably less of an issue in Australia, as the use of vegetable-based inks is more common here. Manage any risk in this area by confirming with suppliers that there is minimal risk of migration from the packaging board; ask for evidence if there is a reasonable level of doubt.	MEDIUM

Design Considerations for Fibre-Based Packaging

3 - Design with Low-Impact Materials		Coatings and pigments may be applied to corrugated board or boxboard during paper-making to improve the smoothness, appearance and structure of the surface and create a good quality printing surface. The most commonly used coatings are made from calcium carbonate (chalk) and kaolin clay. Pigments include substances such as titanium dioxide, polymer (plastics-based) pigments, and talc (hydrated magnesium silicate). While these coatings and pigments are manageable contaminates during fibre recovery, they are not functionally recoverable, and either remain with the recovered fibre or are removed from the pulped recovered fibre and are disposed to landfill. Ask your supplier if it is possible to minimise these non-recoverable components of fibre-based packaging.	
4 - Design for Resource Recovery	Maximise the pulpability and recyclability of recovered fibre packaging	Avoid the use of coatings or layers that reduce the ability to recover fibre from recovered packaging. Pulping machines operate on either a batch or continuous basis, and for both processes the residence time in the pulper is limited. Barrier layers such as plastics, wax, aluminium, and other moisture-resistant coatings may prevent or slow down the pulping (breakup) of the fibre-based layer. Any unpulped packaging will be stripped from the pulper as a contaminant, even though it may be mostly composed of wood fibre. This also applies to wet-strength boards, some of which can be pulped and some of which can't. The same property that makes wet-strength board a useful material – its resistance to moisture – can also mean that it doesn't pulp quickly enough to be recovered. It is impossible to tell how recoverable the fibre in your coated or wet-strength packaging is without specific information from your supplier or recyclers. If in doubt, ask your supplier for third-party certified information on both the repulpability (fibre yield) of the board, and the functional performance of paper made from the recovered fibre. If you can't get this information from your supplier then check with recyclers on the pulping characteristics of your packaging. Some recyclers operate technical facilities that can answer these types of questions, or they may have already done the tests.	HIGH
	Minimise the impact of adhesives and waxes on fibre recycling	Adhesives and waxes cause processing or product quality issues at paper mills. Adhesives will not be recovered during the paper recycling process, so use the smallest amount that fulfils your functional requirements. Pressure sensitive and cold-seal adhesives (which usually contain a natural latex component) are problematic because they adhere to equipment and reduce paper quality. Ask your supplier about adhesive formulations with densities significantly different to water, or that will not break up into small fragments during pulping. Many 'hot-melt' and water-based adhesives (such as polyvinyl acetates) are also difficult to remove during pulping, as they tend to break up into small, hard-to-remove fragments that adhere to paper-making equipment or reduce paper quality. Large particles of adhesive are easier to screen out. Consider using hot-melt adhesives that have a density that is greater or less than water, as these are easier to remove during pulping. Alternatively, use thicker beads (blobs rather than strips) of a tougher adhesive, which is less likely to fragment into very small pieces during pulping. Try to avoid the use of water-soluble adhesives, as these can't be screened out and build up on pulping and paper-making equipment over time.	HIGH

Design Considerations for Fibre-Based Packaging

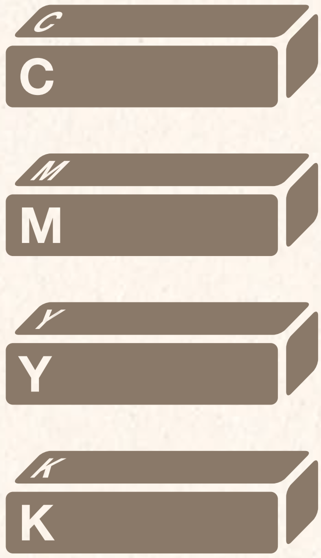
4 - Design for Resource Recovery		Consider using interlocking tabs as an alternative to adhesives. Wax can cause defects in recycled-content paper and board, and coats paper-making machinery, potentially causing significant maintenance issues. If a wax coating is not a major functional requirement, consider shifting from a wax to a polymer-based coating (e.g. acrylic or PET), or check with your suppliers about the availability of low-wax versions of the board you are using. Polymer coatings dry to form a water-resistant layer but improve the pulpability of end-of-life corrugated board. If an alternative to wax is not available, ensure that the packaging is labelled as ‘Not recyclable’. If in doubt, confirm with recyclers that any adhesives or waxes (and inks/ coatings) that you intend to use are easily removed during pulping, or are otherwise compatible with their process.	
	Minimise the use of inks, lacquers and coatings	Low VOC, water-based and UV-cured inks are cleaner and less toxic during packaging manufacture. However, impacts on recyclability also need to be considered. Water-based inks readily disperse during pulping and cannot be screened out of the pulp slurry, which they will discolour to an undesirable grey colour. A de-inking process can be undertaken after pulping, but this is not usually done during the processing of recovered packaging. De-inking is also chemicals and energy intensive. UV-cured inks are firmly bonded to the surface of the paper and form a polymer layer that can significantly reduce the pulpability of the fibre. Oil-based inks (typically high VOC), often used for offset or rotogravure printing, are more easily deinked from the recovered fibre. You will need to find a balance between your printing requirements, printing impacts, and the recovery of good quality fibre at end-of-life. The best general approach is to minimise the use of inks and lacquers on your packaging. Minimise the use of large areas of fluorescent, metallic and dark colours (especially black), which can lead to specks of unwanted colour in recycled content papers and boards. Fluorescent and metallic ink specks are particularly noticeable. Investigate the use of inks based on vegetable oils, as they are manufactured from renewable materials, are typically low VOC during printing, and are less likely to significantly discolour recovered fibre. With regards to coatings (e.g. chalk or kaolin clay), ask your supplier about the coating options that are compatible with your product. See if it is possible to select coatings that have a lower environmental impact and are compatible with the recycling process. The clay on coated paper can be a useful component to help bind to and remove ink particles in the de-inking process if this is undertaken.	HIGH
	Minimise the number of material types and/ or design for disassembly	Metal and plastic components can be problematic in the paper packaging recycling process, and will not be recovered. They should be avoided or minimised as much as possible. For example, cut-out windows may not require any window material (e.g. a transparent plastic film). If using labels, cut-out windows, rigid plastic/metal components or decorations on your packaging (e.g. a folding boxboard carton), ensure they are either compatible with the fibre recycling process, or can be easily separated by consumers.	HIGH

4 - Design for Resource Recovery		Ensure that packaging with more than one material, e.g. boxes with plastic windows and blister packs, is designed for the different components to be easily separated. Provide consumers with clear recycling instructions. Avoid plastic labels on fibre packaging. Consider using direct print or paper labels, and use an adhesive that is compatible with the recycling process.	
	Provide clear consumer information	Ensure that recycling messages are visible and provide clear guidance to consumers. The Mobius loop recycling symbol is recommended, plus the words 'Please recycle'. Provide a clear anti-littering message for products that are more likely to be consumed away from home. Consider providing information on the post-consumer recycled content of the packaging. Make it clear which components of the packaging (e.g. the fibre component only) to which this relates. See the Introductory Guide for more on labelling in general.	HIGH
	Improve the recyclability of multi-laminate/ poly-laminate cartons, and polymer-coated board grades	Laminated boards are typically made from a high grade 100% virgin fibre layer, as well as layers of other materials (typically polyethylene and/ or aluminium), and are commonly called 'liquid paperboard' (LPB). LPB-based cartons offer many advantages including barrier properties, shelf stability, cube utilisation, and relatively low weight. The two main types are 'multi-laminate' cartons (aseptic LPB) with an aluminium and multiple polyethylene layers, and 'poly-laminate' cartons (gable-top LPB) with a polyethylene layer on the inside only. Multi-laminate board is used for shelf-stable liquid products such as long-life milk, stocks and fruit juices, and it is an excellent material in terms of barrier properties, shelf stability, strength and low weight. A typical structure would be (outside to inside): polyethylene (15 g/m^2), printed layer (2–3 g/m^2), cartonboard (230–400 g/m^2), polyethylene (10–30 g/m^2), aluminium foil (16–24 g/m^2), bonding layer (2–8 g/m^2), and polyethylene (30–60 g/m^2). By weight, 75% of the board is wood fibre, and (unlike poly-laminate board) usually does not have any wet-strength resin incorporated into the fibre, which would provide additional moisture resistance. Poly-laminated board (gable-top LPB) is used for liquid products where an aseptic seal is not required, such as chilled fresh milk and juice cartons, and has many of the same benefits as multi-laminate board. This board grade generally has only one layer of polyethylene (on the inside), no aluminium layer, and the fibre has a wet-strength resin incorporated into it to provide moisture resistance. Both carton types are likely to break up (to a degree) during pulping. Due to the wet-strength resin added to the poly-laminated board, this fibre is less likely to fully pulp. The polyethylene and aluminium layers in multi-laminate board will also impede the pulping of aseptic LPB cartons, and will not be recovered during recycling. Ask your supplier about the recoverability of the fibre in your laminated board. If in doubt, ask them for third-party certified information on the pulpability (fibre yield) of the material and the functional performance of paper made from the recovered fibre. If a high level of end-of-life material recovery is a key design requirement for your packaging, then consider whether there is an alternative packaging format that meets your requirements and is easier to recycle (e.g. made from only one material).	MEDIUM

Design Example

This design example illustrates some of the sustainability design aspects that could be considered during a packaging development or review. The brief is for a corrugated cardboard box for a single toner cartridge[1].

Sustainable design considerations



Design for structural efficiency

Minimise material use, for example by:

- Reducing the height of the buffer area
- Reducing box length
- Reducing fold overlaps
- Reducing the thickness of the board

Design for accessibilitty

Providing a perforated tear strip will make the box easier to open. The tear strip should be large enough for users to easily grasp – there should be an overhanging end that users don't have to separate from the box.

Design the strip to give way completely and easily. Minimise the force requirement for opening packages to less than 2.3 kg of linear force.

Inks and adhesives

Printing inks and adhesives add cost to the production process. They also add costs to the recycling process because they need to be removed from the fibre and end up as waste. Design strategies:

- Minimise ink coverage
- Use vegetable-based inks
- use inter-locking tabs instead of adhesives

Fibre content

Aim to use 100% post-consumer recycled fibre. If this is not possible (e.g. to meet strength or printing requirements) specify a mix of post-consumer, post-industrial and/or sustainably harvested fibre. Virgin fibre should be certified to the Forest Stewardship Council standard, or similar.

Consumer labelling

Encourage the consumer to recycle by including the Mobius loop and a brief message for consumers, e.g. **'This box is recyclable and contains at least 65% post-consumer recycled content.'**

More innovative ideas that could be explored

Design the packaging so that it can be used for a secondary function. For example, to transport a printer cartridge back to a recycler or collection depot.

[1]Based on a toner cartridge package for Kyocera Document Solutions Inc. in Japan, which won a JapanStar Appropriate Packaging Award – see www.packwebasia.com/packaging-japan/japan-packaging-technology/1773-adhesive-free-toner-cartridge-package-saves-33-material-usage

Useful Further Reading

Reference	What is it?
ACOR, 2012. Australian Recovered Paper Specifications (AuRPS), Australian Council of Recycling. 32 pages.	This ACOR document provides detailed specifications for 17 grades of recovered paper and cardboard. It also provides discussion on the paper-making process, and the issues impacting the quality of recovered paper. A key objective of the document is to provide transparency on the composition and quality of recovered paper and cardboard grades. Free download from: www.acor.org.au
APC, 2010. Sustainable Packaging Guidelines, Australian Packaging Covenant. 30 pages.	The SPG is the key document for APC signatories and others to use in undertaking APC-compliant packaging reviews. The objectives of these reviews are to optimise resources and reduce environmental impact, without compromising product quality and safety. Free download from: www.packagingcovenant.org.au/
Arthritis Australia, 2012. Food packaging design accessibility guidelines. 31 pages.	This document provides more detailed guidance on accessibility principles and strategies to improve accessibility of food packaging; prepared in conjunction with NSW Health. For a complimentary copy of the Food Packaging Accessibility Guidelines and several other packaging design reports contact Arthritis Australia at: design@arthritisaustralia.com.au
GreenBlue, 2011. Design for Recovery Guidelines: Paper Packaging, California: GreenBlue. 66 pages.	This US packaging guide provides lots of great information on the different types and composition (e.g. surface treatments and layers) of paper-based packaging, and detail on the impact of design decisions on the recyclability of paper packaging. The document also provides an overview of paper packaging manufacturing processes and paper packaging collection, sorting, and end-of-life options (other than recycling). It also contains an interesting survey of paper mill operators on their key reprocessing issues. Free download from: www.greenblue.org/publications/

Useful Further Reading

ILSI Europe, 2004. Packaging Materials 6: Paper and Board for Food Packaging Applications, Brussels: International Life Sciences Institute (ILSI). 28 pages.

This is a fairly technical report that provides an excellent overview of paper and board manufacturing including chemical additives and coatings. The report also provides detail on the chemical regulatory, safety and toxicology aspects of paper packaging for Europe. Free download from: www.ilsi.org

Sustainable Packaging Coalition, 2009. Environmental Technical Briefs of Common Packaging Materials: Fiber-Based Materials, Virginia: Green Blue Institute. 19 pages.

This SPC report provides life cycle based information and data to assist packaging designers to understand the environmental and human health impacts of corrugated containerboard and boxboard. It focusses on the life cycle phases of raw material extraction to board manufacture. Lots of great information. Order from: www.sustainablepackaging.org

Verghese, K., Lewis, H. & Fitzpatrick, L., 2012. Packaging for Sustainability. 1st ed. Boston: Springer. 384 pages.

This life cycle thinking-based reference book provides extensive detail on just about every aspect of sustainable packaging design. Beyond design, it also contains detailed information on marketing, regulatory and labelling aspects. Order from: www.springer.com/engineering/production+engineering/book/978-0-85729-987-1

WRAP, 2007. Section 5: Material considerations, United Kingdom. 24 pages.

This useful report provides guidance across most packaging material types on material selection, design and recycling, as well as interesting case studies by material type for different primary packaging formats. Free download from www.wrap.org.uk. The WRAP website also has many other reports and guides available on paper and board packaging design

Developed by SRU Sustainable Resource Use   Helen Lewis Research

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