Cut the Wrap!

Packaging Waste and Strategies for Mitigation and Reduction

Packaging waste is an issue that affects almost all businesses, from food and beverage to electronics. Unfortunately most of the materials used in packaging is discarded in ever-growing landfills or burnt, causing severe pollution. In fact, containers and packaging contribute the most to total municipal solid waste. Although packaging can be an unavoidable element to your organization, there are ways that you can reduce your harmful contributions to waste and improve your organization's overall sustainability. This paper explores the various ways businesses can reduce or even eliminate their packaging waste, make smarter, more sustainable packaging choices, utilize packaging alternatives. This paper includes:

- An overview of the current packaging industry
- A breakdown of the negative impacts of packaging and the positive environmental outcomes of reduction
- Detailed strategies that can impact all aspects of production
- Examples of success stories from businesses of all sizes from around the world

Not only will these choices reduce the strain on resources needed to produce packaging and reduce the overall social costs of additional waste and pollution, but they will also reconfigure your business to be more cost-efficient and sustainable. This paper shows you just how simple and effective reducing your packaging waste could be!

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Introduction

For years, manufacturers and consumers alike assumed that products and their packaging could be disposed of after usage without consideration of any social or environmental consequences. However, as studies increasingly demonstrate the gravity of environmental problems like resource/energy scarcity and climate change, more attention is being focused on strategies of mitigation and reduction. In 2006, the US produced about 25.1 million tons of waste, an almost 200 percent increase from 1960, and is increasing every year (EPA, 2009, pp. 1). The containers and packaging category makes up the largest portion of total waste, 80 million tons, but is also the product category with the greatest recovery—with over 40 percent recycled. Therefore, packaging holds not only the potential to intensify environmental problems but also, to curb them through a reduction of its impacts. Faced with issues of growing landfills and increasing greenhouse gas (GHG) emissions and pollution, businesses and organizations have a responsibility to the environment and society to mitigate their environmental impact. This study will explore the ways that businesses can reduce their packaging waste, make smarter and more sustainable packaging choices, and utilize packaging alternatives. Not only will these choices reduce the strain on resources needed to produce packaging and reduce the overall social costs of waste and pollution, but also demonstrate how reconfiguring a business can actually be more cost-efficient and sustainable.

Overview of the Packaging Industry

Packaging is used by virtually every commercial, industrial, and retail business today. Whether it be packaging for retail goods, goods distributed and exchanged between offices, office supply goods from vendors, and many others, packaging is a ubiquitous aspect of business operations. It is a particularly significant concern for the food/beverage industry, electronics retail, medical/pharmaceutical industry, and any nationwide, mass-distribution corporation. In fact, food packaging makes up "approximately 50 percent (by weight) of total packaging sales" (Marsh and Bergusu, 2007, ppR39). Because packaging can occupy a significant portion of an organization's budget, supply chain, and general operations, it is important for business owners and management to be familiar with available options in their purchasing choices, disposal practices and environmental impacts.

Because of the wide variety of existent packaging categories, it can often be confusing and overwhelming to think about, let alone restructure. Generally, packaging can be broken down into several different categories: primary (sales), transport, and secondary packaging. Each category often uses different materials, which means not just that packaging can generate large amounts of waste overall, but also that there are limitless possibilities in every packaging category for reduction and savings. **Primary packaging**, also known as sales packaging, is the first layer of material that is in direct contact with the product sold and is also the packaging that the consumer receives. It includes "any material used by the consumer to transport the goods or keep them until such time that they are used" (Sinclair, 2000, pp. 4). Examples of primary packaging are soft-drink bottles and inner bags of cereal boxes. **Transport packaging** is any material used to protect materials during transport and in bulk packaging. This is often also referred to as tertiary packaging. It includes crates, wooden pallets, and shrink-wrap among others. **Secondary packaging** essentially lies between transport and primary packaging. It includes "any material that is used to allow a good to be sold on a self-service basis, make theft more difficult, or to serve advertising purposes" (Sinclair, 2000, pp. 4). It includes shrink-wrap for a six-pack of soda cans, the box containing the cough medicine bottle and so on. These categories of packaging are not strictly defined and they can often overlap. For example, certain transport packaging can often be considered secondary packaging such as bulk packaging of beverages. While there are different general categories of packaging, there are also different types of packaging materials.

Packaging Materials

Packaging is usually made out of the four following main materials: glass, plastics, metals, and paper and board. Each material type contains several material varieties that vary in costs, durability, permeability, recyclability, and many other characteristics that are important to consider in packaging choices. The following is a breakdown of each material type as it relates to sustainability and waste reduction, focusing mainly on reusability, recyclability, and cost reduction while maintaining quality. The figure below, taken from a U.S. Environmental Protection Agency (EPA) chart of recovery and generation of all products in **Municipal Solid Waste (MSW)** from 2008, shows the contribution and breakdown of packaging and its materials.

Products	Weight Generated	Weight Recovered	Recovery as % of Generation
Containers and Packaging			
Steel	2.55	1.61	63.1%
Aluminum	1.88	0.72	38.3%
Glass	10.05	2.81	28%
Paper and paperboard	38.29	25.08	65.5%
Plastics	13.01	1.73	13.2%
Wood	10.71	1.58	14.8%
Other materials	0.27	Negligible	Negligible
Total	76.76	33.53	43.7%

Figure 1: Recovery and Generation in MSW of Containers and Packaging (2008) Source: EPA, 2009, pp. 7

Glass

Glass is one of the oldest materials used for packaging. It can withstand a large amount of heat and pressure and is impermeable to moisture and gases, making it an ideal packaging for numerous products, especially for food and beverage. Its disadvantages, on the other hand, are that glass is brittle, requires a separate closure, and is heavy and costly to transport. With regard to environmental issues, glass is reusable and recyclable. In fact, recycled broken glass (cullet) "may account for as much as 60 percent of all raw materials" (Marsh and Bugusu, 2007, pp. R41). Glass may be the ideal packaging material for an organization, which has short transportation requirements and is also looking to utilize more recycled material and promote recycling and reuse in its consumers.

Plastics

Plastic material is playing an increasingly important role in packaging, especially in the beverage industry. It is often the preferred material due to its flexibility, strength, and versatility. There are many varieties of plastic derivatives used in packaging products. Some common plastic types used in packaging include **polyolefins** (polyethylene [PE] and polypropylene), **polyester** (polyethylene terephthalete [PET] and polyethylene naphthalate[PEN]) and **polyvinyl chloride** (PVC).

Polyolefins are commonly used to produce shrink-wrap, milk cartons, household cleaner packaging, egg carton foam, and most notably, plastic shopping bags (Marsh and Bergusu, 2007). Though well suited for recyclability and reuse, polyolefins plastics are often discarded in landfills and are not biodegradable. Polyester plastic like polyethylene terephthalete (PET) is often used to produce containers for carbonated drinks, sheets for trays, and films for wrappers and bags. When recycled from soda bottles, PET can be converted into "fibers, insulation, and other nonfood packaging applications" (2007, pp. R42). Though possessing a high recycling potential, the process can often be complicated and highly technical. Polyvinyl chloride (PVC) is used in such products like toothpaste tubes, electronic packaging, bottle sleeves, etc. (PVC in Packaging, 2010). Though lauded for its durability and impermeability, PVC has recently received backlash from environmental and health advocates. Greenpeace, for example, issued an in-depth report on the harmful toxins from various chemicals implicated in the production and use of PVC in Disney's children clothing (GreenPeace, 2004). Not only is PVC difficult to recycle because it is hard to separate and identify from other plastics, but it also has been found to contain cancer-causing toxins that are bad for consumer health and the environment (The Battle Rages on over Use in PVC Clam Shells, 2003). Because of the controversy surrounding PVC, it has increasingly become unpopular in recent times. Many companies, under pressure to avoid the controversy surrounding PVC materials, are switching to alternative, less questionable materials to maintain consumer confidence and a positive corporate image.

Overall, plastic material is seen as very useful for packaging because of its versatility in form and durable resistance to wear, heat, chemicals, and fluids. It is also relatively inexpensive, making it a seemingly ideal material for packaging. However, although plastics are considered recyclable, because the different types of plastics are difficult to identify and separate from other waste, it is not recycled nearly to its full potential. Though plastic packaging generates about 14 million tons of waste per year, less than 10 percent of that is actually recovered through recycling (EPA 2006a OR Marsh and Bugungu R50). Low-density polyolefins (plastic bags) and PEN are the most suitable for reuse whereas, PET and high-density polyethylene (milk bottles) are the most recycled of plastics.

Material	Advantage	Disadvantage
Polyolefins		
polyethylene polypropylene	good barrier to moisture strong resistant to chemicals lightweight cost recyclable high energy source for incineration	poor barrier to gas slightly opaque difficult to identify and separate, and thus recycle, for film form. (easier in semi-rigid form)
Polyesters		
polyethylene terephthalate polyethylene naphthalate polycarbonate	strong withstands heat good barrier to moisture high clarity shatter resistant	difficult to identify and separate (easier in rigid form) relatively inexpensive, but higher cost among plastics
Polyvinyl Chloride		
polyvinyl chloride	moldable resistant to chemicals high clarity inexpensive recyclable	contains chlorine toxic phthalates may leach onto product requires separating from other waste

Figure 2: Types of Plastic: Advantages and Disadvantages

Metals

Metal is considered one of the most versatile of all packaging materials due to its protective properties, malleable and decorative potential, recyclability, and other attractive characteristics. Though metal packaging only constitutes about 8 percent of total MSW, over 50 percent of it is able to be recovered through recycling and reuse, making metal an attractive, environmentally friendly material. The two most common types used in packaging are **aluminum** and **tinplate** (steel).

Aluminum is commonly used to produce cans, foil, plastic packaging, and lamination for packaging. It is lightweight, which reduces transport costs, and is an effective barrier to air, temperature, moisture and chemicals. It is also an ideal candidate for recycling, more in rigid form than in lamination, because it is easy to reclaim and reconstitute into new products. Aluminum is considered expensive in comparison to other metals, however, its recycling potential may compensate for its higher costs.

Tinplate, which is made from low-carbon steel, is used to also form cans for drinks as well as for foods, aerosols, containers, and packaging closures. Like aluminum, tinplate is also lightweight and easy to transport. With regards to environmental impacts, tinplate can be recycled several times without loss of quality and is significantly cheaper than aluminum (Marsh and Bugusu, 2007).

Paper and Paperboard

Paper packaging products make up the largest percentage of total MSW at around 34 percent. Despite its large impact, 58 percent of all paper and paperboard packaging waste generated is recovered and recycled, making it the most recycled material in MSW. It is used to produce corrugated boxes, folding cartons, wrapping paper, milk cartons, and others. Paper is sometimes used in primary packaging; however, the greatest use of paper and paperboard in packaging is in transport and secondary packaging. Paperboard products are generally made from a renewable source, from fiber pulp derived from used paper and paperboard and wood, and are easily recyclable. Additionally, their low cost, reusability and durability make paper and paperboard a very useful material in packaging.

Packaging and its Environmental Impacts

Packaging can adversely affect the environment at any stage during its life cycle from harvest of raw materials and production to waste and disposal of packaging materials. It is the leading contributor to total MSW, contributing 30.8 percent of the total 250 million tons of waste as of 2008 (Figure 3). The packaging industry can waste energy and contribute harmful emissions to the atmosphere, negatively impacting climate change and the environment. Its effects are seen in the following areas: landfills, waste incineration, and energy consumption in production.

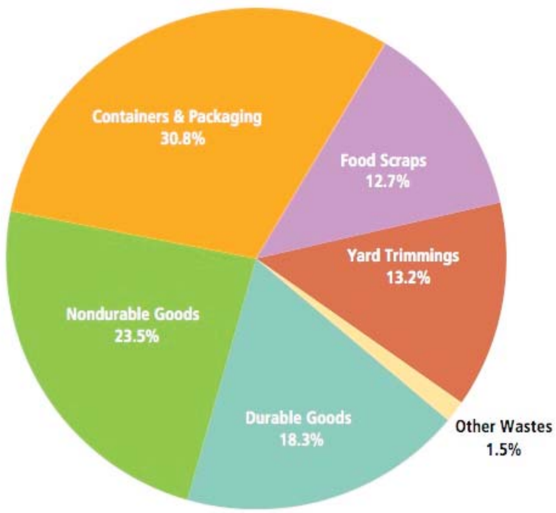


Figure 3: Total MSW Generation (by category), 2008 Source: EPA, 2009, pp. 6

Landfills

Landfilling is the most common method of waste disposal in the US and over 250 million tons of waste are discarded each year (EPA, 2006). Although the number of landfills in the US is steady declining, the average size of each landfill is actually increasing (EPA, 2006). Improper disposal in landfills and poor landfill design, construction and management can lead to harmful contamination of groundwater. Furthermore, landfill emit toxins in the air such as carbon dioxide (CO_2), methane (CH_4), and a whole host of volatile organic compounds (VOC)

Source: http://blog.lib.umn.edu/evans391/architecture/Garbage_landfill.jpg

that contribute to the greenhouse effect and climate change (Marsh and Bergusu, 2007, pp. R50). Furthermore, these atmospheric emissions can have a harmful effect on human health by adding toxic pollutants into the air that can cause asthma and even cancer. Lastly, landfills also have social consequences because of their growing infringement upon communities, poor environmental aesthetics, and so on, causing much political dispute. There is some potential for remediation through methane gas recovery. Methane gas, the most abundant of the landfill emissions, can be captured and used to produce electricity in gas-fired power plant. However, the necessary infrastructure for landfill gas capture can be expensive and the use of landfill gas is still not environmentally optimal—burning natural

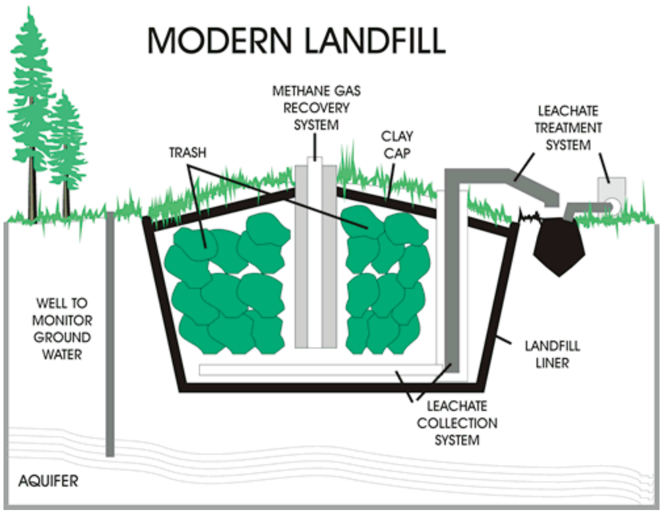


Figure 4: Diagram of a Landfill System

gas is still a cleaner option. Though all landfills should utilize landfill gas recovery technology, your waste contribution to landfills should be minimized for a greater environmental impact.

Waste-to-Energy Incineration

Waste incineration has been seen by many as a solution to the landfill problem; however, it does not come without its own set of environmental problems. Waste incineration has considerable sustainability potential due to its waste-to-energy recovery process that can create heat and electricity. However, only 12 percent of waste is currently incinerated with energy recovery with only a 24 percent efficiency to produce electricity (EPA, 2007, pp. 9). Furthermore, waste incinerators require "considerable initial capital, and construction takes 3 to 5 years" (Marsh and Bergusu, 2007, pp. R51). Though waste-to-energy incinerators possess an attractive potential to not only reducing waste and landfill usage but also to producing alternative energy, it has costly technological burdens that prevent widespread implementation. Additionally, waste incineration causes harmful air emissions and release of toxic pollutants. For example, CO_2 is emitted when "products derived from fossil fuels (such as plastics) are burned" (2007, pp. R51). Other pollutants emitted can include particulate matter and non-CO_2 greenhouse gases like sulfur dioxide (SO_2) and nitrogen oxide (N_2O). Though waste-to-energy consumption may seem to resolve the issue of waste accumulation and energy scarcity, it does not have an overall positive impact on the environment and may be too costly to implement.

Finally, the energy required to produce materials used in packaging is an often overlooked source of CO_2 and excess energy consumption. Products with more material than necessary, in addition to products using non-recycled, non-reusable materials, are less energy efficient. The more energy required to produce a material or product, the greater the strain on energy demand and the level of CO_2 emissions (EPA, 1998, pp. 3). According to a study by Marko P. Hekkert et. al. (2000) about CO_2 emissions of packaging materials, aluminum and certain types of plastics require the most energy-demanding production. This is measured using the parameter **gross energy required** (GER) values for material production. For example, aluminum uses a total of 139.1 Giga-joules per ton (GJ/ton) of energy where as glass requires only 12.7 GJ/ton. The energy required to produce certain materials should be weighed with the recyclability, costs, and other parameters of the material in order to assess its overall efficiency.

Improper and/or excessive use of packaging can also lead to a host of other negative consequences. For example, packaging made from natural resources such as paper and paperboard promotes deforestation (EPA, 1998, pp. 3). This would lead to resource exploitation, in addition to loss of biodiversity and a decrease in CO_2 absorption from trees. Unnecessary packaging can increase the prevalence of litter and food waste, due to the trend in the US to package food in large portions. By reducing food portions in packaged foods, not only would packaging waste be reduced but the change may also promote a healthier diet. The other alternative is to package food in bulk amounts to reduce the packaging needed for individually wrapped food items. Depending on the material and design choice, packaging can have a wide range of effects on the environment, at varying costs to the producer.

Why Care About Packaging Waste?

As previously discussed, packaging waste can lead to a wide array of environmentally degrading effects. From that perspective alone, packaging waste reduction is of high priority for businesses that want to reduce their carbon footprint and overall environmental impact. The environmental benefits of environmentally-sound packaging decisions include, but are not limited to (EPA, 2001, pp. 3):

- Improve public and occupational health and safety
- Improve wildlife habitat
- Decrease, air, soil, and water contamination
- Improve compliance with environmental regulations
- Promote a sustainable economy
- Develop markets for environmentally preferable goods and services
- Reduce GHG emissions
- Conserve energy

Packaging waste reduction clearly poses a net social and environmental benefit, which is advantageous for businesses looking to become more socially responsible. However, packaging waste reduction has also been shown to produce benefits for the businesses themselves as well.

Waste reduction results in several economic benefits for businesses and organizations. Environmental performance provides businesses with a competitive edge and can "be the differentiating factor that influences consumers' purchasing decisions" (EPA, 2001, pp. 4). Environmental awareness can signal social responsiveness to important stakeholders, improving public opinion of an organization. Numerous researchers found that "social responsiveness is positively related to a firm's stock market performance, … increased investment levels into the firm…[and] improved employee morale and customer goodwill" (Carter et. al., 1999, pp. 221). As consumers increasingly prefer environmentally friendly organizations, these economic benefits may result in greater revenue, which can cover the cost of initial operations and purchasing restructuring to be "greener". Packaging waste reduction and sustainable packaging can also increase a business's profits by reducing costs, both waste disposal costs and manufacturing costs. An organization can reduce waste disposal costs by requesting that vendors use more eco-friendly transport packaging and also by promoting reuse and recycling within an organization and with its consumers. Manufacturing costs can be lowered by using less material in packaging as well as using recycled material that is often times the cheaper alternative. There are not only social and environmental benefits to reducing the impact of packaging and packaging waste but also economic incentives for businesses as well.

What Now? Solutions to Packaging Waste

The first step towards establishing a more sustainable solution to packaging waste is to utilize the traditional waste management hierarchy (Figure 5). The "three Rs" that make up the hierarchy are "reduce, reuse, and recycle" (Dewees and Hare, 1998, pp. 446).

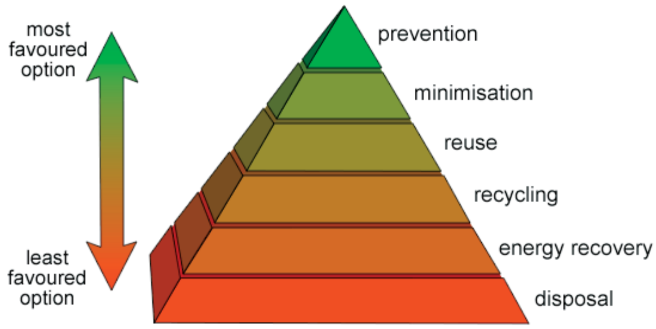


Figure 5: Waste Hierarchy Pyramid
Source: www.greengrowth.org

The hierarchy is manifested in several programs that focus on source reduction (reduce), take-back or leasing agreements (reuse), and recycling programs. Though the hierarchy is an adequate starting point to begin thinking about feasible waste reduction strategies, it has also been criticized for being lop-sided with certain programs garnering greater success for only one aspect of the waste management pyramid. Recently, business strategists and scholars have been promoting a more holistic and out-of-the-box analysis of packaging waste beyond the three Rs as being more effective in overall sustainability (Sonneveld et. al., 2005). To best maximize waste reduction strategies and improve overall business sustainability, it is important to look at both the traditional hierarchy as well as unconventional and new ideas that lie outside the traditional paradigm such as innovative eco-design, invention of new packaging materials, creative reuse of packaging, and other strategies.

Lastly, there are several organizational programs and guidelines offered by the EPA that help foster better practices and waste reduction in business. Launched in 1994, EPA's WasteWise Endorser Program engages businesses and organizations of all sizes, breadth, and functions to become educated about the benefits of waste reduction and to implement better practices. Its membership now exceeding 2,000 partners, WasteWise offers businesses and organizations the following benefits (About WasteWise, 2010):

- Reducing purchase and waste disposal costs
- Toll-free helpline for technical assistance
- Annual Climate Profile describing greenhouse gas reduction
- Public recognition in WasteWise publications, case studies, and meetings
- Networking in member and regional forums
- Opportunity to receive WasteWise Awards that recognize outstanding achievements
- Outreach and educational materials

One of the largest divisions of waste targeted by the EPA is packaging, making the WasteWise program a helpful tool for any organization looking to reduce their packaging waste. WasteWise also has a peer exchange program, allowing companies to contact each other and share information and techniques on waste reduction (EPA, 1985, pp. 2). WasteWise is a helpful education tool and support system to begin the process of packaging waste reduction. More information and resources regarding WasteWise can be found at: http://www.epa.gov/waste/partnerships/wastewise/index.htm.

In order to incorporate strategies that are both in-line with the waste management hierarchy as well as those that lie outside of it, this next section will be structured to encompass the whole spectrum of methods. It begins with strategies in the post-production phase, in which existent packaging waste impacts are mitigated, to pre-production and supply chain-focused strategies, which are aimed more to reduce packaging waste before its produced. This section will also cover areas outside of the immediate supply chain and business operations to incorporate transportation processes and vendor partnerships.

Post-Production Strategies

Not all packaging waste reduction strategies need to be implemented in the production phase of a product. Many of the harmful effects previously discussed can actually be mitigated or accounted for after the waste and pollution has been produced. Because waste is an unavoidable aspect of business, strategies to lessen their negative impacts in the environment are important to explore. Some post-production strategies include waste incineration, composting, and full-cost pricing.

Waste incineration/ Waste-to-Energy

Waste incineration was previously discussed in light of its environmental drawbacks; however, this should not detract from its appeal as a preferable alternative to landfilling and moreover, littering. Waste incineration can reduce MSW that cannot be recycled or composted by 70-90 percent (Marsh and Bergusu, 2007, pp. R45). It can also be used to produce energy through steam, which in turn produces heat and electricity. Though combustion of waste can cause harmful emissions as well, the benefits of energy recovery and reduction of landfilled waste can partially outweigh the emissions, especially considering landfills themselves release harmful methane emissions regardless. There are three types of incinerators: mass-burn incinerators (accepts all types of as-is MSW, meaning unprocessed and unsorted waste with the exception of too-large items), refuse-derived fuel incinerators (removes non-combustibles and recyclables before combustion), and modular combustors (smaller, more mobile versions of mass-burn incinerators).

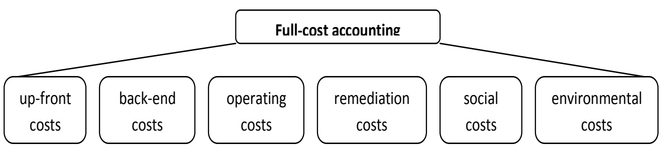
Because waste incineration, especially **waste-to-energy** (WTE) processes, can partially alleviate the issue of growing landfills and rising energy costs/ scarcity, it is growing in increasing popularity as a mitigation technique. In 2004, the US had “94 combustion facilities of which 89 were WTE facilities, with a processing capacity of about 95000 tons [of waste] per day” (Marsh and Bergusu, 2007, pp. R45).

Composting

Another method of packaging waste mitigation is the promotion of composting. **Composting**, which the EPA considers a form of recycling, is “the controlled aerobic or biological degradation of organic materials” (Marsh and Bergusu, 2007, pp. R45). Choosing packaging materials that are composed of organic materials such as wood and paper, like paperboard boxes, can produce products that can be composted. Furthermore, **biodegradable** polymers (biopolymers) such as cellophane, polylactide, edible films, and biodegradable plastics can all replace non-biodegradable packaging materials which can help solve the littering problem as well as positively impact landfilling. Frito-Lay has converted all of its 10½ oz. SunChips packaging to biodegradable polylactic acid (PLA), which decomposes in just 14 weeks with no harmful byproducts (Why We Made a Better Bag, 2007). Composting of organic matter and the degradation of biopolymers can result in environmentally friendly by-products such as natural fertilizer, CO_2 (in soil), water, and so forth. The benefits of biodegradable materials are not so absolute, unfortunately. Biodegradation and composting can be difficult in landfills due to a lack of proper exposure to oxygen and moisture. Furthermore, recycling can be compounded by the use of blended or modified polymers that may be difficult to separate in the recycling process (Marsh and Bergusu, 2007, pp. R46-47). However, despite these drawbacks, biodegradable packaging materials are still gaining commercial interest and are worth considering, especially because of their ability to reduce harm from littering.

Full-Cost Pricing

Lastly, another way that organizations can practice packaging stewardship without changing the product itself is with full-cost pricing. Full-cost pricing, also known as **full-cost accounting** (FCA), is intended to "internalize waste management costs and correctly



signal consumers and producers of packaged goods on the position of a particular package in the waste management hierarchy and on the level of impact the package has on the environment" (Sinclair, 2000, pp. 2). Differing from standard accounting, FCA focuses on the flow of economic resources, taking into account past and future outlays, overhead (oversight and support services) costs, and operating costs. Not only will the environmental impacts be priced and therefore economically accounted for, but full-cost pricing will also promote more eco-friendly consumer preferences and more sustainable purchasing and production choices within a business. Essentially this "tax" on pollution and environmental degradation, can then be reinvested in recycling programs and other sustainable initiatives or allow for businesses that do practice sustainably to gain a competitive edge.

Take-Back Programs

Take-back programs can be used for a variety of purposes to reduce packaging waste. Though not very popular in the US, take-back programs in Canada and in Europe have promoted recycling on behalf of producers as well and reuse of packaging. Reuse and refill systems will be discussed at a later point; however, take-back programs have also been used to ensure that products and packaging is properly recycled and disposed, placing the responsibility on the producer rather than consumer. Take-bake programs can enable businesses to ensure that their products and packaging stays out of the waste stream and also helps facilitate recovery and reuse.

The EPA has some great resources for the reuse and recycling of electronic products. The EPA's Electronics Reuse and Recycling Directory includes a list of original equipment manufacturerst that take back electronic products for re use or recycling as well as scrap dealers or business that can utilize certain materials from the item or refurbish them entirely for reuse (EPA 1998, pp. 12). The directory can be found online at www.epa.gov/epaoswer/non-hw/recycle/reuse/electdir/recycle1.htm. This could be a great resource for reducing electronic waste in general as well as serve as an exemplar for possible take-back programs of packaging specifically.

Source Reduction Strategies

Rather than mitigating the effects of generated waste, organizations can have an even greater impact (and greater savings potential) by preventing unnecessary waste before it is produced. The following strategies are aimed specifically at targeting an organization's purchasing, production and distribution choices. Most waste reduction strategies in the supply-chain fall under the category of source reduction: lightweighting, sustainable purchasing, refill/take-back programs, and other such initiatives. The possibilities of waste reduction in the supply-chain are limitless with the support of EPA guidelines, industry partnership, and a wealth of proven success stories. Source reduction has been considered one of the most effective policies and is highly endorsed by the EPA. It is defined as "any change in the design, manufacture, purchase or use of materials or products (including packaging) to reduce their amount or toxicity before they become municipal solid waste" (Reduce and Reuse, 2009) Source reduction benefits include conservation of resources, reduction of GHG emissions, reduction of material and production costs, increased operational efficiency and many more.

Source reduction has been integrated into several EPA-sponsored programs, notably the Extended Product Responsibility approach (EPR), an approach adopted by WasteWise partners in the 1990s (EPA, 1998, pp. 2). Rather than focusing on what an individual manufacturer can do to reduce his/her waste, EPR introduces a "product systems approach…to encompass entire product systems and ask how all the players in the produce chain… can collaborate to reduce environmental impacts and resource use"(EPA, 1998, pp. 2). Hewlett-Packard, a WasteWise partner, integrated EPR into its operations through its product stewardship program which aimed to minimize waste and environmental impacts at all points in the life-cycle of an HP product from design to manufacturing and disposal. Their product stewardship program seeks to use less raw materials as inputs, design products that are easier to reuse and facilitate disassembly and reduce waste and emissions during manufacturing (1998, pp.5). EPR promotes the designing of products to use less material, more recyclable material, fewer toxic constituents or greater recycled content. Source reduction can be achieved through lightweighting, sustainable purchasing, and eco-conscious packaging design.

Lightweighting

Lightweighting is the process of using "thinner gauges of packaging materials either by reducing the amount used or by using alternative materials" (Marsh and Bugusu, 2007, pp. R44). Most packaging materials such as plastic bottles, glass containers, and aluminum cans have all reduced in weight over the years. Companies like Anheuser-Busch Companies Inc. have taken advantage of the lighter material and have lightweighted their 24-ounce aluminum cans in 2003, resulting in 5.1 million pound material use reduction (Marsh and Bergusu, 2007, pp. R44). Because recycled materials are often lighter and less expensive than virgin material, lightweighting through container substitution, for example, a shift from glass and steel to plastic and aluminum, can also reduce waste and production and transport costs. Additionally, studies of improvement measures show that a nine percent reduction in CO_2 emissions is achievable by using lighter packages in primary packaging alone (Hekkert et. al., 2000, pp. 1). For example, Fetzer Vineyards redesigned their wine bottles to use 25.5 percent less glass than their previous model. This reduction in glass materials translates to a 985-ton reduction in CO_2 emissions, reducing the vineyard's overall carbon footprint. Furthermore, Fetzer Vineyards incorporated an eco-friendly label made from recycled paper and printed with soy ink to their new bottle design (Environmental Leader, 2010). Lightweighting has been proven to be effective in impacting other categories of packaging as well.

If primary packaging cannot be lightweighted, secondary packaging is often an easier and safer target for source reduction. Warner-Lambert, a healthcare consumer product manufacturer, eliminated the outer paperboard cartons on a line of cold formula remedies, opting rather for only the shrinkwrapped bottle. This step alone prevents the generation of over 340 tons of paperboard per year. Therefore, lightweighting is not just a strategy to be used to target primary packaging but can beneficially reduce packaging waste at any stage in production and distribution.

Though lightweighting is a great way to achieve source reduction, purchasing managers should also be aware of the risk of increased damage and spills. Honest Tea switched their bottles to PET plastic, which was 22 percent lighter than their traditional glass containers. However, the thinner material posed a high risk of denting, causing Honest Tea to redesign their bottle. Unfortunately, consumers raised concerns about a reduction in the actual product delivered due to the new design (Our Philosophy: Packaging, 2010). Therefore, issues of lightweighting are not isolated to other packaging concerns and the requirements of lightweighting must be balanced with concerns of design, consumer perception. With careful planning and evaluation, lightweighting of packaging can reduce waste, save production and transport costs, and lessen the impact of packaging on the environment.

Environmental/Sustainable Purchasing

Another strategy for source reduction is by preventing non-recyclable, unsustainable materials from entering the supply chain at all, through a process called environmental or sustainable purchasing. The EPA, under its WasteWise partnership effort, developed its environmentally preferable purchasing (EPP) program. EPP encourages government agencies, businesses, and institutions to choose sustainably produced, environmentally sensitive products and services, such as recycled packaging. This program extends beyond the scope of WasteWise by

> "encouraging organizations to consider not only the durability recyclability and recycled content or product purchased but also the impact of their purchases on biodiversity, air and water pollution levels and worker and consumer safety" (EPA, 2001, pp. 2).

The EPA designates which products can be made with recovered and recycled materials and procurement managers, in turn, are obligated to purchase the product with the highest level of recycled material content. Because purchasing is at the beginning of the supply chain, a business cannot achieve sustainability without integrating "green" decisions into its purchasing choices. Purchasing managers must take into account the actual composition and make-up of purchased materials as well as the final disposition of those materials. Carter et. al. (2000) suggests that purchasing managers can impact further change by "[asking] upstream members of the supply chain to commit to waste reduction goals and to design and provide the purchasing firm with the materials and components identified…for disassembly and life-cycle analysis" (pp. 222). The EPA acknowledges the importance of collaboration through its encouragement of establishing an EPP team. An effective EPP program is made possible by thorough planning and proper involvement and education of all levels in an organization. An EPP team would be responsible for reviewing past purchases, education employees and consumers of purchasing changes, and establishing set goals. Because purchasing is the first stage of production, it holds the greatest potential impact on the overall supply-chain, making the existence of a supervising committee to be of paramount importance.

Another means of sustainable purchasing is to purchase supplies in bulk containers to reduce the amount of transport packaging. The purchasing department of State Farm Mutual Automobile Insurance Company worked with a supplier to have paper shipped in containers holding 2,500 sheets as opposed to individually wrapped reams of 500 sheets. This simple change prevented the generational of six tons of waste annually (EPA, 1995, pp. 6). Purchasing more economical bulk packs, another trend in source reduction, reduces the need for more packaging material per unit. It also saves on transport costs for distributing products more frequently with smaller-packaged goods.

This example demonstrates many crucial elements to sustainable purchasing. Firstly, the purchasing managers at State Farm made use of partnerships with other aspects of the value chain stream. Partnerships not only promote sustainability beyond simply the organization or business itself but also allowing both sides to save on costs. Furthermore, State Farm's decision also created greater efficiency for their own business by decreasing the amount of time wasted unwrapping and unloaded paper from the supplier. Their purchasing change also incorporated the packaging in which the supplies (paper) were transported, by requesting that paper be delivered in corrugated boxes, which are made from recycled materials. The way that State Farm was able to initiate this change in their procurement was by establishing a Waste Management Committee, consisting of members from seven key departments: purchasing, data processing, corporate law, audio/visual, corporate administrative services, regional office administrative services, and safety and environmental health.(EPA, 1995, pp. 7) Therefore, the purchasing department of State Farm ensured that all aspects of their procurement process were made more environmentally friendly as well as efficient.

Environmental/Sustainable Design

From sustainable purchasing, businesses can continue "greening" their supply chain by considering environmentally conscious design in their manufacturing and final product. Not only are materials becoming lighter by better production technology but better product design can also achieve source reduction. The EPA also has a program from sustainable design called Design for Environment (DfE). This program encourages the incorporation of environmental consideration into the design of manufacturing processes and finished products. Procter & Gamble redesigned their plastic bottles used for vegetable oil containers from the traditional cylindrical shape to a rectangular design. The new geometry required a thinner layer of plastic, using "30 percent less plastic than before [and] eliminating about 2.5 million pounds of plastic per year" (EPA 1995, pp. 9). Furthermore, improvements in traditional plastic packaging are being developed, like the plastic pouch (flexible packaging) and the polycarbonate (PC) bottle for use in the beverage industry (Hekkert, 2000, pp. 17). Both the plastic pouch and the PC bottle offer a lightweight alternative to traditional materials. Moreover, the PC bottle, which is already widely used in the Dutch market, is refillable and reduces shelf space. Not only are new materials being developed for packaging, but innovative design that promotes creative reuse and environmental sustainability.

Though not widely prevalent in the packaging market, unique and innovative packaging design, incorporating sustainability, is proving that with a little creativity, the limitations to sustainable packaging can be questioned and overcome. Take Pangea Organics for example. Its all-natural, organic skincare line uses secondary packaging that not only avoids environmental harm entirely but actually contributes back to it as well! After removing the label, consumers can soak the box, which is laced with basil and/or amaranth seeds, in water and plant it (Dugas, 2009). While reducing waste, this innovative packaging also adds back to biodiversity and encourages the consumer to become more environmentally conscious. Other innovative examples include the lite2go Lamp, in which the packaging itself becomes the lampshade for the light bulb and fixture contained within. By utilizing packaging in the product itself, the lite2go lamp eliminates packaging all together as well as utilized recycled material for the lampshade/packaging, label, and other components. As environmental issues increase in priority and popularity, so will the future of packaging design increasingly incorporates environmental considerations and waste reduction.

Figure 6: lite2go Lamp
Source: http://knoend.com/work/lite2go.html

Life-cycle Assessments

Life-cycle assessment (LCA) is one tool businesses and organizations can use to assess the environmental impacts of their packaging. LCA measures environmental impacts of a product or process by: compiling an inventory of material and energy inputs and the subsequent environmental emissions, evaluating the potential environmental impacts based on the gathered inventory, and finally interpreting the results to assess an overall life-cycle.

LCAs can help business managers assess the quality of environmental sustainability of their product packaging, which can better inform design choices. The major stages in an LCA calculation include "raw material acquisition, materials manufacture, production, use/reuse/maintenance, and waste management" (LCA 101, 2008). Because an LCA incorporates the impacts of a product from each stage of its product life, it can thoroughly express the broader extent to which product packaging design can impact production and the environment.

Reusable/Refillable Packaging

Another strategy in sustainable design that can have a large environmental impact, although has not received as much corporate attention, is the use of refillable, reusable packaging. In the Netherlands and Germany, many PET bottles are refillable due to new improvements in which PET bottles can be cleaned at temperatures up to 75 degrees Celsius (Hekkert, 2000, pp. 15). Although the process energy requirements are higher for reusable packaging can be higher due to extra transport and cleaning, it often requires lower material input and lower total CO_2 emissions during the life cycle (Hekkert, 2000, pp. 20). The materials most suitable for reuse or re-fill, especially in primary packaging for the food and beverage industry, are glass and PET or high-density polyethylene bottles, due to their heat resistance and durability, though trials are ongoing for other potential materials.

Refill products can also be used for household cleaners by utilizing a reusable dispenser with refillable cartridges. For example, in 2008 Arm and Hammer introduced a new line of "Essential Cleaners" which uses a reusable trigger spray bottle with a refill system of replaceable cartridges of cleaning concentrate (PRNewswire, 2008). This new system (Figure 7) uses up to 80 percent less packaging than traditional, non-refillable cleaners.

Figure 7: Arm and Hammer Essentials
Source: www2.prnewswire.com

Furthermore, by using cleaner concentrate rather than premixed, diluted solution, the refillable cartridges use smaller, lighter packaging and the consumer can use their own tap water from home to refill the bottle. This system benefits both producer and consumer because it requires less material production and cuts production and transport costs as well as accrue savings for the consumers who now only need to purchase the less expensive refill cartridges rather than a whole new bottle. Though refill/reuse systems are quite effective in reducing packaging waste as well as providing the greatest environmental benefit, they sometimes are harder to implement and have higher initiation and transport costs.

Transport Packaging Reduction Strategies

Although most of the strategies discussed so far can be applied to all levels of packaging (primary, secondary, transport, etc.), the following section will discuss efforts to reduce transport packaging specifically as many companies are increasingly focusing on reducing waste of products they send and receive. The manner in which shipments are packaged can often be altered to eliminate unnecessary transport packaging, packaging used in received shipments can be reused for outgoing shipments, pallets used to hold incoming shipments can be more sustainable or reusable, and so on. EPA suggests that businesses and organizations, when analyzing how to reduce waste in transporting processes, ask themselves two questions:

> (1) Is each packaging component necessary for shipping?
> (2) Does each component help significantly in the presentation or protection of the product? (EPA, 1995, pp. 5).

Using this basic questionnaire, businesses and organizations can directly identify areas for potential reduction and allows for every aspect of distribution to be analyzed.

Target Stores, for example, suspected that many resources and expenses were being wasted in excess packaging during distribution of merchandise to retail stores. Subsequently, Target negotiated an agreement with their vendors to eliminate individually wrapping items, tissue paper, cardboard inserts, pins, collar inserts, tape, and clips (EPA, 1995, pp. 4). Though skeptics believed that these changes would result in merchandise arriving in stores wrinkled and unfit for immediate in-store presentation, Target conducted several test runs and found that there was no loss in sales due to presentation and apparel merchandise still arrived in stores wrinkle-free and presentable. This change in transport packaging resulted in a 1.5 million pound waste reduction and a savings of $4.5 million in just one year. Furthermore, Target also increased labor productivity by saving time workers had previously spent opening and unwrapping shipments.

Packaging waste can also be avoided in transport through the use of reusable pallets and transportation containers, mainly corrugated and paperboard boxes. Pallets used during distribution and transport are usually made out of wood, which often splinter and become damaged, interrupting production. Pepsi-Cola Bottling of Phoenix switched to reusable (and recyclable) plastic pallets, which cuts the generation of wood waste by over 50 percent in addition to conserving labor for repairing broken pallets, costs for pallet cleaning and other unneeded expenses (EPA, 1995, pp. 4). Furthermore, FreshPak has developed a new plastic slip sheet, which weighs two-pounds and is as thick as notebook paper, to be used in lieu of the traditional packaging pallet. Studies show that it may reduce shipping and freight costs by 25 percent (Environmental Leader, 2010). There are also external organizations such as the National Wood Pallet and Container Association and The International Association of Pallet Recyclers that can help organizations locate and contact pallet refurbishers and pallet suppliers who are interested in receiving pallets for reuse in a materials exchange program (EPA, 1995, pp. 11). Therefore, though a switch to plastic pallets can promote reuse and avoid waste and inefficiency, simply forming partnerships and taking advantage of other resources can help make existent wooden pallets sustainable.

Switching not only pallets but also shipping containers to reusable options possesses huge incentives for savings as well as doing good for the environment. Container standardization, both manufacturers and suppliers agreeing to use only a few set container sizes, allows for containers to be reused by various parties instead of being sent back. When considering container standardization, procurement managers should also consider nestability, in which containers can be fitted inside each other after use, and handling and storage efficiency, so that empty containers can be disassembled and flattened . These considerations also make containers more durable and protective, saving money on costs of replacements. Although reusable containers can save money and waste, the switch also has some barriers. Firstly, companies must invest a lot initially to purchase a large number of reusable containers, so that a sufficient number will always be available while empty containers are returned. Furthermore, reusable containers are often significantly more expensive than single-use containers (EPA, 1995, pp. 10). However, for businesses and organizations with shorter distance and frequent deliveries, a switch to reusable containers may prove to be cost-effective as well as improving environmental efforts.

Other aspects of transport packaging to consider "greening" are packing materials such as air bags and packing peanuts. The EPA suggests using air-filled bags in shipping cartons rather than foam peanuts. Not only are the foam peanuts non-biodegradable, they use more material and therefore cost more energy to produce. However, new developments in packing peanuts that are sorghum and starch-based, can avoid the environmental costs of using traditional foam peanuts. Packing peanuts come in four varieties: white, pink, green, and biodegradable. White and pink peanuts, which are made of polystyrene, are the least sustainable though do possess some degree of recyclable/reusable potential. Green peanuts are made of 100 percent recycled material and are the cleanest, most presentable option. Finally, biodegradable (edible) peanuts, made of sorghum or cornstarch, are the most eco-friendly although they sometimes leave a dusty residue (Packing Peanuts Buying Guide, 2009). However, because packing peanuts are more expensive to transport because they are bulky and lightweight, in which case, using air-filled bags may be the preferred alternative. Although packing material in shipping cartons is but a small aspect of all packaging concerns, simple changes in material choice whether it is a switch to air-filled bags or to green/biodegradable peanuts, has much wider environmental impacts.

Marketing Your Green Packaging

Packaging serves an interesting role with regards to eco-marketing; not only can it bring out the greatest environmental improvements in a product but it also serves the purpose of marketing those changes. However, in order to signal these beneficial changes to the public, companies must market their new green packaging choices. Primary (sales) packaging can include advertisements of the green improvements made to the product and even the packaging itself. Although there is no standard or officially assigned designation for green packaging, several organizations, including Green Seal (www.greenseal.org), Global Ecolabeling Network (GEN) (www.gen.gr.jp), Green Cross, and Ecologo, offer third-party certification and verification of the environmental attribute of a product (Carter et. al., pp. 221) & (EPA, 2001, pp. 9). The organization, Green Seal, sets environmental standards by which products can be judged and compared to each other, awarding a "Green Seal of Approval" to products that impose less environmental harm. It also issues a monthly report to partners, including businesses, colleges, governments, and other organizations, examining environmentally preferable products and services and presenting a comparative analysis for consumers. Carter et. al. (2000) claim that "revenues can be positively impacted when customers prefer the products of environmentally friendly firms" (pp. 221). Lastly, organizations like Scientific Certification Systems (SCS) (www.scs1.com) offer certifications of specific environmental claims and can conduct third-party LCAs. As more and more businesses green their operations, utilizing green marketing to identify improved packaging can award a business a competitive edge. As discussed previously in this paper, the Carter et. al study points out that increased environmental and social responsibility can greatly increase a firm's stock market performance and its rapport with financial institutions and its customers (Carter et. al., 1999, pp. 221). Green marketing is an essential aspect for the success of sustainable packaging, in order to draw consumer attention and differentiate their products.

Blueprint to Packaging Waste Reduction

With so many possible pathways and strategies to choose from, getting started on packaging waste reduction can seem like a daunting, insurmountable task. This section will break down all the information and tips elaborated in this white paper into an easy to digest and easy to use set of guidelines. By providing a general blueprint to packaging waste reduction, the aim is to help businesses in taking the first step towards becoming more sustainable.

To start off, a general overview of the overall lifecycle of all inputs and outputs of packaging can help assess where reductions can and should be made. In analyzing the life cycle, here are a few questions to ask:

- Is this packaging absolutely necessary for the product and its final delivery?
- Are the inputs used in packaging the most cost-efficient and sustainable?

Computing lifecycle assessments of packaging and of your products can help identify areas of especially high environmental costs that should be immediately targeted. Breakdown calculations of packaging into the three general categories to make it easier to target one aspect at a time rather than packaging as a whole.

- Primary or secondary packaging reduction:
  - Lightweighting
  - Sustainable purchasing
  - Eco-design
  - Switching to reusable packaging
- Transportation packaging reduction:
  - Reusable plastic pallets
  - Eliminating unnecessary transport packaging
  - Reusable shipping containers
  - Eco-conscious packing materials such as airbags, biodegradable packing peanuts
- Existing packaging waste reduction:
  - Use WTE facilities to dispose of waste
  - Composting
  - Full-cost pricing
  - Recycling/ take-back programs

The task of reducing packaging waste can also be initiated successfully by utilizing a variety of available programs and resources, such as the following provided by the EPA and other institutions:

- WasteWise Partnership (http://www.epa.gov/wastes/partnerships/wastewise/index.htm)
- Environmentally Preferred Purchasing (http://www.epa.gov/epp/)
- Design for the Environment (http://www.epa.gov/dfe/)
- Extended Product Responsibility (http://www.ilsr.org/recycling/epr/index.html)

With so many resources, support and sample strategies available, the difficulty should not be how to reduce packaging waste but which pathway to pick first!

Conclusion

Almost every business or organization is affected by packaging whether it be the packaging from vendors, retail packaging, or packaging in transport between offices. It contributes the largest proportion of waste in MSW and can consume a considerable amount of a business', let alone the environment's, resources and energy. Unlike in most of Europe, Canada, and Australia, which have federally regulated stewardship programs, the US has no official regulations, allowing consumers and manufacturers to discard their waste without any levies or restrictions. However, an increasing amount of attention is being focused on environmental and social responsibility of businesses. In order to become more eco-friendly and gain a competitive edge, businesses and organizations are targeting their packaging as an area for improved environmental performance and retrench excess costs.

The EPA offers several voluntary initiatives such as the Extended Product Responsibility and Environmental Purchasing programs, under the umbrella of its WasteWise business partnership program that promotes waste reduction through collaboration, partnerships, and support. These programs offer successful case studies, technical support, operations guidelines and advertising and award incentives to participating organizations. They also help facilitate partnerships between vendors and manufacturers and distributors to ensure that sustainability initiatives are implemented throughout the entire life-cycle of a product.

Finally, there are many ways a business can reduce packaging waste on their own by scrutinizing their operations, using developed criteria to identify areas of possible waste reduction in their packaging use. Strategies in the supply-chain, labeled generally as source reduction, include packaging lightweighting, sustainable purchasing, and sustainable packaging design. However, packaging waste does not have to be reduced by changing production. Implementing take-back, recycling, reuse, and proper waste disposal programs ensure that products and packaging are used efficiently and disposed of responsibly. Furthermore, it has been proven that targeting transport packaging in distribution alone can greatly reduce a business's overall packaging waste, as demonstrated by Target and Pepsi-Cola. With such a variety of possible strategies and support, packaging waste reduction not only reduces a business's environmental impact but also makes financial business sense in reducing costs and increasing efficiency.

Glossary

Aluminum – lightweight, silvery white metal derived from bauxite ore, where it exists in combination with oxygen as alumina. Aluminum is highly resistant, flexible and possess high embossing potential. It is easy to reclaim and process into new products in recycling. However, aluminum is relatively more expensive compared to other metals.

Biodegradable (waste) - is a type of waste, typically originating from plant or animal sources, which may be broken down by other living organisms. Biodegradation is the chemical breakdown of materials by a physiological environment. There are no industry standards for what is and isn't considered biodegradable.

Cradle-to-grave – a variant of life-cycle assessments, an evaluation of the environmental impacts of a given product or servce. It is the full analysis from manufacturing (cradle), to use, and to disposal phases (grave). All inputs and outputs are considered in each

Composting – Composting is the decomposition of plant remains and other once-living materials to make an earthy, dark, crumbly substance that can be added to houseplants or garden soil. Composting can be done aerobically or anaerobically, or with or without air. Aerobic composting requires the compost pile to be turned regularly. Anaerobic composting is less labor-intense (does not require turning) but is a slower process. Compostable products, defined by ASTM International standards 6400 or 6868, biodegrade in commercial composting facilities at a specified rate (usually 180 days or less).

Full-cost pricing/accounting – a practice where the price of a product is calculated by a firm on the basis of its direct costs per unit of output plus a markup to cover overhead costs, profits, social costs, negative externalities and so on. The overhead costs are generally calculated assuming less than full capacity operation of a plant in order to allow for fluctuating levels of production and costs. Also known as true cost pricing/accounting.

Gross energy requirement (GER) – total amount of energy required for producing and delivering a product/service.

Landfill – a site for the disposal of waste materials by burial and is the oldest form of waste treatment. It is colloquially referred to as a dump and is a major source of methane gas into the atmosphere.

Life-cycle assessments (LCAs) – An assessment and evaluation of the environmental and social costs of a product. It is a way to account for the effects of the cascade of technologies responsible for goods and services. There are several varieties of LCAs: cradle-to-grave. Cradle-to-gate gate-to-gate cradle-to-cradle well-to-wheel economics input-output life-cycle assessments depending on the scope and specificity of the LCA.

Lightweighting – The act of decreasing the weight of a product or packaging by using lighter constructing materials or through product re-design.

Municipal solid waste (MSW) – a waste type that includes predominantly household waste (domestic waste) with sometimes the addition of commercial wastes collected by a municipality within a given area. They are in either solid or semisolid form and generally exclude industrial hazardous wastes. Also known as urban waste or more generally as, trash or garbage.

Polycarbonate (PC) – a thermoplastic polymer variety of plastic. It is easily malleable, temperature resistant, transparent, and highly impact resistant. There is some controversy surrounding the use of PC in food packaging due to bisphenol A (BPA) which has been found to transfer from container to food. Usually designated by the number #7 or just as PC on the packaging PIC label.

Polyester – condensation polymers formed from ester monomers that result form the reaction between carboxylic acid and alcohol. It includes polyethylene terephthalate (PET or PETE) and polyethylene naphthalate (PEN). It is storng, resistant to chemicals and lightweight. IT is easily recycled in rigid form but is difficult to identify and separate for films. It is also generally inexpensive, albeit relatively costly compared to other plastics. PETE plastics are labeled as #1 in PIC labels.

Polyolefin – collective term for polyethylene (PE), polypropylene (PP) and other less popular polymers made from simple olefins, or alkene. It possess good moisture barrier, durability, a light weight, and recyclability. It is also a great energy source in incineration. It is a common material for egg cartons, milk containers, plastic bags, yogurt containers, squeezable food bottles, etc. Though generally recyclable in semi-rigid form, identification and separation is more difficult for films. It has low costs. High density PE is designated as #2, low-density PE is marked as #4, and polypropylene is #5 in PIC labels.

Polyvinyl chloride (PVC) – addition polymer of vinyl chloride that is heavy, stiff, ductile, strong, and transparent as well as inexpensive. It is difficult to recycle because it is used for such a variety of products and the incineration of PVC poses environmental problems due to its chlorine content. It also poses health threats because of its risk of leaching toxic phthalates. It is designated by a #3 in PIC labels.

Primary packaging – First-level product packaging such as the bottle, can, jar, tube, etc., that contains the item sold. It is the last packaging thrown by the consumer.

Secondary packaging – the packaging that encloses the product or primary packaging until use. It is usually used to protect the product, prevent theft, and provide advertising support. Sometimes it is used interchangeably with transport packaging.

Transport packaging – packaging or packaging materials used in transporting or distributing products from point A to point B. It includes corrugated boxes, pallets, foam peanuts, shrink wrap, plastic bins, storage containers etc.

Tinplate – it is produced from low-carbon steel by coating both sides of plackplate with thin layers of tin. It possesses excellent barrier properties to gases, water light and odor. It is also highly ductile and formable. It possesses a relative low weight and is easily recycled many times without loss of quality. It is cheaper than aluminum.

Waste-to-energy (WTE) incinerator – the energy recovery process of creating energy in the form of electricity or heat from the incineration through combustion of waste source. WTE facilities produce electricity directly or a combustible fuel like methane, ethanol or synthetic fuels. Also called Energy from Waste (EfW).

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