Life Cycle Inventory

Packaging Options for Shipping Soft Goods in E-Commerce and Catalog Sales

Businesses, individuals, and governments shipping non-breakable items via a common carrier (such as the U.S. Postal Service, UPS, or FedEx) have many different packaging options to choose from. Corrugated boxes with void fills are a common option. Void fills include flowable loose fills ("peanuts") such as those made from expanded polystyrene or corn starch, inflated polyethylene "air pillows", bubble wrap, and sheets, rolls, or pads of paper. Shipping bags are another popular option. Bags can be unpadded or padded and made entirely from paper, a variety of plastic resins, or combinations of paper and plastic components. Each of these packaging options has advantages and disadvantages in performance and cost.

The packaging options also impact the environment in a variety of different ways. All packaging materials come from raw materials that have to be grown and harvested or extracted from the earth. Energy is required for electricity production and fuels are used to manufacture and transport all kinds of packaging materials. Fossil fuels (coal, natural gas, petroleum) are often a significant energy source. Further, a variety of atmospheric and waterborne pollutants are generated during fuel combustion and manufacturing. Some of these pollutants are released into the environment where they may harm human health and natural ecosystems, and even alter the planet's climate.

To better understand these environmental and natural resource issues, the Oregon Department of Environmental Quality (DEQ), with assistance from the U.S. EPA and Metro (the regional government of the Portland metropolitan area) commissioned a life cycle inventory study of 26 different packaging options. The study was conducted by Franklin Associates, a Division of Eastern Research Group (ERG). This fact sheet summarizes some key results and answers some commonly-asked questions about the study (hereafter referred to as "the DEQ/Franklin study").

Why Life Cycle Analysis?

Many of today's environmental challenges are complex. Changing packaging to reduce solid waste may have unintended consequences elsewhere, such as an increase in energy use, greenhouse gases, or water pollution. Life cycle analysis can be a valuable tool in understanding trade-offs between alternatives and also identifying where in the product life cycle the greatest environmental burdens occur.

26 Packaging Options

The 26 different packaging options studied included 5 different kinds of shipping bags and a corrugated box with 8 different types of void fills. For each of these 13 packaging systems, two options were evaluated: one with lower levels of post-consumer recycled content, and another with higher levels.

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Updated: 07/14/05
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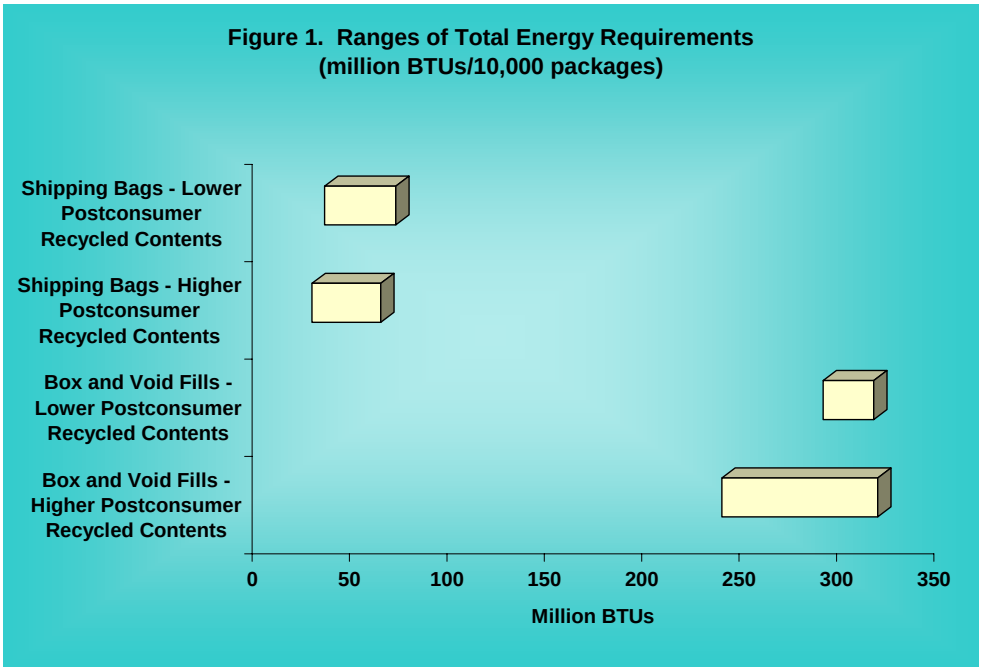
05-LQ-031

Box with Void Fill Options:	Shipping Bag Options:
Inflated polyethylene air packets	Unpadded bleached kraft paper shipping bag
Polystyrene foam loose fill	Unbleached kraft paper shipping bag with newspaper padding
Starch based loose fill	Bleached kraft paper bag with polyethylene bubble padding
Molded pulp loose fill	Unpadded polyethylene bag
Crumpled unbleached kraft paper	Polyethylene bag with polyethylene bubble padding
Crumpled newsprint	
Shredded corrugated	
Shredded office paper	

Key Findings

The DEQ/Franklin study evaluates total energy use, energy use by source (coal, petroleum, nuclear, etc.), total solid waste, and approximately 80 different atmospheric and waterborne emissions over the packaging life cycle, from raw materials extraction through manufacturing and transportation to end-of-life recycling, landfilling, or combustion. The study contains several hundred pages of results and discussion. A few key findings include the following:

Shipping bags tend to have lower environmental burdens in most categories studied. The DEQ/Franklin study finds that because they use significantly less material in their manufacture, and ship more compactly, all ten of the shipping bag options have significantly lower total energy requirements than any of the box/void fill combinations. This is true for all of the shipping bags evaluated, even padded bags with little to no recycled content and few convenient recycling options. Figure 1 illustrates life cycle energy requirements per 10,000 packages for different categories of packages (for example, all 5 of the different shipping bags with lower post-consumer recycled content, and all 5 of the different shipping bags with higher post-consumer recycled content).



Similar results are found for solid waste, greenhouse gases, and most of the other atmospheric and waterborne pollutants studied. (See the report for additional details.)

Increasing post-consumer content can reduce environmental burdens. Increasing the post-consumer recycled content of packaging materials can reduce environmental burdens in a number of areas. In many cases, using post-consumer recycled content reduces total energy use (and associated

pollution), reduces life cycle greenhouse gas emissions, reduces the extraction and consumption of virgin resources, and provides markets that help keep recyclable materials out of landfills.

However, specific to the use of post-consumer recycled materials, the DEQ/Franklin study illustrates three important environmental caveats that many people find surprising:

- For a business shipping non-breakable items in a corrugated box with low post-consumer content, **using shipping bags offers significantly greater energy savings than increasing post-consumer content of the box and/or changing void fills**, as Figure 1 shows. Similar results are found for raw materials, including fossil fuel use, solid wastes, greenhouse gases, and many of the atmospheric and waterborne wastes evaluated in the DEQ/Franklin study. Put differently, waste prevention or using less material (lightweight bags) yields greater reductions than increasing post-consumer content.
- **Increasing post-consumer content doesn't guarantee reduced burdens in all environmental categories.** Corrugated boxes are an interesting example. On average, it takes less energy to manufacture corrugated from post-consumer waste than from virgin resources (wood chips). But looking at where the energy is derived yields an interesting finding. The virgin pulping process generates significant quantities of process wastes (bark, limbs, pulping liquors) that are waste by-products of the paper-making process. Most virgin mills burn these wastes for fuel, reducing their use of fossil fuels. In contrast, paper and paperboard mills using post-consumer fiber typically depend on fossil fuels for a higher percentage of their energy needs. As a result, while post-consumer corrugated requires less *total* energy to manufacture when compared to virgin corrugated, its use of *fossil fuel derived energy* is much more similar to virgin corrugated, on average. This finding is specific to virgin and recycled corrugated and kraft paper and does not apply to most other materials.
- **Materials with high levels of post-consumer materials are not guaranteed to have lower burdens than competing materials with low levels of post-consumer materials.** Take for example flowable loose fill made from molded pulp. While made from 100% post-consumer content material (typically old newspapers), molded pulp conventionally requires significant amounts of natural gas in the drying process. It also ships less compactly to the order fulfillment center, and weighs more than many other void fill options, thus increasing petroleum use in transportation. A box shipped with molded pulp loose fill will require more energy (both total and fossil fuel) over its life cycle than the same box shipped with virgin polystyrene or polyethylene void fills.

Once you've chosen a packaging material, it typically makes good environmental sense to try and maximize the level of post-consumer recycled content. However, be wary of choosing a packaging material *only because* it contains high levels of post-consumer recycled content.

Recyclability and recycled content are not always good predictors of environmental burdens. As Figure 1 shows, just because a packaging material is easy for consumers to recycle in curbside or other recycling programs, does not guarantee that it has lower environmental burdens than materials for which widespread recycling programs are not readily available. And as Figure 1 and the discussion of molded pulp loose fill above illustrated, just because a packaging material contains high levels of post-consumer content does not guarantee that it has lower burdens than a different material with lower levels of post-consumer content. While recyclability and recycled-content are important environmental considerations, the DEQ/Franklin study demonstrates that they aren't the only (or even the most important) ones.

Minimizing box size and total fiber content can result in significant environmental savings. Many businesses concerned about the environment focus on recycled content and void fill considerations. Assuming that boxes are necessary, reducing box sizes and fiber content may lead to more significant environmental savings than simply changing void fills.

For example, compare life cycle energy for boxes and void fills. For the box and void fill options studied (excluding shredded paper), total energy use "upstream" of the order fulfillment center (packaging manufacturing and bulk transportation) averages 6.8 times higher for the box than for the void fills. Reducing the size of the box can save on both fiber and void fill, since a smaller box uses less fiber and also requires less void fill. It can also lead to significant benefits in shipping, as more boxes can fit into a long-haul truck. In contrast, changing void fills does nothing to address the environmental burdens associated with the box.

For more information about optimizing box sizes and fiber content, click here.

"Upstream" burdens may be significantly greater than "downstream" burdens. Many people focus on packaging as a solid waste problem. All types of packaging can cause problems if littered (especially materials that decompose slowly or don't decompose fully), and air toxics and other pollutants are released if packaging is burned in fireplaces or backyard burn barrels. The DEQ/Franklin study didn't fully compare environmental burdens "upstream" of the consumer (resource extraction and manufacturing) against those "downstream" (landfilling and disposal) because of insufficient data on airborne and waterborne pollution resulting from the landfilling of different packaging materials.

However, data does exist for one airborne pollutant from landfilling packaging: methane, a potent greenhouse gas. Using data from the DEQ/Franklin study, and methane emissions data from the U.S. EPA's Office of Solid Waste, DEQ conducted additional analysis to compare the "upstream" versus "downstream" greenhouse gas emissions of packaging options. Assumptions were made to maximize downstream emissions relative to upstream: we assumed that all of the packaging is landfilled (in a landfill with average methane controls) and we counted none of the carbon dioxide from combustion of wood wastes used as fuel in papermaking. Even with these assumptions, over the life cycle of a corrugated box with newsprint void fill (low post-consumer content), only 8% of the total greenhouse gas emissions occur "downstream" of the consumer. 92% of the emissions were associated with resource extraction, manufacturing, and transportation of the packaged good to the consumer. This suggests that "upstream" considerations are likely to be more important than "downstream" issues.

Commonly Asked Questions

So are shipping bags "better" than corrugated boxes?
The DEQ/Franklin study does not claim that any type of packaging is "better" than another. The study is a life cycle inventory study, not an impact study. That is, it inventories raw material inputs, solid wastes, and atmospheric and waterborne pollutants, but does not evaluate those inputs and outputs for their impact on the environment. Further, the DEQ/Franklin study was limited in scope to non-breakable "soft goods" items (such as clothing) shipped in e-commerce or catalog sales. In this application, many businesses find that using bags offers significant cost savings in several areas (procurement, labor, and freight). For an example click here. However, for many other types of items, such as breakable goods, corrugated boxes are an ideal packaging material, and any reduction in packaging waste from using shipping bags could be overwhelmed by increased product damage and resulting waste.

How can an all-plastic shipping bag have lower energy requirements than an all corrugated box with paper void fill? I thought plastic was made from oil, and paper comes from trees.
Plastic shipping bags are typically made from polyethylene, which is made from ethylene derived from both petroleum (oil) and natural gas. On average, more natural gas is used to make ethylene in the U.S. than petroleum. Regardless, even though paper is "made from trees" (and recycled paper), significant amounts of energy (including fossil fuels and electricity derived from fossil fuels) are used in the manufacturing process. Further, products shipped long distances in shipping bags are shipped more compactly, on average, than products in corrugated boxes, so bags can also result in energy savings during transit from the order fulfillment center to the customer.

Despite this, the DEQ/Franklin study makes no claims regarding the broad or general comparison of "paper" vs. "plastic". In reality, there are many different plastic resins and grades of paper used in packaging production. Environmental burdens are very much a function of the specific type and amount of material used, which varies by application. For example, the DEQ/Franklin study does not evaluate paper vs. polyethylene retail shopping bags.

The study shows that recycling and recycling considerations aren't very important, correct?
Emphatically, NO! The DEQ/Franklin study does not compare recycling against other options for end-of-life management of wastes. Rather, the study evaluates options from a purchaser's point of view. The benefits of recycling (relative to landfilling) have been well documented elsewhere and DEQ strongly supports efforts to recycle materials.

How is this study different from other life cycle studies?
The DEQ/Franklin study contains several features that represent improvements over many of the packaging life cycle studies that were conducted in the U.S. in the 1980s and '90s. These include:

- Goal and scope definitions and inventory analysis methodologies are consistent with the methodology for life cycle inventory as described by the Society of Environmental Toxicology and Chemistry (SETAC) and in the ISO 14040 Standard documents.
- The study underwent a critical review by a panel of three independent life cycle practitioners.
- Historically, many life cycle studies in the U.S. have been funded by businesses or their trade associations that have a financial interest in the outcome. Studies with results that are unfavorable to the sponsor are often suppressed and not made public. In contrast, the DEQ/Franklin study was wholly funded with public funds and all results have been made public.
- The study documents provide extensive documentation of methodologies and data that are available to the public.

What are some of the study's limitations?
All studies of this nature have limitations, and the DEQ/Franklin study is no exception. A full description of limitations is included in the report document. Some key limitations include:

- The study relies entirely on domestic (U.S.) data. While much stock packaging used in the U.S. is made here, some is not. This can be significant environmentally, as some other countries have much less stringent regulation of pollution from energy providers and manufacturers. In fact, because of the relatively strong environmental regulations in the U.S. (particularly when compared to some Asian countries), "buying domestic" is an often overlooked but potentially important strategy for reducing environmental burdens.
- The study relies on national averages for energy supplies, resource use, and emissions from manufacturers. Individual manufacturers may use energy supplies that are considerably different than the national average, and/or may have pollution releases that are considerably smaller (or greater) than industry averages.
- The study does not evaluate or include information on several life cycle stages. For example, it does not address greenhouse gas impacts associated with different types of forest practices. It does not include emissions data from the litter or on-site burning of packaging waste, and does not quantify burdens associated with the production and use of pesticides used to grow corn and trees.

Where can I find more information?
You can view the entire study (and appendices) on line at: http://www.deq.state.or.us/wmc/solwaste/data/LifeCycleReport.htm. For additional information, you can contact DEQ's project manager for this study at allaway.david@deq.state.or.us.

Alternative formats (such as large type, Braille) of this document can be made available. Contact DEQ's Office of Communications & Outreach, Portland, at (503) 229-5317