

APPENDIX E

WASTE MANAGEMENT

OVERVIEW

This appendix discusses the fate of packaging materials that have served their intended purpose of delivering packaged soft goods to a consumer. Options include the following:

- Reuse by the customer for returns of unwanted mail-order goods
- Reuse by the customer for shipping other outgoing goods
- Recycling by the customer
- Disposal by the customer
 - On-site burning (small percentage)
 - Littering (small percentage)
 - Managed municipal solid waste stream
 - Landfill
 - Combustion with energy recovery

Packaging used for returning unwanted goods may be reused, recycled, or disposed when received at the order fulfillment center.

Currently, it is estimated that about 80 percent of discarded municipal solid waste (MSW) in the U.S. that is not diverted for reuse, recycling, or composting is landfilled, and the remaining 20 percent is burned in waste-to-energy facilities (Reference E-1). Therefore, combustion of 20 percent of the postconsumer materials that are discarded and not reused, recycled, or composted is included in this study. In the LCI energy results, an energy credit for waste-to-energy combustion of 20 percent of disposed packaging components is assigned to each system.

Customer Management of Packaging Materials

The study assumes that 10% of the packaging materials sent to customers will be reused to return the packaged products to the distribution center/order fulfillment center. Customers may choose to return products because they are not wanted (gifts) or due to size, color, defects, or other reasons. Ten percent is an assumption based on very limited data from Norm Thompson Outfitters and the anecdotal experience of study contributors (Reference E-2). According to Norm Thompson, returns are typically shipped to its order fulfillment center in their original packaging materials.

Thus, decisions regarding ultimate end-of-life management of the packaging materials are made at two different locations: the residential customer (90%) and the order fulfillment center (10%).

Reuse/Recycling/Disposal of Packaging by Residential Customers. Although many of the packaging materials used in this study are technically recyclable and/or reusable, actual reuse and recycling by residential customers depends on many factors, including the following:

- Customer access
 - to recycling programs (curbside or drop-off)
 - to packaging stores that accept loose fill for reuse
- Types of materials accepted by recycling programs
- Customer awareness that materials are reusable/recyclable
- Availability of residential space to store materials until they can be recycled/reused
- Convenience of participation in recycling programs
- Customer level of environmental commitment

The following assumptions were made in assessing residential reuse/recycling of packaging:

- Because of the low value and relative bulk of packaging materials, they are likely to be recycled only by customers with access to curbside recycling.
- The only materials likely to be accepted by curbside recycling programs are unpadding, unlined kraft paper shipping bags and possibly other all-paper(board) packaging components such as crumpled kraft paper or newsprint, corrugated boxes, molded paper loose fill, and all-paper padded shipping bags. Few if any curbside programs would accept shredded loose fill, pillow packs, polyethylene film shipping bags, or composite shipping bags.
- Except for the 10% of packaging used for returns, the only materials expected to be reused by customers are EPS and cornstarch loose fill. Although molded pulp loose fill is equally reusable, it is a new product that customers are unlikely to be familiar with and thus less likely to save and reuse. The larger size of the cushion cubes compared to foam loose fill “peanuts” may also make the molded pulp less appealing to customers for storage and later reuse. Molded pulp loose fill is also unlikely to be accepted by packaging stores for reuse because its appearance is very different from EPS and starch-based foam loose fill shapes, and stores would not be expected to store and reuse molded pulp loose fill separately from foam loose fill. Because the lower reuse of molded pulp shapes is based on expected customer behavior rather than functionality of the product, the LCI report will provide guidance on how to adapt molded pulp results to reflect reuse equivalent to foam loose fill.

Residential recovery/recycling of various paper grades was analyzed in the study **Recovered Paper: Future Challenges and Opportunities**, prepared for the American Forest & Paper Association by Franklin Associates, Ltd., July 9, 2002. Table 5-4 in that report, “Residential Postconsumer Generation and Recovery, 2000”, showed 12% recovery of residential corrugated, but residential recovery of shipping bags and other packaging paper was insignificant.

Reuse of EPS loose fill was addressed in the study **Waste Management and Reduction Trends in the Polystyrene Industry, 1974 – 1994**, prepared by Franklin Associates, Ltd. for the Polystyrene Packaging Council in August 1996. A survey of 39 mailing services and catalogue businesses indicated that 50% of the loose fill that they used was loose fill returned to their stores by consumers (standard deviation 40-65%). It is assumed that a similar percentage of customers that do not have access to packaging stores (e.g., rural mail-order customers) would save and reuse loose fill at home.

Reuse/Recycling/Disposal of Packaging by Order Fulfillment Centers. Table E-1 shows assumed rates of recycling and reuse for packaging materials used for return shipments of goods. (This is not the same as consumer returns of packaging materials to mailing service stores for use, discussed in the preceding section.) Reuse of packaging materials to return unwanted items to order fulfillment centers represents a second useful life of the packaging material, replacing the need for the customer to purchase new boxes, shipping bags, or envelopes.

The study assumes that all loose fill materials are reused at a rate of 80%, as long as they are received and can be stored and returned to packing stations in the same format (same volume) as new (purchased) loose fill. This applies to inflated polyethylene air packets, polystyrene loose fill, corn starch loose fill, molded paper loose fill, shredded OCC, and shredded office paper. Because the materials have much more financial value reused than recycled, the study assumes that if they aren't reused, these materials will be disposed, so the recycling rate for these materials is 0%.

Because corrugated boxes will have had labels affixed to them twice already (once to the customer and again for the return) the study assumes that the order fulfillment center will not reuse the boxes a third time. Most order fulfillment centers are likely to have corrugated cardboard recycling service, so the study assumes that the returned corrugated cardboard boxes are recycled at a rate of 90%, with the remaining 10% disposed.

Kraft paper void fill and newsprint void fill is reusable, but reuse of these materials requires greater effort and/or additional storage space (compared to unused product in flat sheets or rolls) because they have been crinkled/wadded up. The study assumes that these materials are less likely to be reused than the flowable and other loose fills, for which bulk dispenser systems and storage may already be in place. Kraft paper may be recycled with corrugated and newsprint/newspaper is a fairly common recyclable in warehouse/shipping environments as well. For these materials, the study assumes a 20% reuse rate and a 40% recycling rate, for a total diversion rate of 60%, with the remaining 40% disposed.

**Table E-1.
Assumed Rates of Reuse and Recycling for Packaging
Returned to Order fulfillment centers**

Packaging Material	% Recycling	% Reuse
Corrugated	90%	0%
Inflated polyethylene air packets	0%	80%
Polystyrene foam peanuts	0%	80%
Cornstarch loosefill peanuts	0%	80%
Flowable loosefill made from recycled newsprint	0%	80%
Purchased Kraft paper (unbleached)	40%	20%
Purchased newsprint-style paper	40%	20%
Loosefill OCC shredded on-site	0%	80%
Loosefill high grade paper shredded on-site	0%	80%
PE bag(s) without liner	0%	0%
Kraft bag(s) without liner	40%	0%
Kraft paper bag with PE air-padded liner	0%	0%
Kraft bag with 100% news padding	0%	0%
PE bag with PE air-padded liner	0%	0%

It is very unlikely that shipping bags will be reused as they are designed for single-use but may be reusable if re-taped. Recycling for the kraft-only bag is assumed to be 40% (same as kraft void fill paper). Recycling for all other shipping bags is assumed to be 0% due to their low value (macerated newsprint), multi-material construction, and/or lack of recycling opportunities.

Management of Discarded Packaging

Packaging that is not reused or recycled by consumers typically becomes part of the managed municipal solid waste stream. It is recognized that some small fraction of postconsumer packaging may be burned by consumers, particularly in rural areas, or littered; however, no data exist to quantify these amounts or their impacts with any degree of confidence. Thus, disposal of postconsumer packaging by on-site burning or littering is not included in this analysis. This analysis considers only landfilling and WTE combustion as management options for postconsumer packaging.

Landfilling of Discarded Packaging. Approximately 80 percent of all discarded municipal solid waste in the U.S. that is not diverted for reuse, recycling, or composting is currently being landfilled. This analysis examines landfilling as a waste management option. The energy requirements for landfilling operations include the energy required to collect and transport solid waste to the landfill and to run the compacting equipment at the landfill.

The energy to transport materials to the landfill is derived by converting the weight of each material to the volume it occupies in the packer truck and multiplying the volume by the average fuel use per truckload. The packer truck densities used in this study are reported in Table E-2. A typical packer truck has a 25-cubic-yard volume and generally achieves a volume utilization of 80 percent. Packer trucks are assumed to use approximately 10.4 gallons of diesel per load (Reference E-6) on average, although actual fuel use will depend on the mode of transportation and distance to landfill, which can vary widely between communities. The amount of diesel fuel allocated to haul the postconsumer solid waste is calculated by the following equation:

$$\frac{\text{Wt. of Discards}}{\text{Packer Truck Density of Discards}} \times \frac{10.4 \text{ gal diesel}}{25 \text{ cu yd} \times 0.8} \quad (\text{Equation 1})$$

The diesel fuel requirements for the operation of landfill equipment are calculated using Equation 2.

$$\frac{\text{Wt. of Discards}}{\text{Landfill Density of Discards}} \times \frac{500 \text{ gal diesel}}{2,667 \text{ cu yd}} \quad (\text{Equation 2})$$

The materials buried in the landfill are reported in the analysis as postconsumer solid waste. The solid waste is reported both by weight and by volume. The landfill density factors shown in Table E-2 are used to convert the weight of the discarded materials to the volume they occupy in the landfill. These factors are based on landfill samples and compaction tests.

Combustion with Energy Recovery. Approximately 20 percent of the nation's disposed municipal solid waste is burned rather than buried in a landfill (Reference E-1). The majority of MSW incinerators recover the energy released from burning the wastes, primarily to generate electricity. This analysis reports the energy content of the materials burned in MSW incinerators. The energy content of the materials evaluated in this study is based on the higher heating values (HHVs) reported for the postconsumer materials. These values are listed in Table E-3. The weight of the material burned is multiplied by its HHV to determine the amount of energy released. Most MSW incineration facilities produce electricity but not steam. Usable energy production is actually HHV x (thermal efficiency) x (transmission efficiency). Thermal efficiency for the generation of electricity from WTE combustion of MSW is around 33 percent or lower. Transmission losses are about 8 percent. As a result, the usable energy delivered from combustion of MSW is HHV x 0.33 x (1/1.08), or about 28 percent of the HHV of the material. The energy credit is shown separately in the LCI energy results in the report.

Table E-2

PACKER TRUCK AND LANDFILL DENSITY FOR PACKAGING

	<u>Packer truck density (lb./cu. yd.)</u>	<u>Landfill density (lb./cu. yd.)</u>
Polyethylene Film Packaging	544	670
Polystyrene Packaging	200	240
Paper Packaging	602	740
Corn Starch Packaging	1700	2000
Molded Pulp Packaging	664	819
Newsprint/Newspaper Packaging	602	740
Corrugated boxes	609	750

References: E-1, E-7, and E-8

Source: Franklin Associates

Table E-3

HIGHER HEATING VALUES AND ASH CONTENT OF MATERIALS

	<u>Ash Content (percent)</u>	<u>Higher Heating Value (HHV) (Btu/lb)</u>
Kraft Paper	1.01%	7,261
Newsprint/Newspaper	1.43%	7,979
Low-density polyethylene (LDPE)	0%	19,965
Linear Low-density Polyethylene (LLDPE)	0%	19,985
Polystyrene, foam	0%	17,840
Corrugated	5.06%	7,945
Corn Starch	1.06% *	7,560
Molded Pulp	1.43% **	7,979

* The ash content for food waste is assumed for corn starch.

** The ash content for newsprint is assumed for molded pulp.

References: E-8, E-9, and E-10.

Source: Franklin Associates

The quantity of solid waste for each system is reduced when postconsumer materials are burned. The ash content of the materials is used to determine the quantity of solid waste contributed by the portion of materials that is burned instead of landfilled. Air and waterborne emissions data from the combustion of specific postconsumer materials are not available. These emissions are also not available for landfilling of specific materials. Therefore, the air and water emissions associated with combustion and landfilling are not addressed in this report.

REFERENCES

- E-1 U.S. EPA. **Municipal Solid Waste in the United States: 1999 Facts and Figures.** Franklin Associates, Ltd. June, 2001.
- E-2 Research conducted for Oregon Department of Environmental Quality by David Allaway, DEQ.
- E-3 “Curbside collection participation: Influences and motivations.” Rebecca Davio, Ph.D. **Resource Recycling**, August 2001, Vol. XX, No. 8.
- E-4 **Recovered Paper: Future Challenges and Opportunities.** Prepared for American Forest and Paper Association by Franklin Associates, Ltd. July 9, 2002. Table 5-4 Residential Postconsumer Generation and Recovery, 2000.
- E-5 **Waste Management and Reduction Trends in the Polystyrene Industry, 1974 – 1994.** Prepared for the Polystyrene Packaging Council by Franklin Associates, Ltd. August 1996. Page 18.
- E-6 Personal communication between Franklin Associates, Ltd. and Bob Yost of Douglas County, Kansas. February, 2003.
- E-7 **Estimates of the Volume of MSW and Selected Components in Trash Cans and Landfills.** Prepared for The Council for Solid Waste Solutions by Franklin Associates, Ltd. and The Garbage Project. February 1990.
- E-8 Franklin Associates, Ltd. estimate.
- E-9 **Thermodynamic Data for Biomass Materials and Waste Components.** American Society of Mechanical Engineers. 1987.
- E-10 Fire, Frank L. **Combustibility of Plastics.** Van Nostrand Reinhold. 1991.