ADDENDUM: PEER REVIEW PANEL REPORT AND CONSULTANT RESPONSES

Life Cycle Inventory Of Packaging Options For Shipment Of Retail Mail-Order Soft Goods: Final Draft Report And Final Appendix, December, 2003

Peer Review Comments Submitted February 17, 2004
And Consultant Responses

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Process for Review

Peer review team members were provided copies of the draft final report and appendices (dated December, 2003) and an Excel file containing the results of the life cycle inventory. Individual members of the team shared their comments on these documents and the overall study with each other. After discussion of these individual comments, the Chair of the Review Team synthesized them into the following peer review report. Note: the Reviewers were unable to review each individual data point and how data were combined (i.e. data calculation and computational structure) in detail.

Review Summary

This Life Cycle Inventory (LCI) of soft goods packaging was, for the most part, well-constructed and developed in accordance with ISO 14040/14041 documents on life cycle goal and scoping and inventory. The mail-order soft goods packaging systems, corrugated boxes with various types of dunnage and shipping bags, are well defined. Package logistics were modeled for a ground-delivered package shipped from an order fulfillment center in western Oregon to a customer in central Missouri. An overview of the assumptions, data source and data analysis methods, is provided, however, the transparency of the report can be improved. This study is supported by a comprehensive set of Appendices that describe an extensive life cycle inventory database. The conclusions drawn from this study are consistent with the results for both packaging systems. Recommendations for improving the report are indicated below. For example, data categories for environmental emissions should be more explicitly defined. Other recommendations related mainly to clarifying limitations and assumptions of the study and the inventory data presented in the Appendix. The inventory should be more transparent to enable tracking of data sources in each module. It's unclear how data quality for model parameters are translated to the overall quality of the final results, i.e. how data with poor quality influence the uncertainty of the results. Gravity, uncertainty and sensitivity could be better highlighted in the discussion.

MAJOR RECOMMENDATIONS (NOT RANKED)

1. Define data categories for environmental emissions more explicitly, i.e., list the pollutants tracked.

Response: A full list of atmospheric emissions can be found in results tables 2-6, 2-7, 3-6, and 3-7. The list of waterborne emissions is shown in results tables 2-8, 2-9, 3-8, and 3-9. This has been stated in the Executive Summary.

2. It would be useful to model airfreight in addition to ground-based logistics but this would require additional modeling. Additionally, consider a sensitivity analysis that explores changes in distribution distance.

Response: It is agreed that it would be useful to model airfreight, but this was beyond the scope and budget of the project. A section providing guidance for readers on how to estimate the burdens for different distribution distances by road has been added to the end of Chapter 3 of the report. Readers interested in understanding the importance of the ground freight component relative to other life cycle steps will find that transportation to consumer is shown as a separate category in Chapter 3 figures.

3. It does not appear that fabrication scrap losses are accounted for. Plastic fabrication losses are often small; is this also the case for the paper-based products?

Response: For most packaging components, fabrication data (including scrap rates) were either collected specifically for this study or taken from Franklin Associates' LCI database. Data were not available for the fabrication of shipping bags from their component materials. This limitation is clearly stated in the report results chapters. A section has also been added to Chapter 1 under System Components Not Included. Finally, a section has been added to the end of Chapter 3 providing guidance on using the material production data modules to estimate the effect of different fabrication scrap rates.

4. An overview of the Appendix should be provided that indicates the overall age of the data and processes modeled.

Response: The Franklin Associates LCI database has been developed over many years. Individual process/material data sets contributing to material process trees are continuously updated as new LCI projects involving these unit processes are conducted or as new or updated public data sources become available. Thus, for any packaging product modeled, the sources and ages of individual contributing unit process data sets within the model varies, making it difficult to concisely describe the age of the overall dataset. In Chapter 1, an overview of the age and source of the final material production and fabrication data sets for each packaging material has been added in the section Process Data (subsection Sources), and a general description of the age of the fuels and energy database has been added to Chapter 1 in the section Fuel Data.

5. Limit the claim of following ISO standard to goal and scope definition and inventory analysis.

Response: Agreed that this is appropriate, since this report is limited to a life cycle inventory and does not include impact assessment. Text has been added to the Introduction of Chapter 1 to clarify this.

6. Clarify how data quality affects the overall quality of the final results.

Response: An additional chapter has been added to the report to address this issue in greater detail. Chapter 4 provides an explanation of Franklin Associates' criteria for meaningful differences in LCI results, supported by statistical arguments with hypothetical data and taking into account representative standard deviations, variances, and "t" statistics for desired confidence levels.

7. Clarify the recycling allocation method that was used, per comment #10 below.

Response: This comment is believed to refer to the question regarding solid waste allocation (Item 9 under **Executive Summary** comments). Text has been added to the report to clarify the methodology used.

8. The discussion on data accuracy versus data quality should be expanded and clarified (see point 9, Body of Report, below).

Response: Revisions have made to text to address the suggestions and comments in Item 9 under **Body of Report** comments.

EXECUTIVE SUMMARY

1. Table ES-1: It would be helpful to add a subtitle to clarify this table for the reader. Definition of Packaging Options. Two corrugated box options (1 and 2) and eight dunnage options including a no dunnage option.

Response: The purpose of this table is to define the weights and compositions of the individual packaging components that are analyzed in various combinations in the study. The study does not evaluate a "no dunnage" box option. The table title has been modified: "Definition of individual packaging components modeled in the study (Study models corrugated boxes used in combination with various dunnage options.)" The titles of the corresponding Tables 2-1 and 3-1 have also been changed.

2. ES-4; Scope and Boundaries; third bullet: "Glues, adhesives, and other inputs accounting for less than one percent of the weight of product were not included." If several components each with individual weights slightly less than one percent are excluded the impact on the results might be significant. In addition while the energy burden may be negligible for these elements their environmental emissions may be significant. What percentage by weight of the total product system is inventoried?

Response: In Chapter 1, section Miscellaneous Materials and Additives, under System Components Not Included, it is noted that cornstarch loose fill contains greater than one percent proprietary plasticizers that could not be modeled since the composition of the proprietary constituents was unknown; thus the cornstarch loose fill was modeled as 100% cornstarch. Because the identity of the proprietary materials is unknown, their potential impact on results cannot be estimated. The scope of the study did not include detailed compositional analysis of all packaging components. Based on the general compositional data available on other packaging materials, no other materials were knowingly excluded from the analysis.

3. "Data were not available for the fabrication of shipping envelopes from their component materials; thus, the burdens for shipping bags are understated by an unknown amount." How significant is this lack of data? should it be noted more often than it is? especially under "limitations?"

Response: See response to Item 3 under **Major Recommendations** comments.

4. ES-4: the word "envelope" is used in discussing the shipping bag system but it is not explained how the envelope is different from the bag.

Response: The terms were used interchangeably. For clarification, the report has been revised to use only the term "shipping bag."

5. Space conditioning was not included in the scope of the analysis but this process can be significant. DOE data for the industrial sector indicates that non-process energy use including HVAC and lighting accounts for 10 -15 percent of the total end use fuel energy consumption in the case of electricity and natural gas. (http://www.eia.doe.gov/emeu/mecs/mecs98/datatables/d98n6_4.htm)

Response: Space conditioning was not explicitly included in the scope of the study; however, primary LCI data are often based on overall facility utility use and may include some space conditioning data. In addition, based on the practitioner's experience, HVAC and lighting may account for a significant percentage of total electricity and natural gas use for facilities where relatively low-energy processes such as assembly processes are conducted, but they are generally an insignificant percentage of total energy use for facilities where higher-energy processes such as chemical processing or fabrication processes take place. The space conditioning section of Chapter 1 has been revised to better describe this issue, including adding reference to the DOE website.

6. Transport of packaging items from the manufacturer to the order fulfillment center was inventoried but secondary and tertiary packaging components were not apparently inventoried. These components can potentially have a significant burden depending on their mass and composition. Was any attempt made to examine these components?

Response: Inclusion of secondary and tertiary packaging used to deliver packaging items to the order fulfillment center was not within the scope of this study. This is noted in Chapter 1, section Secondary Packaging, under System Components Not Included. The types of secondary packaging used in bulk shipments of packaging materials (e.g., steel or reinforced plastic strapping, plastic bags or film, etc.) are generally small in mass relative to the mass of the packaging delivered, or are reusable and commonly reused many times (pallets, plastic boxes, etc.) such that the burdens per delivery of packaging are small.

7. The study defined a representative customer in central Missouri for modeling purposes. Given that customers are distributed across the country it would be helpful to conduct a sensitivity analysis on the transportation distance from the distribution center to the customer.

Response: See response to Item 2 under **Major Recommendations** comments.

8. Solid Waste ES-8: Indicate in this section that the transport of packaged product has a negligible contribution to the total solid waste. White bar in figure ES-2 is not visible presumably because its magnitude is too small.

Response: Text has been added to explain that the only solid waste from transport of packaged product is fuel-related waste, which is too small relative to other life cycle stages to show up on the results figure ES-2.

9. Solid waste credit is made for the recycled content of the package. This statement is unclear and seems to conflict with the recycling allocation method described in the Methodology of Chapter 1. Which recycling allocation rule was used? Chapter 1 suggests that the EPA LCI Guidance Manual (1993) allocation method 2 was used but the solid waste credit wouldn't be assigned to the packaging system. This method indicates that if the original product is recycled the solid waste burden for that product is reduced by the amount of waste diverted from the disposal phase. The product system that uses the recycled material picks up the burdens for

processing of the secondary material but avoids virgin material production burdens.

Response: For postconsumer recycled content of packaging in this study, the initial product system generating the material is assigned all of the burdens for material production and none of the disposal burdens, while the system using the postconsumer material is assigned none of the material production burdens and all of the disposal burdens for packaging that is not recycled or reused. The solid waste credit shown in Figure ES-3 is assigned to the initial system that produced the postconsumer material used in the packaging. Figure ES-4 thus shows the net solid waste benefit, i.e., how using postconsumer material produced by the initial system (thus diverting it from solid waste) offsets packaging disposal burdens for the packaging systems utilizing postconsumer recycled content. Text has been added to the report for clarification.

10. It would be helpful to provide a list of environmental emissions (data categories) that are inventoried.

Response: See response to Item 1 under **Major Recommendations** comments.

11. Emissions from combustion of packaging wastes were not modeled. This exclusion is understandable given the lack of material specific emissions data. Carbon dioxide emissions, however, could be estimated with reasonable certainty by assuming complete oxidation of the carbon content in each material.

Response: This is discussed in Chapter 1, under System Components Not Included, section Emissions from Combustion and Landfilling of Postconsumer Waste. This section notes that complete oxidation of the carbon content may not be an accurate representation of mixed MSW combustion (which often contains wet wastes and is burned with very low efficiency under less than ideal conditions for complete combustion to carbon dioxide). Because of the uncertainty in emissions data for MSW combustion, as well as for other end-of-life disposal options such as decomposition in landfills, it was decided not to include end-of-life atmospheric emissions in the analysis.

12. Overall Conclusions - General rule: any box system that is more than four times as heavy as a shipping bag will require more cradle to production energy than the shipping bag. This factor is two times for solid waste and greenhouse gas emissions. Energy and greenhouse gas emissions generally correlate well. Can you explain the difference between the factor four and factor two?

Response: The overall energy includes the energy of material resource, that is, the energy content of fuel resources used as material inputs to plastic products. This represents an energy content that does not result in combustion emissions. An explanation has been added to the comparative factor discussion in the Executive Summary and Chapter 3 of the report.

BODY OF REPORT

1. 1-1 (revised): Insert the phrase "shared allocation approach" somewhere here (the term is used on the next page without being defined).

Response: The term "shared allocation approach" has been inserted in the third sentence of the first paragraph of the Recycling section of Chapter 1.

2. Figure 1-1: The product recycling on this diagram should be labeled closed loop recycling and/or another arrow could be added to represent open loop recycling.

Response: The return lines on the figure labeled "Product Recycling" apply to both types of recycling; the difference between open-loop and closed-loop recycling is the number of cycles before the material is disposed. Wording has been added to the diagram to clarify this.

3. The functional unit should be specified with more detail. Packaging required to deliver 10,000 packages of mail-order soft goods to customers does not by itself indicate a well-defined system. Soft goods can range in size from heavy wool blankets to tee shirts. The package size and weight parameters, which are defined in the Appendix, should be summarized here (i.e. sooner in the report). The location of the distribution center and customer and the delivery distance should be indicated here as well as mass and volume of the product being delivered. ISO14040 1997 (E) defines the functional unit as a measure of the performance of the functional outputs of a product system. Specification of the functional unit consists of the magnitude and duration of service, including the product's life span. The purpose of the functional unit is to provide a reference to which the inventory data are related to ensure alternatives are compared on a common basis. For each product system or alternative being assessed, the amount of product necessary per functional unit is known as the reference flow (International Standards Organization 1998). Definition of the reference flows must include the type and quantity of materials and energy linked to the functional unit and the number of times materials must be replaced during the analysis lifetime. From Cooper, J.S. "Specifying Functional Units and Reference Flows for Comparable Alternatives," recently published in the IJLCA.

Response: Wording has been added to the Functional Unit section of Chapter 3 to clearly define the mass and volume of the representative soft goods order shipped as well as the locations of the order fulfillment center and customer and the shipping distance. While all chapters contain a Functional Unit section, Chapter 3 is the appropriate place to add the detailed functional unit description because this chapter is where the functional unit is applied (i.e., to weight the data modules developed in Chapter 2, using the LCI methodology described in Chapter 1).

Specify the base year.

Response: Added as requested, in Chapter 3 Functional Unit section.

4. 1-4: W is capitalized in "kwh"; should read kWh.

Response: Corrected.

5. Precombustion energy is not a common term used in energy analysis. Life cycle energy literature often uses the term "upstream energy" to refer to extraction, processing, and distribution. It may be useful to also include this term as a parenthetical note: (precombustion energy is also referred to in the literature as upstream energy).

Response: Suggested parenthetical note has been added at the first text reference to precombustion energy (Chapter 1, second paragraph in section **Energy Requirements**).

6. Energy embodied in wood is not inventoried. This convention was recommended in the US EPA LCI Guidance Manual. Alternatively, this energy source can be tracked separately and reported as a renewable energy.

Response: Chapter 1 clearly explains the reasoning why energy embodied in wood is not included in the inventory. In the United States, wood's predominant use is as a material input to wood and paper products. The use of wood as a material input does not result in a depletion of finite fuel resources; thus Franklin Associates' methodological approach does not include inventorying the embodied energy of wood-based products. However, wood-derived energy used in the production of paper products in included in the inventory, and the energy recovered through waste-to-energy incineration of disposed paper packaging is included in the net energy results.

7. Particulate matter - The analysts recognize the difficulty in obtaining particulate emissions data categorized by size range. The analysts should also indicate that PM 2.5 is now considered the size range of most concern for human health effects. A note of caution could be provided here stating that assessing environmental consequences of unclassified particulate emissions is challenging for several reasons.

Response: Because this analysis is limited to an inventory and does not include impact assessment, the issues of health and environmental consequences are beyond the scope of the report. However, some additional wording has been added for informational purposes.

8. Inclusion of Inputs and Outputs - "Any material less than one percent of the mass in the system is generally considered negligible." Clarify this rule. Exclusion of many smaller components by mass could result in a significant oversimplification and underestimation of the system burden. A cautionary note should also be provided indicating that the use of mass exclusion criteria could result in oversight of minor constituents that are highly toxic.

Response: Text has been added to this section to clarify.

9. Data quality – while we would like to some day be able to say something about accuracy, the methodology is not there yet. "In a complex study with literally thousands of numbers, the accuracy of the data and how it affects conclusions is truly a complex subject, and one that does not lend itself to standard error analysis techniques." This is true but techniques such as Monte Carlo analysis can be used to study uncertainty. The greatest challenge is the lack of uncertainty data or probability distributions for key parameters, which are often only available as single point estimates.

   "Each number by itself contributes little to the total, so the accuracy of each number by itself has a small effect on the overall accuracy of the total. " This is a bit overstated. Should reword: "by itself [may] contribute little to the total" It depends on the magnitude of the uncertainty for each parameter and the sensitivity of the final result to changes in each parameter.

   "It is assumed that with careful scrutiny of the data, any errors will be random. That is, some numbers will be a little high due to errors, and some will be slightly low, but in the summing process these errors cancel out." Such errors do not cancel out completely and will contribute to the overall uncertainty in the results.

Response: Revisions have made to text to address above suggestions and comments.

10. 1-11: While this introduces <u>some</u> subjectivity into the uncertainty analysis" Drop "some"

Response: Change made as suggested.

11. The DQI approach is the best available means for characterizing uncertainty given the scarcity of uncertainty data. Data quality indicators were reported with inventory modules presented in the appendix. It is not clear how the data quality indicators are used to create a stochastic model and how the output is a distribution of values.

Response: Because stochastic modeling was outside of the scope of this study, the data quality indicator discussion in this section was for informational purposes only and does not apply to the modeling approach used in this analysis. The text discussion of DQIs has thus been removed from Chapter 1 to avoid confusion.

12. The LCI traces energy and environmental emissions. Mineral resource extraction measured as the mass of ore mined is not inventoried. Available datasets often don't include minerals extracted and therefore the inclusion of this data category is not possible. While this might be the case, this limitation should be indicated.

Response: Individual unit process data sets in the full appendix document submitted to the peer reviewers include resource use (such as wood, ore, etc.) associated with the output product of each specific unit process. However, there was not a “rolled-up” weighted summary of upstream resource use based on each unit process’ contribution to the final output of packaging material. A public version of the appendices prepared under this project does include a “rolled-up” cradle-to-production table for each packaging material showing resource use per output of packaging material. (Note: The public appendices were prepared concurrently with the peer review and thus were not available to the peer reviewers; however, they contain no information that was not provided to the peer reviewers. The cradle-to-production tables are developed from the individual unit process data sets and material flow diagrams examined by the peer reviewers.)

13. Energy of Material Resources, already discussed above.

Response: See response to Item 6 under **Body of Report** comments.

14. 1- 12: “Critical review is specified in ISO standard 14040 as an optional component for LCA/LCI studies.” However, 14040 goes on to say that “a critical review shall be conducted for LCA studies used to make a comparative assertion that is disclosed to the public…”
    ISO 42 and 43 are for Impact Assessment and Interpretation, not dealing with Inventory.

Response: As suggested earlier, clarification has been made that this study complies with ISO standards for Life Cycle Inventory. While ISO 14040 does not specifically require peer review for LCIs, because this study will be publicly released the sponsor of the study wished to have the study peer reviewed in order to ensure that the study used a valid, ISO-compliant life cycle methodology. Wording has been added for clarification.

15. 1-17: It is acknowledged that this assumption may introduce some error.” Change to “will likely introduce error.”

Response: Changed as suggested.

16. Comparisons of LCA databases have shown that airborne and waterborne pollutant emissions for a particular material production inventory can easily vary by 200%. Energy and solid waste values are generally more agreeable between databases.

Response: Text has been added to the second paragraph of the Environmental Emissions section of Chapter 1. There is also a similar statement in the last paragraph on page 4 of Chapter 4.

17. “Half of the unpadded LLDPE area assumed to be produced overseas and imported to the West Coast” Indicate source for assumption.

Response: Of the two companies selling unpadded plastic shipping bags that provided data for this study, one produced bags domestically and one provided bags produced overseas. Text added to report.

18. Electricity - “Users of electricity, in general, cannot specify the fuels used to produce their share of the electric power grid.” This is changing with deregulation and users can purchase green power with a defined fuel mix. I do support the use of the average grid in modeling, given the often lack of data about fuel mixes.

No response required.

19. Emissions from combustion - “Theoretical carbon dioxide ….., however, this may not be an accurate representation of the results of mixed MSW combustion.” The carbon balance would expected to be reasonably accurate particularly in comparison to other data inputs.

Response: See response to Item 11 under **Executive Summary** comments.

20. Space conditioning is discussed in the Executive Summary section.

Response: See response to Item 5 under **Executive Summary** comments.

21. Secondary Packaging is discussed in the Executive Summary section. Exclusion can be significant as stated above.

Response: See response to Item 6 under **Executive Summary** comments.

22. 2-6: “fabrication scrap losses can have a significant effect on results.” This is certainly true, were they modeled here?

Response: See response to Item 3 under **Major Recommendations** comments.

23. Energy Results - Based on the uncertainty in the energy data, energy differences between systems are not considered significant unless the percent difference is greater than 10 percent. This is based on the judgment of the analysts but was not a calculated criterion. This should be stated as such.

Response: Wording has been added to clarify. Also, Chapter 4 has been added to the report to provide further background on Franklin Associates’ criteria for meaningful differences in LCI results, supported by statistical arguments.

24. 2-11: “Natural gas …in the generation of electricity” is repeated.

Response: The discussion in the first paragraph (heading “Energy Profiles”) describes all the different ways in which natural gas, petroleum, and coal contribute to energy results.

Subsequent statements refer to how these resources contribute to energy reported for specific packaging systems (e.g., paper-based and plastic).

25. 2-12: Solid Waste - Differences in solid waste results between systems are not considered significant unless the percent difference is greater than 25 percent. This is based on the judgment of the analysts but was not a calculated criterion. This should be stated as such.

Response: See response to Item 23 above.

26. Environmental Emissions - The analysts state clearly the large expected uncertainty associated with emissions results.

No response required.

27. No valid impact assessment methodology exists. TRACI is an impact assessment tool developed by US EPA which seems to contradict this statement.

Response: Many detailed impact assessment methodologies exist, including TRACI. However, there are inherent problems with using the output of LCIs as input for impact modeling. The output of an LCI is an aggregated summary of the total quantity of substances released over the life cycle of a product system. These emissions occur at different geographic locations, over different time periods, at different concentrations, with different human exposures, into different bodies of water, etc., and thus are inherently lacking the specificity necessary for a true evaluation of impacts on human health and the environment. This is not a criticism of any impact assessment methodology, but rather an acknowledgement of the limitations. Wording has been revised to reflect this.

28. 3-3 (revised): Omit the discussion on CO2 being part of the natural carbon cycle and a net contributor to global warming. It really goes beyond the scope of this study, which is an inventory analysis (and this is an impact-related conclusion), but also, it is repeated later on page3-6 (which is more appropriate being in the conclusions section).

Response: The detailed emissions tables (Tables 2-6 and 2-7, Tables 3-6 and 3-7) report fossil and non-fossil CO_2 separately. For consistency with the EPA, natural carbon cycle CO_2 (non-fossil) is not included in greenhouse gas calculations, but fossil CO_2 is included. It is this practitioner’s position that greenhouse gas calculations using IPCC global warming potentials are another inventory calculation and do not fall under the category of impact since no projections are made regarding actual global warming effects associated with emissions from packaging systems. The discussion of the shift from wood-derived CO_2 to fossil fuel-derived CO_2 with increased recycled content of paper(board) systems has been removed from the main emissions results section and retained in the conclusions section.

29. 3-6: Insert recycle content between lower and box in the last line of the first paragraph.

Response: Done.

30. 3-26: Chlorine and sulfur emissions were highest for the bag system, what process(es) might be accounting for these differences?

Response: These are associated with virgin bleached kraft production. An explanatory sentence has been added to this paragraph.

APPENDICES

In general the Appendices are well documented. References are clearly identified for each inventory module presented.

Appendix A

1. It would be helpful in Appendix A to provide a section that describes the temporal boundaries for modeling the energy systems. The range in years over which the energy systems and technologies are modeled and then specific information about key systems such as the fuel mix for the US grid.

Response: An initial overview statement has been added to the Appendix A Introduction: This version of Appendix A was last completely updated in 1998 using the most current data sources that were available at that time. Most of the public data sources for fuel use and emissions were 1995-1997 publications. Combustion energy values are 1995 values. Average fuel use for electricity generation is 1996 data. Crude oil production data are 1994 values, while refinery data are 1993 values. Specific sources of data on the production and combustion of each fuel and for electricity generation are clearly referenced in the text and tables, with full source information (including age) provided in the References section at the end of the appendix. Note to reviewers: At the same time that this packaging study was being conducted in 2003, Franklin Associates was updating our fuels and energy database; however, this update was not completed in time to use it for the packaging study.

2. The Scope section could also provide an overview of the data categories inventoried. Each inventory module presents environmental emissions but it is not clear how comprehensive the analysis was. Without a description, the reader can assume three possible cases for specific pollutants not listed: zero emissions, negligible emissions, or not reported due to lack of data.

Response: The level of completeness in emissions reporting is certainly a major area of uncertainty in LCIs, for exactly those reasons identified by the reviewer. Unfortunately, emissions data sources generally do not provide the information necessary to determine completeness of reporting. The practitioner can only work with the information that is available. However, as each unit process is analyzed, the data analyst researches the process and looks for obvious omissions in reporting or suspect data and follows up accordingly. These issues are discussed to some extent in Chapter 1 of the report, in the sections **Environmental Emissions, Methodology for [Process Data] Collection/Verification**, and **Data Accuracy**.

3. A clear definition for the solid waste data category would also be useful. What wastes are included here (e.g., hazardous solid wastes, industrial wastes, mining wastes excluding overburden?, municipal solid waste)

Response: Except for classifying wastes as hazardous, the reporting of process solid wastes may include any or all of these types of waste, depending on what is relevant for each unit process. Each unit process description writeup in the appendices provides a description of the types of solid waste that are associated with that process.

4. A-10: Method for allocating burdens to co-products from petroleum refining should be described.

Response: Allocation approach is described in the last paragraph of the Petroleum Refining section.

5. A-20: W is capitalized in "kwh"; should read kWh

Response: Corrected throughout appendices.

6. Minor correction 3413 should be changed to 3412 Btu/kWh

Response: Conversion factor can vary slightly depending on the source conversion table used. No change made.

7. A-23: Other renewables currently make up 2.1% of the net generation in the US for 2001 http://www.eia.doe.gov/neic/brochure/elecinfocard.html

Response: This appendix was based on 1997 data sources for fuel use for electricity generation, as can be seen from the Appendix A references for electricity.

8. A-23: I recommend changing "unconventional" energy sources to "renewable" energy sources.

Response: Text has been changed to read: Renewable energy sources other than hydroelectricity, such as geothermal energy, solar energy for steam generation, and biomass energy, produced less than one percent of the total electricity generated in the U.S. in 1996.

9. Non-utility generated electricity is currently about 11 percent of the total US electricity generation. Need to change “currently” to the year “199x” these data are applicable. The 2001 non-utility fraction is 30%.

Response: Text has been changed to read: In 1996, non-utility generated electricity was about 11 percent of the total ...

10. Glossary: Biomass definition. I recommend substituting the EIA definition: Biomass (as an energy source): Organic non-fossil material of biological origin constituting a renewable energy source.

Response: EIA definition added to original definition.

11. Glossary: Particulate Matter definition from EPA glossary (http://www.epa.gov/OCEPAterms/pterms.html)

PM-10/PM-2.5: PM 10 is measure of particles in the atmosphere with a diameter of less than ten or equal to a nominal 10 micrometers. PM-2.5 is a measure of smaller particles in the air. PM-10 has been the pollutant particulate level standard against which EPA has been measuring Clean Air Act compliance. On the basis of newer scientific findings, the Agency is considering regulations that will make PM-2.5 the new "standard".

Note: The NAAQS for PM2.5 were established in 1997.

Response: Glossary definition has been revised to include PM 2.5 information. Information is often not available to report LCI particulate emissions by particle size classification.

Appendix B

1. B-12: “While Pactiv would not divulge the exact composition of the bubble material, a representative did state that the nylon represents less than 5% of the material, by weight. Preliminary comparison of the burdens of nylon and polyethylene by Franklin Associates showed that modeling the bubble material as a LDPE/LLDPE/nylon blend would not yield significantly different results than modeling the bubble material without the nylon but would increase study costs.” This statement should be qualified since the material production inventories for LDPE and nylon are quite different. These differences become less significant when the nylon inventory is weighted for a 5% mass fraction.

Response: Text has been revised to clarify the material compositions modeled and to clarify that the statement is based on composition-weighted averages of the LCI burdens for the respective materials.

2. B-14: Couldn’t the product of 17.5 x 12 inches fit in the Stock #6 box? Was extra space provided for protection?

Response: It is assumed that this comment refers to the Stock #6 bag shown on the referenced page B-14. According to the study sponsor, while the length and width of the packaged product were within the #6 bag dimensions, the product height did not allow use of this bag.

3. B-18: Box void volume seems excessive but if that is the industry standard then model is valid. This could be a real opportunity for source reduction.

Response: Void volumes reflect packaging practices of experienced order fulfillment packaging staff and thus represent actual current industry practices. It is agreed that this could be an important opportunity for source reduction.

Appendix C

1. It is not clear whether the inventory modeling considered scrap from the fabrication of packaging. It is expected that scrap rates would be very low and in many cases less than one percent.

Response: See response to Item 3 under **Major Recommendations** comments

2. It would be useful to provide an inventory module that summarizes the cradle to gate environmental burdens for each packaging material. This would facilitate the comparison of results from this study with other material databases such as APME.

Response: See response to Item 12 under **Body of Report** comments.

3. C-37: Pesticides were not included in the inventory. Pesticide use in corn production can lead to significant environmental burdens. For example, atrizine used in corn production is a major contaminate of groundwater and surface water. A statement to this effect would be appropriate.

Response: Added.

Appendix D

1. D 16: This study focuses on the ground delivery of parcels. It is expected that many parcels are shipped by air. It would be interesting to explore the implications for the overall study results of shipping by air rather than ground.

Response: See response to Item 2 under **Major Recommendations** comments.

2. D19: The modeling of the allocation of transportation burdens needs to be more transparent. The source for the results presented in Table D-2 is clear but the next steps in determining the energy and environmental emissions should be described.

Response: Wording has been added to this section indicating that, based on the results in Table D-2, fuel use and emissions for transportation of packaged product were modeled based on the fuel economy for a volume-loaded vehicle rather than a fully weight-loaded vehicle.

Appendix E

1. The end of life system is very complex. This method presented is clear. A more comprehensive model of EOL was developed by RTI and involved Franklin Associates.

No response required.

PEER REVIEW PANEL QUALIFICATIONS

Curriculum Vitae

Mary Ann Curran
LCA Research Program Manager

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Ms. Curran directs the System Analysis Branch's Life Cycle Assessment (LCA) research program which includes the development of LCA methodology, the performance of life-cycle case studies, life-cycle workshops and conferences, and the development of a life cycle data directory website (www.epa.gov/ORD/NRMRL/lcaccess). As an expert in LCA, she provides technical support to several EPA offices in developing policy and regulations including guidelines for the federal procurement of environmentally-preferable products.

Ms. Curran also provides technical review and assistance to outside groups on clean product design and development. She has participated in the technical peer review of industry-sponsored life-cycle studies, including electricity, diapers, cleaners, plastics, coal ash, and building products. She represents the Agency in two international activities for establishing LCA-based guidance: the International Standards Organisation (ISO) LCA subcommittee and the Canadian Standards Association (CSA) life-cycle design committee. Ms. Curran works closely with the Society of Environmental Toxicology and Chemistry (SETAC), which has been instrumental in advancing LCA awareness, and serving on the advisory committee for the development of a North American database. She also serves on the editorial boards of the *International Journal of Life Cycle Assessment* and *Environmental Progress,* as well as on the Executive Committee for the American Center for Life Cycle Assessment.

Since 1990, Ms. Curran has authored and co-authored numerous papers which address LCA concepts and applications. She has presented EPA's activities in LCA-related research at technical meetings across the U.S. and in Europe. She co-authored and edited a book entitled "Environmental Life Cycle Assessment" which was published by McGraw-Hill in July 1996.

Ms. Curran has been with the EPA's Office of Research and Development since 1980. She holds a Masters degree in Environmental Management and Policy from the International Institute for Industrial Environmental Economics (IIIEE) at Lund University, Lund, Sweden (1996) and a Bachelor of Science degree in Chemical Engineering, from the University of Cincinnati, Cincinnati, Ohio (1980).

Curriculum Vitae

Joyce Smith Cooper, PhD
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Dr. Cooper has been a key researcher in Life Cycle Assessment as well as a faculty member of the University of Washington. She has developed LCA curriculum for University level courses. Curriculum development focuses on the use of LCA in an interdisciplinary Design for the Environment course for seniors and graduate students. She has also been a key participant in the establishment of ACLCA (American Center for Life Cycle Assessment).

Dr. Cooper's LCA experience includes methodological advances focusing on specification of functional units and reference flows for comparable alternatives, integration of LCA into the product design process, and process and materials selection.

Her case study experience has focused on emerging technologies such as advanced aircraft and automotive materials and fuel cells.

In addition, Dr. Cooper has achieved excellent teaching effectiveness ratings including courses in sustainability and design for the environment.

Her publications include 12 refereed archival journal publications, 8 refereed conference papers and articles, and 8 project reports, most of which are LCAs. In addition, she is an advocate of the use of LCA in design and of a structured LCA peer review process.

Prior to joining the University of Washington faculty she worked in the private sector for Battelle Memorial Institute, Research Triangle Institute, University of Tennessee Center for Clean Products, Polaroid Corporation, and E-Systems.

Dr. Cooper holds a BS in Mechanical Engineering from Rensselaer Polytechnic Institute (1987), an MS in Environmental Engineering from Duke University (1991), and a PhD in Environmental Engineering from Duke University (1996).

Curriculum Vitae

Gregory A. Keoleian, PhD
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Dr. Keoleian as Co-Director of the Center for Sustainable Systems is directly involved in the primary mission of the Center which is to organize and lead interdisciplinary research and education on the application of life cycle based models and sustainability metrics.

He has been involved in teaching and research at the University of Michigan for over 20 years, and has an impressive list of accomplishments in Life Cycle Inventory (LCI)/Life Cycle Assessment (LCA) and related fields. He has been principal investigator on 29 funded research projects totaling over $3 million since 1989. Nine of these projects involved LCI/LCA projects, and the balance are in related areas such as design for the environment, pollution prevention, and industrial ecology. In addition, Dr. Keoleian has authored or co-authored more than 100 articles and papers for professional journals, peer reviewed technical reports, technical papers, plus presentations at conferences and workshops. Finally, he has authored or co-authored books or chapters in books on the subject of Life Cycle Assessment, industrial ecology, and pollution prevention. In short, he has been a leader in the fields of LCA, pollution prevention, and industrial technology.

Dr. Keoleian has also been a peer reviewer for a number of LCI/LCA reports.

Dr. Keoleian has BS degrees in Chemical Engineering and Chemistry (1980), a MS degree in chemical engineering (1982), and a PhD in Chemical Engineering (1987) all from the University of Michigan.