FINAL REPORT

Marks & Spencer Plc

Streamlined LCA Study of Sandwich Packaging Systems

January 2003

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For and on behalf of
Environmental Resources Management

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Position: PARTNER

Date: 27th JANUARY 2003

EXECUTIVE SUMMARY

Introduction

This report details the results of the Streamlined Life Cycle Assessment (LCA) Study conducted for Marks and Spencer Plc.

The purpose of the study is to compare the energy and waste footprint for cardboard and plastic packaging for sandwiches. The 'cradle-to-grave' energy consumption and waste generation for each packaging system has been identified and quantified and environmental profiles produced.

The study quantifies the energy and waste footprint resulting from the production of raw materials and energy, the manufacture, transport and sale, and the use of the packaging.

Energy consumption associated with the packaging has been traced back to resources extracted from the environment. Energy consumption has therefore been reported as extracted energy and relates to the calorific value of the resources extracted.

Waste that can be attributed to the packaging or failure of the packaging at each stage of the life cycle has been determined.

Life Cycle Waste and Energy Profiles

Table 1 details the waste generated from each life cycle stage for each packaging type.

Table 1 ***Life Cycle Waste Profiles for the Two Packaging Systems per Tonne of Sandwiches Dispatched for Retail***

Life Cycle Stage	**Plastic Skillet kg**	**Cardboard Skillet kg**
Packaging Production	10.3	14.1
Transport to Packing Plant	0.0	0
Packaging Plant	15.3	15.5
Post Dispatch Waste	84.1	68.3
Waste associated with wasted Product	2.5	2.5
Total	112.2	100.4
Recycling Benefit	-4.8	0.0
System Total	**107.4**	**100.42**
Non-biodegradable Waste	**87**	**24**

The results show that there is little to choose between the two systems in terms of total waste. However, the cardboard system, as would be expected, results in a lower amount of residual non-biodegradable waste.

Table 2 details the extracted energy consumption from each life cycle stage for each packaging type.

The results show that the plastic skillet performs marginally better than the cardboard skillet system.

Table 2 ***Life Cycle Energy Profiles for the Two Packaging Systems per Tonne of Sandwiches Dispatched for Retail***

Life Cycle Stage	**Plastic Skillet MJ**	**Cardboard Skillet MJ**
Packaging Production	8094.3	8310.3
Transport to Packing Plant	10.9	9.0
Packaging Plant	219.4	0.0
Energy Consumption Associated with Wasted Product	517.3	517.3
Total	**8841.9**	**8836.6**
Recycling Benefit	-449.0	0.0
System Total	**8392.9**	**8836.6**

Conclusions

In terms of total waste and extracted energy, there is little difference in the systems. However, the assumptions made with regard to the performance of the systems post dispatch to Marks & Spencer (assumed to be the same for both systems), and the assumptions made regarding the production of cardboard skillets, mean that no firm conclusions can be drawn.

Before recommendations can be made, real case data needs to be obtained to assess the cardboard system.

The study demonstrates that packaging contributes less than 14% of the extracted energy associated with the production of the packaging materials and the sandwiches.

CONTENTS

1 INTRODUCTION

This report details the results of the Streamlined Life Cycle Assessment (LCA) Study conducted for Marks and Spencer Plc.

The purpose of the study is to compare the energy and waste footprint for cardboard and plastic packaging for sandwiches. The 'cradle-to-grave' energy consumption and waste generation for each packaging system, has been identified and quantified and environmental profiles produced.

The study quantifies the energy and waste footprint resulting from the production of raw materials and energy, the manufacture, transport and sale, and use of the packaging.

Energy consumption associated with the packaging has been traced back to resources extracted from the environment. Energy consumption has therefore been reported as extracted energy and relates to the calorific value of the resources extracted.

Waste that can be attributed to the packaging, or failure of the packaging, at each stage of the life cycle has been determined.

1.1 INTRODUCING LIFE CYCLE ASSESSMENT

Business interacts with the environment through a number of routes:

- the production and supply of materials and energies they use;
- their business operations;
- the disposal of wastes; and
- the use and disposal of their products.

At each of these stages in the life cycle, natural resources are consumed and emissions (to air, water and land) released to the environment. This view of a business is referred to as the environmental footprint.

Life Cycle Assessment (LCA) is a standardised methodology allowing practitioners to trace back to the environment all of the resources consumed and all of the emissions to air, water and land, at each stage in the manufacture, use and disposal of products. These exchanges with the environment are then related to potential environmental impacts such as global warming, resource depletion and ozone depletion.

1.1.1 Streamlined LCAs

In streamlined LCA, the study scope is restricted in order to target specific issues or aspects of the footprint. Restricting the extent of the system studied, the resolution of the data collected or the range of environmental impacts/issues to be addressed, facilitates the use of LCA as a management tool. When conducting comparisons, it is only necessary to assess differences in the systems studied. In this way, a study can be streamlined without affecting the results of the study.

Streamlined LCAs provide valuable information about key stages of the life cycle or specific issues, such as the energy, global warming and resource depletion footprint of a company without requiring the resources of a full LCA.

1.2 THE JUSTIFICATION FOR USING A LIFE CYCLE APPROACH

By taking a life cycle approach, the benefits and dis-benefits of packaging choice can be realised.

Packaging provides a positive service in protecting food and goods during storage, distribution, retail and storage in the home. This service results in environmental benefit, as it protects the resources that have been expended in producing the packaged product. However, the manufacture and use of packaging results in environmental impact.

To make informed decisions regarding the use of packaging, it is essential to have a complete picture of packaging systems, both of the packaging itself and the product it is going to contain. Only LCA can provide this holistic function. The balance of environmental impact between packaging and product is not the only factor in making packaging decisions. Both packaging and product serve economic functions; they generate income and point of sale packaging provides an advertising function to assist in the sale of the product. An objective of managers, with regard to the environmental performance of packaging systems, is to minimise the environmental impacts while maintaining or improving the advertising and protection functions of packaging.

2 GOAL AND SCOPE OF THE LIFE CYCLE ASSESSMENT

The objective of the study was to quantify the lifetime energy consumption and waste generation of two packaging systems for sandwiches. The study determined the significance of each life cycle stage and informs Marks and Spencer Plc (M&S) of the implications of packaging choices, for the life cycle energy and the waste burden associated with each packaging system.

The scope defines the boundaries of the systems to be studied, the data required, the functional unit and any assumptions and limitations.

The packaging systems to be assessed were specified by M&S as:

- plastic skillet; and
- cardboard skillet.

The study will be used to inform packaging choice.

This study has not been subjected to external peer review.

The functional unit for the study was the dispatch of 1000 kg of 'ham, cheese and pickle sandwiches'.

2.1 THE SYSTEM BOUNDARIES

The system boundary separates the system of interest from the technosphere (economic system outside the system of interest) and the natural environment.

Defining the system boundary addresses what is included and excluded from the system under study.

The system diagram for the packaging systems is provided graphically in *Figure 2.1.*

The following life cycle stages have been included:

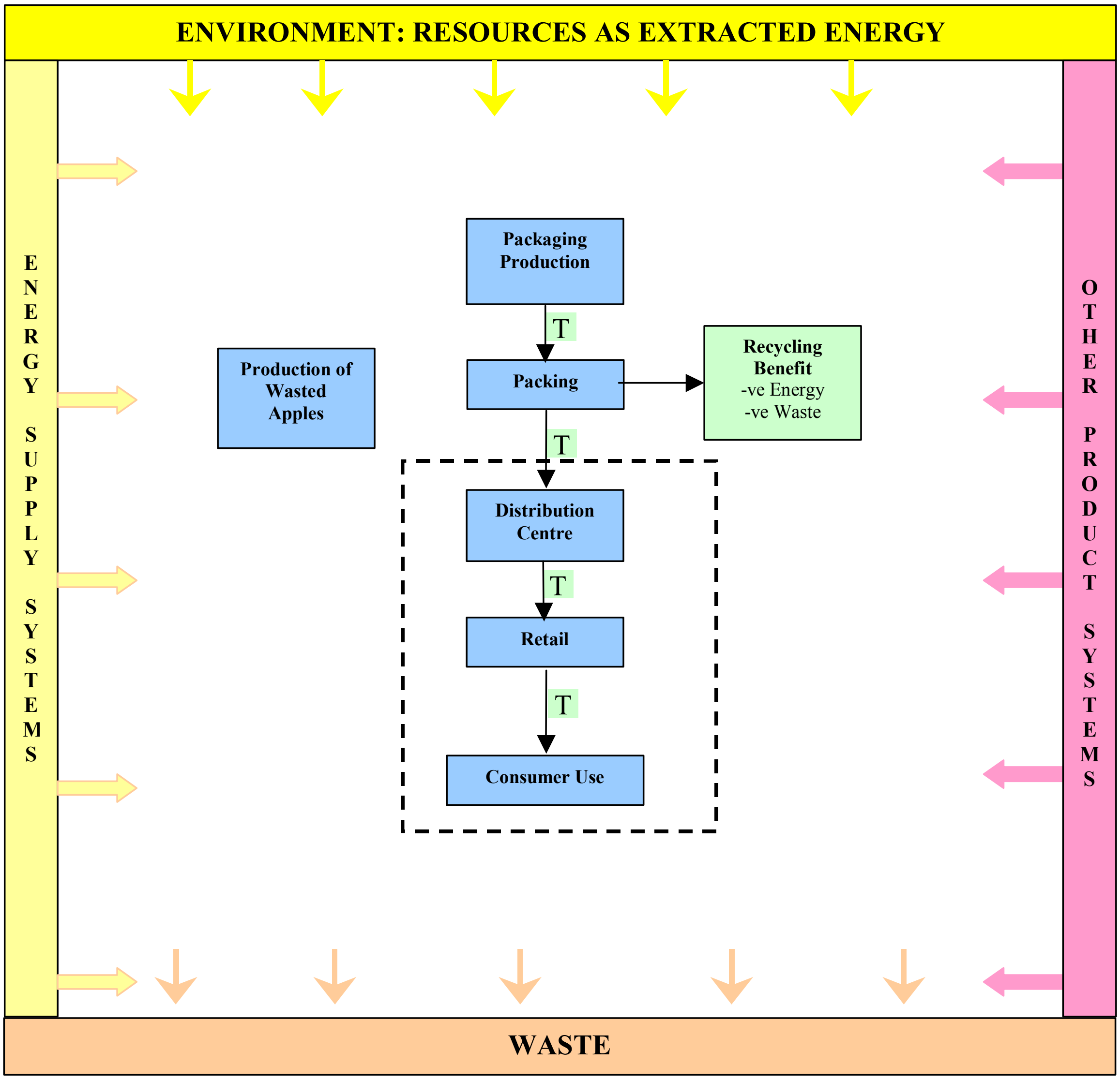
- extraction of resources and production of materials;
- transport; and
- packing and filling.

The two packaging systems perform the same function, the shelf life of the sandwich is the same for both. As the cardboard packaging system is hypothetical, we will assume that it performs the same protection function as the plastic wedge.

Post packing, there is no difference in the systems with the exception of weight and type of waste generated. We have therefore excluded the energy consumption of these stages and addressed solely the weight and type of waste generated as a result of the sandwich packaging materials.

End of life disposal has been excluded due to the insignificance of energy consumption associated with disposal in comparison with other life cycle stages and because waste has been assessed as the end point.

Figure 2.1 *System Diagram*



3 POLYSTYRENE SANDWICH WEDGE

3.1 SYSTEM DESCRIPTION

Polystyrene sheet is supplied to the sandwich making plant where it is formed into a wedge (skillet). Once formed, an information card and a sandwich are inserted into the wedge. The wedge is then film sealed and a label attached. The filled skillets are then placed on display trays (polypropylene), twelve per tray. These are loaded into reusable transit boxes and shipped to Marks & Spencer distribution centres, before being dispatched to stores. In the stores, they are placed on the shelves in the display trays. The display trays are discarded once empty. Polystyrene wastage from the packing plant is sent for recycling.

Table 3.1 details the weights of the different packaging items.

Table 3.1 Packaging Weights

Packaging Component	Material	Weight g
Skillet (wedge)	Polystyrene	10
Film Window	OAP-PE	3
Card insert	Card	1
Label	Paper	0.5
Display tray	Polypropylene	50
Transit crate	PP	2033

Figure 3.1 details the material flow and wastage for the system.

3.2 SANDWICH PRODUCTION

Table 3.2 details the extracted energy associated with the production of ingredients for the most popular sandwich; 'Ham cheese and pickle upgrade sandwich' (70 mm skillet). The extracted energies detailed are estimates based on previous studies of food production. It has not been possible to determine the waste generated as a result of production and processing activities for each ingredient. However, a figure of 20% does not seem unreasonable.

Figure 3.1 Material Flow for Plastic Sandwich Packaging

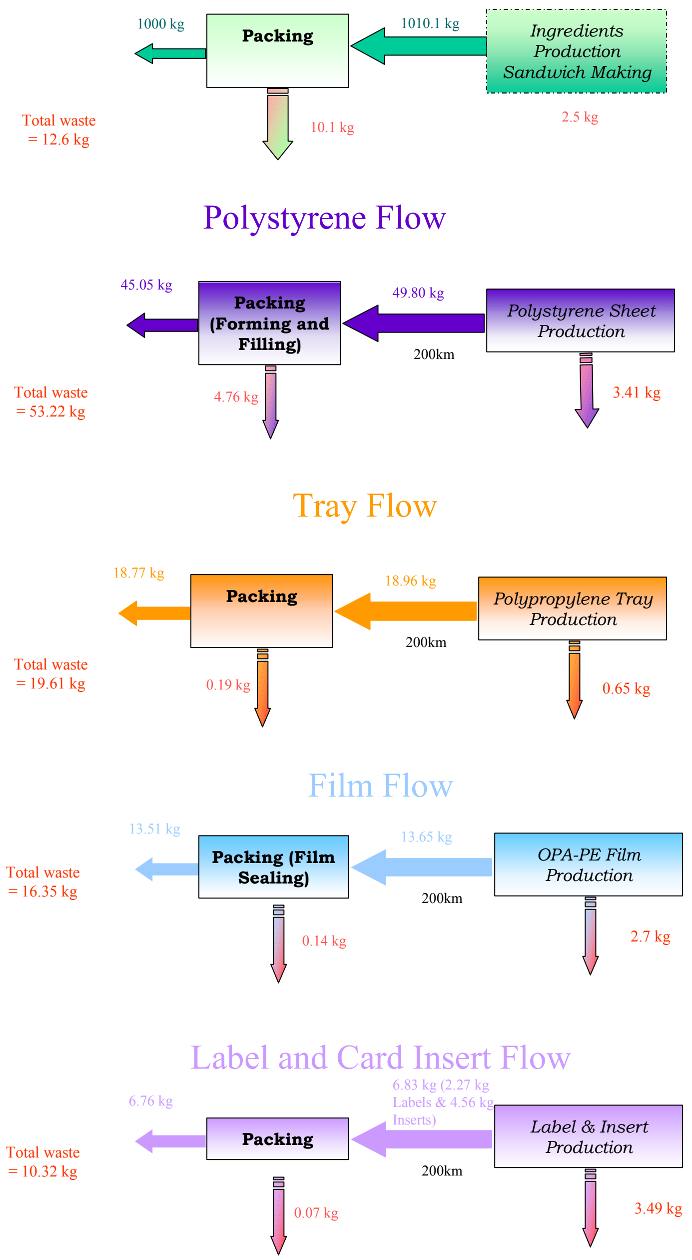


Table 3.2 *Extracted Energy Associated with the Production of the Ingredients for the Popular Ham, Cheese and Pickle Sandwich (70 mm Skillet)*

Ingredient	Extracted Energy MJ per kg	Average Extracted Energy MJ/kg	Weight of Ingredient per Tonne of Sandwiches kg	Extracted Energy per Tonne of Sandwiches
Bread	13 – 44	28.5	360	10 270
Lettuce	3.4 – 160	81.7	90	7360
Ham	46.2 – 95.2	70.7	230	16 242
Pickle	No data: Assumed average of other ingredients	57.7	77	4418
Cheese	38 – 62	50	144	7207
Mayonnaise	No data: Assumed average of other ingredients	57.7	99	5718
Total				**51 216**

Source of data: Energy Use in The Food Sector, Swiss Federal Institute of Technology

3.3 PACKAGING PRODUCTION (AS DELIVERED TO SANDWICH MANUFACTURER)

3.3.1 Polystyrene Sheet Production

The skillets are formed from polystyrene sheet, at the sandwich production plant. For the purposes of this study, we have assumed that the polystyrene sheet is produced from High Impact Polystyrene (HIPS) resin. Data from APME detailing the energy requirements and solid waste generation associated with the production of HIPS has been used (Eco-profiles of the European Plastics Industry: Report 4, 1993) together with the fabrication data for PVC sheet, which have been adjusted by 20% to account for higher energy requirements of PS (*Eco-profiles of the European Plastics Industry: Report 10, 1997*). Extracted energy per kg of sheet produced equates to 116 MJ, plastic waste per kg of sheet equates to 0.0034 kg, and solid waste generation from the production of the resin equates to 0.065 kg per kg of sheet.

The solid waste burden associated with the production of the 49.80 kg of sheet entering the packing plant equates to 3.41 kg.

The extracted energy burden associated with the production of the 49.80 kg of film entering the packing plant equates to 5776.8 MJ.

3.3.2 OPA-PE Film (Oriented Nylon(OPA) and Polyethylene (PE) laminate film)

For the purposes of this study, we have assumed that the film is a 50/50 split between the two.

The production of nylon resin consumes 143 MJ extracted energy per kg and generates 0.31 kg of waste (*Eco-profiles of the European Plastics Industry: Report 66, 1997*).

The production of low density polyethylene polymer consumes 88.55 MJ per kg, and solid waste generation from the production equates to 0.039 kg per kg (*Eco-profiles of the European Plastics Industry: Report 3, 1993*).

We have used data for LDPE film production to estimate energy consumption associated with OPA-PE film production. The production of LDPE film consumes 6 MJ of extracted energy per kg of film produced and resin wastage is approximately 2% (*Eco-profiles of the European Plastics Industry: Report 10, 1997*).

The data above results in an extracted energy consumption of 124 MJ and 0.198 kg of solid waste per kg of film produced.

The solid waste burden associated with the production of the 13.65 kg of film entering the packing plant equates to 2.7 kg.

The extracted energy burden associated with the production of the 13.65 kg of film entering the packing plant equates to 1693 MJ.

3.3.3 Polypropylene Tray Manufacture

The trays are formed from polypropylene sheet and delivered to the sandwich making plant. Data from APME detailing the energy requirements and solid waste generation associated with the production of HIPS has been used (*Eco-profiles of the European Plastics Industry: Report 4, 1993*) together with the fabrication data for PVC sheet which have been adjusted by 80% to account for higher energy requirements of PP, (*Eco-profiles of the European Plastics Industry: Report 10, 1997*) and generic APME forming data. The APME forming data suggests that forming of sheet into a product consumes 80% of sheet forming energy. Extracted energy per kg of polypropylene trays would therefore equate to 105.37 MJ, plastic waste per kg of trays equates to 0.0034 kg, and solid waste generation from the production of the resin equates to 0.031 kg per kg of sheet.

The solid waste burden associated with the production of the 18.96 kg of trays entering the packing plant equates to 0.65 kg.

The extracted energy burden associated with the production of the 18.96 kg of trays entering the packing plant equates to 1997.8 MJ.

3.3.4 Label Manufacture

The extracted energy, 91.5 MJ/kg, and solid waste generation, 0.51 kg/kg, for 'paper- coated bleached' (source: *PEMS)* has been used to estimate the energy associated with the labels.

The solid waste burden associated with the production of the 2.27 kg of labels entering the packing plant equates to 1.16 kg.

The extracted energy burden associated with the production of the 2.27 kg of labels entering the packing plant equates to 207.7 MJ.

3.3.5 *Card Insert Manufacture*

The extracted energy, 91.5 MJ/kg, and solid waste generation, 0.51 kg/kg, for 'paper- LDPE Laminated coated bleached' (*Pira International, PEMS software)* has been used to estimate the energy associated with the labels.

The solid waste burden associated with the production of the 4.56 kg of inserts entering the packing plant equates to 2.33 kg.

The extracted energy burden associated with the production of the 4.56 kg of labels entering the packing plant equates to 417.24 MJ.

3.3.6 *Reusable Transit Box/Crate*

As the use of crates will be the same for both packaging systems these have been excluded from the study.

3.4 *BURDEN ASSOCIATED WITH TRANSPORT*

For the purposes of this study, it has been assumed that the packaging materials are transported 200 miles to the packing plant.

For the purposes of bulk transport, we have used an extracted energy use of 0.608 MJ per tonne-km.

Table 3.3 ***Transport Energy Use***

Component	From-To	Weight Kg	Distance km	Tonne - km	Energy MJ
Packing Materials	Manufacture to Packaging Plant	89.24	200	17.85	10.85

3.5 *PACKING ACTIVITIES*

The forming of 70 mm polystyrene skillets consumes 1.138 MJ of electricity per kg of skillets produced. This equates to 4.87 MJ extracted energy per kg.

The extracted energy burden associated with the production of the 45.05 kg of skillets entering equates to 219.4 MJ.

3.6 *RECYCLING BENEFIT*

The 4.76 kg of polystyrene is recycled. The production of recycled granulate consumes 7.06 MJ extracted energy per kg (*Delft University of Technology,* *1996*). The production of virgin polystyrene polymer consumes 101.38 MJ kg. The net saving associated with recycling 4.76 kg of waste polystyrene is therefore 448.96 MJ.

3.7 POST PACKING WASTAGE

With the exception of reusable trays, all sandwich packaging is discarded. This amounts to 84 kg per tonne of sandwiches dispatched for sale.

3.8 BURDEN ASSOCIATED WITH WASTED SANDWICHES

Sandwich waste totals 10.1 kg per tonne of sandwiches dispatched for sale.

The extracted energy consumed in producing the wasted sandwich ingredients equates to 517.3 MJ. Solid waste associated with producing the wasted sandwich ingredients equates to 2.5 kg.

4 CARDBOARD PACKAGING

4.1 SYSTEM DESCRIPTION

The sandwich skillets would be delivered to the sandwich making plant as unfolded die cut cardboard with window pre-glued. The pre-forms would be folded and the sandwich inserted. The filled skillets are then placed on display trays (polypropylene), twelve per tray. These are loaded into reusable transit boxes and shipped to Marks & Spencer distribution centres, from which they are dispatched to stores. In the stores, they are placed on the shelves in the display trays. The display trays are discarded once empty.

4.2 PACKAGING WEIGHTS

4.2.1 *Weight of a Cardboard Skillet*

ERM conducted a survey of cardboard wedges (60-80 mm) and found the weights to range between 10 and 14 g.

For this study we have assumed that the weight of cardboard in a skillet is 10 g and the film window is 1 g. The cardboard is assumed to have a polyethylene coating.

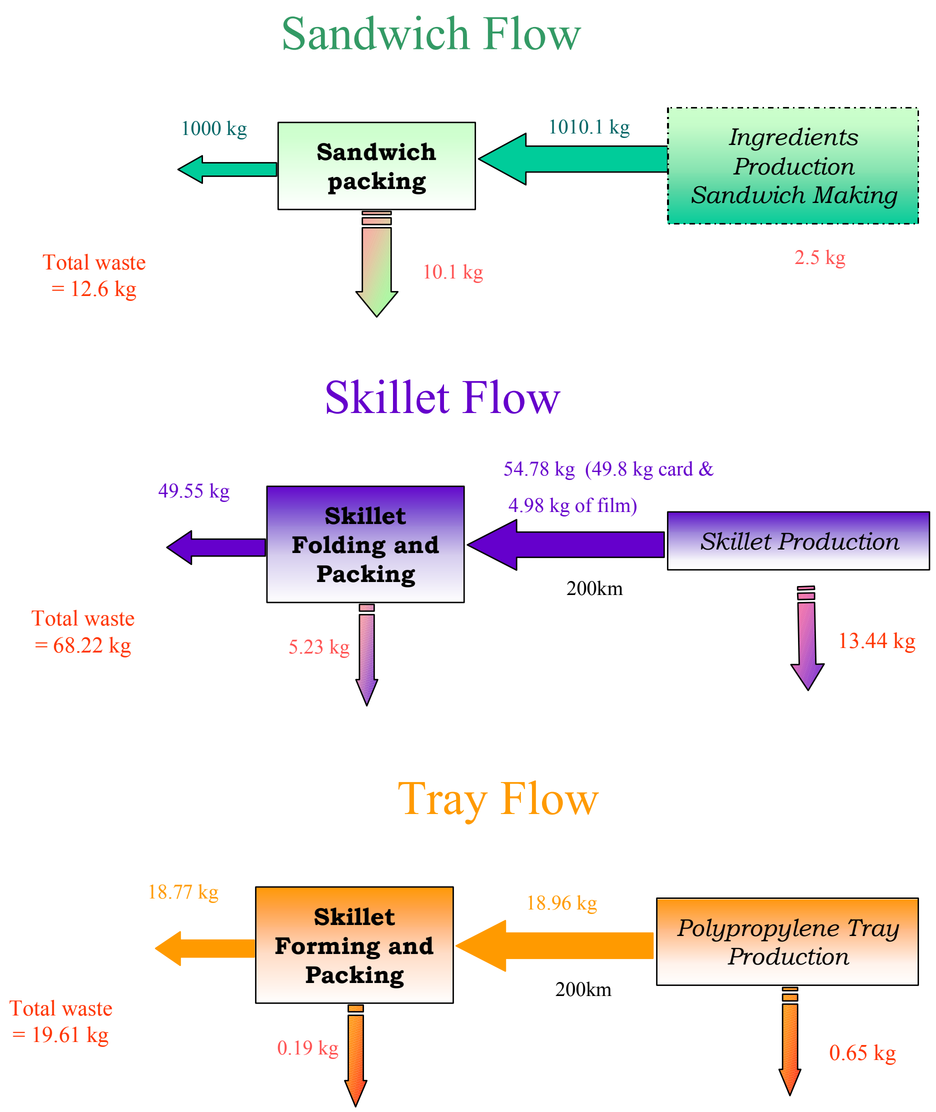
4.2.2 *Weights of Packaging Components*

Table 4.1 Packaging Weights

Packaging Component	Material	Weight g
Skillet (wedge)	Card	10
Film Window	OAP-PE	1
Display tray	Polypropylene	50
Transit crate	PP	2033

Figure 4.1 details the material flow and wastes for the system.

Figure 4.1 Material Flow for Cardboard Packaging System



4.3 SANDWICH PRODUCTION

The table below details the extracted energy associated with the production of ingredients for the most popular sandwich 'Ham cheese and pickle upgrade sandwich' (70 mm skillet). The extracted energies detailed are estimates based on previous studies of food production. It has not been possible to determine the waste generated as a result of production and processing activities for each ingredient. However, a figure of 20% does not seem unreasonable.

Table 4.2 Extracted Energy Associated with the Production of the Ingredients for the Popular Ham, Cheese and Pickle Sandwich (70 mm Skillet)

Ingredient	Extracted Energy MJ per kg	Average Extracted Energy MJ/kg	Weight of Ingredient per Tonne of Sandwiches kg	Extracted Energy per Tonne of Sandwiches
Bread	13 – 44	28.5	360	10 270
Lettuce	3.4 – 160	81.7	90	7360
Ham	46.2 – 95.2	70.7	230	16 242
Pickle	No data: Assumed average of other ingredients	57.7	77	4418
Cheese	38 – 62	50	144	7207
Mayonnaise	No data: Assumed average of other ingredients	57.7	99	5718
				51 216

Source of data: Energy Use in The Food Sector, Swiss Federal Institute of Technology

4.4 PRODUCTION OF CARDBOARD SKILLET

4.4.1 Die Cut Printed Laminated Cardboard

The extracted energy, 91.5 MJ/kg, and solid waste generation, 0.51 kg/kg, for 'paper- LDPE Laminated coated bleached' (*Pira International, PEMS software)* has been used to estimate the energy associated with the cardboard skillet.

Energy use for die cutting and creasing has been ignored as a survey of cutting and folding machines suggests an extracted energy use of less than 1MJ per kg of cardboard sheet processed. However, material loss of 20% has been assumed for this process (the window being the major source of loss).

The solid waste burden associated with the production of the 49.8 kg of die cut cardboard equates to 12.45 kg (62.25 kg of cardboard sheet entering the cutting process).

The extracted energy burden associated with the production of 62.25 kg of cardboard equates to 5695 MJ.

4.4.2 Window

For the purposes of this study, we have assumed that the window is the same material as that used for the plastic skillets OPA-PE film (Oriented Nylon(OPA) and Polyethylene (PE) laminate film) (we have assumed a 50:50 split).

The production of nylon resin consumes 143 MJ extracted energy per kg and generates 0.31 kg of waste (*Eco-profiles of the European Plastics Industry: Report 66, 1997*).

The production of low density polyethylene polymer consumes 88.55 MJ per kg, solid waste generation from the production equates to 0.039 kg per kg (*Eco-profiles of the European Plastics Industry: Report 3, 1993*).

We have used data for LDPE film production to estimate energy consumption associated with OPA-PE film production. The production of LDPE film consumes 6 MJ of extracted energy per kg of film produced and resin wastage is approximately 2% (*Eco-profiles of the European Plastics Industry: Report 10, 1997*).

The data above results in an extracted energy consumption of 124 MJ and 0.198 kg of solid waste per kg of film produced.

The solid waste burden associated with the production of 4.98 kg of film equates to 0.99 kg

The extracted energy burden associated with the production of 4.98 kg of film for the windows equates to 617.5 MJ.

4.4.3 *Summary of Skillet Production*

The extracted energy burden associated with the production of 54.78 kg of skillets entering the packing plant equates to 6312.5 MJ.

The solid waste burden associated with the production of 54.78 kg of skillets entering the packing plant equates to 13.44 kg.

4.4.4 *Polypropylene Tray Manufacture*

The trays are formed from polypropylene sheet and delivered to the sandwich making plant. Data from APME detailing the energy requirements and solid waste generation associated with the production of HIPS has been used (*Eco-profiles of the European Plastics Industry: Report 4, 1993*) together with the fabrication data for PVC sheet which have been adjusted by 80% to account for higher energy requirements of PP (*Eco-profiles of the European Plastics Industry: Report 10, 1997*) and generic APME forming data. The APME forming data suggests that forming of sheet into a product consumes 80% of sheet forming energy. Extracted energy per kg of polypropylene trays would therefore equate to 105.37 MJ, plastic waste per kg of trays equates to 0.0034 kg, solid waste generation from the production of the resin equates to 0.031 kg per kg of sheet.

The solid waste burden associated with the production of the 18.96 kg of trays entering the packing plant equates to 0.65 kg.

The extracted energy burden associated with the production of the 18.96 kg of trays entering the packing plant equates to 1997.8 MJ.

4.4.5 *Reusable Transit Box/Crate*

As the use of crates will be the same for both packaging systems these have been excluded from the study.

4.5 BURDEN ASSOCIATED WITH TRANSPORT

For the purposes of this study, it has been assumed that the packaging materials are transported 200 miles to the packing plant.

For the purposes of bulk transport, we have used an extracted energy use of 0.608MJ per tonne-km.

Table 4.3 *Transport Energy Use*

Component	From-To	Weight Kg	Distance km	tonne -km	Energy MJ
Packing Materials	Manufacture to Packaging Plant	73.74	200	14.75	8.97

4.6 PACKING ACTIVITIES

The folding and filling of the cardboard skillets would be done manually.

4.7 POST PACKING WASTAGE

With the exception of reusable trays all sandwich packaging is discarded. This amounts to 68.32 kg per tonne of sandwiches dispatched for sale.

4.8 BURDEN ASSOCIATED WITH WASTED SANDWICHES

Sandwich waste totals 10.1 kg per tonne of sandwiches dispatched for sale.

The extracted energy consumed in producing the wasted sandwich ingredients equates to 517.3 MJ. Solid waste associated with producing the wasted sandwich ingredients equates to 2.5 kg.

5 LIFE CYCLE WASTE PROFILE

The table below details the waste generated from each life cycle stage for each packaging type.

The results show that there is little to choose between the two systems in terms of total waste. The difference between the systems is within the margin of error on the basis of the assumptions made. However, the cardboard system, as would be expected, results in a lower amount of residual non-biodegradable waste.

Table 5.1 Life Cycle Waste Profiles for the Two Packaging Systems per Tonne of Sandwiches for Retail

Life Cycle Stage	Plastic Skillet Kg	Cardboard Skillet Kg
Packaging Production	10.3	14.1
Transport to Packing Plant	0.0	0
Packaging Plant	15.3	15.5
Post Dispatch Waste	84.1	68.3
Waste associated with wasted Product	2.5	2.5
Total	112.2	100.4
Recycling Benefit	-4.8	0.0
System Total	**107.4.**	**100.42**
Non-biodegradable Waste	**87**	**24**

6 LIFE CYCLE ENERGY PROFILE

The table below details the extracted energy consumption from each life cycle stage for each packaging type.

The results show that the cardboard skillet performs marginally worse than the plastic system. The difference between the systems is within the margin of error though and a clear conclusion cannot be drawn. The cardboard system is a hypothetical system and the assumptions made, though reasonable, lack robustness.

Table 6.1 Life Cycle Energy Profiles for the Two Packaging Systems per Tonne of Sandwiches Dispatched for Retail

Life Cycle Stage	Plastic Skillet MJ	Cardboard Skillet MJ
Packaging Production	8094.3	8310.3
Transport to Packing Plant	10.9	9.0
Packaging Plant	219.4	0.0
Energy Consumption Associated with Wasted Product	517.3	517.3
Total	**8841.9**	**8836.6**
Recycling Benefit	-449.0	0.0
System Total	**8392.9**	**8836.6**

7 THE IMPLICATIONS OF USING BIODEGRADEABLE PLASTICS AS AN ALTERNATIVE TO THE POLYSTYRENE SKILLETS

The extracted energy associated with the production of biodegradable plastics is considerably lower than that associated with the manufacture of petroleum based polymers.

The extracted energy associated with the production of the plastic skillet and film totalled 7469 MJ (49.80 kg of PS sheet and 18.96 OPA-PE film).

Data from Novamont S.p.A. detailing the energy requirements and solid waste generation associated with the production of biodegradable film has been used to assess/estimate the likely effect of a switch to biodegradable skillets. Energy per kg of film packaging is 60.73 MJ and waste generation is 0.13 kg per kg of film packaging (0.06kg of special waste and 0.07 of non-dangerous waste). On the basis of the above extracted energy burden, the reduction in energy consumption would be in the region of 3000 MJ. The reduction in non-biodegradable waste would be in the region of 70 kg. A change to biodegradable plastic would result in the plastic system performing better than the cardboard system for both extracted energy and waste generation.

8 CONCLUSIONS

In terms of total waste and extracted energy, there is little difference in the systems. However, the assumptions made with regard to the performance of the systems post dispatch to Marks & Spencer (assumed to be the same for both systems) and the assumptions made regarding the production of cardboard skillets mean that no firm conclusions can be drawn. It is reasonable to assume that the performance of cardboard skillets would be marginally worse than that of plastic skillets due to robustness both in folding and packing and in handling post dispatch. If this were the case, then the plastic skillets would become the preferred option in terms of both extracted energy and total waste.

Before a firm recommendation can be made real case data needs to be obtained to assess the cardboard system.

The study demonstrates that packaging contributes less than 14% of the extracted energy associated with the production of the packaging materials and the sandwiches. The packaging on a weight for weight basis consumes twice the extracted energy as the product (sandwiches). However, the packaging contributes less than 10% of the final product weight, and therefore provides an excellent environmental service in protecting the product, as long as product wastage without packaging is greater than 20%.