

PPS EQUIPMENT

CARBON FOOTPRINT REPORT FOR RETURNABLE TRANSIT EQUIPMENT

RESEARCH REPORT BY THE HUMBER SEAFOOD INSTITUTE

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Executive Summary

Most food products are transported on boxes/pallets at some time during their life. These boxes are frequently manufactured from disposable materials that have a life expectancy of only one use. In today's green economy the demand for reducing the environmental impacts is needed. Due to the rising demands, industries are alternately looking for boxes that can be recycled or reused thereby reducing the number of boxes dumped into the landfills. PPS Equipments have recognised this rising potential in reusable boxes and have started applying green principles in the supply chain.

PPS Equipment is an UK based firm that specializes in renting and washing pallets that are mainly used for carrying food and pharmaceutical products around UK. They currently deal with Returnable Transit Equipment (RTE) and this study is focused on plastic crates and fish boxes which are manufactured from polypropylene (polymer based material).

This report helps in analysing the benefits of using plastic crates and the advantages of them over Cardboard/Polystyrene boxes (single usage boxes). The report highlights the carbon emissions that occur throughout the products life cycle from the manufacturing of the boxes until it has been recycled. By determining the carbon emissions the company can then act to further reduce it. The calculations use the outline of Public Available Standard 2050, which is a new carbon footprint approach for calculating the green house gas (GHG) emissions. This tool applies the approach to convey improved understanding of the GHG emissions that arises from the supply chain. The report discusses the advantages of using plastic reusable boxes against the traditional cardboard boxes.

The use of 20kg plastic crates in comparison to Cardboard caused a saving of 52% and against polystyrene of 89%. These findings show that plastic crates are cost effective, durable and are eco friendly over one use packaging.



1. Introduction

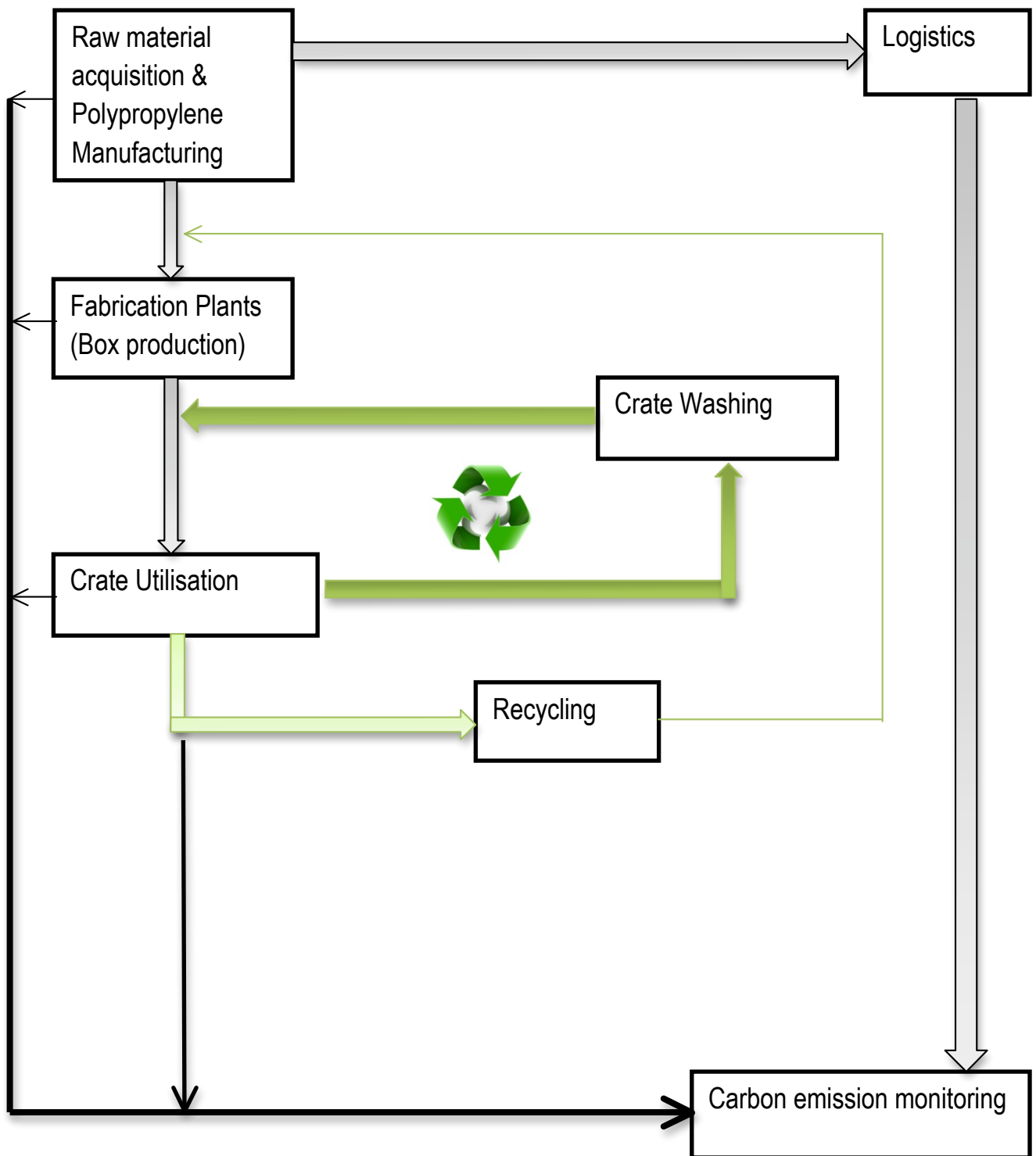
PPS Equipment is located in United Kingdom and supply and wash Returnable Transit Equipment (RTE). They rent plastic pallets and boxes out to various food production sites across the UK and offer various services to the industry including packaging sales, repairs and washing. They currently have two wash sites located in the Midlands (PPS Midlands) and in Grimsby (PPS EAST). The aim of this report is to model the carbon footprint of the boxes during their normal use in the supply chain of food products.

CARBON FOOTPRINT

A carbon footprint is “the total set of GHG (greenhouse gas) emissions caused directly and indirectly by an individual, organization, event or product” (Carbon Trust, 2007). Energy is an important requirement for production, transportation and disposal activities. These activities may cause emissions causing critical impacts to the environment. Industries have to take measures of minimising the carbon emissions during the whole supply chain process. The first step in this process is the use of process mapping

1.1. SUPPLY CHAIN FOR ONE USE PACKAGING

Plastic Crate Supply Chain



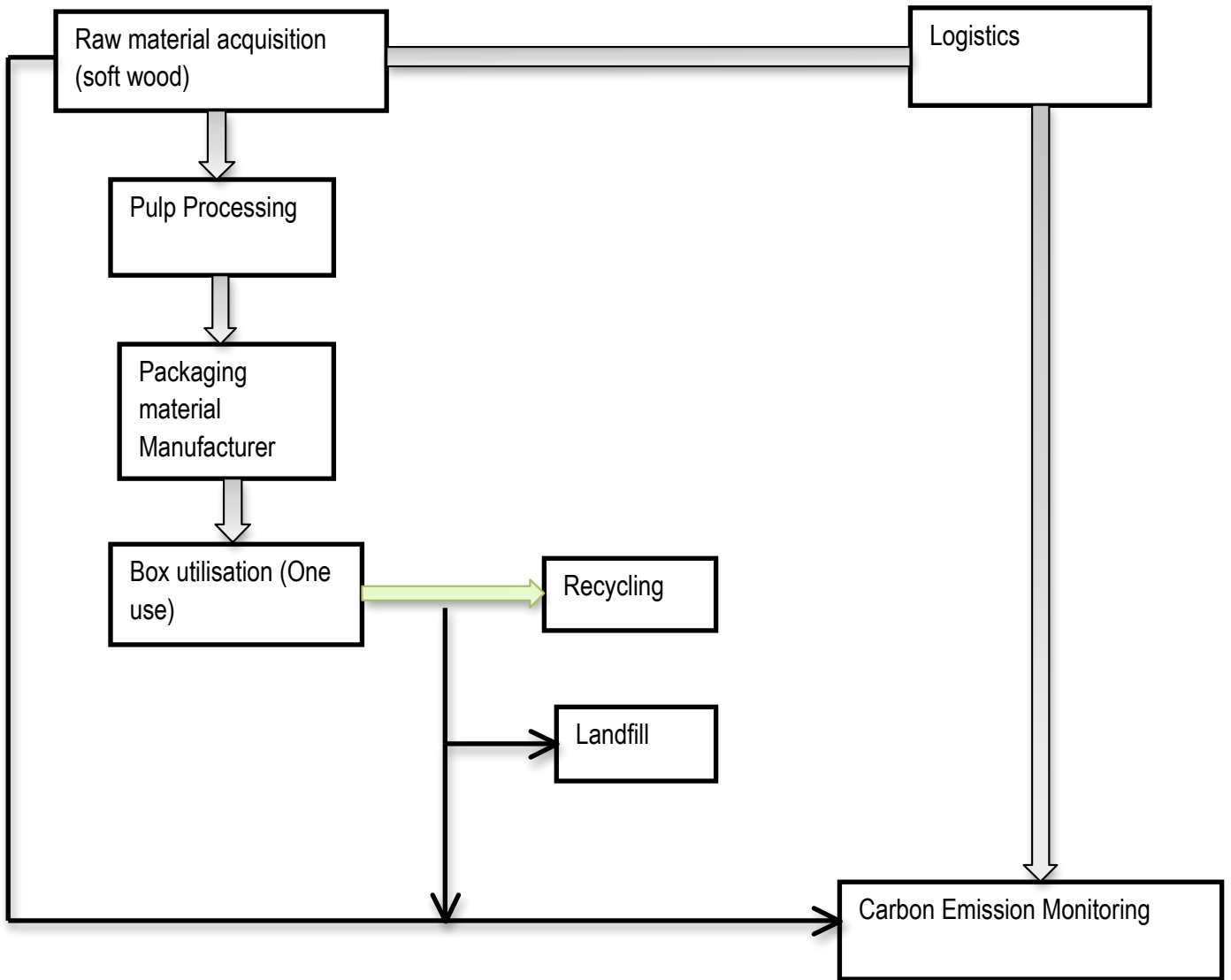
Direction of Logistics



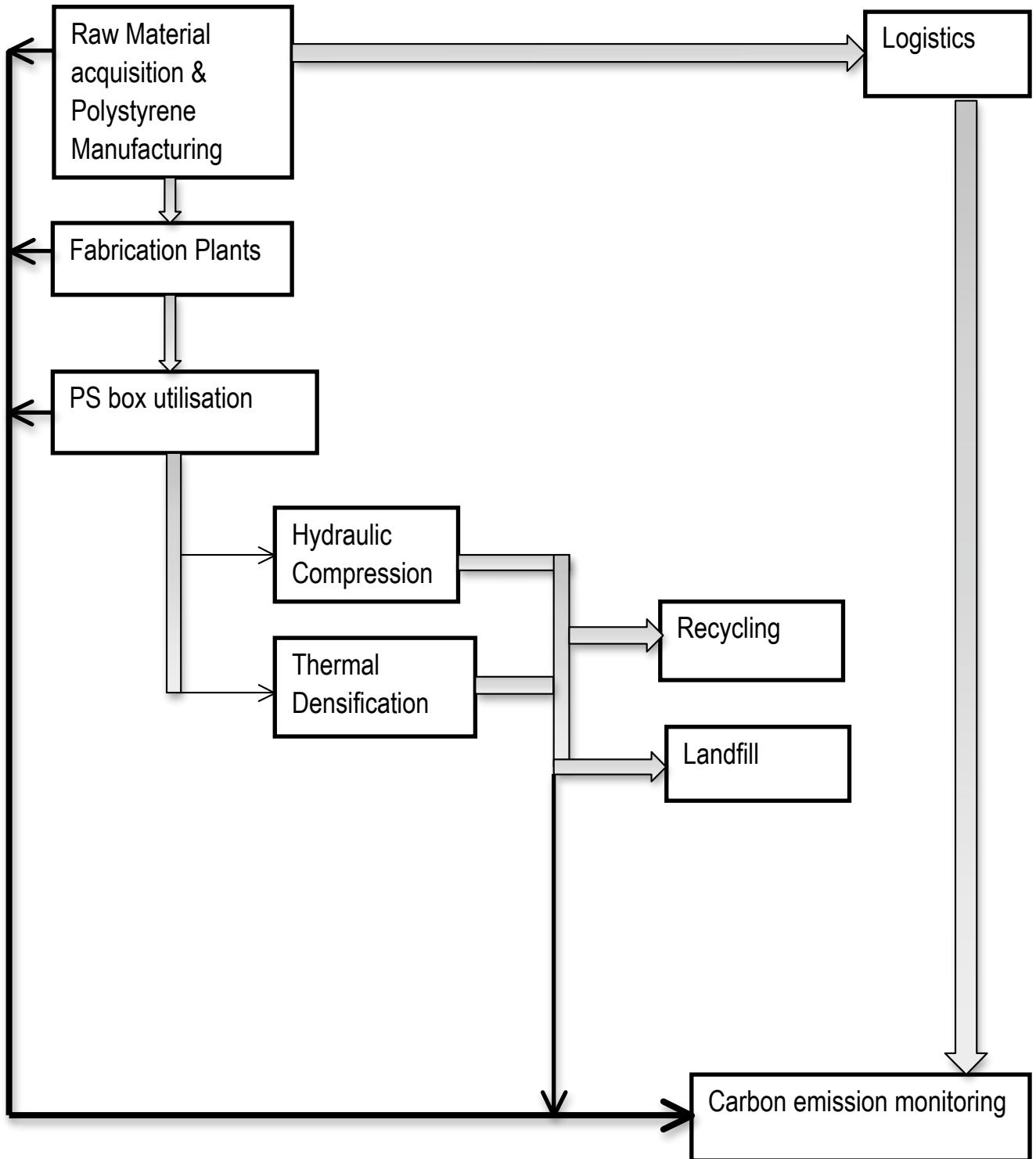
Carbon Emission



Cardboard box supply chain



Polystyrene Supply Chain



Thermal densification reduces the volume of polystyrene by approximately 95%, forming small dense blocks which are sterile, easy to handle and can be stored indefinitely then sold for incineration or for the production of fuels. The densified blocks can also be sold and remade into new products like coat hangers, picture frames, replacement hardwood and garden furniture (Styromelt™). The company will have to pay for this type of disposal. Hydraulic compressors are used to form a single PS block.

The figures previous depicts an end- to- end supply chain of material flow from the raw materials acquisition until the crate has been reused, added to landfill or burnt. From a supply chain point of view, energy is used during transportation and manufacturing, which creates carbon emissions, also called greenhouse gases and has an impact on the environment. According to Carbon Trust, (2007) the two main reasons for calculating carbon footprint are

- To manage footprint and reduce carbon emissions.
- To report the footprint accurately to the third party.

The challenge for companies is to reduce their carbon footprint and whether they have the ability to quantify their current emission levels.

Methods

The agreed method to carry out this scoping was under Life Cycle Analysis as governed by the ISO 14040 and 14044 standards. This is set up under four phases as shown below:

Goal and scope

In the first phase, the LCA-practitioner formulates and specifies the goal and scope of study in relation to the intended application. The object of study is described in terms of a so-called functional unit. In this study one packaging unit is used. The volume of both boxes compared is the same and so the unit is consistent. Apart from describing the functional unit, the goal and scope should address the overall approach used to establish the system boundaries. The system boundary determines which unit processes are included in the LCA and must reflect the goal of the study. Finally the goal and scope phase includes a description of the method applied for assessing potential environmental impacts and assumptions used.

Life cycle inventory

This second phase 'Inventory' involves data collection and modelling of the product system, as well as description and verification of data. This encompasses all data related to environmental (e.g. CO₂) and technical (e.g. intermediate chemicals) quantities for all relevant and within study boundaries unit processes that compose the product system.

The data must be related to the functional unit defined in the goal and scope definition. Data can be presented in tables and some interpretations can be made already at this stage. The results of the inventory is an LCI which provides information about all inputs and outputs in the form of elementary flow to and from the environment from all the unit processes involved in the study.

Life cycle impact assessment

The third phase 'Life Cycle Impact Assessment' is aimed at evaluating the two (or more) functional units. Impact potentials are calculated based on the LCA results. The next steps are normalization and weighting, but these are both voluntary according the ISO standard. Normalization provides a basis for comparing different types of environmental impact categories (all impacts get the same unit). Weighting implies assigning a weighting factor to each impact category depending on the relative importance.

Interpretation

The phase stage 'interpretation' is the most important one. An analysis of major contributions, sensitivity analysis and uncertainty analysis leads to the conclusion whether the ambitions from the goal and scope can be met. More importantly: what can be learned from the LCA? All conclusions are drafted during this phase. Sometimes an independent critical review is necessary, especially when comparisons are made that are used in the public domain.

PAS 2050

The PAS 2050 has been developed by BSI British Standards and co-sponsored by the Carbon Trust and the Department for Environment, Food and Rural Affairs (Defra). It provides a standard for institutions or individuals their Greenhouse Gas (GHG) emissions from their business.

PAS 2050 is the world's first product carbon footprint "standard". It aims to make carbon footprints of goods and services ("products") comparable so that businesses can better realise efficiencies in their supply chains (and resultant cost savings) and consumers making procurement decisions can be more informed on the associated carbon emissions of their purchases.

The assessment of greenhouse gas (GHG) emissions arising from products (goods and services) is emerging as a high profile application of life cycle assessment (LCA), with an increasing desire from retailers and other supply chain organizations to better understand, and in some cases communicate, the carbon footprint of products.

PAS 2050 was jointly sponsored by the Carbon Trust and the UK Department for Environment, Food and Rural Affairs and was published by the British Standards Institution on 29 October 2008.

The development process for PAS 2050 resulted in a specification that includes specific requirements that limit the interpretation of the underlying LCA approach to product carbon footprinting. These requirements, including goal setting and life cycle inventory assessment, aspects of system boundary identification and temporal aspects of GHG emissions, clarify the approach to be taken by organizations implementing product carbon footprinting, and simplify the application of LCA procedures in relation to product carbon footprinting.

PAS 2050 for organisations

- Supports understanding of key sources of emissions within a product lifecycle and highlights which organisations are responsible for the largest share.
- It helps in identifying the emission reduction opportunities and their relative importance in a product's lifecycle.
- It facilitates the evaluation of alternative product configurations in case the previous product does not comply with the PAS 2050 specification.
- It also provides operational and sourcing options on the basis of their impact on product GHG emissions. Gives a benchmark for measuring and communicating emission reductions.
- Provides improved consistency for the measurement of product's GHG emissions, using a common, recognised and standardised approach.
- Supports corporate responsibility reporting.
- Helps researchers determine the degree of uncertainty of their footprint measurement.

PAS 2050 for consumers

- Provides confidence that the lifecycle GHG emissions being reported are based on a standardised, robust method.
- Provides greater understanding of how their purchasing decisions impact GHG emissions.

The widespread interest in PAS 2050 from individuals and organizations, together with the development of similar guidance by other organizations, confirmed that there is a need for clarification, certainty, and requirements in the field of product carbon footprint analysis. The use of PAS 2050 to refine, clarify, and simplify existing LCA methods and standards has resulted in specific approaches to key GHG assessment issues being developed; it is important that future standards development work considers the impact of these approaches and their further refinement.

Benefits of PAS 2050

To the organisation

The organisation can benefit by identifying its carbon footprint effect on the environment, implementing the carbon reduction strategies there is a possibility of financial gain to the organisation. An important financial gain is by promoting the organisation's brand image as being environmentally responsible. Supporting this corporate social responsibility agenda ensures the organisation its place on the competitive edge. There is a possibility that this could change the customer's buying decisions and may attract new businesses.

The assessment of Greenhouse Gas emissions from the products or services of the organisation gives an idea to the organisation of the measures and strategies to be framed. One of the main objectives of PAS 2050 is to reduce the GHG emission and if organisation inculcates flexible strategies demonstrating the purpose, it will be sure to find financial gain from it.

Reusing the products is one of the efficient ways of reducing the carbon footprint on the environment. Recycling even though is considered as a green technique to lower carbon footprint, the process of recycling poses to be more complicated and less efficient with regard to GHG emissions. Although the plastic crate is recyclable, less waste will be emitted to landfill by washing and reusing the box.

Measuring the carbon footprint of the organisation's product across its value chain will provide information that they need to improve on reducing the GHG emissions and with this the company can even financially gain from it as explained above. The customers will have a positive opinion on the company as they will be involved in a better and cleaner cause (Guide to PAS 2050, 2008)

To the consumers

The consumers will have confidence in buying the products which will be ecologically responsible. The customers will have the freedom of selecting and deciding on more financially and psychologically viable products in the market.

1.2. Calculations of Carbon Footprint

Carbon emission calculations for the rental of packaging against one use disposable food packaging

The calculations are based on an example UK supply chain in the food industry over a distance of 500 kilometres. Assuming that the plastic crate travels 52 trips a year from food supplier to retail and considering the disposal of the packaging at the end of its working life. There is a comparison of two different packaging methods.

Cardboard and plastic crate

Polystyrene and plastic fish box

Assumptions made

- Total distance -500 km
- Vehicle used - Standard UK trailer
- Maximum weight trailer can carry - 24 tonnes
- Fuel used – diesel
- Plastic Crate / fish box life span used – 5 years
- Weight of Plastic Crate – 1.6kg
- Weight of Cardboard Packaging – 0.65kg
- Weight of Polystyrene – 1.4kg
- Weight of reusable fish box – 2.6kg
- Capacity of Polystyrene and plastic fish box – 20kg

The plastic crate is manufactured entirely of Polypropylene and is comparable to the current 'one' use packaging made of cardboard.

The carbon emissions for the transport figures are from a sheet of conversion factors openly accessible from the DEFRA website (1). The carbon emissions for the manufacture of polyethylene and polypropylene are from a study in Japan that was published in the International Journal of Life Cycle Assessment (2). Carbon emission data for cardboard packaging are from a report published in the Journal of Clearer Production (3) and polystyrene from the University of Utrecht (4)

References for Product Manufacturing

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Manufacture Emission Costs

Carbon emissions per kg of manufactured plastics and cardboard

PE = 1.3 kgs co₂ per Kg

PP = 1.4 kgs co₂ per Kg

PS = 1.87 kgs co₂ per Kg

Cardboard = 0.6 kgs co₂ per Kg

Results

Cardboard Box

Details	Calculation	Co2	Running total co2
Manufacture	$0.6\text{co2/kg} * 0.65\text{kg}$	0.39	0.39
Transport to fish supplier	$50\text{km} * 0.9074\text{co2/km} / 4680$	0.0097	0.3997
Transport from fish supplier to retail	The transport emissions would be attributed to the food product and is the same value for RTE or Cardboard		0.3997
Road Transport to Recycling centre	$50\text{km} * 0.9074\text{co2/km} / 4680$	0.0097	0.4094
Total co2 per box			0.4094
Co2 Emissions over 260 uses	$0.6294 * 260$		106.444kgs co2

Plastic Crate

Details	Calculation	Co2	Running total co2
Manufacture	$1.4\text{co2/kg} * 1.6\text{kg}$	2.24	2.24
Transport to Food supplier from Manufacturer	$50\text{km} * 0.9074\text{co2/km} / 4680$	0.0097	2.2497
Transport from Food Supplier to Retail	The transport emissions would be attributed to the food product and is the same value for RTE or Cardboard		2.2497
Transport to Box Wash facility	$50\text{km} * 0.9074 \text{co2/km} / 4680$	$0.0097 * 260$	4.7717
Washing at PPS	$117.12\text{kwh} * 0.43\text{co2/kwh} / 700$	$0.0720 * 260$	23.4917
Return transport to Food Supplier	$500\text{km} * 0.9074\text{co2/km} / 4680$	$0.0969 * 260$	48.6857
Road Transport to Recycling centre	$50\text{km} * 0.9074\text{co2/km} / 4680$	$0.0097 * 260$	51.2077
Total co2 per box 260 Uses			51.2077
Average per return journey			0.1969 kgs co2
% Saving over one use packaging			52%

20kg box

One use packaging (Polystyrene)

Details	Calculation	Co2 kg	Running total co2 kg
Manufacture	$1.87\text{co}_2/\text{kg} * 1.4\text{kg}$	2.618	2.618
Transport to fish supplier	$50\text{km} * 0.9074\text{co}_2/\text{km} / 693$	0.0655	2.6835
Transport from fish supplier to retail	The transport emissions would be attributed to the food product and is the same value for RTE or Cardboard		2.6835
Road Transport to consolidation centre	$50\text{km} * 0.9074\text{co}_2/\text{km} / 693$	0.0655	2.7490
Electricity to run crushing machine	$22.15\text{kwh} * 0.43\text{co}_2/\text{kwh} / 145$	0.0657	2.8147
Sea Transport to China for recycling	8.36g of CO ₂ /tkm, (17.28 tonnes per container 19127 km)	0.2398	3.0545
Road Transport to Recycling centre	$50\text{km} * 0.9074\text{co}_2/\text{km} / 12000$	0.0038	3.0583
Total co2 per box			3.0583
Co2 Emissions over 260 uses	$3.0583 * 260$		795.1580kgs co2

Reusable fish box (20kg Capacity)

Details	Calculation	Co2	Running total co2
Manufacture	$1.3\text{co}_2/\text{kg} * 2.6\text{kg}$	3.38	3.38
Transport to Food supplier from Manufacturer	$50\text{km} * 0.9074\text{co}_2/\text{km} / 2970$	0.0153	3.3953
Transport from Food Supplier to Retail	The transport emissions would be attributed to the food product and is the same value for RTE or Cardboard		3.3953
Transport to Box Wash facility	$50\text{km} * 0.9074 \text{co}_2/\text{km} / 2970$	$0.0153 * 260$	13.5065
Washing at PPS	$117.12\text{kwh} * 0.43\text{co}_2/\text{kwh} / 400$	$0.1259 * 260$	46.2405
Return transport to Food Supplier	$500\text{km} * 0.9074\text{co}_2/\text{km} / 2970$	$0.1528 * 260$	85.9685
Road Transport to Recycling centre	$50\text{km} * 0.9074\text{co}_2/\text{km} / 2970$	$0.0153 * 260$	89.9465
Total co2 per box 260 Uses			89.9465
Average per return journey			0.3459 kgs co2
% Saving over one use packaging			88.69%

Results

The equipment used in the calculations was a comparison of plastic reusable food containers against cardboard and polystyrene. Major saving in carbon emissions was seen in the use of plastic food crate/box and this was 55% for the plastic crate against cardboard and 89% for plastic fish box against polystyrene.

Landfill of Packaging (Cardboard)

Cardboard is a recyclable product and is calculated as being recycled in the carbon footprint calculation however large quantities do end up in landfill. Cardboard is biodegradable but in the process emits GHG's.

Costs incurred at landfills

More than 330 million tonnes of waste is now produced within the United Kingdom (UK) each year and under the European Union (EU) Landfill Directive, member states are required to cut the amount of biodegradable municipal waste they send to landfill by up-to 75 per cent of 1995 levels in 2010, 50 per cent in 2013 and 35 per cent by 2020 (Environmental Business Resources, 2010).

Landfill tax has increased from £40 to £48 a tonne from April 1st 2010, as the United Kingdom's (UK's) Government attempts to reduce the amount of waste that is ending up in the ground.

Landfill gas emissions

Greenhouse gas emission from landfill is an inevitable by – product from the decomposition of organic waste in this case the cardboard. Because the by – products composes of GHG there is a high concern relating to public health and environmental protection. The chemical composition of landfill gas comprises mostly a mixture of GHG predominantly made up of Methane (CH₄) generally 60% to 35% volume per volume and carbon dioxide (CO₂) 35% -

60% volume per volume. It will also contain traces of hydrogen, nitrogen and oxygen (Guidance for monitoring landfill gas emissions, 2008)

One tonne of biodegradable waste produces between 200 and 400 cubic metres of landfill gas. Waste treatment, including landfill, released nearly 32% of the UK's methane emissions in 2004. About a third of the 500 landfill sites taking significant amounts of biodegradable waste have gas controls and many sites extract the gas for energy recovery. From this we can understand that it is better to reuse and recycle rather than dump cardboard and other plastic materials such as polystyrene into landfill.

Potential risks of GHG emissions

During the process of landfill gas collection, there is a risk of methane accumulation and risk of explosion. But primarily methane is a GHG and causes greenhouse effect in the environment. There is also potential health impact from trace components such as chloroethene, carbon disulphide and benzene (Rosevear, 2009)

Table below shows the time required for different types of cardboard to decay.

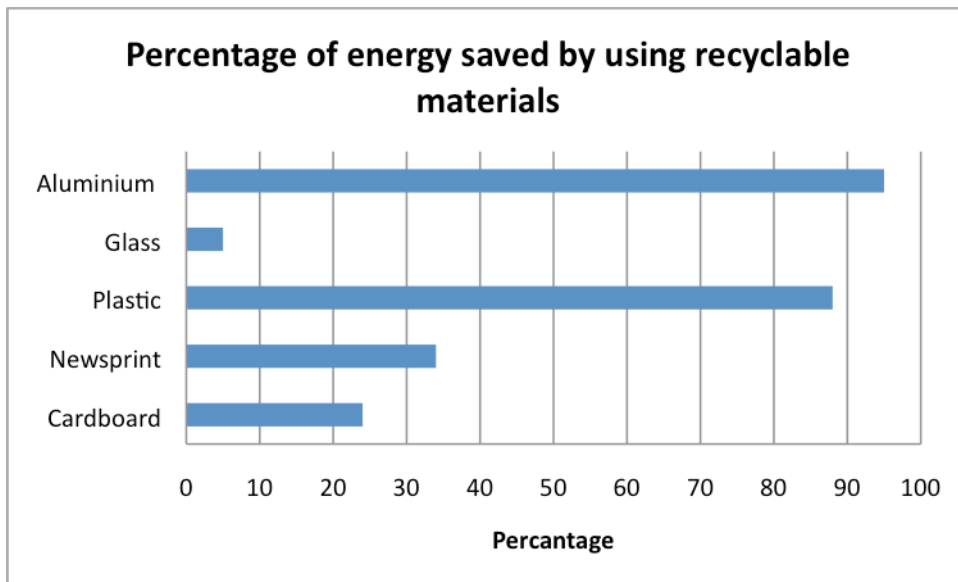
Material	Time and temperature required to degrade	GHG emissions	Percentage of degradation
Flat board Wax coated Cardboard	50 days at 50 ^o C	Methane 60%, CO2 30% others 10%	77%
Cardboard box	2 months	Methane 65%, CO2 30% others 5%	88%

Corrugated can be recycled an average of 7 times before the fibres become too short and they are filtered out as sludge during the pulping process. The sludge is then ready for disposal, but often has one more usage and that is as daily cover at landfills in place of soil (Recycle Guy 2009)

According to a Life cycle analysis report (2008) 22% of the total corrugated cardboard was disposed in 2006 in US of which 18.5% is disposed into landfills and energy recovery. Only 55% of carbon equivalent of corrugated cardboard decays and the carbon in it convert into CO₂ and CH₄. Of the methane from landfill gas only 59% is captured and combusted for

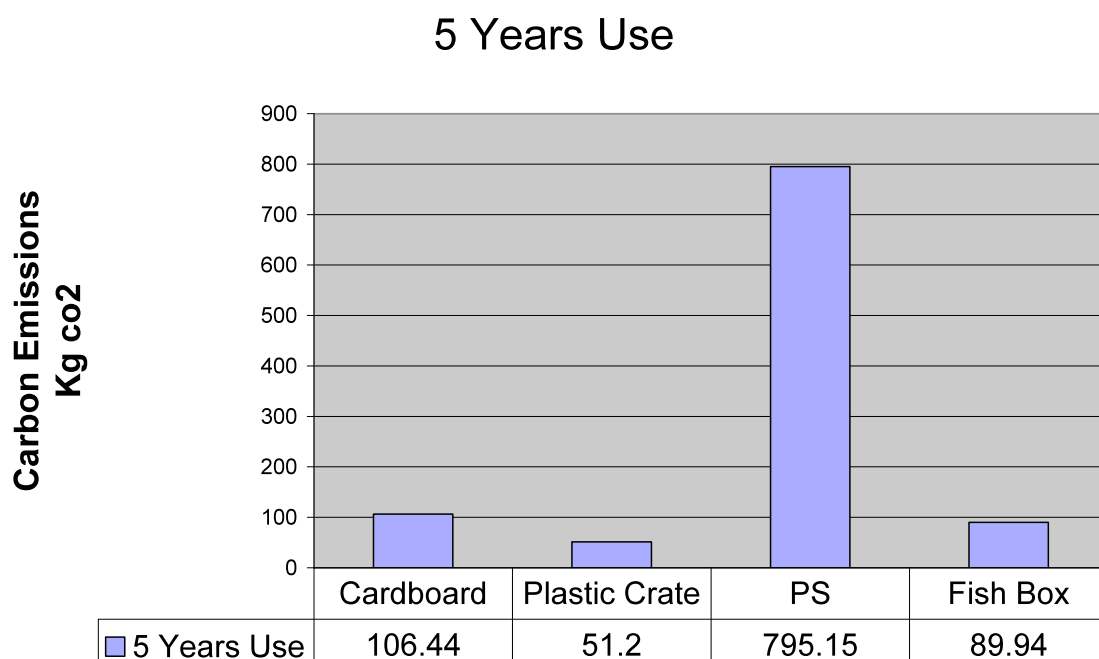
energy recovery and these are just assumptions. From this process we can identify the wastages and environmental concerns from landfill of cardboard

Graph depicting the savings in terms of percentage for using recyclable materials instead of virgin materials

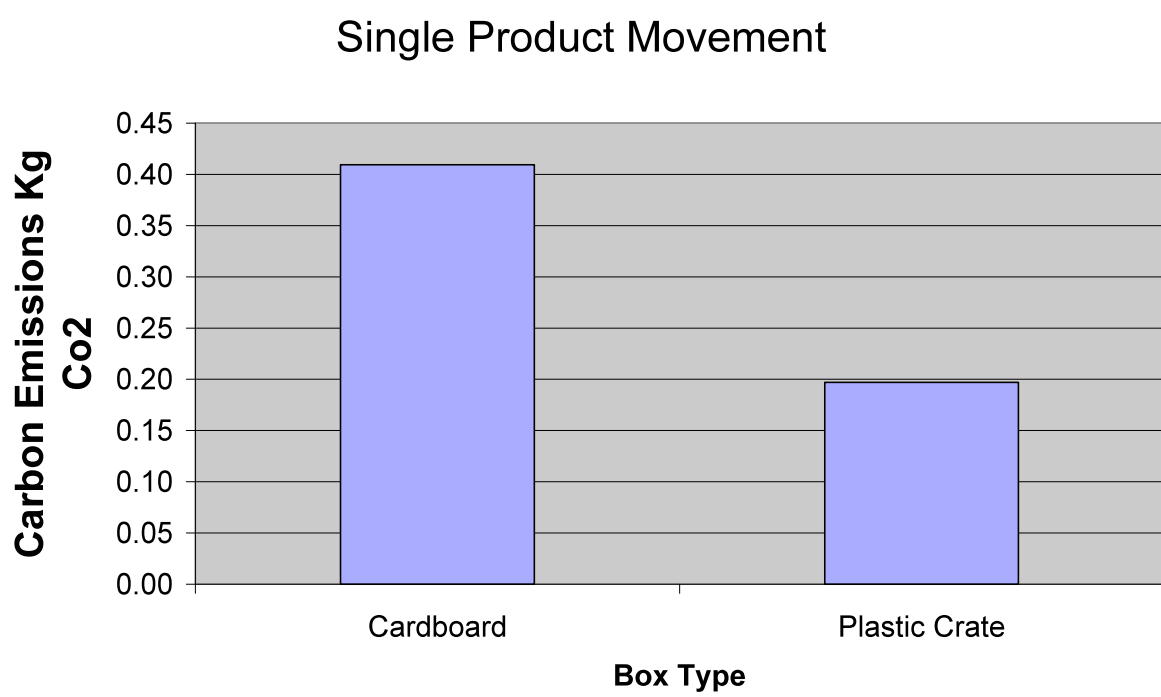
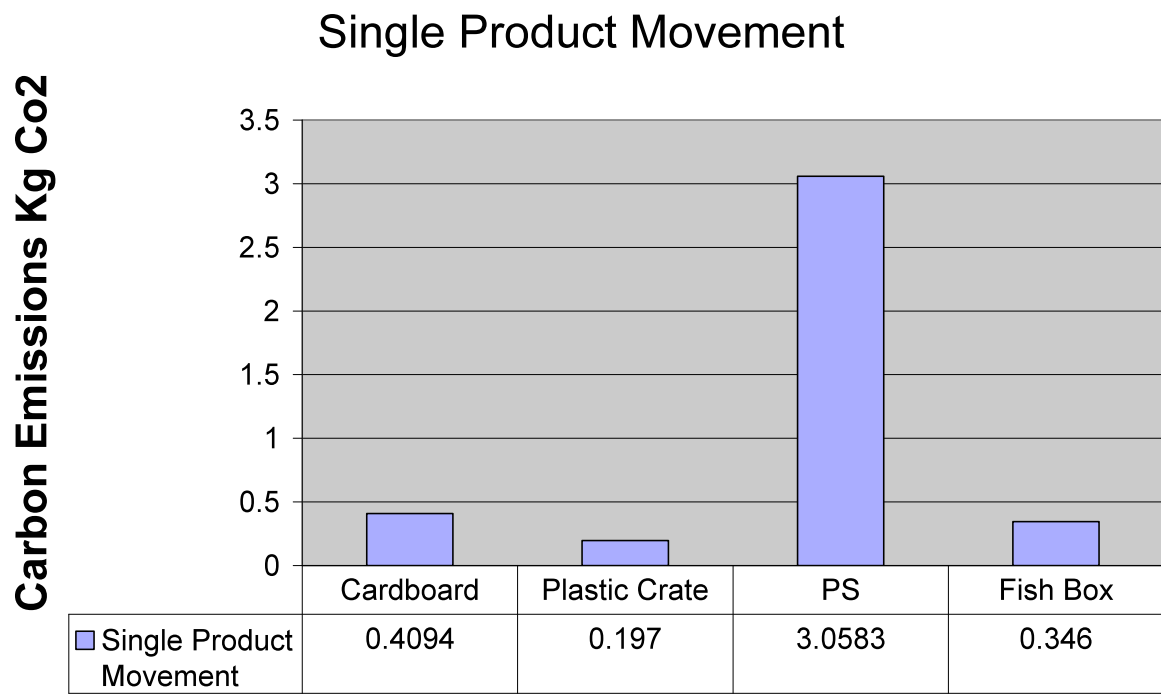


Source: http://www.journeytoforever.org/edu_cardboard.html

Graph showing the total carbon emissions for 5 years and the percentage savings of different packaging materials

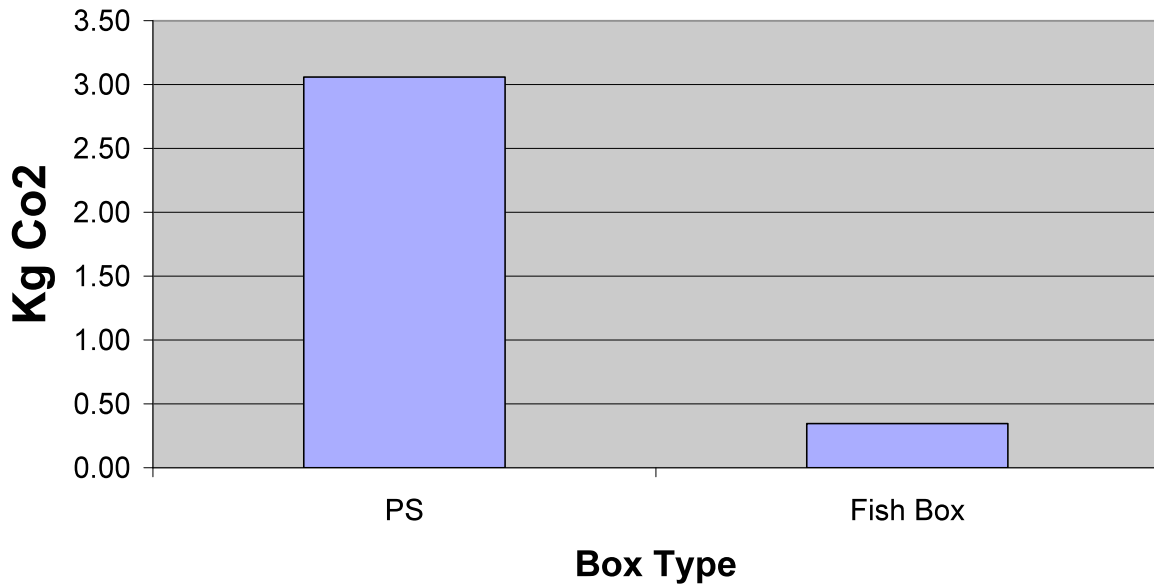


Graph showing the carbon emissions per box



52% Reduction in Carbon Emissions

Single Product Movement



89% Reduction in Carbon Emissions

Table showing the Carbon emissions for Food Transport containers over 5 Years

Constraint	Total CO ₂ emitted			
	Cardboard	Plastic Crate	Polystyrene	Fish Box
5 Years Use	106.44kg CO ₂	51.21 kg CO ₂	795.16kg CO ₂	89.95kg CO ₂

Conclusion and Discussions

Reusable packaging offers an option to the processor and multiple retailers to reduce the carbon footprint of supplying food within the supply chain. The removal of one use packaging is a significant step towards lowering the carbon footprint of packaging in the

supply chain. This is in addition to the environmental saving of not having the risk of one use packaging entering landfill.

The company has invested in a system of reusable plastic transit equipments which proves to be more efficient and eco-friendly than one time use boxes such as cardboard and polystyrene. The company should strive at reducing the carbon footprint of the entire process and to continually monitor and apply best practice. The main activity of reusing plastic crates / fish boxes is washing them before loading them; in this process the company can look at using solar water heaters in order to reduce its electric or gas usage. The machines used to wash these boxes recirculating the water in order to minimise its water usage, in the future the company can look at their own water processing unit to recycle their water needs. There are also options for the organisation to develop the most ecologically friendly chemical solution for washing the boxes and purifying the water. The organisation has an opportunity to equip its new wash plant being set up with higher regard to worker's safety, which may directly or indirectly involve training, clean and safe surroundings, proper signage both on walls and on ground. There is also opportunity to introduce continuous professional development to the workforce to maintain higher productivity and lower accidents.

A saving in carbon emissions of 52% and 89% of plastic crates / fish boxes units against Cardboard and Polystyrene respectively is a strong reason for the replacement of one use packaging. The figure for cardboard would be even higher if the used cardboard is disposed of by landfill rather than recycling or alternative uses.

The Humber Seafood Institute

This work was undertaken by the research and consultancy department of the Humber Seafood Institute in Grimsby. The Humber Seafood Institute works closely with the Seafood Processing sector and associated ancillary support industry. The Institute have worked on many previous on the environmental impacts in the supply chain including the publication by Professor Mike Dillon and William Davies titled "Energy Efficiency in the food industry" and have calculated many previous carbon footprints for seafood companies, packaging companies and retailers.

2. References

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Shell Bridge Group Ltd: