Incitec Pivot Fertilisers Packaging Carbon Footprint

SKM REPORT

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Incitec Pivot Fertilisers

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SKM

IPF Packaging Options Carbon Footprint

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Executive summary

This report provides an assessment of the environmental impact of the current and a proposed future packaging system for transport of fertiliser from Incitec Pivot Limit (IPL) to customers. IPL wished to understand the relative environmental performance of the two packaging systems to inform decision making (i.e. whether to progress with a packaging option), to determine areas of environmental impact reduction and for use in customer communications.

The packaging systems are:

- The Current Scenario – a returnable tonne bag system. This system involves a bag which is manufactured to withstand multiple trips. In the majority of cases bags are transported back to IPL via vehicles used for delivery (backhauling), washed at a contractor site and reused. The total bag weight is 4.25kg, and it is made from a combination of polypropylene and polyethylene; and
- The Future Scenario – a one-way tonne bag system. This system involves the manufacture of a lighter bag (designed with less plastic as it only needs to withstand one trip). This bag is 2.35kg, and is made purely from polypropylene.

As a signatory to the Australian Packaging Covenant, IPL has obligations to “Implement design and procurement processes that drive sustainable design of packaging, consistent with the Sustainable Packaging Guidelines”.

As such, IPL wishes to understand the environmental consequences of a change in packaging from a life cycle perspective. In order to achieve this aim, SKM has undertaken a carbon footprint analysis of the product systems. Using a life cycle approach, the carbon footprint assesses the emissions and removals of greenhouse gases across the lifecycle of the packaging system, from raw material extraction to make the packaging materials, through to disposal, reuse or recycling.

The carbon footprint is an aggregation of all of the emissions of greenhouse gas from across the life cycle. The aggregation is reported in equivalents of carbon dioxide (i.e. the emissions of all gases are scaled to the potential impact on global warming that an equivalent amount of carbon dioxide would have). A carbon footprint is a useful proxy for other environmental impacts as it is often closely related to energy generation, resource consumption and material disposal.

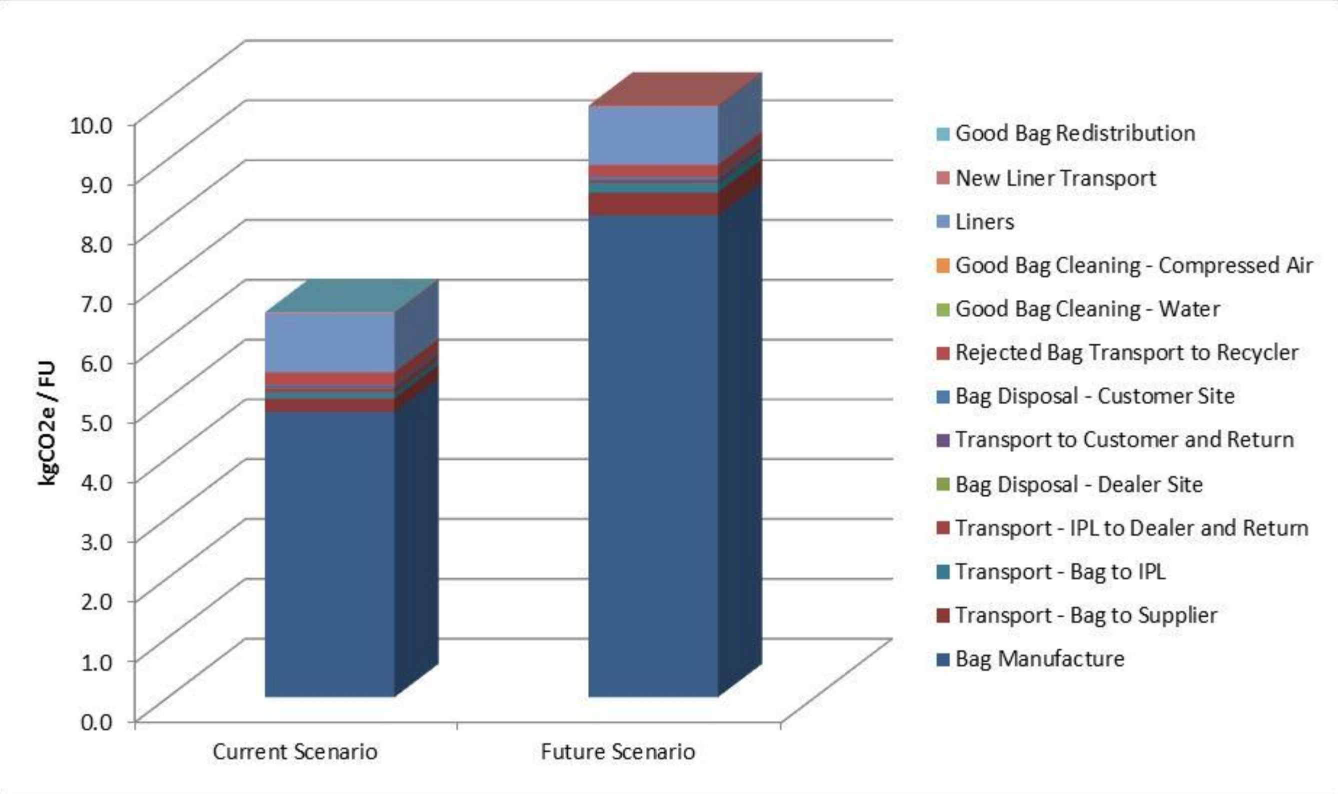
Given the focus of the study on packaging materials, the other impact assessed here is waste generation across the life cycle – specifically focussing on the end of life options for the packaging. As the systems are both based on polymers, the degradation of these in a landfill will be very slow and not give rise to significant levels of greenhouse gas emissions. Assessing the waste generation separately therefore addresses this aspect in highlighting the system that gives rise to the greatest level of waste to landfill.

The following life cycle stages are considered:

- Raw Material Extraction
- Plastic Production
- Bag and Bag Liner Manufacture
- Transport of Bag to Retailers, IPL, IPL Dealers and customers (plus return as appropriate)
- Bag Disposal;
- Preparation for bag reuse (as appropriate – including washing)

The results of the assessment are shown in Figure ES.1.

Figure ES.1 : Summary of Results



The results show that the most significant contributor to the carbon footprint is the bag manufacture, which incorporates the virgin raw material production as well as the film extrusion for the bag. The Current Scenario is lower than the Future Scenario despite having a higher weight as the impact is divided for this section by the number of uses (3).

The second largest contributor is the manufacture of the liners. This represents a significant emissions source for each system as the liner is not reused and is sent out with 60% of all deliveries.

Transport represents a relatively small aspect of the impact. Transport emissions are allocated by weight to packaging only (i.e. the impact associated with transporting the product is not included where relevant). This is typical for such a study. The greatest impact is related to the transport of the bags from manufacturer to supplier, given the distance involved and the weight of bags transported.

The results show that the Future Scenario has a worse environmental profile than the Current Scenario. This is because the impact associated with the manufacture of the Current Scenario bag, when divided by the number of reuses, is lower than that of the Future Scenario. Whilst the impacts of transport for the Future Scenario are higher than that of the Current Scenario, they are not significant enough to outweigh the impact of the bag manufacture.

Waste and recycling generation are shown in Table ES.1.

Table ES.1 : Waste Generation

Area of Life Cycle	Current Scenario-	Future Scenario	Waste Type / Destination
Disposed at Dealer Site	0.18 kg	0.07 kg	Assumed Landfilled
Disposed at Customer Sites	0.92 kg	1.36 kg	Assumed Landfilled
Total Disposed	**1.10 kg**	**1.43 kg**	**Assumed Landfilled**
Recycled by IPL (Bag)	1.07 kg	1.12 kg	Recycled
Recycled by IPL (Liner)	0.27 kg	0.17 kg	Recycled
Total Recycled	**1.34 kg**	**1.29 kg**	**Recycled**

As can be seen, the greater wastage rates at customer sites (assumed to be 50%) leads to a greater waste to landfill level. However, due to the lower bag weight, and the fact that there is greater wastage upstream, there is a lower requirement for recycling needed at IPL sites.

Summary and Recommendations

Although the environmental impact was identified to be greater for the Current Scenario, relative to the Future Scenario, a sensitivity analysis was undertaken, which revealed that the most sensitive parameter is the number of reuses for the Current Scenario. If the total number of uses is less than the 3 modelled, then the Future Scenario becomes increasingly more comparable in terms of total impact.

Further – to improve the environmental impact of the future scenario, use of recycled material would result in a lower overall environmental impact.

SKM recommendations are provided in detail in Section 3.3 at the end of this report. In summary they are:

- Confirmation that the number of reuses used in the modelling is accurate;
- Should the Current Scenario be maintained, efforts to minimise environmental impact should focus Current Scenario on maximising bag re-use;
- Investigate alternatives to virgin polypropylene for the replacement sack to determine if they can produce a lower overall environmental impact;
- Engage with current bag manufacturers and future alternative bag suppliers (if appropriate) to identify options for lower carbon / energy opportunities for bag manufacture;
- Investigate the opportunity to develop a closed loop recycling system for the bags (i.e. a system whereby used sacks are used to create new sacks);
- If a closed loop system is not pursued, to avoid higher levels of waste at customer sites, it is recommended that IPL facilitates a take-back scheme for its used packaging via the current routes for return if the Future Scenario is put into place.

1. Introduction

Incitec Pivot Ltd (IPL) is considering a switch from a returnable packaging system for bulk transport of fertilisers, to a one-way system. This means that instead of the packaging being returned to IPL from customers following use of the product (for cleaning and refill), the packaging may now either be disposed of by the customer, or IPL may put into effect a collection and disposal / recycling system.

As a signatory to the Australian Packaging Covenant, IPL has obligations to "Implement design and procurement processes that drive sustainable design of packaging, consistent with the Sustainable Packaging Guidelines". This is to be achieved through the following performance goals:

1. **Design:** optimise packaging to use resources efficiently and reduce environmental impact without compromising product quality and safety.

2. **Recycling:** efficiently collect and recycle packaging.

3. **Product Stewardship:** working with others in the supply chain.

As such, IPL wishes to understand the environmental consequences of a potential change in packaging from a life cycle perspective. In order to achieve this aim, SKM has undertaken a carbon footprint analysis of the product systems. Using a life cycle approach, the carbon footprint assesses the emissions and removal of greenhouse gases across the lifecycle of the packaging system, from raw material extraction to make the packaging materials, through to disposal, reuse or recycling.

A carbon footprint is essentially a life cycle assessment looking at one environmental indicator only (greenhouse gas emissions). A carbon footprinting approach was selected to evaluate environmental impact of the packaging system of interest, as the dominant impacts are likely to be associated with manufacture, transport and disposal of the packaging, for which greenhouse gas emissions are the major environmental concern. Greenhouse gas emissions are also a useful proxy for other indicators – such as energy consumption across the life cycle. To supplement the carbon footprint a qualitative review of solid waste, as a secondary indicator of environmental impact, was also undertaken.

1.1 This Report

This report is split into the following sections:

- Section 2 – A description of the methodology used, and the input parameters / assumptions applied; and
- Section 3 – A summary of the results, along with a simple sensitivity analysis.

2. Assumptions / Methodology

This section contains details of the study undertaken, including the definition of the goal and scope, boundaries and functional unit, as well as a description of the modelling steps for each of the life cycle stages. It is important to define and describe these features in order to provide a defensible, repeatable and transparent assessment of the impact of the packaging change.

2.1 Goal and Scope

2.1.1 Goal

The goal of this assessment is to understand the relative environmental performance of two packaging systems. The results of the assessment will be used in decision making (i.e. whether to progress with a packaging option), opportunities assessment (i.e. determining areas of environmental impact reduction) and customer communications.

2.1.2 Scope

The packaging system being studied relates to the packaging used to transport fertiliser from IPL sites to customers (typically farmers). The product is shipped in quantities of 1 metric tonne, and the packaging is therefore a 'tonne bag' – i.e. a woven plastic bag capable of carrying 1 tonne of the product.

The two options being studied are:

- The Current Scenario – a returnable tonne bag system. This system involves a bag which is manufactured to withstand multiple trips. It is transported back to IPL via backhauling using the vehicles used for delivery (in most cases), washed at a contractor site and reused. The system also includes a liner in some occasions for the bag which is needed to assist in weather protection for the product. The bag is intended to used approximately 3 times before being disposed; and
- The Future Scenario – a one-way tonne bag system. This system involves the manufacture of a lighter bag (designed with less plastic as it only needs to withstand one trip). IPL is considering putting into place a take – back system for these bags- but the best solution for this has not yet been determined. These bags also require a liner on occasion.

2.1.3 Functional Unit

The functional unit is a reference to which all impacts are scaled. It is important that the functional unit is representative of both packaging systems to avoid bias. In this study, the functional unit for both systems is the packaging required to deliver 1 tonne of fertiliser on one occasion.

2.1.4 Assessment Criteria

The environmental impact of both systems will be measured in terms of the carbon footprint of each functional unit over its life cycle and the solid waste generated.

The carbon footprint is an aggregation of all of the emissions of greenhouse gas from across the life cycle. The aggregation is reported in equivalents of carbon dioxide (i.e. the emissions of all gases are scaled to the potential impact on global warming that an equivalent amount of carbon dioxide would have). A carbon footprint is a useful proxy for other environmental impacts as it is often closely related to energy generation, resource consumption and material disposal.

Given the focus of the study on packaging materials, the other impact assessed here is waste generation across the life cycle – specifically focussing on the end of life options (post manufacturing) for the packaging. As the systems are both based on polymers, the degradation of these in a landfill will be very slow and not give rise to significant levels of greenhouse gas emissions. Assessing the waste generation separately therefore addresses this aspect in highlighting the system that gives rise to the greatest level of waste to landfill.

2.1.5 Data Requirements

The study is built upon data provided by IPL, and data derived from databases containing greenhouse gas emissions factors for various processes. IPL liaised with the supplier that provides both packaging systems for specific data.

2.1.6 Modelling

The modelling was undertaken in Microsoft Excel (see Screenshots in Appendix A). For the carbon footprint and waste generation being assessed, this software was deemed most appropriate in that it provides a simple, transparent and readily accessible program in which to build up a new model. Should a full Life cycle assessment (LCA) be undertaken, specialised software would be required to make calculations and to manage more extensive data.

2.2 Boundaries

The boundaries of the study define which aspects of the life cycle are included and which are not, and provide a firm basis upon which to undertake calculations. In defining the boundaries for this study, consideration was given to those areas within the life cycle that could be reasonably influenced by either system. The boundaries of the study and inclusions have therefore been made on a ‘materiality’ basis, rather than including those aspects that are either easy to include, or tell a good story for either scenario.

Process maps for both systems are presented in Figure 2.1 and Figure 2.2. These show that the system boundaries include all life cycle stages from raw materials extraction to make the packaging material, through transport, use, preparation for reuse and disposal / recycling.

The study does not include any of the following:

- Impacts associated with the product itself (manufacture, loss, use or disposal). These are considered to be the same for both systems and therefore not included;
- Impacts associated with filling and storing the packaging. Whilst the storage of bags poses a risk to IPL, the carbon footprint impact is considered to be negligible (and is the same for both systems);
- Impacts associated with bag failures. Whilst bag failures can be serious from a health and safety point of view, the potential impact on the carbon footprint has been calculated to be negligible;
- Emissions associated with use and reuse of pallets (the tonne bags are typically transported on a pallet). This is considered to be the same for both systems.

Figure 2.1 : Process Map – Current Scenario

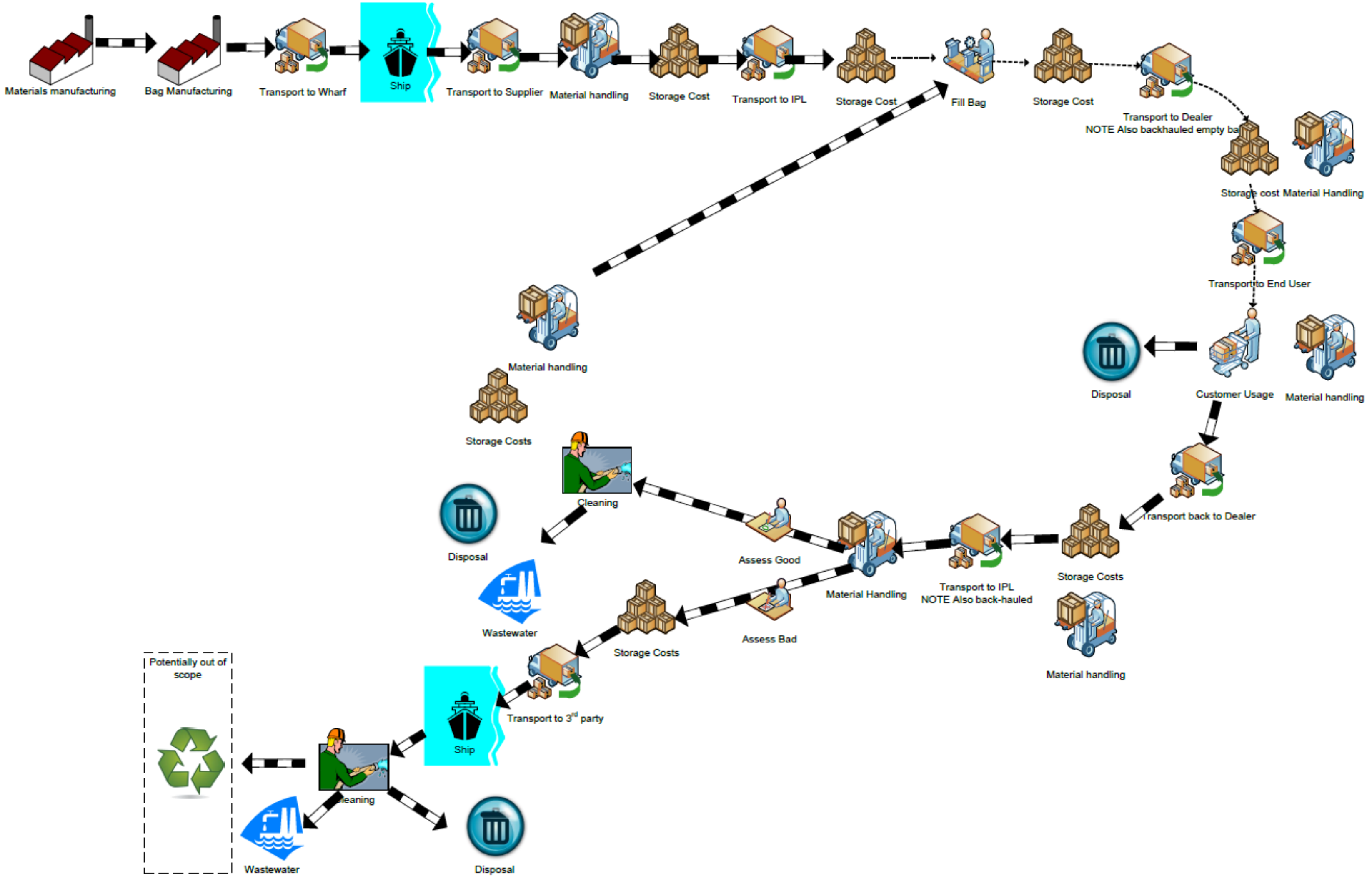
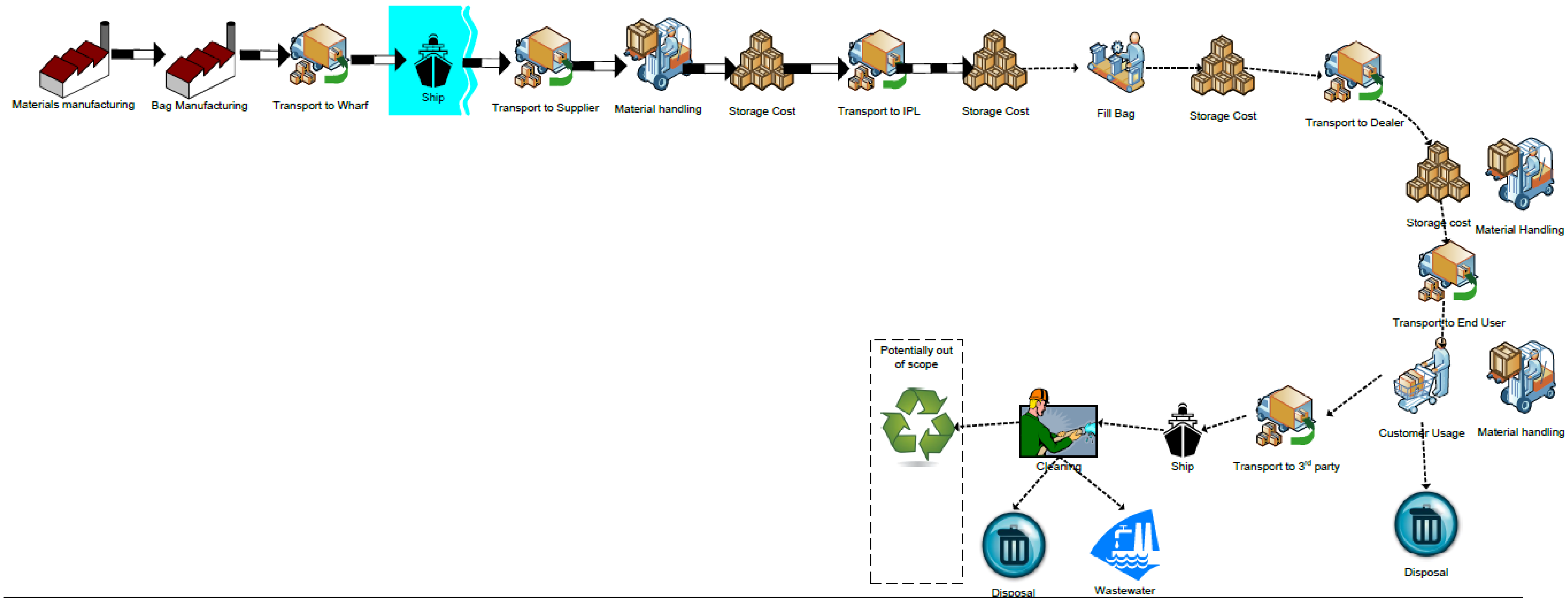


Figure 2.2 : Process Map – Future Scenario



2.3 Process Steps

This section outlines the inclusions, exclusions and assumptions at each stage of the life cycle.

2.3.1 Packaging Manufacture

Carbon footprint emissions factors for plastics manufacture were taken from publically available data. These emissions factors include all impacts up to and including creation of a granulate plastic from raw materials (for polyethylene) and to a woven material (for polypropylene). The emissions factors used were representative of European production (as no specific data for the actual manufacture were available). The modules represent the production of plastics from virgin raw materials (i.e. no recycled content).

Conversion of the polyethylene plastics granulate into a film was assessed using a carbon factor for extrusion moulding specific to film. This factor includes the greenhouse gases per kg of input plastic granulate.

Separate emissions factors were used for different polymers, and applied to the different weight of each component as shown in the Table below:

Table 2.1 : Raw Materials

Component	Material	Weight (kg)
Current Scenario – Walls	Polypropylene	3.20
Current Scenario –Straps	Polypropylene	0.45
Current Scenario – Spout and Spout Cover	Low Density Polyethylene	0.60
Future Scenario – Complete	Polypropylene	2.35
Liner (both Systems)	Low Density Polyethylene	0.60

Emissions factors were sourced from a variety of sources including the Bath ICE database, Plastics Europe and EcoInvent. The total emissions for manufacturing 1 bag for each system (including all emissions upstream of the factory gate) were therefore calculated to be:

- **14.3 kgCO_2e** for the Current Scenario; and
- **8.1 kgCO_2e** for the Future Scenario proposed bag.

2.3.2 Transport to Bag Supplier

Transport of the new packaging system from manufacturer to bag supplier is assumed to be via road and sea. A B-Double truck is assumed (with a nominal assumed distance of 30km) and container ship (with distances calculated to the three destination ports of Sydney, Melbourne and Brisbane from Thailand (Bangkok)). The sea distances are weighted according to the bags sales facilitated via each of the Australian ports.

Emissions factors for the vehicles represent emissions per tonne kilometre. This means the emissions associated with moving one tonne of freight 1 kilometre. The emissions factors are multiplied by the above distances and the weight of transported material to determine the emissions.

2.3.3 Transport to IPL

Transport from the Bag Supplier to IPL sites is also assumed to be a mixture of road and ship. Assuming the suppliers are located at the cities identified in the section above, distances from these ports to the IPL sites were calculated, and weighted for the percentage of sales that go through each site. The result is an average distance travelled by each sack.

2.3.4 Number of Bag Reuses

One of the most important parameters in the model for the Current Scenario is the number of times that the bag is reused before it must be taken out of commission (and sent for recycling). Under footprinting protocol, all upstream emissions from this point are divided by this figure when making a comparison with a single use system. The average number of reuses for the Current Scenario is 3; therefore this is applied in the model.

2.3.5 Bag Liners

Bag liners are used in both systems to protect the product from the weather. IPL assumptions suggest that 60% of all tonne-bag deliveries have a liner. Details of the liner are provided in Table 2.1. The liner is used once only and sent for recycling if returned to IPL.

2.3.6 Transport to Dealers and Return to IPL

Emissions associated with transport of the product to dealers from IPL are based on a nominal distance of 150km. It is assumed a B-Double is used for transport, with approximately 30 tonne-bags per load. Vehicle maximum fill-level is assumed to be 38 tonne bags, which means it is operating at approximately 80% capacity.

Outward journey and return journey emissions are calculated using the above fill level, and a fill level assuming back-haling 100 empty sacks for the return leg. In reality, the empty sacks will not make much of a difference to the vehicle’s unladen fuel efficiency so the model is relatively insensitive to this parameter. We assume in the model that 5% of bags are returned to IPL using a dedicated vehicle.

It is assumed that of the bags returned to the supplier under both systems, 95% are returned to IPL, with the remainder sent to landfill for disposal. Disposal emissions are calculated from an emissions factor provided by Defra (the UK Department for Environment, Food and Rural Affairs).

2.3.7 Transport to Customer and Return to Dealer

Transport from the dealer to customers is assumed to be via a rigid truck with an assumed distance travelled for each of 20km.

For the Current Scenario, it is assumed that 80% of the bags at customer sites are returned to dealers.

For the Future Scenario, it is assumed that 50% of the bags at customer sites are returned to dealers.

Discussion Point: The incentive for customers to return packaging under the Current Scenario and Future Scenario may not be so different in reality – depending on the recycling infrastructure supported by IPL in the Future Scenario. This parameter is not very sensitive in the model, however, any increases in reuse rates are likely to benefit the Current Scenario only.

It is assumed that as a worst case, the bags not disposed of at customer sites are landfilled. However, consideration should be given to whether these are combusted at site – therefore giving rise to greater greenhouse gas emissions (note: this has not been modelled in this assessment). In contrast, greenhouse gas emissions from landfill disposal of plastics are relatively small given the long time it takes for such materials to degrade in the environment.

2.3.8 Recycling Bags Unfit for Reuse

It is assumed that under the Current Scenario, 10% of the bags that make it back to IPL are unfit for reuse. It is also assumed that the liners cannot be reused.

Under the proposed future one-way system, it is not yet decided whether the bags will be aggregated for recycling at IPL sites, but this is assumed for this model. Under the Future Scenario, it is assumed that all returned bags and liners will be sent for recycling.

Under both systems, it is assumed that the bags are back-hauled using empty vehicles to IPL sites and exported via Melbourne, Sydney or Brisbane to a recycler in China.

2.3.9 Cleaning and redistributing Good bags

Under the Current Scenario, of the 90% of returned bags that are fit for reuse, it is assumed that 30% require washing out with a hose and 70% require use of a compressed air hose. Water supply and treatment emissions are accounted for using a Defra emissions factor (with the assumption that 7.5 litres are used per bag for cleaning). Emissions associated with compressed air use are calculated assuming a 5kW compressor, with 40% of the time on load, and being on for 10 seconds per bag. Emissions from electricity consumption are an average of state factors for Queensland, NSW and Victoria. Emissions associated with drying are not required given that they are dried in the sun.

2.3.9.1 Bag Failure rates

Bag failure rates were calculated for both systems from data supplied by IPL. In both cases, the failure rates were too small to be significant and are therefore not modelled (<0.05%).

3. Summary of Results and Recommendations

This section shows a summary of the results, including a breakdown per life cycle stage and an analysis of the sensitivity and potential options for the future.

3.1 Summary of Results

3.1.1 Carbon Footprint Results

Figure 3.1 below shows the side-by side comparison of the two systems, with the details provided in

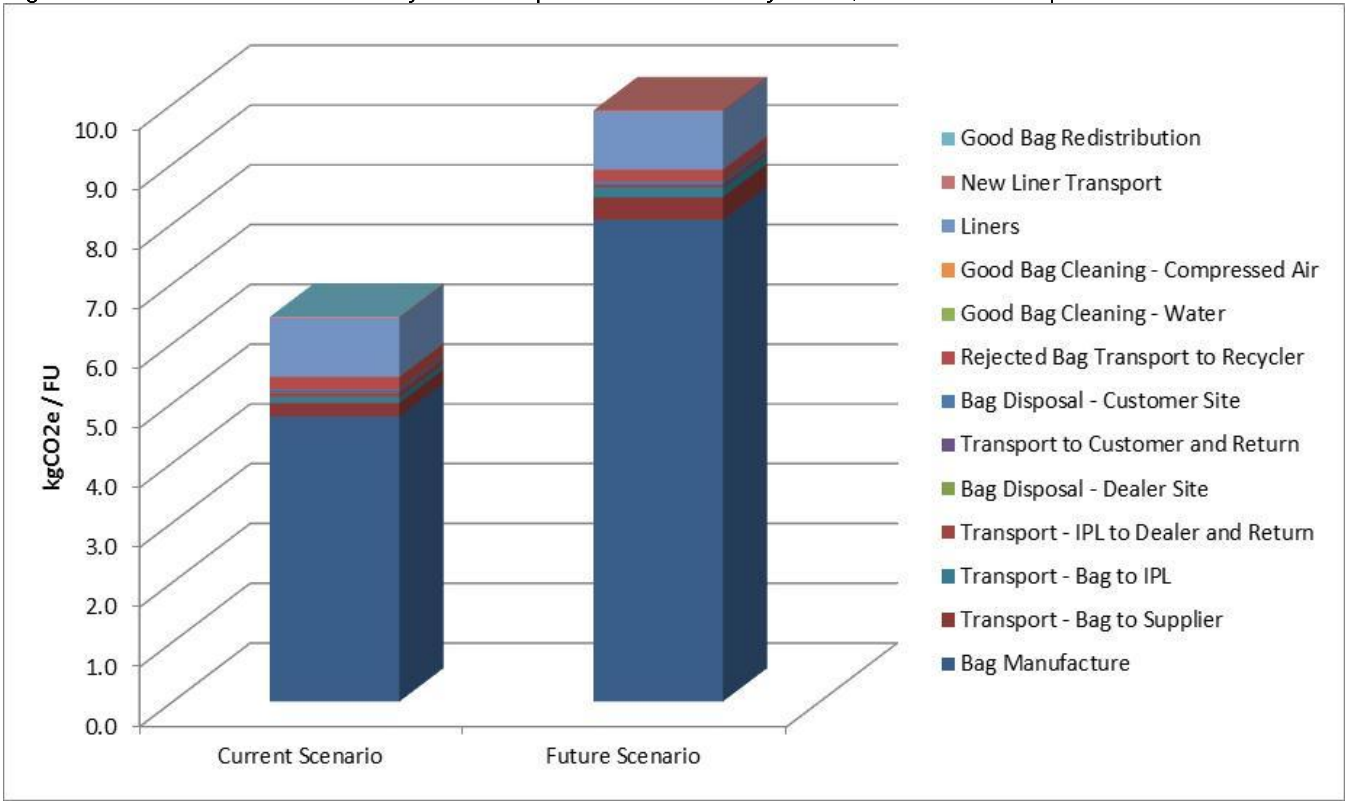


Table 3.1.

Figure 3.1 : Summary of Results

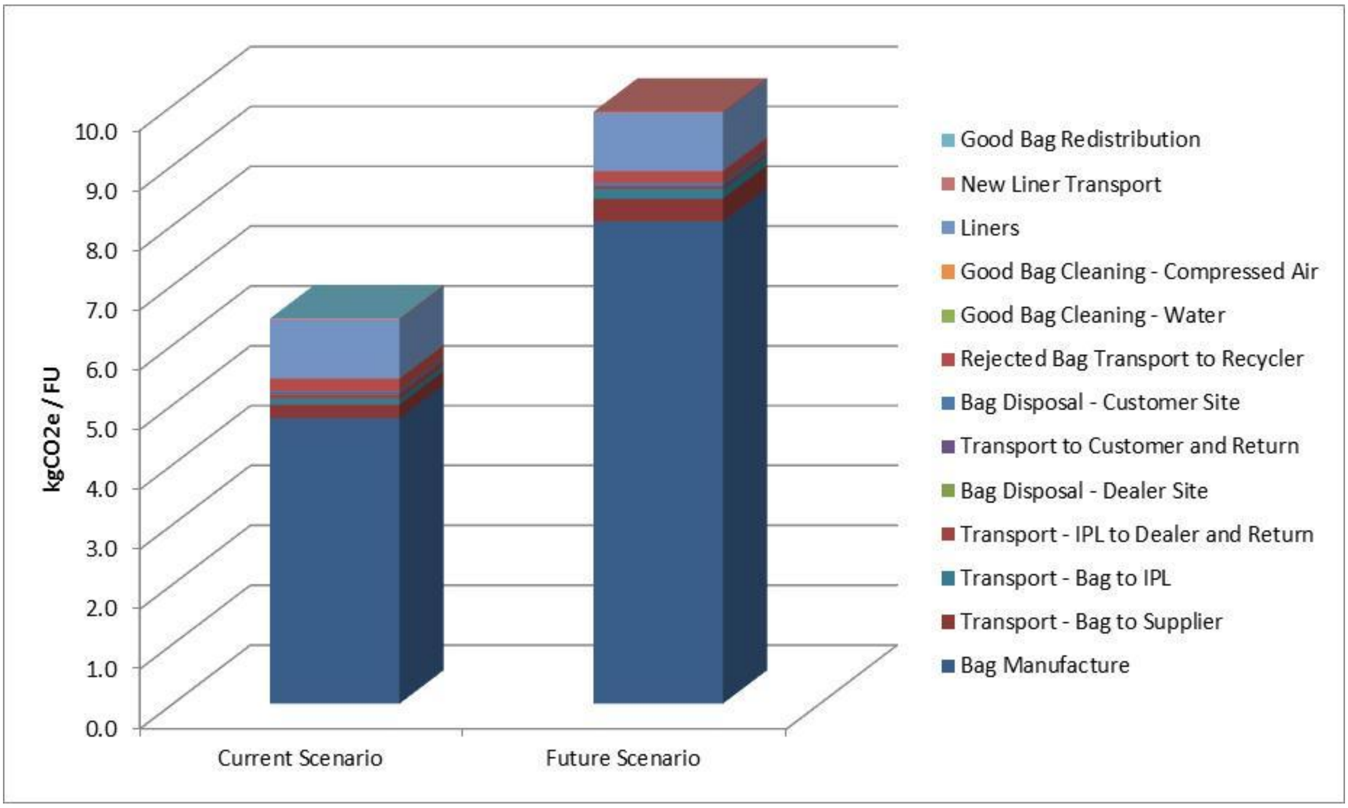


Table 3.1 : Carbon Footprint

Area of Life Cycle	Scenario 1 – Current (kgCO_2e)	Scenario 2 – Future (kgCO_2e)
Bag Manufacture	4.771	8.061
Transport - Bag to Supplier	0.228	0.378
Transport - Bag to IPL	0.098	0.163
Bag Filling	Not modelled	Not modelled
Transport - IPL to Dealer and Return	0.072	0.042
Bag Disposal - Dealer Site	0.006	0.002
Transport to Customer and Return	0.022	0.013
Bag Disposal - Customer Site	0.031	0.046

Area of Life Cycle	Scenario 1 – Current ($kgCO_2e$)	Scenario 2 – Future ($kgCO_2e$)
Rejected Bag Transport to Recycler	0.202	0.194
Good Bag Cleaning - Water	0.001	NA
Good Bag Cleaning - Compressed Air	0.003	NA
Liners	0.971	0.971
New Liner Transport	0.025	0.025
Good Bag Redistribution	0.010	NA
Bag Failures	Not modelled	Not modelled
Total	**6.439**	**9.895**

Figure 3.1 shows that the most significant contributor to the carbon footprint is the bag manufacture, which incorporates the virgin raw material production as well as the film extrusion for the bag. The Current Scenario is lower than the future scenario despite having a higher weight as the impact is divided for this section by the number of reuses.

The second largest contributor is the manufacture of the liners. This represents a significant emissions source for each system as the liner is not reused and is sent out with 60% of all deliveries.

Transport represents a relatively small aspect of the impact. Transport emissions are allocated by weight to packaging only (i.e. the impact associated with transporting the product is not included where relevant). This is typical for such a study. The greatest impact is related to the transport of the bags from manufacturer to supplier, given the distance involved and the weight of bags transported.

The results show that the Future Scenario has a worse environmental profile than the Current Scenario. This is because the impact associated with the manufacture of the Current Scenario bag, when divided by the number of reuses, is lower than that of the Future Scenario. Whilst the impacts of transport for the Future Scenario are higher than that of the Current Scenario, they are not significant enough to outweigh the impact of the bag manufacture.

3.1.2 Waste Results

The waste generation levels from each scenario are shown in the Table 3.2:

Table 3.2 : Waste Generation

Area of Life Cycle	Scenario 1 - Current	Scenario 2 - Future	Waste Type / Destination
Disposed at Dealer Site	0.18 kg	0.07 kg	Assumed Landfilled
Disposed at Customer Sites	0.92 kg	1.36 kg	Assumed Landfilled
Total Disposed	**1.10 kg**	**1.43 kg**	**Assumed Landfilled**
Recycled by IPL (Bag)	1.07 kg	1.12 kg	Recycled
Recycled by IPL (Liner)	0.27 kg	0.17 kg	Recycled
Total Recycled	**1.34 kg**	**1.29 kg**	**Recycled**

The figures presented above are the average wastage rates per single delivery. For the future scenario, the weights therefore add up to the total bag weight (2.35kg) and the total liner weight (0.60kg for 60% of bags). For the Current Scenario, the situation is made more complex by the fact that the bag is reused 3 times, so the weight provided is a function of the wastage rates at each stage and the amount of reuses.

As can be seen, the greater wastage rates at customer sites (assumed to be 50%) leads to a greater waste to landfill level. However, due to the lower bag weight, and the fact that there is greater wastage upstream, there is a slightly lower level of recycling needed at IPL sites. These results would therefore favour the Current Scenario as achieving a lower waste to landfill disposal.

3.2 Sensitivity Analysis

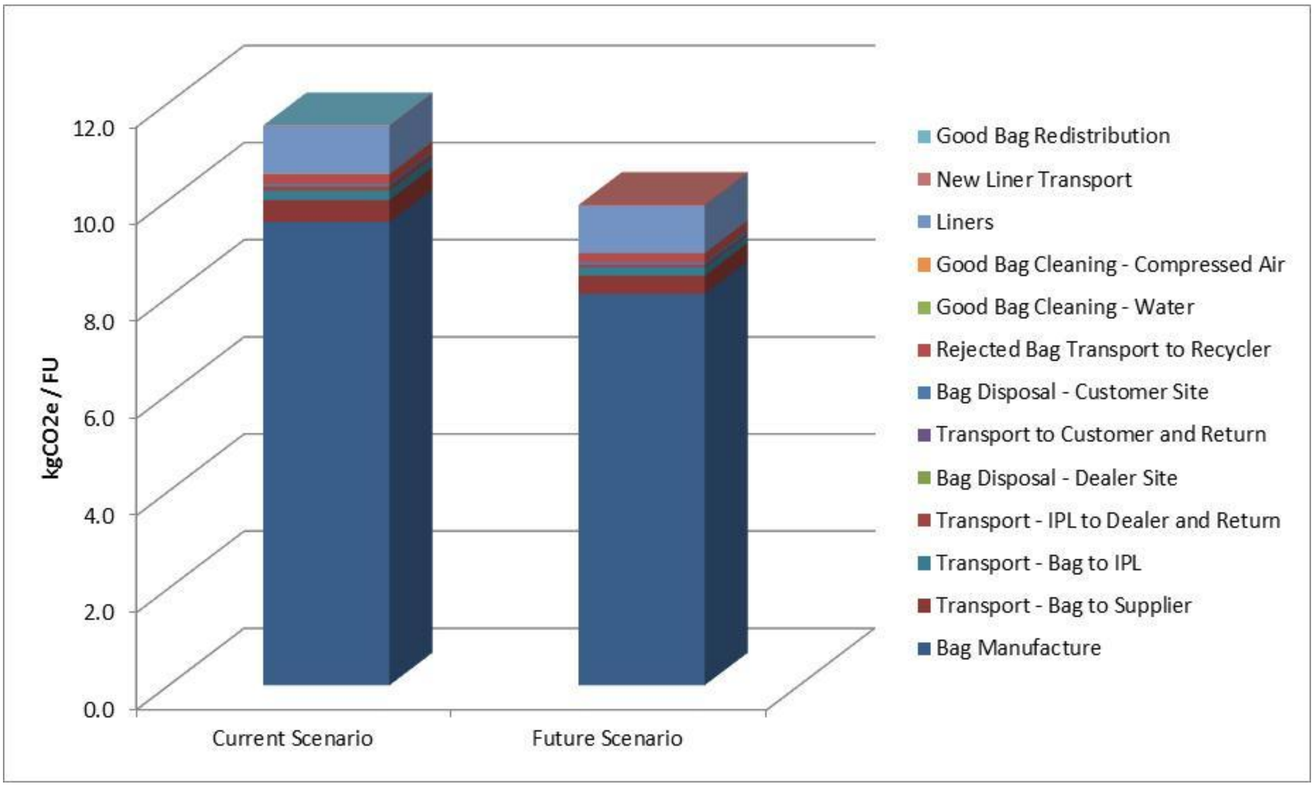
The results of the carbon footprint analysis are determined by the assumptions made during the development of the model and the data input to the model. In order to test the robustness of the results and the impact of different assumptions, sensitivity analysis can be undertaken for parameters for which the model may be sensitive or for which the assumptions significantly influence the overall results. Sensitivity analysis was undertaken on the following to review the impacts of the assumptions on the results.

3.2.1 Number of reuses

The model is very sensitive to the number of reuses of the bag. In discussions with IPL, it was noted that the number of intended reuses for the sacks is 3, but that often the maximum number of reuses achieved is 1.5.

If this parameter is used in the model, the results are shown in Figure 3.2.

Figure 3.2 : Results with Number of Reuses set at 1.5



In this scenario, the number of reuses of the Current Scenario packaging is reduced, and therefore the impact of manufacture is divided fewer times. Comparatively, then the Future Scenario is then preferable from an environmental perspective.

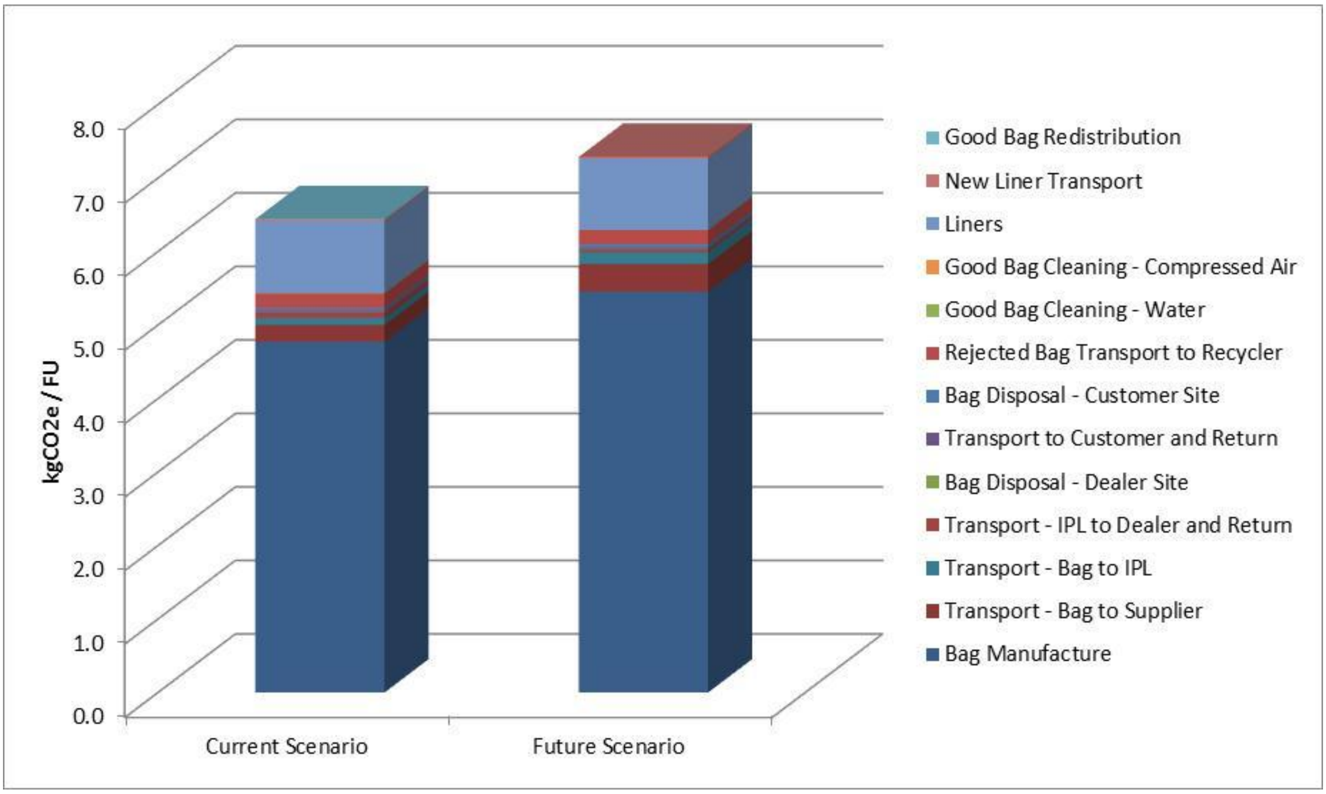
In determining a future course of action (from an environmental perspective), the question is therefore whether the system is underperforming and can be improved, or whether the system can't be improved easily and so therefore is best option is to move to the Future Scenario.

3.2.2 Bag Material

An additional option to reduce emissions for bag manufacture would be to switch from a virgin material to a recycled material for the future scenario, therefore an analysis was undertaken to review the impact of this change. There are few emissions factors available for recycled polypropylene, and the emissions factor depends on whether the plastic is recycled via a closed loop process, or an open loop process. Closed loop processes involve the material retaining its original properties such that it can be recycled into the same product on an ongoing basis, whereas closed loop processes involve degradation in the material properties such that it can only be used for lower grade applications.

The emissions factor used for virgin polypropylene is 3.43 $kgCO_2e$ / kg. In comparison, an emissions factor sourced from Defra suggests that this could be 2.32 $kgCO_2e$ / kg for recycled materials, which represents the energy needed to collect, clean, shred, remelt and reform the polypropylene. Using this factor in the model, the results are shown in Figure 3.3. It is assumed that the same weight of packaging for recycled vs virgin plastic material would be required. However, the functional properties of recycled packaging and virgin plastic may differ. Therefore further investigation would be needed to confirm the necessary weight of plastic needed to achieve the same functional properties for a recycled packaging system in comparison with a virgin plastic system.

Figure 3.3 : Results with Recycled Plastic used for Future Scenario



The results for using recycled material in bag manufacture of the one-way system are much more comparable to the existing process; however it is still projected that the overall emissions would increase.

3.3 Key Observations and Recommendations

Our key observations and recommendations are as follows:

- The results are highly sensitive to the number of times the current packaging system is reused before being sent for recycling. This number should be confirmed.
- The transport legs for the system are relatively small when compared to the emissions associated with the plastics manufacture. This is especially the case when current delivery vehicles are used to back-haul used packaging. Therefore focus in reducing environmental impact should focus on bag re-use (in the current process) or lower impact bag manufacture (in the proposed future process).
- The reuse the packaging generates significant environmental benefit. This suggests that only a much lower impact material used to replace the current virgin polypropylene sacks would generate a lower overall environmental impact. Investigations should be made into potential alternatives to virgin polypropylene for the replacement sack to determine if they can produce a lower overall environmental impact.
- IPL could engage with current bag manufacturers and future alternative bag suppliers (if appropriate) to identify options for lower carbon / energy opportunities for bag manufacture, this might include lower carbon energy sources (including manufacturing in countries with lower emissions electricity) and or locations with higher energy efficiency in production).
- In support of the above recommendation, it is possible that more detailed information from the packaging manufacturer could result in changes to the results. Generic information has been used on plastics manufacture and processing. Should these generic factors not be representative of IPLs supply chain, then there is the potential for the results to change for both scenarios. We do not think at this stage that this would be worthwhile pursuing but note that it is a future option.
- Given that the Current Scenario involves production of new plastics, and the used plastics are sent for recycling, there is an opportunity to develop a closed loop recycling system for the bags. This approach would be consistent with obligations under the Australian Packaging covenant to: implement policies or procedures to buy products made from recycled materials and establish collection and recycling programs for used packaging materials generated on-site. This represents a good story for customers, as well as potentially having economic benefits. For either scenario, it is recommended that IPL investigates opportunities for using recycled content;
- Even if a closed loop system is not pursued, to avoid higher levels of waste at customer sites, it is recommended that IPL facilitates a take-back scheme for its used packaging via the current routes for return if the future scenario is put into place.
- After bag manufacture, the next highest contributor to the carbon footprint is the use of liners. There is a potential to investigate and if possible reduce the use of liners used, provided this could be done without jeopardising the integrity of the materials being supplied. This would benefit both scenarios modelled, as well as reducing waste generation.

Appendix A. Example Model Screenshots

Figure A.1 : Model Screenshot – Current Scenario Manufacture and Initial Transport

	[purple]	= User inputs	
	[green]	= Constants or emissions factors - must be checked	
	[orange]	= References to other sheets	

Stage

Stage			
1 Bag Manufacture			
1a Walls Material	Polypropylene		Email A Travis - 8/7/13
1b Walls Weight	3.2	kg	Email A Travis - 8/7/13
1c Straps Material	Polypropylene		Email A Travis - 8/7/13
1d Straps Weight	0.45	kg	Email A Travis - 8/7/13
1e Spout and Covers Material	Low Density Polyethylene		Email A Travis - 8/7/13
1f Spout and Covers Weight	0.6	kg	Email A Travis - 8/7/13
1g Total Bag Weight	4.25	kg	Email A Travis - 8/7/13
1h Walls Material Emissions Factor	3.43	$kgCO_2e$ / kg	PP Orientated Film - Bath ICE Database
1i Straps Material Emissions Factor	3.43	$kgCO_2e$ / kg	PP Orientated Film - Bath ICE Database
1j Spout Material Emissions Factor	2.45	$kgCO_2e$ / kg	Polyethylene Granulate (Plastics Europe) http://lca.plasticseurope.org/index.htm
1k Raw Material Emissions	13.99	$kgCO_2e$	
1l Manufacturing Emissions Factor	0.537	$kgCO_2e$ / kg	Extrusion Moulding (Film). 1kg input = 0.976kg output. EcoInvent 2004.
1m Manufacturing Emissions	0.322	$kgCO_2e$	
1n Total Emissions	14.312	$kgCO_2e$	
2 Transport to Bag Supplier			
2a Vehicle Type 1	B-Double		Assumption
2b Fuel Consumption	0.028	litres / t.km	http://eprints.qut.edu.au/16193/1/Ashis_Parajuli_Thesis.pdf
2c Vehicle Type 1 Direct Emissions Factor	0.08235696	$kgCO_2e$ / t.km	
2d Vehicle Type 1 Indirect Emissions Factor	0.00572824	$kgCO_2e$ / t.km	
2e Vehicle Type 1 Distance	30.00	km	See 'Site Distances' tab
2f Vehicle Type 2	Ship (Container - Average)		
2g Vehicle Type 2 Direct Emissions Factor	0.01605	$kgCO_2e$ / t.km	
2h Vehicle Type 2 Indirect Emissions Factor	0.00301	$kgCO_2e$ / t.km	
2i Vehicle Type 2 Distance	8,298.81	km	See 'Site Distances' tab
2j Total Direct Emissions	0.577	$kgCO_2e$	

Cover Page | Calculations - Current | Calculations - Future | Results | Site Distances | Figures

Figure A.2 : Model Screenshot – Future Scenario Manufacture and Initial Transport

(purple)	= User inputs
(green)	= Constants or emissions factors - must be checked
(orange)	= References to other sheets

Stage

1	**Bag Manufacture**			
1a	Bag Material	Polypropylene		Email A Travis - 8/7/13
1b	% Recycled	0	%	Email A Travis - 8/7/13
1c	Bag Weight	2.35	kg	Email A Travis - 8/7/13
1d	Raw Material Emissions Factor	3.43	$kgCO_2e$ / kg	PP Orientated Film - Bath ICE Database
1e	Raw Material Emissions	8.0605	$kgCO_2e$	
1f	Manufacturing Emissions Factor	0.000	$kgCO_2e$ / kg	Not required
1g	Manufacturing Emissions	0.000	$kgCO_2e$	Not required
1h	Total Emissions	8.061	$kgCO_2e$	
2	**Transport to Bag Supplier**			
2a	Vehicle Type 1	B-Double		Assumption
2b	Fuel Consumption	0.028	litres / t.km	http://eprints.qut.edu.au/16193/1/Ashis_Parajuli_Thesis.pdf
2c	Vehicle Type 1 Direct Emissions Factor	0.08235696	$kgCO_2e$ / t.km	
2d	Vehicle Type 1 Indirect Emissions Factor	0.00572824	$kgCO_2e$ / t.km	
2e	Vehicle Type 1 Distance	30	km	Assumed - manufacturer to port. Not sensitive.
2f	Vehicle Type 2	Ship (Container - Average)		Assumption
2g	Vehicle Type 2 Direct Emissions Factor	0.01605	$kgCO_2e$ / t.km	
2h	Vehicle Type 2 Indirect Emissions Factor	0.00301	$kgCO_2e$ / t.km	
2i	Vehicle Type 2 Distance	8,298.81	km	See 'site distances' tab
2j	Total Direct Emissions	0.319	$kgCO_2e$	
2k	Total Indirect Emissions	0.059	$kgCO_2e$	
3	**Bag Storage**			
		No differences between systems		Not modelled
4	**Transport to IPL**			

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