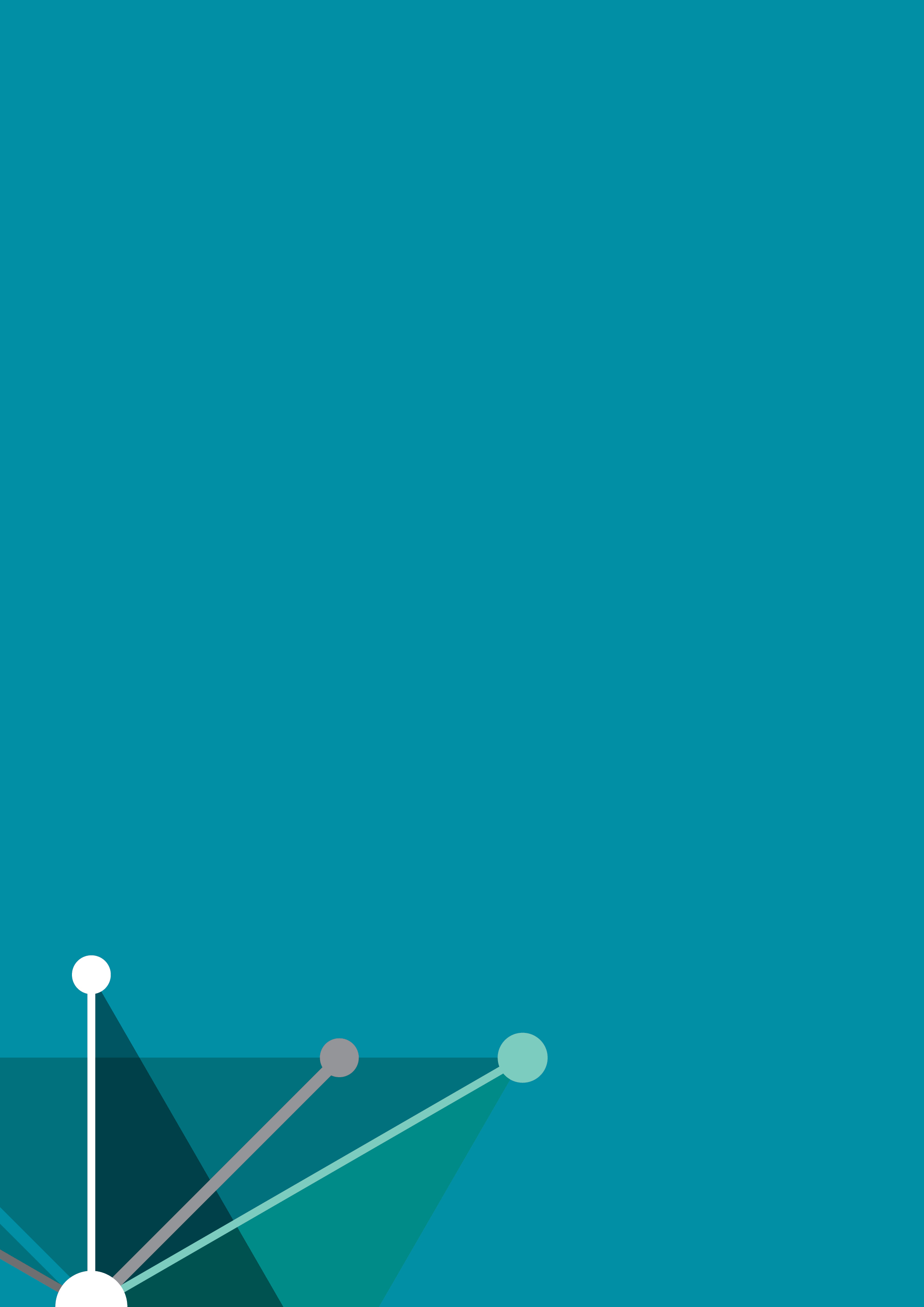


**Centre for Supply Chain   
and Logistics**

**Prepared for Composite Material Engineering (CME) Pty Ltd.  
August 2017**

Innovative Pallet Life Cycle Assessment

**Deakin University CRICOS Provider Code: 00113B**



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**The Research Team**

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# List of Abbreviations

ALCAS Australian Life Cycle Assessment Society

AusLCI Australian National Life Cycle Inventory Database

CFC Chlorofluorocarbon

CME Composite Materials Engineering

CO2  Carbon Dioxide

HDPE High Density Polyethylene

ISCL Institute for Supply Chain and Logistics

ISO International Standards Organisation

LCA Life Cycle Assessment

LCIA Life Cycle Impact Assessment

LPG Liquid Petroleum Gas

NO Nitrogen Oxide

PM Particulate Matter

UV Ultra Violet



EXECUTIVE SUMMARY

# Executive Summary

Composite Materials Engineering (CME) is the principal business of the CME Group. The Company currently operates from two manufacturing sites in Bayswater in Melbourne’s eastern suburbs. The company has been supplying moulded composite parts to the automotive industry since the 1970s. With the closure of automotive assembly plants in Australia by Holden, Ford and Toyota, this major aspect of CME Group’s business activity will cease. The Company is therefore investigating the options available to re-focus its manufacturing activity to a new industry/sector.

CME formulates, manufactures, and compression moulds long glass fibre composite materials. A composite material can be defined as a combination of a matrix and a reinforcement, which when combined provides properties superior to the individual components. In the case of a composite, the reinforcement is the fibres which are used to fortify the matrix in strength and stiffness.

For several years the Company has also been designing and producing high tech composite pallets and tote boxes for the logistics sector. These products are fundamental to national and global supply chains and the CME Pallet is particularly suited for the safe carriage of food and pharmaceuticals. In recent years, major food manufacturers and integrated logistics companies have demonstrated their interest in the CME pallet for a number of reasons: supply chain productivity; product traceability; food safety; efficiency; cost reduction; and company investment.

Currently, CME Pty Ltd is in the process of preparing a business case for the innovative composite pallet for food manufacturing and logistics and distribution sectors, with the engagement of the Institute for Supply Chain and Logistics (ISCL), Victoria University. As a part of the business case, the company planned to conduct a Life Cycle Assessment (LCA) to compare the innovative composite pallet with alternative products in the market place.

This report outlines the LCA conducted for the CME composite materials pallet in comparison with its current market alternatives of wooden and plastic pallets. The LCA has been conducted to model the environmental impacts from the three types of pallets from raw materials acquisition stage to the waste/disposal stage of their life cycle. Three life cycle models were developed using SimaPro 8.2.3 LCA modelling tool for three pallets (wooden, plastic and CME innovative composite) and the environmental impacts were assessed through 13 impact categories. These categories represented various aspects such as impacts for human health, ecosystem quality, climate change and natural resources.

The results of the LCA for pallet alternatives showed that CME composite materials pallets were highly environmentally sustainable when compared with the plastic pallets in terms of energy consumption, transportation, usage and the disposal and wooden pallets in terms of transportation, usage and disposal phases of their life cycle. The highest environmental impact from the CME composite materials pallet occurred during the production stage of its life cycle. The production stage of CME pallet showed some impact on the ecosystem quality (mainly for water and air quality) compared to wooden and plastic pallets due to the production of the glass fibre and polypropylene required for the manufacture of glass filled polypropylene. However, the recycling ability of the product mitigates these remaining impacts of the CME composite materials pallet, during the future stages of its life cycle.

The overall impact for the complete LCA of the three pallet alternatives showed that, in the longer term, CME composite materials pallets are more environmentally sustainable than pooled plastic pallets in almost all the life cycle phases and majority of the phases for the pooled wooden pallet, under the assumptions used.



INTRODUCTION

# Introduction

According to the International Standard for Life Cycle Assessment ISO14040, Life Cycle Assessment (LCA) is a technique that assesses the environmental aspects and potential impacts associated with a complete life cycle of a product. The LCA is conducted through three major steps as follows:

* Compiling an inventory of relevant inputs and outputs from a product system
* Evaluating the potential environmental impacts associated with those inputs and outputs and
* Interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study (ISO, 1997).

The LCA assesses environmental impacts throughout the product’s life, from raw material acquisition through production, use and disposal (cradle to grave). The outcomes of a LCA can be used for variety of decision making processes. The phases and applications of LCA are shown in Figure 1.



Figure 1: Phases of an LCA (ISO, 1997)

LCA provides several benefits for industry and as well as consumers. From the integration of LCA for the overall product development, companies can obtain several environmental, occupational health and safety and risk management benefits. It further provides the companies the opportunity to consider aspects of the life cycle where application of cleaner product and process options might apply. The information obtained through LCA will also guide the consumer towards decision making with regard to environmentally sustainable purchasing, transportation and energy consumption options.

To develop a life cycle model, the material and energy inputs for each and every stage of the product are required alongside information on the waste generated in the respective stages. Figure 2 shows a sample life cycle model that is used for the LCA analysis of a product. When comparing the life cycle of different products, a common functional unit should be used to maintain a single reference. Generally, the life cycle model begins from the raw materials acquisition stage or raw materials production. However, the system boundaries in a life cycle model can be defined according to the scope of the study and certain stages can be omitted if determined insignificant (Renouf et al., 2016).

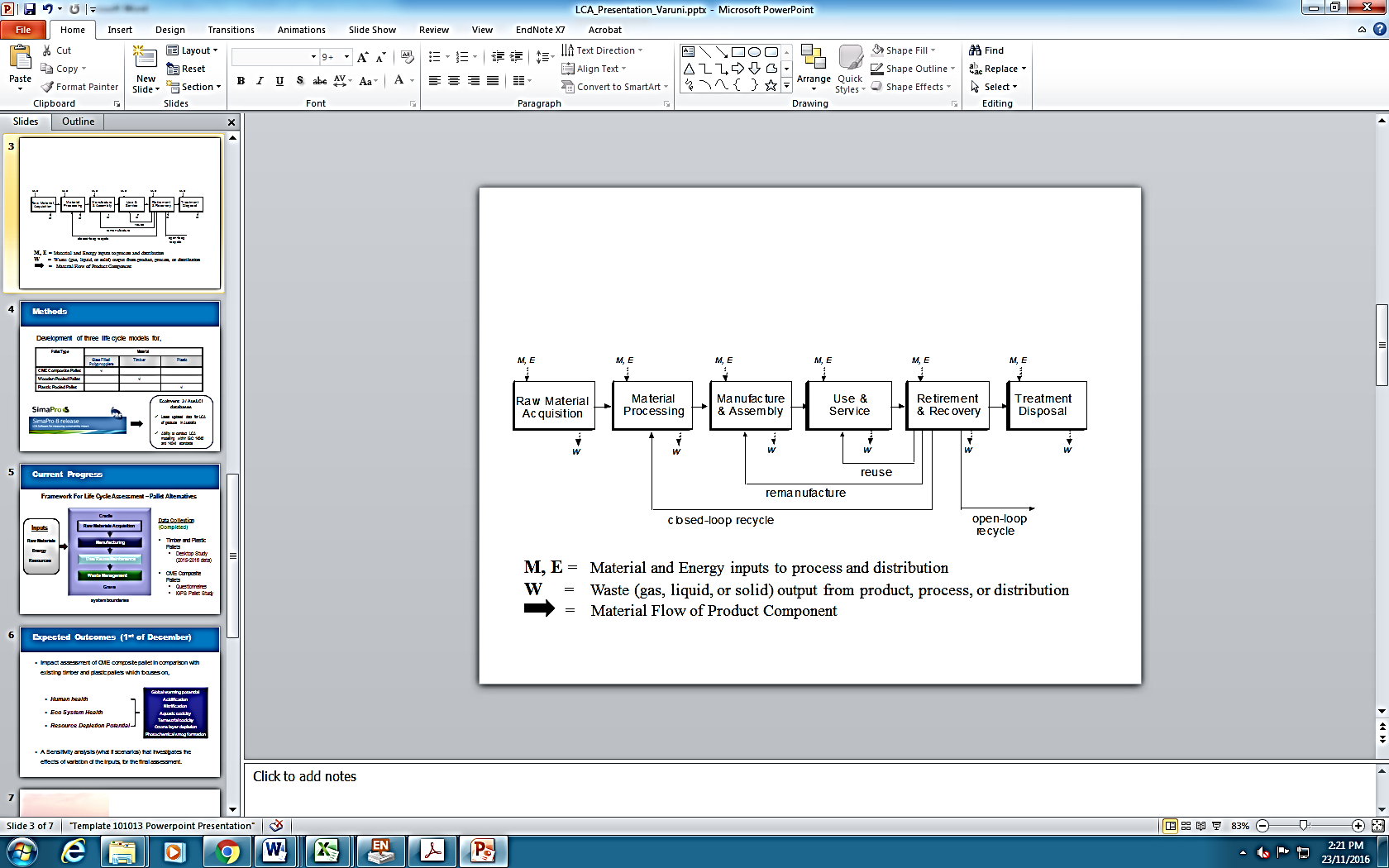


Figure 2: Sample Life Cycle Model for a Product

There are different impact categories that represent the environmental aspects of the product life cycle in the LCA process. These impact categories generally represent the potential of damage for human health, ecosystem quality, climate change and natural resources.

In this study, LCA was conducted for 13 categories for each of the pallet alternatives as recommended in IMPACT 2000+ LCA methods by Jolliet et al. (2003). The 13 impact categories considered for the LCA in present study are as follows:

* Global warming
* Mineral resource depletion
* Fossil fuel depletion
* Ozone layer depletion
* Photochemical oxidation
* Acidification
* Eutrophication
* Particulate matter
* Human toxicity, cancer
* Human toxicity, non-cancer
* Freshwater ecotoxicity
* Ionizing radiation
* Water scarcity.

## 1.1 Objectives

The major objectives of the study were as follows.

* To conduct a complete LCA for the innovative CME composite materials pallet.
* Develop life cycle models for other market alternatives pooled wooden and plastic pallets and,

To compare the environmental sustainability of CME composite materials pallet with pooled wooden and plastic pallets.

## 1.2 Methodology

### 1.2.1 Pallet Alternatives

The first step of LCA is to define the goal and scope of the study. As stated earlier, the study aims on conducting a LCA for the CME composite materials pallet and compare it with their key market alternatives. Life cycles of the pooled wooden and plastic pallets were compared as the alternatives to the CME pallet. Table 1 presents the information on the three different types pallets used for the LCA.

**Table 1: Pallet Alternatives for the LCA**

|  |  |  |
| --- | --- | --- |
| Pallet Type (1165 ×1165 mm) | Weight | Materials |
| CME Composite Materials Pallet | 19.8 kg | Glass filled Polypropylene |
| Pooled Wooden Pallet | 43 kg | Wood |
| Pooled Plastic Pallet | 34 kg | High Density Polyethylene (HDPE) |

Each of the different types of pallets reviewed in this study were considered to be transporting a wide range of non-bulk items (e.g. food, electronic goods, consumer goods) by making multiple trips between a product manufacturer and a warehouse/distribution facility. The dimensions of the Australian standard pallets are 1165 × 1165 × 150 mm.

### 1.2.2 Data Sources and Quality

The data required for the LCA of wooden and plastic pallets were obtained through an extensive literature search and estimations based on the data publicly available from Australian pallet manufacturers. The data on the life cycle period, amount of raw materials used, use and distribution, repair and maintenance times, and the amount of waste generated for wooden and plastic pallets were obtained from a previous LCA conducted by Edge Environment Pty Ltd, NSW (Bengtsson and Logie, 2015). The data regarding the production of CME composite materials pallet were obtained through detailed questionnaires and personal communication with the pallet manufacturer. There are limited data available on the pallet life time of CME composite materials pallet. The assumptions for the life cycle period of CME composite materials pallet were made based on the results of physical properties tested for the pallet, comparing it with a similar composite materials pallet introduced in the US market (iGPS, 2008).

### 1.2.3 Functional Unit

To compare the life cycle impacts of different pallet systems, a single reference unit is required which is known as functional unit in LCA. In the present study, a functional unit of 1000 customer trips was used, which carries the same load. The number of pallets required for 1000 customer trips for each of the alternative pallet was obtained based on reasonable assumptions of pallet life time, from the literature sources such as information published by iGPS (2008) for composite materials pallets and Bengtsson and Logie (2015) for wooden and plastic pallets.[[1]](#footnote-1)

### 1.2.4 System Boundaries and Assumptions

The system boundaries for the LCA were defined as the next step. The pallet systems investigated in this study included following life cycle stages:

* Raw materials production
* Manufacture of the pallet
* Distribution and use of the pallet
* Hire, de-hire, maintenance and repair
* Pooled pallet relocation
* Waste/disposal

The information on modelling the wooden pallets were obtained from Bengtsson and Logie, (2015), based on the data provided by China Merchants Loscam holdings, Australian pallet manufacturers. The timber required for wooden pallet manufacture was assumed to be sourced from Victoria.

The plastic pallets modelled in this study were considered to be manufactured from 100% recycled plastic. The information on the raw materials used for the plastic pallet manufacture was obtained from Bengtsson and Logie, (2015), based on the data provided by Smorgen Group (Vicfam), Melbourne.

Manufacture of CME composite materials pallets requires the production of glass-filled polypropylene. The polypropylene required for the production was assumed to be sourced from Victoria and the glass fibre was considered to be imported from China according to the manufacturer’s information. The CME composite materials pallet was assumed to be made from 30% glass-filled polypropylene. Table 2 shows the amount of raw materials used for each alternative pallet, the other materials used and the energy requirements for the pallet manufacture.

**Table 2: Materials and Energy requirements for the Pallet Alternatives**

|  |  |  |  |
| --- | --- | --- | --- |
| Pallet Type | Amount of Major Raw Materials Used | Other Materials Used | Energy Requirements |
| CME composite Materials Pallet | Glass Fibre (Kg) – 5.94  Polypropylene (Kg) – 13.86 | None | Electricity (kWh) – 30.29[[2]](#footnote-2) |
| Pooled Wooden Pallet | Timber (m3) – 0.044-0.066 | Nails (Kg) – 0.39  Paint (L) – 0.14-0.16 | Electricity (kWh) – 0.47-1.00  LPG (MJ) – 0.39-1.56 |
| Pooled Plastic Pallet | HDPE (Kg) – 35.7 | Carbon Black (as a UV inhibitor) (Kg) – 0.357 | Electricity (kWh) – 37.5 |

All three pallet compositions considered in this study are manufactured by companies in Melbourne and assumed to be manufactured on an average of 50 km from their first use. To compare the fuel consumptions attributable to the pallet weights, a 50 km trip by an articulated truck was assumed in this study from its manufacture and first use.

For the hire, de-hire, maintenance and repair, wooden pooled pallets require various repair actions such as repairing the damaged pallets (including timber and nails), repainting the pallets and re-issue back into circulation, re-painting pallets black for secondary use by 3rd party and disposing discarded pallet parts. The wooden pallets have assumed to get repairs around 5 times per year. The plastic pallets are not usually repaired and considered to be only occasionally cleaned at depot (Bengtsson and Logie, 2015). At the end of life, plastic pallets were assumed to have sent to the recycling facility. CME composite materials pallets are also not repaired and completely recycled at the end of the life. From the recycled materials, 60% is claimed to be used for the production of pallets with the same properties and the remaining 40% is claimed to be recycled to generate other products according to the manufacturer’s information.

The pallet pooling requirements include the transportation of de-hired pallets from remote locations to main depots for maintenance or re-hiring. The average relocation distance for the pallets were obtained from literature and assumed to be a total of 246 km for de- hire, 159 km by rail, 79 km by road and 8 km by ship (Bengtsson and Logie, 2015). These distances were assumed for all three pallets.

Generally, the pallets are repaired only if the cost of the repair is lower than the cost of manufacturing a new pallet. If the pallets are not repaired, part of them will be sent to landfill or dismantled with some of the functional parts used to repair other pallets. For the pooled wooden pallets used in this study, 25% of the mass of the pallet was assumed to be disposed to landfill and the remaining 75% was assumed to be combusted for energy, used for landscape mulch or animal bedding (NSW Environmental Protection Agency, 2012).

For the pooled plastic pallet, each pallet is made from 35.7 kg of recycled HDPE and 1.785 kg of recycled HDPE is yielded to the landfill at the end of its life. The CME composite materials pallet does not generate any waste to the landfill and has been considered as 100% recyclable to produce new pallets or other products.

### 1.2.5 Exclusions from the study

The aspects which were excluded from the present LCA of pallet alternatives are listed as follows.

* Manufacture, maintenance and decommissioning of capital equipment
* Amount of product damage and rejected shipments
* The safety of workers handling the pallets
* Pallet handling equipment damage at product manufactures and warehouses
* The energy, materials and water used in the recycling process
* Emissions, solid waste and wastewater generated from the recycling process

### 1.2.6 Life Cycle Inventory and Impact Assessment Methods

To model the life cycle inventory of this study, SimaPro modelling tool was used, which is one of the leading commercial software packages for LCA. As stated earlier, the model applied 13 impact categories that represent human health, ecosystem quality, climate change and natural resources which were analysed during the LCA.

The LCA for the pallet alternatives was conducted in accordance with Australian LCA guidelines. The impact assessment method used in this study was the Australian Life Cycle Assessment Society (ALCAS) Best Practice Life Cycle Impact Assessment (LCIA) Recommendations V2.01. The Australian National Life Cycle Inventory Database (AusLCI) was used as the main database for the LCA. Libraries from the AusLCI database were used for the impact assessment of the stages of life cycle that takes place in Australia.

* AusLCI System Processes
* AusLCI Shadow Database
* AusLCI Unit Processes

For the stages of life cycle that takes place outside Australia (e.g: manufacturing some of the raw materials.) the ecoinvent v3 database was used which is developed by Swiss Centre for Life Cycle Inventories. The latest version of Simapro (v 8.2.3.0) was used to assess the environmental impacts of pallet alternatives throughout their life cycle.



RESEARCH FINDINGS

# Research findings

The findings of the comparative analysis for wooden, plastic and CME composite materials pallets for various impact categories are described in graphical formats. The percentage contributions for environmental impacts by alternative pallets were assessed through considering five major aspects in the product life cycle as follows:

* Production of the pallets
* Energy consumption
* Transport
* Usage and operational phase
* Waste/Disposal of the pallets

## 2.1 Production of the Pallets

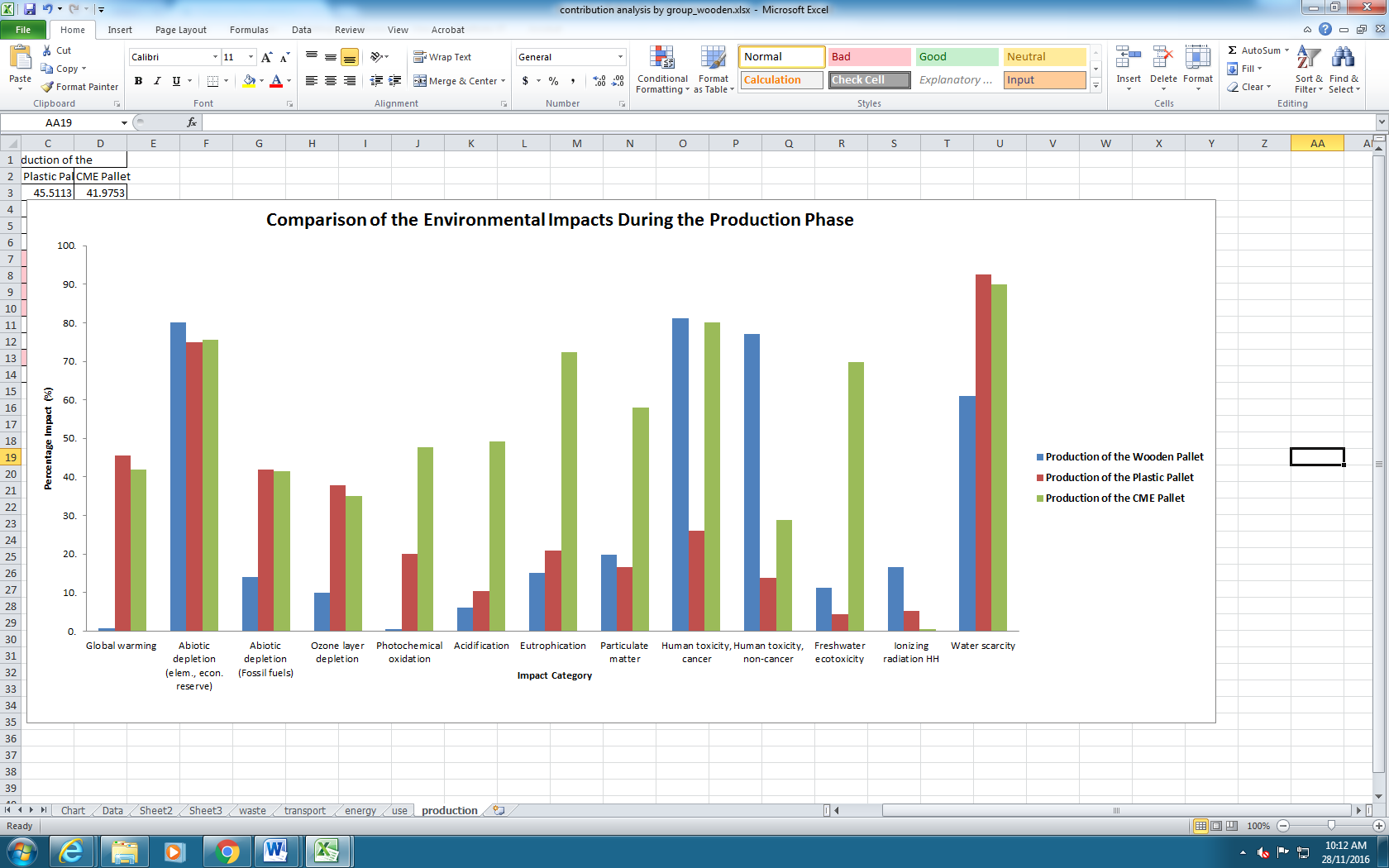
Figure 3 shows the percentage environmental impacts of the production phase of three pallet alternatives.

Figure 3: Comparison of the Environmental Impacts during the Production Phase

The comparative assessment of the environmental impacts during the production stage of pallets shows that CME composite materials pallets have high impact in the categories of photochemical oxidation, acidification, eutrophication, particulate matter, freshwater ecotoxicity (impacts for water and air) and human toxicity, non-cancer with respect to their alternatives. The analysis conducted by SimaPro shows that the highest environmental load during the production stage of the CME pallets occurs during the production of polypropylene and glass fibre, which are the raw materials used for the manufacture of the pallets.

For the remaining 7 impact categories, CME pallet showed lower impact percentages with respect to the plastic pallets however had higher impacts than the wooden pallets during the production stage. From the three pallet alternatives considered, the wooden pallet shows the lowest impact during the production stage, which can be explained by the materials and processes involved in the production process. However, in comparison with the production stage of the plastic pallets, CME pallets showed lower or almost similar impacts across the majority of the categories.

## 2.2 Energy Consumption

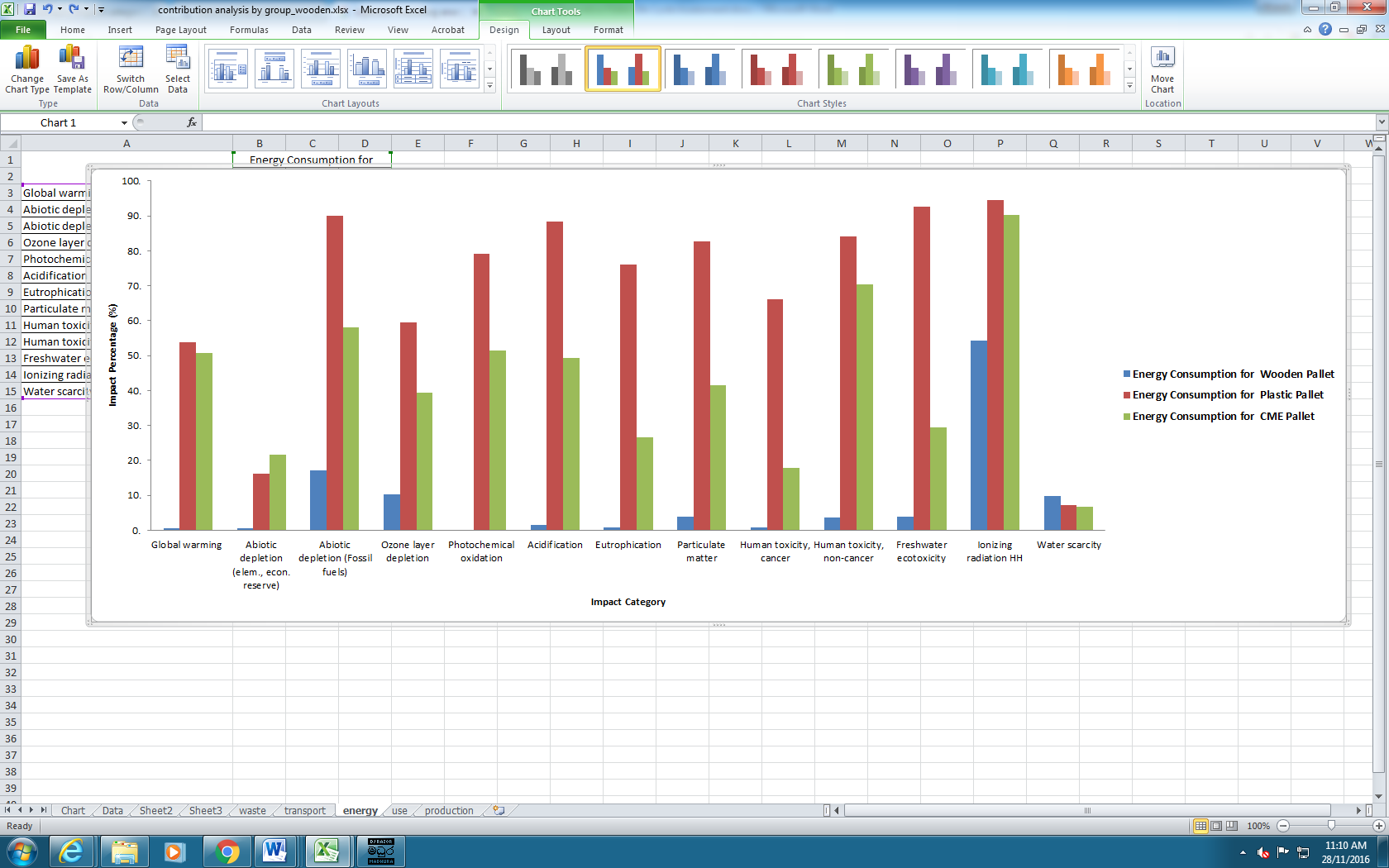
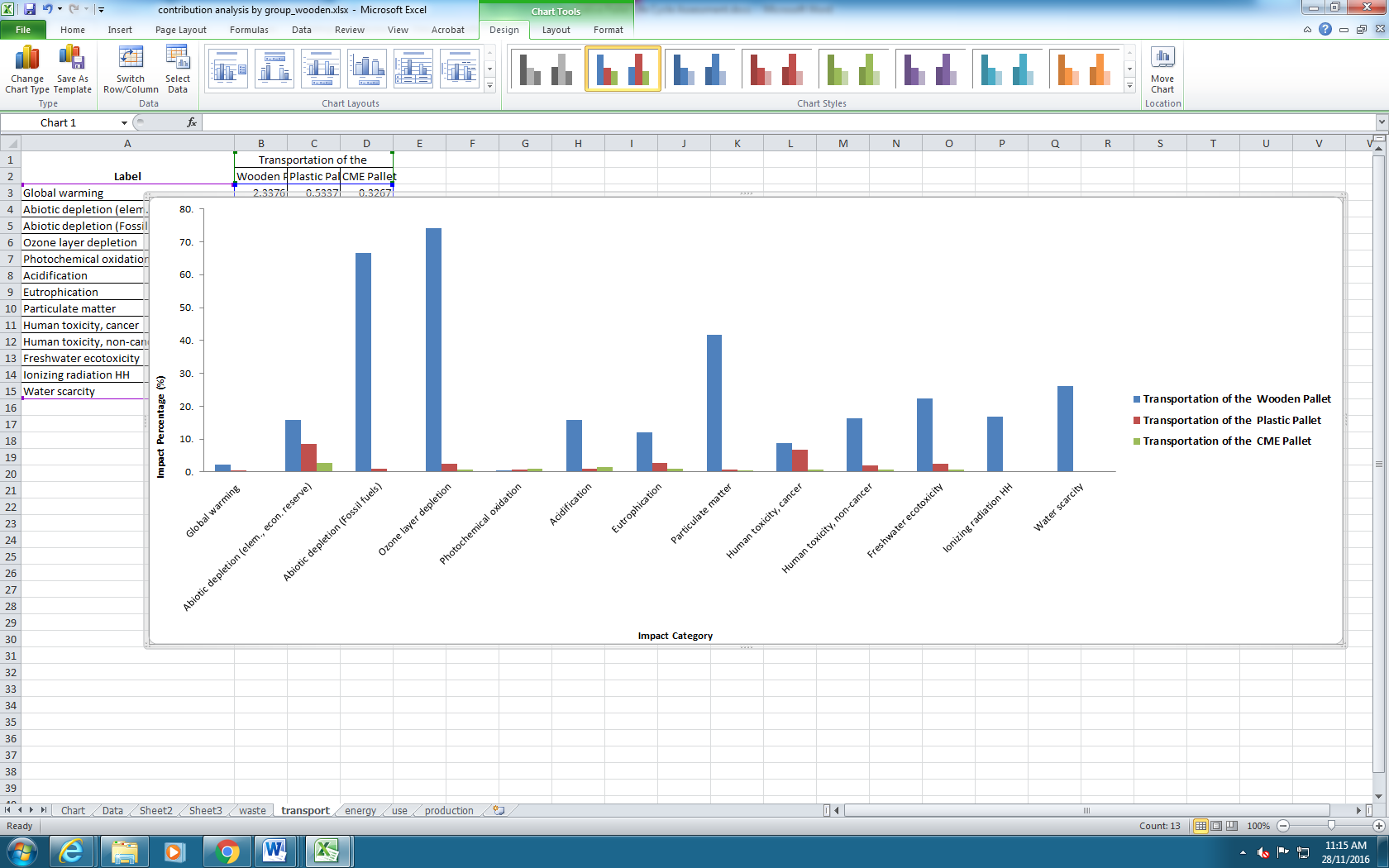
Figure 4 shows the percentage environmental impacts occurring from the energy consumption for three pallet alternatives.

Figure 4: Comparison of the Energy Consumption Impacts

Among the three pallet alternatives considered, the plastic pallet had the highest environmental impacts due to energy consumption during the complete life cycle. The CME pallet has significantly lower impacts from energy consumption compared to plastic pallets during the LCA. The reasons for this can be explained as the longer life cycle period and the lighter weight of the CME pallet compared to the plastic pallet. Similar to the production stage, the lowest impact from energy consumption is shown by the wooden pallet. Energy consumption is also attributable to the processes involved in the production phase such as injection moulding in manufacturing the plastic and CME pallets.

## 2.3 Transportation

Figure 5 shows the percentage environmental impacts that occur during the transposition operations for the three pallet alternatives.Figure 5: Comparison of the Environmental Impacts during Transportation Phase

From the three pallet alternatives assessed, the transport phase is a high environmental contributor for the wooden pallet compared to plastic and CME pallet. This can be explained by the factors such as shorter useful life time of the wooden pallet compared to the two alternatives, the additional transport to inspection and repair stations and the heavier weight in comparison with the plastic/CME composite materials pallets. Since the CME pallet has longer life time and less weight compared to the wooden and plastic pallet, among the three pallet alternatives considered, CME pallet shows the highest environmental sustainability with respect to its market alternatives during the transportation phase.

Climate impacts are of interest to businesses in assessing the sustainability of their products. The CME materials pallet shows almost zero impact on global warming during its transportation stage compared to wooden and plastic pallets.

## 2.4 Usage and Operational Phase

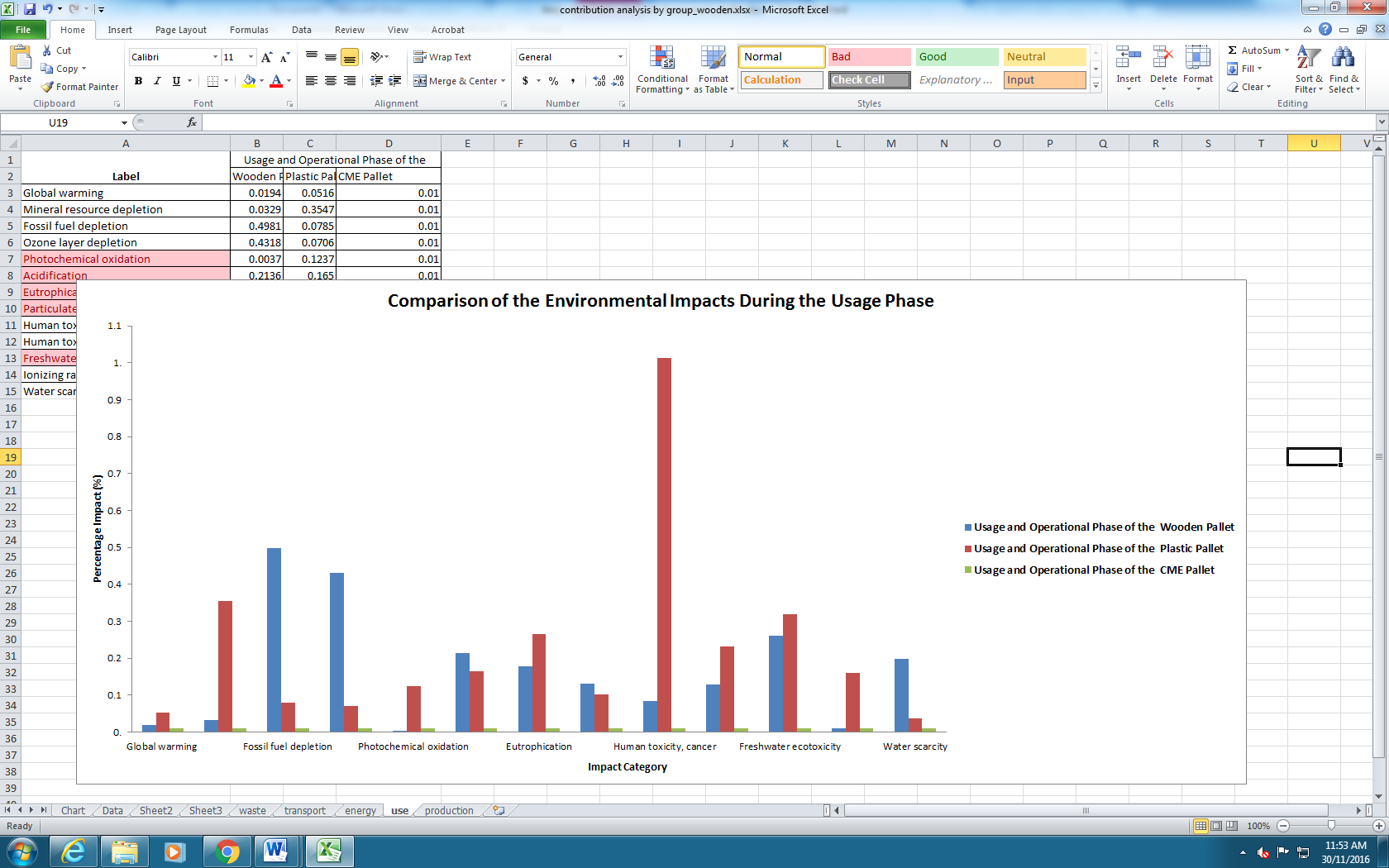
Figure 6 shows the percentage environmental impacts occur during the usage and the operational phase of the three pallet alternatives.

Figure 6: Comparison of the Environmental Impacts during Usage and Operational Phase

The CME composite materials pallet shows the lowest environmental impacts during its usage and operational phase of the life cycle, compared with the other two pallet alternatives. The higher environmental performance during usage can be explained as the higher number of trips per pallet (longer life cycle periods), less repair requirements compared to the wooden/plastic pallets and the relatively lighter weight. When compared to the other phases analysed, the usage and operational phase has the lowest percentage impacts for each category (impacts below 1%). Even though the impacts for human toxicity, cancer has shown a higher value for the plastic pallet compared to CME pallet, it should be noted that the percentage difference between the impacts within these two pallets are only around 1% during the usage phase. The differences between the human toxicity levels for plastic pallet and CME pallet can be explained by the lesser number of CME pallets required within the functional unit considered (1000 customer trips), compared to the plastic pallets.

### 2.5 Waste/Disposal of the Pallet

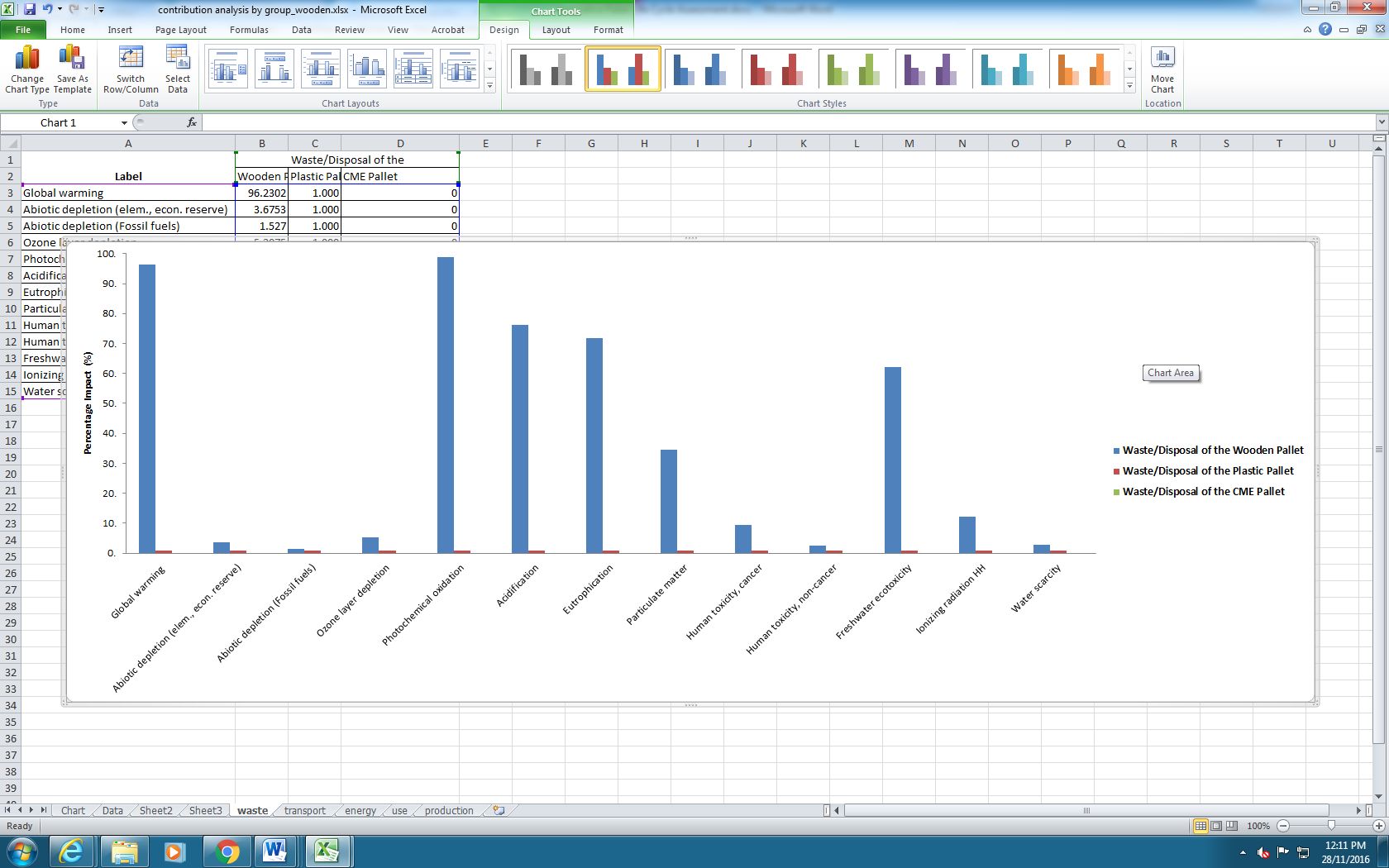
Figure 7 shows the percentage environmental impacts that occur during the waste/disposal stage of the three pallet alternatives.

Figure 7: Comparison of the Environmental Impacts during Waste/Disposal

The assessment of the environmental impacts of the waste/disposal stage of pallet alternatives shows that the wooden pallet has the highest contribution during this phase, in comparison with the other two alternatives. Reasons for the high impact of wooden pallets during the disposal stage can be explained as the amount of raw material that ends in landfill and remaining wood that is used for other purposes such as combustion for energy, during the end of their useful life. Plastic and CME pallets are made up of recyclable materials and these recycled materials can be re-used for the manufacture of other products.

The CME pallet has the lowest (almost zero) impact during its disposal stage compared with the alternative pallets, due to the recyclability of the material to produce similar pallets or other products.

## 2.6 Overall Results of the Impact Assessment for Three Pallet Alternatives

The overall impact assessment was conducted for the three pallet alternatives based on ALCAS best practice LCIA recommendations, for the various phases of their life cycle discussed above. Figures 8, 9 and 10 show the overall impacts by wooden, plastic and CME composite materials pallets respectively.

Figure 8: Complete Life Cycle Impacts from the Australian Wooden Pallet

Figure 9: Complete Life Cycle Impacts from the Australian Plastic Pallet

Figure 9: Complete Life Cycle Impacts from the Australian Plastic Pallet

Figure 10: Complete Life Cycle Impacts from the CME Pallet

Based on the complete life cycle impacts assessed, it is evident that the highest environmental impact from the wooden pallet occurs from its waste/disposal phase; whereas energy consumption for the plastic pallet has the highest overall impact during its life cycle. For the CME composite pallet, environmental impacts are highest during the production and energy consumption phases.

The waste/disposal scenarios for wooden pallet and energy consumption for the plastic pallets are stages of the life cycle which are difficult to control. The production stage of CME pallet has a high environmental load due to the procurement and manufacture of raw materials. Since part of the recycled materials (60%) are used to reproduce the CME pallet with the same properties in future life cycle scenarios, the impacts from the production stage can be significantly reduced and this can provide overall greener benefits compared to the pooled wooden and plastic pallets in the longer term.



DISCUSSION, CONCLUSIONS AND RECOMENDATIONS

# Discussion, conclusions and recommendations

A complete Life Cycle Assessment (LCA) was conducted for the innovative CME composite materials pallet and its two major market alternatives pooled wooden and plastic pallets. The LCA was conducted in accordance with the Australian Life Cycle Assessment Society (ALCAS) Best Practice Life Cycle Impact Assessment (LCIA) Recommendations, using SimaPro 8.2.3 life cycle modelling tool.

From the three alternative pallets assessed, CME composite materials pallet showed lower environmental impacts for all the 13 impact categories for transport, usage and waste/disposal phases, compared to the polled wooden and plastic pallets. The transportation phase for CME pallet showed significant environmental benefits compared to both wooden and plastic pallets due to the longer life cycle period, light weight and low repair requirements of the pallet. The environmental impact from the energy consumption of the CME pallet was higher than the wooden pallet however was lower than that of plastic pallet. The usage phase of the CME pallet also had a substantially smaller environmental footprint than the wooden and plastic pallets due to the high number of trips per pallet compared with the wooden and plastic pallets. The waste/disposal phase at the end of the life of CME pallet showed almost zero impacts due to the complete recyclability of the material to regenerate new pallets or other products.

One of the major phases where CME composite materials pallet showed significant environmental impact compared with its alternatives is the production stage. Among the 13 impact categories considered in the LCA, for the production stage, CME pallet had higher impacts for 6 impact categories (which mainly represented impacts for air and water) than its alternatives. The SimaPro analysis showed that, during the production stage, the highest environmental load occurs from the processing of raw materials glass fibre and polypropylene, which are required to manufacture the composite material for the pallet. Hence, this can be identified as a hotspot in the life cycle of CME pallet, which affects for the product’s overall environmental sustainability. However, this is a stage of the life cycle where CME does not have any control. It has been identified that 60% of the composite material can be recycled into produce the pallets with similar properties. Due to the material’s recyclability to regenerate new pallets, during the later stages of the product life cycle, the impacts from the production stage will become considerably reduced. Therefore, it can be concluded from the overall LCA that, in the longer run, CME composite materials pallet provides significantly high environmental sustainability compared to the plastic pallet during the complete life cycle and wooden pallet considering the life cycle stages of transportation, usage and disposal. .

One of the major limitations of this study was the data availability. Due to the innovative nature of the CME pallet, most of the data used in this study were based on assumptions with respect to similar international products available in literature.. Some of the physical properties tested for the CME pallet (i.e. tensile strength, flex strength, flex modulus) are considerably high compared to its market alternatives which could result in an increased number of trips per pallet life time. Therefore, this could further lead to reduce the overall life cycle impacts of the pallet. Hence, it should be noted that the results obtained during this LCA is highly sensitive to the assumptions made during the analysis.

Therefore it is recommended that the Company continue to collect data to validate the assumptions made in this report, particularly in respect to validating the pallet life duration and clarifying distances for transportation. In addition, conducting a sensitivity analysis to identify the sensitivity of the various assumptions made during this study and how they affect the final LCA (i.e. increasing/decreasing the number of trips per each pallet) would be further beneficial to validate the results presented in this report.

In the present LCA conducted, the glass fibre required for the manufacture of the CME pallet was deemed to be sourced as an imported raw material. It would further reduce the environmental footprint of the product by transportation, if the glass fibre can be sourced domestically whenever possible.

The LCA did not assess the environmental impacts that may occur due to product damage or rejected shipments in importing this material. The damage to the CME pallet is anticipated to be lower than wooden or plastic pallets according to the results available from the impact testing. Moreover, this LCA did not include the environmental impacts that may occur during the recycling process of the pallet. There can be various energy consumption requirements, materials and as well as emissions associated with the recycling process of composite material. Therefore, it would be beneficial to conduct an extended LCA by considering these factors in the future, to further understand the environmental benefits of the innovative pallet.



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# Appendices

## Appendix A

Assumptions and data sources on the life cycle periods of pallet alternatives

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Pallet type | Functional Unit (Trips) | Pallet life Time (trips/pallet) | Functional Unit (Pallets) | Expected Life Time (Years) |
| CME composite Materials Pallet | 1,000 | 150[[3]](#footnote-3),4 | 7 | 10 years[[4]](#footnote-4) |
| Pooled Timber Pallet | 1,000 | 83[[5]](#footnote-5) | 12 | 5- 7 years[[6]](#footnote-6) |
| Pooled Plastic Pallet | 1,000 | 63[[7]](#footnote-7) | 16 | 2- 3 years[[8]](#footnote-8) |

# Glossary

**Global warming -** A gradual increase in the overall temperature of the earth's atmosphere generally attributed to the greenhouse effect caused by increased levels of carbon dioxide, CFCs, and other pollutants.

**Abiotic depletion (elem., econ. reserve)-** Consumption of the economic mineral reserve faster than it can be replenished.

**Abiotic depletion (Fossil fuels) –** Extraction of natural gas, oil and coal reserves at a rate higher than nature replenishes them.

**Ozone layer depletion -** Ozone depletion describes two distinct but related phenomena as: a steady decline of about four percent in the total amount of ozone in Earth's stratosphere (the Ozone layer), and a much larger springtime decrease in stratospheric Ozone around earth's Polar Regions.

**Photochemical oxidation -** Photochemical oxidation is the reaction of a chemical change in a substance which causes it to lose electrons which is initiated by light. A common example is photochemical smog which is caused by hydrocarbons and NOx reacting under the influence of UV light.

**Acidification -** The act or process of making something sour (acidifying), or changing into an acid.

**Eutrophication –** Eutrophication is the depletion of oxygen in a water body, which kills aquatic animals. It is a response to the addition of excess nutrients, mainly phosphates, which induces explosive growth of plants and algae, the decaying of which consumes oxygen from the water.

**Particulate matter -** Atmospheric particulate matter – also known as particulate matter (PM) or particulates – are microscopic solid or liquid matter suspended in the Earth's atmosphere.

**Ecotoxicity -** Ecotoxicity, the subject of study of the field of ecotoxicology (a portmanteau of Ecology and Toxicology) refers to the potential for biological, chemical or physical stressors to affect ecosystems.

**Ionizing radiation -** Radiation consisting of particles, X-rays, or gamma rays with sufficient energy to cause ionization in the medium through which it passes.

**Water scarcity -** Water scarcity is the lack of sufficient available water resources to meet the demands of water usage within a region.

1. Please refer to Appendix A for the assumptions made on the life cycle periods for each of the pallet alternatives and the number of pallets used for the present LCA, based on the selected functional unit. [↑](#footnote-ref-1)
2. The energy requirement to manufacture glass filled Polypropylene composite material was obtained from Joshi et al. (2004) and the energy requirement to manufacture the CME pallet was obtained from the manufacturer’s information. [↑](#footnote-ref-2)
3. Source – iGPS (2008) [↑](#footnote-ref-3)
4. Source – Manufacturer’s Information [↑](#footnote-ref-4)
5. Source – China Merchant Loscam Holdings Australian Wooden Pallet obtained from Bengtsson and Logie, (2015) [↑](#footnote-ref-5)
6. Source - Bhattacharjya and Walters, (2012) [↑](#footnote-ref-6)
7. Source – Smorgen Group (Vicfam) Recycled Plastic Pallet obtained from Bengtsson and Logie, (2015) [↑](#footnote-ref-7)
8. Source - Brindley, (2010) [↑](#footnote-ref-8)