Analysis with Business Model Life Cycle Assessment for Innovation of a Circular Business Model

A case study of rental products at events

Master's thesis in Industrial Ecology

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2023
www.chalmers.se
Report No. E2023:81

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SUMMARY

Plastic waste in seas and oceans is growing and becoming a larger problem. As of 2022, it was estimated that there are 139 million tonnes of plastic waste in the Earth's aquatic environments where it harms wildlife and ecosystems (OECD, 2022). Simultaneously as the plastic waste in the oceans increase, legislations, and regulations to mitigate the environmental problem of plastic waste are beginning to being implemented (European Parliament, Council of the European Union, 2019). The Swedish government has decided that by 2024, no disposable cups with more than 15% of plastic is allowed to be sold, as response to the European Parliament's legislation (Swedish Government, 2021).

With new business models appearing, a problem rises. Substituting old business models with new ones that uses multiple use products is only beneficial if the new business models are more environmentally sustainable than the old ones. Furthermore, there has been a problem when trying to assess the environmental performance of business models as conventional product LCA often is used for assessment but fails to capture the social and economic dimensions of business model (Böckin et al., 2022). As conventional product LCA assesses a physical entity, the product as a unit and not the entire business model.

The aim of this project is to understand the environmental performance of the Light My Fires rental business model for events. Furthermore, the study aims to enable business model innovation by running a sensitivity analysis that shows how the environmental impacts changes due to changes of the business model such as the return rate, rental price, loss fee, storage location and material and manufacturing cost. Lastly, the intended outcome of the project is to answer what the environmental performance of the studied business model is, what environmental hotspots there are, and suggest courses of action to maintain profit of the company while minimising the environmental impact. The functional unit of the study was desired profit level during an event season for Light My Fire.

The GWP per f.u. was: 0,037 kg CO_2 eq/f.u. It was found that the largest hotspots for all impact categories: Global warming potential$_{100}$, Marine aquatic ecotoxicity, Acidification, Terrestrial ecotoxicity, Fresh water aquatic toxicity, Human toxicity, Abiotic depletion, Ozone layer depletion, Photochemical oxidation, Eutrophication, Abiotic depletion (fossil fuels) analysed, were the production for making up for losses depended on the return rate, the transports between Västervik, Gothenburg and Malmö, and the production of polypropylene. Interestingly, it was revealed that the return stations effect on the environmental performance of the business model was of great significance. From the sensitivity analysis it was found that the most significant change in environmental impact with a high possibility of implementing was to increase the return rate after each event. By increasing the return rate to 85% the business model would lower the kg CO_2 eq/f.u. with 23% as production of new products were decreased and ultimately decreasing the need for extra transports. Furthermore, it showed that moving the storage facility to the same city as the event reduced the contribution to total emissions from transports with 8%. Further, combining the increase of return rate, with the change of storage facility entails a 32% reduction in kg CO_2 eq/f.u.

Studies have shown that sustainable business models are considered to reduce impacts to environment and society (Bocken et al., 2014). However, this study showed that marketing business models as sustainable without analysing its entirety could have implications in the form of unforeseen impacts. Subsequently, there are possibilities to improve sustainable business models with business innovation using the BMLCA method. Ultimately, the BMLCA worked as a tool for analysing and evaluating the environmental performance of a rental business model used at events with a timeless functional unit. The rental case differed from previous conducted studies since the case was conducted at a real event which has not been done previously, however, the method presented in this study could be successfully modified and subsequently applied to the rental business model at events.

Keywords: BMLCA, business model innovation, environmental impacts of business models.

Table of contents

1. Introduction

Plastic waste in seas and oceans is growing and becoming a larger problem. As of 2022, it was estimated that there are 139 million tonnes of plastic waste in the Earth's aquatic environments where it harms wildlife and ecosystems (OECD, 2022). Simultaneously, as the plastic waste in the oceans increase, legislations, and regulations to mitigate the environmental problem of plastic waste are beginning to form (European Parliament, Council of the European Union, 2019). The Swedish government has decided that by 2024, no disposable cups with more than 15% of plastic is allowed to be sold, as response to the European Parliament's legislation (Swedish Government, 2021).

With the implemented plastic regulations, implications arise for event organisers in Sweden, as many events often rely on the disposable products for the sales and distribution of their beverage and food. The events must change and rethink their old habits of using disposable products that generate large amounts of waste and instead look for new solutions (Swedish Government, 2021). As the organisers are looking for solutions, possibilities for actors supplying multiple use products solutions could arise. In response to the Swedish Government actions towards the event industry, Light My Fire has developed a circular business model called *At event*. The business model intends to adopt a reusable product that could be used for several events and thus reduce the plastic waste.

However, substituting the old business model with a new one that uses multiple use products is only beneficial if the new business model is more environmentally sustainable than the old one. Furthermore, there has been a problem when trying to assess the environmental performance of business models as conventional product LCA often is used for assessment but fails to capture the social and economic dimensions of business model (Böckin et al., 2022). Recently, the *Business model life cycle assessment* (BMLCA) method has been developed with its intention of accounting for entire business models instead of solely a product or product system when assessing environmental performance of business models (Böckin, Goffetti, Baumann, Tillman, & Zobel, 2022).

The purpose of this project is to analyse a circular business model for the Swedish company Light My Fire. The analysis would highlight the environmental impact of the product system's processes and tying them with the economics of the business model. Furthermore, the study aims to enable business model innovation by running a sensitivity analysis that shows how the environmental impacts changes due to changes of the business model. The analysis could then be used to provide a better understanding of their business model and to highlight improvement areas that could be both environmentally and economically beneficial.

Currently, as the BMLCA is a novel tool in assessing environmental performance of business models, there is little research done in the field. Two studies have previously been conducted (Goffetti et al., 2022; Sandqvist & Westberg, 2022) where the functional unit (f.u.) have been based on a determined time period business model.

No BMLCA has been conducted on a business model concerning events where the time period of the f.u. is timeless i.e., previous BMLCA studies have been conducted on business models where the time period has been determined such as a quarter or a year, whereas this study focuses on only event duration but disregards the time of the events. It is therefore a research gap that this study aims to fill by investigating the BMLCA's compatibility when there is no determined time period.

1.1 Aim

The aim of the project is to understand the environmental performance of the Light My Fires rental business model for events. Furthermore, the study aims to enable business model innovation by running a sensitivity analysis that shows how the environmental impacts changes due to changes of the business model. Lastly, the intended outcome of the project is to answer what the environmental performance of the studied business model is, what environmental hotspots there are, and suggest courses of action to maintain profit of the company while minimising the environmental impact.

2. Background

In this section the theoretical background of the project is established and key concepts that will help in understanding the project are explained in detail. The background will also provide an understanding of the knowledge gap within the field of research. The background is based on the methodology of the literature review described in chapter 3.1.

2.1 Decoupling economic growth from resource use

In the interest of continuing human prosperity and well-being, decoupling of economic growth from environmental impacts is of essence. Decoupling is often presented as one of the solutions to maintaining the economic growth while decreasing the environmental impacts from economic activity to be able to reach the sustainable development goals within the Paris Agreement of reducing carbon emissions (Huang, et al., 2021). The Paris agreement (UNFCCC, 2015) state that the increase in global average surface temperature must stay within 1,5-2 °C to reduce the risk of potential harmful effects that might follow (WWF, n.d).

Decoupling is the concept concerning disengaging the economic growth and the correlation between environmental impacts (UNEP, 2011). The concept can be defined as either relative or absolute. A relative definition of decoupling refers to higher rates of economic growth than the growth rates of environmental impacts or resource use. In contrast to the relative definition, absolute decoupling refers to a decrease in environmental impacts or resource use irrespective to the rates of economic growth (Ward et al., 2016).

However, the concept of decoupling could be difficult to apply on individual business companies since the concept is often discussed at a macro-economic level instead of firm level (UNEP, 2011). Since the current measurement of decoupling is GDP in relation to the environmental impacts on a national level (UNEP, 2011), the lack of guidance for companies to apply the concept to its businesses on a smaller scale, is called for. Subsequently, the need for a tool to be able to measure companies' environmental performance while decoupling the profit on smaller scale is of essence.

2.2 EU-directive on plastic ban

The current linear economy that creates value by producing and selling as many products as possible, in combination with overconsumption of plastic products and single use products has become an emerging problem. The plastic products end up as litter in the oceans and on beaches. 85% of the total waste in the oceans was plastics, and out of the littered plastics, half of it was single use plastics (European Parliament, Council of the European Union, 2019) Furthermore, the plastic waste that ends up in the ocean stems from single use products which ultimately degrades to micro-plastics that have potential to negatively impact oceans ecosystems (Andrady, 2011).

Subsequently the EU directive that was established in 2019 has the intention to counteract the plastic consumption by constraining the usage of single use plastic and consequently reduce the plastic waste that ends up in oceans. The directive has a ten-year plan that will stepwise increase the demand on both the producers of plastic products and the total infrastructure around the waste treatment of plastic products. The directive is meant to be implemented at national level for countries within the EU, and Sweden has already taken actions to start implementing the directive.

One of the intended purposes of the EU directive on plastic ban is that it should be seen as a driver towards transitioning to a circular economy (European Parliament, Council of the European Union, 2019) and in turn encourage circular business models.

The first actions that the Swedish Government has implemented is the requirement on the supplier of beverages and food in single use products. By January 1st, 2024, the supplier also needs to provide the customer with a circular alternative to the single use product unless they are using only paper products for their business. The government has stated strict guidelines to larger actors that they need to provide the beverage or food in a reusable container that are supplied at the service location. The actors also need to take effective measures to allow the reusable containers to be reused in a circular system. At the service location, the actors need to inform the customer about the reusable alternatives, the environmental contribution that follows from continuing usage of single use products and the effects from reducing the usage of single use products (Swedish Government, 2021).

The Government will also implement restrictions concerning the use of single use cups that contains more than 15% plastic. The ban intends to reduce the number of plastic products that are used in general and specifically, in the restaurant and event industry. Finally, the Swedish Government also intends to increase the recycling rate of plastic and are putting pressure on the EU to implement directives that all newly produced plastic products should contain at least 30% recycled plastic (Swedish Government, 2021).

2.3 Circular economy

Circular economy (CE) is a concept that revolves around keeping materials and resources in use for as long as possible (Benton et al., 2014). The idea of CE is to gather the waste and use it as resources for new products, and by doing so, reducing the need for additional virgin resources. There are various ways for minimising the waste created from societal processes and these can be described as resource life-extending services (RLES). RLES consists of services such as reuse, recycle, remanufacture, servitisation, repair, waste-to-energy, product longevity approaches and cascading of products (Blomsma & Brennan, The emergence of circular economy: a new framing around prolonging resource productivity, 2017). Like RLES, the R framework is a strategy to reduce the waste generation and is besides systems perspective, one of two core principles that the CE concept consist of (Kirchherr et al., 2017).

The R framework is often named 4Rs framework and describes the order in which measures should be taken and is ranked after how beneficial they are for the reduction of waste and constitutes of the four processes: reducing, reusing, remanufacturing, and recycling (Ellen MacArthur Foundation, n.d.). Reducing the need for a product is considered the most beneficial waste reducer, as less material is required when demand for the product or material is lowered. When reusing, the lifetime of the product or material is instead increased, subsequently leading to less demand for new products which in return also lowers the demand for resource use and thus lowering the waste generated. Remanufacturing of products requires additional material to replace broken parts, which creates less waste than when discarding the entire product. Recycling also reduces the need for new resources but require additional energy to be able to transform the materials (Kirchherr et al., 2017; Ellen MacArthur Foundation, n.d.; King et al., 2005).

Systems perspective focuses on how all parts of a system and not only individual parts, must be accounted for when working with sustainability. Otherwise, there is the potential risk of creating new ecological problems as one change is implemented without regards to how it might affect other parts of the system or chain. Similarly, it is the same when working with sustainability through CE where a change in business strategy might lead to increased transports for example. Hence it is important to observe every part of the system to avoid unwanted side effects to implemented changes as well as narrow analyses (Lifset & Graedel, 2002).

2.4 Sustainable and Circular Business models

With the increased need for CE in society and its increasing implementation, Circular Business Models and Sustainable Business Models have begun to develop more and more. Bocken et al. (2020) summarises sustainable business models as:

> Sustainable business models are about the ways in which organisations create, deliver, and capture value for customers and stakeholders, to support a safe and just operating space for humanity and all living entities to flourish.

In addition to how ordinary business models generate profit and where the focus is put on *value proposition*, *value creation and delivery*, and *value capture* (Richardson, 2007), the sustainable business model further assures reduced impacts to environment and society (Bocken et al., 2014).

Circular business models focus on creation of value, while emphasising the need for circular flows of resources, or ''closing the loop'' (Geissdoerfer et al., 2020). Further, Geissdoerfer et al. (2020) states that there are four strategy concepts that generate the circular business models and that these are: Cycling, Extending, Intensifying and Dematerialisation. Cycling entails that materials and resources are used multiple times within the system before being discarded. Extending the lifetime of products focuses on design for longevity (Carlsson et al., 2021), and a marketing of products and materials that promotes long use phases. Intensifying is addressing the need for concepts such as sharing economy that reduces the overall need for resources. Lastly, dematerialisation exchanges the need for resources by moving from consumption of products to services instead (Geissdoerfer et al., 2020).

To conclude, the two concepts; sustainable business models and circular business models are both described as concepts that promotes business models that are better for the environment and society. The main difference is that the circular business model is more closely connected to the core principles of circular economy.

2.5 Assessing Sustainable and Circular business models

According to (Bocken et al., 2016) the currently used quantitative assessment of circular business models are Life cycle assessment (LCA) and Material flow analysis (MFA). The LCA is used to assess the product system's environmental performance which could be used to identify opportunities within the product system thus improve the environmental performance. The MFA is used to get an overview of the flows of materials that are within the systems boundary but are not used to give strategic innovations of the business model in the future. Continuing, Bocken et al. (2016) argues that the Circularity canvas (Blomsma, 2015) could be used to assess circular business models. The Circularity canvas is a tool used for mapping current resource flows in a business model, but much like the MFA the Circularity canvas lacks the strategic business model design for evaluating and improving the environmental performance of business models.

(Lüdeke-Freund et al., 2018) describes the problem with the current used methods as not sufficient and thus:

> Assessing the actual sustainability performance of such business models requires methods and metrics that capture the ecological, social, and economic performance of sustainable business models.

The current methods do not capture the ecological and economic performance of sustainable business models. Subsequently there is a lack of sufficient methods when assessing the environmental performance of circular and sustainable business models.

2.6 BMLCA

As a result of the increasing amount of business models claiming to be circular or sustainable, the need of evaluating their environmental performance has appeared. The solution to this has been the development of the Business Model Life Cycle Assessment (BMLCA) (Böckin et al., 2022).

An ordinary LCA is a tool for assessing a product system's environmental performance (Baumann & Tillman, 2004), and while LCA being good assessing product systems, it is not applicable to the assessment of business models (Böckin et al., 2022). The BMLCA differs from an ordinary LCA mainly by the definition of the f.u. Contrary to how the f.u. is defined in LCA normally i.e., to allow for comparison between product systems based on their function, the BMLCA's f.u. is the financial function of a business model, i.e., the profit of the business model. The f.u. of the BMLCA hence allows for the understanding of the possible profitability tied to environmental performance of circular business models as opposed to ordinary LCA where profit is neglected (Goffetti et al., 2022). Furthermore, the BMLCA varies in its execution from the original LCA, as it divides the goal and scope definition into a descriptive phase, and a coupling phase (Böckin et al., 2022). In the coupling phase the focus is on formation of equations that couple the monetary flows with material flows in the business model are created as well as stating the f.u. (Böckin et al., 2022).

The previous research within the field is two cases where the BMLCA has been used for assessing the environmental performance of business models. In one of the cases the method was applied on a shell jacket with two separate business models. Two business models were direct consumption where sales responded to the number of jackets produced, either a high price with a higher quality or a faster production with lower quality and lower price. The two methods were compared with a rental model of the shell jacket where the total transactions did not correspond to the number of produced jackets. The f.u. used in the case was profit over one month. The conclusions that were made from the comparison between business models was that the rental business model can lead to decoupling environmental impacts from profit. The specific parameters that were of importance for the result was price, rental efficiency, and the transportation methods from the customers. (Böckin et al., 2022; Goffetti et al., 2022).

The second study that has been conducted using BMLCA was on an automotive company and compared five of the company's different business models as well as investigating the usefulness of the BMLCA method (Sandqvist & Westberg, 2022). The different business models were two sales models and three subscription models. The f.u. that was used was a business period over 25 years since the lifetime of a car was determined to be within the span of that period (Sandqvist & Westberg, 2022). The study found that the BMLCA methodology is applicable to products with long lifetime and that produces emissions during its use phase, but also how it was possible to use an ordinary LCA and modify it to use as input of the BMLCA. The conclusions that derived from the comparison between business models was that direct sales to customer were favourable compared with selling to dealers. The most favourable subscription business model was determined to be the Multicycle since it had the best environmental performance of the five. The Multicycle business model remarkets the vehicle between subscribers which results in a cycle of users. (Sandqvist & Westberg, 2022).

The two different cases are widely different since the shell jacket have a shorter lifetime with less complex components in comparison to the latter which had a longer lifetime and a more complex structure to the product itself. The two products also differed as the shell jacket did not have emissions in the use phase, while the automotive business model had. Both previous conducted BMLCA cases will be used as guidance in the novel field of research.

2.7 Summary of background

To summarise what has been described, decoupling the economic activity and the environmental impacts has been proven to be one of the solutions to decrease carbon emission while maintain economic growth. The decoupling needs to be assessed at company level and subsequently, the need for a tool to be able to measure companies' environmental performance while decoupling the profit on smaller scale is of essence. The EU directive on plastic ban and the following actions that the Swedish Government has implemented towards the suppliers at events requires reusable and circular alternatives. The need for alternatives present opportunities for circular companies within the event business to position themselves in the market.

The directive should be seen as a driver for transition towards circular economy, a concept that revolves around keeping materials and resources in use for as long as possible. There are several ways and methods to reduce the need for additional virgin resources and circular and sustainable business models have emerged as a possible solution. With the increased need for circular economy in society and its increasing implementation, Circular Business Models and Sustainable Business Models have begun to develop more and more.

Sustainable business models and circular business models are both described as concepts that promotes business models that are better for the environment and society. However, because of business models claiming to be circular or sustainable, the need of evaluating their environmental performance has appeared. Since the current used methods are insufficient when applied on circular or sustainable business models, a new tool is required. The solution to this has been the development of the BMLCA.

The BMLCA differs from an ordinary LCA mainly by the definition of the f.u. Contrary to how the f.u. is defined in LCA normally i.e., to allow for comparison between product systems based on their function, the BMLCA's f.u. is the financial function of a business model, i.e., the profit of the business model. Hence, the f.u. of the BMLCA allows for the understanding of the possible profitability tied to environmental performance of circular business models as opposed to ordinary LCA where profit is neglected. The method presents an opportunity to decrease the environmental performance while maintaining the profit for the business model.

3. Methodology and Materials

In this chapter the projects methodology is explained. It starts with the literature review that was conducted and is followed by the description Light My Fire's business model, the BMLCA and the interpretation of the results. Continuing with the limitations that were implemented during the project and finally the sensitivity analysis that was conducted in the study. The BMLCA method was used to help answering the aim of the study and was selected to be the appropriate method due to its characteristics to link the monetary transactions with the environmental performance of the business model.

3.1 Literature review

The first step of the project was the literature review. It was conducted to create an understanding for what the previous research was in the field was and to understand how circular and sustainable business models work, what they are and how they are assessed. Furthermore, the review was conducted to create a background on what EU-directive would mean for businesses and events that are affected by its implementation. The results from the literature review formed the background of the project and was also used as a basis for discussion of the results. The review was carried out using several different sub searches within the following terms:

- Decoupling economic growth from environmental impacts
- EU-directive plastic ban
- Circular economy
- Industrial ecology
- Business models
- Sustainable business models
- Circular business models
- Assessing sustainable business models
- BM-LCA

The search engines Google scholar and Chalmers library was used for finding published papers that were peer-reviewed on the subjects. The articles used for the literature review was found at the first two pages of results. Furthermore, the references of those articles used were investigated and sometimes used for further information on the subject or for information of other subjects.

3.2 Light My Fire's rental business model

The rental business model was a collaboration with the *Retake* concept research project between Light My Fire, Panter, Karlstad University and Stiftelsen Chalmers Industriteknik in Sweden. The project aims to implement and evaluate circular systems for food and beverage at events, such as Gothenburg Horse Show 2023 (GHS). The system itself includes the possibility to trace the products used during the events throughout the operating phase, washing, logistical and other handling of the products. The expected outcome from the project is to create a more sustainable event with the focus to reduce litter and the cleaning cost while simultaneously maintaining or increasing the customers satisfaction. The results from the project will also support guidance for future events that want to implement reusable packaging, because, as of January 1st of 2024, actors who supplies food and beverage for take-away in Sweden are required to offer reusable packaging options in a rotation system. Although the retake project is a part of the business model at GHS event, it will not be in the future. Hence, these extra processes and work that stems from the project is excluded in this analysis.

During GHS, Light My Fire supply the event with a product called Cup'n Lid, which is illustrated in Figure 1. The products' intended purpose is to replace the single use products at the event. Light My Fire provides the Cup'n Lids via truck freight and with a single shipment of all products at once. The Cup'n Lids are then stored at the event venue and used continuously throughout the event. The number of Cup'n Lids sent to GHS was budgeted to cover for the whole event's need, and no washing was planned between different days. For the GHS event, Light My Fire sent 6000 cups and 3000 lids. In the calculation a Cup'n Lid is assumed to be one cup and a half lid as the lids are allocated to the number of cups.

Figure 1 - The Cup'n Lid used at GHS.

When the customer acquired a cup of coffee at the event, the customer was asked if a lid was desired to complement their cup and was then handed the product with the liquid in it. The original plan was for people to use the product without the lid, but it was found that most customers wanted a lid for their beverage. The customer was then allowed to bring their coffee wherever they pleased at the venue. After the customer had finished their beverage, the customer was supposed to return the product to one of the 40 designated return stations located around the venue. Figure 2 shows the return stations that were used at the event. The return stations were throughout the days are emptied to collect the used Cup'n Lids by removing the top lid of the return station and switching the plastic bag inside. When the event was finished, all the used Cup'n Lids were returned to Light My Fire for washing at their own production facility in Västervik, Sweden, where they were later stored until the next renting opportunity.

Figure 2 - Return station used at GHS.

3.3 BMLCA

The methodology of the BMLCA in this study was based on the three articles created by Baumann et al. (2022), Böckin et al. (2022) and Goffetti et al. (2022).

3.3.1 Goal and scope

The first step of the BMLCA was, like the ordinary LCA, to conduct the goal and scope definition. However, the BMLCA differs by dividing the goal and scope into two phases, which were: *the descriptive phase* and *the coupling phase.* The descriptive phase described the business model, by detailing what processes were a part of it and its implementation. Further, the geographical and system boundaries was described, as well as time period of the business model and what impact categories that was used for the LCIA. The descriptive phase also described the characteristics of the product in the study.

The first part was to create and illustrate an initial flowchart over the business model were all processes and flows was described. The time period of the analysis was set based of the length of the usage of the Cup'n Lid. The geographic boundaries were selected based on the company's location, production of material and the event that was being analysed.

The environmental impact categories were selected based on the previously created LCA of the company and from literature. The LCA that was used as a basis was created for one of the other plastic products that the company produced called Bowl'n Lid. The Bowl'n Lid was made from the same material as the Cup'n Lid, but the intended function was to preserve food in a container as a lunchbox.

To understand which parts of the product system that were included in the company's business model and how these were related to their surroundings, a product chain organisation (PCO) analysis was conducted. The PCO was used to connect the amount of production *q* and how it depended on the number of transactions between value chain actors within the company's business model. Subsequently the actors were mapped in the product chain to identify which steps belonged to whom and, which and what transactions took place in the company's business model. Since the business model was a rental, the rate of *q* depended on how long the lifetime of the product was and how long it would take to replace the product.

After the descriptive phase of the goal and scope was finished, the coupling phase was conducted by deciding the functional unit (f.u.) of the study and by creating the coupling equations needed.

Firstly, the f.u. was defined by using the definition from (Böckin et al., 2022):

> A certain amount of profit, π, over a business period, *T*, from customer transactions for a particular set of products from a particular business.

To facilitate the analysis of the company's business model from an environmental perspective using a quantitively method, the business model needed to be coupled with the chosen product from the company. From coupling the monetary flows with energy and material flows, every operation within the company could be expressed with its own equation and the relation to the selected product. To be able to set up the equations within the business model, the correct data needed to be gathered in this study's case. The data on the revenues and costs of the business model was supplied from the company. The equations were based on the business model and its transactions.

3.3.2 Life cycle inventory

In the life cycle inventory, data on the economic aspects and data linked to the material flows of the business model was collected. Most of the data collected stemmed from the company's LCA on the Bowl'n Lid and was adjusted to fit the Cup'n Lid. Marginal data was gathered from the company regarding the information about the business model, actors, suppliers, and producers. Marginal data was used since the specific case of GHS was analysed and all parameters and data were related to this case. As previously mentioned, the economic aspects of the business model were critical when conducting a BMLCA hence data on costs all over the supply chain was obtained from the company. The company also provided the data for logistics and transportations within the business model.

When all the data was collected on the business model, LCA software was used to model and then calculate the environmental loads in relation to the f.u.

3.3.3 Life cycle impact assessment

In this step the classification of the different environmental loads was conducted, to ensure that all the correlating impacts of the business model was accounted for. Afterwards, the characterisation of the environmental loads resulted in the different potential impacts, these impacts was based on the previously conducted LCA as mentioned in 3.3.1. This step was also conducted using the same software as in the life cycle inventory assessment.

The results were then transferred into an Excel document where graphs and charts were created to facilitate for better understanding for the reader. The graphs created was illustrating how the different processes contributed to the different impact categories that was analysed. Further, the resulting data was used in the sensitivity analysis that followed.

3.3.4 Data collection

The data used when modelling the business model in openLCA was based on the previously conducted LCA report on the Bowl'n Lid from Miljögiraff as mentioned. Light My Fire provided the contact person for the RFIDs who functioned as an intermediator towards the producer Stora Enso. The contact person supplied data on the material used, weight of the materials, and production location of the RFID tags. The transportation data was not presented from Stora Enso, hence the online sea distance calculator *Shiptraffic.com* was used. The data from the event itself was collected from our own observations at the event, as well as additional information provided from Light My Fire. The economical information was given by Light My Fire.

3.4 Sensitivity analysis

After the BMLCA was conducted, the sensitivity analysis was conducted to gain insight on which parameters had influence over the environmental performance of the business model. And, to investigate how these changes could be used for business model innovation. The sensitivity analysis was created by using the coupling equations and altering parameters to be able to understand the parameters relationship to the final environmental performance. The parameters of the business model that were changed were economical parameters, such as renting price or production cost. Furthermore, there were changes strictly related to the business model, such as change of return rates or change of storage sites.

The sensitivity analysis was conducted using the Excel worksheet where the data from the LCIA was located. Each process was linked according to the coupling equations which allowed for the adjustment of parameters. When the parameters were changed, they resulted in a change in number of events required to maintain the same profit as the f.u. e.g., the change of increasing the rental price parameter would result in a shorter time period to reach the intended profit, thereby reducing the number of events that would be required, and ultimately changing the environmental performance. With the adjusted parameters different impacts of the business model followed. These results were then compiled into tables and graphs to illustrate what changes led to reduced emissions/f.u. and how large the reductions were compared to trade-offs.

3.5 Limitations

During the scoping process, the selected rental business model was the most equipped for analysis, of the three business models that Light My Fire had under their project "Engångsfritt" (Light My Fire, Engångsfritt, nd). The company Light My Fire have other similar business models that are intended to be used, but they are not operative and ready to be analysed to the same extent as their rental business model for events. Another reason for selecting solely the rental business model was the planned event GHS that took place during this project. In previous projects that have been conducted using BMLCA, several business models have been compared with each other to understand the environmental performance and the differences between them. However, in this case, only one business model was used in the analysis and the focus would therefore be to tune the selected business model to be more environmental performing while maintaining the profit generation.

The intention to compare materials used in Cup'n Lid was determined to not be possible due to the time constraint of the project. The main reason for excluding comparison between materials was both the time-consuming modelling part of the project and the interpretation of the results. However, it must be acknowledged that it would have been interesting to analyse the possible environmental effects in changing materials used in the cups as the LCA that the company has produced compare three different types of plastic and study only uses one of them.

When modelling the business model in openLCA there was some cut-offs in transportation during the extraction of the raw material needed for production of the Cup'n Lids. The transportations from extraction to processing of material later used in the making of Cup'n Lid was not included. Instead, it was assumed that the materials needed for the processes within the business model was processed beforehand and the transport to Light My Fire's facility was the only transport included for the respective materials. The reasoning for the limitation is that the modelling used in the project was based on the modelling of Bowl'n Lid conducted by Miljögiraff that had done similar cut-off.

A further limitation to the study was that the sensitivity analysis of the results was made solely for the global warming potential impact category. This is also due to the time constraints of the project where it would require significantly more time to illustrate and describe what each change would entail for the business model.

4. Business Model Life Cycle Assessment

In this chapter, the BMLCA's various parts for the rental business model will be presented. It starts with the goal and scope definition, where both the descriptive and the coupling phase is described. Thereafter, the life cycle inventory analysis is presented, followed by the life cycle impact analysis. After the LCIA, the interpretation of the results with the sensitivity analysis is described and lastly, a summary of the results.

4.1 Goal and scope definition – Descriptive phase

The Cup'n Lid that is being analysed in the study is a multiple use plastic cup with a capacity of 250 ml and a weight of 62.4 g. Of the total weight, 42.4 g stem from the cup and the remaining 20 g from the lid. The Cup'n Lid's intended function is holding liquids, beverages, and edibles. The product mainly constitutes of two materials which are polypropylene (PP), and a pigment used for used to colourising the PP (Light My Fire, n.d). The PP amount to 98 % of the total material used in the product and the pigment to the remaining 2 %.

As can be seen in Figure 3, there are processes that lay outside of Light My Fire's own production. These are the suppliers of the components that create the Cup'n Lid. In the case of GHS there were also RFIDs placed at some of the products in a research attempt to observe if the use and return pattern would change when the customer used a product with a RFID, compared to the original product. The production and extraction to supply the RFIDs are also part of the two processes outside of Light My Fire's own production.

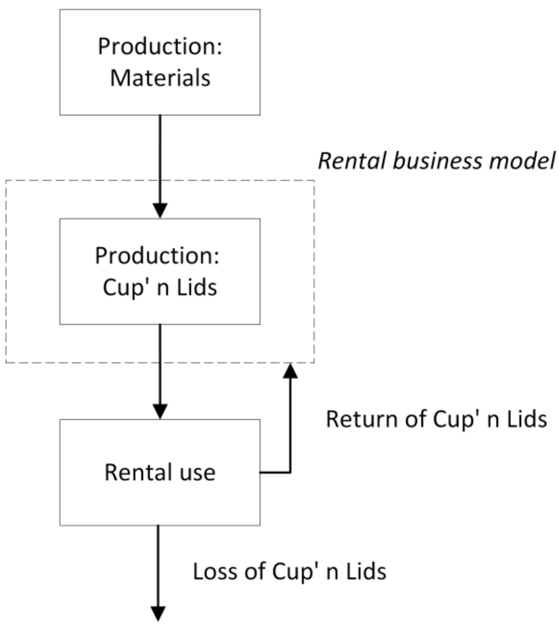

Figure 3 - Initial flowchart of the rental business model.

The selected system boundaries are cradle to grave to facilitate analysis of the entire life cycle of the circular business model. As can be seen in Figure 3, the analysed system begins with production of materials that are used to produce the Cup'n Lid. After production, the Cup'n Lids, were in the case of GHS, fitted with *Retake* stickers and half of the products with RFID tags. The Cup’n Lids are then stored in warehouse at the same location as production. The cups are then shipped to the rental use at the events. During the event there is a loss of products hence the return rate of cups is needed to be analysed. After the event the returned used Cup’n Lids are transported to washing and are either determined to be in satisfied condition to be used in upcoming event or deemed to be of insufficient quality, and subsequently sent to recycling. The recycling is planned to be done inhouse in the production chain at the same location as the production of the cups at Västervik, Sweden. The selection of recycling site at the same place as the production creates a closed flow of resources that is beneficial towards the circular business model.

However, the combination of a long lifetime and a high loss rate of the products led to the recycling process being outside of the scope for this study. Out of the 6000 cups, 1293 were lost at the event, and out of the 3000 lids, 1189 were lost, indicating a significant loss rate of the business model. The Bowl’n Lid analysed in Miljögiraff’s LCA, on behalf of Light My Fire, had a lifetime of 150 uses. A number that was derived from testing by simulating the use of cutlery in the Bowl’n Lid and by washing of the product. As the Cup’n Lid do not require cutlery for use, the assumption that the product has a higher lifetime than the Bowl’n Lid was made. In addition, as it is more likely that all cups will be replaced due to losses before they are worn out, the recycling process is excluded from the analysis.

The lost Cup’n Lids at the events is assumed to be discarded in the residual waste bins at the event arena. This assumption stem from the fact that, where the products went is unknown, and by modelling them as residual waste a “worst case scenario” is being adapted. The products could be brought home with the customers after the events or thrown in plastic waste collection. But as there is no way of telling how the lost products were disposed of, it is better to assume that they are incinerated along with the other residual waste from the event and used for energy and heat recovery.

The geographical boundaries of the BMLCA are set to Sweden for the business model since the rental events only take place within the country and globally to produce the plastic. The time period for the analysis is set to ten events as it was deemed as a plausible time horizon for the business model to generate the intended profit.

4.1.1 Impact categories

To aggregate the environmental impacts from the circular business model, a life cycle impact assessment (LCIA) is done. The choice of impact categories follows from the LCA report from Miljögiraff (Miljögiraff, 2023) on the Bowl’ n Lid. The LCA software that was used to model the life cycle of Cup’n Lid was openLCA with impact assessment method CML-IA baseline since it was used to some extent in the original report. The database ecoinvent3.8 was used as data source. The impact categories used in the CML-IA are: *Global warming potential*$_{100}$*, Marine aquatic ecotoxicity, Acidification, Terrestrial ecotoxicity, Fresh water aquatic toxicity, Human toxicity, Abiotic depletion, Ozone layer depletion, Photochemical oxidation, Eutrophication, Abiotic depletion (fossil fuels).*

4.1.2 Product chain organisation

In Figure 4, it is illustrated where Light My Fire are in relation to the actors within the business model. Then the identified flows within the business model are presented as costs and revenues in the product chain. The revenues of the business model are illustrated with a R for the revenue and C for the costs. There are costs linked to all production processes of the business model, but also due to storage, washing of the cups. Furthermore, there are costs located all over the life cycle linked to transportation of the gods and products. The revenues generated from the business model is located at the transaction between Light My Fire and the event organiser i.e., the business model generates all its revenues when the product is rented by the event from Light My Fire.

In Figure 4, the identified actors within the product chain are presented. The red boxes represent different actors, the black arrows correspond to material flows and finally, the green arrows represent monetary flows between actors. The figure illustrates how the company uses two different suppliers for material for their cups, with a third supplier of the RFID tags that later are applied to the cups. In total, five monetary flows are identified between actors. Supplier 1 produces the Polypropylene used in the cups. The other material supplier for the cup is supplier 2 and provides the pigment to the Polypropylene. Supplier 3 provides the RFID tags that are applied to the cups to be able to scan the cups in the recycling stations as mentioned. The scanning is used for easier counting of the returned cups to avoid manually counting. Supplier 4 provides the return stations made of carboard that are used to collect the cups at the event. The customer receives the Cup'n Lid after an economic transaction to the Light My Fire.

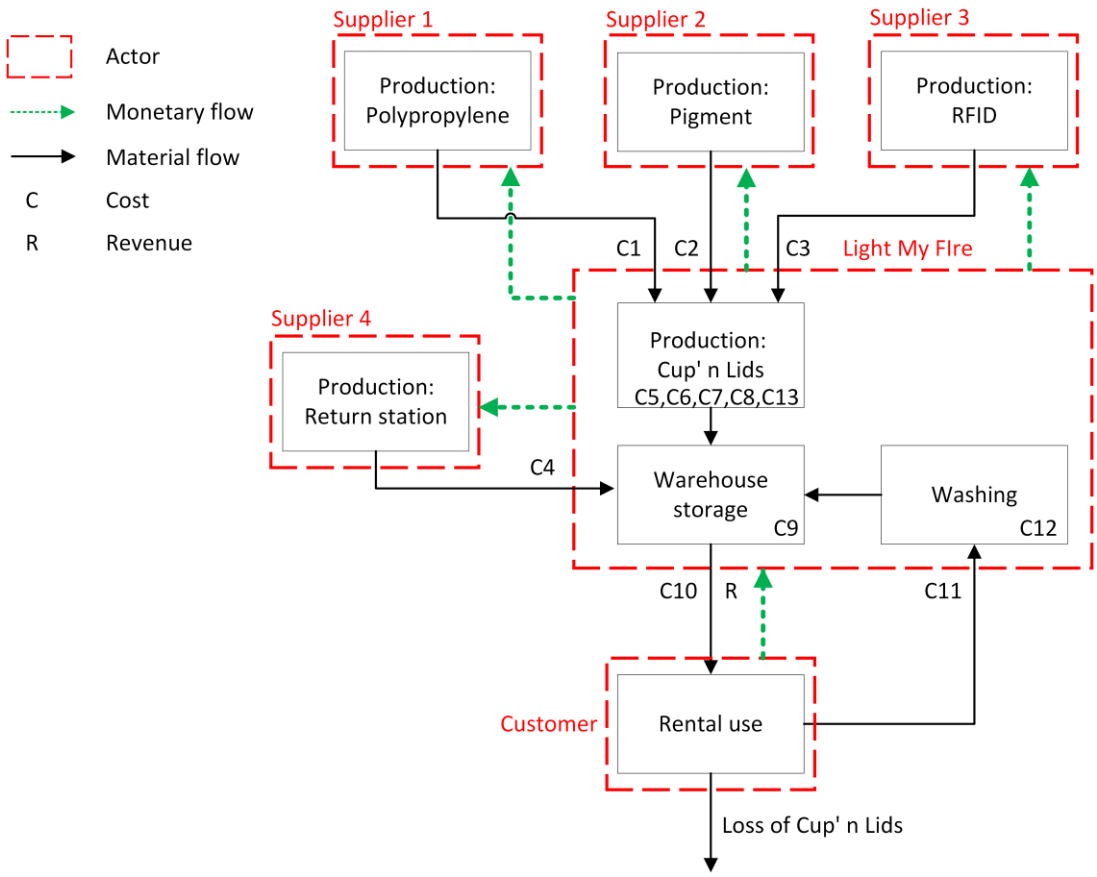

Figure 4 - Flowchart illustrating actors, monetary and material flows, costs and revenue of the business model.

The profit generated from the business model can be described with the equation of profit and is described in equation 1 below. Where π is the total profit, R is the total revenue generated and C corresponds to the total cost of the business model.

$$\pi_{rental,n\ events} = R_{total\ revenue,n\ events} - C_{total\ costs,n\ events} \quad (1)$$

As there is only one revenue stream in the business model, the total revenue is equal to the revenue generated from the transaction between Light My Fire and the event multiplied with the number of events *n*, as can be seen in equation 2:

$$R_{total\ revenue,n\ events} = R_{revenue\ from\ transactions\ from\ event\ organiser} \cdot n \quad (2)$$

The costs of the business model can be divided between direct costs and indirect costs. The different costs are described in Table 1 below. Here the direct costs are further divided into sub costs. As can be seen in Table 1, the cost from all four suppliers includes the material needed and the transport required for the product and business model. In both cost 1 and 2, the cost of losses has been included since the reproduction of a new cup is the same as the initial cup cost. However, the reproduction of cups will not include the RFID tags as decided by Light My Fire. In both previously mentioned costs, the deduction of the initial investment cost for the machine needed for producing products is also included. The machine can be used for other products as well in the assortment and are allocated as total investment cost of machines divided by the number of injections used for a product, divided by the estimated lifetime of Cup'n Lid.

The percentual addons on the labour (C5) and energy (C7) for production and the maintenance & repair (C8) were merged from Light My Fire, the costs were calculated as a single cost. The cost for the machine (C6) producing the Cup'n Lids was presented as write-off cost for each Cup'n Lid produced. The rent of storage facility (C9) is the cost of storage required for the Cup'n Lids between events. Both costs 9 and 10 are direct cost of the transportation costs to the customer at the event and back to the washing facility. Finally, the washing (C12) cost includes both water, electricity, and labour cost. The indirect cost could be identified as the administrative (C13) cost that includes organising, negotiation, and contact with potential customers.

Table 1. List of direct and indirect costs of the business model.

Direct		
Cost 1	Material & transport from supplier 1	Polypropylene used in the product
Cost 2	Material & transport from supplier 2	Pigment for colouring the product
Cost 3	Material & transport from supplier 3	RFIDs used on the products
Cost 4	Material & transport from supplier 4	Material for the return stations
Cost 5	Labour for production	
Cost 6	Machine producing Cup'n Lids	Write-off, of the machine cost
Cost 7	Energy for production	Electricity and heating
Cost 8	Maintenance & repair (equipment)	
Cost 9	Rent of storage facility	
Cost 10	Transport from storage/factory to customer	
Cost 11	Transport from customer to storage/factory	
Cost 12	Washing (including water, energy, and labour)	
Indirect		
Cost 13	Administrative cost	Organising and planning for events when renting to customers

The total cost of the business model is therefore equal to all 13 costs combined, and is described in equation 3:

$$C_{total\ costs,n\ events} = C_{direct} + C_{indirect} \quad (3)$$

Consequently, the profit is described in equation 4:

$$\pi_{rental,n\ events} = R_{revenue\ from\ transactions\ from\ event\ organiser} - $$
$$-(C_{direct} + C_{indirect}) = R_{revenue\ from\ transactions\ from\ event\ organiser} - \left(\sum_{i=1}^{13} C_i\right)$$

(4)

4.2 Goal and scope definition – Coupling phase.

In this section the second part of the goal and scope definition is presented. The functional unit of the project will be described, and the coupling equations will be presented.

4.2.1 Functional unit

The functional unit of the study is the expected profit for the business model with a time period of an event season. The expected profit of the business model was used as basis for the functional unit there is one business model assessed and the aim is to primarily evaluate the environmental performance of the already existing business model as well as allowing for business model innovation. The expected profit is not disclosed in this report due to confidentiality.

The time period of the functional unit was determined since the business model had a significant initial investment cost to supply the required products for the first event. Therefore, it was deemed that events of one season would be sufficient for primarily breaking even on the initial investment cost and allowing the business model to generate profit. As events differ in duration, it was determined that all events were of the same length. Since the time period is in events, the functional unit will be static hence the inflation will not be accounted for.

4.2.2 Coupling equations

When coupling the profit to the business model, each revenue and cost in Table 1 were used as basis for the coupling. In equation 5 the relation between the revenue and rental price for the cups divided by the number of cups rented is presented. *q* denotes the number of Cup'n Lids for one event and *n* the number of events. It shows that the revenue from the business model depend on the price of renting.

$$R_{total,n\ events} = R_1 \cdot q \cdot n \quad (5)$$

The cost for PP used in the production including transportation from supplier 1 and with q. The equation shows how the total cost for PP is dependent on the quantity of Cup'n Lids produced.

$$C_{supplier\ 1} = (C_{polyproylene} + C_{transport\ of\ polypropylene}) \cdot q = C_1 \cdot q \quad (6)$$

In equation 7 the material for pigmentation used in production including transportation from supplier 2, multiplied with q. As in the previous equations, the total cost of pigment for the business model depends on the number of Cup'n Lids produced.

$$C_{supplier\ 2} = (C_{pigment} + C_{transport\ of\ pigment}) \cdot q = C_2 \cdot q \quad (7)$$

In equation 8, the total cost for RFIDs is presented. The cost of RFID depends on the cost of transport and materials of the RFIDs multiplied with the number of RFIDs used and as the number of RFIDs only was used for half of the Cup'n Lids, *q* is dived by 2.

$$C_{supplier\ 3} = (C_{RFID} + C_{transport\ of\ RFID}) \cdot q/2 = C_3 \cdot q/2 \quad (8)$$

In equation 9 the cost of producing the return stations including material cost, transportation from supplier 4 and plastic bags required for one return station at the event multiplied with number of return stations used at an event *rs*. The number of return stations used were as mentioned 40 which are planned to be reused for the entirety of the event season. In addition to the return stations, plastic bags were used. The cost of plastic bags depends on the number of return stations, whilst the return stations depend on the size of the event. The return stations can be used for the whole season in contrast to the plastic bags that are a single use product.

$$C_{supplier\ 4} = (C_{corrugated\ board\ boxes} + C_{transport\ of\ return\ stations} + \\ + (C_{plastic\ bags} + C_{transport\ plastic\ bags}) \cdot n) \cdot rs = C_4 \cdot rs \quad (9)$$

In equation 10, the production cost for labour, energy and maintenance & repair of equipment are all included. Furthermore, the cost of the machine producing the Cup'n Lids is written off in these costs. All costs are then multiplied with *q* to create the total cost for producing the Cup'n Lids needed for an event season. This results in the total cost of producing the required amount of Cup'n Lids for the business model.

$$C_{production} = (C_{labour} + C_{machinewrite-off} + C_{energy\ for\ production} + \\ + C_{maintenance\ \&\ repair}) \cdot q = (C_5 + C_6 + C_7 + C_8) \cdot q \quad (10)$$

In equation 11, the cost of producing new Cup'n Lids to compensate for the lost Cup'n Lids at the events is presented. The cost equals the cost of material ($C_{supplier\ 1}$ and $C_{supplier\ 2}$) and the total cost of production multiplied with the loss rate *l.* The loss rate equals (1-return rate). It is then multiplied with the number of events *n* subtracted by the first event, as there is no production to compensate for losses before the first event.

$$C_{loss} = \left(C_{supplier\ 1} + C_{supplier\ 2} + C_{production}\right) \cdot \mathrm{l} \cdot (\mathrm{n} - 1) \quad (11)$$

In equation 12 the cost of storage of the cups between events is presented as the cost of storage multiplied with the storage area required for the cups, divided by the total size of the storage.

$$C_{storage} = C_9 \cdot Storage\ area\ required/Total\ size\ of\ storage \quad (12)$$

In equation 13 the cost of transports back and forth from events is presented. The cost depends on the number of events *n*. In the GHS case C10=C11, but as the original idea was to have storage elsewhere, the two transport costs are divided.

$$C_{transport} = (C_{transport\ from\ factory/storage\ to\ event} + C_{transport\ from\ event\ to\ factory/storage}) \cdot n = (C_{10} + C_{11}) \cdot n \quad (13)$$

In equation 14, the cost of washing is described as the cost of water, electricity and labour required for washing of the returned Cup'n Lids that are represented by *q* multiplied with the return rate *rr*, multiplied with the number of events *n.*

$$C_{washing} = C_{12} \cdot q \cdot rr \cdot n \quad (14)$$

In equation 15 the administrative cost is presented and described as the cost of organising and planning for events when renting to customers multiplied with number of events *n*.

$$C_{administrative} = C_{13} \cdot n \quad (15)$$

When the profit is calculated the relationship between the environmental performance and the profit of the business model is calculated using equation 16:

$$Emissions/\pi_{rental,n\ events} \quad (16)$$

Where the *Emissions* are the calculated sum of all emissions linked to the business model. Equation 16 can further be used for calculating the impact from different processes throughout the business model.

4.3 Life cycle inventory analysis

The data on the life cycle inventory is based on the LCA created by Miljögiraff on behalf of Light My Fire and is adjusted to represent the Cup'n Lid in the study. Furthermore, data is also based on information from Light My Fire. The resulting quantities used for producing the number of needed products for the events are presented in Table 2. The low-density polyethylene used for plastic bags depends on the number of events n as the plastic bags are disposed of after use.

Table 2. Materials needed for all events, excluding losses at the events.

Material	Amount
Polypropylene	346.24 kg
Pigment	6.29 kg
Silicon (Chip in RFID)	13.50 g
Aluminium (Antenna in RFID)	135.00 g
Paper (RFID logo)	322.50 g
Corrugated cardboard (Return stations)	22.65 kg
LD-PE (Return stations)	240.00 kg

As the company produces the Cup'n Lids with materials that have been purchased and, in some cases, imported from other countries transports contribute to a significant part of the emissions. The total transports are presented in Table 3 where all distances used when calculating transports are shown. The LCI-data on the PP and the pigment is collected from the LCA created by Miljögiraff, while the data on RFIDs, return stations and the Cup'n Lids are gathered by personal communication with Light My Fire and by literature. The transportation distances used in Sweden was gathered using Google Maps.

When modelling the business model for this study in openLCA, the ecoinvent3.8 database was used as source data for all processes. The transportation distances that were used in the modelling is the same as presented in Table 3.

Table 3 - Data on transport means and distances for the business model.

Material/Product	Stretch	Transport type	Distance
Polypropylene	Denmark – Västervik	Truck (EURO6)	1190 km
Pigment	Ängelholm – Västervik	Truck (EURO6)	350 km
RFIDs	Shenzhen (China) – GBG – Västervik	Sea freight Truck (EURO6)	12699 nautical miles 317 km
Return Stations	Malmö – Västervik	Truck (EURO6)	375 km
Cup'n Lid	Västervik – GBG	Truck (EURO6)	317 km
Cup'n Lid (lost)	GBG – Municipal incineration plant	Truck (EURO6)	10 km

Table 4 shows the distances used when modelling the two scenarios, storage of Cup’n Lids in Gothenburg and storage of the Cup’n Lids in the Malmö and are used in the sensitivity analysis.

Table 4 - Data on the transportation distance when altering the storage facility location.

Material/Product	Stretch	Transport type	Distance
Cup’n Lids	Malmö – GBG	Truck (EURO6)	269 km
Cup’n Lids	GBG – GBG	Truck (EURO6)	4 km
Cup’n Lids	Västervik – Malmö	Truck (EURO6)	375 km

In Figure 5, it is illustrated how the business model with its processes and transport methods was modelled in openLCA. As can been seen in the top left corner, the loss production represents the production to cover for losses after events and was specifically modelled in this study. The production of Polypropylene is transported from Denmark to Västervik by truck. The pigmentation is produced in Ängelholm and then transported by truck to Light My Fires production facility.

In this study, the production to cover for losses of Cup’n Lids after events and the original production is similar in terms of flows but differs in quantity. The quantity of the flows in the production to cover for losses highly depends on the return rate from the events. The original production that can be seen in the middle and top right corner also includes the RFID production that will only be included in the first batch of produced Cup’n Lid. The RFID tags are produced in Shenzhen in China and then transported by ship to Gothenburg and then by truck to Västervik for the remaining distance. In the bottom left of the figure, the production of return stations is presented. The return stations are transported by truck from Malmö to Västervik and then included in the transport from Västervik to GHS.

As the lost Cup’n Lids were assumed to be discarded in residual waste, they are modelled in openLCA as being transported via truck to the incineration plant that is located outside of Gothenburg. At the plant, the lost products are incinerated.

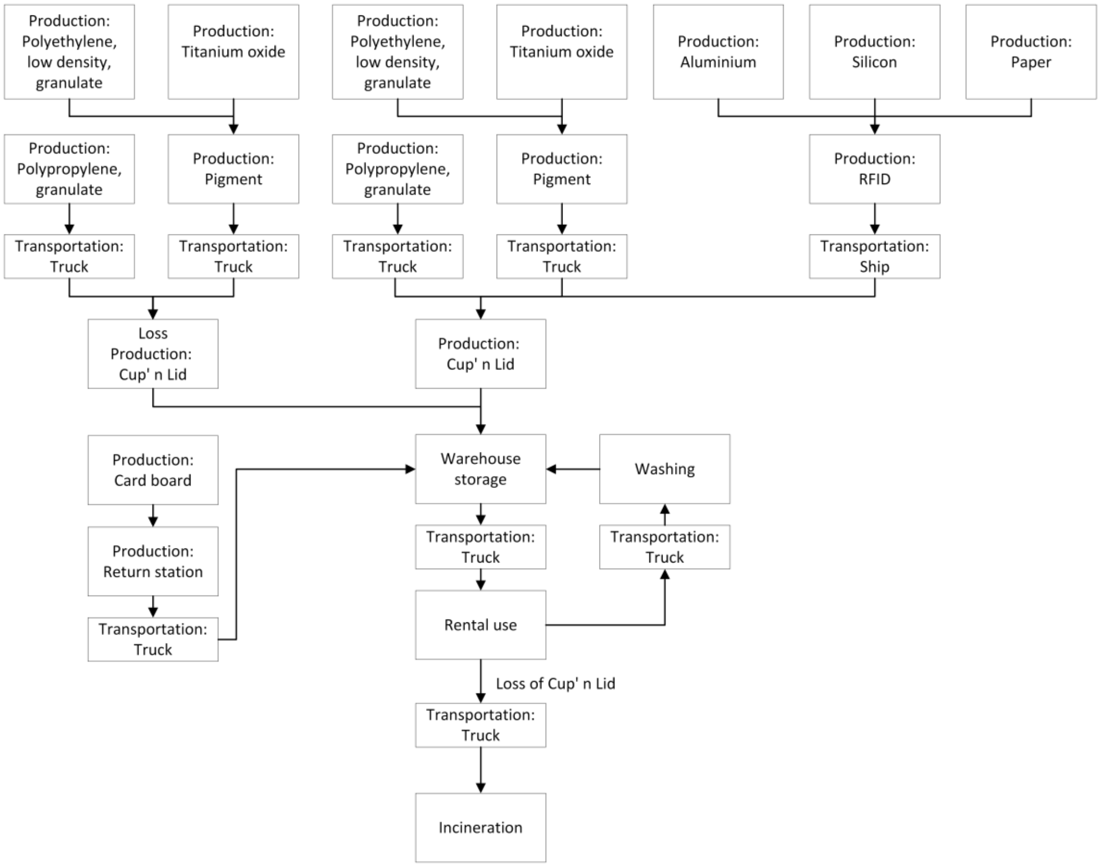

Figure 5 - The modelling of the business model in OpenLCA including the processes and transportation methods used.

4.4 Life cycle impact assessment

In Figure 6 the global warming potential (GWP) is presented for the business model. As can be seen in the figure, the production due to losses of Cup'n Lids is the largest contributor to the GWP and amounts to 44,8% of the total emissions. The reason for the high impact from losses production is linked to the return rate of the business model. As the return rate is 78,5% for the cups and for 60,4% for the lids, there is a high need for producing new products to sustain the following events.

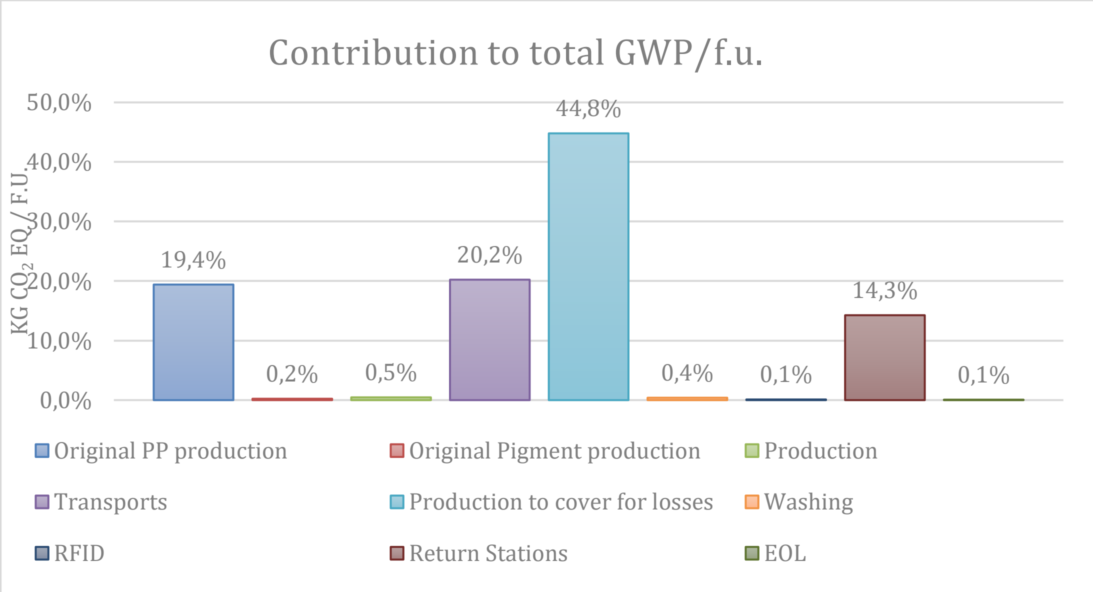

Figure 6 - Contributing processes to GWP of the business model based on their share of CO_2 emissions/f.u.

Further, Figure 6 shows that the third largest contributor to the business model is the production of the PP for the Cup'n Lids with 19,4% of the emissions. This process accounts for production of the original batch of 6000 cups and 3000 lids produced for the first event. As can be seen in the figure there is little impact form the contribution from the original production, which is because there is no emission from production except from the energy production. The energy used for the production facility in Västervik is renewable and causes small amounts of emissions related to the production.

The return stations, as can be seen in Figure 6 account for 14,3% of the total emissions of the business model. The main reason for this is due to the number of plastic bags that are required for an event. The plastic bags were required to be changed repeatedly as a lot of the cups were thrown with beverage still in them causing leaking. The smallest contributors are pigment production for GHS, RFID production and washing which all amounted to less than one percent of the business models global warming potential.

Following the production covering for the losses at the events, the second largest contributor to the impact category GWP is the transports which results in 20,2% of the business model's emissions. Figure 7 illustrates how much each transport process contributes to the total emissions of the business model that are related to transports. As can be seen in Figure 7, the largest contributor is the transports related to loss production i.e., transports for material to produce new Cup'n Lids to cover for the lost products in the business model. The second largest contributor among the transport processes are the transports to Gothenburg before each event, followed by the return transport after the events. The reason that these two transport processes do not equally contribute is because of the emissions being calculated by weight multiplied with distance. Since the current design of the business model results in losses of Cup'n Lids at the event, the weight being transported back from the events is lower than the weight being transported to them.

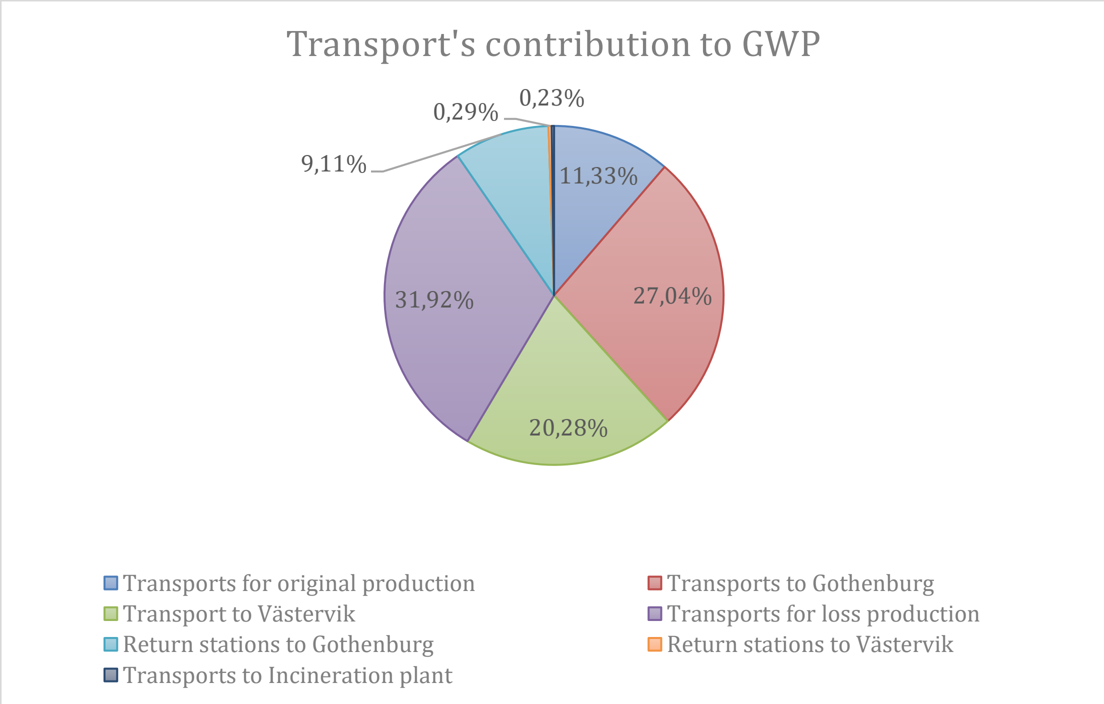

Figure 7 - The different transport processes' contributions to the total emissions from the transports linked to production for all events.

Figure 8 illustrates the environmental performance of the business model for the climate change impact category. The figure shows each process in the business models emissions/f.u. in g CO_2 eq/f.u. The relationship between the processes is the same as in Figure 6 and as can be seen the largest contributing process is the production to cover for losses with 16,28 g CO_2 eq/f.u. The transports are the second largest contributor which results in 7,53 g CO_2 eq/f.u. followed by the PP production for GHS. The fourth largest contributor is the production for return stations with 5,31 g CO_2 eq/f.u. The total global warming potential/ f.u. of the business model resulted in 37 g CO_2 eq/f.u.

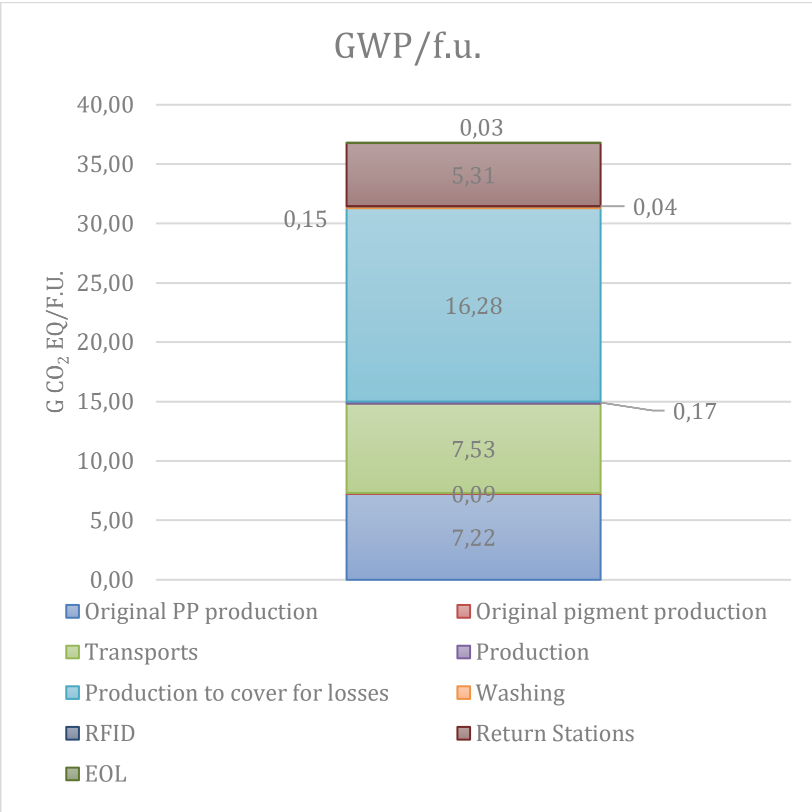

Figure 8 - GWP/ f.u. for each process of the business model in g CO_2 eq/f.u.

In Figure 9 the contributing processes to marine aquatic ecotoxicity (MAE) is presented. Like the GWP, the production covering for the lost Cup'n Lids is the biggest contributing process also in the MAE. However, the two impact categories differ in contribution from transports and from return stations. As can be seen in Figure 9, the contribution from the return stations accounts for 20,01% for the MAE impact category.

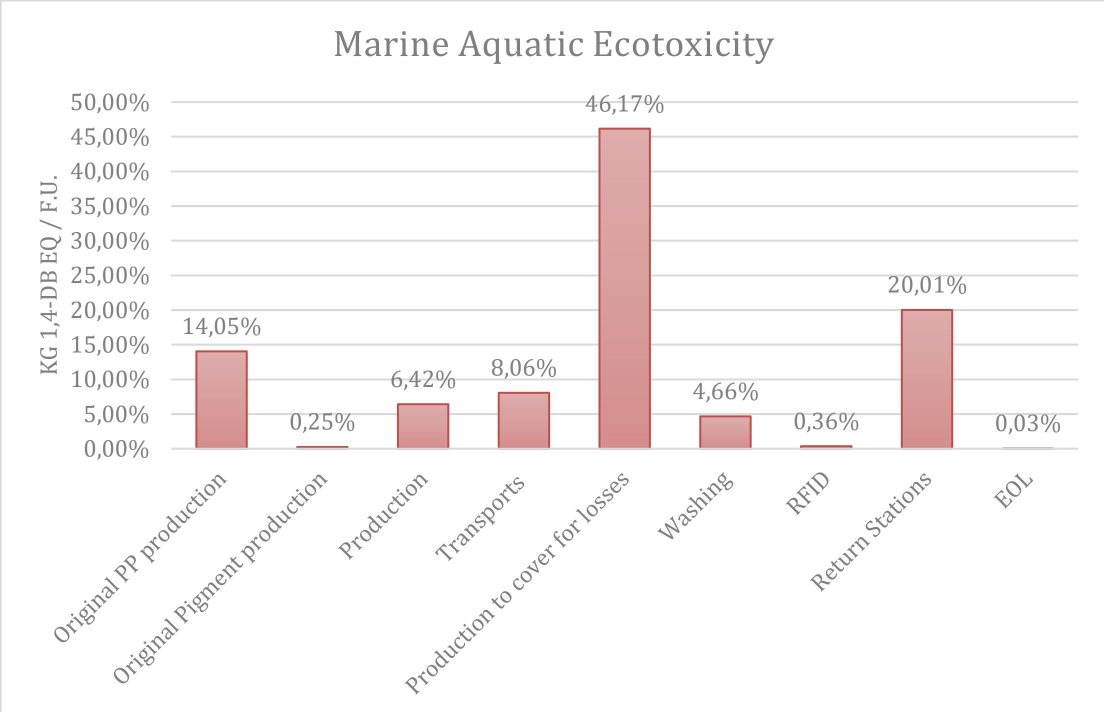

Figure 9 - Contributing processes to the marine aquatic ecotoxicity of all events combined.

Figure 10 shows the relationship between the two contributing processes: corrugated board box production and plastic bag production. Like in the case of GWP, the number of plastic bags required to facilitate the return stations functioning is the main reason as to why the return stations results in such a contributor for the total MAE of the business model.

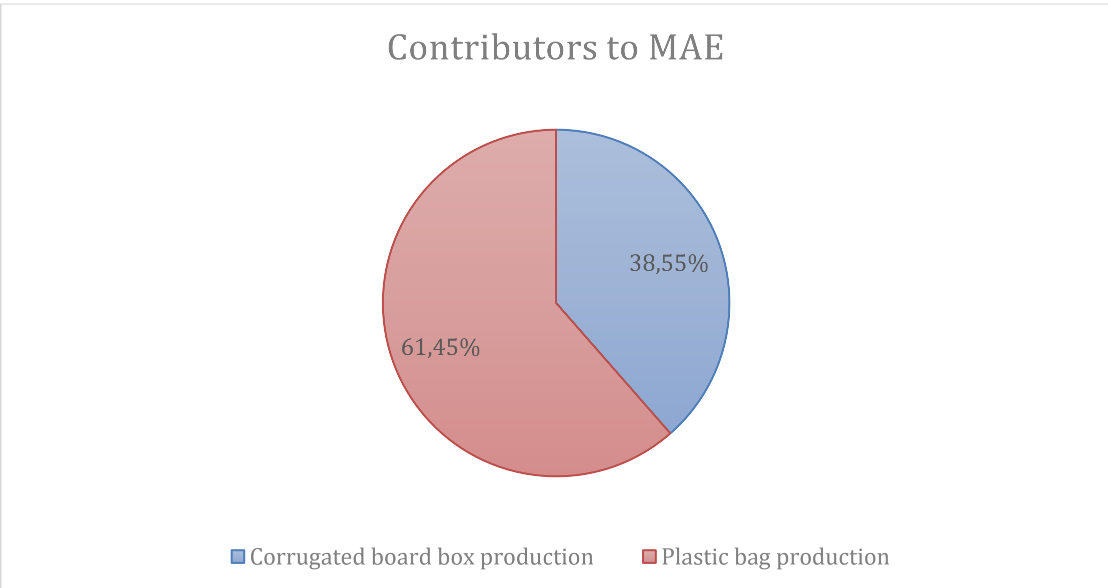

Figure 10 - Contributing processes to the total marine aquatic ecotoxicity of the return stations.

Figure 11 illustrates the processes contributing to the acidification and as can be seen in the figure, the results follow a similar pattern as the two previous impact categories, GWP and MAE, where the production for covering of the losses is the highest contributor with 47,47% of the emissions, followed by PP production, return stations, and transports.

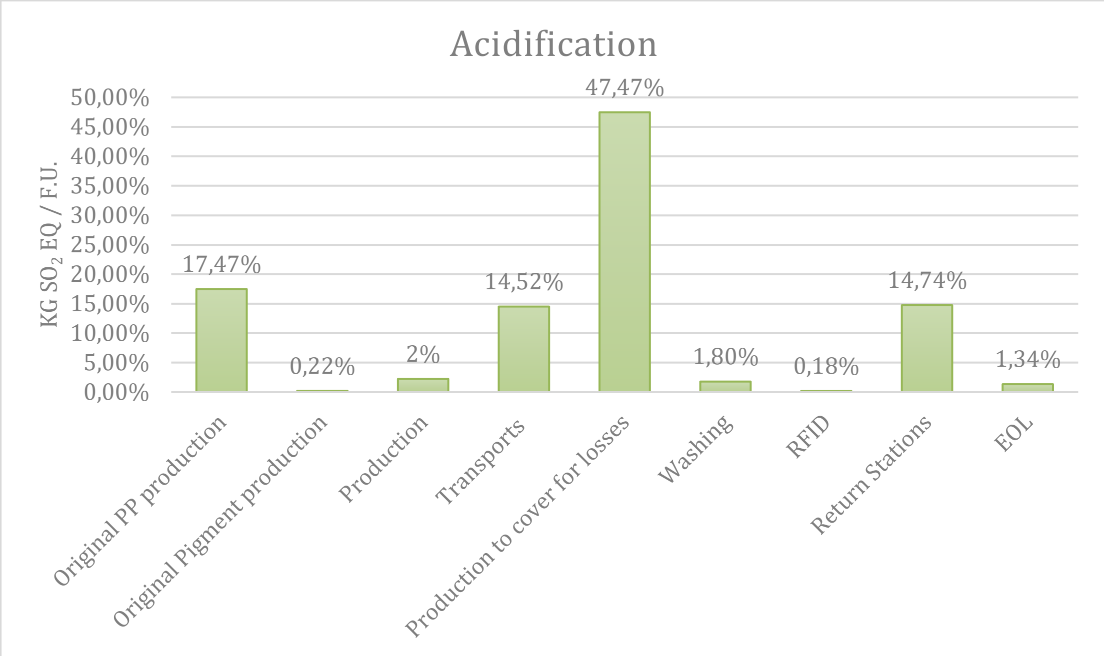

Figure 11 - Contributing processes to the acidification of all events combined.

In Figure 12 the contributions from the business model's different processes to the terrestrial ecotoxicity of the business model are presented. As can be seen in the figure, it differs from the previously presented impact categories GWP, MAE and acidification. The terrestrial ecotoxicity's largest contributor in the business model are the production for cover of losses with 33,61%, followed by transports of 31,44%. The third largest contributor is the return stations with 15,86% contribution. Notably, the original production of PP accounts for 10,01%. The production process of the products accounts for 4,88% of the emissions per f.u.

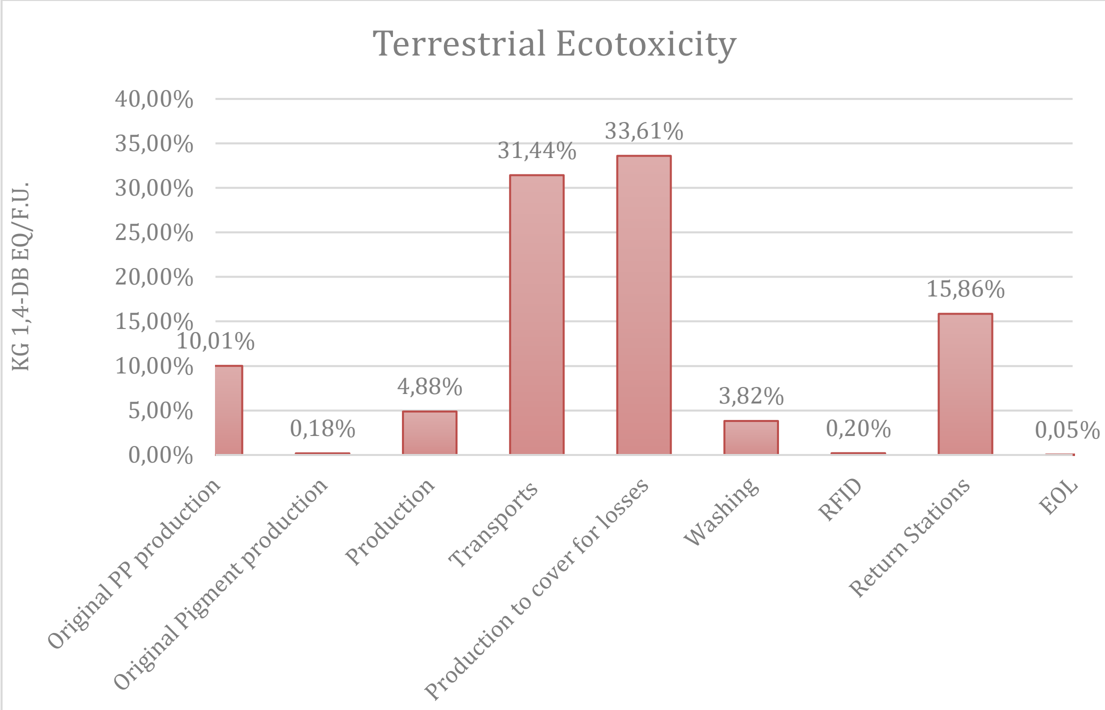

Figure 12 - Contributing processes to the terrestrial ecotoxicity of all events combined.

Figure 13 illustrates the various transport processes that are part of the total transports in Figure 12. As can be seen, there are three major contributors to the total impact. These are transport for the loss production, meaning the transports needed to produce new Cup'n Lids to cover for the losses. The other two are the transports between the event, with highest being the one transported to Gothenburg when the shipment is heavier. The return transport to Västervik is lower because of the losses of products at the event.

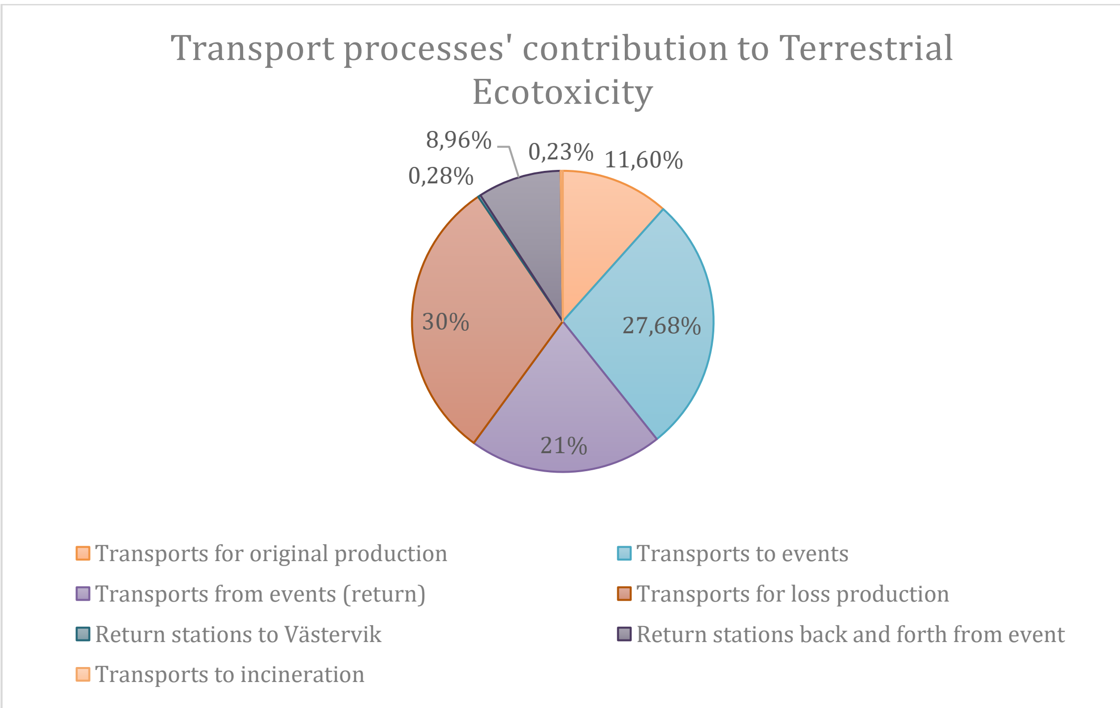

Figure 13 - The different transport processes' contributions to the total impact from the transports of the business model on terrestrial ecotoxicity.

Figure 14 illustrates the contributing processes for eight different impact categories. As can be seen, the impact categories human toxicity, freshwater aquatic toxicity, abiotic depletion, eutrophication, and abiotic depletion of fossil fuels follow the general pattern of the previously presented impact categories. However, the ozone layer depletion and photochemical oxidation stand out. The transports of the ozone layer depletion impact category are the highest contributor with 45% of the total emissions. Furthermore, the washing process accounts for 9% in the freshwater aquatic toxicity, 7% in the human toxicity impact category and 2,5% in the eutrophication impact category. For the FAT and HT categories, the largest contributor to the washings total impact is the energy production.

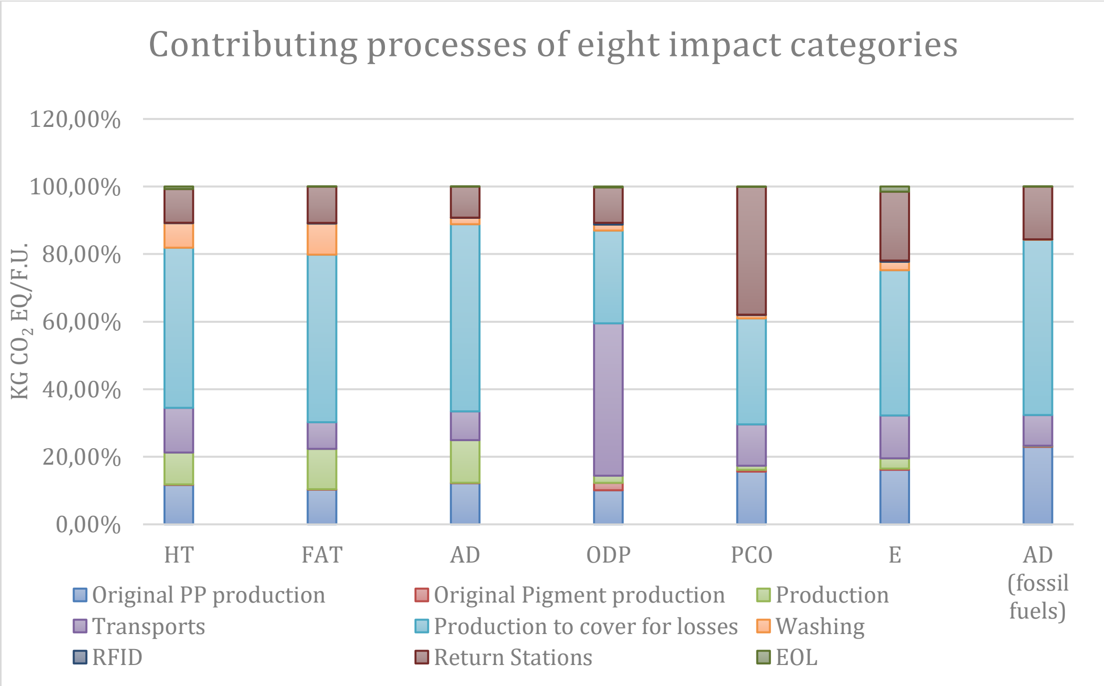

Figure 14 - Contributing processes to human toxicity (HT), freshwater aquatic toxicity (FAT), abiotic depletion (AD), ozone layer depletion (ODP), photochemical oxidation (PCO), eutrophication (E), abiotic depletion of fossil fuels (AD (fossil fuels)).

The ozone layer depletions biggest contributor is the transports of the business model and each transport process' individual contribution can be observed in Figure 15. The main reason for the high impact from transports are due to fact of the transport methods used in the model. In the business model all transports within Sweden are via road freight i.e., trucks running on diesel. Since the rental model is transport intense it results in high impact of the ozone layer depletion. As can be seen in Figure 15 the transports from the production covering for the losses of the business model is the biggest contributor and depends on the return rate of the Cup'n Lids after each event. The second and third biggest contributors are the transports to and from the events.

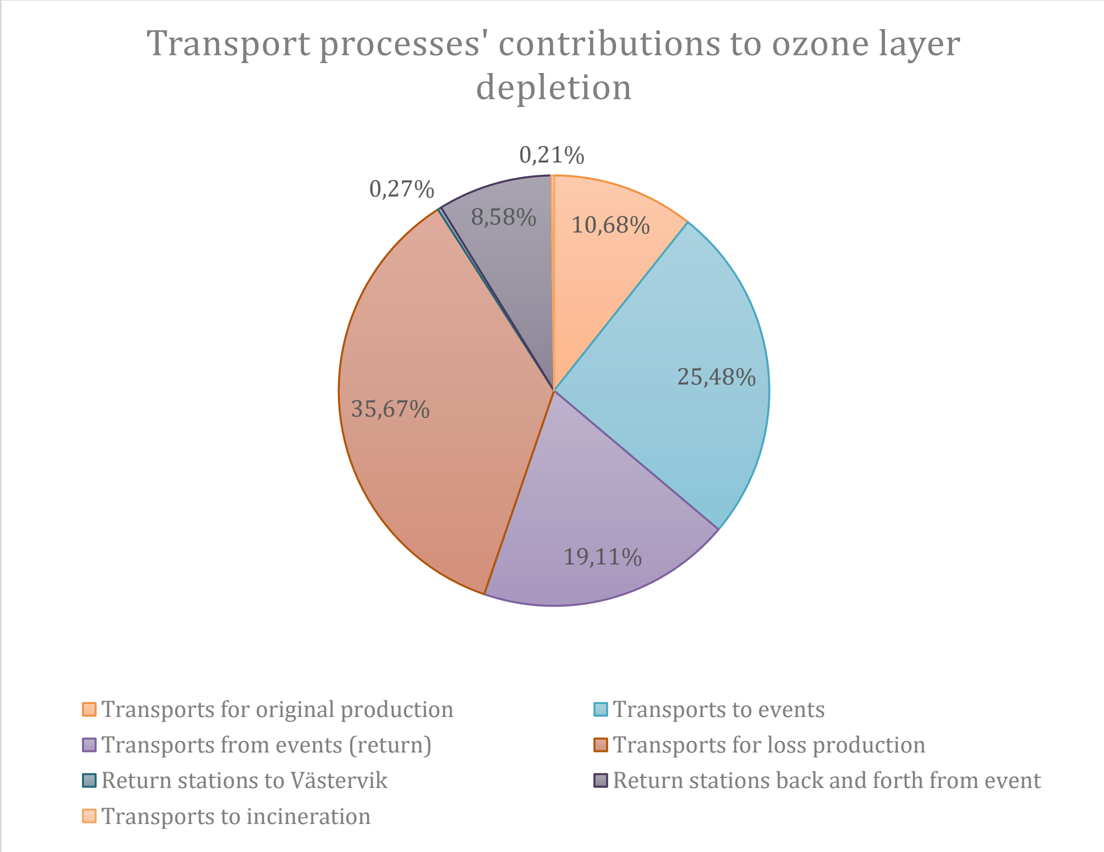

Figure 15 - The different transport processes' contributions to the total impact from the transports of the business model on ozone layer depletion.

The photochemical oxidation's biggest contributor is the return stations used for the business model as can be seen in Figure 16. Notably, the return stations account for 38% of the emissions in the photochemical oxidation impact category. Viewing the contributing processes of return stations total impact in Figure 16 shows that the production of corrugated board boxes accounts to 1,51% of the total impact from return stations, while the production of plastics for the bags used in the return stations account for 98,49% of the total photochemical oxidation impact. Like the MAE impact in Figure 10 the reason for this is the large number of plastic bags required to facilitate the functioning of the return station at the events.

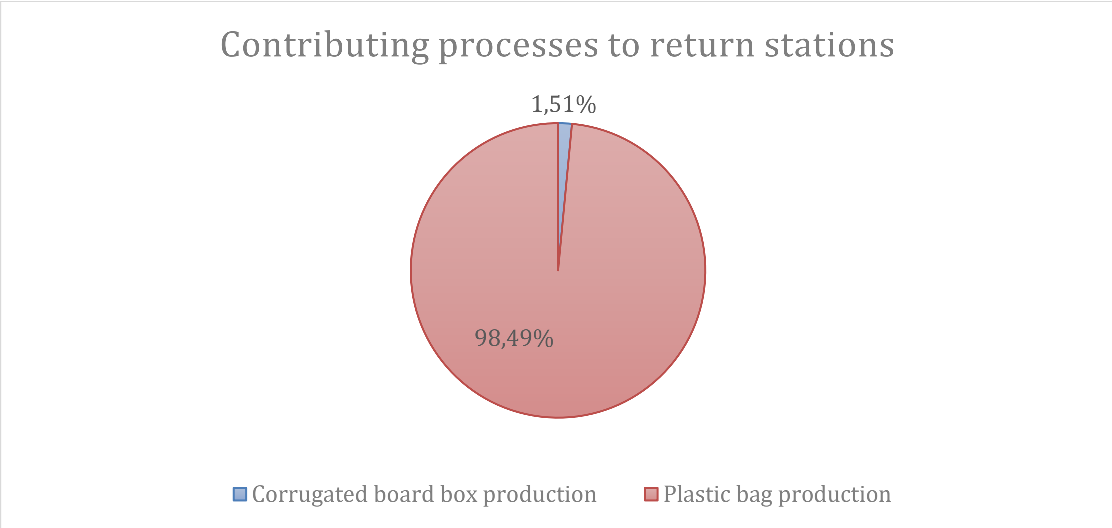

Figure 16 - Contributing processes to the total photochemical oxidation of the return stations.

4.5 Interpretation

Following from the results of the BMLCA, the highest impact for the business model stem from the production to cover for losses in almost all impact categories. In many of the impact categories it accounts for almost half of the business model's emissions. The basis for this is the low return rate, which creates a high demand for production of new Cup'n Lids. Increasing the return rate, could result in a lower contribution from the production to cover for losses, ultimately leading to a reduction of the business model's environmental impact. The return rate's impact on the business model's environmental performance is therefore determined to be tested in the sensitivity analysis.

Another process that contributes with significant impacts to the business model's total environmental impact is the transports related to the business model. In many of the impact categories, the transports correspond to approximately 20% of the environmental impact. As could be seen in Figure 7, Figure 13, and Figure 15 there are three main contributing factors to the transports, where the largest is the transports related to cover for losses i.e., transports of materials to the production facility in Västervik. It is followed by the two processes where the Cup'n Lids are transported to the events. Two parameters can be identified as significant for these three transport processes, and these are the *return rate* and the *storage location*. The return rate affects the transports by creating a higher demand for new products, leading to more mass being transported to the production facility, ultimately leading to larger emissions from transport. Although, it also affects the transports back from events as less mass is transported when the return rate is high and thereby reducing the emissions. Thus, it is another argument for investigating the effects of the return rate in the sensitivity analysis.

The storage location affects the environmental impact of the business model by altering the length of the transports. Therefore, it is of interest to investigate different storage locations for the business model in the sensitivity analysis to understand the impact from it.

The return stations contribution to environmental impact of the business model were important and the reason for the high impact from the return stations is the plastic bags used within them. The return stations contributed to approximately 15-20% of the environmental impact in the different categories. For the photochemical oxidation the return stations stood for 38% of the environmental impact. It becomes clear that the return stations need to be investigated further.

Notably, it can be seen in the results that some processes are insignificant to the environmental impact of the business model. Initially, concerns were raised for the RFIDs' contribution to the environmental performance of the business model, but as can be seen in the results, the RFIDs resulted in a small impact. Although, the impact is still an impact which the business model could do without.

5. Sensitivity analysis

In the following section sensitivity analysis will be presented. To answer the aim of the study the sensitivity analysis is used. The sensitivity analysis is conducted so that different parameters of the business models are changed one parameter at the time to investigate what the effects of certain changes are. Further, the sensitivity analysis is extended by changing multiple parameters at the time to create the lowest possible environmental impact while maintaining the desired profit in an extended sensitivity analysis.

The sensitivity analysis is compiled in Table 5, and as can be seen in the table it is structured into four columns. The sensitivity category denotes what part of business model is being changed. The second column describes what parameter is changed and the third column how the parameter was altered. Finally, the last column illustrates the results from the change, where 100% is relative to the base case. However, if the result form the change is lower than 100%, there has been a decrease of kg CO_2 eq/f.u. with a certain percent. A result above 100% implies that it has been an increase in kg CO_2 eq/f.u. of a certain percent.

Table 5 - Sensitivity analysis of the business model related to GWP.

Sensitivity category	**Parameter changed**	**How the parameter changed**	**Rental business model, kg CO_2 eq/f.u. [% change]**
Altering design for product service for rent	Return rate[1]	+6,5% to 85% return rate	77%
		+10% to 90% return rate	65%
		+15% to 95% return rate	54%
		-6,5% to 72% return rate	113%
Altering revenues	Rental price	+29%	91%
		+57%	84%
		+114%	72%
		-14%	110%
	Loss fee	+13%	96%
		+33%	91%
		+60% (BE)[2]	81%
		-13%	108%
Altering logistics	Storage location	Gothenburg	92%
		Malmö (Loss directly to Gothenburg)	98%

[1] The return rate of the lids is assumed to be reduced to the same return rate as the cups even though the original loss rate is higher than the loss rate for the cups.

[2] The Break-even increase implies that the fee is set to the individual production price of a new cup and lid.

		Malmö (Loss to Malmö)	100%
Altering production	Material cost	+5%	109%
		+10%	119%
		+20%	125%
		-5%	100%
		-10%	96%
		-20%	89%
	Manufacturing cost	+5%	105%
		+10%	108%
		-5%	98%
		-10%	95%

Return rate

The results from changing the return rate of the business model are significant as can be seen in Table 5. It shows that with an increase of 6,5 percentage units of the return rate to make the return rate 85% of all Cup'n Lids results in a 23% decrease of kg CO_2 eq/f.u. Simultaneously, the same decrease of the return rate results in a 13% increase of the kg CO_2 eq/f.u. When continuing to increase the return rate it shows significant reductions in the kg CO_2 eq/f.u., and thereby indicating that this area is something that Light My Fire should focus on improving. While the company require a fee per lost cup and lost lid, that fee do not cover the cost of producing an entire new Cup'n Lid. Thereby, increasing the return rate of their products would lead to an increased profit of their business model.

In Figure 17 the contribution to the total GWP from different parts of the business model is illustrated for the five cases described above. As can be seen in the figure, the most significant change in the cases is how the contribution from production and transports due to losses change because of the changing return rate. In the case with the return rate of 95%, it shows that the contribution from production and transports due to losses is the lowest because of the number of lost Cup'n Lids are the lowest in this case. As mentioned, the lower the number of lost products the lower is the need for producing and transporting new products consequently and thus, the emissions/f.u. are lowered as well. The figure also shows how large the increase of emissions/f.u. are from an increase in lost Cup'n Lids.

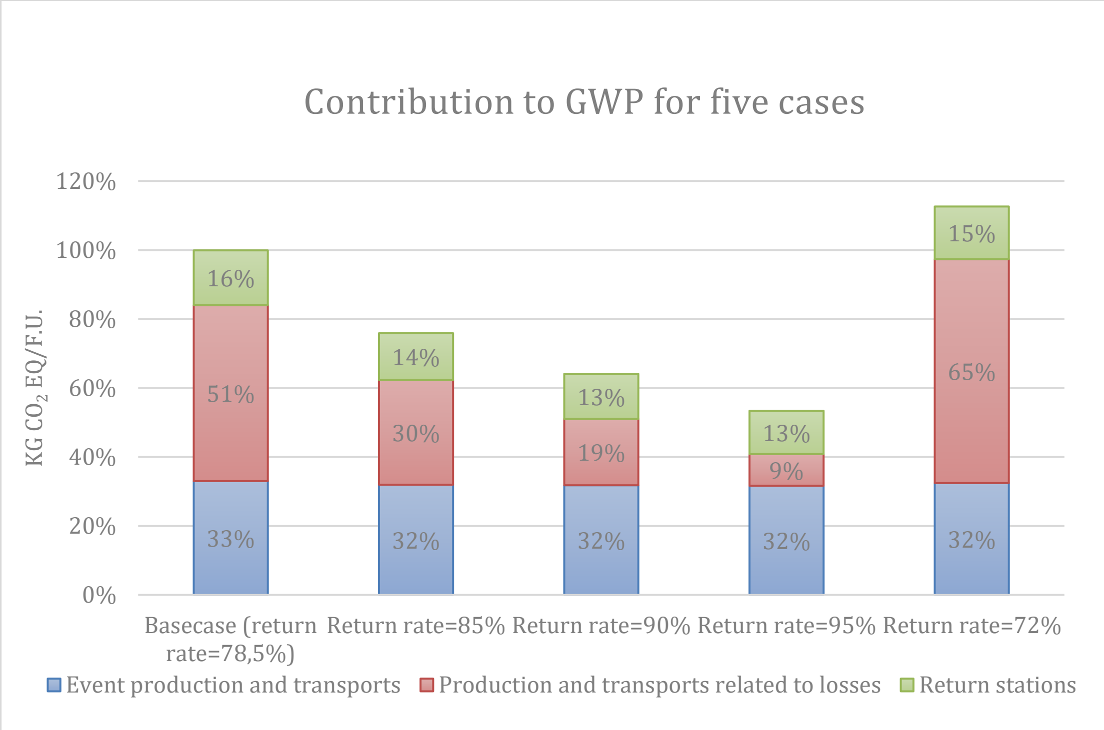

Figure 17- Contribution to GWP for five cases with return rates: 78,5%, 85%, 90%, 95% and 72%.

One of the key concerns regarding the business model were the low return rates from GHS. Light My Fire stated that they were estimating up to 15% loss rate of the events, which was underestimated. When GHS was finished, and the losses were counted, it showed that the return rate were 78,5% for the cups and 60% for the lids. That means that the return rates of the business model were of great significance when calculating the environmental loads from it.

The reason for the two return rates is that 6000 cups and 3000 lids were sent to the first event. Out of those 6000 cups, 1293 cups were lost and out of the 3000 lids, 1189 lids were lost. This implies that when a cup was disposed of incorrectly, often, it would also have a lid attached to them. There are two main plausible reasons for the losses at the event. Number one being that they are discarded incorrectly as previously mentioned. Instead of disposing of the used Cup'n Lid in the return station, the consumer disposes the product in one of all the other waste stations at the event. The other one, is that the consumers bring the Cup'n Lid with them when they leave after the event.

Several measures were taken to decrease the loss rate. One measure was to see if the consumers behaved differently if they could see that Cup'n Lid had an RFID on it. Another measure was to try connecting the consumer to their Cup'n Lid together with the company Panter and their app. The idea was that all consumers were to scan a QR-code and register their Cup'n Lid when they bought it. However, it was scrapped early in the event due to the time it took to download the app and register the product. It also led to queues which made the plan to inefficient. A third measure was to put up signs around the arena with information on what to do with the product after it had been used, why the products were used, and why they needed to be recollected after use. Stickers with the same information were also attached to the products.

In other words, there were a lot of measures taken to reduce the waste of the Cup'n Lids at the events. However, they were not enough to make the consumer understand or want to follow the procedure. Increasing the number of return stations around the arena could be one possible future measure for reducing the loss rate, by simplifying the disposal of the product for the consumer. Another reason for the high loss rate could be that the consumers follow their old patterns when buying a coffee or similar and do not reflect on the change of way of disposal. It could also be due to reluctance from consumers that are comfortable in their own pattern and would rather throw the Cup'n Lid in the nearest bin than walking extra for disposing of it at a return station. All these possibilities are important factors that need investigation. Currently Light My Fire is conducting research together with Karlstad University concerning these areas which could provide important information for the company moving forward.

As the return rate change was modelled as the base case, then increasing the return rate to 85%, 90% and 95%. The case with 72% was also investigated. For all these return rates, the cups and the lids would have the same return rate. Implying that, while the increase for the 85% case would be 6,5 percentage units for the cups, the actual increase for the lids would be 25 percentage units. The reason for this way of modelling was that the cups and the lids were modelled as one Cup'n Lid i.e., one cup and half a lid as mentioned earlier in the study. Out of convenience this led to return rates being what they were which could be considered a bit unrealistic for the lids, especially in the two cases where the return rate is 90 and 95%.

However, from the results, it was derived that there are many benefits of increasing the return rate dramatically for the lids. This is because of the loss fees that Light My Fire claim when lids are lost. This fee does not cover for the expenses of producing them, causing monetary losses that the company should minimise as much as possible. By investigating what the emissions per f.u. would be in the sensitivity analysis is therefore of importance for providing data and understanding on what impacts these losses have on the company's business model.

Changing the return rate based on the same percental change could be unwise as the relationship between the cups and lids is strong in this study's case. If one cup is lost, generally one lid is lost as well. Also, as the changed percentage means different changes of the cups and lids in practice.

Rental price

In Table 5 and Figure 18, when altering the revenues by first increasing the rental price with 29% a decrease of 9% of kg CO_2 eq/f.u. is the result. The continued increase in rental price for Cup'n Lid decreases the kg CO_2 eq/f.u. An increase of 57% in rental price results in a 16% decrease. The largest tested increase in rental price was 114% and resulted in a decrease of 28% in kg CO_2 eq/f.u. The increase in rental price shows that a small increase of rental price results a rather large reducing factor in kg CO_2 eq/f.u. The increase in price could be a sufficient way to reduce the business models emissions whilst maintaining the profit. Decreasing the rental price with 14% results in 10% emissions/f.u. increase.

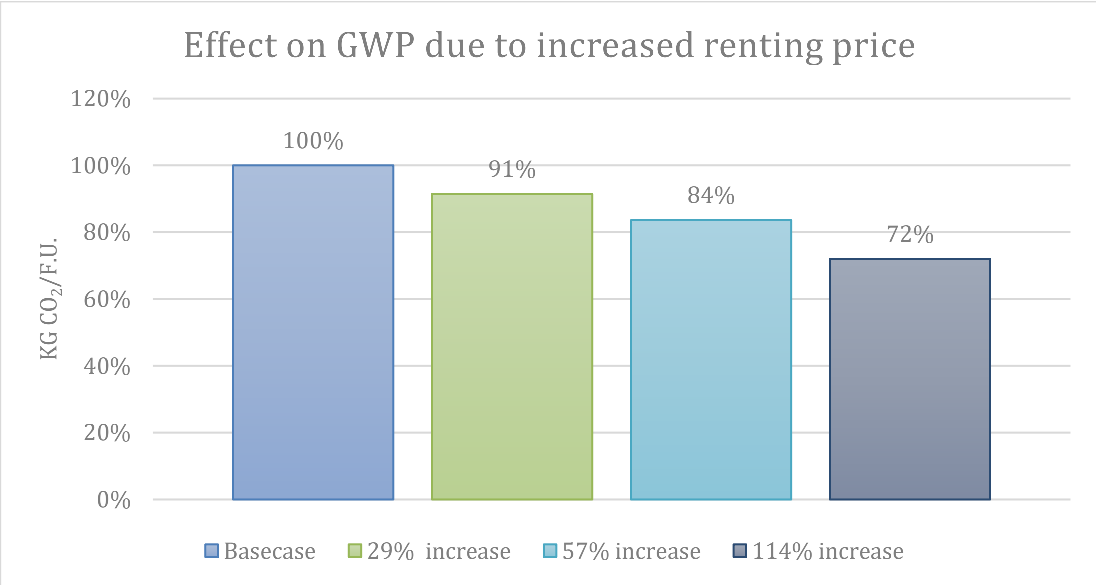

Figure 18 - The effect on kg CO2 eq/f.u. due to the increase of the price for renting the Cup'n Lid.

When altering of revenue sensitivity parameter, it could be argued that increases are high. Looking at the parameter renting prices, it shows that the price for renting of the Cup'n Lid increases with 29%, 58% and 114%. These increases are because the cups and the lids have different renting prices. The company hosting the event are required to pay more for the cup than for the lid. It is a consequence of the modelling of the business model. Furthermore, as the increases are originally changed by a certain amount of SEK, the percentual changes comes off as irregular. The percentage is disclosed instead of the price increase in SEK due to the economic figures of the business model are confidentially. Like the return rates the increase in renting price were the same for both the cup and the lid, although the lid had a lower initial cost of renting. Thus, creating a larger increase in the lid's renting price, while the cup's renting price is kept more reasonable. The percentual increases displayed in Table 5 are based on the combined average increase from both the cup and the lid's renting prices.

Loss fee
Light My Fire has included a loss fee to mitigate the costs that follow from the losses of products at events. In the base case, the loss fee does not cover up for the total cost of producing a new Cup'n Lid. When altering the loss fee to an increase of 13%, it results in a decrease of 4% of kg CO_2 eq/f.u. Continuing to increase the loss fee with 33% per lost unit, the kg CO_2 eq/f.u. decreases with 9%. Finally, when the loss fee is set to the break-even cost of producing a new Cup'n Lid it results in a decrease of 19% in kg CO_2 eq/f.u. However, a decrease of the loss by 13% results in an increase of 8% kg CO_2 eq/f.u.

The fee is supposed to cover some of the economic losses that stem from the production of new products in the business model. The final increase of the fee is set to the break-even for the production i.e., the cost for losing Cup'n Lids, for the renter, is the same as the total cost of production for the Cup'n Lid. The increase is large as the original fee for the loss of lids only account for 38% of the production cost of the lids, meaning, that there is an economic loss of 62% for every lost lid.

Hence, increasing the lids loss fee is both reasonable and could likely be more acceptable for the renter than increasing the rental price. Increasing the rental price of the business model, likely mean a loss in competitiveness as other alternatives might be cheaper, while an increase in loss fee instead removes the focus from the renting price and instead puts it on that the producing company not losing too much money from losses at the events. Furthermore, increasing the loss fee could incentivise the renter to decrease the loss rate at the events and thereby split the responsibility of waste generation. As the European Parliament gradually increase the restrictions of plastic waste in Europe (European Parliament, Council of the European Union, 2019), the need for both consumer and producer responsibility increases. Thus, motivating the renter by increasing the loss fee could prove useful in doing so.

Storage location
Altering the logistics within the business model and specifically, the storage location between events were analysed and can be seen in Table 5. The first change in parameter was moving the storage to Gothenburg from Västervik to analyse the effect of a shorter transportation distance between events. Changing storage location to Gothenburg resulted in an 8% decrease in kg CO_2 eq/f.u. When altering the location to Malmö instead, it resulted in a decrease of 2% in kg CO_2 eq/f.u. from the base case. The first of two Malmö cases included the losses transported directly to Gothenburg from Västervik which resulted in a slight improvement in comparison when shipping the losses to Malmö before Gothenburg. The case with storage in Malmö and with loss transport to Malmö from Västervik resulted in a minimal improvement with a decrease of 0% in kg CO_2 eq/f.u. from the base case scenario. The changes in storage location between events indicates that the best scenario is when the storage location is as close as possible to the event, and thereby reduces the total transportation distance which subsequently reduces the kg CO_2 eq/f.u.

Figure 19 shows how the emissions/f.u. varies as the storage facilities of the business model changes, the figure excludes the case with storage in Malmö and where the losses are transported to Malmö. As can be seen in the figure, there are three scenarios investigated, where the base case is having storage in Västervik, which results in 100% of the emissions from transports. In the second case on the other hand, the storage is in Gothenburg and thus leading to shorter transport distances which ultimately results in 20% of the base case's emissions/f.u., or a decrease of emissions/f.u. of 80%. The last case is where Light My Fire's storage facilities in Malmö are utilised which leads to a slight decrease of emissions/f.u. and results in a 16% decrease.

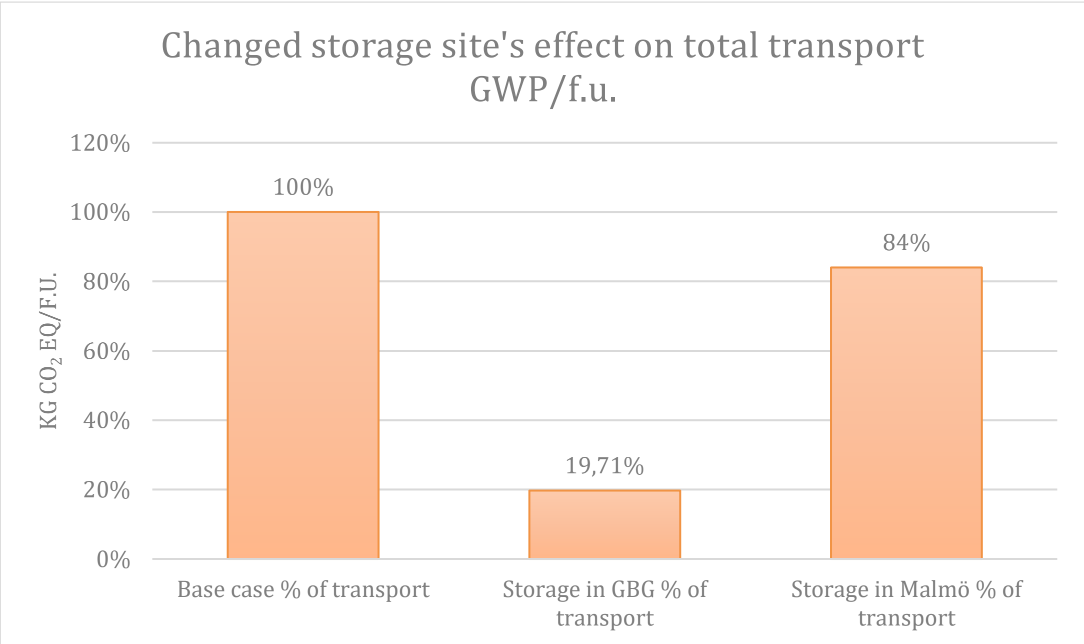

Figure 19 - Emissions of transport related to the total transport emissions for three different storage location cases.

Figure 20 shows how the three cases in Figure 19 relates to the total emissions/f.u. of the business model. As can be seen in the figure, the base case where storage is in Västervik has the highest kg CO_2 eq/f.u. and biggest part of the total kg CO_2 eq/f.u. while the second case, where storage is moved to Gothenburg has the lowest part of kg CO_2 eq/f.u. Case two means that emissions/f.u. of the business model has been lowered from 10% to 2,1% of the total kg CO_2 eq/f.u. Further, these results indicates that for the expansion of the business model, it is beneficial to have multiple storages across the country to reduce the transports needed to supply events in other parts of Sweden.

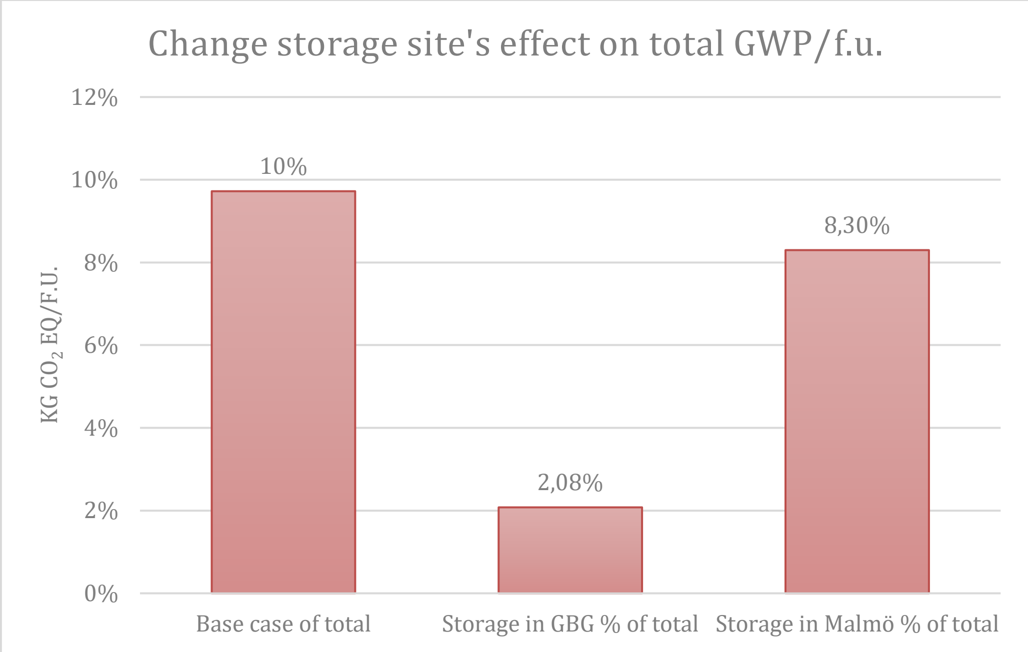

Figure 20- Emissions of transport related to the total emissions of three different storage location cases.

The three cases stated in Table 5 are based on where Light My Fire operates and have production, as well as where the first event was held, in this case Gothenburg. All three cases are equally credible to be adapted by the company but viewing it from the environmental performance viewpoint it shows that storage in Gothenburg is the best in terms of a reduction in emissions/f.u. The conclusion can be drawn that it is preferable to maintain storage close to the events, consequently reducing emissions from transport. Though, that conclusion builds on that all events are held in the same area. If the event would have been spread out across the southern part of Sweden it is possibly better to have storage elsewhere. As the business model expand, it can be beneficial to have storage facilities in multiple locations in Sweden to minimise transport emissions. Something that also has been expressed as a possibility from the company's perspective in the long run.

When calculating the emissions per f.u. for the different cases the difference in price of transport for the different storage facilities were not calculated due to the presentation of the transport cost from Light My Fire. Intuitively, it would be cheaper to transport shorter distances than longer distances, which would lead to decreasing costs for the case with storage in Gothenburg. Therefore, the results of the analysis still stand as reasonable, as the difference from including the different costs of transport would be that Gothenburg's case would have a larger decrease in emissions/f.u. than it currently has.

Material cost

The altering of material cost, as can be seen in Table 5, present both the increase and decrease of parameter. A 5% increase in material cost result in an increase of 9% in kg CO_2 eq/f.u. Continuing to increase the material cost, an increase of 10%, result in an increase of 19% in kg CO_2 eq/f.u. compared to the base case. Finally, an increase of 20% corresponds to an increase of 25% in kg CO_2 eq/f.u.

When instead reducing the material cost with a 5%, the emissions/f.u. remains the same. For 10% decrease in material cost the kg CO_2 eq/f.u. reduces with 4% instead, which indicates that the decrease in material cost has an effect in reducing the total kg CO_2 eq/f.u. Finally, the largest decrease in material cost is 20% and result in a 11% decrease kg CO_2 eq/f.u. The relation between reducing material cost and decreasing the kg CO_2 eq/f.u. shows that Light My Fire could improve within the area of the business model, although other parameters have shown greater potential.

The cost of materials was altered by multiplying the cost of material including the transportation with 5, 10 and 20% for both increase and decrease cases. The change in material cost could stem from a change in energy price and the production cost that follows from the subcontractors for the Cup'n Lid. The energy price could affect the subcontractor's production phase while the fossil fuels price could affect both the extraction of raw materials as well as the transportation phase.

Manufacturing cost

As can be seen in Table 5 the manufacturing cost is changed. The manufacturing cost represents the labour, energy and maintenance & repair of equipment and has been presented as a percentual addon to the material cost. Because of this the manufacturing cost was increased and decreased using percentage units instead of percentage from a value. When altering the manufacturing cost with an increase of 5 percentage units it results in an increase of 5% in kg CO_2 eq/f.u. When instead altering the parameter by increasing with 10 percentages units, it results in an increase of 8% in kg CO_2 eq/f.u. from the base case. On the other spectrum when altering the parameter to a decrease of 5 percentage units, it results in a decrease in kg CO_2 eq/f.u. with 2% from the base case. Additionally adding 5 percentages units and decreasing the manufacturing cost with 10 percentages units results in a 5% decrease in kg CO_2 eq/f.u.

The connection between the manufacturing cost and the total kg CO_2 eq/f.u. shows that the internal cost within the production can lead to some decreasing in kg CO_2 eq/f.u. The connection presents an opportunity for the company to further investigate their own operation to improve within the area.

The cost of manufacturing was presented from the company as a percentage that was added on the cost of materials. The changes that were made, was 5 and 10 percentage units increase and decrease. The manufacturing cost was primarily altered because of the connection to the internal cost within the production that are affected by energy and fuel prices. The price changes could affect both the production phase of Cup'n Lid as well as the transportation.

5.1 Extended sensitivity analysis

In Table 6 the extended sensitivity analysis is shown. Here multiple parameters are changed simultaneously to understand the potential emission reductions that are possible while maintaining the profit of the business model. It is structured like Table 5 and where the resulting percentage above 100% indicate an increase in emissions per f.u. and below 100%, indicate a decrease of emissions per f.u. The parameters changed were decided based on the results in Table 5, where the most possible and prominent reductions are investigated further.

Table 6 – Extended sensitivity analysis of GWP/ f.u. based on combinations of parameter changes.

Parameters changed	**How the parameter has changed**	**Rental business model, kg CO2 eq/f.u. %**
Return rate & loss fee	85% & +13%	75%
	85% & +33%	73%
	85% & +60% (BE)	70%
Return rate & rental price	85% & +29%	71%
	90% & +29%	60%
	95% & +29%	51%
Rental price & loss fee	+29% & +13%	87%
	+57% & +33%	77%
	+114% & +60% (BE)	62%
	+29% & +60% (BE)	75%
	+57% & +60% (BE)	70%
	-14% & +60% (BE)	85%
Return rate & storage location	85 % & Gothenburg	68%
	90% & Gothenburg	56%
	95% & Gothenburg	44%
Return rate & rental price & loss fee	85 % & +29% & +13%	69%
	90% & +29% & +13%	60%
	95 % & +29% & +13%	50%
	85% & +57% & +60% (BE)	62%
	90 % & +57% & +60% (BE)	55%
	95% & +57% & +60% (BE)	48%
	85% & -14% & +60% (BE)	74%
	90 % & -14% & +60% (BE)	64%
	95% & -14% & +60% (BE)	55%

Return rate and loss fee

As can be seen in Table 6, the altering of the loss fee to 13% in combination with a set return rate of 85%, it results in a 25% decrease in kg CO_2 eq/f.u. In comparison to only altering the return rate to 85% in Table 5, the addition of increasing the loss fee as well reduces the kg CO_2 eq/f.u. with two percentages units. Continue to increase the loss fee to 33% with the set return rate, the kg CO_2 eq/f.u. reduces with 27% and a two percentage units' difference from the previous case. When increasing the loss fee to the break-even cost the kg CO_2 eq/f.u. reduces with 30% from the base case. The result indicates that the combination of return rate and loss fee parameters decrease the kg CO_2 eq/f.u. to some extent, but the main reduction stem from increasing the return rate.

Return rate and rental price

When setting the rental price to an increase of 29% and altering the return rate between 85%, 90% and 95% it results in significant reductions. When the return rate is set to 85% the resulting decrease in kg CO_2 eq/f.u. amount to 29%, for 90% return rate the decrease amount to 40% and the 95% return rate results in a 49% decrease of kg CO_2 eq/f.u. Comparing to only changing either the rental price or return rate, as is done in Table 5, it shows that the return rate change contributes to the largest part of the reductions but the rental price contribute more than the loss fee does for reducing the emissions/f.u.

Rental price and loss fee

When altering the combined parameters of rental price and loss fee, as can be seen in Table 6, it shows that when increasing the rental price with 29% and the loss fee with 13% the kg CO_2 eq/f.u. reduces with 13%. The relation showcases how simultaneous increases of both the rental price and the loss fee presents an opportunity for Light My Fire to reduce the total kg CO_2 eq/f.u. When comparing the combination of rental price and loss fee with Table 5, where one parameter was changed at a time, the combination of the lowest increase in rental price and loss fee results in a total kg CO_2 eq/f.u. decreases of 13% instead of 9% when increasing the rental price.

Continuing to increase both parameters to 57% and 33% respectively, the decrease of kg CO_2 eq/f.u. is 23% instead. When comparing the combination with the increase of only the rental price in Table 5, the altering of the single parameter result in a 16% decrease kg CO_2 eq/f.u., meaning a benefit of 7 percentage units is had from changing both rental price and the loss fee. Further increase of both parameters with 114% in rental price and a 60% increase of the loss fee changes the results to a decrease of 38% in kg CO_2 eq/f.u. When comparing the highest increase in rental price in Table 5 with the addition of break-even cost to the rental price, the difference between the two is 38% decrease compared to 28% decrease in kg CO_2 eq/f.u.

When altering the rental price with 29% in combination with the break-even fee, the kg CO_2 eq/f.u. reduces with 25% in comparison to the base case. When increasing the rental fee to 57% with set break-even fee it results in a 30% decrease in total kg CO_2 eq/f.u. The relation between altering the two parameters and the kg CO_2 eq/f.u. shows how the increase in both parameter decreases the kg CO_2 eq/f.u. When comparing cases against each other it can be found that increasing the rental price and lost fee with 57% & 33% and 29% & break-even has similar decrease from the base case. The comparison of cases indicates that there is more than one way to combine the parameters to reach similar levels of decrease.

Figure 21 illustrates what happens when the renting price is increased in combination with an increase of the loss fee. As can be seen the biggest decrease in emissions/f.u. stem from the increased renting price and when combining the two changes, the emissions/f.u. is reduced with 13% to 87% of total kg CO_2 eq/f.u.

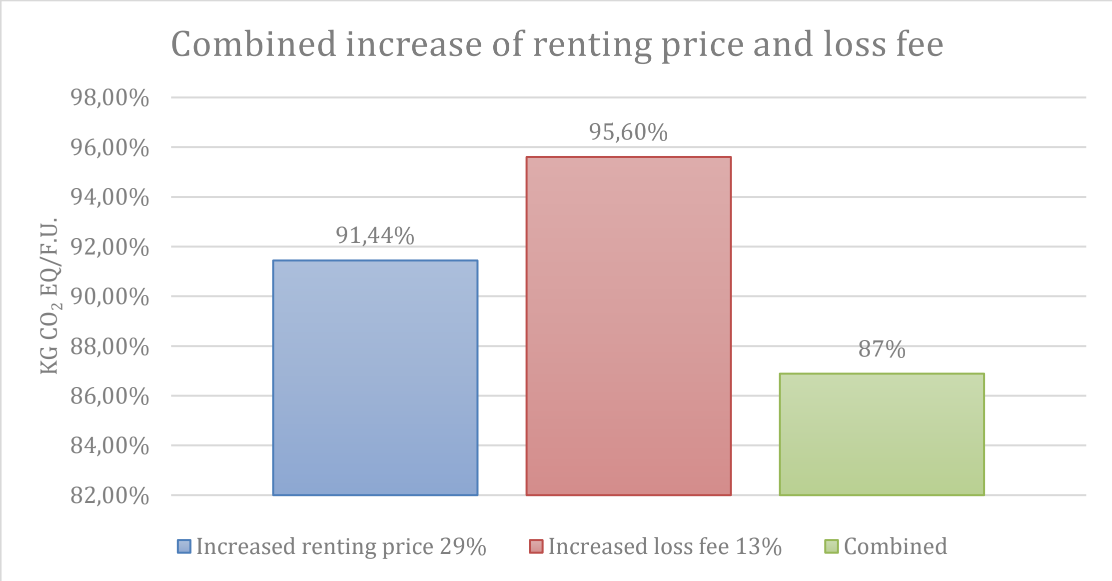

Figure 21- Increased renting price's, increased loss fee's and both increases' combined part of the total kg CO_2 eq/f.u. for all events.

By decreasing the rental price, Light My Fire strengthens their competitiveness on the market, while simultaneously retaining the profit of the business model by increasing the loss fee, ultimately leading to a business model that could attract renters. Viewing it from the perspective of maintaining profit whilst minimising the environmental impact, this combination shows potential. However, this concept builds on the will from Light My Fire's customers, the renters' willingness to pay for events with high loss rates. It also puts more of the responsibility, as mentioned, on the renters' will and ability to minimise the losses. This topic is something that should be investigated further but was addressed in this study due to time constraints.

Return rate and storage location

In Table 6 the combination of the return rate and the storage location is presented. As the return rate is 85% and the storage location has been set to Gothenburg, a 33% decrease in kg CO_2 eq/f.u. is had. When comparing the result from Table 6 and the combination of return rate and storage location with Table 5 and the single storage location parameter it shows that the introduction of return rate results in a larger decrease. The combination of an increase in return rate to 85% and Gothenburg as storage location decrease the kg CO_2 eq/f.u. with 33% in comparison to 8% when only shifting location to Gothenburg. Further strengthening the conclusions that the return rate is the most significant parameter to work with.

While increasing the return rate to 90% the decrease results in 44% of total kg CO_2 eq/f.u. compared to the base case. The relation between the two parameters stems from that less cups need to be transported in the loss production from Västervik to Gothenburg. In combination with the reduced transportation distance from the returned cup at the event, the impact becomes notable. The result is impactful and attainable which present an opportunity for Light My Fire to improve within the selected areas. Finally, increasing the return rate to 95% with the storage location in Gothenburg, the decrease results in the lowest outcome of all the tested combinations. The combination of parameters results in a 56% decrease in total kg CO_2 eq/f.u. from the base case.

Figure 22 illustrates two scenarios, where different parameters are changed. The first parameter being a decreased renting price and an increased loss fee for the base case and the second one, a decreased renting price and increased loss with an 85% return rate. The figure also presents the two parameter changes: decreased renting price and increased loss fee as standalone changes for reference i.e., the first two bars in Figure 22. As can be seen in the figure the combination of the two changed parameters results in a 15% decrease of emissions/f.u. as opposed to 13% in the case of increasing both parameters as in Figure 22. The combined decrease in renting price with increased loss fee with an 85% return rate results in 26% reduction of emissions/f.u., while for the increased loss fee 13% and 85% return rate a 25% decrease, as seen in Table 6.

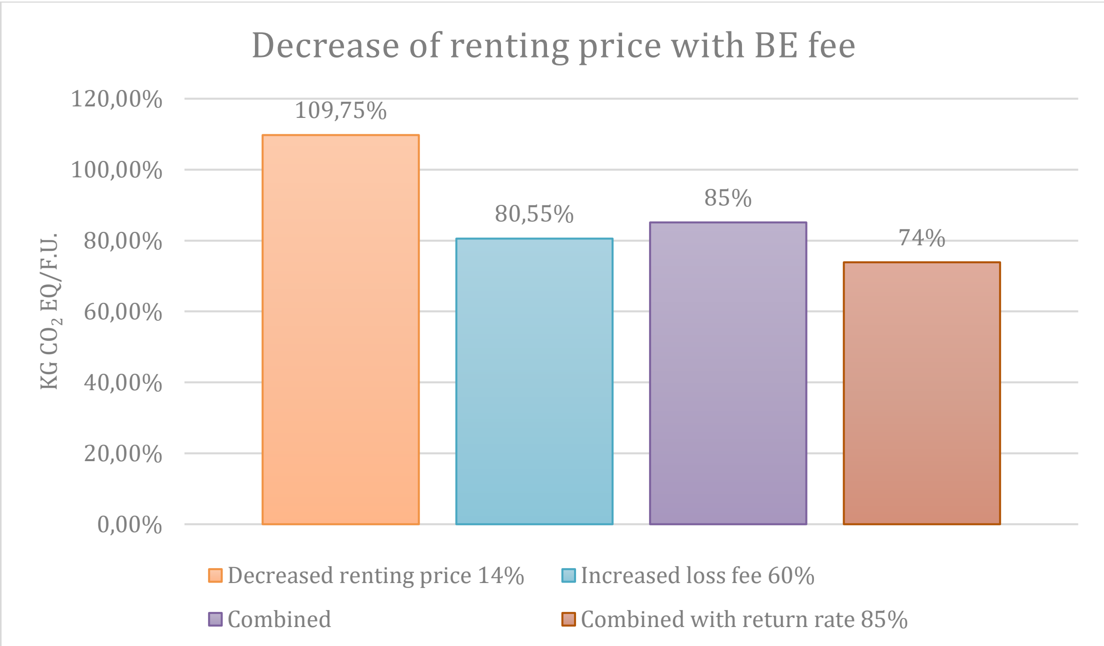

Figure 22 - Decreased renting price's, increased loss fee's and both increases' combined part of the total kg CO_2 eq/f.u. for the base case return rate and with a return rate of 85%.

Return rate, rental price and loss fee

As can be seen in Table 6 the combination of altering three parameters at the same time represent a broad change in the business model. When altering the return rate, rental price, and the loss fee simultaneously in several combinations the decrease from the base case is noticeable. The first combination of 85% return rate, 29% increase in rental price and 13% increase in loss fee results in a decrease of 31% in kg CO_2 eq/f.u. Continuing to increase the return rate with the previous set rental price and loss fee, the total kg CO_2 eq/f.u. decreases with 40%. When switching to the highest selected return rate of 95% the kg CO_2 eq/f.u. decreases with 50%.

In Figure 23 the relation between the loss fee and how it affects the total emissions/f.u. for different return rates with a set increase in renting price is presented. For 85% return rate, the decrease is 29,9%. When increasing the loss fee with 13%, the decrease is down to 31,3%. It is only a slight difference between the currently used loss fee. When altering the loss fee to 60% the decrease in kg CO_2 eq/f.u. is instead 39%.

For the 90% return rate with the same renting price and the original loss fee, the decrease in kg CO_2 eq/f.u. is 40,1%. When increasing the loss fee to 13%, the decrease is 40,8%. Finally increasing the loss fee to break-even, the decrease in kg CO_2 eq/f.u. is 45,9%.

For 95% return rate the decrease in kg CO_2 eq/f.u. is 49,6% with the currently used loss fee. When increasing the loss fee to 13%, the decrease is 50,5% and with the break-even fee, the decrease in kg CO_2 eq/f.u. is 52,8%.

When comparing the different cases, the decrease in kg CO_2 eq/f.u. is 9,1 percentage units from increasing the loss fee to break-even fee in the 85% return rate. For 90% return rate the same comparison is 5,8 percentage units decrease and for the 95% return rate, the change is 3,2 percentage units. The results show that the increase in loss fee becomes less influential when the return rate increases.

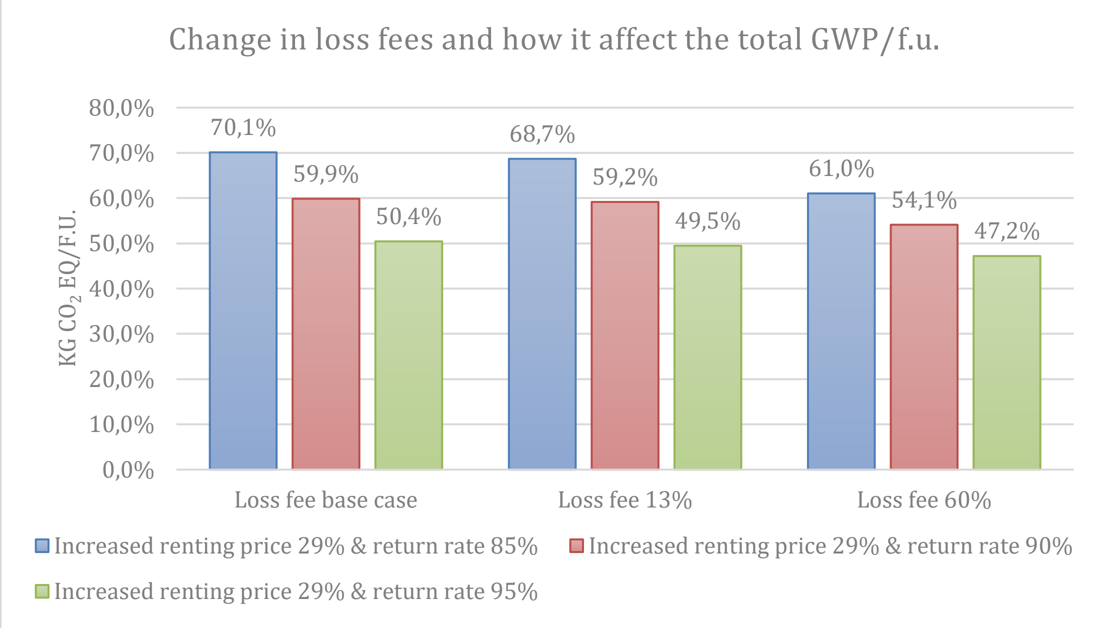

Figure 23- How the change of loss fee contributes to the emissions per f.u. for the business model.

Continuing to analyse the same combination of parameters that are being altered with an increase in both rental price and loss fee to 57% and 60 (BE) % individually. The result from altering the return rate from 85%, 90%, 95% with the previous set parameters in rental price and loss fee shows a 38%, 45% and 52% decrease respectively from the different return rates. The combination indicates that a broad change in different parameters within the business models can give substantial result in decreasing the total kg CO_2 eq/f.u.

When altering the same set of parameters but with a decrease in rental price with 14% the decrease is still significant but not to the same extent as when increasing the rental price. The decrease in rental price result in a 26% decrease in total kg CO_2 eq/f.u. when the return rate is 85%. For a return rate of 90%, the result is instead a decrease of 36% from the base case in total kg CO_2 eq/f.u. Finally, when increasing the return rate to 95%, the decrease is down to 45% of total kg CO_2 eq/f.u. The combination of increasing the return rate, which has been proven to be significant for the business model, and increasing the loss fee to break even, the rental price can be reduced while still decreasing the total kg CO_2 eq/f.u.

5.2 Evaluation of results

As a lot of the changes of the sensitivity analysis indicates that there is great improvement potential, it is of interest to understand which might be the most plausible. There is also an interest to those parameters that would not significantly affect the cost of the renter as a way of maintaining the competitiveness of the business model.

Starting with the first parameter change in the sensitivity analysis in Table 5 it shows that there are great improvements to the environmental performance of the business model when improving the return rate of Cup'n Lids. Comparing the reductions due to this parameter with the others of the table, it shows strong indications that this is something that Light My Fire should focus on. Further, the increase of return rate is something that both Light My Fire and the renting company would benefit from, causing it to be more susceptible to success than otherwise as both companies cooperate in their work of minimising the losses and to minimise the costs.

The change of rental price as well as the change of loss fee could potentially affect the expansion of the business model more than the change of loss rate as the potential customers are less enticed by a product significantly more expensive than the previously used single use products. The current rental business model entails a 43,4% cost increase (D. Martin, personal communication, May 15th, 2023) for the events in comparison to the currently single use paper cups. However, switching to reusable cups will not be required for events that are already using paper mugs and thereby there is a need for the reusable cups to be competitive in renting price to sway these events. A possibility remains for events who would market themselves as sustainable that agrees to higher prices to avoid large waste generation.

A way to maintain competitiveness would be to decrease the rental price of the Cup'n Lid, and instead increase the loss fee to break-even to create incentives for the renter to increase the return rate of the Cup'n Lids. When doing so, there is potential for the renter to mitigate their expenses by shifting the responsibility of the return of the Cup'n Lids to the renter. This solution does not generate the largest reduction in kg CO_2 eq/f.u. but is something that should be investigated further.

Changing the storage facilities of the business model on the other hand, affect the renter less and shows contribution to a better environmental performance of the business model as transports are reduced. Hence, the logistic parameter is something that could be utilised by Light My Fire if need be.

Deriving from the extended sensitivity analysis in Table 6, it shows that when implementing increased return rate, but also increasing the loss fee for the renter small improvements is made compared to only changing the return rate. In the case of changing rental price and loss fee it also shows that the improvement to the business model mostly stem from increase in renting price as can be seen in Table 5, rather than increasing the loss fee. Furthermore, the conclusion that the loss fee has little effect on the business model's emissions/f.u. is further strengthened by the case where return rate, renting price and loss fee are increased as seen in Table 6 and further illustrated in Figure 20. It entails that Light My Fire should focus on other measures than the loss fee. The combination of increased return rate and a change in logistics to storage in Gothenburg or close to the events creates a significant improvement for emissions/f.u. while it simultaneously does not affect the customer by increasing the renting price or increasing the loss fee. Although, the extra storage facility would come at a cost as Light My Fire's warehouse in Västervik would remain in operation and thereby could impact the renter with increased costs.

To summarise, the most beneficial improvement that can be done for the business model would be to decrease the loss rate and thereby increase the return rate. By doing so, the production of lost Cup'n Lids would be greatly reduced and thus decreasing the emissions. Furthermore, changing logistics are a way of significantly reducing emissions from transports. Shifting the responsibility to the renter to assure high return rate might be a way for the business model to expand as it allows for a higher cost competitiveness.

6. Discussion

In this chapter the method and the results are discussed. What decisions were made during the study, what has affected the study and it results, how the results might be used, and what different problems have arisen as well as future research is presented.

6.1 Credibility of results and what factors that affects them.

For the sake of comprehensiveness only the GWP impact category was used when performing the interpretation step of the BMLCA as it would require extensive reporting of tables and charts to illustrate how emissions/f.u. of other impact categories would look. Also, from the LCIA it was found that for most of the impact categories, the relationship among the processes were somewhat similar which further allowed for the avoidance of the other impact categories in the sensitivity analysis.

As the modelling of the business model and the production of the Cup'n Lids are made by modifying and using the results from the LCA created for the Bowl'n Lid, small deviances in the results could have followed. Because the Bowl'n Lid is a product made from the same materials but with other dimensions, and as the LCA software used were not the same as the one used for the original LCA. However, as the goal of the study was to find environmental hotspots of the business model and to propose solutions to them, small inaccuracy in the results do not affect the outcome of the study with significance. Furthermore, as the relationships between processes still stands, the results still indicate whether the changes to the business model would affect the emissions/f.u. positively. Further, by presenting the results in relation to the base case further reduces the problem with the accuracy of the results as the relationship between processes in the life cycle is more interesting than the exact emission per process. In other words, it is more interesting for the study, how the changes of one parameter impacts the whole business model than if that change reduces that process with 0,01 amount of kg CO_2 eq/f.u.

However, the cost versus benefit of the changes is something that is not accounted for in this study but is something that is of significance as changes are made and suggested without an accurate picture of how implementable they are in the end. Changes to the business model varies in their possibility of implementation and is therefore something that could be considered further to strengthen the results.

In some of the processes of the business model assumptions were made when modelling them. For instance, in the case of RFIDs, Stora Enso would disclose the full product description regarding production location and the specific metal in the antenna (B. Sunesson, personal communication, April 23rd, 2023). The company referred to a patented proprietary metallic alloy antenna material that are not used on the market. Only that the metal used in the antenna did not consist of silver or copper. Therefore, the assumptions that it was made from aluminium were made. Aluminium together with the previously mentioned materials, are the most common material for antennas in RFIDs (Roberti, 2019). This assumption creates an uncertainty in the credibility of the results relating to the RFIDs, but as they accounted for less than one percent in all impact categories it was deemed sufficient to use. The main reason for the RFIDs low contribution to the total emissions/f.u. was due to them only being a part of the original production batch. Light My Fire disclosed their plan of not using RFIDs in the future and thus the business model's loss production was modelled without the RFIDs. Furthermore, the weight of the RFIDs, and especially the light weight of the antenna making the effects of the uncertainty less substantial.

The RFIDs were assumed to be produced in Shenzhen, China, as the information provided by Stora Enso were that they were produced in China. Shenzhen is an industrial port city and other RFIDs were produced there (Made In China, n.d), and thus it was assumed that the RFIDs used in the Cup'n Lid also were produced there.

The RFIDs' potential impact on the environmental performance of the business model were something that were of interest at the beginning of the study. However, as the company has since decided to exclude RFIDs from their products moving forward, in combination with a "ECO-labled" RFID being used, the impact from them were low and therefore not significant enough to warrant further investigation. The RFIDs used were Stora Enso's ECO Hook Rain RFID label (Stora Enso, n.d) and even though its relatively low environmental impact, the environmental impact related to them were unnecessary as they did not contribute to better handling of the generated waste at the event, which was their intended purpose.

Furthermore, comparing the results with the previously conducted BMLCA studies is a way of verifying them. Comparing to the shell jacket company studied by Goffetti et al. (2022) there are some similarities as in where the rental business models generate their emissions. In the rental business for the shell jacket company most emissions stemmed from transportation processes both in production and in use phase. In this study it was found that the transports related to the business model were the second largest emitters behind the production to cover for losses. The return rate of the Cup'n Lids was one of the key factors for the production to cover for losses being the biggest contributing process. Had the return rate been lower, transports would instead be a higher contributor to the environment impact of the business model and thereby more like the results of the shell jacket study. Rental business models have high impacts from the transportations which is something that should be kept in mind when designing them. The reason for the high impacts form transportation is due to the extra transports required to maintain the business model. For a conventional business model where the customer buys the product from the producer no return transports are required. In the rental case, there are instead transports back and forth with products to maintain the business models profitability which increases the environmental impact. Hence, it is important for the business model owner to be aware of the increased transports and do their best to minimise them in different ways. Therefore, it is important to both minimise waste but also to minimise the distances which the products need to be transported.

6.2 Use of results

The use of the results can be used for multiple purposes. Primarily, the intended use of the results is to provide Light My Fire with understanding and information on what processes and parameters are important and could be changed to improve their environmental performance while maintaining their economic profit of the business model. The results show how changes in moving storage location closer to the event, increasing the return rate and subsequently reduce the production to cover for losses could provide large improvements for their environmental performance of the business model. Ultimately, the results can be used for Light My Fire as a basis on expanding their business model but also if restructuring of the business model is of interest to decrease the emissions per f.u. One of the uses for the BMLCA is to use the method in business model innovation (Böckin et al., 2022). In the case of this study the method shows potential as the environmental performance linked with economic parameters provide large possibilities in how different paramaters affect the outcome. Using the Excel-file where the sensitivity analysis was conducted, proved useful in creating scenarios and possible changes and ultimately seeing the results from the changes in emissions per f.u.

There is a risk when doing studies on environmental impacts and performance, that the results are used to greenwashing practices and products, either by "cherry-picking" results or by emphasising results and trying to make them significant. If the results are to be used in marketing, they would hence need to be third-party reviewed to ensure the results and methodology.

6.3 BMLCA

The project used a f.u. that were timeless, meaning that it stretched over ten events, disregarded the time-value of money, and was based on potential profit of the business model to support business innovation. The results of the study showed that BMLCA could be used for timeless business models but created some concerns. As the nature of many business models require substantial investments in early stages, the investment cost for rental business models were higher than the revenue from the renting i.e., loss is made initially. This causes a problem for example, if only one event is analysed in the BMLCA, because of the loss. The interpretation of the results would be difficult since it would imply that emissions per f.u. would be negative. What that entail is difficult to interpret which makes the BMLCA method less suitable for analysing business models that are operating and do not generate profit. On the other hand, it also shows that the BMLCA could be a method best suitable for business model innovation in this case.

6.4 Return stations

From the results it was found that the return stations had a significant impact on the overall environmental performance of the business model. It showed that these impacts mostly stemmed from the production of plastic bags.

Concerning the return stations impact on the business model, multiple implications were noticed during the study. A primarily point of discussion concerning the return stations is the lack of disposal of liquid remaining in the cups, which is need for further development of the business model. As mentioned, there are currently no disposal stations for liquids remaining in the Cup’n Lid. The liquid is thereby thrown together with the Cup’n Lid into the return stations, creating both mess and in some cases leakage of the return stations. Consequently, as the return stations are made of corrugated board boxes, there are a risk that the return stations are ruined as they get wet. Currently, it is assumed that the return stations would be reusable for all ten events investigated. But it is unlikely that this will be the case. As the return stations have been wet the structure of them are jeopardised as deformation of the corrugated board box occurs. Furthermore, it is unlikely that Light My Fire or the company renting the products want to use return stations that have been deformed due to the cosmetics of them. Instead, it would be likely that new would be produced to provide a more professional look for the company and to satisfy the customers of those who are renting the products for their events.

The production of return stations is, in this study, modelled as one batch of return stations. Light My Fire would benefit from implementing a solution to the remaining liquids in the Cup’n Lid in the form disposal stations. This implementation could increase emission per f.u. of the business model due to increased transports and production of disposal stations unless there are stations already available at the events. Further, solutions such as smaller Cup’n Lid for the consumer would reduce the amount material needed in production but also the amount of beverage wasted which could prove beneficial in maintaining the return stations intended lifetime and not increasing the emissions related to the business model. This solution could also be more cost effective for the events if the servings were smaller, but the price of the beverage is maintained. However, it could lead to dissatisfaction among the customers which need to be considered.

Implementing solutions to decrease the liquid disposed in the return stations would prolong the return stations lifetimes. Consequently, the emissions due to production and transports of new return stations would be avoided, which would be preferred from an environmental viewpoint. If dispose stations would have to be produced and transported to the events, there is a risk of increasing emissions/f.u. in comparison to produce new return stations, thus losing the benefits that the dispose stations are intended to provide.

Another concern regarding the return stations is the number of plastic bags that is required to maintain them. Both due to leaking and the bags filling up made it necessary to replace the bag in the return station with a new, frequently, over the course of an event. The number of plastic bags have a large environmental impact and their contribution to the increase of emissions per f.u. is not negligible. As the motivator for the business model is to reduce the single use plastics, the number of plastic bags that are disposed of after use, contradicts message of the business model. Reducing the need for these plastic bags would be a crucial part in creating the circular business model that is desired. It states the question if there are possible solutions to the return stations problems, either by changing the material used for the collecting bags to something else, or by changing the solution of the return stations entirely. Changing the material composition of the return stations into a more durable one, could be the way forward. Although, it would likely result in higher emissions from both production and transports and is something that needs to be investigated further.

6.5 Future research

Something that can be explored further concerning BMLCA, is the investigation of the feasibility of the changes tried in a sensitivity analysis, when using the method for business model innovation. By implementing a cost benefit analysis on changes would make the results more accurate in terms of the profitability. Changing the manufacturing costs, does not entail that the producing company can just cut wages for their workers. Instead, it would most likely need investments and restructuring which come at a cost. If the cost benefit analysis is then implemented in the BMLCA, it would allow suggestions and results with a higher credibility. Therefore, this is an area that need future research in both the implementation, but also if it would create different conclusions compared to the original BMLCA.

Another topic for future research would be investigate the negative profit that could follow from analysing a business model over a certain time period. For instance, when only analysing the first event of the business model it resulted in a large initial cost that resulted in a negative value. How can the method still be used when a negative value is attained is something that need to be researched further in the future. This problem is especially of interest when existing business models are investigated and the BMLCA is not used for business model innovation. When these types of business models are investigated and are not generating profit, the emissions per f.u. will always be negative.

7. Conclusion

The aim of this study was to analyse the environmental performance of the business model while using the case of GHS as a basis. Furthermore, the aim was to investigate where the environmental hotspots of the business model were located and what changes can be done to decrease the environmental impact while maintaining profit of the business model.

The GWP per f.u. was for the global warming potential category was: 0,037 kg CO_2 eq/f.u. and where the largest contributor to the environmental impact per f.u. stemmed from the production making up for the losses at the events. During the study it became apparent that the largest hotspots for all impact categories analysed were the production for making up for losses, the transports, and the original production of PP. Interestingly, it was revealed that the return stations effect on the environmental performance of the business model was of great significance.

From the sensitivity analysis it was found that the most significant change with a high possibility of implementing was to increase the return rate after each event. By increasing the return rate to 85% the business model would lower the kg CO_2 eq/f.u. with 23% as production of new products were decreased and ultimately decreasing the need for extra transports. Furthermore, it showed that moving the storage facility to the same city as the event reduced the contribution to total emissions from transports with 8%. Further, combining the increase of return rate, with the change of storage facility entails a 32% reduction in kg CO_2 eq/f.u. Finally, it was found that the change of the loss fee had little impact on the reduction of kg CO_2 eq/f.u., while the change of renting price had a higher impact.

Sustainable business models are considered to reduce impacts to environment and society (Bocken et al., 2014). However, this study showed that marketing business models as sustainable without analysing its entirety could have implications in the form of unforeseen impacts. Subsequently, there are possibilities to improve sustainable business models with business innovation using the BMLCA method. Ultimately, the BMLCA worked as a tool for analysing and evaluating the environmental performance of a rental business model used at events with a timeless functional unit. The rental case differed from previous conducted studies since the case was conducted at a real event which has not been done previously, however, the BMLCA method could be successfully modified and subsequently applied to the rental business model at events.

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