Heineken

Universiteit Utrecht

Reducing the carbon footprint of glass packaging in the beverage sector in the context of consumer convenience

Student ID: 6263968
Student Email: s.r.favrin@students.uu.nl
Supervisor: Dr. Ric Hoefnagels
Internship at: Heineken
Heineken supervisor: Lawrence Hambling, *lawrence.hambling@heineken.com*
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Preface

Before starting on the journey through this thesis, take a moment to collect your thoughts and prepare yourself for an interesting, though-provoking and – admittedly – long read.

This thesis is the end-result of nine months of hard work, under the guidance of two wonderful supervisors: Ric Hoefnagels from Utrecht University and Lawrence Hambling from Heineken. The research was combined with a six-month internship at Heineken and was consequently conducted in collaboration with Heineken Global Procurement and Heineken Netherlands. Although the thesis was a stand-alone project, it did fit in the broader program from Heineken called 'Drop the C', which is aimed at minimalizing carbon emissions in their operations. Furthermore, in parallel to my thesis, Heineken Netherlands ran several pilots to investigate the viability of shifting the whole Dutch market to returnable bottles, which provided to be a good source of inspiration.

The key concern that gave rise to this thesis was that the drive towards convenience for the consumer would inherently complicate reducing carbon emissions from Heineken's operations. To investigate the extent to which this phenomenon held sway and how it could be handled, this project was initiated. Although their concern was well-founded, several strategies have been formulated to deal with this phenomenon, which form the key content of this thesis.

The difficulty is the consideration whether you want to influence consumer behaviour or whether you want to create sustainable packaging with lower environmental impact, because these two considerations are not always in line. ~ Steenis (2019)

Abstract

In pursuit of reaching targets set by the Paris Agreement, businesses in the consumer goods market must commit to significant carbon emission reduction. The consumer plays a pivotal role in determining the effectiveness of these carbon emission reduction strategies through its purchase behaviour. Previous studies have typically assessed these strategies in the consumer goods market from only one of two perspectives – environmental impact assessment or consumer purchase behaviour – and therefore tend to ignore the opportunities and barriers of connecting these two topics. To prevent this misalignment, this research has investigated carbon emission reduction strategies by conducting and integrating both a carbon footprint analysis and consumer research. The scope of the carbon footprint included glass packaging in the beverage industry within the Netherlands, using input data from Heineken, for which the research was performed. Additionally, data for the consumer research on the Dutch consumer was collected through six expert interviews and a review of four studies performed by Heineken Netherlands. Finally, since the volume consumed in the Netherlands only represents 2% of the global volume packed in glass bottles by Heineken, a case study on the United States was performed to explore what was needed to apply the results to other operating countries of Heineken. From the integration of results of the carbon footprint analysis and the consumer research, three carbon reduction strategies were derived: the transition from one-way to returnable glass bottles, lightweighting and increasing the national recycle rate. Within the Netherlands, the most recommendable strategy is to transition to returnable bottles, which can additionally be supported by the lightweighting of returnable bottles. Implementing these two strategies would decrease the carbon footprint by 16%. For successful implementation, especially the dissemination of knowledge on the benefits of reuse is required to address the issues introduced by deposit money and wear and tear. Furthermore, various unit volumes and smaller packaging sizes need to be introduced to both increase portability and to be able to fulfil the consumption scenarios that are currently addressed by one-way glass bottles. Finally, the case study on the US has revealed several factors that need to be taken into account when upscaling this research. For the carbon footprint, supplier emissions, transportation distance and parameters for disposal have major influence on the results. For the consumer research, it is important to take into account the differences in take-back culture, legislation, disposal infrastructure and the general perception of sustainability.

Executive summary

To support Heineken on their aim to keep emissions at a similar level in 2030 relative to 2018, the primary aim of this thesis was to explore strategies to decrease the carbon footprint in glass packaging. The carbon footprint is, however, not static and is influenced by consumer demand. Heineken expressed its concern that consumers increasingly demand more convenience-oriented packaging – such as smaller unit volumes – which increase the carbon footprint of glass packaging. Therefore, the key research question has been formulated as: "*how can the carbon footprint of glass packaging in the beverage sector be reduced in the face of consumer convenience demands*?" The analysis was performed within the Netherlands as this is one of the key markets for Heineken, as well as to facilitate the consumer research. Overall, the purpose of the study was fourfold:

- To identify the carbon footprint of one-way and returnable glass packaging from Heineken in the Netherlands.
- To examine the consumer purchase decision-making process to derive drivers and barriers in stimulating consumers to adopt sustainable innovations.
- To identify carbon reduction strategies that satisfy consumer convenience demands.
- To examine what is required to apply the learnings gathered from the Dutch case to other countries with a different culture and disposal infrastructure. To that end, a case study on the United States was performed.

Data was gathered using different methods to fulfil each purpose. To gather the necessary input for the carbon footprint analysis, the Carbon Footprint Baseline Model 2018 from Heineken was used as well as additional primary data to increase the accuracy of the carbon footprint and to fit the scope of the current research. For the consumer research, two methods were utilised. First, six expert interviews were held with packaging and consumer behaviour experts from the industry or research organisations. Secondly, data was gathered from internal consumer research from Heineken Netherlands, who have been studying the potential for transitioning to returnable glass bottles within the Netherlands over the past year. Finally, to perform the case study on the United States, a former Heineken USA employee was interviewed and a document analysis was done based on the previous Heineken research provided by this employee.

1. The carbon footprint

In the carbon footprint analysis, four life cycle stages were examined: packaging production, beverage production (bottle cleaning and cooling), distribution (inbound, outbound, warehousing and last mile) and the consumption stage (use and disposal). The carbon footprint from the returnable bottle is roughly 60% lower than the carbon footprint of the one-way bottle (Figure 1). This difference is primarily a consequence of the trip rate, which lowers the carbon footprint of packaging production for returnable bottles, while this is a key impact hotspot for one-way bottles. Distribution has a relatively low impact – 3% for one-way bottles and 11% for returnable bottles –, but the US case study showed that distribution can have a significant impact over longer distances, up to 29.5 and 65.2kg CO_2e per hectolitre respectively for one-way and returnable bottles for export to the West Coast of the United States. Nevertheless, up to a transportation distance of 5,312 kilometres by heavy truck and around 12,000 kilometres by ocean vessel, the returnable bottle has a lower carbon footprint than one-way bottles, making it the more sustainable alternative (based on carbon emissions) in almost all scenarios.

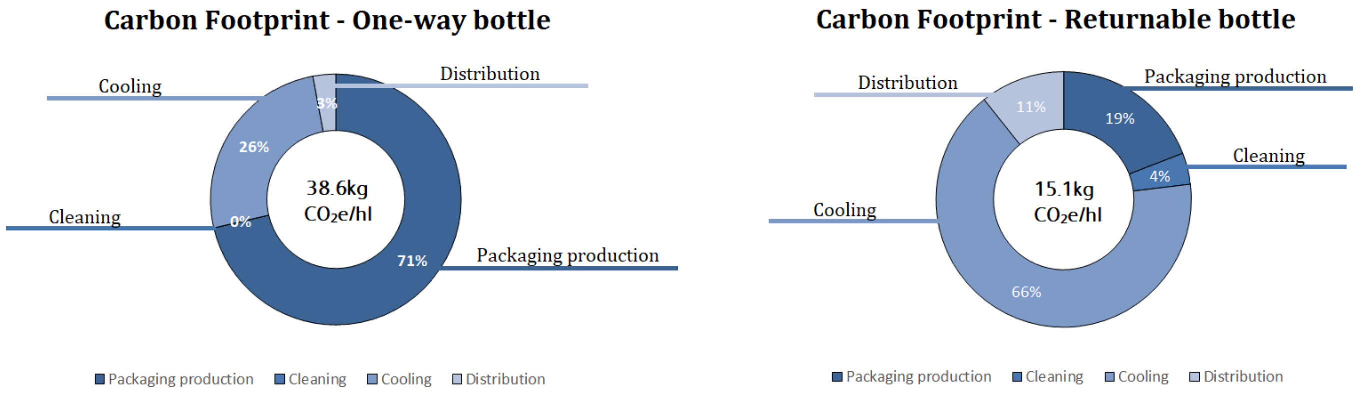

Figure 1 - Carbon Footprint results for one-way bottles (left) and returnable bottles (right) in the Netherlands

Several strategies have been discussed to stimulate carbon footprint reduction (Figure 2). Three strategies form the core of the remaining part of the study due to their relation to consumer purchase behaviour and convenience:

- Transition to returnable bottles
- Decreasing the weight of packaging
- Increase the national recycle rate

To evaluate their viability from a consumer perspective, consumer research was performed on the consumer drivers and barriers with regards to these strategies.

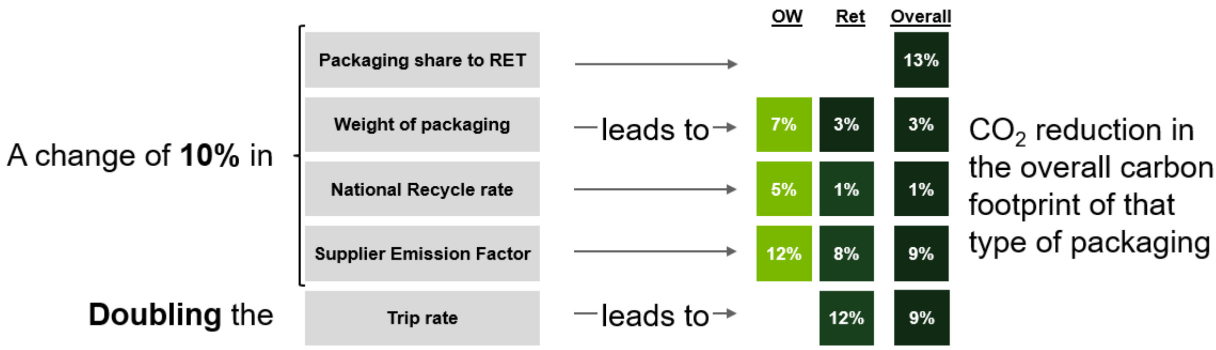

Figure 2 - Carbon Footprint reduction potential. Ow = one-way, Ret = returnable.

2. Consumer purchase behaviour

The implementation of effective carbon reduction strategies relies on the willingness of consumers to fulfil their role in accepting these strategies and to behave accordingly. For a large part, this is decided by the consumers' purchase decisions, as these form the touchpoints with business. The purchase decision-making context was analysed using an integrated model of consumer purchase behaviour. By analysing the purchase behaviour process, one key barrier and one key driver have been identified.

The key barrier to land sustainable innovations to the consumer is the Fast Moving Consumer Goods (FMCG) purchasing context. Since FMCG products are typically low-cost products with high turnover, purchase decisions for these goods are not made under high cognitive effort, resulting in a low-involvement purchase scenario. In this scenario, consumers do not actively process information about the products they are buying. As a result, this makes heuristics like brand predisposition, categorisation[1]

[1] Categorisation is defined as the process of placing objects into classes or groups. If in a consumers' perception beer beverages are supposed to be consumed in glass, he or she will only look for beer in glass packaging as any alternative packaging material does not belong to this mental category.

and habitual purchase an important part of the decision process. Therefore, if consumers are not familiar with sustainable products, or in other words, sustainable products are not in their evoked set[2], they will repeatedly refrain from buying the sustainable alternative.

A key driver that can help overcome this issue is the personal ecological norm. The personal ecological norm consists of three elements: environmental awareness (what is the issue?), awareness of relevance of own behaviour (why should I act?) and awareness of one's own abilities to act (what can I do?). It is linked to the barrier presented by the FMCG context; the higher the personal ecological norm, the more conscious consumers are about their choices in the store and the consequent impact on the environment. Furthermore, only individuals with a strong personal ecological norm are likely to accept minimal trade-offs with regards to convenience, but at this moment in time, the majority of the consumers are still quite sceptical of the importance of sustainability. The prime barrier to a high personal ecological norm is the lack of knowledge. Consumers frequently underestimate the GHG emissions of consumption products and therefore do not recognise the importance of their purchase decisions. Even if they are aware of this, the majority of the consumers do not know what they can do about it.

The best remedy for both discussed barriers is to inform consumers on environmental issues and what they can do about it. Two manners of communication can be utilised. As consumers do not actively process information in the purchasing context, companies should make use of non-active information transfer, such as design cues, nudging or framing to ensure short-term purchase behaviour change in the stores. To facilitate longer-term behaviour change, a broader communication strategy should be maintained in parallel. Part of this broader communication strategy should be to inform the consumer about the sustainability elements that are addressed by the company, what choices they can make to contribute to sustainability and why this is important.

3. Strategies for carbon emission reduction

In the analysis of the carbon footprint, three strategies were defined that could reduce the carbon footprint and stand in relation to consumer behaviour. Here, these strategies are discussed in relation to consumer convenience demands.

Transition from one-way to returnable bottles – type of packaging

In order to transition to returnable bottles, consumer demands that are currently fulfilled by one-way bottles will need to be satisfied by returnable bottles. The largest barrier to fulfil these requirements is the inconvenience of disposal that is associated with returnable bottles. First of all, there are three contextual factors that – if present – decrease the perception of ease of disposal of returnable bottles: 1) a large distance to the supermarket, 2) a small-sized residence from the consumer and 3) a perceived high inconvenience of returning the bottle. If these contextual factors are prominent, a one-way glass bottle is often preferred. Secondly, three additional product-related characteristics affect the acceptance of returnable bottles:

- **Deposit money.** The deposit can be considered as a financial barrier due to extra investment needed to buy returnable bottles. Additionally, it carries the obligation to return the bottle to the supermarket, which can be perceived as inconvenient.
- **Wear and tear**. Wear and tear affects the aesthetical value and perceived quality of returnable bottles.
- **Availability of different unit and pack sizes**. Currently, only the returnable crate (twenty-four 30cl bottles) is available. Therefore, returnable bottles are not able to fulfil all consumption scenarios that can be fulfilled by one-way bottles, as sometimes smaller packaging sizes or unit volumes are desired (e.g. on-the-go).

Several recommendations with regards to ensuring consumer acceptance are:

[2] The evoked set is a range of alternative products or brands that are considered in a purchase decision.

- Communicate on the benefit of returnable bottles and assure consumers that wear and tear does not influence the quality of the glass and if it does, it is taken out of production. Wear and tear is usually merely an aesthetic issue which sparks the association of lesser quality; this needs to be overcome.
- Communicate to consumers why it is better to reuse than to recycle. There is scepticism about the added sustainable value of returning versus recycling glass, as consumers are unsure what exactly happens after handing in their returnable bottle. This elicits unwillingness to pay a deposit. As the decreased disposability and the financial investment of the deposit appear to be the biggest concern for consumers, it is important for consumers to know why they are putting in extra effort.
- Ensure availability of different unit volume and pack sizes to satisfy the demands of different consumption scenarios. Furthermore, the portability of returnable bottles could be improved by providing consumers with the opportunity to purchase a hard-cased reusable bottle case that consumers can use to transport loose returnable bottles.

If the identified barriers are overcome and a transition to returnable bottles is made, the carbon footprint of the Netherlands can be decreased by 13%, or 2.4 kg CO_2e per hectolitre.

Decreasing the weight of glass packaging
The potential for carbon reduction comes forth from lightweighting potential. From a consumer perspective, lightweighting of a packaging material is barely noticeable unless it is communicated by the brand. This reduces the complexity of implementing this strategy, making it beneficial for companies to prioritise weight reduction. An alternative method to reducing the weight is to focus on higher unit volumes. A higher unit volume relates to a lower weight-content ratio [kg/hl], which consequently lowers the carbon emissions per hectolitre. However, the results indicate that there is a clear market to be satisfied by smaller unit volumes (e.g. consumers desire unit convenience), mainly originating from the growing number of small- or single families, elderly and on-the-go consumption. Therefore, although it is attractive to increase unit volumes from a carbon footprint perspective, from a consumer perspective it is not.

Due to the high share of returnable bottles, lightweighting has less potential to reduce the carbon footprint in the Netherlands. In total, a reduction of 3% – or 0.6kg CO_2e per hectolitre – of the total carbon footprint within the Netherlands can be achieved for each 10% weight reduction. Lightweighting is a better strategy in countries with a higher share of one-way bottles, such as the US, since then it can accomplish its full potential. Nonetheless, it is recommended to continue efforts on lightweighting as it not only affects the volume consumed in the Netherlands, but also all products that are exported, thereby decreasing the carbon footprint of all volume produced in the Netherlands as well.

Increasing the country recycle rate
The Netherlands has a long history with recycle and return schemes for glass bottles and currently has a recycle rate of 84%. Nevertheless, three primary barriers are recognised that prevent proper disposal conduct by increasing the (perceived) inconvenience of disposal:

- On-the-go consumption scenarios are growing, which increases the chances that consumers dispose of their products incorrectly.
- There is still a lack of environmental awareness and knowledge on recycling. Especially for consumers that have a low personal ecological norm, convenience is much more important which prevents these consumers from putting in the effort to properly dispose of glass bottles.
- Factors such as distance to the bottle bank or supermarket, frequency of disposal, the perceived difficulty of recycling and the low portability of glass contribute to the perception of inconvenience.

It must be acknowledged, however, that individual companies like Heineken have little influence on country recycle rates, except for lobbying for regulation, collaborating with the industry to improve the recycling infrastructure and through communications to the consumer to increase awareness and understanding of the importance of recycling. As a consequence, the potential for a single company to affect the recycle rate is low and therefore it is only expected to grow organically. In 2015-2016 the country recycle rate grew by 1% within the Netherlands. If this continues on a yearly basis, the carbon footprint for glass packaging within the Netherlands will decrease by 0.15% or 0.03kg CO_2e per hectolitre per year. Therefore, due to the low carbon reduction potential and limited influence of a company to influence this, it is recommended to focus on the other strategies for the Netherlands. In chapter 11.4, however, a strategy to increase the recycle rate for the US is discussed shortly.

4. Synthesis

The primary aim of this thesis was to answer the question: *how can the carbon footprint of glass packaging in the beverage sector be reduced in the face of consumer convenience demands*? In Table 1 an overview is given of the three proposed strategies and their carbon footprint reduction potential. Combined with the consumer research, it is concluded that the transition to returnable bottles has the most potential for the Netherlands, although lightweighting is in turn the most accessible strategy since it does not face any consumer barriers. The country recycle rate has the least potential, mainly due to the limited influence of individual companies on the recycle rate and the low organic growth factor within the Netherlands. In summary, if the transition to returnable bottles prioritised and lightweighting is implemented as a carbon emission reduction support strategy, the carbon footprint can be reduced by 16% in total (3kg CO2e per hectolitre).

Table 1 - Carbon footprint potential for every 10% increase in the two recommended strategies.

STRATEGY (Δ=10%)	CARBON FOOTPRINT
TRANSITION TO RETURNABLE	-13%
LIGHTWEIGHTING	-3%
COMBINED	***-16%***

5. Scaling up the results

The conclusions drawn for the Dutch market cannot be generalised to other countries, especially with regards to countries with a different culture, different packaging mix and/or infrastructure regarding glass disposal. Furthermore, carbon footprint calculations can differ significantly between countries, primarily due to differences in supplier emissions, transportation distances and disposal parameters. Nonetheless, the methodology used in this research can be used to get insights in the carbon footprint hotspots and in the related consumer behaviour of different countries. In order to perform similar research elsewhere, the following questions can be asked:

- Is there a disposal infrastructure available? Is waste management effective?
- Is legislation supportive of the required disposal infrastructure (for one-way and/or for returnable bottles)?
- Are consumers used to recycling or reuse – or in other words – is there a take-back culture?
- Is sustainability perceived positively? Do consumers have high personal ecological norms, or is there a supportive social norm?

By answering these questions, combined with a carbon footprint analysis of that country, it can be determined whether the strategies proposed in this study are also relevant to the country under examination and what additional research is necessary.

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1. Introduction

The beverage industry is part of the Fast Moving Consumer Goods (FMCG) market and is characterised by low prices, high volume and high turnover. These characteristics imply low product life-times, increasing the susceptibility to the environmental impact of packaging (Ellen MacArthur Foundation, 2013). In accordance, the carbon footprint of packaging for Heineken Netherlands represents 50% of their total environmental impact (Heineken NV, 2019).

The carbon footprint, as a measure of environmental impact, is an important consideration for business as legislative requirements increasingly put pressure on the reporting- and improvement of carbon footprints (Pandey & Agrawal, 2011). The Paris Agreement has, for instance, set the long-term target for participating countries to keep global average temperature rise well below 2 degrees above pre-industrial levels (United Nations, 2015). In the Netherlands, this would require around 90-100% reduction of carbon emissions compared to 1990 (van Vuuren, Boot, Ros, Hof, & den Elzen, 2017). In the recently designed Dutch climate agreement, the aim is to reduce CO_2-emissions by 49% by 2030, requiring serious commitment from all parties within society (Klimaatberaad, 2018). The 2030 goal would, however, only reach halfway to the required reduction for the goal set by the Paris Agreement.

Consumers are additionally requesting a higher level of environmental performance as a pre-requisite of product purchase (Rokka & Uusitalo, 2008). Although purchase criteria such as price and quality remain the prime drivers of purchase decisions (Birgelen, Semeijn, & Keicher, 2009), consumers are increasingly including environmental performance of a product as a secondary determinant (Nordin & Selke, 2010). Therefore, as soon as the primary demands are met, environmental considerations can be the deciding factor for product purchase (Young, 2008). The primary demands are, however, also evolving. Besides the regular determinants such as price and quality, consumer convenience is growing as a potent driver for purchasing decisions (Silayoi & Speece, 2004). These dynamics are also recognised in the industry and have been acknowledged to form two trends: 1) the demand for sustainable packaging (Arena International, 2017; Kalpana & Sivakumar, 2017; Mohan, 2017) and 2) a growing desire for convenience (Grand View Research, 2018; Kalpana & Sivakumar, 2017).

1.1 The problem context

The concept of sustainable packaging and the consequent minimisation of waste is not new in the beverage industry. For decades, beverage companies have maintained reuse strategies by reprocessing brewing residue into animal feed, utilising returnable bottles and crates and by introducing container-deposit schemes. The second trend, however, introduces a new issue. Whereas the industry is in principle set up for a lower carbon footprint – leaving aside issues of optimisation of reuse and recycling rates – consumers are increasingly demanding products that are easily transportable and disposable and want them to be available whenever they want and wherever they go. Products that offer these characteristics enjoy a competitive advantage by requiring less time and effort to satisfy the individual's needs (Hicks, 2017). On the other hand, this kind of products and related packaging that satisfy the convenience criteria often also incorporate a higher environmental footprint (Hicks, 2017). This phenomenon introduces a complex situation where there seems to be a trade-off between fulfilling demands for consumer convenience and carbon footprint performance in a highly competitive market. The question therefore arises of how to solve this apparent paradox. This represents the underlying theme which is aimed to be tackled within this thesis.

An important element in tackling this paradox is understanding consumer purchase behaviour, as consumers possess the capability to prevent and decrease environmental harm by purchasing sustainable products (Joshi & Rahman, 2015), as well as doing the opposite by fulfilling their own convenience desires. In the end, it is human behaviour which determines environmental impact, not the products itself.

“It is not the [plastic] packaging which throws itself in the ocean, but rather we who are at fault” ~ Keuenhof (2019)

The unfortunate truth is, however, that consumers often do not have perfect knowledge on which product fulfils their needs and especially have limited knowledge on which products embody the least environmental harm (Vermeir & Verbeke, 2006). Research from Van Dam (1996) illustrated that consumers base their beliefs of environmental harm only on their perception of environmental harm produced by the post-consumption treatment of waste, while the brunt of the environmental impact originates from packaging, production and transportation. This knowledge gap is expected to be especially present for the low involvement purchase context of beverages, which limits the degree to which consumers are consciously making purchase decisions (Silayoi & Speece, 2004). This is confirmed by the research from Camilleri, Larrick, Hossain, & Patino-echeverri (2018), who indicate that even though individuals daily consume consumption goods such as food and beverages, they are often unaware of the processes – and consequent GHG emissions – bound to these products.

1.2 Literature review

To address the influence of consumer convenience on the carbon footprint, this research borrows primarily from two strands of research: environmental impact assessments and consumer purchase behaviour. Environmental impact assessments have been performed for a wide range of products, both within academia and in business. The most common form of analysis is life cycle assessment (LCA). The goal of these assessments is to find the impact ‘hotspots’ and to provide recommendations to diminish these hotspots, either through product and/or supply chain improvements or by introducing alternative products that provide a similar function using different materials or ways of delivering the function. Few LCAs have however been performed on the beer industry. In total seven LCAs have been found. Detzel & Mönckert (2009) found that the determining factor in their LCA on beer beverage packaging in Germany was the transportation distance and the number of refills in the case of glass bottles. Furthermore, Pasqualino, Meneses, & Castells (2011) assessed the environmental impact of juice, wine and beer in the Spanish market, looking at the indicators Global Warming Potential (GWP) and Cumulative Energy Demand (CED). Saxe (2010) has performed a literature review of LCAs on both beer and wine to compare the two products on their climate footprint. Garnett (2007) did a similar comparison on the greenhouse gas emissions of beer, wine and spirits within the UK. Talve (2001) carried out an LCA to quantify the environmental performance basic lager beer and identify environmental hotspots, Koroneos, Roumbas, Gabari, Papagiannidou & Moussiopoulos (2005) executed an LCA to identify the environmental impact of the production and distribution of beer in Greece, while Cordella, Tugnoli, Spadoni, Santarelli & Zangrando (2008) did a similar exercise for a small brewery in Italy. Depending on the country and type of beer product examined results differ significantly, suggesting that every value chain should be examined individually to find suitable recommendations.

The link between environmental assessments with consumer convenience – or even consumer behaviour in general – has equally received limited attention. The main reason seems to originate from the difficulty of incorporating the qualitative elements of consumer behaviour into the LCA framework (Wever & Vogtländer, 2013). A study that has attempted to incorporate consumer convenience in a regular LCA is the study from Hicks (2017), who has examined the environmental implications of consumer convenience in different manners of coffee-making through LCA. Other research have tried to incorporate qualitative measures by using alternative methodologies such as the eco-costs/value ratio (EVR) to provide a more holistic assessment of sustainable packaging (Svanes et al., 2010; Wever & Vogtländer, 2013). Including consumer behaviour in analysing environmental product of different kinds of packaging is important because consumers are the ultimate users of the product. If consumers decide that a single-use plastic bottle is their preferred manner of consuming a certain beverage, then companies can either attempt to change this preference, or make improvements in the life cycle of the bottle to minimise environmental harm. This means that even though an LCA would show that a certain packaging type is preferred from an environmental point of view, this would be of no value if consumers’ demand is otherwise. Therefore, a major gap in research on environmental impact is the limited 'connection' to real world phenomena by not taking into account consumer purchase behaviour.

Consumer convenience is an important element of consumer purchase behaviour as it is perceived to be conflicting with increasing environmental performance. Despite the plethora of research on consumer behaviour, especially in marketing research, consumer convenience has recently been largely overlooked (Farquhar & Rowley, 2009), specifically with regards to its connection with environmental impact. Consumer convenience is most commonly defined as satisfying the end goal of reducing consumer's time and effort in either storing, use or disposal of the product (Berry, Seiders, & Grewal, 2002; Farquhar & Rowley, 2009; Hicks, 2017; Kelley, 1958). As perceptions of time and effort expenditure for certain task differ per individual, this thus acknowledges that 'convenience is many things to many people' (Yale & Venkatesh, 1986, p.405). One of the goals for this research is to explore which kinds of product attributes add up to form the experience of convenience for different consumers in buying (beer) beverages and which carry the most importance.

Several studies that have looked at consumer purchase behaviour have defined attributes of consumer convenience. The study from Lindh, Olsson, & Williams (2016) explored what packaging characteristics are perceived to be important to consumers and whether these are in line with environmental considerations. They found that consumers mostly perceive functional characteristics, such as ease of opening and material choice of packaging, as important. They further conclude that these considerations are primarily motivated by convenience, and not by environmental concerns. Other research include Rokka & Uusitalo (2008), who explored the importance of environmental attributes of packaging compared to other relevant product attributes, including convenience. Ottman, Stafford, & Hartman (2010) and Mee & Clewes (2013) have both elaborated on how businesses can improve the appeal for environmentally preferable products to consumers to stimulate environmental friendly purchase behaviour. Furthermore, research has looked at consumer attitudes and behaviour with regards to minimising environmental impact (Bhamra, Lilley, & Tang, 2011; Matthies, 2005; Ölander & Thøgersen, 1995; Silayoi & Speece, 2004; Welfens, Nordmann, & Seibt, 2016). These studies, although ranging various different topics, provide a starting point for looking at environmental purchase behaviour and consumer convenience demands.

In contrast to the LCA studies discussed above, consumer behaviour research seems to lack the quantitative element to link consumer purchase behaviour to environmental impact. The overarching issue is that if these two strands of research are not connected, there is the danger that interventions are implemented without consideration of the effects on either environmental impact or consumer behaviour. Using a combination of these approaches could therefore prevent such risk and at the same time provide a more comprehensive account by providing different perspectives on the issue at hand (Bryman, 2012).

> "*The problem with sustainability is that people come up with various sustainable interventions, but do not account for the possible effects these interventions might have". ~ Steenis (2019)*

1.3 Aim of the research

As a result of the identified literature gaps, the aim of this research is to look at the subject of consumer convenience both from a behavioural and an environmental impact perspective. To facilitate a detailed analysis, the research is performed using a detailed case study of the beverage producer Heineken. Over the past years, Heineken has been able to steadily decrease their total carbon footprint by 6.3% (Heineken NV, n.d.). However, the described consumer convenience trends in parallel with growing volumes put increasing pressure on their carbon footprint.

The primary aim of the research is to reconcile the trend of increasing consumer convenience with the minimisation of environmental impact of primary packaging. Three broad objectives are identified:

- The first aim is to examine Heineken's carbon footprint and the influence of consumer convenience aspects on the carbon footprint. Specifically, this research will look at the carbon footprint for returnable and one-way glass packaging value chains for the following two reasons. First, glass packaging represents around 65-70% of the primary packaging in the beer industry in the Netherlands (Statista, 2016). Second, the convenience trend is expected to shift consumption from returnable towards non-returnable glass packaging and therefore to increase the carbon footprint.
- The second objective is to identify opportunities to reduce the carbon footprint. To that end, consumer purchase behaviour is analysed to identify the drivers for convenience purchases and the necessary interventions to stimulate more environmental friendly behaviour. Here, it is important to recognize that the interventions that would lead to the least environmental impact from an LCA perspective can only achieve this if consumers also adopt this solution. This would result in an understanding of what business can do to avoid a trade-off between convenience and environmental impact. To facilitate the identification of relevant strategies, a Rapid Evidence Assessment had been performed before starting the research. This assessment can be found in Appendix 1.
- A final objective is to upscale the gathered insights of the 'best practice' Dutch case to the US. This final step is important as, although the Dutch value chain is quite advanced, it only represents a small segment compared to regions like the US where significant improvements can still be made. By comparing the two cases, recommendations have been formed to use the methodology of the current study in other countries as well.

1.4 Research questions

In order to tackle these challenges, the following research question needs to be answered: "*How can the carbon footprint of glass packaging in the beverage sector be reduced in the face of consumer convenience demands?*" To answer this primary research question, several sub-questions need to be answered:

RQ 1) What is the carbon footprint of the value chains of returnable and non-returnable glass bottles?

RQ 2) What determines purchase decisions of consumers?

RQ 2.1) How does consumer convenience affect purchase behaviour?

RQ 2.2) What role do environmental considerations play in the purchase decision in comparison to consumer convenience elements?

RQ 3) What strategies can beverage companies employ to stimulate consumer behaviour that produces minimal environmental impact?

RQ 4) Can learnings from the Netherlands be scaled up to other regions like the US?

The overarching framework presented in Figure 3 provides an overview of the research. The research is divided into two main parts, the carbon footprint (Chapter 4) and consumer purchase behaviour (Chapter 5 and 6), and is brought together in the subsequent chapter (Chapter 7), which combines the insights gathered from both types of research to provide an overview of consumer-oriented strategies that companies can employ to reduce their carbon footprint. Before ending the study with a discussion (Chapter 9) and conclusion (Chapter 10), the US case study is examined to look at what is required to scale up the results from the Netherlands (Chapter 8).

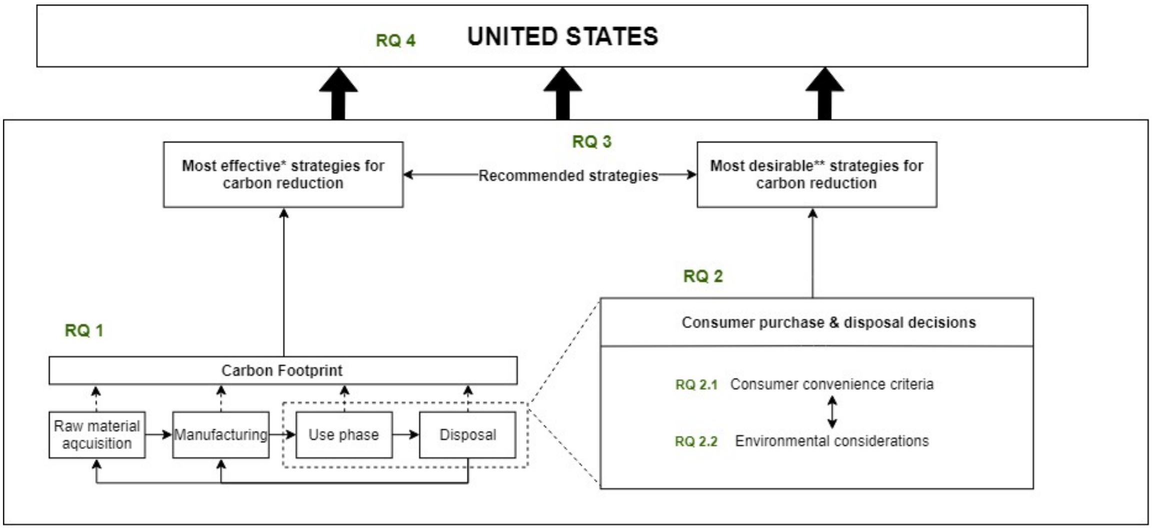

*Figure 3 – The overarching framework of the research. *These interventions are most effective from the quantitative LCA point of view. ** These interventions are most desirable in the perspective of the consumer and include convenience criteria and environmental considerations.*

1.5 Relevance of the research

From a scientific perspective, the relevance of this study lies in the connection that is made between quantitative environmental impact assessment (LCA) and consumer purchase behaviour with a focus on consumer convenience and sustainability. The combination of quantitative and qualitative research on the impact of consumer convenience purchase behaviour on the environment is limited, while this would be valuable to i) better connect scientific theory with real world phenomena and highlight the importance of holistic research and ii) to find a balance between LCA with its primary focus on the environment and behavioural theory with its main focus on the consumer. On the concept level, this research further aims to provide more clarity to what consumer convenience entails for the consumer in the low involvement purchasing context of the beverage industry.

The social relevance of the research originates from the identification of relevant strategies that beverage producers can adhere to in order to decrease their environmental impact without having to accept major trade-offs with consumer convenience. By combining the perspective of consumer convenience and behaviour with quantitative measures of environmental impact, interventions can be proposed that fulfil the criteria on both ends. By identifying such symbiosis this research contributes to the transition towards more sustainable business, as at this point businesses often still struggle in striking the right balance between environmental concerns and their core business.

2. Theoretical Framework

To answer the research questions, two strands of research are discussed. The first part describes the carbon footprint and respective value chains of the two packaging types, while the second part elaborates on the relevant theory of consumer purchase behaviour with regards to convenience and environmental decision-making, which is combined in an analytical model that will guide that part of the research.

2.1 The Carbon Footprint

In accordance with the primary aim of this research – the reduction of GHG emissions – a LCA is performed. LCA is a tool to assess environmental impact throughout the life cycle of a product, from raw material extraction to its end-of-life (Finnveden et al., 2009). Its purpose is to highlight input and output flows within a product's life cycle that constitute of the highest proportion of environmental harm (Guinée et al., 2011). The LCA methodology can be used to calculate GHG emissions in the form of a single issue LCA called the 'carbon footprint' (Wiedmann & Minx, 2008). This research has examined the carbon footprint of two product value chains – returnable and non-returnable glass bottles – within the Netherlands. The definition for the carbon footprint used here is proposed by the British Standards Institution, which has defined the carbon footprint as the GHG emissions that arise from a product across its life cycle (BSI, 2008). These include the greenhouse gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), as well as compound gases including hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (Ibid.).

2.1.1 The value chain of returnable and non-returnable primary glass packaging

The LCA stages under study are presented in the value chain of glass packaging in Figure 4. Two product routes can be distinguished: off-trade and on-trade. The off-trade sector – which is the focus of this research – is visualised in the upper route. Consumers buy their products from actors like supermarkets and consume their product elsewhere. In contrast, a characteristic of the on-trade sector is that the product is consumed at the same location where it is purchased, such as bars or restaurants. This distinction is important as it requires different channels and strategies for waste management.

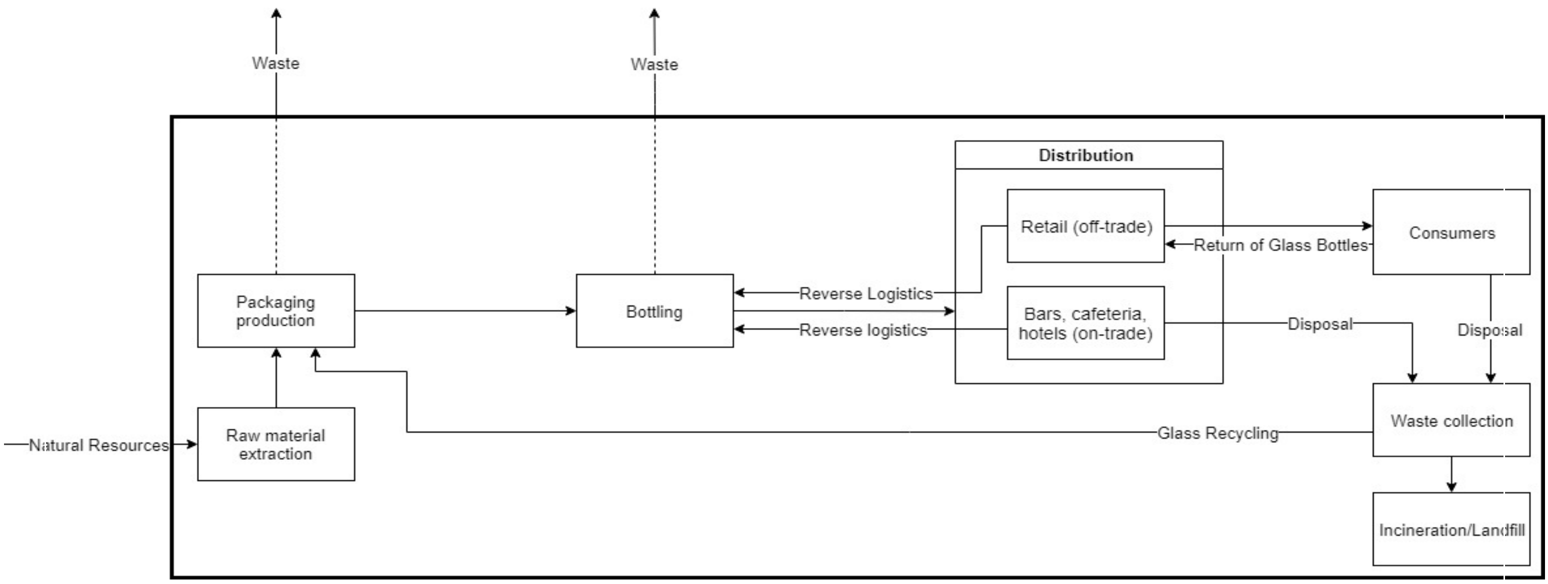

Figure 4 - A simplified value chain of returnable and non-returnable glass

2.1.2 Life cycle impact of returnable and non-returnable primary glass packaging

The life cycle impact of glass packaging is dominated by two high-impact stages: production of bottles and its transportation. The production process of glass is energy intensive due to high thermal demands in the beverage container production and the steam pressure needed for beverage filling (Larsen, Merrild, & Christensen, 2009; Simon, Armor, & Földényi, 2016). Second, due to the rigidness and high weight of the material, the transportation impacts of glass in terms of GHG emissions are relatively high compared to alternatives such as plastics or aluminium (Detzel & Mönckert, 2009). Much effort has therefore already been put in lightweighting glass bottles (Amienyo & Azapagic, 2016; Heineken NV, 2015).

A proper waste management system can help to off-set part of the environmental impact. Here, the waste hierarchy can function as a guiding framework (Kirchherr, Reike, & Hekkert, 2017). The waste hierarchy is an important element of the Circular Economy and promotes the minimisation of environmental harm through a range of strategies that are ranked according to their effectiveness of reducing environmental impact. The most comprehensive waste hierarchy consists of the 9R's (Figure 5) introduced by Potting, Hekkert, Worrell & Hanemaaijer (2017). Ideally, strategies that are high on the waste hierarchy are utilised to decrease environmental impact.

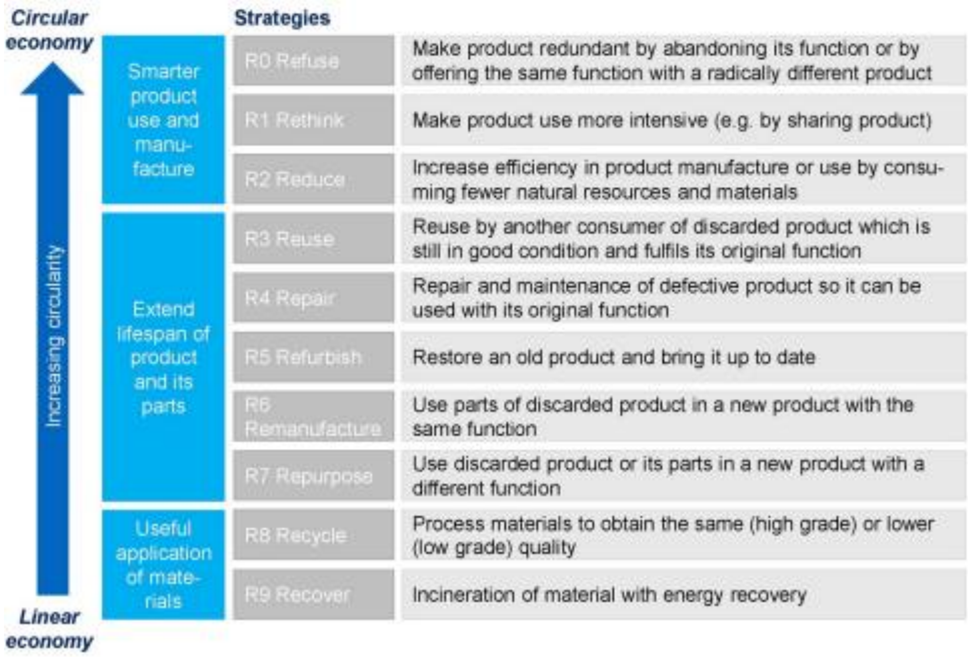

Figure 5 – The 9R Framework (Potting et al., 2017)

There are situations in which it is not feasible or desirable to utilise the highest R. For example, the local recycling of glass bottles could yield less impact than reuse if the latter requires bottles to be transported back and forth across the globe. For the glass packaging value chain, there are three main routes of waste management: incineration[3], recycling and reuse. Incineration is the strategy that is lowest on the hierarchy – landfilling excluded – as the value of the material is completely lost and the energy recovered is not enough to compensate for this (Pasqualino et al., 2011). The second route is recycling, where used bottles are crushed, sorted by colour and made into a material called cullet. The use of cullet in the (re)production of glass lowers the melting point and substitutes for the use of carbonates, which lowers the overall GHG emissions of the production process (Krivtsov et al., 2004; Larsen et al., 2009). The quality of glass does not degrade through recycling, although part of the material is lost in the recycling process disabling an 100% efficient recycling process (Larsen et al., 2009). When possible, closed-loop recycling[4] should be considered, as this saves considerable impact of GHG emissions as opposed to

[3] Although glass is not combustible, part of the waste stream does end up in incineration via municipal waste treatment, where it forms bottom ash which is subsequently used in, for instance, road construction (Goodwin, 2013).
[4] *Closed-loop recycling* is a recycling system where the material is recycled to be reproduced for its original purpose within the same industry. On the other hand, *open-loop recycling* is a recycling system where the material that is recycled is used for a different purpose than its original function. Often, this is referred to as *downcycling* (Chilton et al., 2010)

open-loop recycling (Chilton, Burnley, & Nesaratnam, 2010). Significant savings can already be obtained if glass is recycled instead of ending up on a landfill or being incinerated.

The preferred route is reuse, which is done using returnable glass bottles that are cleaned, sterilised and refilled. Reuse of glass bottles prevents virgin production altogether and therefore avoids the energy intensive production process. This represents vast potential of decreasing environmental impact from glass bottles by going from a one-way bottle design to a refillable bottle (Larsen et al., 2009; Lewis, 1996; Miettinen & Hamalainen, 1997; Simon et al., 2016). In their study, Simon et al. (2016) concluded that using refillable glass bottles instead of one-way bottles would lower the GHG emissions to such an extent that already after two refills it is the most preferred material in this impact category. Unfortunately, consumers are demanding smaller packaging which has not been adapted to being refillable and which contain a higher weight relative to the product, resulting in a higher environmental impact. To that end, it is important to understand the underlying need for convenience of consumers and consequent purchase behaviour.

2.2 Consumer purchase behaviour

In the life cycle of a product, consumers play an important role in the use and disposal phase, although their demand significantly affects the other life cycle stages as well. In this chapter, the underlying theory on consumer purchase behaviour is treated in relation to both environmental considerations and consumer convenience.

2.2.1 The buying context of beverages

Products in the Fast Moving Consumer Goods (FMCG) market are characterised by their low price and high turnover. This results in low information search due to the low perceived importance of the product (Chaudhuri, 2000). As a consequence, consumer purchase behaviour is typically characterised as 'low involvement' in this sector (Silayoi & Speece, 2004). This implies limited conscious thought put into a consumer's product purchases, partly due to limited (financial) impact of choosing the 'wrong' product (Silayoi & Speece, 2004). This low involvement buying context has its repercussions on the likelihood of pro-environmental purchase decisions and perhaps magnifies the desire for convenience. In contrast to buying high involvement products, consumers do not search for relevant information on the range of alternatives that they can choose from and rather behave according to heuristics, such as prior experience, brand familiarity, visual cues or price (Barber, Ismail, & Dodd, 2007; Silayoi & Speece, 2004). If consumers find a product that tastes satisfactory it is likely to generate repeat purchases, leading to the creation of habitual purchases that are generally hard to change (Kemp, 2013).

2.2.2 Consumer purchase behaviour models

To unravel the complexity of purchase scenarios, the theory of Buyer Behaviour was developed by Howard & Sheth (1969). The emphasis of this model is on the process that an individual is subjected to when making a purchase decision. Examining this process can help find touchpoints where businesses can influence consumers towards more desired behaviour. The issue with the model is that due to its complexity, it is also hard to perform explicit measurements, especially with regards to the unobservable nature of many of the intervening variables (Foxall, 1990; Loudon & Della Bitta, 1993). Additionally, although the model describes purchase behaviour in general, it is not adapted to include environmental considerations into purchase decision making. For that reason, the norm-activation model is introduced. The norm-activation model is an integration of several elements from the original norm activation model (Schwartz & Howard, 1982) and the theory of planned behaviour (Ajzen, 1991). The model is visualised in Figure 6.

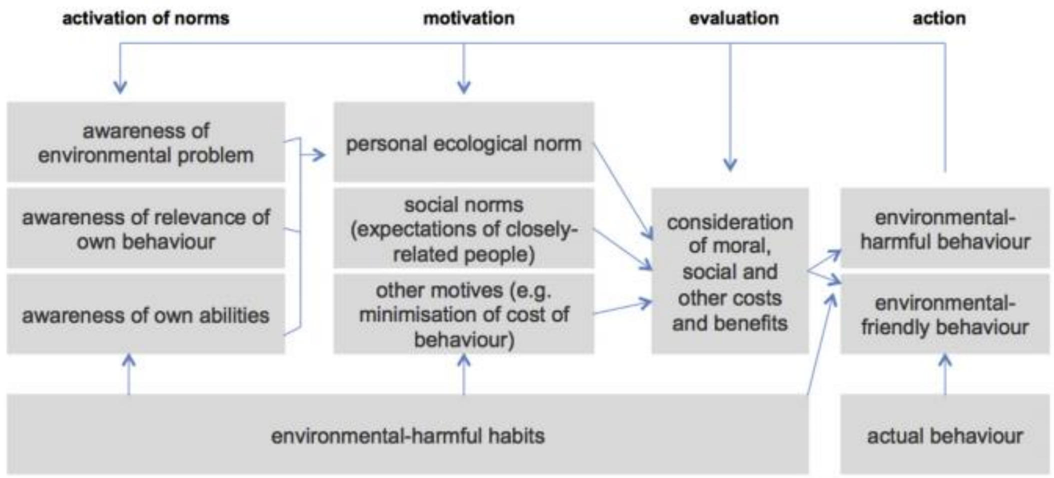

Figure 6 - The integrative norm activation model adapted from Matthies (2005)

The model is divided into four phases: the activation of norms, motivation, evaluation and action. A prerequisite of environmental friendly behaviour is that an individual is aware of the problem, realises the potential relevance of his/her own behaviour and acknowledges his/her capability to change the behaviour (Welfens et al., 2016). Without this understanding, the personal ecological norm[5] is disconnected from the environmental problem and will decrease the overall individual's motivation to act in an environmental friendly manner. The motivational phase is a conjunction of an individual's ecological norm and the (perceived) social norms in place. A strong enough ecological social norm may still guide an individual to behave in a socially desirable manner, regardless of their personal norm. Thus, the personal norm is partly derived from and affected by the social norm (Schwartz, 1973). Other motives are any remaining motivational ques originating from behavioural intentions such as the minimisation of cost or the maximisation of convenience. These motives are heterogeneous across individuals, but can have major impact on the purchase decision. By having a driver 'other motives', the model allows for assessment of personal or situational considerations that affect an individual buyer. In the evaluation phase, the motivational considerations are evaluated with regards to their importance to the individual. The final phase, action, is a result of the three previous phases. All phases, except the evaluation phase, are moderated by environmentally harmful habits.

Within the scope of this research, an integrated model of the two theories is proposed (see Figure 7). Essentially, the model is an extension of the norm-activation model from Matthies (2005) with a range of elements from the theory of Buyer Behaviour, namely: the input, predisposition, sensitivity to information and the importance of purchase. The addition of input variables is important in this context as this provides the touchpoints that businesses have with their consumers. The input variables are "the environmental stimuli that the consumer is subjected to, and is communicated from a variety of sources" (Bray, 2008, p.11). Howard & Sheth (1969) consider three main inputs: significative, symbolic and the social environment. Significative elements are the actual product or brand attributes with which the consumers come into direct contact (Loudon & Della Bitta, 1993), while symbolic elements refer to the representations of products and brands which are conveyed through marketing and advertisements (Foxall, 1990; Howard & Sheth, 1969). The social environment input, which is represented by the influence of family and friends, is left out of the scope of this research. The buying context of the FMCG market is taken into account by introducing the elements 'predisposition' and 'importance of purchase' to the model. By acknowledging that consumers might not have high involvement in the purchase process, and thus rely mostly on habit, personal and social norm, and previous experience, the model

[5] The personal ecological norm is the expectation that people have for themselves with regards to actions in favour of the environment (Martin, 2011).

can include less rational decision-making. Predisposition is “a preference toward brands in the evoked set[6] expressed as an attitude toward them” (Bray, 2008, p.12). Together with the importance of purchase (e.g. the perceived risk of buying a faulty product) it affects the evaluation of a product purchase. Moreover, predisposition also has an influence on what kind of information – and from whom – is processed by the individual. Brands and products that are outside of the evoked set are not considered to be relevant and therefore input variables have limited effect in these situations.

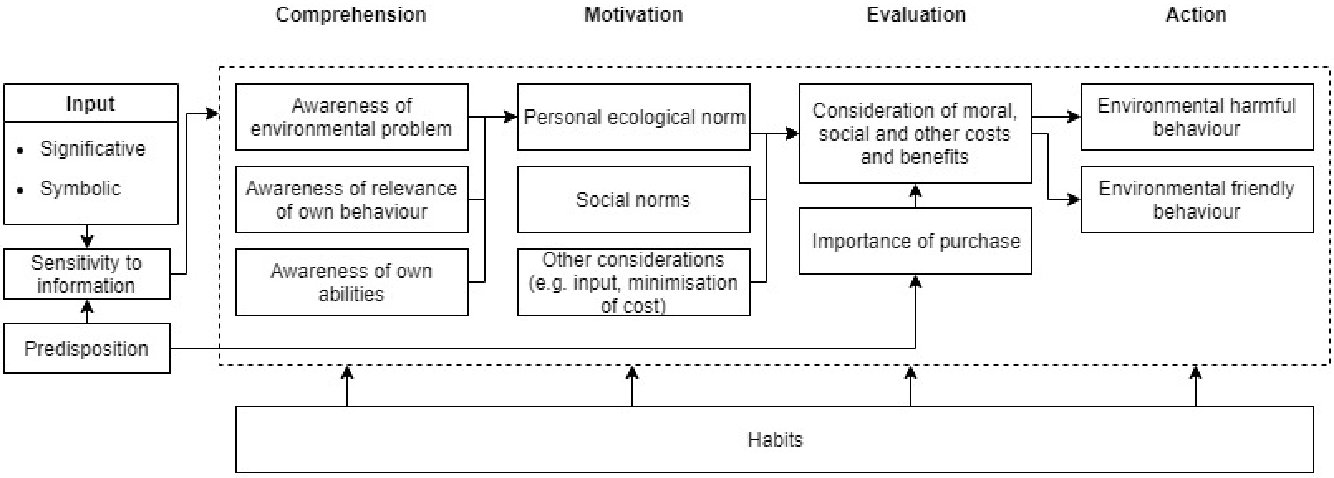

Figure 7 - Integrated model of buyer behaviour within an environmental decision-making context

2.2.3 Consumer convenience

Input variables that are of specific interest are the ones that create the experience of convenience to the consumer. Generally, consumer convenience is understood as the value proposition of companies to reduce consumer’s time and effort in either storing, use or disposal of the product (Berry et al., 2002; Farquhar & Rowley, 2009; Hicks, 2017; Kelley, 1958). In a world where time constraints are ever more common, consumer convenience is an influential motivator for product purchase, owing to the direct relationship between a lack of time and a desire for convenience (Brown & McEnally, 1992). Both effort and time expenditure are recognised to be the non-monetary price consumers pay for purchasing and utilising product (Berry et al., 2002; Farquhar & Rowley, 2009) and are therefore (consciously or subconsciously) aimed to be avoided by the consumer (Farquhar & Rowley, 2009).

Various studies have sought to define the concept of convenience. In order to derive what convenience means in the context of packaging, a short overview is given from a range of studies that have either aimed to conceptually define consumer convenience, or have explored product attributes of packaging including convenience attributes. In Table 2, these attributes and concepts are listed.

[6] The evoked set is a range of alternative products or brands that are considered in a purchase decision.

Table 2 - Concepts and attributes of consumer convenience

SOURCE	CONCEPTS	PRODUCT ATTRIBUTE
(YALE & VENKATESH, 1986)	• Time use • Accessibility • Portability • Appropriateness • Handiness • Avoidance of unpleasantness	
(KELLEY, 1958)	• Form convenience • Time convenience • Place convenience • Quantity or Unit convenience • Packaging Convenience • Readiness Convenience • Combination Convenience • Automatic Operations Convenience • Selection Convenience • Credit Convenience	
(ANDERSON & SHUGAN, 1991)	• Accessibility • Ease of storage or handling • Labour-saving convenience	• Size • Preservability
(ROKKA & UUSITALO, 2008)		• Package is re-sealable
(DAM & TRIJP, 1994)		• Easy disposal • Easy use • Easy storage • Easy to open
(LINDH ET AL., 2016)		Ranked according to % of respondents mentioning the attribute • Easy to re-seal (27%) • Easy to open (26%) • Packaging size (24%) • Easy to pour (15%) • Easy to fraction/flatten/throw away in recycling (11%) • Easy to handle (8%) • Weight (6%) • Geometrical shape (5%)
(SILAYOI & SPEECE, 2007)		• Ease of dispensing • Ease of use • Shape
(BIRGELEN ET AL., 2009)		• Ease of carrying • Physical design of the package

From this review on different forms of convenience, six forms of convenience can be directly related to packaging: portability, appropriateness or unit convenience, handiness, form convenience, disposability and storability.

i. **Portability**. Portability allows consumers to consume the product at any location he or she desires (Yale & Venkatesh, 1986).

ii. **Unit convenience.** This characteristic fulfils the specific needs of the consumer in terms of volume of the product (Kelley, 1958; Yale & Venkatesh, 1986). Due to the correlation of volume with size of the product, and the low differentiation in shape of the product within glass bottles for beer beverages, form convenience is merged with this convenience category. Form convenience refers to the convenience and availability of different shapes or sizes of the product packaging (Kelley, 1958).

iii. **Handiness.** Handiness of packaging makes the product easy to utilise and therefore makes consumption require less effort (Kelley, 1958; Yale & Venkatesh, 1986).

iv. **Disposability.** This characteristic refers to how easy it is to dispose of the product (Dam & Trijp, 1994; Kelley, 1958; Lindh et al., 2016)
v. **Storability.** Storability determines the capability of storing the product easily and for considerable time without decreasing the quality of the product (Anderson & Shugan, 1991; Dam & Trijp, 1994; Lindh et al., 2016).

These five types illustrate the classes of attributes of packaging which constitute of the overall convenience of a product. The question remains which of these attributes are essential and consequently need to be fulfilled before consumers take into account environmental considerations. Different prioritisation might therefore be needed.

3. Research design

This research has been facilitated by a case study of Heineken within the Netherlands. By taking Heineken as the focal firm, a detailed analysis could be provided of the value chain of a beverage producer and has therefore led to more practical recommendations than if a general approach to the alcoholic beverage industry had been taken.

To investigate both the behavioural motives and the environmental impact of the consumer convenience trend within the two glass packaging value chains, a hybrid approach was taken. The theoretical framework has outlined the relevant topics. In Figure 8, these topics are combined in the theoretical framework based on Chapter 2. Both quantitative and qualitative methods were employed to highlight topics that would be inaccessible to the individual methods. To that end, the research was structured in two interconnected parts. The first part (Part 1) consisted of the analysis of the carbon footprint. By analysing the key impact categories, a range of strategies have been deducted, which have served as the main input for the second part of the research. The second part (Part 2) consists of the qualitative research methods, namely the expert interviews and a critical review of the consumer research performed by Heineken. These inputs have been examined through the lens of the integrated model of purchase behaviour (Figure 7) to reveal consumer barriers and drivers to the strategies derived from the carbon footprint.

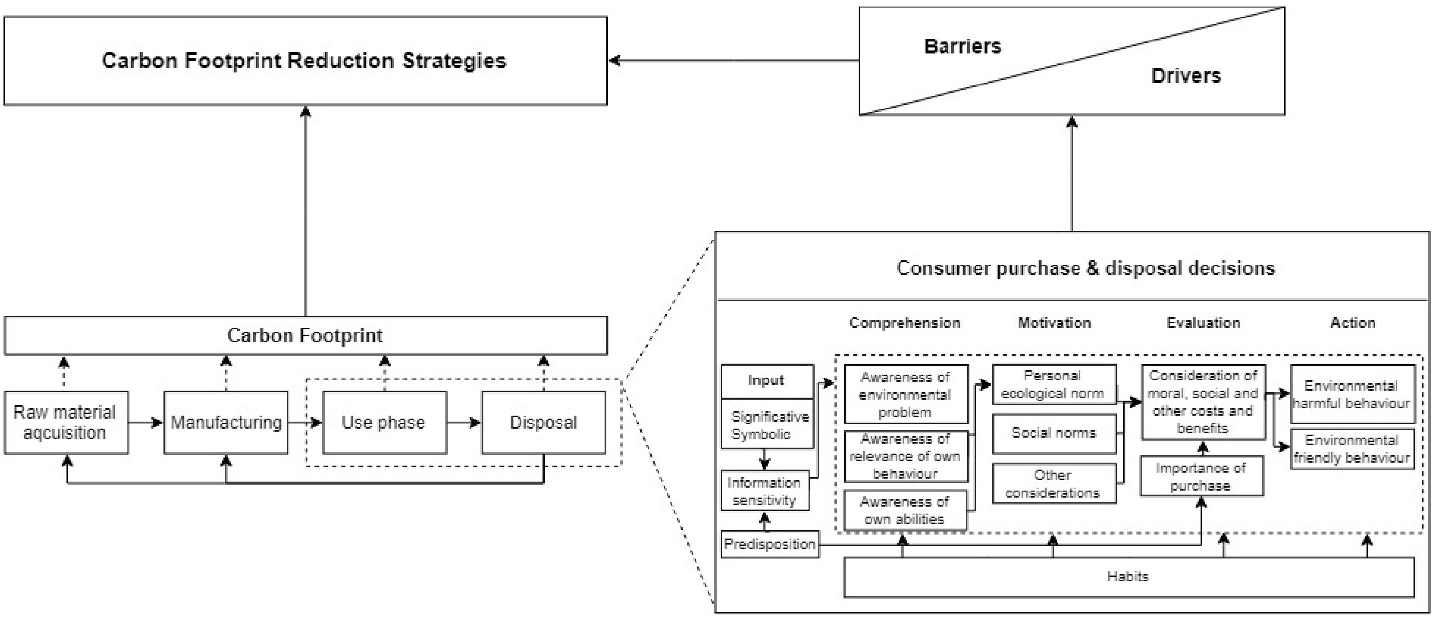

Figure 8 – Theoretical Framework

Part 1: Carbon Footprint

3.1 Carbon Footprint Methodology

The carbon footprint executed by Heineken is aligned first and foremost to the Beverage Industry (BIER) Sector Guidance for Greenhouse Gas Emissions. The calculation method follows the scope and boundaries defined by the European Commission guidelines for the Product Environmental Footprint Category Rules (PEFCR) for beer (European Commission, 2018b). Additionally, the scope and calculation principles are compared to the requirements of three protocols; the GHG protocol Product standard, the GHG protocol Corporate Standard (scope 1 and 2) and the GHG protocol Corporate standard (scope 3). The GHG standard is built upon the foundation of broader LCA frameworks, such as ISO 14040/44 series and the PAS2050 methodology (GHG Protocol, 2011). Unlike these standards, however, the GHG Protocol is specific for the climate change impact category (carbon footprint). The calculation process is similar to the LCA Framework described in the ISO 14040/44 series, which exists of four iterative phases, 1) the Goal and Scope, 2) Inventory Analysis, 3) Impact Assessment and 4) Interpretation (International Organisation for Standardization, 2006). Detailed information on the scope of the current study, calculations and data inputs is given in section 4.1 – Life Cycle Inventory. Finally, to examine the effect of certain variables on the carbon footprint, a sensitivity analysis was also performed.

3.1.1 Goal and scope definition

The carbon footprint was used to quantify the environmental impact of two types of glass packaging: one-way and returnable glass bottles. The goal of this analysis was to identify environmental impact 'hotspots' along the life cycle. In the second part of the research, the identified hotspots have been linked to consumer purchase behaviour and associated convenience demands to identify which hotspots are susceptible to consumer purchase decisions and what strategies could be implemented to reduce the environmental impact.

The functional unit in both product systems was set at one hectolitre (hl) of beer beverages produced for consumption by the end-consumer. The geographical and temporal scope of the carbon footprint are determined as the Netherlands in 2018. The system boundary is considered to be cradle-to-grave and is discussed in more detail in chapter 4.1.

3.1.2 Data gathering

Data was primarily derived from the most recent Carbon Footprint Baseline Model (CFBM) 2018, the internal carbon footprint tool of Heineken. To accurately represent the carbon footprint, predominantly primary data was utilised or collected, also for upstream emissions. In the case primary data was not available, secondary sources (e.g. from the European Commission (2018b) or FEVE (2019)) were used. In the case both types of data sources were not available, assumptions have been made or averages and estimates have been used, which are then highlighted in chapter 4.1.

Part 2 – Consumer behaviour

3.2 Expert Interviews

Expert interviews formed a key part in gathering qualitative data. The purpose of these interviews was threefold. First of all, the interviews functioned as a validation process for the conceptual framework constructed in Chapter 2.2.2 (Figure 7) and as an additional input for the analysis of consumer purchase behaviour alongside the review of existing consumer research performed by Heineken. This triangulation of results was particularly important for the review of consumer research as the prime limitation found in the Heineken studies was that the research designs were capturing consumer intention and not actual behaviour. Expert insights could overcome this limitation to some extent, as i) they could base their insights on their broad base of experiences in the field and thus give an overview of how consumers are behaving in general, and ii) the experts were judging other people's behaviour, hence (socially) desirable answers did not need to be given (Choong, Ho, & McDonald, 2002). Secondly, the expert interviews also provided additional insights on the carbon footprint of one-way and returnable glass bottles. Finally, the interviews were utilised to bridge the gap between the carbon footprint and the consumer behaviour studies. By utilising the knowledge base of experts with different areas of expertise, several topics belonging in either the environmental assessment or the consumer domain could be linked.

Semi-structured interviews were utilised as this allowed for the exploration of previously determined topics according to the interview guide, but left the opportunity for the interviewer to explore related topics in response to what were considered to be significant replies (Bryman, 2012). Two interview guides were constructed which were tailored to the two categories of experts that were interviewed, namely those with a packaging orientation and those that were more oriented towards consumer behaviour (see Appendix 2).

The sampling of relevant stakeholders was done through generic purposive sampling. This meant that the appropriate units of analysis were identified before conducting the interviews based on a set of criteria that were determined by the research questions (Bryman, 2012). These criteria involved that:

i. Experts needed to have experience with sustainable packaging. Experience was either judged on working experience of (previous) jobs held by the expert, or based on research output.
ii. Experts needed to be familiar with either of the two main research topics: the carbon footprint of packaging and consumer convenience.
iii. Only one expert per organisation was interviewed. This criterion was chosen to avoid overrepresentation of a particular standpoint.

In total, eleven experts were contacted. Two experts referred to others in their organisation as better fit to answer the questions for this research, while the remaining three experts declined for different reasons (i.e. time constraints, area of expertise not in line with the topics to be discussed, or no response). Experts were not all contacted at the start of the research, since the number of expert interviews was based on the level of theoretical saturation[7], which was considered to be reached after six interviews (Table 3). Different phases of the life cycle were covered by the expertise of the experts, giving a broad overview of the subject in scope.

The interviews were all recorded and manually transcribed. The manual transcription process served as a pre-coding exercise and allowed the researcher to get a better sense of the data acquired. The coding exercise was done in NVivo 12 and was based upon elements of Grounded Theory proposed by Glaser, Strauss & Strutzel (1968) and followed a sequence of steps described as open, axial and selective coding in order to form respectively concepts, categories and finally theory (Bryman, 2012).

Table 3 - List of interviewed experts

#	NAME	ORGANISATION	AREA OF EXPERTISE	LIFE CYCLE PHASE
1	Nigel Steenis	Wageningen University	Marketing & Consumer Behaviour	Consumer behaviour
2	Lise Magnier	TU Delft	Consumer research - Product Innovation Management	Consumer behaviour
3	Björn de Koeijer	CRISP	Product-Market Relations and sustainable packaging	Sustainable business
4	Marcel Keuenhof	KIDV	Sustainable packaging	Sustainable packaging
5	Fabrice Rivet, Michael Delle Selve & Adeline Farrelly	FEVE	Director, Environment, Health and Safety and Senior Communications Manager & Secretary General	Glass bottle manufacturing
6	Josefine Geiger	Rijksuniversiteit Groningen	Environmental Psychology	Disposal

3.3 Critical review of Heineken consumer research

Heineken Netherlands, the operating company of Heineken for the Netherlands, had performed a range of studies in 2018 to examine the potential of replacing one-way glass packaging by returnable bottles in the Dutch market. This exploration is part of their overall strategy to reach 100% circularity by 2030. Due to the tight connection of these studies with the current research topic, the studies are critically reviewed and used as an input for the research on the elements of consumer convenience in glass beer bottles. An elaborate discussion on the methodology of each study is presented in Appendix 3. In total four studies were reviewed:

- **Heineken 0.0% study.** A study performed to test the feasibility and desirability of the switch towards returnable packaging for Heineken 0.0%. The data collection was done via two methods: conjoint analysis and a survey, both with n=648.

[7] Theoretical saturation is reached if no new or relevant data can be extracted from interviewees to further contribute to the research question and the surrounding theory (Bryman, 2012)

- **Heineken (HNK) & Koos Service Design.** This research was performed to explore what values are important to consumers when buying beer packaging. Moreover, several design interventions were explored to stimulate the transition to returnable bottles. The research made use of two data collection methods: qualitative interviews (n=18) and user testing (n=6).
- **The Conversation Studio – A mono-shopper analysis.** This study addressed the question what the purchase motives and drivers are for consumers to buy one-way bottles with a unit volume of 25cl and a twist-off cap. This gave insights in what the essential drivers are for product purchase for these buyers and, in turn, what the requirements are for the transition to returnable bottles. Data collection was performed through a questionnaire consisting of six open and multiple choice questions (n=104).
- **Blauw - Image and use of beer packaging.** The aim of the study was twofold. First, Heineken was interested in the associations consumers have with different types of packaging and at which moments they would consume them. The second goal was to explore which packaging size was ideal for which situation and why. Data was collected through a survey (n=130).

3.4 Scaling up – United States case study

Aside from the research performed on the Netherlands, a case study of the United States (US) is conducted. The aim of this case study was to examine whether both the methodology and the results from the research on the Netherlands could be applied to other countries and how this methodology can be replicated in other markets. In order to make a comprehensive comparison between the US and the Netherlands, the characteristics of the beer market and the disposal infrastructure in the US are discussed. Additionally, insights on consumer behaviour are gathered and the carbon footprint of Heineken USA is calculated.

The information gathered for this case study is a combination of a literature review and an interview with a former Heineken USA employee, S. Kersten-Johnston, who additionally provided a range of previous studies performed by Heineken USA on the disposal infrastructure and the potential for returnable bottles within the US as input for the literature review.

4. PART 1 - Carbon Footprint

4.1 Life Cycle Inventory

The Life Cycle Inventory (LCI) is the "*phase of life cycle assessment involving the compilation and quantification of inputs and outputs, for a given product system throughout its life cycle*" (International Standard Organisation, 1997, p.2). Within the scope of the research (Figure 9) all energy inputs and respective output emissions are calculated. The scope includes both fore- and background processes. For foreground processes primary data of the unit processes available within Heineken was used, while for background processes primary data was not always available due to it being out of the control of the company. In the case background data is utilised for calculation purposes, a reference to the source will be provided. Unreferenced data originates from internal Heineken databases.

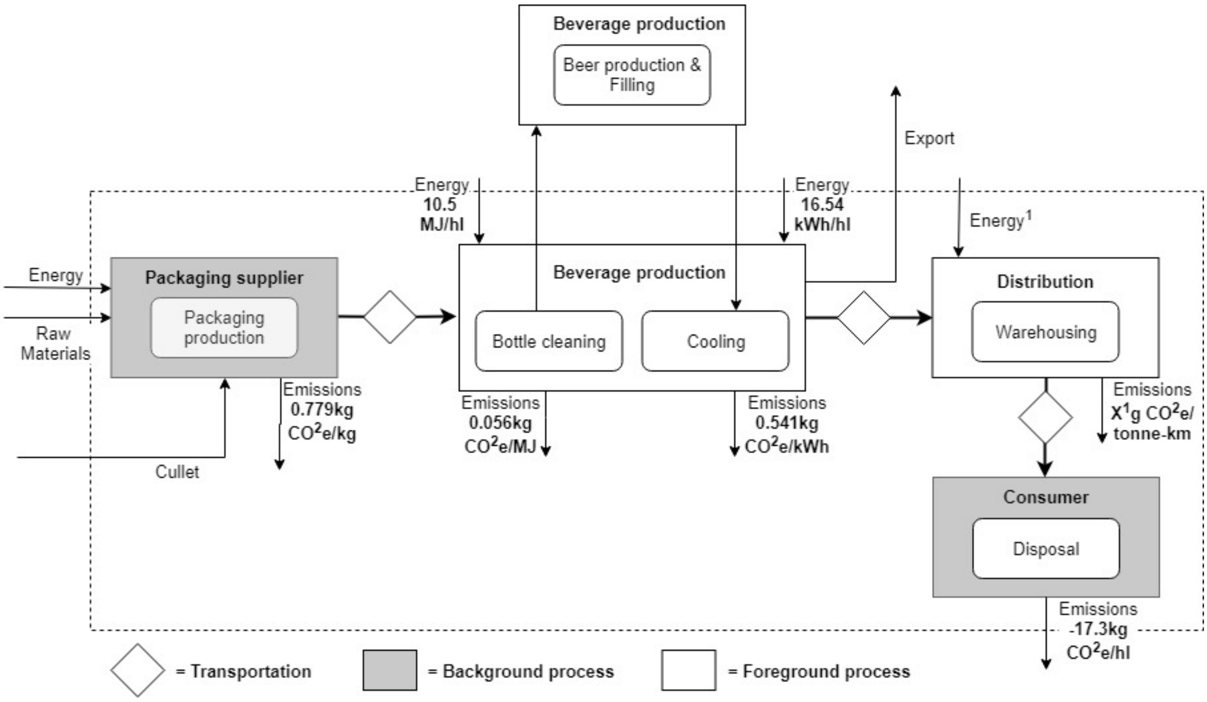

Figure 9 - System boundary. [1] Energy and distribution emissions depend on the type of transport and differ per packaging type. See 4.1.3 for the LCI of distribution.

The investigated system has been divided into four sub-systems:

i. ***Packaging Production***: Raw material acquisition, production of glass and the production of bottles. As this sub-system is not within control of Heineken, these processes are aggregated into a single unit process.
ii. ***Beverage production***: The production of beer itself is left out of scope. In scope are the bottle cleaning and cooling of the final product.
iii. ***Distribution***: Inbound, warehousing, outbound and last mile transportation. The geographical scope is the Netherlands, initially leaving exports out of scope. A case analysis is performed to review the impact of exports to the US.
iv. ***Disposal***: Within the use phase only the end-of-life is considered. As disaggregated background data on the disposal stage was available, a more detailed approach is taken. The home-cooling of products is added to the calculation done in the second sub-system, beverage production.

4.1.1 Packaging production

The production process of glass packaging is examined as one unit process, producing a single carbon footprint based on aggregated data of the unit processes needed for glass production. The resulting carbon footprint is a weighted average of carbon footprints (based on their production volumes) from the suppliers of glass bottles to Heineken Netherlands. These suppliers all have their own individual carbon footprint depending on the country, electricity grid, share of renewable thermal and electrical energy used, production efficiency and percentage of recycled content used for glass production. The key suppliers of Heineken Netherlands are based in Poland, Germany and the Netherlands. Primary activity data on the aforementioned factors was collected via a supplier survey sent out by Heineken. Consequently, the Circular Footprint Formula[8] introduced by these PEFCR guidelines is used to calculate the emissions (kgCO_2e/kg glass packaging) per supplier (see Table 4).

Table 4 - Average Supplier Emission Factors

SUPPLIER COUNTRY	EF PRIMARY PRODUCTION (KG CO_2E/KG GLASS PACKAGING)
NETHERLANDS	0.79
GERMANY	0.74
POLAND	0.98

The element of recycled content that is used in the Circular Footprint Formula to calculate the emissions of glass production is interesting. As Adeline – Secretary General of FEVE (the European Glass Container Federation) explained: '*There is a business incentive for us to use recycled glass. Not only for environmental reasons, but it lowers the temperature and therefore the energy requirements and CO_2 emissions. There isn't really an obstacle to putting as much recycled content into our bottles. The limiting factor, however, is availability of good quality cullet and the respective collection*.' Some reasons for the shortage of cullet are losses in waste processing, losses due to cullet leaving the system through open-loop recycling and due to growing demand for glass bottles. Additionally, a lot of one-way glass bottles are also exported – for instance to the US – where a lot of cullet also disappears outside of the value chain of glass bottles (Rivet, 2019). Delle Selve illustrated the issue of limited supply by saying: '*If you see Europe as a kind of pie, then [...] if one company starts producing with 20% more recycled content, another one will lose the 20%*' (Delle Selve, 2019). Hence, although glass manufacturers would prefer to produce glass bottles with high recycled content to reduce their carbon footprint, this is often not possible.

The weighted average primary production of glass packaging from Heineken's suppliers accounts for 0.779kg CO_2e/kg glass packaging. This emission factor is converted to the functional unit (1 hl) by multiplying it with the weight-content [kg/hl] ratio of one-way glass. The weight-content ratio of Heineken's one-way glass packaging is 57.45kg/hl[9]. Therefore, the average kgCO_2e/hl of primary packaging production is 44.76kg CO_2e/hl. Due to the relatively high weight-content ratio, glass requires more material per hl than other packaging materials resulting in a high emission factor per hectolitre.

The primary origin of the high emission factor lies in the energy intensive glass production process. A quarter of the energy emissions in production come from electrical demands, while 75% originates from thermal demand, mainly due to the combustion of natural gas (van Leeuwen & Griffioen, 2018). The high thermal demand is necessary to melt and form the glass into the desired glass container. Furnaces that melt the glass can reach temperatures of around 1650°C and account for around 75% of all energy consumed at the plant (Larsen et al., 2009). The addition of recycled content (cullet) significantly lowers this required temperature and consequently also the energy demands, as it only needs to be melted and does not require additional chemical reactions which have already occurred in the first production cycle (Rivet, 2019). The CO_2e emissions are therefore primarily a result of energy requirements, not because of the inherent process. If the energy demand would be met by renewable sources or clean electricity, CO_2e emissions would be almost non-existent except for the remaining emissions – around 20% - that arise from chemical reactions in the process of glass-making (Delle Selve, 2019; Rivet, 2019) and logistics (van Leeuwen & Griffioen, 2018).

[8] The Circular Footprint Formula is a formula used to calculate CO_2 emissions in three categories: material, energy and disposal. The formula is elaborately explained in the Beer PEFCR of 2018 by the European Commission (2018a).
[9] The weight/content ratio is calculated, as the term implies, by dividing the weight of one-way glass packaging by the respective unit volume.

For returnable glass bottles the impact of primary production is significantly lower. Emissions from primary production for a returnable bottle are divided by the expected trip rate (the expected frequency of circulation). Trip rates tend to vary a lot depending on the country and the type of bottle, but since accurate data is not available a conservative estimate is used by Heineken of 4kg CO_2e/hl, which roughly translates to 14 trip rates for the Netherlands. This assumption is relatively low compared to other estimations, where FEVE estimates a trip rate of 40 (Rivet, 2019) and the European Commission suggests a trip rate of 30 (European Commission, 2018a). To illustrate the impact of the trip rate, a sensitivity scenario is constructed to examine the effect of various trip rates (section 4.3.1).

4.1.2 Beverage production

This stage of the life cycle consists of three main processes: beer production and filling of the beer bottles, the cleaning of (new) bottles and the cooling of finished products. Since beer production and filling is similar for both packaging types – one-way and returnable – it is left out of the scope of this research. For the calculations of emissions within the remaining processes, IPCC emission factors are used by Heineken for calculation of direct emissions, while for upstream emissions EcoInvent v3 factors are used. On-site CO_2e emissions are taken from their own management system.

Cleaning

Both one-way and returnable bottles are subject to a cleaning process before the bottles can be filled with beer. The newly produced one-way bottles are rinsed at low temperatures, primarily to speed up the filling process by creating a wet surface. The impact from washing one-way bottles is therefore negligible and mainly constitutes of water use which is out of scope of the current research. In contrast to one-way bottles, returnable bottles require a more intensive cleaning process with heated water as beer (and other) residues may still be present from the previous consumption cycle. Incoming returnable bottles are first screened for deviations by comparing the incoming bottle with a picture of a new bottle. If any deviations exist, such as signs of wear and tear, chipped glass or residues other than liquid (e.g. cigarettes), the bottle gets rejected and taken out of the production process. If the bottle is still in good shape, it enters the cleaning process. The cleaning process for returnable bottles requires 10.5 MJ/hl of thermal energy. A conversion factor for natural gas of 0.056kg CO_2e/MJ (IEA, 2015) is used as this is the main source for fulfilling thermal demands. This results in an emission factor of 0.59kg CO_2e per hectolitre.

Cooling

Although cooling is here presented as being part of the beverage production, it is interlinked with processes throughout the rest of the life cycle. Most of the emissions from refrigerators are a result of the energy use (Broekema, 2010), making the production and end-of-life of fridges negligible. Depending on the supply chain of a beer bottle – whether it is sold to retailers and eventually the consumer (off-trade) or whether it is sold via hotels, bars & restaurants (on-trade) – cooling emissions can differ. Three cooling channels are in scope of this research as other channels, like draught beer systems, are not relevant for the off-trade supply chain nor for glass bottles (Table 5). Data on electricity use of the cooling systems is based on Heineken data presented in Table 6.

Table 5 - Cooling Channel Split for Heineken Netherlands for the off-trade market

	FRIDGES ON/OFF PREMISE	HOME COOLED
SHARE	11%	89%

Table 6 - Electricity use of the cooling systems based on Heineken data and assumptions.

TYPE OF COOLING SYSTEM	ELECTRICITY USE	BACKGROUND
BEVERAGE FRIDGE ON/OFF-PREMISE	24.8 kWh/hl	992 kWh/year at 40hl/year, based on Heineken data
HOME COOLED	15.0 kWh/hl	150 kWh/year and a throughput of 1000 kg

In the calculation of their carbon footprint, Heineken uses the assumption for home cooling of 150 kWh/year. This assumption has been compared to a report of Milieucentraal (n.d.-b), of which the data is presented in Table 7. As it is unlikely that all households are in possession of a A+++ refrigerator – mainly due to the long expected lifetime of refrigerators of 15 years and the relatively recent availability of affordable high standard refrigerators (Milieucentraal, n.d.-b) – it is concluded that the A++ energy label offers a more realistic representation of electricity consumption of an average refrigerator. Therefore, home cooling is assumed to consume 175 kWh/year, as opposed to 150kWh/year.

Table 7 - Electricity consumption of different types of home fridges. Source: (Milieucentraal, n.d.-b)

ENERGY LABEL	FRIDGE-FREEZER COMBINATION	TABLE-TOP FRIDGE	CLOSET-MODEL FRIDGE	FRIDGE WITH DOUBLE DOORS	AVERAGE
A+++	160	80	90	140	118
A++	240	120	130	210	175
A+	300	150	160	279	222

The country specific emission factor of electricity is taken from IEA (2015), being 0.541 kg CO_2e/kWh for the Netherlands. Using the channel split and emission factor for cooling in the Netherlands, cooling is responsible for 9.89kg CO_2e/hl. No distinction is made between the returnable bottle and the one-way bottle, because despite that returnable bottles are slightly thicker on average and therefore should have lower thermal conductivity (which increases the energy required to cool the material), the difference in energy consumption is expected to be negligible.

4.1.3 Distribution

The distribution of beer consists of four stages: inbound packaging, warehousing, outbound packaging and the last mile (Figure 10). Only the distribution of packaging is considered, leaving the transportation of raw materials out of scope. The calculations are based on the methodology used by Heineken, which is based on a couple of standards such as the BSR Clean Cargo report (BSR Clean Cargo Working Group, 2015) and the EcoTransit methodology (EcoTransit, 2018). The assumptions and formulas related to the methodology will be explained per unit process.

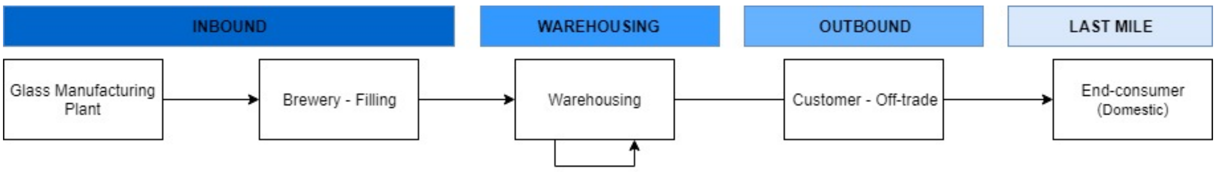

Figure 10 – Visualisation of the distribution supply chain

Inbound distribution

Glass bottles are imported either from the Netherlands, Germany or France. All transport is done by three types of heavy trucks using diesel fuel with different load capacities: 26-40t, 40-44t and 44-60t. The following formula is used to calculate gCO_2e emitted per tonne-km:

$$\textbf{gCO}_2\textbf{e/tonne-km} = \sum_j ((((EF_{i,100\%} - EF_{i,0\%}) * WU_{i,j} + EF_{i,0\%}) * TD_{i,j}) / TK_{i,j} * 1000)$$

Where:

- $EF_{i,100\%}$: emission factor of the used type of truck (i) at full capacity
- $EF_{i,0\%}$: emission factor of the used type of truck (i) at zero capacity
- $WU_{i,j}$: the average weight utilisation of the used type of truck (i) per shipments on a particular route (j).
- $TD_{i,j}$: the distance travelled in km on a particular route (j) by the used type of truck (i)
- $TK_{i,j}$: the tonne-km per shipment on a particular route (j) by the used type of truck (i).

Table 8 and 9 present the data from road transportation for inbound packaging gathered from the Heineken Green Logistics team. As most of the imported glass bottles are procured from the above mentioned three countries – Netherlands, France and Germany – the transportation distances are relatively short with an average below 100km.

Table 8 - Emission Factor per transport type for inbound

GCO$_2$E/TONNE-KM	TRUCK 26-44T	TRUCK 40-44 T	TRUCK 44-60 T
ONE-WAY BOTTLE	58	49	49
RETURNABLE BOTTLE	-	46	42

Table 9 - Parameters for the calculation of the Carbon Footprint of distribution for in- and outbound

INBOUND PACKAGING

Vehicle Type	Fuel Type	EF 0% [kg CO2-e/km]	EF 100% [kg CO2-e/km]	Average WU	Average Distance Km
Truck 26-40 t	Diesel	0.72	1.18	66%	84
Truck 40-44 t	Diesel	0.72	1.26	83%	159
Truck 44-60 t	Diesel	0.87	1.68	75%	71

OUTBOUND PACKAGING

Vehicle Type	Fuel Type	EF 0% [kg CO2-e/km]	EF 100% [kg CO2-e/km]	Average WU	Average Distance Km
Truck 40-44 t	Diesel	0.72	1.26	78%	84
Train - Container 40 ft	Electric	0.41	0.41	86%	1009
Barge - Container 20 ft	Diesel	0.23	0.23	80%	99
Barge - Container 40 ft	Diesel	0.46	0.46	92%	104

Warehousing

Inputs for the calculations of emissions in warehousing are based on the total surface area and the respective electricity use per square meter. This data is collected by Heineken based on primary data. The total area of the warehouses based in the Netherlands is 116,080m^2. Data on the electricity use and used emission factor are presented in Table 10. The total tonne CO_2e emitted by these processes divided by the total volume of beer stored results in 0.14kg CO_2e/hl.

Table 10 - Emission factors for regular and green electricity. Emission factors are calculated using primary data of Heineken.

ELECTRICITY TYPE	ELECTRICITY USE [KWH/M^2]	EMISSION FACTOR [KG CO$_2$E/KWH]	SHARE
GREEN ELECTRICITY	41	0.08	48%
REGULAR ELECTRICITY	79	0.57	52%

Outbound distribution

Three modes of transport are utilised for outbound transport: truck (40-44t), train (Container 40ft) and two types of barges (Container 20ft/40ft). For each mode of transport, the gCO_2e/tonne-km is calculated using the formula presented in the section on inbound distribution:

$$\textbf{gCO}_2\textbf{e/tonne-km} = \sum_j ((((EF_{i,100\%} - EF_{i,0\%}) * WU_{i,j} + EF_{i,0\%}) * TD_{i,j}) / TK_{i,j} * 1000)$$

Details on each of these factors are outlined in Table 9. Due to the geographical scope, transportation distances are small with average transportation distances of approximately 100km. In the primary data available for outbound transport from Heineken, no distinction is made between packaging types. Therefore, emissions are allocated to the two considered packaging types – one-way and returnable bottles – by utilising the packaging split from inbound transportation, where this distinction has been made. The result of formula is shown in Table 11. Returnable bottles are characterised by a lower gCO2e/tonne-km as more tonnes are transported for similar distances due to returnable bottles and the required crates used for transportation being heavier than one-way bottles and their respective secondary and tertiary packaging.

Table 11 - Emission Factors per transport type for Outbound

GCO_2E/TONNE-KM	TRUCK 40-44T	CONTAINER 40FT - TRAIN	CONTAINER 20FT - BARGE	CONTAINER 40FT - BARGE
ONE-WAY BOTTLE	39	12	9	13
RETURNABLE BOTTLE	32	10	7	10

Last mile

As the last mile is not controlled by Heineken and is also partly driven by emissions from the consumer, the assumption is made that the last mile is approximately 15% of the outbound emissions of scenario 1. This estimation is based on feedback by the operating companies from Heineken in each country.

Overall, the distribution emissions account for an emission factor of 1.2kg and 1.7kg CO_2e per hectolitre respectively for one-way- and returnable bottles.

4.1.4 Disposal

Emissions allocated to disposal are calculated using the Circular Footprint Formula. This formula integrates the input of virgin material in production, the recycled content, energy use at end of life, energy recovery at end of life and disposal (European Commission, 2018c). Information on the different aspects of this formula was collected in disaggregated form from Heineken background data. For that reason, it is shortly discussed here.

Six elements are represented in this formula, described by the (European Commission, 2018b) as:

Disposal: $((1-A)\ R_2 \times (E_{recyclingEoL} - E_{V^*})) + (R_3 \times E_{ER}) + ((1-R_2-R_3) \times E_D)$

- **A:** allocation factor of burdens and credits between supplier and user of recycled materials. EFCR guidelines indicate that the burdens and credits due to recycling should be split between supplier and user of recycled materials. The allocation split depends on the type of packaging material (glass, aluminium, steel, PET, etc.). For glass packaging material the factor is set to 20/80.
- **R_2:** the proportion of the material in the product that will be recycled (or reused) in a subsequent system. R2 therefore takes into account the inefficiencies in the collection and recycling (or reuse) processes.
- **R_3:** the proportion of the material in the product that is used for energy recovery at End of Life (EoL).
- **$E_{recyclingEoL} - E_V^*$:** the emission factor of recycling at EoL.
- **E_D:** specific emissions and resources consumed (per functional unit) arising from disposal of waste material at the EoL of the analysed product, without energy recovery.
- **E_{ER}:** specific emissions and resources consumed (per functional unit) arising from the energy recovery process (e.g. incineration with energy recovery, landfill with energy recovery).

The emission factor resulting from completing the formula with the variables presented in Table 12 is -0.301 kg CO_2e/kg glass packaging. Converted by the weight-content ratio [kg/hl] of one-way glass packaging, this results in -17.30kg CO_2e/hl.

Table 12 - Elements of the Circular Footprint Formula

Allocation Factors			Emission Factors		
A	R2	R3	ErecyclingEoL – EV*	E_D	E_{ER}
0.20	84%	16%	-0.45	0.03	0.00

4.2 Impact Assessment and Interpretation

In the previous section, the emission factors for all unit processes have been calculated per packaging type. In the following section, the results of the carbon footprint will be presented and analysed.

4.2.1 Results

The carbon footprint from Heineken Netherlands of both glass packaging types is presented in Figure 11. The five unit processes are presented in the figure, where the fifth unit process – disposal – is combined with packaging production as the disposal phase represents the negative emissions that originate from the recycling of the produced packaging material.

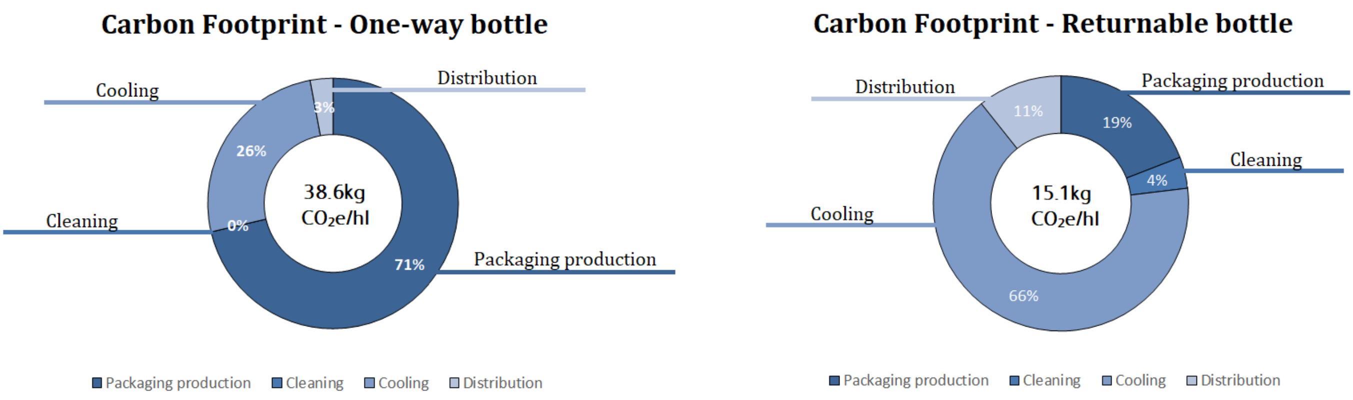

Figure 11 - Carbon Footprint results for one-way bottles (left) and returnable bottles (right)

One-way glass bottles constitute of by far the most impact, both in absolute terms as in relative terms, and result in 44.76kg CO_2e/hl as opposed to 15.07kg CO_2e/hl for a returnable bottle. In the domestic market, one-way glass packaging represents 11% of the glass packaging sold, while returnable bottles fulfil the remaining 89% of the market. If Dutch export is included, the one-way bottle share increases to 74%. This provides a clear opportunity to reduce CO_2e emissions by transitioning to returnable bottles, as a returnable bottle emits around 60% less CO_2e than a one-way bottle per functional unit.

4.2.2 Impact Hotspots

Due to the different nature of both packaging types, the impact hotspots vary. Therefore, a short discussion will be provided for both packaging types.

Impact Hotspots – One-way glass bottles

The environmental impact from one-way glass bottles is dominated by packaging production. This has two reasons. First of all, glass packaging has a much higher weight-content ratio [kg/hl] relative to other packaging materials (Figure 12), requiring more material per hectolitre of beer sold. Second, the production process of glass packaging is energy intensive due to the high thermal demands of melting the glass to such an extent that it can be formed into a glass bottle in a mould (1650°C). There are a couple of opportunities to reduce the impact of the thermal demand necessary for production. One such opportunity is to increase the recycled content (i.e. the input of cullet) in glass bottles. However, as mentioned in the LCI the supply of cullet is limited due to various reasons such as the country recycling rate, the loss of recycled glass within waste streams (e.g. due to contamination) or due to cullet being used for other purposes such as road building (Rivet, 2019). To counter such losses, industry-wide collaboration is needed to ensure increased efficiency of the recycling infrastructure.

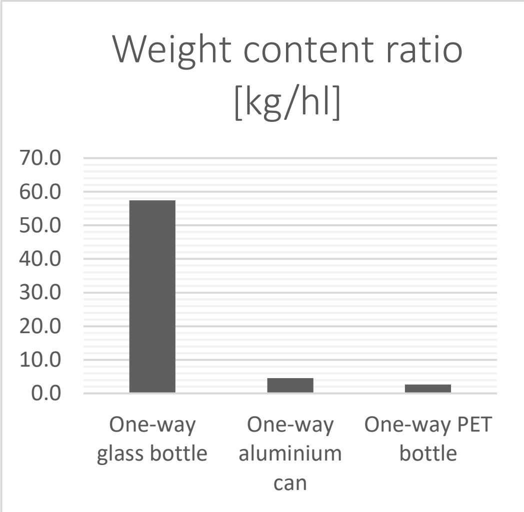

Figure 12 - Weight content ratio of different packaging types

Another opportunity is the use of renewable energy in the glass manufacturing plants. Currently, around 6% of the thermal demand and 21% of the electricity demand is supplied by renewable energy (van Leeuwen & Griffioen, 2018). Similar to the issue of cullet, this opportunity is also a question of supply. Investments need to be made to increase the supply of renewable energy in order to cover a larger share of the electricity demands. Further innovations also need to be made to ensure that the required heat can be met by renewable energy. One such innovation is called electric boosting, which can be used to replace part of the thermal demands. Electric boosting can be used to increase the temperature from 1200°C – the temperature at which glass becomes electrically conductive – to melting temperature at 1600-1650°C (van Leeuwen & Griffioen, 2018). If the electricity used for electric boosting originates from renewable energy, emissions can be significantly reduced.

A second driver that significantly contributes to the carbon footprint of one-way glass bottles is cooling. The biggest part of the volume produced is home cooled, which represents 89% of the volume. The remaining 11% is cooled in fridges on/off-premise. Household refrigerators are more efficient than fridges used on- and off-premise by Heineken (Figure 13). Although cooling represents the second most impactful unit process, the potential for reduction is rather low due to the low influence of Heineken on the efficiency of refrigerators used for the home-cooling of beer. Energy efficiency improvements will most likely continue to induce a downward trend on cooling emissions, as refrigerators get replaced at their end-of-life by more efficient refrigerators. However, as the expected lifetime of a refrigerator is 15 years, this tends to be a slow-moving trend (Milieucentraal, n.d.-b). For the refrigerators on- or off-premise in possession by Heineken, emissions can be reduced by continuing replacement of inefficient refrigerators by state-of-the-art refrigerators and increasing the throughput. Furthermore, green electricity can be used to provide for the electrical demands of these refrigerators to further lower the emissions.

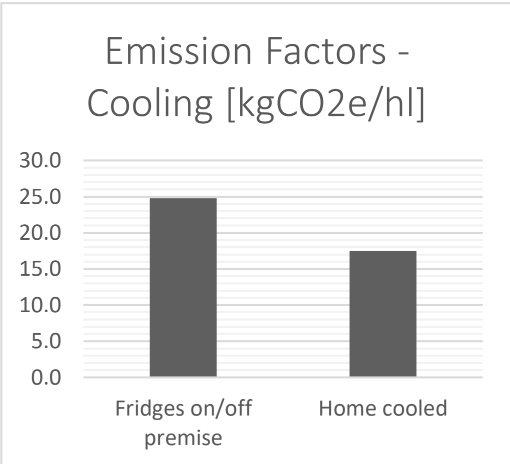

Figure 13 - Emission Factors for cooling

A final life cycle process with high impact on the carbon footprint is the disposal process. As explained in Chapter 5.1, the disposal emissions are calculated according to the Circular Footprint Formula. This formula pertains to three end-of-life routes: recycling, incineration and landfilling. According to the waste hierarchy, recycling is most desirable for one-way bottles, as opposed to incineration and landfilling. The Netherlands has a recycling rate of 83.7% for glass (FEVE, 2019; see Figure 14). Every kilogram of glass recycled substitutes some amount of virgin glass used elsewhere, either in the form of recycled content for new glass bottles (closed-loop) or in other product systems (open-loop). Therefore, recycling adds negative emissions to the carbon footprint and relieves part of the emissions from glass production. Increasing the country recycling rate still has some potential as countries such as Sweden, Finland and Belgium have obtained a recycling rate of 90-100% (FEVE, 2019). These high recycling rates are achieved by installing effective bottle bank systems and investing highly in consumer awareness, although each country requires local solutions. Regardless of local conditions, however, an important factor is getting consumers accustomed to take-back and recycling culture (FEVE, 2019)

Figure 14 - European recycling rates. Source: FEVE (2019)

Impact Hotspots – Returnable glass bottles

An opportunity to significantly reduce carbon emissions is to address the third R: reuse. Returnable glass bottles address this opportunity. In the Netherlands, 89% of the volume *sold* within the Netherlands is packed in returnable bottles, although only 26% of the volume *produced* in the Netherlands is packed in returnable bottles (the remaining 74% consists of one-way glass bottles that are primarily exported). Due to the amount of times that a returnable packaging is cycled, the burden of production is significantly reduced. Therefore, not the production phase but cooling is the largest contributors to CO_2e emissions. After cooling, packaging production is still the second largest contributor to the carbon footprint of returnable glass bottles. As pointed out in the life cycle inventory, the extent of the impact of production depends on the assumption that is taken for the trip rate of a returnable bottle. For the current calculation a trip rate of 14 is used, although some organisations claim that a returnable bottle could be circulated for 40 times (Milieucentraal, n.d.-a; Rivet, 2019), which would more than halve the emissions of production for returnable bottles. To stimulate the increase of trip rates two requirements need to be fulfilled:

1) The bottle needs to be more robust than one-way bottles. Returnable bottles are always heavier than their one-way counterpart, as they need to be able to resist impact from multiple consumption cycles and remain attractive over the lifetime of the bottle. Signs of wear and tear can discourage consumers from buying returnable bottles (Magnier, 2019). These signs of wear and tear are also a key reason for the conservative estimate of Heineken in terms of trip rate; if a glass bottle has too many signs of wear and tear it is taken out of the rotation to prevent damage to the premium image of the Heineken brand (Griffioen, 2019).
2) Consumers need to return their bottles using the deposit system. A high return rate ensures the viability of the return system and increases the average trip rate per bottle. Therefore, motivational cues such as the deposit system are needed to encourage compliant behaviour of consumers.

Finally, a unit process that gains increased importance for returnable bottles is distribution. Distribution is responsible of 11% of the overall emissions in the scenario where only national distribution is taken into account. Outbound transportation is responsible for the largest impact (Figure 15) for two reasons, i) filled bottles are heavier than the empty glass bottles transported in inbound transportation and ii) the transportation distances of outbound distribution are generally longer. The question is at which transportation distance the emissions of returnable bottles rise to such a level that it becomes an unviable alternative to one-way bottles. This will be examined in the section 4.3.5 and to some extent in the US case in Chapter 8.4. Opportunities for the reduction of emissions in distribution revolve around either decreasing transportation distances through route maximisation, increasing fuel efficiency, transitioning to an electrical transportation fleet or optimising the geographical distribution of beer filling and glass manufacturing plants.

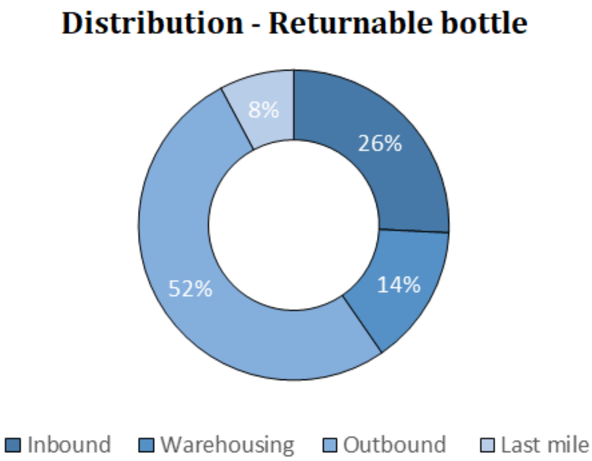

Figure 15 - Share of emissions per unit process

4.3 Sensitivity parameters

Within the carbon footprint there is a range of parameters that have a significant influence on the carbon footprint. Literature has indicated several of these parameters (Detzel & Mönckert, 2009; Wood & Sturges, 2010), such as:

- Raw materials and energy used in manufacture (OW)
- Trip rates (RET)
- Transportation distance
- Recycled content
- Recycling rates

These parameters will be discussed – except for recycled content – under the following five topics: type of packaging, weight, country recycling rate, glass supplier emissions and transportation distance. For each of these parameters, a sensitivity analysis has been performed to examine to what extent they affect the carbon footprint of the volume consumed within the Netherlands. Recycled content is not discussed separately, due to its complexity as a parameter for glass bottles. Although recycled content is an important KPI for other packaging materials such as plastic, it is difficult to use this construct in a similar manner for glass. As previously indicated, the main issue is that cullet is significantly limited in supply (Rivet, 2019). For that reason, recycled content cannot be easily manipulated. Regardless, it is implicitly taken into account in the production of glass packaging since a higher percentage of cullet does significantly decrease the energy demands and therefore carbon emissions.

4.3.1 Type of packaging

As illustrated by Figure 16, the carbon footprint of a one-way bottle is much higher than the carbon footprint of a returnable bottle. The current share of returnable bottles in hectolitre volumes is 89%. Every 10% shift from the share of one-way bottles to returnable bottles decreases the total carbon footprint by 2.35kg CO_2e per hectolitre. In the case that Heineken Netherlands is able to achieve 100% returnable bottles, the carbon footprint is reduced by 23.5kg CO_2e per hl of beer produced compared to 100% one-way bottles. Although the volume consumed within the Netherlands comprises to a large extent already of returnable bottles, the total volume produced (including export) consists of only 27% of returnable bottles. Much carbon reduction can therefore be gained if the volume to export countries can be transitioned to returnable bottles. This, however, increases the complexity of the supply chain and the question is whether returnable bottles are still viable over longer distances. This is further explored in both section 4.3.5 and Chapter 8.

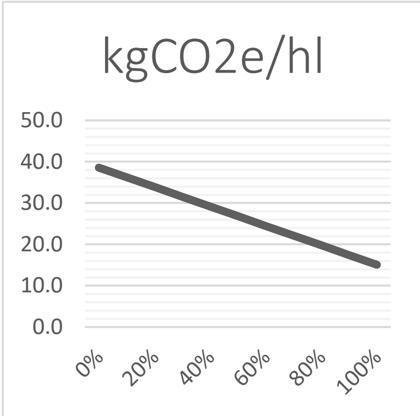

Figure 16 - The Carbon Footprint in the case of the transition towards returnable bottles

Trip rate

The trip rate is of prime importance for the calculation of the carbon footprint for returnable bottles. For the calculation of the current carbon footprint, a trip rate of 14 has been used. Nevertheless, as mentioned previously, trip rates are estimated to be higher by several organisations (e.g. FEVE, Milieucentraal). In Figure 17 the impact of various trip rates is illustrated. Doubling the trip rate to 30 would halve the carbon footprint from packaging production, while decreasing the overall carbon footprint of returnable glass bottles by 12% (1.6kg CO_2e per hectolitre). Since Heineken does not have information on the exact trip rate and therefore uses a conservative trip rate estimation, further research into an accurate representation of the trip rate of returnable glass bottles within the Netherlands can help achieve a more accurate representation of the carbon footprint.

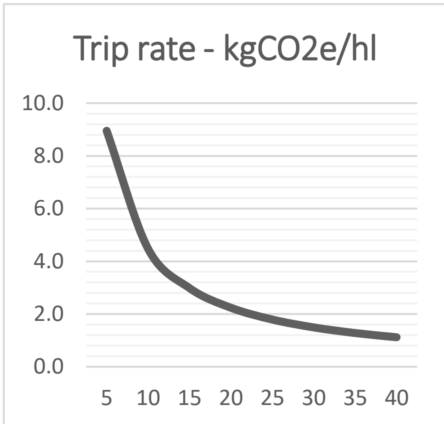

Figure 17 - Effect of increasing the trip rate

4.3.2 Weight

A reduction in weight translates to less material use and therefore lower the cost. On the other hand, weight is also the most sensitive parameter within the carbon footprint of glass packaging, with a 1:1 relationship with the carbon footprint of packaging production. Therefore, every 10% reduction in weight decreases the emissions of packaging production by 10% as well. A reduction in weight, however, also has ramifications on the distribution and disposal emissions:

- 10% reduction in weight reduces distribution emissions of one-way bottles by 7.9%
- 10% reduced material use also results in 10% less material that is recyclable.

Taking these factors into account, a 10% reduction in weight for one-way bottles will lead to a 7.4% reduction of the total carbon footprint of one-way bottles. For returnable bottles, the situation is slightly different due to the following reasons:

- Both the emissions from packaging production and the disposal phase are divided by the trip rate of returnable bottles. Therefore, the impact of a change in these phases are decreased by this trip rate.
- Returnable bottles are on average 28% heavier than one-way bottles leading to a higher weight-content [kg/hl] ratio. Therefore, a 10% reduction in weight has more impact on the emissions in distribution than in the case of one-way bottles. A 10% change in weight for returnable bottles reduces distribution emissions by 8.5%.

Overall, a 10% reduction in weight for returnable bottles leads to 3% reduction in its carbon footprint.

Depending on the unit volume and the type of glass – amber, green and flint – there is varying potential for lightweighting within the Heineken portfolio. In Table 13 the lightweighting potential for Heineken Netherlands is portrayed per type of glass material. Once these potentials are fulfilled, there is not much room for further manoeuvring without technology or process innovation. Since the thickness of the bottle is restricted by the strength of the material, one route of improvement is to use thermal treatment to reinforce the glass, thereby reducing the amount of glass needed to prevent breakage (Rivet, 2019).

Table 13 - Lightweighting potential of Heineken Netherlands. Lightweighting percentages are based on the lowest weight in their portfolio.

AVERAGE LIGHTWEIGHTING POTENTIAL	AMBER	GREEN	FLINT
ONE-WAY GLASS	10%	11%	14%
RETURNABLE GLASS	17%	4%	13%

There are a range of factors that can impede further lightweighting potential. First of all, glass manufacturers are restricted by certain product requirements that imply a minimum thickness of the glass to ensure that the product does not break and can resist the internal pressure (Keuenhof, 2019). Furthermore, glass manufacturers are bound to their capital investment. To produce glass bottles, liquid glass is put into a mould where the bottle is blown into shape. By improving this process to reduce the thickness of the blown bottles, manufacturers need to invest in new moulds which means investing thousands of euros. Manufacturers will not likely make these investments before their old capital goods are amortised (Keuenhof, 2019). Finally, there is a difference in per manufacturer, where manufacturers have optimised different product types.

4.3.3 Country Recycling Rate

The country recycling rate is the third sensitivity parameter highlighted by literature. In the Netherlands, the recycling rate of glass is estimated to be 83.7% (FEVE, 2019). If recycling rate within the Netherlands is increased by 10% the carbon footprint for end-of-life decreases by 12% for both types of packaging. However, the overall carbon footprint decreases by 5% and 1% respectively for one-way bottles and returnable bottles. The potential for increasing recycle rates within the Netherlands depends on increasing the efficiency of the present infrastructure as well as stimulating proper disposal conduct for consumers. Although there is still potential for increasing the recycling rate, influencing the country recycle rate cannot be done by one company alone. Therefore, industry collaboration is needed.

4.3.4. Glass supplier emissions

As Heineken does not have direct influence on the packaging production, supplier choice is essential in determining the carbon footprint especially for one-way packaging. In Table 4, the bandwidth of emission factors of suppliers in various countries was presented. The lowest emission factor belongs to a supplier in the Netherlands with 0.74kg CO_2e/kg packaging, while the (weighted) average is 0.80 kg CO_2e/kg. In the hypothetical case where all glass bottles could be produced by the supplier with the lowest emission factor, packaging production emissions could be reduced by 5% (from 44.8kg CO_2e/hl to 42.7kg CO_2e/hl) for one-way packaging. The total carbon footprint for each type of packaging would be reduced by respectively 6% for one-way bottles and 7% for returnable bottles. Therefore, working with suppliers to decrease their carbon footprint is crucial.

4.3.5 Transportation distance

The Netherlands, due to its geographical characteristics, is characterised by short transportation distances regardless of where in the country products are distributed to. Nonetheless, 77% of the total volume produced is exported to other countries. The distribution of products to these export countries – such as the US and Canada – does entail significant transportation distances. This is especially the case if returnable bottles would have been utilised, as returning bottles from these countries would constitute of substantial impact from logistics.

As a previous LCA on beer highlighted the importance of distribution in deciding between one-way and returnable bottles (Detzel & Mönckert, 2009), an investigation is done as to whether transportation distance can be a deciding factor in the choice between returnable and one-way glass bottles. The calculations are done for a heavy truck (26-40 tonnes payload), an ocean vessel from Northern Europe - Northern America (East Coast) and an Ocean Vessel from Northern Europe - Northern America (West Coast). The emission factors of both transportation types are presented in Table 14. The emission factors for the truck is gathered from Internal Heineken Data, while the emissions of the ocean vessels are derived from the methodology of the BSR Clean Cargo report (BSR Clean Cargo Working Group, 2015, 2018). Some assumptions are made to correct for a number of factors:

- As BSR calculations are based on TTW (tank-to-wheel), a conversion factor of 1.088 is used to convert it to WTW (well-to-wheel).
- The BSR calculations only include CO_2 emissions and no other GHG emissions as most emissions derive from fuel consumption of the engines. To correct for this slight difference, a conversion factor of 1.01 is used to convert it to CO_2e emissions.
- The load factor is assumed to be 70%. Based on an analysis of all the largest trade lanes, BSR concluded that the average utilisation is around 70%, which aligns with findings from IMO and WSC
- As the calculations of distance from load port to discharge port is most often calculated through online tools, it is typically based on the shortest distance. Therefore, a distance adjustment factor is applied of 1.15

Table 14 - Emission Factors for each transport mode. EC = East Coast, WC = West Coast

MODALITY	TYPE	EMISSION FACTOR 0% CAPACITY	EMISSION FACTOR 100% CAPACITY	WEIGHT UTILISATION [$WU_{I,J}/WU_{RET}$]
TRUCK	Truck 26-40 t	0.746	1.200	OW: 97%/0% RET: 97%/54%
OCEAN (EC)	Container 40 ft	0.218	0.218	n/a
OCEAN (WC)	Container 40 ft	0.210	0.210	n/a

The emissions per packaging type per hectolitre are calculated using the following formula:

$$\mathbf{kgCO_{2e}/hl:}\ (((EF_{i,100\%} - EF_{i,0\%}) * WU_{i,j} + EF_{i,0\%}) * TD_{i,j}) / VL_{ship} + (((EF_{i,100\%} - EF_{i,0\%}) * WU_{ret} + EF_{i,0\%}) * TD_{i,j}) / VL_{ship}$$

Where:

- **$EF_{i,100\%}$:** emission factor of the used transportation type (i) at full capacity
- **$EF_{i,0\%}$:** emission factor of the used transportation type (i) at zero capacity
- **$WU_{i,j}$**: the average weight utilisation of the used transportation type (i) per shipment on a particular route (j).
- **WU_{ret}**: the $WU_{i,j}$ for the return trip of the empty packaging. For returnable bottles, the WU_{ret} is 43% lower than the $WU_{i,j}$ due to the missing volume. An empty return trip with 0% WU_{ret} is assumed for one-way bottles. As the products transported by ocean vessel are transported per container which is chartered per shipment, no return transportation for one-way bottles is accounted for (only returnable bottles need a container for the return trip).

- **$TD_{i,j}$**: the distance travelled in km on a particular route (j) by the used type of truck (i)
- **VL_{ship}**: the volume in hectolitre per shipment. Respectively 152hl for one-way bottles and 127hl for returnable bottles.

The maximum transportation distance is calculated based on the carbon footprint presented in section 4.2.1. All other life cycles (e.g. packaging production, cooling) are kept constant, while only distribution is changed to deduce the maximum transport distance before one-way bottles are more beneficial from a carbon footprint perspective than returnable bottles. From the carbon footprint presented in Figure 11 (section 4.2.1), the current difference between the one-way bottle and returnable bottle is 24kg CO_2e per hectolitre without taking distribution into account. Using the formula presented above, the maximum transportation for each transport type are deduced (Table 15). The emissions for distribution using these maximum transportation distances are presented in Table 16 It should be acknowledged that these transportation distances are calculated holding every other variable equal (ceteris paribus). If, for instance, a one-way bottle is transported to a country with a lower recycle rate – and therefore lower negative disposal emissions – the maximum transportation distance increases and vice versa. These calculations show that for many instances the distribution of returnable bottles is not a limiting factor, unless it is transported over extreme distances.

Table 15 - Maximum transportation distance per transport type

TRANSPORT TYPE	MAX DISTANCE [KM]
TRUCK	5,312
OCEAN (EC)	11,980
OCEAN (WC)	12,390

Table 16 - Carbon Footprint per packaging type using the distribution emissions of the maximum transportation distance

TRUCK [KG CO_2E/HL]	**PACKAGING PRODUCTION**	**CLEANING**	**COOLING**	**DISTRIBUTION**	**DISPOSAL**	**TOTAL**
ONE-WAY GLASS BOTTLE	44.76	-	9.89	67.50	(17.30)	104.85
RETURNABLE GLASS BOTTLE	4.09	0.59	9.89	91.28	(1.24)	104.62
OCEAN (EC) [KG CO_2E/HL]	**PACKAGING PRODUCTION**	**CLEANING**	**COOLING**	**DISTRIBUTION**	**DISPOSAL**	**TOTAL**
ONE-WAY GLASS BOTTLE	44.76	-	9.89	17.15	(17.30)	54.50
RETURNABLE GLASS BOTTLE	4.09	0.59	9.89	41.16	(1.24)	54.50
OCEAN (WC) [KG CO_2E/HL]	**PACKAGING PRODUCTION**	**CLEANING**	**COOLING**	**DISTRIBUTION**	**DISPOSAL**	**TOTAL**
ONE-WAY GLASS BOTTLE	44.76	-	9.89	17.15	(17.30)	54.50
RETURNABLE GLASS BOTTLE	4.09	0.59	9.89	41.16	(1.24)	54.50

4.4 Synthesis

A range of parameters were discussed and from the sensitivity analysis, the carbon emission reduction potentials were calculated, which are presented in Figure 18. The portrayed reduction potentials are not cumulative. For one-way packaging it is clear that all reduction opportunities that are aimed at decreasing emissions from packaging production are the most effective. Overall, however, most potential arises from the switch to returnable glass bottles in combination with increasing trip rates. These aspects are not changed lightly and are tightly intertwined with consumer behaviour with regards to glass beer packaging.

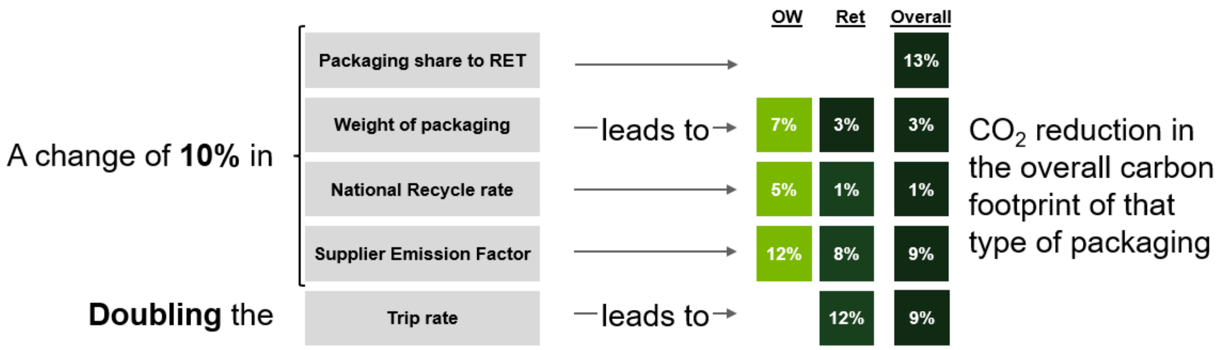

Figure 18 – Carbon Footprint reduction potential for volume produced in the Netherlands. OW = one-way, RET = returnable.

Not all discussed parameters are influenced from a consumer-oriented perspective. From the five discussed parameters, the first three parameters – type of packaging, weight and national recycle rate – are primarily related to consumer behaviour, while the latter two – supplier choice and transportation distance – are more organisational factors. These innovations are mostly driven by optimisation of existing structures and products. To move towards more sustainable packaging, however, changes in consumer purchase behaviour will be necessary and might require new solutions. Each of the three carbon footprint parameters that are in tight connection with consumer behaviour will be at the core of the remaining part of this thesis. Due to the importance of the shift to returnable packaging from a carbon footprint perspective and its intertwined nature with consumer convenience demands, this strategy receives most emphasis.

PART 2 – Consumer Behaviour

The carbon footprint analysis was performed to assess the carbon emission output throughout the packaging value chain. The carbon footprint is, however, not static. One significant variable that affects the carbon footprint is consumer demand. Therefore, in Chapter 5, the behavioural underpinnings of consumer purchase behaviour with regards to sustainable packaging will be discussed. This gives an overview of the drivers and barriers that can be expected when implementing strategies to decrease the carbon footprint. In Chapter 6, the insights from Chapter 5 will be applied to the three strategies defined in the previous section.

Before continuing with the results, a definition of consumer convenience is established. As consumer convenience does not have one accepted definition, the expert interviews were used to gather insights into how the experts defined consumer convenience. As expected from the literature review, experts did not provide a unified definition but rather named separate elements (Table 17). Nevertheless, based on their input, consumer convenience is therefore defined as "*design options implemented by the company that reduce time and effort of transporting, consuming, storing and disposing of the product*". As emphasised by Geiger, however, the provision of convenience depends significantly on the context. This is discussed further in chapter 6.1.

Table 17 - Elements of consumer convenience as stated by four experts

EXPERT	ORGANISATION & EXPERTISE	DEFINITION
NIGEL STEENIS	Wageningen University, Marketing & Consumer Behaviour	Convenience is defined as how you can transport, how you can open it, how you can close it and the shelf life of the product.
MARCEL KEUENHOF	KIDV, Sustainable packaging	Convenience in the widest sense from a consumer perspective is that they do not have to return the packaging to the supermarket
LISE MAGNIER	TU Delft, Consumer research - Product Innovation Management	Design options that are more convenient for people are those that make them do less effort
JOSEFINE GEIGER	Rijksuniversiteit Groningen, Environmental Psychology	There are more ways to convenience and it depends on the context whether something is convenient to the consumer or not.

5. The integrated model of consumer purchase behaviour

This section will provide an answer to RQ 2: what determines the purchase behaviour of consumers? The implementation of effective carbon reduction strategies relies on the willingness of consumers to fulfil their role in accepting these strategies and to behave accordingly. For a large part, this is decided by the consumers' purchase decisions, as these form the touchpoints with business. Answering this research question therefore provides insight in how companies can steer consumers towards a higher acceptance of carbon reduction strategies. To answer the research question, the integrated model introduced in section 2.3 (Figure 19) is used as a guiding framework.

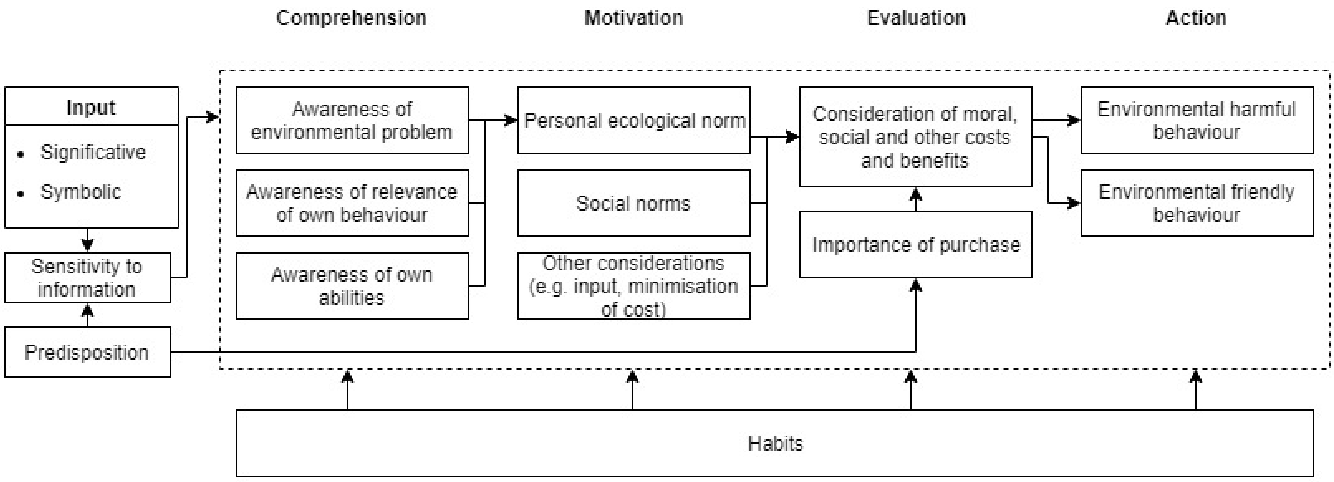

Figure 19 - Integrated model of purchase behaviour within an environmental decision-making context

5.1. Comprehension – The personal ecological norm

A prerequisite of sustainable purchase behaviour is that consumers have a general understanding of the necessity for more sustainable products. This understanding can be summarised as the personal ecological norm. The personal ecological norm consists of three elements: environmental awareness (what is the issue), awareness of relevance of own behaviour (why should I act) and awareness of one's own abilities to act (what can I do).

What is the issue?

Four out of the six experts directly mentioned the lack of knowledge as a pertinent barrier. As de Koeijer rightly acknowledged, no one has the perfect knowledge on what is necessary to create a sustainable society, hence it is only logical that the consumer does not either (de Koeijer, 2019). The intangible nature of sustainability and the obscured consequences of an individuals' environmental misconduct further proliferates the complexity.

A greater concern arises if consumers believe they have sufficient knowledge, but in fact have an incorrect perception of reality (Steenis, 2019). In their article, Steenis, van Herpen, van der Lans, Ligthart, & van Trijp (2017) tested the sustainability association people had with certain packaging materials and found a negative correlation of -.37 between the rating of sustainability provided by environmental assessments and the sustainability rating given by consumers. This negative correlation indicates that if consumers perceive a packaging as sustainable, it is actually less sustainable and vice versa (Steenis, 2019). This was supported by Keuenhof, who agreed that there is a large discrepancy between what is truly sustainable from an environmental analysis point of view versus consumer perception (Keuenhof, 2019). This creates the situations where people have misconceptions of the sustainability of a packaging material (Geiger, 2019b), which increases the difficulty of persuading consumers to purchase sustainable products, since it is more difficult to persuade consumers with a strong (negative) association than consumers who have none (Steenis, 2019). Fortunately, glass is perceived by the consumer as one of the most sustainable packaging material, even in the case of one-way glass

(Keuenhof, 2019; Steenis, 2019). Consequently, consumers are likely to be more willing to acknowledge sustainability claims about glass.

Why should I act and what can I do?
Besides the required understanding, consumers should be made aware of the relevance of their own behaviour as they often wonder why they should do something or act in a certain manner (Delle Selve, 2019). Consumers still frequently underestimate the GHG emissions of consumption products like food products (Camilleri et al., 2018) and therefore feel no need to act. Providing the relevant information on the contribution of glass packaging to carbon emissions and ways to reduce it (choosing returnable bottles, properly disposing of their bottles etc.) should give them more confidence in that what they are doing is actually contributing to a better environment. How this information should be communicated to consumers is discussed in chapter 5.2.2.

'Consumers want to know why they should choose glass to be sustainable. And the content of such a message is key. If you claim a packaging is recyclable and recycled, you have to be sure that it is true'. ~ Delle Selve (2019)

5.2 Motivation
A positive personal ecological norm forms part of the intrinsic motivation of consumers that is required for sustainable purchases. However, two other elements have an impact on whether consumers are motivated to consider purchasing sustainable products: the social norm and additionally any other consideration that a consumer might have, such as the maximisation of convenience. The latter considerations are heterogeneous across consumers and depend heavily on the consumption scenario for which the product is required. However, on one aspect all experts agreed: trade-offs between sustainability and other functional characteristics (price, quality, convenience etc.) need to be avoided for sustainability to be a salient topic. Consumers purchase the products that best fulfil the required purpose. They will not choose the sustainable alternative if it provides them with an inferior product (Steenis, 2019).

"*If you go back in functionality, convenience and ease of use, I am not sure whether that is going to work*" *~ Magnier (2019)*

Even if a consumers' personal ecological norm is not positive, a consumer might still be inclined to choose sustainable packaging if the social norm is supportive. This is acknowledged by Geiger, who indicated that people care a lot about normative issues. Environmental friendly behaviour, as it is good for the environment and for future generations, makes them both feel good about themselves and lets them show to other people that they are a good person (Geiger, 2019b). Whether the social norm is currently supportive, however, is debatable. Although there is a greater general awareness of sustainability issues, the majority of the population still has no real interest (Keuenhof, 2019). Nonetheless, as sustainability moves up the political and the consumers' agenda, the social norm will progressively be of greater influence.

5.3 Evaluation
Various studies show that consumers generally are generally motivated to purchase sustainable packaging (Vermeir & Verbeke, 2006; Young, Hwang, Mcdonald, & Oates, 2010), however, somewhere between the intention of doing something good for the environment and actual purchase behaviour, it goes awry. In part, this could be a consequence of the intangible nature of sustainability, as it is a rather high-level and abstract concept; an individual will rarely feel the direct consequence of his or her actions. While these high-level concepts might be important to consumers in terms of personal ecological norm and how they want to be perceived, at the moment of purchase a consumer is much more likely to utilise

low-level concepts that have a direct impact on their personal lives, such as price and quality of the product (Keuenhof, 2019; Magnier, 2019; Steenis, 2019).

The problem with sustainability is that it is not a personal benefit; you never do it for yourself. It is very abstract. However, if a consumer has to pay five euros more it is immediately clear, while if some sustainability claim is made consumers can never verify this. ~ Steenis (2019)

The reason for the preference for the utilisation of low-level concepts is in part a consequence from the Fast Moving Consumer Goods context, which is characterised by low involvement. Purchasing these goods is part of the household activities and individuals will try to minimise the time spent on these activities to reserve time for family activities or hobbies (Magnier, 2019). As a result, consumers rarely spend time to additionally process information on sustainability cues. In consequence, purchase decisions are often made by using heuristics, unconscious mental associations based on earlier experiences or intuition (Steenis, 2019). Therefore, habits have a strong influence on people's behaviour within this context. Another shortcut that results in lower (sustainability) information processing is the problem of categorisation (Magnier, 2019). Categorisation is defined as the action or process of placing objects into classes or groups (Stevenson, 2010). For instance, if consumers are used to buying their water in PET bottles and a new, more sustainable carton packaging would be introduced, these consumers would most likely not even consider the carton packaging since it does not fit in their mental category of water containers (e.g. it is outside of their evoked set). If the sustainable alternative is not part of a consumers' evoked set, it is difficult to change this perception.

"Consumers are under high cognitive loads most of the time, so when they are doing their groceries, they have plenty of stuff on their minds and therefore they do not process all the options that they have in front of them, they just go for what they know or what they are used to" ~ Magnier (2019)

5.4 Input

As indicated by the model (Figure 19), there are two facets of input: significative and symbolic input. Significative elements are the actual product or brand attributes with which the consumers come into direct contact (Loudon & Della Bitta, 1993), while symbolic elements refer to the representations of products and brands which are conveyed through marketing and advertisements (Foxall, 1990; Howard & Sheth, 1969).

5.4.1 Significative input

A wide range of product characteristics can influence the purchase decision of the consumer at the point of sale, such as brand preference, quality, price, availability of the desired product, sustainability and convenience. The question remains which of these characteristics are prime drivers of purchase behaviour. According to Schils & Hoogwerf (2018) and Farrelley (2019), brand preference is by far the most important driver of product purchase (Figure 20). It encompasses a certain set of quality, price, convenience and sustainability characteristics based on the brands' value proposition. Therefore, as long as the product stays consistent with the brand image and quality that consumers expect to gain by buying this brand, minor changes in the product will not have a significant impact on the purchasing behaviour of consumers. It further aligns to the concept of categorisation and brand predisposition; if a certain brand is preferred only the alternatives within that brand are evaluated (Farrelly, 2019), leaving any alternatives from other brands out of scope. The brand value proposition and image also influence the extent to which sustainability can be integrated. Sustainability is best integrated with premium brands like Heineken, because sustainability products are associated with a higher price (Robinson &

Smith, 2002). Attempting to integrate sustainability within the brand can therefore only be credible and effective if it fits that mental association (Steenis, 2019).

> "*You do not want budget brands to include sustainability, because the whole proposition of those brands is to curtail all peripheral aspects to provide the best price-quality ratio. Adding sustainability will therefore only mess with that perception*" ~ *Steenis (2019)*

Although price is often perceived as the primary driver, 3 out of 5 experts attest that price is not that important for beer due to the relatively low price differences between competing brands. However, although price differences may not be large between brands, the price perception between packaging types is. For instance, glass packaging is perceived to be of premium quality, while aluminium cans are often perceived as cheap or inferior (Delle Selve, 2019; Steenis, 2019). Additionally, price is also considered to be a key driver for consumers in buying the returnable crate as it is considered as a cheap drinking option, especially considering the continuous price discounts (HNK & Koos Service Design, 2018).

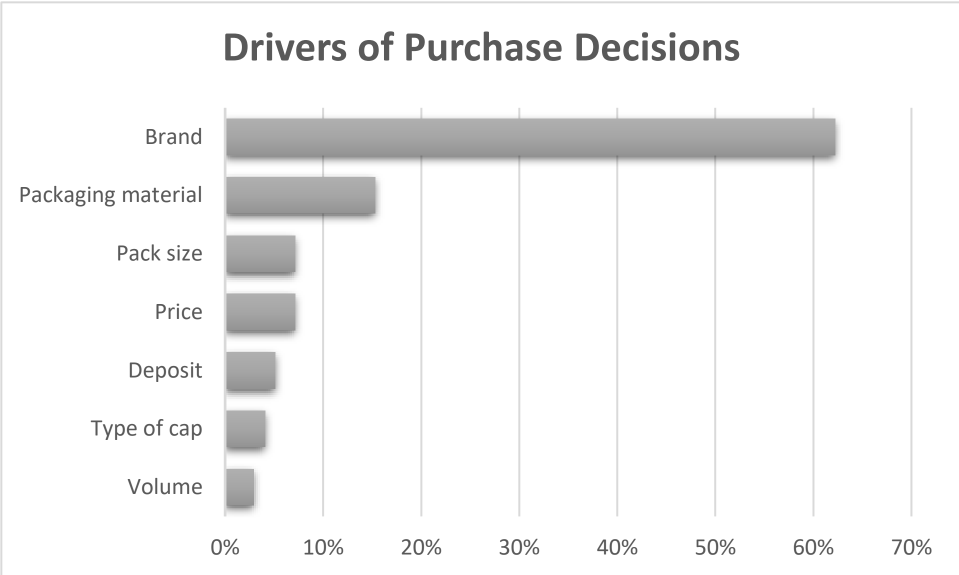

Figure 20 - Importance of various drivers of purchase behaviour. Source: Schils & Hoogwerf (2018)

According to Schils & Hoogwerf (2018), the second driver for purchase behaviour is the type of packaging material (Figure 20). The packaging material and shape imply a certain set of characteristics which include price, quality, deposit money, unit volume and overall convenience. However, before consumers decide on the required packaging, they typically have a consumption scenario in mind. This has a significant influence on the product choice as well, as the majority of the consumers will match the product packaging requirements with the consumption scenario in mind. In the study performed by Heineken and Koos Design Service, four consumption scenarios have been identified in the Heineken studies for the off-trade market: on-the-go, individually at home, with a small group at home and with a large group at home (HNK & Koos Service Design, 2018). Each consumption scenario implies different needs in terms of fulfilment of convenience characteristics and is therefore the main cognitive frame in which purchase decisions are made. In their categorisation of consumption scenarios, HNK & Koos Service Design (2018) connected each scenario to a range of convenience attributes that are particularly valued by the consumer in that context (Figure 21). The preferred convenience attributes in each consumption scenario cannot be fulfilled equally by each packaging type. Therefore, consumers might prefer different packaging types in different consumption scenarios. In summary, consumers generally go through the decision process in the order presented in Figure 22.

Finally, sustainability is only considered as long as no trade-offs are made with the other functional characteristics. Therefore, in order to deliver sustainable alternatives, the value proposition of a product should not only be dependent on sustainability, but should be combined with other functional characteristics, with convenience as the most beneficial factor to combine with (Steenis, 2019). In conclusion, instead of perceiving sustainability as a primary driver of product purchase, it should be considered an add-on to gain competitive advantage or drive a differentiation strategy, especially in the FMCG market where products are generally quite alike.

"[Sustainability] really is on top of people's mind and they want to behave accordingly, but they don't. And that is the crux of sustainability. Everyone thinks it is a good thing to do, but if the time arrives they do not choose for that, so you need to deliver something else as well" ~ Steenis (2019)

Figure 22 - Consumption scenarios and related convenience elements. Source: HNK & Koos Service Design (2018)

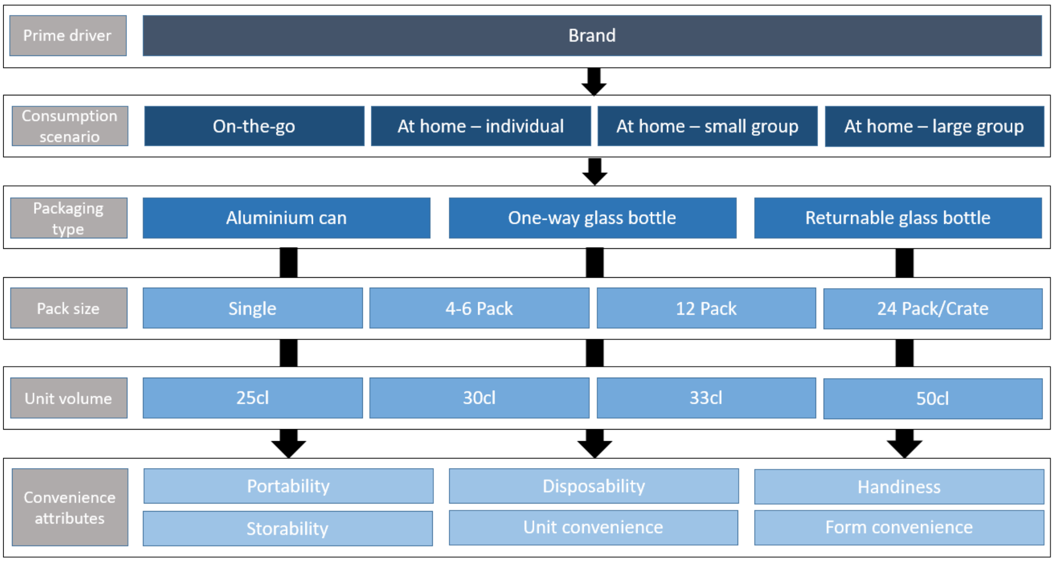

Figure 21 - Purchase decision process for a consumer

5.4.2 Symbolic input

Since knowledge and awareness were identified as barriers to environmental friendly purchase behaviour, communication on sustainability is an important but complicated topic. Companies must be careful with stating their facts as objective truths, since calculations regarding sustainability often depend on what system boundaries and processes are included and what assumptions are made to calculate sustainability in an objective manner (Magnier, 2019). If brands are aiming to communicate sustainable characteristics of their packaging, several factors need to be considered.

Target group

Different consumer groups require different types of communication. Contextual factors like income, education, age or personal interests all play a role in determining specific behaviour of an individual (Magnier, 2019). These contextual factors as well as previous experiences of the consumer can influence whether consumers are willing to contribute to environmental wellbeing by purchasing more sustainable products. For instance, consumers who are more likely to behave in a sustainable manner are usually well-educated, have a higher income and a medium to high environmental awareness (Geiger, 2019b; Magnier, 2019). It is therefore essential to know what the target audience is in order to build the right tactics and tools to deliver the sustainability message.

In the research performed by HNK & Koos Service Design (2018), a categorisation of six consumer groups is made (Figure 23). On one extreme, there is the consumer group that has no interest in sustainability, while aiming to maximise their convenience: the Carefree Dodger. On the other extreme is the Green Rationalist consumer group, who is set upon gathering detailed information to make the most sustainable decisions. The majority of the consumers can still be categorised in the three groups on the upper row whose primary goal is to maximise convenience (Magnier, 2019). This is in line previous findings, where it is stipulated that primary functional criteria – such as convenience of use, price and quality – need to be fulfilled first before environmental considerations are of importance (Dam & Trijp, 1994; Steenis, 2019).

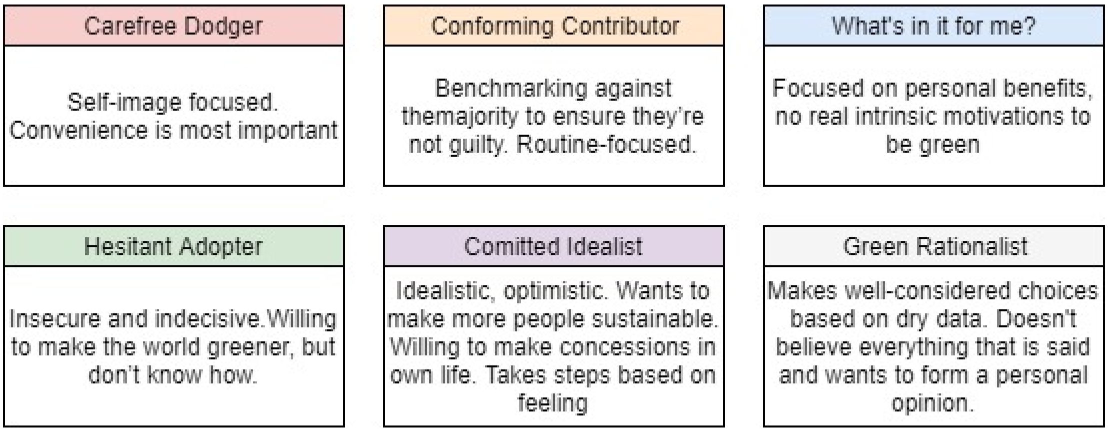

Figure 23 - Consumer profiles. Source: HNK & Koos Service Design (2018)

Credibility of the message

Previous research revealed that consumer groups with lower environmental awareness are also the most sceptical about sustainability, which exacerbates the issue as precisely these individuals need to be persuaded to behave more sustainably (Magnier, 2019). The sceptical attitude of consumers can to some extent be attributed to the fear of greenwashing: the purposeful communication of misleading information with regards to sustainability. Although greenwashing is often defined as deliberate miscommunication by the company, that need not be the case, since as long as the consumer perceives the message to be greenwashed the accusation still stands (Seele & Gatti, 2017). To prevent such accusation, companies need to ensure that the content is true and can be verified. To increase credibility of the message, other parties such as environmental NGOs can also be used to endorse the message (Delle Selve, 2019). The aim of such endorsement is to create a shared understanding between consumers of what is appropriate or good (Southerton, McMeekin, & Evans, 2011) and to influence what is understood as the social norm. Finally, communication on sustainability is more effective for branding and improving company perceptions but is rarely effective for direct product purchases

(Steenis, 2019). The consumer is more inclined to adhere to sustainability statements if a message provides advice on sustainable behaviour, rather than when a company is directly trying to sell a product.

The delivery of the message

In purchase scenarios the sustainability messages on the product or its packaging should be simple, powerful, short and easy to grasp. Only consumers that have a real interest in sustainability will want more in-depth information, although this information can best be provided elsewhere, such as on the company website. Labels and symbols can be appropriate to fulfil the role of short and simple information transfer, but only if these labels are standardised and known to the consumer (Magnier, 2019). Most effective, however, are ways that convey the message while avoiding the need for consumers to actively process information, as at the moment of a purchase decision, consumers do not actively search for information due to time constraints or simply a lack of interest. Examples of methods that utilise the unconscious transfer of information are framing, nudging or the use of design cues (Magnier, 2019; Steenis, 2019). For instance, by depicting a tree on a product packaging, consumers automatically associate it with sustainability (Geiger, 2019b). The disadvantage of these unconscious information transfer techniques is that although they are effective in steering consumers towards certain purchase behaviour at the moment of purchase, it does not create any real change in long-term behaviour (Magnier, 2019; Steenis, 2019). To ensure long-term behaviour change companies should maintain a broader communication strategy in parallel and linked to the communication in purchase scenarios. Part of this broader communication strategy should be to inform the consumer in a more detailed manner on the sustainability elements that are addressed by the company (Keuenhof, 2019).

> "*[In a purchase scenario] a consumer thinks for thirty seconds, looks whether something is on discount and then chooses. So they are not actively looking for sustainability information on the packaging. Therefore, the influence of providing information on the packaging for the consumer to read is limited." ~ Steenis (2019)*

Finally, companies should be careful of communicating a sustainability message that includes any financial claim in the same context, since financial considerations always overrule sustainability considerations (Geiger, 2019b). Furthermore, not all sustainability innovations lend themselves to communication. Primarily innovations that are visible or have a significant impact are appropriate for communication, since innovations that do not fulfil these criteria can expect consumer criticism (Steenis, 2019).

6. Consumer convenience related to the proposed strategies

In this chapter, the theoretical underpinnings discussed in the previous chapter are applied to the three strategies that were proposed in the analysis of the carbon footprint: transitioning from one-way to returnable, decreasing the weight of packaging and increasing the country recycle rate. In Figure 24, the connection between the strategies and consumer behaviour is highlighted for each of the strategies. For instance, the country recycle rate is defined for a major part by the disposal behaviour of the consumer. For each of the strategies, these connections with consumer behaviour are explained.

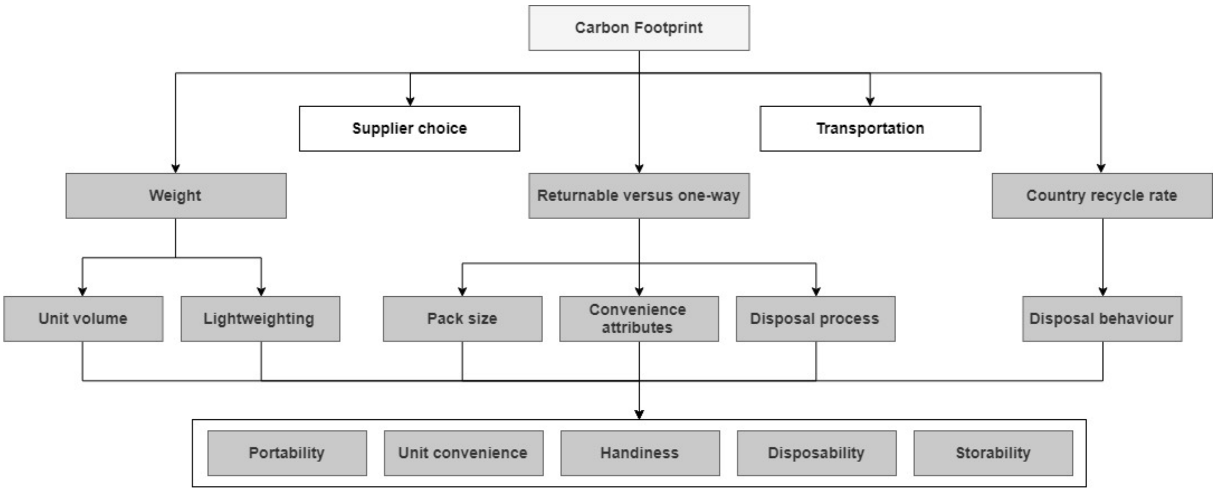

Figure 24 - The link between the carbon footprint and elements of consumer convenience

6.1 Transition from one-way to returnable

The analysis of the carbon footprint revealed that there is ample potential for CO_2e reduction in switching from one-way glass bottles to the returnable glass bottle. The question is whether this potential remains if consumer demands are taken into account. In the study from Schils & Hoogwerf (2018) consumers were asked what drove their preference for the different packaging types, which is presented in Figure 25. These results confirm that there is a large variance in the drivers for choosing a packaging type. Although aluminium cans are out of the scope of the current research, it is important to recognise that not all consumption scenarios can be fulfilled by glass only. Aluminium cans are recognised as best packaging type for on-the-go scenarios due to its advantages in terms of portability and disposability. Moreover, since the packaging is more flexible and often smaller than its glass counterpart, it is also valued in terms of storage. The drivers for two types of glass packaging are discussed in more detail in the following sections.

Reason for preference	*Convenience category*	Aluminium can	One-way bottle	Returnable bottle
This packaging is (compared to the other types) the most environmental friendly	Sustainable	7%	9%	67%
Easy to dispose of the empty packaging	Disposability	44%	33%	24%
I do not have to return the packaging at the supermarket (due to the deposit)	Disposability	37%	63%	0%
The packaging is easy to take with me	Portability	48%	18%	6%
I can store the packaging easily	Storability	50%	8%	8%
The packaging is satisfying to drink from		11%	22%	23%
This packaging guarantees the quality of the product		6%	7%	13%
This packaging is less heavy	Portability	25%	2%	1%
In this packaging the right volume is provided	Unit convenience	8%	10%	9%
I do not have to pay an extra deposit		13%	23%	0%
This packaging type is sturdy		17%	4%	3%
In this packaging the product stays cooler longer		9%	4%	4%
Other		6%	2%	7%

Figure 25 - Drivers for preference of packaging type. Source: Schils & Hoogwerf (2018). Pricing was not taken into account in this research.

6.1.1 One-way glass bottle

The main driver for this packaging type identified in both the expert interviews and in the study from Schils & Hoogwerf (2018) is the convenience of disposal. The convenience of disposal primarily derives from the absence of a deposit, which prevents consumers from having to pay extra upfront – affecting the price perception – and having to return to the supermarket with their empty bottles. However, a contrasting perspective is provided by a later result in the same research (Figure 26). Respondents were asked to indicate the ease of disposal per packaging type. The results indicate that respondents are rather indifferent to which packaging they prefer on the basis of the disposal process and even indicate that the one-way glass bottle is the least convenient. Although there is a difference in disposability between a one-way and a returnable glass bottle, the difference in disposability is likely much smaller between both types of glass bottles than between the glass bottles and an aluminium can as aluminium cans can be discarded in the bin, while both types of glass bottles have to be disposed of in dedicated bottle banks or at the supermarket (Steenis, 2019). Therefore, if a consumers' main driver is convenience of disposal, he or she will choose an aluminium can rather than making the choice between the two types of glass bottles.

"I don't think there is a significant difference in consumer convenience between the two disposal routes. However, there is a difference between having to bring away the glass or to throw away waste in the bin. The bin of course always has the consumer preference". ~ Steenis (2019)

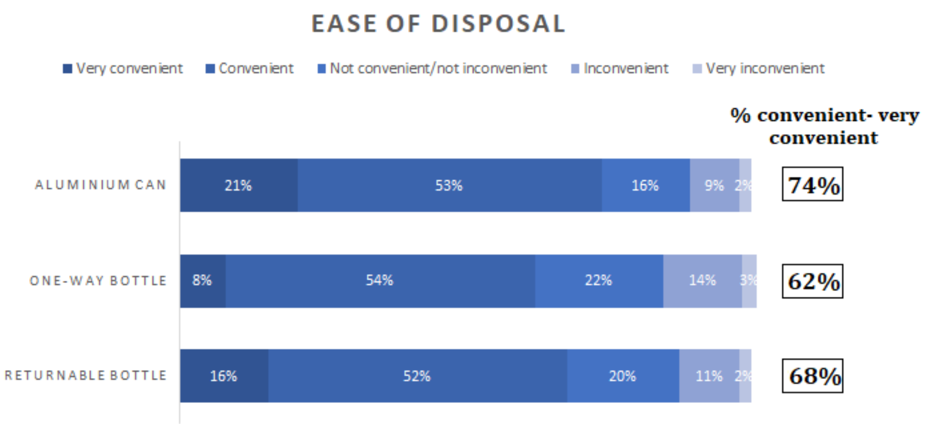

Figure 26 – Question: Indicate per type of packaging to what extent it is convenient or inconvenient to dispose of the packaging (ease of disposal). Source: Schils & Hoogwerf (2018)

Clearly, a more nuanced view is needed to determine the basis on which consumers choose one-way glass bottles. The context in which the consumer operates is a major influencer of disposability. The importance of context is emphasised by Keuenhof: "*bottle banks are often already in the neighbourhood of supermarkets. If consumers already have their empty glass jar of pickles, they could take their one-way bottles to the same bottle bank, but on the other hand, if they have to buy new jar of pickles they might as well take their returnable bottles with them to the supermarket*" (Keuenhof, 2019). Thus, the context in which a consumer operates can be favourable for choosing either of the two glass bottle types. This can depend on:

1. The distance to the supermarket and bottle bank as well as the distance between of the two.
2. The size of a consumers' residence. Consumers may prefer one-way glass bottles due to a lack of storage space when living in a smaller apartment, because of the availability of smaller pack sizes of one-way bottles and/or the fact that they do not have to store them in order to retain the deposit (Magnier, 2019).
3. The take-back culture of the country (Delle Selve, 2019). Depending on what disposal process is habitual and perceived as the baseline disposal behaviour – either recycling or returning a bottle – this process will not be considered inconvenient.

In conclusion, the prime driver of choosing one-way bottles is the ease of disposal, but only for the consumers in which the contextual factors make it more convenient (e.g. large distance to a supermarket, lack of storage space). If the contextual factors are favourable, however, returnable bottles can function as an equal – or better – alternative.

6.1.2 Returnable glass bottle

Of the 648 respondents in the study of Schils & Hoogwerf (2018), 51% indicated their preference for the returnable glass bottle. Especially for consumers that are not brand loyal, the lower relative price of crates can be a significant driver in purchasing returnable bottles, especially due to the frequent discounts on crates (HNK & Koos Service Design, 2018). Aside from price, a primary driver for their preference for this type of bottle is its superior environmental performance (Figure 25). As was concluded in chapter 5.2, however, environmental performance can only become a driver for the majority of the consumers if there is no significant trade-off with other packaging characteristics, such as price, convenience and quality. This suggests two propositions, either all 51% of the respondents are committed environmentalists and would choose any sustainable packaging over the regular packaging, or – which seems more likely – the returnable bottle fulfils all required functionalities these respondents demand.

The latter conclusion is reinforced by the results of the study of Schils & Hoogwerf (2018), where respondents were asked to make the distinction between whether the Heineken 0.0% bottle is returnable – and thus has a deposit – or not. Even though currently all Heineken 0.0% bottles are one-way bottles, only 37% of the respondents could correctly identify them as such (Figure 27). This result contrasts the hypothesis that all respondents choosing for the returnable bottle make this decision for environmental reasons, since the majority cannot tell the difference at all.

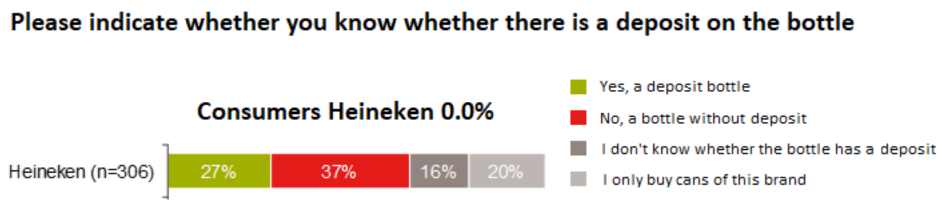

Figure 27 - Result of the question whether respondents know on which bottles there is a deposit. Source: Schils & Hoogwerf (2018)

It was established that contextual factors regarding disposability can affect the preference for either one-way or returnable bottles. Aside from these contextual factors, there are also functional characteristics of the returnable bottle that provide a barrier for a transition towards returnable bottles that have to do with the disposal stage, namely deposit money and wear and tear.

A proportion of consumers appears to make the distinction between one-way and returnable bottles in financial terms due to the deposit money required for the returnable bottle[10]. In the study from Schils & Hoogwerf (2018), 23% of the respondents indicate that their preference for one-way bottle is based on the lack of a deposit that has to be paid up front. Therefore, the increased price perception, the unavailability of money during a period of time and the potential loss of deposit money in some consumption scenarios (e.g. in case of a large festivity with limited control on the proper preservation of returnable bottles) all account for the reluctance of some consumers to purchase returnable bottles. Even after the returnable bottles are bought, consumers balance the price of the deposit to the effort they have to put in the disposal process. In the study of HNK & Koos Service Design (2018) several of the respondents admitted that they disposed their glass bottles in the bottle bank or even in regular waste, regardless of a deposit being present. Keuenhof concurred with the carelessness of some consumers. He stated: *"I think there are indeed consumers who think: 'for ten cents I can throw them in the bottle bank"* (Keuenhof, 2019).

A final factor influencing the purchase behaviour of consumers is the wear and tear of the returnable packaging. Wear and tear can be the result of the use of returnable bottles in multiple cycles. In general, if a packaging is only a little damaged, people tend to avoid it and buy another product which looks better (Magnier, 2019). The question is how strong this perception is in the beer market, as returnable bottles have been around for quite some time. On that note, Keuenhof commented that *"in the past wear and tear would have been perceived as inferior, but nowadays you could market it as a bottle with a story. Used several times, so more sustainable"* (Keuenhof, 2019). As people are becoming more used to or made more aware of the benefits of returnable packaging, wear and tear could be turned into a positive symbol of sustainability instead of the negative association that is currently prevalent.

6.1.3 Pack size

A variable that affects purchase decisions for both types of packaging is pack size. Although the pack size does not have a direct consequence on the carbon footprint, it is important in terms of consumer convenience and availability. Additionally, pack size has implications for price perception, portability and storability of the product. In general, one-way bottles have a wider range of pack sizes, whereas the returnable bottle is typically associated with the 24-bottle returnable crate. Although the crate is perceived as a sustainable and cheap drinking option in which bottles can be stored easily and which ensures sufficient supply for potential guests, they are also considered to be inconvenient to carry, to store and to dispose of (Blauw, 2018; HNK & Koos Service Design, 2018). Therefore, returnable bottles are lacking the availability of different pack sizes for different consumption scenarios, which are available for one-way bottles.

Other trends that affect the desired pack size are the increasing desire for consumption on the date of purchase and therefore purchase smaller portions day-by-day, rather than taking stocks (Delle Selve, 2019). Additionally, consumer profiles are changing and smaller households tend to prefer smaller packs (Magnier, 2019). For the consumer segment that wants to avoid inconveniences, four- or six-packs are more attractive since they take less space, can be transported by bike and have less total volume which

[10] The value of the deposit depends on the unit volume and the crate (Biernet, n.d.).

- Below 0.25l glass bottle: no deposit money
- 0.25-0.5l glass bottle: €0.10
- Clip-lock bottle: €0.20
- A crate carries a deposit of €1.50 when empty, €3.90 when filled.

supports consumers that desire moderation (Blauw, 2018). To facilitate a transition towards returnable bottles, the availability of smaller pack sizes is therefore crucial.

6.2 Weight

Glass packaging is characterised as a packaging material with a relatively high weight compared to other alternatives. This has its implications on consumer perception and convenience, both positive and negative. On the one hand, glass packaging is heavy, especially in larger quantities, and therefore perform rather poor in portability and disposability compared to alternatives like the aluminium can (see Figure 25). On the other hand, weight is associated to premiumisation and quality (Keuenhof, 2019; Rivet, 2019). The importance of the different aspects – portability convenience or quality – depend on the consumption scenario. Weight can also have a positive influence on the disposal behaviour of consumers. If packaging has lower weight, consumers are more inclined to dispose of it in an improper manner since it has a lower perceived value (Keuenhof, 2019).

> *"If consumers buy a glass product, they are much more careful with it than with a plastic bag which they can throw on the ground" ~ Keuenhof (2019)*

From the carbon footprint analysis, lightweighting was perceived as highly desirable due to its cost savings and potential for decreasing the carbon footprint. Also from the consumer perspective such a strategy can be beneficial. Naturally, the lighter the bottle, the better its portability. Nevertheless, consumers hardly notice any difference if the packaging material remains similar (Magnier, 2019; Steenis, 2019). Therefore, lightweighting can be performed without the consumer noticing it as long as the shape or size of the packaging does not change.

Unit volume

Besides the direct weight of glass as a packaging material, the unit volume of the bottle also influences the carbon footprint. The larger the volume of the bottle, the less packaging material is used per litre of beer. Although from a carbon footprint point of view maintaining large unit volumes make sense, it is more complex from a consumer perspective as consumers demand variation and flexibility. To examine whether there is potential for reducing carbon emissions through increasing the unit volume, the drivers for smaller unit volumes – such as the 25cl glass bottle – were explored.

The study from The Conversation Studio (2018) concluded that the value of a one-way 25cl bottle derives from its ease of opening (it has a twist-off cap), moderated volumes for responsible or quick consumption, and ease of disposal where no care has to be taken in getting a deposit back. Portability is also important, which ties into the fact that 28% of the participants (n=101) consume the product on-the-go and another 64% out-of-home. Similar conclusions were made in the research from Blauw (2018), adding that the format is too small for many consumers, although the unit size means that it is less likely that the beer will get warm before it is consumed, making it ideal for outside consumption.

The expert interviews led to similar conclusions; unit volumes are likely linked to moderation or increased portability for on-the-go scenarios. Additionally, it is a matter of changing consumer profiles. The quantity of smaller, and single-person families is growing and these households have different demands than traditional households as they are likely to prefer smaller volumes (Delle Selve, 2019; Marceux, 2019). Similarly, elderly people living on their own also require smaller portions (Keuenhof, 2019). In conclusion, there is a clear market to be satisfied by smaller unit volumes with the increased importance of on-the-go consumption scenarios and changing family structures. Therefore, although from a carbon footprint perspective it is attractive to increase unit volumes, from a consumer perspective it is not.

6.3 Country recycling rate

The disposal stage can be regarded as the most inconvenient phase of the consumer journey. The moment of consumption has passed and consumers are left with the unfortunate task to return or recycle their glass waste, which necessitates the consumer to leave their homes. Fortunately, the

Netherlands has a history with recycle and return schemes for glass bottles. This is important, as it is acknowledged that the largest driver to return glass bottles is whether the disposal procedure fits within people's existing routines (HNK & Koos Service Design, 2018). Nonetheless, compared to other materials which can be disposed in the regular bin, both returning and recycling glass are inconvenient (Keuenhof, 2019).

Barriers to proper disposal conduct

Even though the disposal process is habitual for the majority of the Dutch consumers, around 16% of the glass does not get recycled (FEVE, 2019) and an unknown part of the returnable glass bottles is not returned. There are a several barriers that are responsible for improper disposal conduct. One factor that can constitute of a barrier is the consumption scenario. Especially consumption scenarios in which disposal requires more effort, such as in on-the-go scenarios, consumers are more inclined to improperly dispose of their packaging, making these waste streams are difficult to control (de Koeijer, 2019; HNK & Koos Service Design, 2018).

Another factor which plays a role in almost all sustainability-related behavioural issues is the lack of environmental awareness and knowledge of proper recycling conduct. In a study by Geiger (2019a), where the author emphasises that consumers with a low personal ecological norm are less inclined to recycle. As Keuenhof put it *"people think that glass is glass, right? Whether it is a tea glass or a jar for pickles. Some people also put ceramics in the glass bin"* (Keuenhof, 2019). The consequence is that the glass waste stream gets contaminated, which lowers the quality of the cullet and consequently also of the percentage of cullet that can be used in a bottle. Especially in consumer groups which are less engaged with environmental friendly behaviour, convenience plays a role. These consumers perceive the disposal process as too much effort or feel that they already have so many aspects to think about with regards to recycling that they are allowed to put in less effort (Keuenhof, 2019). Factors such as distance to the bottle bank or supermarket, frequency of disposal and the perceived difficulty of recycling contribute to the perception of inconvenience (Geiger, 2019b). Finally, the fact that glass performs poorly in portability is also relevant, particularly for consumers with disabilities or elderly people.

> *"I can manage taking one or two crates to a supermarket a kilometre away, but not everyone can. Especially if you have ten empty bottles, then I can imagine that people throw them in the bin once in a while" ~ Keuenhof (2019)*

7. Company strategies for carbon footprint reduction

After having discussed all factors that determine the purchase behaviour of consumers in a FMCG context and the role of convenience in the three strategies, the results from the carbon footprint and the consumer research can be integrated. After each strategy and its associated barriers to overcome are discussed, an estimation of the carbon footprint reduction potential is provided. The calculated potential is based on both the analysis of the sensitivity parameters in the carbon footprint (Figure 28). By integrating all previous findings, the third research question "*What strategies can beverage companies employ to stimulate consumer behaviour that produces minimal environmental impact?*" is answered.

Figure 28 - Potential for carbon reduction based on volume consumed in the Netherlands for the three key strategies

7.1 Type of packaging – transition from one-way to returnable bottles

From a carbon footprint perspective, transitioning towards returnable glass bottles represents the most desirable strategy. From a consumer perspective, however, three factors were recognised to impede the transition from one-way to returnable glass bottles: wear and tear, deposit money and availability of different volume and pack sizes. In the next sections, it is discussed how these barriers can be overcome.

7.1.1 Unit convenience and consumption scenarios

As consumers purchase their desired product based on the expected consumption scenario, availability of the right unit type is crucial. For companies like Heineken, this means introducing multiple unit volumes (25cl, 30cl or 33cl) and pack sizes (6-pack or 12-pack) for their returnable glass bottles. However, the issue with smaller pack sizes is that the financial incentive of the deposit can be too low (HNK & Koos Service Design, 2018). By introducing smaller crate sizes or modular crates (which can be split in smaller crate sizes if necessary), the financial incentive can be improved as a deposit for the crate is added. Moreover, smaller crate sizes could increase the portability of returnable bottles as well as function as a smaller storage unit.

Regardless of the availability of different unit volumes and pack sizes, the returnable bottle cannot fulfil all consumption scenarios equally well. On-the-go consumption is more difficult to fulfil with returnable bottles, since that would require consumers to preserve their bottle until they are at a supermarket or return home, something consumers do not prefer as it requires too much effort. From the various research conducted by Heineken Netherlands, it can however be concluded that apart from the 25cl bottle, most Heineken products are either consumed at or around the consumers' homes (Kantar TNS, 2017; Schils & Hoogwerf, 2018; The Conversation Studio, 2018). Even for the 25cl bottle, the majority of the bottles are consumed at home (70%) or on out-of-home occasions (64%), while only 28% of the respondents indicated that they consumed the bottle on-the-go (The Conversation Studio, 2018). The share of the 25cl bottles of the volume produced in the Netherlands is 24%. As 96% of the one-way bottle volume produced in the Netherlands is exported, the on-the-go scenario would therefore address less than 0.3% of the volume *produced* in the Netherlands and therefore does not present a significant barrier to the transition towards returnable bottles. Nevertheless, to avoid losing this market share, either one-way glass bottles can still be supplied (which in the end suffer from the same disposal constraint, although bottle banks are more accessible) or alternative packaging materials such as the aluminium can need to be provided, which currently all have higher carbon footprints than returnable glass bottles. Only PET bottles have a similar carbon footprint, but these are unlikely to be accepted by the consumer as a beer beverage container (leaving aside other environmental issues associated with plastics). New low-weight innovations such as flax (Arthur, 2018) or wood fibre bottles (Carlsberg Group, 2016) might provide to be portable sustainable alternatives in the future.

7.1.2 Deposit money and wear and tear

To overcome the remaining negative associations with wear and tear and deposit money a strong communication strategy is needed. Wear and tear is usually merely an aesthetic issue which sparks the association of lesser quality, just as Heineken 0.0% had the association that it is 'uncool' (Abboud, 2019). To overcome this association for Heineken 0.0%, Heineken recommended their operating companies in different countries to spend up to 25 percent of their marketing budget (Abboud, 2019), which signifies the relevance of communication in changing perceptions. By creating a positive or at least less negative association with wear and tear, acceptance of wear and tear could be increased which could perhaps justify looser restrictions on the condition of a returnable bottle before it gets rejected (as long as quality requirements are met) and therefore increase trip rates, lowering the carbon footprint.

Although deposit money does not necessarily suffer from negative associations, since the majority of consumers even positively associates it with environmental wellbeing (Schils & Hoogwerf, 2018), deposit money still faces apprehension due to the need for financial investment and obligation to return the bottle. In parallel, there is scepticism about the added sustainable value of returning versus recycling glass, as consumers are unsure what exactly happens after handing in their returnable bottle (HNK & Koos Service Design, 2018; Rivet, 2019). As a consequence, the deposit money is seen only as an obligatory and financial nuisance rather than added value. Communicating about the reasons for the deposit – why consumers should return their bottle – and the beneficial impact of it, can increase the willingness for consumers to pay such a deposit. Naturally, this strategy should be employed in addition to making the disposal process more convenient, which is a final barrier to the convenience-oriented consumer segments in purchasing a returnable bottle. This is discussed in section 7.3.

7.1.3 Potential for carbon reduction

As most of the barriers presented in the previous two sections can be overcome by the described interventions – mostly in the form of increased communication – it is not expected that consumer purchase behaviour constitutes of a major barrier to the transition from one-way to returnable bottles within the Netherlands. As the current share of returnable is 89%, it is likely that a shift of 10-11% is viable. Switching the remaining 10-11% would decrease the carbon footprint by 2.35-2.62 kg CO_2e per hectolitre, which is 13-15% of the current carbon footprint (Table 18).

Table 18 - Carbon footprint reduction when moving to a 100% share of returnable bottles.

KG CO_2E/HL	PACKAGING PRODUCTION	CLEANING	COOLING	DISTRIBUTION	DISPOSAL	TOTAL (89% RET)	TOTAL (100% RET)
ONE-WAY GLASS BOTTLE	44.76	-	9.89	1.22	(17.30)	38.57	
RETURNABLE GLASS BOTTLE	4.09	0.59	9.89	1.74	(1.24)	15.07	15.07
						17.69	**15.07**

7.2 Lightweighting

Lightweighting is a strategy which involves both cost savings and carbon footprint reduction. As pointed out by de Koeijer, '*if you can reduce material usage by 10% through lightweighting, which means you reduce cost as well as the carbon footprint, you would be out of your mind as a company to not grab that opportunity*" (de Koeijer, 2019). If lightweighting is performed on packaging without communicating it to the wider public, consumers are unlikely to notice the difference in weight. Although lightweighting can be marketed as a sustainable innovation, on its own it is essentially a linear strategy where the same packaging material is used to a lesser extent (Steenis, 2019). Therefore, companies should be careful with solely communicating lightweighting efforts – especially regarding one-way bottles – as this might be critically received by consumers who question the effort and commitment of a company if lightweighting one-way bottles is 'all they do for sustainability'. It can, however, be used in combination with other strategies, like the transition to returnable bottles, as that goes beyond increasing the efficiency of a linear strategy. In conclusion, as long as the communication of lightweighting of one-way bottles is avoided, lightweighting is likely to be received positively by the consumer. Therefore, consumer purchase behaviour is expected to have no negative influence on the carbon footprint potential of lightweighting.

As lightweighting strategies are not influenced by consumer demand, the potential calculated in chapter 4.3.2 (see Figure 28) can be reached as long as the operational barriers are overcome. Consequently, a 10% reduction in weight for one-way bottles will lead to a 7% reduction of the total carbon footprint of one-way bottles, or an equivalent of 2.8kg CO_2e per hectolitre. A 10% reduction in weight for returnable bottles additionally results in a 3% reduction in the carbon footprint of returnable bottles, or the equivalent of 0.4kg CO_2e per hectolitre. In total, this leads to a reduction of 3% – or 0.6kg CO_2e per hectolitre – of the total carbon footprint within the Netherlands, as a consequence of the high share of returnable bottles (89%).

7.2.1 Unit volume

The smaller the unit volume, the higher the relative weight of the packaging needed per hl. Every kilogram of glass produced increases the carbon footprint by 0.799kg CO_2e, which is multiplied by the weight-content ratio [kg/hl] to get the emission factor per functional unit [hl]. Therefore, the higher the weight-content ratio, the higher the resulting carbon emissions.

According to Heineken forecasts, the average unit volume of glass bottles produced in the Netherlands will decline by 2% over the course of twelve years for one-way bottles and increase by 4.4% for returnable bottles. This confirms the trend recognised in chapter 6.2, where it was expected that due to the evolving consumer profiles and increased desire for moderation for some consumer groups, the availability of smaller unit volumes would become more important. Nevertheless, the expected trend has only established itself slightly for one-way bottles, while the reverse is true for returnable bottles. Instead, the unit volumes of both types seem to be converging towards 330 millilitres. The expected change in unit volume results in a 2.1% *increase* per kgCO_2e per hectolitre for one-way bottles and a 4.2% *decrease* per kgCO_2e per hectolitre for returnable bottles. Overall, following the current packaging split (RET: 89%, OW: 11%), this indicates that the carbon footprint would decrease by 3.5% over the course of twelve years. This would lead to a reduction of 0.5kg CO_2e per hectolitre after twelve years.

7.3 Disposal behaviour and country recycle rate

Since perceived difficulty and convenience of recycling play a major role in consumers' disposal behaviour, innovations that reduce disposal effort can stimulate the recycling and return rate. Effective measures to reduce effort include decreasing the distance to the bottle bank by increasing the amount of available bottle banks (Geiger, 2019b; Rivet, 2019), introducing smaller crate sizes (Blauw, 2018) or supplying hard-cased reusable bottle cases that consumers can use to transport their individual bottles to improve its portability.

According to a study from Lee, Eatherley & Garcia (2018), the highest country recycle rates are achieved in the cases where there is "*source-separated collection of glass packaging, good governance of waste management systems, and effective public communication initiatives (p.57)*". Since the first two factors are present in the Netherlands, the latter is especially important in increasing the recycle rate. Communication on proper recycling conduct and especially on the reason for recycling or returning glass bottles is therefore essential to provide consumers with the right motivation. Particularly in the case of returning bottles to the supermarket, consumers may not know whether the bottle is going to be refilled or crushed and then re-melted (Rivet, 2019). As discussed in section 5.2.2, the best approach is to convey this information in a manner for which the consumer has to put in the least effort, since the majority of the consumers would not take the time and effort to look for such information (Keuenhof, 2019). In her research, Geiger (2019a) proposes such an approach, where she postulates that the prime driver of sustainable behaviour is the packaging design itself. If the packaging design is perceived to be sustainable, consumers are more likely to behave sustainable as well in disposal. To be perceived sustainable, it is especially important to link the aesthetics with the environment (for instance by depicting a tree if the packaging is made from paper). Finally, it is again important to collaborate with a governmental or NGO type of organisations as to keep communicating the message of how and why to recycle on a regular basis in a credible and non-biased manner (Keuenhof, 2019).

7.3.2 Potential for Carbon Reduction

Arguably, the country recycle rate is the most difficult parameter to influence from a brands' perspective, as brands do not have a lot of influence on the disposal behaviour of consumers apart from making the packaging convenient to dispose of by, for example, introducing smaller crate sizes or hard-cased packs which can facilitate portability. Since both types of bottles are made from glass, both require out of home disposal and are therefore by definition considered to be inconvenient to dispose of. Solutions to make the disposal process more convenient – such as increasing the availability of bottle banks – are usually outside of the scope of the brand and require an industry-wide or national approach. A similar picture arises in terms of communication on recycling or returning glass bottles, as this information is more credible from outside organisations rather than the brands. For that reason, limited potential to decrease the carbon footprint is expected on top of the general trend of the recycle rate.

The recycle rate in the Netherlands has been relatively stable over the last years (FEVE, 2018, 2019), increasing by only 1% between 2015-2016. Assuming that the trend of 1% increase of the country recycle rate will continue, the carbon footprint for one-way bottles will decrease by 0.53% – 0.21kg CO_2e per hectolitre – and for returnable bottles by 0.1% or 0.02kg CO_2e per hectolitre. Overall, as the majority of the share is kept by returnable bottles, this will decrease the carbon footprint of glass packaging by 0.15% or 0.03kg CO_2e per hectolitre per year.

7.4 Synthesis

In summary, from the three discussed strategies the transition to returnable bottles has the most potential for the Netherlands, although lightweighting is in turn the most accessible strategy. The high share of returnable bottles (89%) results in the limited potential for the strategies other than a further transition to returnable bottles. Since returnable bottles are cycled multiple times, the glass production and disposal emissions are spread out over various life cycles, lowering the effect of a change in these parameters on the overall carbon footprint. The first priority for all volume produced for consumption within the Netherlands is therefore to transition to a 100% returnable bottles. If all strategies are combined, the carbon footprint can be reduced by 17% in total (3kg CO_2e per hectolitre), which would reduce the carbon footprint to 14.73kg CO_2e per hectolitre (Figure 29).

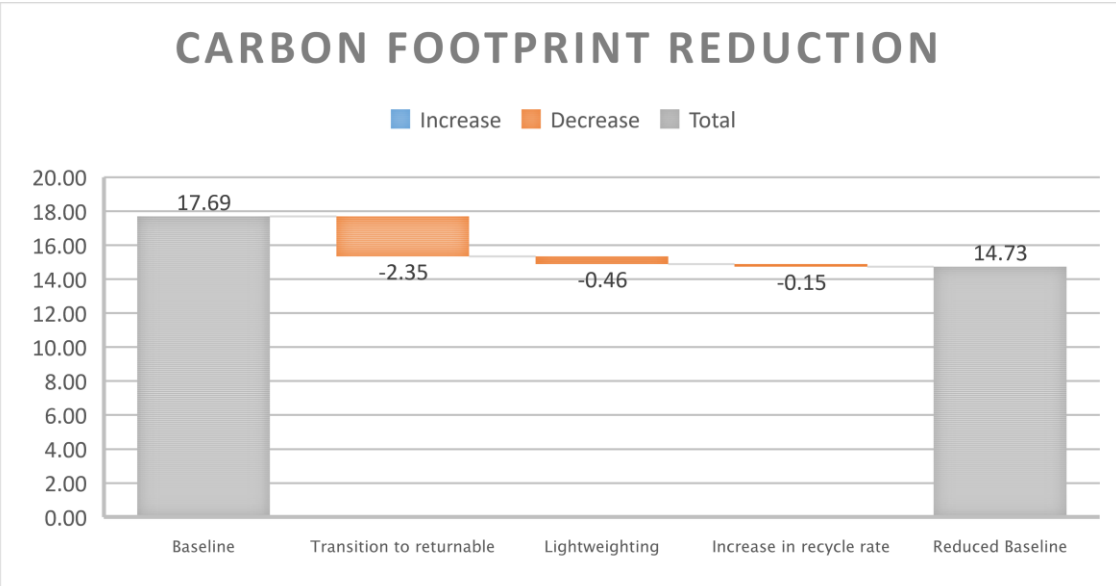

Figure 29 - Combined carbon footprint reduction

8. Scaling up – US case study

The majority of the volume in glass bottles produced by Heineken Netherlands (77%) is not consumed domestically. In the previous analysis of the results, export has not been taken into account since it is outside of the geographical scope of the Netherlands. The purpose of this chapter is to examine what is required to scale up the results from the Netherlands to other countries with a different infrastructure (e.g. different waste collection system or reverse logistics) or cultures around the refilling or recycling of glass bottles. To that end, a case study is performed on the United States. The choice for the United States as a case study is based on two reasons:

1. 67% of the volume of one-way bottles imported by Heineken in the US is produced in the Netherlands. At the same time, the US is the largest export market for the Netherlands.
2. In the United States, the tradition of using returnable bottles – which is pervasive in the Netherlands – is largely gone. Therefore, it provides an interesting case study on the importance of consumer behaviour and habit with regards to returnable bottles.

Within the United States there is a large difference between states in terms of regulation, habits and other elements relevant for the carbon footprint. The largest difference exists between states that have the Bottle Bill legislation, and the countries who do not. Bottle Bills ensure a multi-stream waste infrastructure through which glass is collected separately from other materials, unlike what happens in kerbside collection where all waste is collected in one container, often leading to contamination (Collins, 2017). Bottle Bill states generally have a recycling rate of glass of around 60-65%, while non-Bottle Bill states have a much lower average recycling rate of only 24% (Container Recycling Institute, n.d.; Glass Packaging Institute, 2015). In appendix 4, a description of how a Bottle Bill works is given by examining two states: California and New York.

8.1 United States beer market characteristics

Since Heineken does own a brewery in the US, all Heineken beer beverages is imported. The volume is primarily produced in two countries: Mexico (32%) and the Netherlands (67%). All Heineken beer is imported into the US for two main reasons:

i. *Brand image.* Heineken is considered a premium import beer: its value comes from the fact that it is produced outside of the US. If it would be produced locally it would lose this image and risk losing market share (Griffioen, 2019; Keuenhof, 2019).
ii. *Alternatives are costlier.* The volume sold in the US is not significant enough to build multiple breweries at different locations in the US. Having only one inland brewery would require more financial investment and would potentially also emit more greenhouse gases due to large transportation distances by truck, whereas currently most imported beer is transported by ship. Transporting beer in bulk and only bottling in the US would reduce the carbon emissions significantly, but this is not feasible due to quality concerns that would arise if beer is transported in bulk over such distances (Griffioen, 2019).

No returnable bottles are utilised in the US as the entire volume is imported and no return infrastructure exists. US consumers seem to prefer international beer brands, resulting in a large import flow of imported international brands, making it complex to maintain a refillable bottle system (Adams, 2006). Recently, however, microbreweries and regional craft breweries seem to gain in importance, potentially increasing beer consumption on a more regional scale and thereby opening up opportunities to pack these products in refillable bottles in some states (Fitzner, 2018).

8.2 United States consumer behaviour

Environmental awareness, knowledge of recycling and knowing the reason to recycle are all relevant factors for increasing recycling rates (Delle Selve, 2019; Fensl, Rubin, & Walsh, 2019). In the Netherlands, the deposit system for returnable bottles and recycling of glass bottles in bottle banks is culturally embedded into day-to-day practices. In the US, however, recycling is not part of the culture (Heineken

USA, 2018). The Recycling Partnership (2019b) conducted a survey among 2000 respondents to get their opinion on recycling, climate change and waste. Although awareness and attitude are not an issue – 87% of the consumers felt recycling is important – respondents indicate that recycling is difficult (29%), that they lack adequate access (52%) or that it is not convenient (33%) (The Recycling Partnership, 2018, 2019b). The latter factor indicates much similarity with the research performed for the Netherlands: convenience is an important factor in disposal decisions. The middle two factors, however, point towards a more structural barrier: a lack of a proper recycling structure.

8.3 Shortcomings of the recycling infrastructure

Bottle Bill states such as California and New York perform well in comparison to other states in terms of waste management, owing to the multi-stream waste management system elicited by these Bottle Bills. However, overall only 39% of the Heineken volume imported into the US is sold in states with a Bottle Bill in place (22% and 9% in, respectively, California and New York) and even in Bottle Bill states not all bottles are collected through the deposit system. In other states, waste management is most often organised through kerbside collection. According to the Container Recycling Institute (2019b), approximately 73% of the US citizens had access to kerbside recycling in 2017. If kerbside programs are not available, drop-off programs are provided. Hence, a large proportion of the waste streams in the US is single-source, i.e. no separation of waste is performed at source. Although this is often the cheaper option in terms of waste collection, it results in contaminated waste streams, thereby lowering the quality of the available resources. Since glass is fragile, it often breaks into small pieces and is mixed with the other materials and glass colours and consequently gets contaminated to the point that it cannot be used as cullet for new bottles, but is instead used for road construction or as landfill cover (Kersten-Johnston, 2019). The economics of this end-use of recycled glass are poor: operators of a kerbside program often have to pay Material Recovery Facilities (MFR) to get rid of the glass. The average commodity revenue of single-stream glass was -$20 per tonne in March, 2019 (The Recycling Partnership, 2019a). Nonetheless, even source-separated drop-off glass faces a similar issue. In 2017, kerbside glass had the negative value of -$21 per tonne, while source-separate drop-off glass performed only slightly better with -$19 per tonne (Container Recycling Institute, 2019b). The consequence of these high costs for processing glass is that multiple organisations have dropped glass from their recycling programs (The Recycling Partnership, 2016). Subsequently, consumers have to travel further if they want to recycle their bottles, adding to the inconvenience of the disposal process.

This situation represents the largest barrier for glass recycling; there is no incentive to recycle glass due to the low commodity value (especially of single-source glass), there is no end market (due to the low quality) and consequently there is also no incentive to invest in better waste management systems to ensure high quality cullet for new bottle-making. This presents a stark contrast to the European situation, where there is high demand, but a large shortage of cullet. Nonetheless, attempts to export cullet from the US to Europe had been halted due to the low quality of the contaminated cullet from the US (Kersten-Johnston, 2019).

8.4 United States Carbon Footprint

In order to get an idea of what effect the three strategies discussed for the Netherlands would have on the carbon footprint of Heineken in the US, the carbon footprint of the glass bottles exported to the US is constructed. As the bottles are produced in the Netherlands, the emission factor of production remains similar. However, cooling, distribution and disposal all differ. Data for cooling was not available for the US, hence, as this life cycle process does not differ between the two glass bottle types and since cooling is not affected by any of the three strategies, it is left out of the scope of this exercise. The life cycle inventory for distribution is presented in Appendix 5, as the calculations required slightly different parameters than the calculation performed in Chapter 4 for the Netherlands. The calculation for disposal remains similar, although it consists of different parameters specific to the US.

In calculating distribution emissions, two scenarios have been considered; distribution to 1) the East Coast and 2) the West Coast of the US. The transport route of both scenarios is presented in Figure 30. Table 19 shows the emission factors and transportation distances in both scenarios. Inbound distribution comprises of the transportation from the brewery of Zoeterwoude to one of the US ports, while outbound distribution consists of the distance covered from the ports to the final consumer. Data on the transportation distances was collected from the Heineken Green Logistics stream. Warehousing is left out of scope of this calculation due to its small contribution to the overall distribution emissions.

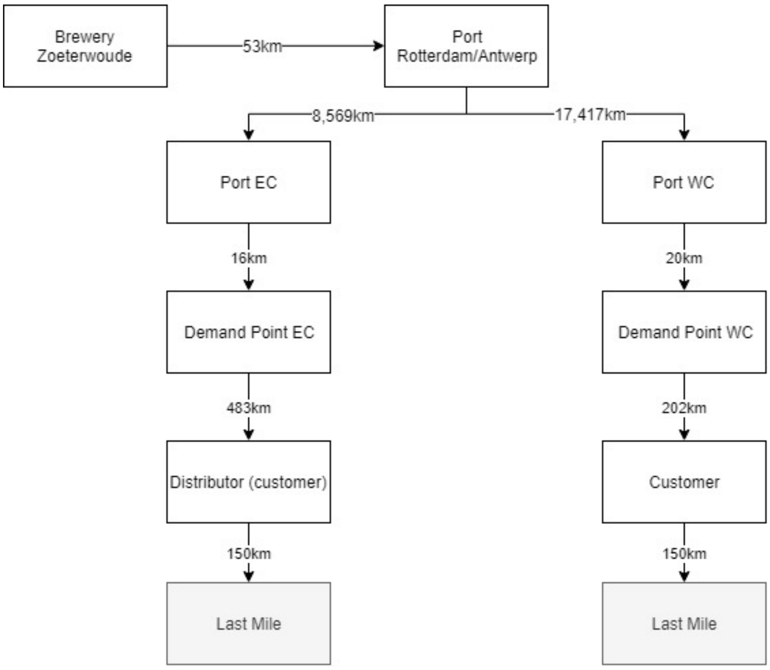

Figure 30 - Transport route to the East- and West Coast of the US

Table 19 - Emission Factors and Transportation distance for the US scenarios per packaging type

	ONE-WAY BOTTLES		RETURNABLE BOTTLES			
	EF East Coast [kg CO_2e/hl]	EF West Coast [kg CO_2e/hl]	EF East Coast [kg CO_2e/hl]	EF West Coast [kg CO_2e/hl]	Transport distance [km] - East Coast	Transport distance [km] - West Coast
INBOUND	12.9	24.8	30.4	58.8	8,622	17,474
OUTBOUND	8.3	4.7	11.2	6.4	649	372
TOTAL	**21.2**	**29.5**	**41.5**	**65.2**	**9,271**	**17,846**

Disposal emissions were calculated using the same formula as presented in chapter 4.1.4. Four scenarios were considered:

- **Non-Bottle Bill states**, where the average recycle rate is 24%. This scenario is calculated for both the East- and the West Coast.
- **East Coast**. Disposal parameters are based on the data collected on New York in Appendix 4. The recycle rate in New York is 70%.
- **West Coast**. Disposal parameters are based on the data collected on California in Appendix 4. The recycle rate in California is 69%.

The disposal emissions of returnable bottles are similar to the Dutch case, as it is assumed that these bottles are returned and therefore recycled eventually in the Netherlands. All in all, the carbon footprint in these three scenarios is presented in Table 20.

Table 20 - Data on Carbon Footprint per life cycle stage in all three scenarios

EAST COAST NON-BOTTLE BILL STATE	**PACKAGING PRODUCTION**	**CLEANING**	**DISTRIBUTION**	**DISPOSAL**	**TOTAL**
ONE-WAY GLASS BOTTLE	44.76	-	21.20	(3.77)	62.19
RETURNABLE GLASS BOTTLE	4.09	0.59	41.53	(1.24)	44.98

EAST COAST NEW YORK	**PACKAGING PRODUCTION**	**CLEANING**	**DISTRIBUTION**	**DISPOSAL**	**TOTAL**
ONE-WAY GLASS BOTTLE	44.76	-	21.20	(14.00)	51.95
RETURNABLE GLASS BOTTLE	4.09	0.59	41.53	(1.24)	44.98

WEST COAST NON-BOTTLE BILL STATE	**PACKAGING PRODUCTION**	**CLEANING**	**DISTRIBUTION**	**DISPOSAL**	**TOTAL**
ONE-WAY GLASS BOTTLE	44.76	-	29.51	(3.77)	70.51
RETURNABLE GLASS BOTTLE	4.09	0.59	65.18	(1.24)	68.63

WEST COAST CALIFORNIA	**PACKAGING PRODUCTION**	**CLEANING**	**DISTRIBUTION**	**DISPOSAL**	**TOTAL**
ONE-WAY GLASS BOTTLE	44.76	-	29.51	(13.78)	60.49
RETURNABLE GLASS BOTTLE	4.09	0.59	65.18	(1.24)	68.63

The resulting carbon footprints indicate that for the US, distribution plays a more significant role than in the Netherlands. Distribution now contributes 92-95% of the carbon emissions in the carbon footprint of returnable bottles, and 34-42% for the carbon footprint of one-way bottles. Also disposal plays a much more significant role due to lower recycle rates, especially in the non-Bottle Bill states.

To examine whether the three strategies discussed for the Netherlands are also effective in the US, the carbon footprint reduction potentials were calculated. As shown in Figure 31, there are key differences with the carbon footprint potential calculated for the Dutch supply chain. First of all, the transition to returnable bottles shows the lowest potential, especially in the West Coast scenarios due to the high distribution emissions that are the result of return logistics. Second, the other two strategies have a higher carbon reduction potential due to the 100% share of one-way bottles on which these strategies have the largest impact. From these reduction potentials, it can be concluded that the preferred strategy for the US is the lightweighting of bottles produced in the Netherlands (which would also have an effect on the Dutch carbon footprint). Increasing the country recycle rate elicits the second highest carbon reduction potential, but as discussed in the previous section, it is difficult to improve in the non- Bottle Bill states due to the current ineffective disposal infrastructure. The best course of action therefore seems to be to either implement a private reverse logistics infrastructure to promote recycling (or even reuse) of glass bottles or to lobby for a Bottle Bill. Finally, although the transition to returnable bottles does not show nearly as much potential as in the Netherlands, it must be acknowledged that the weights of glass bottles can only be reduced to a certain extent, while there is much more room for improvement in the share of returnable bottles compared to one-way bottles. In the hypothetical case that all exported bottles to the East Coast are shifted to returnable bottles, a reduction of 28% in carbon emissions can be gained (17.2kg CO_2e per hectolitre). For the West Coast, however, the shift to returnable bottles is not desirable unless the returnable bottles are transported from/to a closer destination, such as Mexico.

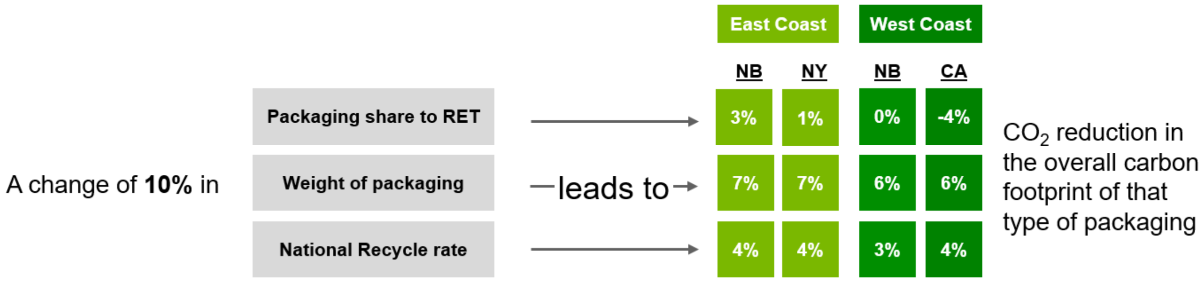

Figure 31 - Carbon Footprint reduction for each 10% change for the three strategies in all four scenarios. NB = non-bottle state, NY = New York and CA = California.

Finally, a couple of additional insights on the three strategies can be gathered from comparing the US with the results from the Netherlands that can be relevant to consider when aiming to apply these strategies in other countries:

- For all strategies, the packaging mix is important. If the share of one-way bottles is high, both lightweighting and increasing the country recycle rate are much more beneficial than when the share of returnable bottles is high, as both strategies affect the emission factor of glass production which – in the case of returnable bottles – is divided through the trip rate.
- The transition to returnable bottles with bottling in the Netherlands is only recommendable when the transportation distances are lower than 12,000km (Chapter 4.3.5). Furthermore, if consumers are to some extent familiar with a take-back culture or are used to recycling other materials, both the transition to returnable and increasing the country recycle rate are easier to facilitate, especially with the right communication strategy to overcome any remaining consumer barriers.
- Increasing the country recycle rate is difficult in all cases. Requirements for a high recycle rate are 1) an effective disposal infrastructure, 2) supporting legislation and 3) consumer knowledge and awareness. For each country, it should be explored which of the three requirements are not met and efforts should be focussed on improving that parameter.

8.5 Potential for upscaling the findings to other countries

This chapter aimed to answer the question '*can learnings from the Netherlands be scaled up to other regions like the US?*' From the information gathered on the US, it can be concluded that at least it is not a straightforward duplication exercise. Due to the difference in disposal infrastructure, the strategies of transitioning to returnable bottles and increasing the recycle rate are much more complex in the US than in the Netherlands. Whereas in the Netherlands it is a matter of overcoming barriers of consumer behaviour, in the US the barriers are much more related to the inefficient disposal infrastructure and large distribution distances. Therefore, it can be concluded that the gathered insights on the carbon footprint for the Dutch case can only be applied to other countries that present a similar scenario to the Netherlands. This means that transportation distances should not be larger than presented in the scenario of the West Coast of the US, as otherwise the transition to returnable bottles is ineffective in reducing carbon emissions. Moreover, a reasonable disposal infrastructure should exist, since if these structures are not yet available, targeting consumer behaviour is futile. Finally, it should also be acknowledged that cultural differences may affect the generalisability of the results. Therefore, additional consumer research studies should be conducted regionally to account for local characteristics of consumer purchase behaviour.

Aside from direct duplication, the case study has shown that the methodology can be replicated in order to derive the effectiveness of strategies from both a carbon footprint perspective, a consumer perspective and even from a structural perspective (e.g. are the right structures in place to facilitate the strategies). By comparing the carbon footprints, it can be concluded that especially the variables on distribution and disposal can constitute of significant differences. Moreover, although this was not the case in this comparison, supplier emissions can also differ significantly per country. In order to perform consumer research in other countries, the following questions can be asked:

- Is there a disposal infrastructure available? Is waste management effective?
- Is legislation supportive of the required disposal infrastructure (for one-way and/or for returnable bottles)?
- Are consumers used to recycling or reuse – or in other words – is there a take-back culture?
- Is sustainability perceived positively? Do consumers have high personal ecological norms, or is there a supportive social norm?

By answering these questions, combined with a carbon footprint analysis of that country, it can be determined whether the strategies proposed in this study are also relevant to the country under examination and what additional research is necessary.

9. Discussion

The research aimed to provide beverage producers with effective strategies for carbon emission reduction that take into account the increasing desire of consumers for convenience. Both the carbon footprint and the implications from consumer purchase behaviour and convenience on the proposed strategies have been elaborately discussed. In this chapter, these results will be compared to the existing literature and will be evaluated on their contribution to this literature, as well as the validity of the methodology and the findings.

9.1 The Carbon Footprint

In Table 21 an overview is provided of the conclusions made in the literature on the key hotspots within the life cycle of beer packaging. In most cases, packaging production constitutes of the most significant impact in the life cycle of beer , but it is not always found to be the primary impact hotspot for one-way glass packaging (Garnett, 2007; Detzel & Mönckert, 2009). For returnable bottles, the key impact hotspot is generally recognised to be distribution (Detzel & Mönckert, 2009; Garnett, 2007). In the analysis of the carbon footprint of Heineken within the Netherlands, the key impact hotspot for one-way bottles was determined to be the production stage, while for returnable bottles, the main impact hotspot was cooling. This indicates that between the different studies, significant differences exist. These differences between LCA studies may arise from a multitude of reasons, such as the scope of the analysis covering different life cycle stages, the usage of different data sources or due to a different functional unit. For instance, in Garnett's research, the impact of each life cycle stage was calculated using a top-down approach – from aggregated data to more unit-specific data – while the current research followed a bottom-up approach by aggregating data from different SKUs[11] from Heineken into one carbon footprint representing either type of glass bottle. Significant differences in the carbon emissions per functional unit – especially with regards to distribution (Table 22) – were found between the current study and the analysis from Detzel & Mönckert (2009). The underlying reason for this difference is unknown as the authors do not elaborate on their calculation method or data input, but it most likely a result from differences in either input data or emission factors used.

Due to these differences between studies, the range of GHG emissions varied greatly between studies. As the review of Saxe (2010) of eleven LCAs on beer production indicates, values for the *total* life cycle varies from 80 to 150kg CO_2e per hl of beer. This variation underlines the importance of collecting primary data on unit processes per company, because more accurate and higher quality assessments are reached by utilising primary sources rather than using estimates, averages or secondary data from existing databases (European Commission, 2010). Especially if the carbon footprint is used for monitoring, forecasting or identifications of opportunities to reduce carbon emissions, it is essential that the data and scope is tailored to the specific organisation and contains a high degree of accuracy.

Table 21 - Overview of conclusions drawn in various beer LCAs

Author	*Impact hotspots*
Koroneos et al. (2005)	This authors concluded that *bottle production* was responsible for 78% of the global warming potential. Similar to this research, they excluded the cultivation of raw materials from their scope. The functional unit was defined as one bottle of beer (0.52 litre beer and 0.545kg of green glass).
Cordella et al. (2008)	*Beer consumption phase, glass bottle production* and *barley cultivation* were found to be the critical stages of the beer life cycle. Functional units under consideration were beer in 20l returnable stainless steel kegs and beer in 33cl one way glass bottles.

[11] A Stock Keeping Unit (SKU) indicates a unique product meant for sale.

Talve (2001)	*Agricultural processes* were the most impactful life cycle stage, although bottle production and recycling were excluded from the analysis. Functional unit was defined as 505 six-packs (10hl) of lager beer packed in glass bottles.
Garnett (2007)	The *consumption stage* is the key hotspot for beer, followed by *transport* and then *packaging production*. The analysis was performed based on an aggregated level, therefore including different packaging types.
Detzel & Mönckert (2009)	The primary hotspot was identified to be the *transportation* of bottled beer. The functional unit has been defined as the type and amount of packaging required to pack and deliver 1,000 l of beer to the point-of-sale. Packaging types under consideration were a refillable glass bottle, a disposable glass bottle, a steel can and an aluminium can, all having a unit volume of 330ml.

Table 22 - Carbon emissions per functional unit for two transportation distances. Carbon footprints of the current study are based on section 4.3.5 Transportation distance

KG CO_2E PER HL	100KM	680KM
DETZEL & MÖNCKERT (2009)	9.2	18.4
CURRENT STUDY	1.2 - 1.7	8.6-11.7

In the current study, various assumptions were made within the calculation of the carbon footprint, primarily with regards to returnable bottles. For the calculation of one-way bottles, hardly any assumptions needed to be made, except for cooling – which is discussed in the next paragraph – and the packaging split in outbound distribution, which did not have significant impact. Regardless, two variables should be stressed that are important to maintain high quality data due to their key role in the calculation of the carbon footprint of one-way bottles: the weight of the packaging and the supplier emission factor. Especially the latter factor is sensitive. Whereas the data on the weight of the glass bottles is known within Heineken (internal data), the emission of glass bottle production can only be provided by the suppliers. Not all suppliers are – and were – willing to provide the necessary information because of confidentiality concerns. Additionally, yearly improvements in supplier emissions can also have a substantial impact (i.e. a 1% reduction reduces the total carbon footprint by 0.9%). Therefore, this data needs to be continuously updated for a good representation of the carbon footprint. Despite the increased complexity of data collection from external suppliers, Heineken currently has collected the emission factor data for more than 95% of their glass bottle suppliers (Griffioen, 2019).

The majority of the volume consumed within the Netherlands is provided in returnable bottles. Currently, cooling represents 66% of the impact, which can increase to 70% if the transition to 100% returnable bottles is made. Although cooling had no direct interconnection with consumer behaviour, the high impact makes it a salient topic to explore for further reduction. Aside from cooling, packaging production is still considered an impact hotspot for returnable bottles as it represents 19% of the carbon footprint. Both impact hotspots – cooling and packaging production – depend to some extent on assumptions in calculating the carbon footprint for returnable bottles. For the cooling emission calculations, the most sensitive variable is the channel split (e.g. what kind of cooling systems are used). The channel split is currently assigned based on previous calculations performed in 2015 with the assumption that the current split remained roughly similar. Further research should be conducted with Heineken's retail partners on the actual channel split to verify whether this assumption is indeed correct. A second important and sensitive variable is the trip rate, which significantly affects the emissions from bottle production for returnable bottles. In this study, the trip rate is based on the estimation of fourteen reuse cycles made by Heineken based on feedback from their operating countries. Heineken currently does not collect information on the country specific trip rates and uses the global average emission factor for returnable bottles in calculating its carbon footprint. To reduce uncertainty in the calculation of the carbon footprint of returnable bottles, data can best be collected on the trip rate per country instead of using a global average emission factor.

9.1.1 Carbon Footprint limitations

As data was not continuously and purposively gathered for all variables in constructing the carbon footprint within Heineken, some assumptions or generalisations had to be made in order to do the calculations. Assumptions, estimates or averages were used primarily in the following variables:

- Trip rate
- Cooling channel split
- Packaging split in outbound distribution

Despite that primary data was missing for these variables, the results of the carbon footprint discussed in chapter 4.2 can be considered robust. In whatever extreme these variables are considered, it would not affect the overall conclusion that returnable bottles emit less CO_2e emissions than one-way bottles, nor would it affect the recommendations. Nonetheless, it is recommended for Heineken to examine how data on these variables can be gathered to ensure the collection of primary data for all important variables. For all other variables, primary data was used or collected, also for upstream emissions. In the case primary data was not available, secondary sources (e.g. PEFCR, FEVE) were utilised.

Finally, it must be acknowledged that a single issue LCA, such as the carbon footprint, does not provide a complete picture of what is sustainable, as it represents only one facet of environmental sustainability as a whole. The beer industry typically has an extensive focus on the carbon footprint and water usage, while other environmental aspects of sustainability (e.g. eutrophication, acidification and resource depletion) are of lesser importance. However, a company that performs well on the carbon footprint might not be sustainable if it results in burden shifting. Therefore, although the current study provides a good representation of the carbon footprint of Heineken within the Netherlands, it does not make any judgement on its sustainability.

9.2 Consumer research

No fixed theoretical approach has been established in previous research to integrate the quantitative carbon footprint assessment with qualitative consumer research for the purpose of creating carbon emission reduction strategies. Therefore, the utilised methodology was a first effort to combine and integrate these two topics on a strategy creation level. In contrast, other approaches have been suggested on a product level. For instance, Wever & Vogtländer (2013) have used the approach of Eco-costs/value ratio (EVR) to combine the environmental impact, the cost and the perceived (qualitative) value of products in one quantitative value, the EVR. By taking into account both the quantitative aspects – environmental impact and cost – and the qualitative perceptions of value creation, it provided an equal opportunity for sustainable and traditional alternatives to be compared on equal terms and allowed the integration of these three topics. An alternative method on product level to combine the topics of environmental impact and convenience was used by Hicks (2017). By examining the environmental implications of three different styles of coffee-making, where one style was characterised by high convenience, the environmental impact of the convenient style could be compared to the other styles that were lower in convenience. This presents a second method to find products with the lowest trade-off between the environmental footprint and convenience. However, since the aim of the current study was to examine the effectiveness of different carbon reduction strategies on a packaging category (one-way and returnable glass) rather than comparing the performance of the packaging of different SKUs, both methodologies were not considered to be suitable for the current research. Instead, separate research on consumer purchase behaviour and convenience was performed to derive consumer barriers and drivers for the three carbon emission reduction strategies. Nonetheless, depending on the aim, companies therefore have access to multiple methodologies to integrate qualitative input from consumers into their environmental assessments.

9.2.1 The integrated model of consumer purchase behaviour

For the purpose of analysing consumer barriers and drivers for the carbon reduction strategies, the proposed analytical model (section 2.2.2) was used. The model provided a comprehensive account of the process undergone by consumers in purchase scenarios and was able to consider both convenience and sustainability characteristics. It has served as an extension to the norm-activation model developed by Matthies (2005) with elements of the Theory of Buyer Behaviour from Ajzen (1991). The integration of these models has been an attempt to address some of the critique on both models. First of all, the original norm-activation model by Matthies (2005) assumes that when consumers have acquired sufficient knowledge and act on their personal and the social norm, this will lead to sustainable behaviour. It does consider 'other costs and benefits', but this is vaguely defined and gives no direction in what manner these other costs and benefits affect the purchase decision. Therefore, to cater for the specific setting of the FMCG purchasing context and the importance of functional product characteristics in purchasing decisions of sustainable products, the elements of the Theory of Buyer Behaviour – the input, (brand) predisposition, sensitivity to information and the importance of purchase – were introduced. Second, the critique given on the Theory of Buyer Behaviour is that it relies too heavily on cognition, while it neglects any influence that can result from affect (Hale, Householder, & Greene, 2002), which is a strong component in the model developed by Matthies (2005). By acknowledging that consumers might not have high cognitive involvement in the purchase process, and thus rely mostly on habit, personal and social (ecological) norm, the model can include less rational decision-making that typically characterises decisions made in the FMCG context.

In the examined purchase decisions for sustainable products, environmental awareness and knowledge are two important and recurrent themes. Without awareness on environmental issues, consumers are primarily interested in convenience attributes regardless of the environmental performance of the product. The issue is that the kind of products that satisfy the convenience criteria often incorporate a higher environmental footprint (Hicks, 2017). Once consumers are aware of the environmental harm associated to their purchase or disposal behaviour, they are also more inclined to purchase sustainable packaging and dispose of their empty glass packaging correctly. This confirms the findings of Joshi & Rahman (2015), who found that an individual's environmental concern and knowledge can constitute of a significant driver towards consumer green purchase behaviour. Joshi & Rahman (2015) further assert that a strong personal and social norm increases a consumers' involvement in purchase scenarios. This is confirmed by this research; if consumers have higher environmental awareness, they are more inclined to actively look for information and make their choice based on conscious decision-making. This prevents purchasing situations which rely heavily on habit, brand disposition or categorisation, which provide a disadvantage for sustainable packaging as these products are usually not in the consumers' evoked set.

Nonetheless, even in the cases where consumers seem to be aware of the environmental issues of packaging, actual purchase behaviour does not always reflect this. One explanation is that, although doing well for the environment is rewarding for individuals on a more abstract level, functional characteristics of the product are usually more important in a FMCG purchase scenario. The type of packaging, quality of the product and convenience are the functional characteristics that are primary drivers of product purchase for beer in glass bottles. Environmental considerations are only salient when consumer demands with regards to the functional characteristics are fulfilled. Peattie & Belz (2013) stipulate that, indeed, consumers are interested in sustainable products, but they are generally unwilling to compromise in cost, performance and convenience. Therefore, sustainable products that do not offer similar functional characteristics as traditional products are doomed to fail (Peattie & Belz, 2013). In contrast to the conclusion in this study, the research of Birgelen et al. (2009) concluded that consumers are willing to trade off functional characteristics for sustainability, except for price and taste. In their research, the authors investigated the relation of environmental considerations to other consumer purchase considerations for beverages. Disposability and unit convenience are however not discussed, which may well explain the difference between their study and the current research as both unit convenience (e.g. are different unit volumes and shapes available) and the ease of disposal were identified as influential drivers of product purchase.

9.2.2 Consumer convenience related to the three strategies

Consumer convenience was understood as the value proposition of companies to reduce consumer's time and effort in either storing, use or disposal of the product (Berry et al., 2002; Farquhar & Rowley, 2009; Hicks, 2017; Kelley, 1958). This definition is supported by the results from the expert interview, who defined consumer convenience as design options that reduces time and effort in transportation, consumption, storage and disposal. One important nuance should be added to this definition: the perception of convenience is context-dependent (personal and situational). It is therefore important to acknowledge different consumer groups and consumption scenarios which demand a varying range of convenience attributes.

Although consumer convenience is identified as one of the primary drivers – both in this research as well as in others (Dam & Trijp, 1994; Hicks, 2017; Rokka & Uusitalo, 2008)– defining the impact of consumer convenience on the carbon footprint discussed in chapter 7 is complex. In the three strategies explored for carbon footprint reduction, convenience played various roles:

1) Returnable bottles perform worse than one-way bottles on two types of convenience: disposability and unit convenience. First of all, returnable bottles are considered inconvenient for disposal due to the necessity to return the bottle, as well as due to the deposit payment. Second, returnable bottles are currently only provided in a twenty-four bottle crate in one unit volume (30cl). If a full transition is considered, different pack sizes and unit volumes need to be introduced in order to fulfil the unit convenience demands that are currently fulfilled by the one-way bottles. With the proposed interventions, however, the transition to returnable bottles is considered to be feasible.
2) Changes in the weight of the packaging are not noticeable if the packaging material is the same. However, consumer convenience does have impact on the unit volumes that are available to the consumer. The desire for smaller unit volumes has a negative influence on the carbon footprint.
3) The country recycle rate is also influenced by consumer convenience, particularly by disposal convenience. The extent to which consumers decide not to dispose of their glass bottles properly due to convenience considerations and the magnitude of the effect of this on the recycle rate is, however, not known and might require additional research. Furthermore, more research is required to explore what effect the proposed solutions in this paper – higher availability of bottle banks, smaller or modular crates or e-commerce – can have on the perceived disposal convenience and consequently on the recycle rate.

In overcoming potential convenience-related barriers of the discussed strategies, the provision of information through a broader communication strategy was established to be an effective measure as consumers with higher personal ecological norm are more likely to consciously consider their in-store decisions and to choose sustainable products. The conclusion that communication is essential for stimulating sustainable consumption and disposal supports results from the research of Mee & Clewes (2013), Silayoi & Speece (2007) and Welfens et al. (2016). Grossman & Wisenblit (1999) additionally proposed that the evaluation of attributes and information in a low involvement purchase context is less important than packaging design elements such as graphics and colour. The current study supports this conclusion, as it was found that non-active information transfer through packaging design is preferred over active information transfer in the purchase scenario. However, for long-term behaviour change aimed at strengthening consumers' personal ecological norm, frequent repetition and exposure of the sustainability message is required outside of the purchase scenario (Evison & Read, 2001; Pickton & Broderick, 2005).

9.3 Limitations and future research

Previously, the limitations of the carbon footprint have been discussed. Several limitations of the overall study still remain and give rise to future research topics.

First of all, the four Heineken studies that were used as data input predominantly used designs which measure the intention of consumers to purchase certain products and rely on direct answers of consumers on their purchase drivers (see discussion on the methodology of these studies in Appendix 3). Results from these types of studies tend to suffer from the intention-behaviour gap, where actual behaviour in the supermarket differs from insights gained in the research. This limitation was attempted to be overcome by the expert interviews and by taking the FMCG context into consideration (which reflects the in-store influences). Nonetheless, for more accurately measuring actual behaviour other research designs need to be considered. One such design is Home User Testing, which relies on input data generated by consumers while using the product and thereby producing data that is more in line with reality. Such research design was considered within the current research, however, due to time and resource constraints it was not executed. Therefore, it is suggested to perform this type of research in the future.

A second limitation derives from the geographically limited scope of to the Netherlands, and to a small extent to the US. Heineken is active in 170+ countries which all have different carbon footprints and culture that could lead to significant differences in results. Results can therefore only be generalised with great care. Further research is needed to embark on similar exercises in other countries where, unlike the Netherlands, a strong take-back culture or infrastructure is not present and which may therefore require different solutions. Moreover, gathering of country-specific data on consumer behaviour and relevant variables for the carbon footprint is essential in finding local solutions. A further limitation of the current methodology is that only few countries can be researched at the same time due to the limited geographical/cultural scope that can be examined by consumer research. In the case that a large portion of the produced glass bottles are exported, like in the Netherlands, only a small portion of the volume can therefore be examined. To draw conclusions for the whole production, consumer data would need to be gathered from all 116 countries it exports to, or at minimum of those countries with dissimilar conditions. Nonetheless, if the consumer research is not performed, there is a risk that strategies to reduce the carbon footprint are not effective due to misalignment with consumer demands. Therefore, this trade-off needs to be considered.

Finally, there was limited literature available for the case study of the United States. This is likely an artefact of the generally much lower involvement with reuse and recycling of glass packaging, which in turn is a consequence of the low commodity value. Fortunately, Heineken USA had performed a range of studies on this topic, which were used as input in the literature review. However, from an academic perspective, it is desirable to drive more academic research on these topics within the US in order to get a better view of the mechanisms at work within the different states that influence consumer behaviour and the effectiveness of the disposal infrastructure. Ironically, research on these topics were available in countries where a high recycle/reuse rate already exist, whereas countries who need improvement, like the US, lack this information. It would therefore be desirable to drive the agenda in these countries to cover these relevant topics in countries where they are lagging behind.

9.4 Scientific and societal relevance

As emphasised throughout the research, a key aim of this thesis has been to combine the quantitative carbon footprint analysis with qualitative consumer insights to arrive at effective and feasible solutions to decrease environmental impact over the whole life cycle of glass packaging for beer. This is especially relevant due to the incongruence that interventions derived from an environmental analysis can have with the market environment and respective consumer demands. By combining these two elements such inconsistencies have been avoided, advocating for research that can elicit such symbiosis of different research designs. In addition, this study has extended the research on environmental impact of glass packaging in the beer industry. Only few environmental analyses have been performed on beer packaging, of which none focussed on the Netherlands or on the comparison between one-way and returnable glass packaging over the whole life cycle. Broadening the base of environmental assessments is important due to the varying data sources, operational boundaries and assessments methods taken by researchers. Finally, in terms of the consumer behaviour part of the research, this thesis has supported the integrated model of consumer purchase behaviour and added additional elements from the Theory of Buyer Behaviour including the importance of purchase, which turned out to be of significance within the purchase behaviour of consumers in a FMCG context. This integrated model should be considered in future research on consumer behaviour within this industry, as it was well-equipped to understand the less rational decision-making context of the FMCG sector.

From a business perspective, the prime value derives from the proposed strategies for beverage producers to reduce their carbon footprint. By providing beverage companies with a range of strategies to reduce their carbon footprint and presenting ways to overcome the identified consumer-related barriers, this research provides them with leverage to make the required steps to meet the goals set by the Paris Agreement. Additionally, the strategies derived from the carbon footprint provide beverage companies with a set of KPI's on which they support further efforts to reduce carbon emissions. A second insight provided by this research is the value in combining knowledge on the carbon emissions of packaging with marketing research. Especially in large organisations there often seems to be a cross-functional misalignment between marketing and procurement, where marketing aims for the best consumer experience and assigns lower importance to emission reductions and procurement wants the lowest cost and emissions and tends to neglect consumer demands. Therefore, symbiosis should be sought to increase the effectiveness of carbon reduction strategies that fulfil both the organisational and the consumer criteria. This requires tighter collaboration between the two departments. Finally, another manner in which value is created – especially for Heineken – is through the comparative case between the US and the Netherlands. This comparison has both shown that the current methodology can be used to derive effective strategies for carbon reduction, but at the same time it highlighted the importance of a regional approach to the carbon footprint and respective consumer behaviour, since every region has different parameters that influence both analyses. As each case will have their own results, different foci might be required to reduce the various impact hotspots and to deal with diverse cultures and habits that can affect consumer purchase behaviour.

10. Conclusion

This thesis investigated the opportunity to decrease the carbon footprint of glass packaging while taking into account the potential consumer-related barriers in implementing the proposed strategies. In this context, the research addressed the question: "*How can the carbon footprint of glass packaging in the beverage sector be reduced in the face of consumer convenience demands?*" Two types of glass packaging have been examined, returnable and one-way glass bottles, where the returnable bottle represented the sustainable alternative, with only 40% of the emissions of a one-way glass bottle over its life cycle.

A range of strategies for carbon footprint reduction are available. Three primary strategies that stand in relation to the consumer have been discussed: the transition from one-way to returnable bottles, weight reduction and increasing the national recycle rate. For the volume consumed within the Netherlands, the transition towards returnable bottles is the most recommended strategy. It is tightly intertwined with consumer behaviour, but fortunately returnable bottles appear to fulfil all functional criteria with the exception of disposability and they are already well-implemented in the Netherlands, making a full transition easier. Disposability should be further facilitated through various measures, such as introducing smaller crates to increase portability. Moreover, in order to fulfil the demands for different consumption scenarios that are currently fulfilled by one-way bottles, different unit volumes and packaging sizes should be introduced. Additionally, the transition can best be supported by a communication strategy aimed at increasing the personal ecological norm, but more specifically at consumers' knowledge on the benefits of reuse and tackle the potential barriers of the deposit and wear and tear. If this is performed effectively, the potential for carbon reduction might be even larger if consumers from other brands are reached and can be persuaded to choose for returnable bottles as well. Lightweighting is the second recommended strategy, as it is not influenced by consumers and can therefore be implemented over the whole portfolio of glass bottles produced in the Netherlands while only having to take into account operational considerations (e.g. theoretical limitation of glass thickness). As a result, when the glass packaging used for production in the Netherlands is lightweighted, this additionally benefits all countries to which these products are exported to as well . The final strategy, increasing the country recycle rate, is the least effective carbon emission reduction strategy of the three. In part, this is a result of the high share of returnable bottles in the Netherlands. The largest concern is, however, the complexity of improving the recycle rate. Many stakeholders are involved and improving the disposal infrastructure can be challenging as this usually needs to happen in collaboration with local/national governments. A single company can therefore not significantly affect the recycle rate and therefore it always requires collaboration with other stakeholders. A company can, however, decrease the inconvenience associated with disposing of both types of glass bottles by increasing the portability of packaging and thereby increase the convenience in recycling or returning a bottle. Regardless, however, it is recommended to focus on the other two strategies as these are both more effective and accessible. In summary, all barriers and the recommended solutions for the three strategies are presented in Table 23. If the two recommended strategies – transitioning to returnable bottles and lightweighting – are successfully implemented, the carbon footprint can be reduced by 16% or 3kg CO_2e per hectolitre. Including a 10% increase in the country recycle rate would only increase this reduction to 17%.

To successfully implement the proposed strategies, several conclusions can be drawn from the consumer research. First of all, it is important to realise that consumers operate within a FMCG context, which implies low involvement decision-making based on heuristics. Any attempt to influence behaviour therefore either needs to rely on non-active information transfer in the store, or else on the broader communication strategy outside the store. The most important element to influence in consumer purchase behaviour is therefore the personal ecological norm, as this determines a person's attitude and intentions towards sustainable packaging and at the same time increases the in-store involvement. If consumers are more involved in purchasing sustainable packaging, it will be easier to implement the proposed strategies, thereby increasing their effectiveness (e.g. if consumers know and prefer the benefits of the returnable bottle and acknowledge the necessity to bring them back, the transition to returnable bottles is much more effective in reducing the carbon footprint). Affecting the personal ecological norm can be done through a longer-term communication strategy in order to facilitate lasting behaviour change. Finally, when advocating sustainable products companies should be aware that sustainability is not a primary driver for purchase behaviour. Sustainability can be used for differentiation and help gain competitive advantage, but only after functional characteristics, including convenience, are fulfilled. From all convenience attributes, portability, unit convenience and disposability played the biggest role in purchasing decisions for beer beverages, although the extent to which each of these attributes are important depends on the consumption scenario.

Finally, the consumer research gathered for the Dutch market cannot be applied directly in other countries with a different culture, different packaging mix and/or infrastructure regarding glass disposal. First of all, in many countries – like the US – the priority is to improve the (non-)existing disposal infrastructure (e.g. bottle banks, return facilities, uncontaminated waste streams etc.), since a functional infrastructure facilitates recycle- and – if applicable – reuse rates. If these structures are not yet available, targeting consumer behaviour is futile. Second, the extent to which consumers behave differently in other countries – and therefore the extent to which the current results can be utilised – requires more research. For countries who have a take-back culture, or at least familiar with recycling waste, the results are more likely to be relevant than those who do not have such fundamentals present. Finally, although results cannot be directly duplicated, the methodology used in this research can be replicated in other countries to both get insights in their carbon footprint hotspots and in the related consumer behaviour. However, it is most relevant for countries with low export volumes, as the consumer research can only be performed per country as behaviour can differ significantly across countries and regions.

Table 23 - Overview of barriers and solutions for the three strategies for carbon reduction

STRATEGY	BARRIERS	PROPOSED SOLUTIONS
TRANSITION FROM ONE-WAY TO RETURNABLE	• Disposability of returnable bottles • Lack of unit convenience provision	• Communication the benefits of reuse over recycling and why returnable bottles should be chosen over one-way bottles. Additionally, assure consumers on the quality of returnable bottles, even if wear and tear is visible. • Introducing different unit volumes (25cl, 30cl) and smaller packaging sizes (4/6-pack) for returnable bottles to address different consumption scenarios and increase portability and therefore disposability.
LIGHTWEIGHTING	• No consumer-related barriers for lightweighting • Removing smaller unit volume bottles from the portfolio is not recommended	
COUNTRY RECYCLE RATE	• Perceived inconvenience of the disposal process • On-the-go scenarios	• Provide the opportunity for consumers to purchase/get access to hard-cased reusable bottle cases that consumers can use to transport loose returnable bottles. • Introduce smaller packaging sizes for returnable bottles to increase disposability • Collaborate with other organisations or the national government to increase awareness on the benefits and importance of recycling

11. Recommendations for Heineken

Reducing the carbon footprint is an important element of the sustainability strategy of large organisation like Heineken. Every small improvement has enormous impact due to the large scale of operation. Apart from fulfilling sustainability targets set by the company, external pressure to operate in a sustainable manner is growing. This is essential to acknowledge; at this moment sustainability is still a 'novelty' and can add significant value to the brand image. However, this is changing fast as policy-makers, consumers and other organisations are also increasingly engaged with sustainability. In a few years, a wide range of sustainability aspects will no longer receive positive acknowledgement, but form the status quo, where companies face negative consequences if they are not there yet. A key recommendation is therefore to keep driving sustainable change, as Heineken has the capabilities to harness sustainability as a competitive advantage rather than something to be fulfilled obligatorily.

11.1 Next steps to reduce the Carbon Footprint of glass packaging

The primary goal of this research was to find ways to reduce the carbon footprint of glass packaging. Three key strategies have received attention: transitioning from one-way to returnable glass bottles, lightweighting and increasing the country recycle rate. Here, some recommendations are given for implementation. The strategies are presented in order of prioritisation.

- *Transitioning from one-way to returnable glass bottles.* Although a tight link exists between the transition to returnable bottles and consumer behaviour, it is expected that consumer acceptance is high as long as functional criteria are met. Several recommendations to ensure consumer acceptance are:
    - Communicate on the benefit of returnable bottles and assure consumers that wear and tear does not influence the quality of the glass and if it does, it is taken out of production. Wear and tear is usually merely an aesthetic issue which sparks the association of lesser quality. This needs to be overcome, just as Heineken 0.0% had to overcome the association that it is 'uncool' because it has no alcoholic content (Abboud, 2019).
    - Communicate to consumers why it is better to reuse than to recycle. There is scepticism about the added sustainable value of returning versus recycling glass, as consumers are unsure what exactly happens after handing in their returnable bottle. As the inconvenience of the disposal process (including the deposit) appears to be the biggest concern for consumers, it is important for consumers to know why they are putting in extra effort. This should be paired with decreasing disposal effort.
    - Ensure availability of different unit volume and pack sizes to satisfy the demands of different consumption scenarios. Secondly, portability and disposability of returnable bottles should be improved. This could be done by:
        - Smaller crate sizes (e.g. 6-pack, 12-pack) or modular crates
        - Provide the opportunity for consumers to buy hard-cased reusable bottle cases that consumers can use to transport loose returnable bottles.
- *Lightweighting.* Since lightweighting does not interact with consumer behaviour, no barriers exist and is therefore the most accessible of the three strategies.
- *Increasing the country recycle rate.* It is acknowledged that Heineken has little influence on country recycle rates, except for lobbying for regulation, collaborating with the industry to improve the recycling infrastructure and through communications to the consumer to increase awareness and understanding of the importance of recycling.

Aside from these strategies, a range of interventions for each impact hotspot are discussed in chapter 4.2.2. One such strategy that is worth mentioning is the increase of the recycled content of glass containers. As F. Rivet from FEVE emphasised, there is a shortage of cullet in Europe (Rivet, 2019). This provides a good opportunity to collaborate with Heineken USA, as the US suffers from oversupply of recycled glass. A barrier to overcome is the contamination of the cullet, which is a consequence of the single-stream waste management currently prevalent in the US. A potential strategy is discussed in section 11.4.

When these strategies are desired to be applied to other countries than the Netherlands, some considerations can be taken into account:

- For all strategies, the packaging mix is important. If the share of one-way bottles is high, both lightweighting and increasing the country recycle rate are much more beneficial than when the share of returnable bottles is high, as both strategies affect the emission factor of glass production which – in the case of returnable bottles – is divided through the trip rate.
- The transition to returnable bottles with bottling in the Netherlands is only recommendable when the transportation distances are lower than 12,000km (Chapter 4.3.5). Furthermore, if consumers are to some extent familiar with a take-back culture or are used to recycling other materials, both the transition to returnable and increasing the country recycle rate are easier to facilitate, especially with the right communication strategy to overcome any remaining consumer barriers.
- Increasing the country recycle rate is difficult in all cases. Requirements for a high recycle rate are 1) an effective disposal infrastructure, 2) supporting legislation and 3) consumer knowledge and awareness. For each country, it should be explored which of the three requirements are not met and efforts should be focussed on improving that parameter.

11.2 Carbon Footprint recommendations

In the calculations performed in the carbon footprint analysis, a range of variables were identified that have a significant impact on the result of the calculations. Currently, for some of these variables only (global) estimates are available. The most important variables that need a more accurate or local approach are:

- *Trip rate.* The trip rate is currently not taken into consideration for the calculation of the carbon footprint of returnable bottles. Instead, a fixed emission factor for production is utilised of 4kg CO_2e per hl. However, as shown in Figure 17 (section 4.3.1) the trip rate has a large impact on the allocated production emissions for returnable bottles; every added cycle of a returnable bottle decreases its carbon emissions by 12%. As the trip rate depends on a number of factors that vary per region (e.g. disposal infrastructure, acceptance of wear and tear, consumer behaviour with the bottles, fragility of the bottles etc.), more research should be done on local/regional trip rates. This is especially relevant for upcoming markets like Nigeria and Ethiopia, which both have significant volumes in returnable bottles.
- *Supplier emission factor*. The most important variable for one-way bottles is the supplier emission factor, which is responsible for 71% of the carbon footprint emissions of one-way bottles. Keeping these emission factors up to date is therefore of prime importance for the packaging carbon footprint, as the supplier emission factor can differ significantly from location to location. Working together with suppliers to get a more accurate representation of their carbon footprint is therefore essential. If data gaps are filled, suppliers can be grouped in terms of carbon footprint performance which can help prioritise which suppliers require more attention.
- *Weight.* Another variable that has a large influence on the carbon footprint is the kilogram of material used per bottle. Since weight has a one-on-one relationship with the carbon footprint of the packaging production life cycle process, it is important to have an accurate database of weight of each bottle. Currently, these weights had to be manually adjusted. Especially when considering building a carbon footprint that is updated on a more regular basis, and when the effort on lightweighting the bottle portfolio is continued, it is recommended to ensure that each operating company can input their (new) weights automatically in the system.

Besides these variables, more attention should be given to the calculation of the carbon footprint of returnable bottles in general, especially if the transition from one-way to returnable is pursued. As mentioned above, the current emission factor for the production stage is fixed at 4kg CO_2e per hectolitre. No distinction is made between different bottle volumes and weights used in different regions. Furthermore, significant difference between emission factors of returnable bottles in different regions can exist due to differences in bottle weight optimisation, local trip rate and transportation distances.

In summary, the collection of accurate data is the prime concern for the carbon footprint of Heineken. Without a high degree of accuracy, the carbon footprint cannot fulfil the role it should have; a model that provides insights in inefficient processes and which can be used to drive innovation to decrease environmental impact and increase economic performance. If accurate input data is safeguarded, carbon footprint results can be used for a range of purposes, such as KPI assessments, goal-setting, opportunity analysis, scenario building and so on. A couple of recommendations can be made to take into account when improvements are made to the carbon footprint model:

- Ensure that enough time is spent on managing the data architecture and potentially use this time to improve data gathering systems to avoid inaccurate or incorrect data input at its origin (SAT data).
- Ensure accessibility to accurate data on all variables discussed above. Especially for the variables that vary significantly depending on the region, it is important to have accurate data as this will help operating companies to get a better insight in their own carbon footprints, rather than a global average. If operating companies are confident that the carbon footprint accurately represents their current state, it will also help acceptance of this model as a basis for target-setting and continuous improvement.
- Ensure that the future carbon footprint model can handle different scopes. Currently the model is set up to create the carbon footprint of each operating company and of the global average. However, it is helpful to be able to (automatically) change the scope to get the carbon footprint per packaging type as well. This can help in decision-making of what packaging type to focus on and what the impact hotspots are.

11.3 Consumer behaviour

It is clear that consumer purchase behaviour can have an impact on the carbon footprint. As discussed in chapter 7.1, communication is critical to create consumer acceptance, specifically for the deposit and wear and tear on returnable bottles. Furthermore, communication can increase consumer awareness and understanding of the sustainability of different types of packaging and respective disposal procedures, which enhances the viability of the proposed strategies. The following factors should be taken into account when communicating about sustainability:

- Often financial considerations overrule sustainability. One opportunity could be to represent the environmental impact of a product in financial terms (shadow pricing), to ensure that sustainable products – which occasionally cost more to avoid environmental impact – can compete on an equal playing field as traditional products which often have a higher environmental cost attached. Besides using shadow pricing to communicate externally, it can also be used in internal communication as many decisions are ultimately cost-driven.
- Communication needs to be credible. Ensure that communication is factual and transparent. Credibility can also be gained by collaborating with third parties who possess environmental credentials.
- Utilise non-active information transfer to avoid the expense of time and effort of the consumer at product purchase (e.g. avoid extensive information on labels). For long-term behaviour change, a broader communication strategy for outside the purchasing context is needed. This

type of communication should be focussed on increasing environmental awareness around glass packaging and not focus on specific SKUs.

Finally, when decisions are made to decrease carbon footprint using strategies that are affected by consumer behaviour, it is paramount to connect with the Commerce team, as they often have a closer connection with the consumer and therefore better insight in whether the proposed strategies will have repercussions the consumer. Much of the research on the transition from one-way to returnable bottles was indeed gained by collaborating with the commerce team from Heineken Netherlands, who are currently running pilots to gain definitive insight into how the transition to 100% returnable bottles can best be pursued.

11.4 Recommendations for the US

Because many waste streams in the United States are single-source, disposed glass is easily contaminated, leading to low quality cullet which cannot be used as recycled content for new bottles. This leads glass bottle manufacturers to prefer virgin material over the low-quality cullet which consequently lowers the demand of cullet. Since there is no end-market for cullet, it is plagued by low commodity prices, due to which many waste management companies refrain from further investing in improving the disposal and recycling process. In conclusion, a vicious cycle exists which is difficult to break. For Heineken, the best approach is therefore to work around the deficient glass disposal infrastructure. In most Bottle Bill states, source separation of bottles exists. In these cases, it would be most beneficial to collect all glass bottles – including bottles from other brands – by collaborating with the relevant waste management organisations. One option is to collect the Heineken brand bottles for reuse, although most bottles will not be fit for reuse. These bottles – together with the bottles from other brands – can be sold to their glass manufacture supplier which can consequently melt the bottles for subsequent use in new bottle production. Since the bottles are separated at source, no contamination issue should occur, making the cullet also fit for European markets. In non-Bottle Bill states, source-separated collection might be more difficult. In these states, investments into source-separated methods of collection might be needed (e.g. reverse vending machines or collaboration with independent recycling centres). Further research should be done to explore some of the possibilities to increase the recycling rate of Heineken bottles.

Other research could look at the possibility of setting up a returnable system to the US from Mexico or the Netherlands. As shown in chapter 4.3.5, even though the distribution of returnable bottles produces significantly more emissions compared to one-way bottles, returnable bottles constitute of less total environmental impact as long as the one-way transportation distance stays below 5,312 kilometres when bottled beer is transported by truck or 12,000km by ocean transport. This is confirmed by the US case, where it is shown that at least for the East Coast it is beneficial to transition to returnable bottles – especially for non-bottle bill states – as it reduces the carbon footprint by 2.2kg CO_2e per hectolitre. From Mexico, the distance is much shorter and therefore likely also more beneficial. Similar results were obtained in a research by Heineken USA and TerraCycle, who compared the impact of importing a one-way bottle with their own returnable bottle system, both from the Netherlands and from Mexico. They concluded that for both countries "*it is possible to design a durable refill model that has a net lower impact than a single use distribution system*" (TerraCycle & Heineken USA, 2017). As both results indicate that from an environmental perspective the returnable system is beneficial, further calculations should be performed to look at the feasibility of the logistical arrangements and the consequent cost of the distribution of returnable bottles back and forth from the Netherlands or Mexico to the US. Additionally, more research should then be performed to gauge US consumer acceptance of returnable bottles. Most likely, returnable bottles have the most potential to be viable in the states with a Bottle Bill in place.

11.5 Areas for further research

Two areas for further research are derived from the current study. The first recommendation is to extend this research to other countries that have significant impact on the carbon footprint, but operate in a different cultural setting than the Netherlands (e.g. Mexico, Brazil, and Nigeria). As was shown in the comparative case study with the US, different conditions in each country can have significant effect on the carbon footprint and additionally, consumers can react differently on sustainable interventions thereby either representing a larger or smaller barrier to sustainable interventions.

Secondly, further research is advised on the potential for e-commerce as although Heineken expressed interest in this strategy, it was largely out of the scope in the current study. E-commerce can be utilised to avoid the inconvenient disposal process altogether, an alternative is to increase efforts on e-commerce. This option is explored in the study of HNK & Koos Service Design (2018), where take-back service is proposed to pick up empty crates and bottles. Nevertheless, the participants indicated that this would not be a reason to buy and would only be of value in the case of crates, as consumers would feel encumbered by having to call a take-back service for smaller pack sizes (HNK & Koos Service Design, 2018). Potentially, in the case where the take-back service is combined with online sales, the uncomfortable feeling of handing in a six-pack of empty beers is considerably less if it is combined with a new order of beer. An opportunity for Heineken to gain experience with such a system could be to partner with Beerwulf, an e-commerce platform for craft beer in which Heineken is the sole major investor. Alternatively, as Heineken NOW (now called Drinkies) is recently launched country-wide, Heineken has got their own e-commerce platform which can explore the suggested take-back service alongside their online sales. The requirement of such a service in terms of the carbon footprint is that no extra traffic should be generated just to take back empty crates (Keuenhof, 2019). Another benefit of such an e-commerce system is that the load on supermarkets in terms of take-back would be reduced which decreases storage needs and time spent in sorting by staff (HNK & Koos Service Design, 2018). Currently, some supermarkets are sceptical about their role in the take-back of returnable bottles as it requires space that otherwise could be used for selling products and additionally necessitates extra personnel and thus cost (HNK & Koos Service Design, 2018). However, it is unknown what the exact impact would be on the carbon footprint if products would be sold through e-commerce channels. On the one hand, it would increase distribution emissions, but this is to some extent offset by lower 'Last Mile' emissions (as consumers do not have to drive to the supermarket to get their beer) and perhaps it would increase recycle rate due to higher convenience of disposal.

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14. Appendices

Appendix 1 – Rapid Evidence Assessment

1. Background

The primary aim of this project is to decrease the carbon footprint of Heineken. The main issue is that another trend currently visible within the beer beverage industry, the consumer demand for convenience, is currently being satisfied by products with a higher carbon footprint. Therefore, solutions need to be found which appeal to consumers in the current state of the industry (thus taking into account the trend of convenience) that lower the environmental impact of Heineken. The aim of this review is therefore to find proven factors that appeal to consumers and stimulate the right behaviour to reduce the carbon footprint. To that end, a review will be performed of cases on the topic of stimulating environmental friendly purchase behaviour within the beverage industry.

2. The REA question

The main question that needs to be answered to get a good overview of potential interventions is:

"What interventions have successfully been implemented within the beverage industry to lower environmental impact by altering or facilitating certain consumer (purchase) behaviour?"

The main question is answered through two additional supplementary questions:

1. What strategies are available to beverage companies to reduce their carbon footprint?
2. What characterises successful measures?

In order to provide a good overview of studies that are relevant to the context described in Section 1, a PICOC table is constructed.

Table 24 - PICOC

Picoc		
Population	Who?	Beverage Producers, consumers
Intervention	What or How?	Introducing measures that lower environmental impact and are directed at the use and disposal phase
Comparison	Compared to what?	Status quo
Outcome	What are you trying to accomplish / improve / change?	Lower carbon footprint
Context	In what kind of organization / circumstances?	Beverage producers in a highly competitive setting under pressure of both consumer demands and pressure to decrease their carbon footprint.

3. Search criteria

Inclusion criteria

1. **Date**. After the year 2000
2. **Language.** English
3. **Type of Studies**. Grey literature, reports, academic articles
4. **Study design.** Only case studies for academic articles
5. **Measurement.** It should report i) an intervention that satisfies the description in Table 24, Intervention, ii) affect beverage producers and iii) discusses impacts of the intervention.
6. **Outcome.** Lower environmental impact
7. **Context.** See Table 24.

4. Search strategy

Initially, two search strategies were used to get an overview of all potential categories of interventions that decrease environmental impact. First of all, the websites from the top ten beverage producers were screened for cases on sustainable packaging interventions. This resulted in four different cases from four companies. The second strategy was to use the search term "reducing environmental impact beverage industry" on Google. This resulted in another seven cases. Other search terms that have been used, derived from cases found by the previous two methods, are "reverse vending machine" and "introduction deposit-return scheme glass bottle" which both added one case. Using these search terms, four categories were defined: Recycling infrastructure, product delivery innovation, packaging design innovation and consumer-focussed innovation. These four categories were used to specify more detailed search terms.

1. Recycling infrastructure (TOTAL = 4)

Found 2 additional cases using the search term "deposit scheme implementation case" (1) and more specifically "Norway deposit return system beverage packaging" (1).

2. Product delivery innovation (TOTAL = 2)

Found 1 additional case through the search term "product delivery innovation in the beverage industry", via the website from WOUB digital (WOUB Digital, 2018).

3. Packaging design innovation (TOTAL = 10)

5 additional cases were identified by using the search terms "beer packaging innovation" (2), "Sustainable packaging innovation beer" (1), "sustainable beverage packaging innovation aluminium can" (1), "sustainable design aluminium cans" (1) and "product delivery sustainable innovation packaging beverage industry", via the website from Smithers Pira (Smithers Pira, 2014)(1).

4. Consumer-focussed innovation (TOTAL = 4)

Found 1 additional case using the search term "beer beverage sustainable innovation packaging".

In total, 20 cases were found. It must be noted that when similar innovations were found, it was chosen not to document these as new innovations when the outcome was similar and brought no new insights. This was, for instance, the case for lightweighting innovations which have been implemented by all major organisations in the last few years.

5. Main Findings

Two supplementary questions were asked in order to provide the overview of different interventions within the beverage industry: 1) what strategies are available to companies to reduce their carbon footprint and 2) what are success factors of those strategies?

As the first question is oriented towards providing an overview of potential interventions, it includes a range of innovations that are still in development, while the second question is only based on the cases that are already on the market in order to derive success factors.

1. What strategies are available to beverage companies to reduce their carbon footprint?

Four main strategies have been deduced from the analysed cases: 1) recycling infrastructure innovation, 2) product delivery innovation, 3) product design innovation and 4) consumer-focussed information campaigns. Each of these strategies imply different stakeholders to be responsible for the desired outcome of reduced carbon footprint. This is visualised in Figure 32. Only the second and third category have direct connection between a company's innovation efforts and its carbon footprint. The other two categories are dependent on the behaviour or cooperation of other stakeholders in order to decrease the overall carbon footprint.

Figure 32 - Spectrum of responsibility

1. *Recycling infrastructure innovations*

This category encompasses interventions that require a multitude of stakeholders to implement. In the beverage industry, there seems to be one dominant mechanism that has been introduced in the last decades in which beverage producers are also important stakeholders: the deposit-return scheme. There are still many countries in which such a mechanism is not implemented, despite the success of other deposit-return schemes, as for instance Finland, Germany, Netherlands and Estonia all have 90%+ return rates (Schneider, Karigl, Reisinger, Oliva, & Süßenbacher, 2011). In the UK, the retail company Iceland has started a small-scale pilot for implementation of reverse vending machines to experiment with the potential of implementing a deposit return scheme in the UK. However, the UK government acknowledged that the implementation of such a scheme needs to be nation-wide as to avoid unfair price competition.

2. *Product delivery innovation*

From the case review it is clear that there is limited opportunity within the beer industry with respect to product delivery innovation. The two studied cases both relate to soda beverages. In the first case, PepsiCo has introduced 'Drinkfinity', a brand that provides a refillable plastic water bottle which can be flavoured by adding pods with fresh ingredients to the mix, thereby creating a 'customisable hydration system' (PepsiCo, n.d.). The second case presents a similar customisable product delivery method. Coca Cola has updated their Coca Cola Freestyle vending machines, which now provide more than a 100 different drinks. Consumers can get their drinks in a refillable beverage container equipped with a chip that remembers previous choices and therefore aims for increased convenience (Nowak, 2018). Innovations of this kind are more difficult in the beer industry, as the brewery process introduces limitations to possibilities of providing the product instantly on-the-go or at home.

3. *Product design innovations*

Product design innovations are the most common interventions within the beverage industry. This is expected, as these innovations can be done directly by beverage producers and is part of the value proposition of these companies. Three types of design innovations have been identified: Lightweighting, packaging material innovation and using design to engage consumers in pro-environmental behaviour.

The first intervention, lightweighting, has already been implemented by most organisations as it provides the most straightforward way to reduce the carbon footprint of packaging by using less material for the same beverage container. Care has to be taken, however, that the packaging maintains similar quality.

Packaging material innovations have come in a range of new materials. First of all, a variety of alternative packaging materials have been introduced (see Table 25). Carlsberg recently introduced a biodegradable bottle made from wood fibre, SAS Green Gen Technologies introduced a biodegradable bottle from flax, while Coca Cola introduced their PlantBottle 2.0. In the domain of plastic bottles several material innovations have also been done, with for instance PepsiCo introducing both the EcoGreen bottle – made from 100% recycled PET (rPET) – and a different Tropicana bottle, which utilised a new type of resin (Polyclear® EBM PET 5505) in 2012 to facilitate the recycling process by preventing clogging. All these material substitution innovations have been predominantly focussed on improving the post-consumer recycling process. A case with similar intent is the new label printing technology from AFGA, which has been applied to the PET bottle design from 'Brouwerij Martens' in Belgium. This technology uses direct printing on bottles, thereby avoiding the need for labels, and is supposed to be recyclable in the current recycling system.

Table 25 - Overview of a range of alternative packaging materials

Company and name	Description of the alternative packaging materials	Source
Ennstal Milch, Cartocan	Cartocan is a carton board alternative to the aluminium and PET can. The prime advantage of Cartocan is its weight, which is not even half as much as that of PET. The use of 50% renewable raw materials in Cartocan generates significantly fewer greenhouse gas emissions than in the energy intensive production of primary aluminium.	(Sharma, 2014)
Coca Cola, PlantBottle 2.0	The PlantBottle 2.0 is made from 100% plant-based material and is fully recyclable. PlantBottle packaging maintains the high-quality package consumers expect but with the added benefit of being made from renewable materials. Coca-Cola currently uses sugarcane and waste from the sugarcane manufacturing process to create PlantBottle packaging.	(Journey Staff, 2015)
SAS Green Gen Technologies, Zero-glass bottle	The bio-based flax bottle is made of flax fibre composite (91% bio-based). The inner film is still not bio-based, but this is expected to be addressed with PLA plastics. The company expects to be able to launch bamboo, hemp and sugarcane containers as well.	(Arthur, 2018)
Carlsberg, Green Fiber bottle	The Green Fiber Bottle is a fully biodegradable bottle made from moulded paper pulp. The innovative impulse-drying technology being used to develop the bottle aims to ensure that energy consumption during production is equal or less to current alternatives.	(Carlsberg Group, 2016)

4. *Consumer-focussed information campaigns*

The fourth category is characterised by its aim to provide consumers with sufficient information to make educated decisions with regards to environmentally beneficial purchase or disposal behaviour. The cases explored here represent some of the approaches that are taken in the beverage industry. The Recycle Rally program set up by PepsiCo represents an educational approach by providing schools with (online) resources to educate their students on proper environmental conduct with regards to recycling. A different approach taken by PepsiCo, although at the time unsuccessful, has been to partner with NGOs to provide consumers with the required know-how for efficient recycling processes. An important take-away from this project was that if such partnerships are to be successful, the NGOs in question should have a sole focus on the topic at hand as to avoid the message being lost amidst other messages on different topics.

An alternative way to convey information to the consumer is through labelling, although there is uncertainty of the effectiveness of labelling on stimulating the right behaviour in academia (Southerton et al., 2011). Nonetheless, several different labelling schemes have emerged that aim to increase awareness on recycling and reduce the confusion with how to recycle, such as How2Recycle and OPRL (On Pack Recycling Label).

2. What characterises successful measures?

On the system-level, several factors were identified that ensured the success of the deposit-return scheme:

i. Schemes such as the deposit return scheme that contain price mechanisms need to be implemented nation-wide to avoid unfair price competition

ii. The return of beverage containers is made *convenient* for the consumer as it is possible to return a container to any retailer where they already go to buy their groceries.
iii. It has become a consumer *habit* to return their drink containers to the retailer, mainly due to the long persistence of the return system for glass bottles. This makes it easier for consumers to also accept other schemes that require them to hand in their beverage containers, such as for aluminium cans or single-use plastics.
iv. Consumers are more likely to alter their behaviour in response to a financial penalty (e.g. a deposit) than a financial incentive (e.g. a discount). This is known as the negativity bias, which surmises that bad events have a much greater effect on individuals than positive ones of the same magnitude (Baumeister, Bratslavsky, & Vohs, 2001).

It is likely that the latter three success factors are not specific to such a system-level scheme and are therefore also generalizable to other interventions to reduce environmental impact. The importance of convenience is also emphasised in the cases within the category of product delivery innovation. Both cases, Drinkfinity and Coca Cola Freestyle, aim to provide convenience by providing easy and instant on-the-go solutions. Furthermore, they both highlight the importance of fulfilment of current consumer values, which include characteristics such as choice, customisability, personalisation and the increasing interest in an environmental conscious lifestyle.

Similar success factors are described in the cases from the category of packaging design innovations. These cases additionally highlight that in order for the innovation to succeed it must fulfil similar requirements as the package it replaces, especially with regards to quality and price. This is best illustrated by a quote from Coca Cola on the introduction of their PlantBottle 2.0: "PlantBottle packaging maintains the high-quality package consumers expect but with the added benefit of being made from renewable materials" (Journey Staff, 2015). The importance to avoid trade-offs, at least on certain product characteristics, is also acknowledged by academia. For instance, the study from Birgelen, Semeijn, & Keicher (2009) shows that respondents to their survey are willing to trade off various product attributes in favour of environment-friendly beverage packaging, except for *taste and price*.

Finally, the success of information campaigns is intertwined with packaging design for recyclability. Consumers can buy 100% recyclable products, but if they do not recycle the packaging properly it is of little use. Therefore, consumers need to be constantly made aware of why it is important to recycle, what is required of them and how they should recycle (Maunder, Sharp, Croy, & Pennie, 2003). By addressing these issues in education – as is done by Recycle Rally from PepsiCo – it should common knowledge, making individuals and their families more likely to properly recycle. In conveying this type of information to the consumer it is important to keep it simple and clear. Due to the proliferation of materials that consumers need to recycle in different manners, consumers have trouble to properly recycle every material according to the right procedure. Clear messages from a credible source and simple labels on products can help reduce this confusion.

7. Synthesis and conclusion

The reviewed cases seem to suggest roughly similar patterns that lead to successful implementation, although they do demonstrate that there are different ways in which each strategy can be applied. One observation from these case studies is, however, that most interventions seem to be incremental innovation. Lightweighting is the perfect example of this; almost every major beverage producer has decreased the weight of its packaging over the last decade in order to decrease their carbon footprint. Other interventions of more radical nature are significantly sparser. This could signify the difficulty of moving beyond traditional product delivery, either due to supply chain limitations or limitations set by the inherent nature of the product.

Overall, four types of strategies have been identified: 1) recycling infrastructure innovation, 2) product delivery innovation, 3) product design innovation and 4) consumer-focussed information campaigns. Each of these strategies have their own success factors, see Table 26.

Table 26 - Synthesis of success factors per strategy

	Success factors
Strategy 1	To move consumers to the right behaviour, recycling infrastructure innovations should focus on making recycling *convenient* and *habitual*. Associated price mechanisms are most effective if negligence of recycling negatively affects the consumer – as opposed to rewarding consumers that do recycle. Moreover, the price mechanisms should be implemented regionally or nationally to avoid unfair competition.
Strategy 2 & 3	No trade-offs should be made between being environmentally more beneficial and essential product characteristics such as price and quality of the packaging. Additional qualities of packaging that seem to appeal to consumers are convenience (on-the-go consumption, portability, ease of consumption etc.), customisability/personalisation and use of environmentally beneficial materials/design.
Strategy 4	It is important to create awareness on how, why and what to recycle. This is best done by keeping provided information simple and to the point, as to avoid confusion.

8. Limitations:

There are several limitations to this case review that need to be taken into account.

- Although this case review is aimed to be comprehensive, there might be cases that are missing from this review. This could either be a consequence of the search criteria or from the fact that the majority of the cases come from the grey literature due to the focus on pragmatic insights, instead of theoretical. Nonetheless, these are concessions made in order to provide a 'rapid' review.
- As the cases are primarily from company innovations, data on in-depth results of intervention were frequently limited or non-existent. Moreover, in some other cases the innovation was only introduced recently and therefore no data on results were available yet.
- Finally, the presented success factors are derived from the perception of the brands themselves and therefore not necessarily represent objective success factors from a consumer perspective. It could well be the case that the success of these brands hinges on their ability to create new *wants*, instead of satisfying consumer *needs*.

9. Implications for practice

This case review could offer some practical insights in what strategies could be utilised to decrease the environmental of primary packaging. It presents a range of interventions with a different scope, from more system-level to consumer-focussed approaches. Furthermore, it outlines some success factors for each type of strategy that can be considered to increase chances of a new intervention to be successful.

Appendix 2 – Interview guides

14.1 English Interview guide: Packaging-oriented Experts

Introductory question

My research is about how to decrease the carbon footprint of glass packaging in the context of consumer convenience demands.

1. What is your experience with the topic?

Theoretical underpinnings – Convenience demands & environmental considerations

2. How would you define consumer convenience in packaging? **Provide your own definition of consumer convenience afterwards**
    a. How do these convenience demands reflect in glass (beer) packaging?
    b. How important are these aspects relative to other functional characteristics, such as quality and price?
3. And how important are environmental considerations for the consumer in comparison to the previous characteristics?
4. How does glass as a packaging material perform on this front compared to other packaging? What is the consumer perception?
5. Are consumers aware of the environmental impact of (one-way) glass packaging?
    a. No: Would they change their purchasing behaviour if they are aware of the impact?
    b. Yes: How can companies like Heineken promote the use of sustainable packaging, like returnable glass bottles? What stimuli are needed to convince consumers?
6. For companies: Do environmental considerations within packaging have a prime origin within marketing or are there also operational considerations to switch to sustainable packaging?
7. How does sustainability play a role in the glass industry? How important is it to the competitive position?

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8. What is, in your opinion, the best way to reduce the environmental impact of glass as a packaging material?

There are three main impact hotspots with regards to glass packaging: weight, returnable or one-way bottle and country recycling rate (disposal).

i. Weight

Light weighting is an approach many companies take to decreasing CO_2 emissions. However, the theoretical minimum weight is still often lower than what is currently in the market.

9. What are barriers to minimising the weight of glass packaging?
    a. What are operational barriers?
    b. What are consumer-oriented barriers?
10. Do you think consumers notice the differences in weight?
    a. Is the weight of a bottle important for the perception of consumers of the bottle? Why?

Related to the weight of the bottle is the portion size. The bigger the bottle, the more beneficial as it requires relatively less material per hl.

11. Why are smaller sized portions attractive for consumers?
12. Would a beverage company lose consumers if it stops offering smaller portions?

ii. Returnable vs one-way packaging

13. What are advantages of one-way packaging over returnable packaging?
    a. For the company?
    b. For the consumer?
14. What is/are the barrier(s) for switching to only returnable packaging?
    a. For the company?
    b. For the consumer?
15. Different countries have a different share of returnable bottles. Do you think all countries have the potential for returnable bottles?
    a. Is it something that has to be culturally accepted before it is possible?

iii. Disposal & country recycling rates

Proper disposal is essential for both the recycling rate for one-way packaging and the return rate for returnable packaging.

16. What are difficulties for consumers in the disposal process?
    a. For ***one way*** packaging*?* How can this be improved?
    b. Would consumers accept bottles made from 100% recycled content? **(Optional)**
17. For **returnable** packaging: How can the disposal process be optimised as to maximise consumer convenience (minimise time/effort)?

iv. **Ending**

18. Are there any remaining topics that we did not discuss that have an impact on the carbon footprint through consumer convenience?

Optional

19. From the perspective that returnable bottles are considered less portable and more of a hassle in terms of disposal, is e-commerce an alternative method for returning bottles from the consumer's homes?
20. Are there alternative packaging options that contain less environmental impact than returnable bottles (granted that the infrastructure for returnable bottles is present)?
    a. Are these options desirable from a consumer perspective?
    b. Are they scalable?

14.2 Dutch Interview guide: Packaging-oriented Experts

Introductie vraag

Mijn onderzoek gaat over hoe bierproducenten hun carbon footprint van glazen verpakkingen kunnen verminderen met het oog op consumentengemak (consumer convenience).

1. Wat is uw ervaring met dit onderwerp?

Theoretical underpinnings – Convenience demands & environmental considerations

2. Hoe zou u consumer convenience definiëren? **Geef hierna ook je eigen definitie van consumer convenience**
    a. Hoe reflecteren deze elementen van consumer convenience zich in glazen (bier)verpakkingen?
    b. Hoe belangrijk zijn deze elementen ten opzichte van andere functionele karakteristieken zoals prijs en kwaliteit?
3. En als u kijkt naar duurzaamheid overwegingen, zijn deze belangrijk voor de consument?
4. Hoe presteert glas als je het vergelijkt met andere verpakkingsmaterialen? Wat is de consumenten perceptie?
5. Zijn consumenten zich bewust van de milieu-impact van eenmalige glazen verpakkingen?
    a. ***Nee, dan:*** Zouden consumenten hun koopgedrag veranderen als ze zich bewust waren van de impact die hun keuze verpakking heeft?
    b. ***Ja, dan:*** Hoe kunnen bedrijven als Heineken duurzamere verpakkingen, zoals het statiegeld flesje, promoten aangezien ze nog niet in grote getalen worden verkocht?
6. **Als je kijkt naar de beweegredenen voor bedrijven**; Hebben duurzaamheidsoverwegingen alleen een marketingfunctie of ook operationele beweegredenen?
7. Wat voor rol speelt duurzaamheid in de glasindustrie? Hoe belangrijk is duurzaamheid voor de competitiviteit van glasproducenten?

Glazen verpakkingen

8. Wat denkt u dat de beste manier is om milieu impact van glazen verpakkingen te verlagen?

Binnen mijn onderzoek heb ik mij gericht op drie belangrijke impact hotspots met betrekking glazen verpakkingen: gewicht, herbruikbare of eenmalige verpakkingen en de landelijke recycling rate.

i. Gewicht

Light weighting is een strategie voor bedrijven om hun CO_2-emissies van verpakkingen te verminderen. Ondanks dat het al veelvuldig gedaan wordt zit het theoretisch minimum nog vaak lager dan wat gemiddeld op de markt is.

9. Wat zijn barrières met betrekking tot het minimaliseren van het gewicht van glazen verpakkingen
    c. Wat zijn operationele barrières?
    d. Wat zijn consumentgerichte barrières?
10. Zijn consumenten zich bewust van verschillen in gewicht tussen verschillende glazen flessen?
    e. Is het gewicht van de fles belangrijk voor consumenten perceptie? Waarom?

Gerelateerd aan het gewicht van een fles is het gewicht/volume ratio. Des te lager deze ratio, des te beter (minder materiaal per hl).

11. Wat maakt kleinere porties aantrekkelijk voor consumenten?
12. Zou een bierproducent klanten verliezen als deze stopt met het aanbieden van kleinere portie groottes?

ii. *Returnable vs one-way packaging*

13. Wat zijn de voordelen voor eenmalige verpakkingen ten opzichte van herbruikbare verpakkingen?
    a. Voor het bedrijf?
    b. Voor de consument?
14. Wat zijn de barrières om volledig over te stappen naar herbruikbare verpakkingen?
    a. Voor het bedrijf?
    b. Voor de consument?
15. Hebben alle landen potentie voor de transitie naar herbruikbare glazen verpakkingen?
    a. Is het belangrijk dat herbruikbare verpakkingen in de cultuur van een land zit?

iii. Disposal & country recycling rates

Correcte afvalscheiding is essentieel voor de recycling rate voor eenmalige verpakking en het terugbrengen van herbruikbare flesjes is essentieel voor de return rate.

16. Wat zijn de belemmeringen voor consumenten in het correct verwerken van lege glazen verpakkingen?
    a. Voor eenmalige verpakkingen? Hoe kan dit verbeterd worden?
    b. Zouden consumenten een fles van 100% recycled content accepteren? **(Optioneel)**
17. Hoe kan het wegbrengen van herbruikbare flessen worden geoptimaliseerd om consumer convenience te maximaliseren?

iv. Ending

18. Is er nog een aspect wat we niet besproken hebben maar wel impact heeft op de Carbon Footprint als gevolg van consumer convenience demands?

Optioneel

19. *Vanuit het perspectief dat herbruikbare flesjes minder handzaam zijn en daardoor meer moeite kosten om het terug te brengen: is e-commerce een goed alternatief om daarbij sales en return te vergemakkelijken?* ***(Optioneel)***
20. *Zijn er alternatieven voor glazen verpakkingen die minder milieu impact hebben?* ***(Optioneel)***
    a. *Voldoen deze opties aan de eisen van de consument?*
    b. *Zijn ze schaalbaar voor bierproducenten?*

14.3 English Interview guide: Consumer behaviour experts

Introductory question

My research is about how to decrease the carbon footprint of glass packaging in the context of consumer convenience demands.

1. What is your experience with the topic?

Theoretical underpinnings – Convenience demands & environmental considerations

2. How would you define consumer convenience in packaging?

Provide your own definition of consumer convenience

3. Is there a *recent* trend towards more convenience in packaging? If yes, why do we see that trend now?
4. What phases of the customer journey requires most time and effort with regards to glass beer packaging
5. How do convenience demands reflect in (glass) packaging?
    a. How important are convenience characteristics relative to other functional characteristics, such as quality and price?
    b. And how important are environmental considerations for the consumer in comparison to the previous characteristics?
6. Are consumers aware of the environmental impact of (one-way) glass packaging?
    c. **No:** Would they change their purchasing behaviour if they are aware of the impact?
    d. **Yes**: How can companies like Heineken further promote the use of sustainable packaging, like the returnable bottle? What stimuli are needed to convince consumers?
7. Regarding the goal to make consumers buy more sustainable packaging: is the low involvement and habitual purchase behaviour that is common for FMCG goods a barrier towards more sustainable purchase behaviour?
    a. **Yes:** What does this mean for the approach business has to take to stimulate sustainable purchase behaviour of consumers?
        i. Are functional characteristics of packaging of single importance? So does the change need to be 'forced'[12]?
        ii. Or can consumer purchase behaviour be changed by sustainable packaging and communication/information?
    b. How can consumers be best approached to stimulate the purchase of sustainable packaging?
8. **For companies:** Do environmental considerations within packaging have a prime origin within marketing or are there also operational considerations to switch to sustainable packaging?

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There are three main impact hotspots with regards to glass packaging: weight, returnable or one-way bottle and country recycling rate (disposal).

v. Weight

Light weighting is an approach many companies take to decreasing CO_2 emissions. However, the theoretical minimum weight is still often lower than what is currently in the market.

9. Do you think consumers notice the differences in weight?

[12] With forced I mean integrated in packaging and not necessarily visible to the consumer. Thus, in achieving a sustainable outcome the consumers do not play a role.

    a. If so, is a lighter bottle perceived as worse than a heavier bottle, or vice versa? Why?

Related to the weight of the bottle is the portion size. The bigger the bottle, the more beneficial as it requires relatively less material per hl.

10. Why are smaller sized portions attractive for consumers?
11. Would a beer producer lose market share if it would stop supplying smaller portion sizes? Why?

vi. Returnable vs one-way packaging

12. What are advantages of one-way packaging over returnable packaging?
    a. For the company?
    b. For the consumer?
13. What is/are the barrier(s) for switching to only returnable packaging?
    a. For the company?
    b. For the consumer?
14. How can consumers be best persuaded to purchase returnable packaging? What incentives are needed?

vii. Disposal & country recycling rates

Proper disposal is essential for both the recycling rate for one-way packaging and the return rate for returnable packaging.

15. What are difficulties for consumers in the disposal process of one-way bottles?
    a. How can this process be optimised?
16. Is there difference in the convenience of the disposal process for returnable bottles in comparison with one-way bottles?
    a. How can the disposal process be optimised as to maximise consumer convenience (minimise time/effort)?

viii. Ending

17. Are there any remaining topics that we did not discuss that have an impact on the carbon footprint through consumer convenience?
18. *Returnable bottles are considered less portable and more of a hassle in terms of disposal, is e-commerce an alternative method for returning bottles from the consumer's homes?*

14.4 Dutch Interview guide: Consumer-oriented Experts

Introductie vraag

Mijn onderzoek over hoe bierproducenten hun carbon footprint van glazen verpakkingen kunnen verminderen met het oog op consumentengemak (consumer convenience).

1. Wat is uw ervaring met dit onderwerp?

Theoretical underpinnings – Convenience demands & environmental considerations

2. Hoe zou u consumer convenience definiëren? **Geef hierna ook je eigen definitie van consumer convenience**
3. Is er een *recente* trend naar consumer convenience voor (glazen) verpakkingen? Waarom zien we deze trend juist nu?
4. Welke fase van de zogeheten 'customer journey' kost voor de klant het meest tijd en moeite met betrekking tot glazen bierflesjes?
5. Wat zijn elementen van consumer convenience in glazen verpakkingen?
    a. Hoe belangrijk zijn deze elementen ten opzichte van andere functionele karakteristieken zoals prijs en kwaliteit?
    b. Hoe belangrijk zijn duurzaamheidsoverwegingen voor de consument ten opzichte van de voorgaande karakteristieken?
6. Zijn consumenten zich bewust van de milieu-impact van eenmalige glazen verpakkingen?
    a. ***Nee, dan:*** Zouden consumenten hun koopgedrag veranderen als ze zich bewust waren van de impact die hun keuze verpakking heeft?
    b. ***Ja, dan:*** Hoe kunnen bedrijven als Heineken duurzamere verpakkingen, zoals het statiegeld flesje, promoten aangezien ze nog niet in grote getalen worden verkocht?
7. Met betrekking tot het stimuleren van duurzame verpakking aankopen: is de geringe betrokkenheid en herhaal aankopen die typisch zijn voor FMCG-producten een barrière voor de aankoop van duurzame verpakkingen?
    a. **Ja:** Wat betekent dit voor de aanpak die bedrijven moeten volgen om duurzame aankopen te stimuleren?
        i. Moeten bedrijven de transitie naar duurzame verpakkingen 'forceren' door duurzaamheidaspecten automatisch te integreren met hun verpakkingen?
        ii. Of kan consumentengedrag vanzelf veranderen door middel van de juiste communicatie en informatie?
    b. Hoe kunnen bedrijven consumenten het best stimuleren met betrekking tot het kopen van duurzame verpakkingen?
8. **Als u kijkt naar de beweegredenen voor bedrijven**; Hebben duurzaamheidsoverwegingen alleen een marketingfunctie of ook operationele beweegredenen?

Glazen verpakkingen

Binnen mijn onderzoek heb ik mij gericht op drie belangrijke impact hotspots met betrekking glazen verpakkingen: gewicht, herbruikbare of eenmalige verpakkingen en de landelijke recycling rate

v. Gewicht

Lightweighting is een strategie voor bedrijven om hun CO_2-emissies van verpakkingen te verminderen. Ondanks dat het al veelvuldig gedaan wordt zit het theoretisch minimum nog vaak lager dan wat gemiddeld op de markt is.

9. Zijn consumenten zich bewust van verschillen in gewicht tussen verschillende glazen flessen?
    a. **Ja**: Wil de consument liever een zwaardere of een lichtere fles? Waarom?

Gerelateerd aan het gewicht van een fles is het gewicht/volume ratio. Des te lager deze ratio, des te beter (minder materiaal per hl).

10. Wat maakt kleinere porties aantrekkelijk voor consumenten?
11. Zou een bierproducent klanten verliezen als deze stopt met het aanbieden van kleine porties? Waarom?

vi. *Returnable vs one-way packaging*

12. Wat zijn de voordelen voor eenmalige verpakkingen ten opzichte van herbruikbare verpakkingen?
    a. Voor het bedrijf?
    b. Voor de consument?
13. Wat zijn de barrieres om volledig over te stappen naar herbruikbare verpakkingen?
    a. Voor het bedrijf?
    b. Voor de consument?
14. Hoe kan de consument worden gestimuleerd om herbruikbare verpakkingen te kopen? Wat voor stimulansen zijn hierbij belangrijk?

vii. Disposal & country recycling rates

Correcte afvalscheiding is essentieel voor de recycling rate voor eenmalige verpakking en het terugbrengen van herbruikbare flesjes is essentieel voor de return rate.

15. Wat zijn de belemmeringen voor consumenten in het correct verwerken van lege eenmalige glazen verpakkingen?
    a. Hoe kan het wegwerp proces verbeterd worden?
16. Zit er verschil in het gebruiksgemak van het wegbrengen van herbruikbare verpakkingen in vergelijking met eenmalige verpakkingen?
    a. Hoe kan dit worden geoptimaliseerd om de consumer convenience te maximaliseren? (minimaliseren van tijd en moeite)

viii. Ending

17. Is er nog een aspect wat we niet besproken hebben maar wel impact heeft op de Carbon Footprint als gevolg van consumer convenience demands?
18. Vanuit het perspectief dat herbruikbare flesjes minder handzaam zijn en daardoor meer moeite kosten om het terug te brengen: is e-commerce een goed alternatief om daarbij sales en return te vergemakkelijken?

Appendix 3 – Discussion on the methodology of the four Heineken studies

An elaborate discussion on the methodology of each study is presented in this Appendix.

Study 1: Heineken 0.0%

The first reviewed study is a research from Heineken Netherlands with regards to Heineken 0.0%. In order to test the feasibility and desirability of the switch towards returnable packaging, Heineken 0.0% was chosen as a pilot product for the transition towards returnable bottles. The aim of this study was therefore to examine whether the switch to returnable bottles would form a risk for Heineken's market share or whether new buyers could be attracted.

Methodology

This study has been performed in collaboration with GFK, a major market research company from Germany. The sample consisted of a GFK consumer panel. The selection of participants were based on whether they had consumed 0.0% Heineken or other lager brands within the last twelve months and were above the age of 18. Of the 1139 invited participants, 648 participants correctly completed the research, of which N=306 were buyers of Heineken and N=342 were buyers of other 0.0% brands. As the research was based on computer assisted web interviewing, this denotes a high response rate compared to what is expected from the literature (Crawford, Couper, & Lamias, 2001), with reported response rates of web surveys varying between 27-37% (Guterbock, Meekins, Weaver, & Fries, 2000; Kwak & Radler, 2000; Medlin, Roy, & Chai, 1999). The research consisted of a conjoint analysis with eighteen additional survey questions to gain further insights. The conjoint analysis was based on six elements – brand, price, unit volume, pack size, type of packaging material, type of cap and deposit money. The research aim had been to find out which of these elements were prime drivers for product choice. A parallel aim was to gain an indication of the market share when returnable bottles would be introduced.

This methodology presents the typical issue with this kind of research and – as will be discussed – with the other research as well. All findings are based on an indication given by the consumer, not on observations of actual behaviour, giving rise to the intention-behaviour gap. Nonetheless, by choosing a conjoint research design, consumers can at least compare a range of products as they would in the supermarket, thereby giving a more realistic representation than in the case of direct questions about preferred attributes of a product.

Study 2: HNK & Koos Service Design

The second study is performed by Koos Service Design for Heineken Netherlands and consisted of two parts. The first part of the research was aimed at gaining explorative insights into consumer profiles and the consumer value proposition for different packaging types of beer beverages. The second part of the research contained a more in-depth exploration of design interventions throughout the consumer journey and whether these interventions could entice the consumer to purchase returnable bottles. These interventions were mostly revolving around disposal solutions (e.g. a take-back service, smaller returnable crates) and increasing convenience of returnable bottles and packs.

Methodology

The research design of the first part of the research consisted of qualitative interviews with consumers (n=18), while the second part utilised the user testing research design (n=6). For an explorative qualitative research it need not be the aim to establish a complete description of all elements that play a role. Instead, new insights are sought that contribute to the issue at hand (Malterud, Siersma, & Guassora, 2016). The sample size of the qualitative interviews seems to be sufficient to accomplish this.

For the user testing the Google Sprint method (Design Sprints, n.d.) was applied to gain insights in the riskiest and most important assumptions around the desired consumer journey. To test these assumptions, three prototypes were used:

- a 3d-printed returnable 25cl multipack
- a highly embossed new version of the Heineken 25cl bottle
- a flyer/brochure of the Heineken Now take-back service

These prototypes were tested with five Heineken mono-drinking consumers using 60-minute in-depth interviews. In total, nine assumptions were tested (see Table 27).

Table 27 - Assumptions tested in User Testing

#	Assumptions
1	Take-back service is a reason to buy
2	A durable multipack that is heavier but sturdier is acceptable to the user
3	Adding an opening function on the crate replaces convenience of the twist-cap
4	Newly designed, heavier bottle makes the experience more premium
5	Using 25cl bottles supports a premium experience (disproved)
6	A good feeling ('Karma') is a driver to return the bottles (disproved)
7	A durable multipack is desirable to return the bottles
8	A return service supports a careless experience (like disposing in the trash or bottle bank)
9	Users are open to change their habits when hearing about sustainability consequences

The sample size of the design sprint was based on the work of Nielsen & Landauer (1993) and Nielson (2000). These authors had created a formula to determine the optimum sample size for user testing, resulting in the recommendation that "*the best results come from testing no more than 5 users and running as many small tests as you can afford*" (Nielson, 2000). It should be noted, however, that this recommendation is based on web-page user testing and is only suitable for target groups of similar makeup. If there are different consumer groups with significantly different behaviour or demands, a higher sample is recommended (Nielson, 2000). As only mono-drinking Heineken consumers are used to test nine assumptions, the sample size seems to be insufficient for any definitive confirmation or rejection of the stated hypotheses for consumers outside of this target group. Nonetheless, it offers explorative insights which could be used to further develop prototypes and can be used as valuable input of further pilot studies.

Study 3: A Mono shopper analysis

The third study executed by The Conversation Studio in assignment of Heineken addressed the question what the purchase motives and drivers are for consumers to buy one-way bottles with a unit volume of 25cl and a twist-off cap. Revealing motives for buying these one-way bottles could potentially give insights in what is essential for these buyers and what are requirements for the switch to returnable bottles to be successful.

Methodology

The research was set up by The Conversation Studio, who created a questionnaire consisting of in total six open and multiple choice questions. The questionnaire was put up as an advertisement on Facebook at two instances:

- 12-10-2018 until 14-10-2018 under the Dutch target group of age 18-75, both male and female.
- 14-10-2018 until 15-10-2018 under the Dutch female target group of age 30-75.

Data was gathered through Upinion, a market research company which sets up surveys in, among others, Facebook Messenger. In total, 104 consumers participated in the survey of which 54% male and 46% female. All age groups were represented, albeit with the majority of the participants being either between 20-29 or 30-39 (respectively 35% and 31%). Participants had been screened out of the data in case they had not consumed the product within the last four months. A consequence is that the remaining participants might be biased towards consumers with a particular affiliation to either Heineken or the product of interest. Therefore, results can only be generalised to the broader population and other product categories than the 25cl bottle with great caution.

Study 4: Image and use of beer packaging

The final study discussed in this research was performed by Blauw in corporation with Heineken Netherlands. The aim of the study was twofold. First, Heineken was interested in the association consumers have with different types of packaging and at which moments they would consume them. The second goal was to explore which pack size was ideal for which situations and why.

Methodology

The research was conducted using respondents from the 'Biercommunity' from Heineken, an online platform with a community of beer drinkers that like to share their opinion with Heineken. Within this platform, a survey was conducted to evaluate different packaging types and pack sizes with a total of 130 participants. The fact that respondents are gathered from a dedicated community has both benefits and drawbacks. The benefit is that these participants are likely to be engaged with Heineken products and consume them on a regular basis, therefore being more knowledgeable than randomised participants. The drawback is that due to the relatively small and closed-off respondent base, the results gathered are not necessarily generalizable to the broader population.

Appendix 4 – Bottle Bills in the states of California and New York

Within the United States there is a large difference between states in terms of regulation, habits and other elements relevant for the Carbon Footprint. A brief overview is provided on two of the Bottle Bill states in the United States: California and New York. These states are chosen due to their importance for Heineken in terms of volume (they represent respectively the first and fourth highest volumes) and due to their geographical spread: the first is situated on the west coast, while the latter is on the east coast.

California

California is one of the ten states in the US that has container deposit legislation, called 'Bottle Bill'. In California, the Bottle Bill requires consumers to pay a California Redemption Value (CRV) – the equivalent of a deposit – when purchasing beverages from a retailer. The deposit is 5 US$ cents for beverage containers below 700ml and 10 cents for beverage container higher than 700ml. This deposit is fully returned to the consumer once the containers are redeemed at a recycling centre. Only for containers that are eligible CRV containers a deposit can be redeemed (CalRecycle, 2019). Unlike in other states, retailers are not required to collect empty containers. Instead, independent recycling centres have been established, although supermarkets may have recycling facilities at their facilities if they are certified by the Department of Conservation (Nielsen & Walker, 2003). If no recycling centre is available in the supermarket, a recycling centre is required to be present within the 'convenience zone' of 500m of the store with a revenue of at least two million dollars (Californians Against Waste, 2015; Container Recycling Institute, 2019a; Fensl et al., 2019). Overall, a recycling rate of 69% for glass is reached (CalRecycle, 2018). According to CalRecycle, 88% of the recycled beverage containers were recycled at redemption centres, and the remaining 12% were recycled through kerbside and drop-off programs in 2017 (Container Recycling Institute, 2019b).

New York

A Bottle Bill is also present in New York in a slightly different format. A five cent deposit is required on all glass, metal or plastic containers of less than one gallon (3.78 litres). Empty containers can be redeemed at any vendor that sells that type and brand of the container. Typically, consumers can deposit their empty containers in Reverse Vending Machines, which provide a five cent voucher that can be exchanged for credit or cash in the shop (Cherry & Acquario, 2016). Similar to California, only beverage containers that are bought in New York are eligible for a deposit redemption (Department of Environmental Conservation, n.d.). After collection, the containers are picked up by third-party services that initiate the recycling process (Cherry & Acquario, 2016). The redemption rate under the Bottle Bill is around 70% for all beverage containers (Cherry & Acquario, 2016; Department of Environmental Conservation, n.d.). Nonetheless, a large part of the empty containers still end up in kerbside collection, which is a more convenient disposal route for many consumers (Lange, 2019). As a deposit on empty containers that end up in kerbside collection can still be redeemed, this has led to the emergence of 'canners', people that collect empty bottles and cans on the streets as a means of income. This phenomenon was illustrated in the short documentary Redemption (2012), "*in which empty beverage containers become a symbol for poverty and exploitation*" (Jorgensen, 2013). This perception that getting back a deposit for a beverage container is for the poor further taints the already questionable consumer engagement with recycling.

Appendix 5 – LCI Distribution; Case study United States

In order to calculate the carbon footprint from the export volume to the United States, additional information was needed alongside the LCI presented in Chapter 4.1.4 for the Netherlands. As Heineken Netherlands does not transport returnable bottles to the US (or overseas for that matter), the calculation is based on a hypothetical case.

LCI: Distribution

Transport distances were collected for both the West- and East Coast. If not mentioned otherwise, data was collected from the Heineken Green Logistics stream. Distribution emissions were calculated for both one-way bottles and returnable bottles, using two transport modes:

- Ocean transportation with a standard 40ft Container with the following specifications (BSF Expediteurs, n.d.) :
  - **Interior size** (L x B x H): 12.01m x 2.33m x 2.38m
  - **Door size** (B x H): 2.33m x 2.28 m
  - **Suitable for** 20 standard pallets of 1000mm x 1200mm
- Heavy truck 26-40 tonnes using diesel fuel. It is assumed that a similar content can be transported as in the 40ft described above.

The hectolitre transported per shipment for each packaging types has been calculated based on the above parameters, and the size of the secondary/tertiary packaging from both packaging types. It is assumed that both packaging types are stacked to a height of 8 packs on a standard pallet with the height of 0.144m. Following Table 28, for every shipment of one-way glass bottles, 1.2 shipments of returnable bottles have to be made to transport the same amount of hectolitres.

Table 28 - Calculation for hectolitre per shipment

	One-way glass bottles	Returnable glass bottles
Type	Heineken pack 24 x 330ml	Heineken crate 24 x 330ml
Secondary packaging size (L x B x H)	0.371m x 0.248m x 0.242	0.4m x 0.3m x 0.25
# Packs on a pallet	12	10
# Packs in a container	1920	1600
Hectolitre per shipment	**152**	**127**

The emission factors of both transportation types are presented in Table 29. The emission factors for the truck is gathered from Internal Heineken Data, while the emissions of the ocean vessels are derived from the methodology of the BSR Clean Cargo report (BSR Clean Cargo Working Group, 2015, 2018). Some assumptions are made to correct for a number of factors:

- As BSR calculations are based on TTW (tank-to-wheel), a conversion factor of 1.088 is used to convert it to WTW (well-to-wheel).
- The BSR calculations only include CO_2 emissions and no other GHG emissions as most emissions derive from fuel consumption of the engines. To correct for this slight difference, a conversion factor of 1.01 is used to convert it to CO_2e emissions.
- The load factor is assumed to be 70%. Based on an analysis of all the largest trade lanes, BSR concluded that the average utilisation is around 70%, which aligns with findings from IMO and WSC
- As the calculations of distance from load port to discharge port is most often calculated through online tools, it is typically based on the shortest distance. Therefore, a distance adjustment factor is applied of 1.15

Table 29 - Emission Factors for each transport mode. EC = East Coast, WC = West Coast

MODALITY	TYPE	EMISSION FACTOR 0% CAPACITY	EMISSION FACTOR 100% CAPACITY
TRUCK	Truck 26-40 t	0.746	1.200
OCEAN (EC)	Container 40 ft	0.218	0.218
OCEAN (WC)	Container 40 ft	0.210	0.210

The emissions per packaging type per hectolitre are calculated using the following formula:

$kgCO_2/hl$: $(((EF_{i,100\%} - EF_{i,0\%}) * WU_{i,j} + EF_{i,0\%}) * TD_{i,j}) / VL_{ship} + (((EF_{i,100\%} - EF_{i,0\%}) * WU_{ret} + EF_{i,0\%}) * TD_{i,j}) / VL_{ship}$

Where:

- **$EF_{i,100\%}$:** emission factor of the used transportation type (i) at full capacity
- **$EF_{i,0\%}$:** emission factor of the used transportation type (i) at zero capacity
- **$WU_{i,j}$**: the average weight utilisation of the used transportation type (i) per shipment on a particular route (j).
- **WU_{ret}:** the $WU_{i,j}$ for the return trip of the empty packaging. For returnable bottles, the WU_{ret} is 43% lower than $WU_{i,j}$ due to the missing volume. An empty return trip with 0% WU_{ret} is assumed for one-way bottles.
- **$TD_{i,j}$**: the distance travelled in km on a particular route (j) by the used type of truck (i)
- **VL_{ship}:** the volume in hectolitre per shipment. Respectively 152hl for one-way bottles and 127hl for returnable bottles.