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The Closed-Loop Endeavour

A Case Study on Barriers and Enhancements of the PET Bottle-to-Bottle Recycling Systems in Germany and Sweden

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Fabian Bayer Jonas Bergmann

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Master Thesis within Business Administration

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Abstract

Problem: The demand of beverages in PET bottles is constantly increasing. In this context, environmental, technological and regulatory aspects set a stronger focus on recycling. Generally, the reuse of recycled material from post-consumer PET bottles in bottle-to-bottle applications is seen as least environmentally harmful. However, closed-loop systems are not widely implemented in Europe. Previous research mainly focuses on open-loop recycling systems and generally lacks discussion about the current German and Swedish systems and their challenges. Furthermore, previous studies lack theoretical and practical enhancements for bottle-to-bottle recycling from a managerial perspective.

Purpose: The purpose of this study is to compare the PET bottle recycling systems in Germany and Sweden, analyse the main barriers and develop enhancements for closed-loop systems.

Method: This qualitative study employs a case study strategy about the two cases of Germany and Sweden. In total, 14 semi-structured interviews are conducted with respondents from different industry sectors within the PET bottle recycling systems. The empirical data is categorised and then analysed by pattern matching with the developed theoretical framework.

Conclusion: Due to the theoretical and practical commitment to closed-loop recycling, the Swedish PET bottle recycling system outperforms the Germany system. In Germany, bottle-to-bottle recycling is currently performed on a smaller scale without a unified system. The main barriers for bottle-to-bottle recycling are distinguished into (1) quality and material factors, (2) regulatory and legal factors, (3) economic and market factors and (4) factors influenced by consumers. The enhancements for the systems are (1) quality and material factors, (2) regulatory and legal factors, (3) recollection factors and (4) expanding factors. Lastly, the authors provide further recommendations, which are (1) a recycling content symbol on bottle labels, (2) a council for bottle quality in Germany, (3) a quality seal for the holistic systems, (4) a reduction of transportation in Sweden and (5) an increase of consumer awareness on PET bottle consumption.

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Abbreviations

b2b	Bottle-to-bottle
b2f	Bottle-to-fibre
BCC	Bottle Consolidation Centre
CEO	Chief Executive Officer
CLSC	Closed-loop supply chain
CO_2	Carbon Dioxide
DC	Distribution Centre
DKR	Deutsche Gesellschaft für Kreislaufwirtschaft und Rohstoffe mbH
DPG	Deutsche Pfandsystem GmbH
EU	European Union
PET	Polyethylene terephthalate
PVC	Polyvinyl chloride
r-PET	Recycled polyethylene terephthalate (in form of flakes or resin)
RVM	Reverse vending machine
SCM	Supply chain management
SEK	Swedish Krona
TPL	Third party logistics provider
UV	Ultraviolet rays
v-PET	Virgin polyethylene terephthalate resin

List of Definitions

Association: Organisation that represents and consolidates the interests of a specific industry sector, e.g. German car manufacturers.

Bale bottles: Post-consumer PET bottles that are compressed and formed to quadratic bales.

Bottle filler: Business organisation that produces PET bottles out of preforms and fills them with beverages.

Bottle preform manufacturer: Manufacturer that produces bottle preforms out of PET flakes or resin (cf. Appendix 1).

Bottle return/recollection rate: The rate to which extent PET bottles are returned or reclaimed. Within a deposit system, it describes the rate to which consumers return PET bottles.

Bottle-to-bottle: Post-consumer bottles are recycled to food-grade PET flakes or resin, which are then used in their original application: the manufacturing of new bottles (cf. closed-loop recycling; Figure 2-3; Noone, 2008).

Bottle-to-fibre: Post-consumer bottles are recycled to PET flakes or resin, which is then used in fibre applications with lower quality requirements than the original use. Subsequently, fibre is typically used for the production of textiles (cf. open-loop recycling; Appendix 2; Noone, 2008).

Closed-loop recycling: Part of closed-loop supply chains which are distribution systems that combine manufacturing and remanufacturing. The focus is set on recycling and reusing the post-consumer material for the same application (Savaskan et al., 2004; Shen et al., 2010).

Deposit system: Market-based instrument that mandates a surcharge when a product is purchased and provides this surcharge as a refund when the product is returned by consumers. In the context of this study it is characterised as beverage container deposit systems.

Food retailer: An organisation that primarily sells groceries. In the context of this study, food retailers provide and run RVMs.

Open-loop recycling: Part of open-loop supply chains, in which partly or all distributed products are returned and reused. The focus is set on retrieving the post-consumer material and using it for other applications with lower requirements than the original one (Shen et al., 2010; Ekvall & Tillmann, 1997).

PET bottle recycling system: System that consists of various actors in the PET bottle industry with the main target to recycle PET bottles. This includes the closed-loop PET bottle recycling system. It exemplarily consists of a bottle collector, recycler, preform manufacturer, bottle filler and food retailer (cf. Appendix 3).

PET bottle: Beverage container made of polyethylene terephthalate. Both disposable and reusable PET bottles exist.

PET flakes: Form of appearance of PET. PET flakes are a final recycling product, occur in a shredded form and can be used for remanufacturing (cf. Appendix 4).

PET resin: Form of appearance of PET. PET resin can either be v-PET or r-PET. PET resin has gone through thermal manufacturing processes and appears as small pallets (cf. Appendix 5).

Post-consumer PET bottles: Returned PET bottles after consumption.

Recycler: Business organisation that processes and recycles returned raw material for reutilisation.

Reverse vending machine: A return vending machine is the physical automat that takes back post-consumer PET bottles and typically provides a coupon for refund.

r-PET: Recycled polyethylene terephthalate is raw material that has been reclaimed after post-consumer usage and processed through recycling.

v-PET: Virgin polyethylene terephthalate is raw material that is produced directly from the petrochemical feedstock such as crude oil and natural gas. It has never been used or processed before.

Yellowing: Discolouration of mostly clear PET to PET material with a yellow colour cast.

1 Introduction

This chapter presents an overview to the subject. Firstly, the background provides information regarding different types of reverse logistics and the current significance of polyethylene terephthalate (PET) consumption and recycling. By employing a funnel approach, the relevant challenges are then established. Thereafter, the purpose of this study including research questions is presented. The chapter concludes with the relevant scope and delimitations and provides a brief overview of the study's outline.

1.1 Background

Within the topic of supply chain management (SCM), currently reverse logistics is a prevailing and critical subject with an increasing importance to *'any business involved in the manufacture, distribution, and service and support of products of any type'* (Blumberg, 2004, p. V). Shorter product lifecycles and an increasing value of the product itself including the used materials are a selection of the eclectic reasons of reverse logistics' importance in modern times of commerce (Blumberg, 2004). Economic, technological and especially regulatory trends emphasise reverse logistics topics to a more enhanced extent. Notably, regulations in terms of sustainability and economic pressure strengthen interest in reverse logistics in order to recover and utilise valuable products, technology and used material for economic opportunities and improving the environmental performance of a business (Blumberg, 2004; Savaskan, Bhattacharya & Van Wassenhove, 2004). According to Rogers & Tibben-Lemke (1998, p. 2), reverse logistics is defined as *'the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements'*.

According to Blumberg (2004), the term of closed-loop supply chains (CLSC) describes the condition of an upstream product flow executed by the same organisation responsible for the downstream product flow. The term of upstream product flows is considered as a synonym to reverse product flows and therefore is part of reverse logistics. Savaskan et al. (2004) refer to closed-loop supply chains as distribution systems that combine manufacturing and remanufacturing. Pohlen & Farris (1992) claim that especially reverse logistics flows for recycling purposes differ in their characteristics and channels from the downstream flows for the same product. The implemented reverse channel from a recycling perspective intends to *'accumulate, transport, and process the material for remanufacture into a recycled product'* (Pohlen & Farris, 1992, p. 35).

The previously described definition of closed-loop supply chains might vary in today's business environment. In the context of outsourcing logistics services to third-party logistics (TPL) providers, up- and downstream product flows might not be carried out by a single organisation. Outsourcing in general is defined as the '*use of external companies to perform logistics functions that have traditionally been performed'* internally (Lieb, 1992, p. 29).

Over the last decades, consumption of plastics has grown rapidly and consequently the amount of plastics waste as well. Plastics in general are created out of the non-renewable resources of oil and gas. A share up to approximately 8% of the world's oil

and gas production are used for plastics production and manufacturing (Hopewell, Dvorak & Kosior, 2009). To a large extent, it is used to produce packaging or short-living products. Considering, the feedstock as well as manufactured products, Hopewell et al. (2009) define the use of plastics as not sustainable. However, plastics recycling is a mechanism to reduce the general environmental impact of using plastics. Various recycling technologies avert a main disadvantage of plastics consumption – the increasing amount of plastics waste often after a single use (Arena, Mastellone & Perugini, 2003; Hopewell et al., 2009). Particularly when applied to post-consumer plastics packaging, recycling demonstrably reduces the environmental impact of those products (Ross & Evans, 2003) and even allows firms to minimise cost (Lea, 1996).

Particularly the consumption of polyethylene terephthalate (PET) has markedly increased caused by a growing consumption of PET bottles (Parra, Ania, Arenillas, Rubiera & Pis, 2004). Especially characteristics of PET such as its low weight, durability and inexpensiveness cause the high popularity among manufacturers and consumers (Hopewell et al., 2009; Welle, 2011). Notably, in terms of containing beverages it evolved to the most attractive packaging (Welle, 2011). This consequently results in increasing amounts of PET waste and the displacement of refillable beverage containers out of glass and beverage cartons on the beverage container market (Das Erste, 2015; Parra et al., 2004; UBA, 2011; UBA, 2013).

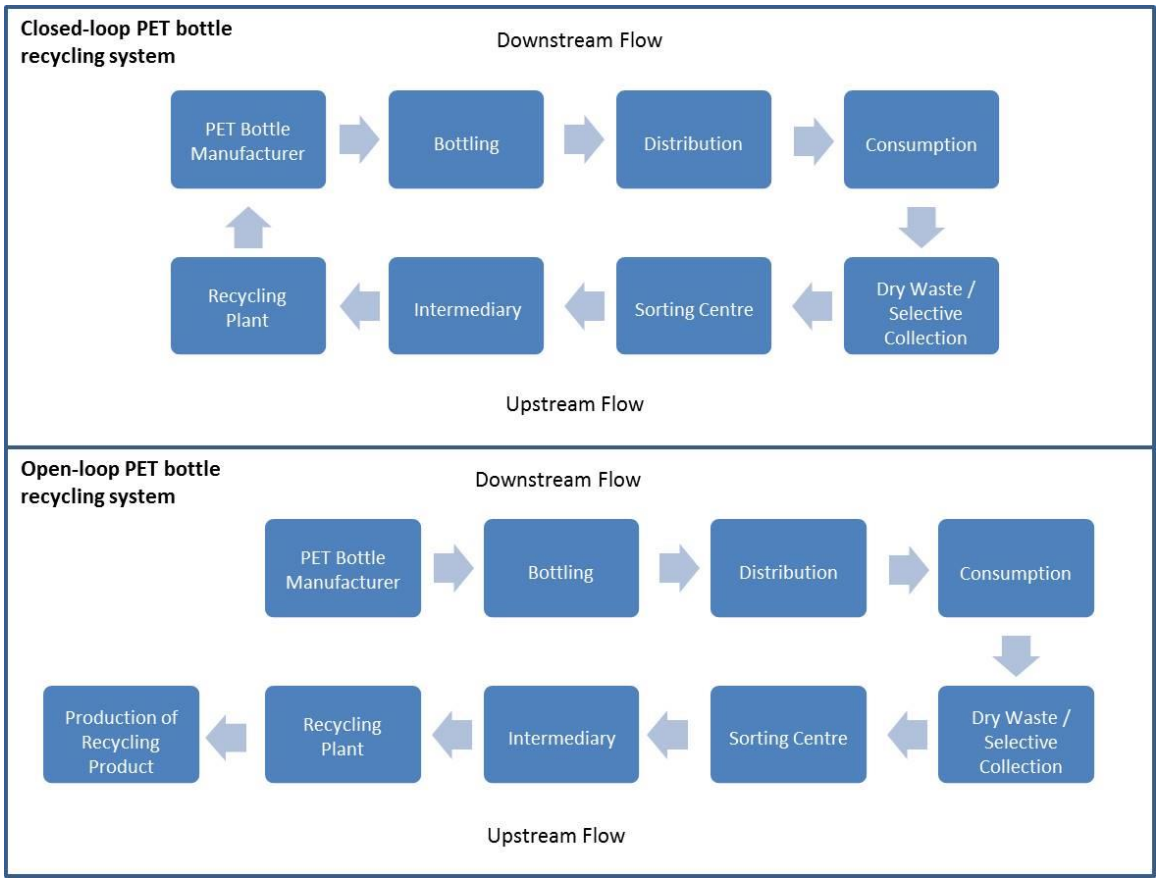

Figure 1-1 Simplified Closed-Loop and Open-Loop PET Bottle Recycling System

The main challenge faced by the involved supply chain actors is the reclamation of post-consumer PET bottles in order to meet the growing demand. Hence, a stronger emphasis is put on recycling processes for PET, but also environmental, technological and

regulatory aspects set a stronger focus on recycling. Various studies demonstrate that PET recycling has a significant positive effect on the environmental burden of PET bottle production and consumption (Chilton, Burnley & Nesaratnam, 2010; Ross & Evans, 2003; Shen, Worrell & Patel, 2010). Furthermore, PET bottle recycling characterises an opportunity of employment and cost reduction for businesses (Nascimento, Trevisan, Figueir & Bossle, 2006).

PET bottles are mainly recycled or reprocessed through bottle-to-bottle (b2b) recycling, bottle-to-fibre (b2f) recycling and incineration (Shen et al., 2010). Within the context of PET bottle recycling, b2f is considered as an open-loop mechanism, whereas b2b depicts a closed-loop recycling system (Shen et al., 2010). Open-loop recycling is defined as '*material and energy being used in more than one product'* (Ekvall & Tillman, 1997, p. 155). Shen et al. (2010) methodologically describe an open-loop recycling system with the help of the cut-off principle. The cut-off principle distinguishes between the virgin product and the recycled product (Shen et al., 2010). Figure 1–1 depicts a simplified closed-loop and open-loop recycling system. Noone (2008) states that approximately one tenth of post-consumer PET bottles are recycled and remanufactured to bottles (b2b) worldwide. The vast majority of post-consumer PET bottles are recycled to fibres (b2f) (Noone, 2008). However, fibres cannot be additionally recycled, as mixing PET fibres with other textile fibres causes separation infeasibility of the several additives in the textile (Shen, Nieuwlaar, Worrell & Patel, 2011). Additionally, the high crystallinity of PET fibre constrains mechanical recycling processes (Shen et al., 2011). Therefore, textiles made from recycled PET fibres are mainly used for incineration or landfilling (Shen et al., 2010).

Post-consumer PET bottle recycling is strongly dependent not only on the business environment but also on the legal environment. Given that regulatory factors vary from country to country, consequently post-consumer PET bottle recycling differs as well. Thus, the legal frameworks in both focus countries Germany and Sweden differ from each other. However, deposit systems as an important prerequisite for b2b recycling exist. Additionally, recycling is already applied vastly in both focus countries. The systems in Germany and Sweden offer opportunities for further development and enhancements in terms of closed-loop recycling, which are further discussed in this study.

1.2 Problem Statement

Extensive research has already been conducted on the subjects of greenhouse gas emissions analysis combined with an evaluation of different PET waste recycling processes (Chilton et al., 2010; Nakatani, Fujii, Moriguchi & Hirao, 2010; Ross & Evans, 2003; Shen et al., 2011; Shen et al. 2010; Song & Hyun, 1999). These life-cycle assessment studies show that the environmental impact of PET recycling systems is lower than alternative non-recycling disposal methods such as landfilling or incineration (Nakatani et al., 2010; Kuczenski & Geyer, 2013). Referring to the aforementioned growing public importance of sustainability, a closed-loop recycling system in which new PET bottles are produced from PET bottle waste fulfil this criterion to the highest degree (Wollny, Dehous, Fritsche & Weinem, 2001). However, literature mainly discusses the aspects of open-loop PET recycling (Altun & Ulcay, 2004; Shen et al., 2010; Shukla, Harad & Jawale, 2008). Since this is not the most advantageous process

in terms of sustainability (Wollny et al., 2001), a critical dispute is lacking at this point, representing the first identified literature gap.

An important aspect for a best practice process (e.g. the most sustainable recycling process) is its implementation (Laugen & Boer, 2007). However, little research has been conducted on how such closed-loop systems can be implemented, operated and enhanced in the long term. There is a lack of analysis of business opportunities, incentives and economic factors that go beyond environmental aspects. Studies about the technical operations of the processes are prevalent (Callari, 2013; Sinha, Patel & Patel, 2011), but not connected with critical success factors such as enhancements and incentives for a sustainable industry. When planning and operating a supply chain, not only the technical part has to be considered but also how to achieve efficiency and effectiveness of the supply chain, the regulatory setting, value proposition, profitability and supply chain design (Rao Tummala, Phillips & Johnson, 2006). Conducting a comprehensive literature review, it has been revealed that studies which include the aforementioned business-related factors specifically for PET b2b recycling systems are rare. Secondary research using appropriate keywords in well-established scientific databases such as Scopus and Web of Science only obtained three publications, namely Eik (2005), Nascimento et al. (2006) and Welle (2011). This depicts the second gap in literature.

Furthermore, the most recent trends in the PET recycling industry, for instance improved automated sorting processes, an increasing quota of mechanical recycling and ultimately cost reduction due to technical development make closed-loop recycling processes more competitive (BIO Intelligence Service, 2013; Eik, 2005). This rationale partly contradicts with the current status of closed-loop recycling systems in the focus countries: a holistic implementation has not taken place yet, while PET bottles constantly increase their market share especially in Germany (Das Erste, 2015). Furthermore, present-day studies on the German and Swedish PET b2b recycling systems and its main challenges were not found at all. This depicts the third gap in literature.

The field of PET b2b recycling is considered as an evolving industry that calls to be studied thoroughly (Welle, 2011). In contrast, there is little academic research that points out explicit measures for supply chain actors on how to enhance the closed-loop recycling systems. Hence, this depicts an underdeveloped area of study.

1.3 Purpose

Summing up, three main gaps in literature were identified. Firstly, the main focus in literature is set on open-loop recycling and b2f recycling processes rather than explicitly b2b recycling. Closed-loop systems are only looked at from a technical and environmental perspective including the calculation of emissions. Secondly, the closed-loop recycling mechanisms and approaches are missing a connection with business opportunities and incentives for all involved supply chain actors. Thirdly, there is a lack of research about closed-loop PET bottle recycling systems specifically in Germany and Sweden analysing each country's current characteristics and differences. Recognisably, there must be barriers which hinder holistic closed-loop PET bottle recycling, since it is not fully implemented yet. Hence, this study intends to cover the identified gaps in literature. Herein, the emphasis is laid on business opportunities and incentives while

taking account of already conducted life-cycle assessment evaluation. Consequently, the purpose of this thesis is:

'To compare the PET bottle recycling systems in Germany and Sweden, analyse the main barriers and develop enhancements for closed-loop systems'.

In order to fulfil this purpose, three research questions have been formulated. The first step is to establish a detailed understanding of the current PET bottle recycling systems in Germany and Sweden including deposit system, selection and separation processes. Thus, the first research question is:

RQ1: How are the PET bottle recycling systems in Germany and Sweden currently operated and what are their differences?

Based on the current setting, it is noticeable that closed-loop recycling systems are not fully implemented in both countries yet. Consequently, the reasons for this matter need to be identified and summarised. Hence, the second research question is:

RQ2: What are the main barriers to introduce holistic closed-loop PET bottle recycling systems in Germany and Sweden?

Considering the results of previous research stating the environmental advantages of b2b recycling processes, it becomes evident that these barriers need to be eliminated in order to create a baseline for a more sustainable PET bottle recycling industry. Therefore, the third research question is:

RQ3: How can the closed-loop PET bottle recycling systems as well as resulting opportunities and incentives for involved actors in Germany and Sweden be enhanced?

In order to answer these research questions and fulfil the purpose, a holistic multiple case study with organisations active in the German and Swedish PET bottle recycling system is conducted. Based on the findings from the research questions, the intention is to contribute to theory regarding the identified gaps in literature.

1.4 Scope and Delimitations

The study is conducted in the area of business administration and covers research within the SCM field. The scope of the study can be shown with the help of an onion (cf. Figure 1–2). As shown in the outer layer, the overall theme is reverse logistics, which is related to the reuse and reutilisation of products in a broad sense. In this context, plastics recycling processes are the relevant reverse flows. This study's focus lies on PET bottle recycling systems, with the closed-loop recycling systems in Germany and Sweden – the onion's inner layer – as its main field of interest.

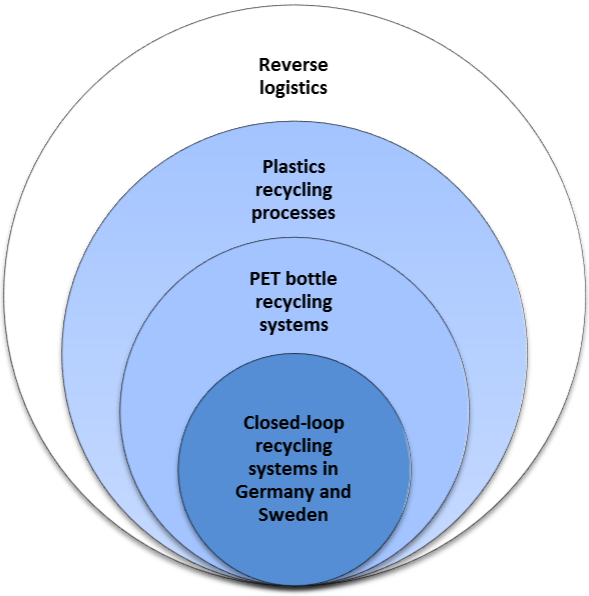

Figure 1-2 Scope of the Study

Consequently, this implies some delimitations for the study. Other countries besides Germany and Sweden will not be part of the study, since it would exhaust the study's scope. While the focus process is the closed-loop recycling system – the inner layer of Figure 1–2 – this does not imply an in-depth analysis of technical practices since this is a study within the field of business administration. However, an overview of the current practices and recycling processes as well as SCM procedures is certainly given to foster comprehension of the context. In relation to the limitations section, this study will not necessarily cover every single actor and perspective out of both focus countries' PET bottle recycling systems.

1.5 Outline of the Thesis

As depicted in Figure 1–3, the first chapter portrays the introduction to the study's topic, containing background information, the problem description and the subsequent research questions. In chapter two, the detailed frame of reference is highlighted, giving a summary of the current state of research within the field and presenting the theory on PET bottle recycling systems.

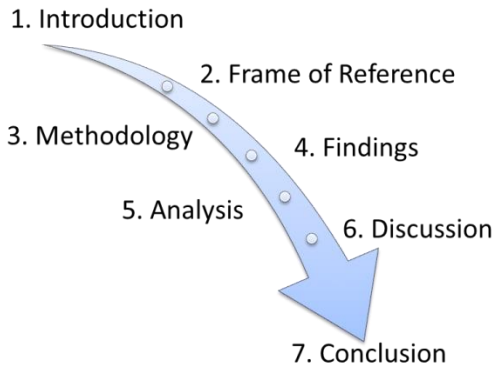

Figure 1-3 Outline of the Thesis

Chapter three defines research design of the conducted empirical study and contains the research approach, research strategy, data collection, data analysis and research quality. After the data collection process is completed, chapter four presents the findings in an organised way. Subsequently, the findings are analysed and compared with the theoretical data from the frame of reference. In chapter six, the analysis is discussed and further recommendations are stated. In the last chapter, conclusions about the whole study are made. Theoretical contributions, managerial implications, limitations and further research suggestions are covered as well.

2 Frame of Reference

This chapter provides the study's relevant theory. First, plastics recycling in Europe and in particular processes for PET recycling as well as sustainability aspects are described. Then, based on exposable information both focus countries' current deposit and recycling systems are described. Lastly, barriers and enhancements regarding PET bottle recycling derived from literature are specified.

2.1 Introduction to Frame of Reference

2.1.1 Plastics Recycling in Europe

The plastics production and recycling industry is of large importance in Europe. According to Plastics Europe (2015), the European Union (EU) countries (without Croatia plus Norway and Switzerland) rank second in plastics materials production worldwide and cover 20% of the global supply. Only China surpasses the European countries with a 25% share of global production. Within Europe, the highest demand is concentrated in Germany (25.4%), followed by Italy (14.3%) and France (9.7%). Sweden ranks 11th in the list.

Within the European plastics industry, the largest sector is represented by the packaging applications, which cover approximately 40% of the total demand (Plastics Europe, 2015). As already described in detail in section 1.1, PET is mainly used for beverage containers. PET accounts for one third of all packaging applications and thus is the most used type in the packaging sector (Hestin, Faninger, & Milios, 2014). Nevertheless, only a minor part of the overall generated plastics waste is recycled, the main use is incineration and landfill (Plastics Europe, 2015; cf. Figure 2–1). For this reason, the EU has introduced the EU Waste Framework Directive to implement the general recycling target of 50% for all household waste (PRE, 2012).

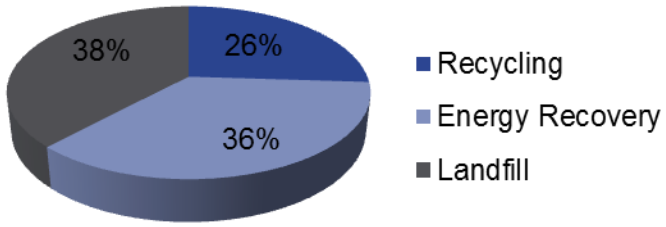

Figure 2-1 Use of Plastics Waste in Europe

According to Welle (2011), a prerequisite for accomplishing significant recycling rates for post-consumer PET bottles is a high recollection rate. However, the recollection rates of deposited and non-deposited PET bottles in European countries differ significantly and range from 93.4% in Germany to 12.5% in Bulgaria (Petcore, 2015). In Sweden, 82.6% are recollected while the European average is 57.2% (Petcore, 2015). Besides that, the possibility of contaminated PET bottles in the waste stream emphasises the necessity to apply technically advanced recycling processes for decontamination (Welle, 2011).

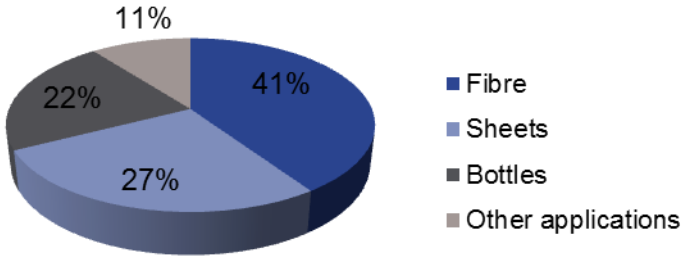

Figure 2-2 Applications of Recycled PET in Europe

The recycled PET (r-PET) is used for different purposes (cf. Figure 2–2). European statistics about the end markets after recycling show that the majority goes into fibres. The mere amount of 22% is used in a closed-loop b2b recycling system in Europe, while the largest part goes into an open-loop with different purposes. From a global perspective, the application is shifted even further towards b2f recycling and covers a total of 72% (Noone, 2008).

2.1.2 Processes in PET Recycling

Park & Allaby (2013, p. 742) define the general term of recycling as '*the reprocessing of discarded waste materials for reuse, which involves collection, sorting, processing, and conversion into raw materials which can be used in the production of new products*'. Referring to PET bottle recycling, this firstly involves the collection of used PET bottles from kerbside waste, drop-off locations or specifically implemented refill/deposit systems (BIO Intelligence Service, 2013). The waste then has to be sorted according to material and colour. In the next step, several processes are distinguished in order to understand the technical background. Hopewell et al. (2009) give an overview about the different methods used regarding to recycling processes (cf. Table 2-1).

Table 2-1 Different Methods in Recycling (adapted from Hopewell et al., 2009)

American Society for Testing and Materials (ASTM) Standard	International Organisation for Standardisation (ISO)	Corresponding terms
primary recycling	mechanical recycling	closed-loop recycling
secondary recycling	mechanical recycling	open-loop recycling / downgrading / downcycling
tertiary recycling	chemical recycling	feedstock recycling
quaternary recycling	energy recovery	valorization / incineration / thermal recovery

Primary recycling refers to a mechanical process in which the properties of the thermoplastic material are maintained (Hopewell et al., 2009). It is crucial to use the same type of polymers in this process to avoid inferior quality by mixing different waste streams (PRE, 2012). The included process steps are grinding, washing, separating, drying, re-granulating and compounding (PRE, 2012).

In secondary recycling, the same mechanical processes are used, but with the difference of an altered product use of the recyclate. Instead of using the r-PET in the initial application such as PET bottles, it involves a modification procedure but no chemical process (Recycling Consortium, 2014). Additionally, Hopewell et al. (2009) assert

secondary recycling for the use in applications which typically do not include v-PET. The efficiency of mechanical recycling generally varies and averages at approximately 60%, while the other 40% cannot be fully recycled and are used for other purposes such as different industries (downcycling) or energy recovery (BIO Intelligence Service, 2013).

In tertiary recycling, chemical processes are applied in order to retrieve the petrochemical components of the PET. The degraded chemicals can then be used for plastics remanufacturing, production of different chemicals or as alternative fuel (Sinha et al., 2010; PRE, 2012). However, this is generally found to be economically unviable due to reversing of the intensive previous polymerisation process (Hopewell et al., 2009).

Quaternary recycling refers to the recovery of energy from the PET waste through incineration. However, since there is no material output for the reuse of new products, this option is thought to be reasonable mainly for non-recyclable material (BIO Intelligence Service, 2013).

The products which are typically made from r-PET are fibres (e.g. carpet, fleece jackets, comforter fill, shopping bags), containers (e.g. beverages, food and non-food items), films and sheets as well as strapping (American Chemistry Council, 2015). From a life-cycle perspective, the processes can then be distinguished between closed-loop systems (b2b; cf. Figure 2–3) and open-loop systems (such as b2f; cf. Appendix 2).

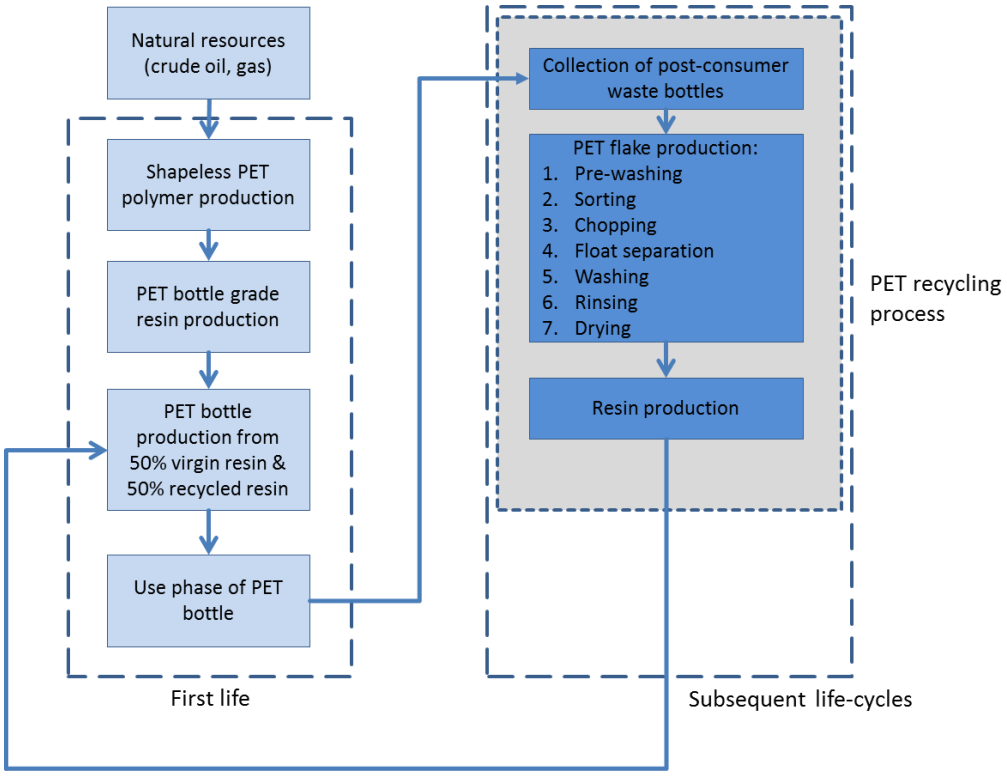

Figure 2-3 Bottle-to-Bottle Recycling System (adapted from Welle, 2011)

The left side of the figure depicts the process steps in the first life-cycle of the PET bottle, e.g. a new bottle is produced from crude oil. The right side presents the PET recycling process and the link of the recycled material back into the production process,

since it is generally always mixed with virgin PET (v-PET). In various studies, the closed-loop and open-loop systems have been evaluated regarding their life-cycle assessment. This sustainability aspect is discussed in the following section.

2.1.3 Sustainability

While several definitions of the concept of sustainability exist, the relevant framework adopted for this study's purpose defines sustainability '*as a condition of balance, resilience, and interconnectedness that allows human society to satisfy its needs while neither exceeding the capacity of its supporting ecosystems to continue to regenerate the services necessary to meet those needs nor by our actions diminishing biological diversity*' (Morelli, 2013, p. 6). There is an interdependence of ecological, social and economic systems, which are also referred as the three pillars of sustainability (Carter & Rogers, 2008). Specifically, in the field of SCM companies should consider these three pillars within the whole supply chain while conducting business (Seuring & Müller, 2008).

Within these pillars, attention has to be drawn upon the following aspects. Firstly, supply risk management refers to managing economic, environmental and social risks in the supply chain (Carter & Rogers, 2008). Transparency should be emphasised towards stakeholders and their feedback. The organisations' sustainability efforts must be linked with the overall strategy and corporate culture instead of managing them individually. From a holistic perspective, to accomplish sustainable practices one particular area of interest is the management of reverse flows in a supply chain. Within reverse flows, the reuse and recycling of post-consumer products plays an essential role (Govindan, Soleimani & Kannan, 2015).

Referring to the growing significance of sustainability, various studies have been carried out about the life-cycle assessment of the aforementioned recycling processes. Chilton et al. (2010) identify the reduction of all kinds of green-house gas emission when PET bottles are recycled and replace v-PET. More specifically, closed-loop recycling depicted the least environmentally harmful option in that study. This is backed up by Nakatani et al. (2010) and Kuczenski & Geyer (2013) in further studies. Additionally, it can be noted that '*many if not most plastic applications are in effect "over-engineered" if made from virgin plastics: in other words, virgin plastic could be substituted by recycled material and product functionality would not be affected'* (BIO Intelligence Service, 2013, p. 20). Hence, recycled material has the same properties and substitutes v-PET resin without detoriating the quality of the end product when using advanced procedures (Welle, 2013).

Comparing these findings to the recent statistics presented in section 2.1.1, it is noteworthy that only 22% of PET waste in the EU is recycled in a closed-loop system, where new bottles are actually made from the recycled material of old ones. The vast majority of 40.5% that goes into the b2b process is recycled only once, for the reason that fibres cannot be additionally recycled. As a result, it can be concluded that the described process of b2b recycling has to expand exhaustively within this industry in order to become further environmentally sustainable.

2.2 Deposit Systems and PET Bottle Recycling

2.2.1 Germany

In 1991, Germany issued a packaging ordinance (*'Verpackungsverordnung'*) with the aim to reuse and recycle packaging material within one or multiple standardised recycling systems (Hartlep & Souren, 2011; Patel, von Thienen, Jochem & Worrell, 2000). Germany has a deposit system on beverage containers made of glass, plastic and cans.

Due to the increasing popularity and consumption of PET bottles, the German legislature modified the packaging ordinance and introduced a container-deposit on disposable beverage containers – including PET bottles – in 2003 (Parra et al., 2004; Hoffman, 2011). This initially aimed to reduce PET bottle consumption and indirectly tried to raise the share of reusable beverage containers (CRI, 2015; DPG, 2016a). However, the share of reusable beverage containers nonetheless constantly decreased since 2003. By 2013, the quota accounted for 46.2% - meaning that 53.8% of every drink was filled in a disposable beverage container (BMUB, 2015).

This deposit amounts to 0.25 € per disposable beverage container (CRI, 2015; DPG, 2016a). A main advantage of deposit systems is the fact that the vast majority of deposited beverage containers is returned to a point of sale. Consumers then receive their financial refund. In Germany approximately 96% of deposited PET bottles are returned (IK, 2015). Thereby, the purity of variety is remarkably high. Since retailers face a take-back obligation on the type of beverage containers they sell, a seamless collection system for post-consumer PET bottles is given. The legal framework and the financial clearing for the container-deposit system on disposable beverage containers are managed by DPG Deutsche Pfandsystem GmbH (DPG) (DPG, 2016a). In conclusion, DPG provides the deposit system but is not responsible for PET bottle recycling (DPG, 2016b).

Post-consumer PET bottles are then supplied to recycling companies. Return flows are mainly managed between the first distributor and the food retailer that takes back (DPG, 2016c). The private organisation Deutsche Gesellschaft für Kreislaufwirtschaft und Rohstoffe mbH (DKR) is a large distributor of post-consumer resources including PET bottles. DKR's aim is to distribute these post-consumer resources to recycling companies and enhance their utilisation possibilities (DSD, 2015). Figure 2–4 depicts the simplified return flow for PET bottles until recycling.

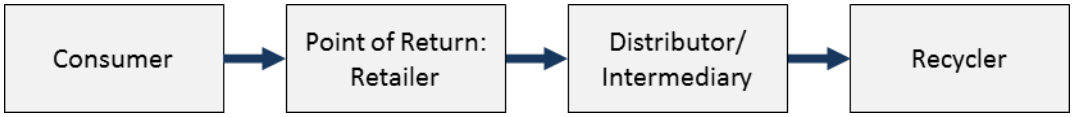

Figure 2-4 Simplified Return Flow in Germany

In 2013, 97.2% of the returned PET bottles in Germany were supplied towards further processing, whereas 80% of PET bottle recycling occurs in Germany (IK, 2015; BVSE, 2016; Schüler, 2015). Around one third of the collected post-consumer PET bottles are recycled to new PET bottles, the rest is used for different applications (SZ, 2014; Das Erste, 2015; IK, 2015). Some organisations and companies – associations, food retailers

and recyclers – highlight their effort and aspiration to enhance and increase PET b2b recycling and its share in Germany (Lidl, 2016; Veolia, 2016a; BGVZ, 2016).

2.2.2 Sweden

In 2006, Sweden set recycling quotas for packaging material which are subdivided into different packaging materials and adjusted respectively. For PET bottles, the recycling quota is set to 90% (Notisum, 2014). Furthermore, it is clearly defined that recycling of packaging can either take place as material utilisation (including b2b recycling) or energy recovery in order to fulfil the proposed recycling quotas (Lilienberg, Purfürst & Sköld, 2006). Energy recovery is not considered as a material utilisation recycling process. Nevertheless, every ready-to-drink beverage in plastic bottles with less than 50% milk or juice sold in Sweden has to be covered by a return and recycling system (Notisum, 2014).

The deposit system for PET bottles was initially introduced in 1994 and modified in 2006. It provides a financial incentive for consumers to return and recycle post-consumer PET bottles (Notisum, 2015). The existing deposit system (*pantsystem*) is in accordance with the legal requirement of a return system in order to achieve these recycling quotas (Notisum, 2014). Since the system is not government-run, any private entity can establish its own return system with approval of the Swedish Board of Agriculture (*Jordbruksverket*) (CRI, 2016). Furthermore, the deposit amount is not clearly determined by law but decided by the entity running the return system (Notisum, 2014).

The Swedish Board of Agriculture approved a nationwide bottle return coordinator that fulfils the legal prerequisites and holds a monopoly position for returned PET bottles (Returpack AB, 2016b; Lilienberg et al., 2006). This bottle return coordinator is a non-profit organisation. It implemented a two stage deposit of either 1 Swedish Krona (SEK) (~0.11 €) or 2 SEK (~0.22 €) depending on the size of the PET bottle (Returpack AB, 2016d).

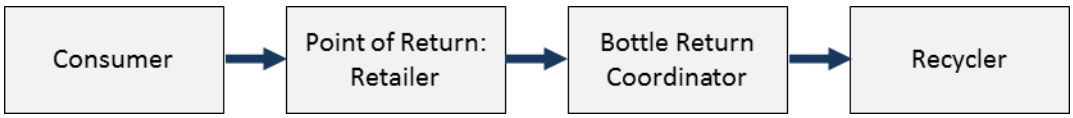

Figure 2-5 Simplified Return Flow in Sweden

The bottle return coordinator's recycling quota for post-consumer PET bottles totalled 83.5% in 2015 (Returpack AB, 2016b). Nonetheless, the legally proposed recycling quota of 90% is not reached. The Swedish bottle return coordinator receives, sorts and bales post-consumer PET bottles. The bales are then supplied to recycling processes. The applied recycling methods are in accordance with the Swedish legislation (Returpack AB, 2016c; Lilienberg et al., 2006). Post-consumer PET bottles are mainly supplied to a recycler in Sweden that produces PET flakes. Detailed figures about the various recycling processes for Swedish PET bottles are not provided and therefore the Swedish PET b2b recycling quota is undefined (Returpack AB, 2016c; Veolia, 2016b). Figure 2–5 depicts the simplified return flow for PET bottles until recycling.

2.3 Barriers in PET Recycling

As the result of a literature review, various barriers for PET bottle recycling in general and b2b recycling in specific are found. These barriers depend on the focus and time of the respective conducted study and are seen as a general theme. However, these findings apply as barriers for b2b recycling as well, since it is a subcategory of PET bottle recycling. The mentioned barriers do not specifically apply to the focus countries Germany and Sweden, since literature with a sole focus on one of these focus countries is not existent.

Firstly, post-consumer PET bottles in the recollection feedstream might be contaminated and damaged by non-food substances (Welle, 2011; Matar, Jaber & Searcy, 2014). Non-food PET bottles can be part of a general PET bottle recollection feedstream and threaten its purity of variety. Hence, high cleaning standards to the recycled PET are required (Hopewell et al., 2009). Furthermore, consumers could fill PET bottles with alienated substances such as chemicals and return them afterwards within the regular recycling system (Welle, 2011). Consequently, strict and demanding requirements exist for the use of r-PET resin in food packaging (Nascimento et al., 2006). These requirements ensure the safety of food packaging that uses r-PET resin as a raw material (Welle, 2013). In association with these requirements, the use of r-PET in food packaging requires an excessive bureaucracy (Nascimento et al., 2006).

Recycling firms are free to decide on the preferred treatment option for post-consumer PET (Gandenberger, Orzanna, Klingenfuß & Sartorius, 2014). Given this flexibility, the recycling firm occupies the entire decisional power over the PET waste treatment options. Most often, an assessment between material utilisation and incineration takes place (Patel et al., 2000). This assessment is often influenced by conflicting interests between stakeholders and potential waste treatment options (Gandenberger et al., 2014). Several authors highlight the cost intensity of the entire recycling system and specifically the recycling processes (Matar et al., 2014; Patel et al., 2000; Nascimento et al., 2006). This cost intensity influences the economic performance and feasibility of PET bottle recycling system negatively. Eik (2005) concludes that the observed PET bottle recycling systems is cost inefficient whereas Grimes-Casey, Seager, Theis & Powers (2007) emphasise the high cost of the bottle return systems.

PET resin out of recycled post-consumer PET bottles might not match the expected quality characteristics for the production of new PET products to a consistent extent (Eik, 2005; Nascimento et al., 2006; Welle, 2011). Matar et al. (2014) pinpoint the insufficiency of sorting processes in sorting centres. Furthermore, a lack of coordination and organisation among actors within the recycling system is revealed. This condition is mainly caused by coordination difficulties between the entities in independent recycling system (Nascimento et al., 2006; Matar et al., 2014). Zhang & Wen (2014) criticise the lack of legal coordination and regulation to determine and organise responsibilities for a PET bottle disposal and recycling system. According to PRE (2012), the plastic recycling rates are undersized by law and cannot be characterised as incentives to enhance PET bottle recycling.

Table 2-2 Barriers in PET Recycling

Barriers	Description	Reference
Contamination of post-consumer PET bottles	- Post-consumer PET bottles are contaminated and partly damaged (Matar et al., 2014) - Non-food PET bottles in recollection feedstream contaminated (Welle, 2011) - Misuse of PET bottles by consumers (e.g. chemicals) (Welle, 2011)	Hopewell et al. (2009); Matar et al. (2014); Welle (2011)
Demanding requirements for use of recycled PET in food packaging	- Requirements for use of recycled PET resin in food packaging (Nascimiento et al., 2006) - Safety of recycled PET in food packaging (Welle, 2013) - Excessive bureaucracy to use recycled PET in food packaging (Nascimiento et al., 2006)	Nascimiento et al. (2006); Welle (2013)
Flexibility to choose between various waste treatment options	- Conflicting interests between stakeholder and waste treatment options (Gandenberger et al., 2014) - Flexibility to choose preferred treatment option (Gandenberger et al., 2014) - Assessment between material utilisation and incineration (Patel et al., 2000)	Gandenberger et al. (2014); Patel et al. (2000)
High cost of recycling system	- Total system cost (Mater et al., 2014) - Cost of bottle return system (Grimes-Casey et al., 2007) - High cost of plastic recycling processes (Patel et al., 2000) - Cost inefficiency of return and recycling processes (Eik, 2005)	Mater et al. (2014); Grimes-Casey et al. (2007); Patel et al. (2000); Eik (2005); Nascimiento et al. (2006)
Inconsitent quality of recycled PET resin	- Output quality depends on the PET bottle input quality - Differing standards for food-grade PET	Nascimiento et al. (2006); Eik (2005); Welle (2011)
Inefficient standards of sorting processes	- Sorting processes (Matar et al., 2014)	Matar et al. (2014)
Lack of coordination between supply chain actors	- Difficulties regarding coordination between independent entities in recycling system - Lack of organisation among various actors	Matar et al. (2014); Nascimiento et al. (2006)
Lack of legal coordination and incentives for PET recycling system	- Lack of regulated laws or organisations responsible for PET bottle disposal and recycling (Zhang & Wen, 2014) - Legal recycling rates too low (Plastic Recyclers Europe, 2012)	Zhang & Wen (2014); Plastic Recyclers Europe (2012)
Low ecological consumer awareness and incentives to return PET bottles	- Lack of incentives to return bottles (deposit) (Eik, 2005) - Consumer awareness while discarding waste (Nascimiento et al., 2006) - PET bottles are improperly separated and mixed with conventional waste (Nascimiento et al., 2006)	Eik (2005); Nascimiento et al. (2006)
Low efficiency or non-existence of collection system for post-consumer PET bottles	- Insufficient collection systems for PET bottles (Hopewell et al., 2009) - Lack of collection system (Grimes-Casey et al., 2007) - Lack of collection and recycling system (Zhang & Wen, 2014) - Cost inefficient collection system (Hage & Söderholm, 2008) - Collection inefficiency (Eik, 2005)	Kuczenski & Geyer (2013); Hopewell et al. (2009); Grimes et al. (2007); Zhang & Wen (2014); Oromiehie & Mamizadeh (2004); Plastics Recycler Europe (2012); Welle (2011); Hage & Söderholm (2008); Eik (2005)
Market preference for virgin PET resin over recycled PET resin	- Existence of market for recycled resin	Nascimiento et al. (2006); Oromiehie & Mamizadeh (2004)
No fixed quota for recycled PET in new products established	- Lack of fixed quota for recycled resin in new PET products (Nascimiento et al., 2006) - Regulatory flexibility of recycling objectives (Gandenberger et al., 2014)	Nascimiento et al. (2006); Hopewell et al. (2009); Gandenberger et al. (2014)
Reduction of recycled PET's average molecular weight (hydrolysis)	- Possible disadvantages for bottle strength	Oromiehie & Mamizadeh (2004)
Stronger economic incentives for incineration than recycling	- Stronger economic incentives for incineration than recycling (Gandenberger et al., 2014) - Demand by industries for cheap energy sources - Saving potential of recycling too small (Lea, 1996) - More emphasis on material utilisation than incineration (Eik, 2005)	Gandenberger et al. (2014); Lea (1996); Eik (2005)
Taxes on PET bottles and/or recycled PET	- Double taxing of recycled material	Eik (2005); Nascimiento et al. (2006)

According to Eik (2005), incentives for consumers to return PET bottles are insufficient. Current deposit values do not incentivise and promote the return of PET bottles (Eik, 2005). In a framework without a deposit system, Nascimento et al. (2006) criticise the lacking consumer awareness while discarding waste. As a consequence, PET bottles are improperly separated and mixed with conventional waste what in turn exacerbates PET bottle recycling. Grimes-Casey et al. (2007) and Zhang & Wen (2014) generally state the lack of a PET bottle collection and recycling system. If collection systems are existent, their cost and collection inefficiency as well as their insufficiency is reviewed (Hopewell et al., 2009; Eik, 2005; Hage & Söderholm, 2008; Oromiehie & Mamizadeh, 2004; Plastic Recyclers Europe, 2012).

Oromiehie & Mamizadeh (2004) also require the existence of a market for r-PET. Regardless the fact of an existence for r-PET, various authors criticise the lack of an established fixed quota for r-PET in newly manufactured PET products (Hopewell et al., 2009; Nascimento et al., 2006). A further factor to consider in relation to r-PET and its characteristics is hydrolysis. Hydrolysis commonly occurs during processing of r-PET resin (Oromiehie & Mamizadeh, 2004). The average molecular weight of r-PET is reduced and makes it liable to thermal exposure, reduced melt viscosity, impact resistance and reduced mechanical properties (Oromiehi & Mamizadeh, 2004).

In the context of the previous argument of various PET waste treatment options, Gandenberger et al. (2014) state the existence of stronger economic incentives for incineration than recycling. Energy-intensive industries demand for cheap energy sources as a substitute to fossil energy sources: PET waste. Consequently, the demand for PET waste to be used in thermal recovery and incineration is high (Gandenberger et al., 2014; Eik, 2005). Lea (1996) claims that the saving potential of recycling compared to other waste treatment options is too small. Lastly, PET bottles and r-PET are taxed which increases the total cost of recycling systems (Eik, 2005; Nascimento et al., 2006). The barriers found in literature are depicted in Table 2-2.

2.4 Enhancements in PET Recycling

On the basis of the barriers described in the previous section, there are several potential enhancements and incentives mentioned in literature to improve a PET bottle recycling system (cf. Table 2-3). These enhancements are found based on the focus and time of the respective conducted study and are seen as a general theme for PET bottle recycling. The following enhancements are not specific for the focus countries Germany and Sweden, since there is no literature available. However, it is asserted that these findings apply as enhancements for b2b recycling in Germany and Sweden as well, since it is a subcategory of the recycling system. Additionally, the enhancements mainly refer to improvement of prerequisites for the general recycling system. Hence, improving the prerequisites will consequently refine the bottle-to-bottle system as well.

Firstly, the communication between the different actors in the value-added supply chain should be enhanced in order to change focus to a holistic perspective on the recycling process (Matar et al., 2014; Welle, 2011; Eik, 2005). This would also foster the development of consistent standards for PET raw material (Eik, 2005). One challenge is the contamination of post-consumer PET waste with different kinds of chemicals which can only be removed through advanced recycling processes (Welle, 2011). If these additives are limited, the mechanical recycling is considerably more efficient (Welle, 2011). Additionally, Hopewell et al. (2009) suggest limiting the diversity of plastics

packaging to PET, high-density polyethylene and polypropylene in order to reduce cross-contamination.

Nascimento et al. (2006) assert the cutting of middlemen in the purchasing process of post-consumer PET bottles as a favouring measure to reduce material cost. According to their study in Brazil, middlemen sell the batches of PET bottles to the recyclers with a mark-up of approximately 100%, which harms the final price of r-PET (Nascimento et al., 2006). Another factor with regard to pricing is the exclusion of environmental costs (externalities) in the production, transportation and disposal processes of v-PET from fossil fuel (Nascimento et al., 2006; Matar et al., 2014). Hence, its price is lower and therefore more competitive than r-PET.

Eik (2005) and Nascimento et al. (2006) suggest increasing efficiency in the sorting centres, as these are seen as one essential bottleneck in the recycling system. In case manual sorting processes are established, this can be done by employee training (Nascimento et al., 2006). Additionally, Eik (2005) emphasises the implementation of automatic sorting processes especially when PET bottle volumes increase. This fosters the separation of PET from different materials and transparent bottles from coloured ones (Eik, 2005). Another way of dealing with sorting centres could be the vertical integration to the recyclers (Nascimento et al., 2006). Higher negotiation power and large quantity purchasing of post-consumer PET bottles would lower purchasing cost and therefore raise the price competitiveness of r-PET.

An increase of the PET bottle recollection rate is widely seen as one key factor for the recycling system. Kuczenski & Geyer (2013) suggest implementing a deposit for beverage bottles in order to incentivise customers to return them. In case a deposit system is already in place, Eik (2005) recommends increasing the deposit value per bottle. These two measures foster easier sorting procedures, since PET bottles are then collected separately and not within household or kerbside waste (Eik, 2005). In a Chinese study, Zhang & Wen (2014) introduce the idea of automated reverse vending machines to make the return process for consumers as simple as possible. Furthermore, Nascimento et al. (2006) propose cutting out independent collectors in the system. These take bottles out of the system and sell individually, which leads to a lower volume at the sorting centres. A similar measure is to centralise the collection system to aggregate volumes and then allocate to the sorting centres (Nascimento et al., 2006).

Table 2-3 Enhancements in PET Recycling.

Enhancements	Description	Reference
Closer contact between all partners in the value-added chain	- Closer contact with focus between recyclers and retailers	Matar et al. (2014); Welle (2011); Eik (2005)
Consistent standard for PET raw material specification	- General standard (Eik, 2005) - Decrease amount of chemical additives in PET bottles (Welle, 2011) - Minimise cross-contamination by reducing diversity of packaging materials (Hopewell et al., 2009; BIO Intelligence Service, 2013)	Eik (2005); Welle (2011); Hopewell et al. (2009)
Cut out middlemen for raw material sale / purchase	- Decrease mark-up and increase price competitiveness	Nascimento et al. (2006)
Include externality effects into prices	- Increase price competitiveness since virgin PET from crude oil becomes more expensive	Matar et al. (2014); Nascimento et al. (2006)
Increase efficiency in sorting process	- Provide employee training (Nascimento et al., 2006) - Automatisation of sorting processes (Eik, 2005)	Eik (2005); Nascimento et al. (2006)
Increase negotiation power: Vertical integration of sorting centres	- Large bulk purchasing leads to lower prices	Nascimento et al. (2006)
Increases bottle return collection rates	- Higher deposit value (Eik, 2005) - Deposit on PET bottles (Kuczenski & Geyer, 2013) - Legislation to cut out independent collectors (Nascimento et al., 2006) - Centralisation of collection (Nascimento et al., 2006) - Automated reverse vending machines (Zhang & Wen, 2014)	Nascimento et al. (2006); Eik (2005); Kuczenski & Geyer (2013); Zhang & Wen (2014); Welle (2011)
Introduce quota for recycled PET packaging	- Produced PET bottles have to consist of a fixed part of recycled material	Hopewell et al. (2009); Nascimento et al. (2006)
Loosen requirements for PET food packaging	- Due to current strict standards, complex processes are necessary for recyclers	Nascimento et al. (2006)
Tax exemption for recycled raw material	- Avoid double taxing on recycled material could lower cost for manufacturers	Eik (2005); Nascimento et al. (2006)
Upgrade technology in recycling process	- Large volume machinery can reduce the cost of recycling	Hopewell et al. (2009); Patel et al. (2000)

In regulatory terms, Hopewell et al. (2009) and Nascimento et al. (2006) pinpoint the introduction of a fixed quota for r-PET in packaging applications. This would force manufacturers to include a specific share of r-PET in their process and increases the market demand for this polymer (Hopewell et al., 2009). Besides, there is the opportunity to loosen the current strict requirements for PET food packaging to reduce the effort of b2b recycling (Nascimento et al., 2006). However, depending on the waste mix and sorting processes in place, advanced recycling processes which decontaminate the material could still be necessary (Welle, 2011). A further measure to reduce cost for r-PET is a tax exemption (Eik, 2005). This would prevent taxing the same material repeatedly in every new life-cycle. Therefore, Nascimento et al. (2006) and Eik (2005) propose taxing only the v-PET for the first production cycle and apply an exemption for the use of r-PET.

Hopewell et al. (2009) and Patel et al. (2000) suggest upgrading the technology in the whole recycling process to the current best practices. Especially when volumes gradually increase due to the aforementioned measures, the investing into new equipment is economically viable (Hopewell et al., 2009). Additionally, this ensures a high quality of r-PET, which consequently can be used for closed-loop recycling (Patel et al., 2000).

3 Methodology

This chapter characterises the design of the study's research. Firstly, the research methodology with the underlying philosophy, purpose, approach and chosen procedure are described. Secondly, the research strategy is subdivided into design, data collection, further description of the conducted interviews, and the data analysis method are specified. Thirdly, the research quality with validity, reliability and research ethics is described.

3.1 Research Methodology

The term research methodology is defined as '*an explicit way of structuring one's thinking and actions in terms of research*' (Jonker & Pennink, 2010, p. 150). Hence, in relation to management research, it refers to the manner of learning and studying the social reality.

3.1.1 Research Philosophy

When conducting research, it is important to be aware of the underlying research philosophy in the particular study, as this implies a certain way of viewing the world (Saunders, Lewis & Thornhill, 2014). The different types of research philosophies refer to the process of knowledge development and the consequential nature of this knowledge (Saunders et al., 2014). Bryman & Bell (2011) reflect the two dimensions of research philosophy as ontology (assumptions and nature of reality) and epistemology (constitution of acceptable knowledge in a study field).

In management research, the research philosophies are divided into positivism, realism, pragmatism and interpretivism. Positivism refers to an observable social reality and value-free research developing law-like generalisations as an end result (Saunders et al., 2014). Realism differs from this, as it sees objects independently of the human mind, meaning that our senses show the truth of reality (Bryman & Bell, 2011). Pragmatism suggests that the main focus lies on the particular research question, making it possible to adopt more than one position within a study (Saunders et al., 2014). Finally, interpretivism argues the social world of business and management being too complex to be grasped by explicit laws. Therefore, the researcher must understand the differences of humans in the role of social actors (Saunders et al., 2014).

The philosophy adopted for this study is interpretivism. According to an interpretivist epistemology, focus lies on the details of a certain situation, the reality behind them and the motivation behind actions (Bryman & Bell, 2011). The interpretivist ontology views reality as socially constructed and subject to change (Saunders et al., 2014). This fits well with the study's aim of identifying the barriers for closed-loop PET bottle recycling systems' implementation and analysing the potential enhancements for involved actors. It is not possible to draw definite generalisations due to the high complexity of the focused supply chain. Consequently, this study rather analyses the circumstances and motivations from the organisational actors' points of view.

3.1.2 Research Purpose

Saunders et al. (2014) highlight the connection between the research purpose, the research questions and the following outcome in the form of findings. The research purpose is distinguished between descriptive, explanatory or exploratory. However, one

study may have several purposes or it might change over time (Saunders et al., 2014). A descriptive purpose seeks to show a precise representation of a phenomenon or individual without drawing conclusions from the empirical data (Robson, 2002; Saunders et al., 2014). The objective of an explanatory purpose goes beyond that and looks at how different variables are connected (Saunders et al., 2014). Conversely, an exploratory study seeks '*new insights into phenomena, to ask questions, and to assess the phenomena in a new light*' (Robson, 2002, p. 59).

Exploratory research is particularly appropriate if the exact nature of a problem is unclear (Saunders et al., 2014). It aids the understanding of the initial problem, which fosters the ability to find solutions in the following. Therefore, this study has a mainly exploratory purpose of analysing the barriers for a closed-loop PET bottle recycling system implementation through literature review and interviewing experts in the industry. Nevertheless, the first research question about the current status of the PET bottle recycling systems can be seen as descriptive, since it focuses on a description of the processes. The exploratory purpose allows looking deeply into the involved factors without the necessity of having an extensive literature base for this exact problem. Benefits of exploratory research are the flexibility and adaptation to changing insights as well as a narrowing scope throughout the research (Adams & Schvaneveldt, 1991). As the selection of the research questions proves, this is subsequently done in the study.

3.1.3 Research Approach

The research approach refers to the way of using theory within the study and has essential implications for the research design (Easterby-Smith, Thorpe, Jackson & Lowe, 2008). Three types of approaches are defined by Saunders et al. (2014): induction, deduction and abduction. Induction aims to formulate theory based on empirical data usually collected through qualitative methods (Jonker & Pennink, 2010). On the other hand, deduction refers to theory testing by explaining the causality of relationships between variables (Saunders et al., 2014). This highly structured methodology aims to generalise and is mainly prevalent in quantitative studies (Saunders et al., 2014). Thirdly, abduction integrates both induction and deduction by combining already existing theory with empirical data in order to explore new themes and patterns (Saunders et al., 2014).

The abductive approach suits best for fulfilling the purpose of this study. After reviewing the existing literature on the subject, the research gaps described in the introduction section were found. These gaps make a deductive approach unreasonable since there is little existing theory specifically on the implementation of closed-loop PET bottle recycling systems available to be tested. Only theory from studies in Norway and Brazil could have been used. However, the extensive differences in the collection and recycling systems compared to Germany and Sweden preclude this approach. An inductive approach is rejected as well since theory and empirical data is collected at the same time and existing theory is used to a certain degree. Hence, the study applies the abductive approach to foster understanding of the context of PET bottle recycling by reviewing literature and further on analysing the particular implementation barriers and enhancements for closed-loop recycling systems based on empirical data. After conducting several interviews in Germany and Sweden and comparing the empirical data to theory, the authors realised that further data from certain actors in the PET bottle recycling is needed to understand the holistic process. Hence, interviews with two

associations in Germany and a Swedish bottle preform manufacturer were conducted additionally, which is a clear indication of an abductive approach.

3.1.4 Qualitative Research

Saunders et al. (2014) distinguish between the three different data collection and analysis procedures of qualitative, quantitative and mixed-methods. Qualitative research refers to findings that are not derived by statistical processes or measures of quantification (Strauss & Corbin, 1990). The findings are expressed through words including an analysis through concept formation (Bryman & Bell, 2011). Conversely, quantitative research emphasises the use of numerical data in the collection and analysis procedure (Saunders et al., 2014). A mixed-methods choice includes procedures from both areas.

This study clearly classifies as qualitative research. In order to fulfil the purpose and answer the research questions, the meanings of words in the context of a literature review and expert interviews are analysed. Focus is set on how the involved actors see and interpret the world (Bryman & Bell, 2011), leading to the result of a non-numerical analysis and conclusion.

3.2 Research Strategy

Since this study's aim is to gather empirical data, it is necessary to follow a persistent research strategy in order to answer the proposed research questions (Saunders et al., 2014). This intention is in accordance with Yin's (2014) definition of the research strategy. Yin (2014) defines the research strategy as a plan of actions that guides through the process of answering the research questions and conforming the study's objectives. Considering the research purpose which is explanatory, exploratory or descriptive, researchers are eligible to choose between multiple available research strategies (Yin, 2014). Saunders et al. (2014) and Yin (2014) outline experiment, survey, case study, action research, grounded theory and archival research as research strategies or methods.

As the study's aim is identifying barriers and incentives of a more enhanced closed-loop PET bottle recycling system in Germany and Sweden and consequently suggesting improvements for those two countries' systems, the strategy of conducting a case study strategy was chosen. According to Robson (2002, p. 178) a case study is defined as '*a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence'*. Case studies emphasise the importance of context characterised by the fact that the boundaries between the studied phenomenon and the phenomenon's context are not precisely evident (Yin, 2014). In addition to the definition given by Robson (2002), Yin (2014) further states that the case study is the favourable method when the researchers have '*little control over events'* and '*'how' and 'why' questions are being posed'* (Yin, 2014, p. 2). Saunders et al. (2014) add the interrogative *'what'*. Case studies are mostly used when an exploratory research purpose is chosen since research questions with the recommended interrogatives can be answered (Saunders et al., 2014).

These definitions of the case study are concurring with this study's purpose. Closed-loop PET bottle recycling systems are a real life context and the authors of this study intended to approach and interview various organisations involved in these systems. No

control by the authors of this study was given over the events of closed-loop PET bottle recycling systems in both countries. The proposed research questions involve the recommended interrogatives and this study furthermore follows an exploratory purpose. Consequently, the strategy of conducting a case study was chosen. Different research strategies such as a survey would be inaccurate in meeting this study's research purpose. According to Saunders et al. (2014), a survey is confined in its numbers of variables for which data can be collected and consequently limited in its overall ability to explore and understand the phenomenon's context.

3.2.1 Research Design

According to Yin (2014), the case study strategy can be distinguished into two discrete dimensions. Firstly, it is separated between a single case and a multiple case. The second dimension differs between a holistic case and an embedded case.

Given that a single case study focuses on a unique case such as a single company, the multiple case study approach incorporates various cases. Blumberg, Cooper & Schindler (2011) and Yin (2014) argue that a multiple case study is preferable since the delivered results are more robust and more significant. A multiple case study follows the rationale of collecting findings and observing whether findings occur in various cases. These findings need to be generalised to a certain extent (Blumberg et al., 2011; Saunders et al., 2014). Nonetheless, Yin (2014) limits the case study findings' applicability for generalisation to analytic generalisation, in which a particular set of findings is generalised to some broader theory.

In this context, a multiple case study is applied since both Germany and Sweden were chosen as focus countries. Each country's PET bottle recycling system as a whole is considered as one case. Consequently, this study includes two cases – the German PET bottle recycling system and the Swedish one. Several respondents within each country's system were identified in order to achieve a comprehensive view. In Germany, six respondents from six organisations were selected, while in Sweden eight respondents from six organisations were selected to conduct the research. The underlying selection process is explained in the ensuing section.

Secondly, the case study is distinguished by its unit of analysis: holistic or embedded. A holistic case study solely refers to a unit as a whole, for instance an organisation or a company (Saunders et al., 2014). In contrast, an embedded case study inevitably focuses on more than one unit within an organisation and investigates various logical sub-units such as departments within the organisation (Saunders et al., 2014; Yin, 2014). Employing the perspective of each country's system in a single unit and given that this study focuses on various supply chain actors within the PET bottle recycling system in both Germany and Sweden, its unit of analysis is a holistic case study. In the context of this definition, similarities and especially differences between both respective PET bottle recycling systems are investigated and emphasised.

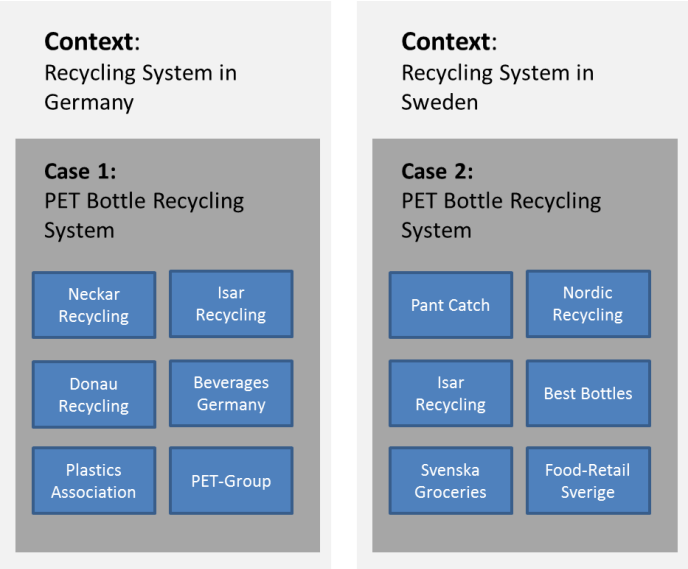

Figure 3-1 Case Study Design

In conclusion, the research strategy of this study adheres to the preconditions for a holistic multiple case study (cf. Figure 3–1). The interviewed organisations are selected and chosen according to their relevancy towards the PET bottle recycling system in both Germany and Sweden.

A further characteristic of research is the time horizon. It is crucial to determine the study's time horizon in advance in order to sustain the results' significance (Bryman & Bell, 2011). Research can either be cross-sectional or longitudinal (Saunders et al., 2014). Cross-sectional research investigates a particular phenomenon at a particular time whereas longitudinal research is characterised as long-term research (Saunders et al., 2014). Due to its time constraints, this study focused on a particular problem at a particular time and thus it was cross-sectional.

3.2.2 Data Collection

The applied methodological approach influences the data collection process (Bryman, 2012). Saunders et al. (2014) mention that the study's overall reliability and validity are significantly impacted by the process at this stage of the study's research. Using a qualitative case study, the empirical data is collected through a mono-method way (Saunders et al., 2014). According to Bryman and Bell (2011), two common methods of collecting empirical data for qualitative research are ethnography and qualitative interviews. An ethnographic strategy was not chosen since it consists of extended participant observation and listening to conversations (Saunders et al., 2014).

Bryman & Bell (2011) introduce expert interviews as a highly prominent method in qualitative research. Generally interviews offer a higher extent of flexibility, which is valued among researchers. A vaster amount of data can be collected by using interviews, which also implies transcription and further analysis (Bryman & Bell, 2011). According to the triangulation, the research mainly focused on conducting semi-structured interviews, but also other forms such as two company visits and informant verification were beneficial. Furthermore, eleven out of 14 interviews were conducted by both authors together and all 14 in languages both are fluent in, which helped reducing observer error and bias.

Interview Design

In order to present significant answers to the proposed research questions, profound knowledge of the research topic is required. By using the abductive approach, this profound knowledge was generated through a literature review and the empirical findings. To accomplish this, qualitative interviews were chosen over ethnography. Qualitative interviews are more advantageous due to their valuable flexibility and the research's time constraint. The interviews were designed to provide a list of themes and questions to ask, including the flexibility to adapt to the particular interviewee. Accordingly, semi-structured interviews were chosen to link the research purpose and strategy (Saunders et al., 2014). Semi-structured interviews offer the advantage to provide a content-related framework for the interview sessions in order to obtain the required in-depth knowledge within this topic. This aim is not in coherence with standardisation of structured interviews. Unstructured interviews were not chosen due to the necessity of addressing the content-related framework appropriately. Existing theory in this topic as well as the research questions were used as basis for the interview design. The flexibility of semi-structured interviews offered the opportunity of discovering new aspects.

Interview Respondents

Bryman & Bell (2011) describe a lack of transparency in many qualitative studies. This is related to the amount of interviews conducted, hence the sample size. The authors consider this issue as a typical method problem of qualitative studies (Bryman & Bell, 2011). Hence, the selection of interview respondents influences the study's overall quality strongly and has to be decided accordingly. The subsequent three criteria were defined to select respondents for the conducted interviews:

- The respondent is involved in an organisation operating in the German or Swedish PET bottle recycling system.
- The organisation is familiar with PET b2b recycling systems.
- The respondent is assigned to a managerial position or a supply chain position with sufficient process overview.

The first criterion aligns with the study's scope and the subject. To generate significant findings and gain in-depth knowledge, interview respondents have to work within the PET bottle recycling system in one of both focus countries. The second criterion is derived from the purpose of the research to explore barriers, enhancements and incentives regarding the PET b2b recycling systems in both focus countries. Accordingly, interviewed organisations need to obtain an enhanced knowledge about closed-loop PET bottle recycling. Alternatively, interviewed organisations are part of the PET bottle recycling system. To provide a holistic view of the closed-loop PET bottle recycling systems in Germany and Sweden, the respondent was required to hold a more managerial position within those systems or possesses a sufficient process overview. Consequently, the third criterion ensured the research's approach to achieve a holistic view of the systems.

Table 3–1 and Table 3–2 depict the different selected respondents and their organisations, the type of organisation, the interview date, its duration and its type of interview. In order to provide anonymity, the names of the corresponding organisations are changed to random fictional names.

Table 3-1 Interview Respondents in Germany

Germany						
#	**Organisation**	**Description**	**Respondent's Position**	**Type of Interview**	**Date**	**Duration**
1	Neckar Recycling	Recycler	Head of Sales PET Flakes	Telephone	2016-03-18	60 min
2	Isar Recycling	Recycler	Head of Sales	Telephone	2016-03-30	1 h 20 min
3	Donau Recycling	Recycler	CEO	Telephone	2016-04-15	45 min
4	Beverages Germany	Bottle Filler	Head of Sustainability and Association Management	Telephone	2016-04-04	1 h 5 min
5	Plastics Association	Association of PET Plastics Packaging	Head of Environment and Sustainability	Telephone	2016-04-18	1h 10 min
6	PET-Group	Association of PET Resin Quality	Commercial Manager	Telephone	2016-04-22	50 min

Table 3-2 Interview Respondents in Sweden

Sweden						
#	**Organisation**	**Description**	**Respondent's Position**	**Type of Interview**	**Date**	**Duration**
1	Pant Catch	Bottle Return Coordinator	CEO	Telephone	2016-04-25	1h 15 min
2	Pant Catch	Bottle Return Coordinator	Head of Customer Management	Face-to-Face	2016-04-26	60 min + 45 min on-site visit
3	Pant Catch	Bottle Return Coordinator	Controller	Telephone	2016-04-25	40 min
4	Isar Recycling	Recycler	Head of Sales	Telephone	2016-04-25	1h 30 min
5	Nordic Recycling	Recycler	Plant Manager	Face-to-Face	2016-04-26	50 min + 35 min on-site visit
6	Best Bottles	Bottle Preform Manufacturer	Purchaser	Telephone	2016-04-27	60 min
7	Svenska Groceries	Association of Independent Food Retailers	Managing Director & Member of Supervisory Board Pant Catch	Telephone	2016-04-18	45 min
8	Food-Retail Sverige	Association of Food Retail Enterprises	Managing Director & Member of Supervisory Board Pant Catch	Telephone	2016-04-18	35 min

In terms of geographical dispersion, no restrictions were set up and therefore respondents were chosen nationwide. The participating organisations were categorised into the referring industry sectors in Table 3–3.

Table 3-3 Categorisation of Participating Organisations into Industry Sectors

Industry Sector	Germany	Sweden
Bottle Return Coordinator	-	Pant Catch
Recycler	Neckar Recycling, Isar Recycling, Donau Recycling	Isar Recycling, Nordic Recycling
Bottle Filler	Beverages Germany	-
Preform Manufacturer	-	Best Bottles
Association	Plastics Association, PET-Group	Svenska Groceries, Food-Retail Sverige

Recycling organisations were chosen since they execute the actual recycling processes. The bottle return coordinator is part of this study due to its responsibility of collecting return PET bottles, organising the deposit system and providing supply material for recyclers. The choice for one bottle filler is based on the fact that this organisation uses r-PET for production. Lastly, associations represent various actors out of the PET bottle recycling system and consolidate the industry's knowledge and preferences. In conclusion, focus was set on the holistic system as much as possible, including several actors with different responsibilities in the recycling system.

Interview Guide

In order to provide a common thread for the conducted semi-structured interviews, an interview guide consisting of four categories was created (cf. Appendix 6). The four categories refer to the proposed research questions as well as to the following analysis. The created categories are introduction and background, current operations in Germany and Sweden, barriers for closed-loop recycling, and incentives and enhancements. The questions were constructed to not be of a leading character but rather allow the respondent to answer in all conscience. The flexibility of semi-structured interviews allowed follow-up questions as a considerable part of the interview sessions.

Interview Procedure

Face-to-face interviews are the preferred form of conducted interviews. The physical presence of both the researchers and the respondent offer the opportunity to react to statements quickly, to ask follow-up questions and to elaborate more detailed (Bryman & Bell, 2011). However, there are limitations such as the researchers' geographic restrictions, the respondents' geographic dispersion, the respondents' availability and the fact that two focus countries were chosen. Thus, telephone interviews offer a suitable alternative (Saunders et al., 2014). Consequently, mainly telephone interviews were carried out due to the respondents' distant locations from the authors.

In terms of language, interviews with companies active in Germany were conducted in German, which avoided language barriers. The interviews with companies active in Sweden were conducted in English. Summaries of the interviews were sent to the respondents and offered them the opportunity to revise and change on a minor scale. The created interview guide provided the researchers with a consistent structure to follow. In addition to this, follow-up questions to responses were asked. The time frame of the conducted interviews was up to 90 minutes.

3.2.3 Data Analysis

A qualitative data analysis is conducted using the collected non-numerical data (Saunders et al., 2014). Due to the diverse nature of qualitative data there is no standardised routine for the analysis. This is caused by its non-standardised and complex features. Saunders et al. (2014) name three different processes to analyse qualitative data adequately: the summarising of meanings, the categorisation of meanings and the structuring of meanings using narratives. Saunders et al. (2014) further state that each process can be applied solely or in combination with each other. Analysing qualitative data is described as a circular process with describing, classifying and ultimately connecting the conducted data (Dey, 2003). In order to follow this definition, a combination of summarising and categorisation was conducted.

The initial step before summarising and categorisation is the transcription of the recorded interviews. To support the transcription process, it is advisable to create a '*record of additional contextual information'* (Saunders et al., 2014, p. 498). For this an interim summary of the study's progress to date was established. Subsequently, these transcripts were summarised to logical main points that enabled the researcher to achieve an overview of the given statements. The drafted summary characterises a simplification for understanding the transmitted information during the interviews. The summary was not only advantageous to recognise relationships between statements but also assisted the categorisation process (Saunders et al., 2014).

The first step of categorisation was to develop appropriate categories. Subsequently, the introduced categories had to be connected with meaningful empirical data. Both steps aligned with the statement of Saunders et al (2014) to adopt codes or labels for grouping the empirical data. The created categories were derived by the findings to each respective research question. This categorisation enabled the authors of the study to categorise findings into various barriers and possible improvements for the closed-loop PET bottle recycling system. Within this step, both cases were contrasted to each other. This categorisation helped to recognise relationships and find conclusions (Saunders et al., 2014).

Applying an abductive approach, empirical findings were required to be analysed and compared to existing theory. A framework was established from the theory. Depending on the data collection and analysis process and regarding the approach, the frame of reference was constantly revised and adapted to fit the study's purpose best. Pattern matching was used to analyse and explain empirical findings with existing theory. The predicted patterns of outcomes regarding the findings were derived from theory in the frame of reference: the barriers and incentives and the enhancements in closed-loop PET bottle recycling systems. The established patterns were used to analyse and compare the findings within the subsequent analysis paragraph.

To analyse data within this study, Microsoft Office programs were used.

3.3 Research Quality

To provide the highest possible quality and credibility, the study closely followed the common tests in the social sciences methods highlighted by Yin (2014). These are construct validity, internal validity, external validity and reliability and should be

emphasised throughout the ongoing research process (Yin, 2014). Moreover, ethical considerations were made to further ensure the research quality.

3.3.1 Validity

Saunders et al. (2014, p. 603) define validity as '*the extent to which research findings are really about what they profess to be about*'. This refers to the causality of a relationship between different factors.

Yin's (2014) first quality criterion is construct validity. During the data collection process, the researcher might use subjective judgement or unclear measures. To prevent this, the authors of this study used multiple sources of evidence (data triangulation), for instance representatives from several actors within the PET bottle recycling supply chain. Transcripts of the interview content were sent to the interview partners for review of accuracy. Also, no personal relationships have been established to the interviewees prior to the study. Since two authors conducted the study, this implies inclusion of different opinions and a more objective perspective.

The second test, internal validity, refers to the data analysis phase of research. Especially during case study work, inferences are made from events that are not peculiarly observed. Concurrence of the inferences should be given with reality (Yin, 2014). To ensure internal validity, pattern matching was used in the study for the data analysis of the different sources of evidence. Additionally, rival explanations were considered in the analysis section as well to assure converging streams of evidence.

Thirdly, external validity deals with the generalisability of the study's conclusions and the replication of the findings (Saunders et al., 2014; Yin, 2014). According to Yin (2014, p. 43), case studies '*rely on analytic generalization […] to generalize a particular set of results to some broader theory*'. The research design aligns with replication logic in the way the concept developed for data collection and analysis was applied. There was an association between theory and findings for both cases of Germany and Sweden and placing into over-spanning categories. Nevertheless, case studies in a small number of organisations as well as the very specific factors and circumstances in the cases question generalisability (Saunders et al., 2014).

3.3.2 Reliability

Reliability refers to the consistency with which other researchers would find the same results, using identical data collection and analysis techniques (Saunders et al., 2014; Yin, 2014). Therefore, Yin (2014) highlights the importance of a case study protocol as a means of operationalisation of every single step conducted in the study. Consequently, the selection criteria for interview respondents as well as the interview guide used in all correspondences are provided (cf. Appendix 6). Furthermore, the data analysis concept is described. This allows other researchers to conduct the same study with the same techniques.

Robson (2002) pinpoints four threats to reliability: subject or participant error, subject or participant bias, observer error and observer bias. To address participant error, all appointments were made at a convenient time for the respondents to prevent distortion of evidence through bad mood or stress. Participant bias was addressed by the anonymity of interview respondents, so that they could speak freely and truthfully

without the fear of potential consequences within the organisation. To limit observer error and bias, the questions from the designed interview guide were asked by both authors and the interpretation and analysis of replies was done jointly in order to include different perspectives.

3.3.3 Research Ethics

Saunders et al. (2014) outline that individuals who are part of the research shall not be exposed to embarrassment, harm or a form of material detriment. Research ethics include integrity, privacy, voluntary participation, consent of participants and confidentiality of data (Jonker & Pennink, 2010).

All these aspects have been considered by the authors of this study throughout the research procedure. Organisations took part in the study on a voluntary basis and the names of the organisations and interview respondents were kept anonymous due to the respondents' requests. The research purpose of the study has been explained to all respondents with the possibility to request further information or withdraw participation. Additionally, all this information was provided in the introductory letter which was sent to all participants beforehand Also, the authors obtained consent for recording of the correspondences before the questions from the interview were asked. During data collection, the authors avoided leading questions or topics that could harm the respondents in any way. The covered themes can be found in the interview guide (cf. Appendix 6); however, the exact questions differed in each interview depending on the flow of the conversation.

After data collection, the interview transcripts were sent back to the respondents in order to check for accuracy of the content and give them the opportunity to revise. They were also offered to receive a final version of this study which was appreciated by many respondents. The utilised data is handled confidentially and can only be accessed by the authors of this thesis. Furthermore, all references used in the study are cited according to the Harvard APA system.

4 Findings

This chapter presents the description of the key findings separated for Germany and Sweden. Due to differentiating standpoints, the findings are categorised according to the industry sector of the organisation. The first section for each country aggregates new information regarding the current operations of the PET bottle recycling systems gained from the interviews. The findings for each industry sector firstly contain general information about the organisations and the respondents' position. Secondly, barriers and problems for holistic b2b recycling are described. The last construct refers to potential actions in order to enhance b2b recycling and incentivise organisations to take part in this system.

4.1 Focus Country: Germany

4.1.1 Operations in the Current PET Bottle Recycling System

The basis and an important prerequisite for the PET bottle recycling system in Germany is compulsory deposit system on disposable beverage containers. However, not all PET beverage containers are covered within this system (e.g. juice) and there are also alternative value streams that include non-deposited PET bottles, which are outside of this study's scope.

After a bottle is returned to a reverse vending machine (RVM), it is mostly not sorted right away and mixed with bottles of different colours as well as cans. These are owned by the food retailer which takes bottles back and shipped to a clearing centre of the coordinator of the German container-deposit system (DPG). Therefore, the entire food retail industry has power about the further use of post-consumer PET bottles. There is only one large food retailer in Germany which has integrated bottle filling and recycling vertically. Other actors sell on the free market. Currently, the bottles are sold mainly to German recyclers, but several other European countries are interested in buying the German post-consumer bottles as well due to the relatively high quality.

The recycling firms then generally execute three steps. Firstly, a pre-sorting process is required in order to feed the machines with appropriate input material. Secondly, non-food grade PET flakes are produced which could then be used in applications such as fibres, sheets and foil. In the third step, the flakes are treated to food-grade PET. The recyclers then sell the r-PET to their customers, which use the material in different ways.

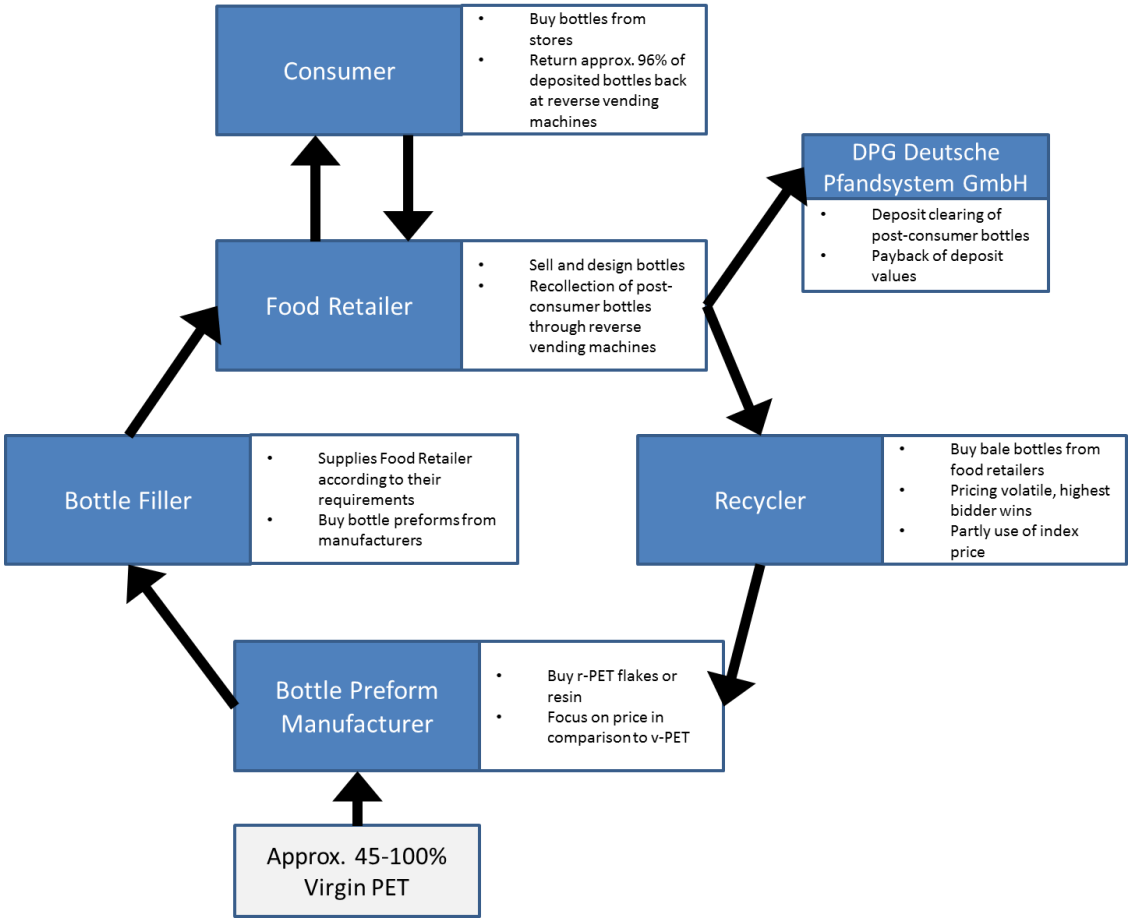

Figure 4-1 Current PET Bottle Recycling System in Germany

Some recyclers are specifically committed and have optimised their processes for b2b recycling, while others supply to various different recycling applications. Currently, in average around 27-30% of all German post-consumer PET bottles are used for bottle-to-bottle recycling. If the r-PET is used for b2b, bottle preform manufactures use them for preforms, which are then used by bottle fillers which blow mould preforms and fill them with drinks. Then, the bottles are sold in food retail stores. Figure 4–1 depicts the current system.

4.1.2 Recyclers

Company Information

Three interviews were conducted with recycling companies in Germany. Neckar Recycling is a PET bottle recycling firm with approximately 200 employees. The firm is part of a large German logistics company which operates globally. Neckar Recycling has the largest single volume of PET flakes in Germany and handles approximately 60,000t PET bottles per annum and produces only PET flakes. Therefore, the firm mainly has customers within non-food PET applications since the vast majority of bottle preform manufacturers use resin. The interview respondent is currently the Head of Sales for PET flakes and has worked in the PET industry in different positions for over 15 years.

Isar Recycling is a PET bottle recycling firm with plants in different European countries. The firm developed a unique b2b recycling process and therefore has its main customers in this field. The recycling firm is part of the German sub-group of an international environmental services provider. The interview respondent's role is Head of Sales for the whole European market and has diverse expertise within the recycling industry.

Donau Recycling is a PET recycling firm with approximately 80 employees. The firm is a subsidiary of a larger bottle filling company which on the other hand is part of a large German retail enterprise group that operates internationally. Due to Donau Recycling being incorporated, its operations and business focus on this retail enterprise group. According to the respondent, Donau Recycling produces approximately 18,000t r-PET resin per annum. The produced recycled resin is then forwarded to an affiliated bottle filler. The interview respondent is the current CEO and co-founder of Donau Recycling.

Barriers

The Head of Sales PET Flakes of Neckar Recycling points out the quality issue of the end product as the biggest challenge for the recycler:

'The sorting within PET recycling has by now a larger significance than the washing. Everyone can boil water, but the sorting is the problem. One has to produce a clean flake with extremely little contamination.'

The high required quality necessitates complex technical processes. Consequently, these require a certain amount of investment, which is a challenge for the economic viability of this business sector. The flakes and resin compete directly with v-PET, and customers of the recycler expect that the price of r-PET is lower than v-PET. These prices are quite volatile and often change on a monthly basis. The recyclers buy bale PET bottles from the retailers, which are interested in selling the bale bottles for a high price in order to increase their profits. Especially the index, according to which prices for bale bottles from retailers are defined, induces a continuous inflationary spiral. However, the recycler's customers such as bottle fillers do not accept to spend these prices for r-PET, since v-PET is equally available.

The respondent from Isar Recycling backs this up:

'The profitability is not really given at the moment. For food-grade PET resin and flakes you have to pay equal or even more than for virgin material in some cases.'

The current low price for crude oil causes a low price for v-PET. On the other hand, prices for bale PET bottles from retailers generally experience an increase, which leads to higher purchasing costs for recyclers.

The CEO of Donau Recycling identifies the PET bottles' characteristics and consequently their recyclability as a main barrier for a more enhanced b2b recycling:

'The existing problem is the recyclability of the actual PET product since the retail industry designs PET products based on marketing and not recycling reasons.'

This identified problem aligns with the CEO's description of the power structure within the PET bottle recycling system. The retail industry as the selling actor decides upon the

PET products introduced onto the market. As a consequence, recycling firms have to work with a hampering variety of PET bottle characteristics and xenobiotics on a chemical level.

Referring to the power structure, Isar Recycling's Head of Sales points out:

'The discounters have power over the whole PET recycling business in Europe. Since Germany has the highest amount in Europe, many other countries purchase bale bottles here.'

A small number of large food retailers have power over approximately 60-70% of the European PET and can therefore set the price. Retailers have significant revenue from the bale sales. Thus, the Head of Sales sees recyclers in Germany in a very reactive position. Furthermore, some bottle fillers, which have a self-proclaimed recycling share in their bottles, might try to exploit the pricing system by few specific purchasing transactions when prices are low, and use v-PET at all other times. By doing so, they might fulfil the average quota but the vast majority of bottles are still made from 100% v-PET.

Furthermore, PET bottles with a high percentage of r-PET will adopt a slight grey tone and therefore look different than completely new bottles (cf. Appendix 9). This can be a problem regarding acceptance for end consumers in the stores. The respondent of Neckar Recycling states:

'100% recycling amount is technically possible, but the bottle looks in such a way that I wouldn't really want to drink from it.'

Moreover, there is a trend for PET bottles to become thinner, which can harm the physical stability. Some problems remain in the bottle return process at the food retailers, since PET bottles are mixed in different colours together with aluminium cans. Supermarkets do not want to lose valuable retail space for bottle collection. The recycler has to separate those materials in order to use high quality input material for its processes. Especially the fact that there is no standard for the ingredients of PET bottles and its labels involves many risks for the recyclers.

Enhancements

All respondents stated regulatory measures as the main enhancement. In Specific, the Head of Sales of Isar Recycling expresses:

'From my perspective, incentives have to be made that […] the whole system is operated by a public institution […] which sets that a certain percentage X of recollected bottles has to be applied in a German recycling system – a quota policy.'

This quota should be assigned to both the food retailers and bottle fillers. In case it is not fulfilled, there would a penalty fee. An important aspect would then be to monitor the recycling quota throughout the whole value stream. The respondent asserts that the only way to incentivise food retailers is by a national or a European-wide legislation, since otherwise those firms would not want to give up their strong position in this market. Moreover, the Head of Sales of Isar Recycling adds:

'Besides that, I am a huge advocate of a controlled quality of the bottle design.'

This goes hand in hand with the quota in order to maintain a certain standard of input material which is suitable for recycling. Several respondents refer to the systems of Sweden, Norway and Switzerland as best practices, since the contents of bottles are proactively discussed with the partners in the recycling system. Also, sorting should be conducted directly at the point of return in the stores to improve overall efficiency. It needs to be proactively discussed which different materials are used in the PET bottles.

An incentive offered by Isar Recycling are Carbon Dioxide (CO_2) certificates of the saved emissions compared to using v-PET. However, this is seen primarily as a marketing instrument and there are no statistics about the effectiveness of this tool.

The corporation which owns Donau Recycling pursues the goal of improving the PET bottle's life-cycle assessment and with it its public image. Since the food retail group possesses one bottle filler and one bottle manufacturer firm as well, a strong internal interest is given. The CEO of Donau Recycling states:

'Generally speaking, the price in economic terms and the material composition in technical terms are pending questions. […] The recycler also has to be accepted as a full-value partner in the entire supply chain.'

The CEO mentions both aspects as potential improvements for an enhanced b2b recycling. Out of the economic perspective, recyclers' profitability has to be given and the r-PET's price has to be appropriate for bottle manufacturers. In terms of quality, a general agreement on the composition of PET bottles on a chemical basis will ease and foster b2b recycling. By increasing the recognition and acceptance of recycling firms in the supply chain, the PET bottle recycling system can be improved holistically.

4.1.3 Bottle Filler

Company Information

Beverages Germany is mainly a bottle filler firm but incorporated a bottle preform manufacturer as well as a PET recycling firm and provides services for the entire closed-loop system. Overall, Beverages Germany has about 1,000 employees. The entire firm is a subsidiary of a large German food retail corporation that operates internationally. Consequently, the firm's operations and business focus on this retail enterprise group. The interview respondent is Head of Sustainability and Association Management of Beverages Germany.

Barriers

The respondent states that the performance of the German PET bottle return system is exceptional, although a return rate of 100% is not achievable. The return system based on the PET bottle deposit ensures a high purity of variety and therefore a higher recyclability. In terms of PET bottle recycling, Beverages Germany is integrated vertically into the food retail corporation. Performing every step after the PET bottle is returned in a retail store in-house enables the firm to operate and monitor its PET bottle recycling system. Consequently, Beverages Germany's PET bottles feature the highest share of r-PET in Germany.

Within the corporation, the respondent sees no major problems regarding closed-loop recycling due to the vertical integration. In general, recycling firms face pressure within

the market in terms of profitability and the price of r-PET. In addition to this, the quality of r-PET deteriorates after several recycling processes and therefore v-PET has to be added.

The large food retailers hold a powerful position within the German PET bottle recycling system, which can be seen disadvantageous to a certain extent. Due to that, the food retailers are enabled to implicitly prescribe and decide about the realisation of b2b recycling.

Enhancements

The Head of Sustainability categorises incentives and reasons for b2b recycling as follows:

'The entire subject is to be considered out of three perspectives: First, intrinsic factors […], secondly extrinsic motivation […] and thirdly economic reasons.'

Within the first category, the respondent points out internal reasons such as material savings (less v-PET) and the utilisation of facilities and production sites. B2b recycling is influenced extrinsically by the existing legal framework and intended amendments and changes in legislation as well as the public opinion. Economically, r-PET has a more advantageous price compared to v-PET and therefore b2b recycling can generate lower (material and production) cost.

In terms of improvements, the respondent mentions that enforcement to achieve certain targets is required:

'If you sometimes do not force the market to do something, then it will not be done.'

Within this context, the respondent mainly refers to the achievements of b2b recycling in the past decade in Germany such as the container deposit and the increase of b2b recycling. Furthermore, the respondent foresees the same need of external enforcement for the future. Especially the German legislation is considered as an important factor for enhancing b2b by passing a new legislative framework. Further improvements could be realised with nationwide standards for used materials and their composition in PET bottles to ease sorting processes and improve the purity of variety and recyclability.

4.1.4 Associations

Organisation Information

Plastics Association is an association of plastics packaging companies with a division for PET packaging. The association's members cover the entire value stream of the PET recycling system except food retailers. The interviewee is responsible for the entire PET division as well as the department of environment and sustainable development within the superordinate plastics packaging association.

PET-Group is an association of more than 20 actors within the PET recycling, bottle filling and preform manufacturing sector. The members cover the whole value stream of the PET recycling system. The respondent is the Commercial Manager of PET-Group. PET-Group's goals cover enhancements of PET bottles under consideration of

ecological aspects. The main goal is to increase the share of r-PET in bottle manufacturing, and hence to increase the overall amount of b2b recycling in Germany.

Barriers

Firstly, the respondent of Plastics Association states the volatile and fluctuating price for r-PET due to various markets as a barrier. It could be more profitable to sell it to producers of alternative recycling applications. Secondly, r-PET achieved the same price as v-PET in peak times what also characterises the constant demand for r-PET. B2b recyclers therefore constantly face a highly competitive market. Thirdly, r-PET deteriorates after various recycling processes and b2b recycling overall has high quality requirements for its input material. Lastly, the food retailers' significant influence on the entire recycling system was mentioned. This influence is fostered by the retailers' power structure position.

The respondent of PET-Group describes barriers in the communication between the interfaces of the different actors. The quality standards differ according to the respective actor. The collected post-consumer bottles are partly contaminated (additives, glue, polyvinyl chloride (PVC) labels) and lack a defined standard for material compositions that do not hamper recycling processes. The second significant barrier is the pricing of PET. In the current setting of low cost for v-PET, the recyclers are in a difficult position, since the recycling procedures evoke certain cost, but still are expected to be priced lower than v-PET. Besides that, the Managing Director also sees b2b recycling in direct competition to other applications such as b2f or foil. The construction of bottles is a further barrier. In most cases, the food retailers set the characteristics of bottles not regarding their recyclability. Retailers are satisfied with the current deposit system and do not see need for action in recycling. According to the respondent,

'The retailers are generally at the top of the food chain. From a legal point of view […], they do as much as necessary but not really more than that.'

According to the respondent of Plastics Association, the entire food retail industry has a comparatively powerful position and key role within the recycling system. This is mainly caused by the ownership of returned PET bottles as well as its less strong interest in establishing a closed-loop system. Nonetheless, the food retail industry does not intervene into the PET bottle recycling system in a broader extent.

Enhancements

Regarding incentives for b2b recycling, the respondent of Plastics Association states the PET bottle's image as well as regulatory factors. By applying b2b recycling, the PET bottle can be promoted as less harmful to the environment. In terms of regulatory factors, b2b is applied to improve the PET bottle's life cycle assessment and to avoid stricter legislation for PET bottles. Both, the public image and regulatory factors interact.

In terms of improvements, the Head of Environment and Sustainability states that an expected law on recyclable material in Germany can have a significant impact on the future development of b2b recycling. Detached of this expectation, further approaches for improvements are mentioned. The respondent aspires stronger collaboration and communication among all actors within the PET bottle recycling system – including

food retailers – in order to establish a high quality process for b2b recycling with a consent set of criteria. Since there are non-deposited PET bottles in the German market, the inclusion of those into the deposit system could be a further step. As a consequence, quality issues have to be discussed with recyclers that require the highest quality of PET.

'Due to its nature of interfering into the market, a regulative act generally requires […] a strong justification such as a weak performance of the market.'

The respondent of Plastics Association requests the voluntary commitment of the various actors to enhance b2b recycling without inflexible regulatory intervention. Overall, the market should adjust itself to a participation in the b2b recycling system on a voluntary basis by agreeing on common targets and a common catalogue.

The Commercial Manager of PET-Group thinks that food retailers should become more active in the recycling system, either by adapting the purchasing specifications or participating in associations such as PET-Group. The respondent sees many aspects that retailers could influence in order to improve the system. The differences in sorting processes could be standardised, which would improve quality of bale bottles sold to recyclers. Quality is an important factor which needs to be increased to make recycling more cost-efficient. Accordingly, more material could go into a closed-loop recycling system. Moreover, collaboration with retailers should be improved. The members are encouraged to advertise the advantages of holistic quality standards and over-spanning systems planning. The Commercial Manager points out:

'It could maybe help if one of the big retailers participated and introduced the standards. Other retailers could then follow this example.'

Since the retailers have large importance in the system as the bottle seller and re-collector, many enhancements could be made if they are included in the associations. Generally, food retailing is the last missing actor in the closed-loop system.

4.1.5 Consolidation of Findings

In order to increase the transparency of the previous findings from all interviews, all stated barriers and enhancements are summarised in Table 4-1 and Table 4-2. A reference is given to the respective organisation that mentions the argument.

Table 4-1 Barriers in Germany

Barriers in Germany		Description	Reference to Organisation
Present in theory	Contamination of post-consumer PET bottles	- Post-consumer PET bottles are contaminated and partly damaged	Neckar Recycling, Isar Recycling, Donau Recycling, PET-Group
	Demanding requirements for use of recycled PET in food packaging	- Requirements and safety demands for use of recycled PET resin in food packaging	Neckar Recycling, Donau Recycling, Beverages Germany, Plastics Association
	High cost of recycling system	- The recycling processes include various technically demanding steps which require high investment	Isar Recycling, Plastics Association, PET-Group
	Inconsitent quality of recycled PET resin	- Output quality depends on the PET bottle input quality	Neckar Recycling
	Inefficient standards of sorting processes	- Sorting in the bottle return machines is not done, bottles and cans are mixed - If bottles are separated, there usually is no colour sorting	Neckar Recycling, Isar Recycling
	Lack of coordination between supply chain actors	- Difficulties regarding coordination between independent entities in recycling system - Lack of organisation among various actors regarding to quality standards	Donau Recycling, PET-Group
	Lack of legal coordination and incentives for PET recycling system	- Lack or insufficiency of regulated laws or organisations responsible for PET bottle disposal and recycling	Isar Recycling, Donau Recycling, Beverages Germany, PET-Group
	Market preference for virgin PET resin over recycled PET resin	- When the prices for virgin PET and r-PET are approx. equal, the bottle manufactureres prefer virgin PET	Isar Recycling, PET-Group
	No fixed quota for recycled PET in new products established	- Lack of fixed quota for recycled resin in new PET products	Neckar Recycling, Isar Recycling, Donau Recycling, PET-Group
Absent in theory	Profitability	- Due to the low crude oil price, virgin PET gets cheaper. At the same, this is expected for r-PET	Neckar Recycling, Isar Recycling, Donau Recycling, PET-Group
	Overcapacity of virgin PET manufacturers	- There are too many manufacturers of virgin PET in Germany	Neckar Recycling
	Overcapacity of PET flake producers	- There are too many PET flake producers in Germany	Neckar Recycling
	Undercapacity of PET resin producers	- The recyclers cannot meet market demand for PET resin	Donau Recycling
	Strong market position of food retail corporations	- Food retail corporations have significant power: They have control over the returned post-consumer bottles and can decide whom to sell to	Neckar Recycling, Isar Recycling, Donau Recycling, Beverages Germany, PET-Group
	Consumer acceptance	- Recycled bottles change the colour towards a slightly grey tone	Neckar Recycling, Isar Recycling, Beverages Germany, Plastics Association
	Changing characteristics of PET bottle	- There is a trend towards bottles with thinner walls - Bottle design is made according to marketing factors instead of recyclability	Neckar Recycling, Isar Recycling, Donau Recycling
	Pricing process	- Pricing for post-consumer bottles and r-PET is determined through indexes - Through individual contracts, the indexes experience a false increasing price spiral	Isar Recycling, Donau Recycling, Plastics Association, PET-Group

Table 4-2 Enhancements in Germany

Enhancements in Germany		Description	Reference to Organisation
Present in theory	Closer contact between all partners in the value-added chain	- Closer contact between supply chain partners's interfaces	Donau Recycling, Plastics Association
	Consistent standard for PET raw material specification	- General standard - Decrease amount of chemical additives in PET bottles	Isar Recycling, Donau Recycling, Beverages Germany, Plastics Association, PET-Group
	Increase efficiency in sorting process	- Better sorting at the reverse vending machines	Neckar Recycling, Beverages Germany, Plastics Association, PET-Group
	Introduce quota for recycled PET packaging	- A specified amount of r-PET has to be used in newly manufactured bottles - The food retailers and bottle fillers have to be included into the fixed quota, since they control the business	Neckar Recycling, Isar Recycling, Donau Recycling
Absent in theory	Adapt legislation about recycable material to increase primary recycling	- Further extrinsic motivator to reuse the material for its intended use (such as a bottle)	Beverages Germany
	Certificate issued by the recycler for companies using r-PET	- The recycler issues a certificate to the customers so that they can prove the savings of CO2	Isar Recycling
	Closer cooperation with food retailers	- Since food retailers have influence on a lot of factors in the recycling system's prerequisites, they are in a key role for improvements	PET-Group
	Enlightenment and clarification with other actors regarding recycling requirements	- Promotion of recycling advantages through personal contacts - Clarification of process requirements regarding recyclability	Neckar Recycling, Donau Recycling, Plastics Association, PET-Group
	Fixed pricing for recylers (post-consumer bale bottles & flakes/resin)	- Since all actors in the industry have the same prices, transparency is ensured - Not possible to introduce this without a legislation	Isar Recycling
	Inclusion of non-deposited PET bottles into recycling system	- Include other bottles such as juices, which are currently not deposited, into the recycling system (in addition potentially also in the deposit system) - This would increase the available material for recycling	Plastics Association
	Industry-wide specifications for PET bottles (design and material)	- All actors confirm adherence to industry-wide standards in order to secure quality of input and output material	Isar Recycling, Donau Recycling, Beverages Germany, Plastics Assocation, PET-Group
	Introduce council for review of specifications for new bottles	- The council reviews every new bottle which enters the German market	Isar Recycling
	Penalty fee in case recycling quota target is not met	- If the required amount of r-PET is not used in new bottles, the respective actor has to pay a penalty fee	Isar Recycling

4.2 Focus Country: Sweden

4.2.1 Operations in the Current PET Bottle Recycling System

The basis and an important prerequisite for the PET bottle recycling system in Sweden is the compulsory deposit system on disposable beverage containers. The Swedish legislation pursues the intention to reuse material for increasing sustainability. For packaging, it requires ready-to-drink beverages with the exception of those containing more than 50% milk and juice to be handled in the deposit system.

PET bottles are mostly returned to food retail stores. The stores own the RVMs. According to the legislation, it is not compulsory to provide RVMs; however almost every food retailer is committed to accept post-consumer bottles. Pant Catch is responsible for the deposit system, its financial flow and furthermore is the owner of all returned bottles (cf. Appendix 7).

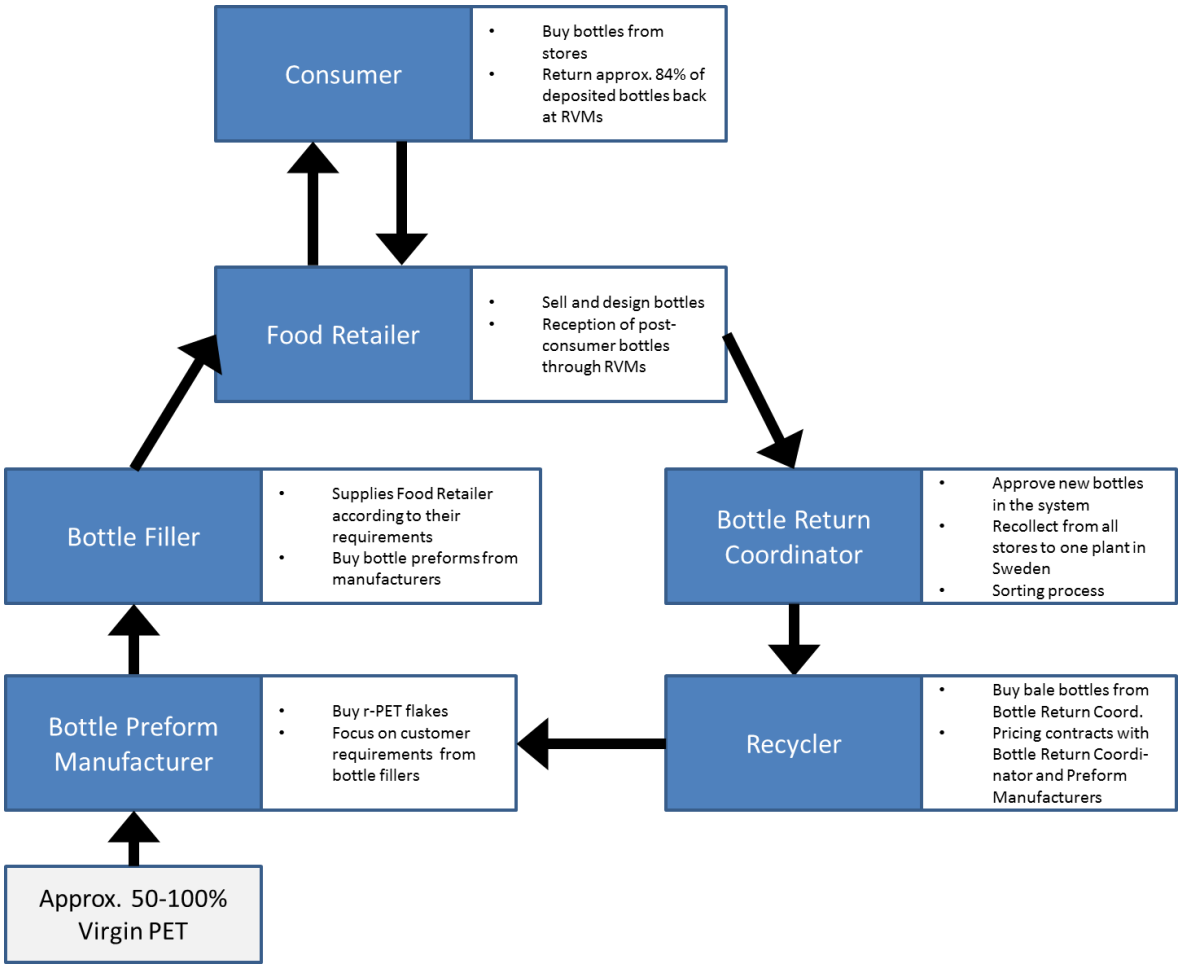

Figure 4-2 Current PET Bottle Recycling Operations in Sweden

Pant Catch solely organises the pick-up and transport to its plant in South Sweden, where all bottles and cans from the whole country are shipped. The actual transportation is conducted by a third-party logistics provider. Most large stores are approached several times per week, while smaller ones are approached approximately once per week. In remote areas, the return flow is organised with the help of return shipments of

the brewers and suppliers. The recyclability of PET bottles newly introduced into the Swedish market is evaluated, tested and approved by Pant Catch.

Once the bottles arrive at Pant Catch's plant, several sorting processes are conducted, after which the bottles are compacted into bales. 100% of clear PET in Sweden and the vast majority of coloured PET are sold to Nordic Recycling, which is located next to the premise of Pant Catch. This cooperation is based on long-term contracts with the common obligation for b2b recycling. Additionally, Nordic Recycling buys post-consumer bottles from abroad in order to ensure high utilisation. Clear PET is then processed into food-grade PET flakes and mainly used in b2b application, while coloured flakes are used for other recycling applications.

The clear flakes are sold to bottle preform manufacturers, which blend in a certain amount of r-PET into the bottles. There is one preform manufacturer which has the leading position in the Swedish market and receives the vast majority of Nordic Recycling's flakes. Finally, the bottle fillers blow mould the preforms and fill the drinks, which are then sold by food retailers.

4.2.2 Bottle Return Coordinator

Company Information

Pant Catch is the coordinator responsible for returning and collecting post-consumer PET bottles and aluminium cans in Sweden. It is approved by the Swedish Board of Agriculture and owned by the Association of Swedish Breweries (alcoholic and non-alcoholic beverage producers) that holds 50%, Svenska Groceries (25%) and Food-Retail Sverige (25%). Pant Catch has more than 50 employees. The first respondent is the CEO and has had many positions within the Swedish beverage industry. The second respondent is the Head of Customer Management. The third respondent is a Controller within Pant Catch and responsible for reporting.

Barriers

Due to the deposit system in Sweden, all respondents state that the return, collection and recycling processes for PET bottles perform in a highly satisfying level.

The CEO sees two main barriers for Pant Catch. The first limitation is that the consumer has to be convinced to return bottles into the system of Pant Catch, and not to alternative systems such as household waste or public trash bins. If a bottle ends up in these other systems, they are usually burned for energy recovery and not recycled into a closed-loop. Secondly, the CEO states:

> *'Our challenge is to always be relevant, always be within reach so that people can easily get rid of the bottles.'*

Sometimes, it may be too hard for consumers to return the bottles without much effort. Also, when they reuse the bottles, e.g. refilling with tap water, after some time the label is gone and they cannot return it into the RVMs.

The Head of Customer Management points out Pant Catch's need to adapt to changing consumer habits. Its task is to incentivise those diversified consumers in a lasting but

also cost-efficient manner. A continuing challenge is the discussion about the recollection handling and performance.

'We have an ongoing discussion with them [stores in Sweden] how much space the RVM and storage space for returned beverage containers shall take up. […] This discussion takes place on a daily basis.'

In addition to this, the adaption of the return area including the RVM to each store's specification depicts a further challenge.

Enhancements

The CEO describes various measures, of which most are partially started to be implemented at Pant Catch. The overall goal is to further increase the recollection rate. This can be done by adaption to the consumer's habits. Pant Catch wants to increase presence especially in areas of on-the-go consumption. It should be possible to return bottles everywhere, even though the deposit might not be paid back at these venues. The Controller states that by providing a more diversified accessibility of point of returns, the effort for consumers is decreasing. Although the brand name is already well-known, advertising effort should be increased to foster consumer awareness in a playful way.

The Head of Customer Management suggests implementing more marketing strategies and increase the organisation's general awareness in public in order to achieve the set recycling targets and provide this material for b2b recycling. Especially younger people seem to be a consumer target group that has to be approached more intensively. New payment methods for receiving the refund are tested and could be rolled out on a larger scale. To approach younger people more intensively, sponsorships for cultural events and sports teams could be enhanced.

By decreasing transportation, the entire process grows more sustainable, states the Head of Customer Management. This can be achieved by RVMs that do not compact returned bottles but shred them and decrease their volume. Pant Catch already pursues to use alternative and renewable fuels for transportation which can be expanded. Overall, the respondent states that the entire closed-loop system should become transparent in an even more extensive manner.

In the current legislation, syrup PET bottles are not part of the system. There might be changes in the future to make the system even more holistic: The Swedish Board of Agriculture suggests that the exceptions when it comes to juice and milk should be taken away. The CEO comments:

'The changes that they are suggesting of opening up the system and not making any of these exceptions are good for the system, because it confuses the consumer. Why should one botte be part of the deposit system but not another bottle?'

This goes in line with the overall idea of making the system simpler and easier to access and use for the consumer.

4.2.3 Recycler

Company Information

Isar Recycling is a PET bottle recycling firm with plants in different European countries. The first respondent is Head of Sales within Isar Recycling for the whole European market and speaks for both Isar Recycling and Nordic Recycling. Nordic Recycling is a subsidiary of Isar Recycling and has more than 30 employees. It is a major recycling firm for the Swedish market and handles more than 25,000t of post-consumer PET bottles per annum. The company buys sorted bale bottles from Pant Catch and manages all recycling operations. The respondent is the Plant Manager and in this position since the build-up of the plant in 2006.

Barriers

According to both respondents, problems and challenges within the Swedish b2b recycling system occur on a small scale due to the system's satisfying overall performance. Firstly, there is the constant issue of material quality. To produce food-grade PET flakes for b2b recycling, the input material quality is required to be constantly high. Since the input material quality is decreasing due to thinner bottles, additives and oxygen blockers, the recycler is put into a dilemma. Due to predetermined bottle ingredients and design this situation is on a rather low degree but still existent. Ongoing quality inspections of already approved bottles for the Swedish market do not exist.

Secondly, Isar Recycling's Head of Sales points out the trend to include PET bottles for juices into the deposit system and consequently the recycling system. Currently, these PET bottles are not included due to statutory provisions. In addition to this, PET bottles for juices are unsuitable for the current b2b recycling processes. These bottles contain an oxygen blocker, an UV-blocker as well as other barriers and multi-layers. Most of these additives deteriorate during the recycling process and turn the entire material yellow. Out of a recycler's perspective, the inclusion of PET bottles for juices is disadvantageous.

Thirdly, both respondents state financial challenges. In Europe, r-PET constantly has to be economically advantageous compared to v-PET. On the contrary, the entire Swedish recycling system is costly due to high transportation and logistics efforts as well as marketing cost of Pant Catch. As a consequence, r-PET is costly and in some cases more expensive compared to v-PET. A number of actors within the system might question the entire system's feasibility. The decreasing prices on bottles depict a potential source of conflicts for the clash of interests of various actors. A decreased price for a bottle results in a decreased handling fee for the point of return (food retailer). Currently, due to the low oil price, the recycler faces a tough situation in terms of pricing. The Plant Manager states:

> *'Now we have a very cheap oil price and that will put the pressure on the virgin material. Then of course it's more difficult for the recycling material to compete with that […].'*

The bale bottles as well as the finished PET flakes are bound to an index, which means that numbers in purchasing and sales fluctuate frequently for Nordic Recycling.

Enhancements

Regarding potential enhancements the Head of Sales states that the current system, its idea and the fact that Pant Catch is a non-profit organisation is satisfying. However, the respondent suggests to not include PET bottles for juices into the deposit system. A further approach is to integrate the recycler (Nordic Recycling) more into the decision-making process of Pant Catch in order to include recycling aspects in a broader extent. A further mechanic for improvement is to increase the deposit amount to achieve a higher return rate. On the other hand, then questions whether such an increase will result in a perceptible increase of the return rate and justify the implementation costs arise.

Overall, the Head of Sales suggests unburdening the entire b2b recycling system from strong economic pressure. The recycling system then is enabled to focus on enhancing the closed-loop system with b2b recycling and increasing the overall sustainability of PET bottles in Sweden.

The Plant Manager referred to other plastics markets where improvements could be done, since there are various other products such as cleaning detergents and mouthwashes sold in PET bottles. However, due to the contamination within the household waste, it is unrealistic to include these into b2b recycling in the near future. As a potential incentive for more firms to participate in b2b recycling, the Plant Manager mentions the CO_2 certificates that Isar Recycling developed. Customers have proof about the amount of saved CO_2 by using r-PET, which could function as a driver for a sustainable brand image.

4.2.4 Bottle Preform Manufacturer

Company Information

Best Bottles is a bottle preform manufacturer for Swedish bottle fillers. The company has more than 100 employees in the local plant and belongs to a globally operating bottle manufacturer. Best Bottles produces preforms fully depending on the customer's requests which range from a share of 0% r-PET up to 50% r-PET in new bottles. The respondent is a Purchaser for the Swedish plant.

Barriers

Regarding the barriers, the respondent states the lightweight characteristic of current PET bottles. Since there is a trend towards making bottles as light as possible, the r-PET flakes are very thin. This causes them to melt faster than v-PET in the injection moulding process. Hence, the quality of bottle preforms may suffer. Additionally, bottles with a high amount of r-PET become slightly greyer. The respondent thinks that from the perspective of end consumers and bottle fillers, this may be seen as negative:

'In this kind of society that we are living in, everything should be nice, clean and beautiful; so you have to change the view of people. When you blend in more r-PET, you will suffer with the clarity of the bottle.'

Enhancements

With reference to the enhancements, the respondent sees higher consumer awareness as very beneficial. More people would buy the recycled bottles when they are well-

educated about the idea behind that. Consumers need to understand that the performance of the bottle is exactly the same as a completely new one, except for the slight colour change. Furthermore, in order to increase bottle recollection, the deposit amount could be increased as a higher consumer incentive.

4.2.5 Associations

Company Information

Svenska Groceries is an association representing independent food retailers in Sweden. The association has a variety of trade topics on its agenda and also helps the retailers with corresponding issues such as logistics and environmental projects. Svenska Groceries holds 25% of Pant Catch. The respondent is the Managing Director of Svenska Groceries and also functions as a member of the supervisory board of Pant Catch.

Food-Retail Sverige is an association representing Swedish food retail chains. The organisation is neutral to competition, has no managing function and represents their interests. Food-Retail Sverige holds 25% of Pant Catch. The respondent is the Managing Director of Food-Retail Sverige as well as a member of the supervisory board of Pant Catch.

Barriers

As one of the main barriers, the Managing Director of Svenska Groceries identifies bottle compression in the supermarkets. Since the bottles decompress slowly afterwards, they take more space and therefore increase the transportation volume. Regarding the recycling quote of 85% of PET bottles, the respondent asserts that customers mainly collect and return the bottles when they consume the drinks at home, but on-the-go the bottles are put into random trash bins. The return rate for PET bottles varies depending on the bottle's size. The return rate for smaller bottles (0.5l) is ~82% and ~90% for larger bottles (1.5l). The Managing Director of Food-Retail Sverige explains this difference with consumer habits and the partly lacking consumer awareness especially among younger people. Sometimes people also use the bottles again, e.g. when refilling them with tap water. Another factor is the relatively low deposit amount of 1 SEK per smaller sized bottles. The respondent of Svenska Groceries explains:

'The more valuable the deposit is, the higher the interest is.'

An additional problem regarding transportation is the huge distances that need to be covered in the recycling system. On the other hand, in middle and north Sweden the population is very sparse, so there is no recycling plant in that area. The respondent of Svenska Groceries states:

'It's not environmentally sound to take a bottle from Kiruna to southern Sweden. […] I think the environmental impact from transportation eats up the benefits of recycling'

Regarding problems within the b2b recycling system, the respondent mentioned material aspects of the input material as well as quality features of r-PET. The input material is contaminated by different PET compositions as well as impurities.

Enhancements

According to the Managing Director of Food-Retail Sverige, the b2b recycling system is driven by the increasing environmental awareness, the image boost for involved recycling system actors and mainly the Swedish legislation on a return and recycling system. Overall the PET bottle recycling system – and consequently b2b – could be improved by increasing the consumer awareness especially for the sub-group of young men with more excessive marketing strategies and a higher number of easily accessible RVMs.

The aforementioned compression problem needs to be fixed, but there is no technology available for that yet. Moreover, other beverage packaging such as syrup could be included into the recycling system. This would increase the amount of input material for recycling considerably, but factors such as diverse bottle contaminants in these types need to be regarded. In terms of regulatory interference, the respondent of Food-Retail Sverige aspires a European legislation on recycling targets and quotas rather than national laws.

4.2.6 Consolidation of Findings

In order to increase the transparency of the previous findings from all interviews, all stated barriers and enhancements are summarised in Table 4-3 and Table 4-4. A reference is given by which respondent in terms of industry the arguments are mentioned.

Table 4-3 Barriers in Sweden

Barriers in Sweden		Description	Reference to Organisation
Present in theory	Contamination of post-consumer PET bottles	- PET bottles are contaminated when used as input material for recycling	Isar Recycling, Food-Retail Sverige
	Demanding requirements for use of recycled PET in food packaging	- Material requirements and safety demands for use of recycled PET in food packaging	Isar Recycling, Best Bottles
	High cost of recycling system	- High cost of entire recycling system - Post-consumer PET bottle collection and marketing costly - Substantial transportation expenses	Isar Recycling, Pant Catch
	Inconsitent quality of recycled PET resin	- Output quality depends on the PET bottle input quality - Challenge for both recycler and preform manufacturer	Isar Recycling, Best Bottles, Food-Retail Sverige
	Low ecological consumer awareness and incentives to return PET bottles	- Current return rate of post-consumer PET bottles of approx. 85% - Dependent on consumer habits	Pant Catch, Svenska Groceries, Food-Retail Sverige
	Market preference for virgin PET resin over recycled PET resin	- Bottle fillers and beverage producer criticise r-PET bottles appearance; preference for "clearer" material - r-PET has to provide a price gap in comparison to virgin material - Virgin material price - price gap = r-PET price	Isar Recycling, Nordic Recycling, Best Bottles, Svenska Groceries
	No fixed quota for recycled PET in new products established	- Various actors aspire high extent of r-PET in new bottles, in practice system is diversified - r-PET quota depends on bottle fillers' and beverage producers' preferences	Nordic Recycling, Best Bottles, Svenska Groceries
Absent in theory	Changing characteristics of PET bottle	- With approval of bottle design by Pant Catch problems are reduced but not eliminated - Bottle design is made according to marketing factors instead of recyclability - Used materials for bottle, labels, caps and adhesives - Trend towards thinner and ligther bottles; hampers recycling processes	Isar Recycling, Nordic Recycling, Best Bottles
	Consumer acceptance	- Recycled bottles change the colour towards a slighty grey tone - Consumer habit for "clean and nice" new products	Best Bottles
	Lack of subsequent quality inspections of PET bottles	- Lack of subsequent quality inspections of PET bottles after initial approval of bottle to Swedish market	Isar Recycling
	Lacking functionality and return possibilities of reverse vending machines	- Difficultly accessible and available return points for consumers in some areas	Pant Catch, Food-Retail Sverige
	Pricing process for r-PET	- Pricing formulas between Pant Catch, Nordic Recycling & Best Bottles oriented on indexes - Indexes include virgin material prices - Interest conflicts between system actors about economic targets (lower prices, higher handling fee)	Isar Recycling, Pant Catch, Nordic Recycling, Svenska Groceries
	Profitability	- Profitability of entire recycling system - Subsidies	Pant Catch, Svenska Groceries
	Space requirements for RVMs and bottle storage	- RVMs and space utility for return areas and storage space for returned bottles - Point of sales (food retailers) demand space as sales area	Pant Catch
	Transportation of post-consumer PET bottles	- Volume of compressed post-consumer PET bottles - Transportation efforts - Long distances	Pant Catch, Svenska Groceries
	Trend of inclusion of non-deposited PET bottles into recycling system	- Inclusion of yet excluded and non-deposited PET bottles (e.g. juice bottles) with different material composition into deposit and recycling system - Those bottles use additives, UV-blockers, oxygen blockers and various barriers - Difficulties for recycling process	Isar Recycling

Table 4-4 Enhancements in Sweden

Enhancements in Sweden		Description	Reference to Organisation
Present in theory	Closer contact between all partners in the value-added chain	- Closer contact with focus between recyclers and retailers	Isar Recycling
	Consistent standard for PET raw material specification	- Minimise contamination by reducing diversity of packaging materials - Overall higher degree of post-consumer bale bottles	Isar Recycling, Food-Retail Sverige
	Increase efficiency in sorting process	- Sorting in machines can be improved so that compacting lasts longer	Svenska Groceries
	Increases bottle return collection rates	- Increase deposit values: For smaller bottles such as 0.5L this could increase the recollection rate	Isar Recycling, Pant Catch, Svenska Groceries, Food-Retail Sverige
	Upgrade technology in recycling process	- Since the r-PET flakes are very thin, an upgrade on injection moulding machines technology is needed to utilise the material better	Best Bottles
Absent in theory	Certificate issued by the recycler for companies using r-PET	- The recycler issues a certificate to the customers so that they can prove the savings of CO2	Isar Recycling
	Inclusion of non-deposited PET bottles into recycling system	- Include bottles of other drink types such as syrup, which are not deposited currently	Pant Catch, Nordic Recycling, Svenska Groceries, Food-Retail
	Increase functionality and return possibilities of reverse vending machines	- Make the machines more accessible - Use of machines which can take all bottles / cans at one time (decrease of waiting time) - Offer new online payment methods for the deposit refund upon returning the bottles - Bottles should be shred right away in the machine to save space - Adapt capability of revending machines to the store size - In areas such as festivals, vacation areas or urban areas, more returning possibilities must be available	Pant Catch, Svenska Groceries, Food-Retail Sverige
	Increase marketing to ensure consumer awareness of recycling necessity	- People should learn why it is so important to recycle their bottles - Specifically the target groups of young people / young males need to be more aware of recycling - Collaboration with sports and culture teams	Pant Catch, Best Bottles, Svenska Groceries, Food-Retail Sverige
	Recycler's participation in Bottle Return Coordinator's meetings regarding bottle material requirements	- Pant Catch is in charge of approving new bottles for the market. The recyclers should participate since they know best which aspects of the bottle are critical for recycling	Isar Recycling, Pant Catch
	Reduce impact of transportation of post-consumer bottles to the plant	- The Bottle Return trucks are fueled by HVO (bio diesel) - Better compacting technology in reverse vending machines	Pant Catch

5 Analysis

This chapter presents the analysis of the empirical findings in relation to the existing theory of chapter two. As previously described, the analysis method is pattern matching. The predicted patterns of outcomes from theory are matched with the findings from chapter four. Hence, the analysis is executed and structured according to this study's purpose and the proposed three research questions. Firstly, the holistic PET bottle recycling systems are compared. Then, the main barriers for both focus countries are analysed on the basis of four introduced categories. Thirdly, the enhancements are analysed in main categories combining Germany and Sweden.

5.1 Operations in the Current PET Bottle Recycling Systems

Both focus countries implemented a compulsory deposit system on ready-to-drink beverages in PET bottles in order to stimulate return flows and to increase the purity of variety of the returned material. In 2014, both countries achieved remarkable return rates for deposited and non-deposited PET bottles in comparison to other European countries: 82.5% in Sweden and 93.4% in Germany (Petcore, 2015). In this context, Germany achieves the highest score whereas Sweden does not achieve the governmental goal of a 90% return rate. Potential reasons for the difference in the return rate are undetermined but could be explained by a longer tradition of implemented deposit systems in Germany. The technical processes used for b2b recycling are similar in both countries.

An outstanding characteristic of the Swedish system is its unified process represented by mainly one actor for each step of the recycling system. Those responsibilities are to a certain extent determined in long-term contracts and agreements, especially the appointment of Pant Catch as the nationwide collector. In contrary to that, the German system is depicted by various elements acting independently without a unification. Collected post-consumer PET bottles are traded and sold on the free market with no determined further processing. Although, in Germany DPG is the general superordinate organisation for deposited PET bottles, its only responsibility is the financial clearing with involved actors. On the other hand, Pant Catch in Sweden is the owner of returned bottles and responsible for the financial clearing (cf. Appendix 7). This difference has a major impact on the overall performance of b2b recycling in the respective countries.

Due to its high degree of collaboration among recycling system actors, the clearly defined recycling target by law and the engagement for an enhanced b2b recycling, the Swedish system outperforms the current German system distinctly in terms of b2b recycling. On the other hand, Germany performs b2b recycling but on a less holistic scale due to the lack of a unified process, the lack of b2b recycling as a common goal among actors and varying owners of returned bottles.

5.2 Barriers for Closed-Loop PET Bottle Recycling

In order to analyse the main barriers for Germany and Sweden, the established patterns from theory are shown together with the additional empirical findings in Table 5-2 for Germany and Table 5-3 for Sweden. In case the respective aspects are stated by respondents from the different industry sectors, they are marked (cf. Table 5-3). For the analysis process, barriers are divided into four introduced categories. Those categories are (1) quality and material factors, (2) regulatory factors, (3) economic and market factors and (4) factors influenced by consumers (cf. Table 5-1). Based on the research questions and the importance stated by the respondents, the main barriers are analysed within each category. It can be noted that in Germany six barriers from theory are not matched by the respondents, whereas in Sweden, eight barriers are not matched.

Table 5-1 Categories for Barriers

Categories for Barriers		
Category	**Abbreviation**	**Description**
Quality and material factors	Qlty.	Factors relating to material and quality issues of input and output material; sorting processes; purity of variety
Regulatory factors	Reg.	Factors influenced by legislation
Economic and market factors	Econ.	Factors relating to economic benchmarks, pricing processes, business behaviour and profitability
Factors influenced by consumers	Con.	Factors that are dependent on consumers, their behaviour and their decisions

5.2.1 Quality and Material Factors

Eik (2005), Welle (2011) and Nascimento et al. (2006) identify inconsistent quality of r-PET as a barrier. The output material (r-PET) is logically strongly dependent on the quality of the input material (post-consumer PET bottles). Consequently, this aspect aligns with the barrier of contaminated post-consumer PET bottles (Hopewell et al., 2009; Matar et al., 2014; Welle, 2011). Isar Recycling's respondent confirms and summarises this dependency and challenge as follows:

'If you throw scrap into it [the recycling process], you will in the end get scrap out of it.'

To ensure the production of high quality food grade r-PET, the input material is required to be as pure as possible with the least number of xenobiotics. The general securing of high quality processes and materials is an ongoing and constant challenge. Both aspects are mentioned in the focus countries, with an agglomeration in the recycling industry. Welle (2011) states the influx of (contaminated) non-food PET bottles in the recollection feedstream as problematic. Given that both focus countries have implemented deposit systems for PET bottles, the probability of non-food PET bottles within the feedstream is unlikely. RVMs in both countries only accept PET bottles for food with registered barcodes into the return system.

Table 5-2 Analysis of Barriers in Germany

Barriers in Germany				
Presence in Theory		**Recyclers**	**Bottle Filler**	**Associations**
Quality and material factors	Contamination of post-consumer PET bottles	x		x
	Demanding requirements for use of recycled PET in food packaging	x	x	x
	Inconsitent quality of recycled PET resin	x		
	Inefficient standards of sorting processes	x		
	Reduction of recycled PET's average molecular weight (hydrolysis)			
Regulatory factors	Lack of legal coordination and incentives for PET recycling system	x	x	x
	No fixed quota for recycled PET in new products established	x		x
	Taxes on PET bottles and/or recycled PET			
Economic & market factors	Flexibility to choose between various waste treatment options			
	High cost of recycling system	x		x
	Lack of coordination between supply chain actors			x
	Low efficiency or non-existence of collection system for post-consumer PET bottles			
	Market preference for virgin PET resin over recycled PET resin	x		x
	Stronger economic incentives for incineration than recycling			
Con.	Low ecological consumer awareness and incentives to return PET bottles			
Absence in Theory		**Recycler**	**Bottle Filler**	**Association**
Qlty.	Changing characteristics of PET bottle	x		
Economic & market factors	Overcapacity of PET flake producers	x		
	Overcapacity of virgin PET manufacturers	x		
	Pricing process	x		x
	Profitability	x		x
	Strong market position of food retail corporations	x	x	x
	Undercapacity of PET resin producers	x		
Con.	Consumer acceptance	x	x	x

Table 5-3 Analysis of Barriers in Sweden

Barriers in Sweden					
Presence in Theory		**Bottle Return Coordinator**	**Recycler**	**Preform Manufacturer**	**Associations**
Quality and material factors	Contamination of post-consumer PET bottles		x		x
	Demanding requirements for use of recycled PET in food packaging		x	x	
	Inconsitent quality of recycled PET resin		x	x	x
	Inefficient standards of sorting processes				
	Reduction of recycled PET's average molecular weight (hydrolysis)				
Regulatory factors	Lack of legal coordination and incentives for PET recycling system				
	No fixed quota for recycled PET in new products established	x		x	x
	Taxes on PET bottles and/or recycled PET				
Economic & market factors	Flexibility to choose between various waste treatment options				
	High cost of recycling system	x	x		
	Lack of coordination between supply chain actors				
	Low efficiency or non-existence of collection system for post-consumer PET bottles				
	Market preference for virgin PET resin over recycled PET resin			x	
	Stronger economic incentives for incineration than recycling				
Con.	Low ecological consumer awareness and incentives to return PET bottles	x			x
Absence in Theory		**Bottle Return Coordinator**	**Recycler**	**Preform Manufacturer**	**Associations**
Qlty.	Changing characteristics of PET bottle		x	x	
	Lack of subsequent quality inspections of PET bottles		x		
Reg.	Trend of including yet non-deposited PET bottles into deposit system		x		
Economic & market factors	Pricing process for r-PET	x	x		x
	Profitability	x			x
	Space requirements for RVMs and bottle storage	x			
	Transportation of post-consumer PET bottles	x			x
Con.	Consumer acceptance			x	
	Lacking functionality and return possibilities of reverse vending machines	x			x

Nonetheless, post-consumer PET bottles are contaminated in different manners. Especially the PET bottles' colour and chemical material composition as well as the varying materials used for labels, caps and adhesives hamper the actual recycling processes. According to the respondents, this problem's frequency and importance is higher in Germany. This is caused by the lack of industry-wide specifications on materials used, the lack of quality inspections for input material and less efficient sorting processes of returned bottles. Swedish respondents refer to this problem but it has to be considered on a lower scale especially due to the existing list of approved materials for PET bottles (cf. Appendix 8). As observed on-site at Pant Catch, returned PET bottles are strictly sorted by colour and unshackled of xenobiotics. Like every automated process, those sorting processes operate with a small error rate, but several material controls ensure a high level of purity of variety. A statement of Nordic Recycling's respondent depicts to some extent the quality differences between input materials from different countries:

'We never mix material like that. We always run Swedish material at one step and then other material – such as Norwegian material.'

Since respondents out of both countries emphasise issues regarding contamination of input material and inconsistent quality of r-PET, this barrier overall has to be rated as highly important to the entire b2b recycling process.

Secondly, respondents in both countries point out the demanding material requirements to use r-PET in food packaging applications. This aspect is put into context with the first set of problems. Various researchers (Nascimento et al., 2006; Welle, 2013) describe the generally demanding material requirements for bottles due to the safety of the containing product – the beverage itself. The respondent of Donau Recycling confirms the reasoning for those demanding material requirements:

'Here in Germany, it is first and foremost the product safety of the content [beverage] that matters and less the bottle itself.'

Due to the reasoning of product safety especially in food related applications, the requirements for r-PET are set on an advanced level. According to the respondent of Plastics Association, b2b recycling is considered the most advanced recycling process for PET bottles concluding in strict requirements for food grade recycled resin:

'B2b is in terms of quality the premium recycling application. […]
Accordingly, specific requirements for the processes are set due to the intended use of r-PET as food grade material.'

Since every interviewed sector in Germany mentions this barrier, a cluster within the German system is recognisable. Notwithstanding, the requirements for r-PET in Sweden are certainly equal if not stricter, it is only stated by a selection of respondents. Due to European legislation on the use of r-PET in food applications, differences in the general legal framework are marginal. With Sweden controlling the variety of materials used, the output material is assumedly of higher quality. Hence, Swedish r-PET most likely matches the demanding requirements more regularly and a possible explanation for the different evaluation of this barrier can be made.

'When we started with making PET bottles in 1983 […], a 1,5l bottle weighted 83g. Today, a bottle weighs 39g. It is hard to produce a good item out of such a thin flake.'

This barrier absent in theory mentioned by the respondent from Best Bottles for both countries is the challenge of changing characteristics of PET bottles. Especially the trend to lighter bottles with thinner walls causes difficulties during the b2b recycling process. On the contrary, the trend to save weight is caused by the approach to design bottles more efficiently, to use fewer raw material for production and to reduce transportation impacts. Furthermore, characteristics of PET bottles especially in Germany change regarding the design, materials, and ingredients used. In Sweden this problem is evaluated on a smaller scale due to the required approval for introduced PET bottles, whereas in Germany no limitation is in place. As a consequence, recyclers struggle with constantly changing and newly used materials. Various blockers and additives cause yellowing of PET when recycled.

5.2.2 Regulatory Factors

Barriers in the context of legal coordination and legislative regulation are described in theory by Zhang & Wen (2014) who discuss the lack of laws and regulations for the responsibility of the PET bottle recycling system. In Germany, every respondent highlights this barrier and describes the lack of a unified system as strongly hindering. Since post-consumer PET bottles pass into the food retailers' ownership a plurality of recycling possibilities is facilitated. On the contrary, the Swedish system is distinctly defined by the Swedish legislative and as a consequence no respondent mentions this problem. Regardless their points of return, post-consumer PET bottles are still owned by Pant Catch. This clear difference between both countries affects the overall performance of the Swedish system positively and the German system negatively. Nonetheless, when comparing both markets, aspects such as market size and number of market actors have to be considered.

In accordance with theory, German and Swedish respondents assert the lack of a fixed quota for r-PET in new PET bottles (Nascimento et al., 2006; Gandenberger et al., 2014). Since the decision about the r-PET share in both countries is consequently made by bottle fillers and preform manufacturers, it is only based on their preferences. According to the respondents, a clearly defined fixed legal quota for r-PET would foster and ease the entire b2b recycling tremendously by also forcing actors to use r-PET which recently do not process it.

5.2.3 Economic and Market Factors

Matar et al. (2014), Grimes-Casey et al. (2007) and Patel et al. (2000) identify the high cost of the entire recycling system as a barrier. More detailed, Grimes-Casey et al. (2007) highlight the cost of the bottle return system which applies to the Swedish system based on the empirical findings. A main coordinator for the collection in entire Sweden exists: Pant Catch. According to the respondents, the system works on a satisfying level. Despite that, Isar Recycling's respondent mentions pending issues of dispute in terms of cost:

> *'For some producers and brands it [the Swedish system] is on the one hand close to being too extensive in costs, on the other hand it is apprehended how the Swedish legislative might react if the system collapses or deteriorates.'*

Compared to Germany, the Swedish system is outstanding in terms of marketing and its related cost as well as the transportation of returned PET bottles to its single plant in Sweden.

Furthermore, Patel et al. (2000) determine the high cost of the actual plastics recycling processes as hindering. Through respondents' statements as well as the on-site observation at Nordic Recycling, this statement is confirmed especially by respondents in the recycling sector. Overall, b2b recycling requires a multitude of process steps in order to produce r-PET flakes or resin. In this context, the results in both countries are similar since the processes are parallel. Those recycling processes as well as the machines used in production are costly. Nordic Recycling pursues a high degree of utilisation for its processes being economically viable:

'We need more! [Input material] […] We run continuously; 24 hours a day, seven days a week. We only stop the production for the big holidays. So, we're running approximately 353 days a year.'

A barrier absent in theory and closely related to the problem of high cost is the overall profitability of either actors in the system or the system itself. Mentioned by recycling actors and associations in Germany and the bottle return collector and associations in Sweden, the problem appears omnipresent and frowningly. The respondent of Donau Recycling describes economic benchmarks and profitability as a major barrier for PET bottle recycling:

'Therefore, it is less a problem of collecting and providing [the input material], but more a problem of prices and profitability.'

The recycling processes face high cost, volatile and generally low achievable prices for r-PET, a varying demand for r-PET and especially in Germany a strong competition. Hence, actors within the systems are constantly confronted with economic pressure. Primarily recycling actors point out this problem. Although Swedish respondents mention profitability as a problem, it is less limiting in comparison to Germany due to the unified recycling system in Sweden and long-term contracts between various actors (Swedish Board of Agriculture – Pant Catch – Nordic Recycling). Constant competition faced by German actors primarily refers to the correlated prices for PET on the free market. This results in a stronger threat to the entire recycling system.

The pricing process of r-PET is considered as a further barrier. R-PET has to provide a financial advantage compared to v-PET in order to promote its use. Considering the recent development of the oil price and the constantly high cost of r-PET's recycling processes, the economic advantageousness of r-PET diminishes or even disappears. This overall hampers b2b recycling to a large extent. Therefore, a number of preform manufacturers or bottle fillers prefer v-PET over r-PET.

A mentioned barrier that clusters within the German market is the strong market position of food retail corporations in Germany. According to Isar Recycling's respondent, the European PET market is predominantly controlled by food retailers. Various respondents claim that the majority of retailers have no particular focus on b2b recycling for their returned PET bottles. In Germany this fact is simplified by the food retailers owning returned PET bottles. Food retailers in Sweden do have an influential power but due to the implemented single organisation, this influence is limited.

5.2.4 Consumer Factors

A further set of problems, mainly observed in Sweden, are the relatively low consumer awareness and incentives to return PET bottles. Especially respondents from Pant Catch highlight the importance to further improve the bottle return rate since around 15% of PET bottles are still not returned in Sweden. On the contrary, the respondent of Isar Recycling asserts:

'It is just a too large loss of material. This is caused by people who still do not know about the return system - elderly people - or people who simply do not and will not care about the deposit amount ever. Those will continue to throw away PET bottles.'

Eik (2005) identifies a low deposit amount as hindering and with 1 SEK respective 2 SEK of deposit in Sweden, this statement appears to be confirmed. With a return rate of around 96% for deposited PET bottles, German respondents do not confirm this barrier. Concluded by various respondents, a return rate of 100% is unrealistic. Losses of around 5-10% will always occur due to consumer related and other factors.

In contrast to the low consumer awareness and incentives to return in Sweden, the absent barrier in theory of lack of functionality of RVMs as well as holistically spread locations of return possibilities is stated. Swedish respondents point out that the location and functionality of RVMs are important in order to attract customers. In some cases, both aspects are still disadvantageous and require to be improved.

In both countries, the challenge of consumer acceptance is pointed out by various respondents. PET bottles with a higher share of r-PET slightly change colour as a result of blending in reused material. Such a bottle is depicted by a slight grey tone (cf. Appendix 9). According to the respondents, bottle fillers assume that used appearing bottles might be refused by the consumer (cf. Appendix 9). This assumption concludes in the fact of commonly using a higher quota of v-PET than r-PET for new bottles. Notwithstanding, it is undetermined how the appearance of a PET bottle with high recycling content finally affects the end-consumers' purchase decision.

In conclusion of all categories, Isar Recycling's respondent summarises barriers in both countries as follows:

'Problems and challenges exist in Sweden as well, […] but their intensity compared to those in Germany is less severe. In terms of b2b recycling, Scandinavia is various years ahead of Germany.'

Both focus countries face barriers, problems and challenges in terms of PET bottle recycling and especially b2b recycling. This respondent labels the Swedish system as further developed and advanced than the German system.

5.3 Enhancements for Closed-Loop PET Bottle Recycling

In order to analyse the enhancements for Germany and Sweden, the established patterns from theory are shown together with the additional empirical findings in Table 5-5 for Germany and Table 5-6 for Sweden. In case the respective aspects are stated by respondents from the different industry sectors, they are marked (cf. Table 3-3). For the analysis process, enhancements are grouped and sorted into five established categories. Those categories are (1) quality and material factors, (2) regulatory factors, (3) recollection factors, (4) expanding factors and (5) others (cf. Table 5-4). Based on the research question and the importance stated by respondents, the main enhancements are analysed within the first four categories. It can be noted that in Germany seven enhancements from theory were not matched by the respondents, whereas in Sweden, six enhancements were not matched.

Table 5-4 Categories for Enhancements

Categories for Enhancements		
Category	**Abbreviation**	**Description**
Quality and material factors	Qlty.	Factors relating to material and quality issues of input and output material; sorting processes; purity of variety
Regulatory factors	Reg.	Factors influenced by legislation
Recollection factors	Rec.	Factors relating to return and recollection rate
Expanding factors	Exp.	Factors relating to expand the deposit system and the included types of PET bottles
Others	Oth.	Factors relating to the recycling system, its involved actors and economic characteristics in general

5.3.1 Quality and Material Factors

Eik (2005), Welle (2011) and Hopewell et al. (2009) state consistent standards for PET raw material specifications as fruitful for the quality of input material. In Germany, this statement is found in replies of respondents from all industry sectors. If the quality is consistent and on an overall higher level, less processes for sorting and removal of external non-recyclable materials are required. In Sweden, the respondents see necessity for improvement in this area as well. As it was seen during the on-site process observations at Pant Catch's plant, various sorting techniques are already in place. However, at the recycler the same sorting techniques are done once again in order to ensure the highest possible purity of variety for the input material. In comparison, the respondents who have knowledge about quality matters in both countries, clearly state that while the quality in Sweden is much higher than in Germany, this issue can always be improved further in order to minimise hindrances in the recycling process.

Respondents from all industry sectors in Germany mention industry-wide specifications regarding design and material as an advantage. This goes one step further than solely using the same standards as described by Eik (2005).

In Sweden, this aspect does not seem to be an issue for the respondents. This is due to the country's different approach when it comes to new bottles for the Swedish market. The Head of Sales of Isar Recycling explains:

'It doesn't matter if you are a large and prestigious bottle filler, if you want to introduce a PET bottle in the Swedish market, you have to approach Pant Catch and present your bottle with all contents.'

'By having a guideline [for approved bottle design and material in Germany] we could reduce the problems. In Germany they are infinite, while in Scandinavia we only have a handful of them.'

Table 5-5 Analysis of Enhancements in Germany

Enhancements in Germany				
Presence in Theory		**Recycler**	**Bottle Filler**	**Associations**
Qlty.	Consistent standard for PET raw material specification	x	x	x
	Increase efficiency in sorting process	x	x	x
	Upgrade technology in recycling process			
Regulatory factors	Introduce quota for recycled PET packaging	x		
	Loosen requirements for PET food packaging			
	Tax exemption for recycled raw material			
Rec.	Increases bottle return collection rates			
Others	Closer contact between all partners in the value-added chain	x		x
	Cut out middlemen for raw material sale / purchase			
	Include externality effects into prices			
	Increase negotiation power: Vertical integration of sorting centres			
Absence in Theory		**Recycler**	**Bottle Filler**	**Associations**
Quality and material factors	Closer cooperation with food retailers	x		x
	Enlightenment and clarification with other actors regarding recycling requirements	x		x
	Industry-wide specifications for PET bottles (design and material)	x	x	x
	Introduce council for review of specifications for new bottles	x		
	Panelty fee in case recycling quota target is not fulfilled	x		
Reg.	Adapt legislation about recycable material to increase primary recycling		x	
Exp.	Inclusion of non-deposited PET bottles into recycling system			x
Others	Certificate issued by the recycler for companies using r-PET	x		
	Fixed pricing for recylers	x		

By doing so, it is possible to check for materials which could hamper the recycling process and test them in collaboration with the recyclers. Hence, many potential material problems are proactively detected and can be solved even before the bottle enters the market. This could be a suitable solution to decrease the numerous material issues in German recycling. Although a council for material quality already exists in Sweden, a possible improvement is to consistently include a recycling representative to the meetings. By doing so, there is less bureaucracy and, potential problems can be directly communicated and quickly addressed, e.g. through laboratory tests.

5.3.2 Regulatory Factors

Food retailers and bottle fillers generally develop bottle design and material according to marketing aspects to achieve high sales. Food retailers in Germany have a very strong position. Therefore, regulating material quality is expected to be challenging since risks are involved. Isar Recycling's Head of Sales claims there is no real alternative besides manifestation in law. On the other hand, the Head of Environment and Sustainability of PET-Group prefers to enhance the system by voluntary action steps:

'Due to its nature of interfering into the market, a regulative act generally requires […] a strong justification such as a weak performance of the market.'

Table 5-6 Analysis of Enhancements in Sweden

Enhancements in Sweden					
Presence in Theory		**Bottle Return Coordinator**	**Recycler**	**Preform Manufacturer**	**Associations**
Qlty.	Consistent standard for PET raw material specification		x		x
	Increase efficiency in sorting process				x
	Upgrade technology in recycling process			x	
Regulatory factors	Introduce quota for recycled PET packaging				
	Loosen requirements for PET food packaging				
	Tax exemption for recycled raw material				
Rec.	Increases bottle return collection rates	x	x		x
Others	Closer contact between all partners in the value-added chain		x		
	Cut out middlemen for raw material sale / purchase				
	Include externality effects into prices				
	Increase negotiation power: Vertical integration of sorting centres				
Absence in Theory		**Bottle Return Coordinator**	**Recycler**	**Preform Manufacturer**	**Associations**
Qlty.	Higher degree of quality of post-consumer bale bottles		x		
	Recycler's participation in Bottle Return Coordinator's meetings regarding bottle material requirements		x		
Recollection factors	Increase functionality and return possibilities of revending machines	x			x
	Increase marketing to ensure consumer awareness of recycling necessity	x		x	x
Exp.	Inclusion of non-deposited PET bottles into recycling system	x	x		x
Others	Reduce impact of transportation of post-consumer bottles to the plant	x			
	Certificate issued by the recycler for companies using r-PET		x		

Since this is stated by a respondent from an Association of plastics manufacturers, it can be expected that opposing actions would increase in case the legislature is about to make changes which limit certain actors. In Sweden, this is less of a problem, since Pant Catch is actually owned by the associations of bottle fillers and food retailers.

Another enhancement, which also belongs to the field of legislative measures, is the introduction of a fixed quota for recycled PET packaging (Hopewell et al., 2009; Nascimento et al., 2006). This is matched with recyclers in Germany, while no respondent mentioned this enhancement in Sweden. A quota would mean that each new bottle produced in Germany must consist of a certain share of r-PET. From a theoretical point of view, the quota would be the most direct method to ensure that r-PET is used in a closed-loop application. The Head of Sales PET Flakes of Neckar Recycling suggests 50%. Contrarily, the CEO of Donau Recycling recommends the number of 30%:

'We have the technical feasibility to use recycled material, hence 30% [of a bottle should be made out of r-PET]. You could also say 40%, but I know from discussions that 30% is already seen as the limit by many others.'

For the German recyclers, currently there is no security that the PET bottle will stay on the market long-term with the same conditions like today. In the past, there were already considerations to put a penalty fee on disposable PET bottles in general, in order to make consumers switch back to reusable bottles. The fixed quota would then practically

legitimate the PET bottle, but also set up conditions to make it more sustainable in a compulsory way. In Sweden, no respondent stated the quota as a potential enhancement. The reason for this is the vision of Pant Catch, which is to foster b2b recycling in Sweden. The CEO of Pant Catch explains:

'We have a clear bottle-to-bottle concept.'

The Head of Sales of Isar Recycling estimates that in Sweden more than 80% of the flakes are sold back into the closed-loop. This is a significant difference in comparison to Germany, where the respondents estimated approximately 27-30% of closed-loop application and proves that the Swedish system is more advanced in that matter. However, in Sweden the bottle fillers are still free to decide which material their bottles should consist of. The Purchaser of Best Bottles (Bottle Manufacturer) clarifies:

'There are bottles for the Swedish market made from 100% virgin resin and there are bottles with a blend [of r-PET] – all up to customers' demands.'

Hence, if a certain bottle filler wants to use 100% v-PET for all of the products, this would be possible. This leads to the assumption that a fixed quota could improve the consistency in the Swedish b2b system as well and increase the overall amount of bottles that include r-PET.

5.3.3 Recollection Factors

Several researchers (Nascimento et al., 2006; Eik, 2005; Kuczenski & Geyer, 2013; Zhang & Wen, 2014) describe the increase of the bottle recollection rate as a major enhancement. In the empirical findings in Sweden, this aspect is mentioned by all respondents of Pant Catch as well as the associations and one recycler, whereas the aspect is not matched in Germany. This can be explained by the current recollection rates for both deposited and non-deposited PET bottles measured by Petcore (2015), which show 82.6% for Sweden and 93.4% for Germany. Welle (2011) emphasises the recollection rate as a determining prerequisite for high recycling rates. Hence, the availability of returned bottles would supposedly increase the input material for the recyclers. Eventually, this leads to higher volumes of r-PET which can be used for new bottle manufacturing.

While a small number of measures to increase the recollection rate can be found in theory, several more are found in empirical data for Sweden. The first aspect refers to functionality and return possibilities of RVMs. The vast majority of all returned post-consumer bottles are returned in food retail stores. However, respondents see the trend in lifestyle that many consumers tend to eat and drink on-the-go instead of buying all groceries at food retailers. Hence, to increase the recollection rate, the Bottle Return Coordinator has to increase return points in these areas. Furthermore, the RVMs should be improved regarding speed and alternative payment methods of receiving the refund.

The CEO of Pant Catch sees the simplicity of recollection as the main challenge for the future. The second aspect, which is absent from theory, refers to consumer awareness of the necessity to recycle. Pant Catch's CEO highlights the consumer's responsibility:

'In the end, you have the consumer that we need to convince to return that bottle to our system and that effort […] is better than returning it in some other way'

A lot of marketing is done by Pant Catch since many years, which manifests in the fact that the brand name under which the organisation advertises is well-known all over Sweden. However, especially for consumer groups with low return rates such as young males, more effort is required, such as sponsorships for sports tournaments and clubs. In Germany, there is no advertising and marketing done for returning deposited bottles. One could argue that this is not necessary since the country has the highest recollection rate in Europe. On the contrary, marketing efforts could possibly even increase the rate further. However, the question is in which way the advertising costs reflect the potential improvement in recollection, since it is expected to be only very marginal. Additionally, respondents state that there is always a certain percentage of material loss and 100% return rate cannot be achieved. This applies also to the idea of a deposit increase in Sweden, specifically for small 0.5l bottles which have a significantly worse recollection rate than 1.5l bottles. The Head of Sales of Isar Recycling remarks:

'100% return rate is not possible […]. I suppose you can never wipe out losses of 5-10% only through an increase of the deposit.'

According to Eik (2005) and Nascimento et al. (2006), the efficiency in sorting centres should be improved. The researchers refer to automation and employee training as main aspects. In Germany's empirical findings, respondents from all industry sectors matched improvement of sorting. The respondents refer to the sorting process at the return point, though. Bottles should be separated right upon return and not in subsequent additional process steps by the recyclers. This would streamline the input process and higher quality standards of post-consumer bottles could be achieved. Conversely, when bottles are sorted according to different colours, more space is required at the recollection points in the food retails stores. This is a disadvantage from the food retailers' perspective, since they lose valuable selling space for their products. The overall higher input quality in Sweden explains why this factor is only matched by the respondent of one Swedish association.

In Sweden, the transportation model could potentially be enhanced to reduce the environmental impact. Based on empirical data, currently a fleet of approximately 50 trucks and 25 consolidation centres handles the bottle return process to Pant Catch's plant. An improvement which is already implemented is the use of the renewable Hydrotreated Vegetable Oil (HVO) fuel for the whole fleet. Due to the long distances in Sweden, enhancements in transportation can have large positive impact on the cost and eco-friendliness of the return system. Therefore, more enhancements of the authors of this study can be found in the subsequent section.

5.3.4 Expanding Factors

An aspect not present in theory is the inclusion of non-deposited PET bottles into the recycling system. The aspect is frequently mentioned in Sweden, due to the characteristics of the legislation. The CEO of Pant Catch explains:

'The law includes ready-to-drink beverages with the exception of milk and juice […]. If the products contain less than 50% milk or juice, it needs to be part of the system. What's the real difference if a product contains 48% or 52% juice?'

Hence, Pant Catch puts effort into opening up the system, and a small number of food retailers already joined the deposit system with syrup and other bottles. This shows that

there is lots of room to enhance the system by gradually including all those bottles. Consequently, more material could be recycled into the closed-loop. In comparison, only one respondent from a German association mentioned this enhancement. This is due to the disadvantages of juice bottles in the recycling process. These bottles contain UV blockers and other additives to extend the preservability. The Head of Sales of Isar Recycling asserts:

'These necessary blockers cause massive discolouration and yellowing when heated. This has influence on the colour of the recycled PET and hence on the versatility of the material […]. Which bottle filler wants to sell yellow bottles? […] If these bottles are deposited, this is going to be even more extreme.'

In contrast, in Sweden there are almost no juice PET bottles. The syrup bottles which should be further implemented into the system do not include any additives according to the Purchaser at Best Bottles. Hence, the expansion of the system is much easier for Sweden than for Germany, where solutions for the materials which hamper the recycling process still have to be developed.

Referring to the collaboration in the recycling system, the empirical findings show that food retailers have a powerful position in Germany. Since they have control over the post-consumer PET bottles, respondents from recyclers and associations suggest enhancing cooperation with them. The Head of Environment & Sustainability of Plastics Association asserts:

'Having a holistic quality process is important if the material is used in a closed-loop. If food retailers would commit themselves to the process, this would be a great advantage.'

Contrarily, in Sweden there is no immediate need for action in this field, since food retailers are already integrated into the system through the 50% ownership of Pant Catch and participation in the supervisory board.

6 Discussion

The previous chapter revealed barriers and enhancements for b2b recycling systems in Germany and Sweden. In addition to the potential enhancements developed by theory and empirical research, further potential recommendations to enhance the systems are developed. The following recommendations are based on the analysis, but are neither stated in theory nor directly suggested by the interview respondents. The recommendations are developed through the research process as a whole and partly represent the authors' own ideas and opinions. Nonetheless, in their characteristic as recommendations, the feasibility of those proposed recommendations is assumed and most likely marketable but not verified and tested.

6.1 Recycling Content Symbol

Current PET bottles in both countries contain either a blend of v-PET and r-PET or only virgin material. It is at the very most not recognisable or identifiable for consumers whether a PET bottle contains r-PET. Consequently, consumer awareness for PET bottles with a significant r-PET share is not able to establish. One bottle filler in Sweden exemplarily provides the r-PET share in its specific bottle in text format on the label (cf. Appendix 10).

In this context, a new logo on the bottles' labels is suggested. This logo easily illustrates the individual r-PET share of a particular PET bottle. The initial idea is based on the deposit logos used in both focus countries. Its intention is to firstly inform consumers distinctly in order to generally raise consumer awareness for PET bottles. Secondly, bottle fillers using a high share of r-PET in new bottles are able to promote and depict this sustainable advantage to consumers. In addition to this, a promotional lettering of the respective label is importable.

This logo can either be introduced on a mandatory basis in connection with the compulsory deposit system or on a voluntary basis by bottle fillers. The latter is less expedient since bottle fillers with a low or no r-PET share will not implement it. Consequently, a mandatory approach is recommendable. Then, potential resistance by market actors might occur.

Figure 6–1 depicts an r-PET content logo with exemplary 50% r-PET share combined with deposit logo of both Germany and Sweden. Its applicability is not limited to Germany and Sweden.

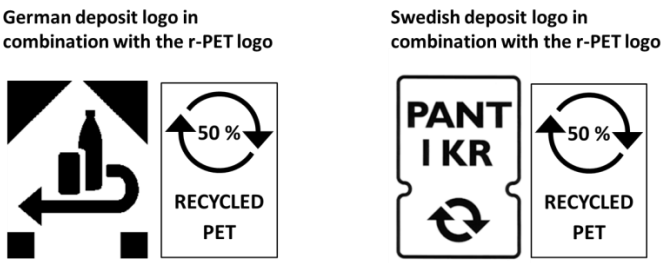

Figure 6-1 r-PET Logo for Germany and Sweden

6.2 Council for Bottle Quality in Germany

The German system could adopt part of the Swedish systems' characteristics in order to function more efficiently. In Sweden, a council consisting of representatives from Pant Catch and the bottle fillers examines bottles before their market entry. Due to the variety of problem sets regarding bottle design, content and material composition in Germany, a similar council is recommended to be established. This idea is based on the general assumption to agree upon overall standards for material composition and design. With the help of the council, every bottle which is supposed to enter the German market will be examined. Consequently, each bottle's recyclability is evaluated and tested beforehand. For various materials used, the effect on r-PET such as yellowing and degrading of viscosity is already known, but infrequently other materials occur in bottles as well. This council would provide a significant help towards higher material quality in Germany.

In addition, the ownership of returned bottles could be changed towards the DPG. The DPG's current goal is to handle the deposit system in an efficient manner. By expanding the responsibility, the organisation could redirect a larger amount of bale bottles towards b2b recycling. This is similar to the Swedish system.

It has to be noted that this recommendation could have potential limiting character for the bottle fillers and food retailers, which use bottle characteristics as an opportunity to differentiate their products from competitors. A limitation of the approved materials for bottles is in conflict with this saleability and promotion approach. Additionally, the loss of ownership could lead to a decrease in profits from sales of post-consumer bottles, since the material is sold to recyclers specialised in b2b. However, in order to foster b2b recycling, the different advantages and disadvantages have to be weighed. Various other possibilities for product differentiation would still be existent.

6.3 Quality Seal for Holistic System

All actors in the PET bottle recycling system have to follow the specified guidelines if a compulsory seal of quality for the entire recycling system is in place. Consequently, approved and non-approved materials are specified for all participating organisations. If the specifications are fulfilled by the actors, they are allowed to illustrate and promote the quality seal for their products. In addition, the guidelines could also include the exact testing procedures which need to be constantly applied in order to receive and maintain the seal of quality.

Unlike the Swedish system, the market of post-consumer bottles in Germany is not regulated. Therefore, it is crucial to have as many actors as possible participating in the use of this seal of quality. Otherwise, large-scale effects could not be utilised and a number of sub-markets with diverging quality standards would develop. Therefore, the developed and already existing quality seal of PET-Group could be extended and applied for the whole German recycling industry. Similar to the previous recommendation, this could have limiting consequences for some actors. In Sweden, an overall quality seal is not existent due to the bottle approval upon market entry.

6.4 Reduction of Transportation in Sweden

Based on statements by Swedish respondents, the current post-consumer bottle return flow is depicted in Figure 6–2. Pant Catch is responsible for the physical collection at either particular food retail stores or distribution centres (DCs). The pick up at DCs is only applied for returned bottles that originate from small and remote stores. Those quantities are shipped to DCs by suppliers. In general, the vaster quantities are picked up at the stores by a compactor truck of Pant Catch's contractors on a regular basis.

Approaching particular stores individually with a compactor truck, this pick-up process causes logistical and technical efforts. The pick-up process overall assumedly follows the milk run concept.

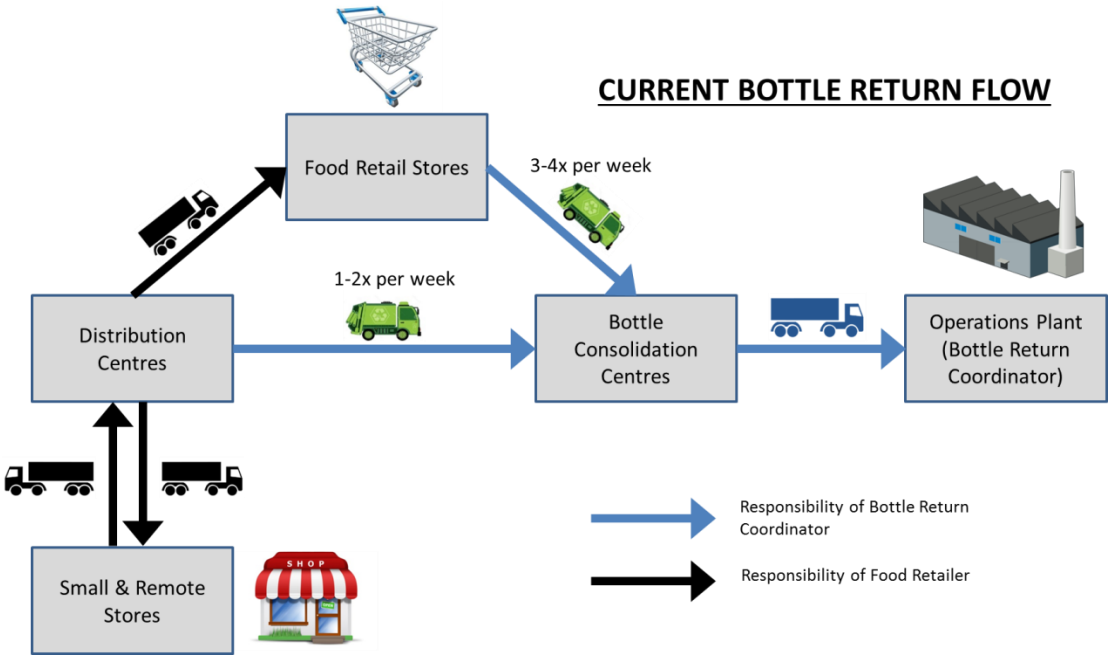

Figure 6-2 Current Bottle Return Flow in Sweden

The first alternative relinquishes the milk run pick-up with compactor trucks (cf. Figure 6–3). Returned PET bottles are shipped to Pant Catch's bottle consolidation centres (BCCs) by the food retailers' suppliers on a regular basis. Those bottles are still compressed by the RVMs and collected in the stores. The initial idea is to use volume in the supplier trucks that becomes redundant once the food retail store has been supplied. This volume is then filled with returned bottles. At the end of its route, the supplier truck approaches a BCC which is equipped with a compactor. Pick-ups from DCs to BCCs are executed on demand. The cost for this additional route by the supplier's truck is covered by Pant Catch. This alternative only applies to geographically denser regions with a nearby BCC to both the supplied stores and the retailer's DC. The quantities of returned bottles from small and remote stores are picked up at a DC by demand with a compressor truck from Pant Catch.

The first alternative provides the advantage to use volume that became redundant after a food retail store has been supplied. The overall utilisation of the supplier's truck is enhanced while the milk run pick-up with specific compactor trucks is economised. The proximity of a BCC to a larger number of food retail stores is required as well as the

collaboration of the food retailer's supplier. Overall, the alternative is advantageous in cost and sustainability terms.

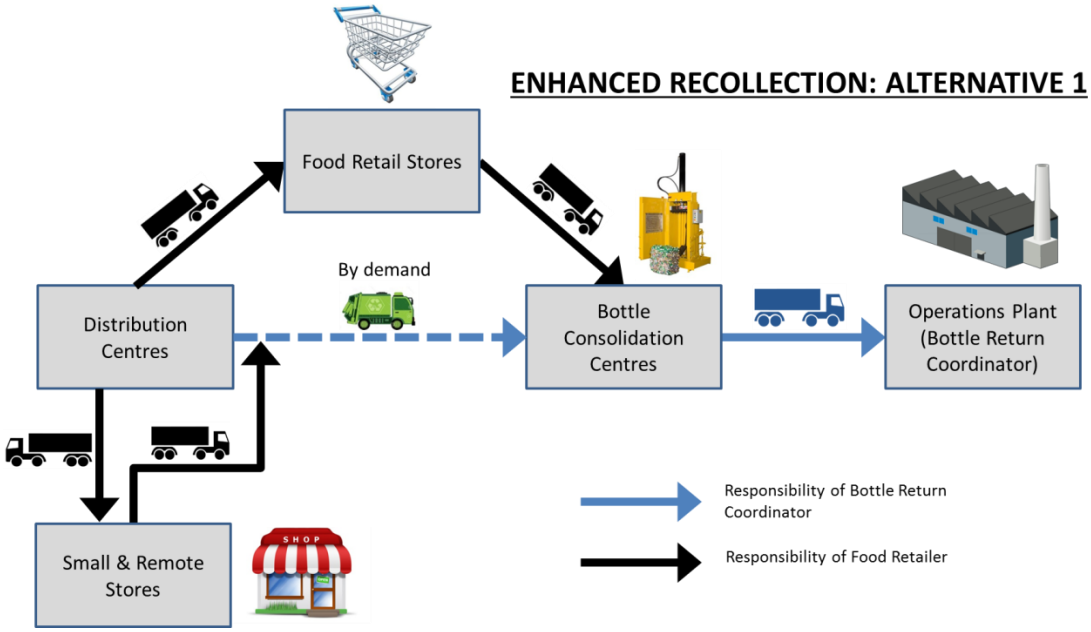

Figure 6-3 Enhanced Recollection for Sweden: Alternative 1

The second alternative (cf. Figure 6–4) is in its outline similar to the first. Returned PET bottles are shipped back from food retail stores to the supplying DC with the supplier's truck. Repeatedly, volume is used that becomes redundant. The pick-up process for small and remote stores remains unchanged. The bottle return coordinator is responsible for the pick-up and collection process from DCs to its BCCs. This step is executed with compactor trucks on a regular basis.

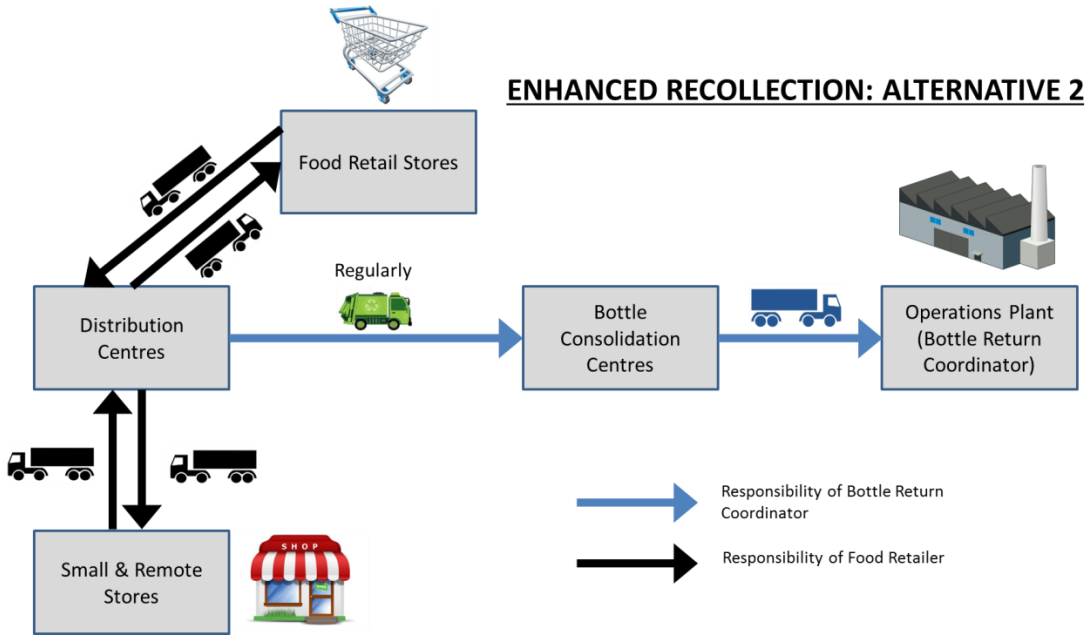

Figure 6-4 Enhanced Recollection for Sweden: Alternative 2

The advantages are similar to the first alternative. The truck's space utilisation is increased while the milk run pick-up is economised. Due to the relinquishment of a double-tracked pick-up system transportation is reduced, cost savings are realised and sustainability is increased.

6.5 Increase Consumer Awareness on PET Bottle Consumption

Since Germany has an existing system of multiway usable and refillable bottles made from glass and PET, this system is regularly compared with the one-way system of disposable PET bottles in terms of sustainability and advantageousness.

The PET bottle examined for the purpose of this study is disposable and not refilled. Due to its popularity and material characteristics, the consumption of PET bottles might further increase in the future. Calculations based on the assumptions from literature and empirical findings are made to illustrate this issue (cf. Table 6-1 and Appendix 11).

In Germany, the share of material used for b2b recycling is a fraction of the totally sold bottles. Consequently, even if bottles are thought to be 100% recyclable, it is not technically possible to realise this extent of recycling. Unlike refillable bottles which are not affected by material losses to such extent way, the end-consumers have to be aware of the bottle only being used once before being recycled. The majority of consumers lack knowledge about what happens with bottles after the return at the RVMs. The authors of this study are convinced that consumers should be aware that the amount of food-grade r-PET gained from all sold PET bottles is relatively low. This might change the consumers' buying behaviour.

Table 6-1 Share of Material used for b2b Recycling

Share of material used for b2b recycling			
Germany		**Sweden**	
Description	**Residual share of sold bottles**	**Description**	**Residual share of sold bottles**
Sold PET bottles	100.0%	Sold PET bottles	100.0%
Recollected bottles through deposit system	96.0%	Recollected bottles through deposit system	85.0%
Losses during recycling process: 30%	67.2%	Losses during recycling process: 30%	59.5%
Current share of material used for b2b: 30 %	20.2%	Current share of material used for b2b: 75 %	44.6%
Estimation of current material used for b2b out of new bottles (incl. labels and caps)	**20.2%**	**Estimation of current material used for b2b out of new bottles (incl. labels and caps)**	**44.6%**

In conclusion, the existing material losses from the point of return to the r-PET production and the share of b2b recycling need to be emphasised more. In this context, the increasing use of PET bottles can be scrutinised. Despite the difficulty to state suggestions or improvements, the non-existence of a deposited refillable bottle system in Sweden could be questioned.

6.6 Summarising Framework

Based on theory, empirical findings, the analysis chapter and recommendations by the authors of this thesis, the following summarising framework is developed and depicted.

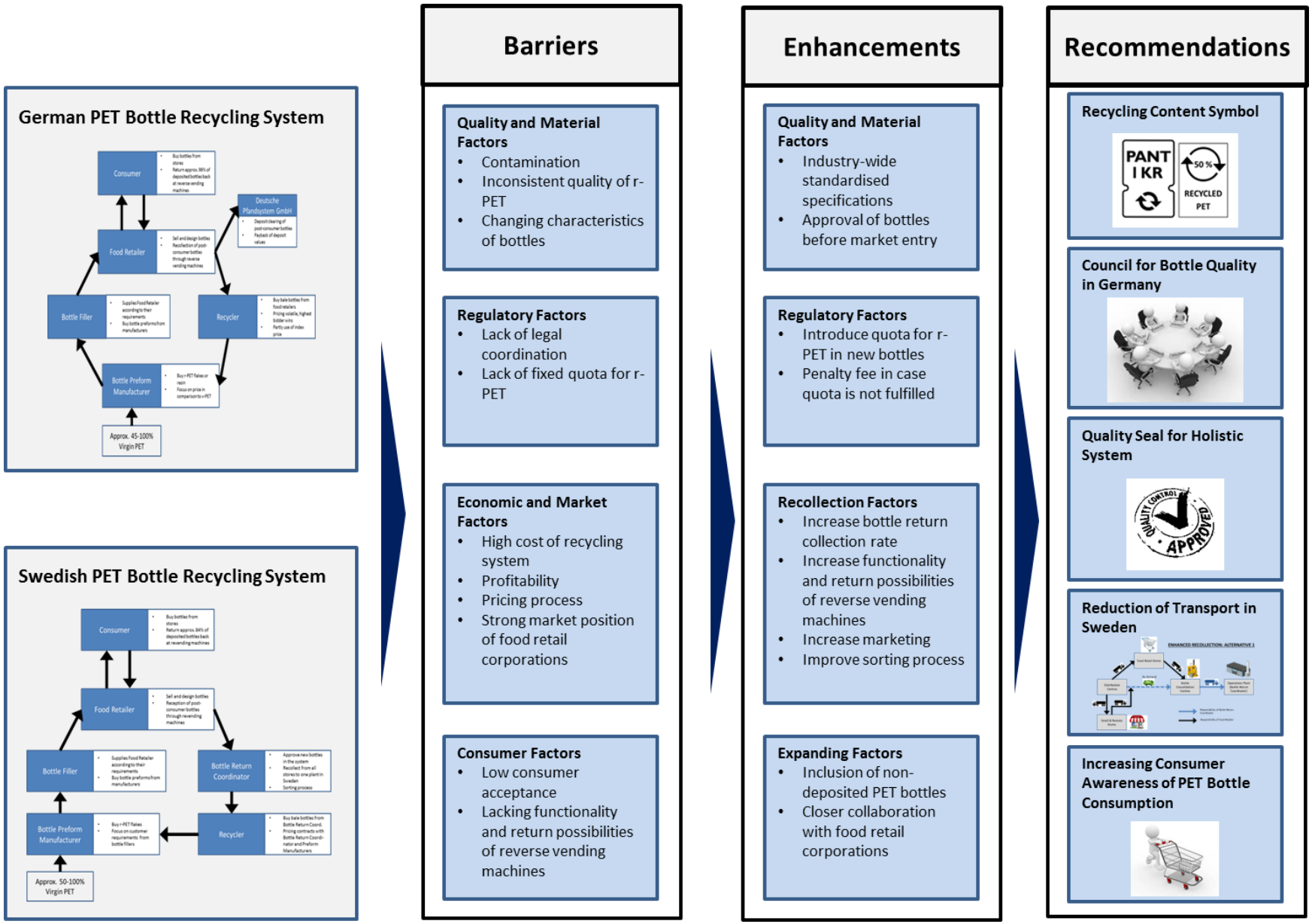

Figure 6-5 Summarising Framework

7 Conclusion

This final chapter concludes the study by summarising the main aspects for all research questions and pointing out the theoretical and practical contributions. In addition, limitations in the empirical study and recommendations for further research are provided.

In conclusion, this study fulfilled its purpose of comparing the PET bottle recycling systems in Germany and Sweden, analysing main barriers and developing enhancements for the implementation of closed-loop systems. The designed research questions were answered under consideration of this study's scope and (de-)limitations.

The first research question targeted the description of both countries' current systems, their operations and differences. As depicted in Figure 4–2, the Swedish PET bottle recycling system is generally unified. Long-term contracts between various actors in the recycling system ensure distinct recycling processes. The Swedish system is theoretically and practically dedicated to b2b recycling. Within the German PET bottle recycling system, no superordinate regulation exists. Material flows of returned bottles are not unified and the further application of r-PET depends on the food retailers (cf. Figure 4–1). Overall, the German system applies b2b recycling on a smaller scale and without a distinct dedication. In comparison, the Swedish system outperforms the German system due to the specific focus on b2b recycling.

To answer the second research question, barriers of PET bottle and b2b recycling were identified from literature. Those theoretical barriers built the framework for the conducted study. Throughout the research, additional factors absent from theory for both Germany and Sweden were revealed. To analyse the barriers, theoretical and empirical findings were matched for each respective focus country. Main barriers were then aggregated and classified into four categories: (1) quality and material factors, (2) regulatory factors, (3) economic and market factors and (4) factors influenced by consumers. Similar to the first research question, the Swedish system's problems are considered less influential.

The third research question was developed to identify opportunities and enhancements for improving the b2b recycling systems in Germany and Sweden. Identically to the investigated barriers, a theoretical framework for enhancements was built. Those theoretical enhancements were combined with the empirical results for each respective country. Thus, main opportunities and enhancements were aggregated into five categories: (1) quality and material factors, (2) regulatory and legal factors, (3) recollection factors (4) expanding factors, and (5) others. In conclusion, suggested enhancements for the Swedish system are on a more detailed level, whereas potential improvements for Germany are holistic and affect the entire structure of the current PET bottle recycling system.

Lastly, this study contributed additional applicable recommendations and enhancements from the authors' perspective for both focus countries. Five recommendations were stated: (1) a recycling content symbol on bottle labels, (2) a council for bottle quality in Germany, (3) a quality seal for the holistic system, (4) a reduction of transportation in Sweden and (5) an increase of consumer awareness on PET bottle consumption. The enhancements and recommendations are applicable in the two focus countries to enhance b2b recycling for PET bottles. To summarise the identified barriers, enhancements and recommendations, a summarising framework is eventually created.

7.1 Theoretical Contributions

In the introduction chapter of the study, three research gaps have been detected. The study contributes to filling these research gaps and is therefore of interest for companies active in the PET bottle recycling industry.

The first research gap being a lack of theory on b2b recycling in terms of sustainability improvement is addressed throughout the entire study. Due to the focus on closed-loop recycling, new insights about its significance and operations from a system perspective are gained.

Referring to the little research about incentives and enhancements of current systems, which is the second gap in literature, the empirical data provides various factors and ideas which can foster the process. The contribution applies specifically to the focus countries of this study. Additionally, the insights are very valuable for implementing a PET bottle recycling system in other countries. The main motivators for most of the actors within the system could be revealed. Especially the differentiating statements are examined in the analysis section and provide a very detailed understanding of the goals and incentives. Regarding the enhancements, the main contribution of the study is revealing nine additional enhancements absent in theory for Germany and seven for Sweden.

The third literature gap, which is the lack of research about the German and Swedish PET bottle recycling systems with its challenges, is addressed through the systems' descriptions and analysis of barriers. Theory about barriers for b2b recycling is broadened considerably through eight additional factors absent in current literature for Germany and nine for Sweden. Overall, the majority of the findings and analysis of the study refer to the second and third research gap.

7.2 Managerial Implications

The study provides various results which are of high interest for practitioners. Firstly, the study provides an overview of the main barriers and challenges that PET bottle recycling systems are confronted with. Managers' awareness of these barriers in the focus countries is increased. Hence, they can funnel their effort to either revealing the root of the problems, or towards possible enhancements of the system. A further practical contribution of the study applies to managers in other countries with the goal to introduce or improve PET bottle recycling. The study gives detailed insights on the challenges which will very likely be encountered.

By outlining and analysing numerous potential enhancements, the study encourages managers from organisations in the system to discuss and define measures to foster closed-loop PET bottle recycling. Contrasting opinions about the necessity of regulative measures such as a fixed quota for r-PET or a council for approving bottle quality are revealed. When weighing the evidence in the analysis, it seems more likely that these measures will foster b2b recycling in comparison to voluntary commitment. However, the potential enhancements need to be acknowledged by all actors. Evidently, this is expected to be a challenging procedure. The study provides the practical basis for the discussion process, but other factors such as economic interests of the actors certainly play a significant role as well.

7.3 Limitations

This study is confronted with several limitations. Although the number of interviews conducted for the study is sufficient to fulfil the research purpose, not all industry sectors in the recycling system are represented. In Sweden, it would provide more insights if bottle fillers were interviewed, since they decide if and how much r-PET they want to have in their bottles. Even though three large Swedish bottle fillers were contacted, none was willing to participate in the study.

In Germany, only one bottle filler was interviewed which is vertically integrated into the recycling system. Hence, it can be assumed that other bottle fillers have different perspectives on the research questions. Furthermore, no respondents from food retailers are present. Since these corporations are particularly powerful in Germany according to many respondents, their points of view could deliver new insights as well. Due to the lack of replies within the time frame of this study, these interviews were not possible to conduct.

Another limitation is the generalisability of the results for PET bottle recycling systems in other countries. Since both focus countries have a deposit system, significant prerequisites are fulfilled which are not present in several other European countries. Other countries can only apply the given enhancements and recommendations if there is a very similar basis in their return and recycling system.

7.4 Further Research

With reference to the previously described limitations, further research in Germany should include the perspective of food retail corporations and bottle preform manufacturers. This would enable an entirely holistic approach in terms of the recycling system. Additional barriers and enhancements for the German system could be found by doing so. Future studies in Sweden should include bottle fillers, since they have the power to decide about the amount of r-PET for bottles in that market.

Furthermore, the feasibility of the enhancements and recommendations in the previous chapters should be investigated. This study only includes interviews between the two researchers and the respondent. Based on the analysis of this study, focus groups with respondents from all industry sectors should be conducted to discuss the practical implementation of the enhancements.

Since especially the Swedish system is very advanced with a high degree of b2b recycling, regarding the improvement of sustainability it would be beneficial for other countries to increase their recycling efforts as well. Therefore, studies in other countries with a high consumption of PET bottles such as the United Kingdom, Italy, Spain and France should be conducted. Enhancements in the recycling systems of these countries could decrease the environmental impact considerably. It is anticipated that partly diverse barriers will be found and thus, the improvements for these countries will look different as well.

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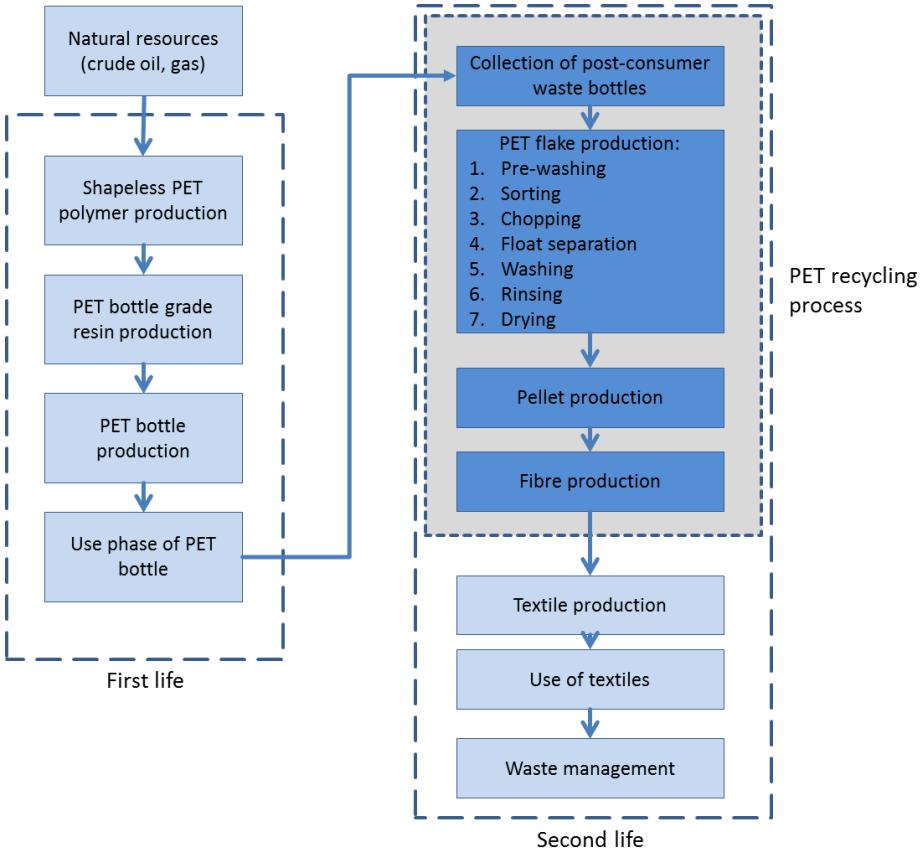
Appendix

Appendix 1: PET-Bottle Preform

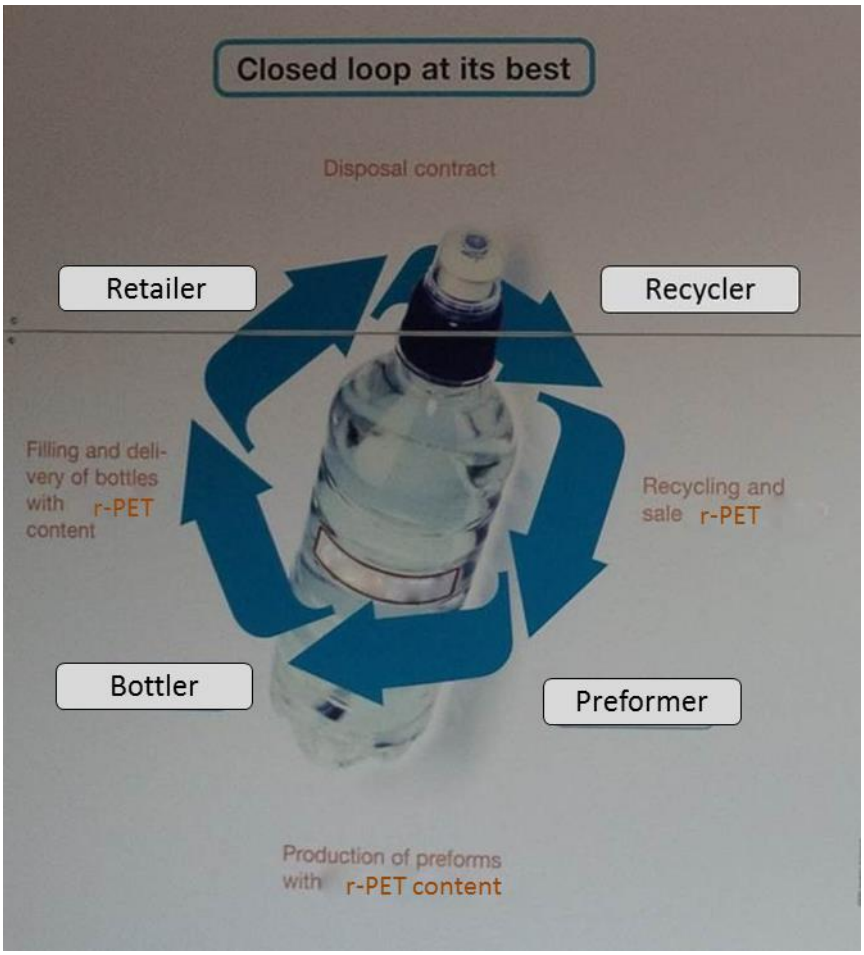
Adopted from AliExpress (2015).

Appendix 2: Bottle-to-Fibre Process



Adapted from Welle (2011)

Appendix 3: Example for Closed-Loop Recycling System by Nordic Recycling



Appendix 4: PET Flakes

Adopted from TOMRA (2016).

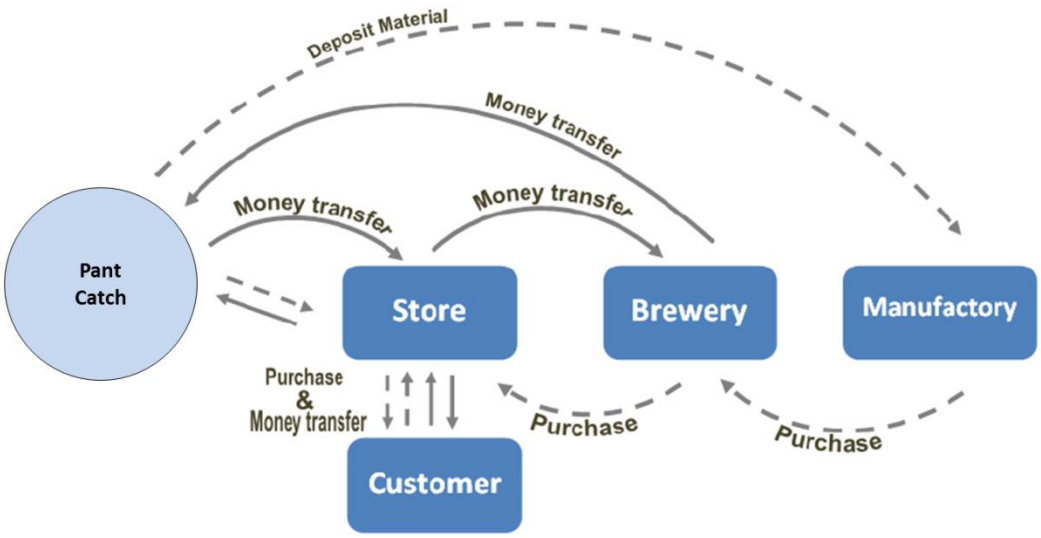
Appendix 5: PET Resin

Adopted from DIYTrade (2016).

Appendix 6: Interview Guide

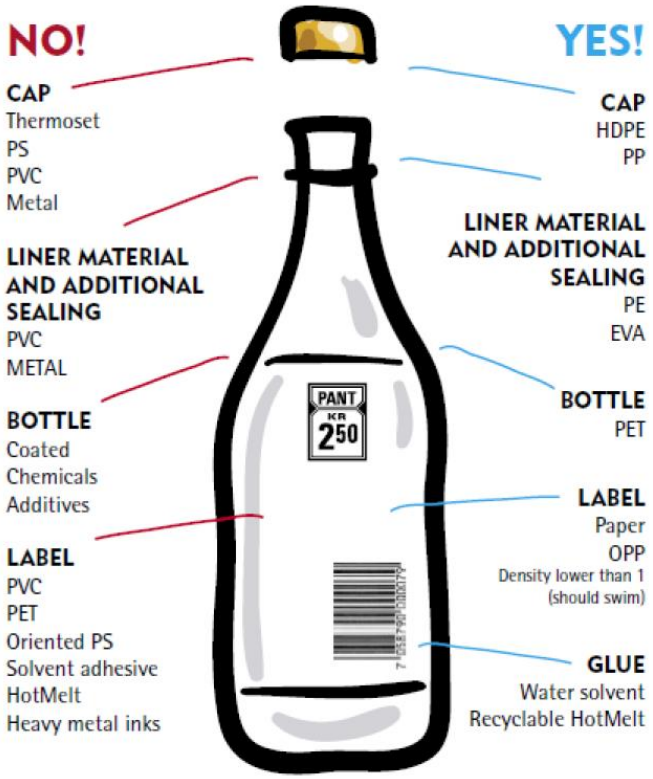
Subject	Interview Question
Introduction & Background	1. Do you need more information about the research we are undertaking? 2. Do you agree to record this interview? 3. Which position do you hold within the organisation? 4. What is your organisation's view on PET b2b recycling?
Current operations in Germany and Sweden	5. How is the reverse flow of PET bottles from point of collection to recycling organised in your country? 6. What are the current problems and bottlenecks within the flow? 7. What type of recycling and what technical mechanism is currently applied for PET bottle recycling in your country? 8. How would you evaluate the overall perfomance of the current PET bottle recycling system in your country?
Barriers for closed-loop recycling	9. What are from your organisation's point of view the main barriers for holistic PET b2b recycling systems? 10. Are there specific bottlenecks in this supply chain and if yes, which ones? 11. What is your view on the power structure within the supply chain and compared to your competition?
Incentives & Enhancements	12. If your org. already participates in the b2b recycling system: What are the main drivers for your company? 13. In your opinion, what are drivers for other actors in the same supply chain? 14. Which factors could be improved specifically for your organisation to implement an overall higher degree of PET b2b recycling? 15. Which factors could be improved to make the current b2b recycling system more competitive and/or efficient? 16. Which factors in context/setting could be improved to increase b2b recycling and what are the prerequisites for that?

Appendix 7: Financial Flows of Pant Catch



Adapted from Sandervig, Schulz, Svedberg, Ulfstedt & Wajåker (2014)

Appendix 8: Approved and Non-Approved Material for Swedish PET Bottles



Appendix 9: Image of 100% v-PET and 100% r-PET Bottles

Appendix 10: Example of r-PET Share in Swedish Bottle

Appendix 11: Losses during PET Recycling Processes

		Anteil (Bezug Sammlung)
Verschlüsse	Verschlüsse	4 - 8 %
	Originalitätssicherungen	
Produktreste	Restflüssigkeiten	5 - 10 %
	Sonstige Produktreste	
Metalle	Getränkedosen	1 - 6 %
	Metallclips	
Folien, Sonstige	Etiketten	4 - 8 %
	Folien Sammelsäcke	
	Bündelungsfolien	
	Flaschenträger etc.	
	Sonstige Fremdstoffe	
PET-Verluste	Filtrationsverluste, Auswaschung, Staubaustrag, Fehlchargen, Versuchschargen, Anlauf- und Auslaufverluste etc.	2,5 - 6 %

Gesellschaft für Verpackungsmarktforschung (2015)