*Master's Thesis Internship – Master Sustainable Business and Innovation*

# The Future Role of Waste Collectors in a Circular Economy: A Case Study of SUEZ

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**Abstract**

The continuous adoption of a circular economy results in reduced waste generation within OECD countries, necessitating future changes in the waste management industry. This research attempts to identify new circular business opportunities for private waste collectors, focusing on enabling circularity through the purification of material streams. In order for private waste collectors to create a sustainable and resource-efficient business strategy, they must incentivise source separation, to reduce waste treatment costs and increase the value of the collected streams. This study uses the private waste collector SUEZ and its collection activities within the hospitality sector as a case study and implements a transdisciplinary research approach. The twofold research method combines a cluster analysis of the waste collection data from SUEZ with a survey in the hospitality sector. The combined results succeed in identifying four distinct types of waste producers, each with unique waste generation and separation habits, as well as different barriers, drivers and strategies to overcome barriers of waste separation. Based on these results a transition model toward a twofold circular business model is proposed. The model is centred around SUEZ's ability to offer a complete collection package and develop a customised multi-compartment bin for their customers.



Keywords: *Circular economy, transdisciplinary research, source separation, cluster analysis*


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# Preface

This thesis fulfils the graduation requirements of the Master's programme 'Sustainable Business and Innovation' at Utrecht University. I researched and wrote this thesis from September 2016 to March 2017.

This project was conducted in cooperation with SUEZ Recycling and Recovery Netherlands, where I undertook an internship for the duration of this research. Although it was often difficult to satisfy both scientific and practical requirements, this research taught me valuable lessons for future projects and emphasised the importance and advantages of transdisciplinary approaches in science.

I would like to thank my supervisors Prof. dr. Ernst Worrell and Raymond de Schrevel, who guided me through this thesis process and helped to ensure the reverence of this study with regard to both science and practice. Furthermore, I would like to thank my third supervisor Wienik Kruithof, who was always available to assist me with data issues.

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# Executive Summary

The continuous adoption of a circular economy, in which no waste exists, requires changes be made to the waste management industry. A circular economy results in a variety of new business opportunities for private companies, one of which is to enable circular streams by purifying (or separating) material streams. This is an opportunity for private waste collectors (such as SUEZ) to futureproof their company and develop new circular business strategies. Source separation is essential to ensure that the separation is most efficient and profitable for SUEZ, since it reduces the costs of any treatment process after collection and increases the value of the collected streams.

This study determines which factors drive or hinder the waste separation of waste producers as well as how SUEZ needs to shift their business model to incentivise waste separation at the source. This study focuses on the hospitality sector, due to its financial importance for SUEZ and currently poor waste separation habits, which allow room for improvement.

**Main findings**

Because companies within the hospitality sector can vastly differ from one another in terms of their waste generation and separation habits, no single strategy exists that can succeed in incentivising waste separation. Rather, the hospitality waste market needs to be separated into multiple types of waste producers with similar characteristics.

The analysis identified four distinct types of waste producers, each with unique waste generation and separation habits, as well as factors which either hinder or incentivise their waste separation:

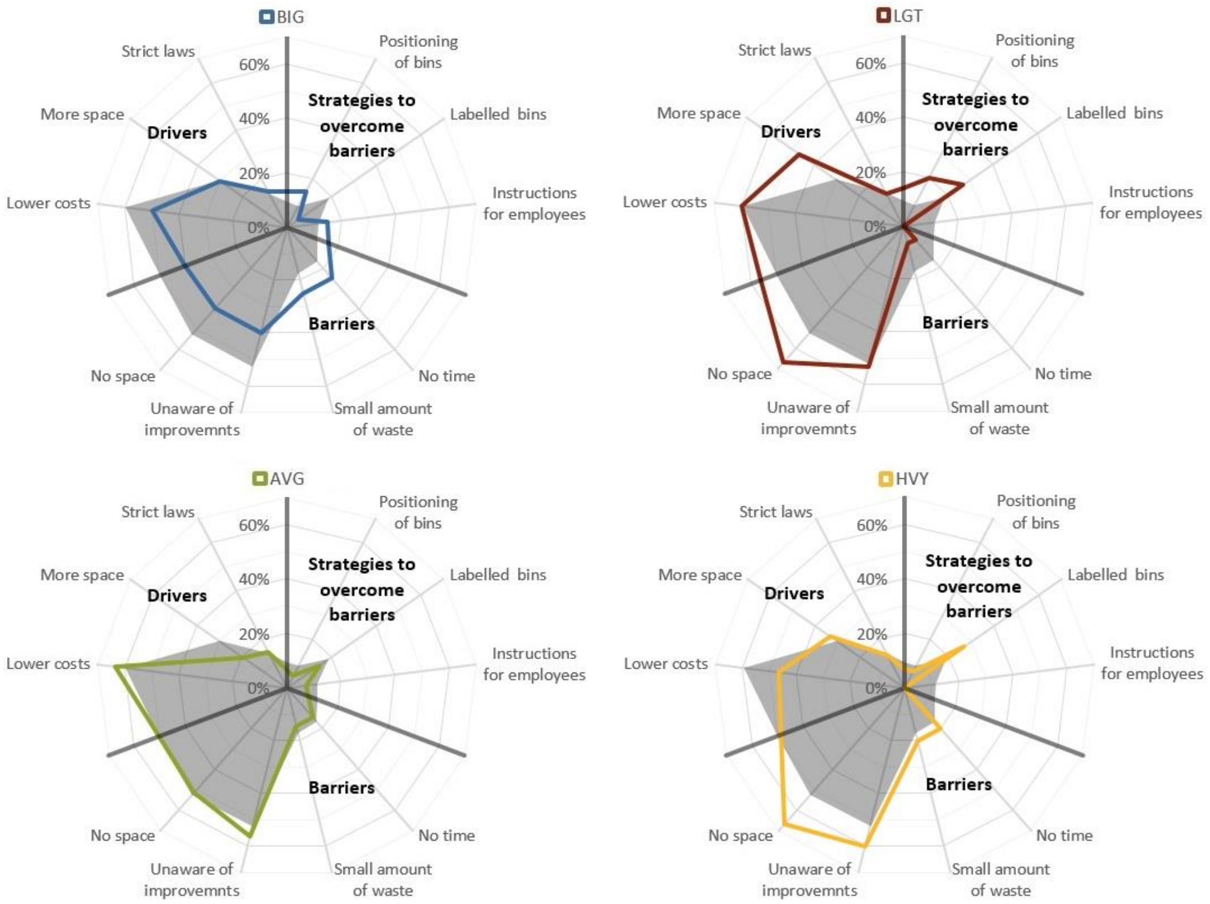
- BIG cluster: The BIG cluster represents medium to large (10+ employees) waste producers within the hospitality sector with high waste separation performance. They have limited possibilities to improve their waste separation, mainly with regard to separating food from residual waste. Space is less of an issue for this cluster; time is more important.

- LGT cluster: The LGT cluster represents small waste producers with light residual waste bins, due to the improper separation of paper and cardboard. The largest issues for them is space, both as a barrier and as a driver.

- AVG cluster: The AVG cluster represents the average waste producer within the hospitality sector and comprises the largest share. Their waste separation can mainly be improved by properly separating food and plastic waste, for which lower collection costs can be an incentive.

- HVY cluster: The HVY cluster represents small waste producers with heavy residual waste bins and low waste separation performance. They lack awareness of waste separation options and have a negative attitude toward separating waste. Offering them lower collection costs and space-efficient solutions will only have limited success on improving their waste separation.

The figure below illustrates the difference in factors that hinder or drive waste separation between each type of waste producer.



**Methods**

The research process was twofold. First, a cluster analysis of the waste collection data from 57,505 SUEZ customers was performed, which resulted in the four distinct clusters. Second, a survey of 156 hospitality companies and customers of SUEZ was conducted. This survey investigated which factors hinder or drive companies to separate their waste. The combined results, provided a detailed image of each cluster, ultimately leading to cluster-specific strategies for SUEZ to improve their waste separation.

**Recommendations**

Based on the results, a twofold business model is proposed:

- <u>Complete collection package:</u> SUEZ should offer a complete service by collecting all of a customer's waste streams. This will create awareness of the streams that can be separated and thus, can potentially be offered at a lower price. Because SUEZ can more effectively collect waste if the collection system is adjusted, the streams become more valuable if separated and as a result, SUEZ can increase their market share in highly competitive market segments.

- <u>Customised multi-compartment bin:</u> SUEZ should introduce a wheelie bin with multiple compartments for each stream; furthermore, the size of each compartment should be adjustable for each customer. Utilising the available data at SUEZ, each customer's waste generation can be estimated to provide suitable bin. This multi-compartment bin largely solves the space problem, because separating waste does not require more space if the compartments are adjusted correctly.

The table below displays the necessary changes to SUEZ's business model dimensions for each business model element. The largest changes for the complete collection package concern organisation: increasing cross-selling among sales departments. With regard to the customised multi-compartment bin, the customers' data need to be utilised to estimate the waste generation and from a technical perspective, a new collection system needs to be implemented.

| | Complete collection package | Customised multi-compartment bin |
|---|---|---|
| **Value proposition** | Offer easy and carefree waste collection | Offer customised, space-efficient, one-stop collection solution |
| **Value capture** | Adjust pricing system to incentive complete package | |
| **Supply chain** | | Close cooperation with producers of collection media |
| **Customer interface** | Increase contact to customers with long-term contracts | Customise bin using customers' waste generation data; Information campaign for correct separation |
| **Organisational delivery system** | Increase cooperation between sales departments | Increase cooperation between collection departments |
| **Technological delivery system** | | Remodel collection system for multi-compartment bins |

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# List of Abbreviations

| | |
|---|---|
| CCC | Cubic Clustering Criterion |
| EMF | Ellen MacArthur Foundation |
| EU | European Union |
| EZ | Ministerie van Economische Zaken |
| ISWM | Integrated Sustainable Waste Management |
| IUCN | International Union for Conservation of Nature and Natural Resources |
| LAP | Landelijk Afvalbeheerplan |
| OECD | Organisation for Economic Co-operation and Development |
| UNEP | United Nations Environment Programme |
| UNPF | United Nations Population Fund |
| VROM | Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer |
| WCED | World Commission on Environment and Development |
| WRAP | Waste and Resources Action Programme |

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# 1 Introduction

## 1.1 Background

The release of 'Our Common Future' in 1987 (WCED, 1987) presented the interconnectedness of environmental, economic and social dimensions and the need to equally manage them on a global scale to ensure future sustainable development. Thus, the Brundtland report was created to overcome the challenges of society (at the time, social inequality and environmental degradation), out of fear of how those challenges could influence the development of the future (WCED, 1987).

Since the release of the report, a number of problems have improved, such as the hole in the ozone layer (Solomon et al., 2016) and the portion of people living in extreme poverty (UNPF, 2014). However, other issues have arguably intensified: the world population has since increased by more than 46%[1] and is further estimated to increase to 9.7 billion by 2050 (United Nations, 2015). This population growth, combined with increased resource demand and a growing middle class has led to the depletion of natural resources and the increased generation of waste (Dobbs, Oppenheim, Thompson, Brinkman, & Zornes, 2011; Hoornweg & Bhada-Tata, 2012).

As a response to the issues and based on the idea of sustainable development, the concept of circular economy emerged (Ghisellini, Cialani, & Ulgiati, 2014). A circular economy provides an alternative to the predominately used, linear economic model of 'take-make-dispose' and promotes closing material loops by recycling streams rather than disposing of them (Charonis, 2012; EMF, 2012; Ghisellini et al., 2014; Scott, 2015).

In recent years, an increasing number of scientific papers have acknowledged the concept of circular economy and discussed its implementation (Lieder & Rashid, 2016). Meanwhile, the Ellen MacArthur Foundation (EMF), among others, continues to promote this concept in business and politics (EMF, 2012). Many cities, regions and countries have moved toward adopting a circular economy; most notably, China established the Circular Economy Promotion Law in January 2009, which promotes the concept of circular economy as an official national development goal (Mathews & Tan, 2011; The Standing Committee of the National People's Congress

[1] Increase from 5.0 billion in 1987 to 7.3 billion in 2015 (The World Bank, 2016)

China, 2008). Moreover, within the EU, the concept of circular economy has become more and more prominent in policy (European Commission, 2015).

## 1.2 Problem definition

The increasing adoption of circular economy, among other sustainable development concepts such as Integrated Sustainable Waste Management (ISWM) and Zero Waste, has resulted in a trend toward reduced waste generation in OECD countries, both per capita and overall (OECD, 2016). The turning point appears to have occurred in 2007, at which time the waste generation per capita decreased by roughly 8%[2] in European OECD countries (OECD, 2016). The need for a waste management system is a result of the linear economic model that disposes of products after use. Thus, the recent focus on sustainable development and the continuous implementation of circular economy will inevitably lead to the need for a change in the waste management industry (Geng, Zhu, Doberstein, & Fujita, 2009; Seadon, 2010; Su, Heshmati, Geng, & Yu, 2013).

Key actors within the Netherlands' waste management system are private waste collectors who collect, separate and treat waste for companies and municipalities (Dijkgraaf & Gradus, 2007). In the shift toward a circular economy, private waste collectors are often disregarded within the research, which instead focuses on municipal solid waste (MSW) on a macro scale (Cherubini, Bargigli, & Ulgiati, 2009; Dijkgraaf & Gradus, 2007; Nakamura & Kondo, 2002) or the technical details of treatment options on the micro scale (Woodard, 2010).

Although the coexistence of economic and environmental interests (Christmann, 2000) as well as the value creation of and business opportunities within a circular economy (Park, Sarkis, & Wu, 2010; Planing, 2015) have been discussed, scientific literature lacks an unsterstanding of circular economy from a business and economic perspective (Lieder & Rashid, 2016). As a result, there is a scientific and societal need to research the future role of private waste collectors within a circular economy, specifically the business challenges and opportunities.

[2] Decrease in municipal waste generation per capita of European OECD countries, from 520 [kg/year] in 2007 to 477 [kg/year] in 2014 (OECD, 2016).

## 1.3 Aim and research question

To fill this gap, this study focuses on answering the following research question:

*How can private waste collectors shift toward a more sustainable and resource-efficient business strategy, in alignment with the continuous adoption of circular economy?*

This question is answered using the following sub-questions:

*(1) What business opportunities exist for private waste collectors within a circular economy?*
*(2) What factors hinder or drive waste producers to separate their waste?*
*(3) What types of waste producers can be identified, in terms of waste generation and separation habits?*
*(4) How can private waste collectors incentivise source separation for each type of waste producer?*

To answer these questions, this study focuses on a case study of the private waste collector SUEZ Recycling and Recovery Netherlands, hereafter referred to solely as SUEZ, and its waste collection activities within the hospitality sector. SUEZ is one of the largest waste collectors in the Netherlands, collecting waste from multiple municipalities and approximately 70,000 companies (SUEZ, 2016). One of its largest and most important sectors is the hospitality sector. Previous research has already identified the hospitality sector as one with opportunities to improve waste separation habits, specifically with regards to reducing and separating food waste (Marthinsen, Sundt, Kaysen, & Kirkevaag, 2012; Papargyropoulou, Lozano, Steinberger, Wright, & bin Ujang, 2014; Pirani & Arafat, 2014). Thus, this sector is of interest from an environmental and economic perspective.

For this purpose, a transdisciplinary research design was chosen, combining various scientific disciplines and collaborating with non-academic stakeholders (Wickson, Carew, & Russell, 2006). Transdisciplinary research is specifically useful for sustainability studies due to its aim of being a transformational scientific field and the focus on complex, real-world problems (Lang et al., 2012).

## 1.4 Overview

Chapter 2 summarises the theoretical background of circular economy, business models and waste management is summarized and answers sub-questions (1) and (2). Thereafter, chapter 3 explains the scientific methods used in this study, including a case description and data collection and analysis of each research method. In chapter 4, the results of the cluster analysis and survey are presented and combined. Sub-questions (3) and (4) are also answered in this chapter. Subsequently, chapter 5 uses the results to propose a suitable business model and the changes necessary for its implementation, thus answering the overall research question. Chapters 6, 7 and 8 summarise, conclude and discuss the results and their implications for science and practice. The following Figure 1 provides an overview of this paper and how the research question and sub-questions are answered.

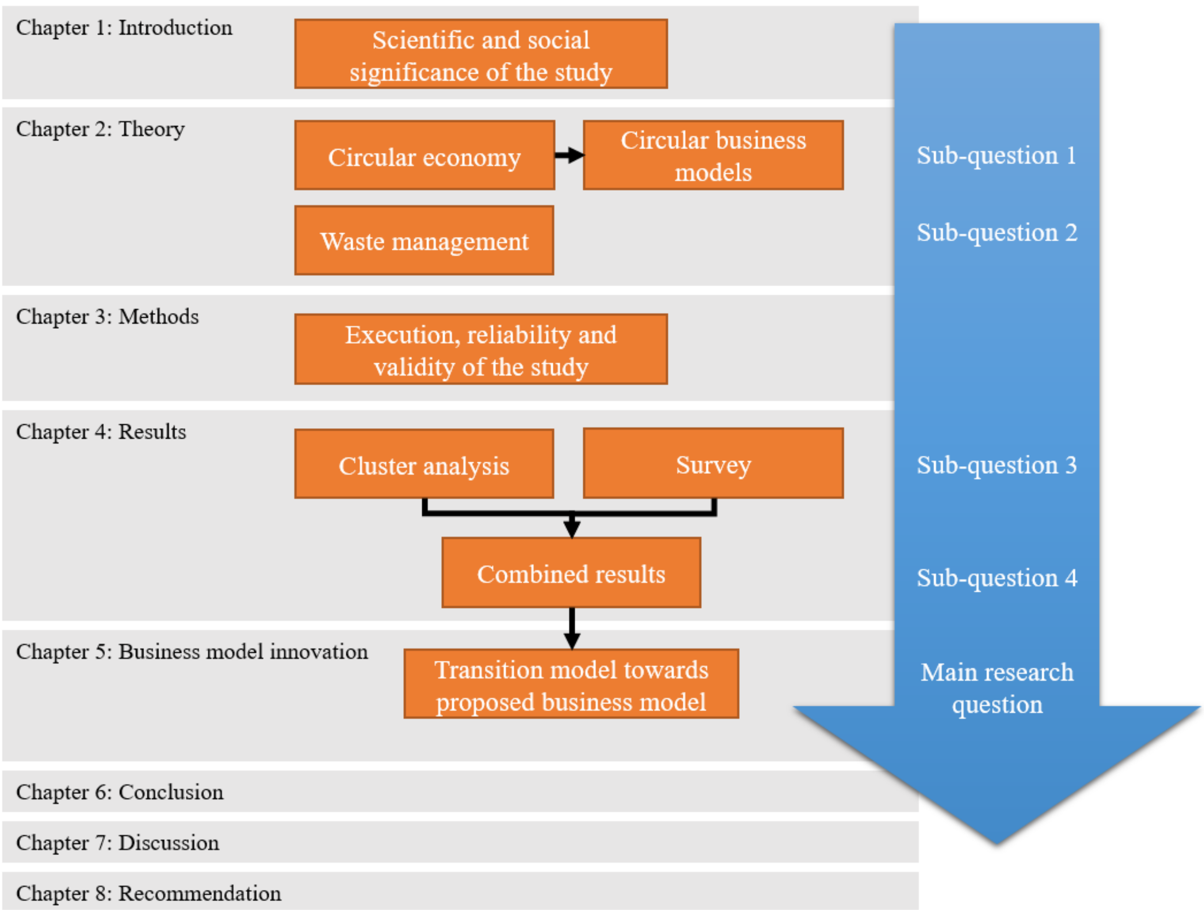


Figure 1: Overview of the structure of the paper.

# 2 Theory

## 2.1 Sustainable development and circular economy

The term sustainable development became widely known, after the International Union for Conservation of Nature and Natural Resources (IUCN) proclaimed its goal to conserve living resources to ensure sustainable development (IUCN, 1980). The World Commission on Environment and Development (WCED) later provided the predominant definition attributed to sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987). The sustainable development of an industry, country or on a global scale should thus address and balance social equity, environmental protection and economic development (Elkington, 1997; Munasinghe, 1995), as well as account for changes over time (Lozano, 2008). This apparently simple and open definition of sustainable development offers a wide range of operational objectives across previous intellectual and political boundaries, although it has led to difficulties with implementation and thus, relies on concrete concepts (Lélé, 1991).

Circular economy can be described as a concept based on sustainable development (Scott, 2015). It acknowledges the limited availability of resources and the need to manage them sustainably for future generations, while primarily focusing on the economic and environmental aspects of sustainable development (Murray, Skene, & Haynes, 2015). The aim of a circular economy is to close material loops by enabling a continuous cycle of the reuse, repair, redistribution, refurbishment, remanufacture and recycle of products and materials (Charonis, 2012; EMF, 2012). A circular economy is seen as a preferable alternative to the currently predominately used linear economic model of 'take-make-dispose' and has been argued as necessary for the future of sustainable development (Boulding, 1966; Murray et al., 2015; Pearce & Turner, 1990). For this research, a circular economy is defined as an economic system designed to be restorative and regenerative (Charonis, 2012; EMF, 2013).

Based on earlier works (Leontief, 1991; Pearce & Turner, 1990; Stahel & Reday, 1976), current approaches to a circular economy combine aspects of Industrial Ecology (Frosch & Gallopoulos, 1989), Cradle-to-Cradle (McDonough & Braungart, 2010), Blue Economy (Pauli, 2010), Biomimicry (Benyus, 1997), Performance Economy (Stahel & Reday, 1976), Eco-design (Lyle, 1996) and the Waste Hierarchy. As a combination of these concepts, a circular economy can be divided into four principles: (1) 3Rs (reduce, reuse, recycle); (2) Designing out waste; (3) Reclassification of technical and biological materials and; (4) Renewable energy (Ghisellini et al., 2014).

The 3Rs principle of circular economy aims at minimising the input of energy and raw material through improved efficiency and lifestyle changes (reduce), using products again for their original purpose (reuse) and recovering and reprocessing products and materials out of waste (recycle) (Ghisellini et al., 2014; Hoornweg & Bhada-Tata, 2012; Sakai et al., 2011). The 3Rs principle has been implemented within the EU Waste Framework Directive as Waste Hierarchy (EU, 2008a), a concept first introduced as Lansink's Ladder in 1979 in the Netherlands (Kemp & Van Lente, 2011). The Waste Hierarchy ranks opportunities to reduce and treat waste in order of preference, with the aim of identifying options with the best overall environmental outcome (Papargyropoulou et al., 2014). As Figure 2 illustrates, the most preferred option is waste prevention, while disposal is least preferred.

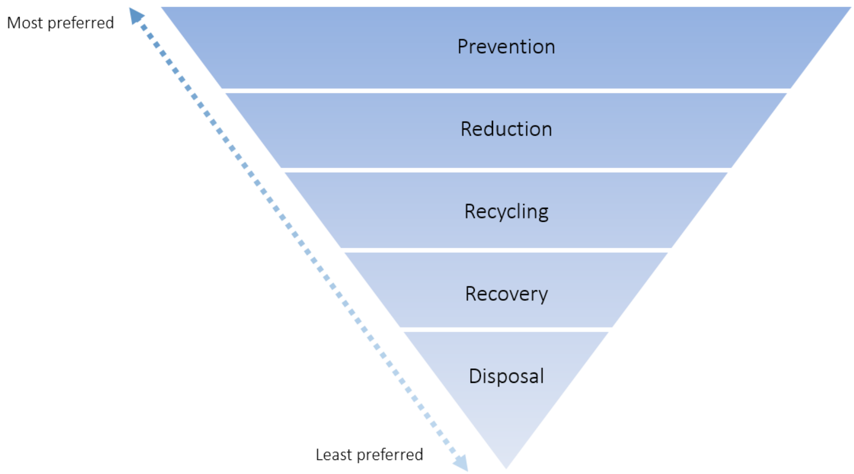


Figure 2: Waste Hierarchy. Adopted from (UNEP, 2011).

Designing out waste is a principle based on the concept of Eco-design, which centres around reducing waste through the better design of products (Lyle, 1996). The reclassification of technical and biological materials is a concept taken from Cradle-to-Cradle, in which a cycle for each of the two types of materials is described, including the different solutions and implications (McDonough & Braungart, 2010). Lastly, the principle of renewable energy is a result of the energy necessary for cycling processes, which in a circular economy is suggested to be generated exclusively out of renewable energy (EMF, 2012).

## 2.2 Circular business models

To assess the business opportunities for private waste collectors within a circular economy, the concept of a circular business model is introduced. For this research, a business model is defined as the blueprint of a company; it defines their activities related to creating, delivering and capturing revenue (Osterwalder & Pigneur, 2010). Although there is no universally accepted description of a business model, a majority of the literature has identified and used a set of business model dimensions to differentiate and compare business models (Bohnsack, Pinkse, & Kolk, 2014; Saebi & Foss, 2015). For each dimension companies choose specific design options that concern how to create value, approach customers or maintain a competitive advantage, forming an overarching corporate strategy. In general, the following four aspects are encapsulated within one or multiple business model dimensions (Boons & Lüdeke-Freund, 2013; Frankenberger, Weiblen, Csik, & Gassmann, 2013; Heikkilä & Heikkilä, 2013):

1. Value proposition: What is offered to a customer?
2. Value capture: Why should it be done? / Where is the value for the company?
3. Supply chain: How is it accomplished?
4. Customer interface: Who is it offered to?

Within a circular economy new circular business models, which resemble the principles of the circular economy, can be identified. Within the literature, multiple attempts have been made to categorise circular business opportunities and business models (Laubscher & Marinelli, 2014; Lewandowski, 2016; Planing, 2015; Renswoude, Wolde, & Joustra, 2015). Based on these attempts, three reoccurring types of circular business models are distinguished for this study, namely (1) transformation of usage, (2) looping streams and (3) enabling circularity (Table 1).

Table 1: Types of circular business models.

| | Planning (2015) | Renswoude et al. (2015) | Lewandowski (2016) |
|---|---|---|---|
| **Transformation of usage** | Cycle I: Longer and more efficient usage;<br>Cycle II: Maintenance, Repair, Refurbishment | Short cycles | Share;<br>Virtualise |
| **Looping streams** | Cycle III: Remanufacturing of products;<br>Cycle IV: Recycling | Long cycles;<br>Cascades | Loop |
| **Enabling circularity** | Cycle X: Energy recovery | Pure cycles;<br>Produce on demand | Optimise<br>Exchange;<br>Regenerate |

Firstly, a number of circular business models intensify or prolong the usage of a product without changing its original purpose or replacing it with a service. Within the literature, these groups of business models are described as value creation through the power of short cycle and dematerialized service (Renswoude et al., 2015) or share and virtualize (Lewandowski, 2016). Examples of this type of business model include: product-service systems (PSS) (Mont, 2002), Sharing Economy (Hamari, Sjöklint, & Ukkonen, 2015) and Performance Economy (Stahel, 2010). Secondly, other circular business models reuse products, by changing their original purpose or recovering materials. Within the literature, these groups of business models are often further distinguished between remanufacturing and recycling (Planing, 2015) or recycling and upcycling (Lewandowski, 2016). Thirdly, many circular business opportunities enable other circular processes to function; This type of circular business opportunity lacks a strict definition and is not mentioned in all categorisations of circular business models. Enabling circularity includes, for example, the production of renewable energy (Lewandowski, 2016), the purification of material streams (EMF, 2012; Renswoude et al., 2015) and the new design and production technologies (Lewandowski, 2016; Lyle, 1996). Following these types of circular business models, this study proposes that private waste collectors have the potential to enable circularity by treating and purifying material streams in a circular economy. Figure 3 depicts where the identified circular business model fit within a circular economy.

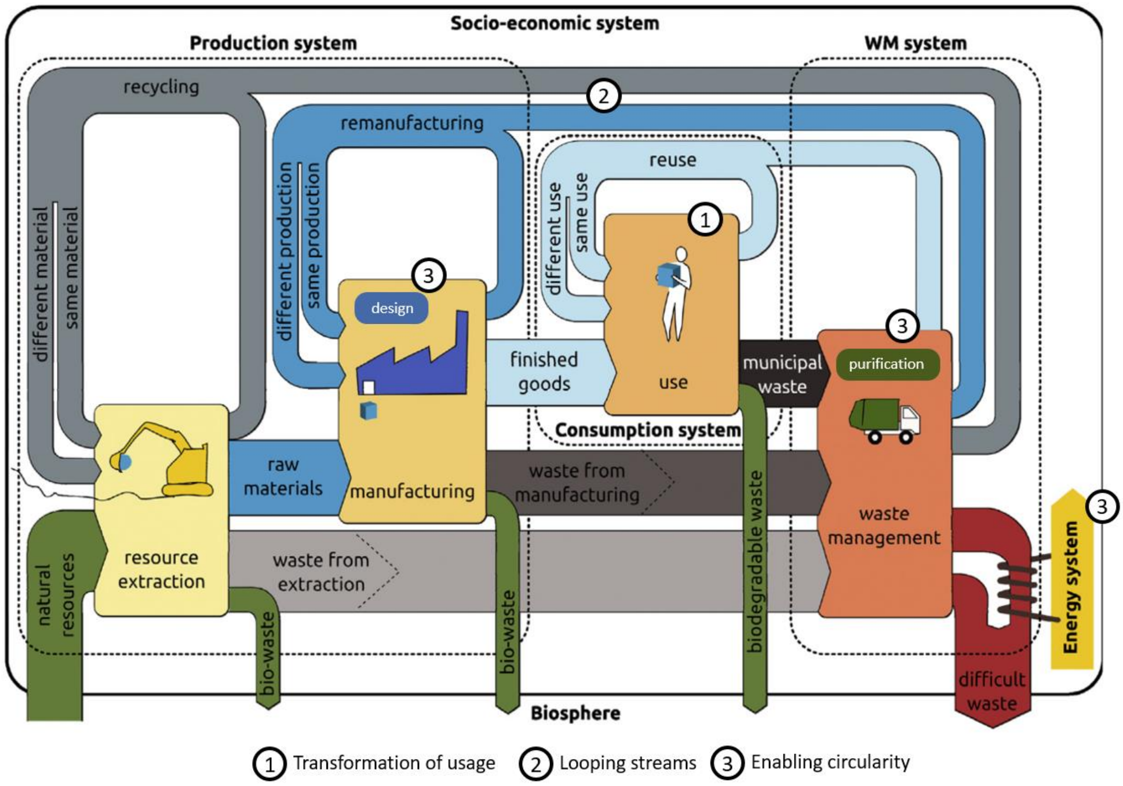


Figure 3: Waste management in a circular economy. Adopted from (Singh & Ordoñez, 2015).

However, identifying the business opportunities within a circular economy is only the first step in adopting a circular business model. Although it can be argued that traditional change management theories can be applied to assist a company's transition from a linear business model toward a circular one (Scott, 2015), the literature provides concepts specific to circular economy. The four business model dimensions (value proposition, value capture, supply chain and customer interaction) can be used to identify the needed changes in the transition toward a circular business (Mentink, 2014). For service-based innovations within a circular economy, such as in the case of private waste collectors, the literature has identified two additional dimensions: organisational and technological delivery systems (Janssen, 2015). The organisational and technological delivery systems describe the required organisational structure and use of technology to deliver a service. The combination of all six dimensions can be used to guide the transition toward a more service-based circular business model.

## 2.3 Waste management

The need to manage waste arose out of the linear economic model of 'take-make-dispose.' Indeed, waste management has historically been driven by the negative effects of disposing of waste and the scarcity of resources (Wilson, 2007). At its core, waste management entails waste collection (pick-up and transportation) and waste treatment (recovery and disposal) (Wilson, 2007). However, in recent years, in alignment with the increased urge for sustainability, waste management has shifted toward what is described as ISWM. This type of waste management implements concepts such as Waste Hierarchy, extended producer responsibility and life cycle assessment (McDougall, White, Franke, & Hindle, 2008; Papargyropoulou et al., 2014).

Waste can be defined as a by-product of human activity which lacks value due to its mixed, and often unknown, composition of possibly valuable materials (McDougall et al., 2008). Depending on further treatment processes, waste can be separated according to a number of criteria (Table 2). To create a sustainable and resource-efficient business model for private waste collectors to purify material streams, waste separation pre- and post-collection are essential to efficiently recycle streams (Consonni, Giugliano, Massarutto, Ragazzi, & Saccani, 2011; Eriksson et al., 2005). Not only does unsorted waste result in higher collection costs, it also requires an increased input of energy and labour to any downstream process and increases the value of waste, if separated correctly (Dijkgraaf & Gradus, 2007; Murray, 1999; Zhuang, Wu, Wang, Wu, & Chen, 2008).

Table 2: Categorisation of waste types. Adopted from (McDougall et al., 2008).

| **Criteria** | **Waste types** |
|---|---|
| Physical state | Solid, liquid (waste water), gaseous |
| Origin | Household, industrial, commercial, construction and demolition waste, etc. |
| Safety level | Hazardous, non-hazardous |
| Material type | Paper and cardboard, glass, plastics, organic, etc. |
| Original use | Packaging waste, food waste, etc. |
| Physical properties | Combustible, compostable, recyclable |

Many studies have analysed barriers that hinder and drivers that incentivise waste separation. Within the literature, environmental awareness (in the form of publicly available information) is seen as a prerequisite for waste separation and has been shown to improve overall recycling performance (Evison & Read, 2001; Perrin & Barton, 2001; Williams & Taylor, 2004). Moreover, the public attitude toward waste separation is also important; indeed, it was found that the attitude toward waste separation and environmental issues can be a significant predictor of waste separation intention and in turn waste separation behaviour (Ghani, Rusli, Biak, & Idris, 2013). However, a number of studies have found that situational factors, such as convenience of separation and available space and time, can prevent waste separation even if there is a high awareness of and positive attitude toward waste separation (Barr, Ford, & Gilg, 2003; Bernstad, 2014). The A-B-C Model describes this phenomena, arguing that environmental behaviour (B) is the result of attitude (A) and external conditions (C) (Guagnano, Stern, & Dietz, 1995).

Although a majority of the aforementioned studies have addressed waste separation in households, the same concepts can be applied to small, independent businesses, specifically with regard to awareness and attitude (Bohdanowicz, 2005). For companies, additional barriers and drivers for waste separation can be found, including lack of space and time, customers demanding separation, improving environmental image and costs of collection (Bohdanowicz, 2005, 2006; Pirani & Arafat, 2014; Revell & Blackburn, 2007). Figure 4 summarises the previously mentioned factors for companies' waste separation, based on the existing concepts concerning the waste separation in households. Even if a general awareness of waste separation is present, a positive attitude toward waste separation and suitable situational factors also need to exist for a company to separate their waste.

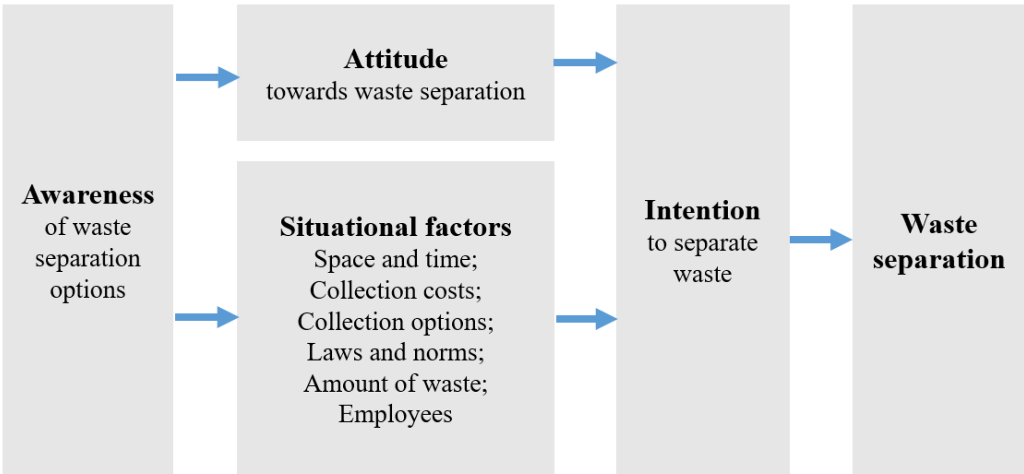


Figure 4: Factors influencing waste separation of companies. Adjusted from (Ghani et al., 2013; Guagnano et al., 1995).

# 3 Methods

## 3.1 Research design

The focus of this transdisciplinary research is to contribute toward knowledge and theory building in science and practice. Transdisciplinary research tries to solve complex, multi-dimensional, 'real-world' problems, by integrating a variety of disciplines and collaborating with researchers and stakeholders (Wickson et al., 2006). The methodological approach to transdisciplinary research is not fixed, but should reflect and correspond with the problem and context being investigated (Wickson et al., 2006). To investigate the contemporary phenomenon of circular economy implications on the business opportunities of private waste collectors an exploratory case study design was chosen as a suitable methodological approach (Yin, 2009). An exploratory case study is suitable, when the behaviour of those involved cannot be manipulated, the boundaries between phenomenon and context are not clear and the intervention being evaluated has no clear, single set of outcomes (Yin, 2009).

The research was conducted in three phases (Figure 5) and modelled after an ideal–typical transdisciplinary research process (Jahn, 2008; Lang et al., 2012), combined with steps of a case study design (Yin, 2009). Phase 1 consisted of identifying a study problem and selecting a case in consultation with researchers and stakeholders to insure its relevance for science and society. In phase 2 quantitative and qualitative data were collected and analysed, in the form of a cluster analysis and survey. Lastly, phase 3 applied the results to scientific and societal contexts by developing a transformation process for implementing a proposed business model innovation.

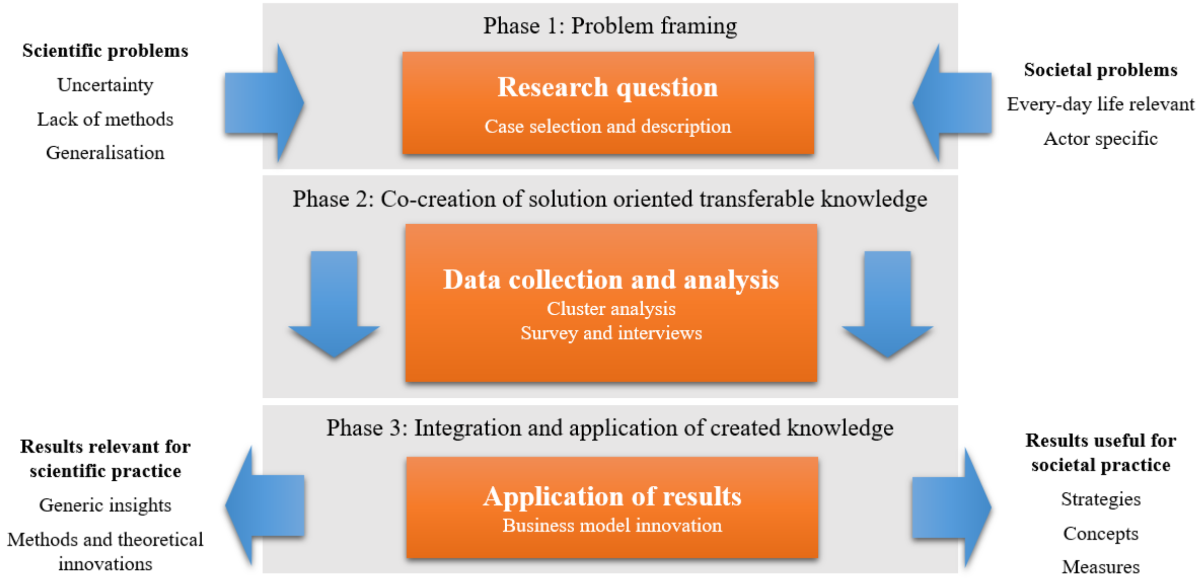


Figure 5: Transdisciplinary research design. Adopted from (Jahn, 2008; Lang et al., 2012; Yin, 2009).

## 3.2 Case selection and description

For this exploratory case study, SUEZ's waste collection activities in the Dutch hospitality sector between 01/11/2015 and 31/10/2016 were used for a study case. While the overarching framework for waste management has been described by the EU Directive 2008/98/EC (EU, 2008a), legislation on waste can different significantly between and within EU countries, as well as depend on the waste type. In the Netherlands, household and industrial waste are handled separately and Dutch law requires every company to contract a certified waste collector to collect their waste (NIWO, 2016; wetten.nl, 2016). Furthermore, companies that have a relevant impact on the environment are obligated to separate their waste, unless doing so is deemed unreasonable due to, for example, space issues, high collection costs or a small volume of waste. The Dutch National Waste Management Plan (LAP) is a policy that specifies for each type of waste above what amount companies should separate them (VROM, 2014).

This study focuses on the hospitality sector and defines it as: all waste producers listed under (I) Accommodation and food service activities in the EU NACE Code level 1, including *"the provision of short-stay accommodation for visitors and other travellers and the provision of complete meals and drinks fit for immediate consumption"* (EU, 2008b). The hospitality sector has been the focus of a number of scientific studies, specifically with regards to food waste prevention, since food waste can comprise more than 50% of the hospitality sector's waste (Marthinsen et al., 2012; Papargyropoulou et al., 2014; WRAP, 2011). Waste generation is considered to be the most noticeable impact of the hospitality sector on the environment, while up to 95% of general waste could typically be recycled or composted and 67% of food waste avoided (Bohdanowicz, 2005; Marthinsen et al., 2012; Nielsen & Green Restaurant Association, 2004).

As presented in Table 3, the composition of hospitality waste is vastly different, which can make it difficult to assess whether a typical hospitality company should separate their waste according to the LAP. Indeed, the food waste generation of hospitality companies can vary between 300 and 4,000 kilograms per employee per year, depending on company type and size (Marthinsen et al., 2012). Following the results of a study from the Waste and Resources Action Programme (WRAP), it can be deduced that the majority of hospitality companies within the UK with 10 or more employees would be above the weekly limit for food waste, plastic and glass and thus, would need to separate (WRAP, 2011). For example, a restaurant with ten employees would produce 220[3] kilograms of food waste per week, being above amount presented in the LAP.

Table 3: Major hospitality waste streams and LAP regulations. The LAP limit indicates the weekly acceptable amount of waste, that does not have to be separated. Adjusted from (Pirani & Arafat, 2014; VROM, 2014).

| **Waste type** | **Range of distribution of total waste** | **LAP limit per week** |
|---|---|---|
| Food waste | 27.8% - 46.4% | 200 kg |
| Paper and cardboard | 19.6% - 39.9% | 0 kg |
| Glass | 5.6% - 26.5% | 30 kg |
| Plastic | 6.7% - 15% | 0 kg plastic foil;<br>25 kg other plastics |

## 3.3 Cluster analysis

As mentioned in the previous chapter, waste generation habits differ within the hospitality sector, making a statistical analysis difficult. To overcome this issue, a cluster analysis was conducted for all waste producers in the Netherlands from which SUEZ collected waste between 01/11/2015 and 31/10/2016. A cluster analysis attempts to objectively identify the natural grouping of similar objects in a dataset and thus, find underlying structures within the dataset

[3] Restaurants with 10-19 employees produce 2.6 tonnes of total waste per year per employee from which 44% is food waste (WRAP, 2011). Thus, 1.144 [tonnes/year] = 0.022 [kg/week] for each employee and 220 [kg/week] for 10 employees.

and identify distinct clusters (Jain, 2010). During this analysis, each waste producer in the dataset was assigned to a cluster in such a way as to make clusters homogenous within and heterogeneous across (Hair, Black, Babin, & Anderson, 2010; Kaufman & Rousseeuw, 2009). Although the focus of this study lies on the hospitality sector, the performed cluster analysis included all waste producers independent of their sector. This made it possible to include more data in the analysis and allowed SUEZ to investigate additional sectors after the conclusion of this study. Thus, all results of the cluster analysis include waste producer sites not only from the hospitality sector, unless otherwise mentioned.

Compared to other multivariate analyses (for example regression models) a cluster analysis can be used without an objective function and in this way, is useful in exploratory research and in cases where the relation of variables is uncertain (Hair et al., 2010; Ketchen Jr. & Shook, 1996). Thus, a cluster analysis is preferred over other multivariate analyses in the case of the waste generation dataset, since it is unclear which factors drive or hinder waste separation performance. In the following sub-sections, the cluster analysis is described in terms of data collection, clustering variables, clustering algorithm, number of clusters and operationalisation.

### 3.3.1 Data collection

As input for the cluster analysis, a combination of three datasets (waste collection, marketing and sales) were used, to allow for a detailed understanding into the characteristics of the waste producers. Within the dataset, waste producers were separated into their different company site, since waste generation and separation habits, as well as other characteristics, can differ between each site. The waste collection dataset consisted of the weight and pick-up location of all of the waste bins collected by SUEZ. This data were collected as part of the core business of SUEZ: waste bins being picked up by waste trucks. Depending on the waste truck, the weight of the bins was gathered automatically either via an on board weighing mechanism or recorded by hand. In a number of cases, not all of the waste bins were measured and the weight of those bins was calculated as the average of the unassigned weight of the overall truck load. This process can result in the data having a poor reliability on a small scale (i.e. when analysing a single waste producer), but is still usable on a large scale. The marketing dataset was created externally and contains basic information of all registered Dutch company sites, such as number of employees and operating sector. The sales dataset consists of contact information and contract details for each of SUEZ’s customers, including the type of waste streams and waste bins being picked up.

From the available data, only certain waste producer sites were considered, following three preselection criteria. First, to have a set timeframe, only the newest waste collection data were considered, between 01/11/2015 and 31/10/2016. Secondly, only waste collected in wheelie bins was considered to insure comparability and also because wheelie bins are the cpmany's most common collection medium (95.8%[4] of waste producer sites have their waste collected in wheelie bins). Thirdly, waste producer sites without residual waste streams being collected by SUEZ were excluded due to the study's focus on opportunities to improve waste separation. Considering these restrictions, 57,505 waste producer sites were used as input for the cluster analysis.

### 3.3.2 Clustering variables

To assess the similitude of waste producer sites and thereby create clusters, clustering variables were needed to compare waste producer sites. Thus, a cognitive approach was taken, as it is in accordance with the theory building goal of this research (Ketchen Jr. & Shook, 1996). Initially, experts were consulted to determine which qualitative and quantitative indicators describe the core characteristics of waste producers and could be used to assess their waste separation performance. Subsequently, the indicators had to be verified to ensure their usability as clustering variables, following several restrictions. For the adopted k-means clustering algorithm (Chapter 3.3.3), only numeric (discrete and continuous) indicators could be used as clustering variables, excluding the geographical location and sector type. Furthermore, to eliminate side effects, clustering variables could not be highly correlated to one another (Appendix A) and should represent a normal distribution as closely as possible, without outliers (Hair et al., 2010; Ketchen Jr. & Shook, 1996). To ensure the latter, several indicators had to be transformed before they could be used as clustering variables. The transformation processes are mentioned below and a detailed overview can be found in Appendix B. Considering the restrictions, the following five indicators were selected as clustering variables:

- Weight of total waste: The sum of the weight of all waste streams SUEZ collected from a waste producer site during the timeframe of this study. Since the weight of the total waste was heavily skewed a log-transformation was performed, to achieve the required normal distribution. Heavily skewed data means, in this case, that many waste producer

[4] 65,366 out of 68,966 waste producer sites have at least one stream collected in wheelie bins.

sites had a relatively low weight of total waste (89.6%[5] of waste producer sites were below 15 tonnes), while few waste producer sites had a very high value (highest value being 1,100 tonnes). The weight of total waste is primarily an indicator of the size of a waste producer site: higher weight of total waste indicates a larger waste producer site.

- Number of employees: The number of employees working at a waste producer site at the start of the research. To be used as a clustering variable, the number of employees needed to be adjusted due to its skewedness, similar to the weight of total waste. Since the number of employees is a discrete variable, a log-transformation would not accomplish the required normal distribution. Instead, an index was created to represent the number of employees. The resulting employee index is a number between 1 and 10, based on the number of employees of a waste producer, which could then be used as a clustering variable. Appendix B provides a detailed description of how the employee index is defined. Information on the number of employees was only available for 64%[6] of waste producer sites and thus, an employee index was missing for the others. Since the cluster analysis can handle missing values (Kaufman & Rousseeuw, 2009) and in order to minimise the amount of excluded data, waste producer sites without an employee index were still considered in the cluster analysis. The number of employees is also an indicator of the size of a waste producers site: more employees indicate a larger waste producer site.

- Source separation level: The source separation level is calculated by dividing the weight of all non-residual waste streams by the weight of all waste streams of a waste producer site, as collected by SUEZ during the timeframe of the study. From the dataset, it can be seen that 65.9%[7] of waste producer sites only have their residual waste collected by SUEZ, resulting in a source separation level of zero. As the survey confirms, these waste producer sites do not necessarily mix their waste, but rather allow their non-residual waste streams to be collected by other waste collectors. So that these findings did not negatively influence the overall statistic, the source separation level was only calculated for waste producer sites with at least two waste streams. The source separation level is an indicator of the waste separation performance: a high percentage indicates a high waste separation performance.

[5] 51,540 out of 57,505 waste producer sites have less than 15 tonnes of total waste.
[6] 36,779 out of 57,505 waste producer sites had information on their number of employees.
[7] 37,869 out of 57,505 waste producer sites only have a residual waste stream collected by SUEZ

- Residual waste density: The residual waste density is the weight of all residual waste of a waste producer site, as collected by SUEZ during the time frame of the study, divided by the combined volume of the bins in which it was collected (weight per volume). Since the volume of the bins, and not the volume of the waste, was available in the dataset (and due to practical reasons of the collection process), the residual waste density was influenced by how full or empty the bins were when picked up. Similar to the weight of total waste, the residual waste density had to be log-transformed to be used as a clustering variable. The density of a waste bin can indicate the material that is inside; for example, plastic waste is lighter than food waste. Thus, comparing the residual waste density of a waste producer site with an ideal residual waste density can be an indicator of the waste separation performance of that waste producer. If their residual waste density is much lower or higher than the ideal value, it means that they throw heavier or lighter material into the residual waste stream, which should have been separated. Determining an ideal residual waste density is difficult and varies between sectors and waste producer size and does not necessarily represent the average residual waste density, since it can be argued that, on average, residual waste is not properly separated. SUEZ expects the ideal residual waste density to be approximately 90 kilograms per cubic meter, based on internal data and experience. Thus, an upper limit of 100 kilograms per cubic meter for residual waste is a typical fixture within SUEZ's contracts.

- Absolute deviation in residual waste density: The absolute deviation of the residual waste density of a waste producer site compared to the average residual waste density of the sector in which the waste producer sites operate. The deviation in residual waste density is similar to the residual waste density and calculated on the same basis, but includes a comparison to the sector average. The absolute value was used as a clustering variable because both a higher and lower than sector average residual waste density can be an indicator of low separation performance.

Even after the careful selection and transformation of the clustering variables, there are still outliers within the dataset. However, since these outliers were not caused by measurement error, but represent real waste producer sites, they were not excluded from the cluster analysis. To prevent clustering variables with a large range of values being weighted more for the creation of clusters, all clustering variables needed to be standardised before being clustered, (Hair et al., 2010; Ketchen Jr. & Shook, 1996).

### 3.3.3 Clustering algorithm

After collecting the data and defining the clustering variables, both were combined in the clustering algorithm to generate clusters. For this research, the k-means clustering algorithm was chosen, since it can handle large number of observations and missing values and is less influenced by existing outliers (Hartigan & Wong, 1979; Kaufman & Rousseeuw, 2009; Ketchen Jr. & Shook, 1996). In the k-means clustering algorithm, the number of clusters (k) is predetermined by the user. The algorithm divides the observations into k clusters so as to minimise the squared error (Euclidean distance) between the empirical mean of each cluster (cluster centre) and each observation within it (Jain, 2010). Thus, clusters produced by a k-means clustering algorithm are compact and spherical (Jain, 2010; Kaufman & Rousseeuw, 2009). The k-means clustering operates in the following steps:

1. Start with (k) randomly-selected or predefined cluster centres and assign each observation to its closest centre.
2. Compute new cluster centroids with the current distribution of observations.
3. Reassign observations to their closest centre.
4. Repeat steps 2 and 3 until no further changes occur.

This process is visualised in Figure 6, in which a k-means clustering algorithms is depicted identifying three clusters within a two-dimensional space over two iterations. The initial selection of cluster centres can have a significant impact on the resulting cluster (Jain, 2010; Kaufman & Rousseeuw, 2009). To assess this effect, ten clustering runs with randomly selected initial centres were compared. The results of the comparison are described in Appendix C and exhibit only slight differences in the resulting clusters.

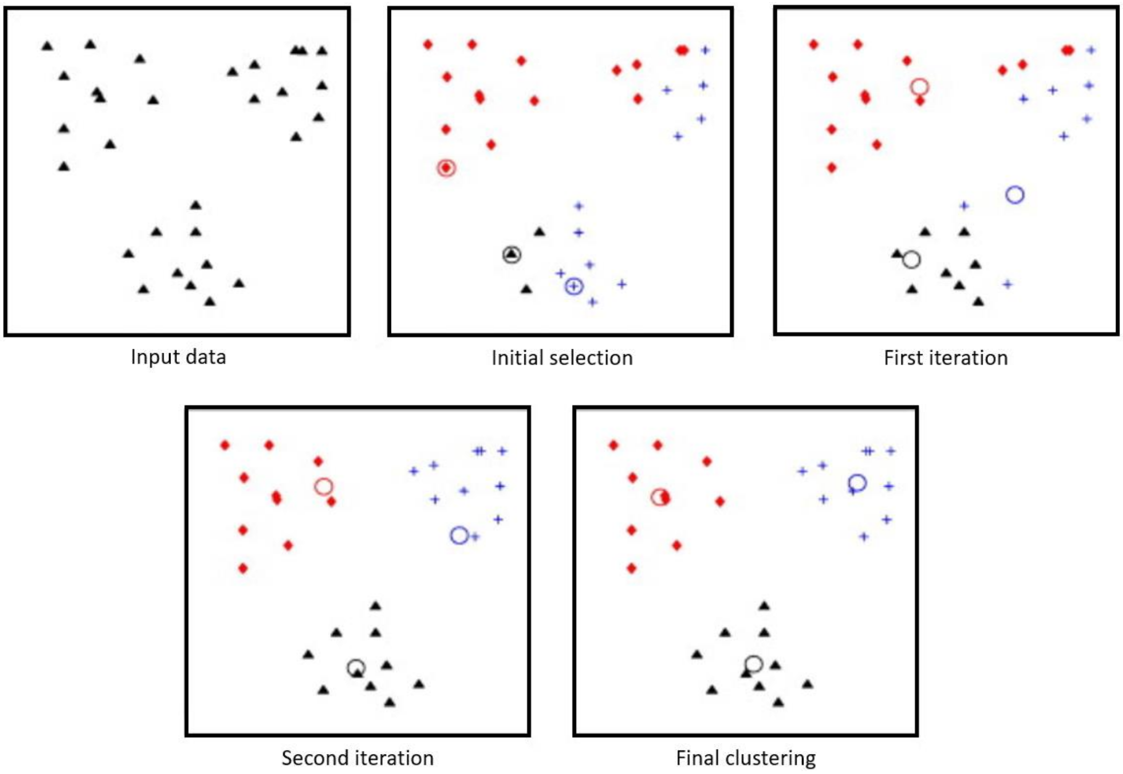


Figure 6: Illustration of k-means clustering in a two-dimensional space. Adopted from (Jain, 2010).

### 3.3.4 Number of clusters

Since the number of clusters must be determined by the user, the Cubic Clustering Criterion (CCC) and the Pseudo F statistics were used as indicators of the acceptability of the resulting clusters to determine a suitable number of clusters. The CCC compared the observed between-cluster variance ($R^2$) to the expected between-cluster variance in a uniformly distributed dataset (Milligan & Cooper, 1985; Sarle, 1983). A positive value for the CCC means that the observed between-cluster variance is greater than expected in a uniform distribution, thus indicating a possible presence of clusters (Sarle, 1983). The Pseudo F statistic represents the ratio of between-cluster variance to within cluster variance (Caliński & Harabasz, 1974). A large Pseudo F statistic indicates closely grouped clusters with a large distance between one another.

Both indicators were compared over multiple clustering runs using a variety of predetermined number of clusters. Plotting both indicators over the number of clusters (Figure 7), the appropriate number of clusters can be found at the 'elbow' of the figure, meaning a local maximum with thereafter decreasing values (Ketchen Jr. & Shook, 1996). In this case, the number of clusters was determined to be four.

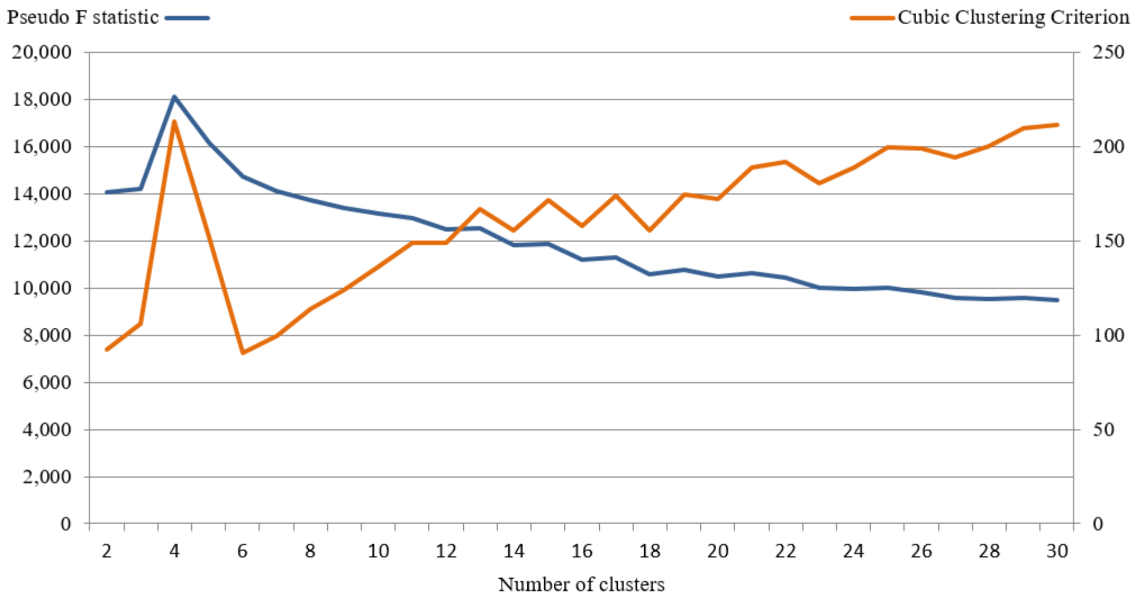


Figure 7: Determining the number of clusters.

### 3.3.5 Operationalisation

The last step of the cluster analysis involves analysing the results and characterising the generated clusters. Clusters can be characterised according to the waste producer sites to which they belong. In addition to the clustering variable (Chapter 3.3.2), waste per employee was used as an indicator to describe clusters in terms of size and waste separation performance; Figure 8 displays how each indicator was interpreted. A majority of the time, the median was used to characterise and compare different clusters, because the average would be misleading due to the strong influence which the existing outliers would have on it. Furthermore, the distribution of the created clusters was compared over different regions and sectors to identify possible region or sector dependencies of certain clusters. For the region, SUEZ’s 18 operating regions were used (Appendix D).

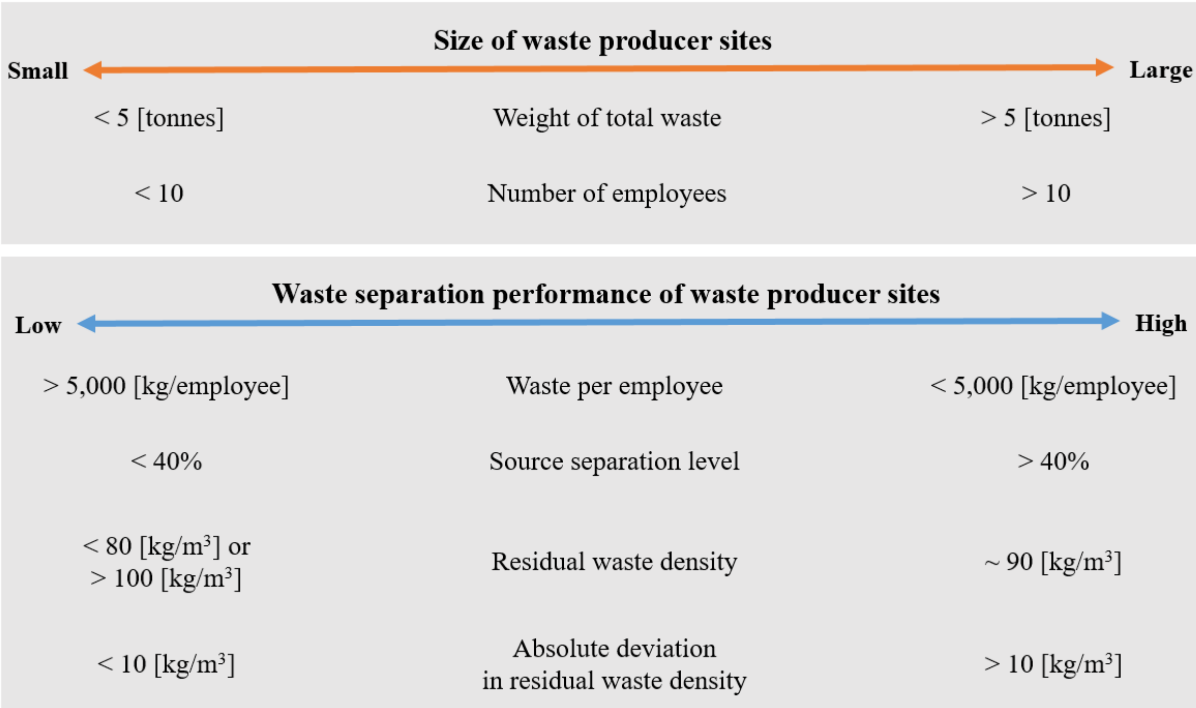


Figure 8: Description of cluster characteristics.

## 3.4 Questionnaire and interviews

After identifying and characterising the clusters, a multiple-choice questionnaire was distributed and semi-structured interviews were conducted among the hospitality customers of SUEZ. The multiple-choice questionnaire was chosen to compare the results of different clusters (Greener, 2008). Moreover, semi structured interviews were conducted to gain a deeper understanding of the waste generation and separation habits of the hospitality sector (Louise Barriball & While, 1994).

### 3.4.1 Data collection

Overall, 987 waste producer sites were contacted via phone and email and asked to participate in the survey either through an interview or the questionnaire. This included all of the waste producer sites within the hospitality sector, for which SUEZ possessed email addresses. Contacting 82 waste producers by phone and 905 by email resulted in 9 interviews and 147 questionnaire responses (60 of which were anonymous and could not be linked to the results of the cluster analysis) and a response rate of 15.8%,[8] which is quite typical for an email survey within the hospitality sector (Jeong, Oh, & Gregoire, 2003; Medina-Muñoz & García-Falcón, 2000). The questionnaire was completed online, while interviews were conducted via phone or in person and lasting for 10-20 minutes. Table 4 provides an overview of the interviewees.

Table 4: List of interviews with waste producer sites. Contains basic information on waste generation and separation habits of each company site that was interviewed.

| | Type | Waste streams collected by SUEZ | Other waste streams | Number of employees | Residual waste density | Cluster |
|---|---|---|---|---|---|---|
| **A** | Restaurant | Residual;<br>Paper and cardboard | - | 4 | 178.10 | HVY |
| **B** | Restaurant | Residual | Grease | 3 | 160.95 | HVY |
| **C** | Restaurant | Residual; Glass | Plastic | 6 | 106.22 | BIG |
| **D** | Snack bar | Residual;<br>Paper and cardboard | Glass | 8 | 107.74 | BIG |
| **E** | Snack bar | Residual;<br>Paper and cardboard | Glass | 3 | 82.89 | AVG |
| **F** | Snack bar | Residual;<br>Paper and cardboard | - | 7 | 82.41 | BIG |
| **G** | Café | Residual;<br>Glass | Paper;<br>Grease | 14 | 72.27 | BIG |
| **H** | Café | Residual | Plastic;<br>Paper;<br>Glass | 2 | 57.24 | LGT |
| **I** | Hotel | Residual;<br>Paper and cardboard;<br>Plastic;<br>Glass | Food waste | - | 67.96 | BIG |

### 3.4.2 Operationalisation

The questionnaire and interviews were designed to identify factors influencing waste separation performance, based on the findings from the literature review (Chapter 2.3) and in consultation with experts from SUEZ. The attitude toward waste separation was assessed according to the importance assigned to it by waste producers, while awareness and situational factors were assessed as either barriers or drivers for waste separation (Table 5). While it was possible to

[8] 156 waste producer sites responded (147 surveys and 9 interviews) out of 987 (905 contacted via email and 82 via phone)

directly compare and analyse the multiple-choice questionnaires for each cluster, the interviews needed to be transcribed and coded (Appendix E).

Table 5: Link between factors influencing waste separation and survey questions. See Appendix F for questions.

| Category | Question | Factor | Example |
|---|---|---|---|
| **Waste generation and separation habits** | 3) | Large waste streams | Residual waste and plastic |
| | 4) | Separated waste streams | Residual and food waste |
| | 5) | Streams collected by SUEZ | Residual waste and glass |
| **Attitude toward waste separation** | 1) | Importance of environmental issues | 4 out of 5 |
| | 2) | Importance of waste separation | 5 out of 5 |
| **Drivers of waste separation** | 9) | Lower costs | Paying less for collection of separated waste |
| | | More space | More space for bins to separate in |
| | | Strict laws | Strictly regulated laws |
| | | Customer demand | Customer demand separation |
| | | Larger amount of waste | More waste to make separation worth it |
| **Barriers of waste separation** | 6) and 7) | Unaware of improvements | No room to improve waste separation |
| | | Unaware of (environmental) benefits | No reason to separate waste |
| | | No space | Not enough space |
| | | Small amount of waste | Not enough glass waste to make separation worth it |
| | | No time | Too busy to separate waste |
| | | Employees | Employees do not separate waste |
| | | SUEZ | SUEZ does not offer suitable solutions |
| **Strategies to overcome barriers of waste separation** | 8) | Labelled bins | Labelled waste bins |
| | | Instructions for employees | Instructions for employees on how to separate waste |
| | | Positioning of bins | Different positioning to avoid confusion |
| | | External consulting | Contact SUEZ to improve separation |

## 3.5 Business model innovation

In the last phase of the research, the findings of both of the previous analyses were concluded into a business model for SUEZ that overcomes barriers and utilises drivers to improve waste separation performance within the hospitality sector. In addition to the input from the cluster analysis and survey, the business model was developed in collaboration with a number of SUEZ experts. Throughout the research, six expert interviews were conducted and eventually, a two-hour seminar was organised. The expert interviews and seminar were used as an aspect of the transdisciplinary research design of this study, resulting in input for the ongoing research and discussions of the results. Table 6 lists the SUEZ experts consulted in interviews and who were present during the seminar. For the proposed business model, a SWOT-Analysis was performed (Hill & Westbrook, 1997) and a transition model was created to determine how the business model can be implemented at SUEZ, in accordance with the six dimensions of service-based innovation (Janssen, 2015).

Table 6: Interviewees and seminar attendees. Interviews are summarised in Appendix G.

| **Business Development** | | |
|---|---|---|
| Paul Valster | Director New Business | Seminar |
| Raymond De Schrevel | Business Development Manager | Seminar |
| **Marketing** | | |
| Jannette de Lange | Marketing Manager | Seminar |
| Wienik Kruithof | Data Analyst | Seminar and interview |
| **Sales** | | |
| Yildiz Visser | Key Account Manager | Seminar |
| Ahmet Oksuz | Account Manager | Interview |
| Renzo Hoebe | Service Advisor | Interview |
| **Others** | | |
| Jan de Vroe | Regional Director | Interview |
| Luc Verhagen | Manager SUEZ.Scope | Interview |
| Jan van Zon | Manager Environment and Safety | Interview |

## 3.6 Reliability and validity

The reliability and validity of this research was ensured and biases were eliminated through the triangulation of method, data and investigator (Golafshani, 2003; Jick, 1979). Method triangulation requires the use of different methods of data collection and analysis (Golafshani, 2003; Jick, 1979), in this case quantitative (a cluster analysis of waste collection data from SUEZ) and qualitative data (expert interviews and waste producer survey), each of which have different weaknesses. When using a cluster analysis, a common concern is the inherent reliance upon the judgement of the research, due to a lack of clear statistics to support the results (Ketchen Jr. & Shook, 1996). However, in addition to the sensitivity test of the initial selection of cluster centres and the assessment of the created clusters using the CCC and Pseudo F statistic (cluster validity), the results of the cluster analysis were also confirmed by expert opinions during interviews and the seminar, as well as by the survey (Ketchen Jr. & Shook, 1996). Furthermore, the qualitative data assists in determining whether a clustering tendency exists, since a cluster analysis create clusters even if no meaningful groups are embedded within the dataset (Barney & Hoskisson, 1990; Smith & Jain, 1984).

Furthermore, as part of this study's transdisciplinary research design, the initial problem descriptions, the research process and the results were discussed with non-academic stakeholders. This collaboration acts as a 'reality check' for research processes and outcomes and allows for the evaluation of the possession of a clear goal, adequate preparation, appropriate methods, significant results, effective presentation and reflective critique (Wickson et al., 2006).

# 4 Results

## 4.1 Cluster analysis

The cluster analysis divided the waste producer sites into four clusters: BIG (big), LGT (light), AVG (average) and HVY (heavy). Figure 9 displays the differences between the clusters, based on their most distinct characteristics, number of employees and residual waste density. The clusters can be distinguished between those consisting of small waste producers with few employees (AVG, LGT and HVY) and medium to large waste producers with many employees (BIG). The three small clusters can be further distinguished according to their residual waste density, ranging from light to heavy. The BIG cluster is far above the ideal residual waste density of 90 kilograms per cubic meter, while the LGT cluster is far below, both indicating a low waste separation performance. Among the small clusters, the AVG cluster is closest to the ideal residual waste density, with a median of 69.78 kilograms per cubic meter. The wide spread and vast differences between the average and the median, in the case of the BIG and HVY clusters, are caused by outliers in the dataset. For example, the BIG cluster includes waste producer sites with up to 12,000 employees, heavily influencing its average.

In addition to the number of employees and the residual waste density, additional indicators can be used to characterise the four clusters. Figure 10 depicts the rest of the five clustering variables, as well as the waste per employee for each cluster, as a box plot. The results for weight of total waste is comparable to that for the number of employees when dividing the clusters into those with small (LGT, AVG and HVY) and medium to large (BIG) waste producer sites. Compared to the number of employees, the weight of total waste exhibits larger differences between the three small clusters, since the HVY cluster has a noticeably higher weight of total waste than the LGT cluster. This can also be observed in the waste per employee indicator. Thus although the HVY cluster has few employees, the waste per employee is the highest for this cluster.

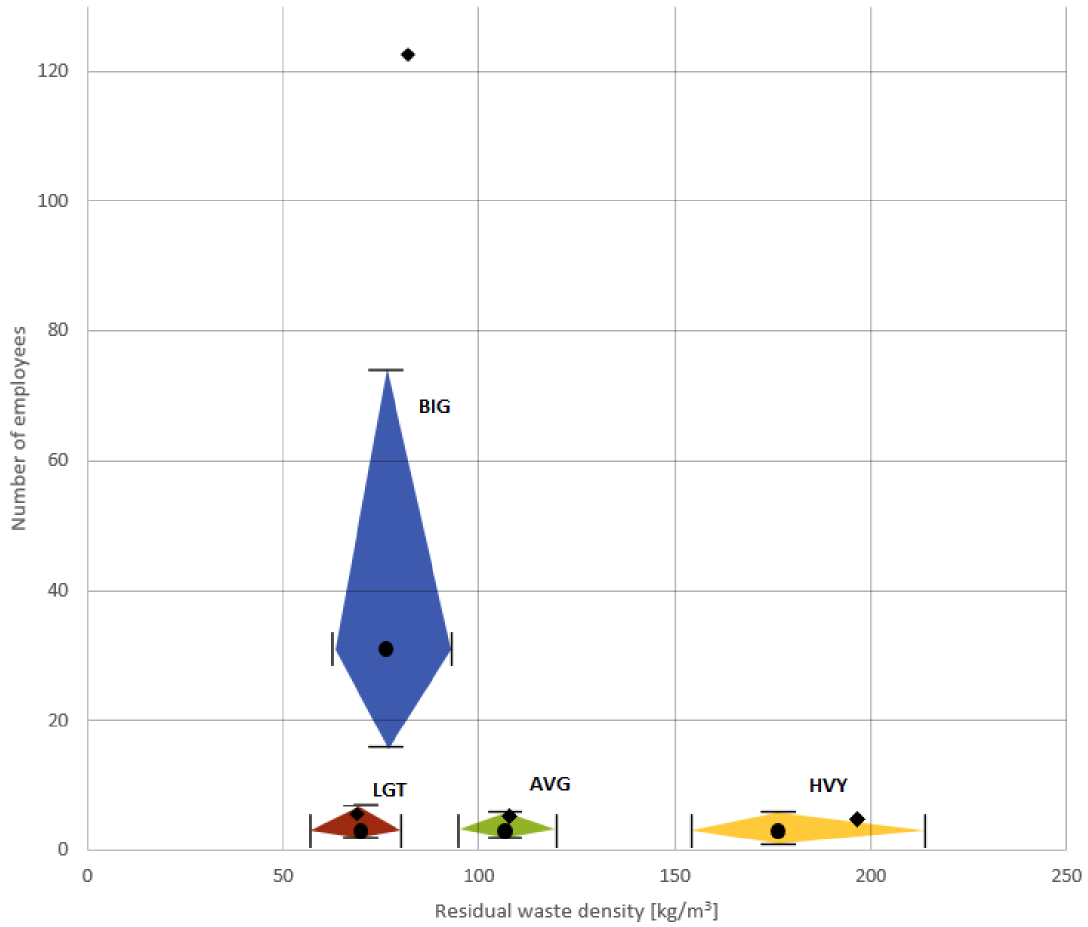


Figure 9: Cluster characteristics in terms of size and waste separation performance. The points indicate the medians, the rhombuses indicate the averages and the bars indicate the 25th and 75th percentiles. N = 57,505 waste producer sites. Values are displayed in Appendix H.

The source separation level, as well as the waste per employee, rank the four clusters in the same order in terms of waste separation performance, with LGT being the best and HVY being the worst. However, the absolute deviation in residual waste density provides different insight into the results. The AVG sector, although almost unnoticeable in the other indicators, exhibits the lowest deviation from the sector average. On the one hand, this does not necessarily oppose the clusters' ranking in terms of waste separation performance by other indicators, because the sector average residual waste density, which is used as a point of comparison, does not necessarily reflect the ideal value. On the other hand, a large deviation from the sector average combined with a low residual waste density, such as in the case of the LGT cluster, can also indicate the improper separation of light waste (such as plastic or paper).

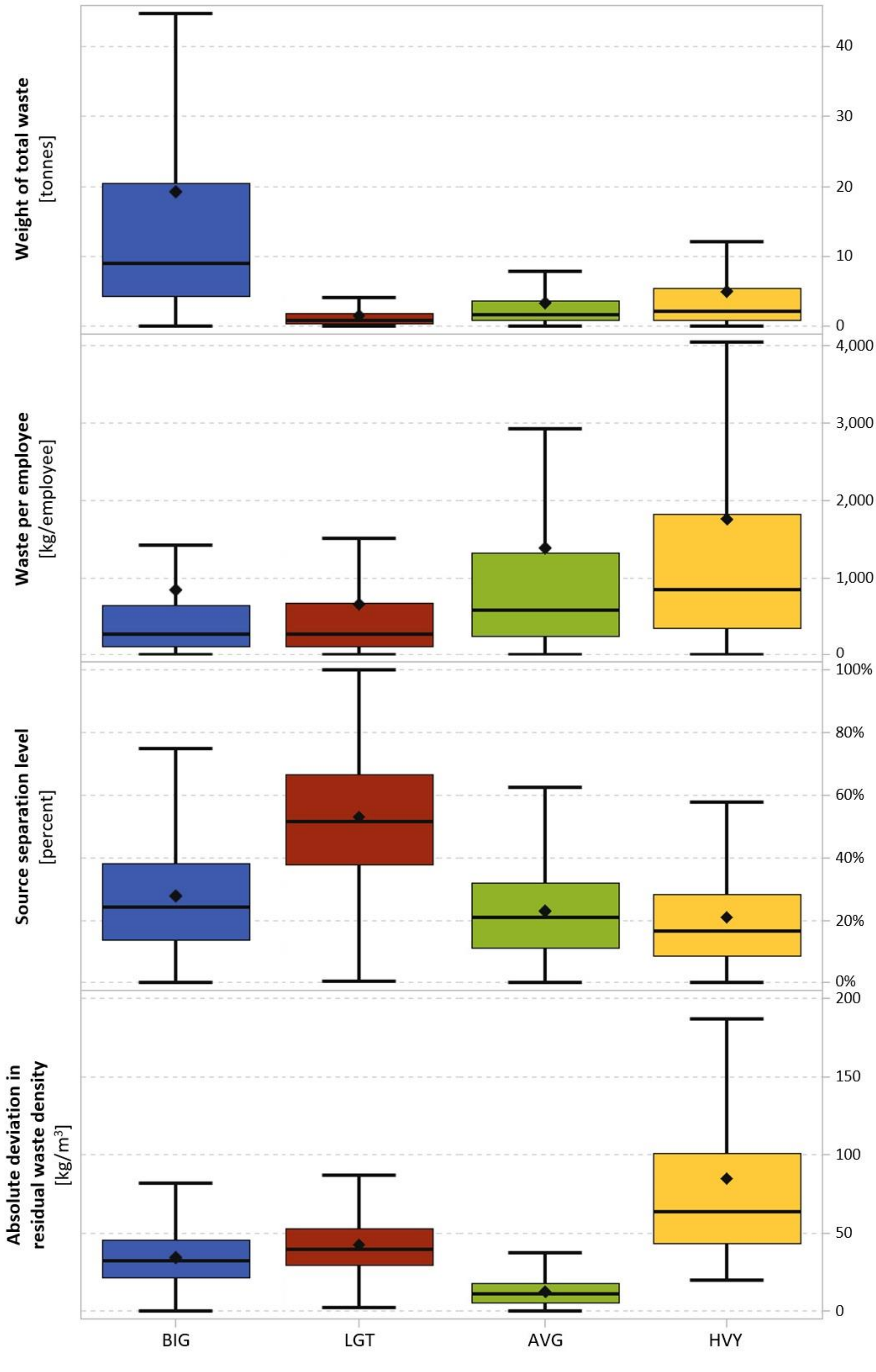


Figure 10: Box plot comparison of cluster characteristics. The box plot presents the medians, 25th and 75th percentiles and the rhombuses indicate the averages. Outliers, whose distances from the interquartile range are greater than 1.5 times the size of the interquartile range, are not depicted in the graph, as indicated by the whiskers (Tukey box plot). N = 57,505 waste producer sites. Values are displayed in Appendix H.

### 4.1.1 Region and sector differences

The waste generation and separation habits of waste producers can also depend on the region and sector. To assess the degree of influence, that regions and sectors have on the waste generation and separation habits of waste producers, the indicators in each region and sector were compared to one another. Table 7 lists the standard deviation of the median for each indicator over all sectors and regions.

Table 7: Standard deviation of indicators over regions and sectors. N = 57,505 waste producer sites.

| | Overall median | Standard deviation | |
|---|---|---|---|
| | | **Regions** | **Sectors** |
| **Weight of total waste** [tonnes] | 2.18 | 0.36 | 1.34 |
| **Number of employees** | 30.02 | 0.79 | 12.57 |
| **Source separation level** | 0.2572 | 0.0315 | 0.0642 |
| **Residual waste density** [kg/m$^3$] | 96.50 | 9.76 | 16.04 |
| **Absolute deviation in residual waste density** [kg/m$^3$] | 30.08 | 1.90 | 6.05 |
| **Waste per employee** [kg/employee] | 445.00 | 101.06 | 244.61 |

As can be observed, waste generation and separation habits depend more on the sector than the region, especially since the weight of total waste and the number of employees change throughout different sectors. The share of the four clusters, however, remain relatively similar throughout different regions, but change more between different sectors (Appendix I). The BIG cluster's share changes especially, as it is primarily defined by the weight of total waste and number of employees. For example, the BIG cluster has the highest share in the mining and quarrying sector (65.2%) and the smallest in the agriculture, forestry and fishing sector (7.8%).

### 4.1.2 Hospitality sector

Since the hospitality sector is the focus of this study, the results of the cluster analysis are more detailed for this sector. SUEZ picked up waste from 4,937 waste producer sites within the hospitality sector over the timeframe of the study. Table 8 presents the distribution of clusters and the median of all of the indicators, as well as how they differ compared to the dataset as a whole.

In comparison to the overall statistics within the hospitality sector, the share of AVG and HVY waste producers is higher, the source separation level aggravates, the amount and density of waste increases and companies shrink.

Table 8: Cluster characteristics of the hospitality sector. N = 57,505 waste producer sites overall and 4,937 waste producer sites in hospitality sector.

| Distribution of clusters | Share | Δ |
|---|---|---|
| **BIG** | 18.80% | -4.6 pp |
| **AVG** | 40.60% | + 7.0 pp |
| **LGT** | 16.90% | -6.9 pp |
| **HVY** | 23.80% | + 4.4 pp |

| Indicators | Median | Δ |
|---|---|---|
| **Weight of total waste** [tonnes] | 4.80 | 2.59 |
| **Number of employees** | 4.00 | -1.00 |
| **Source separation level** | 0.18 | -0.078 |
| **Residual waste density** [kg/m$^3$] | 117.90 | 21.40 |
| **Absolute deviation in residual waste density** [kg/m$^3$] | 32.00 | 1.92 |
| **Waste per employee** [kg/employee] | 1,107.08 | 662.08 |

The median residual waste density increases to 117.90 kilograms per cubic meter and moves further away from the ideal value of 90 kilograms per cubic meter. With 1,107 kilograms per employee, the median is rather small compared to recorded values of up to 4,000 kilograms per employee within the hospitality sector (Marthinsen et al., 2012). The reason for this is the fact that SUEZ does not collect all waste streams from their waste producers, but rather focuses solely on residual waste. This is also the reason for the low source separation level, with a median of 18%.

## 4.2 Survey and interviews

### 4.2.1 Waste generation and separation habits

Comparing the largest streams mentioned with those being separated makes it possible to identify deficits in the current waste separation habit. Figure 11 illustrates the percent of respondents who mentioned waste streams as being large, being separated by SUEZ or otherwise. Most notably, plastic and food waste were mentioned as being a large stream more often than being separated, which indicates room for improvements regarding those waste streams. According to the survey, residual waste was only separated by 67.5% of respondents, which would imply the same conclusion as with plastic and food waste. However, the SUEZ dataset indicated that residual waste is picked up from all of the survey respondents, suggesting a misunderstanding of the survey question. Unsurprisingly, grease was only mentioned once as being a large stream, but mentioned as being separated by 55.1% of respondents. This can be explained due to specific characteristic and regulations for grease, making its separation typical within the hospitality sector. Figure 11 also displays the share of waste streams collected by SUEZ; SUEZ only collects 17.5%[9] from the separately collected grease, plastic and food waste streams, suggesting a possibility for SUEZ to increase their market share.

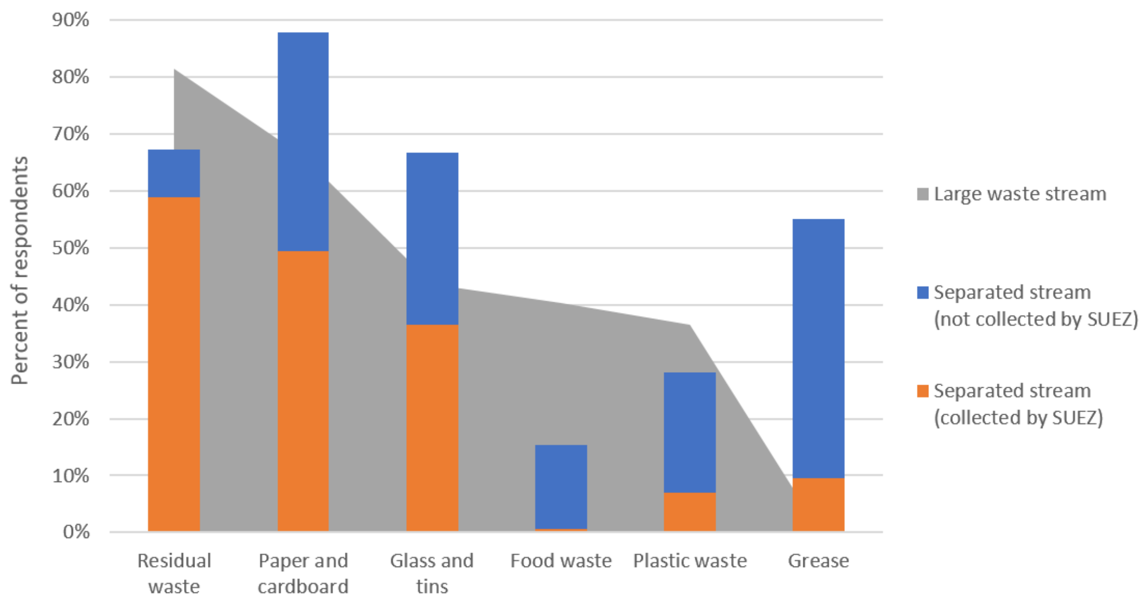


Figure 11: Largest and separated waste streams in the hospitality sector. N=157 survey respondents.

[9] Among all respondents, 154 grease, plastic and food waste streams are separated, from which SUEZ collected 15 streams.

### 4.2.2 Attitude toward environment and waste separation

The attitude toward environmental issues and waste separation are rather positive. Indeed, a high importance was found for both (3.7 out of 5 on average), illustrating the recent increase in awareness of environmental issues within the hospitality sector (Pirani & Arafat, 2014). Figure 12 depicts the connection between the importance of environmental issues and waste separation, with the number of streams separated, to assess to what extent a positive attitude results in waste separation behaviour, as suggested by theory (Ghani et al., 2013). The importance of waste separation appears to have a stronger connection, although both change a relatively insignificant amount. This indicates that waste separation behaviour is to some degree, influenced by the attitude toward environmental issues and waste separation, although not solely. As suggested by theory, if situational factors are not suitable, they can hinder waste separation even in cases where there is a positive attitude toward and awareness of waste separation (Barr et al., 2003; Bernstad, 2014).

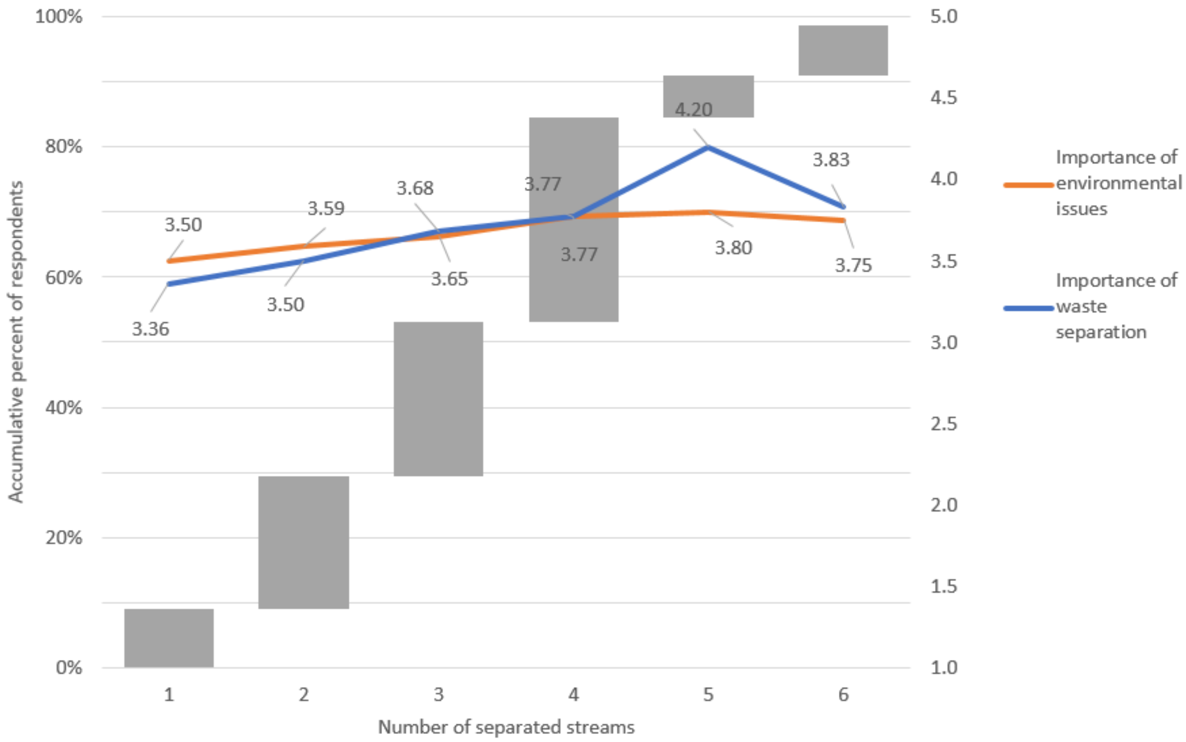


Figure 12: Influence of attitude toward waste separation. Attitude toward environmental issues and waste separation was measured as importance, on a scale from 1 to 5 (1: Not important, 5: Very important). N=157 survey respondents.

### 4.2.3 Drivers, barriers and strategies

Although environmental issues and waste separation are perceived as important and there is potential to improve waste separation, a variety of barriers restrict the waste separation performance. The most common barriers are: a missing awareness of possible improvement and no available space for additional waste bin (Table 9). Additional barriers include: having only a small amount of a certain waste stream (not worth separating), no time to separate waste and being unaware of the environmental benefits of waste separation. In comparison, drivers for waste separation were mentioned less frequently, with only 76.9% of respondents mentioning at least one. The most important drivers are: lower collection costs when waste is separated, more space for additional waste bins and strictly enforced waste separation laws. Strategies to overcome barriers of waste separation are mentioned the least and do not directly correspond to the most common barriers. Overall, the most mentioned barriers and drivers were already identified within the literature as situational factors.

Table 9: Most commonly mentioned drivers, barrier and strategies. Shows the percent of respondents who mentioned a specific driver, barrier or strategy to overcome barrier of waste separation. N=157 survey respondents.

| | **Percent of respondents** | **Factor** | **Percent of respondents** |
|---|---|---|---|
| **At least one driver** | 76.9 | Lower costs | 55.1 |
| | | More space | 30.1 |
| | | Strict laws | 14.1 |
| | | Customer demand | 5.1 |
| | | Larger amount of waste | 4.5 |
| **At least one barrier** | 96.8 | No space | 52.6 |
| | | Unaware of improvements | 52.6 |
| | | Small amount of waste | 17.3 |
| | | No time | 16.7 |
| | | Unaware of (environmental) benefits | 13.5 |
| | | Employees | 8.3 |
| | | SUEZ | 6.4 |
| **At least one strategy to overcome barriers** | 39.1 | Labelled bins | 18.6 |
| | | Instructions for employees | 11.5 |
| | | Positioning of bins | 9.0 |
| | | External consulting | 1.3 |

## 4.3 Combining results

Combining the identified clusters with the survey results, creates a detailed picture of each of the clusters within the hospitality sector. This makes it possible to create strategies to increase waste separation performance for each cluster specifically. The following results are all specific for the hospitality sector.

### 4.3.1 BIG cluster

The BIG cluster primarily consists of medium to large waste producers with more employees and total waste than other clusters. In terms of waste separation performance, waste producer in the BIG cluster perform rather well with a low amount of waste per employee and a relatively high source separation level. The residual waste density is 96.70 kilogram per cubic meter, which is considered to be extremely close to the expected value of SUEZ and is much lower than the overall median. However, the survey indicates the areas in which the waste separation of the BIG cluster still needs improvement. The upper part of Figure 13 represents possible deficits in the waste separation habits, by comparing the percent of respondents who mentioned that a waste stream was large and with those who mentioned that it was separated. Although not frequently being mentioned as a large stream, the BIG cluster does particularly well in separating paper and cardboard. The only major deficit of the BIG cluster remains in separating food waste, since this was more often mentioned as a large cluster than as being separated.

The lower part of Figure 13 depicts the most commonly mentioned drivers, barriers and strategies to overcome barriers of waste separation. In terms of barriers, BIG waste producers mentioned the least barriers overall, with 10% not mentioning any barriers at all. Space and awareness are less of a problem compared to other clusters and BIG waste producers noticed the ability to improve their waste separation by both separating more streams and separating them in a more precise manner. Furthermore, time and the amount of waste are more of a problem compared to other clusters, although they were mentioned by less than 30% of respondents. In terms of strategies, it is not surprising that employee instructions are higher than average, since BIG waste producers have more employees than other clusters. To improve the waste separation of the BIG cluster, they should focus on easy-to-implement solutions that require less space and are suitable for waste streams with a small amount.


Figure 13: Most common survey responses from the BIG cluster. The upper part represents the percent of respondents who did not mention a waste stream as being large while separating it and vise versa. The lower part depicts the percent of respondents who mentioned a certain driver, barrier or strategy to overcome barriers of waste separation. Values are displayed in Appendix J.

### 4.3.3 LGT cluster

The LGT cluster is characterised by light residual waste bins with a median residual waste density of 78.41 kilograms per cubic meter. The light residual waste influences their source separation level, which is the highest out of all clusters with a median of 44.9%. A low residual waste density does not, however, necessarily suggest a high waste separation performance, because it can also suggest light waste being mixed with residual waste. This concern is confirmed in the upper part of Figure 14, where paper and cardboard are lower than any other cluster. Although paper and cardboard waste were mentioned as being separated about the same amount of time as in other clusters, it was more often mentioned as being a large stream. This, combined with the fact that 40% (compared to 25% overall) of the LGT waste producers noted that they could improve separating their waste streams, suggests that the large amount of paper and cardboard waste is not always properly separated and instead ends up in residual waste, thus lowering its density. This appears to be the case for paper and cardboard primarily, since the survey responses for plastic (the other light waste stream) did not change compared to other clusters. Another explanation for the overly light residual waste bins is that bins are not full when they are picked up. According to the survey, 40% (compared to overall 9%) of LGT waste producers said that their bins are not full when they get picked up by SUEZ. During an interview, an LGT waste producer also mentioned seasonally related issues and described their residual waste bins as being *“not full most of the year, so they are very light, [but] during summer season the bins can be very heavy”* (Waste producer H, LGT cluster).

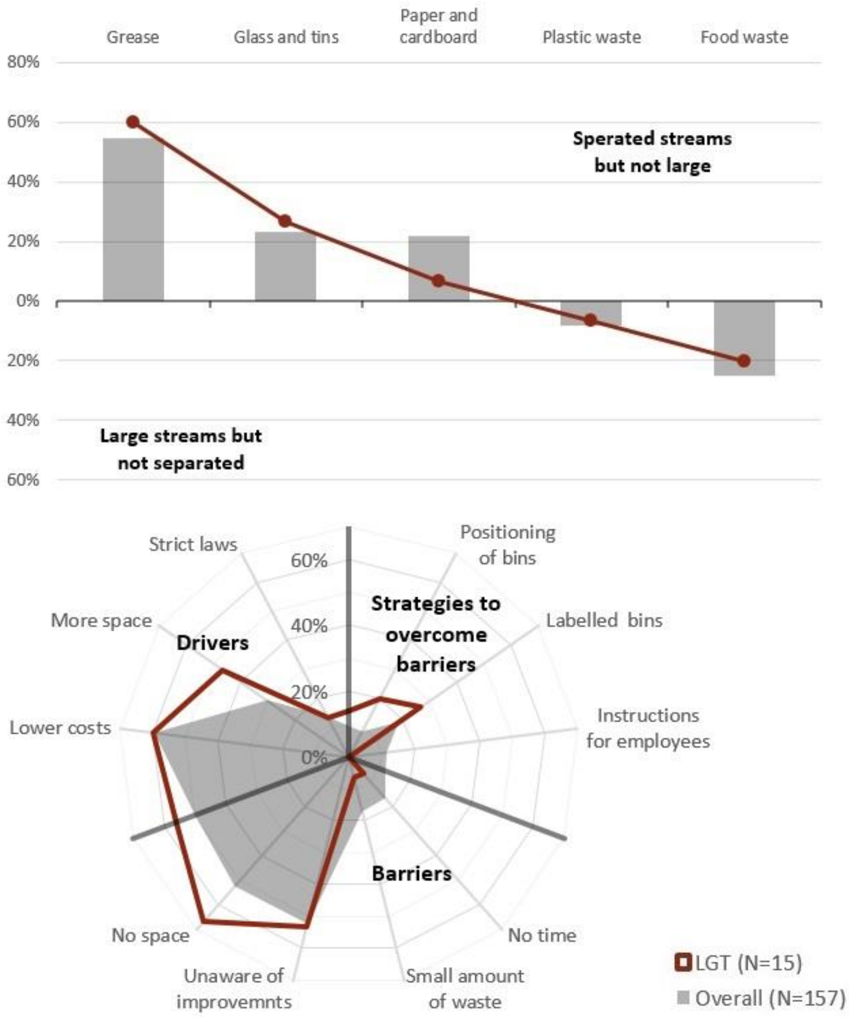


Figure 14: Most common survey responses from the LGT cluster. The upper part represents the percent of respondents who did not mention a waste stream as being large while separating it and vise versa. The lower part depicts the percent of respondents who mentioned a certain driver, barrier or strategy to overcome barriers of waste separation. Values are displayed in Appendix J.

In terms of drivers and barrier of waste separation, space and, to a lesser degree, unawareness are the biggest concerns within the LGT cluster. Other barriers, such as the amount of waste and time, are less of an issue. Notably, the high amount of strategies to overcome barriers of waste separation is also high, with 53.3% of LGT waste producers mentioning at least one strategy. The high number of applied strategies could be the reason for time not being mentioned as a barrier as often, since strategies are viewed as time-saving measures. To improve the waste separation performance of the LGT cluster, they should focus on the proper separation of paper and cardboard and residual waste and use waste bins that are more suitable in size to their actual waste volume to prevent the pick-up of empty bins and the needed space.

### 4.3.2 AVG cluster

The AVG cluster has the most waste producers within the hospitality sector (40.6%) and thus, comprises the largest number of non-anonymous survey responses (58.3%). The AVG cluster represents the average of the waste producers, as it is characterised by few employees and a medium to low waste separation performance. With a median source separation level of 16.3% and a residual waste density of 119.36 kilogram per cubic meter, the average waste producer has room to improve their waste separation.

Room for improvement can also be observed in the upper part of Figure 15, which display large deficits in plastic and food waste. Since the AVG cluster comprises a large portion of the survey responses, the lower part of Figure 15 represents the overall statistics. It is noteworthy that space is not often mentioned as a driver, but still mentioned as a barrier. This makes it unclear whether more available space would lead to improved waste separation. Furthermore, the highest percent of respondents (17.1%) who are unaware of the environmental benefit of waste separation are in the AVG cluster. Thus, solely offering a space-efficient solution would not result in improved waste separation performance; the solution should also be cost efficient or make waste producers aware of possible improvements.

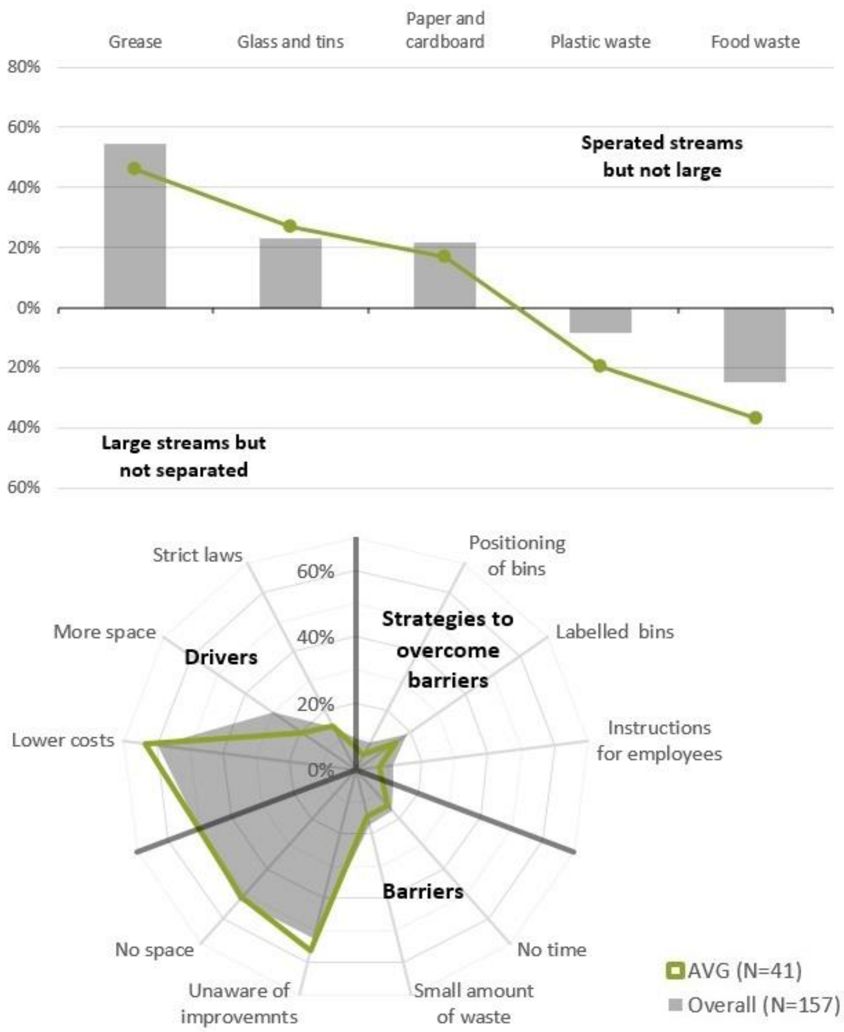


Figure 15: Most common survey responses from the AVG cluster. The upper part illustrates the percent of respondents who did not mention a waste stream as being large while separating it and vise versa. The lower part represents the percent of respondents who mentioned a certain driver, barrier or strategy to overcome barriers of waste separation. Values are displayed in Appendix J.

### 4.3.4 HVY cluster

The HVY cluster represents waste producers with heavy residual waste bins and a median residual waste density of 183.38 kilograms per cubic meter, more than double of the ideal value of 90 kilograms per cubic meter. HVY waste producers also have the most waste per employee and the lowest waste separation level of all of the clusters, indicating an overall low separation performance. The upper part of Figure 16 indicates that food waste has the largest deficit in the HVY cluster, since almost half of the respondents described food waste as a large stream that is not separated. On the other hand, grease is separated by 73.3% of HVY waste producers, although it was only mentioned as a large stream once. The high amount of grease being separated and the high percentage of HVY waste producers describing food as a large stream may indicate the type of hospitality company to which most HVY waste producers belong.

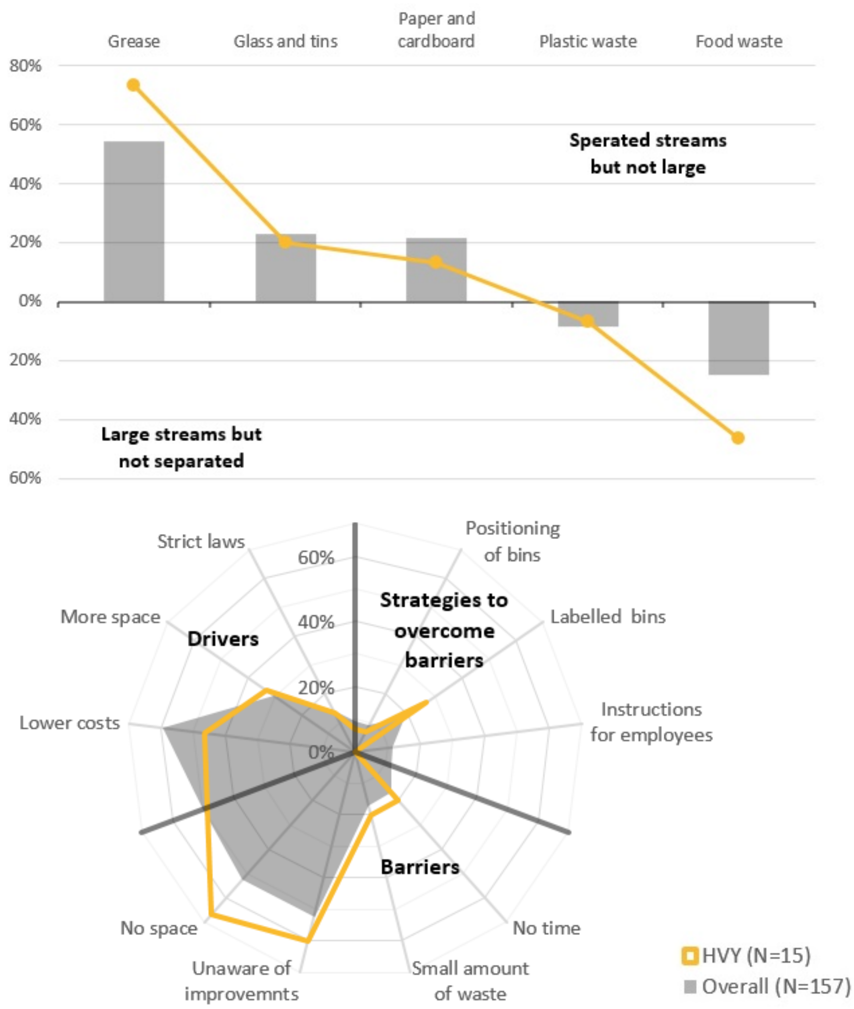


Figure 16: Most common survey responses from the HVY cluster. The upper part presents the percent of respondents who did not mention a waste stream as being large while separating it and vise-versa. The lower part depicts the percent of respondents who mentioned a certain driver, barrier or strategy to overcome barriers of waste separation. Values are displayed in Appendix J.

However, the type of company does not seem to be the only reason for the low waste separation performance, as can be observed in the lower part of Figure 16. Within the HVY cluster there are also issues with being unaware of possible improvements and space. Even reducing the costs for waste collection would only incentivise less than half of the HVY waste producers to improve their separation habits. This attitude can also be observed in the fact that HVY waste producers rate the importance of environmental issues and waste separation lowest of all the clusters (3.27 out of 5). One waste producer from the HVY cluster said during an interview, *“we could start separating more waste, but I do not see the point”* (Waste producer B, HVY cluster). To increase the separation performance of HVY waste producers, creating awareness for and a positive attitude toward waste separation is most important, specifically within the context of separating food waste. The high separation of grease indicates that it is not impossible to incentivise waste separation in the HVY cluster and can serve as a model for food waste separation.

# 5 Business Model Innovation

Based on the findings a new business model was developed for SUEZ, consisting of two elements: (1) a complete collection package and (2) customised multi-compartment bins. This chapter explains both elements in more detail, including their benefits and the needed changes to the current business model dimensions. Subsequently, the business model is evaluated using a SWOT-Analysis.

## 5.1 Complete collection package

The first business model element suggests that SUEZ offer a complete waste collection package to waste producers within the hospitality sector to collect all of their waste streams. While this contract option should be offered to new customers, it should also be incrementally introduced to existing customers. The complete collection package should be priced competitively and be cheaper than if a customer has a contract for each stream separately. Furthermore, the contract should last for a longer period to increase loyalty among customers. The collection system itself would not change for this business model element, as this is part of the customised multi-compartment bin.

The complete collection package solves several of problems identified in the survey. For one, having a complete collection package creates awareness of which waste streams could be separated within the hospitality sector. It would also provide a convenient way for waste producers to separate their waste, which can lead to higher separation performance, as depicted by previous research (Bernstad, 2014; Timlett & Williams, 2009). Furthermore, the complete collection package has financial benefits for SUEZ and would allow them to price their collection service more competitive. If they collect a larger number of well separated waste streams, each stream is more valuable and collection can be arranged more efficiently, collecting multiple waste streams simultaneously. The separation of food waste from residual waste can be especially beneficial for SUEZ because, if sorted properly, food waste can be sold and residual waste incinerated more efficiently. *"If all waste streams are mixed, it is very expensive to treat, separate and incinerate it, whereas separately some streams even have a positive value"* (Jan de Vroe, Regional Director SUEZ).

SUEZ can also benefit from increasing their market share within a highly competitive market, such as for grease. With a complete collection package, SUEZ would have a competitive advantage over other grease collectors, because they can potentially offer the same service for the same price (or cheaper), with the added benefit of offering a carefree customer experience in which the waste producer only needs one waste collector.

The complete collection package is suitable for the AVG and, to some extent, the HVY and BIG clusters, because of a high unawareness of improvements and lower collection costs as a driver. Combined, this addresses 83.1%[10] of waste producers in the hospitality sector. The LGT cluster, on the other hand, might not be as suitable for this business model element due to the issue of space not being addressed by this business model element.

Table 10: Necessary changes to implement a complete collection package. Depicts the necessary changes in each of the six dimensions of service innovations. Darker shades of blue represent more important and difficult changes. Adjusted from: (Janssen, 2015).

| | **Complete collection package** |
|---|---|
| **Value proposition** | Offer easy and carefree waste collection |
| **Value capture** | Adjust pricing system to incentive complete package |
| **Supply chain** | |
| **Customer interface** | Increase contact to customers with long-term contracts |
| **Organisational delivery system** | Increase cooperation between sales departments |
| **Technological delivery system** | |

To implement a complete collection package, several dimensions of service innovations need to change at SUEZ (Table 10). The largest and most difficult change needs to be performed within the organisational delivery system, requiring an increased cooperation between sales departments. *“Cross-selling has been on the agenda for several years, but it is proving to be a rather difficult organisational challenge for SUEZ”* (Paul Valster, Directeur New Business SUEZ). Smaller changes include offering a carefree, all-around solution to customers, as well as closer customer interaction. Finally, the revenue system must change to a revised pricing

[10] 4,105 out of 4,937 waste producers in the hospitality sector are in the BIG, AVG or HVY cluster.

system. Currently, it is often cheaper for waste producers to not separate their waste. Indeed, residual waste containers are roughly the same price as food waste containers per weight, but not per volume. As a result, *"many customers simply get a larger, relatively cheaper residual waste container and throw in their heavy waste, which would normally cost much more to collect"* (Renzo Hoebe, Service Advisor SUEZ). In a revised pricing system, the collection costs should better reflect the value of separated streams and incentivise waste producers to separate their waste.

## 5.2 Customised multi-compartment bins

The second business model element suggests that SUEZ offer customised multi-compartment bins to waste producers. Such bins would possess multiple compartments for each of the waste streams that are collected. The overall size of the container, as well as the size of each compartment would be adjusted according to the expected waste volumes. At minimum, four different bins should be available, to account for the vastly different waste generation habits of each cluster. However, smarter design solutions are possible, such as bins that can be adjusted by the waste producers themselves. For new customers with unknown waste generation habits, a generic bin could be used for a testing period, followed by adjustments, after enough data about their waste volume has been collected. The customised multi-compartment bin should primarily replace the traditional wheelie bins for the final collection. However, a similar solution should also be considered for collecting the waste within the hospitality company (for example, behind the counter of a cafe or in the customer area of a fast food restaurant). *"SUEZ does not offer a bin with multiple compartments for the customer waste, so we just throw all customer waste into the residual waste"* (Waste producer H, LGT cluster).

The customised multi-compartment bin solves several of the issues not addressed by the complete collection package: primarily, space. Collecting multiple waste streams separately, should not be an issue of space, since it does not influence the overall volume of waste generated. Space only occurs as a barrier for waste separation because the offered bins, do not suit the needed volume. Furthermore, an issue of introducing the complete collection package is waste streams with only a small volume; it would be inefficient to collect these streams in a regular-sized bin. The proposed bins are most suitable for the LGT clusters, where space is the most common driver and barrier, but other clusters are also suitable, especially in combination with the complete collection package. Furthermore, offering a combined collection in a single bin could be *"a big selling point for hospitality companies, only having the trouble of one bin being* *collected every week."* (Wienik Kruithof, Data analyst SUEZ). With the customised multi-compartment bin, SUEZ would offer an approachable, sustainable waste solution which would not only improving SUEZ's own image but also that of their customers.

Table 11: Necessary changes to implement customised multi-compartment bins. Shows the necessary changes in each of the six dimensions of service innovations. Darker shades of blue represent more important and difficult changes. Adjusted from (Janssen, 2015).

| | **Customised multi-compartment bin** |
|---|---|
| **Value proposition** | Offer customised, space-efficient, one-stop collection solution |
| **Value capture** | |
| **Supply chain** | Close cooperation with producers of collection media |
| **Customer interface** | Customise bin using customers' waste generation data; Information campaign for correct separation |
| **Organisational delivery system** | Increase cooperation between collection departments |
| **Technological delivery system** | Remodel collection system for multi-compartment bins |

To implement a customised multi-compartment bin, SUEZ needs to undertake large changes to their customer interaction and technological delivery service (Table 11). The customer interaction will no longer be limited to only the initial contract creation. Instead, SUEZ must gather and utilise customers' waste generation data to determine a suitable waste bin. This also demands an improved customer feedback system, in which waste producers can complain about and change the multi-compartment bin they currently possess. Furthermore, customers would need to be informed of how to properly separate their waste and use the multi-compartment bin correctly. Another challenge for SUEZ will be the technical implementation of the multi-compartment bin. For example, collecting glass, food waste and grease with the same truck by exchanging the whole bin instead of emptying it. Indeed, SUEZ has *"a package for garages and workshops, [...] collecting all hazardous waste streams with the same truck"* (Renzo Hoebe, Service advisor SUEZ). To overcome this issue, a geographical focus on a specific region including new and current customers could prove to be the most efficient approach, because collection systems are always tied to a regional collection centres, which also would have to be adjusted as part of the new collection system. In addition to the technical delivery system, the operational delivery system must change accordingly as increased cooperation between waste collection and treatment departments is necessary. A number of smaller changes are also required in the value system (co-developing the bin with manufacturers) and the customer interface (offering a one-stop, space-efficient collection method for multiple waste streams).

## 5.3 SWOT-Analysis

The proposed business elements possess a number of strengths and weaknesses and implementing them promises both opportunities and threats (Figure 17). The strengths of the business model elements are: an improved waste separation performance and thus, the collection of more valuable streams and cost-efficient treatment and incineration of residual waste. Furthermore, collecting all waste streams allows for the efficient collection of waste by collecting all waste streams in a single stop. The unique value proposition of a carefree, space-efficient, sustainable, one-stop complete collection service also allows SUEZ to compete in highly competitive markets and expand into appeal to additional customers. Moreover, a stepwise, regional implementation is possible, counteracting most weaknesses and threats.

Weaknesses of the proposed business elements include: their being based on a markets analysis and not the operational limitations. These limitations were considered in the description of the business model, but a deeper analysis of the feasibility is necessary before implementation. Furthermore, both business model elements work best (and in some cases only) in combination with one another. However, a simultaneous implementation could be difficult, slow and costly, because it requires changes in all six dimension of service-based business innovation and large initial investments to develop the new waste collection system.

Opportunities for the proposed business model elements is the continuous adoption of a circular economy, which requires the waste management sector to change in the future. Although the implementation might be costly and slow, it is eventually necessary. The business model elements are proposed as a mid- to long-term strategy and technological innovation could ease future implementation. The proposed business model elements could also establish SUEZ as a sustainable waste collector, not only focusing on economic but also environmental and social issues.

A major threads of the proposed business model elements is the technological lock-in that can slow or even prevent the introduction of a new collection medium (Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007). This makes it necessary for SUEZ to cooperate and co-develop the new waste bin with manufactures and to inform their customers of the advantages of the new collection system. Furthermore, competitors who focus on as single waste stream may be more efficient and cheaper due to expertise within their fields. However, SUEZ can counteract this by their unique value proposition. Finally, it is uncertain if and to what extent waste separation will improve with the introduction of the proposed business model element. Thus, it is unclear whether the added value from separated streams will cover the costs of implementation.

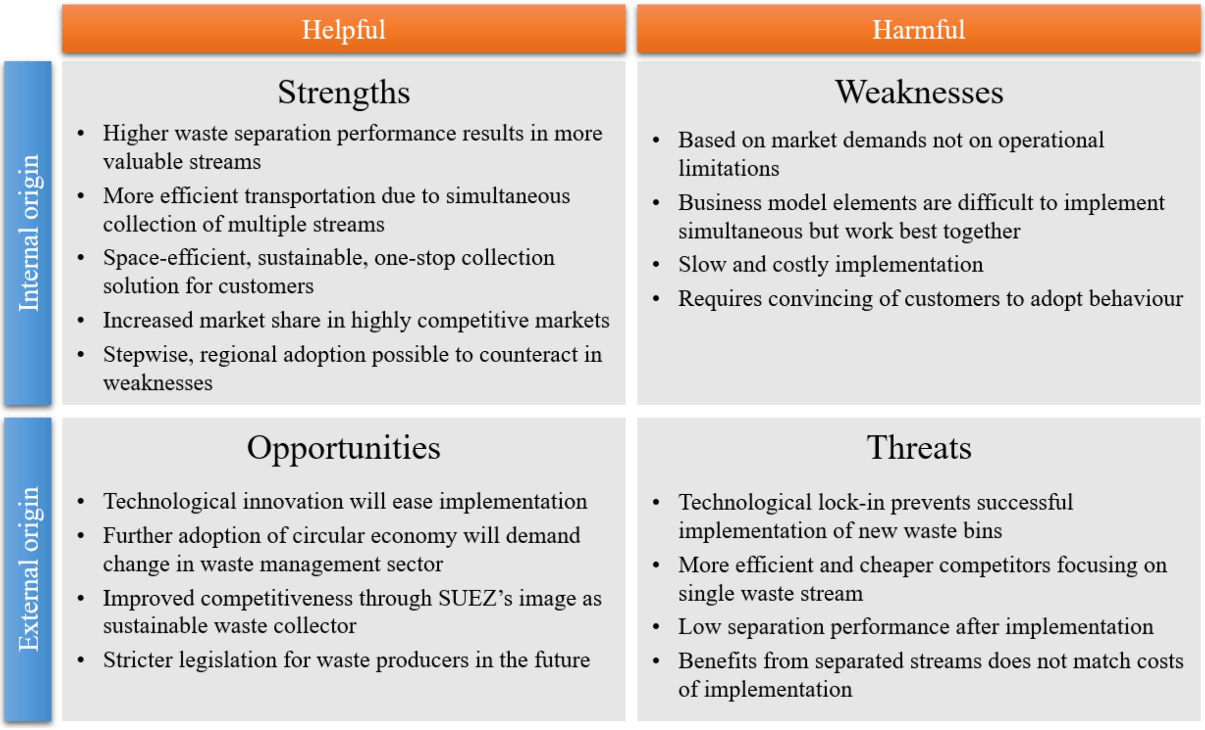


Figure 17: SWOT-Analysis for proposed business model innovation.

# 6 Conclusion

The continuous adoption of circular economy, in which no waste exists, inevitably demands changes to the waste management industry. This study identifies a circular business opportunity for private waste collectors, by enabling circularity through the purification of material streams. To develop a concrete business model and take advantage of this opportunity within the hospitality sector, distinct types of waste producers were identified using a cluster analysis. Each type was analysed in terms of waste generation and separation behaviours, as well as factors that influence their waste separation performance.

Thus, four distinct types of waste producers, with unique constellations of barriers and drivers for waste separation, were characterised. While space, time and awareness were overall the largest factors influencing waste separation, significant dissimilarities can be observed between different types of waste producers. The BIG cluster consists of medium to large waste producers with a high waste separation performance and a relatively small number of barriers and drivers. The LGT cluster consists of waste producers with light residual waste bins due to the improper separation of paper and residual waste. Space is an important barrier and driver for waste separation in this cluster. The AVG cluster represents the average waste producers with medium to low waste separation performance and have room for improvement with regard to separating plastic waste. The HVY cluster represents waste producers with a large amount of food waste and grease and low waste separation performance, primarily due to a lack of awareness and a negative attitude toward environmental issues and waste separation.

Based on those findings, the transformation toward a twofold business model was proposed: (1) offer a complete collection package and (2) introduce customised multi-compartment bins. Both concepts, on the one hand, incentivise waste producers to separate their waste by offering a convenient solution and, on the other hand, provide benefits for the private waste collector by reducing their collection and treatment costs and allowing them to collect more valuable streams. The shift toward the proposed business model elements requires private waste collectors to utilise waste generation data to identify suitable solutions for waste producers, adjust their organisational structure and innovate their technological waste collection system.

# 7 Discussion

As expected, the cluster analysis exhibited the diversity of waste generation habits within and across sectors and the potential to improve waste separation performance within the hospitality sector (Marthinsen et al., 2012; Pirani & Arafat, 2014). Although this study previously discussed the diversity of the waste market, it was unclear if and how many types of distinct waste producers could be identified. Although the cluster analysis relied on the dataset of only one waste collector, it succeeded in introducing four distinct clusters, which reflect the observations made by SUEZ experts. To reinforce validity of the identified clusters, it has been suggested to perform the same cluster analysis with the dataset from the previous year (01/11/2014 to 31/10/2015) (Dolničar, 2004; Ketchen Jr. & Shook, 1996). Comparing the cluster affinity of waste producer sites in both datasets revealed that 68.8% of waste producers are categorised in the same cluster as before. Assuming a random distribution of clusters, only 25% would be expected to be in the same cluster. Furthermore, the characteristics of the four clusters are quite similar (Appendix C). Nonetheless, further investigation of the identified clusters in different sectors is advisable and could help waste collectors segment their customers.

In terms of factors influencing the waste separation of companies, the survey exhibited similar results as previous studies (Bohdanowicz, 2005, 2006; Revell & Blackburn, 2007), with the main barriers and drivers for waste separation being awareness and convenience (lack of space and time). Compared to studies in different countries, the attitude toward environmental issues was surprisingly high, alluding to the plausibility of the possible influence of geo-political, economic and socio-cultural context on the attitude toward environmental issues (Bohdanowicz, 2006). Combining the results of the cluster analysis and survey, revealed that each cluster not only differs in waste generation and separation habits, but also in terms of drivers and barriers for waste separation. This insight should be regarded when formulating strategies to increase the waste separation of waste producers in future studies and is worth further investigation.

Incentivising waste producers to separate their waste would not seem like a substantial change to the business model of a private waste collector. However, provided thorough consideration, a surprisingly large amount of changes to all six dimensions of service-based business innovations are needed to do so. Difficult changes do not only need to be implemented in customer interaction, but also in the technological and organisational delivery systems of the waste collector. This reveals that the deeply embedded, current technological and organisation structure (lock-in) developed out of the linear economic model, which focused on the efficient disposal of waste rather than its reuse. To change this long-lasting system, not only are behavioural changes necessary, but also organisational and technical ones.

The proposed business model elements are an example of the possibility of a private waste collector generating value in a circular economy. However, they only provide a limited representation of the possibilities for private waste collectors, based on the idea of enabling circularity by purifying material streams. Indeed, many other possible approaches were discussed in interviews and during the seminar. One of the most prominent, and to some extent already implemented, business concepts views waste collectors as waste management consultants; Private waste collectors have the necessary knowledge of waste management and treatment options, as well as the data of many waste producers, allowing them to offer benchmarking skills. An example of the currently offered consultancy services of SUEZ is detailed in Appendix K. Another approach views waste collectors as resource brokers, linking the output of one company to the input of another, thereby making circles smaller and more efficient without the need for waste to be collected and treated before being reused or recycled. Within the circular economy Vision 2050, this is described as the waste and recycling sector becoming *"a broker that ensures that raw materials are collected and sorted as cleanly as possible, and that ensures that producers are supplied with sufficient high quality recyclates"* (VROM & EZ, 2016).

Overall, this research discovered surprising results in terms of the characteristics of distinct types of waste producers, which demand further investigation. The proposed business model elements delineate one possibility of the future role of waste collectors within a circular economy. However, many approaches could be considered.

# 8 Advice for SUEZ

As part of the transdisciplinary research approach of this study, the results should not only benefit science, but also be applied in practice. Thus, a number of recommendations to SUEZ are summarised.

This study depicts the usefulness of the available data at SUEZ and how it can be utilised and combined with surveys to gain an in-depth understanding of SUEZ's customers. SUEZ is recommended to value and utilise their data, as it is a unique asset to their business. As has already been done, SUEZ should place a high priority on gathering as much waste generation and separation data from their customers as possible and make the data more reliable and precise. Furthermore, the performed cluster analysis should serve as basis for deeper customer analyses, to better understand their customer bases and how marketing, sales and operational strategies should differ between customer segments. Additional indicators such as seasonal effects (summer and winter), type of company (for example fast food restaurant, snack bar or hotel) or events (such as customers issuing a complaint or visits of sales representatives) should be considered. Furthermore, a similar analysis should be repeated for different sectors, possibly with a different distribution of barriers and drivers for waste separation for each type of waste producer.

SUEZ should also extend their business strategies and try to incrementally adopt the proposed business model elements, starting on a small scale with pilot projects. However, to implement the proposed business model elements, more studies are required, especially from an operational perspective. Future studies can investigate design concepts for the proposed customised multi-compartment bins, as well as compare the potential financial benefit of separated streams with the necessary investment cost needed to implement the proposed business model. Beyond the proposed business model elements, SUEZ should continue to investigate other options and broaden its business activities as a waste management consultant and resource broker.

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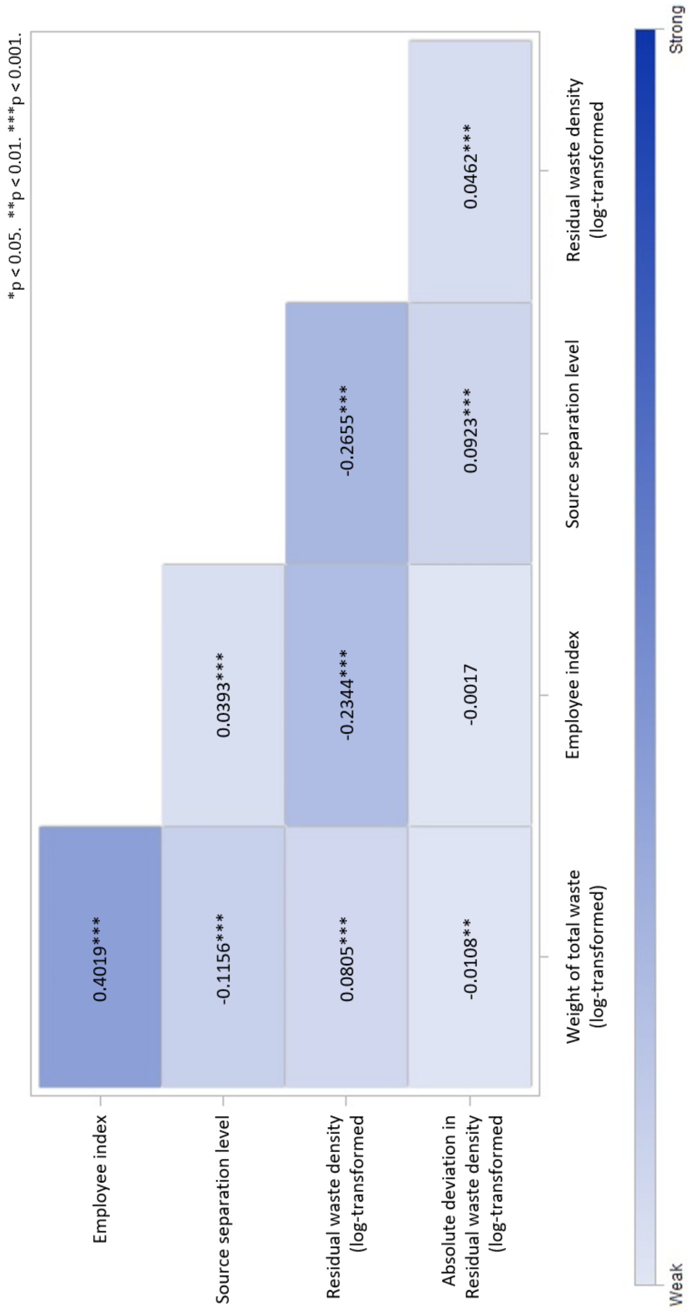
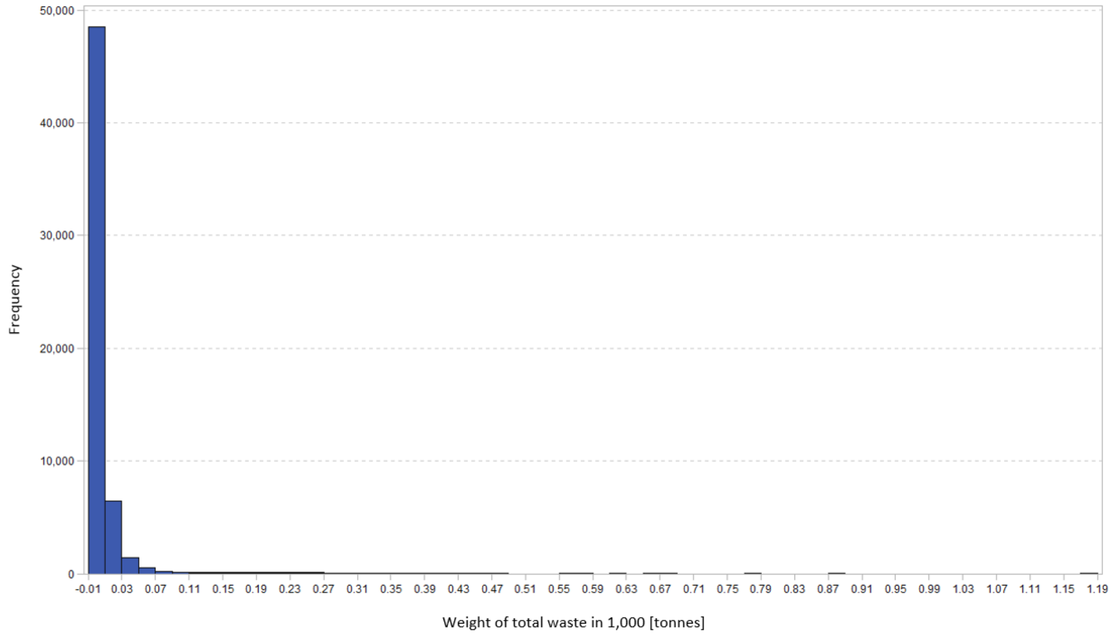
# Appendix A: Correlation of clustering variables



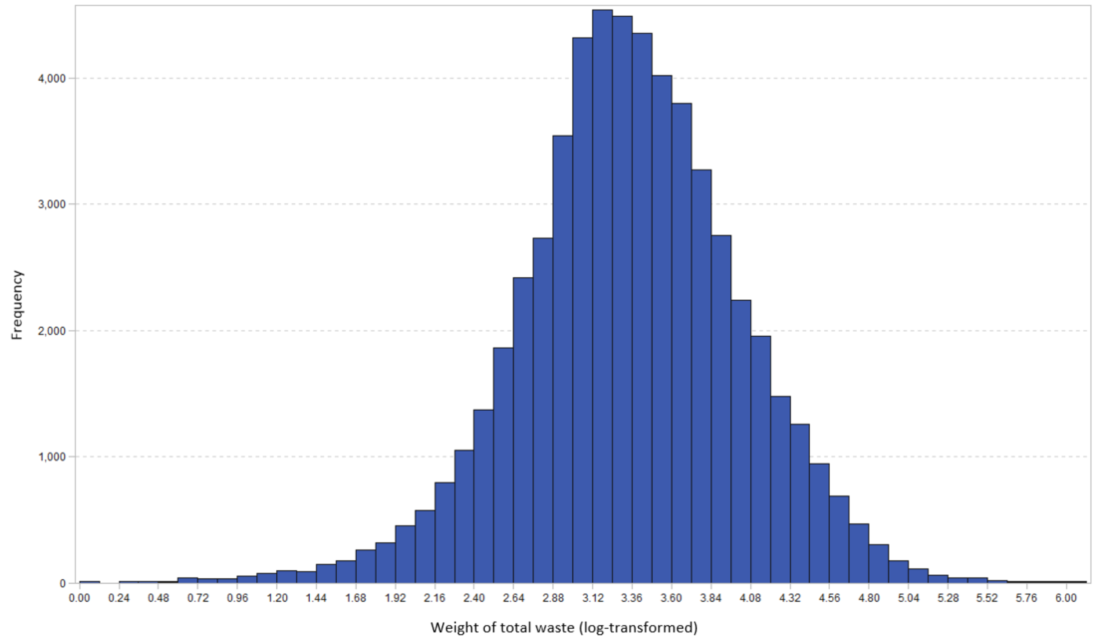
# Appendix B: Transformation of clustering variables

## B1: Weight of total waste

<u>Histogram before transformation</u>

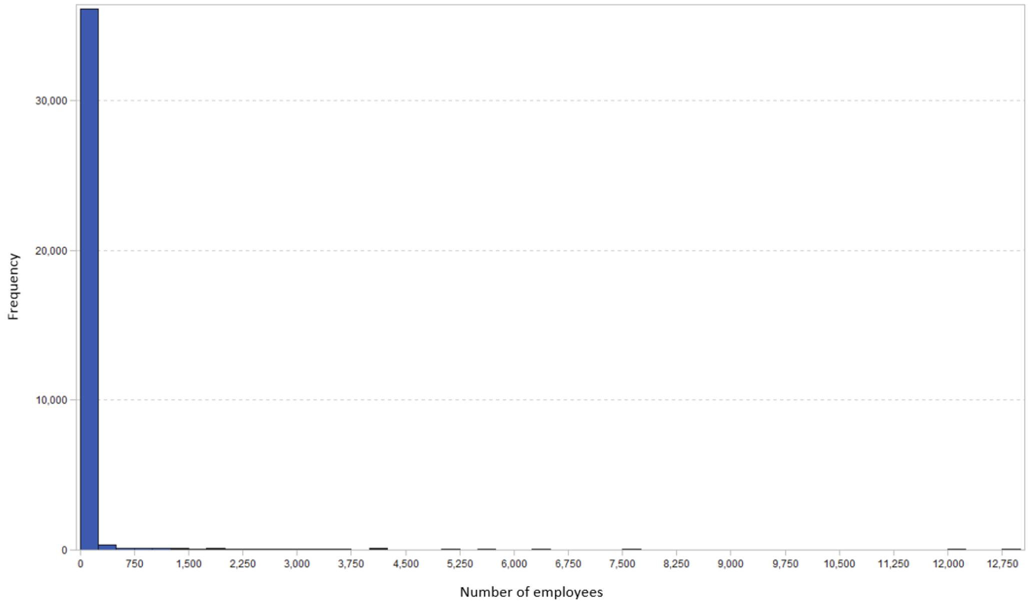



<u>Histogram after transformation</u> f(x) = log (x)



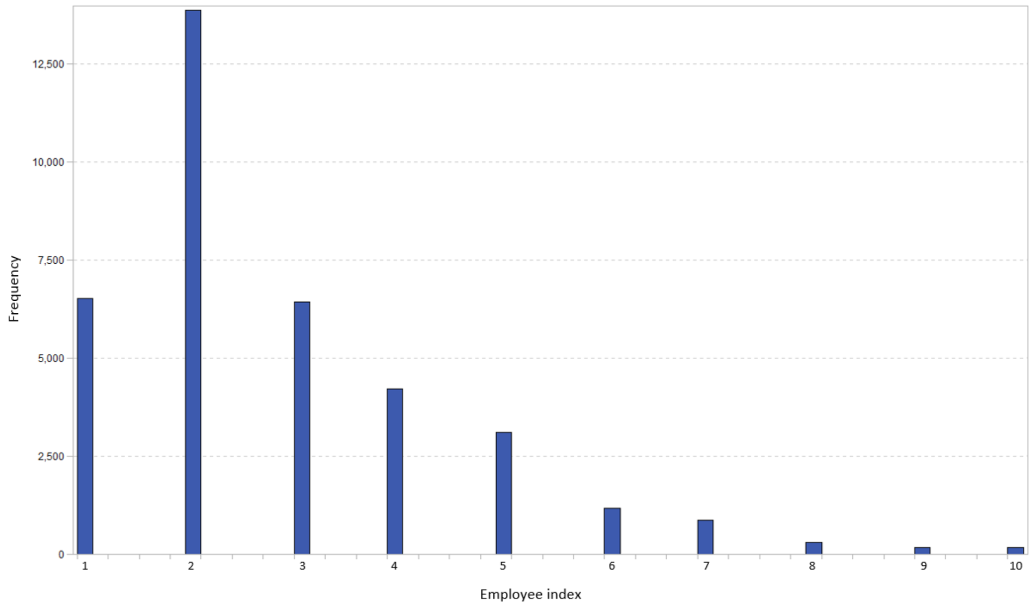
## B2: Number of employees

### Histogram before transformation



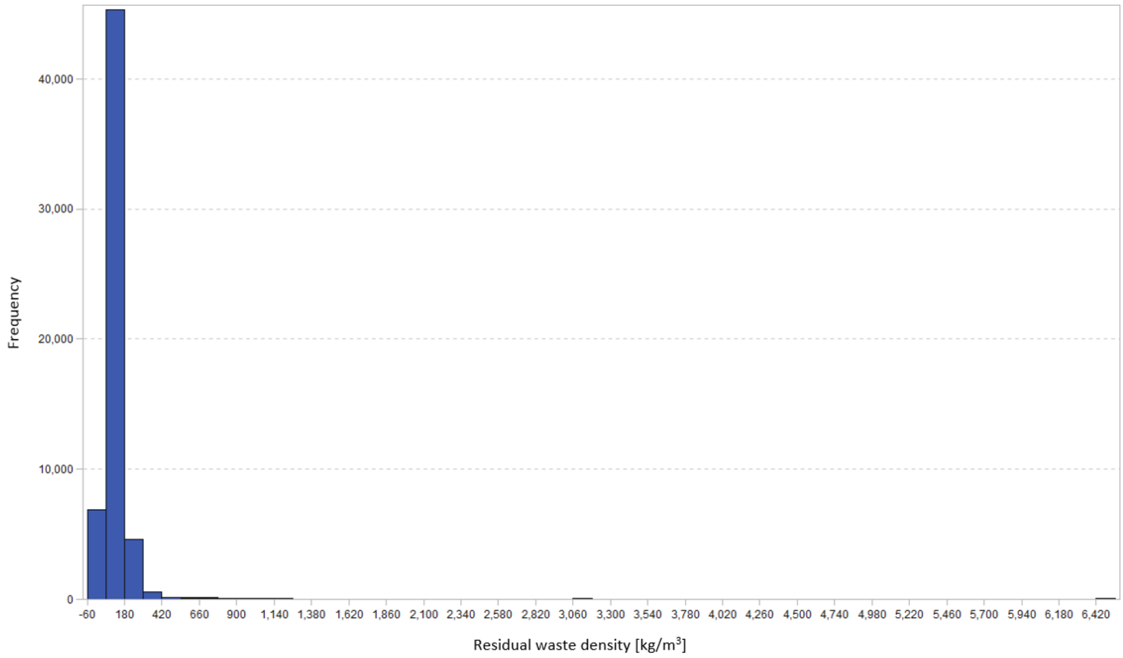

### Histogram after transformation

| Index | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Employees | 1 | 2-5 | 6-9 | 11-20 | 21-50 | 51-100 | 101-250 | 251-500 | 501-1,000 | > 1,000 |

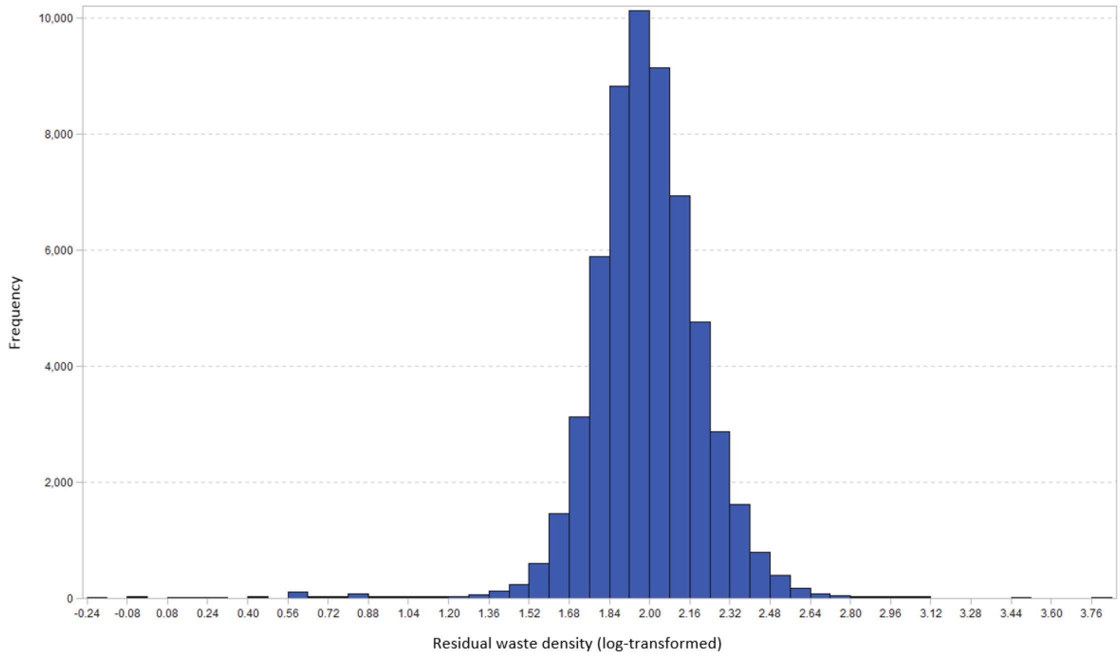


## B3: Residual waste density

Histogram before transformation

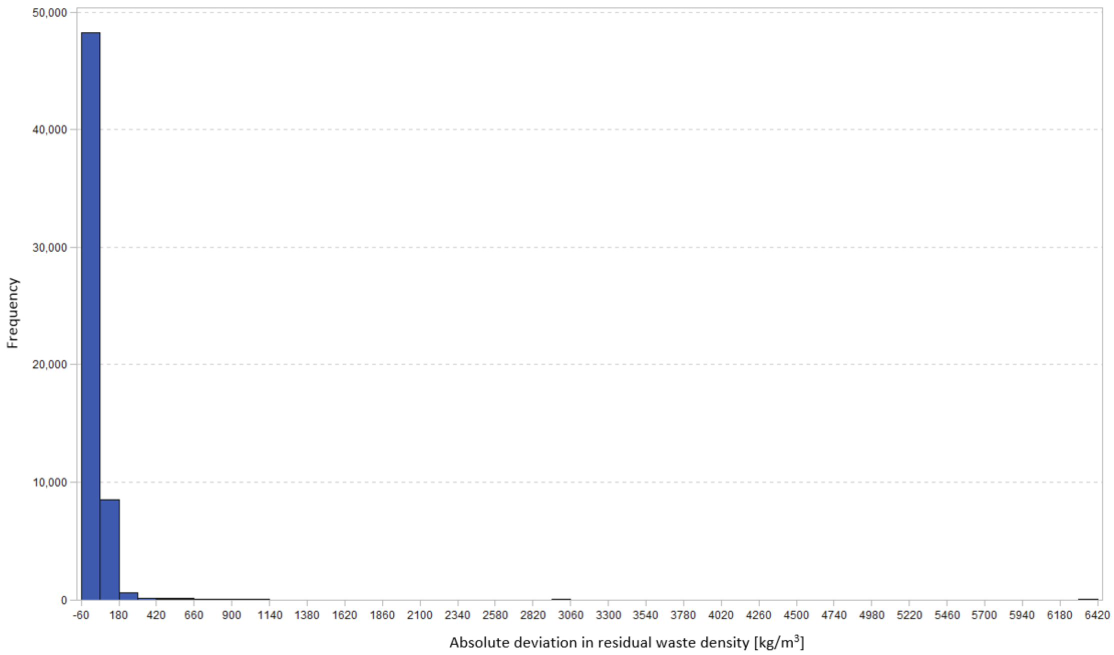



Histogram after transformation $f(x) = \log(x)$

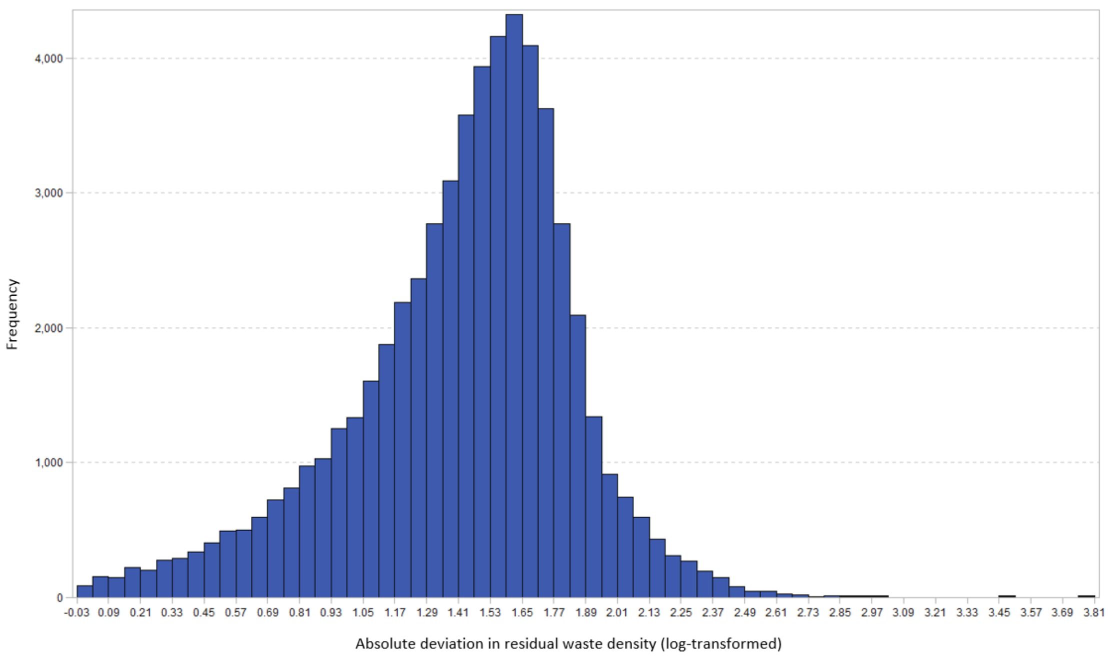


# B4: Absolute deviation in residual waste density

## Histogram before transformation




## Histogram after transformation    f(x) = log (x + 1)



# Appendix C: Comparison of clustering results

## C1: Different initial distribution

Comparison of clustering results of ten runs, with randomly selected initial cluster centres.

| Weight of total waste [tonnes] | | Fist initial distribution | Standard deviation over 10 runs | Relative standard deviation over 10 runs |
|---|---|---|---|---|
| BIG | Average | 19.27 | 0.3155 | 0.0161 |
| | Standard deviation | 38.01 | 0.1700 | 0.0044 |
| LGT | Average | 1.53 | 0.1052 | 0.0649 |
| | Standard deviation | 2.47 | 0.2310 | 0.0930 |
| AVG | Average | 3.40 | 0.2716 | 0.0753 |
| | Standard deviation | 6.44 | 0.7772 | 0.1085 |
| HVY | Average | 5.03 | 0.1082 | 0.0220 |
| | Standard deviation | 9.78 | 0.3056 | 0.0326 |

| Number of employees | | Fist initial distribution | Standard deviation over 10 runs | Relative standard deviation over 10 runs |
|---|---|---|---|---|
| BIG | Average | 122.46 | 0.7767 | 0.0062 |
| | Standard deviation | 493.99 | 1.5359 | 0.0031 |
| LGT | Average | 5.56 | 0.2619 | 0.0478 |
| | Standard deviation | 9.32 | 1.0663 | 0.1281 |
| AVG | Average | 5.22 | 0.2260 | 0.0404 |
| | Standard deviation | 7.19 | 0.7057 | 0.0790 |
| HVY | Average | 4.82 | 0.0452 | 0.0096 |
| | Standard deviation | 8.97 | 0.0761 | 0.0088 |

| Source separation level | | Fist initial distribution | Standard deviation over 10 runs | Relative standard deviation over 10 runs |
|---|---|---|---|---|
| BIG | Average | 0.28 | 0.0057 | 0.0207 |
| | Standard deviation | 0.19 | 0.0019 | 0.0099 |
| LGT | Average | 0.53 | 0.0071 | 0.0146 |
| | Standard deviation | 0.21 | 0.0010 | 0.0048 |
| AVG | Average | 0.23 | 0.0051 | 0.0222 |
| | Standard deviation | 0.16 | 0.0034 | 0.0217 |
| HVY | Average | 0.21 | 0.0034 | 0.0163 |
| | Standard deviation | 0.17 | 0.0032 | 0.0189 |

| Residual waste density [kg/m³] | | Fist initial distribution | Standard deviation over 10 runs | Relative standard deviation over 10 runs |
|---|---|---|---|---|
| BIG | Average | 81.95 | 1.3940 | 0.0169 |
| | Standard deviation | 28.99 | 0.3634 | 0.0124 |
| LGT | Average | 68.85 | 1.6776 | 0.0235 |
| | Standard deviation | 21.32 | 1.1835 | 0.0537 |
| AVG | Average | 107.74 | 0.0729 | 0.0007 |
| | Standard deviation | 17.62 | 0.1353 | 0.0083 |
| HVY | Average | 196.52 | 0.7362 | 0.0038 |
| | Standard deviation | 95.54 | 0.2793 | 0.0030 |

| Absolute deviation in residual waste density [kg/m³] | | Fist initial distribution | Standard deviation over 10 runs | Relative standard deviation over 10 runs |
|---|---|---|---|---|
| BIG | Average | 34.40 | 0.7868 | 0.0231 |
| | Standard deviation | 17.83 | 0.0303 | 0.0017 |
| LGT | Average | 42.58 | 0.8859 | 0.0218 |
| | Standard deviation | 18.22 | 0.1506 | 0.0083 |
| AVG | Average | 12.51 | 0.2414 | 0.0229 |
| | Standard deviation | 8.82 | 0.1607 | 0.0225 |
| HVY | Average | 85.08 | 0.6182 | 0.0075 |
| | Standard deviation | 94.50 | 0.3486 | 0.0038 |

## C2: Different time spans

Comparison of clustering results of two different time spans between 01/11/2015 and 31/10/2016 and between 01/11/2014 and 31/10/2015.

| **Weight of total waste** [tonnes] | | **2015-2016** | **2014-2015** | **Change** |
|---|---|---|---|---|
| BIG | Average | 19.27 | 20.23 | 0.96 |
| | Standard deviation | 38.01 | 147.98 | 109.97 |
| LGT | Average | 1.53 | 1.40 | -0.13 |
| | Standard deviation | 2.47 | 2.14 | -0.33 |
| AVG | Average | 3.40 | 3.50 | 0.10 |
| | Standard deviation | 6.44 | 6.09 | -0.35 |
| HVY | Average | 5.03 | 5.37 | 0.33 |
| | Standard deviation | 9.78 | 10.60 | 0.82 |

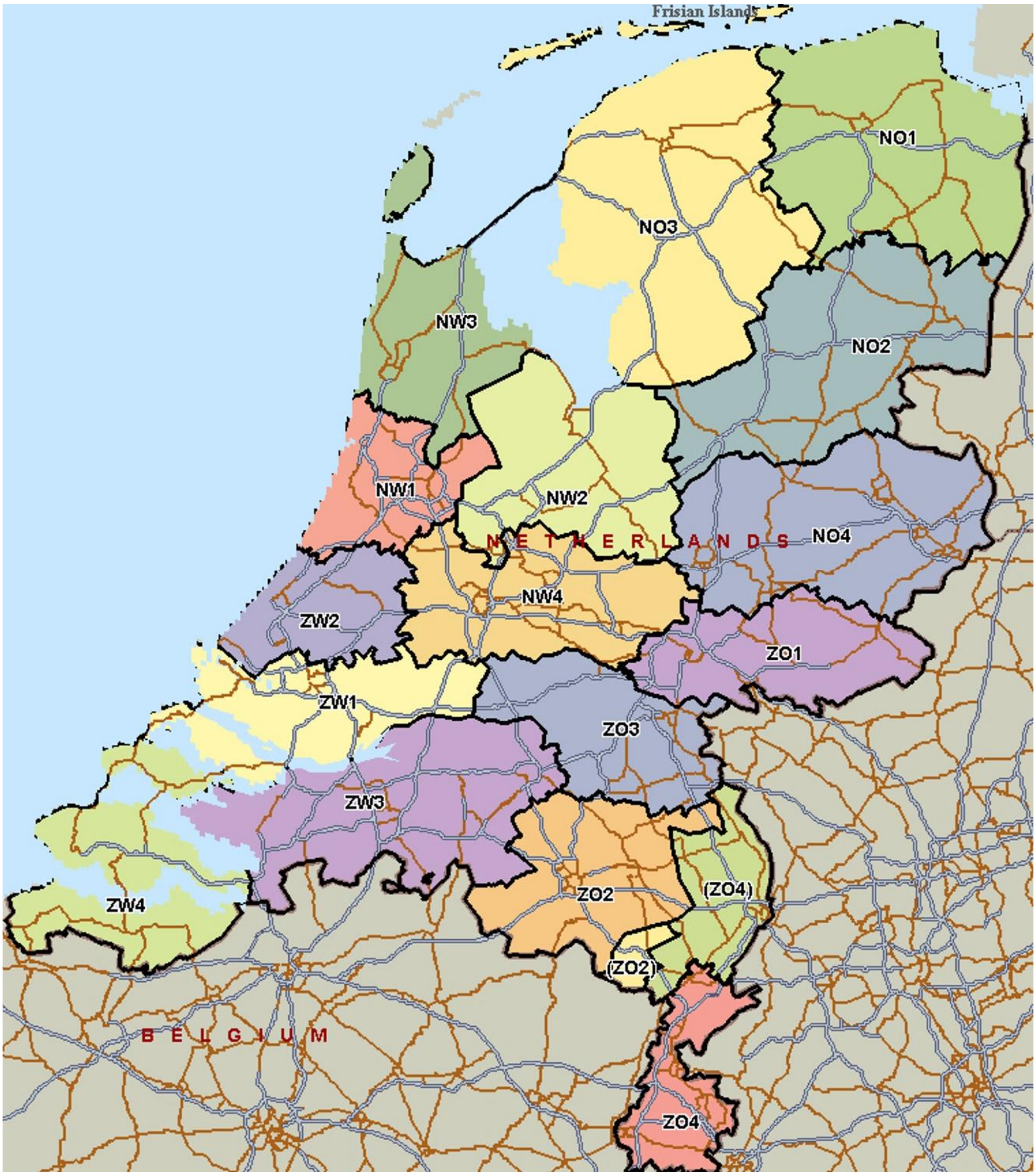
| **Number of employees** | | **2015-2016** | **2014-2015** | **Change** |
|---|---|---|---|---|
| BIG | Average | 122.46 | 122.98 | 0.52 |
| | Standard deviation | 493.99 | 469.52 | -24.46 |
| LGT | Average | 5.56 | 6.22 | 0.65 |
| | Standard deviation | 9.32 | 53.77 | 44.45 |
| AVG | Average | 5.22 | 5.53 | 0.30 |
| | Standard deviation | 7.19 | 8.05 | 0.85 |
| HVY | Average | 4.82 | 5.58 | 0.76 |
| | Standard deviation | 8.97 | 23.12 | 14.15 |

| **Source separation level** | | **2015-2016** | **2014-2015** | **Change** |
|---|---|---|---|---|
| BIG | Average | 0.28 | 0.30 | 0.03 |
| | Standard deviation | 0.19 | 0.20 | 0.01 |
| LGT | Average | 0.53 | 0.51 | -0.02 |
| | Standard deviation | 0.21 | 0.20 | -0.01 |
| AVG | Average | 0.23 | 0.23 | 0.00 |
| | Standard deviation | 0.16 | 0.15 | 0.00 |
| HVY | Average | 0.21 | 0.22 | 0.01 |
| | Standard deviation | 0.17 | 0.18 | 0.00 |

| **Residual waste density** [kg/m$^3$] | | **2015-2016** | **2014-2015** | **Change** |
|---|---|---|---|---|
| BIG | Average | 81.95 | 78.37 | -3.58 |
| | Standard deviation | 28.99 | 27.58 | -1.41 |
| LGT | Average | 68.85 | 69.07 | 0.22 |
| | Standard deviation | 21.32 | 22.22 | 0.89 |
| AVG | Average | 107.74 | 108.32 | 0.58 |
| | Standard deviation | 17.62 | 17.75 | 0.13 |
| HVY | Average | 196.52 | 201.65 | 5.13 |
| | Standard deviation | 95.54 | 105.17 | 9.63 |

| **Absolute deviation in residual waste density** [kg/m$^3$] | | **2015-2016** | **2014-2015** | **Change** |
|---|---|---|---|---|
| BIG | Average | 34.40 | 36.32 | 1.93 |
| | Standard deviation | 17.83 | 18.07 | 0.24 |
| LGT | Average | 42.58 | 43.27 | 0.69 |
| | Standard deviation | 18.22 | 17.88 | -0.34 |
| AVG | Average | 12.51 | 12.81 | 0.30 |
| | Standard deviation | 8.82 | 8.99 | 0.17 |
| HVY | Average | 85.08 | 89.98 | 4.90 |
| | Standard deviation | 94.50 | 104.25 | 9.75 |

# Appendix D: SUEZ operating regions



# Appendix E: Coded waste producer interviews

| | | |
|---|---|---|
| Importance of environmental issues | | maybe 2 out of 5[b];<br>I would say 4 out of 5[c];<br>4 out of 5[a];<br>4 out of 5[h];<br>because it is not our main issue 4 out of 5, still behind finance[i];<br>not important to us at all[b];<br>not important for use[d];<br>I would say it is somewhat important[e];<br>somewhat important for us[c];<br>not most important but still rather important[a];<br>personally it is important[h];<br>it is more and more important[i];<br>it gets more and more important for us[g];<br>I think the environment is an important issue for us all[f]; |
| Importance of waste separation | | 2 out of 5[b];<br>the same, 3 out of 5[e];<br>4 out of 5[c];<br>about the same 4 out of 5[i];<br>for waste separation 4 out of 5[g];<br>5 out of 5[f];<br>not very important[b];<br>not important[d];<br>it is important[c];<br>I think this is important[g];<br>even more important[a];<br>similar to environmental issues[h];<br>I think we are doing really well in separation[f]; |
| Waste generation habits | Large waste streams | rest waste is the biggest[f];<br>by volume I would say residual waste and maybe also paper[a];<br>we have a lot of residual waste but also glass and food leftovers[b];<br>glass and rest waste are the biggest[g];<br>plastic and glass are biggest[c];<br>biggest streams are glass, paper and residual[d];<br>biggest are plastic and paper[e];<br>carton and plastic (from wrapping) [h];<br>food, rest and glass[i];<br>food maybe 30-40%, glass 20%, paper 20%[b];<br>food waste not as much due to high efficiency and little waste[h] |
| | Residual waste | our bins are quite heavy[a];<br>quite heavy I guess but I am not sure[b];<br>our bin is always full, we might order another pick-up during high season[c];<br>it is quite full when picked up[i];<br>my bins are quite light because of the biodegradable packing I have to throw in with the residual waste[f];<br>not full most of the year, so they are very light[h];<br>the bins are normally quite empty but in summer they pick it up twice per week[e];<br>the bins are sometimes full but sometimes not[g];<br>we have a lot of bones, cans and food waste in our residual waste[a];<br>we could also separate compost, glass, or plastic[f];<br>we could separate better I think, especially separation of food and residual waste can be improved[g];<br>mainly the client waste could be separated better[h];<br>we could separate a bit more precise[i] |

| | | |
|---|---|---|
| Waste separation habits | Separated waste streams | we only have residual waste nothing else[b];<br>we separate residual waste and cardboard/paper[a];<br>we separate rest and paper[e];<br>paper and cardboard, as well as rest waste[f];<br>we separate glass, paper and residual[d];<br>we separate plastic, glass and residual waste[c];<br>plastic, paper, glass and residual[i];<br>residual, plastic, cardboard, glass[h];<br>at the moment glass, residual, paper, and grease[g];<br>we also have grease separately[b];<br>food is stored in tanks and picked up only every 2-3 weeks[i] |
| | Waste streams not collected from SUEZ | no, all streams are collected by SUEZ[a];<br>all our streams are picked-up by SUEZ[c];<br>all streams are collected by SUEZ[d];<br>no, all by SUEZ[f];<br>we sell our used grease to a company[b];<br>grease is collected separately[g];<br>glass goes behind the house, there is a container from the city[e];<br>glass goes to a public glass container[h];<br>plastic we throw away at the municipality for free[h];<br>paper is being picked-up/donated[h];<br>only the food leftovers are collected by green point[i]; |
| Drivers, barriers and strategies | Drivers for waste separation | maybe if the costs were lower we could separate more[a];<br>potentially money would help to separate waste[c];<br>maybe money[d];<br>financial incentives like paying less if my waste is separated[h];<br>lower costs for separated waste or being able to sell the waste[i];<br>having more space for bins[h];<br>more space[i];<br>if we would have more of a stream we could separate it[a];<br>waste is important for clients[f];<br>it is easier to handle the waste separately[d];<br>if streams would be separated directly it would help[f];<br>it can be dangerous to mix waste, especially with wine bottles, but nothing happened yet, I think if an accident happened my boss might change the waste separation[b];<br>SUEZ picks up material not waste[f];<br>SUEZ said I need to separate[e] |

| | | |
|---|---|---|
| Drivers, barriers and strategies | Barriers for waste separation | space can also be a problem[g];<br>we have no space to put extra bins[b];<br>also behind the bar there is no space for extra bin[b];<br>we do not have space in the restaurant[c];<br>mainly space[h];<br>space is the biggest issue[e];<br>we only have one waste bin for customers due to space[h];<br>no space to have another bin for customers or have containers in the back[h];<br>I do not think it is necessary to separate more streams[d];<br>we could start separating more waste but I do not see the point[b];<br>no room for improvement[a];<br>not much room for improvement to be honest[e];<br>we are doing quite well already[h];<br>we separate our waste well[a];<br>we do not have time[b];<br>we are too busy with the business[b];<br>we also have no time to separate the waste[c];<br>too busy (time) [i];<br>we do not have other waste types at least not in a large volume[d];<br>we do not have more of any stream[a];<br>not more to separate[a];<br>we only have few streams[d];<br>employees can sometimes be a problem, not separating the waste properly[g];<br>employees do not separate properly, specifically rest and plastics[i];<br>SUEZ did not offer me a better deal to pick up my waste[f];<br>I have biodegradable packaging but SUEZ cannot pick it up from me[f];<br>SUEZ does not offer a bin with multiple compartments for the customer waste[h];<br>I do not need the big container I have at the moment but if I take a smaller one, I would have to order extra pickups in high season, financially that would be more expensive[h];<br>having containers in the street is sometimes bad because neighbours can throw in the wrong waste[c];<br>sometimes it is not really functional to separate waste[i];<br>I think it is important for the environment but I cannot change the problems[c];<br>it can be hard to implement it in my business[f] |
| | Strategies to overcome barriers for waste separation | we do not have any strategies in place[a];<br>we do not have any[b];<br>no, we do not have any[c];<br>we do not have bins labelled[a];<br>labels on the bins that show what goes into them[g];<br>we clearly marked our plastic bin[h];<br>paper is collected in a paper box so that it is obvious[h];<br>we have a separate tray for food waste[i];<br>we have some bins outside to make sure bins are not confused[g];<br>waste separation is mentioned in out employee handbook, describing how waste should be separated[i] |

[a-i] indicates waste producer (Table 4)

# Appendix F: Survey questions

F1: Questionnaire – English

Thank you for taking the time to answer questions about your waste separation. The questionnaire will take approximately 5 minutes to complete. All answers are confidential and no specifics about your company will be shared.

*0) What is the name of your company?*

*1) How important are environmental issues for your company?*

Scale from 1 to 5 (1: Not important, 5: Very important)

*2) How important is waste separation for your company?*

Scale from 1 to 5 (1: Not important, 5: Very important)

*3) What do you think are the largest waste streams of your company?*

- Residual
- Plastic
- Paper and cardboard
- Food waste
- Tins and glass
- Used grease
- Other

*4) Which of the following waste streams do you currently separate?*

- Residual
- Plastic
- Paper and cardboard
- Food waste
- Tins and glass
- Used grease
- Other

*5) Do you have waste streams that are not collected by SUEZ? Which once?*

- Residual
- Plastic
- Paper and cardboard
- Food waste
- Tins and glass
- Used grease
- None
- Other

*6) Where do you see room for improvement in your current waste separation?*

- Separate more streams
- Separate current streams better
- My waste streams are already separated probably
- Other

*7) What problems do you encounter when separating your waste?*

- No space for extra bins
- No time to separate waste
- Employees do not separate correctly
- Not enough volume of a certain waste stream to be worth separating
- Other

*8) How are you trying to overcome those problems?*

- Teach new employees how to separate waste
- Cleary mark bins with the type of waste
- Positioning bins apart from each other to prevent confusion
- Other

*9) What would encourage your company to separate your waste better?*

- Paying less for waste when it is separated
- Being able to sell separate waste streams
- More space for bins to separate in
- Having more volume of a specific waste stream
- Strictly enforced separation laws
- Customers demanding better separation
- To be convinced that separation is important for the environment
- Other

*10) There are big differences between restaurants in terms of how heavy their residual waste bins are. Where would you rank your residual waste bins?*

- Heavy: Due to heavy waste (e.g. waste containing a lot of water)
- Heavy: Due to pressing waste tightly
- Medium
- Light: Due to light, bulky waste (e.g. cardboard)
- Light: Due to not completely filling the bin before pickup

*11) Is there anything else you missed in the survey and would like to point out?*

## F2: Questionnaire – Dutch

Bedankt dat u de tijd neemt om deze enquête over afvalscheiding in te vullen, dit zal ongeveer 5 minuten in beslag nemen. Alle antwoorden zijn vertrouwelijk, bedrijfsspecifieke gegevens zullen niet worden gedeeld met derden.

*0) Wat is de naam van uw bedrijf?*

*1) Hoe belangrijk zijn milieu-gerelateerde zaken voor uw bedrijf?*
Op een schaal van 1 tot 5 (1: Niet belangrijk; 5: Zeer belangrijk)

*2) Hoe belangrijk is afvalscheiding voor uw bedrijf?*
Op een schaal van 1 tot 5 (1: Niet belangrijk; 5: Zeer belangrijk)

*3) Wat zijn de grootste afvalstromen in uw bedrijf?*

- Restafval
- Plastic
- Papier and karton
- Voedsel
- Blik en glas
- Anders

*4) Welke van de onderstaande soorten afval scheidt u op het moment?*

- Restafval
- Plastic
- Papier and karton
- Voedsel
- Blik en glas
- Gebruikt vet
- Anders

*5) Zijn er afvalstromen binnen uw bedrijf die niet door SUEZ worden ingezameld? Welke?*

- Restafval
- Plastic
- Papier and karton
- Voedsel
- Blik en glas
- Gebruikt vet
- Geen
- Anders

*6) Waar ziet u ruimte voor verbetering in uw huidige afvalscheiding?*

- Meer afvalstromen scheiden
- Huidige afvalstromen beter scheiden
- Mijn afvalstromen worden al goed gescheiden
- Anders

*7) Welke problemen komt u tegen bij het scheiden van uw afval?*

- Geen ruimte voor extra containers
- Geen tijd om afval te scheiden
- Mijn werknemers scheiden het afval niet op de juiste manier
- De hoeveelheid afval per afvalstroom is zo weinig dat het niet de moeite waard is om te scheiden
- Anders

*8) Hoe heeft u geprobeerd deze problemen op te lossen?*

- Nieuwe medewerkers leren hoe afval gescheiden dient te worden
- De afvalstroom duidelijk weergeven op de afvalbakken
- De afvalbakken niet bij elkaar plaatsen, om zo verwarring te voorkomen
- Anders

*9) Wat zou u stimuleren om afval in uw zaak beter te scheiden?*

- Minder betalen voor afval als het gescheiden is
- In staat zijn om verschillende afvalstromen te verkopen
- Meer ruimte voor afvalbakken
- Meer volume van een bepaalde afvalstroom
- Als het scheiden van afvalstromen wettelijk verplicht is
- Als klanten vragen om betere afvalscheiding in uw bedrijf
- Als u duidelijk overtuigd wordt dat afvalscheiding echt bijdraagt aan een beter milieu
- Anders

*10) Er zitten grote verschillen tussen bedrijven als het aankomt op het gewicht van hun afval-containers. Hoe zwaar denkt u dat uw afvalcontainers zijn?*

- Zwaar: Als gevolg van zwaar afval (bijv. afval dat veel water bevat)
- Zwaar: Doordat het afval strak aangedrukt wordt
- Gemiddeld
- Licht: Door licht afval met veel volume (bijv. karton)
- Licht: Doordat de bak niet volledig vol zit als ‘ie geleegd wordt

*11) Is er iets dat u gemist heeft in deze enquête, en graag wilt benoemen?*

F3: Interview

1) *How important are environmental issues for your restaurant?*
2) *How important is waste separation for your restaurant?*

3) *What do you think are the largest waste streams of your restaurants?*
4) *How does your restaurant currently sort their waste?*
5) *Do you have waste streams that are not collected by SUEZ?*

6) *Where do you see room for improvement in your current waste separation?*
7) *What problems did/do you encounter when separating your waste?*
8) *How did you/are you trying to overcome those problems?*
9) *What does/would encourage your restaurant to separate your waste better?*

[Explain their performance compared to other restaurants, in terms of waste density and source separation level]

10) *Why do you think your waste separation performance is so high/low?*

11) *Is there anything else you would like to mention about your waste separation?*

# Appendix G: Interview summaries

## G1: Wienik Kruithof

Arnhem, 28 February 2017

*Available data*

SUEZ has external data from all in the Netherlands registered companies, including number of employees, sector and address. Additionally, SUEZ's trucks collect data via an onboard computer when they pick up a waste container (weight, volume, waste type). Also, SUEZ has data from all sales personnel, when they called or visited customers.

*Variables for waste separation performance*

It is important what types of waste streams a company has, how heavy their waste is and how high their separation rate is (non-residual waste compared to overall). With the weight and volume of the waste bins, SUEZ can also calculate the waste density, which can be an important indicator. Other indicators can be the sector and size of the company, as well as weather and seasonal factors.

*Waste density*

Every sector has its own expected residual waste density, but overall SUEZ expects an ideal residual waste density of 90 $kg/m^3$. If a company's residual waste density is around that value, SUEZ can be quite certain that no other streams is mixed with the residual waste. This indicator might not work for a single case and at a single point in time, but over a large amount of data 90 $kg/m^3$ can be expected. If bins are too heavy SUEZ makes a loss, thus the waste density can be used to find companies where waste separation should be checked.

*Combined collection*

Offering combined collection could be a big selling point for restaurants, only having one bin collected every week. But, it would be very difficult to predict the exact amount of waste a company will generate. If a company only has only residual, it cannot be equally divided into different streams, but rather each of the streams has a different amount. However, data can be a very powerful tool to estimate the waste generation of companies.

## G2: Ahmet Oksuz

Amsterdam, 24 January 2017

*Competition*

SUEZ’s share in paper waste is rather low, because the waste collector form the city of Amsterdam is much cheaper. The same goes for grease and food waste with different competitors. SUEZ mostly focuses on residual, paper, cardboard and glass waste.

*New customers*

If a new company is registered, a salesman from SUEZ drives there and ask if they already have someone for their waste collection. If not, an appointment is arranged at which the salesman show them which waste streams they are obligated to separate by law. If a contract is made, normally a limit of 100kg/$m^3$ is set for residual waste and customers pay more if their bins are heavier.

*Hospitality sector*

The hospitality sector mainly has residual, paper and glass waste. In Amsterdam, space is a huge issue for restaurants since they cannot put their container outside because of the APV. Furthermore, restaurants are not obligated to separate their waste, if they do not have large amounts or space for waste bin.

*Combined collection*

Combined collection is difficult because each type of waste has a different pickup time (e.g. daily or weekly). SUEZ sometimes collects glass and food waste combined and in those cases the waste bins are exchanged rather than emptied. Maybe the same could be implemented for paper and residual waste. However, companies always calculate if it worth it for them to separate. It is a trade-off between how long it takes to separate the waste and how much cheaper the collection would be.

## G3: Renzo Hoebe

Amsterdam, 24 January 2017

*Competitors*

One reason for SUEZ collecting a relatively small amount of plastic waste, is that many companies simply throw their waste into public containers for the municipality. Those containers are only for the residents of that area, but companies still use them. This is also the case for glass and paper to some degree. For grease it is different, it is very common that competitors of SUEZ collect it.

*Hospitality sector*

The hospitality sector is big and has a lot of waste. The ideal restaurant would separate food, glass, paper, residual and grease, but the current separation could be a lot better. SUEZ could offer a package of grease, glass and food waste for one price, the pickup might even be more efficient if SUEZ drives there anyway.

*Food waste collection*

Compared to other streams, food waste is very expensive if collected by SUEZ. For example, a 120-liter container that can be filled with food or vegetables (picked-up once per week) will cost about 55-60 euros. For the same price you can get a 660-liter container for residual waste. This is because of the higher density of food waste: in terms of weight the costs are the same but in terms of volume residual waste is much cheaper. Because the weight of the containers is not checked very often, most customers take a large, but relatively cheap residual waste container and just throw in their food waste.

*Combined collection*

We have one truck that collects glass, grease and food waste at the same time. They take the whole container with them and hand out a new one. This is quite common for glass, food and grease but SUEZ still has a separated container for paper and residual waste. SUEZ also offers a package for garages and workshops, where SUEZ collects all hazardous waste streams with one truck.

## G4: Jan de Vroe

Amsterdam, 13 September 2016

*SUEZ operations*

From small companies SUEZ collects paper, food waste, glass and foils in wheelie bins 7 days a week. Besides that, SUEZ has large, open containers with 10-40 $m^3$ of volume, for example used for building and construction waste.

*New customer*

If the new customer is for example a restaurant, SUEZ already knows the type of waste they will have (glass, food and burnable waste) but not the volumes. Normally someone from SUEZ visits the client, looks at the situation and makes a proposition. Some customers are more engaged in their waste than others and ask for specific solutions to save money or to be more environmentally friendly.

*Mono waste streams*

There are a large number of different mono streams. If you look at plastic, there are standard products such as foil, but also other kinds of non-standard products used for packaging. There is not always an economic incentive to separate mono streams and SUEZ only starts collecting them separately if it is worth it. For some streams, companies are obligated by law to separate them, if they generate above a certain amount per week. For example, in the case of paper, food spills, glass and foils.

*Barriers for waste separation*

The reasons why companies do not separate their waste are varied: no space, no time, being unaware of the value of their waste, or it is simply not important to them. Waste separation is a bigger problem in smaller companies, because large companies are more aware of which streams they should separate.

*Billing*

SUEZ is trying to factor in the actual weight of the waste to bill their customers. But it is also important that if all waste streams are mixed, it is very expensive to incinerate the waste, whereas separately some streams even have a positive value.

## G5: Luc Verhagen

Arnhem, 14 September 2016

*Waste management consulting*

SUEZ.Scope offers basic insides for companies: what waste they produce, how much they pay for their waste collection and how they compare to other companies. More in-depth analyses are also possible if customers struggle with specific problems. SUEZ tries to offer this service over a longer period of time, to see if implemented measures change the statistics over time.

*SUEZ's business opportunities*

Look at SUEZ's vision, it is described as 3 Cs: circular, concrete and co-creation. An example of this vision implemented into reality could be with carpet. A large percent of the weight of carpets is chalk (cretaceous). But there are some chemical company that have chalk as a waste, so this can be connected. SUEZ could assist with what they are good at: sorting. SUEZ will not become a broker for carpet tiles, but the manufacturer of carpets will not become that either. A solution could be to create a new company, using the waste separation expertise of SUEZ and the manufacturing expertise of a carpet producer.

*Sustainability trend*

There are two types of companies. One are companies who really want to do something about environment and about CO2 reduction. But there are also companies who only want to show that they do something sustainable. More and more companies really want to do something about environmental impact, which is why SUEZ is being asked for advice more and more often. Not only to solve problems with waste, recycle or reuse, but also to reduce the waste in the first place.

*Cannibalising SUEZ's core business*

If SUEZ.Scope suggests to their customers to reduce their waste, it is also cannibalising SUEZ's core business of collecting waste. However, collecting and treating waste is not very profitable, whereas consultancy can be. If SUEZ implements a consultancy approach in the future, they will make less revenue but be more profitable.

## G6: Jan van Zon

Arnhem, 5 October 2016

*SUEZ waste treatment*

SUEZ has one incinerator in Rosenthal and is partly owner of one, on the other side of the boarder in Emlichheim near Coevorden. Furthermore, SUEZ also does some treatment of hazardous waste and has two big sorting plants: one for construction and demolition waste in Groningen and one for plastic in Rotterdam.

*Dutch waste legislation*

The EU sets the baseline for waste regulation for all European countries in their waste directive. In the Netherlands, all companies need to contract a certified waste company, like SUEZ, to collect their waste. However, if a company only produce as much waste as a normal household it is sometimes handled by the municipality, but this is not officially in law.

*Municipal solid waste*

The difference between municipal solid waste and industrial waste is not always clear. If SUEZ picks up municipal solid waste, it is normally only transportation of waste and not collection. In these cases, the municipality only contracts SUEZ to transport the waste, but SUEZ does not become the owner it. For commercial and industrial waste, normally SUEZ owns the waste after collection and can decide which treatment company can further handle the waste.

*Hazardous waste*

The requirements for hazardous waste are more or less the same. Companies need contract a registered waste collector, who might require a special permit, depending on the type of hazardous waste.

*Reuse waste*

To be allowed to reuse waste, SUEZ needs to argue that they change the waste to something with valuable. The legislation is not really preventing this from happening, as long as the recycler argues about it. The design process of products is more important to enable reuse and recycling of waste.

# Appendix H: Results of cluster analysis

| **Weight of total waste** [tonnes] | **BIG** | **AVG** | **LGT** | **HVY** | **Overall** |
|---|---|---|---|---|---|
| Lower Whisker | 0.02 | 0.01 | 0.00 | 0.01 | 0.00 |
| First Quartile | 4.35 | 0.89 | 0.34 | 0.94 | 0.88 |
| Average | 19.27 | 3.40 | 1.53 | 5.03 | 6.98 |
| Median | 9.11 | 1.73 | 0.89 | 2.22 | 2.18 |
| Third Quartile | 20.53 | 3.69 | 1.84 | 5.41 | 5.89 |
| Upper Whisker | 44.70 | 7.90 | 4.08 | 12.11 | 13.40 |

| **Number of employees** | **BIG** | **AVG** | **LGT** | **HVY** | **Overall** |
|---|---|---|---|---|---|
| Lower Whisker | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| First Quartile | 16.00 | 2.00 | 2.00 | 1.00 | 2.00 |
| Average | 122.46 | 5.22 | 5.56 | 4.82 | 30.02 |
| Median | 31.00 | 3.00 | 3.00 | 3.00 | 5.00 |
| Third Quartile | 74.00 | 6.00 | 7.00 | 6.00 | 12.00 |
| Upper Whisker | 161.00 | 12.00 | 14.00 | 13.00 | 27.00 |

| **Source separation rate** | **BIG** | **AVG** | **LGT** | **HVY** | **Overall** |
|---|---|---|---|---|---|
| Lower Whisker | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| First Quartile | 0.14 | 0.11 | 0.38 | 0.08 | 0.14 |
| Average | 0.28 | 0.23 | 0.53 | 0.21 | 0.30 |
| Median | 0.24 | 0.21 | 0.52 | 0.16 | 0.26 |
| Third Quartile | 0.38 | 0.32 | 0.66 | 0.28 | 0.42 |
| Upper Whisker | 0.75 | 0.63 | 1.00 | 0.58 | 0.84 |

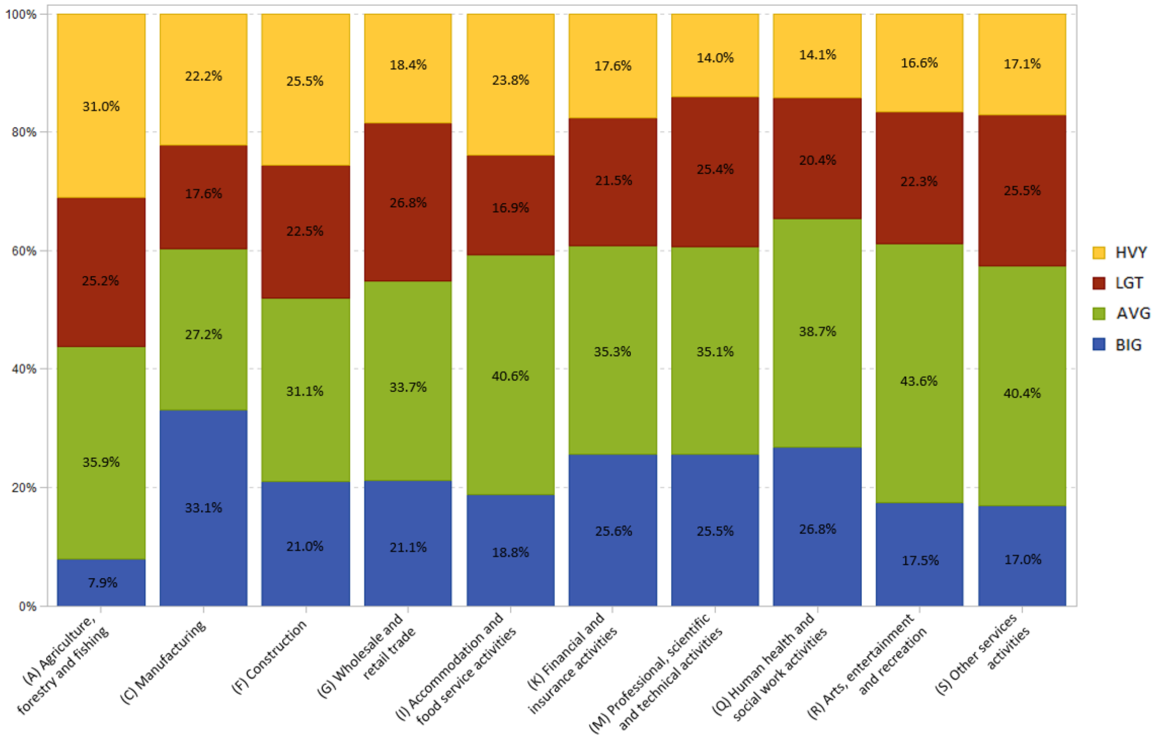
| **Residual waste density** [kg/m$^3$] | **BIG** | **AVG** | **LGT** | **HVY** | **Overall** |
|---|---|---|---|---|---|
| Lower Whisker | 18.76 | 57.73 | 22.13 | 69.28 | 0.59 |
| First Quartile | 62.66 | 94.80 | 57.01 | 154.27 | 73.51 |
| Average | 81.95 | 107.74 | 68.85 | 196.52 | 109.73 |
| Median | 76.24 | 106.72 | 69.78 | 176.42 | 96.50 |
| Third Quartile | 93.02 | 119.87 | 80.30 | 213.86 | 130.30 |
| Upper Whisker | 138.57 | 157.40 | 114.86 | 303.17 | 215.45 |

| **Absolute deviation in residual waste density** [kg/m$^3$] | **BIG** | **AVG** | **LGT** | **HVY** | **Overall** |
|---|---|---|---|---|---|
| Lower Whisker | 0.03 | 0.00 | 2.17 | 20.17 | 0.00 |
| First Quartile | 21.39 | 5.39 | 29.27 | 43.42 | 14.85 |
| Average | 34.40 | 12.51 | 42.58 | 85.08 | 38.84 |
| Median | 32.64 | 11.27 | 39.49 | 64.00 | 30.08 |
| Third Quartile | 45.70 | 18.14 | 52.54 | 100.81 | 49.09 |
| Upper Whisker | 82.07 | 37.24 | 87.43 | 186.80 | 100.46 |

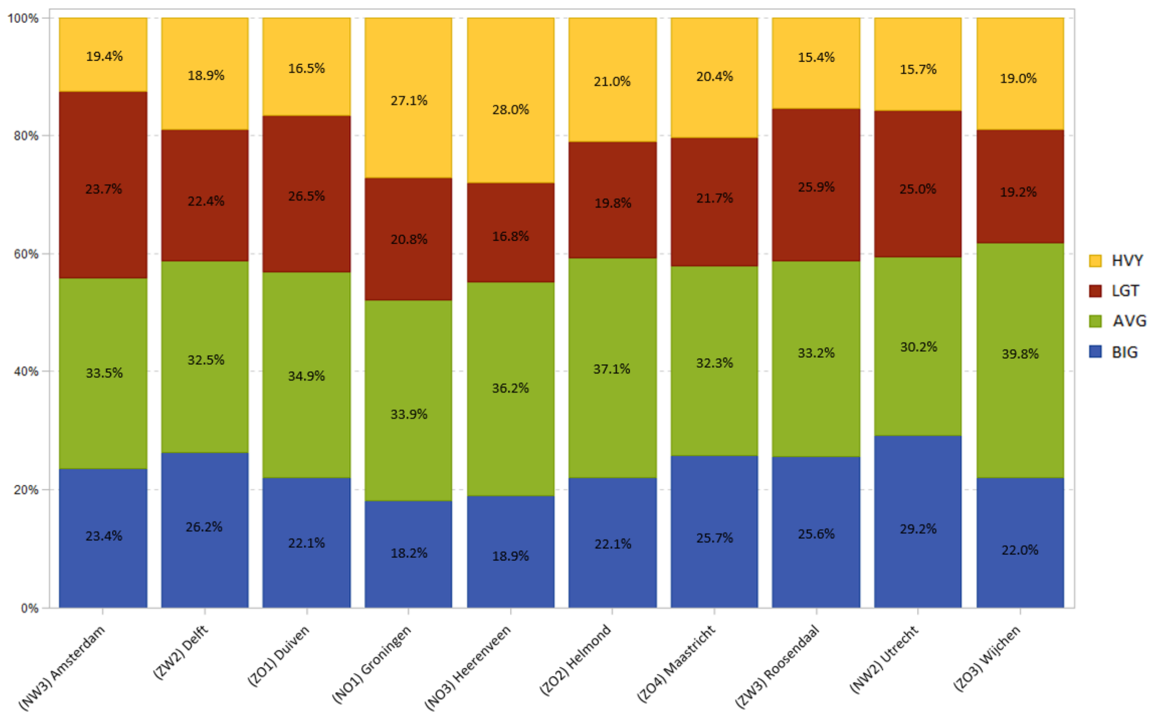
| **Waste per employee** [kg/employee] | **BIG** | **AVG** | **LGT** | **HVY** | **Overall** |
|---|---|---|---|---|---|
| Lower Whisker | 0.02 | 0.26 | 0.08 | 0.74 | 0.02 |
| First Quartile | 109.58 | 248.24 | 105.09 | 345.08 | 175.13 |
| Average | 845.46 | 1,386.65 | 656.24 | 1,759.89 | 1,175.85 |
| Median | 269.05 | 579.09 | 269.45 | 845.16 | 445.00 |
| Third Quartile | 633.06 | 1,317.59 | 665.57 | 1,824.42 | 1,097.00 |
| Upper Whisker | 1,417.44 | 2,920.96 | 1,503.64 | 4,039.76 | 2,479.17 |

# Appendix I: Comparison of sectors and regions

<u>Cluster distribution of sectors with the most SUEZ customers</u>




<u>Cluster distribution of regions with the most SUEZ customers</u>



# Appendix J: Survey results

## J1: Waste generation and separation

| | | BIG | LGT | AVG | HVY | Overall |
|---|---|---|---|---|---|---|
| Large waste streams | **Frequency** | **20** | **15** | **41** | **15** | **156** |
| | Residual | 15 | 12 | 30 | 13 | 127 |
| | Paper | 10 | 12 | 30 | 10 | 103 |
| | Glass | 9 | 5 | 16 | 6 | 68 |
| | Food waste | 7 | 5 | 20 | 9 | 63 |
| | Plastic | 5 | 7 | 20 | 3 | 57 |
| | Grease | 0 | 0 | 0 | 0 | 1 |

| | | BIG | LGT | AVG | HVY | Overall |
|---|---|---|---|---|---|---|
| Separated waste streams | **Frequency** | **20** | **15** | **41** | **15** | **156** |
| | Residual | 18 | 9 | 23 | 11 | 105 |
| | Paper | 17 | 13 | 37 | 12 | 137 |
| | Glass | 11 | 9 | 27 | 9 | 104 |
| | Food waste | 4 | 2 | 5 | 2 | 24 |
| | Plastic | 5 | 6 | 12 | 2 | 44 |
| | Grease | 10 | 9 | 19 | 11 | 86 |

| | | BIG | LGT | AVG | HVY | Overall |
|---|---|---|---|---|---|---|
| Waste streams not separated by SUEZ | **Frequency** | **20** | **15** | **41** | **15** | **156** |
| | Residual | 1 | 1 | 1 | 2 | 13 |
| | Paper | 2 | 12 | 19 | 6 | 60 |
| | Glass | 5 | 9 | 16 | 3 | 47 |
| | Food waste | 4 | 3 | 5 | 0 | 23 |
| | Plastic | 1 | 5 | 11 | 2 | 33 |
| | Grease | 6 | 9 | 16 | 9 | 71 |

## J2: Drivers, barriers and strategies

| | | BIG | LGT | AVG | HVY | Overall |
|---|---|---|---|---|---|---|
| **Drivers of waste separation** | **Frequency** | **20** | **15** | **41** | **15** | **156** |
| | At least one driver | 14 | 12 | 32 | 10 | 156 |
| | Lower costs | 9 | 9 | 24 | 7 | 86 |
| | More space | 6 | 7 | 8 | 5 | 47 |
| | Stricter laws | 3 | 2 | 6 | 2 | 22 |
| | Customer demands | 2 | 1 | 1 | 1 | 8 |
| | Larger amount of waste | 0 | 1 | 3 | 0 | 7 |
| | Others | 0 | 0 | 1 | 1 | 5 |

| | | BIG | LGT | AVG | HVY | Overall |
|---|---|---|---|---|---|---|
| **Barriers of waste separation** | **Frequency** | **20** | **15** | **41** | **15** | **156** |
| | At least one barrier | 18 | 15 | 40 | 15 | 151 |
| | No space | 8 | 10 | 21 | 10 | 82 |
| | Unaware of improvements | 8 | 8 | 23 | 9 | 82 |
| | Small amount of waste | 5 | 1 | 6 | 3 | 27 |
| | No time | 5 | 1 | 6 | 3 | 26 |
| | Unaware of environmental benefits | 3 | 0 | 7 | 2 | 21 |
| | Employees | 2 | 0 | 1 | 1 | 13 |
| | SUEZ | 1 | 0 | 2 | 0 | 10 |
| | Others | 2 | 0 | 2 | 0 | 7 |

| | | BIG | LGT | AVG | HVY | Overall |
|---|---|---|---|---|---|---|
| **Strategies to overcome barriers of waste separation** | **Frequency** | **20** | **15** | **41** | **15** | **156** |
| | At least one strategy | 5 | 8 | 12 | 6 | 61 |
| | Labelled bins | 1 | 4 | 6 | 4 | 29 |
| | Instructions for employees | 3 | 0 | 3 | 0 | 18 |
| | Positioning of bins | 3 | 3 | 2 | 1 | 14 |
| | External consulting | 0 | 1 | 0 | 0 | 2 |
| | Others | 0 | 0 | 1 | 1 | 3 |

# Appendix K: SUEZ waste management report

**Customer: XXX**

Service Address: All