

The design of a sustainable,
hygienic and low-effort bin
to collect and store organic waste
in high-rise buildings



Graduation report
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Disclaimer

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Figure 1. A tractor dumps compost on a field. Organic waste could be turned into compost and dumped back on the land.
Picture: Vlaco.be (2018)



Preface

Dear Reader,

The book which lays in front of you is the thesis I wrote as the final part of my Master's degree in Integrated Product Design in the Faculty of Industrial Design Engineering at the Delft University of Technology. It does not only cover six months of works but also is the result of more than eight years of studying at the University.

During my graduation period, I tried to understand the variety and details of the problem encountered in this thesis. With all this knowledge I tried to find a new solution, which hopefully could contribute to a more sustainable world.

I want to thank everyone, who played a role in the graduation process.

At first, I would like to thank the graduation board for supervising me in this project. Prof. Dr. Ruud Balkenende thank you for the support, patience, and discussing the thesis in a broad variety of topics. Thanks to Michiel van Sinderen for going with me on this journey and to let me be your first graduate student as a mentor.

I would like to thank Menno Wiersma of BinBang for supporting me throughout the process and believing in me through good and bad times. Furthermore, I would like to thank Anja Cheriakova for giving me the opportunity to do this assignment at BinBang and develop my skills in working in a startup environment.

Special thanks to Boris for opening his apartment to do the foto session of the final product.

I would thank everyone who tested a prototype, completed a survey or gave an advice.

I would like to thank my roommates, Kaj, Luuk, and Siemen for supporting me for the past year. I want to thank my brother, Bas, who gave me tips about how I should plan a typical day of the graduation period.

I also want to thank my parents, who always support me, no matter what, and think the results are great.

Enjoy reading!

Bart Krijgsman



Executive summary

The assignment is commissioned by BinBang, a company with the mission to save as much waste as possible from the incinerator. BigBang's focus is on improving the waste separation approach of municipalities, consumers and companies, through their products, and basically by coaching the citizens.

In high rise areas (HRAs) in the Netherlands, organic waste (OW) is hardly separated. Clean and separate collection of OW at the source contributes to a circular economy (Ellen MacArthur Foundation, 2018). Also, the EU has composed a new law which states that all OW must be recycled or separately collected at its source in 2023 (CouncilEU, 2018). Hence, municipalities with HRAs are more problematic.

The municipality of the Hague is used as a case study for this research. 60% of the Hague's inhabitants live in apartments (Onroerend Zaken Bestand, 2018). The average person in the municipality of the Hague separately collected 10.6 kg OW per year, compared to the national average of 79.8 kg per person per year. (CBS5, 2018). To reach the target of separating 75% of all waste by 2020, as set by the Dutch government (Rijksoverheid, 2018), a solution needs to be found to separate OW in HRAs. This was the starting point for this thesis' assignment: "How can the apartment inhabitant be supported in separately collecting OW by means of a product or service? "

The method of approach to the problem in this thesis is based on the basic design cycle (Boeijen et al. 2014). This method proposes the trial-and-error process of design consisting of analysis, synthesis, embodiment and evaluation. Design thinking is used to work towards a final solution which is desirable, feasible and viable. (DAM & SIANG, 2018)

Analysis Phase | Research to OW in High-rise area's

To get a representative view of the behaviour and environment of the apartment inhabitants (AI) in HRAs, a variety of AI, among which are students, a young couple, a family and young professionals, in different types of apartments is researched.

Als have to bring their waste to public containers, in or around the high-rise buildings, which are located in the basement, ground floor and in the hallway.

Als are generally classified into two groups. They are: separators of OW and non-separators of OW.

The main reasons why Als **do not separate OW** are:

- Lack of public containers
- High separation efforts
- Lack of space and time to separate
- Lack of awareness about separating OW:
- Als do not see the need to separate OW
- No idea what belongs to OW

Moreover, the main annoyances for AI who **separate OW** are:

OW is perceived as unhygienic, this includes:

- Dirt
- Leaking trash bags
- Odour
- Fruit flies

Separating OW is perceived as high-effort due to:

- The walking distance to the public container
- The walking frequency to the public container for hygienic reasons.

In a stakeholder analysis, it is observed that 10% of the OW is polluted with other waste fractions, which is a problem for OW processors (Femke Mckinzie, 2018)

Furthermore, municipalities seek for Municipalities are seeking solutions to increase waste separation in an effective and an economical way. (Langeveld, 2014)

Analysis Phase | Business Analysis

To explore viable business opportunities for BinBang regarding the separation of OW in HRAs, internal and external analyses of BinBang were performed, which resulted in a SWOT analysis.

The strengths of BinBang are marketing, branding, communication, their collaborations with municipalities and their proven track record of changing the separation behaviour of people.

Their weakness is their current product portfolio. The products of BinBang do not offer a solution for the main annoyances of AI who separate OW.

The SWOT analysis resulted in seven promising search areas. Meanwhile, the selected search area is: extend the product portfolio with a bin to increase OW separation.

Based on this search area and insights from the analysis, the following design challenge is formulated:

“The design of a bin for the collection and storage of organic waste in high-rise building kitchens and for the transportation of this to a public container.

The product is hygienic, low-effort and sustainable”

A hygienic product has an acceptable odour level and does not allow visual or physical contact between the user and degraded OW. Conversely, a low effort product is defined by the disposal frequency of OW into a public container, which should be equal or less than the disposal of residual waste. A sustainable product is defined as having a minimum lifetime of 10 years, is repairable and recyclable.

Synthesis phase

in a creative session with industrial design students, several ideas were generated for hygienic and low-effort bins. These ideas are combined with literature research about odour reduction methods, which resulted into the following four concepts:

Organic air bin | This bin uses a double-layered bag system to stimulate aerobic digestion in combination with activated carbon to reduce odour.

Bio balcony bin | This bin consists of a top bin for the kitchen counter to collect OW. The top bin can be placed on the bottom bin, which can as well be placed on the balcony to avoid filling the house with odour.

Waste cube | This bin makes an airtight biodegradable package of the daily produced OW. The cubes can be collected over a period of multiple days and brought together with the RW to the public containers.

Cool waste bin | This bin cools OW in the fridge to reduce odour. Because of a lipo- and a hydrophobic nanocoating, there is no need for a plastic bag. The bin can be cleaned by pouring a bit of water in the bin, closing it off watertight and shaking it.

To validate whether the different concepts resulted in the preferred odour reduction, four prototypes were created. These prototypes were each independently tested for one week by the AI households in a four weeks during research during hot summer days in August and September (KNMI, 2018). Cooling is selected as the odour reduction method for the final product because it resulted in not any odour, compared to the other reduce methods of the other concepts, which did result in odour annoyance.

Apart from the odour reduction method validation, the research also generated new insights about product pref-

erences. Based on these insights and cooling as the odour reduction method, the criteria for the final product are set. The most important one is that the product should be placeable in the fridge door during storage and by using at the kitchen counter (because of the lack of space on top) Quick disposal of OW, when the bin is placed in the fridge should be possible. The parts must be demountable for cleaning. The preferred bag type is a normal trash bag which should be biodegradable and non-leaking.

Embodiment Phase

The Frisbox is developed as a solution to OW separation in HRAs. The Frisbox is the first bin to collect OW for several days (low-effort) without odour and fruit flies, done by placing the bin in the fridge (hygienic).

The Frisbox comes with the complementary Friszak, a biodegradable bag, which is non leaking, hygienic in usage and perfectly fits into the Frisbox.

BinBang can introduce the Frisbox to the market by means of a pilot, in collaboration with a municipality, such as the city of the Hague. The pilot can be used to validate the effectiveness and develop the properties of the Frisbox. For the pilot, a version of the Frisbox has been designed with low investment costs.

Evaluation Phase

The Frisbox is evaluated by five AIs households by using the pilot Frisbox for the period of a week, to test if the product fulfils the design challenge. From this evaluation, it can be concluded that the pilot Frisboxes were evaluated positively by the AI and are:

- Hygienic (No odour annoyance, no fruit flies, no leaking bags, no visual and physical contact between the user and degraded OW)
- Low-effort. (Only empty one time a week in public container)
- Sustainable (The product is repairable and recyclable).

The importance of a perfect fit bag like the Friszak is more preferred and supported because of the negative results of too large bags used in the test. The Friszak is a solution for waste processors because it could reduce pollution in OW. The Frisbox is an opportunity for BinBang to change the behaviour of AI in the separate collection of OW in HRAs and to reach the Dutch and European waste separation targets.

How to read this thesis?

Do you want to read this thesis fast?

With a little less depth?

*Then follow the text blocks next to an **orange bar**.*

Those will form the main thread throughout this thesis, showing the main insights and conclusions. It will take roughly 10 minutes to read this thesis this way.

Do you want to take your time to read?

Do you want to understand the process, conclusions and decisions?

*Then follow the **green titles**.*

Abbreviations

ACF	Activated carbon filter
AI	Apartment inhabitant
CE	Circular economy
HRA	High-rise area
HRHH	High-rise household
OW	Organic waste
PLA	Polylactic acid
RW	Residual waste

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In the introduction you will get to know what this thesis is about, how it is related to the circular economy and what the approach of this thesis is.

You are in this part of the project:



Part 1 | Introduction

Analysis phase

Part 2 | OW in high-rise buildings

Part 3 | Business analysis

Synthesis phase

Part 4 | Ideation & conceptualisation

Part 5 | Prototyping, concept evaluation and selection

Embodiement phase

Part 6 | Embodiement

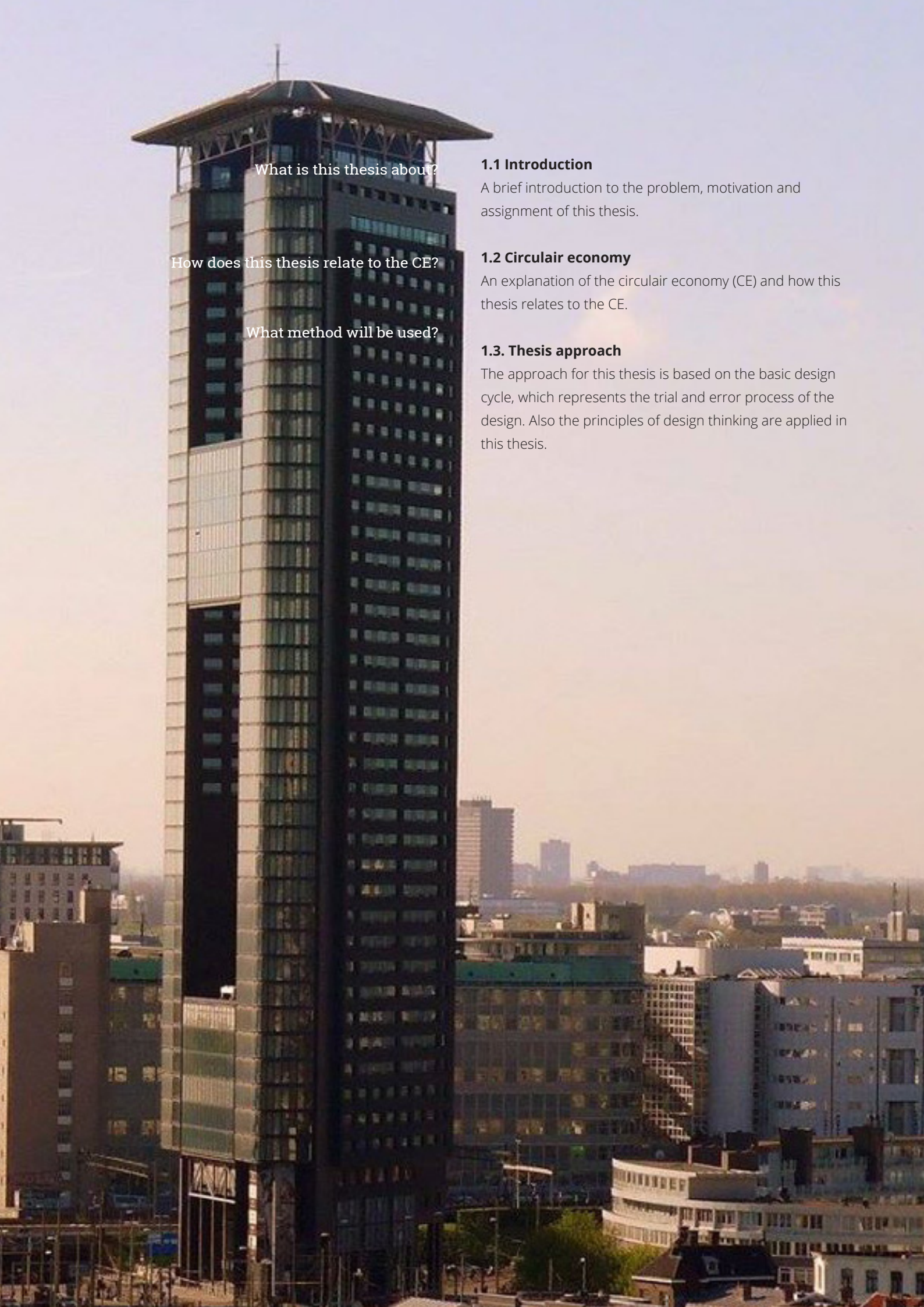
Evaluation phase

Part 7 | Evaluation

Part 8 | Recommendations

Introduction

Part 1



What is this thesis about?

How does this thesis relate to the CE?

What method will be used?

1.1 Introduction

A brief introduction to the problem, motivation and assignment of this thesis.

1.2 Circulair economy

An explanation of the circular economy (CE) and how this thesis relates to the CE.

1.3. Thesis approach

The approach for this thesis is based on the basic design cycle, which represents the trial and error process of the design. Also the principles of design thinking are applied in this thesis.

1.1 Introduction

What is this thesis about?

In February 2018, EU ambassadors approved new rules on waste management and recycling. The targets of the EU to recycle and reuse municipal waste are now set at 55% by 2025 and increase to 65% by 2035. Furthermore, by 2023 all OW needs to be either collected or recycled at its source (CouncilEU, 2018). The source of the waste is the place where the waste originated. In the case of organic waste (OW) in households, this is often the kitchen.

'By 2023, all OW must be recycled or separate collected at its source, according to EU law'

The Dutch government has its own goals and wants to increase the amount of separated waste to 75% by 2020 (Rijksoverheid, 2018). In order to achieve this, the annual unseparated waste produced per person in the Netherlands must decrease from 181 kg per person today to 100 kg per person in 2020. (Milieucentraal, 2018⁴).

The majority of domestic waste in the Netherlands is OW; around 35% of the total for the last 10 years. (Afval circulair, 2018) (figure 2). 58 Kg of the 181 kg of unseparated waste per person per year is OW (figure 2). This is the largest fraction in the unseparated waste.

In this thesis, the city of the Hague will be used as a case city as a starting point to address the problem.

Currently, in the Hague live around 60% in apartments (Onroerend Zaken Bestand, 2018) and the average OW separation per person is 12.3 kg (CBS⁵, 2018), which is significant below the national average.

Furthermore, OW is a valuable waste stream and a preeminent renewable resource which can be entirely recycled to make new resources such as biogas and fertilizer.

'The majority of domestic waste in NL is OW, (35%)'

Problem definition

In areas with high-rise buildings, the separate collection of OW is the lowest when compared to other urban settings. In low-rise areas, OW collection is the highest. Langeveld (2014) found a strong relation between the percentage of high-rise buildings and the amount of residual waste. The more high-rise buildings in an area, the higher the amount of residual

waste. This can be explained because buildings with a garden are better at separating OW, and also generate more garden waste.

Because the majority of total domestic waste is OW and separation of OW is the lowest in high-rise building areas, where a significant part of the OW is produced, it is relevant to focus on a solution in this domain.

'The problem definition of this thesis is: 'OW is hardly separated in high-rise buildings''

Assignment

In order to improve the amount of separated waste in high-rise buildings, this thesis aims to develop a new product/service solution which will contribute to a higher separation rate of OW for apartment inhabitants (AIs) in high-rise buildings.

'The assignment for this thesis is:

How can the apartment inhabitant be supported in separately collecting OW by means of a product or service?'

BinBang

The assignment is commissioned by the start-up BinBang, based in Utrecht. BinBang has the mission to save as much waste as possible per person from the incinerator.

'The assignment is commissioned by:

'BinBang, a company which helps people to separate waste as easy as possible'

The vision of BinBang is to make people and organizations aware of the resources they can save (the bang) and to offer them concrete and attractive solutions which are easy to use (the bin) (BinBang.nl, 2018).

BinBang offers products for apartment inhabitants to easily and comfortably separate waste. Their first product is a stackable bin which offers AIs the possibility to easily separate waste without taking up a lot of space.

*Total domestic waste
in the Netherlands per capita*

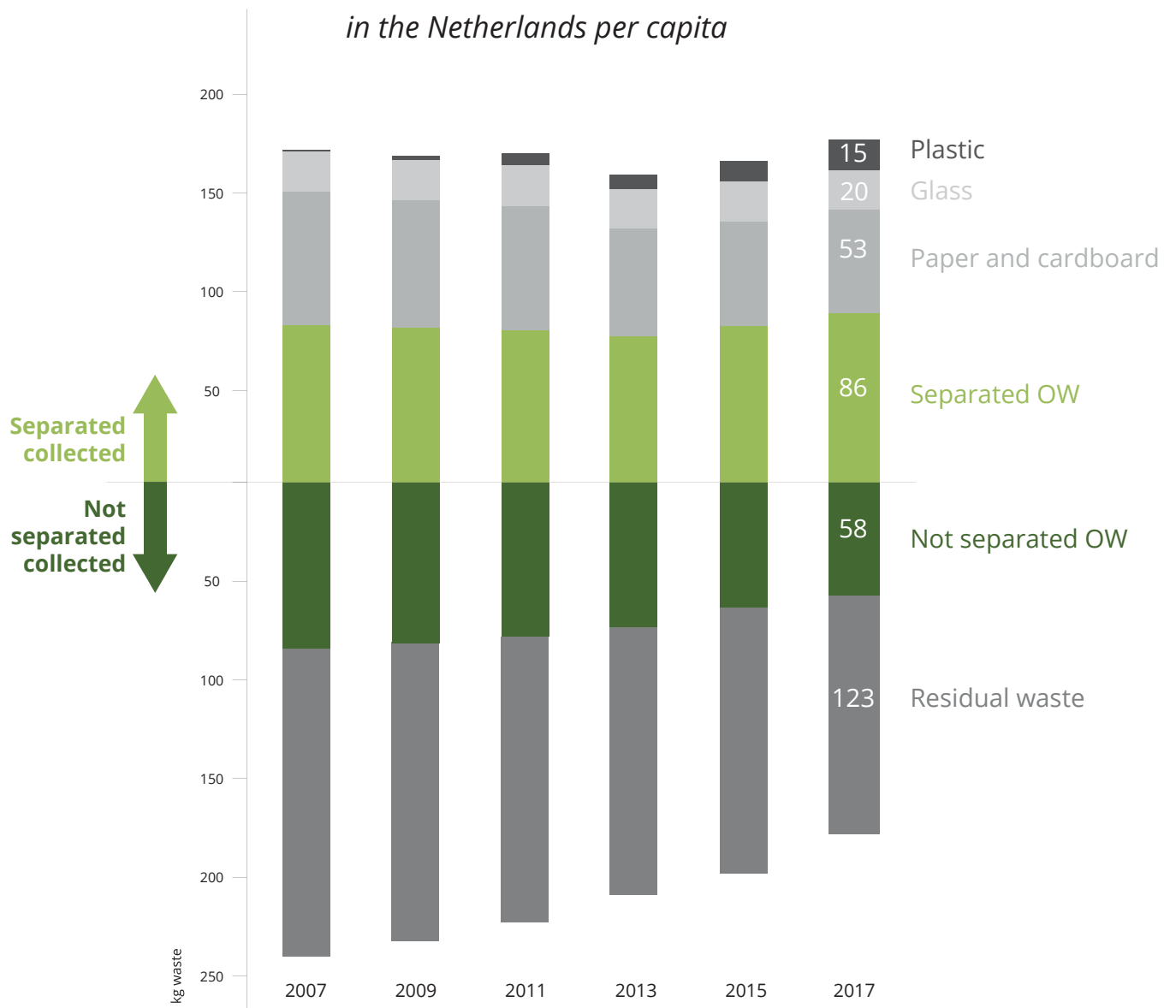


Figure 2 | Waste production per capita in the Netherlands (CBS¹, 2018)

1.2 CE

How does this thesis relate to the CE?

The importance of this thesis is based on the concept of the CE. This chapter will indicate the importance of the CE and how it relates to this thesis.

What is the CE?

The Circular Economy is defined by Geissdoerfer et al. (2016) as being “*a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling*”. p759

Why should we move towards a CE?

According to Meadows et al. (2004), there is a large need to move towards a CE. The CE is seen as a solution for environmental problems such as biodiversity loss, water, air and soil pollution, resource depletion, and excessive land use, which are increasingly jeopardising the earth's life-support systems (Geissdoerfer et al., 2017).

CE diagram

The Ellen MacArthur Foundation is a worldwide organisation supported by decision-makers from businesses, governments and academia, which aims to accelerate the circular economy. A butterfly diagram to display the CE was created (as seen in figure 3).

In a CE, materials are divided into two separate cycles: a biological and a technical cycle. The smaller the cycle, the more eminent the material.

Biological cycle | Examples of bio materials include OW, cotton and water. The availability of these materials is unlimited. Biological materials are adapted by the ecosystem from which they arise. The importance of the biological cycle is to not disturb the ecosystem from doing its work. The streams in the cycle must not become polluted by toxic substances and the ecosystem must not become overloaded.

Technical cycle | Examples of these materials include fossil fuels, plastics and metals. The availability of these materials is limited and they are not easy to recreate. The importance of a technological cycle is that these finite materials are well managed. The materials need to be re-processed and re-used from waste, focusing on the preservation of the quality of the materials. Clean, separate collection of OW at the source contributes to a CE.

*Clean, separate collection of OW at the source contributes to a **circulair economy**.*

A CE is necessary if we want to solve environmental problems such as air and soil pollution.

Thesis relation to CE

In this thesis, a solution will be found to help apartment inhabitants collect OW separately at the source. Collecting OW at the source and processing it into biogas or compost will contribute to a more optimal biocycle.

The separate collection of OW at the source is important for keeping the biocycle unpolluted.

Circular product design.

This thesis is executed within the department of Circular Product Design within the Faculty of Industrial Design Engineering at the Delft University of Technology. The department of Circular Product Design focuses on the development of methods and tools that enable the design of products that are used more than once. It explores areas of circular design strategies, such as product life extension, re-use, remanufacturing and recycling (TuDelft, 2018). During this thesis, the final product solution will be designed in such a way that it can follow the cycle of the technical cycle as shown in figure 3. In other words, the product will be designed in such a way that it can be maintained, repaired, reused, refurbished or recycled.

OUTLINE OF A CIRCULAR ECONOMY

PRINCIPLE

1

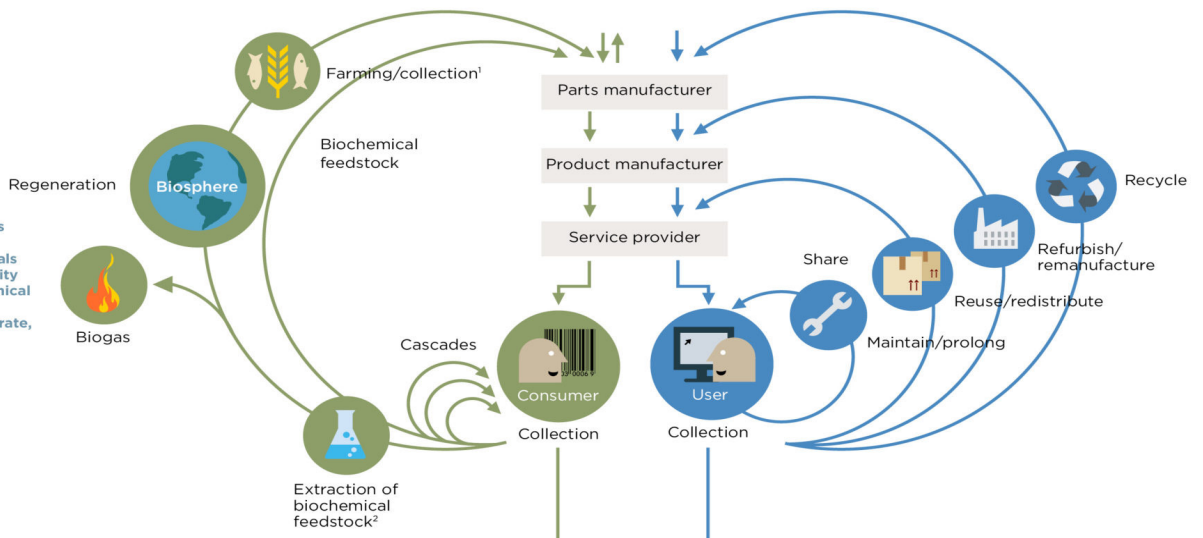
Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows
 ReSOLVE levers: regenerate, virtualise, exchange



PRINCIPLE

2

Optimise resource yields by circulating products, components and materials in use at the highest utility at all times in both technical and biological cycles
 ReSOLVE levers: regenerate, share, optimise, loop



PRINCIPLE

3

Foster system effectiveness by revealing and designing out negative externalities
 All ReSOLVE levers



1. Hunting and fishing
 2. Can take both post-harvest and post-consumer waste as an input
 Source: Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment; Drawing from Braungart & McDonough, Cradle to Cradle (C2C).

Figure 3 | The CE system diagram (Ellen MacArthur Foundation, 2018)

1.3 Thesis approach

What method will be used?

The approach of this thesis is based on the basic design cycle of figure 5. This model represents the trial-and-error process of design. It consists of a sequence of empirical cycles.

The knowledge of both the problem and the solution increases with each cycle.

The cycle is used as a general structure throughout this entire thesis. Within this large cycle, multiple small cycles are made. The cycle consists of multiple phases, as described below.

Analysis phase

This phase consists of analysing the problem; firstly, OW in high-rise areas will be analysed. Secondly, the current strategic situation of BinBang will be analysed by performing an internal and external analysis. Within the internal analysis, strategic strengths and core competences of BinBang are found. Within the external analysis, opportunities and threats are identified. The strengths and opportunities are then combined in the research areas of strategic ideas for innovation and potential new business opportunities. The research area with the most potential in terms of the pillars of business, human and technology has been selected together with BinBang. Based on the selected research area, a design challenge has been formulated. The design challenge describes the design direction: what the product/service should be able to do. It also describes a set of criteria for the final product solution.

Synthesis phase

In this phase, possible solutions for the design challenge are generated and tested. The phase ends with a list of requirements for the final product.

This phase starts with some extra literature research regarding the design direction. Then, ideas for product solutions are generated via creative techniques. These ideas turn into concepts and prototypes which are evaluated in terms of the input that they deliver for the list of requirements.

Embodiment phase

In this phase, a proof of concept is made. Furthermore, the embodiment of the product is elaborated on further and market development is done by hand of a market implementation plan.

Evaluation and recommendation

In this phase a final user test is performed and there will be

*The method used in this thesis is based on **the basic design cycle**. This represents the **trial-and-error process** of design.*

***Design thinking** is used to work towards a final solution which is desirable, feasible and viable*

reflected upon the design challenge, which is formulated at the end of the analysis phase. Furthermore, there will be reflected if the final solution will contribute to the problem of the thesis. Lastly, recommendations will be given to further develop the final solution of this thesis.

Design thinking

The approach of design thinking has become very popular across the world, in many different businesses and industries. Tim Brown, CEO of IDEO, one of the leading global design and innovation companies, describes design thinking as follows:

“Design thinking is a human-centered approach to innovation that draws from the designer’s toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success.” (Ideo.com, 2018)

The pillars of human, business and technology are an important common thread in industrial design. A lot of knowledge and practices at the Faculty of Design Engineering at TU Delft lead back to one of these three pillars. The approaches bring together what is desirable from a human perspective, feasible from a technological perspective, and viable from a business perspective (figure 4).

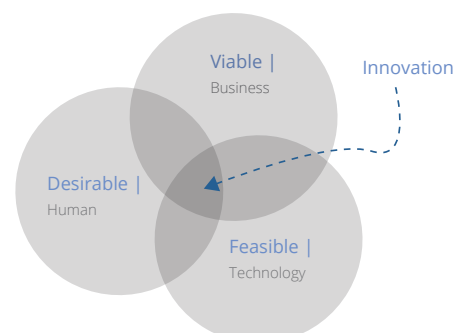


Figure 4 | Pillars for innovation Human, business & technology (DAM & SIANG, 2018)

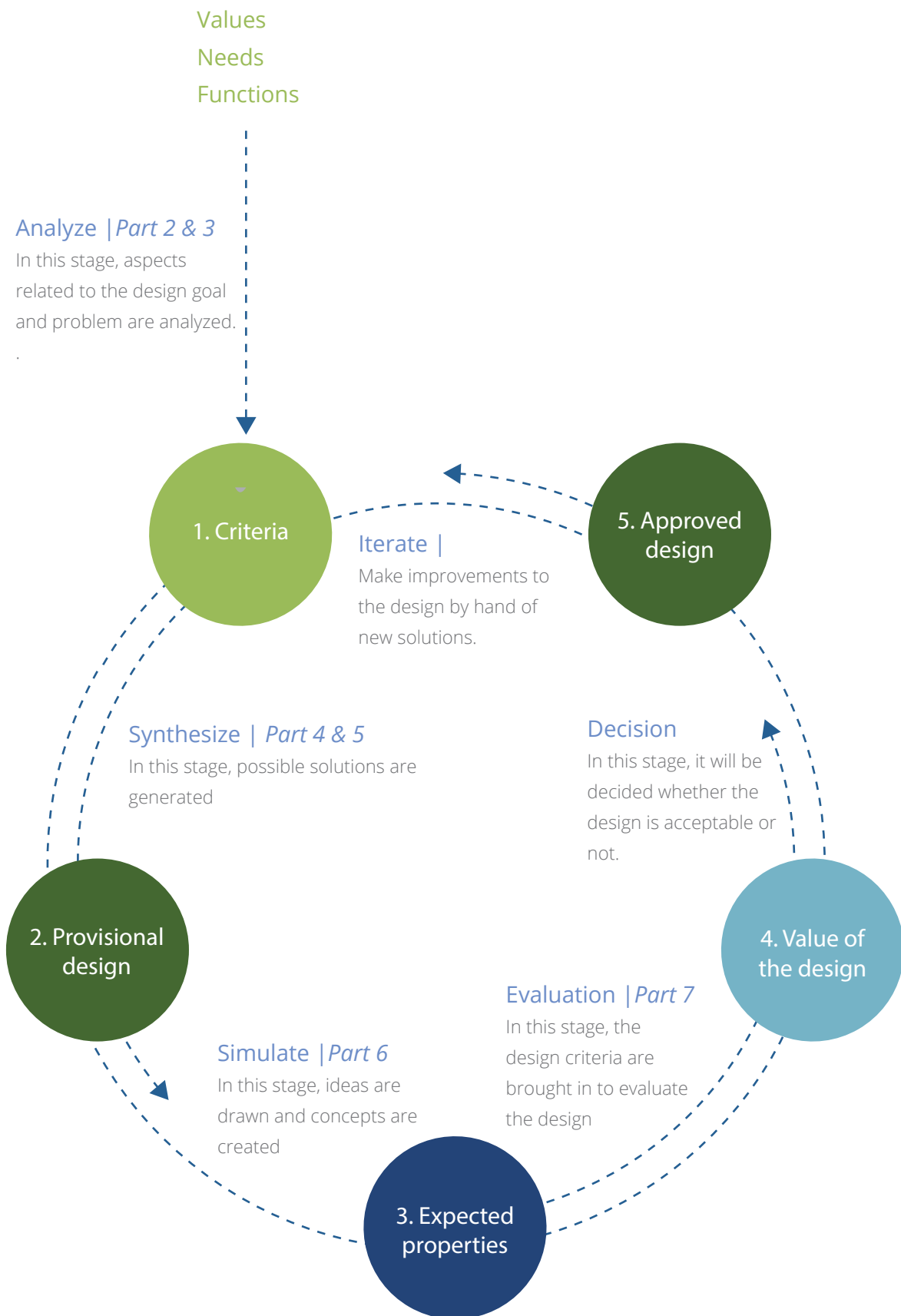


Figure 5 | The basic design cycle, (Boeijen et al., 2014)

A solution for the main problem of this thesis, namely that 'OW is not well separated in high rise areas', requires a deeper understanding of both high-rise areas and OW.

This chapter describes the exploration of both subjects, which are brought together by the people who live in high rise areas (HRAs) and who produce OW: the apartment inhabitants (AIs). This section also provides a deeper understanding of who the AI is.

You are in this part of the project:

Part 1 | Introduction

Analysis phase



Part 2 | OW in high-rise buildings

Part 3 | Business analysis

Synthesis phase

Part 4 | Ideation & conceptualisation

Part 5 | Prototyping, concept evaluation and selection

Embodiment phase

Part 6 | Embodiment

Evaluation phase

Part 7 | Evaluation

Part 8 | Recommendations

OW in high-rise buildings analysis

Part 2

Figure 6 | OW container in Wageningen

What is OW?

2.1 OW

OW consists mainly of fruit and vegetable peels, leftovers and food spill.

What are high-rise buildings?

2.2 High-rise buildings in high rise areas

An overview describes all 12 types of high-rise buildings in the Hague, including their characteristics and location.

How is waste management organized in high-rise buildings?

2.3. Waste management in high-rise buildings

Als must take their waste to public containers. Municipalities that collect OW in HRAs organize this placing public OW containers

Who lives in high-rise buildings?

2.4. User

There are four different types of households in various types of high-rise building: families with children, students, young couples and young professionals.

What are their waste disposal behaviours?

2.5 User behaviour

How, when and where do Als collect and dispose of OW and what are their behaviours and routines?

What problems do Als encounter when disposing of OW?

2.6 User problems with OW

Here, it is found that Als who separate their OW from other waste encounter problems with odour, fruit flies and dirt.

Who is more involved in OW disposal, and what are their problems?

2.7 Stakeholders

Students, young couples and young professionals in various types of high-rise building.

What options are there for the disposal of OW?

2.8 OW routes

In this chapter, it is revealed as to how OW can be recycled. The route with the most environmental advantages is when the OW is collected at the source by Als and transported by a waste truck to a digesting plant, where the waste is processed in an industrial digester and converted into electricity and other resources.

Which products are used for OW disposal?

2.9 OW routes

A description of the wide range of products to collect, store and process OW.

2.1 Organic waste

What is OW?

In this chapter, what OW is (and is not) and how much of it is produced is described. OW production of HRA's in Amsterdam are used, because there are no recent number available of OW production of HRA's in the Hague.

OW

Kitchen and garden waste is known as GFT in Dutch. This is an abbreviation for groente (vegetables), fruit (fruit) and tuinafval (garden waste). In this thesis, organic waste which is produced by AIs will be referred to as OW.

In writing this thesis, it became clear that – even for people who actively separate OW – it is sometimes unclear what is and isn't OW. What is and isn't OW is described on the milieucentraal (environmental focus) website, as shown in figure 7.

OW (OW) in high-rise buildings

CREM (2016) researched the composition of OW in high-rise buildings. From the Hague, there are no numbers or research available about the composition of OW in high-rise buildings. Therefore numbers of Amsterdam are used in this example. Figure 8 shows that in 2015, the average Amsterdam inhabitant produced 370 kg of waste per year. Amsterdam has the highest urbanity rate, with a score of 1 out of 5 (CBS³, 2013). Only 0,5 kg of OW is recycled per person (CBS, 2017).

This is OW

- Potato peel
- Flowers and indoor plants
- Peanut and nut shells
- Eggshells
- Food leftovers (cooked or raw)
- GFT/OW bags
- Cheese rinds not containing plastic
- Kitchen paper, tissues and toilet paper (uncoloured and unprinted)
- Coffee grounds and coffee filters (but not coffee pads)
- Corks
- Small pet manure (e.g. from guinea pigs, rabbits, etc.)
- Oil and grease
- Seafood shells (e.g. from mussels), fish bones and meat bones
- Vegetable and fruit peel
- Garden and pruning waste

One of the characteristics of high-rise buildings is that they usually do not have a garden. Therefore, inhabitants of high-rise buildings hardly produce garden waste. CREM (2016) researched to the composition of OW in high-rise buildings in Amsterdam and found that garden waste and waste produced by flowers and plants comprises less than one percent of the total OW produced by AIs. This seems logical, since apartments do not have gardens.

Compost logo

Only bioplastics which are a collection tool, like biodegradable bags are allowed in the OW (Grosze-Holz, 2018) Bioplastic displaying an "OK compost logo" or seedling logo as shown in figure 9 are **not** desirable in OW. These are bioplastics, such as packages for drinks or food. They need to be disposed in the residual residual waste because they require more 12 weeks to compost. The processing time of regular composting installations is now 4 weeks. Composting bioplastics in these installation results in small pieces of biodegradable plastic in the compost, which are not degraded. Biodegradable plastics can also not be recycled with regular plastics. When biodegradable plastic is mixed with normal plastic during recycling, the overall quality of the plastic decreases. (Milieucentraal, 2018²).

This is not OW

- Ash from ashtrays, fireplaces or barbecues
- Dead animals
- Human and animal hair
- Cheese rindss containing plastic
- Cat litter
- Chewing gum
- Fertilizer
- Matches
- Diapers (these go in residual waste)
- Oasis (floral foam for flower arrangements)
- Paper (small pieces of paper are allowed)
- Tea bags and coffee pads (loose tea and coffee is allowed)
- Dog and cat faeces
- Cigarette butts and ash
- Bird cage sand
- Sand
- Bioplastics with the OK compost logo or seedling logo

Figure 7 | What is and isn't OW (Milieucentraal², 2018)

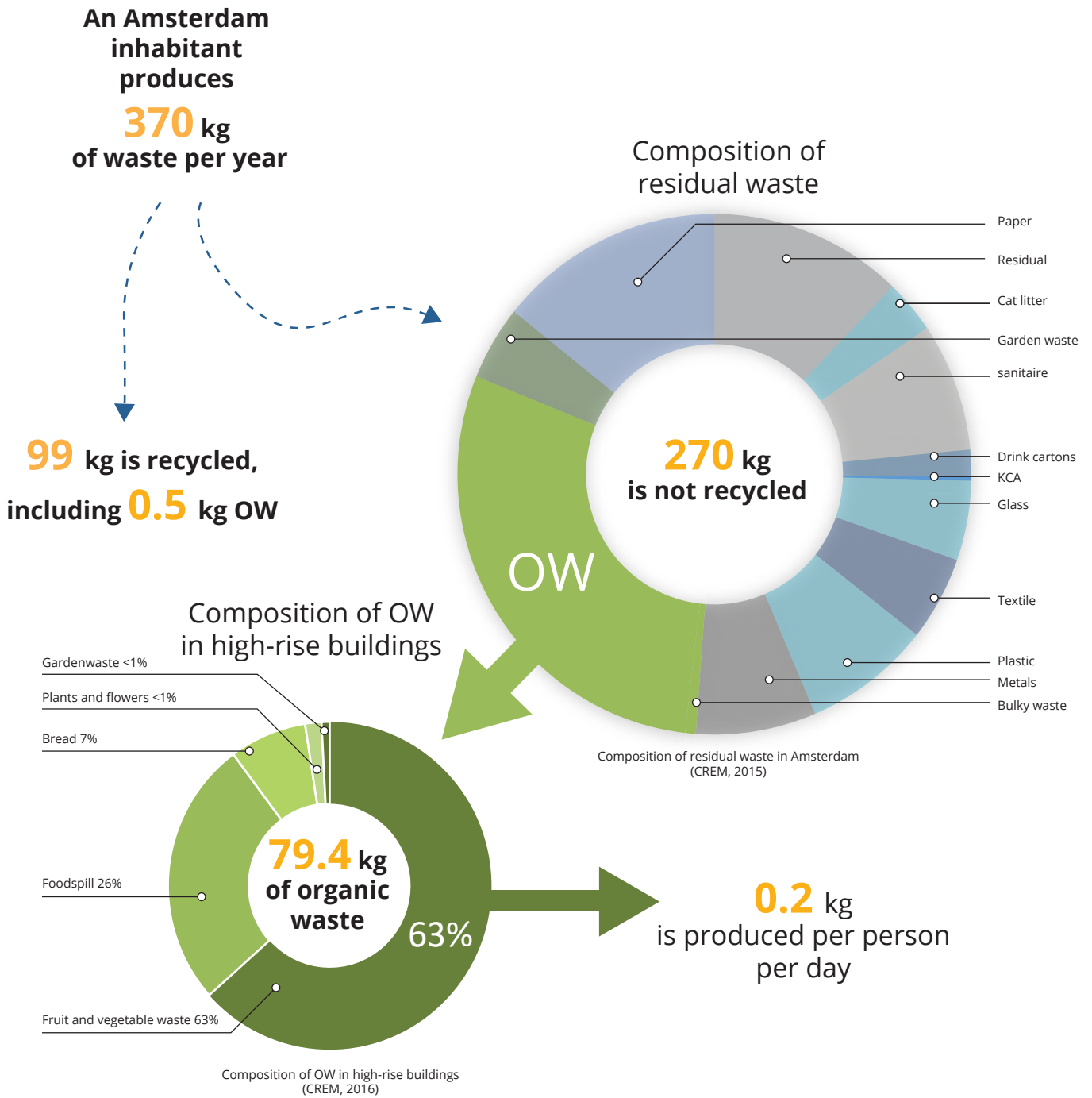


Figure 8 | Composition and production of waste per person per year in Amsterdam



Figure 9 | Compostable- and OK to compost logo



This is





S O W



2.2 Apartment types in high rise areas

What are apartment types?

15% of Dutch citizens live in apartments. This equals more than 2.5 million people (CBS4, 2015). In the Hague this is around 60%. In 2016, only 12.3 kg of OW was collected per capita in the region of the Hague (CBS5). There are 12 different apartment types identified in the Hague.

On 1 January 2018, 532,561 people lived in the Hague. 60% lived in one of 12 types of apartments. This adds up to 320,857 people in 178,730 households (Onroerend Zaken Bestand(OZB), 2018).

Apartment types

12 different types of apartments are identified (OZB, 2018). The overarching characteristic of these apartments is, with exception of ground floor apartments, that they do not have a garden and do not have their own garbage container. In the next chapter, waste management systems in apartments are described in further detail.

The apartment types and numbers in the Hague are shown in the figure on the right (figure 14).

Selection of building types for this thesis

In this thesis, four households in the four different apartment types are selected for a deeper understanding of the environment and properties of these homes. These are terraced

apartment building (figure 10), skyscraper (figure 11), "portiek" flat (figure 12) and apartment (figure 13).

The double apartment and the staircase entrance flat have a lot of similarities with the one floor apartment. They only differ and number of floors per apartment or space. Therefore, the double apartment and the staircase entrance flat are not apart studied in this thesis.

In figure 14, also the type of AI living in the apartments is mentioned. These are starters, students (couple), family and young professionals. The inhabitants of the apartments will be discussed in chapter 2.4.

The most common apartment types in the Hague are selected to further analyses in this thesis. Those are:

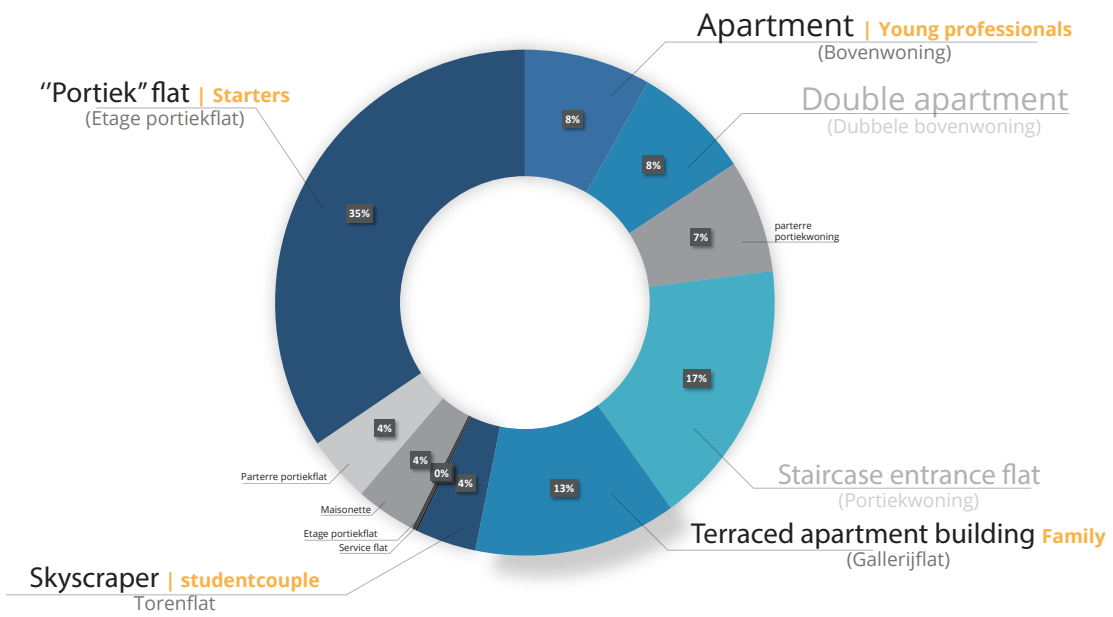
- **Terraced apartment building**
- **Skyscraper**
- **"Portiek" flat**
- **Apartment**



Figure 10 | Terraced apartment building



Figure 11 | Skyscraper



4 high-rise building types are studied in this research,
 representing 81% of all high-rise buildings
 in the Hague.

Figure 14 | Overview apartment types in the Hague (OZB, 2018)



Figure 12 | Portiek flat



Figure 13 | Apartment

2.3 Waste management in high-rise buildings

How is waste management organized in high-rise buildings?

Since high-rise buildings do not have gardens, the government offers a public or common container in which Als can dispose of their waste. Unlike people with their own waste containers, it is hard for Als to know how much waste they produce. When the waste is out of the apartment and out of sight, it is also out of their minds (Design Innovation group, 2015).

Als produce and collect waste in their homes. When they move the waste out of their apartments they must dispose of it in the public containers in or around the flatbuildings by themselves. They do not have their own containers, like people with a garden have.

OW in the Hague

At the moment, OW is not yet separated collected in high-rise buildings in the Hague. The government does not yet offer facilities for the collection of OW. If the municipality of the Hague in the future wants to collect OW, an option would be to place public containers for OW next to public containers for residual waste, plastic, glass and paper. However, the current waste management plan of the Hague (HAP, 2018), which describes measures concerning waste management taken in the city from 2018-2020, there is no investment in the improvement of OW collection. In the other 3 big cities of

Als have to bring their waste to public containers in or around the high-rise buildings.

The containers could be located outside the high-rise building, in the basement, ground floor and in the hallway.

The municipality of the Hague currently only offers containers for residual waste, paper and glass but not for OW.

All households who have to bring waste to a public container belong to high-rise buildings and the target group.

The terraced apartment building has outside containers.

*The skyscraper has a container on **the ground floor.***



Figure 13 | Waste containers 'portiek flat'

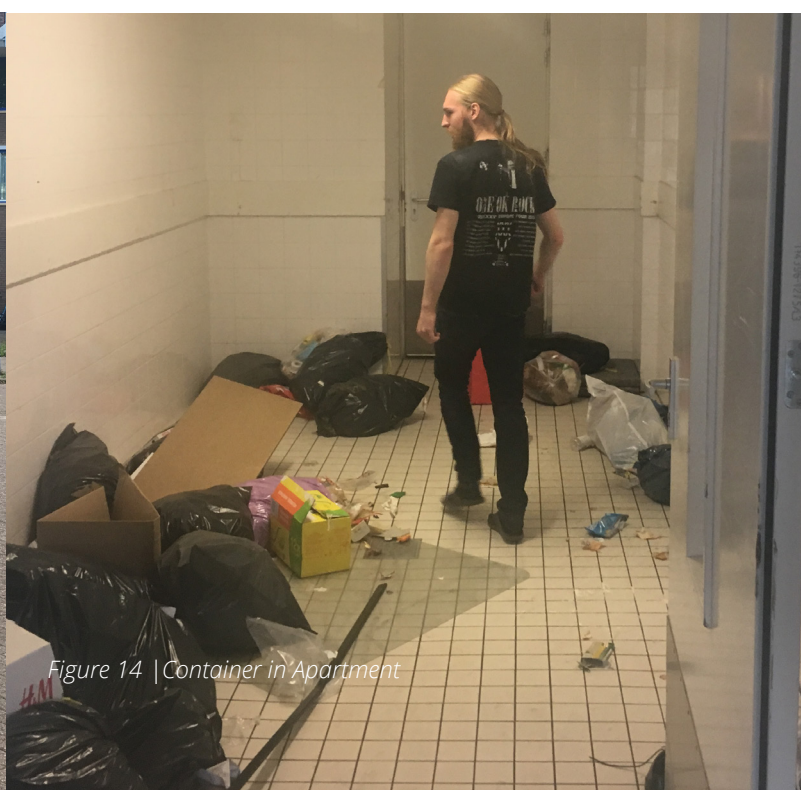


Figure 14 | Container in Apartment

the randstad, Amsterdam, Rotterdam and Utrecht, current pilots to improve waste separation in HRAs are running (VANG, 2018).

OW in Wageningen

In Wageningen 40% of the buildings are high-rise buildings. Wageningen is a city that already offers public containers to collect OW for high-rise buildings (Langeveld, 2014). The OW containers are located alongside containers for other waste types. An impression of these containers can be seen in figure 17. With the placement of the containers 19% of the OW in HRAs is separately collected. The results of a research among the AIs in Wageningen shows that 40% of the AI say they separately collect OW on a regular basis (Langeveld, 2018) One thirds of the AI declare they want something better to separate OW than a 10L bucket, which is free available. The most important reasons why inhabitants do not separate OW are smell and dirt, the lack of space and the perception they do not have enough OW.

From the OW collection in HRA's Wageningen can be concluded that there is a need for better OW collection tools and that a part of the population will separate OW when public containers for OW are placed.



Figure 17 | Public containers for OW in Wageningen

The 'portiek flat has **ground floor** containers



Figure 15 | Containers in skyscraper

The apartment has a container in the **hallway**



Figure 16 | Container in Floor porge flat

2.4 User analysis

Who are living in the high-rise buildings?

The target group for this thesis includes people who live in high-rise buildings. For this thesis, four different households are defined: families, young couples, students and young professionals. From these households, real life personas are made. Personas are representations of intended users, made in order to describe and visualize their behaviour, values and needs described in the Delft Design Guide, p95 (Boeijen et al., 2014). The personas can be used to refer back to when developing a product or service. The extended description of each of the personas can be found in Appendix A.

Selection of households

In the four building types described in the previous chapter, four household types are selected. The participants for this thesis were found by advertisements placed in the these building types. A selection was made from the respondents of the advertisements. The goal of the selection process was to include a broad as possible variety regarding the composition of relationships, number of persons and waste separation behaviour of the households in order to get a good impression of the target group. People aged over 50 and the elderly were not included in the target group, but it would also be worth researching these groups and one-person households in the future. Figure 18 shows the composition of households in the Hague. By including the four personas, 87% of household composition types is covered.

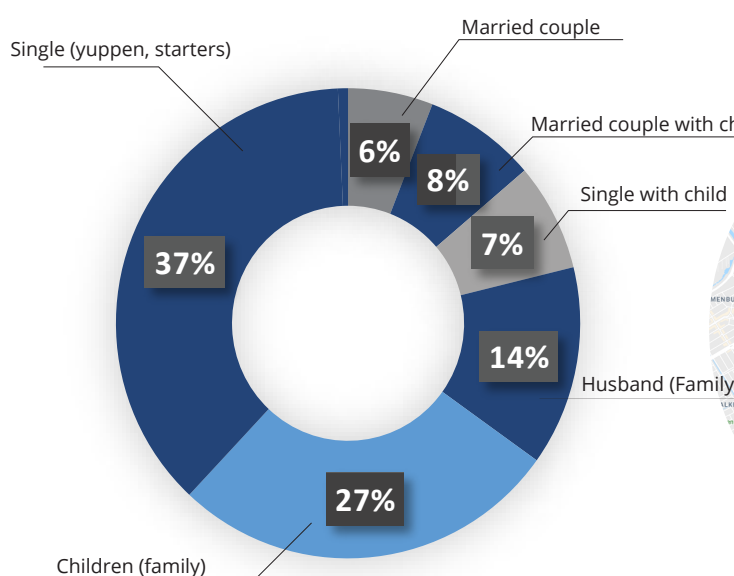


Figure 18 | households compositions of the government of the Hague (DHIC/GDH/DPZ, 2018)

In each of the four selected buildings from chapter 2.2, one household type is selected. These are:

- **Family**
- **Students (couple)**
- **Young couple**
- **Young professionals**

In this thesis, these households represent the target group.

These households were used to develop and evaluate the final product/service of this thesis.

Their main characteristics can be found on the right page.



Figure 19 | Map of location of the buildings (google maps, 2018)



Household 1 | Family

- 1 man** | Abdoel (25),
- 1 woman** | Nazeema (27)
- 1 son** | Aftaar (11)
- 1 daughter** | Alima (6)
- Professions** | Education care, official
- Apartment type** | 'portiek flat'
- Non-separators** | All trash placed in residual waste

Household 3 | Students

- 1 man** | Kevin
- 1 woman** | Vera
- Professions** | Students
- Apartment type** | skyscraper
- Good-but-can-do-better separators** | paper cardboard glass, batteries

Household 2 | Young professionals

- 2 men** | Pieter (26), Koen (26)
- 3 woman** | Berbel (26), Marije (25), Suzan (26)
- Professions** | Doctor, lawyer, trainee Dutch government
- Apartment type** | Apartment
- Classic separators** | Paper/cardboard, glass

Household 4 | Starters

- 1 man** | Paul (31)
- 1 woman** | Kim (27)
- Professions** | Real estate consultant & engineer consultant
- Apartment type** | floor porge flat
- Classic separators** | Paper/cardboard, glass

Figure 20 | Persona's households in the Hague.

2.5 User behaviour

What is their behaviour with waste?

The behaviour of the target group is examined to understand their, behaviour motivations and actions regarding waste disposal. The households described in chapter 2.3 were interviewed about their behaviour.

General behaviour

According to Design Innovation Group (DIG, 2015), four findings were typical of people in high-rise buildings:

- They hardly have any insight regarding the volumes of residual and organic waste that they produce.
- They must often bring their trash outside. Out of the home means out of the head. People forget about the waste that they generate.
- Their behaviour is ad hoc, as AIs can dispose of their waste whenever they like.
- The balcony is the collection point for residual waste before it is taken to the container. During the summer, this is unpleasant; the heat creates a bad odour from the waste.

These behavioural aspects are important to take into account when designing a solution for AIs.

The behaviour of AIs regarding OW can be described as follows.

Most OW is produced whilst preparing food for cooking.

AIs do not want to increase their walking frequency to the public container.

They would rather take all of their waste to the public container at the same time.

AIs usually take their waste to the public container when they leave the house to go to another location.

Four types of separators

DIG (2015) executed a field research commissioned by several municipalities to find out how AIs in Utrecht and Rotterdam deal with waste (separation).

In their field research, DIG visited 22 households (n22) spread across different neighbourhoods in Utrecht and Rotterdam. They defined four types of waste separators: super separators (n5), good but can-do-better separators (n5), classic separators (n8) and non-separators (n5). The four households studied in this thesis were also asked about their separation behaviours. They were then put in order to correspond with the DIG profiles DIG.

Super separators | None of the participants | Not target group

(separate all types of waste)

Super separators already have the will and drive to separate their waste. If everyone was a super separator, the waste problem in high-rise buildings would likely not exist. Therefore, this target group has been excluded from consideration.

Good but can-do-better separators | Students

(separate paper, glass and one other type of waste)

They are also sensitive to social norms and therefore much easier to convince to take action, if the rest of the neighbourhood also participates.

Classic separators | Young professionals, young couples

(separate paper and glass)

They are sensitive to social norms and therefore much easier to convince to take action, if the rest of the neighbourhood also participates but they are not separating as much as the good but can-do-better separators.

Non-separators | Family

(puts everything in residual waste)

They are sceptical of the usefulness of waste separation and need to make a shift in their behaviour. Turning non-separators into separators is the biggest task for municipalities. They need to be approached by municipalities and convinced about the usefulness of waste separation.

Behaviour of the four households

The AIs were asked when, where and how they currently collect OW.

Family

When | They produce OW during the entire day.

Where | Cooking and preparing food takes place at the kitchen counter.

How | When cooking, OW is collected on a plate or in a pan. When finished, the peels are emptied into the trash can.

Young couple

When | OW is produced in the morning and the evening.

Where | OW is produced at the kitchen counter.

How | When finished with preparing food for cooking, the waste is thrown into the residual waste bin.

Students

When | OW is produced during the entire day.

Where | At the kitchen counter.

How | Old packaging is used as a bin to collect OW. Food is prepared on a cutting board but also above the old packaging.

Young professionals

When | OW is produced in the morning and in the evening.

Where | At the kitchen counter. One of the members of the household prefers to prepare food at the table.

How | When OW is produced via the preparation of food, it will be slid from the cutting board into the bin or put in the residual waste bin by hand.

OW production and disposal frequency of residual waste

The OW production of, and frequency of disposing of residual waste in, the households were measured across a period of four weeks.

AIs do not want to increase the empty frequency to the public container. To illustrate this, an example is given. If an AI disposes the residual waste in a public container one time in the week, the AI does not want to walk daily to the public container to dispose OW. The AI wants empty the OW together with the residual waste, because it saves time and effort. Therefore, the storage volume required to store OW is based on the disposal frequency of the residual waste multiplied with the OW production within that time. The storage volumes for each of the households is shown in figure 21. To explain figure 21, the family is taken as an example. The family brings every 3 days residual waste to the public container. Within that time they produce 2L of OW. The required storage volume for a bin to collect OW is 2L.

The figure shows that the volume is that the required volume is based on volume and empty frequency. Because the four households are only a small sample, the required storage volumes could differ for the entire population.

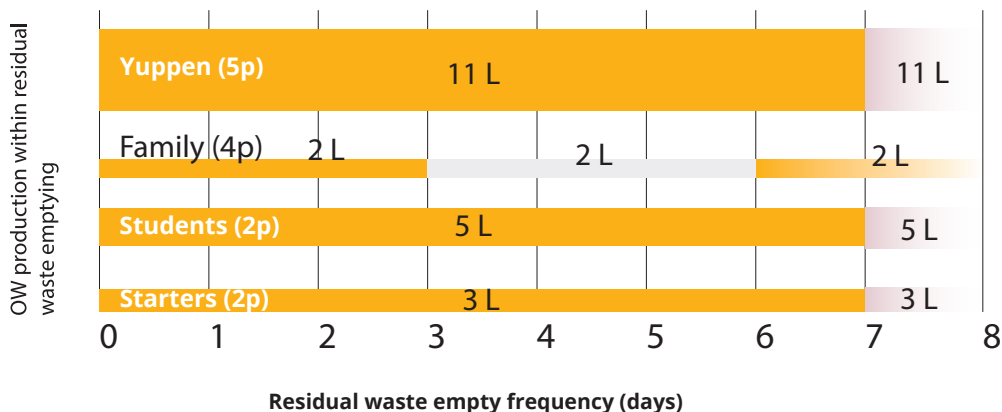


Figure 21 | Production volumes measured by coupling OW in prototype and prototype volume

2.6 User problems with OW

What problems do AI's encounter when collecting OW?

In this chapter, AIs are divided into two groups. The first group is the one that already collects OW; the separators. The other group does not yet collect OW; the non-separators. Via an online questionnaire, both groups of AIs were asked about their motivations and problems in separating or not separating OW. The problems that separators experienced in high-rise areas were also looked at. During field research in Wageningen, several AI households were visited and asked about their motivations and problems regarding the separation and collection of OW.

OW-separators

OW separators were asked what their annoyances were regarding the collection of OW and how they were currently dealing with those annoyances. The biggest annoyances appeared to include odour, leaking trash bags, fruit flies and not knowing how to separate trash.

These annoyances and how AIs deal with them are shown in figure 27. In figure 25, an example of a leaking bag is shown and in figure 26, the Ventimax®. A bin for OW sold by BinBang is shown. Both showing a leaking waste bag, which causes annoyance.

The non-separators

The non-separators were asked via an open question what their motivations were regarding not separating waste, and what would encourage them to start separating. The largest factor as to why AIs do not separate waste is that the

municipality does not offer public containers either nearby or within high-rise buildings to dispose of OW. Other important motivations include that the AIs think that OW waste disposal smells, that they do not have enough space, or that they do not have the right products to separate OW.

Conclusion

From the online questionnaire, it appears that a large part of the problem of this thesis (why AIs do not separate OW) is due to the municipality not offering OW disposal facilities such as public containers. From this, it could be concluded that if the municipality offers public containers, a large part of the main problem of this thesis would be solved. However, the majority of respondents were highly educated. In the previous chapter, a positive relationship was shown between education level and willingness to separate. It could be concluded that other motivations, like OW being "not important" and "not necessary," are significant among the entire population of AIs, which also includes less educated people.

For OW separators in Wageningen, the following problems arose: fruit flies, leaking trash bags, inefficient space usage and odour (which mostly occurs during the summer). These problems were also found by DIG (2015). The final solution of this thesis focuses on attempting to solve these problems.

The main reasons why AI do not separate OW are:

- *The lack of public containers*
- *High-effort of separation*
- *No space and time to separate*
- *The lack of space*

There is a lack of awareness about separating OW:

- *AI do not see the necessity of separating OW*
- *No idea what belongs to OW*

By OW-separators OW is perceived as unhygienic, this included:

- *dirt*
- *leaking trash bags,*
- *odour*
- *fruit flies*

Separating OW is perceived as high-effort

- *walking distance to the public container*
- *walking frequency to the public container for hygienic reasons.*

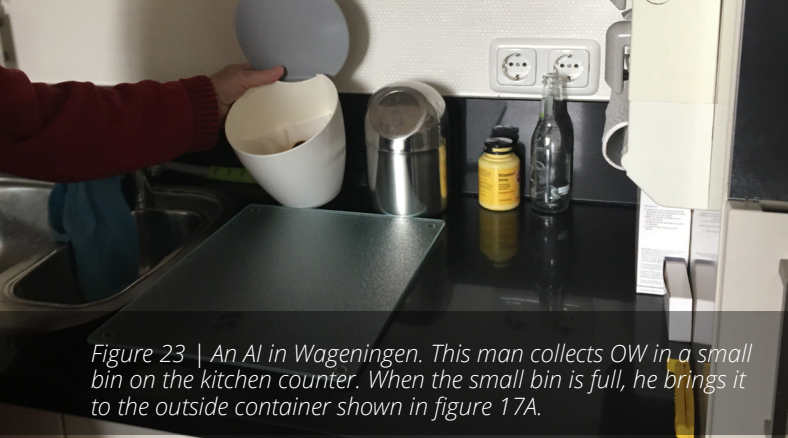


Figure 23 | An AI in Wageningen. This man collects OW in a small bin on the kitchen counter. When the small bin is full, he brings it to the outside container shown in figure 17A.



Figure 24 | An AI in Wageningen. This person collects OW on the balcony, to avoid the odour of OW in the house.

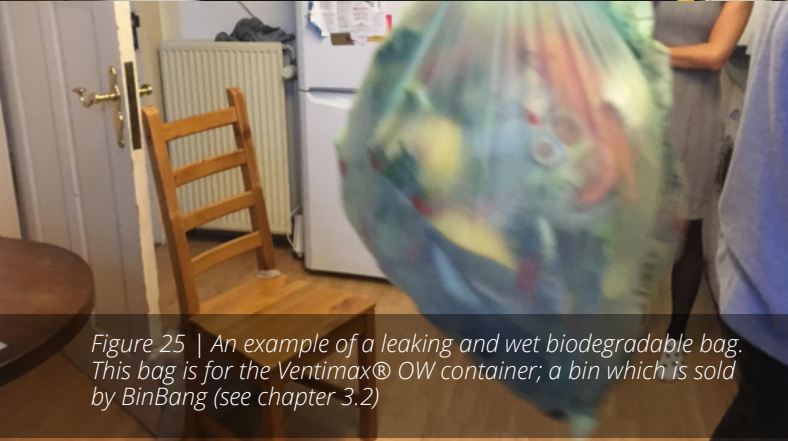


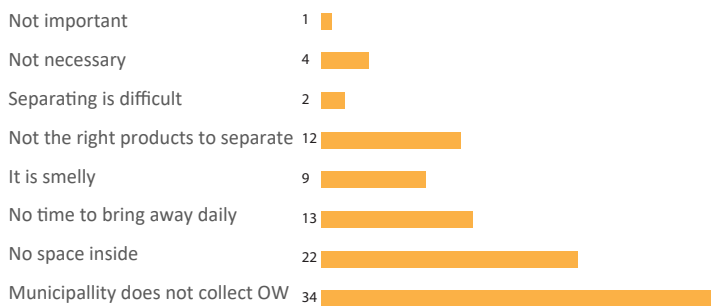
Figure 25 | An example of a leaking and wet biodegradable bag. This bag is for the Ventimax® OW container; a bin which is sold by BinBang (see chapter 3.2)



Figure 26 | The Ventimax® in use by the family. After several days of collecting OW, the family placed a plastic bag beneath the bin to avoid any moisture from leaking on the ground.

This is what AIs who do not separate OW say (N44)

This is why I do not separate OW



I would start separating OW if

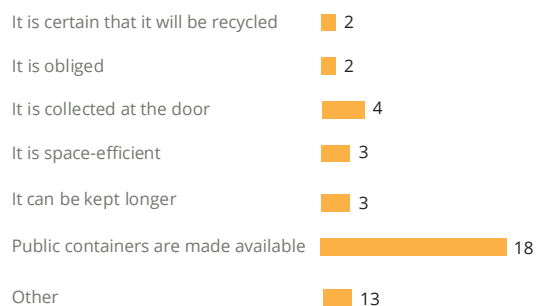


Figure 22 | Motivation for non OW separators.

This is what AIs who do separate OW say (n8)

Main annoyances

It is dirty and smelly



Fruitflies



Leaking trash bags



Not knowing how to separate



How I deal with annoyances

"I use cat litter and pail"

"I use a biodegradable bag"

"I empty my bin frequently"

"I keep OW outside"

"I put a newspaper in the bottom of the bin"

"I use an odour filter"

Figure 27 | 1. Main annoyances separators 2. How separators deal with those annoyances.

2.7 Stakeholders analysis

Who is more involved in the collection and processing of OW?

When collecting OW, it is not only the AI who plays a role. There are more important stakeholders involved in the process of collecting OW. Those stakeholders include the neighbourhood, the municipality and the waste collection and waste processing companies. In this chapter, it is revealed as to what their roles, concerns and/or annoyances are when collecting and processing OW.

Importance of stakeholder map

At the beginning of a design project, it is important to map out stakeholders and their relationships. This is meaningful for discovering ways in which to influence other stakeholders as well as for discovering risks and positive stakeholders to involve in the design process (Weprin, 2016). Getting to know stakeholders' needs and wants is also a part of design thinking which is applied in this thesis. Schuurman (2016) indicated all stakeholders in the waste collecting infrastructure in high-rise areas in the Netherlands. All cash flows in waste infrastructure pass by the municipality. Therefore, the municipality is considered an important stakeholder. Furthermore, the municipality makes the decisions regarding the types of waste collection systems and programmes to be implemented.

Interviews

To find out the needs and wants of the external stakeholders, three interviews were performed. The needs and desires of the municipality and of the neighbourhood were found by separately interviewing two project managers of projects for the improving of OW separation, namely, Saskia van Dongen (2018), project leader of OW separation in the municipality of Rotterdam and Esther van Someren (2018), project leader of OW separation in Ja-vaei-land (a neighbourhood in Amsterdam) by the municipality of Amsterdam. This cities are selected because they run currently project to increase OW separation in high-rise areas and are also large cities like the Hauge. In both cities, there are significant problems regarding OW separation in high-rise areas. The needs and desires of the waste processing and collection companies were researched by visiting the company Indaver in Alphen aan de Rijn. There, the representative of all OW processing companies, Femke Mackenzie (2018), was interviewed. Indaver is processes OW into biogas and compost. The interview questions and answers can be found in Appendix B.



Figure 28 | Overview stakeholder problems

Results and conclusions

In figure 26, all of the stakeholders are shown in a stakeholder map. Based on the interviews, their concerns and motivations are described in the stakeholder map.

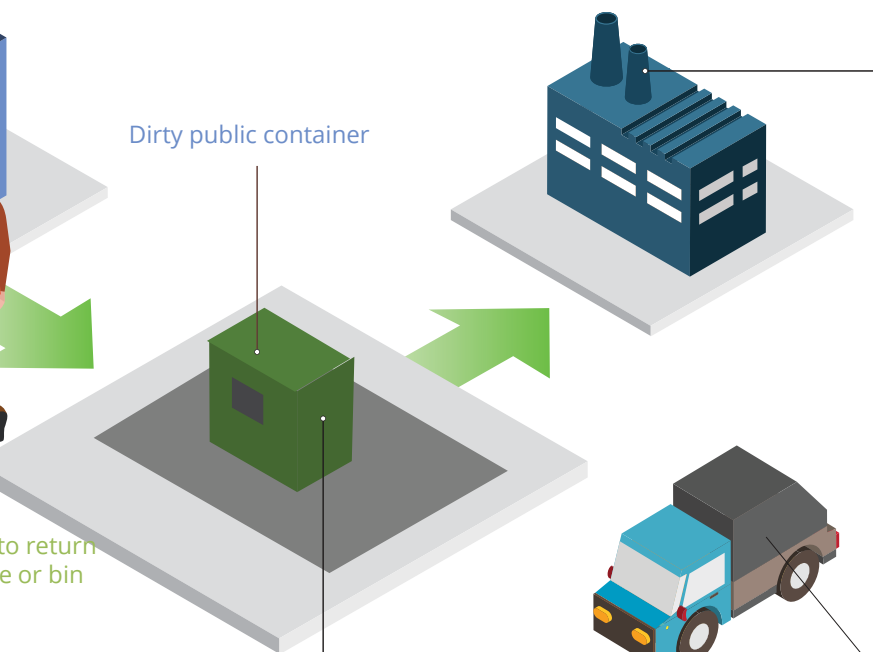
From the interviews with representatives from the municipalities of Rotterdam and Amsterdam and the visit to Indaver, the following conclusions can be drawn:

- Municipalities are looking for effective and economic methods for increasing OW separation. Effective methods regard the percentage of separated OW collected by AIs. Economic methods regard the costs of emptying and cleaning OW containers and coaching of citizens in how they should separate waste.
- The waste processing company, Indaver, is looking for methods and products which will decrease pollution. Currently, OW is polluted with 10% of other waste types, mainly due to the use of plastic trash bags. This pollution cannot be filtered from the compost, and ends up in the soil.
- Neighbourhoods need new OW storage containers that are not disturbing in sight or in smell. Currently, hallways are polluted by leaking OW trash bags during experiments of OW collection in Rotterdam
- Waste collection companies desire containers that can be easily emptied and that are close to the road.

10% of OW is polluted, mainly by plastic trash bags, which results in polluted compost. This compost goes back into the ecosystem. This is a problem for waste processing companies.

Municipalities are seeking solutions to increase waste separation in an effective and an economical way.

part in hallways



Waste processing company |
OW is 10% polluted with plastic bags or other non-biodegradable substances. This results in compost which contains toxic substances.

to return
e or bin

Municipality |
Not all AIs separate OW.
Emptying and cleaning of public containers is costly.

Waste collection company |
Distance between road and public container is large.
Multiple actions such as opening locks

2.8 OW routes

Which routes can OW follow?

There are many different routes that OW can take, from the moment it is produced until it is processed or biodegraded. All of these different possibilities and options for processing waste necessitate lengthy discussion as to which option is the most effective at an environmental level. For example, municipalities are currently testing different methods for the processing of OW, including neighbourhood composting projects, and there are products on the market for composting OW inside the home within 24 hours. Furthermore, businesses are experimenting locally with new ways of processing OW, such as neighbourhood 'worm composters' or local digesters. In this chapter, all the different routes that OW can take are explored. Furthermore, the advantages and disadvantages of each route are discussed. In the next chapter, products or tools that are used in each route are discussed. This overview is based on the four routes researched by CE Delft (2015). CE Delft is an independent research firm doing

The most environmentally friendly route for high-rise buildings is the **bio waste route**. Here, the OW is separated and collected in the house, disposed of in a public container, transported to an industrial digester and processed into biogas, compost or other products.

research in a durable society. These include the residual waste route, the bio waste route, the water route and the new water route. Two other routes have been found in this thesis, which are added to the overview: neighbourhood processing and home processing.

Home processing route

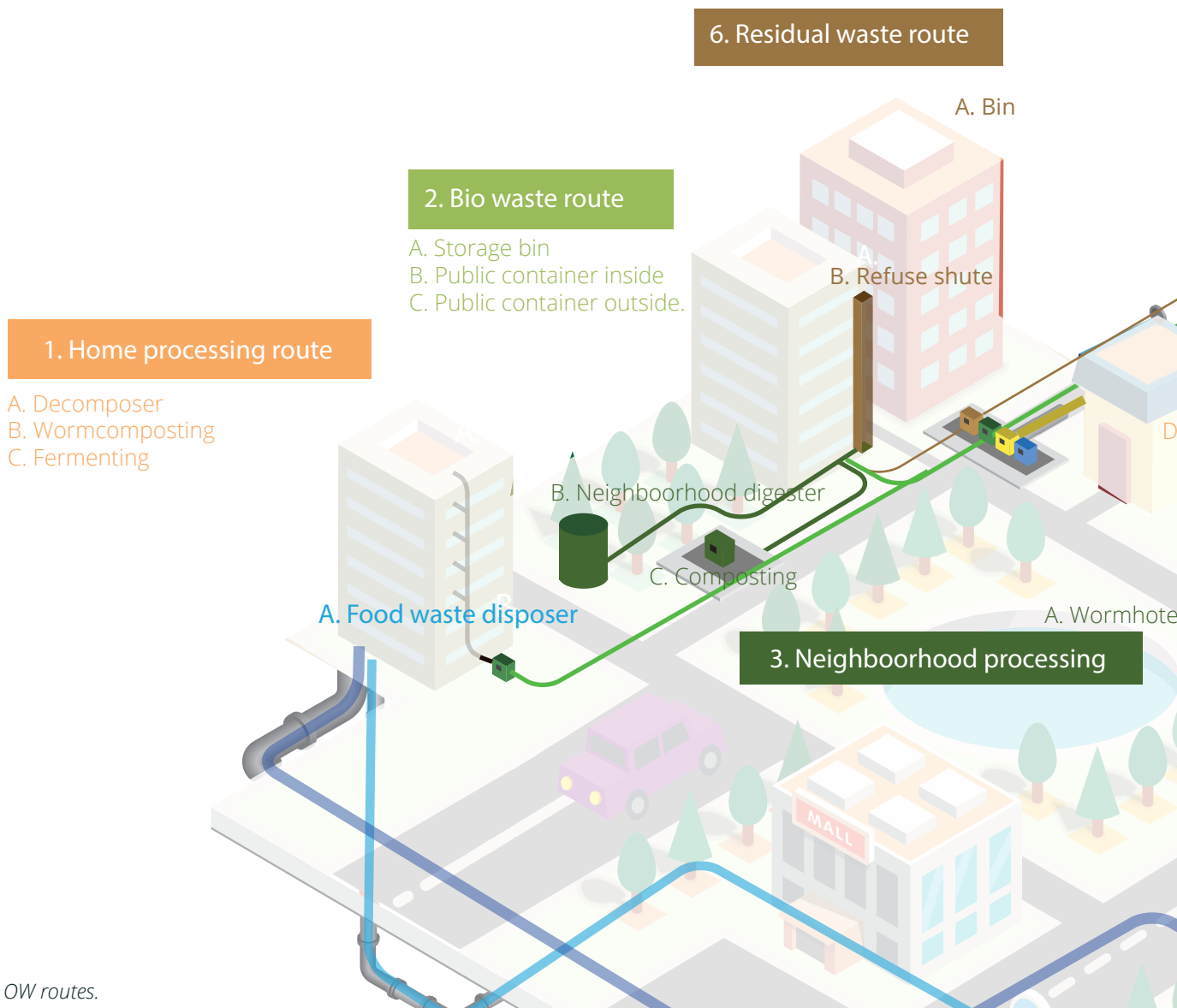


Figure 29 | OW routes.

In this route, OW is recycled at the source by the AIs by using, for example, a compost-bin or worm-bin. The OW turns into compost and/or fertilizer, which can be used locally.

Bio waste route

In this route, OW is separated and collected at the source, disposed of in a public container and transported by truck to an industrial digester and/or composter.

Neighbourhood processing

In this route, OW is collected and separated at the source and composted or digested in the neighbourhood. AI have to separate OW in their homes and have to bring it to the neighborhood.

Residual waste route

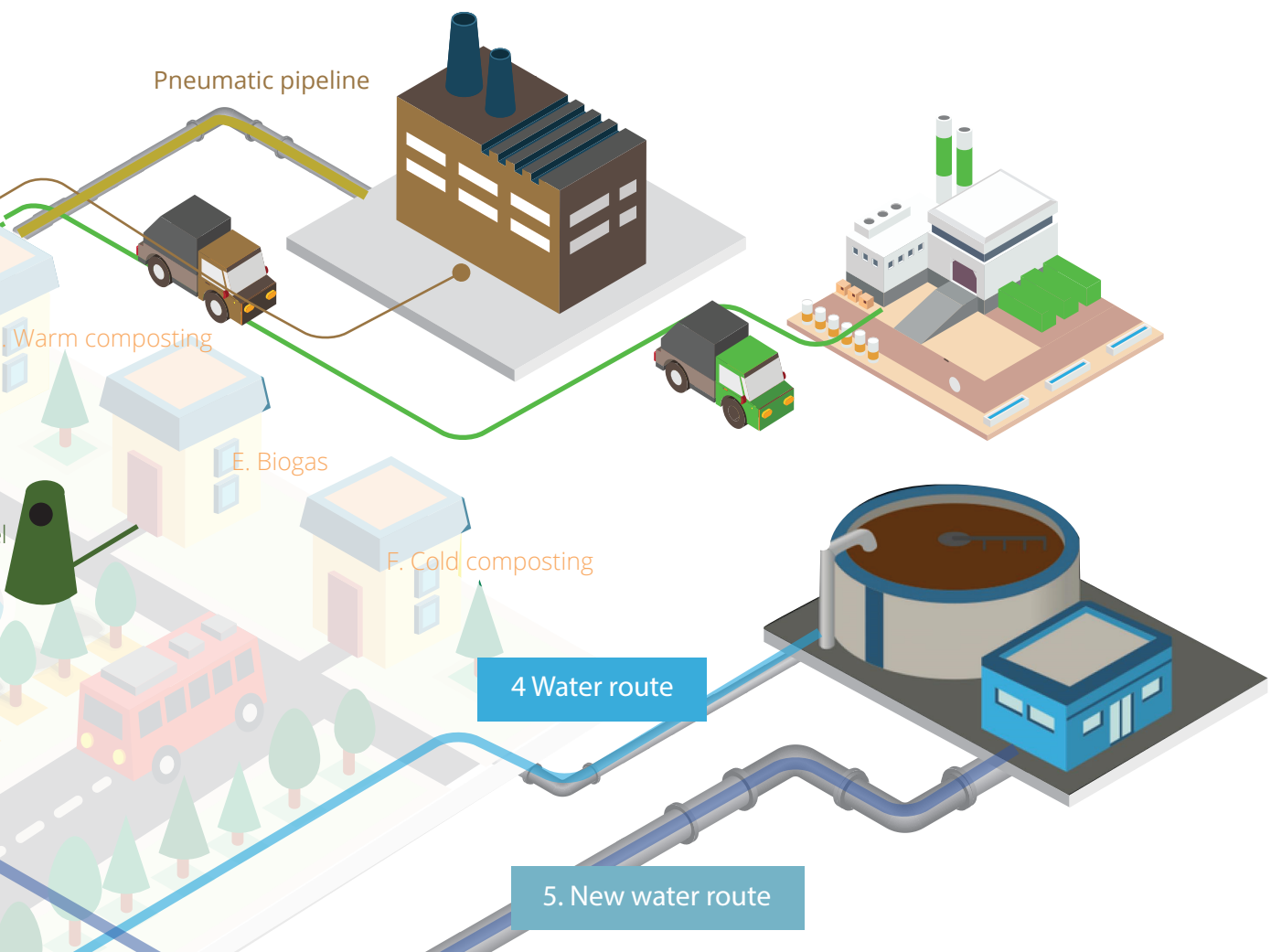
In this route, OW is not separately collected but added to the residual waste. The residual waste will be post separated and all non valueble fractions will end in the incinerator, where it is used to generate energy.

Watteroute and new watteroute

In this route the OW is crushed by a food waste disposer in the sink and transported via the sewage to the sewage treatment plant. The difference between the watteroute and the new water route is the difference in transport of the OW via the sink and the efficiency of the digester. The new water route is in both, efficiency of the digester and transport more optimal, compared to the watteroute.

What is the most optimal route?

CE Delft (2015) researched the environmental impact of the water route, the new water route, the biowaste route and the residual waste route. The route with the most environmental advantages is industrial digestion of OW via the bio waste route. Composting of OW or combustion scores second. The water route have an overall negative impact on the environment, because of the use of energy by food waste disposers and the loss of material in the sewage system.



2.9 Product categories in OW routes

Which products are used in the routes?

Langeveld (2014) describes many interventions and methods for improving the separation of OW in high-rise buildings, including communication, legislation and financial incentives. One of the intervention includes the products to collect, separate or process OW. This thesis focuses on product/service solutions which can contribute to improving OW separation. In this chapter, all product categories that could support AIs in collecting and separating OW at the source are described. Even so, despite this large variety of products, OW is still hardly separated. This chapter will discuss which products could have the most impact in solving the main problem of this thesis.

The product categories were found by desk research and by the input of BinBang employees. The product categories are described in terms of one example product, which represents all other types and models of the products within a certain category.

Setting requirements for a product.

The following requirements are set for the assessment of product categories for the final solution of this thesis.

- The product should be scalable. With a scalable product is referred to how easily it can be implemented by municipalities (chapter 2.7)
- The product should have a price of €20 or less per household, to make the product scalable. Assumed is that products with a higher price will not be bought by for example municipalities.
- The product should be environmentally friendly. Therefore, the product should not use electricity or use extra materials.

1. Products for the home processing route

All products for the home processing route are able to process OW in the home into compost, fertilizer or biogas.

A. Electrical decomposers | An electrical decomposer for use in the kitchen, which can turn OW within into compost within 24 hours, for example, the Zera Food recycler (wlab-sinno-va-tions, 2018).

B. Worm composters (BB²) | This is a worm bin which can be placed in the kitchen. Worms can break down OW. More information about the BinBang worm composter can be found in chapter

C. Fermenting. This anaerobic digestion of OW can be done inside the house.

D. Compost pile in the backyard.

Non electrical products in the bio waste route are considered to have the biggest effect in improving OW separation, because of their scalability, sustainability, usability and costs.

E. Home biogas. It is possible to install products to process OW into biogas in the backyard.

This is not possible in high-rise areas (Homebiogas, 2018).

F. Composters. Composters are able to process OW into compost in a rotating barrel. These can be placed on a balcony.

2. Products for the bio waste route

In this route, OW is recycled at the source by the AIs themselves.

A. Bins to collect OW. An example is the Ventimax® OW bin. This is the bin BinBang offers to her customers to collect OW collection. A more detailed description of this bin can be found in chapter 3.2.

B. Public containers for the collection and storage of OW inside the apartment building. An example is the Fresh station of Sidcon (2018): a container which cools OW and uses ozone to stop odour.

C. Public containers outside apartment buildings. These are placed by municipalities. An example is a public container in the municipality of Amsterdam which can be opened with a card (AT5, 2018).

3. Products for neighbourhood OW processing

The products which are used to separate and collect OW indoors for the biowaste route can also be used in the neighbourhood OW processing route.

A. Worm hotel. Worms break down OW into fertilizer in a neighbourhood in Amsterdam (Municipality of Amsterdam, 2018)

B. Local digester. Neighborhood waste is locally processed into biogas. The picture displays the example of the waste transformers in Amsterdam (Wastetransformers, 2018), where the OW of ten restaurants is digested.

C. Compost pile in the neighborhood.

4. Products in the water route.

One product in the water route is highlighted.

A. The food waste disposer. This is a crusher, which can be mounted below the sink. It crushes OW to small particles

which can be transported with the water in the drain towards the sewage system.

Conclusion

The bio waste route is found to be the route with the most environmental benefits in the previous chapter. Therefore, focussing on developing products in this route could have the most environmental advantages.

There is no storage bin like (2A) yet, which is low-effort and offers a solution for problems like odour, fruit flies and dirt, (chapter 2.6).

Public containers (2C) or containers in the flat building (B) for OW contribute a lot to OW separation as found in the questionnaire (chapter 2.6).

Home processing products are a good solution for processing waste. Home processing is also permitted by the EU law

for 2023 (CouncilEU, 2018). However, home processing products require a lot of effort by AIs. It is assumed that home processing does not suit non-separators and classic separators, as mentioned in chapter 2.5, who are not willing to put a lot of effort into waste separation.

Electrical home composters are low-effort and are a solution for odour, dirt and fruitflies. However, their prices range from €200 - 800, which makes them unscalable, besides that they are also not an environmentally friendly way of processing OW.

It is assumed that products and services for the neighbourhood processing of OW also contribute to an increase in collecting and separating OW at the source. But with neighbourhood processing, AI still have to bring the OW towards the wormhotel or digester, which will cost them effort.



Figure 30 | Product categories OW collection, separation and processing

In this section, the company BinBang is analysed in an internal analysis and the marked market trends and competitors are analysed in an external analysis. After this, the findings of the internal and external analyses are placed in a SWOT matrix. The strengths of BinBang and its opportunities in the marked market are combined into seven search fields regarding the business opportunities for the development of new products and services for BinBang. One of those seven search fields has been selected. Based on this search field, a design direction is formulated. This formulates what and how the product or service to be developed should be like

You are in this part of the project:

Part 1 | Introduction

Analysis phase

Part 2 | OW in high-rise buildings

→ Part 3 | **Business analysis**

Synthesis phase

Part 4 | Ideation & conceptualisation

Part 5 | Prototyping, concept evaluation and selection

Embodiment phase

Part 6 | Embodiment

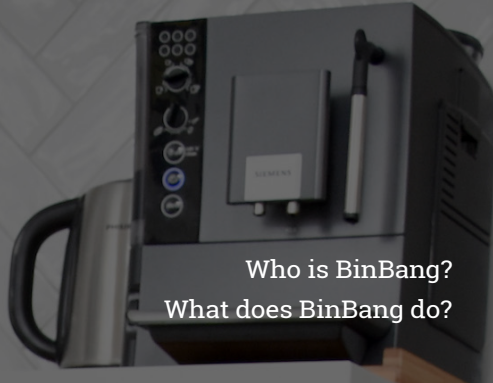
Evaluation phase

Part 7 | Evaluation

Part 8 | Recommendations

Business analysis

Part 3



Who is BinBang?
What does BinBang do?

Which physical products does BinBang offer to its customers? What are the trends?

An overview of BinBang's position in the market.

What are the opportunities for BinBang to address the main problem of this thesis?

Take a decision regarding the direction in which BinBang should move

This design challenge states what will be designed

3.1-3.3 Internal analysis | the company

BinBang is a company whose mission is to work towards a circular economy.

3.4, 3.5 External analysis

BinBang provides products for the collection and separation of OW at the source. Several trends are indicated.

3.6 SWOT analysis

The strengths, weaknesses and opportunities of the market are combined in one overview.

3.7 Search areas

The strengths and opportunities from the SWOT matrix are combined into seven business opportunities for BinBang.

3.8 Search area selection

One of these business opportunities is selected: product portfolio extension.

3.9 Design challenge

The product should follow this direction: The design of a sustainable bin for the kitchen collection and storage of OW in high-rise buildings, which is then transported to a public container. The product is hygienic and low-effort. A list of requirements is added

3.1 Internal analysis | the company

Who is BinBang and what do they do?

This chapter analyses BinBangs structure, activities, mission, vision and ambition. The goal of this analysis is to discover the capabilities of BinBang and to find out how the problem of this thesis could be affiliated with the activities and resources of BinBang.

BinBang focuses on four different customers: consumers, municipalities, companies and schools. The mission of BinBang is to save as many resources as possible from the incinerator. They started with their own product development in 2014, but nowadays they are shifting towards becoming a service organization to deliver services, such as coaching for local residents, to municipalities in order to improve waste separation. BinBang is open to developing new ideas for services and products. Because BinBang is not a producer and developer of products, product development has to be done through collaboration with external parties.

Method

An internal analysis was conducted by interviewing Menno Wiersma, COO of BinBang. An extended overview of the interview can be found in Appendix C. Furthermore, information was retrieved from the BinBang website.

History

Anja Cheriakova launched the first BinBang product, the stackable waste bin (figure 31) in 2015, following a successful crowd funding campaign. Previously, Anja had organized educational classes for primary school pupils about the value of waste. During this period, she noticed that there were no appropriate kitchen appliances for the collec-

*BinBang focuses on **municipalities, consumers** and **companies** to improve waste separation with their products and they also provide coaching to citizens to improve waste separation.*

tion and storage of multiple types of waste. She seized the opportunity to do something with this demand, and started BinBang (BinBang, 2018).

Structure

Since the foundation of the company in 2015, BinBang has grown to an organization with 12 employees by 2018. The regular staff (10 employees) focus on sales, project development, marketing and customer services. Product development, fulfilment and production are outsourced. The fulfilment is currently done by the company Looped Goods.

Customers

BinBang customers include consumers, municipalities, businesses and schools. A brief explanation of BinBangs target groups and its value proposition for those target groups is described below.

Note: In this thesis, the focus is on the target group of AI in the Netherlands, and not on all current BinBang customers. A more detailed description of AI and their needs, wants and waste separation behaviours is presented in chapter 2.2, user analysis.

Consumers | BinBang offers products via its web shop and through various online and offline retail channels. An extended overview of current BinBang products BinBang is given in the next chapter 3.2, product portfolio.

Municipalities | BinBang offers programmes to municipalities for encouraging inhabitants to separate waste by coaching and providing the inhabitants with indoor bins. These projects are mostly focused on high-rise areas in large cities. The most recent project of BinBang was to encourage the inhabitants of the high-rise area Schiemond, in Rotterdam, to improve waste separation. BinBang offered the municipality a programme in which approximately 200 households were coached regarding waste separation during a period of three months. Each participant was offered two stackable BinBang bins, was told how to separate waste and was provided with an explanation as to how they could contribute to a better environment.

Schools & businesses | BinBang sells large volume parties



Figure 31 Stackable bins of BinBang. (BinBang, 2018)

of the bins to schools and businesses. Examples of their customers include Landal Greenparks and the Jaarbeurs (trade fair) in Utrecht.

Vision, mission and ambition

Vision | The future vision of BinBang is to work towards a circular economy (CE). BinBang aspires for a world without waste and in which materials will be reused over and over again (BinBang, 2018).

Mission | The mission of BinBang is to save as many resources (waste) as possible from the incinerator. An example of an incinerator is located near Coevorden, owned by the company Circulus Berkel (CirculusBerkel, 2018). It generates electricity by burning residual waste. By separating waste, resources can be reused and the resources in the earth do not need to be depleted. BinBang wants to contribute in working towards a CE. More information about the CE is given in chapter 1.2.

Ambition | According to Wiersma (2018), the ambition of BinBang is to be profitable by the end of 2018, which seems to be feasible because of its upcoming projects with municipalities. BinBang wants to reach this goal by fully focusing on its coaching projects. BinBangs ambition is that, after five years, it will no longer need to exist as a company. By then, BinBang aims to have been transferred into subsidiary companies. BinBang products will then be under the management of a larger producer or developer. This idea has been raised within the board of the BinBang because it acknowledges its weak position in comparison with large competitors. This is further explained in chapter 3.4.

Track record of BinBang & product portfolio development

To understand the activities and history of BinBang, a time line has been made (figure 32). This shows how the product portfolio has been extended over time and the activities of BinBang within municipality projects (municipality projects are shown in green). An extended description of the background to the municipality projects can be found in appendix D. BinBangs portfolio products, shown in blue, will be discussed in the next chapter.

Development and production

BinBang produces its stackable waste bin via VDL Plastics. This bin is developed by design agency Van Gaalen, Janssen consulting and VDL Plastics, and reviewed by design consultant Van Berlo (Wiersma, 2018).

- Van Gaalen is a home business run by one person, based in Apeldoorn in the east of the Netherlands, which focuses on the development of new products.
- Janssen consulting, based in Duiven in the east of the Netherlands, is a specialist in product development and the manufacturing of plastics for small and medium enterprises.
- VDL plastics, based in Nederweert in the Netherlands, has more than 50 years' worth of specialist experience in 2K injection moulding. Examples of other products that they produce for the consumer market include stair lifts, trailer parts and roof boxes (VDLkunststoffen, 2018).

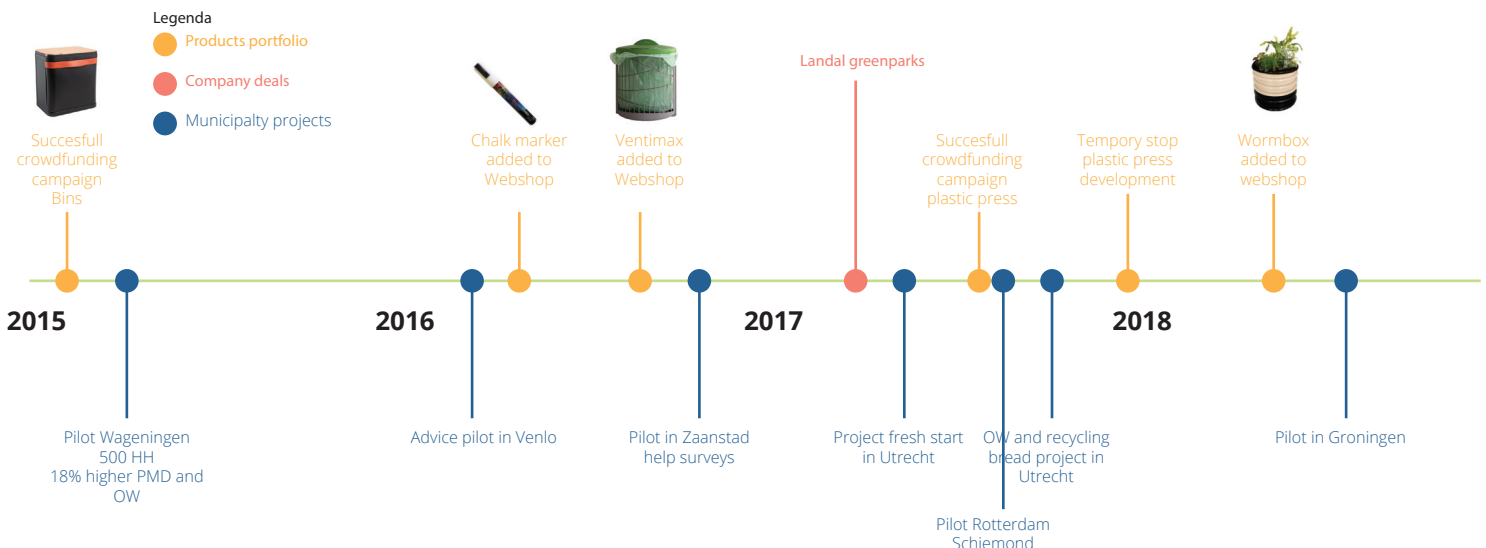


Figure 32 | BinBang track record

3.2 Internal analysis | Strengths & weaknesses

What are BinBangs strengths and weaknesses?

The strengths and weaknesses of BinBang are found in the by organizing a group session with eight employees of BinBang were participating.

During this session the employees of BinBang were asked about what they think personal are strengths and weaknesses of BinBang and what are opportunities and threats in the market for BinBang. There was also time for an open discussion about everyone's input.

Method

The program of the session, the participants and results can be found in Appendix E.

Results

From the group session the following strengths and weaknesses came forward from the session.

Strengths |

- BinBang is strong in marketing and branding. They know to reach the right group of customers. Although BinBang has a bin with a low price/quality ration compared to competitors they still make sales.
- BinBangs is competent in communication, they know how to reach their customers (municipalities, companies and consumers). For example they know how to stimulate residents in Kanaleneiland to increase waste separation (figure 34a) and to make children aware about the value of waste (figure 34b).
- They have proven skills in organizing project for municipalities and are able to change behaviour of people considering waste separation.
- BinBang is flexible, they know how to quickly change direction and reach extra (human) capital.
- They have an educational function which is appealing to their customers.
- They have loyal customers, who buy their products because they believe in the story of BinBang.
- BinBang has good connections in the sustainable and waste sector and knows how to reach third parties.

Weaknesses |

- The price/quality of BinBangs stackable bin is low compared to that of its competitors. In addition, it was found in the product test (ch3.2) that the stackable bin has flaws, for example, bags may leak in the product.
- BinBang has problems in keeping focus. They see a lot of opportunities and they want to start a lot of new projects

BinBangs strenghts are marketing, branding, communication about waste separation and the ability to change behaviour.

Their weaknesses is their current stackable bin, which has a low price/quality compared to their competitors.

and do not finish them.

- There products do not offer a solution for odour, dirt, leaking bags as found in chapter 2.6
- They focus to much on new business ideas, which are in the beginning still non-profitable.

Conclusion

BinBang has a strong set of competences which gives them a benefit to move themselves in the waste separation and collection sector. Their strengths will be used to build on when generating new ideas and business strategies addressing the main problem of this thesis. Also the weaknesses of BinBang will be taken into account when developing a solution in this thesis. This could be done by finding ideas which suit their current activities, to keep the focus or by improving the price/quality ratio of their current products.

The strengths and weaknesses of BinBang are used in the SWOT analysis (chapter 3.6).



Figure 33 | SWOT session employees BinBang



Figure 34a | Handing out bins to inhabitants of the neighborhood Schiedmond in Rotterdam, 2018



Figure 34b | School kids are cleaning the streets in Kanaleneiland in Utrecht for project "Frisse Start" organized by BinBang

3.3 Internal analysis | Product portfolio

Which physical products do they offer to their customers?

This chapter analyses the product portfolio of BinBang and how it contributes to solving the main problem of this thesis. BinBang offers eight different products to its customers, including three different OW solutions. All products are shown in figure 35.

OW solutions

BinBang offers three OW bins to its customers. The Ventimax® (1), the Worm box (2) and the waste bin (3). All products are briefly discussed below.

1. The Ventimax® (BinBang bin)

The Ventimax® is sold by BinBang, but the product is not actually from the brand BinBang but rather from The Compost Bag Company (Compost Bag, 2018). The Ventimax® is the solution that BinBang offers to its customers if they want to collect OW in an appropriate manner and minimize the disturbance of odour.

Product description | The Ventimax® makes use of a

continuous airflow in the bin. An environment that is closed and non-ventilating results in rotting, odours and mildew. In this smart OW bin, air can flow through the side and the lid, resulting in a continuous airflow throughout the bin. Water vapor is minimized directly and so the organic material dries, and as a result, odour and mildew do not get the opportunity to grow or vegetate. The special bags that come with the Ventimax® let water vapor pass through and are compostable. The OW bin can be placed on the kitchen counter, where it has ventilation space and is easily accessible during food preparation.

Product test | No negative reviews about the product can be found on the BinBang website or other websites that sell the Ventimax®. However, according to some BinBang employees, the leaking of the bags in the Ventimax® is considered to be a problem. Therefore, the Ventimax® was tested by three of the households studied (family, students and young professionals) for the period of a week. The following negative results were found:

BinBang currently offers three OW bins to its customers. The products do not offer a solution for odour, fruit flies or leaking trash bags.



Figure 35 | BinBang product portfolio

- The annoyance of odour (found by the young professionals and the family).
- fruit flies (young professionals and family)
- leaking bag, therefore a plastic bag was placed beneath the bin (family)
- dirty hands because of moisture (family, students, young professionals)
- bin was too big for kitchen counter (students)
- unable to estimate the amount of OW in the bin (students).

2. The worm box

The Wormbox is a worm-based composter for households of two to three persons. Several layers can be filled with uncooked fruit and vegetable waste. The worms will turn the material into a fluid fertilizer (BinBang, 2018). The Worm box has been sold twice, once in March 2018 and once in June 2018, since its introduction on the web shop.

3. The stackable waste bin

The stackable waste bin contains small notches in which a biodegradable bag can be positioned. There are three reviews on the BinBangs website concerning the stackable bin. From the reviews, it can be concluded that the current solution is not suitable for all types of bags and that the user needs to put effort in creating their own solutions.

Product portfolio consistency.

BinBangs product portfolio is found to be inconsistent, because the form and designs differ from product to product. Design consistency could ensure that the brand becomes more stable and identifiable. This helps companies to become visibly different from their competitors (Karjalainen, 2007). This may also help BinBang, which is a young brand still in development and unknown by the general public.

Conclusions

The following conclusions can be drawn from analysing BinBangs product portfolio:

BinBang has three products for the collection and storage of OW. These do not offer a solution for the problems found in chapter 2.6, leaking trash bags, odour, space efficiency and fruit flies.

BinBang has one product of its own: the stackable waste bin. The product portfolio is inconsistent. It is a collection of different products (brands) and the products have different form languages. Their appearance do not have similarities. BinBang does not have its own product specifically for OW.



Figure 36 | A Ventimax® tested by students.



Figure 37 | A Ventimax®, leaks during a test by the family.



Figure 38 | A Ventimax®, tested by young professionals.



Figure 39 | A Ventimax®, tested by Young professionals. Moisture collects from the leaking bags in the bin.

3.4 External analysis | trends

A view in the market, what are trends, who are competitors?

In this chapter, a trend analysis is performed. The goal of identifying trends is to find relevant business opportunities for the development of new products and services relating to this thesis. For this purpose, the DEPEST method is used. The DEPEST method is a way to structure trends in demographic, ecologic, political, economic, social and technological aspects (Delft Design Guide, 2016). Furthermore, there is a specific focus on trends in (OW) waste specifically, including within political trends.

The following trends and developments help to identify future AI needs and seek possibilities for the solution of this thesis.

Urbanisation

1.3 million people move worldwide to a city every single week. It is expected that by 2050, more than two thirds of the world population will live in cities (Rabobank, 2016). This means that all cities must reduce, collect and manage waste more efficiently in the future. BinBang could focus on this problem to offer solutions in managing waste more efficiently.

Moving towards a CE

In moving from a linear to a circular economy, waste will no longer be burned or put into a landfill site but instead will return to manufacturers as a valuable resource (Balch, 2015).

Mono streams become valuable

Multiple companies are doing something with mono streams of waste. SOOP, a subdivision of the Amsterdam based sustainable entrepreneurs collective Beeblue is producing soap from orange peels and coffee grounds. Another in Amsterdam based company produces beer from old bread. (morgen, 2018) Milqman, a division of BinBang is focusing on the collection and recycling of only diapers. (BinBang, intern communication).

Private waste processing companies

More private companies are focusing on reusing of waste. Next to the regular waste processing companies, private companies which focusing on waste processing are started. An example of one of these businesses is the Waste transformers. They provide a biogas digester in a small sea

container, within which OW can be transformed to electricity.

Food spill will decline in the Netherlands

In the Netherlands will execute a plan to reduce food spill by half in 2030. (Hegger, 2018) Germany has the same ambitions to half food spill by 2030. (Klockner, 2016) .

Waste companies are focusing more on the reuse of resources

Renewi, one of the largest waste processing companies of the Netherlands is positioning itself as a "waste-to-product" company. Before their name was van Ganzewinkel, now Re(new)l. It is already in the name. Currently, 90% of the 15 million ton of waste they process annually is recycled or used for energy recovery. (Renewi, 2018)

The mindset of population moves towards a sustainable and circular world

Public consciousness of sustainability is growing, yet political leadership is lacking. This will be an opportunity for businesses to show leadership in sustainability, for example, IKEA (University of Cambridge, 2018)

Strong growth of singles

The Netherlands has 2.9 million single people, expected to decrease to 2.4 million by 2030. Still, by then, 4 out of 10 households will consist only one person. The strong growth can mostly be explained by the elderly, who become widows (PBL, 2016).

Emerging technologies

The eight most important technologies at the moment are artificial intelligence, augmented reality, blockchain, drones, the 'internet of things', robots, virtual reality and 3D printing (PWC, 20182).

Scarcity of resources

The demand for resources is increasing because of growing population and wealth. The amount of natural resources is limited and resources need to be reused (PWC, 20181).

3.5 External analysis | opportunities

opportunities and treads according to the COO and confounder of BinBang

Gijs Langeveld (co-founder of BinBang) and Wiersma (COO) are interviewed about their ideas for opportunities and threats for BinBang to address the main problem of this thesis. The questions and interviews can be found in Appendix F. The opportunities and threads are used in the next chapter, SWOT analysis.

Opportunities

The following opportunities came forward from the interviews and are used in this thesis.

Waste transporting systems via tubes

The starting point of this idea is that the flat-inhabitant does not have to think about or put the effort in separating OW. He can dispose of all types of waste in one bin or point. The system shreds the waste and transports it to a collection station. In the collection station, the fragments of waste will be separated into separate fractions so that they can be reused.

Data for OW production

Measuring the OW production of flat-inhabitants in their homes for example sensors could help improving waste separation in a couple of ways. The data could be used to stimulate or reward behaviour in separating waste. It could also aid in the prevention of creating waste. A system could, for example, tell the users that they should buy less food because they have structural leftovers.

Mono streams

Within OW several waste streams could be valuable if they are separately collected. For example, coffee grounds could be used to culture mushrooms, and orange peels could be used to make soap and bread could be used as a stable fuel for biodigester. They are no services or products yet which collect mono streams at the homes of (flat) inhabitants.

Threats

There are two large treads recognised, which could influence the operations of BinBang.

Large competitors of bins

BinBang has large competitors who produce waste bins. These are for example Joseph Joseph or Brabantia. These competitors have a lot more experience to deliver high-quality products at a lower price. Wiersma acknowledges it is hard for BinBang to compete with those competitors. He instead sees BinBang developed ideas for new products and external parties with more experience produce and developed the ideas.

Municipalities reduce their (financial) support in waste separation at the source.

Municipalities are vital to solving waste problems. If they lack to invest in placing facilities for waste separation, it will be hard for BinBang to operate. For example, the placement of a post-separation installation would make separation at the homes of people redundant.

3.6 SWOT analysis

An overview of BinBangs position in the market.

In this chapter a SWOT analysis is performed. The strengths and weaknesses of BinBang found in the internal analysis and opportunities and threats for BinBang found in the external analysis and from the analysis of OW in high-rise buildings are placed in a SWOT matrix.

A SWOT matrix helps systematically analyze the strategic position of a company's business (DDG, 2015, p73).

The strengths of BinBang and the opportunities in the market will be combined in the next chapter to form search areas.

Results

The results of the SWOT analysis are listed in figure 40. A short description is given below.

Conclusion

From the SWOT can be learned, BinBang has strong competences in communication and branding in the waste sector. However, their physical products are lacking behind to other producers of bins. The threat of mature and large competitors of bin developers and suppliers is high, so if BinBang wants to distinguish themselves from them, they should come up with completely new products or innovations, which are a solution for the current gaps in the market and current problems encountered during collecting OW. There are also other product development opportunities where BinBang could focus on besides to normal waste bins. These are focus on waste transporting systems, installations for neighborhoods or systems to collect data about waste production behaviour.

Focusing on collecting mono streams could open a new market. However, it is assumed that it does not directly contribute to the main problem of this thesis. It is assumed that flat-inhabitants and especially non-separators will not start separating OW if they can collect mono streams. Mono streams could be used in public installation to make people aware of the value of different waste fractions.

The SWOT matrix shows where BinBang is good at and what opportunities are for them to dive into.

Strengths	Opportunities
<ol style="list-style-type: none"> 1. Branding, marketing (chapter 3.2) 2. Communication (chapter 3.2) 3. Flexibility (chapter 3.2) 4. Education (chapter 3.2) 5. Loyal customers (chapter 3.2) 6. Collaboration with external parties (chapter 3.2) 	<ol style="list-style-type: none"> 1. Market and BinBang lacks product solution under <€20 to store OW without odour, smell, fruit flies etc (chapter 2.9) 2. Problems in OW separation for AI's include ; odour, effort and, knowledge about separation (chapter 2.4) 3. Mono streams. Diapers, coffee grounds, orange peels, bread are valuable when separate collected. (chapter 3.5) 4. Waste transporting systems via tubes (chapter 2.8 and 3.5) 5. Neighborhood projects; collaboration in waste separation between citizens (chapter 2.9) 6. Measure waste production of flat-inhabitants in their homes with e.g. sensors and use the data e.g. to stimulate or reward behaviour. (chapter 3.5)
Weaknesses	Threats
<ol style="list-style-type: none"> 1. Price/quality ratio low vs competitors (chapter 3.2) 2. OW Bin restrictions; leaking, does not fit. (chapter 3.3) 3. Non-consistent product portfolio (chapter 3.3) 4. Lack of focus: constantly changing focus and strategy (chapter 3.3) 	<ol style="list-style-type: none"> 5. Municipalities reduces (financial support) (chapter 3.5) 6. Large competitors (bin producers) (chapter 3.5).

It also shows what BinBang is not good at and what it should watch out for.

3.7 Search areas

What are the opportunities for BinBang considering the main problem?

In this chapter, seven search areas are established by combining the strengths and weaknesses of BinBang with opportunities for them in this field as shown by the SWOT matrix.

The search areas all focus on business opportunities for developing new product ideas described in the Delft Design Guide, p75 (Boeijen et al., 2014).

Method

The search fields were generated together with two strategic product designers during a hour-long group session. The strategic product designers have been trained in using the method of search area generation. In the session, the strengths of- and opportunities for BinBang were written on post-it notes and placed on a wall (figure 41). From there, the search areas were formed. A more detailed description of this session can be found in Appendix G.

Results

The search areas found during the session were clustered and converged into seven search areas. The research, opportunity and strength that each search area is based on is described. An extended description and sketches of what new products within the search areas could be like can be found in Appendix H.

The strengths of BinBang and opportunities for it in the market were combined into seven business and development opportunities.

These are called 'search areas'. The search areas describe the products that BinBang could possibly develop in order to address the problem of this thesis.

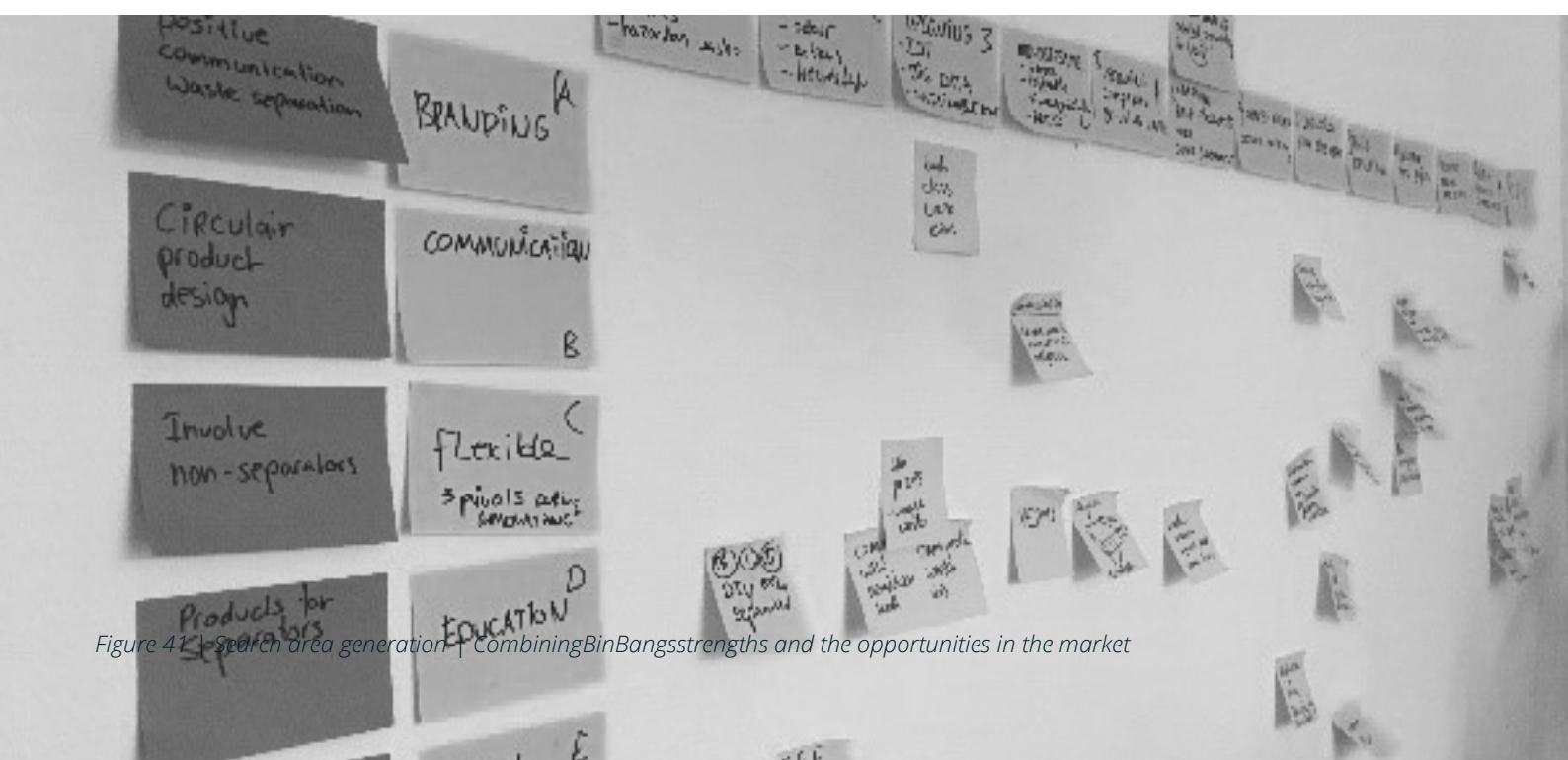


Figure 41 Search area generation | Combining BinBang's strengths and the opportunities in the market



1. Product portfolio extension | Opportunity 1 & Weakness 2

This focuses on the development of a product for the collection OW in order to extend BB's product portfolio. The product should solve at least one of the problems that AIs encounter when collecting OW.



2. Awareness objects/ installations for neighborhoods | Strength 2 & opportunity 3, 5

This focuses on the development of an installation which makes people aware of waste separation and shows the importance of waste separation. These may also function as a micro recycle environment and can be placed next to an apartment building.



3. Measuring waste production & big data | Strength 2 & Opportunity 6

This focuses on a system which keeps track of waste produced. The information can be used by municipalities to reward or punish the behaviour of apartment inhabitants.



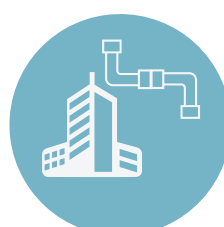
4. Home recycling solutions | Strength 5 & opportunity 3

This focuses on a solution in which apartment inhabitants can recycle OW in their homes. The target group for these type of products is assumed to be super separators.



5. Automatic separation systems | Opportunity 2 & 3

This focuses on disposal systems in apartment kitchens. What would a system in which AIs do not have to think about separation, but in which a machine does all the work for them, look like?



6. The kitchen of the future | Strength 6 & Opportunity 4

This focuses on the development of a system in which waste is collected and transported via a tube system. The AI only has to dispose the waste and the system will do the rest of the work: transporting, separating and cleaning.



7. Product/service system waste collection flat buildings | Strength 6 & Opportunity 1

This focuses on a waste collecting system especially for apartment buildings. Examples could include door-to-door

Figure 42 | Search areas

3.8 Search area selection

Decide the direction in which BinBang should move

From the seven search areas described in the previous chapter, three search areas were selected by BinBang.

The three selected search areas were assessed in terms of their viability, feasibility and desirability in a group session with BinBang. The search area 'extend the BinBang product portfolio' was selected as the best option and is the starting point for product development in this thesis.

Method

First selection | from 7 > 3 search areas | BinBang selected three search areas from the seven search areas described in the previous chapter. They made the selection based on their own preferences and opinions. The three selected areas are shown in figure 43. BinBang's motivations for its choices are that these three search areas fit their current activities and goals best. BinBang is seeking short-term solutions.

Second selection | from 3 > 1 search area |

The assessment and selection of the three selected search areas was conducted by grading the search areas on the three pillars of desirability, viability and feasibility (DAM & SIANG, 2018). The grading was conducted by the founder and the COO of BinBang in a meeting. With the input of this meeting, the level of potential for each of the pillars is determined.

The three pillars are defined as follows:

Feasibility is dependent on technology. The focus will be on short term feasibility. Since 2014, municipalities have been actively seeking OW disposal solutions for high-rise areas. Therefore, the need for a short-term solution is strong. Is BinBang capable of developing products or services in this area?

Desirability is dependent on the value for the customer and the market size. Does someone want to have a product or service in this area?

Viability refers to how well BinBang is able to make a business out of its product or service. Can BinBang turn the product or service in this search area into a business?

Results

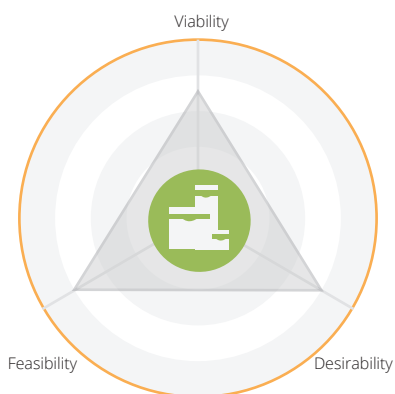
In order to compare the directions, a spider chart was made for each of the search areas (figure 43). The grey surface area represents the size of the potential of the search area. The search area with the largest surface area has the highest chance of succeeding.

- Product portfolio extension has the highest overall score. Product portfolio extension is feasible because of the existing distribution channels and partners of BinBang. Furthermore, the market potential for this search area seems to be high, because of the need of AIs for a solution to collect and store OW (also impacted by the upcoming legislation regarding the separate collection of OW).
- Awareness objects/installations for neighbourhoods suit BinBang's educational function. However, it seems to have a low viability, as sales are expected to be low and completely dependent on municipality finance. Furthermore, it is hard to make this search area scalable, because the objects/installations are likely to require supervision and maintenance. The desirability of this search area is also lacking, because it is assumed that municipalities desire solutions which make a direct impact on OW separation.
- Product/service system waste collection especially for apartment buildings has a high viability and desirability. The viability is high as this sort of service could lead to constant revenue. The desirability is high as it is expected that there is a large target group willing to pay extra for this sort of service which takes all of the effort out of their own hands. The short-term feasibility, however, is low, because BinBang needs to find multiple new partners for the implementation, investment and development of this type of service.

Insights.

- BinBang's motivations for viability and feasibility clearly came forward from the group session (see appendix K). However, it was difficult for BinBang to grade these motivations precisely, because it has no absolute criteria.
- The best way to validate a product or service's desirability is through the use of prototypes (DAM & SIANG, 2018). Because of time restrictions, however, desirability was estimated by BinBang during the group session instead of via real products/prototypes being used by AI.

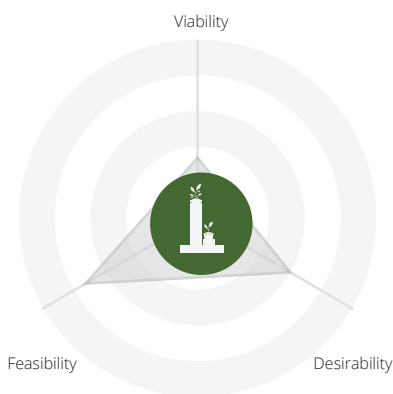
From the seven search areas described in the previous chapter, BinBang selected the three search areas that held the most potential for it as a company.



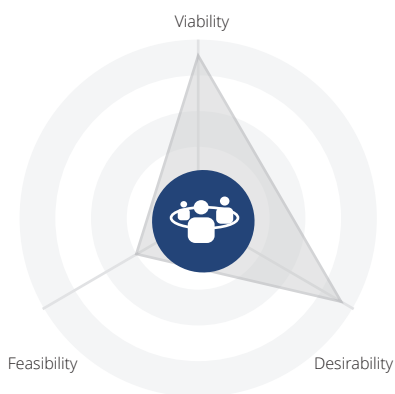
1. Product portfolio extension |



Next, one search area was selected to form the basis for product development in this thesis.



2. Awareness objects/ installations for neighborhoods |



7. Product/service system waste collection flat buildings |

The selected search area has the best combination of feasibility, viability and desirability.

Figure 43 | Search area selection

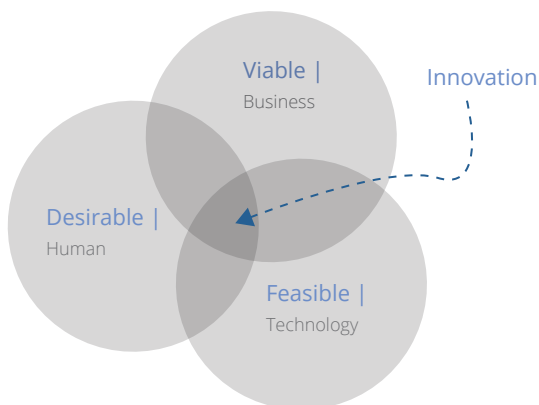


Figure 44 | Pillars for innovation Human, business & technology (DAM & SIANG, 2018)

3.9 Design challenge

Formulation of what the design for this thesis should be and do

In the previous chapter the search area “product portfolio extension” is selected because it has the most potential for innovation in this thesis. In this chapter will be described how the developed product should look like. This is described in a design challenge. The design challenge covers the design direction and requirements. The design challenge is next to the search area based on several problems the AI's encounter during processing OW found in the analysis.

Not all requirements of pugs list are incorporated in this first list of requirements. These will follow in a later stadium in the project.

Requirements & wishes

Each of the elements in the design direction is defined by certain requirements. The categories containing these requirements are based on the 21 categories of Pugh's checklist (Boeijen et al., 2014). The chapter from which each requirement originates is indicated. The list of requirements for the design direction is supplemented with additional optional wishes, which are not necessary but would provide extra advantages to the final product or services if they are met.

The design direction for this thesis describes what is going to be designed and states:

“The design of a bin for the collection and storage of organic waste in high-rise building kitchens and for the transportation of this to a public container.

The product is hygienic, low-effort and sustainable”

1. Mainfunctions

The product must have the following main functions for the **collection and storage of OW**.

R11. Both dry and wet OW can be stored in the product

OW consists of dry and wet substances (chapter 2.1).

R12. The product should fit in the kitchen |

AI's produce the most OW in the kitchen (chapter 2.5).

R13. The storage volume of the product has a volume of 11 liter to store the OW | This is the storage volume for all sizes of households. The Frisbox and Pilot Frisbox is developed for Further research need to be (chapter 2.5).

R14. The product must work independently without an installation in the Apartment | This makes the product easier to scale up. (chapter 2.8).

R15. The product must leak moisture of the OW | Leaking moisture from bags or products results in annoyance. (chapter 3.3).

2. Hygienic requirements |

A **hygienic** product is defined by the following four requirements:

R21. The annoyance level of odour should be acceptable | Annoyance by odour seems to be the largest complaint of AI's who collect OW. Odour prevention is considered to be the most important requirement for the final product. Research in the synthesis phase needs to focus on finding a solution that will meet this requirement. (chapter 2.6).

R22. No physical contact between the user and the OW AI's do not want to touch the OW (chapter 2.6).

R23. No visual contact between the user and degraded OW during daily use | AI's do not want to see the OW (chapter 2.6).

W21. No fruit flies around the product | AI's find fruit flies around the bin annoying (chapter 2.6).

3. Usability

A **low-effort** product is defined by the following four requirements:

R31. Disposal frequency of OW into a public container should be equal or less than the disposal process for residual waste | AI's want to walk as little as possible to reach the outside container. They should not increase their walking frequency to a container for the separation of OW (chapter 2.5). Therefore the bin should have a certain amount of storage space.

4. Transport

A product **for the transportation of OW to a public container** is defined by the following requirements:

R41. The product must be transportable to the public container | This is where AI's need to dispose their waste (chapter 2.3).

R42. Transport should be done with one hand | AI's want to bring all of their waste to the public containers at the same time, which means that they could need to use both hands to transport waste (chapter 2.5).

W43. The user only takes the disposable part to the public container | Some AI's, dispose the waste in the public container and then leave to e.g. work. They do not want to go back to their apartments to bring a container back or wash their hands. (chapter 2.5).

5. Sustainability

A **sustainable** product is defined by the following three requirements and wishes.

R51. The product lifetime should be 10 Years | The parts are optimized for extreme use situations, to increase the lifetime (chapter 1.2).

R52. The product is designed to be repairable | Each of the parts can be replaced (chapter 1.2).

R53. The product must be recycleable | All parts are made of polypropylene. The Frisbox can be disposed of in the plastic waste containers to be recycled. (chapter 1.2).

W51. The product must not use electricity | Using electricity results in less environmental benefits of collecting and storing OW (chapter 2.8).

W52. The product may not use materials other than biodegradable bags to store the waste | Using extra material to store the OW also results in fewer environmental benefits (chapter 2.8).

6. Bag requirements

R61. The product must use a biodegradable bag to store the OW or is biodegradable or uses no bag | 10% of OW in the digester is polluted with mostly plastic and plastic bags (chapter 2.7).

7. Costs

R71. The product must have a selling price of <€20 | To make a large impact, the product price must be below <€20. (chapter 2.9).

3.10 Product positioning

Were should the final solution be positioned in the market?

This chapter determines the place in which the final product should be positioned in comparison to other products for the collection and/or storage of OW. 13 product categories were rated by 30 people regarding the level of hygiene and amount of effort needed. The results are shown in a perceptual map. The final product is also positioned in this map.

Making a perceptual map

To see where the final product must be positioned, 30 students from Delft University were asked to assess the 13 product categories for the collection and storage of OW (chapter 2.9). They assessed the products on the two most important requirements: hygiene and amount of effort needed. The assessment was done by grading images of the products on a scale of 1 to 10 via an online questionnaire. The same pictures and descriptions as shown in the perceptual map were used in the questionnaire. The participants' opinions about the products may differ from opinions after actual product usage. Nevertheless, they give a good indication of what people think about the products. The online questionnaire can be found in appendix I.

Positioning final product for thesis.

The position for the final product in the market is indicated by the orange circle in the perceptual map. This map shows that the final product should be perceived as a product with a high hygiene level and a selling price of less than €40. The blue bars show how much effort the participants considered should be taken to use the product. The final product should involve less effort than the Joseph Joseph bin and a lot less effort than home processing products. The product will involve more effort than a food waste disposer in which the OW is disposed and transported automatically.

Other learnings from the perceptual map.

The perceptual map shows that home composting and processing products are considered to be unhygienic and to involve a lot of effort.

It can also be seen that the two products considered to take the lowest effort by the participants both use electricity. The participants graded the home biogas product as the most hygienic product; the reason for this came not from the research. The Joseph Joseph bin is considered to be hygienic. The reason for this could be that the description states that the bin contains an odour filter. Another reason could be the tight and clean design.

The product should be positioned in the orange circle and should be:

- *Hygienic*
- *low-effort*
- *Selling price <€20*
- *No electricity*



Figure 45 | Positioning matrix final product solution

The process from design challenge to product

In this chapter, four concepts are established. The design direction is taken as a starting point. The first step was to conjure ideas in as broad a spectrum as possible together with design engineering students in a creative session (ch4.1). From this creative session, four product elements arose. The second step was to research odour reduction methods. Making the odour level acceptable (R21) is seen as the most important hygienic requirement. Therefore, further research and ideation will be taken to find a solution to reduce odour. This is outlined in chapter 4.2-4.4. The product elements which arose during the creative session and the odour reduction methods were applied in a concept generation session. This resulted in four concepts which contained all necessary product elements as well as odour reduction methods. In the concept generation session, other requirements (p55) were also taken into account. The concepts were all considered to have the potential of meeting the requirements of the design direction. In part 5, the concepts are turned into prototypes which are tested and evaluated.

You are in this part of the project:

Part 1 | Introduction

Analysis phase

Part 2 | OW in high-rise buildings

Part 3 | Business analysis

Synthesis phase

➔ Part 4 | Ideation & conceptualisation

Part 5 | prototyping, concept evaluation and selection

Embodiment phase

Part 6 | Embodiment

Evaluation phase

Part 7 | Evaluation

Part 8 | Recommendations

Ideation & conceptualization

Part 4

Exploring product ideas.

What is odour and where does it come from?

How can odour be prevented?

Generate product ideas based on the odour reduction methods from chapter 4.3

Four concepts are created

The bin which uses natural aeration to improve aerobic digestion

The bin for on the balcony

The disposable bin

The bin for in the fridge

4.1 Creative session

With a group of industrial design students, a broad spectrum of solutions were explored in order to answer the design direction. The creative session resulted in four product elements which are used in the concept generation in chapter 4.5.

4.2 What is odour?

Odour is formed during the digestion of OW. Most of the odour is formed during anaerobic digestion. This is when there is no oxygen available to break down the OW.

4.3 Odour reduction methods

Six odour reduction methods were selected based on W41 & W42. These are: forced & passive aeration, reduction of moisture, sundry, keeping the OW cool, using an activated carbon filter and sealing the OW.

4.4 Idea generation of odour reduction methods

Based on the odour reduction methods outlined in chapter 4.3, ideas are generated regarding the use of these methods in various ways for products. These ideas are referred to as odour reduction elements.

4.5 Concept generation

The product elements outlined in chapter 4.1 and the odour reduction elements outlined in chapter 4.4 are combined into four concepts in a concept generation session.

4.6 Organic air bin

The first concept is the organic air bin, which uses a double layered bag system to stimulate aerobic digestion in combination with activated carbon to reduce odour.

4.7 Bio balcony bin

The second concept is the bio balcony bin. This concept consists of a top part of a bin to be placed on the kitchen counter to collect OW. This top part can be placed on the bottom part, which can be placed on the balcony, to avoid odour inside the house.

4.8 Waste cube

The third concept is the 'Waste cube'. The Waste cube turns the OW into an airtight biodegradable package. The cubes can be collected over a period of multiple days and brought together with regular waste to the public containers.

4.9 Coolwaste bin

The fourth concept is the Cool waste bin. This cools OW in the fridge to reduce odour. Because of a lipo- and hydrophobic nano-coating, there is no need for a plastic bag. The bin can be cleaned by shaking some water in it (with the lid closed).

4.1 Creative session

Exploring product ideas.

The first step after formulating the design direction in chapter 3.7 was to organize a creative session in which a group of industrial design students was stimulated through creative techniques to generate ideas. Four elements of products ideas that show potential for the design direction arose from the session. These elements are used in chapter 4.5 in the generation of concepts. The session also resulted in two concepts being created by the students.

The extended description of this session, including the presentation and time schedule can be found in Appendix J.

Method

Presentation | At first the students were briefed with a presentation about the topic of this thesis.

Top of mind ideas | Secondly, they had to write down the ideas which sprung to the top of their heads, so that old ideas didn't get in the way of creating new ideas (Stappers, 2012).

How to's | Next, the creativity of the students was stimulated by the 'how to' method, as described in the Delft Design Guide p98. (Boeijen et al., 2014). How tos (H2s) stimulated the students to think about the requirements (R21-R23). The H2's used during the session are described at the right:

1. How to make OW hygienic?
2. How to avoid odour?
3. How to empty OW in an outside container without touching/seeing/smelling it?

In a creative session with design students first as many as possible ideas are created based on the design direction. This resulted in two concepts and elements which are used in the concept generation in chapter 4.5

4. How to avoid dirty hands?
5. How to store (rotting) OW, for a week in the house, without noticing it is there?
6. How to store OW without a bag?

Clustering ideas | After the H2 session, similar and over-lapping ideas were clustered. Thereafter, the students were asked to place 3 dots per person on the ideas that they thought had the most potential, considering the requirements in p55.

Create a concept | In the last part of the session, the group was split into two teams. Both teams had to create a concept based on the ideas generated during the H2 session.

Results

The idea generation session resulted in approximately 80 ideas. These ideas were grouped into the following clusters. A short description of each of the clusters is given.

Transporting systems | Various ideas whereby OW is transported via tubes



Figure 46 | Clustering ideas during the creative

Air freshener | Various ideas whereby perfumes or de-odourants are used to mask odour.

Services | Various ideas regarding services to collect OW

Disposables | Various ideas regarding products which can be disposed of together with the OW.

Outside containers | Ideas regarding systems of public bins.

Anti-bacterial, water and oil repellent materials.

Home compost | Various ideas about composting or processing OW at home.

Close the nose | Various ideas to close the nose of.

Hatches | Various ideas regarding bins with a hatch system which can block odour.

Random | Various random ideas and unrealistic ideas, like a pet who eats the OW.

The concepts created by the two groups are shown below. A description is given below.

Concept 1 | de Gemakbak (the Comfort bin)

In this concept the AI can collect in a duo bin OW and residual waste. The AI can transport the bin as a whole to a public dock system which empties and cleans the bin, so there will be no annoyance by odour or cleaning. Furthermore, the bin contains a lid which can block odour by pressing the odorous air back inside the bin before opening it.

Concept 2. | The Waste press

The waste press is a bin which can be mounted next to the kitchen counter. The unique selling point of the waste press is that it can reduce a large part of the moisture in the OW which results in a lower empty frequency of the system compared to regular bins. The moisture of the OW can be collected in a reservoir and disposed in the sink.

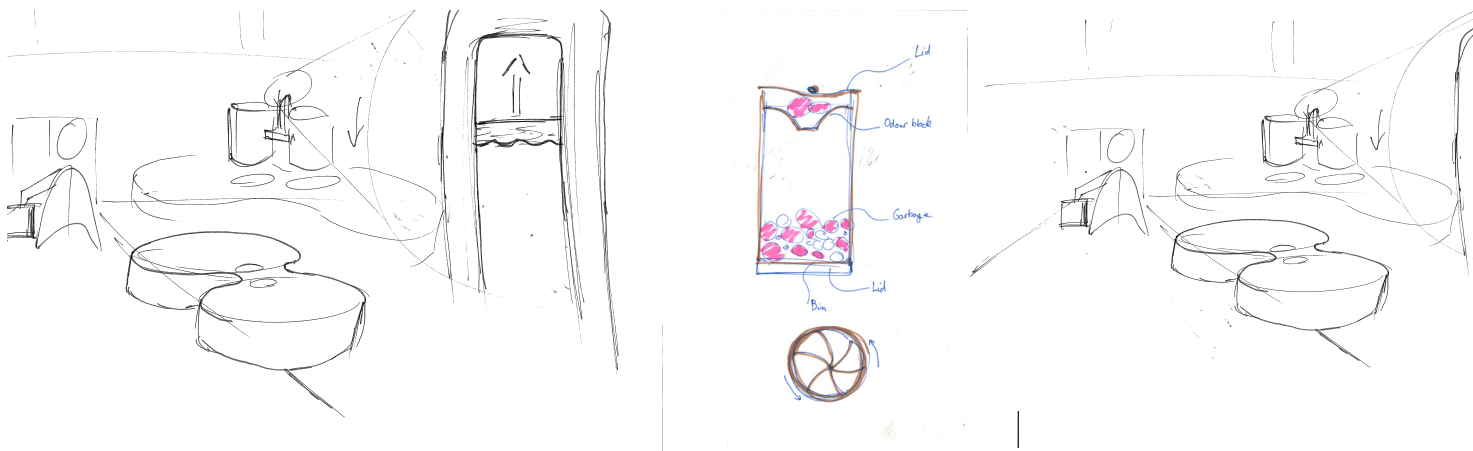


Figure 47 | De Gemakbak

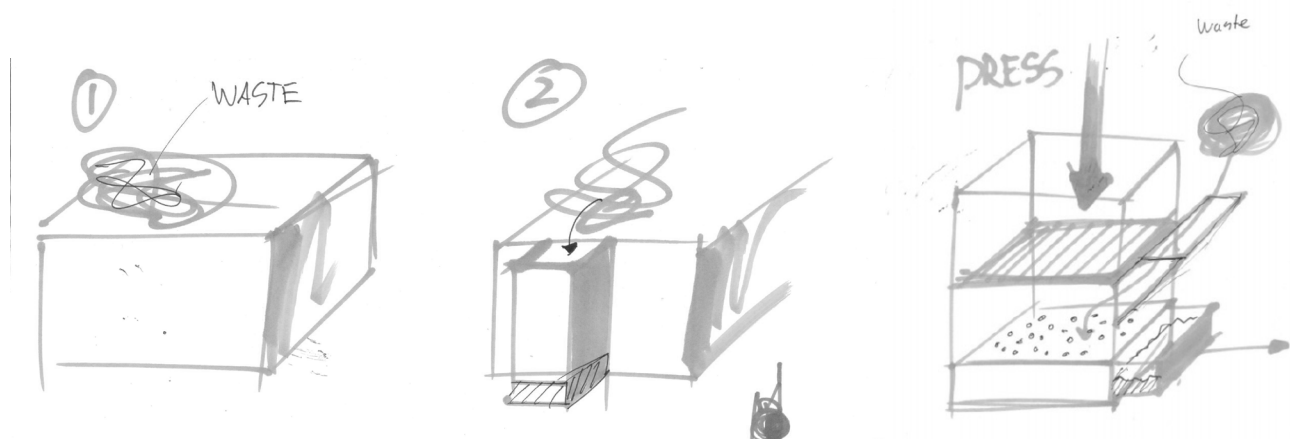


Figure 48 | The Waste press.

Elements for concept creation

Four product element ideas from the creative session are used in chapter 4.5 in concept generation. These elements are:

- The placement of OW outside. This could result in a lot less odour being inside the house.
- Biodegradable disposable bins. Disposable bins do not need to be cleaned and can be thrown away when they get dirty or smelly.
- A (public) docking station for emptying and cleaning bins without odour being released. A docking station could make garbage bags superfluous if it had the ability to directly clean the bin after emptying it. It could prevent odour from escaping into the outside air.
- Use of materials with anti-stick, water and oil repellent or antibacterial properties to avoid odour.

Conclusion

The ideas from the creative session resulted in four elements to be used in further product development.

The assignment for the students in the creative session was to explore as far as possible (diverge) and later to converge towards solutions that suit the requirements of the design direction. The Gemakbak overlaps with the search area “product/service system waste collection system” (p53), which already suggests that it is not directly an appropriate solution for the design direction. The concepts developed by the students are both not adequate answers to the design direction, however elements from within these concepts could be used to develop a product which does meet the requirements. The goal of the session was to explore ideas for the design direction in as broad as possible a manner. This broad exploration did not succeed in finding a concrete solution that meets the requirements.

The elements which are used in the in the concept generation (chapter 4.5) are:

- *Placement of OW outside*
- *Disposable bins*
- *Use of a dock station*
- *Use of anti stick, water- or antibacterial layers*

Basic product elements

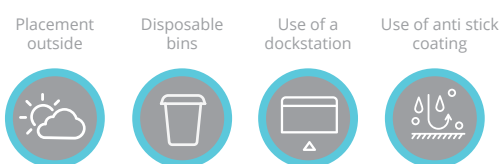


Figure 49 | Elements used in concept generation

4.2 What is odour?

We need to know a little bit more about odour.

The most important requirement as found in this thesis for the final product to be hygienic in use is that the annoyance level of odour should be acceptable (R21). To find a solution for this requirement, it is first necessary to understand what odour is and how it arises from OW. It then needs to be determined as to what an acceptable odour level is. The methods found to stop odour are described in the next chapter (4.3).

What is odour?

The Cambridge dictionary defines odour as follows: a smell, often one that is unpleasant (dictionary.cambridge.org, 2018). According to Jacobs et al. (2007), odour is the perception of certain chemicals within the olfactory area of the sinuses. A typical chemical which causes odour in OW is hydrogen sulfide (H₂S), causing the well-known 'rotten egg' smell. Other examples of chemicals which cause odour include dimethyl amine (CH₃CL₃NLI), which has a fishy characteristic or Methyl mer-cap-tan (CH₃SH) which is characterized by a decayed cabbage odour (Anayet, 2013).

Hydrogen sulfide (H₂S) is used as an example to describe how odour can reach the human nose. To perceive H₂S, the following two steps must take place:

- 1) The H₂S molecule must be released from the OW as a product of the breakdown process.
- 2) The H₂S molecule must reach the olfactory mucus, the area in the nose to detect molecules, and be detected by one of the nerves.

Where does odour come from in the case of OW?

Jacobs et al. (2007) describes three different reasons for the arising of odourous chemicals from OW. These are: odours already present in OW, odours arising from the aerobic breakdown process and odours arising from the anaerobic breakdown process.

Odour present in OW

Before the OW starts breaking down, odours are already released from, for example, fresh fruit and vegetable waste. Examples include limonene from citrus fruits, pinene from woody materials or diethyl sulfide from garlic, all of which are chemicals that give fruits and vegetables their typical smell. These odours are generally not considered to be offensive. However, a mix of these odours could result in an annoying smell.

Odour is formed during the digestion of OW. The most odour is formed during anaerobic digestion. This is when there is no oxygen available to break down the OW.

Aerobic degradation | breakdown with oxygen

In an aerobic process, organic compounds are broken down by oxygen (O₂) and N₂ into CO₂, H₂O, NO₃⁻, NH₄⁺, SO₂⁻⁴ and HPO⁻⁴ cells which are odourless (Gerardi, 2003).

Anaerobic degradation | breakdown without oxygen

When there is a lack of oxygen (O₂) or N₂ available in the aerobic process, the breakdown process will become anaerobic. One of the by-products of anaerobic digestion is hydrogen sulfide (H₂S). Another by-product of anaerobic digestion is methane (CH₄), which is odourless but is an important greenhouse gas (Groeningen, 2011).

What is an acceptable level of odour?

In this thesis, an acceptable annoyance level of odour is defined by how humans perceive odour. This is measured as follows:

An acceptable annoyance level of odour occurs when a person grades the odour with a 5 or lower out of a scale of 10, where 10 indicates an extreme annoyance of odour and 1 indicates no annoyance of odour.

Conclusion

When there is OW, there is odour. Most odourous compounds are formed during anaerobic digestion. Therefore, preventing anaerobic conditions could be a method to reduce odour. In the next chapter (4.3) several methods to prevent anaerobic conditions are described.

Furthermore, methods to prevent odourous molecules from reach the nose and methods to hamper the degradation process are also described in the following section.

4.3 Odour reduce methods

How can odours be prevented?

Based on the knowledge about odour discussed in the previous chapter, we searched for general methods to withhold the molecules that cause odour from reaching the user's nose. The methods for this are subdivided into three categories: prevention of anaerobic conditions, hampering the degradation process and blocking released odours. In total, five odour reduction methods have been selected and will be used as the starting point for the development of product concepts (ch4.4)

Method

To find methods for reducing odour, the prevention and control methods of odours in biowaste processing facilities and industries and preservation methods in the food industry were explored. An overview of these odour reduction methods is shown in Figure 50.

1. Prevent anaerobic conditions

The first category offers methods for optimizing the aerobic degradation process and preventing anaerobic conditions. When there is enough O₂ available in the breakdown process, anaerobic conditions could be prevented. Four methods to make O₂ more available in the process are described.

Forced aeration | Forced aeration is the addition of O₂ into the OW via electrical or mechanical air pumps (Jacobs et al 2007).

Passive aeration | Here, O₂ is added into the OW but no pumps are used. The Ventimax® bin (ch3.2, p42), for example, makes use of natural aeration with an open bin and breathable bag (Jacobs et al 2007).

Optimize proportions | By breaking the OW down into the right proportions, more outside surface area could make contact with the air (Jacobs et al 2007).

Use of additives | Yuan et al (2015) showed that, by adding cornstalks treated with FeCl₃ to the OW, 42% less NH₃ and 76% less H₂S was emitted during the composting process compared to a regular composting process.

Reduction of moisture | OW in high-rise areas consists of around 80% water, compared to 60% water in OW for households who have a garden (Brethouwer, 2018). An excess of moisture could lead to less porosity which results in anaerobic conditions. Drying is among the most ancient and preeminent physical methods of food preservation and is used for fruits and vegetables with a high moisture content (Moses et al 2014). A method following this idea is to place the OW in the sun, or to use paper bags which can withdraw moisture from the OW.

12 odour reduce methods are found from which, five odour reduce methods are selected based on W41 & W42.

A. Forced & passive aeration

B. Reduce moisture

C. Cool

D. Activated carbon filter

E. Sealing

2. Hamper the degradation process

The degradation process is dependent on many factors, including temperature, moisture level, pH level, CN ratio and bacteria (Chen et al, 2005). If one of these factors is disturbed, the degradation process could be hampered.

Cooling | Refrigerators are used to increase the shelf-life of products. This method could also be used for OW. Kasali & Eric Senior (1988) showed that the methanogenic rate during anaerobic digestion increases 2-8 times when the temperature is raised from 17C ° to 30C°.

Heating | This method reduces the moisture and kills the bacteria. This can be done electrically. The 24H composter by Zera Food recycler (as mentioned on p39) makes use of this method.

UV light | Water and liquid from fruit and vegetables are generally very suitable for processing by UV light to reduce the microbial load (Guerrero-Beltr'n and Barbosa-C-novas, 2004). Bins that use UV light are already available on the market, such as the Kapoosh bin (Amazon, 2018). UV light cannot pass through solid materials, thus it can only kill the top layers of the waste

3. Prevent odours from escaping

The last category includes methods which do not try to optimize or stop the degradation process, but rather try to prevent odourous molecules from reaching the nose when they are released.

Activated carbon (C) | Activated carbon has a complex structure consisting primarily of carbon atoms. Because of the intrinsic pore network in the lattice structure of activated carbon, impurities from gases are able to be absorbed (Haycarb, 2018). Activated carbon is already used in the OW bin of Joseph Joseph (Fong, 2018)

Ozone (O₃) | Ozone (O₃) | Ozone is a very unstable molecule and when it comes in contact with a VOC, it loses an

oxygen atom and oxidizes into a less odourous compound and a O2 molecule The Fresh station, a public OW collection container by Sidcon (2018), uses ozone.

Masking odour | Jacobs et al. (2007) describes the method of masking odour. This method uses deodourants with aromas of peppermint, strawberry and eucalyptus. The masking odours also contain neutralizing compounds.

Sealing the OW | Another way of blocking odourous compounds is to make it physically impossible for odourous molecules to reach the human nose by sealing the OW.

Selection of odour reduce methods for the final solution of this thesis.

A selection of the odour reduction methods was made by following two sustainability wishes:

Main function W41 | The product may not use electricity.

Main function W42 | The product may not use extra material to store the waste, other than regular plastic or paper bags.

The selected methods are: A. Forced aeration & passive aeration; B. Reduction of moisture; C. Cooling the OW; D. Acti-

vated carbon filter use and E. Sealing the OW.

These methods were selected because they use an acceptable amount of extra material and/or electricity. For example, cooling of OW can be done by a fridge or freezer, which is available in an average household in the Netherlands – unlike, for example, heating OW to temperatures whereby the moisture evaporates, which requires a lot of energy. Forced aeration could be done mechanically, by wind energy or human power, and could also be done without the use of electricity. For activated carbon use, it is assumed that this requires a relatively low amount of extra material. The bin by Joseph Joseph (Fonq, 2018), which also uses activated carbon, requires that the activated carbon blocks be replaced every two months in order to stay effective.

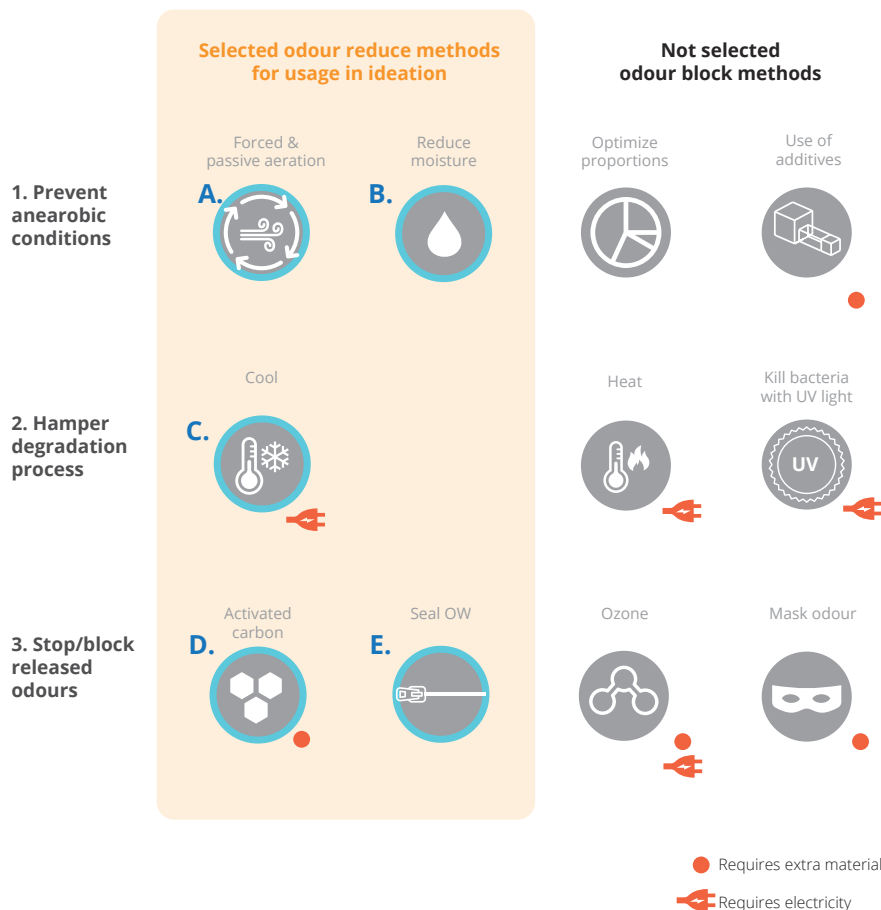


Figure 50 | Selection of odour reduce methods appropriate for the final solution of this thesis.

4.4 Idea generation odour reduce methods

Generate product ideas based on odour reduce methods

In this chapter product ideas are generated based on the odour reduce methods selected in the previous chapter. For each of the odour reduce methods there are found ideas. For each odour reduce method one idea is selected to use in the next chapter concept generation (chapter 4.5)

Method

For each of the odour stop methods an idea generation is executed. An extended overview of these ideas can be found in Appendix K.

Results

All the ideas or the odour reduce methods are visualized in a morphological chart in figure 51. Based on the following requirements a selection is made.

R14. The product must work independently without an installation in the apartment.

R35. Besides from disposing OW, cleaning or bag re-placement there may be not extra actions.

The following odour reduce product elements are selected:

- Use of natural air flow in and around a permeable bag.
- Use of a paper bag to reduce moisture levels in OW.
- Placement of an activated carbon filter in the side of the bin.
- Cooling the OW by placement in the fridge.
- Sealing the waste in boxes at the end of every day.

Based on the selected odour reduction methods outlined in section 4.3, ideas were generated regarding using these methods in products.

Conclusion

Five odour reduction elements were selected for use in helping to develop concepts in the next section. The odour reduction elements were not tested during selection, but were assumed to have potential in reducing odour

Selected odour reduce elements.



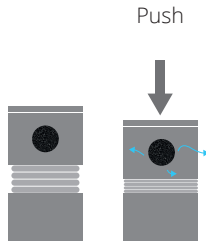
ACF in lid



ACF across entire length of bin



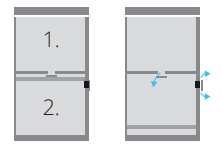
Lid made of ACF



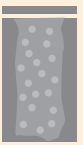
Push air through ACF before opening the bin



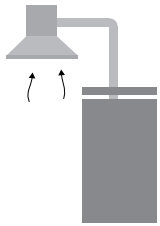
Bin completely made of ACF.



Before opening the bin, all odorous air from segment 1 can be pumped into segment 2. Via segment 2 it will be pushed through an ACF.



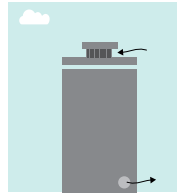
Closed bin with air around a permeable bag.



Connect to ventilation hood



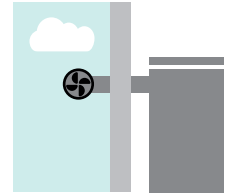
A bin which can be rotated to add air to the OW.



Place outside with suction fan on top



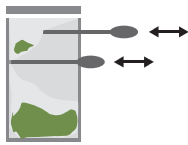
Open bin with permeable bag.



Connect with a tube to outside air



Small boxes which can be closed after every day of use.



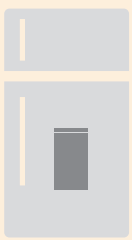
Double layer seal. Two slides to close off the bag will make it unable for odorous air to escape



Seal waste per layer



Double hatch system



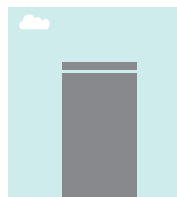
Place bin in fridge



Make an efficient fridge of the bin, with high isolation and lid on top.



Use a conductive material around the bin and cool this down with water.



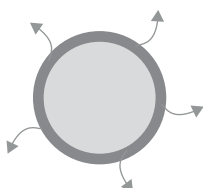
Cooling down by placement outside.



Cooling by evaporation of water and a porous bin



Use paper bag to extract moisture



Centrifuge waste



Press moisture out of OW

Figure 51 | Morphological chart ideas of odour reduction methods

4.5 Concept generation

Four product concepts are created

The ideation session described in chapter 4.1 and the outcomes of chapter 4.4 were the basis for a concept generation session. The session resulted in four product concepts.

Method

The input of this concept generation session included the four elements for products as found in the creative session and the five odour reduction techniques. Furthermore, the requirements described on page 55 were taken into account when generating ideas for the product concepts. An extended overview of the drawings of the concept generation can be found in appendix L.

Results

A total of four product concepts were created to cover all odour reduction techniques and all basic product elements. Each of the product concepts is a proposition for a means to store wet and dry OW in the kitchen (R11 and R12), including an odour reduction method (R21), a method to prevent physical contact between the user and the OW (R22) and a method to prevent visual contact between the user and the OW during daily use (R23).

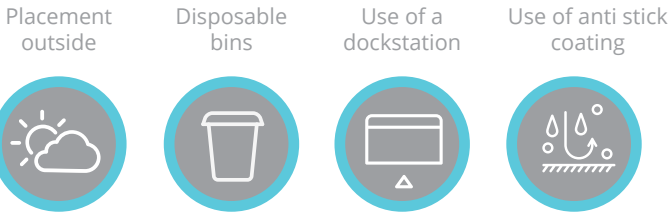
Conclusion

All the requirements of p55 are included in one of the four concepts. Not all of the requirements are covered in each concept. In this stage this is not necessary yet, because there still needs to be found out what the importance of each requirement is. In part five, there will be researched which requirements are the most important by hand of making prototypes of the concepts.

The elements from chapter 4.1 and the odour reduction elements from chapter 4.4 were combined into four product concepts in a concept generation session.

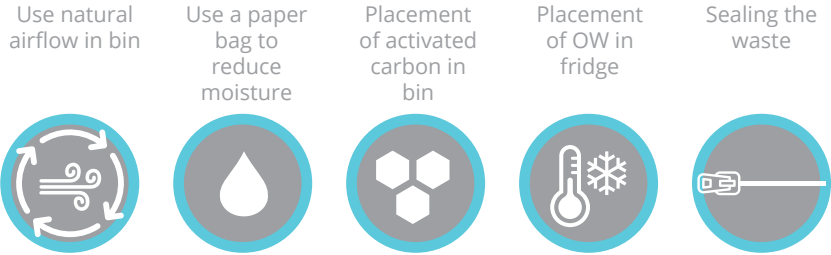
Product elements

In the creative session, four ideas of product elements were found.



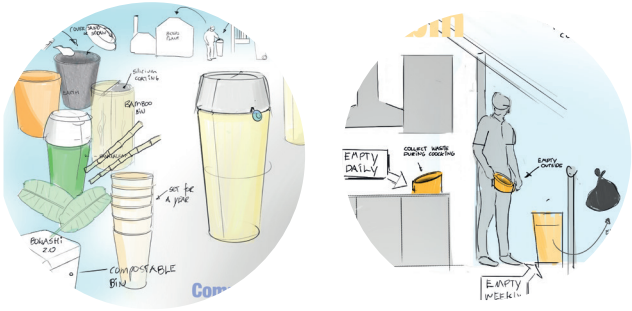
Odour reduction elements

Five methods to reduce odour were found.



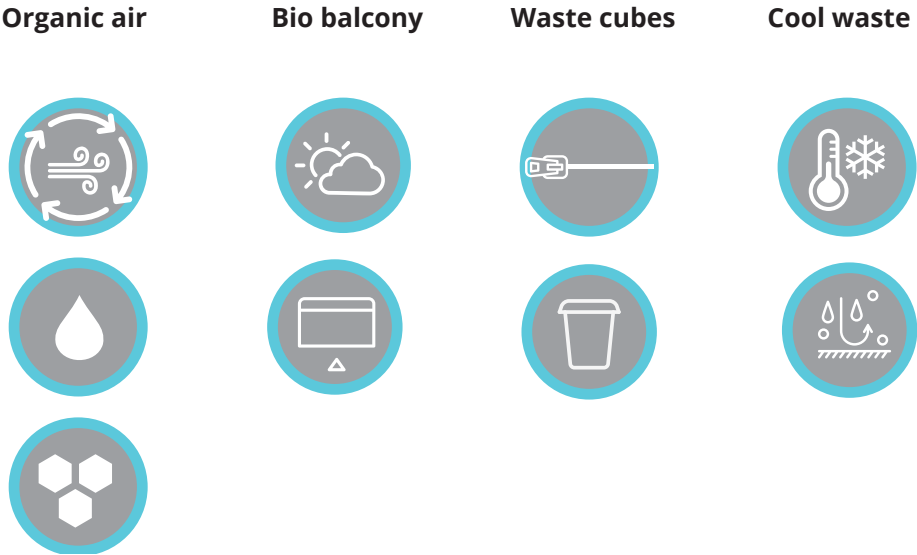
Combining ideas in ideation

An ideation session, taking the elements and requirements of p55 into account, is conducted.



Four concepts

Four concepts were created which combine all the elements.



In the next chapter, a description of each concept is given.

Figure 52 | Overview process.

4.6 Organic air bin

The bin which uses natural aeration to improve aerobic digestion

The Organic air bin combines three odour reduction methods in one. The Organic air can be placed on the balcony or inside the house. It contains an air outlet with an activated carbon filter and a paper bag system to reduce odour.

Proposed solution to meet requirements

Store dry and wet OW (R1) | OW can be stored in the bin because of the double layered bag: a paper bag which provides air around the OW and a biodegradable bag which can soak up the moisture.

Odour reduction method (R21) | Natural aeration permeates the holes in the bag. This is the same principle for reducing odour as used by BinBangs Ventimax® bin. Because the paper bag is smaller than the plastic bag, there is always air surrounding the OW. In regular OW bins, the waste at the bottom of the bin would have no access to fresh air and would start to degrade anaerobically.

No physical contact between the user and the OW (R22) | The handles attached to the paper bag provide a clean handle to transport the bag to the public container.

Disposal frequency of OW into a public container should be equal or less than the disposal process for residual waste (R31) | The AI can collect for 2 weeks OW with the large volume

Intended usage.

The user first has to place a biodegradable plastic bag into the bin. Secondly, the user must unfold the cardboard and place this into the bin. The user can dispose of OW into the bin by opening it with a foot paddle. When the bin is full, the user can pull the cord to close the plastic bag. Thirdly, the user can use the handles of the cardboard to transport the full bag to an outside container. Because of these handles, the user does not have to touch the bag itself and thus will not get dirty hands.

USP's BinBang

BinBang could add a service next to this product to sell the paper bags and active coal refills. The bin can be de-signed in such a way that users only can buy plastic bags and cardboard boxes which fit into the Organic air bin.

*The first concept is **the Organic air bin**, which uses a double layered bag system to stimulate aerobic digestion in combination with activated carbon to reduce odour.*

Possible disadvantages

- Extra waste could be generated because of the double layered bag system. This has a negative impact on the environment.
- Also, the costs for the double layered bag system are expected to be higher than that of regular bags.
- The bin could get dirty, so the user would have to clean the bin eventually.
- The bin cannot be used for other waste types. For example, paper and plastic require differently shaped bins.

ORGANIC AIR

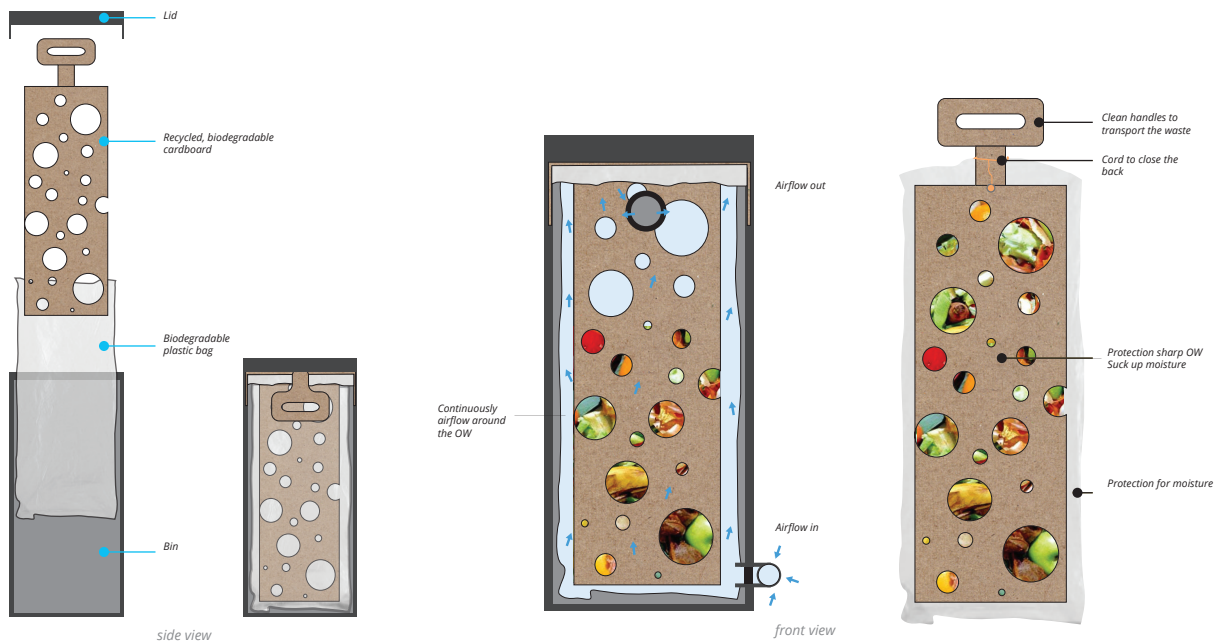
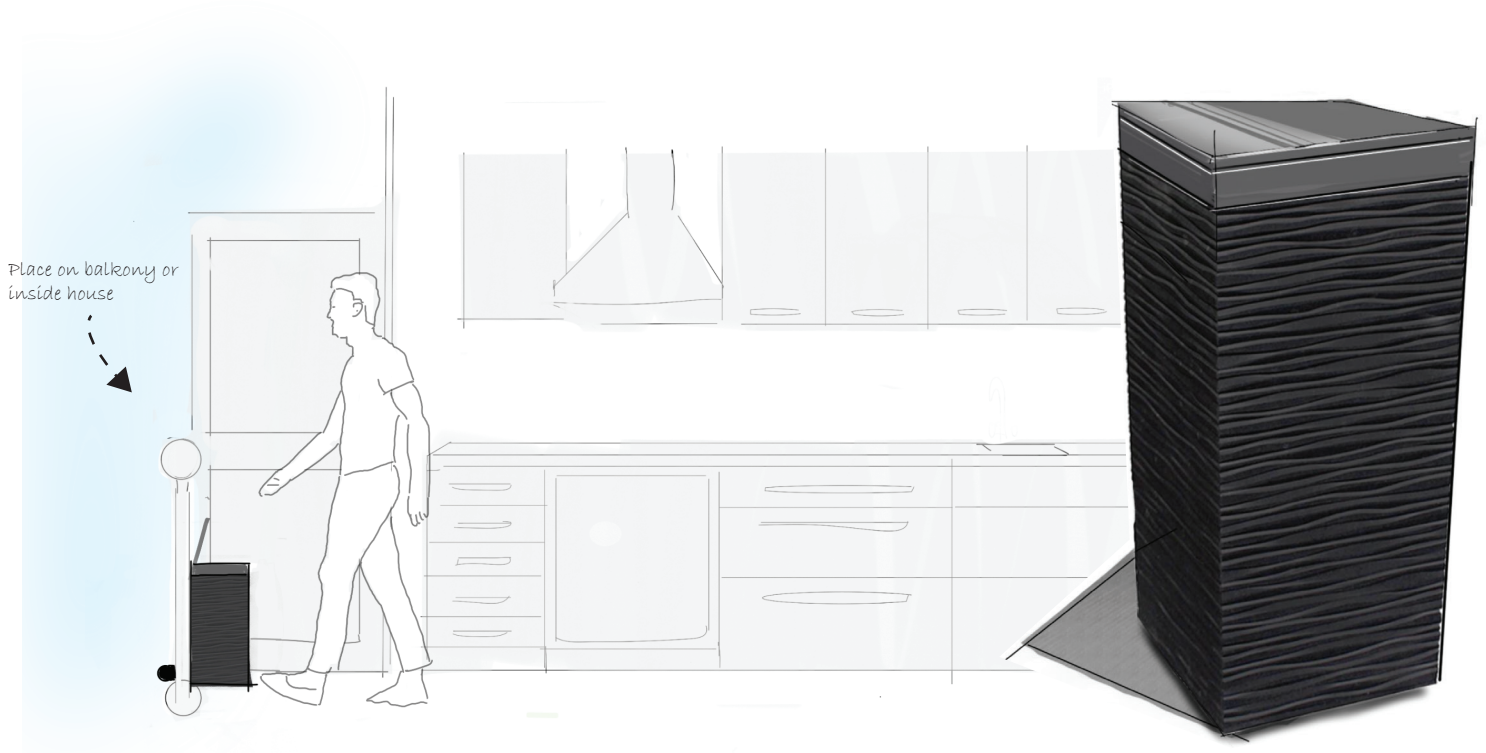


Figure 53 | Organic air

4.7 Bio balcony bin

The bin for on the balcony

The Bio balcony bin resulted from the fact that many AIs keep their OW outside after collecting it in a small bin on the kitchen counter. The Bio balcony bin combines both of these concepts for sections of the bin to be kept both inside and outside. The bin also makes use of a double hatch to avoid releasing odour from the bin.

Proposed solution to meet requirements

The Bio balcony bin is a proposition for a new product design. It suggests meeting requirements R1, R11 and R13 in the following way:

Dry and wet OW (R1) | OW can be stored in the 40 litre biodegradable OW bag which can be placed in the bin.

Odour reduction method (R21) | By placing the bin outside, the odour will no longer be detectable in the house. Furthermore, because of the double hatch system, odour in the bottom bin will not be released during emptying the top bin into the bottom bin.

Another advantage of storing OW outside is that, during winter, the OW will be naturally cooled by the outside temperature. During winter, the temperature inside the house is higher, resulting in more odour inside the house.

No physical contact between the user and the OW

(R22) | The user can place the OW in the small inside bin during daily use. When emptying the OW from the inside bin to the outside bin, the user does not have to touch the OW.

The OW must not be visible during daily use of the product

(R23) | Because of the slide system, the user does not see the OW when the top bin is emptied into the bottom bin.

Disposal frequency of OW into a public container should be equal or less than the disposal process for residual waste

(R31) | The AI can collect for 2 weeks OW with the large volume

Intended usage.

The user can collect OW in the top bin on the kitchen counter. When the bin is full, for example after finishing cooking, the user can place the top bin onto the bottom bin. By pulling the handle, the OW will fall into the bottom bin. Afterwards, the user can detach the two pieces and place them in the

*The second concept is the **Bio balcony bin**. This concept consists of a top bin for the kitchen counter to collect OW. The top bin can be placed on the bottom bin, which can be placed on the balcony, to avoid odour inside the house.*

dishwasher or clean them by hand. In the bottom bin, a biodegradable bag with a When the bottom bin is full, the bag can be emptied like that in a normal bin via a plastic bag.

Possible disadvantages

- The bin could get dirty, so the user would have to clean the bin eventually.
- The bin cannot be used for other waste types. For example, paper and plastic require differently shaped bins.

Bio Balcony

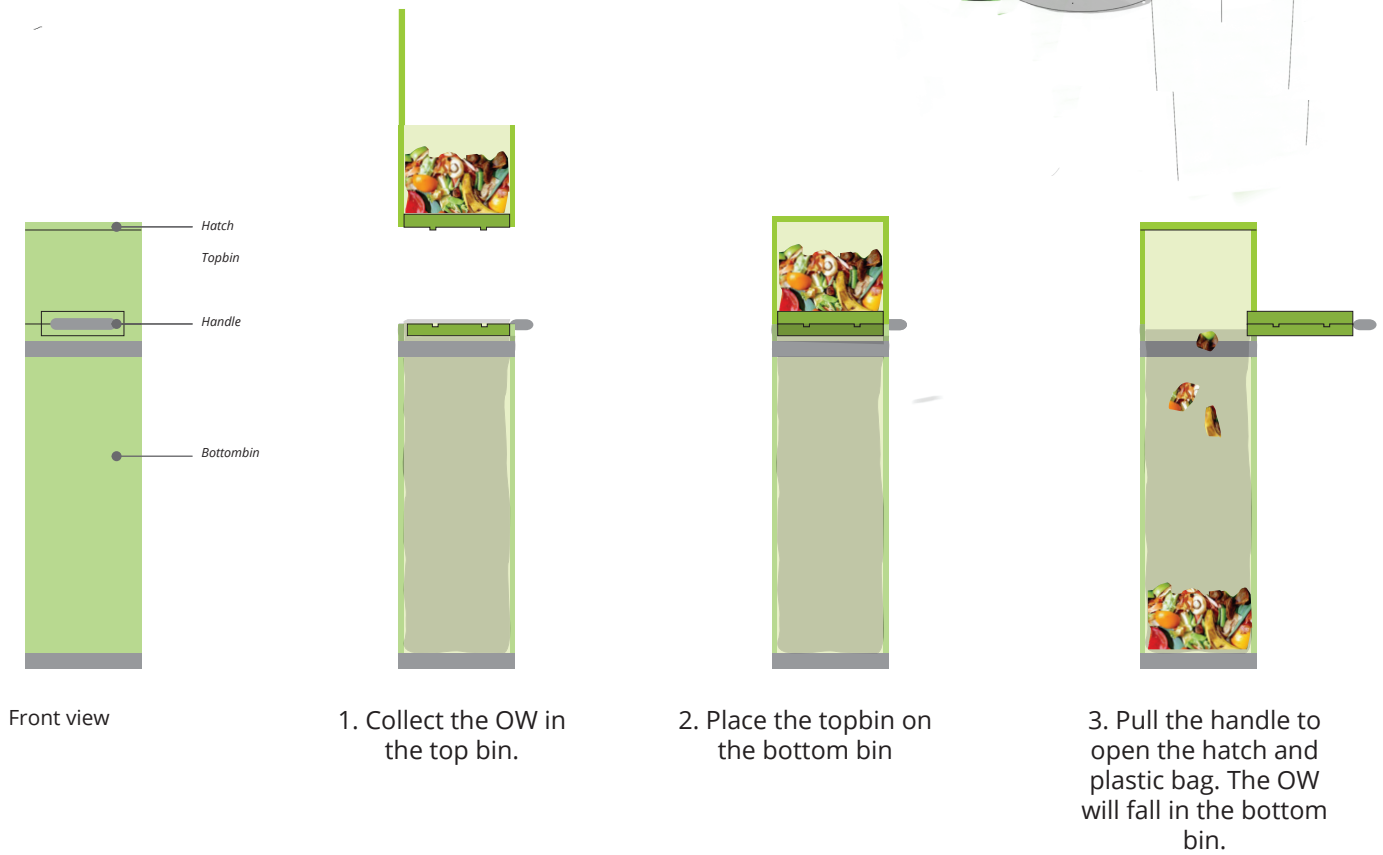
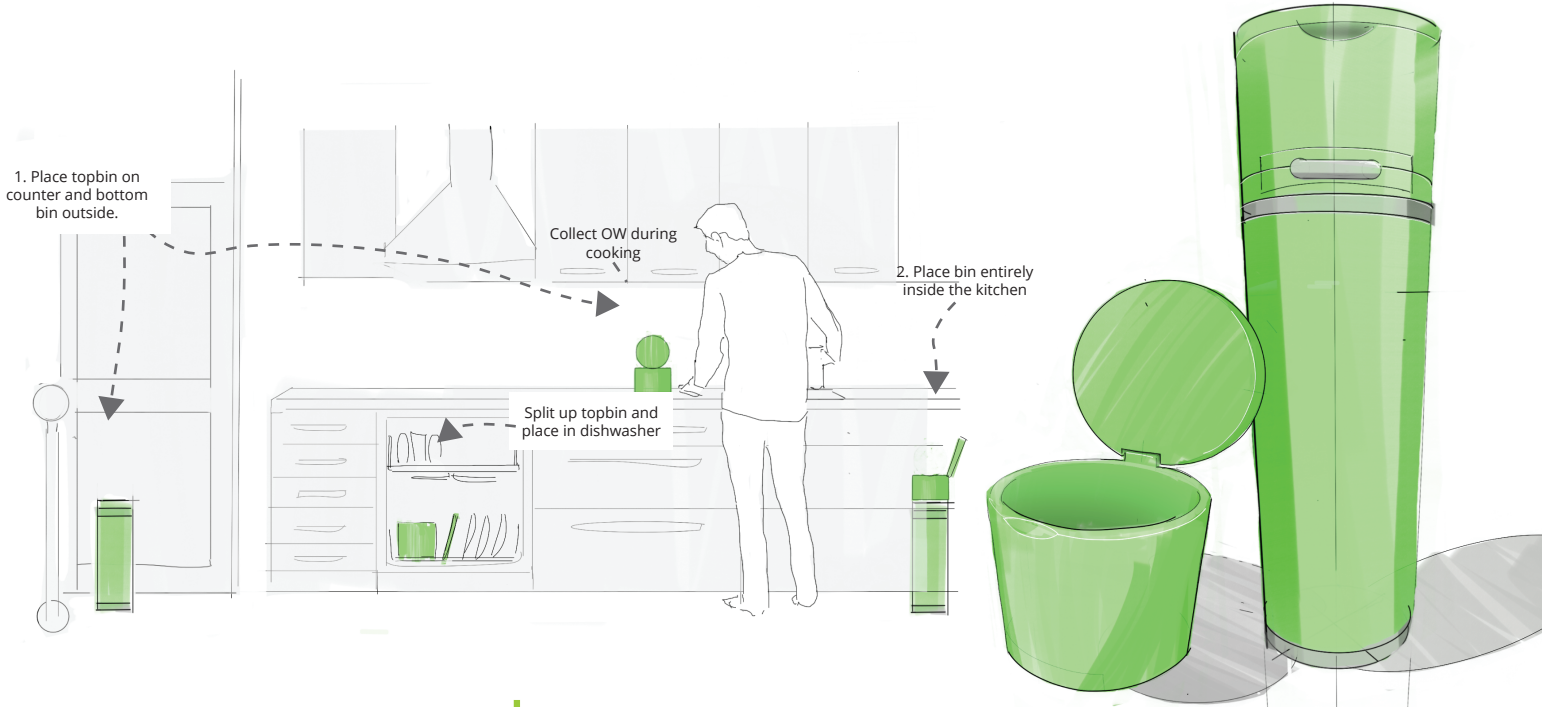


Figure 54 | Balcony bin

4.8 The Waste cube

The disposable bin

The waste cube is a bin which can be completely disposed of. In this way, there is no need to clean the bin or replace the bags.

Proposed solution to meet requirements

The Waste cube is a proposition for a new product design. It suggests meeting requirements R1, R11 and R13 in the following way:

Store dry and wet OW (R1) | The Waste cube is made of cardboard with a polylactic acid (PLA) layer. The PLA layer makes the Waste cube water resistant. To test this, cardboard cups with a PLA layer were filled with water (chapter 4.3). The cups started leaking after 7 days, which indicates that it may be possible to make the waste cube waterproof for a few days, but this needs to be further examined.

Odour reduction method (R21) | The odour reduction method is to seal the OW. Because the OW is closed in an airtight manner, no odour can be released.

No physical contact between the user and the OW (R22) | One Waste cube is used per day. The Waste cubes can be collected until other residual waste is taken to the outside container. Because bag replacement and cleaning of the bin is not needed, there is no physical contact between the user and the OW.

The OW must not be visible during daily use of the product (R23) | There is no contact between the user and the OW as the Waste cube is sealed after each day.

Disposal frequency of OW into a public container should be equal or less than the disposal process for residual waste. (R31) | The AI can collect for 1 week of OW.

Intended usage.

At the beginning of the day, the Waste cube can be unfolded and placed on the kitchen counter. During the day, the user can collect OW in the Waste cube. At the end of the day or when the bin is full, the Waste cube can be sealed airtight with a sticky strip.

The Waste cube can, for example, be used during food preparation and can even be placed on the table during meal times. After use, the bin can be sealed and placed together with the other waste.

The third concept is the Waste cube. The Waste cube makes an airtight biodegradable package of the daily produced OW. The cubes can be collected over a period of multiple days and brought together with the RW to the public containers.

If one Waste cube is used for multiple days, a lid could be included to cover the Waste cube temporarily.

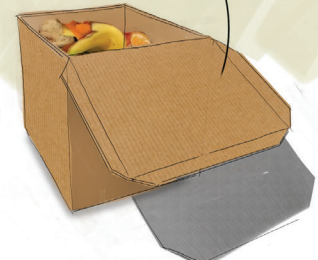
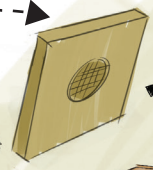
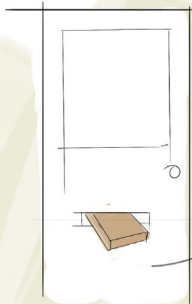
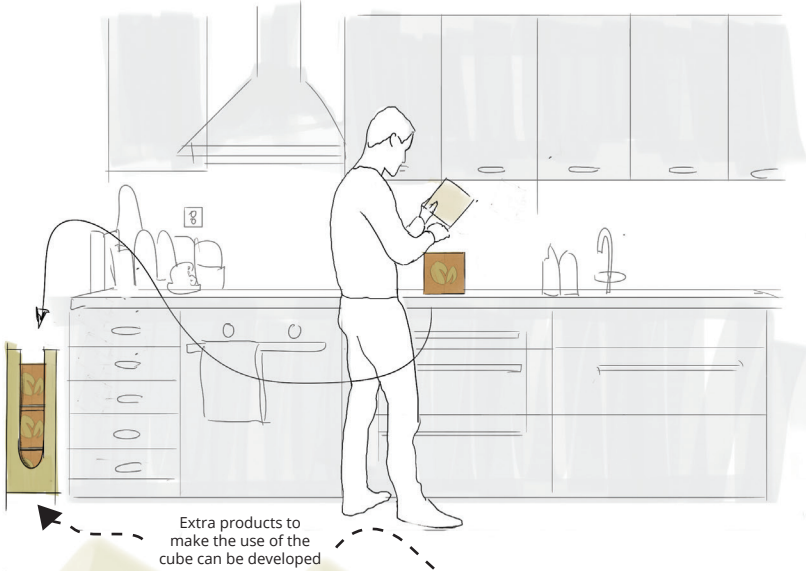
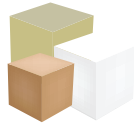
USP's BinBang

- Customers could, for example, take out a monthly subscription to receive the Waste cubes by mail, which leads to repeated sales for BinBang. Because the Waste cubes are foldable, they fit through a letter box, which saves shipping costs.
- BinBang could generate extra sales by providing other components for the disposable boxes, such as a lid; a holder to place the sealed cube into; a suction cup to mount the cube onto the wall; a tool to mount the cube onto the counter; a tool to swipe the OW from the counter into the box; or something to transport the Waste cubes.
- The concept could be extended to other waste streams: for example, a cube made of plastic to collect plastic waste, or a cube made from paper to collect paper waste.

Possible disadvantages

- The cube is easy to copy and cardboard products are hard to patent.
- The environmental impact could be high, because more material would be used than solely regular garbage bags.
- Currently, industrial digesters are not set up to properly process PLA and paper. The processing time of the machines is set at two weeks, but degradation takes 12 weeks (Grosze-Holz, 2018). This process needs to be adjusted to digest the material.
- The AI could forget about the product, which would result in a rotting stink bomb.

WASTE CUBE



1. A set of waste cubes is delivered via mail

2. The user needs to fold the waste cubes and close them with a watertight waste strip

3. For multiday use a reusable lid, with active carbon filter can be placed on top of the cube.

4. When the cube is full, the lid attached to the box can be folded on top.

5. The cube needs to be sealed with the attached stick strip hermetically to avoid releasing any air from the box.

Figure 55 | Waste cubes

4.9 The Cool waste bin

The bin for in the fridge

The cool waste is a bin, which can be placed in the fridge. Inside the bin is a lipo- and hydrophobic nano-coating. This bin can be closed-of watertight. Because of this combination the bin can be cleaned by filling the bin with a bit of water, close of the bin, shake it and empty the bin in the toilet.

Proposed solution to meet requirements

The Cool waste bin is a proposition for a new product design. It suggests meeting requirements R11 and R21 to R23 in the following way:

Store dry and wet OW (R1) | The Cool waste bin is a watertight plastic bin which needs to be emptied into the regular public container for residual waste.

Odour reduce method (R21) | The odour reduction method is to cool the OW.

No physical contact between the user and the OW (R22) | During emptying, the OW will fall into the public container. Because of the handle, there will be no contact between the OW and the user.

The OW must not be visible during daily use of the product (R23) | There will be a button on top of the bin to release the OW.

Disposal frequency of OW into a public container should be equal or less than the disposal process for residual waste. (R31) | The AI can collect for 1 weeks OW with the volume of the bin.

Intended usage.

During daily usage, the user needs to remove the Cool waste bin from the fridge. The user can then place the Cool waste bin on the kitchen counter. When emptying the bin into the public container, the user can use the handle to transport the bin. On the handle, there is a button to open the hatch so that the OW will be released into the public container. To clean the bin, a bit of water has to be poured into it, after which the bin needs to be closed and shaken. The dirty water can then be emptied into the toilet or sink.

The fourth concept is **the Cool waste bin**. This bin cools OW in the fridge to reduce odour. Because of a lipo- and hydrophobic nano-coating, there is no need for a plastic bag. The bin can be cleaned by pouring a bit of water into it, closing it and shaking it.

Possible disadvantages

- Als may not want to keep their waste in the fridge, as they may think that this is dirty or that this takes up too much space.
- The coating might not work

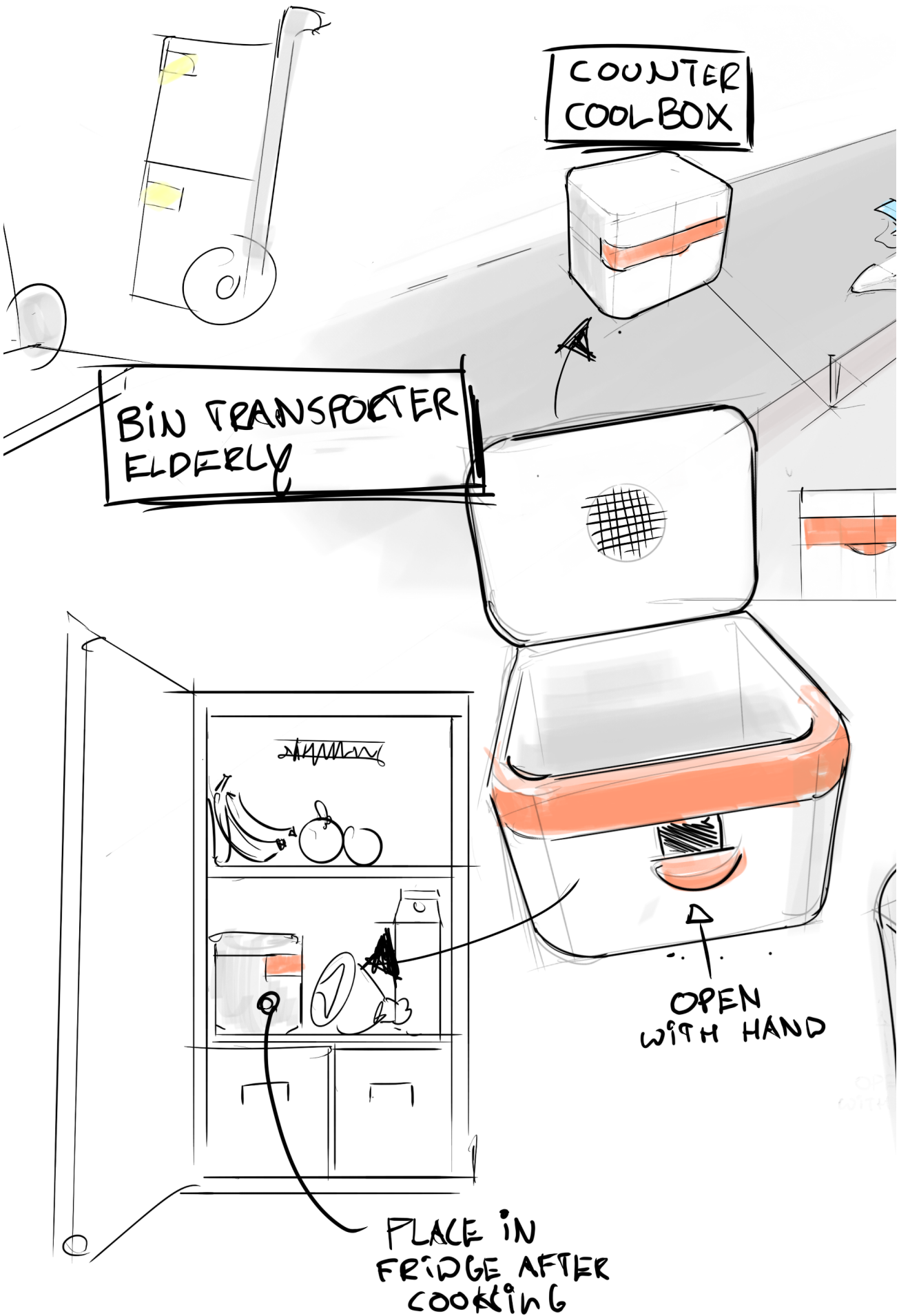


Figure 56 | Cool waste bin

The product concepts from the previous part were turned into prototypes. The four households outlined in chapter 2.4 tested the prototypes for a period of one week. With their input, the odour reduction methods in each of the product concepts are evaluated. In addition, the concepts are also evaluated regarding placement location, bag type and lid type. Using these insights, a set of criteria for the final product solution for this thesis is made.

You are in this part of the project:

Part 1 | Introduction

Analysis phase

Part 2 | OW in high-rise buildings

Part 3 | Business analysis

Synthesis phase

Part 4 | Ideation & conceptualisation

Part 5 | Concept evaluation & selection



Embodiement phase

Part 6 | Embodiement

Evaluation phase

Part 7 | Evaluation

Part 8 | Recommendations

Prototyping, concept evaluation and selection

Part 5

The concepts are turned into prototypes

**An evaluation of odour reduce
Methods by the four households.**

**An evaluation of the product properties by the four
households**

**Translate these insights into criteria
for the final product**

5.1 Prototypes

Each of the concepts is turned into a physical prototype, which simulates the main properties of the product concepts. The prototypes will be used for the evaluation of the concepts.

5.2 Odour reduction method validation concepts

The four concepts are tested by the four households to evaluate the acceptability of the odour level (R11). The prototypes of the Waste cubes used in testing weeks 3 and 4 and all waste cooling prototypes are positively evaluated on R11.

5.3 Product properties evaluated by households

The different properties of each concept product are compared and evaluated by the households. It can be concluded that the preferences for each property differ for each of the. The advantages of each of the concepts will be combined in the final product solution of this thesis.

5.4 Final criteria

The final criteria are set by using the insights from chapters 5.2 and 5.3. The focus will be on one and two-person households in HRAs.

5.1 Turning the product concepts into prototypes

An impression of the prototypes

Each of the product concepts is turned into a prototype. The prototypes simulate the main product properties, such as size, placement, opening method and the odour reduction method used. The odour reduction methods are validated in chapter 5.2 and evaluated by the households in chapter 5.3. During the evaluation process, improvements for the prototypes are made. A description of each of the prototypes is given in this chapter.

Prototype Organic air

The Organic air is completely simulated as it was intended in the design sketch (p66).

Prototype Bio balcony

The prototype of the Bio balcony is also simulated as it was intended in the concept sketch (p68).

Prototype Waste cube

The Waste cube was initially simulated with a disposable cardboard cup including a PLA layer of 1 litre with a lid, see figure below (figure 57). The odour reduction method did not work (see next chapter 4.3). Therefore, the Waste cube was improved by using a biodegradable bag with a PLA layer, and the odour reduction method was changed to activated carbon (figure 61).

Prototype Cool waste

Each of the concepts is turned into a physical prototype, which simulates the main properties of the concepts. The prototypes will be used for the evaluation of the concepts.

The first prototype of the Cool waste bin was a regular 3 litre bin. The second prototype simulated the properties of the Cool waste concept, except the release button and the nano-coating.

Learning through prototyping

The product concepts as described in the previous chapter do not yet meet all the requirements of the design directions. Kiriyama and Takashi (1998) state that by using physical prototypes, new knowledge can be acquired. This is also the goal of the prototyping and testing phase of the concept development.



Figure 57 | First prototype the Waste cube.



Figure 58 | First prototype of the Cool waste bin.



Figure 59 | Prototype of the Organic air bin



Figure 60 | Prototype Bio balcony bin test week.1



Figure 61 | Third prototype of the Waste cube bin



Figure 62 | Second prototype of the Cool waste bin

5.2 Odour reduction method validation concepts

An evaluation of odour reduce methods by the four households

The odour reduction methods used in the product prototypes are evaluated by the four households, who represent the target group (chapter 2.4, p 28.) in a 4-week test period. During the test period, improvements to the odour reduction methods are made. It was found that cooling OW always results in a bin in which odour is below the annoyance level (R11).

Method

The participants tested one of the prototypes for a period of a week in a four week testing period. They all had to store OW for the period of a 7 days. After these seven days they were aloud to empty the bin. They were sent a weekly questionnaire. In this questionnaire, they graded the annoyance level regarding odour and fruit flies. The questionnaire can be found in Appendix M. During the test phase also improvements are made, to the Coolwaste bin and the Waste Cubes. The concept development can be found in appendix N. The test were performed in the last two weeks of August and the first two weeks of September, when the weather was still summer-like in the Netherlands. According to the KNMI (2018), in august the average temperature was 18.5 °C in 2018, which is 1°C above the normal average. The first two weeks of September also had tropical temperatures up to 30 °C. High temperatures result in the highest odour forming, therefore this test was performed in an ideal situation to validate the odour reduce methods of the prototypes.

Results

The results of the four week test period are shown in figure 67. If the odour level during the week was evulated as acceptable by the participants, the odour method is marked in green, when it was not acceptable it is marked in red. The extended results can be found in appendix X.

The odour reduce method of sealing resulted also in strong odour, therefore there is chosen to switch the odour reduce method of the Waste cube to activated carbon in week 3. The results of each of the odour reduce methods is discussed below.

Cooling | Cool waste

Cooling did not result in any annoyance during the four week test period. There were also seen no fruit flies.

Sealing | Waste cubes

Sealing OW was evaluated negatively by two households during the test. A strong odour was released after the

OW was placed in the bin in the morning, sealed and then opened again in the evening. This could be explained by the fact that aerobic digestion was accelerated.

Activated carbon | Organic air and Waste cubes

The Waste cube, tested in the last two weeks of the test period, and the Organic air bin, tested during the three week test period, did not result in odour annoyance when the bins were closed. After multiple days of collecting the OW, the users began to smell odour, at the moment they opened the waste cube or the organic air. In the case of the organic air this odour was not acceptable in all three weeks. In the case of the waste cube the odour levels were considered as acceptable.

After three weeks of testing is decided to stop with the Organic air bin, because this bin resulted in odour levels which were not acceptable. Also, there were fruit flies spotted around the bin during usage.

Placement outside| Balcony bin

The users smelled odour which was far above the acceptable annoyance level. After two weeks is decided to stop testing the Bio balcony bin, because it resulted in a large amount of odour, fruit flies and smell around the bin.

Improvement aeration + paper bag | Organic air.

The Organic air bin, which uses aeration around the OW, resulted in odour above the acceptable annoyance level for all three weeks of the testing period. There was also varied in different bag types but still this resulted in odour annoyance.

Conclusion

From use of aeration method of the organic air can be concluded that the various variations on aeration used in the prototype did not work to reduce the odour. Therefore, this The Bio balcony also is considered as a non effictive method to reduce odour, because odour is moved from inside the house to outside the house, where it still has odour annoyance.

The use of a biodegradable bin in combination with activated carbon has potential, because in the last two weeks it did not result in odour annoyance. However it does not seem to take away the odour during opening of the bin.

Cooling did not result in any odour annoyance and therefore, the final product solution for this thesis will make use of cooling in the fridge as an odour reduction method.

The four concepts were tested by four households to evaluate the acceptability of the odour level (R11).

The prototypes of the Waste cube used in testing weeks 3 and 4 and all Cool waste prototypes were positively evaluated on R11.



Figure 67 | Overview of odour stop

5.3 Product properties evaluated by households

An evaluation of product prototypes by the four households outlined in chapter

The concepts are also evaluated and on the properties; placement, bag type, and lid type and main preference for a concept by the households.

Method

The evaluation is done by interviewing the participants of the households after the four week test period. They are asked on their preferences regarding the properties.

Results & discussion

The results are visualized in Figure 68. When a household prefers a property, it is indicated with a + and when they do not prefer a property, it is indicated with a -. Because the results for each household were quite diversified, they are discussed per property.

Placement

Fridge | None of the households had a problem with OW being together with fresh food in the fridge. However, some of the households declared that it was annoying to first take the bin out the fridge before they were able to dispose of the OW. For example, the young couple could not quickly dispose of an apple core. Lastly, all households complained about the use of space in the fridge. For example, the family, could no longer store the Cool waste in the fridge due to an anniversary.

Kitchen counter | The young professionals and the students both thought that the kitchen counter is the best place for a product to store OW. The young couple and the family also agree that it is a good place, but they think that the bin takes up too much space on their small kitchen counters.

Placement outside | Not a single household preferred a bin placed outside, because they had to constantly walk outside with the OW. The Bio balcony bin decreased the walking frequency to the outside bin to only once per day, which was therefore seen by the family as a positive outcome. However, the transmission of the OW between the top and bottom bin was seen as very unhygienic.

Ground | Placement on the ground was preferred by the family and the young couple. This could be explained by the fact that the ground bin was used in combination with a foot paddle.

Hatch type

Loose Lid | The students preferred a loose lid, because it was easily washable. A loose lid can also be removed during cooking, which the students considered as convenient.

Paddle | Both the family and the young couple preferred a bin on the ground that could be opened with a foot paddle. The cutting board that they both use during cooking can be easily emptied into such a bin type.

Lid with hinge | This was only preferred by the young professionals and the students.

Bag type

Fast clean | None of the households preferred the fast clean bin (having to clean the bin themselves), because it is too much work. The nano-coating and fast clean mechanism as proposed in the Cool waste concept (p72) were not simulated by the prototype, and so the actual design might change the opinion of the users. Also, the second prototype of the bins was even harder to clean because of parts sticking out in the prototype. The young professionals preferred fast clean only if it was very easy. The mother of the family declared that the fast clean bin was not a problem for her, because her son cleaned the bin.

Disposable | The family, the young couple and the young professionals all preferred the disposable bin, because it takes the least effort. The students thought that disposable bins did not feel right, because they constantly threw away material. They also argued that the waste cubes took up too much space.

Normal plastic bag | All households preferred a normal plastic bag as long as it did not leak. The students preferred the normal plastic bag. However, the students did complain that the biodegradable bags felt dirty.

Other findings.

The opening of the bin should be at least 20x20cm. The students and the young couple both said that the Waste cubes were too small to store OW. The opening of the prototype for this was around 10x10cm.

Conclusion

It cannot be concluded that there is one property that is preferred by all of the households. The properties are interdependent other and the ideal properties also depend on the personal preferences of each AI.

For example, placement in the fridge was the least preferred bin type of all of the households, as it took up space and extra effort. However, the households were willing to use up space in the fridge to store OW, if this meant that they did

2.4

not have odour annoyance and fruit flies anymore. Placement of the bin in the fridge was only strongly objected to by the young couple, as they would prefer a little bit of odour in their apartment once in a while over giving up space in their fridge.

The young couple preferred a disposable bin, but would not want to place this on the kitchen counter.

In general, it can be concluded that the AIs in the participating households prefer bin products that cost the minimum amount of effort. This is the reason that the young professionals and the young couple prefer a disposable bin. A disposable bin, which makes use of an activated carbon filter, is also seen as a solution with potential.

The different concept properties of the concept were compared and evaluated by the households. Property preferences are interdependent and differ per household. The advantages of each of the concepts will be combined for use in the final product solution of this thesis.

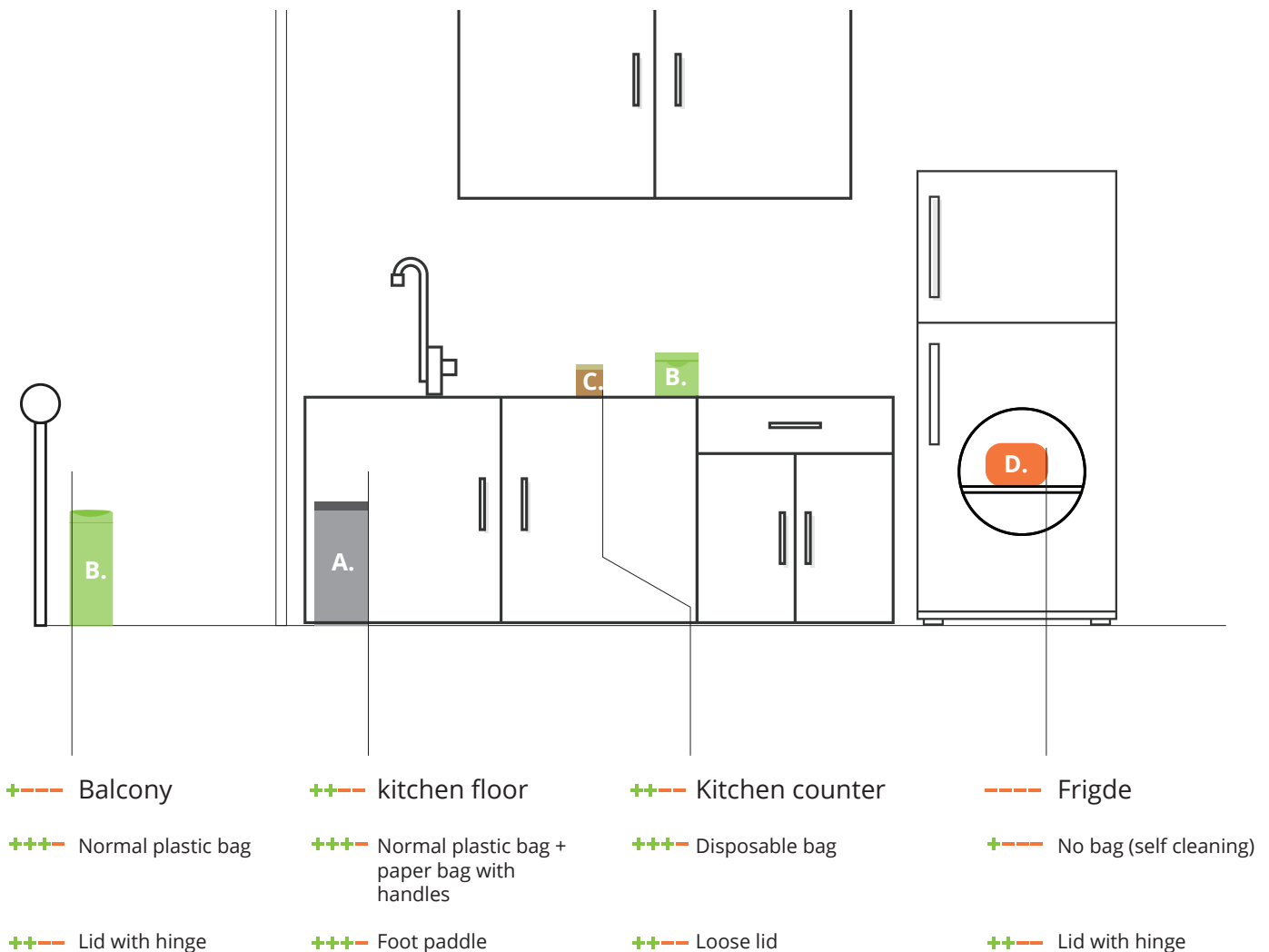


Figure 68 | Overview of the odour reduction methods

5.4 Setting criteria final concept

Translate the learnings into criteria for the final concept.

The insights from the previous two chapters are used to determine the requirements for the final design of this thesis. The concepts which are described and tested are not further developed. Instead, insights from all the prototypes are used to set the requirements for the final design of this thesis.

Focus on cooling

A selection for the final concept needed to be made between cooling and the use of activated carbon. Cooling OW in the fridge is likely to meet this requirement the best and this method has therefore been selected as the final product solution of this thesis.

Placing the bin in the fridge will also prevent fruit flies from gathering around the product (R11).

It was expected that AIs would have problems with keeping OW in their fridges for hygiene reasons, however, this wasn't the case for the participating households.

Setting direction for the final product

Because the households differ in preferences but also in OW production, it has been decided to only focus on one and two-person households for the final product of this thesis. The amount of one-person households will reach 3.4 million by 2030 (PBL, 2018)

Requirements final product from synthesis

The set of requirement of p55 is supplemented with new requirements which came forward from the synthesis.

1. Mainfunctions

R16. Placement fridge door | The households indicated that placing a bin in the fridge was not ideal because of the space it took.

R17. Placement at kitchen counter | When the bin is not in the cooler, it should be placable at the kitchen counter.

2. Hygienic requirements |

R24. Odour reducing by fridge cooling | The anti odour method will be cooling in the fridge.

R25. Parts must be deconnetable for cleaning | Moving parts should be deconnectabe so the entire bin is easier to clean.

R26. No holes or egdes where OW can pile | No edges were waste can get stuck into.

W22. Fit in a dishwasher | The maximum height of the bin is 24 cm. (appendix O)

3. Usability

R32. Bag replacement should take less than 10 seconds | This is how long it takes to replace a bag in a normal waste bin.

R33. The user must feel able to quickly dispose of OW |
R34. The opening of the bin should be 20x20cm |

A smaller opening makes it inconvenient to cut vegetables or fruit above the bin.

R35. Quick disposal single/small pieces OW, when the concept is placed in the fridge | Single pieces of OW, like an apple core or a banana peel, needs to be disposable quickly, without the need of removing the product from the fridge.

R36. Deconnectable Lid with a hinge | The participants prefer a lid which is fixed with a hinge but is also deconnect-able.

R37. Dispose OW from cutting board in bin | The user must be able to swipe OW from a cutting board in the bin. Households use a coating board for fruits and vegetables. From there they dispose the OW in the bin.

6. Bag requirements

The requirements for a the bag are set as follows.

R62. Watertight for a week |

R63. Removable and closable and transportable without getting dirty hands |

R64. The bag must be biodegradable according to NEN-EN 13432 |

R65. The bag must fit exactly in the bin and clamps to the side |

R66. The material of the bag must be non transparent.

R67. €0,20/bag |

R68. Bag must be placeable in a simple movement |

R69. Bag must be removable and closable in one movement |

R610. A normal plastic bag must be placeable in the bin

xIf the user does not want to buy the bags which belongs to the bin, there must be an option to use regular bags.

New ideation & prototypes

Based on the set requirements, a new ideation and prototyping cycle has been conducted (Figure 69). The ideation and prototypes of this second phase resulted in the design for this thesis, which is presented in the next chapter (ch. 6.1)

The final criteria of p55 are supplemented with the criteria based on the insights of chapter 5.2 and 5.3.

The focus will be on one and two-person households in HRAs.

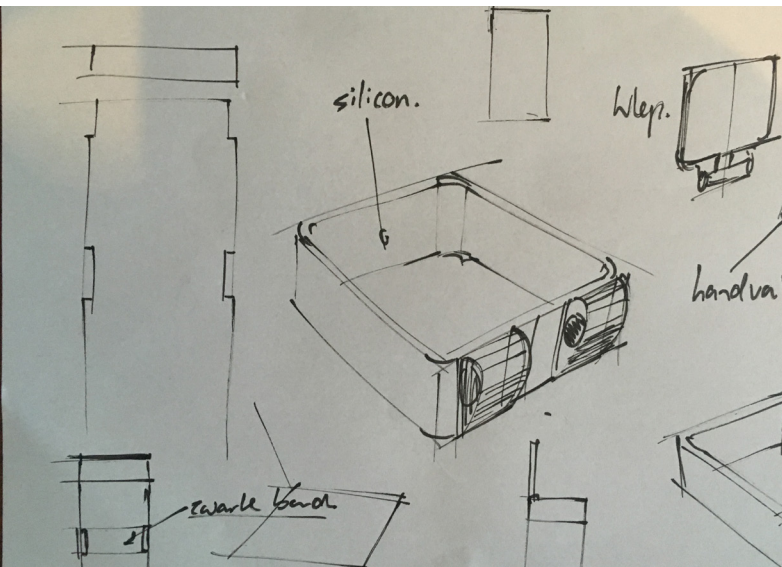


Figure 69 | Ideation and prototyping with new requirements



In this part a design proposal for a bin to store OW in the fridge is given as an answer to the requirements of the design direction (p55) and the requirements resulted from the synthesis (p88). The costs of the product are determined by three injectionmoulding manufacturers. Furthermore, a proposition for a market introduction, transport and packaging of the product is given. Lastly, the product is modelled and optimized for extreme usage by several static studies in Solidworks.

You are in this part of the project:

Part 1 | Introduction

Analysis phase

Part 2 | OW in high-rise buildings

Part 3 | Business analysis

Synthesis phase

Part 4 | Ideation & conceptualisation

Part 5 | Concept evaluation & selection

Embodiement phase

➔ Part 6 | Embodiement

Evaluation phase

Part 7 | Evaluation

Part 8 | Recommendations

Embodiment

Part 6

The solution for this thesis

6.1 The Frisbox

The Frisbox is the first bin that is able to collect OW for several days, without odour and fruit flies, by placement in the fridge.

How can the Frisbox be used?

6.2 Usage

Using a 1:1 size 3D printed prototype of the Frisbox, it is demonstrated in an apartment.

What design choices are made and how can the Frisbox be produced?

6.3 Component details and production

Each of the components is discussed separately regarding its functions, design choices and production.

A design for a perfectly fitting bag in the Frisbox.

6.4 The Friszak

The Friszak is a concept of a biodegradable bag, which is non-leaking, biodegradable, hygienic in usage and fits perfectly in the Frisbox

How is the selling price of the Frisbox structured?

6.5 Cost price of the Frisbox

The price structure of the Frisbox is determined by the production and investment costs of three manufacturers to estimate the selling price.

How can the Frisbox be introduced in the market?

6.6 Market introduction

To introduce the Frisbox in the market, firstly, a pilot version of the Frisbox called the Pilot Frisbox should prove its potential and help the Frisbox to further develop.

The Frisbox could be introduced in the market by supplying Frisboxes and Friszakken for free to all AIs. This could be funded by municipalities and waste processing companies.

The design of the pilot edition for the pilot in the Hague

6.7 Pilot Frisbox (Pilot edition)

The Pilot Frisbox is the pilot edition of the Frisbox, which can be produced with lower investment costs than those of the Frisbox.

How can the Frisbox be packaged and transported?

6.8 Package and transport of Frisbox

The Frisbox could be packaged using limited material and costs. It could be transported relatively cheaply by stacking the bins and supplying all components in one box per sort to distributors. Store employees could assemble the packages of the Frisboxes.

6.1 Frisbox

The solution for the design direction

The Frisbox is the result of the insights of the synthesis phase and is an answer to the list of requirements detailed on page 55 and page 88 of this thesis.

General description

Frisbox is the first bin to collect OW in the fridge. Frisbox is the solution for AI's (apartment inhabitants) in one and two-person households who do not have their own OW container outside, but still produce small amounts of OW. Furthermore, AIs do not want to walk daily to a public container and they do not want to have annoyance of odour. The Frisbox is an answer to this.

Hygienic

Frisbox makes it possible to collect OW without smelling it, touching it, or seeing it for at least a week.

No odour & fruit flies: because the OW is kept in the fridge, there will be no odour and no fruit flies.

No touch: with the cord in the Friszak the user can empty the bin without touching the bag. (more about the Friszak in chapter 6.4).

Without a Friszak, the bin can also be emptied without having to touch the lid because of the slide system.

No sight: because of the long, small shape, fresh OW will always be on top. All OW stays fresh in the Frisbox. Furthermore, because of the black colour of the bin, dirt is hard to see.

Storage for a week

The Frisbox has a storage volume of 4.5 litres, which is big enough for one and two-person households to collect OW for a week. Households with three or more persons could also use the Frisbox, but it is expected that they would then have to empty the Frisbox more often into a public container, as it would become full faster.

Placement

The Frisbox fits in the door of a fridge and has the same depth as the diameter of a regular 1.5 litre cola bottle. The Frisbox can be placed on the kitchen counter, or can be mounted to a drawer or cabinet door beneath the kitchen counter. When the Frisbox is not in use, it should always be placed in the fridge. When the bin is outside the fridge, odour could easily be annoying.

The Frisbox is the first bin, to collect OW for several days, without odour and fruitflies, by placement of the bin in the fridge.

Friszak

The Frisbox uses the Friszak: a bag which is biodegradable, non-leaking and fits perfectly in the bin. The bag will be discussed in chapter 6.4. The Frisbox is the first bin to collect OW for several days, without odour and fruit flies, by placing the bin in the fridge.

Usage & functions

Using a 3D printed model, the usage is explained in chapter 6.2 (p. 94-95).

A more detailed description of each of the parts can be found in chapter 6.3 (p. 96-100).

Circular product design

All components of the Frisbox are made from recycled polypropylene. Next to that, because all components of the bin are made from the same material, at the end of its life, the bin can be collected and recycled in PMD containers (containers especially for plastic, metal and drink cartons). This makes the Frisbox by the end of life easy to recycle.

All components of the bin are detachable for cleaning purposes, but also to make it easy to replace broken parts.

Slogan

The slogan for the Frisbox will be: "Frisbox in the koelkast, GFT that moet cool gast". Translated into English, this means: "Frisbox in the fridge, OW needs to be cooled, dude." The Dutch rap group De Jeugd van Tegenwoordig released the song "Shenky" in 2007. The first lines of the chorus are "Shenky in de koelkast", "Kenk je bent een fool gast". This phrase is widely known among Dutch youth. The goal of the slogan is to make OW separation in the fridge, which seems initially an odd thing to do, cool and acceptable. It also addresses young people who recognize the similarity to the rap group's song.

Logo

The logo of Frisbox shows an infinity loop, referring to a circular economy which should continue forever. The left part of the loop shows an apartment building and the right part shows a tree. Frisbox will be the connection between food waste from cities and nature, representing the bio loop of the circular economy.



Frisbox

“in the koelkast,
GFT dat moet cool gast”



4L

4 litres



for 1 & 2 person households in apartments



Usable without touching organic waste



No odour and fruitflies due to placement the in fridge



Storage for organic kitchen waste

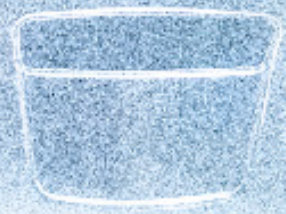
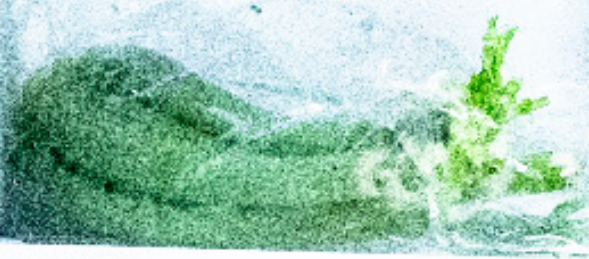


All parts made of recycled polypropylene. 100% recycleble



All components detachable for cleaning, repairing and replacing

Figure 70 | Render of the Frisbox





A new way for the hygienic separation and collection of organic waste for apartment inhabitants.



6.2 Usage

This is how the Frisbox can be used.

Single pieces of OW, like an apple core, can be disposed of without removing the HENKIE from the fridge.

With the hook, the HENKIE can be connected to a door or drawer beneath the kitchen counter.

During cooking, the HENKIE is within arm reach to dispose of OW.

The OW can be swiped right from the cutting board into the HENKIE.

The HENKIE can also be placed on top of the Kitchen counter.

Because of its small long shape, it takes up limited space on the small kitchen counter.



The Freshbag can be removed from the Henki by pulling the cord.



The AI can also choose to transport the HENKIE with the handle



The handle can be used to empty the bin.



The user pushes the lid towards the back of the bin so that the user can empty the Henki into a public container without touching the lid



All components can be easily disconnected to clean the HENKIE.



The bin and all components can be placed loose in the dishwasher.

6.3 Component details & production

What design choices were made and how can they be produced?

In this chapter, a description of each of the five different components is given. The design choices, functions and production are explained per component.

main lid (1) & Lid connector (2)

The lid consists of two parts: the main lid and the lid connector. The lid has a double hinge, so that the bag can be placed all around the top of the bin (see figure 83, p103). The double hinged lid is necessary to make the lid openable when it is placed in the fridge and to place the bag all around the top of the bin. If the lid connector were to be connected to the lid without hinged point, the lid would not be easy to open in the fridge. The lid connector can be placed in the lid and in the bin by bending the component slightly and pushing the balls into the holes. The lid connector can be removed by pulling the component away from the bin and lid.

Handle (3)

By pulling the ends of the handle apart from each other, the handle can be placed in a horizontal position in relation to the bin. In this position, the end of the handle fits exactly into the shape of the bin. The handle stays in position because it bends back into its original shape.

Hook (4)

The requirements for the design of the hook are the following:

1. The hook must be able to be placed onto the dimensions of standard kitchen drawers or cabinet doors. The standard dimensions were retrieved via a visit to the Keuken Concurrent (a kitchen store) and can be found in appendix O.
2. The hook must be collapsible to make the Frisbox fit in the fridge.
3. When the Frisbox is mounted to a door or drawer, the door or drawer still needs to be able to open.
4. The holder must be detachable for cleaning and be optional for the customer

The final hook that is integrated in the design does not make use of a hinge and is still collapsible. The advantage of this system is that, because of its simplicity, it saves costs. Furthermore, it can handle forces well. This is shown in chapter 6.9. Also, it was initially assumed that the edge of the top the bin should be at the same height as the kitchen counter. Figure 77 (p.100) shows how the bin is placed in extreme dimensions of the kitchen.

The Frisbox is designed to be repairable and recyclable. All parts of the Frisbox can be produced by injection moulding.

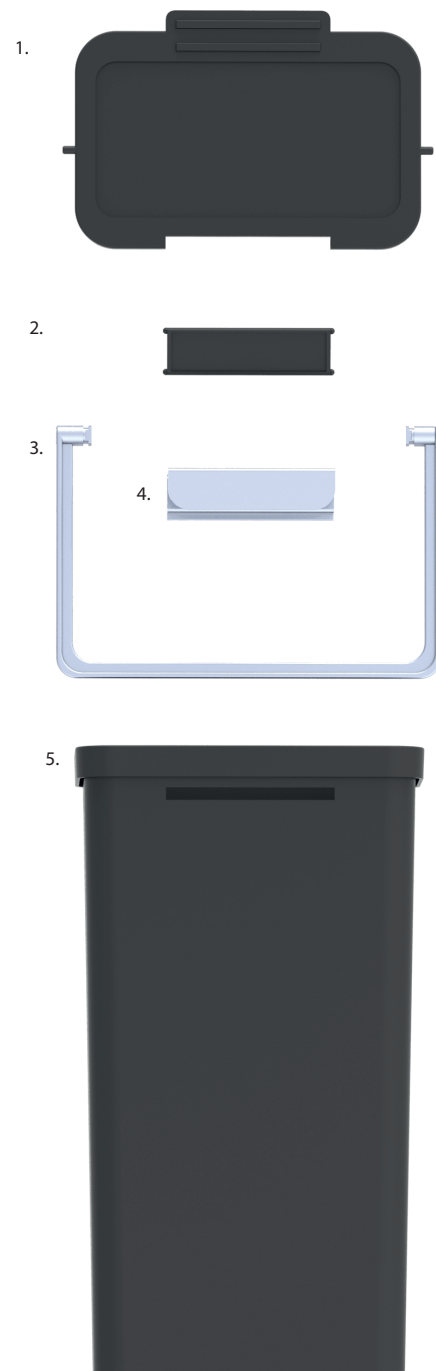


Figure 71 | Exploded view parts Frisbox



Figure 72 | Connect main Lid to lid connector

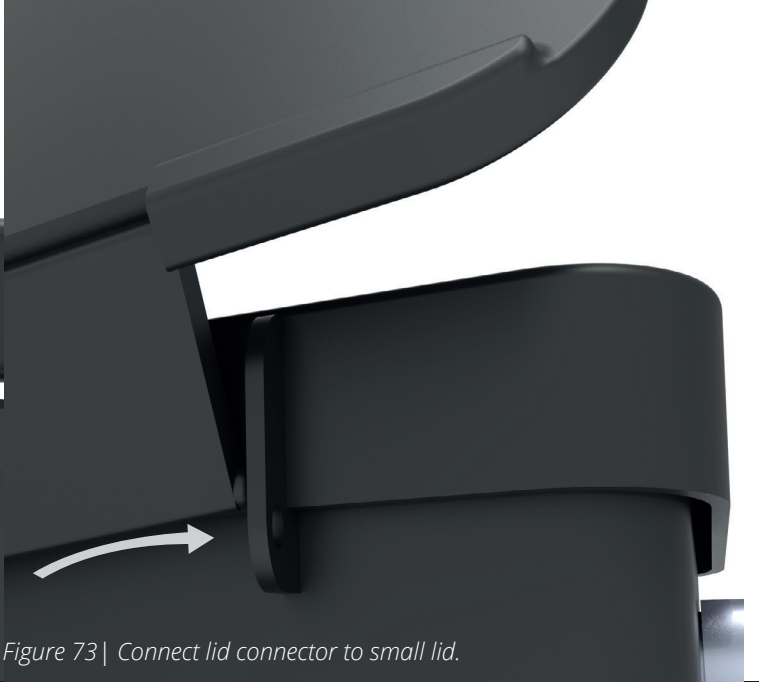


Figure 73 | Connect lid connector to small lid.

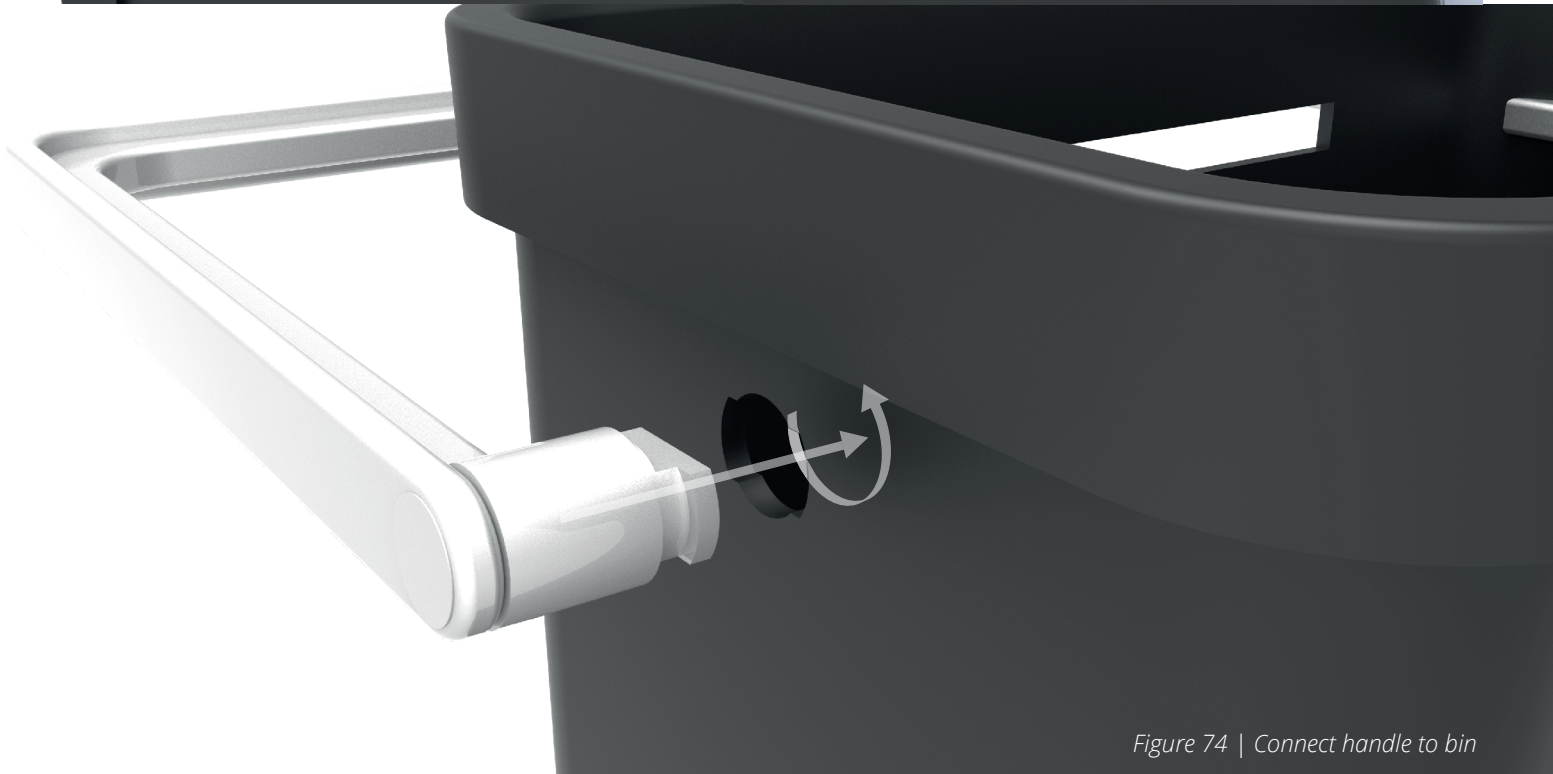


Figure 74 | Connect handle to bin



Figure 75 | Lock lid on bin

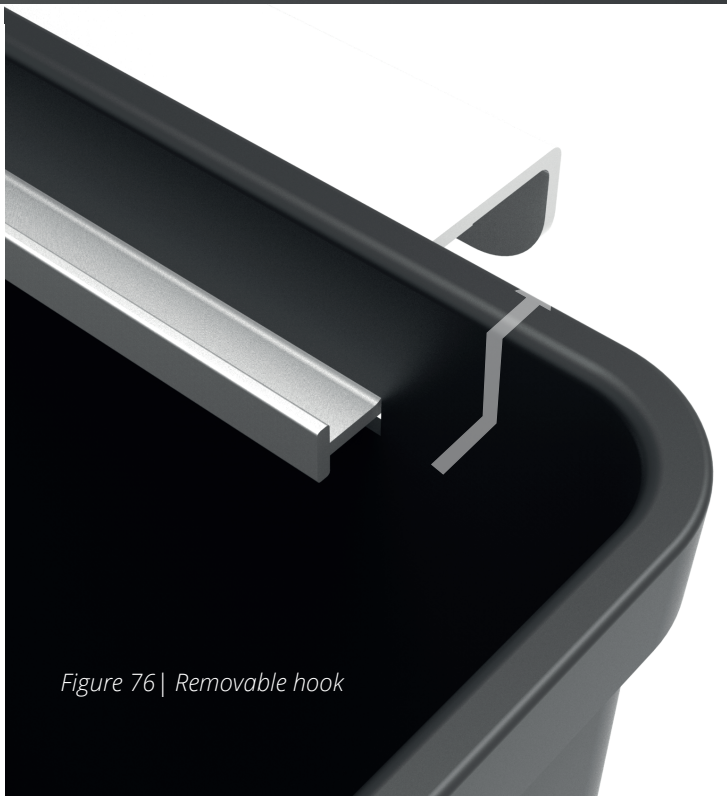


Figure 76 | Removable hook

Bin (5)

The design choices of several elements of the bin are discussed separately.

Shape | The shape is kept as simple as possible and as wide as possible to keep the volume as large as possible. This is important to store as much as possible of OW in the Frisbox. The shape of the bin has a slope of 2°. This is necessary to make the bin draft-able from a twofold mold for injection-molding. Furthermore, it makes the bin stackable. This will enable to transport large amounts of the bins with less volume, which results in lower transport costs.

Dimensions | The bin must be placeable in the fridge door. The dimensions of the bin are based on a standard 1,5L Coca Cola bottle. The depth of the bottom of the bin is 8,3 cm. 1,5 cm smaller than the bottle. The racks in the doors could be smaller than a Coca Cola bottle, the racks slightly bend a little bit. The height of the Frisbox, including the lid is the same as a standard Coca Cola bottle.

Bag border | On the top of the bin is a small border. The border has the function to give extra strength to bin. The top is likely to warp easily. The other function is to hold the Friszak in place.

Rounded corners | The inside of the bin has no sharp edges. The function of this is it makes the bin is easier to clean. There are no edges where OW can easily stick.

Production

All parts can be produced by injection molding. VDL plastics, producer of some of the injection molded parts of the

current bin is able to produce the Frisbox. Also, two Chinese manufactures made a quotation to produce the Frisbox. The bin can be produced by a twofold mold, consisting of an outside and an inside mold. The molds are draft-able in the vertical direction. Next to that five inserts are required. Two inserts for the holes of the handle, to holes for the lid connector and one rectangular hole for the hook. The bin meets all requirements for injection molding. (Awamolding, 2018). The wall thickness is 3mm, which is within the standards of injection-molding. Furthermore the draft-angle is 2°, to make the bin draft-able from the mold. The thickness of the rib thickness 70% of the wall thickness. There are no edges which are smaller than 0,5-0,8mm. Shrinking of the bin after injection molding is also taken into account. Because of the bold surface.

Moulds

VDL plastics, BinBangs current producer and Top Tooling CO LTD and Shenzhen Runpeng Co. Ltd, both producers in China reviewed the parts of the Frisbox.

VDL can produce the parts by four steel moulds. The hook and the Hatch can be produced in one single mould. Which saves costs. The bin consists of 5 inserts and the lid requires two inserts.

Top Tooling Co., Ltd. Is able to produce the entire Frisbox with two mould. The bin will be produced with one mould and the other four parts will be produced in a family parts. Shenzhen Runpeng Precision Hardware Co., Ltd uses three moulds. One for the bin, one for the hook and the handle and one for the lid and lid connector.

More about the production costs of these 3 manufactures can be found in chapter 6.5



Figure 77 | Standard dimensions of kitchen counter and doors. Left: minimum distances. Middle: most common. Right: largest distances.



Figure 80 | Dimensions bin.

6.4 Friszak

A perfect fit trash bag for the Frisbox

Together with Frisbox, a design for a biodegradable accessory bag is made, named the Friszak. The Friszak is an integral and hygienic component of the Frisbox. The following section details the intended bag design, look, and requirements.

The Friszak

The design properties of the Friszak are described to meet the following requirements:

Compostable | The Friszak is made of compostable materials. Current biodegradable bags are made of potato starch or PLA.

Non-leaking | The thickness of the Friszak bag has been adjusted to be non-leaking for at least a week.

Perfect fit | Another essential feature is the perfect fit of the Friszak. The bag fits precisely within the top borders of the Frisbox; contributing to the hygienic look and feel of the bin. A bag which is curved and wrinkled quickly looks and feels dirty.

In addition, the perfect fit of the Friszak will not reduce the storage volume.

Cord | The bag contains a cord or a strip in the top border to remove and transport the bag from the Frisbox without touching the Friszak. This is a crucial element of contributing to the hygienic use.

Non-transparent | Furthermore, the bag is non-transparent, so OW is not visible inside the bag. This is to meet r23. The degraded OW may not be visible.

Easy to place | The bag can be installed within five seconds and removed by simply pulling the cord.

Development of Friszak

Bio4pack is a company based in Germany, who currently produces various biodegradable OW waste bags and capable of making the Friszak. Jeroen van Schendel, sales manager at Bio4Pack (2018), stated that they could potentially produce

The Friszak is a concept biodegradable bag that is non-leaking, biodegradable, hygienic in usage, and fits perfectly in the Frisbox.

the Friszak bags, but meeting the design properties will require research and development. They are also able to make thicker bags, which would further reduce potential leakage. Processing by an industrial digester

Marco Grosze-Holz (2018), a Process Engineer at Attero operate industrial biodigesters for OW, has been interviewed about biodegradable bags and products. According to Grosze-Holz, biodegradable plastics, which meet the NEN-EN 13432 standards, are still hard to break down in the machines. They can only be fully broken down in an integral degradation process of digestion and composting. Therefore, biodegradable plastics are only acceptable as a collection agent and not as - for example, a coffee cup.

Grosze-Holz also stated that biodegradable plastic bags create problems in the machines and must be removed beforehand. How exactly plastic bags affect the machines will require extra research. Testing of the final Friszak model in an integral digestion and composting system is advised. Further research is necessary to elucidate the optimal properties of the Friszakken. A possible solution could be paper bags with a PLA layer, which does not have the structure of a plastic bag and does not hamper processing machines. bag and do not hamper the processing machines.

Figure 81 | Removing the Friszakken with a cord.

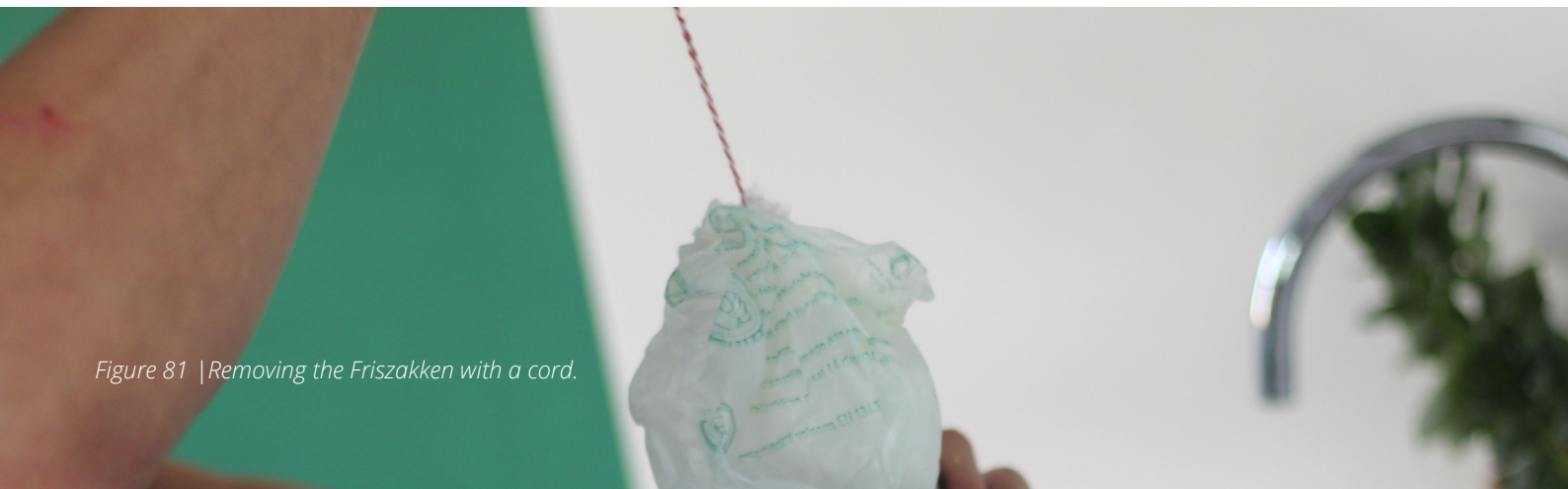




Figure 82 | Product impression Friszak.



Figure 83 | Friszak fit around edges.

6.5 Costs price Frisbox

How is the selling price of the Frisbox structured?

In this chapter, the costs price and final product price is determined by estimating the price structure of the product. Production quotes for the Frisbox was provided by three injection moulding companies.

Three quotes | Three producers

Three injection-moulding manufacturers estimated the production costs for the Frisbox, which are made with VDL plastics. BinBang's currently produces the bins in the Netherlands, and has provided one quote. The next two quotes for the Frisbox were provided from two Chinese manufacturers; these are Shenzhen Run-peng Precision Hardware Co., Ltd, based in Shenzhen and Top Tooling LTD. Co based in Guangdong. The manufacturers are one of the 15 respondents to the placement of an inquiry on the Chinese online marketplace Alibaba. The companies selected for example in this thesis were randomly selected from those 15.

The quotes are based on the quantities of 25.000 and 250.000 pieces. These quantities were selected to give insight on how the costs are related to different production quantities.

Investment costs

Research and development costs are estimated at €10.000 for the products of VDL and 20.000 for the Chinese manufacturers. The research and development (R&D) cost is expected to cover the development process and the first test series. It is assumed that a Chinese contact will be delayed by the distance between China and the Netherlands, and it will cost more time to develop the products overseas.

Transport costs

The transport costs are € 1200 for a sea container of 40ft from the Shenzhen port to the Rotterdam port. If the bins are stacked, it is estimated that one container can contain 5500 Frisboxes. The total costs for transportation of 25.000 Frisboxes are estimated at € 6000. The transport costs for distribution to and from the port are not included in the calculation.

Custom costs

The import duties for products manufactured in China for the European and Dutch customs are calculated with the online tool of the Dutch tax authorities called 'arctictariff'. The Fris-boxes fall in the product category; tableware, kitchenware, other household articles, and hygienic or toilet articles, of plastics and have the code 3924 10 00 90.

Product price structure

The product price structure of the stackable bin of BinBang is used as a starting point to estimate the selling price. The estimations of the operating costs are based on the price structure of the stackable bin of BinBang, and in the range of 15 and 20% per product. (Appendix R).

The depreciation costs of the mould and R&D

These costs are spread over the quantity of HEN-KIE's produced. So in the quotation of VDL, if there will only be 25.000 pieces produced, the R&D costs will be € 4,6 per product, and if there will be 250.000 produced, the R&D costs per product will be € 0,5

No assembly costs

There are no assembly costs because the bin will be delivered in loose parts. The bins will be delivered in large quantities to the stores/municipalities. The employees of the stores will prepare the Frisboxes. This will be discussed in greater detail in the next chapter.

Profit

The profit for BinBang is set at 15% of the selling price for Frisboxes manufactured at VDL. 15% is assumed as the minimum to take as a risk to start with a new product line. The profit per product is set at 50% and 60% for production based in China for the quantities of 25.000 and 250.000. This margin is set higher, because of the low production and moulding costs.

Conclusions

All costs per product are totaled and results in a selling price of € 21,10, which is slightly above the set requirement of € 20 per bin. This includes a profit margin for BinBang of 15%. Therefore, all three manufacturers are appropriate to produce the Frisbox, but profits could increase significantly if a producer in China is selected to produce the Frisbox. Although there are higher costs to transport the Frisboxes, this can be earned back easily because of the lower production and tooling costs. The tooling costs of VDL (containing the moulds for injection moulding) are more than ten times higher than the tooling costs of Shenzhen Runpeng. The production costs per product are five times lower. Note that these prices are a first indication based on the first model of the Frisbox. Improvements could be made in finishing. Because it gives a first indication of the costs price, small costs post, which is not known yet, are not included in the price.

	VDL PLASTICS (1)		Shenzhen Runpeng (2)		Top tooling LTD. Co (3)	
	25000	250000	25000	250000	25000	250000
Bin	€ 2,86	€ 2,77	€ 1,14	€ 1,10	€ 0,96	€ 0,92
Lid	€ 1,46	€ 1,39	€ 0,22	€ 0,20	€ 0,11	€ 0,10
Handle	€ 1,30	€ 1,24	€ 0,04	€ 0,04	€ 0,06	€ 0,06
Lid connector	€ 0,65	€ 0,61	€ 0,13	€ 0,12	€ 0,05	€ 0,05
Hook	€ 0,55	€ 0,51	€ 0,11	€ 0,10	€ 0,14	€ 0,14
total costs p.p (€)	€ 6,82	€ 6,52	€ 1,65	€ 1,56	€ 1,32	€ 1,27
total costs	€ 170.500	€ 1.630.000	€ 41.140	€ 389.400	€ 33.020	€ 316.980

Investment costs (€)

Tooling costs	€ 95.000	€ 95.000	€ 9.944	€ 9.944	€ 18.436	€ 18.436
R&D costs (4)	€ 10.000	€ 10.000	€ 20.000	€ 20.000	€ 20.000	€ 20.000
Investment costs bags	€ 10.000	€ 10.000	€ 10.000	€ 10.000	€ 10.000	€ 10.000
Transport costs (5)	€ 1.000	€ 10.000	€ 6.000	€ 60.000	€ 6.000	€ 60.000
Customs EU (6)	-	-	€ 3.000	€ 28.145	€ 2.146	€ 20.600

Product price structure

Production costs	€ 6,8	€ 6,5	€ 1,6	€ 1,6	€ 1,3	€ 1,3
Depreciation molds & R&D	€ 4,6	€ 0,5	€ 1,6	€ 0,4	€ 2,2	€ 1,1
Order picking	€ 0,1	€ 0,1	€ 0,1	€ 0,1	€ 0,1	€ 0,1
Customs EU	-	-	€ 0,1	€ 0,1	€ 0,1	€ 0,1
Operating costs BinBang(4)	€ 3,0	€ 3,0	€ 3,0	€ 3,0	€ 3,0	€ 3,0
Transport	€ 0,04	€ 0,04	€ 0,24	€ 0,24	€ 0,24	€ 0,24
Profit BinBang	€ 3,0	€ 3,0	€ 6,0	€ 7,5	€ 6,0	€ 7,5
Selling price ex VAT	€ 17,6	€ 13,1	€ 12,7	€ 12,9	€ 12,9	€ 13,3
Selling price inc. VAT	€ 21,2	€ 15,9	€ 15,4	€ 15,6	€ 15,6	€ 16,1

Resources

1. Quotation by VDL plastics (09-11-18) Contact person: Jan Blauwgeers
2. Quotation by Shenzhen Runpeng Precision Hardware Co., Ltd (15-11-18) Contact person: Jenny Wang
3. Quotation by FLS Top Tooling Co., Ltd. (15-11-18) Contact person: Tina zhao
4. Based on price structure stakable bin BinBang. Appendix P
5. Quotation by | Ademar B.V | contact person Robert Lammers | Appendix Q
6. Tarief.douane (2018)

Notes costs Top Tooling

- The DME or Hasco standard mold-base and accessories are not included.
- The mold-base is LKM standard
- 4 Terms of payment:
40% deposit of the P/O con-firmness
30% the first try-out
30% when finished
- Shots samples are provided for up to 3 times to one same address only

Notes costs price estimation VDL

- Product price Bin incl. 5x insert M5, Inserts trough ultra soon
- Product price Hatch incl. 2x insert M5, inserts trough ultrasoon
- Product price Handle incl. 2x insert M5, inserts trough ultrasoon
- Prices per insert are €0,10 p/pcs
- With bigger series than 5.000 automation of inserts is price perspective more interesting. But, this means higher investment costs.
- Product prices are exclusive assembly and packing.
- Product prices including packaging, loose parts in box on a pallet.

6.6 Market introduction plan

How can the Frisbox be introduced in the market?

The market introduction plan is an answer to the main assignment of this thesis: "How can the apartment inhabitant be supported in separately collecting OW by means of a product/service?" It is also a possible solution to the main problem of this thesis: 'OW is rarely separated in high rise buildings.'

General solution

The market introduction and development plan is detailed in this section. The goal is to make as much impact as possible concerning OW waste separation. The strategy to achieve this goal is to make Frisboxes and Friszakken freely available for households in high-rise areas. By doing this, a real impact can be made, as only a small portion of the population is estimated to be willing to pay for products to separate waste. As a starting point for the market introduction, the city of Hague is used. The municipality of Hague also provides free OW containers to their citizens (Afvalaanbieden, 2018).

The Hague currently has a separated waste collection rate of 37.90% (CBS, 2018). This is far below the national average of 57 (CBS, 2018). Currently, the city of The Hague wants to increase their waste separation rate in the period of 2018-2020 from 31% to 35% (Revis, 2018).

The proposed market introduction of the Frisbox provides a solution to increase the OW separation rate; The Hague could potentially increase their rate by more than 5%, help achieving the goal of 45% by 2020.

Horizon 1 | Pilot Stationswijk the Hague

The first step is to start with a pilot of 200 households. The pilot will be executed by BinBang and the municipality of The Hague. A potential starting place is Spoorwijk, a neighbourhood in the Hague contains a relatively large proportion of high rise buildings.

A special model of Frisbox has been developed for this pilot, which has no investment costs and a selling price of €38,5. The pilot version is called the Pilot Frisbox and is discussed in more detail in chapter 6.7.

BinBang will provide Pilot Frisboxes, coaching, and instructions to the AI of Spoorwijk. They will collect feedback about the separation rate and usage of the Pilot Fris-box. The municipality of The Hague must fund the project, and provide public containers to collect the OW and collect the garbage collection. An overview of the costs can be found in Figure 87, p107. The entire overview of the costs for the project can

To introduce the Frisbox in the market, first a pilot version of the Frisbox, the Pilot Frisbox should prove its potential and help the Frisbox further develop.

be found Appendix S. The costs are based on a pilot project BinBang executed in Rotterdam in the neighbourhood Schiedam at the beginning of 2018 and on a pilot in the municipality of Amsterdam in the neighbourhood Java Eiland. The total costs to the municipality of The Hague for this pilot for the municipality are €50.692 - this is €253 per household. An acceptable price compared to the pilot project in Schiedam (costs €265 per household) and the project in Javaeiland (costs €172 per household). Furthermore, waste collecting organizations, like Nedvang could also fund the pilot. This was also done in the Schiedam pilot, to reduce the costs for the municipality of The Hague

The pilot has two goals:

1. Validate the efficacy of the Frisbox in OW separation for the municipality of The Hague.
2. Evaluate the Frisbox properties. What do AI's think about the usage? How is the volume for 1-5 person households? What do AI's think about keeping OW in their fridge?

If the pilot is evaluated positively, then Horizon 2 can be started. Possible improvements can be made on the Fris-box based on the feedback collected of the Pilot Frisbox.

Horizon 2 | Scale-up in Hague.

If the outcomes of the pilot are positive, the Frisbox production could be expanded to a larger scale. The costs of the Frisbox, when produced with VDL plastics, are taken as a starting point. The Frisbox could be produced for €6,52 but requires an investment of at least €95.000 in moulds. Therefore, it is advised to only start producing the Frisbox on a larger scale if the results of Horizon 1 are positive and suggested adjustments are feasible. The plan contains the following points.

The goal is to provide a Frisbox and free Friszakken for every high-rise household in The Hague. Delivering bins, of this quantities, was also done in 12 municipalities of Friesland in 2017 and 2018, where more than 107.000 2,5 litre bins were provided to the inhabitants (VANG-HHA, 2018). The total costs estimate for the municipality of The Hague is €6.4



Pilot Frisbox | Horizon 1

200 pieces
Stationswijk
€ 38,5

Frisbox | Horizon 2

150.000 pieces
The Hague
€ 18,1

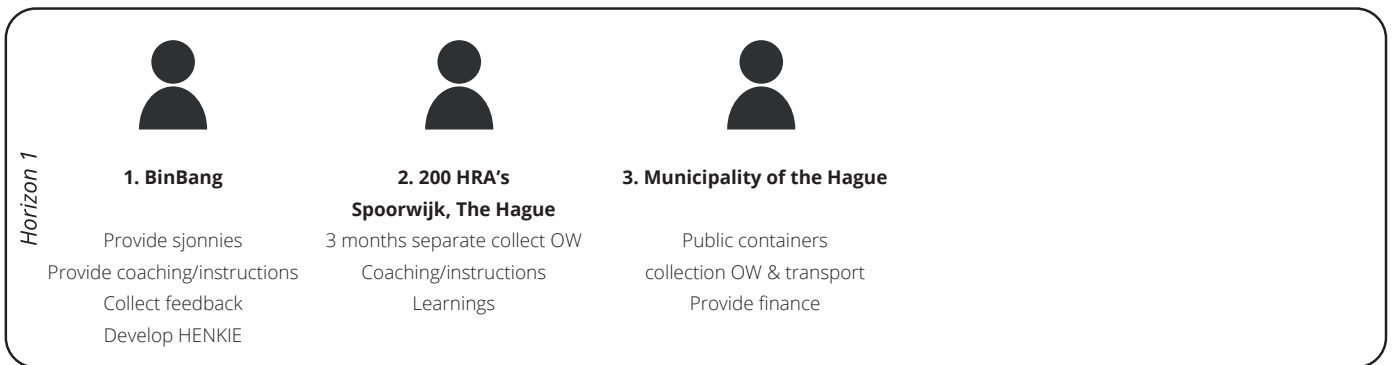


Figure 85 | Stakeholders & tasks horizon 1

If evaluated positively go to horizon 2.

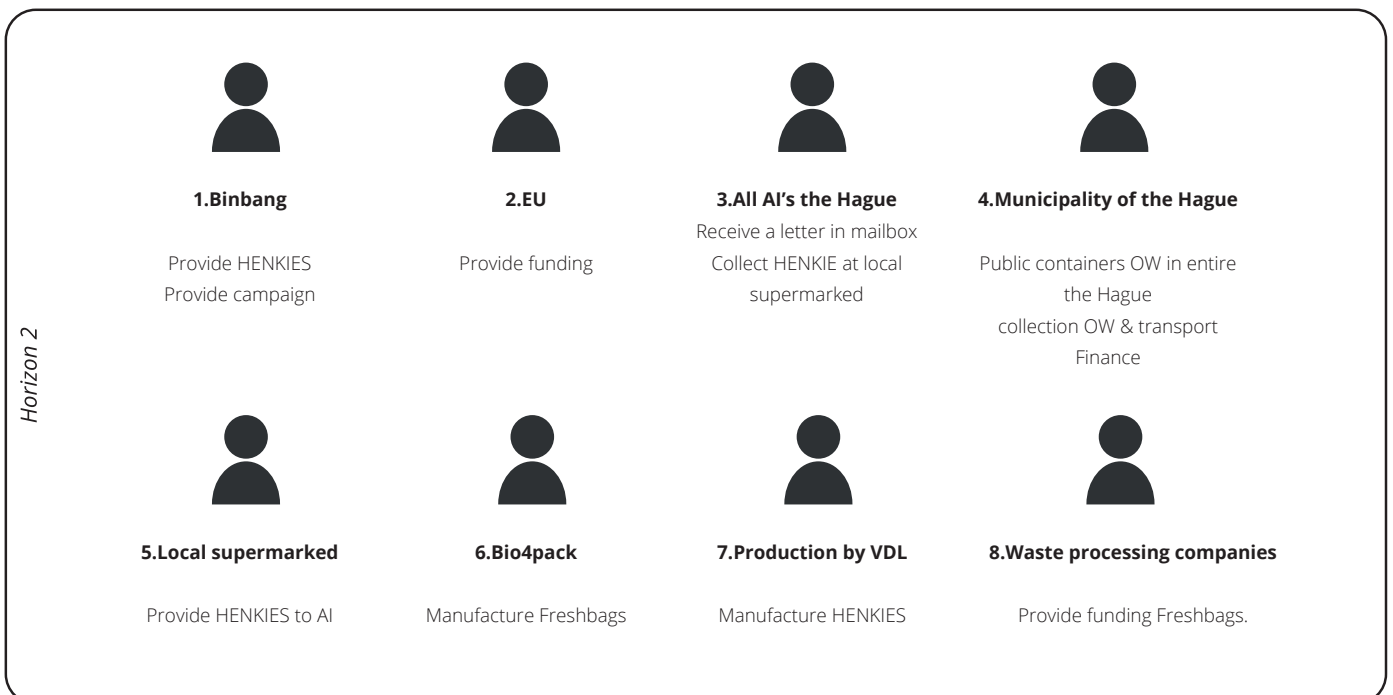


Figure 86 | Stakeholders & tasks horizon 2

million in the first year. These costs cover a free Frisbox for all high-rise households (HRHH), free Friszakken (100 per household per year based on the usage of 2 bags per week), placement of public containers for OW (depreciated over ten years), and collection of OW by waste collection companies. The entire project will result in a profit of €468.000 for BinBang and is based solely on the sales of Frisboxes. The profit margin of €3 per Frisbox is used to calculate the profit. (see chapter 6.5, costs price calculation Frisbox). The financial overview for the scale-up can be found in Appendix T.

How to get the Frisboxes to the apartment inhabitants?

To save on transport costs and to maximize effectivity, the Frisboxes can be collected by interested AI's at local supermarkets for free. Supermarkets are places frequented often by all residents and a suitable location for placing stands to inform and remind consumers. Furthermore, a public location is expected to have high social influence; encouraging people to talk openly about the Frisboxes. Also, it is expected that the need to place the OW containing Frisbox in the fridge will promote discussion among users.

The users will need to assemble the Frisboxes themselves, which will save on assembly costs. Potential Frisbox packaging is shown in chapter 6.8. Sending unsolicited Frisboxes to every household is not advised, based on results of a pilot attempt in Schiemond. Only people willing to separate their OW will do so and the remaining people will not change their OW habits. The analysis found that a large portion of people are willing to separate their OW, but do not have necessary containers or facilities. In this case of the scale up, it is calculated that 50% of all high-rise households will participate and start collecting 80% of their OW separately with the Frisbox.

Promo action Frisbox

All high-rise households will be informed via a promotional advertisement in their mailbox that they can collect a free Frisbox at their local supermarket and are instructed about usage and the goal of the project. This promotional action is estimated to be €1 per household. The goal is to make a convincing and appealing campaign; additional research is advised to ensure this campaign's efficacy.

The Frisbox could be introduced in the market by supply Frisboxes and Friszakken for free to all AI. This can be funded by municipalities and waste processing companies.

According to Jeroen van Schendel (2018), sales director at Bio4Pack, the development costs of the Friszak are hard to estimate. They do not have to possibilities to produce it yet but assume it will be possible in the future.

Funding.

The project could potentially be funded by European grants. One potential grant is the Bio-economy in horizon, which stimulates the transition between fossil and bio-economy. The name of the program is the Food Security, Sustainable Agriculture and Forestry, Marine, Maritime, and Inland Water Research and the Bioeconomy (EC Europa, 2018). Funding via this program is estimated at 10%

Conclusion

This plan is a solution for the municipality of The Hague, which can see their waste separation potentially increase from 37.7 to 42.2%. This can be achieved by 50% of all high-rise households collecting 80% of their OW per year. 50% participant rate of the AI is what Binbang had achieved in the neighborhood Schiemond in Rotterdam.

The plan will also be a potential solution for waste processing companies, like Indaver who have to deal with polluted OW, mainly because of non-biodegradable waste bags. By providing, free, biodegradable bags, this could potentially result in less pollution and save on costs for the waste processing companies. Therefore, it is recommended to research, if waste processing companies could potentially contribute to funding the Friszakken.

Lastly, by the rolling out the scale-up step in the city of The Hague, BinBang could potentially gain a profit of € 468.000 by only selling Frisboxes. This profit could increase two-fold if the Chinese manufacturer produced the Frisboxes. Furthermore, BinBang could also gain profits by providing coaching services to a larger part of The Hague's AI population

OW in high-rise households in the Hague

OW separated p.p.p.y in the Netherlands (2017)	80 kg		CBS, 2018
OW separated p.p.p.y in the Hague (2017)	10,6 kg		CBS, 2018
Average persons per HRHH	1,8		OZB, 2018
Production of OW per household	144 Kg		CBS, 2018
Highrise households	178,730		OZB, 2018
Total AI in HRHH	320857		OZB, 2018

Costs municipality

	Horizon 1	Horizon 2	Source
Number of high-rise households	<i>Pilot (Appendix S)</i> 200	<i>Scale up (appendix T)</i> 156000	CBS, 2018
Cost price municipality per household	€ 267	€ 41	
Total costs municipality	€ 50.692	€ 6.372.299	

Impact use of Frisbox

Total separated collected OW the Hague (2017)	5.457.527 kg	5.457.527 kg	CBS, 2018
If 50% HRHH collects 144 kg OW	14.400 kg	12.868.560 kg	
Total collected OW with Frisbox	5.471.927 kg	18.326.087 kg	
Increase of separated OW in the Hague per year	0,3%	236%	
Households provided with 1 year electricity	1	751	RVO, 2018
CO2 savings (gasoline cars/year)	3211	65750	Dutchrenewergy, 2018

Impact waste separation %

Separated waste in the Hague		37,7%	CBS, 2018
Waste separation with Frisbox		42,4%	

Profit BinBang

Profit per household per product	€ 30	€ 3	
Total profit	€ 8006	€ 468.000	

6.7 Pilot Frisbox (Pilot edition)

The design of the pilot edition for the pilot in the Hague

In this chapter, the Pilot Frisbox is discussed. The Pilot Frisbox is developed to test the potential of the Frisbox without substantial investment costs.

The Pilot Frisbox could potentially be tested in the Spoorwijk in The Hague. Pilot Frisbox is derived from “Haagse Pilot Frisbox,” which is Dutch folk language for “a typical guy in the Hague.”

The model

The main difference between the Pilot Frisbox and the Frisbox are the investment costs. The Pilot Frisbox can be produced without large investment costs. The Pilot Frisbox has exactly the same specifications, functions, and dimensions as the Frisbox. The model differs in the lid, which is loose compared to the Frisbox which has a lid with a double hinge. Furthermore, the pilot bin is more likely to bend, because there is no double top border, as in the Frisbox.

Production

The bin of the Pilot Frisbox can be produced by milling edges in a standard 3mm black foam PVC board. Secondly, the edges will be folded and glued together with the bottom of the bin. The lid will also be produced by hand milling.

Mett Kunststoffen in Apeldoorn can produce these model Frisboxes and has already produced five of them for testing in this thesis. The results of this test can be found in the next section (Section 7). The handle and hook can be produced in China by cold running injection moulding at an investment cost of €2000-4000. The possibility of producing the parts in the Netherlands or using a standard part should be further examined.

Costs

The costs of the Pilot Frisbox are calculated by estimating the price structure of one Pilot Frisbox. A costs price estimation for 200 bins and lids was made by Mett Kunststoffen in Apeldoorn.

The bin can be produced without a mould and will not require an investment cost.

The costs for the assembly of the product are based on the assembly costs for the BinBangs waste tower (Appendix R). A profit margin of 20% for BinBang is calculated. The total costs for a Pilot Frisbox are estimated at €38,47

The Pilot Frisbox is the pilot edition of the Frisbox, which can be produced with lower investment costs than those of the Frisbox.

Costs (€)

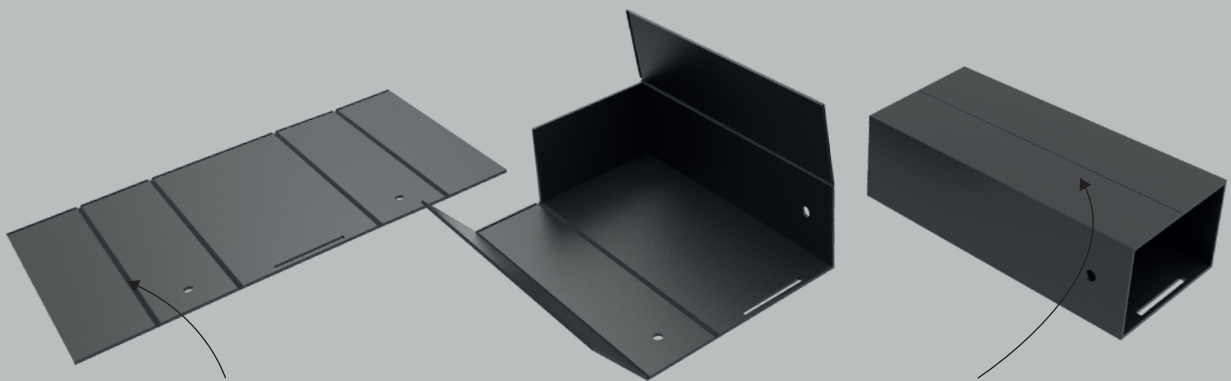
Bin	11,2
Lid	3,65
Hook	5
Handle	5
Bolts	0,5
Nuts	0,3
Assembly	2
profit (20%)	4,1475
Costs exl VAT	31,80
VAT (21%)	6,68
Selling price	38,47

Conclusion

The costs of a Pilot Frisbox per piece is more than twice the price of a Frisbox. However, there are no substantial investment costs required. The Pilot Frisbox has the same properties as the Frisbox and, therefore, an appropriate model to validate the potential of the Frisbox in a pilot. The look and feel could be slightly different compared to the Frisbox. Also, there is a change that the pilot bin is not fully watertight, which could influence the results of the pilot.



Figure 88 | Impression of the Pilot Frisbox



1. Grooves are milled into a piece of standard 3mm

2. The edges are folded, the bottom is inserted and secured with PVC glue.

3. The back edges are secured together with PVC glue.

Figure 89 | Production of the Pilot Frisbox

6.8 Package and transport of the Frisbox

How can the Frisbox be packed and transported?

In this chapter, a proposition is given detailing how the Frisboxes could be packed and transported.

Package

The Frisbox could be packed sustainably, using a single small piece of cardboard to cover the top. This packing method reduces the costs and materials used compared to placing the entire product in a cardboard box.

The cardboard layer could be folded over the edges of the top of the bin and stuck to the bin with biodegradable stickers (Biofutura, 2018), to keep the package securely closed.

Another bio-degradable material could potentially replace the cardboard; this should be further researched.

All parts of the Frisbox could be placed inside the bin. The package would contain material telling the story of the Frisbox, usage recommendations, and information about OW separation. An example of how the package would look is shown in Figure 93.

Transport

The bins can be transported efficiently in stacks. The hatch, lid, lid connector, and hook can be delivered in separate cardboard boxes. The parts will be sent loose, in boxes, to the distributors, in the case of this thesis the supermarkets. The employees of the supermarkets can complete the Frisbox packages (Figure 91), by placing the parts and a roll of Friszakken in the bin, close the bin with the cardboard lid, and sealed with the biodegradable stickers.

The Frisbox could be packaged with limited material and costs by packing the top of the bin. Transport can be done relatively cheap by stacking the bins and supplying all parts in one box and sorted by distributors. Store employees can assemble the packages of the Frisboxes.

Conclusion

A cost-efficient and durable proposition was given for packaging and transporting the Frisbox. If it turns out the Frisboxes get damaged during transport another packaging type could be considered.



Figure 90 | A stack of Frisbox bins.

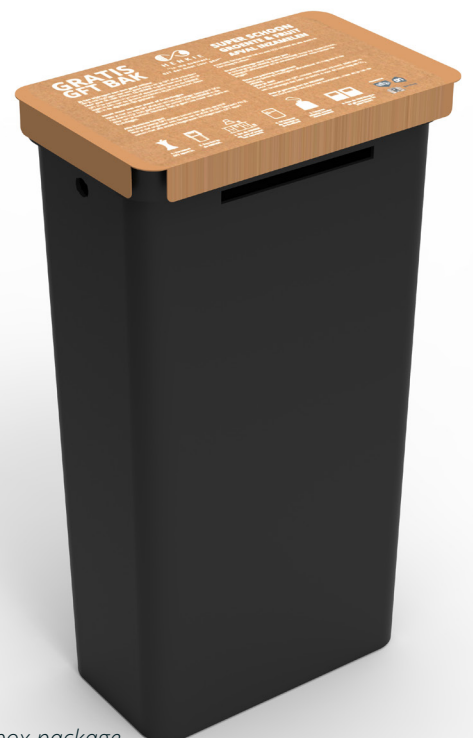


Figure 91 | A Frisbox package

GRATIS GFT BAK



SUPER SCHOON GROENTE & FRUIT AFVAL INZAMELEN

Jij kan bijdragen aan een goed milieu!

Wil jij ook bijdragen aan een goed milieu en je GFT afval scheiden? Maar gaat dit vaak stinken. De HENKIE is gratis bak voor jou om je GFT in te zamelen in je huis of appartement. Je kunt de HENKIE legen in één van de groene containers bij jou in de buurt. Deze zijn in de afgelopen tijd geplaatst.

Nooit meer last van stank of fruitvliegjes

Heb je niet zo veel GFT afval en wil het wat langer bewaren? Of is het warm in je huis gedurende de zomer? Zet de HENKIE in de deur van je koelkast. Hierdoor heb je geen last meer van stank en fruitvliegjes.

Alle Henkies helpen

Alle kleine beetje GFT maken samen een groot verschil! Wist je dat ongeveer een derde van je afval uit GFT bestaat? Als jij samen met alle andere Hagenaars en Hagenaars GFT apart

inzameld, besparen we net zo veel CO2 uitstoot als alle auto's in Den Haag bij elkaar.

Gratis Freshbags voor het hele jaar.

Je ontvangt bij de HENKIE gratis Freshbags. Deze zijn superschoon, biologisch afbreekbaar en te vervoeren zonder vieze handen te krijgen!

Deze verpakking weggooien?

Deze verpakking is biologisch afbreekbaar en mag ook in de HENKIE.

Wist je dat?

Door het koelen van GFT, minder methaan vrij komt. Methaan is een broeikasgas dat 240x zo slecht is voor de ozon laag als CO₂.

Heb je genoeg van de HENKIE?

We kunnen het ons bijna niet voorstellen, maar als je van de



1. Verzamel
GFT apart in.



2. Doe het in
de HENKIE.



3. Zet de HENKIE
op, aan of naast
het aanrecht



4. Of Bewaar
de HENKIE in
de koelkast



5. Leeg de
HENKIE zonder
vieze handen



6. Doe de FRESHbag in
de gft container in
jouw buurt

Powered by:



Den Haag

Figure 92 | An impression of a possible print of the package.



Figure 93 | The content of a Frisbox package.

6.9 Optimize parts Frisbox for usage

Optimalisation dimensions parts in Solidworks

In this chapter, the parts of the Frisbox are optimized for extreme situations of usage. The goal of this optimisation is to extend the product lifetime. The optimisation is done by performing static simulations of the components in Solidworks.

Figure 94 shows what frequently happens to the handle of the stackable bin of the BinBang. The connection point easily breaks, which results in the user throwing away the handle and buying a new one. This is negative for the user's wallet, satisfaction with BinBang products, and for the environment.

Products, which easily break, have a decreased product lifetime. The first cycle of the CE diagram in chapter 1.2 states that a product which is designed according to the circular design principles should maintain as long as possible.

It is desired to also not over-dimension the parts to guarantee strength because dimensioning of overly large parts results in more material use, which leads to extra costs and a higher impact on the environment.

Optimizing the Handle

The most considerable force on the handle is assumed to be concentrated on the connection point with the handle and the bin. This is indicated in Figure 96 with purple arrows.

The situation | The force on these connection points, as shown in figure 95, is assumed to be greatest when the bin is filled with wet OW. The weight of a full Frisbox is estimated to be 4kg (duurzamebedrijfsvoeringoverheden, 2018). When someone walks downstairs to empty the Frisbox in the public container, he could make possibly swing the bin while using his mobile phone. If he is enthusiastic, he could swing the bin with a speed of 30 km/h.

The Frisbox is optimised for extreme usage to extend the product life. Extend product life will reduce the amount of new products that are needed in the future.

An extensive calculation of the forces shown in figure 95 can be found in appendix U.

Results | The von Mises stress in this situation, according to a Solidworks static study, is 2.55×10^7 Pa. A representation of the results of this simulation is shown in Figure 96. This is just below the range of the yield strength of PP of 2.6×10^7 - 3.2×10^7 Pa (Dielectric Core, 2018). This strength is obtained by increasing the thickness of the handle.

Optimizing the Hook

The 2mm hook thickness cannot be adjusted since it is the standard space between a drawer and the kitchen counter. To optimize the strength, the hook can only be adjusted in width. In the simulation, several dimensions of the width were modelled.

Situation | The hook should hold the weight of a filled bin (4 kg). A safety factor of 2 was used, so that the hook could carry a weight of 8 kg.

Results | The width of the hook should be 80mm, to avoid plastic deformation as in the situation described above. In that case, the maximum von Mises stress will be below the yield-stress of polypropylene.

Conclusion

The handle and the hook are optimised to make them appropriate for extreme usage. Per the simulation result, the dimensions of the hook and handle were optimised. There are additional situations, where forces on specific points of the parts could result in plastic deformation. For



Figure 94 | Connectionpoint handle stackable bin BinBang. Left: normal. Right: broken.

example, what happens when the bin falls on the floor? Or the bin could be compressed when placed in the door by another item inside the fridge pressing against the bin. Or the bin is not mounted or demounted in the correct manner. This situation could be further researched to increase the strength of the parts and to extend the product's lifetime. A note is that both parts are optimised

according to a simplified model of reality. As it is just a simulation, it is advised to perform tests with real parts of the handle and hook with real users, to ensure the strength of the parts in different situations.

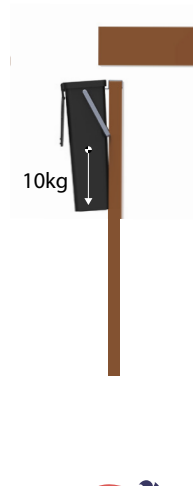
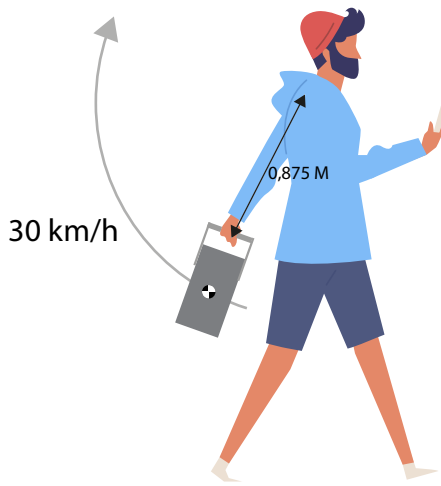


Figure 95 | Extreme Frisbox usage. Swinging with a full bin

Figure 97 | Leaning on the Frisbox when mounted on the cabinet door

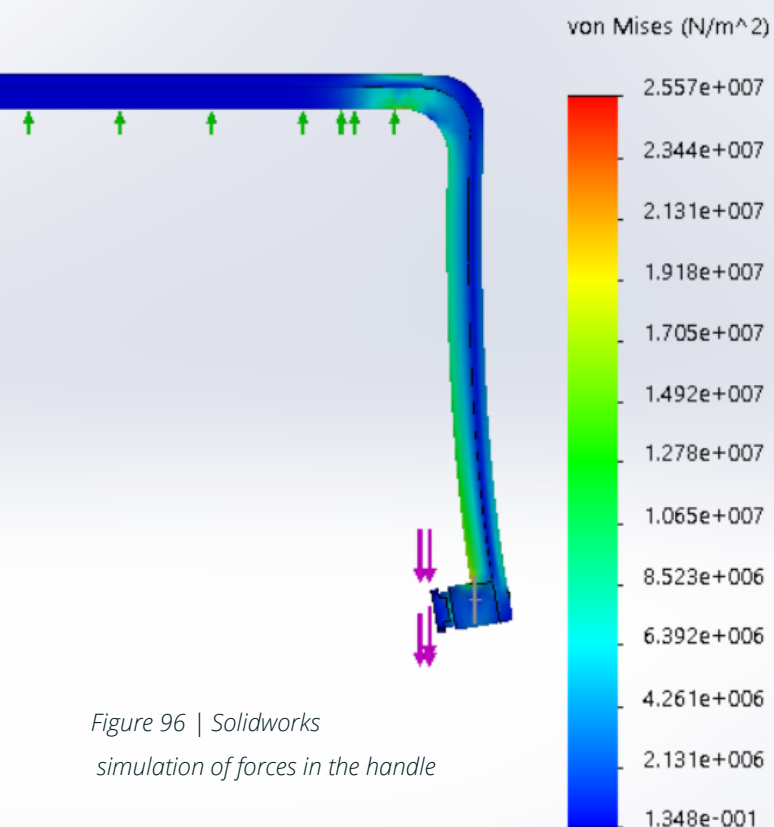


Figure 96 | Solidworks simulation of forces in the handle

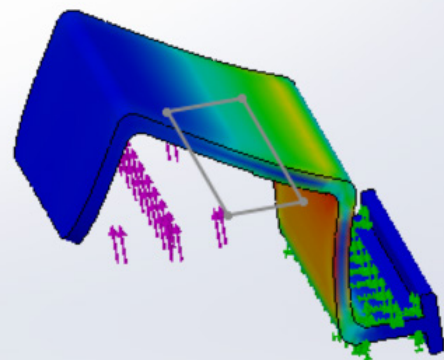


Figure 98 | Static study of the Hook.

This chapter will evaluate how the users perceived the Pilot Frisbox. The firsthand insights of this user-test will evaluate the hygienic and usability requirements. In Chapter 7.2, the design brief will be evaluated based on the requirements of p57 and p87.

In Chapter 7.3 the proposal of the Frisbox and the market introduction plan of Chapter 6.6 are discussed and evaluated and their contribution to the main problem of this thesis.

In Chapter 7.4 recommendations to improve the Frisbox are given, and possible steps in the further development of the Frisbox are given.

In Chapter 7.5 the mailbox edition is discussed. A version of the Frisbox which fits in a mailbox
In Chapter 7.6 the final reflection is given.

You are in this part of the project:

Part 1 | Introduction

Analysis phase

Part 2 | OW in high-rise buildings

Part 3 | Business analysis

Synthesis phase

Part 4 | Ideation & conceptualisation

Part 5 | Concept evaluation & selection

Embodiement phase

Part 6 | Embodiement

Evaluation phase



Part 7 | Evaluation & recommendations

Evaluation & recomm

Part 7

An user test to evaluate the Pilot Frisbox

7.1 Usage evaluation

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A final usertest has been performed.

2 participants wanted to keep the Pilot Frisbox for own use after the test period. The Pilot Frisboxes were evaluated positively on odour annoyance (R21) and had enough storage space for collecting a week OW.

Which requirements are met and which are not?

7.2 Design challenge evaluation

122

All mainfunction, transport and sustainability requirements are met with the final design of the Frisbox. The final product is hygienic and low-effort. All hygienic requirements are met. 6/7 usability requirements are met.

How can the solution contribute to the main problem of this thesis?

7.3 Problem and assignment evaluation

124

The Frisbox has advantages for multiple stakeholders:

The Frisbox is a solution for AI to collect OW that is hygienic and low-effort. The Friszak is a solution for waste processors because it reduces pollution in OW.

The Frisbox could help municipalities in reaching the waste separation targets-goals. The Frisbox could support BinBang in realising their mission and generate extra profit.

What steps could be taken for further development?

7.4 Recommendations

126

A list of recommendations for the Frisbox, Frisbox pilot edition, Friszak and furtherresearch is made.

Another design with potential

7.5 Mailbox edition

127

The first design is made of a Frisbox which can fit in a mailbox package. The advantages of this design are that transport costs are reduced, and the product could fit in the dishwasher. Further, research and development is required.

What did I learn and how do I look back on the graduation period?

7.6 Reflection

128

mandation

7.1 Usage evaluation

An user test to evaluate the Pilot Frisbox

The Pilot Frisbox and the Friszak are tested for a period of a week by two one-person and three two-person apartment households in the Hague. With their input an evaluation of the Pilot Frisbox is made.

The pilot Frisbox has the same properties in usage as the HEN-KIE. Therefore, the results of this test could also be used for the Frisbox. The goal of the user test is to evaluate the following part of the design direction: "The product is hygienic in usage and low-effort". The hygiene and usability requirements will be evaluated. Furthermore, the following research questions will be answered: 1. Would the participants use the pilot Frisbox in the future? 2. How do they feel about keeping OW in their fridge?

Method

Three two-person and two one-person households received a Pilot Frisbox on a Monday evening. All households are in the city of the Hague. The participants are instructed to collect all their OW separately in the Pilot Frisbox for the period of a week. A week later Monday evening the Pilot Frisboxes were collected and the participants are interviewed.

Results

The results of bin OW volume after a week of usage and the number of days eaten at home are shown in figure 99. Furthermore, the results are given per question and household.

A final usertest has been performed.
Two participants wanted to keep the Pilot Frisbox for own use after the test period.
The Pilot Frisboxes were evaluated positively on odour annoyance (R21) and had enough storage space for collecting a week OW.

Figure 100, shows the bin in use during meal preparation and Figure 101 shows how the bins fit in the fridges of the participants.

Annoyance level by odour.

A score of 0/10 for four of the five households. 4/10 by the end of the week for one household. This was still acceptable. What is acceptable or not acceptable was determined in Chapter 4.2

Would you use this bin in the future?

H1. "Yes, because I think odour and fruit flies are annoying and I did not have those during the week of usage. It takes me quite a while to fill my normal bin and to change the garbage bag. This will be less a problem when OW is not in-between residual waste. Can I keep the bin?" "In the cases when OW will not be collected separately then I would still use it to prevent odour. "A pity, the bin cannot be mounted to the table." The user often cuts OW at the table.

H2. "Yes, the apartment of my boyfriend smell of OW during

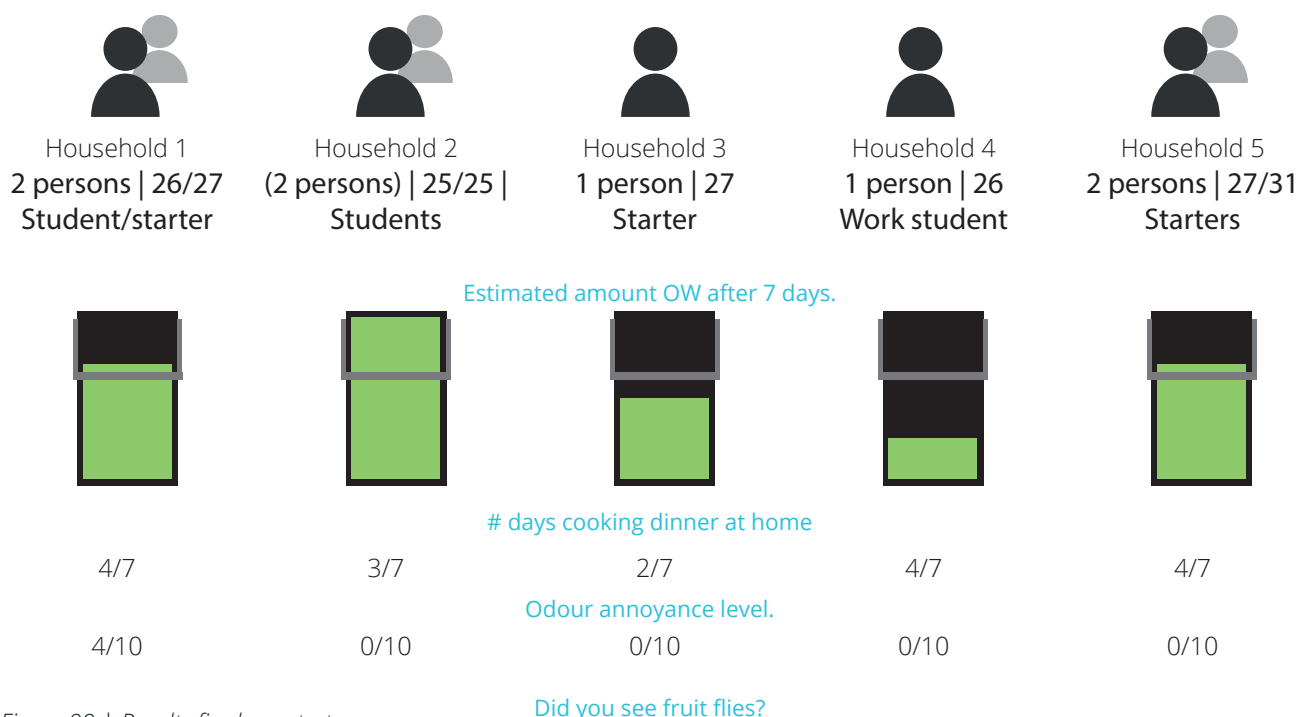


Figure 99 | Results final user test.



Figure 100 | Pilot Frisboxes in final usertest during cooking dinner

summer days.”

H3: “Yes, I would definitely use it. My entire room would smell of OW. This problem will be solved with this bin.”

H4: “Yes. I would like to keep the test model. The usage makes me also more aware about separating OW.”

H5: “No, If I could choose I would prefer a bin which can be placed on the ground and can be opened with a food paddle. I will accept eventual annoyance by odour.”

How did you feel about placing OW in your fridge?

H1: “OW in the fridge is fine.”

H2: “I don't feel like grossed out. I'm neutral about it.”

H3: “First a little bit crazy, but if you think about it, it is not crazy.”

H4: “It is okay, not dirty, as long if it is not going to start leaking.”

H5: “No, it was not unhygienic.”

Did you have the feeling that you could dispose of OW quickly?

H1: “Yes, but I had to be aware of it.”

H2: “Yes, just open the fridge and dispose of grapefruits.”

H3: “It cost me some effort to dispose of tiny bits of OW when the bin is placed in the door”.

H4: “Yes, because it was not more actions. The lid of my normal bin also needs to be opened with one hand.”

H5: “No, I could not open the bin, when it was stored in the fridge”.

Did you touch the OW?

H1: “Yes, because something kept getting stuck in the bag.”

H2: “Yes, to compress it when the bin was full. I did not think this was dirty because I washed my hands afterwards.”

H3: “No.”

H4: “No, I did not touch it.”

H5: “No.”

What did you think about seeing the OW (of the previous days) in the bin?

H1: “I did not notice it.”

H2: “I did not really see it. Because you always see the layer on top, which is quite fresh. I did not feel it was disturbing.”

H3: “Not disturbing, I also have this with my normal bin. It does not bother me.”

H4: “The bin is black and deep, so I did not see the waste.”

H5: “No it was not visible, and it did not bother me.”

The importance of a perfect fit bag is supported by the negative results of too large bags.

4/5 participants preferred mounting the Frisbox to the drawer over placing on the kitchen counter.

What did go wrong when using the bin?

H1: “Swiping the OW in the bin costs some effort because the counter is sticking above the bin. The bin is not deep enough. You can easily throw it beside the bin.

The space it takes in the fridge. Normally we place for example yoghurt in the door.

The handle of the bin needed to be lifted to close the fridge door.”

H3: “The bag was wrinkling, OW kept sticking in the bin” The bags did not fit.

H4: “The bag needs to be closer to the borders of the bin.”

H5: “After doing groceries the fridge is full and the bin could possibly not fit. “I forgot to use the bin. I expect after two weeks you will have a routine for using the bin.”

Was weight of the filled bin disturbing?

All households answered this questions with no.

Do prefer mounted at drawer/door at or placed on top of counter?

H1: “Mounted drawer, because I have limited space on top.”

H2: At counter, “easy to pull garbage into bin”.

H3: At counter, “swiping OW in the bin was easy.”

H4: At counter

H5: At counter

Conclusion

To evaluate upon the part of the design direction “The product is hygienic in usage and low-effort”.

Therefore, the following requirements will be evaluated separately.

R21. The annoyance level of odour should be acceptable.

This was for all participating households acceptable. For 4/5 it was 0/10 and for one household 4/10 by the end of the week. There can be concluded that the storing OW for 7 days in a Pilot Frisbox in the fridge will not lead to annoyance by odour. Fresh OW, still has a smell and cannot be taken away by cooling the OW. Assumed is that the odour (rate 4/10) was caused by this type of odour.

R22. There may be no physical contact between the



Figure 101 | Pilot Frisboxes in final usertest placed in the fridge

user and the OW.

There was physical contact between the participant and OW in one occasion. This was because of compressing the OW to create more space in the bin and to remove OW, which was kept stuck in the border. They mentioned OW kept stick in the plastic bag which did not fit well. This results indicates the importance of why the bag should be perfect fit, like the Friszak is intended.

R23. No visual contact between the user and degraded OW during daily use. 4/5 participants said they did not see it. One of the participants mentioned there is always fresh OW on the top. And another participant said that because the bin is long and deep she did not see degraded OW.

R34. The user must have to feeling to be able to quickly dispose OW.

Three of the participating households declared they had the feeling to be able to quickly dispose OW. One of them said no because she had to remove the entire bin from the container to remove a tiny part. Another participant said it costs effort to dispose tiny bits of OW.

Furthermore, all AI preferred hanging the bin at the drawer or cabinet door above placing the bin on the kitchen counter. This proves the hook, to mount the bin at the counter is a good addition to the Pilot Frisbox.

Empty frequency residual waste.

All participating users empty their residual waste one time a week. The Pilot Frisbox offered them enough storage to store for the period of a week. Therefore, by hand of this usertest requirement R31 (Disposal frequency of OW into a public container should be equal or less than the disposal process for residual waste) is met. The AI of the usertest do not have to walk more than one time to a public container to empty the OW bin.

Do the AI want to use the Pilot Frisbox?

Two participating households wanted to keep the pilot Frisbox after the user test, which indicates they want to have the product. Four participating households see the pilot Frisbox as a solution for odour annoyance. One of them did not and prefers a bit of odour above using space in the fridge. None of the participants had problems with the idea of keeping OW in the fridge, which shows the idea of keeping OW in the fridge could have potential.

The main disadvantages are the space in the fridge users will

Improvements could be made in the dimensions of the Pilot Frisbox, which was to large for some of the fridges.

Making the Pilot Frisboxes better fit in the fridge, contributes to the feeling of AI to be able to quickly dispose OW.

lose when they place the pilot Frisbox in the fridge.

Learnings of the prototype

The product did not fit in two of the five fridges. The depth of the Pilot Frisbox was 10cm. Recommended is to make Pilot Frisbox <9cm deep. Furthermore, the handles were too large. In one of the fridge's the handle needs to be placed in a horizontal position to close the fridge door.

Moisture drops were visible on the inside of the lid. What the user will think about this must be further researched.

Limitations of the user test

The user test did not show the results of using the bin for a longer period. The effects of using the pilot Frisbox for a longer period could be different. For example, what will be the annoyance level of odour when the bin is not be emptied for multiple weeks? Also, dirt could pile up on the surface of the bin.

Only one of the users collected OW, on a regular basis and had a reference with the previous situation of OW; the other users did not.

During the test week, some of the participants occasionally forgot to use the bin. Research on long-term use should investigate how well participants make the pilot Frisbox a part of their routine, since some of them forgot to use it. Furthermore, studies on the long-term use could possibly show what users will do if there is no space in the fridge. Will users stop using the pilot Frisbox? Will they place the pilot Frisbox back in the fridge when there is space in the fridge again?

The user test was only executed by five one- and two-person households. Furthermore, all participants were in the same age range. Further research should examine how a larger and more varied group responds to the usage of the pilot Frisbox.

The user test did not include the use of Friszak. The bags used in this study were watertight and did contain cords, but they did not perfectly fit. The use of the Friszak should be

studied in a usertest.

Recommendations

Recommendation is to study the usage of the pilot Frisbox and a Friszak for a longer period, with more varieties and larger group of AIs. Questions that should be asked in this study are:

1. What will be the user behaviour in the long term? Do the AI want to keep the pilot Frisbox in the fridge? Or, do they think after a period it is inconvenient?
2. Is the product hygienic in use and low-effort over a longer period? Evaluating all the hygienic requirements allows for making a comparative study where there will be a distinction between participants who already collect OW and participants who do not collect OW. Furthermore, there should be a comparative study between the pilot Frisbox and another waste collecting method, for example the Ventimax® of BinBang, to make the advantages of the Frisbox clear towards other OW collection methods.



Figure 102 | Usage of the Frisbox

7.2 Design challenge evaluation

Which requirements are met and which are not?

This chapter evaluates if the goal of the design direction is met. This will be done by evaluating the requirements of p57 and p88 for each part of the design brief.

The design challenge is:

“The design of a **sustainable bin** for the **collection and storage of OW** in high-rise building kitchens and for the **transportation of this to a public container**. The product is **hygienic** and **low-effort**”

Requirements which are marked with a ✓ are met

Requirements which are not met are marked with a X.

Requirements, which need extra research and development for validation are marked with: **R&D**

1. Mainfunctions

All functions to **collection and storage of OW** are met.

R11. Both dry and wet OW can be stored in the product | ✓ (chapter 6.1)

The bin is watertight and enables storage of dry and wet OW.

R12. The product should fit in the kitchen | ✓ (chapter 6.1)

R13. The storage volume of the product has a volume of 11 liter to store the OW | X (chapter 6.1). This requirement has not been met. The storage volume of the Frisbox is 4 liter. For one and two person households the storage volume could be enough to store OW for a week, as shown in the user validation test of chapter 7.1. However, for larger households like those of the young professionals or AI who produce more than 4L OW per week, the storage space is not enough to store OW for the entire week. How the storage volume will be evaluated by households which produce more than 4 liter of OW per week, needs to be evaluated in for example a pilot, as suggested in chapter 6.6.

R14. The product must work independently without an installation in the apartment | ✓ (chapter 6.1)

R15. The product must leak | ✓ (chapter 6.1)

R16. The product must work independently without an installation in the apartment |

R17. Placement fridge door | ✓ (chapter 6.1)

2. Hygienic requirements |

All requirements to make the product **hygienic** are met.

R21. The annoyance level of odour should be acceptable | ✓ (chapter 7.1)

R22. No physical contact between the user and the OW | ✓ (chapter 7.1). Because of the handle of the Frisbox

With the design of the Frisbox the following requirements are met:

6/7 mainfunctions

7/7 hygienic requirements

6/7 usability requirements

All transport and sustainability requirements and wishes.

and the cord in the Frisbox, the user has two options to not touch the OW during emptying of the bin in the public container.

R23. No visual contact between the user and degraded OW during daily use | ✓ (chapter 7.1) Because of the long shape and the dark colour, only Fresh OW is visible.

R24. Odour reduce by cooling in the fridge | ✓ (chapter 6.1)

R25. Parts must be disconnectable for cleaning | ✓

R26. No small holes or edges where OW can pile up | ✓ (chapter 6.1)

R27. No fruit flies around the product | ✓ (chapter 7.1)

W21. Fit in a dishwasher (max height 24cm) | X

The height of the bin is 30cm. Therefore, this requirement is not met. (chapter 6.3)

3. Usability

A **low-effort** product is defined by the following four requirements.

R31. Disposal frequency of OW into a public container should be equal or less than the disposal process for residual waste | ✓ (chapter 7.1) The most important requirement for the low-effort is met. This only applies for 1 and 2 person HRHH. The disposal frequency of OW to a public container will not increase, because they can store OW for a week.

R32. Bag replacement should take less than 10 seconds | **R&D** This is not tested and should require further testing.

R33. The user must feel able to quickly dispose of OW | ✓ (chapter 7.1)

R34. The opening of the bin should be 20x20cm | X

This requirement is not met. The opening is 18x10 cm. In the user test in chapter 7.1 it was noted that one of the participants found the opening too small. This could require extra effort for the AI to dispose of OW from a cutting board into the Frisbox.

R35. Quick disposal single pieces OW when the bin is placed in the fridge | ✓(chapter 6.1)

R36. Deconnectable lid with hinge | ✓(chapter 6.1)

R37. Dispose OW from cutting board in bin | ✓(chapter 6.1)

4. Transport

A product for the transport of OW to a public container is defined by the following requirements:

R41. The product must be transportable to the public container | ✓(chapter 6.1)

R42. Transport should be done with one hand | ✓(chapter 6.1)

W43. The user only takes the disposable part to the public container | ✓(chapter 6.1)

5. Sustainability

All sustainable requirements and wishes are met.

R51. The product lifetime should be 10 Years | R&D The parts are optimized for extreme use situations, to increase the lifetime. (chapter 6.9). If this increase the life time to 10 years, should be validated.

R52. The product is designed to be repairable | ✓ Each of the parts can be easily replaced (chapter 6.3).

R53. The product must be recycleable | ✓ All parts are made of polypropylene. By end of life, The Frisbox can be disposed of in the plastic waste containers to be recycled. (chapter 6.3).

W51. The product must not use electricity | ✓

W52. The product may not use materials other than biodegradable bags to store the waste | ✓

6. Bag requirements

Because the Friszak is only in a conceptual stage not all the bag requirements are validated yet.

R61. The product must use a biodegradable bag to store the OW or is biodegradable or uses no bag | ✓

R62. Watertight for a week | R&D

R63. Removable and closable and transportable without getting dirty hands | ✓

R64. The bag must be biodegradable according to NEN-EN 13432 | R&D

R65. The bag must fit exactly in the bin and clamps to the side | ✓

R66. The material of the bag must be non transparent | ✓

R67. €0,20/bag. R&D

R68. Bag must be placeable in a simple movement

| R&D

R69. A normal plastic bag must be placeable in the Bin | ✓ Normal plastic bags are placeable in the Pilot Frisbox but they do not fit exactly, with the consequence of annoyances.

7. Costs

The selling price of €20 is also met. The selling price can be lower if the manufacturing will be done in China.

R71. The product must have a selling price of <€20 | ✓

Conclusion

It can be concluded that the Frisbox is a sustainable bin, because the parts are optimised for extreme usage situations, it is repairable and recycleable.

The product can store wet and dry OW and is placeable in the kitchen of high-rise buildings.

Furthermore, the Frisbox and the Friszak, both can be used to transport OW to a public container.

The Frisbox is considered as hygienic, because it does not result in odour annoyance and fruitflies. Because of the long shape there is no visual contact between the user and degraded OW. Also, enables the design the user to empty the bin without touching the bag or the OW.

The Frisbox is considered as low-effort because one and two person households could have enough storage space to empty the bin only one time a week, so they do not have to increase their walking frequency to a public container. Also, the user has the feeling to quickly dispose OW.

The Friszak, which is still in a conceptual stage requires extra development and validation. The set of requirements can be used as a starting point to further develop the Friszak.

The costs requirement is also met. The Frisbox could be available on the market for a selling price of €20.

The product is also low-effort because it meets all except one usability requirements.

R34 is not met. The opening is smaller than 20x20 cm. Therefore, it could cost the user effort to dispose of OW from a cutting board in the bin as found in chapter 7.1.

Positionings matrix.

Assumed is that when the Frisbox will be placed in the positionings matrix of page 57, it can be located on the place where the final product should be intended, regarding its properties and price. However, to validate this, a comparative study of the Frisbox with other bins should be performed.

7.3 Problem and assignment evaluation

How can the solution contribute to the main problem of this thesis?

This chapter will evaluate how the design of the Frisbox, Friszak and the market implementation could play a role in solving the main problem of this thesis. Secondly, there will be evaluated how the final solution could have benefits for the different stakeholders. This will be done by evaluating if the final solution is desirable, viable and feasible.

The assignment for this thesis is:

“How can the apartment inhabitant be supported in separate collection of OW by means of a product/service?”

This assignment was formulated to find a solution for the problem definition of this thesis. This is:

“OW is hardly separated in high-rise buildings.”

The market introduction plan of the Frisbox is a proposal for a new product to make this problem smaller and to increase the separation rate in HRAs.

It is assumed that the Frisboxes and Friszakken, when used, could make a difference in the OW separation problem in HRAs. This is especially true for one- and two-person households, where the production of OW and the empty frequency of OW in the public container is low and properties of the Frisbox are fully appreciated. Assumed is also that for larger households or households who produce more than 4 litre of OW a week, the Frisbox could have an advantage.

Advantages for all stakeholders

The Frisbox and the Friszak offer advantages for the stakeholders in the OW collection process identified in chapter 2.7

A solution for the AI

The design challenge was based on the problems AI encounter when collecting OW. Finding a solution for this problems, will make the product desirable. In the previous chapter the design challenge is evaluated positively. Therefore, can be concluded that the Frisbox and Friszak could be desirable by AI.

Limitations of the Fresbin for the AI

A couple of limitations of the design of the Frisbox are recognized. The volume of the Frisbox could be a problem for some households. Households who produce for example eight litre of OW a week need to walk twice a week to the public container. If this is a real problem, could be examined

The Frisbox has advantages for multiple stakeholders:

- *The Frisbox is a solution for AI to collect OW that is hygienic and low-effort.*
- *The Friszak is a solution for waste processors because it reduces pollution in OW.*
- *The Frisbox could help municipalities in reaching the waste separation targets-goals.*
- *The Frisbox supports BinBang in realising their mission and generate extra profit.*

in for example a pilot study, as suggested in chapter 6.6.

Expected is that for some AI, placement in the fridge of the bin is not always possible. This will mean that they have to place the bin outside the fridge. It is expected that odour forming will be accelerated, because there is no ventilation in the bin. Therefore, if the AI want to use the bin they should always place the Frisbox in the fridge.

There are no ventilation holes placed in the bin, because some Fresh OW, like onions release odours which will absorb in the fridge. This results in an unhygienic experience for the user.

Also is expected, that some AI do not want to keep their OW in the fridge because they think it is dirty.

A solution for waste-processing companies

This final solution is desirable for waste processing companies. Waste collecting companies have to deal with pollution in OW, largely caused by non-biodegradable bags. They have to make large investments in removing waste other than OW from the OW. Providing free Friszakken to all AIs and possibly also to people with a backyard could reduce the pollution in the OW. This will contribute to a better environment and reduce the amount of plastics ending up in the soil.

A solution for the municipalities

The final solution could be desirable for municipalities. A combination of the arrangement of public waste collection facilities, behavioural interventions, and the Frisbox and Friszak could contribute to an increase of OW separation in HRAs. This could help municipalities with a high number of HRAs

to reach the 75% OW separation target set by the Dutch government. Furthermore, the Frisbox and Friszak could contribute to achieving EU law standards for 2023, which state that all OW needs to be collected separately or processed at the source. If the plan is really desirable at municipalities still needs to be validated.

A solution for BinBang

The results of this assignment could be used by BinBang to expand their product portfolio with a new product. With this, they could generate extra profit for the company and also realise their mission. The final result is evaluated with Binbang. The production and market plan seems feasible for them. Therefore, it can be concluded that the final solution is also viable. The Frisbox is evaluated by VDL plastics and it also producible. This makes the production of the final product also technological feasible.

Change behaviour for the long term

In this thesis, not much attention has been paid to behavioural change of AI in the long term. However, one of Binbangs core competences is to change and stimulate behaviour. They could use this knowlegde to find an appropriate behavioural change strategy, to implement the Frisbox.



1. Binbang

*The Frisbox supports in reaching their mission
The Frisbox opens new business opportunities*



2. AI

The Frisbox is a tool to collect OW hygenically and low-effort



3. Municipality

The Frisbox helps in reaching waste separation targets



4. Waste processor company

The Friszak could reduce pollution in OW.

Figure 103 | Advantages per stakeholder

7.4 Recommendations

What steps could be taken for further development?

The recommendations discuss potential improvements to the Frisbox and Pilot Frisbox and steps that could be taken in further development. Also, a suggestion for the development of a biodegradable bin is given.

Recommendations for the products

For the Friszak, the Pilot Frisbox and the Frisbox, a separated list of recommendations is composed.

Friszak.

Together with Bio4Pack, the Friszak could be developed. The material and material thickness would need to be determined.

To test the biodegradability of the Friszak, tests should be performed in industrial digesters and composters to find out the biodegradability in these installations.

Frisbox

The following recommendations are for the improvement of the Frisbox model.

Make the Frisbox usable for outside the fridge |

A suggestion for this is to add ventilation holes to the side of the bins which can be opened or closed by the user. By this way, the user can choose to place the Frisbox inside the fridge with the ventilation holes closed or outside the fridge with the ventilation holes open, so that air can flow through the bin.

Furthermore, adjustments in the Friszak could be made to improve air circulation around the OW in the bag.

Adjustment lid connector | The lid connector needs to be adjusted. The lid cannot close properly when a bag is placed in the bin.

Bin made of multiple parts | The bin could consist of various components to make the bin fit in the dishwasher and a mailbox package. A suggestion for the design of this bin is made in chapter 7.5.

Improved handle | The design of the handle could be improved, aesthetically and functionally.

Decrease the production price | The production price could be decreased. This could be done by reducing the number of inserts. Also, the small hatch could be omitted from the design.

Production in China | A middle-man could be used to mediate between BinBang, the Dutch supplier, and the Chinese producers. OrangeRed is a potential middle-man company. They require a fee of 10% of the production costs in China for

their mediation in trade for a quality product manufactured and delivered in the Netherlands (Veldhoven, 2018).

Improved Bin Volume | More research could be done using various types of fridges and how the bin could fit into different refrigerators. For example, the drawer for vegetables could also be a place for the Frisbox.

Strength Stiffness | To guarantee a longer lifetime and durability, more research into simulation and testing of extreme usage situations is advised.

Improved form and design | The design could be improved to make it more suitable in the BinBang form language.

Pilot Frisbox

To further develop the Pilot Frisbox the following points are recommended.

Adjust depth < 9cm | The depth of the Pilot Frisbox should be 9 cm since the Pilot Frisbox of the user tests did not fit in the door of some of the fridges.

Small and thinner handle | The handle was too large. The volume of the bin could be adjusted.

Next steps in further development

In Figure 104, an overview and order is given for the important steps that could be taken to introduce the Frisbox in the market. The starting point of the steps, which should be made, is that from small production and implementation of the Pilot Frisbox, insights can be gathered to improve the product and product implementation for a broad implementation of the Frisbox.

1. Research and Development of Friszak.

The development of the Friszak as proposed in chapter 6.4 is an important step in making the Frisbox work and recommended starting point. The development should contain, as described in the previous section, research into the biodegradability of the Friszak in industrial digesters, and a user test should be performed.

2. Set up a pilot project with the Pilot Frisbox

A suggestion of how the pilot could be set up is described in chapter 6.6, the market introduction. Summarised is recommendations to execute a pilot project, with the Pilot Frisbox to study the effect of the usage considering OW separation and to gather feedback about the usage of the Pilot Frisbox. The detailed recommendations of what should be exam-

ined in this pilot are described in the recommendations of Chapter 7.1. The input could be used to make improvements in the Frisbox.

3. Develop a Frisbox mailbox and make improvements to the Frisbox.

Improvements which could be made to the Frisbox, as described in the previous section. The Frisbox could be further improved by findings from the pilot with the Pilot Frisbox.

The mailbox edition is described in the next chapter (7.5) and could have advantages considering the transport costs and the ease of cleaning. This edition could be further developed. If the mailbox edition is further developed, a comparison could be made between the Frisbox and the Frisbox mailbox edition. It is also recommended to do a life cycle analysis for both of the products to compare product life time. Furthermore it is recommended to perform a life cycle analysis to make a selection between production in China or in the Netherlands. Both could have an advantage. Production in the Netherlands would save transport costs. Production in China could reduce the price, so the turnover of Frisboxes will be higher resulting in a larger impact. Based on these comparisons a product can be selected for the last step: The market introduction of the Frisbox.

4. Market introduction Frisbox.

The last step is introducing the Frisbox in the market. A proposal to do this is described in Chapter 6.6. From the evaluation with BinBang, it became clear that the behavioural aspect is an important part to make the introduction and usage of the Frisbox feasible. The behavioural change of an AI is outside the scope of this project, but attention should be paid to it by Binbang.

It is recommended to design a campaign or program, which could change the behaviour of people encouraging the separation of OW with the Frisbox in the long-term. For example, a reward system where AI's get rewarded financially by disposing of full Friszak bags. This could be enabled by the use of public containers, which can track the AI and the amount of waste they produce. Other instruments to change behaviour can be found in appendix W.

Development disposable bin for in the fridge.

In the synthesis in chapter 5.3 is found that the family, the young couple and the young professionals all preferred the disposable bin above the other concepts, although it resulted in odour above annoyance level.

The development of a disposable bin, which can be placed in the fridge could be further examined. A couple of requirements for the disposable bin could already be given based on the results of this research.

The bins should be compact, when they are unfolded, because AI have limited storage space for the disposable products.

The bin should be placable in the fridge, but if the bin is not placed in the fridge there should be an option to ventilate the bin.

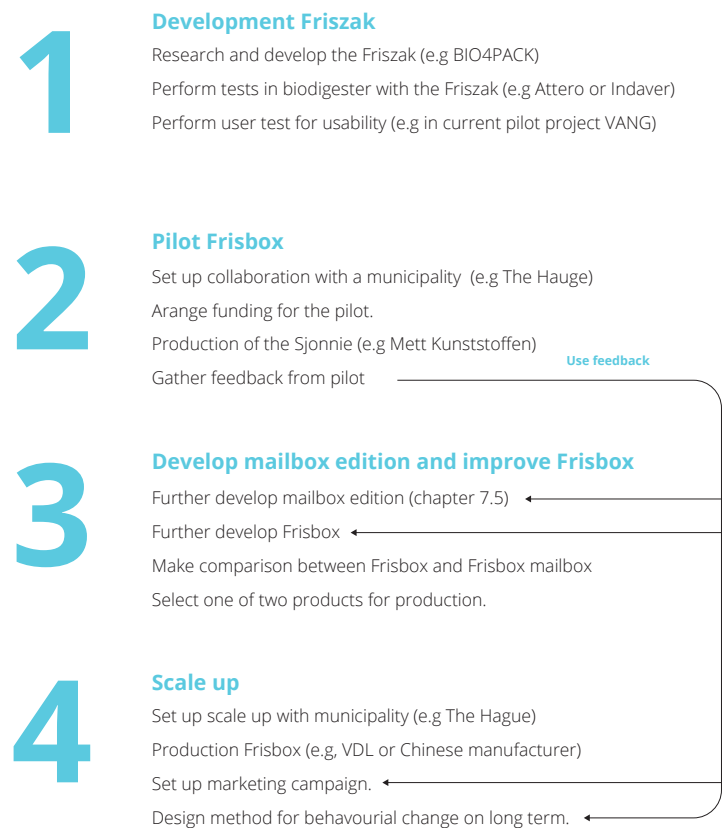


Figure 105 | Possible steps to take to introduce Pilot Frisbox and Frisbox in the

7.5 Mailbox edition

A design proposal for a Frisbox, which fits through the mailbox.

A Frisbox, which fits through a mailbox could have advantages in transporting costs and cleaning. Therefore, an initial design for a Frisbox that fit through a letterbox is detailed in this chapter. Further research and design are required to make a working product according to the requirements of p58 and p88.

Advantages of a mailbox Frisbox.

A mailbox Frisbox could have the following two advantages.

It could fit through the mailbox |

A Frisbox, which fits through the mailbox could be sent to all apartments without handing the bin personally by a coach or a postman. If the package with the bin contains instructions on use, this could make a large impact without contacting all AI personally.

Secondly, a package which fits in the mailbox is cheaper than a regular package.

It could fit in the dishwasher |

This version was evaluated by VDL plastics and the design is not suitable for injection moulding because of the thin side planes. Therefore, adjustments to the model are required to make it mass producible.

Requirements

The maximum size of a package to fall into the category of a mailbox package is 38x265x32 mm (Postnl, 2018). The mail-box edition should fit within these dimensions and a maximum weight 2 kg. Watertight (R15). The bin should be watertight to avoid leaking. This requirement is noted again because it is assumed this could happen easily with a disconnectable bin.

First design

The design is based on the model of the Frisbox and has the same specifications.

The side panels can be slid into each other, and the bottom can connect into the side panel via click fingers. The top of the plates can be held together by a ring, to which the lid is attached. The model has the same hook and handles as the Frisbox. All parts in the model will be produced by injection moulding.

Production

VDL plastics reviewed the design of the Frisbox. According to them, the flat side walls are not suitable for the injection

The first design is made of a Frisbox which can fit in a mailbox package. The advantages of this design are that transport costs are reduced, and the product could fit in the dishwasher. Further, research and development is required.

moulding process. The shape could result in warping and inconsistent material properties through the plate. The other parts can be produced by injection moulding.

Conclusion

It will be an assigned job to make a bin, which is watertight, space efficient, and the same strength and stiffness as the Frisbox design.

As shown in Figure 107, the mailbox edition fits the standard mailbox package.

Recommendations

A couple of suggestions for the mailbox edition are as follows:

It is recommended to look at solutions other than clickable injection moulded parts. For the production of the plates, other manufacture methods could be considered.

The thickness of the click fingers requires further optimising in dimensions regarding strength and stiffness.

It is recommended to research other methods of making a water-tight bin than clicking injection moulded parts together, like in the design shown. Examples of other possibilities could be investigated. For example, the bin could be made foldable with the use of soft plastics or extractable by using rubber-like materials.

In the case when an appropriate model is developed, it is strongly advised to thoroughly compare the advantages and disadvantages between the Frisbox and Frisbox mailbox. The fact that a mailbox edition is better than the regular Frisbox because of the costs savings could be a misjudgment. A mailbox edition could be more expensive in production costs and break down much more easily than the regular edition. These extra costs could exceed the savings in the transport costs, so the benefits of a mailbox edition are not valid anymore.

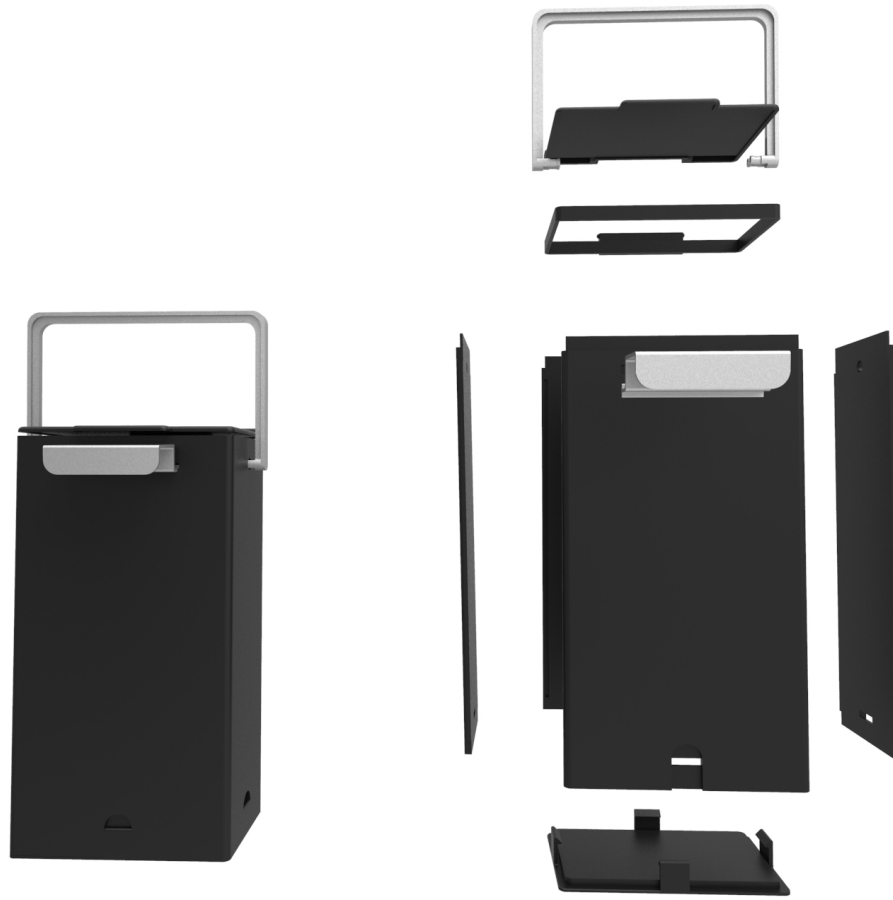


Figure 106 | Impression of a design of the Frisbox mailbox edition

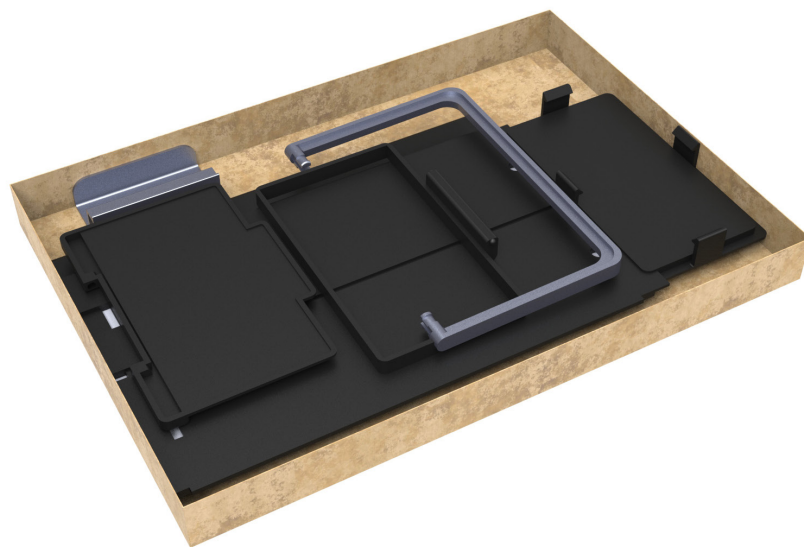


Figure 107 | An Impression of how the Frisbox mailbox edition would fit in a cardboard mailbox with the maximum allowable dimensions of Post NL

8. References

- A. Agapiou & J. P. Vamvakari & A. Andrianopoulos, A. Pappa. (2015) Volatile emissions during storing of green food waste under different aeration conditions.
- Afvalcirculair. (2018). Samenstelling huishoudelijk restafval. Retrieved from <https://www.afvalcirculair.nl/onderwerpen/monitoring-cijfers/afvalcijfers/afvalcijfers-land/samenstelling/>
- AT5. (2018). Java-eiland is al groen, gaan IJburgers nu ook hun gft scheiden? Retrieved from <https://www.at5.nl/artikelen/186537/java-eiland-is-al-groen-gaan-ijburgers-nu-ook-hun-gft-scheiden-2>
- Awamolding. (2018). injection molding rules. Retrieved from <http://www.awamolding.nl/spuitgieten/matrijzen/wanddikte-en-matrijs>
- BinBang. (2018). BinBang webpage. Retrieved from <https://www.BinBang.nl/>
- BinBang². (2018). Wormenbak. Retrieved from <https://www.BinBang.nl/product/wormenbak/>
- Biofutura. (2018). STICKERS EN ETIKETTEN NU GEHEEL BIOLOGISCH AFBREEKBAAR BINNEN 90 DAGEN. Retrieved from <https://www.biofutura.nl/nl/blog/stickers-en-etiketten-nu-geheel-biologisch-afbreekbaar-binnen-90-dagen/>
- Blokker. (2018). Joseph Joseph Intelligent Waste geurfilter – zwart. Retrieved from https://www.blokker.nl/p/joseph-joseph-intelligent-waste-geurfilter-zwart-2-stuks/1386012?1386012=&dfw_tracker=10589-1386012&gclid=Cj0KCQjwr4beBRDNARIsAGZaZ5eXUnbq1BuKgtmMslJD32OtYBJ9M0QGcFAQGrFhSvEYLX5yKDYBbdcaArteEALw_wcB
- Boeijen van A.G.C, J.J Daalhuizen, J.J.M. Zijlstra and R.S.A van der Schoor. (2014). Delft Design Guide.
- CBS¹. (2018). Household waste per kg per inhabitant. Retrieved from <http://statline.cbs.nl/Statweb/publication/?D-M=SLNL&PA=83558NED&D1=121-156&D2=0&D3=a&HDR=T&STB=G1,G2&VW=T>
- CBS². (2018). Municipal waste; amounts. Retrieved from <http://statline.cbs.nl/Statweb/publication/?VW=T&DM=SLNL&PA=83558NED&D1=1-36,121-156&D2=0&D3=11-22&HD=170110-1453&HDR=G1,G2&STB=T>
- CBS³. (2013). Urbanity Amsterdam. Retrieved from: <http://statline.cbs.nl/StatWeb/publication/?D-M=SLNL&PA=82000NED&D1=49-50&D2=a&HDR=T&STB=G1&VW=T>
- CBS⁴. (2015). Dutch citizens in apartments. Retrieved from <https://www.cbs.nl/nl-nl/nieuws/2016/14/vier-op-de-tien-huishoudens-wonen-in-een-rijtjeshuis>
- CBS⁵. (2018). Retrieved from <http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=83452NED&D1=0&D2=a&D3=21,168,396,461&D4=a&HDR=T,G3&STB=G2,G1&VW=T>
- CBS⁶. (2018). Gemeenten zamelen meer afval gescheiden in. Retrieved from <https://www.cbs.nl/nl-nl/nieuws/2018/26/gemeenten-zamelen-meer-afval-gescheiden-in#id=undefined>
- CouncilEU. (2018). Retrieved from EU ambassadors approve new rules on waste management and recycling. Retrieved from <http://www.consilium.europa.eu/en/press/press-releases/2018/02/23/eu-ambassadors-approve-new-rules-on-waste-management-and-recycling/>
- CE Delft. (2015). LCA van de verwerking van voedselresten van huishoudens. Vergelijking van verschillende routes. Restafvalroute, GFT-route, waterketen en nieuwe waterketen.
- Crem. (2016). Crem waste management. Personal communication with Frits Steenhuisen.
- DHIC/GDH/DPZ. (2018). Statistics high rise buildings. personal communication. Richard Vermeulen of government of the Hague.
- D.H. Meadows, J. Randers, D.L. Meadows. (2004). The Limits to Growth. The 30-year Update. Routledge, London
- DAM, R., & SIANG, T. (2018). From Prototype to Product: Ensuring Your Solution is Feasible and Viable. Retrieved from <https://www.interaction-design.org/literature/article/from-prototype-to-product-ensuring-your-solution-is-feasible-and-viable>
- Design innovation group (DIG). (2015). Inzichten in gedrag afvalscheiding in hoogbouw.

- EC Europe. (2018). Retrieved from <https://ec.europa.eu/programmes/horizon2020/en/h2020-section/food-security-sustainable-agriculture-and-forestry-marine-maritime-and-in-land-water>
- Ellenmacarthurfoundation. (2018). Circular economy diagram. Retrieved from <https://www.ellenmacarthurfoundation.org/circular-economy/infographic>
- Esther van Someren. (2018). Interview with government of Amsterdam. Appendix B.
- Femke Mckinzie. (2018). Interview with marketing manager Indaver. Appendix B
- Fonq (2018). Joseph joseph intelligent waste stack. Retrieved from https://www.fonq.nl/product/joseph-joseph-intelligent-waste-stack-afvallemmer-4-liter/156495/?channel_code=544&s2m_product_id=164033&utm_source=ad-words-shopping&utm_content=164033&utm_medium=cp-c&gclid=Cj0KCQjwl9zdBRDgARIsAL5Nyn3XpWcA9gdWN4gHykRYGJDCG6ayBlcGXXul-ABlWuuNGhtBdeS8Mf4aAg0LEALw_wcB&gclsrc=aw.ds&dclid=CNUqtvas790CFYc74Aod1nMByQ
- Geissdoerfer, Paulo Savageta, Nancy M.P. Bocken, Erik Jan Hultin. (2016). The CE e A new sustainability paradigm? *Journal of Cleaner Production*. *Journal of Cleaner Production*, 757-768
- George B. Kasali & Eric Senior. (1988). Effects of Temperature and Moisture on the Anaerobic Digestion of Refuse.
- Grosze-Holz, Marco. (2018). Email correspondence. Appendix V.
- HAP (2018) Tussenbalans Huishoudelijk Afvalplan Den Haag 2016-2020. Retrieved from <https://denhaag.raadsinformatie.nl/document/6212803/3/RIS299198%20Tussenbalans%20Huishoudelijk%20Afval%20Plan%202016-2020>
- Haycarb. (2018). Activated carbon. Retrieved from <http://www.haycarb.com/activated-carbon>
- Hegger, F. (2018). Nederland krijgt beste plan van de wereld tegen voedselverspilling. Retrieved from <https://www.rtlz.nl/algemeen/economie/nederland-krijgt-beste-plan-van-de-wereld-tegen-voedselverspilling>
- Homebiogas. (2018). <https://homebiogas.com/>
- Ideou. (2018). Design thinking. Retrieved from <https://www.ideo.com/pages/design-thinking>
- Insinkerator. (2018). Garbage and food waste disposers. Retrieved from <https://insinkerator.emerson.com/en-gb/insinkerator-products/food-waste-disposers>
- Inzamel middel aanvragen. (2018). Retrieved from <http://www.afvalaanbieden.nl/huis-aan-huis/nieuwe-gft-container-aanvragen>
- J. A. Guerrero-Beltrin, G. V. Barbosa-C-novas. (2004). Advantages and Limitations on Processing Foods by UV Light.
- J. A. Moses, Toma ´s Norton, K. Alagusundaram, B. K. Tiwari. (2014). Novel Drying Techniques for the Food Industry.
- Jeremy Jacobs , Nick Sauer and E. Jane Gilbert. (2007). An industry guide for the prevention and control of odours at biowaste processing facilities.
- Jing Yuan, Qingyuan Yang, Zhiye Zhang, Guoxue Li, Wenhai Luo, Difang Zhang. (2015). Use of additive and pretreatment to control odours in municipal kitchen waste during aerobic composting.
- Kapoosh UV Sanitizing Waste Trash Can/Bin. (2018). Retrieved from <https://www.amazon.com/Kapoosh-Sanitizing-Waste-Trash-Black/dp/B00BF8PM8Q>
- Karjalainen, T.-M. (2007). It Looks Like a Toyota
- Kees Jan van Groenigen, Craig W. Osenberg & Bruce A. Hungate. (2011). Increased soil emissions of potent greenhouse gases under increased atmospheric CO₂
- Kiryama and Takashi. (1998). Strategic knowledge acquisition: a case study of learning through prototyping.
- Klockner, J. (2016). Germany Has An Ambitious Strategy To Halve Food Waste By 2030. HuffPost Germany.
- KNMI. (2018). September 2018 Vrij warm, vrij droog en zeer zonnig. <https://www.knmi.nl/nederland-nu/klimatologie/maand-en-seizoensoverzichten/2018/september>

- Langeveld. (2014). Gft-inzamelingomhoog: meer inzamelen in de hoogbouw. Commissioned by Vereniging AFval Bedrijven. (VANG).
- Mazeproducts. (2018). 245 LT Maze compost tubler. Retrieved from <https://www.mazeproducts.com.au/product/maze-compost-tumbler-245lt/>
- Michael H. Gerardi. (2003). The Microbiology of Anaerobic Digesters.
- Milieucentraal. (20181). Afval scheiden: cijfers en kilo's. Retrieved from <https://www.milieucentraal.nl/minder-afval/afval-scheiden-cijfers-en-kilos/>
- Milieucentraal. (20182). Groente-, fruit- en tuinafval (gft). Retrieved from <https://www.milieucentraal.nl/minder-afval/welk-afval-waar/groente-fruit-en-tuinafval-gft/>
- Milieucentraal. (20183). Groente-, fruit- en tuinafval (gft). Retrieved from <https://www.milieucentraal.nl/minder-afval/welk-afval-waar/groente-fruit-en-tuinafval-gft/>
- Municipality of Amsterdam. (2018). Retrieved from <https://www.amsterdam.nl/wonen-leefomgeving/zelfbeheer/compost-maken-buurt/>
- Onroerend zaken bestand (OZB). (2018). Statistics high rise buildings. Retrieved by Richard Vermeulen of government of the Hague.
- PBL. (2016). one person households. Retrieved from <http://www.pbl.nl/infographic/eenpersoonshuishoudens>
- Post NL. (2018). Dimensions mailbox package. Retrieved from <https://www.postnl.nl/versturen/pakket-versturen/verzendopties/brievenbuspakje/>
- PWC. (2018¹). Klimaatverandering en grondstoffenschaarste. Retrieved from <https://www.pwc.nl/en/topics/megatrends/climate-change-and-resource-scarity.html>
- PWC. (2018²). Tech breakthroughs megatrend. Retrieved from <https://www.strategyand.pwc.com/trend/2018-technology>
- Pieter Jan Stappers. (2012). Convivial Toolbox: Generative Research for the Front End of Design
- Rabobank. (2016). Megatrend 1 - Demografie: groeiend, vergrijzend en samenscholend. Retrieved from <https://economie.rabobank.com/publicaties/2016/maart/megatrend-1---demografie-groeiend-vergrijzend-en-samenscholend/>
- Renewi. (2018). Over Renewi : We richten ons op het verkrijgen van waarde uit afval. Retrieved from <https://www.renewi.com/nl-nl/over-renewi>
- Revis. B.A. (2018) "Tussenbalans Huishoudelijk Afvalplan Den Haag 2016-2020" Retrieved from <https://denhaag.raadsinformatie.nl/document/6212803/3/RIS299198%20Tussenbalans%20Huishoudelijk%20Afval%20Plan%202016-2020>
- Rijksoverheid. (2018). From a linear to a circular economy. Retrieved from <https://www.government.nl/topics/circular-economy/from-a-linear-to-a-circular-economy>
- Samia Enayet. (2013). EVALUATION OF ODOUR ABATEMENT CAUSES FOLLOWING ELECTRODEWATERING OF BIOSOLIDS. P12
- Saskia van Dongen (2018) Government of Rotterdam. Interview. Appendix B.
- Schuurman S.G.M. (2016). Customisation for high-rise waste separation: A toolkit to support municipalities in optimising the waste system
- Sidcon. (2018). Freshstation organic. Retrieved from <https://sidcon.nl/product/freshstation-organic/>
- Stöver. (2018). Introduction page. Retrieved from <https://www.rd.nl/vandaag/binnenland/droogte-legt-oude-loopgraven-bloot-1.1504302>
- Tarief.douane. (2018) Rechten berekenen. <https://tarief.douane.nl/arctictariff-public-web/#!/taric/duty/calculate>
- Tim brethouwer. (2018). Technical adviseur Indaver. Personal communication
- TuDelft. (2018). Circular Product Design. Retrieved from <https://www.tudelft.nl/en/ide/organisation/departments/design-engineering/research-areas/circular-product-design/>
- UniversityCambridge. (2018). 8 sustainability trends that will

define 2018, according to Cambridge leadership network.

Wastetransformers. (2018). Retrieved from <http://www.thewastetransformers.com/projects-development/amsterdam/>

VANG-HHA. (2018). Steeds meer gemeenten introduceren Biobakje. Retrieved from <https://www.vang-hha.nl/nieuws-achtergronden/2018/steeds-gemeenten/>

Veldhoven, Camille. (2018). personal communication. Partner Orange-Red. Retrieved from <https://www.orange-red.com/about-us/?lang=nl>

Wiersma. (2018). Interview. COO BinBang Appendix C

Weeronline. (2018). Introduction page. Retrieved from <https://nieuws.weeronline.nl/26-7-2018-weeronline-live-recordhitte/>

Weprin, M. (2016). Design Thinking: Stakeholder Maps. Retrieved from <https://uxdict.io/design-thinking-stakeholder-maps-6a68b0577064>

Wisdom (2018). Personal communication. Project manager JTO Technology Co. Ltd. (A company within FRD Holding)

Wlabsinnovations. (2018). Retrieved from <https://wlabinnovations.com/pages/zera>

Ye Chen, Jay J. Cheng, Kurt S. Creamer. (2005) Inhibition of anaerobic digestion process: A review

ZOELEN, B. V. (2017). Afval in de Sluisbuurt straks afgevoerd via buizen.