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Reducing the environmental impact of on-the-go food packaging

A search for new solution spaces

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I. Preface

For as long as I can remember I have been intrigued about food. I have always experimented with new ways of preparing, combining and presenting food, as well as philosophising about how society is dealing with food related health problems and environmental impact. It is a topic that affects everyone, every day.

Within diet choices, the perception of food plays an important role, even more than the actual ingredients, taste, texture and nutritional value. A person's mind creates the urge to eat, not the body. I see a future for myself that involves influencing people's minds around food through design and business concepts.

With this graduation project I wanted to challenge myself to find a difficult problem on my own that truly resonated with me and research it really thoroughly, rather than accepting an existing thesis problem from a company or research group. The waste problem caused by single use food packaging turned out to be a perfect match, because of its relation to food, its environmental urgency and the recent developments on the concept of circular economy.

One observation I made and the thing that annoys me personally is that many seemingly sophisticated solutions do not result in a net positive environmental impact, when you consider the entire lifecycle and the displacement of consumption, caused by the solution. A lot of projects are merely started for the sake of environmental awareness or for a future scenario which makes them not very useful for lowering impacts right her and now. Other initiatives are started without taking into account the behaviour of the consumer and, consequently, the likely malfunctioning of the business plan surrounding that particular solution. And there are also projects that improve one aspect while simultaneously increasing the impact in another field. Making their net positive contribution at the very least debatable.

My aim was to see if I could contribute to finding a solution, that could be applied and function with current technologies and as fast as possible, while actually reducing the net environmental impact with minimal concessions.

As ambitious as I started, of course I did not expect to find the holy grail and solve a problem in 20 weeks after decades of attempts by others. But I did not foresee how hard it was to find improvements that actually reduce all types of environmental impact or at least without worsening one aspect by reducing another, while also taking all stakeholders into account.

Many people are concerned about the environment and the future of our planet. The issue with the environment is a social problem which is difficult to solve. I hope that with this thesis, I can contribute to shifting the pessimistic attitude to a hopeful one, showing there are always possibilities to change a situation in a positive way, when we dare to go off the beaten track.

During this project, next to my usual responsibilities, I experienced a house fire, organised an exhibition in the TU Delft Library, struggled with heavy menstrual bleedings, talked about future employment with multiple companies and prepared a 200 km hike through the arctic circle. At times it may have been a bit too much, but luckily I was not alone.

I would like to thank my supervisors for thinking along with me, their feedback and their inspiration to get the most out of this project. I am grateful to all the people who were there for me. Especially for all the support from my loved ones and the daily company of my study buddies in de library, including many coffees made by my colleagues.

Lastly, I hope that you, the reader, can find some inspiration or new perspective that may help you to make our world a little bit better.

Charlotte de Wit

Delft, September 2019

II. Summary

On-the-go food packaging has a significant negative impact on the environment. The awareness of this long existing problem is rising among consumers and policy makers. Although over decades many professionals in various areas of expertise have worked on improvements and tried to find solutions, these solutions all involve trade-offs. An ideal zero waste, circular status in which the world's resources are preserved and their value is maintained has not been reached yet.

New solution spaces need to be discovered, which seems like an impossible job within this already much discussed issue. The present project starts out from the thesis statement that there are still 'voids' to be discovered in the entirety of solution possibilities. A 'void' is defined as a solution space that is not deployed because it is undiscovered, not because it is considered un-useful.

Traditional design ways of problem solving use ideation techniques to come up with different concepts from which the best one is selected. By selecting solutions in this way, solution spaces and possibilities may be overlooked.

Going beyond the traditional design problem solving techniques, this research uses a technique based on abstracting physical working principles of solutions, borrowed from the field of biomedical engineering. By combining problem solving techniques from different engineering disciplines, a systematic overview of solution spaces is created exposing undeployed solution spaces.

In the subsequent phase, the undeployed solution spaces are investigated further to see if there are actual 'voids' among them.

The overview is used to create an innovative solution concept by first clustering the solution spaces in workable solution directions to reduce complexity. By an iterative process of ideating and research, a solution space is selected. Taking the complex interconnected boundary conditions into account – such as the demanding consumer, the profit desiring retailers and the different types of environmental impact –, solution concepts are developed within the selected solution space from which one is selected as final solution concept.

The final solution concept implies separating the presentation function of food packaging from the disposable packaging and shifts the function to a reusable element. The solution concept is developed into an example application: a new packaging is designed for prepacked stuffed wraps. The new packaging is user tested and adapted in an iterative process, based on the test results, until it has shown its potential. Thus, the created systematic overview is verified to uncover at least one ‘void’ and holds the possibility to contain more.

This project aims to contribute to reducing the negative environmental impact of on-the-go food packaging by showing that is worthwhile to search beyond existing solution directions.

The created packaging concept plays both ways: by being part of the theoretical void finding process in verifying the overview and by being part of a practical solution in reducing the amount of single use material. The application of this concept can be explored further in future research.

III. List of contents

Chapter 1

Introduction

Objectives, scope and report structure

This chapter introduces the problem with on-the-go food packaging and how we need to use every possibility to reduce its negative impact on the environment. A thesis statement will be presented, as well as the aim to verify this statement, the research approach and an overview of the structure of this paper.

1.1 The problem with solving the food packaging waste problem

European citizens generate 80 million tons of packaging waste a year, of which around 50 percent is coming from the food sector (Robertson 2012). In these amounts, single use packaging has a significant impact on the environment (Vignali 2016). The awareness of this problem is rising among consumers and policy makers. Product developers can no longer ignore the importance of sustainability within their products (Almeida et al, 2010). Many professionals in different fields have worked on improvements and tried to find solutions, but the problem still exists today.

Most food packaging is not reusable since using non disposable packaging is a lot less convenient. This especially applies to people on-the-go who like to take the product with them and consume it during their travels.

With an important shift from eating at home towards eating on-the-go expected in the coming five years and with millennials willing to spend more money on their food to save time the amount of disposed packaging waste will only grow in this sector. (FSN FoodShopper Monitor, 2018).

Simply leaving out food packaging is not an option: food packaging is essential since it fulfils several disparate functions like containment, protection, convenience and communication (Robertson 2014). To illustrate just one function, protection involves the issue of shelf life: the amount of greenhouse gas (GHG) emissions emitted by food production is much higher than emitted by the production of the packaging around the food, extending the food's shelf life. For a product that has a relative low emission rate like bread, the ratio between emissions from the packaging and food is already 1/20 (Williams and Wikstrom 2011). Other ways need to be found to reduce the impact of packaging on the environment for food sold in on-the-go situations.

The problem of growing waste amounts was first recognised in the beginning of the 1970s (Aarnio, 2008). Developing food packaging which is lighter, contains less material and is less energy consuming started more than 40 years ago to be aplied not only to save money but also as a positive contribution to the waste problem (Erickson, 1988, Thøgersen, 1996). After decades of optimisations, it is in many cases very difficult to cut back the impact even further by reducing the weight of the packaging itself (Robertson, 2009).

Over the time, many other solutions have been deployed. The development of biodegradable plastics, for example, is on a rise. With consumers willing to even pay premium prices for biodegradable containers (Yue, 2010) it seems like a promising direction and an easy 'quick-fix' for a complicated problem. But analyses show that right now, biodegradable plastics can hardly reduce the amount of waste which incinerated or ends in landfill due to a lack of infrastructure. They cannot solve the littering problem either, if they are not worsening it, since the conditions needed for the degrading process are not met outside controlled environments (Ren 2003, Gross 2002, Haider, 2019).

With rising consumer awareness, brands and retailers are working on implementations of impact reducing adaptation as well. Supermarket chain Albert Heijn for example, is experimenting with replacing the packaging functionalities for fruit and vegetables by a hydrating and cooling fog system (Bos-Brouwers, 2018). Unilever started selling more concentrated detergents to save on packaging and transport costs and impact (Nederlandse Vereniging van Zeepfabrikanten, 2008). And the, packaging industry-financed Kennis instituut duurzaam verpakken (KIDV) provides information and tools to make packaging more sustainable.

Large scale trials are in progress from different initiatives to deliver and collect food in a reusable packaging (Recycling netwerk, 2019, Grace, 2019) but because they are home delivering initiatives that provide convenience for the consumer they are not directly applicable in on-the-go situations.

The collective outcome of all the work done so far, is not bringing the desired result, food packaging still puts huge pressure on the environment today. Last year, the converted demand for plastic packaging was around 20 million tons in Europe, from which two thirds are not recycled (PlasticsEurope, 2018). In the Netherlands 20% of all waste consists of packaging (Milieu Centraal, 2018). Packaging should be optimised for all stages in its lifecycle, but solutions at present involve trade-offs (Barlow, 2013). An ideal zero waste, circular status in which the world's resources are preserved and their value is maintained has not been reached yet. Coming up with variations on solutions based on the same working principles, so within the solution spaces explored in the last decade, could help but will not be sufficient.

1.2 Thesis statement

New solution spaces need to be discovered, which seems like an impossible job within this already much discussed topic. Solving a problem means finding a solution that does not violate the constraints. A part of these constraints is used by solution designers to demarcate the entirety of solution spaces early in the process, to make the task of problem solving manageable (Christiaans, 1992).

But by early demarcating, solution spaces can be overlooked. This observation leads to the following thesis statement:

There are still useful undeployed solution spaces that are overlooked in the past decades in finding solutions that contribute to reducing the negative environmental impact of on-the-go food packaging.

Note: Not every undeployed solution space is a potentially useful undeployed solution space. Undeployed solution spaces can be undeployed, not because they are overlooked, but because they are not considered useful taking the constraints into account. The potentially useful undeployed solution spaces can be considered as 'voids' in the current whole of solution spaces and from this point onwards will be referred to by this term. The following example illustrates the definition of a void:

An example solution space is: Preventing sales of on-the-go food items by making them less appealing to buy by law enforcement. A way to reduce the impact of on-the-go food packaging is by creating a law that forces retailers to sell the products for prices ten times higher than they are now, resulting in less purchases. The solution space in which this solution lays is undeployed, not because it is overlooked, but because it is not considered useful, taking the constraints like the democratic political system and economic and social consequences of this solution into account. It is thereby not a void.

1.3 Goal, focus and approach

The goal of this project is to verify the thesis statement: To show there are indeed still useful undeployed solution spaces that are overlooked in the past decades in finding solutions that contribute to reducing the negative environmental impact of on-the-go food packaging.

This project focusses specifically on products *sold* on-the-go, not all products *consumed* on-the-go. The focus is on products that can be consumed straight away, without waiting time and without the need of preparation at home or bringing equipment that is not available on location.

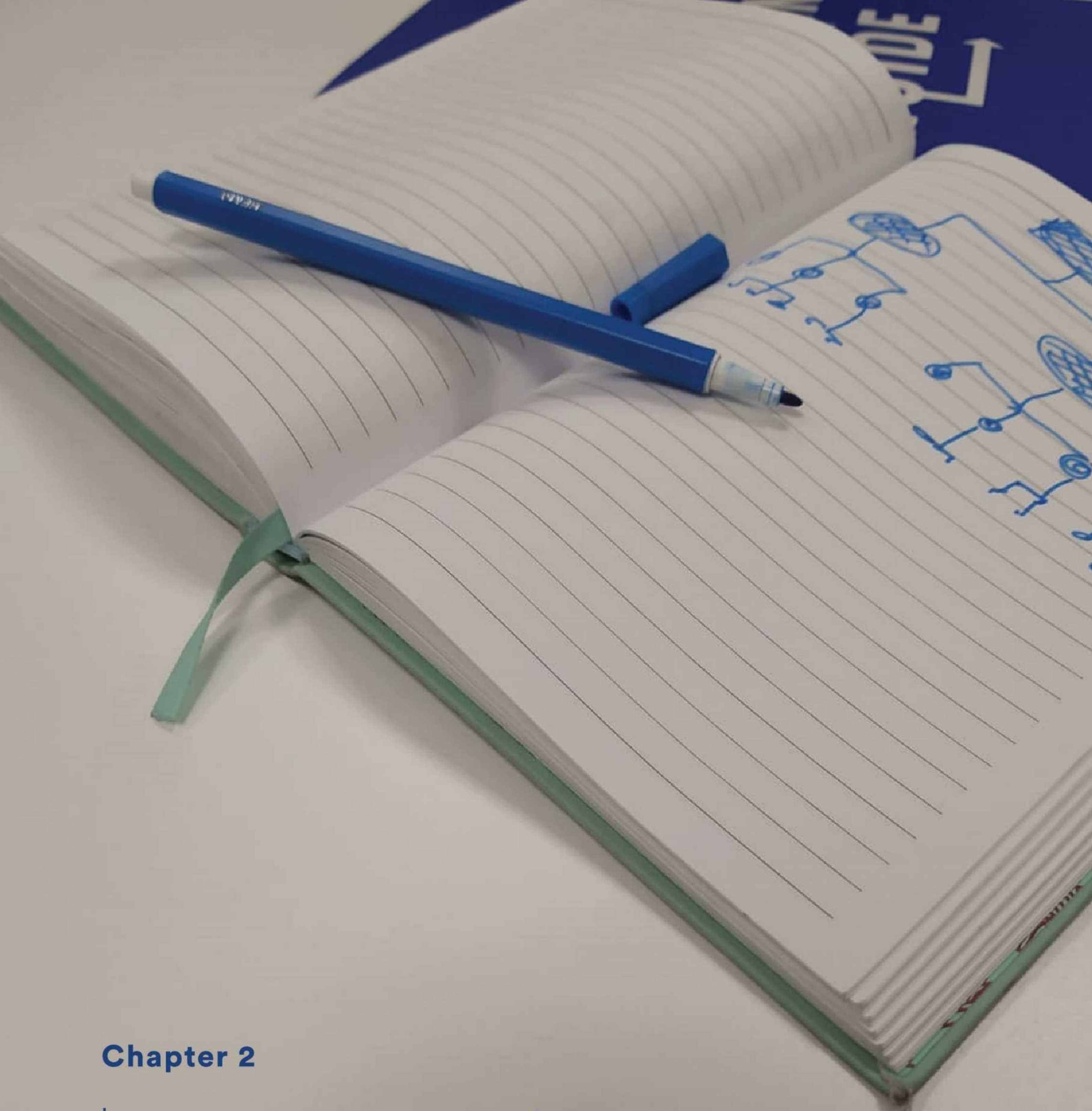
It means that products like fresh prepared meals on location (Fries, wok, pasta) that require some waiting time are beyond the scope of this project.

To uncover undeployed solution spaces, a systematic overview of solution spaces, which is not taking into account any constraints, is created using a technique, for finding innovative technical solutions, that originates in the field of biomedical engineering.

To see if there are voids among the undeployed solution spaces, a more traditional 'Design Thinking' way of problem solving is used. By using the established overview in ideating within the found undeployed solution spaces, a solution concept is created. Its potential is tested to see if it is useful, taking the constraints into account. By verifying the solution concept's potential, its solution space can be considered a found 'void' which verifies the thesis statement.

1.4 Report structure

Chapter two provides the background and reasoning towards the used method for making a structured overview of solution spaces. The result of the established overview is shown at the end of the chapter. Chapter 3 describes the approach taken to find actual voids between the undeployed solution spaces, uncovered by the established overview. Chapter 4 shows how this approach is executed and how an innovative solution concept is created and tested on its potential. Since the way of testing this potential is depending on the specific found solution concept, the testing method and results are discussed in Chapter 4 after explaining the created solution concept. The last parts of the report provide the conclusion, a discussion and recommendations, in Chapters 5, 6 and 7 respectively. Outcomes of literature and other types of research related to the stated problem, that is needed for finding good concrete solutions are, unlike what is common in thesis reports, not discussed early in the report, but only after describing how solution spaces are mapped, when the scope has been narrowed down further and a specific solution space has been selected.



Chapter 2

A systematic approach

Mapping solution spaces

Over the past decades, many solutions have been deployed. This chapter makes clear why it is necessary to use a more extensive approach and to combine solution finding techniques from different fields of expertise to be able to find new, undeployed solution spaces. The technique combination, used to map solution spaces, is explained and the result of mapping the solution spaces is provided. The subsequent chapter discusses how this solution space mapping will lead to identifying actual voids.

2.1 Beyond a traditional systematic design approach

There is no finite number of solution possibilities when it comes to problem solving, since every small variation will create a new solution.

A group of solutions can be based on the same abstract principles. Together they fall within a certain solution space. Solution spaces can be described in great detail, or more generally. The solution spaces described in more detail will fall within the solution space of solution spaces described in less detail. Since solution space description can be made endlessly detailed, there is also no finite number of solution spaces. The solution spaces described in less detail however, can collectively cover the entirety of solution possibilities since we are bound by the laws of nature.

Technical ingenuity alone is not enough to solve a problem. It needs to be combined with creativity (Holt, 1996). Creativity is used to come up with innovative solution concepts that lie within newly discovered solution spaces or can be a new way of applying the solution principles within an earlier deployed solution space. Traditional intuitive design problem solving methods facilitate creativity – for example by helping to get out of idea fixation (Jansson & Smith, 1991) in the ideation process – and provide a structured approach for selecting the 'winning' solution from among the generated ideas. But these methods do not attempt to cover the entirety of solution spaces since this will make the solution finding process needlessly extensive.

Design professionals use constraints early in the process to demarcate the entirety of solution spaces, making the task of problem solving manageable (Christiaans, 1992). But in early demarcating, solution spaces may be overlooked.

Since solutions for the on-the-go food packaging waste problem, generated within the solution spaces that have been deployed over the past decades, have not succeeded in collectively solving the problem, a more extensive radical method, going beyond the more traditional approaches, is equitable for this issue.

2.2 Mapping solution spaces

This research combines a more traditional design problem solving approach with the Abstraction, Categorization, Reflection, Reformulation, and Extension of search results (ACCREx) method, in an attempt to do cover the entirety of solution spaces. The ACCREx method, which was originally deveopped as a teaching method for students in biomedical engineering, rejects intuition-only methods since "there is no rationality and guarantee for exhaustiveness which are an essence of good engineering design" (Breedveld, 2011). It was developed in a design engineering context and not originally intended for more complex social problems.

The working principle of the ACCREx method is an iterative process of abstraction of already found solutions, which can be categorised based on their fundamental differences or working principles. Reflection on this categorisation and reformulation can lead to a logical extension of the amount of categories, in this study; solution spaces. This process is repeated until an extensive categorisation is established, uncovering solution spaces which have not been found or explored earlier. The ordering is structured in multiple layers, dividing more general solution spaces into more detailed solution spaces for every layer, resulting in a upside down 'tree' with the most detailed solution spaces in the lowest row. An illustration of the structure of the 'tree' is shown in Figure 1.

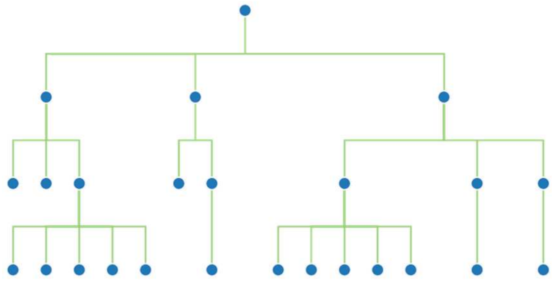


Figure 1: More general solution spaces are divided into more detailed solution spaces for every layer

This research follows the same procedure to establish an overview of solutions spaces, though applying it to a social problem while a deduction approach is used for establishing the first layers of the 'tree'.

To make the procedure suitable for applying to the on-the-go food packaging waste problem, it will be converted from a multi-dimensional* social problem into a one dimensional goal. Where the ACCREx aims for an overview, extensive enough to find undiscovered solution spaces, this research is aiming to cover the entirety of solution spaces in the first layers of the three. This is done by deduction and taking the laws of nature into account.

As noted before, taking constraints into account early in the problem solving process to demarcate the entirety of solution spaces can lead to overlooking solution spaces. Hence, a logical consequence is that, to prevent overlooking any solution spaces, the solution spaces tree must be established without taking any constraints into account. This is problematic, because not taking any constraints into account leads to a vacuum in which the problem solves itself.

Since for this project it is sufficiently accurate to say that our world is bound to the laws of nature, it is safe to take these into account as constraints to create boundaries. For this project, the entirety of solution spaces is defined as covering all solutions that are possible within the boundaries of the laws of nature.

It is important to define the entirety of solution spaces very specifically in this way, since the first layers of the solution space tree will be created by pure deduction to cover the entirety of solution spaces. The deduction can only be pure and complete if it is well defined what is considered complete.

Making sure the first layers of the solution tree are covering the entirety of solution spaces, helps to prevent overlooking huge areas of solution spaces by missing 'branches' in the tree. When completeness cannot be realised by pure deduction, as solution spaces become more detailed in lower layers, the original ACCREx method takes over the deduction approach to create the subsequent layers. In a flawless scenario, every layer of the tree covers the entirety of solution spaces.

*Environmental impact is not expressible in one unit without normalizing multiple different variables into an 'environmental score'**. There are multiple types of impact like greenhouse gas emissions, depletions of resources and toxification of the environment. Putting 'reducing impact' on the top of tree is thereby not a one dimensional goal. More information about the different impact categories can be found in section 4.3

**There are widely accepted standards that normalise the different variables into an 'environmental score', but since this study takes a holistic approach, it is not desirable to just use these standards. It is also very complicated to use them early in the process, since the net improvement needs to be calculated and cannot be quickly deducted by the working principle of a concept. This is something that is made possible if only one variable is taken into account.

2.3 Result tree

By pre-research and brainstorming, ideas are generated and the process is applied as described in section 2.2, resulting in a solution space tree. A small image of the solution space tree is shown in Figure 2. The same figure in a more comfortable reading size can be found as a poster in the sleeve at the inside of the cover of this report. A digital version of this poster can be found in Appendix A

To create the three, the on-the-go food packaging problem is converted in the following one dimensional goal: Decreasing the amount of on-the-go food packaging (mass) which ends up as waste (which means in the incinerator, landfill or as litter).

The goal takes only one variable into account: the mass of the packaging. This is a simplification, for example, less weight does not necessarily result in less environmental impact. (Although it mostly does, it is very hard to come up with an

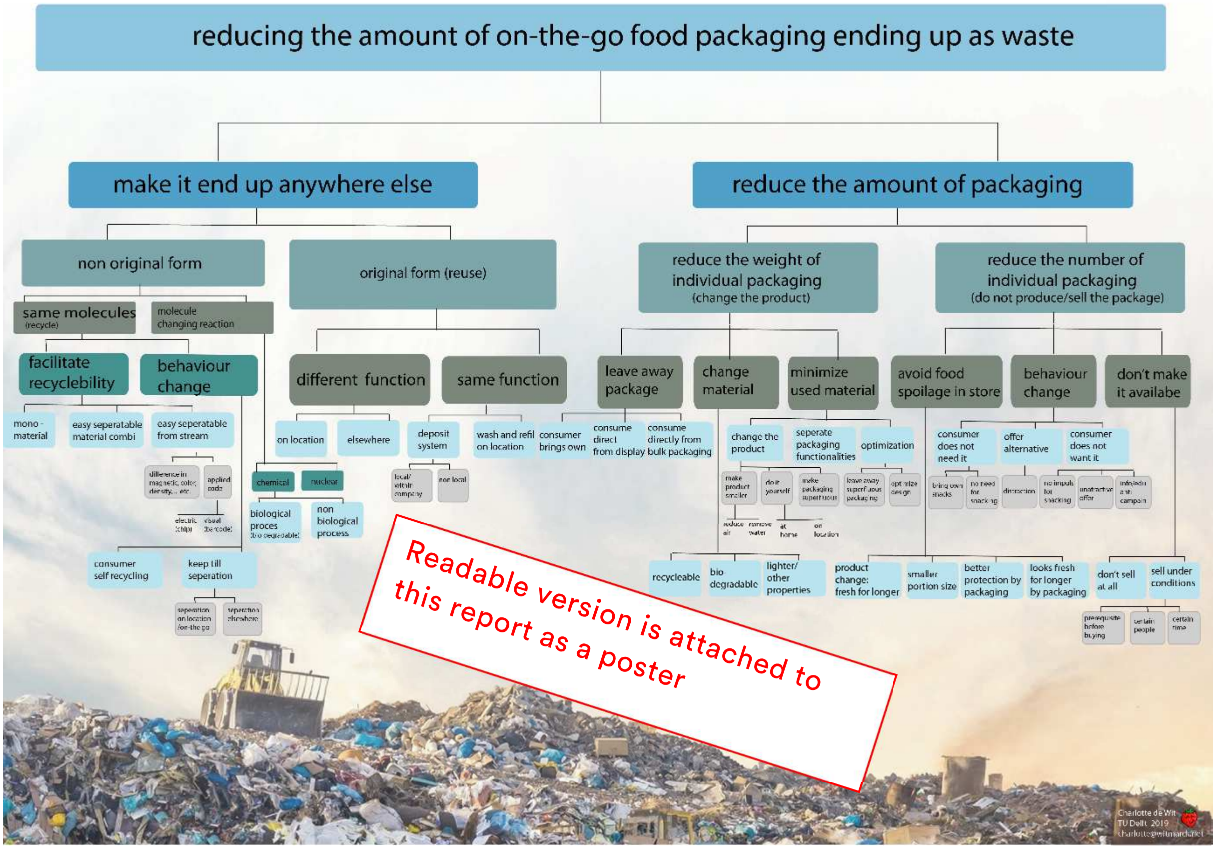


Figure 2: A small image of the created solution space tree. A readable version can be found on the poster attached to this report.

example, making use of current discovered technology that does not work that way). These constraints need to be taking into account later in the process.

This one dimensional goal makes it possible to cover the entirety of solution space in the first layer by taking the law of conservation of mass into consideration. To decrease the mass of packaging, it should either go somewhere else, or never be there in the first place. There are no other possibilities. Although all possible solutions are covered by these solution spaces in the first layer of the tree, more detail is needed to uncover undeployed solution spaces.

The next layer divides the more general solution spaces in more detailed solution spaces. For the dividing of the 'end up somewhere else' solution space, the law of conservation of mass can be used again to ensure covering the entire solution space in the proceeding layer. The mass has to go somewhere else, which can either be in its original form (reused) or not (recycled). There are no other options.

Following logic, the 'prevent packaging' solution space can also be divided in solution spaces that cover the entire originating solution space. Reducing the total mass of the packaging can be done by reducing the mass of individual packaging, or by reducing the total number of packaging. There are no other options. (Except for a combination of solution spaces)

The subsequent layers are not found by deduction but created by the iterative process of the ACCREx method. Although the process aims for completeness, the layers do not emerge from pure logic, so they are likely to collectively not cover the entire space of the solution spaces above them. Scientists from other disciplines might come up with differently defined solution spaces in those layers.

With every layer, more detail is added to the solution spaces by dividing them more. For some 'branches', more layers are created than for others. Knowledge about certain solution areas helps to create more detailed 'branches'. Researchers with a different background might want to lay the focus on other 'branches'. By creating this solution space tree, an implicit focus is already applied. Which is no problem if the tree is made by the person or team that is going to continue and use the tree with this same focus in mind. The complete first layers already provide a basis that ensures less solution spaces are overlooked.

The amount of layers and thereby the amount of detail in the solution spaces is not fixed beforehand. For this solution space tree it is aimed to go detailed enough to uncover undeployed solution direction without making it needlessly extensive.

By deduction, completeness can be ensured, but it cannot be ensured that the least detailed solution space division will be at the top the tree. The tree is made with the intention to put the most abstract division at the top.

Be making other division decisions at the top of the tree, solution spaces from a tree from one scenario could end up in layers much higher or deeper in another scenario. They can even be divided or reoccurring in different branches if they are occurring in lower levels than in another scenarios.

For example: another way to start the three is to divide the solution spaces as follows 1) Sending all used on-the-go food packaging to the moon or 2) Not sending all used on-the-go food packaging to the moon. There is no third option since this is a binary proposal, so by deduction, the completeness can be ensured. But sending all used on-the-go food packaging to the moon is already a quite detailed solution space, and thereby not favourable to be in the top of the tree since it results in unbalanced 'branches'. In de current established tree, the example would fit in the 'make it end up anywhere else' branch. But it is not defined if that is in its original form or not, so this solution space will reoccur somewhere in both branches.

If the deduction steps are done correctly, the first layers of the solution space tree cover the entirety of solution spaces. This is hard to verify. To still have some indication of the tree's completeness, found solutions can be verified to fit within a solution space of the tree.

To test if all solutions that people in a certain group can come up with can be accommodated within one of the solution spaces in the solution space tree, the tree is verified by conducting a group brainstorm session. A report of this verifying session can be found in appendix B. None of the participants of the brainstorm session could come up with a solution that did not fit into one of the solution spaces. This means the tree is complete enough to cover all mentioned solutions.

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Chapter 3

Finding voids

A method for concept development

The tree shown in the previous chapter takes no constraints into account, except for the laws of nature. This chapter demonstrates on how this overview can be used in finding voids. To find voids, all constraints need to be taken into account. To verify if a found undeployed solution space is a true void, it is important to verify if solutions within an undeployed solution space have the potential to work. Following on from abstract reasoning to more concrete steps, this chapter describes a method for concept development taking the mapped solution directions into account. The methods for (user) testing the found solution concept are not described in this chapter, since it depends on the solution concept itself how it should be tested to verify its potential. The subsequent chapter (Chapter 4) will show the results of applying the concept development method from this chapter, as well as the ways and results of verifying the selected concept.

3.1 Undiscovered or rejected solution spaces?

Undeployed solution spaces can either be undeployed because they have not been discovered yet, or because they are simply not useful (yet) taking all constraints into account. In the last scenario deploying just would not make sense or is impossible within the current level of scientific development.

Not every solution space that is uncovered by the tree consequently leads to innovative solution concepts. Potentially applicable solution concepts from newly found solutions spaces need to be tested for not violating any constraints to find out if an actual void is found. If the potential of a solution concept cannot be verified, the associated solution space could either be irrelevant, since its solutions are inapplicable because of the constraints, or it could be that the specific tested example application is insufficiently developed.

So it goes one way: verifying a solution concept can verify its solution space's potential, but if a solution concept cannot be verified, this does not mean the associated solution space is irrelevant.

The solution space tree uncovers undeployed solution spaces, for example, distracting people to prevent them from buying food*, using nuclear reactions to get rid of packaging waste and separating the function from the packaging**. Only by taking constrains into account, the undeployed solution spaces can be shown to be yielding voids. This is done by creating and testing a concept within an undeployed solution space.

*It has been researched on how distraction while eating food has an impact on the total amount of consumed calories at that moment and the rest of the day (Robinson, 2013, Oldham-Couper, 2010, Higgs 2015). Also an indication has been found that boredom or boring activities contribute to the decision to snack (Thomson, 2008). But no specific research, concept application or trial has been conducted about distracting people to prevent them from buying food (on-the-go).

** There are examples where the product is revealed to the consumer only after purchase, which can be seen as separating a function: the presentation function is shifted to a vending machine or the menu card. As for the literature, there are no solutions within this solution space for packaged ready-to-eat food, sold on-the-go, targeted on the consumer as described in the focus of this project (section 1.3)

3.2 Finding constraints

To find applicable solutions within solution spaces, it is important to find what the constraints are for solving the problem. The tree only provides solution spaces without taking all constraint into account, so exhaustive research needs to be done to find these.*

Finding all constraints for the entirety of solution spaces would be unmanageable. So it is important to demarcate the directions in which solutions are aimed to be found.

This can be done by precisely defining a scope**, based on the interests and expertise of the person(s) trying to find an innovative solution. Considering the scope, parts of the solution space tree can be jilted in an early stage. This does not mean that solution spaces are overlooked, since recognition is given to their existence, but the choice is to not look into those directions for now.

As for verifying the void finding potential of the tree, if no applicable solution is found within the chosen scope, it does not mean the tree does not reveal voids. It means that there are no voids found within the particular scope.

* Creating the solution space tree can be seen as the diverging step while the subsequent step can be seen as converting, corresponding with traditional design problem solving techniques. The solution space tree reduces the amount of solution directions that might have been overlooked without use of the tree.

**One aspect of defining the scope is deciding on the timeframe in which the solution should be able to work. Constraints change drastically over time as scientific development and societies' standards and values change. Figure 3 gives a brief overview of some highlights of the history of food sold-on-the go in the last century. It illustrates how constraints changed over time.

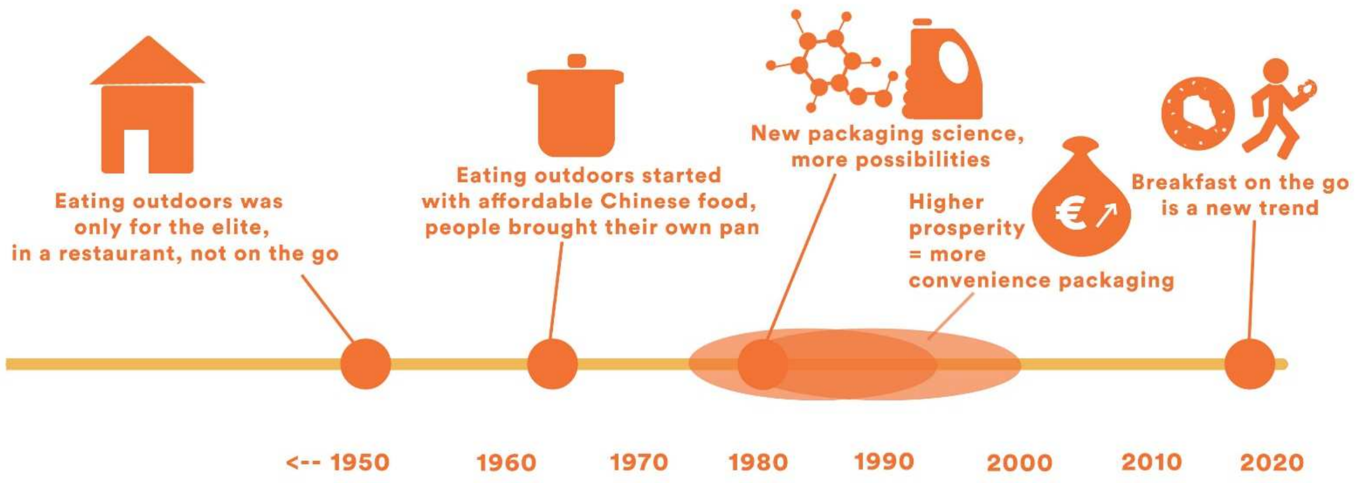

Figure 3: A brief history of on-the-go food.
References used for making this overview: (Van Velzen, 2009), (Montijn, 1991), (FSN FoodShopper monitor, 2018), (Van Hasselt, 2015)

3.3 Curbing complexity & concept creation

After defining a specific scope, parts of the solution tree can be jilted. The tree provides an overview of solution spaces in greater or lesser detail. To curb the complexity and make conscious jilting of part of the solution space tree manageable, the solution spaces that form the bottom of the tree, can be clustered into solution directions. The borders of these clusters are dependent on the defined scope. The most fitted division can be tailor-made for every specialism.

Since the tree works in such a way that solution spaces in a layer underneath other solution spaces collectively cover the solution spaces from the layers above them, the multitude of detailed solution spaces in the final bottom layer should together be covering the entirety of solution spaces, just like any other layer. Because the bottom layers are not created by deduction and thereby do most probably not contain the entirety of solution spaces, clusters will contain solutions spaces from multiple layers of the tree and not just the bottom ones.

After clustering the solution spaces, the clusters that are irrelevant for the scope can be discarded immediately. The remaining clusters, forming solution directions, will be used for an iterative process of research and ideation. The research should be only profound enough to select a convincing solution direction from one of these clusters. Within the selected solution direction, more extensive research can be carried out to find all relevant constraints. With this knowledge in mind, different solution concepts can be created, from which one will be selected.

From the point of selecting a solution direction, the method of a more traditional Design Thinking (Brown, 2008) approach is used, based on intuitive concept creation and systematic assessment, to select the best solution. Which ideating and assessment methods are used, depends on the type of selected solution direction and on personal preference.

3.4 Testing a solution concept

A solution concept that in theory does not violate any constraints will be selected. To verify the potential of the selected solution concept, it must be (user)-tested. This can be done by applying it to a concrete test example.

The test results may be negative, which may be the result of an ineffective concept, or of ineffective example development only. In case of a negative result, iterations on the test example can be done and tests can be executed again until the concepts potential is shown.

If the concept itself is ineffective, iteration on the test example within the solution concept will not lead towards a positive outcome. After a certain amount of iterations, the findings from the tests can be used to attempt to figure out why the solution concept is not successful and directions for further research can be acquired.

The most suitable testing approach is dependent on the selected solution concept. The developed concrete example serves the solution concept test.

Chapter 4

Executing the void finding process

Selecting and testing a solution concept

This chapter contains all the executed steps to find a void. Besides the chosen scope and the process of creating solution directions towards selecting a solution space, it contains all restraints taken into account for the selected solution space, in which the consumer plays an important role. More explorations and fact finding are carried out in the iterative process of ideating and research within different solution directions to considerately select a solution space. This extra information about other solution spaces, which is not providing constraints for the finally selected solution space, is not included in this chapter. After describing the constraints belonging to the solution direction, the subsequent sections describe the selection of a solution concept and the process of verifying its potential.

4.1 Setting scope and clustering solution spaces /curbing down complexity

At the start of the project, a scope has already been defined as only looking specifically at products sold on-the-go, as described in section 1.3. For the constraint finding process, the scope is narrowed down even more. The scope is defined as follows:

- This project focusses specifically on products sold on-the-go, not on all products consumed on-the-go. The focus lies on products that can be consumed straight away, without waiting time and without the need for preparation at home or bringing equipment that is not available on location. (from section 1.3)
- Since this project is executed within the Industrial Design Engineering faculty it was decided to only look for solution concepts within the expertise of an industrial designer.*
- It is decided to only look for possibilities that are applicable in current Western society, with extra attention the Netherlands.
- Even though voids can be found in already deployed solution directions, since these directions can always be divided into more detailed solution spaces, found in the lower layers of the tree, in which voids can be hidden, the choice is to focus only on solution spaces that seem to be undeployed on a fairly 'high' level in the tree.

*This is not only logical because the project is executed within the Industrial Design Engineering faculty, but also necessary, because the tree already contains an implicit focus on the industrial design engineering expertise because it is made by a graduation student from this faculty.

Keeping the scope in mind, 14 different clusters are made within the solution space tree as shown in Figure 4. For better readability, the figure is also provided as an A3 poster in the sleeve at the inside of the cover and as a digital poster in appendix C.

The discarded clusters are tagged from A to G. The solution directions that are explored further are numbered 1 to 7. Table 1 shows the reason not fitting in the scope of every discarded solution direction.

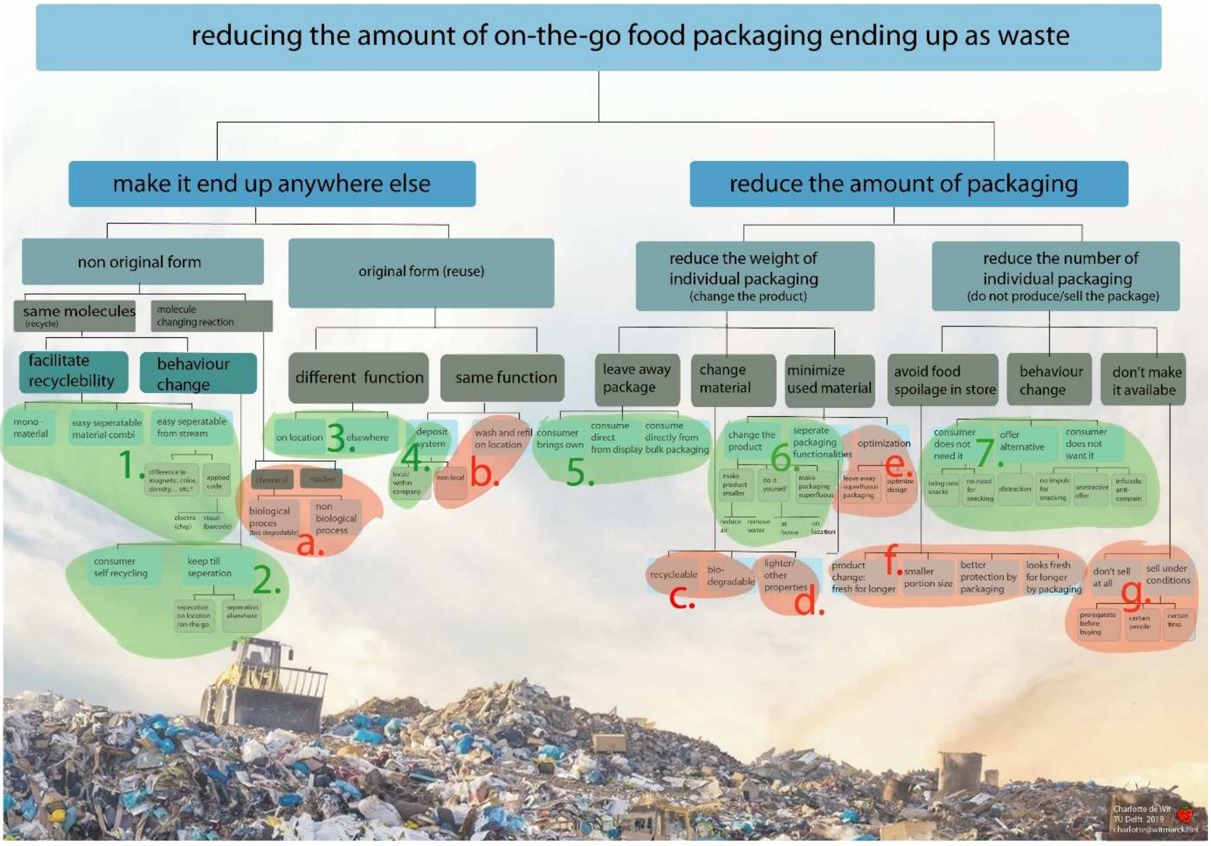

Figure 4: The created clusters. A readable version can be found on the poster attached to this report.

Table 1: The discarded solution directions and the reason for discarding

Discarded solution direction	Reason to jilt
A: Molecule changing reaction	Not within the field of IDE
B: Non local deposit system	Not undeployed, political issue
C: Change material	Not undeployed (see section 1.1)
D: Lighter properties material change	Not undeployed (see section 1.1)
E: Weight optimization	Not undeployed (see section 1.1)
F: Avoid production by avoiding food spoilage in packaging design	Not within field of IDE, molecular/biological issue
G: Do not make it available	Not possible within current society, political issue

4.2 Ideation and selecting solution direction and space

Many concepts and ideas are generated to explore each solution direction. The selected clusters, as described in section 4.1, that are explored further are summed up in Table 2. For every solution direction, a notable constraint found during the research within the solution directions is given.

Table 2: Totable constraints within investigated solution directions

Solution direction	Notable constraint
1. Facilitate recyclability	Although mono-material packaging benefits recyclability, the total used amount of material can drastically be reduced in some cases by combining different materials. With multiple layers stacked on each other to fulfil different functions, a multi-material packaging design can be more efficient and may thereby outweigh the benefits of improved recyclability by mono-material in certain cases.
2. Recycling by behaviour change	It is hard to manage separate waste streams in dense urban areas like areas in and around train stations. Consumers can be stimulated to separate their waste on-the-go, but it will make no impact as yet, since the logistic systems for waste separation on-the-go are not present yet in the Netherlands. Some generated ideas within this direction have the potential to be applied in the future, when the logistics are ready for it. For now, this is outside the scope.

3. Reuse for different function	A lot of secondary functions can be invented for food packaging. But this will only have a positive effect on the environment if the purchase of another object will thereby be prevented. In most cases, this is not realistic since food items are often repeated purchases and the second functionality will already be fulfilled within the first time the package is purchased.
4. Reuse locally for same function	Many on-the-go food products are equipped with a package by a production line in a factory. Moving the packaging step to a local retailer means almost always shifting parts of the production process to the retailer as well, since most packaging functions are needed from the moment the product is ready. Localizing production steps that used to be done in an efficient large scale factory comes with extra costs and in some cases with increased environmental impact.
5. Leave out package	For hygiene and easy handling, some sort of wrapping is desirable for consuming on the go. Consumers are mostly bad planners or seduced to buy a product on the go (Appendix D to F). This makes it impossible to create solutions that make people need to bring their own type of 'wrapping' since it requires planning and already deciding to buy on-the-go before departure.
6. Minimize used material by product change / separating functionalities	Since consumers are often not in need of food, but get seduced to buy the product, the appearance and convenience is very important(Appendix D to F). No concession can be made on these characteristics when the product is changed.
7. Sell less by behaviour change	Behaviour change is the most ideal solution for many of society's structural problems. The problem with behaviour change is that it is very hard to establish. Sustainable behaviour change that goes further than nudging (Sunstein, 2014)or rational override (van Lieren, 2017) takes a lot of time and lies outside the scope for now. Not selling products means less profit for the retailers. Nudging or rational override without cooperation of the retailers on location is very hard, or may even be impossible. Since key stakeholders do not benefit from selling less, there will be no one to implement possible working concepts.

In many cases, investigating the generated concepts and ideas, has led to finding constraints that are violated by the solution concepts and spaces. At the end, the solution space Separate packaging functions is selected from solution direction 7: Minimize used material by product change / separating functionalities, since no constraint has been found yet that is violated by this solution space.

Among the solution directions, there are more concepts and corresponding solution spaces meeting these requirements. Since there is a personal preference for the selected solution direction, those other options are not selected.

4.3 Constraints for selected solution space

To be able to create applicable solutions that actually result in an improvement for the environment within the Separate packaging functions solution space, the following information from the literature is included, as well as information acquired by carrying out three types of explorative research: 1) An interview with an on-the-go product retailer 2) A personal explorative packaging experience 3) Interviews with on-the-go customers. Appendix D, E and F give information about the approach and results of these research tactics. The most important results from this explorative research, that are leading to constraints for the design, are incorporated in this section (4.3).

4.3.1 Packaging functions

Food packaging fulfils different disparate functions. A way to divide those functions into groups is: 1) displaying functions 2) protection functions 3) containment functions.

The Displaying functions include providing information, presenting the food in an attractive way, communication, sending marketing messages to the consumer, etc. Some information cannot be separated from the product since it is required to be present on prepacked foods by European law. This includes product name, ingredient list, allergens, certain nutritional values, expiring date, net weight of the contents and name and address of the manufacturers. This information is often treated as a necessary evil in graphical packaging design and therefore often tucked away using the smallest allowed font size.

The packaging's communication function plays an important role in the consumers' perception of a product. It has a direct influence on the perceived quality and brand preference of consumers (Wang 2013). It is for a reason that for decades packaging has been known as the 'silent salesman' in marketing terms (Vazquez, 2003).

The protection functions include preventing natural deterioration, (the interaction of food with water, gases and fumes, microbiologic organisms like bacteria, yeasts and moulds, heat, cold, contaminants and insects and rodents (Cutter, 2002), physical protection and safety. "For the majority of foods, the protection afforded by the package is an essential part of the preservation process" (Robertson, 2013)

Containment functions include enabling transport, defining portion sizes and convenient consumption on-the-go. ''This function of packaging is so obvious as to be overlooked by many'' (Robertson, 2013). For products sold in an on-the-go situation, consumers also expect them to be especially designed for smooth handling and consuming while being on your way (Jansen, 2015). This report refers to this function as 'consumption comfort'.

Oki & Sasaki state that Reducing material will ''inevitably result in functional loss unless it is compensated for by technological development'' (Oki Sasaki, 2000). For this reason it makes sense to look into separating these functions, away from the packaging, to try to reduce or adapt material without functional losses.

4.3.2 A net positive influence on the environment or an absolute better?

There are dozens of factors that can have an impact on the environment in all stages of a product's life cycle, like greenhouse gas emissions, depletion of resources and fresh water pollution. In life cycle analysis (LCA) literature, individual environmental streams, which can add up to hundreds for a studied product, are condensed into impact categories (Heijungs, 2009). This means, for example, that all associated environmental streams are converted into the same unit. For instace, all GHGs are converted into kg CO2-eq, which adds up to a 'climate change impact' category. The number of impact categories varies per study, but can add up to 23 in the widely used ILCD Midpoint framework (ILCD, 2012). After this step, impacts are usually normalised and weighted to calculate an 'environmental score'. Although impact outcomes can be normalised into, for example, the widely accepted (mili)person equivalent, it is important to keep in mind that any normalisation in this case is liable to interpretation. For example, it is hard to tell the impact of water pollution compares to the impact of greenhouse gas emissions.

Since there are so many factors, a solution that causes a positive influence on the environment in one impact category could result in a negative effect in another category. The net effect of the solution could therefore become very small or even negative. By applying an LCA method, a final normalised outcome can be calculated to compare the impact of the new solution with the old situation. But because the outcomes of LCA methods are liable to interpretation and chosen system boundaries as well, there is no absolute truth in which one alternative is best for the environment due to how impacts were calculated and interpreted. Only solutions that have a positive (or neutral) influence on every category compared to the old situation, can be depicted as absolute better for the environment.

To reduce complexity, while creating concepts, not all impact categories will be taken into account in the design process. The following five types of impact are considered most relevant for the on-the-go food packaging issue:

1. Resource depletion, like minerals and fossils (kg Sb eq)
2. Climate Change (kg CO2 eq)
3. Energy use (kWh/yr)*
4. Depletion of food production capacities (food spoilage) (kg/yr)*
5. Non bio-degradable litter, like the 'plastic soup' (kg/yr)*

*This impact category is not a part of the ILCD Midpoint framework. It is a simplification, combining several impact factors.

- Energy is expressed by the ILCD Midpoint framework in other types of impact like fossil resources. Since the scope is current society and a green energy transition has yet to happen, it is deemed fair to use the simplified form ‘energy use’.
- Food production makes an impact by land use and water use among other things. Since people need food, all impacts are simplified into just ‘preventing food spoilage’.
- Non bio-degradable litter like the ‘plastic soup’ makes an impact by ecotoxicity, acidification, eutrophication, human toxicity and respiratory, inorganics among other things. The simplification makes it easier to assess the created solution on their impact.

As a constraint, created solutions are checked to have less, or at least the same amount of, negative impact in each impact category, compared to the business as usual scenario (BAU). Figure 5Figure 5 shows how concessions on packaging functions, made to improve the impact on the environment, may result in negative impacts as well.

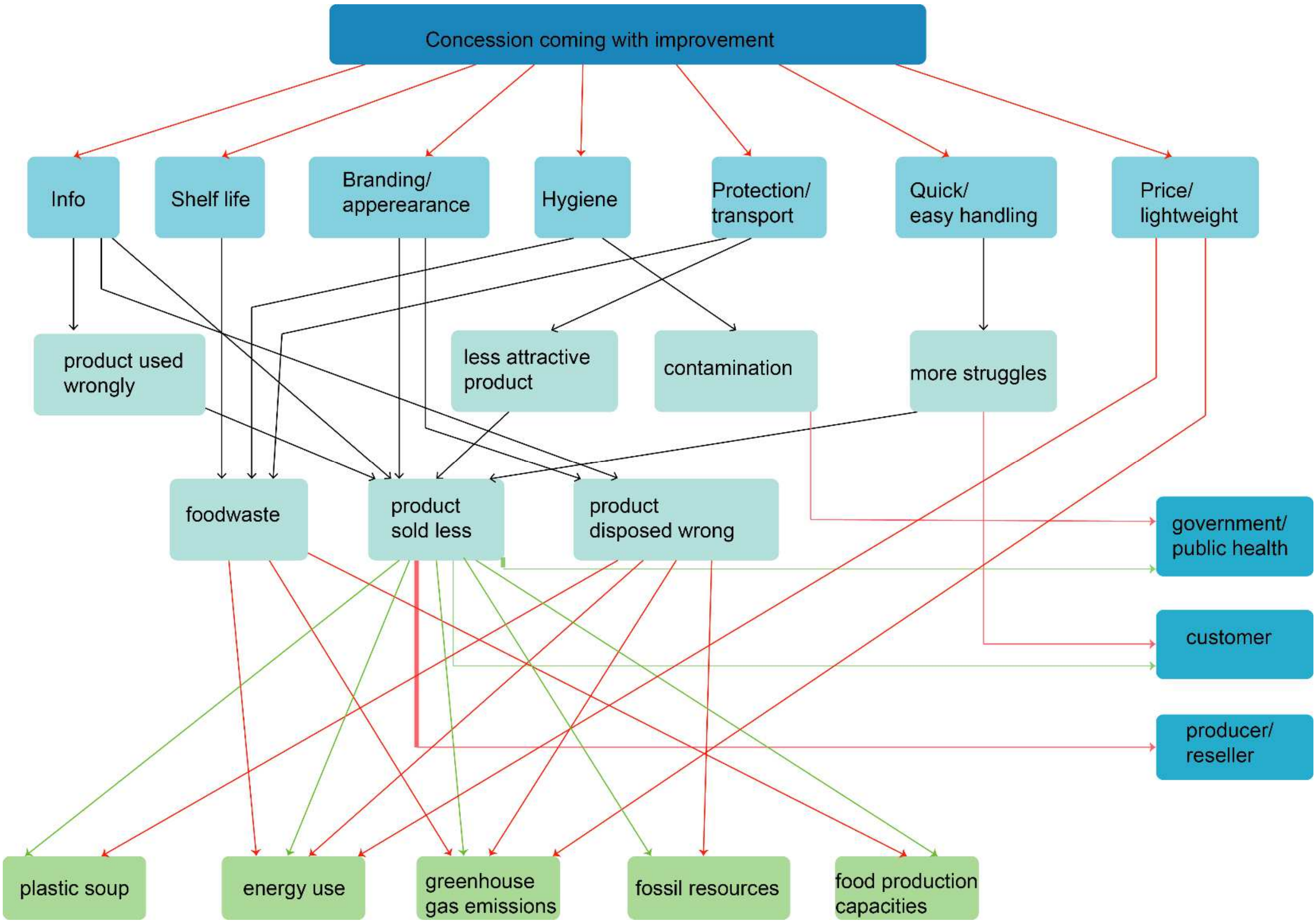

Figure 5: Concessions done on the packaging functions can result in a negative impact for the environment and stakeholders. Green lines indicate a positive effect. Red lines indicated a negative effect.

4.3.3 Life cycle and recycling

Figure 6 shows in orange the most common lifecycle of on-the-go food packaging. To improve on impact points 1 and 5, the lifecycle should change to a more circular one. This can be done by recycling.

Recycling rates of on-the-go food packaging are much lower than for other packaging. Consumers have a harder time finding the right bin while being on-the-go to separate their waste while municipalities have a hard time setting up the needed infrastructure in dense urban areas to collect the different streams of waste separately (NS, 2018). The small part of the plastic on-to-go packaging waste that is recycled cannot be reused for food packaging since contaminations exclude it from safe food contact applications (EFSA Panel on CEF, 2011). However, the also commonly used materials paper, glass and metal are suitable to reuse for food contact applications after recycling.

Paper can only be recycled if it is dry and not contaminated with food residues. It is a common habit of companies in the Netherland to separate their paper waste stream. The possible ink and glue contaminations cause no harm to the recycling process (AfvalfondsVerpakkingen, 2018).

Metal can easily be separated from a waste stream after incineration by magnetic forces. In the Netherlands 95% of all metal is recycled (AfvalfondsVerpakkingen, 2017). Since actions by the consumer or a separate waste stream infrastructure are not needed, this high rate will be around the same for specifically on-the-go food products. A huge disadvantage of metal is the relative high weight and amount of energy needed for processing.

Material choice in designing a solution for current society should be done considerately if taken a circular future into account.

Research has shown that consumers see distorted products as waste while undistorted products are seen as more valuable, which increases the chance that they will keep the product with them until they find an opportunity to dispose it in a recycle bin (Trudel, 2016). The explorative research verifies these findings and suggests the same principle goes for dirty waste versus clean waste. Besides the fact that it is more convenient to bring clean objects along than dirty ones, clean empty packaging is also perceived as more valuable and thereby simply throwing it away wasteful. (Appendix D).

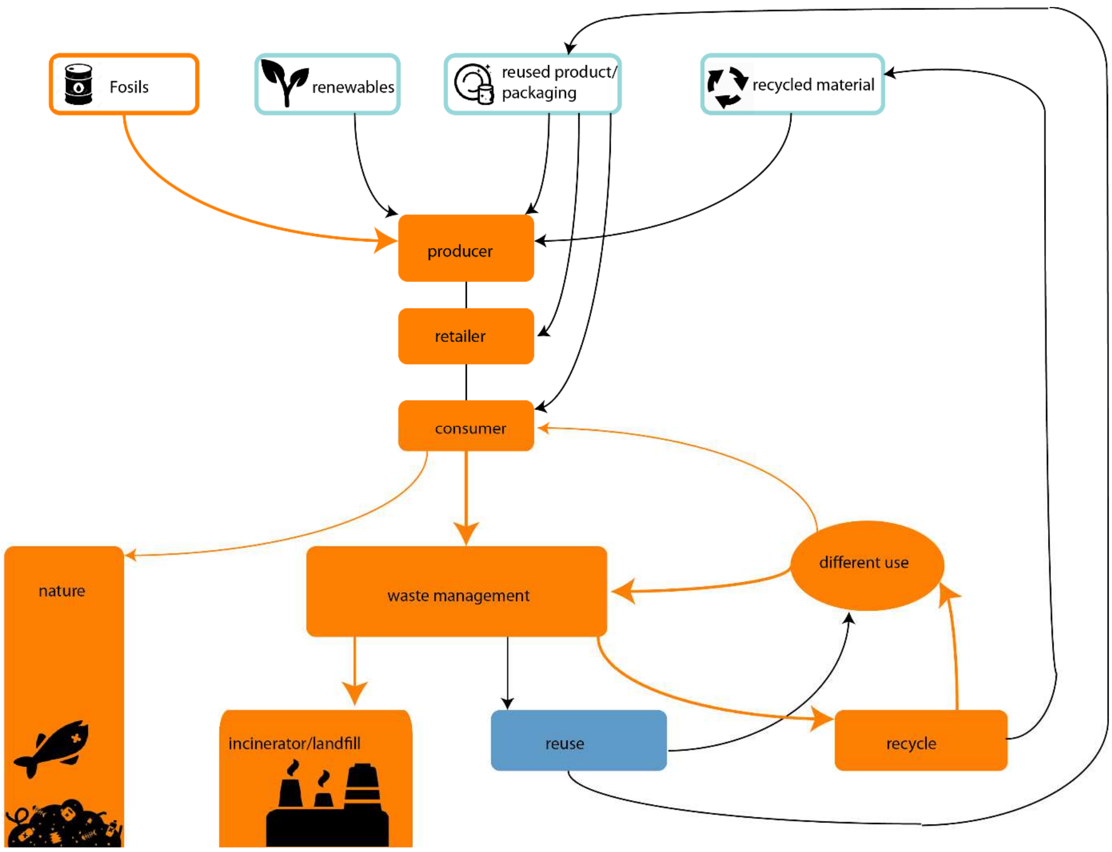

Figure 6: The life lifecycle flow diagram of food packaging for on-the-go situations. The orange elements show the currently most common lifecycle.

4.3.4 The profit seeking producers and retailers

A very important constraint for design solutions in current society is the capitalistic way of doing economics. Any solutions that decreases profits will not be implemented unless there is an external factor forcing a company to do so.

With many on-the-go prepacked products produced in large scale factories, investments are significant and decisions are made not to keep society but shareholders happy.

Sometimes altruistic-looking investments can indirectly lead to profit rise since greenwashing or actual ethical behaviour can please the customers, resulting in positive effects like brand loyalty and a higher willingness to pay (WTP) (Delmas, 2011).

There are a lot of initiatives of small entrepreneurs who like to do good and are prepared to sacrifice profit for the greater good. But since less profit leads to smaller growing possibilities for the company, it unfortunately also leads to a smaller positive impact.

Two examples of current external impulses for the industry to do good for the environment despite causing profit loss are the following 1) the 'plastic pact' is an arrangement in which more than 70 Dutch companies and organisations agreed on using less plastic and recycle more (plastic pact NL, 2019, Koelmans, 2019). 2) The Dutch government is working on a deposit system for 500 ml bottles, which involves great improvements for the environment, but also means higher costs (van Velzen, 2012). These kind of solutions involve complicated political manoeuvring and are beyond the scope of this project

It is important that the solutions do not reduce profit. Therefore, a solution should not reduce sales, increase production price, increase required (expensive) labour

or increase costs in others ways if this cannot be compensated for in another way. This implies that retailers prefer to sell prepacked products that do not involve extra tasks for their staff or logistic difficulties (Appendix D).

4.3.5 The demanding and persuadable consumer

To sell products and make profit, it is obviously vital to know the needs and wishes of customers. So it must be investigated what the crucial characteristics of customer interaction are and for what factors making concessions is an option. The explorative research suggests on-the-go consumers can be divided into three groups, each having their own characteristics (Appendix F).

The smallest group consists of people who created the habit of buying their meals on-the-go. They are willing to pay more for the convenience these ready to eat products offer and buy regularly at convenience shops, with most of the interviewed people doing this even daily.

The second group consists of people who have the habit of eating their meal somewhere indoors or bringing their meal from home, but do occasionally not plan well enough to realise this. Buying their meal on-the-go is seen as a quick fix for their rushed schedule. This group can be divided again in two groups, from which the first one is suggested to be the largest: 1) People who are sensitive to the beckoning offers from convenience shops. Since these people know there are attractive offers sold on-the-go, the effort to realise their originally planned meal decreases. Not planning well can be their excuse to buy the often less healthy and more expensive products in convenience stores. 2) People who are not influenced by the offers and despite their best efforts did not make it to fix their originally planned meal in time. They tend to look for the best price/nutrient balance in the on-the-go item to be purchased.

The third group, which is suggested to be the largest, consists of people who did not plan to buy something on-the-go. They did manage to fix their planned meals on time. They are not hungry or thirsty and are buying food on-the-go because they are seduced by the products. The food purchase is providing a positive impulse for people who are bored, tired, frustrated or for other reasons looking for some enjoyment. It is hard to compete with these products in offering something more sustainable that is not food, since it is not only the purchase itself that stimulates the dopamine reward system in the brain (Hartston, 2012) but it is stimulated again as soon as the fats and sugars from the purchased food are detected by one's taste buds (Bello, 2010).

4.3.6 Attractive products by attractive packaging

Appearance of a product is key when it comes to consumer seduction. All different packaging style elements (colour, graphics, shape, etc.) have an influence on how consumers perceive a product (Magnier 2017). For ready-to-eat foods, transparent packaging has the effect that food is generally perceived as more fresh and of higher quality. If a product is more immediately visible it is significantly more likely to be considered for purchase (Simmonds, 2018). Overpackaging, which is related to marketing rather than technical requirements, adds a more luxurious feeling. A study in which the overpackaging was removed from a house brand's yoghurt packaging showed that removal negatively influences purchase intention by lower perceived quality and convenience (Wiese, 2015).

Providing specific arguments in eco-labelling can result in more trust and positive attitudes towards the product and brand (Atkinson, 2014). However, green scepticism can cause significant damage to the brand's image if a 'green product' is not trusted (Leanidu, 2017). Thus the WTP by the consumer within the new solution concept should not be dependent on the green image of the product, since consumer trust is not always based on facts and cannot be guaranteed for new products (Leanidu, 2017).

Since most on-the-go consumers are suggested by the research to not have planned their purchase beforehand, solutions that involve preparation by the consumer are unlikely to work. However, scenarios are thinkable wherein consumers carry their own reusable container every day, just in case. Apart from the fact that cleaning this container in between uses still requires some sort of planning or preparation, the explorative research (Appendix D) suggests solutions like these will not work either for most products because the right branding and presentation by packaging design plays a huge part in making the product attractive. Making consumers bring their own containers results in selling only the food part of the product that used to be a combination of food and packaging.

There are multiple levels on which the consumer experiences the consumed on-the-go food, which can thereby contribute to the seduction. After a product has been purchased, the food itself, being the first level of experience, is always experienced by eating it. The packaging adds an important part to the experience, but the store and environment also have a big impact. The product (food+packaging) always competes with other products on the shelf. The last level of experience is created by communication from the store or brand before the consumer is even going to the store, like banners, tv commercials or brochure offers.

Figure 7: Consumers experience food on multiple levels

4.4 Selecting a concept within the selected solution space

4.4.1 Two concepts within constraints

Taking all constraints into account as described in section 4.3, two concepts are formulated. Other concepts that were created as well, after some further exploration were indisputable found to be violating one or more constraints and thereby jilted at that point.

A concept that separates the consumption comfort function

The first concept consist of the principle of using a thin foil which contains the food or beverage, providing protection and display functions, and a separate sturdy outer container providing consumption comfort. The concept is shown in Figure 8.

The thin foil consists of the minimal amount of material needed to bring a branded experience and keep the product fresh, but does not provide the sturdiness to comfortably hold it and eat from it. Consumers can buy sturdy containers separately. This results not only in awareness of the existence of the packaging material, but also provides the possibility to not purchase the sturdy container part.

The thin foil keeps any used container clean, so carrying around a reusable container 'just in case' becomes a possibility, since cleaning is not necessary. Many types of foldable containers and 'foil holding possibilities' can be designed as illustrated in Figure 9.

Scenarios are imaginable in which a small-scale deposit or 'reusing' system is introduced for the sturdy outer packages, since without food contact the thorough cleaning operations to maintain hygiene standards and costly logistical adaptations to transfer these parts back to the factory for refilling, are no longer necessary. To accommodate consumers and retailers in contingencies, the foil packaging can be designed in way in which, although not comfortable, it is not impossible to consume the product without an outer container. Foils may be designed to fit in standardized container sizes and need to include some extra material to hold on and to cover the container's rims, assuring eating comfort and preventing smudging.

Looking to the future, when the infrastructure for separate waste stream collection is realised, an additional advantage of not dirtying the sturdy part of the package, is that in the case of using a disposable container, the container is more likely to be kept by a consumer until the right recycling bin is found. In the case

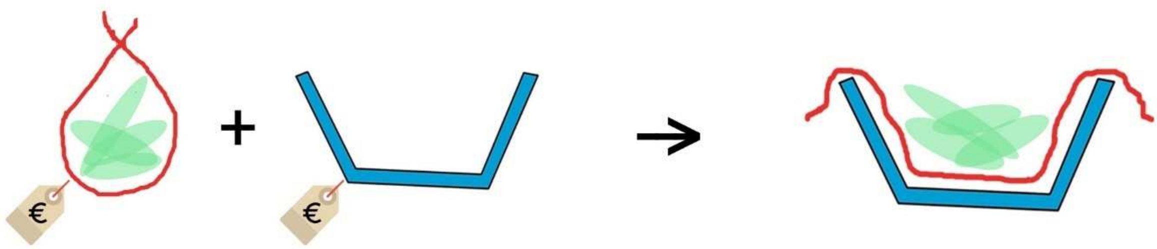

Figure 8: The concept implies separating the consumption comfort function: selling one part which is containing the food and another optional sturdy part.

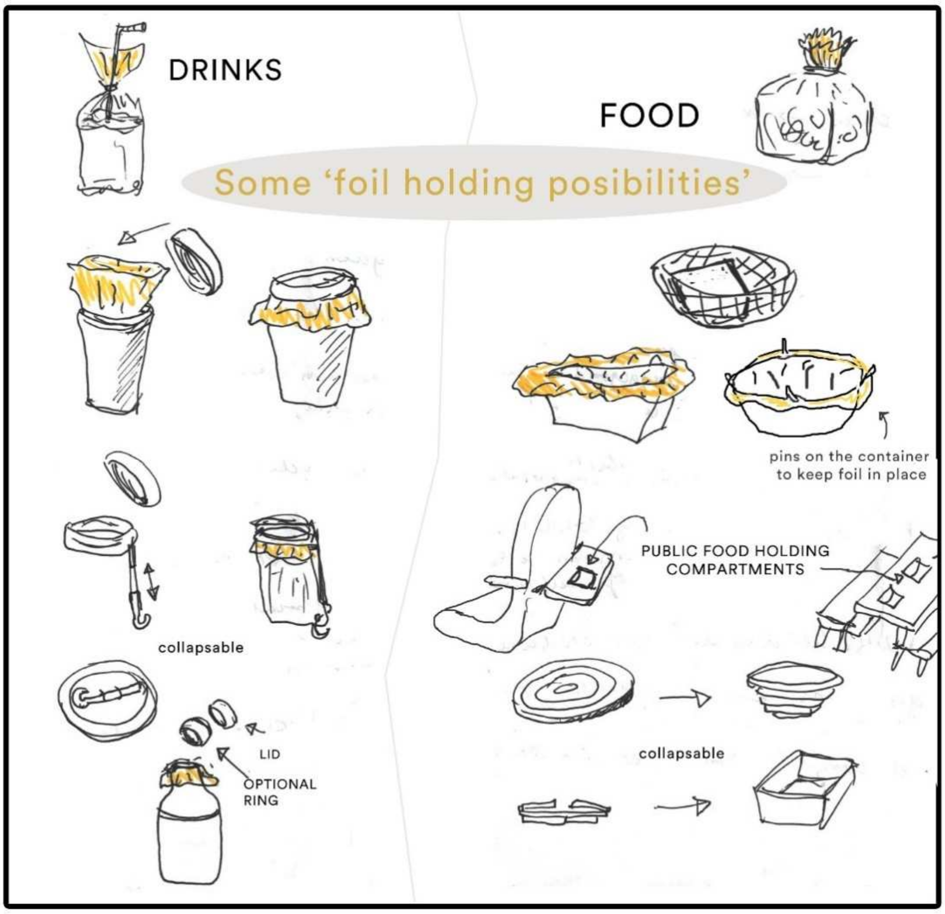

Figure 9: Some 'foil holding possibilities'

that cardboard is used for this container, successful reuse of the material is more likely since it will be dry and uncontaminated. In the case that plastic is used, the plastic is suitable for reuse for the same purpose after recycling since there has been and will be no food contact with the material.

Eating comfort is often provided by sturdiness of the packaging. Giving sturdiness to a packaging often causes most of the packaging weight. Thus by separating this function from the other functions, most of the weight can be dealt with in a more sustainable way. In this way the concept makes less or the same impact on all 5 defined impact categories than it does in the BAU scenario. Nevertheless, although being the smallest part, the thin foil part will mostly still end up as waste.

User research can be carried out to see if the concept of the thin foil in a separate sturdy container, which works in theory, is in reality able to maintain the same level of branding and eating comfort as it does in the BAU scenario, this concept can be researched by user testing.

A material saving presentation shifting concept

The second concept consists of saving packaging material by separating the presentation function from the disposable packaging and shifting this function to a reusable element, as shown in Figure 10.

In many designs, most elements of the packaging contribute to different functions simultaneously. For example: a sealed plastic bowl holding a salad serves shelf life, hygiene, handleability, and presentation at the same time. But in some cases, extra material is added to solely serve one purpose. For food packaging design for on-the-go situations, with respect to the appearance it is especially important to meet customers expectation, as discussed in section 4.3. There are many cases in which extra material is added to serve the presentation function only. This could be overpackaging or integrated extra material.

A consumer's product perception comes from experience on multiple levels as discussed in section 4.3. The presentation function can be shifted from the packaging level to all of the experience levels. This concept focusses on using the store level (Figure 11) to replace the presentation function from the single use packaging by using a tray which takes over this function.

The reusable tray can be designed in such a way that it makes less or the same impact on all 5 defined impact categories, than the saved disposable material does in the BAU scenario.

The concept can be used to design a presentation approach that not only saves material from the disposable packaging, but also decreases the impact on other areas by, for example, enhancing recyclability as well.

If the theoretical concept of shifting the presentation function works in reality, it can be researched by user testing.

To clarify this concept, an example featuring fresh peppers, sold with an extra cardboard tray within the plastic foil that fulfils all functions other than presentation, is given in Figure 12.

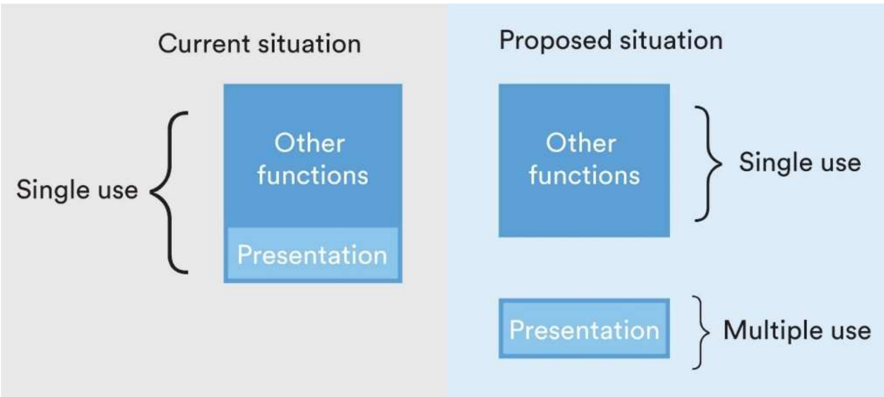

Figure 10: The concept focusses on shifting the presentation function to a reusable aspect.

Figure 11: The concept shifts the presentation function from the packaging to the store level

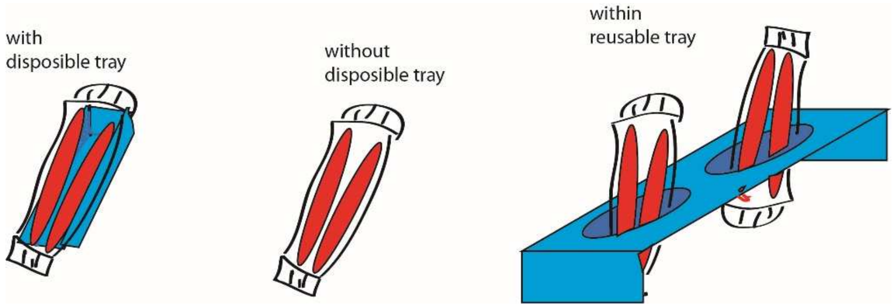

Figure 12: An concept example application featuring fresh peppers

4.4.2 Selecting a concept

Since both concepts could theoretically be applied in a way that does not violate any found constraints, the selection of one of the concepts will be based on wishes rather than constraints. To make the evaluation of the concepts explicit, an intuition based Haris Profile (Harris 1982) is created for each concept, using the following comparison points:

- Application complexity: since the concept's potential needs to be verified, it is desirable for this project that the application step and the testing should be as uncomplicated as possible.
- Reducing negative environmental impact: Both concepts are expected to be beneficial for the environment compared to the BAU scenario.
- Wider picture: Although the scope is within current society, it is desitable to implement concepts that contribute to a circular future scenario rather than being just a temporary quick fix.
- Money savings: Both concepts are expected to be able to be implemented without loss of profit. Nevertheless, solutions that can increase profit are more likely to be implemented soon.

Figure 13 shows the created Haris profiles. The reusable presentation tray concept is selected as best concept for continuation in this project.

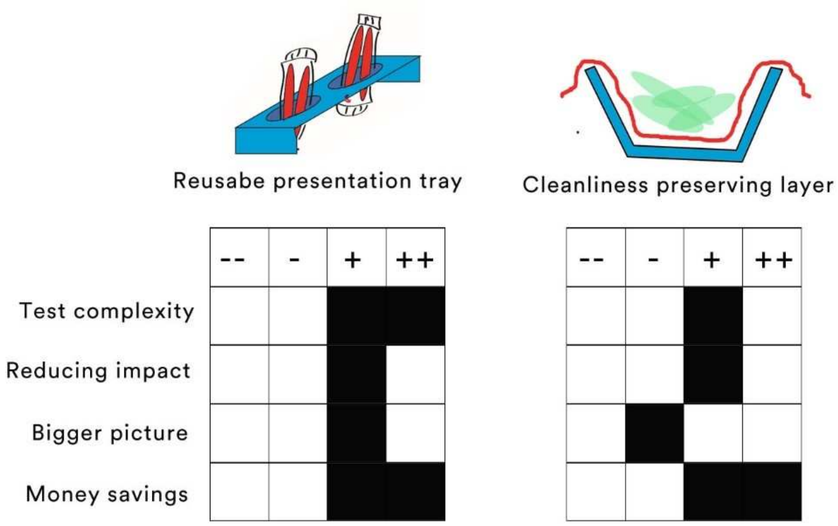

Figure 13: The Haris profiles created for the two concepts

4.5 From concept to concrete test example

4.5.1 Selecting an example product

To be able to verify the solution concept's potential, an example packaging is designed for which the concept is implemented. Every food product is different and needs its own design. The chosen product for this test, is prepacked wraps because they are one of the more complicated cases. Not only does the presentation function of their packaging provide a luxurious feeling, it also places the wraps in an upright position. This is necessary to make the consumers see the filling of the wraps. The transparency of the packaging adds an extra challenge since an opaque packaging can hide flaws in the actual food which this packaging cannot. If the test results are positive for a more complicated case like this, it is more likely that the concept will also work for a less complicated case than the other way around.

There are many different brands selling prepacked wraps. The packaging design is only slightly different for every brand. All observed designs follow the same concept containing a cardboard cup and a transparent flow pack foil suitable for modified atmosphere packaging. In this way the wraps stay fresh for more than ten days. The cardboard cup is only there for the presentation function. Figure 14 shows some examples of packaging designs of different brands.

The verifying test uses a BAU scenario packaging for comparison with the new packaging design. To make sure test participants judge the different designs by its shape and not by brand experience, a relatively less well-known brand is chosen. To create possibilities for testing in different contexts, the selected brand is not a house brand. If presented in a different environment than the store selling it, a house brand could cause confusion. The Qizini brand fulfils all these test requirements and is widely available. Within this brand, the Chicken tandoori flavour is selected as their most mainstream flavour so as to include as many suitable test participants as possible. The packaging of the Chicken tandoori Qizini wraps is shown in the left bottom corner of Figure 9.

Figure 14: Some examples of packaging designs for different brands of wraps. In the left bottom corner the selected Qizini brand is shown.

4.5.2 Implementing the concept for a plausible test setup

An alternative packaging design is created for the Qizini Chicken tandoori wrap, discarding the cardboard cup and replacing its functions by a reusable tray.

The test is set up to investigate if the working principle of the concept could work. All different packaging style elements (colour, graphics, shape, etc.) have an influence on how consumers perceive a product (Magnier 2017). To exclude the influences of these elements from the test, these variables are copied from the original Qizini design as much as possible to keep them constant.

The replacement by a tray involves changes in tasks for the retailer's employees, changes in handling and changes in logistics that need to be taking into account while designing. To create a realistic scenario, the new design is made in a way that can actually be implemented. Figure 16 gives an overview of the alternative packaging design.

Since products in the fast moving consumer industry (FMCI) chance very quick, the reusable tray is designed for a use for one month on average, holding 90 wraps in a lifetime. This does not only enables fast changes in product design, but also plays a role in reduced cleaning tasks for the shop's staff.

Production of the tray is very cheap, since the tray consists of only two pieces of cardboard. These two pieces stay flat, enabling compact transport and can easily be unfolded on location. To assure a smooth picking and placing motion, even when space is narrow, the individual baffles can bend forward and will bent back automatically. To make sure the new design will not take more of this narrow shelf space, it is designed to take the same amount of space as the BAU packaging design.

The most observed amount of wraps on shelf rows is three, the same amount as a standard tray can hold. If a shelf is deeper or more shallow, the carboard tray can be adjusted to hold another amount of wraps.

The weight of one tray is about the same as the cardboard cups is replaces. Since it is designed to hold 90 wraps in a lifetime, the result is that the weight of 87 cardboard cups is saved for every tray. In contrast to the nonrecyclable coated cardboard cups, which made contact with the food, the tray involves no food contact and is fully recyclable without this coating. Since it is the store that deals with disposing the tray and not the consumer on-the-go, chances that it will actually be recycled are higher.

A more detailed report of all design decisions, and the verification of its possible successful applicability from a retailers perspective can be found in Appendix G. Figure 15 shows a picture of the created prototype and the orginial pakaging design.

Figure 15: The final test prototype (left) and the original packaging design (right)

The tested design is one of the many possibilities to implement the concept. For this design the aim is to minimize the environmental impact and price. If the solution concept is successful for this design, it is likely that it can be successful in other designs, which may also be less optimized. Future designers and companies can explore different shapes to distinguish the brand experience.

The test design performs better than, or equally well as the BAU scenario design in all 5 types of impact by using less material per wrap without making any concession on functions that can cause a higher impact in one of the 5 types of impact when not performing well.

This is even the case if the test design would involve concessions on the presentation function as shown in figure Figure 17.

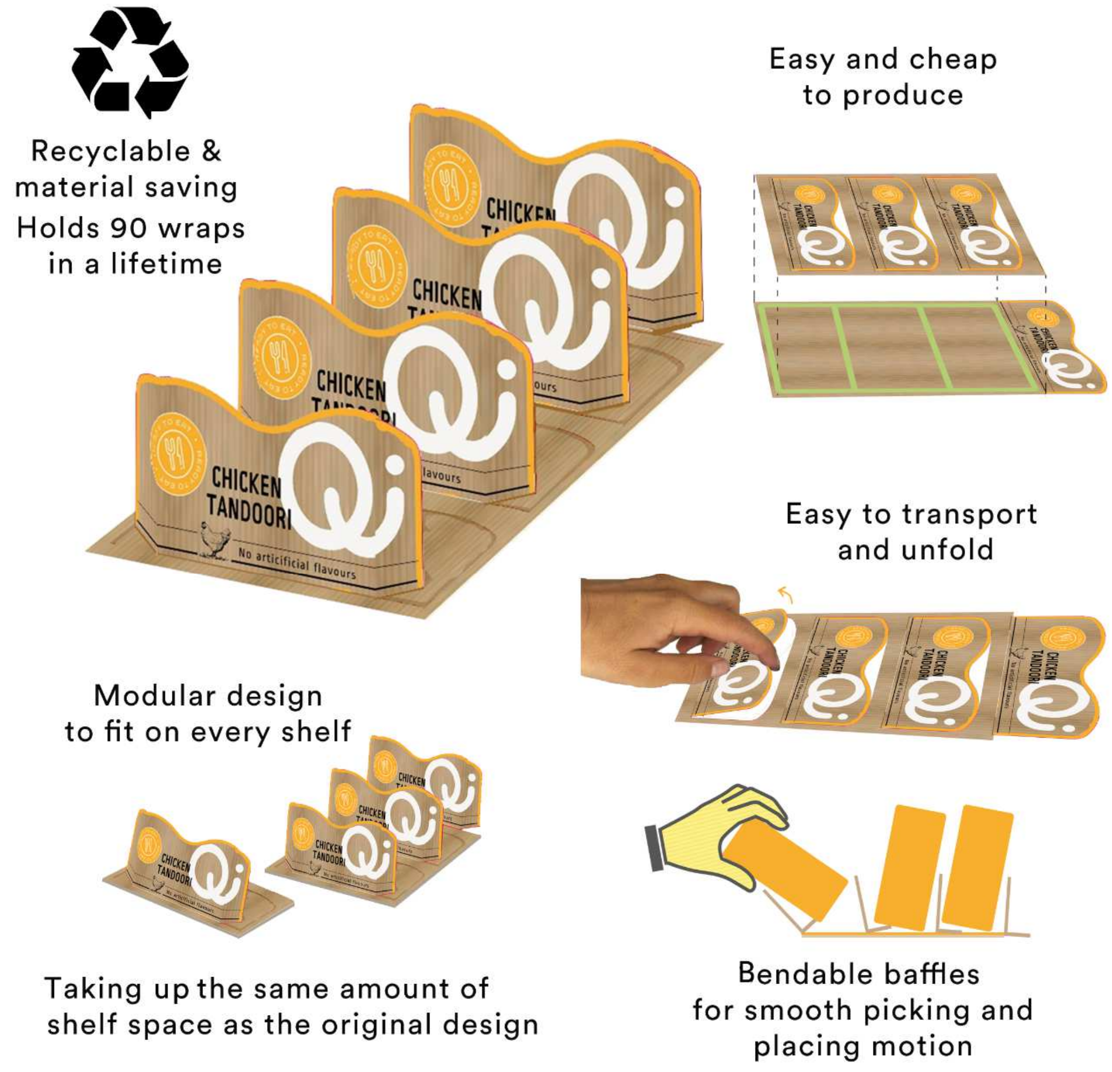

Figure 16: A brief overview of the designed alternative packaging following the solution concept

1.

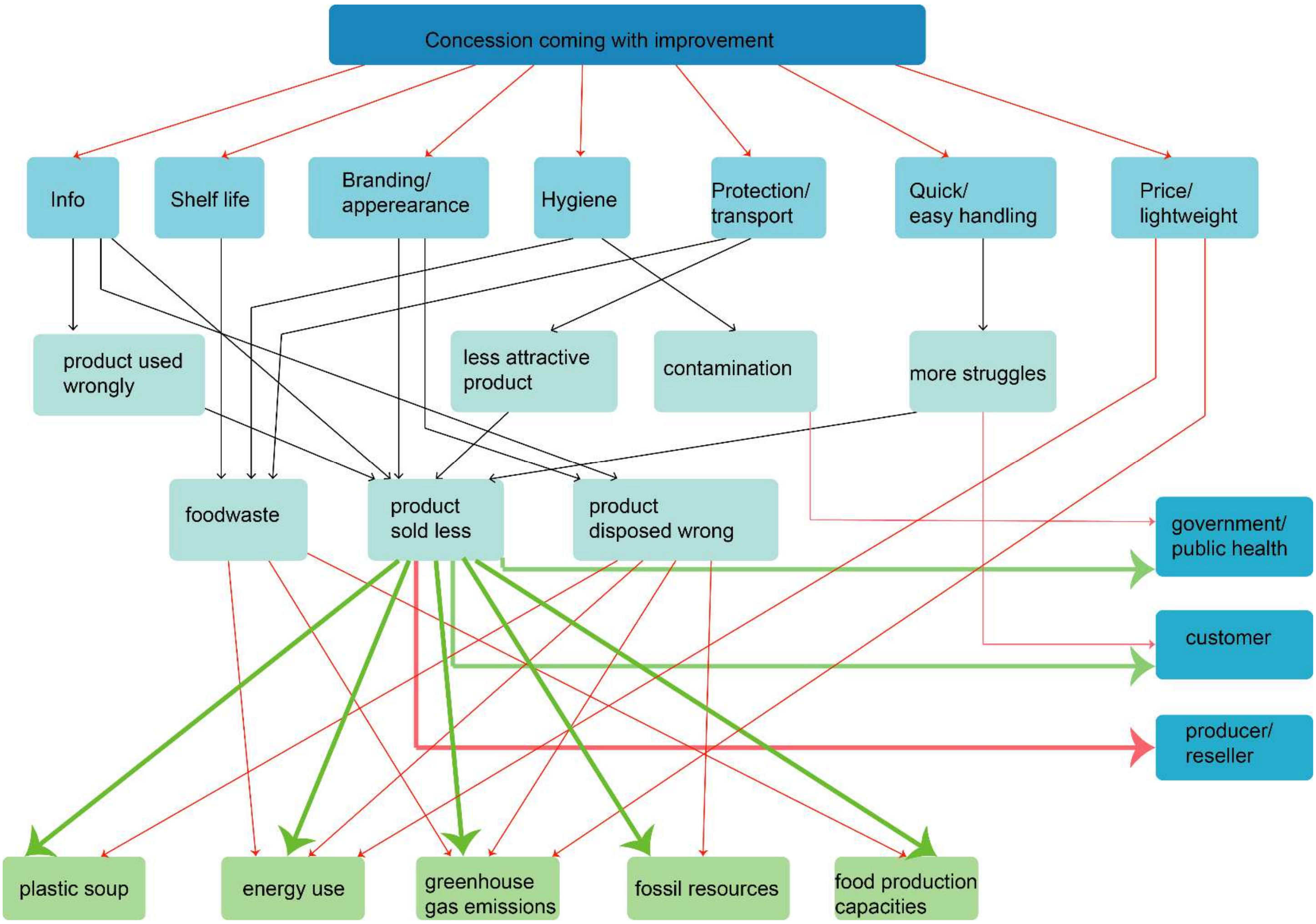

Figure 17: The test design results in less negative impact on the environment, even if it would involve a concession on the presentation function, since malfunctioning in this area will lead to even less negative impact on the environment.

4.6 Testing the test example and iteration until potential has been shown

The verifying tests provide insights about the consumer's perception and preferences concerning the new packaging design compared to the original BAU scenario design by means of qualitative research. A detailed description of the approach and outcomes of these tests as well as the subsequent iteration and tests are presented in Appendix H.

4.6.1 Testing the initial test packaging

In the initial test packaging, the graphic elements of the Qizini packaging design are copied as much as possible for the sticker on the disposable part to keep these variables constant. For this design, insights are gathered in two different ways: by means of a give-away test and a focus group.

In the give-away test, participants are provided with wraps during an unrelated presentation. Being unaware of the test scenario, they are presented with the same type of wraps in three different ways: 1) In the original BAU scenario packaging 2) In the initially designed packaging including the reusable tray 3) In the initially designed packing without the reusable tray. Figure 18 shows the setup.

Participants walked by the table on which the wraps were presented and could take one wrap before or after the presentation. The order in which the wraps are taken was used as an indication for which wrap packaging people unconsciously preferred. After the give-away test, three volunteers from the give-away test group participated in a focus group to discuss the different types of packaging. One person

Figure 18: the setup of the first give-away test

from the focus group had also taken a wrap during the give-away test.

All outcomes considered together, the give-away test and the outcomes of the focus group suggest the original BAU scenario design is predominantly preferred by consumers over the initially designed test packaging.

A main finding is that consumers seem to only see the part of a package that can be taken out of the store as a part of the product. So in their perception, the presentation tray is not a part of the product and thereby not adding a luxurious feeling to the product.

Based on these outcomes, in the subsequent iteration the sticker on the disposable part, which can be taken out of the store, is redesigned. In this adapted design, the tray still fulfils a presentation function in placing the wraps in the upright position and adding a brand experience, while the luxurious feeling is created by the specific sticker design.

The sticker in the new design does not use the graphic elements of the Qizini packaging, but mimics a sticker design often used in fresh departments where products are finished and packed on location. This sticker design is shown in Figure 19. If this design would be implemented, the sticker would be pre-printed before packaging the wraps in a factory, however, it looks like it is printed on location, which results in a more luxurious freshly made on location product impression.

4.6.2 Tests after iteration

For the next iteration, insights are gathered by means of a new give-away test and focus group. This time, the give-away test is done in a more realistic store environment and followed by a small interview for every wrap taken by a participant.

In the give-away test, coffee and food retailer Coffee-Star kindly facilitated the test and placed the BAU scenario packaging and the new packaging design after the last iteration on their shelf between other products. This is shown in Figure 20. People who were walking or sitting close to the, on the TU Delft campus located, store, were asked to participate in a research by answering some questions in return for a chicken tandoori wrap voucher, valid at the Coffee-Star. After asking a few unrelated questions about the TU Delft campus to hide the actual goal of the research, people were suggested to get their free wrap right away since there are not so much wraps anymore.

After the unsuspecting participants unconsciously selected one of the wrap packaging designs and walked to the counter to redeem their voucher, they were surprised to meet the interviewer again and were asked to answer a few questions about their packaging choice in a short interview. All except one of the participants avoided the BAU scenario packaging and unconsciously picked the new packaging design. In the interview, they gave various reasons for their choice such as more sustainable packaging, looks more fresh, looks bigger, looks smaller, and looks more delicious.

The following focus group featured participants talking about the BAU scenario packaging and the new design who had never seen these packaging designs before. This yielded interesting insights on how the new package design is perceived as more basic and less luxurious, while the product itself is perceived as more fresh.

The outcomes of a new give-away test, the consumer interviews afterwards and a second focus group suggest the test design is, after the iteration, predominantly preferred over the original BAU scenario design. Moreover it has the potential to successfully shift the presentation function, achieving sales results that will not cause a decrease in profit.

Figure 19: The sticker design after the iteration

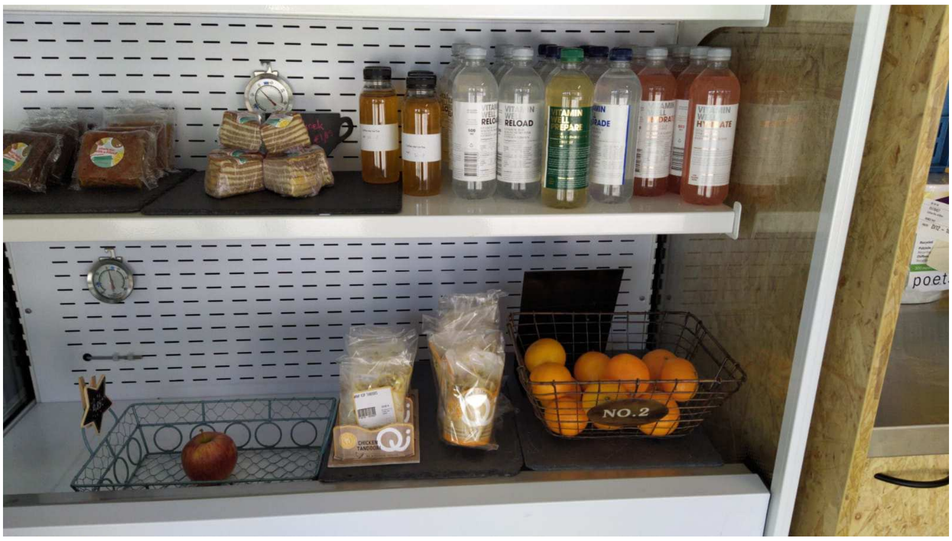

Figure 20: The wraps are placed between the other products at the Coffee-Star

Chapter 5

Conclusions, discussion and recommendations

Extending the search for solutions

This chapter summarizes the findings of this study and discusses the void finding process and future usefulness of the approach created. Recommendations are given at the end of the chapter.

5.1 Conclusions

This research started out from the following thesis statement: *There are still useful undeployed solution spaces that are overlooked in the past decades in finding solutions that contribute to reducing the negative environmental impact of on-the-go food packaging.*

A solution space tree was created, uncovering undeployed solution spaces. After selecting one of these undeployed solution spaces, a solution concept was created and tested by an example test application. The new solution concept showed its potential.

Thereby, at least one void was found by using the solution space tree. The tree might contain more voids, but it would take more research to find and verify those. The void finding process could be repeated, since now only one solution direction has been selected and investigated. Chances are small this was the last and only void to be found. So it was concluded there must be other useful undeployed solution spaces yet to be discovered.

The created packaging concept plays both ways: by being part of the theoretical void finding process in verifying the overview *and* by being part of a practical solution in reducing the amount of single use material. The application of this concept can be explored further in future research.

5.2 Discussion

This discussion will be concerned with the process of void finding and the possible future usefulness of the approach that was created by combining techniques from different engineering fields. A reflection will be given on the mapping of the solution spaces and the use of the resulting solution space tree for concept creation. Subsequently, the final selected solution concept as well as the not selected concept within the function separating solution space will be addressed concisely.

The reusable tray design, derived from the selected solution concept, and the verification of the user test processes will be discussed briefly. A more comprehensive discussion on these implementation details can be found in their corresponding Appendixes G and H. At the end of the chapter, the wider picture of the on-the-go food packaging waste issue will be taken into account.

5.2.1 Finding voids

Considering that the waste issue has already been the subject of extensive research for many decades, adding an innovative solution with potential to the whole spectrum of investigated solutions seems not a promising project. It is not difficult to become sceptical about societies' powers and possibilities to overcome our problems when diving into this topic. By mapping solution spaces and showing there are indeed new solution spaces to be discovered, hopefully this project contributes to a more positive perspective and attitude by demonstrating it is worthwhile to search beyond existing solution directions.

A new more comprehensive approach to problem solving through design is created, going beyond the borders of industrial design engineering, combining techniques from different fields of engineering. Mapping solution spaces as shown in this project can be seen as a pre-procedure to narrow down overlooked solution spaces, before continuing with a more traditional design solution finding approach within the chosen solution directions. A pre-procedure that is not always necessary, but can be utilized for complex issues, including issues other than the on-the-go food packaging waste problem that demand a thorough approach.

To be able to find actual voids by making a solution space tree, a sufficient number of levels need to be created. Simply covering the entirety of solution spaces with general directions in the first layers only helps with not overseeing 'branches' of the tree but is not uncovering anything yet. The general solution spaces that form the base of a 'branch' need to be divided into areas detailed enough to uncover undeployed solution spaces within the 'branches'. What level of detail is necessary depends on how much work and research has already been done in a certain are or 'branch'. When to stop with adding more layers to the tree is based on intuition. For this project the amount of detail in the tree appeared to be enough to find a void.

Since not all layers of the tree emerge from pure logic, layers more towards the bottom of the tree are likely to collectively not cover the entirety of solution spaces. Thus the solution spaces tree will never uncover all voids, no matter how many layers are added for every 'branch'. This is not a huge drawback since creating a tree has shown to still be effective in finding voids. Many different users can apply the technique and get a different outcome, uncovering different voids every time.

This project aimed to find voids between the undeployed solution spaces. The solution space tree does not only contain undeployed solution spaces, but extensively deployed solution spaces as well. Because of the clear overview and identification of these solution spaces the overview offers, the solution spaces tree can also be used to find and not overlook new solutions within deployed solution spaces. These will be less innovative, but small sensible adaptations to existing solutions can add value as well.

Another step that could add great value is looking for a systematic way to map possible worthwhile combinations between solution spaces. Many solutions are based on a combination of solution spaces, such as the developed selected solution concept, which reduces impact by reducing the amount of used material, but also creates prospects for improved recycling of the applied presentation material.

5.2.2 Function separating solution concepts

Two concepts within the separate packaging functions solution spaces are created from which one is selected to verify its potential. For verifying, the solution concept had to be applied in a specific way on an example product. It could be argued that the solution concepts are solution spaces as well, since the concept can be executed in multiple ways. Within concepts, there is no hard line between solution spaces and solutions. Only an applied solution can be seen as purely a solution since applying in the real world means taking conscious or unconscious decisions on all details.

The concept's potential of shifting the presentation function from the single use packaging to a reusable tray was shown by qualitative research. This implies chances are that the concept will be successful if actually implemented, but this has not been proved yet. Further tests and pilot studies can give more assurance while only implementation can provide proof. So a limited chance remains that the found 'verified' void is not a void after all.

5.2.3 Tray design and testing

Much attention to detail was spend for the embodiment of the test packaging design. By lots of iterations, a design was created meeting all requirements while using only two pieces of printed and glued cardboard to make profit enhancing implementation realistic. Although various aspect such as the exact used carboard folding technique and the prevention of possible unwishful movement of the tray relative to the shelf, could be further investigated and optimized, the design is regarded as developed far enough to serve the purpose of verifying the concepts potential.

The qualitative research in which the embodiment was used did not only verify its potential, but also resulted in general valuable insights about consumers, which can be helpful for future development of other products.

The fact that products might be perceived as more fresh when they carry a sticker that appears to have been printed on the selling location, for example, can be further investigated by parties who could benefit from this knowledge.

Pictures of the prototyped test design and the Qizini packaging show a difference in colour in the graphic design, due to printer anomalies. Flaws like these might have had an influence on the outcomes of the tests. A more comprehensive discussion on the embodiment and qualitative research details can be found in their corresponding Appendixes G and H.

5.2.4 Towards solving the society's waste problem

Food packaging creates a much smaller negative impact on the environment than the production of the food it contains. It is estimated that one third of all produced food on earth is not consumed but lost somewhere in the food chain (Gustavsson, 2011). The negative environmental impact of food waste can therefore be seen as a much bigger concern, while more packaging could in fact be a positive contribution for the environment as it can prevent food losses. Yet, the negative impact of food packaging should not be neglected. This becomes more evident when taking into consideration that especially within on-the-go products, the package is not only there to prevent food waste.

To make the solution finding process manageable, as discussed in section 3.2 and 4.1, the scope of this project was narrowed down to looking at just the possibilities within current society within the expertise of industrial design engineering. But the problem, of course, goes much deeper than that. The on-the-go food packaging waste problem can be seen as a symptom of Western society's attitude. People crave for instant satisfaction, little moments of happiness within a rushed life. On-the-go food products are excellent in providing this much wanted activation of the brain's dopamine reward system. It is deemed normal for producers and retailers to make profit by providing these products, even if this results in being unbeneficial for society as a whole. Only if their customers show they do not accept the situation by not buying their products, alternatives are offered. It requires awareness and a strong mind to resist the attractive offers of instant pleasure the food products provide. The real fix is not treating the waste symptoms but changing societies standards and values.

5.3 Recommendations

The created solution space tree uncovers multiple undeployed solution spaces, but could uncover even more if the tree is complemented by people from different backgrounds. Added background knowledge from different areas will lead to more detailed solution spaces in those areas. These spaces could be defined using contributions from a variety of scientists as well as others, including doctors, policy makers, lawyers, engineers, special planners, philosophers, artists, historians. marketeers, teachers, etc. Their input can be gathered by anyone who is interested in complementing the solution space tree.

In this project, one solution space is selected from the solution space tree for concept creation by a number of different steps as described in Chapter 3. To find more innovative concepts, this process can be repeated in further studies. When using this method in other fields, it is important to go through the whole process again, since every step, wether this is curbing down complexity or complementing the tree, is carried out from the perspective of the person who is performing these steps. Using created overviews or even solution directions created by others is only advised if the focus matches exactly.

Even though it is important for every project to establish enough detail in the solution space tree for the specific directions in which solutions are going to be created, the created tree in this project can be reused as it is. And not only by industrial designers, because this tree can be used for inspiration and widening views on the (on-the-go) packaging waste problem. The poster, that comes with this report, can be put up in a prominent spot, wherever people are involved in solving this issue in their own context.

The newly created approach from this project can be used to map solution spaces for a variety of issues other than the waste problem focused on by this study. Examples would include rising obesity rates, the food waste problem, socially isolated population groups, mass migration, demographic ageing and other problems that provide challenges for the future.

The solution concept's potential of shifting the presentation function from the single use packaging to a reusable tray was demonstrated by qualitative research. The test design itself can be used as a starting point for further development and implementation of this solution. Companies can explore the implementation possibilities of the solution concept to see which of their products could be good candidates for application. In the on-the-go sector, all overpacked products, prepacked sandwiches, ice coffees, lunch salads, sturdy fruits and vegetables and premium yoghurts would be highly suitable as a starting points for this exploration.

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