

03-06/2022

INNOVATIONS TO REDUCE FOOD WASTE

WORKER BEES

GREGORY HAMMOND, ALEXANDRA OTTO, ISABEL TORRAS ASPA, MARCEL
KOLASINSKI, MOHAMED YOUSSEFI, MILLA RÄTY

Table of contents

1	Abstract	2
2	Introduction	2
2.1	Meet the worker bees	2
2.2	The Queen bee	2
2.3	How might we.....	3
3	Collection	4
3.1	Research	4
3.2	Analysis of existing Solutions	6
3.2.1	ResQ	6
3.2.2	Matsmart/Motatoes	6
3.2.3	Fiksu ruoka Oy.....	6
3.2.4	Rettermarkt / Glücksstein.....	7
3.2.5	Food sharing Mannheim	7
3.2.6	„Die Tafel“	7
3.2.7	Zu Gut für die Tonne	7
3.2.8	Crowd farming.....	7
3.3	Interviews.....	8
4	Communication.....	9
5	Recycling	10
6	Conclusion.....	11

1 Abstract

The international product development project is a cooperation between the Design Factory at Häme University of Applied Sciences and inno.space at Mannheim University of Applied Sciences (a local Design Factory). The goal of this course is to form several (this year three) multinational teams to develop prototypes according to the client's requirements. During this course, students learn to work in teams, to use design thinking as an innovative development process and to develop human-centered products. The teaching team guides students throughout the course and is available to provide tips and assistance. In this report, we will discuss our insights into food waste, our approach to the topic, and the shortcomings of our product. We will also report on our findings, insights, as well as the data we found through outside research. We will also present an analysis of existing food waste reduction apps and their unique selling points. We will then explain the interview results and the prototype developed from them. Finally, we will elaborate on the insights we gained through our prototype and thus provide recommendations for the further development of a food waste reduction system.

2 Introduction

Creation and innovation are often lengthy processes with only small successes after many failures. That's why we need the inspiration of those who came before us. Those who have mastered their craft, who have achieved a level of perfection that we can only dream of. Our inspiration is the honeybees. These masters have perfected the craft of nutrition. In every way, they surpass us humans. The honeycomb is the perfect form for scalable storage. Their food has an unlimited shelf life. Therefore, nothing is ever wasted. Unfortunately, we humans cannot create such ideal ecosystems. Human supply chains and distributed systems are long, complicated and messy. Therefore, it is not surprising that many products end up in the trash before they reach the end consumer. While there are many industries where this happens, in none is waste more prevalent than in the food industry.

2.1 Meet the worker bees

We are six aspiring worker bees hoping to change our ecosystem to one with less food waste. We come from two schools and six different majors. Isabel is studying Smart and Sustainable Design at Häme University of Applied Sciences (later HAMK) and Alexandra is a Process Engineering student at Mannheim University of Applied Sciences (later HS-Mannheim). Then we have Simon, who is studying International Business at HAMK and Marcel, who is studying Industrial Engineering at HS-Mannheim. Milla is studying Mechanical Engineering at HAMK and Gregory is studying Computer Science at HS-Mannheim.

2.2 The Queen bee

Our sponsor, Weber Packaging GmbH, is a family-run trading company for food packaging. Right at the first meeting, the Weber brothers explained to our team that the goal of this project is nothing less than reducing or adding value to food waste. No easy task. We began brainstorming on the idea, conducting interviews, and gathering other research information on the topic. We also wanted to do some competitor mapping. There are already several charities that give food waste to those in need, so we needed to make sure we weren't competing with them.

2.3 How might we...

The team started to tackle the challenge by defining three How might we -questions. They were the following: How might we reduce food waste? How might we create a platform for users to exchange food? How might we enable food upgrading? All three questions are huge, the topic itself is huge to tackle. Nevertheless, we started by making interviews and research across the food sector. We made similar questions to store owners, employees, restaurant owners and consumers, in Finland, Germany and Spain. The answers were kind of similar but then again nothing alike. Most store owners denied having any problem with the food waste. In Finland many store chains are keeping a ranking list on the matter. This helps to reduce food waste. What we learned from these interviews was not unambiguous and our original idea was to innovate a prototype for the B-to-C sector. After discussing with the sponsors, we decided to go to another direction and build a platform which would connect store owners, bakeries and butcheries to the restaurants and food trucks via a mobile application. The outcome of the interviews is seen on the Appendix 1.

3 Collection

Honeybees collect pollen and nectar as food for the entire colony - this is how we see our research. The design thinking tool we've used in this process is called the Double Diamond, and it encourages discovery, definition, development, and delivery.

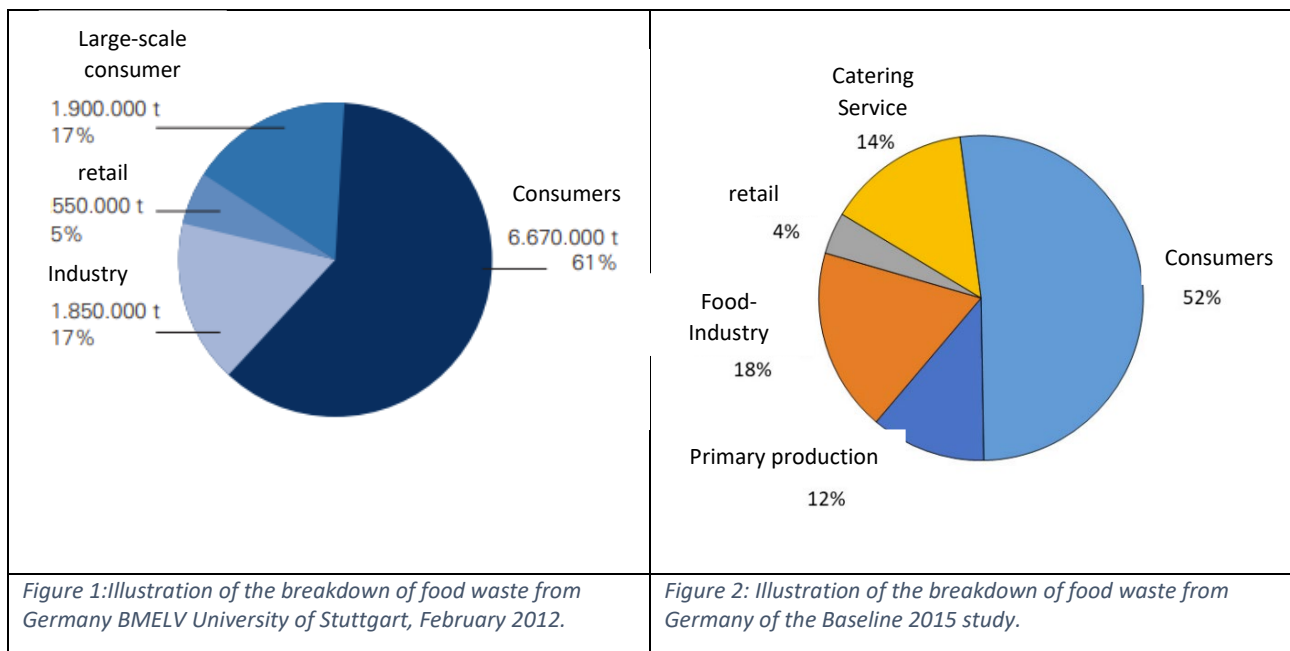
3.1 Research

At the beginning was the research. Similar to the start of every project. The intention of it was to get a general understanding of the waste situation in Germany. For this purpose, the most recent studies regarding food waste were examined.

We got our main information's from one Paper. 2015 - 2019 were the Thünen Institute commissioned by the German Federal Ministry of Food and Agriculture. Their aim was to determine the quantity of Food thrown away in Germany. These Institute bildete eine Kooperation mit der University of Stuttgart Institute for Sanitary Engineering, Water Quality and Waste Management, which already conducted in 2012 a study of food waste with the aim of developing proposals on how to avoid it.

The background of the Baseline study is the EU Waste Framework Directive 2008 and the Implementing Decision (EU) 2019/2000 of 28 November 2019. Every Country of Europe must record his FoodWaste and send a report to the EU until 30/06/2022. After this date, the reports must be annual.

The Summation of food waste was divided into five sectors. Consumers, Catering Service, Primary production, Food-Industry and Retail. The results of the total amount of waste from both studies are shown in Figure 21 and Figure 1.



In 2015, the theoretically avoidable share of food waste from households was around 2.69 million tons (excluding sewerage), of which around 2.21 million tons were disposed of via the municipal waste collection system. Converted to the German population, the food waste volume was approx. 75.2 kg per inhabitant in 2015, of which 32.9 kg could theoretically have been avoided.

It should be noted that the collection of data for both studies cannot be complete due to large data and knowledge gaps and the results are therefore rather a rough estimate. However, it is quickly apparent that both studies came to the conclusion that trade only causes 4-5% of the total food waste. It is important for our interpretations to know how the data are created. Figure 3 shows the total sources of the data. The information on individual traders came from direct measurements at individual supermarkets, as well as counts within a supermarket chain. In the retail sector, surveys and coefficients were also compiled in cooperation with relevant stakeholders.






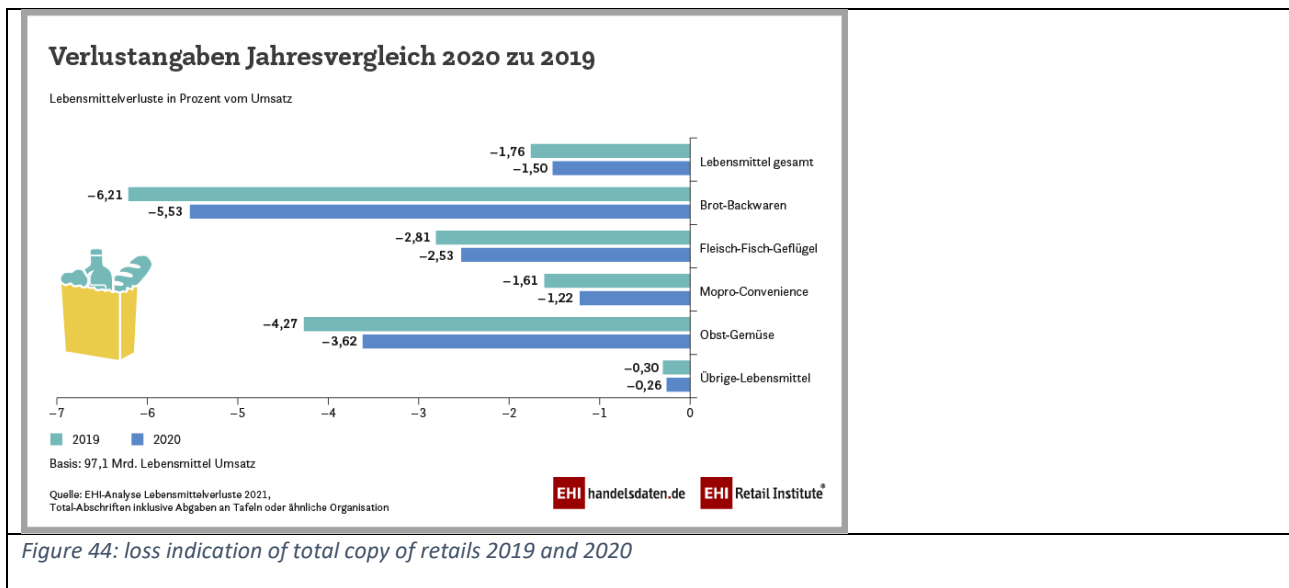
Messmethoden					
Direkte Messung			✓	✓	✓
Massenbilanz	✓	✓			
Analyse der Zusammensetzung der Abfälle				✓	✓
Fragebogen und Befragungen		✓	✓		
Koeffizienten und Statistiken zur Erzeugung	✓	✓	✓		
Zählung/Scannen			✓		
Aufzeichnungen				✓	✓
<input checked="" type="checkbox"/> Angewendete Zulässige Messmethode <input type="checkbox"/> Unzulässige Messmethode					

Figure 3 3: Source: Own illustration, in accordance with Annex III to the draft DELEGATED (EU) ... / ... COMMISSION Decision supplementing Directive 2008/98 / EC of the European Parliament and of the Council with regard to a common methodology and minimum quality requirements for a uniform measurement the volume of food waste from May 3, 2019.

The EHI commissioned its own study due to the bad repute following the documentary Taste the Waste, which spoke of 20 million tons of food waste generated in Germany. This study categorized the waste produced. As was to be expected, baked goods and fruit and vegetables are among the most discarded foods. In total, it was stated that 1.5 of all food sales are donated to Foodbanks or end up in the garbage can.

The figures of the study commissioned by the retail sector are significantly lower than those of the BMEL. However, both studies show a very low food loss in German supermarkets. But we remained critical, since even the figures of the BMEL studies indicate reported data gaps and the result of a study can be influenced by its commissioners. (Figure 4)

There is also a diagonal matrix about this issue in the Appendix (2).



3.2 Analysis of existing Solutions

As there is competition between honeybees and wild pollinators in a way that if there is a certain number of flowers in the area, these can only feed a certain number of pollinators at a time. Well, competition is not always a bad thing since it can help people innovate even more ideas. But sometimes as in the world of honeybees when the nectar and pollen isn't available anymore, it's just too late.

The concept of food waste and the desire to reduce it are not new. Another important part of our analysis was a thorough examination of existing products and tools that companies, and nonprofit organizations have implemented to address the problem. Below we will provide a brief report on such tools.

3.2.1 ResQ

ResQ was founded in Helsinki, Finland in early 2016. It acts as a channel for consumers to "rescue" leftover food from restaurants and supermarkets at a cheaper price. Today it operates at some level also in Sweden, Estonia, Poland, and Germany. Through this app 300 meals are being sold every day and there are over 500 000 registered users in which about 10 000 are purchasing. This truly is a business-to-customer solution that works.

3.2.2 Matsmart/Motatoes

Matsmart was founded in Stockholm, Sweden in 2013 by three friends who got sick of food waste. They started their business together packing up supercheap food deliveries in the middle of the night. In 2017 this spread to Finland and more people took part in this revolution. Matsmart sell stuff that would otherwise be thrown away for overproduction, faulty packaging, seasonal trends or short/sometimes passed best-before dates. It saves the products and sell them at super discounts. And it operates online only. This inspiring operating model is in use in Sweden, Finland, Denmark, Germany, and Great Britain. Only in Sweden and in Finland it is called Matsmart, elsewhere it has a different name – Motatoes.

3.2.3 Fiksu ruoka Oy

Fiksu ruoka Oy was founded in Finland in 2016 and it is basically same as Matsmart. They have a goal of reducing the amount of food waste in Finland and at the same offer their customers wide range of affordable food and consumer goods. Their selection mainly consists of depreciation items, which they buy from Finnish manufacturers, importers, and wholesale chains.

3.2.4 Rettermarkt / Glücksstein

The Rettermarkt was opened last year on the 23rd of April. The owners of the market are Nicolas Rodriguez, Roman Kress und Björn Moschinski. The special thing on this supermarket is that it only has products which nobody has in his supermarket because of due dates or other reasons. Also, they only have vegetarian and vegan articles because one part owner said that the people should trust on their senses (smelling, tasting, looking) before they eat a product of the Rettermarkt and that animal products haven't got such a long duration of freshness. Products which don't get sold in the market will be used in the Glücksstein kitchen, so nothing gets through away. The Aim of them is to through food as less as possible away.

3.2.5 Food sharing Mannheim

Food Sharing Mannheim is a non-profit WhatsApp group with over 220 persons. People have the possibility here to share their food with other persons for free. The process is that People send in the group a picture of their food and where and when it's possible to pick it up. If someone is interested, you need to write a private message to the person. If it's still available, you can easily pick it up.

3.2.6 „Die Tafel“

The Tafel is a non-profit organization that aims to reduce food waste and help those in need. It belongs to and is run by the DRK. Each year, around 265,000 tons of food are rescued and given to over 1.6 million people. The distribution and collection of food from wholesale markets, producers, the food industry, speditionslager and retailers is done by volunteers. There are food distribution points in 950 cities. In Mannheim alone, 100 supermarkets are approached and thus 2.5 tons of food are collected per year. In 2022, this means that 5500 people will be regularly supplied with necessities. Of these, 600-800 kilos must be sorted out, as they can no longer be passed on. 60% of the collection is food with a short shelf life and comes from retail stores. 40% of the collected goods come directly from large-scale industry.

3.2.7 Zu Gut für die Tonne

“Zu gut für die Tonne” - “Too good for the garbage can” is a German initiative driven by the cooperation of the German Federal Ministry of Food and Agriculture and 7 food and agricultural industry associations. In 2020, a common goal was set to reduce food waste per capita by half by 2030. The strategy to achieve this goal is primarily an information campaign. Citizens are to be educated about proper food storage and shopping behavior, and new standards are to be set for what is still usable food and what is truly no longer edible waste. The initiative sees four major points of action, where food waste can be reduced.

1. Changing the political landscape, so that future boards can cooperate better.
2. Process optimization in industry
3. Evoke behavior changes in all participating actors
4. Raise potential research and digitalization.

3.2.8 Crowd farming

Crowd farming is a solution for agriculture created by farmers. It is a platform that enables producers to establish direct contact with the end consumer and avoid middlemen. Through sponsorships, producers can better estimate the demand for fruits and vegetables and can produce according to demand. It is also part of the philosophy of the platform that "ugly fruit and vegetables" do not end up in the garbage can or back on the field because of their appearance but are passed on to buyers as a natural product.

3.3 Interviews

In the second part - the exploration - we conducted several interviews with consumers, retailers, and catering service providers. We conducted the interviews mostly as face-to-face interviews, with some exceptions as email questionnaires. As for retailers, the team conducted a total of 13 interviews in Finland, Germany, and even Spain. With catering service providers, there were not as many interviews, less than 10 in total, but they all more or less said the same thing: they want fresh food for their customers. After we decided to focus on the business-to-business platform, we reduced the consumer interviews to 9. In short, retailers don't see food waste as a big problem, even though the data might prove otherwise.

In Finland, many supermarkets use the so-called ranking system. This system is a competition between stores in the same chain. The stated aim of this competition is to reduce waste of all products offered. Store owners are encouraged to find individual and innovative solutions to reduce food waste in their store. However, due to the diversity of many stores in Finland and the effective gag order on internal policies, further investigation of the matter was stopped. Questions such as actual efficacy. Policies. Multi-store cooperation and many more were left open. As such we can only rely on reports given to us, which we as researchers must always take with a grain of salt. The reports show implemented measures to be quite effective, only amounting to 16% of the yearly total national food waste of 360 million kilos.

In Germany the amount of yearly national food waste in supermarkets is 4% per year out of 12 million tons. While these numbers are by no amount small, it is far more important to address the largest part of the food waste pie chart. Us.

What did we gather from the retail point of view? They want to save money – obviously and the best quality is a fresh quality. The story behind all interviews throughout retail section was the same, food waste is not something to be talked about. It is something that is handled in the background and not brought to daylight. If there is some food waste, it is donated to charities. Most of the stores tend to have an AI controlled purchase solutions that prevent too much food waste piling up.

We also wanted to interview the other end – catering services that might possible be the customers for our application. On this end the verdict was clear, nobody wants to sell possibly rotten food. Most of the restaurant owners take pride in offering good quality dishes from fresh ingredients. Even though some of the 'best before' foods might still be usable, it is still a risk. Catering services live by their reputation and selling food made from ingredients, that even consumers don't always want to buy, is not doing wonders to them.

On the other hand, in the early stages of this course, we surveyed some consumers who said they were taking action to address their food waste. These statements are at odds with data indicating that consumers in Finland and Germany contribute the most to the food waste problem; perhaps we just got lucky with these vigilant consumers.

We did not expect it to be so difficult to get the answers. We had difficulty contacting the right people and getting truthful answers considering the amount of food waste we expected. On the other hand, when we asked the food banks, charities and churches that rely on these donations, we found that there was reportedly not enough food. So what is the conclusion? There are a

handful of political factors at play. Reputation is more important to many markets than food waste and easy costs of devaluation. You'll be lucky to get an honest answer, and most of the time you won't.

The define part of this project concentrated on mostly defining the problem on the business-to-business side so our prototype, a platform between the retail and catering service side could be innovated. The next parts – develop and deliver – are explained in the communication part of this report.

4 Communication

Bees communicate throughout the hive. Precious new nectar spots are celebrated with a dance. As such communicating with our fellow partners is key to reduce food waste. We developed a prototype, a platform that could establish connections and blossom into a network of food savers.

The basic idea behind our platform is to connect the retail and catering services easily and effectively. The first application was made in marvelapp.com and that was further developed into our final prototype via Figma.

The application needs the user to sign in as – for example - a store owner (to offer products) or a restaurant owner (to buy products). After that you will see a homebase with all the possibilities that the application has to offer. And how you can either buy or offer food. You can see these features in the pictures (5).

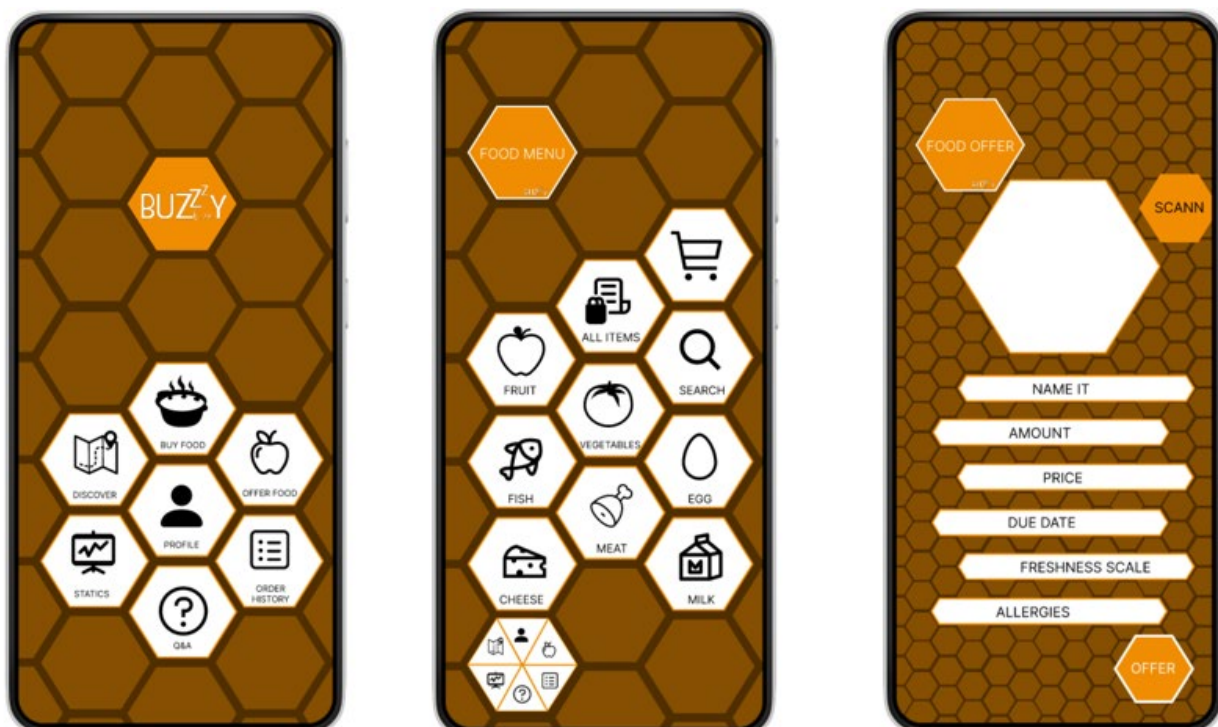


Figure 55 - Homebase, buy food, offer food

The design behind the application is consistent with the honeycombs of the honeybees. This idea innovated from the logo and colouring of our sponsor Weber Packaging GmbH. We wanted to make this platform easy to understand and navigate. The feedback that we got from the

application was positive even though not so many saw a need to it. It was said to be beneficial to have an option to take a picture of a offered product so you would actually see the state of it.

In Finland there is an application called ResQ in use which offers food at a cheap price from the stores and restaurants to the consumers. It is pretty popular at least in the bigger cities and it prevents food waste. The idea is just as simple as ours – you have food that is close to ‘best before’ state and you upload it to the app. Consumers can then buy it for cheaper and everybody wins. We wanted to make this but for b-to-b side.

As the final stage of Double diamond – deliver – we didn’t quite succeed. After prototype testing the verdict was clear – this application, platform between the stores and restaurants – it would not be used. At least not at this stage. But the beauty of developing new things is to innovate, build, test and then repeat.

5 Recycling

However, being inspired by the honeybees that don't even have a bit of food waste, we came up with an additional solution. One of our first idea revolved around a smart refrigerator. This later evolved into the innovation called Food Lockers.

Even though we had our sponsor Weber Packaging GmbH, we were originally supposed to be sponsored by another project which was also involved in the latter half of our project. The SWAP project called ATTRACT is a partnership between CERN and CSEM and developed new ways to use fluid parameters with simple tube segments for use on Earth and in space. For us, this means that this type of technology could be incorporated into food cabinets to provide tailored temperatures. You can read more about this project in Appendices 2 and 3.

The idea behind the food cabinets is simple. Since many store owners feel they don't have as much food waste, it would be beneficial for them to use these lockers. Let's say the local store has two loaves of bread, a few pounds of fruits and vegetables, and three packages of meat - all of which must be consumed before tomorrow night. Instead of throwing this food away, how about taking a picture, uploading it to the website, and having it delivered to the conveniently located food pantry in town. Then the consumer, always in a hurry and looking for a bargain, sees the products, clicks them into his virtual shopping basket and pays for them (at a considerably low price). In return, he receives a code for the grocery closet and can pick up the products on his way home from work, perhaps at a time when the store is already closed.

The next morning, a person with the AdminID for the food cupboard checks for any unsold items, how long they have been there, and throws them away if necessary. In this way, the amount of actual food waste is reduced without compromising reputation (since you, the consumer, know what you are buying), without taking away food that is donated to local food banks/charities/churches, or without drawing attention to the fact that food waste occurs in these stores.

And with the help of this new technology from ATTRACT, each individual locker will be set to the perfect temperature to prevent food from spoiling. In the long run, this could create new jobs, such as delivery people, someone to take care of these machines, administrative staff, etc. Of course, there's also the issue of packaging these products. We don't want the world to drown in

plastic waste, so alternatives must be sought. Fortunately, there are many new innovations in this area that could be used instead of plastic containers. But that's a fight for another project for another day.

6 Conclusion

As we have shown, the project was burdened by a variety of issues, many of which were outside the domain of the traditional design thinking process. Many of our potential stakeholders on the supermarket side were uncooperative either because of internal company policies, shame about their own shortcomings, or fear of reputational damage. Restaurant owners, our other main potential stakeholders, flatly refused to consider our product, arguing that such a tool would provide them with only marginal benefits while posing a tangible risk to their business. In summary, it is not denial of the negative impact of food waste that people are rejecting. Rather, many simply accept food waste as a byproduct of maintaining a manageable workflow. Stakeholders fear that by implementing food conservation measures, their company may suffer from logistical problems, such as food not being available when it needs to be reordered or food simply not being up to standards when purchased. The ongoing problem of storage and refrigeration is not a technical problem, but a cost problem. We would like to point out these concrete problems that account for the failure of our prototype:

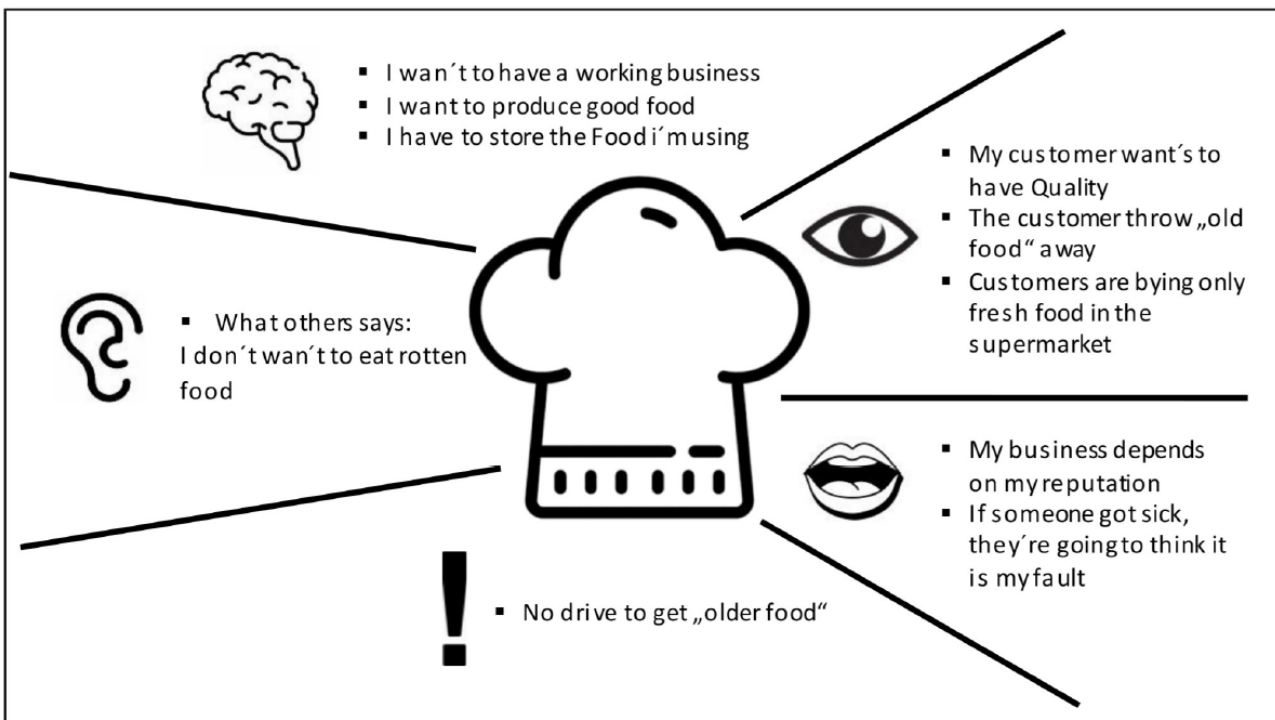
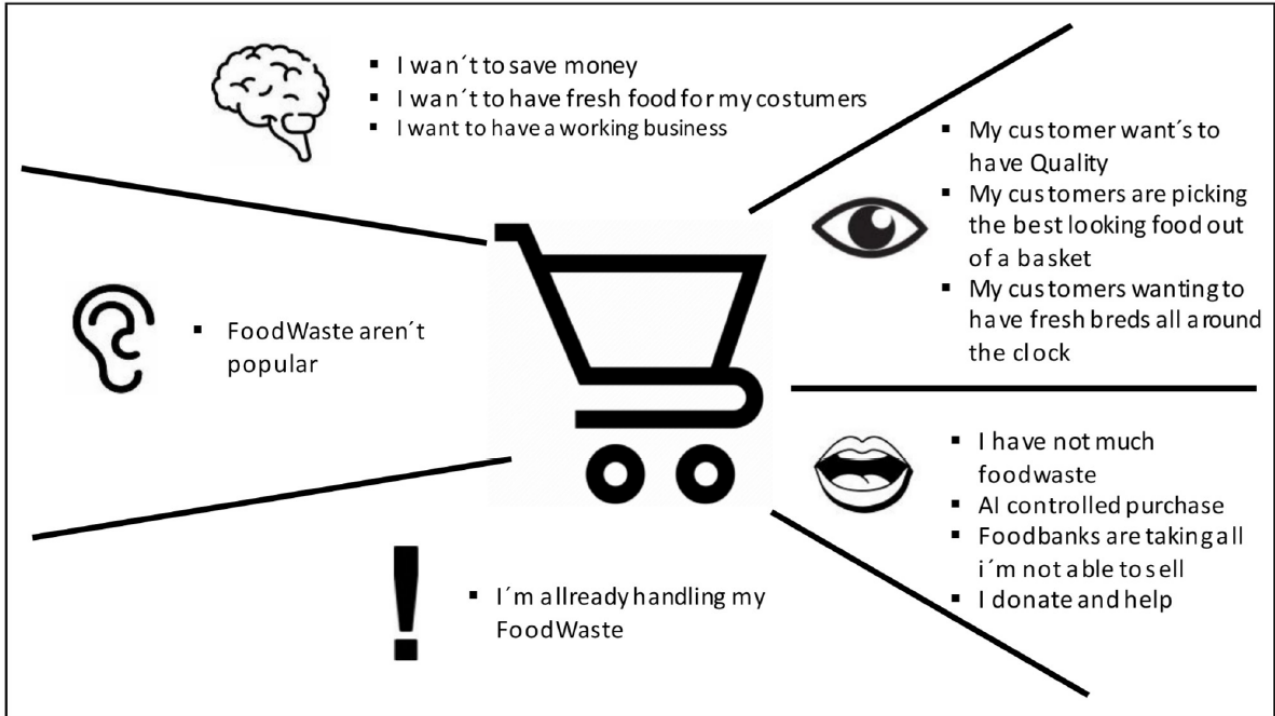
1. our product is one of many solutions that companies could use, with only a marginal USP.
2. the financial incentive to sell/purchase food close to its expiration date is not worth the potential liability that companies acquire.
3. the broader societal view to reduce food waste has reached the end consumer but is not enough to combat the traditional "fresh first" mentality.
4. laws prevent most companies from experimenting with creative solutions to their food waste, leading to complacency.

Combating all these problems is beyond our capabilities at this stage of development. However, we would like to propose some measures to counter many of the above problems.

1. shifting the focus from supermarkets to local producers. This would give them a tool to take back control of the branding and marketing of their products.
2. adding a new label on products indicating when the food was produced/packaged. This would allow professionals to better assess the freshness of a product.
3. aggressive information campaign comparing hyper-fresh foods to the carbon footprint they create.
4. lobbying against strict best-before dates. These rules prevent our food cycle from being dynamic and able to adapt to changing situations.

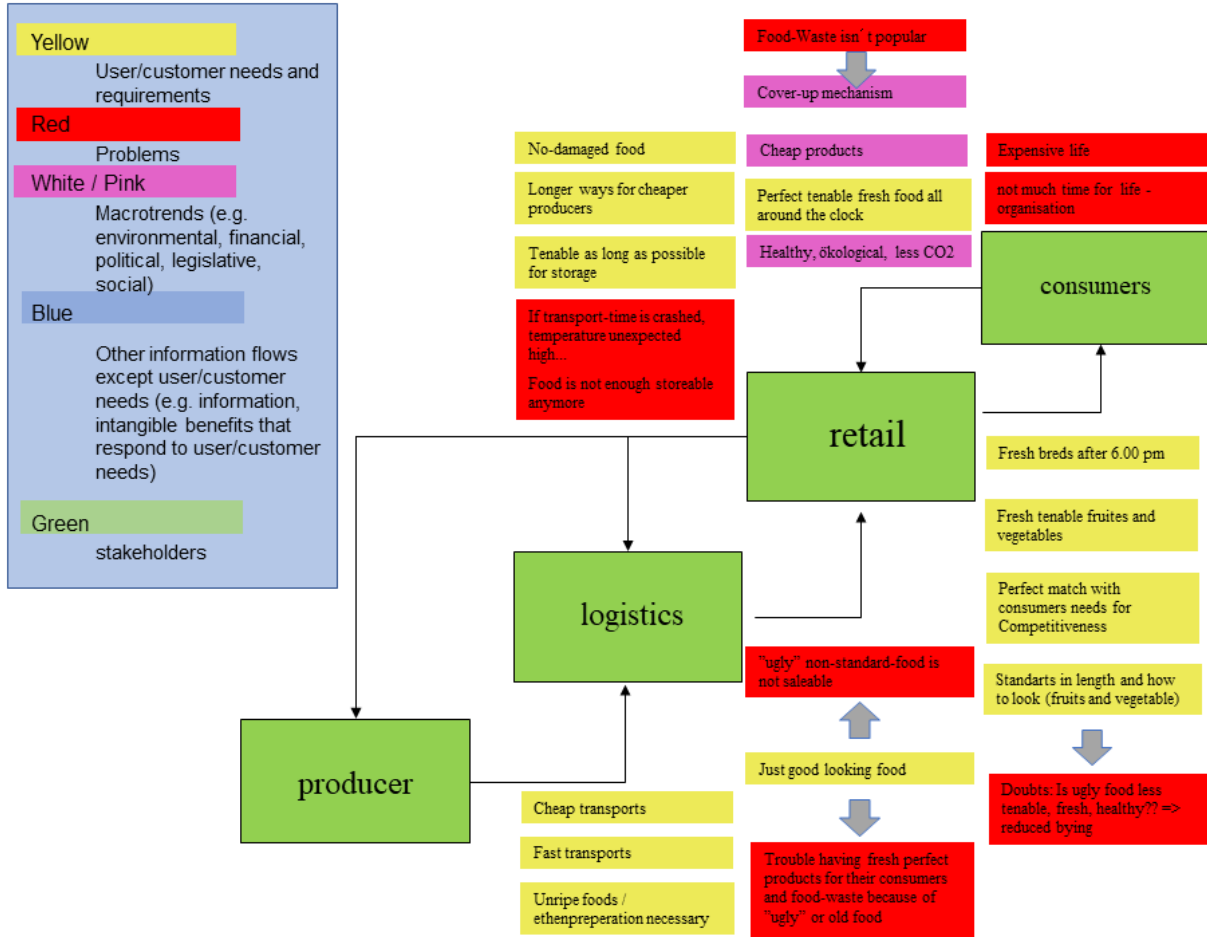
ATTACHMENT 1:

Interview outcomes (retail – restaurant)



ATTACHMENT 2:

Diagonal Matrix about food waste issue



ATTACHMENT 3:

Project Public Summary

The SWAP project in ATTRACT Phase 1 (a partnership between CERN and CSEM) successfully demonstrated the feasibility of 3D-printed segments of pipes, equipped with printed standard hydraulic fittings, integrating an Aerosol Jet printed RTDs in the inner wall of the pipe, i.e. in direct contact with the fluid.

Further developments pursued by CSEM after the end of SWAP improved the quality of the printing, essentially eliminating any need of mechanical post-processing and consolidating the full closure of the instrumented section by resuming the 3D printing operation after the sensor deposition by Aerosol Jet. Furthermore, experience has been made in the introduction of COTS (“Commercial Out of The Shelf”) miniaturized sensors in the process of 3D printing: this paves the way to the possibility of adding to the temperature sensing the capability for the instrumented pipe to host elements not suited for Aerosol Jet printing: e.g. miniaturized pressure sensors, or miniaturized flow sensors.

The main goal of AHEAD is to start from these technology bricks to develop a TRL7 product, bringing the possibility of sensing fluid parameters with a simple pipe segment to an industrial pre-production level, compatible with natural refrigerants: Carbon Dioxide (for detector applications) and Ammonia (for space applications). To reach this goal, two use-cases will be developed: the so called “Refrigeration” use-case targeting earth applications and the “MPL” use-case (Mechanically Pumped Loop) targeting thermal management applications for satellite platforms.

The partners in the proposal gather two beneficiaries mastering all the required technological steps for the full development of the product (CSEM and LISI Aerospace) and a set of end-users (CERN, Thales Alenia Space and NTNU) capable of performing accurate testing and product follow-up allowing for validation of prototypes at different steps of the project and for final qualification in field operation. In particular, the addition of NTNU to CERN and Thales will permit to study and qualify the extension of the potential application of the product to the market of natural refrigeration plants for general purpose terrestrial applications. This will greatly reinforce the strength of the proposal in the context of ATTRACT, by directly introducing an aspect related to environment preservation and reduction of CO₂ emissions.

Meanwhile, in the parallel project ENERGY4OIL of ATTRACT Phase1, the Portuguese spin-off inanoEnergy has developed a technique of energy harvesting from turbulent flows, allowing to produce enough power to operate a sensor and enable wireless transmission of the data. This technology is highly complementary to those developed in SWAP and to be developed in AHEAD. Indeed, the integration of energy harvesting shall enable standalone sensing and wireless data transmission for a very wide range of industrial and scientific IoT applications. The energy harvesting technology will be a central part of the so called “Refrigeration use-case” in AHEAD.

The advantages for future complex cooling systems at CERN is evident, introducing the possibility of an optimal tuning of the system performance on the basis of finely distributed local sensing, while largely reducing the cost and the integration impact of the monitoring instruments presently in use. For space applications, this is the optimization of the fluidic thermal control system by in-situ sensors and focused heating which is at stake with mass and compactness direct impact.

ATTACHMENT 4:

Market and Social Impact Table

Technology scale up (type) developed in the project	Targeted social challenge	Targeted market	Main routes for market deployment envisioned and involved partners
Pipe elements with measurement functions integrated inside, enabling standalone wireless monitoring closer to the process for better process control and optimization.	Reduce energy and food wastes	Refrigeration in markets for: Food processing Comfort cooling and heating Industrial refrigeration	Tracking of food temperature to secure quality and avoid waste. Implementation of demo-sensor in process plants of the food chain. Adaption of control of comfort cooling and heating devices, to reduce energy demand and increase annual efficiency, by applying demo-sensors in heat pump chillers at NTNU. Enable to further improve industrial processes (safety, reliability, maintainability) by utilizing additional data from T-sensors implemented. Applied in NH3 demonstrator at NTNU.
	High-added value functions based on AM, enabling more optimized sizing of MPL systems for improved efficiency, lower mass spacecraft and catalyzing AM adoption 1. Reduce the environmental impact of aircrafts (for instance enabling hydrogen-powered aviation)	Space and Aeronautics	Technologies useable directly on TAS-F satellites platforms manned pressurized space modules and low-cost satellites as well as aeronautics heat exchangers, e.g. liquid H ₂ in combustion systems, or more generally between two streams of gases, which are widely used in many sectors (steelmaking, agro-food...). TRL9 will be reached with a larger number of printed components tested for reliability demonstration at TAS-F and applied to other material / fluid couples in labs.
	Standalone flow measurement to optimize watering systems efficiency in agriculture Standalone water potability monitoring for developing countries	Agriculture 4.0 Water distributors in developing countries	Identification of potential development partners and end-users based on concept demonstration in AHEAD uses-cases, market survey, webinar and call for additional use-cases. Development would involve CSEM, LISI and INANO.
KET bricks to develop various kinds of parts integrating sensor functions: (1) Instrumented cutting tools (2) Instrumented end effectors	(1) Predictive maintenance and process optimization to reduce wastes and maximize throughput	Machine-tool	Product to be developed by cutting tool manufacturer together with CSEM & LISI. Instrumented cutting tool would be purchased to end-users and compatible with existing machine-tool equipment.
	(2) Process monitoring and control for higher performances	Surgical robotics, aptic interfaces	Swiss company identified with needs in for optimized parts integrating sensing functions. Possible follow-up project under Innosuisse funding with CSEM.

¹ AM enables mass and material wastes reduction. AM also catalyzes design digitalization which opens the access to smart factories currently developed with the objective to reach “right first-time” manufacturing and feedstock waste minimization.

See list of abbreviations at the end of the proposal