LeftLovers LoopBin

LeftLovers Team:

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Acknowledgements

Abstract

Glossary

Abbreviation	Description
CO_2	Carbon Dioxide
EMS	European Project Semester
EMCD	Electromagnetic Compatibility Directive
ISEP	Instituto Superior de Engenharia do Porto
LVD	Low Voltage Directive
MD	Machinery Directive
NIST	National Institute of Standards and Technology
NH_4	Ammonium
O_2	Oxygen
PWM	Pulse Width Modulation
RED	Radio Equipment Directive
RoHS	Restriction of Hazardous Substances Directive
SI	International System of Units
USB	Universal Serial Bus
UART	Universal Asynchronous Receiver/Transmitter

Abbreviation	Description
WBS	Work Breakdown Structure

1. Introduction

1.1 Presentation

The “Leftlovers” team consists of six students from diverse nationalities and academic backgrounds who have come together at ISEP to take part in the European Project Semester. Table 1 provides an overview of the team members, including their home countries and fields of study.

Table 1: LeftLovers Team

Name	Home country	Field of study
Emile Amant	Belgium	Civil Engineering
Clara Díaz Martín	Spain	Fashion, Interior and Industrial Design
Qi Xuan Tan	Malaysia	Mechanical Engineering
Lianne Hannah Maria Tibbe	Netherlands	Biology and Medical Laboratory Research
Nathan Audy	France	Industrial and Mechanical Engineering
Simon Lünswilken	Germany	Mechatronic Systems Engineering

1.2 Motivation

As a team, we have chosen the European Project Semester because we believe this experience will enrich us both professionally and personally. Working in a multidisciplinary, international team provides us with the opportunity to collaborate with people from diverse cultures and academic backgrounds. This not only enhances our creativity and problem-solving skills but also prepares us for a professional work environment. Additionally, we see EPS as a way to challenge ourselves, step out of our comfort zone, and further improve our English communication skills. The fact that we get to do this in Porto makes it even more special. Besides everything we learn at school, we also have the opportunity to explore a new city and meet new people along the way.

The process of choosing a topic within our team was quite swift. We each wrote down our individual interests and topic preferences. “Smart food production in small spaces” was a common preference for the topic, while “environment” was a common interest shared by all. To combine these two areas of interest, we aimed to develop a product that would enable food production while also contributing to a more sustainable world. We decided to approach the problem from the end: food production itself was not the main issue we wanted to focus on, but rather what happens to the food afterward. We have all observed the significant amount of food waste, which we find wasteful. From this observation, the idea arose to create an organic waste bin that would allow users to repurpose food waste in a more meaningful way, while also enabling them to grow their own plants—especially for those who live in small spaces and do not have access to a garden.

1.3 Product

In defining our project, we focused on two major themes: “Smartification of everyday objects” and “Smart food production in small spaces”. These themes led us to think about solutions for integrating new technologies into everyday ecological practices. After careful consideration, we chose to focus our work on the design of a smart composter, an innovative device coupled with a mobile application enabling users to produce their own compost from their food waste, in an optimized way.

One of the main challenges of our product is to guarantee odor-free composting, while remaining simple and intuitive to use. To achieve this, our solution will need to incorporate an optimized compost management system, taking care to maintain an ideal balance between wet and dry matter to avoid any malodorous fermentation. Aeration will also be a key parameter: an automated waste mixing and stirring mechanism will be set up to accelerate the decomposition of organic matter and ensure effective homogenization of the compost.

By integrating intelligent sensors, our composter will be able to analyze various parameters such as humidity, temperature and gas consumption in real time. This data will be transmitted to the mobile application, which will guide users by providing personalized advice on how to optimize their compost and avoid common mistakes (excess humidity, lack of aeration, etc.). The aim is to make this practice accessible even to novice users, while guaranteeing high quality compost that can be reused for urban gardening or indoor plants.

In this way, our intelligent composter is part of a circular economy approach, helping to reduce organic waste, enhance the value of bio-waste and raise awareness among city dwellers of more sustainable practices. By facilitating the adoption of composting in urban environments, we are contributing to more responsible resource management, while offering users a connected, modern and efficient solution.

1.4 Problem

The main problem identified is the complexity of accessing a food waste recycling system that is simple, reliable and inexpensive. Currently, most composting solutions require a garden or outdoor space, making them difficult to access for apartment-dwellers living in big cities. Without a solution adapted to their lifestyle, these people find themselves forced to dispose of their organic waste with conventional household refuse, contributing to waste and increasing the amount of waste incinerated or landfilled.

What's more, in many urban areas, local authorities do not offer effective solutions for the collection and recycling of bio-waste. Even when collection points do exist, they are often limited in number, restrictive in terms of timetables or not very well known to the public. Access to information on composting and its benefits is also limited, leaving many city dwellers with no real alternative.

The aim is therefore to provide a dual response to this problem:

1. Provide users with the knowledge they need to understand the principles of composting and integrate it easily into their daily lives.

2. To offer a product adapted to their environment, designed specifically for indoor use, without nuisances (odors, insects) and without the need for outdoor space.

We also identified a second major problem with conventional composting: time and the quality of the compost produced. Traditional composting takes several months, often incompatible with an urban lifestyle where space and patience are limited. Indeed, storing organic waste for long periods of time in an apartment can become cumbersome and unhygienic. What's more, without the right balance between dry and wet matter, the quality of the resulting compost can be mediocre, limiting its usefulness for indoor plants or urban gardening.

Our approach is therefore to offer a solution for faster, more efficient composting, with a product that naturally speeds up the process while guaranteeing optimum quality of the resulting compost.

1.5 Objectives

The main aim of this project is to offer a practical, accessible and effective solution to enable city dwellers to recycle their food waste, even without access to an outdoor space. By responding to the specific constraints of urban living, our product aims to democratize apartment composting and encourage more sustainable bio-waste management.

More specifically, our objectives are to:

1. Facilitate access to composting for city dwellers.
   Our solution must be easy to use and suitable for indoor use. It has to fit into small spaces and address users' hygiene concerns, notably by avoiding odors and the presence of insects. One of the challenges is to make composting as natural and instinctive as selective sorting, so that it becomes an ingrained habit in users' daily lives.
2. Reducing composting time to better meet urban needs.
   Conventional composting can take several months, which is often a deterrent for city dwellers. The aim is to develop a system that speeds up the process, so that quality compost can be produced in just a few weeks. This will enable more efficient waste rotation and more regular use of the compost produced.
3. Ensuring high quality compost.
   Effective compost must be rich in nutrients and easily reusable for indoor plant care, urban gardening or redistribution to local initiatives. Our product must guarantee optimal decomposition of bio waste and provide homogeneous, ready-to-use compost.
4. Raising awareness and supporting users.
   In addition to providing a product, we also want to offer educational tools to help users understand how composting works, the best practices to adopt and the mistakes to avoid. A better understanding of the process will optimize the management of bio waste and increase citizens' commitment to this ecological approach.
5. Contributing to waste reduction and more sustainable resource management.
   Through this initiative, we aim to encourage a transition towards a more environmentally-friendly model, by reducing the volume of waste sent to incineration or landfill. Our solution is thus part of a circular economy, in which every household becomes a player in recycling and the preservation of natural resources.

1.6 Requirements

Our project has established the following requirements to guide the development of the compost bin:

1. Budget Constraints: The total cost of the prototype must not exceed 100 €. Priority should be given to low-cost hardware solutions, including repurposed or recycled components where feasible.
2. Software & Standards: The system must utilize open-source software to encourage community contributions, continuous improvement, and transparency. All measurements and documentation must adhere to the International System of Units (SI), following the NIST International Guide for SI Units.
3. Regulatory Compliance: The product must comply with relevant EU directives, including:
    - Electromagnetic Compatibility Directive (EMCD)
    - Low Voltage Directive (LVD)
    - Machinery Directive (MD)
    - Radio Equipment Directive (RED)
    - Restriction of Hazardous Substances Directive (RoHS)
4. Functional Requirements: The compost bin must efficiently process food waste by shredding it into smaller pieces and actively mixing it to accelerate the composting process, to gain fresh fertilizer every 4-6 Weeks. The final compost should be suitable for plant growth and usable as high-quality fertilizer. The design should focus on optimizing and speeding up the natural composting process using all available means. Additionally, users must be able to add food waste at any time without interrupting the process. An integrated mini-garden should allow users to directly apply the produced fertilizer to grow herbs or vegetables, making it ideal for small living spaces or urban balconies.
5. Usability & Ergonomics: The design must be user-friendly, with intuitive operation and ergonomic considerations for ease of use. Maintenance and cleaning should be straightforward.
6. Sustainability: Materials used in construction should be environmentally sustainable, prioritizing recycled, biodegradable, or low-impact options. The product's lifecycle (production, use, disposal) should minimize environmental harm.
7. Smart Monitoring & Application: A companion mobile application must enable users to monitor key composting parameters (e.g. temperature, moisture and the carbon dioxide level) and receive real-time instructions for optimal compost maintenance.

1.7 Tests

Before LoopBin can be marketed, we must make sure it works properly. That's why we need to carry out tests at each stage of a cycle, mainly to check the elements we've imagined, as well as some complex connections.

- Test connecting the Arduino to the application. The board is equipped with an ESP32 chip that enables it to connect to the Internet. We need to check that this connection works without a hitch, to ensure error-free operation of the prototype.
- Efficiency of the cutting system. Reducing the size of food waste is a crucial step in LoopBin's operation, as it enables a faster response. The efficiency of the system we have devised needs to be verified.
- How the mix system works. Waste mixing is crucial to an odor-free composting process. Its system is associated with the cutting system, but needs to be tested in a different way, which is why a different test must be set up.
- Testing the system for transferring waste to a lower level. The triangular opening for transferring waste from one floor to another is another system we've designed. We need to test its operation, mainly the complete opening of the mobile part, as well as a closure that correctly

retains the waste on one floor.

- Test fan control via the application / sensor operation. Once the connection between the prototype and the application has been established, it's time to check that requests can be sent without malfunctioning, such as requesting information from a sensor, or turning the fan on/off. This is also the way to check that connections have been made correctly, especially humidity sensors, which require the use of the MAX3485 transceiver, and a parallel connection.
- Test battery discharge time. After checking each stage of the prototype's operation, we also need to ensure that it remains functional over time, i.e. that the battery is fulfilling its role correctly.

1.8 Report Structure

Chapter	Description
1. Introduction	Introduction of the team, the topic, the problem, and the objectives within the project
2. Background and Related Work	Background information on the topic and research on already existing solutions
3. Project management	Overview of the methods used for project management within the team
4. Marketing plan	Analysis of the market, identification of the target audience and competitors, and market strategy
5. Eco-efficiency Measures for Sustainability	Measures to minimize the ecological footprint of the project and an overview of the key aspects of sustainable development and eco-efficiency
6. Ethical and Deontological Concerns	Analysis of ethical concerns that need to be considered
7. Project Development	Development of the product from concept to prototype
8. Conclusions	Discussion of everything that has been achieved with the project, what is still missing, and future developments
9. Bibliography	List of all sources used in the project

2. Background and Related Work

2.1 Introduction

Compost bins have evolved significantly in recent years. Compost bins are not just food waste bins. They have become now a key part of eco-living. Modern compost bins are designed with advanced materials, innovative aeration systems, and user-friendly features to optimize the decomposition of organic waste while minimizing odors and pests. They come in all shapes and sizes, from small bins for kitchens to larger ones for backyards. As global interest in sustainability grows, these bins are playing an increasingly important role in promoting eco-friendly practices and reducing environmental impact.

This chapter explores the theoretical background of the composting process, including all the factors that influence it to have the best compost conditions. Additionally, the state-of-the-art technologies used in modern compost bins available on the market are reviewed. Understanding the functionality and design of these systems is crucial for informing the design process of a compost bin. The following sections present findings and insights into the latest advancements in composting technology.

2.2 Concepts

Composting is a natural process where microorganisms break down organic waste into nutrient-rich humus. This happens under aerobic conditions, meaning the presence of oxygen. Several factors affect composting, but they can be controlled by adjusting the material mix, ensuring good airflow, and turning the compost regularly.

The composting process takes place in different stages. It starts with the mesophilic phase (0 – 40 °C), where microorganisms begin breaking down easily degradable materials like sugars and proteins. As the temperature rises, the thermophilic phase (40 – 70 °C) begins. In this stage, heat-resistant microorganisms take over, helping to kill pathogens and weed seeds. After this, the cooling phase starts, where the temperature drops, and microorganisms continue breaking down complex materials like cellulose and lignin. Finally, in the maturation phase, the compost stabilizes, and the result is a nutrient-rich final product **[Florian Amlinger, 2025]**, **[Benjamin Lammert, et al., 2002]**.

Several key factors influence composting. Temperature is important, with the ideal range between 50 °C – 60 °C for efficient breakdown. Moisture also plays a role, as microorganisms need water to survive. The best moisture level is between 55 – 65 %. Another crucial factor is the gas composition. Composting requires oxygen (O_2) to support aerobic microorganisms. The oxygen level should not fall below 5 %, with ideal values between 7 % – 12 %. If oxygen levels drop too low, anaerobic microorganisms start to grow, producing methane (CH_4) and hydrogen sulfide (H_2S), which cause bad smells. Additionally, carbon dioxide (CO_2) levels should stay below 10 – 12 %, and methane levels should not exceed 1 % **[Florian Amlinger, 2025]**, **[Benjamin Lammert, et al., 2002]**, **[Muaid S. Ali, 2017]**, **[K. J. Park, M. H. Choi, J. H. Hong, 2002]**, **[Nisha N. Gurusamy, et al., 2021]**.

To ensure a successful composting process, it is essential to maintain proper airflow, turn the compost regularly, and create a balanced mix of materials. This helps microorganisms break down the waste efficiently, prevents unpleasant odors, and produces high-quality compost. Studies show that the frequency of turning the compost directly affects how long the composting process takes. Turning it twice a week is already sufficient. Adding fully composted humus can also help speed up the process **[Florian Amlinger, 2025]**, **[Muaid S. Ali, 2017]**.

The size of organic particles also affects composting speed. Smaller pieces have a larger surface area, making it easier for microorganisms to break them down. The best particle size is between 0.5 and 5 cm. If pieces are too large, decomposition is slow. If they are too small, the compost becomes too dense, reducing oxygen flow and increasing the risk of anaerobic processes **[Patrizia Messmer, 2022]**, **[GrowVeg, 2025]**.

Another important factor is the Carbon-to-Nitrogen (C/N) ratio, which should be 25–35:1. A good balance of “green” and “brown” waste is necessary:

- Green waste (high in nitrogen, moist, and easy to break down): Includes food scraps (fruit and vegetable peels, coffee grounds, tea bags) and fresh garden waste (grass clippings). These materials increase microbial activity and speed up decomposition.
- Brown waste (high in carbon, dry, and provides structure): Includes leaves, branches, sawdust, cardboard, and paper. These materials improve airflow, absorb excess moisture, and prevent anaerobic conditions.

Too much green waste leads to excess nitrogen, causing ammonia smells. Too much brown waste slows down composting because microorganisms need nitrogen to work efficiently. A balanced mix ensures stable decomposition and high-quality compost. There are different recommendations in the literature on how to balance the carbon-to-nitrogen (C/N) ratio in terms of amounts of green and brown food waste. A common rule of thumb is to mix equal amounts of both. However, some sources suggest using two parts brown food waste to one part green food waste **[Florian Amlinger, 2025]**, **[Benjamin Lammert, et al., 2002]**, **[GrowVeg, 2025]**.

To control the composting process, it is important to adjust the material composition, maintain good airflow, and turn the compost regularly. These steps create ideal conditions for microorganisms, speed up decomposition, and prevent bad odors.

To create optimal composting conditions, several concepts can be found in current technology that help establish these environments. For example, some composting solutions include shredders, as seen in Figure 1 from the Greezy composting solution **[Greenzy, 2025]**.

Figure 1: Greenzy Grinder **[Greenzy, 2025]**.

Many modern compost bins also use IoT (Internet of Things) technology. They have smart sensors. These sensors check temperature, moisture, and the gas consumption. The sensors keep the composting process at its best. Some bins connect to mobile apps, as shown in Figure 2. Users can track progress and get alerts through these apps. The apps also give tips for better composting. This makes the process simpler, especially for beginners **[AMAZON, 2025]**.

Figure 2: GoveeLife Composter allows user to create a composter schedule and monitor the status via the app from everywhere **[AMAZON, 2025]**.

To control odors, many compost bins use activated carbon filters. These filters trap odor-causing molecules as air passes through. Activated carbon is characterized by its highly porous structure, which provides a large surface area for absorbing odors. This property makes it an ideal solution for maintaining odor-free compost bins, particularly in indoor or confined environments. Many compost bins are now designed with replaceable carbon filters, ensuring straightforward maintenance and long-term usability **[Breathe Naturally, 2025]**.

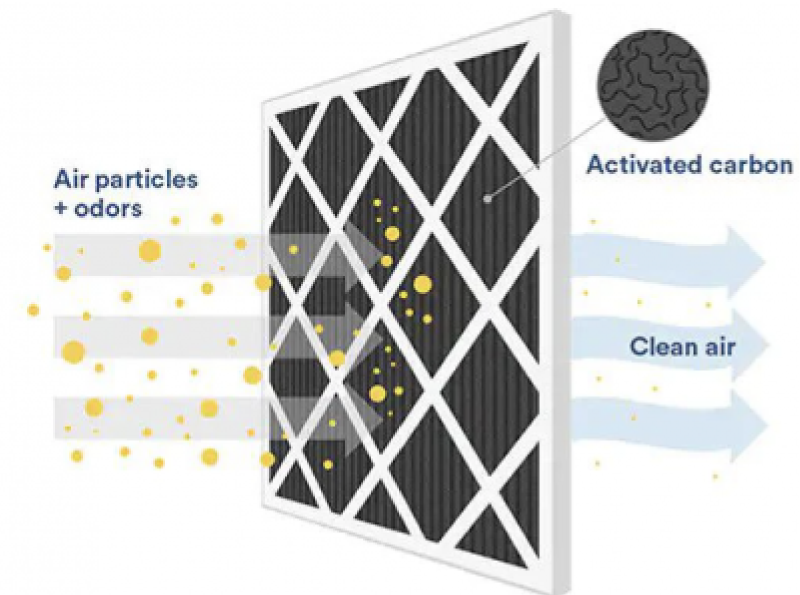

Figure 3: Activated carbon filter **[Breathe Naturally, 2025]**.

Modern compost bins are also designed to work quietly. They use low-noise grinding mechanisms and quiet aeration systems. This makes them suitable for homes, offices, and urban spaces. Quiet operation ensures the composting process does not disturb daily activities.

2.3 Product

As there is already different products on the market, it will be helpful to analyze these and try to find their differences and components that may be useful in our design. The different existing products are analyzed in this chapter. The most notable features per product are discussed, at the end of the chapter a summarizing table is provided with extra general information of the products.

1. Reencle Home Composter The Reencle Home Composter **[reencle, 2025]** is a food waste bin which breaks down the food waste in 24 hours by mirroring the aerobic composting process. It creates and optimizes the environment to speed up the microbial decomposition of food scraps. It uses a mesh filter, carbon filter and an organic additive to avoid bad smell. The company claims that they make real compost and not just dehydrates food. Important to mention is that the optimum compost amount per day is 0.68 kg with a maximum of 2.2 lbs or 1 kg, this shows the high capacity and flexibility for the customer in their personal use. With the starter package and the organic additive, Reencle includes the customer in the composting process.

2. Foodcycler - Eco3 The FoodCycler Eco 3 **[FoodCycler, 2025]** is a food recycler which breaks down the food in 4 to 9 hours. Due to the drying process, no real compost is produced, but a by-product that can be added to the soil of the plants or backyard compost. Different ratios of byproduct to soil are recommended depending on the composition of the food waste. The product is provided of an application which helps the customer to monitor and schedule the composting process. As it is self-cleaning, the product is user friendly.

3. GoveeLife GoveeLife **[AMAZON, 2025]** is a composting bin that uses a drying process to break down the food waste into a mix that can be mixed into the garden soil for fertilization. The product makes it easy to add food waste when it is in composting mode, within 15 minutes the extra food waste can be added. The company claims that the bucket is easy to clean due to the non-stick coating of the inner bucket.

4. InnovaGoods The Electrical Kitchen Composter Ewooster by Innovagoods **[InnovaGoods, 2024]** is another composting bin which uses 3 different stages to break down foodwaste: drying, chopping and cooling. The resulting product is a fertilizer that can be used for the lawn, garden, plants and other uses. It is provided with 3 carbon filters to avoid odors and has a self-cleaning function that takes 1 hour to fulfill. A downside of the product is that the temperature goes up to 115 °C to complete the composting process.

5. Greenzy The Geenzy food waste bin **[Greenzy, 2025]** uses a composting process that includes microorganisms. The whole process of composting takes 2 months to complete while u can keep adding food waste to the bin. It uses a fly trap on the surface to avoid disturbance of flies.

6. Geme The Geme compost bin **[GEME Composter, 2025]** is one of the more expensive products on the market. It uses an aerobic composting system that breaks down the food in 6 to 8 hours. The bin has to be emptied partly every 3 months. The resulting compost is a high nutritious soil. The bin uses catalytic oxidation to prevent odors. This makes it low in maintenance.

7. CEERCLE The compost towers from CEERCLE **[Ceercle, 2025]** use worms in their composting process. This speeds up the process by 4 times compared to traditional composting. This product combines gardening with composting in the compost tower.

8. Hotbin Composting The Hotbin Composting **[HOTBIN Nederland en Belgie, 2025]** is a bin for outside use which is provided with insulated walls that keep the warmth of the natural composting process (microorganisms) inside. This speeds up the process without causing odors. Almost all organic waste can be added to the bin.

9. Lomi Bloom The Lomi Bloom compost bin **[Lomi, 2025]** uses 3 different stages to break down food waste from 3 to 20 hours. With the heating, grinding and cooling stages, it mimics the natural composting process. The bin comes with an application that tracks down the waste footprint of the user with real-time data.

10. Bokashi Bucket The Bokashi Bucket **[Mdr.de, 2023]** uses food waste to create a liquid fertilizer and a pre-compost soil. This is possible by using a fermenting process. Every time the user adds food waste to the bin, it must be sprayed with a liquid mixture called “Effective Microorganisms” that contains bacteria and fungi that help the fermenting process. The effluent must be drained every two to three days. The liquid fertilizer can be added to water for watering plants.

11. Soilkind The Soilkind compost bin **[Soilkind, 2025]** is a bin divided into two chambers. In the first one, the foodwaste is dried and chopped into smaller pieces. The second chamber is for decomposting the foodwaste with the help of microorganisms. The whole process takes 48 hours. Also, the water from the waste gets collected and can be used for watering plants. The bin also is provided with a heat exchanger so the heat from the composting process can be used for drying the food waste in the first chamber.

Table 2 summarizes the main features of the researched products.

Table 2: Comparison of the researched products.

Product	**Price (€)**	**Process**	**Process Time**	**Filters against bad odors**	**Loudness**	**Socket Needed?**	**Daily Food Waste Capacity (kg)**	**Frequency of Emptying**	**Extra Feature**
Reencle	458	Mirroring of Aerobic Composting	24 h	mesh filter, carbon filter, organic additive	< 28 dB	yes	≈1	1-3 months	filter cost: 25 €/year, compost starter pack included
Foodcycler - Eco 3	412	Drying, grinding, cooling	4-9 h	Carbon filter (refillable)	“quiet”	yes	≈1.5	every 2 days	0 methane gas emitted, patented grinding system
Goveelife	227	Drying	4-8 h	2 changeable carbon filters	“superquiet”	yes	≈1.5	every 2 days	for animal and vegetable food, app for monitoring, self cleaning
Innovagoods	298	3 stages: drying, chopping, cooling	6-10 h	3 carbon filters	< 45 dB	yes	≈1.5	daily	self cleaning function
Greenzy	899	Microorganisms	2 months	carbon filter	< 42 dB	yes	≈2	2 months	sensors/humidity, temperature, air quality, process via the app, filter change every 3 months (45 €)
GEME	1000	Aerobic composting	6-8 h	metal ions as catalyst, carbon	35-45 dB	yes	up to 5	2 months	no filter change
CEERCLE	179	Worm composting	2-6 weeks	no filter system	no noise	no	≈1.5	not mentioned	combines composting and gardening, hand-made pottery

Product	Price (€)	Process	Process Time	Filters against bad odors	Loudness	Socket Needed?	Daily Food Waste Capacity (kg)	Frequency of Emptying	Extra Feature
Hotbin Composting	655-805	Microorganisms	30-90 days	no filter	no noise	no	≈0.6	30-90 days	all sorts of food waste can be added
Lomi Bloom	479	Heating, grinding, cooling	3-20 h	carbon filter	< 60 dB	yes	≈1.25	weekly	app with real-time data on waste footprint
Bokashi Bucket	65	Fermenting process	+ 3 weeks	anaerobic process prevents bad odors	no noise	no	≈1.6	2-3 days	creates pre-compost and liquid fertilizer, app for controlling the bin
Soilkind	1490	Grinding and drying system	48 h	carbon filter	39 dB	yes	≈1	every week	regulates temperature, humidity, ventilation and compost maturity, self cleaning

Figure 4 shows the different researched products.

4
: Researched products.

2.4 Projects

After a catastrophic tsunami on ‘Atata Island, **Pacific Grow** **[Merav, 2024]** put their shoulders to the rebuilding of the island in a sustainable and innovative way. Next to installing underground powerlines and a rainwater harvesting system, they managed to install HomeBiogas systems in every household. This allowed the families to use organic waste as a fuel for cooking instead of firewood. As energy was one of the biggest hurdles, this really was a game changer. Also, the liquid fertilizer that was produced by the HomeBiogas system could be used to plant gardens. This created the first steps towards independent food security and sustainable living in the Pacific.

“**Let’s Get Growing**” **[Mary Schwarz, Jean Bonhotal, 2017]** is a guide on how to implement different forms of composting into a school context with educational purpose. While the focus lies in composting itself, they also talk about waste management in general. You can for example organize an on site composting project and let the students help in the construction and maintenance of the different steps. On a smaller scale, you can start worm composting in a classroom so students see the composting cycle in a real application.

“Social, economic and environmental benefits of organic waste home composting in Iran **[Haniyeh Jalalipour, et al., 2025]** is a paper that talks about a pilot project organised in Shiraz, Iran that wants to decrease 10 % of the collected organic waste in a 10-year horizon by making compost out of it with **home compost systems**. The social, economical and environmental impact are discussed. Results are that if Shiraz distributed 10 000 home composter systems, they could decrease the CO_2 emission from landfilling by 9 %. Also, 86 % of participants were willing to manage organic waste generated at home. Controlling the moisture and temperature is described as a difficult topic which can result in poor quality compost. This can decrease the dedication of the participants.

“Home Bio-Waste Composting for the Circular Economy” **[Piotr Sulewski, et al., 2021]** is a case study that tries to implement home composting systems in municipalities near Warsaw (Poland). The study concludes that participants can be motivated to try home composting by lowering the fees for waste collection. The used discount of 6 % was too low, over 80% of the participants expected a reduction of at least 15% of the fee. 40% of participants expected a discount of 30%. This shows that an active support of the local authorities is needed to promote home composting. Also, education about composting is needed as only one-third of respondents are willing to participate in home composting.

The papers that research about home composting show that this is a good solution to make useful use of food waste and decreasing the waste. Nect to that, people can be motivated to use a home composting bin by decreasing the fee for waste collection. Also, by educating kids about home composting in school, future generations may be more open to the concept.

2.5 Comparative Analysis

The market analysis already shows clear differences between the available home composting solutions. A noticeable aspect is the wide range of price categories and the variety of composting methods used. These methods range from drying to microbial composting, worm composting, and hybrid systems.

Another differentiating feature is the type of odor filtration used. Different filter types are employed, but they need to be replaced regularly, which can limit the convenience of use. In addition, some products offer extra features like low noise, self-cleaning, or smart monitoring systems that track the composting process via an app. The duration of the composting process also varies significantly between products.

The variety of existing solutions indicates a growing interest in home composting. This trend could be further promoted through targeted political measures, such as lower waste disposal fees or educational campaigns about environmental protection and composting, as described in **[Piotr Sulewski, et al., 2021]**.

From this analysis, we can identify clear opportunities for positioning a new product that addresses existing weaknesses in the market and stands out.

Our product approach is based on a natural, microbial composting process that produces nutrient-rich and high-quality fertilizer without relying on artificial acceleration methods like heat or chemicals. Unlike quick composters that promise results within a few hours, our system focuses on a continuous process. This allows users to add organic waste at any time, and the finished compost can be removed after several weeks, which provides the more ecologically device.

A comparison with existing products shows that the Greenzy Compost Bin comes closest to this concept, as it also tracks the composting process via an app. However, our product aims to go beyond this functionality by including an integrated plant box. This allows users to apply the composted fertilizer directly and experience the benefits of composting in a tangible way, providing a significant added value compared to the competition.

The only product on the market with a plant box is the CEERCLE Composter, but it lacks any form of digitalization, which results in a less user-friendly experience. Additionally, we aim to undercut the relatively high price of the Greenzy Compost Bin (899 Euros) to make it accessible to a broader customer base.

By combining sustainable composting, smart features, and direct benefits through the integrated plant box, we create a clearly differentiated product with real added value. It is clear that despite the many existing solutions, there is still potential for innovation in the market, especially when technical sophistication, environmental awareness, and user-friendliness are combined.

2.6 Summary

In this study, food waste has been identified as a major challenge, particularly in urban environments where recycling infrastructure is often inadequate, and awareness of sustainable waste management practices is low. Although many households have organic waste bins, they are frequently underutilized, and composting methods can seem complicated to some users.

To address this, the goal is to develop LeftLovers Loopbin — a smart composting system designed to make organic waste recycling easier and more efficient. Based on research into existing compost bins, LeftLover stands out by offering a unique solution that not only simplifies composting but also integrates a garden where users can directly apply the fertilizer.

With features like a built-in monitoring system and an accompanying app, the Loopbin provides real-time feedback on composting conditions to ensure optimal results. This makes it easier for users, particularly those living in urban spaces without access to a garden, to repurpose food waste effectively while growing their own plants. The target audience includes urban dwellers who want an eco-friendly solution for managing food waste and cultivating plants, combining sustainability with convenience.

3. Project Management

This chapter focuses on the key aspects of managing a project, which are essential for its success. It covers different areas such as defining the project scope, managing time, costs, and resources, ensuring quality, and handling communication within the team. Additionally, it looks at risk management, working with stakeholders, and procurement strategies.

The chapter is divided into several sections, each addressing a specific part of the project management process. First, we explore how the project scope is defined and the planned deadlines for each stage. Then, we discuss the cost management, quality control, and the people involved in the project. Communication strategies and how the team plans to manage updates and meetings are also covered.

Finally, the chapter looks at the project plan, with a focus on sprint planning, the tasks to be completed, and the progress made. Each section of the chapter is designed to give a clear overview of how the project will be managed, tracked, and adjusted to ensure successful outcomes.

3.1 Scope

The scope of a project defines the framework needed to ensure a successful outcome. This is detailed in a Work Breakdown Structure (WBS), as shown in the diagram. The WBS serves as a central tool for analyzing and organizing all relevant project components, allowing for efficient management.

In this WBS, the main areas of the project are divided into project management, documentation, initialization, planning, and development. Each of these categories contains specific subcomponents, enabling structured handling and tracking of individual tasks. For example, the project management area includes essential methods such as creating a Gantt chart, a product backlog, or a sprint plan to coordinate work progress. In the development area, key aspects such as the design of the compost bin, the material list, prototype creation, and functional tests are covered.

Using this WBS provides flexibility, as project components can be added or adjusted as needed to ensure a complete overview of project progress and requirements. This helps minimize risks and ensures targeted project control.

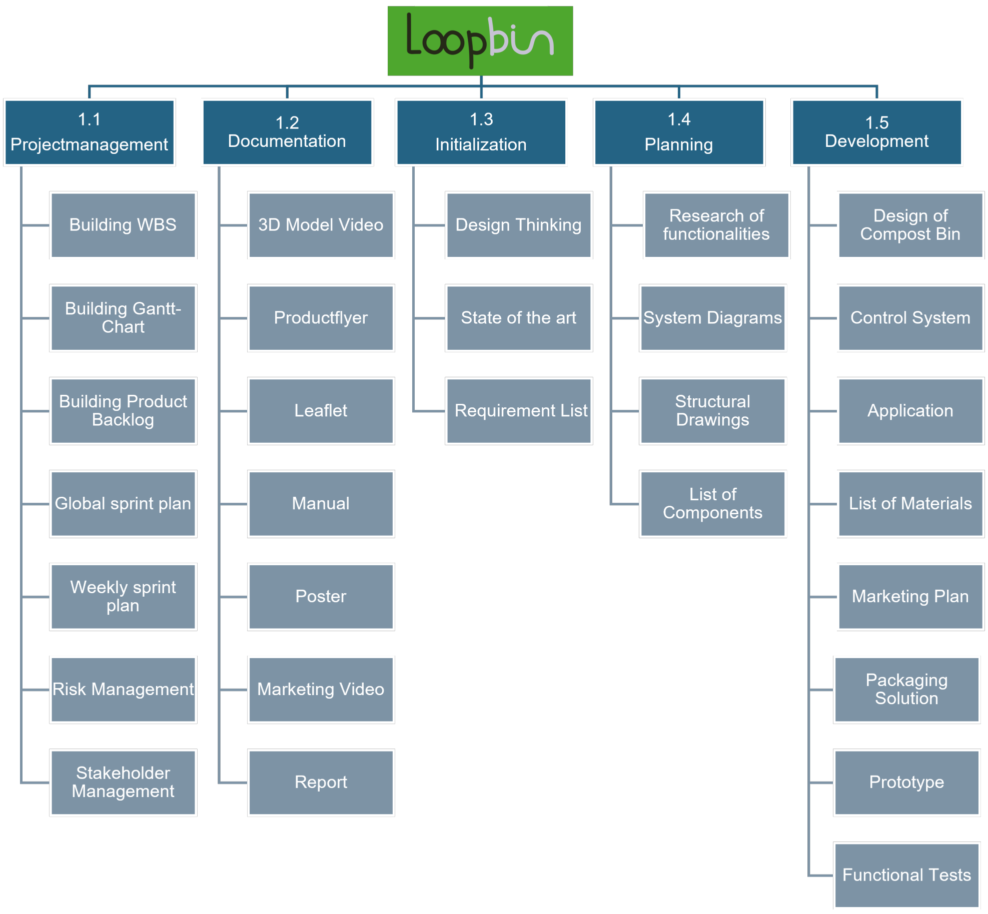

Figure 5: Work Breakdown Structure

3.2 Time

Table 3 shows the deadlines the team has set for the project.

Table 3: Key Milestones of the Project

Date	Description
2025-03-01	top-3 preferred project proposals
2025-03-12	Black-Box
2025-03-12	System Diagrams
2025-03-12	Structural Drafts
2025-03-15	Project Backlog
2025-03-15	Global Sprint Plan
2025-03-15	Initial Sprint Plan
2025-03-15	Gantt Chart
2025-03-19	List of Components and Materials
2025-03-26	System Schematics
2025-03-26	Structural Drawings
2025-03-26	cardboard scale model
2025-04-06	Interim Report
2025-04-06	Interim Presentation
2025-04-10	Present Interim Presentation
2025-04-15	3D model video
2025-04-29	Final List of Materials
2025-05-02	Refined Interim Report
2025-05-14	Packaging Solution
2025-05-28	Functional Tests
2025-06-15	Final Report
2025-06-15	Final Presentation
2025-06-15	Video
2025-06-15	Paper
2025-06-15	Poster
2025-06-15	Manual
2025-06-18	Final Presentation
2025-06-25	Suggested corrections
2025-06-25	MS Teams delivery
2025-06-25	Printed Handout

3.3 Cost

Document the planned vs. effective costs of your project.

3.4 Quality

Document quality metrics that will apply to your project deliverables, associated thresholds and how they should be reviewed.

3.5 People

Identify key people related to the project and associated roles.

3.6 Communications

Document how your team will manage communications, describing communication channels, meetings, etc.

3.7 Risk

Identify key risks (product and project level), evaluate them and define how they should be handled (responses) and monitored.

3.8 Procurement

Document your procurement management strategy including make vs buy decisions, materials/services to be acquired, sources, costs, timings, etc.

3.9 Stakeholders Management

Define how you will manage stakeholders to keep them engaged.

3.10 Project Plan

The ideal sprint duration is one week, starting on Thursday and ending on Wednesday. We chose Thursday as the starting day because it aligns with our project meetings. Each sprint begins with a project meeting, where we reflect on the previous week's sprint and plan for the upcoming week. Tabel 1 shows the Global Sprint Plan 4.

Table 4: Global Sprint Plan

Sprint	**Start**	**Finish**
0	27/02/2025	05/03/2025
1	06/03/2025	12/03/2025
2	13/03/2025	19/03/2025
3	20/03/2025	26/03/2025
4	27/03/2025	02/04/2025
5	03/04/2025	09/04/2025
6	10/04/2025	16/04/2025
7	17/04/2025	23/04/2025
8	24/04/2025	30/04/2025
9	01/05/2025	07/05/2025

Sprint	Start	Finish
10	08/05/2025	14/05/2025
11	15/05/2025	21/05/2025
12	22/05/2025	28/05/2025
13	29/05/2025	04/06/2025
14	05/06/2025	11/06/2025
15	12/06/2025	18/06/2025
16	19/06/2025	25/06/2025

The Project Backlog Table 5 lists all relevant tasks and deliverables of the project. Items are prioritized, with higher-priority entries at the top and lower-priority ones further down.

Table 5: Project Backlog

PBI	Title	Status
A	Define project proposal	Done
B	System Diagrams & Structural Drafts	Done
C	Build WBS	Done
D	Define Project Backlog	Done
E	Define Global Sprint Plan	Done
F	Define Initial Sprint Plan	Done
G	Release Gantt Chart	Done
H	Upload List of Components and Materials	Done
I	Risk Management	To do
J	Stakeholder Management	To do
K	Upload System Schematics & Structural Drawings	In progress
L	Do the cardboard scale model	Done
M	Upload Interim Report and Presentation	In progress
N	Interim Presentation, Discussion and Feedback	To do
O	Upload 3D model video	To do
P	Upload final List of Materials	To do
Q	Upload refined Interim Report	To do
R	Upload packaging solution	To do
S	Upload results Functional Test	To do
T	Upload Final Report, Presentation, Video, Paper, Poster and Manual	To do
U	Final Presentation, Individual Discussion and Assessment	To do
V	Update the wiki with all suggested corrections	To do
W	Place a folder with the refined deliverables	To do
X	Hand in a printed copy of the poster, brochure and leaflet	To do
Y	Hand in prototype and user manual	To do

The Sprint Plan Table 6 outlines the planning for each sprint at its start, as determined during the Sprint Planning session.

Table 6: Sprint Plan

Sprint	Task	Duration (d)	Responsible	Involved
0	A	5	all	all
1	B	3	NA, CD, SL	all
2	C, D, E, F, G, H	5	all	all
3	H, K, L	5	all	all
4	H, K, M	5	all	all
5	M	4	all	all
6	X	X	X	X
7	A	1	Y	X, Y, Z, W
8	B	2	Z and W	X, Y, Z, W
9	E	4	X and W	X, Y, Z, W
10	C	2	Y and Z	X, Y, Z, W
11	E	4	X and W	X, Y, Z, W
12	C	2	Y and Z	X, Y, Z, W

The Progress Register Table 7 records the review of each sprint at its conclusion, including updates to the status of each item.

Table 7: Project Progress Register

Sprint	PBI	Responsible	Involved	Status
0	A	all	all	Done
1	B	NA,CD,SL	all	Done
2	C, D, E, F, G, H	all	all	Done
3	H,K,L	all	all	Done/In progress
4	H, K, M	all	all	Done/In Progress
5	E	X and W	X, Y, Z, W	
6	C	Y and Z	X, Y, Z, W	
7	E	4	X and W	
8	C	2	Y and Z	
9	E	X and W	X, Y, Z, W	
10	C	Y and Z	X, Y, Z, W	
11	E	4	X and W	
12	C	2	Y and Z	

The release Gantt chart visualizes the timeline for key project deliverables, including their start and completion dates, as illustrated in Figure 6.

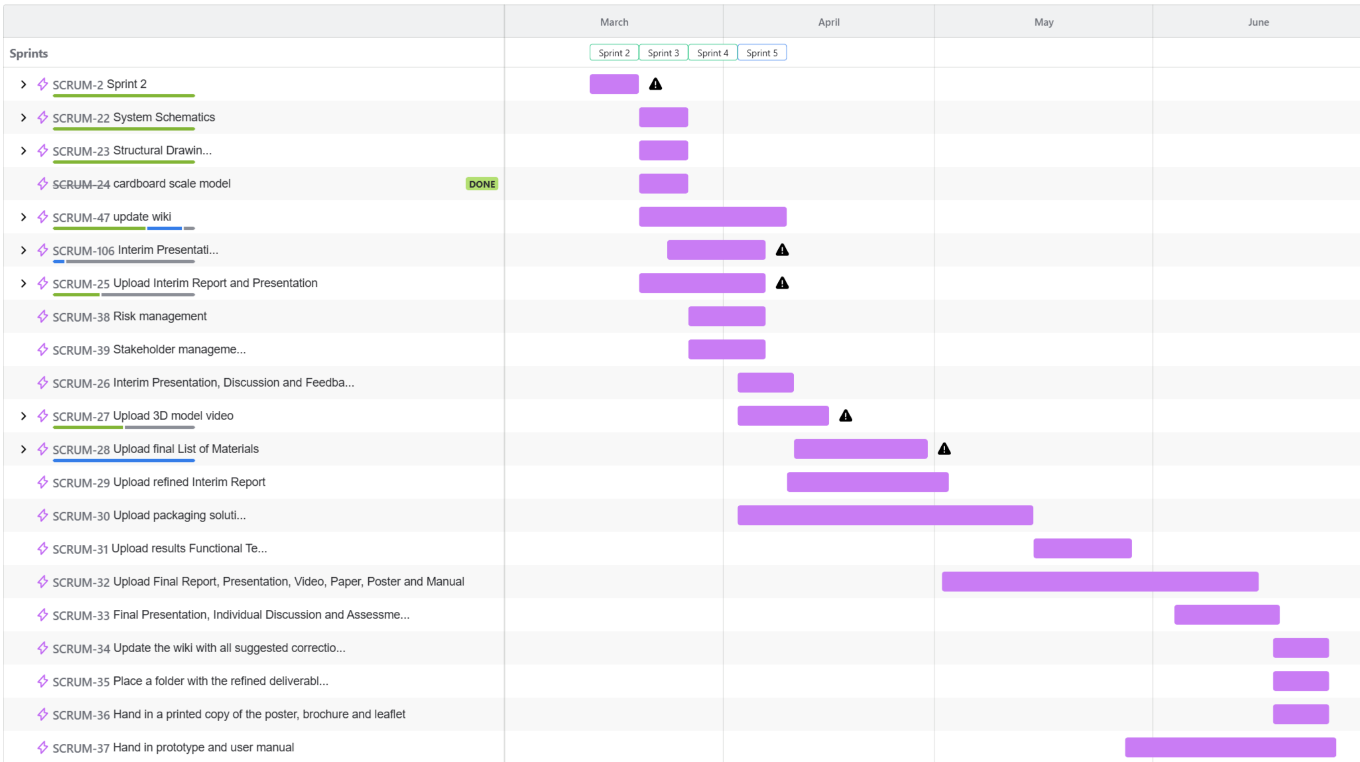

Figure 6: Release Gantt chart

3.11 Sprint Outcomes

Include the outcomes of all sprint reviews (what was the sprint backlog, completion status, planned capacity vs. achieved velocity).

This chapter discusses the different sprints and their outcomes.

3.11.1 Sprint 1 6/03/2025 – 12/03/2025

In the first sprint (Table table 8), the team defined the project with the help of the Design Thinking workshop. After that, the team started researching existing products to write the state of the art and created the first structural drafts and first BlackBox.

Table 8: Sprint 1 Outcome

Tasks Sprint 1	Planned Duration (h)	Real Duration (h)	Involved Members	Status
Define Project	12	14	Everyone	Done
System Diagrams	4	5	N, S	Done
First Structural Drafts	2	3	C	Done
Research	4	5	Everyone	Done

3.11.2 Sprint 2 13/03/2025 – 19/03/2025

In the second sprint (Table 9), the team defined the Project Backlog, Global Sprint Plan, the first initial sprint plan and the WBS. These all help to get a better overview of the project and to break it down in main tasks. Also, the team started working on the material list and drafting the first structural drawings. After feedback from the teachers, the Black Box model was improved.

Table 9: Sprint 2 Outcome

Tasks Sprint 2	Planned Duration (h)	Real Duration (h)	Involved Members	Status
Project Backlog	1	1	C, Q	Done
Global Sprint Plan	0.5	0.5	C, Q	Done
First Initial Sprint	0.5	0.5	C, Q	Done
Gantt Chart	1	1	E	Done
State of the Art	2	3	Everyone	Done
First Component List	2	3	S, N	Done
First Material List	1	3	E, C, L, Q	Done
Flyer and Logo	2	3	C, L	Done
Marketing Plan	2	2	Everyone	Done

3.11.3 Sprint 3 20/03/2025 – 26/03/2025

In the third sprint (Table 10), the team managed to make a first 3D design and cardboard model of the product. Also, the first electronical scheme was created. Next to that, there was a first presentation of the business model and flyer. The final material list wasn't properly finished due to still being busy with the design of the product.

Table 10: Sprint 3 Outcome

Tasks Sprint 3	Planned Duration (h)	Real Duration (h)	Involved Members	Status
First 3D Model	5	7	C, N, Q	Done
Cardboard Model	2	2	E, L, Q	Done
System Schematics	4	4	S, N	Done
Structural Drawings	4	4	C	Not Done
Material List	5	5	N, S	Not Done

3.11.4 Sprint 4 27/03/2025 – 02/04/2025

Starting from the 4th sprint (Table 11), all tasks are properly divided and assigned to the team members with mentioning the estimated time needed. This sprint the team focuses on improving the different chapters of the wiki as the deadline for the interim report is coming closer. some tasks are not fulfilled completely as these are tasks that always will be adapted such as the Bibliography and the Projectmanagement.

Table 11: Sprint 4 Outcome

Tasks Sprint 4	**Planned Duration (h)**	**Real Duration (h)**	**Involved Members**	**Status**
Chapter 1	1	2	N, Q	Done
Chapter 2	5	5	E, S	In Progress
Chapter 3	2	2	E, S	In Progress
Chapter 4	4	4	L	Done
Chapter 5	3	3	N	Done
Chapter 6	7	6	Q	Done
Chapter 7	4	4	S, C, E	Done
Bibliography	2	2	S	In Progress
Project Management	2	2	E	In Progress
3D Model	7	22	C, Q	Done
Component List	5	7	S, N	Done

3.12 Sprint Evaluations

Include the summary of all the sprint retrospectives, including any actions implemented as part of the team's continuous improvement strategy.

To evaluate every sprint, the team discusses every sprint in a retrospective in Atlassin. They started doing this properly from sprint 3. The first and second sprint are summarized from what the team concluded without registering it in a retrospective.

3.12.2 Sprint 1 06/03/2025 – 12/03/2025

After the Design Thinking workshop, the team had the idea to make a compost bin and an application that combines different topics to prevent foodwaste in general. After discussing this, the team decided that the concept of a bin and an application with different functions and partnerships would be too complex to develop. That's why the focus was shifted to developing a bin with an application that focuses on monitoring the composting process.

3.12.2 Sprint 2 13/03/2025 – 19/03/2025

The teachers told us to keep attention to write in a scientific way without using "we" and by staying objective. Also, our material list is more an analyzation and not a final list. We should focus on trying to complete tasks from the beginning in a proper way so we can start working on next tasks.

3.12.3 Sprint 3 20/03/2025 – 26/03/2025

After evaluating the third sprint. The team concluded that tasks should be more divided so everyone knows what is expected and is able to work on different tasks instead of working all together on the same task. Also, for every chapter one teammember is responsible but will not have to write the whole chapter alone.

3.12.4 Sprint 4 27/03/2025 – 02/04/2025

After finishing Sprint 4, the time logged in the child issues isn't shown in the sprint report on the confluence platform or the sprint burndown chart (Figure7). To keep it more easy, the team will try to keep the tasks simple without child issues.

The peak in the curve at the beginning of the sprint shows that more work was added to the sprint after starting it. In the future, the team should first define all the tasks and estimate the needed time before starting the sprint. Also, the curve only goes down when tasks are finished completely, the team may log time but progress will only be shown when the tasks are changed to "done". This explains why only at the end of the curve it goes down. The team logged time during the week but only registered the tasks as finished at the end of the sprint.

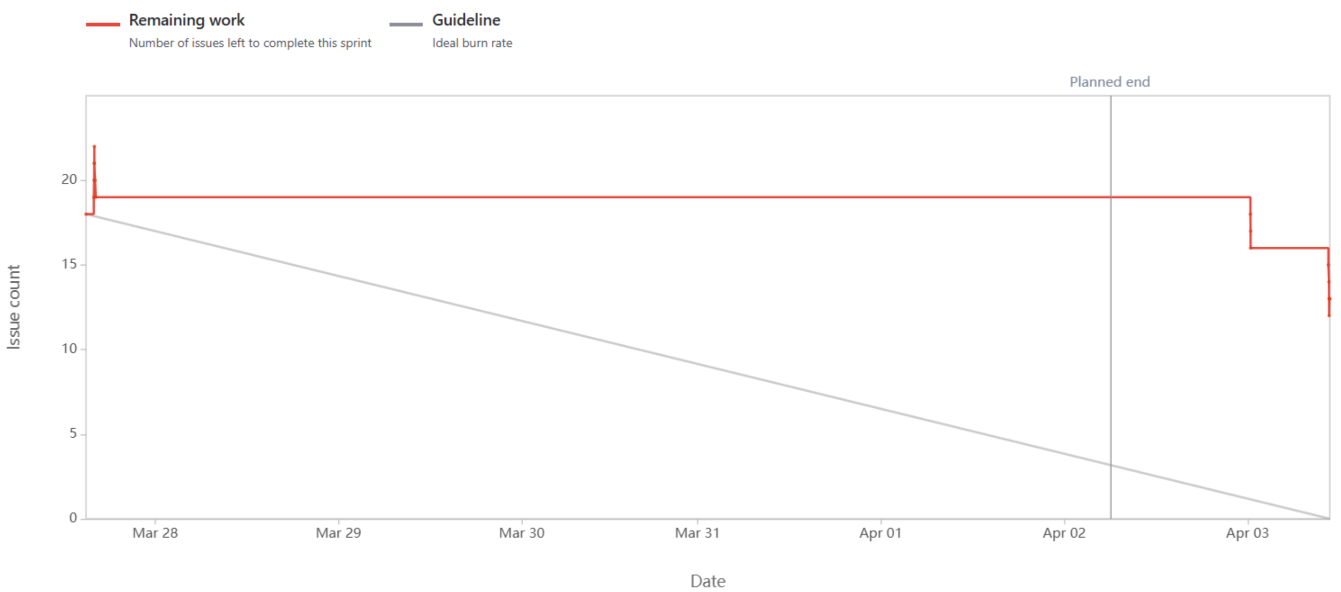

Figure 7: Burndown Chart Sprint 4

3.13 Summary

Provide here the conclusions of this chapter and make the bridge to the next chapter.

4. Marketing Plan

4.1 Introduction

This chapter outlines the strategy for successfully introducing the Leftlovers Loopbin to the market. It includes a thorough analysis of the market, target audience, and competitors. A SWOT analysis is conducted to identify key strengths, weaknesses, opportunities, and potential risks. These insights form the foundation for a well-defined marketing strategy and a strong brand identity. The ultimate goal is to launch a successful, high-quality product at an affordable price while ensuring customer satisfaction.

4.2 Business Idea Formulation

Before engaging with potential customers or developing prototypes, it is essential to refine and clearly define the value proposition. This process involves considering the Big Idea Hypothesis, which consists of six key elements: target customer, statement of monetizable pain, product name and category, statement of key benefit, primary competitive alternative, and primary differentiation. The concept has been summarized in an elevator pitch:

The goal is to develop a product for urban residents without access to a garden who wish to engage in gardening and efficiently repurpose their food waste. To address this need, the LeftLovers Compost Bin has been designed. This innovative solution combines a smart organic waste bin with an integrated garden, allowing users to compost easily while producing high-quality compost that can be used to nourish plants growing on top of the bin. While other kitchen compost bins are available on the market, the LeftLovers Compost Bin stands out by enabling users to monitor the composting process and create a fertilizer tailored to their specific choice of plants. This feature ensures a more personalized and effective composting experience.

4.3 Business Model

To establish a strong market position, it is crucial to define clear objectives within the market. In order to achieve this, a Business Model Canvas was developed, which can be seen in Figure 8

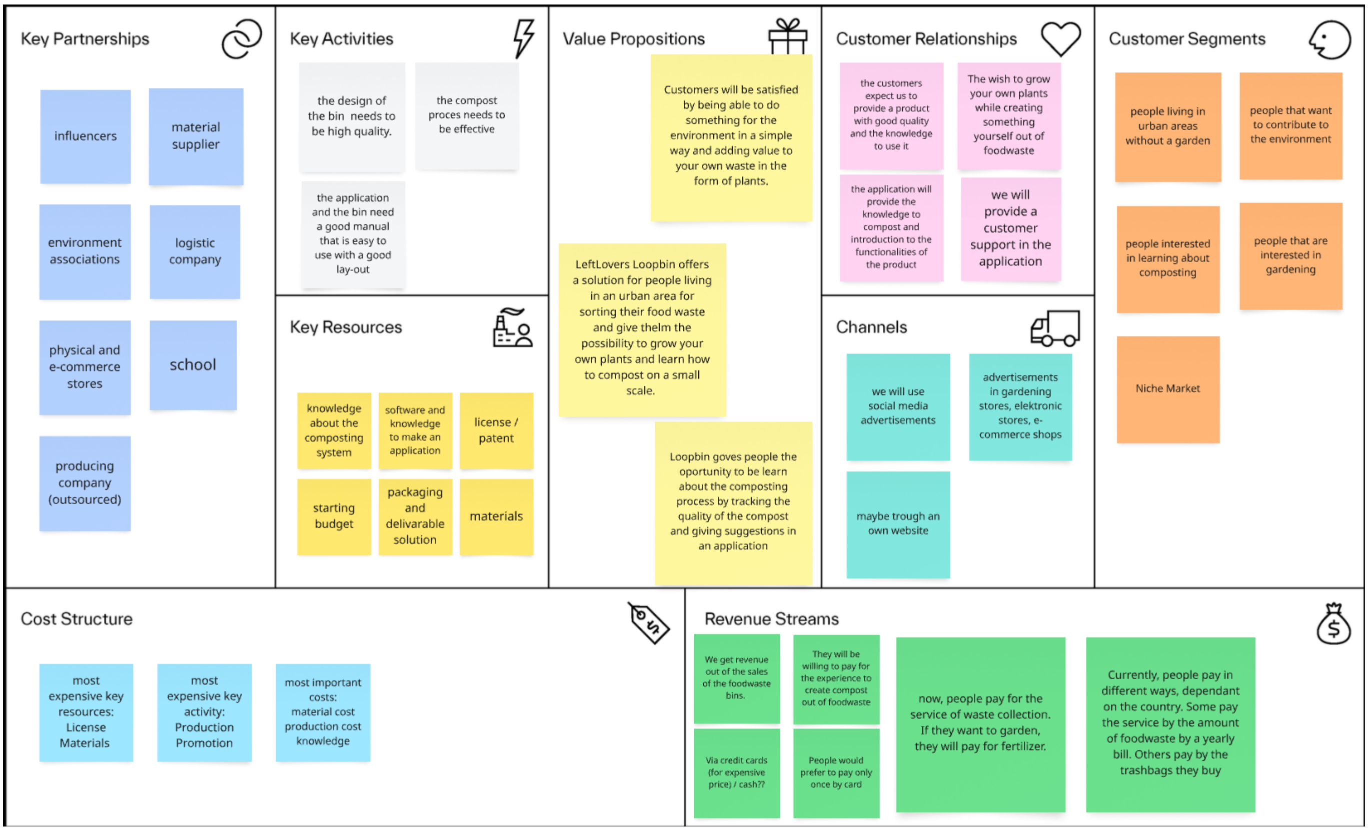

Figure 8: Business Model Canvas

4.4 Market Analysis

To gain a thorough understanding of market dynamics, customer needs, competition, and external factors that may influence the success of a product, conducting a market analysis is essential. This analysis allows for a deeper exploration of the market conditions in which the company operates. A market analysis can be divided into two components: micro and macro.

4.4.1 Micro Analysis

The micro analysis focuses on the factors that are closely related to the company and affect its ability to serve its customers.

One of these factors is the **company’s internal environment**, which includes all departments within the organization that influence the marketing department. This encompasses the company’s vision and strategic goals. In this case, the objective is to raise awareness about food waste and encourage individuals to take more sustainable actions with their food waste. Another critical element is the budget allocated by the company, which plays a vital role in shaping the marketing and product development strategies.

Another factor in the micro analysis is **suppliers**. Companies rely on suppliers to provide the necessary parts and materials for production. In this instance, a strategy will be implemented to partner with suppliers in Portugal, keeping operations local and avoiding import costs.

Customers are another crucial element, and they can be segmented into five distinct groups:

1. Consumer markets: These are individual customers who purchase the product for personal use. This group represents the target audience, particularly urban residents without access to a

garden who wish to engage in gardening and efficiently repurpose their food waste.

2. Business markets: These include companies that purchase the product to resell it. This market segment is not the focus for this product.
3. Reseller markets: These intermediaries can assist in promoting and selling the product. The product will primarily be sold through an online platform, but there are also plans to explore opportunities for sales in gardening stores for example, to aim at the target audience.
4. Government markets: These involve government institutions purchasing products for public purposes. Since the product is designed for home kitchens, it is not targeted at government markets as it is too small for communal spaces.
5. International markets: These are foreign markets where a company sells its product. Given the global population of urban residents, there is potential to expand and sell the product internationally.

Another factor are **competitors**; businesses offering similar products to the same target audience. The analysis in the state of the art has revealed that many kitchen compostbins are expensive, with few offering a built-in garden and an app. To gain a strategic advantage, the goal is to distinguish the product by offering a more affordable and unique solution.

The final element is **publics**. These are groups such as the media or shareholders that have an interest in or influence over the company's success. Maintaining a positive relationship with these groups is essential to avoid damaging the company's reputation. The aim is to create an image of contributing to a better planet by reducing food waste, thereby building a brand that resonates with environmental sustainability.

4.4.2 Macro Analysis

The **macro analysis** focuses on larger societal forces that affect the microenvironment.

The first factor is **economic**. This refers to the economic conditions that influence the buying power of consumers. Factors such as income levels, inflation, and unemployment impact how much consumers are willing to spend. The goal is to provide an affordable solution for urban residents who earn a modest income.

Another factor is **natural**. This pertains to the raw materials used in the production of the product. While composting itself poses no challenges, as leftovers will always be available, the product will be made of plastic, which requires consideration. Given the increasing trend of replacing plastic in everyday products with alternative materials, it may be worthwhile in the future to explore other materials. It is possible that more sustainable options will be discovered over time. For now, plastic is consciously chosen due to its ease of use. Additionally the aim is to create a high-quality product that can last long for the consumer. Considering the fact that the product contributes to reducing food waste, it is hoped that this will ultimately help reduce the ecological footprint.

Another factor is **technological**. This is also crucial for the product, because the technological environment changes rapidly which can create new opportunities. The compost bin will come with an app, which will need to be updated over time to ensure the security and stability of the app. Furthermore, it is essential to ensure that any data collected via the app remains private.

Political factors also play a role. This includes regulations and government policies. In many countries, residents can dispose of their green waste for free in designated bins. If the government were to introduce a fee to encourage the reduction of food waste, it could make it more appealing for consumers to use the compost bin instead.

The final factor is **cultural**. This pertains to the values and norms within a society that influence consumer behavior. The aim is to change how people perceive food waste and to instill a new norm that discourages the careless disposal of food. The goal is to foster a shift in behavior, encouraging people to rethink their approach to food waste and adopt more sustainable practices.

4.5 SWOT Analysis

SWOT stands for Strengths, Weaknesses, Opportunities, and Threats. A SWOT analysis examines these four aspects to identify areas for improvement and strategic growth. **[Asana, 2025]**

Strengths refer to internal factors that contribute to the product's uniqueness and appeal to the target audience:

- **Innovative design** – The Leftlovers Loopbin is more than just a compost bin, this product features an integrated garden on top, making it a unique and multifunctional solution.
- **Smart technology** – Equipped with sensors and an accompanying app, the bin provides users with real-time insights into the composting process, including notifications on when to add materials.
- **Sustainability** – Helps reduce food waste, making it highly attractive to environmentally conscious consumers.
- **Targeted at urban residents** – As the number of people living in small apartments continues to grow, so does the potential customer base.

Weaknesses highlight internal challenges that could hinder success and may require improvement:

- **Material choice** – Although durable, the use of plastic may be perceived negatively by eco-conscious consumers.
- **Limited food waste compatibility** – Certain types of waste, such as meat, are difficult to compost and can produce unpleasant odors. Therefore they can not be thrown into the Leftlovers Loopbin.

Opportunities represent external factors that could enhance success and market growth:

- **Rising awareness of food waste issues** – Growing consumer interest in sustainability increases demand for eco-friendly solutions.
- **Evolving government policies** – Potential regulations, such as taxes on green waste disposal, could drive more consumers toward home composting solutions.
- **Partnerships with eco-friendly brands** – Collaborations with sustainability-focused companies could expand reach and credibility.
- **Expansion into international markets** – The increasing global urban population presents opportunities for scaling the product beyond local markets.

Threats are external risks that could negatively impact success:

- **Competition** – The presence of alternative composting solutions may challenge market positioning.
- **Stricter regulations on plastic use** – Potential restrictions on plastic materials could require adjustments in product design and production.
- **Economic downturns** – Reduced consumer spending power may lead to lower demand for non-essential products.

4.6 Strategy

4.6.1 Strategic Objectives

The strategic objectives are composed of several components. One of them is the target audience, which consists of individuals who live in urban areas, lack access to a garden, are environmentally conscious, lead busy lives, earn a modest income, and seek a durable, cost-effective solution.

The objective of the product is to provide a composting solution for individuals who lack knowledge about composting and do not have outdoor space. Additionally, the goal is to enable users to experience the value of transforming food waste into plants, rather than discarding it. The target audience will be reached through multiple channels, including the company's own website, social media advertisements, e-commerce platforms, and advertisements placed in gardening or electronics stores. Word-of-mouth will also play a key role in generating interest. An interactive relationship with users will be fostered by offering tips via an app, encouraging user participation in the composting process, and showcasing tangible results through plant growth.

Behind the scenes, several activities are necessary for the operation of the business. This includes developing an easy-to-use solution, creating an attractive design, establishing an effective composting process, and implementing an active user solution. Partnerships will be essential for the success of the product. For product development, collaboration with material suppliers and ISEP is planned. To support the product life cycle, partnerships will be sought with logistics companies, retailers, influencers, and environmental organizations. Key resources required include an initial budget, knowledge or licensing for the app, expertise in composting systems, and raw materials. With these elements combined, the creation of the Loopbin will be possible.

For the positive side of the financial model, revenue will be generated from bin sales and the premium app. On the negative side, the costs will include material expenses, production costs, app licensing fees, and advertising expenses.

4.6.2 Segmentation and Targeting

Market segmentation can be analyzed using three key criteria: demographic, psychographic, and behavioral.

Demographic segmentation; who is the customer? This criterion focuses on measurable characteristics, such as:

- Age: Adults, primarily between 20 and 50 years old.
- Living Environment: Urban residents living in apartments or houses without gardens, particularly in densely populated areas of developed countries.
- Income: Middle- to higher-educated individuals with a modest income who are willing to invest in sustainable solutions.
- Household composition: Suitable for singles, couples, and small families.

Psychographic segmentation; what motivates the customer? This category considers values and beliefs that drive consumer behavior:

- Environmental awareness: The target audience seeks to contribute to a more sustainable world

by reducing food waste.
- Innovation-oriented: Open to new ideas and solutions that enhance daily life.
- Healthy lifestyle: A strong interest in growing herbs or vegetables at home.

Behavioral segmentation; how does the customer behave? This criterion examines purchasing behavior and decision-making:

- Cost-conscious: Individuals who have a limited budget and carefully consider their expenses.
- Value-oriented: Consumers who prioritize high product quality and seek value for money.

By defining the LeftLovers Compost Bin's target audience through demographic, psychographic, and behavioral segmentation, the marketing strategy can be effectively tailored to align with their specific needs and preferences.

4.6.3 Positioning

As part of state-of-the-art research, an extensive analysis was conducted on existing kitchen compost bins available on the market. Findings indicate that many of these products share similar characteristics. To introduce innovation in this market, differentiation will be pursued in two key areas: pricing and additional features.

The objective is to minimize production costs, allowing the product to be offered at an affordable price. Additionally, new features will be introduced, including compost monitoring through an app. This app will provide users with valuable insights, assist in creating the ideal fertilizer for their plants, and enhance the overall composting experience. Another distinctive feature of the LeftLovers Loopbin is the integrated mini-garden, enabling users to start growing plants immediately while utilizing the compost produced.

Figure X Figure 9 illustrates the market positioning of this product. It is placed in the upper-left quadrant, as it offers an affordable price along with unique features. In comparison:

- Bokashi bins are inexpensive but lack additional features.
- CEERCLE bins include an integrated garden but are high-priced.
- Lomi bins offer an app but are also high-priced.
- GEME bins are both expensive and lack additional features.

Figure 9: Marketing Position

4.6.4 Marketing-Mix

The marketing mix consists of the four P's of marketing, which include four key elements: product, price, place, and promotion. This framework serves as a strategic guide to effectively market a product to consumers. **[Alexandra Twin, 2010]**

The first P represents **Product**. The LeftLovers LoopBin is an innovative compost bin with an integrated garden, specifically designed for urban residents without access to a garden. It offers unique features, such as compost monitoring and personalized fertilization based on plant selection, ensuring a tailored and efficient composting experience.

The second P represents **Price**. Pricing will be determined based on several factors, including production costs, a fair profit margin, and consumer willingness to pay for the solution. The primary objective is to keep the price as affordable as possible while maintaining customer satisfaction and ensuring profitability.

The third P represents **Place**. The product will be made available for purchase through a dedicated website. Additionally, opportunities for retail partnerships in gardening stores are being explored, as these locations attract individuals passionate about gardening, who align with the target audience.

The fourth P represents **Promotion**. The marketing strategy includes a dedicated website featuring tips and insights on composting. Social media marketing will also play a key role, with educational posts on platforms such as Instagram to engage potential buyers. Furthermore, advertisements will be placed in locations frequented by the target audience, such as gardening stores, to increase product visibility.

4.6.5 Brand

The name of our company is Leftlovers, a play on the words “leftovers” and “lovers”. Our goal is to encourage people to fall in love with their leftovers by showing them how to create something useful out of their foodwaste. The original logo featured a plate with cutlery, which formed a heart shape. The name Leftlovers appeared underneath, with the letter “L” in a different font to emphasize the word “leftover”.

Over time, the logo was simplified. The inclusion of the “L” in the original design could have caused confusion. The updated logo now consists solely of the word “LeftLovers”, with a capitalized “L” in the center to continue highlighting the word “leftover”, as shown in Figure 10. The “V” in the logo is represented by the cutlery from the original design, and a heart symbol is placed above to represent “Lovers.”

Figure 10: LeftLovers Logo

Our product, the smart compost bin from LeftLovers, is called Loopbin. The logo comes in two versions, as shown in figure 11. The larger logo simply displays the word “Loopbin.” We chose the name “Loopbin” because, as the name suggests, it’s a bin that, when used correctly, creates a loop. The compost inside the bin is transformed into fertilizer, which is automatically collected in a planting box, allowing you to grow new herbs and vegetables from your old waste. In the logo design, the two “o”s are connected, as are the “i” and “n,” symbolizing the continuous cycle of waste transformation. The smaller logo features the connected “o”s, with the “i” and “n” linked above, creating a loop-like shape.

Figure 11: Loopbin logo

For the colors in our logos, we have chosen earthy tones such as brown and green. This decision was made to reflect the nature of our product, which is centered around food and composting.

In order to show this concept to the audience, we have developed a flyer, as shown in Figure 12.

Figure 12: Flyer

4.7 Marketing Programmmes

4.7.1 Programmes

4.7.2 Budget

4.7.3 Control

4.8 Summary

Provide here the conclusions of this chapter and make the bridge to the next chapter.

Based on this market/economic analysis, the team decided to create <specify the type of product> intended for <specify the market niche> because <specify here the relevant market-related reasons>. Consequently, the team decided to design a solution with the following <specify here the features added for market reasons>.

5. Eco-efficiency Measures for Sustainability

This section presents the measures put in place to ensure a reduced environmental impact. Initially, the focus will be on environmental considerations, analyzing the reduction of waste and pollutant emissions. The economic aspect will then be addressed to assess the financial viability of the project while ensuring responsible management of resources. The social dimensions will also be examined, considering the implications for the community and the opportunities for raising awareness of eco-responsible practices. A life cycle analysis will assess the ecological footprint of the product at each stage, from design to recycling. Finally, the conclusion will highlight the technical and strategic choices made to ensure a sustainable and effective solution.

5.1 Introduction

Ecology is a major issue in today's world, requiring the systematic consideration of environmental impacts in the development of new products and technologies. The increasing autonomy of many aspects of everyday life underlines the importance of integrating a sustainable approach into these developments.

When defining the project, it was important for the group to consider the ecological as well as the technical aspects. So, the theme chosen was “Smart food production in small spaces”. The idea that quickly emerged was to propose a solution for managing food waste. The decision to develop a food waste management solution was prompted by the lack of accessible and effective measures deployed on a large scale by local authorities and governments.

5.2 Environmental

Composting is a good way of treating food waste yourself. The compost produced can be reused to nourish plants, flowers and so on. However, you'll need a large enough outdoor space for the process to take place.

This is not a feasible solution for people living in cities with little or no green space available. The proposed solution remedies this problem, preventing food waste from being thrown away.

Having this solution at home means you can grow your own plants or herbs for cooking, for example, while making healthier use of your food waste. What's more, the active participation of the user considerably reduces the consumption of the product.

The final environmental aspect of this prototype is the use of PVC as the main material. This is a polymer that can be recycled. This means that most of the product is made from recycled material that can be recycled again. The other components are mainly made of stainless steel, to prevent them from being damaged by contact with the compost.

5.3 Economical

One of the major aspects of developing the prototype is durability. The aim is to create a hard-wearing product that will last for years. It must be easy to use for the user and not require regular maintenance or other breakdowns.

This is part of the economic aspect of LoopBin, as its purchase implies a long-term solution, with no additional maintenance costs.

What's more, as mentioned above, it consumes very little electricity. This means that there are no excessive electricity costs like some other household appliances, just a battery that must be recharged periodically. It also reduces the cost of the prototype, which has fewer electronic components (often very expensive).

Finally, monitoring the process using sensors ensures that compost is optimal, and therefore odor-free. Some existing solutions use carbon filters to reduce odors. These must be changed regularly and involve additional costs (around € 10/month). This is not the case here, so the only expense is the purchase of the product!

5.4 Social

The original idea behind the product is to provide a popular solution for managing food waste. The target audience is the middle class, living in flats in big cities, without necessarily having access to green spaces, gardens…

To achieve this, we need to offer a product that is sustainable, as we discussed earlier, but also economical, so that it is accessible to everyone. The previous chapter explained how costs can be reduced.

What's more, the solution is interactive and fun. The user is a player in the process, acting directly on the process, using the compost mixing system for example. What's more, the application guides users through the process, enabling anyone with little or no knowledge of the subject to produce effective and healthy compost.

The system of mobile boxes to collect compost also adds a social dimension to the product. If too much compost is produced, it can be shared with a neighbor, a relative, etc.

LoopBin's ease of use, fun and low cost make it easy to recommend and affordable for anyone who wants to try it out. This way, someone who has tried it can easily tell their friends and family about it, encouraging them to act for the environment!

5.5 Life Cycle Analysis

In this section, we'll look at issues relating to the manufacture of the product and the composting process.

As mentioned above, the materials used to create the prototype are the following. Firstly, PVC, which is the main material, will be used to make the outside of the bin, its structure. For the inside mechanism, the solution is stainless steel. It's not the most environmentally friendly solution, because its extraction and processing are not ideal. However, stainless steel is infinitely recyclable, and is a durable material, even when in contact with compost. This makes it a suitable alternative for the final product.

Finally, the LoopBin composting process is designed to be as economical as possible, both for the environment and for the user. The food waste is placed in the bin, then mixed and blended in the first stage. This operation is carried out by the user but only takes a minimal amount of time each week. The user will be alerted via the application, which uses various sensor data to detect a need for oxygen or a temperature that is too high.

By transferring to the lower level, you can store compost at different stages of maturation. In this second part, the user no longer needs to mix the waste, only to blend it, even less often than in the first stage.

Finally, when the compost is ready, it is sent to a recycling drawer. This drawer can be placed at the top of the bin to grow herbs, for example, or used on its own to be given away, or to produce other plants.

As mentioned above, the materials used are recyclable, and the electronic components reusable, so once LoopBin has reached the end of its life, it can be completely dismantled and recycled!

5.6 Summary

This section looks at several concepts relating to the ecological aspect of the LoopBin project. The first step is to develop a product that offers users a solution for transforming their own food waste into something that is good for the environment.

The idea is to have a product that is popular, easily accessible because of its price, easily recommendable because it is sustainable and good for the environment, and finally simple to use. Its design makes it an interactive product, with the user as a real player in the composting process, while simplifying its mechanism to have a solution that is less expensive than products on the market.

Finally, the system's sustainability is at the heart of its development. It is designed to be used for a long time, and to be fully recycled at the end of its life cycle.

So, it's a low-cost way of doing your bit for the planet, with a healthy and fun product!

6. Ethical and Deontological Concerns

6.1 Introduction

Ethics are moral principles that govern a person's behaviour or the conduct of an activity. It is important to apply good behaviour in any profession. Deontology is an ethical theory that defines actions as good or bad based on a clear set of rules **[Eldo Frezza, 2017]**. Rules ensure a balance between chaos and order. To allow fair bargaining, we need regulations and guidelines. Without them, only the strongest would prevail, leading to inequality.

This chapter presents the ethical and deontological concerns relevant to our product. During the product development process, it is mandatory to comply with established rules. The impact of the product on the environment is also crucial. It must be in harmony with nature and promote sustainability. Once the product is fully developed, the focus shifts to marketing and sales. These areas also raise ethical concerns. Developers must follow ethical guidelines to ensure honesty and fairness in promotion and sales. Additionally, the liability of the product is taken into account. A product must be safe, reliable, and meet legal standards. If a product causes harm, the responsible party must address the consequences.

By addressing these concerns, we create a responsible and sustainable product. Ethical and deontological principles help us maintain integrity and social responsibility throughout the project.

6.2 Engineering Ethics

In engineering ethics, each country's engineering board establishes its own code of ethics. Our team observed significant similarities among these various codes and selected the most relevant principles for our project. We identified five fundamental principles of engineering ethics that guided our team: integrity and honesty, competence, responsibility, impartiality, and confidentiality.

1. **Integrity and Honesty**
    - Engineers must document all design specifications and test results accurately, avoiding misrepresentation of the product's capabilities.
    - Proper attribution should be given to contributors and external sources to maintain intellectual honesty.
    - Engineers working in diverse teams should foster inclusive collaboration, respecting cultural and professional differences, no matter their religion, gender and personal characteristics.
    - Corruption and bribery must be strictly rejected. Offering or accepting bribes, commissions, or gifts to secure contracts is prohibited.
    - Transparent communication regarding the product's performance and limitations is essential in all technical documentation and presentations
2. **Competence**
    - Engineers shall regularly update their knowledge and skills in line with developments in science and technology.
    - Engineers aim to achieve the best possible results by making the best possible use of the resources at their disposal, and by integrating human, economic, financial, social and environmental dimensions.
3. **Responsibility**
    - Engineers should base design decisions on verified scientific principles, particularly regarding composting mechanisms and material performance.
    - Continuous testing and refinement are necessary to optimize functionality and user safety.
    - Material selection must prioritize sustainability, durability, and end-of-life recyclability to minimize environmental impact instead of quick win.
    - Potential safety hazards, such as structural instability or material toxicity, must be identified and mitigated.
    - Engineers should also not sign documents for projects outside their expertise or without direct supervision.
4. **Impartiality**
    - Engineers must select materials and manufacturing processes based solely on technical merit, sustainability, and project requirements.
    - Personal biases or external influences should not compromise objective decision-making.
5. **Confidentiality**
    - Engineers shall not disclose, without consent, confidential information concerning the business affairs or technical processes of any present or former client or employer, or public body on which they serve.

6.3 Sales and Marketing Ethics

In today's competitive marketplace, businesses must focus not just on customer satisfaction but on building lasting trust and loyalty. Modern consumers evaluate products based on the complete value proposition - including benefits, services, and ethical considerations - rather than just physical attributes alone. Effective marketing serves as the crucial bridge between products and consumers. However, unethical practices can severely damage customer relationships and tarnish brand reputation. When implemented properly, ethical sales and marketing strategies positively influence all elements of the marketing mix of 4 P’s. The 4 P’s stands for product, pricing, place and promotion, as stated in 4.6.4 Marketing Mix.

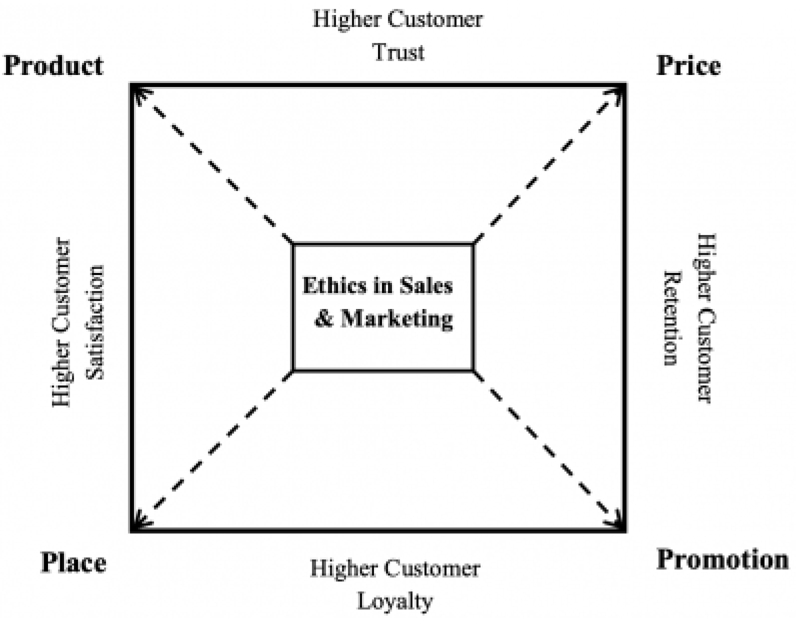

Figure 13: Ethics in Sales and Marketing: Customer Perspectives

As illustrated in Figure 13, this ethical approach ultimately strengthens the customer value proposition. The following sections will explain how the 4 P’s principles apply specifically to our ethical considerations for the project **[Pankaj M. Madhani, 2020]**.

1. **Product** development aligns with consumer needs.
    - Our compost bin marketing must present accurate information. We should clearly state decomposition timelines without exaggeration.
    - For odor control, we will use precise language like “reduces odors” rather than “eliminates odors.”
    - Insect prevention features should be described as deterrents, not guarantees.
    - Data collection requires user consent. We must explain how collected data enhances service quality and ensure that users understand their privacy rights.
2. **Pricing** must remain fair and transparent.
    - Premium features should have justified pricing. Any additional costs—such as ad-free app subscriptions—must be disclosed upfront.
    - Discounts should reflect real savings, not inflated base prices.
3. **Place** must prioritize accessibility and environmentally responsible distribution.
    - We aim to make Loopbin available through channels that are convenient for customers while minimizing environmental impact.
    - Marketers must not conceal product flaws or delivery issues.
    - Sales channels must operate ethically—no coercive or manipulative tactics should be used.
4. **Promotion** must focus on honest and responsible communication.
    - Environmental claims must be realistic and verifiable. Phrases like “100% earth-friendly” should be avoided unless fully supported by evidence.
    - Proper disposal instructions must be included to promote sustainable use.

  - Warnings and instructions should be clearly translated for all target markets.
  - Marketers must never misrepresent product benefits or make false claims about performance.

6.4 Environmental Ethics

Environmental issues are a massive problem that humans need to solve. The depletion of natural resources, pollution, and climate change are growing concerns. Products should always be sustainable and help reduce landfill waste. This is essential to minimize negative environmental impacts and promote a circular economy. Considering environmental ethics when developing a product is crucial. It requires a careful balance between innovation, resource conservation, and ecological responsibility. This includes material selection, packaging, and the product's end function, ensuring minimal harm to the environment while maximizing benefits.

Engineers should work together to create products that are both functional and environmentally friendly. Ethical decision-making in engineering ensures that sustainability is prioritized over short-term convenience. It is important to find harmony between humans and nature. Products should not interfere with the habitats and lives of other organisms. Biodiversity plays a vital role in ecological stability, and disrupting it can have long-term consequences. As part of the Earth, we have a responsibility to protect it by making mindful design choices. To support this, our team has created Loopbin. It transforms food waste into compost, which nourishes plants and reduces the carbon footprint of food waste. This aligns with environmental ethics by promoting waste reduction and sustainable living.

There are some environmental concerns regarding Loopbin’s material. Firstly, PVC is selected as the main material. It is a type of plastic. The main concerns with PVC include microplastic pollution, slow biodegradation, and greenhouse gas emissions during production. However, since the compost bin is designed for indoor kitchen use and is not a single-use product, PVC is still considered safe. Using durable materials extends product lifespan, reducing overall waste production. In terms of design, users can grow plants on top of the compost bin, giving food waste a second life. This feature emphasizes the ethical principle of waste repurposing and supports the idea of closed-loop sustainability. Material selection is further explained in 7.4.1 Structure.

To reduce electricity consumption, our team integrates human power into the composting process. Instead of an electric grinder, the system relies on manual rotation by hand. This reduces energy dependency and encourages user participation in sustainable practices. Additionally, carbon dioxide sensors track gas emissions, allowing users to monitor environmental impact in real time. Transparency in environmental impact is a key ethical consideration, ensuring users remain aware of their footprint. The application guides users in making compost efficiently, minimizing errors and reducing waste. This increases user engagement and encourages long-term use of the product, reinforcing ethical responsibility in daily routines. By fostering environmental awareness and ethical consumption, Loopbin contributes to a more sustainable future.

6.5 Liability

6.6 Summary

Provide here the conclusions of this chapter and make the bridge to the next chapter.

Based on this ethical and deontological analysis, the team chose <specify here the design, technique(s) material(s), component(s)> for the following <specify here the relevant ethics-related reasons>.
Consequently, the team decided to design a solution with the following <specify here the features added for ethical reasons>.

7. Project Development

7.1 Introduction

This chapter outlines the development of the Leftlovers Loopbin, detailing the entire process from initial concept to final product. The first section explores the ideation phase, presenting the first design sketches of potential final products. This is followed by an in-depth look at the product concept and its functionality. Section four focuses on the design process, discussing the technical aspects using a black box model and providing reasoning for material choices. The final part of the chapter covers the prototyping phase and the tests conducted to evaluate the product.

7.2 Ideation

The first brainstorms resulted in the idea to make a smart compost bin that monitors the quality and advices the user for improving the compost. The first drawings are shown in Figure 14.

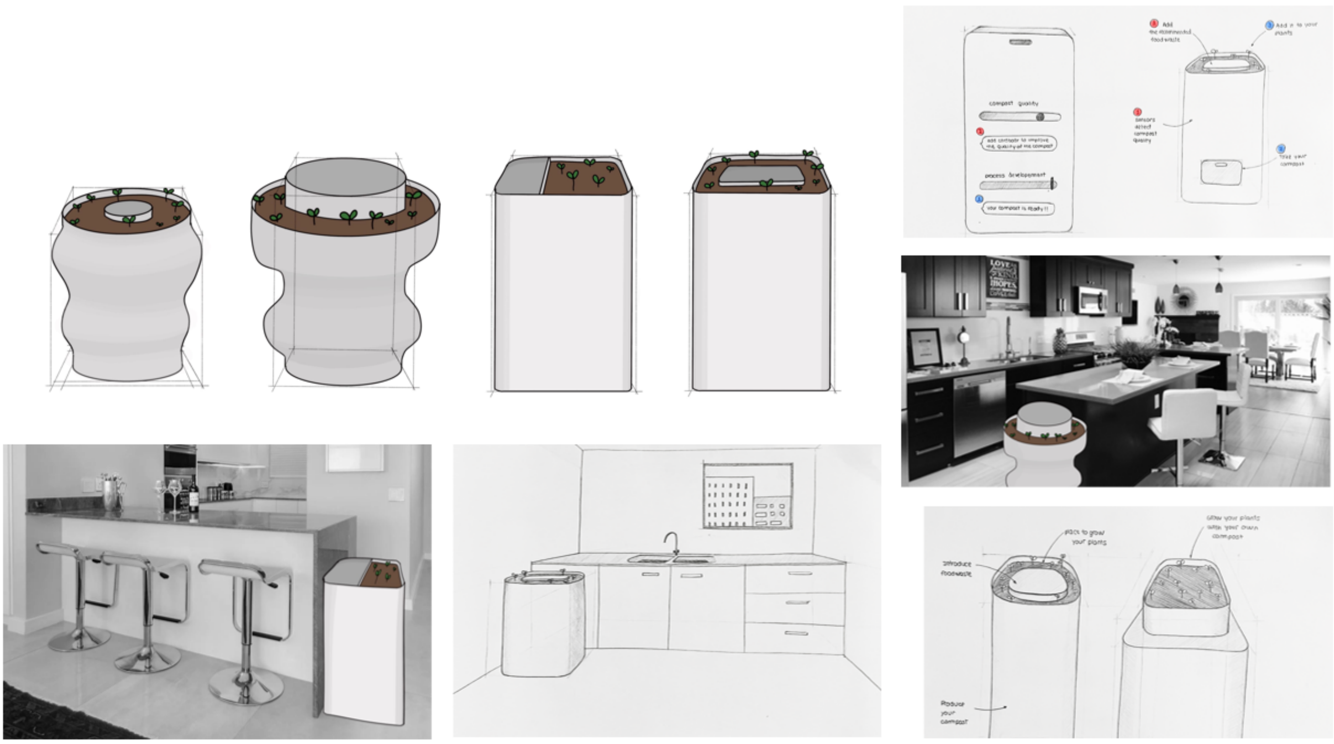

Figure 14: Composition First Ideas

7.3 Concept

After chapter 7.2 Ideation explains the basic idea of the Compost Bin, a detailed description of the concept follows, covering the key properties needed for an optimal composting process to create high-quality fertilizer. This concept is shown schematically in Figure 15 and is based on the theoretical foundations from chapter 2.2 Concepts. The input material for the Loopbin is food waste, which should ideally consist of a 50/50 mix of green and brown waste and should be added to the process continuously. Additionally, it is recommended to add mature compost at the beginning to help kickstart the composting process more effectively.

To speed up the composting process, a shredding step is first carried out. Then, it must be ensured that the composting process is fully completed. This is monitored by checking soil parameters like temperature and moisture, as well as analyzing the gas composition. These values are displayed to the user through an app, which also provides instructions for further steps. These instructions may encourage the user to take active steps needed to properly manage the composting process. Since turning the compost only needs to be done twice a week, this task is performed manually by the operator. This ensures user involvement in the process and helps reduce costs. Additionally, an automated ventilation system ensures proper airflow, creating optimal conditions and preventing unpleasant odors. Through this optimized composting process, it becomes possible to produce high-quality fertilizer for plants, which will also serve as the base for a plant box on top of the Loopbin.

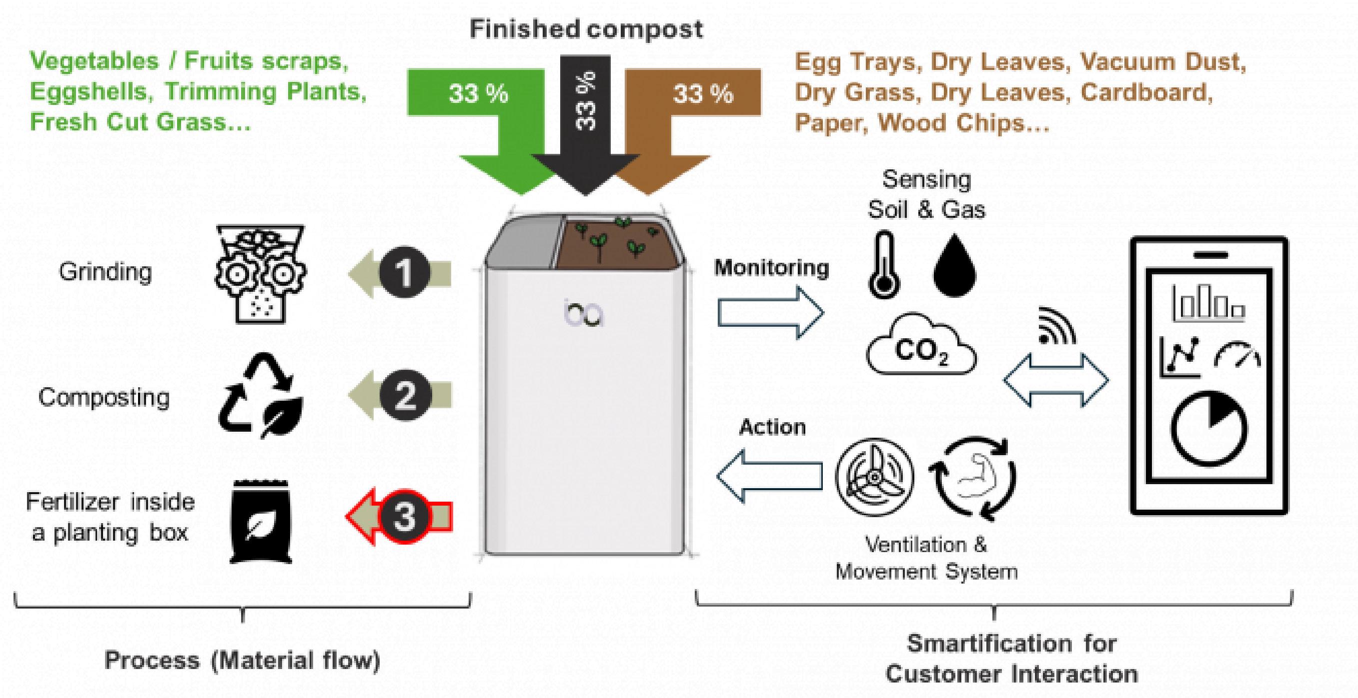

Figure 15: Concept of the LeftLovers Loopbin

7.4 Design

7.4.1 Structure

Initial Structural Drafts

By combining theoretical knowledge, initial conceptual sketches, and the developed concept, it was possible to create the first function-specific drawings of the Loopbin. Figure 16 presents a collection of different illustrations that highlight the various functions of the system.

The left diagram shows the basic structure of the Loopbin, including the functional areas and how the ventilation system is integrated. The middle diagram illustrates the key functions of the shredding and composting process.

At the top layer, food waste can be continuously added. This layer serves as a storage area, but the composting process already begins here. A mixing system shreds the material, and a soil sensor measures temperature and moisture to ensure optimal conditions for the composting layer below.

A manual lever mechanism moves the food waste into the composting layer, where the full composting process takes place. A movement system keeps the compost in motion. This layer also contains another soil sensor and a gas sensor, which monitors the atmosphere. Based on theoretical findings, different gases (O_2, CO_2, MH_4). can be used for monitoring. A follow-up analysis will determine which specific gases should be measured to ensure optimal composting conditions.

Once the composting process is complete, a mechanical floor drop mechanism transfers the finished compost into a storage box, which also serves as a plant box for growing herbs on top of the Loopbin. The app will display notifications to guide the user on when to manually perform tasks such as compost turning and chamber emptying. While the turning process may vary based on sensor readings to create the optimal environment as outlined in the theoretical foundations, the emptying of the chambers occurs every three weeks. This duration, as indicated by the state of the art analysis, is considered ideal for composting shredded and pre-composted food waste, meeting the requirement for composting to be completed within a few weeks. The illustration on the right provides an isometric view of the entire system.

Figure 16: First Structure of the LeftLovers Loopbin

Material Selection

Material selection is a critical step in designing functional and durable products, as it directly influences performance, cost, and user experience. When choosing materials, engineers and designers must consider factors such as strength, weight, corrosion resistance, thermal properties, manufacturability, and environmental impact. For indoor compost bins, the material must withstand moisture, resist odors, and maintain structural integrity while remaining lightweight and easy to maintain. This report evaluates suitable materials based on their properties and suitability for composting applications.

Table 12: Plastic Comparison

Plastic type	**Pros**	**Cons**	**Possibility of 3D-Printing**	**Price***
Polyethylene (PP)	Lightweight, recyclable, resistant to moisture, can trap heat, can withstand bending without breaking	Have limitations when exposed to strong oxidizing acids and some chlorinated hydrocarbons	Yes, but poor adhesion	1.50-3 €
Polypropylene (PP)	Lightweight, stronger and more rigid than HDPE, lightweight, good heat retention	Highly flammable, susceptible to UV degradation and oxidation	Yes	1-3 €
Polyvinyl chloride (PVC)	More rigid than HDPE	Heavier than HDPE, Harder to recycle, Contains chlorine, which can release harmful dioxins during production and disposal, can degrade over time outdoors	Yes, but not common	2-4 €
Polylactic Acid (PLA)	Polyester made from renewable biomass, enviromental friendly, recyclable, industrially compostable	May absorb water	Yes	2.60 €
Acrylonitrile Butadiene Styrene	Strong and rigid, resistant to wide range of chemicals, surface furnish	Less eco friendly (harder to recycle), low resistance to fire, degrade when exposed to sunlight	Yes	1.80-4.30 €

After the team discussion, polyvinyl chloride (PVC) is chosen as the primary material for castings due to its suitability for indoor composting applications. As a widely used plastic, PVC offers several advantages: it is naturally moisture-resistant, which is essential for long-term exposure to compost liquids, and its rigid structure eliminates the need for elastic components. Additionally, PVC provides thermal insulation, helping maintain stable temperatures within the bin and reducing energy requirements for decomposition. Its lightweight nature further enhances usability, making cleaning and maintenance easier for household users. While PVC is technically feasible for 3D printing, its practicality is limited due to concerns about chlorine gas emissions during the printing process, as noted in several studies.

Table 13: Metal Comparison

Metal type	Composition	Pros	Cons	Price per mt*
Stainless steel	Composed of iron and carbon, with at least 10.5% chromium by mass for its corrosion resistance	Highly durable, rust-resistant	Heavy, expensive	1730 €
Galvanising steel	A coating of zinc is applied to steel or iron to offer protection and prevent rusting	Durable, cheaper than other metals	Coating can wear off over time, it will eventually rust	230 €
Aluminium	/	Rustproof, lightweight, good heat retention	Can dent easily, soft metal, can react with acidic compost over time	1770 €

**Prices are subject to change based on market fluctuations and supplier pricing.*

For critical mechanical components such as the grinder and mixers, stainless steel is selected due to its superior durability and corrosion resistance. Stainless steel is an iron-based alloy containing a minimum of 10.5% chromium, which prevents rust formation even when exposed to moist food waste. This makes it ideal for high-stress, long-term applications where hygiene and structural integrity are priorities. The combination of PVC for the main bin structure and stainless steel for moving parts ensures a balanced approach, optimizing both performance and cost-effectiveness.

Mixing Part

After researching different kinds of mixers, the peddle blending mixer was chosen as the best choice for our product as it is used for mixing liquids and solids in food processing and pharmaceutical industry. An advantage of the paddle blending mixer is that it is still effective with a capacity of 20%. As the chambers of our product will not always be completely filled, this is an important factor.

Another option was an Archimedes screw. This mixer type is used in industrial applications such as on farms. A disadvantage of this type of mixer in a vertical use, is that the food waste has to be mixed multiple times to get small enough for an effective composting process. When used in an horizontal way, sharp edges were added to the Archimedes screw to cut the food waste. This application only worked on a high speed and would ask a powerful motor to make it function. The ribbon mixer is also an option but due to a difficult design the paddle blending mixer is a preferred choice.

An overview of the different mixers is seen in Figure 17.

Figure 17: Different Mixers

To combine the mixing and cutting part, sharp cutting parts are added to the floor of the first chamber to avoid the need to clean a separate shredder. This cutting parts will be surrounded by compost that will avoid rotting of food waste that sticks to the parts as these will be broken down into compost. As the cutting and mixing part are combined, these parts will be designed by the team.

Detailed Drawings

The current design and main functions of the Loopbin are shown in Figures 18 and 19. To create a strong and attractive market appearance, the Loopbin has been given a modern and appealing look. It will be available in different colors, as shown in Figure 18.

Figure 18: Design of the Loopbin

Figure 19 also shows the key functions of the stirring system and how each layer can be opened. Both layers use the same basic stirring mechanism, which is operated by a lever. However, the first (top) layer includes extra blades that are used to shred food waste.

The detailed views show how the layers can be opened: by pulling out a pin, one layer can be opened (see top image). Pushing the pin back in will close it again (see bottom image). After this interim report, the next step in the design process will be to improve this mechanism and add technical parts like bearings.

In addition, Figure 19 also shows that the plant box and the fertilizer storage box have the same construction. This helps to improve the functionality and flexibility of the Loopbin.

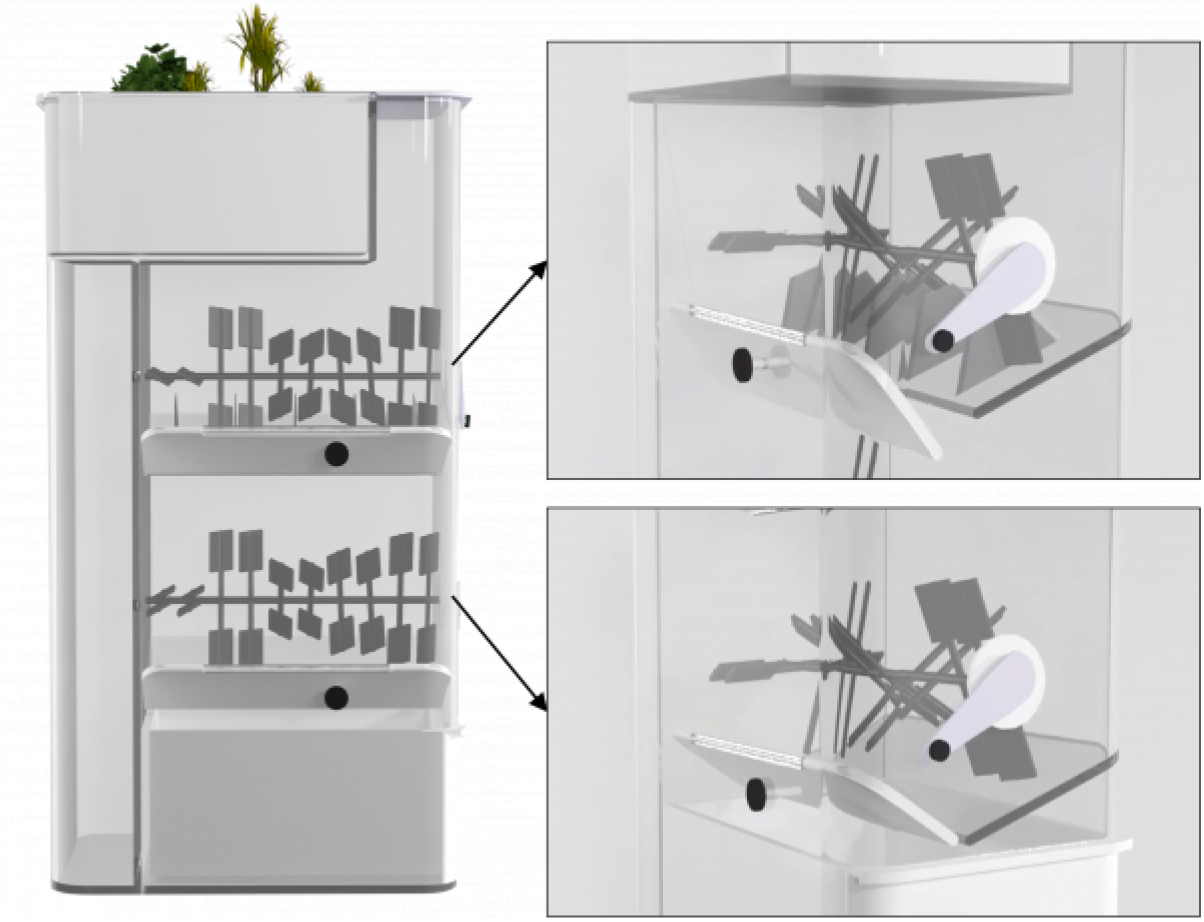

Figure 19: Functions of the Loopbin

3D model with load and stress analysis

…

Colour Palette

…

7.4.2 Smart System

7.4.2.1 Hardware

Black box diagram

The Black-Box model of the LoopBin, shown in Figure 20, illustrates how the system works and its key functions. The LeftLovers LoopBin processes food waste and turns it into nutrient-rich fertilizer. With an integrated plant box for herbs, this fertilizer can be used immediately for growing plants. As a result, the system not only produces fertilizer but also fresh herbs—and optionally vegetables—grown with the help of the compost. Additionally, an external energy source is needed to power various functions.

Each time food waste is added to the FoodBin, it is first chopped into smaller pieces and stored in the upper section. A movement system helps with both chopping and mixing the waste. At the same time, a ventilation system provides enough oxygen to start the composting process. Sensors in this section measure important factors like temperature, humidity, and air quality to ensure optimal conditions.

In the second, closed composting area, the monitoring process continues. Sensors keep tracking the environmental conditions, while a movement system and an additional ventilation system help regulate the composting process.

A central controller manages the entire system and sends the collected data to a connected app. This app shows the current composting conditions and provides guidance for the user to optimize the process.

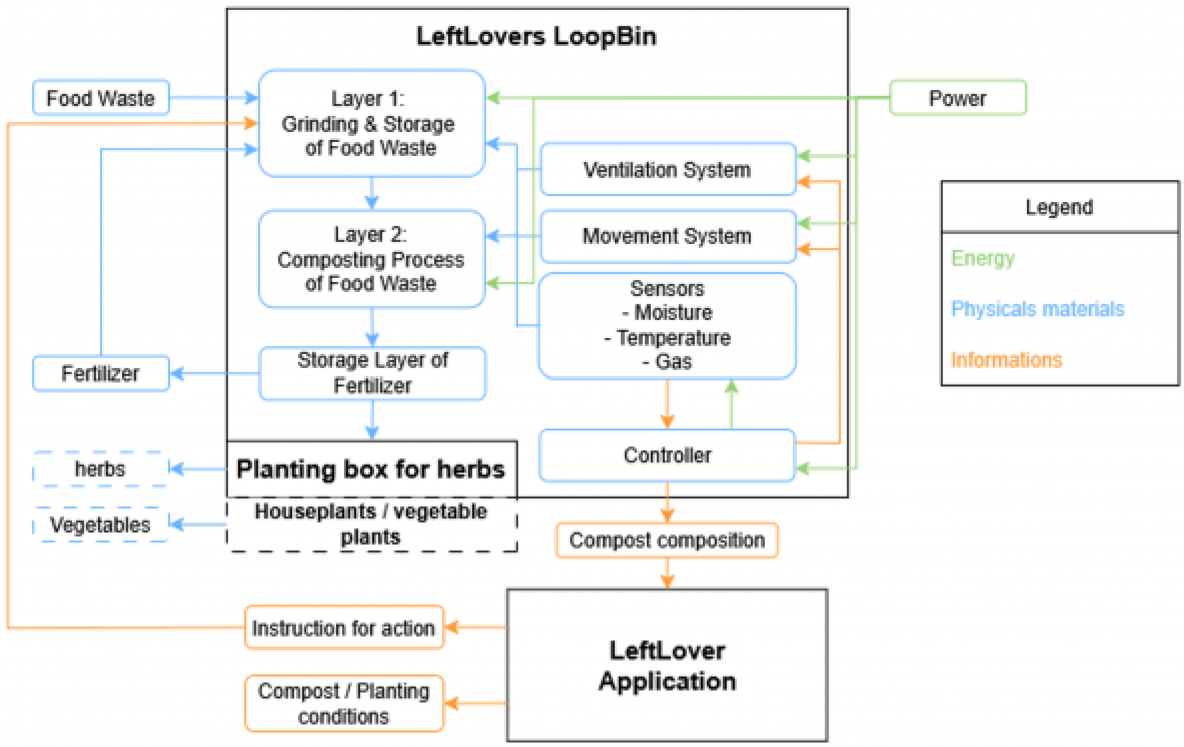

Figure 20: Black Box Model

Hardware component selection

Since all movements only need to be performed a few times per week, they are operated manually and determined by the design of the system. The components used for the monitoring process are standard purchased parts, meaning suitable components must be selected.

The table 14 presents various sensor options for monitoring compost composition. It is advisable to select a sensor that measures both temperature and moisture. Low-cost options like the STEMMA Soil Sensor lack detailed accuracy specifications and require calibration for accurate moisture readings, making them less suitable. Considering price and performance, the SEN0600 sensor is particularly appropriate for this application and has been selected accordingly.

Table 14: Soil Sensor Comparison

Name	STEMMA Soil Sensor	SEN0308	S-Soil MT-02A	SEN0600	SEN0602	DS18B20	Decagon EC-5
Supplier	Adafruit	DFRobot	Seeed Technology	DFRobot	DFRobot	Dallas Semiconductor / Maxim Integrated	Meter Group
Price	7.15 €	14.07 €	75.32 €	27.65 €	56,05 €	~ 4 €	~ 200 €
Measurement	Moisture & Temperature	Moisture	Moisture & Temperature	Temperature, Moisture	Temperature, Moisture, and pH	Temperature	Moisture
Power consumption	3 - 5 V	3.3 - 5.5 V	3.6 - 30 V	5 - 30 V	5 - 30 V	3 - 5 V	2.5 - 3.6 V
Dimensions	76.2 mm x 14.0 mm x 7.0 mm	175 mm x 30 mm	123 mm x 45 mm x 15 mm	123 mm x 45 mm x 15 mm	123 mm x 45 mm x 15 mm	Cable length usually 1 m or more	89 mm x 18 mm x 8 mm
Communication	I2C	Analog	RS-485	RS-485	RS-485	Digital	Analog
Range Temp.	Temperature not mentioned	-	-40 °C to +80 °C	-40 °C to +80 °C	-40 °C to +80 °C	-55 °C to + 125 °C	-
Range Moisture	200 (very dry) to 2000 (very wet)	540 (very dry) to 0 (very wet)	0 % - 100 %	0 % - 100 %	0 % - 100 %	-	0 % - 100 %
Accuracy Temp.	± 2 °C	-	± 0.5 °C	± 0.5 °C	± 0.5 °C	± 0.5 °C	-
Accuracy Moisture	Humidity not mentioned in datasheet	Humidity not mentioned in datasheet	±3 % (0 % - 50 %); ±5 % (50 % -100 %)	±2 % (0 % - 50 %); ±3 % (50 % -100 %)	±2 % (0 % - 50 %); ±3 % (50 % -100 %)	-	±3 %

In addition to the soil conditions, the composition of the compost atmosphere provides key indicators for a successful composting process. Particularly important are the O_2 and CO_2 levels near the compost. Table 15 shows suitable sensors for monitoring these values. It turns out that monitoring the CO_2 level is more cost-effective than monitoring the O2 level. For this reason, it was decided to monitor the CO_2 level. The SCD40-D-R1 sensor offers the best value for money with acceptable accuracy and was therefore selected for the project.

Table 15: Gas Sensor Comparison

Name	SCD40-D-R1	STC31-C	SCD30	T6793-5K	PS1-O2-25%	EZO-O2
Supplier	Sensirion	Sensirion	Sensirion AG	Amphenol Advanced Sensors	Amphenol SGX Sensortech	Atlas Scientific
Price	16.50 €	29,46 €	29,87 €	24.52 €	70,21 €	212,75€
Measurement	CO_2	CO_2, Temperature	CO_2, Humidity, Temperature	CO_2	O_2	O_2
Power consumption	3.3 to 5 V	3.3 V (2.7 V - 5.5 V)	3.3 V - 5.5 V	4.5 V - 5.5 V	400-600 mV	3.3 V - 5 V

Name	SCD40-D-R1	STC31-C	SCD30	T6793-5K	PS1-O2-25%	EZO-O2
Dimensions	(10 x 10 x 6.5) mm³	(3 x 3.5 x 1) mm³	(35 x 23 x 7) mm³	(30 x 15.6 x 8.6) mm³	(11.5 x 11.5 x 5.5) mm³	(63 x 27 x 27) mm³
Communication	I2C	I2C	I2C, Modbus, PWM	I2C, PWM	Analog	I2C, UART
Range	0 - 40 000 ppm	0 - 100 000 ppm	0 – 40 000 ppm	0 - 5 000 ppm	0 - 25 %	0 - 42 %
Accuracy	± 5 %	± 0.5 %	± 3 %	± 3 %	-	± 0.01 %
Response time	60 s	< 0.5 S	20 s	180 s	4 s	1 s

Table 16 presents different ventilation system options. In addition to cost-effective variants, particularly quiet fans were also considered. However, these come with significantly higher costs, so the focus remains on affordable options.

It proved advantageous to design the system for 24 volts, as this voltage is compatible with the soil sensor. For these reasons, the EF80252S2-1000U-A99 fan was chosen for the Loopbin. Compared to the existing market solutions from Table 2, the noise level of this solution is also within an acceptable range, which further supports the selection.

Table 16: Vent System Comparison

Name	EF80251S1-1000U-A99	9S0812L401	EF80252S2-1000U-A99
Supplier	Sunon Fans	Sanyo Denki America Inc.	Sunon Fans
Voltage	12 VDC	12 VDC	24 VDC
Power	1.44 W	0.6 W	1.01 W
Airflow	41.0 CFM	23.3 CFM	37.0 CFM
Noise	33.0 dB	16.0 dB	30.0 dB
Costs	4,75 €	19,70 €	3.00 €
Dimension	80 mm x 80 mm	80 mm x 80 mm	80 mm x 80 mm
Width	25.00 mm	25.00 mm	25.00 mm

In Table 17 shows suitable Controllers for the whole System. In order to process the information supplied by our sensors, and to implement actions in response to this information, we need to implement a microcontroller. Initially, the ESP32 from Espressif Systems seemed the ideal candidate, as it is less expensive than its competitors, and has 2 cores, enabling tasks to be carried out simultaneously (retrieving information from two sensors, for example). Furthermore, at this stage of our study, it has not yet been decided if the system will be connected via Wi-Fi or Bluetooth. This board does not rule out any option, so its choice is coherent for the rest of the project. However, when we were drawing up the circuit diagram, we discovered a new alternative, the Arduino Nano ESP32. This is an Arduino microcontroller equipped with a “u-blox® NORA-W106” chip, which enables it to communicate via Wi-Fi, as well as BLE (Bluetooth Low Energy). What's more, this board can supply power to some of our components, and is equipped with all the pins needed to operate our sensors.

Table 17: Controller Comparison

Name	ESP32 VROOM 32	Arduino Uno	Raspberry Pi
Supplier	Espressif Systems	Arduino LLC	Arduino LLC
Language	Arduino / µPython	Arduino	C/C++ / Arduino / µPython
Protocol	I2C(2)/I2S(2)/SPI(4)/UART(3)/USBOTG(1)	I2C(2)/SPI(4)/UART(2)/CAN(2)/1-Wire(1)	I2C(2)/SPI(2)/UART(2)/PWM(16)
Com/App	Wi-Fi / BLE / Cable	USB	Wi-Fi / USB
Dimensions	18 mm × 25.5 mm × 3.10 mm	68 mm x 53.4 mm x 15 mm (equipped)	21 mm x 51 mm x 1 mm
Price	5 / 8 €	30 €	10 €

Name	ESP32 VROOM 32	Arduino Uno	Raspberry Pi
Heart	2	1	2
RAM/ROM/Flash	520 KB / 448 KB / 4 ⇒ 16 KB	512 KB / 512 KB / 16 KB	264 KB / 16 KB / 2 KB
OP Voltage	3.3 / 5 V	5 V	3.3 V
OP Current	80 mA (Average)	50 mA	100 - 200 mA

Detailed schematics

Figure 21 presents the electronic schematic of the Loopbin. The protocol for connecting the humidity and temperature sensors is not supported by the microcontroller. To remedy this, a device must be installed to enable communication between the sensors and the board. This element also allows two sensors to be placed in parallel, so as to avoid having to duplicate the entire installation. The transceiver used is a MAX3485. It allows you to switch from RS845 to UART, and requires only 3.3 V of power. It can therefore be powered by the board. As explained above, it allows two sensors to be connected to a single board, even if it uses the UART protocol, which supports only one connection. Once connected in parallel, communication with a sensor will take place via its IP. Since they share the same wires, you'll need to specify the IP of the sensor concerned when sending a request. This protocol works on the Master/Slave principle, the master being the Arduino and the slaves the sensors. The only problem is that you can only communicate with one sensor at a time.

The final sensor in the prototype is a gas sensor. Unlike temperature sensors, only one is needed, as it measures directly in the air. For economic reasons, the selected sensor is a CO2 sensor. Too much CO2 means too little oxygen. This makes it possible to define when it is necessary to mix and ventilate the compost. This kind of sensor works with the I2C protocol, supported by the Arduino, so there's no difficulty in connecting it. Its power supply is 5 V, also possible with the board. The final elements in the compost bin can are the fans. They are necessary for good ventilation of the compost, which is essential for an optimal process, and to avoid odors. The simplest solution for controlling these fans is to use MOSFETs. These are switches that can be controlled by the Arduino board. The gate is connected to an Arduino pin, the drain to the fan, and the source to GND. However, a resistor must be placed between the gate and the pin to avoid voltage spikes on the board. Fans require an excessive power supply, which the board cannot provide. For this reason, a battery must also be fitted, to power the temperature sensors.

To finish with the electronic schematic, it's important to connect all the GNDs together, to ensure circuit consistency. The red zone indicated on the schematic is the zone grouping the components that can be assembled together on a Shield, in the dedicated zone on the prototype. The other components are strategically positioned according to their role in the installation.

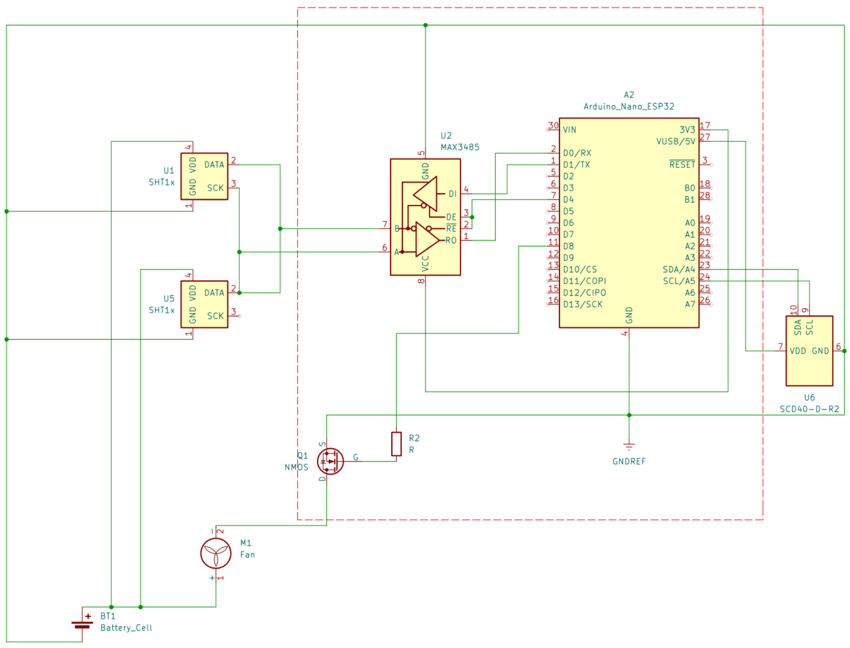

Figure 21: Electronical Schema

Power budget

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7.4.3 Software

Describe in detail the: (*i*) use cases or user stories for the smart device and app; (*ii*) selection of development platforms and software components (use tables to compare the different options); (*iii*) component diagram.

7.4.4 Packaging

Present and explain the: (*i*) initial packaging drafts; (*ii*) detailed drawings; (*iii*) 3D model with load and stress analysis, if applicable.

7.5 Prototype

Refer main changes in relation to the designed solution.

7.5.1 Structure

Detail and explain any changes made in relation to the designed solution, including structural downscaling, different materials, parts, etc.

7.5.2 Hardware

Detail and explain any change made in relation to the designed solution. In case there are changes regarding the hardware, present the detailed schematics of the prototype.

7.5.3 Software

Detail and explain any changes made in relation to the designed solution, including different software components, tools, platforms, etc.

The code developed for the prototype (smart device and apps) is described here using code flowcharts.

7.5.4 Tests & Results

Hardware tests

Perform the hardware tests specified in 1.6 Tests. These results are usually presented in the form of tables with two columns: Functionality and Test Result (Pass/Fail).

Software tests

Software tests comprise: (i) functional tests regarding the identified use cases / user stories; (ii) performance tests regarding exchanged data volume, load and runtime (these tests are usually repeated 10 times to determine the average and standard deviation results); (iii) usability tests according to the System Usability Scale.

7.6 Summary

Provide here the conclusions of this chapter and make the bridge to the next chapter.

8. Conclusions

8.1 Achievements

Discuss here what was achieved (wrt the initial objectives) and what is missing (wrt the initial objectives) of the project.

8.2 Future Development

Provide here your recommendations for future work.

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