Report

Insect farming for soil rebuging

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Acknowledgement

Glossary

Abbreviation	Description
EPS	European Project Semester
ISEP	Instituto Superior de Engenharia do Porto
USB	Universal Serial Bus
FMEA	Failure Mode & Effects Analysis

1. Introduction

European Project Semester (EPS) is a program in the first place for engineering students, but students of other fields of study are welcome as well. It is offered by universities all around Europe and is made to prepare engineering students to face the challenges of the contemporary economy.

The students work on a project with multinational and interdisciplinary teams. The semester lasts at least 15 weeks minimum. The students work together in English and get guided to focus on the product as well as the project **[European Project Semester, 2022]**.

1.1 Presentation

We are Paul-Luchian, Benjamin, Marie, Finn, and Leonie (Figure 1). Five enthusiastic and motivated students from all around Europe and we are Team 1, Team Onesect, from the EPS Project 2022 at Instituto Superior de Engenharia do Porto.

Figure 1: Team Onesect: Paul-Luchian, Benjamin, Marie, Finn, Leonie

Under the guidance of a team of professors at ISEP, we will work on a multidisciplinary project with an ethical and sustainable purpose in mind. We will join our competencies and try to create a product that conforms to all European guidelines and regulations.

Name	Country	Field of Study
Paul-Luchian Petrache	Romania	Engineering and Management of Smart Cities
Benjamin Copinet	France	Packaging Engineering
Marie Vandepitte	Belgium	Product Development
Finn Flügge	Germany	Production and Logistics
Leonie Margetich	Austria	Media Technology

1.2 Motivation

When we look at our motivation to participate in the EPS program, we see that there are multiple reasons but the general idea is the same. We want to expand our knowledge by discovering multicultural ways of engineering and entrepreneurship. By studying abroad, you learn to work out of your comfort zone which improves your out-of-the-box thinking. Thereby, foreign studies enhance your English capacities.

1.3 Problem

In a world of overpopulation, pollution, global warming, and climate change is ecology and sustainability no longer absent from our society. Awareness about the changes that are happening is growing and more people want to make an effort.

The world's population is growing and all these extra mouths need to be fed. This means that the emissions caused by food production will keep increasing. In Figure 2 you can see that the amount of meat that we have consumed the past 10 years has remained roughly constant. It even increased a little bit.

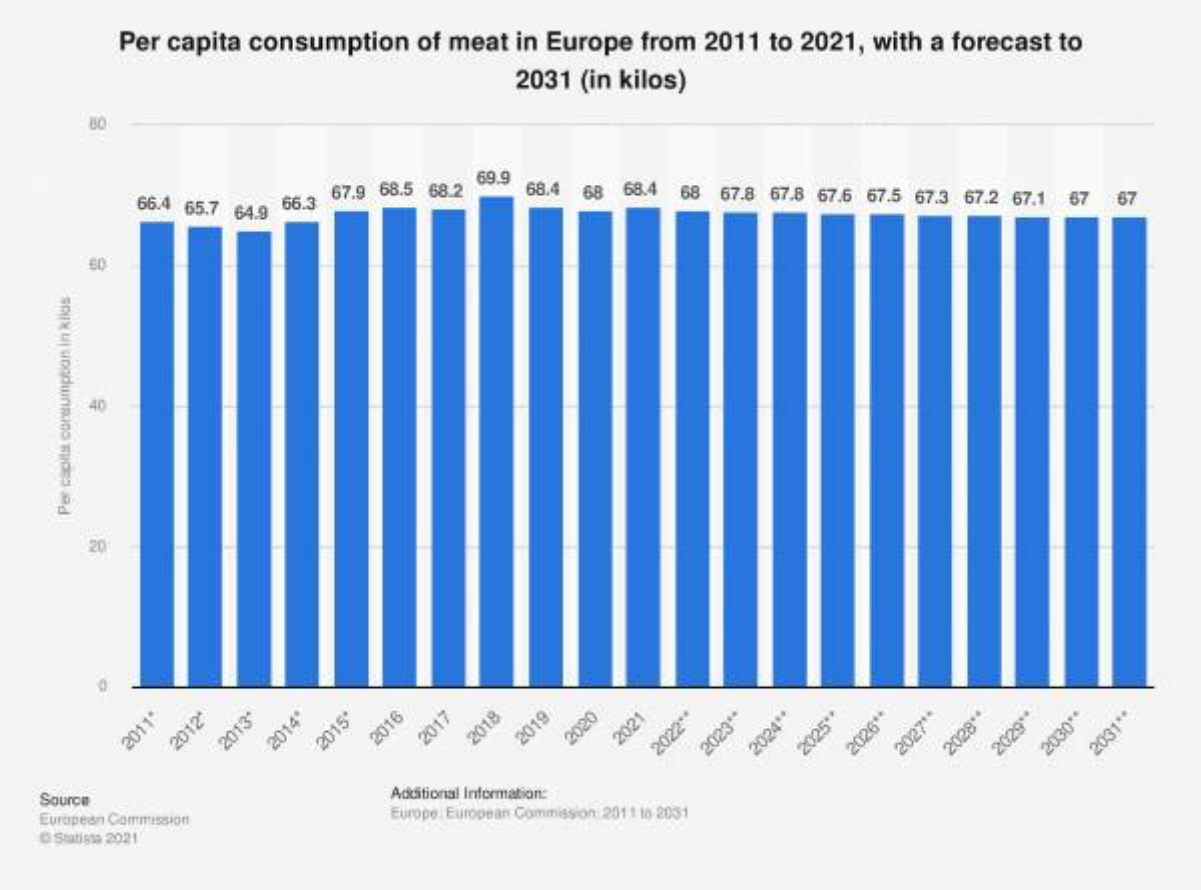


Figure 2: Per capita consumption of meat in Europe from 2011 to 2021, with a forecast to 2031 (in kilos) **[Mahsa Shahbandeh, 2021]**

This is a big problem because the meat sector is on the top of the most polluters in the food industry and their environmental impact is huge, greenhouse gas emissions, agricultural land use and fresh water are increasing **[Hannah Ritchie, Max Roser, 2017]**.

Meat consumption is also responsible for deforestation of wide areas of forests in South America. This causes a loss in CO_2 reduction and an increase in soil erosion. Especially the lack of sufficient CO_2 uptake is a big problem since extra CO_2 uptake is needed because of the large amount of carbon dioxide and methane gas emitted by the animals **[Sara De Vis, 2006]**. Also by using the land to raise these animals, a lot of ecosystems are harmed and suffer from biodiversity loss **[Ilija Djekic, 2015]**.

Although consuming fish emits six times less carbon emissions than consuming beef and five times less than consuming mutton, the consumption of fish still causes a lot of negative climate impacts. Not only are water and sediment affected, but natural habitats are also affected. Abandoned nets cause major changes to the water and oceans. This causes global climate changes **[Emily Petsko, 2021]**.

Another major problem within Europe is the current soil degradation. Our soil is facing problems such as erosion, salinization, contamination, compaction, etc. The decrease of biodiversity and organic matter also affect the health of the soil. This is because our soils are constantly subjected to human activity and they are often not given time to recover. There is a need for sustainable soil management **[Johan Ceenaeme, Filip De Naeyer, Victor Dries, Els Gommeren, Sofie Van den Bulck, Eddy Van Dyck, 2007]**.

The two problems above are closely related, in a report about The State of the World's Land and Water Resources for Food and Agriculture by the UN, they let it be known that soil degradation and

water resource shortages are compromising global food production. According to them, the biggest threat is the loss in soil quality, followed by the loss of biodiversity and depletion of water resources **[Food, Agriculture Organization of the United Nations, 2022]**.

1.4 Objectives

The above problems are just the tip of the iceberg of problems caused by meat/fish consumption and soil contamination. There is an urgent need for soil restoration and an alternative to provide the population with the necessary protein. We with team onesect want to help with this. We want to make alternative forms of proteins easily and simply accessible to everyone. Furthermore, our goal is to eliminate the use of pesticides and other chemical soil improvers. With our product we want to create interest in eating insects and how their lifecycle looks like. We want to spread ecological awareness, and make something that is currently very strange and unusual the norm. The aim is to introduce consumers to the closed loop system. Also, when time and space is limited, we want to offer the option to be self-sufficient.

1.5 Requirements

For our product, we want to work with a closed loop system. The output of our product, the exuvaie of the insects, stimulates plant growth. This forms the food for the insects in the form of organic food waste. In Figure 3 below you can see a representation of our own closed cycle.

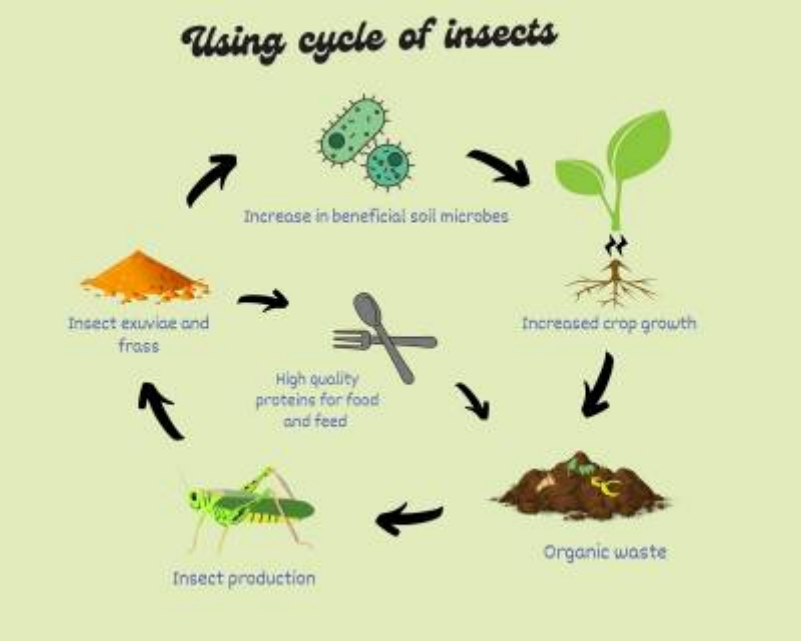


Figure 3: Using Cycle of Insects

As output we create both an organic fertilizer and food for humans and/or animals. The exuvaie of the insects serve as organic fertilizer for (indoor) plants. The fertilizer can be used in various situations, both indoors and outdoors. An absolute requirement is that the fertilizer does not contain additional chemical substances to guarantee the organic identity of the fertilizer. It should provide the plants with additional nutrition and have a positive effect on growth.

The insects themselves will serve as nutrition at the end of our cycle. An accessible way to consume the insects as food must be considered. This can be dried, frozen, powdered…. Therefore, the process from live insects to food must be done in an ethical and safe way. The food must be nutritious and useful to the body.

1.6 Functional Tests

1.7 Project Planning

- Scrum
- Sprints 2 weeks
- Product Backlog
- Sprint Planning
- Sprint Backlog
- Daily Scrum
- Review
- Gantt chart
- Teams
- Moodle
- SharePoint
- WhatsApp

For our project, we decided to use Scrum as a project planning tool. Scrum is basically a framework for project management and working together as a team. Scrum sets up a process that encourages participants to continually evaluate what is or is not working on an iterative basis. Therefore, communication is one of the key elements and is carried out through meetings, so-called events.

1.8 Report Structure

In this report, we begin with a thorough state of the art. We look at the current situation from both a commercial and scientific perspective. In the commercial part we look at the offers and the market around insect farming. Both products and services are taken into account. Emerging companies that want to delve into this are also included in this research. In the scientific part we look at what is possible around the raising of insects. The effects of eating and breeding insects are also looked at in a scientific way.

Next, the project management is stated. How we are going to spend our time, what techniques will be used to e.g., reduce risks, the organization of communication and how tasks will be divided are all part of the project management. The whole approach of the project will be discussed.

After this we move on to the marketing aspect of our product. Next to the branding aspect, a clear target group and strategy are chosen. The market is studied better and we take a clear position within this market. By means of a SWOT analysis, strengths and weaknesses along with opportunities and threats are compared. We submit our product to the marketing mix and see where we can improve. Budget management also falls under this heading.

Afterwards we look at the ecological aspects of our product. A list is made of the possible ecological impacts of our product and how we can improve our product in terms of sustainability. We also take into account the economic and social aspects and the costs that this may entail. Finally, this subsection looks at how the product can find a place in the circular economy.

Together with the ecological aspects, the ethical side of the story is also considered, both on a technical, ecological and social level. Is it responsible to put this product on the market? Does it comply with European regulations? Is the product reliable? Is there room for consumer confidence? These are just a few questions that are answered in this section.

Finally, we give a complete overview of the entire project. The final product is presented and also the road towards it. Both the initial brainstorming phase and the later structural design are shown here. Prototypes, test results and important design choices are shown here.

We finish with a conclusion of the project and possible future visions for our product.

Task	Description
1. Introduction	An introduction to our project and the road to it
2. State of the Art	The current situation around our theme
3. Project Management	How we handle the progress of the project
4. Marketing Plan	The approach in the field of marketing and communication
5. Eco-efficiency Measures for Sustainability	The ecological side of the project
6. Ethical and Deontological Concerns	Ethical justification of the project
7. Project Development	The process and evolutions of our project
8. Conclusions	Final summary of the report and future visions
Bibliography	All sources used during the writing of this report

2. State of the Art

2.1 Introduction

In the state of the art, the situation how it is now is shown. The question “What is currently going on in the world of insect farming?” is answered here. We divided it into a commercial and a scientific state of the art. Both research on the latest advances within the subject and short-term visions of the future are provided. The state of the art gives you a clear vision of the subject and what direction the project will take.

2.2 Commercial State of the Art

Before forming an idea for a possible concept, it is important to know what is already on the market when it comes to insect farming. During commercial research, we took a closer look at some bigger and smaller companies that are in the field of insect farming.

The first conclusion we made is that there are a lot of different possibilities. Insects are used for various purposes such as human diet, pet food, soil fertilizer, dye… The goal of our project is to rebug the soil with the use of insect farming. During our research, we focused more on that motive. Next to that, we also did some research on home-farming kits, to see what the possibilities are on that topic.

Big farms use sophisticated insect technologies to farm a large scale of insects and sell them, or their frass and exuviae, for commercial use. Most of these companies use technology-driven, sustainable, circular, and innovative techniques such as special storage systems, industrial washing machines, control software, and smart measuring tools **[Viscon Group, 2022]**. Because these companies are targeting larger production and target groups, they have done a lot of scientific research on the benefits (and disadvantages) of their projects and products. The main target product of these businesses is pet foods and soil fertilizer.

Further is there also a niche where the output isn’t a product made out of insects, but these companies offer insect farming technologies. They deliver services, machines, technologies, and other facilities to improve the insect farming sector **[Protenga, 2022]**.

The company Livin Farms offers a farming service, by using industrial food waste to make protein powder, lipids, and fertilizer **[Livin Farms, 2022]**. They created a modular construction system for fully automated insect factories for rearing insects on a high scale. By using Plug&Pay technology they provide other businesses with the process to produce insect protein. The customer gets a bi-weekly delivery of seedlings for the production of the insects. Through a 7 days cycle, the customer rears the insects (black soldier fly larvae) on-site to create the desired product for sale.

The association Terreform ONE developed a Cricket Shelter as you can see in Figure 4 **[Terreform ONE, 2022]**. The Cricket Shelter is in the form of an array of structural pods that promote the optimal vicinity for crickets. Terreform ONE is a nonprofit art, architecture, and design research group that fight the extinction of planetary species by creating and designing inclusive spaces and systems that aim for global environmental justice. Their focus is based on ecological planning, biotech architecture, urban systems, and public art. By creating the Cricket Shelter, Terreform ONE wants to educate the general public about its role in sustainable consumption. The installation consists of a series of modular containers that could be customized as needed with ventilation, flexible cricket sacks, and permeable feeder ports. On top of the installation are 25 quills attached to vent the cricket farm naturally and to amplify the stridulation sound while reproducing.

Figure 4: Terreform ONE Cricket Shelter **[Terreform ONE, 2022]**

We see that the number of businesses that supply insect farming at home is remarkably smaller than the number of businesses that do insect farming on a larger scale for other reasons. These home farming installations have different types of uses. For example in Figure 5, the company Livin Farms created The Hive Explorer , the first desktop hive to farm insects, both for personal and educational use. By using their device, you can recycle your food waste from home into alternative proteins and organic fertilizer through the work of mealworms **[The Hive Explorer, 2022]**.

Figure 5: The Hive Explorer by Livin Farms

In Figure 6 you can see the device the company BeoBia designed **[BeoBia, 2021]**. These eco–growing pods and present themselves as the future of pet food. They developed a closed-loop system that turns food waste into mealworm protein and plant fertilizer. The output is pet food ideal for birds, fish, reptiles, and amphibians.

Figure 6: BeoBio eco-growing pod

The offer for devices like this is quite limited. This means that there are still a lot of options for us to come up with an innovative and useful product. In the following Table 1, you can find an overview of all the companies we did research on.

Table 1: Commercial Research

Company Name	**Idea Discription**	**Products**	**Insects**	**Link**
Livin Farms	Insect powered technology forcircular economies: turning industrial food waste into valuable end products (fertilisers, protein, animal feed...)	Hive Explorer set – educational use; Plug&Pay Service; Hive Pro	Mealworms; Black Soldier Fly Larve	https://www.livinfarms.com/home/
Protenga	innovation – especially in nutrition and sustainability and re-thinking insect farming through our technology-driven circular ecosystem approach	Insects for Aquaculture; Insects for Pets; Insects for Poultry; Insects for Crops	Black Soldier Fly	https://www.protenga.com/
Viscongroup	developing the logistical process with our customers	Insect farming technologies	Black Soldier Fly; Mealworms; Cricket; Maggots	https://viscongroup.eu/markets/insects/
Aspire Food Group	building autonomous robotics, centralized distribution systems and custom assemblies to farm our insects from hatch-to-harvest	Insect farming technologies for human food, pet food and fertilizer	Weevil; Cricket	https://aspirefg.com/technology.aspx
BeoBia	Breeding mealworms to produce pet feed and fertilizer	Growing pods to harvest pet food at home	Mealworms	https://www.beobia.com/

Company Name	Idea Discription	Products	Insects	Link
Open Tiny Farms	a simple at-home mealworm farm which released open source with the launch of Open Bug Farm project	Open-source mealworm kit; Cricket farming technology	Mealworms;Crickets	https://www.opentinyfarms.com/about-us.html
Insect Feed Technologies	take food waste and transform it into sustainable, all-natural protein and oil for pet food, aquafeed, and nutrient-rich organic fertilizers for agriculture	Black Soldier Fly Dried Larvae – Pet Food; Black Soldier Fly Insect Meal (Milled Larvae) - Pet Food; Black Soldier Fly Organic Fertilizer (Frass)	Black Soldier Fly	https://www.insectfeedtechnologies.com/black-soldier-fly-organic-fertiliser
Terreform ONE	Design against extinction	Cricket Shelter	Crickets	https://www.terreform.org/cricket-shelter

From this state of the art, we can conclude that the insect farming market is bigger than originally expected. We can use the refined research from the big companies to see what the benefits and disadvantages are from certain insects and methods. The smaller companies and devices can give us inspiration about what are the possibilities and what's already done. The main goal now is to use the right information and make a useful and innovative product.

2.3 Scientific State of the Art

With the choice of the project, there were some questions upcoming regarding for example regulations and general information about insects. First, is insect farming actually better for the environment and still can provide all the required nutrition? Is it allowed to just breed any insects you want for food production? And what insects provide the best protein stats compared to their needed living conditions and the complexity of the habitat in which they live?

Compared to normal livestock farming insect farming has many advantages. Insects at every life stage function as a rich source of animal protein. "Edible insects usually contain more crude protein compared with conventional meat [...]. As food, they can provide essential amino acids at an ideal level, which are generally 76 to 96% digestible." **[Chufei Tang, Ding Yang, Huaijian Liao, Hongwu Sun, Chuanjing Liu, Lanjun Wei, Fanfan Li, 2019]** But not only the level of proteins, but also the amounts of fat, vitamins, and minerals are comparable to those of meat **[Antonella Baiano, 2020]**.

But insects cannot only compete with livestock on a nutritional basis. As there are already more than one million insects described and 4-30million species of insects estimated on earth, they find an ecological niche everywhere, places that are overtaken by humans, but also those which are mostly untouched. "With this diversity and their collective adaptability, they are a much safer source for future food security than are vertebrate animals such as cattle, fowl, or even fish. Since there are insects of some sort on nearly every patch of land on earth, chances are that some local species in every area can be farmed as human food without the need to import nonnative species for the same purpose" **[Ruparao Gahukar, 2016]**.

Furthermore, insects also “win” comparing the environmental aspects. Unfortunately, there has not been much research about this comparison, but Lars-Henrik Lau Heckmann, a Biologist and Ph.D. from The Danish Technological Institute and also an expert in insect farming says that he usually assumes that rearing insects is 100 times more environmentally friendly than raising cattle **[Kristian Sjøgren, 2017]**. The United Nations’ Food and Agriculture Organization (FAO) states that insects not only emit fewer greenhouse gases and produce less ammonia than cattle and pigs, but also require significantly less land and water than cattle and have a much higher feed conversion ratio than cattle, pigs and chicken **[Arnold Van Huis, Dennis GAB Oonincx, 2017]**.

As we already established in our problem description the ongoing anthropogenic-induced climate change, the growing world population, and the shortage of water and land are some of the key challenges we face in close future, which are all attacked by insect farming.

Besides the more positive effect on the environment, even insect waste can be reused. The waste, which divides into frass, basically a mix of the excretions and unconsumed food, and exuviae, the exoskeletons left behind after molting. This “waste” can be used as a highly effective fertilizer as frass and exuviae have “[…] a great impact on soil fertility due to high nutrient and labile C content” **[David Houben, Guillaume Daoulas, Michel-Pierre Faucon, Anne-Maïmiti Dulaurent, 2020]**.

So overall it can be said that insects not only provide the same or even better amounts of nutrition but also are a much safer source of food, which has also fewer negative effects on the environment and even provide a byproduct, which can be used as a highly efficient fertilizer.

As there are many food regulations, we researched what insects are authorized to be farmed and eaten. According to the EU-commissions food regulations, there are only five different insects that are approved. These insects are **[European Commission, 2015]**:

- Whole and ground Alphitobius diaperinus (lesser mealworm) larvae products
- Whole and ground crickets (Acheta domesticus)
- Whole and ground grasshopper (Locusta migratoria)
- Whole and ground mealworm (Tenebrio Molitor) larvae
- Dried Gryllodes sigillatus

After we “narrowed down” the possible insects due to the regulations, we started comparing these insects regarding their life expectancy, the diet which needs to be provided, the general living conditions, how difficult it is to breed and farm them, and also how much frass and exuviae they produce. Shortly after the first research, it became clearer and clearer that Tenebrio Molitor, the yellow mealworm, would be the best choice to go with. Not only it is one of the most economical species to produce protein-rich food, as their dried matter contains around 50% proteins, also during the metamorphosis of larvae into yellow mealworm pupa, up to 6 exuviae can be generated **[Foss, 2019]**.

In addition, other than the Acheta Domesticus, Gryllodes Sigillatus and Locusta Migratoria Mealworms are very slow, as they do not fly, jump, or run at all and move very slowly. Furthermore, they are extremely easy to care for, neither do they need any light nor any water to be added, as they are very efficient at extracting water from the food. Their diet is based on dry cornmeal, rolled oats, breakfast flakes, or similar dry food matter, sometimes some kind of vegetable, potato, or fruit needs to be added to assure their water supply. In addition, they can withstand temperatures from 4°C to 35°C and humidity from 50-75%, but if you want your population to grow faster and have a more stable lifecycle the ideal temperature is around 25-27°C and the humidity from 65-70% **[ExoticNutrition, 2021]**.

2.4 Conclusion

Provide here the conclusions of this chapter and introduce the next chapter.

Based on this study of the state of the art, the team decided to adopt the following <*specify here the architecture, technique(s), material(s), component(s)*> ... because <specify here the technical/scientific reasons>.

3. Project Management

3.1 Scope

The scope of a project sets a frame of the work, necessary to do in order to deliver a proper project outcome. In our case, the scope is defined in a work breakdown structure (WBS), which can be found in **Figure 7**. The WBS is a tool for analyzing and structuring different components of a project for easier and more efficient project management. Ongoing with the project components and sub-components can be added to the WBS as it is not fixed and it gives a global overview of the project and the work done or needed to be done to achieve an appropriate outcome. For that reason and in order to minimize the risk of failure, the WBS is commonly used in many projects and represents a very helpful tool for project management.

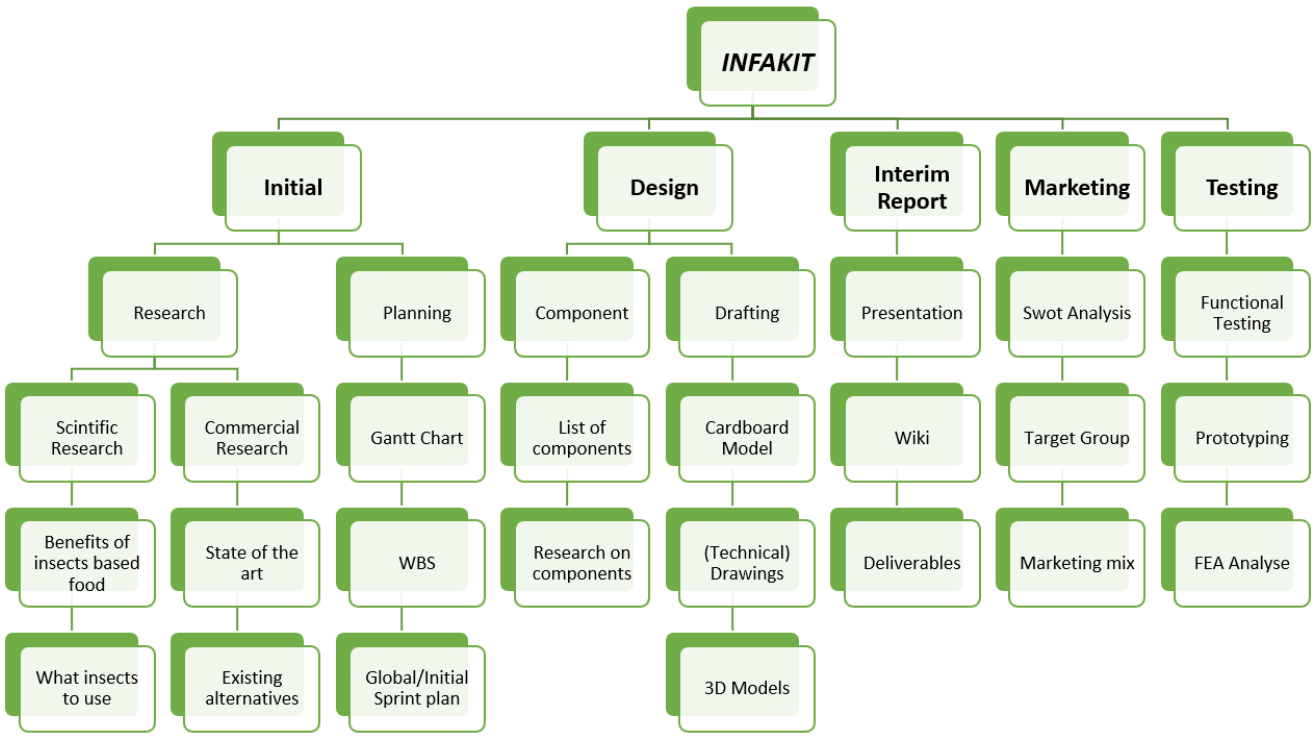


Figure 7: Current WBS of *INFAKIT*

3.2 Time

For the time management component, there are many different things to consider. EPS consists not only of the project and its associated deadlines, but also of a series of courses.

Courses that are part of the EPS project at ISEP:

- Energy & Sustainable Development
- Ethics & Deontology in Engineering
- Marketing & Communication
- Portuguese
- Project Management & Teamwork

Table 2 shows all the deadlines that must be handed in for the project.

Table 2: EPS Deadlines

Date	Deadline
2022-03-06	Project Proposal
2022-03-16	Project Backlog, Global Sprint Plan, Initial Sprint Plan and Release Gantt Chart of the project
2022-03-23	The “black box” System Diagrams & Structural Drafts
2022-04-06	The List of Components and Materials
2022-04-12	The detailed System Schematics & Structural Drawings and the cardboard scale model of the structure
2022-04-14	Upload the Interim Report and Presentation
2022-04-21	Interim Presentation, Discussion and Peer, Teacher and Supervisor Feedbacks
2022-04-27	The final List of Materials (local providers & price, including VAT and transportation) and the 3D Model Video
2022-05-14	Refined Interim Report (based on Teacher & Supervisor Feedback)
2022-06-07	The results of the Functional Tests
2022-06-18	The Final Report, Presentation, Video, Paper, Poster and Manual
2022-06-23	Final Presentation, Individual Discussion and Assessment
2022-06-28	The refined deliverables (source + PDF) together with all code and drawings produced
2022-06-30	The prototype and user manual

To meet these deadlines in conjunction with attending classes, we use an agile method of time management. Scrum allows us to adjust our time schedule according to the current situation. Using sprints, we are able to distinguish the highest priority items from the less urgent goals. In Figure 8 you can see our Gantt Chart to keep an overview of our project and the process towards it.

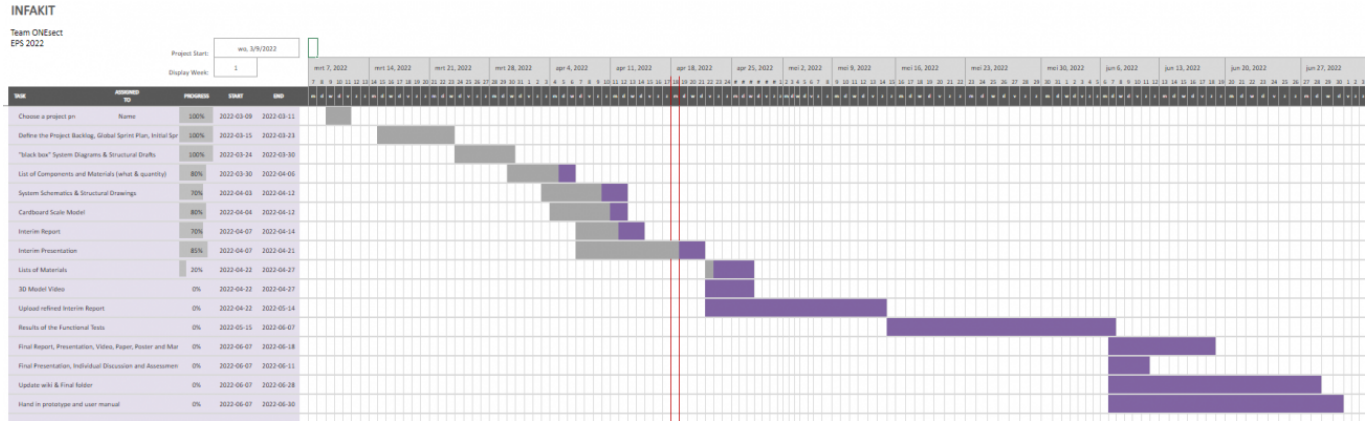


Figure 8: Gantt Chart

3.3 Cost

Document the planned vs. effective costs of your project.

3.4 Quality

In the quality component, we look at the quality of both the product and the project. Although we do not want to present ourselves on the market as a high standard product, we do want to be able to give consumers a guarantee of quality. That is why we look at quality across the board and why we subdivide the quality management component into product quality, service quality and teamwork quality.

3.4.1 Product quality

With our product, we want to come to the market with a quality product that meets as many user expectations as possible. When people purchase the INFAKIT, they are not only taking a product into their home, but also the responsibility of maintaining the mealworms. So, the product should definitely not disappoint after purchase.

We divide the product quality into 4 parts: functionality, components, materials and assembly.

Functionality: The product must do what it promises. The functions of the INFAKIT are clearly communicated to the consumer in advance. It is also important that all functionalities are easily and clearly accessible. Color indications and visual markings indicate the different functions. Redundant functions or elements are avoided to prevent confusion.

Components: To ensure the quality of the different (electrical) components, a list of components is prepared. In this list all the different properties of the components are compared. Based on these properties, the component that best fits within the framework of our product is chosen.

Materials: To choose our materials, we also base them on the list of components. From that list, we choose the components with the materials that appeal to us the most. We keep several pillars in mind, e.g. safety, durability, price …

Assembly: For the assembly we ensure the simplest possible set-up. Redundant parts are omitted and difficult operations in different directions are avoided. This is not only more efficient but also cheaper. For the setup of the product at the consumer we provide a quality user manual. We ensure that the parts slide smoothly into each other and provide protrusions to prevent an incorrect set-up.

3.4.2 Service quality

In addition to product quality, we naturally want to provide good service to our customers. Therefore, the product INFAKIT will not only consist of the physical parts, but there will also be a helpline available. With this helpline people can ask questions or give advice about their mealworms or the INFAKIT. When a question is asked, we strive for an answer within 24 hours.

Furthermore, we want, in time, next to a helpline service also create a community. Through a forum connected to INFAKIT, users can share experiences and answer each other's questions under the supervision of experts. Also, communication via various social media ensures a permanent involvement with the product and our service.

Even in the case of broken components, the modular design makes it easy to buy new replacement parts. Instruction manuals and videos make it possible for the user to repair the product himself.

3.4.3 Teamwork quality

To achieve the above quality levels, of course, good teamwork quality is needed. The key to achieve this is communication. By keeping each other informed on a timely and regular basis of progress everyone is working on, we try to get a clear overview of the current situation of the project. Clear communication goes hand in hand with a clear division of tasks. Using a clear schedule, tasks are assigned to different people and people can also assign themselves a task.

3.5 People

In order for the management of a project to run smoothly, tasks must be divided. It is important to be clear about who is doing what. Inefficient situations and duplication of work can thus be avoided.

It is important to give team members an appropriate task that matches their abilities and interests. Of course, less straightforward tasks also need to be carried out. For these tasks, team members can work together and thus combine their strengths.

Table 3 shows a task distribution of who performed which tasks.

Table 3: Task Assignment

Task	**Person**
Introduction	Finn, Marie
Commercial State of the Art	Leonie, Marie
Scientific State of the Art	Finn, Benjamin, Paul-Luchian

Task	Person
Project Management	Finn, Marie
Marketing Plan	Benjamin
Eco-efficiency Measures for Sustainability	Leonie
Ethical and Deontological Concerns	Paul-Luchian
Project Development	Team
Conclusions	
Project Proposal	Team
Backlog	Leonie, Marie
Global Sprint Plan	Leonie, Marie
Gantt Chart	Leonie, Marie
“Black Box” System Diagrams	Finn, Benjamin
Structural Drafts	
List of Components and Materials	Leonie
System Schematics	
Structural Drawing	
Cardboard Scale Model	Finn, Paul-Luchian, Marie
Interim Report Presentation	Benjamin
3D Model Video	
Functional Tests	
Prototype	
User Manual	

In any case, everything is gone over by the entire team and every decision is clearly briefed with the whole team. This way we ensure that everyone is aware of the content of the report and the state of the project. By informing each other regularly about new progress, we can also work further and in more detail on earlier and further tasks.

3.6 Communications

Clear agreements must be made in order to have good communication within the team and to the outside world. Communication is one of the key elements to make a project run smoothly. It is extremely important to regularly inform each other about the status of the project at that moment. Table 4 shows the main Communication Management during our project.

Table 4: Communication Management

Communication	Goal	Medium	Moment	People
Brainstorming and Ideation	Coming up with ideas and solutions	Physical, Miro	First step in the process of any development	Team
Deliverables	Project Development	Physical, WhatsApp, Teams	The week(s) before the deliverable	Team
Planning	Hand in deliverables on time	Planner, Teams, WhatsApp	Task assignment	Team

Communication	Goal	Medium	Moment	People
Project Updates	Inform the team of further progress	WhatsApp, Teams	Every update	Team
Team Meetings	Devide task, plan, update	Physical	Multiple times per week	Team
Project Meeting	Inform the supervisors of the current situation	Physical, Teams, Mail	Weekly	Supervisors + Team

Also, not only should communication within the team be smooth and on a regular basis, but communication with the various stakeholders is important.

3.7 Risk

Risk Management is used to identify risks and evaluate and prioritize them. This allows us to minimize, monitor, and control the impact of these events. Assessing risks involves risk identification, risk evaluation, risk handling and risk controlling.

We used FMEA (Failure Mode & Effects Analysis) to analyze the potential risks of our product. FMEA is a step-by-step approach for pointing out all the possible failures in any process, whether it is a design, manufacturing, or assembly process. The technique is used to eliminate or reduce all the failures, starting with the ones with the highest priority **[ISIXSIGMA, 2022]**.

Table 5 is a visualization of the risk our product may be exposed.

Table 5: FMEA: Product Risks

Process Step	Potential Failure Mode	Potential Failure Effects	SEVERITY (1-10)	Potential Causes	OCCURRENCE (1-10)	Method of detection	DETECTION (1-10)	RPN SCORE (SxOxD)	Actions to reduce RPN
Installing the device	Wrong installation	Insects escape, wrong monitoring, injuries, fire	7	Assemble the components wrong	6	Escaping insects; unlikely monitoring results	5	210	Visual differences when put in wrong together; Clear user manual
Installing the device	Component is missing	Installation impossible / error	9	Packaging error	2	Counting the components	2	36	List of components; clear user manual
Monitoring the insects	Disrupted humidity / temperature	Mold / smell	10	Sensors (connections) don’t work optimal	3	Smell, color differences, lots of dead insects	6	180	Advice a regular checkup, app remarks unusuality's
Feeding the insects	Put in indigestible foods for insects	Insects die	7	Human error	6	Food doesn’t get eaten, dead insects	5	210	Clear communication about insect diet
Removing frass	Unbalance on the frass component	Frass falls on the ground	5	Human error	3	Spilled frass	2	30	Decent handle; Distribute weight evenly
Freezing the mealworms									

Process Step	Potential Failure Mode	Potential Failure Effects	SEVERITY (1-10)	Potential Causes	OCCURRENCE (1-10)	Method of detection	DETECTION (1-10)	RPN SCORE (SxOxD)	Actions to reduce RPN
Blending the mealworms									
Cleaning the device	Incorrect cleaning of the product, separate parts who are not meant to separate	Damaged parts	9	Using wrong products, not reading the manual	6	Product is not working optimal	8	432	Clear user manual
Cleaning the device	Cleaning electrical parts with water	Broken parts, shock	9	Human error	5	System not working	2	90	Clear user manual, warning signs

1. *Severity: Severity of impact of failure event. It is scored on a scale of 1 to 10. A high score is assigned to high-impact events while a low score is assigned to low-impact events.*
2. *Occurrence: Frequency of occurrence of failure event. It is scored on a scale of 1 to 10. A high score is assigned to frequently occurring events while events with low occurrence are assigned a low score.*
3. *Detection: Ability of process control to detect the occurrence of failure events. It is scored on a scale of 1 to 10. A failure event that can be easily detected by the process control is assigned a low score while a high score is assigned to an inconspicuous event.*
4. *Risk Priority Number: The overall risk score of an event it is calculated by multiplying the scores for severity, occurrence and detection. An event with a high RPN demands immediate attention while events with lover RPNs are less risky.*

Now that we have created an FMEA table, it is important to address the risks with the highest RPN scores. Most dangerous thing for mealworm is moisture and dampness, which create mold and smell. The biggest risks are improper installation and cleaning, disrupted sensors, and feeding the wrong food.

These problems can be easily reduced in the first instance by providing a clear manual with the product. Moreover, this can also reduce other, less crucial risks. The manual should not only be clear, it should also be concise without losing important info. Good, fast readability is the most important feature of a user manual.

3.8 Procurement

For the procurement of the parts of our product, we strive for sustainable and local parts without losing sight of our budget. The project has a limited budget of 100 euros. This means that the price will probably be one of the main reasons why a product will or will not be purchased. Of course, quality should not be compromised under this condition.

Buying within Portugal, preferably Porto, is another criterion. The purchase of local products not only promotes the local economy, often the ecological impact is smaller and the shipping / transport costs are also much lower than an international purchase of goods. Naturally, not only the delivery cost is important, the delivery time is also a reason. The project runs over a fairly short time span, delivery at relatively short notice is essential.

Finally, our product has a life cycle and we want to create an ecological product. Recycled parts and ecologically sound raw materials have a positive influence on the choice of whether or not to buy a product. The production method is also important. We not only want to deliver an ecological product but also an ethical one.

Finally, of course, we want to deliver a safe and responsible product. When using the product, it is important that the user is not exposed to hazardous substances. The purchase of safe components is therefore certainly also a pillar in whether or not to purchase raw materials.

In short:

- Price
- Quality
- Local
- Delivery time
- Sustainable and ethical background
- Safety

3.9 Stakeholders Management

In the following chapter, we are going to identify our key stakeholders, the influence and the interest they have in our project, and how to handle the different groups of Stakeholders. To identify the Stakeholders first needs to be defined what a Stakeholder is: Stakeholders are individuals, groups of people, organizations, or governmental departments, who are on one hand impacted by the outcome of the project, but also, on the other hand, have an influence, either positive or negative, on the project. They have usually a big interest in the success of the project and can be divided into internal (included in the project) and external Stakeholders.

For our project, we came up with 10 different groups of Stakeholders you must keep in mind to manage them properly. We decided not only to take these stakeholders into consideration, which are important right now, e.g. as the “group of supervisors”, but also those which may be more important when we carry out our outcome, for example, the environmental associations. The managing divides into 4 different “levels” of managing:

- Monitor
- Keep informed
- Keep satisfied
- Manage closely

To allocate the Stakeholders to one of these levels, their “extent of interest” and “degree of influence” need to be defined, this is what you see in **Figure 8**:

No.	Stakeholder group	Extent of interests	Degree of influence
s1	Customer	7	6
s2	Supplier	5	3
s3	Environmental association	6	6
s4	Employees	6	4
s5	Government	3	7
s6	Investors/Sponsors	7	6
s7	Competitor	4	4
s8	Group of Supervisor	8	7
s9	Project team	9	9
s10	Project team	5	3

Figure 9: Degree of interest and influence of different group of Stakeholders

To explain our way of managing a little closer we will now inform about one Stakeholder from each field and possible ways to manage them.

One of the biggest and most influential groups of Stakeholders for our project and future company will be of course our customers. They have quite a high interest in the final product and a big influence on the design and execution. Therefore, we decided to **manage them closely**, which can be done for example by carrying out surveys to our customers, having our customer service keep track of complaints and suggestions, or even by analyzing our sales numbers.

A group of Stakeholders which we need to **keep informed** are for example our suppliers. They need information about changes in our products, in our requested amounts and in general about our business situation. We plan to do that by regularly repeating meetings, close contact between our procurement and the suppliers, and a newsletter about changes.

Governmental departments or environmental associations for us need to be **satisfied** by our work and how we carry it out. In this case, the management needs to be adapted more individually to the two groups of stakeholders. The government is already satisfied if we stick to the governmental regulations and laws, pay our takes accordingly and create new workspaces. The environmental associations need to be satisfied by our standards for the insects and would appreciate an environmentally friendly design.

The last field of managing our Stakeholders is **monitoring**, which for example needs to be done with our competitors. This can be done by just normal research, for example on the internet or special occasions like trade fairs or in specific literature like magazines. Furthermore, the exchange of know-how in form of a joint venture or a collaboration can also be a good way to monitor your competitors.

In **Figure 9** you will find all our already mentioned and the unmentioned Stakeholders, allocated to the according field of management:

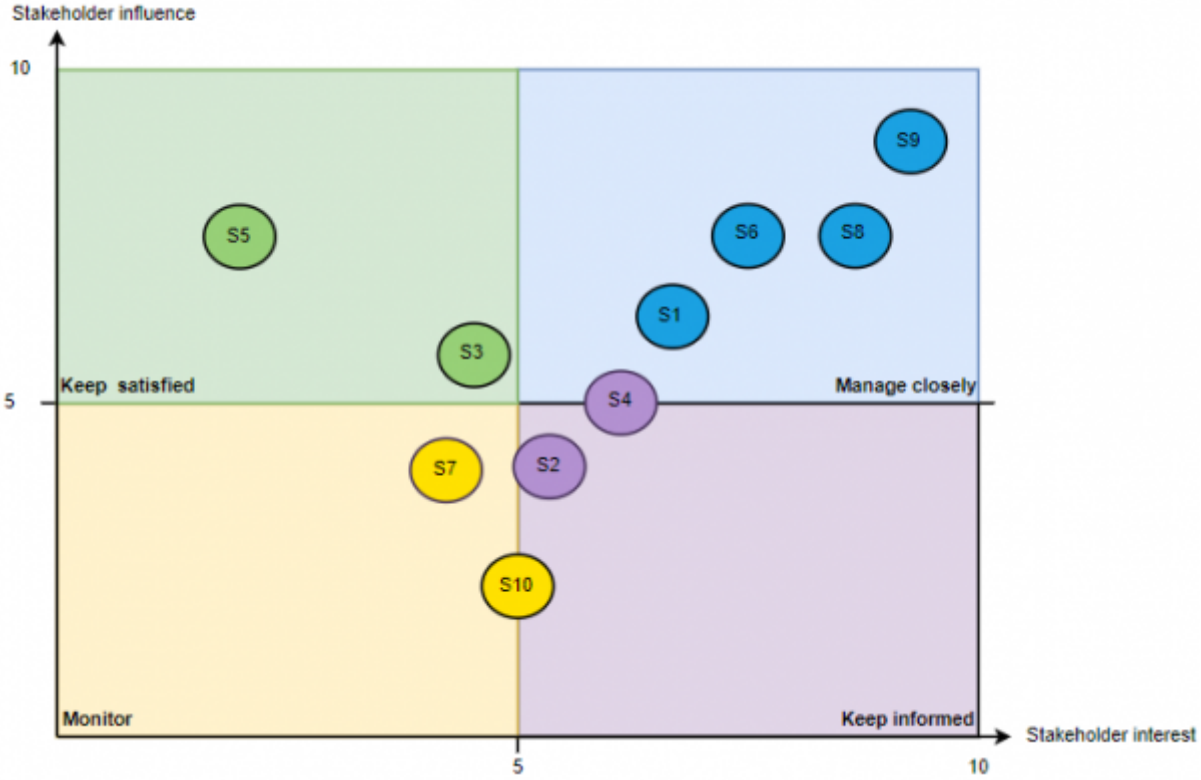


Figure 10: Stakeholders allocated to the according level of management

3.10 Sprint Outcomes

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

3.11 Sprint Evaluations

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

3.12 Conclusion

Provide here the conclusions of this chapter and introduce the next chapter.

4. Marketing Plan

4.1 Introduction

The aim of this chapter is to study the market, to understand its ins and outs and to extract the best possible strategy to carry out our project. To do this we asked ourselves different questions, in particular through the use of tools such as marketing analysis or the SWOT for example.

4.2 Market Analysis

After looking for other company we realize that the market of insect already exist. Regarding theses competitors, we were able to classify them into two categories. The direct one and the indirect one. A direct competitor will be someone or a company that provides the same offers as us. In this case, someone that offers the possibility to, breed insect, to provide eatable insect, to create fertilizer. Instead of that an indirect competitor is someone or a company that provides you a product or a service that can be different as ours but could satisfy the same need and reach the same goal. For example, only selling eatable insect satisfy one of our main goal and can be considered as an indirect concurrent. But another farming home kit would be consider as a direct competitor because our main goal is to allow people to achieve this result by their own. Regarding theses definitions, we agreed on a list of:

Direct competitors:

- *Hive Explorer Set by LivinFarms*. the first device to grow insects at home using also mealworms.

- *BeoBia "eco-growing pods"* . A divice mainly use for pet food laos using mealworms.

Indirect competitors:

- *Insect Feed Technologies* . It provides fertiliser (frass) for soil amendments and dried powder of black soldier fly milled larvae.

- *Protenga*. It is a Larger company on insect technology. It provides an innovative product especially in nutrition and sustainability and re-thinking insect farming through our technology-driven circular ecosystem approach.

- *Bulher* Larger company on sustainable food production with a part in insect technology.

4.3 SWOT Analysis

The SWOT analysis is used for identifying and analyzing the strengths, weaknesses, opportunities and threats of our company.

After brainstorming and discussion, we agree on:

The Strength of our product:

Relative to the product:

- Innovative

- Playful

- Environmental

- Compact

- Not expansive

- Recycling product used to create the kit

Relative to the company or what the product can bring:

- sustainability awareness

- Small company ease to adaptable to the evolving market

The Opportunity that we can exploit:

- The insect market is in expansion, regarding to the law

- Also regarding to the evolution of mentality. People are more used to eat insect than in the last decade.

The Weakness that we should be aware:

- Is the Need to have materials at home to use perfectly the kit. For example to correctly eat the insect, we recommend to freeze them and following that to cook them. That to respect all forms of lifes.

- Is the Need to be involved in the process to obtain the best results. We working on life cycle, so if the consumer decided to leave the kit on his own for months, when he will come back, the life cycle process will be broken.

- That fact that we will surely face a lack of capitals if we receive lots of ask at the same time because we are a small company

- The fact that our product will not be the highest quality on the market regarding our budget

The Threat that we should consider:

- The insect market is still volatile

- To consume the insects with the infakit you have to kill them

- Even if the market is volatile, there is already competitor, which makes it more difficult for us to establish ourselves

We can summarize it with this

4.4 Strategic Objectives

Our Stragety is to launch a new way to sensibilise people to other form of protein nutrition. The goal at the end would, if we create a successful business, to provide solution for major problems such as the end of the world hunger. Giving a new way to provide food to people at the lowest cost.

4.5 Segmentation

The goal here is to define the typical profile of a user of the INFAKIT. At the end, the result would be used to enhance our communication regarding our product. To do that we first answer questions that gave us the different segmentations here:

Geographic segmentation:

It is for zomeone coming from City. Especialy a big one because we want to reach the maximum of people We fought about big one because, in a general way, people are led to be more stimulated than in the countryside and therefore to be more open minded. We are looking to start our product in one Country and especially in a Western countries. Because in EST people are more used to eat insect and at a lower price. This market already exist.

Demographic segmentation:

Young people, involved in new tech. someone who is starting out in life with 1 young child and still have time to manage his free time. We don’t have a specific genders, race or religion for our product but we are aware that some religious beliefs such as the Hanafite prohibit the consumption of insect. At this level, we prefer to leave people to their own interpretation but in the majority of religious beliefs, the consumption of insect is not prohibited.

Psychographic segmentation:

Someone Interested in new tech , curious, dynamic and environmentaly involved. In the general way someone who is motivated to do things at 100 %

Behavior:

Regarding the behaviour, we think that out main target would be someone looking for a new way to have protein add in his alimentation and able to consum insect.

4.6 Strategy/Positioning

Elevator Pitch

For the nature-conscious, technology-interested home gardener for whom a natural compost is not exciting and efficient enough, the nutrenergy inportein smart hive 4.0 is an intelligent home insect farming kit that not only recycles your own food scraps into fertile soil but, unlike small scale home insect farms available on the market, also offers the possibility to process the used insects into edible protein powder for humans. Our solution is based on the latest technology, the most modern monitoring systems and a zero waste approach that allows all products (excuvae, frass) generated in the cycle to be completely converted into usable goods.

Target group

As the target group for our project, we decided to focus on urban residents. Having a garden or a balcony is no necessity. The target audience we want to address is people who follow an ecologically conscious lifestyle and want to explore new, sustainable ways of food production. They often do gardening by themself and have a lot of plants at home both indoor and outdoor. These people try to

buy local goods. Creating as less waste as possible is a great necessity and they use biological food and care products. Because insects aren't that common in our daily life, we must appeal an open-minded audience who are prepared to experiment with an unusual way of dining and farming. They have to want to put the right amount of energy in the process of farming the insects and make a valuable output product from it. Our focus is to farm insects in a closed cycle, that means that at some point the insects have to die. For that reason, it is also important to reach people who are aware of the whole process and who are unlikely to get too emotionally attached with the insects.

4.7 Adapted Marketing-Mix

4.8 Budget

4.9 Strategy Control

4.10 Conclusion

Provide here the conclusions of this chapter and introduce 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 … Consequently, the team decided to create a product with <*specify the features*>.

5. Eco-efficiency Measures for Sustainability

5.1 Introduction

Provide here the summary of this chapter. Bibliography follows!

The most recent report of the IPCC shows that working on environmental and sustainable solutions for world problems become increasingly important. We are in a global climate crisis: while resources are becoming scarcer and scarcer, global temperatures are rising steadily (the UK has even raised the threshold above which it is called a heat wave this year) **[IPCC, 2022] [Met Office, 2022]**.

The goal of the Brundtland Report from 1987 was to develop guidelines for the United Nations to achieve sustainable development by the year 2000 and beyond, defining sustainable development as the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” **[Gro Harlem Brundtland, 1987]**.

They further present three pillars on which sustainable development builds up and which each should be taken into further consideration. The following chapter summaries how the Company

TeamOneSect and its main product the INFAKIT approaches and includes environmental, social and ecological concerns.

5.2 Environmental

A major driver (14%) of global greenhouse gas emissions and usage of land is the worldwide livestock production, which is forecast to increase even further in the coming years as global demand for meat also increases **[Antonietta Baiano, 2020]**. Mealworms could serve as a more environmentally friendly alternative: producing the same amount of protein, for example, requires only about 10% of land compared to protein production from cattle **[Antonietta Baiano, 2020]**.

Furthermore, the used insects require much less water to survive and are way more drought-resistant, which offers a more resource-efficient alternative in the face of ever-decreasing water resources and prolonged droughts **[Antonietta Baiano, 2020]**.

The INFAKIT is a small-scale home farming kit, which aims to introduce people to a protein-rich diet of insects at home and thus stimulate a global rethink on a small scale, which in the long run will trigger a revolution in the food industry.

Moreover, ecological concerns played a major role in the design and packaging of our product. While the latter is going to be completely out of recycled cardboard, the INFAKIT itself relies on modern sensor technology that efficiently controls the use of fans to ensure the ideal environmental conditions for the insects.

In the selection of the electronic components, special attention was paid to efficient and resource-saving (electricity), as well as long-lasting criteria. The possibility to monitor the INFAKIT via app, enables the user to control it even from afar, making the home farming kit even more long-lasting, since suddenly occurring changes in the breeding system easily can be managed even if the user is on vacation for example.

5.3 Economical

An economically sustainable company is committed to compliance with legal requirements and fair staffing of key positions. While profit is desirable and important to ensure sustainability, care is taken not to do so at the expense of human, natural or other resources **[Andrew Beattie, 2021]**.

This company approaches its economical sustainability through a proper risk management, assessing problems and uncertainties to prevent or to find solutions in a timely manner. Further, through forecasting and reevaluating the company is able to adapt to change.

Moreover, needed components for the INFAKIT are procured regionally, which supports the local economy. The eco-efficient approach of the INF which focuses on using as few resources as possible, also has the positive side effect of saving financial resources that can be invested in other areas, like higher quality products or human resources.

5.4 Social

United Nations Global Compact defines Social Sustainability as “identifying and managing business impacts both, positive and negative, on people.” They further state that “directly or indirectly, companies affect what happens to employees, workers in the value chain, customers and local communities, and it is important to manage impacts proactively” **[United Nations Global Compact, 2020]**.

The INFAKIT offers households a new way to connect and explore together alternative ways to recycle waste. It teaches kids to take over responsibility over living animals and educates them about global issues and ways to rethink about them. Moreover, the home farming kit invites its users to overthink their eating habits, hopes to start a discussion and further leading to more openness about alternative food production. Global problems need global solutions – and the willingness of the population to be open for change.

Our company wants to invite people to participate in a larger community: connecting people from all over the world via social network platforms like Instagram to share recipes, best practices, and experiences. Communication is a key value of our company, and we are very keen on being in direct contact with our customers in order to take care of all of their concerns. We know as a company that to become the best version of ourselves and our products we have to be open for change and be flexible enough to adapt for better alternatives – and we are happy to grow with the feedback and input of our customers.

5.5 Life Cycle Analysis

5.6 Conclusion

Provide here the conclusions of this chapter and introduce the next chapter.

Based on this sustainability analysis, the team chose *<specify here the design, technique(s) material(s), component(s)>* for the following environmental reasons...

6. Ethical and Deontological Concerns

6.1 Introduction

Deontology is a term used to describe a philosophy that proposes whether acts are good or bad based on a set of principles. Actions that follow these criteria are considered ethical, while those that do not are not. As a result, ethical and deontological considerations are extremely important and have a significant impact on today's society. To prosper and maintain a favorable image, businesses must address each of these problems. If the contrary occurs in the modern period, it is very likely that social media would hasten the spreading of news, causing it to reach the entire world very quickly

and having a negative influence on the organization. Engineering, sales and marketing, environmental, and culpability are the four key ethical and deontological problems raised by the project in this chapter. For the project to thrive and have a beneficial influence on society, it is critical to analyze these problems, and each concern must be addressed **[The Ethics Centre, 2016]**.

6.2 Engineering Ethics

Engineering is an important and well-studied field. Engineers are required to uphold the highest levels of honesty and integrity as members of their profession. Engineering has a direct and significant influence on everyone's quality of life. As a result, engineers' services must be based on honesty, impartiality, fairness, and equity, as well as a commitment to the public's health, safety, and welfare. Engineers must adhere to a professional code of conduct that compels them to follow the highest ethical standards.

I. According to the National Society of Professional Engineers, the fundamental canons in fulfilling the professional duties of an engineer shall be: [National Society of Professional Engineers, 2019]

1. Hold paramount the safety, health, and welfare of the public.

2. Perform services only in areas of their competence.

3. Issue public statements only in an objective and truthful manner.

4. Act for each employer or client as faithful agents or trustees.

5. Avoid deceptive acts.

6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

II. Rules of practice

1. Engineers shall hold paramount the safety, health, and welfare of the public.

2. If engineers' judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate.

3. Engineers shall approve only those engineering documents that are in conformity with applicable standards.

4. Engineers shall not reveal facts, data, or information without the prior consent of the client or employer except as authorized or required by law or this Code.

5. Engineers shall not permit the use of their name or associate in business ventures with any person or firm that they believe is engaged in fraudulent or dishonest enterprise.

6. Engineers shall not aid or abet the unlawful practice of engineering by a person or firm.

7. Engineers having knowledge of any alleged violation of this Code shall report thereon to appropriate professional bodies and, when relevant, also to public authorities, and cooperate with the

proper authorities in furnishing such information or assistance as may be required.

8. Engineers shall issue public statements only in an objective and truthful manner.

9. Engineers shall be objective and truthful in professional reports, statements, or testimony. They shall include all relevant and pertinent information in such reports, statements, or testimony, which should bear the date indicating when it was current.

10. Engineers may express publicly technical opinions that are founded upon knowledge of the facts and competence in the subject matter.

11. Engineers shall issue no statements, criticisms, or arguments on technical matters that are inspired or paid for by interested parties, unless they have prefaced their comments by explicitly identifying the interested parties on whose behalf they are speaking, and by revealing the existence of any interest the engineers may have in the matters.

III. Professional Obligations

1. Engineers shall be guided in all their relations by the highest standards of honesty and integrity.

2. Engineers shall acknowledge their errors and shall not distort or alter the facts.

3. Engineers shall advise their clients or employers when they believe a project will not be successful.

4. Engineers shall treat all persons with dignity, respect, fairness and without discrimination.

5. Engineers shall at all times strive to serve the public interest.

6. Engineers are encouraged to participate in civic affairs; career guidance for youths; and work for the advancement of the safety, health, and well-being of their community.

7. Engineers are encouraged to extend public knowledge and appreciation of engineering and its achievements.

8. Engineers are encouraged to adhere to the principles of sustainable development1 in order to protect the environment for future generations.

9. Engineers shall avoid all conduct or practice that deceives the public.

10. Engineers shall avoid the use of statements containing a material misrepresentation of fact or omitting a material fact.

As a team, we agree to follow and respect the ethical aspect of our profession as engineers, always thinking about the higher good.

6.3 Sales and Marketing Ethics

Markets are characterized by a clash of interests among multiple stakeholders. There is rivalry for resources, consumers, and pricing, among other things, which creates fertile ground for actions that may not be ethical. To manage markets and marketing, a specific code of behavior, regulations, and procedures known as ethics are essential **[Prachi Juneja, 2015]**.

Our company's sales ethics may propel it to new heights. We will pave the way for client loyalty, improved morale among our sales staff (because we know that we are selling something good, we are not hiding any aspect) and marketing team, and even sustainable growth by incorporating ethical culture into our company **[Pipedrive, 2022]**.

But what is sell ethics? Sales ethics are a set of behaviors that ensure that every lead, prospect, and customer is handled with respect, fairness, honesty, and integrity. It implies that as a salesperson or marketer, you prioritize the individuals to whom you sell. Instead of imposing your agenda on people, you accept their choices and ideas. Considering the long term, ethical sales behaviour makes sense - we want to establish loyalty and trust with consumers by doing the right thing. The outcome ? Higher consumer spending, more engaged staff, and lower business operating expenses. By using an ethical approach to sales, we're stating clearly that we prefer to sell to clients who want to buy from us rather than selling by any means possible.

This strategy will aid in the development of a client base of users that we can serve and support, as well as the development of mutually beneficial connections. This implies that we will not only sell, but also build our business in an ethical and honest manner.

Good practices to follow: [Pipedrive, 2022]

1) Always be honest about the impact your product makes.

2) Don’t attack our competitors.

3) Adopt the **„Serve Don’t Sell Method”**, which is made of five stages:

a. Fit: define your Perfect Fit Client (PFC) using demographic and psychographic factors such as job title, industry, company size, beliefs, core problems, previous experience.

b. Discovery: establish your prospect’s personal and organizational pain points, why this change needs to happen now, their goals, objectives and motivations.

c. Offer: include your prospect’s pain points and goals, how you can help, examples of similar previous clients, options of working with you and a Q&A section.

d. Agreement: send a written proposal, collect and address unmet needs and get a signed contract.

e. Transition: onboard and prepare your client, establish points of contact and send supporting materials and documentation that will make them more successful.

6.4 Environmental Ethics

Environmental ethics is a field of ethics that studies the relationship between humans and the environment, as well as the role of ethics in this relationship **[Rinkesh, 2020]**.

In order to provide a product that is environmentally friendly, our team will focus on these points:

1) Maximize the efficiency with minimal energy consumption. We are choosing the best ratio between the quality of the components and their energy consumption.

2) Using recycled or recyclable materials in our product.

3) Our product is focused on the „zero waste” set of principles.

Another aspect that we consider is the killing of the mealworms and whether this is ethical or not. Recent surveys of U.K. insect farmers found many are concerned about insect pain perception and providing their mini-livestock a “good death.” The most common slaughter methods large-scale insect farmers use are freezing or freeze-drying, with the assumption that the cold-blooded insects will fall asleep and never wake up **[Matan Shelomi, 2021]**.

We consider that, by following these guidelines, we can this achieve harmony between humans, plants, and animals in our environment. Furthermore, the purpose of our research is to contribute to the solution of the food waste problem as well as to provide a simple solution for organic food production in metropolitan areas. This is an excellent technique to feed the world's rising population while adhering to natural principles and preserving the environment to the greatest extent possible.

6.5 Liability

Liability is defined as “the state of being legally responsible for something”. When creating and putting a product on the market, this is a major legal aspect by which the company is protected from lawsuits regarding accidents caused by their product / the usage of their product.

For the EPS project, the team must comply with the following EU Directives to avoid product liability issues:

1. Machine Directive (2006/42/CE 2006-05-17): concerning the danger machines may present to men, such as explosions, vibrations, radiation, finger joints, dangerous substances in flight, force limits for the operation of machines, minimum safety distance **[European Commission, 2006]**.

2. Electromagnetic Compatibility (EMC) Directive (2004/108/EC 2004-12-15): intends to regulate side effects between electronic components that are connected / interface together, like electromagnetic radiation, fields in the vicinity of electronic components, etc **[European Commission, 2004]**.

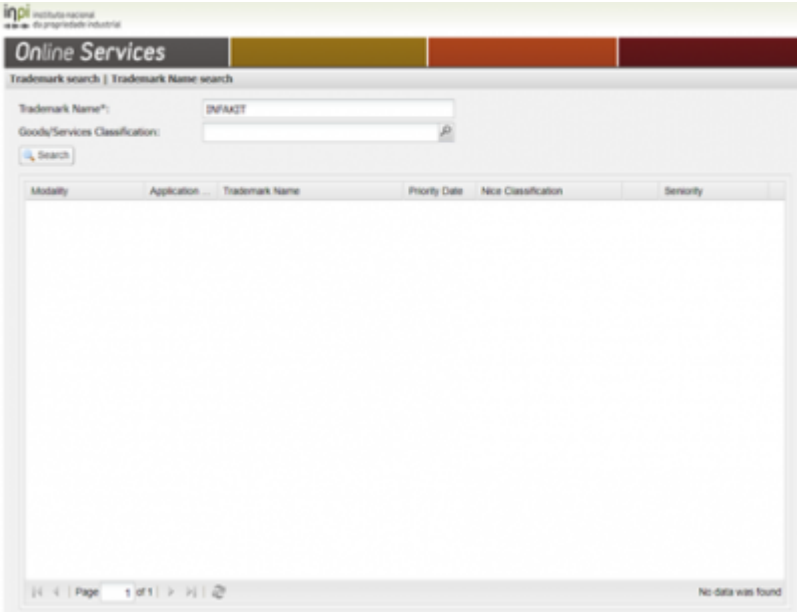
3. Low Voltage Directive (LVD) (2014/35/EU 2016-04-20): concerning health and safety challenges of electrical equipment with defined limits of voltage **[European Commission, 2014]**.

4. Radio Equipment Directive (RED) (2014/53/EU 2014-04-16): a regulatory framework for placing radio equipment on the market, ensuring no interference and data security regulation in radio communication with other devices **[European Commission, 2014]**.

5. Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive (2002/95/EC 2003-01-27): prohibition of the use of certain substances, to protect the environment and public health **[European Commission, 2003]**.

Additionally to these directives, the team needs to respect the rights of other established brands. The protection of a company's goods and services is ensured by making it a trademark. A trademark is a sign used to distinguish the goods or services of a firm in the market and it is protected by intellectual property rights. Apart from the trademark, other signs can be registered, such as logos, geographical indications, etc **[Justica GOV, 2020]**.

The team consulted the European Union Intellectual Property Office (EUIPO) to assure INFAKIT is available, and no results were found.



6.6 Conclusion

Based on this ethical and deontological analysis, the team decided to focus on efficiency during the manufacturing process, use sustainable and recyclable materials, choose suppliers who are transparent about their products and their origins, and keep customers and coworkers in mind at all times during the product development process.

The team will always be honest and follow an environmentally responsible path to build a product that does not harm the environment, uses as little energy as possible, as well as a transparent and honest customer service, because this is the only way for us to grow as a company.

7. Project Development

7.1 Introduction

The following chapter, “project development” describes the ongoing process of developing and carrying out our EPS project idea the INFAKIT. The chapter subdivides into 7 sub-chapters and starts with the ideation of our project idea, which includes the blackbox diagram, first structural drafts, and a cardboard model. Here we explain how our design idea developed and a rough design idea is presented. Furthermore, we talk about our concept of the product, starting with our logo and ending with possible regulations and requirements. In the fourth sub-chapter, the specific project idea and design are stated by detailed drawings, the selection of materials is explained, and a stress simulation test is carried out. The last chapters explain everything about the actual system and system design, what components we use and how are they connected, the realized prototype, and lastly real simulations and tests and a conclusion. At the end of the chapter, you will be able to follow the whole development process of our EPS project idea, from the ideation to the prototype and the testing.

7.2 Ideation

After agreeing on a basic project idea, a home farming kit for mealworms, we started brainstorming about how we wanted to design our INFAKIT, what components it should include and how these components are connected to another.

blackbox diagram, structural sketches and cardboard model

7.2.1 Blackbox

Our first draft of the blackbox diagram was rather rough but included all parts we wanted our INFAKIT to include, **Figure 11**:

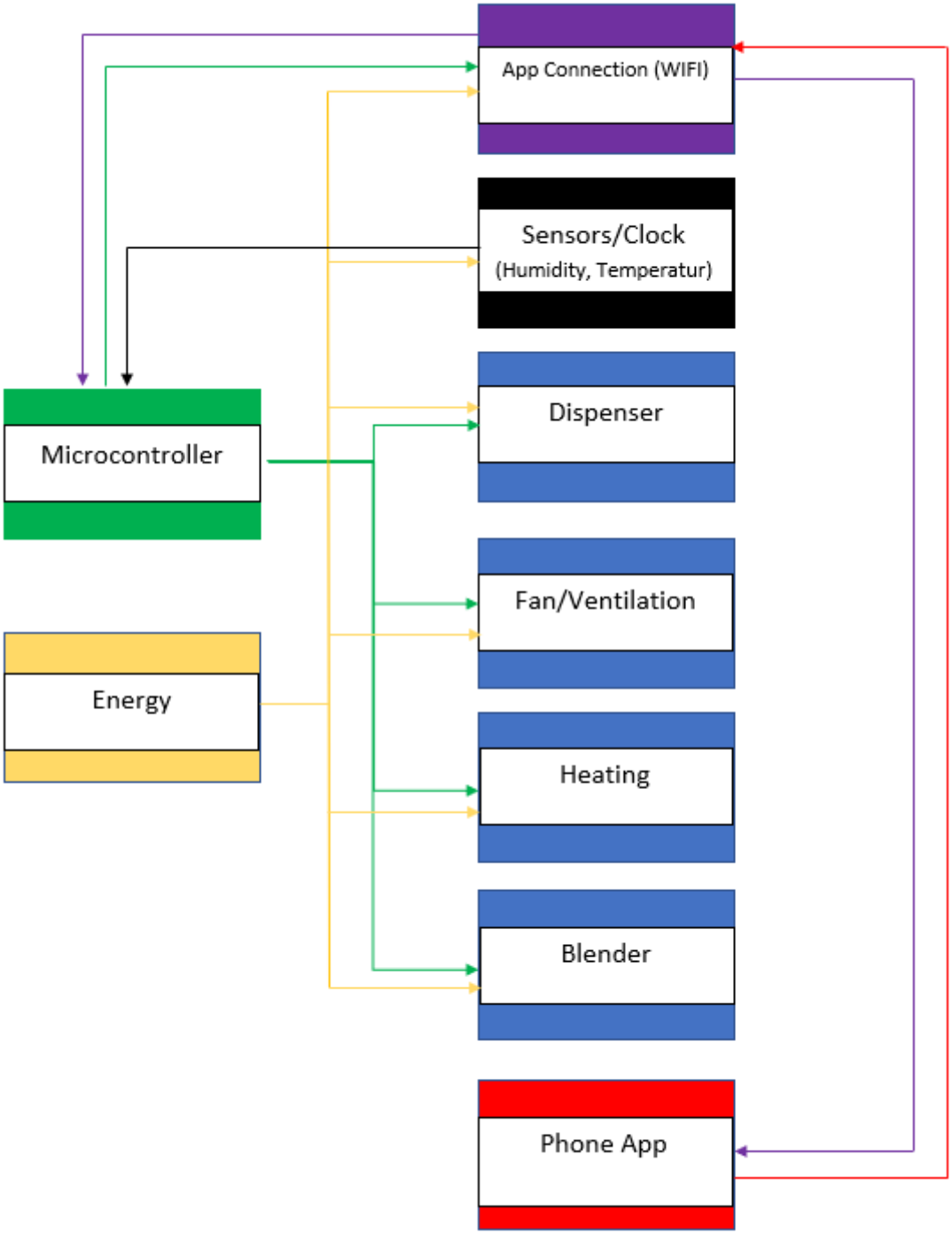


Figure 11: First blackbox diagram

The whole setup is controlled by a microcontroller which provides information to the four actors, heater, blender, fan, and dispenser. Sensors like humidity and temperature provide the microcontroller with information, which it receives, processes, and forward as commands to the actors. In order to be able to control the INFAKIT by a phone app, we included a WIFI connection in the setup. After some more research and discussions, we decided to abandon the heating, which would be used for drying the mealworm, and the blender, to crush the mealworms, as we thought these things are included in almost every household and can easily be done by the people themselves. Furthermore, we decided on an internet-capable microcontroller, so we could omit the WIFI connection. After these decisions, we came up with the following blackbox setup, **Figure 12**:

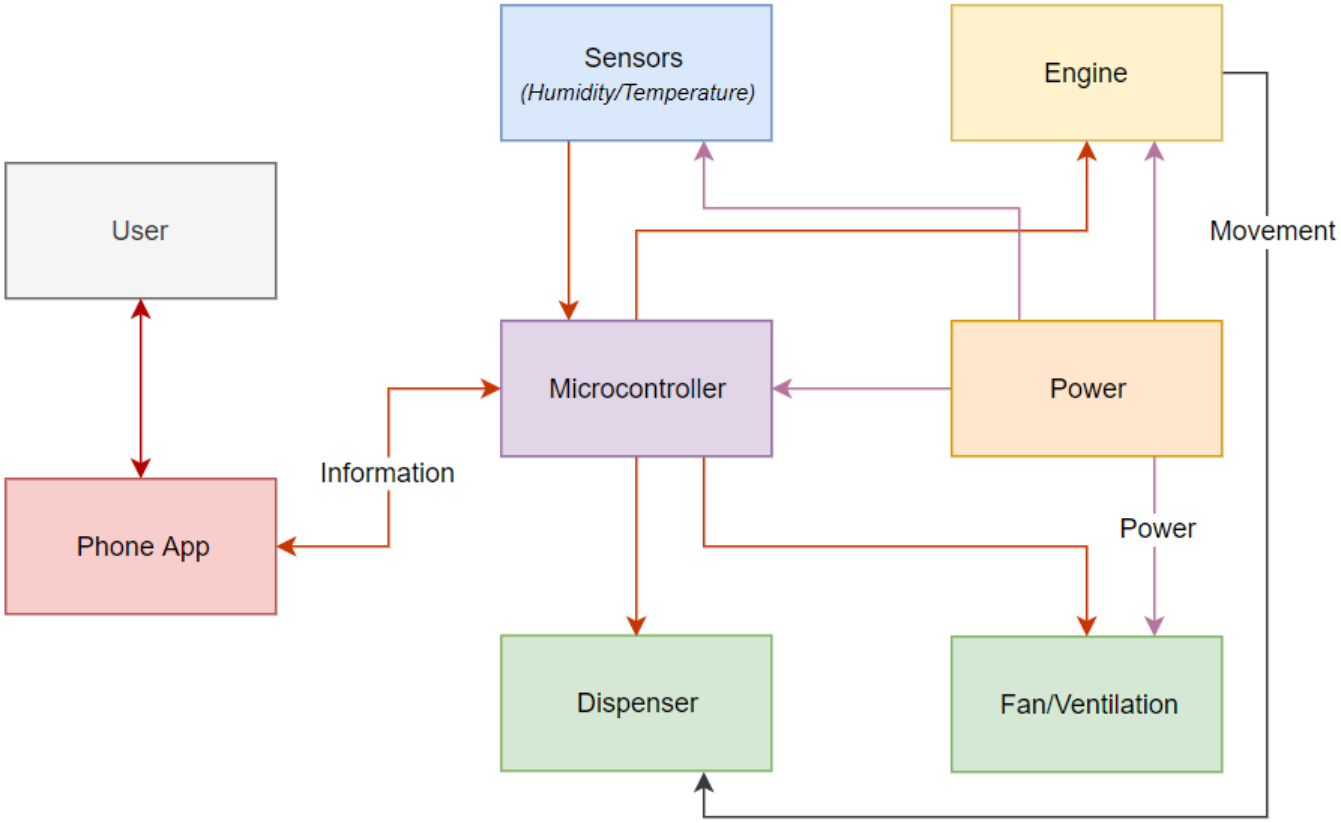


Figure 12: Newer draft of blackbox diagram

7.2.2 Sketching and cardboard model

Ongoing with the technical blackbox diagram we developed our first sketches and design ideas of the INFAKIT, and what it may look like. The first sketch can be found in **Figure 13**:

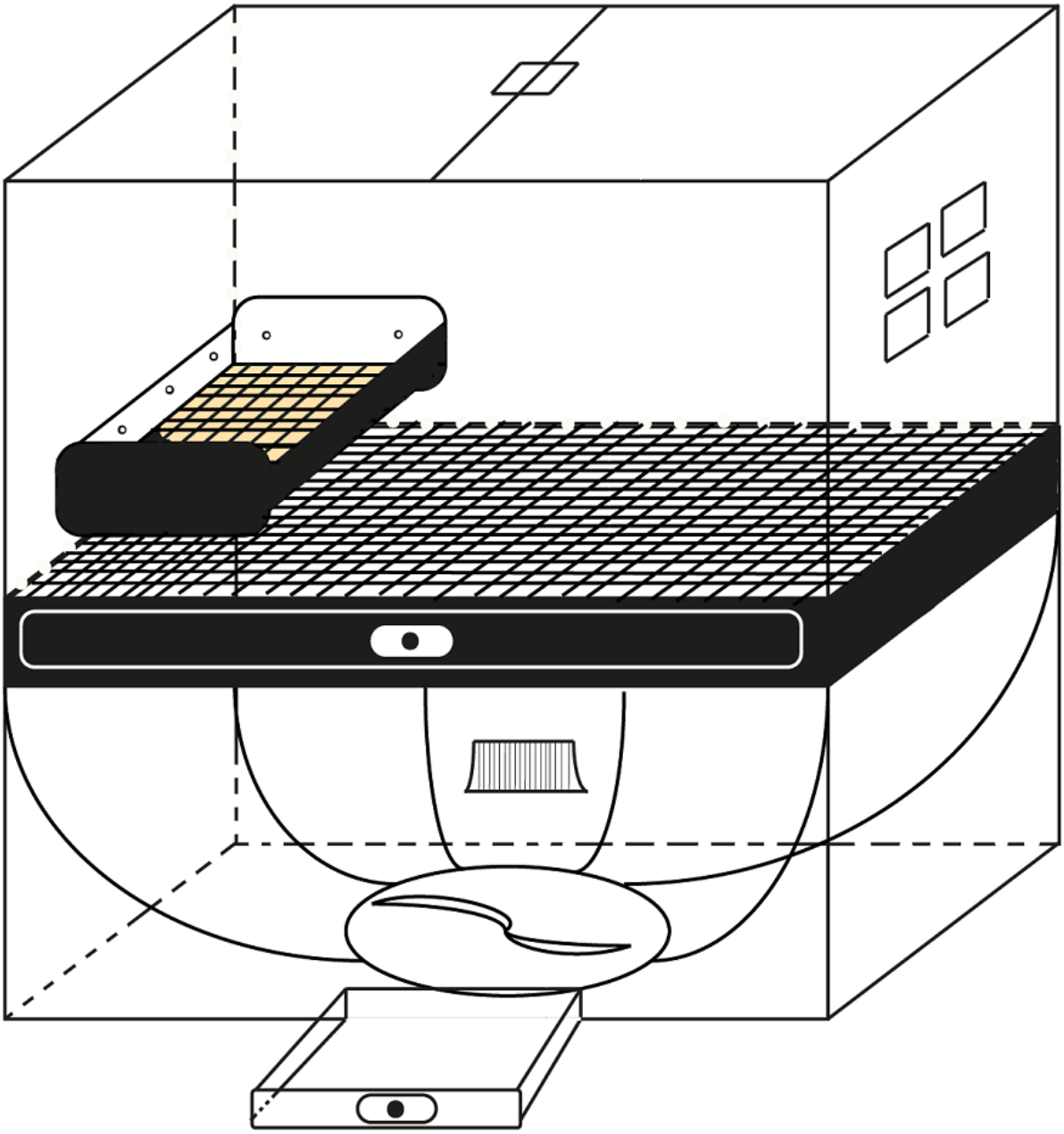


Figure 13: First design idea

As you can see in **Figure 13**, in our first draft the blender (lower level, middle) was still included in our design idea, furthermore, we wanted to keep the larvae, beetles, and eggs in one cage (highest level), which is not possible as the beetles eat the eggs and larvae. In addition, the design was not modular at all, which made it almost impossible to replace broken parts and components. After some more research, sketching and deciding to omit blender and heating, we designed our INFAKIT as shown in **Figure 14 -16**:

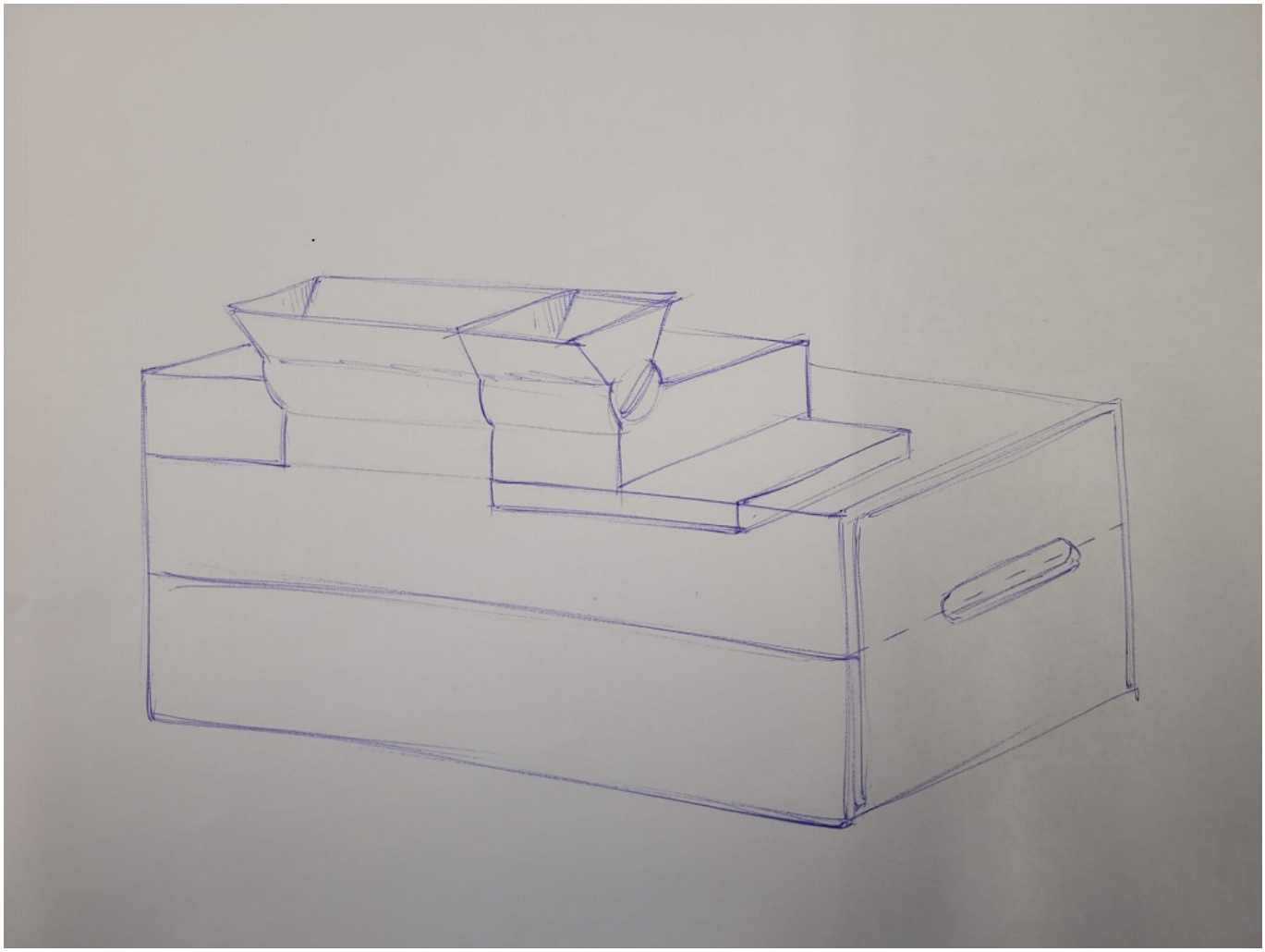


Figure 14: New design idea

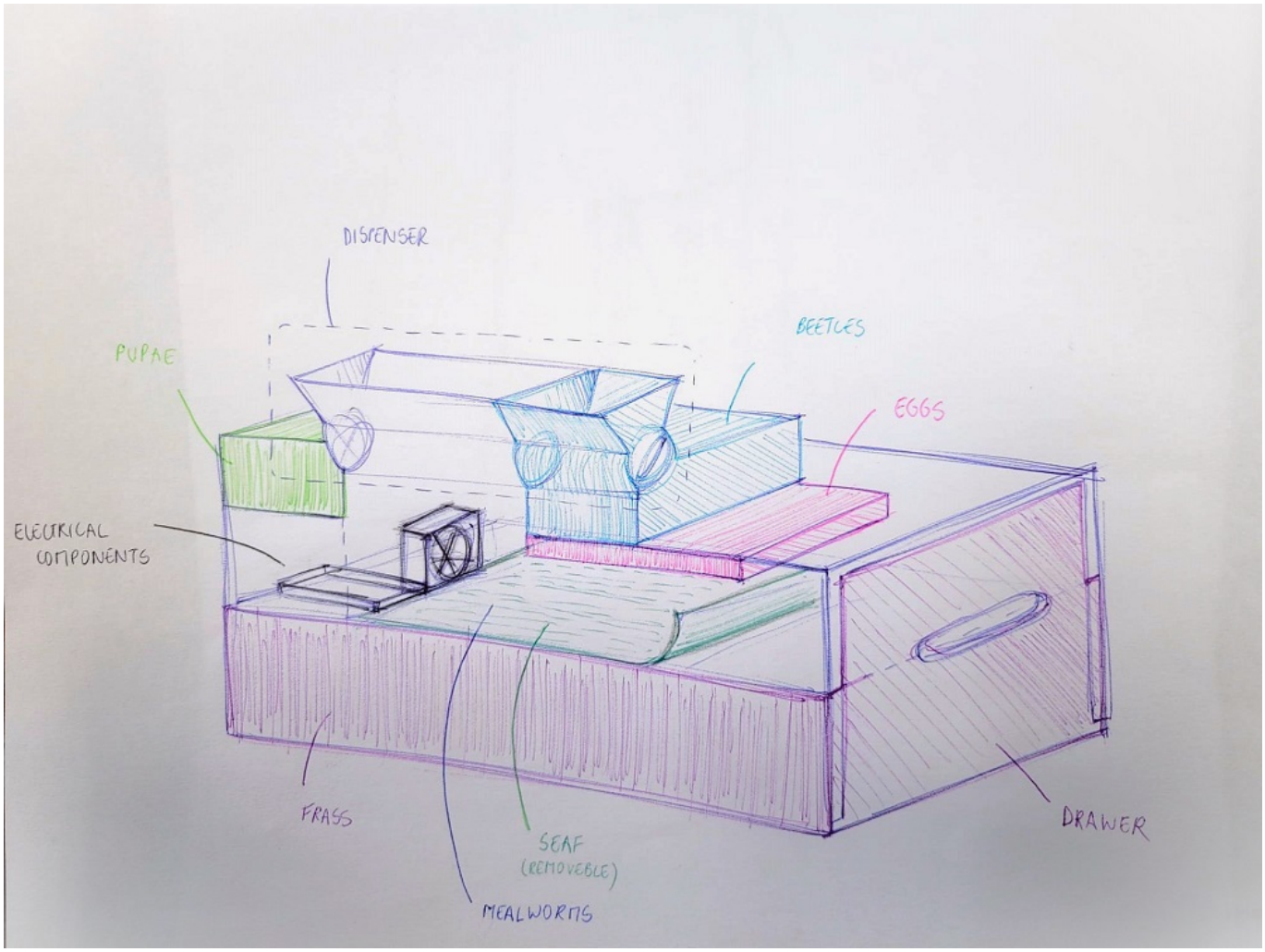
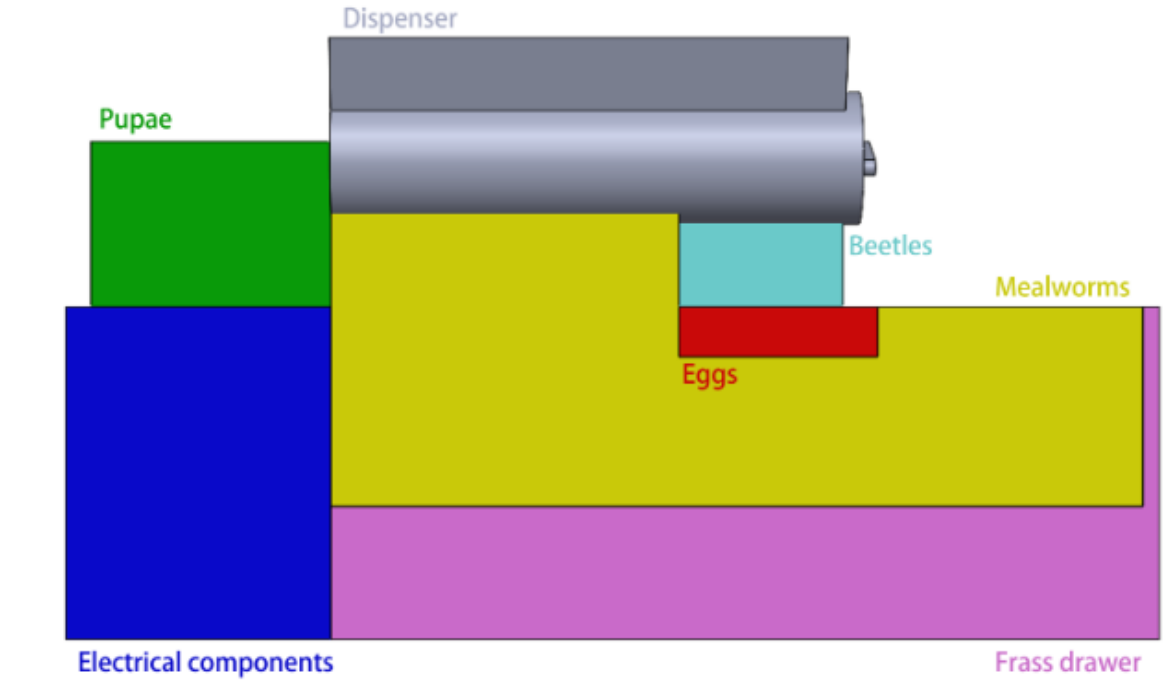


Figure 15: New design idea with colored components



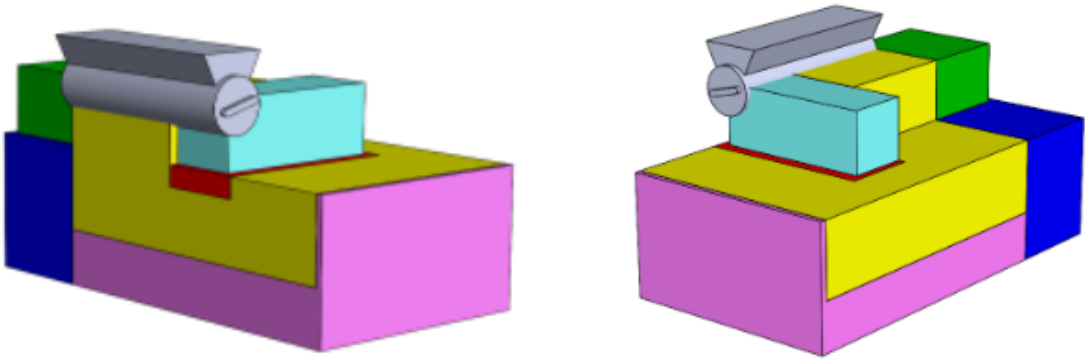


Figure 16: Solidworks design of INFAKIT

Our new design contains:

- Three removable boxes for the three of the four different stages of the mealworm lifecycle (egg, mealworm, larvae, and beetle)
- One removable box, including all the electronics (microcontroller, fan, sensors, and engine) with easy access and the possibility to exchange broken parts
- One removable drawer holding the sieve where the mealworms live and storing the frass and exuviae on a lower level
- One food dispenser which is controlled by the microcontroller and moved by the engine

7.3 Concept

logo, elements, requirements, concerns and regulations

7.4 Structural Design

selection of materials, detailed drawings, load and stress simulation tests

Materials selected will be eco-friendly, but durable. For example, some parts of the system can be made from recycled plastic.

7.5 System Design

choice of components, detailed schematics, simulation

The following table gives an overview over needed components and will be updated over time!

Table 6: List of non-electronical components (overview)

Component	**Subcomponent**	**Description**
Mealworms		25g of medium adult mealworms to beginn a lifecycle
Breeding Boxes	Beetle Box	Plastic
	Breeding Box	Plastic
	Pupae Box	Plastic
	Mealworm Box	Plastic
	Frass & Excuviae Box	Plastic
Twezzers	-	to seperate the different states of the mealworm manually
Sieves	Beetle –> Eggs	
	Mealworm –> Excuvae/Frass	removable

The following table gives an overview over the needed electronical components.

Table 7: List of electronical components (overview)

Component	**Description**	**U Rated/Input/Supply Voltage**	**U Operating Voltage**	**I Current**	**P Power**	**Pmax (calculated)**	**Measurements**	**Price**	**Link**
DC Power Jack Adapter Female	DC supply plug (male) / 5.5 mm / 2.1 mm / screw terminal / 12 mm							€ 1.00	https://www.botnroll.com/pt/adaptadores/1069-conector-alimentacao-dc-21mm-com-terminais-de-aperto.html
12V Male DC Power Socket Jack Plug Wire Connector Cable	DC 5.5x 2.1mm. Wire Specification: 0.15mm² Length: Approx. 27cm Max Current Rating: 2A Max Power Rating: 60W Transmission voltage: 1V~38V Usage temperature: -50℃~65℃ Material: Copper Wire Use for: Led Driver/ Strip connector/ CCTV Camera.Price for 10 cables = 8.57€							€ 1.00	Link in Excel
Power Supply Unit	12 V AC/DC; 5000 mAh	100-240 V 50/60 Hz	Output: 12V	5 A				€ 0.00	provided through supervisors
Fan	Sunon ME70151V1-000U-A99	12 V DC	4.5-13.8 V	0.113 A	1.36 W	1.56 W	70x70x15 mm	9.37€	https://mauser.pt/catalog/product_info.php?cPath=324_62_1254&products_id=048-0278
Micro Servo Motor	No load speed: 0.12 s / 60 degrees (4.8V) Stall torque: 1.6kg/ cm (4.8V)		4.8-6 V	<0.5 A		3 W	22.5×12.5×29.5mm	3.05 €	https://mauser.pt/catalog/product_info.php?products_id=096-6477
Transistor	BS170 MOSFET Pinout		3.3 V	0.5 A		1.65 W		€ 0.44	https://mauser.pt/catalog/product_info.php?

Component	Description	U Rated/Input/Supply Voltage	U Operating Voltage	I Current	P Power	Pmax (calculated)	Measurements	Price	Link
Wemos D1 R32 C/ESP32	ESP32-WROOM-32 in Arduino UNO form factor Working Voltage: 3.3V DC Input Voltage: 5-12 V DC Wifi: 802.11 b/g/n/e/i (802.11n up to 150 Mbps) Bluetooth: v4.2 BR/EDR and BLE specification RAM: 520KB Flash Memory: 32Mb (4M bytes) Power consumption: Max current: 250mA Sleep current: 0.15mA Active without WiFi current: 20mA Operating Temperature: -40C > +85C	5-12 V	3.3 V logic	max current: 0.250 A; sleep current: 0.015 A; active without WiFi current: 0.200 A		0.83 W	68.5×53.7 mm	8.90 €	https://www.botnroll.com/pt/esp/3639-wemos-d1-r32-c-esp32-no-formato-arduino-uno-r3.html
T&H Sensor: DHT11	measures 20-95% humidity, 5% error, temperatures from 0-50 with 2 degrees error	3.3-5 V	3.3-5 V	0.025 A		0.13 W	3.2×1.4 cm	3.30€	https://mauser.pt/catalog/product_info.php?
Potenziometer / Resistance	10 kOhm							€ 0.55	https://www.botnroll.com/pt/potenciometros/159-potenciometro-10kohm.html

- Total cost of electronical components: € 27.61
- Total (worst case, max) power consumption whole system: 7.17 W

In Figure 17 the schematic concept of the electronical setup gets displayed:

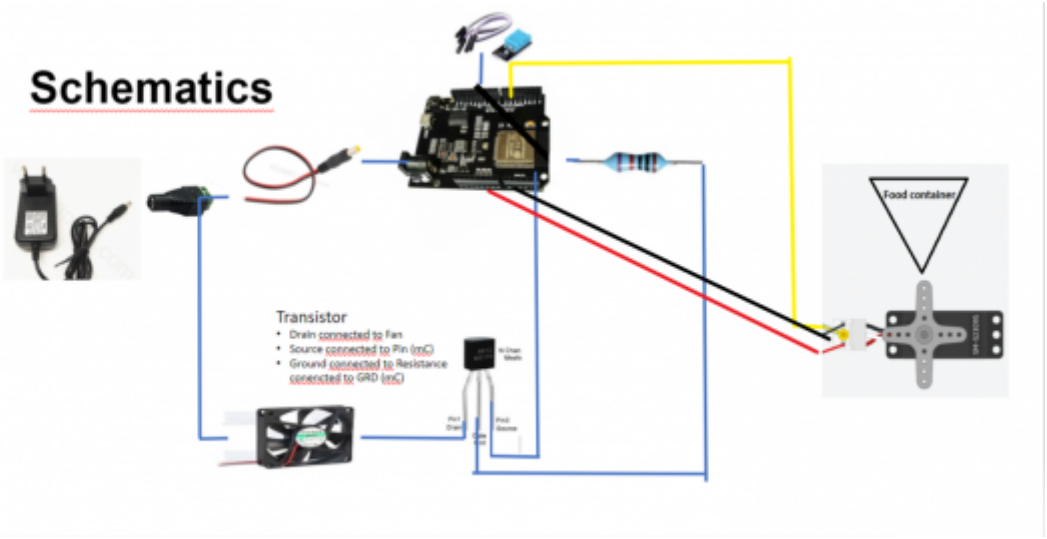


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Figure 17: Electronics schematic

7.6 Prototype

in case it is a downsized version of the designed product

7.7 Tests and Results

7.8 Conclusion

Provide here the conclusions of this chapter and introduce the next chapter.

8. Conclusions

8.1 Discussion

Provide here what was achieved (related with the initial objectives) and what is missing (related with the initial objectives) of the project.

8.2 Future Development

Provide here your recommendations for future work.

Bibliography

Will be added automatically by citing, in the body of the report, entries specified in BibTeX format and stored in the http://www.epswiki.dee.isep.ipp.pt/doku.php?id=refnotes:bib file

PS - *If you have doubts on how to make citations, create captions, insert formulas, etc. visit this page with examples and select "Show pagesource" to see the source code.*

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