Report

Title
Floating Trash Collector

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Acknowledgement

Glossary

Abbreviation	Description
AC	Alternating current
bps	bits per second
CO_2	Carbon Dioxide
DC	Direct current
DO	Dissolved Oxygen
EPS	European Project Semester
FAQ	Frequently Asked Questions
FET	Field Effect Transistor
HDPE	High-density polyethylene
IC	Integrated circuit
i.e.	id est / that is
IoT	Internet of Things
ISEP	Instituto Superior de Engenharia do Porto
L/H	Liters per hour
MCU	Microcontroller unit
NPO	Nonprofit organization
NSPE	National Society of Professional Engineers

Abbreviation	Description
ORP	Oxidation-Reduction Potential
PBI	Project Backlog Item
PE	Polyethylene
PEST	Political, Economical, Social and Technological
PESTLE	Political, Economical, Social, Technological, Legal and Environmental
SWOT	Strengths, Weaknesses, Opportunities and Threats
WBS	Work Breakdown Structure

1 Introduction

The European Project Semester (EPS) is a program during which students from different countries with different academic backgrounds are developing a new product. In the first chapter, we will present the team members and will go more into detail about the problem and our goal to solve it.

1.1 Presentation

The 641 team is part of the European Project Semester (EPS) in spring 2020, at Instituto Superior de Engenharia do Porto (ISEP). Six students from different countries, each one linked to a different culture, with distinctive habits, skills, and scientific fields, have come together to embrace a common challenge: develop a multidisciplinary project to collect floating waste.

Our scientific backgrounds are shown below, in Table 1.

Table 1: Information about the team members

Name	Country	Course of study
António Santos	Portugal	Electrical and Computer Engineering
Bianca Serafia	Romania	Industrial Engineering
Davide Caddia	Italy	Civil Engineering
Evelien Zeeman	Netherlands	Applied Mathematics
Laura Castañer	Spain	Industrial Design and Product Development
Patrick Jørgensen	Norway	Mechanical Engineering

Unfortunately, due to the COVID-19 outbreak, Patrick is no longer a member of the team.

641 is presented below, in Figure 1, identifying each member, just as the team was initially structured.

Figure 1: Team 641

1.2 Motivation

We have chosen to join the EPS program for multiple reasons. First of all, we are interested in working with students from different countries and study fields. Secondly, we aim to improve our English skills. Thirdly, we would like to improve our public speaking and academic writing skills. Finally, we want to improve our collaboration skills.

For our project subject, we have set some requirements. We wanted a project that every member of our project group could contribute to. Furthermore, our project contributes to an essential issue and addressing a worldwide problem, the pollution of the environment. Also, we want our project result to be feasible.

1.3 Problem

Each year an estimated 8 million tons, or 17 billion pounds, of plastic flows into the ocean. First and foremost, an endless flow of trash into the ocean will affect the health of humans and wildlife alike as well as compromise the livelihoods that depend on a healthy ocean. Trash and debris such as fishing gear, straws, and plastic bags pose a deadly threat to marine life. Fishing gear can trap helpless sea turtles and cut through the flesh of whales, while plastic bags are easily mistaken as food and consumed by animals. Straws can be hazardous in that they can get stuck in a nostril, a blowhole, an eye, or even a throat **[Tori Glascock, 2016]**.

No one knows how much unrecycled plastic waste ends up in the ocean, Earth’s last sink. In 2015, Jenna Jambeck, a University of Georgia engineering professor, caught everyone’s attention with a rough estimate: between 5.3 million and 14 million tons each year just from coastal regions. Most of it isn’t thrown off ships, she and her colleagues say, but is dumped carelessly on land or in rivers, mostly in Asia, then blown or washed into the sea. Only less than 1% of the plastic in the oceans does

not float on the surface **[Utrecht University, n.d.]**.

Meanwhile, ocean plastic is estimated to kill millions of marine animals every year. Nearly 700 species, including endangered ones, are known to have been affected by it. Some are harmed visibly—strangled by abandoned fishing nets or discarded six-pack rings. Many more are probably harmed invisibly. Marine species of all sizes, from zooplankton to whales, now eat microplastics **[Laura Parker, 2018]**. Scientists have found microplastics in 114 aquatic species, and more than half of those end up on our dinner plates. Now, they are trying to determine what that means for human health **[Elizabeth Royte, 2018]**.

Most plastic is not dumped intentionally into the ocean. It has been discovered that the majority of the plastic ends up in the ocean through rivers. Because plastic is light and there is so much of it, it ends up being washed down drains by rainwater or blown by the wind into bodies of water that flow into rivers and, ultimately, the ocean. To make matters more challenging, not all plastic is floating on the surface of the water. Plastic has been found in the furthest reaches of the ocean, from the deepest waters of the Mariana Trench to the Arctic and Antarctic **[Julia Jacobo, 2019]**.

Plastic waste threatens lakes as well as oceans. Pollution with plastic waste is not confined to the oceans but poses a growing threat to lakes as well. Researchers who found significant concentrations of the substance in Italy's Lake Garda say that the levels are similar to those found in samples taken from marine beach sediments and that these tiny plastic particles are accumulating in freshwater species and are likely to get into the food chain. Chemicals found in plastics can be poisonous, can damage endocrine systems, or in some cases, cause cancers. The scientists are also concerned that the discovery of significant amounts of plastic in lake environments could have implications for human populations as the waters are often used for drinking and for agriculture **[Matt McGrath, 2013]**.

Unlike ocean plastics, which can get caught up in currents and circulate around the globe, the material swirling in lakes has nowhere to go. It usually comes from nearby sources, such as sewer pipes carrying refuse that’s been washed into street drains, washing machines that send microfibers into city treatment systems, and windblown litter from beachgoers or lakeside neighborhoods **[Susan Cosier, 2020]**.

The team wants to make a start with collecting the trash that has already ended up in natural waters. Collecting the trash should be done continuously and automatically. Lakes are closer to human interaction than oceans, making Soaksy a visible solution and the water pollution a visible problem. Therefore, it is also an educational tool for people, designed to fulfill both purposes.

1.4 Objectives

The **main objective** of the project is to develop a sustainable and efficient floating trash collector. This objective involves designing, building, and testing the prototype.

In the **designing** phase, our main concerns will be related to the collecting system, whether or not it should consist of a vacuum system or a barrier (floating or natural barrier), power source and the sensors. When it comes to the **building** phase, our objectives will consist of creating the list of materials needed, procuring and assembling each component, considering the design, in a sustainable and ethical manner. Finally, **testing** the product is essential. Our objective of this phase is to have a working prototype, improving it if needed.

1.5 Requirements

When developing the project, the International System of Units will be used. When it comes to the budget of the project, a maximum of 100 € is allowed, implying a clean, simple design, with low-cost materials.

Functional requirements:

- Continuous cleaning
- Low energy consumption
- Easy maintenance
- Recyclable components

Standard requirements: - Comply with the following EU Directives:

1. Machine Directive (2006/42/CE 2006-05-17);
2. Electromagnetic Compatibility Directive (2004/108/EC 2004 12 15);
3. Low Voltage Directive (2014/35/EU 2016-04-20);
4. Radio Equipment Directive (2014/53/EU 2014-04-16);
5. Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive (2002/95/EC 2003-01-27);
6. Mandatory adoption and use of the International System of Units (The NIST International Guide for the use of the International System of Units)
7. Use open-source software and technologies
8. Maximum budget: 100 €

1.6 Functional Tests

A set of tests is required in order to verify all the aspects that we need to accomplish, such as mechanical, electrical, and software concerns, described in Table 2.

Table 2: Functional Tests

Condition	Expected result
Floating collector	Floating at water level
Waterproof pump and sensor	The water pump and sensor are fully submersible
Pump working at intended ratings	Dragging water inside the bin as expected
Adjustable structure	Bin platform sliding up and down
Check voltages and currents in all the connections	The voltage and current values could have some margin of error
Sensor readings and processing	Give measurements of distance
Check interface with the motor driver	The output of the driver moves de motor
Test IoT application	Connect system with webpage

1.7 Project Planning

Project Planning is developed according to Agile and Scrum methodologies. This process helps to

coordinate and improve the communication of the team by creating a Project Backlog. A Project Backlog is a list of tasks that have to be done during the project. This Project Backlog makes sure that each team member knows what tasks are in progress and who is doing what. The team members pick a time period. This time period is called a sprint. For every sprint, the team sets a goal. Based on the available amount of working hours in the sprint, the tasks are defined to fit into the sprint duration. It is necessary to have a daily stand-up to overview each team member's daily progress during a sprint. When the sprint is finished, the team creates a retrospective to analyze how to solve possible issues and improve for the next sprint.

The Scrum methodology is presented in Figure 2.

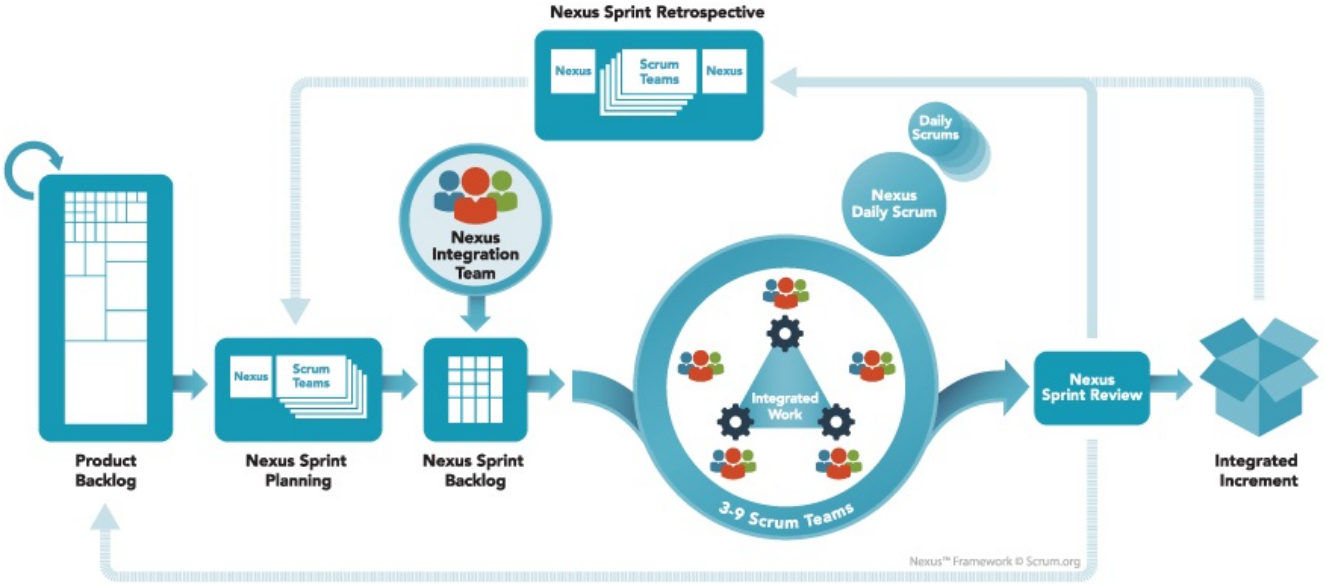

Figure 2: Scrum **[Provexilon Software Engineering, 2017]**

1.8 Report Structure

Our report consists of 8 chapters, each of them addressing a different issue, as shown in Table 3.

Table 3: Report structure

1	Introduction	Presentation of the team members, of the project purpose, requirements, and objectives.
2	State of the Art	Research of different existing products, scientific studies or ideas on the market.
3	Project Management	Documentation of the progress in the Agile management and SCRUM.
4	Marketing Plan	Identify the main target group and strategies to introduce our product in the market.
5	Eco-efficiency Measures for Sustainability	Analysis of Economical, environmental and social, Life Cycle.
6	Ethical and Deontological Concerns	Analysis of the ethical challenges and their solutions.
7	Project Development	Steps to do along with the project: Concept, architecture, components, materials, prototype.
8	Conclusions	Summary of the results and possible future development.

2 State of the Art

2.1 Introduction

As mentioned in the introduction of this report, a lot of floating trash can be found in rivers, lakes, and oceans. The goal of our product is to automatically and continuously retain as much floating trash as possible, without interfering with the marine life. Before deciding what our product exactly will be, already existing products and ideas are compared in this chapter, before taking a conclusion.

2.2 Existing products

2.2.1. Seabin Project

The original idea with floating garbage bins to collect trash was first introduced by two Australian surfers in 2015. The prototype was simple: A bin, a pump, and a net. The pump made water and debris converge into the bin, while the net made sure that only water and small particles escaped the bin. Since then the technology has not seen great upgrades. There have been two upgrades on the prototype in the last 5 years. The first one was a filter that will absorb other liquids than water. The second upgrade, still under testing, is a second bin that also traps microplastic and fibers inside the system **[Seabin Project, n.d.]**.

There are a few other ideas for identical products created by small officials or communities. One of the prototypes from Malta uses solar panels to operate to pump. However, the construction is big relative to the amount of debris it can collect **[Claudia Calleja, 2019]**.

Figure 3: Seabin Project **[DrSails, 2018]**

2.2.2. WasteShark

The WasteShark was created in 2016 by the Dutch company RanMarine **[TudoCelular, 2019]**. This drone is modeled on the whale shark and is designed to clear plastics, bio-waste, and other debris from the water in ports and canals. Its capacity is 160 litres. Also, the WasteShark can measure water quality (temperature, pH, conductivity, DO, ORP, depth, turbidity) and has an onboard GPS and camera. Nowadays there are two available models on the market: manually controlled and autonomous WasteShark **[RanMarine, n.d.]**. The manual WasteShark costs 17 000 USD **[Esan**

Swan, 2018]. This model has a battery life of 8 hours and the drone can be controlled within a range of 3 km. The costs of the autonomous WasteShark are 23 000 USD **[Esan Swan, 2018]**.

The company BluePhin Technologies in the United Arab Emirates sells a very similar product called the BluePhin **[BluePhin Technologies, n.d.]**.

Figure 4: WasteShark **[TudoCelular, 2019]**

2.2.3. Mr. Trash Wheel

Mr. Trash Wheel is an initiative of the American company Waterfront Partnership of Baltimore and was installed in 2014 **[Waterfront Partnership, n.d.]**. Two barriers with a skirt underneath are placed in a river and Mr. Trash Wheel is placed in the middle. The waste flows with the current of the river to Mr. Trash Wheel. Then the waste is placed on the conveyor belt. This belt is powered by a water wheel. If there is not enough water current, solar panels power the system to keep it churning. When the waste reaches the top of the conveyor belt, the trash falls into a dumpster. When the dumpster is full, this dumpster is replaced by an empty dumpster **[Waterfront Partnership, n.d.]**.

Figure 5: Mr. Trash Wheel **[Wikipedia, 2018]**

2.2.4. The Ocean CleanUp

The Ocean Cleanup is a Dutch non-governmental organization founded in 2013 by Boyan Slat **[Wikipedia, 2020]**. The goal of this organization is to remove the plastic from the oceans. To achieve this goal, the organization has a two-part plan: closing the source and cleaning up what has already accumulated in the ocean and does not go away by itself. This means plastic is intercepted in rivers and the plastic is removed from the oceans.

For cleaning the rivers, a barrier and an Interceptor are used. With the help of the government, the barrier is placed in a strategic location in the river. River waste flowing with the current is guided by the barrier towards the opening of the Interceptor. Then the floating waste is placed on the conveyor belt of the Interceptor. The conveyor belt delivers the waste to the shuttle and the shuttle distributes the waste equally over the six dumpsters using sensor data. When the six dumpsters are full, a boat is sent to the Interceptor to empty the dumpsters.
The Interceptor is energy neutral. The waste enters the Interceptor with the current of the river and solar energy is used to power the Interceptor. Since it does not use one barrier, but two separate barriers, boats can still pass. **[The Ocean Cleanup, n.d.]**

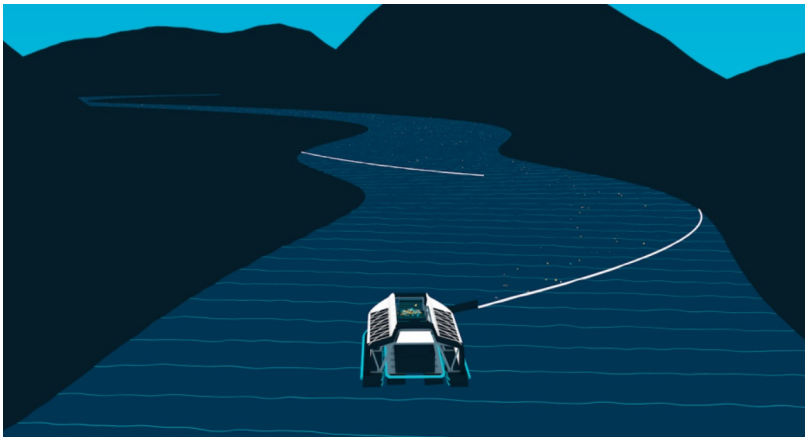

Figure 6: How The Ocean Cleanup cleans the rivers **[The Ocean Cleanup, n.d.]**

A long floater, net-like skirt, cork line, and sea anchor are used for cleaning the oceans. The floater makes sure the whole system floats. Underneath the floater, hangs the skirt. The skirt prevents debris from escaping the system underneath. The cork line prevents overtopping and keeps the skirt floating.
Since active cleanup methods would be too energy-consuming, passive design is chosen for this system. Natural forces (wind, waves, and current) are used to move both the system and the waste in the ocean. By only using these natural forces to move, the system automatically moves to the waste. Because the waste is also moved by these same natural forces.
To catch the waste, the system's speed should be slower than the speed of the waste. This is why the sea anchor was added to the system. The sea anchor slows down the system, and make sure the system collects waste **[The Ocean Cleanup, n.d.]**.

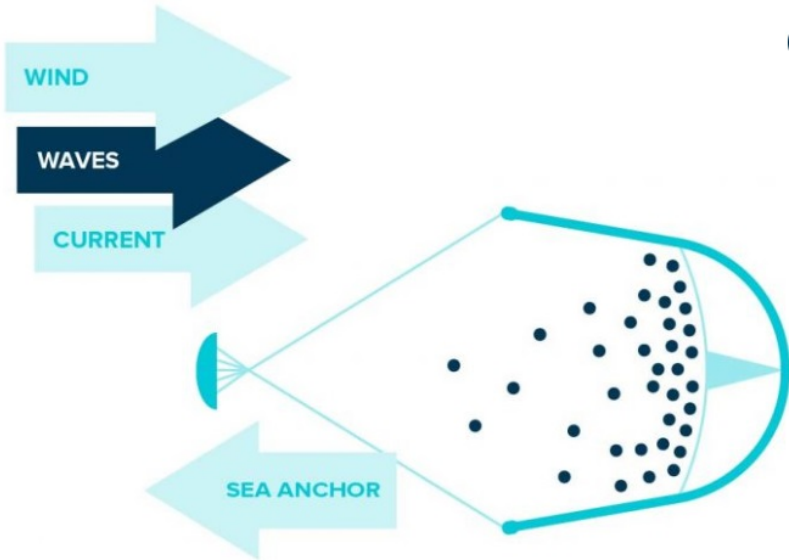

Figure 7: How The Ocean Cleanup cleans the ocean **[The Ocean Cleanup, n.d.]**

2.2.5. The Great Bubble Barrier

The Great Bubble Barrier was founded in 2018 by three Dutch women. The Bubble Barrier is a tube with holes located on the bottom of the water. By pumping air through the tube, a bubble screen is created. It is placed diagonally in the waterway because that way it can use the current of the water to guide the trash into a catchment system at the riverside. Both fishes and boats can pass the Bubble Barrier. Moreover, the Bubble Barrier increases the oxygen level in the water. This stimulates the ecosystem and stops the growth of blue algae **[The Great Bubble Barrier, n.d.]**.

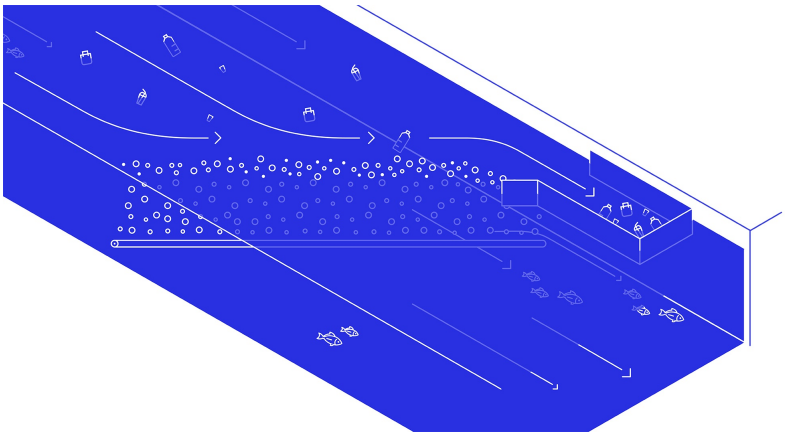

Figure 8: The Great Bubble Barrier **[The Great Bubble Barrier, n.d.]**

2.2.6. SWS80

The SWS80 was created in 2018 by the Mexican company Tecno Productos GAB. This catamaran is designed to collect trash and algae in coastal waters by a sliding platform while the catamaran is in motion **[Tecno Productos GAB, 2019]**. The propulsion system is made of bronze propellers with a rudder. This design has a theoretical performance of up to 21 500 m^2/h **[Tecno Productos GAB, n.d.]**.

Figure 9: SWS80 **[Tecno Productos GAB, n.d.]**

2.2.7. Pond Skimmer

Like pumps and filters, pond skimmers help to keep pond water clean and clear. Traditionally used to help remove floating debris from the surface of swimming pool water, in recent years, skimmers have become increasingly popular mechanisms for maintaining backyard ponds **[Pond Professor, 2019]**.

Figure 10: Pond skimmer

2.3 Existing ideas

2.3.1. River Cleaning

River Cleaning is an Italian startup that deals with the removal of floating garbage in rivers. The river cleaning system is made up of a series of floating devices, positioned diagonally on the course of the river. These floating devices rotate in their axis; when positioned, they allow to intercept plastic waste and transport it to the riverbank, in a special storage area. This technology must be sized according to the size of the river, the strength of the current and any other conditions. It is possible to study the most suitable dimensions to make optimal performance. This system has been designed to come into contact with boats. **[River Cleaning, n.d.]**

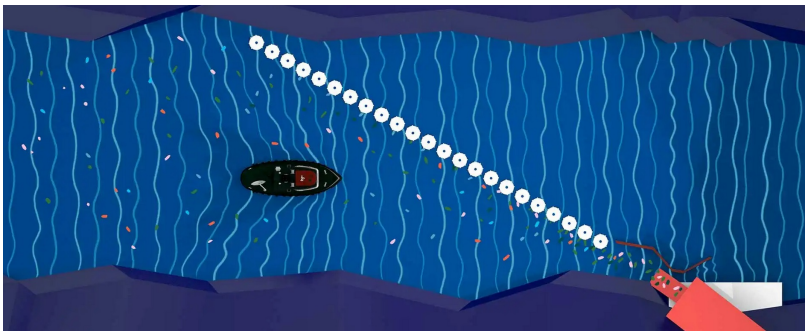

Figure 11: River cleaning **[River Cleaning, n.d.]**

2.3.2. Blue Barriers

SEADS is an Italian startup that invented the Blue Barriers. The barriers are floating barriers, rigid with a resistance that can withstand any condition of the river and large objects carried by currents, such as trees. They will be made of recycled plastic. The barriers can be staggered to allow the normal passage of boats and fish.

They will be positioned diagonally with respect to the flow of water to create a current that transports the waste towards the riverside, where the waste will be accumulated, collected, and sent for selection or recycling. The selection and recycling centers will be placed near the barriers and will be able to accept waste from neighboring areas, creating a service for the community and new jobs for the locals.
At the moment, SEADS made a scale prototype of these barriers and filed a patent. They are working with the University of West of Scotland, Universitas Indonesia, Università di Firenze (University of Florence) and Politecnico di Milano **[SEADS, n.d.]**.

Figure 12: Blue Barriers **[Impakter, 2019]**

2.4 Comparison

Based on the two previous sections, the products/ideas are divided into three types of products. The first type is the water bin represented by the Seabin Project. A water bin is a small product that stays in place and uses a pump to suck water and debris into it. The second type is the water robot, and the WasteShark and BluePhin fall in this category. A water robot is a small moving product that collects trash by pushing the trash to one location. Thirdly is the barrier with a trash collector. The Ocean Cleanup for rivers, Mr. Trash Wheel, The Great Bubble Barrier, River Cleaning, and SEADS fall in this category. A barrier with a trash collector is a static big product that uses the flow of the river and the barriers to collect trash.

In Table 4 below, these three types are compared.

Table 4: Comparison of the three categories of floating trash collectors

	Water bin	**Water robot**	**Barrier with collector**
Type of water*	Static	Dynamic	Dynamic
Autonomous* (1-5)	3	3	4
Capacity	20 kg per bag, adding up to 3600 kg a day **[Seabin Project, n.d.]**	500 kg per day **[RanMarine, n.d.]**	Ocean cleanup: 50 000 kg per day **[The Ocean Cleanup, n.d.]**. Mr Trash Wheel: daily capacity of 50 000 lb(22 600 kg) **[Brandon Baker, 2014]**

	Water bin	Water robot	Barrier with collector
Power supply	Supply: 110 V / 220 V with a consumption of 2.5 A, rated at 500 W **[Seabin Project, n.d.]**	Supply: 12 V feed by 4 x Lithium Iron Phosphate (LiFe PO4) **[Ecocoast, n.d.]**	Ocean cleanup: Solar capacity of 5.6 kWp and Battery capacity of 20 kWh Li-ion **[The Ocean Cleanup, 2019]**; Mr. Trash Wheel: Maximum solar output of 2.5 kW **[Waterfront Partnership, n.d.]**
Green energy	If available can use energy from sustainable sources; in most cases Grid **[Global Opportunity Explorer, 2018]**	Solar power to charge batteries **[Olga Koltsova, 2017]**	Ocean cleanup: Solar energy **[The Ocean Cleanup, 2019]**. Mr. Trash Wheel: Water flow energy **[Waterfront Partnership, n.d.]**
Collecting trash efficiency* (1-5)	3	2	4
Maintenance* (1-5)	2	3	5
Price range	from 3300 € up to 6300 €, depending on location **[Mariel Myers, 2018]**	from 15 500 € up to 20 000 €, depending on the model **[Esan Swan, 2018]**	Mr Trash Wheel: 90 000 € per year **[Alexander Tullo, 2018]**
Impact on environment	Less visible, doesn't interfere with boats and marine life **[Matt Weiser, 2016]**	Small impact **[Catherine Collins, 2018]**	Large but non invasive **[The Ocean Cleanup, n.d.]**
Versatility*	Lakes, pools, oceans, fountains	Ports, lakes (still water)	Rivers (small and medium size)

2.5 Conclusion

Based on this study of the state of the art, the team decided to adopt the technique of the water bin to collect floating trash because we think we can make it cheaper and easier to use than existing competitors on the market.

To further specify our product, we present a pros and cons list in Table 5.

Table 5: Pros and cons

	Pros	Cons
Power from the power Grid	We are sure it is going to support any pump; The Grid may have a big percentage of renewable energy	Dependent of the Grid, with all the consequences it comes with; Can't be used in remote areas
Power from renewable source	Sustainable source; Independent from the Grid	More expensive; More constraints on the pump rating
Pump in water	Compact design	Adds instability to the product; less powerful; more weight on the final product

	Pros	Cons
Pump on land	Could have more power for the same price; Easier maintenance; Could be more robust	Less compact product; Uses more energy to pump water

3 Project Management

3.1 Introduction

For the success of a project an adequate planning is essential. After having determined the main objectives, costs and resources available the management strategy of the project is presented.

3.2 Scope

Scope definition is an essential part of project planning. It helps to determine tasks and distribute all resources. First of all, the team has determined the main objective of the project. Next, the team used a simple hierarchical decomposition structure of all tasks and products that are essential to achieve the final result of the project. One of the widely used structures is a Work Breakdown Structure (WBS), which visually divides the scope into sections, where each provides further definition and detail.

The WBS in Figure 13 is divided into six stages: Initial, Design, Interim, Executive, Test and Final stage. Each stage consists of multiple tasks.

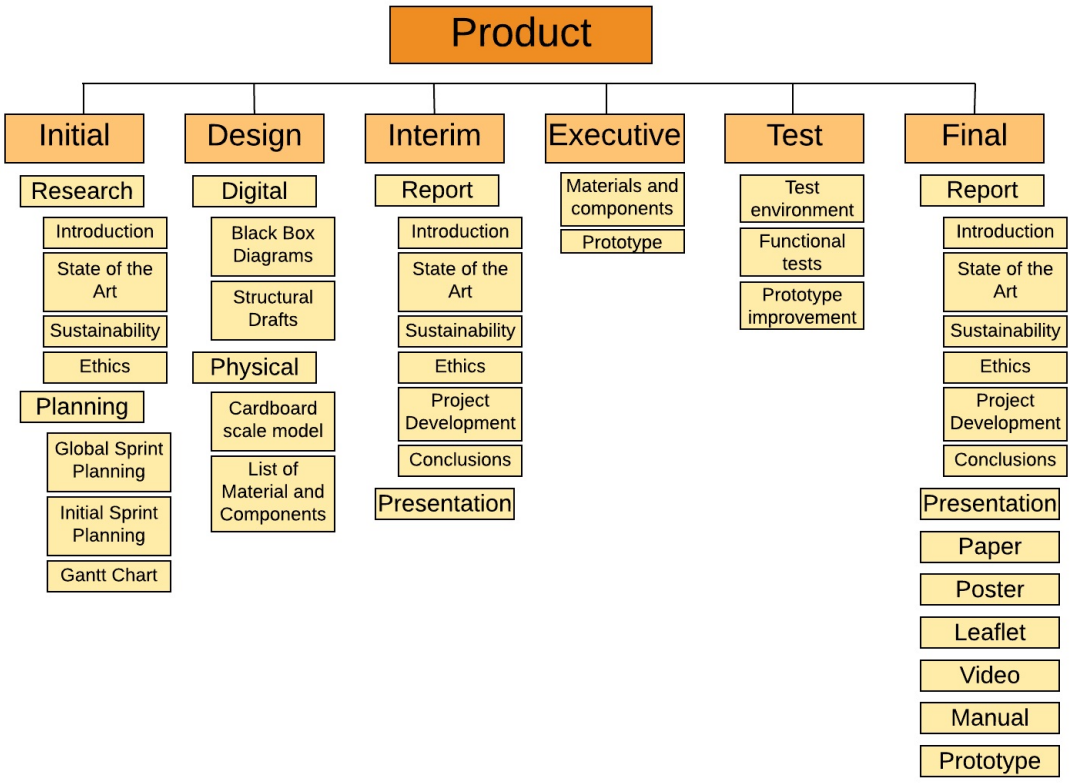

Figure 13: Work Breakdown Structure

3.3 Time

During the EPS@ISEP project, the following deadlines are set:

- 2020-02-24 Project proposal
- 2020-03-05 Project Backlog, Global Sprint Plan, Initial Sprint Plan, Release Gantt Chart
- 2020-03-10 Black Box Diagram, System Diagrams and Structural Drafts
- 2020-03-27 System Schematics, Structural Drawings, 3D Modelation and cardboard scale model
- 2020-04-01 List of Materials (what & quantity)
- 2020-04-08 Interim Report
- 2020-04-16 Interim Presentation, Discussion and Peer, Teacher and Supervisor Feedbacks
- 2020-04-23 List of Materials (provider, price, quantity, including VAT and transportation)
- 2020-04-30 Final video of the 3D Model
- 2020-05-06 Refined Interim Report
- 2020-05-13 Packaging solution
- 2020-06-02 Functional Tests
- 2020-06-12 Final Report, Presentation, Video, Paper, Poster and Manual
- 2020-06-16 Final Presentation, Individual Discussion and Assessment
- 2020-06-19 Update the Wiki
- 2020-06-23 Demo of prototype or 3D model, simulation and companion applications

Based on the WBS in Figure 13 and the deadlines, we created the Gantt Chart as seen in Figure 14 below. This Gantt Chart uses the six stages as shown in the WBS (Figure 13) instead of using all the tasks, because with all the tasks in it, the Gantt Chart would look to complex and unusable. During every stage, the team continues working on the report. Furthermore, also the holidays are visible in pale pink and the weekends in pale grey.

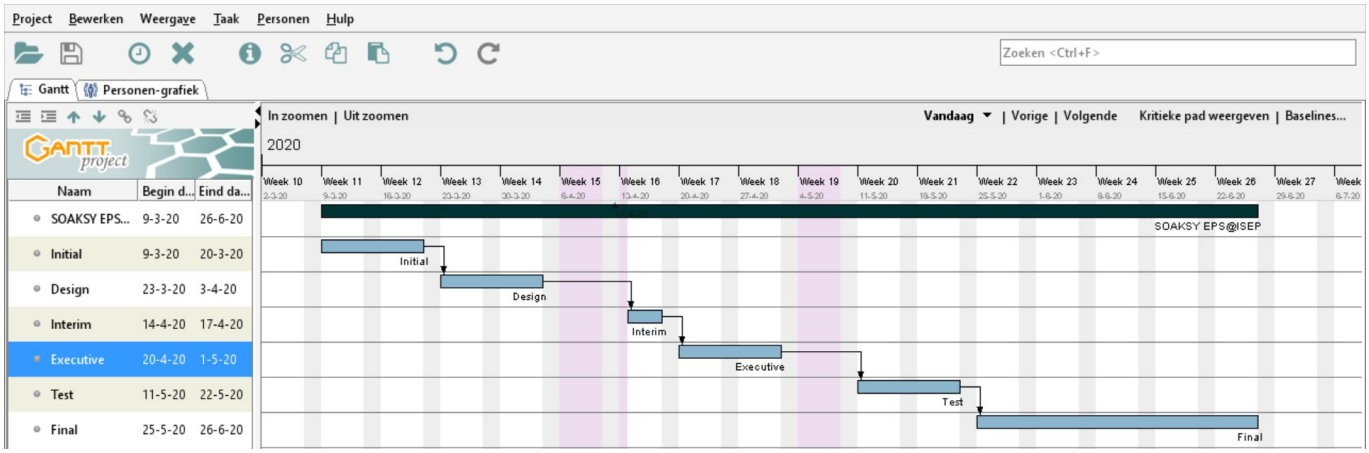

Figure 14: Gantt Chart

3.4 Cost

In this section the planned and effective costs of the project are documented. First, we look into the costs for the materials and components of our prototype and secondly, the costs of labor.

3.4.1. Material costs

The materials for the actual product are not decided yet. Nevertheless, the research for the materials

of the prototype is done in section 7.3 Components and in section 7.4 Final list of components the material costs for the prototype are shown. Based on this list, the material costs are calculated. Table 6 shows the list of components for the prototype and the total material costs. The material costs for the prototype will be €107.93 in total.

Table 6: List of materials for the prototype

Functionality	Name	Price (€)
Pump	Velleman VMA421: Water Pump	12.20
Sensor	JSN-SR04T-2.0 Ultrasonic Waterproof Range Finder	16.50
Microprocessor	Espressif ESP32 DevKitC-32D	13.60
Motor Driver	Integrated Circuit L298n DUAL FULL-BRIDGE DRIVER	3.17
12 V to 3.3 V and 5 V DC/DC converter	DC-DC Buck Converter Step-down 12V to 3.3V / 5V	3.81
Wide input voltage to 12 V DC/DC converter	XL6009 DC-DC Boost Buck Adjustable Step-Up Voltage Converter Module	4.06
Schottky diode	SB2100 - Schottky Diode 2A 100V	0.36 (2 units)
Power supply AC/DC to 12 V	Switching Power Supply 12V 1.5A	4.80
Photovoltaic panel	Photovoltaic Panel Silicon Monocrystalline 20W / 12V	29.99
Bird repeller	Holographic Owl	6.26
Delivery fees	**.**	**13.18**
Total	**.**	**€107.93**

3.4.2. Labor costs

As EPS students, we do not have income. But it is interesting to see what the labor costs will be, if we decide to establish an actual company after the EPS. The average nominal wage in Portugal is €1188.06 per month **[Trading Economics, 2019]**. Being a start-up, we did not earn profit yet. That is why the monthly wage of our employees will be lower than the average nominal wage in Portugal, for the first year at least. Each of our employees will earn €1000 per month in the first year. The labor costs for the first year is shown in Table 7. The labour costs for the first year of our start-up will be €60,000.

Table 7: Labor costs for the first year

Employee	Monthly wage (€)	Yearly wage (€)
Antònio	1,000	12,000
Bianca	1,000	12,000
Davide	1,000	12,000
Evelien	1,000	12,000
Laura	1,000	12,000
Total	**€5,000**	**€60,000**

3.5 Quality

In this section of the report, the project quality will be discussed. Project quality means meeting the needs of the customers, i.e. fit for use. The project quality is divided in two quality types: Service Quality and Product Quality. Both are found important for the customers of our company. Our company will guarantee this quality with the following plan.

3.5.1. Service Quality

User manual
The manual shows the different components of the Soaksy and explain how the Soaksy works. This will reduce the number of questions that the customer has. Moreover, the manual prevents accidents caused by incorrect use from happening.

Returnable product
When the Soaksy is not working anymore, the customer can reach us via email or phone and we will pick it up for free. We will recycle the usable parts of the Soaksy and so be more sustainable.

Website
Using the website soaksy.com helps us to be visible for possible customers and owners of the Soaksy. We would like our website to contain the following topics:

- Information about Soaksy
  Explains what the Soaksy does and convinces possible customers to buy the Soaksy.
- Information about the team
  Introduces the team members and discusses our motivation to create the Soaksy.
- FAQ
  The Frequently Ask Questions and their answers help customers to find an answer on our website to questions that are already asked by previous customers.
- How to reach us (Email and phone number)

If the question can not be found in the FAQ, the (possible) customer can reach us via email and phone.

- Reviews

A customer can leave a review about the Soaksy. That way, possible customers can read the opinions of the Soaksy users.

- User Manual

The user manual will be delivered together with the Soaksy and will also be available on our website.

- Terms and Conditions

3.5.2. Product Quality

Functional requirements

Our soaksy should meet the following functional requirements to meet the need of the customer:

- Continuous cleaning
- Low energy consumption
- Easy maintenance
- Recyclable components

Inspection
Before delivering the Soaksy to a customer, it should be checked for errors.

Continuous improvement
For our Soaksy to stay marketable, we want to improve our Soaksy continuously.

3.6 People

The people related to the project, the human resources, are one of the key factors for a successful project. The team members are an important part of the human resources. They are responsible for multiple tasks. By allocating the tasks to specific team members, the team knows who is doing what at any time. Moreover, the team knows who is responsible for every task. If some task is failing, the team can easily find out who is responsible for this and help. Table 8 presents the allocated tasks and the responsible team members.

Table 8: Responsibility Assignment Table

Task	**Responsible**
Initial research	
Task allocation	Team
Introduction	Bianca, Evelien
Market research	Davide, Evelien, Laura
Planning	
Gantt chart	Evelien
Black box diagram	António
Design	
3D Models	Bianca
Schematics	António
Structural Drafts	Bianca
Technical Drawings	Bianca
List of materials	António
Interim report	
State of the art	Davide, Evelien, Laura
Project management	Bianca, Evelien
Marketing plan	Evelien, Laura
Sustainability concerns	António
Ethical concerns	Evelien
Building	
Animation/Simulation	Bianca, Davide
Materials assembly	Team
Electrical circuit	António

Task	Responsible
Initial research	
Testing	
Functional tests	Team
Sensors	António
Final	
Report and presentation	Team
Poster, Paper, Video, Leaflet	Davide, Laura
Review of content	Bianca, Evelien

Apart from the team members, other people are also involved in the project. Together the team members and these people are referred to as stakeholders. A stakeholder is defined as an individual, group, or organization, who may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project **[Project Management Institute, 2000]**. The stakeholders in this project and their role are presented in Table 9.

Table 9: Stakeholders and their role

Stakeholder	Role
Team members	Owners
Benedita Malheiro	EPS coordinator
Benedita Malheiro, Cristina Ribeiro, Jorge Justo, Manuel Silva, Paulo Ferreira, Pedro Barbosa Guedes	Supervisors
Ana Barata, António Arrais de Castro, Cláudia Facca, Luís Castanheira, Luis Lopes, Paulo Ferreira, Sandra Luna	Teachers
ISEP	Sponsor
Suppliers	Suppliers
Customers	Final users

3.7 Communications

A project as multidisciplinary and diverse as what we are doing would be impossible without good communication. That is why it is necessary to ensure that all members have the opportunity to express their convictions (thus increasing positive discussions and diversity of opinion) and to ensure that the problems that arise during the project are properly addressed. Poor communication can worsen time management and deteriorate the relationship between team members. Communication is one of the pillars of a good project.
PMI recommends the definition of a Communication Management Plan, documenting communication methods, models, technologies and frequency **[Project managment institute, 2013]**. According to the Project Management course, the Communication Management part should include :

- Mapping between stakeholders and communication needs: analysis of stakeholders, responsible for the provision of each type of communication, frequency, when and where each communication will take place;
- Communication methods and technologies used to communicate;
- Communication templates: how, in which format the information will be communicated and how

the project information will be collected, communicated and distributed;

Due to the global health situation you can not have direct communication with team members, this type of communication is the fastest and the least misunderstood, to try to fill this gap you opt for telematic communication using apps and software that allow you to make video calls or share the screen in real time (Skype, Zoom, Teams) and messaging (WhatsApp, Messenger).

Table 10: Communication matrix

What	Who	Why	When	How
Deliverables	Everyone	To not miss the deadline	Before the deadline	Upload the wiki
Scheduling team meetings	Everyone	To schedule a team meeting	Everyday	WhatsApp
Holding team meetings	Everyone	To decide next steps/brainstorm/work on the project	Once a week	Skype
Meeting with the supervisors	Everyone	To inform the supervisors about the current state of the project	Every Thursday	Microsoft Teams
Interim presentation	Everyone	To get feedback from the supervisors for the first part of the project	16-04-2020	Zoom
Share researched materials	Everyone	To show the materials that have been researched	Whenever possible	Onedrive, WhatsApp, Wetransfer

3.8 Risk

Risk is an uncertain event or condition that, if it occurs, has an effect on at least one project objective. Risk management shall focus on identifying and assessing the risks to the project and managing those risks to minimise the impact on the project. There are no risk-free projects because there are an infinite number of events that can have a negative effect on the project. Risk management does not consist of eliminating risks, but in identifying, assessing and managing risks **[Wiley et al., 2012]**.

It is useful to make a distinction between what is a danger and what is a risk: The danger indicates something that has the potential to cause damage, while the risk is the probability of damage occurring, based on exposure to that danger.
In our project management classes, we have been taught how to manage risks and how the risk process can occur. These steps of risk creation/effects are illustrated in table 11.

Table 11: Explanation Table

Trigger	Cause	Event	Consequence
This is the event that begins to put things in place that will eventually start the risk process	This is incident that will directly result in the event that causes a change in our design / decision making process (otherwise known as the event)	This is what will happen to our project development process as a direct result of the cause of the risk	This is how our development process has been changed and how it has affected our project as it continues into the future

As with any project, dealing with risks is inevitable, and so we have to accept them and assess whether we can control them. So instead of trying to control whether it will happen or not, let’s look at ways in which we can control the outcomes that arise as a result of these risks; some risks will affect the project more than others. During the completion of our project we are able to adopt some strategies to manage risks in the best possible way:

- Accept that risk is going to happen (if unavoidable) and work through it taking into account all the lessons that have been learned during the process of addressing the issue.
- Transfer the risk to someone more capable of solving the problem by removing the work from the workload and ensuring that it is addressed with my more qualified someone to solve the problem and this in turn eliminates the possibility of being harmful to your work.
- Avoid the risk altogether by modifying the process currently underway for one in which this risk will no longer be an issue means that you must be able to change the creative process or planning to no longer use any tool/ resources had to be used when dealing with the problem.
- Mitigate the risk of reducing the impact of such emissions and reduce the likelihood that the risk will always become a problem in the first place. This is a classic example of many hands doing light work and ensuring that the problem is not a big problem that consumes too much time/manpower/resources/etc.

Table 12: Risk analysis

Description of the risk	Trigger	Effect	Probability	Impact	Importance	Strategy
Lack of appropriate prior knowledge	Not studying enough, thinking it may be too complicated	Have to fix these Knowledge	Medium	Medium	Medium	Do research, ask for help
Absence of team members	Illness, laziness, accidents, injury	Team can't work well	Low	Medium	High	Be in the meetings whenever it is possible
Design Error that causes water to damage the electronics	Lack of knowledge or human error	Product stop to work	Medium/High	High	High	Have a good design
Bugs in Software	Human Error	Product may Work Improperly	Medium/High	Low	Low	Repair error or find an alternative solution
Missing deadlines	Poor project management or unforeseen circumstances	Project failure	Low	High	High	Monitoring deadlines setting our own milestones earlier
Quarrel between team members	Misunderstanding/Personal problems	Project may suffer/bad work atmosphere	Medium	High	High	Maintain correctness/good relations

Description of the risk	Trigger	Effect	Probability	Impact	Importance	Strategy
Stakeholder interference	Change in the current market or change of public appearance	Selling the product become harder	Medium	High	High	By continually updating our stakeholders on our projects and having meetings with them we can continually receive feedback from them

3.9 Procurement

Procurement is the act of obtaining goods and services. The procurement procedure shall include the preparation and processing of an application, as well as the issuance of the receipt and approval of the payment. This is a vital part of any business, because it is impossible for a business to survive if the supply price is greater than the profit made by the product **[Business Dictionary,]**.

To decide whether it is a good purchasing strategy for your company, these three points need to be implemented:

- Compare the quality-price ratio from the available suppliers.
- Take the maximum advantage of the material we have at our disposal.
- Look for suppliers located in Porto to decrease the shipping cost.

3.10 Stakeholders Management

A stakeholder is defined as an individual, group, or organization, who may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project **[Project Management Institute, 2000]**.The needs of the stakeholders should be met so that the risk to the project is low. By meeting their needs, the result would also be the best possible product. The stakeholders for the project in question are:

- Team members
- Benedita Malheiro
- Project supervisors, i.e. Benedita Malheiro, Cristina Ribeiro, Jorge Justo, Manuel Silva, Paulo Ferreira and Pedro Barbosa Guedes.
- Teachers, i.e. Ana Barata, António Arrais de Castro, Cláudia Facca, Luís Castanheira, Luis Lopes, Paulo Ferreira and Sandra Luna.
- ISEP
- Suppliers
- Customers

Table 13: Stakeholders table

Stakeholder	Role	Action	Interest	Influence	Reference
Team members	The project's creators	Develop the project	High	High	TM

Stakeholder	Role	Action	Interest	Influence	Reference
Benedita Malheiro	Supervise closely	Manage the project closely	High	High	BM
Project supervisors	Supervise closely	Manage the project closely	High	High	PS
Teachers	Teach subject	Help providing knowladge	Medium/High	Medium	TC
ISEP	Sponsor	Provide resources to develop the project	High	Medium	ISEP
Suppliers	Provide neccessary materials	Sell supplies	Medium	Low	SU
Customers	Obtain the product	Buy the product	Low	Medium	CS

A visual conceptual map helps to undertend how is distributed:

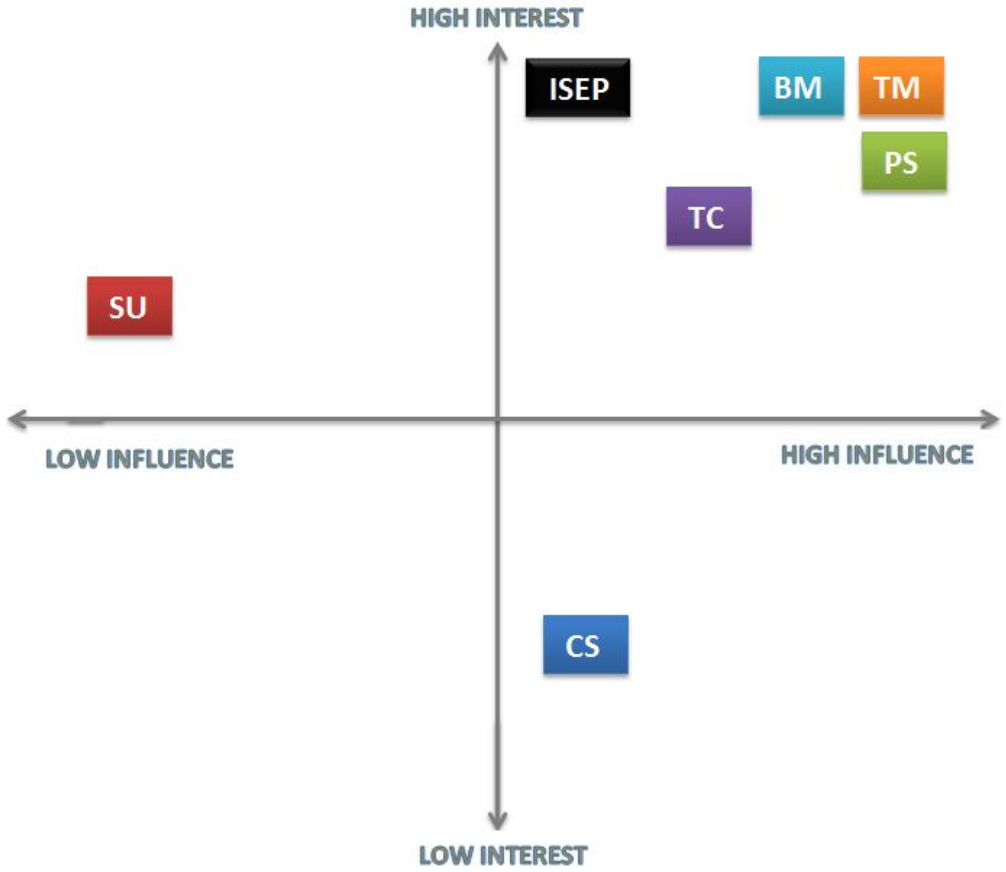

Figure 15: Stakeholder Analysis Matrix

3.11 Sprint Outcomes

Scrum is a framework for project management that emphasizes teamwork, accountability and iterative progress toward a well-defined goal **[M. Rouse, n.d.]**. This framework uses the following:

- **Daily stand-up** Every day the team has a short stand-up meeting. During the daily stand-up the team reviews what was done the day before and plans what work will be done in the current

day. Also, problems that happened are discussed.

- **Sprint planning** Every Monday the team plans what will be done in the current week. The planned tasks are allocated to certain team members and the duration of each task is estimated.
- **Sprint review** Every Friday the team reviews the sprint planning that was made on Monday. The team discusses which tasks are completed and which tasks are not. If a task is completed, the real duration is added.
- **Sprint Retrospective** Every Friday the team reflects on the sprint process. It is discussed what was positive and what was negative. Based on the positive and negative reflection, three categories are created: Start doing, keep doing, stop doing.

Based on the academic calendar offered by EPS@ISEP, the number of sprints is decided as well as their start and finish date. When each sprint takes place is shown in Table 14.

Table 14: Global Sprint Plan

Sprint	Start	Finish
1	09-03-2020	13-03-2020
2	16-03-2020	20-03-2020
3	23-03-2020	27-03-2020
4	30-03-2020	03-04-2020
Easter Break	06-04-2020	13-04-2020
5	14-04-2020	17-04-2020
6	20-04-2020	24-04-2020
7	27-04-2020	01-05-2020
8	04-05-2020	10-05-2020
9	11-05-2020	15-05-2020
10	18-05-2020	22-05-2020
11	25-05-2020	29-05-2020
12	01-06-2020	05-06-2020
13	08-06-2020	12-06-2020
14	15-06-2020	19-06-2020
15	22-06-2020	26-06-2020

The Project Backlog consists of all deliverables that should be completed during EPS@ISEP. The Project Backlog Items (PBI) are ordered based on priority, i.e. highest priority at the top and lowest priority at the bottom. Each deliverable also has a status: To do, Doing or Done. Thus the Project Backlog is continuously updated. If a deliverable is done, then it lowers in the Project Backlog. In Table 15 the Project Backlog is shown.

Table 15: Project Backlog

PBI	Title	Status
A	Product concept	Done
B	Backlog	Done
C	Global Sprint Plan	Done
D	Gantt chart	Done
E	Blackbox Diagrams and Structural Drafts	Done

PBI	Title	Status
F	Interim report	Done
G	Structural Drawings	Done
H	List of Materials	Done
I	Refined Report	To do
J	Building prototype	To do
K	Functional tests	To do
L	Final Report	To do
M	Final presentation	To do
N	Video	To do
O	Paper	To do
P	Poster	To do
Q	User Manual	To do

The completed sprints are presented in Table 16, 17, 18, 19, 20, 21 and 22. These sprints are weekly and based on the Global Sprint Plan (Table 14) and the Project Backlog (Table 15). The team begins a new sprint every Monday and ends the sprint every Friday.

Table 16: Sprint Plan 1

Task	Estimated duration (h)	Real duration (h)	Members involved	Status
Global Sprint Plan	1	0,5	Evelien, Davide	Done
Work Breakdown Structure	1	1	Evelien, Bianca	Done
Initial Sprint plan	1	1	Bianca	Done
Black Box Diagram	1	2	Antonio	In progress
Structural Drafts	2	-	Bianca	In progress
Introduction report	6	-	Bianca, Evelien, Laura	In progress
State of the art	10	-	Evelien, Patrick, Davide, Laura	In progress
Backlog	1	1	Bianca, Antonio	Done
Gantt chart	3	-	Patrick, Laura	In progress
Introduction of chapters	2	1	Davide	Done
Comparison table	2	2	Team	Done

Task	Estimated duration (h)	Real duration (h)	Members involved	Status
Decide product concept	5	5	António, Bianca and Patrick	Done
Flyer	5	3	Davide	Done

Table 17: Sprint Plan 2

Task	Estimated duration (h)	Real duration (h)	Members involved	Status
Black Box Diagram	1	2	Antonio	Done
Structural Drafts	2	4	Bianca	Done
Introduction report	6	-	Bianca, Evelien, Laura	In progress
State of the art	10	10	Evelien, Patrick, Davide, Laura	Done
Gantt chart	3	-	Patrick, Laura	In progress
Leaflet	5	3	Laura	Done
Logo	3	1	Bianca	Done
List of Materials	8	-	António, Patrick and Laura	In progress

Table 18: Sprint Plan 3

Task	Estimated duration (h)	Real duration (h)	Members involved	Status
Introduction report	6	9	Bianca, Evelien, Laura, António	Done
Gantt chart	3	-	Patrick, Laura	In progress
List of Materials	8	-	António, Patrick and Laura	In progress
Marketing Chapter	15	-	Evelien, Laura	In progress
Sustainability Chapter	15	-	António	In progress

Task	Estimated duration (h)	Real duration (h)	Members involved	Status
Ethics Chapter	15	-	Evelien, Davide	In progress

Table 19: Sprint Plan 4

Task	Estimated duration (h)	Real duration (h)	Members involved	Status
Interim presentation Powerpoint	2	4	Davide	Done
Gantt chart	3	2	Evelien	Done
List of Materials	8	-	António	In progress
Introduction check	1	1	Bianca	Done
State of the Art check	1	1	Bianca	Done
Project Management	15	-	Bianca, Evelien	In progress
Marketing	15	-	Evelien, Laura	In progress
Sustainability	15	-	António	In progress
Ethics	15	5	Evelien, Davide	Done
Project Development	10	-	António, Bianca	In progress

Table 20: Sprint Plan 5

Task	Estimated duration (h)	Real duration (h)	Members involved	Status
Interim Presentation	2	2	Team	Done
List of Materials	8	-	António, Bianca	In progress
Project Management	15	-	Bianca, Evelien	In progress
Marketing	15	-	Evelien, Laura	In progress
Sustainability	15	-	António, Davide	In progress
Project Development	10	-	António, Bianca	In progress

Table 21: Sprint Plan 6

Task	Estimated duration (h)	Real duration (h)	Members involved	Status
Decide look and feel for our brand	1	1	Team	Done
Apply the look and feel to our materials	2	2	Davide, Laura	Done
List of Materials	12	-	António, Bianca	In progress
Apply teachers' feedback to report	3	-	Team	In progress
Apply teachers' feedback to flyer and leaflet	1	1	Davide, Laura	Done
3.5 Quality	2	2	Evelien	Done
3.6 Communications	2	-	Evelien	In progress
4.2.1 Analysis of the macro environment	1	1	Laura	Done
4.7 Budget	1	2	Laura	Done
4.8 Strategy Control	2	1	Laura	Done
4.9 Conclusion	1	1	Laura	Done
5.5 Eco-efficiency measures	2	-	António	In progress
5.7 Sustainability report	1	-	António	To Do
Sustainability chapter review	1	1	António	Done
Black Box Diagram improvement	1	1	António	Done
7.5 Power Budget	1	1	António	Done
Project Development chapter review	3	-	António, Bianca	In progress

Table 22: Sprint Plan 7

Task	Estimated duration (h)	Real duration (h)	Members involved	Status
3D Model Video	5	5	António, Bianca, Davide	Done
List of Materials	12	-	António, Bianca	In progress
Apply teachers' feedback to report	3	5	Team	Done
3.7 Communications	2	2	Davide	Done
3.8 Risk	2	1	Davide	Done
3.9 Procurement	2	1	Davide	Done
3.10 Stakeholders Management	2	-	Laura, Evelien	In progress
3.13 Conclusion	1	1	Laura	Done
5.5 Eco-efficiency measures	2	-	António	In progress
5.7 Sustainability report	1	-	António	To Do
Project Development chapter review	3	-	António, Bianca	In progress
Marketing chapter review	1	2	Evelien	Done
Paper Problem Statement	1	1	Evelien, Bianca	Done
Paper State of the Art	1	1	Evelien	Done
Microsoft Planner	1	1	Laura	Done

Table 23: Sprint Plan 8

Task	Estimated duration (h)	Real duration (h)	Members involved	Status
Final 3D Model Video	5		António, Bianca, Davide	To Do
List of Materials	12		António, Bianca	In progress
3.10 Stakeholders Management	2		Laura, Evelien	In progress

Task	Estimated duration (h)	Real duration (h)	Members involved	Status
5.5 Eco-efficiency measures	2		António, Davide	To Do
5.7 Sustainability report	1		António, Evelien	To Do
Project Development chapter review	3		António, Bianca	In progress
Refined 3D model	5		Bianca	To Do
Apply teacher Luis' feedback Marketing	5		Laura, Evelien	To Do
Apply teacher Luis' feedback Ethics	2		Davide	To Do
Simulate the electrical circuit	3		António	In progress
Build IoT interface	8		António	In progress
Paper Project Development	4		António	To Do

3.12 Sprint Evaluations

The Sprint Retrospective is also called Sprint Evaluation. Every Friday the team reflects on the sprint process. The team discusses what was positive and what was negative. Based on the positive and negative reflection, three categories are created: Start doing, keep doing, stop doing. Due to the outbreak of the coronavirus, the classes of Project Management were postponed and the team did not start in sprint 1 with the Sprint Retrospective. After sprint 5 the team started with doing Sprint Retrospectives. The Sprint Retrospective is shown in Table 24.

Table 24: Sprint retrospective

Sprint	Positive	Negative	Start doing	Keep doing	Stop doing
5	Interim presentation and report went well	Started working on the report too close to the deadline Using chapters in sprint planning is vague	Working on the report on a daily basis Using sections in the sprint planning	Having skype meetings almost every day	Postponing work

Sprint	Positive	Negative	Start doing	Keep doing	Stop doing
6	The intern communication went well We estimated the duration of the planned tasks well We showed progress to the project supervisors Using sections in the sprint planning	We did not finish all the tasks we planned Some of us missed a meeting We did not do a daily meeting	Discussing via call instead of chat	Using sections in the sprint planning	Missing meetings
7	Combining work Follow scrum methods	Did not do all the tasks Sprint planning in three different places	-	Working well together	-

3.13 Conclusion

In conclusion, by using Scrum methodology of working to develop our project instead of classical methodology has allowed the team to organize more properly. Planning together in a more Agile way has determined an optimal management strategy in order to achieve all objectives. Every Monday the team plans the Sprint's week which consists on dividing the work in different tasks to accomplish smaller goals just to be more productive. By estimating the time of which task will lasts and every team member is assigned the tasks according to their skills, this fact had helped us to save more time in each task and do it successfully. At the end of each specific Sprint we made a retrospective to know how to improve the next Sprint. In that way we can consider that the project had been managed efficiently and strategically.

In the next chapter, we will develop marketing plan and define potential marketing strategies.

4 Marketing Plan

4.1 Introduction

The goal of this chapter is to provide a marketing plan for our product, taking into account the current market. It will help us to identify possible issues, trends, opportunities, threats and where to invest time and resources to start our business.

The analysis will cover, in the first phase, the market and potential customers, then evaluate the objectives, the price, and finally, the discussion of the product and its promotion to establish the most appropriate market launch strategy for the product.To sum up, after having analysed these different points and created a solid base, the product will be able to establish long-lasting and ever-present relationships with the audience and market. The main steps that are going to be followed are:

First, the market analysis will collect information for designing a marketing strategy and concrete marketing measures that gives us an input to recheck the situation. It is divided in into three levels:

two externals levels (macro and meso environment) and one internal level (micro environment). Second, the SWOT analysis will identify internal or external factors that are favourable or unfavourable for the viability company/product. Third, we will identify which are the Strategic Objectives of the product by using smarter methodology. Fourth, we will define and visualize the brand and the product position in the market. Fifth, we will develop a Marketing Mix, consisting of the 4 P's, to find the right combination of factors to provide value to target customers. The finals steps are the budget and strategy control to ensure that marketing objectives are attained.

4.2 Market Analysis

The Market analysis will define the work environment and helps to reduce the risk by understanding the potential market collecting and evaluating information by suppliers and buyers to make purchases or sales decisions and customer conditions. Knowing the market situation will let us to visualize the current position and establish future position of our product on it.

This analysis will be used to design a marketing strategy and concrete marketing measures that gives us an input to recheck the situation during the development process and make a more viable product. After have analysed the market and gather information we will be used to create SWOT matrix analysis in the next section that serves as a basis for visual decision-making.

The market analysis is divided into three levels (Figure 16):

- Macro environment: related to the contextual environment which includes Social, Technological, Economical, Environmental and Political developments
- Meso environment:represents transactional environment as Demand, Suppliers, Distribution channels, Strategic partners, competitors and propositions.
- Micro environment: exposes about inner Organization values and goals defining the Vision, Mission, Strategy, Resources, Competences, Processes, Products and Services.

The macro and meso environment together form the external analysis and the micro analysis is the internal analysis.

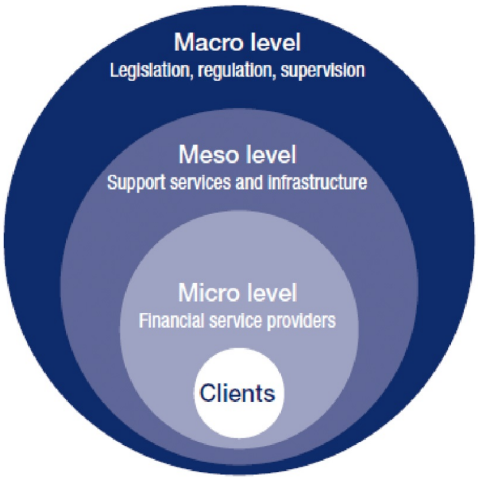

Figure 16: Marketing analysis **[Thinah Moyo, 2012]**

4.2.1 Analysis of the macro environment

Macro-environment is the view of the market in the worldwide scale. It analyses which future trends

could change the demand and market behaviour, which means all the factors that we are not able to manage but which will impact in our product or on the processes of organization. A variant of the PEST analysis is the PESTLE analysis. PESTLE is a really useful framework to assemble for the starting company or entering a foreign market. The PESTLE analysis consists of Political, Economical, Social, Legal and Environmental macro environmental factors to be taken into consideration for a marketing analysis **[CIPD, 2020]**. These factors can be divided into Opportunities and Threats and be used as the base for SWOT matrix.

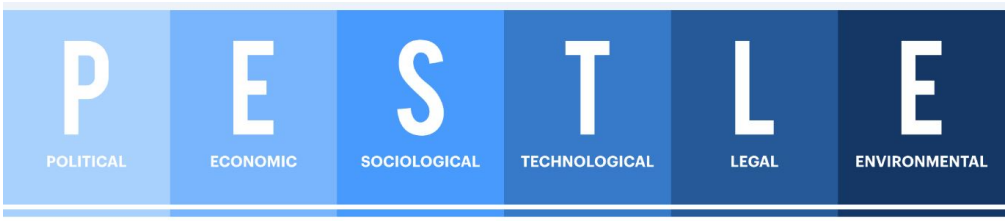

Figure 17: PESTLE analysis **[Lucidchart Content Team, n.d.]**

Political

Opportunities

- Most European countries allow free flow of people and trade between countries **[Schengen Agreement, 2017]**.
- The United Nations set 17 Sustainable Development Goals in 2015 that should be achieved by the year 2030 **[United Nations, 2015]**. The Soaksy contributes to fulfilling the goals Clean Water and Sanitation, Sustainable Cities and Communities, Climate Action and Life Below Water.

Threats

- The refugee and corona crisis in Europe probably put the Schengen Agreement under strain **[Gideon Rachman, 2020]**.
- Citizens could lose faith in politics, if a prime minister mishandled the corona crisis **[Chris Miller, 2020]**.

Economical

Opportunities

- People feel the need to be more environmental friendly, because we as humans have caused this environmental crisis **[N. Matthews, P. Keys, 2019]** and are willing to spend more money on the environment.

Threats

- Most economists assume that a worldwide recession is already underway, because of the coronavirus. **[L. Chutel S. Raj D. Politi P. Goodman, A. Dahir, 2020]**

Social

Opportunities

- Protecting the environment is found more and more important in the European countries **[Environmental Performance Index, 2018]**.

Threats

- People might not like the Soaksy being always in the lake.

Technological
Opportunities

- More and more processes are automated **[N. McCarthy, 2017]**.

Threats

- The Soaksy is not fully automated. It has to be emptied every once in a while.

Legal
Opportunities

- No relevant factors.

Threats

- The mechanisms of the Soaksy are quite similar to the Seabin.

Environmental
Opportunities

- The Soaksy helps to collect floating trash that pollutes a lake.
- The Soaksy can use sustainable energy.
- The Soaksy is made of sustainable materials.

Threats

- Possible alteration of wildlife by the sound of aquatic pump.

4.2.2 Analysis of the meso environment

Suppliers
The definition of a supplier is a company, person, etc. that provides things that people want or need, especially over a long period of time **[Cambridge Dictionary, n.d.]**. Our supplier should be trustworthy, this means the supplier should provide the right products on the right time. Also, our supplier should be cheap and deliver good quality products.

Competitors
The definition of a competitor is a company in the same industry or a similar industry which offers a similar product or service **[Business Dictionary, n.d.]**. The competitors of the Soaksy are companies that also sell products or services that clean lakes.

Demand
Demand is defined as desire for certain good or service supported by the capacity to purchase it **[Business Dictionary, n.d.]**.

Partners
A partner is defined as an individual who joins with other individuals (partners) in an arrangement (partnership) where gains and losses, risks and rewards, are shared among the partners **[Business Dictionary, n.d.]**. The Soaksy company could be partners with one or multiple non profit

organizations that also want to clean natural waters. For example, The Ocean Cleanup could be our partner.

4.2.3 Analysis of the micro environment

To analysis micro environment we will use a tool called 7S model of McKinsey. The 7-S model can be used in a wide variety of situations, for example, to:

- Improve the performance of a company.
- Examine the likely effects of future changes within a company.
- Align departments and processes during a merger or acquisition.
- How best to implement a proposed strategy.

Consists on Strategy, Structure, Systems, Management Style, Shared Values, Staff and Skills.

Skills & Stuff: Our team consists of five very motivated students. We are all from different study fields. The five study fields in our team are: Electrical and Computer Engineering, Industrial Engineering, Civil Engineering, Applied Mathematics, Industrial Design & Product Development. Also, we are from five different European countries. This means there are a lot of cultural similarities between us, but also some differences.

Strategy: The main strategy's objectives of our team are to create the project in a limited time since 17th of February to 23th of June with not own resources. These goals are no long-term so it can be considered as a weakness because some parts of the report are not deep analysed as it could be. One of the objectives is to find sponsors to invest in our product and try to figure out where are gaps in the current market's scope to make space between known stablished companies.

Structure: How the team is organized is by dividing the tasks depending on the capacities of each member to develop more successfully the specific task. We have no team leader so every point is augmented and accepted by all the members having the same rights and votes. This structure makes equality between the team and the team is aware of possible outcomes or misunderstood.

Systems: In this point we are going to analyse and measure the procedures and processes that the team has to carry out. To discuss the progress done each week, the team has a meeting with the teachers to fix some problems and keep doing the initial Sprint plan. Teacher's feedback helps to adjust the tasks which improve doing the project.

Management Style: We are following Agile methodology which consists on knowing what's every team member doing during the week and communicating to know how the project is going on. The decisions are made by all team's members in equal conditions. If some of the team members have some problem, it will be communicate to the team and manage to help as it is possible.

Shared Values: In order to success in the project our team has common and priorities values. The team is motivated, multicultural and works to keep the ethics. Those ethics and values is what makes us distinguish and helps us and make our final decisions.

4.3 SWOT Analysis

SWOT stands for Strengths, Weaknesses, Opportunities and Threats. The main proposals of SWOT analysis are to identify internal or external factors that are favourable or unfavourable for the viability

company/product. This framework is very useful at the beginning of the project to support plan strategic exercises visualizing possible opportunities and uncover threats. SWOT analysis is built by internal diagnostic which consist on analysing strengths and weaknesses of the inner company and external diagnostic that analyses the outside environment opportunities and threats.

The SWOT Matrix Analysis is created from the macro-environment (4.2.1) and the micro-environment (4.2.3).:

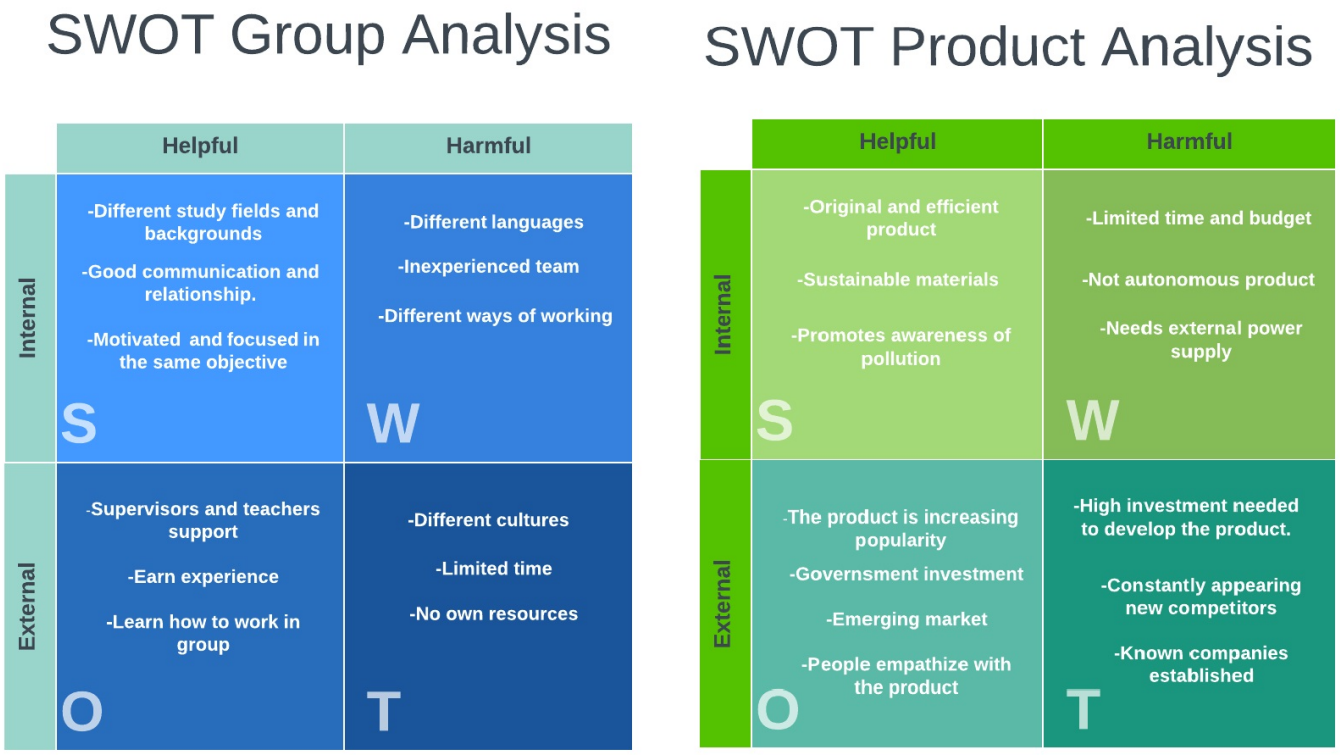

Figure 18: SWOT Group Analysis and SWOT Product Analysis

From the SWOT product analysis, we can conclude that the costumer's awareness of the current situation of polluted waters makes it easier to get sponsors or government investment. This point helps against the high investment that is required to develop the product. However, being in an emerging market there is the threat of constantly appearing new competitors and get a gap in the market between well known companies established like The Ocean Cleanup or The SeaBin Project.

4.4 Strategic Objectives

Marketing strategic objectives are an important part of a marketing plan. Without defined objectives, the marketing plan is unclear and it is very difficult to achieve an unclear plan. For creating a clear marketing plan, the SMART principle is used **[K. Kosaka, n.d.]**.

- **“S” – Significant/ Stretching/Specific:** What is going to be achieved with reference to marketing goals? Target a specific area for improvement with clear and understandable language.
- **“M”- Measurable/Meaningful:** Objectives should be defined by quantified or qualified parameters to monitor progress and measure results so that final results can be replicated and evaluated.

- **“A” – Achievable/ Attainable:** It is important to make sure the goals and steps that are going to be realized are achievable knowing the existent limitations, time and resources.
- **“R” – Reasonable/ Realistic,/Relevant:** Defining our priority tasks and objectives in accordance with the long-term plans established. Focus on ethical values.
- **“T” - Time-based/Timely:** The goals should be reached in a limited time. This limited time is determined based on being aware of the possible outcomes and the difficulty of each goal.

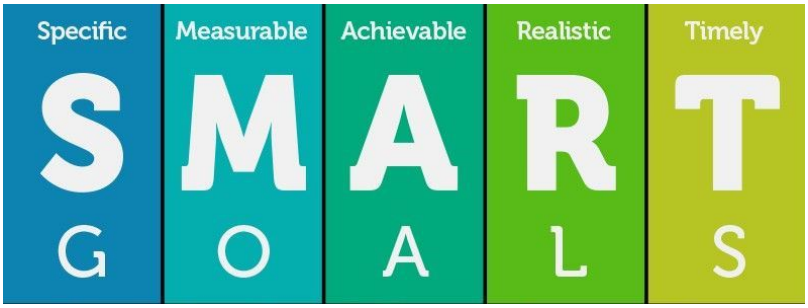

Figure 19: SMART principle **[Clara Anna, n.d.]**

The main strategic objectives for Soaksy product will be:

- Create the redesign leaflet and flyer product by the teachers feedback before the 8th of April 2020.
- Finish testing phase before June 2020.
- Build 3D Soaksy's prototype before the 20th of June 2020.
- Create a long-life power supply system before the 15th of June.
- Revise and finish the project report before the 15th June of 2020.
- Develop an economically sustainable product by using renewable energy.
- Make life product cycle as circular design after product life.
- Find sponsors and funding to the business by the end of 2020.
- Popularize and promote Soaksy by media advertising.
- Establish Soaksy's company before August 2021.
- Create a business website and online sales at the end of 2021.
- Make a platform for feedback users at the end of 2021.
- Start Soaksy selling in European countries at the end 2022.
- Expand selling all over the world at 2025.

4.5 Strategy/Targeting/Positioning/Brand

For our product we choose the name “Soaksy”. Firstly, because it is a short and catchy name. The second reason is that our product will be used in the water and thus will get “soaked”. Thirdly, our product will use a pump that “sucks” in the floating trash and the word “sucks” sounds a lot like the word “soaks”.

In the design of our logo, we want to show that our Soaksy has to do with the world's water environment. That is why we choose to change the “O” of Soaksy into a world and highlight the waters. Also, we placed some water on the “Y” of Soaksy. In Figure 20 the Soaksy logo is shown.

The brand name Soaksy and the website soaksy.com are still available **[Brandbucket, n.d.]**.

Figure 20: Soaksy logo

In order to know the real market competitors, the more comparable products have been analysed to identify the gaps in the market and to take advantage of the possible opportunities. To visualise the market scope, two perceptual maps have been made to define what the position of our product and company is.

The product perceptual map makes a comparison between efficiency and price with the established products on the market. Our positioning strategy is aimed at obtaining an attractive product that stands out for its low price and efficiency. Soaksy is a product that requires low power supply and low maintenance. The perceptual map for the product is shown in Figure 21.

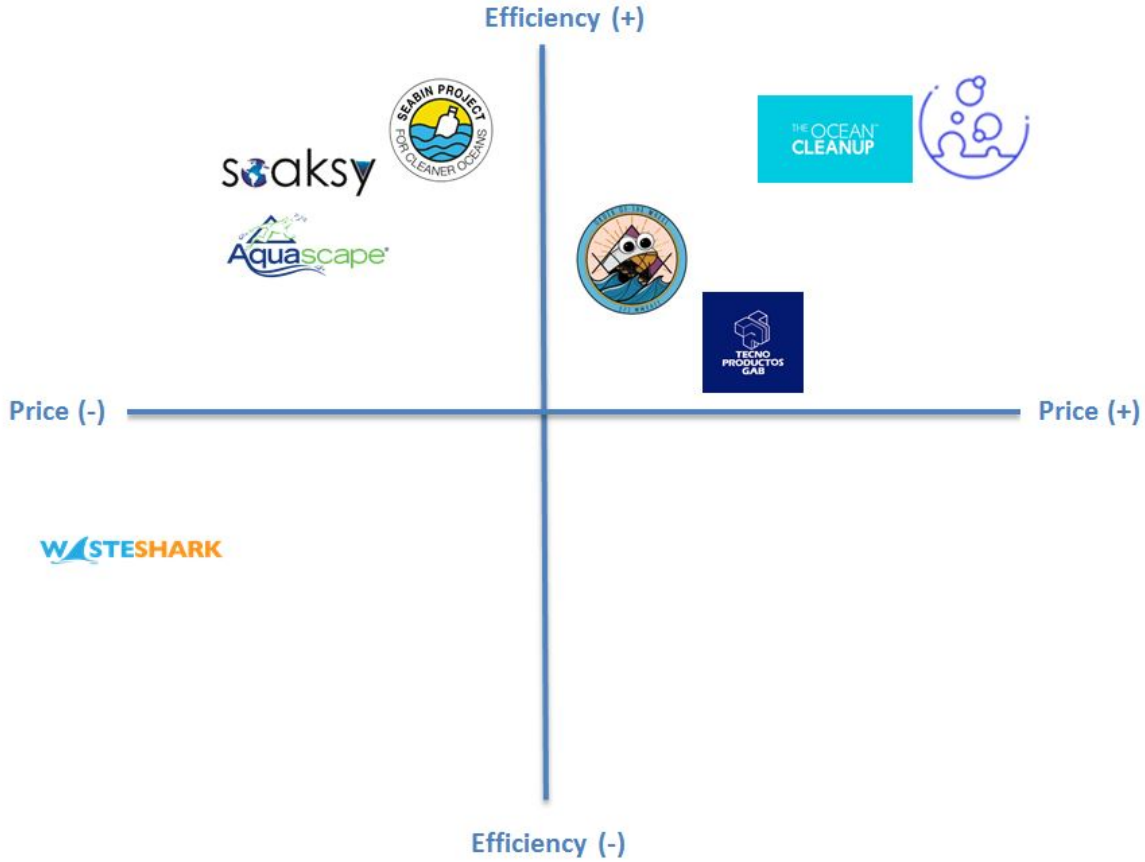

Figure 21: Product Perceptual map

The second perceptual map in Figure 22 shows the company's value position and the values on which we want to specialise. The main value is sustainability, our product is made of recycled materials. Being loyal to our vision of promoting awareness of polluted waters, the Soaksy is made of recycled materials and is powered by renewable energy sources. This gives an extra value that is appreciated by the potential customers and makes Soaksy's brand high positioned compared to its competitors.

Figure 22: Companies Perceptual map

4.6 Adapted Marketing-Mix

The Marketing Mix consists of the 4 P's and helps a company to find the right combination of factors to provide value to its target customers **[OER Services, n.d.]**. The Soaksy Marketing Mix consists of the following 4 P's:

Product
The Soaksy will collect floating trash in lakes by pumping water into it.
Price
The exact price of the Soaksy is unknown yet. The price of the prototype will be a maximum of €100.
Promotion
We will seek contact with local governments in Portugal and with NPO's. Also, we will use the website soaksy.com and social media (such as Facebook, Instagram and Twitter) to promote the Soaksy.
Place
We will start selling the Soaksy online at soaksy.com in Portugal. If possible, we would like to expand the Soaksy market to other European countries.

Figure 23: Marketing Mix **[OER Services, n.d.]**

4.7 Budget

Our marketing budget is needed to promote the Soaksy. Marketing can be done via online advertisement, posters, flyers, folders, videos and fairs. Nowadays, for promoting a product we need a good social media communication and featured YouTube advertisement to get the attention of our potential customers. Facebook, Instagram, Twitter, Snapchat, LinkedIn and other social networks will keep the attention to possible customers that want to collaborate and contributing in capital in the project in platforms like Kickstarter. Also we have to focus on 60+ year old people that are not so used to using social media, so we will require an investment in newspaper advertisement and TV.

Our potential customers are public institutions. By getting publicity on social media and creating our own company page, the chance that sponsors will find us and invest in our company increases significantly. We have an initial cash contribution from each team member for possible expenses. The incomes and expenses for marketing are shown in Table 25.

Table 25: Marketing incomes and expenses

Incomes	**Price (€)**
Kickstarter Platform	3000€
Initial capital for each member of the team (500€x5)	2500€
Initial Sponsors	4000€
Expenses	
Company's Page	1000€
Hosting	20€
Advanced Seo positioning	280€
Social media advertising	3000€
Radio advertisement	900€
Newspapers advertisement	1500€
Total	**+2800€**

4.8 Strategy Control

According to Kotler: “Marketing control is the process of measuring and evaluating the results of marketing strategies and plans and taking corrective action to ensure that marketing objectives are attained.” **[S. Ghose, n.d.]**. To achieve this, we need to continuously improve our product and processes. We choose to use the method PDCA: PLan-Do-Check-Act/Adjust **[J. Bosgra, n.d.]**.

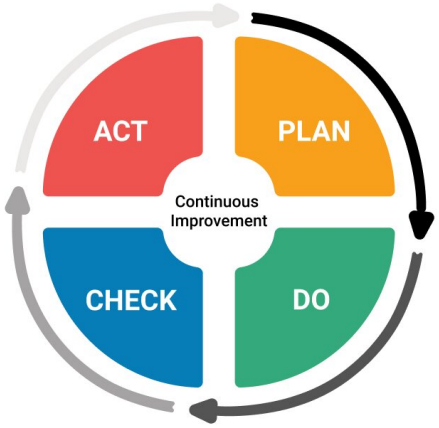

Figure 24: PDCA **[kanbanize, n.d.]**

- **Plan:** Consists on assessing the current situation and evaluate and predict what issues and outputs may be and plan how to fix it. Establish an agreement about what methodology is going to be followed until the end of the project, in this case Agile, and make sure the objectives and goals are understood by all team members. Avoid big changes during the process only when it's completely necessary and analyse and predict the results.
- **Do:** In this phase, by executing the action of the previous step, we will execute the plan to test potential solutions and build a process to achieve our goals, while gathering data for further analysis.
- **Check:** We will check and make a retrospective about the correct applied methodology plan. We will study the results collected and compare its effectiveness to decide which solution will be implemented and support for achieve our goals. We will continue testing until we have viable results that suit our expectations.
- **Act:** The final step, once the past mistakes have been identified, is when the corrective actions are made. It allows the method be redefined anew in the future and be used for continuous improvement operations. If the results are successful, the process can be standardized. If not, the team will focus on the issues and repeat the cycle until obtain the proper solution.

4.9 Conclusion

Based on this market analysis, the team decides to create a floating trash collector intended for governments and people interested in reversing the current water pollution situation. We have defined the main strategic objectives and analysed the possible threats and opportunities to develop our product and predict future issues. This is why the team decided to create Soaksy by using recycled materials and using renewable energy, which gives an extra value that is appreciated by customers and positions the Soaksy brand high above its competitors. Our positioning strategy is aimed at obtaining an attractive product that stands out for its low price and efficiency. It is a product

that does not need a high power supply and requires little maintenance. To promote our product, we invest in social media advertising to attract potential customers who want to participate and contribute to our project.

In the next chapter, we will study the necessary sustainable measures to take into account in our product.

5 Eco-efficiency Measures for Sustainability

5.1 Introduction

Sustainability is a complex concept. The most often quoted definition comes from the UN World Commission on Environment and Development: “sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” In the charter for the UCLA Sustainability Committee, sustainability is defined as: “the physical development and institutional operating practices that meet the needs of present users without compromising the ability of future generations to meet their own needs, particularly with regard to use and waste of natural resources. Sustainable practices support ecological, human, and economic health and vitality. Sustainability presumes that resources are finite, and should be used conservatively and wisely with a view to long-term priorities and consequences of the ways in which resources are used”**[UCLA Sustainability, n.d.]**.

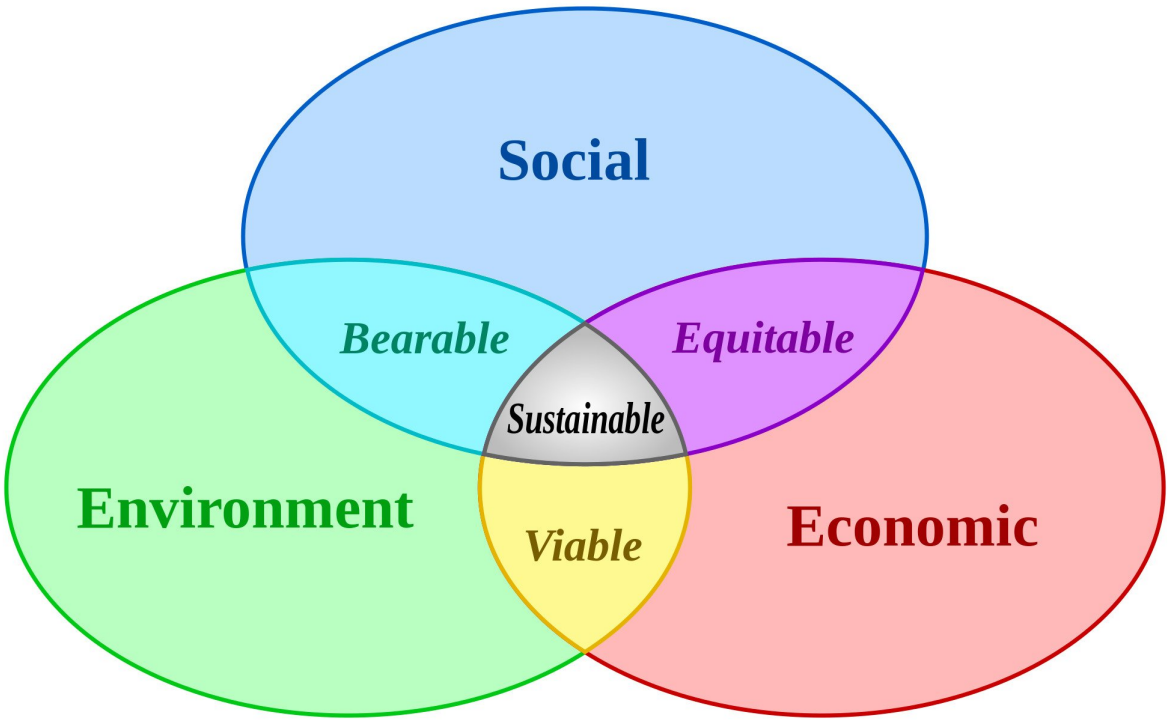

Figure 25: Sustainable Development at the confluence of the constituent parts.

5.2 Environmental

Environmental sustainability is the rate of use of renewable resources, avoid using non-renewable resources and create as little pollution as possible. If resources cannot be used indefinitely, then they are not sustainable. When all three pillars of sustainability are solid, people live in a system where

high quality life is the norm. They have a clean and healthy environment, a decent level of economic well-being and a solid level of social achievement **[Thwink, 2019]**. Therefore, in accordance with the above reasons, it was essential for this project to use environmentally friendly and respectful materials, such as natural materials or materials that could be easily recycled/reused. However, the materials used shall meet the characteristics required to withstand moisture.
The lakes and ponds that exist in urban spaces are places where the effects of pollution are easy to reach, but it is not so easy to remove. With our project we intend to tackle this specific problem by implementing a system that collects waste on the surface of these same lakes.
The team decided to feed Soaksy also with a solar panel, as well as with traditional methods, making it a hybrid product and usable in adverse weather conditions. The solar panel absorbs sunlight as a source of energy to generate electricity or heat. Abundant solar energy in all countries of the world. From the point of view of energy security and sustainability, it seems logical to make the most of available solar energy technologies, and when not available Soaksy can continue to clean the lakes, minimizing greenhouse gas emissions and the use of non-renewable sources.

5.3 Economical

Economic sustainability is the ability of an economy to sustain indefinitely a certain level of economic production. In a sustainable economy, growth strengthens competitiveness, nature protection and the reduction of environmental impact. Nowadays, society does not respect the environment, most countries in the developed world simply pollute and eventually ruin in the name of profit, for example when a company has a high pollutant factor it can pay more taxes to get everything back on track. This solution is economically advantageous but disastrous for the environment.
We intend to use local materials, if possible recycled materials, that comply with environmental regulations.
Our team has decided to focus (in addition to GDP) also on the environment trying not to weigh on it, creating a product (Soaksy) that cleans lakes from floating garbage and hopes to help create a common environmental awareness.

5.4 Social

Although for most people sustainable development only means nature protection, a further pillar of this concept was the social dimension. The social dimension is focused on improving social equality. If we all make a small effort towards sustainability we will also benefit from it, for example a cleaner air or being able to swim in the clean lake near home.
The Soaksy is also meant to be an educational tool, reminding people that such a product is necessary because there is garbage to remove in the first place.
legislation: Maximum CO2 of 1250 parts per million (ppm) according to Portaria n.º 353-A/2013 **[MINISTÉRIOS DO AMBIENTE, 2013]**
recommendation: The National Institute for Occupation Safety and Health (NIOSH);the level of CO2 should never rise above 1 000 ppm **[co2 levels at home, 2017]**; the National Sleep Foundation (NSP) - the humidity level should always be kept between 30 % to 60 % **[sleepfoundation.org,]**.

5.5 Eco-Efficiency solutions

The term eco-efficiency was coined by the World Business Council for Sustainable Development (WBCSD) in its 1992 publication “Changing Course”. This concept describes a vision for the production

of economically valuable goods and services while reducing the ecological impacts of production. In other words eco-efficiency means producing more with less.[https://books.google.pt/books?id=UAF-DwAAQBAJ&pg=PT158&lpg=PT158&dq=wbcsd+critical+producing+more+with+less&source=bl&ots=1Jwyozx3ad&sig=ACfU3U3wqJWNCjKOmnza6S0vbVg6VIG0jQ&hl=pt-PT&sa=X&ved=2ahUKEwjJv4qUxvroAhXeDmMBHbzFA5MQ6AEwAXoECAkQAQ#v=onepage&q=wbcsd%20critical%20producing%20more%20with%20less&f=false]
According to the WBCSD, critical aspects of eco-efficiency are:

- A reduction in the material intensity of goods or services
- A reduction in the energy intensity of goods or services
- Reduced dispersion of toxic materials
- Improved recyclability
- Maximum use of renewable resources
- Greater durability of products
- A increase in the service intensity of goods or services

5.5.1 Environmental Management System (EMS)

An EMS is defined as the organizational structure, responsibilities, practices, procedures, processes, and resources for implementing and managing an organization's environmental affairs while ensuring conformity to its policies, standards, and stakeholders' expectations.
We decided to use this system as it can help identify where eco-efficiency opportunities occur within a company.[http://wbcsdservers.org/wbcsdpublications/cd_files/datas/capacity_building/education/pdf/EfficiencyLearningModule.pdf]

5.6 Life Cycle Assessment

Life-Cycle Assessment is a decision-making tool to identify environmental burdens and evaluate the environmental consequences of a product, process or service over its life-cycle from cradle to grave or cradle to cradle in the case of products that can be recovered and recycled or reused, such as our product.
[http://wbcsdservers.org/wbcsdpublications/cd_files/datas/capacity_building/education/pdf/EfficiencyLearningModule.pdf]
The company responsible for making the product must apply a Life cycle Assessment based on the theory of Circular Economy, as shown in Figure 26.

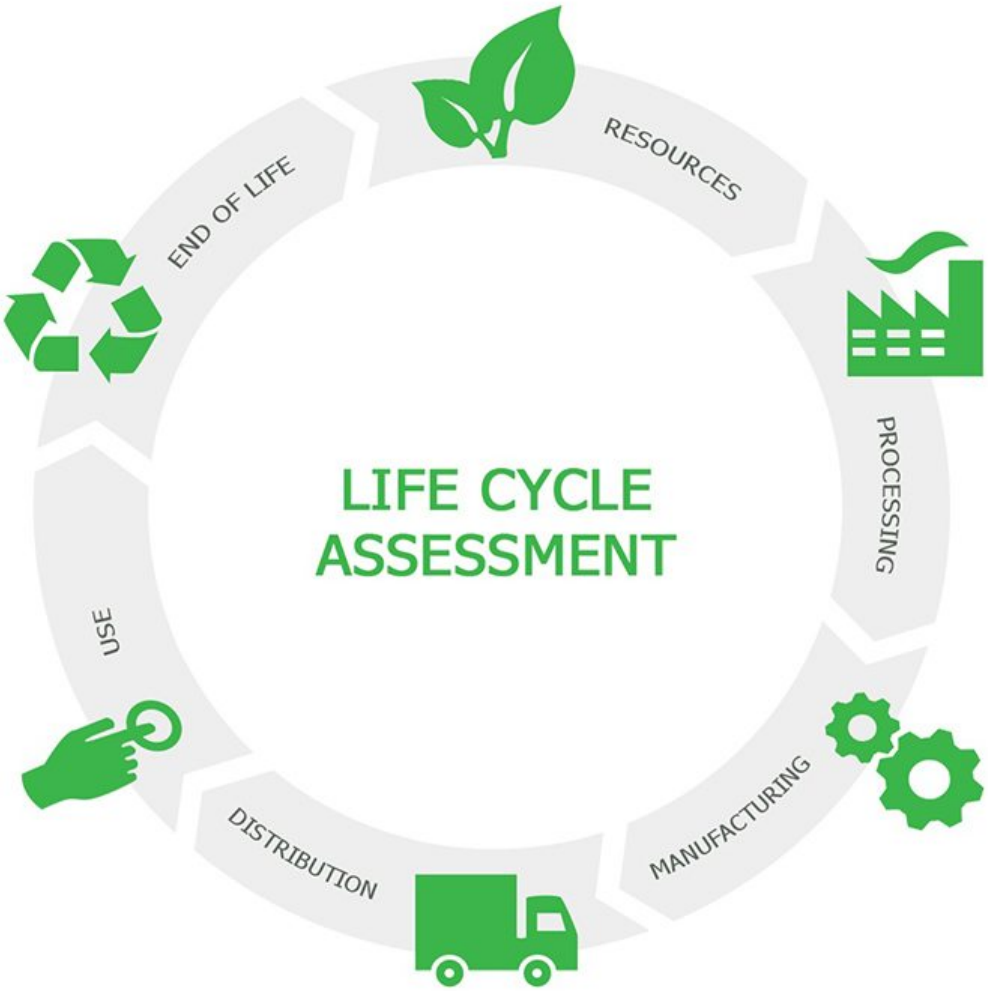

Figure 26: Life-Cycle Assessment

5.6.1 Resources

The materials to be used must respect existing environmental regulations and make use of local resources.

An optimal source of resources will be recycled materials, such as HDPE plastic, the plastic most used with food products and the most easily recyclable.

As far as electronic components are concerned, it would be ideal to make agreements with local manufacturers and stores in order to have the cheapest possible material remaining local.

5.6.2 Processing

The processing of resources would have to apply techniques with minimal environmental impact.

Examples of techniques would be to use efficient renewable energy technologies and also use as few processing steps as possible.

5.6.3 Manufacturing

The manufacture will be done with as few people as possible, using machines and specialized labor for this purpose.

The result of this manufacture will be a product that still has to be adjusted to the place of application. The person who will make the final adjustment will have to have some technical degree.

5.6.4 Distribution

The distribution of this product should start in the country of origin, expanding to other countries if the demand justifies.

The transportation will be done by a company under contract from the warehouses to the place of application.

The packaging of the product will be made of cardboard, of recyclable reference.

5.6.5 Use

The product is made to last for years, with minimal emissions during this time.

The product implements a system that allows it to be powered by solar energy during most of its operation, reducing the environmental impact and providing the user with energy savings.

5.6.6 End of life

At the end of the product's life, the user should contact us to collect the product at no cost to the user.

With the product we would use all recyclable materials to turn into resources for new products.

The electrical materials would be reconditioned for new products if possible.

With all non-recyclable and non-repairable materials, we would dispense according to the regulations.

5.7 Sustainability report

5.8 Conclusion

Based on the sustainable study carried out, the team chose to use stainless steel for the rigid structures and HDPE plastic for the waste container. These materials are easy to recycle and have a long lasting effect, two essential characteristics for our product.

6 Ethical and Deontological Concerns

6.1 Introduction

Ethical and deontological concerns are influencing the entire society more and more. They are major key factors in each company. By neglecting these factors and counting them as irrelevant, it can affect a business very negatively. In this era of social media, all kinds of news spread quickly. Especially negative news. A morally wrong case can have a great relevance worldwide, and very quickly impact on the reputation of the involved company. When this happens people lose confidence in society and this could degenerate into a decline in sales and stock market. Therefore, general ethical and deontological concerns should not be overlooked, as these could become key factors in a business relapse.

6.2 Engineering Ethics

Engineers have a great impact on the lives of the people on this planet. The people working in this sector are involved in the design, analysis and construction of infrastructures, machines, devices, etc. which condition the quality of life and health of the people who use them during their daily lives. It is therefore very important that these professionals behave in a good ethical and moral way.
Engineers play an important role in today's society, conditioning our lives in three different ways **[NSPE, 2019]**:

- Human: Engineers should develop and create products in line with the safety, health and well-being of the public.
- Environment: Engineers should develop and create products that are environmentally friendly, or that are as environmentally friendly as possible. Studying the product life cycle. This is one of the greatest challenges of this century, as our society faces climate change.
- Society: Engineers should develop and create products for the benefits of the whole society and contribute to a better society, creating solutions to connect, or help people.

Code of ethics was discussed in many engineering societies. The one that was the more up to date is the Code of Ethics brought by the National Society of Professional Engineers (NSPE).

Engineers, in the fulfillment of their professional duties, shall **[NSPE, 2019]** :

- Hold paramount the safety, health, and welfare of the public.
- Perform services only in areas of their competence.
- Issue public statements only in an objective and truthful manner.
- Act for each employer or client as faithful agents or trustees.
- Avoid deceptive acts.
- Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

6.3 Sales and Marketing Ethics

Every company that enters the market must interact with a constant competition for everything it seeks at its internal resources, customers, price, etcetera. In order to win as many of these clashes as

possible, companies carry out different activities, using tactics and campaigns. The constant presence of competition within the market inevitably leads to a clash between different players. These clashes can sometimes lead to unprofessional behaviour such as price competitions, branding wars and the use of unfair practices. To avoid this phenomenon, one can use ethical marketing. This is not a real strategy, but is more a school of thought in which responsibility, equity and honesty are promoted.

There are eight ethical marketing principles **[Nicky LaMarco, 2018]**:

- Truth and honesty are appreciated and respected in all types and marketing channels.
- Marketing personnel must be guided in their professional activity by their personal ethics.
- Advertising for your product should not be confused with news and entertainment.
- The marketers will be honest and transparent about who sponsors their products.
- Consumers must be treated fairly.
- Consumer privacy is appreciated and respected at all times and at all costs.
- Marketing must comply with rules and regulations issued by the government or organisations.
- Ethics should be discussed openly and honestly in all marketing decisions.

Our team wants to make sure that the customer's wishes and expectations are met. As a team we also want our Soaksy to have a fair price. This means that the price should cover all the costs we have made and also provide a profit for society. But it also means that customers can see where the price comes from and that they agree that they get the value for their money. Even if the goal is to keep the price as low as possible, we want the ecological footprint to be as small as possible. This will lead to the increase in the selling price, but it will provide added value to the product.

6.4 Environmental Ethics

Environmental ethics is a branch of ethics that studies the relationship between human beings and the environment and how ethics plays a role in this. Environmental ethics believe that human beings are part of society as well as other living creatures, which includes plants and animals. Plants and animals are a very important part of the world and are considered a functional part of human life. Therefore, it is essential that every human being respects and honors this and uses morality and ethics when it comes to these creatures**[enviromental ethics, 2019]**.

There are many different environmental ethics that could be held, ranging from the human-centred (or "anthropocentric") to the more nature-centred (or "non-anthropocentric") vision. Non-anthropocentrists support the promotion of intrinsic nature rather than instrumental or use value for human beings**[Ben A. Minteer, 2017]**.

While the world's population has increased seven-fold from 1 billion to more than 7 billion inhabitants during the last two centuries, so has the consumption of the planet's natural resources. This behavior places great emphasis on the planet's life-support capabilities**[UNFPA, n.d.] [Andrew Light & Alan Holland John O'Neill, 2012]**.

Our team will try to apply the following points to the project to make it as sustainable as possible for the environment and to help our planet during the Anthropocene:

- Maximum efficiency with minimum energy consumption.
- Materials must be environmentally friendly.
- Reach maximum product life.

6.5 Liability

Companies willing to create and sell a product must confront themselves with the responsibility for their product. Liability is the legal aspect of the product, which prevents the company from being sued for damages or accidents caused by their product or its use. In order to avoid product liability issues, our team has decided to comply with the following EU directives:

- **Machine Directive** (2006/42/CE 2006-05-17): It concerns the danger that the machine might present to man: Explosions, vibrations, radiation, finger joints, dangerous substances in flight, force limits for the operation of machines, the minimum distance for safety, etc. **[EU machinery legislation, 2019]**.
- **Electromagnetic Compatibility Directive** (2004/108/EC 2004-12-15): This Directive regulates side effects between electronic components that interface with each other. These side effects may be electromagnetic radiation or fields in the vicinity of electronic components. The Directive provides that “the electromagnetic disturbances generated shall not exceed the level above which radio and telecommunication equipment (…) cannot operate” **[EMC Directive, 2014]**.
- **Low Voltage Directive** (2014/35/EU 2016-04-20): Concerns the health and safety risks of electrical equipment with an input or output voltage of 50 V and 1000 V for AC and 75 V and 1500 V for DC **[LVD, 2014]**.
- **Radio Equipment Directive** (2014/53/EU 2014-04-16): Soaksy is an “electrical product (…), which intentionally emits and/or receives radio waves for radio communication and/or radiodetermination purposes” **[RED, 2014]**.
- **Restriction of Hazardous Substances in Electrical and Electronic Equipment Directive** (2002/95/EC 2003-01-27): Prohibition of the use of lead phthalate, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, polybrominated diphenyl ether, bis(2-ethylhexyl), butyl **[RoHS 2, 2011]**.

Our team decided to create a user manual for the Soaksy, protecting it from accidents caused by incorrect use of the product.

6.6 Conclusion

Based on this ethical and deontological analysis, the team chose to focus on efficiency and high standards for every stage of the production process, including the choice of suppliers and components, the sale and marketing of the product and providing a two-year guarantee. The team decided that in the event of Soaksy malfunction, the product will be returned to the factory, the reuse of working parts and the recycling of faulty components.

7 Project Development

7.1 Introduction

After research on the state of the art, the project managment, marketing, sustainability and ethical

considerations, we want to show the steps we have followed to make and produce our prototype. In this chapter we will explain the development of the project, starting with the black box to show the overall structure of the system in the most general way possible. After you can see the architecture with the cardboard model, structural drawings with the final design and electrical diagrams of the details.

7.2 Architecture

7.2.1 Black box Diagram

In Figure 27 the Black Box Diagram is shown.

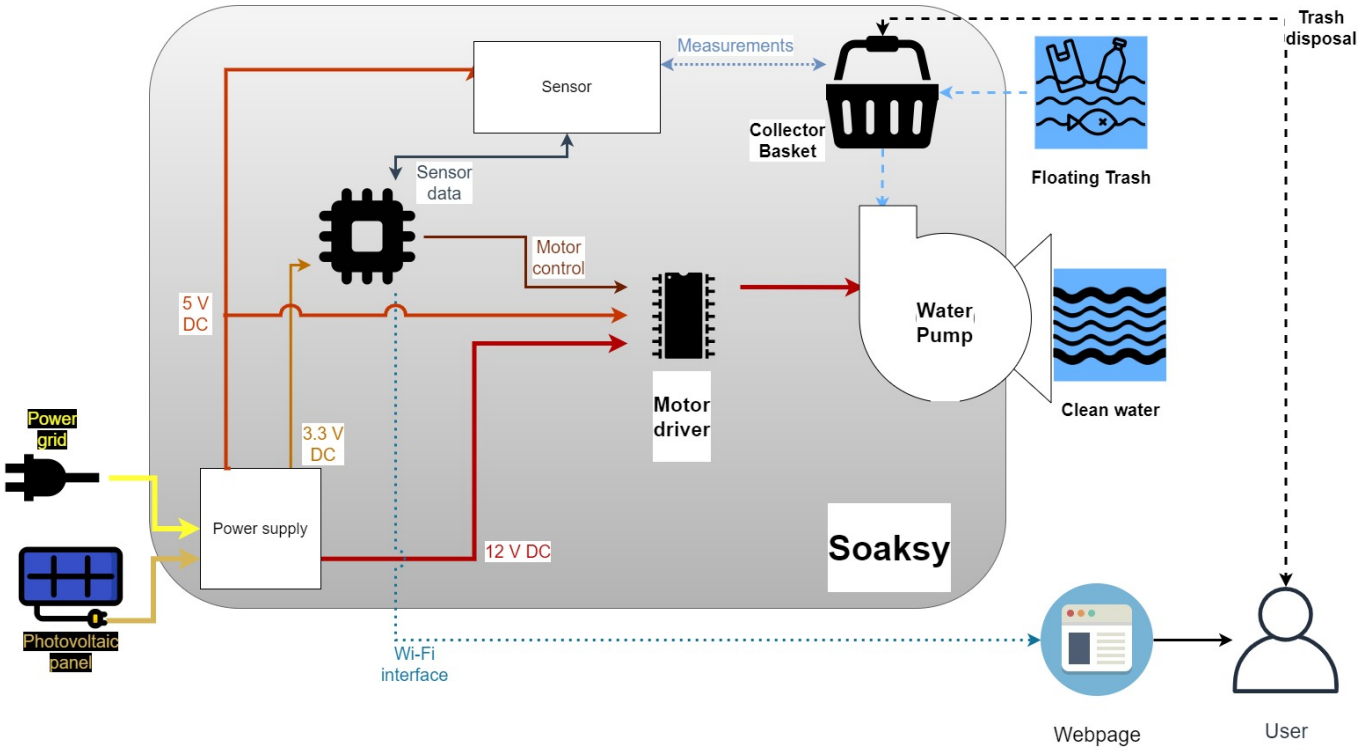

Figure 27: Black Box Diagram

The system absorbs the floating garbage through the water pump into the container so that it can be collected in the future.
With the water in the container, the system uses sensors to measure the level of the waste inside the bin.
The waste level status is presented to the user via a webpage.
Finally, the water is expelled from the water pump into the lake again.
This process occurs in a cyclical way and is interrupted when the user removes the container.

7.2.2 Technical Drawings

Figure 28 displays the technical drawing for this project.

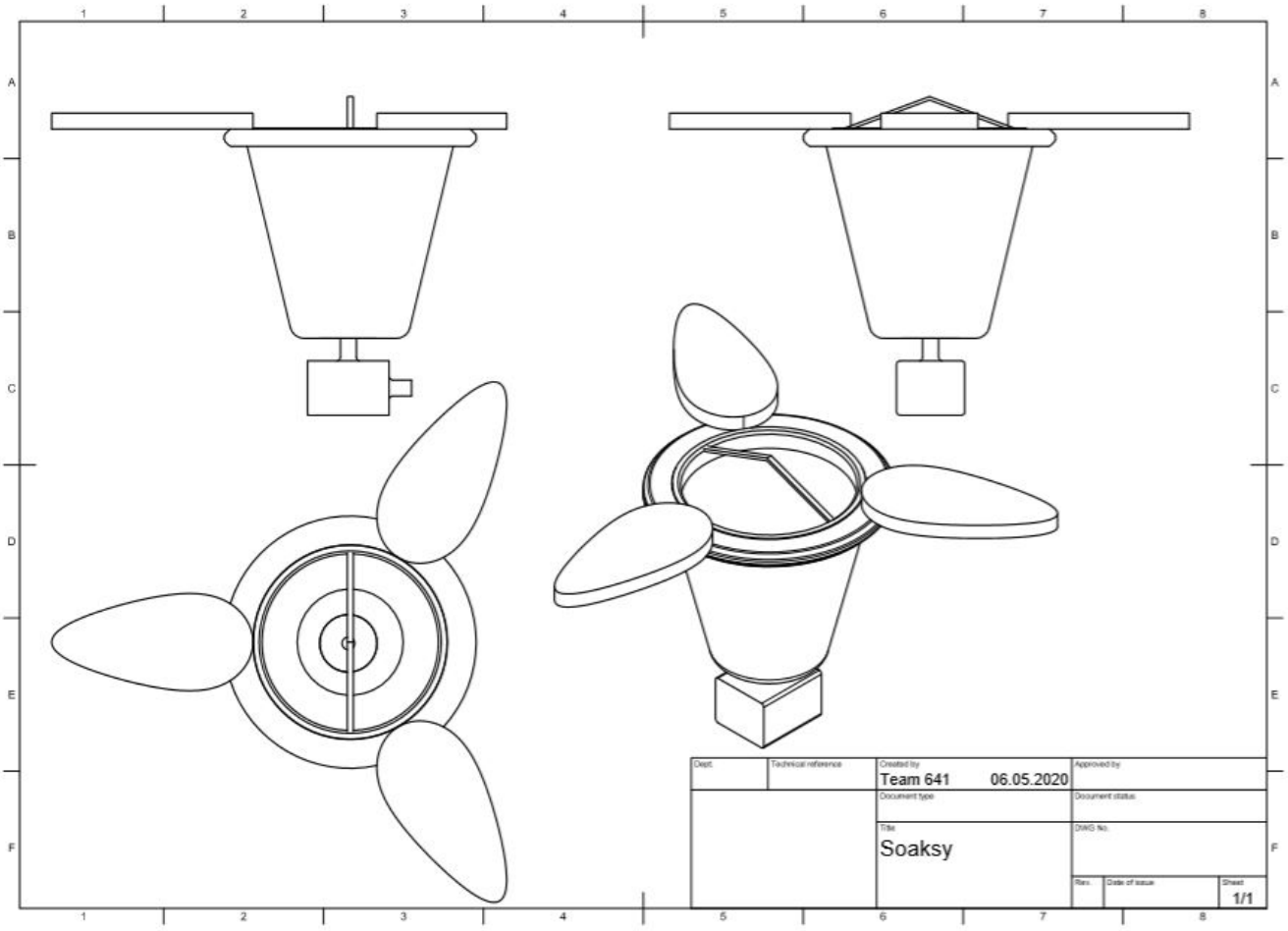

Figure 28: Technical Drawing

7.2.3 3D model

Figure 29 displays the 3D concept for this project.

Figure 29: 3D model

7.2.4 Structural Drafts

Figure 30 displays the Structural Drafts for this project.

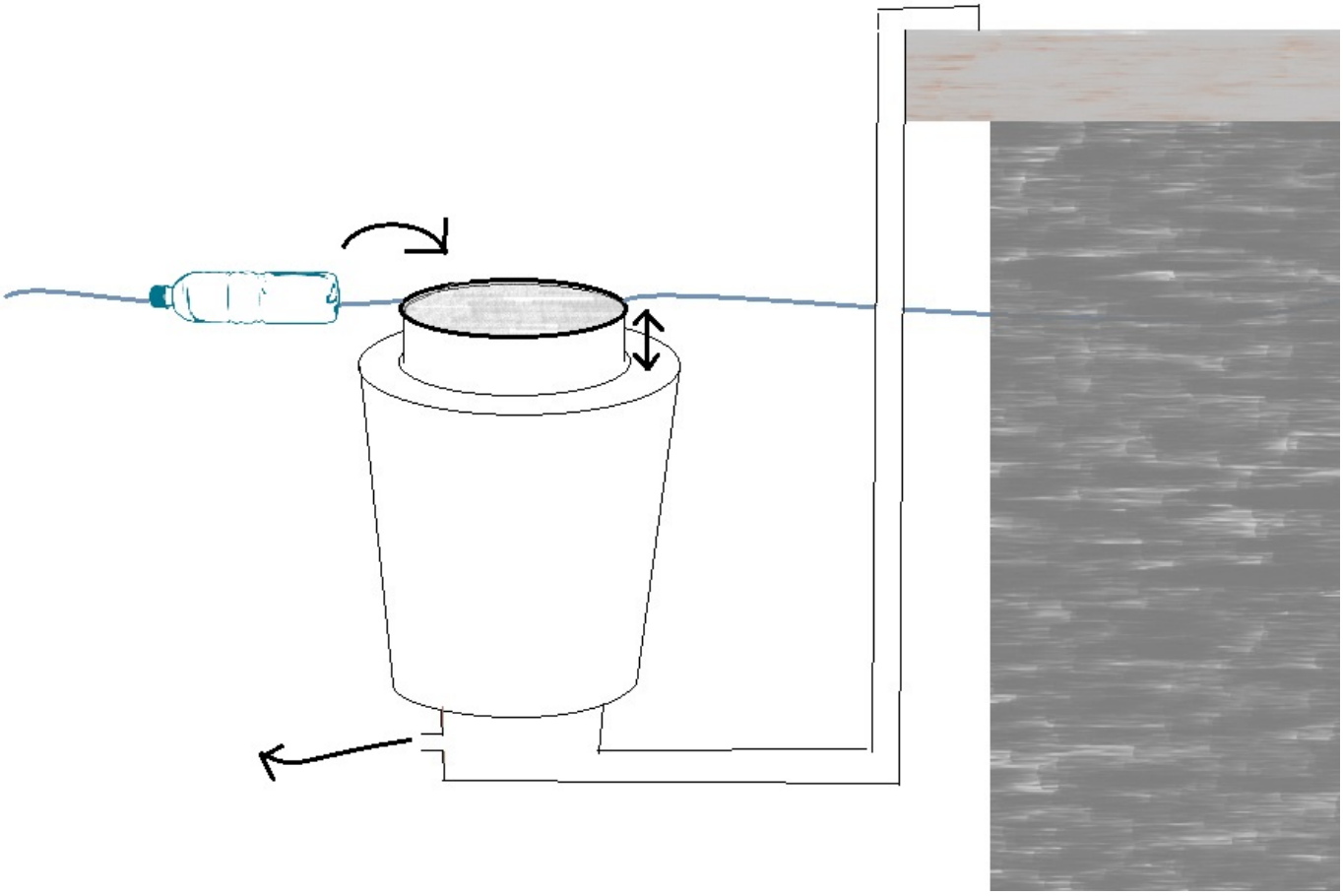

Figure 30: Structural Drafts

7.2.5 Electrical schematics

Figure 31 displays the Electrical Schematic of the system.

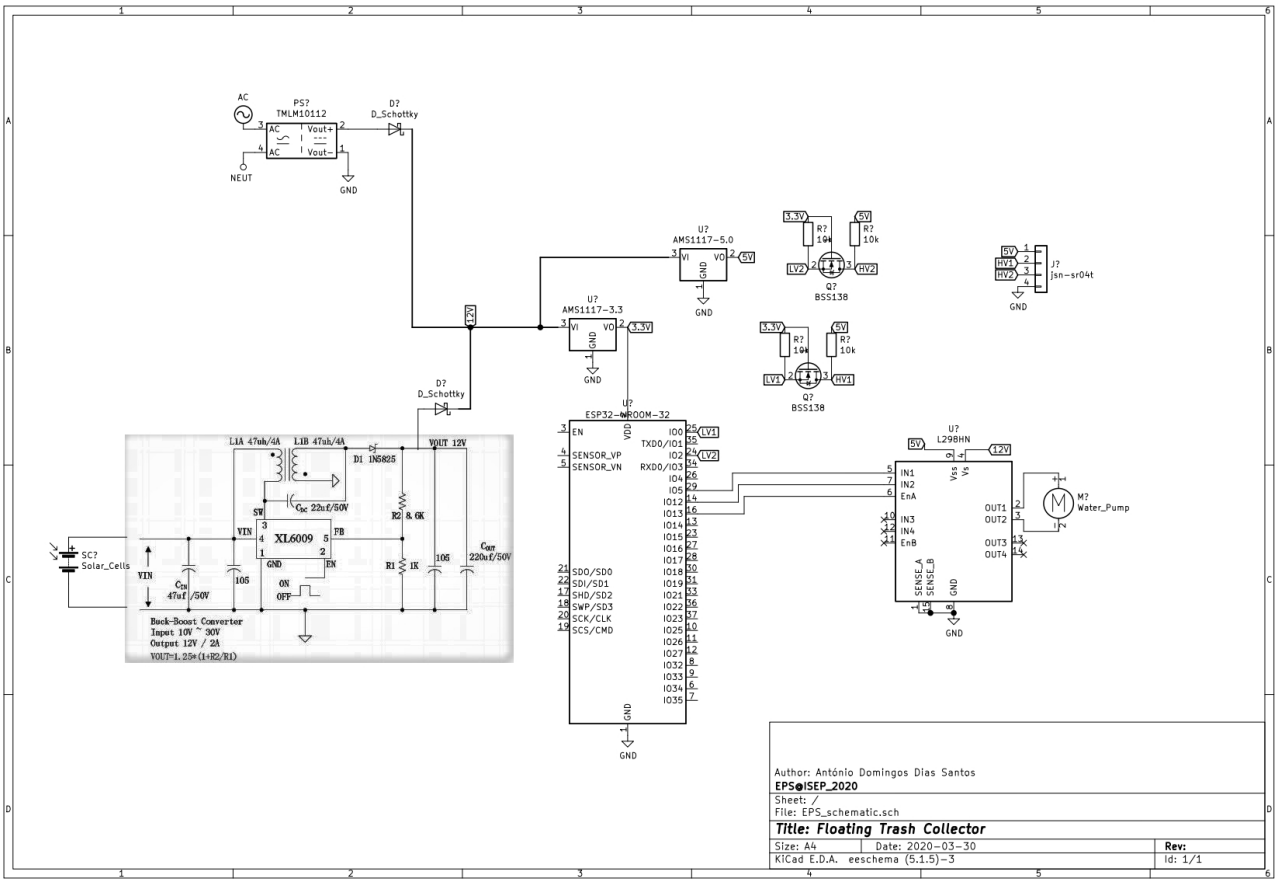

Figure 31: Project Electrical Schematic

The system can be powered in two ways: by the electric grid or by a solar panel.
In the case of the photovoltaic panel, it is necessary to have a converter that regulates the voltage and, in the case of using the grid, it is necessary to convert AC from the grid to DC.
These two ways have to output a voltage of 12 V DC and include protection against electric current reversal.
This output will supply two converters, one from 12 V to 3.3 V and another to 5 V, and a driver to power the water pump motor.
The 3.3 V converter will supply the microcontroller, while the 5 V converter will supply a distance sensor that measures the garbage level in the container, and the internal logic circuit of the pump driver.
The distance sensor requires a logic level converter on the trigger and echo pins to interface with the microprocessor.
The microprocessor also interfaces with the water pump motor via the driver.

7.3 Components

In this chapter, we will proceed with the study, research, and consequent decision of the materials to be used in the theoretical implementation of the prototype.

This chapter is in line with the conclusions reached in previous chapters.

7.3.1 Comparison of materials

The essential specifications for the materials used for the bin and structure are shown in the Table 26 below.

Table 26: Materials for design comparison

	Cork	**Polyethylene (PE/HDPE)**	**Stainless steel**
Production	Can be machined, routed, lathe-worked, cut using similar techniques to woodworking, and can be formed using a process like compression-molding plastics	As with many commodity thermoplastics, PE can be formed using several methods. The most common are probably rotational molding and blow molding	Compared to other steels, stainless steel is versatile in terms of processing – it can be folded, bent, forged, deep drawn, and rolled. Standard grades are difficult to machine because of the hardness of the material, although specific grades are available that are much easier to machine. As a result of this versatility, it is suited to production volumes ranging from one-off to mass production.
Sustainability issues	Cork trees absorb up to five times more CO_2 than other trees, while producing a new harvest of cork bark every nine years	One of the most widely recycled plastics. Concerning the environment, there are many factors to consider, one of which is the ability of single materials to be separated from each other. HDPE is identified by the number 2 in the recycling symbol.	Recyclable.
Cost	Relatively inexpensive	Rotational molding HDPE is only slightly more expensive than bottle grade PET.	£3.20 ($5) per kg

	Cork	**Polyethylene (PE/HDPE)**	**Stainless steel**
Source	Portugal is one of the world's biggest exporters of cork and accounts for 60% of the world's production, producing over 300.000 tonnes a year. Spain, Algeria, and Morocco are also large producers.	Widely available from multiple global suppliers.	According to the US Geological Survey in 2011, world steel consumption was expected to be 1.398 million tonnes. China is responsible for almost half of the world's iron production, which in 2011 was 700.000.000 tonnes.
Key features	Poisson ratio of 0, Renewable, Biodegradable, Elastic, Vibration dampening, Shock dampening, Impermeable to liquids, Impermeable to gases, Good heat insulation	Versatile processing, Waxy surface, Low friction, Excellent chemical resistance, Springy toughness, Easy to color match, Recyclable	Non-corrosive, Excellent toughness, Achieves a high polish, Difficult to cold work due to hardness, High-temperature resistance, High weight, High cost, Recyclable
Advantages	Versatile, Good strength-to-weight ratio, Water-resistant, Biodegradable	Low cost, Easy to process, Versatile, Tough, Recyclable	Versatile processing, Extremely tough, Finishes well, High-temperature resistance, Recyclable
Disadvantages	Can suffer from dated, cut-price associations	Not readily biodegradable	High cost, Difficult to cold work

7.3.2 Brief description of the components in use

- **Pump**: The water pump positioned at the bottom of the submerged container is the main component of the project as it allows the floating garbage to move from the water surface into the container.
- **Sensor**: Sensor to detect when the container reaches maximum capacity. The information acquired by the sensor will be processed by the microprocessor.
- **Micro-controller**: The microprocessor is an integrated circuit that contains all the logical functions for processing data from the sensor, sending the system status to a webpage and controlling the operation of the motor that runs the water pump.
- **Logical level converter**: This component allows the interface between the microcontroller and the sensor. This component is necessary because the microcontroller and the sensor operate at different voltage levels (3.3 V and 5 V respectively). The component raises or lowers the voltage level depending on the direction of current.
- **Motor driver**: This component is the interface between the water pump's motor and the micro-controller. The motor requires more current than the microcontroller can provide, so the function of the motor driver is to increase the current so it can drive the motor.
- **Power circuit**: This circuit ensures the correct transport and distribution of electricity from the power supply to the appropriate loads (water pump, sensor, microcontroller, motor driver).
- **Power Supply AC/DC 12 V**: The connection between the power grid and the project is made via an AC/DC power supply, with an output voltage of 12 V. Power supplies like this employ a transformer to convert AC mains electricity into a lower AC voltage. Then a rectifier converts

the AC output voltage of the transformer to a cyclic DC voltage, followed by an analog electronic filter to regulate the DC voltage.
- **DC/DC converters**: There will be used two types of DC/DC converters in this project, with different purposes. Firstly, to fix the output of the photovoltaic panel at 12 V there will be used a step-down, or buck, switching converter. Secondly, to convert 12 V from the grid conversion or photovoltaic panel into lower-rated voltages to power the microcontroller, sensor and logical circuit of the motor driver, a low-dropout (LDO) voltage linear regulator will be used.
- **Power diodes**: In order to prevent a back feeding in the power circuit, power diodes are going to be placed after the conversion to regulated 12 V DC in both power sources.
- **Photovoltaic panel**: This power source will feed the project during the day, converting solar photons into electrical energy through the photovoltaic effect. Incorporate in the project as a mean to make the project more independent and sustainable.
- **Bird repeller**: In order to protect animals, mostly birds that share the same location as the prototype, from dangers that may occur when these interact, as bird repeller mechanism needs to be set in place.

7.3.3 Pump

The water pump will be the main component of the system, all other components being sized around it.
Therefore it is necessary to carry out a study to find out which type of pump is best used in the prototype.
In this study we consider two aspects: the type of power supply (DC vs AC) and the environment where they operate (Submersible vs Surface).

7.3.3.1 DC vs AC pumps

In order to carry out the process of choosing the water pump, it will be necessary to decide what type of supply such a pump will have.

In Table 27 water pumps with AC supply and DC supply are compared.

The design water pump should have the following characteristics:

- Be as quiet as possible so as not to disturb people and animals;
- Longer life span to be a more autonomous system with fewer costs in the long run;
- Efficient to reduce the energy consumption of the system.

These characteristics are fulfilled by DC-powered water pumps.

Table 27: Pumps with AC supply and DC supply comparison

Type	Efficiency	Noise levels	Price	Lifetime
DC	More efficient and so requires less solar panels to operate	Less noisy	More expensive	Has a longer life as it uses motor coils manufactured from pure copper

Type	Efficiency	Noise levels	Price	Lifetime
AC	Less efficient	Noise will increase with usage	Less expensive	Uses motor coils manufactured from aluminum/copper to achieve competitive prices

7.3.3.2 Submersible vs Surface pumps

Continuing with the study of water pumps, these can be divided into two groups regarding the place where they are placed: submersible and surface. In the Table 28 there are advantages and disadvantages of each of these types of pumps.
Considering the requirements of the system, submersible pumps are the most suitable, as they present:

- Less noise and visual impact on the environment, as it is located below the water level;
- Greater energy efficiency, because less work is needed to move the water and also does not present problems of overheating.

Table 28: Submersible and surface pumps comparison

Type	Pros	Cons
Submersible	Submersible pumps may be less complex or more energy-efficient. Capable of raising water from a greater depth - i.e. over 7 m. No priming problems. Less noise. No overheating of the motor. The pump is not seen.	A submersible pump is more expensive to buy since it needs required waterproof casing. Submersible pumps are located inside the tank, and so some dismantling is required before accessing the pump. Waterproof Seals can corrode over time allowing water to get into the motor. This seal also makes motor access and repairs more difficult.
Surface	More accessible, easier to examine and work on. Offer greater pressure than pumps which are submersible.	Can be very noisy, even those that claim to run very quiet. Need covers to protect the pump from weather, reduce the noise and to look nicer. Surface-mounted pumps are not as shielded from their surroundings.

7.3.3.3 Options and choice of water pump

After choosing the type of supply and positioning location, it is now possible to search the market for water pumps with such characteristics. The market product search can be found in Table 29.

Table 29: Pumps comparison

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Manufacture guide
Velleman VMA421: Water Pump	Input: 12 V DC Max. current: 0.35 A Consumption: 4.2 W Max. flow: 240 L/H Acoustic noise: <40 dB Working time: > 30.000 hours(can continuously work) Dimensions: 51 x 34 x 42.7 mm	12.20	PHOTO	Aquário	Portugal (Aquário store)	0.08	Velleman
TMC 06302	Input: 12 V DC Max. current: 1.5 A Consumption: 18 W Max. flow: 378 L/H	13.73 + 7.99 (transport fee) = 21.72	PHOTO	Motamarine	Portugal	-	TMC
TMC 0430107	Input: 12 V DC Max. current: 3 A Consumption: 36 W Max. flow: 1060 L/H\\Note: Max. continuous operation should not exceed 15 minutes.	15.02 + 7.99 (transport fee) = 23.01	PHOTO	Motomarine	Portugal	-	TMC
TMC 04301	Input: 12 V DC Max. current: 2 A Consumption: 24 W Max. flow: 380 L/H\\Note: Max. continuous operation should not exceed 15 minutes.	12.89 + 7.99 (transport fee) = 20.88	PHOTO	Motomarine	Portugal	-	TMC

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Manufacture guide
Johnson L450	Input: 12 V DC Max. current: 2.5 A Consumption: 30 W Max. flow: 2940 L/H Note: See seller's page for head/flow correlation.	30.00	PHOTO	Hidraulicart	Portugal	0.27	ManualsLib
Bluefish Zp1-600	Input: 12 V DC Max. current: 1 A Consumption: 12 W Max. flow: 600 L/H Acoustic noise: <40 dB Working time: > 30.000 hours.	38.38	PHOTO	MiniInTheBox	Europe	0.37	Made-in-China

After the product research in the market, it was concluded that the best water pump available in the Portuguese market to implement in the prototype would be "**Velleman VMA421: Water Pump**".

The reasons of choice were the following:

- Considering the number of components and the distribution of the budget, the cheapest pump was chosen, because it does not matter the capacity of the pump for the prototype phase.
- Although it presents the lowest values in the Table, it presents detailed information about its characteristics.

7.3.4 Sensor

Table 30 contains the research on the sensor that will measure the level of waste in the bin.

Table 30: Sensors comparison

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Datasheet
JSN-SR04T-2.0 Ultrasonic Waterproof Range Finder	Operating voltage: 5 V DC Static current: 5 mA Operating current: 30 mA Operating range: 25 cm to 4.5 m Resolution: 0.5 cm Detecting Angle: <70 ° Operating Temperature: -10 to 70 °C Cable Length: 2.5 m Dimension: 41 mm * 28.5 mm	16.50	PHOTO	botnroll	Portugal	0.054	...
Adjustable Infrared Sensor	Power supply: 5 V Control Output: 100 mA Circuit. Consumption <25 mA Response time: <2 ms Direction: ≤15 ° Range: 3 to 50 cm adjustable for opacity and transparent objects Shell material: plastic Sharp 30 mm (length) x 20 mm (wide) x 13 mm (thickness) with a 45 cm lead wire.	8.95	PHOTO	botnroll	Portugal	-	dfrobot
HD-DS25CM-3MM IR Break Beam Sensor - 3 mm LEDs	Sensing Distance: Approx 25 cm Power Voltage: 3.3 V to 5.5 V DC Emitter Current Draw: 10 mA at 3.3 V, 20 mA at 5 V Output Current Capability of receiver: 100 mA Transmitter/Receiver LED Angle: 10° Response Time: <2 ms Dimensions: 20 mm x 10 mm x 8 mm Cable Length: 234 mm	3.60	PHOTO	botnroll	Portugal	0.003 (each half)	Adafruit (in Mandarin)

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Datasheet
Sharp GP2Y0A21YK	Working Voltage DC 5 V. Working Current 0.20 A. Max Range 0.2 m. Output Voltage at max range 0.4 V. Output Voltage at min range 2.3 V.	11.95	PHOTO	botnroll	Portugal	-	sparkfun
HC-SR04P Ultrasonic Range Finder 3.3 V to 5 V	Working Voltage DC 3.3 V to 5 V Working Current 2 mA Working Frequency 40 Hz Max Range 4.5 m Min Range 0.02 m Measuring Angle 15 degree Trigger Input Signal 10uS TTL pulse Ranging accuracy 3 mm I/O pins are 5 V and 3.3 V compliant	3.69	PHOTO	PTRobotics	Portugal (PTRobotics store)	-	sparkfun Shares the same datasheet as the previous version (HC-SR04)

Two types of sensors were considered for the sensor choice: ultrasonic and infrared.

One of the requirements of the sensor is that it is water-resistant, the only sensor listed in our survey with such a feature being the “JSN-SR04T-2.0 Ultrasonic Waterproof Range Finder”.

7.3.5 Microprocessor

The Table 31 contains the market research on the micro-processors available on the market and compatible with the project.

Table 31: Microprocessor comparison

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Datasheet
Espressif ESP32 DevKitC-32D	Wi-Fi: Protocols 802.11 b/g/n (802.11n up to 150 Mbps) A-MPDU and A-MSDU aggregation and 0.4 µs guard interval support Frequency range 2.4 to 2.5 GHz	13.60	PHOTO	botnroll	Portugal	-	espressif

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Datasheet
.	Bluetooth: Protocols Bluetooth v4.2 BR/EDR and BLE specification Radio NZIF receiver with –97 dBm sensitivity Class-1, class-2 and class-3 transmitter AFH Audio CVSD and SBC.	.	.	.	.	.	.
.	Hardware: Module interfaces. SD card, UART, SPI, SDIO, I2C, LED PWM, Motor PWM, I. 2S, IR, pulse counter, GPIO, capacitive touch sensor, ADC, DAC, On-chip sensor Hall sensor Integrated crystal 40 MHz crystal Integrated SPI flash 4 MB Operating voltage/Power supply 3.0 V to 3.6 V Minimum current delivered by power supply: 500 mA Operating temperature range –40 °C to +85 °C.	.	.	.	.	.	.

Microcontroller research is not extensive as there is not much variety available on the Portuguese market that meets the project's requirements. The microcontroller to be implemented will have to be of low consumption, with Wi-Fi connection module. So with a brief research it became clear that the development board “Espressif ESP32 DevKitC-32D” would be the most appropriate choice for the project.

7.3.6 Logical level converter

Table 32 contains the logical level converter considered to make the interface between the sensor and the microcontroller.

Table 32: Logical level converter comparison

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Datasheet
3.3V & 5V Logic Level Converter	Input voltage: 3.3 V and 5 V Working current: Max. current:	2.50	PHOTO	https://www.botnroll.com/pt/conversores-nivel-logico/166-bob-08745.html	Portugal	-	http://cdn.sparkfun.com/datasheets/BreakoutBoards/BSS138.pdf

All logic level converters found are based on the FET BSS138, so we chose the cheapest option on the market.

7.3.7 Motor Driver

Table 33 contains the market research on the motor driver available on the market needed to interface the pump and the micro-controller.

Table 33: Motor Driver comparison

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Datasheet
L298n Dual Bridge Dc Stepper Controller	Driver power supply: + 5 V to + 35 V Driver output current (max.): 2 A Logic power output Vss: +5 V to +7 V (internal supply +5 V) Logic current: 0 to 36 mA Controlling level: low -0.3 V to 1.5 V, high: 2.3 V - Vss Enable signal level: low -0.3 V to 1.5 V, high: 2.3 V- Vss Max power: 25 W Operating temperature: -25 to +130 °C Dimensions: 69 x 56 x 36 mm	7.50	PHOTO	aquário	Portugal (Aquário store)	-	Arduino Portugal

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Datasheet
L298N Dual H-Bridge Motor Driver	Logical voltage: 5 V Drive voltage: 5 V to 35 V Logical current: 0 mA-36 mA Drive current: 2 A (MAX single bridge) Storage temperature: -20 to +135 Max power: 25 W	7.93	PHOTO	PTRobotics	Portugal (PTRobotics store)	-	Arduino Portugal
Driver Motor DC L298N Ponte H	Operational Voltage: 4 to 35 V Max. current: 2 A per channel or 4 A max Logical voltage: 5 V Logical current:0 to 36mA Temp. limits: -20 to +135 °C Max. Power: 25 W	5 + 4 (transport fees) = 9	PHOTO	makers	Portugal	0.030	Arduino Portugal

With the product search available it became apparent that there wasn't much driver diversity, with most options involving variations of the ic l298n. We chose the module “L298n Dual Bridge Dc Stepper Controller” to interface between the mcu and the pump motor, as it is cheaper than the other option and with similar features.

7.3.8 Power circuit

7.3.8.1 DC/DC converters-12 V/3.3 V and 5 V converter

The study of the 12 V to 3.3 V and 5 V converters available on the market can be found in Table 34.

Table 34: 12 V/3.3 V and 5 V converter comparison

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Datasheet
DC-DC Buck Converter Step-down 12 V to 3.3 V / 5 V	One input: DC 6 V - 12 V Output: 3.3 V (+ - 0.05 v error), 5.0 V (+ - 0.05 v error) Max. current output: 800 mA Operating junction temperature range: -40° C to +125° C Minimum operating current: 12 mA Short circuit current: 1.1 A	3.81	PHOTO	PTRobotics	Portugal (PTRobotics store)	-	Alldatasheet
3.3 V And 5 V Breadboard Power Supply	Input voltage: 6.5 V to 12 V DC or via USB cable Output voltage: 3.3 V and 5 V Maximum output current: 700 mA.	3.80	PHOTO	Electrofun	Portugal (Electrofun store)	-	-

Although the two converters have very similar characteristics and also the same price, “DC-DC Buck Converter Step-down 12 V to 3.3 V / 5 V” was chosen because there is more information about it.

It is important to point out that although for the size of this prototype the use of low-dropout regulator (LDO) is acceptable, in the process of scaling up the project this will no longer be viable. In said case, the best substitute for this component is a buck switching regulator.

7.3.8.2 DC/DC converters - Wide input voltage/12 V converter

In Table 35 are present the converters considered to convert the voltage range supplied by the photovoltaic panel to 12 V stable.

Table 35: Wide input voltage/12 V converter comparison

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Datasheet
XL6009 DC-DC Boost Buck Adjustable Step-Up Voltage Converter Module	Module Properties Non- isolated boost (BOOST) ; Rectification Non-Synchronous Rectification Input Range 3.8 V to 32 V Output Range 1.25 V to 35 V Input Current 3 A (max), no-load 18 mA (5 V input, 8 V output no-load is less than 18 mA Conversion efficiency <94% Switching frequency 400 KHz Output Ripple 50 mV (the higher the voltage, the greater the current, the greater the ripple) Load Regulation ± 0.5% ; Voltage Regulation ± 0.5% Operating Temperature -40 ℃ to +85 ℃	4.06	PHOTO	PTRobotics	Portugal (PTRobotics store)	-	HAOYU STAR Electronics
Tension regulator LM2596 Conversor DC-DC Step Down	Input voltage: 4 to 40 V Output voltage: 3 to 35 V Output current: 2 A nominal current, 3 A max. (adviced to place a heat sink if power is greater than 15 W) Efficiency: up to 92% (bigger output, greater the efficiency) Switching speed: up to 150 KHz; Max. output power: 15 W Temperature operating range: (-40 ℃ a 85 ℃)	4.50	PHOTO	Electrofun	Portugal (Electrofun store)	-	

The “XL6009 DC-DC Boost Buck Adjustable Step-Up Voltage Converter Module” was chosen because it allows the voltage supplied by the panel to be increased or decreased to obtain 12 V stable output from this converter. With this feature, the system is expected to run on solar panel power for longer.

7.3.8.3 Schottky diode

In Table 36 the diodes to be used to protect the circuit from changing the direction of current are considered.

Table 36: Schottky diode comparison

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (g)	Datasheet
SB2100 - Schottky Diode 2 A 100V	Maximum reverse voltage: 100V Conducting current: 2 A Semiconductor structure: individual diode Capacity: 80pF Housing: DO15 Pulse current max.:50A	0.18 x 2 units = 0.36	PHOTO	PTRobotics	Portugal (PTRobotics store)	0.383	SMC Diode Solutions
SMC Diode Solutions	Max. peak reverse voltage: 40 V Max. rectified current: 3 A Repetitive peak forward current: - Max. reverse current (25 ° c): 0.5 A Max. forward voltage: -	0.40 x 2 units = 0.80	PHOTO	Aquário	Portugal (Aquário store)	-	ST

The “SB2100” diode was chosen because it is the cheapest option with sufficient ratings for this project.

7.3.8.4 Power Supply AC/DC 12 V

In Table 37 are some options to connect the prototype to the power grid.

Table 37: Power Supply AC/DC 12 V comparison

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Datasheet
Switching Power Supply 12 V 1.5 A	Input voltage: 110-240 V AC 50 / 60 Hz Output voltage: 12 V Dc Current: 1500 mA Plug dimensions: 5.5 x 2.1 mm Dimensions: 80 x 53 x 33 mm	4.80	PHOTO	PTRobotics	Portugal (PTRobotics store)	0.2	-
Power supply 240 V AC / 12 V DC 1 A	Input: AC 110-240V to 50 / 60 Hz Output: 12 V DC\\Current: 1 A	3.75	PHOTO	Aquário	Portugal (Aquário store)	-	-
Power Supply AC / DC 12 V 3 A Adapter	Input: AC 110-240 V to 50 / 60 Hz Output: 12 V DC\\Current: 3 A.	6.30	PHOTO	Electrofun	Portugal (Electrofun store)	-	-

Considering the existence of a possible disparity between the current consumed by the system in theory and the actual consumption, the source that debits 1 A is not sufficient, so it was chosen to use “Switching Power Supply 12 V 1.5 A”.

7.3.8.5 Photovoltaic panel

Alimentation analysis: on-grid vs off-grid vs hybrid vs only grid (for DC pump).

In Table 38 a brief evaluation is made of the types of installations possible with photovoltaic panels and also the possibility of not using them.

This study aims to conclude which is the best power system for the project.

Table 38: Photovoltaic panel comparison

Type	Pros	Cons
Grid and Solar panel (no battery) ; Aka On-grid	These systems do not need batteries ; Can operate 24/7 ; Cheapest in the long term	Not able to function or generate electricity during a blackout, especially during in the night ;Partially dependent on the energy market
Off-grid (solar panel only)	Independent from the grid. Best choice for more remote areas that are far from the electricity grid.	Needs battery and respective control system. More expensive than on-grid because of the cost of batteries.

Type	Pros	Cons
Grid and Solar panel + battery ; Aka Hybrid	Able to automatically isolate from the grid (known as islanding) and continue to supply some power during a blackout. ; Can operate 24/7	Needs battery and respective control system ; Most costly system
Only grid (no solar panel)	These systems do not need batteries ; Can operate 24/7 ; Cheapest installment	Not able to function or generate electricity during a blackout ; Fully dependent on the energy market

After research and comparison of the different types of possible installations, it is concluded that the best feeding option for the project will be to use a system powered by the power grid and by a photovoltaic panel, without energy storage (aka on-grid). This system brings the greatest number of advantages:

- No cost with batteries, characteristic of off-grid and hybrid systems. These batteries also have extremely harmful chemicals for the environment.
- It can work in the same continuous, alternating between the power supplied by the solar panel and the power grid;
- Little impact of the energy market, as it works most of the time with energy from the photovoltaic panel, which also makes this system the most viable in the long term.

In Table 39 are presented some photovoltaic panels that will be able to feed the prototype.

Table 39: Photovoltaic panel prototype comparison

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Datasheet
Photovoltaic Panel Silicon Monocrystalline 20W / 12 V	Nominal Power 20 W Cell type Monocrystalline ; Number of cells in series 32 Maximum power current (Imp) 1.23 A ; Maximum power voltage (Vmp) 16.2 V Open-circuit Voltage (Voc) 19.1 v ; Short circuit current (Isc) 1.47 A Dimension 360 * 490 * 25 mm ; Weight 2 kg Maximum system voltage: 500 V Temperature coefficient of PMPP (%) -0.48 / ° C ; Temperature coefficient of Voc (%) -0.34 / ° C ; Isc temperature coefficient (%) + 0.037 / ° C Temperature range -40 ° C to + 85 ° C Cable length / Connector type: 20 m / s, 6 g Output tolerance + 3% Frame: Aluminum frame	29.99	PHOTO	Castro Electronica	Portugal (Castro Electronica store)	2	-

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Datasheet
Photovoltaic Panel Silicon Monocrystalline 50W / 12 V - ProFTC	Nominal Power 50W \\Cell type Monocrystalline ; Number of cells in series 36 Maximum power current (Imp) 2.75 A ; Maximum power voltage (Vmp) 18.2 V Open-circuit Voltage (Voc) 21.5 V Short circuit current (Isc) 2.23 A Dimensions 670 * 540 * 30 mm Weight 4.1 kg Maximum system voltage: 500 V Temperature coefficient of PMPP (%) -0.48 / ° C ; Temperature coefficient of Voc (%) -0.34 / ° C ; Isc temperature coefficient (%) + 0.037 / ° C Temperature range -40 ° C to + 85 ° C Cable length / Connector type 20 m / s, 6 g Output tolerance + 3% Frame, Aluminum frame	49.99	PHOTO	Castro Electronica	Portugal (Castro Electronica store)	4.1	-

Name	Description	Price (€)	Photo	Seller	Local of export	Weight (kg)	Datasheet
Monocrystalline 30W Ecosolar Solar Module	Power: 30 W Voltage in open circuit (Voc): 21.50 V Voltagem on point of maximum power (Wmp): 18.20 V Short-ircuit current (Isc): 1.98 A Nominal current (Imp): 1.65 A Maximum voltagem of system: 600 V DC Tolerance: +/- 3ºC	37.00	-	Damia Solar	Spain	2.25	-

With the research of photovoltaic panels available on the market it is possible to conclude that the best option would be “Photovoltaic Panel Silicon Monocrystalline 20W / 12 V” because it is the panel that presents the minimum ratings to feed the prototype, so it will be an efficient and well sized choice.

7.3.9 Transport fees of Portuguese stores

During the research and selection of the electrical components, care was taken to use as few suppliers as possible, so that the delivery cost is shared among several components.

The suppliers considered and their delivery costs are shown in Table 40:

Table 40: Delivery fees

Supplier	Delivery fee (€)
Aquário	3.95
PTRobotics	4.31

7.3.10 Bird repeller

Table 41 shows several methods of keeping birds away.

Table 41: Bird repellers

Name	Description	Set up	Price (€)	Photo	Seller	Local of export
Holographic Owl	Pack of two reflective owls + two rattles. This bird repellent emits unique visual flashes and sound effects to keep birds away like pigeons or sparrows. A very effective Anti-Pigeon product. Its reflective effect helps to protect wildlife, fruit trees, vegetable gardens, cultivated fields and newly sown lawns. This bird scavenger can also be positioned on the balconies as an excellent bird scare. Very economical, it does not hurt wild animals or cause damage to pets. Resistant - weatherproof. Maintains reflective effect for a long time.	This repellent can be affixed to trees, it can be suspended over plants, shrubs or plantations. For best results, apply this repellent before bird damage begins.	6.26 + 4.92 (delivery fee) = 11.18	PHOTO	ECOCED	Portugal
Bird Repellent Balloon	Visual scare-off system for birds that replicates of the eyes of bird predators in a 3D balloon, efficient in combating several types of birds. The visual effects obtained by moving these balloons in the wind is extremely intimidating and aims to keep birds away from the places.	1. Fill the ballon ; 2. Place Mylar (included) in pupil of the balloon ; 3. Attach the Mylar tail to the bottom of the Bird Hunting Balloon ; 4. Hang the balloon	12.29 + 4.92 (delivery fee) = 17.21	PHOTO	ECOCED	Portugal
Ribbon scare Birds	Repellent tape that emits visual flashes of light in a unique way, creating movement in order to ward off wild animals such as birds and deer. With the help of the wind, this repellent tape reflects sunlight in a multicolor pattern that works like a scarecrow, sending birds a danger signal and a “recommendation” to leave the place. The presence of these flashes gives the birds the feeling that there is a predator or a rival in the area.	Hang strips of tape near the spot you want to protect.	2.63 + 4.92 (delivery fee) = 7.84	PHOTO	ECOCED	Portugal

Name	Description	Set up	Price (€)	Photo	Seller	Local of export
Woodside Large Realistic Bird Owl Decoy Scarer	Owl - Bird Scarer can protect your pond fisheries and outdoor area from predatory birds and menacing pests. Manufactured from a hardwearing durable construction and fitted with an integral base stand this wide-eyed majestic animal boosts a verisimilitude presence to make birds think twice about attacking your garden or pond and can be employed all year round.	Place in an open space near the area that will guard, preferably in high ground.	12.95 + 5.47 (delivery fee) = 18.42	PHOTO	Fruugo	Portugal

Bearing in mind that the bird repeller aims to keep birds away from the proximity of the prototype, the type of method that will work best will be one that has an effect on an area around the place where it is placed, rather than limiting an area with a barrier physical.

So “Holographic Owl” was chosen to fill this need, as it has the following characteristics:

- Easy to install, taking into account that the prototype is on the shore of a lake;
- It has three factors that intimidate birds, these being reflective surfaces, rattle sounds and the shape of a predatory bird;
- It is resistant to the environment because it is made of metal.

7.4 Final list of components

In the table 42 there are presented the final list of materials, along with the total cost and operating temperature of the prototype:

Table 42: List of materials for the prototype

Functionality	Name	Price (€)	Operating temperature range (°C)
Pump	Velleman VMA421: Water Pump	12.20	-10 to +60
Sensor	JSN-SR04T-2.0 Ultrasonic Waterproof Range Finder	16.50	-10 to +70
Microprocessor	Espressif ESP32 DevKitC-32D	13.60	–40 to +85
Logical level converter	3.3V & 5V Logic Level Converter	2.5	-
Motor Driver	L298n Dual Bridge Dc Stepper Controller	7.50	–25 to +130
12 V to 3.3 V and 5 V DC/DC converter	DC-DC Buck Converter Step-down 12V to 3.3V / 5V	3.81	-40 to +125

Functionality	Name	Price (€)	Operating temperature range (°C)
Wide input voltage to 12 V DC/DC converter	XL6009 DC-DC Boost Buck Adjustable Step-Up Voltage Converter Module	4.06	-40 to +85
Schottky diode	SB2100 - Schottky Diode 2A 100V	0.36 (2 units)	-55 to +150
Power supply AC/DC to 12 V	Switching Power Supply 12V 1.5A	4.80	-
Photovoltaic panel	Photovoltaic Panel Silicon Monocrystalline 20W / 12V	29.99	-40 to +85
Bird repeller	Holographic Owl	6.26	-
Delivery fees	**.**	**3.95 + 4.31 + 4.92 = €13.18**	**.**
Total	**.**	**€114.76**	**-10 ° C to 60 ° C**

7.5 Power Budget

In order to demonstrate the connections and their electrical values between the components, the system's Power budget is shown below.
This information is divided in tables between the main system loads, power distribution circuit and power sources. In each of these tables we find the input and output values of each of the components, as well as the components that make direct connection and the total value of the electrical properties.

7.5.1 Main loads of the system

In the table 43 are the power budget for the main system loads.

Table 43: Power budget for the loads

Component	Input Voltage [V]	Input Current [A]	Input Power [W]	Powered by	Output Voltage [V]	Output Current [A]	Output Power [W]	Powering
Pump	12 DC	0.35	4.2	Motor driver	-	-	-	-
Ultrasonic Sensor	5 DC	0.030	0.15	12 V to 3.3 V and 5 V DC/DC converter	5 DC	0.030	0.15	-
Microprocessor	3.3 DC	0.5 (minimum demanded by source)	1.65	12 V to 3.3 V and 5 V DC/DC converter	2.64 DC	1.1 (max)	2.904	-
3.3V & 5V logic level converter	3.3 DC	-	-	-	5 DC	0.06	-	-

Component	Input Voltage [V]	Input Current [A]	Input Power [W]	Powered by	Output Voltage [V]	Output Current [A]	Output Power [W]	Powering
Motor Driver	12 DC and 5 DC (logic circuit)	0.35 + 0.024 (logic circuit) = 0.374	4.488	12 V to 3.3 V and 5 V DC/DC converter and Wide input voltage to 12 V DC/DC converter or Power supply AC/DC to 12 V	12 DC	0.35	4.2	Pump
Total Input	-	0.904	10.488	-	-	-	-	-

7.5.2 Power Distribution Circuit

In table 44 are the components that make the power distribution circuit.

Table 44: Power budget for the distribution circuit

Component	Input Voltage [V]	Input Current [A]	Input Power [W]	Powered by	Output Voltage [V]	Output Current [A]	Output Power [W]	Powering
12 V to 3.3 V and 5 V DC/DC converter	12 DC	0.554 + 0.012 (logic circuit) = 0.566	6.792	Wide input voltage to 12 V DC/DC converter or Power supply AC/DC to 12 V	3.3 DC(for MCU) and 5 DC(for sensor and Motor Driver logic circuit	0.5 + (0.03+0.024) = 0.554	1.65 + 0.27 = 1.92	Microprocessor, Sensor and Motor Driver's logic circuit
Wide input voltage to 12 V DC/DC converter	3.8 to 32 DC	1.23	20	Photovoltaic panel	12 DC	0.566+0.35=0.916	10.992	12 V to 3.3 V and 5 V DC/DC converter and Motor Driver
Schottky diode	12 DC	0.916	10.992	-	12 DC	0.916	10.992	-
Total Output	-	-	-	-	-	0.916	10.992	-

7.5.3 Power Sources

In table 45 are the power sources of the system.

Table 45: Power budget for the electrical sources of the system

Component	Input Voltage [V]	Input Current [A]	Input Power [W]	Powered by	Output Voltage [V]	Output Current [A]	Output Power [W]	Powering
Power supply AC/DC to 12 V	100 to 240 AC 50/60 Hz	-	-	Electrical grid	12 DC	1.5 (max)	18	12 V to 3.3 V and 5 V DC/DC converter and Motor Driver
Photovoltaic panel	-	-	-	Sun	16.2 (max)	1.23 (max)	20	Wide input voltage to 12 V DC/DC converter

7.6 Functionalities

For the system to work effectively it must have the following features:

- The parts closer to the water are waterproof.
- For most of the running time the energy source is renewable.
- Option to communicate with the user via digital remote platform.
- Simple maintenance.

7.7 Tests and Results

Table 46 shows the tests that the project needs to pass in order to be effective.

Table 46: List of tests for the prototype

Condition to test	Expected result
Floating collector	Floating at water level
Waterproof pump and sensor	The water pump and sensor are fully submersible
Pump working at intended ratings	Dragging water inside the bin as expected
Adjustable structure	Bin platform sliding up and down
Check voltages and currents in all the connections	The voltage and current values could have some margin of error
Sensor readings and processing	Give measurements of distance
Check interface with the motor driver	The output of the driver moves de motor
Test IoT application	Connect system with webpage

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

The prototype that was presented is of a very small scale. In order to become a product that can compete in the market it will have to be increased in scale.

But this process of augmentation will not simply be using components with higher capacities.

The final product to be developed from this prototype must have at least the following characteristics:

- The water pump used must be powered by an AC source as it can have the same power and consume less current when compared to DC pumps.
- If the pump supply is AC it can be connected directly to the power grid, but it can also have the option of being supplied with a photovoltaic panel, as in the prototype. However, a DC/AC inverter is required between the panel output and the pump.
- When it comes to dissuading animals from approaching the product, a repellent will have to be implemented that has a wider area of effect, as the area of influence of the product is also amplified.

An optimal addition to the product would be the measurement of pollution levels in the water. With this feature it could demonstrate to the user the evolution of pollution levels over time and it could still suspend the system if the pollution levels reach a predefined minimum.

Another addition to the product would be the option of using waste collection containers capable of filtering oil from the water and even capturing micro plastics.

Although the production cost and selling price will be higher, the product would still be viable on the market.

9 Bibliography

Will be added automatically by citing, in the body of the report, entries specified in BibTeX format and stored in the http://www.eps2020-wiki1.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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