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Acknowledgement

Glossary

Abbreviation	Description
CO_2	Carbon Dioxide
EPS	European Project Semester
EU	European Union
ISEP	Instituto Superior de Engenharia do Porto
LCD	Liquid-Crystal Display
LED	Light-Emitting Diode
MDF	Medium Density Fiberboard
PDCA	Plan Do Check Act
PESTEL	Political Economic Social Technological Environmental Legal
SMART	Specific Measurable Achievable Realistic Timely
SWOT	Strengths Weaknesses Opportunities Threats
USB	Universal Serial Bus
UV	Ultraviolet
WBS	Work Breakdown Structure

1 Introduction

In the first chapter of the Report, the general information will be presented as followed. The team and their motivation are stated first, then related to the actual project topic the problem, objectives, requirements the basic functional tests are presented in lists and small paragraphs. After that organizing topics like the project planning and the report structure are made to give a better understanding for the reader.

1.1 Presentation

The ChamaleAnt group consists of six different persons from different countries with different cultures, habits, and expectations. The team name came to life due to the principles match the qualities of a chameleon and an ant. For example just like a chameleon, the directive is to embrace each of these differences and adjust to the others to become a better and closer team. Next, to that, it expects to work together for the benefit of the group just like ants do. By being able to use all the different (educational) skills existing, the aim of the project is to develop a great solution for a solar dehydrator product while enjoying and learning from the knowledge of every single member. Figure 1 identifies each member of the team including their nationalities and backgrounds.

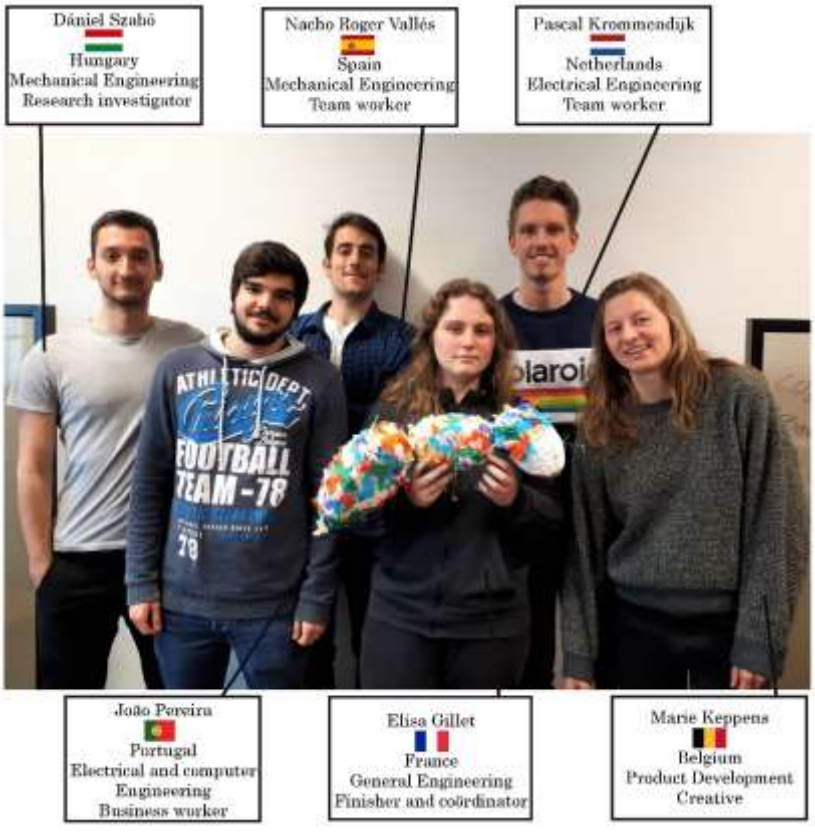


Figure 1 - The ChameleAnts Team

1.2 Motivation

The ChameleAnt's members are participating in the European Project Semester (EPS) with the aim of learning and achieving certain personal and community-related goals. These were defined during team-building sessions in the third week of February, before designing and artistically creating the group's mascot. It was not only taken into consideration the principles of the EPS program and adjust those to the specific group criteria but it was also agreed to supported and maintained the focus on the goals by evaluating the progress of these frequently. The team objectives are as follow:

- Strengthen Teamwork
- Explore different cultures throughout the project
- Integrate study, explore and use every members special ability
- Communication skills
- Avoid assumptions, discuss more
- Trust

In the following months, the group members of ChameleAnt are striving to achieve those goals. Next, to the team’s personal objectives, the main motivation in this specific project comes from the urge of making an impact on the world. Sustainability is one of the key aspects to consider these days. And that is why excitement and motivation are necessary to contribute to getting one step closer to full sustainability by developing a solar dehydrator.

1.3 Problem

The problem regarding this project is that fresh food has a large volume and needs energy consuming storage support in order to keep the lifecycle longer. Next to that the costs of keeping the fresh unprocessed food really fresh are higher than ever before. The main costs will be seen in the amount of waste that results in fresh food not being consumed in time.

Furthermore related to the actual project development, the problems the team might encounter are reaching the goals of high sustainability and low energy consumption while staying in budget, as there could be expensive materials or electronics. There are also unknown topics like biology of food and natural materials that could challenge the team's current expertise. The team also has to take different properties of different types of food into account while trying to dry it and make sure the food does not get moldy or too dried out.

1.4 Objectives

The objectives for this project are to conceive a device by design and develop a dehydrator product from scratch. This device needs to fulfill certain requirements such as being powered by solar energy. It has the purpose of preserve food for longer use, to prevent any bacteria on food, and also prevent mold, with minimal or close to none energy consumption. In other words, it has to be a sustainable product for the future at the lowest cost possible.

Furthermore, on a more educational meta-level, the project team is dedicated to improving existing abilities. These are sumarize as followed:

- open communication in a multidisciplinary and multicultural group
- teamworking combined with abstract problem solving
- discover new branches of industries, studies, and work methods
- having sustainability and low costs in the main focus

This all means a strive towards a better future. Taking into consideration that in order to improve at any level it is essential to always be open to receive feedback.

1.5 Requirements

The project requirements are:

1. Reuse existing components or use low cost hardware solutions;
2. Complying with the following EU Directives:
   I. Machine Directive [1];
   II. Electromagnetic Compatibility Directive [2];
   III. Low Voltage Directive [3];
   IV. Radio Equipment Directive [4];
   V. Restriction of Hazardous Substances (RoHS) in Electrical and Electronic Equipment Directive [5];
3. Mandatory adoption and use of the International System of Units [6];
4. Use open source software and technologies;
5. Maximum budget: 100 €;
6. Dry food in a healthy way by avoiding any bacteria;
7. Sustainable and green operation, production and materials.

1.6 Functional Tests

For now, the team thought about some tests that could be interesting to realize such as:

1. Optimal temperature range and angle of the solar panel
2. What are the dimensions the fan to create the best airflow
3. Using a dark chamber to reduce/eliminate the loss of nutrition
4. How to shift/rotate the products periodically
5. If it is necessary, we can make faster the process by cutting the products in half
6. What is the proper temperature after the surface moisture is gone
7. Using a conductive material could be useful to make the process more effective
8. After the drying process, how much is the water level value which we have to reach

There are 2 types of airflow in the dehydrator: the first one is the natural circulation where the airflow is driven by the temperature difference and the second one is forced convection where the airflow is driven by a fan which can be powered by a battery or a solar panel (it depends on the size of the fan).

1.7 Project Planning

Project planning englobes all the setups necessary in order for a project succeed. It's the process to establish the steps required to define the project objectives, clarify the scope of what needs to be done and develop the task list to do it, also known as Project Backlog [7]. The team chooses to instead of using the classical approach in project management and planning, the waterfall, to utilize an agile approach with the Scrum methodology. Taking in considerations not only the supervisor's recommendations but also due to the ability to adjust to change better than the waterfall model and the existing of studies comparing the results of both favoring the agile approach, as shown in Figure 2. However, for a rough overview of the project activities, milestones, and task allocation, table 1 was structured [8].

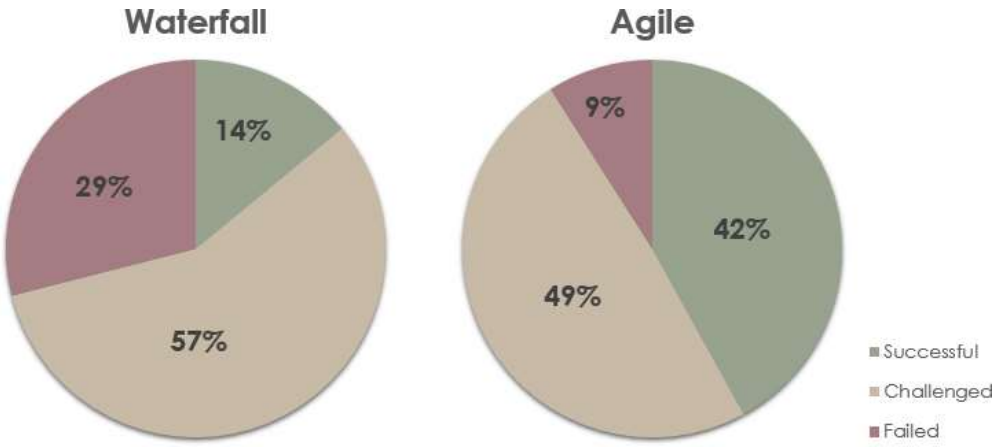


Figure 2 - Waterfall vs Agile project success rate [8]

Table 1 - List of Tasks

Task	Responsible
Initial Research and Planning	
Task Allocation	The team
Gantt Chart	João
Principle Research	Marie & Daniel
Competition Research	Nacho & João
Features and Possibilites Research	Elisa & Pascal
Specific Planning	
System Diagram (Black Box)	Elisa
Structural Drafts	Marie
Design	Marie
List of Materials	Elisa & João
Interim	
Project Management	Pascal
Marketing Plan	Elisa & Nacho
Sustainability Concerns	Marie
Ethical Concerns	Daniel
Construction	
Coding the Software	Pascal
Assembly of the Materials	
Circuit Assembly	
Testing	
Functional Test	
Electronics Test	
Corrections	
Final	
Final Report & Presentation	
Poster, Paper, Video, Leaflet	
Review of the Wiki contents	

1.8 Report Structure

This report is divided into 8 chapters. Table 2 displays that organization and structure.

Table 2 - Report Structure

Task	Description
1	Introduction
2	State of the Art
3	Project Management
4	Marketing Plan
5	Eco-efficiency Measures for Sustainability
6	Ethical & Deontological Concerns
7	Project Development
8	Conclusions
	Bibliography
	Appendix

2 State of the Art

2.1 Introduction

In this chapter, the objective is to do the initial research before developing the actual product or solution. It is about the basic working principle of solar dehydrators, the current market situation in relation to them, and the possible features and functions can be added to the system. The team started doing a brief study about existing products in the market for home or industrial use and the different technologies that already exist for electric and solar dehydrators in order to define the path and finally saying how our product should be, starting from the materials and continuing with the system, electronics, and design.

2.2 What is a Solar Dehydrator?

To introduce the product, a solar dehydrator is a device that uses solar energy to dry food, wood or even clothes. The principal function of a solar dehydrator is to dehydrate, which consists in extracting the moisture of a body, food product or material. Modern dehydration techniques have been motivated by all the advantages that dehydration has, such as compactness (dehydrated food has about 1/15 of the bulk of the original product), or, as bacteria and molds need water to grow, the fact that the product will not rot because microorganisms cannot grow when food is sufficiently dehydrated.

2.2.1 Components of the solar dehydrator

There are 4 main components in a solar dehydrator [9] that are described below and in figure 3.

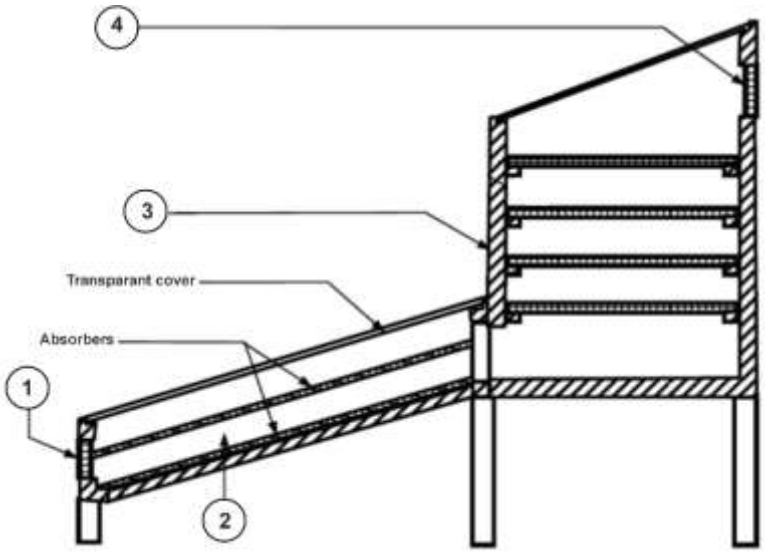


Figure 3 - Components of the solar dehydrator [10]

1. The air intake, that will provide fresh air from outside for the drying cabinet
2. The air heater or solar collector, which is a box that heats the fresh air. It is a box with a transparent cover on top and inside it is some absorbers, that is to say, black surfaces to capture the sun's heat more easily
3. The drying cabinet, which is a place where you put the raw food that you will dry
4. The air outlet, that is necessary to let escape the moist air

2.2.3 Types of solar dehydrators

Direct type

In this case, the solar radiation impacts directly the material to be dried, as shown in figure 4. The material to be dried is placed in an enclosure, with a transparent cover of glass or plastic on it (Plate 2A). The sun heat acts on the material and enclosure and causes a heat build-up due to the “greenhouse” effect. Thus, the temperature inside the chamber becomes higher. The glass or plastic cover serves one more purpose of reducing direct convective losses to the environment, which further becomes beneficial to raise the temperature of the product and the chamber respectively. The collector and drying chamber are usually painted black to absorb the maximum amount of heat [12]. However, convective and evaporative losses occur inside the chamber from the heated material. Direct solar dryers are cheap to make and easy to use. However, it does not allow temperature control. It is hard to protect the product that is drying from external factors. Furthermore, many fruits and vegetables may change color and many vitamins are lost if they are exposed to sunlight for too long [13].

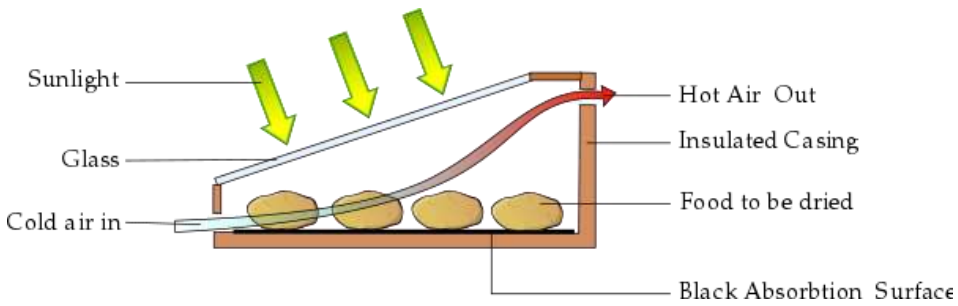


Figure 4 - Example of Direct Solar Dehydrator

Indirect type

In indirect solar dryers, solar radiation doesn't impact directly the material to be dried. The air is heated in a solar collector and then ducted to the drying chamber to dry the product, figure 5. As the hot dry air stream passes through this unit, it removes the moisture of the product. It is possible to control the temperature with this kind of dryer, thus, better quality of the product is obtained than in a direct dryer [14]. Moreover, since the product is not exposed to ultraviolet radiation, the color and texture remain unchanged. The solar radiation produces heat within the bulk of the product upon penetration through its porous skin and changes the color and texture. However, indirect dryers are more expensive to make and harder to use [15].

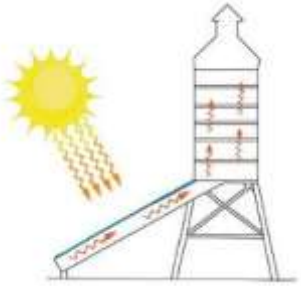


Figure 5 - Example of Indirect Solar Dehydrator

Mixed type

These dryers combine direct solar radiation onto the transparent cabinet and preheated air in a separate solar collector to provide the heat required for the drying operation. As visible in figure 6, the cabinet and the solar collector case are both transparent in order to have the maximum amount of solar radiation use [16]. The product is drying the food that is put in there to dry simultaneously by both radiations with downward conduction of heat and the convection of heat from the solar air Heater. This principle combines two advantages and dries food faster, however it also affects the food by getting exposed to Ultra Violet Light from the sun [17].

Figure 6 - Example of a Mixed Solar Dehydrator

Hybrid type

The Hybrid type of solar dehydrator can be thought of like a modern version of the solar dehydrator that is typically done as a hobbyist's garden project. In this type, other sources of heat energy such as fan powered by solar PV are used to supplement solar heat and allow for a faster rate of drying, figure 7. The combination of solar energy with other technologies increases the system efficiency and provides the advantage of continuous drying even during nights or in the cloudy day [18]. Even though an extra cost is involved with extra technology, hybrid dryers provide benefits of reducing drying time, labor cost and improving the final quality [19].

Figure 7 - Example of a Hybrid Solar Dehydrator

2.2.4 Reasons for dehydrating food

Dehydration is a fantastic way to preserve food for the future. There are many reasons why We like dehydrating food: it's safe, it's easy, and it's cheaper than buying dehydrated food. Better yet, the food itself is more nutritious, it's lightweight, it doesn't take up much space, and some of it is absolutely delicious. [20]

Preserve food

- Economic part: dry food in the season when the food is very cheap (seasonal food) and then preserve it the whole year
- Reduce food waste in periods of overconsumption
- Longer storage duration

Keep healthy / nutritive value

- Large quantity of vitamins, fiber, mineral, and carbohydrates
- Reduced amount of fat
- Improved quality of food

Easy to transport

- More compact because of size difference afterward
- Doesn’t need special infrastructure → reducing energy

Less energy consumption and storage space in comparison with freezing

- Mitigates consumption of conventional sources of energy like fossil fuels so they allow reducing CO2 emissions

In comparison with food dried directly by the sun

- No degradation of materials
- Clean (no access for dust, rain, wind)
- Keeps animals and insects away from food

2.2.5 Parameters which affect the performance

We have to be careful about what fruits or vegetables will be dried because they have different content of moisture which demand different working method.

In order to increase efficiency and reduce the waiting time, it's essential to comprehend the factors that may affect the process. Next, 6 parameters were exposed that affect the performance of the drying process **[22].**

a) Type of food

Every type of food has a different allowable maximum temperature and drying time we can see in Table 3.

Table 3 - Characteristics of different types of food **[21]**

Product	Moisture content Initial (%)	Moisture content Final (%)	Max. allowable temp. (°C)	Drying Time (h)
Onions	85	6	55	48
Onion flakes	80	10	55	24
Onion rings	80	10	55	
Tomatoes	95	7	60	36
Green peas	80	5	60	8-10
Grapes	80	15-20		32-40
Apples	82	11-14	65-70	24-26
Figs	70	20	70	32
Bananas	80	15	70	15
Cassava	62	17		
Copra	30	5		
Tobacco	90	10		96
Coffee	65	11		288
Garlic flakes	80	4		48
Chilies	80	5		48
Ginger	80	10		168
Cabbage	80	4	65	48
Tea	80	3		96
Pepper	71	13		48
Turmeric	80	10		120
Potato chips	75	13	70	72
Paddy, raw	22-24	11	50	
Paddy, parboiled	30-35	13	50	
Maize	35	15	60	
Wheat	20	16	45	
Millet	21	4		
Corn	24	14	-	
Rice	24	11	50	
Cauliflower	80	6	65	
Carrots	70	5	75	48
Green beans	70	5	75	48
Garlic	80	4	55	
Cabbage	80	4	55	
Sweet potato	75	7	55	
Red lauan	90	20		
Potatoes	75	13	75	
Spinach	80	10		
Prunes	85	15	55	
Apricots	85	18	65	
Peaches	85	18	65	
Guavas	80	7	65	
Mulberries	80	10	65	
Okra	80	20	65	
Pineapple	80	10	65	
Yams	80	10	65	
Nutmeg	80	20	65	
Sorrel	80	20	65	
Cocoa beans	50	7	-	
Cotton	50	9	75	
Cotton seed	50	8	75	
French bean	70	5	75	
Groundnuts	40	9	-	

b) Amount of dried food

The more food you have in the drying cabinet, the more dried air you need. A bigger amount of food will increase the risk of obtaining poor quality dried food. By putting less food in the drying cabinet the drying rate of the solar dehydrator increases but sometimes this may cause a loss of energy.

c) Pre-treatment of food

If the food is well pre-treated before starting the drying process, the required drying rate and the drying time will shrink. Pre-treating the food consists in:

- Sorting (use young, tender, not too ripe and of good quality fruits and vegetables)
- Cleaning (remove sand, dirt, toxic products)
- Peeling (remove roots, stems, damaged parts)
- Cutting (improve the evaporation surface, avoid degradation, for example: quarters, slices, etc.)
- Bleaching (cook for a very short time in boiling water, guarantees quality and conservation as well as increasing the speed of dehydration).

d) Temperature

A higher temperature inside the drying cabinet rises the drying rate and decrease the drying time, only if the moisture content is high. If the moisture content is low, the temperature level doesn't result in a significant improvement.

Controlling the temperature is very important when drying different type of food in one machine because every type of food has its own characteristics in terms of temperature and drying time.

e) Airflow rate

The air may not have sufficient contact time with the product to remove moisture so the efficiency of heat solar dehydrator will increase. But an insufficient airflow rate will increase the drying temperature and slows down the drying process.

You have to find the right balance for the airflow taking into account the other parameters like temperature.

f) Relative humidity of air

The drying duration becomes shorter when the air has low humidity. If the relative humidity of the air is high, a higher amount of energy is required so a slow drying rate is obtained.

2.2.6 Condensation Solutions Research

Considering that a solar dehydrator will operate in it's best condition when the sun is heating up the collector significantly much so that the air gets hot. Whenever you work with temperature and water, the team has to consider what to do when condensation appears. This becomes especially important when trying to keep the heat inside the cabinet, because the product should extract water from the food and get rid of it by transporting it through a chimney out of the cabinet without condensating. The next list of questions take this matter into perspective and will clarify the obstacles the project members could face when working with heat [23].

Where does the moisture come from?

- From the food that dehydrates,
- From the outside air,
- Water molecules that absorb energy in form of heat:
  - at a certain level (temperature/energy) the molecules distance themselves from each other,
  - evaporate and become lighter than the air molecules.

When does the moisture/humidity turn into condensation?

- When the evaporated moisture touches something significantly lower in temperature.
- For example a cooking pan with water is placed next to a glass plate which is at room temperature (20°C). The steam from the cooking hot water (about 100°C) touches the glass.
- The evaporated water molecules give their energy to the glass plate and turn from gas form to liquid form with their surface tension holding them on the glass plate as drops.

How to reduce condensation?[24]

- Heat up every material inside the system in order to have no temperature difference and thereby no energy difference. The water stays evaporated.
  - Significant amount of energy is needed in order to do that (initially).
  - After heating everything up it should stay heated.
  - *Solution*: Isolation in order to preserve the produced heat and reduce condensation

Where to go with the evaporated water?

- “Heat always travels up” (convection principle)
- Try to let the humid air only move up
- *Solution*: fans lightly moving the molecules up

2.2.7 Evaporation Research

The goal is to dry food inside of the cabinet. But next to that the consumer does not want to cook/steam them, therefore the solar dehydrator needs to have a temperature limit.

“There are three key parts to evaporation: heat, atmospheric pressure (determines the percent humidity), and air movement.” See table 4 for the outcome. [25]

More or less evaporation:

Table 4 - Evaporation with different Conditions

Condition	Rate of evaporation
Humidity	Nonproportional
Flow of air	Proportional
Pressure on food	Nonproportional
Surface Area	Proportional
Higher Temperature	Proportional

2.2.8 Airflow techniques

In order to take full advantage of the airflow to originate mass transfer, see the importance in Appendices, it's crucial to understand what is considered the most fundamental principles.

- An air mass flow rate of 0,035 kg/m^2s was optimal for drying most agricultural products [26]
- Optimal temperature range for drying these same products was 319,65- 329,65K [27]
- An increase in airflow in a collector increased the efficiency of the conversion of solar energy into more usable forms of energy at the expense of a drop in air temperature [28]
- Increasing the height of an added chimney improved the thermosiphoning abilities of the dryer [29]
- Airflow in a convective air system is directly linked to change in air density due to temperature, the thermosiphoning abilities of the dryer and airflow are proportional [30]

- An increase in surface roughness of collector material caused a pressure loss along the airflow line suggesting that the airflow had been impeded with a consequential decrease in dryer efficiency [31]
- Increasing the depth of the product in the dryer bed decreased the airflow rate and thus decreased the efficiency of the collector [32]

Important note: A smaller number of trays would decrease the drying time and the total product output while a higher number of the tray would decrease the throughput while increasing the drying time. [33]

2.3 Our Competition

2.3.1 SEDONA Express Metal Dehydrator

Electrical dehydrator

Characteristics [34]:

- Compact design that fits in any kitchen
- 11 stainless steel trays to dehydrate
- 1 closed tray for easy cleaning: it is placed below and collects everything that may fall from the trays. It is removable - and easy clean
- 3 dehydration programs: FAST (fast), RAW (at low temperature) and COMBO (through the TST System: sequential control of the temperature in two phases - “Two-Stage Sequential Temperature”)
- Digital control panels, which facilitate their use
- Digital temperature selector from 25º C to 75º C, to program temperatures from grade to grade
- Timer, for automatic stop, up to 150 hours
- Air filter to filter particles. It can be washed and reused, plus it comes with a spare one
- Glass door with hinges to be able to see inside and to put in and take out trays with ease
- Interior light: LED
- Silent operation
- The manufacturer recommends using it 10 cm away from other appliances or furniture

Figure 8 - Dehydrator SEDONA **[35]**

2.3.2 ZEFIRO-SOLAR Food Dehydrator

Solar dehydrator

The Zefiro Max or Tunnel is about 20 feet long. The entire roof is made up of Menegatti panels. Fans draw warm, dry air through the units during the day and cooler, moist air at night. Where electricity is available, the Zefiro only needs 50 watts of power, less than one 60 watts light bulb, whereas the Zefiro Max requires 500 watts of electrical power. **[36]** (Figure 9)

Figure 9 - Solar dehydrator ZEFIRO **[37]**

2.3.3 Kascade Solar Dryer

Solar dehydrator

Kascade developed a modular drying system, made from first-class materials like aluminum and glass. The Kascade “Solar Dryer” is equipped with special rolling “Cassette Trolly’s” to transport the materials through the dryer and to make on / offloading of products quickly and easily. Drying Omena fish, mangos, bananas, etc. takes approximately 4 hours. The size of the “Solar Dryer” can be adapted to the number of products which need to be dried. The Kascade “Solar Dryer” can be built and removed

without leaving a trace. All materials can be recycled and there is no waste involved in the process of drying. No fossil energy needed.

Human waste is available in abundance, but unfortunately, it causes problems in many areas due to lack of proper treatment. It is possible to turn this waste into energy, simply by drying it. By one estimation, a single American's daily sludge output can generate enough electricity to light a 60-watt bulb for more than nine hours. The Kascade "Solar Dryer Tunnels" are equipped with rolling drying tables to transport the materials through the dryer. After the material is dried it is ready to use, either as fertilizer or as a base for fuel. **[38]** (Figure 10)

Figure 10 - Solar dehydrator Kascade **[39]**

2.4 Possible Features & Components

This topic has been a creative process of brainstorming for many features and add-ons on the actual solar dehydrator. It might contain some non-realistic idea's which are only part of the brainstorm. Furthermore, most of these possible components need to be discussed and be weighed against the range of necessity and luxury. Therefore, this is only an overview to sort every matter that could be part of our final solution.

Sensors

- Humidity sensor
- Light sensor for detecting day and night or too much light input
- Temperature sensor for detecting if the solar panel needs to be closed or opened more
- Airflow sensor
- Battery level sensor

Electronics

- Fan for bringing fresh air in and moisture out
- Electro-mechanical opening and closing lids (for bringing in fresh air or isolating the chamber)
- Battery pack
- Control unit (Arduino, Atmega, Raspberry Pi)
- Solar panel + converter unit
- User interface (display, touch display, keys, buttons or knobs)

Case

- Case materials (sustainable materials, reused materials, wood, plastic, polymer, etc.)
- Case form (cubic, cylinder, etc.)
- Traying possibilities (plate, grills (steel grills), hanging hooks, something like a fishing net, rotating or static trays, square or round trays)
- Movement (rotating joint to follow the sun, winding up the system and let it be a counter like a kitchen timer for cooking, wheels under the construction to be able to move it around)

Others

- Angle of the solar-heat collector (maybe extending legs of the system)
- Colour for the solar heating platform
- Coating material against different weather conditions
- Solutions against condense water (double layered isolation, look at solutions condensation, salt to the system against humidity and moisture)

These components and ideas are still in the brainstorming process. There may come more of these throughout the initial research and design phase. In the course of the development phase, many of these points can also be neglected due to budget or necessity reasons.

2.5 Conclusion

As you can see, in these three sections there are a lot of ideas and possibilities available to make this project as interesting as can be. Our competition does either not think of sustainability when thinking of a home use dehydrator. The other commercial competitor that thinks of sustainability and the solar attribute does not develop a product you can have inside your house. This gave us the opportunity to combine both. The four different types of solar dehydrators are narrowed down and the team chose to make an intelligent **hybrid indirect type**.

There are advantages like:

- protecting the food from direct UV radiation
- the electrical power in order to get more monitoring abilities
- being able to add more electronics and expansion features that are stated in future developments
- a guided and speed up drying process with fans and sensors

Based on this study of the state of the art, the team decided to adopt the following components to the final solution:

- Solar panel
- Power converter
- Battery
- Control unit (e.g. Arduino)
- Ventilation fans
- Temperature sensors
- Humidity sensors
- Cables
- Hinges for cabinet doors
- Fiberglass mesh (trays)
- Plywood (case)
- Anti-insects mesh (in- and outtake)
- Polycarbonate (transparent solar collector)
- Black sustainable paint

For all specific quantities, component numbers and visual help, look further into the report to see the outcome of the list of materials, components and design ideas.

With the research concluded it's important to comprehend how the project has been and will continue to be managed according to the standards covered in the next chapter.

3 Project Management

3.1 Scope

Having a field that is defined and limited to certain activities, goals, and achievements is an essential part of the planning. This comes in handy when the team needs to stay on track and wants to avoid doing too much or not enough in a project. In figure 11 the scope of the whole project is displayed roughly in phases and deliverables. As seen in the “Start-up Phase” and the “Specifying Phase” there is a connection between the two. The reason behind this is some overlapping activities and goals that rely on each other or need to be corrected/changed after a certain deadline hit.

Next, to that, the scope is normally defined after discussing all the different types of requirements that the project is about and the solution will have. However, the fact that this project is part of the EPS the supervisors have generally predefined the scope of this project by laying out a list of deliverables that can be seen in the time management chapter below.

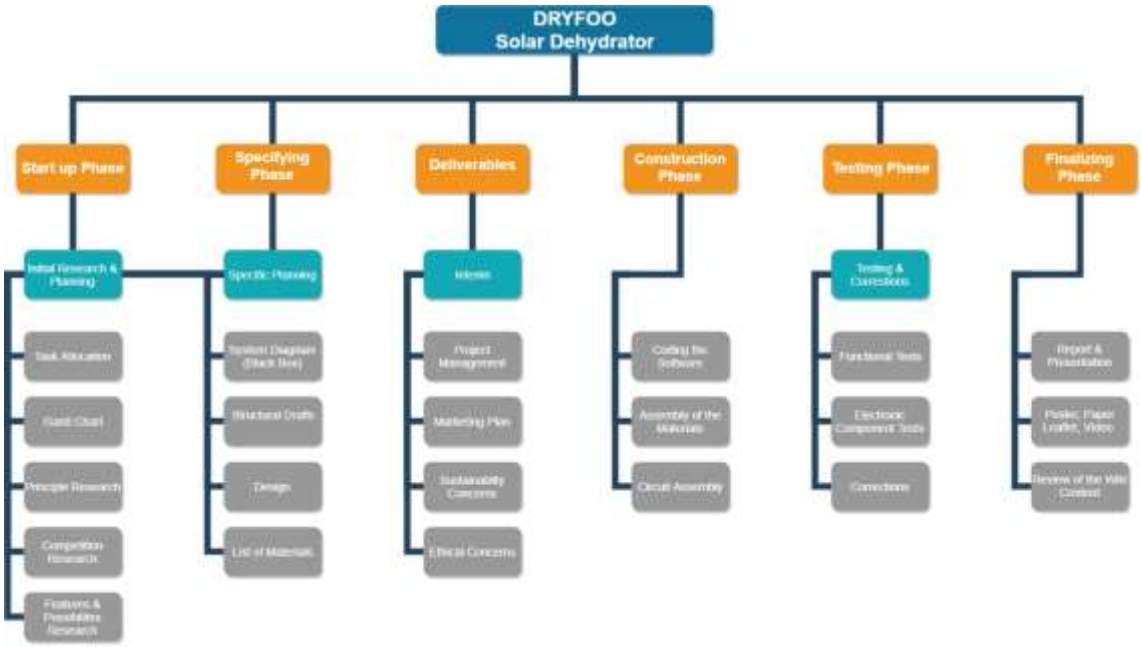
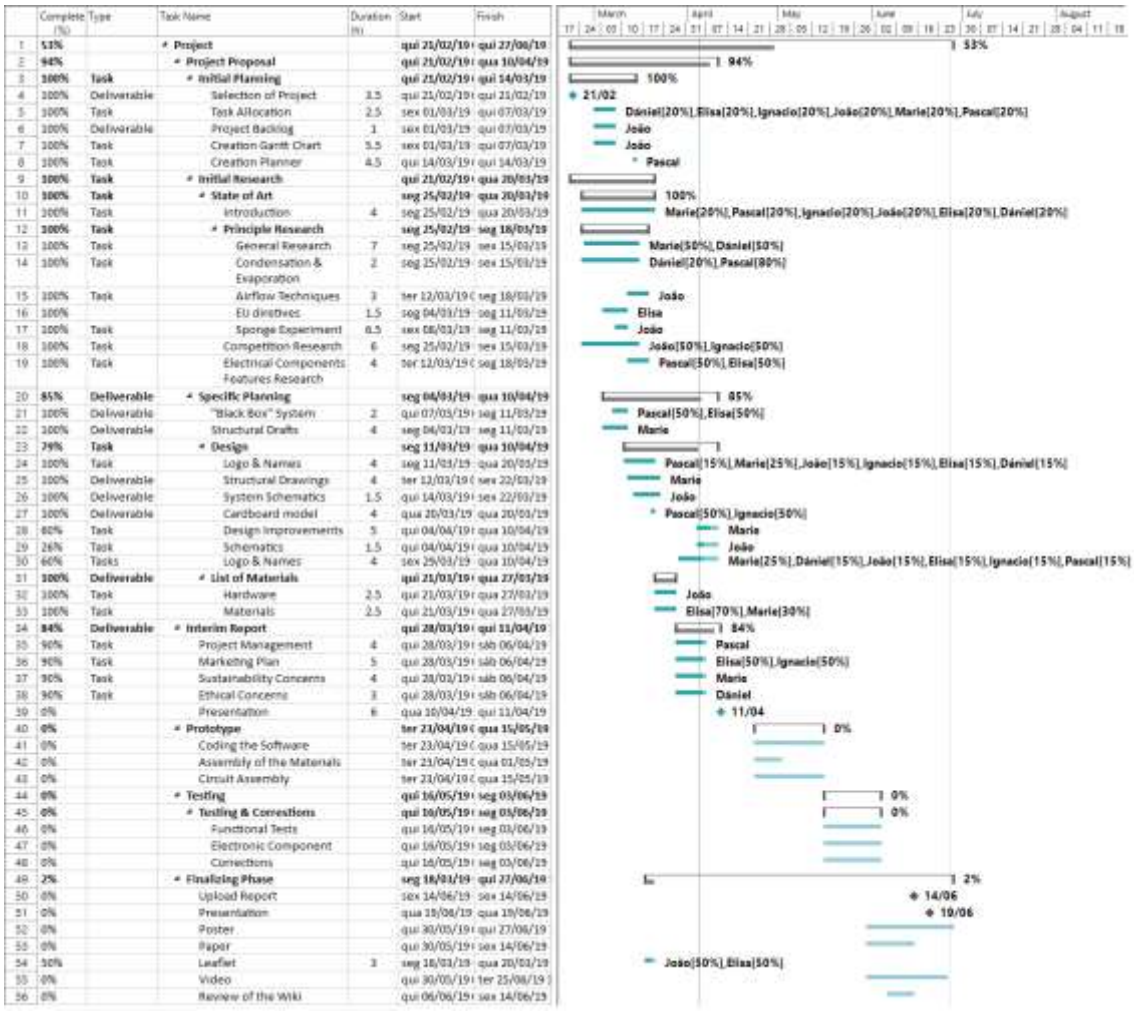


Figura 11 - WBS

This means that the scope is packed with activities, deliverables and plannings that normally take more time than a single semester and will eventually be the cause of less focus on the actual final solution.

3.2 Time

Time is the second important key part of managing the project. Of course, the team has deadlines in order to be on time and has a fixed point of time management. A Gantt chart has been created which contains the tasks, time and resources needed of each activity, as shown in Figure 12. This graph helps to control & monitor the project advancement and manage the available time in the most classical way, for example, to speed up working velocity when they notice they are behind. Thanks to Table 5, the team knows the current tasks and the deadlines of the next deliverables. It is also another way to do tasks in the order they need to be done. These two illustrations should help to get the time management in order.



	Complete (%)	Type	Task Name	Duration (h)	Start	Finish
1	53%		Project		qui 21/02/19	qui 27/06/19
2	94%		Project Proposal		qui 21/02/19	qua 10/04/19
3	100%	Task	Initial Planning		qui 21/02/19	qui 14/03/19
4	100%	Deliverable	Selection of Project	3.5	qui 21/02/19	qui 21/02/19
5	100%	Task	Task Allocation	2.5	sex 01/03/19	qui 07/03/19
6	100%	Deliverable	Project Backlog	1	sex 01/03/19	qui 07/03/19
7	100%	Task	Creation Gantt Chart	5.5	sex 01/03/19	qui 07/03/19
8	100%	Task	Creation Planner	4.5	qui 14/03/19	qui 14/03/19
9	100%	Task	Initial Research		qui 21/02/19	qua 20/03/19
10	100%	Task	State of Art		seg 25/02/19	qua 20/03/19
11	100%	Task	Introduction	4	seg 25/02/19	qua 20/03/19
12	100%	Task	Principle Research		seg 25/02/19	seg 18/03/19
13	100%	Task	General Research	7	seg 25/02/19	sex 15/03/19
14	100%	Task	Condensation & Evaporation	2	seg 25/02/19	sex 15/03/19
15	100%	Task	Airflow Techniques	3	ter 12/03/19	seg 18/03/19
16	100%		EU directives	1.5	seg 04/03/19	seg 11/03/19
17	100%	Task	Sponge Experiment	6.5	sex 08/03/19	seg 11/03/19
18	100%	Task	Competition Research	6	seg 25/02/19	sex 15/03/19
19	100%	Task	Electrical Components Features Research	4	ter 12/03/19	seg 18/03/19
20	85%	Deliverable	Specific Planning		seg 04/03/19	qua 10/04/19
21	100%	Deliverable	"Black Box" System	2	qui 07/03/19	seg 11/03/19
22	100%	Deliverable	Structural Drafts	4	seg 04/03/19	seg 11/03/19
23	79%	Task	Design		seg 11/03/19	qua 10/04/19
24	100%	Task	Logo & Names	4	seg 11/03/19	qua 20/03/19
25	100%	Deliverable	Structural Drawings	4	ter 12/03/19	sex 22/03/19
26	100%	Deliverable	System Schematics	1.5	qui 14/03/19	sex 22/03/19
27	100%	Deliverable	Cardboard model	4	qua 20/03/19	qua 20/03/19
28	80%	Task	Design Improvements	5	qui 04/04/19	qua 10/04/19
29	26%	Task	Schematics	1.5	qui 04/04/19	qua 10/04/19
30	60%	Tasks	Logo & Names	4	sex 29/03/19	qua 10/04/19
31	100%	Deliverable	List of Materials		qui 21/03/19	qua 27/03/19
32	100%	Task	Hardware	2.5	qui 21/03/19	qua 27/03/19
33	100%	Task	Materials	2.5	qui 21/03/19	qua 27/03/19
34	84%	Deliverable	Interim Report		qui 28/03/19	qui 11/04/19
35	90%	Task	Project Management	4	qui 28/03/19	sáb 06/04/19
36	90%	Task	Marketing Plan	5	qui 28/03/19	sáb 06/04/19
37	90%	Task	Sustainability Concerns	4	qui 28/03/19	sáb 06/04/19
38	90%	Task	Ethical Concerns	3	qui 28/03/19	sáb 06/04/19
39	0%		Presentation	6	qua 10/04/19	qui 11/04/19
40	0%		Prototype		ter 23/04/19	qua 15/05/19
41	0%		Coding the Software		ter 23/04/19	qua 15/05/19
42	0%		Assembly of the Materials		ter 23/04/19	qua 01/05/19
43	0%		Circuit Assembly		ter 23/04/19	qua 15/05/19
44	0%		Testing		qui 16/05/19	seg 03/06/19
45	0%		Testing & Corrections		qui 16/05/19	seg 03/06/19
46	0%		Functional Tests		qui 16/05/19	seg 03/06/19
47	0%		Electronic Component		qui 16/05/19	seg 03/06/19
48	0%		Corrections		qui 16/05/19	seg 03/06/19
49	2%		Finalizing Phase		seg 18/03/19	qui 27/06/19
50	0%		Upload Report		sex 14/06/19	sex 14/06/19
51	0%		Presentation		qua 19/06/19	qua 19/06/19
52	0%		Poster		qui 30/05/19	qui 27/06/19
53	0%		Paper		qui 30/05/19	sex 14/06/19
54	50%		Leaflet	3	seg 18/03/19	qua 20/03/19
55	0%		Video		qui 30/05/19	ter 25/06/19
56	0%		Review of the Wiki		qui 06/06/19	sex 14/06/19

Figure 12 - Gantt Chart

Table 5 - List of Deliverables

Deadline Dates	Description
25/02/2019	Choose a project proposal
06/03/2019	Define the Project Backlog, Global Sprint Plan, Initial Sprint Plan and Release Gantt Chart of the project
11/03/2019	Upload the "black box" System Diagrams & Structural Drafts to the wiki
22/03/2019	Upload the detailed System Schematics & Structural Drawings to the wiki and do the cardboard scale model of the structure
27/03/2019	Upload the List of Materials (what & quantity) to the wiki
06/04/2019	Upload the Interim Report and Presentation to the wiki
11/04/2019	Interim Presentation, Discussion and Peer, Teacher and Supervisor Feedbacks
23/04/2019	Complete the List of Materials (local providers & price, including VAT and transportation) to the wiki
30/04/2019	Upload refined Interim Report (based on Teacher & Supervisor Feedbacks)
03/06/2019	Upload the results of the Functional Tests to the wiki
14/06/2019	Upload the Final Report, Presentation, Video, Paper, Poster and Manual
19/06/2019	Final Presentation, Individual Discussion, and Assessment
25/06/2019	Update the wiki, report, paper with all correction suggestions
	Hand into the EPS coordinator: a CD with the corrected deliverables (source + PDF) together with all code and drawings produced
	Hand in a printed copy of the corrected report and poster
27/06/2019	Hand in the prototype and user manual

However as one of the team's teachers used to say, "planning in this (early) stage of the project is not advisable and only ends up in changing the plan later on". Therefore as mentioned in the scope-section, the team uses the Scrum approach on time management. Instead of holding onto the whole GANTT chart for a whole semester, the tasks, goals, and activities are split into smaller chunks of time. One week is one sprint and a doable amount of work is done in that sprint. Nothing more nothing less. This way the team can focus on that time on specific tasks and not worry about the future until the end of the sprint.

Next, to this time management approach, the project team is determined to do tasks as soon as they get recognized or given and not work towards deadlines. One of the key goals of the team is striving for faster response on a personal and work ethics level. Therefore, there will be more time to make corrections, have a low level of stress and get a higher working standard which results in a higher standard of quality (See 3.4 Quality). Although the complete time for the whole project planning and development is stacked into a semester which is, looking at the scope, not enough time to make a really thought through solution to the problem. However, the team has to work with it and it makes the best out of it.

3.3 Cost

Time is money but without money, you won't have time either. Therefore, calculating the costs of the project in advance is more important than the actual development of the product afterward. As for the costs we can differentiate between work resources and material resources. Both are important to the project. However, Work resources won't be important in this case because we are students at a university and not paid employees.

- **Work Resources**

Work resource depends on the time and quantity of workers involved in the project. This budget is calculated on the hour cost and the duration on the worker work. But as the Team is in a school project, it is canceled from the budget even if has been calculated theoretically. As you can see in figure 13 the optimal workload & therefore the costs on working hours should be evenly divided on every group member. This will make the amount of responsibility on everyone's shoulders even. Therefore, you can talk and discuss on the same level as yourself. In theory, this is the best approach however this will differ in reality because of the difference between tasks and study background. As you can see in 3.5 People, certain people are chosen for certain topics.

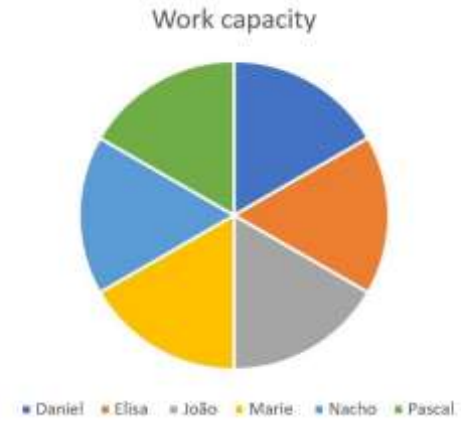


Figure 13 - Optimal Workload for the whole group

- **Material Resources**

A material resource is based on the price of each component and its quantity. Table 6 and 7 displays the lists of materials and their prices. In case of checking the links and further details, look in the deliverables section for the excel file. These lists are made having as reference the budget of 100 Euros. Therefore some components are also reused, refurbished or second hand if the institutions (ISEP) storage has some components to spare.

Table 6 - List of components

Component	Voltage (V)	Current (A)	Power (W)	Price (€)	Quantity	Total Price (€)
Arduino Uno	5	0,02	0,1	14,9	1	14,9
Solar Panel	6	0,2	1,2	10,75	1	10,75
Battery	3,7	-	-	3,9	1	3,9
Battery Holder	-	-	-	1	1	1
Battery Charger	5	1	5	1,95	1	1,95
Voltage Booster	5	0,6	3	3,5	1	3,5
Fan	5	0,15	0,75	3,95	1	3,95
Servo Motor	3,0/7,2	-	-	3,75	1	3,75
Display LCD 2IC	5	-	-	7,9	1	7,9
Temp. and Humid. Sensor	1,9/3,6	0,15	0,495	9,84	1	9,84
Electrical Storage Box	-	-	-	2,75	1	2,75
Diode	1,1	1	1,1	0,1	2	0,2
LEDs	2,1	0,2	0,42	0,15	3	0,45
Wires (25 m)	-	-	-	3,2	1	3,2
Buttons	-	-	-	0,15	2	0,3
Resistors	-	-	-	0,05	5	0,25
Breadboard	-	-	-	0	1	0
Capacitors	16	-	-	0,1	1	0,1
Extension cable Servo	-	-	-	1	1	1
Transistors	-	-	-	0,15	1	0,15

Table 7 - List of materials

Part	Material name	Area (m^2)	Length (m)	Attributes	Price per m^2 (€)	Quantity	Total Price (€)
Transparent Front	PVC	0,11466	-	Bendable (< 1 mm)	14,99	1	1,7187534
Bended Front Rest	PVC	0,125	-	Bendable (< 3 mm)	0	1	0
Straights parts of the case	Wood (preferably plywood)	0,625	-	Width: 10 mm (depends on ISEP's stock)	2	1	0
Trays and air holes mesh	Plastic mesh	0,070125	-	Provided by Benedita	0	1	0
Tray bars	Wood (preferably plywood)	-	4,5	10 mm x 10 mm	0	3	0
Collector (paint)	Black paint (mat)	0,07	-	Provided by Abel	0	1	0
Collector (metal sheet)	Aluminium	0,09226406	-	50 cm x 25 cm	5,99	1	5,99
Screws	-	-	0,02	Pack	2,56	1	2,56
Glue	White wood glue	-	-	In a tube	-	1	3,99
Sliding lock latch	Stainless steel	-	-	Waterproof	4,45	1	4,45
Hinges (door)	Stainless steel	-	-	Waterproof	1,99	2	3,98
Isolation between gaps and connections	Silicone	-	-	-	-	1	2,49

The total prices are as follow:

- Total price for electronics: 69,84 €
- Total price for electronics: 25,1787534 €
- **Total Cost: 95,018753 €**

3.4 Quality

In order to achieve quality, the project group needs to look at different attributes of quality which are written in 3 topics. All these topics directly affect the overall quality of the product and the resulting documentation at the end of the project.

- Employee & Team Work Quality

There are several objectives to think of when looking at the employees and the teamwork within the project group. There are the personal skills and abilities, are they useful to the tasks and activities in the project itself and is every branch of the project that is involved covered by at least one person? Next to that the quality of the teamwork will affect the result being one complete product or a summary of materials containing a lot of different components and parts which don't fit the whole product. For example, it is not good teamwork if later the case materials are chosen based on sustainability and the electronics chosen only based on price. It will result in a product with different attributes which are not delivering the same message.

- Material & Component Quality

The quality of the material that is being used for the product will result in the most visible part of the overall quality. It is therefore important to test and refine the materials and components used. They will be given a high precision and durability standard during those tests to minimize the risk of failure (more of that in risks).

- Time Quality

As mentioned above, time is also a significant part of the project management. Not only there but it can also be found in the quality of the product. Less time will eventually result in working faster with less regard to details and precise working. This will result later in for example less qualitative measurements, worse documentation or choices regarding the solution. Therefore it is mandatory to also have good time management in mind.

Next to those 3 topics, testing and refining the product after development is a huge pro when talking about quality. Therefore we refer to the introduction chapter where the functional tests are displayed. Based on that there will be a testing phase guaranteeing the highest standard of quality at the end. Table 8 includes the summary of different parameters which can directly or indirectly affect the overall quality of the outcoming product. In order to keep the standards high, the following standards and requirements need to be fulfilled.

Table 8 - Quality Minimums & Maximums

Description	What?	How (much) ?
Internal & Work Ethics		
Time Efficiency	Work Capacity	240 h
Time Efficiency	Minimum Sprint Efficiency	50%
Finances	Budget	max. 100 €
Materials	Sustainable Origin	Portugal
Materials	Conform EU Directives	Health, Low Voltage & Mechanics
Electronics		
Sensors	Temperature Precision	+/- 0,5 °C
Sensors	Humidity Precision	+/- 5 %
Power	Ratio of Production to Consumption	>= 0
Power	Low Power Consumption	Overall: < 5 W
Other Materials		
Wood for the housing	Reused & Local	from Portugal
Transparent Front	Light transmittance	80%

3.5 People

“With great power comes great responsibility”. That's what uncle Be used to say to Peter Parker. In order to have the responsibilities straight, an overview has been created in the form of the table shown in table 9. It displays the **temporary** (the first draft without any info about making those kinds of tables) responsibility table of the team members, the supervisors, and the most important teachers.

The Team uses initials to fill the table, meanings are:

R = Responsible ; W = Worker ; A = Approval ; C = Consultant ; I = Informant; Q = Quality tester

Table 9 - Temporary People's Responsibility

Tasks	Elisa	Dániel	João	Marie	Nacho	Pascal	Supervisors	Abel Duarte	Benedita Malheiro
Task Allocation	R	R	R	R	R	R	A,I		
Gantt Chart			R				A,I		
Principle Research		R		R			A,I		
Competition Research			R		R		A,I		
Features & Possibilities Research						R	A,I		
System Diagram (Black Box)	R						A,I		
Structural Drafts				R			A,I		
Design				R			A,I	C	
List of Materials	R		R				A,I	C	C
Project Management						R	A,I		
Marketing Plan	R				R		A,I		
Sustainability Concerns				R			A,I		
Ethical Concerns		R					A,I		
Interim Report	R,W	R,W	R,W	R,W	R,W	R,W	A,I		
Coding the Software						R	A,I		
Assembly of the Materials							A,I		
Circuit Assembly							A,I		C
Functional Tests							A,I		
Electronics Test							A,I		
Corrections							A,I		
Final Report & Presentation							A,I		
Poster, Paper, Video, Leaflet							A,I		
Review of the Wiki Contents							A,I		

3.6 Communication

In this section, the significance of communication will be discussed. In order to be on the same page during reoccurring events like weekly meetings, table 10 will help to stay organized. Here you will see the importance of certain activities and who is involved in that. Therefore it is mandatory to involve and inform the right team members for each activity.

Table 10 - Communication Matrix

What?	Why?	Who?	When?	To whom?
Brainstorming	Development of ideas for the best solution in the end	The whole team (divided by 3 for initial)	During the startup and specifying phase	The team
Deliverables	Having continuous monitoring process during the project time	Responsible person for the deliverables	On the specific deadlines	The supervisors and responsible teachers
Weekly Supervisors Meeting	"Updates and progress presentation for monitoring purposes, Q&A time"	The whole team and supervisors	Every Thursday	The supervisors
Weekly Team Meeting	More personal as above. Being communicative towards the other team members	The whole team	Every Thursday	The team
Daily Scrum Stand Ups	break progress into smaller chunks and review problems and blocks	Individual	Daily	The team
Interim Presentation	Showing the goals, solutions, and ideas before the physical development and assembly of the proposed solution	Responsible presentators	11th of April	The supervisors

As you can see in figure 14 below, the communication within the team is mostly consistent with oral communication. Keeping it personal is one of the biggest advantages in order to have good communication. Furthermore, the main conversations are driven through Whatsapp but also copied to Facebook Messenger because one of the team members won't use WhatsApp for that matter. With a small percentage left there is the OneDrive and the Office Planner included in the communication distribution. These also affect the communication positively as the team members can always fall back on these when searching for tasks that are done by the others or to revisit what to do if someone forgot their task.

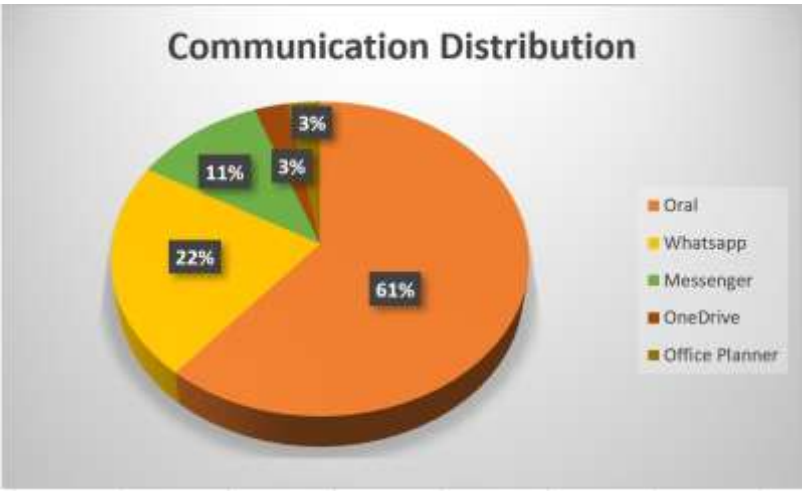


Figure 14 - Communication Distribution

3.7 Risk

Sorted by categories, table 11 displays the first draft of the risk management table. Every risk has its cause and effect but next to that the team needs to make sure what to do in order to avoid the risk or take the right action to certain risks. Furthermore, the team should prioritize the risks by impact and probability. This helps to make the safest and most qualitative solution of all in the end. Table 11 defined information clarifies the risks that are taken into account and managed.

Table 11 - First draft of the risk management table

Risk Description	Cause	Effect	Response Strategy	Impact	Probability
Internal Risks					
(Emotional) Team Disagreement	Not communicating enough and being too emotional in discussions	Arguing because of personal issues and not factual matters	**[Mitigate]** communicate more between team members. Talk it out (personal issues)	Medium	Medium
Physical and mental injuries	Sickness, broken bones, too much sport or anything else	Not being able to work and not able to reach deadlines	**[Mitigate]** talk about personal matters that affect progress. **[Transfer]** the tasks of that person to someone else	Medium	Low
Time Management	Not meeting deadlines, not working continuously	Not being on time and not finishing OR working too fast and lowering quality	**[Avoid]** being late and start working directly	High	Low
External Risks					
Supplier Delay	Not in stock, transportation problems	Affects time management	**[Avoid]** being late with the purchase	High	Medium
Supplier Faults	Components failure, low quality (in packaging)	Affects components failure	**[Mitigate]** with the supplier to claim a guarantee and replace the components quickly	Medium	Low
Rebuying Materials and Components	Suppliers Faults, Damage to limited materials, components failure	Higher costs and time consumption in delivery	**[Mitigate]** as mentioned above	High	Medium to Low
Misinformation	No information given, not traceable information (nothing on Moodle)	Developing the wrong requirements and unnecessary research/development	**[Mitigate]** take initiative to be informed about unclarities	Low	Medium
Canceled Classes	Illness of the teacher, etc.	See Misinformation	**[Transfer]** Teacher should brieve somehow else	Low	Medium
Technical Risks					
Components Failure	Low quality and low precision	Buying new ones, meaning time risks	**[Avoid]** Make sure the quality is good and be thoughtful with handling and placing it	High	Low
Damage to limited materials	Non-cautious use, preparation or shaping	Buying new materials, meaning time risks	**[Avoid]** Be thoughtful with the materials and do not overuse	Medium	High
Digital Data Loss (Documents and Softwares)	Computer problems	Re-writing code and recovering all documentation	**[Transfer]** the data to a cloud and make copies and back-up	High	Low

3.8 Procurement

Procurement is the process of acquiring and buying products, goods or services from external suppliers. The process was used to make sure that the Team received products at the best possible price but also high quality compared with other external suppliers, i.e. the best value. However, in order to beget the most sustainable product possible, the team must search for reusable materials in the workshop of ISEP and see what they don't have to buy them.

For this project, the Team was only allowed to choose suppliers from Portugal, which meant that there were more restrictions on what could be used in the final product. However, most bigger suppliers have a branch in Portugal like Mouser. It is only possible to know what is bought externally when the actual list of materials are being used as order list and the team had a look into the storage room of materials in ISEP. Till then there are only speculations as to what will be bought and what is reused.

3.9 Stakeholders management

As seen in table 12 the different entities and persons that can have influence on the project is shown. For better understanding in the list below every entity is explained.

- Stakeholders are the persons and groups of interest in this project. They directly and sometimes indirectly affect the project development as well as the outcome of the development.
- In this project there are of course the **team members** which are responsible for the whole creation of the project. Without them there would be no result nor would there be any progress.
- The infrastructure of the university where the team can develop and create the product is supplied by **ISEP**. Also, this institution grants them the ability to study there and continue their process in a specific room. It also houses libraries, laboratories, workshops, and cafeterias.
- The **supervisors** are a team of teachers who are dedicated to monitoring the progress of each team and give tips and adjustments to plans if needed or requested. With approvals and tips from the supervisors the team may and can continue working on their project more confident.

- Different from the Supervisors are the normal **teachers**. They are not part of the supervisors and are therefore not present in the meetings. However, they teach the

subjects like Sustainability, Marketing, Ethics, Project Management and Communication which are all part of the specific planning and preparation of the solution. They are helping and consulting in main choices before developing the product.

- Last but not least are the **suppliers**. This group has a low interest in the team and only sells components and materials. When the team is making the orders according to the time management, the suppliers will have low power and low influence.

Table 12 - Stakeholders table

Who	Role	Power	Influence
Team members	Creator	High	High
ISEP	Sponsor	High	Low
Benedita Malheiro	Main supervisor	High	Medium
Supervisors	Team supervisor	Medium	High
Teachers	Teach subjects	Low	Medium
Suppliers	Provide materials	Low	Low

3.10 Sprint Outcomes

When looking back onto the Scrum approach of the project management you can review several tasks, tables and calculate the efficiency of the working method the team is using. Table 13 illustrates how the past sprints were going seen in hours of work. The team's work capacity is calculated by using the number of hours per day one can work, multiply it by the amount of team members and multiply it finally by the count of days you normally work. The team decided to do a normal work week of 5 days and 8 hours a day. Therefore, the total work capacity is 240 hours. However, because the team also needs to attend and focus on classes the actual available capacity is the work capacity subtracted by the total hours of classes that occur in that specific week. The sprint velocity is the summation of all the completed tasks in one sprint and together with the available capacity creates the total work efficiency of the team which is calculated as followed:

$$Efficiency_{Percentage} = 100 * \frac{Velocity}{Capacity_{available}} = 100 * \frac{Hours_{CompletedTasks}}{(Amount_{Days} * Hours_{Working} * Amount_{Teammembers}) - Hours_{Classes}}$$

Based on this the project manager calculated the efficiency for the past sprints. Table 13 below shows this per sprint in rows.

Table 13 - Sprint Capacities & Velocities

Sprint	Work Capacity	Available Capacity	Sprint Velocity	Efficiency
1	240 h	78 h	60 h	76,90%
2	240 h	84 h	47 h	55,90%
3	240 h	57 h	52 h	94,70%
4	240 h	117 h	48,7 h	41,70%
5	240 h	102 h	34,5 h	33,80%
6	240 h	105 h	57 h	54,20%
7	240 h	147 h	61,5 h	41,80%

As you can see table 13 shows relatively changing efficiencies throughout the sprints. This can be easily explained by counting in the knowledge of scrum: This means that the team is learning how to use the approach in the first 3 sprints after that the estimation of the tasks lengths and the amount of tasks increased because “they can do more” with their time. Next to that some bigger tasks that were going on through 3 sprints were actually completed in the third sprint so all the invested are counted only in that one sprint. That's why the velocity is so high in the third sprint and so low in the first two.

Furter details about how the tasks were estimated and distributed among the team members is shown down in tables 14, 15, 16, 17, 18 and 19. Over time the sprint reviews and the calculated velocities will come on further because nobody can see the future now.

Table 14 - Sprint 1 Review

Start: 18th February 2019					End: 24th February 2019
Task Name	**Responsible People**	**Duration**	**Priority**	**Status**	**Notes**
ID03 Selection of the Project Proposals	whole group	2 h	High	done	
ID17 Features Research	Pascal & Elisa	1 h	High	Not done	This initial research will take time until the fourth sprint
ID19 Principle Research	Marie & Daniel	1 h	High	Not done	This initial research will take time until the fourth sprint
ID16 Competition Analysis	João & Nacho	1 h	High	Not done	This initial research will take time until the fourth sprint
Features Research	Pascal & Elisa	15 h	High	Done	
Principle Research	Marie & Daniel	20 h	High	Done	
Competition Analysis	João & Nacho	20 h	High	Done	
ID02 Teambuilding report (individual)	whole group	2 h	Medium	done	
ID01 1st weekly report	João	1 h	Low	done	
Sprint Velocity:		60 h			

Table 15 - Sprint 2 Review

Start: 25th February 2019					End: 3rd March 2019
Task Name	**Responsible People**	**Duration**	**Priority**	**Status**	**Notes**
ID20 Defining the target group Field Identification	whole group	8 h	High	Not done	After much discussion the team will ask the marketing teacher for help
Defining the target group Field Identification	whole group	2 h	High	Done	
ID17 Features Research	Pascal & Elisa	1 h	High	Not done	
ID19 Principle Research	Marie & Daniel	1 h	High	Not done	
ID16 Competition Analysis	João & Nacho	1 h	High	Not done	
Features Research	Pascal & Elisa	10 h	High	Done	Worked on that but not finalized
Principle Research	Marie & Daniel	15 h	High	Done	Worked on that but not finalized
Competition Analysis	João & Nacho	15 h	High	Done	Worked on that but not finalized
ID15 Air Flow techniques	João	4 h	Medium	Not Done	This is added to the principle Research later
ID14 Condensation Solution Research	Daniel & Pascal	4 h	Medium	Not done	This is added to the principle Research later
ID07 1st & 2nd Gantt chart	João	1.5 h	Medium	Done	
ID06 2nd Agenda & Minute	Pascal & João	Choice	Medium	Done	
ID05 Project management Creating this Backlog	Pascal (till now)	3 h	Low	Done	
ID04 2nd Weekly Report	Pascal & Nacho	0.5 h	Low	Done	
Sprint Velocity		**47 h**			

Table 16 - Sprint 3 Review

Start: 4th March 2019					End: 13th March 2019
Task Name	**Responsible People**	**Duration**	**Priority**	**Status**	**Notes**
ID20 Defining the target group Field Identification	whole group	6 h	High	Not done	After much discussion the team will ask the marketing teacher for help
Defining the target group Field Identification	Whole Group	2 h	High	Done	
ID17 Features Research	Pascal & Elisa	10 h	High	Done	
ID19 Principle Research	Marie & Daniel	10 h	High	Not done	This initial research will take time until the fourth sprint
ID16 Competition Analysis	João & Nacho	10 h	High	Done	
Principle Research	Marie & Daniel	10 h	High	Done	
ID13 Black Box Diagram	Pascal & Elisa	2 h	Medium	Done	
ID12 Structural Drafts	Marie	4 h	Medium	Done	
ID15 Air Flow techniques	João	4 h	Medium	Done	
ID14 Condensation Solution Research	Daniel & Pascal	4 h	Medium	Done	
ID09 3rd Chairman	João & Pascal	Choice	Medium	Done	
ID08 3rd Weekly Report	Daniel & Elisa	0.5 h	Low	Done	
ID10 Explore EU Directives	Elisa	1 h	Low	Done	
ID11 Sponge Experiment	João	6.5 h	Low	Done	
Sprint Velocity		**54 h**			**Note: it is that much because many tasks from other sprints got completed here**

Table 17 - Sprint 4 Review

Start: 14th March 2019					End: 20th March 2019
Task Name	**Responsible People**	**Duration**	**Priority**	**Status**	**Notes**
ID20 Defining the target group Field Identification	whole group	4 h	High	Not done	After much discussion the team will ask a teacher for help
Defining the target group & Field Identification	Whole group	2 h	High	Done	
ID19 Principle Research	Marie & Daniel	3 h	High	Done	
ID35 Define Logos & Names	Whole group	3 h	Medium	Done	
ID44 Making and Presenting the Leaflet	Elisa & João	2.5h	Medium	Done	
ID43 System Diagrams & Cardboard Model	Marie & Pascal	4 h	High	Done	
ID42 Presenting Ethical Issues Example	Pascal	2 h	Medium	Done	
ID34 2.3 Competition Analysis	Nacho	2.5 h	Medium	Done	
ID25 Create real Sprint plans	Pascal	2.5 h	Medium	Done	
ID33 Service Idea's for the Solar Dehydrator	Marie	2 h	Low	Done	
ID32 2.1 Introduction Upload	Nacho	3 h	Low	Done	
ID31 2.2 Everything you need to know... Upload	Marie & Daniel	5 h	Low	Done	
ID24 2.4 Possible Features & Components Upload	Pascal & Elisa	3 h	Low	Done	
ID23 1.1 Presentation chapter Upload	Marie	1 h	Low	Done	
ID22 1.2 Motivation chapter Upload	Pascal	2 h	Low	Done	
ID30 1.6 Functional Tests Upload	Daniel	1.5 h	Low	Done	
ID29 Change & Optimize this Backlog	Pascal (till now)	1.5 h	Low	Done	
ID21 Organize the OneDrive	Pascal	0.25 h	Low	Done	
ID28 Update General Gantt Chart	João	1 h	Low	Not Done	Is a continuously tasks
Update General Gantt Chart	João	4 h	Low	Done	
ID27 4th Agenda & Minute	Nacho	Choice	Medium	Done	
ID26 4th Weekly Report	Marie	1 h	Low	Done	
Sprint Velocity		**48.75 h**			**Note: it is that much because many tasks from other sprints got completed here**

Table 18 - Sprint 5 Review

Start: 21st March 2019					End: 27th March 2019
Task Name	**Responsible People**	**Duration**	**Priority**	**Status**	**Notes**
ID20 Defining the target group Field Identification	whole group	2 h	High	Not done	Again, After much discussion the team will ask the marketing teacher for help
Defining the target group & Field Identification	Whole group	2 h	High	Done	
ID50 List of Materials	João & Elisa	5 h	High	Done	
ID46 Making & Choose the Design	Marie & Whole Group	12.5 h	High	Done	
ID48 Materials Comparisons & Choices	Elisa	5 h	Medium	Done	
ID47 Electronic Component Comparisons & Choices	João	5 h	Medium	Done	
ID41 Ventilation & Fan Choice	Daniel	2 h	Medium	Done	
ID28 Update General Gantt Chart	João	1 h	Low	Not Done	Is a continuously task, but nothing done this time
ID55 Setting up Scrum Tables	João	1 h	Low	Done	
ID57 Update Planner	Pascal	1 h	Low	Done	
ID37 5th Chairman	Daniel	Choice	Low	Done	
ID36 5th Weekly Report	Daniel	1 h	Low	Done	
Sprint Velocity		**34.5 h**			

Table 19 - Sprint 6 Review

Start: 28th March 2019					End: 3rd April 2019
Task Name	**Responsible People**	**Duration**	**Priority**	**Status**	**Notes**
ID20 Defining the target group Field Identification	whole group	2 h	High	Done	
ID51 3. Project Management Chapter	Pascal	10 h	High	Done	
ID52 4. Marketing Plan Chapter	Elisa & Nacho	10 h	High	Done	
ID53 5. Sustainability Concerns	Marie	6 h	High	Done	
ID54 6. Ethical Concerns	Daniel	7 h	High	Done	
ID58 Think about new Names & Logos	Whole group	8 h	Medium	Done	
ID40 Organize some Wiki Chapters	Whole group	12 h	Medium	Not done	Continuously doing till the end
Organize some Wiki Chapters	Whole group	2 h	Medium	Done	
ID49 Design Improvements	Marie	3 h	Medium	Not done	Gets lower priority this time. No deadline for it till now
ID67 Make these Sprint Reviews	Pascal	6 h	Medium	Done	
ID39 Upload some Photos of Competition	Pascal	1 h	Low	Done	
ID28 Update General Gantt Chart	João	1 h	Low	Not done	Has a low priority due to no deadline till now....
Update General Gantt Chart	João	2 h	Low	Done	
ID61 Write Conclusion of State of the Art	Pascal	2 h	Low	Done	
ID59 6th Chairman	Daniel	Choice	Low	Done	
ID54 6th Weekly Report	Nacho	1 h	Low	Done	
Sprint Velocity		**57 h**			

Table 20 - Sprint 7 Review

Start: 4th April 2019					End: 10th April 2019
Task Name	**Responsible People**	**Duration**	**Priority**	**Status**	**Notes**
ID69 Make real Interim Presentation	Marie	6 h	High	Done	
ID83 Update Electrical Schematic	João	2 h	High	Done	
ID68 Design New Logos	Nacho & Marie	4 h	High	Done	
ID66 Coating Material Comparison & Choice	Pascal	4 h	High	Done	
ID80 Paste List of Material in PM Chapter	João & Elisa	1 h	High	Not Done	
ID79 Organized Project Development	João, Marie & Elisa	1.5 h	High	Done	
Organized Project Development	Marie & Elisa	1 h	High	Done	
ID78 Update Marketing Conclusion	Nacho	1 h	High	Done	
ID77 Update/Add References in PM Chapter	Pascal	2 h	High	Done	
ID76 Update new Gantt Chart again	João	1.5 h	Medium	Not Done	
ID75 Update 2.2.4 Reasons: references + text introducing topic	Daniel & Marie	1 h	Medium	Done	
ID74 Update 2.2.6 Condensation references + introducing next topic	Pascal	2 h	High	Done	
ID73 Update topic 1.3 Problem & 1.4 Objectives	João	1 h	Medium	Not Done	
ID72 Update Abbreviation table	Elisa	1 h	Medium	Done	
ID71 Update Sprint Reviews (also in PM Chapter)	Pascal	4 h	Medium	Done	
ID40 Update the Introduction Chapters (2.1)	Nacho	1.5 h	Medium	Done	
ID49 Design Improvements	Marie	8 h	Medium	Done	
ID60 Update List of Materials	João & Elisa	3 h	Medium	Done	materials not done (refer to ID80 for next)
ID45 Update Leaflet	Pascal	5 h	Medium	Not Done	After the new logo is made
ID70 Sprint Reviews in PM Chapter	Pascal	3.5 h	Medium	Done	
ID28 Update General Gantt Chart	João	5 h	Low	Done	
ID64 7th Agenda & Minute	Elisa	Choice	Low	Done	
ID65 7th Weekly Report	João	1 h	Low	Done	
ID62 Add Sources to Bibliography	Whole Group	6 h	Low	Done	Goes on until the wiki is completely done
Add Sources to Bibliography	Whole Group	4 h	Low	Done	
Sprint Velocity		Ca. 61.5 h			

3.11 Sprint Evaluations

3.11.1 Sprint Review & Summary

To summarize the sprints keep the length of 5 workdays in a 7-day sprint. Starting from Thursdays and ending on Wednesdays, the sprints have the right start after the supervisors' meetings that are planned every week. In the previous chapter in table 13 you could see how the sprints have gotten fewer classes and more free time to work on the project. However, the actual work that is being done varies from sprint to sprint. Reasons behind this are the lack of knowledge of estimating the right time for certain tasks and some more important tasks that exceeded the boundaries of three sprints and count only in one sprint (Sprint 3). However, efficiency is tending to increase during the past time. That either means the team is improving or the estimations of tasks are done better. *Personally I'd say both*.

Next, there is an own planned scrum meeting every Tuesday. This means the team can review one day before the end of each sprint how tasks are going and if someone needs help finalizing a certain task. Furthermore, the team is involved in everyone's work by seeing the daily stand up notes. In there every member writes what they worked on yesterday, what they are working on today and if they have difficulties working on it.

As seen in the list down below, on a personal and professional level the team is striving towards better performance and behaviour throughout the group. These will mainly be

achieved by keeping open communication towards each other and being open to improvement. Based on that goals the team is doing overall very well in case of personal management.

3.11.2 Scrum Feedback

Stop doing:

- Getting late to supervisors meeting (Meeting 1)
- 2-hour meetings (do not work while a meeting) (Meeting 2)
- Joao: interrupting people (Meeting 2)
- Discuss a bit after the meeting, which comment of the supervisors we will keep in mind and which ones we will care about (Meeting 3)

Start doing:

- De-stressing activity: Try to do a Social Team Meeting (beers, pool, café) every week, trying to talk to each other in another atmosphere apart from the university/project (Meeting 1)
- Look at agenda's and documents that are created to give feedback and suggestions to it. (Meeting 1)
- Keep meetings short & Chairman in the middle! (Meeting 1)
- Just present progress, do not make progress during the meeting (show & tell) (Meeting 2)
- Marie & Elisa: speak up in a full and loud classroom (Meeting 2)
- Daniel: be open & visible with your progress (be vocal about your finishes) (Meeting 2)
- Daily Stand Ups in the Planner/OneNote (Meeting 3)
- Daniel taking leadership if he is assigned to it (Meeting 3)
- Remind each other of the meeting on Tuesdays (Meeting 4)

Keep doing:

- Communication is good. (Meeting 1)
- Meetings are really a good way to have an overview. (Meeting 1)
- Like the work ethics (dividing tasks & getting to work) (Meeting 1)
- Short meetings is nicer (Meeting 4)
- Daily Stand Ups fill in (Meeting 4)

3.12 Conclusion

First of all, the project team itself uses the Scrum approach as a method of working and planning together more agile than in a classical approach. In this current approach, the team is able to communicate more by telling the progress and blocks every day in the daily stand-ups. By dividing the tasks into smaller sections called “sprints” the team can focus on their deadlines on a smaller scale and stay clear minded for the future.

The three biggest subsections of this chapter can sum up the whole chapter. The Scope Definition, Time Management, and Costs Considerations define the other 6 subsections as they are dependent on each other. The scope is easily said the definition of what needs to be done and what won’t be done in order to have the best solution at the end. When talking about time management the team decided to take a very energy costing strategy. This strategy is defined not only by everyone keeping deadlines in mind but also to work and plans ahead of deadlines. Costs are minimized and thoughtfully calculated based on the budget of 100 Euros. Only the material resources and costs will be calculated. The work resources will not be taken into account as mentioned above.

Based on these three defined subsections, the other subsections ***Quality***, ***People***, ***Communication***, ***Risks***, ***Procurement*** and ***Stakeholders Management*** rely on those three others. With the scope, time and costs defined the overall quality measurements and definitions are clearer. It will not be the most qualitative product of all because the time is only a semester, the scope is pretty full with extra deeds to be done that are coming from other branches. Having only 100 Euros as a budget really cuts down to the quality as well. As many people know, the more financial opportunities you have the better you can think of more specific and qualitative precise components and materials.

So finally looking back the project management is done in a new agile way of working. You can take one of the six chapters and argue the management style based on the first three subsections of the project management.

In the next chapter, the approach to the Marketing plan for this project will be discussed.

4 Marketing Plan

4.1 Introduction

This part of the report focuses on the importance of marketing as an essential part of the business world.

As a brief definition, Marketing is the discipline responsible for studying the behavior of markets and the needs of consumers. Analyze the commercial management of companies in order to attract, capture, and retain the final customers through the satisfaction of their desires and the resolution of their problems.

Throughout this chapter, the team will show our marketing plan, starting with the realization of market analysis, SWOT (Strengths, weaknesses, Opportunities and threats) analysis and defining our strategic objectives, segmentation, positioning, and strategy. To finish, information about the budget and the control strategy will be given.

4.2 Market Analysis

The market analysis is used to analyze the environment of the company and to find about the strengths, weaknesses, opportunities, and threats (see SWOT Analysis) to create/reinforce the strategy used. The market analysis is composed of three smaller analyses:

1. Analysis of the macro-environment
2. Analysis of the meso-environment
3. Analysis of the micro-environment

These three analyses can be summed up in Figure 15 :

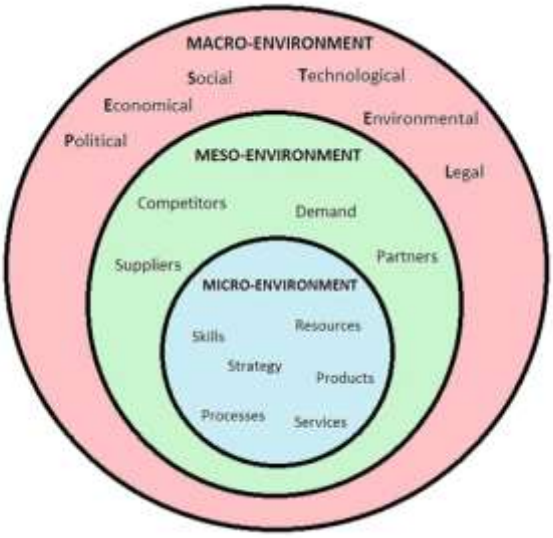


Figure 15 - The three environments

In this project, the team will only do the macro-environment analysis and the micro-environment analysis.

4.2.1 Macro-Environment Analysis

To do the analysis of the macro-environment, the team used the PESTEL Analysis (Political, Economic, Social, Technological, Environmental and Legal), a tool to understand market growth, to evaluate the opportunities and threats of the external environment of the company. Table 21 shows the different factors of the macro-environment that make an impact on the company. These factors can be divided into **Opportunities** and **Threats** and sorted into the six criteria of the PESTEL Analysis.

Table 21 – PESTEL Analysis

List of factors	Opportunity	Threat
Use of renewable technology (solar) and low power consumption, low-cost drying, can emotionally touch people who are active for the environment	Environmental, Economical, Social	
Competition: clients buying already dried fruits would make the dehydrator useless (ex: Fruut) but also simply buying a dehydrator from another company		Economical
Use of solar energy which means no problems in terms of politics or laws (ex: no taxes on polluting and non-renewable energies)	Political, Legal	
Technology "less" advanced that might not interest people who simply want efficiency (ex: electrical dehydrators)		Technological

The opportunities are in the environmental, economic, social, political and legal fields. The use of renewable technology and low power consumption is an opportunity as it doesn't use any fossil energy. This makes the drying low cost. As it is eco-friendly with the use of the sun as a power source, it can emotionally touch people who care and are active for the environment. These three opportunities can be sorted in the environmental, economic and social fields. The use of solar energy means that the product won't be troubled by any environmental laws or politics. There won't be any taxes on polluting or non-renewable energies either. This makes opportunities in the political and legal fields. Despite all these opportunities, there are also threats to the project. The renewable energy market is a growing one but that also means there is growing competition, and this competition can be quite important. Companies selling dried fruits or other dehydrators companies, whether they sell electrical or solar dehydrators are a threat. Electrical dehydrators are a threat because even if the team is part of the solar dehydrators market, it is also part of the broader dehydrators market. Because of that, it is an economic threat. Finally, linked to the previous point, as the drying technology is "less" advanced than for electrical dehydrators, our product might not interest people who just want efficiency. It is a technological threat.

4.2.2 Micro-Environment Analysis

For the analysis of the micro-environment, Porter's five forces analysis was used. It is a tool to analyze the competition of a market. Figure 16 represents the five forces of Porter.

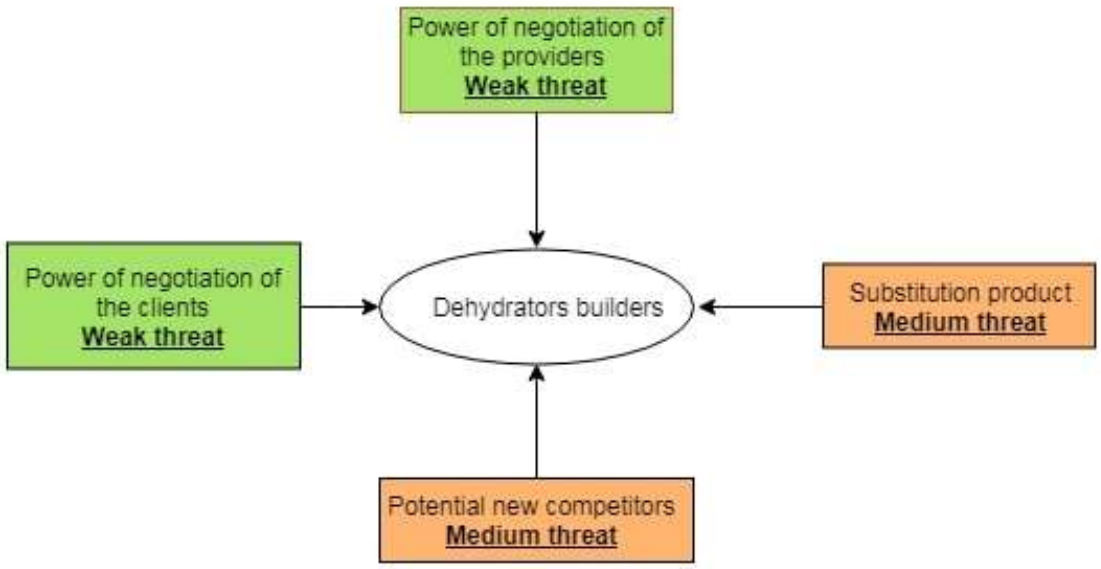


Figure 16 - The five forces of Porter

- Power of negotiation of the providers (Weak):

The components used to make the solar dehydrators are all or almost all quite simple and cheap. It is made of mostly wood, transparent glass, and a few electronic parts. Because of that, no provider is essential or anything like that, so their power is low.

- Power of negotiation of the clients (Weak):

The clients of this type of product isn't especially demanding as the product is quite simple and easy to use. There is also maybe not even a need for after-sales service. The only thing needed is that the product dry food.

- Substitution product (Medium):

As the product is using solar energy, it might not be as efficient as dehydrators using other energy sources like electricity. Because of that, the clients targeted should be those interested in saving money and those emotionally touched by the fact that it is an environment-friendly product. Despite that, it still means a loss of potential clients.

- Potential new competitors (Medium):

Solar, and more broadly, renewable energy, the industry is becoming quite an important field because of nowadays environmental concerns. That means that more and more companies are interested in that field because it can bring profit. More companies interested means more competition.

- Rivalry in the dehydrators market (High):

The rivalry in the dehydrators market is quite high. There are a lot of competitors such as Excalibur, Sedona, Stöckli Dörrex for the electrical dehydrators but also Clipsol, Zefiro, Kascade for the solar ones. The rivalry is one of the most threatening aspects of this market.

4.3 SWOT Analysis

The SWOT Analysis is the analysis of the Strengths, Weaknesses, Opportunities, and Threats of the company/product based on an internal and an external diagnostic. The internal diagnostic helps in analyzing the strengths and weaknesses of the company/product itself while the external diagnostic helps in analyzing the opportunities and threats of the outside environment. The SWOT Analysis is done from the macro-environment (see *4.2.1*) and the micro-environment (see *4.2.2*) analyses. With these two analyses, the following SWOT Matrix was created (Table 22):

Table 22 - SWOT Matrix

	STRENGTHS	WEAKNESSES
INTERNAL DIAGNOSTIC	Focusing on renewable energy (solar). Can influence two markets: the more "closed" market of solar dehydrators and the broader one of the dehydrators in general. Use of quite advanced technology for sensors and mechanisms that other solar dehydrators don't usually have.	Despite influencing two markets, the product is at a disadvantage for the dehydrators in general
	OPPORTUNITIES	**THREATS**
EXTERNAL DIAGNOSTIC	Growing demand for products using renewable energy and having low power consumption. Ecological, making it emotionally touching for people. Unaffected by laws and politics which punish polluting and non-renewable energy	Quite a strong and growing competition. "Better" technology exists for drying in terms of efficiency

This table shows that the strengths are mainly the use of renewable energy, the use of sensors and the fact that the product can influence two markets. The weakness linked to that is that even if the product influence two markets it is clearly at a disadvantage against electrical dehydrators for people who only want efficiency. The opportunities and threats are as seen above in the *Macro-Environment Analysis*.

4.4 Strategic Objectives

When designing a good marketing plan, in order to achieve the planned objectives, it is advisable to follow any of the existing methods, in order to set strategic objectives; One of those methods is the SMART method. SMART is an acronym for Specific, Measurable, Realizable, Realistic and Timely.

When the team speaks of SMART, it refers to the following types of objectives:

• **S**pecific:

- Define the goal as much as possible with no unclear language.
- **WHO** is involved, **WHAT** the team wants to accomplish, **WHERE** will it be done, **WHY** are we doing this (reasons, purpose), which constraints and/or requirements does the team have?

In the definition of objectives, it is essential to detail and specifies as much as possible, so that it may be useful to consider sub-objectives that specify and reinforce the main objective.

• **M**easurable:

- Can the team track the progress and measure the outcome?
- How much, how many, how will the team know when our goals are accomplished?

This characteristic is one of the most relevant factors in the processes of continuous improvement and quality. The objective must conform to feasible measurement criteria.

• **A**ttainable/**A**chievable:

- Is the goal reasonable enough to be accomplished? How so?
- Make sure the goal is not out of reach or below standard performance

The objectives have to adjust to the reality of the person and their environment so that they are challenging but without unrealistic expectations. If you want to achieve your goal, you must assume your current situation, knowing the existing talent and limitations.

• **R**elevant:

- Is the goal worthwhile and will it meet your needs?
- Is each goal consistent with the other goals the team has established and fitted with your immediate and long term plans?

Raise the objective according to the result to be achieved, establishing it in positive. If the team wants to set a goal, it is important that by putting awareness in it, suppose the desired result, not something disposable.

• **T**imely:

- Your objective should include a time limit. Ex: The team will complete this step by month/day/year
- It will establish a sense of urgency and prompt you to better time management.

Finally, as indicated above, this goal must have a moment of realization, in a future and desirable scenario.

Figure 17 - The SMART Goals *[40]*

Getting SMART objectives from both you and your team ensures that your employees are committed to the results of the organization and their own professional development. Be careful in its approach and allocate the appropriate time and attention is the way to get it.

According to the project, the team main objectives will be:

- Creating the final prototype before 30 of June.
- Creating a website for the brand and advertising and promoting through social media.
- Start our production with 15 Solar Dehydrator units.
- Unordered List ItemSell 15 units during the first/two year.
- After the first year, the team will sell under demand. Just in Time production.
- Expanding DryFoo sells in the rest of European countries.
- Develop and produce a solar panel in order to decrease our costs and increase the team income and to create a new range of business.

4.5 Segmentation

Market segmentation is the process of dividing a market of potential customers into segments, or groups based on different characteristics. The segments created are composed of consumers who will respond similarly to marketing strategies and who share traits such as similar interests, needs, or locations. In dividing or segmenting markets, researchers typically look for common characteristics such as shared needs, common interests, similar lifestyles or even similar demographic profiles. The overall aim of segmentation is to identify those segments that are likely to be the most profitable or that have growth potential.

Many different ways to segment a market have been identified. Business-to-business (B2B) sellers might segment the market into different types of businesses or countries. While business to consumer (B2C) sellers might segment the market into demographic segments, lifestyle segments, behavioural segments or any other meaningful segment. **[41]**

Figure 18 – Segmentation [42]

4.5.1 Geographic segmentation

Geographic segmentation creates different target customer groups based on geographical boundaries. Because potential customers have needs, preferences, and interests that differ according to their geographies, understanding the climates and geographic regions of customer groups can help determine where to sell and advertise, as well as where to expand your business.

In the geographic plane, the product will be focused mainly towards the countries with the greatest number of annual solar hours, because the main source of energy is solar energy. The image refers to the European map divided by colors in relation to the solar hours in each region / area. Mainly, the sale of our product will be focused on countries with the greatest number of solar hours per year, such as: Portugal, Spain, France, Italy, Malta, Turkey and Greece.

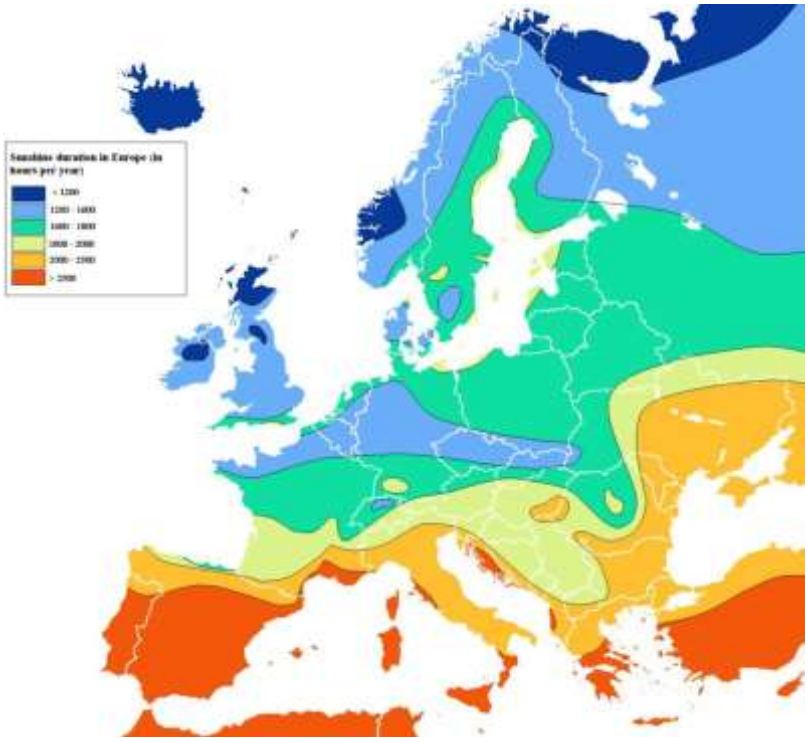


Figure 19 - Annual solar hour zones in Europe [43]

Since the project is being carried out in Porto, Portugal, the beginning of sales will focus on the two main cities of Portugal: Lisboa, the capital of the country, and Porto. Over time, the sales results in these two cities will be analyzed periodically and in this way the decision will be made to go one step further: to expand sales to the rest of European countries with the highest number of solar hours per year.

4.5.2 Demographic segmentation

Demographic segmentation sorts a market by demographic elements such as age, education, income, family size, race, gender, occupation, nationality, and more. Demographic segmentation is one of the simplest and most commonly used forms of segmentation because the products and services the people buy, how the people use those products, and how much the people are willing to spend on them is most often based on demographic factors.

The main objective, as the team has said before, as destination of sale of our product is Portugal, later the team would try to expand to the rest of Europe. For the demographic segmentation to make sense, it is necessary to study both the level of wealth at European level and population density per country. Given that the product has specific characteristics (manufacturing, components and design, among others) the team will have to take into account the two factors to be studied: level of wealth and population density.

As Portugal is the country in which the team are developing the project, it will be the country in which we launch the product to the market. Due to the population density of Portugal, Lisbon and Porto are the main target cities for the sale of our solar dehydrator. In the following image you can see the population density depending on the area of Portugal. Logically, Lisbon, the capital, is the city with the highest population density followed by Porto, the second city in the country, in terms of size, located in the northern part of the country.

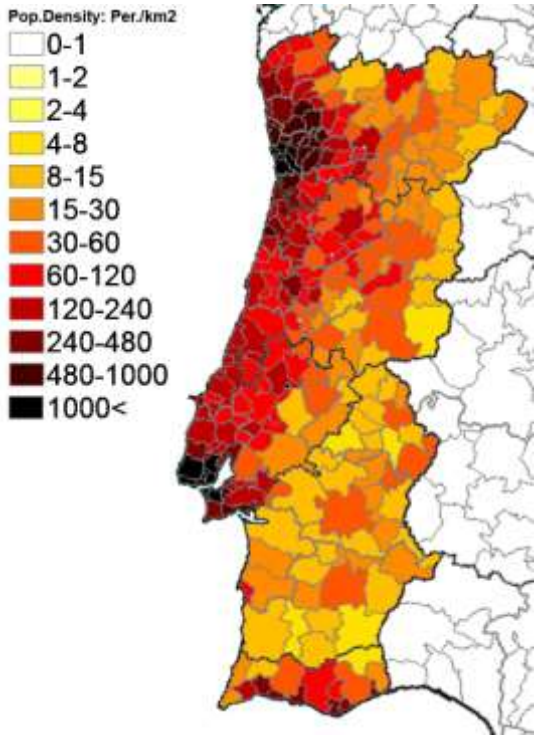


Figure 20 - Population density in Portugal *[44]*

The level of wealth is another factor to take into account when taking the next step once the sale of the product is “consolidated” in Portugal. The solar dehydrator is a product that reunites high quality characteristics: electronics, systems, design and production, therefore the product will be focused on people with a medium-high level of acquisition. Although the main objective of the sale outside Portugal is the countries with more hours of sunshine per year, the level of wealth in the European countries is a very important data for future positioning of our product. In the following image you can see the level of wealth at European level:

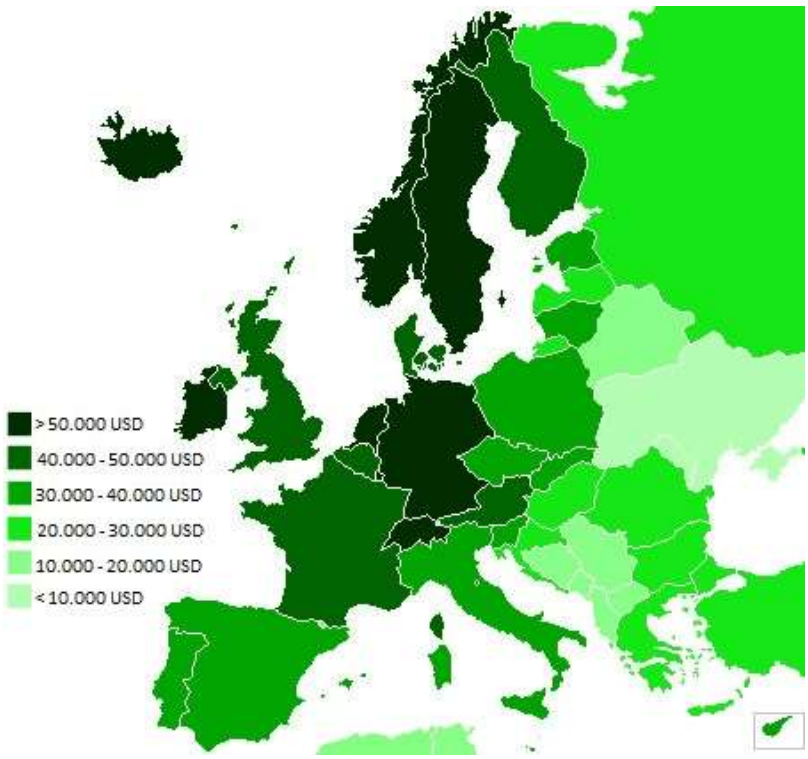


Figura 21 - Wealthness level in Europe [45]

4.5.3 Behavioral segmentation

Behavioral segmentation divides markets by behaviors and decision-making patterns such as purchase, consumption, lifestyle, and usage. For instance, younger buyers may tend to purchase the body wash, while older consumer groups may lean towards soap bars. Segmenting markets based on purchase behaviors enables marketers to develop a more targeted approach.

The team sells the solar dehydrator to people who like to be more sustainable and healthy without giving up some comfort. People would like to know more about where the food comes from and try to eat more seasonal, local and fresh food. Next, to this, people should love to be more independent of the food market but without spend that much time on it, because people have a busy life. This idea should result in a small

scaled solar dehydrator to use at home. So the team has to keep in mind that the target group should feel attracted to the product.

Additional to this, the team has the idea to expand the scale of our product so the team can sell it to urban farms. In this case, the individual consumer will buy already dried food and the urban farmers should maintain the solar dehydrator. The difference with an urban farm is that you can harvest your own food, people are responsible for the growing process. The difference with a community garden is that the company gives people access to a piece of land so people don't have to think about the facilities [46].

4.5.4 Psychographic segmentation

Psychographic segmentation takes into account the psychological aspects of consumer behavior by dividing markets according to lifestyle, personality traits, values, opinions, and interests of consumers. Large markets like the fitness market use psychographic segmentation when they sort their customers into categories of people who care about healthy living and exercise.

On the one hand, regarding psychological segmentation, as well as the product promotes sustainability and the use of renewable energies, such as solar energy, it is a product committed to the environment, eco-friendly, the main objective is the people positioned on the side of the environment, the fight against climate change, people who want a “greener” world, women and men with an Eco-friendly mentality.

On the other hand, our product is also aimed at people who care about their health and physical condition, since the objective of our Solar Dehydrator is to eat fruit in a different way, as a snack, while maintaining the original flavour of the fruit. Furthermore, our product helps on prolonging the life of the food, since extracting the water and moisture from the fruit to prevent the bacteria from reproducing, therefore, helping to preserve the fruit in good condition. [47]

4.6 Strategy/Positioning

For the strategy and positioning, the team analyzed what the state of the competition was by making a competition mapping (Figure 22). It was based on some criteria that have been judged to be the most important: price, size, efficiency and economical or not.

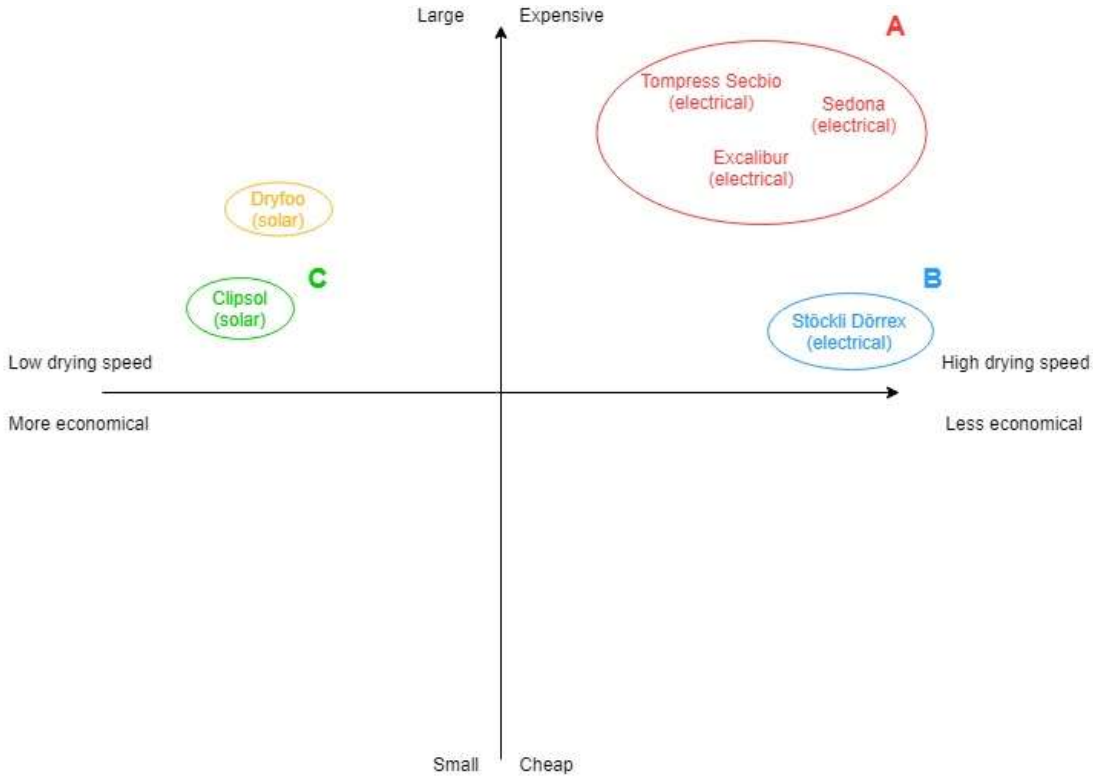


Figure 22 - Competition Mapping

This mapping has been realized using data of 5 different types of dehydrators. The efficiency has been evaluated comparing the drying time of an ananas slice of around 5 mm for each dehydrator. The prices and drying times for those dehydrators are as follow:

- Tompress Secbio: 390 € and 24 h
- Excalibur: 340 € and 16 h
- Sedona: 380 € and 10 h
- Stöckli Dörrex: 240 € and 10 h
- Clispol: 250 € (no information on the drying time but it is naturally higher because this dehydrator uses solar energy)

Three different types of dehydrators divided into three groups can be observed. Group A is composed of the electrical dehydrators that are very efficient but also quite expensive. Group B is constituted of the electrical dehydrators that are less expensive but smaller and also very efficient, group C is composed of solar dehydrators that are less efficient than electrical dehydrators but more economical. This map shows two points about the market. First, most dehydrators are electrical, and second, non-electrical dehydrators are generally quite expensive, and whenever they are cheaper than Dryfoo, they are often sold in kits and look very handmade with no technology at all inside. The team's product compared to the solar dehydrator of group C is more expensive because of the use of technology that the other dehydrator lacks. It also dries food faster thanks to the addition of the fans.

4.7 Adapted Marketing-Mix

The marketing-mix is based on the method of the 4 P's (Product, Price, Promotion and Place) as represented in Figure 23:

Figure 23 - The 4P's of Marketing-Mix [48]

In this subchapter, each "P" is analyzed concerning the team's product proposal:

- **Product:** The product will allow the user to dehydrate all kind of food in an ecologic way while being automatic, and will also possess an interface with which the user can interact. This way, the user can see the current temperature and humidity and adjust them if he/she wants to.
- **Price:** The exact price of the product is not known yet, but the budget for the prototype is 100 €. The team needs to consider all production costs for the final product, thus the final price of the product may be around 300 €.
- **Place:** The product can be bought on the company's website. It will be available in Portugal first but selling in Spain is also considered for the near future.

- **Promotion:** The team will mainly use, for now, social media, like Facebook or Instagram and the website.

4.8 Budget

Advertisement is an important part of marketing because it raises the awareness of people towards the product. As such, the team must think about the budget it is willing to use in such promotion. Table 23 sums up the marketing budget.

Tabela 23 - Marketing Budget

Expense	Budget (€)
Leaflet	600
Poster	200
Online Advertising	2000
Professional Website	1000
Social Media	1200
Total	5000

4.9 Strategy Control

The control and evaluation of the strategy consists of measuring the impact that the planned actions have had. This process helps the company to know and analyze if the proposed planning is really directing the organization in the right direction.

This contemplates two important phases: supervision and then the study of the results. Controlling a strategy involves verifying that the planned actions are being carried out, that the plan is followed. In this way, the results can be measured in the light of relevant data. It is logical to think that, if the team does not carry out in a methodical way the steps ordered by the strategic planning, the team will not be able to know later if the design works or not.

For its part, the evaluation of the strategy gives a clear picture of what happens with the company. It tells what is happening with the organization and where it is going. Also, it allows to carry out corrective actions in the case of being necessary. It could be said that the control phase is more oriented towards immediate action thanks to supervision; while the evaluation serves to gather information, and then plan actions that improve the company's future.

An effective control strategy is the PDCA cycle or the Deming cycle, which is a continuous quality improvement strategy in four steps: **P**lan, **D**o, **C**heck and **A**ct.

- **Plan:** Plan ahead for change. Analyze and predict the results.
- **Do:** Execute the plan, tanking small steps in controlled circumstances.
- **Check:** Check, study the results.
- **Act:** Take action to standardize or improve the processes

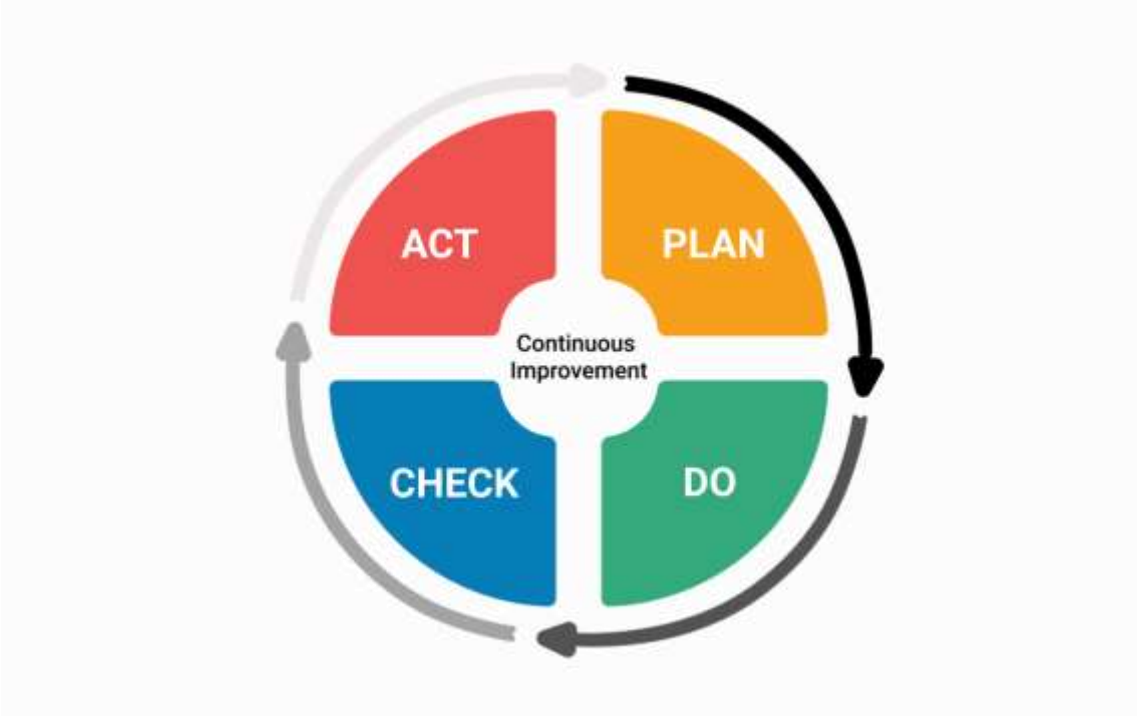


Figure 24 - Deming Cycle [49]

The results of the implementation of this cycle allow companies to comprehensively improve competitiveness, products and services, continuously improving quality, reducing costs, optimizing productivity, reducing prices and increasing market share. profitability of the company or organization.

The control and evaluation of the strategy is an equally important step as the planning itself. If the team considers that planning is the process that allows us to guide, then its control and evaluation tells if the team is heading to success or failure. That companies have a promising future depends directly on the actions that have been planned for that purpose. Therefore, it is essential to know if the right decisions were made, if the business environment has changed in such a way that the strategy is not adjusted to reality. Similarly, understand if the people are on the right track and there is the possibility of taking more and new opportunities.

4.10 Conclusion

Based on the macro-environmental study the team can identify the different factors that will have an impact on the company, dividing them into opportunities and threats. After the micro-environmental analysis, the team has clear the competence in the market as

well as the possible power of negotiation with customers, suppliers and the existing competition. Thanks to the two previous analyzes, the team has been able to carry out a complete SWOT analysis, which has helped to identify the strengths and weaknesses from an environmental point of view so that the team can know our opportunities and take advantage of them.

In the strategic part, the team has worked with the SMART method to define the objectives in a precise way and to enter effectively in the market. Through this analysis the team has been able to make the segmentation of the consumers and in this way to be able to define our target group.

Consequently, the team has created DryFoo, a sustainable Solar Dehydrator that respects the environment by using solar energy as a source of energy and transforming it into heat which helps to dehydrate the fruit so that the conservation of it is more long-lived, without losing the nutritional properties and maintaining the flavor original of the fruit. All this is achieved by designing a product with the equipment and the necessary system to control fundamental parameters such as temperature, air flow and air density.

In the next chapter the team will talk about the necessary measures to take into account in such a way that the product, DryFoo, adapts to the fundamental needs to contribute with sustainability and try to help the planet with, for example, the reduction in the energy consumption.

5 Eco-efficiency Measures for Sustainability

5.1 Introduction

Our planet is running out of resources. On Planet Earth many people live together and all of them have different needs and habits. At this moment, the way in which these needs are fulfilled is too harmful to the Earth. Sustainability helps to satisfy the needs of the present without damaging the planet and doesn't restrict the next generation in meeting their own needs.

Preserving food is a human need that has existed as long as humanity. There are different ways to preserve food for a long period. The most common way is freezing. This process requires constant electricity supply so it consumes a lot of energy. Another way to preserve food is by drying it, for example with a dehydrator. In comparison with freezing, this storage technique is much more energy efficient. Only the drying process uses energy. Once the food is completely dry, it can be easily stored without any further energy consumption. Moreover, it is possible to use green energy resources to supply the dehydrator of energy. That is what the solar dehydrator does. It is an energy efficient product that uses the sun to dehydrate the food. Additionally, the dried food is easily storable in an airtight jar. This is positive for the energy consumption during transportation because it doesn't require any special infrastructure like for example a cooled truck. Furthermore, dried food is more compact than fresh food so the amount of food that fits in one truck is higher than with fresh or frozen food.

Nevertheless, sustainability is more than just reducing energy consumption. The World Summit on Social Development identified three pillars that contribute to the philosophy and science of sustainable development. Those three pillars are environmental development, economic development, and social development. [50] In this chapter, we discuss them and point out how we believe our project contributes for these pillars. After this, the whole life cycle of our product is described.

5.2 Environmental

Environmental sustainability is about protecting the environment on different aspects.

One of the aspects is the regulation to prevent pollution and to keep carbon emissions low. DryFoo works almost completely on renewable resources. The radiation of the sun is being used to create heat inside and to induce electricity by using a solar panel. This electricity drives the fan and the arduino so that the conditions inside the cabinet can be automatically controlled. If the sun is not shining, a small battery supplies the system of energy so that the drying process can continue.

Another aspect is to reuse, reduce and recycle materials and resources as much as possible. All the construction materials are recyclable. The Arduino, fan, and sensors are components that can be reused. Consequently, all the components should be easy to remove to make recycling, reusing or repairing possible. This is considered during the design process.

5.3 Economical

The general definition of economic sustainability is the ability of an economy to support a defined level of economic production indefinitely. The world's nations presently define their top economic goal in terms of Gross Domestic Product (GDP). This is the total amount of products produced within a nation, usually within one year [51] .

This results in an economic system where producing new products, services and technologies are one of the most important concerns. The current system is more focused on producing new things instead of wondering if it is needed or not. This mindset has a bad effect on the planet, like too much pollution and scarcity of resources. Economic development helps to encourage businesses to adhere to sustainability guidelines beyond legislative requirements. It is up to politics to define these guidelines, rules, and laws. Those guidelines and rules have to be preventive and not curative. For example, a company that has to pay for the extra CO2 emission that it has produced is a curative guideline. This is good for the economy but still harmful for the environment because the pollution isn't reduced.

DryFoo has a low impact on the environment. It is made out of locally produced materials from local suppliers. The selections of suppliers is a well-considered choice. Before making an agreement, the team will check if they really care about sustainability. This way, Besol don't burden the environment indirectly.

5.4 Social

A first aspect of social development is the awareness to protect people's health and wellness from pollution and other harmful activities. DryFoo contributes to this in the next two ways:

Natural materials and coatings

To be sure that the food doesn't become polluted, natural materials and coatings are used. So that when the temperature rises inside, possible harmful fumes will be prevented.

Improve the quality of food

The solar dehydrator produces dried food which has a large number of vitamins, fiber, mineral, and carbohydrates. The drying process also reduces the amount of fat in the food. Solar dehydrator improves the quality of the food and contributes to the user's health.

Another aspect of social development is education. This includes encouraging people to participate in environmental sustainability. This can be reached by giving people what they want without compromising the quality of life. The main need for the target group of DryFoo is to live a healthy life without much effort. To fulfill this demand, a satisfied feeling needs to be created. The solar dehydrator will give the user two different types of satisfaction. The first one is a feeling of independence when the user eats his self-made snack by only using the sun. To optimize this feeling Dryfoo is automatically controlled. Whereby, the user should not put a lot of effort to receive a good result. The second type of satisfaction is the feeling of being healthy and good for the planet. Dried food is a healthy snack and it feels even much healthier when it is completely dried on solar energy.

5.5 Life Cycle Analysis

Figure 25 is a schematic overview of the life cycle of a product. Each product goes through all this stages. The idea behind this scheme is that each stage can be accomplished by working on the result of the previous stage. So that all the materials and resources can circulate as long as possible. In the next paragraphs, each stage of the life cycle of DryFoo is clarified.

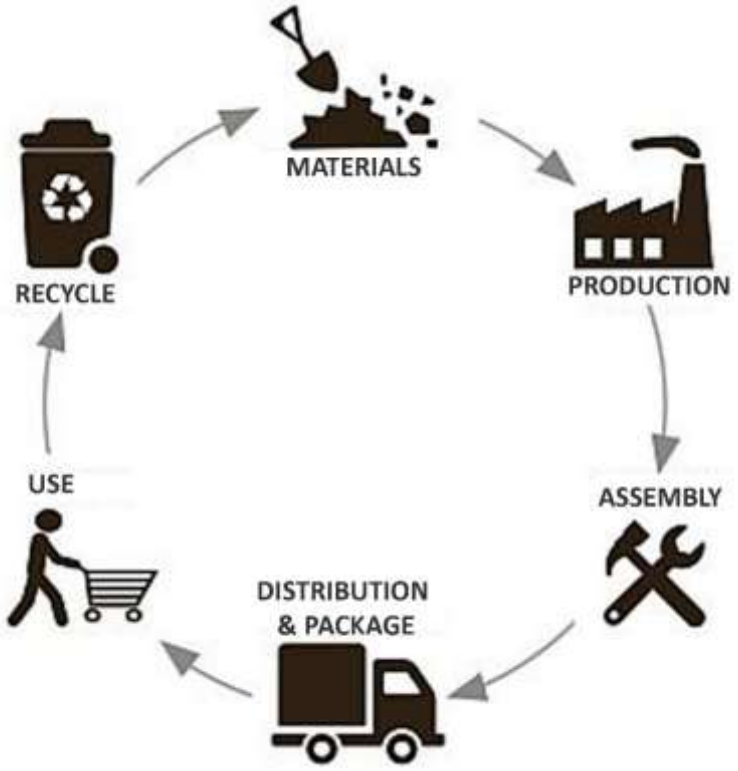


Figure 25 – Life Cycle

Materials

DryFoo is for around 90% made out of maritime pine wood. This is a type of pine wood native to the Mediterranean region. It is a natural and recyclable material, a good insulator, easy to clean and bendable. Glued wood types (ex. plywood, MDF, softboard, etc.) are most of the time cheaper but they can only be recycled as fuel for energy generation. So massive wood fits better in the life cycle idea than plywood because it is completely recyclable and it is possible to make new products out of it. Even if maritime pine wood is protected by some paint or oil it stays entirely recyclable. For the reason, that the percentage of paint and oil is negligible according to the volume of the wood. To keep the wood as natural as possible, natural oils and eco-friendly black paint is used to finish it. In the range of massive wood types, maritime pine is one of the best options because of the properties. It is quite easy to work with machinery or hand tools and it allows a good finishing. It holds mechanical fasteners well and glues easily [52].

Additionally, it represents 30% of the Portuguese forest so it is a local material and also generously present [53].

Production

DryFoo has three bendable parts. Two of them are made out of wood. The other part is the transparent side made out of PVC. To bend these two materials, energy efficient production techniques are used. Before bending, the parts need to be cut out of a sheet. To minimize the waste of materials, the parts are optimal arranged on one sheet. This also applies for the unbent parts. After cutting, the parts can be folded or further detailed.

Assembly

To reduce costs and waste, it is critical that the product can be assembled unambiguously and correctly. If there are several ways to assemble it, the chance on errors is bigger. This can result in more material waste and working hours costs. To prevent those disadvantages, groves and holes are provided in each part so that the product can be assembled quickly and just in one way. Though this results in more production steps during the production, it should decrease the costs and for sure the amount of waste. Additionally, it is also meaningful to think about design for disassembly. To attach different parts made out of the same materials, glue and screws are used. Parts made out of a different materials are only fastened by screws. This way, each material can be properly sorted for further recycling.

Distribution & package

DryFoo will be launched first in Portugal. Later on, the company shall sell their products in Spain as well. Besol is a small and local company which aims to keep their carbon emission low by using green resources and vehicles. DryFoo will be packed in strong cardboard produced in Portugal. Cardboard is a perfect material to protect the product during transportation. The package is designed in such a way that it should be easy to store without using too much space. Besol provides products that are totally produced in Portugal made out of local materials.

Use

Due to the fact that DryFoo works with green resources, it has almost zero energy consumption. The only cost during use is eventually a new battery or a broken component. It is beneficial that the product can be repaired easily. All the components must be easily removable so it can be quickly replaced without harming the product. To make this possible, all the vulnerable components are hidden in a resealable space so

access is simple. Furthermore, everything must to be easy to clean. This is necessary to keep the food clean and bacteria free. The user can find more information in the manual about how to maintain the product well for a maximal lifespan.

Recycle

It is essential to keep the recycle process as accessible as possible. Otherwise, the user will lose his patience and slack the thoroughness of it. To ensure this, DryFoo is made out of the same material as much as possible. The single parts made out of a different material are easy to separated from each other after use. This way, it is evident to sort all the materials quickly. Additionally, the manual is provided with a topic about how to recycle the product the right way. Because only a small percentage of users reads the manual, every part has a mark with the type of material.

5.6 Conclusion

Society is facing many challenges associated with our modern consumer lifestyle; the growing numbers of people on the planet, security of food supply, clean water, and power among the greatest. It is demonstrated that several key factors need to be considered and appropriately addressed to achieve overall sustainability for human activity and development. This project implement these key factors as much as possible.

In the first place, dehydrating food is a sustainable way to preserve food. The solar dehydrator dehydrates food by using renewable energy resources. Besides the product itself, saves the outcome energy as well. Dried food is more compact and don’t need special facilities during transportation. So the whole dehydrating process is energy efficient and less polluting. With DryFoo it becomes easy to complete this dehydrating process. The conditions inside are automatically controlled so the user will get an healthy snack without that much of effort. This gives the user a satisfied feeling so much that they get convinced to participate in environmental sustainability.

In the second place, DryFoo purpose to close the life cycle perfectly. DryFoo is largely made out of maritime pine wood which is a natural and excellent recyclable material. By using the same material as much as possible, the recycling process becomes more accessible. The few parts made out of a different material are fixed to each other by screws. This way, it is effortless to separate all the different materials for further recycling. Not only recycling but also reusing is crucial. To ensure that components like the arduino or fan can be reused and repaired, they are hidden in a resealable space so access is simple. Another important ambition is to avoid material waste. All the parts are cut out of sheets. Arranging them smartly on the sheet contributes to less waste. Next to this, there

is just one way to assemble all the parts so the chance on errors is smaller. Less errors means less waste and working hours costs.

Finally, Besol intend to stay local and keeps there carbon emission low. DryFoo will be launched first at Portugal and later on in Spain. The products shall be transported in a package made out of cardboard produced in Portugal. Just like the cardboard, are all the others parts of DryFoo locally produced and provided by local suppliers.

6 Ethical and Deontological Concerns

"It takes less time to do things right than to explain why you did it wrong." - Henry Wadsworth Longfellow

6.1 Introduction

In this chapter, we will present five main ethical and deontological concerns. These are ethical issues on engineering, sales and marketing, academic concerns, environmental impacts, and liability. It is essential to pay equal attention to every principle. These ethical concerns must be respected in order to provide the highest quality to our customers, to protect our environment and to maintain our reputation and reliability.

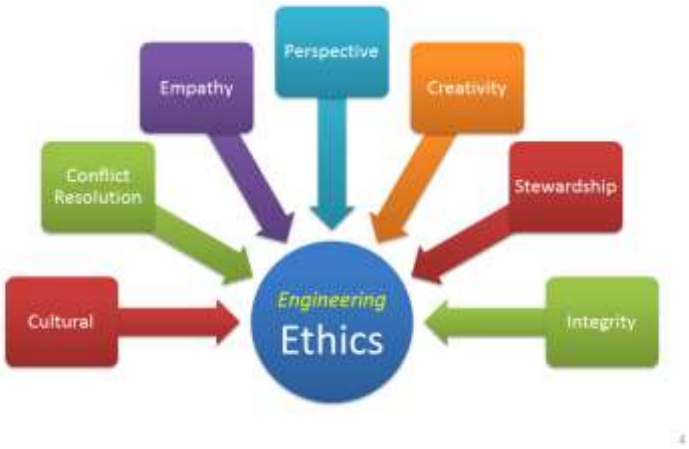


Figure 26 - Ethics in Engineering **[54]**

6.2 Engineering Ethics

General principles **[55]**:

1. Engineers shall hold paramount the safety, health, and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.
2. Engineers shall perform services only in areas of their competence.
3. Engineers shall issue public statements only in an objective and truthful manner.
4. Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.

5. Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others.
6. Engineers shall act in such a manner as to uphold and enhance the honor, integrity, and dignity of the engineering profession and shall act with zero-tolerance for bribery, fraud, and corruption.
7. Engineers shall continue their professional development throughout their careers, and shall provide opportunities for the professional development of those engineers under their supervision.
8. Engineers shall, in all matters related to their profession, treat all persons fairly and encourage equitable participation without regard to gender or gender identity, race, national origin, ethnicity, religion, age, sexual orientation, disability, political affiliation, or family, marital, or economic status.

6.3 Sales and Marketing Ethics

Ethical sales and marketing, or simply ethical marketing practices, isn't really a marketing strategy. It's more a school of thought that guides marketing efforts. Through sales ethics and ethical marketing, responsibility, fairness, and honesty are promoted. Of course, this is a difficult subject to tackle because it is highly subjective and everyone has slightly different ideas of what constitutes right and wrong. Because of that, ethical marketing isn't so much a rule system as it is a system of guidelines.

Figure 27 - Bussiness Ethics[56]

There are eight principles of Ethical Marketing [57] :

1. The common standard of truth will be observed in all forms of marketing communication.

2. Personal ethics will guide the actions of marketing professionals.
3. Advertising is set apart from entertainment and news and the line is clear.
4. Marketers will be transparent about who is paid to endorse their products.
5. Consumers will be treated fairly, depending on who the consumer is and what the product is.
6. Consumer privacy will be respected and upheld at all times.
7. Marketers will comply with standards and regulations set by professional organizations and the government
8. Ethics should be discussed in all marketing decisions in an open and honest way.

6.4 Environmental Ethics

Environmental ethics refers to the moral relations between human beings and their natural environment. More specifically, it refers to the value that mankind places on protecting, conserving, and efficiently using resources that the earth provides [58].

We will try to apply the following points to our solar dehydrator:

- Maximum efficiency with a minimum energy consumption
- The materials must be environmentally friendly
- Reaching the highest possible product lifetime

6.5 Liability

For this project we have to take into account the following EU directives concerning liability during the development of the product:

- **Machinery (MD):** Concerns the danger the machine could have on humans: explosions, vibrations, radiations, getting your finger stuck, airborne hazardous substances, force limits for machinery operation, the minimum distance to be safe, etc. [59].

- **Low Voltage (LVD):** Covers health and safety risk on electrical equipment with an input or output voltage of 50 and 1000 V for alternating current and 75 and 1500 V for direct current [60].

- **Restriction of the use of certain Hazardous Substances (RoHS):** Forbids the use of Lead, Mercury, Cadmium, Hexavalent chromium, Polybrominated biphenyls, Polybrominated diphenyl ether, Bis(2-ethylhexyl) phthalate, Butyl benzyl phthalate, Dibutyl phthalate, and Diisobutyl phthalate [61].

- **General Food Law:** Covers all stage of food and feed production and distribution, that is to say: feed production, primary production, food processing, storage, transport, and retail sale. It explains the principal requirements and procedures when making a decision in matters of food and feed safety **[62]**.

- **Food Safety:** Assures control systems and evaluates compliance with EU standards in the food safety and quality, animal health, animal welfare, animal nutrition, and plant health sectors **[63]**.

6.6 Conclusion

There are no more important or less important principles, we have to pay attention to all of them. These ethical concerns must be respected in order to provide the highest quality to our customers, to protect our environment and to maintain our reputation and reliability. Ethics is important to bring the maximum good or benefit to society and to the enterprise as well. The ethical code of ethics can improve the quality of working and can secure the public interest. An insurgency in ethics is expected to uproot the effective ethical selfishness that justifies the market as the prevalent basic leadership device in our general public. We hope that these rules will help us to make our ideas profitable and reach our desires.

7 Project Development

7.1 Introduction

This chapter performs the development of this project, starting with the first crazy ideas and ending with a final solution following by a prototype. The chapter is divided in different sections. The first section ‘Architecture’ is about the design process. It represents the way how the final solution is arose. The second section ‘Materials’ shows a list of all the materials that are used for the prototype. The third section ‘Components’ gives an overview of all the necessary components to make DryFoo automatically controllable. The fourth section ‘Functionalities’ explain the main functionalities of DryFoo . The fifth section ‘Test and Results’ shows the development of the tests performed with the prototype. The results of those tests gives us a better analysis of how good DryFoo meets the requirements. The last chapter ‘Conclusion’ is a sum up off the main relevant point from this whole chapter.

7.2 Architecture

In this chapter, we will present the black box diagram, the cardboard model and all the drawings we made along with the SolidWorks models. We will also add the detailed schematics of the electronic components.

7.2.1 Black box diagram

The black box diagram is used to visualize all inputs and outputs of a system without paying too much attention to the internal working. Figure 28 represents the black box diagram for DryFoo.

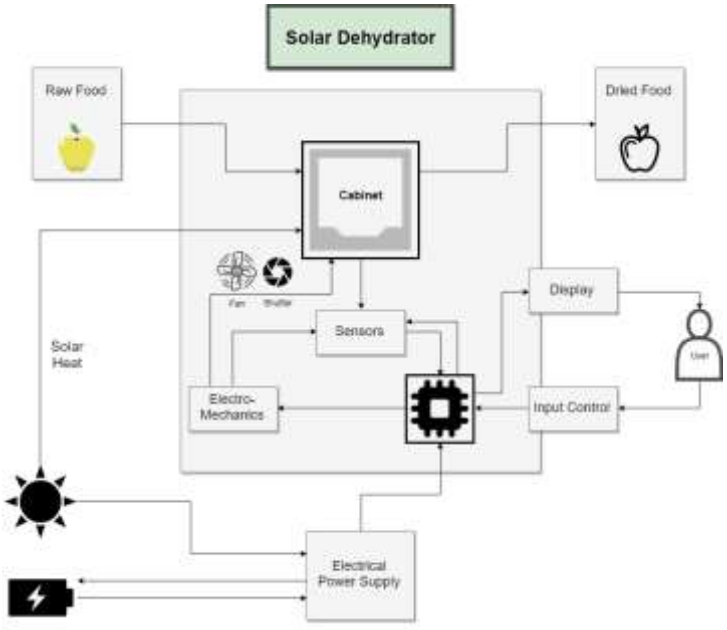


Figure 28 - Black box Diagram

7.2.2 Cardboard model

Figure 29 displays the cardboard model for DryFoo. A cardboard model is often used in engineering to make a fast and cheap version of a product using only cardboard, glue and a mean of cutting. This physical model shows the main features of the product. On this way, the usefulness and practicality of the features can be evaluated easier.

Figure 29 - Cardboard Model

7.2.3 Drawings

Design idea's

Figure 30 presents the quick designs of all the different ideas for the design and look.

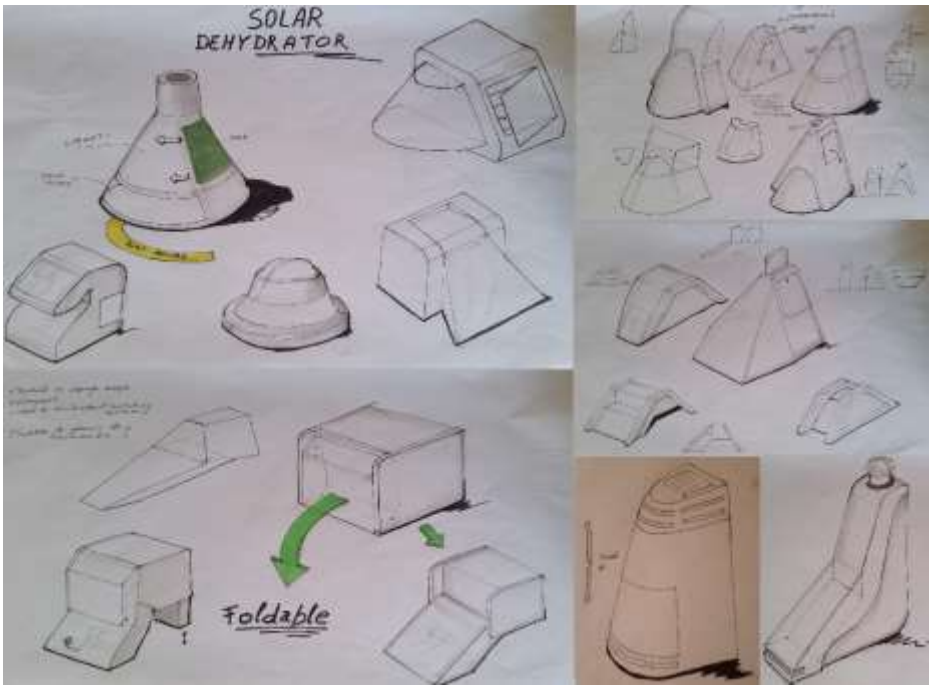


Figure 30 - Design Drafts

Structural idea's

Figure 31 represents the quick designs for the ideas about the structure and mechanisms.

Figure 31 - Structural Drafts

7.2.4 SolidWorks Model

In Figure 32, some renders from the solidworks model are proposed.

At the bottom are some sloping holes where the fresh air can enter the solar catcher. After this the solar catcher heats the fresh air. The transparent front plate is bent for over 180°. On this way, the sun shines on the solar catcher during the whole day without a rotation system. The warm air shall rise to the top. The form is conical upwards to increase the airspeed as compensation for the reduced temperature at the top. The chimney is provided of sloping holes so the warm air can escape but the rain can't come in.

Figure 32 - SolidWorks Model

On Figure 33 it is visible that the solar dehydrator has four trays. In total, there is a space of 50 cm by 50 cm to place the fresh food to dehydrate. They are made out of wood and a metal mesh. Through a hinged door, it's easy to place the food on the trays.

Figure 33 - Details of the trays

Figure 34 gives an detailed view of the fan. Through the closing lid, pushed by a servo motor, the air flow is optimized. The position of the servomotor depends on the humidity and temperature inside the cabinet. These two parameters are measured by sensors. This controlling system in combination with the fan ensure the optimal conditions to dehydrate the food.

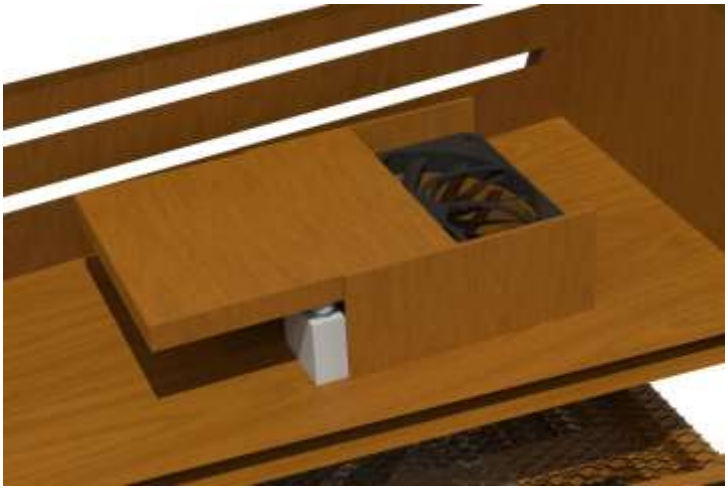


Figure 34 - Details of the fan

Figure 35 gives a good view of the top. On top of the chimney is a solar panel that provides power to the fan and the controlling system.

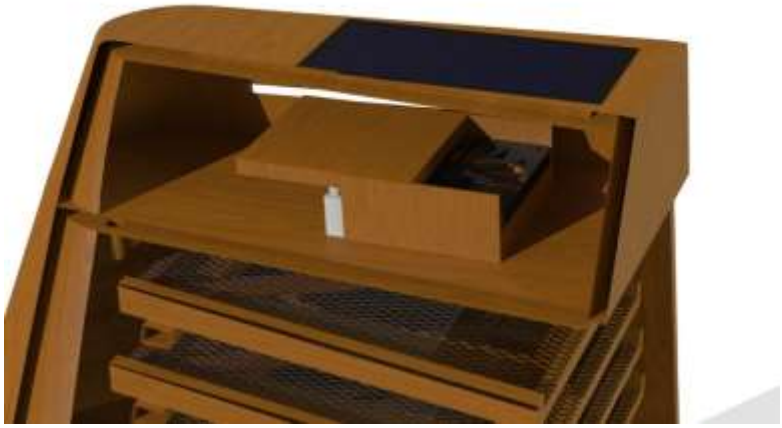


Figura 35 - Solar Panel

7.2.5 Detailed Schematics

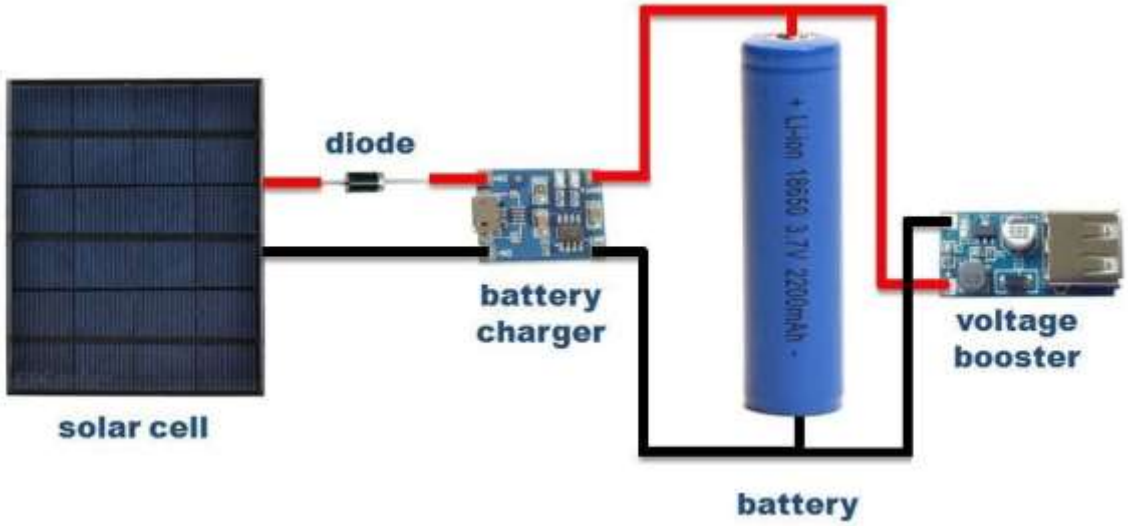


Figure 36 - Electronic Schematics

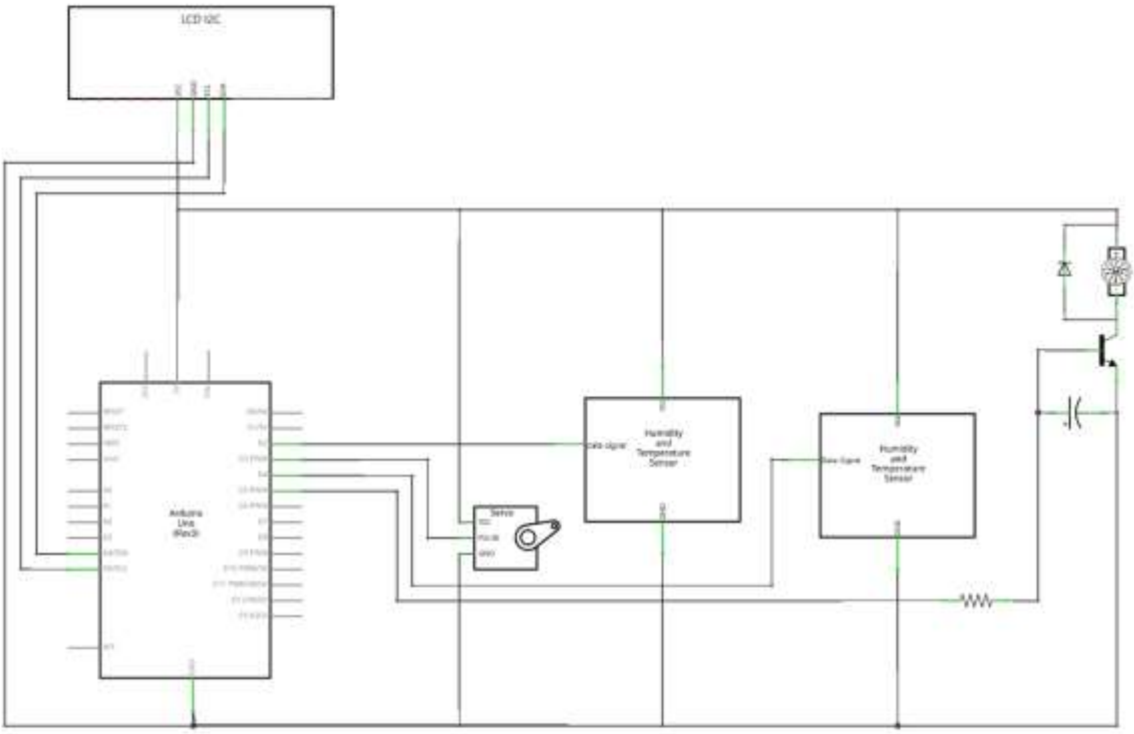


Figure 37 - Detailed Electronic Schematics

7.3 Materials

Table 24 shows the list of materials we made for the prototype with their sources.

Table 24 - List of materials with their sources

Part	Material name	Area (m²)	Length (m)	Attributes	Price per m²	Quantity	Total Price (€)	Source
Transparent Front	PVC	0,11466	-	Bendable (< 1 mm)	14,99	1	1,7187534	http://www.leroymerlin.pt/Site/Produtos/Madeiras/Vidro/Acrilico/81931171.aspx
Bended Front Rest	PVC	0,125	-	Bendable (< 3 mm)	0	1	0	From Benedita/Abel
Straights parts of the case	Wood (preferably plywood)	0,625	-	Width: 10 mm (depends on ISEP's stock)	2	1	0	From ISEP
Trays and air holes mesh	Plastic mesh	0,070125	-	Provided by Benedita	0	1	0	From ISEP
Tray bars	Wood (preferably plywood)	-	4,5	10 mm x 10 mm	0	3	0	From ISEP
Collector (paint)	Black paint (mat)	0,07	-	Provided by Abel	0	1	0	From Abel
Collector (metal sheet)	Aluminium	0,09226406	-	50 cm x 25 cm	5,99	1	5,99	[illegible]
Screws	-	-	0,02	Pack	2,58	1	2,58	[illegible]
Glue	White wood glue	-	-	In a tube	-	1	1,89	[illegible]
Sliding lock latch	Stainless steel	-	-	Waterproof	4,45	1	4,45	[illegible]
Hinges (door)	Stainless steel	-	-	Waterproof	1,99	2	3,98	[illegible]
Isolation between gaps and connections	Silicone	-	-	-	-	1	2,49	[illegible]

7.4 Components

The following tables 25, 26, 27, 28, 29 and 30 present some of the different components we may use for our prototype.

Tabela 25 - Temperature Sensors

Temperature Sensor	Temperature Range (°C)	Accuracy (°C)	Input Voltage (V)	Price (€)
LM35DZ	0 to 100	±0,5	4 - 30	1,75
DS18B20	-55 to 125	±0,5	3 - 5	3,75
LMT86LP	-50 to 150	±0,25	2 - 5,5	0,73

Tabela 26 - Temperature + Humidity Sensors

Temp. + Humid. Sensor	Input Voltage (V)	Temp. operation range (°C)	Temp. accurac	RH accuracy (%
DHT11	3 - 5	0 to 50	±2	±5
DHT22	3 - 5	-40 to 80	±0,5	±5
RHT03	3,3 - 5,5	-40 to 80	±0,5	±5
SI7021-A20-GM1	**1,9 - 3,6**	**-40 to 125**	**±0,4**	**±3**
HTU21D	1,5 - 3,6	-40 to 125		±2
HIH6030-021-001	2,3 - 5,5	-40 to 100		±4,5

Combined temperature and humidity sensors are usually showcased as high-quality products and it can be presented as a good solution when price is taken into consideration.

Tabela 27 - LCD

LCD	Feature	Supply Voltage (V)	(Price €)
Shield Display LCD 16x2	SHIELD + KEYBOARD	5	6,9
LCD 16x2	-	5	5,55
LCD 16x2	**I2C**	**5**	**7,2**

Tabela 28 - Servomotor

Servomotor	Input voltage (V)	Temp. Operation range (°C)	Torque (kg/cm)	Current consumption (mA)	Price (€)
Futaba S3003 Multi Purpose Servo Motor	4,8	-20 to 60	3,2	-	15,93
Hitec HS-422 Deluxe Servo Motor	4,8	-20 to 60	3	520	15,93
Servo FS5106B - Generic High Torque Standard	4,8-6	-30 to 80	5	980	15,74
Servo Motor SG90 9g Tower Pro	**4,8**	**-30 to 60**	**1,6**	**-**	**3,75**

Tabela 29 - Batery

Battery	Type	Output voltage (V)	Capacity (mAh)	Price (€)
18650 Cell Holder	Li-ion	3,7	2500	6
Torch P20	Li-ion	3,7	9800	3,8

Table 30: List of Components

Component	Quantity
Arduino	1
Solar Panel	1
Battery Charger	1
Voltage Booster	1
Fan	1
Servomotor	1
Display LCD	1
Temp. + Humid. Sensor	2
Diode	1
Switch	1
LED	**To be defined**

7.5 Functionalities

7.6 Tests and Results

7.7 Conclusion

8 Conclusions

8.1 Discussion

8.2 Future Development

- Catching the evaporated water
- Using the extracted water from the food for other farming purposes
- Internet of Things: Connected and controllable at any time

Appendices

1. Sponge Experiment

In order to understand better the influence of the airflow in mass transfer we were challenged to do an experiment with sponges as represented in figure 38.

Procedure:

- Place two identical wet sponges in two different situations: One in a box in the sun & the other in a room without sun, in front of a fan.

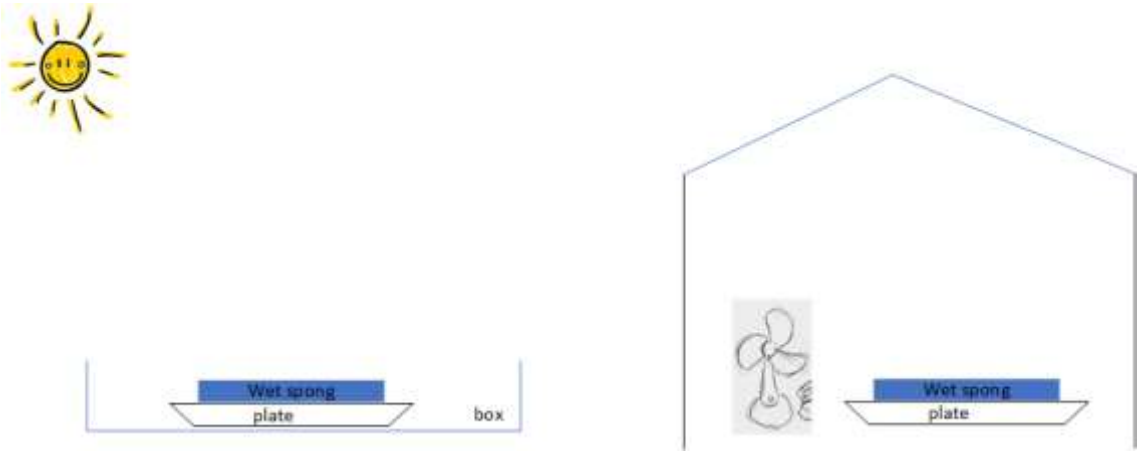


Figure 38: Sponge Experiment

- Turn on the fan when you put the other sponge in the sun.
- Measure the mass of the two sponges every 15 minutes.
- Draw the graph of the drying as a function of time.

Results:

Table 31: Measurements with Sun

Time (min)	Mass (g)
0	198
15	195
30	195
45	193
60	193
75	192
90	192
105	190
120	189
135	189
150	186
165	186

Time (min)	Mass (g)
180	185

Table 32: Measurements with Fan

Time (min)	Mass (g)
0	183
15	179
30	177
45	176
60	175
75	173
90	172
105	172
120	171
135	170
150	170
165	169
180	168

Final graphics:

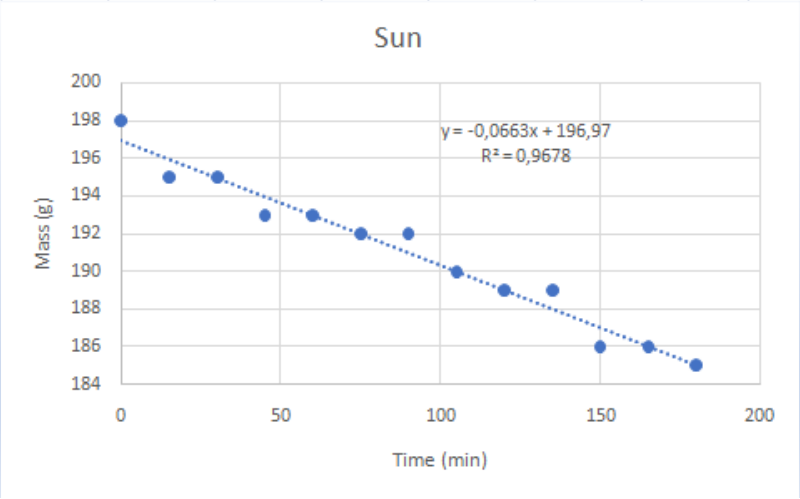


Figure 39: Graphic of sponge with sun

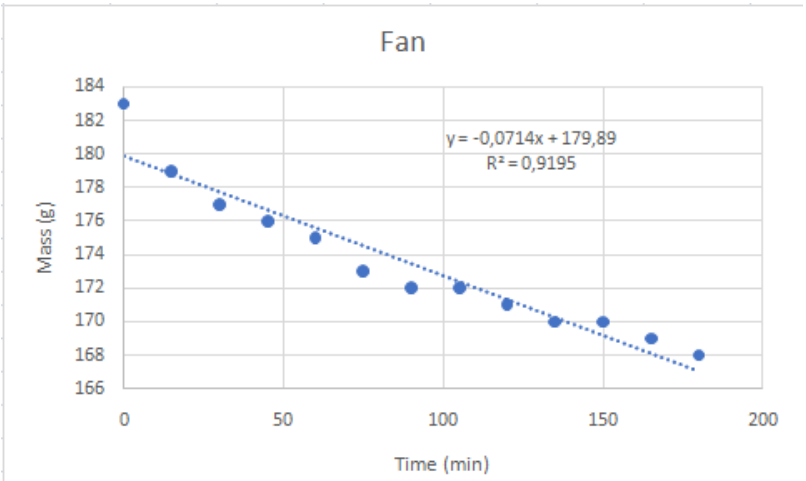


Figure 40: Graphic of sponge with fan

Conclusion

In short, base on the results obtained we can conclude that the use of the fan was more efficient than the use of the sun due to the occurrence of mass transfer that allowed the water to vanish instead of keeping in continuous contact with the sponge as in the sun scenario.

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