Final Report

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Solar Food Dehydrator

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Abstract

Around the world, the growing concern about sustainability, self-reliance, healthy diets, and the increasing interest and use of solar energy make our project and our goals as interesting as important. We are developing a product for a very specific and relatively new market niche, which is however rapidly expanding. Our target group – private consumers, such as small farmers, families with a garden or a terrace, or simply any person who is concerned about maintaining a healthy diet and a healthy planet – is one that will keep growing in the years to come.

The project consists in developing and building a solar food dehydrator. It is a food processing device which is used to extract moisture from different kinds of foods or herbs. The product is specifically designed for the dehydration of fruit and vegetables. The goal is to develop an optimized and ideal fruit and vegetable dehydrator, encouraging the use of food dehydration as a healthy and efficient method for food preservation.

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Glossary

Abbreviation	Description
DIN	Deutsches Institut Für Normung
DIY	Do It Yourself
EPS	European Project Semester
EU	European Union
ISEP	Instituto Superior de Engenharia do Porto
LCD	Liquid Cristal Display
PMMA	Polymethyl methacrylate
PV	Photovoltaics
R&D	Research and Development
SWOT	Strengths, Weaknesses, Opportunities and Threats
W	Watt
WBS	Work Breakdown Structure

1. Introduction

1.1 Presentation

Rike Brunke, Hubert Nogal, Dániel Berényi, Adrian de la Torre, Léonore Hood: We are five students of different cultural backgrounds and study fields. Together we form a team, working on one same project: building a fully functional Solar Dehydrator. Every team member has a specific role in this project, according to each person's strengths and weaknesses. However, we value teamwork and work together successfully and in joint effort, sharing our knowledge, in order to achieve our goal.

1.2 Motivation

The choice of this project was given by the consensus of all members according to our individual skills as future engineers. Although the Solar Dehydrator was not our first option, after analyzing and interpreting each proposal offered by the EPS direction, we thought convenient to develop this product. The demands of the briefing fitted perfectly with the

team, what establishes a high probability of success.
The main challenge is to innovate in the field of Solar Dehydrators. In advantage, we realized that its market is mostly focused and based on systems with energy supplies, and in terms of fully solar powered systems, there is no clear path to follow regarding such devices.

The lack of knowledge and experience in this project is not a weakness, but strength. It is a reliability of fresh ideas and non-common points of view to develop this product, such an ideal environment to break into with a new concept and to position our project as a benchmark in this sector.

1.3 Problem

We are tasked with building a solar dehydrator. The main obstacles of this task, which we have to overcome, are:

- Dry fruit and vegetable efficiently and make it easy to preserve. The quality of the final results is very important to us.
- The dehydrator should be portable/mobile
- The device should be environmentally friendly and sustainable: the control and monitoring unit should be powered by solar energy, which means we have to use a solar panel, connected to a battery
- The temperature has to be regulated and should not go above 70 °C: we will need to integrate motorized vents and possibly fans, as well as a functional automatic temperature sensor (programmed with Arduino)
- Since we have a limited budget for the equipment, we need to plan the list of materials carefully and do exact research.
- We need to develop a marketing plan, find a market niche and a target group for our innovation.

1.4 Objectives

Our goal is to build a fully functional, sustainable and environmentally friendly solar dehydrator. It should also be portable and easy to transport, so that it can be used in as many locations and situations as possible for an optimized use. Food dehydration is a

process that has been used for decades and our objective is to develop a innovative yet simple device which gives our customers the possibility to do so efficiently and without wasting energy. We want to design our product so that it appeals to our specific target group. Next to the technical and sustainable part of the project, we also want to guarantee our customers that by using our product, they will consume food that is healthy, natural and rich in vitamins.

In order to accomplish this project and fulfill all our objectives, we will do some intensive research, gain solid knowledge on the subject and run some tests on our product, to get the best results possible.

1.5 Requirements

These specific features should be included in the solar dehydrator:

- The dehydrator should be portable/mobile (relatively light, reasonable dimensions, wheels)
- The inside temperature should not go above 70 °C
- The dryer box needs to have a good isolation, so that the temperature is stable. It is important that there are no holes or cracks on the walls of the box. These would allow air to get in and out the box and would disturb the balance of the airflow. The two air vents should absolutely be the only openings of the box.
- It needs temperature sensor and motorized vents and fans, in order to regulate temperature and air flow.
- The controls should be powered by solar energy (a solar panel will be fixed on top of the dehydrator and connected to a battery)
- The device should be environmentally friendly and sustainable (it should not need to be powered by electricity, but only by solar energy)

Due to practical and organizational issues, we do not have access to an appropriate solar panel. This is why our control unit will temporarily need to be plugged in to an external power socket. However, the dehydrator is developed to be “solar-panel-ready”, and once a solar panel and a appropriate battery are made available, only few changes need to be made so that the control unit can be powered only by solar energy. Since working with

solar energy was our initial idea, and a big part if the concept for the solar dehydrator, this idea will be assumed in the entire report, especially for what concerns the chapters on state of the art, marketing and the sustainability.

For the accomplishment of our project, we also have to meet these requirements:

- Use of existing equipment and/or low cost hardware
- Use of open source and freeware software
- Adopt the International System of Units
- Be compliant with the machinery EU Directive

1.6 Use Cases

Following features will define our solar food dehydrator and the situations in which it can be used:

- It will be portable (light-weighted and mounted on wheels) so it is easy to move around your garden or terrace (always move it out of the shade and into the sun) and to bring back inside your house in the winter or when it is raining.
- There will be between 3 and 5 drying shelves in the dryer box, so relatively large amounts of food can be dried at the same time. However, the shelves can be totally removed from the dryer box, so it is possible to use only 1 or 2, if there is less food to dry. The estimation of the size of each shelve is around 0.2 m^2. So the final product will have a dehydrating surface between 0.6-1 m^2, enough for a domestic use scenario.
- Initially, an absorber plate was supposed to be installed underneath the drying shelves, in order to take in the water and moisture that drips out of the food. They were to be made of micro fibre towels because these absorb moisture efficiently. Our product would come with two absorber plates: after 2 to 3 uses, the used, moist plate should be removed and replaced with the second, dry one. The moist plate can be placed on a dry surface in the sun and be left to dry out again. This should not take more than one day. For the latest concept of our product, however, we decided that we would not need an absorber plate any more for the following reason: The humidity and moisture that will be extracted from the food will automatically be rejected through the top air vent, thanks to the controlled air flow

system (humid hot air rises).

- All electronic and mechanical parts are powered by solar energy (a solar panel will be mounted on the roof of the dehydrator). The device does not need to be powered by any other source. In case of low sun radiation, energy will be stored in a battery, so the dehydrator can still function with all its features for several hours. Moreover, when the temperature starts to sink, the vents will be closed in order to trap and keep the heat inside the dryer box.
- In order to optimize the drying process, and thereby the results, the dryer comes with a built-in alarm (timer) which rings when the fruit is dried (according to average guidelines), a programmed temperature sensor which is connected to small motorized vents, which open or close automatically depending on the inside temperature of the box). Apart from these features, the dehydrator is to be handled manually.
- The dehydrator is designed to be used in countries with a reasonably high amount of sun radiation and low humidity during the summer and early autumn months, and where the climate allows you to grow your own fruit and vegetable outdoors (see Table 1). It is not designed for industrial purposes or mass production, but for private individuals, who own or have access to a garden or a terrace.
  Table 1 depicts the average temperature values in the months from April to October, in the countries in which we want to sell our dehydrator. It also shows average values of hours of sun per day, and sunny days per month.

Table 1: *Comparison of climate conditions between countries*

	Germany	Switzerland	France	Italy	Portugal	Spain
Average temperature	22° C	22° C	20 to 30° C	25° C	24° C	26° C
Average number of rainy days per month	15	14	5 to 17	3	8	5
Average number of sunny days per month	6 h/d for 12 days	7 h/d for 13 days	5 to 9 h/d for 12 to 22 days	8.5 h/d for 25 days	7.5 h/d for 19 days	9 h/d for 23 days

* These values are the average temperature values in the months from April to October. France has the biggest difference between the lowest and the highest value. This is why

we chose to represent the average temperature as a values between two values.

1.7 Functional Tests

In order to succeed with the full functionality of the Solar Dehydrator, the product has to be submitted to a variety of tests to warrant the optimum usability. These tests have to be not just with the proper operation of the product itself, so for the human interaction as well. Mechanical tests are the main concern. Mechanical tests involve the correct function of each part of the Solar Dehydrator, such as quality of the assembly, safety tests and so on. On the other hand, we have the electrical part that has to do with the autonomous control of the dehydration process. The handicap on this field is how to properly manage the variation of temperature. The Solar Dehydrator will be provided with built-in temperature sensors and a waste gate system for the purpose of keeping an ideal environment to dehydrate. Power supply tests have also to be done. One of the challenges of this project is to achieve the self-production and consumption of energy, avoiding all the contamination chain behind most energy companies. This is our little contribution to the world.
Finally, usability tests are a must. Even if the dehydrator does its work properly, an easy and intuitive design provides the customer with confidence and commitment towards the product and the company behind.

1.8 Project Planning

In order to establish the project plan, Work Breakdown Structure was created, in which entire arrangements and work division of the project are included. What is more, the Gantt chart was developed in order to in further phases of the project. Complete effort to establish WBS and Gantt chart was done with the usage of Microsoft Project software. The service of program was presented during Project Management classes. The Work Breakdown Structure of our team is presented below.

1.9 Report Structure

The Table below describes the structure of this report and shortly explains the content of each chapter.

Table 2

Table 2: *Report Structure*

Chapter	Description
1 - Introduction	Presentation of the main problems, motivation and objectives of the project
2 - State of the art	Description of different technologies already available on the market and presentation of selected one
3 - Marketing	Situation of the product and the company in the current market
4 - Sustainability report	Enhancement of sustainability in the engineering area including life-cycle and energy consumption analysis
5 - Ethical and deontological concerns	Legitimacy and legality analysis
6 - Project requirements and product development	Explanation of entire hardware and software and information concerning construction of the prototype
7 - Conclusion	Discussion about the project and further possible developments

2. State of the Art

2.1 Introduction

In this chapter, we will describe our product and its status in the current market. The aim is to give a clear overview of the design, functionalities and the components of our solar dehydrator, while comparing it to existing related products and the technologies used. In doing so, we will also justify the need of our product on today's market.

Our chosen product is the Solar Dehydrator we want to be a part of the solar industry which is still growing. There are already some similar products worldwide which are explained in the next chapter. For having a difference to some other companies we decided that our solar dehydrator is designed for drying fruit and vegetable. The main goal for our product is consequently to drain 85-90% of the moisture from the fruits or vegetables. After that they are preserved and could be eaten as a snack or in muesli. The aim of the preserving is to cure the fruit or vegetable. Table 3 depicts few examples:

Table 3: *Food humidity*

Food humidity table:

Once dried, the fruit still contains 10 to 15 % of water.

Food	Humidity	Humidity when dried	Moisture extracted
Apple (average size)	80 ml	8.75 ml	71.25 ml
Banana (average size)	120 ml	15 ml	105 ml
Zucchini (100 g)	93 ml	11.62 ml	81.38 ml
Pineapple (100 g)	85 ml	10.62 ml	74.38 ml
Grapes (100 g)	82 ml	10 ml	72 ml
Tomatoes (100 g)	95 ml	11.87 ml	83.13 ml
Aubergine (100 g)	92 ml	11.5 ml	80.5 ml

2.2 Related products and market competition

After having done some research about solar dehydrators and similar products on the current market, we have come to the conclusion that there are three major types of related products/projects:

- The first is executed on a larger scale and at an industrial level, however mainly in developing countries:

Companies such as “Shri Industry” and “NRG Technologists” [NRG Technologists Pvt. Ltd, n.a] provide the devices and facilities for drying large quantities of materials, using only solar energy. Focusing on the example of “Shri Industry”, following observations have been made: Their dryers are conceived to be used on a larger agricultural level, for example by food processing companies (added value in foods such as fruit, nuts, vegetables), but also textile industries (fabric drying purposes). Their dehydrators are the size of small industrial greenhouses. They very much look like greenhouses on the outside, with a not quite transparent surface, which is however permeable to sunlight. There are openings on the top of the boxes, and a space between the material of the box and the ground enables the air to flow properly. The devices of “Shri industry” operate only on solar energy, and therefore avoid any power consumption. However, no controls or electronic components are used. Their goal is to manufacture modern, yet natural, sustainable and hygienic dehydrators. Shri Industry is based in India, their products are manufactured locally, and are targeted to Indian industries [n.a., 2012].

Figure 1 represents the inside of a solar dryer machine, manufactured by Shri Industry. These dehydrators are used on a larger agricultural scale in developing countries (in this case: India).

Figure 1: Shri Industries dehydrator machine [n.a, 2012]

Figure 2 depicts the inside of a Shri Industry solar drying device, during the dehydration process of Alma Sweet Supari (traditional Indian snack).

Figure 2: Shri Industries dehydrator machine drying Alma Sweet Supari [n.a, 2012]

- Do It Yourself solar dehydrators:

As questions of health, sustainability and self-reliance take a growing place in developed countries around the world, more and more people show an interest in building their own solar dehydrator [Eben Fodor, 2006]. After having done some research, it is easy to say that there is an increasing number of websites, books, health magazines or workshops dedicated to “green living” (sustainability, energy, healthy nutrition, etc.). Many of those platforms offer explanations, construction plans or tutorials for building a solar dehydrator by yourself. Companies such as “SunWorks TM” or “Build It Solar” even sell building kits which contain all the necessary materials and components [SunWorks Technologies LLC, 2014]. The user then has to put the device together. “Do It Yourself” solar food dehydrators are simple devices. The dryer box is usually made out of wood, sometimes metal, and one of the surfaces is a glass panel. The shelves are often similar to barbecue grids. Wholes are made at the top and at the bottom of the box to let the air flow [Gary Reysa, 2015].

Figure 3 shows a fully assembled and functional solar dryer kit by Sunworks TM.

Figure 3: DIY dehydrator building kit by Sunworks TM [n.a, 2012]

Figure 4 represents a 100 % DIY dehydrator device, constructed by Dennis Scanlin.

Figure 4: 100% DIY Dehydrator by Dennis Scanlin [Dennis Scanlin, 2014]

- Electric Kitchen Devices:

Other similar products exist on the current market, such as “Excalibur - America's best dehydrator” in the USA [n.a, 2012], the “Biochef” dehydrator in Australia [n.a, 2015], and various food dehydrators by “Severin”, a German company which specializes in kitchen utensils. However, all these products do not work with solar energy, but need a external power supply. In all these cases, the product itself is not designed to be autonomous or sustainable, and consume a big amount of energy (a power supply of 250 to 600 W is necessary for the dehydrators to work).

Additional competitors in this category on the current market are:

– “Stöckli Dörrex”, a Swiss company which manufacture food dehydrators with synthetical drying grids, their price range starting at 109.90 € [n.a, 2015];

– “Severin OD 2940”, a German company which produces dehydrators for fruit and vegetable that consume a relatively low amount of energy and sell their product for 50 € [n.a, 2015];

– “Sedona TM”, another German company, who sell food dehydrators which require a 550 W power supply, are bigger and heavier, and cost 399 € [n.a, 2013];

– “Bomann DR 435 CB Dehydrator” produced by the German company, requires a 250 W power supply, works with a similar air flow system to our product, and costs 25 € to 40 € [n.a, 2012].

However, none of these dehydrators work with solar energy: they require an external power source, meaning they have to be plugged into a socket in order to work and the user consumes and will pay for more energy.

Figure 5 shows one of Sedona TM's electric food dehydrator devices.

Figure 5: Sedona TM dehydrator [n.a, n.d]

- The Greengineer's solar dehydrator:

The main differences in our solar dehydrator, compared to all other related projects and products we have found during our research are the following:

Our product will be manufactured for and used by private individuals, at the same level as a kitchen utensil, for example. The manufacturing as well as the distribution will remain in Germany at first. This will enable us to observe the success our product has on a smaller and restricted geographical scale, before we decide to expand our market and export the product. Our target group and market are quite specific, so in our start-up phase, we want to concentrate on creating good customer relationships and make sure our product satisfies the consumer's needs. Furthermore, by limiting our territory of production and distribution, we reduce financial and environmental impact of transportation. The target groups of this specific solar dehydrator are private people (singles, couples or families) who own or have access to a garden or a terrace, and small farmers, who want to dry seeds for the next season's crops, or simply to preserve the surplus of harvested food. The dehydrator is professionally manufactured and well finished. The user will not need to put any parts of the device together by himself. It is optimized for the drying of fruit and vegetables, which means a smaller range or products, but better results. The device is portable, user friendly and offers a simple yet modern control unit, powered by a solar panel.

2.3 Product Requirements and Functionalities

In order for our solar dehydrator to stand out next to all the similar products, these requirements must be fulfilled: Our product needs to be sustainable, practical, user friendly, as autonomous as possible, versatile and innovative.

The sustainability aspect is our main concern. Putting aside the fact that the very concept and use of such a product is sustainable (a way of preserving food naturally), our goal is to take this idea of sustainability further and integrate it into the product itself: All the materials we plan to use for the dehydrator are recyclable and/or long lasting ,such as wood, Polymathy Methacrylate (PMMA) or brass. Furthermore, we want to focus on a low power consumption: The controls and other electrical components will be powered by solar energy (solar panel should be mounted on the top of the dryer box).

The height of the dehydrator when closed to be carried should be over 0. 96 m and should not exceed 1. 20 m. This height is determined by anthropometric measurements as shown in chapter 7.2.3 and also by the research of similar products as shopping trolleys. It also

must be taken into account that there is a value of tolerance given by the grade of inclination at the time of transporting. The example measurements are indicated in Figure 6.

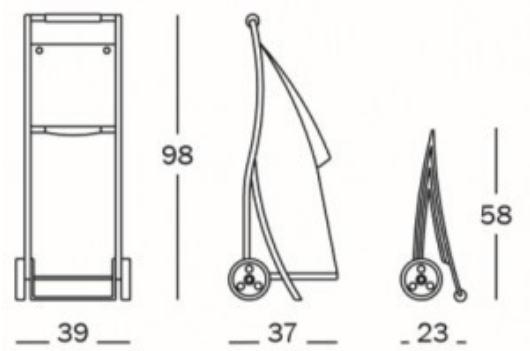


Figure 6: Example of shopping trolley measurements

A set of wheels will be mounted on its foldable legs, so the dryer is portable. The shelves that are in the dryer are box easily removable, in order to load and unload the food, and for cleaning purposes. These features make our product practical.
To continue on the user friendly aspect, the dehydrator is equipped with two temperature sensors, one humidity sensor and an Liquid Crystal Display (LCD) screen (mounted outside of the box) which shows the user the measured values inside the dryer box. The user can thereby check for himself if the dehydrator is functioning properly. Also, there will be a built-in timer and alarm, so the user can set the approximate drying duration according to which type of food he is drying. The working process of the alarm system starts with the selection of the product it's going to be dehydrated. The processor makes an approximation of the end of the process and it's when the alarm does his job by awarding the user to check the current status of the food. Finally, a user manual comes with each purchased dehydrator to ensure the correct usage of the client towards the product.

Our product is autonomous because there is an air vent built in to the dryer box, which is programmed to open and close automatically depending on the inside temperature and humidity of the box. A controlled airflow is crucial for the drying process.
The dehydrator is versatile, which means it can be applied to multiple use cases: It can be used in different locations, such as private gardens, terraces, balconies or public parks. It can be left outside in summer (preferably sheltered!), but can easily be stored indoors, even in a small apartment. It can be used by people of all ages. The dehydrator is

optimized for the drying of fruit and vegetables. However, seeds and herbs can be dried in it too.

All these features make our product unique and innovative.

2.4 The Heating Tunnel

The heating tunnel will be fixated to the bottom of the dryer box. The tunnel is hollow and open at both ends, in order to let the air pass through it. Inside the tunnel, along the whole length, a metal mesh will be fixed to its lower surface, in order to quickly heat up the air that passes through it. At the point where the tunnel touches the dryer box, there will be a vent, where the hot air of the tunnel flows into the dryer box. It will also provide a variation of the inclination in order to face more accurately the sun rays.

A study of the sun rays declination of Porto, Portugal, all around the whole year has been made thanks to Keisan Online Calculator, with a result varying between 55 and 17 degrees and are presented in Figure 7.

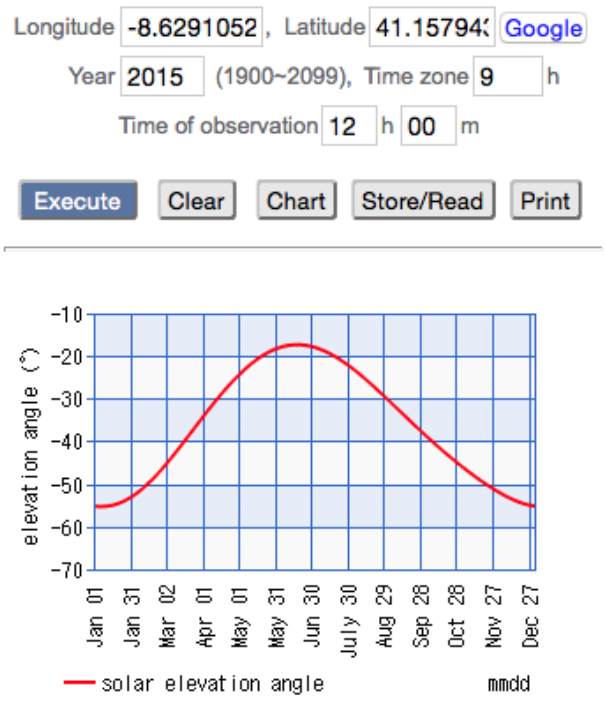


Figure 7: Sun rays declination in porto along year 2015

In terms of materials, the tunnel will be made out of wood with a plate of glass in the upper

face. Glass is ideal for this work thanks to its properties as transparent and robust to keep in the heat while resisting the damage made by sunlight and rain and allows infrared rays come through to heat the air.

2.5 The Dryer Box

The dryer box is the main part of the dehydrator. It must be well designed and the material carefully chosen. As the dehydrator should be portable, the dimensions of the dryer box does not exceed 1m2. Initially, the walls of the box were supposed to be made out of cedar wood, due to its appropriate properties in terms of wet conditions, where cedar wood shows a high resistance to damage compared to other types of wood, such as pine wood. The front surface however, was going to be made of PMMA, for optical reasons, so the user can se the drying fruit inside the box. This front surface is the “door” of the dryer box: Of course, the dryer box has to open and close easily, in order to load and unload the fruit and vegetable. Inside the box, three dryer shelves offer enough surface to dry a good portion of food. These shelves are fine metal grids (preferably brass, to avoid oxidizing), and are easily removable, in the same way that oven grids are. The bottom surface of the dryer box will have a small opening, to let excess moisture from the fruit or vegetable drip out if necessary. Two motorized vents - one at the top and one at the bottom of the box, where the tunnel is (see 2.4) - will open and close depending on the inside humidity and temperature level of the box. Usually, a constant air flow helps reduce the humidity level, so the vents should stay open most of the time.

Currently, we are using pine wood for the entire dryer box (including the door) and the heating tunnel (except for the top surface, which is made out of glass). The wood is coated with water resistant varnish, in order to reduce any weather related damage that is done to it.

Figure 8 presents a concept for the dryer box.

Figure 8: Concept detail of the dryer box

2.6 Electronic Control and Solar Panel

The innovative and most complex part of our product is the control unit. For optimized results, the temperature, humidity and air flow inside the dryer box will be regulated automatically. Therefore, the dehydrator will be equipped with:

- an Arduino board will be fixed on the dehydrator, as the central controller for following components:
- two temperature sensors (fixed on the inside of the dryer box, one at the top and one at the bottom, in order to evaluate the temperature differences depending on the height - the temperatures should be kept between 30 °C and 70 °C depending on what fruit or vegetable is drying)
- one humidity sensor (also fixed on the inside of the box, helps evaluate the level of humidity: inside the box, the air should be kept as dry as possible, so as not to damage or contaminate the fruit)
- one motorized vent on the top of the dryer box - this vents is crucial to a proper air flow. If the humidity level rises over a certain level, the vent should be open to the maximum, in order to let the humid air rise up and exit by the top vent and fresh, dry air enter from the bottom intake thanks to the nature of pressure, which always forces to maintain the same values.
- one LCD screen (mounted on the outside of the box, the screen displays the temperature and level of humidity inside the box, for the user to see at any time. It will also be connected to a small input keyboard, with which the user can manually configure certain settings)

- an alarm/timer (as a small bonus feature, the user will be able to set the approximate duration of the drying process, depending on the sort of fruit of vegetable he is drying - durations and temperatures are specified in the user manual - and the alarm will ring when the time is over, or simply as a warning, for the user to check on his food, halfway through the process)
- in future development: a solar panel (the panel will be mounted at the back of the dryer box, is such a way that its angle and position towards the sun can be changed easily if necessary. The solar panel is the power source of the electrical control unit of the dehydrator)
- in future development: a battery (connected to the solar panel, in order to store energy)

2.7 Conclusion

To conclude, it is safe to say that the concept of the solar dehydrator is far from being new. However, the current market for this kind of product is still limited. Solar dehydrators are being used more and more in developing countries such as India, to reduce waste, process the large surplus of harvested foods, and give added value to this food. These dehydrators are used on a relatively large agricultural scale. However, many of them are not ideal, when technical and sustainability aspects are taken into account. Products that are more similar to our dehydrator exist on the American and Australian market, but are still rare in Europe. Therefore, our most relevant competitor at the moment is the “Do It Yourself” (DIY) community, who share information on different platforms (websites, magazines…) about how to build your very own personal solar dehydrator. This “competitor” however, is not on the current economic market. A solar dehydrator similar to our's has not been released on the european market yet. The concept, the design, the eco-friendly materials and technical innovations make it more than worthwhile.

3. Project Management

3.1 Scope

The Project Scope pertains to the work necessary to deliver a product. Requirements and deliverables define the project scope, therefore it is critical that the stakeholder is in agreement with the information discussed in the proposed plan. In case if you start the

project without knowing what you are supposed to be delivering at the end to the client and what the boundaries of the project are, there is a little chance for you to success. In most of the instances, you actually do not have any chance to success with this unorganized approach.

When it comes to our project, our scope is to build portable solar dehydrator for vegetables and fruits which will not be harmful for the environment with useful devices contributing to this process, such as temperature and humidity sensors, lcd display, automatic vents and alarm. In order to meet our expectations, the solar dehydrator must be:

- user friendly, giving opportunity to control it without hesitations
- light and small so obstacles with portability will not occur
- waterproof in order to protect solar dehydrator from bad weather conditions
- solid and sustainable providing user with reliability and longevity
- environmental friendly enabling to recycle and not polluting atmosphere

As far as deliverables are concerned, we are obliged to prepare:

- report in which complete focused and salient information concerning solar dehydrator is included. Moreover, in order to present our ideas more clearly, images and graphs are also contained
- presentation during which essential matters from the report are delivered. What is more, such a presentation gives opportunity to show our knowledge and convince audience personally
- wiki webpage on which project progress is being carried and current amendments are being implemented
- leaflet which aim is to gain attention and encourage people to buy our product by pointing the most paramount information
- scientific paper presenting information so that it is easy to retrieve, and to present enough information that the reader can duplicate the scientific study
- manual to our product due to which people will be assisted during usage of our device. It contains a guide on how to use the main functions of the system
- poster advertising, attracting and giving information about the solar dehydrator in

both textual and graphic elements

- video outlining our entire EPS experience, including development of our project, the erasmus life in Porto and our final project

In order to organize the team's work into manageable sections, the WBS was created in consideration of being both comprehensive and specific when conducting a project.

Figure 9 displays the structure of our WBS.

Figure 9: WBS

Taking into consideration the structure of WBS, the ideation was the most crucial phase.

3.2 Time

In order to illustrate a project schedule, we decided to use a Gantt chart. It is used in project management to create a clear picture of the steps which have to be taken during the project.

Our Gantt chart illustrates stages of our project from 2015-03-02, when it started, to the 2015-06-18, when the final presentation takes place. Every project task is shown as a bar with the starting and finishing date.

Gantt chart enabled us to instantaneously check at which stage of the project we are, if we have any delays, and what should be done in the nearest future. It is also an excellent tool to follow the work of our team during the EPS project. The chart is presented in Figure 10.

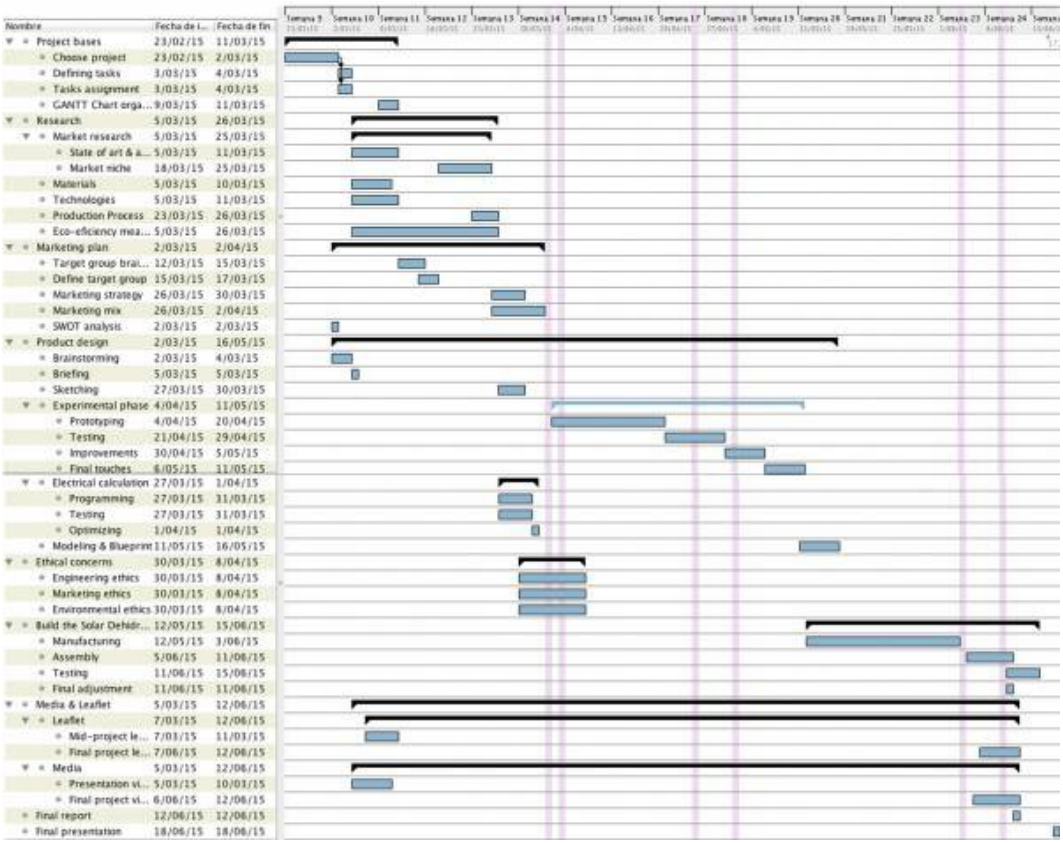


Figure 10: Gantt chart

3.3 Cost

Cost estimating is a basic activity in cost engineering. It is the process of developing an approximation of the probable costs of a product, program, or project, computed on the basis of available information. A cost estimate is often needed to support evaluations of project feasibility or funding requirements in support of planning. It is also used to establish a budget as the cost constraint for a project or operation, and to determine the most economical operation or method to manufacture a product. Furthermore, cost estimating is part of the Project Cost Management which includes the processes involved in planning, estimating, budgeting, and controlling costs so that project can be completed within the approved budget.

From the point of view of this EPS project it is vital to mention the so called manufacturing cost. It is the sum of costs of all resources consumed in the process of making a product. Costs of manufacture become a great concern to the profitability of a product. There exist numerous methods on how to conduct the cost estimation. The three most common are:

- Group Method - representatives of all the departments in the company state the costs for producing the product from their point of view.
- Comparison Method - compares the current project activities to previous, similar projects. The degree of similarity between the prior project and the current project affects the accuracy of the estimate.
- Detailed Method - the detailed approach uses bills of materials and drawings to estimate the cost of each item, subassembly, and main assembly. This method is also the most expensive to execute since it requires many hours of work to collect data and construct the estimates, but it is also the most accurate method.

When it comes to types of costs direct and indirect (overhead) costs can be distinguished. In order to identify all the costs properly, one has to first break the project down into a set of definable tasks, and next estimate each task separately by means of cost.

Direct Costs:
Are attributable to the project and are proportional to the number of units made. Those include:

- labour costs - cost of workers who can be easily identified with the unit of production. Depending on the type of manufacturing, particularly in labour-intensive processes, labour costs can be the dominant cost factor.
- material costs – costs of raw materials and devices used in the production.
- tooling costs – these are costs of tools and features are specifically for the manufacture of the product.
- utilities costs – include energy costs (electricity, gas, oil) as well as water, sewer, waste disposal, steam and other services.
- operating costs – costs of the things that are consumed during a production process (lubricants, towels, ear plugs, etc.).

Indirect Costs:
Indirect costs, also called overhead, can be defined as costs incurred for the general operation of the business (necessary business expenses). They are not applicable to any one product, and consist of fixed and variable costs.

- indirect fixed costs – these are the costs which do not alter on the basis of the number of products produced. These can include: equipment, buildings, interest (debt), and insurance (fire, liability, etc.).
- indirect variable costs – costs that change with a change in the quantity of items produced. They can include: cleaning services, maintenance, engineering, R&D, sales, lighting and heating, office expenses, etc.

Taking into consideration our project, we are only exposed to direct costs, mainly material costs, as indirect costs are covered by the university. Our budget is 200 €, therefore it is crucial to find perfect balance between price and quality in order not to exceed the budget. Table 4 and table 5 display the allocation of human and materialistic resources.

Table 4: Resources list

Resource Name	Cost	Type	Initials	Max Units	Standard Rate	Overtime Rate	Cost Per Use	Accrue At	Base Calendar
Hubert Nogal	1 681,60 €	Work	H	100%	4,00 €/hr	0,00 €/hr	0,00 €	Prorated	Standard
Murat Güşan	1 452,80 €	Work	M	100%	4,00 €/hr	0,00 €/hr	0,00 €	Prorated	Standard
Adrian de la Torre	1 619,20 €	Work	A	100%	4,00 €/hr	0,00 €/hr	0,00 €	Prorated	Standard
Leo Hood	1 622,40 €	Work	L	100%	4,00 €/hr	0,00 €/hr	0,00 €	Prorated	Standard
Rike Brunke	1 622,40 €	Work	R	100%	4,00 €/hr	0,00 €/hr	0,00 €	Prorated	Standard
Dániel Berényi	1 580,80 €	Work	D	100%	4,00 €/hr	0,00 €/hr	0,00 €	Prorated	Standard
Arduino	22,90 €	Material	A		22,90 €		0,00 €	Prorated	
temperature sensor	9,27 €	Material	t		9,27 €		0,00 €	Prorated	
wood	20,38 €	Material	w		20,38 €		0,00 €	Prorated	
servomotor	13,16 €	Material	s		13,16 €		0,00 €	Prorated	
steel	18,79 €	Material	s		18,79 €		0,00 €	Prorated	
wheels	19,50 €	Material	w		19,50 €		0,00 €	Prorated	
metal grid	12,18 €	Material	m		12,18 €		0,00 €	Prorated	
lcd	14,76 €	Material	l		14,76 €		0,00 €	Prorated	
wires	4,12 €	Material	w		4,12 €		0,00 €	Prorated	
power supply	8,92 €	Material	p		8,92 €		0,00 €	Prorated	

Table 5: Resources cost list

Resource Name	Cost	Type	Initials	Max Units	Standard Rate	Overtime Rate	Cost Per Use	Accrue At	Base Calendar
Type: Work	**9 579,20 €**	**Work**		**600%**			**0,00 €**		
Hubert Nogal	1 681,60 €	Work	H	100%	4,00 €/hr	0,00 €/hr	0,00 €	Prorated	Standard
Murat Güşan	1 452,80 €	Work	M	100%	4,00 €/hr	0,00 €/hr	0,00 €	Prorated	Standard
Adrian de la Torre	1 619,20 €	Work	A	100%	4,00 €/hr	0,00 €/hr	0,00 €	Prorated	Standard
Leo Hood	1 622,40 €	Work	L	100%	4,00 €/hr	0,00 €/hr	0,00 €	Prorated	Standard
Rike Brunke	1 622,40 €	Work	R	100%	4,00 €/hr	0,00 €/hr	0,00 €	Prorated	Standard
Dániel Berényi	1 580,80 €	Work	D	100%	4,00 €/hr	0,00 €/hr	0,00 €	Prorated	Standard
Type: Material	**143,98 €**	**Material**					**0,00 €**		
Arduino	22,90 €	Material	A		22,90 €		0,00 €	Prorated	
temperature sensor	9,27 €	Material	t		9,27 €		0,00 €	Prorated	
wood	20,38 €	Material	w		20,38 €		0,00 €	Prorated	
servomotor	13,16 €	Material	s		13,16 €		0,00 €	Prorated	
steel	18,79 €	Material	s		18,79 €		0,00 €	Prorated	
wheels	19,50 €	Material	w		19,50 €		0,00 €	Prorated	
metal grid	12,18 €	Material	m		12,18 €		0,00 €	Prorated	
lcd	14,76 €	Material	l		14,76 €		0,00 €	Prorated	
wires	4,12 €	Material	w		4,12 €		0,00 €	Prorated	
power supply	8,92 €	Material	p		8,92 €		0,00 €	Prorated	

3.4 Quality

In order to deliver a high quality project following issues have to be concerned:

- Customer Satisfaction

If the customer doesn't feel the product produced by the project meets their needs or if the way the project was run didn't meet their expectations, then the customer is very likely to consider the project quality as poor, regardless of what the project manager or team thinks.

- Inspections, testings, requirements

Monitoring deliverables to evaluate whether they comply with the project's quality standards and to identify how to permanently remove causes of unsatisfactory performance.

- Continuous Improvement

Continuous improvement is simply the ongoing effort to improve products, services, or processes over time. These improvements can be small, incremental changes or major, breakthrough type changes.

3.5 People

Human resources management means to hire, maintenance and motivate employees to

better fulfill their responsibilities in order to achieve the company's goals. Each idea, each service, each product or action is creation of human's work. Human resources is an abbreviation, which sometimes causes confusion - not people are a resource, but they have resources: the knowledge, skills, etc. However we must remember that by signing the agreement, the employer employ the whole person, not just the resources at its disposal. HRM describes people together with their capacity, skills, knowledge, experience and qualifications. In this approach, together with natural resources and capital resources are part of the economic resources. For the determination of the people in the company you use different terms like Employees, human resources, human capital, the potential of social organizations and human resources. A significant impact on the relations of employees in the enterprise is the quality of the labor market, where people and organizations are functioning [Nalepka A, 1998].It is determined by supply and demand for labor, which in turn affects the level of remuneration. Human resources are seen as assets of the company. In the field of Human Resource Management there exist two alternate approaches to the worker. The first is economic and quantitative - the worker is treated as a typical resource material, which should give effect to an appropriate higher level of investment. The second approach focuses attention to the man and puts on communication, motivation and leadership looking for ways to improve employee engagement. The first approach is called hard, the other - soft. Modern concepts of human resource management clearly directs interest in the organization of human resources and treat them as basic capital required for the development of the organization, as well as possibilities to ensure its smooth functioning in a changing and competitive environment. Human Resource Management is a very important process, both in terms of the structure of its components and methods of conduct that can be used in every stage of the process. Ability to human resource management is regarded as one of the basic skills in the structure of management skills.

There are couple elements of human resources management process [J. Lichtarski, 1997]:

- Human resource planning - is planning aimed at satisfying the future needs of the organization with regard to personnel both internal and environmental factors,
- Recruitment - preparation a group of job candidates according to plan human resources; choice - two-way process in which the organization decide whether to offer a job candidate and the candidate must decide whether to accept this offer,

- Implementation (adaptation employee) - this is a program aimed at conflict-free inclusion of new employees to the organization,
- Evaluation of effects of work - a constant process of providing subordinates about the effectiveness of their work,
- Staff training (development) - a process for maintaining or increasing the efficiency of his current position,
- Rewarding employees - related to their motivation.

In order to work effectively as a team, division of work according to individuals strengths were made. Figure 11 depicts how individual tasks were distributed accordingly.

Solar dehydrator	
Ideation	
Brainstorming	Adrian de la Torre[20%];Dániel Berényi[20%];Hubert Nogal[20%];Leo Hood[20%];Murat Güşan[20%];Rike Brunke[20%]
State of art	Adrian de la Torre[20%];Dániel Berényi[20%];Hubert Nogal[20%];Leo Hood[20%];Murat Güşan[20%];Rike Brunke[20%]
Concept definition	
Product feature	Adrian de la Torre[20%];Dániel Berényi[20%];Hubert Nogal[20%];Leo Hood[20%];Murat Güşan[20%];Rike Brunke[20%]
Design	Adrian de la Torre[20%];Dániel Berényi[20%];Hubert Nogal[20%];Leo Hood[20%];Murat Güşan[20%];Rike Brunke[20%]
Research	
Materials	Adrian de la Torre[15%];Dániel Berényi[20%];Hubert Nogal[15%];Leo Hood[20%];Murat Güşan[20%];Rike Brunke[20%]
Technologies	Adrian de la Torre[10%];Dániel Berényi[20%];Hubert Nogal[15%];Leo Hood[20%];Murat Güşan[20%];Rike Brunke[20%]
Life cycle	Adrian de la Torre[20%];Dániel Berényi[20%];Hubert Nogal[20%];Leo Hood[20%];Murat Güşan[20%];Rike Brunke[20%]
Production process	Adrian de la Torre;Dániel Berényi;Hubert Nogal;Leo Hood[50%];Murat Güşan;Rike Brunke[50%]
Planing	
Task allocation	Adrian de la Torre[20%];Dániel Berényi[20%];Hubert Nogal[20%];Leo Hood[20%];Murat Güşan[20%];Rike Brunke[20%]
Swot analysis	Hubert Nogal[60%]
Work breakdown stru	Adrian de la Torre[25%];Hubert Nogal[50%]
Gantt chart	Adrian de la Torre[30%]
Marketing	
Target group	Leo Hood[40%];Rike Brunke[40%]
Market niche	Leo Hood[50%];Rike Brunke[50%]
Marketing strategy	Leo Hood[20%];Rike Brunke[20%]
Marketing mix	Leo Hood[30%];Rike Brunke[30%]
Development	
Hardware	
Sketching	Adrian de la Torre[30%];Hubert Nogal
Pattern	Adrian de la Torre[40%];Hubert Nogal
Prototyping	Dániel Berényi;Hubert Nogal;Leo Hood[70%];Murat Güşan;Rike Brunke[70%];Adrian de la Torre
Testing	Dániel Berényi;Hubert Nogal;Leo Hood;Murat Güşan;Rike Brunke;Adrian de la Torre
Improvements	Dániel Berényi;Hubert Nogal;Leo Hood;Murat Güşan;Rike Brunke;Adrian de la Torre
Final touches	Dániel Berényi;Hubert Nogal;Leo Hood;Murat Güşan;Rike Brunke;Adrian de la Torre
Software	
Programming	Arduino[1];Adrian de la Torre[30%];Dániel Berényi[50%]
Testing	Adrian de la Torre[30%];Dániel Berényi[50%]
Optimalization	Adrian de la Torre[40%];Dániel Berényi
Build -up	
Manufacturing	metal grid;servomotor[1];solar panels[1];steel[1];temperature sensor[1];wheels[1];wood[1]
Assembly	Adrian de la Torre;Dániel Berényi;Hubert Nogal;Leo Hood;Murat Güşan;Rike Brunke
Testing	Adrian de la Torre[50%];Dániel Berényi[50%];Hubert Nogal[50%];Leo Hood[50%];Murat Güşan[50%];Rike Brunke[50%]
Final adjustment	Adrian de la Torre[50%];Dániel Berényi[50%];Hubert Nogal[50%];Leo Hood[50%];Murat Güşan[50%];Rike Brunke[50%]
Distibution	
Advertising	Rike Brunke[50%];Leo Hood[50%]
Selling	Rike Brunke[50%];Leo Hood[50%]

Figure 11: Distribution of individual tasks

Table 6 is a Role and Responsibility Matrix; it shows the team's task allocation and each person's position for each task.

Table 6: *Role and Responsibility Matrix*

	Adrian	Frederike	Leo	Hubert	Murat	Daniel
Report: State of the Art	Approver		Responsible/ Informer	Consulter		
Report: Marketing		Responsible/ Informer	Approver/ Consulter			
Report: Ethics and Deontology	Approver	Approver	Consulter			Responsible/ Informer
Report: Sustainability	Approver/ Consulter				Responsible/ Informer	
Report: Product Development	Responsible/ Informer		Approver	Consulter		
Report: Project Management	Approver/ Consulter	Approver		Responsible/ Informer		
Product Design/Solid Works	Responsible/ Informer	Approver	Approver/ Consulter	Approver	Approver	Approver
Cardboard Prototype	Responsible/ Informer	Approver	Approver	Consulter		
Study and Choice of electrical components	Approver/ Consulter			Informer	Responsible	Responsible
Scientific Paper	Consulter	Responsible	Responsible	Approver/ Informer		
Poster &Leaflet		Approver	Responsible	Consulter/ Informer	Approver	
User Manual	Consulter	Responsible	Approver/ Informer	Responsible		
Final Video	Consulter	Approver	Responsible/ Informer	Approver		
Product Construction	Responsible/ Informer	Responsible	Responsible	Approver/ Consulter	Responsible	Responsible

3.6 Communications

Communication management takes into consideration information flow about every issue connected with our project between entire team in order to Communication is an essential part of conducting business, and therefore we are using various methods to communicate in our workplace.

Face-to-Face Communication:

Most of the time our communication is based on meetings. These type of communication takes place at least once a week. Moreover, every week meeting with supervisors takes place on which entire problems and We strongly believe that face-to-face communication is the most efficient way of work.

Email:

Email is a preferred method of communication with supervisors as we can discuss with them our dubts and issues anytime. Emailing enhances efficiency because it is quick to send and quick to respond to and you can even include attachments that are essential to the subject being discussed in the email conversation.

Facebook:

It is cheap, user friendly and furthermore it is a fast way of communicating with each other. Furthermore, nowadays it is the most popular online social networking service.
Table 7 describes the communication process between team members, supervisors and teachers during the project.

Table 7: *Communication register*

What	Who	How	When	Why	To whom
Weekly performance appraisal	Team	Meeting	Every week	To control and administrate project development	Team
Weekly supervisors meeting	Team	Meeting	Every week	To present and evaluate current work	Supervisors
Team meeting	Team	Meeting/facebook	Every week	To discuss and develop the project	Team
Contact with project client	Team	Meeting/mail	Once a two weeks	To present and satisfy client requirements in order to reach the agreement on project design	Client
Contact with direct superviosr	Team	Meeting/mail	Once a two weeks	To discuss project design, further improvements and entire complications	Direct superviosr
Interim deliverables	Team	Presentation/wiki	09/04/2015	To present and get evaluation of already accomplised work	Supervisors
University	Teache	Classes	Every day	To broaden knowledge and	Students

What	Who	How	When	Why	To whom
course	rs			provide students with essential information for further project developments	
Material list feedback	Teachers	Mail	Each time after sending file	To correct and give advice concerning every component	Team

3.7 Risk

Risk management is attempting to identify and then manage threats that could severely impact or bring down our project. Generally, this involves reviewing operations of our team, identifying potential threats to the project and the likelihood of their occurrence, and then taking appropriate actions to address the most likely threats. To be effective, risk management must be proportionate to the size and nature of our project. Avoiding all risk would result in no achievement, no progress and no reward. The benefits of risk management in projects are huge. We can minimise the impact of project threats and seize the opportunities that occur. This allows us to deliver our project on time, on budget and with the quality results our project sponsor demands.

Table 8 represents all the potential risks the team might encounter during the project, and their possible consequences.

Table 8: *Risk register*

Risk	Consequence	Response	Owner	Rank
Inappropriate materials selection	Inability to construct previously designed model	Change the material list and try to obtain proper components	Adrian	0.06
Conflicts with stakeholders	lack of agreement which leads to slowing down the project development	discussion, communication and finding compromises	Hubert	0.06
Illness of team members	missing deadlines due to overallocated tasks	efficient and well considered division of additional obligations	Leo	0.05

Risk	Consequence	Response	Owner	Rank
Lack of experience and knowledge	Inability to predict various conditions of the project	self development and research in project issues	whole team	0.02
Poor design	project failure and dissatisfaction of stakeholders	Investigation in details of design and carful performance	whole team	0.12
Unfavourable weather conditions	impossibility of carrying out the experiment	design of emergency element of construction (such as light bulb)	Rike	0.2

Table 9

Table 9: *Inappropriate materials selection*

probability–> impact	very low (0,1)	low (0,3)	moderate (0,5)	high (0,8)
very low (0,05)				
low (0,1)				
medium (0,2)		0,06		
high (0,4)				

Table 10

Table 10: *Conflicts with stakeholders*

probability–> impact	very low (0,1)	low (0,3)	moderate (0,5)	high (0,8)
very low (0,05)				
low (0,1)				
medium (0,2)		0,06		
high (0,4)				

Table 11

Table 11: *Illness of team members*

probability–> impact	very low (0,1)	low (0,3)	moderate (0,5)	high (0,8)
very low (0,05)				
low (0,1)			0,05	
medium (0,2)				
high (0,4)				

Table 12

Table 12: *Lack of experience and knowledge*

probability–> impact	very low (0,1)	low (0,3)	moderate (0,5)	high (0,8)
very low (0,05)				
low (0,1)				
medium (0,2)	0,02			
high (0,4)				

Table 13

Table 13: *Poor design*

probability–> impact	very low (0,1)	low (0,3)	moderate (0,5)	high (0,8)
very low (0,05)				
low (0,1)				
medium (0,2)				
high (0,4)		0,12		

Table 14

Table 14: *Unfavourable weather conditions*

probability–> impact	very low (0,1)	low (0,3)	moderate (0,5)	high (0,8)
very low				

probability–> impact	very low (0,1)	low (0,3)	moderate (0,5)	high (0,8)
(0,05)				
low (0,1)				
medium (0,2)				
high (0,4)			0,2	

3.8 Procurement

Procurement management is known to help an organization to save much of the money spent when purchasing goods and services from outside. To do that we have to compare the cost of all items against quality. It's therefore crucial to manage suppliers performance carefully, to ensure that they deliverables meet our expectations. Although there may be several suppliers, who provide the same goods and services, careful research would show whom of these suppliers will give us the best deal for our project. Due to restrictions we are only allowed to use local Portuguese shops and websites. However, not all goods and services needed to be purchased from outside.

3.9 Stakeholders management

It is well known that to be successful, management of the stakeholders is extremely important. It is essential for us to know how we have to communicate with people who are involved in EPS and how much power and interest they have in our project. In order to know the stakeholder better as well as better understand their impact on our project, we have conducted the 'stakeholders analysis', which aims at knowing how to successfully get the support from different parties.

The analysis was made in four steps:

1. Defining all of the stakeholders.
2. Finding their interest in our project.
3. Finding the power they have over the project.
4. Mapping the stakeholders on the graph

Figure 12 depicts graphical stakeholders analysis.

Figure 12: Stakeholders positioning

1. Team Members:

The first and probably the most important stakeholder is our team. Indisputably, we have the highest level of power and interest over our project. The results depends mostly on our determination, motivation and time management. Others stakeholders can be very helpful with their knowledge and motivation, however the work is to be done by ourselves. All this makes us the most important stakeholder as we have to work for our success.

2. Supervisor Paulo Ferreira (client):

Paulo is another predominant stakeholder due to the fact of being our client. His requirements are crucial and must be taken into consideration in our project. Moreover, he is our Electronics Crash Course lecturer, therefore he can also provide us with tremendously important electronic information.

3. Supervisor Abel José Duarte (team supervisor):

The third main stakeholder that we have identified is Abel José Duarte. As our supervisor he is a paramount stakeholder, and thus he definitely has a huge power over our project.

In fact, he is following our work and gives us advice on how we should proceed. Moreover, he can provide us with his vast knowledge on dehydrating process. However, his interest in the project is a little bit lower than ours, but still very high as he wants us to do a great job. Due to the fact that he is an expert in the field, he will probably not learn anything new from our work.

4. Society:

Finally, we have identified society as a stakeholder of our project. Society has very low interest, because of quite low expectations and power with regard to our work. However, because healthcare is a very important domain in our society, we think that in the future we might be able to participate in the improvement of the quality of life.

5. Supervisors (jury):

Supervisors are really important stakeholders, because they have a very high level of power as they will grade us and they also show a pretty high level of interest due to the fact that they will read our report. Moreover, they will be present during the final presentation, therefore we have to try to satisfy their requirements.

6. Supervisor Benedita Malheiro:

We identify Benedita as a stakeholder, because she is supervising the entire EPS program and because of her expertise in the team project management. As a head of entire supervisors she is very powerful in decision-making and everyone takes into consideration her opinion.Obviously, she wants every group to be successful and will expect a very professional and convincing presentation. However, she does not have a very high interest in our work as she overviews all the projects and cannot follow each group separately.

7. Solar dehydrator researchers:

The next stakeholders that we have identified are the solar dehydrator researchers. We can benefit from all those researchers through the literature (reports, articles, etc.), because as far as our team is concerned, this literature is really important as it provides all the knowledge about this process. However, the researchers as individuals are not very important stakeholders as they neither have interest in our project nor direct influence on it.

Table 15 represents each stakeholder's level of power and interest in the project.

Table 15: *Stakeholders register*

Person(s)	Power	Interest
Team members	High	High
Supervisor Paulo Ferreira	High	High
Supervisor Abel José Duarte	High	High
Society	Low	Low
Supervisors (jury)	High	Medium
Supervisor Benedita Malheiro	High	Medium
Solar dehydrator researchers	Low	Low

3.10 Conclusion

Project Management is one of the pivotal aspects of project realization. It is a useful tool that enables the team or the project leader to evaluate the risks of a project, the position and responsibilities of the people involved, the cost and the budget, and specify the product requirements, and manage the durations and deadlines of the individual tasks. All in all project management allows all the people involved in the project to keep up with what is going on on a daily basis.

Thanks to useful programs such as “Microsoft Project” or “Gantt Chart Project”, our team was able to allocate each task to a member, set the deadlines and/or expected durations for each task and/or each deliverable, and check up on the completion status of every task. This way, we managed to stay up to date and organized.

4. Marketing Plan

4.1 Introduction

The Solar Dehydrator is a product for a special market niche. Appealing to the potential consumer group requires a detailed marketing plan. The main goal is also to define our market, to make a segmentation and work out our location in this market. After different

analysis which get explained in this report more detailed the other important aim of a marketing plan is to create a coordinated marketing mix for our consumer group. Marketing planning is therefore an important task in the company which should be characterized in part by a systematic approach on the other hand of creativity and flexibility.

4.2 Market Analysis

In a market analysis first of all we have to specify the entire target market in which we find ourselves with our product. In exchange for that we need to collect different information from secondary sources to identify the market potential and the need. Some sources are for example literature like market surveys, classified directory, data bases and as the most important thing the internet. The main goal here is to know in which market is a need for our product it´s really necessary to choose the right target market. A market analysis is not just past-and present oriented it is also possible to predict potential events in the future. A lot of research is the most important step to do to find the proper market for your product. In our case with our product the solar dehydrator the whole market is drying something with the sun light. Since we are a start up company we will stay in the European market for now. To cover various fields in the market analysis it requires a micro and macro analysis. These differ in the following: The macro analysis deals with influences from the external environment. For this purpose it is operated by the Pestle analysis. The Pestle analysis consist of P for political like are there any laws or rules which influence our product in the target market, E for economic determines what directly impacts a company and have resonating long term effects, S for social here cultural trends and demographics factors are examined, T for technological what kind of innovations in the technology are there which may affect operation for the industry and the company a detailed research is necessary, L for legality in an internal and an external view. In this part observing laws like safety standards and consumer laws. The last E for environment this one is the crucial aspect in the pestle analysis especially for certain industries where the climate and weather has an important role.

According to this analysis there is an over view for the whole external environment for the market in which the product is situated. If we apply this analysis to our product we get following results:

For the P: We don´t have to pay large attention for the political part because we are located in the European market where are uniform laws also in the commercial way in the

majority of the countries. We will start in Germany and go on with some chosen countries. Table 16 depicts the comparison of weather conditions in different European countries.

Table 16: *Weather comparison*

	Germany	Switzerland	France	Italy	Portugal	Spain
Average temperature	22° C	22° C	20 to 30° C	25° C	24° C	26° C
Average number of rainy days per month	15	14	5 to 17	3	8	5
Average number of sunny days per month	6 h/d for 12 days	7 h/d for 13 days	5 to 9 h/d for 12 to 22 days	8.5 h/d for 25 days	7.5 h/d for 19 days	9 h/d for 23 days

Moreover our solar dehydrator is portable therefore not that big that there would be problems with prohibiting illegal building. Moreover the majority of the European countries are in a safe political situation mainly Germany.

For E like economic it is different because the solar energy is used worldwide and the market is still growing. In 2009 the photovoltaic solar industry generated 38.5 G$ globally with sale of solar modules and the installation of solar systems. The largest market is in Germany that’s the reason why we want to sell our product in this country as well although there are not that many hours of sunshine. But solar energy is quite favoured in Germany [IHS Inc., 2015]. A big market from the solar industry in Germany is in the private sector. Figure 13 presents Germany's Energy Revolution Still People Powered.

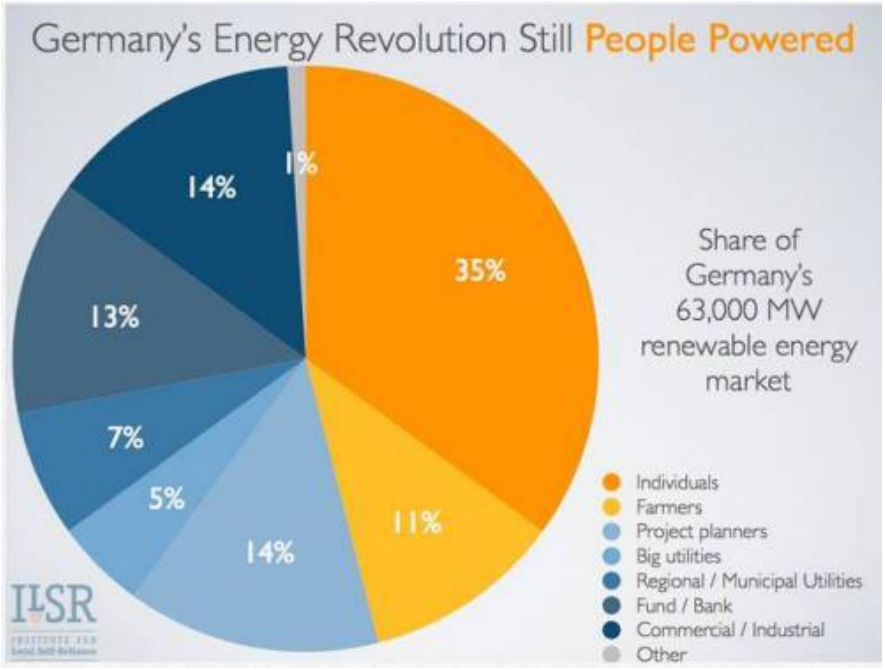


Figure 13: Germany's Energy Revolution [John Farrell, 2013]

The market potential has not been exhausted. But in countries where there are subventions an assessment is difficult because with subventions there is no correct reflection from the purchasing power. Since the subventions from government stopped in 2012 the investments for big companies decreased.[n.a, 2014] But our concept just to use solar energy is quite new especially in the food dehydrator market and it is seldom represented in the solar industry. Most of the companies which work in this industry sell solar energy in terms of photovoltaic or solar panel and thereby a mix from solar energy and electricity from a socket.

For S social part the thinking about the destroyed world and therefore the importance of environment protection has greatly increased in the recent years in Germany. Supporting new ways of energy such as solar energy is really common. Many people want Germany to play a pioneering role against the global warming. Mainly young educated people with daily internet access have a high interest in environmental protection.[n.a, 2010] Moreover the demographic trend in Europe and also in Germany goes to an aging society [Prof. Dr. Paul Gans, Dr. Ansgar Schmitz-Veltin, 2010]. Our product is adapted to that trend because it is not that big and consequently portable. So it is really easy to handle with the wheels which makes it usable for all ages. Furthermore the cultural trend in many European countries goes in the direction to eat healthier and more fruits and vegetable from organic

farming. Various people don´t want belong to the “disposable society” any longer. In Germany this trend becomes more and more hip. Germany is famous as a society where everything must be really fast and do various things in between also the meals. The awareness about healthy food as organically grown increased a lot [Sarah Amadio, 2014]. T the technology of the solar energy is constantly evolving. We try to be on the current technological level. Solar energy has been already around 25 years on the market but to use it in a single way without any net electricity. Figure 14 depicts the dependency between German solar PV and yearly electricity consumption.

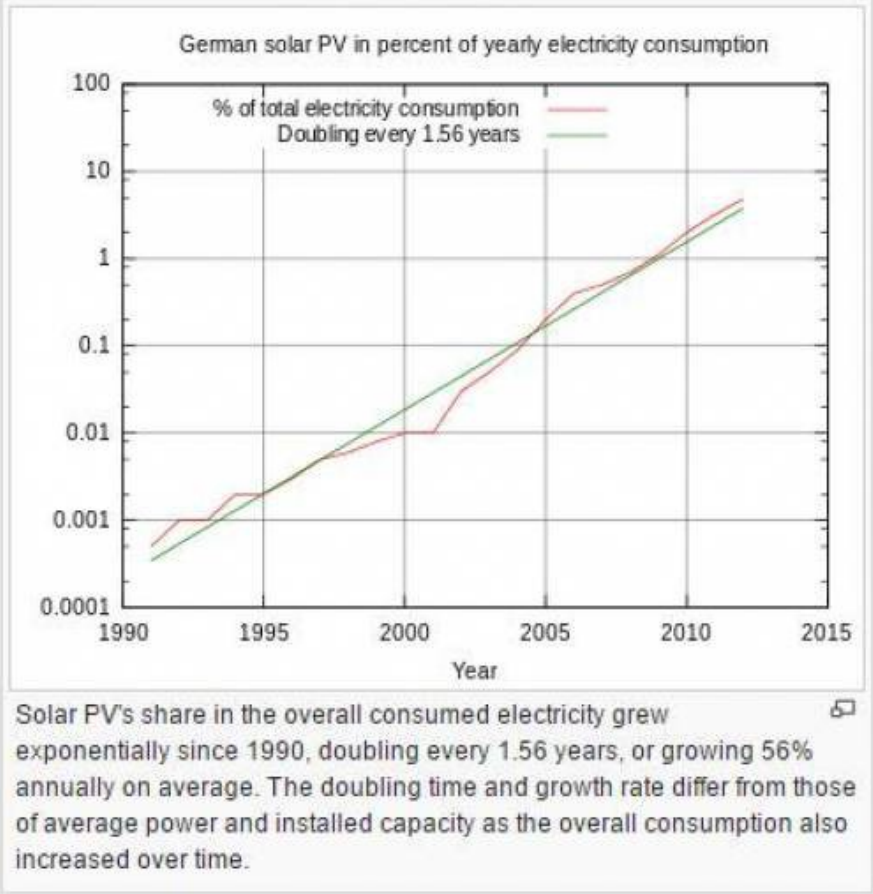


Figure 14: Solar PV's share [n.a (Wikipedia), 2015]

Drying fruit with this type of electricity is an innovation in this market segment. The solar electric energy demand has grown by an average 30% per annum over the past 20 years. For staying attractive and worthwhile the development works in a fat way to find more effective solar panels. In Hameln they won a new type of solar panel which is more efficient they have already some proper results. L in the legality the most important object for our product that it is proof against fire. So a safety standard must be given. In other

respects there are not that many laws for our product which influence the development. E in the environmental way we have to study the weather and select the countries where we want to sell the solar dehydrator. Our target market is deeply formed from the weather. Therefore there must be a designated hour of sunshine hours and preferably not that much humidity (see Table 16). Figure 15 presents the global radiation in Germany.

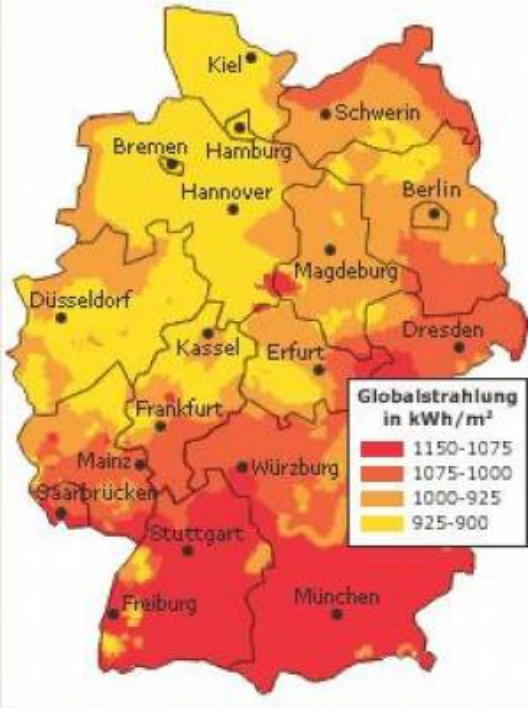


Figure 15: German's global radiation

Out target group is strongly represented in cities such as Hamburg, Munich, Berlin. In the named cities there are following values were measured in the summer [n.a, 2015]:

Berlin : 680 h
Hamburg : 645 h
Bayern (Munich): 638 h

Micro Analysis:

A micro analysis tries to analyse the internal environment from the company covered the definition of the market and the analysis of the industry. The research here is about the differentiation of the market and the customer, with regard to the following questions who and where are the customers, which different channels of distribution will reach the

customer. Why the customer wants to buy our product or why he will prefer our product and how much is he willing to pay for that. Another point of the micro analysis deals with the suppliers who are our suppliers and are they easy to find. Also here is to analyse the competition. Who and where is our competition and with a comparison about points like service, communication, sale service where are their distributions channels. Our market delineation is product related as the product was selected before a market analysis was done. The relative market is the whole solar electric energy market but we want to distinguish ourselves from the photovoltaic systems. We want to demonstrate to use the solar energy in as useful as possible without having a big installation of a system and especially without using normal electricity. Our product works in a natural way it is not needed to have the solar dehydrator in the near of a socket. Additionally the solar dehydrator is designs for private persons or families with their own garden or terrace. We don’t want to operate with big companies. The solar electricity market is one part of our target market the other one is every tool for drying food. There are small dehydrators for the kitchen whereby it is possible to dry fruit vegetable and often meat as well. These dehydrators are in the methods and design are really similar to our product but the biggest and most important difference is that they need a socket. So there is no drying in a natural way and it is just for using inside. Likewise we find ourselves partly in the solar market and partly on the dehydration market. For both there are components which distinguish our product from the other providers/products.

Competitor Analysis:

Since we must define our competition in a broader sense, all the companies who are involved in food preservation and food processing methods are relevant to us. However, for this chapter, we will concentrate only on European companies and use cases, since our own company is still in the developing phase, and our product will only be manufactured and distributed in Europe for the time being.

Other food preservation and processing methods include freezing, pickling, making jam, preservation in salt, and smoking. All these methods are very different to drying food, which is why we don't consider them as actual competition. However, the process of drying food has advantages over the methods listed above:

- the process of smoking is restricted to fish and meat, whereas we specialize in the preservation of fruit and vegetable. Moreover, it requires a large amount of salt, and

smoke components can infiltrate the food.

- foods that are preserved by freezing are prone to lose a certain share of vitamins, especially when they need to be thawed out and re-heated to eat or cook with. Furthermore, the thawed food has to consumed rapidly, since it tends to rot quickly.
- the process of making jam is a very long one and it requires the presence and attention of the person making it. What's more, is that jam contains a large amount of sugar, which makes food drying the healthier method. Finally, jam is usually eaten with other foods such as bread, whereas dried fruit can be eaten anywhere, at any time, on their own, as a small healthy snack.
- preservation in salt, like smoking, is mainly used for fish and meat and would not fit our purposes (fruit and vegetable). Moreover, the large amount of salt makes it rather unhealthy, especially when consumed regularly.
- the process if pickling is used a lot for vegetable, and comes closest to our food preservation method. However, pickling is done with vinegar, which would not work for fruit (for questions of taste). Furthermore, the peculiar taste of pickled food does not appeal to everyone.

For the reasons listed above, our actual competition will cover every company which dries any type of food and/or offers products for drying food, as well as the many companies who deal with solar energy. However, our competition in the field or solar energy companies is limited, since none of these companies engage in processing food. Our competition in a narrow sense are companies who offer relatively similar products, with the same benefits for the client as our product. Here, our rival-products are kitchen dehydrators for indoor use.

- The Stöckli Dörrex from Switzerland with synthetically grids a device for drying fruit, vegetable, mushrooms and herbs. The price started at 109.90 €.[n.a, 2015]
- Severin OD 2940 from Germany this one is a device which need less electricity just 0.4 € for drying 300 g apple. It has 5 different shelves which a ground of 31cm2 the time for drying is about 6 to 7 hours and the price is about 50 €. It is made of plastic, has an on/off switch, and the height of the dryer shelves is adjustable [n.a, 2015].
- Sedona TM from Germany has a glass door and a small digital screen and less noise. Moreover it has 9 shelves but need 550 W and is with 10.6 kg really heavy

and not easy to handle for everyone. For the drying needs some films which must be ordered separately and the price is already by 399 € [n.a, 2013].

- Bomann DR 435 CB Dehydrator also from Germany with 5 shelves circulating air and a safety that the temperature doesn't reach a value under a special temperature. This dehydrator needs less energy with 250 W and the price is about 25 to 40 € [n.a, 2012].

For most of the dehydrators there is the suggestion to change the order of the shelves when half of the drying time is over. Our biggest strength or advantages towards our competition is that our clients have no more cost after the purchase in terms of cost for electricity or service. Moreover our solar dehydrator is for outside so the product does not take up any extra space in the house. Furthermore we attach importance to the easy handling for everybody try to use little weight resources and the wheels make our product portable.

The biggest weakness towards our competition is the price. We do not have an exact price right now but we will be definitely higher than "Bomann" or "Severin", because we are still a start up and our range is specialized in one product for the first years. The big companies as "Bomann" or "Severin" have a large range thus they could split their costs of all types of their products and be cheaper

Suppliers:

Here we have to have a look if it is easy to find suppliers for our resources because if there are a lot of different suppliers for the same product usually the price is less. For the solar panel or wood there are a lot of different suppliers directly in Germany. There will be no problem to change the supplier if something goes wrong or if prices are changing. Most of the wood companies in Germany work in a sustainable way because there are laws how to operate in this business. Another important point for the choice of a supplier is about the transport cost as who pay that and who does it. Therefore for the wood we will order through" Holzhandel- Deutschland" because they deliver the goods everywhere in Germany and have some certificates and a huge range.[n.a, 2014] For the sensors of the of temperature, the motor and the battery there are many suppliers in Germany but most of the products are coming from china. But our company wants to support companies who manufacture in German. Also it is not sustainable to take something from China. Made in

Germany is also a sign of quality and we attach importance to high quality. “Rössel Messtechnik GmbH” is the suitable company for the electrical technology [n.a, n.d]. (In order that our main supplier is the ISEP faculty in Porto). For the battery we chose as a supplier the “Ansmann AG” because they also have a huge range and emphasize quality. They get involved for being environmental friendly so the main company philosophy fits with our intentions. But the choice of companies who sell batteries is really large in Germany so we will not have a problem if there are some delivery bottlenecks [n.a, 2015].

Target group:

The Greengineers Company intends to reach a modern kind of customer, who is willing and able to invest in a sustainable, energy-saving way to prepare healthy food – by drying e.g. vegetables from their own garden. Meat and all kinds of animal products are excluded, this Solar Dehydrator is solely made for vegetarian and/or vegan foods. Nowadays, with a growing importance and public awareness of economic sustainability, and the consumer’s rising willingness to make a change and – most important – pay for it, solar-powered tools and products are gaining popularity and will be playing major roles in the near future, as fossil energy resources slowly come to an end. Meanwhile, the modern middle class people (and above) of all ages desire better food, as they have a growing awareness and understanding for a natural, healthy cuisine: the new Slow Food target group as young educated people with internet access who are also willing to be part of changing the world. This target group, as they aim to help the environment by “eating responsibly”, is likely to be attracted by a green, environmentally-friendly solar product which helps them fulfil their purposes of preparing healthy, organic food – at its best from their own garden and with a reduction of food waste due to its preservation through the drying process. Our target group is located is Germany in the beginning because there is a big potential as stated in the macro analysis.

4.3 SWOT Analysis

The aim of the Strengths Weaknesses Opportunities and Threats (SWOT) analysis is to figure out the strengths and the weaknesses for the present time and the internal part. On the other side also the threats and the opportunities for the future which is the external part. The SWOT-analysis is an instrument for the strategic planning for companies it is important take the right marketing strategy.

Our strengths consist as we are very customer orientated and we are following the new and really important trend to be sustainable and green with the using of solar energy. Our clients are independent from the prices for the electricity. While we are an international team we have insights in different markets in form from a local view which is probably different which from some facts out of the newspaper. Our product is an innovation especially for Porto. One of the weaknesses from our project is the less time and the specified budget also no one of our team did a project like this before so there are not that much experience. We are surely inflexible with the prescribed deadlines so if something goes wrong is will be difficult to stay in time or fix it that the result is good. The opportunities be composed mainly of the demographic change and also the awareness for the environment and to eat healthy like the own dried fruit without any toxics in it. Another point is the development of the technology and the curiosity of working or more using solar energy. The largest threat for our product are the companies which prepare a lot of different kitchen staff like named in the competition analysis. These companies have a huge assortment and therefore it is possible for them to produce in a cheap way.

4.4 Strategic Objectives

Strategic objectives are require for new market recovery or the development of new sale areas. Thus the strategic marketing serve as a long-term marketing conception. Our main strategic objectives is to find the gaps in the market achieve new target groups and associated therewith the development of new markets. Moreover it is really important for us as we are a start up company that we will increase our name recognition. Since we are more public in Europe and have a save position in our target marketing the chosen countries we plan an expansion in two years. The plan implied to expand partly to the United States as California because here is also a high number of sunshine hours (8) [n.a, 2015].

4.5 Segmentation

In the market segmentation is the overall market divided into different market segments. The selection of these segmentation follow specify target criteria. Market segments can be classify by products or by customer. Customer segmentation are for example age, income, job or gender. The product segmentation can be done e.g. consumer goods or investment goods. Moreover there are segmentations with regard to demographical, geographical and psych graphical. The aims from a market segmentations especially in our case are:

- to find the neglected sub markets thus the market gap
- determination of the relevant sub-markets
- the accurate position for new products
- proper satisfaction of customers needs

In order to present market segmentation more clearly, graphical structure was created which is presented in Figure 16.

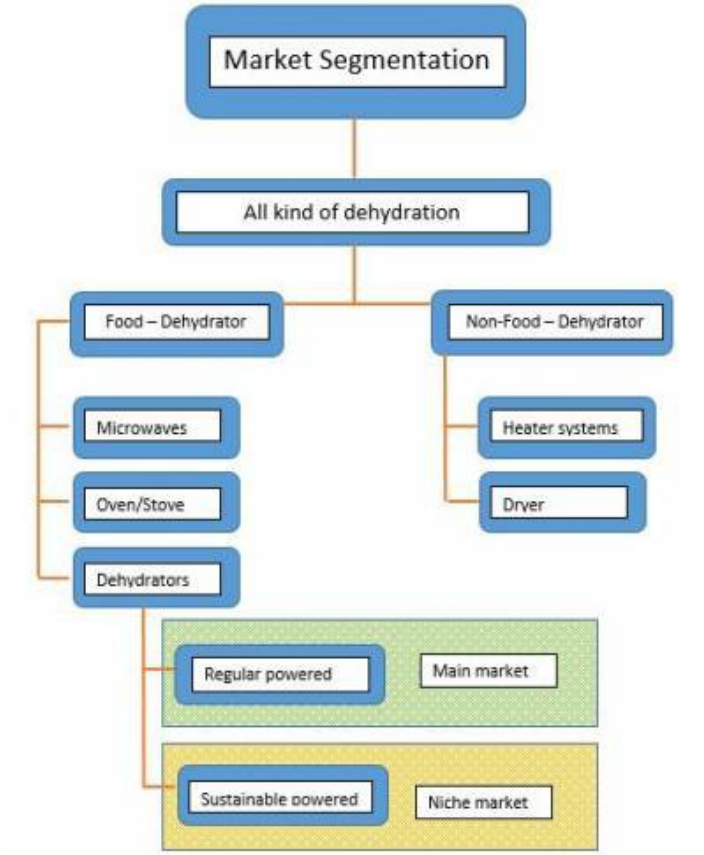


Figure 16: Market segmentation

The macro-geographical delimitation for our product is the market in Europe, the micro geographical delimitation are more or less similar habitats like people who has the opportunity to have a solar dehydrator on their own property. In psychographic regard we consider people with the same lifestyle who love the nature and prefer to eat something which was produced by their own. Figure 17 depicts dependency between market position and ratio efficiency-price.

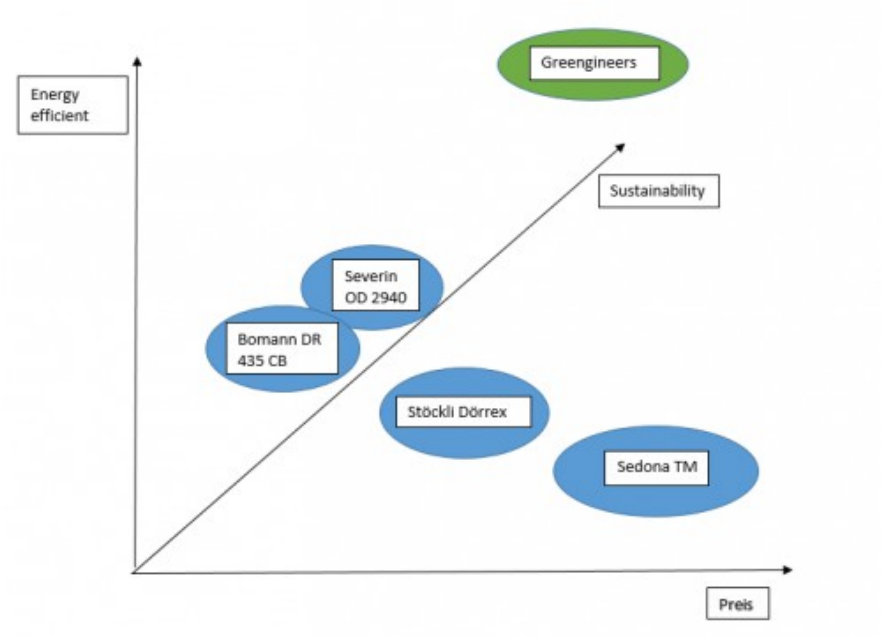


Figure 17: Market position in terms of ratio efficiency-price

4.6 Strategy/Positioning

Positioning:

From the attached graphic can be inferred where we want to position ourselves against our competition. We place particular weight on the sustainability of our product and the energy efficiency of it. Our objective to be as sustainable as possible and at the same time be able to compete with our competitors in cost effective manner. So our differentiating feature is our sustainable product design. Because our product are designed in sustainable manner our production cost are higher and the consumer price are higher too. Our selling arguments are that through our sustainable power supply the consumer saves money on using the machine because there no costs for energy anymore. Furthermore our target group are people which have a strong feeling of connection the environment and place great value for eating healthy and save the world.

4.7 Adapted Marketing-Mix

Product:

A product includes a list of specific features that help define the customer value. Our company, the “Greengineers” is developing and offering a solar dehydrator which will be portable and for private use. The main purpose of our product is to give our customers the possibility to prepare healthy food by themselves while being environmentally friendly. Furthermore, by preparing and preserving food in this manner (dehydration) we support

waste reduction, by encouraging our clients to stop throwing away so much food: Any surplus food that is processed in our dehydrator can be kept for at least a year. By using our solar food dehydrator, our clients will save money on energy, since no surplus energy costs arise. Also, they might save money on certain types of food (in our case: fruit and vegetable). Customers have the opportunity to eat healthily, as our solar dehydrator dries the food slowly, in order to retain most of the vitamins. Our product belongs to the durable goods.

Food dehydrators are already established in the current market, however our solar food dehydrator is an innovative and optimized product. Dehydrators for food, seeds and materials already exist, but only few of them work with solar panels or have a monitoring/control unit. Most dehydrators that are used on a small scale (private use) do not work on solar energy but require an external power supply (socket electricity). Others are simple, “Do It Yourself” devices that have no electrical components at all.
Our solar food dehydrator is portable, designed specifically for fruit and vegetable, has a control unit, which is powered only by solar energy. Our product includes new technical features, yet is still fully autonomous. This is the crucial differentiation from our competitors. Therefore we can speak of innovation. We are as sustainable as possible also with our commonly used resources.

Price:

Defining the price policy is the most important step in order to work out the ideal price of the product. Issues to consider are prime costs, strategic positioning, request and competition. Figure 18 illustrates what components form a price.

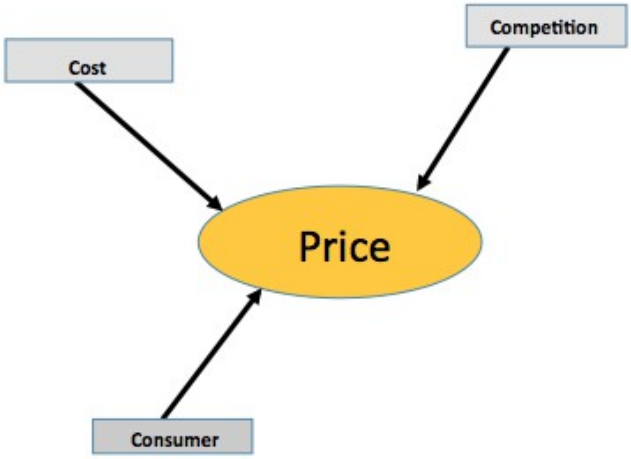


Figure 18: Price components

Basic characteristic price policy decisions are:

- fast implementation
- large impact force
- high speed of tremolo

There are two different strategies to define the price of a product:

- The “Skimming” strategy implies relatively high prices, thereby rapidly covering the costs of development. The customers have to be willing to pay the initially high price of the product, but this price will be lowered over time, for example when the competition gradually steps in. In theory, this strategy should be used for specific or innovative products with a high added value.
- The “Penetration” strategy implies relatively low prices. The aim of this strategy is to rapidly obtain a high market share. This strategy is usually used for products that are already established on the market, but for which a new, low cost brand attracts the consumer's attention.

To start with, we decided to use the Skimming strategy for our product, as our development costs are high and our market niche/target group is still relatively small and specific. Moreover, we offer a high quality product which implies that we use high quality, long-lasting materials. Our company invests in sustainability which, at the beginning, will

be connected to higher costs. We operate in a small market niche so it is important for us to cover our prime costs but also to protect our position in the target market. So we will adapt our price to the properties of our product.
We will start by offering single size products in order to get an impression of the consumer's reaction to it, and to have one fixed price for our product. Once our customers (start purchasing our product in higher quantities (minimum limit: 5 dehydrators) we will offer a discount. The larger the quantity, the higher the discount percentage. This discount is mainly put in place for our more important customers and larger distributors. Moreover, according to customer demand over time, we may start producing the dehydrator in different sizes (smaller and easily portable, and bigger, to produce larger quantities of dried food).
However we cannot set an initial price yet, as we are not finished with the product development. First of all we need to test the final prototype (which we will build at ISEP) to make sure all the features are working as we expected. This will enable us define the main part of our prime cost and, later on, the final price of our product. Gradually, we would like to expand our market to several different European countries (Germany, Switzerland, Austria, France, Spain, Italy, Portugal). Thus, we will need to differentiate and adapt prices according to the country.

Promotion:

The third “P” stands for Promotion. The main concerns here are how to reach the target group and which instruments of communication should be used. For the promotion we need to consider which message the company wants to deliver to the consumers (content) and the instruments or methods of communication (support). The instruments should be chosen according to the target group. Nowadays there many different possibilities and promotion solutions. The classical ways of promotion such as print promotion (posters, advertisements in magazines), audiovisual advertisement on television or in the cinema, audio promotion on the radio and outdoor advertising. Modern promotion methods such as online marketing, mobile marketing, direct marketing, public relations, sponsoring, trade shows are growing more and more important.

Which marketing methods are suitable for our company?
We will practice online marketing as it has many advantages: Advertising online is not expensive, it is an easy way to reach out to a large number of consumers and there are a

lot of different possibilities to operate with it. Moreover it has a high accessibility for different target groups, the flexible individualization is also very high in this communication instrument. We will create our own web page, as well as a Facebook page which present and describes our company and our products.
Another instrument which is suitable for us is the trade show. Trade shows which specialize in presenting garden utensils, tools and furniture such as “Home &Garden” in Hamburg, “Gartenlust und Kunstgenuss” in Berlin or “Garten München” in Munich. Most of the people who visit trade shows are interested in the specific products that are presented, and basically represent the target group. That affect makes it easier to lead a conversation sale. Trade shows would give us the opportunity to present the entire product, along with all its features, as well as the outcome – the dried fruit and vegetables. Additionally, this marketing method makes it easier to start a personal and long lasting customer relationship.

Direct marketing is another instrument which represents our company well. A suggestion for direct marketing would be to offer some samples of our dried fruit while explaining to the potential customer how our product works and what our company's intentions are. We will be placed in large, so-called “hipster” cities like Berlin, Munich and Hamburg. These open-minded cities are ready to take on new trends, especially environmentally friendly ones. In such cities, it is also shown that citizens tend to eat healthily and accord importance to their diet, more so than in smaller cities or villages. For the direct marketing to work, we should chose the location of our stalls carefully: big, open spaces such as parks, large squares or near organic food stores. The advantage of advertising in famous, central squares is that not only locals, but also tourists have the opportunity of getting to know our product: This makes our marketing international while avoiding high travel costs. Another worthwhile promotion possibility is outdoor marketing. We will organise this kind of marketing in the cities listed above. This way, we can hand out samples of dried fruit and vegetable to passers-by and present the dehydrator itself. Consumers will get a precise idea of our goals as a company, our product, and the results, and may think about buying their own.

Place:
This part of the Marketing Mix is about the distribution of our product to the clients. Following decision areas must be worked out.

- Formation of the distribution system
- Formation of the selling activities
- Arrangement of the relationship with the suppliers

The operating system consists of several distribution institutions which are combined to form the chain of distribution.

There are direct and indirect distribution channels. Indirect distribution implies that the company itself does not sell their product directly to the client; the distribution goes through another company. Our company will use direct distribution, mainly because we want to stay in close contact with our clients. There are many important advantages in direct sales: We have full control over the quantity of our sales and can communicate directly with our clients. If a customer needs help with something, we are able to react rapidly and offer our services. However, we alone are responsible for the entire marketing section.
Another main issue is how our company will stay in contact with its clients. According to our chosen promotion methods, we will have direct personal contact with customers, not only during trade shows but also online. Our website and Facebook page will enable clients to contact us at any time.
Our main distribution channel for the first two years will be over the Internet. Clients will be able to order the solar dehydrator on our web page. Additionally, we will present and sell our products in specialized trade shows.
For future logistic issues, it is important for our company to find good local suppliers, a warehouse to store our resources and products, as well as an efficient and sustainable packaging method and design. Another essential point is finding an easy and efficient way of transportation for the solar dehydrators from the workshop/factory to the client, with a low environmental impact.
Our chosen distributer to start with is OBI. OBI has 352 stores in Germany and is well presented. Furthermore this company expands every year with more stores around Europe, which gives us an easy opportunity to export our product to other European countries.Another argument for this choice is the distributer's dedication to environmental protection and sustainability, which fits with our company's philosophy. OBI also delivers large and small items for little money, and thereby fulfils all our expectations [n.a, n.d].

It is crucial for the marketing mix that the product, price, promotion, place all fit together and complement each other. When this is the case, and the customer is willing to buy our product for the defined price, there will be a successful market launch for our product

4.8 Budget

For an effective marketing mix and good promotion it is essential to have enough money. Especially during the first year it is crucial to promote the company, to spread its name and to achieve a steady customer basis. At the beginning, the company should be willing to spend a larger part of the budget on promotion than it usually would.
Our company disposes of roughly 5000 € for the first year. For us to achieve the highest benefits, it is essential to decide on the suitable methods of promotion. The Facebook page is completely free of charge. A small part of the budget will be used to finance our other promotion methods:

- Webpage/homepage (0.20 to 0.50 €) per month
- Booth fee for the trade shows (depends on the show and the location)
- Direct marketing (offer food samples outdoors)

Outdoor marketing, just like print advertising, are two of the most important promotion instruments. However, there are strong price fluctuations which mainly depend on the country. In Germany one super poster costs roughly 878.55 € [n.a, 2013]. Public promotion can be very expensive, which is why it is important to manage the company's money in the most efficient way possible when it comes to marketing. Using free promotion as much as possible can turn out very useful, as well as taking part in free events which have to do with our product. It is sufficient to have two people from the team who present the company during events and trade fairs, which also makes it possible for us to represent the company at several events at the same time if necessary.

4.9 Strategy Control

Inspection:

The last step in a marketing plan are the inspections. This is an essential part in order to examine if the goals that have been set for the company have truly been achieved. There are two different types of inspection: the success inspection and the personal inspection.

The success inspection reviews the economic efficiency and the progress of the entire marketing plan.
The personal inspection examines the people who are responsible for the marketing plan. Both of these inspections have to be performed constantly. Only then is it possible to react early enough to change something in terms of promotion methods or personal and interpersonal issues.
In order to make the inspection easier and more efficient, it is useful to define certain key performance indicators such as the profitability of products, markets and clients. These key performance indicators enable companies to react before any mistakes happen.
In our case, following points need to be examined:

- How profitable are our promotion actions? If our methods are not cost-efficient enough, it might be necessary to change them and try different marketing methods.
- Our quality – we need to guarantee high quality products and that our resources are sustainable, long-lasting and/or recyclable.
- The relationship with the customers – we operate in a small market niche, therefore it is necessary that we create, cultivate and maintain good relationships with our customers. Inspection is really important. If a project is planned, it is crucial to examine its outcome constantly, in order to react in good time, if any changes are necessary. If we actively implement both inspections, we will have a well organized and properly structured marketing plan.

4.10 Conclusion

It is necessary to establish a marketing plan in order to analyse the customer's needs before developing the final product. Furthermore, we made a market analysis based on macro and micro environmental level as carry out the PESTLE analysis and analysed the competition. With this information we defined our target group and specified our market segment. We positioned our company in the defined market segment. As we are a start up company and still in the development phase, we will start by selling our product in Germany for the first two years. Later, we will expand our market to other European countries, such as France, Italy, Spain, Portugal, Austria, Switzerland. We will follow the business to customer system, in order to stay in close contact with our customers and maintain a good, long-lasting relationship with them.

best possible way, a way that appeals to the customer's needs. The goal is it to have an ideal mix, a fair price adapted to the product, and to be at the correct place at the correct time. The choice of an appropriate promotion strategy and a suitable distribution channel will attract a large number of new clients.

To sum up, our company, the “Greengineers” is developing a portable solar dehydrator for private people for all ages who have a garden or terrace. This dehydrator will work with solar energy so no extra costs of electricity arise. With this special function we fill a relatively new market niche in this field.

5 Eco-efficiency Measures for Sustainability

5.1 Introduction

Let’s start with an analogy to introduce this concept. Imagine the world we form part of as a tree. Imagine any kind of tree, and now try to figure out how to make it grow as perfectly as a tree can grow. The cornerstone of the growth has to be with three factors: light, air and substrates. The light provides the necessary energy to transform the substrates into nutriment while the air works, as complementary contribution in the chemical process, to provide enough carbon to the substrates to transform them into carbohydrates. That said, it’s inconceivable trying to make it grow ignoring light in the process, or ignoring the substrates or the air as well. This capricious triangle is what sustainability is about. Sustainability is the action of finding equilibrium between three primordial and basic factors in the evolution of the human being, such as social, economical and environmental. Each and everyone of these three topics is essential having them under control to ensure a prosperous life, not only about everything that surrounds our company as a product contribution to the world, but a contribution direct to the world itself. This balance is achieved through the imposition of various conditions that affect all the different factors mentioned before in the way to build a harmonic relation between them during the whole cycle of the process.

The main principle is as easy as every action done has to satisfy the human needs of actual generations without compromising the welfare of the incoming generations. Keeping awareness capable of avoiding the human to self-destruct itself, not only in actual situation, but also throughout its existence.

measures have been carried out to achieve this target. We have crumbled each and every one of the actions in terms of social, economical and environmental, which are presented below.

5.2 Environmental

The environmental impact is maybe one of the most disputed factor in the society nowadays, and this is why most of the people tend to associate directly sustainability with environmentally friendly, even when it's just a part of it.
To have an idea of how much can we contribute in reducing the environmental impact, we have divided the whole process into two differenced parts: Manufacturing and Use. The main goal of doing this is to have a clear view of most of the actions that concerns to our project and to the environment.

5.2.1 Manufacturing

5.2.1.1 Materials

This section concerns to the most relevant materials in the Solar Dehydrator.
Most of the product is going to be made from a singular material. By using less kinds of materials is a good point to limit the scope in order to increase the control of life of the residues not only by the point of view of the obtaining, also for the future life cycle.
As far as we pretend to base most of the product in a single material it has to accomplish some expectations as environmental friendly in obtention, distribution and refusal.
In an ideal system, our company would be producer and provider of our own materials, but this is near to a utopia. All the requirements to make this possible are totally out of range.
To ensure a good behavior in the environmental aspect, we look forward to a material that is provided under a sustainable control on the process. This means that the times of production are over the established minimums to ensure the total recovery of the environmental properties.
With the objective of providing a constant power supply to the electronic system, the Solar Dehydrator needs to have an incorporated battery. The programmed obsolescence is a fact and it is not also a problem towards the customer, it is a problem towards the amount of energy necessary to the recyclability and maintaining of the nature. A long-life battery will decrease most of the impact, looking always for a good ratio life-impact.

why we need to reduce the amount of harmful materials by increasing the quantity of eco-friendly ones. The total sum of this materials is quite reduced so even when we cannot avoid the contamination, it is pretended to approximate this values to a negligible point.

5.2.1.2 Process

It must be considered that a Solar Dehydrator is not a product with a high sells-flow. It is convenient to adapt the rhythm of the production to the rhythm that the market imposes, and take advantage of this opportunity to do things in a proper way.

The waste reduction is also a must. Every excess of material it's not just an economical cost, but also an energetic chain that is wasted in vain. Second life solutions have to be studied. Most of them are probably to not provide any kind of economical benefit, but it is all about symbiosis, our dumps may be others solution.

Finally, one of the determinant factors is location. Although we try to avoid non-sustainable actions internally, our way of planning the business can make us fail in the external part, and this still affects directly to our company sustainable plan. Our location is going to be in Europe, Portugal exactly. As far as we know that, the majority of the materials are going to be bought locally. It doesn't ensures the best option, but thinking as a new company, our chances are quite limited and this is what more odds gives us to trust in.

5.2.2 Use

In terms of usage, we are limited to mention that our approach of the functionality of the Solar Dehydrator is based mostly in exploiting as much as possible the energy given by the sun, what supposes a big amount of energy save.

We must take into account not only the energetic saving of our system, but also the energetic saving that supposes the fact of reducing the market consumption of the foods that are dried by increasing its lifespan.

5.3 Economical

The food dehydrators market is very specific and reduced, and if we talk about the solar food dehydrator it's almost non-existent. This means that companies that are in competing in this market have a high risk. Due to dis risk, most of the products have a really high price in relation with what the customer is really buying.

market products are under the constant renovation with facelifts that in an unfair way refuse stablished technologies or usage processes and properties. By producing a well-crafted and designed product, with long-life expectations a consumerism reduction can be provided.

Finally, if we think about a favorable scenario where our product has massive sells, we could talk about a possible reduction of over-consumerism in our society. This fact could reduce the necessity of growing most of the foods in short ranges of time, causing an increase of the quality of the products. But this is not a realistic scenario. The impact of the Solar Dehydrator is going to be really small, but we must not forget that every action counts.

5.4 Social

As the environmental sustainability requires a preservation of the nature, the social sustainability requires a preservation of the well being of the human race as a society. Maslow's pyramid is the best example to describe the needs of each and every human as individual.
Going from the inside to the outside, the employees are the main resource we have. By creating a good environment inside the company we obtain commitment towards the company. Their needs are our needs.

Figure 19 depicts the most important aspects about how to attend to employees.

Figure 19: Maslow's pyramid

Flexible working is one of the hardest but better ways to demonstrate faith in the employees, and they will payback by themselves with their best.

As we provide a product defined as healthy and eco-friendly, an immersion in this two topics is mandatory. It won't only give benefits in terms of knowledge and a fresh point of view, also affecting to their lives. The immersion in the psyche of the employees turns out into a common path of thinking, and it is reflected unconsciously in the personal and professional development.

*"*Mens sana in corpore sano" - Juvenal

Next step is taking care about the ones we have a direct relation with, suppliers. Our strong values reflects the willing on change, and this is how we understand the progress of society. The suppliers are expected to pass a minimum of requirements to be part of our mission. The connection between companies with same aspirations make the gears work smoothly. A previous analysis and study of our suppliers not only keeps us in our way, it also can illustrate us with some knowledge to improve.

Finally, at the end of this chain we've got the customers. Once we've applied these measures should be enough from us to justify to the customer our sustainability plan, but we need to include them as well. A familiar relation with the customer is known that ensure a strong union between them and the company. The company is not only about to sell and make profit, it's about to provide a satisfactory service. Customer service is implemented with social skills and the product itself provides a user friendly relation, attracting the attention of everyone around the product.

5.5 Life Cycle Analysis

The life cycle is the study and analysis of the whole situations and processes all along the product service, since the day it is manufactured until the day it is refused. So it's directly related to the environmental sustainability.

In terms of materials the consideration has to do with the obtaining of the goods, the manufacturing phase, maintenance and the refusal end.

In order to provide some comfort to the customer we need to find the way to involve the customer in the life cycle process. The materials are going to be chosen wisely to avoid any alteration all along its lifespan.

As mentioned before high percentage of the Solar Dehydrator is going to be made from a singular material, which pretends to provide a long-life quality product with almost none

maintenance and a high rate of recyclability. This and most of rest of materials and components are expected to last more than the whole product itself.
About processes has been taken in account that our implication in the obtaining and manufacturing of most of the products is quite limited so we must center our attention in the steps of the process we have fully control. On the score of reducing the environmental impact not only materials must be studied, also how are we supposed to design the Solar Dehydrator to make it as recyclable as possible. In terms of processes and design it requires a smart design, easy to assemble and disassemble, avoiding excess of energy and time consumption in both phases. A good point is also the disposition of the materials, preventing to mix materials that once the Solar Dehydrator is refused.

5.6 Conclusion

Eco-friendly may be the closest adjective to the Solar Dehydrator. It is true that sustainability is not all about environmental, it also must concern about the economical and social aspects, but it is a fact that it has a strong value in terms of eco-sustainability. The implementation of a system capable of self-supply al the energy needed is just the tip of the iceberg. A brainwash in society is needed to make it realize that the industrialization is not the only chance. Nature is totally able to provide us most of our needs as the dehydration of food in this specific case. By implicating people to develop his own goods or needs we are growing a sustainable seed in their conscience.
Being realistic, our market niche pretends to be very limited, but it has to be said that the world mentality is changing little by little into a green thinking. The road is hard, but there's no road if we don't walk step by step.

6. Ethical and Deontological Concerns

6.1 Introduction

*"*Ethics is knowing the difference between what you have a right to do and what is right to do." - Potter Stewart

In this chapter we will present five main ethical and deontological concerns and prove how we apply them to our work. These are ethical issues on Engineering, Sales and Marketing, Academic concerns, environmental impacts and liability. We have to concentrate to all ethical concerns. The Solar dehydrator, what we are developing will follow the rules listed

above. These ethical concerns cannot be missed because we have to care about future customers, reputation and reliability.

6.2 Engineering Ethics

Engineering Ethics is the study of moral issues and decisions confronting individuals and organizations engaged in engineering. The Study of related questions about moral conduct, character, ideals and relationships of people and corporations involved in technological development [n.a, 2015]. Engineers Uphold and advance the integrity, honour and dignity of the engineering profession by [n.a, n.d]:

- Using their knowledge and skill for the enhancement of human welfare.
- Being honest and impartial, and serving with fidelity the public, their employers and clients.
- Striving to increase the competence and prestige of the engineering profession.
- Supporting the professional and technical societies of their disciplines.

There are rules to the Engineering Ethics in the “Professional Engineering Code of Ethics”. We are going to keep and use this standards during and after the construction of the project.

- Hold paramount the safety, health, and welfare of the public. The users’ safety and health is the most important. Based on these will we design our dehydrator. We use high quality of materials. We take care of avoidance of burning injury. Besides we keep in mind the sustainability.
- Take care for the relationship of each employer or client. We treat understanding and respectfully all team members, recognizing their unique contributions and capabilities. We will be honest and polite with each customer, and serving with fidelity the public, their employers and clients.
- Perform services only in their areas of competence. We are different engineers with different knowledge and from several countries. Each of us have a diverse background. We try to keep a contact with the right person/expert. And we don’t want to make something if is not in our field of study.

6.3 Sales and Marketing Ethics

Sales and Marketing Ethics are basic principles and values that govern the business practices engaged in promoting products or services to consumers [n.a, 2015]. With our solar dehydrator a main marketing idea is that the system is very sustainable. We would like to create a product that will not pose a menace. Its structure will enable safe use. Our plan is to create an appliance that as far as possible is the most environmentally friendly.

6.3.1 Pricing

Following ethical guidelines in pricing means prices have to be clear without hidden charges. The consumer has to know how much he is going to pay when he makes the purchase. Your prices have to reflect both the cost you incur in delivering the product or service and the value the customer expects to receive.
In our case we have the price for the product itself and we could guarantee that there are no more cost for electricity. We also will offer a guarantee for two years that means if there is something broken by reason of bad material our client get the repair for free. We offer a long life and sustainable product the price is adapted to our quality.

6.3.2 Products

We would like to provide a product for future customers with good quality. Ethical sales and marketing offer only safe products that are suitable for their intended use.
We offer a high quality product which ensures correct functionality. There are no hidden information, we just use natural and high quality resources for our product. So we guarantee that the product works in a right way.

6.3.3 Promotion

Sales and marketing include promoting your products and services to potential customers. Ethical promotion portrays your offers honestly and accurately, without links to attractive lifestyles that are not relevant. You have to promote your products and services on their own merits and highlight those features that members of a target market might find valuable when promoting to that market segment.
Following these ethical guidelines is good for the business practice because it increases the customer satisfaction.
In our promotion we don´t want to use improper pictures to get attention from the clients. We want to follow the ethical guidelines we will tell the truth in our promotion. Our photos

or images reflect our product so the vegetable and fruit looks like that and are be eatable.

6.4 Academic Ethics

Academic integrity/ethics is the moral code or ethical policy of academia. This includes values such as avoidance of cheating or plagiarism, maintenance of academic standards, honesty and rigor in research and academic publishing [Bert Markgraf, Demand Media, 2015].

Plagiarism: an act or instance of using or closely imitating the language and thoughts of another author without authorization and the representation of that author's work as one's own, as by not crediting the original author [n.a, 2015].

Cheating: trying to present a work that one is not own or using forbidden methods to pass an exam.

Working in cooperative with other team members requires mutual respect, understanding and trust. We are able to assistance ourselves at difficulty.

To achieve the goal of having a fresh idea by offering a new concept we don't want to have any contamination of external information. Plagiarism is totally avoided in our project, but it has to be said that we don't have enough knowledge about all the fields required for the Solar dehydrator. Many research is going to be done, but the way to maintain a fair use of this information without trying to show it as genuine knowledge, all the external information is going to be referenced in the bibliography section. Figure 20 presents academic ethical concerns.

Figure 20: Academic Integrity

6.5 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 [Nathan Reed, 2012]. We will try to apply the following points to our solar dehydrator:

- Ensure the appropriate humidity.
- Create the right temperature.
- Maximize production capacity as much as possible with the minimum energy.
- Choose products that are the most environmental friendly
- To extend the dehydrator's life choose high quality.

Figure 21 represents our concern for environmental care.

Figure 21: Environmental care

6.6 Liability

The last but not least point that we have to talking, it's about the liability. To avoid unpleasant situations there are many rules that we have to take in consideration. And unconditionally we must to keep the rules and be ready to face the consequences. To decrease the number of possibilities that such a situation happens we have to always care about our liability to:

- The law
- Supervisors
- Environment

- Future customers
- EU and local government directives

Our solar dehydrator is meeting with following directives:

- Directive 2006/42/EC on machinery [n.a, 2015]
- Electrical Safety: Low Level Voltage Directive
- Restriction of Hazardous Substances (ROHS) in Electrical and Electronic
- Equipment Directive
- Mandatory adoption and use of the International System of Units

We must to do everything to avoid accidents that could risk the customers' health. Our product will be tested so it is not dangerous or injurious to humans in any way.

6.7 Conclusion

We will take in consideration all the rules of ethics during the build of dehydrator because this is essential for project working. We strongly believe that thereby we will reach the desired result.

7 Project Development

7.1 Introduction

This Project phase is about the tangible part of the development of the product. The result must show the best qualities always adapted to the requirements of the client and the budget limitation as well. The information shown in the Architecture chapter are hypothesis. The proposals are given based in theoretical knowledge giving feasible solutions, therefore some of the information may vary along the project development with the target of adapting and improving the final qualities of the product.
First concept design was done at the beginning of the project to materialize the idea of the product, but it is all about conceptualization. The final design may notably vary from this first sketched and rendered design. Figure 22 and 23 present our first concept.

Figure 22: First concept render in dehydrating position

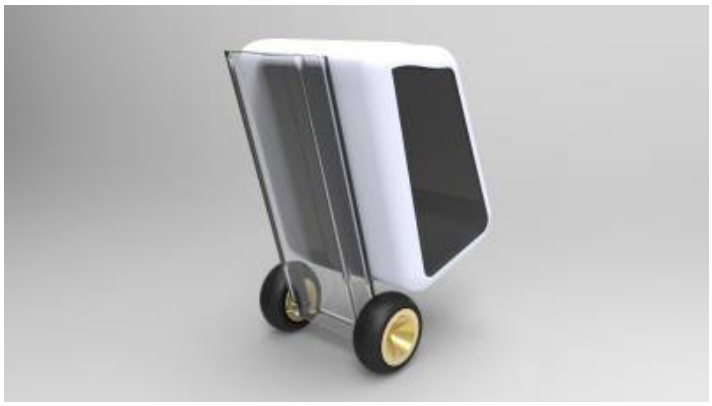


Figure 23: First concept render in portable position

7.2 Architecture

The architecture of the Solar dehydrator although it looks simple at first glance, its simplicity is the main handicap of this project. Such a basic working system that requires so little becomes a real challenge at the time of presenting a full range of improvements without ending up in a hard and complex solution.

From the functional point of view, the target is maintaining the common design of the market solar dehydrators adapting an electronic control system for maintaining the interior of dehydrating chamber in optimum conditions for the process. Another good point to develop is conferring a character of mobility to the product, adapting the requirements to physical customer usage needs.

To accomplish this process is necessary contemplating a temperature and airflow values inside the dehydrating chamber. The own nature of the hot air, which density is inferior to the cold air, works as an engine creating a circulation of air from the lower levels to the upper ones. The scheme of the airflow is based in a vertical way. Thanks to that fact, the

air will come into the dehydrator by the down side and then will be rejected, once it has been used to heat and dehydrate the chamber and food, through an air vent allocated in the top of the Solar dehydrator.
It was also considered controlling the intake temperature of the air to prevent an interruption of the process due to airflow without the temperature values required. An air vent right in the intake would control the quantity of air coming inside. This hypothesis was rejected. In case of implementing this hypothesis we would have problems of pressure inside the dehydration chamber, not permitting the hot and wet air going outside the chamber. Moreover, in the worst case it would allow air coming inside by the outtake air vent, what would suppose a big problem in terms of humidity.

In order to explain the concept design, first of all it's going to be presented the bases of the Solar dehydrator operations:

The performance of the system is based in the dehydration of food thanks to a constant airflow coming through it. Ideal conditions for the air are low values of humidity and high values of temperature. The more temperature the air has, the more total capacity of absorbing humidity it has.
Airflow movement is produced in a natural way, so the objective is introducing hot air into the chamber, fill it with as many humidity as possible and reject it quickly to avoid the contamination of the becoming air and the food itself.

How to implement this process in real life?
An analysis of the different sections of the project is presented below, differencing between mechanics, electronics and anthropometrics.

7.2.1 Mechanics

The principle of air heating is made through contact heat transfer. The power source is the infrared light of the sun rays. To capture this energy there is a heating tunnel. This tunnel with prism shape is opaque by all of its faces but the upper one, which is transparent to favour the light come through. The interior of the tunnel is almost empty but for a metal grid disposed all along with the objective of trapping the heat and transfer it to the air current that flow around it.

Once air is heated, it must be transported to the dehydrating zone. To achieve that, the tunnel must have an inclined ascendant position giving direction to the air to go directly inside. The inclination is going to be variable to suit with the incident angle of the sun rays depending on the month of the year it is being used. The legs allocated in the rear part of the product will enable the variation of inclination of the tunnel.

In the interior of the dehydration chamber the food is settled over grids that allow the air come through in a vertical way. There are various levels of grids to permit the most quantity of food being dehydrated.

In terms of temperature, it must be avoided overheating values to prevent the food getting ruined. Depending of the aliment there are specific values. Figure 24 illustrates examples of approximate values in the dehydrating process.

Figure 24: Average values of temperature and time of dehydration in terms of the product via the Excalibur Dehydrator (electrical kitchen dehydrator)

An air vent in the top of the dehydrator is the attendant to control the temperature values by opening and closing the chamber. A servomotor that works under the orders of a processor performs this action. The processor does permanent temperature lectures. This air vent is also under the clue of humidity levels, so if the humidity values are also over the

optimums, the processor will also send an opening order to avoid the food to get cooked. Mobility in the dehydrator is favored by a modular design. The heating tunnel can be displaced with a way guides and adapt its position with the dehydration chamber, performing a unique body. In the lower part of the tunnel a pair of wheels is settled, making the usage and transportation of the product more pleasant. Figure 25 presents the way of changing solar dehydrator from static to portable.

Figure 25: Conceptual storyboard of transformation from static to portable

Another problem to take into account is the isolation of the food to bugs and other physical agents from the exterior that can affect in a negative way to the food. The use of nets in both intakes to prevent the entry of unwanted solids is mandatory.
To illustrate some of the design changes in a graphic way, in the following pictures details as the allocation of the air vent, the interior guides of the new shelves and the initial idea of the rear support system. Also are included some of the different parts draws with references to the main measurements of each. In the assembly draws it is shown in the three critical positions. Lowest position in operation, highest position in operation and compact position, prepared to be carried out. In the compact position must be taken into account that this is not the position the user is going to held while the transporting, it is just

reflected the maximum point of attack. Figures from 26 to 31 depict computer visualizations and figures from 32 to 38 display solar dehydrator measurements.

Figure 26: Solar dehydrator detail nº1

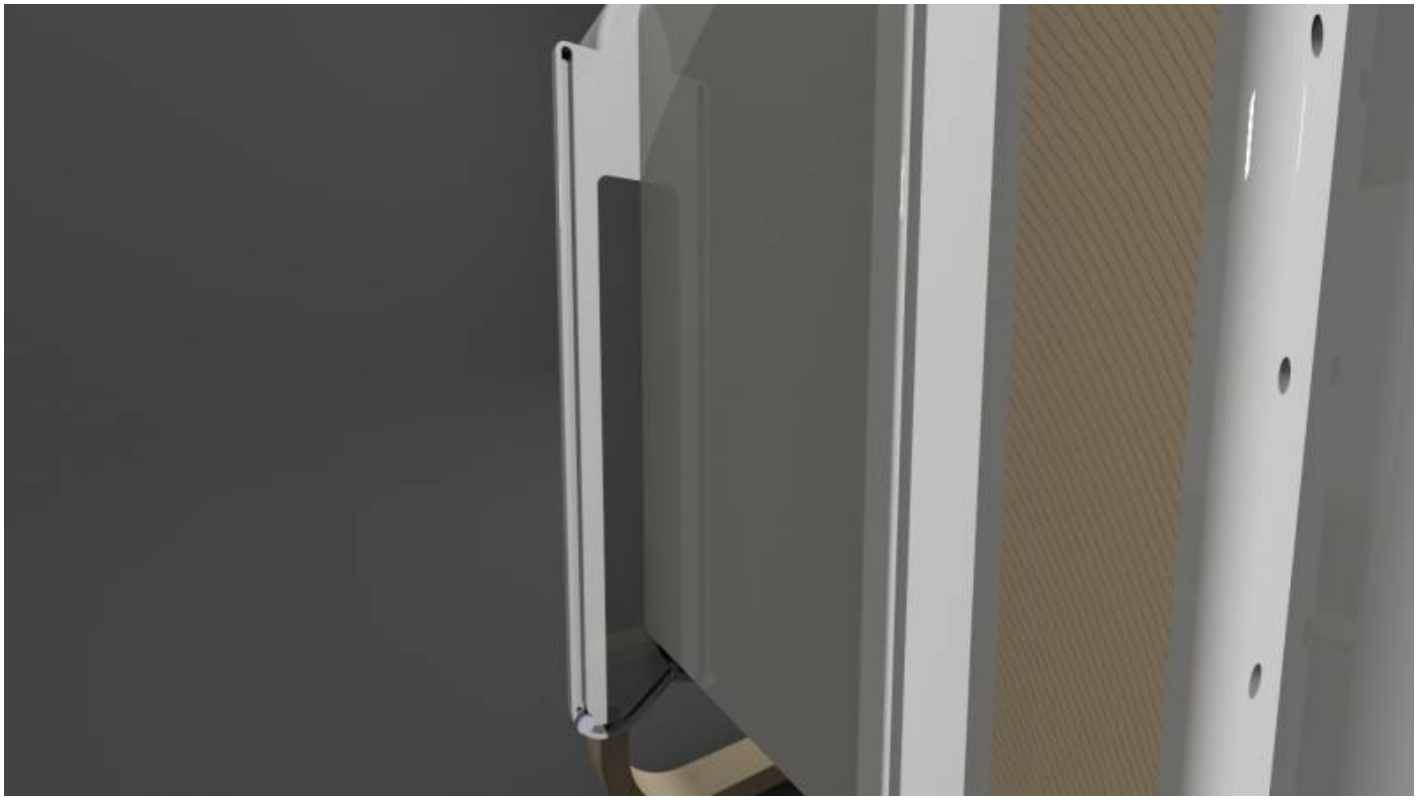


Figure 27: Solar dehydrator detail nº2

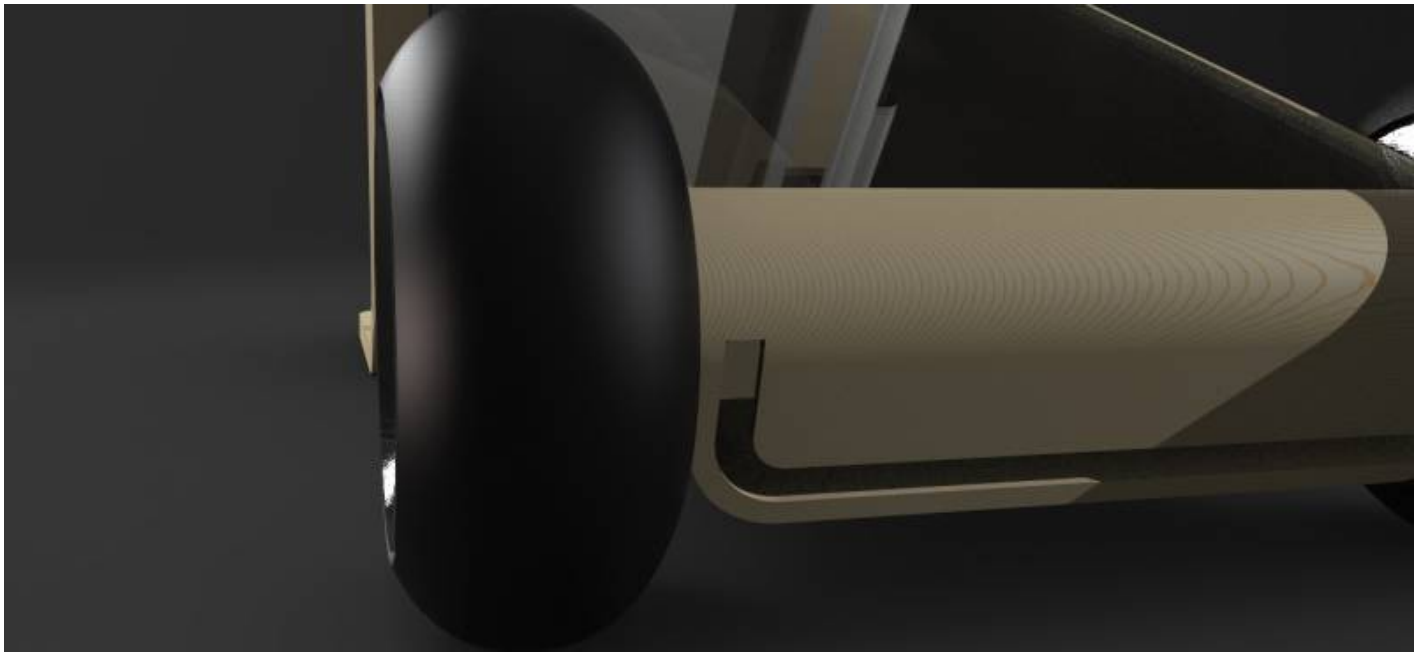


Figure 28: Solar dehydrator detail nº3

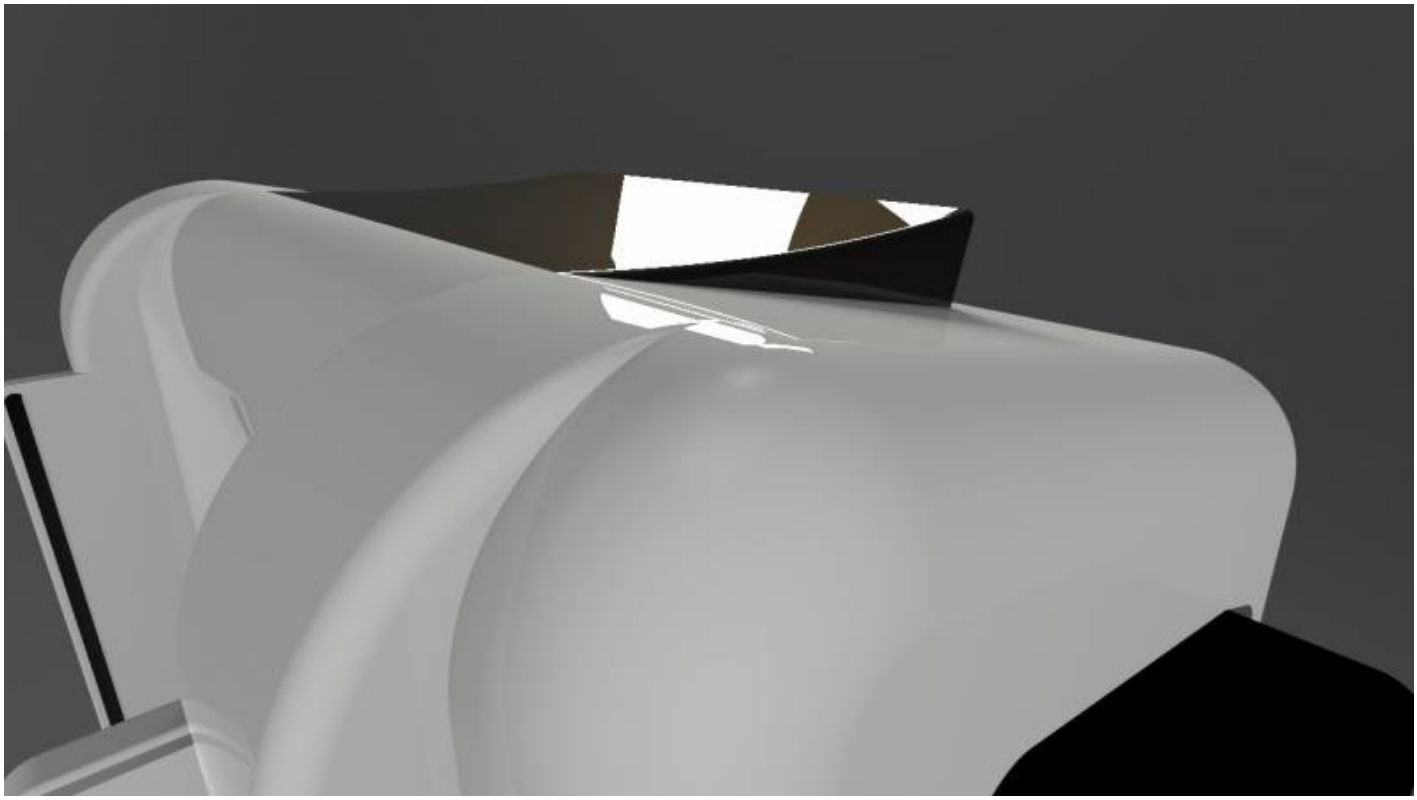


Figure 29: Solar dehydrator detail nº4

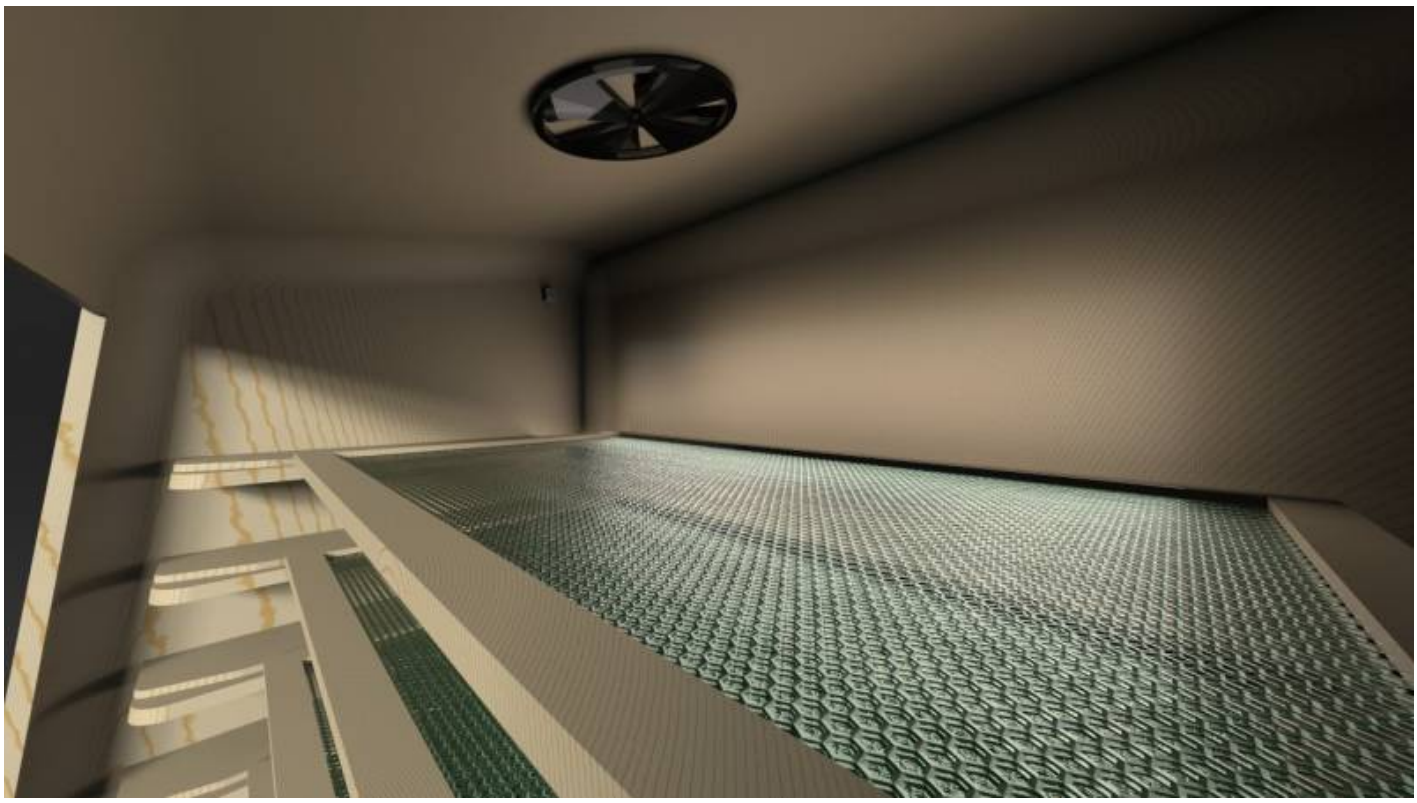


Figure 30: Solar dehydrator detail nº5

Figure 31: Solar dehydrator detail nº6

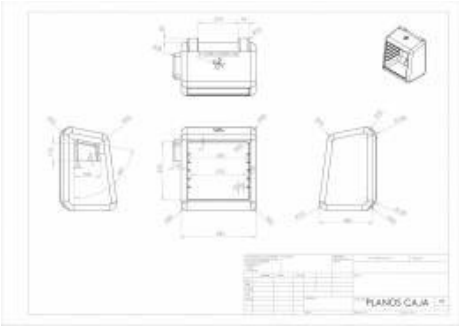


Figure 32: Dehydrating box main measurements

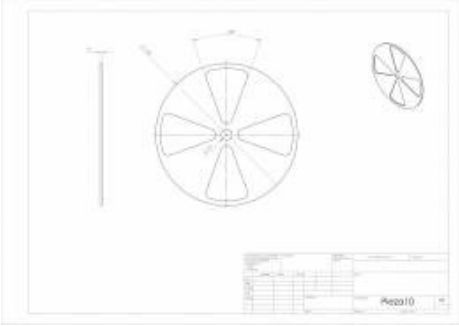


Figure 33: Dehydrating box main measurements

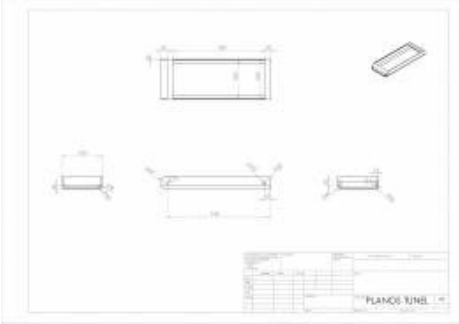


Figure 34: Heating tunnel main measurements

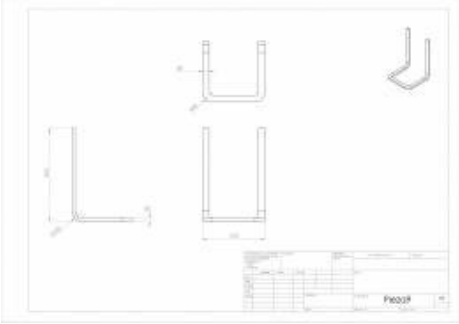


Figure 35: Legs main measurements

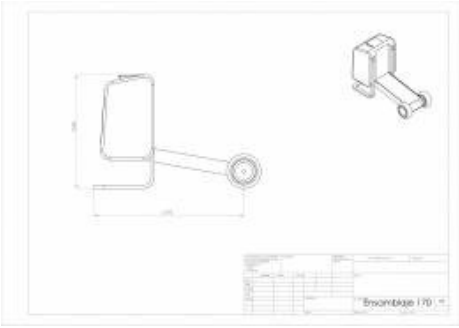


Figure 36: Solar dehydrator with tunnel at 10º of inclination main measurements

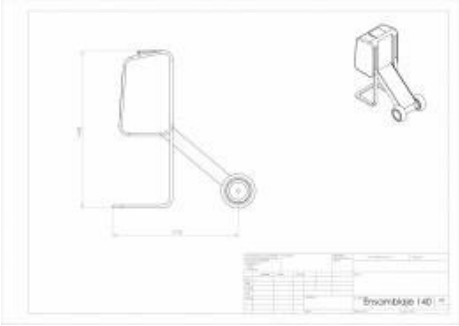


Figure 37: Solar dehydrator with tunnel at 40º of inclination main measurements

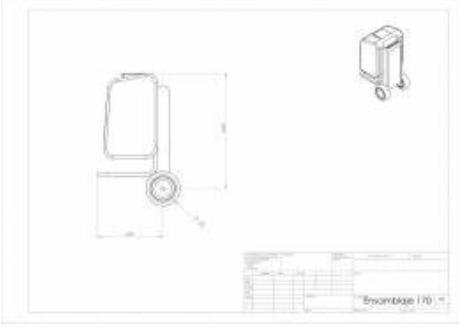


Figure 38: Solar dehydrator in portable position main measurements

7.2.2 Electronics

Once the whole functions are presented, it is needed to perform the whole control of the process.

As mentioned before, a variety of sensors have to be controlled in order to actuate the servomotor and achieve an ideal atmosphere inside the chamber. But this is not all. It has been proposed creating a full autonomous system. A system capable of self-supplying energy to avoid unnecessary energy consumption from the net, positions the dehydrator as a 100% solar product.

Adapting a self-power supply system is not enough. As soon as the sun goes out, the photovoltaic panels may not offer enough energy to support the system and make it shut

down. The integration of a battery to the system provides a constant supply. This battery is directly connected to the processor, having the photovoltaic panel in a background feeding the battery. To ensure the security to the components and to the user, as soon as a photovoltaic panel is being used, it is required to adapt a solar charge controller in between the battery and the panels.

Concerning to the user experience, we want to give an intuitive and kind interaction between the product and the customer. The system is supported with an LCD display that shows directly to the user all the information needed to start the process. To interact with the system it is also required some keyboard or any kind of control to give the user the chance to select his different needs depending on the requirements on the food that is going to be dehydrated. Figures 39 and 40 illustrate the electronic schematics.

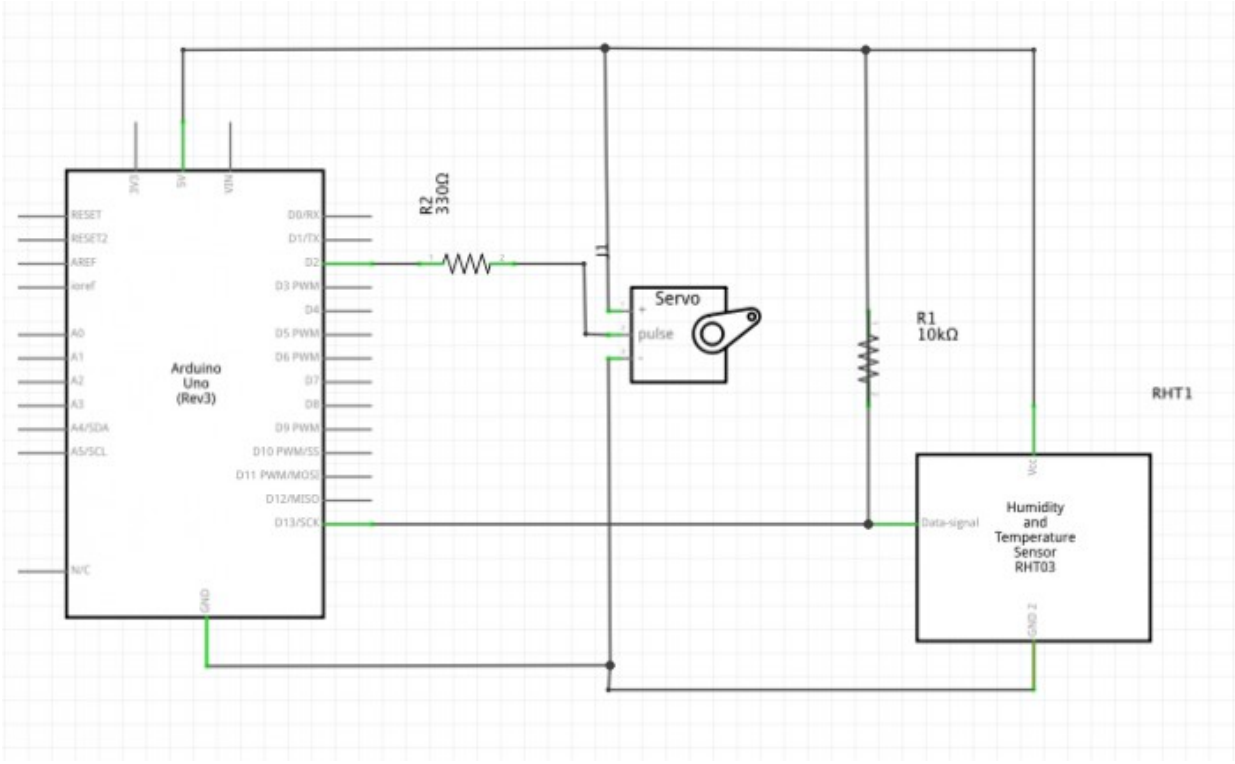


Figure 39: Electronics wiring diagram approximation

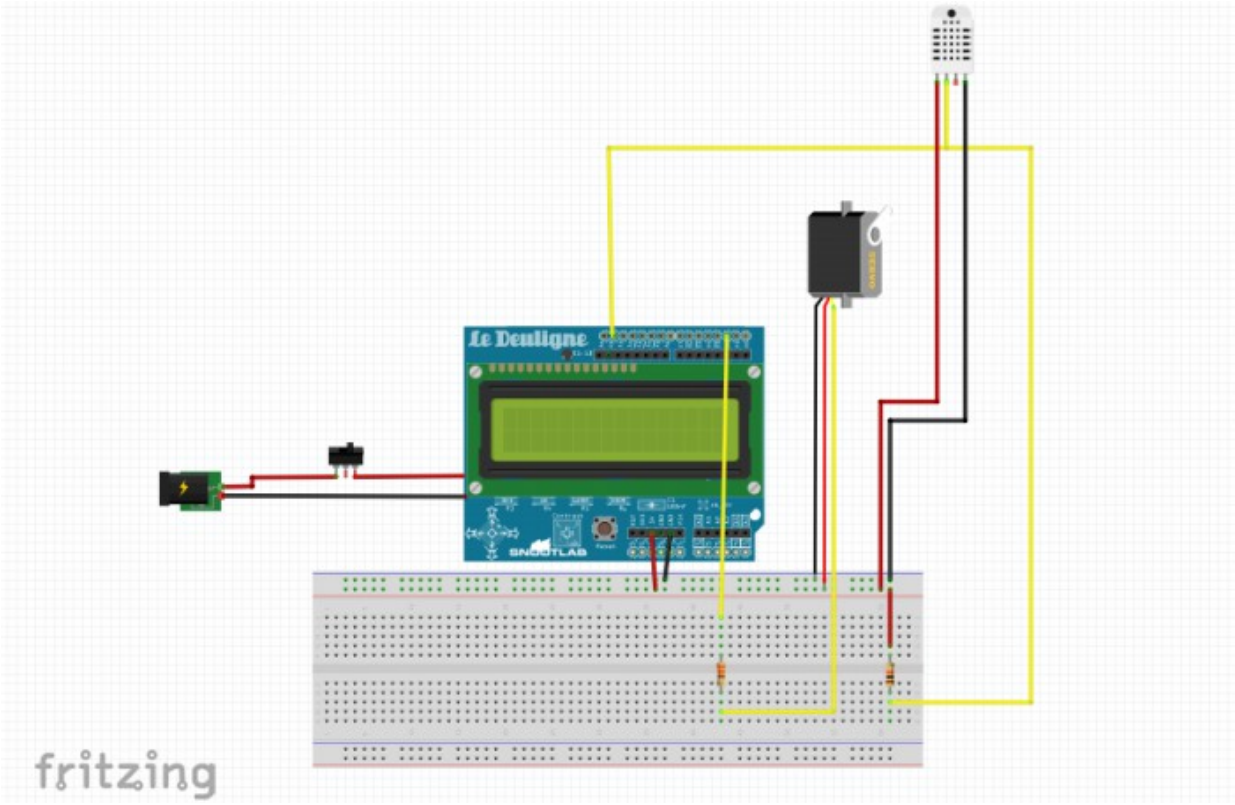


Figure 40: Electronics graphic schematics approximation

An approximation of the circuit is shown above. Due to the limitations of the program it was not possible to add the photovoltaic panel and with the correspondent regulator. Also the battery is not as shown in the images. It's just a representation of the whole system connections.
This template or sketch is valuable for a short future to test the circuit requirements in a proper way before doing the physical circuitry. Voltmeters, Ammeters and Ohm-meters are provided in the software, so the fully regulation of values according to the data sheet of every component is going to be study thanks to this application.

7.2.3 Anthropometrics

*"*Design for humans"
This is the slogan that better fits this chapter.

Anthropometrics has to do with the adaptation of every product to the physical properties of the human being. The adequacy of the measurements of the Solar dehydrator have as a goal a comfortable use towards the final user. It's the final detail that makes a functional product into a pleasant product.

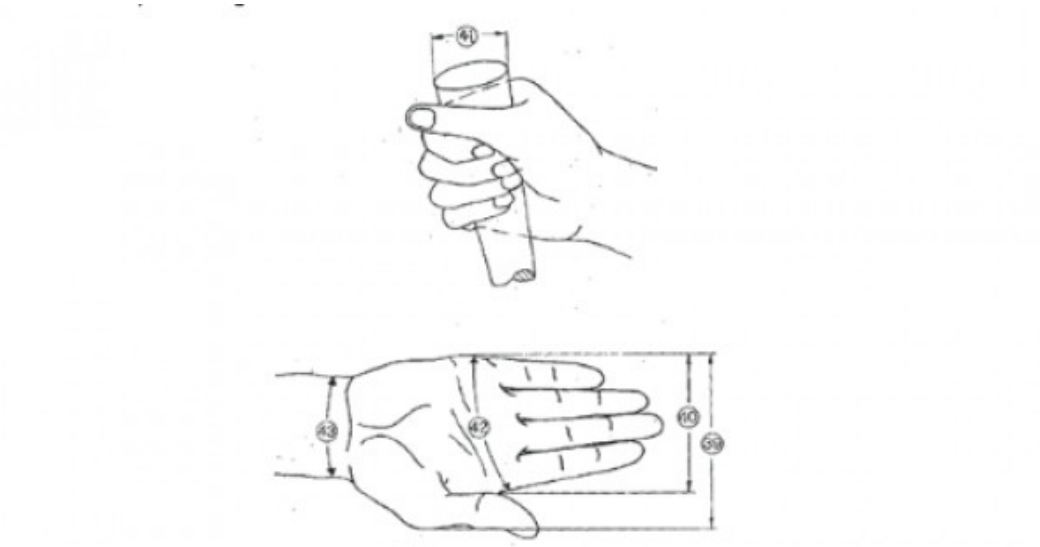
The study is mostly focused around the portability aspects of the product [Jose Luis Melo, 2009]. The determination of the size is dependent of the physical values of the final customer. Females and males are taken into account to realize an universal design. The necessary values are shown in anthropometric studies under the control of international regulations as Deutsches Institut für Normung (DIN). Figure 41 represents some major anthropometric body measurements.

	HOMBRES			MUJERES		
DESIGNACIÓN	VALOR LÍMITE INFERIOR	VALOR MEDIO	VALOR LÍMITE SUPERIOR	VALOR LÍMITE INFERIOR	VALOR MEDIO	VALOR LÍMITE SUPERIOR
EN POSICIÓN ERGUIDA						
A. ALCANCE HACIA DELANTE	662	722	787	662	722	787
B. PROFUNDIDAD DEL CUERPO PARADO	233	276	318	233	276	318
C. ALCANCE HACIA ARRIBA	1910	2051	2210	1910	2051	2210
D. ESTATURA	1629	1733	1841	1629	1733	1841
E. ALTURA DE LOS OJOS PARADO	1509	1613	1721	1509	1613	1721
F. ALTURA DE LOS HOMBROS	1349	1445	1542	1349	1445	1542
G. ALTURA DE LOS CODOS DESDE EL PISO	1021	1096	1179	1021	1096	1179
H. ALTURA ENTRE PIERNAS	752	816	886	752	816	886
I. ALTURA DE LA MANO	728	767	828	728	767	828
K. ANCHO DE HOMBROS ENTRE ACROMIOS	367	398	428	367	398	428
L. ANCHO DE LA CADERA	310	344	368	310	344	368
EN POSICIÓN DE SENTADO						
A. ALTURA DEL CUERPO DESDE ASIENTO	849	907	962	849	907	962
B. ALTURA DE LOS OJOS DESDE ASIENTO	739	790	844	739	790	844
C. ALTURA DE LOS HOMBROS	561	610	655	561	610	655
D. ALTURA DE LOS OJOS DESDE ASIENTO	193	230	280	193	230	280
E. ALTURA DE LAS RODILLAS	493	535	574	493	535	574
F. LARGO DE PANTORRILLA A PIE	399	442	480	399	442	480
G. DISTANCIA DE CODO A PIE DE AGARRE	327	362	389	327	362	389
H. PROFUNDIDAD DEL CUERPO SENTADO	452	500	552	452	500	552
I. DISTANCIA NALGA RODILLA	554	559	645	554	559	645
K. DISTANCIA NALGA PIE	964	1035	1125	964	1035	1125
L. ESPESOR DEL MUSLO	117	136	157	117	136	157
M. ANCHO SOBRE LOS CODOS	399	451	512	399	451	512
N. ANCHO DE ASIENTO	325	362	391	325	362	391

Figure 41: Anthropometric body measurements

Specifying about the product, two important variables are the size of the handle to carry the Solar dehydrator, and the maximum points of mobility of the arm in a rear and extended position.

The diameter of the handle has to be under some maximum values to avoid the sliding off the hand and also a minimum values to avoid an excess of weight pressure in the palm or fingers of the user. Figure 42 show some measurements of human hands, which help with the design of the handle.



Dimensiones en cm	PERCENTIL					
	HOMBRES			MUJERES		
	5%	50%	95%	5%	50%	95%
39. ANCHO DE LA MANO INCLUYENDO DEDO PULGAR	9,8	10,7	11,6	8,2	9,2	10,1
40. ANCHO DE LA MANO EXCLUYENDO EL DEDO PULGAR	7,8	8,5	9,3	7,2	8,0	8,5
41. DIÁMETRO DE AGARRE DE LA MANO*	11,9	13,8	15,4	10,8	13,0	15,7
42. PERÍMETRO DE LA MANO	19,5	21,0	22,9	17,6	19,2	20,7
43. PERÍMETRO DE LA ARTICULACIÓN DE LA MUÑECA	16,1	17,6	18,9	14,6	16,0	17,7
* Las medidas corresponden al anillo descripto por los dedos pulgar e índice						

Figura 3.9. Medidas de la mano (Según Norma DIN 33 402. 2° parte).

Figure 42: Anthropometric hand measurements

In order to determine the height of the Solar dehydrator, the optimum angle of movement has to be studied and fitted between the commodity values of mobility of the user arms. By determining the shoulder and hand heights and the maximum angles of mobility a range of correct actuation can be calculated providing the correct position of usability of the product. Figure 43 depicts different angles and possible arm positions.

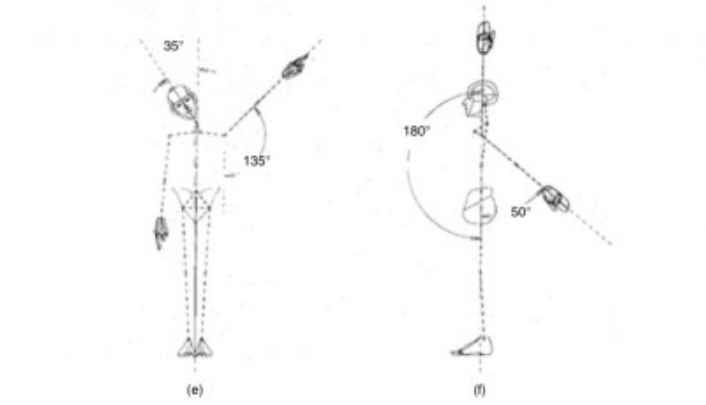


Figure 43: Anthropometric angles of arm attack measurements

This is the main anthropometric data to take into account in the final development of the physics and shape of the Solar dehydrator. Moreover, other aspects will be studied as far as we can intervene in its performance. Aspects as storyboard facilities, intuitive solutions or expression of information.

7.3 Components

The following tables present all the different components we may use for our prototype. Different types of sensors, LCD screens and servo motors are compared, and their features are listed. Below the tables, our final chosen components are listed.

Table 17

Table 17: *Temperature Sensors*

Temperature sensor	Temperature range (°C)	Accuracy (°C)	Input voltage (V)	Price (€)
LM35DZ	0 - 100	±0.5	4 - 30	2.34
ds18b20	-55 - 125	±0.5	3.0 - 5.5	4.5
595-LMT86LP	**-50 - 150**	**±0.4**	**2.2 - 5.5**	**0.905**

Table 18

Table 18: *Humidity Sensors*

Humidity sensor	Input voltage (V)	Temp operation range (°C)	RH accuracy (%)	Price (€)
HTU21D	**2.5 - 3.6**	**-40 - +125**	**±2**	**12.52**
HIH6030-021-001	2.3 - 5.5	-40 - +100	±4.5	6.03
634-SI7021-A20-GM1	1.9 - 3.6	-40 - +125	±3	5.47

Table 19

Table 19: *Temperature+Humidity Sensors*

Temp + Humid sensor	Input voltage (V)	Temp operation range (°C)	Temp accuracy (°C)	RH accuracy (%)	Price (€)
DHT11	3 - 5	0 - 50	±2	±5	4.6

Temp + Humid sensor	Input voltage (V)	Temp operation range (°C)	Temp accuracy (°C)	RH accuracy (%)	Price (€)
DHT22	**3 - 5**	**-40 - +80**	**±0.5**	**±5**	**9.27**
RHT03	3.3 - 5.5	-40 - +80	±0.5	±2	9.36
AM2302	3.3-5.5	-40 - +80	±0.5	±2	13.97

1x DHT22 Humidity + Temperature sensor

Combined temperature and humidity sensors are usually shown as high quality products, and they also go by the hand of a good ratio in terms of price.

Table 20

Table 20: *LCD*

LCD	Type	Supply Voltage (V)	Price (€)
Itead 1602 LCD	SHIELD + KEYBOARD	5	6.70
ARDUINO LCD MODEL: PTR001467	**SHIELD + KEYBOARD**	**5**	**14.76**
16×2 Character LCD (Parallel Interface) - Model INM-0286	EXTERNAL	5	11.01
LCD 16×2 Powertip PC1602LRS-FWA-B-Q	EXTERNAL	5	12.98

1x ARDUINO LCD MODEL: PTR001467

Table 21

Table 21: *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 -	**4,8**	**-30 to 80**	**5**	**980**	**13.16**

Servomotor	Input voltage (V)	Temp operation range (°C)	Torque (kg/cm)	Current consumption (mA)	Price (€)
Generic High Torque Standard					
Hitec HS-311 Servo Motor	4.8	-20 to 60	3	-	10.58

1x Servo FS5106B - Generic High Torque Standard

In order to prevent any system failure, it was decided to choose a high quality servomotor. The specifications fit with our requirements, specially in terms of temperature operation range, which is one of our biggest handicaps. The torque provided is high enough for our air vent and the price is what finally makes it really worthwhile.

Table 22

Table 22: *Power supply*

Battery	Type	Output voltage (V)	Maximum output Current (A)	Price (€)
ULTRACELL JOIN 1.3-12	**Lead-Acid**	**12**	**1.3**	**8.92**
KINGMAX BATTERY	Li-Po	7.4	1	10.50
USB Battery BAT01025	Li-Po	5.5	1-2	33.20
USB/SOLAR Battery BAT01022	Li-Po / Solar	5-9	1-2	29.20
HR9-6	Lead-Acid	6	120	21.40

1x ULTRACELL JOIN 1.3-12

This battery is focused for domestic use as for kids toy-cars kid for example. Ensures safety, low maintenance and allows the connection to a rechargeable source, as it is a solar panel in this case.

Table 23

Table 23: *Tunnel transparent sheet*

Transparent sheet	Type	UV Stability	Toughness	Transparency	Infrared permittivity	Scratch resistance	Price
Ceramic	**Glass**	**EXCELLENT**	**POOR**	**EXCELLENT**	**EXCELLENT**	**EXCELLENT**	**GOOD**
Polymeric	**PMMA**	**EXCELLENT**	**FAIR**	**EXCELLENT**	**GOOD**	**VERY GOOD**	**HIGH**
Polymeric	PET	VERY GOOD	EXCELLENT	VERY GOOD	-	GOOD	GOOD
Polymer	PC	VERY GOOD	EXCELLENT	EXCELLENT	-	VERY GOOD	HIGH

Glass: 0.3 m2 (0.85 m * 0.35 m) x 4 mm of thickness is required.
PMMA: 0,4 m2 x 4 mm of thickness is required.

Table 24

Table 24: *Wood*

Wood	Resistance	Maintenance attention	Price
Pine	Low resistance to humidity. Low resistance to impact. Fair resistance to strength	High	**Low**
Iroko	High resistance to humidity. Good resistance to impact. Good resistance to stress.	Very low	Average
Cedar	High resistance to humidity. High resistance to impact. Very good resistance to stress.	Very low	High
Cork	High resistance to humidity. High resistance to impact. Low resistance to stress.	Low	Low

9 m² x 5 mm of thickness required.

Any of the woods shown above can be used for our project. Cedar is the most valuable one but the price can exceed the budget estimated for this product. Iroko is the second option due to its good properties in terms of wet conditions. Third one would be Cork, also looking for the wet conditions, but with cork we may find some problems of stiffness. Finally Pine wood has a good price and with the correct maintenance by the customer can be a long-life product. We would like to avoid pine to reduce the maintenance of the product and facilitate and improve the comfort of the customer.

Final dimensions:

- for the wood:

7500 mm x 1000 mm x 20 mm

- for the metal :

850 mm x 340 mm x X –> the thickness is not important.

- for the glass:

850 mm x 350 mm x 4 mm

Final components:

- Buzzer:

1x PTR000607 - Buzzer 5 V

The buzzer requirements are very basics. It is only expected to emit any kind of sound to attract the attention of the user in order to check the food out. A basic and cheap buzzer is enough to satisfy the necessities of the product.

- On/Off switch:

1x Rocker Switch - SPST (round) - Modelo INM-0744

Necessary to connect and disconnect the electronic system whenever it is not being used. This component will decrease the energy consumption while it is not being used.

- Processor:

1x Arduino UNO Rev3

Arduino provides the project everything that's needed and expected in terms of functionality of the electronic system. Arduino UNO has been chosen thanks to his compatibility with the LCD+KEYBOARD SHIELD chosen and also for the number of pins provided by this specific model, which fits perfectly with our requirements.

- Solar panel:

Solar panel measurements should be below 0.3 m * 0.5 m and able to charge a battery of

12V. The panel is preferred to be polycristaline to avoid the decrease of production common in monocristaline panels when the temperature increases over 25ºC.

- Voltage regulator:

A Voltage regulator is needed according to the solar panel requested. In order to protect the battery from a possible overproduction of the solar panel it is mandatory to install a security regulator in between both components to ensure a long-life and secure product.

- Metal sheet:

4x Steel Metal Lath (0.85 m * 0.35 m approximate measurements)
This is the most common metal heater sheet used for solar dehydrators. The reason is that the mesh provides a high rate of heat transference from the steel to the air.

MATERIALS SUMMARY:

1x DHT22 Humidity + Temperature sensor
1x ARDUINO LCD MODEL: PTR001467
1x Servo FS5106B - Generic High Torque Standard
1x ULTRACELL JOIN 1.3-12
Glass: 0.3 m2 (0.85 m * 0.35 m) x 4 mm of thickness is required.
PMMA: 0.4 m2 x 4 mm of thickness is required.
1x PTR000607 - Buzzer 5V
1x Arduino UNO Rev3
4x Metal laticce (0.85 m x 0.35 m approximate measurements)
1x Voltage regulator to 12 V max
1x Solar panel below 0.3 m x 0.5 m and able to charge a battery of 12 V
1x Cola branca madeira 1 kg - 3.99 € (Leroy Merlin)
4x Painel pinho 2000 mm x 500 mm x 18 mm - 9.99 €/u (Leroy Merlin)
4x 50 Buchas madeira 6 mm - 2.19 €/u (Leroy Merlin)
2x Roda vermelha con rolamento - 9.99 €/u (Leroy Merlin)
1x Barnish Bondex intemperie satinado - 11.49 €/u (Leroy Merlin)
3x Trinchas Junior Cerdas PR - 2.99 €/u (Leroy Merlin)

7.4 Functionalities

The target of our product is, as explained during the whole project, to dehydrate food. This

section concerns to the explanation of all the features taking into account and how are performed by the solar dehydrator.
The main process is bringing the air in through the lower part of the heating tunnel, heat it, make it pass through the dryer box and take it out once it is considered to be useless and keep the process going on. But how are we controlling this process?
The control method developed to achieve that target is based in an Arduino controlled system. By using The Arduino as brain of the air conditions controller, it was required to have inputs with values of temperature and humidity, the cornerstones of a precise and quality dehydration. Once this values are read, Arduino compares them with the values programmed in its memory and evaluates if it has to send an output signal to a servomotor that will open or close an air vent by considering if it is necessary to keep a proper environment inside the dryer box.

So, how was developed the proper program to control this requirements?
First, it was needed to interpret the values provided by the temperature and humidity sensor. The sensor used is a DHT22. In order to be able to read the values of the DHT22 it was needed to download the proper library to allow Arduino consider how to interpret the signals sent by the sensor. Once it is done, those values have to be managed to adequate the proper control of the servo. By programming a code using simple conditions, Arduino was capable to know when should it send orders to the servomotor. This conditions are based in coding with If statements.
If statements are used as a comparison operator whether a certain condition is reached as in this case happens with humidity or temperature values. The format of If statements is the following:

```
if (Input Value > 50)
{
// “Do something” //
}
```

In the case of the basic sketch used to evaluate the proper read and control of the signals, it was used a pair of LEDs, one controlling temperature output signals and the second one controlling humidity output signals. So the If conditions used for this test, which is the base of the whole program, where h is the read value of humidity and t is the read value of temperature.

Once the values are under control, it was thought to be necessarily considered the possibility of having a full range of different values in order to adequate the process to the kind of food desired to dehydrated by the user. This implies that the user needs to interact with the Arduino to be capable to select the proper program. That’s the main reason of having an LCD Shield with buttons in the electronic system. The LCD permits a visual interaction and the buttons permit the user to surf through a specific menu where it is shown a variety of foods to dehydrate. The use of an LCD and moreover the use of buttons requires also a specific library. Here in Figure 44 is shown a flow chart of the code used for the Solar dehydrator.

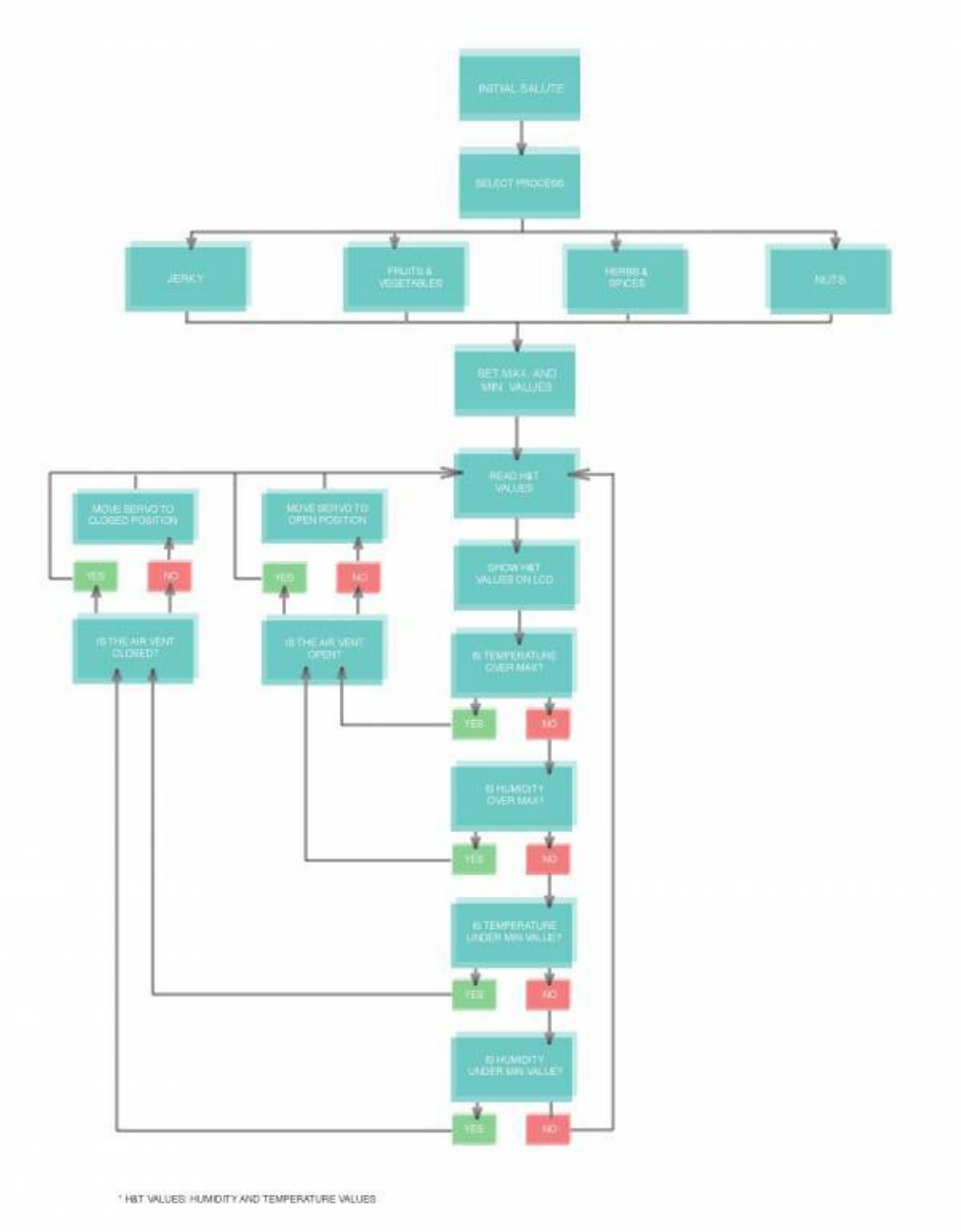


Figure 44: Flow chart of the coding for the control unit

The process now is more complex. The whole variety of products have to be set and the program has to know which food has been selected. This implies that when a food program is selected the whole rest of the code has to be obviated. A basic way to develop this program is by using counters and If statements. The counters are arbitrary values that work inside an If condition. Every time the If condition is accomplished, it's added or subtracted one unit from this value. For example, every time the button Down is pressed, an arbitrary value called x which is x = 0 is added one, so the result would be x = 1. If it is

pressed twice, x value would be x = 2. By this way it is possible to attach a singular value to each food and once the button Select is pressed, the x value is read by the program and knows which program was selected and needs to be read. Otherwise, for menus with four or less than four products to select, each button but select and reset are coded directly to a single process. In this case, each of the buttons has its own variable in the code. This is used in the way that once a button is pressed, the process of the button is shown in the LCD, so the variable, for example u, turns from u = 0 to u = 1. Then button select is pressed and the process starts. In order to avoid multiple variables with value 1, which allows the code of a specific process be read, every time one button is pressed, it is not only changing its own variable, also the rest of the buttons variables turning them into value x = 0. Thanks to that coding, the Arduino will always run only one process at a time.

7.5 Tests and Results

The submission of the product to several tests is required to ensure the correct functionality and security of the product. It is disaggregated in different parts to evaluate, focusing in every system and in the totality of it to detect and evaluate how is every part of the dehydrator performing, differencing between electronic tests, structural tests and finally the process of dehydration itself.

7.5.1 Electronic system

Due to the facilities and quickness provided by the electronics, it was the first development and test done in a physical way done in the project of building a solar dehydrator. First of all, the whole of the components where tested to prove their correct functionality, finding a problem in the LCD shield, where the values attached to the buttons had different values than the ones provided in the data sheet. The buttons of the LCD shield work by an emission of a specific frequency that is read by the Arduino when pressed. A program to ensure the correct functionality was uploaded to the Arduino. This program shows you in the LCD a message telling you which button are you pressing, showing in this case imprecise lectures in most of the buttons. Due to the unfamiliarity with that products it was solved by varying the values of frequency in the code and by an attempt and mistake process. Finally the test succeed with every button being correctly recognized by the Arduino.

Once each and every one of the components passed the test, a code for the dehydrator had to be written. It was required a very specific functionality, read humidity and

temperature values and provide a maintain a specific environment by controlling the movement of a servomotor. First of all was doing a base program with the basic functionality of the system. If the Arduino processor reads values over the maximum required being in terms of temperature or in terms of humidity, it had to send an order to the servomotor. The opposite case had to be considered also. If values are below the maximum required, an order with opposite movement had to be sent to the servomotor. In order to obtain results in an easy way to interpret, have first impressions and prove that every parameter was working correctly, servomotor was obviated and substituted by two LED. Each LED was under the control of different parameters. One under the control of temperature values and the other one under the control of humidity values, so it could be tested that both orders were being interpreted correctly. The lectures of the humidity and temperature sensor were programmed to be shown in the LCD shield to facilitate the evaluation. The result was totally satisfactory. Both LED were turning on when the maximum values imposed were exceeded and turning off when values were below the maximum limits.

Figure 45, Figure 46, Figure 47 depict the electronic control unit, during a testing process.

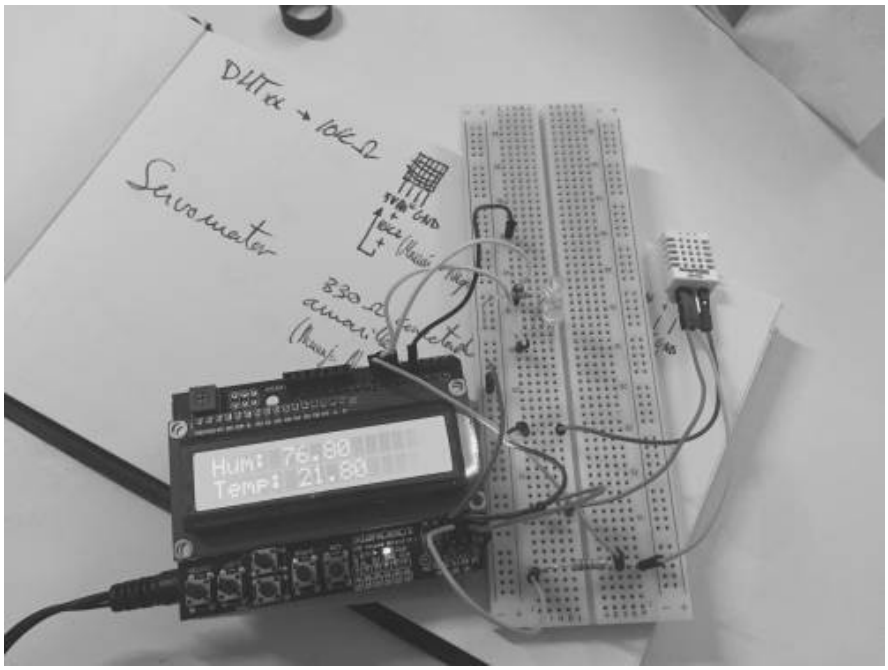


Figure 45: Electronic system with values under maximums programmed for the test

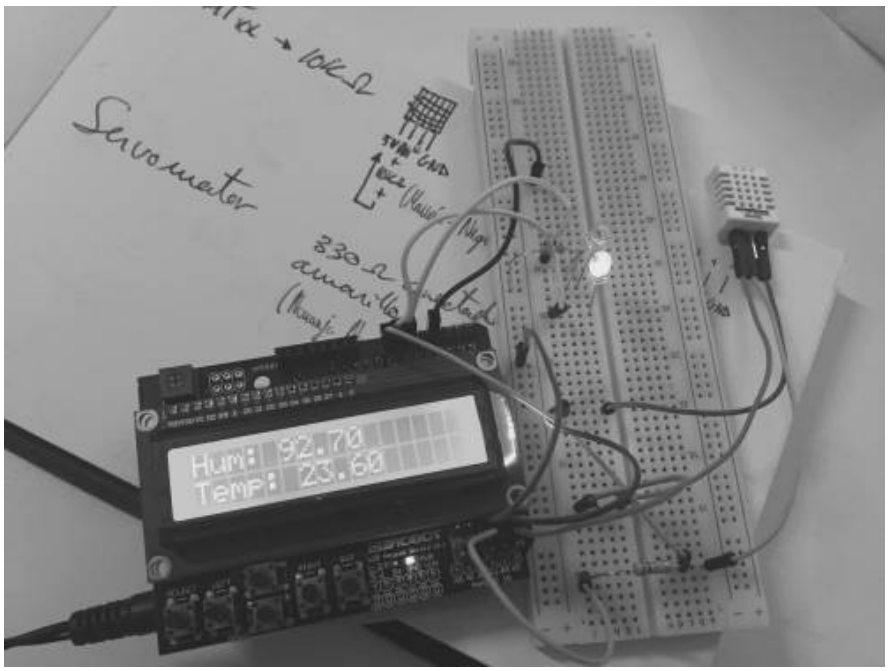


Figure 46: Electronic system with humidity value over the maximum programmed for the test

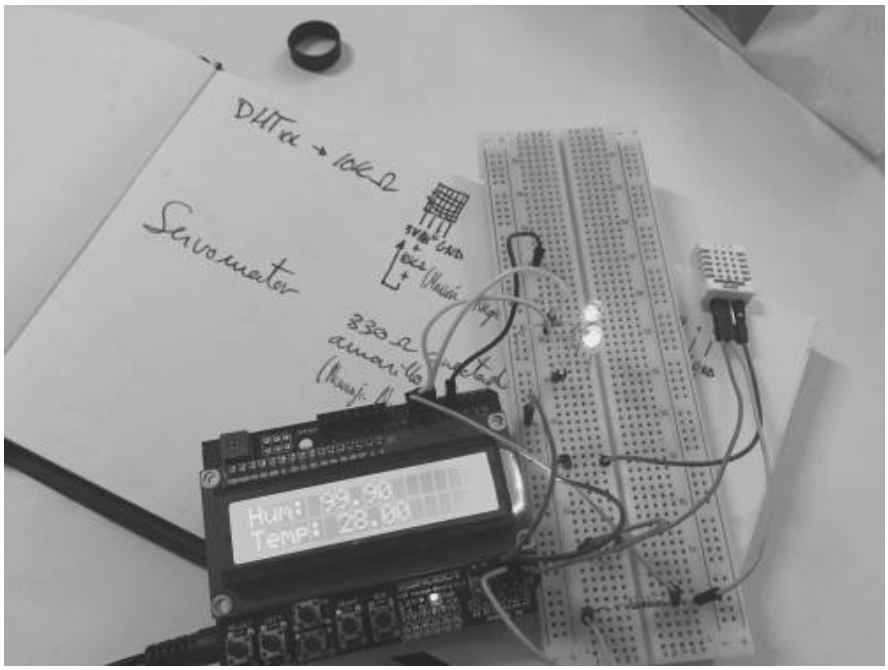


Figure 47: Electronic system with both values over maximums programmed for the test

This test was the cornerstone of the electronic system. The proper orders to control the servomotor just had to be coded to turn as the LED were lighting, considering turning on a clockwise movement and turning off a counter clockwise movement. The menu has been configured to provide the different codes depending on the fruit or vegetable which are supposed to be dehydrated. Last details, such as welcoming the user through the LCD

(“Hello”-message) were also coded and tested, with positive results. This will help provide a closer relation between the user and the product.

7.5.2 Structural analysis

The structure is the main concern in terms of product design. Not only the functionality has to be on the correct path, but the security and insurance of long-life is a must. Once the structure of the product is designed it has to be tested in terms of equilibrium stability, structural assembly stability and movability of specific parts of the product. Once all the parts are built, first test is to ensure the structural static stability of each part just by applying some forces in different directions and points randomly and by an observation method determine if its everything in its correct location and position. Second test concerns the free movement of the movable parts of the product. Parts are moved in translation or rotation movements depending on its functionality to check nothing interrupts the movement. The movable parts checked are the heating tunnel, the legs and the air vent closing. The movement of the legs and the air vent are just checked by observing the circuit are supposed to do, looking nothing interrupts it. A critical point of the design tests is the heating tunnel. The main trouble is not fitting correctly the heating tunnel with the box, allowing air come from the outside to the inside of the dryer box. To solve this problem, bands of rubber are used in the outline of the cavity of the dryer box to avoid any kind of air leak. Finally, an equilibrium stability test is made to ensure the solar dehydrator to be able to stand without falling. This test is done under conditions of a flat and smooth ground in first place, progressing to vary the conditions with different inclinations of the ground and get values from the position limits of the product.

7.5.3 Dehydration process

The dehydration process is the most critical test in the product development. The test consist in submitting the solar dehydrator in a real scenario of work. The theoretical knowledge is proved and errors are ensured to appear caused by the inexperience. The main goal is to achieve the maximum temperature expected, which will be oscillating around 65 ºC. The product is placed in the outside facing the sun and values are read through the LCD. Low heat achievements conditions the design of the tunnel to be changed, closing the inner air take by reducing its open area. This fact conditions the air to spend more time in the heating tunnel, what implies more heat caption. Once the maximum heat temperature is achieved, the overheating has to be controlled in order to

measure if the air vent out-take is enough. Some more tests have to be done to optimize de function of the servomotor located in the air vent in order to avoid a constant movement if temperature oscillates permanently around the values of dehydration, causing a high rate of power consumption. Finally, once everything is set up as required, the first real test is done. Food is introduced in the dryer box of the dehydrator and during a long-time test it is proved if it does really works. The main problem of this part of the tests is the high amount of time required between one test and the other. Any changes have to be carefully studied, in order to reduce the waste of time during this entire process.

7.6 Conclusion

The Solar Dehydrator as a product is mostly defined at this point. The whole of the functionalities have been limited and defined and structural measure references have been developed. The first part of the process has been mostly accomplished, but this doesn't mean the end of research and optimization of the product.

Until this point, theoretical concepts are defining the product, but what it's going to really define the final product is the performance developed in the tangible part of the project, the creation of a physical product. This part requires the fully attention of the team in order to analyze if the product is achieving all the goals pretended. This means there will be changes in the idea, loads of test phases to provide a quality product and the constant research to optimize the system as it's expected from the client.

8. Conclusions

8.1 Discussion

During our semester in ISEP, we worked on a project which consists in conceiving a solar food dehydrator.

Until now, the project went very well as far as the conception and the design of our product goes. We worked together on the product requirements, the functionalities and the design. To recapitulate these points, we decided our solar food dehydrator should be portable (foldable heating tunnel, adjustable legs, wheels, handle, light materials), attractive visually (simple, minimalistic design, combination of materials such as wood, glass and metal), efficient and autonomous (controlled air flow, automatic air vents, efficient heating tunnel), innovative (electronic control unit with temperature sensor, LCD screen with keyboard, alarm), and user-friendly. After a lot of research and brainstorming, we agreed on a final

design and on the required features of the product. Technical sketches, final renders and 3D models of the final product were realized, as well as conceptual storyboards, to help visualize its different features and functionalities.
Furthermore, certain materials that we wished for at first could not be ordered because of financial and/or practical issues: Instead of PMMA, we are now using glass, and instead of the initial cedar wood, we are now using ply wood. These changes are not crucial for the project. Using ply wood instead of cedar wood can even be seen as an advantage, since this material is lighter and thereby contributes to the portability of the device.
At the moment, our team is still in the construction phase. The electronic control unit has already been assembled and the coding with Arduino has worked out well. However, the outer shell of the dehydrator (tunnel and dryer box) still needs to be put together (the wood has already been cut).

At this point, following steps have been achieved:

- construction of the outer shell
- integration of the dryer shelves (metal grids) into the dryer box
- mounting of the wheels on the heating tunnel

These steps still need to be executed:

- folding mechanism for portability (adjustable legs and rail mechanism for the tunnel)
- integration of the control unit into the device
- final touches such as varnishing

Currently, the control unit requires an external power supply, which needs it needs to be plugged into a power socket in order to work. This is the main and crucial difference to our initial concept: The control unit was supposed to be powered only by a solar panel (connected to a battery - connected to the unit). This was also the main argument for marketing and sustainability and was supposed to be one of the major innovations compared to other, already existing products (combining sustainability and power-saving with the possibility of an electronic control and monitoring unit, which makes the device autonomous). However, to due organizational issues concerning the planning of such a

circuit, as well as the material list, the given budget, and the availability of certain components, we were provided with a power supply, so as to connect the control unit to the mains. This is not a big issue regarding the final results, and will not impact the dehydrating process. However, it has an impact on the energy consumption of the device. This way, the dehydrator is not autonomous as it was supposed to be.
However, for future development, the control unit can be improved so as to be “solar-panel-ready”, once a adequate circuit has been designed and a solar panel and battery are available.
For now, we are looking forward to make some progress on the building phase and test our device once it is ready.

8.2 Future Development

At this point, the solar food dehydrator has been presented in detail, regarding its design, functionalities, special features and the results of preliminary tests. However, the construction phase for the final product is not over yet. Although the control unit has been assembled and tested, functional tests on the finished product need to be carried out on a long-term period. Since this solar food dehydrator is the first of its kind on the market, the project is open to any kinds of improvements and must stay under constant development. These future changes will take into consideration technical progress, innovative ideas regarding the design, as well as customer critics and demands.

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