Water Pyramid

Desalination System: Water Pyramid

By Team 5

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Acknowledgement

This interim report shows the half port of the project team 5 have accomplished. First of all we want to thank the school ISEP which offered us the chance to work on a European Project Semester in Porto. Furthermore thanks to the teachers and supervisors the team was able to make progress in this project. Especially Cristina Ribeiro which is our main supervisor.

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Glossary

Abbreviation	Description
DFA	Dimensional Fund Advisors
EPS	European Project Semester
GDP	Gross Domestic Report
GPI	Genuine Progress Indicator
HDI	Human Development Index
ISEP	Instituto Superior de Engenharia do Porto
MED	Multiple-Effect Distillation
MSF	Multi-stage Flash Distillation
RO	Reverse Osmosis distillation
SHD	Simple Homemade Desalination
SMI	Social Media sustainability Index
VC	Vapor Compression distillation
WBS	Work Breakdown Structure

1 Introduction

In this chapter we provide brief informations about our project and how this report will look like. We start by presenting ourselves and then there will be few words about our motivation, problem that our project is trying to solve, objectives, requirements and functional tests.

1.1 Presentation

Team 5 (also known as GIVE ME 5) is a group of five international students with different scientific backgrounds that have come to Instituto Superior de Engenharia do Porto for the European Project Semester. Our team includes a Belgian Civil Engineer, a South Korean Mechanical Engineer, a French Packaging Engineer, a Polish expert in Logistics and a Spanish Electrical Engineer. The team members are shown in Figure 1.

Water Pyramid

Marion MILESI Pol Valls Min Ji Kang Maciej Pogoda Lies Augustyns

Figure 1: team: Give me 5

1.2 Motivation

Water desalination is a really important topic in the beginning of 21st century. The oil peak is coming and we need to start thinking about our future.

Facts are straight. Only 2,5 % of the water in the world is fresh water Amount_of_fresh water. It leaves us with 97,5 % that currently we are not using. About 80 % of people in the world live around 60 miles from the coast, so desalination is an obvious response to the lack of fresh water. Idea of water desalination is few generations ahead of us, because untill 2050 there will be 9.7 billion people on our planet and most of them will born in Asia and Africa So it is clear that the world will need more fresh water.

The process now exists in many places, but it is still not as common as it should be. On smaller scale it is used on ships and submarines since surroundings are perfect for obtaining water that way.

Currently 95 % of water desalination process is made with help of fossil fuels, because it is efficient and cheap. In a view of oil peak coming considering only the use of green energy should be a strategy that we need to develop. The process is really simple so we want to find a way to make it better and more efficient using only sustainable energy.

1.3 Problem

As it was mentioned before, we live on a planet which will not get any bigger and still there will be 30 % people born in next 30 years. Since water is necessary for life to exist on our planet we will need a lot more than we are using right now. Desalination process will help with using the water that currently is undrinkable and our project will help make it more common and accessible for everyone in an easy way.

1.4 Objectives

Our target is to design a sustainable desalination system. The objective of the project is to construct a water desalination system in a dome structure. This system will be able to work only by using renewable energy. The sun power will be used to run and to control the process. The sea water will be heated by the sun and by the difference of temperature between the inside and outside of the system water will easiliy evaporate and then condensate.

There are several target audiences: governmental institution, refugees and for private costumers (people living on water, boaters, Eco-lovers and surfers who live near by the beach). Due the dimensions of the pentagons of the dome our system can not be bigger than 3,27 m².

1.5 Requirements

Before starting on the project, the project was shown with their requirements. The team must have these requirements at all time at their disposal. The requirements of the project are:

- Use distillation and solar radiation
- Reuse provided materials
- Use low cost hardware solutions
- Use open source software
- Not exceed 150 €
- Comply with the Machine (2006/42/CE 2006-05-17)
- Electromagnetic Compatibility (2004/108/EC 2004-12-15)
- Low Voltage (2014/35/EU 2016-04-20)
- Radio Equipment (2014/53/EU 2014-04-16)
- Restriction of the use of certain Hazardous Substances (ROHS) EU Directives.

1.6 Functional Tests

There are several tests that needs to be done to verify and prove that our solution is working. This part of the project is very important to develop a well working water desalination system. Our team needs to focus on few aspects.

1. First of all finding the materials which will be used to build our product. There are few things to be made in our project and not all of them can be build with just one material. Materials has to be chosen which will be best for brine container, purified water container, the dome of the panel, the base of the panel etc.
2. Secondly our team needs to check which way of desalination would be a perfect choice for the product taking in account different wheather conditions.
3. The evaporated and condensated water will be clean enough to be drinkable, but not healthy to drink all time. Be sure of this statement, tests must be done
4. Finaly the electronical system is needed which would help making the process autonomous.

1.7 Project Planning

According to obtain a complete project. Different tasks must be made before several deadlines. This are the deliverables. To pick up the deadlines, our team planned to make milestones for every deliverables one day or more before the deadline. Between the milestone and the deadline the team can discuss whether should be improved/changed/accepted. The deliverables of the project are:

- Black Box diagram
- System schematics
- List of materials and components
- Final report, Final presentation
- Paper
- Poster
- Manual
- Video

To have a clear view to get these deliverables. A WBS and Gantt chart is made, which is explained and seen respectively in 3.1 Scope and 3.2 Time

1.8 Report Structure

Table 1 Report subdivisions displays subdivisions of our project.

Table 1 Report subdivisions

Subdivisions	**Description**
1	Introduction
2	State of the art
3	Project Management
4	Marketing Plan
5	Eco-efficiency Measures for Sustainability
6	Ethical and Deontological concerns
7	Project Development
8	Conclusions
9	Bibliography
10	Appendices
9	Bibliography
10	Appendices

2 State of the Art

2.1 Introduction

This chapter introduces technologies related to water desalination. We explain how the process works and how we can divide it. We also describe existance of similar products, techniques and technologies in the market. Most of it will be based on scientific sources that were found online or in libraries.

2.2 Definition and general information

Desalination is a process that is about removing minerals (mostly salt) from saline water (sea water), which should result in obtaining water that could be used for washing/cleaning, agriculture purposes or even drinking. It was first used by Greek sailors in the 4th century B.C. by evaporating sea water and creating drinking water.

According to research last year there were 18 426 desalinations plants in the world which had been producing more than 86.6 million cubic meters of water per day. More than 300 million people around the world rely on desalinated water for some or their daily needs of water. International desalination association, 2016. *Desalination by the Numbers.* Most of them exist in parts of the world that are low on fresh water like Saudi Arabia or Israel.

2.3 Types of water desalination

In this section we want to describe ways to desalinate water with examples. There are a lot of those, so we will pick the most common one and we will write about some advantages and disadvantages.

2.3.1 Water desalination techniques powered by fossil fuels

Because of the cost and efficiency these are the most common types of water desalination. They divide into two main technologies: - thermal desalination (multi-stage desalination, multiple-effect desalination and vapor compression), - membrane desalination (reverse osmosis).

2.3.1.1 Multi-stage flash distillation (MSF)

The process here is all about sea water vaporization at low temperature in a vacuum. Vapor condense to form fresh water. In a vacuum the boiling point of water is lower so it requires less energy in a whole process. The brine heater is heating sea water between 90 °C and 110 °C, but before the cold seawater reaches the heater it flows through condensing coils in vacuum flash chambers.

This process has two purposes:

- It heats the cold seawater before flowing to brine heater (saves energy),
- It condensate the flashed steam in containers to produce freshwater (temperature difference).

In the picture below you can see how the process actually works. Figure 2 Multi-stage flash distillation schematic.

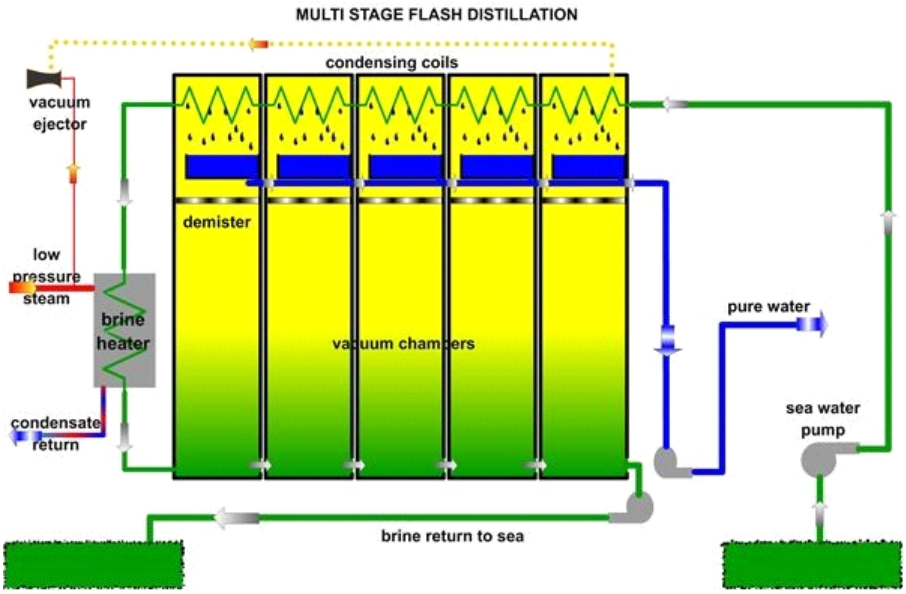

Figure 2: Multi-stage flash distillation schematic Bright hub engineering, 2012. How Desalination by Multi-stage Flash Distillation Works.

Later hot brine enters the flash vacuum chamber. Part of the water evaporates instantly, because temperature of the water is higher than the boiling temperature at vacuum pressure. The steam rises to upper part of the container and when it contacts the condensing coils it condense to pure water. Salt and other forms of dirt remains at the bottom of the container. The steam ejectors allow to produce necessary vacuum in the containers for the process. The brine flows to the next container where process repeats. This is why process is called multi stage flash distillation. Multiple containers makes the water a better product, since it is not possible to remove all salt in just one distillation process.

Energy requirement:

- Electrical energy for pumping the water.
- Steam energy for heating the brine.

Total energy requirement: 17 kWh/l

In 2000 multi stage flash distillation produced about 60 % of all desalinated water in the world.

Example of MFS plant:

Figure 3 displays the Jebel Ali plant in the United Arab Emirates can produce 2.13 billion liters of water per day.

Figure 3: Jebel Ali plant Time, 2015. This Plant in Dubai Makes Half a Billion Gallons of Fresh Water a Day.

2.3.1.2 Multiple-effect distillation (MED)

Multiple-effect distillation is a process which consists of several containers with decreasing levels of pressure and temperature. The one with higher pressure and temperature is first in the process and last one is maintained in lower pressure and temperature. In the container there is steam implemented to the system by tubes and to generate a temperature difference the sea water is falling down from the top of the container. This process allows the steam in the tube to condensate and at the same time sea water that has fallen partly evaporates and goes to the second container and process reapeats with brine that has not evaporated. Since in the next container there is lower pressure and temperature it allows the water to evaporate more easily. This process is repeated in a series of "effects" as represented in Figure 3 for example.

Figure 4 displays the Multiple-effect distillation schematic

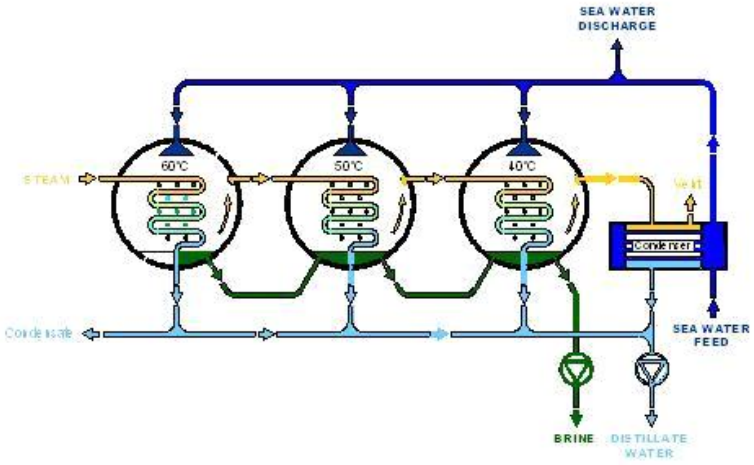

Figure 4: Multiple-effect distillation schematic Entropi veolia, 2014. Multiple Effect Distillation.

Example of MED plant:

Figure 5 displays the Tianjin Desalination Plant in China can desalinate 100 000 m^3/d.

Figure 5: Tianjin Desalination PlantWATER & WASTEWATER INTERNATIONAL, 2016. Cambodian water authority wins Stockholm Industry Water Award.

2.3.1.3 Vapor compression (VC)

This kind of distillation is the third most common type of thermal desalination. In this process heat is delivered by compressed vapor. When water evaporates, heat is recycled back to the remaining feed water. This type of desalination is usually performed by a mechanical driven compressor or a blower.

Figure 6 displays the Vapor compression process schematic

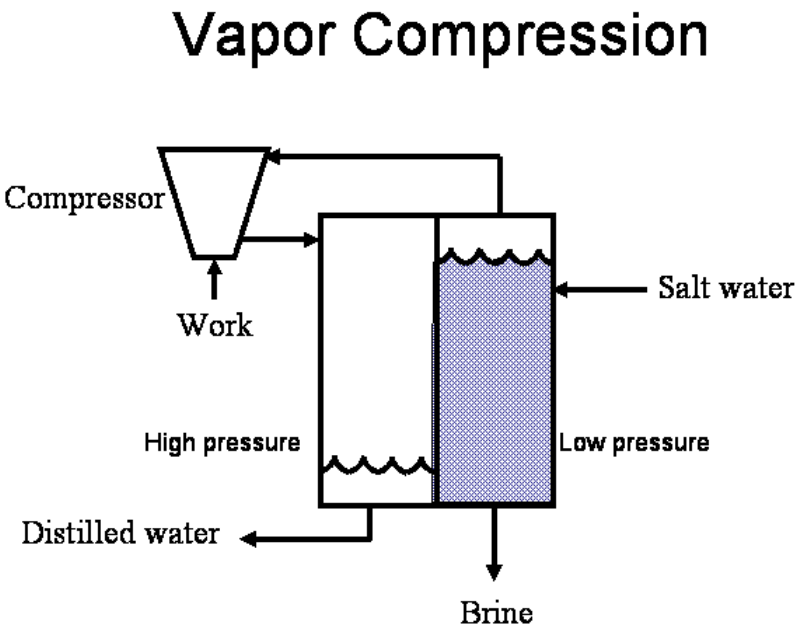

Figure 6: Vapor compression process schematic Vapor compresion.

2.3.1.4 Reverse osmosis (RO)

Reverse osmosis is different from the processes mentioned before. Reverse osmosis depends on a membrane technology. In this case we need a semi-permeable membrane, which allows the process to remove ions, molecules and larger particles from the water. In reverse osmosis pressure is applied to the water and than through the membrane flows from 95 % to 99 % clean water.

Example of RO plant:

Figure 7 displays the Sydney desalination plant can produce 500 million liters of water per day. It covers 15 % of water usage in Sydney. It won desalination plant of the year award in 2011.

Figure 7 Sydney desalination plant Sidney destiilation plant, 2014. Infrastructure.

Figure 8 displays a reverse osmosis desalination process schematic

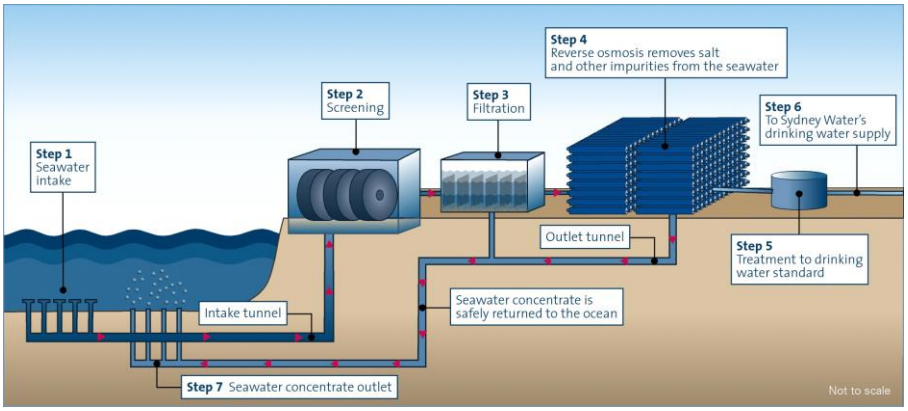

Figure 8 Reverse osmosis desalination process schematic Reverse osmosis, 2014. Infrastructure.

2.3.2 Water desalination techniques powered by renewable energy sources

Most of them are the same techniques, but the only difference is they are powered by giant solar panel plants, hydroelectric power plants or wind farms. There are also exceptions and one of them is idea of our project. In this part we will show some ways for simple homemade water desalination.

2.3.2.1 Simple water desalination (SWD)

Figure 9 displays a homemade desalination place

Figure 9: Homemade desalination place WIKI HOW, 2016. How to Desalinate Water.

Idea is simple, we are putting a brine water in the bowl and in the middle we have a cup. We insert a small rock in the middle just a little above the cup to help the condensated drops to fall into the cup. We need to put the whole system in the sun to heat up water which will allow it to evaporate and when temperature is lower, it will condensate to the cup.

2.3.2.2 Our approach

Our approach is quite similar to the previous one. It is really simple, there is no membranes or compressors. It all depends on solar power which is heating the water inside the pentagon-based pyramid. Than the water is evaporating, condensating and finally being collected on sides of the pyramid.

This method is really easy to implemante at home for everyone.

Figure 10 displays the solar desalination schematic

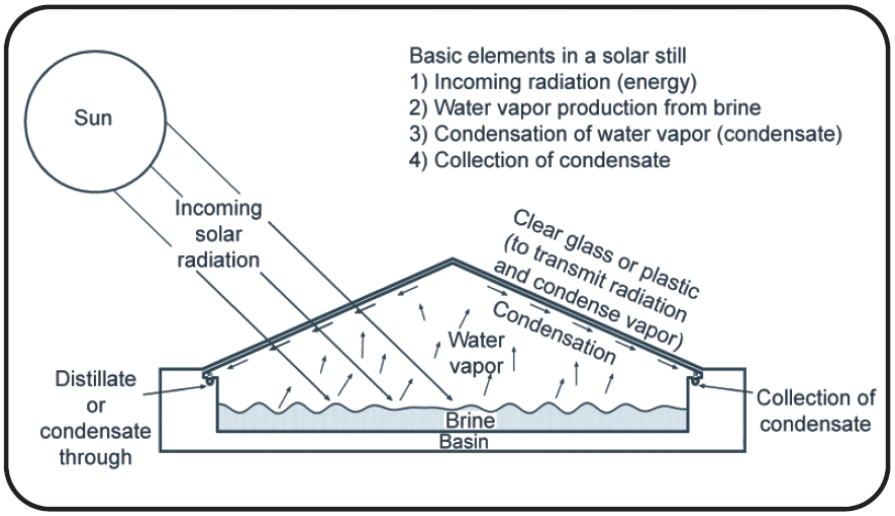

Figure 10: Solar desalination schematic Sustainable sanitation, water management, 2012. Desalination.

2.3.3 Comparsion

	Advantages	Disadvantages	Capital cost (USD/m³/d)	Operational cost (USD/m³)
MSF	- low operating cost when waste heat (from power plant for example) is used for the process,- quality of brine water is not as important as in the reverse osmosis technology,- leading technology for large-scale seawater desalination (used for 40 years, in 2000 was used in 60% cases)	- requires larger space than other (RO) desalination plants,- large amount of water is needed for production and cooling,- requires large energy input if it is not using waste heat (from power plant for example),- process is used mostly in Middle East where energy costs are not that high	1,200-3,000	0,7-1,5 (with waste heat)
MED	- very low electrical consumption (less than 1 kWh/m3; which is less than MSF or RO),- have a low maintenance cost (only low pressure pumps to change), operate at low temperature (<70oC) to avoid corrosis,- quality of water is not as important as in RO system	- high operating cost when waste heat is not available for the process	1,000-3,900	0,4-0,8 (with waste heat)
VC	* lowest cost comparing to the MSF or MED,- smaller equipment needed for the process	- maintenance on compressors and heat exchangers is greater than in MSF and MED,- high energy consumption	1,000-1,300	0,5-1,2
RO	- low energy requirments due to distillation without water phase change,- RO technology produces better water for cooking purposes,- RO filters are eco-friendly as the do not produce any chemicals,- process removes 99% of bacteria and pyrogenic substances from the water	- water is usually acidic (often below 7.0 pH),- process removes most of minerals	500-1,200 (brackish water) 1,000-2,500 (sea water)	0,2-1,2 (brackish water), 0,2-1,7 (sea water)
SWD	- easy to build for everyone,- low operation cost,- uses only solar energy, - minimum space needed	- it is not good for larger-scale process, - produces low amounts of water	N/A	N/A
Our approach	- easy to implementate,- produces more water than any other solar powered system,- uses only recyclable materials,- uses only power that comes directly from the Sun,- do not need much space	-cannot produce as much water as big desalination plants	N/A	N/A

2.4 Design

1. The panel has a surface 5 m², calculated by the formula of a hexagonial: A= 1,5*sqrt(3)*z² with z= 1,384 m. The same length is for the pentagonial. We are going to use the pentagonial panel. Assume this will be the length, we are going to made a panel of z=1.384 with a width of approximately 0,10-0,20 m.

2. Cardboard Model This model is based on the experiment using a pyramidical shaped glass with the salt water in the middle. The purified water will drop off the glass and will poor in the holes. This is seen on the picture Cardboard Model. This we did to catch up easy the purified water. The question is still how to get the salt out of the saltwater container.

3. The water that needs to go to the panel will be pumped with an aquarium pump

4. To pour the purified water to the surface, we will need a tube

Figure 11 displays the Cardboard Model

Figure 11: Picture Cardboard Model

2.5 Conclusion

In this chapter we wanted to show and describe what is desalination and what are current desalination techniques - how they work, what energy source they need, are they easy to implement etc. From this chapter we can learn that there are many ways to desalinate water, but they are complicated and not as easy as they should be for ordinary people. In the next chapters, we would like to show our methods and technology, also present the materials we will use and explain our choices.

3 Project Management

A management study is fundamental to obtain a succesfull project.

Management concerns first of all **Time, Price, Quality** for making a sustainable and efficient project. Next, providing an overview of the tasks division between the **team members**, release a better management. Moreover, it is critical to manage the **risks** which can occur during the project and how to keep the **stakeholders** satisfied.

All the running of the project is built on the project management.

3.1 Scope

Project scope is the part of project planning that involves determining the list of specific project goals, deliverables, tasks, costs and deadlines. In this section the scope of product and project are explained.

Product scope

The features and the functions that characterize our product are:

- Creating drinkable water from seawater
- Collecting salt from seawater
- Using sustainable resources
- Providing clear water to a dome structure

Project scope

To have a clear view of the different phases of the project, a progress matrix is needed. A work breakdown structure (WBS) is a technique to get a clear view of the scope. It is a diagram where the project is broken down in phases, which are broken down in deliverables. Tasks can be allocated to each deliverables if needed. The WBS of the Desalination project is shown below in WBS. During the semester, this matrix will help the team to not forget any of the following steps.

Figure 12 displays WBS

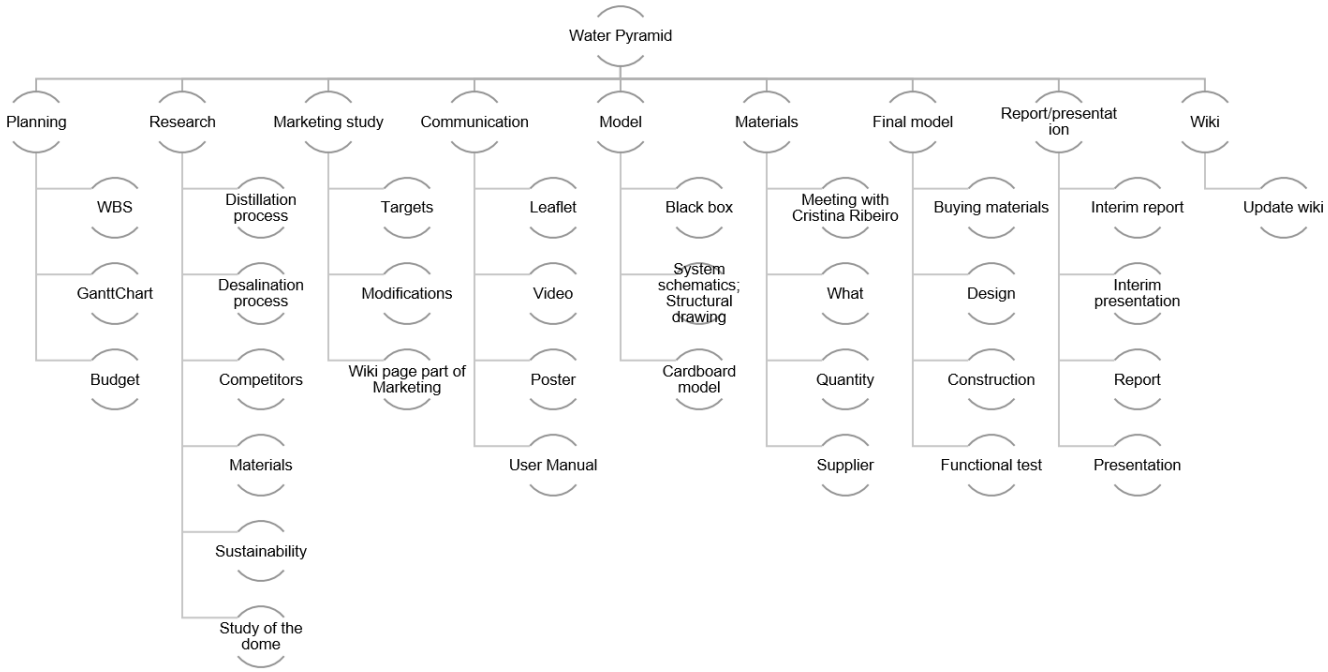

Figure 12: WBS

3.2 Time

An essential aspect of the project is Time Management.

Advantages of Time Management are:

- Stress reduction
- Sense of Accomplishment
- Pursuing other objectives
- Prioritization and efficiency
- Planning

The client needs deliverables at a certain deadline. It is very important to respect that. Here, the customers are the coordinators of the EPS program from ISEP. In the Table 2: Deliverables shows the deliverables and their deadline of the project.

Table 2: Deliverables

Deliverables	**Deadline**
Gantt Chart	2016-03-08
System Diagrams and Structural Drafts	2016-03-14
Cardboard scale model	2016-03-29
List of Materials (what &quantity)	2016-04-04
List of Materials (local providers &price - including VAT and transportation)	2016-04-11
Upload the Interim Report and Presentation to the wiki	2016-04-16
Interim Presentation, Discussion and Peer, Teacher and Supervisor Feedbacks	2016-04-21
Upload refined Interim Report	2016-04-29
Upload Functional Tests'Results	2016-05-30
Upload the Final Report, Presentation, Video, Paper, Poster and Manual	2016-06-11
Final Presentation, Individual Discussion and Assessment	2016-06-16
Update the wiki with all correction suggestions,Hand in a CD with the corrected deliverables (source + PDF) together with all code produced to the EPS coordinator, Hand in one printed exemplar of the corrected report to the EPS coordinator	2016-06-21

Hand in the prototype and user manual to the client, Receive the EPS@ISEP certificate	2016-06-23

To help managing the deadlines, MS Project will be used to create the Gantt Chart. Different information is represented in the schematic: the tasks, the duration of tasks, the people attached to the task, deadlines, milestones and cost. In the picture below, the Gantt chart is shown. This will be updated at the end of the project when all the tasks, their duration and the people attached to the file are known for sure.

3.3 Cost

The project has a budget limit of 150 euros. It is necessary to implement a cost management in abbility to control the budget.

Advantages of Cost Management are:

- Stress reduction
- Pursuing other objectives
- Prioritization and efficiency
- Awareness

There is a separation of costs. **Work resource** depends on time and **Material resource** has a fixed price.

To start, this is the summarized Table 3 of our electronical components, with the quantity and the price

Table 3 Cost electronical components

Component	Quantity	Cost
Arduino uno r3	1	
Humidity sensor	4	
Valve	1	
Water pump	1	

The Work resources and their prices are summarized in Table 4.

Table 4 Cost work resources

Resource name	Type	Cost (€)
Maciej	Work	0
Marion	Work	0
Min Ji	Work	0
Lies	Work	0
Pol	Work	0

To finish, in Table 5 you will find the rest of the needed ressources for the system, the materials, quantity, cost and suppliers.

Table 5 Needed resources

Components	Type	Material	Quantity	Cost	Supplier name
Pyramidical transparents covers	Material	PMMA	4.15 *1.15 m	2 mm thick for 39.99 €/m²	LEROY MERLIN
Salt container	Material	Slate	(0.8*2*pi) m		Valongoslate
Tube	Material	PVC	3*0.30 m		
Vessel purified Water	Material	PVC	Base : 2.76 m² / Walls : 4* 0.05 m*1.38 m		Brico depot
Container for purified water	Material	PVC	10 l		Brico depot
Jonction cover/container	Material	Glue and molding			
Tap	Material		1	20 €	Brico depot
Sink	Material		5 l		Brico depot

3.4 Quality

For every project, quality is the proof of its success. In our time, consumers ask for quality and products working well for a long time. ISO 8402-1986 defines quality as the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs.

To manage good quality, you have to be aware of:

- The raw materials: it is important to check the degree of quality of our raw materials, because the final quality of our product will depend on them.
- The equipment conditions: it is essential to have a good equipment maintenance to keep a constant level of quality for our product. And do not hesitate to change some part which can generate quality troubles.
- The safety: The main dangerous aspect of our product is the glass material.
- The sense of details: obtaining a product with quality, it is important to think about every detail.

Our final deliverable is water. This water will be in contact with living beings, like humans or plants. If the quality of released water is not good enough, health issues could appear for plants or humans. Given its possibility, quality is a crucial point of this project.

3.5 People

The task allocations divides the tasks between the members of the team according to our knowledges and our desires. Even if each people is attached to one task, the team always work together to help each other at any time. Table 6includes the different tasks and the people allocated to them.

Table 6 Task allocation

Phases	**Subphases**	**People**
Planning	WBS	Lies;Marion
	Ganttchart	Lies; Marion
	Budget	Lies; Marion
Research	Distillation process	Team
	Desalination process	Team
	Competitors	Maciej; Min Ji
	Materials	Team
	Sustainability	Lies; Pol
	Study of the dome	Lies; Marion; Pol
Marketing study	Targets	Maciej; Min Ji
	Modifications	Maciej; Min Ji
	Wiki page part of Marketing	Maciej; Min Ji
Communication	Leaflet	Lies; Marion; Min Ji
	Video	Maciej
	Poster	Lies; Marion; Min Ji
	User Manual	Pol
Model	Black box	Pol
	System schematics; structural drawing	Lies; Marion; Pol
	Cardboard model	Lies; Marion; Pol
Materials	Meeting with Cristiana Ribeiro	Team
	What	Team

	Quantity	Team
	Supplier	Team
Final Model	Buying Materials	Team
	Design	Team
	Construction	Team
	Functional Test	Team
Report/ Presentation	Report	Team
Wiki	Update wiki	Team

By using the RACI matrix. It will be clear how the task allocation is managed. Every task can have a Responsible team member, an Accountable team member, a Consulted team member and an Informed team member. These variables means:

- Responsible: This person is responsible for this part of the project (this task). He/she will make the task with help if needed.
- Accountable: The teammember is responsible of the final result of the task. If the task is not managed good at the end. The Accountable and the responsible are to blame.
- Consulted: This person can be consulted or can give advice if needed.
- Informed: The teammember is informed about the task when the deadline arrives.

The RACI matrix of team 5 is found in Table 7:

Table 7 RACI matrix

Phases	**Subphases**	**Lies**	**Maciej**	**Marion**	**Min Ji**	**Pol**
Planning	WBS	A	C/I	R	C/I	C/I
	Ganttchart	R	C/I	A	C/I	C/I
	Budget	A/R	C/I	A/R	C/I	C/I
Research	Distillation process	A/R/I	A/R/I	A/R/I	A/R/I	A/R/I
	Desalination process	A/R/I	A/R	A/R/I	A/R/I	A/R/I
	Competitors	C/I	A/R	C/I	A/R	C/I
	Materials	A/R/I	A/R	A/R/I	A/R/I	A/R/I
	Sustainability	A/R/I	C/I	C/I	C/I	C/I

	Study of the dome	A/R/I	C/I	A/R/I	C/I	C/I
Marketing study	Targets	A/R	C/I	A/R	C/I	C/I
	Modifications	A	C/I	R	C/I	C/I
	Wiki page part of Marketing	A	C/I	R	C/I	C/I
Communication	Leaflet	A	C/I	R	R	C/I
	Poster	R	C/I	R	R	C/I
	User Manual	C/I	A	C/I	C/I	R
	Video	C/I	A	C/I	C/I	R
Model	Black box	C/I	R	C/I	C/I	A
	System schematics; structural drawing	I	C	R	C	A
	Cardboard model	I	C	R	C	A
Materials	Meeting with Cristiana Ribeiro	C	C	C	C	C
	What	R	C/I	C/I	C/I	A
	Quantity	R	C/I	C/I	C/I	A
	Supplier	R	C/I	C/I	C/I	A
Final Model	Buying Materials	A	A	A	A	A
	Design	A	A	A	A	A
	Construction	A	A	A	A	A
	Functional Test	A	A	A	A	A

Report/ Presentation	Report	A	A	A	A	A
Wiki	Update wiki	A	A	A	A	A

3.6 Communication

Communication within a group is the key for an efficient work. To have a good communication, you have to pay attention to the codification of the message, to be sure that the message is understood by the two actors : sender and receiver. It's important to speak the same language, to use the same technical definition, to be aware in order to codify the message, to respect the cultural issues, etc, if you want to avoid failure inside your communication system. This Communication system can be summed up with the diagram in Figure 13.

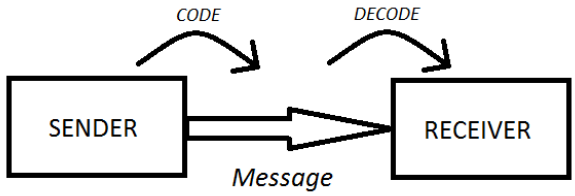

Figure 13 Communication system

There are two main ways of communication the team adopted:

Face to face Every week, the entire team meets to make the balance sheet of the project: Goals, decisions, evolution, solving problems, etc. Even by allocating the different tasks of the project between all the members, most of the time all the team worked together to exchange easily information, questions and always have a mental support.

Internet At the beginning of the project the team created a facebook group. In this group the team shares all the files and plans all the meeting. While working at home the Facebook group was an easy and fast way to communicate in case of doubts or any pratical questions. To conclude one of the strengths of our group is communication. All team members are really fouces on having a good and fast communication and it has absolutly been not a problem.

The Communication Matrix on the next page in Table 8 sums up our communication strategy.

Table 8 Communication Matrix

	What	Who	How	When	Why	To whome	Code
1	weekly team meeting	team	meeting	every Wednesday	developing project	team	english, orally, Facebook
2	weekly supervisor meeting	team	meeting	every Thursday	confirm	supervisors	english, orally, Wiki
3	interim Report	team	wiki page	16/04/2016	to get external advice, to inform	supervisors and professors	english, text, wiki
4	interim presentation	team	Prezi, orally	21/04/2016	to introduce our project	supervisors, classmates, professors	english,orall y
5	final Report	team	wiki page	11/06/2016	to show the project	supervisors and professors	english, text, wiki
6	final presentation	team	prezi, orally	16/06/2016	to introduce our project	supervisors, classmates, professors	english, orally
7	printed exemplar of the report + Deliverables	team	printed version	21/06/2016	to complete our project	supervisors	english, text, CD
8	the EPS@ISEP certificate	EPS coordinator	paper	23/06/2016	to certificate our EPS	team	english, text
9	Wiki page	team	wikipedia	always accesible	to show the project	everybody	english, text, wiki

3.7 Risk

According to ISO 31000, risk can be defined as the effect of uncertainty on objectives. Risk management is the identification of the risk itself, its effect and searching for a solution to avoid these effects. The risks that occur during a project can be related to the product/system itself (system risk) or the making of (external and internal risks). External risks are risks that are not foreseen, the team needs to be aware of these risks. Internal risks can be avoided by the team if they handly accurate and with justice. The risk management table is seen in Table 9 .Buisiness Dictionary, 2015. *risk management.*

Table 9 Risk analysis

Risk ID	Description	Cause	Effect	Trigger	Response	Owner	Last review
Internal risk							
1	Non-functional teamwork, misunderstandings between teammembers	Bad communication, delays, bad or unfinished work, no progress	Scope: Fix the misunderstanding; Time: depends on the issue; Cost: a lot of working hours	teambonding	3. Restarting communication, redistributing the task, applying team building measure learned	x	x
2	Non-respect of the delays/deadlines	unforeseen events that occur	Scope: Not being ready for deliverables, Time: the duration of the delay, Cost: working hours + extra hours	reminding everyone of the deadlines	2. making extra hour, asking for an extension	x	x
External risk							
3	Customer changes his requirements: The product and its property change, modification of all	the purpose of the previous requirement are not satisfying enough	Scope: adjust the design, Time:2 weeks, Cost: buying new materials	carefully listening what the consumer wants	2. adjusting at the best, being reactive/creative	x	x

	the project						
4	Material does not fulfil our satisfaction	Bad quality	Scope: Check the quality of the material we buy , Time: delivery time of new material, Cost: the cost of new material	Check quality before buying	2. Negotiating with the supplier, having backup supplier plan	x	x
System risk							
5	Non optimal working of the system: Heat is not sufficient	Bad weather	Scope: using other systems to get heat Time: time to install the heating system, Cost: heating system and working hours	waiting, working , plugging in the heat system	optimize the system	2.Provide heat by an another way	x
6	Electronical system failure	Arduino failure	Scope: desalination will be impossible , Time: process will stop and wasting time to fix the problem, Cost: Worse case scenario is replacing the Arduino, this cost could be 20 €	Short circuit	1. Mitigate – back up arduino	team	x
7	Leak in the pyramide:, the process will not work	Scope: evaporation will be hard, Time: buying and putting a nem PMMA cover, Cost: buy a new triangle PMMA and	leak	2. having tight seal and resistant materials	team	x	

		working hours					

3.8 Procurement

Procurement management is an area of logistics that is responsible for all equipments, goods and raw materials available for the team/project. It is necessary for those purchase sourcing raw materials from suppliers to provide the team to work sustainable. Providing the project with goods on time, with optimized quality for a good price as pointed out in Figure 14 .

Figure 14: Procurement

To fulfill the procurement management the team must undertake the following steps:

1. Identification of need: It is important to clearly identify the good and services needed. One mistake in this step can induce loss of money and delay on the project. The list of materials are shown in the pdf

2. Qualified suppliers: To make a sustainable project, finding sustainable suppliers is essential. The analysis of the sustainability of the suppliers is including in chapter 5. Eco-eficiency Measures for Sustainability

3. Delivery: Throughout the delivery process, the materials must be checked based on time, quality and cost. Our materials will be provided near by Porto.

4. Analyzing results: Analyzing the results based on used materials and energy consumption is necessary to complete the project and to improve what is needed. Deltabid, 2016. *Procurement Management.*

3.9 Stakeholders management

The project is influenced by several people, the stakeholders. These are anyone who has power and/or is interested in the project. For this project team members, supervisors, professors, the school itself, suppliers and future clients are the stakeholders. All the expectations of these stakeholders must be fulfilled. Stakeholders can be divided into four categories.

1. Those with high power and interest in the project, are the people who have to be managed closely.

2. Those with high power but lack of interest, are the people who has to keep satisfied.

3. The ones with low power but with a high interest must be kept informed.

4. Others are people with low power and interest in the project but still can influence the project. These are monitors.

All the stakeholders must be kept satisfied. They all have an impact in developing the project. Those with high power must be kept satisfied. Stakeholders from category 1 and 2 have a high influence on the project. They say if some things can be or can't be done. Those with a high interest must be kept informed. Stakeholders from category 3 and 4 want to know all about the developing of the project. In Table 10 Program management, 2010. *Stakeholder Analysis Template.*

Table 10 Assessment

	Who	role	can influence	is influenced	expextations	Power	Interest	stakeholder strategy
A	Augustyns Lies	Teammember	yes	yes	High	High	High	Managed closely
B	Kang Minji	Teammember	yes	yes	High	High	High	Managed closely
C	Milesi Marion	Teammember	yes	yes	High	High	High	Managed closely
D	Pogoda Maciej	Teammember	yes	yes	High	High	High	Managed closely
E	Valls Aguila Pol	Teammember	yes	yes	High	High	High	Managed closely
F	Cristina Ribeiro	mean supervisor	yes	no	High	High	High	Managed closely
G	Benedita Malheiro	head of supervisors	yes	no	High	High	Medium	Managed closely
H	Other supervisors	supervisors	yes	no	High	Medium	Medium	Managed closely
I	Professors	teaching	yes	no	High	Medium	Medium	Keep

								Informed
J	ISEP	Financial and provide us everything to make the project	yes	no	Low	High	Low	Keep satisfied
K	Suppliers	Provers of the material	yes	no	Low	Low	Low	Monitor
L	Future clients	Buyers of the system	yes	yes	High	High	High	Keep satisfied
M	Hometown school	scholarship, they give the ability to go on EPS	yes	no	High	High	Low	Keep satisfied

The project stakeholders can be seen with their rate of power and interest in the project. This can all be visualized in a stakeholder map.

Figure 15 displays a stakeholder map dividing the 4 categories by a rating from low to high

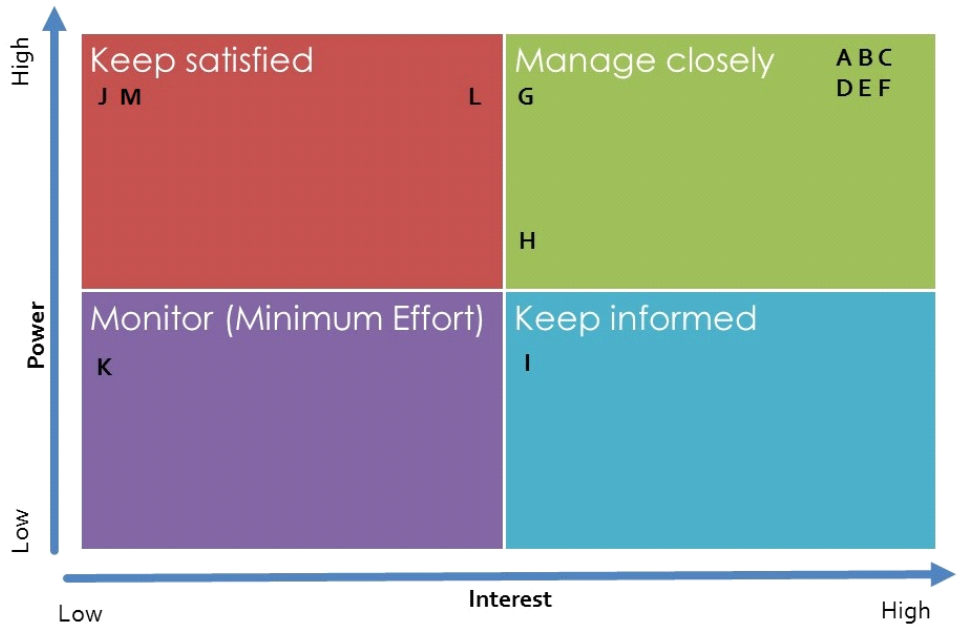

Figure 15: First impression design

3.10 Conclusion

A project management part is essential to start a project. This management makes a clear overview of the proceeding of the project. First Time, cost and quality are outlined. Communicating and finding out how people are involved in the project are elucidate in several parts of the project management:

- People
- Communications
- Risk Management
- Procurement
- Stakeholders management.

4 Marketing Plan

4.1 Introduction

Marketing is operating activities that enterprise provides products and services to customers for profits. The goal of enterprise develops products or services which satisfy the customer's desire through marketing activities and after that, they make their profits from that. ***Marketing*** plan is so important because it includes a product, price, place, and promotion. In addition, it is a formal document in an organization which explains the necessary actions to achieve its marketing objectives.

In this chapter, we will analyze our product. After that, our team will mention our product in terms of marketing by analyzing our potential customers, setting up marketing strategy, and considering the marketing means.

Table 11 displays necessary actions to achieve marketing objectives.

Table 11 Marketing objectives

Section	Purpose
Executive Summary	Presents a quick overview of the plan
Market audit	External and internal analysis
SWOT analysis	Strengths, weaknesses, opportunities and threats
Objectives	Define the company’s objectives
Marketing strategy	Segmentation, targeting and positioning
Marketing mix	Product, Price, Place and Communication, including digital marketing strategy and loyalty strategy
Action programmes	Present information of detailed actions
Budgets	A projected financial plan
Controls	Indicates how the marketing plan is monitored

4.2 Market Analysis

Figure 16 displays the marketing environment

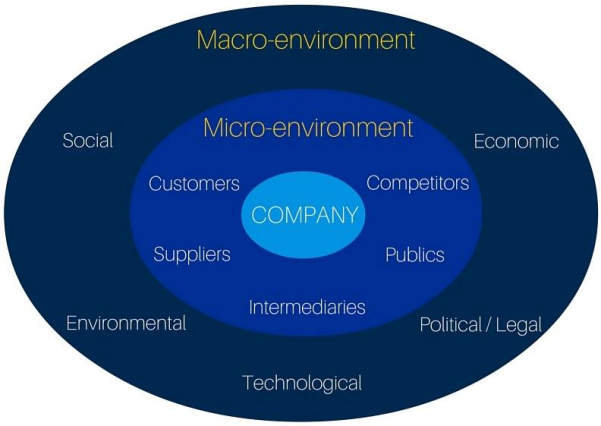

Figure 16: Marketing Environment

Marketing environment surrounding the company can be divided into two parts: the immediate area "Macro-Environment" and the uncontrollable area "Micro-Environment".

4.2.1 Macro-Environment

"Macro-Environment" has Factors or elements in an organization's immediate area of operations that affect its performance and decision-making freedom. It includes social, environmental, technological, political/Legal, and Economic Environment.

4.2.1.1 Social

Countries, people, and companies try to find the ways how people can save water and use that efficiently because of increasing of water shortage. Among them, for water desalination, California conducts 2 desalination projects and Pakistan starts desalination project which is delayed before. Also companies, for example POSCO Energy in Korea, are promoting desalination. However, sometimes desalination projects are failure like New York's project. That means that water desalination projects are not always viable. So each country and city has to consider about their conditions. If our products were provided, countries and companies would have interested in not only big scales of projects but also small scale of projects. In addition, they could find other solutions from our product.

4.2.1.2 Environmental

95% of current water desalination is being made up fossil fuels. On the other hand, our product operates with sustainable technology: solar panel. This means it doesn't use substances that generate pollution like fossil fuels. And its body is made of recyclable polymers such as PVC, so our product can be used after the end of life.

4.2.1.3 Technological

Features of our product is that it utilizes simple principles.

- It gathers drinkable water by using evaporation and coagulation of the liquid.
- People can stop or operate the product by using the simple button operations.
- We can exchange container or parts easily through upper side of product.

Additionally, the system is automatically controlled so the elderly and young children can easily use the product who have difficulty in learning new operations.

4.2.1.4 Political/Legal

The feature of our product is able to create drinkable water from unusable water by using sustainable energy: solar energy. It is the way that create something from nothing and also can save the energy. If countries try to encourage people to use our product, they could get more ECO- friendly advantages. When the government give the legal benefits, such as tax cuts, to people who think about environment and try to save the energy, they will choose more ECO-friendly way even they take little inconveniences.

4.2.1.5 Economic

When people use our product, they don't have to utilize products that use electricity like water purifier. Users don't need to pay the energy bills because our products are operated by solar power. So they can save their money and obtain economic profits from them. Also government are able to make extra energy for preventing energy shortage because the usage of energy will decrease.

4.2.2 Micro-Environment

"Micro-Environment" has major external and uncontrollable factors or trends that influence an organization's decision making and affects it strategy and performance. It includes customers, suppliers, intermediaries, publics, competitors.

4.2.2.1 Customers

※Before we mention customers, our product will be part of "Dome Shelter." But our project is only for "Water Desalination". So in this part, our team will describe separately to "Dome Shelter".

Customers defined as groups that purchase a company's goods and services. Our targeting customers are governmental institution, refugees(like Africa) and for private customers (people living on water, boaters, Eco-lovers and surfers who live near by the beach)

<u>Governmental institution</u>

If water shortage happened because of natural disasters like drought , the governmental institution have to conduct policy about using water (like California in 2014). If they provided our product to people, institution don't need to suppress the water use to public property like grave and also offer new product to people for water conservation.

<u>Refugees (like Africa)</u>

The refugees that need real help like Africa countries have thin water , have no rain, or have lots of useless water like muddy water. By using our product, people who live in that area don't need to go far away for getting fresh water. They just can get drinkable water easily from our product and muddy water.

<u>People living on water, boaters, surfers who live near by the beach</u>

There are a lot of water around people who live on water, berth their boat on the river for living, and live near by the beach. But they don't get useful water easily. Our product can make drinkable water from a lot of water resources with sustainable energy. And solar panel will work well because they live relatively open space.

<u>ECO-lovers</u>

Eco-lovers will have interest in our product for sure, and they buy it. Because they love and think about ECO life and our product can produce drinkable water without using fossil fuel which generate pollution. And they will find out another ways to help environment by using our product, It will help the environment get better.

4.2.2.2 Suppliers

Suppliers defined as groups that provide resources needed to produce goods and services, important link in the “value delivery system”. In creating our product, we need glasses for upper side, pump for moving seawater, Arduino for controlling our desalination system automatically, polymer container for gathering purified water, etc. We cannot buy our material only in Portugal, so our team will produce our product by finding the materials that have most suitable qualities and supplier who provide us reasonable price.

4.2.2.3 Intermediaries

Intermediaries defined as groups that help the company to promote, sell, and distribute its good to final buyers like resellers. We also can use personal selling for selling strategy, but it has disadvantages that takes so much time and is most expensive promotion tool. Therefore, our products are likely to be sold or shared through intermediaries. For example, it can be shared by agencies, such as UNICEF for helping people who need help. Additionally, our products are going to be sold camping company like Decathlon or Big market like CONTINENTE.

4.2.2.4 Publics

Publics defined as groups that have an interest in or impact on an organization's ability to achieve its objectives. We try to explain the purpose and environment-friendly features of our product, people will consider about our product and can catch our intention. Then our team can building good relations with people also obtain favorable publicity, and build up a good corporate image.

4.2.2.5 Competitors

Competitors defined as groups that serve a target market with similar products and services. When our team searched technological information about our product, we were able to confirm that a designer already produced an product that has similarity with our product. His name is Gabriele Diamanti and he is a freelance Industrial Designer, based in Milan. His product name is “Eliodomestico” and it is a solar household still for the developing countries. This product is only for developing countries, but there are so many characters which we can consider. Eliodomestico also uses seawater and ECO-friendly. But it doesn't need electrical control system, just only operate with solar energy. It can produce maximum 5 l per day and it makes more drinkable water than existing things that produced 3 l per day on average. Also it is easy to maintain and also good impact on the local economy. We have to find advantages from his product, and develop our product much better.

Figure 17 displays the eliodomestico

Figure 17: Eliodomestico

4.3 SWOT Analysis

A SWOT analysis is a structured planning method that evaluates four elements of a project/a business/a product. Picturing the Strenghts, Weaknesses, Opportunities and Threats in a matrix gives a proper view of the four aspects. The SWOT reminds us to be carefull for the Weaknesses and Threats and to use the Strenghts and Opportunities to grow.

- Strengths are atributes of an organisation or product that is helpful to achieve the objective.
- Weaknesses are attributes of the organization or product that is harmful to achieve the objective
- Opportunities are external conditions which are helpful to achieve the objective.
- Threats are external conditions which could do damage to the business's performance.

The SWOT analysis of our project is given in the picture below. Their are more important postive arguments then negative, what gives a higher opportunity to grow in the project.

Figure 18 displays the SWOT analysis of our project.Their are more important postive arguments then negative, what gives a higher opportunity to grow in the project.

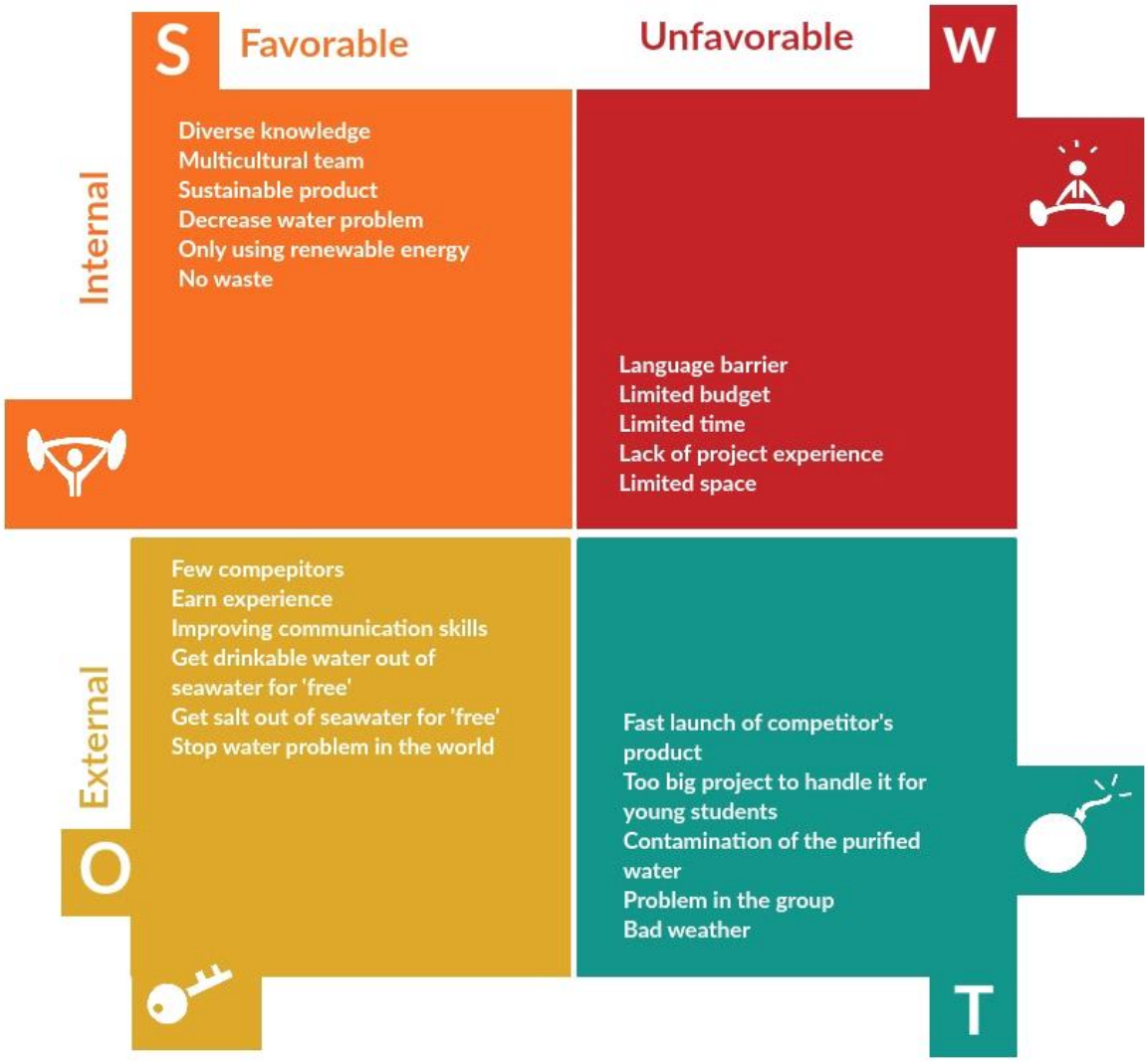

Figure 18: SWOT Analysis

4.4 Strategic Objectives

Figure 19 displays the Marketing strategy planning process

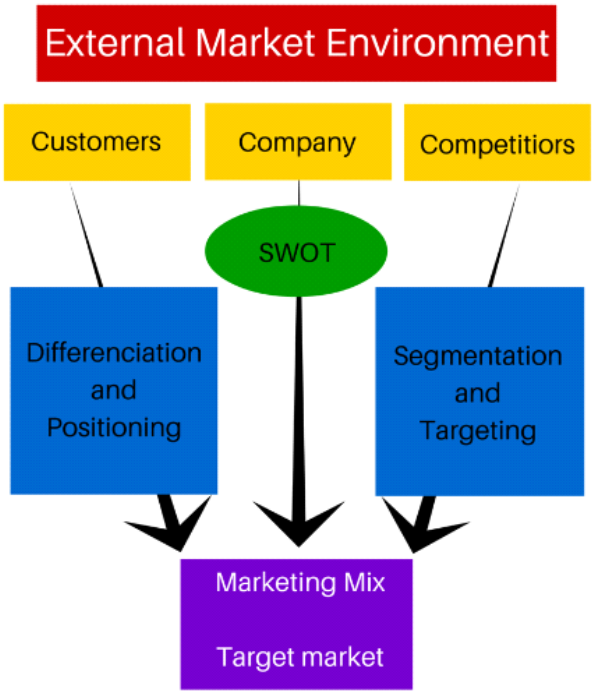

Figure 19: Marketing strategy planning process

Uncertainty and competition have increased significantly and effective marketing is essential for survival and prosperity. When we try to produce products, we have to think about 5 things: SMART.

- S (specific): details exactly what need to be done.
- M (measurable) : Achievement or progress can be measured.
- A (Achievable): Objective is accepted by those responsible for achieving it.
- R (realistic): Objective is possible to attain. (important for motivation effect)
- T (timed): Time period for achievement is clearly started.

4.5 Segmentation

4.5.1 Segmentation concept

Concept is dividing markets into smaller segments that can be reached more efficiently and effectively with products and services that watch their unique needs. Requirement for effective segmentation

- Measurable: Size, purchasing power, and profiles of segments can be measured.
- Accessible: Segments can be effectively reached and served.
- Substantial: Segments are large or profitable enough to serve.
- Differential: Segments are conceptually distinguishable and respond differently to different marketing mix elements and programs.
- Actionable: Effective, programs can be designed for attracting and serving the segments.

4.5.2 Market segmentation

Market segmentation is for those things:

- Identify bases for segmenting the market.
- Develop segment profits.

4.5.2.1 Levels of market segmentation

Table 12 displays the marketing segmentation.

Table 12 Marketing segmentation

Segmentation	**Definition**
Mass marketing	Same product to all consumers (no segmentation, e.g. Coca-cola: at one time)
Segment marketing	Different products to one or more segments. (some segmentation, e.g. hotels)
Niche marketing	Different products to subgroups within segments (more segmentation, e.g. standard of luxury SUV's)
Micromarketing	Products to suit the tastes of individuals and locations (complete segmentation)
Marketing strategy	Segmentation, targeting and positioning
Marketing mix	Product, Price, Place and Communication, including digital marketing strategy and loyalty strategy
Action programmes	Present information of detailed actions
Budgets	A projected financial plan
Controls	Indicates how the marketing plan is monitored

Our products are applicable to Niche marketing because our products set specific users e.g. country, company, and some people who really need.

4.5.3.1 Geographic segmentation

Among the target Customers, there are refugees (like Africa) and people living on water, boaters, surfers who live near by the beach. they are good for explaining the geographic segmentation.

First of all, The refugees that need real help like Africa countries have thin water , have no rain, or have lots of useless water like muddy water. By using our product, people who live in that area don't need to go far away for getting fresh water. They just can get drinkable water easily from our product and muddy water.

Secondly, There are a lot of water around people who live on water, berth their boat on the river for living, and live near by the beach. But they don't get useful water easily. Our product can make drinkable water from a lot of water resources with sustainable energy. And solar panel will work well because they live relatively open space.

4.5.3.2 Demographic segmentation

Our product's operation is so easy and electrical systems are controlled automatically, everyone can utilize our product. This product is related with essential component: water. So we will develop our product can be used everywhere that water is present.

4.5.3.3 Psychographic segmentation

Users can reduce their stress from obtaining purified water in the hard condition by using our product. By obtaining a more purified water, they will be able to release their thirst and further maintain the cleanliness of their surrounding and environment. Then their surroundings will get better, and they will try to find a way to improve their quality of life.

4.5.3.4 Behavioral segmentation

Users use our product and are able to get purified water continuously, they will feel satisfaction and be existing customers. Also they automatically do promotion to our potential customers. That situation will help us increase sales. Or publics find that some people's hard condition get more better, they will have interested in our product and we can get more profits from regional or global interest.

4.6 Strategy/Positioning

How to deploy a long term marketing strategy is innovative and its aim is continuous improvement. The width of the expansion is to be integrated and be most suitable adjustments, be sure to configure all marketing functions. Marketing strategy involves a three-dimensional deployment of analysis, the whole of the things of the most appropriate strategy, organizational strategy to find the opportunity. To develop these strategies, there have a lot of relationships with non-marketing companies, namely human resources, accounting, etc.

Product's positioning for market is the way the product is defined by consumers on important attributes. And product is compared with competing products simplifies the buying process by helping consumers organize products into categories.

Market must:

- Plan positions to give their products the greatest advantage in selected target markets.
- Design marketing mixes to create these planned positions.

Figure 20 displays the positioning strategy of our product.

Figure 20: Choosing a positioning strategy

Competitive advantage is extent that a company can position itself as providing superior value to selected target markets.

4.7 Adapted Marketing-Mix

Figure 21 displays the Marketing mix

Figure 21: Marketing mix

Defining our marketing mix is essential to establish the company's strategic position and to being able to connect with the right audience. The marketing mix consists of 4 parts: price, place, product, and promotion. They are 4 fundamental things company should define in order to reach a certain target audience.

4.7.1 Product

Figure 22 displays the levels of products

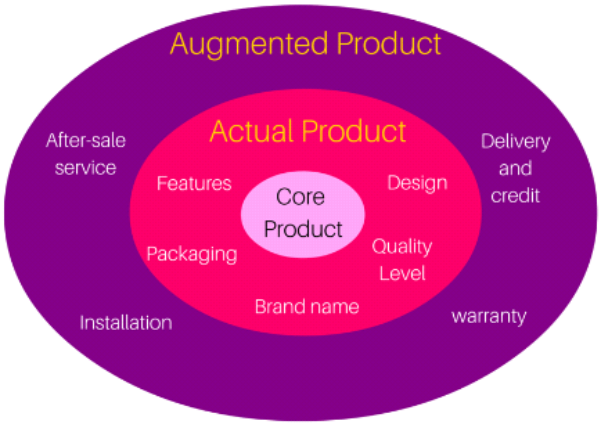

Figure 22: Levels of products

A product is anything that can be offered to a market for attention, acquisition, use, or consumption and that might satisfy a want or need.

4.7.1.1 Product Attributes

Our product will be produced with a high quality in order to perform fully the role of the itself. It should also be a priority to stability when it is installed in combination with the dome at the top. Appearance is to be consider a situation in which the product can be damaged by weather factors, such as wind or rain. So it has to be designed in optimal conditions. In addition, a top angle for obtaining the purified water efficiently should be set through calculation. Because even though the product is safe, if the efficiency was low, it could be useless. Inside of the product, customers are unavoidable to do manual operation because of removing salts, the product is located in ceiling, so product has to be designed in easy and safe way for eliminating salts. For example aged people or children, it is hard for them to remove salts from ceiling because the weight of salts are heavy. Then the height of salts will be higher, the system will be controlled automatically and the system doesn't work anymore. Eventually they cannot get enough purified water even they have our product. Compared with competitor's products, noticeable difference is that our product is available with automatic controls. We have to appeal this feature and encourage to potential consumers to purchase. The design of appearance is very simple. Due to the feature of the product, upper side has to be satisfied the conditions to receive the sunlight well, and inside container which is for sea water, should be able to obtain and preserve the heat well. Therefore, we will use a material for upper that can receive heat but also cool the heat well, such as glass, container that holds the sea water will be painted in black to receive and preserve heat well.

4.7.1.2 Product Branding

Figure 23displays our product's logo

Figure 23: Our product's logo

By branding our product, we can tell a story, provide legal protection, and help segments market.Our team has to concentrate on printed information appearing on the product: labeling. Because labeling can identify product or brand, describe several things about the product, and explain how to use our product with simple graphics.

4.7.2 Price

Table 13 displays the internal and external factors that determinates the price of the product.

Table 13 Presentation of Team Members

Factor	**Features**
Internal factors	Marketing objectives, marketing mix strategy, cots, and organizational considerations.
External factors	Nature of the market and demand, competition, and other environmental factors. (e.g. economy, resellers, government, social concerns)

In aspects of cost, we have to think about fixed costs that don't vary with sales or production levels and variable costs that do vary directly with the level of production, such as raw materials.. From that costs, we can get total costs that sum of the fixed costs and variable costs for any given level of production.

Also our team will use “Market penetration.” Market penetration is a pricing strategies that setting a low price for a new product in order to penetrate the market quickly and deeply. It can attract a large number of buyers and win a larger market share. The refugees that need real help like Africa countries have thin water are also our customers, so we cannot set a high price for our product. Also when the price is high, governmental institution cannot provide so many people because of their limited budget.

4.7.3 Place

We have to think about distribution channel. Distribution channel is set of independent organizations involved in the process of making a product or service available for use or consumption by the consumer or business user. Why marketing intermediaries used because that results from their greater efficiency in making goods available to target markets. In addition, offers the firm more than it can achieve on its own through the intermediaries; contacts, experience, specialization, and scale of operation. Our products are likely to be sold or shared through intermediaries. For example, it can be shared by agencies, such as UNICEF for helping people who need help. Additionally, our products are going to be sold camping company like Decathlon or Big market like CONTINENTE.

4.7.4 Promotion

Figure 24 displays communication mix of our product

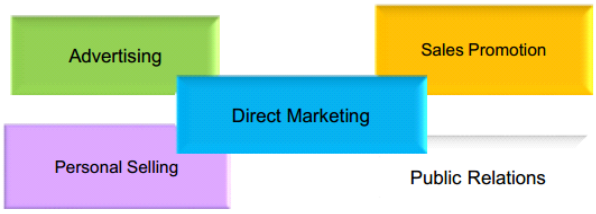

Figure 24: Communication mix

With integrated marketing communication, the company carefully integrates and coordinates its consistent, and compelling message about the organization and its products.

4.7.4.1 Setting the overall communication mix

Table 14 displays our crew.

Table 14 Presentation of Team Members

Type	**Feature**
Advertising	It reaches many buyers, repeals message many times, impersonal, and expensive.
Personal selling	Personal interaction, relationship building. Most expensive promotion tool.
Sales promotion	Wide assortment of tools, rewards, quick response, effort short-lived.
Public relations	Very believable, dramatize a company or product, and underutilized.
Direct marketing	Non public, immediate, customized, and interactive.

According to the customer's characteristics of our product, we will choose advertising and public relations as communication mix. By advertising our team can appeal our message directly to many potential customers even is expensive. When our team uses public relations, we can building good relations with people also obtain favorable publicity, building up a good corporate image. We will utilize website, News, special events, written materials, and etc.

4.8 Budget

For creating our model, our team make a budget by comparing and analysis many suppliers. Before we prepare the budget, it is important to have an overall understanding of the expected goals and objectives that are to be accomplished with the budget. Our team has to consider the raw materials carefully because ISEP provide us the limited budget: maximum 150 euros.

4.9 Strategy Control

Marketing control is an important function of marketing. Using suitable controls, any omission in marketing and plans could be detected and corrected to direct it towards the marketing objectives and goals. Marketing control provides the means of testing whether desired goals and results are actually being achieved or not. Control involves measurement, evaluation, and monitoring. Resources are scarce and costly so it is important to control marketing plans. Control involves setting goals, measuring performance, evaluating performance, taking corrective action. *If corrective action is taken, an investigation will need to be undertaken to establish precisely why the difference occurred.* [7](http://www.marketingteacher.com/marketing-controls/)

Figure 25 displays the marketing control process

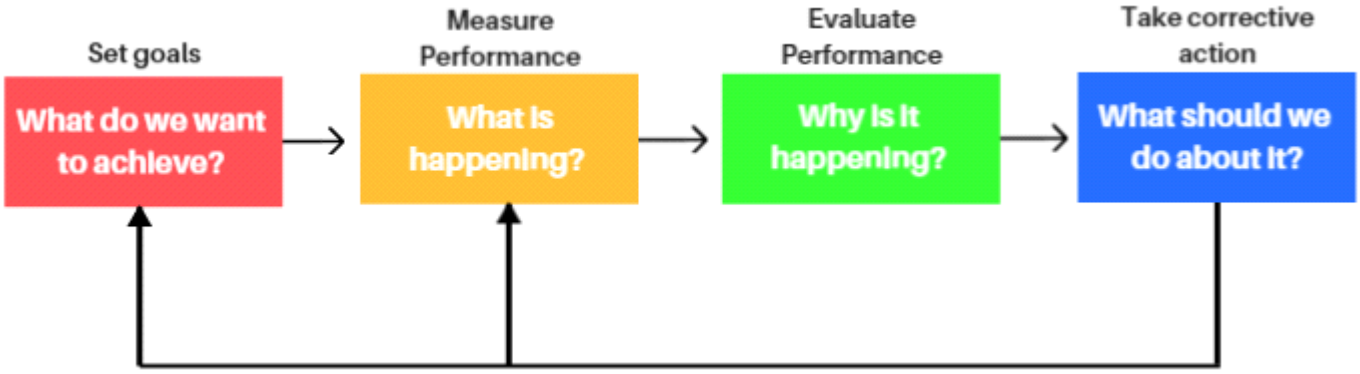

Figure 25: Marketing control process

The purpose of this project is to make drinkable water from undrinkable water. Furthermore, we want our product to contribute for social and environmental improvement. If our team just wanted to sell the products for our profits, it might not be considered about setting target customers and environmental component, such as using sustainable technology. We would like to inform people of the intent and purpose through our products. Our team cannot do measure performance and evaluate performance about marketing parts itself because the product is not completed and commercialized yet. But we assume that our product is manufactured and commercialized. First of all, products will go through a number of tests and trials before production is completed. For example, the angle of upper cover required to gather the purified water is very important because product should get the sunlight and also cohere the water drops. Our team have to do many experiments for finding the optimum angle because we cannot get 100 percent of efficiency only through theoretical calculations. If our product is commercialized, our team have to find Intermediaries and need our own marketing tools. We are going to conduct and repeat many different strategies for our product. After that our team can get optimum marketing plan.

4.10 Conclusion

To summarize this chapter, marketing is not just “selling a product”. It has to be considered by the external environment such as social, economic, environmental, technological, and political/Legal. Additionally, internal environment such as customers, competitors which is including how to sell product. Team has to plan a marketing strategy of the product through analyzing the strengths, weaknesses, opportunities, and threats. Also by establishing segmentation, we can be reached more efficiently and effectively with products and services that comprises their unique needs. Then our team analyze the characteristics of the product and set up the place we will sell our product , sales promotion, and the product price. Our team has to decide the production and budget by considering the budget given to us. After that, the product will be introduced into the market.

Next chapter, presents the Eco-efficiency Measures for sustainability regarding the Water Pyramid.

5 Eco-efficiency Measures for Sustainability

5.1 Introduction

Nowadays the Sustainability is seen as a global concept. Water resources are a key element in sustainable development, the largest share is agriculture, followed by industry and households. The growing future needs will show the already serious shortfalls in investment, as well as other weaknesses such as poor sector efficiency and inadequate prices. The three main elements of sustainable development are environmental, economical and social. This three elements are explained in this chapter of the report.

5.2 Sustainable development

Sustainable development can be defined as a development that meets the needs of the present without compromising the ability of the future generation to meet their own. The three main elements of sustainable development are economic, environmental and social. To get sustainable development, the following three has to be combined:

- Social and environmental can be defined as **Bearable**
- Social and economical can be defined as **Equitable**
- Economic and environmental can be defined as **viable**

Figure 26 displays the three main elements, and what it generates, when we mix them, as we explained before

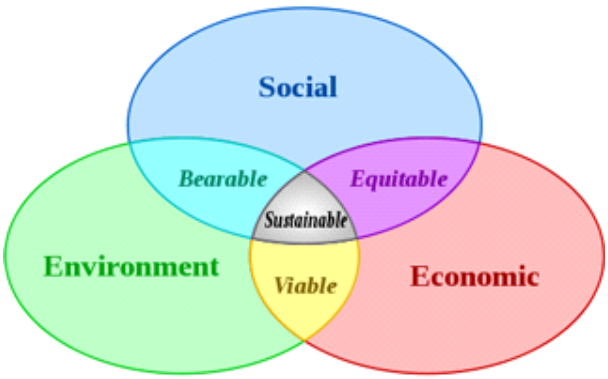

Figure 26: Sustainability main elements

There are several indicators to measure sustainable engineering to get data from a country, product or business. Examples of this measuring are:

- SOCIAL: HDI (human development index), SMI (social progress index), Happy Index
- ECONOMIC: GDP (gross domestic report)
- ENVIRONMENTAL: Ecological footprint

All combined in one index is seen as most equivalent to measure the sustainability is the GPI (genuine progress indicator). This indicator has 26 factors: 11 for social, 9 for environmental and 6 for economic. Examples of measurements form the GPI are: Income Distribution, resource depletion, pollution, long-term environmental damage. The value of GPI are given in dollars [$]. The main challenge to obtain a high GPI is:

- Provide more value with less environmental impact
- Disconnect the growth of welfare of the use of material resources,
- Improve the economic and ecological efficiencyRedefining progress, 2014. *About Sustainability Indicators.*

5.3 Environmental

To can call our product, we have to take in count this three main ideas

1. For renewable resources, the rate of harvest should not exceed the rate of regeneration (sustainable yield).
2. For pollution The rates of waste generation from projects should not exceed the assimilative capacity of the environment (sustainable waste disposal).
3. For nonrenewable resources the depletion of the nonrenewable resources should require comparable development of renewable substitutes for that resource.

If our products doesn't accomplish this, it won't be environmentally sustainable.Berit Anderson, 2013. *A Guide to Environmental Stewardship.*

Our purpose is making drinkable water from seawater by using raw material and sustainable energy (sunlight and no fossil fuels). The system makes it able to get purified water with solar power without environmental pollution.

5.3.1 Process

To obtain an eco-friendly system we have to:

- Save energy and use renewable energy for our production. Using Energy from the Sun, with Solar panels, to produce the necessary energy to make the sensors, and the pump work.
- Design for Assembly (DFA): integrates design, the main idea of this is to minimize the cost of a product, by minimizing its design. If a product has fewer parts it will take less time to assemble it, thereby it will reduce the costs. Stienstra, David, 2006. *Design for Assembly.*
- Design for Disassembly (DFD): this methodology must be implemented to speed the disposal process. Using this method of disassembly at the beginning of the design phase and promoting it will allow for parts to be recycled easier at the end of the product life.Guy, Brad Ciarimboli, Nicholas, 2006. *Desing for Disassembly.*
- Not be a team that uses a lot of paper, the manuals, and other documents do not need to be printed out by sending your workplace communications to the email inbox, you can reduce your environmental impact.

5.3.2 Pollution Control

The pollution is action or process of making land, water, air, dirty and not safe or suitable, using substances that help this process happen. To make our project environmental, we will have to make a pollution control.

In our process we will:

- Adopt environmental responsible activities like (Zero Pollution), because the less waste off energy and resources of our product, it will make it more efficient.
- Select materials for the product design that are recyclable. We will choose the materials that can be reused and recycled with the lowest cost, taking in count, which are the best for our design. Our goal is to develop a product in the most efficient way that we can, and reduce the nonenvironmental products.

5.4 Economical

Economic sustainability is the most elusive component of the triple bottom line approach. There is a universal consensus that businesses must be economically sustainable: economic growth, the quality of the system and the amount of selling product matters. Our product will be made of of components from Portugal and also 100 % will be manufactured in this country. This will help to reduce the cost of transportation and also increase the employment rate of Portuguese people.

The water pyramid ecological footprint, it is important to

- reduce water and electricity consume when making the system.
- transport the system in only one box to reduce the space needed. The box will contain a manual to help the consumer using the system.
- have components which will be as ecological, recyclable, longlasting, qualitative and efficient as possible for a reasonable price.
- manufacture the product with production methods and technologies focusing on sustainable production. The development of sustainable.
- The collection of salt from the water from the sea, to re-use for another utility, or maybe for sell it

manufacturing practice is seen in two different stages: First of all to manufacture our product, we will work with the “6R” (reduce, reuse, recycle, recover, redesign, remanufacture). Afterwards, in the process, we should have to optimize our technological improvements. We will focus our work on energy efficiency, waste reduction, practices to improve the environment and reducing contamination impacts.Jawahir, I S, 2008. *Sustainable Manufacturing.*

Our aim is to create a desalination plant for a dome, focusing on economic development and environmental protection simultaneously. We will do it choosing the materials, and methods of production that are more adequate, taking in count the relation between price and quality.

5.5 Social

Social Sustainability is defined as “the ability of a community to develop processes and structures which not only meet the needs of its current members but also support the ability of future generations to maintain a healthy community.Business Dictionary, 2015. Social Sustainability. The product has to be complaint with the customers needs. The keywords for this aspects of sustainability are social justice and human dignity. At first, the product must be defined as eco-friendly. It won't only give benefits in terms of knowledge and a fresh point of view for the employees. It will also provide to our employees common way of thinking and it is reflected unconsciously in the personal and professional development. By making them feeling better, they will work better. The second aspect to consider is to taking care about the suppliers. Our strong values reflect that we are involved in the change and this is how we can work for the progress of society. The suppliers are expected to pass a minimum of requirements to be part of our mission. So a previous analysis and study of our suppliers can help us improve our project and adapt to new ideas or requirements, always by keeping sustainability in mind. Finally, we have got the users. A familiar relation with the users helps to ensure a strong union between them and the company. The company is not only about selling and making profit, it's about satisfying the user's needs. User service well implemented with social skills and helping with our eco-friendly product provides a better user company relation.

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5.5.1 Life Cycle Analysis

A life Cycle Analysis is the analysis of a product system for assessing the potential environmental aspects and potential aspects associated with a product by undertaking four steps: Compiling an inventory of relevant inputs and outputs, evaluating the potential environmental impacts associated with those inputs and outputs and interpreting the results of the inventory and impact phases in relation to the objectives of the study.

- ISO 14040.2 Draft: Life Cycle Assessment - Principles and Guidelines

Figure 27 displays the phases of life cycle analysis

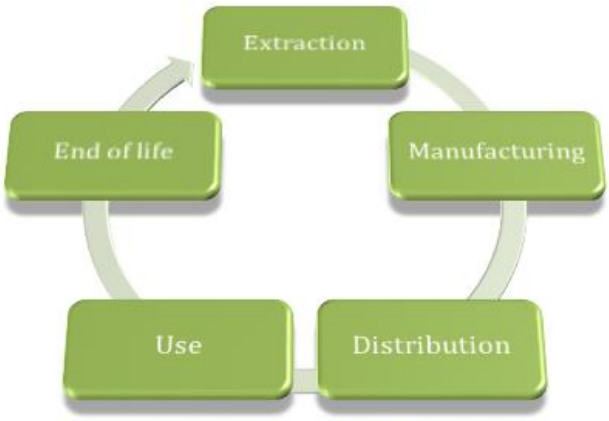

Figure 27 life cycle analysis diagram

5.5.2 Extraction of Raw Materials

Analysis and quantification of the main components for the desalination process will be reviewed thoroughly, highlighting which raw materials, energy and resources are used throughout the production and transportation processes. All chosen Material can be seen in point 3.3 Cost.

When buying all materials the sustainability of the company must be at a high level.

The LCA of the materials are:

1. PMMA is a versatile, durable, recyclable and sustainable material.

- PMMA is a light but strong material. This may have influence on the weight the dome can bare
- PMMA had a long lasting lifetime. Approximately 10-20 years
- PMMA has an optimal recyclability.
- It can be melted and extruded into a new product of PMMA.
- Furthermore it can be easily splits back into its original monomer MMA by heat transfer, and used again for other purposes.[25]

2. PVC is made of oil and salt. Nevertheless oil is a non-Eco-friendly material. The magnitude of CO2 emission for the material is lower than aluminum, glass and other petrochemical products. Furthermore the PVC has a long lifetime of over 15 years and is 100 % recyclable[26]

3. Slate is a Natural stone of the Valongo which has many advantages like:

- The Valongo is near Porto
- Slate has a lifetime to up to 150 years.
- Slate is resistant to salt[27]

4. Glue and molding: By using molding, the PMMA can still by recycled into MMA and PMMA. The water resistant glue for PVC is most of the time not eco-friendly. It can contain bad chemicals and it hard to recycle. But were still going to use glue because the design needs not a lot of glue. And after using the project. It is easy to dissolve the glue and the recycle the other products.[28]

The materials that we will use, will be:

PMMA (polymethylmethacrylate): We will use this material instead of glass because of:

- Is more lighter
- It is less dangerous because it breaks without splintering , so it is especially handy for easily breakable crystals large dimensions.
- Easily adopt any form. It can be colored easily. It is more transparent.
- High impact resistance, about ten times more than glass.[29]

Slate, we will use this material, instead of pottery because of:

- It has very low porosity
- The water absorption is between 1.5 to 2%
- Is resistant to weather impact
- His corrodibility is from 0,4 to 0,7 %
- Absorbs the heat energy from the sun because of the dark color.
- We can get it from the nature, we don't have to waste energy heating it to no have porosity.[30]

In Tubs, use PVC instead of copper because of:

- Is less corrosive.
- Has a low price.
- Doesn't mix any particles with the water, because it there's not corrosion.
- Uniformity of the complete system in same material[31] [32]

In Vessel purified Water and Container for purified water we will use PVC instead of glass

- Has excellent function with a lower price.
- Lightweight.
- Resistance to the humidity
- Inert and harmless , allows the Conservation of properties organoleptic Water for human consumption
- Chemical stability of the material which prevents decomposition.
- No oxidation and corrosion.[33]

5.5.3 Design Process

After look some different designs, we found unique design of the desalination plant, which will be manufactured by us with the minimum of environmental impact. When we design our product, we will try to reduce the quantity of material, and the energy used Building it and without producing pollution. All design process is made by computer software, this will reduce the waste of paper if we have to make any change and also lets see the model in 3D.

5.5.4 Manufacturing and Production

In this process we will try to product the materials to build the desalination plant, using the less materials as possible, reduce the waste and emissions on the manufacturing and use the less energy, or resources to generate our product.

5.5.5 Packaging and Distribution

The distribution plan for the product from our manufacturing warehouse to the final user is to minimize the transport and packaging emissions. We plan to produce the materials to build the desalination plant, and put it inside a box, and send it to the customer, with one employee that will build the structure. Our idea is to design a transport box which will use less space to be transported in an easy way besides it will be a support for the safety of the materials. We have to find the best route in terms of time, cost, environment, and safety for our distribution.

5.5.6 Customer Maintenance

Our team will provide the product with an user manual to instruct the users. The user manual includes an online service link and a phone number to help the clients if they can't solve at their own.

5.5.7 End of life

The end of life includes the recycling of the product. Once the user decides that the product is it hardly damaged, we will offer the possibility to take care of the environmentally correct recycling.

ISO 14040 Environmental management. Life cycle assessment. Principles and framework.

Genève ISO, 2006. ISO 14044 Environmental management. Life cycle assessment.

Requirements and guidelines. Genève, ISO, 2006

5.6 Conclusion

As a resume, our goals must be eco-friendly and energy independent by only using the energy of the sun, it has to provide the energy to work. We have a strong value of environmental aspect, however, we have to work on economic and social aspects too to make our product arrive to all of the different markets we can arrange. The team gives a high value on this topic. The sea water users will use, must be turned into purified water to make sure the clients have access to use it.

Also we can use the salt from the sea, to use it for cook, or other utilities. The salt is a common product, and we can get it while we obtain purified water, without wasting energy, not producing any pollution, and any additional cost to the process.

6 Ethical and Deontological Concerns

6.1 Introduction

In this part, the Ethical and Deontological Concerns of our project are exposed. [34]

In one hand the Ethical concerns are the doubts or problems that can appear in every project. The responsible has to determine, in the way that affects to the people, if it's a wrong or a good thing. On the other hand, the Deontological concerns are the Part of ethics which deals with the duties, especially those which govern the professional activity, like the duty to the community, to the employer, to the client, to the profession and to the colleagues.

In the Kant's categorical imperative about deontology, we can find this : "Act only on that maxim through which you can at the same time will that it become a universal law." Ethics and deontological issues concern everyone and have their place in each society, exactly as its should be in the middle of each project.[35]

The five ethic and deontological concerns which will be developped for the Pyramid Water are:

- Engineering Ethics
- Sale and Marketing Ethics
- Academic Ethics
- Environmental Ethics
- Liability / Responsibilities

6.2 Engineering Ethics

Engineering ethics is about the rules of engineering ethics that you always have to apply in a project. Beeing engineer means have responsabilities. Their decisions impact the environment, the society and the company. Therefore, this field is governed by some practices of engineering according to a code of ethics.

The engineering ethics study is focus on choose a code of ethics, describe the guidelines considered and make a critical review.

For the Water pyramid, the **AAWRE** code is chosen (American Academy of Water Resources Engineers). This code contains the standards of good practices for an engineer but also specifications about water ressources. This code is perfectly adapted to this project.[36]

These are the objectives of the AAWRE:

- Identifying and certifying engineers with specialized knowledge in water resources for the benefit of the public.
- Recognizing the ethical practice of water resources engineering at the expert level.
- Enhancing the practice of water resources engineering.
- Supporting and promoting positions on water resources issues important to the public health, safety and welfare.
- Encouraging life-long learning and continued professional development.
- Looking at the objectives of the AAWRE code, Give me 5 make the choice to focus on « Recognizing the ethical practice of water resources engineering at the expert level » and « Enhancing the practice of water resources engineering ». These objectives are about respecting the engineer profession in our work and behavior, but also respecting the water resources of this word.
- These are the fundamental principles of the AAWRE code of Ethics :
- Using their knowledge and skill for the enhancement of human welfare and the environment.
- 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.

All the fundamental principles of the AAWRE code are important and the team chose to respect and apply them all. Their represente the prestige of this profession and all the concepts that the team chose to respect the day when all of us chose to become engineers.

These are the fundamental canons of the AAWRE code of Ethics:

- Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties.
- Engineers shall perform services only in areas of their competence.
- Engineers shall issue public statements only in an objective and truthful manner.
- Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.
- Engineers shall build their professional reputation on the merit of their services and shall not compete unfairly with others.
- Engineers shall act in such a manner as to uphold and enhance the honor, integrity, and dignity of the engineering profession.
- Engineers shall continue their professional development throughout their careers, and shall provide opportunities for the professional development of those engineers under their supervision.

Among all this canons, « hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties » and « act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest » are the most relevant points for this project and the most important concept for the group.

During all the differents step of the project, all the team will respect this engineering code of ethics, but some points are more important than others for this project.

6.3 Sales and Marketing Ethics

Sales and Marketing ethics is about the relationship between the company and the clients.

Nowadays, a lot of company are so interesting by making profit and winning money that they stop respecting their clients. In other words, they used the trust of their clients and advertising to dupe them and their rights. This selfish principle maybe increase at the beginning the sales but at the end that enrole the lost of credibility of the company and the dissatisfaction of the client. Moreover false advertising or disclosure of risks can be dangerous.

The sales and marketing ethics analysis is focus on trust and credibility and consumer rights.

In our project the choice to be completely transparent and honest with our clients was taken to create a sustainable relationship based on trust. The objective is to make true and efficient advertising and to propose a quality product. If this two actions are well done, all our customers will buy the expected product and be impressed by its utilization, so become faithful clients of the company.

Moreover, « Give me 5 » took the decision of establishing the price according to ethical considerations.

The prices are not fixed yet, but the profit of the company will be chosen according to the work provided for the project, the price of the raw materials, and the clients. To resume, the company will make profit of the system, but not an unreasonable profit. The goal of the group is not to make profits of others but help the people to access to clean water. The price will be fair, rewarding the work supplied and allowing people to buy it.

6.4 Academic Ethics

Academic ethics is about respect and honesty in your work. It worries that people steal the ideas or sentences of other and used them as its own. This practices are unfair, not respectable and should be banned. At the opposite, if you respect your sources always declaring them, you can enrich your work and putting forward the work of other people through your project.

The academic ethics analysis is focus on inaccurate information or forging documents, plagiarism and cheating.

For this project, all the team was inspired by different sources and information to make the project realistic and efficient, but always in the respect of academic ethics. Sources could be books, articles, internet web site, thesis and etc. but all the source used are summarized in the bibliography at the end of the report.

According to this principle, the conclusion is that the project doesn't represent any Academic Ethics issues.

6.5 Environmental Ethics

Environmental ethics is about the relationship between humans and environment. It worries that men do not conflict with the development and evolution of natural beings. Indeed, all the product has a certain impact on the environment and it's essential to manage and decrease this impact for the well-being of the next generations and the planet. Human projects have to be always in accordance with the nature instead of damage it.

The environmental ethics study is focus on the project's impact on the environment, the environmental risks and the sustainability of the project.

The water pyramid needs energy to evaporate the water and the only energy used to heat the water is the solar energy. This energy is unlimited and sustainable, without any impact on the environment.

For the materials, two different plastics are used, Perspex and PVC. The both are easily recyclable so without any impact on the environment as well. The system contains also some rocks from Portugal.

According to the different below information, we can conclude that the project doesn't represent Environmental Ethics issues.

6.6 Liability

There exist four kind of liability: Legal, Crime law, labor and professional liabilities.

For the pyramid water, we can have potential Legal, Crime law, and professional liabilities.

6.6.1 Criminal Liability

The criminal liability can be resumed by different steps:

1. Typification : Is the crime a law ? The crime must be written on the law
2. Illicit: is it an illicit action or not? Self-defense should be analyzed
3. Imputation: did the person really committed the crime?
4. Intent: Is was done on purpose? With the intention to do it?
5. Punishability

When you reach to the last step, you could be punished for the crime. Sanctions and punishments are applied.

We must be careful to avoid accidents that could expose consumer to risk. Indeed, our final product is water, and the consumer will ingest the clean water inside his body so the risks in case of failure is huge. In the process we have to have a verification system in the clean water container before the consumption to avoid damages.

6.6.2 Legal Liability

The legal liability concerns the collateral damages, material as moral caused by the crime.

The accused should repair if possible, or restore, or at worst reimburse the victim.

The potential legal liability of our project will be in case of the hospitalization of a consumer because of the ingestion of bad things contained in the water.

6.6.3 Professional Liability

The professional liability concerns the current rules in your work, the relationship with your colleagues, and everything affecting the company.

All the group will follow the engineering code of ethics during all the project to avoid all professional potential liabilities.

6.7 Conclusion

In the nutshell, ethical and deontological concerns affect many areas that we have to take into consideration during all our project. Our engineering code of conduct lead us to have good practices in our work, and bring also some fundamentals rules about the various associates and the environment.

Then, in the sales and marketing paragraph, the decision of presenting our company and our product with honesty was took to promote the authenticity and the quality of our work.

The academic ethics chapter shows the importance of respecting stranger's work by not using plagiarism and always specified our sources in our bibliography. Next point was the environmental ethics that develop the sustainable aspect of our project, always respecting the environmental and being in accordance with it.

The last chapter apply about liability, tooking in consideration all the liabilities that can be applied to our project in case of failure and founding some preventive solutions to decrease the risks.

Finally, this part summarized all the ethical and deontological concerns what the team studied during the project and show how solutions to avoid them has been found. A lot of respect results from this part, a characteristic which also represents “Give me 5” team.

The next chapter will relate the development of our project, step by step, until our final system.

7 Project Development

7.1 Introduction

In this part the progress of the project is unrolled all along the development of our water pyramid.

The water pyramid is required to transform salty water from the sea to drinkable water in a sustainable way. The final system should be able to supply a wooden dome with water.

In this part, all ideas our summed up. Including their problems, tests and solutions. The importance of this part is to inform supervisors and interested people. While doing this, they are able to see and to contribute in the project.

7.2 Architecture

7.2.1 First concept

Our first idea was focused on the chemical extraction way, this is shown in Figure 28.

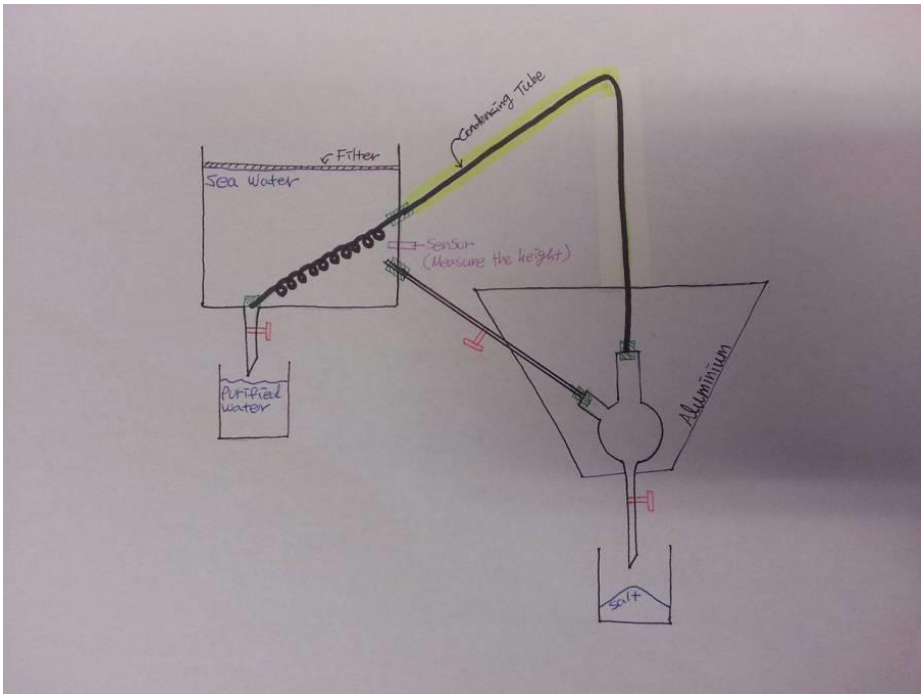

Figure 28:First idea

7.2.1.1 Elements

- Big container for the salt water:
- The idea is to let the users pour the sea water in the container.
- There will be a filter above the container, to avoid the entrance of undesirable dirt.
- The temperature of the inside and the outside of the container must by as high as possible
- The Pump must have a working level high enough to pump up the water
- One sensor will be used just above the tube to alarm when the container must be filled with sea water.
- Inside the container three holes must be made. One on the bottom and one on the side, to let the condensing tube cross the container. The third hole will be used to lead the water in the balloon.
- Reaction Balloon: A 3-neck round bottom flask with outlet for making the reaction: buying a new one will be too expensive so it is necessary to find a used one. If it's not possible, we can create a balloon with a cap at the bottom.
- Solar Oven: Cone shape, cover with aluminum, with the balloon in the center.
- Two collectors, one for the clean water and one for the salt.
- A tube, composed by two parts; one should keep the heat and one should help to cool and condense the steam.

7.2.1.2 Operations

1. The user put salt water in the big container.
2. The water flow through the tube to the balloon.
3. Solar energy gathered in the solar oven heats the balloon and water inside. Rock or biomass presence can increase this effect.
4. Distillation process start: the steam rises through the condensing tube.
5. The condensing tube cross the big container of sea water and condense the steam into liquid.
6. The purified water is collected in a container.
7. When the amount of salt is big enough, it is possible to collect the salt using the outlet in the bottom of the balloon, into a container.

7.2.1.3 Problems

This solution was a scholar one, easy to apply in a lab for a little quantity but not available outside and too difficult for our project. Next step is finding a smarter solution, more exotic. It's how the second concept appeared.

7.2.2 Second concept

To find a solution more appropriate, the focus in our research is on a system adapted to an exterior environment. Going backwards to determine the concept of the condensation process. The main goal was to make a huge difference of temperature to create first the evaporation (vapor phase) and next the condensation (liquid phase). Thanks to our reflexion, advices and some researches, there was a second idea shown in Figure 29.

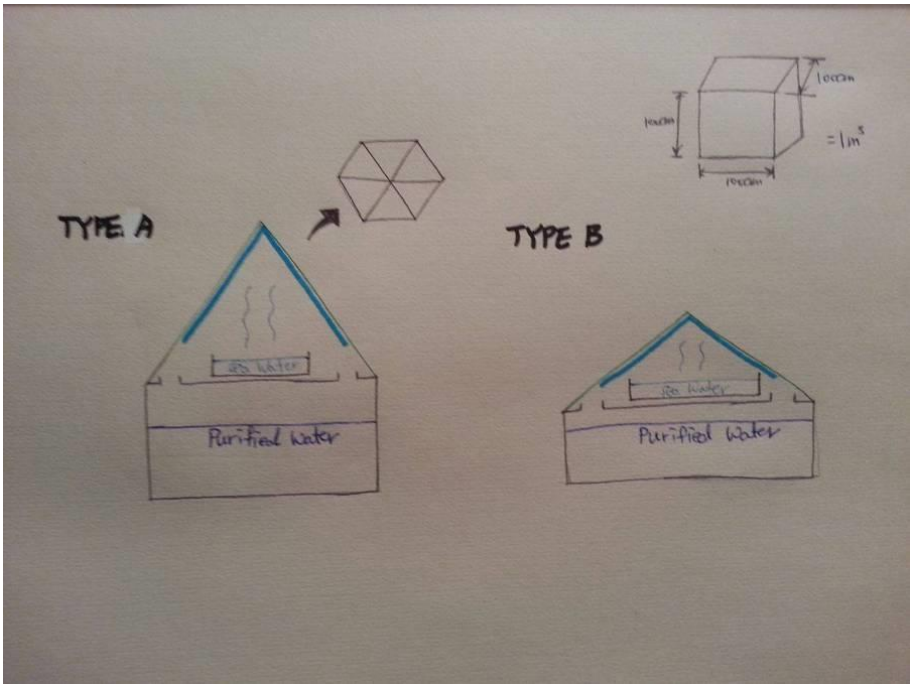

Figure 29: Second idea

7.2.2.1 Elements

- Container for the salt water :
- The container should be dark to absorb the heat of the sun
- The container should be small to increase the evaporation process
- Container for the clean water: This container should collect the clean water after the evaporation and condensation phases.
- Pyramid : made out of glass to allow the sun to cross and heat the inside and heat the salty water

7.2.2.2 Operations

1. The user put salt water in the dark and small container.
2. The sun heat in inside of the pyramid and the salty water.
3. The evaporation of the water start.
4. The water condenses while in contact with the glass walls.
5. The water flows along the inside walls of the pyramid and go to the clean water container.
6. When the salty water container is empty. Someone has to poor more water. This process can be continued until there is too much salt inside. In that case, the salt must be removed.

7.2.2.3 Problems

This idea is very good, but everything should be done manually and this is not possible if the pyramid is on the top of a 2.5 m of high dome.This must be made automatically.

A lot of question appeared as well at this step of the development:

- Is the pyramidal shape the most adapted? What about a round shape?
- Is the glass the best material? What about plastic?
- Which container for the salt ?
- How to automate the process? How to bring the salty water inside its container and how drain it?
- Which test has to be done next?

According to the test results and some secondary research, a third concept is made. At this time this concept will be the last explained before deliver the interim report.

7.2.3 Third and final concept

In Figure 30shows the scheme of our final schematic with the improvements of the second version is given.

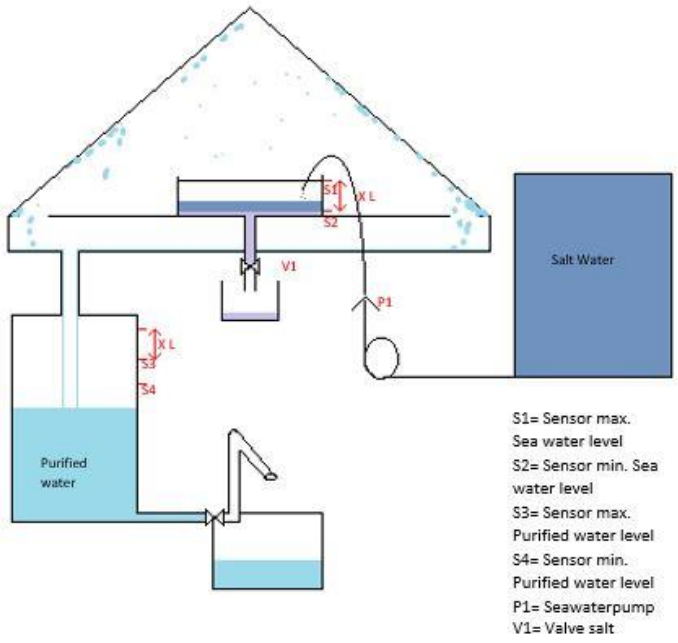

Figure 30: Final concept

The central area is the pyramidal part where the dessalination process will happen. To separate the water from the salt, the brine will be placed in that dark and thick container in the center of the pyramid.

The sun will beat down on the walls and heat the inside of the pyramid. This heat will release the evaporation of the water.

Thanks to the difference of temperature between the inside and the outside of the pyramid, the water vapor will condensate on the walls.

The water will be collected by the bottom and the salt will stay in the container.

Around this system components are needed to make this continuous:

- 2 bigs containers, one for the salty water and one for the clean water,
- 1 pump to bring the salty water from it container into the pyramid.
- 4 Ultrasonic sensors which handle the pump to manage the level of water in all the system,
- 1 valve to release the salt extraction at the end of the process. A little bit of salty water will help it to go down.

The components, the functionalities, the tests and results of our final concept will be explained further in the next part.

7.3 Tests and Results

7.3.1 Evaporation

First of all it is important to know if evaporation of sea water can really happen by heating the salt water.

For this uncertainty, salty water can be heated in a cooking pot to see what will happen. Shown in Figure 31First test

If after the end of the test, only salt crystals remain at the bottom of the pot. The team knows for sure the evaporation will happens. For this experiment it is possible to use the wisdom of the group to know the evaporation will happen.

For this during the summer at the beach. People who come out from the sea, dry without using a towel, only using the sun and body warmth to evaporate the salty water of the body.

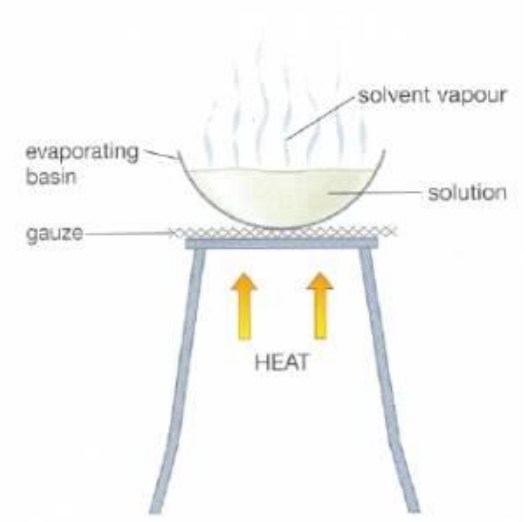

Figure 31 First test [6]

7.3.2 Testing the ground idea of the system

The next step is to discover if a box out of Perspex is able to create a big difference in temperature between the inside of the box and outside the box to make evaporation and condensation happen.

For this experiment the team went to the roof of the F-building of ISEP with a pyramidical Perspex, thermometer, sea water, a container for the sea water to see if the process works.

More details of this experiment is seen in **1.7 Project development**

Figure 32Desalination

Figure 32: ground idea

7.5.3 Optimize the system

After this, it is important to know which material to use to increase the velocity of the process. For this different kind of salt containers will be used to do the testing.

7.3.4 Shape of structure

The most important thing for our project is experiment. There are many conditions to make an experiment. The first was made by a plastic plate and a jar. After 4 hours testing in good conditions (sunny place, no rain, warm temperature) the results were very unsatisfied.

To change conditions, there were 4 cases of water desalination system:

- **First condition**: Put the plate with salted water in the center of black-colored container. Cover is round-shaped. We can get purified water at edge of plate. Shown in Figure 32

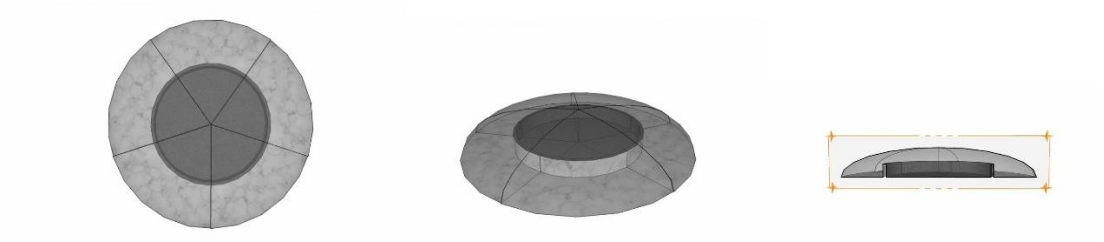

Figure 33 First condition

Picturing the panel with a bowl shaped glass with 1 big round container of salt water and 1 small round container of purified water in the middle

- **Second condition** : Put the plate with salted water in the center of black-colored container. Cover is pyramid-shaped. We can get purified water at edge of plate.

Shown in Figure 34

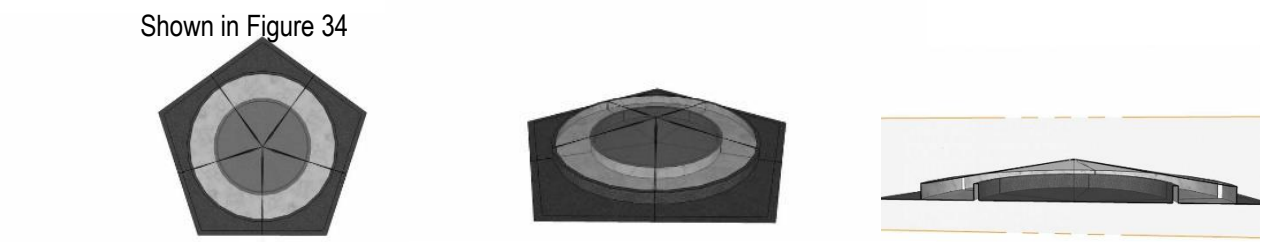

Figure 34 Second condition

Picturing the panel with a triangle shaped glass with 1 big round container of salt water and 1 small round container of purified water in the middle.

- **Third condition:** Put the plates with salted water in the edge of black-colored container. Cover is round-shaped. We can get purified water at center of plate. Shown in Figure 35

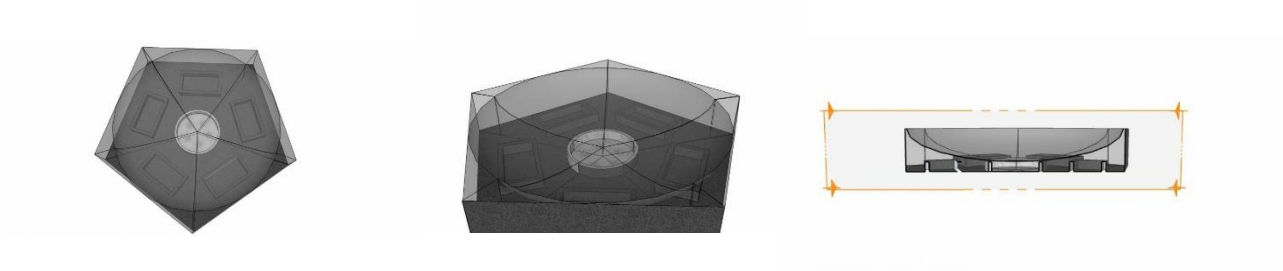

Figure 35 Third condition

Picturing the panel with a bowl shaped glass with 5 containers of sea water and 1 round container of purified water in the middle.

- **Forth condition** : Put the plates with salted water in the edge of black-colored container. Cover is pyramid-shaped. We can get purified water at center of plate. Shown in Figure 36Figure

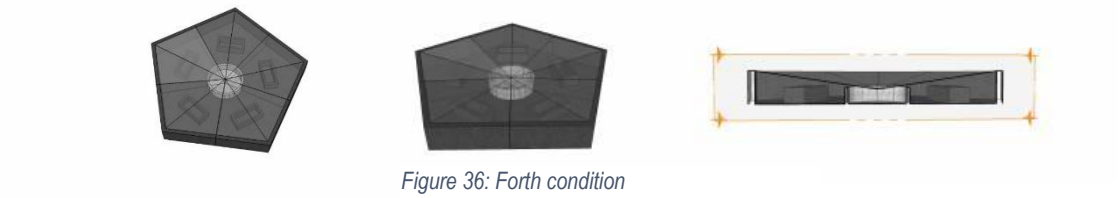

Figure 36: Forth condition

Picturing the panel with a triangle shaped glass with 5 containers of sea water and 1 round container of purified water in the middle.

They were 4 proposals of building the model, those are made in Sketch Up and the drawings can be find in the report.

The system will be made with the **salt water in the middle and the pyramidal shape Perspex.**

For this the team has arguments:

- It is easier to have one container of salt (water) to refresh.
- The pyramidal shape will be easier to build. the 5 glass triangle pieces will be attached with each other by some junctions
- It will be safer to use the pyramidal shape of Perspex. The junction parts will hold the Perspex together.
- One triangle glass can be opened to have fresh air and stop the process. By opening it, the salt can be collected and the container can be cleaned to add fresh saltwater.

7.5.2 Materials

The material which will help the evaporating process best can be glass or a safer transparent material like Perspex.

By the help of Cristina Ribeiro and her colleague the test between a pyramidal shaped Perspex and a small bottle of glass could be made on the roof of the F building from ISEP by good conditions (approximately 21 °C and no rain).

In the Figure 37 the samples and results are shown. In the pyramidal volume (Perspex) are two containers placed, to check the difference between a large container and a small container.

In the jar is one small container (the same as in the pyramidal volume) to check the difference between the shapes of the transparent material.

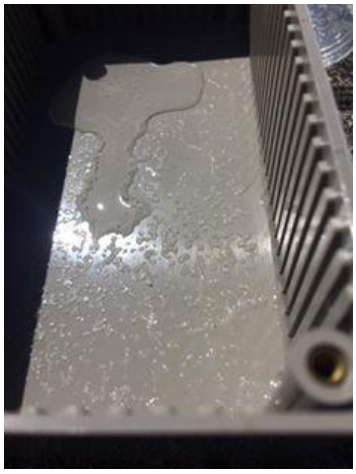

Figure 37 Samples and results

Test results can be seen in Table 15 and Table 16

Table 15 Results

	Glass: small container	**Perspex: small container**	**Perspex: big container**
Waterlevel start	10	10	10
Waterlevel after 24 h	4	2,4	2.5
Evaporated	60	76	95

Table 16 Weather conditions

Weather conditions	start	Average night	Stop 24h
Apple forecast [ºC]	17	10	14
T measured [ºC]	24		14
T measured in pyramidal volume			30.4

Conclusion about the test

The pyramidical and Perspex wins from glass and a jar.

The tests will continue with the winning shape and material. By following tests, the team must take the following notes in consideration:

- The pyramidical volume was not closed. Their was another Perspex box putted next to the volume to close. This was not sufficient next time the open side will be covered with a transparent film.
- The difference between the temperature inside and outside the volume must be measured again. This is a very important parameter
- Will the temperature be a big factor? What will the difference be by a temperature of 20 °C or 10 °C?
- It was putted on the roof (more than 50 m high) and the roof has some walls to hold up the wind. Will this be a big influence when the system will be put on a dome of a height of approximately 4 m without any walls to block the wind.
- The container needs the have a big surface. Will the color/ materials also influence the evaporating process? Which material will be best?

7.4 Electronical overview

To make the Water Pyramid autonomous, an electronic system will be integrated. The Arduino intelligence will be used to control 1 pump, 1 valve and 4 sensors like you can see in the following blackbox in Figure 38.

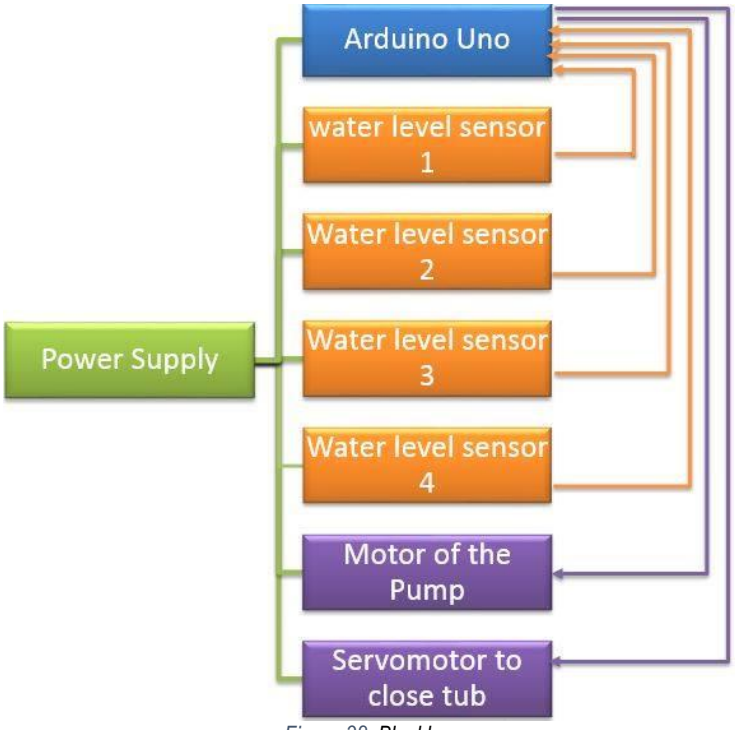

Figure 38: Blackbox

This system needs 4 ultrasonic sensors: [37]

- 2 ultrasonic sensors are considered as INPUT and follow the maximal level of water possible in the container of clean water, and the one inside the pyramid which contains the salty water.
  Those sensors are here to avoid any overflow and all the consequences that this problem can generate after.
- 2 ultrasonic sensors are considered as INPUT PULLUP and follow the minimum level of water possible in the container of clean water, and the one inside the pyramid which contains the salty water.
  Those sensors are here to restart the process when the container is empty for the salty water container or when the container of clean water have enough place to receipt more water. On this last container, the level of clean water will be always high to have a big stock and available water all the time.

Those ultrasonic sensors will detect the presence of water at the sensor level. The sonic waves emitted by the transducer are reflected by an object and received back in the transducer, so if something appears between them, the sonic waves will change and the presence of water detected.

This system needs 2 OUTPUT, one pump to fill and refill the container of salty water and one valve to release the salt at the end of the desalination process. The Arduino programmation appears in Figure 39 and Figure 40.

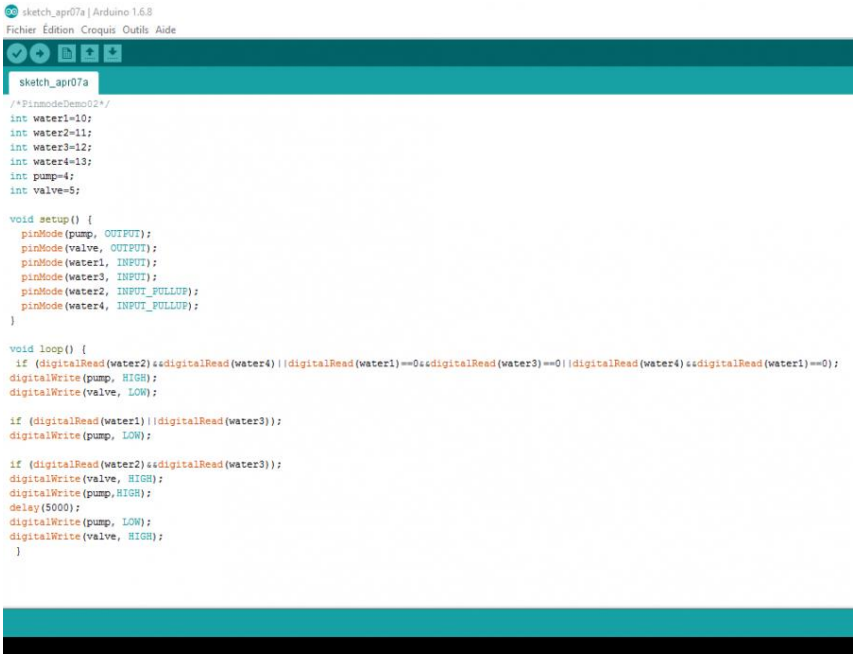

Figure 39: Arduino programmation

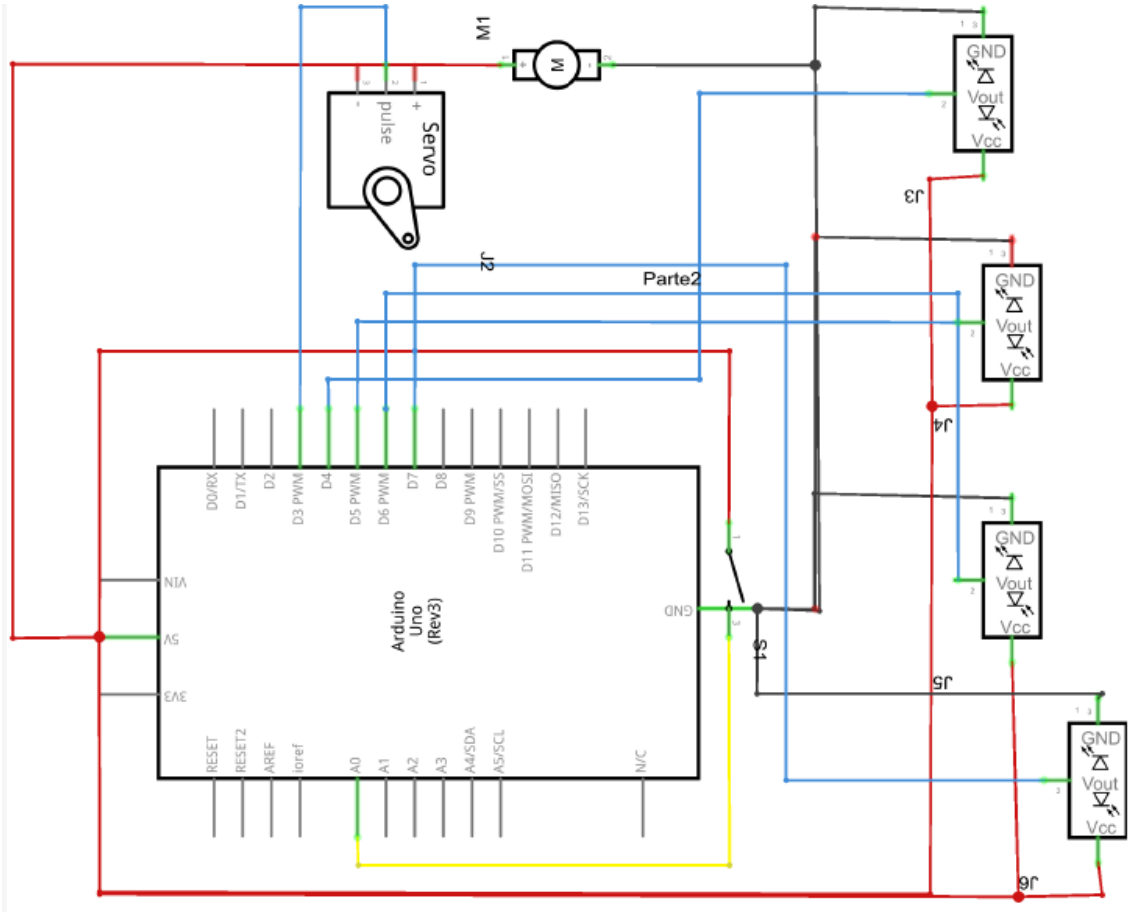

Figure 40: Arduino schematic

7.5 To go further

This report is made in the middle of the project. Next step will be:

- choosing the material of the container
- Making calculation of thermodynamics to ensure the measurements of the components
- Finding the optimal solution to desalinate water by thermodynamics
- Testing if the purified water is drinkable
- Building the scale model: buying materials, assembling the different components and make test to see the efficiency of the project.
- Finish the report by improving the State of the art, Project Management, Marketing Plan, Eco-efficiency Measures for Sustainability, Ethical and Deontological concerns and Project Development.
- Preparing the Final Presentation with the Final Deliverables

In the following two months the team will carry out a good project by accomplishing the previous tasks.

7.6 Conclusion

In this chapter we have written about the ways of how the team managed to develop our ideas of this project. We showed how our conceptions have changed over the time.

Based on test results, material is chosen and making the electrical schematic for our project makes the whole process easier and more user-friendly.

8 Conclusions

Just making product through establishing a theme for a product, recording the process, and building physical models by using data from experiment does not mean end everything.

Our product will be improved constantly for getting better conditions and our team will obtain feedback from customers and supervisors.

In this unit, we mention about overall discussion of our product, and consider about future development for reaching more complete conclusions about the project and product.

8.1 Discussion

When our team proceeds the project at first time, we target the subject and our product is envisioned from that subject. After establishing unrefined foundation, we make the approximate model and set materials and suppliers.

Also our team starts to record every data from project at the same time (like management, marketing planning, state of art, and etc.). In the process, it takes a lot of time and effort.

After admitting feedback from supervisors and doing experiments, we will make the real model which is close to Final model.

Based on the results of the real model, our team is able to assess the completeness, quality of our product, and also applying knowledge of sustainability.

In order to produce better product, we decide to embark on more precise work.

8.2 Future Development

First of all, our product focuses on sustainability and Eco-friendly, but our team cannot avoid contamination because we will utilize the artificial parts for our product (even solar panel is artificial thing). In addition, it is sure that contamination will occur when our product is produced.

Therefore, our team will consider the method of generating the least contamination for environment.

Secondly, precise calculations. We will struggle with getting the optimal efficiency and minimum cost to product the product by calculating the quantity of energy that it can get, the total time required, method of system control for optimum effect, and also calculations for appearance.

Here is a first reference [38] and a second reference [39].

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