Report

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Glossary

Abbreviation	Description
CO_2	Carbon Dioxide
CPU	Central Processing Unit
EPS	European Project Semester
GDP	Gross Domestic Product
ISEP	Instituto Superior de Engenharia do Porto
RACI	Responsible, Acountable, Consulted, Informed
RAM	Responsibility Assignment Matrix
ROHS	Restriction of Hazardous Substances
SMART	Specific, Measurable, Achievable, Relevant, Timed
SWOT	Strenghts, Weaknesses, Opportunities, Threats
USB	Universal Serial Bus

1 Introduction

1.1 Presentation

Team N.4 consists of five students, all with different backgrounds of education and all from different countries. We are spending the spring semester of 2018 in Porto working at ISEP on our European ProjectSemester

The team members:

- Marta Majewska (Logistics) from Poland
- Melanie Tscholl (Media Technologies) from Italy
- Manuel Baptista (Mechanical Engineering) from Portugal
- Christopher Mahon (Electric, Electronic and Energy Engineering) from United Kingdom
- Sven Bergervoet (Industrial Product Design) from The Netherlands

Figure 1: Group Picture

Five foreign people have been connected to create one big project. Our mascot during the integration day was a colourful unicorn - to remind us to be creative and fun during the implementation and development of our project.

Figure 2: Teambuilding day photo

We hope that by using our already acquired knowledge from our countries and the new knowledge gained in Portugal in ISEP, we will be able to implement the whole project with a satisfactory final result for teachers and us as members of the team, as well as meet all the requirements related to it.

1.2 Motivation

Before starting a project, there is always a motivation behind it and figuring out why are you doing this project is one of the key elements of our motivation. Always remember what is at the the core is of the project. At the beginning of this semester we started with a group from all sorts of backgrounds, all from different countries to work on a project that is in our case the Outdoor Intelligent Shader. The motivation is to create a new market relating to 'shaders'. This means combining a traditional shader with **smart** electronics that are able to connect, share and interact with its user or other smart devices. Not only is the motivation based on the product but also the fact that that we as a group try to work together, learn from each other and expand our point of view. While we are all from different countries, speak different languages and have different cultural backgrounds, we are still highly motivated to work as best we can with each other.

1.3 Problem

Before starting to work on the product the problems need to be defined. This is so you are working to a specific goal. In this case that solving the problems that occur during the construction of the Outdoor Intelligent Shader.

The main problem is: How can a shader be constructed so that there is a constant shade on the terrace while using **smart** electronics?

Now the main problem is set, it needs to be broken down in sub-problems:

- What is the design?
- How can it be constructed?
- How do the electronics work?
- How is this product going to be presented to the target audience?

1.4 Objectives

The objectives of this project are to design an outdoor intelligent sun shader that detects the sun by itself with the aid of software that knows the path of the Sun. It will be very useful for the consumer because the product will provide shadow without the permanently changing of the position of the shader. The aim is to put technology, modern design, and also sustainability in an everyday product. What we want to reach is that people will feel more comfortable in a greener planet which cares of sustainability. Our other objective is to work well in a team and to learn to cooperate in a multicultural environment. The European project semester is also about to observe deadlines and to take it seriously, in other words to be responsible. It is about discussion, listening, support and coming to a decision together.

1.5 Requirements

Before starting a project, it is really important to set up all the wishes and requirements for your product. This is done via the list of requirements, represented in **Table 1**. The list shows via different categories which requirement belongs to which part. During the project the list of requirements will change it is a so called 'living document'. Throughout the project new ideas and insides will pup up or different ways to approach the problem will occur. Also, the part description is added to give a clear visual of what requirement it for what part.

Requirement Number	R/W/Q	H/M/L	Description Requirements	Part Specification	Source	Date Requirements
Target Audience						
1.1	R	H	Shader needs to be built for people at home. A structure that can rest on a terrace			16th of March
1.2	R	M	The shader must fit a table for eight people (2500×110)			16th of March
1.3	R	M	The users need to be able to walk around the table within the measurements of the shader with, at least, 70 mm		Dined Table	16th of March
1.4	R	H	Shader must fit a full grown adult man (Shader height at least 2300 mm)	Construction Bow		16th of March
1.5	R	H	Shader must provide shade during the day based on a 180 degrees movement			16th of March
Hardware						
2.1	R	H	Structure may undergo an elastic deformation of a maximum of 0.5% with a force of 2 KN			16th of March
2.2	R	M	The shader must fit a table for eight people (2500×110)	Construction Bow		16th of March
2.3	R	L	Recycled steel must be used for the structure for at least 20 %	Contruction Bow		16th of March
2.4	R	H	During a heavy rainfall of 0.76 cm of rain per hour the structure must maintain waterproof to protect the electronics	Construction Bow	[1]	16th of March
2.5	R	H	The mesh must maintain it's strenght and can bend throught in the middle section with maximum of 20 mm with a force of 100 N	Mesh		16th of March
2.6	R	H	Construction bow will not be removed during the winter			3rd of April
Software						
3.1	R	H	All electronics must fit within the construction bow of the product			3rd of April
Design						
4.1	R	H	Powder coat black for modern look	Construction Bow		3rd of April
4.2	R	M	Dark grey mesh for modern look	Mesh		3rd of April
Marketing						
5.1	R	H	Prototype Budget, - 100 €			3rd of April

Table 1: Team Requirements

1.6 Functional Tests

We, as a team, need to evaluate if the product we are projecting is well done, and for that we are going to do a few functional tests. The main objective of this tests is to find problems not detected during the theoretical part of the project so we can correct them and have a functional product, ready to be placed on the market. The test we are going to do are:

- **Motor torque** - Check if the motor has enough capacity to provide the amount of force needed to move the shader
- **Delay** - Check the delay between the controller order and the actuator response
- **Gear Functionality** - Capacity of the gear to keep up with the movement
- **Structure safety** - This test needs to be done in a simulation software, because the prototype material is different from the one we are going to use in the actual product, and for that reason we can't do these test in a real model

1.7 Project Planning

Table 2 shows the different tasks the team needs to perform, as well as the person/people responsible for it.

Task	Responsible(s)
Initial Planning	
Task Identification and Allocation	Manuel/Sven
Gantt Chart	Manuel
Technical Research	Christopher/Melanie
Market Research	Marta
Initial Budget Planning	Marta
Purpose Definition	All
Specific Planning	
System Diagrams	Melanie/Christopher
Structural Drafts	Manuel/Sven
Design	Sven
List of Materials and Budget Re-planning	Marta
Interim	
Eco-Efficiency Measures for Sustainability	Sven
Ethical and Deontological Concerns	Melanie
Project Management	Manuel
Upload Interim Report and Presentation	Christopher
Interim presentation	All
Upload Refined Interim Report	Marta
Complete List of Materials	Marta
Construction	
Construction Hardware	Manuel/Sven
Construction Software	Christopher/Melanie
Testing	
Product Testing and Corrections	Christopher/Manuel/Sven
Upload Functional Test Results	Marta/Melanie
Final	
Upload the Final Report and Presentation	Christopher
Upload the Movie, Poster, Manual and Leaflet	Melanie
Final Presentation, Individual Discussion and Assessment	All
Upload the Wiki with all Correction Suggestions	Marta

Table 2: Task identification and allocation

1.8 Report Structure

Section	Title	Description
1	Introduction	Brief description about the project, the objectives and requirements
2	State of Art	Technological and market research. All the information that might help us decide how to do our project
3	Project Management	The task and time allocation. How the team manage our time and tasks considering the resources the team has
4	Marketing Plan	Who's our target audience
5	Eco-efficiency Measures for Sustainability	All the concerns the Team needs to take care in order to have a sustainable product
6	Ethical and Deontological Concerns	All ethical concerns regarding the project
7	Project Development	Development of the project, problems faced and how the team solved them
8	Conclusions	A brief summary about the project and main conclusion

Table 3: Report Structure

2 State of the Art

2.1 Introduction

The existing products, as well as, the electronics that are available in the market and can be used in our project are going to be presented in this chapter. It will serve to get new ideas that we may, or may not, implement in our product. The research concerning the existing products includes intelligent and non-intelligent shaders, because the intelligent shaders market is very small yet, and don't provide many solutions.

2.2 Existing Solutions

In this part, we are going to unveil the four solutions that already exist in this field of study, taking in to account that only one of the solutions is intelligent.

2.2.1 Parasol

Purpose:

The actual purpose of a parasol, is to provide shadow to offer some comfort, and to prevent people from catching sunburns that could result in serious health problems. There are two main kinds of parasols, the ordinary beach parasol, as presented in **Figure 3**, are seen usually at beaches and pools. There are also commercial parasols, as shown in **Figure 4**, normally used by restaurants, cafes, hotels, etc. The purpose is the same for both, what changes is the panorama where they are inserted.

Figure 3: Ordinary Beach Parasol

Figure 4: Commercial Parasol

Structure:

In this section, we need to split these two types of parasols because they are built with different kind of objectives, and so the way their structure is projected is different. The ordinary beach parasols are normally made with very cheap and weak materials, such as plastics with some cloth on top. This type of parasol is lightweight, so is very easy to transport. There are also some parasols made with iron, those are a little bit heavier, but the possibility of disassembling the parasol means these parasols are also very easy to transport. The commercial parasols are usually made with better materials, are more resistant, because they are made to businesses, which means the security and sturdiness of the parasol needs to be way higher than in the ordinary parasol. This differences are perceptible if we compare **Figure 3** and **Figure 4**.

Table 4 includes the pros and cons of beach parasol, and **Table 5** includes the pros and cons of a commercial parasol.

Pros	Cons
Cheap product	Weak materials
Easy to transport	Need to be adjusted by hand (Not intelligent)
Effective in its purpose	Short life cycle

Table 4: Ordinary Beach Parasol Pros and Cons

Pros	Cons
Effective in its purpose	Expensive product
Strong materials	Need to be adjusted by hand (Not intelligent)
Longer lifecycle	Hard to transport

Table 5: Commercial Parasol Pros and Cons

2.2.2 Canopy

Purpose:

A canopy is an overhead structure able to provide shade or shelter, so it does the same thing as parasol but is more robust and usually is a fixed structure, it is used normally in terraces and public

spaces. A canopy can be made of various materials, such as, vinyl, acrylic, polyester or canvas.

Structure:

This type of product is usually very steady, robust and strong, as shown in **Figure 5**. The modern ones have very high strength-to-weight ratio, and the fabric used to do the ceiling of the canopy has some important characteristics when it comes to human security, such as flame retardant and strength.

Figure 5: Garden Canopy

Table 6 considers the pros and cons of this structure.

Pros	Cons
Strong structure	Fixed structure
Long life cycle	Not intelligent

Table 6: Canopy's Pros and Cons

2.2.3 Awning

Purpose:

An awning is a sort of a supplemental cover that helps control intense sun exposure and heat. This kind of structure can be stationary, as presented in **Figure 6**, retractable, as shown in **Figure 7**, or a mixture of both, like in **Figure 8**, usually, awnings are made of materials like aluminium, cloth, vinyl, or wood. They are placed on the outside of a building, usually supported by a wall. Once this type of structure prevents that the full spectre of heat enters the building, it helps to save some money because it decreases the need for air conditioning.

Figure 6: Stationary Awning

Figure 7: Retractable Awning

Figure 8: Mixed between a fixed and retractable awning

Structure:

Since it can be stationary, retractable or mixed, the sturdiness depends on the type of awning selected. The retractable ones are usually less resistant and more fragile than the fixed ones, however they offer the possibility to choose between catching sun and have some shade, the mixed options represent, in our opinion, an upgrade, because it has strong material as the stationary ones but provide to the user the possibility to choose between catching sun or have some shade.

Table 7 includes the pros and cons of stationary awnings, **Table 8** includes the pros and cons of a retractable awnings and **Table 9** includes the pros and cons of mixed awnings.

Pros	Cons
Not too expensive	Fixed structure
Helps to save money on energy	Non-intelligent structure
Effective in its purpose	Short life cycle due to weather tear

Table 7: Stationary Awnings Pros and Cons

Pros	Cons
Helps to save money on energy	Big initial investment
Possibility to choose between catching sun or have shade	If motorized, need to replace the motors periodically
Longer lifecycle	Hard to clean

Table 8: Retractable Awnings Pros and Cons

Pros	Cons
Helps to save money on energy	Impurities can stop the path of the canvas
Possibility to choose between catching sun or have shade	If motorized, need to replace the motors periodically
Sturdy as the fixed ones	Big initial investment

Table 9: Mixed awnings Pros and Cons

2.2.4 ShadeCraft Sunflower

Purpose:

This product follows the sun to provide a consistent shade, as well as comfort with some high-end features, such as built in speakers, Wi-Fi, Bluetooth, HD camera to take selfies, it has also its own source of energy powered by some solar panels.

Structure:

In order to provide the best for their costumers, ShadeCraft installed some high-end features in their product, shown in **Figure 9**. Such as, wind sensors, that will measure the velocity of the wind so if the wind is too strong the structure can closes by itself, a proximity sensor, used to protect the costumer, it works by calculating the distance between the Sunflower and the obstacle in question to make sure it doesn't hit anything when is opening, environmental sensors, such as, temperature, humidity, UV radiation, air quality, this sensors are ther to provide information to users, it also as an app that is directly connected to the ShadeCraft Sunflower and displays all the information measured by the sensors.

Figure 9: ShadeCraft Sunflower

Table 10 contains the pros and cons of this product.

Pros	Cons
High tech instruments	You need a garden with space
Provide comfort	Very expensive
Follows the movement of the sun (intelligent)	

Table 10: Shadecraft Sunflower Pros and Cons

2.3 Electronics/Technology

Sun Tracking

There are two different ways of following the route of the sun during the day. The first possibility is to use sensors that measure the intensity of the sun. TSL45315 for example, as presented in **Figure 10**, is a digital ambient light sensor. It gives back measured values in Lux. With these values it would be very easy to give the command to move the motors to get the shade in the right position. It is also easier to find different sources for certain components of coding which are needed for our shader. On the other hand, it is very complex to choose the right position of the sensors and also the cabling could be difficult.

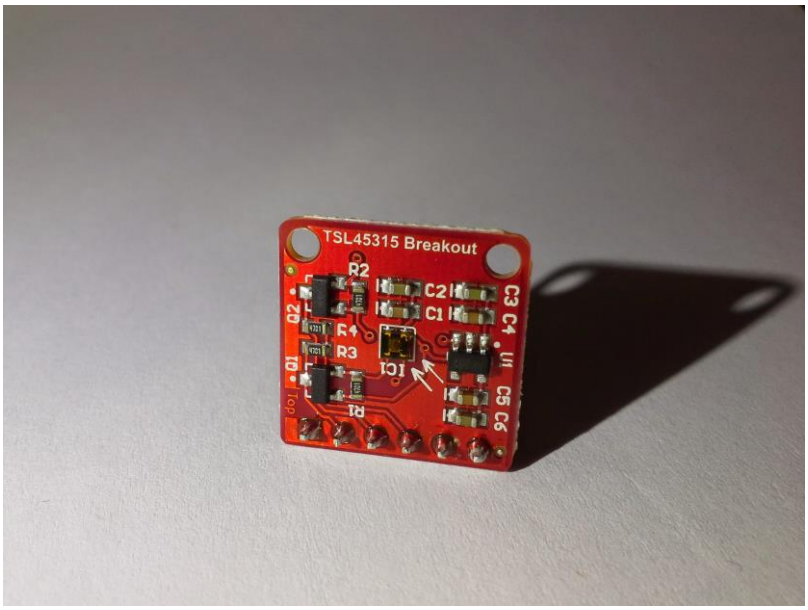


Figure 10: Light sensor TSL45315

The second option is to program a real time clock that already knows the apparent movement of the sun. Here it is necessary to set the date, the time and the geographical location. Then the position of the sun has to be calculated. There already exists a code of Solar Position Algorithm for Solar Radiation Applications which is useful for our sunshader because it is very precisely. The advantage of this option is that the sensors are not needed, and the cabling is much easier.

Controller

A controller will give the possibility to choose where the shader should stay. Probably the consumer doesn't want to cover the spot with the shader even if there is sun. So he has the option to move it wherever he wants. It is planned to program a controller for the phone. The consumer can just press two buttons (one for activating the manual movement, one for choosing the direction) and this sends an impulse to the motors to move in the desired direction.

2.4 Conclusion

After the research in the state of art, our team decided to combine some features from different types of structures. We want to build a fixed structure, semi-deployable, which means that some parts of the structure can be easily disassembled in order to have a longer life cycle and to clean easier. We want to provide shade and comfort to people, with a structure that can be used in terraces and gardens. The main objective of our project is to provide a consistent shadow over a table. We believe there is a gap in the market that we can explore.

3 Project Management

3.1 Scope

The scope shows in **Figure 11** of a chart that explains how the project is structured. In this way is managed to work according a structural way.

Figure 11: Scope

3.2 Time

In order to help the team to manage time, we used a gantt chart, as presented in the **Figure 12** and **Figure 13.**

	Task Mode	Task Name	Duration	Start	Finish
1		**Outdoor Intelligent Shade**	**73 dias**	**Seg 26/02/18**	**Qui 21/06/18**
2		**Analysing**	**3 dias**	**Seg 26/02/18**	**Qua 28/02/18**
3		**Planning**	**3 dias**	**Seg 26/02/18**	**Qua 28/02/18**
4		Problem	1 dia	Seg 26/02/18	Seg 26/02/18
5		**Target Audience**	**1 dia**	**Seg 26/02/18**	**Seg 26/02/18**
6		Research User	1 dia	Seg 26/02/18	Seg 26/02/18
7		Existing Products	1 dia	Ter 27/02/18	Ter 27/02/18
8		**Economical Analisys**	**1 dia**	**Ter 27/02/18**	**Ter 27/02/18**
9		SWOT	1 dia	Ter 27/02/18	Ter 27/02/18
10		Requirements	1 dia	Qua 28/02/18	Qua 28/02/18
11		**Ideation**	**3 dias**	**Qui 01/03/18**	**Seg 05/03/18**
12		**Analysing**	**3 dias**	**Qui 01/03/18**	**Seg 05/03/18**
13		**Product View**	**1 dia**	**Qui 01/03/18**	**Qui 01/03/18**
14		Intentions	1 dia	Qui 01/03/18	Qui 01/03/18
15		Perception	1 dia	Qui 01/03/18	Qui 01/03/18
16		Aesthetics	1 dia	Qui 01/03/18	Qui 01/03/18
17		Product Ideas(20-40 ideas)	1 dia	Qui 01/03/18	Qui 01/03/18
18		10 improved ideas	1 dia	Sex 02/03/18	Sex 02/03/18
19		Morfological Researc	1 dia	Seg 05/03/18	Seg 05/03/18
20		Gantt chart	0 dias	Seg 05/03/18	Seg 05/03/18
21		Task identification	0 dias	Seg 05/03/18	Seg 05/03/18
22		Task allocation	0 dias	Seg 05/03/18	Seg 05/03/18
23		**Concept**	**29 dias**	**Ter 06/03/18**	**Seg 23/04/18**
24		**Analysing**	**29 dias**	**Ter 06/03/18**	**Seg 23/04/18**
25		3 concepts	1 dia	Ter 06/03/18	Ter 06/03/18
26		**Final Concept**	**28 dias**	**Qua 07/03/18**	**Seg 23/04/18**
27		Black Box, structural drafts	4 dias	Qua 07/03/18	Seg 12/03/18
28		Upload black Box, structural drafts	0 dias	Seg 12/03/18	Seg 12/03/18
29		Detailed schematics, structural drawings,cardboar	9 dias	Ter 13/03/18	Sex 23/03/18
30		Upload Detailed schematics, structural drawings,cardboar model	0 dias	Sex 23/03/18	Sex 23/03/18
31		Choosing materials	2 dias	Ter 03/04/18	Qua 04/04/18
32		Upload selection of materials and components	0 dias	Qua 04/04/18	Qua 04/04/18
33		Search local providers	13 dias	Qui 05/04/18	Seg 23/04/18
34		Upload selection of local providers and final list of materials and	0 dias	Seg 23/04/18	Seg 23/04/18
35		**Interim Presentation**	**11 dias**	**Qui 05/04/18**	**Qui 19/04/18**
36		**Planning**	**11 dias**	**Qui 05/04/18**	**Qui 19/04/18**
37		Evaluation meetings	11 dias	Qui 05/04/18	Qui 19/04/18
38		Upload deliverables	0 dias	Sáb 14/04/18	Sáb 14/04/18
39		Presentation	0 dias	Qui 19/04/18	Qui 19/04/18
40		**Construction**	**14 dias**	**Ter 24/04/18**	**Sex 18/05/18**
41		**Planning**	**14 dias**	**Ter 24/04/18**	**Sex 18/05/18**
42		**Hardware**	**14 dias**	**Ter 24/04/18**	**Sex 18/05/18**
43		Process material matrix	1 dia	Ter 24/04/18	Ter 24/04/18
44		**Materials**	**1 dia**	**Qua 25/04/18**	**Qua 25/04/18**
45		Sustainability	1 dia	Qua 25/04/18	Qua 25/04/18
46		**Processes**	**12 dias**	**Qui 26/04/18**	**Sex 18/05/18**
47		Shaping	12 dias	Qui 26/04/18	Sex 18/05/18
48		Joining	12 dias	Qui 26/04/18	Sex 18/05/18
49		**Software**	**12 dias**	**Qui 26/04/18**	**Sex 18/05/18**
50		Materials	12 dias	Qui 26/04/18	Sex 18/05/18
51		Specifics	12 dias	Qui 26/04/18	Sex 18/05/18
52		Upload refined repo	0 dias	Qua 02/05/18	Qua 02/05/18
53		**Testing**	**11 dias**	**Seg 21/05/18**	**Seg 04/06/18**
54		Component tests	11 dias	Seg 21/05/18	Seg 04/06/18
55		Upload functional test	0 dias	Seg 04/06/18	Seg 04/06/18
56		**Report**	**10 dias**	**Ter 05/06/18**	**Seg 18/06/18**
57		Write final report	10 dias	Ter 05/06/18	Seg 18/06/18
58		Upload final report	0 dias	Seg 18/06/18	Seg 18/06/18
59		Upload Deliverables	0 dias	Seg 18/06/18	Seg 18/06/18
60		**Final Presentation**	**3 dias**	**Ter 19/06/18**	**Qui 21/06/18**
61		Evaluation meetings	3 dias	Ter 19/06/18	Qui 21/06/18
62		Presentation	0 dias	Qui 21/06/18	Qui 21/06/18

Figure 12: Gantt Chart

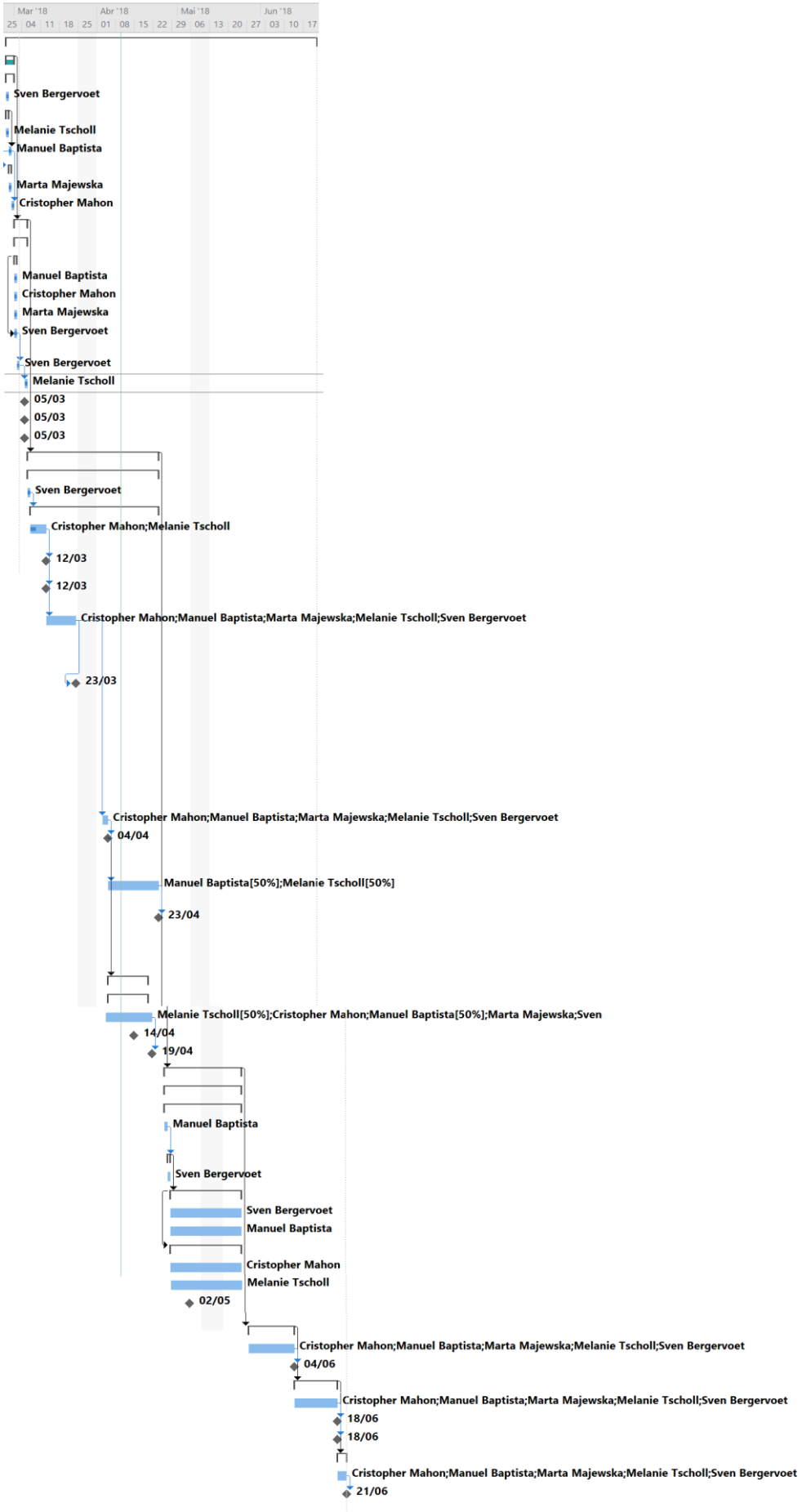


Figure 13: Gantt Chart

3.3 Cost

3.4 Quality

Quality management is defined as the practice of making sure that outcomes, benefits and processes of any particular project meet the requirements that were set forth by the stakeholders and that the final product is fit for purpose.

Broadly speaking quality management as interpreted by our group can be broken down into seven sub-groups of project management ideologies. These seven sub-groups are as follows:

- **Customer Focus**
  Throughout the process of our project we must be constantly aware of what our customers are most likely to value in their product and to ensure that our product does simply not emulate the exact same functions and aesthetics as other products on the present consumer market we will be competing against. Also, it is important to uphold a good, healthy customer relationship to do what we can to ensure loyalty from our current customers and to increase good word-of-mouth promotion to let potential customers know we are a good choice.

- **Leadership**
  In undertaking this project, we initially had to set out clear milestones that we wish to achieve as an organization to ensure that we create not only the product we want to but an effective working environment in which we are able to as productive as possible within our group. This means establishing clear leadership when facing certain obstacles and ensuring that we can meet targets as successfully as possible by empowering the most qualified members of our team to be in charge of the most relevant sections of this project based on their individual experience. As well as taking charge of each section of the project at the beginning of the project, it is also important to ensure that contributions of each team member are made clear to others so that they get the credit they deserve and if any part of the project needs changing that individual is most qualified to do so. This is particularly important in our project to ensure that each team member is given an appropriate level of trust to make sure that they can complete individual sections of the project/report.

- **Engagement of people**
  Whilst it is important to ensure the most qualified people lead specific parts of the project it is also important to ensure that where possible, the more people we can put on a section of the project the better to ensure the quality of the work is as good as it can be and to give as many team members as possible the chance to offer their personal insight to the project to improve it in any way we can. This also allows as a group to take note of just how well each individual team member is doing in the project and allows to have more open discussions as a group about any problems we may be facing.

- **Process approach**
  By taking what is called a process approach it allows us to view activities as processes so that we can better break them down in to manageable pieces of work for each team member and to measure just how difficult or attainable each task is and see how each task can lead to another. This also allows us the opportunity to prioritise any chances we get to make our work better and to better ourselves as students and team members throughout the project and to also give us the chance to use our team resources more effectively.

- **Improvement**

  This sub-group applies to us in the respect that we as a team are constantly looking for new ways to improve our efficiency and are always talking about how we have improved on our past weeks of work. We like to acknowledge and congratulate individuals who make particularly big strides in improving their work ethic and contributions to the project.

- **Evidence-based decision-making**

  Our team is constantly updating and changing parts of our project to try to make the best product we can and we make these changes based on evidence-based decision-making. We always look for the cheapest or more effective components and materials to work with and compare them to the current set of materials we have to reduce our costs and to do all that we can to make our product as good as we can within our budget and still keeping within our requirements for what we need our product to do.

- **Relationship management**

  To ensure we keep as good of a relationship as possible with our stakeholders and suppliers we must consider exactly what we want from them and do what we can to not waste their time, effort or money. Where possible we should consult with out stakeholders to ensure that if there are any issues within our ideas/designs that they are given the chance to offer their opinion on how we can best improve our design or construction process. At all times we should be able to share information with them whenever they request it so they can make informed decisions based on the most up-to-date facts.

3.5 Human Resources

One of the most important factors during a multi-disciplinary project is the the way the different specialties are bring together, if well managed, it can lead a team to success and if the management is not the best, it can reflect in the project. Since we are in a academic environment, we have supervisors that helps us providing feedback which allow us to improve our project.

In order to work with other persons on a project we divided the work to be more efective. In **Table 11,** each task was assigned to different roles. As a team, we decided to use the Responsibility Assignment Matrix, also known as RAM or RACI matrix, because it is an appropriate tool for assigning roles.

The Responsibility Assignment Matrix is composed by the following roles:

Responsible (**R**): Who is assigned to work on the area.

Acountable (**A**): Who makes the final decision.

Consulted (**C**): Who can help with technical information.

Informed (**I**): Who must be informed when a decision is made.

Task\People	Christopher	Manuel	Marta	Melanie	Sven	Supervisors	Subject Teacher
Task Identification and Allocation	R	R	R	R	A	I	C
Gantt Chart	I	A	I	I	I	I	C
Technical research	A	R	R	R	R	I/C	
Market research	R	R	A	R	R	I	C
Initial Budget Planning	I	I	A	I	I	I	C
Purpose Definition	R	R	R	R	A	I	
System Diagram	R	R	I	A	R	I	
Structural Drafts	I	A	I	I	R	I/C	
Design	I	R	I	I	A	I/C	
List of Materials and Budget Planning	R	R	A	R	R	I/C	C
Interim Presentation	R	R	R	A	R	I	I
Interim Report	R	R	R	A	R	I/C	C
Construction Hardware	I	A	I	I	R	I/C	
Construction Software	A	I	I	R	I	I/C	
Product Testing and Corrections	R	R	I	I	A	I/C	
Upload Functional Test Results	I	I	R	A	I	I/C	C
Upload the Final Report and Presentation	A	R	R	R	R	I/C	C
Upload the Movie, Poster, Manual and Leaflet	I	I	I	A	I	I/C	C
Final Presentation, Individual Discussion and Assessment	R	R	R	R	R	I/C	
Upload the Wiki with all Correction Suggestions	R	R	A	R	R	I/C	C

Table 11: Responsibility Assignment Matrix

3.6 Communications

The main objective of communication management is to guarantee a respectable teamwork and a good working environment. In short words communication is delivering and receiving messages. It can be done in words but also in electronical ways like emails, giving advices to machines etc. For this project communication is one of the most important things and it is also kind of a big challenge because the team consists of people from different countries with other languages and cultures. No one of the team members has worked together before and so it is very important to get to know the strengths and weaknesses of the others.

To have a good communication strategy a plan called key of strategies has to be worked out.

Table 12 shows the components which have to be communicated, from whom, when, why and how. Encoding and decoding means to translate a message in an easy way. Decoding a message is extracting the meaning of a message in ways that make sense for the receiver.

What	Who	When	Why	How
Meetings with supervisors	Team members and supervisors	Every Thursday	Get feedback on the project, going to the right way	Presenting the status of the project, getting spoken and written feedback (Email)
Project planning	Team members	Few times a week	Setting intern deadlines for the project	Talk about the project after the lessons, writing on the facebook group
Team meetings	Team members	Depending on the work which has to be done	To discuss what are the next steps	Talk together in different locations (class, others houses), make suggestions, discuss
Deliverables	Team members	Depending on the deadlines	To be on time	Divide the work, every team member gets a part to do, in the end the work will be put together and discussed

Table 12: Communication Table

3.7 Risk

A risk can be defined as an event that occurs throughout the duration of the project that has unforeseen consequences that can affect: Cost/Budgeting, Time/Scheduling and beginning of next steps (bringing the whole project to a standstill). As with most things that are beyond human control we can say that some risks are more likely happen during our course than others.

In our project management classes, we have been taught about risk management and how the process of risks can occur. These stages of risk creation/effects are illustrated in the **Table 13**.

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

Table 13: Explanation Table

For example, it is far more likely that a delivery of our materials will be delayed than a natural disaster will happen to destroy the building we are in. Due to this reasoning it is entirely feasible and indeed possible to construct a table to illustrate and better identify which risks are more likely to occur than others whilst also addressing the cause behind the risks, the impact they will have on the project's completion and the proposed strategy we should undertake in order to solve or prevent the issues these risks could result in. This is presented in **Table 14**.

Description of the risk	Trigger/ cause	Risk owner (who is responsible for the risk)	Probability	Impact	Importance	Strategy
Lack of appropriate prior knowledge	Not studying enough, thinking it may be too complicated	All	Medium	Medium	Medium	Do research, ask for help.
Absence of team members	Illness, laziness, accidents, injury	All	Low/Medium	Medium	High	Be in class whenever it is possible, work from home
Lack of required tools	Lack of oversight	All	Low	High	Medium	Plan everything before
Material damage	Traffic (accident), mishandling the material, mistake by the delivery company	All/Delivery Company	Medium	High	High	Order more than just one item where possible, be careful
Material delay	Bad weather, Worker strikes, traffic (accidents), not putting order in soon enough	All/Delivery Company	Medium	High	High	Review company delivery history, order first class delivery, use delivery tracker
Loss of prior research	Computer malfunction/virus, user error	All	Low	Medium	Medium	Back up files and research with team members/on google drive
Inability to continue working together	Breakdown of colleague/classmate relationship	All	Low	Medium/High	High	Keep open lines of communication with team members, identify problems as soon as they arise and solve them as best we can.
Initial design flaws/inabilities	Lack of experience with designing specific parts	Melanie/Sven/Manuel/Christopher	Medium/High	Low/Medium	Medium	Throughout teamwork and constructive criticism from stakeholders we can find new and better design ideas
Stakeholder interference	Change in the current market or change of public appearance	All	Low/Medium	Medium/High	Medium/High	By continually updating our stakeholders on our projects and having meetings with them we can continually receive feedback from them

Table 14: Risk Table

As with any project conducted under these circumstances we must realise that there are certain risks to our projects successful completion and accept that these risks are a possible eventuality that we may not be able to control. So, instead of trying to control whether or not they will happen, we instead look at ways in which we can control the outcomes that arise as a result of these risks. As can be expected certain risks will affect the project more than others. Throughout the course of completing our project we are able to adopt certain strategies to the risks we are likely to encounter these are as follows:

- Accept that the risk is going to happen (if unavoidable) and work through it taking on board any lessons that were learned throughout the process of facing the issue

- Transfer the risk to someone more capable of resolving the issue removing work from your workload and ensuring it is dealt with my someone more qualified to fix the problem and this in turn removes the possibility of it being detrimental to your work

- Avoid the risk altogether by changing the process currently being undertaken to one where this risk will no longer be an issue meaning that you must be able to change your creative or planning process to no longer use whatever tools/resources had to be used when dealing with the issue

- Mitigate the risk to decrease the impact of said issue and to lower the probability of the risk ever becoming an issue in the first place. This is a classic example of many hands making light work and ensuring that the problem is not a large issue that consumes too much time/manpower/resources etc.

3.8 Procurement

Procurement is the act of obtaining goods and services. The process of procurement includes some preparation and processing of a demand as well as the receipt emition and approval of payment http://www.businessdictionary.com/definition/procurement.html | 12th of April. This is a vital part of any business, because it is impossible to a company to survive if the price of procurement is bigger than the profit made by the product.

Since we have a budget of 100,00 € and the restrain of only be able to buy products from portuguese suppliers, the team needs to be agile in order to find the best options to our project, some of the things we need to take in mind are:

- Compare the quality-price ratio from the available suppliers

- Take the maximum advantage of the material we have at our disposal

- Look for suppliers located in Porto to decrease the shipping cost

3.9 Stakeholders management

One of the most important parts of a successful project is the ability to manage all the stakeholders expectations and power. A stakeholder is a person or entity that has influence on the team or is influenced by the team. In order to manage properly the stakeholders we must take in mind the role, expectations, power and interest of the stakeholders, measuring their influence in this topics. First of all, is necessary to identify all the stakeholders connected to the project, and those are:

- **Team Members**
- **EPS Coordinators**
- **Teachers**
- **Suppliers**
- **ISEP**
- **Final Consumer**

In order to organize all the information, the team built **Table 15**.

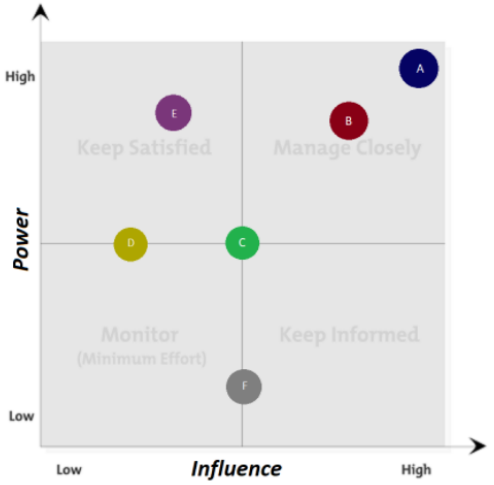
Reference	Stakeholder	Role	Expectation	Power	Influence	Graph
A	Team Members	Project Creators	Develop the project	High	High	
B	EPS Coordinators	Supervise the project	Provide feedback in order to improve the project	High	High	
C	Teachers	Teach subjects	Provide the necessary knowledge to develop the project	Medium	Medium	
D	Suppliers	Provide neccessary materials	Sell supplies	Medium	Low	
E	ISEP	Sponsor	Deliver a project theme and resources to develop the project	High	Low	
F	Final Consumer	Buy the product	Receive a proper built product	Low	Medium	

Table 15: Stakeholders Analysis

3.10 Conclusion

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

4 Marketing Plan

4.1 Introduction

This chapter of the report will contain all important information about our target demographic, the promotion of our product and comparative analysis of other products. Below you will also find information about: SWOT analysis, strategic objectives, segmentation and adapted marketing mix. Furthermore, we will attach information about budget and strategy control. In addition, we have attached information about our questionnaire, which we conducted among people from different countries and at different ages.

4.2 Market Analysis

Each business, regardless of the size and area of activity, in order to be able to function smoothly and constantly should monitor what is happening in their environment. Especially in the case of starting a new business/launching a new product on the market, it is necessary to conduct a thorough analysis of the surroundings around. The final conclusions should help us to recognize our chances, threats and limitations inherent in the environment, which should help to prepare the right strategy to present our product to the market.

Answers to basic questions about the company's environment are very important in order to verify the potential market and recipients.

- Under what economic conditions does the enterprise function?
- What are the potential trends of the development of the product?
- What solutions should be used to achieve success in a given competitive situation (eg. product promotion among potential recipients)?

We divide the enterprise's environment into microenvironment and macro-environment. The analysis must always concern the whole enterprise environment.

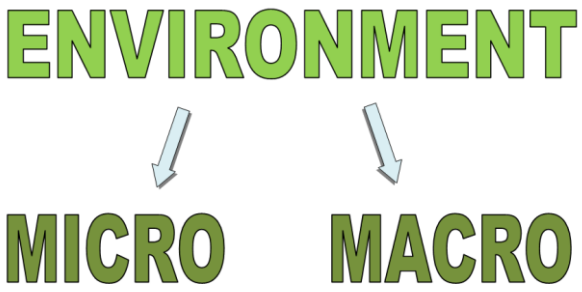


Figure 14: Market environment

- Micro-environment: Affects the working of a particular company only, to which they relate to. In addition it has a direct impact on the business activities.
- Macro-environment: Affects the functioning of all the company entities, operating in the economy. It has a big influence to all business groups.

Specific division into environmental sections:

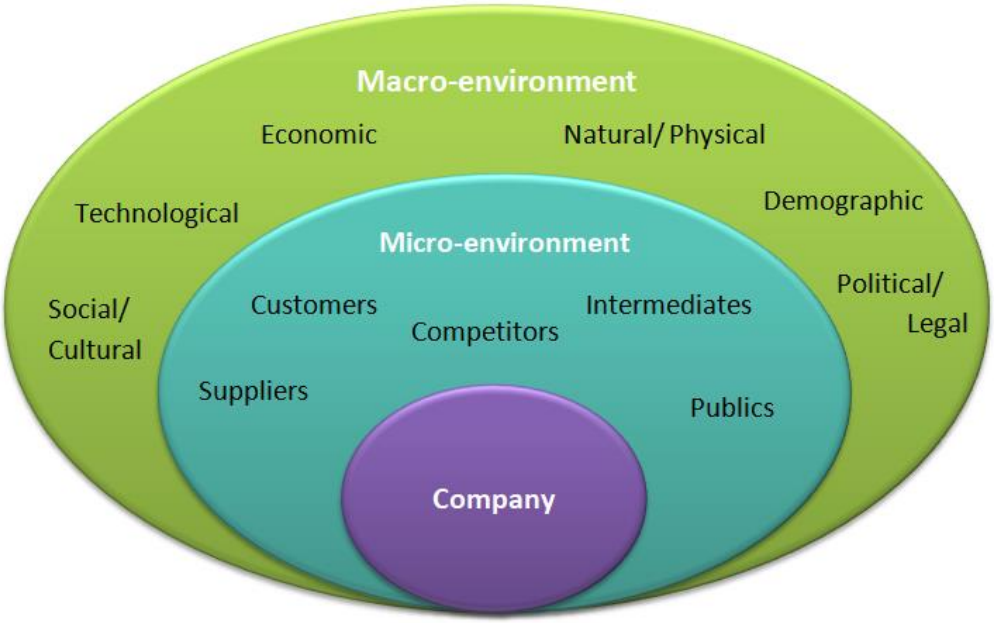


Figure 15: Micro and macro environment

4.2.1 Micro environment

The micro environment of a company is also called a closer environment. In economic terms, these are all economic entities that affect the company, but the impact of which can also affect the company. This micro environment determines the conditions for the company's development and operation in its industry and geographically defined market.

The microenvironment mainly includes:

- customers
- raw material suppliers
- competitors
- producers of substitute goods
- producers of complementary goods
- workforce
- shareholders
- market regulators
- strategic allies

The easiest way is to divide the micro-environment into 5 categories:

Suppliers: Individuals and business entities that provide the enterprise with the resources needed. It's all about negotiating prices, quality and delivery times. The quality of the relationship between the entrepreneur and the suppliers often determines the quality company's functioning and its market position.

It is worth mentioning many examples of active participation of suppliers in building the company's success:

- participation in the promotion of goods and services
- offering favorable delivery terms (eg extended deadlines payments)
- the possibility of obtaining rebates or other financial benefits
- short delivery periods

Especially in the case of small units having an idea for a business (like our team's idea) and not having adequate resources, the importance of favorable terms of purchase grows.

Our product contains a lot of electrical components like a stepper motor, power supply and also building materials. All of these products can be bought here in Portugal. However, the final selection of all materials (for a product in original dimensions) at the suppliers can only be approved after testing the prototype. Becouse than we can know if all the intended goals have been done and if there is no need for making some improvements.

Customers: It answers the question of who is our buyer/our client (B2B or B2C, local or international, etc.) and what is the reason for buying our product. What can make a person buy our product, why someone wants to spend money on our product and not some other competitive one.

Our goal is private individuals purchasing goods and services for the purpose satisfying individual needs like typical families who live in houses with gardens. Our product, due to the technology contained inside, will not be for the poorest people. It will definitely cost more than the ordinary Sunshade umbrella. But it does not change the fact that our product will be able to buy for people equally at the average level of life, as well as those who earn a lot. Furthermore, our product has no competition on the market, because no one has ever created this type of product. The only threat can be ordinary conopy, which are already built in some homes and people will not destroy the already created constellations to buy ours.

Intermediaries: They support the company in the distribution of products and services and support the company in the promotion. The most common are wholesalers, retailers, transport and courier companies, research and advertising agencies, banks, and insurance institutions.

Setsun would be mainly sold business to consumer (B2C) but can also be sold in the further business to business (B2B). Our goal is to get to the customer as quickly as possible and that's why we think that the best strategy is to promote our products on the internet. Both individual customers and companies will be able to purchase the product thanks to the online store.

Competition: Defines the conditions for the functioning and development of a company in a given sector or market segment. The competitive environment consists of all business entities that directly cooperate with the company or compete in the process of satisfying the needs of consumers. However, it should be remembered that the competitive advantage is not static, it changes with increasing volatility in the environment. It competes for the future, not for the present moment.

Everyone who consider the competition should pay attention to the following elements:

- the number of competitors on the potential market and their strategies
- industry development phase
- size and market shares
- costs of withdrawal from the market
- strategic alliances (groups)

Our product is one of a kind, because it combines with shape something similar to the shape of conopy but with technique, electricity, system inside and also modern/stylish look. There are several products on the market that work similarly, but no product reacts to the sun and does not change

its position depending on the position of the sun in the sky. Therefore, we think that we are able to find our niche and gather a group of recipients who may be interested to buy Setsun.

Publics: Every company has the responsibility to please the public. All activities of each company should be considered in terms of public opinion and their impact. Society has the power to help us achieve our goals, and it can also knock out our chances of success. However, satisfying the needs of all recipients is practically impossible. Each person has his own view, opinions on the subject and it is hard to hit the tastes of each person. Therefore, it is very important that the company (from the beginning of its activity) has their own target market - in other words a group of people to whom the company will want to reach.

In the case of our product, the target group are families with houses with gardens. In our opinion, the basic principles that our product must fulfill are:

- have a modern look (so that the product in the garden looks good - a modern, fashionable look)
- it was useful (so that the buyer knew why he bought the item)
- fulfilled the application of following the sun (the argument that distinguishes our product from the others)
- Setsun was friendly to the environment

4.2.2 Macro environment

The company's macro environment is all factors that have a direct impact on the company, but they can not be regulated by them themselves. So macro environment creates favorable conditions for the functioning of the company and the factors that create these conditions, the company called the surroundings of the company.

The surroundings that occur in macroenvironment are as follows (https://blog.oxfordcollegeofmarketing.com/2014/11/04/the-impact-of-micro-and-macro-environment-factors-on-marketing/) :

Demographic forces: Phenomena involving population fluctuations, natural increase, age of buyers, etc.

This determinant is not so important for our product, because our target are families or families in children. In fact, our product can be purchased by anyone who owns a house with a garden. Fluctuations in population or population growth will not change the needs of people who want to settle in beautiful areas, preferably with their own home. More and more people are moving out of the city center due to the emission of dangerous toxins in the city. They settle on the outskirts of cities or in the countryside. We believe that this need of people to have a piece of their place on earth will not change that's why our product can be in constant circulation regardless of demographic fluctuations.

Economic factors: These are phenomena related to the economy, which may facilitate or hinder the functioning of the enterprise.

In the case of our product, the economic situation may affect the number of products sold or the price of materials that we will need to create Setsun.

Natural/physical forces: This is an area that draws attention to renewable energy sources and natural resources, such as forests, agricultural products, marine products, etc. There are also natural non-renewable resources, such as oil, coal, minerals, etc.

During production planning, our team pays a lot of attention to choose the best materials for

production, and also to not harm the environment.

Technological factors: The skills and knowledge applied to the production associated with technologies and techniques.

Thanks to the skills acquired in previous projects of our team members, we are able to better plan the production process and the choice of materials. In this field, we use much of Sven Bergervoet's knowledge and experience in Industrial Product Design as well as the experience of Manuel Baptista in Mechanical Engineering and Christopher Mahon in areas such as: Electric, Electronic and Energy Engineering.

Political and legal forces: Laws and the influence of political elites are included in them.

We assume that our product will be environmentally friendly, so we should not have any legal problems with introducing it to the market. When designing the product, we wanted to meet as many standards as possible, which our product should fulfill.

Social and cultural forces: They include social factors, such as social behavior, current trends, lifestyle, etc.

Our product is designed to use the most environmentally friendly materials as possible. We want to show that although our invention has electronics and technologies in it, it can be also eco-friendly. We want to use this as the main argument in our sale of the product on the market, so that people know for what they pay money and that do not contribute to the deterioration of global environmental conditions. What's more, we hope that the popularity of the product will increase thanks to people defending the environment. Thanks to this, we hope that it will gain publicity about our product, which will make it fashionable and a larger group of customers will be interested in buying our product.

4.3 SWOT Analysis

SWOT analysis (or SWOT matrix) leads to an understanding of strengths and weaknesses enterprises and to identify opportunities and threats that flow from the outside environment. From the entrepreneur's point of view, the most important element of this analysis is assessment of strengths and weaknesses of the company, generating from the environment opportunities - favorable circumstances and the risks and preventing the development of activities of the entity.

Letter	Explication	Description
S	Strengths	Company's activity aimed at increasing the efficiency of its operation or gaining a competitive advantage. Everything that is an advantage over others.
W	Weaknesses	Company's activity that reduces its efficiency or prevents competitive advantage. Everything that is weakness, barrier, defect relative to others.
O	Opportunities	"Attractive" area for potential activity an enterprise on which a competitive advantage can be achieved. Everything that creates a chance for a positive change.
T	Threats	The emergence of an unfavorable phenomenon in the environment, which may lead to a weakening of the company's position in the absence of an appropriate response. Everything that creates the danger of adverse change.

Table 16: Explanation of the SWOT analysis

However, it is worth remembering that in the SWOT analysis it is not necessary to systematically isolate all points and describe all factors, but to identify key factors that can have a decisive impact on the future of the company or the success of a specific project.

Below we present our SWOT analysis with our strengths and weaknesses as well as opportunities and threats for our project.

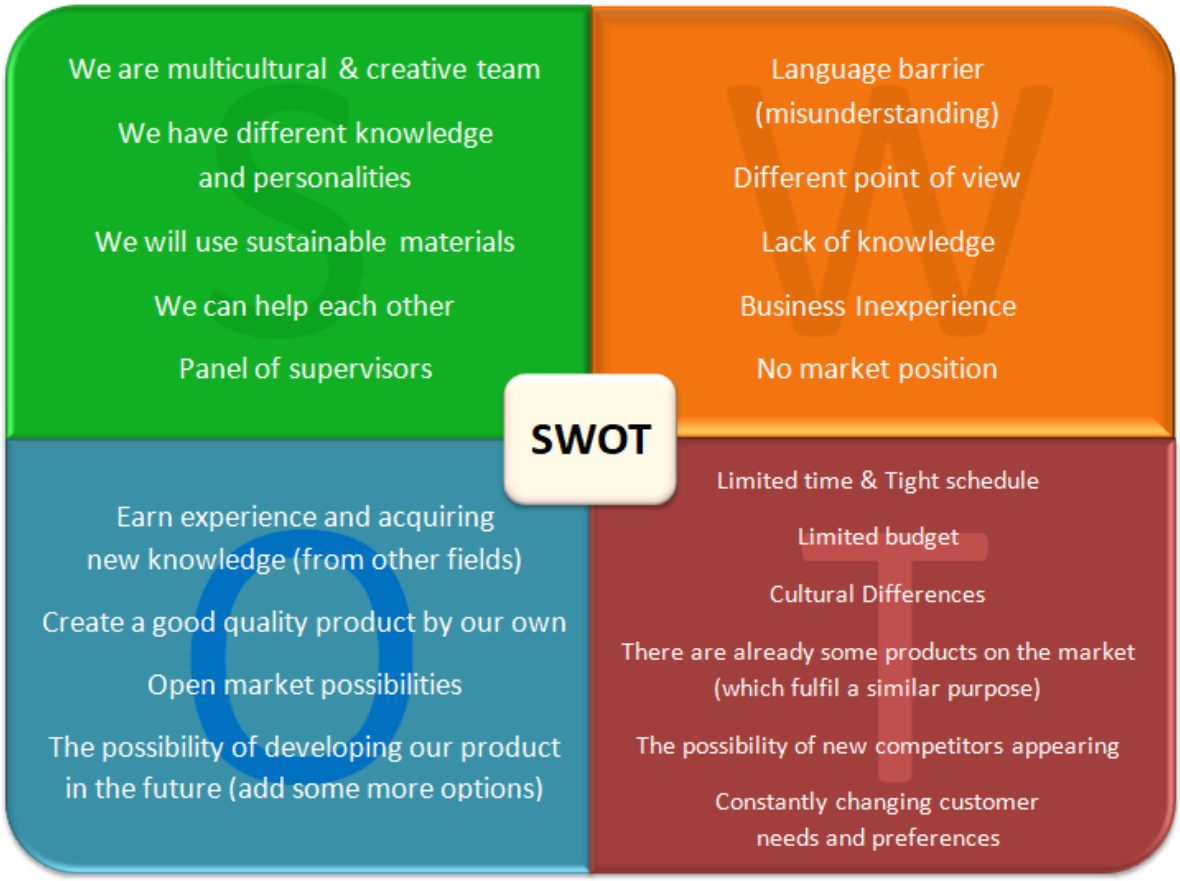


Figure 16: SWOT analysis

As you can see in our SWOT analysis, strengths and weaknesses are mostly internal factors, while opportunities and threats are external factors. It is also possible to interpret it in a different way as strengths and weaknesses are the features of the current state, and opportunities and threats are expected future phenomena. However, the best summary is the statement that strengths and weaknesses are factors depending on us (those on which we have a planning and management influence), and opportunities and threats are objective factors on which we have no direct causative influence. For example, our weakness is lack of knowledge and possible mistakes in understanding each other. That's why it's up to us how much time and effort we will put in the project so that every member of the team knows all the details and progress of work and in critical situations even to use a dictionary so that all words used in the project are known and understood by all team members. However, looking at our threats, we have no influence that they are already some existing products on the market with similar using or that the needs and preferences of customers are still constantly changing. Our motto is to be creative and positive, which is why we focus on our strengths. We believe in our opportunities of success. We try to fight with our weaknesses and also observe the changing market, to know what threats can wait for us.

4.4 Strategic Objectives

In order to be able to successfully accomplish goals, both life and work goals, first of all, goals should be properly determined. This is what the SMART method has been created for. SMART is an acronym for 5 words: specific, measurable, achievable, relevant, timely defined.

Figure 17: SMART method

According to this method, a correctly set goal should have the following characteristics:

- **SPECIFIC** = simple, concrete message

  The goal can not be vague. It should be easy to determine exactly what we want to achieve in a simple and detailed way. How often have we heard when someone is talking to a child: "start learning". This is a typical mistake. When we want a child to really learned something, we should show some commitment and after that be sure that the child has understood what we mean. Issue a specific command. For example: "do tasks 28 to 36" or "read the text on pages 49 and 53". The same principle will apply in companies. The wrongly formulated goal will look like this: "increase customer satisfaction", "increase sales". But: "increasing the sales of time management training by 10% compared to 2012" - this is a full compliance with the first letter of the SMART principle.

- **Measurable** = computable, calculable

  It is a goal formulated in such a way that we can express or at least measure the degree of its implementation numerically. The target should have strictly defined parameters. We need to know when to start, what stages to go through and when to finish. We also should determine and after that we should know that the stage has been completed.

- **Achievable** = available, attainable

  In other words, realistic. A too ambitious goal undermines faith in its achievement and motivation to implement it. You always have to consider whether the task is possible to achieve at all? It is very important to remember that all goals should always be adapted to the currently owned resources: time, adequate technological resources, financial resources and staff.

- **Relevant** = important, meaningful
  The goal should be an important step forward and at the same time it must be a definite value for who will carry it out. Example: A specific goal should be chosen so that the employees who will implement it can identify with it. Only when they recognize that the goal is right and makes sense, will they effectively strive to achieve it. A good way to do this is to simply reconcile the tasks together with the employees in an active manner so that the employee is aware that he / she participates in their appointment.

- **Timed** = timely defined, specified in time
  The goal should have a precise time horizon in which we intend to achieve it. Everyone should have a schedule where can find the date of the beginning and end of the main objective as well as its individual stages - than everyone knows what to do. Then the action and time management is effective. In this situation everything it's just under control.

S.M.A.R.T. or S.M.A.R.T.E.R ? Over the years, the "smart" method in some enterprises has evolved to the "smarter" method. Two letters **"E"** and **"R"** are added.

The letter "E" comes from the word: **Evaluate**. This method consists in checking whether our goals are being evaluated. Assessing our goals every day is much easier to achieve. Why? Because long-term goals (for example: several months) we can easily ignore if we are responsible for many tasks at the same time. Each time, we should make sure that we have set up the system to assess our goals and make an objective assessment.

The letter "R" comes from the word: **Readjust**. The last step of this method is to check whether all our goals we have set before are correctly formulated. It may turn out that we are pursuing to some goal, but we do not achieve good results or see improvement in our actions. Readjust does not mean that we need to throw away your goals and start everything all over again. This means that we should try a different approaches until we get closer to your goals. That's why constant assessment is so important every day. If we do not rate, we can not measure our progress.

Our next goals will be:

- Create a working prototype before 4 June 2018
- Complete the entire WIKI website before 15 June 2018
- Create an official website where people can buy our product - by the end of September 2018
- Create a database of people interested in purchasing our product from Portugal- by the end of November 2018
- Popularize and promote our product in other countries thanks to strong advertising (such as Spain, Italy, Greece - in warmer European countries) - between February and May 2019. So that for the holiday season, people could get your product.

4.5 Segmentation

4.6 Strategy/Positioning

4.7 Adapted Marketing-Mix

4.8 Budget

4.9 Strategy Control

4.10 Conclusion

5 Eco-efficiency Measures for Sustainability

5.1 Introduction

During the past decades Eco-efficiency and Sustainability are subjects that became really important. During the past 100 years we already used 50% of all our natural resources while the homo-sapiens are already existing for more than 40.000 years. This means that during the 0,0025% that humans exist we used an incredible amount of our earths resources. we're destroying our forests, taking all our natural resources out of the ground, in the near future ecological refugees is going to be the topic of the day. This is just an example of a big amount of problems that we are facing when it comes to saving our planet. The average footprint of all the people of the world is 1,5. this means that we need 1,5 earths to maintain our way of living. And compare that of the footprint of Europe that is an average of 4,5. We consume so many products that if this continues we are not able to maintain our way of living. That our way of living in this moment is not Sustainable does not mean that it will be like that in the future. We people have the ability to change the world. which is going to take a long time, but eventually we will get there. With designing and constructing this product we will look carefully at the eco-efficiency and the sustainability. That the outdoor intelligent shader will match all the pillars of sustainability, shown in **Figure 18**.

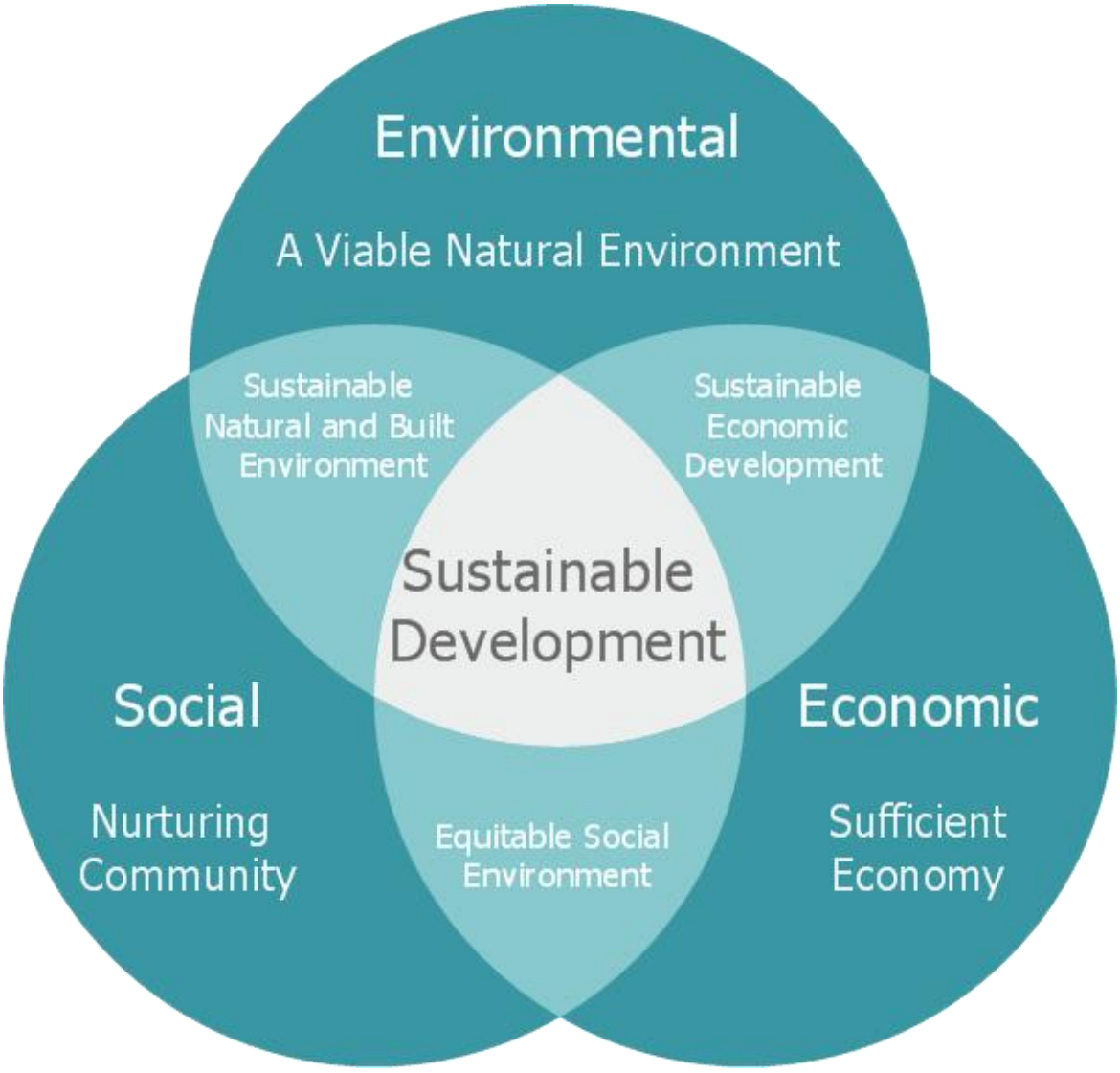


Figure18: Economic, Social and Environmental sustainability

5.2 Environmental

One of the ideas the current society has, although all the information that already exists, is that the natural resources available in our planet are unlimited and we can exploit it without any kind of repercussion, when in fact the things are not like this. In order to achieve an environmental cleaner planet, we need to find a way to protect our resources from those who want to earn money at any cost, such as gready corporations. The path we must follow is to support a different type of behavior, where we should focus in things like:

- Reducing fossil fuel consumption
- Recycling and better waste management
- Use of renewable energy
- Organic Farming
- Protect the forests

5.2.1 Materials

On all levels of materials, impacts on the environment will occur. From the collection, processing to raw material till the production of the parts from the specific material. During the construction of this product the environmental impact should always be taking in to consideration at all times. The use of renewable materials and recycled materials will be used as much as possible.

These following materials will be used:

- Low Carbon steel
- Stainless steel
- Copper

For every material the amount that can be recycled or that is successfully recycled on a large base is really different. At this moment large amount of metals are recycled compared to plastics (**Figure 19**). Also for making the product recycled materials can be used in two ways:

- Use recycled materials for the product.
- Use materials that can be recycled at the end of its life cycle.

For our product it is really important to always keep sustainability in our minds and focus on what's good for our earth.

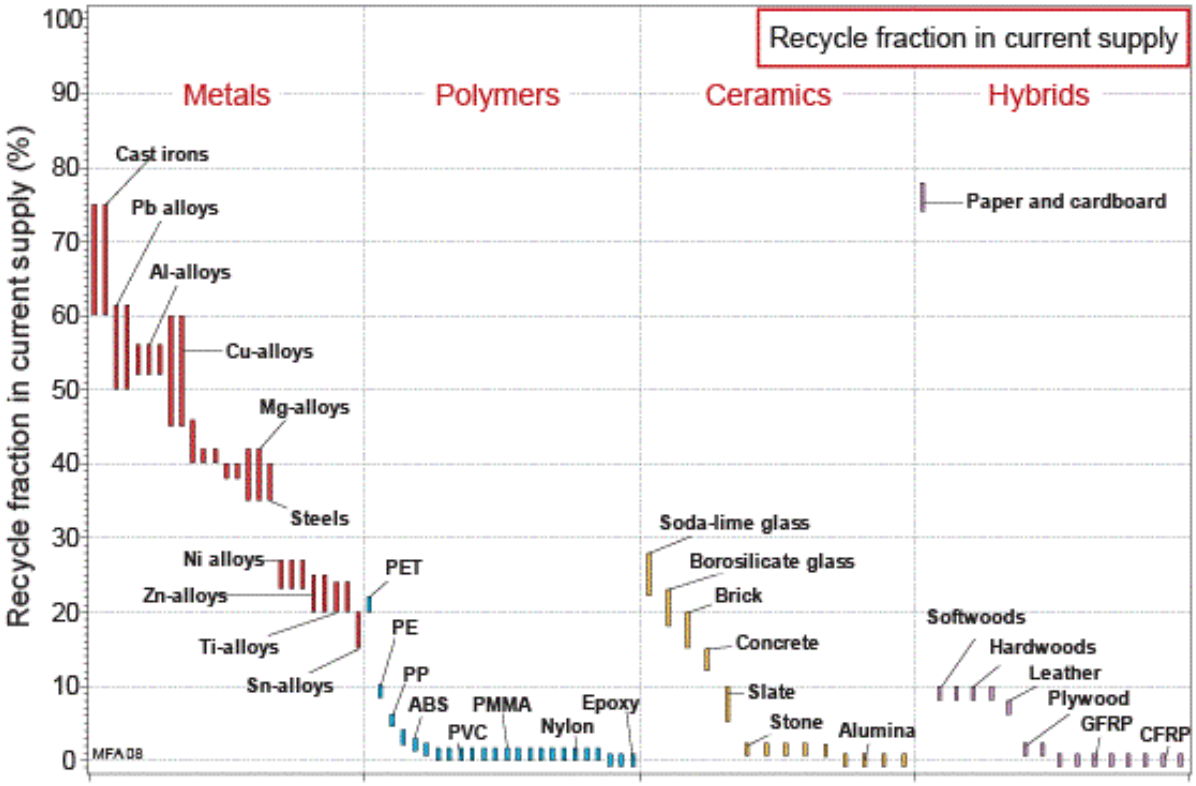


Figure 3. The fractional contribution of recycled material to current consumption. For metals, the contribution is large; for polymers, small (2005/ 06 data).

Figure 19: Recycle fraction in current supply

Not only is it important for a material to be able to be recycled but also the amount of effort it takes to process a material. In this case we talk about a carbon intensity. This intensity is measured in the amount of CO_2 that is produced for one Kg of material. In this graph (**Figure 20**) are two lines shown that say 'recycled' and 'virgin'. The recycled line shows the amount of CO_2 that is produced when the material comes from other products that are been reshaped for its new purpose. The virgin line shows the amount of CO_2 produced when the material is collected from the earth (the very first stage of winning materials). For every material shown in the graph it is a shocking difference between the virgin and recycled materials. Recycled materials show that it is way better for the environment.

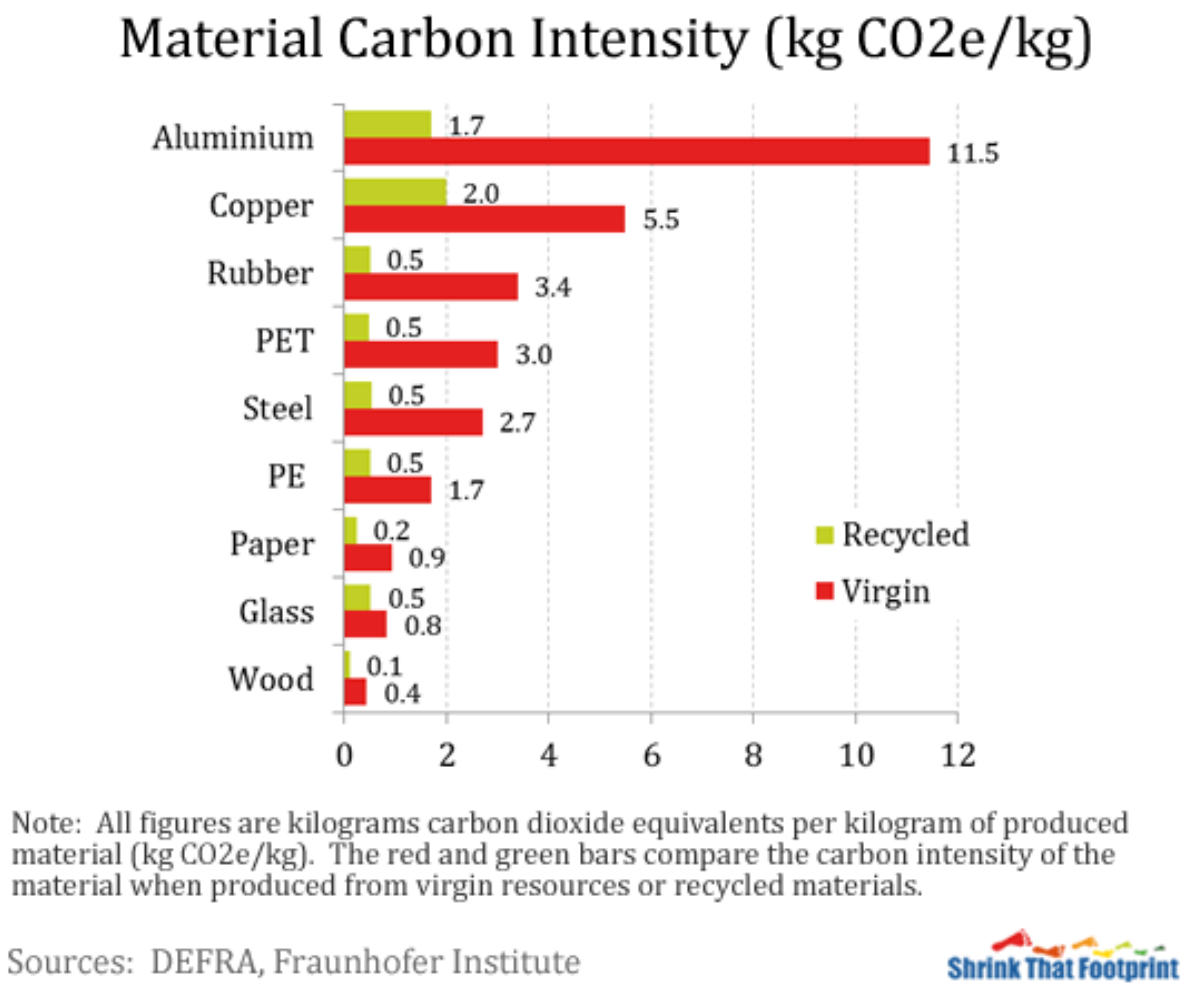


Figure 20: Material emissions

Low Carbon steel

Low Carbon steel is an material that is most common in construction work. This material is an alloy of iron with carbon, often a little manganese, nickel, and silicon. Low in 'low carbon steel' means that the amound of carbon in the material is less than 0,25%. The metal is at the same time, strong, tough, easily formed and very cheap. What in this chapter is so important is that this is one of the metals that is most likely to be recycled (**Figure 19**). Low carbon steel is a steel type that is compared to many other materials has a rather low CO_2 intensity than other materials. Although the use of recycled materials will keep the CO_2 intensity even lower (**Figure 20**).

Stainless steel

Stainless steel is a wide used material that is mostly known for its property that it prevents the steel from corrosion. This is due its oxide layor. Stainless steel alloys are made from iron with chromium, nickel and often four or five other elements. Also with Stainless steel it shows that it is an material that can be easily recycled. (**Figure 19**). Also for Stainless steel which is also a steel type is also an material with a rather low CO_2 intensity (**Figure 20**).

Copper

Copper is also a wide used material in our product. This is because of the wiring in the product. The wire will go from the shader to the Powersupply and this can add up a lot of copper wires. Compared to the two types of steel earlier explained copper is a material that is less likely to be

recycled (**Figure 19**). Also, for the amount of CO_2 that is released it produces a lot more.

5.3 Economical

Achieve a sustainable economy model is a hard thing to do. A company needs to have in mind, that besides the fact that profit is important, in order to be sustainable, the company needs to take care of the social and environmental problems while it has profit. We live in a world where consuption is seen as a normal thing and the big corporations take advantage of that to run after profit without any kind of social or environmental conciousness. The public in general does not do anything against that because the idea that big corporations pass, is that is impossible to have a confortable life without prescind those things.

The most used economic indicator is the *Gross Domestic Product* also known as **GDP**, it is used to measure the economic activity of a region, the main problem about this indicator is that it has some limitations such as:

- It does not distinguish between an investment in good things or in bad things, so an environmental disaster can contribute positively for an economy growth
- It does not take in account the distribution of growth, which means big corporations can make a lot of money while the ordinary people struggle and can not make a lot of money, and still counts to a positive economic growth
- It does not take in account if there is an excessive use of the resources, for instance, if all the ducks were killed and sold in the space of a year, the economic growth would increase but it would cause a clear crisis in the ducks market.
- It does not take in care of things that helps the society but does not have any kind of commercial value, such as volunteering, research, etc.

For the reasons written before **GDP** can not be considered a development indicator.

In the following pictures we are going to present some Portuguese **GDP** data, such as *Portugal* **GDP** *Growth Rate Evolution between 1960-2017* presented in **Figure 21**, the *Portugal* **GDP** *Annual Per Capita Evolution between 1960-2017* shown in **Figure 22** and the *Portugal* **GDP** *between 1960-2017* in **Figure 23**.

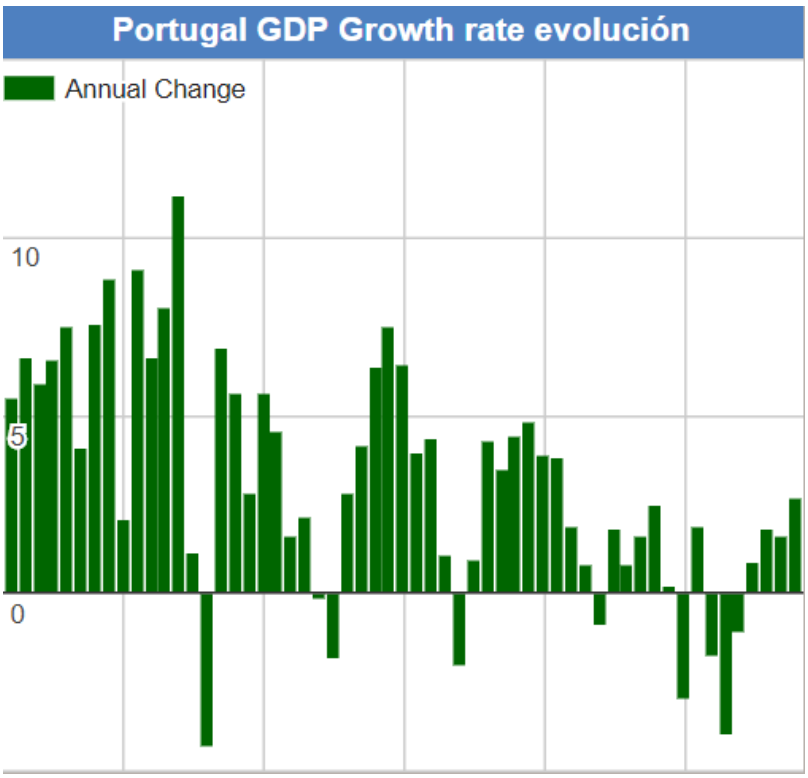


Figure 21: Portugal **GDP** Growth Rate Evolution between 1960-2017

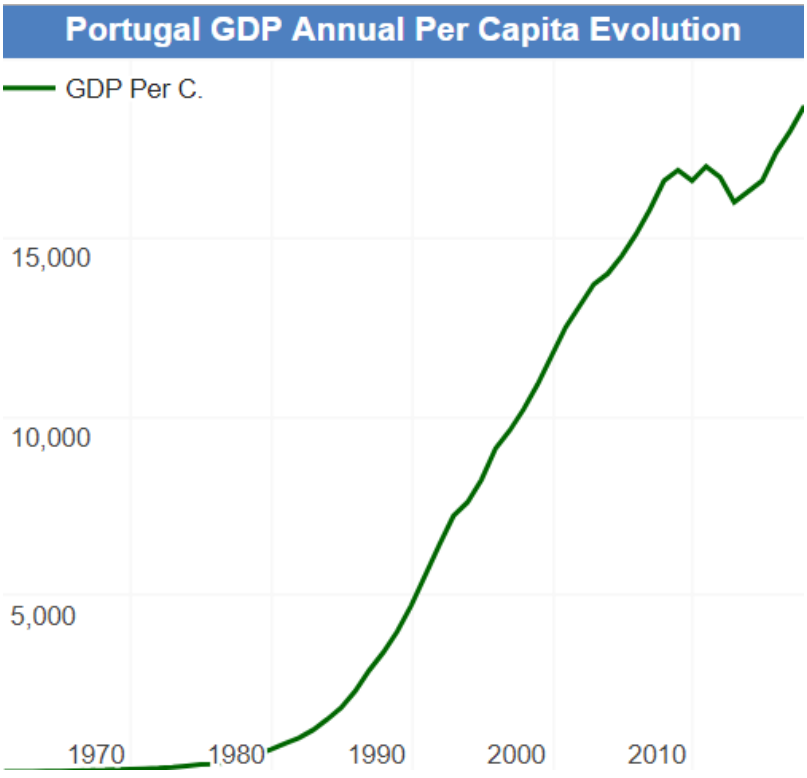


Figure 22: Portugal **GDP** Annual Per Capita Evolution between 1960-2017

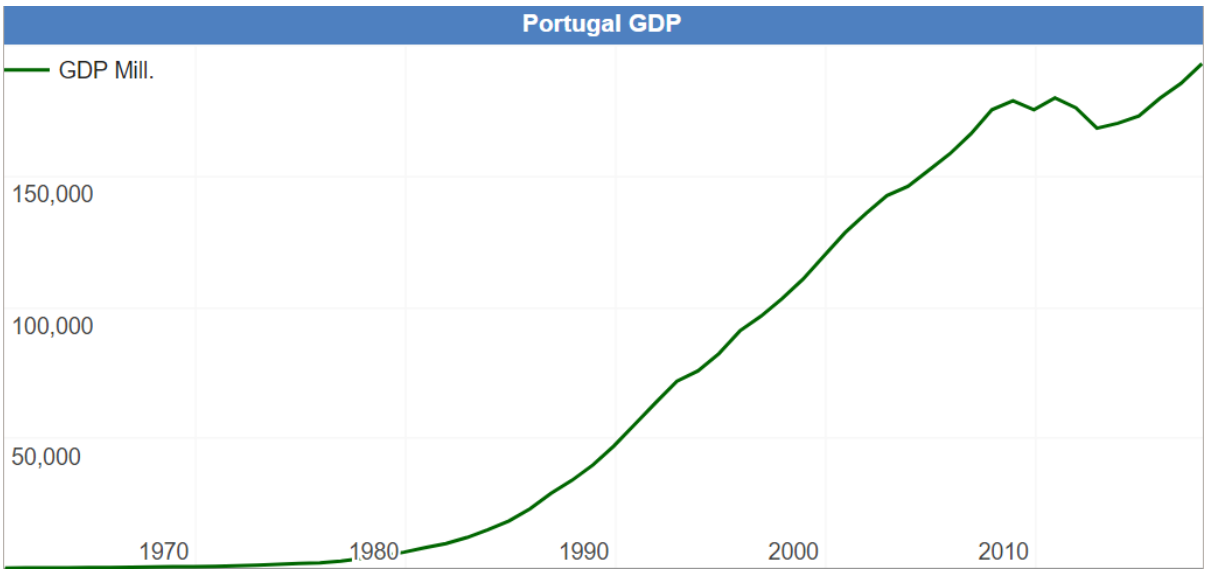


Figure 23: Portugal **GDP** between 1960-2017

Our team want to do things in the right way and to achieve a sustainable model we are going to buy all the products needed to our project from local providers, it will certainly help the portuguese economy to prosper and maybe even create some work stations.

5.4 Social

Social sustainability is avoiding changes in the environment which might have bad effects on subsequent generations. In other words, it is an effort to provide the people after our time a green, healthy and livable place in the world. Thus, social sustainability is also strongly connected with ethics.

Not only by saving the planet can you make a product sustainable it is also about people. People that work for your company or are somehow involved to your product. Of course your costumer needs to be really happy with your product. But what about the people that manufacture your product or do you know if the people that are working in the iron mines have good working conditions?

Before you choose a company that will deliver materials to the factory it is really important to know where the material is coming from. where the material is made, in which conditions it is made, how do the people get paid and do they need to make long hours a day with little brakes. This is a concern that is very common when talking about materials that come from for instance China.

For all the employers of the factory it is really important that they work in the right conditions. Working with large machines can often be a dangerous job. Every machine will be safe to use to keep the risk of injuries as low as possible. They also will work according a regular working schedule as it is in Portugal. Also the loan of the employees will be leveled with the kind of work they are doing.

In our case successful, social sustainability is to be understood that the team but also the consumers receive satisfaction of human needs in fact in the form, that the Environment has still the possibility to reproduce itself and that it does not have to endure damages and losses over a long period of time. Social justice, say and human dignity are also a big part of social sustainability.

Social sustainability is very important, if several people have to work together. That’s why it has to be ensured that every team member feels good and involved. To provide a good climate within the group following points are respected:

- Every team member should be sure in his part of work. If this is not possible, it should be taken advantage of help in online forums, of other students or experts.
- Sustainability and efficiency are a very important point and should have a high priority for the team.
- Every team member should stick to the developed code of ethics without exception.

Even if all of the involved stick to the plan, it could nevertheless come to certain issues such as overwork, accidents, disputes related to the work and so on. Then it is important to accost these problems quickly and to find a solution as soon as possible. It must be possible to hold a meeting and to discuss at any time. The most important thing is to show honesty and respect for the others. Also, outsides are allowed to complain about the team if security or the environment get endangered. Those problems will be also discussed and solved within the team.

5.5 Life Cycle Analysis

Life Cycle Analysis is a really difficult task to do. Most of the products that are pushed into our society have a linear life cycle. This means that during the process of making a product from collecting the resources till the end of life is not completed. The circle is not round, there is a waist of materials. If it would be a complete circle, this means that during that process there won't be a waste of energy or materials. This is called durability.

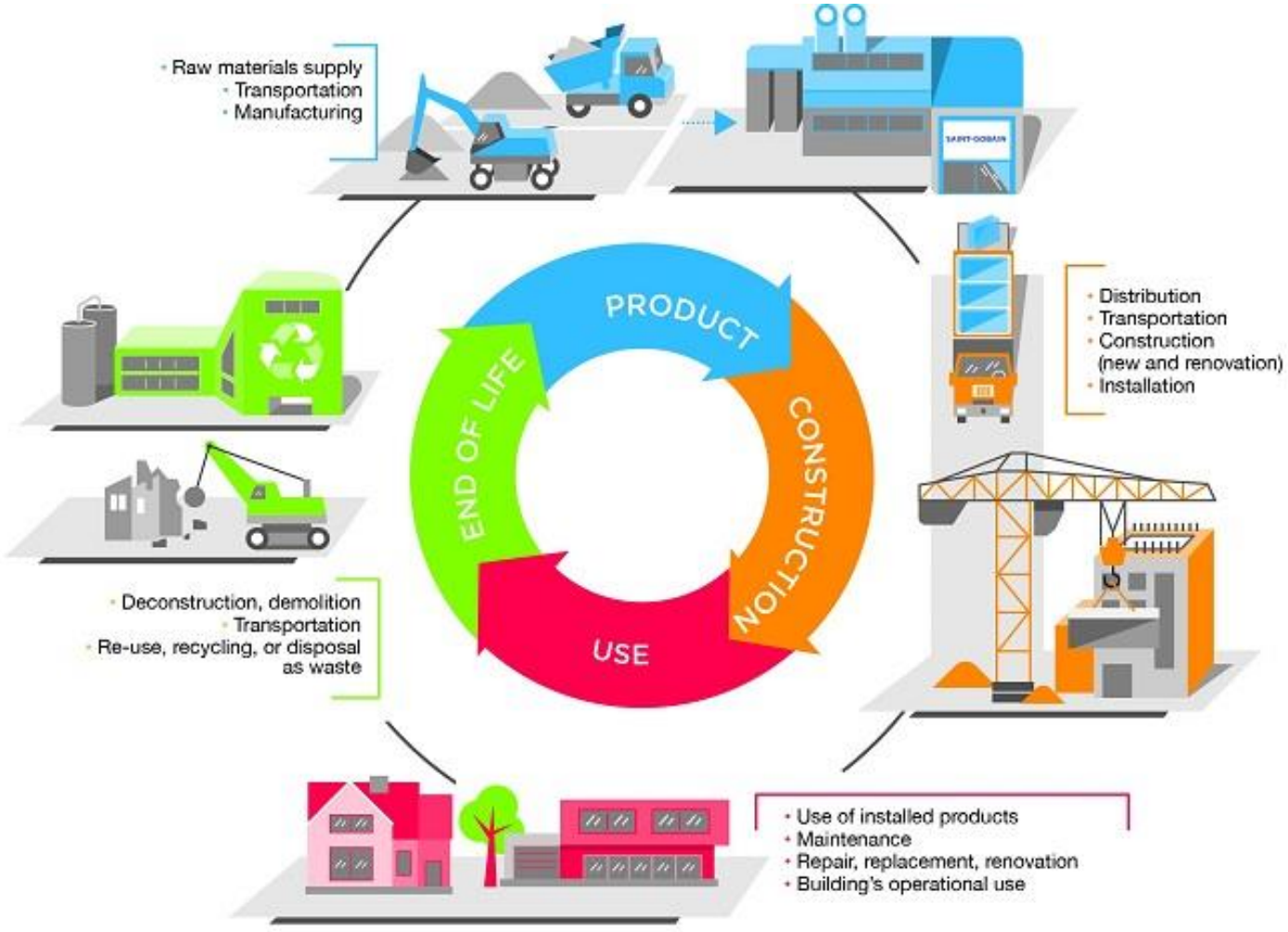


Figure 24: Life Cycle Analysis

5.5.1 Product

Raw materials supply

Just as all other products, materials need to be collected. For producing a material the environmental impacts are enormous.

Material analyse

As shown in the previous chapter the materials in this product have a big impact on environment. Even with the use of recycled materials.

Transportation

All kinds of materials are been collected or made all over the world. This means that with a rather complex product that has a lot of different parts from each different materials the only options are to use materials that come from all over the world. These transportation methods that are most common are:

- Boat
- Plane
- Truck

This amount of material that are used in this product come by boat and are taking with trucks to its final destination.

Manufacturing

Manufacturing can be done by local providers here in Portugal, but that will not say that the product will be produced here in Portugal. Big manufacturing countries like China or India are also a option to manufacturing this product, because the labor in these countries are way lower then in comparison with Portugal. As shown in **Figure 25**, China is one of the countries with the highest industrial output. In this case the parts will be Manufactured here in Portugal. Most of the parts will be made with machines, but it will add extra labor for the assembly. Some Parts will be assembled in the manufacturing factories while others because of transport will be done at the main factory where all products will come together. This is because not all the parts will be made in the factory from this product.

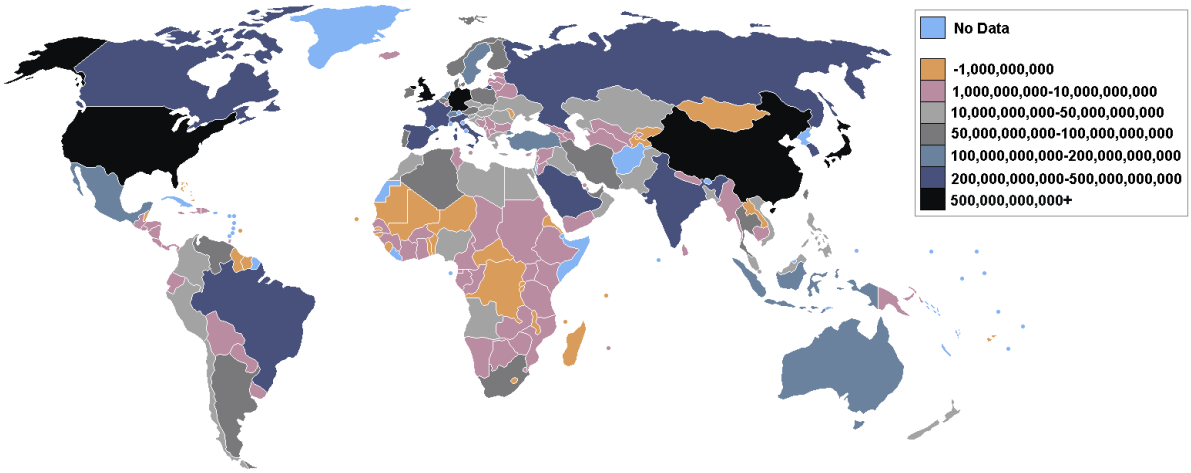


Figure 25: Countries by industrial output

5.5.2 Construction

Distribution

After the product has been assembled at the factory in Portugal, the distribution of the product throughout the whole county can start. The distribution of all the parts will be done by truck

Transportation

Concerned the transportation of the product, each truck will carry up to a maximum of three products. The trucks will be specified to only carry this product. The product will not be delivered fully assembled. This saves a lot of space on the truck. Also for the transportation from truck to the standing place on the terrace can be done more efficient if not fully assembled. The parts will be transported from the truck to the standing place by a forklift truck or a crane.

Construction (new and renovation)

When the parts of the whole product arrive at it's destination the construction of the part on the spot can start. the most efficient way to do that is to let the construction-workers be on the sport at the same time as the product arrives. Sharing a forklift truck to not only put it on the spot, but also position it the correct way to assembly the product. For the renovation or service on the product it is possible let a mechanic come of to take a look at the product and replace a part where needed. If bigger parts of the construction will need to be replaced that goes according to the same procedure as when a new part arrives.

Installation

Transportation and installation are in this case really similar. Transportation from the truck to the house is an intense part of the installation. During the installation at the beginning, the forklift truck or the crane are needed to place the big construction parts on its place. When these parts are on the correct position the work vehicles will not be necessary anymore. The next steps will be done with the help of mechanics that have the knowledge to assemble the product. This can be defined as cabling from the shader to the power source the following processes will be done by small electronic tools like a drill.

5.5.3 Use

Use of installed products

After the whole product is installed and works as it shoot be the users can finally enjoy there new shader. The Setsun will only use electrical power that's been drawn from the house to the product. When in use the power will go to the motors and the CPU in the product.

Maintenance

The Setsun will require little maintenance. The only maintenance required is to clean it ones in a while, just to keep the canopy clean and prevent mechanical parts from breaking if there for instance comes dirt in.

Repair, replacement, renovation

When pieces are broken or basically not work anymore, the product will be turned off until the mechanic that will pass by for service says the product can be turned on. A mechanic will be informed by the costumer the inform about a possible problem. the mechanic will drive to the location and will try to solve the problem on the spot. a Service vehicle will provide him with the needed materials to solve most of the problems. If structure is damaged or broken the use of work

vehicles is needed.

Products's operational use

During the operational use of the product it will only cost Electrical power to keep the Motor and CPU working.

End of life

Deconstruction, demolition

The Setsun is easily deconstructed as most of the parts are bolted together and can be Deconstructed in the exact opposite way as it is installed. For the demolition of the product, most of the parts can be recycled.

Transportation

After the product is disassembled, there is a possibility that parts from the Setsun can re-used in new Setsun products. We give the option to take in old parts to renew them.

Re-use, recycling, or disposal as waste

All electronics can be screwed out of the product, so the leftover parts can be recycled. Most of the parts are build out of the exact same material which causes parts to be easily recycled as well.

5.6 Conclusion

6 Ethical and Deontological Concerns

6.1 Introduction

Ethics is a very important but also a difficult topic. It doesn't decide what is right or what is wrong, it is kind of a system for moral principles. These principles show how to make decisions and how to lead the life. It is very important that the team analyses different ways to find the best solution with almost no ethical issues. The project and also the interaction with the team members has to be good for every individual and the society. The topics which the team has to deal with are:

- How to live a good life?
- What is right and what is wrong?
- Moral decisions
- Responsibilities and rights

Since every country has a regulation about ethical correctness the team created an ethical code of conduct during the work for the project. If there arise any problems, the team has to counteract those issues.

Code of ethics (Team 4):

- Respect is paramount
- Every team member has the same rights
- Decisions will be discussed and decided together
- Everybody has to be honest and say his opinion
- The developed product should not impair the consumer/ environment

6.2 Engineering Ethics

The project team consists of five members from different countries with different engineering backgrounds and experience. For this reason, it is very important to find out the strengths and weaknesses of every member. Everyone has other opinions, knowledge and experiences when talking about ethical issues. When developing the product there are a lot of ethical hurdles which the team has to handle with. Licensed software and open sourced projects are essential for ethical correct engineering. On this way, safety and also legal problems can be prevented. The team canot assure that ethically incorrect behaviour is impossible because, as mentioned in the introduction, ethics do not decide what is right and what is wrong, it just gives us an idea of moral principles.

6.3 Sales and Marketing Ethics

The special thing of Setsun is that it is truly honest and transparent to its customers. Also in the marketing of the product it was very important for the team to not make false claims or promises. The key is to offer neither more nor less depending on costs, quality and value.

6.4 Environmental Ethics

Environmental ethics are also a very important part of the project. Nowadays peoples' consummation is extremely high. Most of the time it is not their fault. It all starts with the companies. A lot of firms are not caring about sustainability or the future environment. They try to hide their bad treat of the environment and to sell everything in a way to get the most profit. On the other hand, sustainability and environmental caring can be used as a good marketing tool. These

days people are more enlightened in what happens to our environment and how our consummation affects our world. For our group it is very important to be a good model for others. As we set sustainability as one of our objectives it is necessary to think about efficiency, renewability and a greener world in general. With a budget of 100€ our team tried to figure out the most effective and best material to provide these requirements. The materials are purchased locally to avoid a long, environmentally damaging path but also to support Portuguese companies.

6.5 Liability

The team has the moral obligation to present a liable product to the costumers, so it has to work properly, and the inside components have to be obtained from certified suppliers.

The product will be accompanied by a product manual. In this manual there will be instruction on how to use the product and all the features that the product offers.

The EU has some requirements regarding the machinery and electronics that needs to be followed. These requirements are:

- Machinery Directive - 2006/42/CE 2006-05-17
- Electromagnetic Compatibility Directive - 2004/108/EC 2004-12-15
- The Low Voltage Directive - 2014/35/EU 2016-04-20
- Radio and Telecommunication Terminal Equipment Directive - 2014/53/EU 2014-04-16
- ROHS (Restriction of Hazardous Substances in Electrical and Electronic Equipment) - 2017/2102/EU 2017-11-15

Some of these directives don't apply to our project, however, the team believes they should be mentioned. For instance, *Setsun* does not have any type of radio or telecommunication, so this directive does not apply to our product.

6.6 Conclusion

7 Project Development

7.1 Introduction

This section of the report details the different sections of product development of our outdoor intelligent shader, the development of which can be split up into different more detailed sections. It includes individual sub-sections relating to; the initial structural design, the electronic configuration, control systems and black box diagrams, software development and mechanical components.

7.2 Architecture

7.2.1 concept choosing

The following chapter is about the design, construction and the electronics of the shader. During this phase we faced a lot of difficulties with the design. There are so many different solutions with all its advantages and disadvantages. Eventually we end up making a chart that shows which design will come out best.

As shown in the **Figure 26** there are 6 different concepts shown:

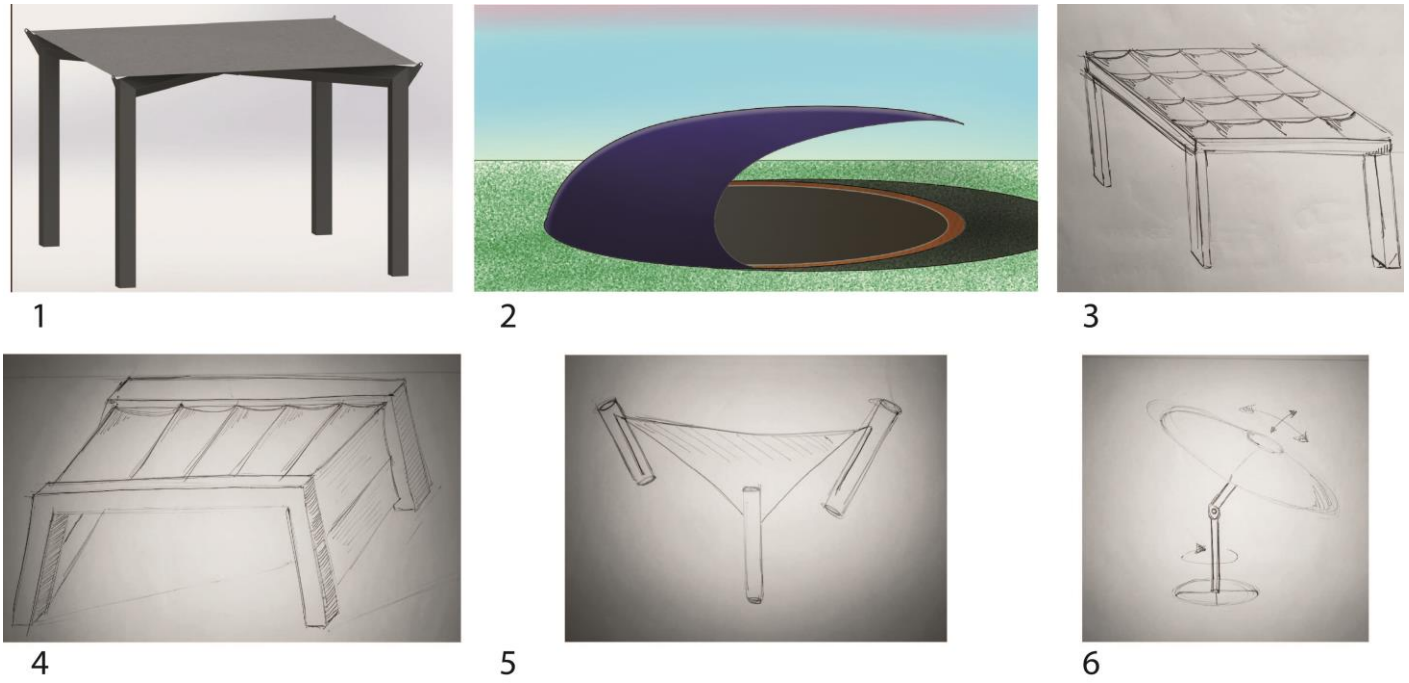


Figure 26: Design concepts

Here a quick explanation of every design:

1. **Canopy:** this canopy has a fixed roof with on the 4 sides individual shaders that can go down.
2. **Ball design:** this shows a ball shaped structure that turns during the day over a rails.
3. **Individual shaders:** this shader has multiple individual small shaders that can open a close to provide a pattern of shade where needed.
4. **Bow shader:** two metal bow structures with a stretched cloth in the middle that moves 180 degrees during the day.
5. **Pole structure:** a structure where the three poles move up and down to change the position of the sun.
6. **SMART parasol:** this is a regular parasol that moves with the sun to maintain its shadow directly underneath it.

With all that information the concepts were ranked from one to five and eventually the one with the most points is the concept that is going to be further developed.

As shown in the **Table 17** below the chosen concept is **number 4**.

	Design	Electronic	Construction	Cost	Marketing	Total
1	2	3	3	2	3	**13**
2	5	3	1	2	4	**15**
3	3	1	4	1	3	**12**
4	4	4	4	3	3	**18**
5	5	4	3	2	3	**17**
6	3	2	4	3	4	**14**

Table 17: Concept Point Chart

7.2.2 Morphological chart

This concluded that **number 4** is the one that's going to be the base of the development for this product. At the beginning a design is not based on any construction or electronics. It's still a rough idea. To get grip on this the use of a morphological chart is really helpful. This chart shows many possibilities to solve a particular problem. In this case it is to move the cloth from one side to the other. By combining the different ideas it eventually shows a possible solution for the problem.

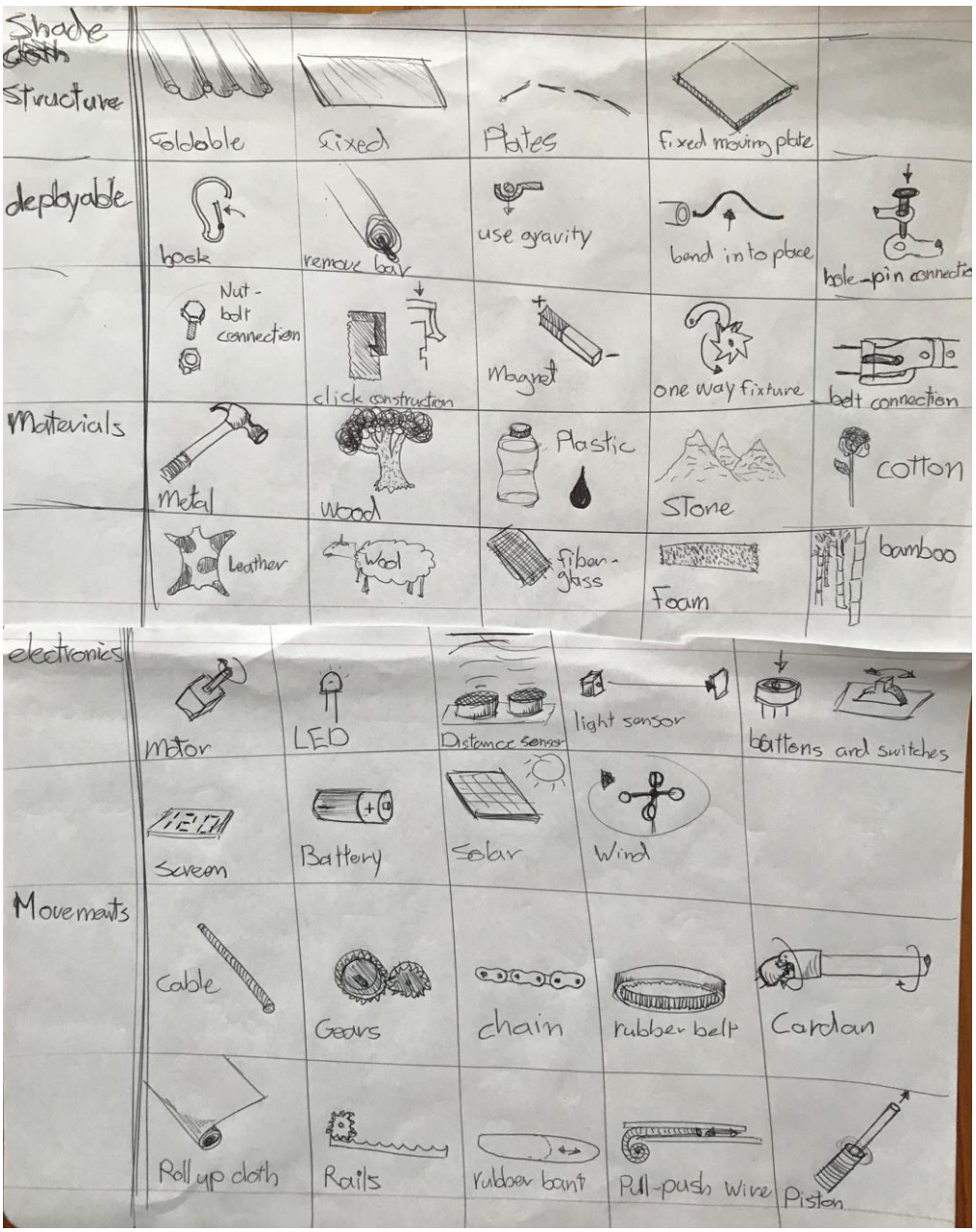


Figure 27: Morfological chart

After everything about what the design would look like with the morphological chart the final design the idea was to use a roll-up system at both sides of the shader. There are no movement components needed because the strength of the cloth is used. Just like a cable it's very strong in pulling force and not in pushing force. So, this means that there's one motor that rolls up the cloth at one side and one on the other side.

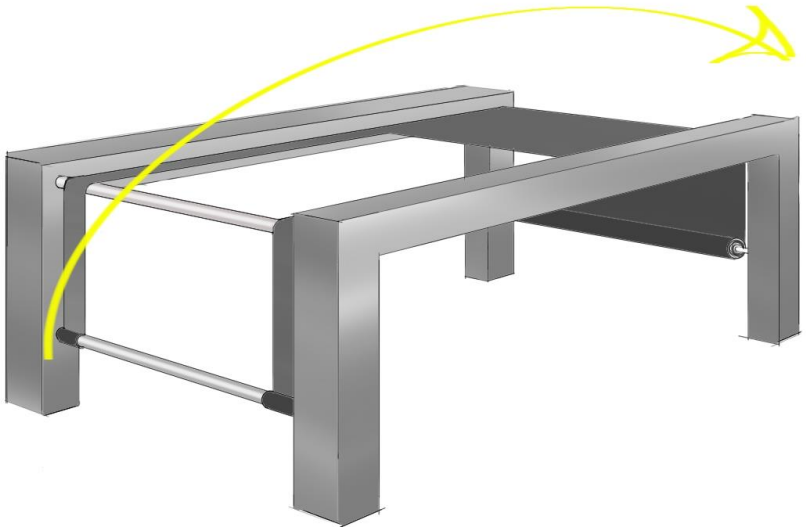


Figure 28: Final design

7.2.3 Aesthetics

The idea of how a product should look like is a very important aspect of designing. The product must have its own special appearance, especially when designing for a luxurious product.

Figure 29: Aesthetics

Figure 30 displays the black box diagram of the system for the shader. It shows the components which are needed for our project. Changes could be made to this because of the development process.

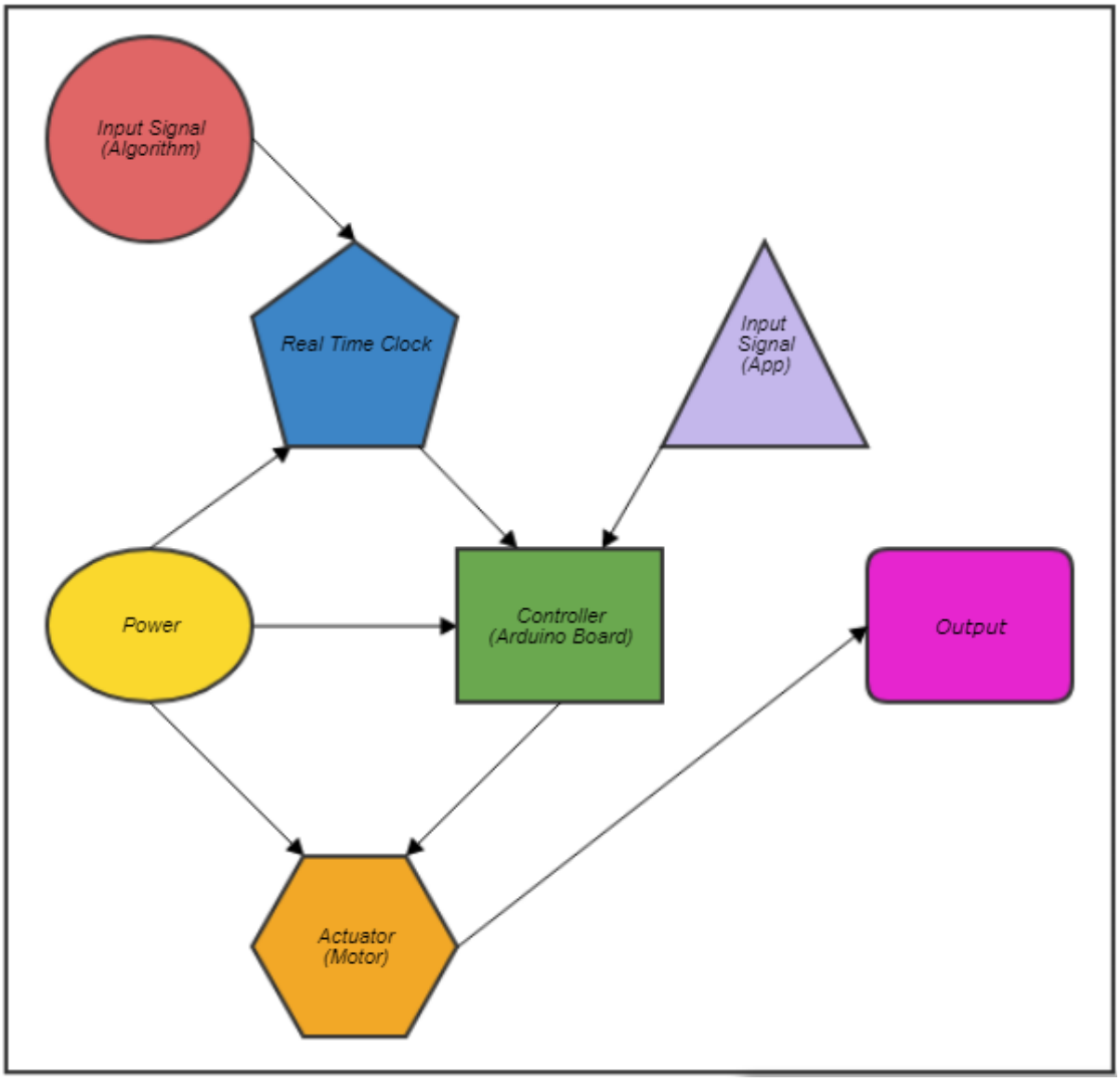


Figure 30: Blackbox diagram

The input signal is either a button (app) or the algorithm. When the shaders move by themselves, the algorithm reads the time in the clock and then gives a signal to the controller. The controller activates the electric motor so that the shader can move. The process is the same when pushing the button, but in this case the algorithm and the real time clock are not needed. The command to move the shader comes from an external remote control found on an app on the users' phone.

7.3 Components Product

In the next chapter there will be a full explanation of all the finished components for the product and for the prototype. Every part will be explained with the following information:

- Part appearance
- Part use
- Part material
- Part strength

Components product

In this part we'll break down the total product in assemblies to its parts. All parts are made in SOLIDWORKS.

A001 Outdoor intelligent shader (head assembly)

At first is the complete product. The shader is based on three big components.

- The construction bow
- The rolling bars
- The mesh

Figure 31: Final design

A002 Construction bow

Appearance

The first assembly forms the basis of the whole structure as presented in **Figure 32**. This construction will absorb most of it's force because it's used to mount on the floor and all of the other assemblies and parts will be mounted to this construction. It will also form a base for all the electronics that will be fit within the hollow structure.

Figure 32: Construction bow

Shaping

In the image below is shown what the structure would look like ‘add image of final structure’ This structure is a simple constructed structure which uses compared to other designs les manufacturing processes. Also, a square design has the advantage that underneath the shader it gives the maximum amount of space to walk underneath it. The construction bow exists out of 3 main parts:

- P001 pole
- P002 pole mirror
- P003 top bar
- P00… pole motor

These three pieces gives the advantage to make the construction even more simple. The two bows that are going to be used are completely identical which saves a lot of manufacturing processes concerning the bath size. The square tubes are made out of 200x200mm steel with a thickness of 3mm. this gives the structure enough strand to outstand a force in the middle of the structure of 2000N which causes a deformation of less than 2mm that is considered as acceptable in the List of Requirements (shown in the image below).

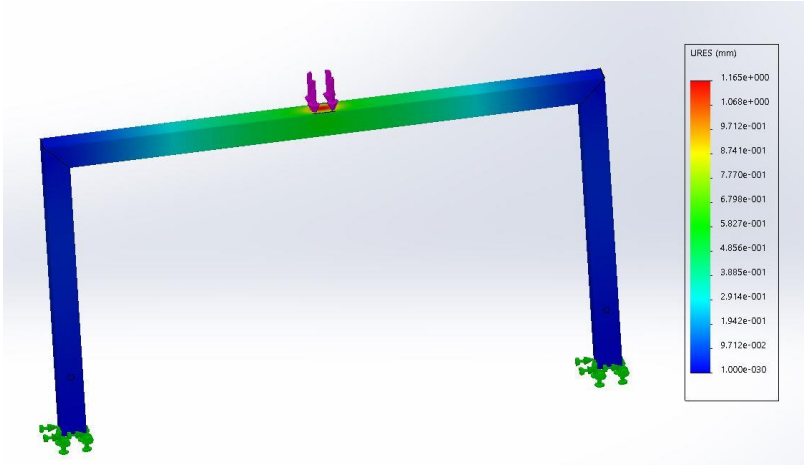


Figure 33: Construction bow

Material

To choose the right material for its purpose the program that's called CES Edupack is used. This program helps to funnel the materials to a small group of materials to choose from. The understanding information shows the limits we put up to choose the material:

- Material in 'Bulk Form'
- Price of 2 EUR/kg
- Recyclable
- Only Metals and alloys
- Hot metal extrusion as shaping process (because of the hollow square form)
- Graphic that shows Young's modules (GPa vs. Price (EUR/kg)

Now we set all the different limits the next step is to look at the graphic. In the image shown below there are only a couple colored dots. These dots are the only left over materials that can be used for our product (from 3986 to 552 materials).

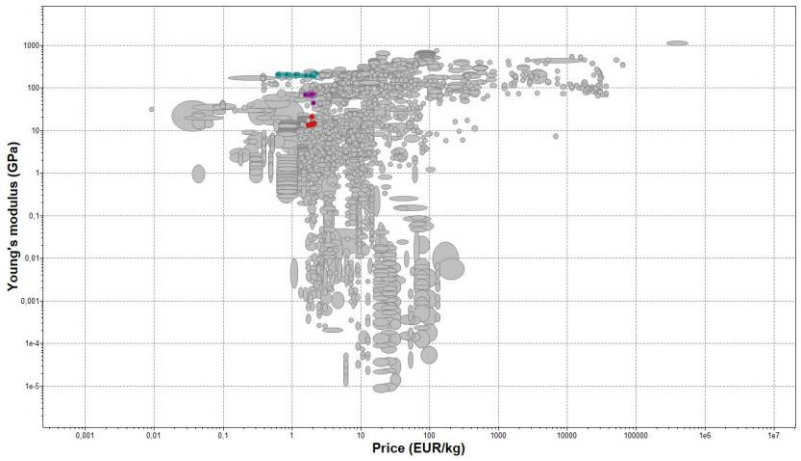


Figure 34: Graphic all materials

After that an index and display line is added. This line shows a balance between the Young's modules and the price. So the strongest material with the lowest price is shown eventually. In the image shown below is the line with the leftover materials. This line is based on the following formula E^(1/2)ρ. This is the formula for a beam structure (others are for a panel or tie).

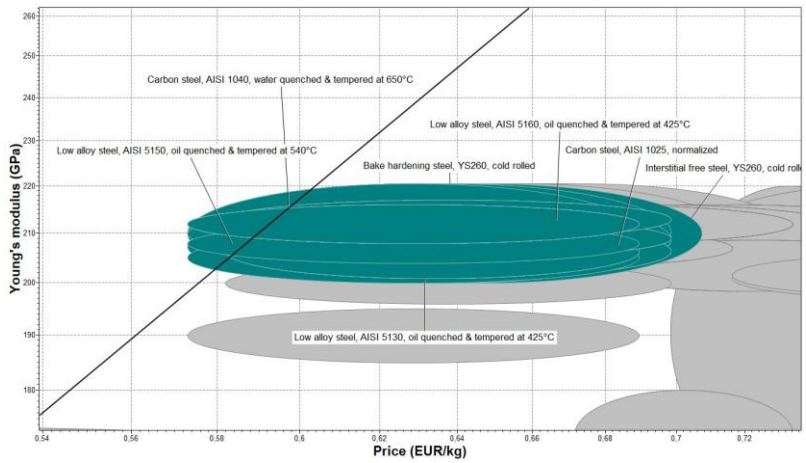


Figure 35: Material chart inzoom

All these types of steel are really close together, but eventually is chosen for a Carbon steel. The specific type of carbon steel is not specified as it depends on the manufacturers possibilities. Carbon steel is the ideal steel for our project as it can be recycled, easily welded, easy to process and very cheap. It's not stainless witch can be seen as a downside, but the structure is going to be powder coated so the structures steel wont rust.

Joining

First of all, the construction bow forms the basis of the complete product. So many other parts will be connected to the structure. To join the pieces together stainless steel nuts and bolts will be used. This is done so there is no need to weld anything to the construction bow and it is also easy to remove.

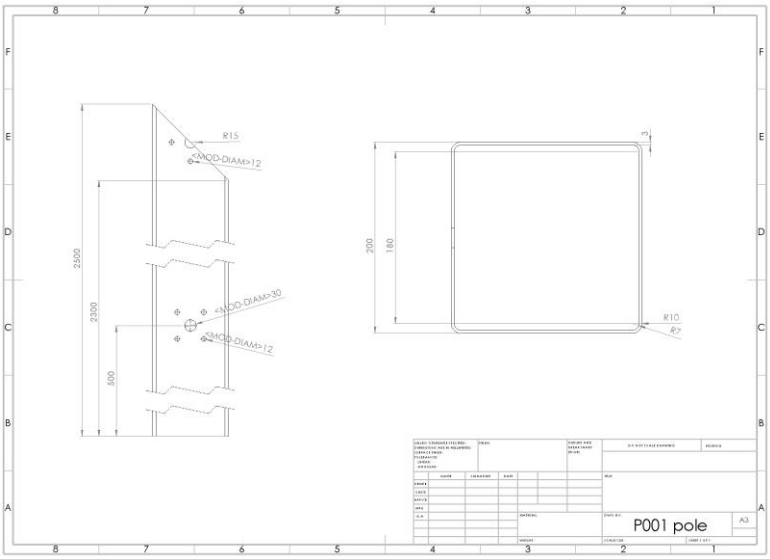
Surface treatment

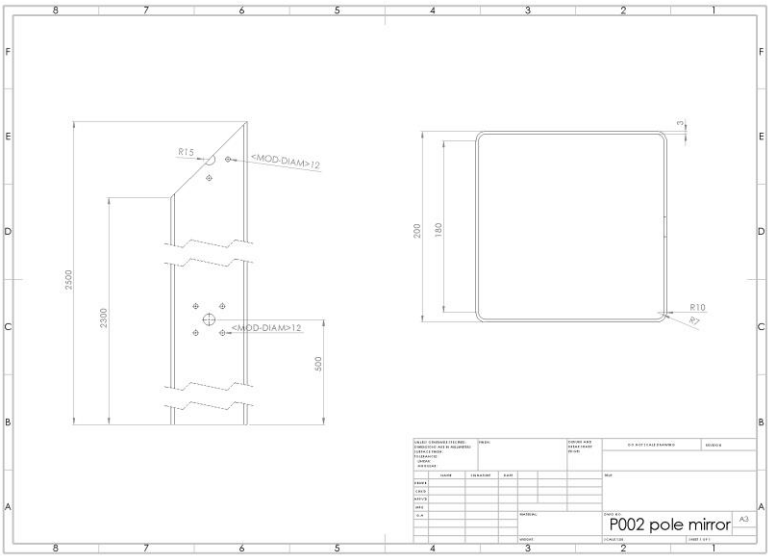
For the surface treatment of the construction bow are two different types of surface treatments used.

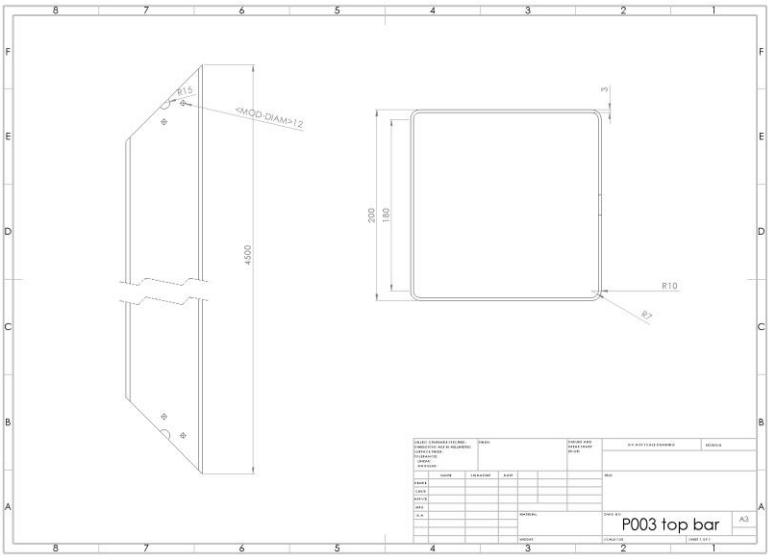
- Hot-dip galvanizing
- Spraypaint

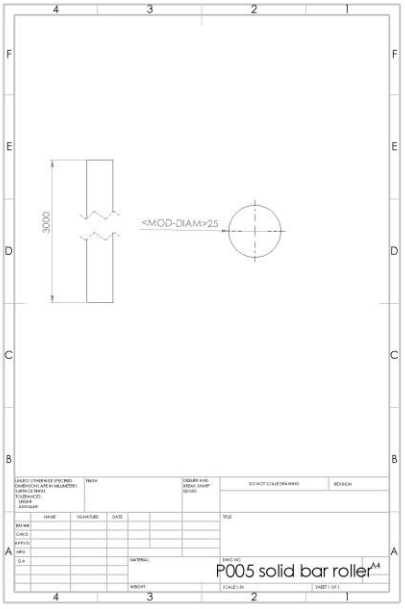
Hot-dip galvanizing: This is a surface treatment that is often used to protect metals from corrosion. It is an excellent long-term corrosion projection. Galvanizing is preferred over painting because of a metallurgical bond between the coating and underlying steel. Also because the construction bow uses hollow beams the inside can also be protected from corrosion. In terms of economics, galvanizing is inexpensive, despite being energy intensive. And also the coating has a very good resistance against mechanical damage. But if we look at the environment, it uses some hazardous chemicals for the process.

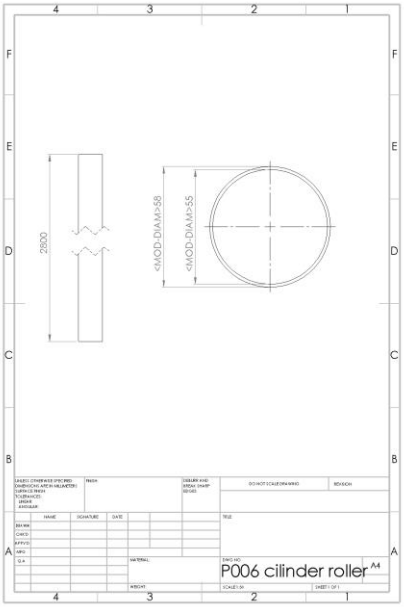
Spraypaint: As hot-dip galvanizing does not give the construction bow a particular color a final surface treatment is added to match the esthetics of the product.

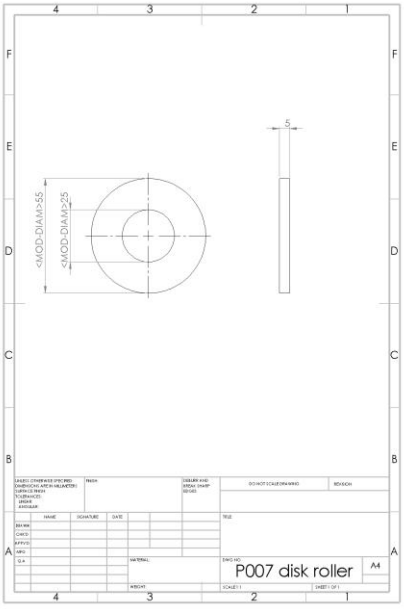



R15
<MOD-DIAM>12
2500
2300
<MOD-DIAM>12
500
200
180
R10
R7
P002 pole mirror
A3


R15
<MOD-DIAM>12
4500
200
180
R10
R7
P003 top bar
A3


3000
<MOD-DIAM>25
P005 solid bar roller
A4


2800
<MOD-DIAM>58
<MOD-DIAM>55
P006 cilinder roller
A4


5
<MOD-DIAM>55
<MOD-DIAM>25
P007 disk roller
A4

Appearance prototype

Figure 36: Prototype

Components prototype

The prototype will be having a total different approach than the original product. It will function like the final product, but it will be 1/5 of the original size. Also it will be made out of wood which is an material that can be easily processed for prototypes. All the electronics will be put underneath the base plate. This is done because the construction bow is made out of wood, so it won't fit in the structure. Here we see the schematics for the electronics layout

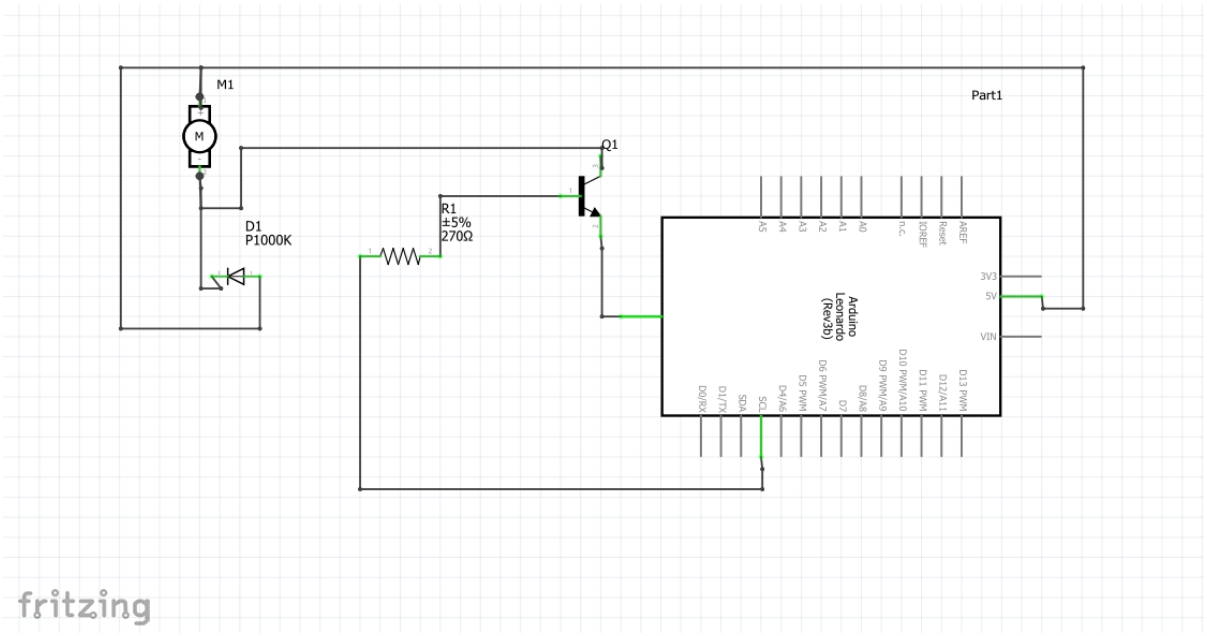


Figure 37: Electronic Schematics

Materials prototype

Number	Description	Material	Supplier	Component reference	Quantity	Unitary price	Final price
1	40*40*2400 structure	Wood (Pine)			2	5,81	11,62
2	700*1000*10	Wood (multiplex)			1	9,95	9,95
3	2700*9ø	Wood (Pine)			1	2,29	2,29
4	Inside 9ø mm bearing	Metal (Stainless steel)			6	2,06	12,36
5	5000*500	Polyester			1	9,81	9,81
6	Woodglue	Woodglue			1	1,59	1,59
							Total: 47,62

Table 18: Material List

7.4 Functionalities

Automatic sun shader: We are going to use an algorithm that calculates where the sun is positioned in relation with the geographical point where the shader is placed. The values provided by the algorithm are going to insert data into the controller and that data will be sent to the actuator. This is a very reliable way to locate the sun because there are some factors that can't affect the data collecting, such as weather conditions or any kind of external influence, these problems can be found when a light sensor is used. The data will be provided to the arduino board form time to time.

Manually controlled sun shader: If the user wants to control the shader himself, he can easily use his phone. In this case, the phone replaces the algorithm. There exists an app called “Blynk”. It was developed to control an Arduino with the phone in an easy way. There are many possibilities to connect with the Arduino (USB, Ethernet, Wifi, Bluetooth etc.). The setup is very easy: upload the sketch on the board and immediately it is possible to add buttons, sliders, value displays, graphs and many more.

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