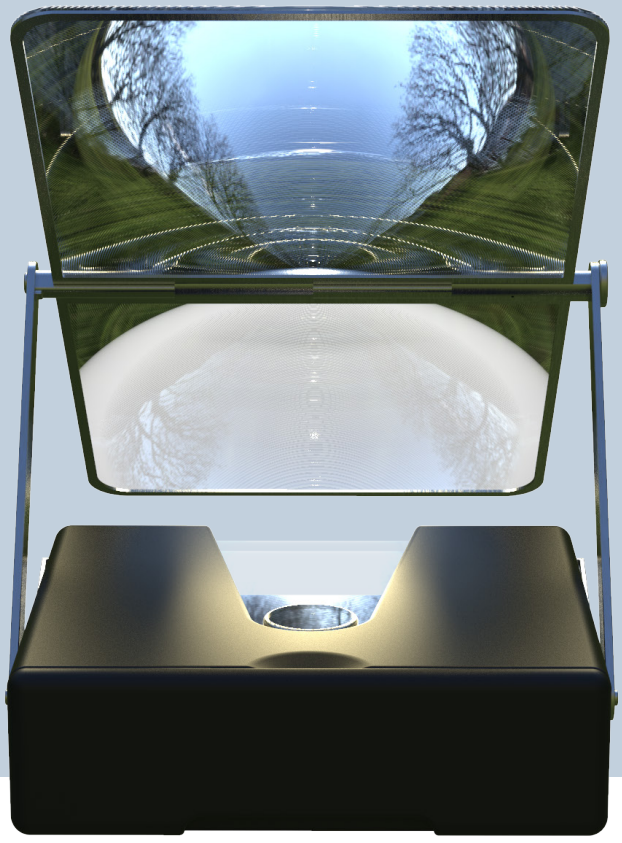
SUN IT

PRODUCT REPORT

Clara Rodriguez Ríos / Ofelia Anna Cornelia Hove / Péter Császma

JUNE 2021



MSc04 / ID05

AALBORG UNIVERSITY

Industrial design

Title
SUN IT

Report
Product

Theme
Solar cooking

Project theme
Master Thesis

Project period
01.02.2021 -03.06.2021

Supervisor
Christian Tollestrup

Technical supervisor
Radoslav Darula

Pages
24

Clara Rodriguez Ríos

Ofelia Anna Cornelia Hove

Péter Császma

ABSTRACT

The purpose of this Master Thesis project was to create a a new innovative product meant to combat the amount of waste created using disposable grills during summer. The proposed solution offers a sustainable and fire-safe alternative for cooking outside during summertime and aims to spread this danish tradition all over the globe.

The ambition of the product is to create awareness around how the available resources on earth are used, and to take advantage of the resources that will not run out, like the sun. This has been achieved by the development of a product that uses a Fresnel lens and thereby benefits from the power of the sun. The use of this simple and effective technology should create awareness among people in a country like Denmark, where Outdoor cooking is a big part of the Danish summer culture. The result is a portable and durable product, designed to live up to modern living standards.

The product proposal has been developed in collaboration with Artlinco, who has assisted with feedback and knowledge in materials and manufacturing processes.

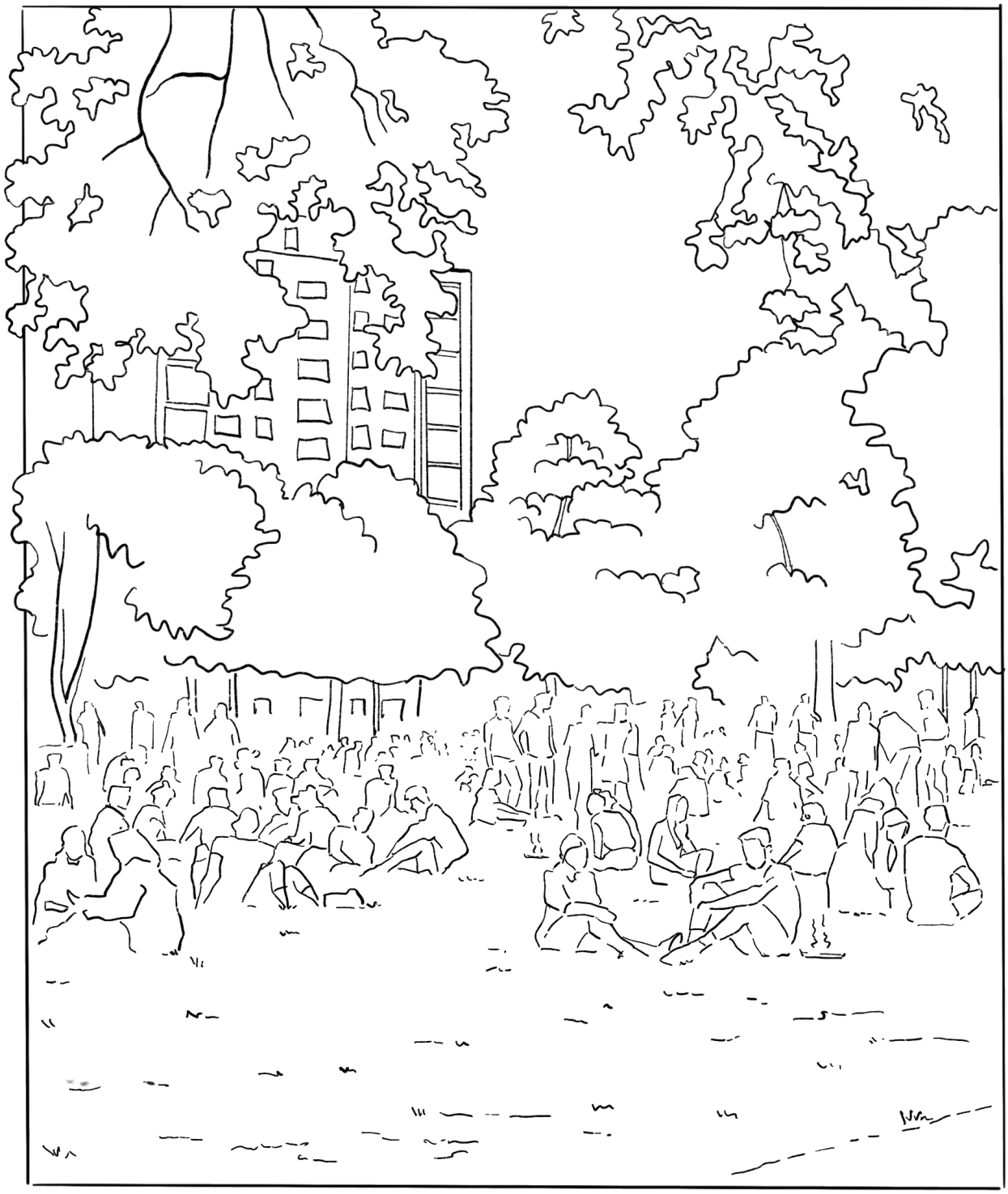
TABLE OF CONTENT

OUTDOOR COOKING

Outdoor cooking is a big part of the Danish summer tradition. It is an activity that creates a gathering point for friends and family. During summertime, as soon as the sun goes out, those who live in the city tend to go to public green areas like the parks to enjoy the day.

Outdoor cooking today mainly relies on the use of gas or charcoal to heat the grill. In public spaces, people tend to go for the quick and easy solution; the disposable grill. This results in a big amount of used and thrown grills. The use of gas or charcoal in both disposable and portable grills contributes to carbon emission and also increases waste production. Together with the risk of creating a fire, the existent solutions seem to have left space for improvement.

The sun took us out and we took him in.
The energy that brings the sun's presence is the reason we left our houses. Why do we not make use of this energy source instead of the polluting alternatives we use nowadays?



SUN IT

Light and portable

A sustainable alternative that uses solar power

Avoids the risk creating fires

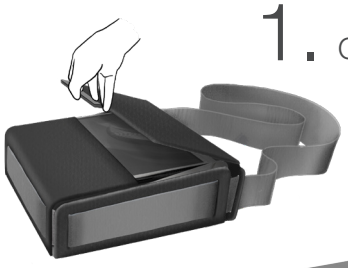
Upgrade in the picnic experience by offering the possibility of cooking juicy food in a stylish and modern way

A durable and long-lasting product that requires low maintenance

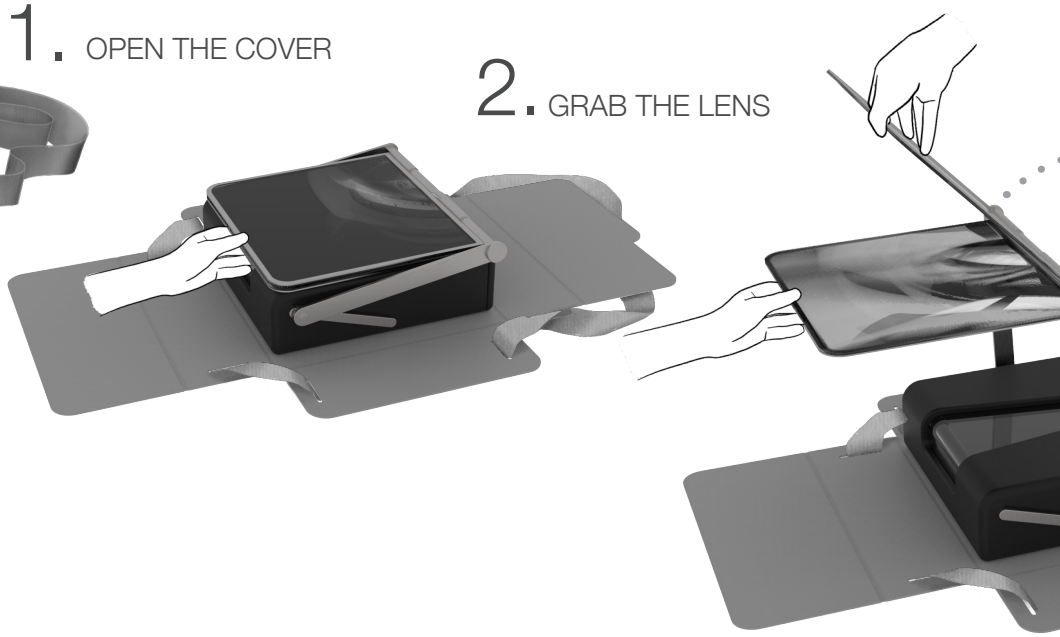
SUN IT is a new innovative way of cooking food outside with friends and family during the summertime.

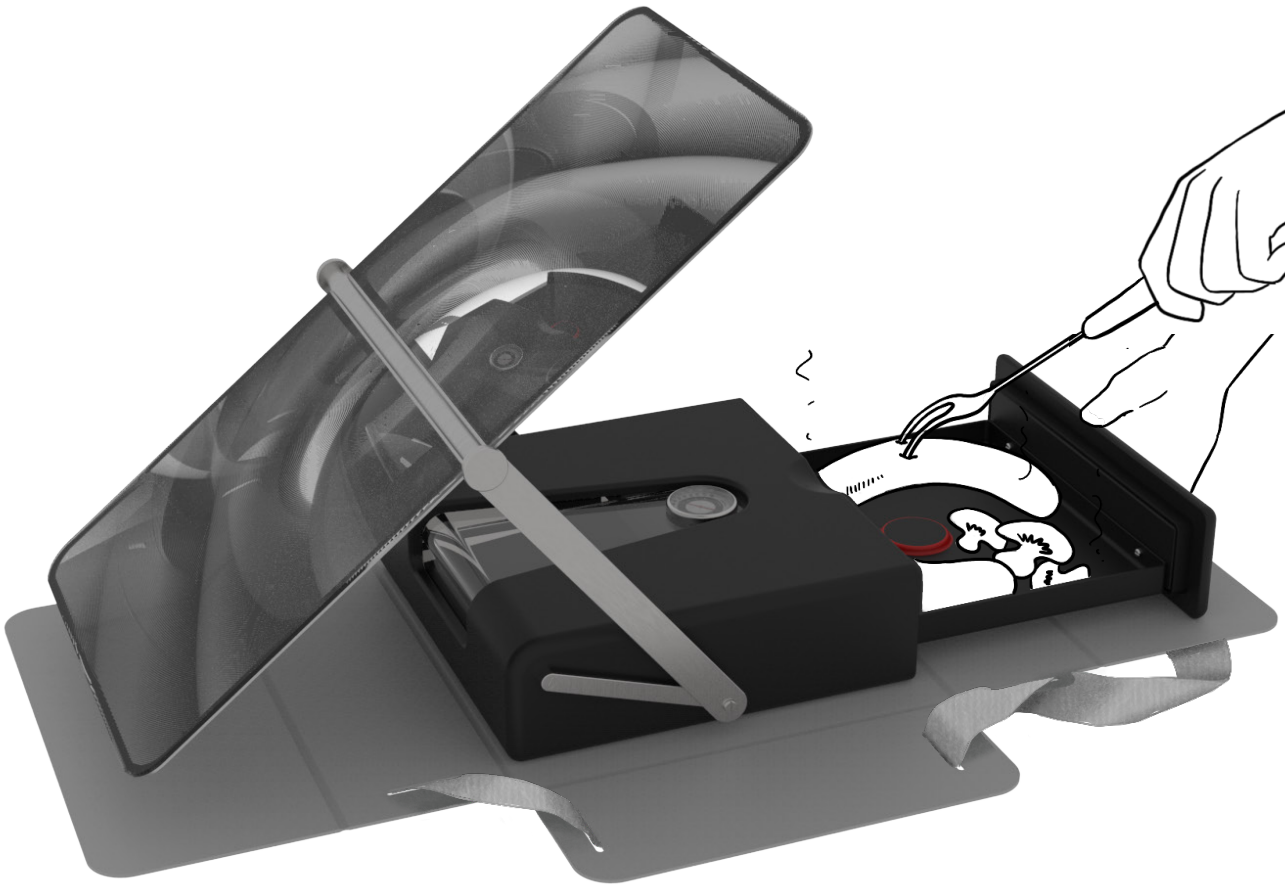
The mission of SUN IT is the creation of a cooking product capable of living up to the modern life standards thus avoiding the waste of an energy source. This product proposal creates an opportunity to benefit from the power of the sun by using it to cook food. Reducing the carbon footprint of the current solution and moving a step forward towards a more sustainable world.

1. OPEN THE COVER

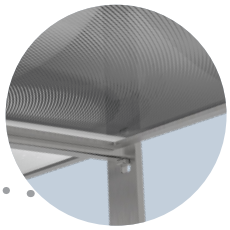


2. GRAB THE LENS

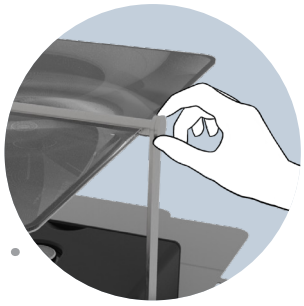


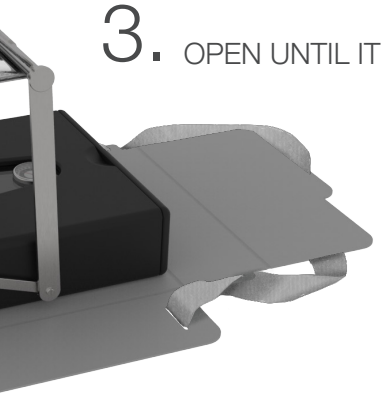


6. SUN IT UP!

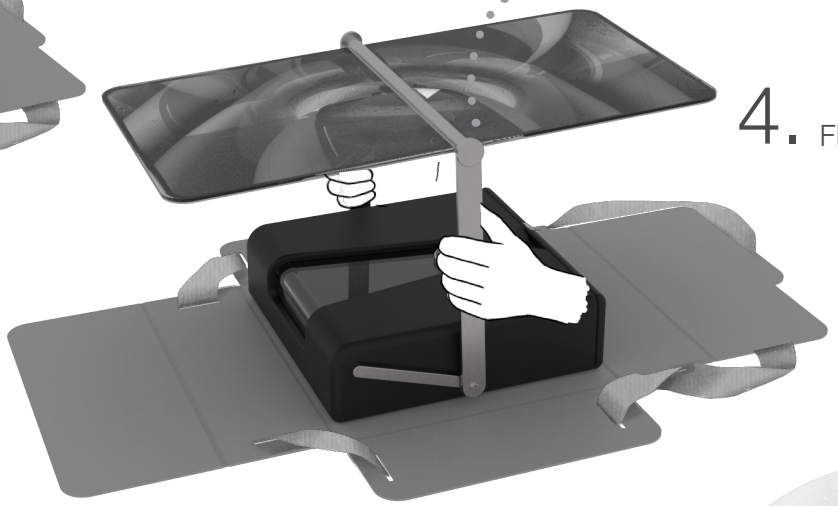


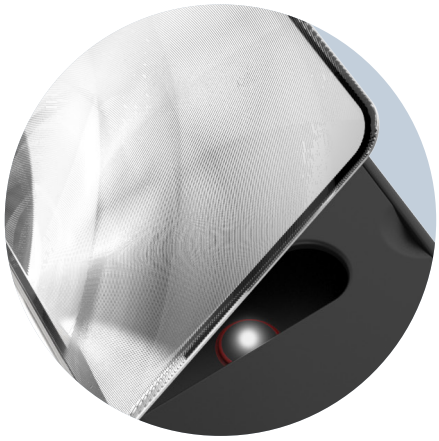
3. OPEN UNTIL IT STOPS

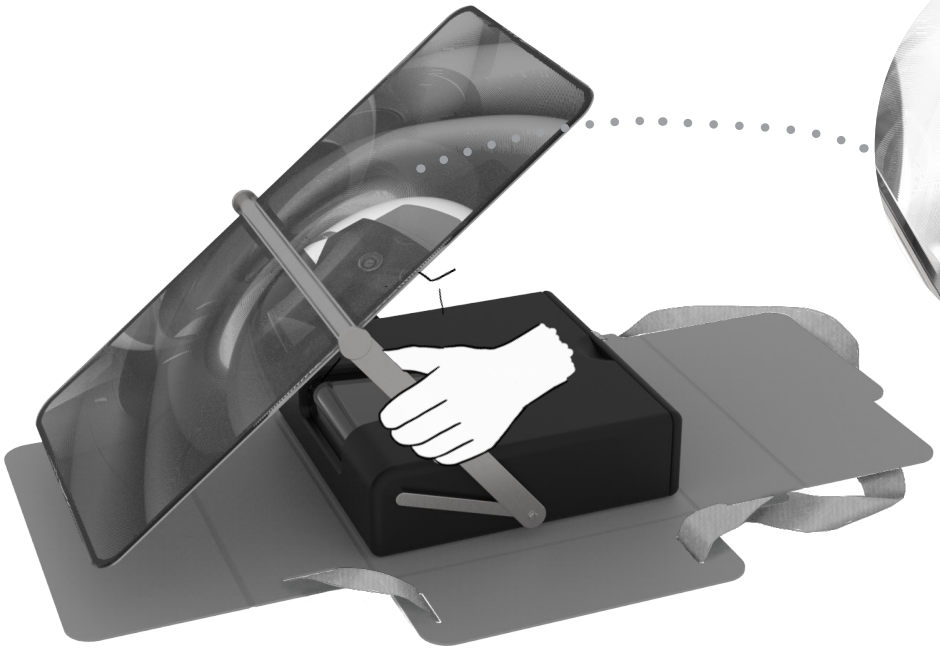




4. FIX THE POSITION

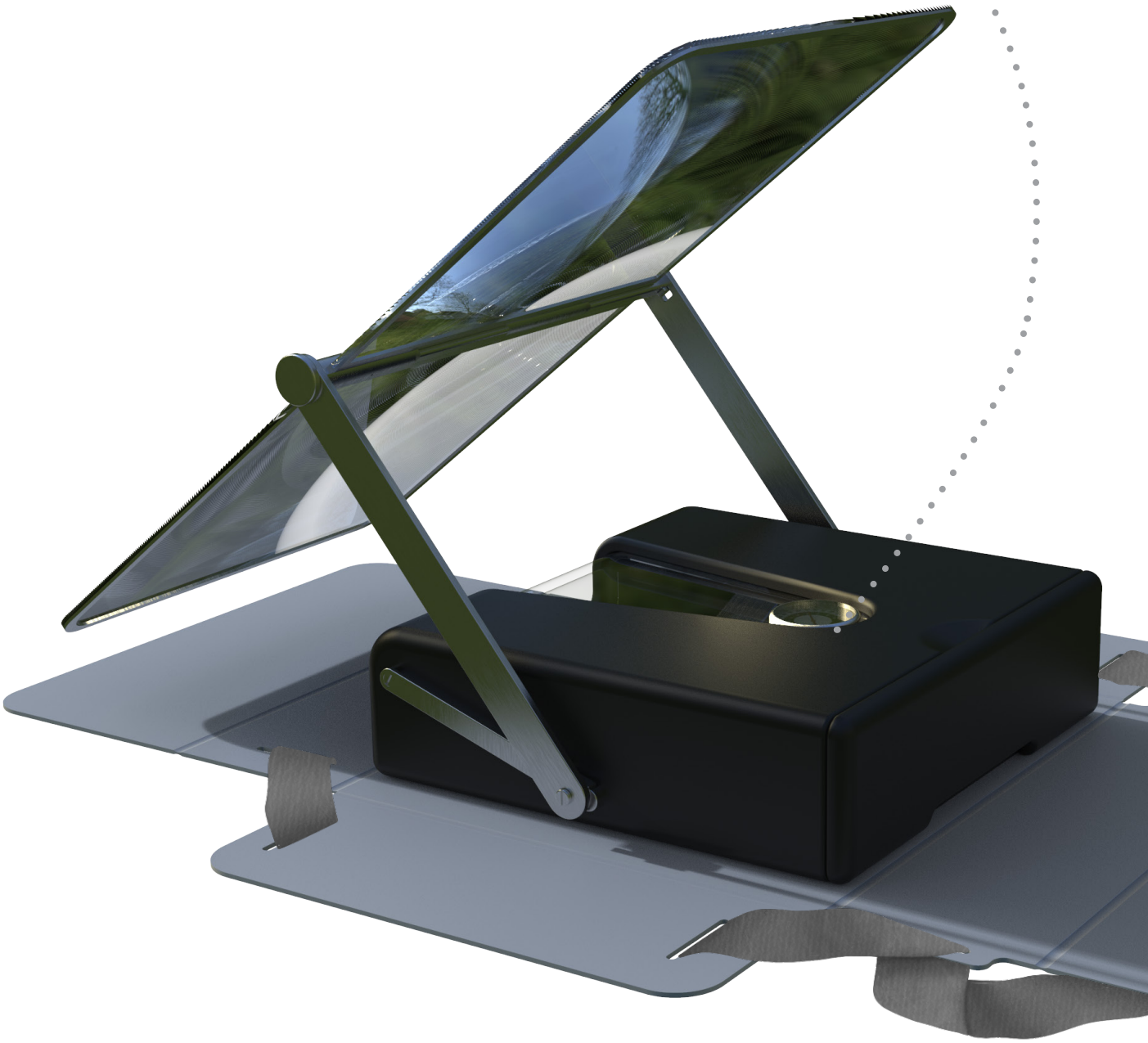


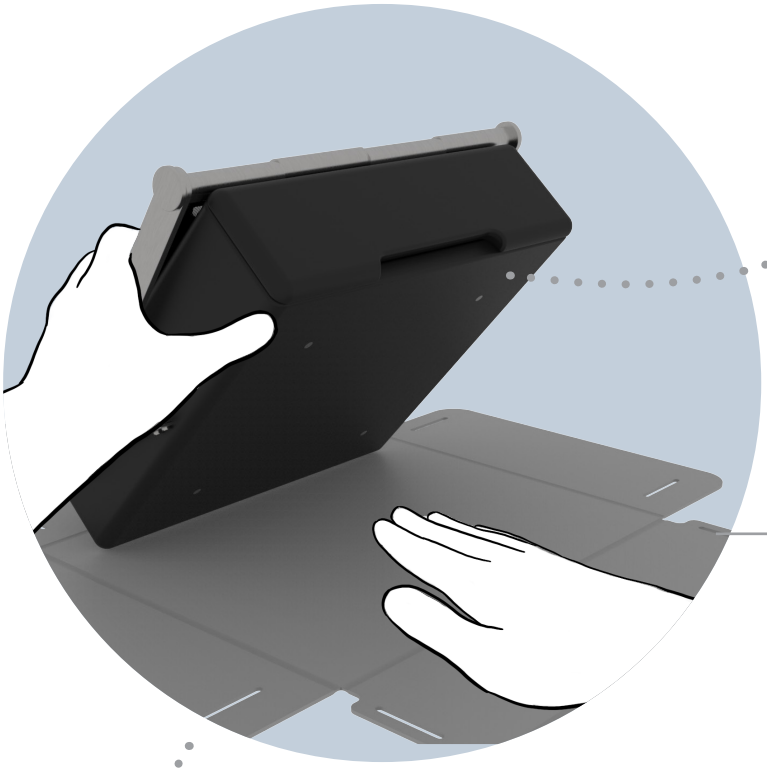




5. TILT IT UNTIL YOU CAN SEE THE LIGHT INSIDE THE RED TARGET

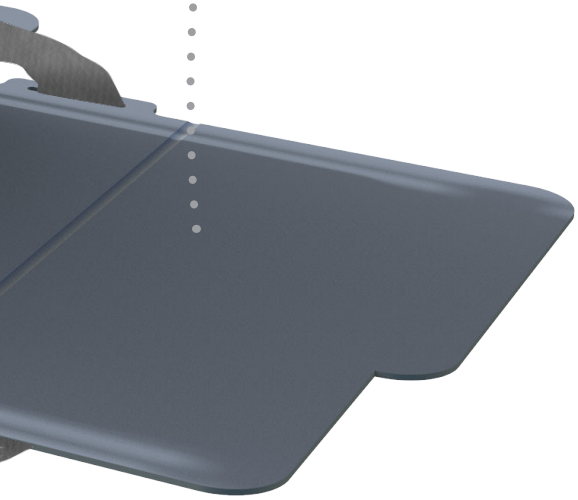
THERMOMETER



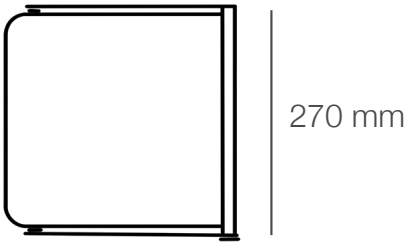


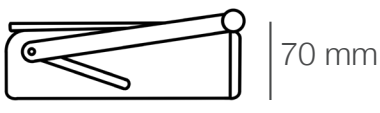
MAGNETS (X 4)

EASY TO REMOVE COVER



GENERAL DIMENSIONS





240 mm

HOW DOES IT WORK?

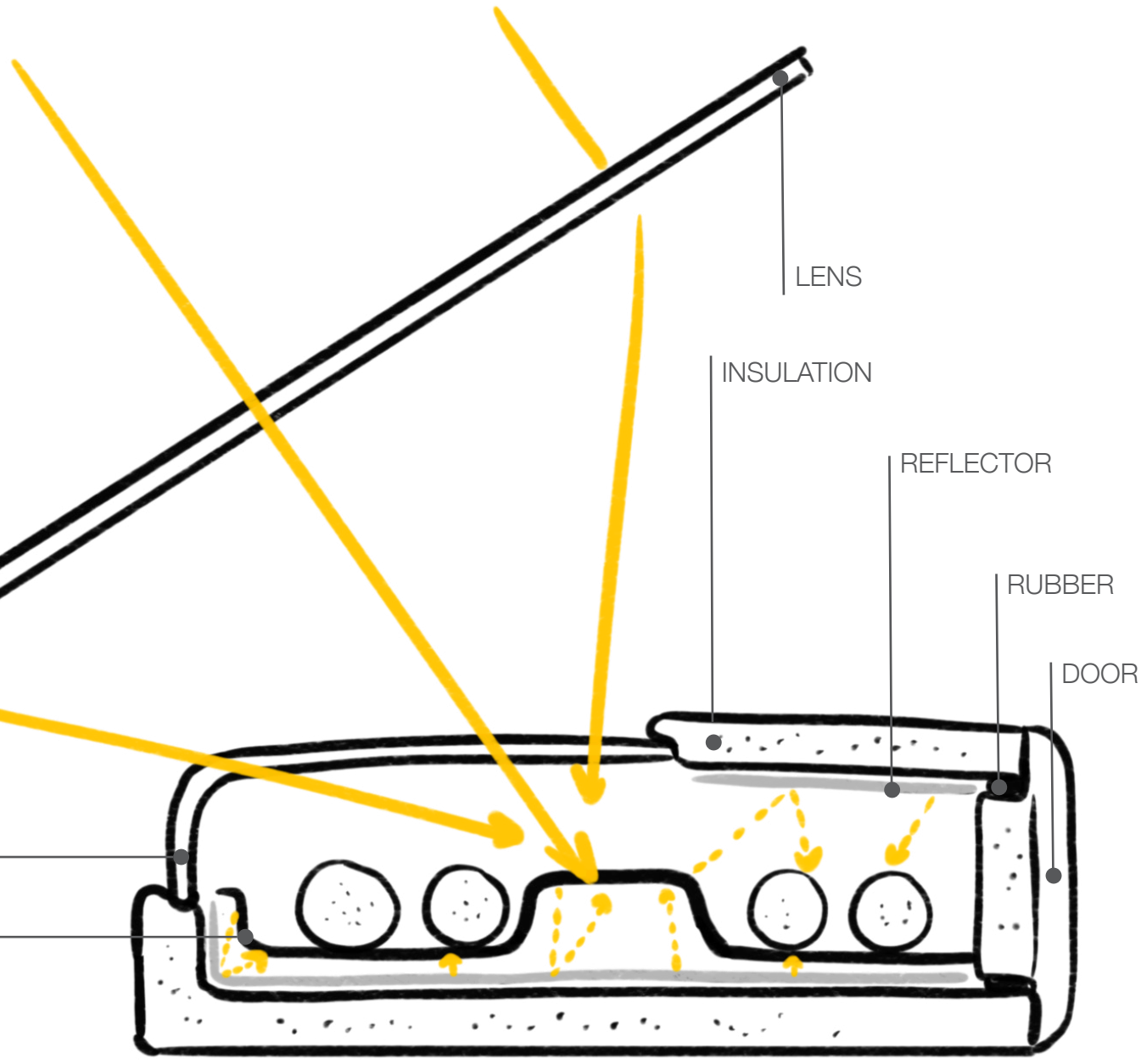
WORKING PRINCIPLE

SUNIT´s Working principle is based on the power of focusing from the sun with the help of a Fresnel lens. They follow the same physical principle that magnifying glasses do, but in a lighter and more customizable solution.

When SUNIT is correctly orientated towards the sun the light is focused on a centered elevation in the tray. This causes the surface to achieve high temperatures, as the focal point of the lens can easily heat up to 300C.

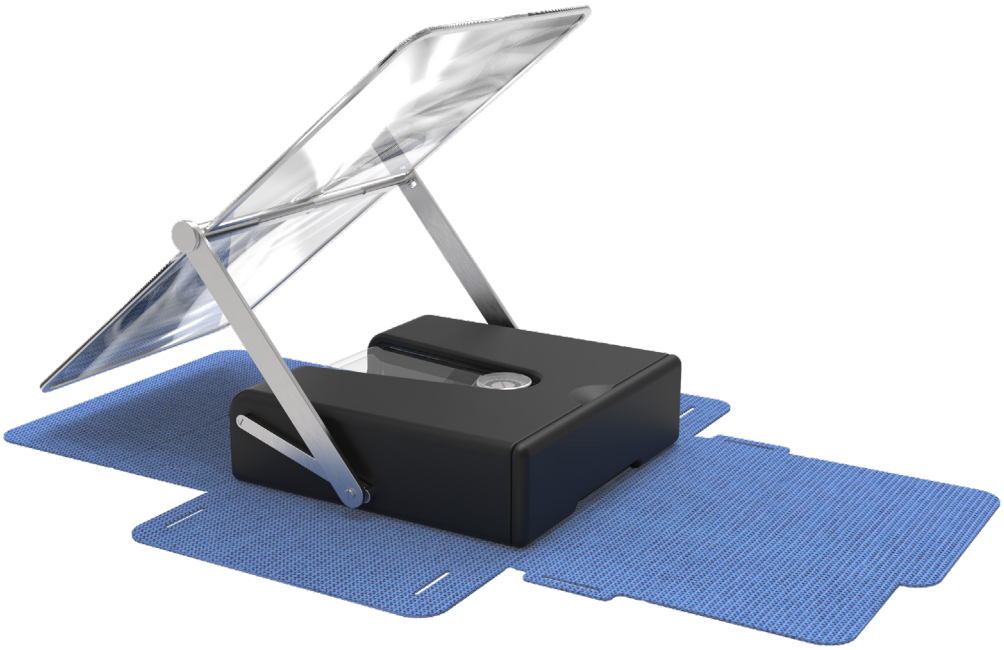
The heat is transferred from the tray to the food. The hermetic closure of SUNIT, made by a rubber seal around the door, causes the retention of the heat inside the box.

To improve its efficiency SUNIT has well-insulated walls that are also covered with a reflecting surface on the inside, causing the heat emanating from the hot tray to be reflected back to it.


LENS
INSULATION
REFLECTOR
RUBBER
DOOR

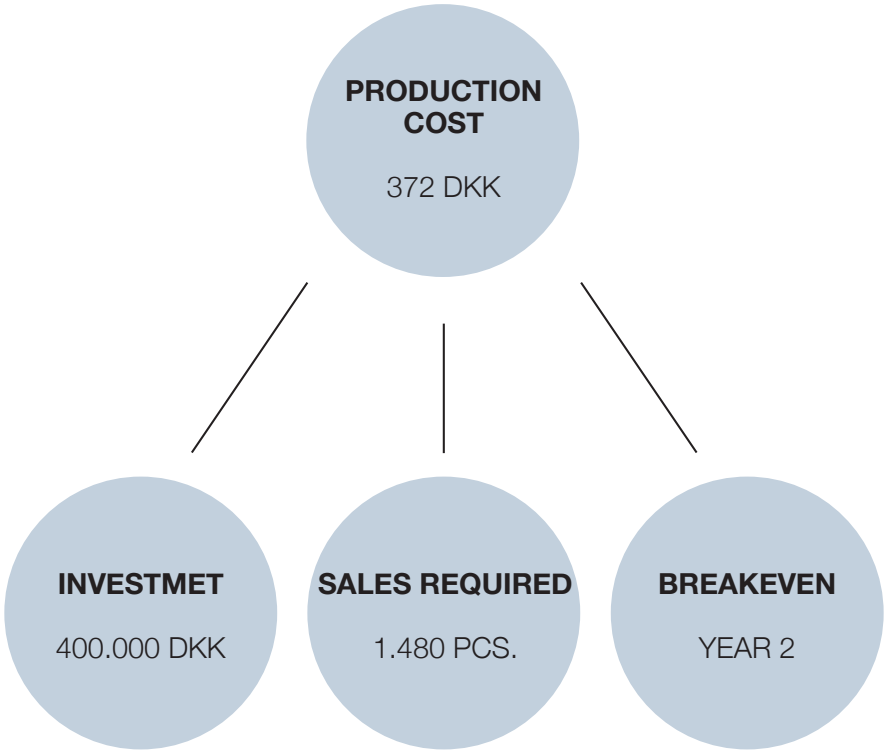
TAKE IT EVERYWHERE

GIVE IT SOME COLOR!



PRICING

The pricing of SUN IT is based on broader market research, keeping the sales price on the same level compared to products in the same category can put SUT IT t in a beneficial position, offering new and different solutions for the same amount of money. The price is also reflected by the production cost and having a healthy business with a positive turnover in the long run.

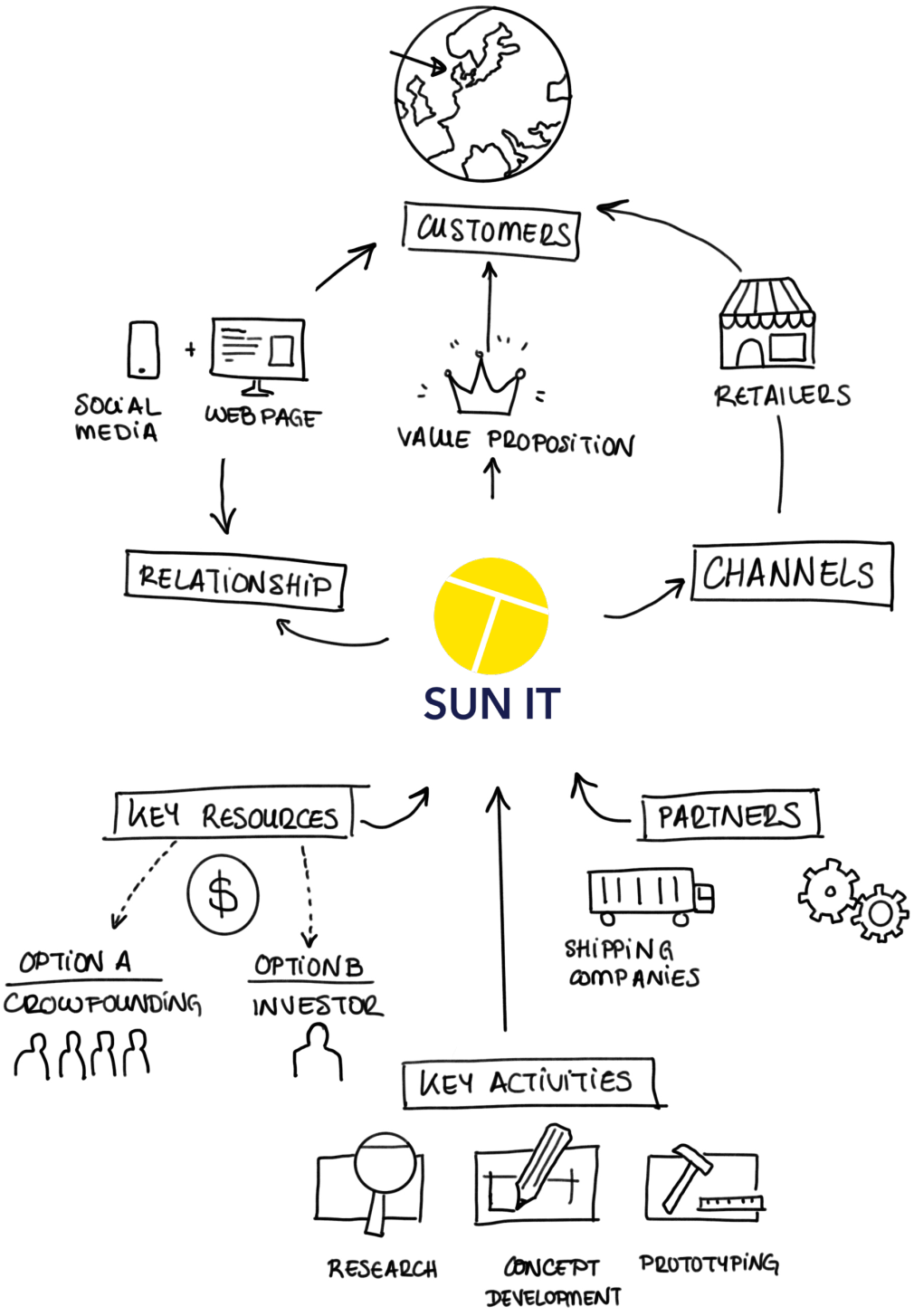


COST AND INVESTMENT

The initial investment is 400.000 DKK. The largest costs are primarily due to the cost of developing prototypes and investing in tooling costs. The investment also covers the cost of not selling the product on the market the first year, as the first year is for prototype development.

The aim is to hit 0,1 % of the target group in Denmark in the second year. The result is breakeven in the second year after 1480 sold units.

BUSSINES MODEL



EXPANSION

Denmark has a tradition of grilling and is willing to spend money on this product area. The product is expected to be easily expanded to the Scandinavian countries: Norway and Sweden due to the similar weather conditions and a similar culture of grilling in green public places.

Afterwards, the product will get expanded to the southern European countries. The Mediterranean countries often have fire regulations during the dry summer. SUN IT creates a new opportunity for the Mediterranean countries to cook food outside without the risk of starting a fire.

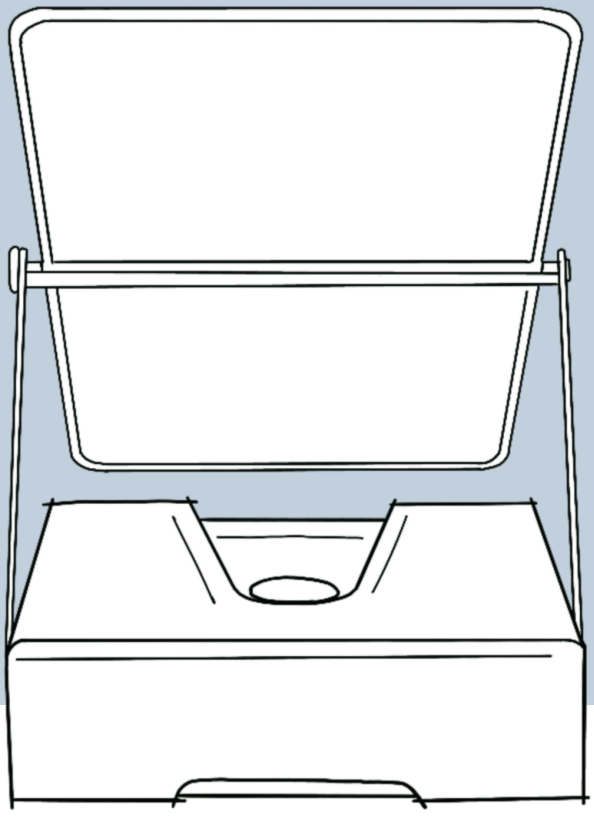
SUN IT

SUN IT

PROCESS REPORT

Clara Rodriguez Ríos / Ofelia Anna Cornelia Hove / Péter Császma

JUNE 2021



MSc04 / ID05

AALBORG UNIVERSITY

Industrial design

Clara Rodriguez Ríos

Ofelia Anna Cornelia Hove

Péter Császma

PREPHASE & ACKNOWLEDGEMENTS

This project is developed by the team MSc4ID05, at Aalborg University. The report is the final result of a Master thesis in Industrial Design. This project contains three reports; a product report, a process report with a following appendix and a folder of the technical drawings. The project was developed from February 1, 2021, to June 25, 2021, with a hand-in date of June 3, 2021.
The development of the project has been in collaboration with the company Artlinco. They have assisted with feedback and knowledge during the development process.

For the great feedback and guidance, a big thanks to our supervisor Christian Tollestrup, and co-supervisor Radoslav Darula for technical support. Thanks to Søren Xerxes Frahm, founder and CEO of Artlinco for a great collaboration. Lastly, thanks to all users for great feedback and support.

THE TEAM

Title
SUN IT

Report
Process

Theme
Solar cooking

Project theme
Master Thesis

Project period
01.02.2021 -03.06.2021

Supervisor
Christian Tollestrup

Technical supervisor
Radoslav Darula

Pages
100

ABSTRACT

The purpose of this Master Thesis project was to create a new innovative product meant to combat the amount of waste created using disposable grills during summer. The proposed solution offers a sustainable and fire-safe alternative for cooking outside during summertime and aims to spread this danish tradition all over the globe.

The ambition of the product is to create awareness around how the available resources on earth are used, and to take advantage of the resources that will not run out, like the sun. This has been achieved by the development of a product that uses a Fresnel lens and thereby benefits from the power of the sun. The use of this simple and effective technology should create awareness among people in a country like Denmark, where Outdoor cooking is a big part of the Danish summer culture. The result is a portable and durable product, designed to live up to modern living standards.

The product proposal has been developed in collaboration with Artlinco, who has assisted with feedback and knowledge in materials and manufacturing processes.

COLLABORATNG PARTNER

Artlinco is a Danish consultancy with over 350 projects and close to 20 years of experience. They highlight their skills as following:

- Insight into customer, market, and competitor
- Innovation, development, and concrete solutions
- Implementation and realization

Before starting the project, we knew we wanted to work with a problem case that was “real”. The company Artlinco got contacted. They presented a range of different cases to work on for the project. We ended up choosing the one we saw potential and challenges in, which was the idea of making a solar cooker for hikers. During the research phase, it will be possible to see how the original proposal from them was redefined into a slightly different challenge, which will be the driver of the final product proposal.

The interest of this collaboration is that both parties gained something good. Artlinco got the opportunity of having a free collaboration project to increase its portfolio. And we got the benefit of their knowledge and experience from the 370 they have already been part of. Thanks to this collaboration, we also got extra guidance through the process with a foot in real-life experience.

READING GUIDE

This project presents four documents. It is recommended to read the documents in the following order: Product report, Process report, Technical drawings and Appendix.

01: Product report; represents and defines the final product and key-aspects

02: Process; describes the development process in more detail of the products appearance, aesthetics, use, functionalities, construction, manufacturing and business aspects.

03: Technical drawings; communicates the construction and assembly of the proposed product

04: Appendix; represents worksheets

The report has been divided into five parts: framing, concept development, detailing, implementation, and epilog, to present the process understandably.

Sources are presented by the Harvard method. The sources are shown directly in the text, and the full source is at the end of the process report. The illustrations are numbered chronologically, with the full list at the end of the process report. All documents in the appendix will be referred to in the text.

0

Alignment

1

Framing

2

Concept development

3

Detailing

4

Implementation

5

Epilog

INTRODUCTION

In Denmark, outdoor cooking activities are a big part of the national DNA and lifestyle. During summer, people enjoy spending time in the parks around the city doing a picnic, grilling, listening to music and chilling. Nowadays, the most popular products used in these activities are disposable grills and portable gas/charcoal grills. The disposable grills hardly ever get recycled, and the result is the creation of an enormous and unnecessary amount of waste. These products have the risk of creating a fire. That is why in most southern European countries, fire regulations prohibit using any of these products.

The project is driven by the desire of walking towards sustainability by taking the best possible advantage of natural resources. This project will look into a new innovative way of developing a durable outdoor product that offers a sustainable alternative, which gives people the possibility of cooking outside without the risk of creating a fire.

This project´s main challenge is fitting an existing technology, the Fresnel lens, into a product and to find a smart and feasible way of using solar power, in a concrete context where it also creates a value proposition. The value chain of the project can be considered a technology push (Hansen, 2019), that is why a big part of this project is based on experimentation.

The focus of this project is not to solve the current context of a product, but to push a change in the way people address outdoor cooking today. That is the reason why this project can be considered as design-driven innovation more than a user-centred design. The aim is not to optimize an existing product but to change it. (Haase and Laursen, 2019)

01 FRAMING

This chapter unfolds the discovery of the problem case and the choice of direction. This has been done by digging into the chosen scenario and the target group for the product proposal, understanding what needs and problems the final product proposal should fulfil.

An analysis of the current portable-cooker market will help to understand the market potential of the proposed idea, the context and the remarkable characteristics of existing products.

After this, research in solar power methods will help set the technical direction of the project. Research about cooking will be unfolded, regarding the different cooking temperatures for food and the cooking methods.

The chapter will finally end with a design brief that will translate the gathered information into a list of goals this project will aim towards.

1.THE STARTING POINT

1.1 FIRST DIRECTION

The first phase of this master thesis project was to find a problem case to work with. The problem case had to be able to be solved by developing a product, within the given time frame.

The first direction considered was the development of a solar stove for developing countries. After reaching out to different contacts in Africa, it was possible to realize, that was not a way to go.
The problem case was found, after contacting the design consultancy, Artlinco. They offered the following challenge:

“Design a light, compact sun cooker for hikers.”

Both the proposed context and technology needed to be validated before starting the design process. The first step was, therefore, a quick context evaluation, that will end up in a clear project frame.

CONTEXT VALIDATION

An investigation into hikers routines was set-up, to validate the proposal. The result of the investigation revealed that it would be a dead-end to go in that direction (see interviews in appendix 1).

When hikers go on a trip, they pack as light and compact as possible. They usually cook in the evening, when there is no sun. They can not count on the sun to be there, so if they had a solar cooker, they would need a backup cooker, which means double space and weight. Therefore, this scenario did not fit this product case.

It was needed to go into a new direction and the main requirement this had to fulfil was the following:
Finding a scenario where the sun was important and always present.

Finding a scenario where the sun was important and always present.

1.2 CHANGE OF DIRECTION

The reasons that constituted the decision making in the new choice of direction were the following:

THE PERFECT SCENARIO

'The Scandinavian tradition of outdoor cooking in the parks during summertime.'

Through observation, it has been possible to set and verify a trend. Due to the harsh weather conditions of winter, in general, Scandinavian people will not get out of their home as much, since rain, wind and cold make it difficult to enjoy outdoor activities.

However, when summertime comes, there is an exponential increase in outdoor and lots of people can be found in the parks picnicking. It was observed that this activity changes during summertime depending on whether the sun is out or not. The days the sun shines and the temperature is warm ,the parks are more crowded with people than usual. That may seem a vain and obvious realization, but it shows a clear relationship between the sun and the picnic activity, making the sun play a major role in this kind of activity. Therefore it is almost possible to guarantee its presence in this scenario, making it the perfect fit to develop a solar powered cooker.

A GREAT TARGET GROUP

There is a significant potential regarding the target group: the target group can be considered almost as wide as the one for a pan, as there is not a specific type of person who likes to cook food outdoors.

Because the target group is wide, there will be a focus on the younger generations since the tradition of grilling outside in parks or beaches is mainly practiced by young people and families.

An advantage of this target group is its availability and easy access.
There is rising interest in caring about the environment in the younger generations. And also, this group is expected to be open to new solutions/technologies since they are part of the younger generations and are more used to new technological trends, which also fits with this project proposal.

AN EXCITING CHALLENGE

The team found this theme to be exciting. The theme offered the possibility of digging deep into an unknown technology and an opportunity of making a product out of it. The challenge is to create an interesting value proposition both for the target group and for the environment.

ill. 1 The context

1.3 PROJECT POTENTIAL

AN OPPORTUNITY FOR CHANGE

Further research and observations helped to see the potential this project could have:

FIRE LIMITATIONS

One of the biggest drawbacks of the current solutions, especially the disposable grill, is the risk of creating a fire. When people are done grilling and need to throw out the grill, they tend to forget that the charcoal is still hot. That results in melted trash cans or the trashcan set on fire. (Færre vælger engangsgrill, 2015) People often tend to forget that it is not allowed to place the disposable grill directly on the grass, as it leaves a burned spot. (Grill – Se hvor du må grille, n.d.) And in some cases, the grill gets dug into the sand, so others at the beach will risk getting burned on it. (Grill med ren samvittighed, 2018)
People risk getting burns on their feet due to people who set up the grill directly on the sand, which leaves the sand burning hot. (Færre vælger engangsgrill, 2015)

During the summertime, there will often be specific fire regulations due to dry periods. In Denmark, it's allowed to grill in most parks and beaches. In dry periods it's important to check where it's allowed. (Grill i naturen – Er det tilladt? - GrillStart.dk, n.d.)

However, in most southern countries, this tradition is not allowed due to fire regulations. That is part of the opportunity this project represents since it opens up the possibility of creating a fire-free product that could expand this tradition and upgrade the outdoor cooking experience of people.

ENVIRONMENTAL AWARENESS

The two most popular products in the market are portable charcoal/gas grills and disposable grills:

A disposable grill consists of approximately 0,5 kg of charcoal.(Nordic Season engangsgrill - 23 x 30 cm - Grill og grilltilbehør, n.d.) 1 kg charcoal emits around 3 kg of CO2. That ends up in a very high number, as people tend to grill more than once in the summer. (Buckwalter, 2019). One of their biggest advantages of disposable grills is their convenience. They are a very cheap and easy-to-transport product. However, the trays are often left at the beach or park and rarely get recycled.

A press release estimated that half a million disposable grills are being sold in Denmark. In Norway, this number is 1,2 million each summer. That means a high CO2 emission each year, just on grilling with disposable grills. The press release shows that the sales are falling on disposable grills, this might mean a positive tendency to a change of behaviour. (Færre vælger engangsgrill, 2015)

Most portable grills use charcoal. Fossil coal emits a lot of CO2, and the charcoal will often keep burning after the grilling is over because people forget to take it out. (Grill med ren samvittighed, 2018). One of the main drawbacks of this product is its transportation, as they are much heavier and bulky than the disposable grill, which makes them a more inconvenient product.

This short analysis, together with an increasing behaviour in the customer's consumption towards sustainability (Feldwick, 2020) represents another clear opportunity to develop a product that offers customers a sustainable cooking alternative.

ill. 2 Waste problem

ill. 3 Starting fires

2. MARKET RESEARCH

After framing the project, market research helped to get a better overview of the context and a better understanding of the opportunities this project could bring into the market. The market research will also aim to evaluate if the target group is the right one by establishing the first contact with potential users.

2.1 PORTABLE COOKERS ANALYSIS

On the market for outdoor grills and cookers, there are different product solutions. This investigation will give an overview of the different kinds of products on the market. Furthermore it will show how they differ in both functionalities, choice of fuel, portability, and aesthetics.

ill. 4 Mini grill

01 MINI GRILL

Weber Go-Anywhere data:

Price: 1.299 DKK
Dimensions: Length: 59 cm, Width: 30 cm,
Hight: 21 cm
Weight: 6,58 kg
Fuel type: Gas
(Weber Go Anywhere gasgrill - Gasgrill, n.d.

ill. 5 Disposable grill

02 DISPOSABLE GRILL

BBQ data:

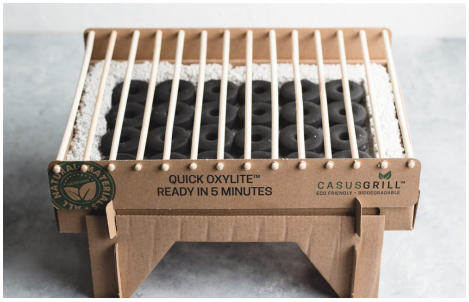
Price: 49 DKK
Dimensions: Length: 31 cm, Width: 24 cm,
Hight: 5 cm
Weight: 1.105 kg
Fuel type: Coal
(Øjeblikkelig grill sølv aluminium, n.d.)

SHORT DESCRIPTION:

The high-end Weber Go-Anywhere grill is one of Weber´s smallest portable grills. This grill´s best transport is the car since its weight and volume make it difficult to carry around or fit a backpack. This project's target group lives in the city and will mainly move around either by foot, bus, or walking, which makes this product more uncomfortable to carry to a picnic. The grill works on gas. Environmentally speaking, gas is a better option than charcoal, although it still emits CO2.

SHORT DESCRIPTION:

The disposable grill is a one-time use grill made of aluminium and works on charcoal. All of these factors have a negative environmental impact. The grill has an easy setup, and it is easy to transport in a bag. This product is the cheapest (not in the long run) and fits the size of grilling to a couple of people. These reasons make the disposable grill one of the best-selling products in Denmark during summer.



ill. 6 Eco disposable grill

03 ECO DISPOSABLE GRILL

Casus grill data

Price: 59 DKK
Dimensions: Length: 31 cm, Width: 23,5 cm, Hight: 5,5 cm
Weight: 1.105 kg
Fuel type: Coal
(Miljøvenlig engangsgrill - bionedbrydelig og nem - Simpelt.dk, n.d.)

ill. 7 Traditional hiking

04 TRADITIONAL HIKING

Trangia data

Price: 599 DKK
Dimensions: 18,5 x 10 cm
Weight: 900 g
Fuel type: Alcohol
(Trangia 25-3 Ultra Light køkken, n.d.)

ill. 8 Advanced energy

05 ADVANCED ENERGY

CampStove 2 Bundle data

Price: 1.909 DKK
Dimensions (grill part): Length: 24 cm, Width: 30 cm, Hight: 26 cm
Weight: 2.250 kg
Fuel type: Renewable biomass
(CampStove 2 Bundle, n.d.)

ill. 9 Solar oven

06 SOLAR OVEN

GoSun Go data

Price: 862 DKK
Dimensions (grill part): Length: 36 cm, Width: 18 cm, Hight: 8 cm
Weight: 0.9 kg
Fuel type: Sun
(Go, n.d.)

SHORT DESCRIPTION:

The more sustainable alternative to the disposable grill is made of a biodegradable material and charcoal. It is more sustainable than the normal disposable grill, however, it is still using charcoal which emits CO2. In the long run, this product is expensive and still has a negative environmental footprint.

SHORT DESCRIPTION:

The Trangia set is a compact, light, and portable product. It works either with alcohol or gas fuel, and it is mainly used in camping and hiking scenarios. However, it has been relevant to analyze for some of its interesting characteristics, such as its compatibility. The product has been designed to be as light and compact as possible, making it very easy to pack and transport. This product also has the advantage of offering the possibility of cooking, which allows preparing more elaborated recipes. Its use hasn´t been often seen in a picnic environment. This could be both because people are not interested in cooking but it could also be related to what this product represents. Its robust look and camping identity could be a barrier to introducing it in other kinds of environments, such as the city. Where people usually are more concerned about fashion and trends.

SHORT DESCRIPTION:

The CampStove 2 is a device where it is possible to both grill and boil. It is fueled by biomass such as wood, which is both time-consuming and emits CO2. Its interest lies in the ability it has to both grill and boil, widening the cooking possibilities. As an extra feature, it offers the possibility of charging the phone while cooking. The device is not as easy to pack as Trangia, since it consists of many different parts. Also as Trangia, it has a very camping look that has been accentuated by the use of very bright and contrasting colors.

SHORT DESCRIPTION:

The GoSun Go is a very portable oven. This solution is environmentally friendly as it runs on solar energy. The solution works like an oven that can achieve up to 280C, this allows the product to cook every kind of food, from boiling water to cooking, baking, and even roasting. Its cooking time is estimated to be between 20-45 minutes. It has a capacity of 0,4L, which offers food for one single person. The shape of the tube limits the type of foods you can cook and makes it less comfortable to handle. This product has been designed to be able to fit a wide number of scenarios, from a hiking/camping trip to a picnic in the park.

2.2 MARKET POTENTIAL

To get a better understanding of people 's interest in grilling a survey was made. 100% of the asked people are used to grilling outdoors. 78 % of them grill from ´almost every week´ to ´monthly´ in the summer. And 72 % of the people don't have a portable grill, which shows the large percentage of people that will be more lucky to buy a disposable grill. More information about the survey can be seen in Appendix 2.

Approximately 2.1 million Danes own a grill. Grilling is a huge part of the Danish culture. It brings people closer together and creates a gathering point. Danes are also the nation that spends the most money on a grill, in one year they spend 74 DKK per inhabitant. In comparison in the US, this number is 5 DKK. (Rebensdorff, 2014)

Consumer behaviour shows an increasing willingness to pay more for a sustainable product. Even though they are willing to pay more, sustainability must be a secondary benefit for the consumer. The products should add value besides being more sustainable than other solutions. (Feldwick, 2020)

Research in the market shows how the market contains either the expensive gas or charcoal grill or the disposable one. There is no product in between. Despite the increasing interest in sustainability.

2.3 POTENTIAL USER PANEL

TARGET GROUP

When designing a new product, the user is often well defined, to be able to target exactly that kind of person. However, in this project, the user description is very wide. When it comes to outdoor cooking, it is possible to see all kinds of age groups enjoying this activity. That is why the buyer of the product proposal has not been precisely defined by age, profession or personality type.

There are, however, some tendencies and characteristics they will be likely to share:

- Care for the environment, and most likely they will prefer buying second-hand clothes and organic food
- Live in the city and enjoy going to the green areas to get fresh air and socialize
- Students and young families

POTENTIAL USERS

The following is a preview of the potential users that have given feedback during the process.

Julius
25 years old
German
Architecture student
Loves cooking and spending time trying out new recipes, cares about sustainability. He loves biking and uses it as much as he can
Lives in Copenhagen

Ida
25 years old
Danish
Cand.mag in danish and crisis communication
Prefer to buying second hand clothing and daily use her bicycle to get around
Lives in the center of Copenhagen

Anthon
27 years old
Danish
HR & country manager at We Feat
Enjoy cooking on a high level
Lives in the center of Aalborg, from Copenhagen

Nina
25 years old
Australian
Architecture Student
Cares about sustainability and likes grilling in the park but feels bad for the environmental impact of disposable grills. She also loves biking around
Lives in Copenhagen

Miruna
22 years old
Romanian
Student: Multimedia design
Lives in Aalborg

Emilie
23 years old
Danish
Architecture student
She is very social and loves spending outdoor time with her friends
Lives in Aalborg

The full list of potential users can be found in Appendix 3.

LATE USER FEEDBACK

It is a design/technology-driven project and not a user-need project. Something similar happened with products such as the iPhone, that introduced a new and unexpected way of delivering the same result as its ancestors. Therefore, in projects like this, user feedback naturally comes afterwards. This forces designers to be very aware of the context they design for and the trends that are driving the moment. That is another reason that makes the chosen context a fitting one for this project. Since the potential users were close to the team, both in age, culture, tendencies and occupations.

However, this project also has a potential user panel. They have been involved, as much as needed to carry on with the project. At the beginning of the project, they were contacted just to be mentioned the project goal and see their reaction, which turned out to be very positive.

"I think your idea is incredible, so good, I would definitely use it if you choose to get it produced" - Emilie

"First of all, I wanted to say I think this idea is great and that it has a lot of markets, especially here in Denmark. People use it so much in the parks, and the disposable ones are a big waste, I used one last weekend actually. - Javier

Because the users cannot help putting elements together, contacting them came later in the process. The development required time to understand the final shape the productneeded to have to fulfil its purpose, before getting user feedback. They were also contacted in the development phase to get a better understanding of the appearance and aesthetics they would expect a product like this to have.

Further contact with them will be expected after the hand-in. By that time the team will be able to have a working prototype to show, making their feedback more valuable and real.

3.4 MARKET RESEARCH REFLECTION

The disposable grill is way cheaper than the durable gas and charcoal grill. But if ten disposable grills are used each summer, then after only three years a gas or charcoal grill is a better investment to buy. However, despite the price reduction in the long run a drawback appears, the discomfort of carrying around a heavy and bulky product. Showing that there is space for the creation of a very portable product within the price range of a portable grill.

The increasing interest in sustainable solutions that people seem to be aware of could open another space for improvement on the market. However, people do not seem to care too much about it when it comes to paying more. Therefore the sustainability goal will also open a challenge in terms of cost and production. If the product would not only be a weight reduction but comes with a highly positive environmental impact, its value would increase considerably.

All the observed products in the market, except the Go Sun Go, are banned in other countries due to fire regulations. This both disables danish people from doing this activity when travelling abroad and it is also an impediment for other countries to join and enjoy a picnic that includes cooking. Again this can be identified as an encouragement towards the creation of more products like the Go Sun Go.

The market research has also opened a question. The most common product seen in parks are grills: is this because people only want to grill or is it because they do not have another option? There are existing products that would fulfil the desire of cooking, such as Trangia, however, they are not usually seen in the parks, which again opens up a question: Is it because people do not desire to cook, or is it because they do not fit the context? There are products, such as the Go Sun Go, that cook, designed for picnicking. This gives the hint that there may be a potential in cooking in these environments. Cooking usually requires more time and and energy from the user, than grilling. However, it would upgrade the eating experience outdoors. Therefore, it seems there could be an interesting opportunity in the development of products that can cook and widen the recipe possibilities.

In conclusion, based on this market research, it has been possible to observe a hole in the market where a new and innovative outdoor cooking product could fit, confirming that the project proposal could be the one fitting it. The characteristics of this product are summed up as follows:

EASY TRANSPORTATION

- An appealing aesthetic that fits the city context, capable of living up to the modern living standards.
- A durable solution that lowers the waste generated by disposable grills
- A more sustainable solution that lowers the carbon footprint of the existing products
- Being able to provide desirable food quality
- Avoid the creation of fire, so that the product can be used in countries with fire regulations

3. TECHNOLOGY RESEARCH

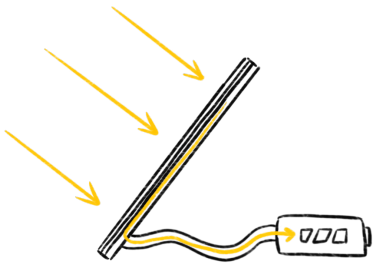
3.1 SOLAR ENERGY TECHNOLOGIES

To cook/grill food, it's necessary to achieve a certain temperature. During a hot summer day, the sun can feel quite hot, but it is far from being hot enough just by itself to fry meat. However, with the help of some simple tools and following basic laws of physics, it is possible to boost and focus the power of the sun to achieve a temperature high enough to cook.

Focusing light beams in one point is one part of the challenge, but another is what happens to the heat achieved in the focal point. Heat retention and distribution are the keys to building a well-functioning solar oven. Usually, everything that is getting heated up needs to be well isolated since the point where heat is focused may not be strong or big enough.

3.1.1 HEAT COLLECTION

Capturing and collecting solar energy is one of the main segments within renewable energy sources. There are several possible methods and technologies available for doing so. All of these lay on the same basic principle as they all try to collect the same thing: sunlight. Therefore, the bigger the surface of the collector, the better, since more rays will be captured.



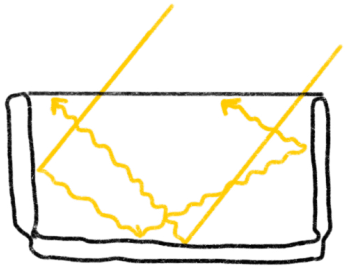
ill. 10 Solar Panels

SOLAR PANELS

Solar panels are less “traditional” and rely more on technology. They are used to produce electricity by collecting sunlight. It would be possible to use this electricity for heating up a solar cooker, however, that would require the use of big panels and the implementation of large-capacity batteries, which would make the product extremely heavy. (See illustration 10)

MIRRORS

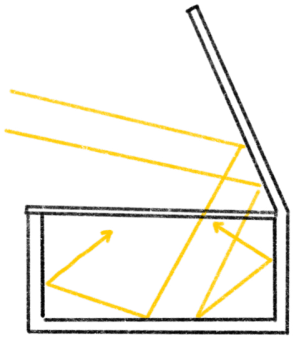
Mirrors can be implemented in solar cooking in many ways and shapes. They have the ability of reflecting light, therefore heat. They can be used to reflect and guide light beams into a desired area, causing it to warm up. The different mirrors have been classified in three main different types:



ill. 11 Reflective surface

REFLECTIVE SURFACES

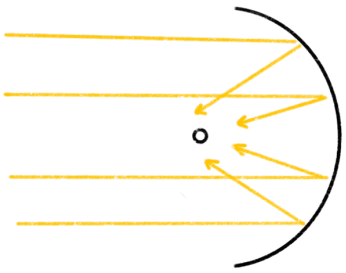
Any kind of surface that reflects light has the potential to become a solar cooker for instance even textiles. The smoother the surface is, the better the reflection, and therefore the more efficient the solar cooker will be. This offers the possibility of creating very compact and foldable solar cookers since the reflective cover can be easily folded and flat-packed. On the other hand, their rough surfaces and lack of fixed geometry makes them very inefficient. (See illustration 11)



ill. 12 Flat mirrors

FLAT MIRRORS

Flat mirrors are the easiest and cheapest way to use mirrors for solar cookers. Any flat surface can become a mirror by covering it with a reflective material, meaning that even a simple box shape that has been isolated can become a solar cooker. However, it is important to highlight that they only reflect light, and because of their flatness, they can not focus the light on one single point. This means that, even though they are a great and inexpensive solution to guide and collect light from a larger area into a smaller one, they do not have the power and accuracy of other methods. (See illustration 12)



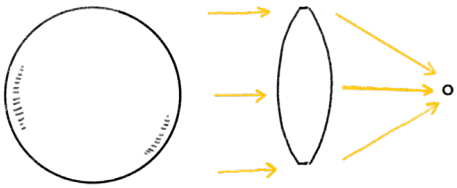
ill. 13 Parabolic mirrors

PARABOLIC MIRRORS

Parabolic mirrors are an advanced version of flat mirrors. A curved parabolic surface covered with a reflective material creates an optimal geometry to direct all the light beams into its center. This makes parabolic mirrors more accurate and efficient than flat mirrors. On the other hand, they are also more expensive and take up a lot of space because of their fixed and curvy geometry. (See illustration 13)

LENSES

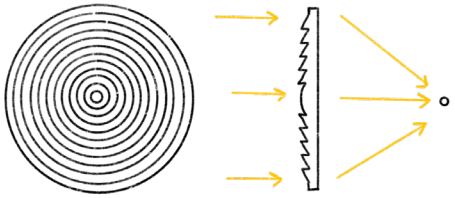
In the same way, as parabolic mirrors do, lenses can focus light in one single point. Their main difference is that light is not reflected in them but goes through them. Their geometry causes the passing light to be redirected and focused in on one point. Just like mirrors, the bigger the surface is the more light they will be able to focus, and therefore, the higher the temperature will be in the focal point. There are two main types of lenses considered in this project:



ill. 14 Traditional lenses

TRADITIONAL LENSES

Traditional lenses are usually made out of glass. They work very well on a small scale, however, the dimensions that would be needed for a traditional lens to warm up a solar cooker would make it very heavy, difficult to handle, and expensive. Making them impossible to use in a product that aims to be compact and easy to transport. (See illustration 14)



ill. 15 Fresnel lens

FRESNEL LENS

Fresnel lenses came up as a lightweight solution for traditional lenses.
They created by milling circular ribs with a special triangular geometry on one of the sides of a plastic sheet. Their main advantage is, therefore, their lightness.
These lenses can be cut in half or folded and still operate the same way when the pieces are put back together. (See illustration 15)

3.1.2 HEAT DISTRUBUTION

Another important factor related to cooking is the importance of a fast and even heat distribution. Two ways of achieving this are:

- The use of very conductive materials in the cooking area to ensure heat reaches all the cooking surface as fast as possible.
- The use of homogeneous shapes to ensure an homogeneous heat distribution, avoiding the creation of corners where heat would take longer to arrive.

3.1.3 STORING THE COLLECTED HEAT

As mentioned before, another important factor to increase the temperature of a solar cooker is heat retention. This will not only improve the efficiency of the oven but at the same time, it will mean the product will be able to still work under short periods of clouds. In these periods the oven would not be able to increase its temperature, however, it would be able to retain the gained heat. This means food will keep being cooked while the cloud is there. It is possible to differentiate between two main methods of approaching this, a more traditional and a more advanced one that will be explained next.

TRADITIONAL HEAT RETENTION:

- Important factors that can help to achieve good heat retention in a solar cooker:
- Hermetic closure, an airtight cooking space that makes sure heat cannot escape with the steam
- Black walls for the cooking area and for the zone where the light would be focused, so it can absorb as much as possible without reflecting it back.
- Inside walls covered with heat reflective materials, making the light beams be “trapped” in the enclosure and would bounce around, improving the efficiency.
- Well isolated walls to prevent heat loss.
- Vacuum insulated walls or the use of glass vacuum tubes to improve isolation.
- The main material used for the construction should have low conductive capabilities to improve isolation.

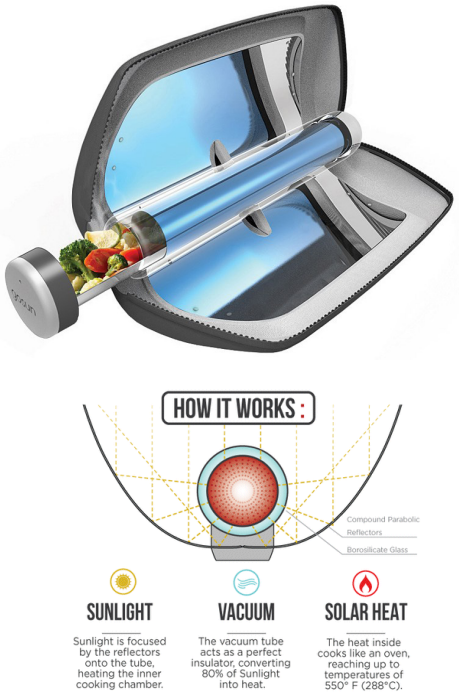
ADVANCED HEAT RETENTION:

There are other technologies, such as the use of molten salt or paraffin waxes, that can be used to boost heat retention. Introducing these technologies in a solar cooker would make it store heat for a longer time. Meaning that it could even be used in times when the sun was not there, for instance during the night. The downside of these technologies is the need for a large volume of these materials to achieve effectiveness, which would result in a heavy construction. Another issue these technologies bring along is a safety problem since damage to the product could cause these toxic materials to get in contact with the food.

3.2 SOLAR COOKER ANALYSIS

Further analysis of the closest solar competitor products will provide interesting insights into the concept development.

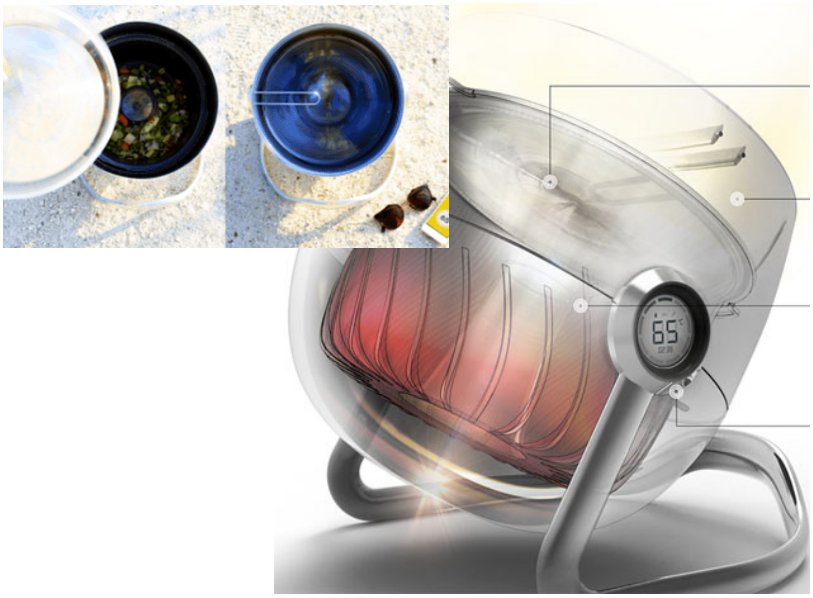
The analysis is based on observations and online reviews of both Go Sun GO and Solari. Other solar competitor products can be found in Appendix 5. These two products have been considered the closest to this project since they both try to provide a portable cooking tool for a picnic context based on solar power.



ill. 16 Go Sun Go

GO SUN GO

The Gosun go is a small portable solar cooker, optimal for outdoor use. It is based on a vacuum isolated tube, called a Rand-tube. According to their website that can boost their cooking performance by 3 times. The Go Sun Go collects sunlight by 2 parabolic mirrors placed around the two sides of the tube, heating that all along its length see illustration xx. The product has the advantages of being lightweight (1 kg), small (36x18x10 cm), and easy to set up.
On the other hand, the cooking volume is considerably small (0,4 l), making it suitable for mostly only one person, and according to user feedback cooking times are quite long (at least 20-45 minutes in optimal conditions). Another disadvantage of the product to note is the shape of the tube as a cooking area. The shape limits food types that can be prepared in the product and the tube is not transparent, so the user has no direct vision of the food while it is being cooked. Also, the tray where the food is placed achieves very high temperatures and is very exposed to human touch, meaning the user will need to be extra careful not to burn his hand when handling it. (Go, n.d.) See illustration 16)



SOLARI

Solari is a portable solar cooker concept heated up by a Fresnel lens that also functions as a lid. The concept is the winner of a James Dyson Award, and even though it is not on the market currently it provides some interesting insights. To increase heat retention, the inside of the product is covered with polished stainless steel that works as a radiation trap, all the light that is guided inside bounces around the pot, boosting the performance of the cooker.
The product is meant to be portable, therefore the legs that help the user to orientate the lens towards the sun can also function as handles to carry the cooker around, however, its voluminous size and shape do not seem to be suitable for long walks or biking.
Besides its bulkiness, another downside of this product is the possible small lens size compared to the volume that needs to be heated up. Another insight to highlight is the position of the food. The positioning of Solari in the sun's direction comes with the rotation of the whole product. This, together with the hole in the middle of the pot, where food can easily go inside, will probably harm the user interaction, making the cooking surface uncomfortable to use. (Project Solari Portable Solar Cooker | Portable Solar Cooker, n.d.) (See illustration 17)

ill. 17 Solari

3.3 CHOICE OF TECHNOLOGY

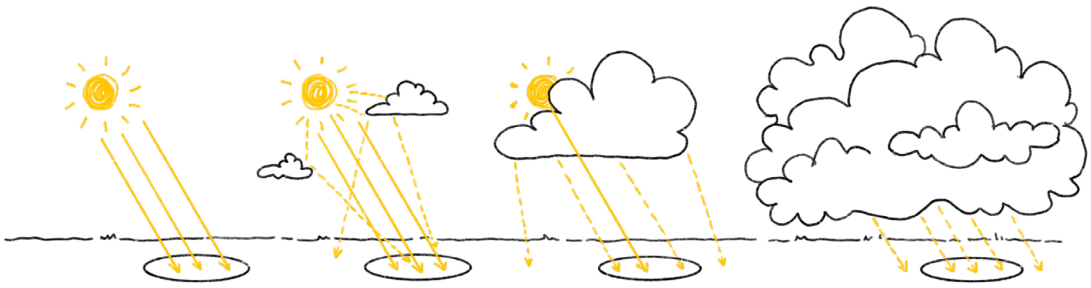
This technology research has shown that the use of more traditional technologies such as mirrors and lenses can be very convenient for a project like this one. They can be very efficient and they do not have all the complexity the more sophisticated technologies introduce (more pros and cons for each technological option can be found in the Appendix 4.

When it comes to creating a portable and compact product Fresnel lenses seem to offer a big advantage compared to mirrors. Flat and flexible mirrors are light and easy to pack, however, they can not focus the light at one point, which makes them less efficient than a Fresnel lens. Parabolic reflectors, even though they are as efficient as a Fresnel lens, are more difficult to pack since they have a very bulky geometry. Fresnel lenses, however, offer both an effective method of focusing the light and a very easy to fold and flat-pack solution. Besides, they also offer an economic advantage, since they are a standardized and low-cost product. However, with the mirrors the heat can be focused on a point under the food, with a Fresnel lens the heat will always come from above. This is the main challenge this technology introduces and it will have a big impact on the final design.

All these findings confirmed that the use of Fresnel lenses could be the most helpful technology to develop this project.

3.4 THE SUN PATH

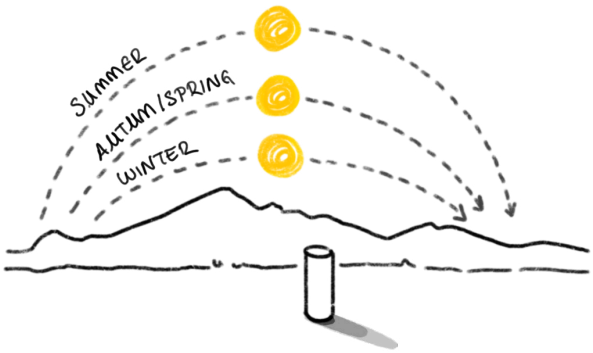
Relying on the power of the sun means many different factors have to be taken into consideration. Solar cooking depends on the weather. It is impossible to use a Fresnel lens to focus light during the night as the sun is not there. Even during the day, different weather conditions mean different amounts of light and energy reaching the surface of the earth. Heavy clouds can block a lot of sunlight, reducing the amount of energy that is possible to collect by a Fresnel lens. The following graph shows the typical sunlight range available. Densely overcast weather is not really part of the scenario this project is working with, since under these conditions people are very unlikely to be outside home picnicking. However it is interesting to see how partly cloudy weather can even increase the sunlight levels due to the reflection of nearby clouds. (Effect of the Weather on Solar Panels - Leading Edge Turbines & Power Solutions, n.d.) (See illustration 18)



Clear and sunny	**Partly clouded**	**Overcast**	**Cloudy**
90% - 115%*	60% - 120%*	20% - 60%	10% - 40%

***Sunlight levels might be increased beyond 100% due to reflections from clouds

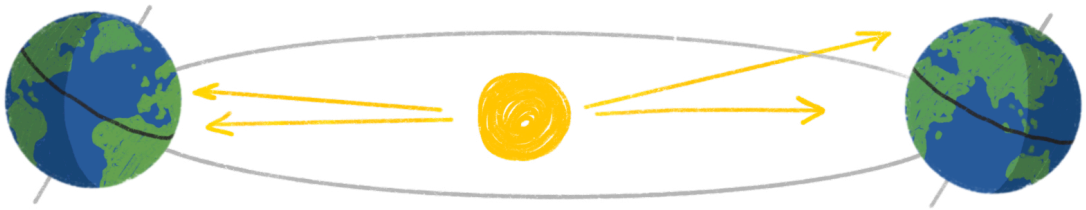
ill. 18 The sun path



ill. 19 The sun path 2

Other influencing factors are the time of the day, the year, and the geological location. Depending on the time of the day the sun is one height or another one see illustration 19. At midday, the sun achieves its highest point and also the strongest heat power. This range of hours where the sun is higher matches perfectly the nordic lunchtime.
Depending on the time of the year the sun path will also change and light will reach the Earth from a different angle and a different distance, making a big difference in the power that is possible to harvest. (See illustration 19)

During winter the sun will be more inclined to the people living above the Equator, making the sun path lower. This effect can also be seen in shadows since they will appear longer. However, in the summertime, the sun will be more perpendicular to the countries above the Equator, for this reason, shadows will be shorter and the location of the sun will be the highest at midday. Since this project focuses on summertime, the high locations of the sun during this period will have a positive impact on the product design, avoiding the need of covering a very wide angle spectrum. (Try This - Solar Cooker Challenge, 2015)

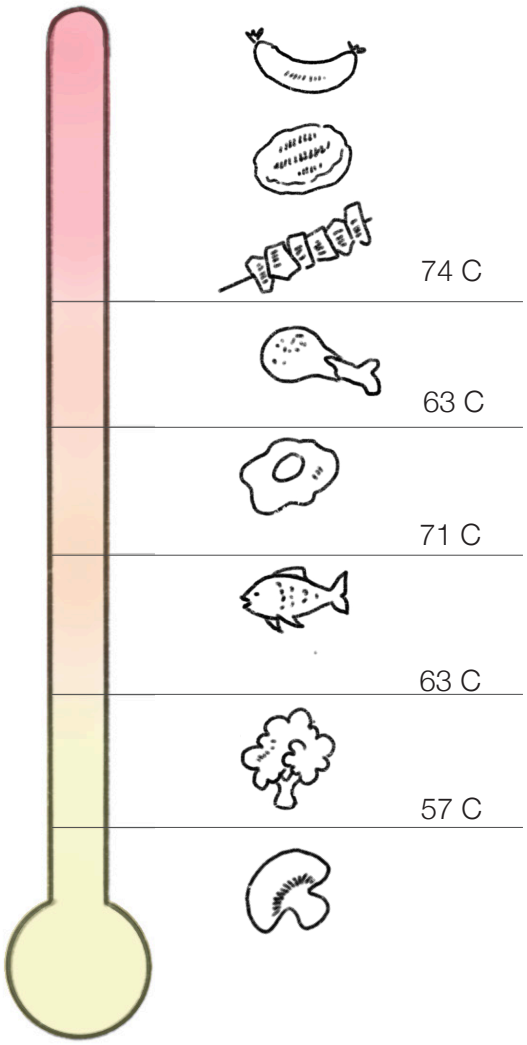


ill. 20 The sun path 3

4. COOKING RESEARCH

4.1 COOKING TEMPERATURES

Research regarding the needed cooking temperatures in the product have been gathered in this graph.

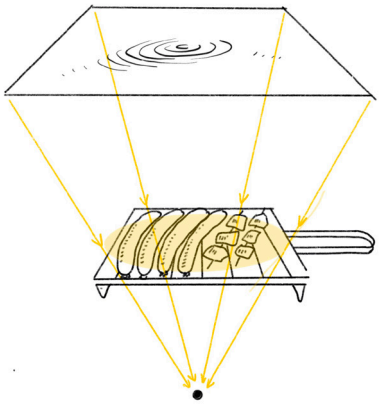


This shows that for instance dishes based on fish and vegetables would be the easiest to cook, since they only need to achieve 57 Celsius degrees in the inside in order to be cooked. However, dishes based on meat will need more time and energy in order to achieve up to 74 Celsius degrees inside. (Thermometers and Food Safety, n.d.) (See illustration 21)

ill. 21 Cooking tepetratures

4.2 COOKING METHODS

The temperature needed to cook can be achieved in different ways, and depending on the method used the taste of the food will change. Looking at the possibilities solar cooking offers, it has been possible to establish a classification on the two main options that can be achieved:

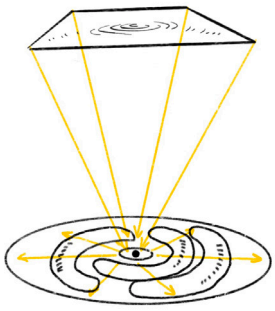


ill. 22 Direct cooking

DIRECT COOKING

In this project, direct cooking is understood as the method that places the food directly under the light beams, as shown in the illustration 22. The advantages of this method is the possibility of instant grilling the food, (Solar Power BBQ in Mid-Air with Fresnel Lens - YouTube) When using a big Fresnel lens, the focal point can achieve temperatures up to 500 degrees which is too high for cooking, this temperature can be regulated by changing the distance between the cooking object and the focal point, as shown in illustration 22. The further the object is from the focal point, the lower the temperature will be. This also offers an advantage, which is related to dimensions. The focal point is the place where all the light beams are focused from the lens in one point, resulting in the achievement of the highest temperature. The further from the focal point, the more the light beams will cover, and the lower the temperature will be.

The research has shown this method is possible, but it requires a big Fresnel lens. (Solar Power BBQ in Mid-Air with Fresnel Lens - YouTube) This project will also try to understand what is the compromise between the lens size and the heat created. In order to see if there is a possibility of obtaining the needed energy with a reasonably portable lens size.



ill. 23 Indirect cooking

INDIRECT COOKING:

This is the solar term used to refer to something similar to stewing. Indirect cooking occurs when the heat provided by the lens is not enough just by itself, further solutions are required to achieve the desired cooking temperature. In this case the product will have to focus on maximizing heat retention in order to keep and distribute as much heat as possible. (See illustration 23)

These two methods find their solar equivalent in the traditional kitchen in what has been classified as Grilling and Steaming, as shown in this chart:

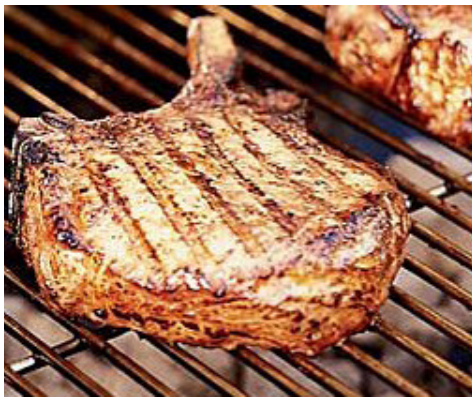
Direct cooking ----- Grilling

Indirect cooking ---- Steaming

A short description of this different methods will help understanding the differences between them:

GRILLING:

- Grilling usually takes place at temperatures around 190 -230 C (How to Make Your Meat as Healthy as Possible, n.d.)
- It is a very popular method because of the tasty flavour that leaves on the meat, however it leads to the production of potential harmful chemicals, like AGEs (Advanced glycation end products) which are linked to increasing the risk of different diseases (How to Make Your Meat as Healthy as Possible, n.d.)



ill. 24 Grilling

STEAMING:

- It usually takes place at 100 C, the temperature needed for water to start evaporating
- It provides a uniform cooking throughout the food
- It is very healthy since it doesn't need to incorporate oil (Steaming (Moist-Heat Cooking Method) | Jessica Gavin, 2019)
- It is one of the best ways to taste the real flavour of food (Steaming (Moist-Heat Cooking Method) | Jessica Gavin, 2019)
- The texture of the food will be left out moist and tender. Steaming (Steaming (Moist-Heat Cooking Method) | Jessica Gavin, 2019)
- The nutrients in the food will not leach out, so vitamins and minerals are retained Steaming (Steaming (Moist-Heat Cooking Method) | Jessica Gavin, 2019)
- A basic simple recipe takes around 25 minutes to be done. (how to steam meat – African Food Joint, 2012)
- It's enough with the water contained in meat in order to cook it. (how to steam meat – African Food Joint, 2012)

ill. 25 Steaming

CONCLUSION

Since this project is based on solar cooking it is probable that the needed temperatures for grilling would be hard to achieve and it would likely require perfect conditions and could take a lot of time compared to traditional grilling. This means the product will not be able to compete against a portable grill when it comes to achieving a grilled texture, look, smell or taste. Therefore the main focus of the project will be stewing food and exploiting its possibilities as a starting point, leaving open the possibility that the product could be able to achieve enough temperature to leave some burned marks on the food. In that case this would be considered as a plus.

Research on steamed food has shown that there is a wide variety of recipes that can be achieved. This has been considered as a possibility of upgrading the outdoor cooking experience into a healthier activity with food that provides all its juiciness and taste. Therefore the solar cooker would not only be providing a more sustainable way of cooking but also introducing an upgrade in food healthiness, quality and therefore in the experience.

5. FRAMING SUM UP

PROBLEM SUMMARY

Sustainable choices are becoming an increasing tendency globally. Denmark is one of the countries where being climate-conscious is a general awareness among the citizens. The younger generation Z is particularly concerned with social responsibility and sustainability. The older generation Y share the increasing awareness and are willing to pay more for a sustainable product. (Den danske forbruger anno 2019 handler mere bæredygtigt, 2019)
On the market for the grill, we see some alternatives to the charcoal or gas grill, but none being both durable, portable and user friendly. The most used grills like charcoal, gas and disposable grills emit a high number of CO2, which is why we see a need for a change and a hole in the market.

TARGET GROUP

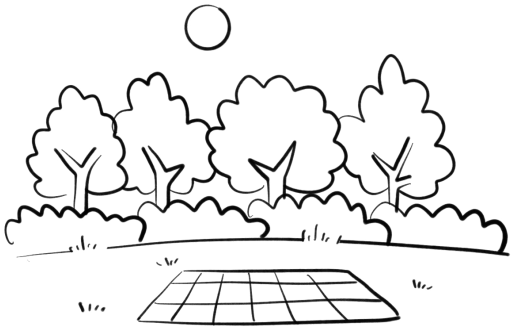
The primary target group is people who care for the environment and are willing to invest in a durable grill for use in the summertime. The target group will typically live in a bigger city and therefore require a small portable grill when going to the green areas in the city.

CONTEXT

The innovative grill works under conditions with direct sunlight in the summertime. The product is developed with the purpose of being used in parks and beaches where you usually grill with your friends or family.

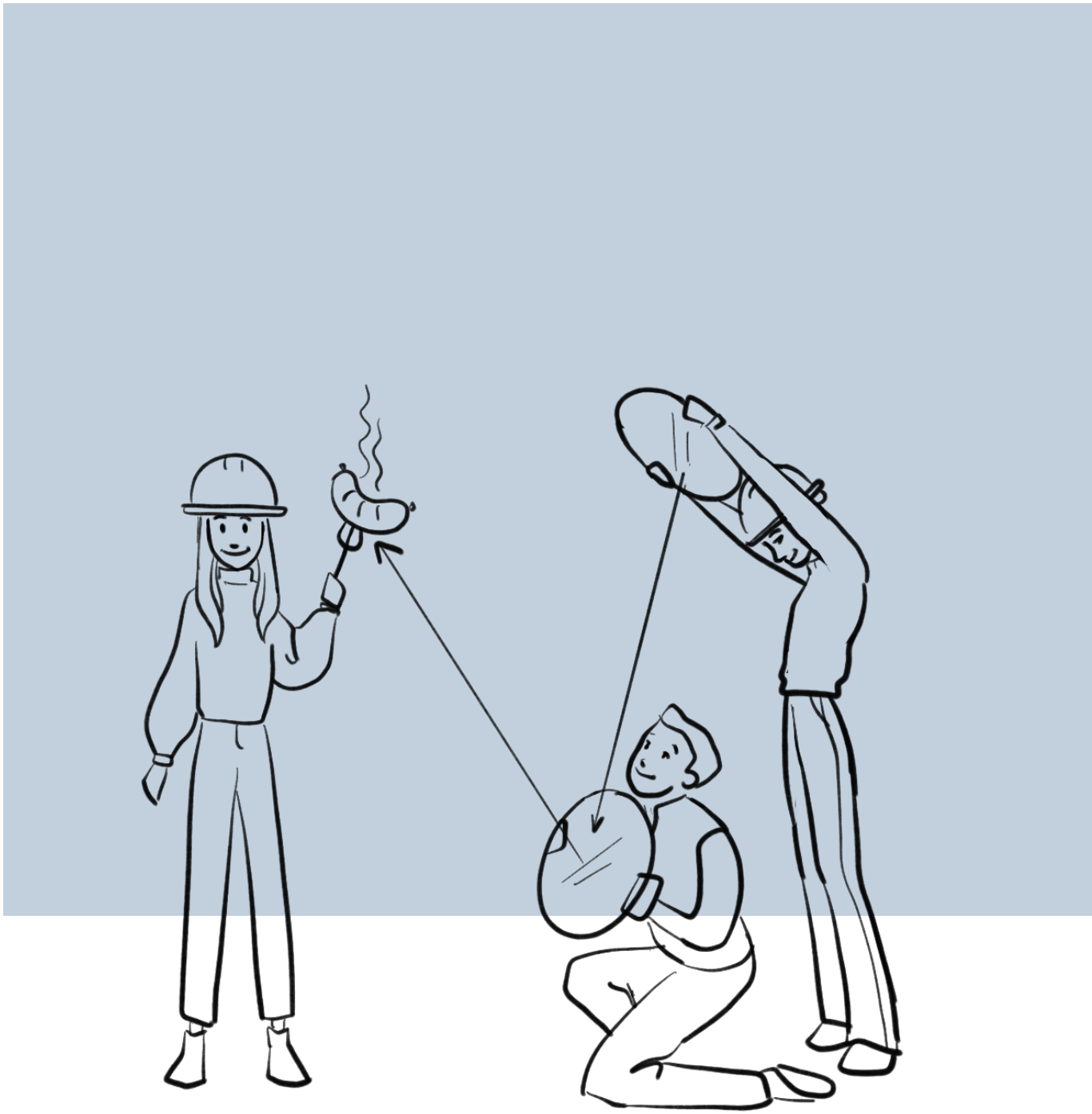
PROBLEM STATEMENT

"How can we develop a safe, durable and portable outdoor cooking product that offers people an appealing and sustainable outdoor cooking alternative that lives up to the modern life standards?"



DESIGN BRIEF 1.0

	NEED / DESIRE - WHY
KEY DIMENSIONS	**Similar capacity to a disposable grill (2 people)**
	Lens: big enough to provide the needed heat for the desired volume
	Minimum volume (to increase heat retention)
SET UP AND USABILITY	**Quick and simple setup**
	Intuitive Clear orientation towards the sun
	"It's working" feedback
	Right set up
COOKING FUNCTIONALITY	**Minimize the cooking time, similar to a disposable grill (25 min)**
	Possibility of boiling water (100 degrees)
	Food achieved up to 73 degrees inside in order to be cooked
SAFETY	**For the environment** Avoid the creation of a fire
	For the user Avoid burning the food
TRANSPORTATION	**Easy to carry arround either in a bike / backpack / by hand**
	Light weight, around half the weight of a portable grill, aprox. 3,5 kg
DURABILITY AND MAINTEN-ANCE	**Similar durability to a portable gas grill** * Would be nice to protect the lens
	Hit resistance
	Easy to clean
AESTHETICS	**Robust look**
MARKET ACCESSIBILITY	**Lower the manufacturing cost**
SUSTAINABILITY	**Lower the carbon footprint compared to the disposable or portable gas grill**



02 CONCEPT DEVELOPMENT

The development of this project has been hand in hand with physical experiments in an iterative process. This has helped to narrow down the possibilities of the used technology and therefore sharpening the project.

The first concepts have been classified, according to the kind of cooking method they use. Afterwards, an experimentation phase will validate the concepts, showing which one got validated. This iterative process got carried throughout the whole development phase.

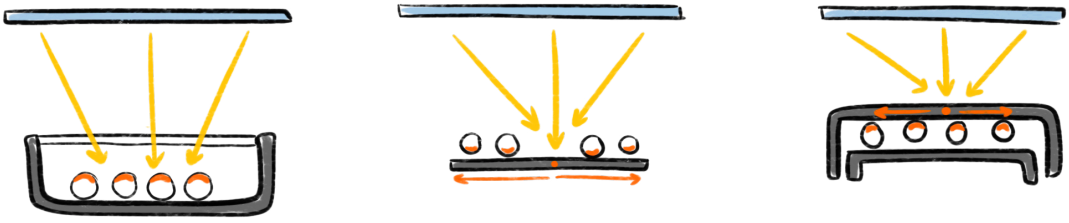
The result is a clear direction to follow that will be further detailed in the second ideation. Here more experiments that helped shape the concept will be carried out.

In the end, a scheme will sum up this process of the gained insights and the impact they had on the design.

1. IDEATION AND EXPERIMENTATION

1.1 FIRST IDEATION

A first ideation round was conducted. Several ideas were brought to the table, (they can be seen in Appendix 6) after analyzing them, it was possible to group them according to the cooking principle they were based on. And so it was possible to make the following graph (see illustration 26) showing the sum up of these principles.



ill. 26 Cooking set up

Concept A - direct cooking: This principle opened up the possibility of placing the food directly under the sun. From the technology research, it was already known that to achieve enough cooking surface it would be needed a very big Fresnel lens. However, its exact dimensions were unknown at this point. Based on this possible negative scenario these concepts tried to build walls around the food to retain as much heat as possible. The functionality of this concept depended on the relation between temperature and distance to the focal point. Further experiments with lenses will show if it was possible to find a reasonable compromise between the lens size, the cooking area desired dimension, and the temperature the lens could achieve on that desired surface.

Concept B - Indirect cooking (from the bottom to the top):
This method would focus the light of the lens on a point from which the heat would be distributed to the food in the same way as traditional cooking, with the only difference that in this case, the "pan" would have an area in the center where food could not be placed. Several concepts were developed under the thought that the transferred heat would be enough to grill the food. However this was also uncertain, therefore some other concepts offered the possibility of protecting the cooking area, trying to improve the heat retention of the product.

Concept C - Indirect cooking from the top to the bottom:
This method revolutionizes cookers by placing the heating source on top of the food. This was decided according to Fresnel lenses´ way of focusing light from the top to the bottom. This concept avoids the creation of a region in the center of the pan where the food can not be placed. On the other hand, the food needs to be covered and in touch with the heating surface. A fact that could have a negative impact when cooking, since food usually has different geometries. Heat is naturally transferred from the bottom to the top, however, this concept was placing the heat source over the food. Showing the need for tests that could show whether this was a feasible path or not.

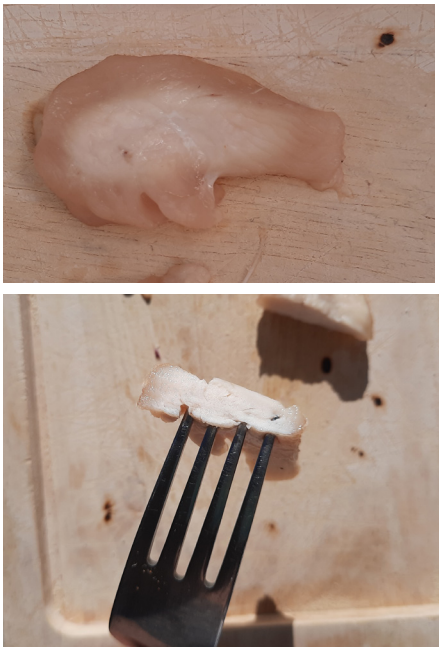
1.2 VALIDATION

After this text add an intro: After this first ideation round it was clear the need for an experimentation phase that could solve the rosed questions. Three different experiments will now be unfolded, each of them will try to answer a different question.

EXPERIMENT 1: DIRECT COOKING - HEAT RETENTION / NO HEAT RETENTION

After the ideation of the concepts, the first experiment was set up, using the first Fresnel lens the team gained access to. The first experiments were not enough to help decide on whether this could work or not, since the size of the lens was tiny compared to the one the product would have. (See illustration 27-28) However the experiments helped realizing the big impact heat retention has on the speed food gets cooked.

NO HEAT RETENTION



ill. 27 Without heat retention

HEAT RETENTION

ill. 28 Heat retention

CONCLUSION

It was possible to see a difference between the experiments that applied heat retention and those that did not (See illustration 27-28). The chickens covered by plastic were able to be cooked in around 30 minutes.

Whereas the other ones, in the same amount of time, only go partially cooked.

EXPERIMENT 2: HEAT RETENTION - INDIRECT + DIRECT COOKING

Further experiments were developed after having access to a bigger lens in the size of 30 x 30 cm2.

In this experiment the light was directly focused on top of the chicken (direct cooking). The result in both cases was that all the chicken inside the pot got cooked. The difference was that the chicken directly under the focal point got burning marks.

The experiments helped to realize the need to tilt the cooking surface to avoid the walls of the pot blocking the entering light. It was considered to tilt the cooking surface. However, it got reconsidered as an impediment to moving on with this concept since it went against the requirement of comfortable cooking because it would not provide easy access to food. (See illustration 29)

ill. 29 Heat retention- Indirect / direct

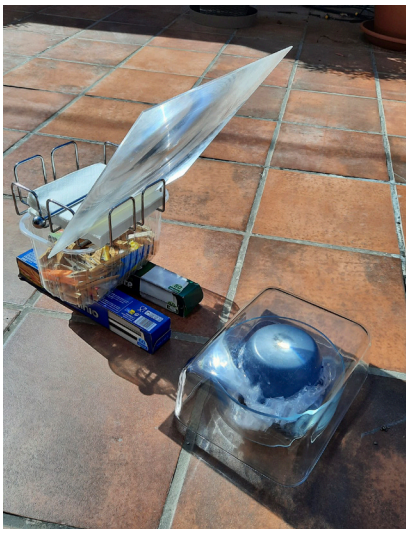
CONCLUSION

- A lens of 30x30 did not give enough cooking surface to grill a meal
- The food gets cooked because of the heated moist created inside the pot
- The light beams enter in a perfect shape when the cooking surface is parallel to the lens surface. Making necessary to tilt the cooking surface to achieve this orthogonality
- The walls of the pot can block the entrance of the rays when they are higher than 3 cm, making it necessary to tilt the cooking surface to allow all the rays to enter the pot

EXPERIMENT 3: HEATING FROM THE BOTTOM VS HEATING FROM THE TOP

Concept C had opened the possibility of a new cooking method.
Therefore, an experiment was set up to be able to choose between direct cooking (ideal), indirect cooking (heating from the bottom) and indirect cooking (heating from the top): (See illustration 30-31)

FROM THE TOP TO THE BOTTOM



ill. 30 Heating methods 1

FROM THE BOTTOM TO THE TOP

ill. 31 Heating methods 2

CONCLUSION

The ideal would be direct cooking, it would be the fastest, and it would provide the burned grilled look. However, the previous experiments have shown that the possible grilling surface that can be achieved with a 30 x 30 cm lens is not big enough, meaning it would be necessary to use a bigger lens. That goes against the requirement of making a portable product to bring with you. The requirement was prioritized over the wish of being able to get the grilled,burned look.

Indirect cooking tried to work against the laws of physics and proved not to be a solvable challenge. Whereas in traditional cooking the heat naturally flows from the bottom and up, cooking the food on its way up, this other method would require an extra amount of energy, to saturate the upper part of the cooker, forcing heat to reach the lower places too. It would always lead to unevenly cooked food, and it would be necessary to access the food and turn it around to avoid it burning, which would mean opening the system and losing all the retained heat.

The result concluded that Concept D was not the way to go. It was clear that the only possible way to cook was from the bottom and up. It was necessary to go back to the previous concept and face the challenges it offered and solve them. Parallel with the experiments, simulations were made in order to gain more insights and validate the experiments up to a certain level. (appendix 7)

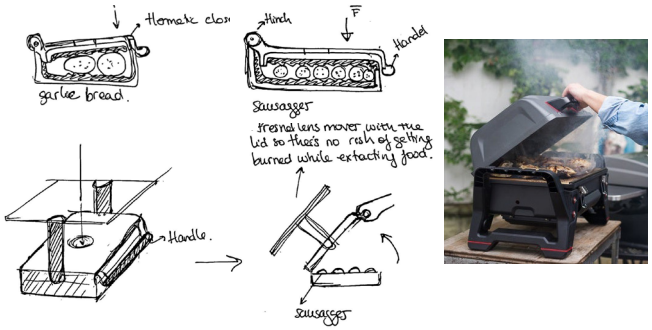
1.3 SECOND IDEATION

The starting point of this second phase is the desire of having a big lens that can fold into a smaller structure and a container that should somehow allow both the way of light to the tray and safe access to the food by the user.

An second ideation phase tried to fulfilled this in the following three concepts:

CONCEPT A

The safe access to food in these first concepts got inspired by the existing gas grills. When opening the lid, the lens would be out of its working position. That means no harm to the user. However, this idea was difficult to combine with the foldability and positioning of the lens.
(See illustration 32)

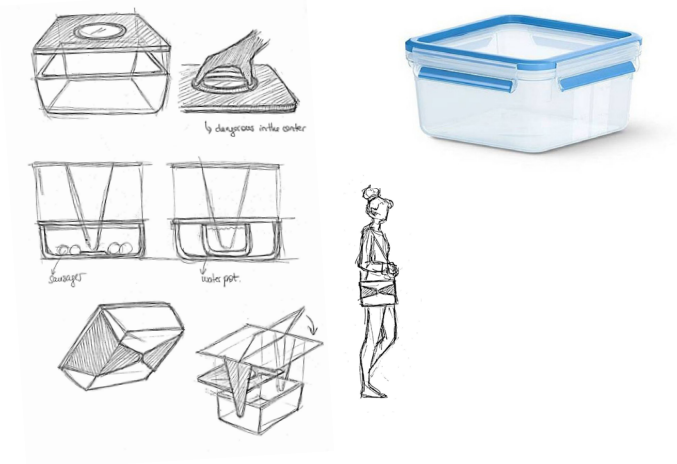


ill. 32 Concept A

CONCEPT B

Other concepts got inspired by the Tupperware structure, a container and a lid that closes hermetically. See illustration 33. The main problem of these concepts was accessing food. Seen from a psychosocial perspective, it does not seem logical to put the hand between the lens and the focal point, as it feels unsafe for the user.

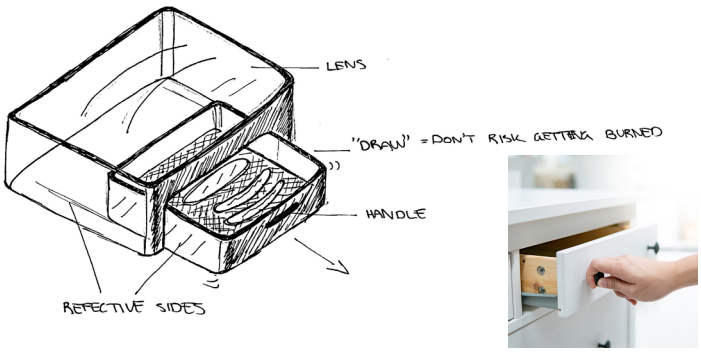
The concept explored the possibility of transforming the product into a wearable piece, as shown in one of the concepts in the first ideation. (See illustration 33)



ill. 33 Concept B

CONCEPT C

Some concepts got inspired by a drawer, which adds an advantage of easy and safe access to food. (See illustration 34)



ill. 34 Concept C

1.4 PROBLEM SLICING

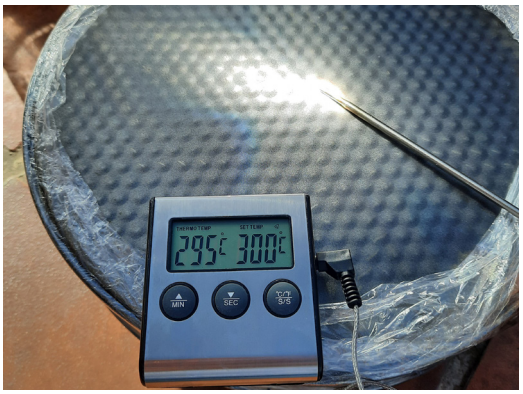
When developing more details these concepts arose several challenges. These problems have been divided into different sections, where each of them is explored to find an answer. This iterative process of ideation and experimentation has helped to narrow down the possibilities and therefore shaped a final concept proposal.

1. INCLINATION

The main concern of this experiment was to answer the following:

Question 1:The need to tilt the tray was an answer to ensure the orthogonality between the cooking surface and the lens. and therefore avoid the distortion of the projected image of the sun, as its possible to seen in the first drawing. Was this a real problem when the projected image was just a point?

Question 2: As seen in the first experiments, the tray walls could turn into a problem when the sun is low since the lens would have to be more angled, and most of the rays would be stopped by these walls. That seemed to imply the need of tilting the tray to ensure all rays are getting inside (see illustration 35). The result of the tilted surface could mean a problem for food access and product functionality since it would make the food tilted.



ill. 35 Inclination

CONCLUSION

The answer to these questions was obtained by the following experiments and reflections.

Answer 1: An experiment was conducted to see the distortion on the shape that had a focal point on a surface not parallel to the lens. The result showed that it did not affect either the focal point dimensions or the temperature achieved which were more than 300 degrees. The used thermometer only measured up to 300 degrees.

Answer 2:The solution to these problems came out simply, however, the achievement of this solution is the result of all the trial and error done so far.
It consists of having a box that follows the drawer principle and has a cut in one side to ensure that light can go through the wall and reach the desired focal point. (See illustration 35)

2. LENS FOLDABILITY

This experiment aims to explore the possibility of cutting the lens into two pieces. By doing so, it creates an opportunity of having a foldable lens. (See illustration 36)

ill. 36 Lens foldability

CONCLUSION

The experiment showed that the lens was capable of achieving a high temperature despite the middle piece being covered and blocking the light.

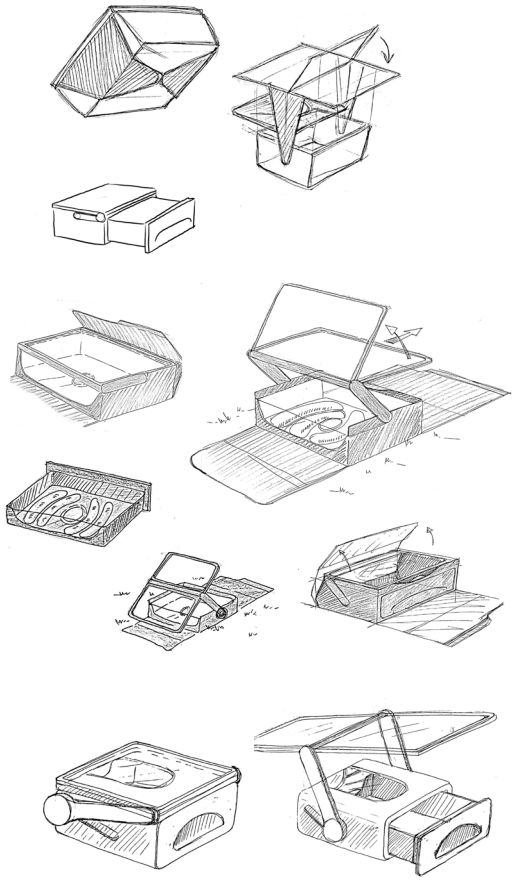
3. THE RAIL PRINCIPLE

To achieve a foldable lens that could easily be set up and that would not be removable. It was necessary to find a system that allows the lens to be easily set up and not be rremovable, it for safety reasons.

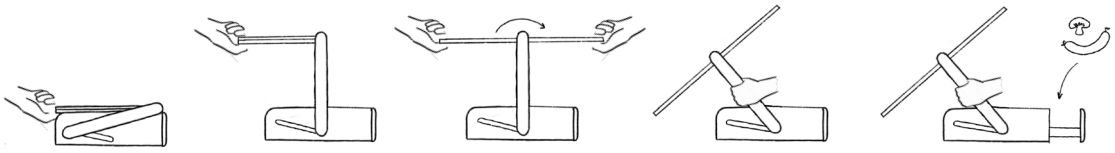
Different ideas got developed (see illustration 37) however, none of them succeeded in fulfilling these two requirements. In all cases it got complicated, expensive to manufacture, difficult to set up and involved many moving mechanical parts, increasing the fragility of the product.

In the end, it was possible to create a solution that could give a successful answer to these two requirements (see illustration 37-38). This solution consists of two diagonal rails attached to the cooking box. This rail would hold a piece that could move only in the direction marked by the rail, and at the same time, it would incorporate a hinge that would need to be activated to turn the arms into the vertical position. At the end of these arms, there would be another hinge holding the folded lens.

The resultant user interaction would be the one expressed in the following illustration 37-38



ill. 37 The rail principle

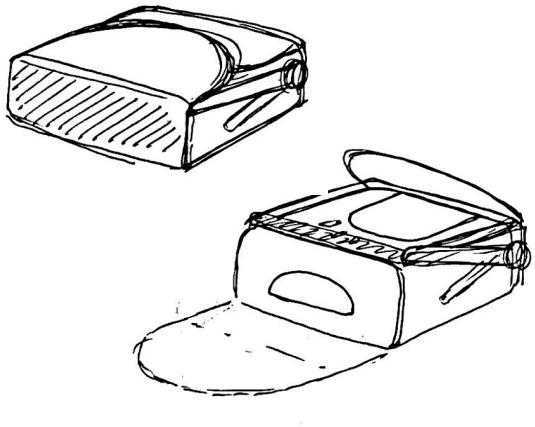


ill. 38 The rail principle 2

4. SAFETY

Question 1: Are all the lens positions safe?

Question 2: How can the product be safe to use throughout the whole user scenario?



ill. 39 Safety

CONCLUSION

Answer 1: The movement of the lens was mimicked by an experiment. The result made it visible how the position of the lens could result in danger for the environment around the cooker. In illustration 39, it shows how the lens is horizontal and the sun is not, the focal point will be outside of the cooking area.

Answer 2: This is derived into the need for a solution that protects the surroundings. The solution is an integration of a cover that has been thought of from the beginning. The cover will protect the lens from hits and scratches through transportation. The creation of a cover results in having two advantages:Protecting the folded lens while being transported and protecting the surrounding while being in use

5. SUN ORIENTATION

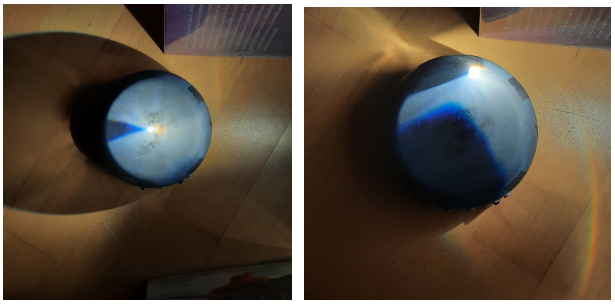
Question 1: How does the user know when the product is orientated correctly towards the sun?

ill. 40 Sun orientation

CONCLUSION

Answer 1: The correct orientation towards the sun can be achieved by looking at the shadow of the box, as it is shown in the pictures. It shows that there is not a need for a special geometry for the box to help the user understand how to orientate it towards the sun. (See illustration 40)

Question 2: How does the user know the lens is orientated correctly towards the sun?



ill. 41 Sun orientation 2

CONCLUSION

Answer 2: Once the product faces the sun correctly. The next step will be to orientate the lens correctly, which is perpendicular to the sun. This position will be guaranteed by a circle marked in the cooking tray. The circle should look like a target point making sure the user can easily identify what it is and its purpose. Therefore, the goal for the user will be to tilt the lens until they can see the light inside the target point.
An experiment was conducted to understand how fast the sun moves in 30 minutes, and therefore how big the target point should be and if this dimension would be manageable in the design.

The result of the experiment was that the sun moved 4 cm in 30 min. That means the need for a circle of 8 cm. The experiment was conducted during spring. In spring, the sun is still low and therefore moves at a higher distance in a shorter time compared to summer. The time frame of 30 minutes was considered to be too long. When using a gas grill people usually check the food with a frequency of around 5-10 minutes. (Try This - Solar Cooker Challenge, 2015)

It was decided that the reasonable checking time is around 15 minutes, which is in a spring scenario, the result is a diameter of 4 cm. (See illustration 41)

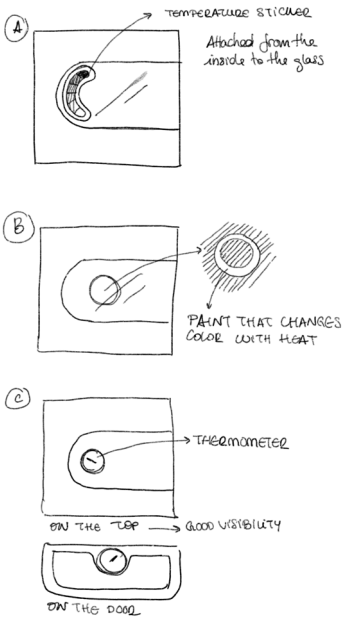
6. TEMPERATURE INDICATION

How does the user know that the food is getting cooked?

The first experiment showed that when the product is getting heated inside, condensation will be a factor. Thereby the user gets the feedback that the product is working and the food is getting cooked.

Condensation is a factor that decreases the transparency of the surface and therefore avoids the light coming inside. That shows the need of using a hydrophobic material to cover the interior of the window on the box.

It was considered a significant factor to implement feedback that would let the user know in a trustable way that the product is working. Therefore the incorporation of a thermometer was explored (see illustration 42).



ill. 42 Temperature indication

7. THE CAPACITY

To carry out accurate experiments that could confirm that the technology would work on a bigger scale, detailing of the capacity was done.

To define the capacity (volume) of the product, the dimensions of the base and height needed to be defined. It was needed to find requirements that guided these decisions. These decisions were taken in an internal discussion where calculations were done as an argument for going into one common direction. The decisions were divided into lens size, which would define the base size and height of the product.

CONCLUSION

The conclusion of these experiments was satisfactory and worked as a proof of concept. Taking into consideration that the conditions were not ideal for several reasons:

- The transparent film is thin, causing too much heat loss

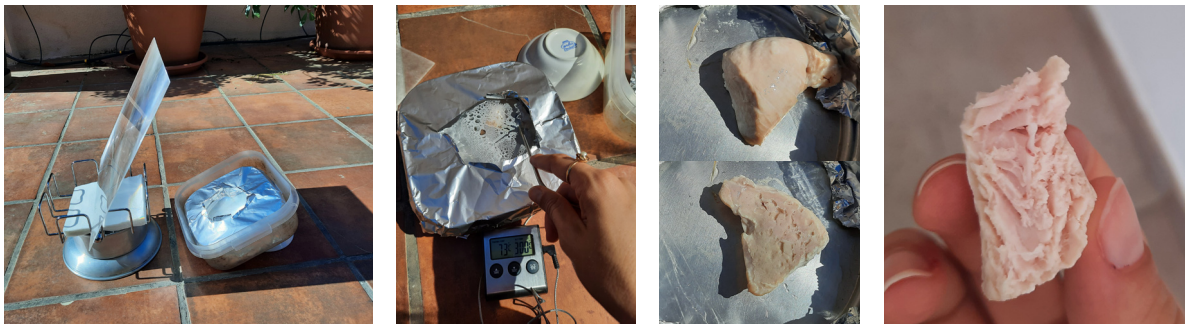
The insulation was primitive and far from the one that could be achieved in the final product
The film was not hydrophobic, allowing condensation to stick to it and decreasing the transparency of the window.

Therefore, even though it has not been possible to confirm, it is expected that the final product will have a much better heat capacity. Making the food ready in a shorter time and with better results. It could even happen that the pan reached the temperature that left some burn marks in the food.

It is not currently possible to say how many people this product can cook for since it depends on the type of food users decide to make and on cooking time.. For instance, if the users want to cook sausages; then the product has enough space to fit around five sausages inside, which would be the first round for five people. (See illustration 43-44)

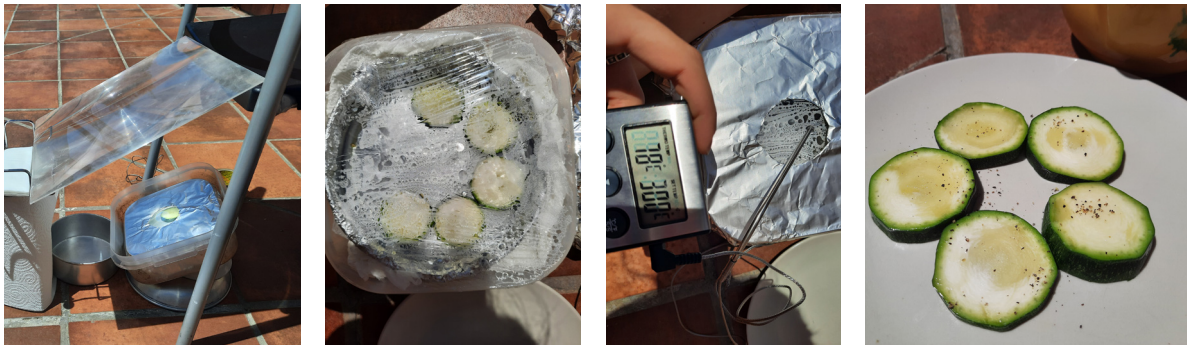
However, if they are cooking vegetables, then in the first round, people will consume a bigger portion. In that case, the solar cooker will be able to provide around two rations per round.

CHICKEN EXPERIMENTS



ill. 43 Chicken experiment

VEGETABLES EXPERIMENT



ill. 44 Vegetables experiment

8. AESTHETICS AND PRODUCT IDENTITY

In this project the main aesthetics has been shaped by its functionality. Once the functions began to be clarified it was easier to have a discussion about how to play with the shapes and components in order to compose an appealing product. To do so, several mood boards and colour palettes were created taking inspiration from current cooking products. Each of them followed a different trend: camping, modern, vintage and futuristic style. The mood boards were translated into the product. Finally, the material was sent to possible users for validation. The whole document regarding aesthetics that was sent to the users can be seen in Appendix 9.

USER VALIDATION

The feedback from the users was that they prefer the modern, simplistic look when it comes to the aesthetics of the design. When it comes to the colours of the product, they prefer natural, earthy colours. (Appendix 9) That was aligned with the vision of creating a timeless design that is durable, not only in the structure but also in the visual perception of the product.

This validation helped the team create the mood board that should work as a guide for the final aesthetics of the product.

CONCLUSION

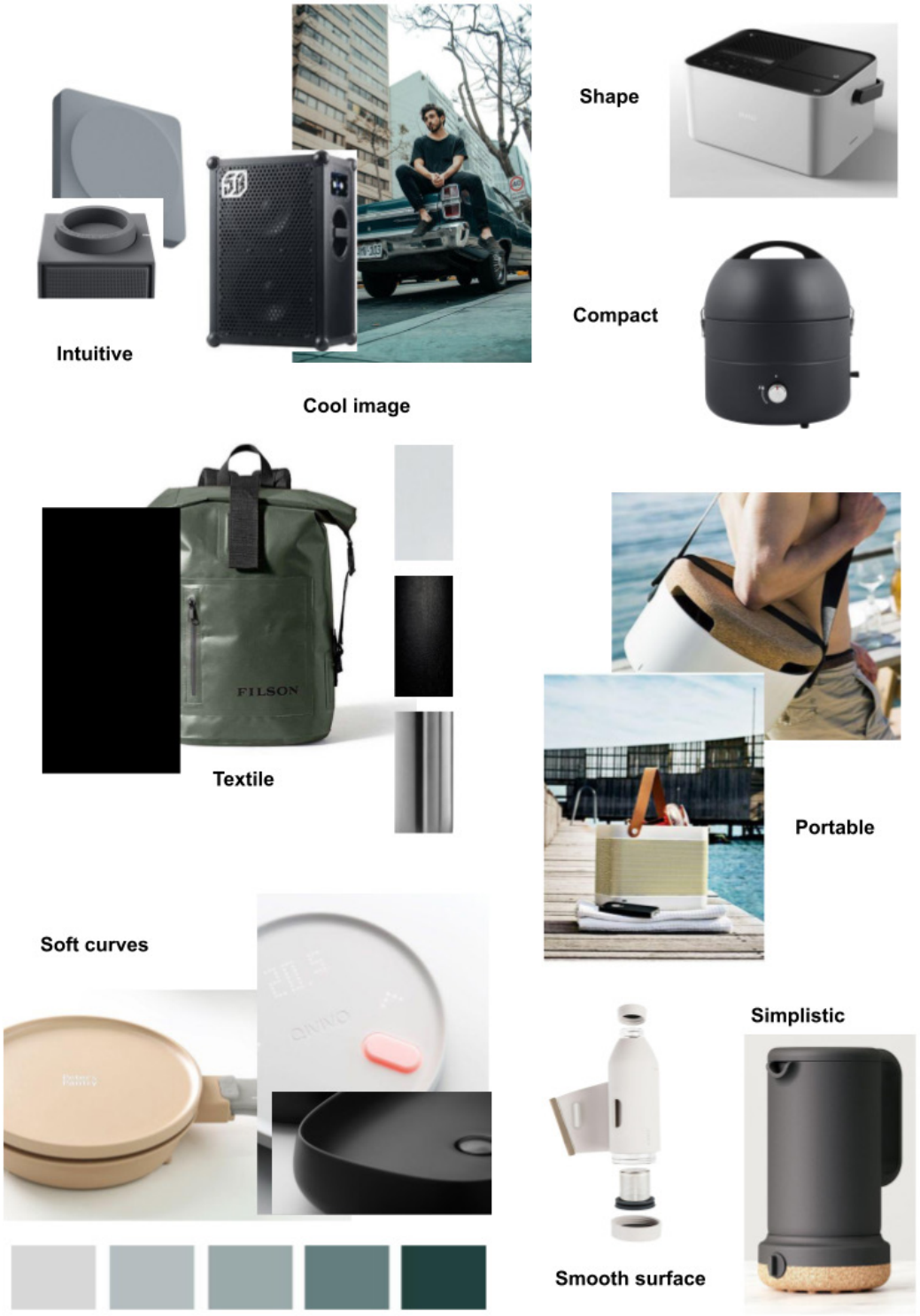
By making the shape of the product very square with smaller design details, the aesthetic of the product should look robust, durable and resistant. There should not be sharp or aggressive edges to create a friendly and accommodating look. There was a desire to make the product look cool but resistant, like the speaker that currently is popular among the young generation of boys.

Some portable products have inspired ways of integrating a strap in an elegant and contemporary way, using a material that contrasts with the rest of the product both in texture and colour.

For exterior surfaces, the plastic touch with textures has been found as the most desirable, similar to the black kettle or the compact grill. These surfaces create a quality feeling and have a robust look, making sure the user is not afraid of using or breaking it.

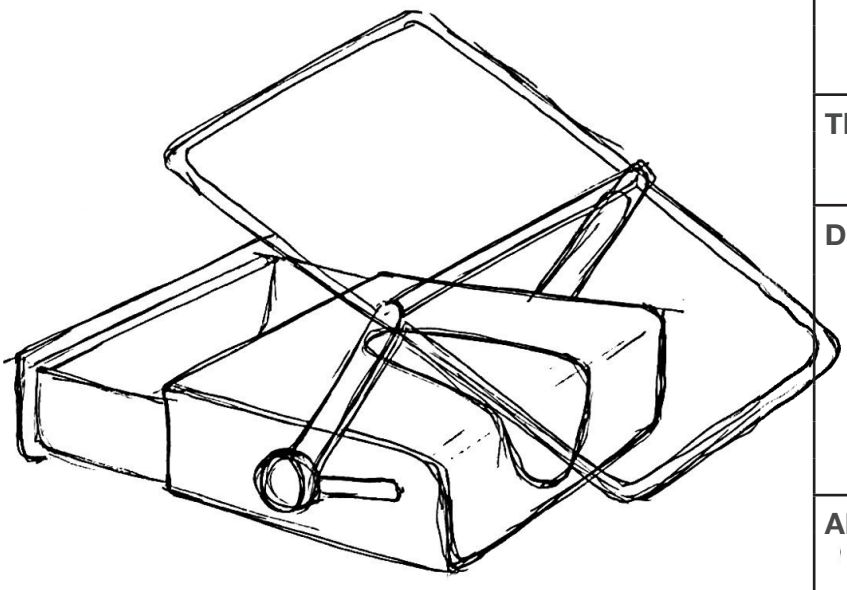
For the exterior textile surfaces, the look of the backpack is an inspiration, which has a smooth plastic surface resistant to both scratches and water and is easy to dust off sand or soil. The goal is to create an intuitive product. The inspiration could be products with contrast in shape but done in an elegant and distinguished way. These factors should all contribute to a modern and simplistic design.

By having natural colours and a simplistic design, the product aims to be unisex. Today mostly men dominate the grill area. By making a grill with a less masculine look, the product solution might make a change in this behaviour. (See illustration 45)



ill. 45 Moodboard

2 CONCEPT SUM UP



These experiments (further information can be seen in appendix 7) done doing this chapter together with the validation provided by the flow simulations in the appendix) have been able to provide a first architecture for the product that has been gathered in the drawing above.

KEY DIMENSIONS
SET UP AND USABILITY
COOKING FUNCTIONALITY
SAFETY
TRANSPORTATION
DURABILITY AND MAINTENANCE
AESTHETICS
MARKET ACCESSIBILITY
SUSTAINABILITY

	NEED / DESIRE - WHY	MORE DEFINED NEED / DESIRE - HOW
	Similar capacity to a disposable grill (2 people)	
	Lens: big enough to provide the needed heat for the desired volume	**Foldable lens minimum 900 cm2**
	Minimum volume (to increase heat retention)	
	Quick and simple setup	**Reduce the number of interactions**
	Intuitive Clear orientation towards the sun	**Clear designated area for the sun to hit (target)**
	"It's working" feedback	**Incorporation of a system that shows the temperature is rising**
	Right set up	**Perfect horizontality lens when it is unfolded (180 degrees)**
		Controlled and precise lens movement
	Minimize the cooking time, similar to a disposable grill (25 min)	**Increasing heat efficiency**
		Ensure a hermetic closure
	Possibility of boiling water (100 degrees)	Ensure a good insulation: avoid heat loss
		Increase heat concentration
	Food achieved up to 73 degrees inside in order to be cooked	Homogeneous shape
		Use of good conductor materials
		Optimize light entrance
	For the environment Avoid the creation of a fire	Restrict the movements of the lens, forcing the focal point to always be in a controlled region
		Lens cannot be deatached from the box
		Cover that protects the floor
	For the user Avoid burning the food	Clear distinction between the focal point and cooking area
	Easy to carry arround either in a bike / backpack / by hand	* The product could incorporate a strap
	Light weight, around half the weight of a portable grill, aprox. 3,5 kg	Reduce metalic material
		Use of light materials
	Similar durability to a portable gas grill * Would be nice to protect the lens	Cover to protect the lens from sckratches
	Hit resistance	The product should be reduced to a compact shape after use
		Use of strong materials, skratch resistant
	Easy to clean	Avoid groves and places where dirt can build up
		Removable parts for cleaning
		Easy to clean surfaces
		Design for disasembly and easy to replace parts
	Robust look	Overdimension of components that look weak
		Simple and compact design, with minimum amount of components so there are visually less weak points
	Lower the manufacturing cost	Simple design, reduce the number of needed components and materials
		Use of the material and manufacturing process that allows cost and time reduction
		Design for desasembly and easy to replace parts
		Use of standardized components when possible
	Lower the carbon footprint compared to the disposable or portable gas grill	Use of recycled materials
		Reduce the number of components and materials used

03 DETAILING

This chapter enters the design details and studies the best way of shaping and manufacturing each component to ensure the concept developed in the previous chapter, can be carried out. During this phase, the collaboration with Artlinco has been valuable. Since they have a lot of experience, their understanding of the manufacturing processes and cost is extensive, making it easier for them to estimate their influence on the design.

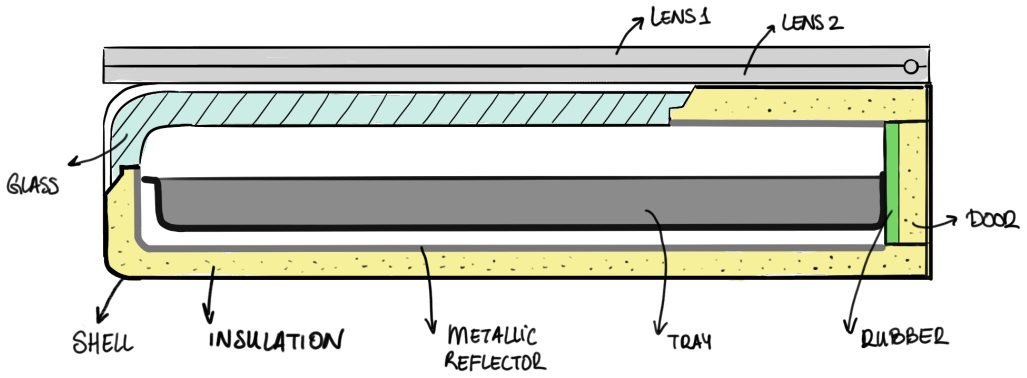
The chapter will consist of the possibility of seeing the impact that both the manufacturing process and costs had on the design and therefore in the decision making.

The design of the product has been done to be as feasible and realistic as possible, and special attention has been drawn to the cost reduction. Therefore the product attachment components will mainly be standardized, and the components with special functions have been specially designed for the product.

The chapter starts with a sum up of the previous chapter, showing the different parts of the concept that need to be detailed. Then the chapter will be divided into several components that need to be detailed. In the end, a design brief will be presented as a specification list that will allow the reader to follow the evolution of the requirements and see the materialization this product proposal offers to them.

1 COMPONENT DETAILING

1.1 THE BOX



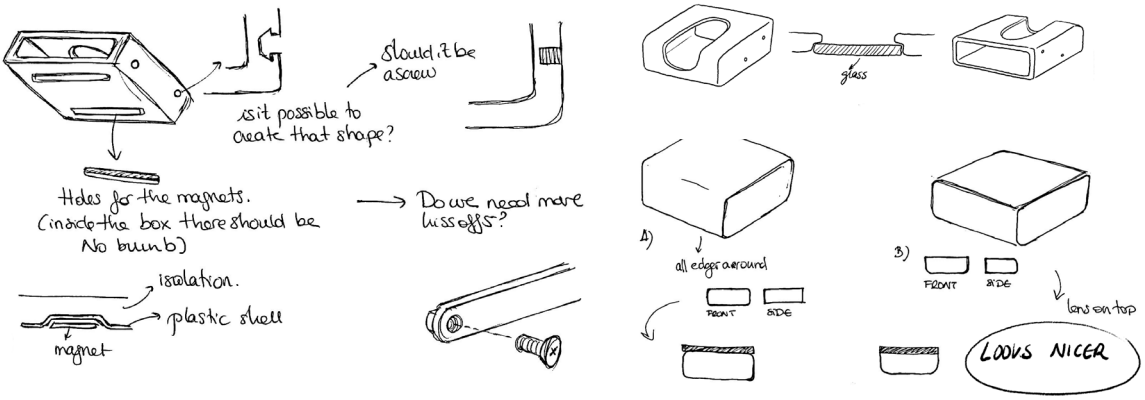
ill. 46 The box - cut

THE SHELL

MATERIAL AND MANUFACTURING PROCESS DISCUSSION

The material and manufacturing of the shell have opened up a discussion. On the first thought, the use of metal got considered to look more natural and fit better the storytelling of the developed product, since plastic has an unsustainable stigma. However, this process helped us realize that in this case, the most sustainable way to go with keeping up with the requirements and functions was the use of plastics.

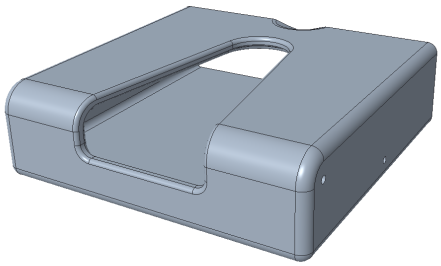
The manufacture of the box in metal would be more complicated, time-consuming, and expensive. Manufacturing the box in plastic can be produced in two steps: First, a rotational moulding would create an outer plastic layer shaping the product, and then a PU foam would be injected between the two layers to secure proper insulation.
The main goal of the box is to isolate the interior, to retain as much heat as possible. Using metallic material would go against these requirements, as it is a good heat conductor.
If metal was chosen the introduction of colour would have been a problem since metallic components can lose their colour coat when scratched.
Plastic materials can be strong and withstand harsh weather conditions and behave well concerning wear and tear.
The plastic box will not be able to be recycled due to its manufacturing process, however, this is the most durable component of the product, and it is expected to be a long lasting product.
The plastic that shapes the box will be 60% recycled HDPE.
Instead of using an isolation material, vacuum isolation could be implemented. Even though it would fulfill the requirements in terms of heat retention and safety, it would mean extremely difficult and expensive manufacturing for the main box. (See illustration 46-47)



ill. 47 Developing the shell

SHAPE DETAILING

The evolution of the shells appearance it is shown in the following illustration see illustration 48
During the detailing of the main box some basic guidelines were taken into consideration to fit the chosen manufacturing methods. Sharp edges and corners are impossible to carry out. Ensuring an optimal wall thickness everywhere and a shape that is possible to rotational mould. Other components would be fixed to the main box by screws. In order to make it possible, molded threaded inserts would get placed in the walls of the product.
On the bottom surface there must be cutouts for the magnets that would hold the cover in place.
On the bottom surface there would be a whole where the isolation material can be injected later during the process. This would eventually be cove



ill. 48 Detailing the shell

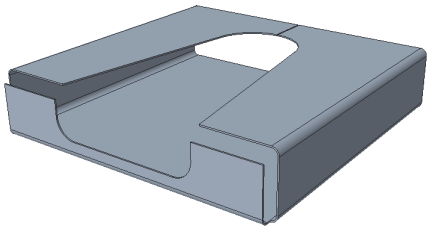
THE SHELL

- Material: HDPE 60% recycled for the exterior shell and PU foam for the isolation
- Manufacturing process: Rotational molding of the exterior shell and injected foam

THE INSIDE REFLECTOR

Shape detailing:
When detailing the component, there were two main alternatives see illustration 49.
A: Creating a bend metallic cover that could go inside the shell
B: Cutting rectangular pieces of thin metal that are glued to the interior walls of the product

Option B was challenging and costly due to the glued attachment of the metal pieces, therefore Option A was chosen. The bent metal is usually a cheap solution, and it would not require any glue, just the existence of tolerance between components to ensure the extraction of the reflector was not possible unless force was applied to it on purpose.



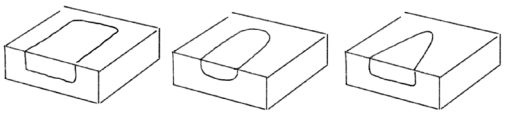
ill. 49 The inside reflector

THE INSIDE REFLECTOR
- Material: Aluminum
- Manufacturing process: Laser cutting and bending

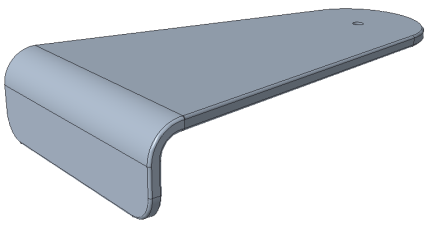
THE WINDOW

The window is a laser-cut and bent acrylic plate with an interior hydrophobic coating that reduces the negative impact on its transparency due to water condensation. see illustration 50.

It would be glued to the interior walls of the box to create more space to put the hand between the lens and the acrylic that it is easier for the user to put the hand around the lens and grab it. Using a silicone glue would ensure the hermetic closure of the cooking space and ensure the perfect fit of the window to the box.



Evolution of the window shape



ill. 50 Detailing the window

THE WINDOW

- Material: Acrylic with additives that will make it withstand high temperatures
- Manufacturing process: Laser cut and bendt

1.2 TEMPERATURE INDICATION

The introduction of a thermometer had been considered throughout the concept development phase, however it had not been decided how. On the detailing phase two main possibilities arose:

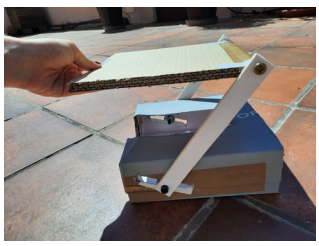
A sticker thermometer:
This way the thermometer could be easily integrated in the design, different ways of integrating this in the design where explored see illustration xx,
It was considered it could be a less durable solution, since its attached by glue on a component that will be exposed to high humidity
Also the reliability of this thermometers was unknown

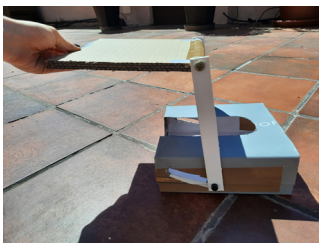
A standard grill thermometer
This would also be a cheap alternative, since its a standardized component
Its attachment would require drilling a hole in the acrylic
It could also be easily integrated in the design in the hole left between the acrylic plate and the shell. This way it would not interfere with the folded lens on top and it would also be located in the best position for the user to see it.

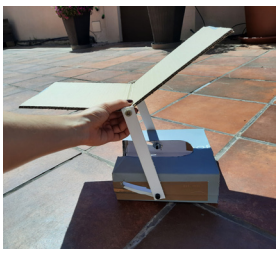
1.3 THE RAIL PRINCIPLE

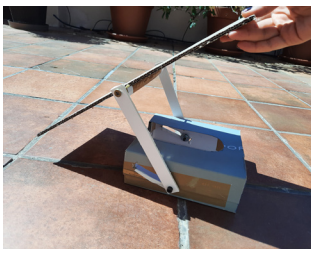
To have a better feeling on this principle a quick mockup was built, see illustration 51. The mockup confirmed the easiness and comfort of the served as validation of the concept:


1


2


3


4


5

The rail system has been the most difficult part to shape in this product. It was necessary to solve different positions with the limited amount of movements and components.

ill. 51 Rail principle mock-up

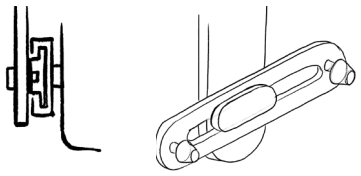
THE RAIL

The original design had a rail directly on the shell, which seemed to be the best solution, however, that was not possible to mould. The next idea was to create an independent rail and place it with screws in the shell. This solution called for the need of incorporating two inserts on each side of the box. This would affect the mould cost however it was the compromise that had to be accepted to be able to manufacture the rail.

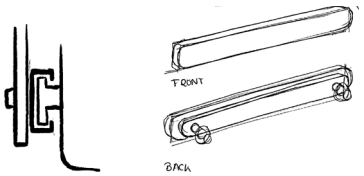
There were two options when shaping this component. (See illustration 52-53)

- Option A
- Option B

Both options had a similar complexity, however option B was considered to be better looking and also a geometry where dirt was less lucky to build up.



ill. 52 Option A



ill. 53 Option B

MATERIAL AND MANUFACTURING PROCESS:

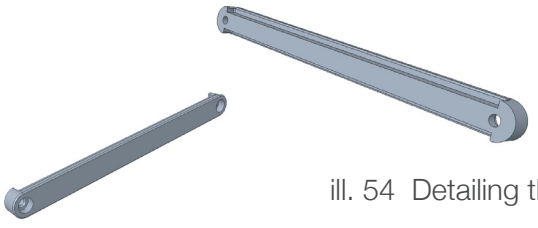
Plastics:

- It is cheaper when manufacturing is done on a large scale
- It is possible to be done with a snap connection, meaning it is not needed with an insert and therefore less material would be used. although then it would not be possible to replace it

Metal:

- It is cheaper for a small scale (prototypes)
- It would be necessary to add two inserts in the shell
- It could be replaced since it is attached with screws
- Stronger construction for holding the lens
- Premium quality feeling compared to plastic for the users and feels stronger than plastic

There is no perfect solution, both materials have their advantages. Metal was chosen for the concept proposal since it is easier to manufacture for the prototypes, but later in the process plastic solutions could be tested and replace the metal components for a cheaper and lighter final product. (See illustration 54)



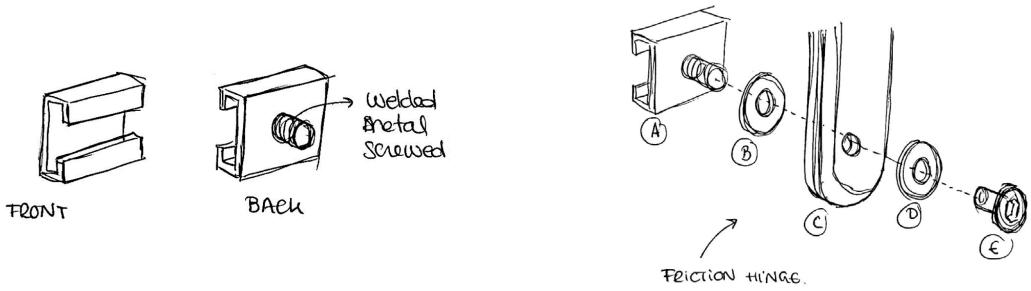
ill. 54 Detailing the rail

THE RAIL

- Material: Stainless steel
- Manufacturing process: milling

THE SLIDER

The hinge regulates the movement of the lens to orientate it perpendicular to the sun direction. It was necessary to make it precise and comfortable. In the beginning, it was considered incorporating a click system. Similar to the one used to regulate the handle of most baby strollers. (See illustration 55)



ill. 55 The slider

Going in this direction would highly increase the cost of the product since it could not use a standardized component. Besides, the precision of a system like that one was not the most desired. Because the positions are fixed and therefore the lens could only move at certain angles.

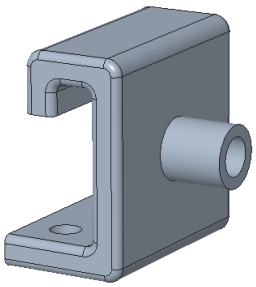
The other alternative was using a friction hinge system. The advantage of this method is that it is precise and allows all kinds of angles, it is comfortable for the user and it can be done with standardized components and is therefore cheaper. The only drawback is that it could occur that after prolonged use, the hinge gets loose. The design will incorporate a screw on the outside, so that the user can adjust the tightness themselves. The optimal strength of the friction hinge needs to be further explored and experimented on functioning prototypes. The hinge needs to be strong enough to hold the weight of the lens in any position, even withstand wind up to a certain level. On the other hand the user must be able to adjust it easily, the right balance has to be found through experiments.

MATERIAL AND MANUFACTURING PROCESS:

This piece could be made either out of plastic or out of metal the choice of material would affect the shape. (See illustration 56)

Plastic:
- It is cheaper in large amounts
- It can be done as a snap connection, simplifying the geometry and reducing the number of components needed.
- It would be thicker than the metal one since it would need to incorporate a screw inside, creating a bulkier look

Metal:
- It is cheaper on a smaller scale
- It needs extra bolts to attach it to the rail
- It is less bulky since the screw can be welded
- Provides higher quality feel for the user



ill. 56 Detailing the slider

Same as with the previous component, there is no perfect solution, both materials have their advantages. Metal was chosen for the concept proposal since it is easier to manufacture for the prototypes, but later in the process plastic solutions could be tested and replace the metal components for a cheaper and lighter final product.

THE SLIDER

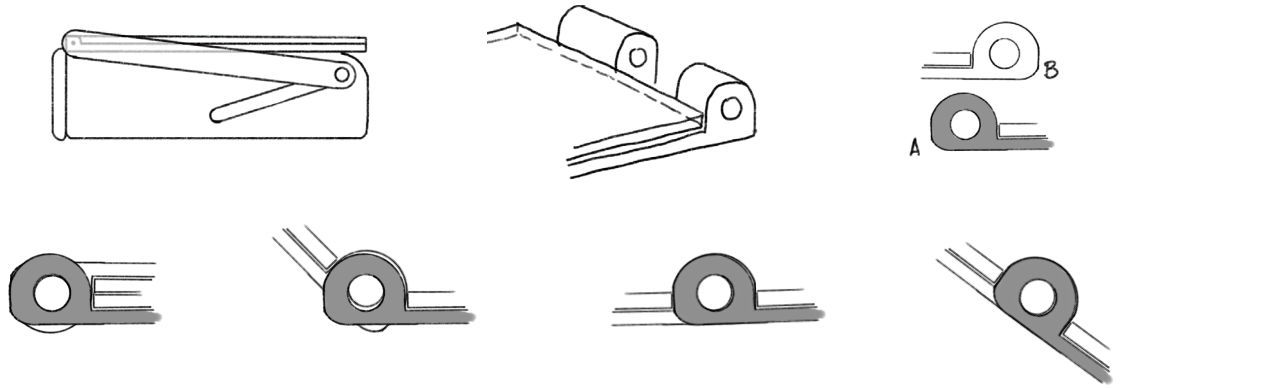
- Material: Stainless steel
- Manufacturing process: howmilling

THE LENS HINGE

Due to the numerous requirements needed to make the hinge work, the component geometry will be designed specifically for its purpose. Meaning it will not be able to be a standardized component.

The hinge needs to fold the lenses and place them on top of each other, 0 degrees. So it will still open them up, keeping an angle of 180 degrees between the lenses and with an angle of 90 degrees with the arm.

Its shape has been explained in the following illustration 57.



1. Lens folded | 1. Lens opening | 3. Lens stays horizontal | 4. Lens is tilted towards the sun

ill. 57 Developing the lens hinge

The difficulty of this piece was that it was hard to combine with the need of introducing a bump in the handle that would be able to stop it. This is because the lens needs to have a wide number of positions and be in different directions from its original position to its functional set-up. illustration xx The hinge would not only be connected to the lens, but it would support it all around its edge from the bottom in a 5 mm wide stripe, this will be further detailed in the lens paragraph.

Both sides have been designed to be symmetrical to use the same punching tool, removing the extra material to lower the cost.

MATERIAL AND MANUFACTURING PROCESS

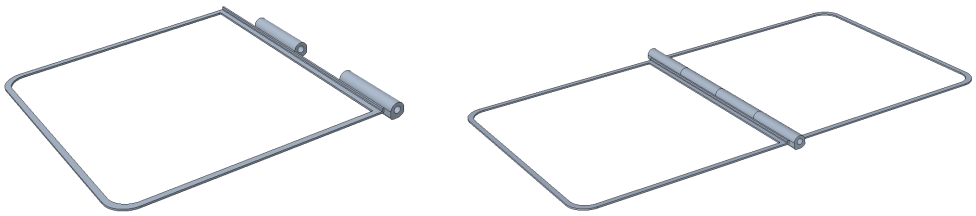
Plastic:

- It can be extruded and a cutting machine would afterwards remove the material from the centre of the frame and recycle it.
- It is a light material
- It would be cheaper than metal on a mass-production scale

Metal:

- It would need to be manufactured in more steps: the cylindrical part would be either extruded and afterwards be welded to the cut and bent plate.
- It would be stronger
- The width of the plate could be thinner, making the product look lighter
- There is not so much waste of material

It was decided to go with the metallic solution, since the plastic direction would involve removing a big part of the extruded profile to achieve the final desired shape. Further on this could be reconsidered with an updated design for the hinge. (See illustration 58)



ill. 58 Detailing the lens hinge

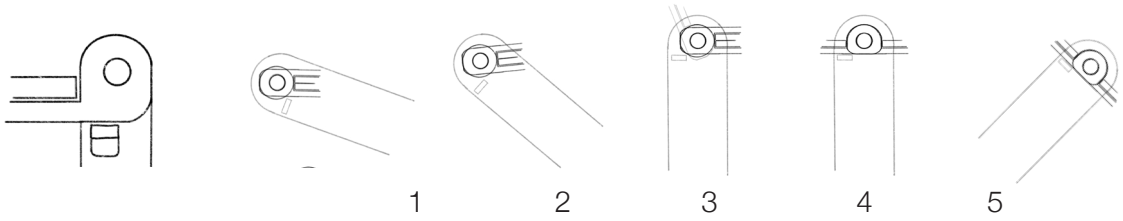
THE LENS HINGE

- Material: stainless steel
- Manufacturing process: extrusion, laser cutting. Bending of the side plate and welding

THE ARMS

The arm had to comply with different requirements: It needed to somehow stop the lens after opening it at an angle of 90 degrees. This position ensures that the focal point will always occur at the end of the handle.

The introduction of a bump to stop the lens rotation at 90 degrees had to be meticulously thought and designed parallel to the design of the hinge to ensure they both fit together.
During this process, it was possible to see that the bump could only be in one of the sides, since in the other one it would crush with the exposed side of the lens hinge, avoiding it to rotate. see illustration 59.
The arms need to be strong enough to hold the lens in a fixed position, on the other hand their weight should be minimized.



ill. 59 Developing the arm

MATERIAL AND MANUFACTURING PROCESS

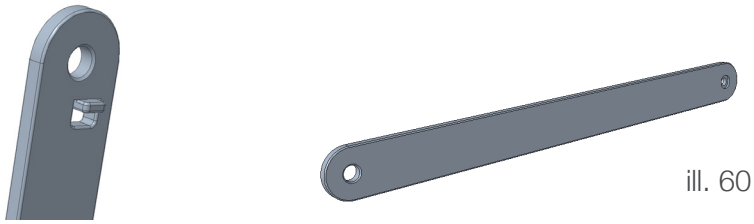
Plastic:

- Cheaper in the long run
- It would be manufactured by injection moulding
- Need to increase its width to ensure its strength

Metal:

- It does not have such a high price since it can be a standardized profile that has been milled into the desired shape and with the needed holes.
- Gives a premium look

Having done these considerations the team decided to made it out of metal due to its strength and premium look. (See illustration 60)



ill. 60 Detailing the arm

THE ARMS

- Material: stainless steel
- Manufacturing process: milling

1.4 THE LENS

Fresnel lenses are standardized elements. However, the one this product uses has a special geometry, which means that it will be necessary to contact the manufacturers and ask for this special size. Fresnel lenses are widely customizable, depending on the angle of the cuts on their surface it is possible to set their focal distance and their size easily.

Regarding its attachment to the lens hinge, several considerations were made, see illustration 61.

ill. 61 The lens

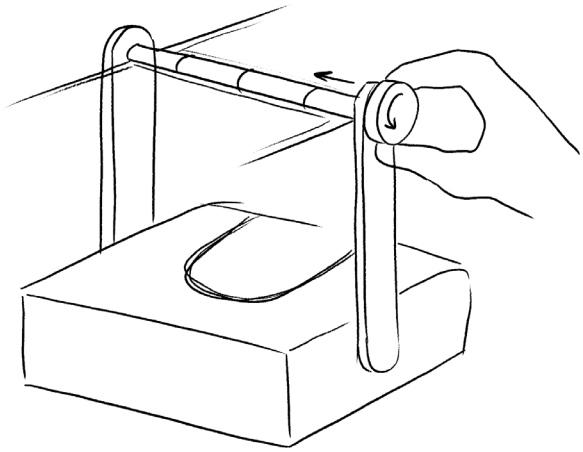
Based on these considerations, it was decided to go for the most simple one. Both to lower down costs and to reach the most simplistic design without compromising its functionality. Therefore Option E got chosen. Here the lens would be glued to its frame. It was considered to use a solution that used bolts, however, this would add more costs and it would also compromise the looks of it. The decision to glue the lens, would mean that both the lens and the joint would be sold together as a unique piece when the user needs to replace it.

THE LENS
- Material: plastic
- Manufacturing process: standardized component cut to the right shape

THE CROSSBAR

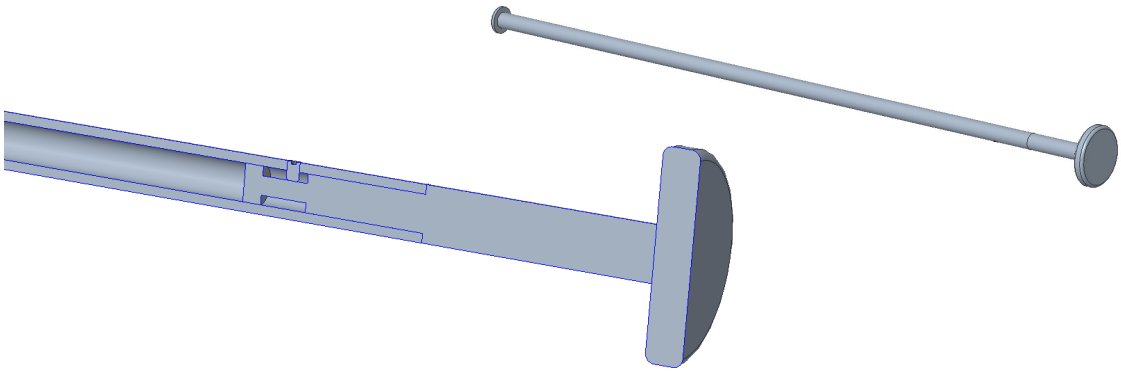
This connection consists of three main components: The two lens hinges, the cross bar that holds together the lens hinges and connects them with the two arms.

The impossibility of creating a system consistent enough to hold the lens in the 90 degrees position introduced the need of designing an adjustable threaded component that pulled the arms together when tightened, making sure the lens between the arms is truly fixed and avoiding it to rotate. see illustration 62.



ill. 62 Developing the crossbar

The lens fixer was put together with the crossbar holding the lens and the arms together see illustration xx. A steel pipe would hold the lens hinges together and provide an axis for their rotation. As an extension to this crossbar a threaded insert would be inserted so that the user can tighten or loosen from the outside. To make sure it is impossible for the user to remove and lose this part a grub-screw would block it where the thread ends. This piece could also be manufactured either in metal or in plastic. It was considered a better option to do it in metal since manufacturing it in plastic would call for the need of three pieces, whereas the use of metal reduces it to two pieces that have been welded together. Furthermore, the introduction of metal gives a more sophisticated look and more strength. (See illustration 63)



ill. 63 Detailing the crossbar

THE CROSSBAR
- Material: stainless steel
- Manufacturing process: milling and welding

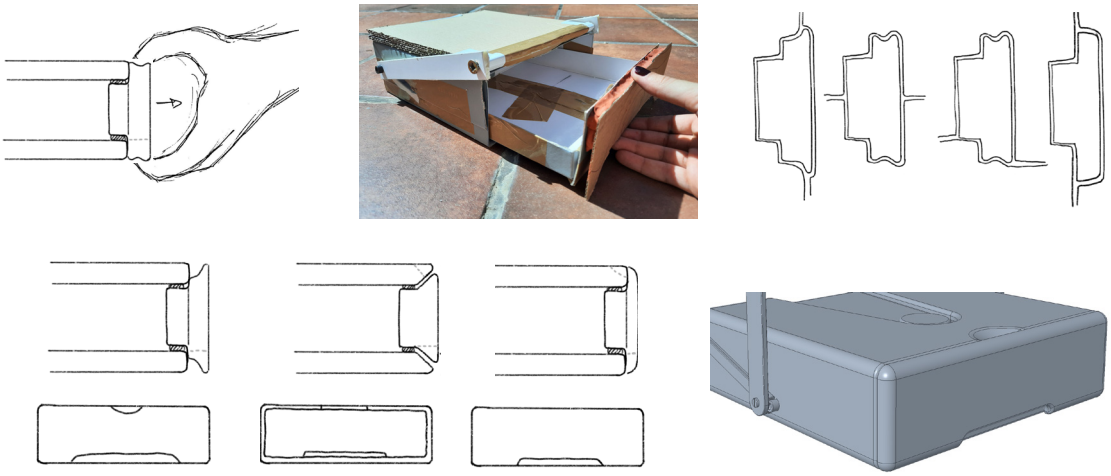
1.5 THE DRAWER

The drawer had to be removable, easy to clean, secure, comfortable to place the food inside, possible to close hermetically, cheap to manufacture and it needs to have insulation inside.

THE DOOR

The need for insulation inside the door called for the same manufacturing process used for the shell. It was a consideration to have during the design process since its shape had to fit this manufacturing process.
Regarding its shape and system, different possibilities occurred. (See illustration 64)

The first ideas include extra material that would be used to mark those places in touch with the user's hand to increase the intuitiveness of the product. However, this meant an extra cost in the manufacturing process that could be avoided.

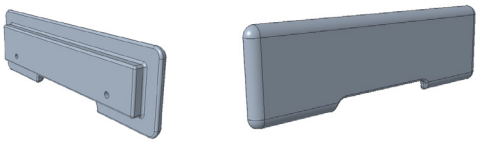


ill. 64 Developing the door

To avoid extra cost the following shape was created: The shape answers the need of making the door intuitive since it marks the places where to hold it and at the same time make it functional. It has a grove that prevents fingers from sliding and thereby making it easy to pull out.

To ensure the hermetical closure of the door, this element will have a rubber piece wrapped around the interior.

A final round of ideation helped polishing its shape to make it as subtle and as aesthetic as possible. illustration xx Further experiments regarding the size and the shape of the drawer are required to be carried out in prototypes to make sure it fits the hand of the users perfectly. (See illustration 65)



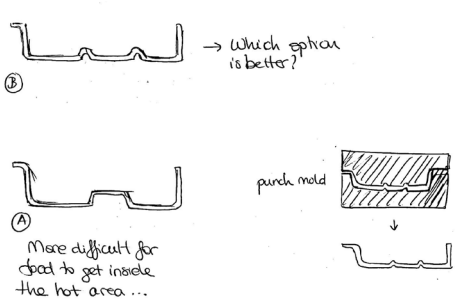
ill. 65 Detailing the door

THE DOOR
- Material: HDPE and PU
- Manufacturing process: Rotational molding

THE TRAY

The tray needed to have round corners to ensure it was easy to clean and it had to be done in a good conductor material to ensure heat distribution was done in the most efficient way possible.

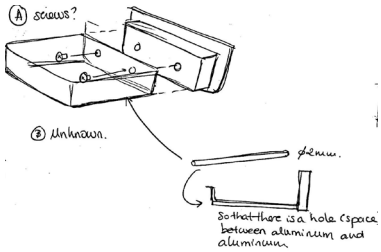
The shape has evolved during the detailing phase, see illustration 66-68. The first idea was to create a smooth bump around the focal area to distinguish it from the rest of the tray. After considering the need of creating a clear definition of this area, both physically (to avoid food going inside by mistake) and visually (to ensure its visibility through the window) it was decided both to incorporate colour around it and elevate the whole region.



ill. 66 Developing the tray

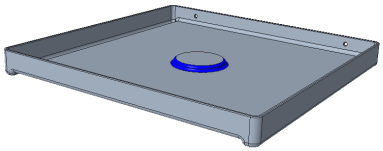
The manufacturing process of this object would be made by punching, which calls for a soft draft angle on the tray, around 1 degree.

The need for a separation between the tray and the reflector called for introducing a system that would maintain this distance fixed. The first consideration was glueing two pieces of plastic under the tray, avoiding the extra cost in the incorporation of extra material. It was decided to incorporate two groves in the tray. The groves will be created together with the rest of the tray in one single punch. This solution creates direct contact between two metals, which would mean that heat will transfer quicker to the reflector. However, since the walls are well insulated this was not considered a secondary problem that would not have a big impact on the functionality of the product.



ill. 67 Developing the tray 2

The attachment between the tray and the door was considered to be done by screws. This solution increases the price since it means the need of having two inserts in the door. However, this makes the attachment more durable and resistant, it introduces the possibility of replacing the tray in case it was needed. The surface of the tray must be black to ensure it can absorb as much heat from the light beams as possible without reflecting them back. This would be done by covering the cooking surface with Teflon just as on regular pens. The side of the bump in the middle is painted red to help the user guide the light into the dedicated area.



ill. 68 Detailing the tray

THE TRAY
- Material: Aluminum and teflon cover
- Manufacturing process: Punching

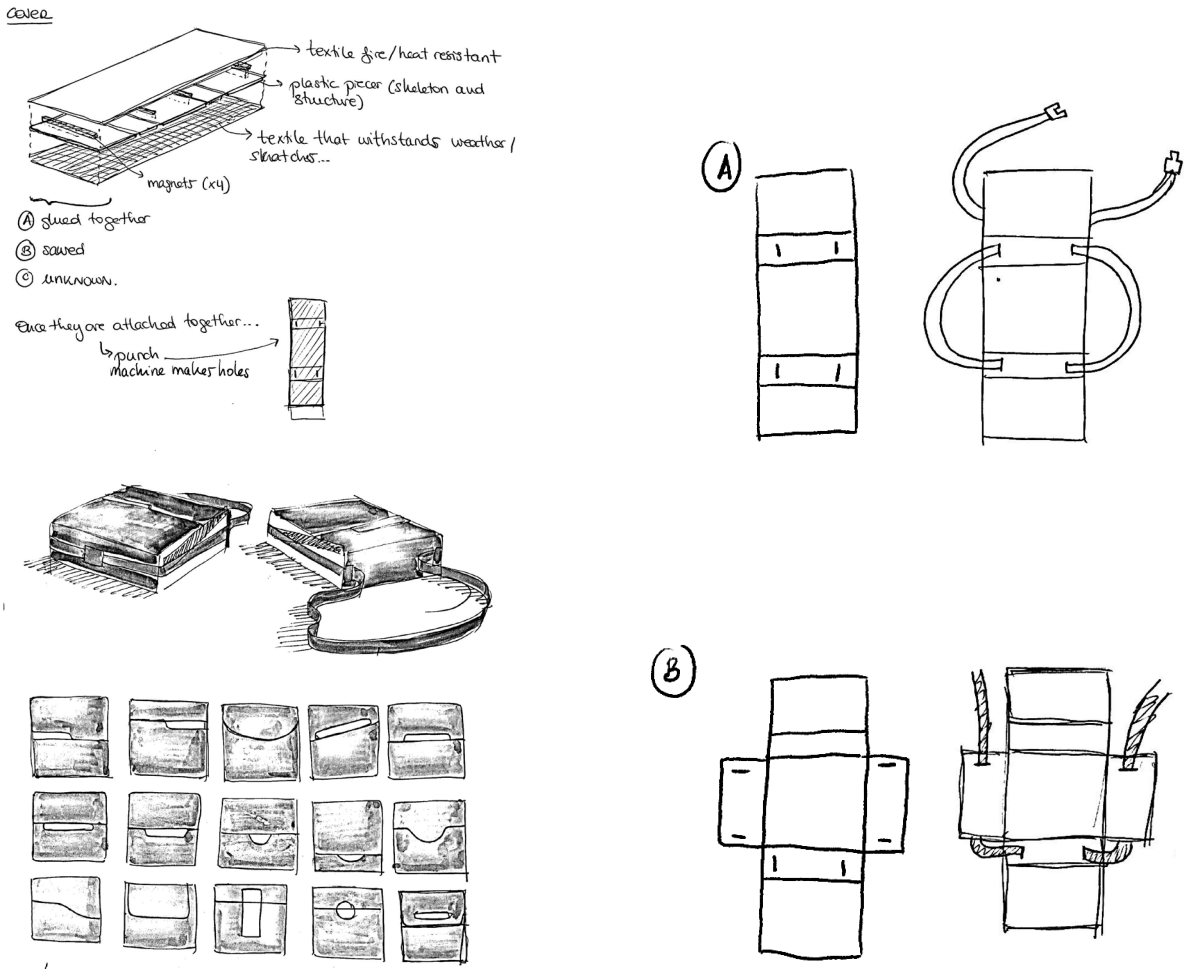
1.6 THE COVER

The function of the cover is both protecting the lens during transportation and the ground while being in use. Its functionality calls for the need of a fire-resistant material in the inside layer and an easy to clean textile on the outside, preferably water-resistant since this element is going to be in contact with the ground.

Between these two layers, the introduction of magnets could facilitate the user interaction: two magnets will hold the cover to the shell and another two will close the cover after use.
To strengthen the cover and give it structure, it got decided to incorporate a thin plastic layer.

The attachment of a possible strap should be as discreet and simple as possible, since this is a feature that not all users will use. Therefore, the strap would not have a big impact on the final cost. Therefore it was decided that the strap would be fixed to the cover by some cuts on the sides.

Possible shapes and strap attachments were explored see illustration 69.



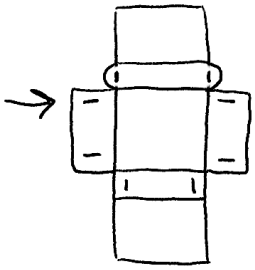
ill. 69 Developing the cover

To decide between the two main concepts a mock up was done and tested. see illustration 70.

ill. 70 Developing the cover - mock-ups

The solution with two extra wings offered three main advantages compared to the other one:

- Better floor protection
- Better look when closed
- Better strap support



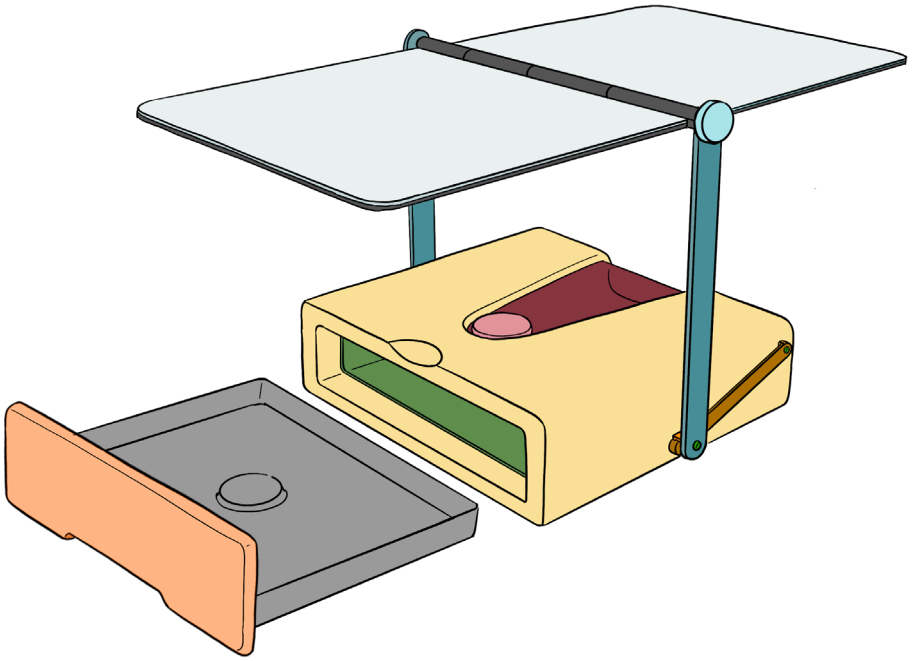
Therefore Idea 2 was chosen over Idea 1.
A final design round enabled polishing the design, creating the following shape illustration 70.

THE COVER

- Material: Patio Outdoor (kvadrat.dk), magnets and HDPE structure
- Manufacturing process: Glueing and sawing

The assembly of the product can be found in Appendix 11

2 DETAILING SUM UP



- Lens
- Lens hinge
- Lens fikser
- Handle
- Slider
- Rail
- Shell
- Acrillic
- Door
- Tray
- Tray Reflector
- Therometer

ill. 71 Product components

SPECIFICATION LIST

This list is a first step before the bill of materials and a sum-up of the detailing phase. This table shows the evolution of the gathered requirements and their materialization on the final proposal.

Depending on the requirement its materialization will be a component, a dimension or an implemented characteristic. Therefore this specification list has two main purposes:

List the components that will be needed and relate them to their origin. Making it easier to argue why a component has been needed and what special features configure it

Provides quantitative data of the dimensions from the key aspects of the product. Some dimensions have not been specified in this chart because they do not answer directly to a requirement. These can be considered as secondary dimensions, since their exact definition is more connected to the next natural phase of the product, the manufacturing process, and therefore it may be subjected to changes. However an approximate dimension of each component will be proposed in the technical documentation.

To facilitate the readings of this chart, a color has been designated to each component. The gathered specifications of each color have helped shape the final component and design.

	FIRST DESIGN BRIEF
	SECOND DESIGN BRIEF
	DETAILING PHASE
*	WISH

	NEED / DESIRE - WHY
KEY DIMENSIONS	**Similar capacity to a disposable grill (2 people)**
	Lens: big enough to provide the needed heat for the desired volume
	Minimum volume (to increase heat retention)
SET UP AND USABILITY	**Quick and simple setup**
	Intuitive Clear orientation towards the sun
	"It's working" feedback
	Right set up
COOKING FUNCTIONALITY	**Minimize the cooking time, similar to a disposable grill (25 min)**
	Possibility of boiling water (100 degrees)
	Food achieved up to 73 degrees inside in order to be cooked
SAFETY	**For the environment** Avoid the creation of a fire
	For the user Avoid burning the food
TRANSPORTATION	**Easy to carry arround either in a bike / backpack / by hand**
	Light weight, around half the weight of a portable grill, aprox. 3,5 kg
DURABILITY AND MAINTENANCE	**Similar durability to a portable gas grill** * Would be nice to protect the lens
	Hit resistance
	Easy to clean
AESTHETICS	**Robust look**
MARKET ACCESSIBILITY	**Lower the manufacturing cost**
SUSTAINABILITY	**Lower the carbon footprint compared to the disposable or portable gas grill**

MORE DEFINED NEED / DESIRE - HOW	IMPACT ON THE DESIGN - WHAT
Foldable lens minimum 900 cm2	Minimum lens size: 46X23 cm2
	Aprox interior capacity: 21x21x4 cm3
Reduce the number of interactions	Use of magnets to easiy attach and deattach the cover from the shell
	Use of magnets to open and close the cover
Clear designated area for the sun to hit (target)	Circle of 6 cm diameter bump for the focal area
	Elevation of the focal area by 4 mm to increase visible differentiation from the rest of the tray
Incorporation of a system that shows the temperature is rising	Standarized grilling thermometer
Perfect horizontality lens when it is unfolded (180 degrees)	Flat side on the lens hinge that forces the lens to be 180 degrees when opened
Controlled and precise lens movement	Friction hinge system between the arm and the slide system to acuratly control the arm rotation
Increasing heat efficiency	
Ensure a hermetic closure	Rubber around the door
Ensure a good insulation: avoid heat loss	Hollow shell of PP (approx 2 mm wall thickness) and interior PU foam (aprox 10 mm thcik)
	Bended acrilic plate to close the hole that allows the entrance of light in the box
Increase heat concentration	Metal reflector
	Use of black color in the tray to increase heat capture
	Minimize window dimensions (dimension matches the dimension of the sun path)
Homogeneous shape	Squared geometry with rounded edges
Use of good conductor materials	Use of aluminum, the best conductor after gold
Optimize light entrance	Hydrophobic sticker under acrilic plate to avoid condensation that reduces the acrilic transparency
Restrict the movements of the lens, forcing the focal point to always be in a controlled region	**System that keeps 90 degree angle between lens and arm**
	Lens hinge
	Arm has a bump that stops the lens rotation at 90 degrees
	Lens fixer that hold the lens hinge + arm together and stabilizes its position by friction
Lens cannot be deatached from the box	**Creation of a slide in system that holds the lens to the box:** rail, insert inside the shell to screw the rail in, screws to attach rail to shell, claw that slides though rail, screw that attaches claw + handle, washers for the friction hinge, screw that closes the friction hinge system
Cover that protects the floor	3 layer material: fire prove textile + plastic structure + plastic water proof exterior textile
Clear distinction between the focal point and cooking area	Elevation of the focal area 4 mm to avoid food getting inside it
* The product could incorporate a strap	
Reduce metalic material	Use of HDPE plastic for shell
Use of light materials	Plastic shell
Cover to protect the lens from sckratches	Cover design
The product should be reduced to a compact shape after use	Lens is folded and the slide mechanism compacts the lens on top of the shell
Use of strong materials, skratch resistant	PP shell
	Unpainted metal handle
Avoid groves and places where dirt can build up	Round corners on the tray + Round corners on the interior of the shell
Removable parts for cleaning	Detachable cover
	Removable drawer
	Removable reflector
Easy to clean surfaces	Use of water repellent plastic textile for the cover
Design for disasembly and easy to replace parts	Tray, rail and slider are fixed by screws
Overdimension of components that look weak	4 mm width arm
Simple and compact design, with minimum amount of components so there are visually less weak points	Incorporation of the thermometer in the hole left by the acrilic plate to avoid it sticking out
	Hided washers inside the handle
Simple design, reduce the number of needed components and materials	Punched rail in the tray to avoid extra material
	Design of drawer in one single piece
Use of the material and manufacturing process that allows cost and time reduction	Creation of the shell in two steps: rotational molding + injected foam
Design for desasembly and easy to replace parts	Bolted tray, rail and claw
Use of standardized components when possible	Rubber, lens, bolts and thermoter
Use of recycled materials	60 % recycled HDPE for the box
Reduce the number of components and materials used	Punched rail in the tray instead of adding extra piece to separate the tray from the reflector

04 IMPLEMENTATION

The product implementation has been relevant throughout the whole process design. In the beginning, it was important to evaluate the possibility of creating a relevant value proposition in the market. And throughout the design development, it has been important to consider the manufacturing costs's impact and limitation on the design.

This chapter will offer a final overview of these considerations. First, the product value proposition will be specified under the brand identity, where the product will also receive a name and a representative logo. After that, the possible strategies that could be adopted to enter the market will be evaluated. The financial aspects of launching this product to the market will be unfolded in the last section.

1 BRAND IDENTITY

1.1 PRODUCT NAME

SUN IT is a new cooking product that comes with a new way of cooking food outdoors. The proposed product offers the user the possibility of “sunning the food up”’. This concept name aims to establish a clear distinction with the grilling concept, to ensure the user’s expectation is not mislocated.

To reinforce the product’s image a representative logo was designed for the product.
The logo consists of a bright yellow circle that makes reference to the sun. Inside of the circle, there is a minimalistic silhouette of the product seen from the side.

SUN IT

1.2 VALUE PROPOSITION

EXPERIENCE AND FOOD QUALITY

This product offers an alternative to outdoor cooking that aims to widen up and therefore enrich the outdoor experience by “sunning the food up”. This offers the possibility of cooking meat in a way that is more juicy and tasty than the grilled or fried one, and an upgrade on the variety of recipes that can be cooked on a picnic day. In the proposed solution, there is no need for handling any gas or hot charcoal, which might lead to opening the area of interest, as grilling is known for being primarily dominated by men.

SUSTAINABILITY

SUN IT is a new innovative way of cooking food outside with friends and family during the summertime. This product proposal creates an opportunity to benefit from the power of the sun by using it to cook food thus reducing the carbon footprint of the current solution.

USER INTERACTION

SUN IT is intuitive and fast to set up, in few interactions. The food is placed within a tray that is easy to pull out to access the food. The cooking time of the food is similar to using a disposable grill, so around 30 min.

TRANSPORTATION

The product is easily transported by the crossbody strap. The product is also small enough to be placed in a bag if this is to be prefered.

SAFETY

The product is safe to handle, and there is no chance of burning the grass or anything else in the surroundings. This is due to the fire-resistant cover and the restricted movement of the lens. These factors aim to make the user feel safe and to have fun while cooking and not being obligated to keep an eye on the product the whole time.

DURABILITY AND MAINTENANCE

The product was designed for easy reparability, all parts of the product can be disassembled and replaced, making the product durable and able to last for many years.

2 BUSINESS STRATEGY

2.1 MARKET POTENTIAL

The product will be of great quality and the cost follows. It is therefore not affordable for everyone. SUN IT will be launched in Denmark as the starting point, where there is a healthy economy, and then expand to other Scandinavian countries that also share this outdoor grilling tradition, since the goal of the product is to dissuade people from using disposable and charcoal grills, which are mainly used in the Scandinavian countries.

The proposal has been tested both in Denmark and Spain, two countries with different geological locations, therefore it can be expected for this product to work in all countries that go from the Equator to at least Denmark.

Many of the Mediterranean countries have fire regulations laws because of the risk of forest fires. By having fire regulations these countries don't have the same tradition for outdoor cooking. So they can only do picnics based on cold food packed from home. It could be interesting for them to have the possibility of upgrading their experience by "sunning up" meat or vegetables without the risk of creating a fire. Therefore an expansion to the south would be likely to end up happening.

PRIMARY TARGET GROUP
As mentioned, the main target group of the product is people who live in one of the bigger cities and enjoy grilling outside in the summertime. They are environmentally aware and often buy organic food.

SECONDARY TARGET GROUP
Another possible target group are people who enjoy going on camping trips. They could benefit from this product, by limiting the amount of battery, gas- or charcoal they need to cook their food when the sun is a present factor.

VALIDATION- POTENTIAL USER FEEDBACK
After contacting the possible users, the feedback from them has been positive, and it gives the hint that there is an interest in purchasing the product proposal.

“I really like the shape you have done so far.You are definitely on the right path. I like it” - Javier

“Super nice that you guys can actually cook sausages with it. Really cool idea. I think one really strong point about this whole idea is not only the waste reduction, but also that there is no fire involved: no risk for fire spreading in a dry summer, no risk at camping grounds, no risk for children, you could do it even in the dryest forest national park without risking any wildfire!! That's pretty cool! ” - Julius

“Wow! I was not expecting this final look when you mentioned to me the project at the beginning! This looks so nice and modern!! - Miruna

2.2 BUSINESS MODEL

Finding the right business strategy puts a lot of factors into the discussion. The business plan intends to make sure the company can get a profit in the end. There is no correct way of going into the market. It is essential to be aware of your competencies and the stakeholders and fill in the competencies that are not in the team. To get closer to deciding on this business model, different options will be explored.

For turning the business into a company with a profit, the “Break Even analysis” has been used to calculate the initial investment.

OPTION A: STARTUP
-> Crowdfunding

When getting into a startup it’s important to be aware of the competencies of the team, as you have to deal with everything yourself. There is a big risk and responsibility.
An opportunity when doing a startup is to do crowdfunding. This can provide money to the final prototypes of the product solution. Crowdfunding can indicate if there is an interest in the product in the market.

One of the advantages of doing the startup is to be very involved in the prototyping and position in the market.

-> Finding investors

Another option is to find an investor that would be interested in going into the startup in a collaboration. An investor is an advantage when it comes to being able to help with the initial investment. One thing is money, but the biggest advantage is their knowledge. Therefore choosing the right investor is important, and make sure they have the experience and knowledge in the lack of competence in the startup team. An investor often has a huge amount of contacts, which is useful when launching a new product on the market.

OPTION B: SELLING THE PRODUCT PROPOSAL TO A COMPANY THAT WOULD PRODUCE IT AND SELLING IT

An alternative business strategy is to sell the idea to a company that would be interested in producing it and selling it. Here we don’t get all the profit and don’t make the decisions.

SALES CHANNELS

Option A: Selling it on an own webpage

Option B: Selling it by retailers

2.3 SCALABILITY

After ensuring the product proposal can succeed on the market, the scalability of the product can be explored.

The scalability of the product proposal can be taken in different directions. One possibility is the physical scale. Here a family-sized product would be developed, that can fit more food inside of the tray.

Scaling it up even more it could be upgraded to a non-portable or semi-portable solution, to have in the garden. This kind of solution would also introduce a change in the concept, since a bigger lens size would mean a bigger focal point, and therefore enough surface to cook directly under the sunlight. This means that in this concept, grilling would be an option. The advantage of this system is that it would be faster than any other grilling method since there is no need to light up a fire and wait for it to settle down, or turn on the gas and wait for it to be hot enough to grill. With this method, the surface of the food would instantly be burned if placed directly in the focal point.

To achieve a more desirable and less dangerous temperature for the product, it would only need to locate the cooking surface closer to the lens, meaning further from the focal point, and therefore in a place where the temperature would be lower and at the same time, the cooking area would be larger.

Such a solution would require special attention to the safety of the product, especially in the semi-portable solution. The safety requirements could be so high as to impede the existence of the semi-portable solution. In both cases, for the same safety reasons, special attention would have to be drawn into the movement of the lens that adjusts its position towards the sun. How big of a restriction this would be would need further investigation to evaluate the feasibility of this proposal.

After developing a more challenging product proposal, with high demands and restrictions, the knowledge and resources would make it possible to offer an appealing solution in the market segment.

3 ECONOMY

3.1 SALES PRICE

To determine a reasonable sales price two different perspectives were taken into consideration. A broader market research was made to explore the sales price of products currently on the market in the same, outdoor/transportable grill category. These products can be considered as competitors from the users perspective, keeping the sales price on the same level can put SUN IT in a beneficial position offering something new and different for the same amount of money as a regular gas grill. Looking at the competitor products this price range SUN IT must fit in was determined to be around 1600 DKK. The competitor comparison can be found in Appendix 10.

From the other perspective SUN IT has to be able to generate income for the company, meaning the sales price has to aligned with the manufacturing and assembly costs. Both Sunit and the distributors must earn money by selling the product and VAT must be included as well.

At this stage, it is impossible to predict all the manufacturing costs for SUN IT, since further experimentation is needed together with working prototypes to validate or update the details presented as the final product proposal. The manufacturing cost is estimated based on material costs, the cost of the manufacturing process and salaries/working hours of the employees manufacturing them. (Appendix 12).

UNIT PRICE		
Retail price including VAT (25%)	1.394	DKK
Retail price excludeing VAT	1.115	DKK
Contribution (distributor)	372	DKK
Sales price	744	DKK
Contribution (SUN IT)	372	DKK
Production cost	372	DKK

3.2 CE CERTIFICATION

When launching a new product in the EU, a CE certification is needed. CE certifications ensure the product complies with the rules in the launched country and the rest of the EU.

The certification proves that the product has been assessed by the manufacturer to meet EU requirements for safety, health and environmental protection. The certification costs money, but the amount depends on the procedure that applies to the product, how complex the product is, etc. (CE-mærkning, 2021)

ill. 72 CE mark

3.3 INVESTMENT

In the first round of production Sunit is aiming to produce 1.500 units. This number is based on the targeted potential users in Denmark. There are 1,48 million people aged between 20-39 living in Denmark in 2021. Selling Sunit to 0,1% of this target group in the second year would mean 1.480 sold products. The reason behind starting sales and putting the product on the market only in the second year is the fact that further validation and experimenting is necessary as well as prototyping (Denmark: total population by age group 2021 | Statista, 2021).

Development as a one-off cost includes further experimenting, prototyping and other developments costs like salaries for the first year before sales start.

Marketing consists of a one-off cost for a website design and further marketing activities like advertisements and maintenance costs for the website monthly.

Details about tooling cost can be found in Appendix 12.

This means for SUN it to be able to hit the market in one year, an investment of 400.000 DKK is needed (investment plus fixed costs during the first year).

INVESTMENT			
	One-off cost	Monthly cost	
Development	200.000		DKK
Marketing	5.000	2.000	DKK
CE mark	5.000		DKK
Tooling cost	110.000		DKK
Rent		3.000	DKK
Telefon, internet, mobile		500	DKK
Legal counseling		1.000	DKK
Total investment	320.000		DKK
Monthly cost in a year		78.000	DKK

3.4 BUDGET

The breakeven analysis of Sunit is based on the estimated product price and the number of sales over the years. Sunit could reach break-even during the second year of operation, in the year where the product would hit the market. After four years the company would make over 1.37 million DKK as profit.

BREAKEVEN ANALYSIS	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Number of units sold	0	1.480	1.776	2.131
Sales price	0	744	744	744
Production cost	0	372	372	372
Fixed cost	78.000	78.000	78.000	78.000
Turnover	0	1.100.528	1.320.634	1.584.760
Variable cost	0	550.264	660.317	792.380
Contribution margin	0	550.264	660.317	792.380
Investment	-320.000	-398.000	74.264	656.581
Contribution	0	550.264	660.317	792.380
Remaining	-398.000	74.264	656.581	1.370.961

05 EPILOG

SUN IT is a product that is a proposal result of a bigger project, our master thesis. Meaning this project has two parts: the process and the project. Here we will discuss both of them separately.

1 CONCLUSION

The drive for this Master Thesis project has been to create a new innovative way of cooking food, to create a more sustainable solution. By investigating the use of a Fresnel lens it has been possible to create a solution that removes the need of using gas or charcoal and thereby limit the footprint set on the environment.

Danes have a tradition of grilling and love to gather around this activity. Grilling is a part of Danes DNA, why this behaviour should not be changed but offer a sustainable alternative to this activity.

Disposable grills are currently the preferred solution when using public green areas like the park or beach to grill. They are cheap, easy to transport and quick to set up. However, they leave a huge waste. People struggle to dispose of it the right way, as it needs to cool down before it's manageable. This leads to burned trash cans or people who simply leave them on the ground. The disposable grills use charcoal, which harms the environment, as a huge amount of disposable grills are used during summertime.

The market offers alternative solutions using solar energy, but they compromise on multiple factors, like the amount of cooking possibilities.

This resulted in a portable and sustainable product solution that opens up a new way of cooking food by using the power of the sun. The use of the Fresnel lens creates the possibility of an alternative way of cooking food outdoors.

SUN IT offers a cooking surface, as big as the disposable grill. It is intuitive and easy to set up. It can be transported in multiple ways; using the crossbody strap or packing down in a backpack. It is easy to clean, by the removable tray. And it is a durable product, thoughtfully designed to last for many years.

SUN IT is competitive on the market, as it offers a better solution than the competitors of solar grills. Compared to Go Sun Go, this product solution offers a better cooking surface and more space. Compared to portable gas and charcoal grills, SUN IT weighs less, is easier to transport, and is more sustainable. The disposable grills are hard to compete with due to the cheap price. However, this solution is cheaper in the long run and of course durable and more sustainable.

2 REFLECTION

The realization of this project has opened up the space to reflect regarding the product, the process and the three main aspects that have been part of it: the collaboration with Artlinco, the subject election and the group work

PRODUCT
The final product proposal fulfils the demands set for the solution. It has market potential due to the innovative and alternative way of cooking.

If more time was available crowdfunding would be set up. This would give a hint to know if people are willing to invest and are interested in a product like this. One problem with the use of solar power is that some people might not trust its efficiency.

The product proposal does not consist of any electronic components, this means that we have access to all the product details, and not end up having a black box of electronics. This also means there has been time to look deeper into the small details of the product. The manufacturing aspect has been a huge part of choosing the right solutions for the details, without ending up at a huge cost. As we haven't worked with manufacturing processes in real life, it has been a struggle to know how to solve some details and a lot of time has been spent finding the right solution.
If something were to be re-done more collaboration with users and asking more well-thought question would have been done. (what could this be? we have asked them how many they buy per year)

Feedback on the final proposal would be prefered, if more time was available and asked them if they would like to have the possibility of cooking and if they consider it an upgrade. The testing was sometimes messy and unstructured.

If more time was available, it would be preferred to set up experiments, where it was possible to cook a complete meal. That would help to get a deeper understanding and knowledge about what kinds of foods are possible to make.

PROCESS

Collaboration with Artlinco
The collaboration with Artlinco has been an enriching experience, and perspectives were gained from the 'real business world´ and many years and projects of experience. It has helped us to get a deeper understanding of the mindset of a businessman, and his way of thinking when approaching a design problem.

Companies are often focused on the goal and do not spend much time on methods. However, they have a practical approach to the project. Throughout the meetings, constructive feedback was provided. The meetings helped us move on and gave guidance in the places knowledge is lacking for instance, regarding materials and manufacturing processes.

Doing our collaboration we lead to understand the impact cost has on the design. We had discussions about the details, regarding what material to use, shape and manufacturing process. Here trying to find the balance between all these forces to achieve the best design at the price that would make it accessible for the users.

Doring our collaboration we agreed that we were the ones to make all the decisions and were free to frame the project as we wanted to. Alinco has been on the side as a helping hand but has not impacted the framing of the project.

The subject election
The startup phase of the project was very stressful trying to find a suitable problem to work with. Finding a subject that has the right amount of difficulties to solve and still being interesting is difficult. However, despite the good energy and hard work of the team, if the subject is not consistent enough, it is not really possible to see our abilities as designers in the project.

We contacted Artlinco intending to find an interesting theme to work on in collaboration. Artlinco presented multiple design problems to work with, we chose one of them and framed it to our needs.

It has been a very enriching process, to have a design/ technology-driven project. Meaning that the decisions were not directly based on the user's needs, and the starting point was not a concrete problem or need. The project driver was the challenge of creating a product with a clear value proposition based on an existing, but not very explored technology, in the cooking segment: The Fresnel lens.
We accepted the challenge because of our drive towards the possibility of exploring technology and being able to create a product that would change the negative footprint on the environment without a negative impact on the user's routine.

Teamwork
This team consists of an international team with different backgrounds and competencies. It has been equal and healthy teamwork where we all shared the same goal. This has created a flexible and helpful dynamic where we have been able to listen to each other and respect each other's opinions. We are a team with different skill sets and interests. There has been a nice flow and communication, and it has been natural to divide tasks between us. Despite the task division there has been a great knowledge sharing. This constructive dynamic has kept feeding back the project till the end. We have always had the feeling of moving forwards. Due to Corona-19, the work has been done through Teams' meetings. This could have harmed the process, however, it has been an opportunity to walk towards efficiency. The day consisted of two meetings, one in the morning; where we would talk about the structure of the day, and one in the afternoon, where we would talk about the personal achievements of the day and it opened the space to discuss our different opinions and findings etc. The responsible and proactive attitude of the members of the group has also been an important factor. There has never been a problem of measuring who has done what or how many tasks have each of us accomplished. We trusted each other and wanted to give the best of us. This set a ground of trust that created a very comfortable work environment.

LITERATURE LIST

African Food Joint. 2012. how to steam meat – African Food Joint. [online] Available at: <https://africanfoodie.wordpress.com/tag/how-to-steam-meat/> [Accessed 2 June 2021].

Buckwalter, J., 2019. How much CO2 is emitted from burning 1 kg of charcoal? - Quora. [online] Quora.com. Available at: <https://www.quora.com/How-much-CO2-is-emitted-from-burning-1-kg-of-charcoal> [Accessed 13 March 2021].

Coolpriser.dk. n.d. Øjeblikkelig grill sølv aluminium. [online] Available at: <https://www.coolpriser.dk/shop/oejeblikkelig-grill-soelv-432021p.html?gclid=Cj0KCQiA4feBBhC9ARIsABp_nbVAYd2AcMEnCpPKPhBaqqYxOFHQUjQOjP-BlYoBQYIqSKpcI11pXz_EaAnnyEALw_wcB> [Accessed 2 March 2021].

Cookware & More. n.d. Thermometers and Food Safety. [online] Available at: <https://www.cookwarenmore.com/blog/thermometers-and-food-safety-/?utm_source=pinterest&utm_medium=social> [Accessed 2 May 2021].

Csr.dk. 2019. Den danske forbruger anno 2019 handler mere bæredygtigt. [online] Available at: <https://csr.dk/den-danske-forbruger-anno-2019-handler-mere-bæredygtigt> [Accessed 11 May 2021].

Dn.dk. 2018. Grill med ren samvittighed. [online] Available at: <https://www.dn.dk/nyheder/grill-med-ren-samvittighed/> [Accessed 3 March 2021].

Elgiganten. n.d. Nordic Season engangsgrill - 23 x 30 cm - Grill og grilltilbehør. [online] Available at: <https://www.elgiganten.dk/product/husholdning/grill-og-grilltilbehor/KG123620/nordic-season-engangsgrill-23-x-30-cm> [Accessed 13 March 2021].

Elgiganten. n.d. Weber Go Anywhere gasgrill - Gasgrill. [online] Available at: <https://www.elgiganten.dk/product/husholdning/grill-og-grilltilbehor/gasgrill/WEB1141068/weber-go-anywhere-gasgrill?gclid=CjwKCAjwnPOEBhA0EiwA609ReSG-fzcEuV2Kv5ZlSWBkrRUA3MOY0Aziq_1OQ9D9mlRin5flPAV6swBoCrZUQAvD_BwE&gclsrc=aw.ds> [Accessed 13 April 2021].

Eventyrsport.dk. n.d. Trangia 25-3 Ultra Light køkken. [online] Available at: <https://www.eventyrsport.dk/trangia-25-3-ultra-light-0321100202.html?c=122802&s=18502> [Accessed 2 March 2021].

Feldwick, H., 2020. Sustainable behaviour change | Research World. [online] Researchworld.com. Available at: <https://www.researchworld.com/sustainable-behaviour-change/> [Accessed 13 March 2021].

GoSun. n.d. Go. [online] Available at: <https://gosun.co/products/go> [Accessed 2 March 2021].

GrillStart.dk. n.d. Grill i naturen – Er det tilladt? - GrillStart.dk. [online] Available at: <https://grillstart.dk/grill-i-naturen-er-det-tilladt/> [Accessed 13 March 2021].

Haase, L. and Laursen, L., 2019. INTRODUCTION - AID Instruction 1.

Hansen, P., 2019. Production & Economy, Parameter Analysis.

Healthline. n.d. How to Make Your Meat as Healthy as Possible. [online] Available at: <https://www.healthline.com/nutrition/how-to-make-your-meat-as-healthy-as-possible#TOC_TITLE_HDR_3> [Accessed 6 May 2021].

Jessica Gavin. 2019. Steaming (Moist-Heat Cooking Method) | Jessica Gavin. [online] Available at: <https://www.jessicagavin.com/steaming/> [Accessed 2 June 2021].

Kvadrat.dk. 2021. Patio Outdoor. [online] Available at: <https://www.kvadrat.dk/en/products/upholstery/1295-patio-outdoor> [Accessed 2 June 2021].

Københavns Kommune. n.d. Grill – Se hvor du må grille. [online] Available at: <https://www.kk.dk/artikel/grill-se-hvor-du-maa-grille> [Accessed 13 May 2021].

Leadingedgepower.com. n.d. Effect of the Weather on Solar Panels - Leading Edge Turbines & Power Solutions. [online] Available at: <https://www.leadingedgepower.com/support/help-with-solar-panels/effect-of-weather-on-solar-panels.html> [Accessed 2 June 2021].

Mynewsdesk. 2015. Færre vælger engangsgrill. [online] Available at: <https://www.mynewsdesk.com/dk/elgiganten/pressreleases/faerre-vaelger-engangsgrill-1185162> [Accessed 13 March 2021].

Project Solari. n.d. Project Solari Portable Solar Cooker | Portable Solar Cooker. [online] Available at: <https://www.projectsolari.com> [Accessed 2 March 2021].

Rebensdorff, J., 2014. Grill – en måde at være dansk på. [online] Berlingske.dk. Available at: <https://www.berlingske.dk/samfund/grill-en-maade-at-vaere-dansk-paa> [Accessed 13 April 2021].

Simpelt.dk. n.d. Miljøvenlig engangsgrill - bionedbrydelig og nem - Simpelt.dk. [online] Available at: <https://www.simpelt.dk/hverdag/hoejtider/sommer/miljoevenlig-engangsgrill/?gclid=Cj0KCQiA4feBBhC9ARIsABp_nbWh0KooqVqJrG-Lk-KSTAkgMv5q2-2gBzKvGEq-zAg59uKv9sGQ1JigaAppfEALw_wcB> [Accessed 2 March 2021].

Sites.google.com. 2015. Try This - Solar Cooker Challenge. [online] Available at: <https://sites.google.com/a/wyckoffschools.org/solar-cooker-challenge/solar-angle/try-this> [Accessed 2 May 2021].

Statista. 2021. Denmark: total population by age group 2021 | Statista. [online] Available at: <https://www.statista.com/statistics/570654/total-population-in-denmark-by-age/> [Accessed 2 May 2021].

www.outnorth.dk. n.d. CampStove 2 Bundle. [online] Available at: <https://www.outnorth.dk/biolite/campstove-2-bundle?gclid=Cj0KCQiA4feBBhC9ARIsABp_nbUN8DInBvnammQQs8bjkvb2BzrriXGnpimpadRYYFpV7_qAJvW4LPQaAokeEALw_wcB> [Accessed 2 March 2021].

Your Europe. 2021. CE-mærkning. [online] Available at: <https://europa.eu/youreurope/business/product-requirements/labels-markings/ce-marking/index_da.htm#abbr-ID0E1> [Accessed 28 May 2021].

2019. Solar Power BBQ in Mid-Air with Fresnel Lens. [image] Available at: <https://www.youtube.com/watch?v=ksVLop-0VAdM> [Accessed 2 June 2021].

ILLUSTRATION LIST

Illustrations listed below are only from external sources, non listed are the project teams own illustrations

ill. 1 The context https://greeklist.co.uk/whats-on/google-maps-enimerosi-gia-polykosmia/

ill. 2 Waste problem https://www.devonlive.com/news/devon-news/horrific-burns-show-you-shouldnt-1575911

ill. 3 Starting fires https://holbaekonline.dk/2018/07/16/engangsgrill-antaendte-skraldespand/

ill. 4 https://www.elgiganten.dk/product/husholdning/grill-og-grilltilbehor/gasgrill/WEB1141068/weber-go-anywhere-gasgrill?gclid=CjwKCAjwnPOEBhA0EiwA609ReSGfzcEuV2Kv5ZlSWBkrRUA3MOY0Aziq_1OQ9D9mlRin5flPAV6swBoCrZUQAvD_BwE&gclsrc=aw.ds

ill. 5 https://www.coolpriser.dk/shop/oejeblikkelig-grill-soelv-432021p.html?gclid=Cj0KCQiA4feBBhC9ARIsABp_nbVAYd2AcMEnCpPKPhBaqqYxOFHQUjQOjPBlYoBQYIqSKpcI11pXz_EaAnnyEALw_wcB

ill. 6 https://www.simpelt.dk/hverdag/hoejtider/sommer/miljoevenlig-engangsgrill/?gclid=Cj0KCQiA4feBBhC9ARIsABp_nbWh0KooqVqJrGLk-KSTAkgMv5q2-2gBzKvGEq-zAg59uKv9sGQ1JigaAppfEALw_wcB

ill. 7 https://www.eventyrsport.dk/trangia-25-3-ultra-light-0321100202.html?c=122802&s=18502

ill. 8 https://www.outnorth.dk/biolite/campstove-2-bundle?gclid=Cj0KCQiA4feBBhC9ARIsABp_nbUN8DInBvnammQQs8bjkvb2BzrriXGnpimpadRYYFpV7_qAJvW4LPQaAokeEALw_wcB

ill. 9 https://gosun.co/products/go

ill. 16

http://www.spicytec.com/2017/10/cooking-with-solar-power-on-go.html

https://tecnoneo1.rssing.com/chan-20554777/all_p60.html

https://travel.thaiza.com/tips/381819/

ill. 17

http://leblogdestendances.fr/high-tech/solari-four-solaire-portable-15655

https://www.dailymotion.com/video/x29ikll

https://www.homecrux.com/page/709/?wordfence_logHuman=1&hid=1F6A90C0D82F21E5344D114D29085325

https://www.pinterest.dk/pin/90986854951978723/

ill. 24 https://glovoapp.com/pl/pl/piastow/zaza-grill-ptw/

ill. 25 https://www.yummy.ph/recipe/beef-steamed-with-oyster-sauce-recipe

ill. 32 https://www.nytimes.com/wirecutter/reviews/best-portable-grills/

ill. 33 https://www.klingel.de/p/emsa-dose-3d-perfect-clean-clip-close-4T2614

ill. 34 https://streeteasy.com/blog/ideas-to-increase-your-homes-value/

ill. 72 https://www.sik.dk/erhverv/produkter/fyrvaerkeri/vejledninger/fremstilling-import-og-salg/ce-maerkning-fyrvaerkeri

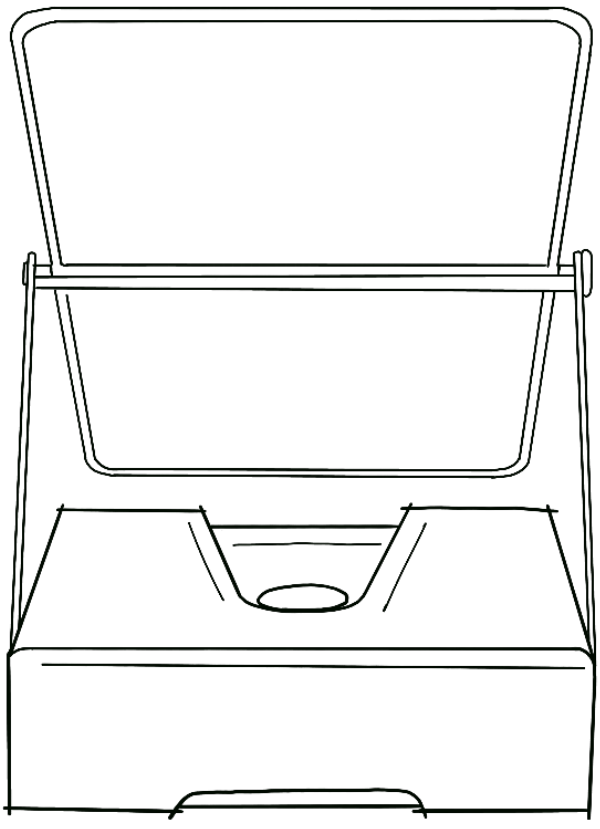
SUN IT

SUN IT

TECHNICAL DRAWINGS

Clara Rodriguez Ríos / Ofelia Anna Cornelia Hove / Péter Császma

JUNE 2021



AALBORG UNIVERSITY

Industrial design

MSc04 / ID05

Clara Rodriguez Ríos

Ofelia Anna Cornelia Hove

Péter Császma

Title
SUN IT

Report
Technical drawings

Theme
Solar cooking

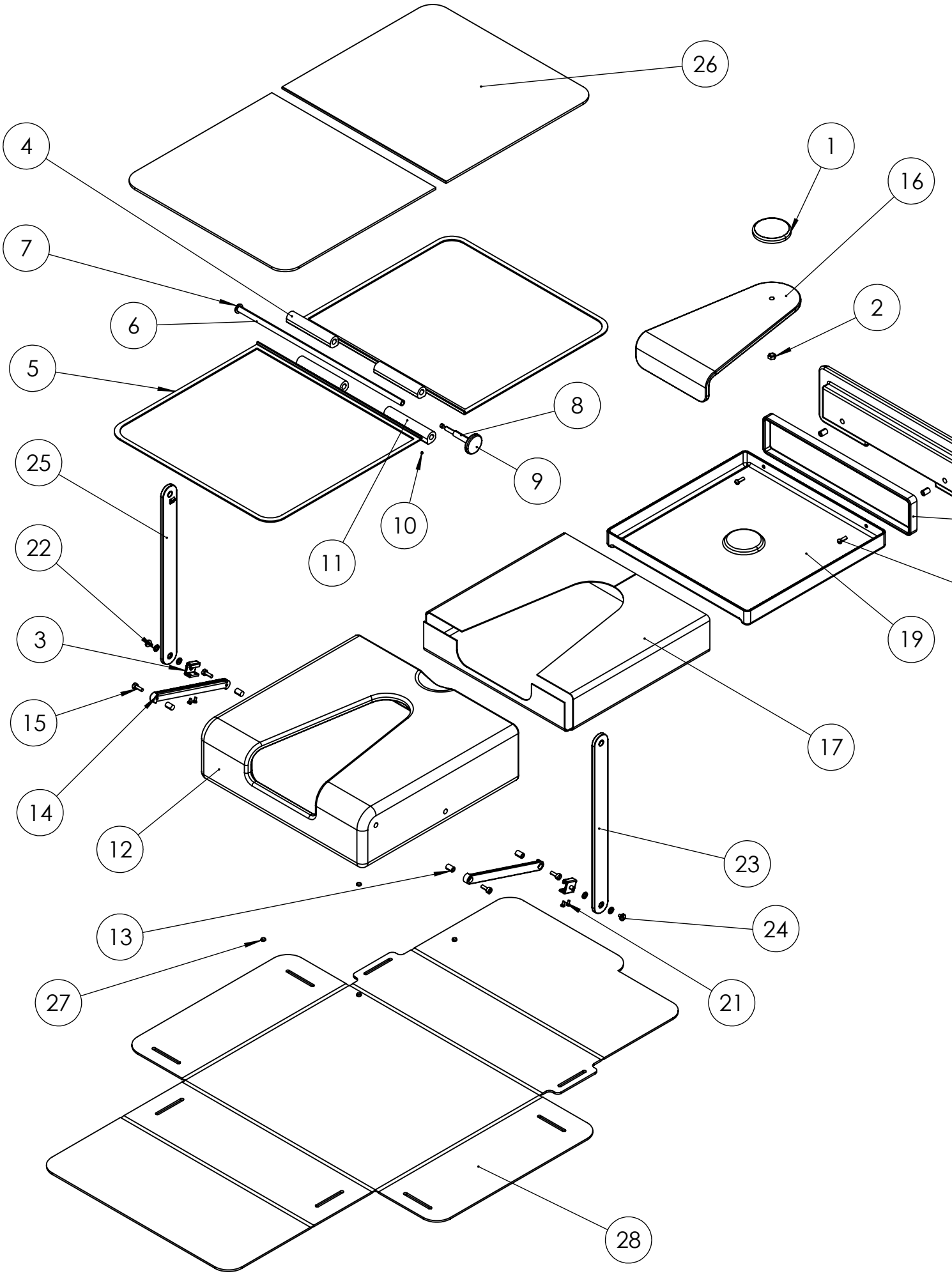
Project theme
Master Thesis

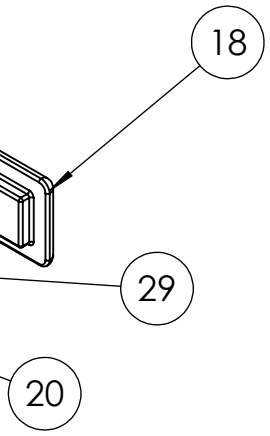
Project period
01.02.2021 -03.06.2021

Supervisor
Christian Tollestrup

Technical supervisor
Radoslav Darula

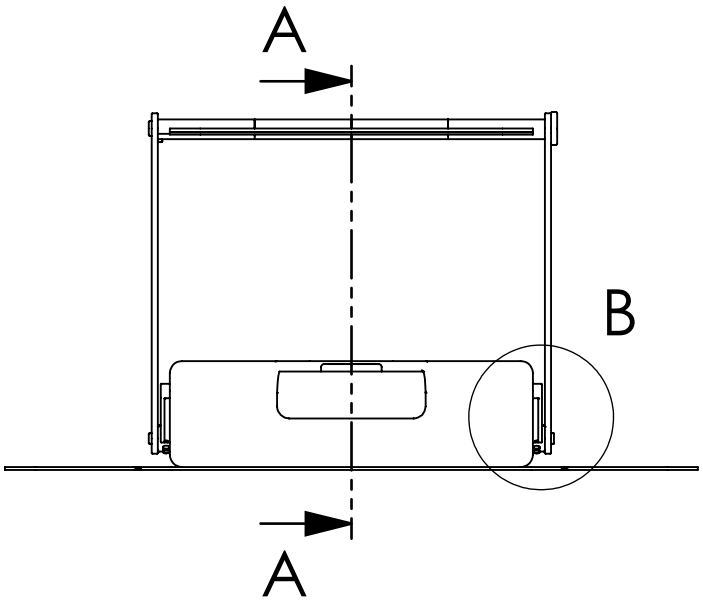
Pages
30

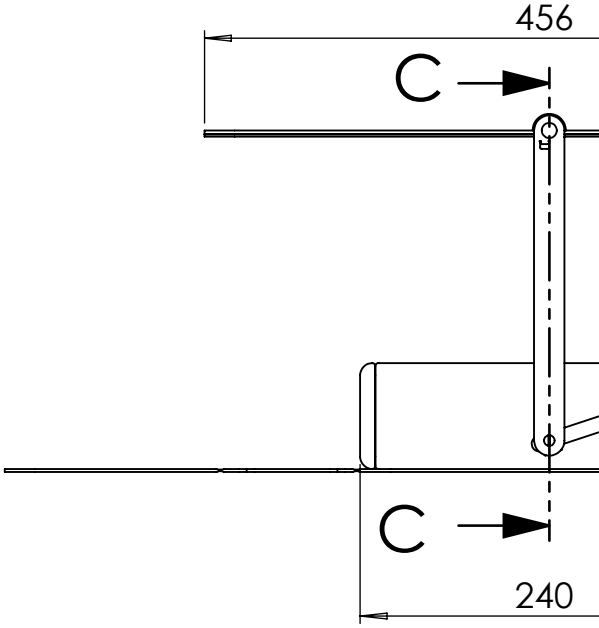

26
4
1
16
7
6
2
5
8
9
25
10
11
22
19
3
17
15
14
12
23
13
24
27
21
28

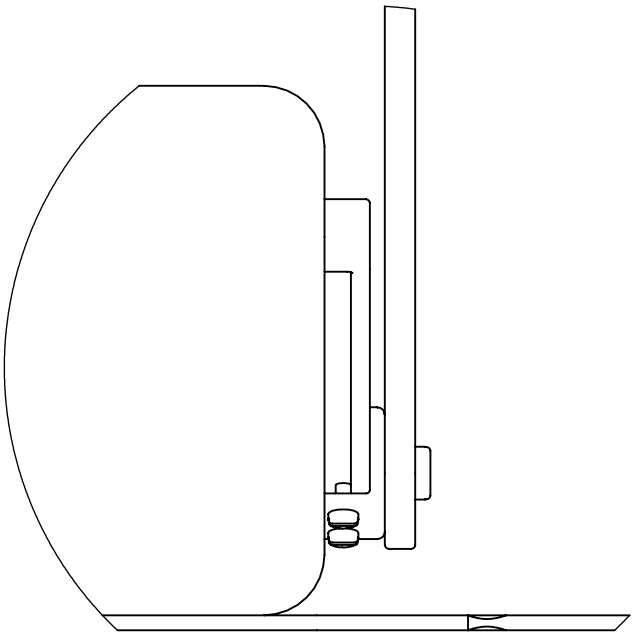


ITEM NO.	Part name:	Drawing #:	QTY.
1	Thermometer	Standard	1
2	Thermometer bolt	Standard	1
3	Slider	3	2
4	Joint	5	3
5	Frame	6	2
6	Crossbar beam	8	1
7	Crossbar end	9	1
8	Lensfixer beam	10	1
9	Lensfixer head	11	1
10	Grub screw	Standard	1
11	Joint special	12	1
12	Main box	13	1
13	Threaded insert	Standard	6
14	Rail	14	2
15	Box screw	Standard	4
16	Window	15	1
17	Reflective cover	16	1
18	Door	18	1
19	Tray	19	1
20	Door screw	Standard	2
21	Slider screw	Standard	4
22	Washer	Standard	4
23	Right arm	20	1
24	Friction screw	Standard	2
25	Left arm	21	1
26	Lens	22	2
27	Magnet	Standard	4
28	Cover	23	1
29	Door rubber	Standard	1

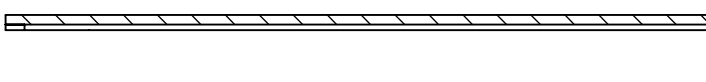
Date:	Mass:	MA4-ID5	SUN IT
30.05.2021	2,9 kg		
Drawing #:	**Scale:**	**Part name:**	
1/23	1:5	Exploded view	

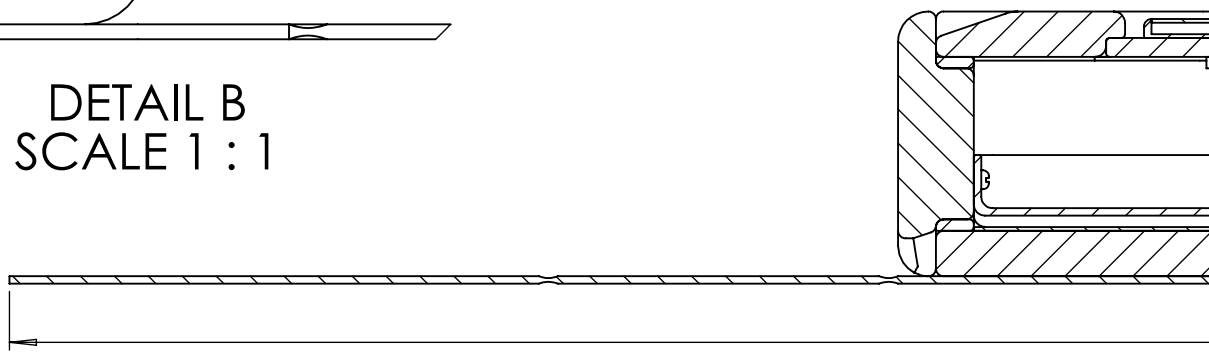




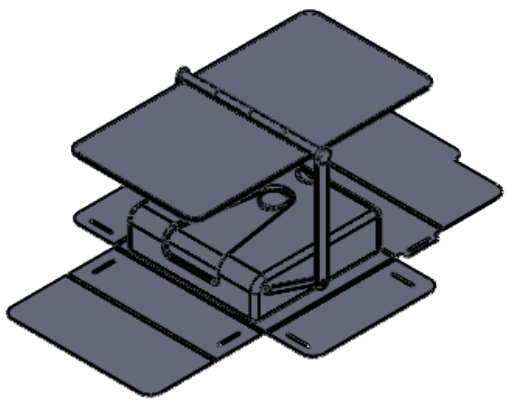


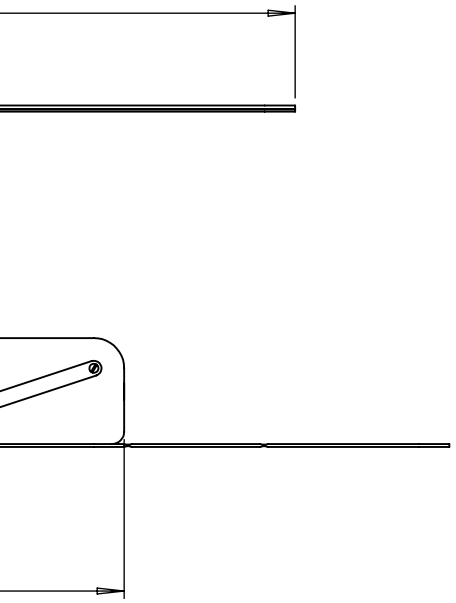
DETAIL B
SCALE 1 : 1

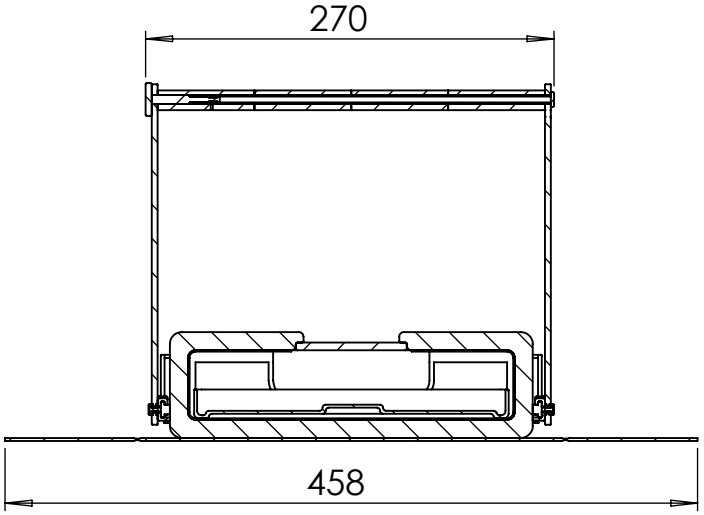




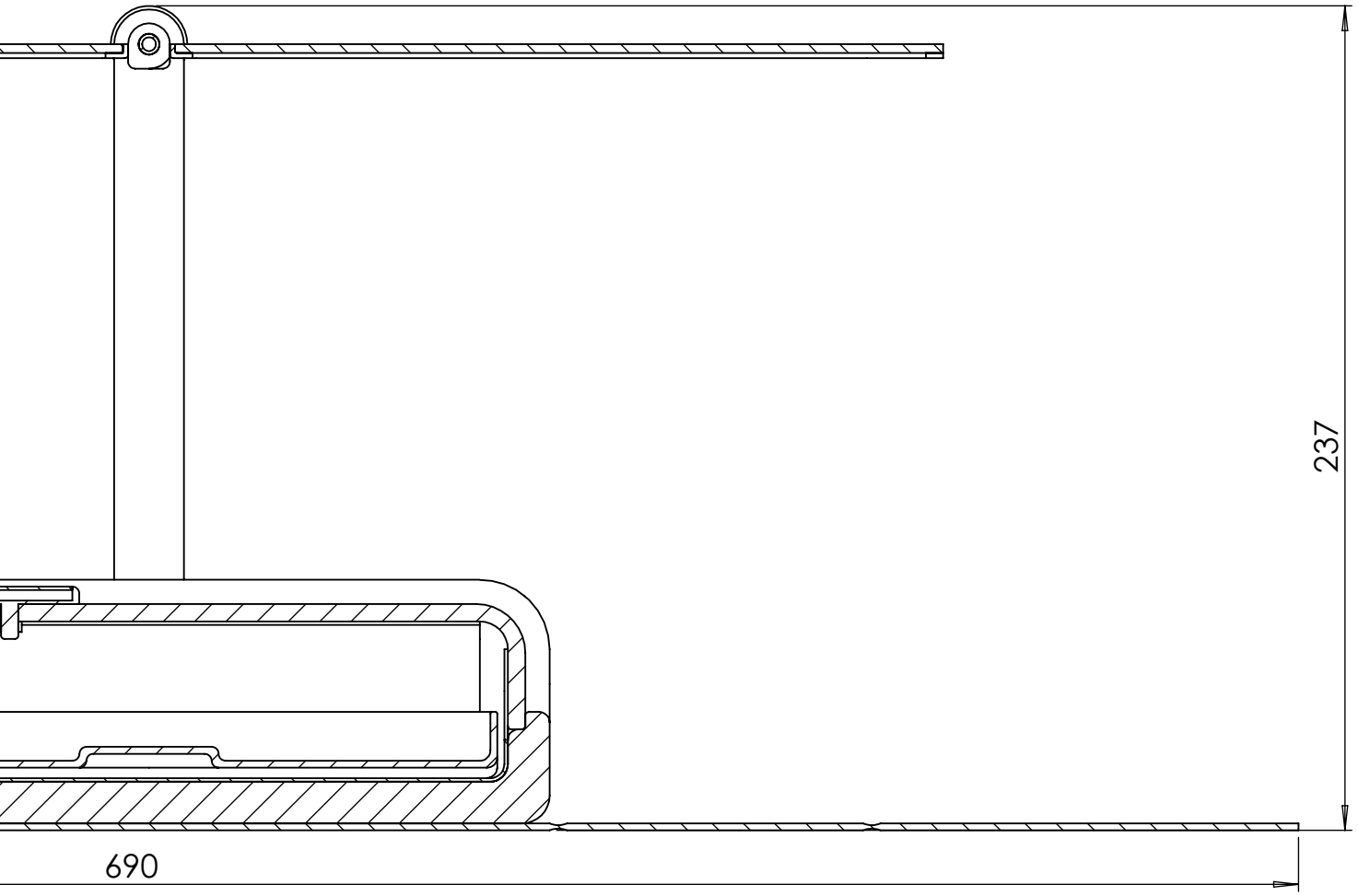
SECTI
SCAL







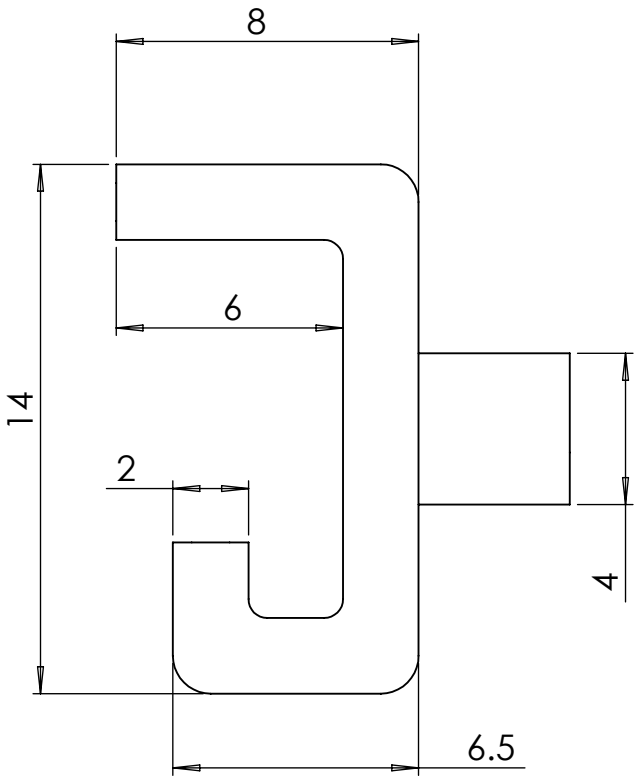
SECTION C-C

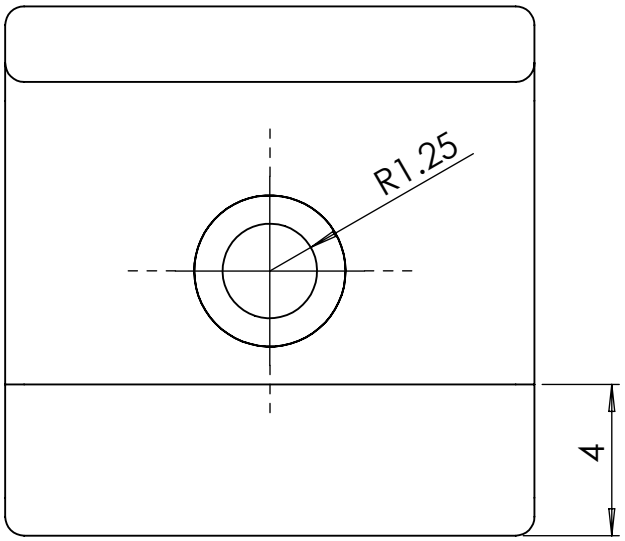


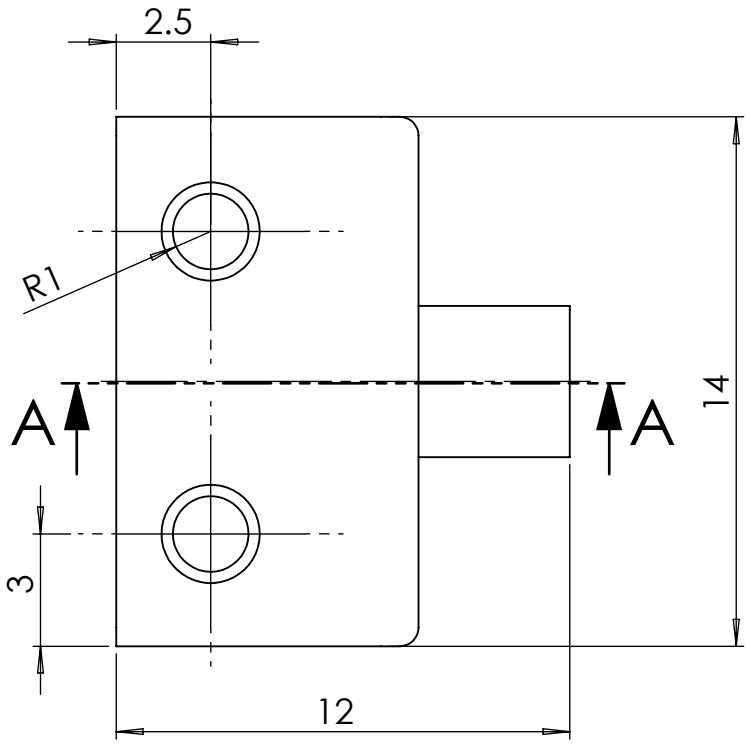
ON A-A
LE 1 : 2

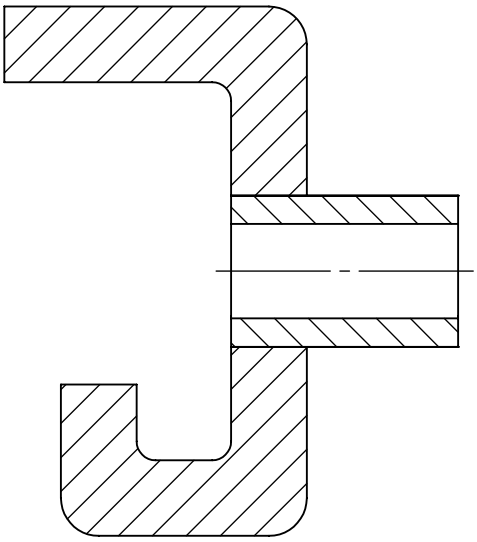
Find bill of materials on drawing 1.

Date:	Mass:		
30.05.2021	2,9 kg	MA4-ID5	SUN IT
Drawing #:	Scale:	Part name:	
2/23	1:5	Main assembly	

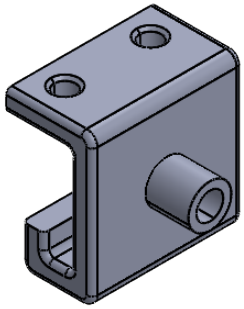




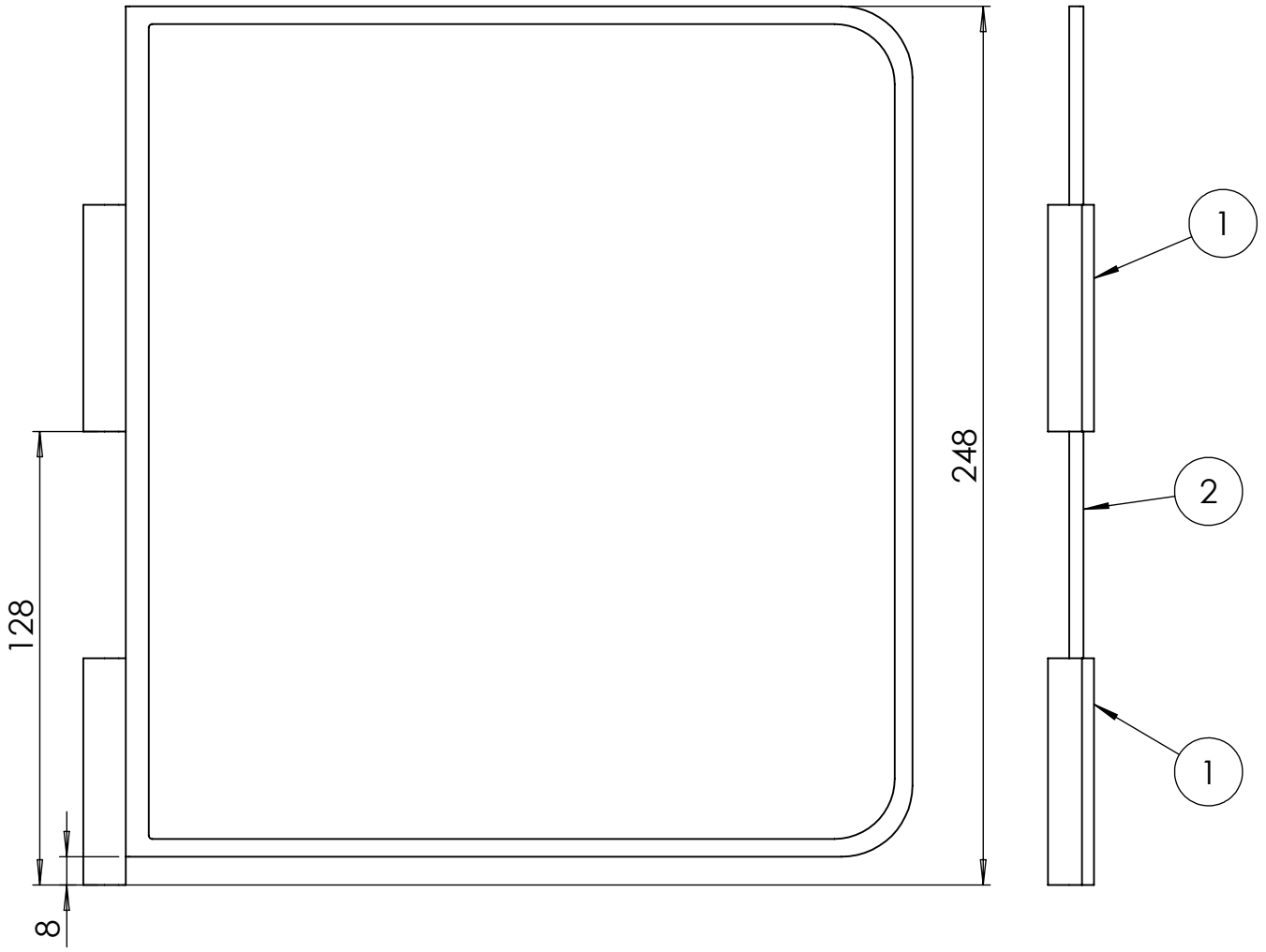


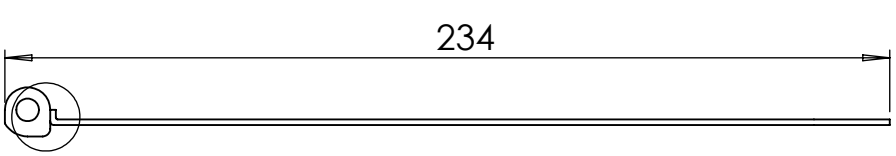


SECTION A-A

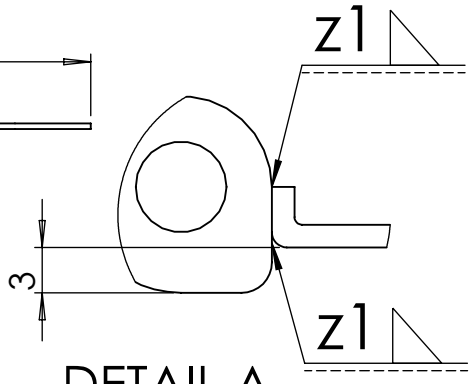


	Mass: 5,9 g	Material: Stainless steel	MA4-ID5	SUN IT
Drawing #: 3/23	Scale: 5:1	Date: 30.05.2021	Part name: Slider	

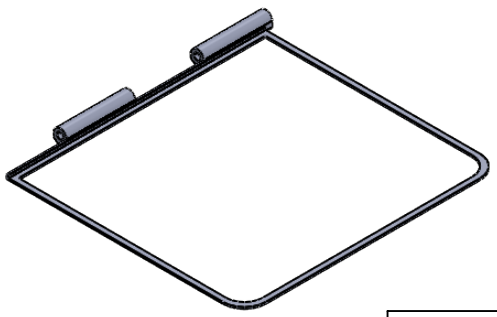




A



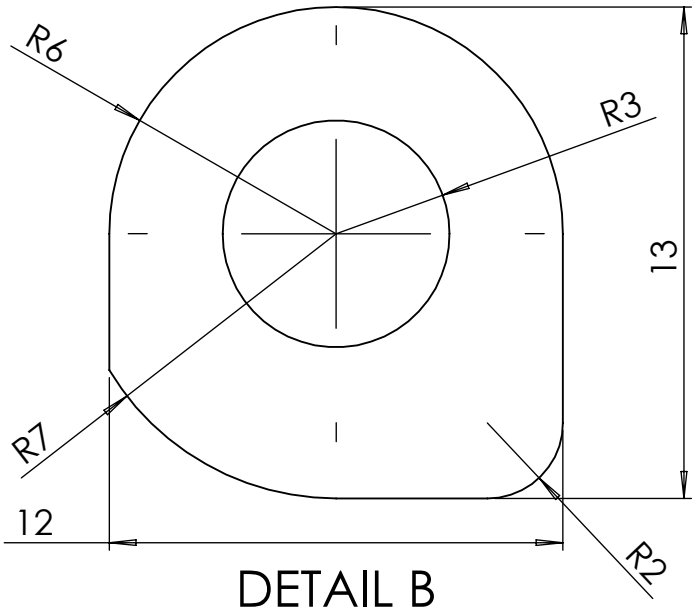
DETAIL A
SCALE 2 : 1



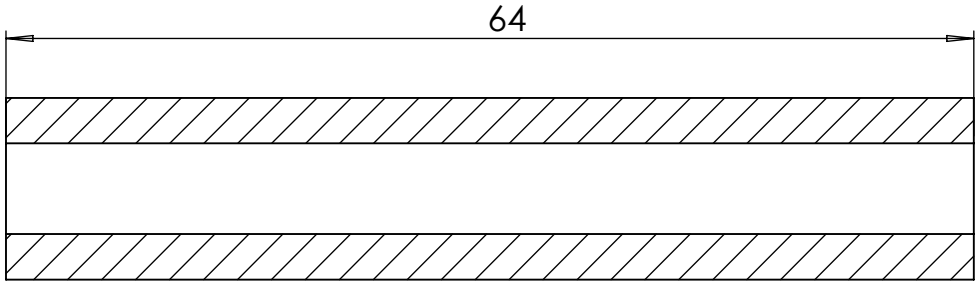
ITEM NO.	Part name	QTY.
1	Joint	2
2	Frame	1

Mass:	Material:		
170 g		MA4-ID5	SUN IT

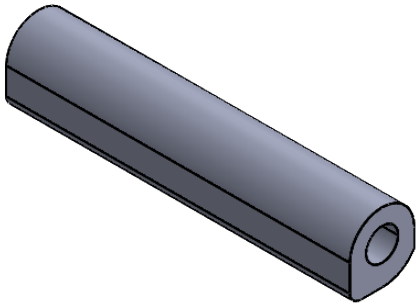
Drawing #:	Scale:	Date:	Part name:
4/23	1:2	30.05.2021	Lens joint subassembly



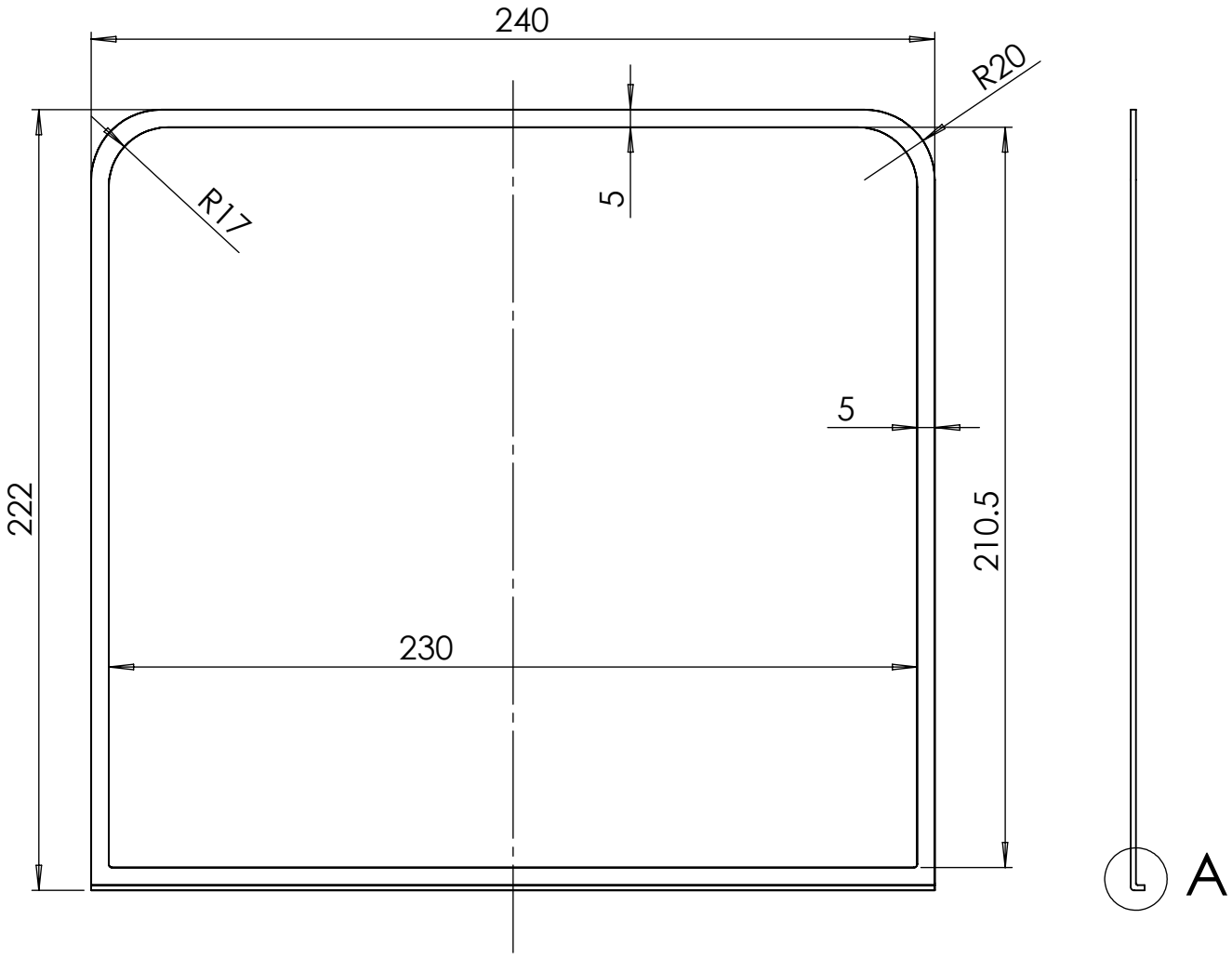
DETAIL B
SCALE 5 : 1



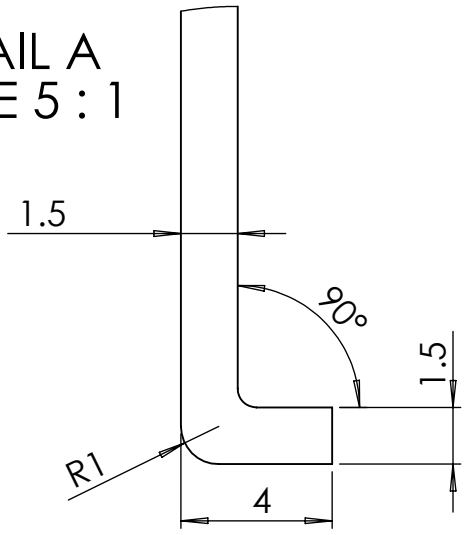
SECTION A-A

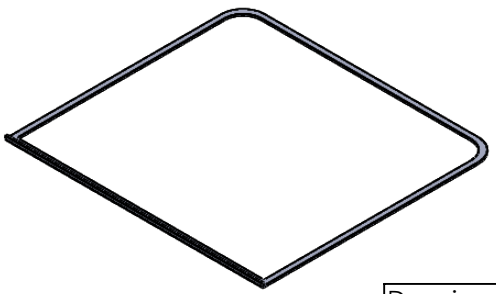


	Mass: 53 g	Material: Stainless steel	MA4-ID5	SUN IT
Drawing #: 5/23	Scale: 2:1	Date: 30.05.2021	Part name: Joint	

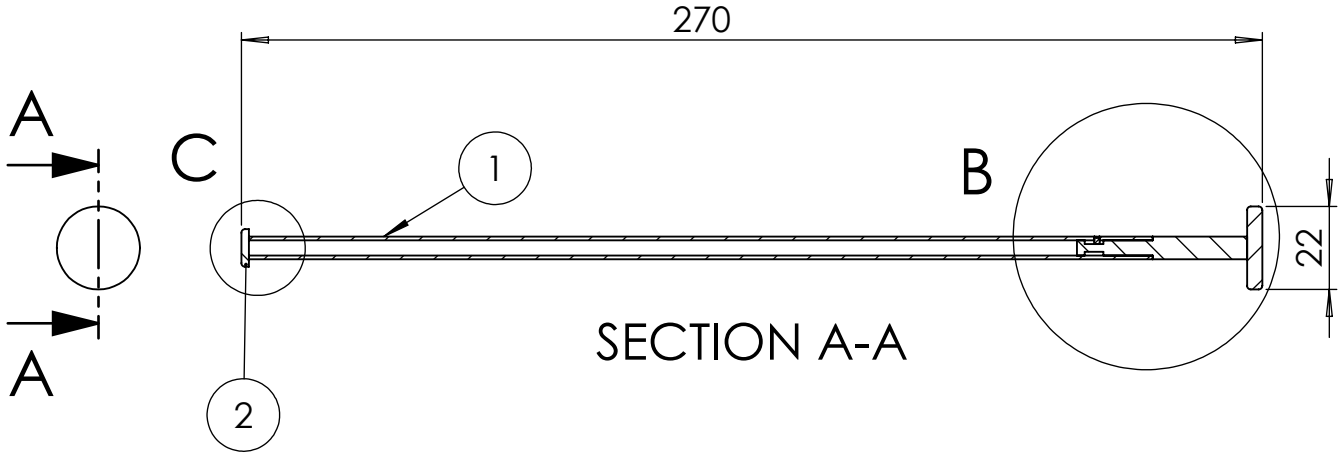


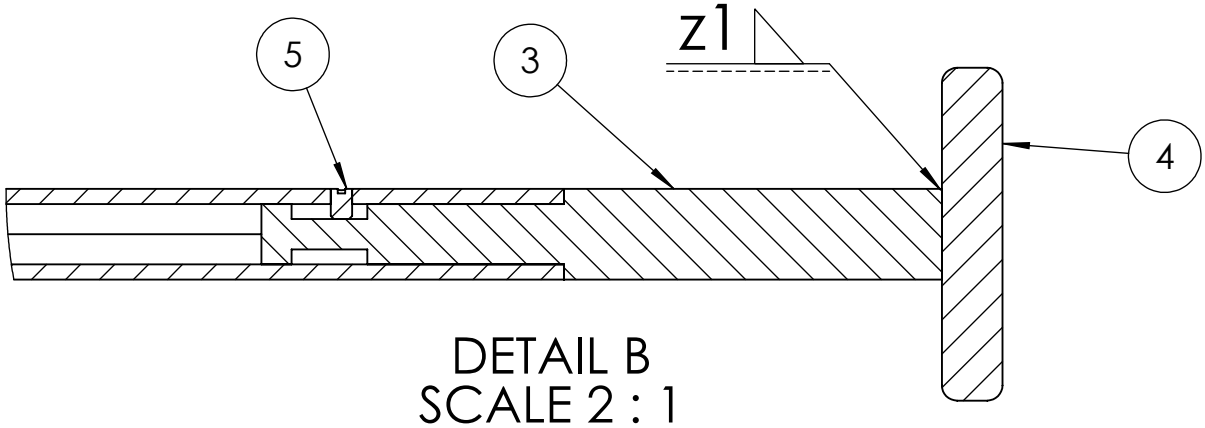
DETAIL A
SCALE 5 : 1



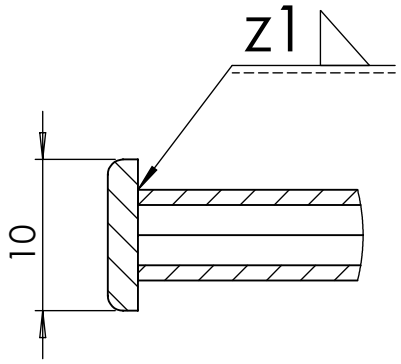


	Mass: 64 g	Material: Stainless steel	MA4-ID5	SUN IT
Drawing #: 6/23	Scale: 1:2	Date: 30.05.2021	Part name: Frame	



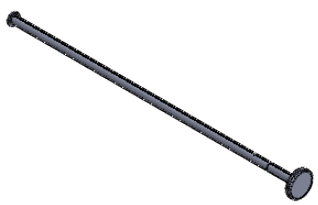


DETAIL B
SCALE 2 : 1



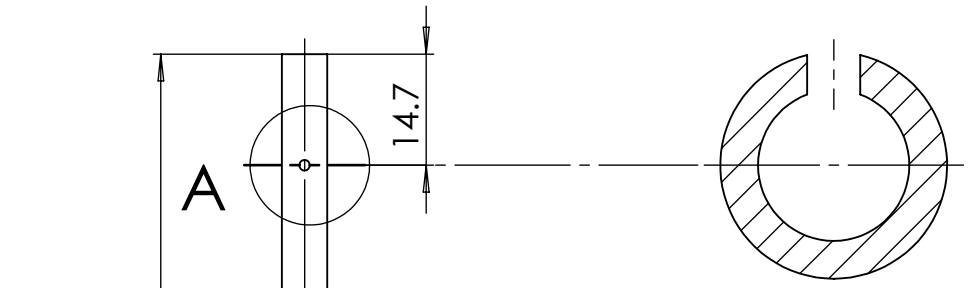
DETAIL C
SCALE 2 : 1

ITEM NO.	Part name	QTY.
1	Crossbar beam	1
2	Crossbar end	1
3	Lensfixer beam	1
4	Lensfixer head	1
5	Grub screw	1

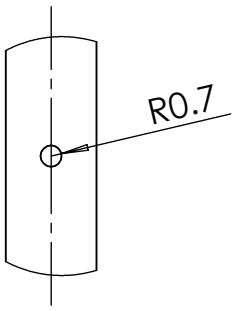


Mass:	Material:		
50 g		MA4-ID5	SUN IT

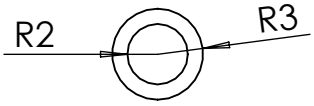
Drawing #:	Scale:	Date:	Part name:
7/23	1:2	30.05.2021	Crossbar subassembly



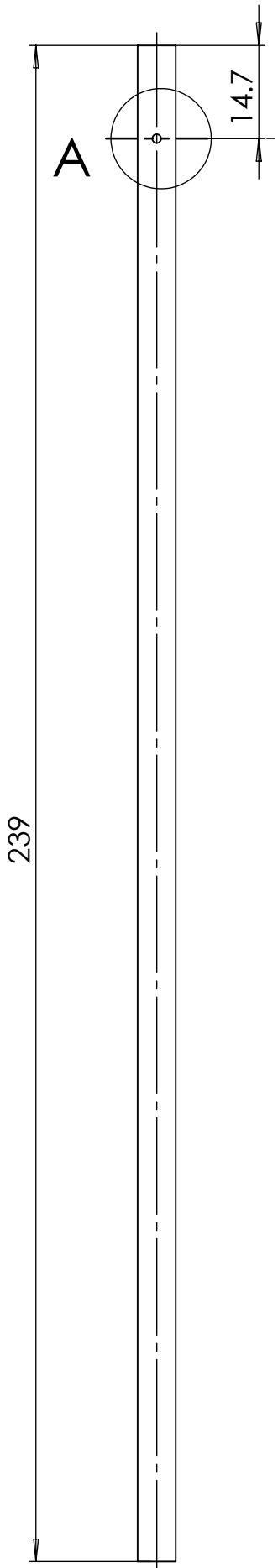
SCALE 5:1

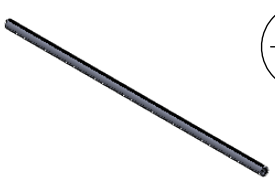


DETAIL A
SCALE 2 : 1



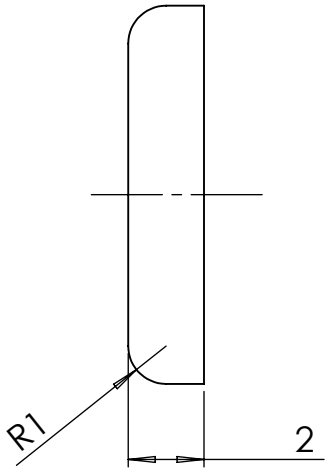
DETAIL B
SCALE 2 : 1

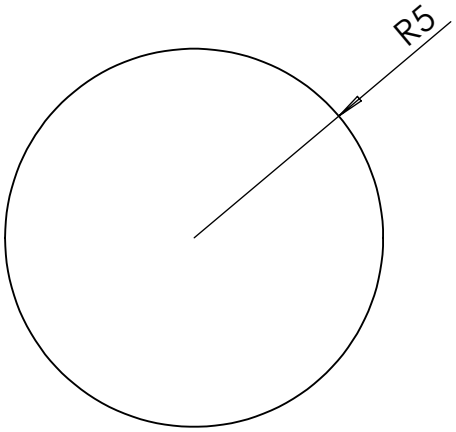


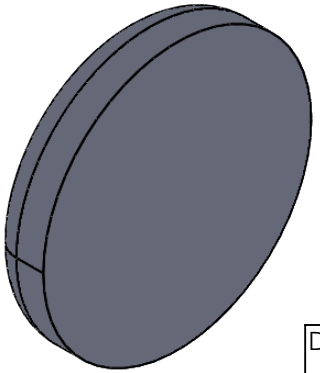


Mass:	Material:		
30 g	Stainless steel	MA4-ID5	SUN IT

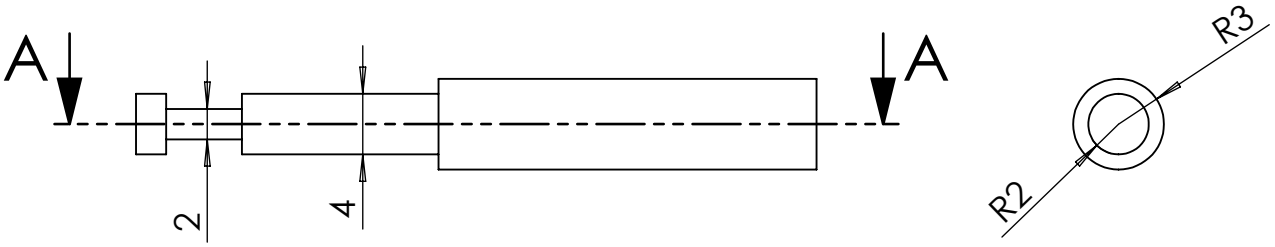
Drawing #:	Scale:	Date:	Part name:
8/23	1:1	30.05.2021	Crossbar beam

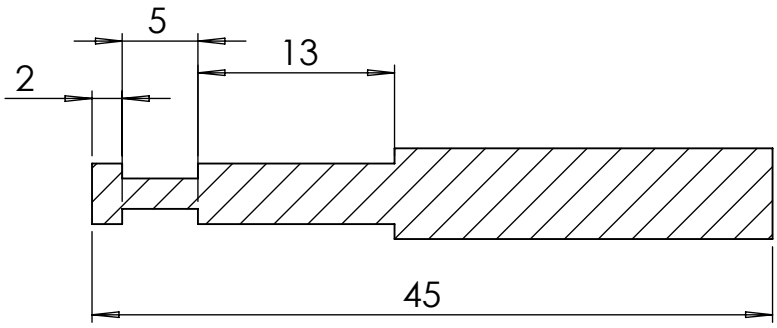




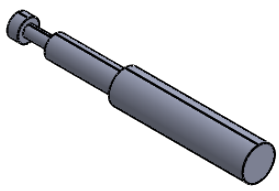


	Mass: 2 g	Material: Stainless steel	MA4-ID5	SUN IT
Drawing #: 9/23	Scale: 5:1	Date: 30.05.2021	Part name: Crossbar end	

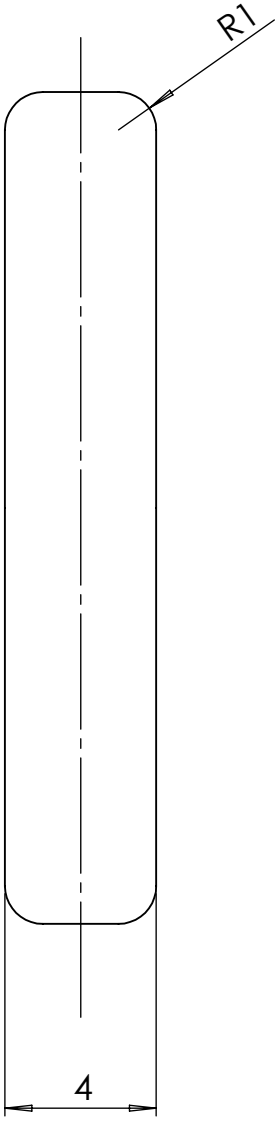


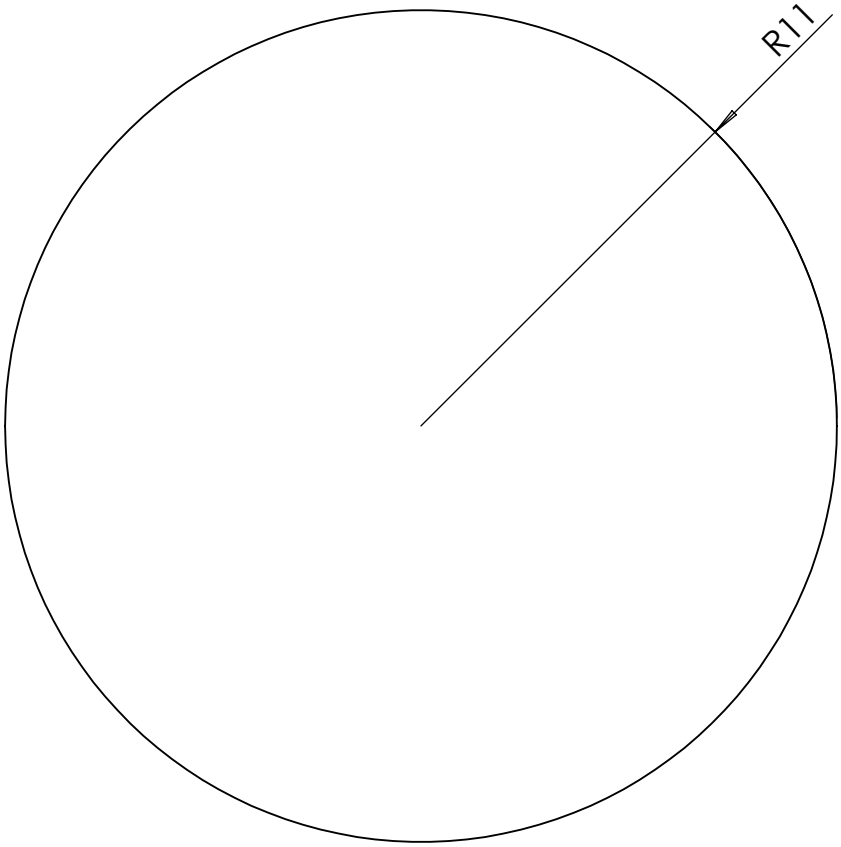


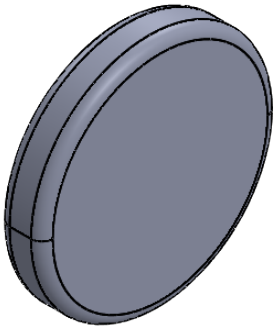
SECTION A-A



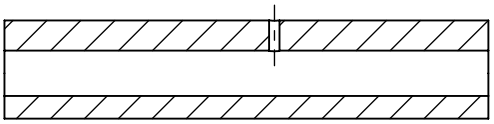
	Mass:	Material:		
	7 g	Stainless steel	MA4-ID5	SUN IT
Drawing #:	Scale:	Date:	Part name:	
10/23	2:1	30.05.2021	Lensfixer beam	



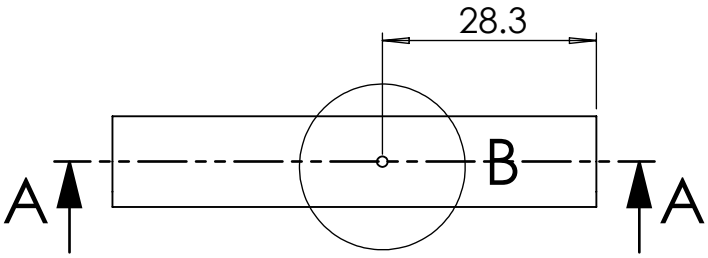


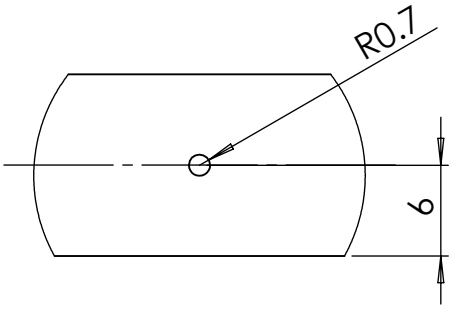


	Mass:	Material:		
	12 g	Stainless steel	MA4-ID5	SUN IT
Drawing #:	Scale:	Date:	Part name:	
11/23	5:1	30.05.2021	Lensfixer head	

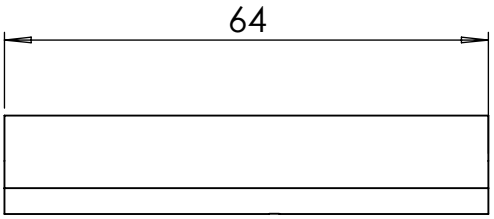


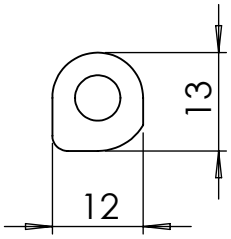
SECTION A-A

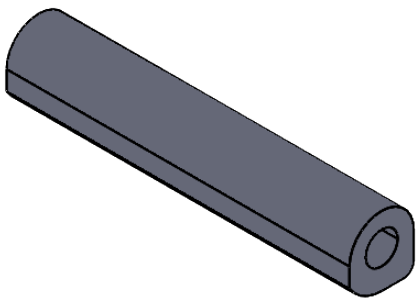




DETAIL B
SCALE 2 : 1



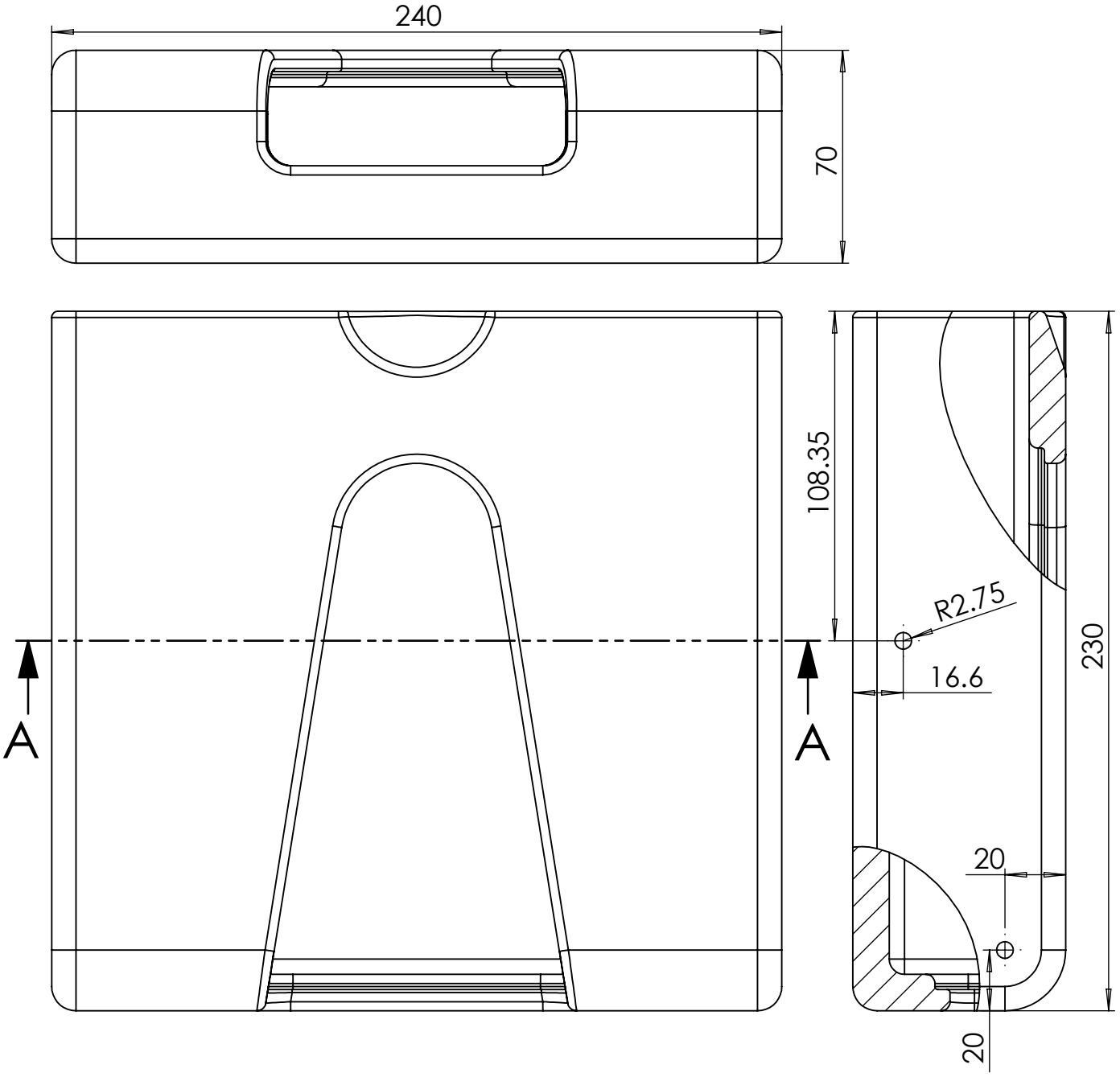


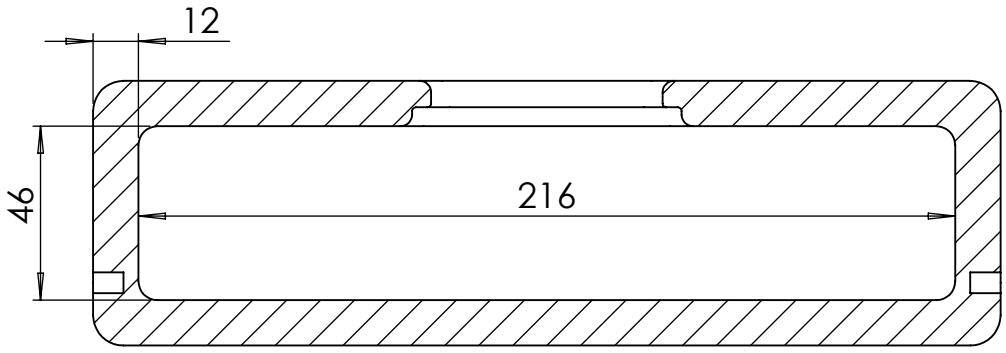


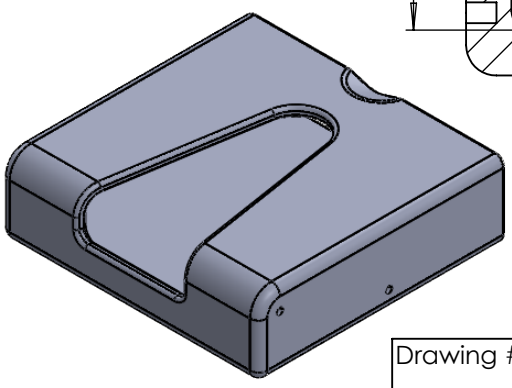
Same dimensions as Joint with an extra hole.

Mass:	Material:		
52 g	Stainless steel	MA4-ID5	SUN IT

Drawing #:	Scale:	Date:	Part name:
12/23	1:1	30.05.2021	Joint special



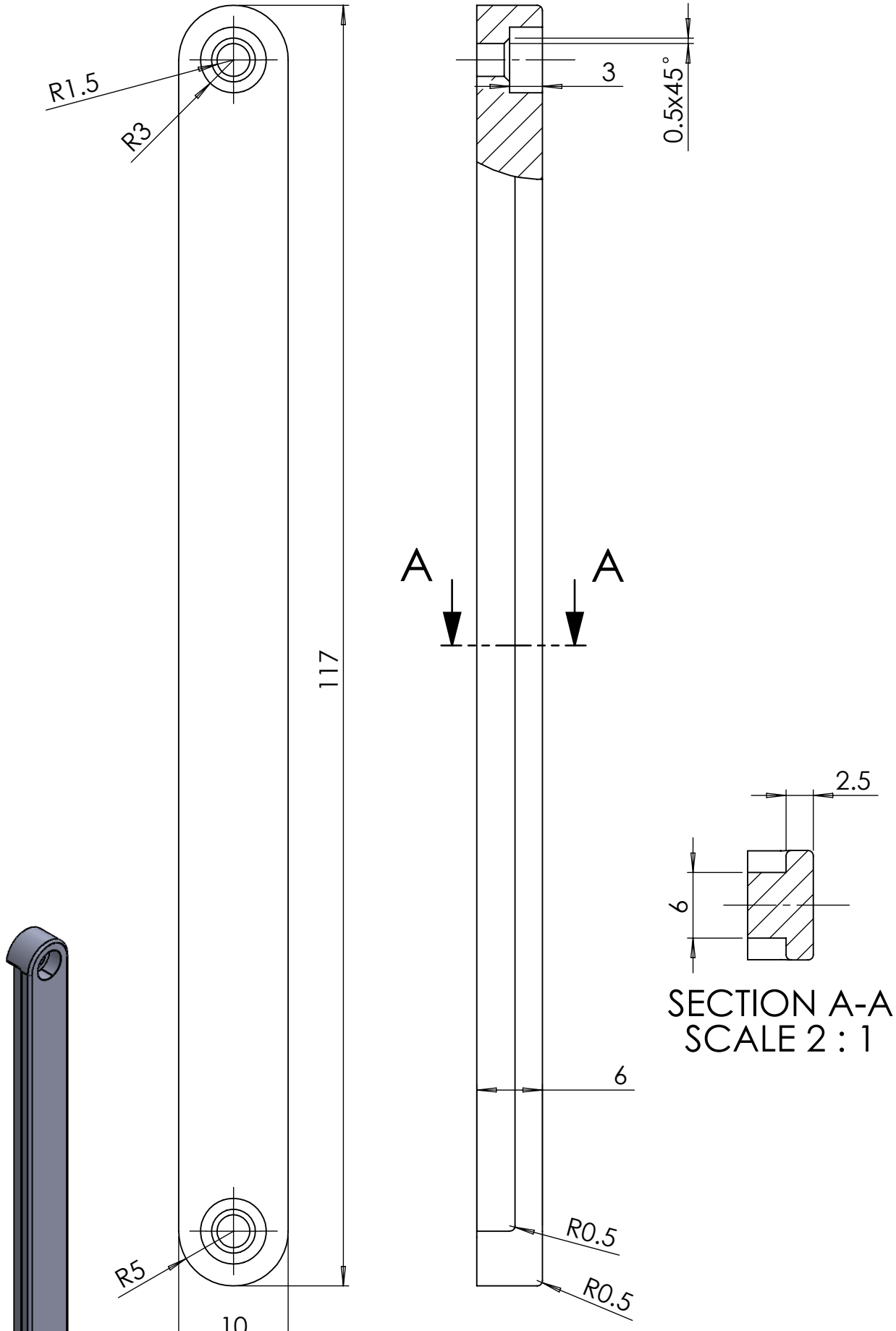


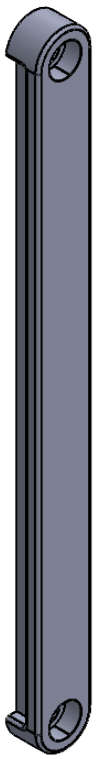


SECTION A-A

Mass:	Material:		
0.8 kg	HDPE and PU	MA4-ID5	SUN IT

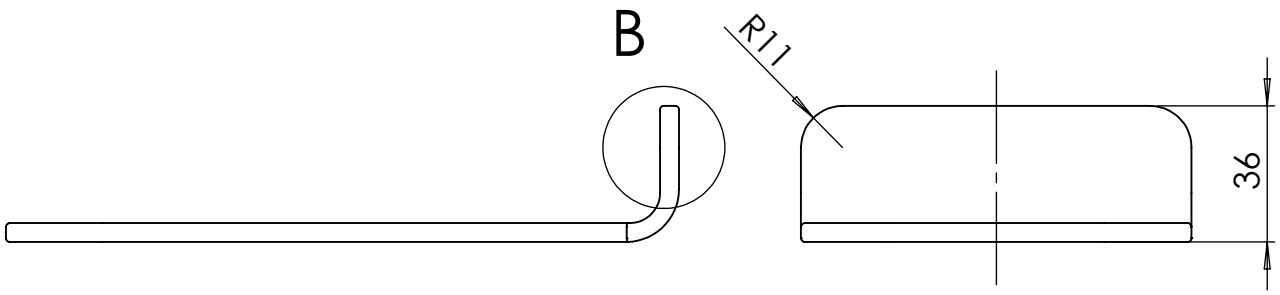
Drawing #:	Scale:	Date:	Part name:
13/23	1:2	30.05.2021	Main box

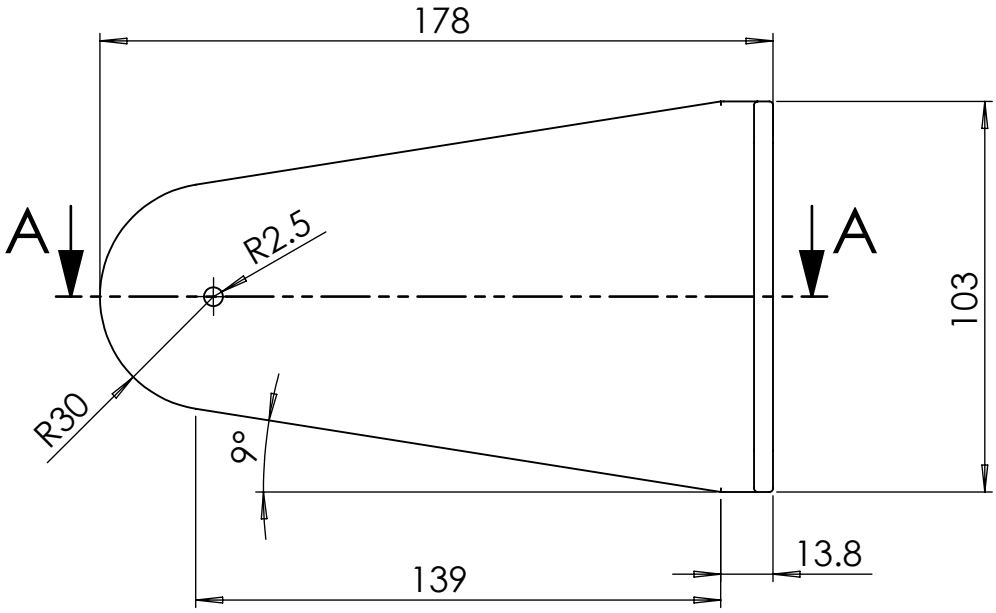


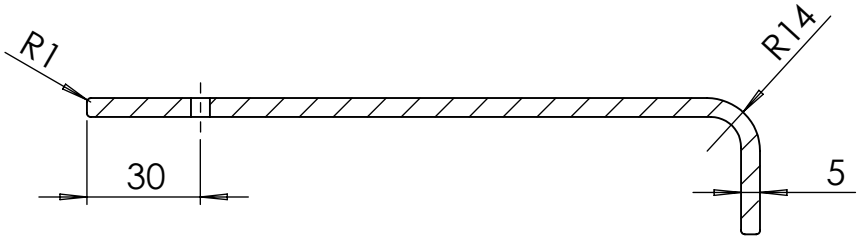


Mass:	Material:		
41 g	Stainless steel	MA4-ID5	SUN IT

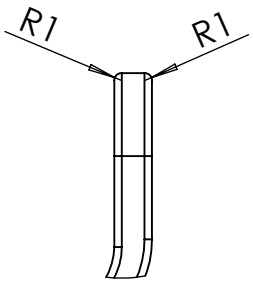
Drawing #:	Scale:	Date:	Part name:
14/23	2:1	30.05.2021	Rail



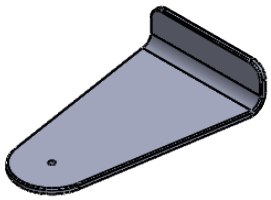




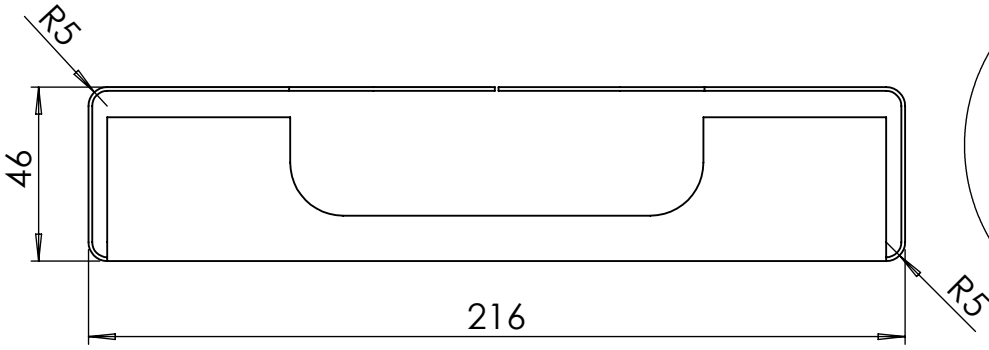
SECTION A-A

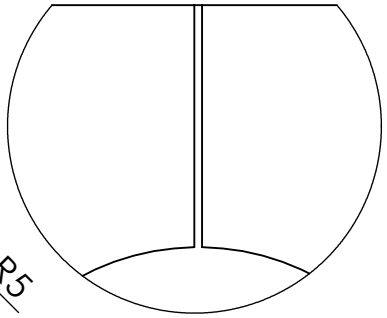


DETAIL B
SCALE 1 : 1

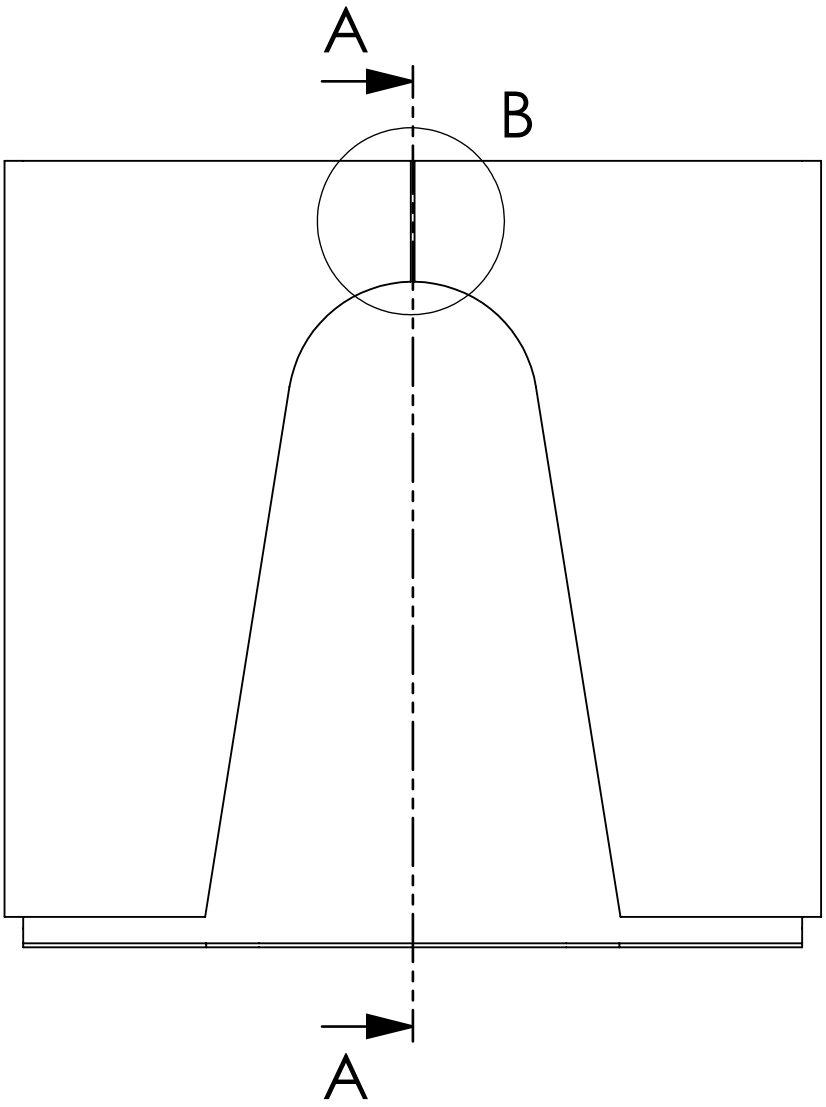


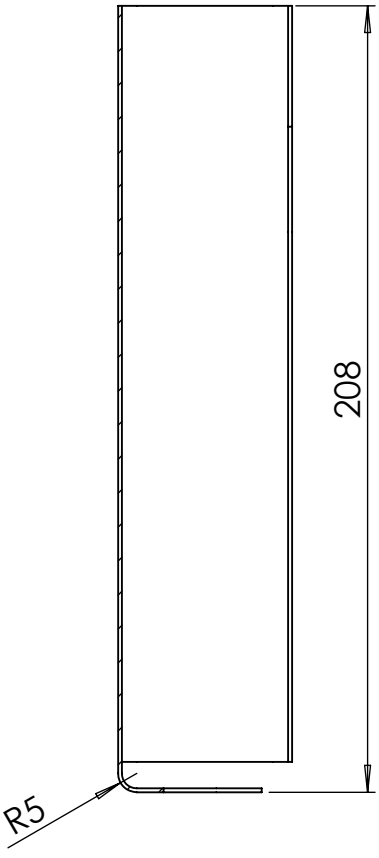
	Mass:	Material:		
	94 g	Acrylic	MA4-ID5	SUN IT
Drawing #:	Scale:	Date:	Part name:	
15/23	1:2	30.05.2021	Window	



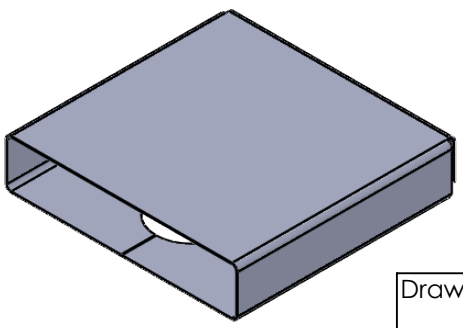


DETAIL B
SCALE 1 : 1

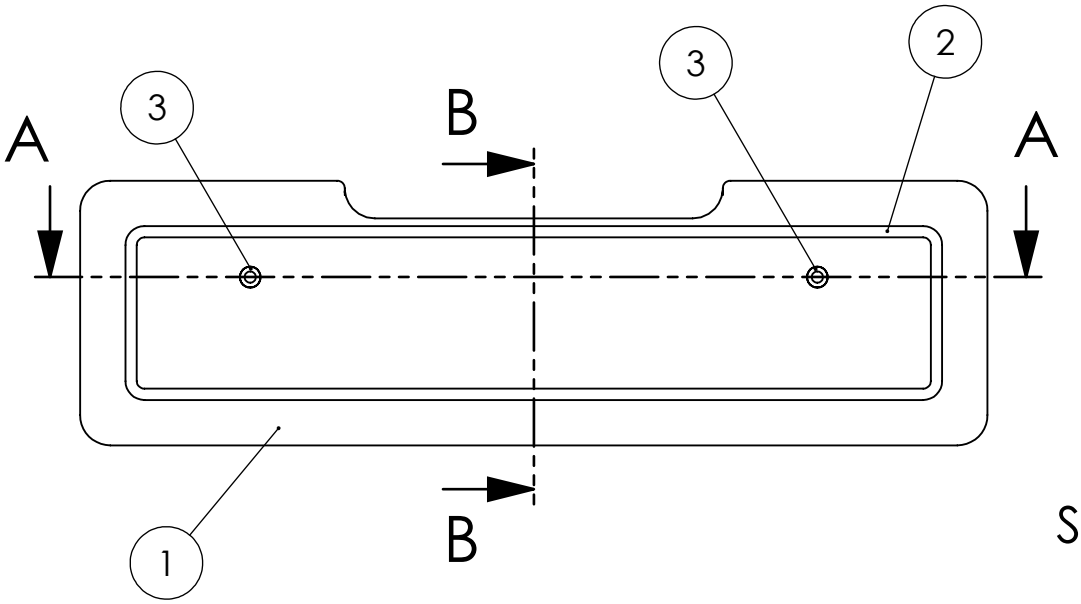


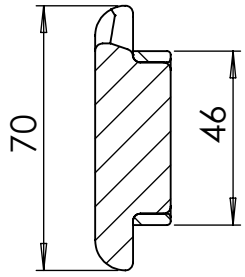


SECTION A-A
SCALE 1 : 2

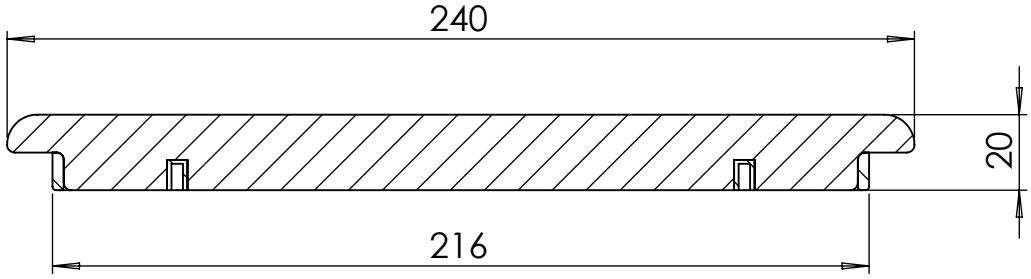


	Mass: 256 g	Material: Aluminum	MA4-ID5	SUN IT
Drawing #: 16/23	Scale: 1:2	Date: 30.05.2021	Part name: Reflective cover	



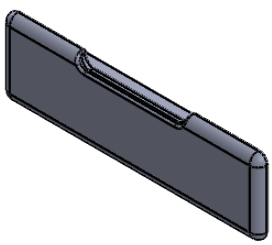


SECTION B-B



SECTION A-A

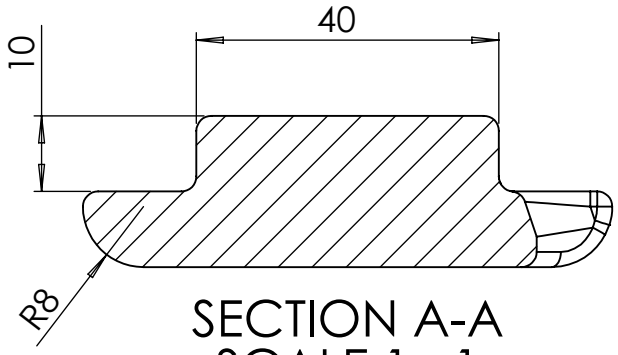
Rubber is glued to the door.



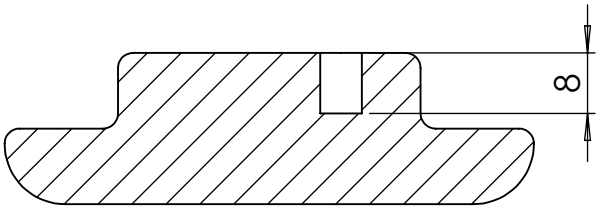
ITEM NO.	Part name:	Drawing #:	QTY.
1	Door	18	1
2	Door rubber	Standard	1
3	Threaded insert	Standard	2

Mass:	Material:		
167 g		MA4-ID5	SUN IT

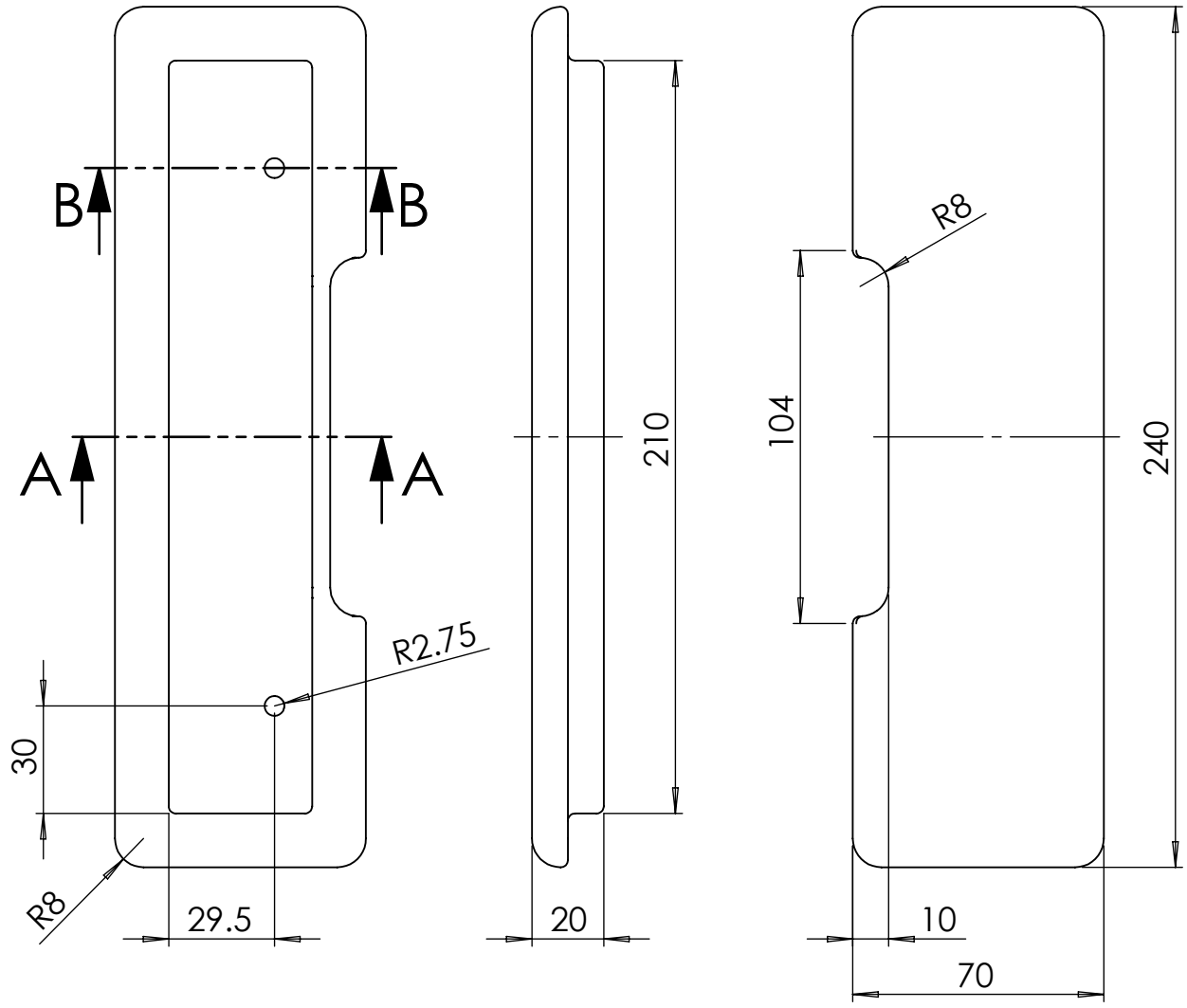
Drawing #:	Scale:	Date:	Part name:
17/23	1:2	30.05.2021	Door subassembly

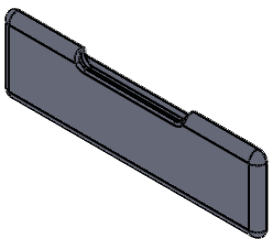


SECTION A-A
SCALE 1 : 1

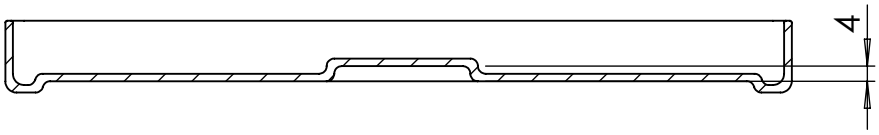


SECTION B-B
SCALE 1 : 1

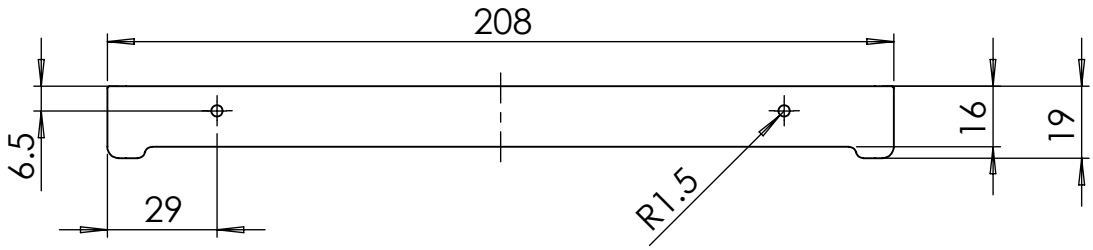


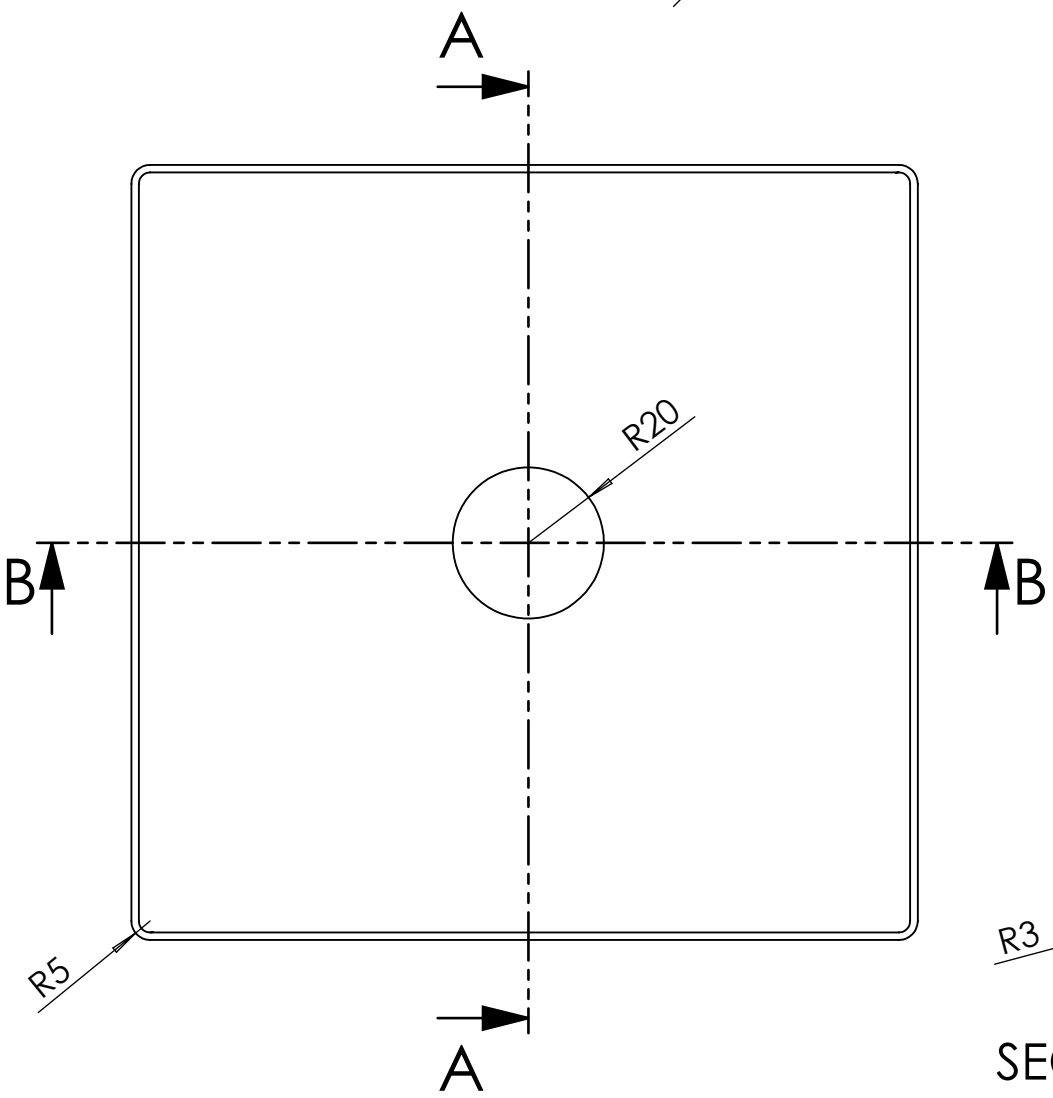


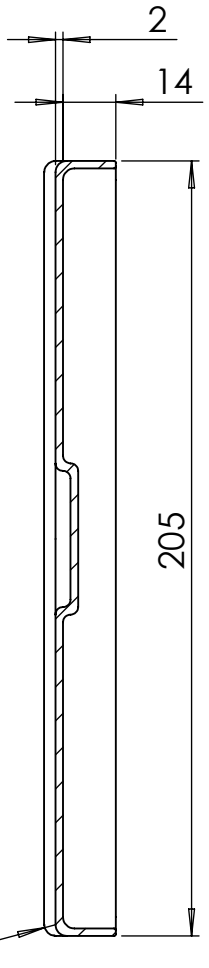
	Mass:	Material:		
	147 g	HDPE and PU	MA4-ID5	SUN IT
Drawing #:	Scale:	Date:	Part name:	
18/23	1:2	30.05.2021	Door	



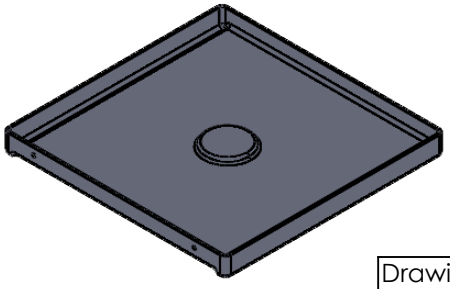
SECTION B-B



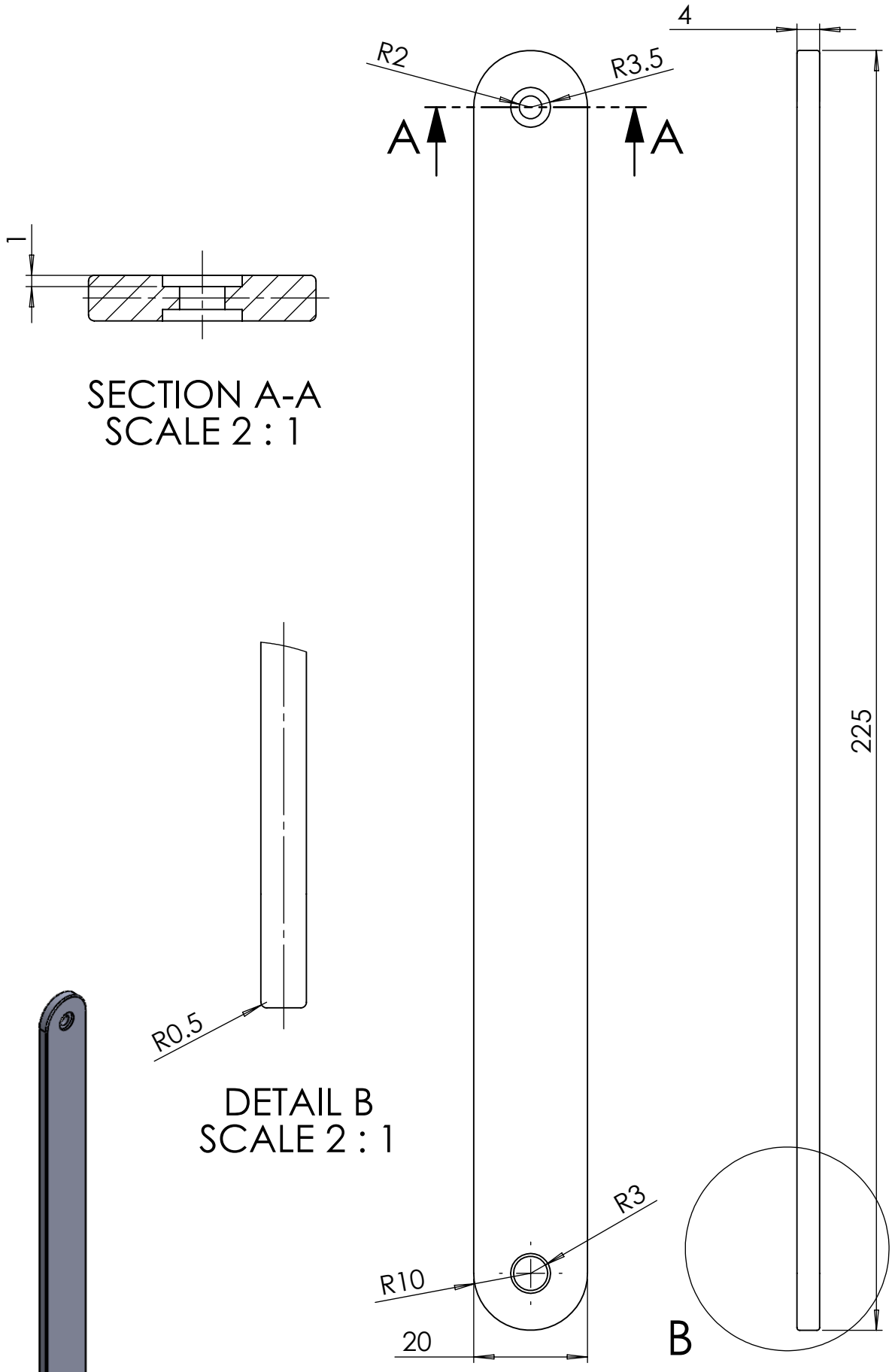




SECTION A-A

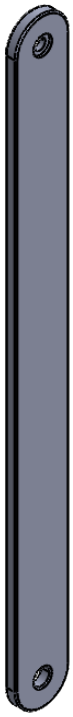


Mass:	Material:		
0,3 kg	Aluminium	MA4-ID5	SUN IT
Drawing #:	Scale:	Date:	Part name:
19/23	1:2	30.05.2021	Tray

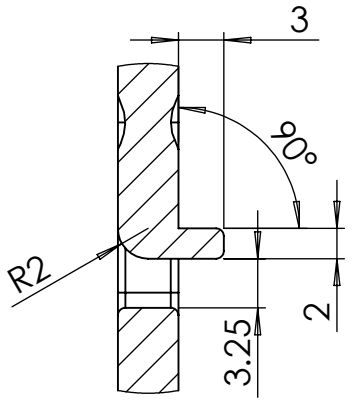


SECTION A-A
SCALE 2 : 1

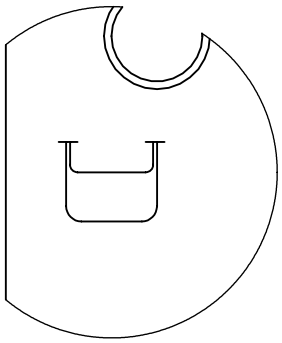
DETAIL B
SCALE 2 : 1



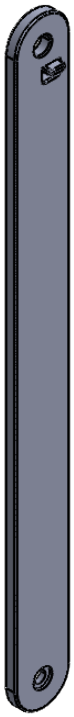
	Mass: 137 g	Material: Stainless steel	MA4-ID5	SUN IT
Drawing #: 20/23	Scale: 1:1	Date: 30.05.2021	Part name: Right arm	

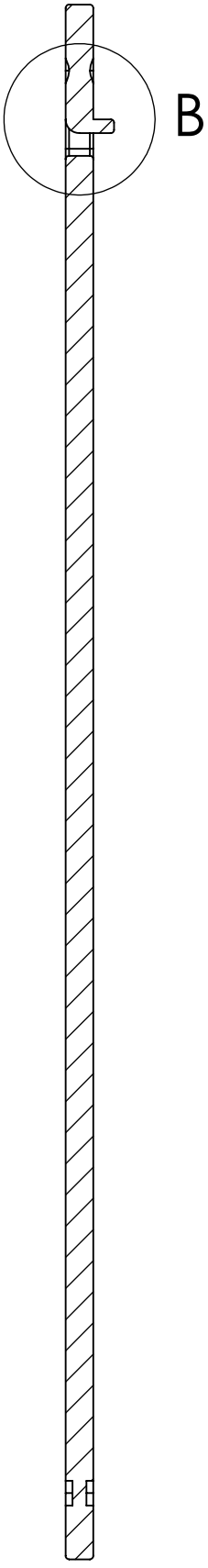


DETAIL B
SCALE 2 : 1

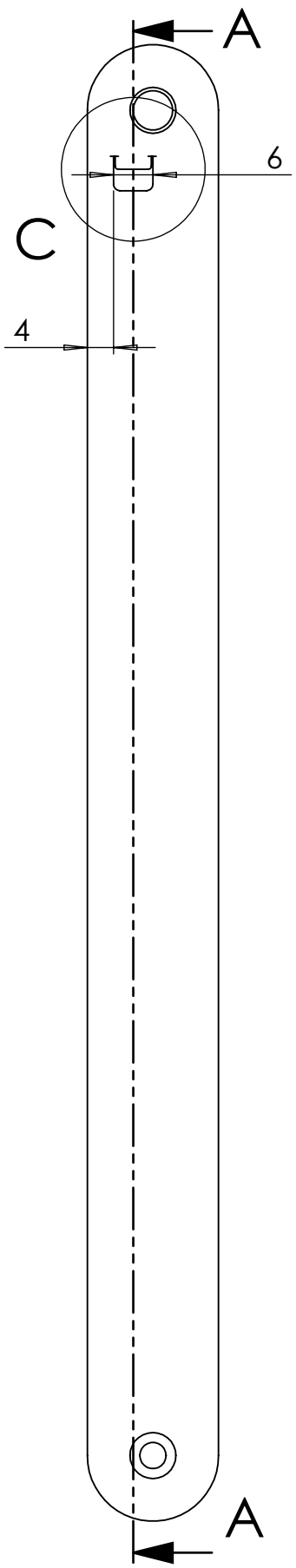


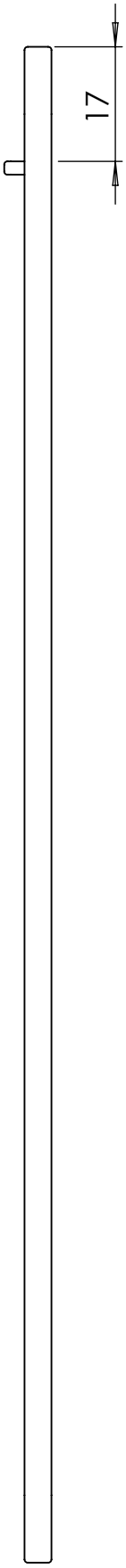
DETAIL C
SCALE 2 : 1





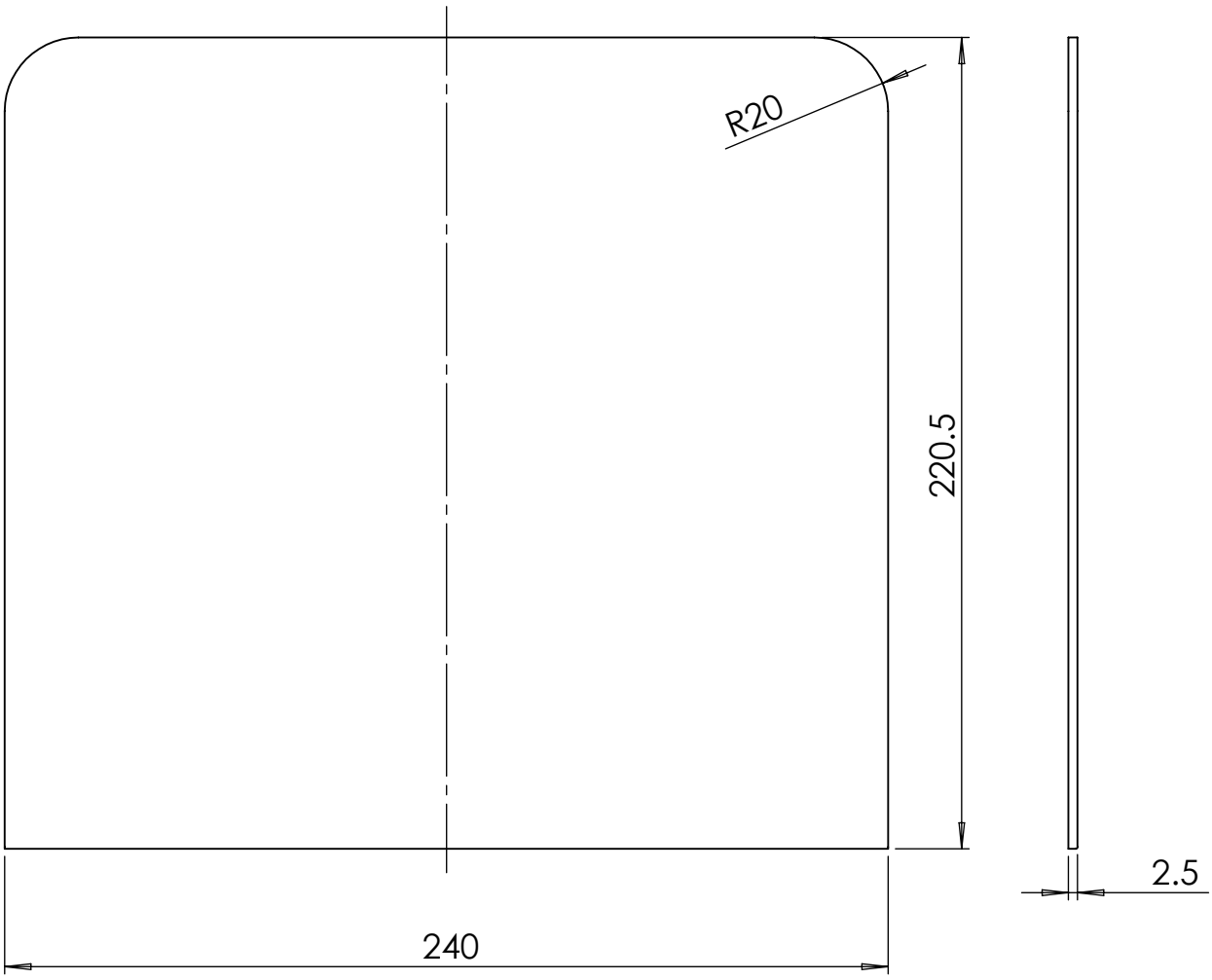
SECTION A-A

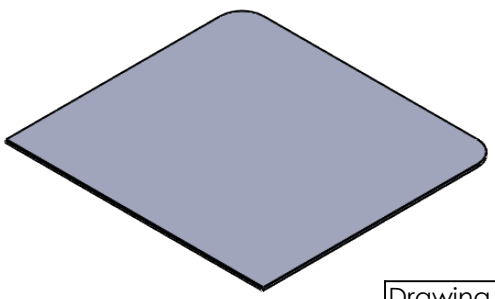




Same main dimension as right arm.

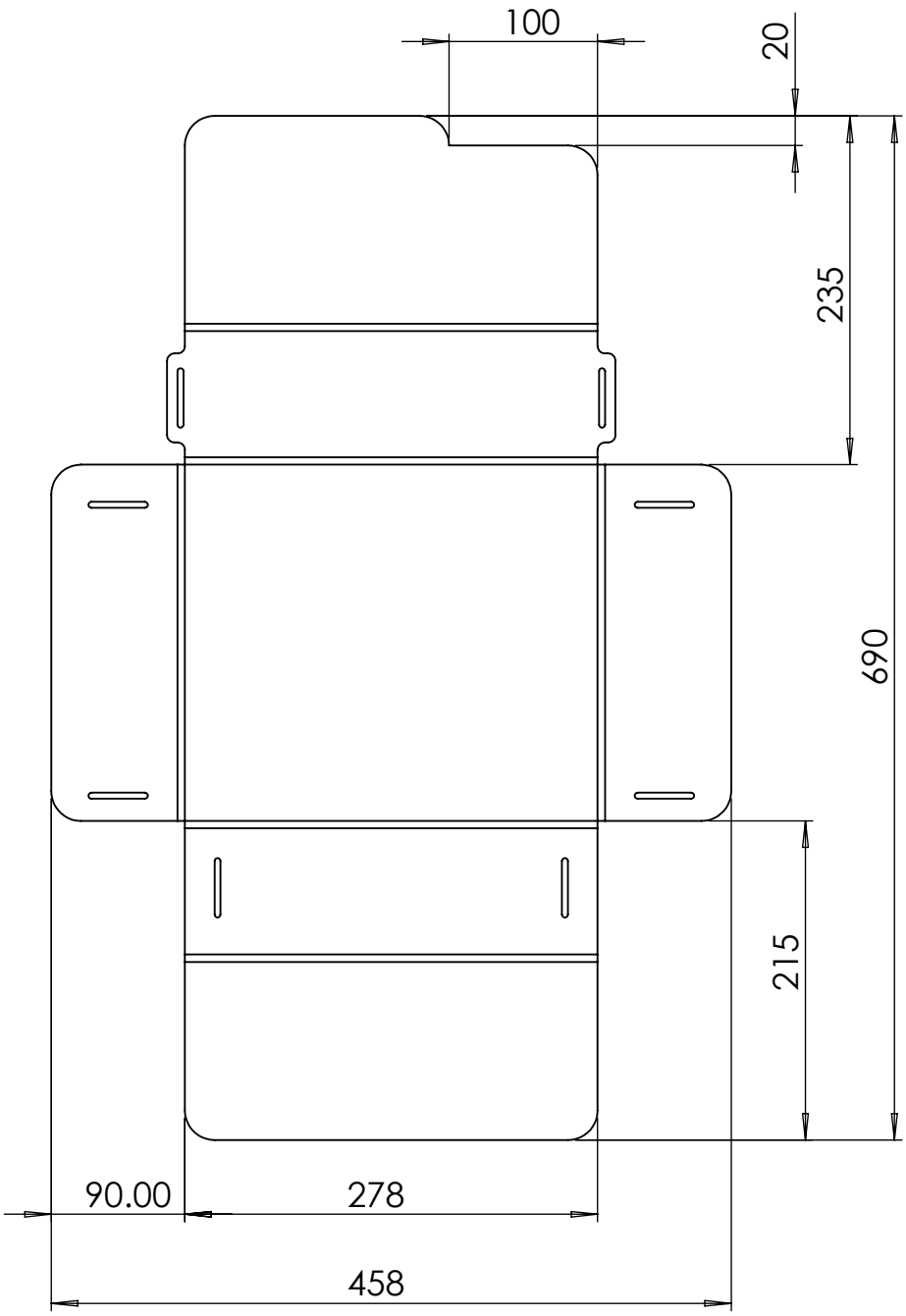
	Mass:	Material:		
	137 g	Stainless steel	MA4-ID5	SUN IT
Drawing #:	Scale:	Date:	Part name:	
21/23	1:1	30.05.2021	Left arm	

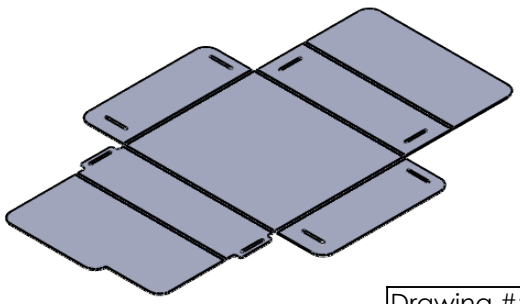




Cutting shape for the standard lens component.

	Mass:	Material:	MA4-ID5	SUN IT
Drawing #: 22/23	Scale: 1:2	Date: 30.05.2021	Part name: Lens	





Cutting template for the cover.

Mass:	Material:	MA4-ID5	SUN IT

Drawing #:	Scale:	Date:	Part name:
23/23	1:5	30.05.2021	Cover

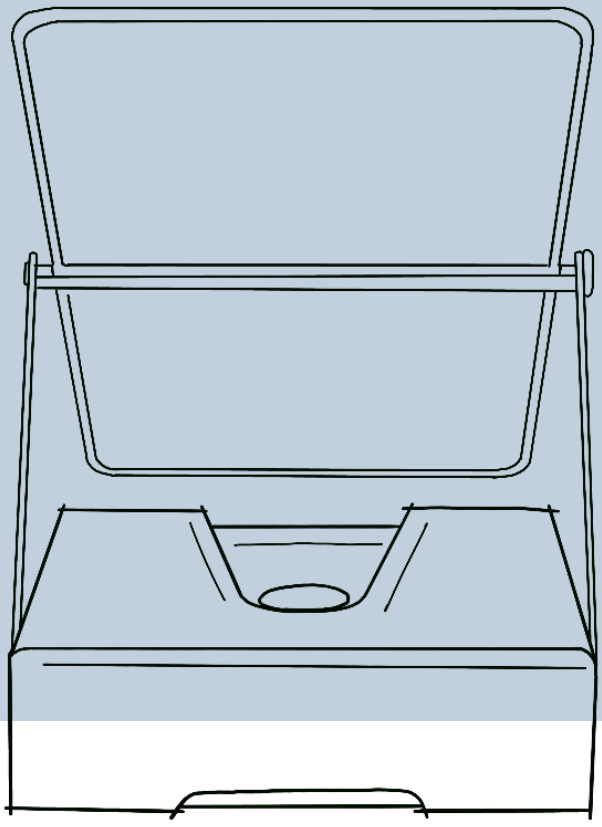
SUN IT

SUN IT

APPENDIX

Clara Rodriguez Ríos / Ofelia Anna Cornelia Hove / Péter Császma

JUNE 2021



MSc04 / ID05

AALBORG UNIVERSITY

Industrial design

Clara Rodriguez Ríos

Ofelia Anna Cornelia Hove

Péter Császma

Title
SUN IT

Report
Appendix

Theme
Solar cooking

Project theme
Master Thesis

Project period
01.02.2021 -03.06.2021

Supervisor
Christian Tollestrup

Technical supervisor
Radoslav Darula

Pages
48

1 Interview with hikers

An interview got set up to get a better understanding of hikers and their routines. The interview showed how hikers usually cook in the morning and night, where the sun is less strong or not there. Therefore creating a product for hikers is not the optimal scenario.

Date: 18.02.21

How often do you go hiking? (summer/winter)

Lea: I have more smaller trips, 1-2 day usually doing summer time as we don't have any holidays.

Sira: Not so much lately. Mostly because we don't have holidays for our studies. But whenever my family goes, so usually one time a year in the summer holidays.

How many days? Typical trip, tell us about it

Lea: For me it's very different. I have had a lot of trips where you had a car with you or you had a small house or something. And then have a lot of day trips. But I also had trips a few days on the road. But the last couple of times we have had sup boards that we bought a few years ago. And then we paddled to somewhere and slept and then the next day papple somewhere else and sleep there. On the front of the sup board we had packed all of your stuff under the eleatics bans and then put all our stuff in drybags, so no backpacks.

Sira: It is usually just day trips, so maybe we will go for like a week or two to Sweden or something like that and then drive around to the different places. And then we will take a good day trip for a couple of hours and then return to the base and then maybe take a trip the next day and then at some point move the base to another place. We have camps in the middle of the woods. The more woods we can go in, the better. That is kind of the part of being in nature and everything. But we have a rented car or our own depending on where in the world we are. With us so that things that have to be dry are often in the car. We sleep in a tent next to the car. So by that I often have access to a lot of things at the end of the day. We also cannon sometimes and then put all our stuff into a waterproof box. and then put that in the connon.

How many people are you on a hiking trip?

Lea: Usually it's just my boyfriend and I that goes together. And if it's more people then it's usually his family, so we are like 6-7 people.

Sira: Me, my dad, my stepmom, my stepbrother, my little brother, my half brother and sometimes my little sister so about 5 sometimes a bit more. And sometimes also my grandparents. So even though we have a car, we fill up the car with people. And it's good bonding.

What kind of food do you usually eat? And what equipment do you use for cooking?

Lea: We also have a trangia (my boyfriend's old one), and also a Jetboil, something quite similar, but with gas instead. I think Jetboil heats up much faster. So usually we bring both. If we have storage for it. Just because it's hard to cook for two people being very hungry. First of all it's a bit slow on the trangia, compared to the jetboil at least. Also if you cook pasta, and it almost gets cold, before you are able to cook the other stuff for the pasta. But we will cook pasta in one of them and then the tomato soup or something in the other one.

WHICH ONE WOULD YOU BRING IF YOU ONLY WOULD TAKE ONE?
Uhh thats a hard one. The good thing about the jetboil is that it´s with gas, so it's easier compared to having a bottle of this fuel, for the trangia. And we haven't found a great way of bringing the fuel, so we always have this disgusting bootle, with this very sticky fuel. I definitely prefer gas. And the small thing inside the trangia, where you put the fuel in, then if you don't use all of it, then you have to empty it and it takes a long time to cool down. And it's just very sticky and disgusting. It's just crap, seriously.
I think the problem with the Jetboil is that it only has this one pot, but you don't have a pan, so then you need the trangia anyway. We also have this gas thing for the trangia, so that's a third solution that we have.
And I think we eat almost the same as Sira said. Like pasta, rice, canned tomatoes and stuff like that. Also noodles, we figured out that they are nice to bring, because it's very lightweight and you only have to boil water. So it's very fast compared to other kinds of food. And it's better than a lot of the other food you can buy. I don't think we really enjoy making food, because it also takes too long, and you are so hungry before the food is ready. We also boil water for hot drinks. Also in the summer, we make coffee or tea in the morning, just to get something.

Sira: We use trangia as our equipment. And then we have a couple 2-3 of those with us, because we are a big family. And then if we can have a fireplace, then we will use that and have a bigger pot on that.
And regarding what we eat is a lot of carbs. Rice, pasta, and then also some canned food. Witch is disgusting now, but it tastes great after a long hike. It also depends on how long the trip is. If it is more weeks we use more canned food. And if it's shorter we will bring some vegetables or something. Not so much meat, because it needs to be cold.
Also while hiking we usually bring a loaf of bread, and we eat it constantly, just to keep having some energy. Because when first the sugar level gets low, hell breaks loose. So we need to make sure that we always are full. It's important to keep warm, if you first get cold, it's very hard to get warm again.
We also boil water for hot drinks. With my familie we always have to have coffee in the morning, my stepmom can not function without coffee, so we have some for her. And then in the evening when we start to get colder, we will make some tea, or coffee, just something to get hot. And in the winter we will bring hot juice on the hike. We don't really boil water on the go.
It's not so much the cooking that you enjoy, it's when you eat together.

How many times do you cook? at what hour? How much time do you spend on it?

Lea: I agree, I can't put time on it. But I would be impressed if it could be cooked in 15 min from start to end. We also make warm breakfast, dinner and cold lunch.

Sira: The less the better. 1 min would be great but if it takes 20 min to make some food then it takes 20 min. I can't really put time on it. But we usually eat in terms. We eat oatmeal in the morings, cold food for lunch, because we don't want to make a stop on the way, and then hot food for dinner.

When do you usually wake up?

Lea: It really depends on how long we are going to walk the next day to the next stop. If it is a long way we will wake up early, but if it's only a few hours we are not in a rush to wake up.

Sira: Yes you kind of backtrack it, it's not so much in the summer where there is light, but you at least want to get there before the sun gets down. And then you find out how many hours you are going to spend on walking and then you take the time to wake up early if that is needed. In the summer there will be sun when we wake up.

Where are the places that you usually go hiking?

Lea: I think it's mostly Denmark, Norway and Sweden. But I also had great trips in Germany, France and Spain. Germany is great, they have a lot of woods.

Sira: We have a summerhouse in Norway and one in Sweden, so we go there a lot. And then if we are traveling to another place then we were in Scotland last summer, where we did find some different places where we hiked. But usually Norway or Sweden.

Are you aware of the regulations regarding gas stoves? Have you ever been to a place where trangia is forbidden? What do you do then?

Lea: But can't you always fire up with gas? Us: No. Ohh I had no idea. But we would never start a fireplace if there weren't a "setup" for it. I don't know if we even took the trangia with us to Spain because it's so hot in the summer.

Sira: I don't know the different regulations, I don't know if my father knows them. Of course we know when it's really really dry, we have to be very careful. We have made a fireplace, where we were not supposed to but then we made it on rock and had water by hand if something should happen. I mean we are usually "nature people" who go hiking, so we know how to take care of nature as well and look for signs. So of course we have the biggest respect for nature.

How do you clean the equipment, after eating? And do you use plates/ bowls?

Lea: We used to do that as well, but then we figured out that we can use baby wipes to clean with. They are really good for cleaning up after you have been eating. And if you don't have a lot of water I think it's a good solution.

Sira: For us it's not really a problem. We have a sponge and then we have a jar of soap usually. And it doesn't take a lot of space.

What is your opinion on the existing solar cooker? Did you know about its existence? Would you buy it - and why not?

Lea: No I don't know them, but I have heard that in the military, they have these bags where you break something and then it will heat up. But I haven't heard of any solar powered cookers. But last summer I bought a solar device to charge my phone and we took it to Germany, but some days there were not enough sun to charge my phone. So I was very disappointed because it's a small thing to charge.

Would it fit the trips you are on?
Sira: I haven't heard anything about solar cookers.. But I think it will be problematic to use in a forest, or if it is cloudy, what are we going to do then?

Would it fit the trips you are on?
Lea: There would be sun, because it's often in the summertime we hike.

Is there sun or light in the mornings where you usually go hiking?

Lea: I don't think I would believe in a solar cooker that was able to work on cloudy days. But I think even if I was going to buy some equipment online and then scrolling through all of these solutions, and finding a solar solution I think I would need a friend telling me okay this work or something. It should be someone very close to me, before I would believe it. Honestly I don't think I would ever believe it even if I read about it.

Sira: There would be. When we are constantly outside it would be in the summertime. We are in Norway and Sweden where there is sun. If it is winter skiing then we have a cabin, so we would not need a cooker there, because we have a stove. But in the first scenario it would work if it works on cloudy days, I think we would be able to find a spot in the forest where there is light. You would not take the chance to trust that it works on cloudy days. Because it sucks to be somewhere and not have any food. If you make a product that works on cloudy days I think you have to do a lot of food work to make sure they trust that it works. Because I would have my doubts. And if I bought it, I would test it like ten times beforehand on cloudy days, to make sure it works.

I think our solutions will be a more hybrid product

Sira: But then why would I need to bring an extra product to carry around? If it can't be a trangia then I don't think I would bring it. I don't want extra equipment because it would be in my backpack. You always try to pack as light as possible, and as practical as possible.

Lea: But also, one of the really cool things about the trangia is it's a genius product, all the things can be packed very well so it doesn't take a lot of space. Same with the Jetboil, you can stuff the gas into the pot. So it's very compact, there is no room inside that is not taken advantage of and that is really a great thing.

Do you know how many days one container of gas lasts?

Sira: We never run out of gas, we always make sure we have some kind of backup.

Lea: I think maybe two years ago my boyfriend and I tried to make some calculations on it. and how much gas we used for a two days trip, because it's so hard to measure. I have it somewhere, I'll send it to you guys. We have never run out of gas, because we always bring too much.

What about summer grills? Do you ever buy a disposable grill? Or do you have your own grill?

Sira: I think I bought one once, but that's it. We wouldn't grill if we don't have one. I don't really grill in the parks in summer really. But I also think it's because of my eco heart, I can't take it with so much waste.

But what if you had a solar solution?
If it can fit into my su budget, then sure. I would really consider buying one, I think that would be great. Yes, bringing it on a bike is important or a backpack.

Lea: I brought plenty of the disposable grills, like a lot of times. And I think if we go to the park somewhere then maybe a friend has a grill. I think speaking of using a grill to use in the summer, it really important that you can bring it on a bike and that it's not too hot afterwards so you can get it back home again. And then the scale is much bigger, because you are more people. But bringing it on a bike - I know it's a problem.

How many people do you usually gather in the summer?

Sira: I think 4-5 people.

Lea: I think if you can cook for like 5-6 people it would be great.

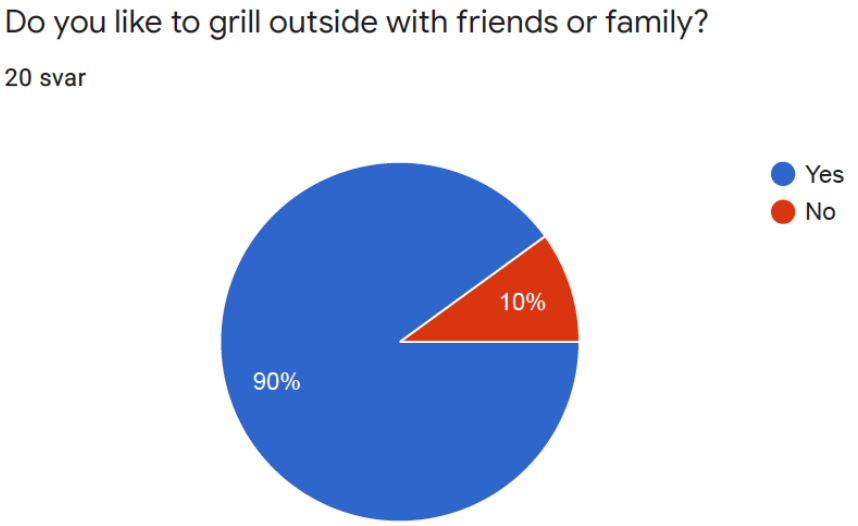
Is there anything you would like to add?

Sira: One thing that you have to be aware of is that it really has to be robust, because it's usually in the bottom of the backpack so there is a lot of weight on top of it. Also you have to be able to drop it on a rock without it breaking. Also the lighter the better. And then if you can feed a family of six people then it would be great.

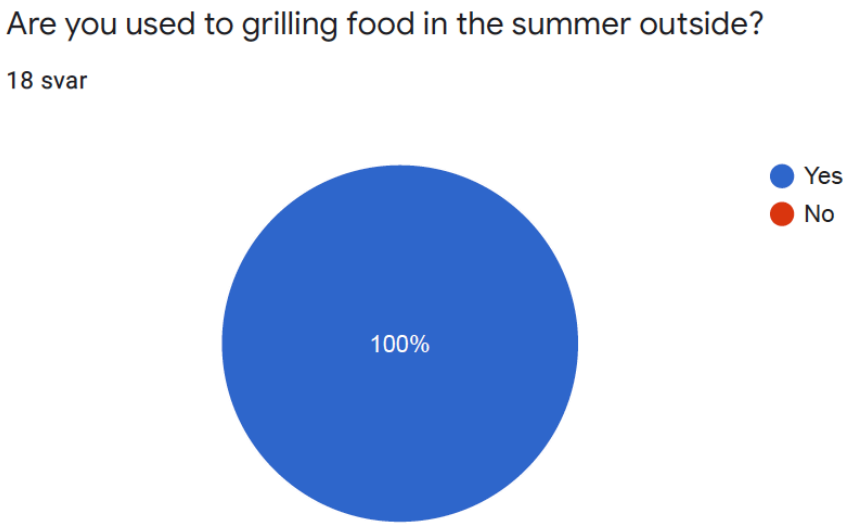
Lea: Also use the space inside of it, so it's very compact.

2 Survey: How do you prepare food outdoors?

The survey about grilling outdoors got set up to know more about the potential users' grilling habits. The result shows that 100% is used to grilling outside. 83,3 % asked would be interested in changing from charcoal/gas to a more sustainable alternative solution. The answers give a hint, about an interest in the proposed solution, from potential customers.



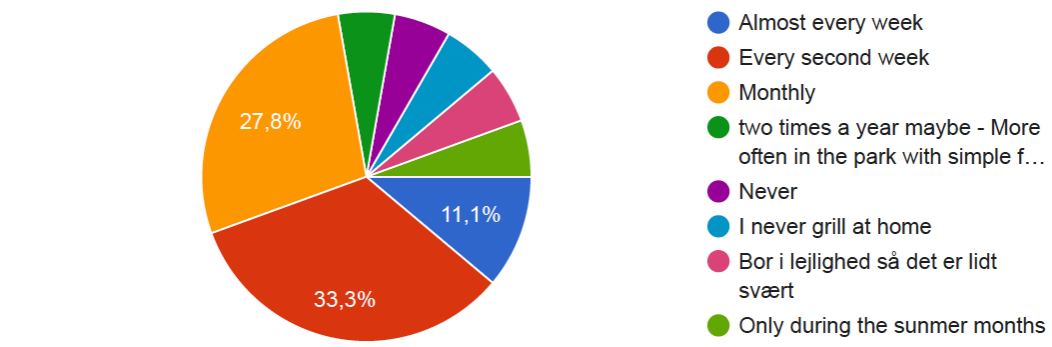
ill. 1 Survey question 1



ill. 2 Survey question 2

How often do you grill at home?

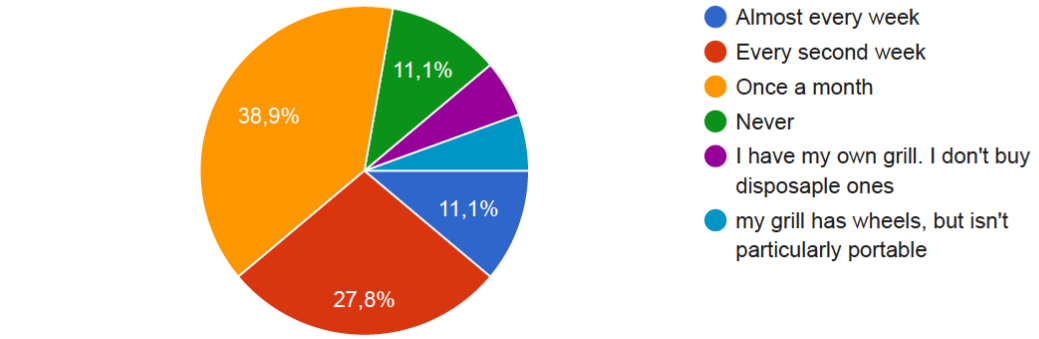
18 svar



ill. 3 Survey question 3

How often do you grill outside with a portable grill during summer?

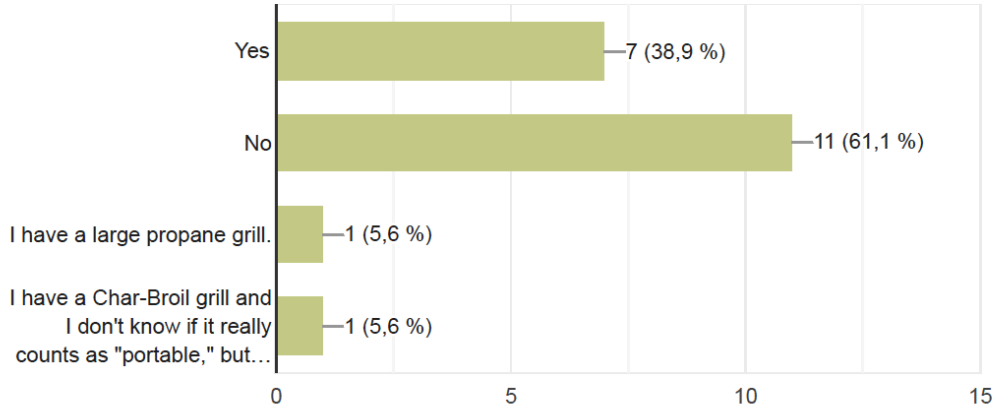
18 svar



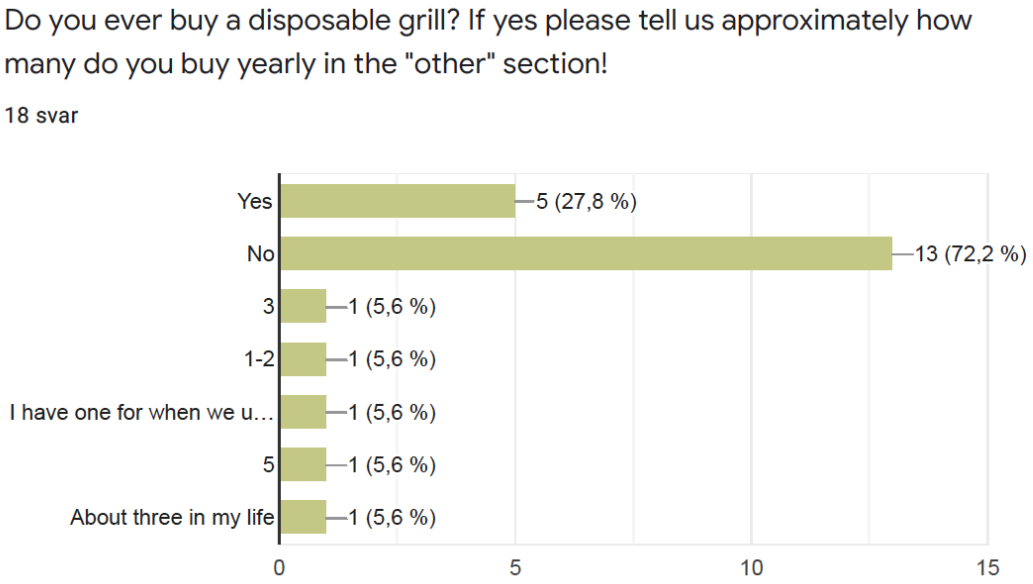
ill. 4 Survey question 4

Do you own a portable grill? Feel free to tell us in the "other" section the specific type if you have one!

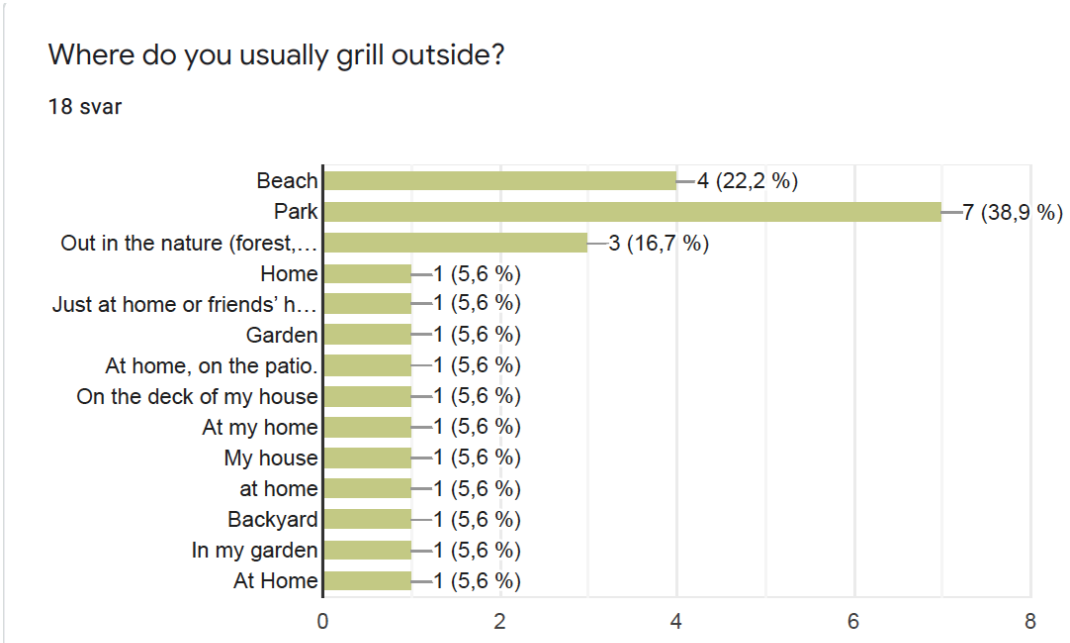
18 svar



ill. 5 Survey question 5



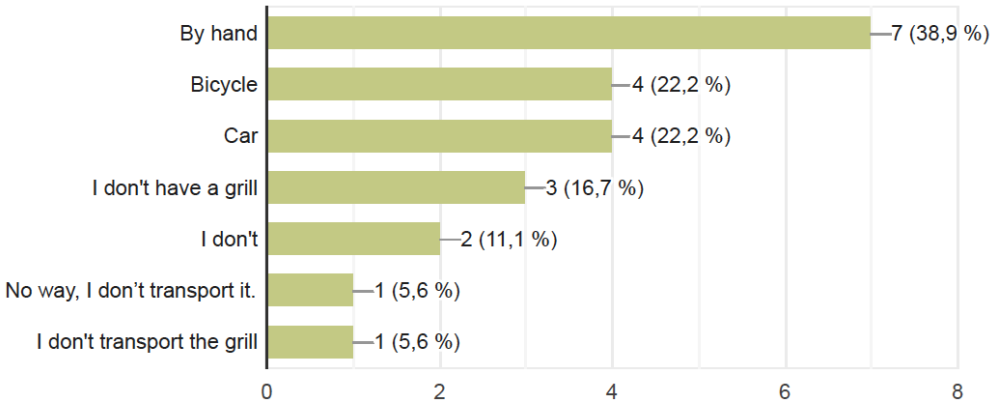
ill. 6 Survey question 5



ill. 7 Survey question 6

How do you transport the grill?

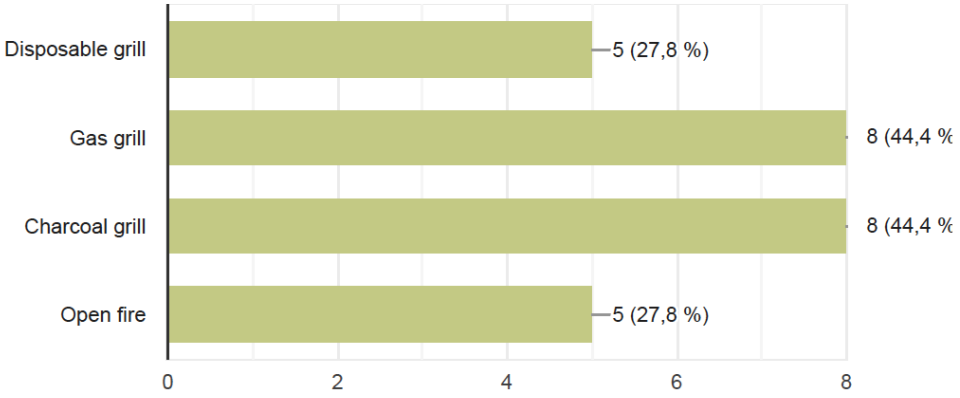
18 svar



ill. 8 Survey question 7

What do you use to grill with outside?

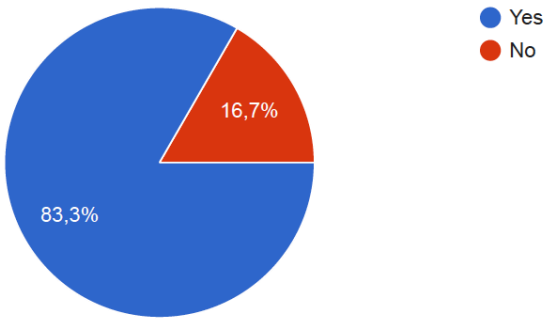
18 svar



ill. 9 Survey question 8

Would you change from using charcoal/gas to a more environmentally friendly alternative solution?

18 svar



ill. 10 Survey question 9

3 Potential users

Shown below is the full list of the potential users. They have been used throughout the process to give constructive feedback and insights.

Line:
21 years old
Danish
Barista at We Feat

Bashar:
23 Years old
Danish
Industrial Design Student

Frederikke:
25 years old
Danish
Radiograph

Christoffer:
26 years old
Danish
Architecture Student

Anna:
26 years old
Danish
Newly graduated from University of Copenhagen

Christine:
55 years old
Danish
School leader at: Helsingør Lilleskole

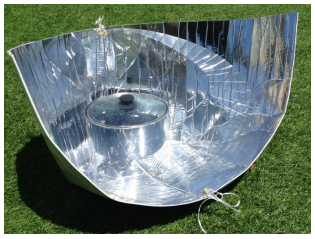
Valdemar:
19 Years old
Danish
High School student

Henrik:
58 years old
Danish
Physiotherapist

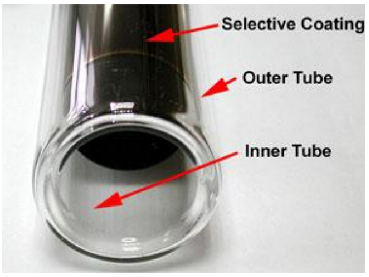
Siska:
47 years old
Danish
Life coach

4 Technologies: products

This cart is made with the aim of getting a better overview of the different categories of technologies and in what kind of product they are used in.

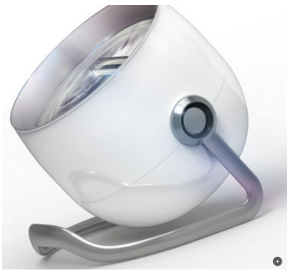
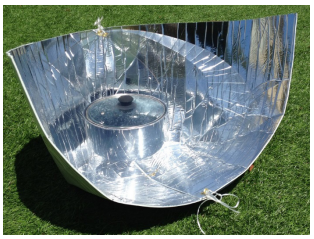
TECHNOLOGY		PREFERENCE PRODUCT	PROS	CONS
MIRRORS	Flat		• Fixed correct geometry • Quality	• Price • Fixed geometry (difficult compactability)
	Soft		• Flexible position • Price	• Fluffy • Quality
FRESNEL LENS			• Effficiency • Focal point visible • Price • Flexible material	• Flexibility • Size • Quality
SOLAR PANEL			• Battery charging	• Not enough power

ill. 11 Technology products inspiration

HEAT RETENTION	Closed box		• Price • Simple system	• Effficiency
	Vacuum tube		• Effficiency	• Price • Fixed geometry • Difficult access • Cleaning
	Paraffin wax		• Heat storage for several hours	• Heavy
	Molten salt		• Heat storage for several hours	• Heavy • Dangerus

ill. 12 Technology products inspiration 2

4. 1 Combination

TECHNOLOGY COMBINATION	REFERENCE PRODUCT
Hard mirror + vaccum tupe	
Hard mirror + Fresenel lens + closed box	
Closed box + hard mirror surface	
Closed box + soft mirror surface	

ill. 13 Technology products combination

5 Technologies: pros and cons

The cart shows an overview of the different possible technologies that would be used in the product proposal. To get closer to choosing the right ones for the product, pros and cons have been set up to get a better overview. By setting them up side by side, it should make the decision making easier as they are possible to compare.

MIRRORS	Flat	+any flat surface can be covered with it (hard) +cheap	- even though it helps reflecting the sun, it is not focusing it
	Parabolic	+fixed geometry, providing optimal angles to focus the sun into 1 point +most effective mirror to use for a solar cooker	- geometry needs to be parabolix, hard to turn that into a portable concept - more expensive than flat/soft mirrors
	Soft	+soft materials like textiles can be covered with reflective surface +compact, foldable solution	- less effective than hard mirrors since the geometry is not perfect
FRESNEL LENS		+efficient focusing of the sun into one point +visible focal point with high temperature +slim, light, even flexible plastic sheet +cheap +can be cut and folded	- needs to be as big as possible to operate sufficiently
SOLAR PANEL		+ charging electronic devices	- not enough power to operate a cooker - energy storage is only possible with heavy and big batteries

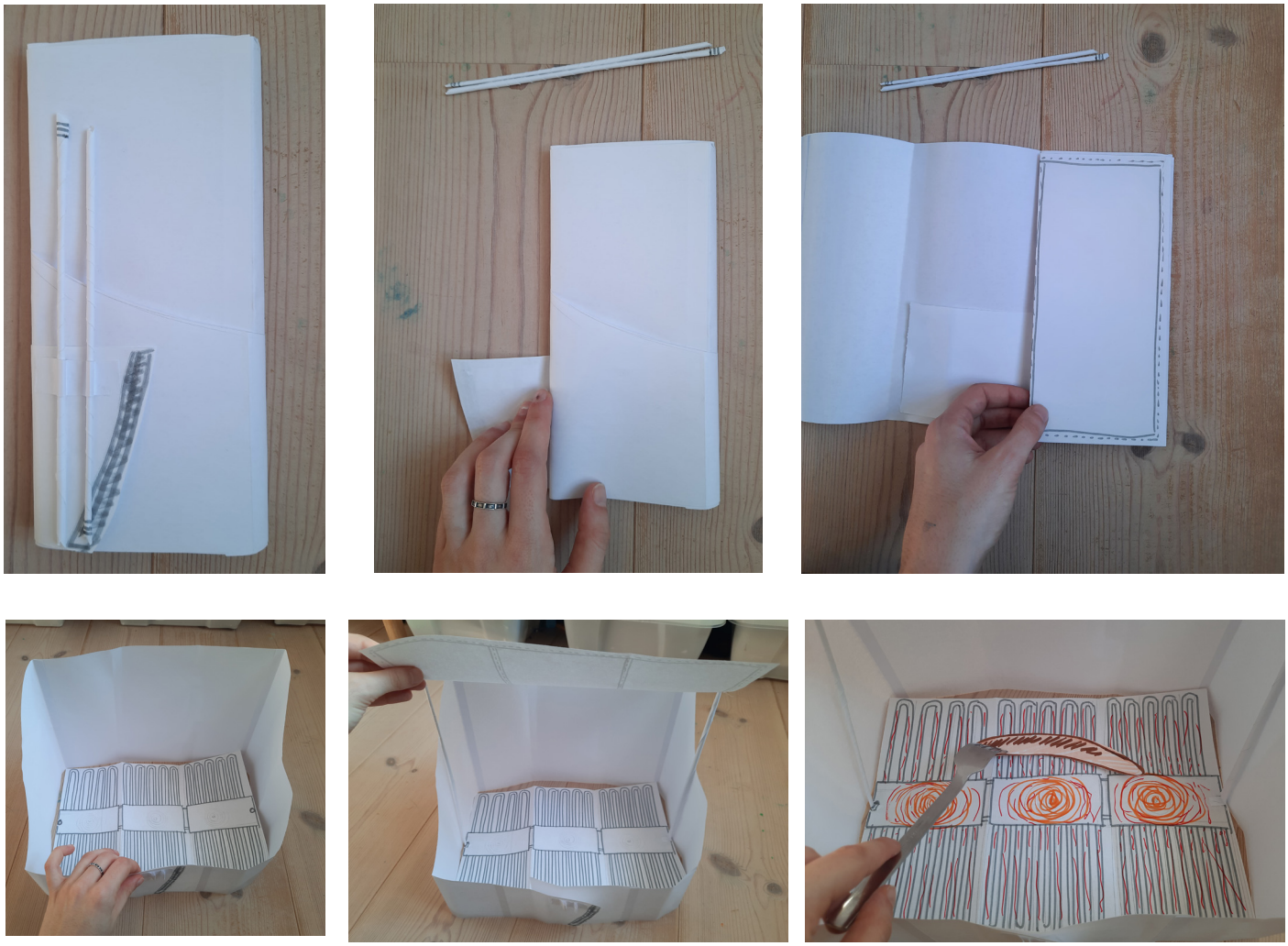
HEAT RETENTION	Closed box	+easy to create +cheap solution, no special technologies or components needed (like a simple pot)	- there are more efficient solutions for heat storage
	Vacuum isolation	+better heat storage	- more expensive solution, harder to manufacture - limitations regarding shape and compactness
	Paraffin wax	+ storing heat for several hours even after sunset (depending on size)	- heavy - to keep enough eat large size can be needed - safety
	Molten salt	+ storing heat for several hours even after sunset (depending on size)	- heavy - large size, hard to make it compact - safety

6 Concept development

6.1 Concept mock-ups

Under some of the initial concept, we wanted to implement the factors; foldable and portable. The following shows three concepts that unfold the possibility of incorporating this in the final concept. (See in the following illistrations 14, 15 and 16)

CONCEPT 1



ill. 14 Concept: Fold

CONCEPT 2

ill. 15 Concept: Portable bag

CONCEPT 3

ill. 16 Concept: Umbrella

6.2 Heat efficiency

By looking at what Go Sun Go and Solari do to optimize the heat retention of their products, it was possible to understand what was the best way to go in terms of heat efficiency. As a result of this analysis (see research) it was possible to extract the following requirements to ensure heat optimization:

HEAT RETENTION:
- Hermetic closure: possible use of rubber around the door
- Use of black colour in the circle where the sun hits to increase its power and around the tray, to captivate the heat reflected from the reflector
- Heat reflectors: to reflect the thermal waves emitted by the heated tray
- Insulated walls: to avoid heat loss, stocking all the possible heat, making temperature arise.

HEAT DISTRIBUTION:
- Use of aluminium for the tray
- Homogeneous shapes: the box cannot be shaped like a circle, which would be the optimal shape, but it will be shaped as a square with rounded corners, instead of a rectangle (as shown in previous ideation) to ensure the heat is distributed as well as possible. Using a circular shape would be the best solution for heat distribution, but it would limit the size of the lens as it would be impossible to fit a larger lens to the main body of the product.

Lens size

The used lens so far was 30x30= 900 cm2, and it worked. Meaning that the final product should be able to achieve this surface or more and an optimal volume to heat up.

Inspired by the existing products in the market, the first thought was to have a dimension of around 20x30cm (approx the disposable grill dimension), meaning the unfolded lens would have a surface of 40 x 30 = 1200 cm2 (double the size of the main body). However 20x30 is a rectangle, so the heat would probably distribute more unevenly. It seemed more reasonable trying to tend to a more homogeneous shape. The ideal one would have been a circle, however, this was not possible to carry on with the given requirements. Therefore the square seemed to be the best option.

The goal was to obtain a square that created a volume as small as possible since the bigger the volume, the more difficult it would be to heat it. This volume had to be big enough to fit a reasonable amount of food.

A lens of 20x20 would provide a reasonable cooking size, but the lens surface would be 20x40= 600 cm2, which was below the minimum required surface since it did not even reach the prototyping lens size.

A lens of 22X22cm would mean 22x44=968 cm2, still not enough.

A lens of 23x23 would provide a surface of 23x46=1058 cm2, a lens a bit bigger than the one we have used for prototyping, meaning this was the minimum lens side the product could have.

Height

This product needed to comply both with functionality and capacity requirements, meaning that the volume needs to have a dimension that is possible to heat up and at the same time big enough to fit a wide variety of food.

Most meats and sliced vegetables can be fitted into a height of 4 cm, if bigger pieces of food are wanted it would require a height up to around 7 cm. However, the bigger the volume the more difficult it would be to heat it.

A conflict of requirements was taking place, and in this case, it got chosen to prioritise function over capacity and therefore choosing the minimum possible size, which is approximately 4 cm.

Taking into consideration an approximate dimension of 1,4 cm thickness for the insulated walls. This discussion ended up showing that the product dimensions would have to be approximate:
23x23x6 cm, which leaves an interior volume of 21x21x4= 1764 cm3

7 Experiments

The following shows all of the experiments done, intending to find a setup that can work under the given context. The concept development has been highly affected by the result of the experiments.

EXPERIMENT 4: Indirect cooking bottom-up

11-03-2021

Purpose:
Indirect cooking (lense focusing on the pot and not on the chicken), closed box with reflective material.

Set up:
The pot was wet from the previous experiment, perhaps that made it harder to heat the pot and the chicken? (See illustration 17)

The results concluded:
The chicken looked cooked in 15 minutes but it looked a bit more jelly than the previous experiment

Insights:
The reflected part was in a shadow, showing it may not have provided anything

Next step:
Try experiment without the reflection and trying to optimize the heat retention of the pot

ill. 17 Experiment 4

EXPERIMENT 5: Cooking several pieces, direct + indirect

17-03-2021

Purpose:
Direct cooking from the window and then try to warm up several chicken prizes

Set up:
- The temperature was around 6
- There was wind
  (See illustration 18)

The results concluded:
- The chicken looked cooked in 10 minutes
- The chickens got heated up in around 5 minutes

Next step:
Placing more than one chicken inside the pot and the light is only pointing at one to see if they all get cooked? Is it hot enough inside the cup?

ill. 18 Experiment 5

EXPERIMENT 7: Measurement of the heat in the focal point

25- 03-2021

Purpose:
Measurement of the temperature in the focal point, so that we are aware of the power we have at the begging and how it is distributed along the surface

Set up:
Placement of the focal point at the end of the thermometer stick (See illustration 19)

Conclusion:
We can reach more than 300C in the focal point

Next steps:
- Ideate on how to keep as much heat as possible:
- Heat retention
- Heat conduction

ill. 19 Experiment 7

EXPERIMENT 9: Cooking from the top to the bottom in a bigger area

26- 03-2021

Purpose:
From ideation: maybe the best thing would be to heat food from top to the bottom to avoid tilting the tray, which would be annoying for the user. Concept-based on a “hermetic” panini maker.

Set up:
- The experiment was done in Spain (spring) at around 11 am
- We took two oven cake trays, one fitting inside the other one.
- We put the sausages in between, the bottom tray makes the pressure of the sausage against the upper tray, the one that will be heated up by the sun.
- We covered the space between trays with plastic film, to improve the hermetic closure
  (See illustration 20)

The results concluded:
Only the sausage in the middle, directly under the sunlight, was brown on the surface in contact with the metal. The bottom of this same sausage was not cooked. The rest of the sausages were much less cooked.

Next step:
Compare the heating from the top and heating from the bottom

ill. 20 Experiment 9

EXPERIMENT 15: The ideal volume

20-04-2021

Purpose:
Make a better calculation on which volume we can heat up and what the desired volume is we would like to achieve and try to find the balance between these two. Our desire and the restriction is given by the lens.

Hand calculation:
The lens we have used is 30x30= 900 cm2, and it worked. In our product, we should be able to achieve this surface or more, and an optimal volume to heat up
We wanted to have a dimension of 20x30 (approx the disposable grill dimension), meaning the unfolded lens is 40 x 30 = 1200 cm2. However 20x30 is a rectangle, so the heat would probably distribute more unevenly. It seems more reasonable trying to tend to a more compact shape, a square. A square that creates a volume as small as possible, the bigger the volume the more difficult it will be to heat it.
If we do a box of 20x20 its a reasonable size, we would have a cooking area of 400cm2 but the lens would be 20x40= 600 cm2, which is too little, it does not even reach the size we use for prototyping
A 22X22 box would mean 22x44=968 cm2, still not enough.
A box of 23x23x7cm would provide a folded lens of 23x23, so a surface of 23x46=1058 cm2, a lens a bit bigger than the one we have used for prototyping.

Comparison with other products: Solari
They have a plastic shell (isolation)

Hand calculations:
A box of 23x23x7cm would provide a folded lens of 23x23, so a surface of 23x46=1058 cm2, a lens a bit bigger than the one we have used for prototyping.

Comparison with solari:
Solari seems to work, they use a much smaller lens and a much bigger volume they heat up. Our lens is bigger and the volume we heat up smaller, this indicates that there is a high chance our product would work and even better than Solari
Also, the surface of our product is more convenient for cooking than the one offered by Solari or Go Sun Go

Next steps:
Make a more faithful experiment with the measurements extract from this

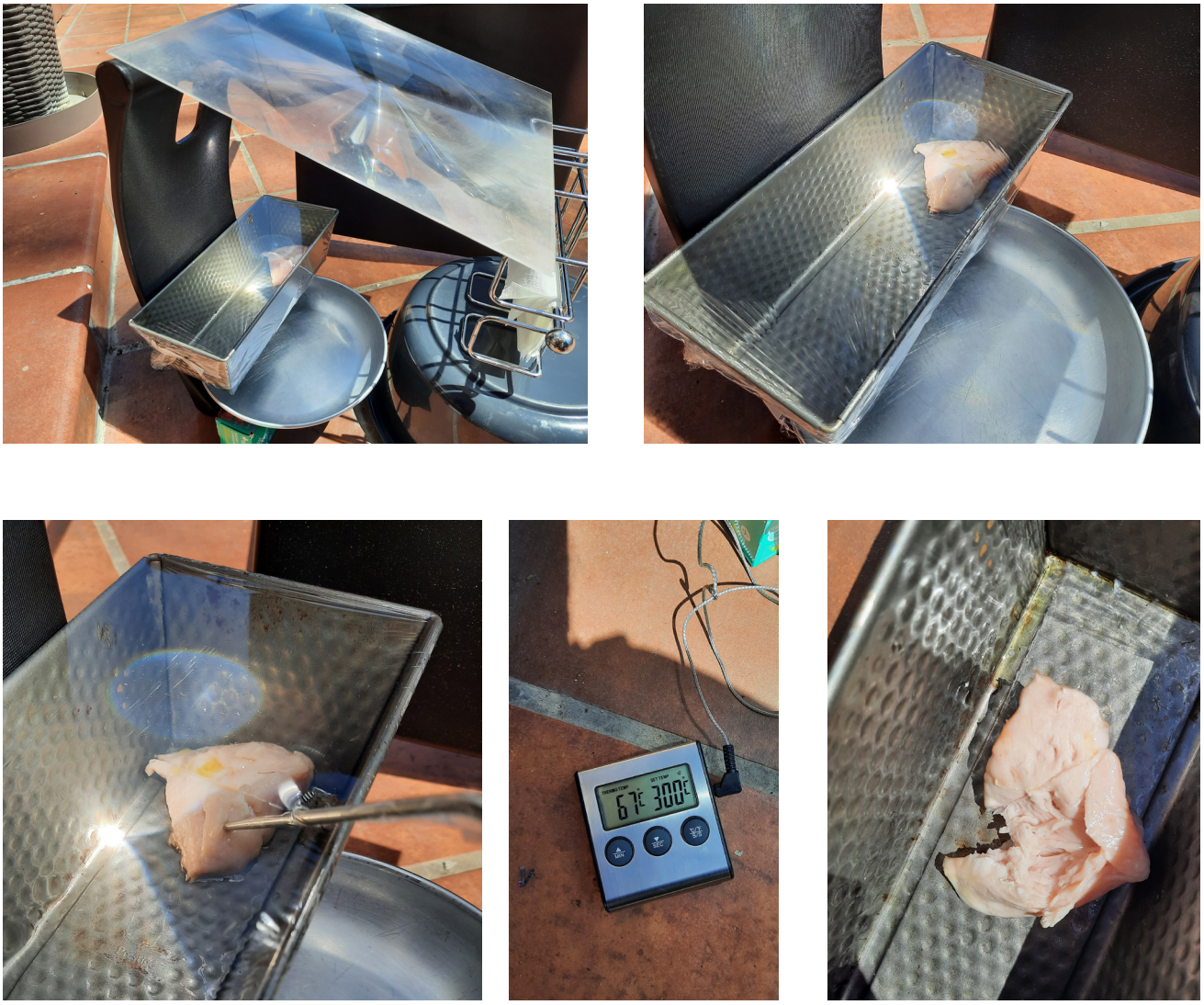
EXPERIMENT 17: Prove of efficiency

04-05-2021

Purpose:
Compare the previous set-up with a not so good one and see the impact of what we think are key point have on the cooking.

Set up:
Oven black tray (unknown metal), covered in transparent foil and placed under the sun. (See illustration 21)

Conclusion:
- The chicken took much longer to be cooked it was not very well cooked.
- After an hour under the sun, it had only reached 67 degrees on the inside. And it should achieve at least 70.
- So, it DOES make a BIG difference in the setup. PROVE OF CONCEPT, ISOLATION IS NEEDED



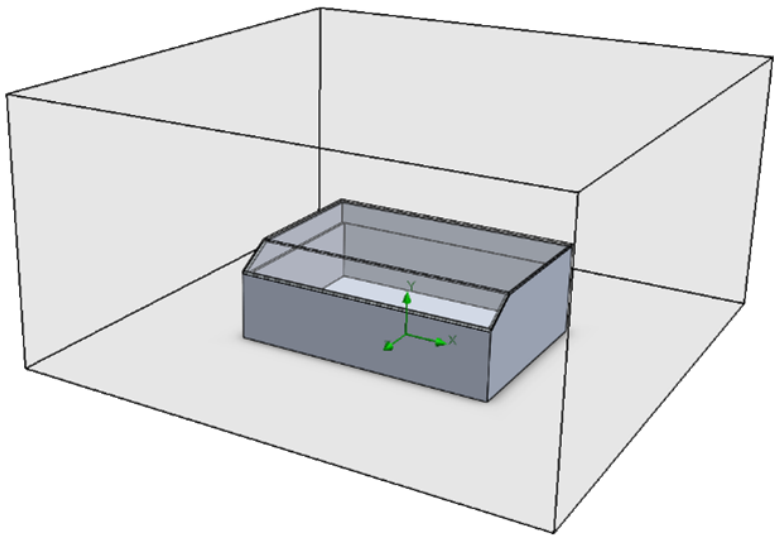
ill. 21 Experiment 17

8 Simulations

In parallel with experimenting virtual flow simulations were made to compare, understand better and validate the results up to a certain level. To carry out simulations a simplified geometry was created for the main box and the cooking space volume in Solidworks. Then the program's flow simulation feature was used to set up the environment and the conditions to run the simulation. In the following worksheet details and results of these simulations can be found.
In the simulation instead of simulating the sun with a functional Fresnel lens in the model, the setup was simplified to make it faster. The Fresnel lens and the sun were replaced by a heat source with equal power in the small area in the middle, where the focal point would be positioned.
The main setup in all simulations is the same. The object is placed in the middle and it is surrounded by air. The air temperature is 20 Celsius.

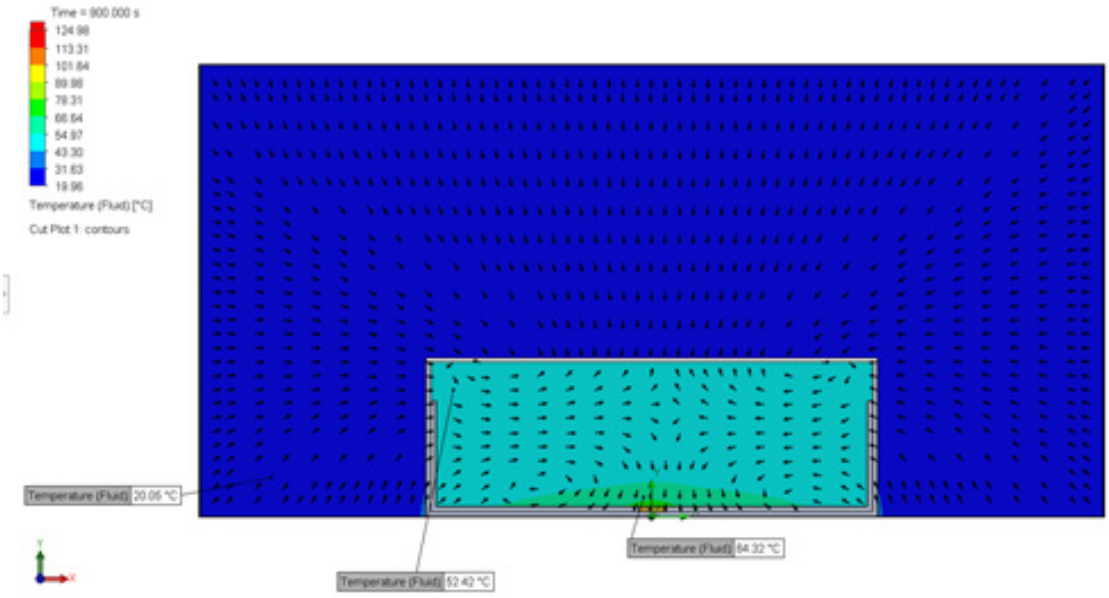
Calculation to determine the power heat source
In optimal, sunny weather conditions direct solar irradiance can reach 1000 W/m2. To be realistic and without knowing the final shape and size of the Fresnel lens, 100 W was used for the heat source in the simulation. The reason behind this lies in the estimation of using a lens size that is around 15% of a square meter. This 15% would still mean 150 W for the lens size, but it was reduced by 33% to make it more realistic as the full amount would mean perfect location and weather condition. (Zhao et al., 2018)

Results of first simulations
A simplified box shape (35x25 cm base, 12 cm height) was made of aluminium and covered with a glass lid. (See illustraion 22)



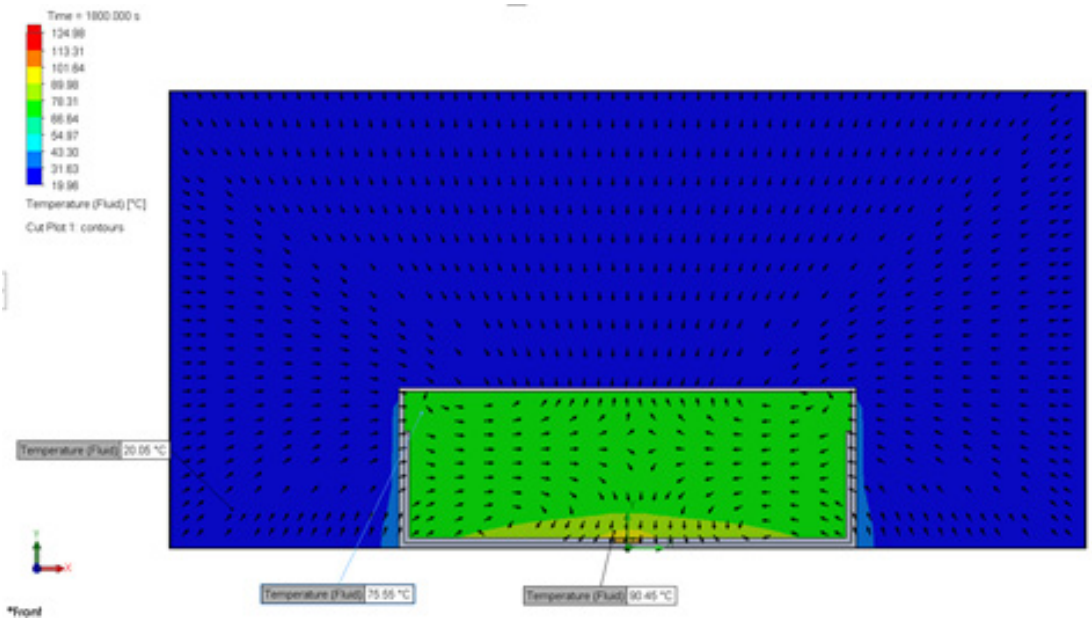
ill. 22 Simulation 1

After 15 minutes the air temperature inside was at least 52 Celsius and around the focal point it almost reached 70 Celsius (See illustraion 23)



ill. 23 Simulation 2

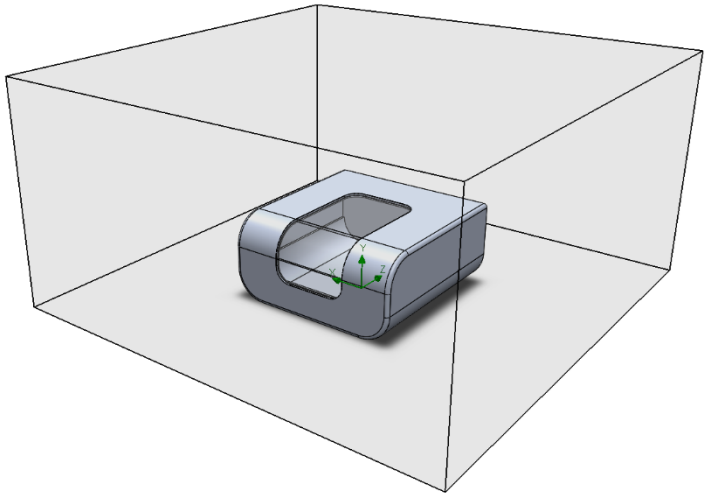
After 30 minutes the air temperature in the box reached at least 75 Celsius everywhere and it was more than 90 Celsius close to the focal point. (See illustraion 24)



ill. 24 Simulation 3

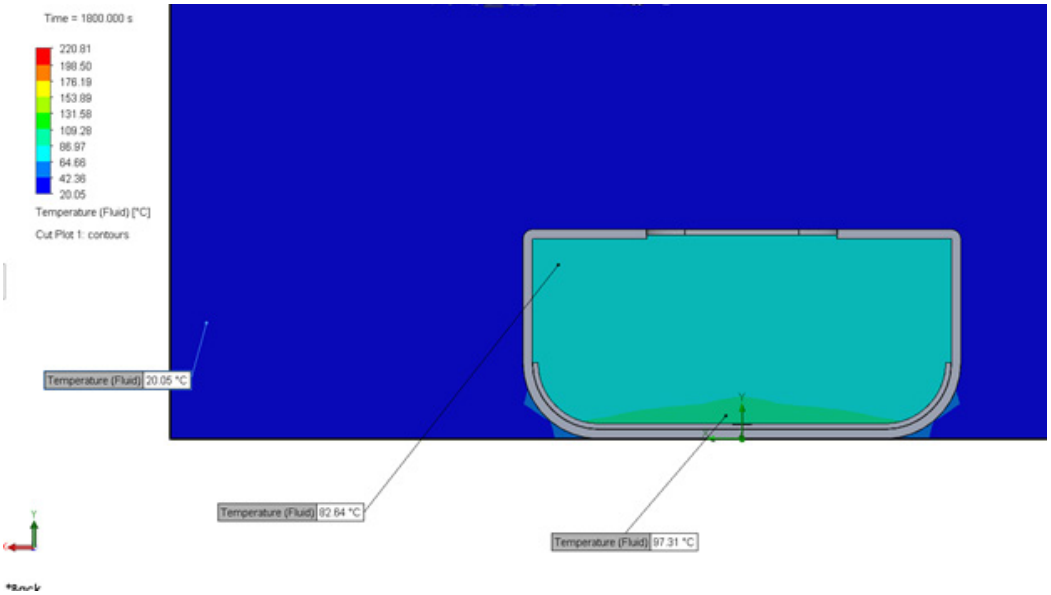
Results of second round of simulations

The main shape of the cooker was specified (23x23 cm base, 11 cm height) to be more realistic to the proposal. (See illustraion 25)



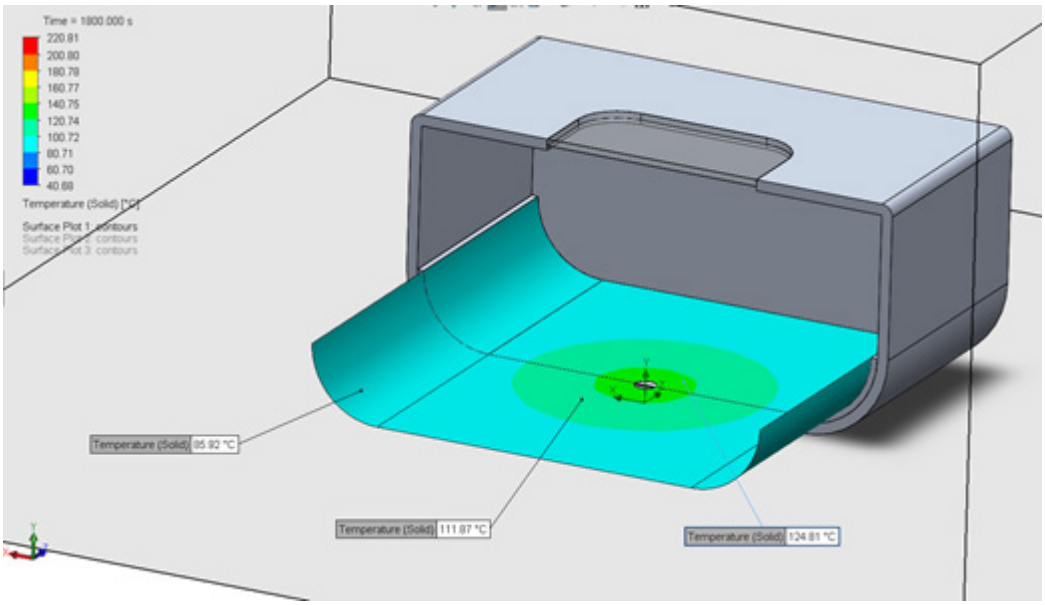
ill. 25 Simulation 4

After 30 minutes the air temperature reached at least 82 Celsius everywhere inside the cooker and it was close to being 100 Celsius around the focal point. (See illustraion 26)



ill. 26 Simulation 5

The cooking surface after 30 minutes got heated up to at least 85 Celsius on the sides and it was over 100 Celsius moving closer to the heat source. (See illustraion 27)



ill. 27 Simulation 6

Conclusion

These simulations made it possible to compare our experiments to something being closer and more realistic to an optimal setup. The experiments and these simulations showed the same behaviour and result in terms of measured temperatures and heat spread making it possible to say they validate each other. It is important to highlight that both the experiments and the simulations were used as tools to understand how closed volumes can be heated up and to determine dimensions based on the available lens size and power it can provide. Both the experiments and the simulations were made without optimal isolation and materials, meaning the further developed concept with the optimized dimensions is assumed to heat up better with the same conditions. The simulations provided more insight into how important it is to determine the minimum required inside volume that is optimal for cooking but not too big to heat up.

9 Aesthetic direction

To get a hint about what direction to go in aesthetically. The potential users got asked about what style they prefer. The answers from them were taken as an inspiration and not as a result of how the final aesthetics is going to be. (See in the following illustrations 28 - 36)

ill. 28 Question 1

ill. 29 Question 2

ill. 30 Question 3

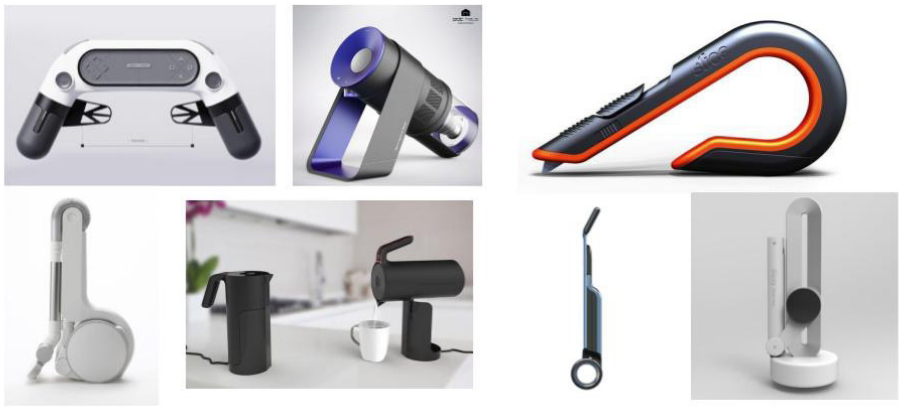
Stylish / modern direction

ill. 31 Question 4

Vintage camping

ill. 32 Question 5

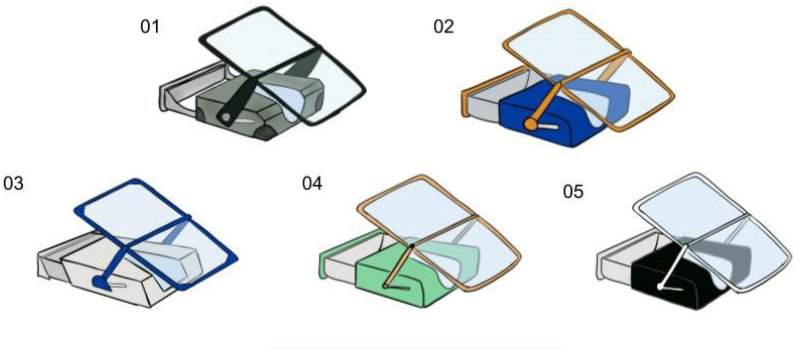
Future direction



ill. 33 Question 6

Overall shape

Here we tried to get inspired in the different styles we presented. Which one do you prefer?



ill. 34 Question 7

Shoulder strap?

The product can be easily transported inside a backpack, but we thought it could be interesting to add a strap so that you don't need a backpack. The product can fit inside the food bought in the groceries (covering the function of a bag).

Do you think it's interesting to add a shoulder strap?

Would you use it to transport the food from the shop to the park?

ill. 35 Question 8

Color palette

Here we tried to get inspired in the different styles we presented. Which one do you prefer?

- Earthy colors

- Military

- Neutral colors (black/ white /grey)

- Splash of color

ill. 36 Question 9

Answers from users (Aesthetic questions)

Christine:
55 years old
Danish
School leader at: Helsingør Lilleskole

If you were to buy our product which style would you like it to have?
camping/hiking
stylish/modern

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
1,3,4

Do you think it's interesting to add a shoulder strap?
Yes to the shoulder strap

Would you use it to transport the food from the shop to the park?
No I would not use it to transport food in it

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
Earthy Colors, Military and neutral

Line:
21 years old
Danish
Barista at We Feat

If you were to buy our product which style would you like it to have?
stylish / modern or camping / hiking - because I feel it is primarily those situations I would use it in. For example, for trip on the beach, it is obvious to use it there

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
I like No. 5 best as it seems most minimalist and simple.

Do you think it's interesting to add a shoulder strap?
Can you perhaps make it so that you can take a shoulder strap on and off yourself? So you can choose. Personally, I would probably collect it all in a backpack, because I would probably have to have a blanket or similar with me too.

Would you use it to transport the food from the shop to the park?
No

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
I like the earthy colors the most

Bashar:
23 Years old
Danish
Industrial Design Student

If you were to buy our product which style would you like it to have?
I think vintage style is super nice, it is clearly my favorite! Number 2 would be modern!

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
Overall shape I would say number 5, it seems quite stylish and minimalist, I like!

Do you think it's interesting to add a shoulder strap?
The shoulder strap is clearly a plus, because personally I cycled with that little regular grill, and ended up falling off my arm and down into the front wheel so I fell and had to sew my elbow and foot haha. So mega win!

Would you use it to transport the food from the shop to the park?
I would definitely use it for groceries (barbecue food) when I have it with me anyway

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
I like the earthy colors or neutral colors, but am mostly for the neutral, but it is hard!

Valdemar:
19 Years old
Danish
High School student

If you were to buy our product which style would you like it to have?
Camping / Hiking

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
01 military

Do you think it’s interesting to add a shoulder strap?
Yes it can make it more flexible in usability, maybe one that could be taken off, according to people’s needs.

Would you use it to transport the food from the shop to the park?
Probably only in a few cases, I would probably always have it in a backpack.

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
Military

Henrik:
58 years old
Danish
Physiotherapist

If you were to buy our product which style would you like it to have?
I would prefer vintage camping

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
01 military

Do you think it's interesting to add a shoulder strap?
Yes

Would you use it to transport the food from the shop to the park?
Not necessary - I would use a cool box

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
Nr 02

Siska:
47 years old
Danish
Life coach

If you were to buy our product which style would you like it to have?
Stylish/modern

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
Nr. 04

Do you think it's interesting to add a shoulder strap?
Yes

Would you use it to transport the food from the shop to the park?
Yes

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
Earthy colors

Frederikke:
25 years old
Danish
Radiograph

If you were to buy our product which style would you like it to have?
Stylish/modern + Vintage camping

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
05

Do you think it's interesting to add a shoulder strap?
Yes

Would you use it to transport the food from the shop to the park?
Yes

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
Natural colours

Christoffer:
26 years old
Danish
Architecture Student

If you were to buy our product which style would you like it to have?
Stylish/modern

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
03

Do you think it's interesting to add a shoulder strap?
Yes, as long as its clean, it would be an excellent future, but after use, there could be dirt left from cooking with would do I won't use the strap (if dirty, I would prefer a bag)

Would you use it to transport the food from the shop to the park?
Nope

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
Natural colours

Anna:
26 years old
Danish
Newly graduated from University of Copenhagen

If you were to buy our product which style would you like it to have?
The military style is very raw and delicious. A man would probably love to have it
Modern and clean Scandinavian look is also a classic, I would also buy this type of design
The vintages are beautiful, very stylish and would not go out of style.

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
They are all nice and have great colors !! I like both the color combination and also just the neutral ones. Probably like 1, 2, 4 and 5 the most

Do you think it's interesting to add a shoulder strap?
I would definitely use the strap.

Would you use it to transport the food from the shop to the park?
I would never use it as a backpack, as it is smartest for campers / ordinary people going to the beach. But know that many girls would not go with backpack

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
Uuuuh great !! I like them all, am mostly a fan of 1-3 - these are great colors. The last one is nice too, but the others are more Scandinavian look

Emilie Hellerup
23 years old
Danish
Architecture Student

If you were to buy our product which style would you like it to have?
Simple elegant neutral tones and stylish modern version, also vintage camping is quite nice

Do you think it's interesting to add a shoulder strap?
No, I think people will usually carry a backpack anyway, and if it can fit there i don't think they would carry it on the side. But you could always make one where its possible to to take it off and you have the opportunity for both

Other comments:
I think your idea is incredible, so good, i would definitely use it if you choose to get it produced!

Javier:
24 years old
Spanish
Student: Masters degree in Product design at Aalborg university

If you were to buy our product which style would you like it to have?
Something between camping and what you call modern, I wouldn't do it completely modern since it's something you are going to have on the floor, so if you make it look very delicate then it feels bad putting it in the grass. I think it should like like if it falls it wouldn't break

Do you think it's interesting to add a shoulder strap?
It could be a nice to have

Other comments:
First of all I wanted to say I think this idea is great and that it has a lot of market, especially here in denmark. People use it so much in the parks, and the disposable ones are a big waste, I used one last weekend actually. I really like the shape you have done so far. The shape I like very much, I'm just concerned the arms will not be strong enough? But other than that you are definitely in the right path. I like it

Nina:
26 year old
Australian
Architecture Student in Aarhus

If you were to buy our product which style would you like it to have?
Camping style and military neutral colors

Here we tried to get inspired in the different styles we presented. Which one do you prefer?
02 and 05

Do you think it's interesting to add a shoulder strap?
Yes to shoulder strap, especially if I could bike with it!

10 Competitive price analysis

This competitive price analysis aim is to gather information about the prices for gas and charcoal grills on the market. This information is needed to make sure the price of the proposed solution is competitive with the ones that already exist on the market. The median price is 1.666 DKK.

Mini BBQ gasgrill

Price: 1.395 DKK
(Mini BBQ gasgrill, 2021)

ill. 37 Product 1

Gasgrill Kuchoma

Price: 2.000 DKK
(Primus Gasgrill Kuchoma, 2021)

ill. 38 Product 2

Weber® Q1200 gasgrill

Price: 1.599 DKK
(Weber Q1200 Gasgrill - flere transportable grille her, 2021)

ill. 39 Product 3

Morsø Forno Gasgrill Piccolo

Price: 2.995 DKK
(Morsø Forno Gasgrill Piccolo, 2021)

ill. 40 Product 4

Everdure HBCUBEG Cube kulgrill

Price: 1.215 DKK
(HBCUBEG Cube kulgrill fra Everdure, 2021)

ill. 41 Product 5

Weber Smokey Joe Premium Bærbar Kulgrill

Price: 794 DKK
(Bestil Smokey Joe Premium Bærbar Kulgrill, 2021)

ill. 42 Product 6

11 Assembly

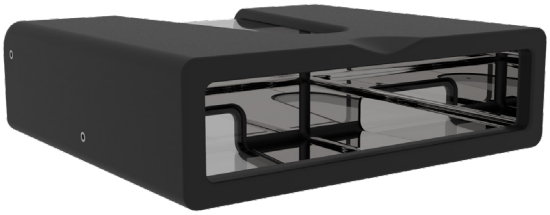
The final step of manufacturing before sending the product off to stores or customers is the assembly. In the following steps it is explain how SUN IT is put together.

First the magnets are glued in place on the bottom surface of the main box. (See illustration 43)

ill. 43 Assebly 1

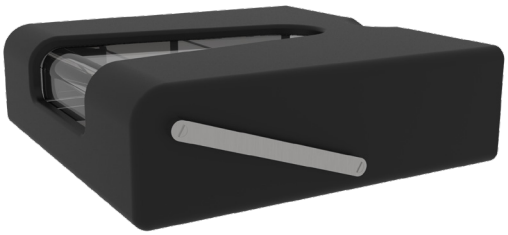
This is followed by gluing the window in place with silicone glue. (See illustration 44)

ill. 44 Assebly 2



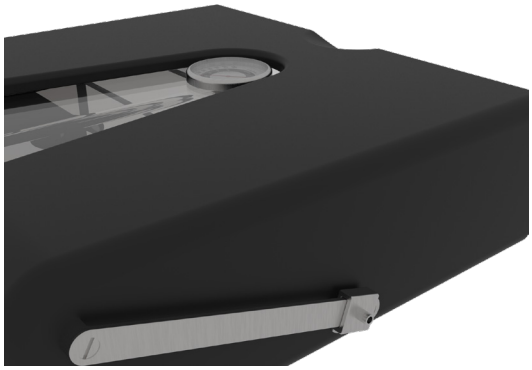
After the window, the reflective inside cover is placed into the main box. (See illustration 45)

ill. 45 Assebly 3



The rails are fixed to the main box on both sides by screws fitting inside the moulded threaded insert in the side of the main box. (See illustration 46)

ill. 46 Assebly 4

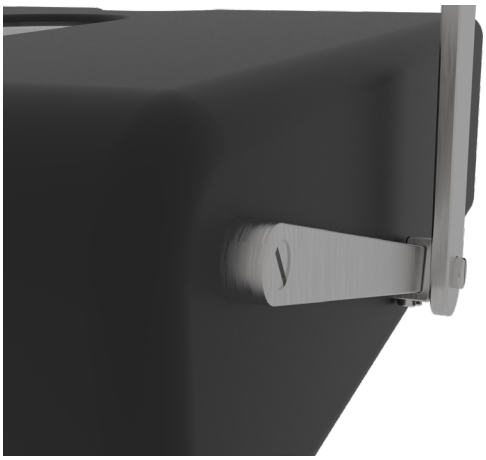


In the next step the sliders are put on the rails on both sides and screws are being installed in them preventing them to fall off, but not limiting them in their movements. In the meanwhile, the thermometer is placed to its place and fixed by a bolt from the inside. (See illustration 47)

ill. 47 Assebly 5

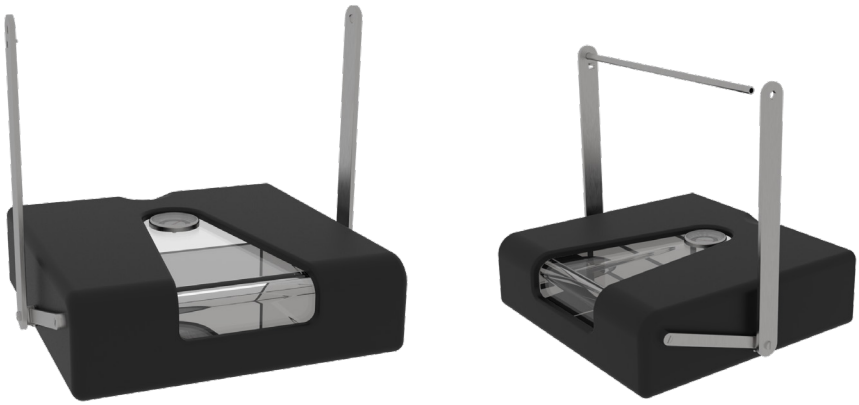
The arms and the friction hinge are being installed, meaning the washers and the arm is placed on the beam sticking out of the slider and fixed by a friction screw. This screw needs to be adjusted to provide the optimal friction for the user and to hold the lens in position. (See illustration 48)

ill. 48 Assebly 6



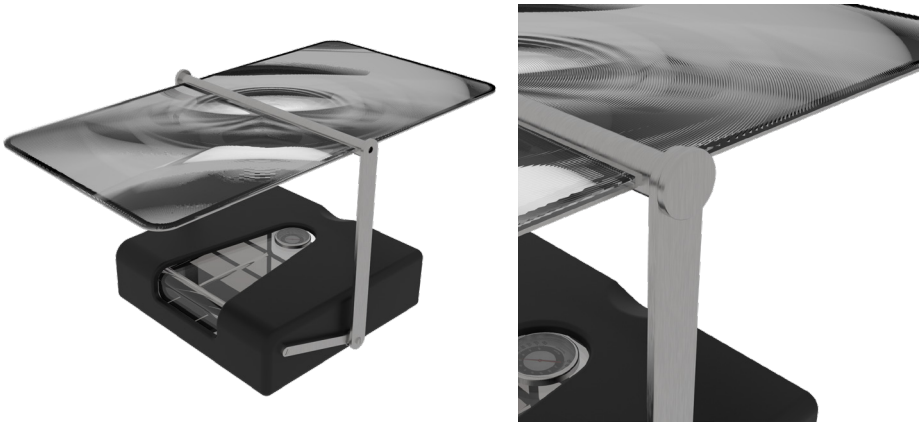
The crossbar is being slided into the arms. (See illustration 49)

ill. 49 Assebly 7



The lens hinges and the lens that is already glued to the hinges are put on the crossbar in position. (See illustration 50)

ill. 50 Assebly 8 & 9



The lens fixer completes the crossbar from the other side, making sure the lens parts can rotate around it if needed, but it is also possible to lock them. (See illustration 51)

ill. 51 Assebly 10 & 11

Last, but not least the rubber is glued on the door for proper isolation and the cooking trey is fixed to the side of the door by two screws. (See illustration 52)

ill. 52 Assebly 12

SUN IT is all set up and ready to use!

ill. 53 Assebly 13 & 14

12 Manufacturing cost

Population in DK age 20-39:	1.480.000

UNITS SOLD		
Year 1	0	Units
Year 2	1.480	Units
Year 3	1.776	Units
Year 4	2.131	Units
Year 5	2.557	Units

TOOLING COSTS		
Main box mould	70.000	DKK
Door mould	20.000	DKK
Punch tool	20.000	DKK

MANUFACTURING COSTS					
Part	Main manufacturing method	Estimated price		Amount	Price for one product
Main box	Rotaional moulding and isolation injection	60	DKK / piece	1	60
Door	Rotaional moulding and isolation injection	16	DKK / piece	1	16
Food tray	Punching and teflon surface treatment	20	DKK / piece	1	20
Window	Cutting and bending	15	DKK / piece	1	15
Reflective cover	Cutting and bending	15	DKK / piece	1	15
Rubber isolation	Extrusion	5	DKK / piece	1	5
Rail	Milling	10	DKK / piece	2	20
Slider	Milling and welding	15	DKK / piece	2	30
Arm	Cutting	10	DKK / piece	2	20
Lens hinge	Milling, cutting, bending and welding	25	DKK / piece	2	50
Crossbar	Cutting, milling and welding	25	DKK / piece	1	25
Cover	Cutting and sewing	20	DKK / piece	1	20
Assembly	-	20	DKK / piece	1	20
Packaging	Cardborad box	5	DKK / piece	1	5
					321

Standard component	Price		Amount	Price for one product	
Threaded inserts	0,8	DKK / UNIT	6	4,8	
Screws	0,6	DKK / UNIT	13	7,8	
Washers	0,3	DKK / UNIT	4	1,2	
Magnets	1	DKK / UNIT	4	4	
Magnets strips	2	DKK / UNIT	4	8	
Strap	5	DKK / UNIT	1	5	
Lens	20	DKK / UNIT	1	20	
				50,8	
TOTAL COST OF PRODUCTION	**371,8**	**DKK / PRODUCT**			

References

Davidsenshop.dk. 2021. Weber Q1200 Gasgrill - flere transportable grille her. [online] Available at: <https://www.davidsenshop.dk/weber-q1200-gasgrill-sort-c-id34335-p-62501643437?gclid=CjwKCAjwqcKFBhAhEiwAfEr7zU_Lnp2nsgM5VkWqbSH41CN1M-eT-9h3jcA2Fln7LDO-7IM9plj7lehoCt70QAvD_BwE> [Accessed 28 May 2021].

Kitchen One. 2021. Bestil Smokey Joe Premium Bærbar Kulgrill. [online] Available at: <https://www.kitchenone.dk/produkt/weber-smokey-joe-premium-baerbar-kulgrill/?utm_source=partnerads&utm_medium=affiliate&utm_campaign=26990&paid=26990&pacid=60b0bad52f7893.71109458> [Accessed 28 May 2021].

Kitchen One. 2021. HBCUBEG Cube kulgrill fra Everdure. [online] Available at: <https://www.kitchenone.dk/produkt/everdure-cube-kulgrill-grafit/?shopping_id_click=1067-1092-12054&gclid=CjwKCAjwqcKFBhAhEiwAfEr7zTut2-zVbhXF9bll6nbKG5tLX6b0t3VsLEIMTdgPDMhU5vkSWSFiORoCbaoQAvD_BwE> [Accessed 28 May 2021].

LIVING FLAMES. 2021. Mini BBQ gasgrill. [online] Available at: <https://livingflames.dk/products/mini-bbq-gasgrill?variant=28970554622045&gclid=CjwKCAjwqcKFBhAhEiwAfEr7zZlOlv80Op4EV628kYMj0PH1MNSJXv-AIuKKjpc4uOLE-lqHpRbU3xoCNxcQAvD_BwE> [Accessed 28 May 2021].

Neye.dk. 2021. Primus Gasgrill Kuchoma. [online] Available at: <https://www.neye.dk/primus-gasgrill-kuchoma-id-15005000000/?dfw_tracker=34954-15005000000&gclid=CjwKCAjwqcKFBhAhEiwAfEr7zY8MxqjiQMm61jkyUJIYYbeR7e_zltTOykmq8hoR0IDUTQNWyLdSHBoCARAQAvD_BwE> [Accessed 28 May 2021].

Pejsen.com. 2021. Morsø Forno Gasgrill Piccolo. [online] Available at: <https://pejsen.com/produkt/outdoor/morsoe-outdoor/morsoe-forno-gas-piccolo/?pa-partnerid=26990&paid=26990&pacid=60b0b77245c739.57146924> [Accessed 28 May 2021].

Youtube.com. 2021. Solar Power BBQ in Mid-Air with Fresnel Lens. [online] Available at: <https://www.youtube.com/watch?v=ksVLop-0VAdM> [Accessed 28 April 2021].

Zhao, Y., Zheng, H., Sun, B., Li, C. and Wu, Y., 2018. Solar Energy. [online] ScienceDirect. Available at: <https://www.sciencedirect.com/science/article/pii/S0038092X18308788> [Accessed 22 May 2021].

Illustrations

Illustrations listed below are only from external sources, non listed are the project teams own illustrations

ill. 11 Technology products inspiration

https://www.pinterest.dk/pin/508203139171144537/

https://www.solarcooker-at-cantinawest.com/solarcooking-howitworks.html

http://prepforshtf.com/fresnel-lens-solar-cooker/

https://backpackdroid.com/best-solar-backpacks-reviews/

ill. 12 Technology products inspiration 2

https://www.sinnerup.dk/eva-trio-gryde-36-l-rustfrit-staal-ny.aspx

https://www.researchgate.net/figure/Fig-1-An-evacuated-tube-shown-from-its-open-end_fig1_315297073

https://www.ebay.co.uk/itm/273291564564

https://scandinaviantraveler.com/en/people/the-salt-man-of-malta-a-family-business

ill. 13 Technology products combination

https://www.rei.com/product/141910/gosun-go-portable-solar-cooker

https://www.tuvie.com/solari-portable-solar-cooker-uses-suns-energy-to-slow-cook-your-meal/

https://www.indiamart.com/proddetail/box-type-solar-cooker-16140512288.html

https://www.solarcooker-at-cantinawest.com/solarcooking-howitworks.html

ill. 37 Product 1: https://livingflames.dk/products/mini-bbq-gasgrill?variant=28970554622045&gclid=CjwKCAjwqcKFBhAhEiwAfEr-7zZlOlv80Op4EV628kYMj0PH1MNSJXv-AIuKKjpc4uOLE-lqHpRbU3xoCNxcQAvD_BwE

ill. 38 Product 2: https://www.neye.dk/primus-gasgrill-kuchoma-id-15005000000/?dfw_tracker=34954-15005000000&gclid=CjwK-CAjwqcKFBhAhEiwAfEr7zY8MxqjiQMm61jkyUJlYYbeR7e_zltTOykmq8hoR0lDUTQNWyLdSHBoCARAQAvD_BwE

ill. 39 Product 3: https://www.davidsenshop.dk/weber-q1200-gasgrill-sort-c-id34335-p-62501643437?g-clid=CjwKCAjwqcKFBhAhEiwAfEr7zU_Lnp2nsgM5VkWqbSH41CN1M-eT9h3jcA2Fln7LDO-7lM9plj7lehoC-t70QAvD_BwE

ill. 40 Product 4: https://pejsen.com/produkt/outdoor/morsoe-outdoor/morsoe-forno-gas-piccolo/?pa-partne-rid=26990&paid=26990&pacid=60b0b77245c739.57146924

ill. 41 Product 5: https://www.kitchenone.dk/produkt/everdure-cube-kulgrill-grafit/?shopping_id_click=1067-1092-12054&g-clid=CjwKCAjwqcKFBhAhEiwAfEr7zTut2-zVbhXF9bll6nbKG5tLX6b0t3VsLElMTdgPDMhU5vkSWSFiORoC-baoQAvD_BwE

ill. 42 Product 6: https://www.kitchenone.dk/produkt/weber-smokey-joe-premium-baerbar-kulgrill/?utm_source=partnerads&utm_medium=affiliate&utm_campaign=26990&paid=26990&pacid=60b0bad52f7893.71109458

SUN IT