Solar Cookers for Africa
Appendices

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Appendix A: Test results of the Sun-stove

Done by the ECSCR (European Committee for Solar Cooking Research) in 1999. The shape of the Sunstove changed a bit since this test is done.

Dimensions (cooking pos.):	66 x 63 x 38 [cm]
Number of pots and nom. volume:	one, two or three removable pots
Test pot content:	1.5 l
Aperture surface:	0.28 m2
Heating time (water):	
- Cold start (40 - 80° C)	*90 minutes
- Cold start (40 - 96° C)	*takes 120 minutes to reach 87? C
- Hot start (40 - 80° C)	*78 minutes/**62 minutes/
- Hot start (40 - 96° C)	takes 120 minutes to reach 93? C/**90 minutes/***76 minutes
Max. temperature (oil):	*114? C after 130 minutes
Continuous cooking	*boils 3 l of water in a day
Heat loss with lid open	*cools from 90? C to 80? C in 5 min
Comments	*low thermal performance for a box cooker; average pot content for the aperture; rarely requires tracking
Handling	Easy, two-step access to pot; very simple to track and use, easy, two-step access to pot; very simple to track and use, easy to transport; light wind can open transparent cover, which could be more securely mounted.
Application	cooker for small families; adapted for low-temperature cooking
Evaluation for technology transfer/local production	Is already produced in South Africa
Contact address	SunStove, 1 Parklands Saldahana Street, 1501 Benoni, RSA Tel/Fax: +(27)119692818 R. Wareham, 3140 North Lily Rd, Brookfield, Wi 53005, USA Tel +(1)4147811689; Fax +(1)414810455
Legend	*ECSCR; tested in SA; **original model, ***original model with absorber

Appendix B: Interviews

Interview Marlett Balmer

September 16th 2009, 14.30, Johannesburg.

Marlett Balmer is working on the University of Pretoria and for ProBEC (The Programme for Basic Energy and Conservation). ProBEC is a programme that manages and stimulates the establishment of various projects based on basic energy conservation in 10 member states in SADC (Southern Africa Developing Countries) (Probec, 2009) Their interventions include efficient use of energy devices, giving policy advice and developing new knowledge on biofuel. Marlett Balmer wrote a review on solar cooking impact in South Africa. It should be noted that she is mentioned as Marlett Wentzel in this report.

The interview started with a short introduction of Industrial Design and the explanation of my Bachelor final assignment.

What is your opinion about the Sunstove?

It's the only commercial available box cooker in South Africa. All the other box cookers we used in projects and evaluations were prototypes. So this one was actually a box cooker that was available and people can buy it if they want, whenever they want. However, it is a very slow box cooker and it's not really strong: I saw it can bend when you put heavy pots in it or you are too rough with it. The quality is not exceptional: sometimes you can see some of the isolation coming out, the black paint on the bottom is scratched and disappears after a while. But still, it is something you can pay, since it's often between R200 and R250. People like the fact that the Sunstove is robust. You can store it easily and if it accidently drops, it's not immediately broken and it's light so you can easily transport it.

What is important to people when they buy a box cooker?

Price and performance. They want to know what they have to pay and if it is possible to may in instalments and how long it will take them to make a meal.

What do you think is a good or maximum price to let a box cooker be a success?

During or evaluations we noticed that 200 Rand is some kind of psychological boundary. It's a price that even the poor people can afford. Everything above 200 Rand has an influence on the family, it should be discussed, people have to save for it, it is becoming something big above 200 Rand.

But when you are asking more, you should think of other cooking add-ons. Like a microwave, it is not something you can use on its own day after day, but people do pay 1000 Rand for it. But they get something that looks serious so they trust it.

At the same time, your target market is really important. One of the main target markets are the poor people and for them 200 Rand is this psychological boundary. Besides that you've got the outdoor enthusiasts as well and they are sometimes willing to pay more.

What is a minimum performance for a Box Cooker in South Africa? How would you measure performance?

Most poor people are not really interested in the maximum temperature of a box cooker. They want to know how long it is going to take to boil a litre of water or to make rice for 4 or 5 stoves. So during our projects we told people that it would take 2,5 hour to make a meat stove and that was what they wanted to hear. And this whole "good performance" is more an academic argument, because as soon as somebody decides to buy a solar cooker and have access to it, they already know it's going to take longer than when they would use electricity or a wood fire. So at that moment, the price is interesting for them and they already made the decision that they want a box cooker. The time doesn't really matter anymore. So even if you have the most efficient box cooker with the highest temperatures, it's still going to take longer than usual, you still need the sun and you still cannot cook when it's raining and the users know that. But to give more an answer to your questions: we used cookers where it took 1,5 to 2 hours to make a stove and people were fine with that.

But it depends again on your target market. Green campers are maybe more academic and they want to know what the maximum temperature is and how long it will take to reach that.

Which dimensions would you recommend? I read a bigger cooker will take longer since there is more air that must be heated.

I don't know that much about dimensions. I know the more sun comes through the lid, the better it is, and the better your isolation, the higher the temperature. I don't think it is necessary to heat the whole chamber. It is important that you heat the pot and to do so, you want to heat the base as well where the pot is put on. That's why you paint the bottom black, so you can transfer the heat from the bottom to the pot.

Do you have box cookers you would recommend?

We used sometimes the T16, also called the Ishisa. It's made in France at a company called Synopsis and it was very good. But really difficult to make, since it has 46 different parts and really expensive. But people loved it, because it had such a good performance. It used a material called fluteboard, some kind of plastic with little air pockets in it, which made a very good isolator. The problem was that it is quite a brittle material and not durable. When we came back to places where people used this T16 for a while they were often broken because the materials used were not very durable.

I heard something about the ULOG, it's made out of canvas and this one is especially interesting for green campers. So it depends on your target market what kind of product you want to sell.

So when you are looking for some other box cooker and you would like to make some adaptations: improve the isolation. Glass is a very good isolator but it takes a lot of problems with it, like shipping, storing and especially getting it in shops.

Manufacturing: Which manufacturing methods would you recommend? And which materials?

On paper, we can make a lot of box cookers and sell them all because on paper there is a big potential market. Unfortunately we still have not yet convinced a strong manufacture. The T16 for example consists of 46 different parts and manufacturers are not able to make all these different parts, so it would be better to select different manufacturers and assemble it at the end all at once. But still... 46 is way too much and it's not feasible.

I don't know that much about materials. It is important how well it isolates. Glass is excellent, but difficult to transport and brakes sometimes because something falls down on it. I don't have really something I could recommend, just look at the costs, the durability, if it's easy to store etc.

And where can it be sold? Shops? Or internet? Your article says it should be sold in a package with an fuel efficient stove and a heat retention device, that it must be sold in shops and outlets were other household appliances are sold as well, but it must be sold with a demonstration as well. How does this work?

And again for these target markets: the lower income group doesn't have internet access, so door-to-door selling would be best or something like a Tupperware party where you can get a demonstration and people can ask questions. At the same time, outdoor enthusiasts will look in a camping shop. It could be possible to sell box cookers in shops for the lower income groups but then you do need a shop like a furniture shop for furniture: a shop that is specifically for household equipment and that is reliable. But you have to sell more than 1500 cookers a month if you want to get it in a great shop. So South Africa is extremely difficult because we've got so many different target groups with completely different wishes and possibilities.

I'm going to pay more attention to the design, since this will really help to get it accepted. Do you have got recommendations?

Yes, we used one cooker, I thought it was called ULOG and although its performance was alright, people said it looked too much like a coffin. Because people are buried in wooden boxes and that was exactly what the ULOG was. Although I've seen another model, maybe from ULOG as well, which was made out of canvas and available in yellow, red and blue and that was so lovely! That was really nice.

It is desirable to follow the trends. A couple of years ago, everything was white. A white refrigerator and a white microwave etc. Nowadays everything is aluminium, so follow the trends and let it suit. In the sixties and seventies everything was orange and brown so it depends on time.

And again: the target market. A green camper might want to have black one that doesn't show dirt or something.

Interview Crosby Menzies

September 2009, Johannesburg

What is your target market?

Difficult question, there are actually two target markets. Families with low incomes and green outdoor enthusiast. This second group is able to pay more for a box cooker and this money can be used to make box cookers cheaper for poor families. It's two worlds in one.

Where do you want to sell your cooker? Just South Africa or Southern Africa?

SADC (Southern Africa Developing Countries). After a while, these people will start imitating the designs and make cookers on their own. Angola, Botswana, DRC, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe.

How many box cookers have you sold in the past? And do you think this will increase or decrease?

We started about 2 or 3 years ago with selling cookers, earlier, we did especially projects to introduce Solar Cooking. In these years we sold about 1500 cookers, it might increase in the future because more and more people are getting aware of the possibilities of solar cooking.

What are the costs of a Sunstove for the customer and for you/Margaret?

The customer pays 500 R for a Sunstove, to produce it: 285 R. We need this margin because it is often insecure if people are actually going to take the box cooker after they ordered it.

The outer case of the Sunstove is made by injection moulding. This mould was sponsored by the Americans, otherwise it would have been way to expensive. Margaret has this mould and when I get an order, she can make them on demand, although she always have about 200 cookers in stock.

A lot of money for these projects come from relations with all kind of organisations you met somewhere. You need this network and partially everything fell just in the right place together to get this working. You need your social relationships.

What do you think a new cooker should cost?

Well if it could be 500 R as well, that would be fantastic, but I don't think this is realistic. If it could be between 1000 and 1500 R it is OK. If the production costs are about 1000 R, than we will manage something.

Do you have some more information about feedback on the Sunstove? Mails? Reports?

Not really. People who were not satisfied, said it was too slow, but other users were happy with the time they needed, so it also depends on their expectations.

What do you think the performance should be?

It just has to be able to make a good meal. It would be perfect if the cooker could reach 80° in 15 minutes. Good quality box cookers can take 40 minutes to get 1 litre boiling. This is however not the main use of boxes. A good box reaches around 140° C.

Your opinion about dimensions and weight?

It has to be able to accept 2 reasonable sized pots, like 2 5-6 L pots. About the weight: a woman should be able to lift it. To do this in a nice way 10-14 kg is a maximum.

Which sales channels do you want to use? You said shop, but that's only possible if your target market contains enthusiast outdoors as well.

Most poor families don't have internet access in the first place. They see their neighbours using the cookers and they want such a cooker as well. So they ask were they got it and at that point I got a call. For the outdoor enthusiasts the big camping stores are find, like the Cape Union Market. Hardware stores want them as well. Other shops: Macro, Dians, Cash and Carry, Mica especially.

Design?

More round shapes would be nice, but it's not necessary. It's more important we get a nice cooker for the right price.

Should the cooker be waterproof?

When it's raining, you cannot cook, so it doesn't have to be waterproof while using. Most people

want to keep their cookers safe indoors anyway, so it's not really necessary and as soon as you've got a good insulation, you will probably have a fair amount of water proofing for the inner chamber anyway.

Manufacturing process and materials?

We've got almost every material you have in Holland. Everything should be here, except for the reflector materials, maybe it is difficult until we narrow down what material we will use. I know a cooker that is made by alanod and its reflecting material is called the miro. For manufacturing processes as well: we've got almost everything here, just check the yellow pages and you will find out. We use laser cutting at the moment for the dish cookers but I also like the idea that people with basic carpentry tools can put it together. In other SADC countries not every manufacturing method is available.

We've got a packaging company in South Africa specialised in packaging: nampack. They can supply a lot of different plastic materials for a good price. So they are an interesting contact.

Interview Margaret Bennett

September 23th, by phone, Johannesburg

Margaret is the manufacturer of the Sunstove.

We got the mould sponsored by another company, otherwise we would never be able buy the mould. We found a company that has a machine that is big and strong enough to actually make the outer case using blow moulding. However, this company can only make these when at least 1000 cases are ordered. So we bought 1000 cases. When we make a Sunstove, we buy an aluminium printing plate, we buy insulation and we buy a lid. The assembling of a Sunstove is done by hand, including the painting.

The lid is made from plastic (really expensive) what we order as a complete roll. This roll has to be imported from the USA, the width of this roll is exactly twice the width of a lid. So we start with cutting this roll exactly in half and we don't waste anything. From one roll we can get 274 lids.

The inside of a Sunstove has exactly the size of one printing plate. The size of such an printing plate is twice the size of a big newspaper. It is possible to get other sizes printing plates but these plates are not very common and as soon as we started to sell more Sunstoves, we had to change the design, because we couldn't get the right printing plates anymore.

Appendix C: List of available box cookers

This appendix contains a list of currently available box cookers and explains why some designs are considered in this project and some not. First of all, it should be clear that only 'traditional' box cookers are considered, which is an insulated closed box with at least one reflecting part.

A lot of cookers have been designed and tested just by somebody with a great idea. Most of these cookers never came to a level higher than a prototype in the backyard. The following cookers are noticed and used as an inspiration source, but not serious considered as a replacement for the Sunstove:

30-60 cooker, Happy Sunshine Cooker (or Easy Lid Cooker, a cardboard DIY model, made by some enthusiasts), Kyoto box (or minimum solar oven), SolCooker, Solar Barbeque, Sunstar, Sol-Cafe (a prototype made for schools in India), Sport Solar Oven (a DIY model, especially for campers in the USA), Solar picnic, goat size solar stove, collapsible solar box cooker, Jose sol, Solar Nest, Solar Bug, Boom chef solar grill, solar tent, solar range portable, heavens flame London, eurosolarbox and the Solar Flare.

Cookers that did came above the level of prototyping, but had other problems were: ORES cooker (no working contact details), the All season solar Cooker, Sunspot (only meant for one person), Walloven (to use this cooker you have to rebuilt your house to integrate the cooker in your wall) and the Neverhorno(a combination of a box cooker, an cooking device using electricity, wood or charcoal and a refrigerator. As a consequence, this cooker is really expensive (€850,-) and not what this project is looking for)

Most useful inspirations were:

A research on solar ovens for intertropical zones in Mexico showed a prototype with a door on one side of the box cooker so the reflector and the lid can hold their positions when introducing the meal.

The All season solar cooker does not meet the definition of a box cooker since it is not a closed box. This cooker uses a very reflective tape and material called 'fluteboard', which is corrugated plastic, these materials could be very useful.

Shapes like the shape of SolCooker, this cooker used a cylinder as box, with stands to prevent it from tilting back- or forwards as can be seen in figure 1.

figure 1: Sol Cooker

The Solar electric Hybride oven is in the first place a solar oven but offers the opportunity to use electricity when the sun goes down or on cloudy days. This means a complete extra electrical circuit and this will increase the price dramatically. Besides that, electricity is often not available at rural areas, so this cooker will not be considered.

Cookers

Dierckx: The Dierckx Cooker is developed in the Netherlands and his shape is very traditional for a box cooker. Their design is used in Vietnam and Burkina Faso. Due to this successes, the Dierckx cooker will be considered in this project.

Indian Cookers: Although box cookers are still not widely accepted all over the world: they are accepted in India. There is no main manufacturer, but a lot of small industries, that design their own box cooker by a set of specifications developed by the Ministry of Non-conventional Energy Sources, which can be ordered at the Bureau of Indian Standards. Unfortunately, attempts to get in contact with this Bureau or one of the manufacturers did not succeed.

Jura Sol Oven, Australia: This cooker is a copy of the ULOG, see ULOG.

Lazola: The Lazola oven is developed in Germany. Despite several attempts, it was not possible to get a good contact with the company. Contact with the South African factory making Lazola Cookers did not succeed before November, more about this

conversation can be found in appendix D. Due to these problems, the Lazola is not considered in this project.

Pil kaar: The Pil Kaar is used in Chad and produced in Germany. The Pil Kaar will be considered as a replacement for Sunfire Solutions.

Sun Cook: The SunCook can be a two-reflector or one-reflector box cooker. SunCook made two models: one for tropical zones and one for temperate zones, where the tropical zone version is way cheaper. The tropical zone version is available here and because of its good reviews, this cooker will be considered.

Sun Oven: the SunOven is one of the most respected box cookers from the USA. This cooker is used in a lot of different countries and quite successful, what might be the reason that this cooker is the only cooker that is patented. This model will be considered.

Sun Scoop: The Sun Scoop is developed for people with lower income in urban areas. It is focused on creating jobs and produce everything locally to ensure maintenance. The SunScoop will be considered, especially because of the use of flute board, which is like corrugated cardboard, but made of plastic.

Sunstove: this is the model that must be replaced because of its lower performance. It will be used as a reference in the comparison between potential new box cookers.

T16/REM5/Ishisa: This model, made by Synopsis in France has good reviews. It has been manufactured in South Africa but they stopped because the costs of production were too high. Synopsis would love to see the T16 back to work but the manufacturing process will need serious adaptations. This cooker will be considered.

ULOG: The ULOG, sometimes called 'Soul', is originally from Swiss and can be ordered as an already build box cooker, as an building kit or just the plans without the materials. The ULOG is available as the ULOG light, the ULOG regular and the ULOG family. It's a model that is sold for years now and used in a lot of projects and will be considered.

Appendix D: Contact with the cooker manufacturers

Dierckx: Contact with the manufacturer of the Dierckx cooker, Arie de Ruiter, started in April 2009 and on April 24th 2009, a visit to the company in Sliedrecht took place. Arie de Ruiter showed the workshop and how he made the cookers. Only goal of this man is to help people to cook and to do that, he offers cookers and money he earned at the second-hand shop he runs as well. He is working on his own and every now and then he gets help. Despite the language problems he succeed in teaching somebody from Burkina Faso and from Vietnam how to make a cooker. He gave them building plans and a mould for the inner box and they went back to their own countries and started manufacturing and with great success: they are still building these cookers in Vietnam and Burkina Faso.

ULOG: First contact with Michael Götz was in April 2009. He has his own company in Switserland, where he built his own cookers and sells them for many years now. He also wrote the book "Kochen mit der Sonne" with Rolf Behringer to explain and introduce solar cooking in Europe. He encourages new projects and will give all the information he can give. At the start he was a little bit sceptic due to the amount of projects he saw fail because of poor research by students but this never stopped him from giving advice.

Pil Kaar: In September 2009 there was some email contact. Bernie Mueller answers and explains everything but will not give his building plans unless he is sure that it the manufacturing process will be similar to how it is done now in Chad.

SunScoop: Steve Harrigan is the brain behind the SunScoop in the U.S.A. Contact took place by email and was quite similar to the contact with Bernie Mueller: willing to help, but it is still his product so he should have benefit if it is used in South Africa as well.

SunCook: Sunfire Solutions already had contact with SunCo, the company in Portugal that manufacturers this cooker. Some of these cookers have already been imported in South Africa and sold here. Looking at the relationship and earlier contact, it is not wise to contact this company for building plans and local manufacturing options.

SunOven: This cooker is from the U.S.A. and their website is very clear on what is possible or what not. If you want to use this cooker, you have to sell at least 250 of these cookers before you get the building plans and help with starting up local manufacturing. Not willing to discuss anything else.

T16: Michael Grupp is the owner of the idea of the T16, made by the company Synopsis in France. Due to high manufacturing costs, the T16 is not manufactured anymore. In October he told everything about the T16 and his history and opportunities on the phone and sent some additional information by air mail afterwards. He would love to help and restart the T16, but no building plans exist at all, so this would mean quite a project.

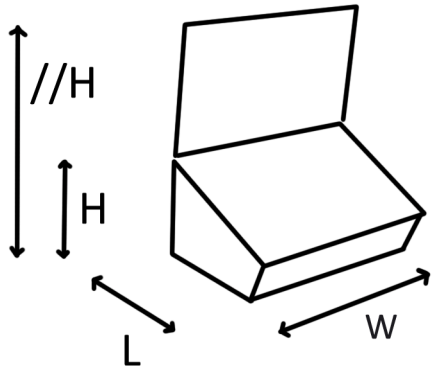
Lazola: Sunfire Solutions tried to contact the company in Germany a couple of years ago. After a lot of attempts, contact finally succeed, but still, getting one of these cookers turned out to be impossible. In May of this year, I tried to contact them as well, but again, no response. The Lazola Cooker is built in Vereeniging, South Africa as well at a company called ELNATAN. In the beginning of November, Klaus Triebe from ELNATAN, came to Johannesburg and told everything we wanted to know for so long but could not get. He sells two cookers, a high and a low end, distribution prices are R2250 and R1400 and sales prices: R2640 and R1650. He hardly gets any profit of it and making this model cheaper than this will be almost impossible. He is careful and everything should go slow.

Dimensions

	Sunstove	ULOG	SunCook	SunOven	Dierckx	Pil Kaar	SunScoop	T16
Width – outside	75	50	54	57//85	68	44,5	Unknown	50-72
Inside	41-58	34	35-46	33	32-55	36,5	56	32-50
Length – outside	50	50	59	46//77	57	44,5	Unknown	47
Inside	27-44	27-37	41-46	25-37	42-56	36,5	46	32
Height – outside	15-35	20-42//93	29//78	21-41//82	16-40//93	29//73	Unknown	23-30//79
inside	18-29	14-30	17	21-29	15-27	25	Unknown	16-23
Weight (kg)	5	5-9[1]	16	9,5	16	10	Unknown	16

[1] 5 kg if made out of fabric and wood, 9 kg if made out of only wood.

figure 2: dimensions, all dimensions are in cm.



Manufacturing - outer box

	Sunstove	ULOG	ULOG light	SunCook	SunOven	Dierckx	Pil Kaar	SunScoop	T16
Material	Plastic	Wood	Fabric, with wooden skeleton	Plastic (PP)	Plastic (ABS) and wood	Wood	Wood	Flute board (corrugated plastic)	Epoxy
Process	Blow injection moulding	By hand	By hand	Injection moulding	Injection moulding	By hand	By hand	By hand	By hand
price	R85	±€25,- /R276	'cordura'-like fabric and wood ±€25,- /R276	Price of mould/total + material per unit	Price of mould/total + material per unit	±€25,- /R276	±€25,- /R276	Unknown	Unknown

The exchange rate on September 14th 2009: $1,- = R7,58; €1,- = R11,06

Manufacturing - inner box

	Sunstove	ULOG	ULOG light	SunCook	SunOven	Dierckx	Pil Kaar	SunScoop	T16
Material	Aluminium printing plate	Aluminium printing plate	Aluminium printing plate	Parabolic mirror	Black plastic	Aluminium printing plate	Aluminium	Aluminium sheet	Epoxy with aluminium sheets
Process	By hand	By hand, cutting and fold	By hand, cutting and fold	Cut and glue, machines	Injection moulding	By hand, using a mould	By hand	By hand	By hand
price	Transport costs	Transport costs	Transport costs	Unknown, probably more than normal glass	Price of mould/total + material per unit	Transport costs	€50/R553	Unknown	unknown

Manufacturing - insulation

	Sunstove	ULOG	ULOG light	SunCook	SunOven	Dierckx	Pil Kaar	SunScoop	T16
Material	Fibre glass	Wool	Wool	Unknown	Rockwool	Wool, straw, hey, etc.	Hemp	- (insulating by reflecting inner box)	Unknown
Process	By hand	By hand	By hand	Unknown	Unknown	By hand	By hand	-	By hand
price		±€6,-/R66[2]	±€6,-/R66	Unknown	±€12/R132	±€6,-/R66	Unknown	-	Unknown

Based on €17/2 kg, price in the Netherlands

Manufacturing - lid

	Sunstove	ULOG	ULOG light	SunCook	SunOven	Dierckx	Pil Kaar	SunScoop	T16
Material	Polycarbonate	Double glass	Glass and PET	Double glass	Single glass	Double glass	Single glass	Double glass	Single glass
Process	Cutting by hand	By hand in window frame	By hand in window frame	Unknown	Unknown	Ordered in right size, by hand	-		By hand
price	R105	±€7,-/R77	±€6,-/R66	Unknown	Unknown	±€20,-/R221	€20/R221	Unknown	±R50

Manufacturing - reflector

	Sunstove	ULOG	ULOG light	SunCook	SunOven	Dierckx	Pil Kaar	SunScoop	T16
Material	-	Wood and reflecting foil	Plastic offset sheet (al-mirror 'Solarlack')	Plastic and thin mirror sheet	Aluminium sheet	Wooden plate and aluminium foil	Acrylic mirror	Polyester with silver reflecting surface	Aluminium sheet
Process	-	By hand	Cutting by hand	Injection moulding and cutting	Shears, machine or hand	Glue by hand	Cutting by hand	Cutting by hand	By hand
price	-	±€10,-/R110	unknown	unknown	unknown	±€5,-/R55	Unknown	Unknown	Unknown

Manufacturing - assembling and total costs

	Sunstove	ULOG	ULOG light	SunCook	SunOven	Dierckx	Pil Kaar	SunScoop	T16
Assembling	By hand, 0,25 h – 0,5 h	By hand	By hand	Unknown	By hand	By Hand	By Hand	By Hand	By hand
Labour hours[1]	Less than 1 hour	Couple of hours	Couple of hours	Less than 1 hour	About 1 hour	Couple of hours	Couple of hours	1-2 hours	Unknown
Total price manufacturing[2]	R285	€100,-/R1106	€75,-/R830	Unknown	Assembling is 50% of the price	€40-€100/ R442-R1106	unknown	$75/R570	Unknown
Sales price	R500	€200,-/R2212 to €300,-/R3318 [5]	€190/R2101	€249,-/R2754	$289,-/R2190	€75,-/R830	€241,-/R2665	unknown	Unknown
Building plan available	Yes	Yes	Yes	Only if company is involved	Only if company is involved	Yes	In consultation with company	No	No
Patent	No	No	No	Yes	Yes	No	No	No	No

[3] This includes the time to get material in machines and get products out but does not include the time a machines needs to do a certain working
[4] Including screws, hinges, paint, nails etc.
[5] Depending on area, mostly assembled

Performance

	Sunstove	ULOG	SunCook	SunOven	Dierckx	Pil Kaar	SunScoop	T16
max. Temperature in °C	88	130-160	150-200	160	140 (In the Netherlands)	150	150	150
Angle of reflector	-	Adjustable	Adjustable	Locked at 110-120° with glass	5 different positions	Adjustable	3 different positions	Locked at 110° with glass
Airtight made by....	Lid: - inner box: aluminium pressed tight and stapled	Lid: Felt; inner box: not really airtight	Lid: precisely fitting, heavy; inner box: precisely fitting	Lid: rubber; inner box: precisely fitting, screws	Lid: rubber; inner box: aluminium pressed tight	Lid: precisely fitting; inner box: precisely fitting	Lid: rubber; inner box: silicone	Lid: rubber; inner box: existing out of one piece polyester

Usability

	Sunstove	ULOG	SunCook	SunOven	Dierckx	Pil Kaar	SunScoop	T16
Weatherproof	+	-/~[6]	++	~	~	~	+[5]	++
Transport	~	+	-	~	-	+	++	-
Protection again theft	--	-	Yes, but only against theft of food by animals ~	-	--	-	-	-
Cleaning	+	~	+	~	~	~	~	~
Get pots in and out	--	--	+	+	+	-	+	-
Checking the food	-	~	~	+	~	-	+	~
Set up for use	+	~	+	+	+	~	+	~
Turn to sun	+	+	+	-	+	+	+	+
Durability	~	~/+[4]	+	++	+	+	~[5]	++
Overall score on a scale 1-5	2,9	2,7/2,9	3,7	3,2	3,1	2,9	3,6	3,1

[6] Depending on the use of fabric or wood. Legend: -- = really bad/not available; - = not very well; ~ = not good, not bad; + = good; ++ = very well

ULOG Light

+ The ULOG is elegant to see (less ungainly than others)
+ It is lighter than most other models.
+ Building plans are free accessible and for that, the price can decrease dramatically

* The ULOG is not made in mass production yet
* ULOG concentrates on Europe, no big introduction projects done in developing countries

- The lid with reflector is fastened at the front side of the oven. Due to the weight of the lid and the reflector, the oven will tilt when taking pots out.
- The building kit for the ULOG light you can order from Swiss contains weak wood which can cause permanent damage when accidentally dropped.

figure 3: ULOG Light

DIERCKX

+ The cooker is accepted in the Netherlands, Vietnam and Burkina Faso on a large scale
+ The manufacturer in the Netherlands is willing to sponsor the mould for the inner box if decided to use this model

* The model has been optimised for production by hand on a large scale in Vietnam and Burkina Faso

- It is a really heavy cooker, due to the use of wood
- The reflector can only be adjusted in a couple of positions.

figure 4: Dierckx

T16

+ had very good feedback after introduction projects in Southern Africa
+ manufacturer would be really happy to cooperate

* no building plans available at all

- Lid is not able to stay open on its own, user has to hold it while putting pots in or out

figure 5: T16

SUN SCOOP

+ easy to transport
+ already introduced in Africa
+ design is quite flexible

* The Sun Scoop is optimised for local production by hand to create more employment

- Manufacturer only willing to cooperate if he get paid for it
- No evaluations or feedback on this cooker could be found
- Doesn't have an insulation

figure 6: Sun Scoop

SUNSTOVE

+ light
+ easy in transport
+ already introduced in Southern Africa

* mass production optimised, mould for blow injection moulding already available

- Hard to get pots in or out because of bending lid
- Lid is not insulating very well

figure 7: Sunstove

PIL KAAR
+ manufacturer willing to cooperate
+ already used in Chad and for that adapted to mass production

* Due to using the best materials, working really precisely and instruct cooker builders for three years, the price is quite high

- Lid and reflector should be lifted at the same time to open the lid
- Nothing prevents the lid from falling down so you have to hold it while getting pots in or out
- Made out of wood

figure 8: Pil Kaar

SUN COOK
+ very strong and durable
+ already made in mass production

*available in two versions: the normal SunCook and the tropical version which is less expensive because of leaving some additional extra out

- very heavy
- reflector is not very well attached to the main construction
- cooperation with producer more difficult

figure 9: Sun Cook

SUN OVEN
+ already used in other countries
+ very durable

* due to patent protection, local manufacturing and building plans is possible after ordering, assembling and selling 250 SunOven from the USA and a 2 week training course in the USA. Assembling it locally reduce the price with 50%, manufacturing completely locally can reduce the price with another 10%-30% (www.sunoven.com)

- patent protected
- reflects sun in your eyes when approaching the cooker. No way to approach the cooker without getting sun in your eyes
- reflectors cannot be adjusted to the sun

figure 10: Sun Oven

Appendix F: Performance of some box cookers

Comparing box cookers can be done in several ways. One of them is by measuring the temperature the oven gets. However, this does not always tell you something about the temperature the food will get. Boiling water in a closed pot is a reliable way to test an oven but still difficult because as soon as you lift the lid to see if it is boiling, you lose so much heat the water will probably stop boiling before you could check it. To avoid these problems the following method is used:

The SunOven, the Sunstove, the ULOG Light and the SunCook were placed in the sun with a plate with ice cubes. This plates had a black bottom. As a reference, a plate with ice cubes is placed in the sun without any cooker or other device. The time it took the cooker to melt the ice cubes is measured. Using this method, it is easier to see which cooker is faster. This test is done twice, one time with a 'cold start' (before use the cookers were placed inside) and one time with a 'hot start' (the cookers already had one hour of sun).

Test done on the 24th of September 2009, Johannesburg. Sunny, sometimes partially clouded.

Cold start at 12.36

12.49 - ULOG Light	13 minutes
12.50 - SunOven	14 minutes
12.51 - SunCook	15 minutes
12.53 - Sunstove	17 minutes
12.59 - plate	23 minutes

Hot start at 14.16

14.25 - ULOG Light	9 minutes
14.26 - SunOven	10 minutes
14.28 - SunCook	12 minutes
14.30 - Sunstove	14 minutes
14.42 - plate	26 minutes

It is striking that the order of fastest to slowest cooker is the same in both situations: the box that heats up the fastest also has probably the highest end temperature. The following issues were noticed during the melting process:

- The SunCook was less effective later on the day, because the lid is horizontal instead of placed under an angle. The front side caused a shadow in the box itself as can be seen in figure 11.

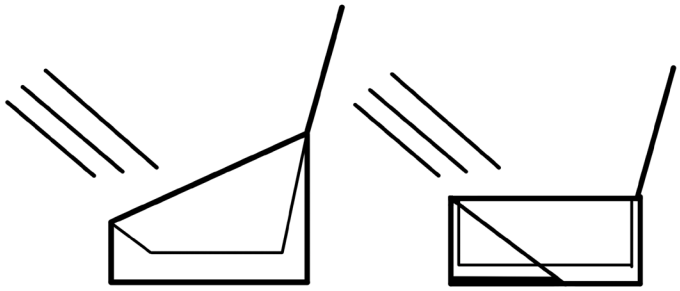


figure 11: difference between straight and inclined lid

- No matter where you stand, if you try to get something in or out the SunOven you will have sunlight reflected in your eyes making it hard to see what you are doing without damaging your eyes.
- The lid of the Sunstove is very flexible and for closing you need two hands. Getting the food out must be done with one hand, if you want to pick up the pot with two hands, you have to remove the lid completely. In case you have more than one pot on in the Sunstove, you will lose a lot of heat.
- Reposition the complete stove to the sun should be done every two or three hours, more important is to adjust the reflector.

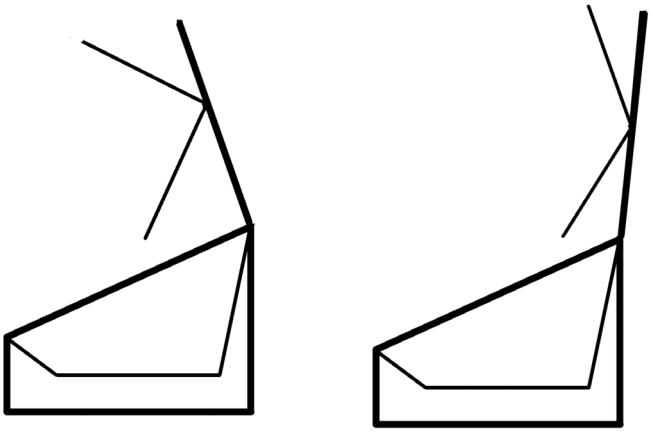


figure 12: adjusting the reflector

The ice-cubes test gives only information about the ability of a box cooker to collect heat, it is giving hardly information about the insulation of the cooker, or what the influence on the meal is when you open the cooker once or twice during the cooking process. It is better to actually cook a meal, bread or cake in the cookers to compare them. Sunfire Solutions already demonstrated the SunStove and the SunCook on a couple of events while baking cake. The experience was that the SunCook was twice as fast as the SunStove since the SunCook was able to bake two cakes in one day and the SunStove could just baked one.

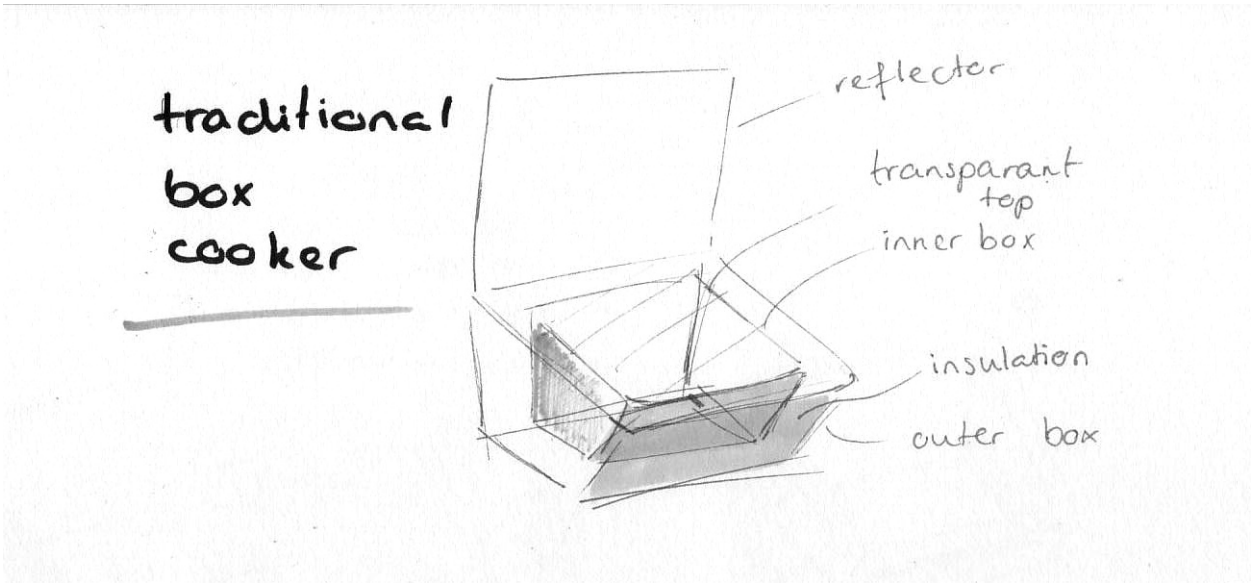
On the 13th of October another test was done. Muffins in paper cups were placed in the SunCook,

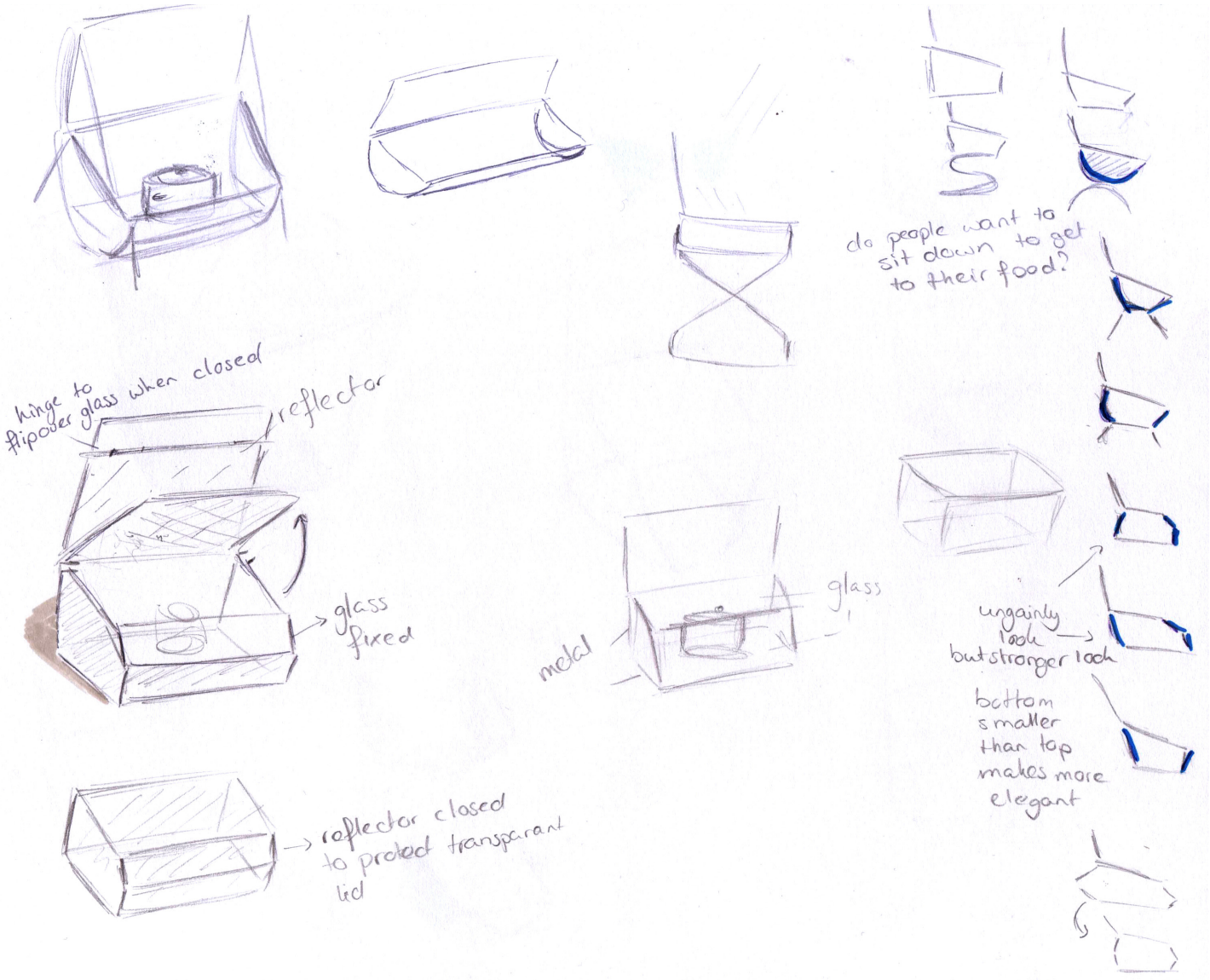
the ULOG, the SunStove and the T16. According to the recipe, the muffins had to be baked at a temperature of 180 °C for 20 minutes. Because the temperature will serious drop when opening the cooker, the first check on the muffins was done when they started to get a bit brown topping. At the first check (after almost 40 minutes), the muffins in the ULOG, the SunCook and the T16 were almost ready. At the second check (after about 50 minutes), the muffins in the ULOG, the SunCook and the T16 were ready, the Sunstove needed still 20 to 30 minutes more to finish the muffins. The muffins from the SunCook were a little bit darker on the bottom. Checking on the muffins was done by putting a fork into the muffins and pulling it out, when the fork comes out dry and clean, the muffin is ready. Otherwise it will be wet or contain some paste.

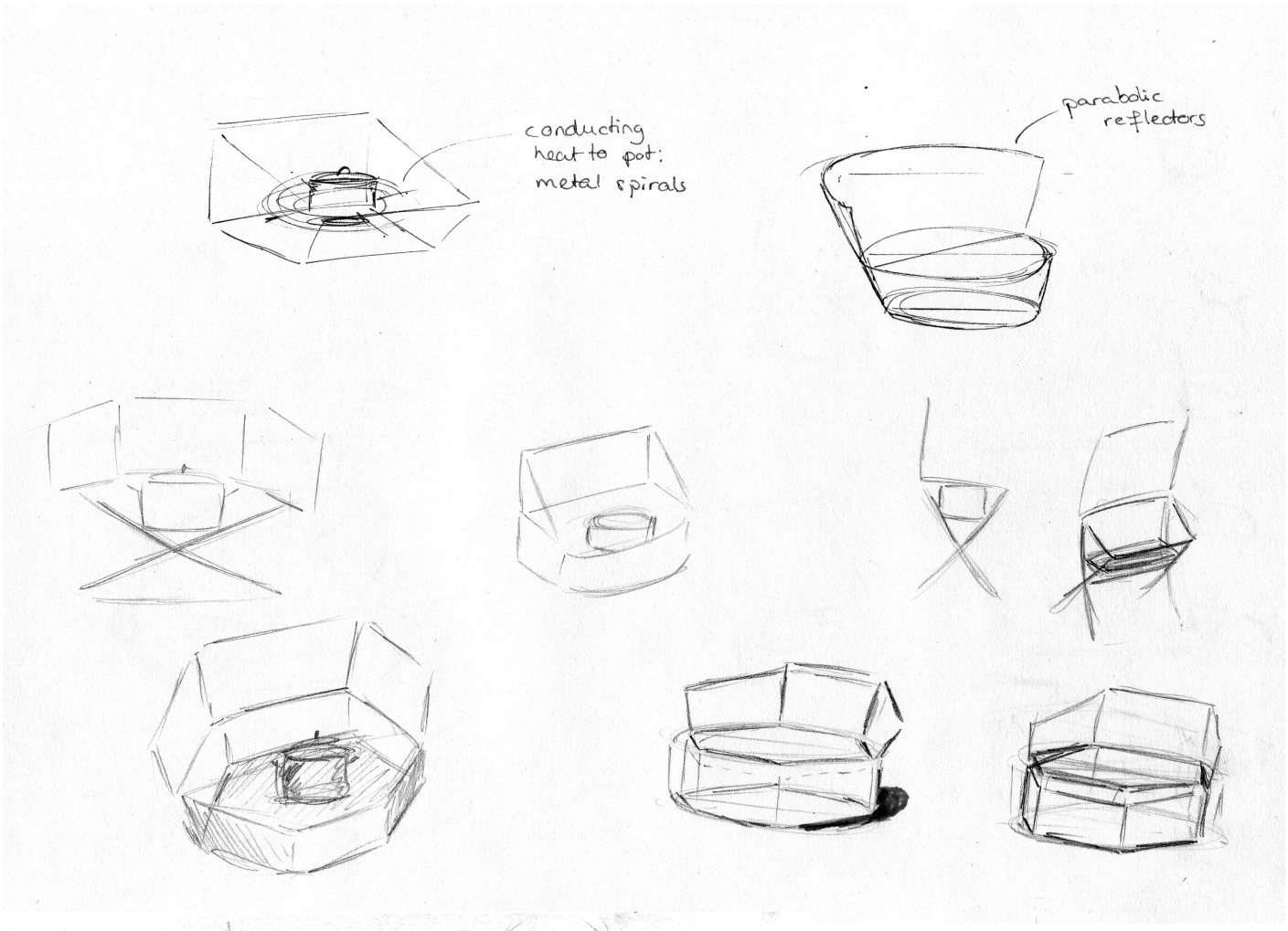
A condensation test is done by placing the SunCook, the T16 and the SunStove in the sun with a bit of water in the cooker. The water will start to cook and condensation will appear on the inside of the cooker. This happened with all the cookers with exception of the SunStove. Both the SunCook and the T16 have one or more small gaps between the inner box and outside. When filling these gaps up with felt, the condensation became worse. Other conclusions: The condensation disappeared after a couple of minutes when the glass got warmer. The polycarbonate of the SunStove did not get as hot as the glass of the T16 and the SunCook. The single glass of the T16 got the same temperature as the double glass of the SunCook.

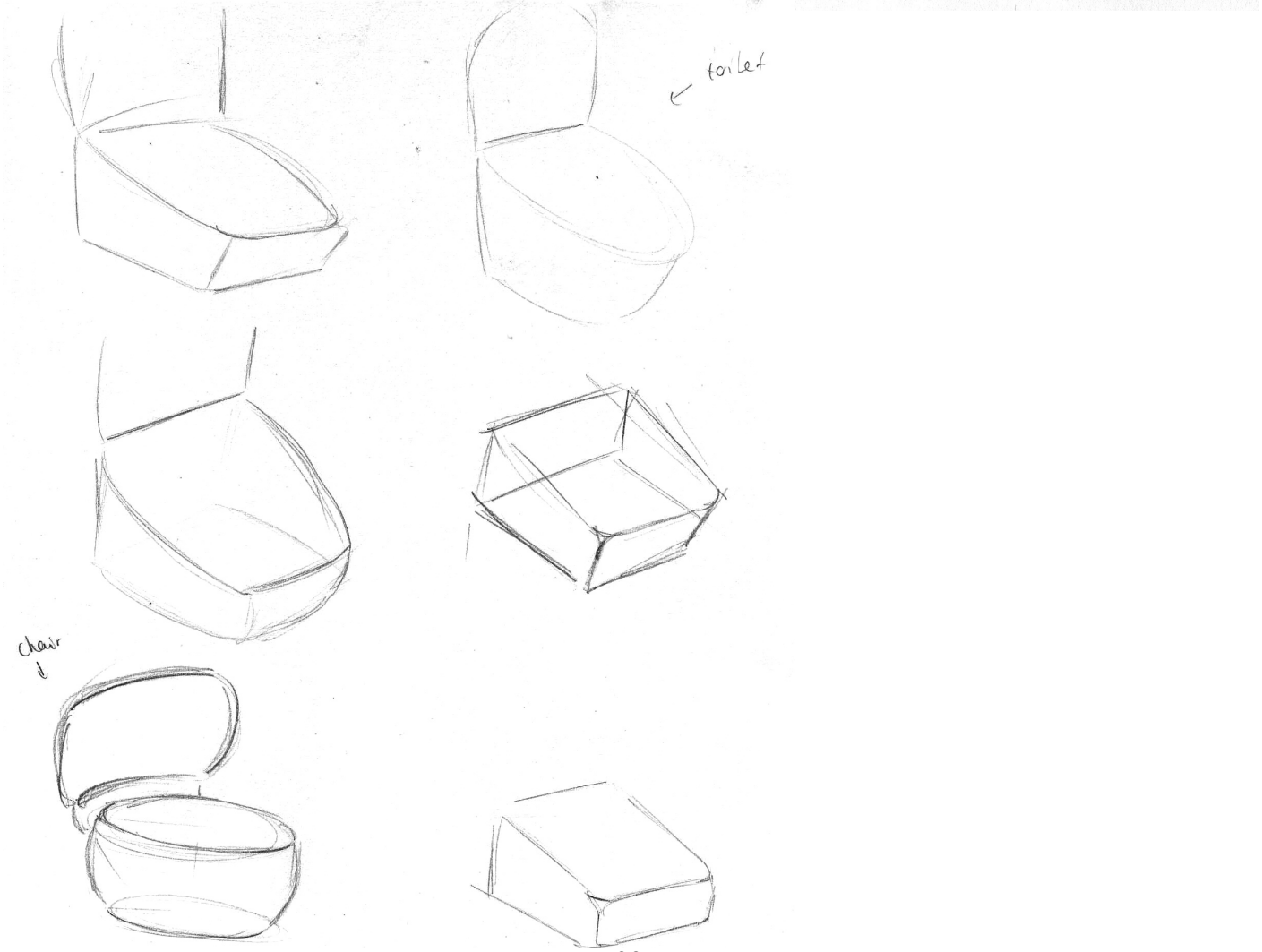
Appendix G: Sketches and drawings

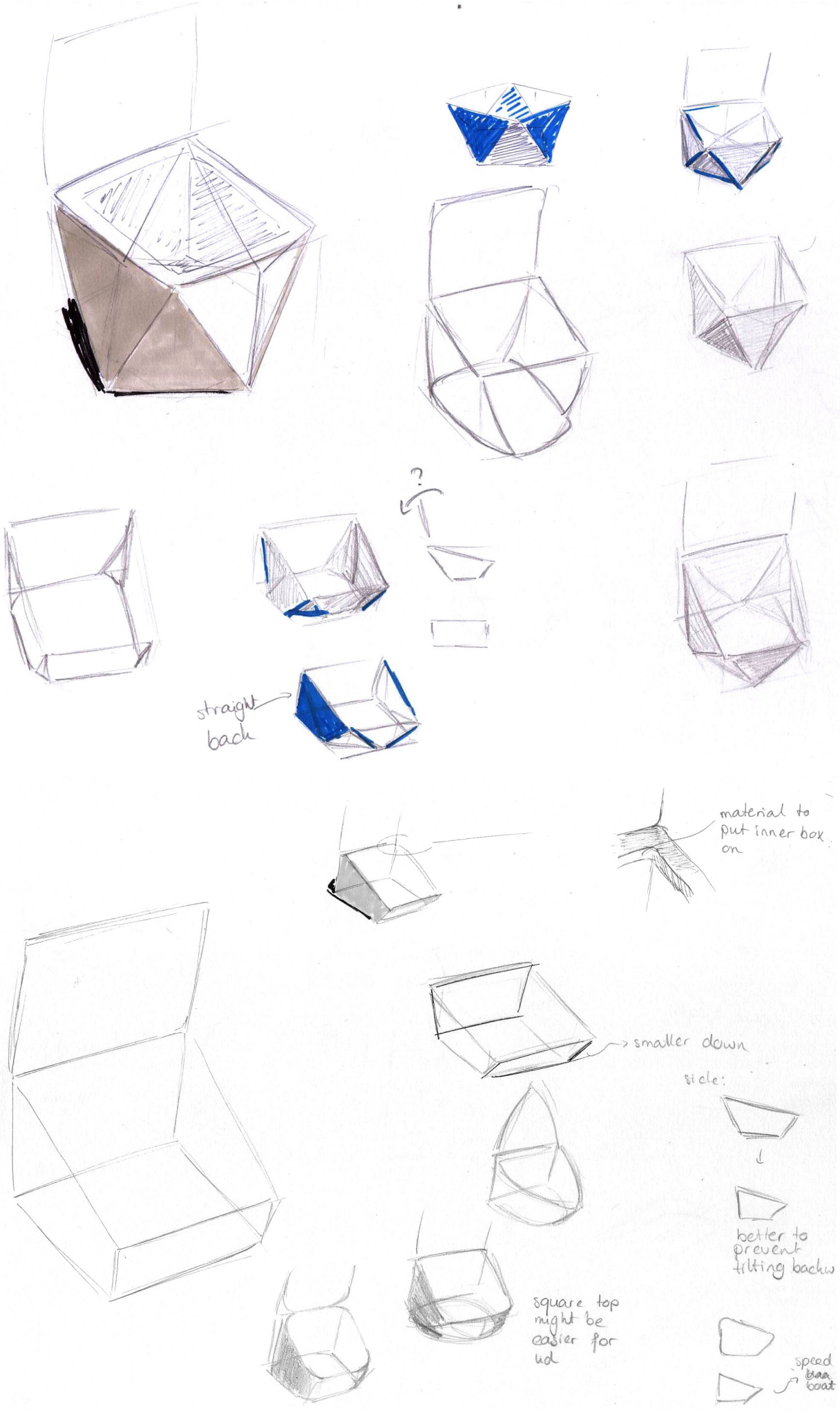
Shape study



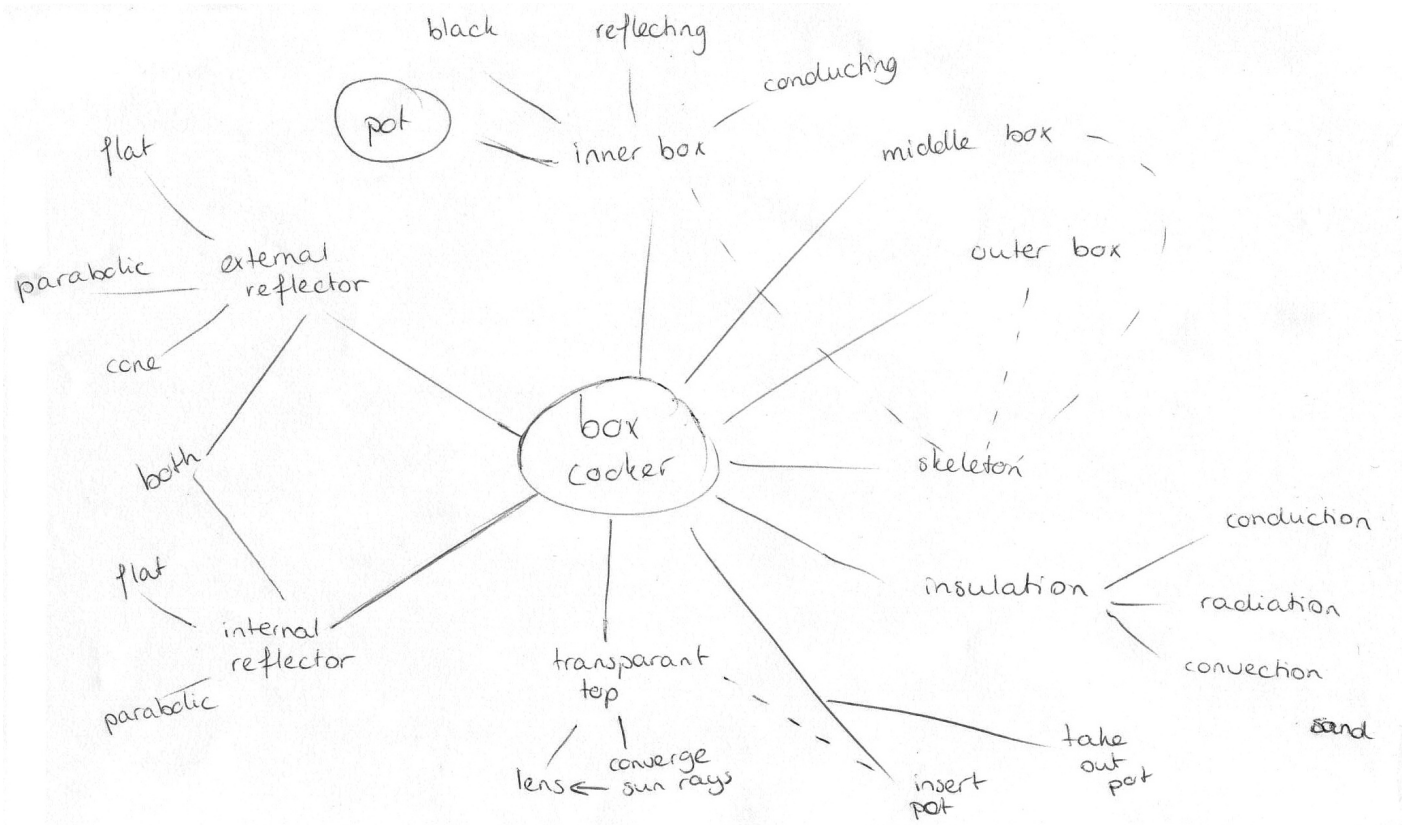


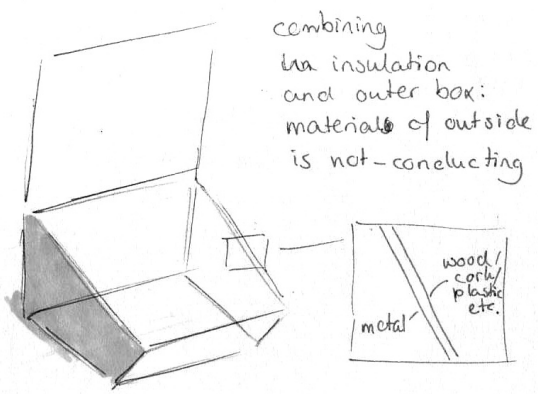

conducting heat to pot: metal spirals
parabolic reflectors


toilet
chair

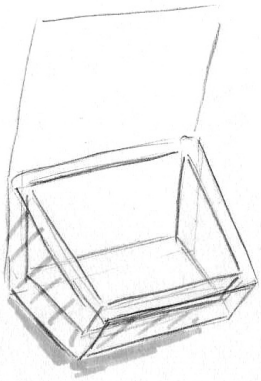

straight back
material to put inner box on
smaller down
side:
better to prevent tilting backw
square top might be easier for lid
speed baa boat

Brainstorm to combine parts:

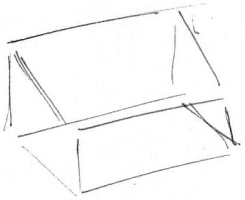


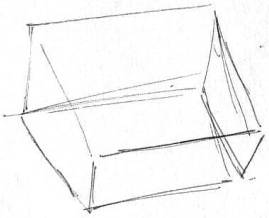


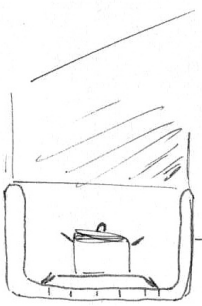
combining
insulation
and outer box:
materials of outside
is not-conducting



combining
lid and
outer box:
both transparant

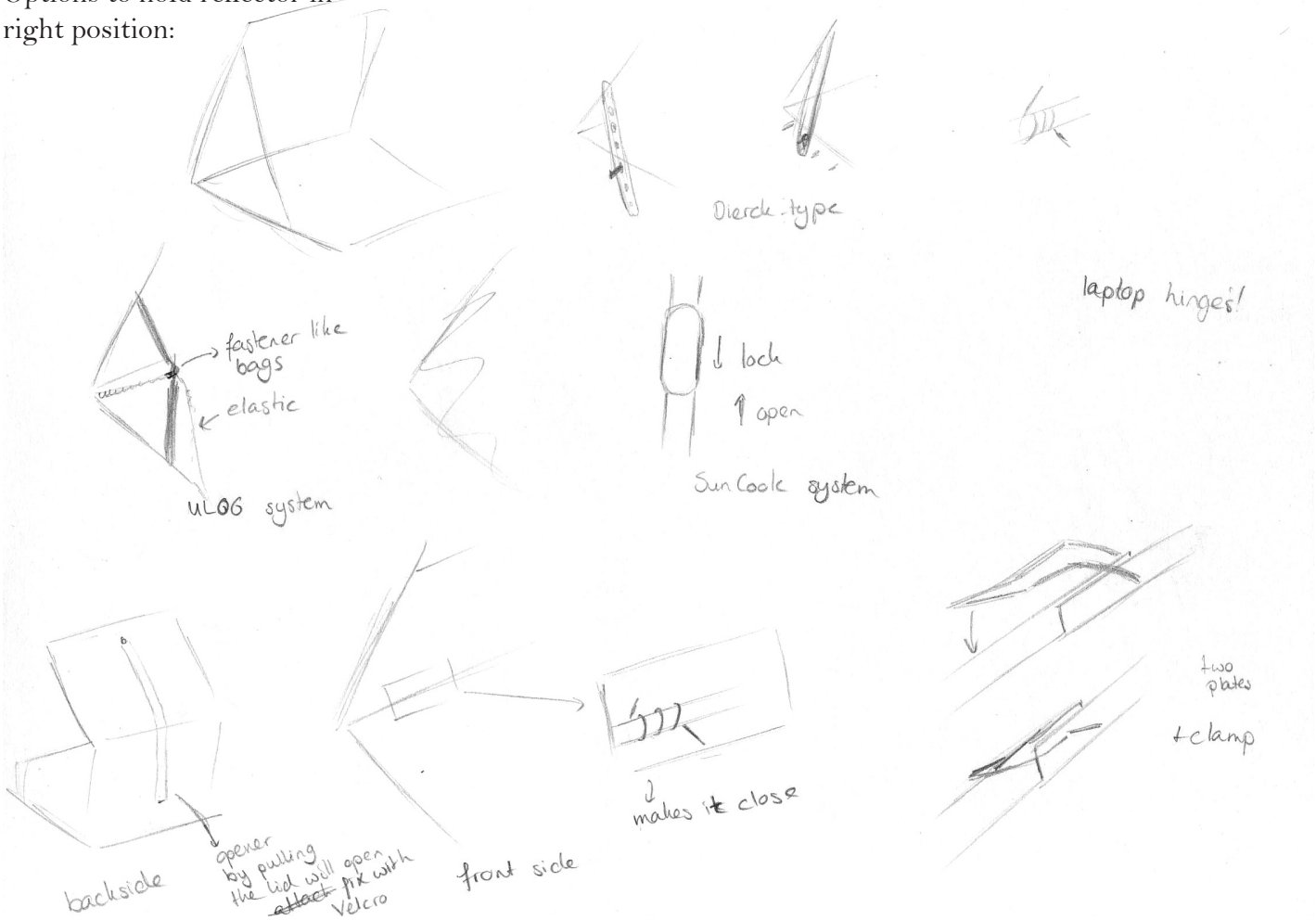


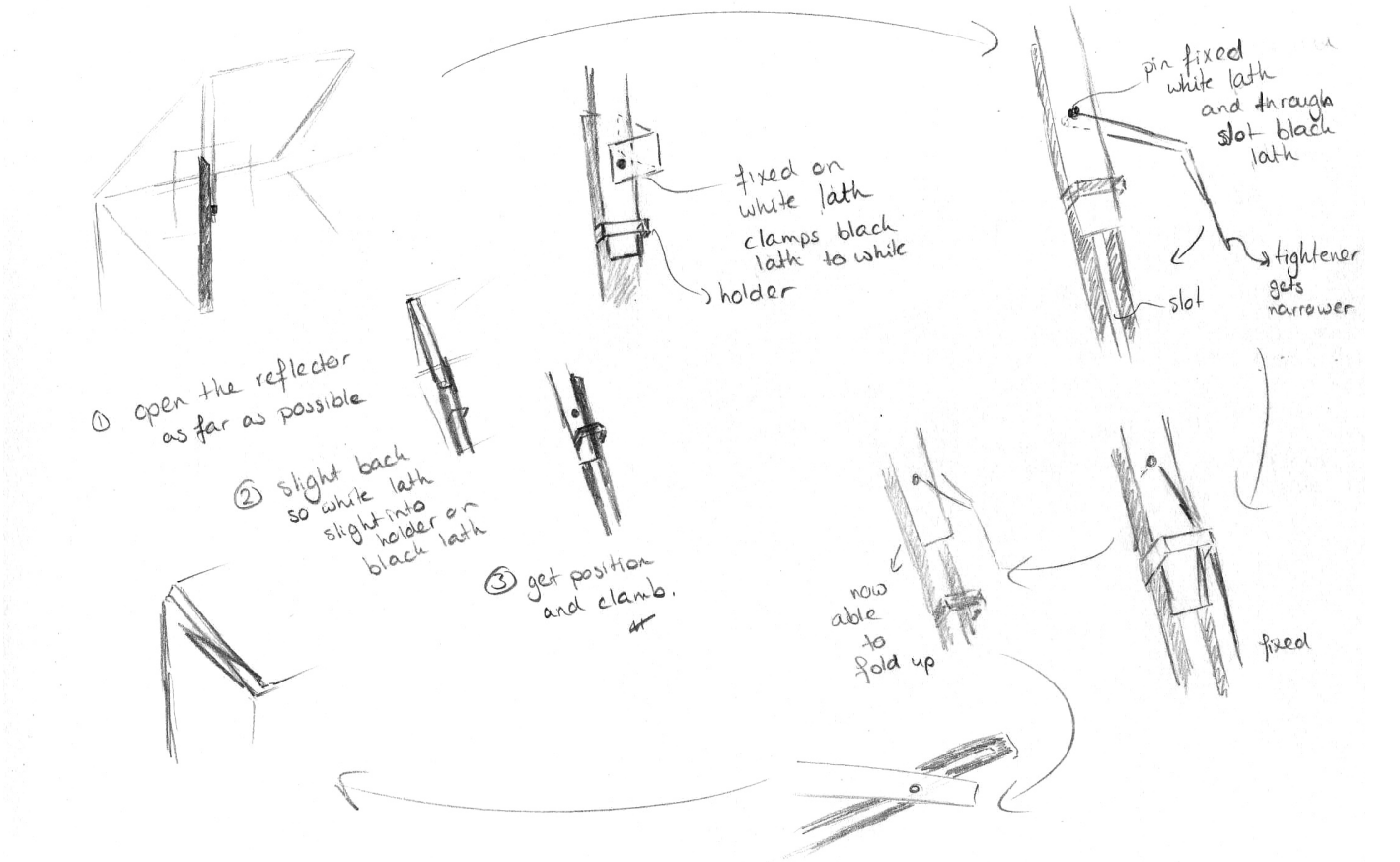


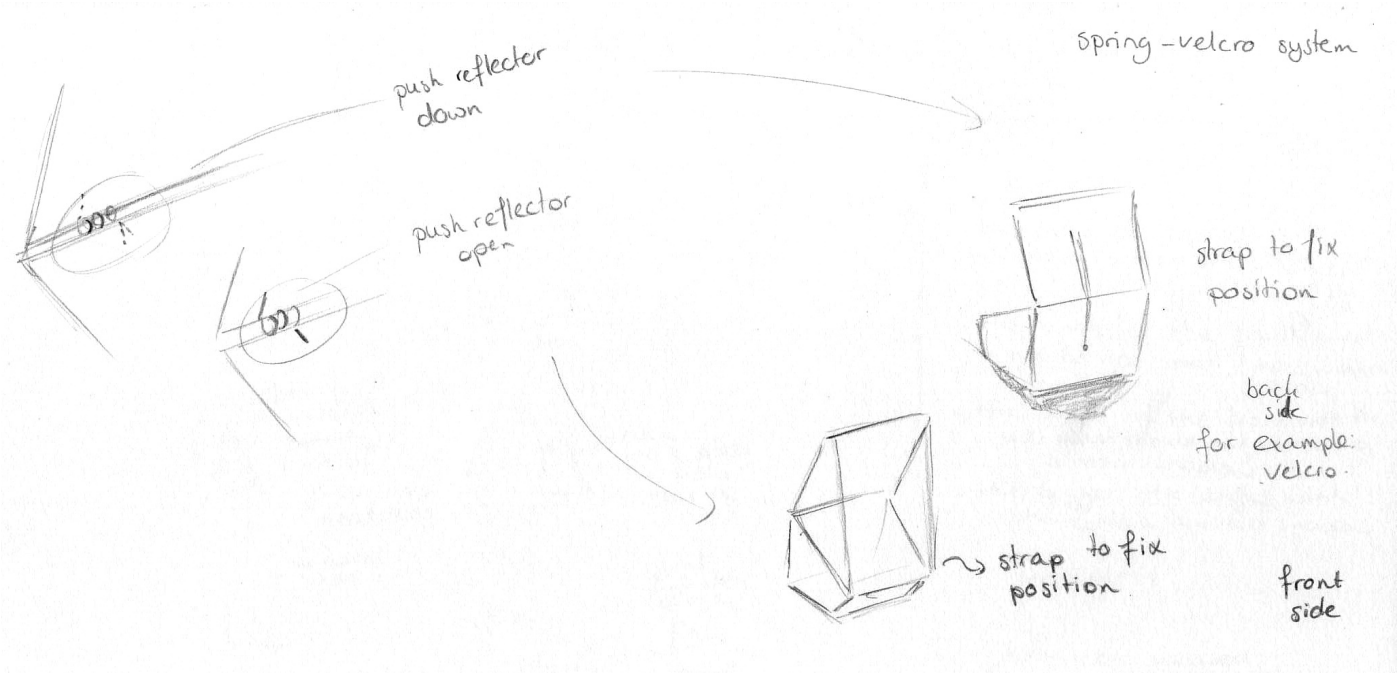


combining inside and outside
separate pot holder

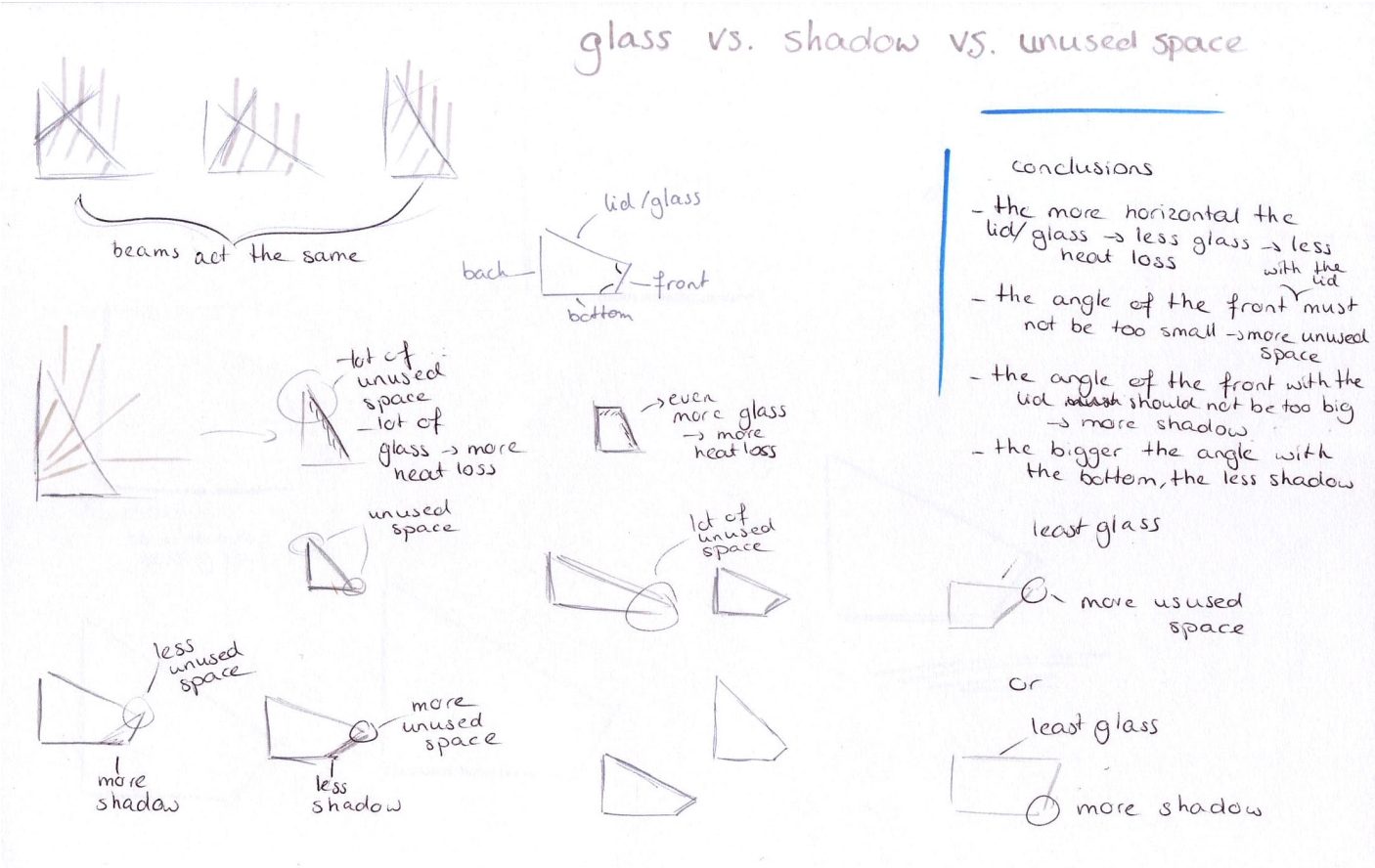
Options to hold reflector in right position:

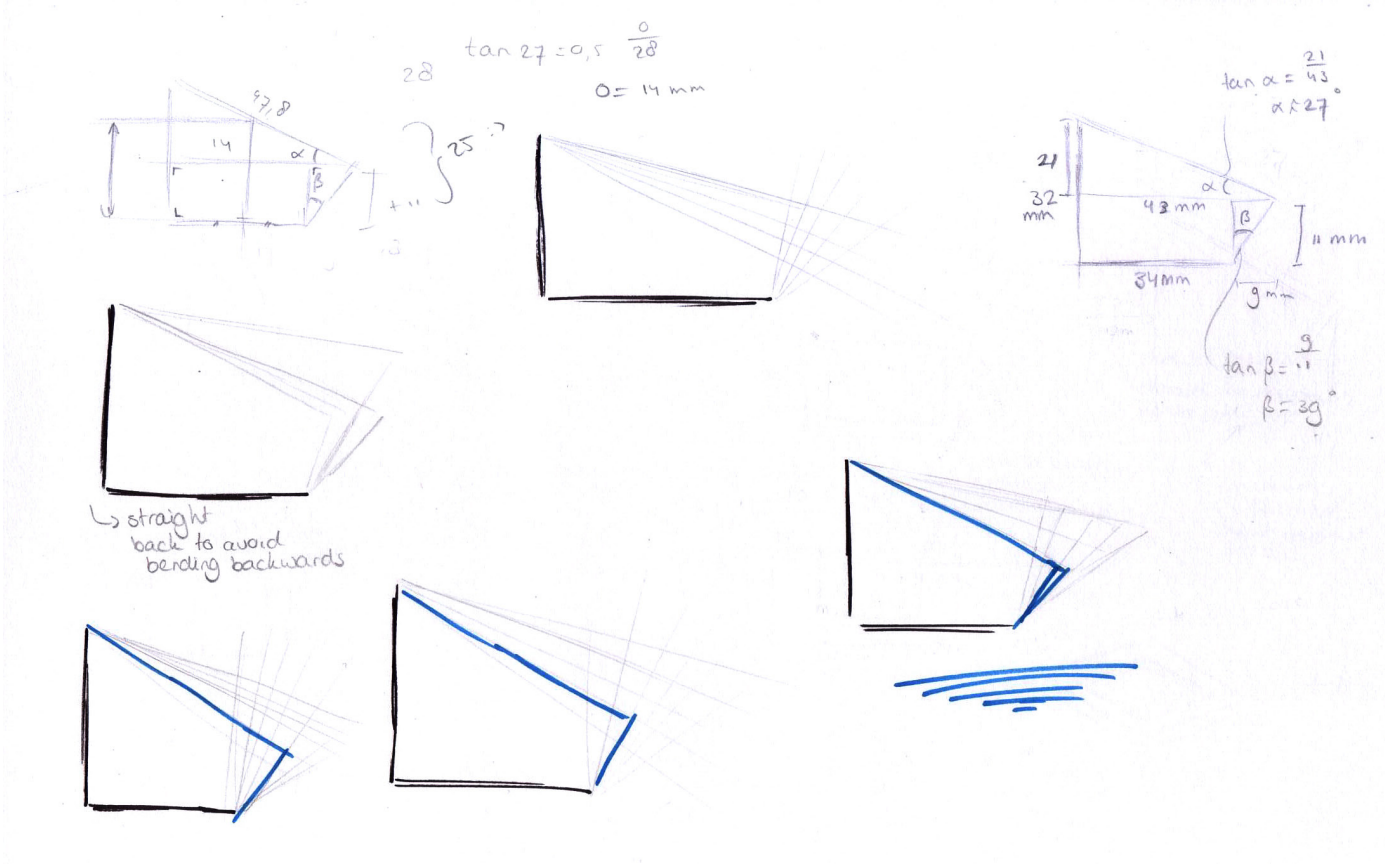




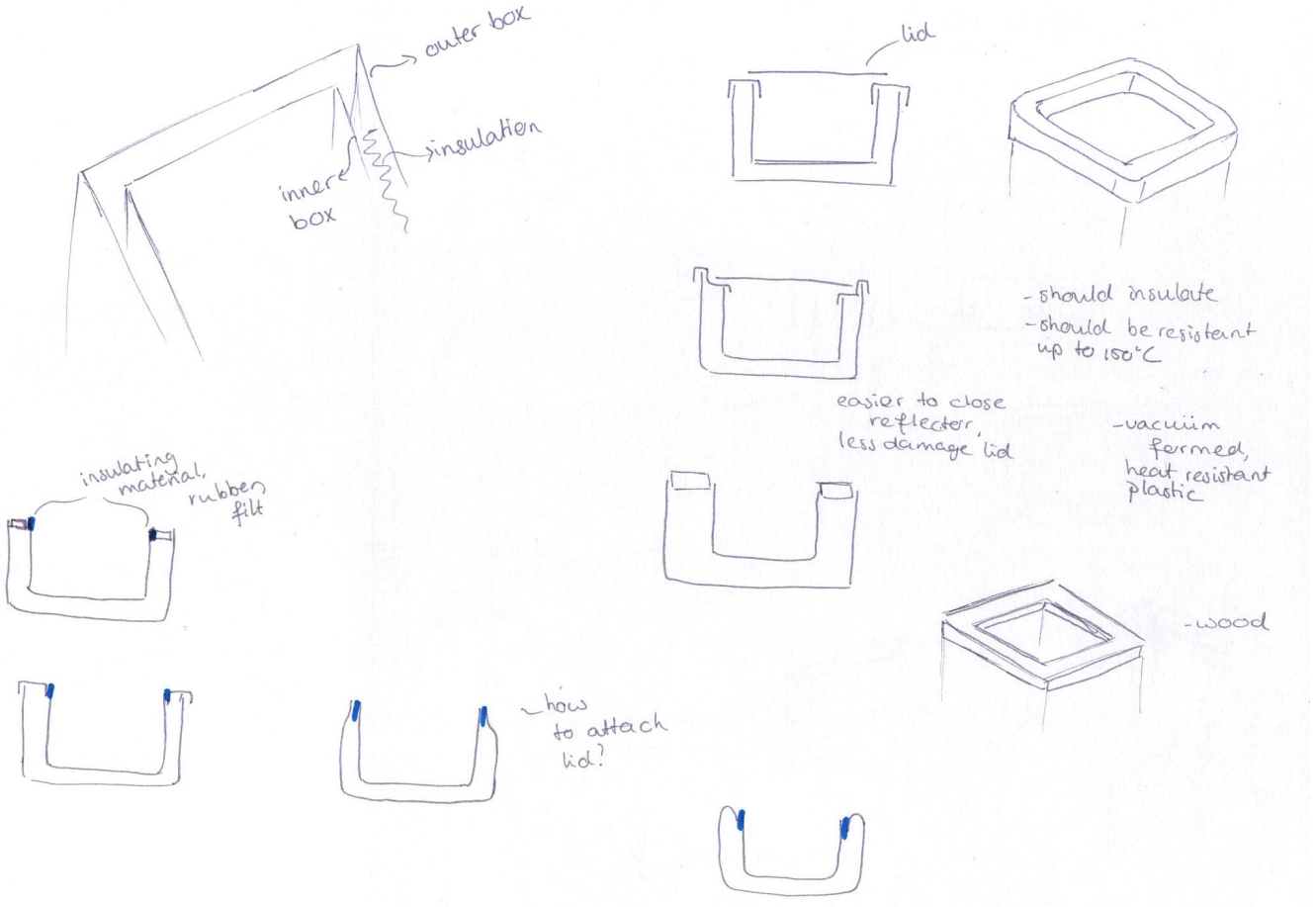


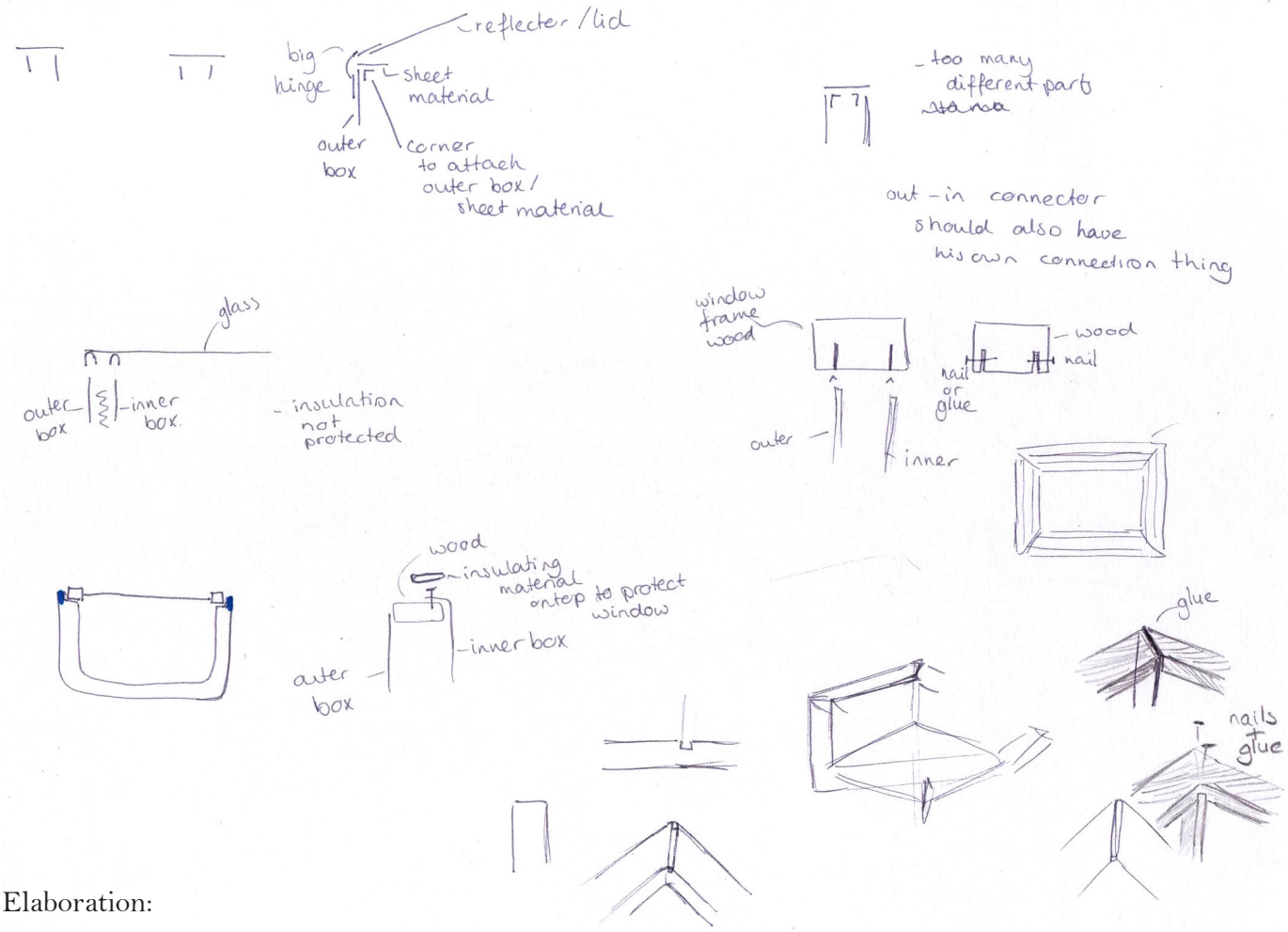
Optimal inner box size and shape:



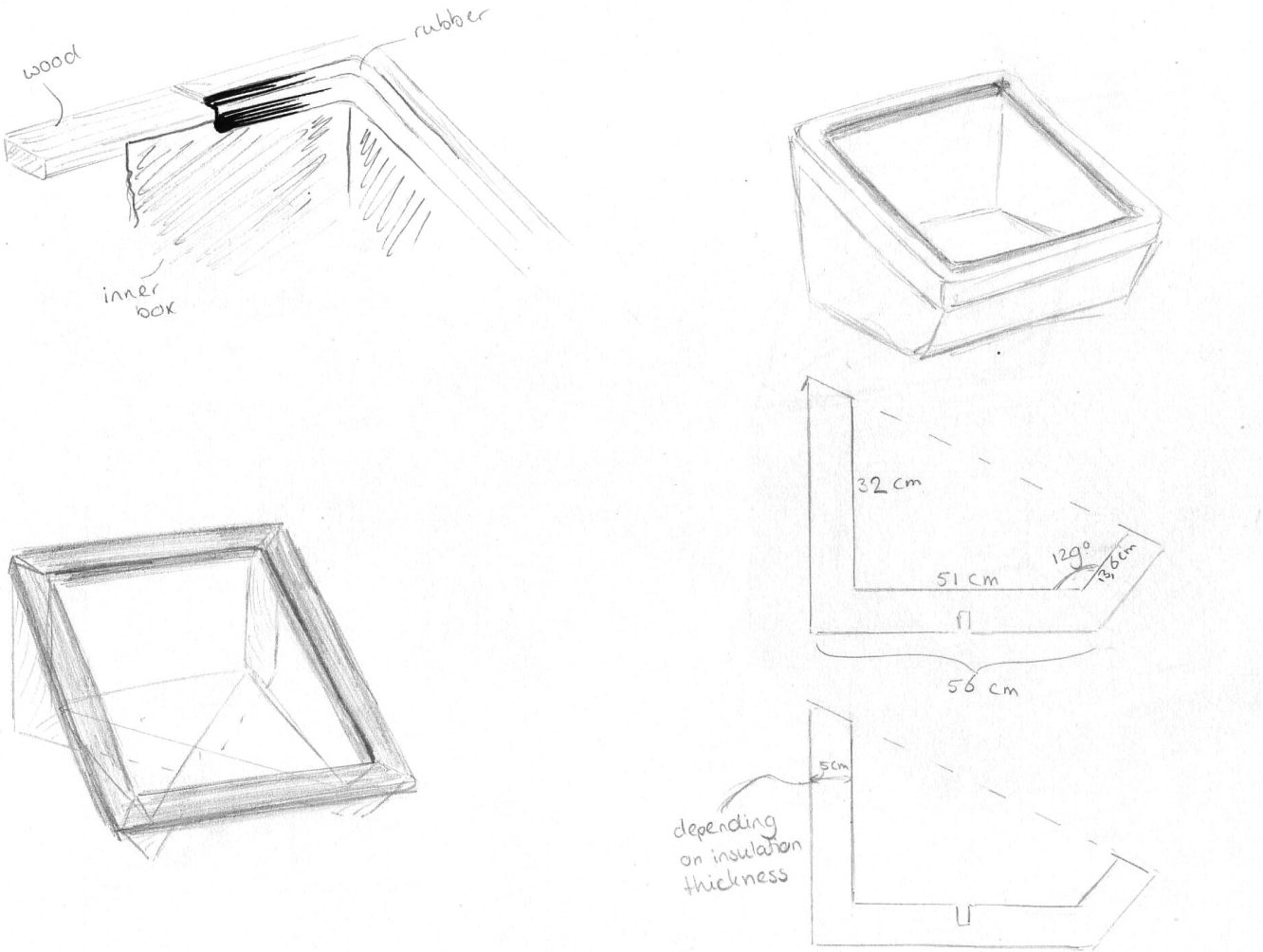


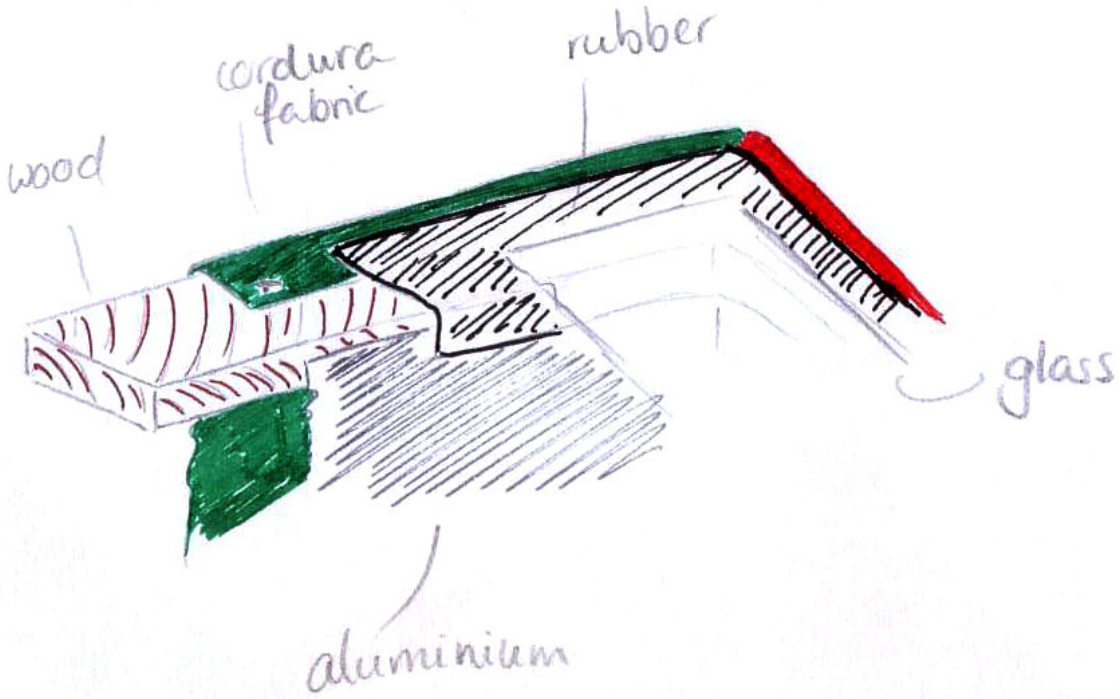
How to attach inner box to outer box:



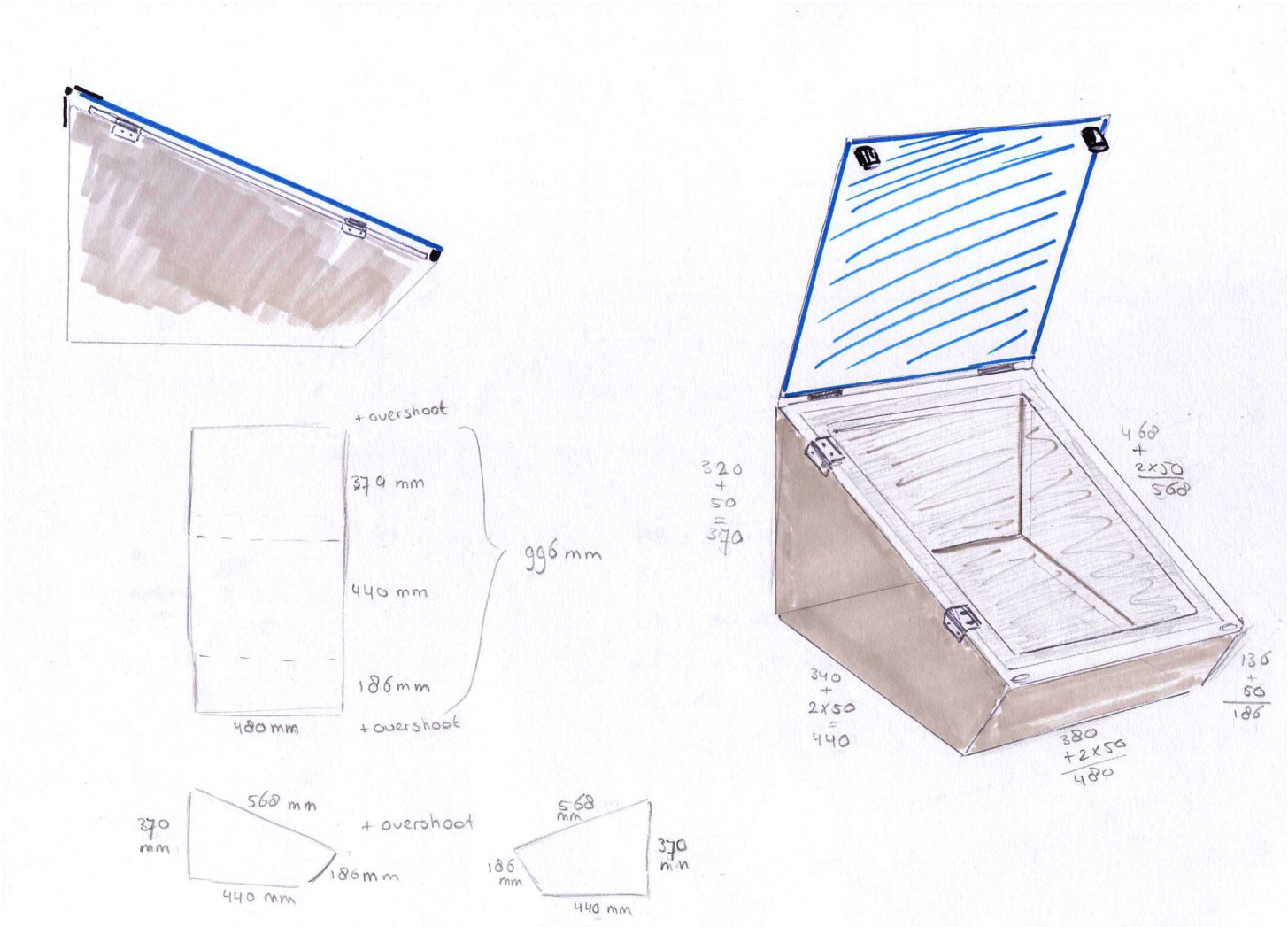


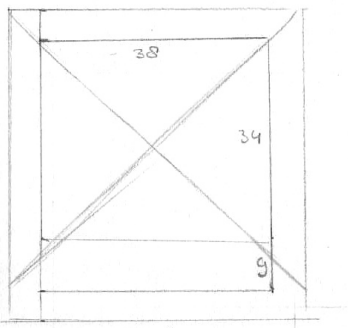
Elaboration:

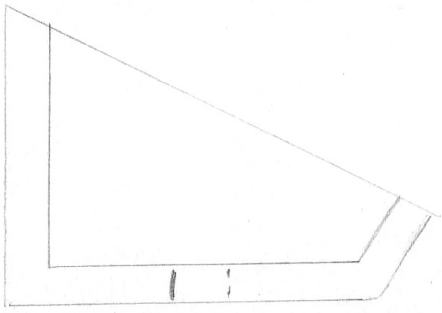


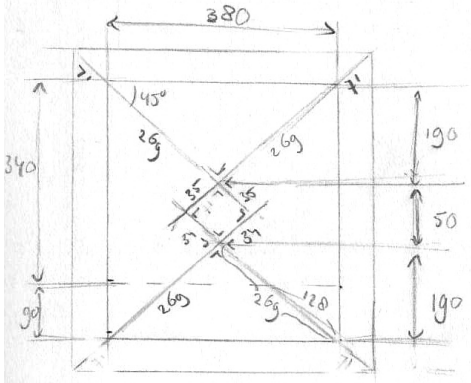

wood
cordura fabric
rubber
glass
aluminium

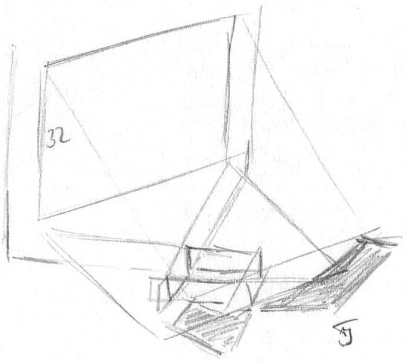
Dimensions:

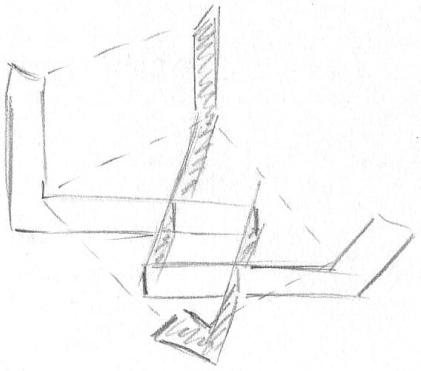

+ overshoot
379 mm
440 mm
186 mm
996 mm
480 mm
+ overshoot
320 + 50 = 370
460 + 2x50 = 568
340 + 2x50 = 440
380 + 2x50 = 480
136 + 50 = 186
370 mm
568 mm
+ overshoot
186 mm
440 mm
568 mm
370 mm
186 mm
440 mm

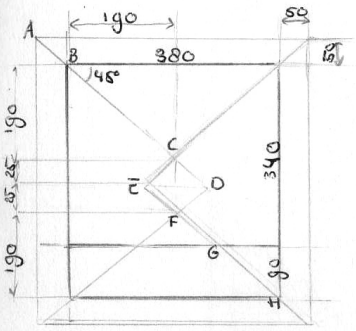


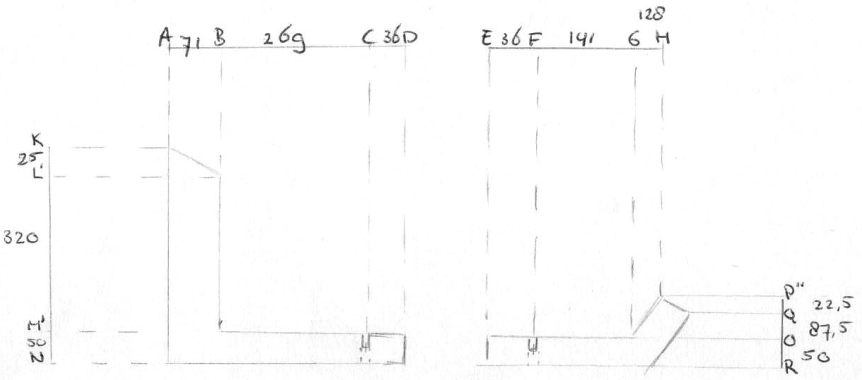


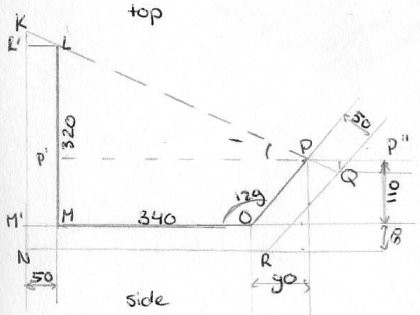












$AB = \sqrt{50^2 + 50^2} = 70{,}71$ mm $\rightarrow$ 71 mm

$BC = \frac{190}{\cos 45°} \approx 269$ mm

$CD = \frac{25}{\cos 45°} = 35{,}4$ mm $\rightarrow$ 36 mm

$EF = CD = 36$ mm

$FG = FH - GH = 269 - 128 = 141$ mm

$GH = \frac{90}{\cos 45°} = 127{,}3$ mm $\rightarrow$ 128 mm

$FH = BC = 269$ mm

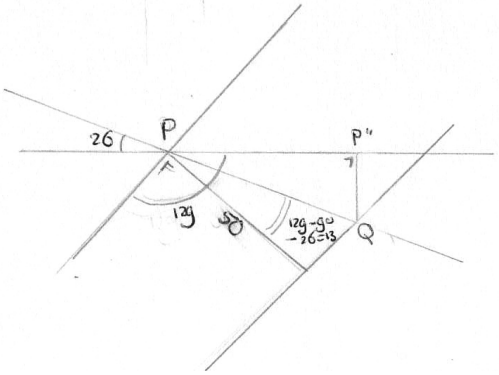
$\angle LPP' = \tan^{-1} \frac{210}{480} = 26°$

$KL' = \tan 26° \times L'L = \tan 26° \times 50 = 24{,}4 \rightarrow 25$ mm

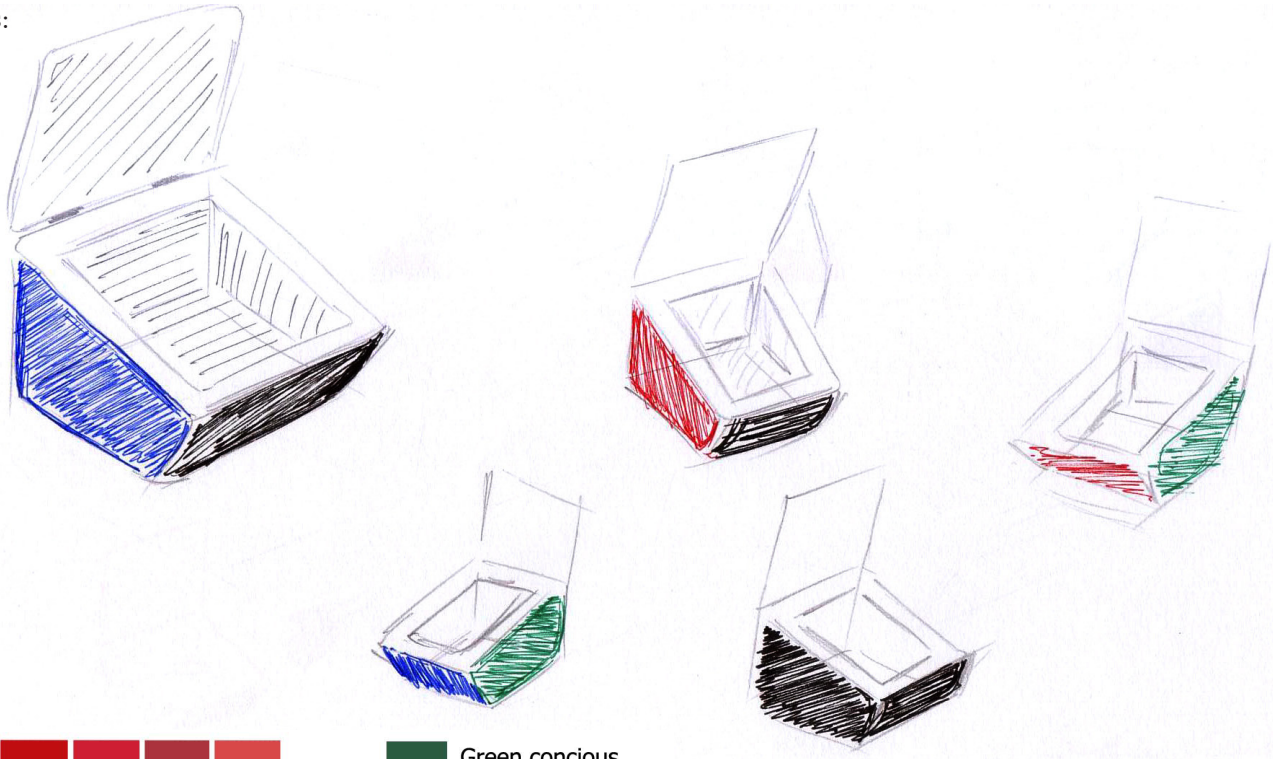
$PQ = \frac{50}{\cos 18°} = 51{,}32$ mm

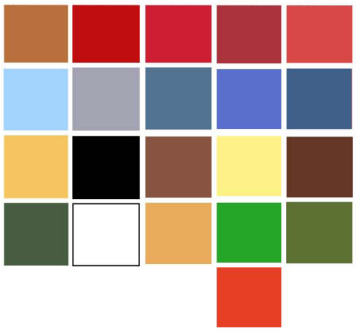
$QO = PO - P''Q = 110 - 22{,}5 = 87{,}5$

$P''Q = \sin 26° \times PQ = 22{,}5$ mm



Colours:





Green concious environment

Green concious

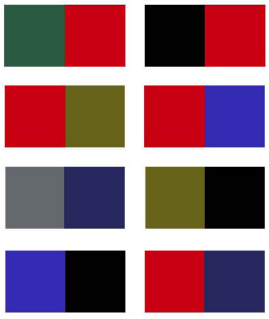
Clothes
Cooking appliances
Sunfire solutions

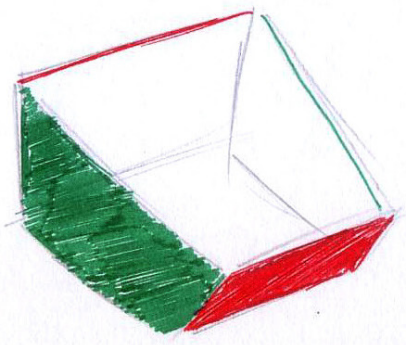
Cooking appliances

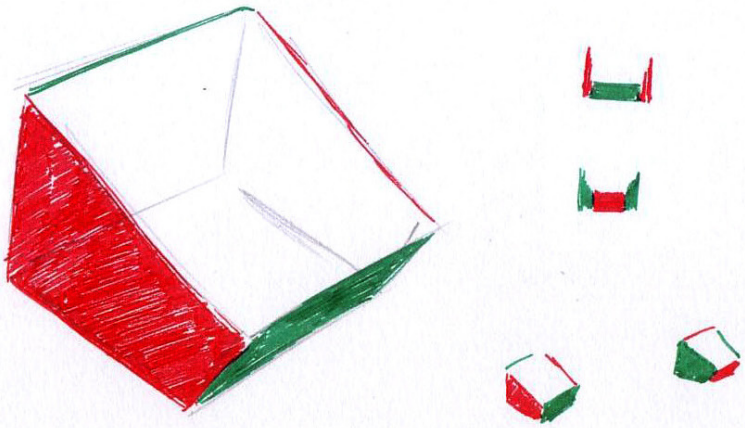
Green concious
Earth
Camping

Cooking appliances

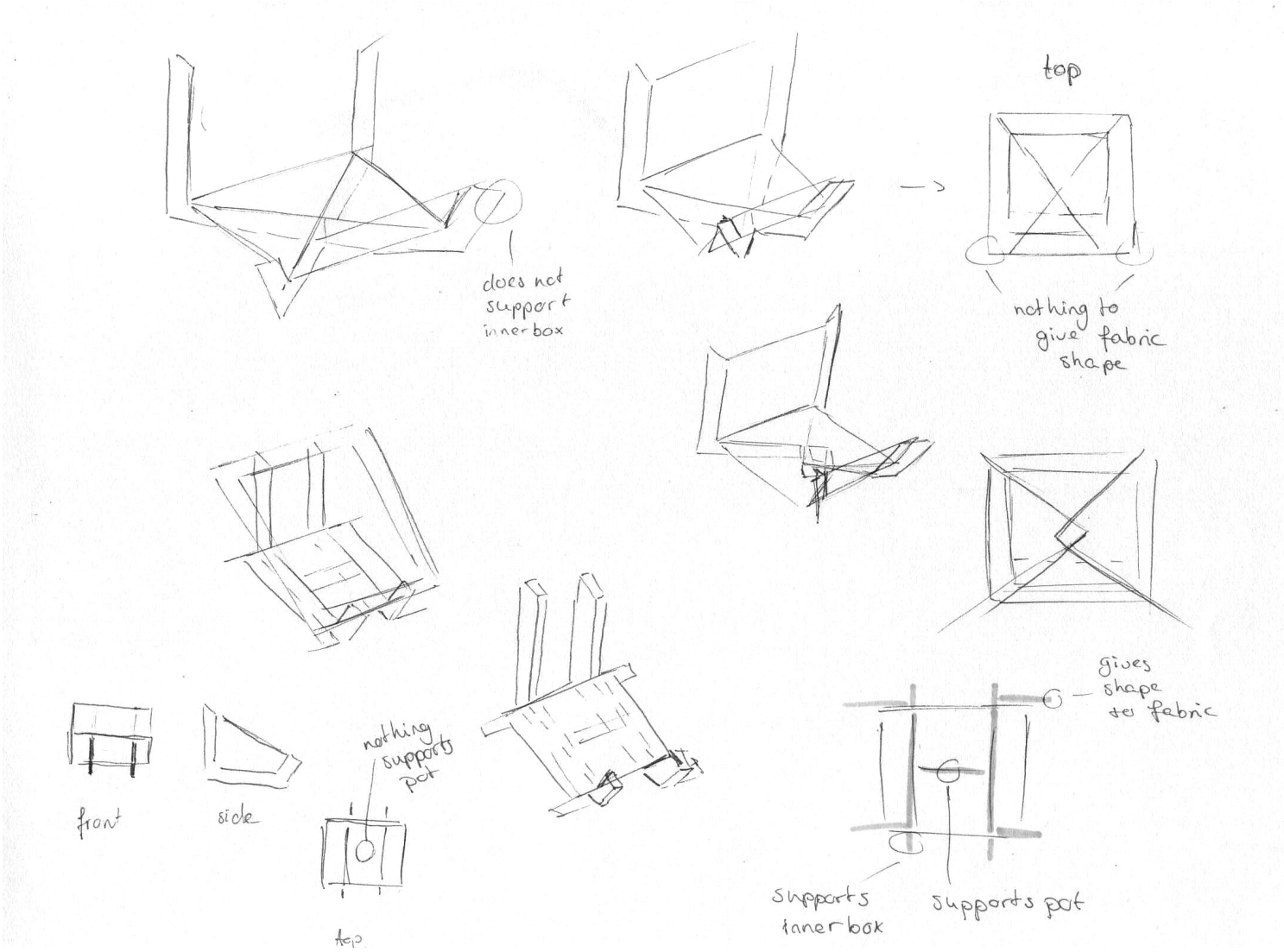
Clothes
Sunfire Solutions







Skeleton options:



Appendix H: Contact with the Target market

In the week of October 12th to October 16th, the SCI-BONO centre in Johannesburg organised the Earth Science week. During this week, kids from primary schools and high schools learned about environmental problems and possible solutions by listing to people who were involved with environmental projects in South Africa. I was asked to do a talk as well about Solar Cookers. After the talk, I asked the kids to draw cookers for me as they thought their parents would like it. They took the drawings home after I saw all of them. Most of them had never any drawing lessons at school, so some of them tried to imitate the pictures.

Most valuable conclusion: most of them got wheels underneath the cookers. The girls made designs on the outside, the boys made plain cookers.

On October 21st a project with parabolic cookers started in Soweto. Sunfire Solutions supplied 5 parabolic cookers, with trailers and bicycles, sponsored by Nedbank. The trailers with cookers were given away to 5 poor woman who would start to make food with the cookers and sell it. By joining the demonstration, a lot of information could be gained, especially since Stuart, the contact person of Sunfire Solutions in Soweto, has already experience with the SunStove. Interesting conclusions of that day:

- A lot of people have never heard of a cooker and have no idea what to do. They could easily put a cooker into the fire because they think that is the way to use it. An easy manual should be provided, if possible attached (painted) on the cooker.
- The technical insight is often horrible. A lot of people had never mathematics (geometry) or drawing lessons and never played with LEGO or made IKEA furniture. They do not see how something is working, even if it is really straightforward: if one part has 3 pins and the other part has 3 holes on exactly the same place, they will not come to the conclusions that these parts could be attached to each other.
- A demonstration should be given to show people what is possible and what not.
- The really poor people don't mind what the cooker looks like. For them it is already a miracle that you can cook with the sun and they are really willing to try as soon as they saw it happen, no matter what it looks like. Even the old Sunstove without lid and insulation coming out, was a miracle to them.
- A lot of people just don't know what's out there. They will not come out to see if there is a solution for their problems because they don't believe and expect it. The cooker should go to them.

Sunstove:

- The inner box of the Sunstove started to wrinkle due to the heat. Because of that, the inner box popped out the outer box casing, so the insulation came out.
- The lid of the Sunstove was disappeared, a good idea for a next product is not to have any loose parts, they will disappear.

Appendix I: Materials and manufacturers

Fabrics:

On October 27th, Richard from J.G. Train came by to explain more about his material. He offers a material that is used for tents, called poly cotton ripstop. It has a wax layer which makes it waterproof as long as people do not rub it off trying to clean it. This material is offered in a roll that is 1,83 wide and costs R76/m excluding VAT. Including: R86,64 for 1,83 m2 or R47/m2. His company does not have cutting facilities, so it would be preferred if we can order this material as a roll and otherwise in quantities up to 5 meter. The material weights 240 gr/m2 and is made in India at a company called Hiltex. They offer a similar material without ripstop, this is 280 gr/m2.

An estimation of the surface needed would be: 0,4*0,4 (ground) + 0,4*0,2 (front) + 0,4*0,4 (back) + 0,4*0,2*3 (both sides) = 0,64 m2 of course you would have some loss so let's say you need 0,75 m2 for a cooker. This results in a price of 47*0,75= R35,25.

On November 2nd, Roger from Linings and Textile showed some samples of Cordura 600 D and P/W twill. Cordura costs 18 R a meter excluding VAT and is 1,47 m wide. Although it has a waterproof polyester coating it is not a 100% waterproof, so if it rains, the insulating could get wet. The material is made with polyester which is flammable but not as bad as nylon. The material weight 400 gram/m2. P/c twill costs 20 R a meter and is 1,40 wide and less flammable, however this material is absolutely not waterproof and for that maybe not the best.

To order we can send an email to keith@linings.co.za with attention to Roger. He handles Rogers orders. For the cordura a normal sewing-machine can be used, it only needs a special needle and thread (Teflon thread). Roger has details of some good sewers in Johannesburg.

A cost estimation for the Cordura, based on the surface calculated above: R10,50 including VAT for the outer box.

Corrugated plastic:

Corrugated plastic is found at a company called Falcon under the name of 'correx', a 4 mm sheet will cost R33,5/m2 including VAT. This material can be used as a cheap, light and strong material for the outer box or for the reflector. In case it is used for the reflector it should be noted that this material has a ribbed surface, if the reflective material is a tape of paint instead of a sheet, this will have a negative influence on the reflectivity. The option of corrugated plastic is discussed with the designer of Durattract, a company specialised in plastics. More about this can be found under "plastic".

Falcon also offer ABS sheets of 3mm thick with a size of 1250x2500 mm and a price of R374 excluding VAT. If you are careful you can make 15 sheets of 40x50 cm out of the main sheet, which leads to a price of R28,43 per sheet including VAT.

Wood:

The best quote for an outer box in wood came from SJC Carpentry, which offered a 9mm plywood box for R490, a 16 mm plywood box for R685 and a 16 mm chipboard box for R395, all including VAT.

Space Blanket:

Also called emergency blanket is a thin film of reflecting material to keep people warm when they supercooled. This material can be supplied for 5R a blanket, which is 2 x 1,1 meter. If you're careful you can get 10 sheets out of it.

Plastic:

On October 28th a visit to Durattract took place; this company is working with vacuum forming, plastic fabrication, injection moulding and press moulding. Reason of the visit was the fact that Durattract needed more information on what a box cooker is to make the best quote. After the conversation a new meeting for October 30th was planned with their designer (Mark Mangold) to come to the easiest and cheapest design (figure 13).

- Although Sunfire Solutions is keen on injection moulding as soon as a sponsor can be found for the mould, it is still not a good option. When after a year or so turns out that the box cooker needs some more adaptations, a new mould should be made and

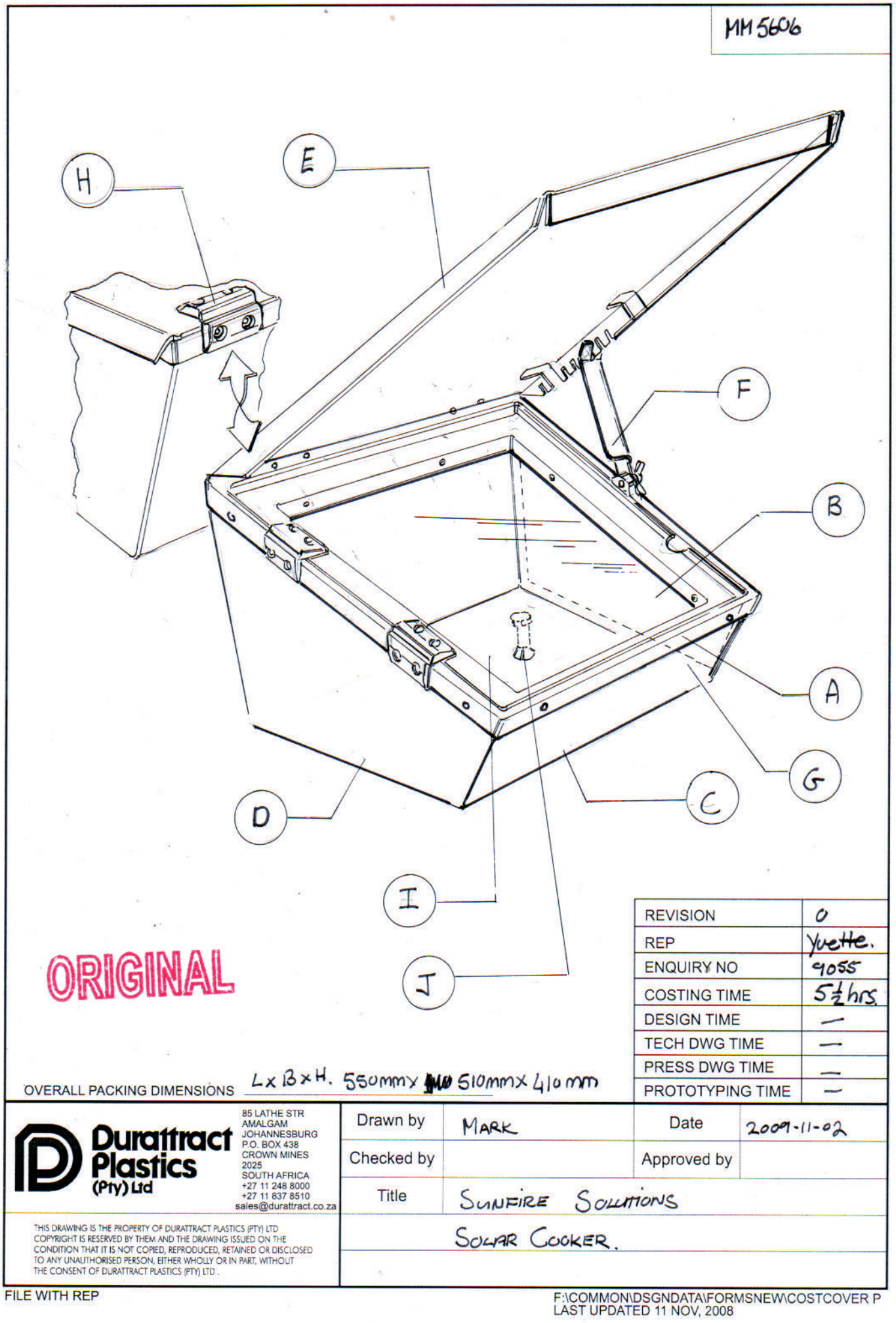


figure 13: design by Durattract

a new sponsor should be found. This risk that this will not succeed is way too high. Replacing a vacuum forming mould is easier.

- Vacuum forming is not an option for the whole outer box, since this box will be up to 40 cm high. The material that it is made of has to be stretched seriously which makes it less strong. 40 cm is too high.
- The inner and the outer box should not be able to touch each other since the inner box will reach temperatures up to 150° C. When the aluminium of 150° is attached to the outer box, the plastic will probably melt or deform.
- The material used will be 3 mm ABS sheet. The available colours are black, white and transparent. Other colours are possible but should be ordered in bulk (at least one ton) which is not desirable.
- The sheet material will be bent from front to back and two sheets will be glued and strengthened on the sides. To attach the inner box to the outer box, little aluminium spacers will be used on the bottom with a small insulation material between the aluminium spacer and the outer box. On top a vacuum formed square will be place which will attach the inner box to the outer box (again with a bit insulation material in between) and will the material where the hinges of the lid and the reflector can be placed on. This will be ABS or Polycarbonate. The lid will be polycarbonate but it is optional to replace it with glass. The reflector will be ABS sheet as well with the edges bent to strengthen it.
- Corrugated plastic, also called fluteboard or correx, could be used. It is strong, light and cheap. However, as soon as this material is bent, it is not very durable anymore and it will last maybe 6 months. Because it will be used outdoors and it from experience could be said that these cookers should be very tough, corrugated plastic is a risk that is too high to take.

Insulation:

Insulating materials that are used before in solar cookers are fibreglass, wool, rock wool, hay or straw or reflecting materials, like space blanket (also emergency blanket). The prices are based on 0,5 m2 needed material, including VAT.

Vedder and Moffat offers an insulating material called iw24, 50 mm thick, which is 1,2 m by 5 m and costs R289,5 excluding VAT or 1,2 m by 0,604 m which costs R36,40 excluding VAT. They also offer rockwool, 50 mm thick in a roll of 1,2 by 5 m for R657,40 excluding VAT. Converted to 0,5 m2 (estimation based on surface of inner and outer box) this would mean: R28 for an insulation of iw24 including VAT and R62 for a rockwool insulation including VAT.

Insulation convertors offers fibreglass as well. They have fibreglass blankets up to 25 mm thick in a roll that is 10 m long and 1,2 m wide, with a price of R485, excluding VAT. If it is ordered in bulk, 7,5% will get off the price. Converted to 0,5 m2 the price will be R23 per box and in bulk and R21,5 if ordered in bulk.

Foamworld has foam sheets of 5 cm thickness, and 2,3 by 1,9 m for R450. Converted: R58 per box.

Tape:

One of the parabolic cookers sold by Sunfire Solutions uses a reflective tape which would be perfect for the reflector or inner box of this cooker, this cooker is made in China. Some other box cookers, like the All Season Cooker, use already reflective tape, for example Duck band metal repair tape (Walmart), Shurtape AF912 (available at Lowes in the US) and Nashau 322 (available at Home Depot). However, most of these materials are not available in South Africa and the online shops in the USA do not ship materials overseas. An alternative was found at the company Falcon. They sell Rtape Printable metallic Films. The Smooth Silver is very similar to the tape of the Chinese parabolic cooker and costs 140 R a meter and is 1,22 m wide excluding VAT. For a reflector that is 0,4 by 0,5 m would this cost R26 including VAT. For the sides of the inner box would that be R32 (surface of 0,45 minus the bottom of 0,34*0,34m)

Metal:

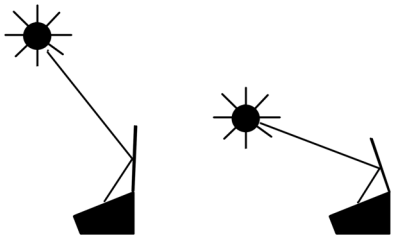
All the metal prices are given by the laser cutter that supplies the parabolic cookers for Sunfire Solutions. The prices are including VAT. For the inner box, a solid works sheet model is made, this model is also used for weight and surface calculations.

Appendix J: User guide

This is a start for the user guide that should be made for the new solar box cooker.

How to make your cooker ready for use.

- Take your cooker outdoors and place it on a dry, flat piece of ground.
- Point the cooker with the glass lid facing to the sun
- Adjust the reflector in a position where it reflects sun into the cooker. If your reflector is in the right position, you will see a light spot on the bottom of the cooker.
- Open the lid, pot your pots inside and close the lid.



What to do during cooking

- Try to avoid opening the lid, check your food as less as possible, because every time you open the lid, heat will escape and lengthen your cooking time
- Check every half an hour or hour if your cooker and reflector are still pointed to the sun

When can I cook?

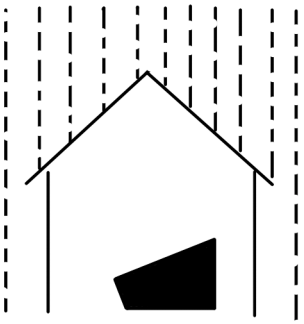
You can cook when the sun is shining. When you hold your hand in the sun and can see your fingers shadows, the sun is strong enough to cook. Some clouds are not a problem but if there are more clouds than sun, cooking will be much slower. If you cannot see any shadow from your fingers there is not enough energy coming through to cook on.

How long will it take me?

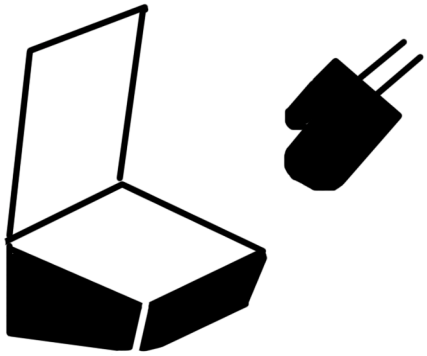
The oven will need 1, 5 to 2 times your "normal oven" cooking time. If you put the cooker outside and let it heat before you start to cook, it will be less.

Instructions

- Use as little water as possible. The more water you use, the longer it will take.
- Always use a black pot. If you do not have a black pot, take an ordinary pot and paint the outside of the pot black with a heat resistant paint. The thinner the wall of the pot, the faster your food will cook.
- If you want to clean the cooker, do so with a little bit of water, a mild soap and a towel or soft sponge. Never use tools that could scratch parts of the cooker
- Store the cooker inside after use to protect it from rainy weather or theft



- The inside of the cooker will get really hot during cooking, be careful when you take your pots out, always use gloves



Problem solving

- The glass condensates. Usually, the condensation will disappear when the lid gets hot from the sun. In addition you could treat the oven side of the lid with an anti-fog spray or soap.
- If something brakes down, please contact the manufacturer to see if it is possible to repair your cooker.

Recipes

[...]

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