Solar cooking in Kenya –

Development of a concept to increase diffusion

Master's thesis in Industrial Design Engineering

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CHALMERS UNIVERSITY OF TECHNOLOGY
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MASTER'S THESIS 2021

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Cover: Visualisation of the final concept in a user environment

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Abstract

This is a master thesis in Industrial Design Engineering written at the Department of Industrial and Materials Science, in the end of 2020 and beginning of 2021.

Almost three billion people use some kind of fuel to cook over open fires and as a result breathe in harmful smoke, which causes millions of deaths each year. Engineers Without Borders have initiated a project concerning solar cooking, since making use of free and available solar energy as a source when cooking has proved to both help fight poverty and decrease the risk of exposing the users to danger. Kenya has been the centre of operating solar cookers in East Africa and it is decades old in the country. Despite this much less than 1% of the population uses it. In this project an extensive take on the situation of today in Kenya has been made in order to identify obstacles to solar cooker diffusion. The aim of the project was to increase the understanding of today's user situation and develop a concept that intends to contribute to an increased solar cooking diffusion in Kenya.

Overall, the project followed a workflow of design thinking with iterations of the various phases. Through the theories of diffusion of innovations and domestication, user issues connected to the usage of solar cookers were investigated. Some of the methods used for conducting the research was analysing previous solar cooker project evaluations, collaborating with representatives from organisations engaged in solar cooking and interviewing the targeted user. This resulted in different identified problem areas, such as the material and the construction of the solar cooker being too vulnerable in order to withstand the user environment.

The intention of the presented user journey was to give a vivid description of the situation of today with the solar cooker and target group put in a realistic context. Three design concepts were created in an attempt to solve the most prominent product issues. One final concept was chosen, mainly because of its durability properties. The concept was named JiKoni (jiko=stove and koni=cone) and it is a type of panel solar cooker called conical cooker. The conical cooker was chosen since that type of cooker suits the geographical placement of Kenya in relation to the sun. The conical cooker was also considered to have great development potential, seeing that there are few but appreciated versions available today. JiKoni was created to withstand the user environment and to make the user feel safe to leave it during its time-consuming cooking. The concept is estimated to be more expensive compared to solar cookers that are usually used today but the benefits of a more durable cooker, in terms of e.g., being able to keep it for a longer period of time without frequent need of repairs, are meant to outweigh the price. This is meant to decrease the diffusion of solar cooking in Kenya since a product that could be used more also will be more exposed to others. The more the product is visible and appreciated, the more likely it is that other people will be willing to adopt it.

Acknowledgments

Throughout the process of this master's thesis project, we have received a great deal of support and assistance. We have (virtually) met many amazing and dedicated people who have made it possible to conduct this project.

Firstly, we would like to thank Hanna Hasselqvist, our supervisor, and MariAnne Karlsson, our examiner, at Chalmers University of Technology, for believing in our project and for all the valuable input and guidance throughout the project.

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We want to extend a special thanks to the organizations Asulma Centre, Farmers With a Vision and Ecomandate Foundation in Kenya who constantly supported and helped us throughout the project. Thank you for your time, efforts and generous support. With your help and valuable insights in solar cooking, we were able to carry out invaluable interviews in Kenya.

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Last but not least, we would like to express our love and gratitude to our families and friends for believing in us in carrying out this project.

Table of content

1. Introduction

This chapter presents and describes the background of the project followed by its purpose, aim and objectives. Research questions are defined to clarify what the project wanted to examine. Moreover, demarcations that have been taken into account during the project are presented.

1.1. Background

Today approximately four billion people in the world struggle to afford everyday necessities (Rosling et al., 2018). The United Nations are engaged in trying to end world poverty (United Nations [UN], 2020). They have put together 17 global goals (known as Sustainable Development Goals) aimed to work towards a better and more sustainable future for all. Engineers Without Borders (EWB) is a non-governmental organisation that works both locally and globally with projects connected to the Sustainable Development Goals (Engineers without borders Sweden, 2020). EWB is involved in areas concerning energy, waste management, water, sanitation, food production and processing as well as digitalization in low-income areas and has initiated a project concerning solar cooking.

EWB states that Kenya is one of the places where they operate and where solar cooking is rather common, and also rated as the 13th out of 25 countries in the world in terms of solar cooking potential. According to Solar Cookers International (2021), Kenya has been the centre of operating solar cookers in East Africa and is decades old in the country. Despite this much less than 1% of the population uses it (Kairu, 2019).

Solar cooking is an old method that uses the energy of direct sunlight to heat and cook food. It has been utilised in different parts of the world to gain both economic and environmental advantages (Solar Cookers International [SCI], 2018). According to SCI (2018), making use of free and available solar energy as a source when cooking has proved to both help fight poverty and decrease the risk of exposing the users to danger. Almost 3 billion people use some kind of fuel to cook over open fires and therefore risk to breathe in harmful smoke. This has in turn caused millions of deaths each year.

Introducing solar cooking has shown to contribute to all the 17 United Nations SDGs. However, despite the many benefits of the solution there are a number of obstacles for solar cooking diffusion (Hjalmarsson & Karnebäck, 2020). The technology has existed for at least 70 years but papers, research and documentation at the academic level are few. Even though there is a gap in the research concerning the use of solar cookers, there is limited data that states problems associated with why the full potential of solar cooking has not been reached (Hjalmarsson & Karnebäck, 2020). A major issue is though believed to be a failure to consider and integrate local needs, culture and perspectives. In addition, the existing solar cooker solutions require major changes concerning the cooking behaviour of the user and changes in the daily routines in general. For instance, it cannot be expected that the users will start to cook outside when they are used to indoor cooking.

There is also a problem with the image of solar cooking (Hjalmarsson & Karnebäck, 2020). Many people, though seemingly very poor and with few apparent options, still wish to hang on to their sense of personal dignity, no matter how constrained that this might appear. Solar cooking is not seen as an appealing or glamorous way of cooking food. This leads to an image of solar cooking as a technology for 'the poor'. It is therefore not attractive to the intended target group (who do not want to be seen as poor). In this context, people will be disinterested in solar cookers because of the stigma associated with them.

In summary, the data that do exist (a limited number of articles and project evaluations), indicates that the obstacles to solar cooking adoption are complex and need further investigation in order for us to fully understand the situation. Therefore, there is a need to further examine the situation which, in turn, calls for adequate user studies.

1.2. Purpose

The purpose of this project was to increase the usage of solar cookers among economically disadvantaged people in Kenya and hereby contribute to better health and environment and to economic growth in the long term for these people. By developing the product with consideration to previously overlooked aspects, the idea was to deliver a solution that to a greater extent meets the needs of the intended user. An increased utilization of solar cooking would benefit, not only the individual, but also contribute to a more sustainable world as a whole.

1.3. Aim and objective

The aim of this project has been to, in cooperation with Engineers Without Borders, increase the understanding of today's use(r) situation and develop a concept that intends to contribute to increased solar cooking diffusion in Kenya. The objective was to define the user context and develop one or several design concepts, with adequate representation and explanations, representing how today's issues could be solved.

1.4. Research questions

The main question guiding the process was the following:

How can (some of) the problems connected to the product usage be solved in order to get more economically disadvantaged people in Kenya to adopt the solar cooker as a part of their everyday life, in a way that benefits their living situation?

In order to be able to answer the main research question, the following subset of questions were explored:

- What does the solar cooking situation look like today in Kenya and why is the solar cooker not a bigger part of their everyday life?
- In what way can a solar cooker become a natural part of already existing cooking practices?
- What are the local needs, culture and perspectives and how can these factors be considered when developing a new solution?
- What are the aspects that have resulted in a negative user perception of today's product? How can these aspects be considered when developing a

new concept in order to avoid a negative and achieve a desired, positive perception?

1.5. Demarcations

The target group within the project has been limited to people living in Kenya on income level two, although solutions may apply to other countries with similar conditions. Unfortunately, field studies were not possible to carry out due to covid-19. Furthermore, the concept solution is presented as visuals with explanations, without any full-scale prototypes.

The project did not address manufacturing and cost analysis in detail. The target group has limited economic resources but there are cheap solutions offered today that still do not get adopted due to their shortcomings as a product. Instalments are becoming more usual and can make it possible for people to buy a product that originally would have been too expensive. With that being said, the cost of the product was taken into consideration, but it was not a deciding factor when developing concepts.

2. Theoretical framework

The theoretical framework consists of the theory of diffusion of innovations (Rogers, 2003) and the theory of domestication (Silverstone & Mansell, 1996). The theories explain how new ideas or innovations are spread and approached by society. This project has called for special attention to parts of the theories which concern the interactions between products and people. The theories slightly overlap each other why it has been necessary to combine them in a suitable way, as illustrated in figure 2.1.

The diffusion of innovations theory focuses more on the path towards a decision to either adopt or reject a new idea, where domestication targets the actual usage that occurs when the individual owns the innovation. Together they describe the different steps that the user might experience before obtaining the product and when interacting with it, along with the relationship that is built between user and product.

The first stages of the theory of diffusion are *prior conditions, characteristics of the decision-making unit (knowledge stage)* and *perceived characteristics of the innovation (persuasion stage)*, which are taken into account in this project. Thereafter, the domestication theory follows with the four phases which are *appropriation, objectification, incorporation* and *conversion*.

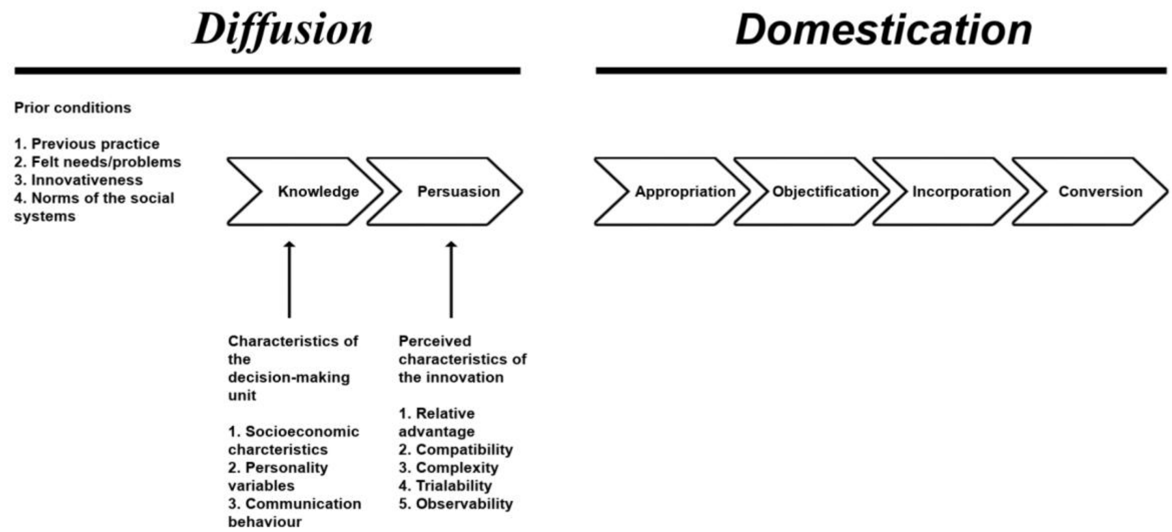


Figure 2.1
The theory of diffusion of innovations (left) and the theory of domestication (right) combined. Adapted from (Rogers, 2003; Silverstone & Mansell, 1996).

2.1. Diffusion of innovations theory

The diffusion of innovations theory, developed by Everett Rogers in 1962, describes how a new idea or product spreads among a population in a social system over time. The outcome of this diffusion is that people, as part of the social system, either adopt or reject the innovation (Rogers, 2003). According to Rogers (2003), adoption is a decision that an individual takes and is described as "*a full use of an innovation as the best course of action available*" (p. 57). This means that individuals change their behaviour and do something differently than what they have done before the adoption.

In order for the individual to either adopt or reject a new idea, he or she goes through a decision-making process, which begins with an individual getting introduced to a new idea (Rogers, 2003). Throughout the process, a number of characteristics affect and shape the attitude of individuals towards a decision of adopting or rejecting the innovation. The decision-making process of an innovation is divided in five steps but in this project, only two steps of the decision-making process are taken into consideration.

In the process of introducing and adopting an innovation, it is of high importance that individuals are informed about an innovation's potential advantages and disadvantages in order to reduce arising uncertainties of the innovation (Rogers, 2003). This results in making the individuals aware of the eventual consequences arising when they seek information about the innovation. This in turn results in a reduction of uncertainty of the innovation. Uncertainty is regarded as an obstacle to the adoption of innovations.

Presented below are characteristics and attributes influencing the process of an individual's journey towards deciding to either accept or reject an innovation.

2.1.1. Adopter categories

An important concept in the theory is adopter categories. Adopter categories refer to a division of a social system's members based on the relative time at which an innovation is being adopted (Rogers, 2003). The categories can be divided into two main groups, the earlier adopters (innovators, early adopters and early majority) and the later adopters (late majority and laggards) (Rogers, 2003). The first group of adopters are more likely to experience new innovations and either hold leadership roles in the social system or have good interaction with other peers (Sahin, 2006). The second group is defined as more sceptical about innovations, waiting for others to adopt it and also have a more negative attitude towards change (Sahin, 2006).

2.1.2. Prior conditions

Prior to the process of decision-making of an innovation, there are a number of conditions that affect the upcoming process (Miranda et al., 2016). Relevant prior conditions are *felt needs and problems*, and *norms of the social systems*. Felt needs and problems refer to considerable shortcomings of today's commonly used products. Lastly, established norms of the social system refers to common behaviour patterns and values among individuals (Rogers, 2003).

2.1.3. Knowledge stage: Characteristics of the decision-making unit

The process when an individual is introduced to the existence of an innovation is called the *Knowledge Stage* (Rogers, 2003). According to Rogers (2003), it is here where the individual investigates the existence of the new idea by addressing what the innovation is, how and why it works. The stage also includes personal characteristics that affect the decision-making process: *communication behaviour, socioeconomic characteristics* and *personality variables* (Almeida et al., 2017).

Communication behaviour
Individuals in the social system have different communication behaviours (Rogers, 2003). Rogers (2003) discusses and compares the communication behaviour among different adopter categories and how it affects their decision-making in terms of either adopting or rejecting an innovation. Social participation and interconnections through interpersonal networks are among the factors that affect individuals in this stage. Rogers (2003) describes that later adopters are less exposed to mass media and less engaged outside their own social system. They learn about most of the innovations via close relations such as friends and family members. He also discusses the importance of leadership among early adopters, who are highly capable of influencing their neighbours and friends.

Socioeconomic characteristics
According to Rogers (2003), generalized socioeconomic characteristics are more complicated to apply on individuals. Formal education and social status are among the factors that have an impact on individuals' opportunity of knowing about an innovation. However, some innovations require high initial investments to pursue an adoption and unlike individuals among later adopters, innovators have the economic benefits to cope with higher levels of uncertainties.

Personality variables
Similar to socioeconomic characteristics, personality dimensions are tricky to measure (Rogers, 2003). A few personality characteristics among the different adopter categories can though be anticipated according to Rogers (2003). For instance, later adopters tend to be more dogmatic than early adopters. Rogers (2003) ascertains that highly dogmatic individuals have a hard time welcoming new ideas due to strongly held beliefs and habits. Individuals holding on to their beliefs and values might prevent them from seeking for change and the existence of new ideas.

2.1.4. Persuasion stage: Perceived characteristics of the innovation

The *Persuasion Stage* describes the formed negative or positive attitude of an individual toward an innovation (Rogers, 2003). In this stage and compared to the former stage, the individual is rather emotionally than cognitively involved. During this phase, the individual is affected by a number of factors that determine the rate of adoption in the decision-making process. These factors are called perceived characteristics of the innovation and are presented below as *relative advantage, compatibility, complexity, trialability* and *observability*.

Rate of adoption is the relative speed of an innovation's adoption by individuals and is usually measured as the number of adopters in a defined period of time (Rogers, 2003).

Relative advantage
According to Rogers (2003), relative advantage is how much more efficient an innovation is considered to be in comparison with existing solutions, for instance in terms of economic profitability, initial costs, social prestige, and comfort factors. Some innovations are adopted to result in reduction of occurrence of unwanted future events. These are called preventive innovations and have a slower rate of adoption due to difficulties in perceiving innovation's relative advantage.

Compatibility
Compatibility concerns the extent to which an innovation is regarded as consistent with current values, traditions, previous experiences and potential user needs (Rogers, 2003). The more compatible, the quicker the adoption.

Complexity
Complexity characterizes the degree to which an innovation is perceived as difficult to understand and use by an individual (Rogers, 2003). A higher degree of complexity can lead to a slower rate of adoption.

Trialability
Rogers (2003) describes trialability as the degree to which an innovation can be tried and tested by individuals. The more an innovation is trailable, the less the uncertainty and the quicker it may be adopted.

Observability
Observability is the degree to which the results of an innovation are visible for individuals (Rogers, 2003). The more the results are visible, the more likely the uncertainties are eliminated and the quicker the innovation is adopted.

2.2. Domestication theory

Domestication theory is initially an approach in Science and Technology Studies (STS) and media studies that describes the processes by which Information & Communications Technologies (ICTs) are 'tamed' or appropriated by its users (Berker et al., 2006). It has been used to examine how people adopt or use technology in a particular way, and to examine constraints and pressures that inhibit adoption. The theory originally derives from anthropology and consumption studies, disciplines that explain how goods and possessions enter into our lives and what symbolic meaning they have (Haddon, 2011).

Domestication theory focuses on the dynamics between user, environment and a product (ICT) and how this dynamic can be analysed economically, culturally and sociologically/politically (Silverstone & Mansell, 1996). When there is interaction between the former it is often possible to observe a domestication process. The overall process is that the product is being integrated into the structures, daily routines and values of users and their environments (Berker et al., 2006). User, environment and product all need to adjust to one another throughout the process in order for a domestication process to be fully completed. Sometimes the interaction comes to an end and the product does not get fully domesticated, e.g., due to the user not being satisfied with the product (Carter et al., 2013). If more and more people feel like this then the overall development of the product will halter, leading to an even more alienated product with few users.

2.2.1. Appropriation

The first step in the process is called appropriation and describes how an artefact moves from just being a commodity to being an actual possession (Falck & Schnedler-Sørensen, 2018). This happens when a consumer buys a product and brings it home. By leaving the formal and entering the moral economics of the household, the product is now a part of a household and is physically and symbolically accessible by the people living there. It is of interest to investigate and consider how the product enters the home of the user. Depending on where you live you might have access to certain distributors, which affects what kind of products you decide to appropriate.

2.2.2. Objectification

In the second phase the user and the environment change to fit the product better (Carter et al, 2013). The artefact is not only given a place, but also a role within the aesthetic environment of the household. This type of positioning of the product reflects the values, tastes, and style of the product owners, since these all influence the choices made. It could also give an insight into which parts of the home that are private or shared, or whether it is targeted at adults, children, male, or female within the home.

An object could aesthetically be a well-fitted belonging to the home environment and therefore be displayed in a way that is not only justified by functionality of the object, but also its mere style (Berker et al., 2006). The surrounding environment is already established before the instalment of the object, but it is not fixed and can be rearranged to suit the changed conditions, though there could be aspects of a household that restrict certain places from being a possible fit. For example, if the product requires electricity, then a room without a power outlet might complicate the usage to such an extent that you chose to place it somewhere else.

2.2.3. Incorporation

If objectification represents placing, then the equivalent term for incorporation would be timing (Silverstone & Hirsch, 1992). This phase describes how the artefact is incorporated into the everyday life of the household by becoming a part of a regular routine and time structure - it emphasizes the actual usage of the product. When a routine like this is established, it is possible to see how the product is utilized by the user and what kind of activities it is a part of (Carter et al., 2013).

It is possible to see improvements that could be made to the product when looking at how the user tries to incorporate the product into their life (Berker et al., 2006). People often find ways to overcome shortcomings of the product, e.g., by modifying the product or changing their own behaviour in order for the product to work better. This is usually a short-term solution since the product is not always designed for these alterations and can give unforeseen consequences in the long term. A successful closure of this phase would mean that issues like these have been overcome (Carter et al., 2013). This does not automatically mean that the following phase, *conversion,* has not been entered by the user. Aspects connected to conversion could still be experienced by the user, even though issues that are typical for incorporation still arise.

2.2.4. Conversion

With conversion the object is communicated both symbolically and materially by the user to the public world (Silverstone & Hirsch, 1992). The product could give an indication of the values of the household for external visitors and represent the identity, judgement, taste, and style of the household (Carter et al., 2013). This is the phase where users within the household may come to define their relationship to the product. It is also where activities such as maintenance of the product occurs. Such subroutines might be buying disposable items that belong to the product, repairing broken details, replacing parts or thoroughgoing cleaning.

2.3. Summary

The theory of diffusion of innovations explains important factors when introducing the product (i.e. solar cooker) to people. The chosen phases of diffusion are utilized and presented as *conditions prior to solar cooking, characteristics of the decision making concerning the solar cooker* and *perceived characteristics of the solar cooker*. The phases will help to establish how the life of the user looks like before obtaining the solar cooker and what kind of aspects that influence the initial reactions to learning about it. In *conditions prior to solar cooking*, will be explained what kind of context the potential user is currently operating in and issues that arise independent of the solar cooker. With *characteristics of the decision making concerning the solar cooker* will be established how the potential user learns about the existence of the solar cooker and how their personality affects what they think about it. In *perceived characteristics of the solar cooker* will be presented what potential users think about the solar cooker and how useful it could be for them.

The theory of domestication should facilitate the understanding of what happens when the user owns the product and uses it. The four main phases are *appropriation of the solar cooker, objectification of the solar cooker, incorporation of the solar cooker* and *conversion of the solar cooker* and compose the structure for the forthcoming research concerning domestication, allowing the user behaviour to be studied through the aspects described in each phase. In *appropriation of the solar cooker* information will be presented how and where the user receives the solar cooker and what type of solar cooker the user has, along with other cooking related products that the user already has. In *objectification of the solar cooker* will be established where the user chooses to place the solar cooker in relation to usage. The actual usage of the solar cooker will be explained in *incorporation of the solar cooker*. The last phase, *conversion of the solar cooker*, will show what kind of deeper-rooted relationship that the user has with the solar cooker.

3. Process and methods

This chapter describes the way the project was carried out and the methods considered appropriate for this project. Overall, the project followed a design thinking workflow divided into the following phases: *explore, define, develop* and *finalize* as illustrated in figure 3.1. Iterations of the various phases were implemented and used throughout the project as an important part of utilizing design thinking (IDEO, n.d.). Most methods are derived from the following books: *Effektiva metoder för konstruktion och design* by Johannesson et al. (2013) and *Design: Process och metod* by Wikberg Nilsson et al. (2015).

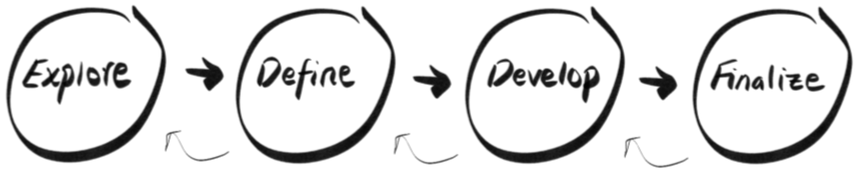


Figure 3.1
The project divided into four phases, illustrating their overall flow and iteration between phases.

3.1. Explore

The *explore* phase was used to gather all information needed for the project. The phase gave insight into the subject of solar cooking, the context of use and the target group. The methods used in the phase were literature studies, ethnography through digital resources and interviews.

3.1.1. Literature Studies

The literature studies worked as the first step to approach the project as a whole and are often used in the early stages of a project (Wikberg Nilsson et al., 2015). It gave insights that made it possible to later continue with other methods that required a deeper knowledge, such as formulating interview questions. The two main areas of study were *solar cooking* and *Kenya*.

Solar cooking
To be able to understand the subject better, information about solar cooking was gathered. Articles explaining the principle of solar cooking and products that are used, helped to understand the product and identify areas important to study further. The literature consisted of reports distributed and written by members of EWB and articles from the SCI website.

Kenya
In order to learn about the context of use, general information about the country, such as food culture and earlier solar cooking projects, was studied. Five different solar cooker project evaluations were analysed. Three of the projects were conducted in Nyakach in Kisumu, one in Kakuma refugee camp and one covered Kenya in general. The former provided comprehensive reports produced over the course of many months by SCI and gave extensive insight into the usage of solar cooking in those regions relevant for the project. The content was analysed to understand what

types of solar cookers that were being used, what purposes they were used for, to what extent the solar cookers were being used, how the product affected the lives of the users, if the users had to change their lifestyle in order to be able to use the product, what the users thought of the product and general areas of use that worked well compared to areas that did not work well. The outcome of the study worked as a base for further research and together with interview answers (see 3.1.3) worked as a useful resource.

3.1.2. Ethnography through digital resources

Ethnography through digital resources is specifically designed to study cultures and communities online (Cocq, 2019). It was used as a complement in order to collect as much information as possible considering that no field studies were possible to perform. However, by studying videos portraying the everyday life of people in Kenya, especially cooking related activities, it was possible to observe the target group. This was of great value since information regarding how people behave can get lost when only obtaining information from secondary sources. The online video-sharing platform YouTube was used to find material. By searching for keywords such as "cooking in Kenya" and "solar cooking in Kenya" it was possible to access information valuable for the project. The digital resources also worked as inspiration for the illustrations presented in Chapter *7. User journey*. In table 3.1, each observed video is listed and numbered. Throughout the presented result, information presented from the videos are numbered according to this table.

Observed videos				
Number (no.)	**Video name**	**Stove**	**People**	**Length**
1	*Clean Cookstove Project in Kenya*	Three-stone stove and improved cookstove	Kenyan women living in free settled community	00:11:00
2	*Solar Cooking in Kenya*	Solar cooker	Kenyan women and men living in refugee camp	00:02:55
3	*Suncookers: A solution rises every morning*	Solar cooker	Kenyan women and men living in free settled community and refugee camp	00:18:23
4	*A more Durable Solar Cooker for Desert Refugee Camps*	Solar cooker	Women and men all over the world (Kenyan refugee camp among others)	00:17:47
5	*Kenya Cooks with Improved Stoves*	Three-stone stove and improved cooking stoves	Kenyan women living in free settled community	00:03:35

Table 3.1
The observed videos.

3.1.3. Interviews

Interviews are used for the purpose of finding out about users' experiences, behaviours, opinions and attitudes about the product or service studied (Wikberg Nilsson et al., 2015). A variety of different types of interview methods are available.

Considering the information needed and with respect to the limited possibilities, different interviews were carried out with both solar cooker organisations and with people within the target group.

Interviews with entrepreneurs

Interviews with entrepreneurs working with organisations promoting solar cookers in Kenya were conducted. A total of four interviews were carried out with representatives of three different organisations. These organisations are Asulma Centre, Ecomandate Foundation and Farmers With a Vision, which are located in Nairobi, Nairobi and Busia respectively. These organisations were recommended from our contact person at EWB.

The interviews were conducted as a combination of semi-structured and structured interviews through both digital meetings via Zoom and by e-mail. Semi-structured interviews are based on a few prepared questions or topics to use as a guide during an interview (Pollock, 2020). Not all questions are necessarily used and are a list of topics to talk about during the interview. Structured interviews consist instead of sets of questions prepared in advance to be asked according to the planned order (Pollock, 2020). Two different semi-structured interviews via Zoom were carried out with the entrepreneur representative of Ecomandate Foundation. During the interview, probing took place which led to exploring and investigating unintended valuable topics. In addition, structured interviews via e-mail were conducted with each of the two remaining organisations.

The purpose of these interviews was gathering valuable information about the current solar cooking situation in Kenya, exploring experienced problems and needs from the point of view of a solar cooker promoter.

Interviews with target group

People from the target group were interviewed in structured interviews, in order to get a better understanding of their situation, factors that influence their everyday cooking and their relationship to solar cooking as well as to confirm that general information collected about Kenya and solar cooking could be applied to our specific target group. Structured interviews give control over the interview and allow answers to easily be compared to each other (Pollock, 2020).

Interviews were conducted with 42 people (31 women and 11 men) from either Kisumu or outside Nairobi. The interviewees were selected according to the chosen income level for this project and they were categorized as either users of solar cookers, or a family member to a user, (n=15), previous users that had stopped using solar cookers (n=13) and people that never had used solar cookers (n=14). Three different structured interview guides, as presented in Appendix I, were formulated according to these three categories. The interview guides all had some aspects in common, such as general questions about the interviewee concerning family situation, everyday life and cooking habits. What was different between them concerned the interviewee's relationship to solar cooking. Users were asked e.g., about their situation today with the solar cooker; people who had stopped using their solar cooker were asked e.g., how their situation used to look like and why they stopped using it and people who had never used a solar cooker were asked e.g., what they thought about the product. The interviews were conducted by contacted entrepreneurs since it was not possible for us to be on site in Kenya (due to the covid-19 situation). The interview guides were e-mailed to the entrepreneurs and clarifications and instructions were later communicated through video conferences, phone calls or e-mails to confirm that the entrepreneurs knew how to properly conduct the interviews.

3.2. Define

The *define* phase was about analysing and compiling the gathered data. The process was initiated with a user journey which resulted in different development areas being identified followed by a set of guidelines operating as underlying tools for the upcoming *develop* phase. The methods used in this phase were the *KJ-method, User Journey*, ending with *solution guidelines.*

3.2.1. KJ-method

Qualitative information from literature studies, ethnography through digital resources and interviews was analysed using the KJ-method in order to get a better overview of the data, by grouping similar and frequent occurring topics and issues according to a main structure based on the theories (cf. Johannesson et al., 2013). Information from literature studies and netnography was analysed digitally and colour coded according to source. The interview answers were analysed in a similar way but transcripts were printed and cut out individually and placed on a large board along with post-its denoting the topic. Each interview statement was both colour coded and marked with a symbol to be able to trace the statement back to its source. The process required discussions between the group members and there were several rearrangements made until a satisfactory and consensus result was achieved. The topics that were identified in the theories were later used as headings for the presented result. From the diffusion theory, the identified topics were *conditions prior to solar, characteristics of the decision making concerning the solar cooker* and *perceived characteristics of the solar cooker* and from the domestication theory, the identified topics were: *appropriation of the solar cooker, objectification of the solar cooker, incorporation of the solar cooker* and *conversion of the solar cooker.*

3.2.2. User journey

A user journey is a visual representation of how an individual relates to and interacts with a certain product or service over time. According to Wikberg Nilsson et al. (2015), it is a method used for clarifying and identifying experienced events in all steps a person performs during the use of a product or service. The aim is to gain a deeper understanding of the process that the user goes through. For a more realistic and experience-awakening view of the user journey, a *Persona* is used in combination to evoke a user presentation as a reference for the reader (Wikberg Nilsson et al., 2015).

In the project, a persona and a journey were combined based on the results generated by the KJ-method, prior to the step of identifying guidelines. The chosen type of solar cooker product in the user journey was based on a product that was commonly used among many interviewees and that included a majority of crucial emerging issues and pleasures. Initially, a description of a person belonging to the target group was presented, emphasizing common needs, desires, thoughts and experiences. The user journey addressed several different parts of the journey, such as the moment the person learned about the product's existence, how the product was used over one day from start to end, and if the user stopped using the product and why. During the entire description of the user journey, both identified problem areas and pleasure points were described to take place in an appropriate and actual context.

A second user journey was created in the later stage of the project to be compared with the first one. The second user journey was produced in the stage of concept finalization, where the final concept was put into a new context of use. This was made in order to highlight affected user areas and show the intended benefits. The new user journey was studied by the entrepreneur from Farmers With a Vision in order to confirm that the description was realistic and that the concept actually could benefit the assumed user as described.

3.2.3. Solution guidelines

The guidelines, for creating concept ideas, were produced to summarize solutions to the different identified user problem areas and to express what kind of requirements the solar cooker concept should fulfil. By combining two methods, i.e. formulating a function analysis together with creating design guidelines, a version that was more well-suited for the project could be utilized. A function analysis could be made by listing different functions that the concept should have, using a system of combining a verb with a noun in order to express the functions (Johannesson et al., 2013). Design guidelines are often more describing to their nature and have a more flexible format, making it easier to use as a first step when setting the frame for the idea generation phase (Interaction Design Foundation, n.d.). Design guidelines are also built on the principles of design which help develop guidelines that present a clearer path into how the solution might look like. It was fruitful to use a mix of these two since some requirements were more fixed than others. An example of the formulated guidelines is "offer solar cooking", expressed in a typical function analysis manner, like the function that the solution had to offer. It was not intended to be changed in any way during the idea generation, it was rather used as a constraint. The guideline of "durable material and construction" was derived as a design guideline and worked as a powerful tool to create several different ideas.

3.3. Develop

The section presents the process underwent when developing a final concept making use of the results obtained from the previous phase. The procedure began with a collage of representative photos followed by *idea generation, concept development* and *concept selection*, with iterations between each step. Finally, a concept was finalized and visualised using software programs.

3.3.1. Styling board

A styling board is a collage of photos representing how other products or services have addressed needs similar to the ones that you intend to address (Wikberg Nilsson et al., 2015). The solutions can proceed from the same or completely different areas but primarily fulfil the same functions. The aim is to get inspired in preparation for the stage of idea generation by looking at how other artefacts solve the same identified problems by form and shape, materials and colours.

During the project, a styling board was created by looking at the areas identified as in need for development followed by searching for possible solutions on the market that solve different needs. The styling board operated as a first step into the idea generation step.

3.3.2. Idea Generation

Initially it was desirable to develop many different ideas, without thinking too critically about their feasibility. To stimulate the creation of ideas two different idea generation methods were used: braindrawing and SCAMPER. The styling board worked as inspiration.

Braindrawing

The idea generation stage was entered by using the method of braindrawing, which is a non-verbal method in which the group members sketch and create ideas with focus on quantity rather than quality (Wikberg Nilsson et al., 2015). With the styling board as inspiration different ideas were individually generated using both pen and paper and the digital drawing tool Procreate. Then each member of the design duo presented the ideas to each other and explained the reasons behind them. The drawings were exchanged between each other and further developed in different directions. The method helped produce the first sets of ideas of the project.

SCAMPER

Scamper is a creative brainstorming technique that encourages a product developer to think how ideas generated from braindrawing sessions could be improved (Wikberg Nilsson et al., 2015). The name of the method derives from the seven letters that stand for Substitute, Combine, Adapt, Modify, Put to another use, Eliminate and Reverse. These words are used and asked during the improvement of the ideas.

This method was used in the process of idea generation for the purpose of further developing produced ideas. Each group member combined and modified their own, but mainly each other's ideas, with lots of iterations during the process. The method resulted in a number of potential sub-solutions and ideas used in the next phase of concept development.

3.3.3. Morphological analysis

Ideas generated in the previous phase were gathered and organised for further development using systematic methods. The outcome of the concept development process was a number of potential concepts.

A morphological analysis is a method used for producing complete ideas by combining different sub-solutions (Johannesson et al., 2013). In the project, a number of main functions that derived from the solution guidelines were listed on each row with corresponding sub-solutions in a matrix. The sub-solutions were then systematically combined by drawing polygons in the matrix. The combinations were made with consideration to geometric and physical compatibility between the sub-solutions. The method resulted in a total of three potential concepts. Remaining sub-solutions were screened out due to resulting in unreasonable and incompatible complete solutions.

3.3.4. Pugh evaluation matrix

The goal of this step of concept selection was to choose a concept among the three potential concepts that were produced by means of the morphological matrix. The procedure was possible using the systematic method *Pugh evaluation matrix*.

A Pugh matrix is a method of systematically choosing the best, among several possible solutions (Johannesson et al., 2013). In a Pugh matrix, the selection is based on relative comparisons between different concept solutions and a reference solution. The method serves as a basis for the final concept selection.

In the project, a Pugh matrix was created based on the solution guidelines listed as criteria. The evaluation was made of the three remaining concepts with a reference product (the CooKit solar cooker). The reference product was selected based on being the most evaluated solar cooker and widely used among users in the target group. The method resulted in different concept scores and rankings which led to one concept chosen for further development.

3.3.5. Moodboard

A moodboard was used to create a direction for and style of the selected concept. The method of creating a moodboard is a powerful tool for designers in order to communicate with more than just words (Johannesson et al., 2013). By collecting visuals, such as images, it is possible to get an idea of the visual gestalt of the concept. Photos of objects that were considered to represent and express the desired style of the concept were collected and put together in a collage.

3.4. Finalize

The chosen concept underwent a finalization phase where further developments were made with the help of feedback from organisations and EWB. Further sketches and prototypes were developed and a list of criteria completed the last step before final 3D visualisations were made of the concept.

3.4.1. Feedback

The described context and target group, along with the identified development areas were discussed and evaluated with EWB and with one of the entrepreneurs. The early stages of the idea generation were presented to EWB. This was a way to confirm that discovered and highlighted areas of interest actually mattered, but also to get further ideas and investigate overlooked aspects.

Since the actual users were difficult to get in contact with and the concept produced was in a relatively early stage of development, the options for choosing suitable evaluation methods concerning the final concept were limited. Still, the presented ideas and visualisations worked as support for discussions with EWB and the contacted entrepreneurs in Kenya. It was especially important to get the feedback from the entrepreneur at Asulma Centre who had great insights about the conical cooker that was chosen in the project as the type of panel cooker to be further developed. Questions that were asked during the evaluation were e.g. *what are your thoughts when you see this concept?, could you see the user benefiting from this concept?, and how do you see it in comparison with current solar cookers?* A new user journey was also presented in order to give a better understanding of how the concept actually would work and to offer user situations in a context to reflect upon. Some of the insights of the evaluation did lead to changes regarding the final concepts, others that required more work are included as recommendations for future development in *16. Conclusion and recommendations for future development*.

3.4.2. Further sketches and prototypes

This stage required less individual work and more cooperation between the group members in order to create a precise solution. When still exploring possible solutions, physical and digital drawings were made along with simple prototypes and estimations regarding measurements and how the cone would fit inside the ring (see Appendix IV).

In the project, smaller scale physical prototypes were made to physically experiment different shapes as representations of the chosen concept. The prototyping was based on a truncated cone placed in a fixed ring. The purpose was to investigate the rotational movement of the cone in the ring which was crucial in order to make sure that the product could undergo directional change according to the movement of the sun. The shape of the cone, in combination with the ring, was also analysed using the computer-aided industrial design software Alias. This was to establish how the shape of a tilted cone relates to a circular ring.

3.4.3. List of criteria

Before the finalization of the concept design criteria were formulated to control that the solution would improve the user situation. The list worked as a strict version of the solution guidelines, with more precise requirements regarding the specific selected concept. The list of criteria should include other areas of interest than just the needs of the user, such as technical and other quality aspects (Johannesson et al., 2013).

3.4.4. Finalization of concept

In order to create the final visualizations, the computer-aided industrial design software Alias and Vred were used to produce a three-dimensional model of the concept with renderings.

EXPLORE

In the following chapter, gathered data and information about solar cooking and the Kenyan target group in the intended context are initially presented. Next, the collected data and information about the user in relation to product usage are analysed and presented according to the theories of *diffusion of innovations* and *domestication*. The results of the analysed data are presented in accordance with the structure of the theories. Furthermore, a user journey is presented, summarizing the data analysed, followed by a number of identified development areas and guidelines for the next concept phase of the project.

All information presented is based on literature studies and interviews made with the target group and solar cooker entrepreneurs, if not otherwise stated. Results from the ethnography through digital resources where studies were made of videos, are also presented.

4. The context

All information presented in this chapter is based on the literature studies and interviews made with the entrepreneurs. Results from the ethnography through digital resources, where studies were made of videos and blogs, are also presented.

4.1. Solar cooking

Solar cooking is the generic term for when utilizing the energy of the sun in order to cook food, without first transforming the solar energy into electricity, which makes the efficiency much higher compared to using e.g., solar PVs (Solar Cooking International [SCI], 2020e). By using reflective surfaces, sunlight can be directed into a concentrated spot and the converted heat caught by a combination of insulation and absorbing surfaces and materials, as seen in figure 4.1.

Solar cooking is made outside and requires sunshine in order to work. Different places in the world have different amounts of sun which is a crucial aspect in how suitable the method is. Countries close to the equator, such as Kenya, Rwanda, Nigeria, Chad, Algeria, Libya, Egypt, Sudan and many others on the African continent have ideal solar cooking conditions (Parry, 2012).

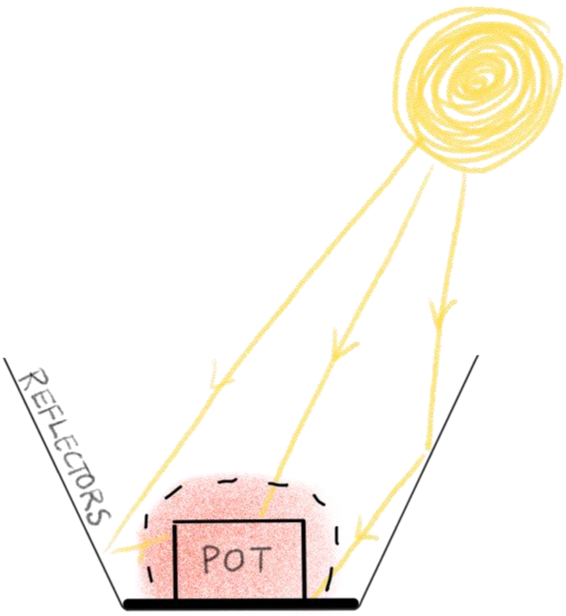


Figure 4.1
An illustration showing the principle of a solar cooker.

Kenya lies close to the equator, towards a 0 degrees latitude (Solar Cooker at Cantinawest, 2017). The sun approaches a 90 degrees angle at midday which means the sun is directly overhead, compared to other places far away from the equator that never face direct sun in the same way. The only adjustments needed towards the sun are according to the solar elevation angle that varies throughout the day.

Compared to many other cooking methods solar cooking is time consuming, but on the other hand it does neither require the user to be present while the food is cooking, nor will it pose a risk of overcooking the food (SCI, 2020e). However, since the sun does not always shine it is not always possible to use a solar cooker. Furthermore, most solar cookers do not have a capacity that suits the needs of larger families, which is why users have other stoves as well. Integrated solar cooking is an expression to clarify that solar cookers need to be integrated with other cooking methods since people cannot solely rely on the sun.

4.1.1. Solar cooker models

The three most common types of solar cookers are box cookers, panel cookers, and parabolic cookers (SCI, 2020e). There are uncountable numbers of variations, but they are often based on these types. For best results, most solar cookers are meant to be used with a dark surfaced pot with some kind of insulation.

The panel cooker
The panel cooker has a relatively large reflector that surrounds a horizontal area made to put the pot in (SCI, 2020e). The construction is lightweight and possible to fold together. It is often made of a thin material such as cardboard that is covered in foil or reflective plastic sheets. The pot is placed in the centre of the panel with some type of transparent enclosure to retain heat, which could be a plastic bag wrapped around it, or a plastic sheet that surrounds the walls of the pot. Panel cookers usually achieve temperatures of 110 - 140 °C (230 - 284 °F) which is on the lower spectra of what solar cookers usually could achieve. It takes between 2-4 hours to cook most foods and during that time the solar cooker should be redirected to follow the sun. The most popular panel cooker is the CooKit, as shown in figure 4.2, which is used in many different contexts, e.g., refugee camps. The CooKit cooker is easy to build and the materials are cheap.

Figure 4.2
The panel solar cooker called CooKit.

[Photograph], by Asulmacentre Selvhelpgrp, 2020a, Facebook (https://www.facebook.com/photo.php?fbid=544710726034136&set=pb.100014856404451.-2207520000..&type=3).

Three other commonly used panel cookers types are the Conical solar cooker, the Copenhagen solar cooker and Haines 1 (SCI, 2019). The Conical solar cooker is a funnel shaped cooker allowing all the sunlight to enter the large opening to reach the smaller bottom (SCI, 2015). Similar to the CooKit, the Conical solar cooker is easy and inexpensive to make, however not as widespread and there are few commercial versions. Symmetrical conical cookers placed in a stand, as shown in figure 4.3, are especially suitable for countries around the equator, where the angle of the sun only depends on time of the day and not as much on the altitude angle (Solar Cooker at Cantinawest, 2017; Jones et al., n.d.).

Figure 4.3
The conical solar cooker.

[Photograph], by Asulmacentre Selvhelpgrp, 2020b, Facebook (https://www.facebook.com/photo.php?fbid=1019851825186688&set=pb.100014856404451.-2207520000..&type=3).

The Copenhagen solar cooker, see figure 4.4, is a curved shaped and inexpensive solar panel cooker mainly made from four reflective vinyl covered panels held between a base plate (SCI, 2020f). Compared to typical panel cookers, the curved shape of the Copenhagen cooker makes it more stable in windy conditions.

Figure 4.4
The Copenhagen Solar Cooker.

[Photograph], by Asulmacentre Selvhelpgrp, 2020c, Facebook (https://www.facebook.com/photo.php?fbid=975616169610254&set=pb.100014856404451.-2207520000..&type=3).

Haines 1, see figure 4.5, is a panel solar cooker that is often used for efficient water boiling (SCI, 2020g). The reflector has a flat bottom and a parabolic shape made from metalized polyester which is said to be resistant to oxidation and scratching. Accessories included are a cooking sleeve and a circular cover made for insulating the cooking pots, creating a greenhouse effect and to keep the reflector stable when there is a wind.

Figure 4.5
The solar cooker Haines 1.

[Photograph], by Asulmacentre Selvhelpgrp., 2020d, Facebook (https://www.facebook.com/photo.php?fbid=957917068046831&set=pb.100014856404451.-2207520000..&type=3).

The box cooker
The box cooker, as shown figure 4.6, is made out of an insulated box with the lid of the box as the reflector, half opened to reflect the sunlight down into the box (SCI, 2020h). Another transparent lid covers the top of the box and makes sure that the heat stays. The box could be made of cardboard or wood, with stuffed double walls to increase insulation. The pot is placed inside the box and unlike the open construction of the panel cooker that requires a separate plastic bag or sheet, the box cooker is insulated enough when the transparent lid is closed. Solar box cookers typically cook food at temperatures between 90 - 200 °C (194 - 392 °F). The cooking time is similar to the panel cooker. It is possible to build simple box cooker versions yourself even though manufactured ones are better sealed. The box cooker is more expensive to buy compared to the panel cooker.

Figure 4.6
The box solar cooker.

[Photograph], by Asulma Centre Self Help Group., 2020e, Facebook (https://www.facebook.com/Asulma-Centre-Self-Help-Group-1019285011511571/photos/2277081235731936).

The parabolic cooker
Parabolic solar cookers use a parabolic-shaped reflector, as seen in figure 4.7, in order to direct the sunlight to a concentrated, small area (SCI, 2020i). The reflector is usually made of high heat resistant plastic and is held up by some kind of stand that allows frequent adjustments. The parabolic cooker does not require any other insulation than that of the cooking pot. The pot is placed in a stand in the middle of the concave side of the parabola and will reach high temperatures. Parabolic solar cookers

typically cook food at temperatures between 120 - 230 °C (248 - 446 °F) which allows for food to be fried and grilled. In order to achieve this it is important to reorient cooker during the cooking time, often every fifteen minutes. The cooker is difficult to build and expensive to buy.

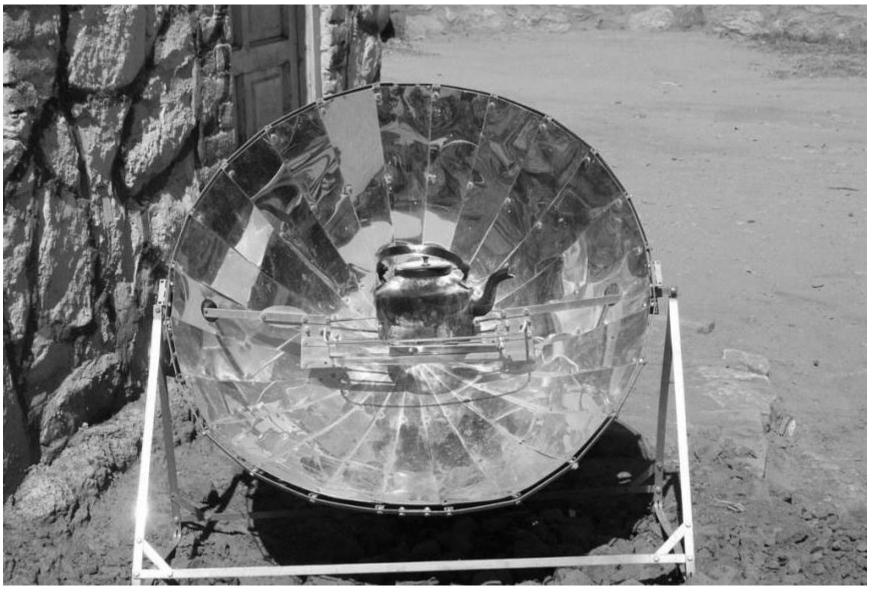


Figure 4.7
A parabolic solar cooker.

From *Solar Cooker* [Photograph], by Huffman, T., 2010, Flickr (https://www.flickr.com/photos/99287245@N00/4499722022). CC BY 2.0

4.2. The Kenyan target group

Kenya is a country located in Eastern Africa, centred at the equator, as seen in figure 4.8 (Countries and their Cultures, n.d.). The country has a coastline on the Indian Ocean and borders South Sudan to the northwest, Uganda to the west, Tanzania to the south, Somalia to the east and Ethiopia to the north. Kenya's capital is Nairobi, which is also the largest city of the country. The current population of Kenya is estimated at around 54 million people (Worldometer, 2021). The Kenyan population is divided into more than 70 ethnicities with the largest ethnic group called *Kikuyu*. The official languages spoken in Kenya are Swahili and English, the latter being inherited from the British colonial rule (Languages of Kenya, 2021). However, Kenya is a multilingual country with 62 languages spoken by the various of ethnic groups (Discover Africa Safaris, n.d.).

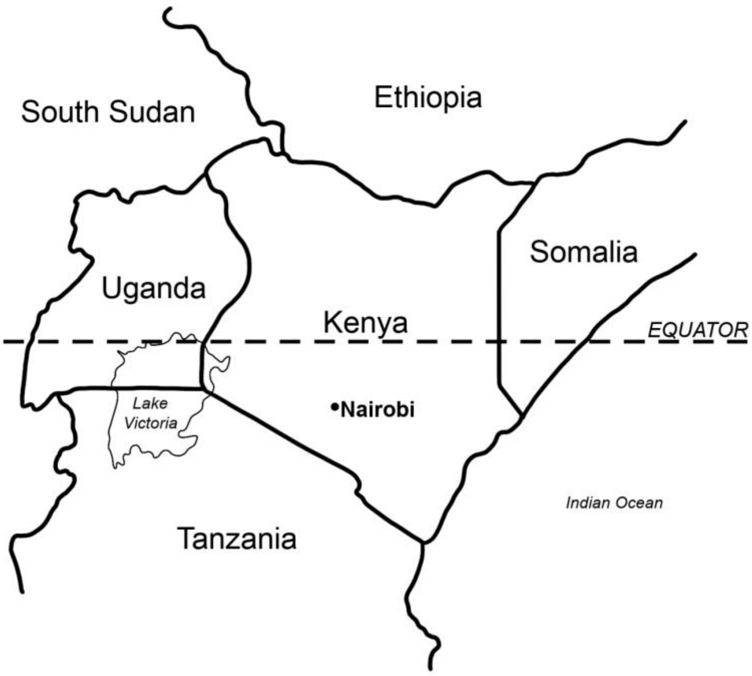


Figure 4.8
A map of Kenya.

According to Hans Rosling (2018) there are four levels of income in the world. The chosen target group in this project is individuals with a level two income in Kenya. The selected land areas specifically studied in this project are foremost the south west parts of Kenya: areas around Nairobi, Eldoret (city in Uasin Gishu County), Busia, Kisumu, Kisii (with exception for Kakuma Refugee Camp). A major part of the identified information regarding solar cooking in Kenya covers these areas. The areas of interest are free settled communities in rural settings and even though some information is gathered from refugee camps, in the target group is not included the communities in refugee camps.

People on level two earn between 2 and 8 United States Dollar (USD) a day and are not struggling as much as people on level one. However, they still have extremely limited resources and constantly face challenges due to the physical work that they are exposed to. Usually they work as farmers and are able to save some money to buy other necessities e.g., chickens, which in turn means production of eggs. A bike is regarded as a crucial purchase on level two and makes a huge difference on someone's lifestyle. Having a bike allows them to travel longer distances in a shorter time. It is used when for instance heading to work or fetching water, which could also be directly collected from rain outside of their homes. Meals are still simple and might consist of vegetables, meat or eggs that are bought from local shops or markets or come from their own property. Some people on this level can afford gas stoves instead of cooking over an open fire. Owning a gas stove allows children to go to school instead of spending their time collecting wood. Living on level two means that basic medication can be afforded if needed. However, if someone is unlucky enough to encounter severe sickness or damage caused by natural disaster, this could mean stepping down to level one.

When comparing different groups of people with each other, the economic situation is sometimes confused with cultural differences. Rosling et al. (2018) argue that though it is difficult to draw an exact line between them, there are a lot of similarities between people on the same level even if they are from widely different cultures. For example, the way people heat water or cook food is very much dependent on their income level, rather than their culture. Still, there are differences within these ways. The method might be principally the same, but since the context may vary and people behave differently, there will be cultural variations.

4.2.1. Weather

Since Kenya is located at the equator, the weather differences are small between summer and winter (Ham, 2021). The country has a tropical climate with daytime temperatures averaging between 20°C - 28°C (68°F - 82°F). According to the interviewed entrepreneur from Asulma Centre, the areas covered in the project receive approximately 180 days of sun each year. During the year the sun rises earliest at 5.29 a.m. (end of November) and latest 7.03 a.m. (end of July), and the sun sets earliest at 5.45 p.m. (beginning of June) and latest at 7.13 p.m. (middle of January) (Vackertväder, 2020). The climate is suitable for solar cooking, though there are both a dry season, ranging from October to March, and a wet season, ranging from April to September (Climates to travel, n.d.). The different seasons does not imply that it is either constant sunshine or constant rainfall, but that one or the other is more occurring.

4.2.2. Economy

Over the past decade Kenya has made reforms that have driven sustained economic growth (World Bank Group, 2020). The country still faces challenges such as poverty, inequality, climate change, continued weak private sector investment and a vulnerable economy. The proportion of Kenyans living on less than the international poverty line, 1.90 USD per day has declined from 43.6% (2005/06) to 35.6% (2015/16) (World Bank Group, 2018). According to Gapminder (2020), a tool based on the Four level-theory, the average Kenyan income would correspond to the lower spectra of level two.

4.2.3. The homes

The average family size in Kenya is 4.0 people per household, typically consisting of two parents and children (Njanja, 2019). However, during an interview with the entrepreneur from Ecomandate Foundation, it was said that this number is higher in lower income regions with an average family size between six and ten people.

Around 70% of the Kenyans live in rural areas, having in mind that more and more people are moving to the cities in search for work (Countries and Their Cultures, n.d.). Two major urban areas in Kenya are Nairobi and the south-eastern city Mombasa, where most people live in apartment buildings. In the countryside however, housing styles differ from one ethnicity to another. According to the entrepreneur from Ecomandate Foundation, houses are either rectangular or round and are in most cases made of either or a combination of grass, sticks and mud. Roofs are usually made of grass or of iron sheets, as seen in figure 4.9, if the household is able to afford it. In counties like Samburu and Turkana, situated in the Rift Valley province, beehive-like houses called Manyatta houses are common. Some people have chosen to use modern building materials such as bricks or cement blocks and corrugated iron or tin for the roofs.

Figure 4.9
A woman in front of a typical house in rural Kenya.

From *Caren in front of a Kenyan House* [Photograph], by Chacon, S., 2007, Flickr (https://www.flickr.com/photos/52724571@N00/1393943878). CC BY 2.0.

According to Hans Rosling (Rosling et al., 2018), living on level two, independent of where you live on earth, the basic facts and lifestyle are quite similar. A common house for the level two income group in the rural parts of Kenya might consist of between one single room and four rooms, depending on the affordability. These rooms include a living room, bedroom(s) and kitchen.

Typical kitchens in the parts of rural Kenya and among households on level two have been noticed in all videos to vary among the households. Many Kenyans do the cooking inside of their house, even though outside cooking occurs (Amosy et al., 2010; Kaburu et al., 2019). Inside cooking has the benefit of warming up the house, shedding light, scaring away pests and making it more difficult for animals or people to steal the food or the stove itself (Njagi, 2018). It was observed in video no. 5 that some kitchens are included in the main house and are either a separate room or placed in a certain corner as a part of another room in the house. It was also noticed in video no. 1 that some households rather had a separate room outside the main house. In addition, the belongings included in the kitchen were rather similar among different households. Main utensils included, beyond cooking stoves, are aluminium pots called sufurias and wooden spoons as shown in figure 4.10. The sufurias are mainly placed either on the floor or on self-made shelves. There is often some kind of a seat close to the cooking spot, either a chair or a stool.

Figure 4.10
Woman stirring food with a wooden spoon in a sufuria.

From *Cassava flour and water are heated and mixed together to create a food called 'ugali'. Mkuranga district, Tanzania. Photo H.Holmes/RTB* [Photograph], by Roots, Tubers and Bananas, 2017, Flickr (https://search.creativecommons.org/photos/2d5dabd7-4b6e-40cf-9b64-e50a2b935ba3). CC BY 2.0.

4.2.4. Health issues

Today about 3 billion people around the world still cook food using fuels and technologies producing high levels of household air pollution (World Health Organization, 2018). Harmful cooking practices are causing many diseases and close to 4 million people are dying each year as a consequence of household air pollution. Women and children, who spend the most time close to the domestic house, are the most affected. In Kenya most people use some type of wood stove and the soot causes a lot of health issues (Kairu, 2019).

Moreover, a common health problem among adult women in Kenya is low back pain (Kipruto, 2018). This due to the nature of their daily responsibilities and routines which are often physically demanding as seen in figure 4.11. In many parts of the rural parts of Kenya, farming is a common role among females in order to produce food for their households. Farming activities combined with household chores include postures like bending, stooping, twisting and the act of carrying heavy loads. These are factors that contribute to high occurrences of low back pain among women in rural Kenya.

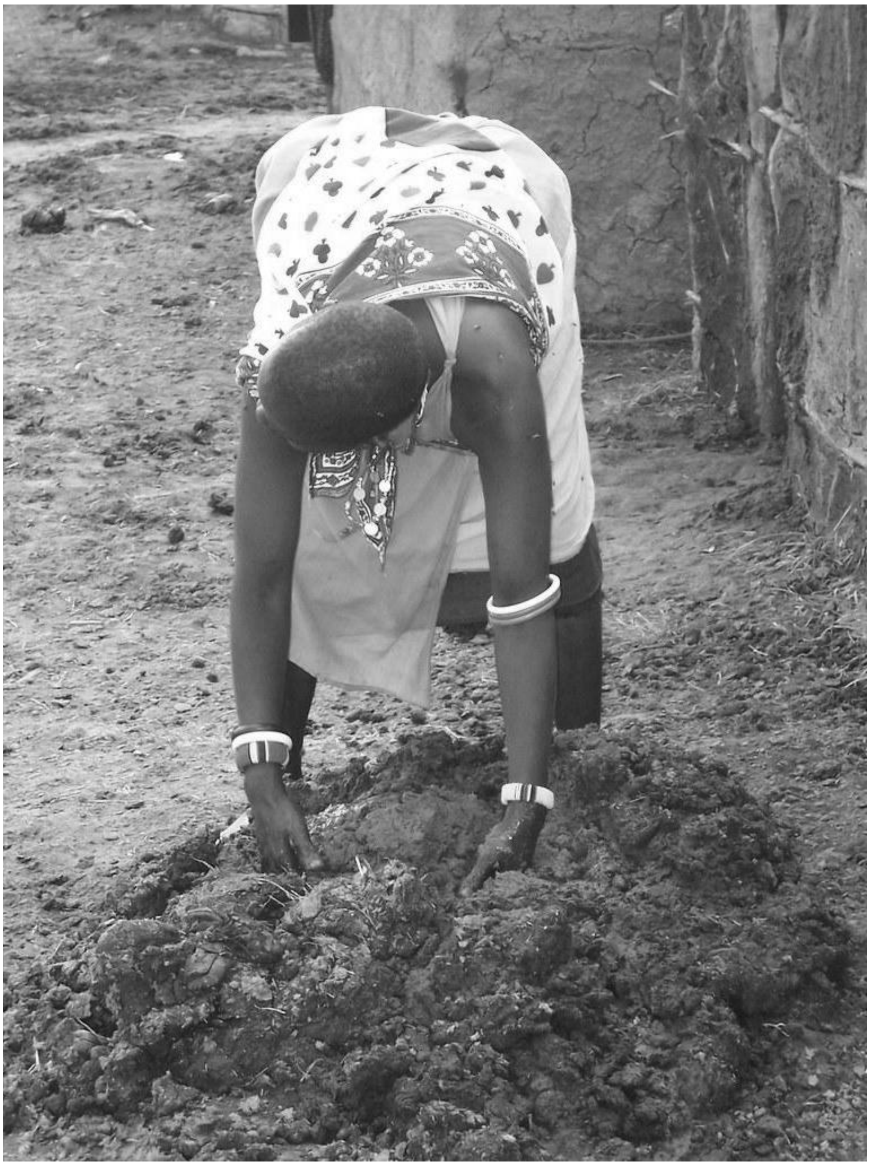


Figure 4.11
A Kenyan woman doing a physically demanding activity.

From *Masai Woman collecting dung* [Photograph], by Chrissy Olson, 2005, Flickr (https://www.flickr.com/photos/82733598@N00/119466718). CC BY-ND 2.0

4.2.5. Food culture

Tea and coffee are grown in Kenya and the country is the world's biggest exporter of black tea (Reuters Staff, 2020). Tea is also frequently consumed, especially in the morning. Chai, which means tea in Swahili, is an important part of the typical Kenyan breakfast and is usually served very milky and sweet (Siyabona Africa, 2021). Fermented milk is popular since many Kenyans are lactose intolerant. In more rural areas the fermented milk (maziwa lala) is common. Kenyan breakfast tends to be rather sparse. Except for the chai, a piece of bread (mkate) or some porridge is common in the morning. Stews, porridges and fried food are common as lunch and dinner. Kenyan food staples are maize meal (cornmeal), rice and cereal such as millet and sorghum. Other common foods are vegetables (such as green leaves/kale, kachumbari (type of tomato), onion, beans and meat (such as beef, goat or chicken).

Some typical Kenyan dishes are ugali, sukuma wiki and githeri (Nicci, 2020). Ugali is a cornmeal porridge made by mixing maize (corn) meal with boiling water. It is a staple of the Kenyan diet and is eaten by many in Kenya on a daily basis (Cockburn, n.d.). It is usually served as a side for stews, curries, meat, fish or vegetable dishes.

The texture is rather stiff which makes it suitable to use to scoop up other foods. Many locals eat with their hands and a small piece of ugali can then be used to scoop up the sauce.

Sukuma wiki is Swahili and means "stretch the week" (KPBS Public Media, 2013). In Swahili there is no specific word for kale or collard greens, even though they are staples of the East African diet. Rather they call it "stretch the week" to emphasize how these greens can easily fill out the everyday menu since they are grown fairly easily. Sukuma wiki can also include tomatoes, onion and spices and are sometimes served as a side for meat or ugali, as shown in figure 4.12, or just eaten alone (Low Carb Africa, 2020). Githeri is a one-pot meal made up of a mixture of beans and corn that are cooked together with water (Nicci, 2020). Just like with sukuma wiki it is common to also add tomatoes, onion and seasoning.

Figure 4.12
Ugali served with sukuma wiki.

From *Ugali & Sukuma Wiki* [Photograph], by Jai, P. 2009, Flickr (https://search.creativecommons.org/photos/048d6ced-8978-4582-b35f-0ea71321f735).

The food culture has some variations depending on where in Kenya you are (Odede et al., 2017). Some areas that are of interest for this study, such as Kisumu and the Nyakach region, are located close to Lake Victoria which influences the diet of the residents living there. Some frequently eaten fishes are tilapia, nile patch, omena and fingerling fish. They are often eaten together with ugali.

4.2.6. Cooking habits

Generally, people on level two spend a lot of their resources and efforts on their daily meals, which means that everyday life revolves around food (Rosling et al., 2018). Rosling (2018) points out that "You eat the same for almost every meal, every day of every week. You dream about food that is more varied and more delicious..." (p. 140). People on level two in Kenya still cook the traditional food that can be found all over Kenya. Depending on the circumstances, households might cook simpler versions of the typical dishes, exclude more expensive ingredients and have few variations between dishes.

In most places in Kenya women do the cooking, and when they cook together with someone it is often their daughter. In an interview made with one of the entrepreneurs, it was said that it is a way of teaching the daughters the skill of cooking as a preparation for when they have a family of their own. In an interview with the entrepreneur from Ecomandate Foundation, it was stated that in rural and low-income areas the men leave for work, often construction work, in the morning, to return in the evening. Usually, they do not return home for lunch, but instead there is the possibility to buy food from women selling lunch for approximately 0,5 USD. The children attend school every day, no matter the income class of the family, since authorities are very strict and will punish parents who will not follow education laws. In urban setups the children often stay at school for lunch if the parents can afford the lunch fee, whereas in rural areas the children will return home during this time and afterwards go back to school. When the children and the father return in the evening the whole family is gathered for supper, this is the time of the day when they all come together and eat, which makes it the most important family time for many people.

Indoor cooking is the tradition and it is mostly done on the floor, sitting down when possible (Cornwell, 2007; Amosy et al., 2010). The floor offers a stability that they cannot find elsewhere, but it is such a widespread tradition that even people with alternative solutions also chose to cook on the floor. In Kenya the cooking pot is called sufuria, which is a Swahili word. It is a flat based and handleless cooking container, used in many Kenyan households for cooking, serving and storing food (Wikipedia, 2020). Sufurias are made in aluminium and are locally manufactured. In the following, a description of the general cooking process is presented in a list of steps. The steps are based on watched videos no. 1 and 5 from rural parts of Kenya.

General cooking steps:

1. Cooking session starts by sitting down and preparing food in the (often) black deep aluminium sufuria with no handles. Cleaning and chopping ingredients such as leaves and meat, varying between different pots.
2. Preparing stoves with fuel and placing it where they are going to cook.
3. Setting the stove and then placing the pot above, sometimes with a lid on (could be a lid or another pot).
4. Then often sitting down close to the stove (sometimes standing rather crooked up or sitting nearby).
5. Getting up to adjust the stove or stirring the pot.
6. During, when the food is cooking, other chores are sometimes made but they often need to watch the stove.

According to the interviews, the utensils are then cleaned, usually with water and soap. Ashes need to be taken care of and the sufuria might need to be scrubbed due to burned food. If needed, charcoal is replaced, wick is changed and paint is applied to avoid rusting.

4.2.7. Stoves and fuels

About one in every two (49%) households in Kenya uses only one type of stove option, while 36% alternate between two types of stoves (Kairu, 2019). The remaining 15% have three or more options. 70% of all Kenyans use some type of wood stove as either their primary or secondary cook stove, almost all of these people live in rural areas. The traditional three-stone stove, as seen in figure 4.13, uses wood as fuel and it is the most commonly used cooking technology in Kenya, with more than half of the population using it and almost 30% of rural residents choosing it as their preferred way of cooking (Nation, 2020). The stove consists of three stones placed on a fire with a pot resting on top of it. Sizes can differ depending on how big the stones are. The stoves are built by hand so each one is unique. In video no. 5, it was shown that more Kenyans are starting to use improved stoves, which is a type of wood stove that requires less firewood and produces less smoke, compared to the three-stone stove. There are different versions but the general principle is that the fire is trapped inside of the closed construction, making the heat transfer more efficient to the cooking pot.

Figure 4.13
The three-stone stove.

From *Three Stone Fire* [Photograph], by Clean Cooking Alliance (CCA), n.d., CCA (http://catalog.cleancookstoves.org/stoves/215).

Another common stove is the Kenya Ceramic Jiko (KCJ), shown in figure 4.14, a type of Energy Saving Stove (ESS), which is used in over 50% of all urban homes and about 16% of rural homes in Kenya (Solutions Site, n.d.). It is a portable, charcoal-burning stove with a ceramic inner lining and metal cladding (Engineering For Change, n.d.). The stove is hourglass shaped and at the top there is room for one cooking pot. This stove usually weighs from 3 to 6 kg and its diameter varies from approximately 30 to 50 cm (Centre For Ecological Sciences, n.d.). Compared to the three-stone stove the KJC can reduce the consumption of fuel by up to 20-50% (Ekouevi et al., 2014).

Figure 4.14
The Kenya Ceramic Jiko.

From *Kenya Ceramic Jiko* [Photograph], by AIDG, 2007, Flickr (https://www.flickr.com/photos/16253691@N00/533788023) CC BY-NC-SA 2.0

A kerosene stove is a common cooking appliance in lower- and middle-income households in Kenya (Ombati et al., 2013). 1.7 million households in Kenya, or 14% of the total population, cook with kerosene (Kairu, 2019). At least 27.7% of these are urban households and 3.2% rural areas. Some Kenyans use LPG (liquefied petroleum gas) stoves which is an even more efficient way of cooking (Wandei & Harper, 2018). The method requires a larger initial cost compared to previous mentioned stoves and gas is usually not as available as firewood or charcoal, leading it to be a rather uncommon method though the usage is increasing. Between 1999 and 2018, the number of households using LPG gas increased about six times from approximately 0.6 to 3.7 million (Kairu, 2019). Alternative cooking technologies like ethanol stoves, biogas, briquettes, pellets and solar cookers are collectively used by less than 1% of Kenyan households.

90% of rural Kenyans in Nyakach use wood, crop residues, dung, and other combustibles for daily cooking (Dennery, 2007). Just like with the usage of stoves it is common to use a combination of different fuels, but firewood alone is the most common form of fuel used for cooking, between 50% and 65% (Kwach & Onono, 2008; Dennery, 2007). One third of rural Kenyans in Nyanza use charcoal for daily cooking (Dennery, 2007). Charcoal is a frequently used fuel because it is considered the most convenient fuel due to its flexibility to cook whenever needed and for the easy usage that requires no training (Kaburu et al., 2019). Kerosene use for cooking is still prevalent in urban low-income areas, though it is not very common in rural areas (Kairu, 2019). It is slightly more expensive than previously mentioned fuels and its explosiveness makes it a more dangerous option. It is often used among smaller families or when cooking small meals (Amosy et al., 2010). Dishes that are mostly cooked using firewood are tea, porridge, ugali, and githeri. Charcoal and firewood are also combined for cooking ugali and githeri. In the Kakuma refugee camp firewood is preferred for cooking dried food such as beans and ugali (Owiti, 2003). Charcoal stove is most popular for cooking meat. An ESS is most used for cooking vegetables.

5. Diffusion - the user before obtaining the solar cooker

5.1. Conditions prior to solar cooking

The first step of diffusion involves in what kind of context the user is currently operating and how that might affect the user before they are even introduced to the idea of solar cooking. The areas that are of importance are felt needs and problems and norms of the social systems.

5.1.1. Felt needs and problems

Traditional cooking activities are usually taking place on a relative low height, as observed in video no. 1, e.g., on the ground. It was observed that people varied a lot between sitting and standing up while performing the cooking, having an extreme bent posture as shown in figure 5.1. Constantly working with a poor posture is one factor among other factors that has led to low back pain among women in rural Kenya (read more in *4.2.4. Health issues*). However, it is one of few possible ways of cooking among households living on level two in rural parts and cooking on an open fire is limited to the ground. Placing traditional and common cooking stoves (read more in *4.2.7. Stoves and fuels*) as close to the ground as possible is also a more stable and safe way of cooking. Further health issues arise when individuals perform these cooking activities, such as air pollution. Also, utensils used were observed in videos no. 1 and 5, as being frequently covered with soot due to the presence of fire in cooking activities. Looking at the traditional way of cooking and what is lacking, the situation is many times due to the limitations of available safe replacements.

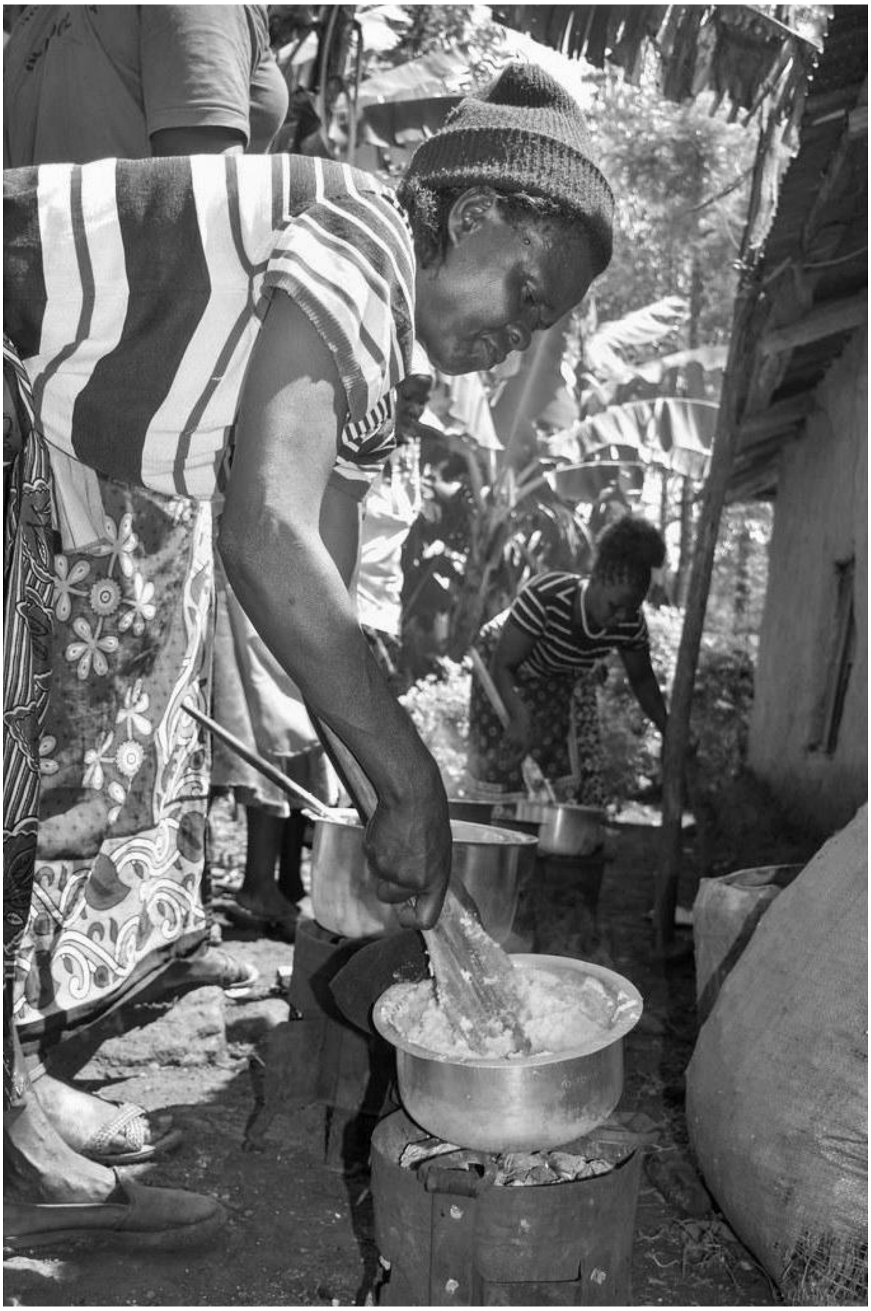


Figure 5.1
Kenyan women performing cooking activities.

From *CIMMYT - SVE - KEN - 20200310 - 0007* [Photograph], by CIMMYT, 2020, Flickr (https://www.flickr.com/photos/44760652@N05/49884257557). CC BY-NC-SA 2.0.

5.1.2. Norms of the social systems

Women usually do the cooking, either the mothers do it themselves or they get help from their daughters. It has been explained that this is a way of preparing the daughters for future responsibilities. Many previous solar cooking projects have shown an increased cooking engagement by men (Kaburu et al., 2019; Kwach & Onono, 2008; Owiti, 2003). However, according to the entrepreneur from Ecomandate Foundation, this engagement did not last long and things went quickly back to normal where women solely carried out the domestic cooking activities. This behaviour shows difficulties in changing norms that have become a part of a group's operational structure. Also, according to the entrepreneur, curiosity could be what initially attracted the men. Despite the workload that women do, such as working on the fields, fetching water, cooking, taking care of the children, etc. it is usually the men that control the money and property in a family.

Uncertainties are generated when new innovations are introduced and are perceived as new by individuals (Rogers, 2003). Since it is common with indoor cooking in Kenya, an outside solution like the solar cooker can appear strange. It might not only be of practical reasons, but rather the fact that it is such an old and widespread habit that it has become the norm. Given that fire is what they are used to as fuel for cooking, switching to using a product made of cardboard and aluminium foil might not be persuasive enough. When observing video no.3, it was obvious that the husbands could not believe that their wives had cooked food with a solar cooker. Instead, they had thought it was secretly prepared on an open fire. They had described the solar cooker as odd-looking, insisting the product would not be able to cook anything with.

5.2. Characteristics of the decision making concerning the solar cooker

In this section, the topics described are individuals' communication behaviour, socioeconomic and personality variable characteristics. These topics are addressed in relation to how individuals have been introduced to solar cooking, from whom and what they have heard about it.

5.2.1. Communication behaviour

The target group has shown to make little or no use of mass media channels and learns about new ideas from peers, via interpersonal communication channels (Kwach & Onono, 2008). They are not active information seekers about new ideas and their interpersonal networks, which is the interaction people have with each other, do not extend over a wide area, so they do not reach people outside their local system (Power Africa, 2020). For instance, all interviewed individuals had learned about solar cooking either through family or friends or through demonstrations made by nearby organisations. These organisations are not operating everywhere in Kenya, so people only hear about them if they happen to live close to where the organisations are operating (SCI, n.d.). It is difficult to find information about solar cooking on your own. Similarly, awareness is created through public demonstrations (Sunews, 2006). After the demonstrations, individuals showed no need for more convincing and no doubts remained. Before they left after the demonstration, the next question was usually where they can buy the cooker and how much it will cost. When observing video no. 3, it was noted that awareness had also been created and spread through songs among groups of women, by honouring the benefits of the product. The downside of solar cooking, i.e., that it is very different from existing, well established cooking methods, could actually be positive when it comes to demonstrating it. Many observing individuals in video no. 3 became curious at the sight of the product, which is a positive thing since they want to know more about it and engage with it (Wanzala, 2019).

It was shown in video no. 3 that the demonstrations made by several organisations also have opened the possibility of new jobs, e.g., early adopters of the solar cooker working as local influencers and distributors (Women's Earth Alliance [WEA], 2012). Since early adopters of the solar cooker have a higher degree of opinion leadership than later adopters, these influencers have the opportunity to inspire their friends and people around to start using solar cookers.

5.2.2. Socioeconomic characteristics

The socioeconomic situation has a great impact on individuals on level two. Some innovations are costly to adopt and require large initial investments. If a potential user is dealing with uncertainties concerning the investment of a solar cooker, he or she might not want to risk losing their money due to the investment. Individuals on level two are not able to cope with high levels of uncertainty about an innovation, since they cannot afford buying a product that will not work for them. They have a very limited amount of money and buying and getting food is a big part of their total resources and efforts. They do not have many other options so if a stove that they buy fails to meet their needs, then their entire life will be affected by it.

Also, lack of education can increase the risk of not taking the product seriously, e.g., lack of knowledge concerning solar energy. Many years ago, in a very early introduction of solar cooking, people assumed it as witchcraft from the start (Kwach & Onono, 2008; Innes et al., 2008). In contrast, utilizing the possibilities of cooking in the sun can decrease the need of frequently collecting firewood and children can instead dedicate themselves to studying and hopefully achieve higher levels of education (Dennery, 2007; Kwach & Onono, 2008; Owiti, 2003).

5.2.3. Personality variables

Changing people's attitudes and old habits are hard and as long as there is one piece of wood left, people would rather use it before trying something new and to them unexplored (Sunews, 2008b). Even though there are many downsides of using firewood the users know that it works, which makes this the safest option compared to what they see as unknown methods. Some individuals on level two preferred receiving help with firewood rather than accepting the solar cooking demonstrations (Kaburu et al., 2019). Such a significant change in the everyday life of people might require personalities with open mindedness to change. Individuals among later adopters need to receive a lot of information about solar cooking in order to understand what benefits there are and how to reach them.

5.3. Perceived characteristics of the solar cooker

Perceived characteristics of the solar cooker deal with what the potential user thinks about solar cooker and how useful it could be. It emphasises how the product is perceived in terms of relative advantage, compatibility, complexity, trialability and observability.

5.3.1. Relative advantage

Many interviewees had the idea that the product would save them money if they bought it, compared to solutions they were using today. One reason had to do with the fact that they knew that they did not have to buy as much fuel if converting to solar cooking. Yet, since solar cookers partly operate as preventive innovations (read more in *2.1.4. Persuasion stage: Perceived characteristics of the innovation*) with rewards after a longer time of use, individuals might have a hard time perceiving the long-term profitability of the product. Saving time and energy were two factors to describe the perceived relative advantage that the solar cooker would have compared to stoves they were already using, seeing that collecting wood is very time consuming and that when cooking with solar you can leave the cooker unattended and engage in other activities. Before buying the product, a few interviewees had also seen great potential with the portability of the solar cooker. They wanted to be able to easily move the cooker for storing and cleaning purposes.

One of the many benefits of the solar cooker is the avoidance of unwanted diseases that is today caused by fire stoves used indoors (Dennery, 2007; Kwach & Onono, 2008). The unwanted consequence that is avoided by adopting a preventive innovation is however difficult to perceive due to being a non-event, i.e., the absence of something that otherwise might have happened.

The relative advantage of preventive innovations is difficult for a person in an organization to immediately demonstrate to their clients, because the advantages occur in some future and unknown time. Thus, the relative advantage of a preventive innovation is highly uncertain.

5.3.2. Compatibility

According to the entrepreneur from Ecomandate Foundation, traditional dishes are an important part of many people's lives in Kenya, and it might be even more valuable for someone whose life revolves around food. If a stove seems too different compared to what is used today, then there could be doubts whether it will be suitable for cooking dishes typically made. In a discussion with the entrepreneur, it was mentioned that when the cooker was introduced, inhabitants were having a negative attitude towards the idea, assuming it to be a European product that will not work for Kenyan dishes.

5.3.3. Complexity

Solar cooking is quite different from traditional ways of cooking which makes it difficult to use without proper training (Dennery, 2007). Cooking with the sun compared to fire makes little sense for a lot of people and some think that it just will not work or that the food will have a strange taste. It also looks very different, so even though the steps of using it might not be that complicated, the mere look of it makes people confused. Some observers describe users' fascination when seeing the product for the first time but with an adequate demonstration they usually get enough information to grasp the concept of solar cooking (Wanzala, 2019).

5.3.4. Trialability

According to Rogers (2003), having the opportunity of trying a new product before choosing to adopt it can increase the rate of adoption. In a public demonstration in Kenya, locals were allowed to test and be included in the demonstrations of the product which involved cooking, tasting the food cooked by a solar cooker (Kaburu et al., 2019; Sunews, 2009b). This resulted in people expressing their satisfaction when uncertainties and doubts concerning usage were eliminated and they instead began wondering where they could get a solar cooker (Sunews, 2006). Among individuals interviewed, many stated that they had tried solar cookers at demonstrations arranged by organisations, before actually buying one.

5.3.5. Observability

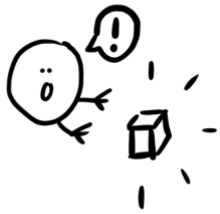
More visibility of the results of an innovation can lead to a higher probability of the innovation to be adopted. The entire construction of a solar cooker is both simple and visible, there is no hidden technology and the number of parts is few, making it easy for people to observe what is going on. No smoke is emitted during the use of the product which is often something people notice since this is an extensive issue with traditional cooking stoves (Kwach & Onono, 2008; Omariba, 2006).

When women in Kajiado, south of Nairobi, had been introduced to solar cooking, scepticism was initially expressed (Mulama, 2006). They were unwilling to believe that solar cookers made of cardboard containers lined with aluminium foil could be possible to use for cooking food only by being placed in the sun considering that fire is what they are used to. This attitude remarkably changed when they had seen a final result of well-cooked food which in turn broke the uncertainty of being able to cook food with the sun.

At demonstrations people are often surprised by the great taste of solar cooked food (Sunews, 2009b). They are even surprised that the food is properly cooked. When they witness this process and realize that no fire is needed, that the only energy that is utilized came from the sun, they understand the possibilities of the product and often express their interest.

Many of the interviewed users who had never used a solar cooker, thought about solar cookers as a possible way of saving money. However, as previously mentioned, some solar cooking advantages occur in the future. This calls for both comprehension and knowledge about savings and long-term profitability and of course the possibility of investing. Being relatively limited to only living one day at a time slows the rate of adoption. However, the solar cooker entrepreneur from Ecomandate Foundation stated that when the target group had been asked to reflect upon their fuel consumptions, they surprisingly realized how much money they had actually spent on it.

6. Domestication - the user obtaining the solar cooker and using it



6.1. Appropriation of the solar cooker

At the stage of appropriation, the solar cooker becomes physically and symbolically accessible by the people in the household. This happens when a person buys, receives and assembles the product. Purchase is often done through an organisation or local solar cooker shops and the payment could be split into smaller sums over time in order to facilitate the investment.

6.1.1. Organisations

Solar Cookers International is an organisation that distributes solar cookers in Kenya, among other places (Innes et al., 2008). They have representatives that work for them in order to sell the cookers to customers. In an initiative called The Sunny Solutions project, SCI introduced the solar cooker "CooKit" to local communities, often women's groups, since women are the primary users, and selected people that were motivated to take on the role as saleswoman, also called Solar Cookers Representative (SCOREP). SCI then trained the SCOREPs on how to properly demonstrate the product and then they sell it door to door. SCI have also engaged in projects where solar cookers are given out for free in order to further encourage the diffusion of the product. This has led to an increase of the usage in some areas but could at the same time have halted the diffusion in other ways since potential users have expressed that they will not buy a solar cooker, but rather wait until it is given out for free (Kwach & Onono, 2008; Innes et al., 2008). Of the solar cooking project evaluations studied in this project, almost every user involved got their solar cooker from SCI.

Asulma Centre is a non-governmental organisation (NGO) close to Nairobi in Kenya and since 2015 they practice and teach about solar cooking and how to integrate it into the everyday setting (Karnebäck, 2019). They also build and sell solar cookers, such as the panel cooker CooKit, box solar cookers and conical panel cookers. Among the people interviewed, several had learned about solar cooking through Asulma Centre and also bought their cooker from them.

Farmers With a Vision is a local community organisation in Bumala, Kenya that have been engaged in solar cooking since 2008 (SCI, 2020d). Similar to Asulma Centre, they are trying to spread the technology of solar cooking by teaching school children and performing demonstrations in open marketplaces (Karnebäck, 2019). They also make and sell box solar cookers and panel cookers and they have reached some of the interviewed people with both knowledge and cookers.

6.1.2. Purchase of the cooker

Interviewed users bought their solar cookers between 2009 and 2020. Most users stated that saving money, improving their health and the environment and being able to do other things while the food is cooking, were their reasons for buying the solar cooker. There were also reasons such as that they got interested and intrigued when they saw it being demonstrated and that they got convinced by the tastiness of solar cooked food.

6.1.3. Solar cooker in the user setting

It is important to understand that the solar cooker can never completely replace all other stoves in the household, no matter the engagement of the user or the capacity of the solar cooker. A household has to have at least one other option for periods of the day when the sunlight is not sufficient (morning and evening) and for cloudy days, and often also when actually using the solar cooker, since the capacity of it is not always enough for cooking a meal for an entire family (Karnebäck, 2019; Kaburu et al., 2019). The interviewed users often have two or three stoves, including the solar cooker. Except for the solar cooker it is common to have a firewood stove (three-stone stove), gas cooker (LPG), a kerosene stove, an energy saving stove (fuel is charcoal or briquettes), an improved fireplace or a Jiko (ESS with charcoal or briquettes). It is also rather common to have a hay basket, also known as a fireless cooker. The hay basket usually consists of a sturdy, outer construction like a plastic basket and a soft inner filling made of fabric and wadding, as seen in figure 6.1. There are also products like the Wonderbag, that is a foam insulated bag which comes in sizes up to 45 cm in diameter (SCI, 2014). Except the firewood stove most stoves are portable, which makes them possible to use at different places. If an area, where the three-stone stove is set, becomes flooded by rain then the users have to build a new one somewhere else.

Figure 6.1
The fireless cooker called hay basket.

[Photograph], by Asulma Centre Self Help Group, 2020f, Facebook (https://www.facebook.com/Asulma-Centre-Self-Help-Group-1019285011511571/photos/4770449999728368).

6.1.4. Common solar cookers and related products

The most common solar cookers among interviewed users are panel cookers, but also box cookers are common. Popular panel cookers are, in particular the CooKit, but also Haines, Copenhagen and conical versions. The box solar cookers are rarely mentioned as a specific model but are built in different variations depending on the local solar cooking organisation. Solar cookers also need plastic bags or plastic sleeves, which could be included when buying the solar cooker. A black sufuria, see figure 6.2, is preferred since black absorbs heat, but people use unpainted aluminium pots as well. The sufurias are sometimes blackened by the soot from other stoves and then users do not have to paint them in order to increase efficiency. It was observed from video no. 2 that the pots are usually heavily dented with uneven lids that lessen the efficiency of the solar cooker, since heat is escaping. The purchase of a solar cooker sometimes includes a WAPI or other indicators for pasteurizing water (Kwach & Onono, 2008).

Figure 6.2
A black and dented sufuria.

From *Kastrull, husgeråd* [Photograph], by Rose-Marie Westling, Statens museer för världskultur, n.d., (http://kulturarvsdata.se/SMVK-EM/objekt/1554856). CC BY 4.0.

6.2. Objectification of the solar cooker

Here objectification refers to the objectification of the solar cooker, describing how and where the individual chooses to place the artefact, when in use or stored and the issues that arise around the positioning. The product is placed differently depending on the user's environment and e.g., whether the cooker is going to be used for cooking or whether it is to be stored.

6.2.1. Cooking outside the house

The solar cooker is not possible to use indoors, so the user has no choice but to use it outside. Since "outside" is not really a specific place, it could mean different places for different users. Most interviewed users stated that it is often used outside the home of the user (or sometimes at the workplace) far enough from the shadows of buildings and trees. Among people using the traditional three-stone stoves, it has been shown that this cooking method is utilized both indoors and outdoors (Amosy et al., 2010; Kaburu et al., 2019). However, when using these stoves, the placement of them is often not limited by the surroundings such as shadows, even though the unpleasantness of smoke could affect it to some extent.

6.2.2. Cooking on the floor and ground

Whether the cooking is made with a solar cooker or another stove, it is almost always performed on the floor or on the ground (Amosy et al., 2010). Compared to the change from inside to outside cooking, solar cooking does not require the user to change their behaviour in this respect. The technique is still problematic since it urges the cook to bend over in an extreme position in order to reach the stove. Explanations of why cooking on the floor is the norm can vary, from that there are no other available surfaces, and that it is the most stable alternative to that surfaces like tables or such are intended for people to sit at, to eat and socialize. It was observed in videos no. 1 and 5 that the homes are usually quite simple, with few rooms and a sparse interior, which makes it difficult to sustain a habit of cooking on a surface level above the floor.

6.2.3. Cooking at the workplace

One of the interviewed users, a peasant farmer, stated that she brought her solar cooker along with her to the fields to cook her breakfast while working. Since a typical morning at the farms lasts till approximately 12:00 pm, she arrived home in time for preparing the rest of the lunch using other cooking devices. She reported during the interview that she cooks the rest of the lunch on an open fire and prepares part of the supper using the solar cooker. Similarly, another of the interviewed users who was working in a shop, reported that she uses her solar cooker at work for cooking her lunch. In this case she can avoid going back home for lunch as well as buying or bringing food to the workplace.

One interviewee, who used to solar cook next to her shop, had to stop when a new building was built nearby, which created a shadow. This is an example of how different (work)places can affect the use of the product. If a workplace offers limited sunlight, it will most likely mean difficulties in using the solar cooker. Farmers usually work in open sunny areas in comparison to a shop owner who might be surrounded by shadows.

6.2.4. Outside circumstances and problems that follows

Outside spaces that have a lot of shadowing are less useful for solar cooking. Some interviewed users state that they stopped using their solar cookers when they had to live or work in a setting with more restricted space. One interviewed user moved to a new building where there was no space to place the cooker and since it is not possible to use inside, the user had to stop using it. Another user remained in the same building but the landlord decided to put up a new building, shadowing the previous solar cooker spot.

As mentioned earlier, weather conditions affect the performance and thus the experienced reliability of using a solar cooker. It was reported that users were disappointed over the fact that their solar cookers were ineffective and non-functional on cloudy and rainy days and when drifted by wind (Karnebäck, 2019; Kaburu et al., 2019). Places that are suitable for solar cooking are usually quite unprotected and exposed to wind, since the lack of shadows means that there are few surrounding obstacles, see figure 6.3. The ground is in most cases made up of soil, with elements of sand and vegetation, making the solar cookers even more vulnerable during rainy days, see figure 6.4. Weather conditions like these calls for rethinking the construction of the solar panels, in order to decrease the tendency of affecting the user negatively (Owiti, 2003). Also, when this happens, some users tend to put away their solar cookers and go back to what they were used to; even when the sun returns they might have a hard time starting again because they have lost the habit of using the product. Many of the interviewed users stated rain as the main problem behind not keeping up the habit of solar cooking.

In addition to weather conditions, it has been reported that food has sometimes disappeared as it was left outside and out of sight cooking using the solar cooker (Kwach & Onono, 2008). In an extreme situation, incidents like housebreaking by armed thieves stealing solar cooking kits has taken place (Kaburu et al., 2019). However, these issues have been more common in densely populated communities where people live close to each other, for instance refugee camps and crowded villages (Owiti, 2003).

Lastly, product damages by animals have shown to be an additional factor resulting in difficulties and uncertainties in adopting the solar cooker. The solar cooker panels are made from paper and aluminium foil, hence the reason why they are prone to destruction (Owiti, 2003). Termite attacks were a further factor when not properly storing the cooker, leaving the panels unusable. Users usually throw their cookers away when these attacks happen as they are beyond repair.

Figure 6.3
A photo from rural parts of Kenya showing the conditions on windy days.

From *Engendering the Response to Climate Change*[Photograph], by Bread for the World, 2011, Flickr (https://www.flickr.com/photos/28475454@N04/15603802269). CC BY-NC-ND 2.0

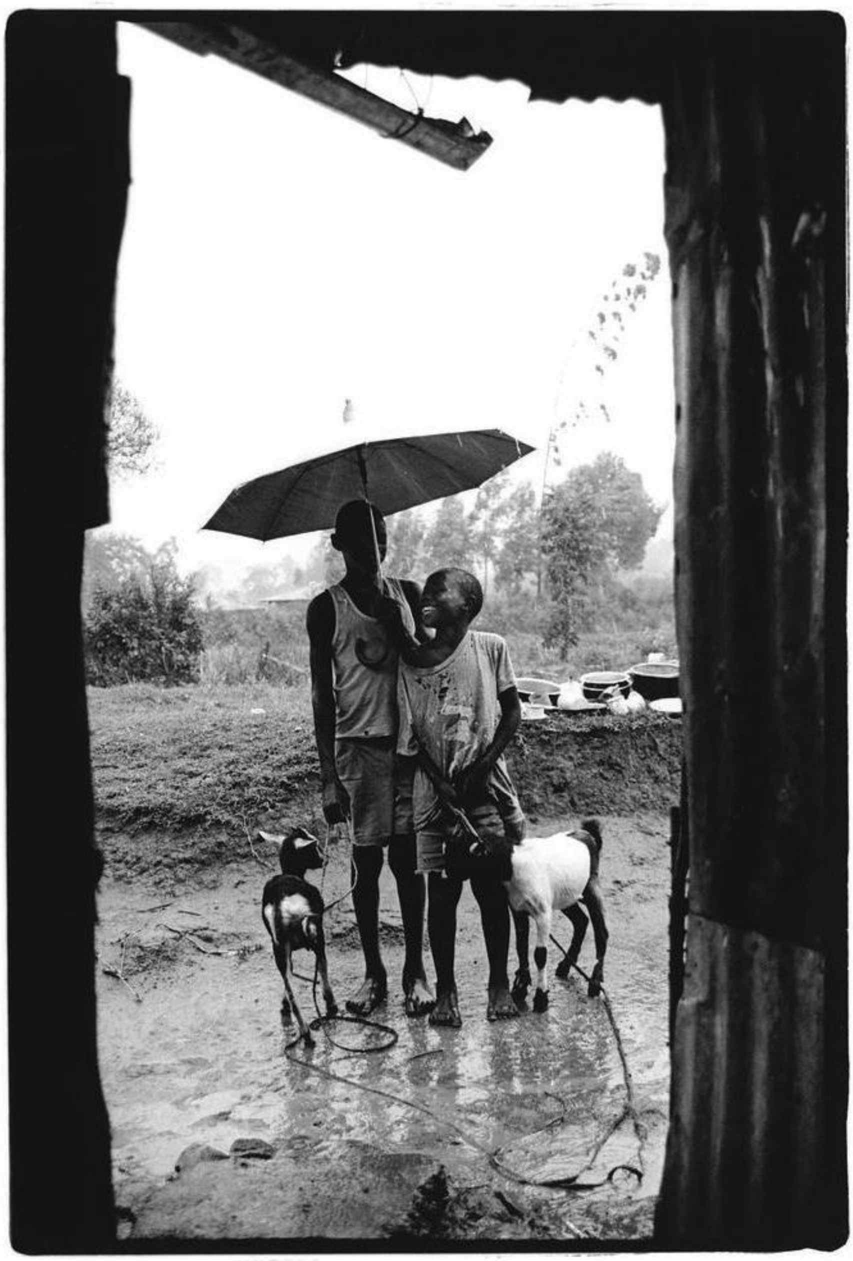


Figure 6.4
A photo from the rural parts of Kenya showing the surroundings in rainy days.

From *Village boys and goats in the rain in Western Kenya*[Photograph], by International Livestock Research Institute, 2004, Flickr (https://www.flickr.com/photos/7155605@N03/5244470561). CC BY-NC-SA 2.0

6.2.5. Storage

The solar panel cookers are sometimes placed in a bag made for transportation and storing, according to the entrepreneur from Farmers With a Vision. However, users are informed to make sure that the cookers are dry before placing them in the bag to avoid weather that could cause damages, children playing with it, theft and termites (Owiti, 2003). When the Farmers With a Vision asked users where in the house they stored their solar cookers, the responses varied between the households. Some wanted to make sure that the cooker was stored in a place where it could easily be found. Others preferred storing it in the safest place to avoid theft, such as a bedroom. Many also stated they preferred placing the cooker in the kitchen where other cooking related items were stored.

6.3. Incorporation of the solar cooker

The technology or object has to be actively used for it to be considered to be incorporated in the household (Hynes & Richardson, 2009). Therefore, the following information refers to how a solar cooker is actually being used in the household with time as a crucial factor in the incorporation phase. The product has to be included in the daily routines of the household (Silverstone et al., 1992). The solar cooker is mostly used for cooking, even though some users also use it to pasteurize drinking water, heat bathing water and sometimes also dry food (SCI, 2020d). Since the most frequent reported use of the solar cooker has been using it for cooking food, the presented result is a reflection of that.

6.3.1. Everyday routines

Looking into the routines on a daily basis, it is common to eat three times per day divided into breakfast, lunch and dinner. Breakfast is usually eaten between 6 - 10 a.m., lunch between 12 - 2 p.m. and dinner between 6 - 9 p.m. It is not possible to cook an early or large breakfast using the solar cooker, since the sun is not sufficient at that time. However, some users could cook a later breakfast for only themselves, during earlier work hours. Lunch and dinner can be cooked with the solar cooker but since the solar cooker requires more time in order for the food to be properly cooked, the user must start earlier to be able to eat at the usual time. From 9 a.m. until 4 p.m. the sun is sufficient enough to cook with. This means that in order to cook lunch using the solar cooker the user has to start around 9 a.m. to be able to have lunch at 12 p.m., and after that dinner preparations can start whenever but not too late (depends on how much food you cook, what kind of food, if it is winter or summer time) but usually not later than 2 p.m. (Karnebäck, 2019). Many users are aware of this and some state that it is important to prepare the food early when the sun is overheads.

In Asulma Centre, close to Nairobi, solar cookers can be used approximately 20 days a month or 220 days per year (Karnebäck, 2019). How often solar cookers are actually used varies a lot among households, depending on the different daily routines and family circumstances. There are statistics based on project evaluations, stating that the solar cooker was being used up to three times a week (Owiti, 2003). Some of the interviewed users made a daily habit out of using it, at least when the sun was shining.

6.3.2. Integrated solar cooking (ISC)

As previously mentioned, solar cookers never completely replace all other stoves in the household and must therefore be used in combination with other cooking methods. Current solar cooker users have shown to somehow integrate it with other cooking methods. There are different ways to do this and the same household could alternate between these options:

1. Many interviewed users cook the entire meal using one stove. For instance, using the solar cooker for making lunch and then another stove to cook breakfast or dinner. It is easier for smaller families to manage cooking an entire meal using the solar kitchen. Making lunch using only the solar cooker is also common when the family is split, such as when one person cooks for themselves at work.

2. Individuals could use both the solar cooker and another stove at the same time to be able to cook one meal existing of two main components, e.g., they cook one dish, such as sukuma wiki, in the solar cooker and another dish, such as ugali, on the three-stone stove.

3. Users could begin by cooking the food using the solar cooker, then finish cooking on another stove. This happens in such a way that one type of food is first softened (e.g., vegetables) using a solar cooker and directly after cooked on another stove (Sunews, 2009a). Interviewed users also stated that it could also be that they use a hay basket to finish the solar cooked food or to maintain the heat until it is time to eat. There are also examples of using the solar cooker as a finishing step after the food has been heated by another stove.

It could seem as though the solar cooker is the only method that requires a type of "back-up", but other stoves have their shortcomings too. Just like solar cooking is impossible when it is too cloudy, the other stove options have their limitations. If people have no firewood or other fuels, they might not have another option but to solar cook.

6.3.3. Family size matters

An important impact on the experienced performance was found to be the total members of a household. It was shown that almost all households with a total of three or less people considered the solar cooker as enough for cooking a meal for the whole family. However, households with more than three family members indicated a need for always integrating and combining other cooking methods when cooking for the entire family. One interviewed user expressed that "When I cook I integrate the solar cooker with an improved fireplace because it is not enough to cook a meal for my whole family of seven". Similarly, a user from a household of eight members stated that they stopped using the solar cooker because of its capacity, while a user of the same professional background but of three family members said that the solar cooker was enough to cook an entire meal for the family.

6.3.4. Preferred way of cooking

Of the interviewed solar cooker users, only one preferred the solar cooker (in combination with the energy saving stove), when asked what their favourite way of cooking was. Instead, most preferred the gas stove because it cooks the food fast and efficiently. All gas stove owners stated it as their favourite way of cooking. A gas stove could be more expensive than other stoves, why not everybody owns a gas stove. A kerosene stove was preferred by both a single-person household and a five-sized family, with the argument that kerosene is an affordable fuel and that it offers an efficient way of cooking. The energy saving stove and improved fireplace proved also to be popular, with arguments such as the energy saving stove would let you do other things while the food is cooking and the improved fireplace uses firewood, which is cheap at the same time as it does not emit as much smoke as a regular three-stone stove. An interviewed user stated that "I love cooking using the energy saving stove because once you start cooking, you can do other things". Another interviewed user, who got firewood for free, thought that the three-stone stove made the best option and expressed "My favourite way of cooking is the three-stone fireplace, because I get firewood free".

6.3.5. The cook

According to the entrepreneur from Ecomandate Foundation, in Kenya, cooking is commonly the responsibility of the woman in the family, often a mother. Naturally if there was no woman in the household, the men had to cook. Most of those interviewed were women and they claimed to be the one who made the cooking in the household, though they often cooked together with someone like their daughter or sister to split the burden of cooking or to teach the other one how to cook. One interviewed user stated that "I cook alone, because the children are male, males do not cook where there is a female adult in the house".

6.3.6. Cooking session

There are no exact detailed steps that everyone follows when using a solar cooker, it is rather a flow of activities that could differ in order. With some exceptions, the product does not require precise steps and the same user might alternate from day to day.

Procedures could also differ depending on what food is being cooked. The solar cooker is relatively slow in its cooking, so foods are being boiled in their own juices rather than being fried. This means that it is favourable to cook lighter foods and that less water is required. Common dishes that were cooked in the solar cooker were mainly vegetable based dishes, ugali, rice and sometimes meat and eggs. Though, according to the entrepreneur from Ecomandate Foundation, some users do not feel comfortable cooking ugali in a solar cooker since the traditional way of cooking is different to the way you do it in a solar cooker. A favourite local staple, omena (a Lake Victoria sardine), is considered most tasty when solar cooked (Dennery, 2007). Dishes that users could not cook easily using a solar cooker were mainly hard beans, dry maize and traditional chapati bread.

A common first step among a majority is planning and preparing for what is to be cooked, since you have to start earlier than compared to other stoves, in order to fully exploit the sun's energy.

General steps of using the solar cooker according to the interviewed users and videos no. 2, 3 and 4:

1. (Prepare the food by washing, cutting, chopping into small pieces. This is not different from other stoves though the pieces could be made smaller to increase efficiency).
2. Carry the solar cooker outside to an open place.
3. Open/unfold the cooker and let it face the sun.
4. Wash the cooking sufuria and the lid.
5. Put and mix the ingredients together in a clean sufuria.
6. Cover the sufuria with a lid.
7. Place the sufuria in the cooker and insulate.
8. Let it cook.
9. Check the food and stir it after some time, check if it is ready.
10. When the food is ready, remove insulation from pot, often using potholders.

11. Carry the sufuria to rest of the family and eat.
12. Get the solar cooker and clean it with a dry or moist cloth, bring it to storage.

Below are presented details about the steps, differences between the solar cookers and traditional stoves and problems arising.

Preparation: (step 1-7)

Cleaning reflectors

The cookers were sometimes dusted before usage in order to ensure that they were clean and shiny, before placing the food in it and to maximizing reflectiveness.

Making the cooker ready

Compared to the panel cooker, the box cooker is a closed construction and could be preheated in the sun, which would make it slightly more efficient when eventually placing the pot with the food inside of the cooker. However, there was no connection between the usage of a box cooker and this behaviour, it was rather a matter of how time consuming the preparations of the food was, according to videos no. 2, 3 and 4. For instance if the dish required extensive washing, cutting and chopping then it was made before setting the cooker into the sun, often with the user sitting comfortable with the pot in their knee, inside their house or right next to it. If cooking ugali or other dishes that do not require a lot of preparation, the solar cooker would then be placed in the sun as a first step, though this would still not be enough time for a proper preheating. In contrast to traditional stoves that should not be lit well in advance, since they reach high temperatures fast and the user does not want to waste fuel, the solar cooker would even benefit from preheating. The user might handle the solar cooker as a traditional stove only out of habit.

Insulating

The insulation in a panel cooker is made possible with a plastic sleeve or a plastic bag, which the user puts the pot in and secures with a ribbon. The plastic sleeve can be secured by first wrapping it around the pot and then fixating it with a clip. Interviewees that use panel solar cookers stated that they sometimes feel the need to double insulate it, making sure that the heat does not escape. The box cooker has an inbuilt insulation so in order to insulate the pot the user only needs to close the transparent lid.

Fixating

The panel cookers are easily caught by winds, since the entire construction is lightweight and the panels work like sails (Owiti, 2003). As observed in video no. 4, it is common to prevent this by placing heavy stones on the cooker and attach strings to it in order to create a tent-like solution. The strings will in combination with the stones keep the cooker fixed to the ground, but also keep it from collapsing. The conical version of the panel cooker does not have a collapsible construction, but it can get caught by the wind (SCI, 2015). There have been examples where the user utilizes overturned stools or chairs in order to keep the cooker in place.

During: (step 8-9)

Time it takes

The cooking process takes a couple of hours, depending on what type of food that is being cooked and the quantity. Stew, vegetables, ugali, pre-soaked beans and corn and rice take approximately 2-3 hours to cook, while hard beans and corn take 4-5 hours, compared to traditional stoves where it takes half the time (Owiti, 2003). The solar cooker does not require the user to stir the food often so the user might only do it once or twice, mostly to check if the food is ready. Checking the food is usually complicated in a solar cooker that uses a plastic bag as insulation (SCI, 2020b). In a panel cooker the secured plastic bag has to be untied and the hot pot has to be removed without getting burned or spilling. It is slightly easier in a box cooker where the transparent sheet is lifted in order to access the food.

Cooking zone

When observing videos no. 1 and 5, it was shown that when cooking with more traditional stoves, there is often some kind of chair or stool placed in the cooking zone, either close to the stove, to be able to control the cooking without having to constantly stand up, or a few steps away for longer periods of resting or for cooking preparation purposes. Still, the user stands up frequently during cooking since there are a lot of manoeuvres that are difficult to perform while sitting down, such as lighting the fire, placing the pot on top or stirring the food. In video no. 3 it was shown that when using the solar cooker, which is further away from the traditional cooking zone, the user would rather leave the cooker if they feel they need to sit down. The user never makes any efforts sitting down close to the solar cooker. When cooking with an open fire, the cooking place is never left for a long period of time and the user is required to be much more present. This deep-seated habit is in contrast to the possibility of actually being able to leave the cooker, and therefore might cause complications in developing a habit of leaving the solar cooker.

Activities during

While the food cooks in the solar cooker some users are able to carry out other activities, which is often seen as a great advantage, instead of having to constantly watch a fire. The activities could consist of other chores, working, visiting neighbours and friends or playing with children. A user stated that "The best part is I can run an errand or do laundry while our meals cook. Cooking beans and stews is easy now" (Dennery, 2007, p. 1). Since the cooking time in a solar cooker is relatively long, it is a waste of time to not take the opportunity to do other things, it even creates anxiousness to only wait for the solar cooker to finish the food (Sunews, 2009a). However, the users have to be aware of the possibility and feel comfortable enough to leave the solar cooker. An inexperienced user might not appreciate the unusual habit of not being present and involved while cooking, since many people are used to being very involved when cooking with fire (Sunews, 2009a). Depending on the nature of the surroundings there are also differences in how safe it is to leave the solar cooker unattended (Kaburu et al., 2019). Issues with theft are more occurring in refugee camps where households tend to lie close to each other and food is even more a rarity. Usually, the cooker itself is not attractive for thieves, but the food inside.

After: (step 10-12)

When the food is ready

After a couple of hours of cooking in the sun, users go and check if the food is well cooked and ready to be removed from the cooker. If the solar cooker type used is a box cooker, the transparent insulator is opened and sufuria is thereafter released and brought to the house. If the cooker is a panel type, the procedure is mainly the same. However, if the insulators used are plastic bags, users usually check if the food is ready by slightly opening the bag and taste the food with a spoon. One issue here that has been noted and stated is the challenge of removing steaming food from the bag without spilling the food or burning the hands. When users are assured that the food is ready, the sufuria is removed from the bag. The user could then leave the cooker and the plastic bags with stones securing them to the ground, in order to be able to eat straight away, or disassemble the panel and clean with a dry or moist cloth before storing it inside.

6.4. Conversion of the solar cooker

Conversion is the process whereby the users within the household may come to define their relationship to the solar cooker. Only when an object is in the conversion phase, i.e. communicated both symbolically and materially to the public world, is the household's judgement, taste, and style, as well as participation in a social structure, confirmed.

The partial processes associated with the conversion aspect of domestication reflect the role the technical artefact may have in household members' relationships with the wider social world. This could include the more symbolic aspects of objectification, such as the artefact's place within the social network of the household, but also work that users may have to do in order to maintain the artefact in working order, e.g., purchasing disposable items that are needed to use the product.

6.4.1. Maintenance

The most used solar cooker, the panel cooker, requires plastic bags as insulation. This is often the part of the product that is most prone to be worn out (Dennery, 2007). When buying the cooker some plastic bags could be included, but after a while the user needs to get more bags. In the long run this is both expensive and harmful for the environment (Kwach & Onono, 2008). There has also been a ban on plastic bags recently, which have forced many people to stop using them (Agape Volunteers, 2020). Among the interviewed users the majority that had stopped using their solar cookers stated that it was because of the ban. One interviewed user expressed the following "... the government banned use of plastic bags, so when the plastic bag that it [the solar cooker] came with became unusable, I had no option but to stop". The actual panel also needs maintenance work. Many low-cost solar cookers are made of simple materials that break rather easily. The CooKit is often made of foil covered cardboard that will be damaged by frequent use or moist (Kwach & Onono, 2008). Users sometimes sew together pieces to keep them from falling apart, but others might not have the possibility or will to maintain it (Sunews, 2008). Many users had discarded their solar cookers after break-down due to lack of repairs and maintenance skills (Kaburu et al., 2019). An interviewed user stopped using the solar cooker because of the cost of replacements needed and the need for repair.

6.4.2. Habits in the long-term

When being used to a certain way of cooking it is often difficult to change, especially when food plays such a large part of your life. Hence, replacing your stove would mean an entire change of lifestyle. Different issues with the compatibility of the product make it difficult for the user to make the solar cooker a part of their daily habit and the user returns to use traditional ways of cooking (Kaburu et al., 2019). Even though solar cooking could offer a better life for many people, it is more convenient to stay the same. One interviewed user stated "I just did not get used to the idea. I am used to cooking using firewood". It is clear that collecting firewood is both time consuming, and expensive to buy, compared to the energy of the sun that is a free and inexhaustible source. Still, the solar cooker requires adjustments of routines which are uncomfortable for the user. Another interviewed user did not even give a specific reason for stopping using the cooker. On the other hand when people dare to change their lifestyle, it could not only improve practical parts of their life, but also empower them as human beings (Innes et al., 2008). To witness that efforts made paid off is to realise one's potential, even in other areas too. One user expressed that "The solar cookers just made us bolder… pushed us to take risks that we'd grown a bit wary of taking, and these leaps over dangerous crevasses have led us to much higher, firmer ground" (Sunews, 2009).

6.4.3. Relationship between the artefact and the wider environment and social world

Some of the people interviewed, both current users and no-longer users said that they had talked to people outside the household about solar cooking. When individuals were asked what they had talked about, the most recurrent topics were benefits of the solar cooker and sharing experiences, as well as giving each other advice concerning usage.

A further context where solar cookers had been displayed to others outside the home, is during events such as birthdays. Since the solar cooker is suitable for baking cakes, many users have reported that they have started baking more after buying a solar cooker (SCI, 2020a). Traditional cooking methods, such as the three-stone stove, is impractical for this kind of activity due to its high and uneven heat. The solar cooker has made it easier to celebrate certain festivities and users can now see the product as a symbol for making this possible. Ramula (2005) expresses the importance of the solar cooker:

> The thing that I enjoy most when cooked through this solar cooker is cake which my mother prepared during my happy birthday. I was attentively watching the way she was cooking it. I keep telling my friends who came to my birthday that we used a solar cooker to cook cakes. They really appreciated and they encouraged their mothers to buy solar cookers and both their parents have bought solar cookers and they really enjoy cooking with it. (Solar cookers in Nyakach: a youth perspective)

One woman using a solar cooker, observed in video no. 3, had incorporated her cooker in her daily kiosk activity. The woman used her solar cooker for baking and selling cakes for raising her income, as well as supporting starving people. It was noticed how customers immediately showed interest, asking her about how she prepared the cake, which later led to many conversations regarding solar cooking.

Another woman, observed in video no. 3, who had spent a lot of her money and time on firewood, bought the panel solar cooker CooKit from SCI. When she had been using it for some time, she noticed that she had saved enough money to buy things she could not afford before, she stated that "With the money I have saved, I have rabbits, chickens, ducks and a radio as well as other small, but nice things. I have bought goats; one is called Solar International" (00:12:59 - 00:13:18). The name of the goat is a reference to the organisation name, this is an example of how the user defines the relationship between the artefact and the social world. The product had improved her life and she was eager to let people around her know that. In addition, the area around her house had become more fruitful since she stopped taking down trees and other plants for her fireplace, which in turn lead to a better environment for the enlarged livestock she now has and has made the relationship to her solar cooker even stronger.

Similarly, in the observed video no. 3, when a user was asked about his opinions on owning a solar cooker, he mentioned that instead of spending money on firewood, which is something that you can only use once, he could buy a cow and enjoy the benefits over and over. This shows how solar cooking, using the energy of the sun, has made an impact on his life, making it possible to have a production of milk. The family could then both consume the milk and make money on selling it to others.

Likewise, some of the interviewees currently using a solar cooker expressed that owning a solar cooker had benefited them in their daily lives by relieving them from the stress caused by entirely relying on firewood. An interviewed user stated that "I changed life from the stress of not cooking when I don't have firewood to utilizing abundant solar energy".

It has appeared from several previous solar cooking projects how songs are continuously used in celebration of the advantages from using solar cooking, showing surrounding people how pleased and thrilled they are in order to contribute to the spread of the product and therefore a healthier and brighter future (Kwach & Onono, 2008). In the observed video no. 3, groups of women, who had switched to solar cooking, sometimes gathered together to cook food, socialize and dance while they were singing about how their lives had been improved since the change. The women in video no. 3 sang "We are going to cook with the sun, we are going solar, we are cooking with the sun, you can stay with the smoke, we are going solar, we are cooking with the sun, you can collect the wood, but for us we are going solar, we are cooking with the sun, we are going solar…" (00:16:59 - 00:17:28).

DEFINE

At the beginning of the project, different kinds of development areas were considered possible to explore, depending on the outcome of the result. In the previous phase we have explored and identified several different obstacles and shortcomings with solar cooking diffusion. The solar cooker has been investigated and analysed, prior to when the product was introduced to people until what happens when the user owns the product. There are a lot of different aspects that affect the diffusion of solar cooking and the solar cooker. The physical product itself is deficient in many different ways, which is an important aspect to consider. This is also the aspect that is chosen to work further with when developing a solution concept. However, the produced information in the prior phase should be possible to be utilized as a base for other areas of solutions if desired, such as solutions concerning organisations or other products that could be developed to facilitate the usage of solar cookers.

The *define* phase presents a user journey addressing several different parts of the user's journey with the product. Thereafter, identified development areas are introduced and presented. The phase is completed with a list of solution guidelines summarizing the requirements needed for a concept to fulfil in order to solve the identified user problem areas.

7. User journey

The user journey is a summary of the stated user issues connected to the solar cooker. The issues are put in a context with a persona that is meant to reflect the user of the stated target group.

MARY IN KISUMU

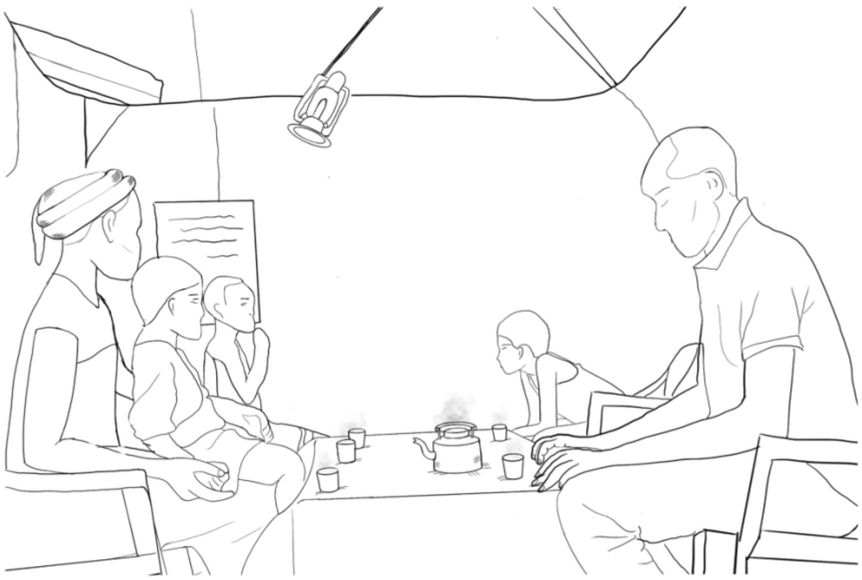
Mary is a 42-year-old woman, living with her husband Ben and their three children in a small house in Kisumu. Two years ago, she bought a panel solar cooker called CooKit, after seeing a demonstration in her village. She initially thought it looked weird and could not understand how it would work to cook food with. The people demonstrating it told her that the solar cooker would make her use less firewood and when thinking about how awful coughs her children have had lately, due to smoke from their three-stone stove, she was intrigued to try it. Her husband was harder to convince since he was not sure the cough was a result of their firewood stove. He was rarely present when food was being cooked so he did not realise the great effect it had on their health. Since having the main responsibility over the household economy, he did know that a lot of their money was being spent on firewood, which made him agree to buy the solar cooker.

THE DAY BEGINS

Mary is the first one to wake up at 5.00 a.m. in the morning, she peeks outside and cannot feel any rain against her face. She is relieved and says a silent prayer that it will stay this way, recalling the past few days filled with rain and the unused solar cooker collecting dust in some corner of the house. The sun has not yet risen when she starts to prepare the breakfast tea for her family. Sitting down, next to the fireplace in the corner of one of their two rooms, she lights the firewood and then places the sufuria, filled with water and tea leaves, on the fire. One of the children has woken up and is screaming for her, but she knows she cannot leave the fire unattended.

BREAKFAST

The family sits down by the table to enjoy the breakfast together. Mary tells the kids that she will not be coming home for lunch today, so they should not forget to bring food with them to eat in school instead. When they are finished eating Mary prepares for her work on the farm. She is a peasant farmer which means that she is one of many farmers working at the same farm, but with different areas of responsibility. Her salary is that she gets to keep a small part of the harvest, the family then keeps a part, and the rest they will sell at the market to earn money. Mary packs her working and sun cooking tools and starts her journey to work, but soon needs to head back when she remembers that she has forgotten the plastic sleeve for it, not using the solar cooker for some days has made her lose her habits.



WALKING TO WORK

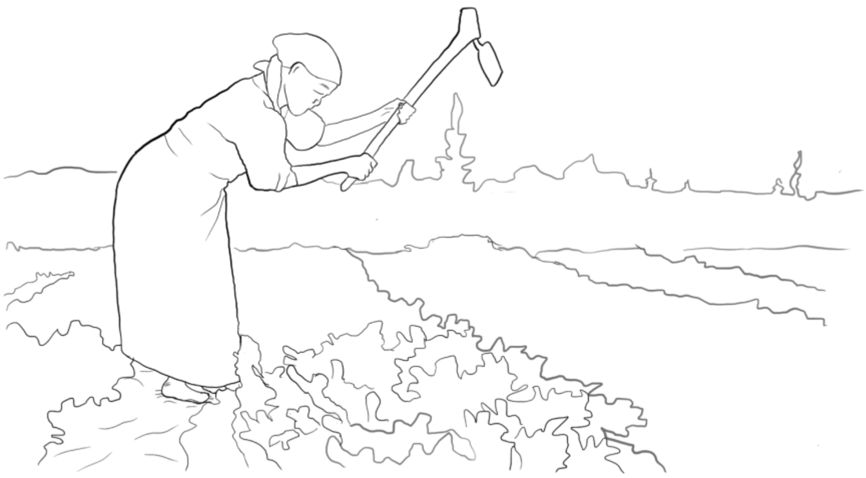
She continues her way to the farm when she sees a familiar face and a conversation begins. The person asks Mary if she is still using her CooKit, since hers got damaged and she did not know how to repair it. Mary replies, saying that she sewed it back together.

Ben has only brought the solar cooker a few times to his work as a market vendor. He and his friends usually buy lunch from a woman that passes the market every day at noon. The market is crowded with people and stalls so there are few open spaces to put the solar cooker. Every time he has tried to use it shadows casted from nearby stalls has caused him to constantly move the cooker. He knows that it is better if Mary brings it with her since the farm offers more suitable places, besides he always feels uncomfortable cooking since it is not very common for men to do that, if they do not have to.

AT WORK

Mary arrives at the farm at 6.30 a.m. and puts her cooker down together with the rest of the utensils. Then she goes towards the field where she sees her co-worker ready to start reaping the kale and the corn. When Mary gets closer, one of her co-workers wants to know what she is carrying. Mary explains that it is a solar cooker but is met with a confused expression "What do you mean cook with the sun? With a piece of folded cardboard? I would not trust it for my food!". Mary tells her she will explain more another time and they start to work.

Two hours of work later, they pause for a little break and Mary takes the opportunity to set the solar panel to let it cook while she continues the work.



Today Mary only had to prepare food for herself since the children had brought leftovers from yesterday to school. She unfolds the panel, assembles parts of the panels together and places it on the ground, making sure it is facing the sunshine. Today she just wanted to prepare something that she could eat fast so she mixes water together with maize flour in the black painted sufuria, then she covers it with a lid. When she looks up, she is surprised to see that her panel has flown away, so she grabs it immediately and collects some heavy stones that she can put around the cooker to make it stay. Minutes later she hears the landowner calling for her due to the complications with the solar cooker that took additional time. With no time to spare she places the sufuria in the cooker and insulates it with the sleeve that she finally had brought along with her. She leaves the solar panel with the sufuria inside and goes back to work, hoping that no stranger will pass by and steal the unattended food. While working she makes sure to keep an eye on the cooker and adjust the parts of the panels that have come loose. At home she has strings that can be attached to the panels to make sure it does not collapse.

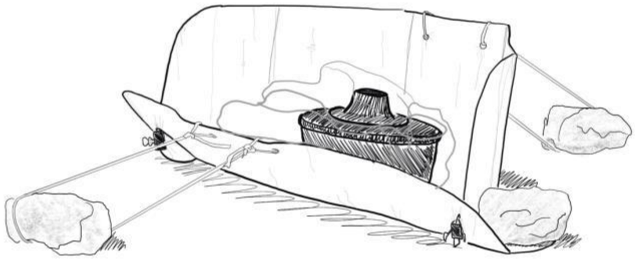
Time passes and the work schedule ends just in time for lunch. She walks towards the solar panel to check the food and realises it would have required a bit more cooking, but since she has to get back home, she settles for the result. When she uses the solar cooker at home there is always the possibility to add the food to a hay basket, if clouds or sunset disrupt the cooking, but she could never carry more than she already does for work. Now when she removes the plastic sleeve from the sufuria she starts to think about how she used to have plastic bags as insulators. Plastic bags were usually tightly closed but she had to make the switch due to the ban of plastic bags. Also, the sleeves do not cover the lid, so the heat is not trapped in the same way. In addition, the sleeve is made for a pot and a lid in prime condition but after using them for many years, often on the fire, they are bumped and the lid fits loosely, causing heat leakage and a more insufficient cooking.

BACK HOME

When she arrives home at 1 p.m. she leaves her stuff before she sits down to eat her cooked ugali. The time it took to walk home and the uneven lid have made the food slightly colder. After eating her food she gets up to clean the plate and the sufuria in order to begin preparing the second meal that needs to start cooking before the sunshine becomes insufficient. For supper she has planned to serve sukuma wiki with ugali, since she got some extra kale over from the farm today. She takes a seat in the kitchen among the cooking utensils and starts chopping the greens into smaller pieces.

Afterwards, she unfolds the solar panel again and sets it outside in the sun, far away from the house where no shadows can bother, and cautiously dusts the panel from dirt and food spillages earlier today. The family also owns a Jiko that they sometimes use right outside their house since it is easy to transport, compared to the firewood place that is more complex to move. She originally thought that the solar cooker could be used in the same place as the Jiko, but after a while realised that it required a much more open space where no shadows could cause problems. This made her put the solar cooker a few meters away from the house, though with new issues arising such as winds more easily catching the cooker.

So - once again she fixates the panel to the ground by using stones and this time combining it with attached strings for further stability. She brings a sufuria filled with the chopped vegetables and places it in the cooker. She also brings the sleeve insulator and this time she double insulates it with an additional sleeve for more powerful cooking. Now she lets the food cook and walks back to the house.

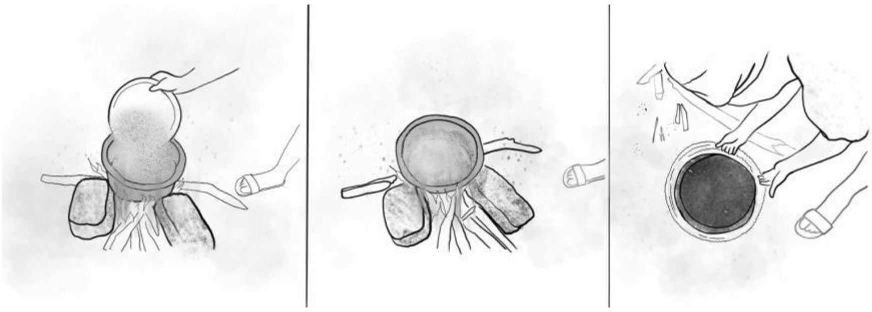


AFTERNOON

Back in the house she starts cleaning and sweeping both inside and in the garden outside the house. Her back begins hurting so she takes a short break to stretch her back. Her children arrive home from school which means she can leave the home and the solar cooker outside, without being afraid that weather changes would damage the unattended cooker and go to the market to sell some of the collected greens. On her way back home from the market she makes sure to pass the forest close to her house to collect some wood that she will need later today to cook the rest of the meal with.

COOKING DINNER

Mary arrives home and continues to prepare the supper. First, she walks toward the solar cooker to check the food in it and stir. Soon it is 5 p.m. and the sun is about to set and is not as strong as earlier so she brings the hay basket from the kitchen and transfers the sufuria from the solar panel to the basket to keep the cooking going. Then she wipes off the spillages from the panel with a dry cloth, folds the panel and carries it together with the hay basket back to the house. Immediately she lights the firewood in the kitchen corner and puts the water filled sufuria on top of the fire, waiting for it to boil. Her hands are dirty of soot but she is so used to the flames that it does not bother her. She brings the flour and starts pouring it into the warm water and stirs vigorously with a wooden spoon until it is finished. While moving the porridge from the hot pot, she burns her hands a couple of times.



When food is ready to be served, she brings the vegetable stew from the hay basket and divides the dish between the plates. When everyone has finished their food, Mary gets up to clean the utensils and her daughters join her to help and ease the workload. It takes some time to clean the sufuria that was used on the fireplace, because of burnt food and soot.

CELEBRATING

Tomorrow is Mary's daughter's birthday. Usually, it is difficult to bake any cake, because the fire emits uneven and too intense heat, but the solar cooker has made it possible. Mary has planned a party and the guests will be so surprised when they see the panel cooker preparing the cake in the garden. She is excited for tomorrow knowing how happy the kids will be!

8. Identified Development Areas

As a summary of the results, identified development areas have been formulated. These are product usage areas with frequent recurring issues that affect the user experience in a negative way. The areas are not entirely separated from each other and often touch upon the same problems but from different perspectives. In total ten areas have been identified which are described below.

8.1. Different from traditional way of cooking

A solar cooker looks very different from traditional stoves which has created doubt and low trust from potential users. The three-stone stove and the Jiko (KCJ) are much more robust when it comes to materials and construction and it seems as though this could be an important factor when it comes to trusting the product as a user. Using a solar cooker is also very different from traditional ways and requires training concerning its proper use and how to adapt traditional dishes for solar cooking. In addition, it is difficult for the user to access information, such as how it works, where it can be bought or even its mere existence.

8.2. Durability

The aspect of durability covers a lot of product issues that the user is experiencing. As mentioned, the solar cooker is often made in a way that does not withstand environmental stresses in a long-term perspective. The materials and the construction of the product enable the product to be easily transported, because of the weight and collapsibility, but it is also what makes the product prone to break. The foil covered cardboard is also a cheap solution, but some people are not convinced that it will work at all and many cases of broken solar cookers are proving them right. Compared to the three-stone stove and the Jiko, the solar cooker is much more vulnerable when exposed to the prevalent conditions such as rain, wind, dirt and pests like termites.

8.3. Back pain

The back pain problem is not just related to solar cooking, but to most chores done by the user. The user is often operating in a heavily bent position, causing the back to hurt. With other stoves that have a shorter cooking time and that are used closer to the houses, the user often mixes the standing bent position by sitting down on a chair or stool. The area where the solar cooker is used usually lacks any sitting possibilities, so the user continues to operate from a standing position.

8.4. A lot of products

A solar cooker user needs other stoves as well. Users often have a three-stone stove, a Jiko, some also own a gas cooker or a kerosene stove and a fireless cooker such as a hay basket. It is cumbersome and expensive to own many different products and even though a solution to the limited cooking capacity of the solar cooker would be to buy another one, it will only add even more products. The different products are often used in connection to each other but they do not have anything in common product wise.

8.5. Users loses habit

Activities connected to food, such as getting food, getting fuel and cooking, is a big part of the user's life. Changing the habits associated with cooking is an extensive task and affects many aspects of everyday life. It is impossible to use the solar cooker when it is raining and sometimes there are periods with rain every day. When the sunshine eventually returns, the user may have gone back to using other stoves and lost the habit of using the solar cooker. When this happens the relationship between product and user weakens, making the user less prone to incorporate the solar cooker with their everyday life and forget how to properly use it.

8.6. Outside problems

The solar cooker needs to be put in a place with as much sunshine as possible and where there is a low probability of shadows. These kinds of space are often exposed to wind since the absence of potential shadows makes it unprotected. The solar cooker is not seldom made of light materials with sometimes an unstable construction, forcing the users to fixate it with stones and wires in fear of the cooker collapsing or blowing away. Also as previously mentioned, the solar cookers are vulnerable when exposed to the conditions such as rain, dirt and pests like termites.

8.7. Insulation issues

The plastic bag is banned and has made users stop utilizing the solar cooker. The plastic bag insulated the entire pot but made it complex for the user to access the food. An alternative is the plastic sheet that is wrapped around the pot, but it does not offer complete insulation since the lid is uncovered. The solar cooker requires effective insulation in order to work properly but the pots and lids that are used are often so damaged that they are not close fitting anymore, causing heat losses and as a result prolonging the already time-consuming cooking.

8.8. Maintenance

Since many solar cookers are prone to breaking, they need frequent repairs. The user has limited resources in order to fix this and the low diffusion of the product makes it difficult to get support from other people or places, such as stores. It is not unusual that people stop using the solar cooker when this happens. The reflective panels of the solar cooker are often made of foil applied to other, more sturdier materials. Sometimes the foil gets damaged or ripped off and needs to be changed, which also results in added burdens for the user.

8.9. Theft

One of the benefits of the solar cooker is for the user to be able to leave it unobserved for a longer period of time while it cooks. However, the cooker is placed on the ground and the open construction makes it easy for by-passers to notice the food. Curious animals or hungry thieves have access, and even though the food is more often stolen than the actual cooker, it is easy to grab everything and go.

8.10. Seen as a poor-man's product

The material and construction of some solar cookers both look questionable and require a lot of adjustments which further reinforces the idea of the solar cooker as a cheap product that is only used if there is no other option. It is a vicious circle since people with a higher income level tend to reject it and then people from lower level incomes, who does not want to be seen as poor, adopt this behaviour.

9. Solution guidelines

As a further result of the identified problem areas, solution guidelines were formulated. Since the physical product itself was considered deficient in many different ways, the solution guidelines also revolve around solving the shortcomings of the product. The guidelines are based on the problems identified but constructed as solutions instead, e.g., the problem with the cooker collapsing in the wind was formulated as a solution that the cooker should be "safe in wind conditions". Since the guidelines are based on the problems experienced by the targeted user, they are applicable to cookers that the user owns. As mentioned in *6.1.4. Common solar cookers and related products,* panel cookers are the most common type, however some users had box cookers. The solution guidelines are applicable to both types, though the more extensive use of panel cookers have emphasized issues connected to this type.

In total there are 22 different solution guidelines, as seen below. Guidelines marked with a star (*) are considered to be crucial in the development of a solar cooker, based on the main function of being able to cook with the sun in the intended context. Other guidelines should be incorporated as much as possible.

- The solution should offer solar cooking with reflective panels that concentrate the sunshine.*
- The solution should be stable and possible to be put on the ground without collapsing.*
- The solution should offer insulation which cannot be plastic bags. It must be possible to insulate the pot and the insulation must be accessible to open relatively easily by the user during the cooking.*
- The solution should be movable during cooking. In case of arising shadows or sudden rain, the cooker must be possible to move.*
- The solution should be safe in wind conditions.*
- The material and construction of the solution should be durable.
- The solution should require as few redirections and check-ups by the user as possible.
- The solution should be intuitive, easy to understand and use and not require additional training.
- The solution should be able to be redirected towards the sun (there should be a balance between the efficiency of the solar cooker and time spent redirecting it).
- The solution should be ergonomic by promoting an ergonomic body posture.
- The solution should be transportable (e.g. collapsible).
- The solution should be possible to store (e.g. either small or collapsible).
- The solution should provide a shape, surface and construction that is water and food proof.
- The solution should be easy to clean (with a dry or moist cloth).
- The solution should allow the food to be easy accessed by the user.
- The solution should offer other areas of use (utilize the solution for other purposes in the user's everyday life and routine).
- The solution should be compatible with other user products.
- The solution should resemble traditional ways of cooking style and method wise.

- The solution should express autonomy in a way that the user should feel safe leaving the cooker.
- The solution should be discreet and not easily accessed by passers-by.
- The solution should not allow the food to be visible and easily accessed by passers-by.
- The solution should enable larger cooking capacity, either by itself or combined with other solar cookers.

DEVELOP

The concept step describes results derived from the *develop* phase of the project. Presented are the chosen cooker type to develop further, created ideas, concepts and finally the selection of one concept.

10. Developing the conical solar cooker

As a first step of creating a concept, the conical solar cooker was chosen as the specific product to develop further. In order to make use of the user study results, without adventuring the main function of the solar cooker, it was important to proceed from a solar cooking type that is being used today. The panel cooker was the most used solar cooker type among the target group and CooKit was the most used panel model. Of the interviewed users who had not stopped using their solar cookers, the conical type, which is also a panel cooker, was as common as the CooKit. The difference is that the CooKit has been more refined through many years of development, still with a lot of user issues.

The conical cooker is also suitable for a place like Kenya, as mentioned in *4.1.1. Solar cooker models*. When studying the solution guidelines and what kind of requirements that the new concept should fulfil, the conical was also considered to have development potential compared to other cookers used. The other panel cookers used, CooKit, Haines and Copenhagen, are based on a fixed shape and construction and it is difficult to develop these further without compromising on the main function of being able to cook with the sun.

The conical types made at Asulma Centre, as mentioned in *6.1.1. Organisations,* are widely used but are built in similar ways as they are building the CooKit and therefore face similar user issues. It was also confirmed by the project initiator and Asulma Centre that they saw potential in the development of the conical type. Hence, in the ideation of ideas, it was decided to base the development of concepts on a conical solar cooker type.

10.1. Ideas

All solutions are based on the principle of a conical cooker which is a type of panel solar cooker. The ideas are based around certain problem areas and are not complete product solutions. Inspiration for the solutions came from the styling board, see figure 10.1, with products that solve similar issues as the ones identified with the solar cooker.

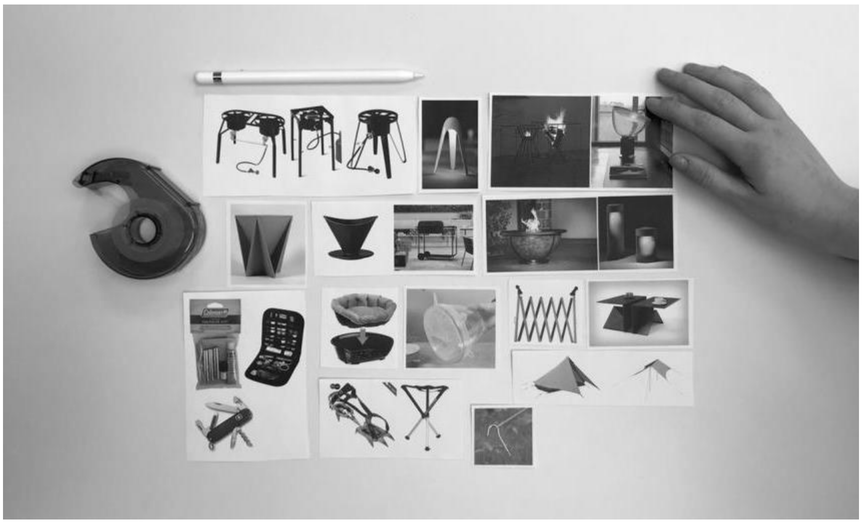


Figure 10.1
The styling board with inspirational product solutions.

10.1.1. Durable solutions

In order for the solar cooker to both be durable and express durability, there are a couple of aspects that need to be taken into consideration. It is clear that both material and construction of the product can affect how durable it is. Weather and wind had a negative impact on the vulnerable cooker, where it either collapsed or got damaged. A majority of the target group live in relatively exposed areas, hence the importance of incorporating products that should not have to be treated as fragile, are water and termite resistant and obviously tolerate high sun exposures.

Other products that the user has consist of some sort of metal and have proved to last over longer periods of time, without frequent need of adjustments or repairs, such as the sufuria. Compared to cardboard many metals can withstand water, dirt and everyday usage much better. In order to create a more sustainable solar cooker this could be a useful material. The surface of the metal could be polished to create the reflective panels without having to add another material to the construction, such as when foil is added to the cardboard of the solar cooker. By limiting the number of materials that the product is made of, the risk of parts falling apart from each other could potentially be reduced. A negative aspect is that the choice of metal might complicate the transportability. It is possible to make lightweight constructions of metal, even though it would not be as light as many other materials, but to make it collapsible in the same way as cardboard constructions would be a challenge.

Another idea is having a construction made in metallized polyester which is a more flexible and light material that improves the possibilities of transporting a product made of it. The material is based on a polyester with a thin metal coating. The metal coating is for creating the reflective surfaces on the solar cooker. An additional reason why polyesters could be used is not being vulnerable to termite attacks. This makes the idea more durable since the user can keep the product for a longer period of time. Moreover, this solution is believed easy to clean due to even surfaces. As previously mentioned, solar cookers are "sometimes" exposed to water, so having a construction made of polyester, the solar cooker would not face this problem.

The construction of the product could be much more robust and rigid in order to better withstand the conditions. This would add both to the stability of the product and make it less prone to be in need of repair.

10.1.2. Solar cooking combined with other products

The solar cooker should be combined with other products that the user usually owns in order to make it a more natural part of existing practices. One idea is to make the cone reflector applicable to the Jiko in a way that utilizes the Jiko as a stable stand for the solar cooker, as seen in figure 10.2. The user often varies between the stoves and uses them in connection with each other by e.g., pre-cooking the food in the solar cooker and finishing the cooking on the Jiko. With this solution the user only needs to remove the panels and light the Jiko, which will lessen the steps between the usages of stoves. The hope is to make the user as comfortable with the solar cooker as the Jiko, seeing that they are almost the same stove but with different fuels, rather than an entirely different stove. Sometimes the food has not been properly cooked by the solar cooker, e.g., due to sunset or lack of time, so instead of the user feeling disappointment there could be a more natural transition to the Jiko which will finish the food.

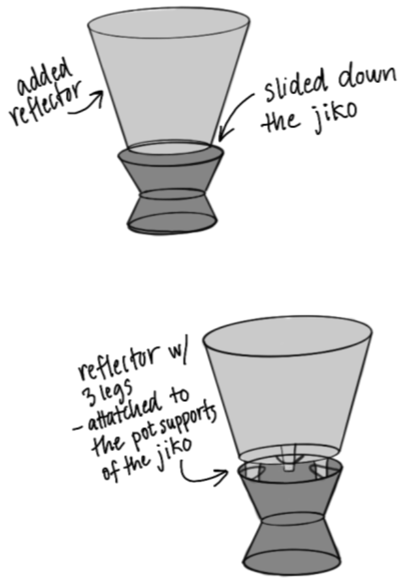


Figure 10.2
Combining the solar cooker with the jiko stove.

The hay basket is used both by solar cooker users and people without a solar cooker. Just like the solar cooker it cannot be solely relied on and requires the user to own several cooking products. By combining the solar cooker with the hay basket, the number of products would be less, as seen in figure 10.3. This could also mean that the solar cooker would have a purpose even on rainy days. Today the hay basket usually has some kind of outer construction in a sturdier material, compared to the soft inner filling made to maintain the temperature of the pot that is placed inside. If the solar cooker works as the outer construction then the filling could be held in place by it. Even if the cooker would not be used as a solar cooker at these times, the thought is that the user would still cook with it and be more prone to actually use it when the sunshine returns, keeping the user from losing its habits.

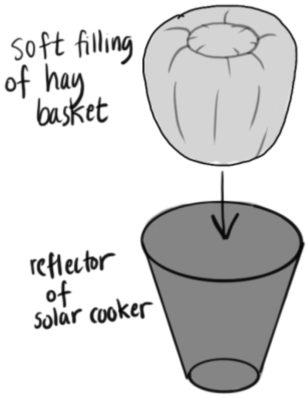


Figure 10.3
Utilizing the solar cooker as a hay basket.

10.1.3. Solar cooking using a number of panels

The idea is to enable the use of several solar cookers at the same time by placing conical cookers close to each other on a stand. The stand is a one-piece part that gathers the cookers close to each other into one unit. Even though the idea does not encourage combining different kinds of stoves together, it promotes combining a number of more than one solar cooker in order to increase the cooking capacity that many users expressed as a problem. Also, since the cookers are placed on a higher stand, the idea encourages users to maintain a healthier working posture. When the user only wishes to use one conical panel at a time, he or she can push the stand back to its "main" position as shown in figure 10.4.

Figure 10.4
Several solar cookers in one product.

10.1.4. Solar cooker for other areas of use

This solar cooker idea is divided into two separate main parts consisting of the conical reflector panel and the cylindrical shaped bottom part supporting the reflector panel. On top of the cylindrical form, there is an upturned spherical cap with a black surface where the pot can be placed. The product idea is composed of two different parts but should be used together in order to fulfil its function of solar cooking. The user begins by placing the two parts on the ground as seen in figure 10.5, followed by picking up the cylindrical part from the ground by grabbing the spherical form and placing it down and in the centre of the conical part. Then the user raises the conical form and fixates its position. Finally, the user can put down a sufuria on the black surface inside the cooker panel and start cooking. Since the panel is placed relatively high, the user will not need to bend over and experience any back pain.

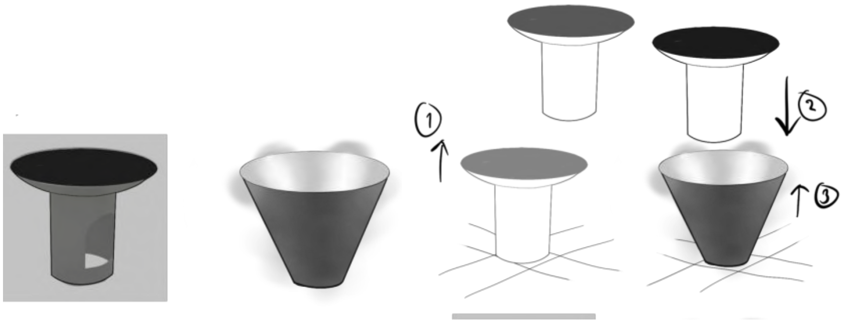


Figure 10.5
Using the solar cooker as a stool.

The loss of habit of using a solar cooker has been described as (in part) a result when weather conditions do not enable the use of it. When the user cannot use the product for cooking, the cylindrical part of the product could be used as a stool. The purpose is utilizing the product on a daily basis in order to maintain or even strengthen the relationship between the product and user. Part of the product will remain incorporated in the everyday life of the user and he or she will hopefully not forget about its existence when there is sunshine (again). However, there is a risk that the user might continue solely using one of the parts as a stool and forget about the second part.

10.1.5. Insulation

In order to ensure sufficient insulation, the solution needs to be compatible with the often-dented cooking tools. The solution must also be compatible with different sizes of pots and lids. Even though most of them have approximately the same size, some flexibility is important.

One idea is that the sleeve that has replaced the plastic bag could be accompanied by a cone shaped cover on top that would encapsulate both pot and lid in a house-like construction, as seen in figure 10.6. The cone would be made in the same transparent, airtight material as the sleeve to make sure that the sunshine can reach the pot and that the heat will stay.

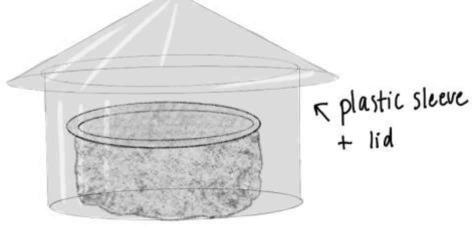


Figure 10.6
The house-like insulation.

Another idea is to make an entire new lid for the pot that also works as insulation, see figure 10.7. It could be made of glass to be more durable than the insulation made in pure plastic. It still needs to fit a selection of sizes which is solved with a wide edge of silicone for adjustment according to pot diameter. The silicone edge would also make the lid fit the pot better because of its elastic properties, compared to today's lid which, just like the pot, is made of aluminium.

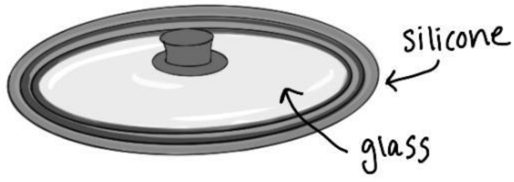


Figure 10.7
The glass lid insulation.

The lid could also be made entirely in silicone or another type of soft plastic, as seen in figure 10.8, instead of having a glass component. This way the lid would not break if dropped on the ground and there would not be any risk of components detaching from each other. The lid should still be transparent to make sure that as much sunshine as possible is captured.

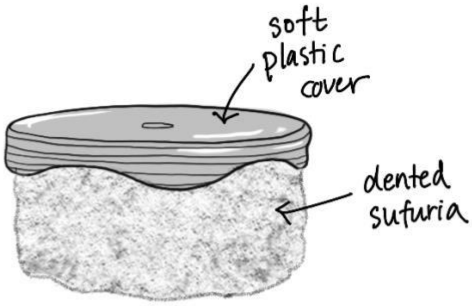


Figure 10.8
The soft insulation lid.

The simple heat insulation idea presented in figure 10.9 is a circular one-component product that geometrically fits circular forms. To perfectly fit a conical solar cooker, the base of the conical shape of the cooker must acquire a constant base radius. The circular sheet is placed on top of the conical solar cooker and gently let down along with the cone until the diameter size of the sheet approaches a perfect fit in the cooker, see figure 10.9. An insulation should not cause any complications for the user when accessing the food. When the user wishes to taste or check on the food, he or she can easily remove the disc from the cone.

Figure 10.9
The circular insulation disc.

10.1.6. Support for stability and ergonomics

The solar panel cooker is vulnerable to outside forces. There is a need for some kind of support, like the stones that the user puts on the cooker in order for it to not collapse or be blown away by the wind. The shape of the cone is also unstable since the part with the smaller diameter has to be closest to the ground. A solution is to support the reflector in some way, as seen in figure 10.10.

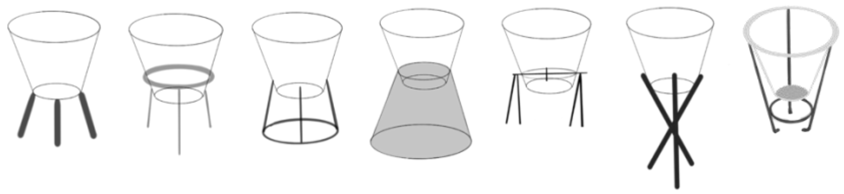


Figure 10.10
Different ways of supporting the cone.

The ground is in most cases made up of soil, with elements of sand and vegetation. It is an uneven and porous surface on which the solar cooker is supposed to be placed and left for a longer period of time. Whether the solar cooker is elevated or not, it needs to have a secure position which creates demands for contact with the ground, as seen in figure 10.11.

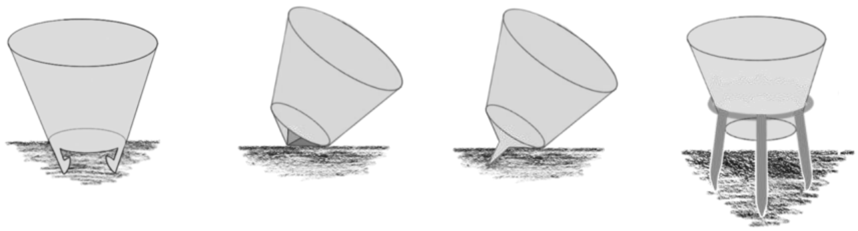


Figure 10.11
Different ways of securing the position of the cone.

10.1.7. Transportable

It has been observed that individuals might be interested in carrying the solar cooker along to work. Depending on the profession of the users, it was communicated that solar cookers either accompanied users to work and then back home or were carried and left at the workplace for continuous usage.

This solar cooker idea, figure 10.12, is meant to be made of a flexible and reflective material, such as metalized polyester, that enables the user to fold it in such a way that he or she can effortlessly bring it along anywhere. The cooker consists of two parts connected to each other. The reflector sheet is basically an adjustable arc that together with a circular base make up a conical solar cooker, as seen in figure 10.12. The circular base is attached to the arc for the purpose of it not getting lost. When the solar cooker is not used, the arc is rolled up and the base surface can be turned upwards. In afternoons or earlier in the day when sun is not completely overhead in the sky, this solar cooker idea can adopt a wider cone shape due to the flexibility of the material so the user neither needs to redirect the whole cooker towards sun nor carry out any complicated adjustments. The person using it can both use it on the ground or on higher surfaces if so desired.

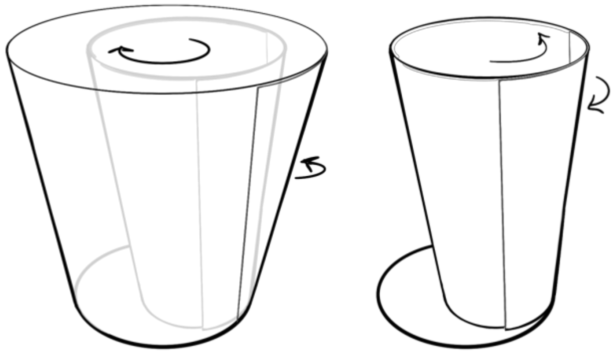


Figure 10.12
The adjustable arc cone.

A second idea for enabling transportability of the cooker is making use of small wheels attached to the bottom of a stand. This way, the user can move the product from one place to another without any arduous job of carrying the solar cooker. There are two grips, as shown in figure 10.13, for facilitating the movement and direction of the stand. Only by placing a conical solar cooker inside the stand, the product is ready to be transported. However, due to use environment conditions, small wheels might not be practical and may quickly be destroyed.

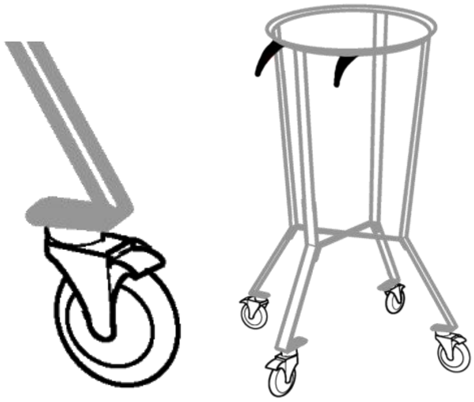


Figure 10.13
The two grips of the cone stand with wheels.

10.1.8. Repair kit

The problem of not being able to repair the solar cooker when it breaks could be solved by including a repair kit as a part of the product. This would facilitate for the user who might not have the resources or knowledge to be able to fix it on their own. The kit could consist of tools and materials that would help fix most typical problems. Today users sometimes experience that collapsible solar cooker breaks along the folding line due to material fatigue. A needle and thread or tape with instructions would then work as a helping guide for the user and make sure that the user does not stop solar cooking because of broken and unfixed parts.

11. Concepts

Presented below are the three concepts, as a result of the morphological analysis (see Appendix III). The concepts are called Concept 1 - modular cone, Concept 2 - compatible cone and Concept 3 - durable cone. All of them are based on the previous presented ideas but are further developed and put together into entire concepts. Some ideas were not possible to combine with each other, creating different concepts with different specializations.

11.1. Concept 1 - modular cone

The philosophy of the modular concept is to benefit flexible use and make repair easy, by creating a product that consists of many different separate components. The concept is meant to encourage the user to utilize more than only one reflector in order to increase the capacity of the cooker. It should also reduce the risk of thefts, both concerning food and product. The concept consists of one or two reflector cones, an expandable cone stand, an insulation part and a repair kit.

The reflector cone is made of the same type of material that the panel cooker usually is made of, which is foil covered cardboard. Together the two materials make up a lightweight construction with separate pieces that could be independently exchanged if one of them would break. The product could include two reflectors from the start if the user comes from a bigger family that is aware of the capacity limitations solar cookers sometimes pose. There could also be the possibility of starting off with one reflector and then expanding the number if needed as seen in figure 11.1.

Figure 11.1
Concept 1 with one cone capacity to the left and two cone capacity to the right.

A stand will keep the cone in place and improve the operating height for the user. The stand has rings where the cone is to be placed. Inside each ring there is a small hook that will enable a more secure fixation of the cone, considering wind and theft. The cone has a hole in its wall where the hook can enter and thereby lock the position of the cone.

The stand should enable the user to cook with either one or two reflectors, making the usage flexible and increasing the cooking capacity when needed. A stated user issue was that the solar cooker cannot cook enough food for an entire family which forces the user to cook part of the meal on another stove. If the capacity of the solar cooker is increased, then the user might feel that it is easier to rely on the solar cooker solely. Since the solar cooker does not require much attention during the actual cooking, another reflector will not put more stress on the user.

The stand is made up of cylindrical bars that can be extended due to its telescopic-like construction, see figure 11.2. In its original state the stand offers space for one reflector cone. If two reflectors are to be used then it is possible to expand the stand into a wider construction, revealing an additional space for the second reflector. When the user only wishes to use one conical panel at a time, he or she can push the stand back to its main position. The user could also make sure to leave the stand extended even when only using one reflector. In that way the product looks more cumbersome to steal since it would be more difficult to carry away.

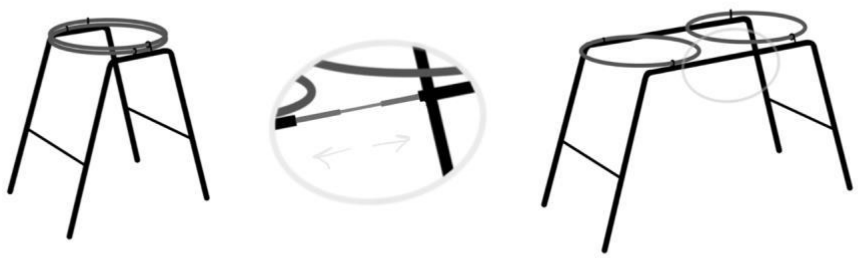


Figure 11.2
Far left shows the stand in its original state, the illustration in the middle shows how the stand is extendable and far right shows the stand in its extended state.

The concept includes the house-like insulation idea, where the entire pot and lid are covered, as seen in figure 11.3. The walls of the insulation house are mounted to the base of the cone. When the user has put the cone in the stand, the cooking pot filled with food is ready to be placed at the bottom of the cone, inside the walls of the insulation. The "roof" of the insulation is placed on top, covering the cooking pot in a way that enables the sunshine to reach the pot at the same time as it is making sure that the heat will stay. In order to make it more difficult for passers-by to access and steal the food the insulation also works as a protective shield for the food, which is the reason for mounting the insulation into the cone. The insulation roof fits inside the insulation walls perfectly and has tabs on the side that helps fixation and detachment. These tabs are made in the same transparent material as the rest of the insulation and are not easily detected by someone who does not know what to look for. The user should be able to access the food without hassle, but it is positive if a potential thief gets confused by the seemingly inaccessible pot of food.

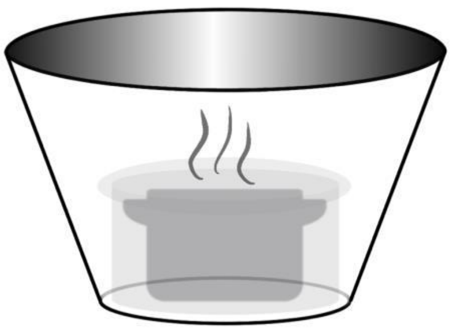


Figure 11.3
An illustration that shows the cone containing insulation and cooking pot.

The concept includes a repair kit and instructions for how to take care of the product as a preventative tool for possible breakages of the product as shown in figure 11.4. The kit would work as a helping hand for the user who might not have the knowledge or resources to fix the problem on their own. Even though the solar cooker is not used when it is raining the cardboard of the reflector could be damaged when being cleaned or stored, either by moist or pests. In addition, the weather could fluctuate between sunshine and rain. Damaged cardboard could e.g., be fixed with tape or other fixation products as a 'quick fix'. Needle and thread could be used for sewing together pieces as a more long-lasting procedure. The repair kit should also include a package of glue if the foil comes off from the cardboard and extra foil if pieces have disappeared.

Figure 11.4
An illustration showing the repair kit that should be included in the product along with instructions on how to use them.

11.2. Concept 2 - compatible cone

Concept 2 addresses the needs of frequently moving the cooker between home and work. A concept that has to be moved from one place to another calls for flexible and adaptable parts that do not demand too "much effort" from the user. A simple construction that is essentially composed of one arc made of metalized and PVC plastic films that together with tent-like spikes and glazing system constitute a complete operating solar cooker. The arc makes up a cone with both a lateral surface and a base part, where the lateral part has a reflective surface and the base part of quadrilateral surfaces are in darker colour, as shown in figure 11.5. On one side of the edge of the reflective part, there is a so-called 'locking tab', see figure 11.5, which can attach to cross sections along the lateral surface of the arc to achieve a certain conical shape. The cross sections on the arc are intended for enabling different angles of the cone, for the purpose of adjusting the conical solar cooker to the position of the sun during the day as shown in figure 11.6. The cone is wider when the locking tab is attached to the cross-section near the edge, the intention is to have to make as few readjustments towards the sun as possible. The cone is narrower when the locking tab is attached to one of the cross-sections further away from the edge. The reason for obtaining a narrower cone is a more efficient cooking time, though that requires more frequent adjustments.

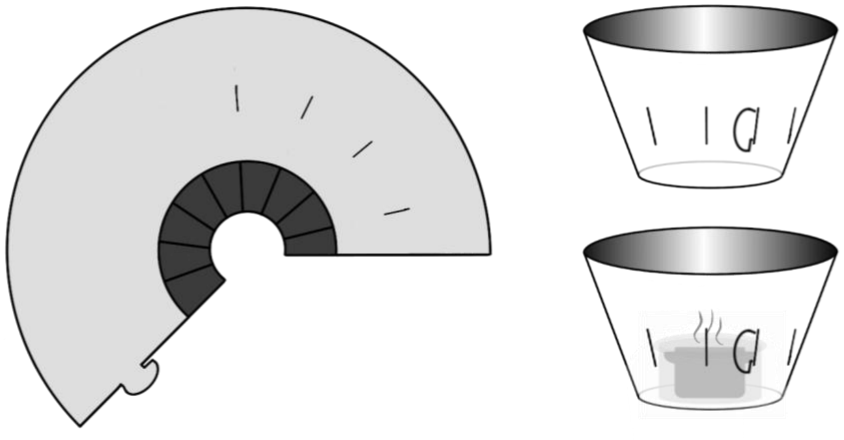


Figure 11.5
Illustrations of the cone showing the cross-sections and the locking tab.

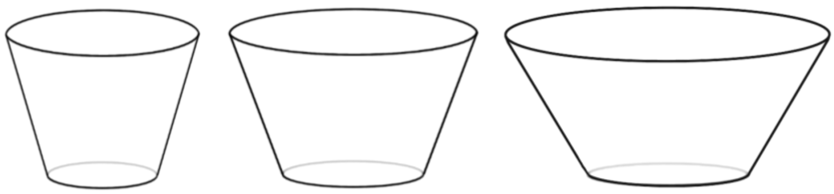


Figure 11.6
The cone in different opening angles.

Three tent-like spikes are a part of the concept and are used in order to fixate and stabilize the conical cooker on the ground. These spikes are placed from the inside of the cooker, on the edges of the bottom base part, through grommet holes and down into the ground, as shown in figure 11.7.

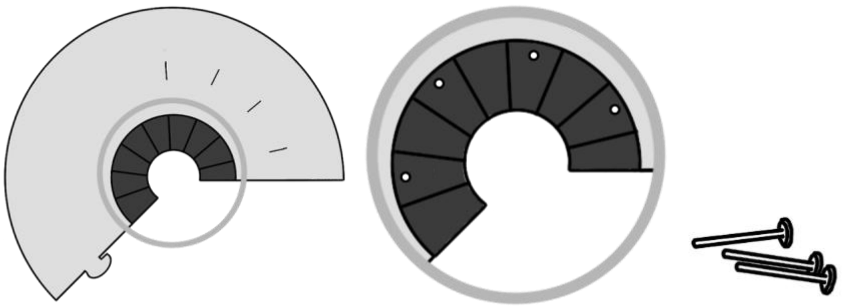


Figure 11.7
Illustrations of the holes that the belonging spikes should be placed in.

The flexible and adaptable characteristics of the concept is meant to also be utilized in such a way that it can operate with other products, such as the Jiko stove and the hay basket. Thanks to the adjustable angle and diameters of the cone, the cone can be positioned inside the circular shape of various Jiko stoves sizes, as seen in figure 11.8. Besides, the cone is applied to the Jiko in a way that utilizes the Jiko as a stable stand for the solar cooker that also improves a healthier working posture than completely on a ground. This combination allows a more natural part of an already existing product and encourages users to use them in connection with each other, for instance by pre-cooking the food in the solar cooker and finishing the cooking on the Jiko, as previously described in *10.1.2. Solar cooking combined with other products*. The same applies for combining it with a hay basket or other cylinder-like structures to which the solar cooker can be attached or fit into.

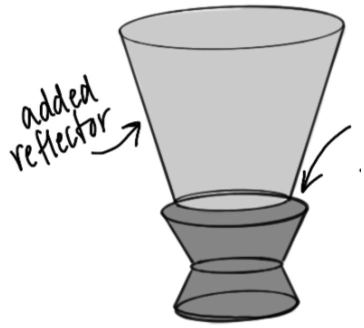


Figure 11.8
The reflector added to a Jiko.

The concept includes a soft and flexible cover made in silicone, as shown in figure 11.9. Thanks to material properties, the cover is easily applied by the user and fits various different sufuria sizes. This heat insulation idea does not demand any sufuria pots in good conditions, considering that earlier studies showed that the sufuria used were often worn out and uneven in shape, and is therefore suitable for all sufurias.

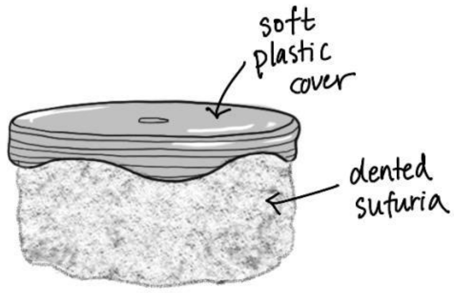


Figure 11.9
Soft plastic covering a dented sufuria.

When the solar cooker is not in use, the arc is rolled up into an oblong cylinder-like shape with the quadrilateral surfaces of the arc bent downwards, see figure 11.10. To retain its position, a string is tied around the cylindrical shape of the cone and carried away.

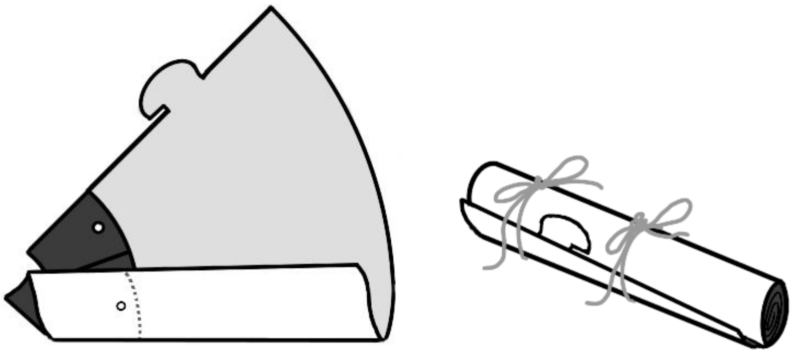


Figure 11.10
The arc rolled up into an oblong cylinder-like shape.

11.3. Concept 3 - Durable cone

Concept 3, as seen in figure 11.11, is meant to be durable by having a simple construction and consist of few materials. It is made up of a cone, a three-legged stand and an insulation disc. The cone and stand are made entirely in aluminium which is a reliable material considering the intended use context. Aluminium possesses the many qualities of metals but is relatively light and does not rust, even though corrosion can happen. The material is still heavy enough to not pose a problem considering windy conditions.

Figure 11.11
Concept 3.

The cone is meant to be placed in a stand that consists of a ring with three legs as shown in figure 11.12. The outside walls of the cone will rest against the inside surface of the ring, which will create a reliable support. The legs are angled to secure the position and offer stability to the solar cooker. The legs will also increase the height of the product and help the user to maintain a healthier working posture.

Figure 11.12
The stand of the concept.

The inside of the cone is supposed to be polished in order to work as the reflector. Instead of having a foil attached to the panel of the cooker, this polished surface will reduce the number of materials. It is possible to create highly reflective aluminium surfaces and since there is no smoke involved during the cooking, the surface has a chance of being kept intact.

The outside of the cone is meant to have a much coarser surface as shown in figure 11.13, which would also be the case of the ring of the stand. This should increase the contact friction between the two components and make sure that the cone is not sliding from its intended position. The idea is also to make the cone redirectable according to the angle of the sun. The frictional force should be large enough to make the redirected cone stay in place, but small enough for the user to be able to make the change of position without too much effort, see figure 11.14.

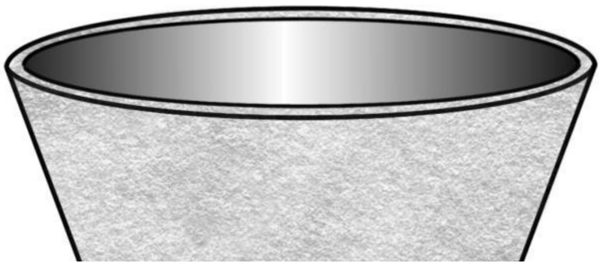


Figure 11.13
The outside surface of the cone is coarse compared to the shiny inside.

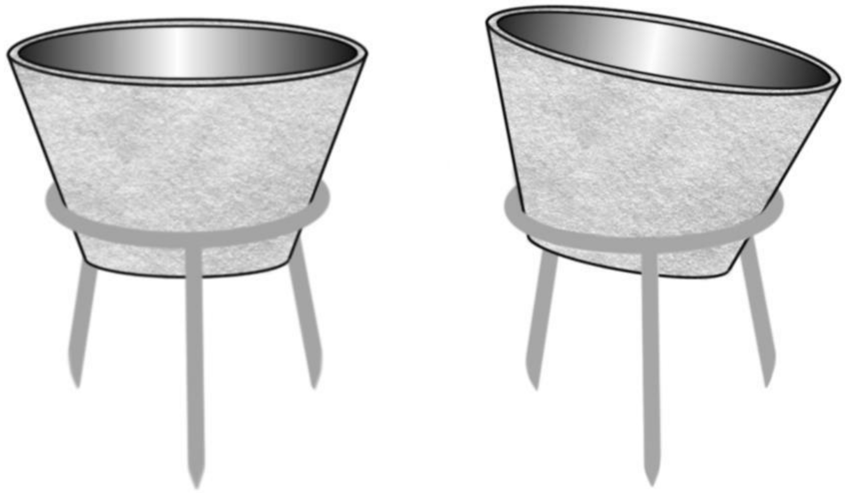


Figure 11.14
The left shows the solar cooker in its upright position and to the right the cone is angled according to the sun.

Concept 3 uses a transparent disc enclosing the pot as an insulation as shown in figure 11.15. The insulator disc is a one-component circular part that fits the conical shape of the cooker due to circular circumferences. In order for the component to fit with a variety of sufuria sizes, the disc maintains a certain diameter that allows a certain space between pot and disc. The transparent disc is placed on top of the conical solar cooker and gently let down along with the cone until the diameter size of the disc reaches a perfect fit in the cooker, without touching any sufuria below.

Figure 11.15
The blue part illustrates the insulation of the cooker.

The simple shape and sturdiness of the conical component allows combination possibilities with other cooking related products, such as hay baskets as illustrated in figure 11.16. Hay baskets are often used in combination with solar cooking and other ways of cooking, in order to maintain the heat of the food.

Figure 11.16
Concept 3 with a soft filling in order to work as a hay basket.

When the solar cooker cannot be used for cooking in the sun, the product can fulfil other tasks. Due to the robust construction and the material that the conical part is made of, it can be used for purposes such as collecting rain water.

11.4. Concept Selection

The selection of a concept was made with support from a Pugh evaluation matrix, see table 11.1. The three concepts were compared to the reference product - the existing CooKit. All three concepts performed better than the reference, even though concept 1 had a net score close to that of CooKit. Concept 3, the durable cone, got the highest net score and was chosen as the concept to develop further.

Criteria	**Reference product** (CooKit)	**Concept 1**	**Concept 2**	**Concept 3**
Stable (on the ground)		+	0	+
Insulation (usability/ compatibility)	*sleeve*	0	+	+
Movable		+	0	+
Safe in wind		+	0	+
Safe in rain		0	+	+
Durable construction		0	0	+
Redirectable		-	+	+
Ergonomic		+	0	+
Durable material		0	+	+
Transportable		-	0	-
Storage		-	0	-
Cleanable		0	+	+

User accessibility		-	-	-
Theft-proof		+	+	+
Other areas of use		0	0	+
Compatibility		0	+	0
Traditional		0	0	+
Capacity		+	0	0
Sum +		6	7	13
Sum 0		8	10	2
Sum -		4	1	3
Net score	0	2	6	10
Rank		3	2	1
Continue?		No	No	Yes

Table 11.1
The Pugh matrix.

Concepts 2 and 3 had insulation principles that could be combined with the sleeve that is being used today, making them score higher compared to Concept 1 that was much more limited. The insulation of Concept 2 was even possible to combine with Concept 3, making it interesting as a separate function, even though Concept 2 as a whole was not chosen to develop further.

The highest scoring concept performed well in thirteen of the total sixteen criteria. The main focus of the concept was durability which proved to be a useful aspect for many different criteria. It was no surprise that this concept performed well in areas such as "durable construction", but it also scored high in e.g., "stability", "safe in wind", "safe in rain" and "cleanable".

The criteria that Concept 3 scored higher on in comparison with other concepts were the following: Durable construction, other areas of use and traditional. Both Concept 1 and Concept 2 consist of a number of parts which in turn increase the risk of product breakage unlike Concept 3 that is based on few parts and assemblies. The material that Concept 3 consists of, i.e. aluminium, resembles the materials used in traditional kitchen utensils compared to cardboard and metallized polyester that are not commonly used in other daily kitchen products.

What Concept 3 scored lower on compared to the reference product, the CooKit, was transportability, storage and user accessibility. The low scores of the criteria "transportable" and "storage" were due to durable material and construction properties which make Concept 3 more difficult to transport the product easily in long distances and more difficult to fold for efficient storage.

11.5. Moodboard

The moodboard is a selection of products representing and expressing the desired style of the concept with keywords such as durability, trustworthiness and timelessness, see figure 11.17. The products are all old Kenyan products, some which are still used today. Each product is made out of a few different materials and has few details and separate parts but are still highly functional.

Figure 11.17
Moodboard of the durable concept.
Top row. Left: *Turkana bowl.* Middle: *Sufuria.* Right: *Basket.* Bottom row. Left: *Armband (Bracelet).* Middle: *Three-legged wooden stool*. Right: *Pickaxe.*

From *Turkana Bowl* [Photograph], by Orient House, n.d., Orient House (https://www.orienthouse.com.au/product/uncategorized/turkana-bowl/).

From *Sufuria* [Photograph], by Lillo, O, n.d., (https://oskarlillo.com/Sufuria).

From *Korg, basket, kyondo* [Photograph], by Statens museer för världskultur, n.d., Statens museer för världskultur (http://www.kringla.nu/kringla/objekt?text=swahili&sida=5&referens=SMVK-EM/objekt/1188568). CC BY 4.0

From *Armband* [Photograph], by Statens museer för världskultur, n.d., Statens museer för världskultur (http://collections.smvk.se/carlotta-em/web/object/1300509). CC BY 4.0

From *Three-legged wooden stool* [Photograph], by WEART, n.d., WEART, (https://www.weart.com/en/tripod-wooden-stool.html).

From *Redskap, hacka, pickaxe, jembe (swahili)* [Photograph], by Statens museer för världskultur, n.d., Statens museer (http://collections.smvk.se/carlotta-em/web/object/1559799). CC BY 4.0

FINALIZE

The chosen concept underwent a finalization phase where further developments were made concerning e.g., the exact angle of the cone, the tilting mechanism and the positioning of the pot. A number of criteria were formulated before creating the final version of the concept – JiKoni.

12. Concept refinement

The chosen concept needed further development since there were still areas that had been overlooked. Based on the feedback of the chosen concept, from EWB and two of the entrepreneurs from Asulma Centre and Farmers With a Vision, some aspects that required examination were identified. Access to a document, describing suggested development of the current conical cooker at Asulma Centre, was provided and it presented some useful information regarding suitable angles for the conical in order to maximise the uptake of sunlight. It was stated that the cone should have a wide opening angle to be able to catch the rays of the sun during a longer period of time, without having to redirect the cone frequently.

Still, it was recommended that a slight redirection of the cone should be possible in order to utilize the sun in the morning and late afternoon. Suggested was a possible directional change of approximately 20 degrees if the cone had an opening angle of 60 degrees. It was pointed out that the principle of the redirection of the concept seemed to have potential but needed further investigation, which was done by building prototypes (see Appendix IV). The prototypes gave positive indications about the movability of a cone in a ring, like the construction of the suggested concept and increased friction supported a fixed position. The cross-section of the 60-degree cone was analysed at three different angles (5, 10 and 20 degrees) to evaluate how the cone would fit against the ring. The cross-section appeared to have a small deviation from the circular ring, which made it possible to assume that a 20-degree angled cone could remain in a fixed position (see appendix IV).

Redirecting the cone would also mean that the pot placed on the bottom of the cone would be redirected. Concerns were raised regarding whether the food-filled pot would spill out its content or even tumble over. The limited cooking capacity of solar cookers in general was discussed as a positive aspect in this case, since the pots are often sparsely filled.

Since the panels of the concept are thought to be made in a single material and not covered by a separate foil, it was discussed whether this would be possible to manufacture. In order for the solar cooker to work effectively the panel surfaces should have a reflection factor of 85% - 90% or more. Manufacturing aspects to consider, such as if the material and construction could be produced in Kenya, was also brought up. The entrepreneur from Farmers With a Vision stated the concept had potential to be manufactured in Kenya by training village tinsmith who could produce the conical solar cookers.

The idea of combining the solar cooker with a hay basket was not entirely neglected, but to include a soft inner filling with the current concept would lead to additional parts and additional costs. The commonly used Wonderbag, the foam insulated bag, could work as the inside in order for the user to be able to utilize products they might already own.

It was decided to name the concept by including the Swahili word for “cone”, which is “koni”. Since “jiko” means “oven”, the two words were combined to “JiKoni”, which also happened to mean “kitchen”.

12.1. List of criteria

As a development and refinement of the solution guidelines, an updated list of criteria could be formulated, see table 12.1. Insights from the feedback helped to define the guidelines further and also formulate new criteria that the concept should fulfil. Each criterion was numbered and new criteria explained further below the table.

List of criteria		
No	**Criteria**	**Description**
1.	Offer solar cooking	
2.	Reflect sun	There must be enough uptake of sun rays reflected in the conical cooker. The cone should have an angle of 60°
3.	Prevent double reflection	Incoming sun rays should only be reflected once before hitting the dark bottom plate. Equal length of all sides of the cone.
4.	Contain reflector	Highly reflective inside the surface of the cone. Highly polished aluminium.
5.	Hold pot	There must be enough space for an averaged sized sufuria and that space must be where the concentration of sunlight is.
6.	Offer insulation	Cannot be a plastic bag. The insulation should be flexible according to used pot diameter. The insulation should have a diameter allowing different heights of typical used pots and pans.
7.	Provide movability (during cooking)	E.g., solar cooker must be able to be moved if shadows suddenly would occur.
8.	Endure wind	The solar cooker should not be easily caught by the wind.
9.	Endure rain	The construction and material of the solar cooker should not be damaged by rain.
10.	Provide durability (construction)	The construction of the solar cooker should be able to withstand everyday use in an outside environment (dirt, food, water, handling etc.) Thickness of aluminium ca: 1.5 - 2 mm.
11.	Provide durability (material)	The solar cooker should be made of aluminium.
12.	Allow autonomy	The user should be able to leave the cooker for a longer period of time. There should not be the need of frequent adjustments.
13.	Allow redirection	Be redirectable towards sun. A slightly redirectable cooker allows for a more efficient cooking but it should not require frequent adjustment by the user.
14.	Offer working height	During cooking the user should not be required to drastically bend down to operate the cooker. In order for the height to be ergonomic the middle height of the cone should be 90 cm above ground.
15.	Provide user accessibility	Users should be able to access the food relatively easy during cooking.
16.	Complicate non-user accessibility	Passers-by should not easily be able to detect and steal the food during cooking.
17.	Facilitate transportability	When the cooker is not in use it should be possible to transport it e.g., between storage and a specific cooking place (should not be permanently fixed to the ground).
19.	Allow cleaning	Material and construction should allow for easy cleaning by the user (using moist cloth). Surfaces should be easy to access for cleaning.

20.	Enable combinations (with other products)	Except solar cooking the product should be able to be used as a hay basket (e.g., Wonderbag, 45 cm in diameter).
21.	Offer storage possibilities	Except solar cooking the product should offer storage possibilities (e.g., collection of rainwater).
22.	Express durability	The user should trust that the product will last for everyday use and for a long time.
23.	Express autonomy	The user should feel safe to leave the cooker for a long time in order to be able to do other things while the food is cooking.

Table 12.1
List of criteria.

Criteria 2.
In order for the solar cooker to require as few adjustments as possible, the cone should have an opening angle of 60 degrees as stated in criteria number 2 (SCI, 2001). The 60-degree angle of the cone enables it to catch a maximum of sunlight, while still efficiently concentrating the energy required for the cooking.

Criteria 3.
A reflector with a 60-degree angle could have equal length of walls and bottom to increase the chance of incoming sun rays only having to be reflected once before hitting the dark bottom plate, securing the ray from bouncing away from the cooker (Rimstar, n.d.).

Criteria 4.
The cone is made of aluminium and the inside surface should work as the reflector. The reflector needs to have a reflection factor of 0.85 - 0.90 as stated before. According to studies made, highly polished aluminium can reach reflectivity up to 80 - 87% (Engineering ToolBox, 2012). Hence, the reflective surface of the cone can acquire the recommended reflection factor that is needed in order to function. However, for further development, this requirement needs to be examined and tested in a real use context making sure the polished surface does not get affected in an outdoor environment.

Criteria 6.
The insulation is a combination of both a flexible cover and a rigid disc. The flexible cover should be flexible according to sufurias (flanges included) between 25 and 35 cm in diameter. According to the entrepreneur from Farmers With a Vision, a common sufuria is 28 cm with flanges. Looking at the rigid disc, a thickness of 3 mm is considered sufficient for its intended application (Cut My Plastic, 2019). It should also have a diameter allowing different heights of typical used pots and pans. A sufuria with the largest diameter of 35 cm is around 17 cm in height (Kenya Bureau of Standards, 2014). Finally, there must be at least 5 cm space above the sufuria, hence the diameter of the insulator disc was estimated at 75 cm.

Criteria 10.
The thickness of the aluminium is based on the thickness of similar objects. Sufurias usually have a thickness between 0.6 - 3.0 mm (Kenya Bureau of Standards, 2014). Criteria number 10 is based on the thickness of the larger versions of sufurias.

Criteria 11.
According to Cao (personal communication, January 22, 2021), in general aluminium has good corrosion resistance. In addition, alloy composition also affects the corrosion resistance of aluminium. The more the alloying content is increased the poorer the corrosion resistance. This means that the stand should also be in aluminium in order to prevent any corrosion that might happen if, for instance,

aluminium and steel would be joined together (Armao, 2014). However, this needs to be evaluated and tested in a real use context for ensuring its functionality.

Criteria 14.

A recommended height for a safe working position is around 90 cm (Arbetsmiljöverket, 2020; Armcokenya, 2021). The user will operate the solar cooker from different heights, both at the bottom of the cone and the top of the cone or in between. That is when, for e.g., the cone is placed down in the stand, when the cone is removed from the stand or when food is checked and stirred during the cooking. It is impossible to choose a height that perfectly suits each interaction, but if the middle height of the cone is 90 cm above the ground, then the user will always operate close to the recommended height.

13. The final concept – JiKoni

Figure 13.1
The final concept, JiKoni.

The final concept is JiKoni, see figure 13.1, the name derived and combined from two words, iiko and koni which means stove and cone in Swahili. In addition JiKoni means kitchen. JiKoni is a conical solar cooker of high quality made to last for a long time due to its robust construction and choice of material. The durable design is also reflected in the style of the product; the simple and classical shape will keep it relevant as an everyday object, inspired by the products in the moodboard (figure 11.17). With its generous opening angle, the concept demands a minimum of frequent adjustments for an overall cooking effectiveness. The cooker is not made to be frequently moved or transported; it is made to make the user feel safe to leave the cooker to its time-consuming cooking. The design includes few components and few assembled parts, as seen in figure 13.2, and is made of a durable and strong material.

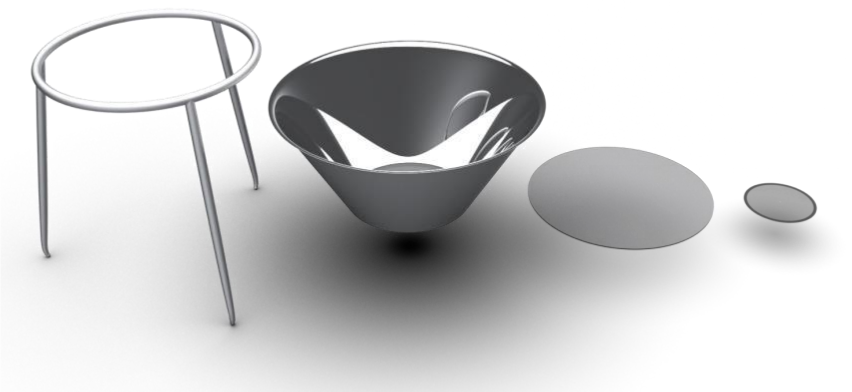


Figure 13.2
The product's four components. From the left: The stand, the cone, the insulator plate and the insulator lid.

13.1. Cone

JiKoni consists of two main parts, the reflector cone and the stand that holds it. In addition, there are two kinds of insulation components. The reflector cone is truncated in its shape, see figure 13.3, allowing a black painted bottom plate with space for a pot. It is entirely made of aluminium. In contrast to the inside walls that are highly polished and reflective, its outside walls have a coarse surface which will not reflect as much light but allow a better fixation to the stand. The cone will reach high temperatures, just like any other stove, so the user has to continue to use some kind of cloth when adjusting the cone or checking the food.

Figure 13.3
The reflector cone of the concept.

13.2. Stand

The stand consists of a ring along with three legs, as seen in figure 13.4, and it is made entirely from aluminium with a hollow circular profile. The stand has an adequate height of 90 cm which will help the user to maintain a healthier working posture. The inside of the ring has a rougher surface to make it possible for the cone to be fixed in the desired position by increasing the friction between the cone and the ring. The legs are angled to secure the position and offer stability to the solar cooker. At the far end of each leg the angle is changed and the diameter is smaller. This is supposed to benefit the fixation of the cooker against the ground. The hook-like leg ending should offer a better grip and thereby further add to the stability of the cooker. The ground often consists of soil, with elements of sand and vegetation, which could be porous enough to let the solar cooker legs slightly sink in.

Figure 13.4
The stand of the concept.

13.3. Insulators

There are two insulators, as seen in figure 13.5, meant to increase the effectiveness of the cooker. The first insulator component consists of a 3 mm thick circular disc made of transparent polycarbonate (PC) plastic for high strength and thermal stability (up to 135°C) compared to other plastic options which are remarkably less stable at high temperatures (plexiglass is stable at only ca 65°C). The PC plate is meant to be placed inside the reflector and above the sufuria, supported by the walls of the cone. For added insulation and heat effectiveness, a second insulator made of transparent silicone is utilized to cover a top of a sufuria. The chosen material was based on the criterion 'flexibility' in order to adopt different sizes of sufurias.

Figure 13.5
The two insulators of the concept.

The inside bottom of the cone is painted black, see figure 13.6, to make sure that the incoming sun rays are absorbed and not reflected once again. The heat is then trapped close to the pot and the cooking will be more effective.

Figure 13.6
A view from above shows the inside of the cone, revealing both insulators and the black painted bottom.

13.4. Working height

The total height of JiKoni is 112 cm with a stand height of 90 cm and a cone height of 43 cm. When the cone component is placed in the stand, the ring on the stand reaches up to the middle height of the cone as illustrated in figure 13.7. The user will operate both below and above the height of 90 cm and hence the height of the stand. When the user is carrying the cone to the stand, the working height is beginning at 90 cm, unlike when the cone is fixed in the cone and the user is reaching the sufuria placed in the bottom. In addition, the cone being placed on a relatively higher height has beneficial consequences for both children and adults. Firstly, it is not as reachable for (small) children and therefore safer in regard to the produced heat. Secondly, the height makes it safer for everyone in regard to glaring (from the reflector) compared to if it would have been at a lower height.

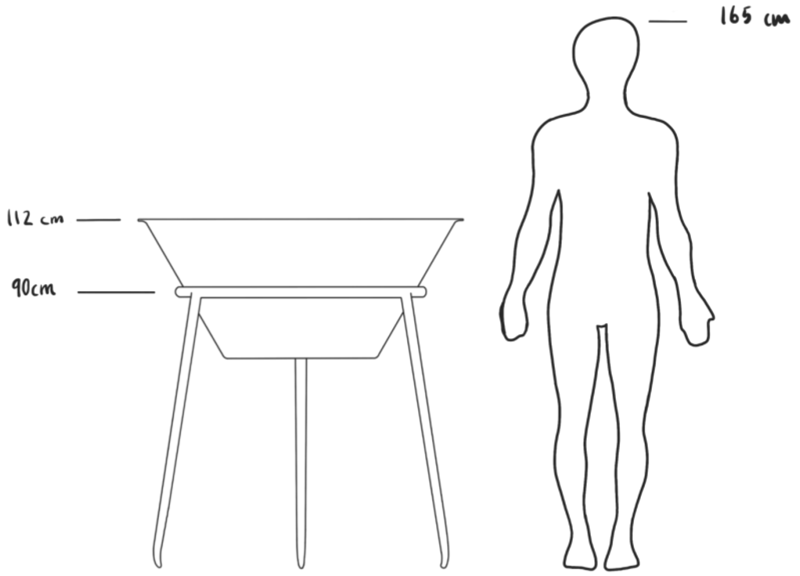


Figure 13.7
An illustration showing the relation between the conical cooker concept and the average user height.

13.5. Tilted cone

JiKoni is made to be autonomous in a sense that it allows the user to feel the freedom of being able to do other things while the food is cooking. The 60-degree angle of the cone enables it to catch a maximum of sunlight, while still efficiently concentrating the energy required for the cooking. In the morning and in the evening, when the sun has a lower elevation angle, the cone can be adjusted to better face the direction of the sun, as seen in figure 13.8. In order to tilt the cone in a desired angle, the user either pushes or pulls the edge. When letting go of the cone it stays in the same position because of the high friction between the outside walls of the cone and the ring of the stand. The construction does not allow any extreme angles, but since the cone has a generous angle to begin with, it should not be necessary either.

Figure 13.8
The cone slightly tilted in the stand.

13.6. Insulation plate

Any insulation should not cause any complications for the user when accessing the food. When the user only wishes to taste or check on the food, he or she can smoothly remove the insulation plate by gently pressing down at the edges. When it thereafter slightly rotates, he or she can easily grab the edges and place it vertically in the cone, see figure 13.9. Due to occurring tolerances in production, there will probably be some irregularities in fittings. However, since there is always a need for some steam ventilation when cooking in order to prevent any bubbling or unwanted pressure, the irregularities will advantageously generate vent holes in the insulator plate.

Figure 13.9
The insulation plate slightly flipped in the cone.

13.7. Insulator lid

The second insulation component, the silicone insulation lid that is attached to the pot, see figure 13.10, making a perfect fit due to the elastic properties of the material. Even in the case of dented and uneven sufurias the lid will create effective insulation and trap the heat and moist, as opposed to the aluminium lid that is often used today. When the silicone lid is covering the pot and the user wants to access the food, he or she removes the cover by pulling the silicone edges up. The lid could also be used in other contexts. When carrying the pot with food it would make sure that no spillages would occur and if used with other stoves it would increase the effectiveness of those as well.

Figure 13.10
The silicone insulator lid of the concept.

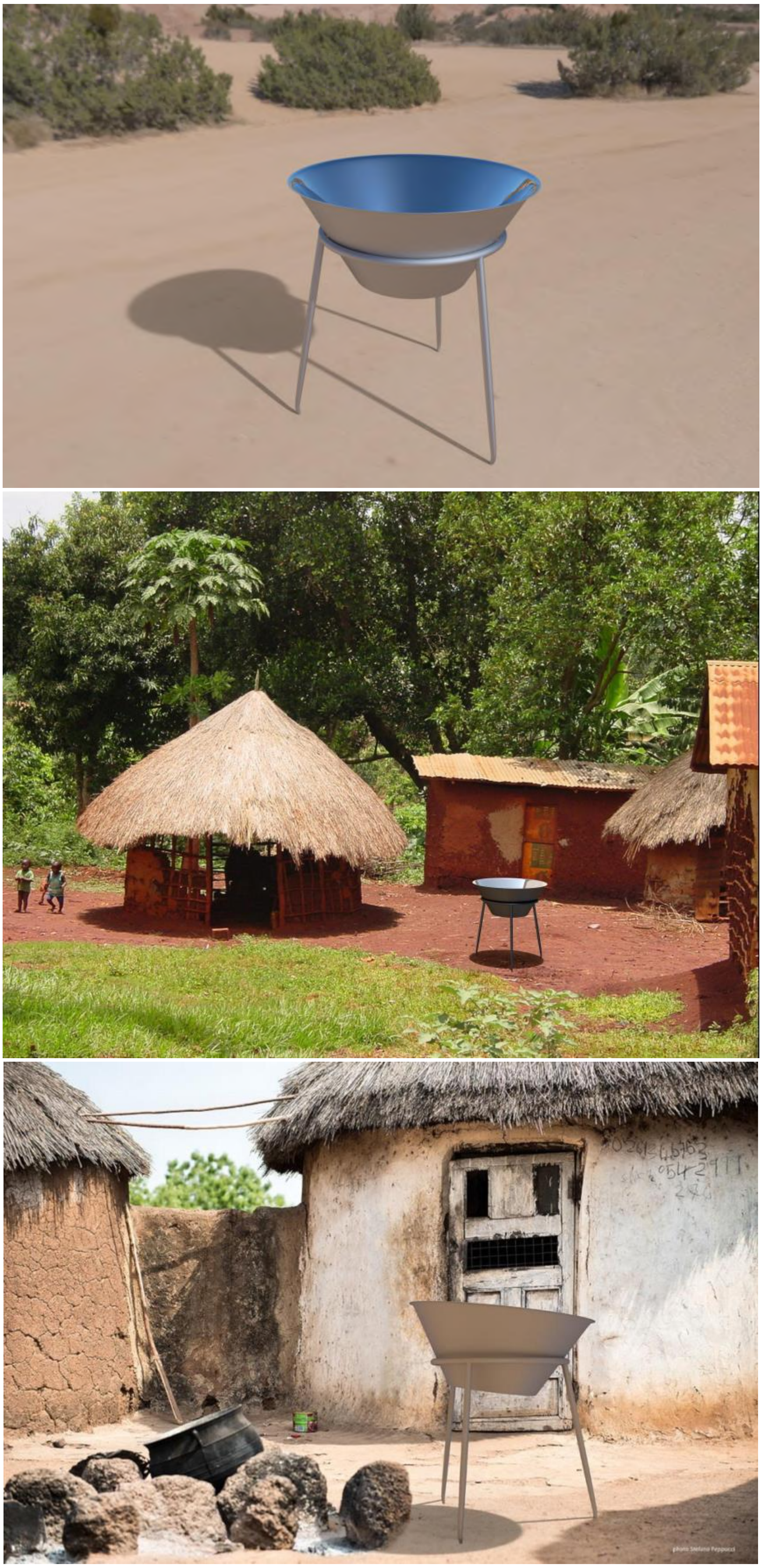


Figure 13.11
A collage of the JiKoni in the user environment.

From *Local Houses* [Photograph], by Laura, 2005, Flickr (https://www.flickr.com/photos/72758504@N00/44337690) CC BY-NC-ND 2.0 Adapted with permission

From *The doors of the other* [Photograph], by Stefano peppucci, 2014, Flickr (https://www.flickr.com/photos/30029230@N08/13122211733) CC BY-ND 2.0 *Adapted with permission.*

13.8. Other areas of use

The simple shape and solidness of the cone component allow combination possibilities with other cooking related products. Hay baskets are often used in combination with solar cooking and other ways of cooking in order to maintain the heat of the food. The hay basket usually consists of a sturdy, outer construction like a plastic basket and a soft inner filling made of fabric and wadding. If the conical panel could replace the outer construction, the many user products needed could be reduced. The robust cone would be able to carry the soft filling together with a sufuria filled with food, as seen in figure 13.12. With a bottom diameter of 50 cm (see Technical aspects), all sizes of Wonderbags, the foam insulated bags with the largest size of 45 cm, are suitable for use. An additional area of use is when used outdoors as a container for collecting water from rain. This is advantageously utilized when the conical cooker is not possible to use during rainy days. Neither fabric or water leaves scratch or can cause any other damages on the reflective surface of the cone.

Figure 13.12
The JiKoni could also work as a hay basket.

13.9. Technical aspects

The measurements of the cone reflector are based on two fixed parameters: the opening angle of 60 degrees, as seen in figure 13.13, and keeping the diameter of the bottom plate in the same length as the walls of the cone (for complete calculations see Appendix V). The 60-degree angle enables less adjustments of the cone and the relationship between the sides increases the chance of incoming sun rays only having to be reflected once before hitting the dark bottom plate.

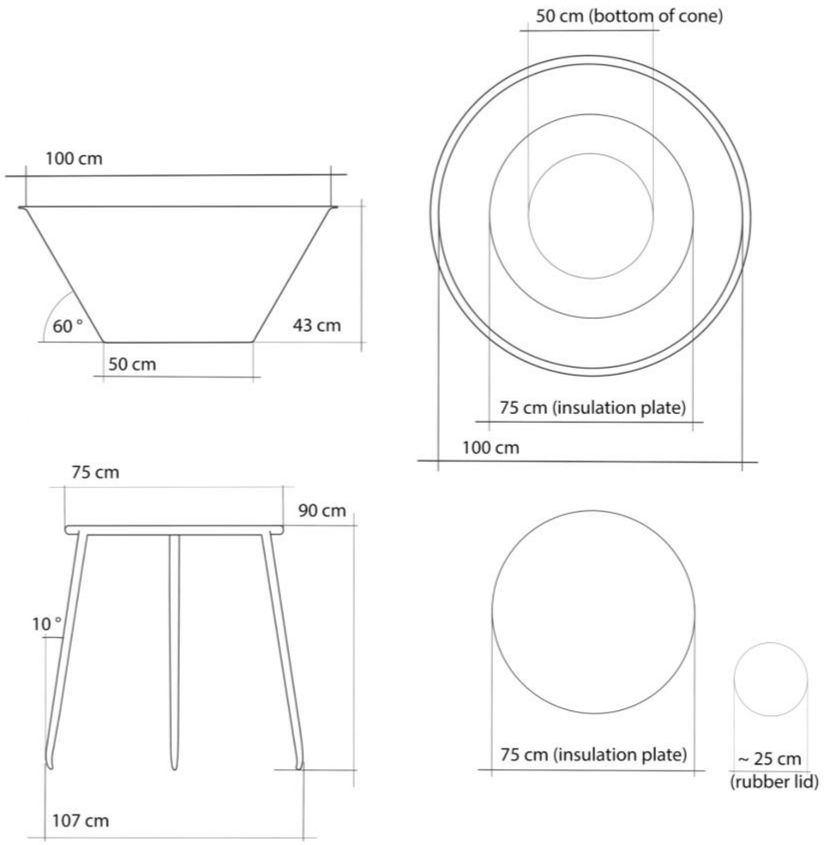


Figure 13.13
Blueprint of JiKoni.

The thickness of the aluminium is set to be 1.5 - 2 mm. The chosen thickness of the materials is based on similar existing products, but it is difficult to give an exact number since the specific construction of the concept might have other requirements (which would require prototyping or construction calculations). The product is estimated to weigh in total between 7.7 - 10.6 kg (the cone between 4.95 - 6.6 kg, the stand 1.2 - 2.4 kg, the insulator plate with a thickness of 3 mm ca: 1.6 kg). The weight will complicate the movability of the product but keep it safer in different critical conditions, neither wind nor rain will affect it in a negative way. The user will not have to worry about any cardboard breaking down because of water damages or having to secure the cooker with stones or strings in order for the cooker to not be blown away. Theft is supposed to be complicated by the heaviness of the product, and the food less apparent due to it being hidden in the bottom of the cone. The product should enable the user to do other things while the food is cooking and not require frequent attention or use of strength.

13.10. Price estimations

An approximate price estimation of the concept would be 5,800 KES (53 USD). The estimation is based on the total price of each component. The cone was compared to a large sufuria in the same size, which costs 1,700 KES (D, 2021). The cone would need more surface treatment than a sufuria, so the price of the cone was set to 1.5 times the cost, or 2,550 KES. The stand would not need to be polished, but it does have a more complex shape. The stand was also set to a price of 2,550 KES. The larger insulation plate made of polycarbonate could be bought in sheets for 385 KES per kg when ordering 1,000 kg (Alibaba, 2021). It would only have to be cut out from the sheet so the manufacturing cost should not define the cost, which would be 1.5 times 385 (since the plate weighs 1.5 kg) or 578 KES. Finally, the silicone lid could be bought for a price of 510 KES, though including six pieces, making a single lid cost 96 KES (Cdon, 2021).

When buying a CooKit from the SCI website the price is set to 50 USD (5,500 KES) for US purchases (SCI, 2021). When SCI has sold CooKits in Kenya, as described in *6.1. Appropriation of the solar cooker,* the price has been set to 3 - 7 USD (330 - 770 KES), but sometimes they have given them away for free. It is difficult to say if JiKoni could also be distributed with a lower price when teaming up with organisations in similar ways, but if possible, that could make the estimated price lower than what is currently stated.

14. New user journey

The new user journey shows why the proposed concept would benefit the user compared to the current cooker. The entrepreneur from Farmers With A Vision reviewed the document in order to confirm that the description was realistic and that the concept actually could benefit the user as described. According to him the presented journey was realistic, relevant and applicable.

THE DAY BEGINS
Mary is the first one to wake up at 5 a.m. in the morning, she peeks outside and cannot feel any rain against her face. She is relieved and says a silent prayer that it will stay this way, so that she can finally make use of her conical cooker in the sun. The past few days have been filled with clouds and rain. However, during the rainy hours of the day, the cooker has been placed outside for collecting water and in other cases it has been used as an enclosure for the hay basket.

In the meantime of eating her breakfast, Mary prepares the ingredients needed for the lunch that she will be letting cook in peace while she will be at the farm. Afterwards, she mixes the ingredients in a sufuria and covers it with a transparent rubber lid for ultimate effectiveness. Thereafter, she places the sufuria inside the conical cooker, brings the circular insulator and positions it directly on top of the cooker and gently lets it down just right above the sufuria. She brings the conical cooker with its content outside and walks towards the aluminium stand that has been left outside overnight.

The conical cooker is placed straight down in the stand without tilting it, making sure it will face the sun while she is away. While she will be at work, the sun will reach its highest point in the sky at midday. When Mary goes back to the house to get ready for her working day, she feels relieved knowing that compared to her previous CooKit panel cooker, the conical cooker will not be blown away if hit by any wind. Compared to the CooKit, the food inside the sufuria is now considered more hidden and less apparent thanks to the high reflective walls and the elevated position covering the content.

Mary packs her working tools and starts her journey to work when she sees a familiar face and a conversation begins. The person notices Mary not carrying her previous solar cooker along with her to work and wonders why she has not. Mary explains that she has now replaced it with a new durable solar cooker that she can leave at home while at work. She also highlights the fact that she is now free of continuously repairing the cardboard panels whenever they were about to fall apart.

AT WORK
Mary arrives at the farm at 6.30 a.m. and starts working. Two hours of work later, they pause for a little break and Mary now has the opportunity to enjoy her break instead of going through a stressful time of setting up the cooker.

Time passes and the work schedule ends just in time for lunch. She starts to think of the food cooking at home in the conical cooker and looks forward to having a well-cooked lunch. In comparison to the former solar cooker, the cooking is allowed to go on for a longer time and does not get interrupted with any heat loss while she is going back home. In addition, she feels relieved that she does not need to be carrying a lot of items after an intense work schedule in the fields.

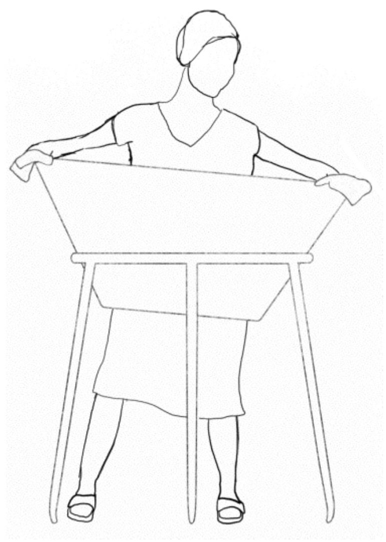
BACK HOME

When she arrives home at 1.00 p.m. the solar cooker has been in the sun for a longer time compared to when she brought it to work. The food is also hot in time for her lunch. She brings the sufuria, still covered with the rubber lid, back to the house in order to eat. The cooker, along with the insulation plate, is left in the sun since it is going to be used for dinner as well. Usually, she would have to set up the cooker once again, after being transported from work, but now it is ready for her whenever she likes.

After eating her meal, she gets up to clean the plate and the sufuria in order to begin preparing the second meal before the sunshine becomes insufficient. She dries the conical cooker from food spillages made earlier today, but compared to the solar cooker she had before, she does not have to be afraid of ruining any cardboard with water. Moreover, the stand allows the cone to be better protected from the environment, so dust and dirt do not as easily reach the cooker. Even though the solar cooker is a few meters away from the house, Mary does not have to worry about winds catching the cooker since it is heavy enough to maintain a stable position. She remembers when she had to secure the old one with stones and strings in order for it to not collapse or be blown away. That is not a problem anymore.

She brings a sufuria filled with some chopped vegetables, covered by the rubber lid, and places it in the cooker. The rubber lid insulator is elastic and fits much better than the usual dented lid, creating a more airtight and effective cooking space (she even uses it in combination with her other stoves in order to get the food to reach a high temperature quicker). She puts the insulation plate on top of the sufuria and walks back to the house.

AFTERNOON
After cleaning for a while, Mary checks the food and can finally relax her back. The conical cooker allows her to stand up in a straight position while still having full control over the cooker. Since it is later in the afternoon, the sun has a lower elevation angle, so Mary redirects the cone. She then goes to the market to sell some of the collected greens, not afraid of leaving the cooker without supervision. Later, on her way back home from the market, she makes sure to pass the forest close to her house to collect some wood that she will need later today to cook the rest of the meal with.



COOKING DINNER

Mary arrives home and continues to prepare the supper. First, she walks toward the solar cooker to check the food by easily flipping the insulation plate and slightly opening up the rubber lid on the pot. Soon it is 5 p.m. and the sun is about to set and not as strong as earlier so she brings the cushion inner filling, that along with the conical cooker, form an effective hay basket. She transfers the sufuria into the cushion and places it in the cone, letting the food continue to cook. The rest of the dinner is cooked over fire. When food is ready to be served, she brings back the soft inner filler with the sufuria inside but leaves the solar cooker outside for next day's birthday celebration.

CELEBRATING

Today is Mary's daughter's birthday. Usually, it is difficult to bake any cake, because fire emits uneven and too intense heat, but the solar cooker has made it possible. After breakfast Marry prepares the cake batter in a sufuria and places it in the solar cooker that has already begun to warm up since it has been in the sun all day before noon. Later the guests arrive and since the cake is nearly finished, they all gather around the cooker with excitement. A friend admires the conical cooker and wants to know more about it. Mary is proud to explain how it works when people are this interested and some of the kids are even begging their parents to get one!

15. Discussion

The chapter contains a discussion of the project, focusing on the areas of fulling the aim, process, methods and collected information and the final concept.

15.1. Fulfilling the aim

One part of the aim was to increase the understanding of today's user situation. An extensive part of the project was devoted to establishing this. Not only was the interaction between user and product defined, but also surrounding circumstances, such as the usage of other cooking related products and everyday life aspects. By not only examining the shortcomings of the solar cooker we believe that a better understanding of the users and their needs have been reached. The research was conducted in order to develop a design concept, but the presented information does not have to be limited to support that kind of activity. People interested in the subject as such might find it useful for other purposes as well.

The other part of the aim was to develop concepts that were intended to increase the diffusion of solar cooking in Kenya. It was important that the aim did not specify that the concept necessarily had to be a new solar cooker product. By having a more open approach to the issue of solar cooking diffusion, we were not limited to the physical product as such, but rather focused on the interaction between product, user and context. The identified user problems that seemed to halter the diffusion of the product was carefully considered when creating the new concepts, with the purpose of solving the problems. What could be discussed is if it is that simple - stating the problems and then solving them. There are always multiple ways of solving an issue and new problems might occur while doing so.

15.2. Process, methods and collected information

The project type would under normal circumstances demand on-site research. Since it was not possible to travel due to Covid-19, all work had to be conducted without any direct contact with the intended context. This made it impossible to perform any studies without the involvement of other people and in addition, we often had to rely on secondary sources. The main drawback was to not be able to make direct observations of the user interacting with the product in the natural use context. The information gathered about the user has instead been filtered by other people before reaching us. This is one of the reasons for the extensive research work and large number of references - no single statement has not been high-lighted without the support from many other sources as well.

The theories used, *diffusion of innovations* and *domestication* gave great insight into how ideas or innovations are spread and approached by people. It gave us the tools to understand the complexity of the user and use situation and how and what to look for when analysing the information. The theory of domestication suggested that products can be "tamed" by its users and that a product that is fully tamed does not longer cause any problems for the user. Whether such products exist at all could be questioned, but it was clear that the solar cooker had not completed that process, though the research showed that the product had been somewhat involved in all four phases of domestication (appropriation, objectification, incorporation and conversion).

The reason for the project even to exist was because there is a lack of research made in the field of solar cooking, especially in places with economically disadvantaged people. Gathering information from only a few sources lessens the chance of verifying whether the presented results apply also to a larger group of people. Since the research made stretches beyond the extent of solar cooker usage, the information used is not limited to those few resources. The paucity of data also made the gathering of information time consuming, which in turn led to limited effort spent on developing a design solution. Still, the extensive research was considered to be of such great importance that its influence on the design proposed was more positive than the lack of time it created.

Several of the solar cooker project evaluations that were analysed in this project were made at the request of SCI, though performed by independent sources. Still, there could have been circumstances where the authors were encouraged to foremost present positive aspects of the projects. Similarly, some of the videos that were observed were also made by solar cooking organisations or solar cooker enthusiasts and it might have affected the content. Throughout the project we have tried to compare different statements with each other to get a more nuanced information.

Since the interviews made were not conducted by us, but by the contacted entrepreneurs in Kenya, it was not possible to ask supplementary questions which is important when trying to understand the user and user behaviour. The entrepreneurs work with solar cooking and some had taught about and sold solar cookers to the interviewees. The interviewees could have felt the need to adjust their answers in order to please the entrepreneurs, intentionally or unintentionally. In addition, when interviewees described their cooking sessions, a few might not have carefully thought through the exact process of cooking, but rather described it as it naturally pops up in their mind.

When defining the problems with today's user and use situation it became clear that the product as such did contribute to a lot of the issues and that it would be necessary with a new version of the cooker. Based on the most used solar cooker type, observed in projects and interviews, it was decided that the panel cooker was chosen as the type to develop further, hereby neglecting the box cooker and the parabolic cooker. It is not clear whether the panel cooker actually is the cooker with the most potential, though it was the cooker with most documented usage.

When the users got to state their most preferred stove and why, it was apparent that the gas stove with its short cooking time was a favourite. Overall a typical problem experienced by the user was that the solar cooker was slow. There is no question that a much faster solar cooker would solve a lot of issues connected to its usage, but it would require a whole new type of technology. This meant that the problem had to be tackled from another perspective. When examining why the aspect of time was such a crucial component it was discovered that a lot of users could not leave the solar cooker for a longer period of time or did not feel that they could do so. This led to the importance of creating a solution that the user could rely on. Not least did the aspect of durability play an important role to be able to fulfil this, but also to satisfy other user needs.

15.3. The final concept

Part of the project aim was to develop a concept that intends to contribute to the spread of solar cooking. This was to be achieved by developing a solar cooker based on the collected and produced information built on the local needs, culture and perspective of Kenyan people living on level two. It was concluded that the lack of durability as a whole is a crucial factor that have resulted in undesired negative user perception of today's solar cookers. Therefore, durability was considered as the most prominent element needed in the development of a concept in order to achieve a desired positive product perception.

In order for the solar cooker to have the quality of being able to last long without being damaged, elements such as weight, material, form and minimizing product failures were taken into account and applied to the concept. However, when JiKoni, the conical cooker was developed and conceptualized, other functional uncertainties arose regarding performance. First, the product has neither been constructed nor built in a real scale prototype model and hence could not be tested. Decisions, technical decisions in particular, were mainly based on available information through easily reachable sources. This leaves room for improvement but can also raise some concerns. JiKoni is not completely optimized regarding cost and manufacturing – these aspects were left out of the project scope, yet they are essential details considering it as a concept intended for people living on level two conditions. However, the shape and material of the cone are similar to a sufuria and can be assumed to be possible to manufacture in Kenya. Some technical details of the concept were chosen according to achieving its full durable potential but are rather expensive. However, changing these might be possible but would also affect the functionality in its intended use context and the life length of the product. The concept as a whole is heavy, which can have both positive and negative impacts on the usage. The concept is relatively heavy in order to meet the criteria of being stable and robust, but it is a matter of whether the set dimensions can be further scaled or not and still meet the performance criteria. In order to fulfil the requirement of being a durable solution, the concept also had to be made of as few components and assemblies as possible for minimizing the risk of product breakages and failures. Hence, the concept is not a transportable concept intended to move between home and work but rather a steady and long-lasting solution that fits into the intended use context.

Looking at the parts of the concept in detail, there are a couple of important concerns to highlight. First, considering that the cone is made in aluminium and that it is to be used in the sun, there are uncertainties regarding the generated heat and whether it is safe for coming into contact with or not. Also, the thickness of the aluminium walls was set according to the wall thicknesses of sufurias that are similar to the form and size of concept. This resulted in a proposed thickness of 1.5 - 2.0 mm which should be sufficient for the purpose. Additional prototyping could possibly show if this number could be lower, resulting in a slightly lighter and cheaper product. Given that the inner surface of the cone is polished aluminium and the exterior has a coarse surface, it is difficult to ensure that the material strength would not be negatively affected. On the other hand, the strength of the material is highly relying on the structure and composition of the aluminium and could be adjusted according to the product's required performance.

Second, there are further development possibilities regarding the choice for the insulators and, above all, the plastic plate. The choice of the specific PC plastic was made based upon the heat-resistance properties compared to other plastics. However, there are lack of investigations into whether the plate might buckle/bend when there is no interaction between it and the user. In order to determine whether the plate is stable in its spot, product testing of its set material and dimensions must take place. It is further crucial for ensuring that principle of flipping the plate is feasible.

Despite the mentioned uncertainties that are the result of no product testing, it is clear that the concept is optimized for its intended use context while technical and detailed cost and manufacturing estimations need to be further investigated. We believe that the principle of this concept development would positively affect the cultural and local integration of solar cooking but in order to achieve an ultimate solar cooking potential it must also be complemented with education and communication that facilitate the economic situation for people living on level two.

16. Conclusion and recommendations for future development

There is still a paucity of data concerning the usage of solar cooking but hopefully this project has contributed to an increased understanding of the solar cooking usage in Kenya and how a solution to some of the experienced user issues might look like. The user research made is extensive, but it should still be noted that the project has not been conducted in direct contact with the actual user and use environment. The project started with a relatively open brief of the challenges of exploring the obstacles and shortcomings with solar cooking diffusion in Kenya from a distance due to the situation of Covid-19. After months of extensive research making use of accessible information and with the assistance of EWB and the entrepreneurs on site, a considerably deeper contextual understanding of the situation as a whole was accomplished.

The panel cooker type was chosen to be further developed in this project. It should be of interest to examine whether another type of solar cooker could be developed with the presented user research as a starting point. Even though the panel cooker was the most common type, the extensive research made could offer insights sufficient enough to understand user and use needs beyond those connected to only the panel.

At the end of the concept development, the entrepreneur from Farmers With a Vision suggested a wider diameter on the insulator plate to place it even closer to the top of the cone arguing that the cooking would become more efficient. He also claimed that the concept would be possible to produce, for instance by educating a tinsmith in a village to manufacture the product as additional suggestion to producing it in a similar way as a sufuria.

Even though the project has given valuable and constructive results, it has indeed left room for improvements. As considered in the discussion, there are a few challenges making this conical cooker concept producible. A next step would be further technical examinations with calculations regarding material and manufacturing costs in order to optimize and make it possible for production. It also requires more scale prototypes and user testing in the intended use context.

Finally, a longer-term solution calls for building not only products but also local capacity, skills, knowledge, experience, and expertise that empower the target group to meet their own needs.

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Appendices

Appendix I - Interview questions

Interview questions for user of a solar cooker

GENERAL:

1. Please fill in your:
    a. Age:
    b. Sex:
    c. Main current activity:
    d. Number of adults & children in your household:

2. Describe a typical day with a few sentences:

EATING HABITS:

1. How many times do you cook in your household on an average day?
    a. And at what time do you cook?

2. Who does the cooking in your household?
    a. Do you cook together? Why?
    b. If yes, who do you cook with? Why?

3. Please list the foods that are cooked regularly in your household. Does it depend on day/season?

4. Specify type(s) of cooker(s) you use, type of fuel and the average time spent to cook (except solar cooker)

    Type of cooker: Fuel: Average time:

5. What is your favorite way of cooking? Why?

SOLAR COOKING:

1. How did you hear about solar cookers in the first place?

2. Do your friends/neighbours use a solar cooker?

   a. If no, What do they use instead? and do you know why?

3. Do you talk about solar cooking with your friends?
   a. If yes, What have you talked about?

USAGE:

1. When did you/they buy it?
2. Why did you/they buy it?
3. What type of solar cooker do you have? (panel, box or parabol & name of cooker)
4. What did you think about the product before you bought it?
5. What do you use your solar cooker for? (e.g.: Cooking, Heating water for bathing, Heating water for drinking, Drying/food preservation, Other - specify)
6. Is the solar cooker enough to cook a meal for your whole family? If not - how do you solve that?
7. What are the steps of using your solar cooker? (e.g.: preparation, during and after). Describe with few sentences.
8. Did you need to adjust the solar cooker in order for it to work? (Have you made any adjustments to your solar cooker?)
9. How do you clean your solar cooker?
10. How do you maintain it? (for ex. repair/buying new plastic bags)
11. Have you ever stopped using your solar cooker?
    a. If yes, why?
    b. If no, have you once thought of stop using it? And why?
12. Did you need to change your habits when you started using the solar cooker? How?
13. Do you regret buying the solar cooker?
    a. If yes/no, Why?

Interview questions for users that have <u>stopped</u> using a solar cooker

GENERAL:

1. Please fill in your:

a. Age:
b. Sex:
c. Main current activity:
d. Number of adults & children in your household:

2. Describe a typical day with a few sentences:

EATING HABITS:

1. How many times do you cook in your household on an average day?
    a. And at what time do you cook?

2. Who does the cooking in your household?
    a. Do you cook together? Why?
    b. If yes, who do you cook with? Why?

3. Please list the foods that are cooked regularly in your household. Does it depend on day/season?

4. Specify type(s) of cooker(s) you use, type of fuel and the average time spent to cook (except solar cooker)

    Type of cooker:
    Fuel:
    Average time:

5. What is your favorite way of cooking? Why?

SOLAR COOKING:

1. How did you hear about solar cookers in the first place?

2. Do your friends/neighbours use a solar cooker?
    a. If no, What do they use instead? and do you know why?

USAGE:

1. Why did you buy the solar cooker?

2. For how long did you use the solar cooker before you stopped using it?

3. What type of solar cooker did you have? (panel, box or parabol & name of cooker)

4. What did you think about the product before you bought it?

5. What did you use your solar cooker for? (e.g.: Cooking, Heating water for bathing, Heating water for drinking, Drying/food preservation, Other - specify)

6. When was it not possible to use the solar cooker (except when cloudy)?

7. Do you think it was easy or difficult to use the solar cooker? Why?

8. What were the steps of using your solar cooker? (e.g.: preparation, during and after). Describe with few sentences.

9. Did you cook certain dishes in the solar cooker? Specify.

    a. Are there any dishes that you couldn't cook using the solar cooker?

10. Did you need to adjust the solar cooker in order for it to work?

    a. If you did adjustments, explain what and how?

11. Did you need to change your habits when you started using the solar cooker? How?

12. Why did you stop using your solar cooker? specify problems you experienced

Interview questions for <u>non-users</u>

GENERAL:

1. Please fill in your:
    a. Age:
    b. Sex:
    c. Main current activity:
    d. Number of adults & children in your household:

2. Describe a typical day with a few sentences:

EATING HABITS:

1. How many times do you cook in your household on an average day?
    a. And at what time do you cook?

2. Who does the cooking in your household?
    a. Do you cook together? Why?
    b. If yes, who do you cook with? Why?

3. Please list the foods that are cooked regularly in your household. Does it depend on day/season?

4. Specify the type(s) of cooker(s) you usually use, type of fuel, and the average time spent to cook.

    Type of cooker:
    Fuel:
    Average time:

5. Where do you cook? specify

6. What are the steps of your cooking routines?
    a. How do you prepare your cooking session?
    b. What do you do during the time while the food is cooking?
    c. How do you clean your cooking device(s)?
    a. How do you maintain it? (e.g. repair)

7. What is your favorite way of cooking? Why?

WHAT HAVE YOU HEARD ABOUT SOLAR COOKER:

8. Have you heard about a solar cooker?
    a. If yes, How did you hear about it?

    b. If no, what are your first thoughts when you hear "Solar cooker/cooking"

9. Have you ever used/tried a Solar Cooker?
    a. If yes:
        i. What type of solar cooker have you tried?

        ii. Where did you try it?

        iii. Why didn't you want one?

    b. If no:
        i. Why haven't you tried a solar cooker?

        ii. Have you once thought of trying/buying one?
            a) If yes, Why?

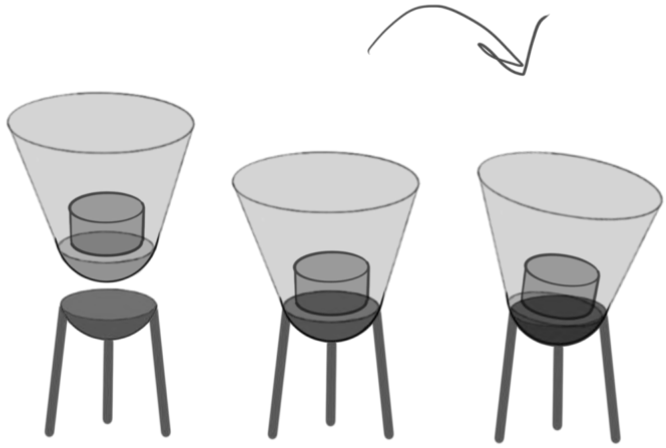
            b) If no, Why?

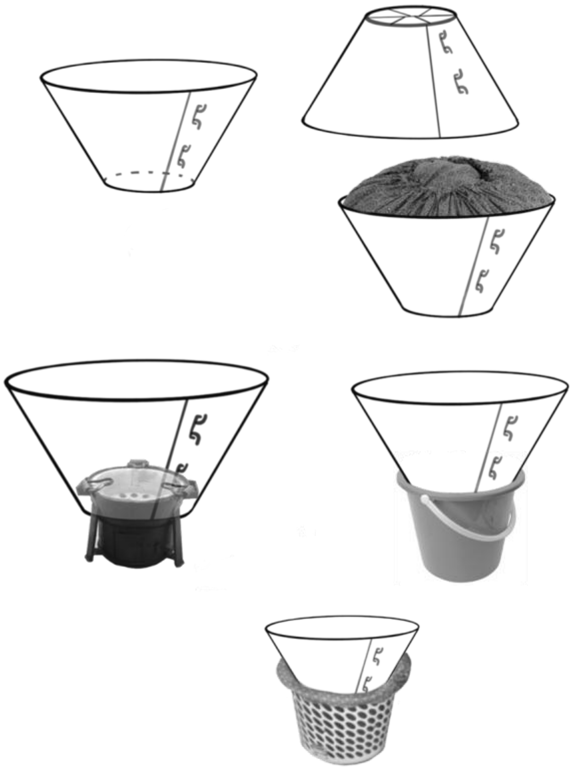
10. Do your friends/neighbours use a solar cooker?
    a. If no, What do they use instead? and do you know why?

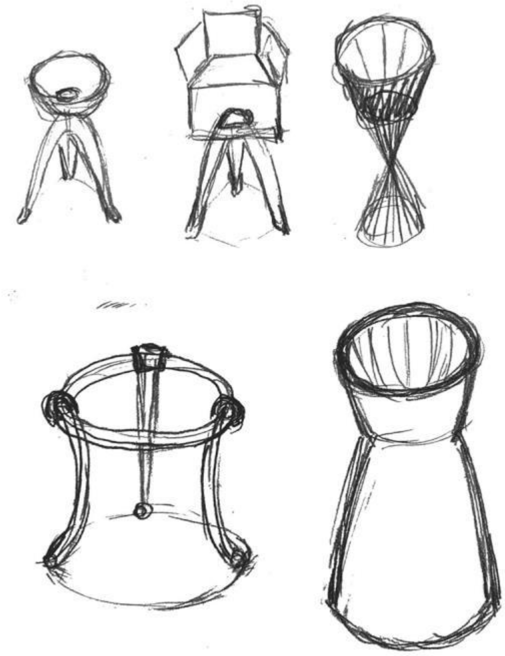
11. Do you talk about solar cooking with your friends?
    a. If yes, What have you talked about?

12. Do you want a solar cooker? Why/Why not?

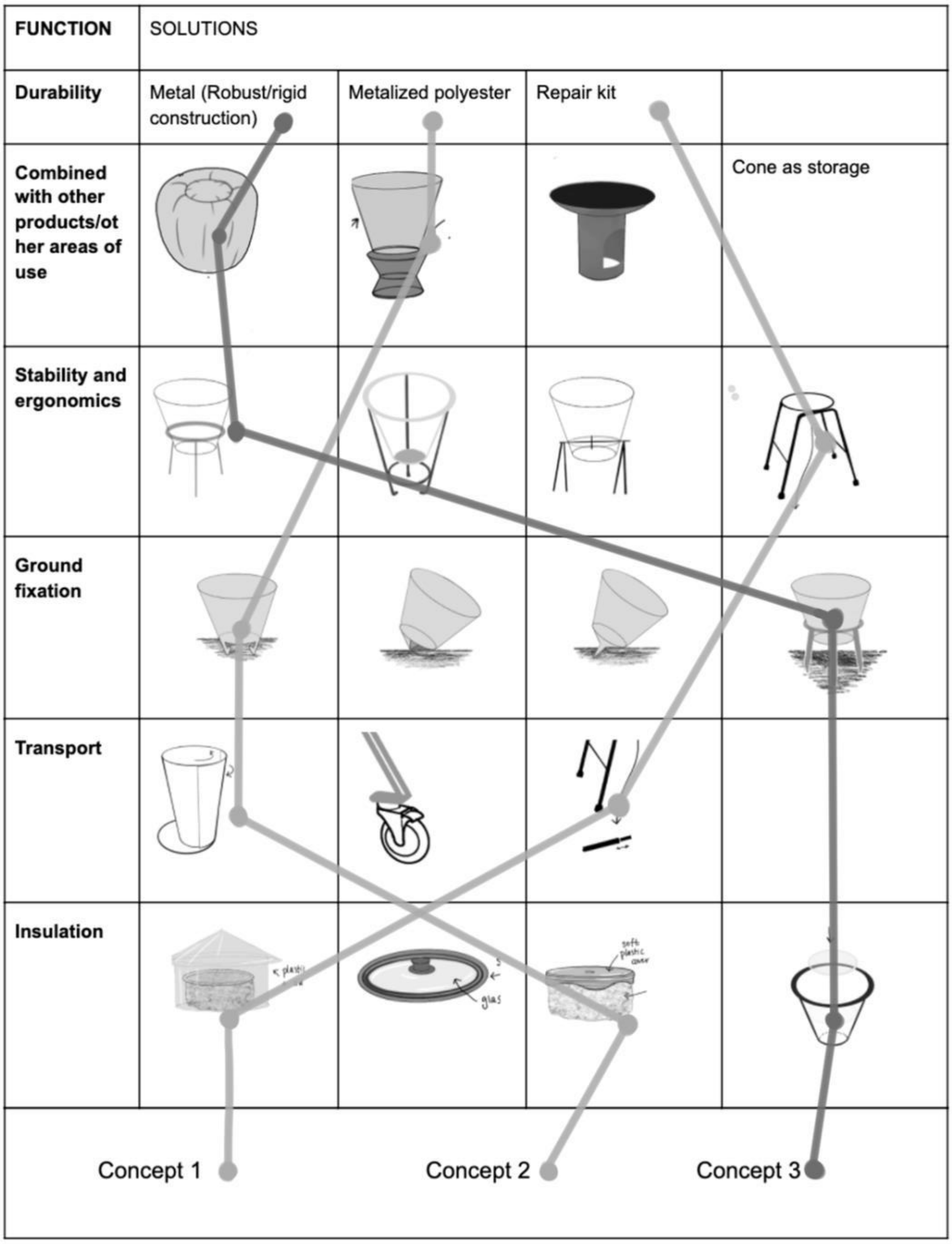
Appendix II - Idea sketches



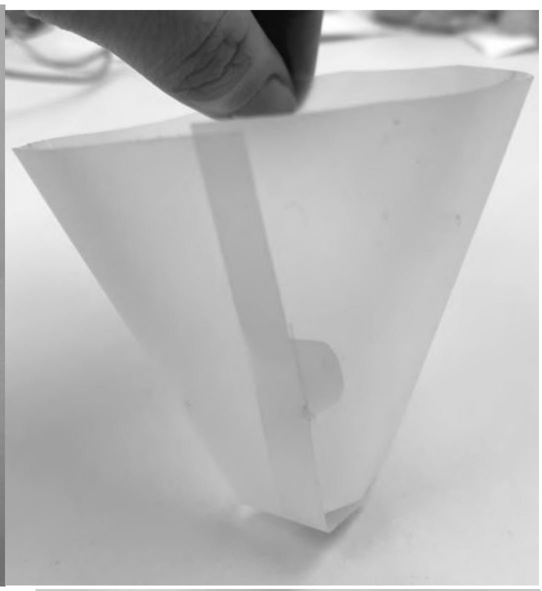




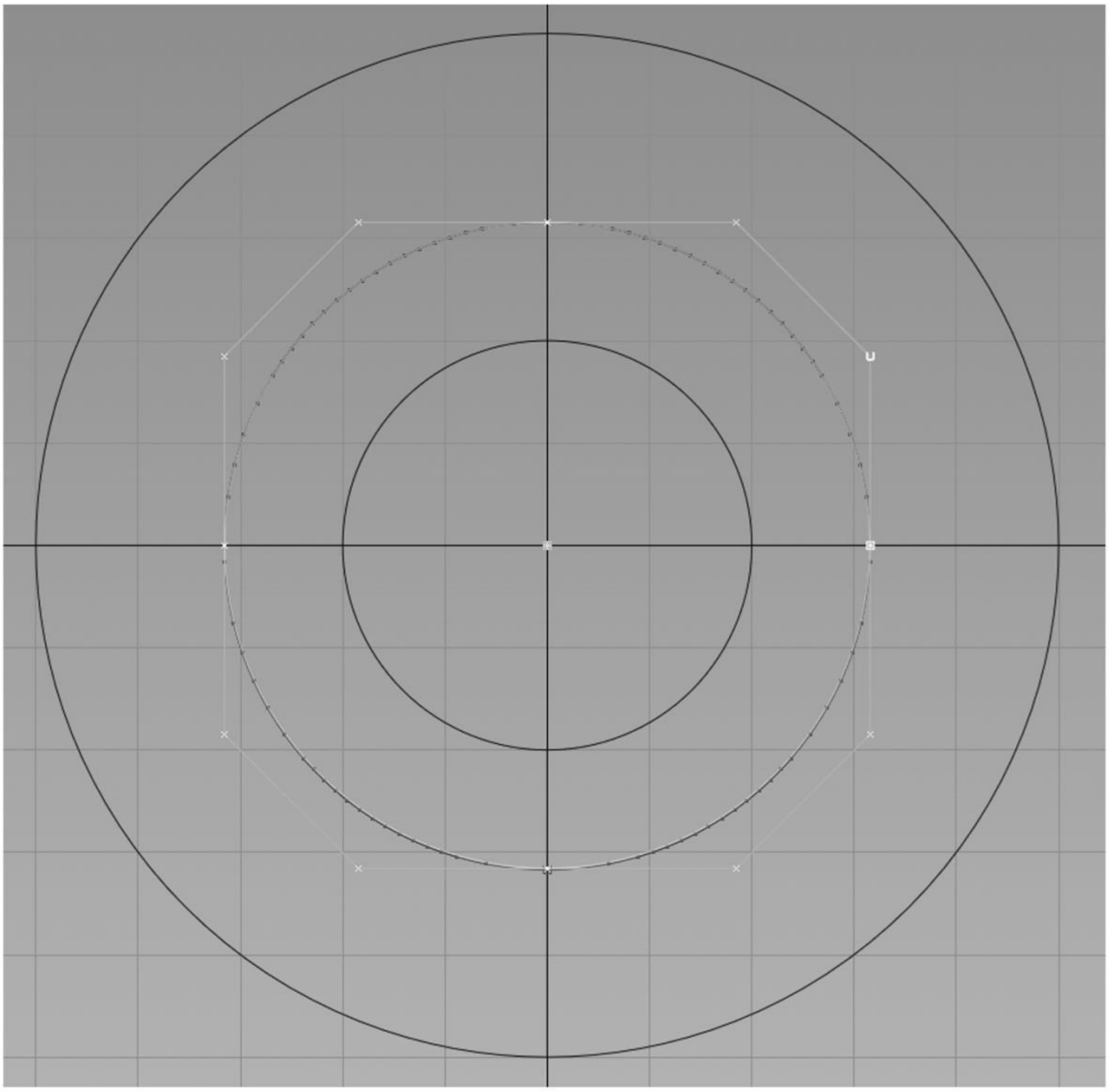
Appendix III - Morphological analysis



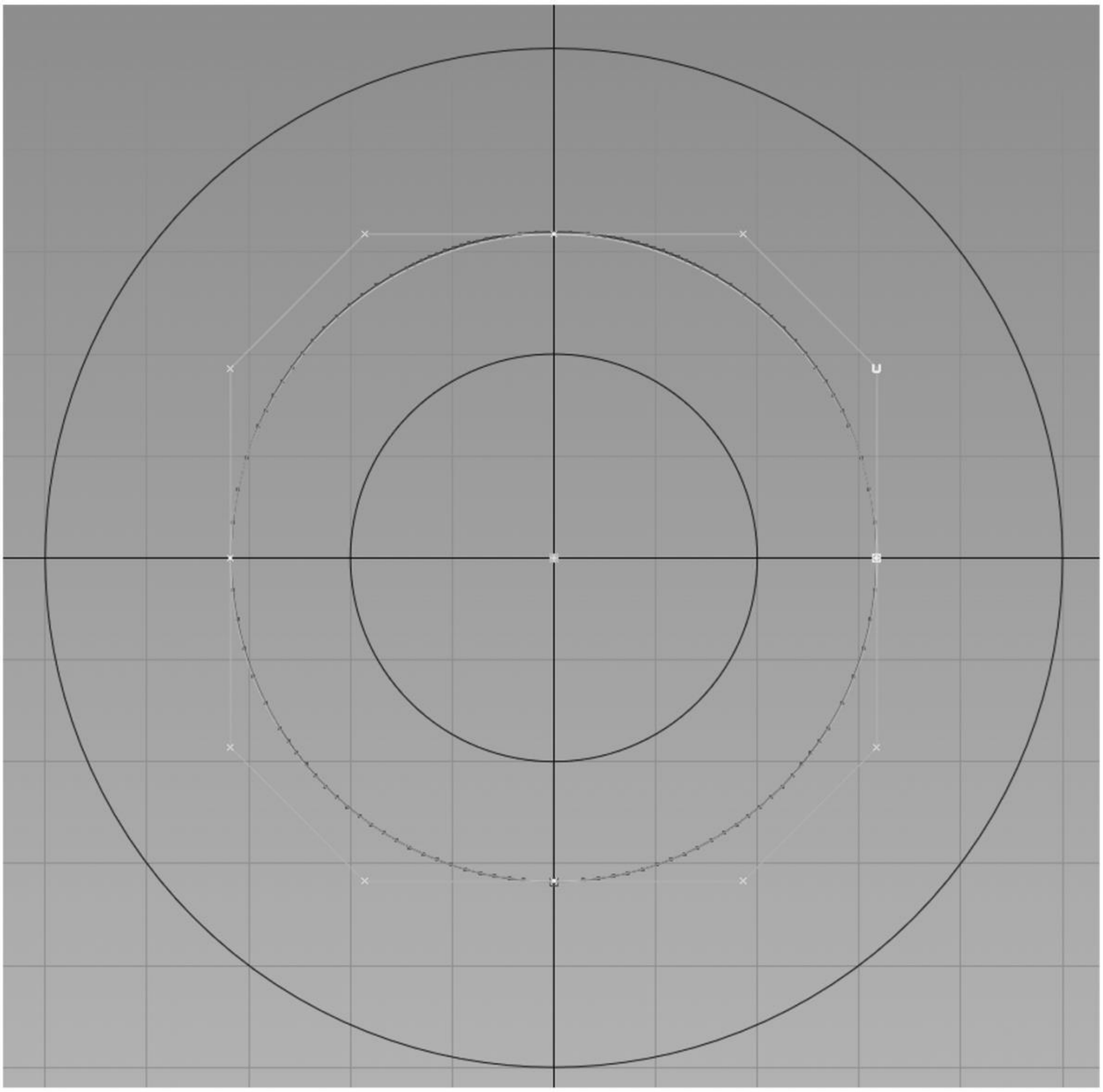
Appendix IV - Prototypes of concept



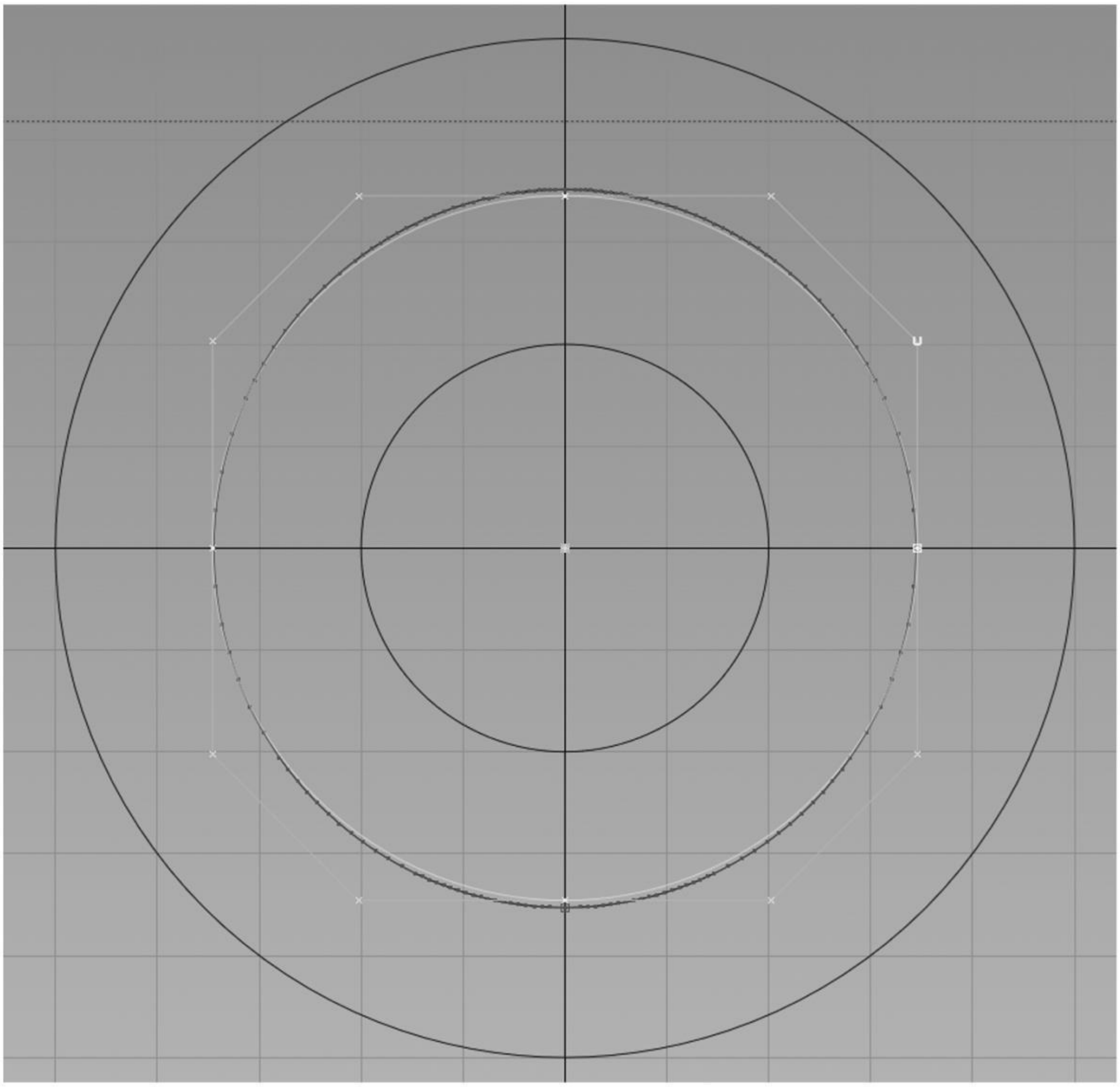
Cross-section of the 60-degree cone in three different angles (5, 10 and 20 degrees) to evaluate how the cone will fit against the ring.



5 degrees

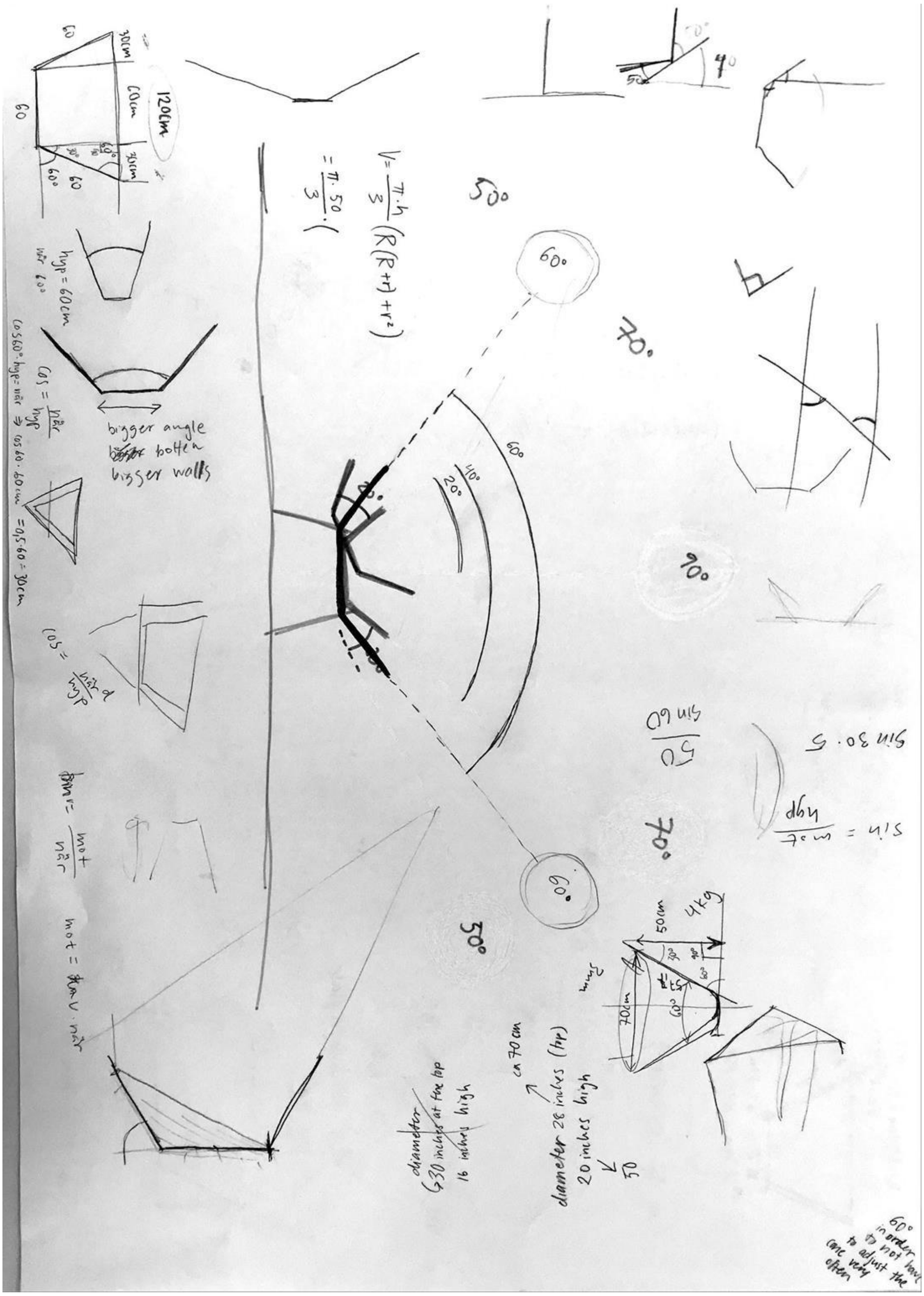


10 degrees



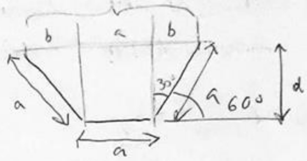
20 degrees

Appendix V - Calculations of the final concept



measurements cone

kon 60° ca 50cm långa väggar
botten & väggar lika långa



$a = 50cm$

$d = \cos v \cdot hyp$
$\Rightarrow \cos 30 \cdot 50 \approx 43{,}3\ cm$

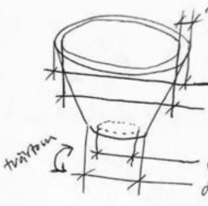
$c = a + 2 \cdot b$

b = mot.sträcka $\left(\tan v = \frac{mot}{när} \Rightarrow mot = \tan v \cdot när\right)$

$b = \tan 30 \cdot 43{,}3 \approx 25\ cm$

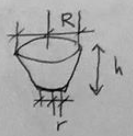
$\Rightarrow c = 50 + 2 \cdot 25 = 100\ cm$ (Samuel & Henk had between 80 cm & 120cm)

volume of cone



$V_{tot} = kon_{stor} - kon_{liten}$

$V_{avkapad\ kon} = \frac{\pi \cdot h}{3} \cdot \left(R(R+r) + r^2\right)$



$\rightarrow kon_{stor} = \frac{\pi \cdot 43{,}3}{3} \cdot \left(50(50+25) + 25^2\right) \approx 198\ 378{,}5\ cm^3$

$\rightarrow kon_{liten} = \frac{\pi \cdot 43{,}3}{3} \cdot \left(49{,}8(49{,}8+24{,}8) + 24{,}8^2\right) \approx 196\ 343{,}5\ cm^3$

$V_{tot} = 198\ 378{,}5 - 196\ 343{,}5 \approx 2035\ cm^3$

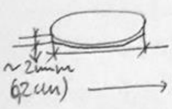
$\Rightarrow V_{tot} = 2035\ cm^3$

mass of cone

density aluminium $= 2{,}7 g/cm^3$

$m_{cone} = V_{tot} \cdot density \Rightarrow 2035 \cdot 2{,}7 \approx 5495\ g$

volume + mass of cone bottom



$V_{cylinder} = \pi \cdot r^2 \cdot h$

$\Rightarrow \pi \cdot 25^2 \cdot 0{,}2 \approx 392{,}7\ cm^3$

$m_{cylinder} = 2{,}7 \cdot 392{,}7 \approx 1060\ g$

$m_{tot} = m_{cone} + m_{cone\ bottom} =$
$= 5495 + 1060 \approx 6555\ g$
$\approx 6{,}6\ kg$

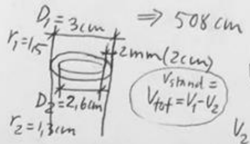
Volume +mass stand

hollow cylinder profile

same thickness as cone ~ 2mm (0,2cm)

aluminium density ~ 2,7g/cm3

$$l_{tot} = \underbrace{l_{tot\,legs}}_{3\times 91cm} + \underbrace{l_{ring}}_{\text{omkrets ring} \Rightarrow \pi \cdot d = \pi \cdot 75}$$



$\Rightarrow$ 508 cm (total height of cylinder)

$V_1 = \pi \cdot r_1^2 h = \pi \cdot 1{,}5^2 \cdot 508 \approx 3590 cm^3$

$V_2 = \pi \cdot r_2^2 h = \pi \cdot 1{,}3^2 \cdot 508 \approx 2697 cm^3$

$\Rightarrow V_1 - V_2 = 3590 - 2697 = 893 cm^3$

$m_{stand} = V_{stand} \cdot alu.dens. = 893 \cdot 2{,}7 \approx 2{,}4kg$

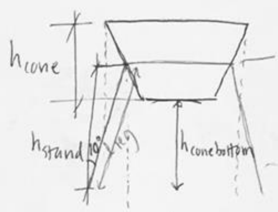
Volume stand +mass

$V_{torus} = 2 \cdot \pi^2 \cdot R \cdot r^2$

$\Rightarrow 2 \cdot \pi^2 \cdot 37{,}5 \cdot 1{,}5^2 \approx 1665 cm^3$

$m_{tot} = 10{,}6kg$

measurements stand



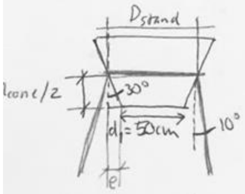
$l_{leg} \Rightarrow hyp = \frac{när}{\cos v} = \frac{90}{\cos 10} \approx 91cm$

$h_{stand} = 90 cm$

$h_{cone} = 43{,}3cm$

$\Rightarrow h_{cone\,bottom} = h_{stand} - h_{cone}/2 = 90cm - 43{,}3/2 \approx 68 cm$

D_{stand} (ring)



$D_{stand} = d_1 + e \times 2$

$\tan v = \frac{\overbrace{mot}^{e}}{när} \Rightarrow mot = \tan v \cdot \underbrace{när}_{\frac{h_{cone}}{2} = \frac{43{,}3}{2}}$

$\Rightarrow \tan 30° \cdot 21{,}65 \approx 12{,}5$

$\Rightarrow D_{stand} = 50 + 12{,}5 \times 2 = 75 cm$

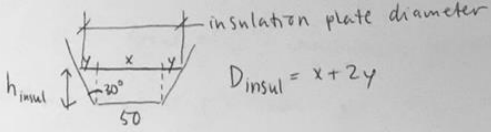
measurements Insulation plate

(thickness ~ 3mm (0,3cm))

(density ~~glass~~ plastic ~1,2g/cm3)

sufuria height ~ 17cm

→ margin for insulation height ~ +5cm



$D_{insul} = x + 2y$

$\rightarrow h_{insul} = 17 + 5 = 22cm$

$\tan v = \frac{mot \leftarrow y}{när \leftarrow h_{insul}} \Rightarrow y = \tan 30° \cdot 22 \approx 12{,}7cm$

$D_{insul} = 50 + 2 \cdot 12{,}7 \approx 75 cm \Rightarrow r_{insul} \approx 37{,}5$

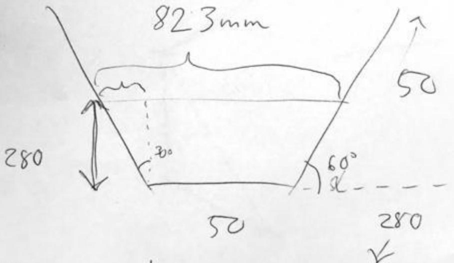
$V_{insul} = \pi \cdot r^2 \cdot h = \pi \cdot 37{,}5^2 \cdot 0{,}3 \approx 1325 cm^3$

$m_{insul} = V_{insul} \cdot density \Rightarrow 1325 \cdot \cancel{2{,}8} \cdot 1{,}2 = 1590g$

$$= \frac{\pi \cdot 52}{3} \cdot \Big(\underbrace{\overset{120\cdot 180}{120(120+60)} + \overset{+3600}{60^2}}_{25\,200}\Big) = 1\,372\,248 \text{ cm}^3$$

$$V_2 = \frac{\pi \cdot 52}{3} \cdot ($$

insulation plate



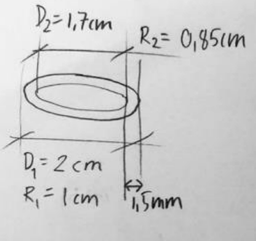
$$\tan 30 \; \frac{\text{mot}}{\text{när}} \Rightarrow \tan 30 \cdot \text{när}$$

mass ~ 1,5mm & 2cm
thickness stand diameter

$$\frac{1{,}5\text{mm}}{2\text{ mm}} = 0{,}75$$

$$\Rightarrow 6{,}6 \text{ kg} \cdot 0{,}75 = 4{,}95 \text{ kg}$$

tot mass of cone



$$V_1 = \pi R_1^2 \cdot h = \pi \cdot 1^2 \cdot 508 \approx 1596 \text{ cm}^3$$

$$V_2 = \pi R_2^2 \cdot h = \pi \cdot 0{,}85^2 \cdot 508 \approx 1153 \text{ cm}^3$$

$$V_{tot} = V_1 - V_2 = 1596 - 1153 = 443 \text{ cm}^3$$

$$m \Rightarrow 443 \cdot 2{,}7 \approx 1196 \text{ g} \quad (1{,}2\text{kg})$$

$$m_{cone+stand} = 4{,}95 + 1{,}2 = 6{,}15 \text{ kg}$$

$$\therefore m_{product} \approx 6{,}15\text{-}10{,}6 \text{ kg}$$