solarSACK

Master thesis product report
MSc04-ID9
Anders Alexander Venning Løcke
Louise Sandahl Ullmann
18.05.2017

TITEL PAGE

Title	Solarsack- Lille slogan?
Project theme	Water purification in East Africa
Project focus	Product design and interactions in an East African context
Project period	01.02.2017- 12.06.2017
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Main supervisor	Christian Tollestrup
Technical supervisor	Mikael Larsen
Number of pages, Product report	X

Louise Sandahl Ullmann

Anders Alexander Venning Løcke

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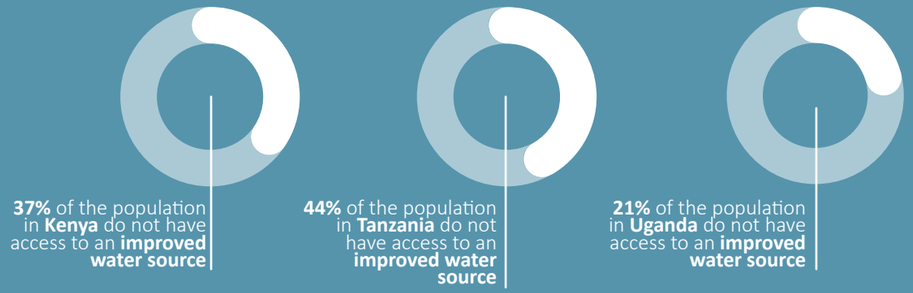
A NEW WAY TO **PURIFY WATER**

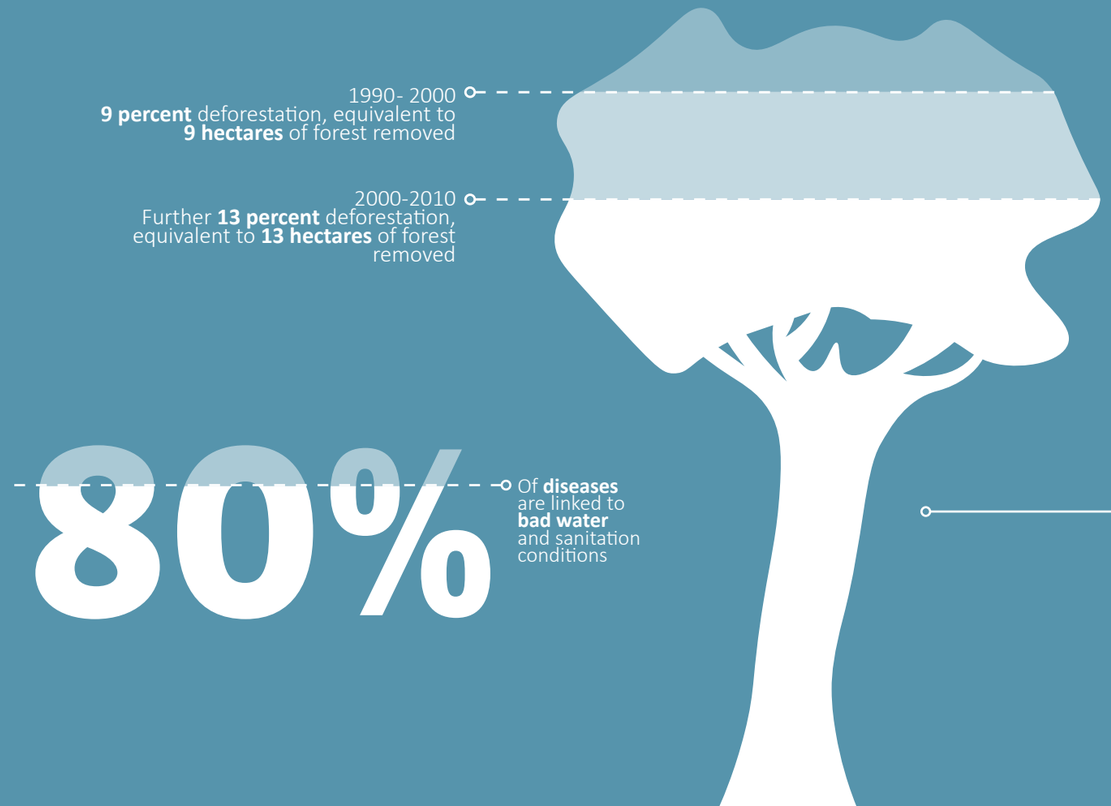
We wanted to find a new and improved way to purify water without the use of charcoal. For this, we chose an unlimited resource that is no harm to nature and wildlife in Africa – The sun! During our master thesis in Industrial Design, we have developed SolarSack. Solarsack purifies water using the UV-rays from the sun. Solarsack can purify 4 liters of water in just 4 hours. Solarsack is developed with a focus on low production costs and high functionalities. Solarsack can be purchased for 5 DKK and can be used up to 60 times, producing 240 liters of water. This is 0,02 DKK per liter clean water. Solarsack is thereby a cheaper and more environmentally sustainable solution than the competitors.

- Anders Alexander Løcke and
Louise Sandahl Ullmann

solarSACK

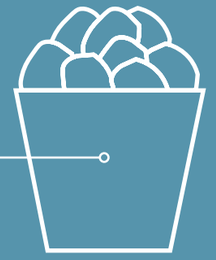
A HUGE **PROBLEM**!





More than 47 million people in Uganda, Kenya, and Tanzania do not have access to a safe water source. This leads to 80% of all illnesses being linked to poor water and sanitation conditions. Boiling the water is the most common purification method, but the huge amount of charcoal used, has led to increased deforestation being a threat to nature and wildlife. Another tradeoff is the increased price of charcoal. Therefore, charcoal is both expensive and a limited resource.

Boiling is the most commonly known purification method in East Africa. Approximately 90% boils the water in the slum areas. In Kenya, 18.4 million people use 70 kg charcoal per year, per person. This has great consequences for the forest and nature life. East Africa's 107 million hectares of forest shrank by more than 9 percent to 98 million hectares between 1990 and 2000, and a further 13 percent to 85 million hectares in 2010 due to rampant deforestation (Ligami, 2015). The increased demand for charcoal combined with the increased deforestation results in the prices for charcoal increases. It has also resulted in, that people living in rural areas and refugee camps have to walk long distances to collect wood, with the risk of being attacked from competing wood collectors



Charcoal are primarily used for cooking and boiling water

Water source in Malimila slum, Uganda

Water source in Adjumani refugee settlement, Uganda

solarSACK THE **SOLUTION**

SolarSack is highly efficient at killing bacteria that causes diseases by only using the energy of the sun. This means that no chemicals are added, no CO2 is emitted and no charcoal is needed.
SolarSack lives up WHO's requirements for purification products.

NO ELECTRICAL POWER NEEDED

NO CHEMICALS ADDED

NO NEED FOR WOOD FUEL

ALL YOU NEED IS THE SUN

TESTED AND APPROVED METHOD

A sunny surface with no shadows

Solarsack is simple and easy to use. It requires very few steps before the water is safe to drink. All you need is a SolarSack, water, and a good surface with no shadows.

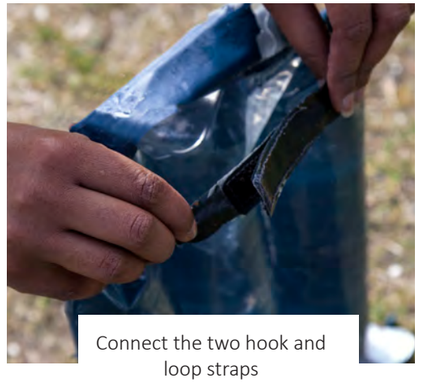
USERS SCENARIO

Pour the contaminated water into SolarSack

1

Roll down the opening a few times

2



Connect the two hook and loop straps

3

Place the SolarSack in the sun for purification

4

Store the purified water in the shadow and let it cool down

5

ELIMINATES BACTERIA

SolarSack lives up to WHO's requirements for purification products. Solar sacks can remove between 99,9% - 99,999% of bacteria. Some of the common bacteria that is found in drinking water are mentioned here.

Most of the bacteria are intestinal bacteria found in animal's meet and feces. The poor water sources cause that humans become sick from the bacteria found in the animal feces. A common symptom of the diseases is diarrhea.

E-COLI
99,999%

E-coli is present in humans intestinal and helps the digestive system. But, some E-coli bacteria has evolved causing diarrhea. E-coli can be transmitted from human to human through drinking water

SALMONELLA
99,99%

Salmonella is an intestinal bacteria which comes from animals such as poultries, pork meet, and beef meet. Salmonella can be transmitter through the water.

COLEREA
99,999%

Cholera is common in East Africa and is an intestinal bacteria secreted in human feces. The bacteria transmits from human to human through drinking water.

CAMPYLOBACTER
99,99%

Campylobacter is an intestinal bacteria found in animal feces, primarily cattle, pigs, and chickens. The bacteria transmits to human though drinking water.

YERSINIA
99,9%

Yersinia is an intestinal bacteria found in animal feces, primarily pigs. The bacteria transmits to human though drinking water and by eating pig meat.

SHIGELLA
99,99%

Shigella is an intestinal bacteria causing bloody diarrhea. Approximately 1 million people die every year of Shigella. The bacteria transmits through drinking water

GIVE ME SOME **FEEDBACK**!

If the UV rays are not strong enough for solar pasteurization, the indicator will remain white, not show the sun

When the UV rays are strong enough for solar pasteurization, the indicator will turn blue, and a sun will appear, telling the user that the product is activated, and is in pasteurization mode.

As the only product on the market, SolarSack gives a reversible, visual feedback on when the sun is strong enough for solar pasteurization. The users can thereby, always get visual feedback regarding if the whether is fit for solar pasteurization or not.

GIVE ME **INSTRUCTIONS**!

The user manual is designed based on studies and tests in Uganda and Kenya. It is adapted to the locals perception of icons and symbols. More than 80 different tripe are to be found in Kenya and Uganda, where many of them speak different languages. The user manual mainly consists of illustrations as illustrations and visuals is a universal language compared to text writing. The common language of East Africa is English, and more and more know how to speak and read English. Supplemented text in English is added to the user manual, as extra insurance, if one can not understand the illustrations.

*The **user manual** is **easy** to read and **understand**!*

Rosie, Malimila slum, Kampala

EASY TRANSPORTATION

The design of SolarSack integrates a water entry and a handle that is strong enough to carry the 4 liters of water.
The handle makes it easy to transport the SolarSack while doubling as a mounting system for storage and cooling of the water.

Slit to lock the snout

Snout

The water exit is made of reinforced plastic film, making it easy to open and close the water exit. A slit in the reinforcement locks the snout, and thereby secures the water.

It is easy to control the water pressure of the water flow with the fingers so that you can empty the sack quickly or, just fill a cup.

The reinforcement is in a white dyed plastic film, so you can see if the water exit is dirty.

INTERACT WITH THE **WATER EXIT**

Marks from dirty fingers

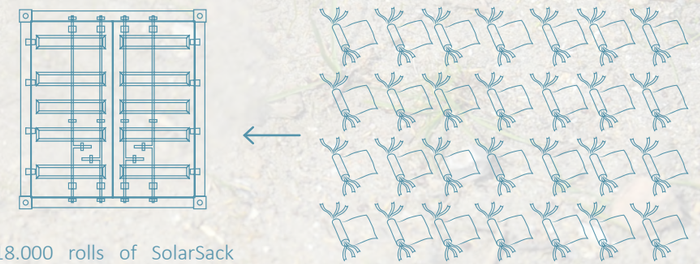
Low water pressure

High water pressure

DESIGNED FOR **SHIPPING**

SolarSack is designed with both users and stakeholders in mind. This has generated requirements for the volume of the product during transportation and distributing. Solarsack can change volume from 60 cm3 to 4000 cm3 when filled with water. This means that the changing volume avoids transporting a larger amount of air, making it easier and cheaper to transport and distribute.

10 SolarSacks in a roll



18.000 rolls of SolarSack can fit in a 20ft container

ITS ALL ABOUT THE **DETAILS**

Every single piece of the Solarsack serves a purpose, combining features that optimize the pasteurization process, user experience, and longevity.
A short walkthrough of the main details of Solarsack is seen to the right.

Handle for **transporting** and **hanging** SolarSack

Water entry. Easy to pour water in to SolarSack

Dispense line, for indicating how much water should be poured in SolarSack

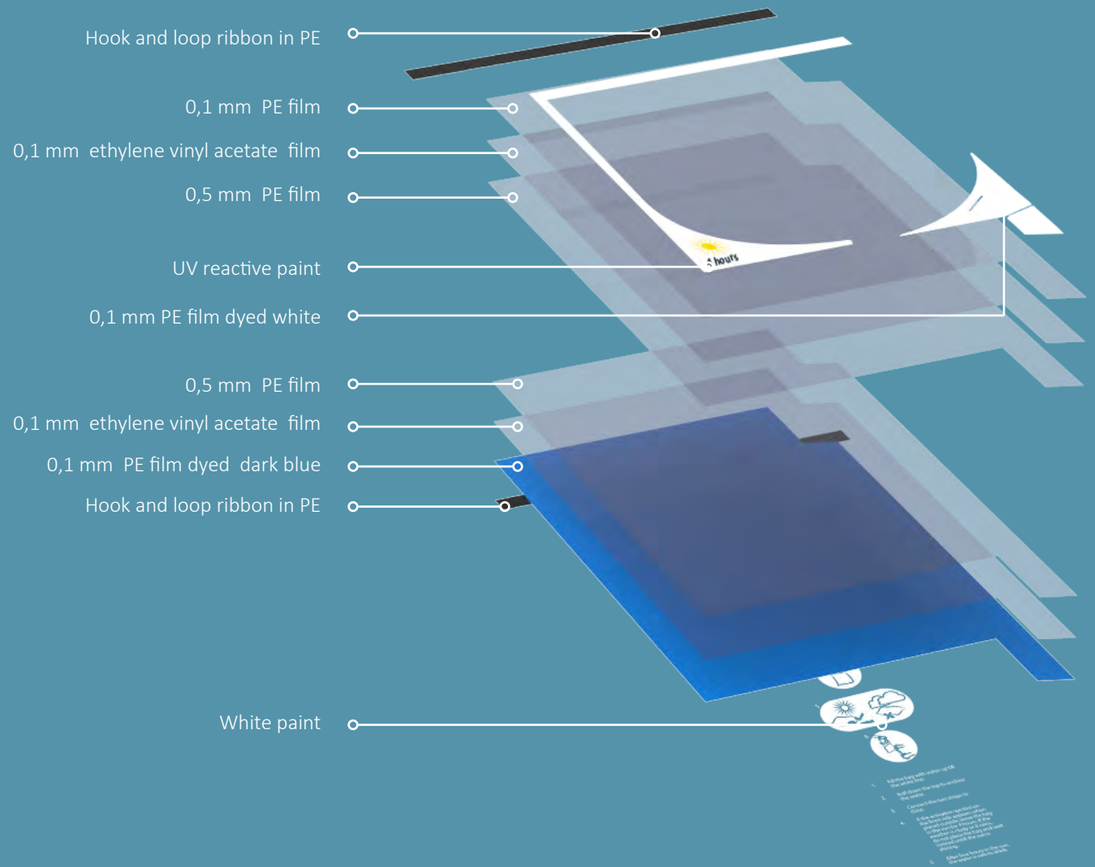
SolarSacks has **bladders**, making the bag **less wobbly** and **easier to use**. The bladders also controls the water depth, which **improves** the solar pasteurization effect.

The **dark blue background** absorbs the heat from the sun **accelerating** the pasteurization process

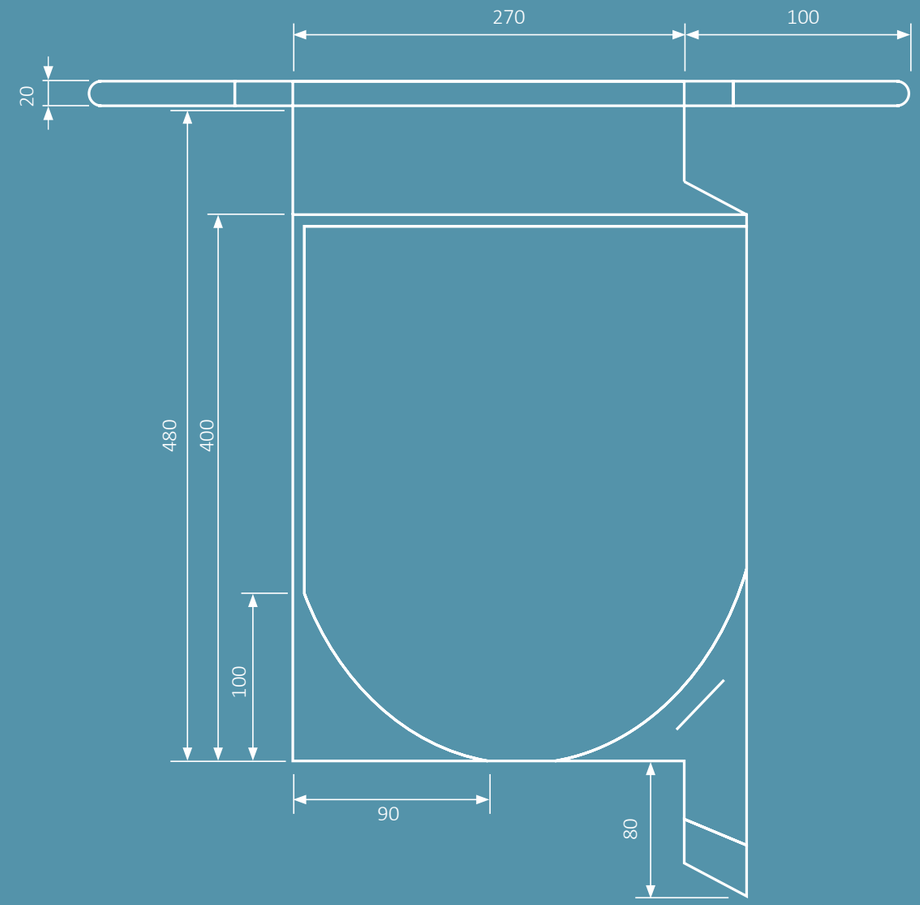
The **indicator spot**, changes **color and appearance** when SolarSack is in pasteurization mode.

Water exit and a reinforced coner, making it **easy** to open and close the water exit.

EXPLOSION



DIMENSIONS



All measures are in millimetres

SOLARSACK FOR **REFUGEES**

Potential market within refugee camps in East Africa

Refugees in Adjumani refugee settlement
222.000

Refugees in Dadaab refugee camp
250.000

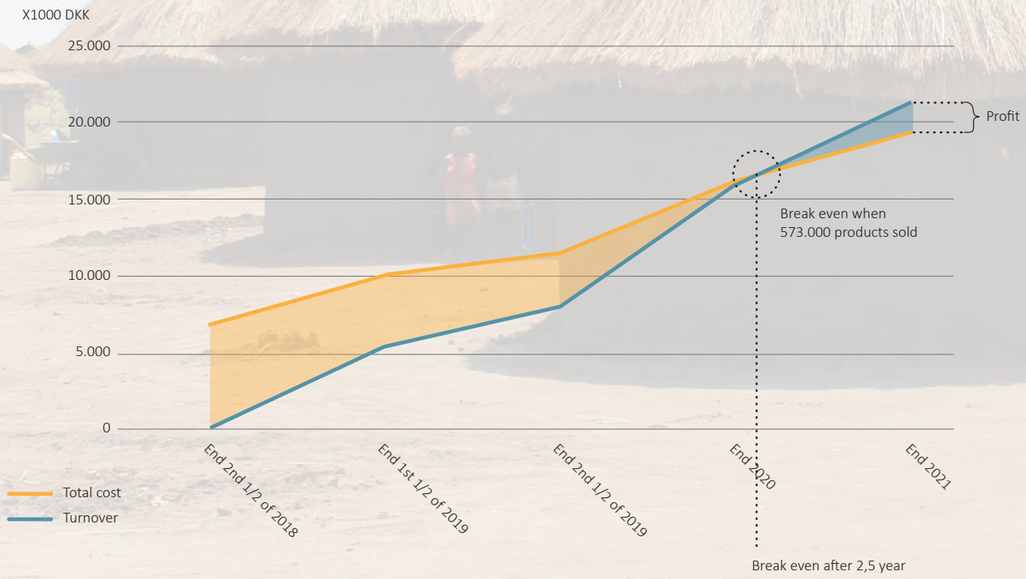
Refugees in Kakuma refugee camp
164.000

Purchasing price, NGOs

240 liters of clean water

0,01 DKK / liter of clean water

Break even for sales to NGOs operating in East Africa



Solarsacks are sold directly to NGOs, and can then be distributed to the refugees. The break even analysis is based on the market of refugee camps in East Africa. Solarsacks can be used in other parts of Africa and parts of Asia, e.g., India. Solar sacks can also be distributed in areas of natural disasters. The main requirement is that the weather is fit for solar pasteurization. For 2,80 DKK a solar sack can provide approximately 240 liters of clean water. That is 0,01 DKK per liter clean water.

SOLARSACK FOR **SLUMS**

Potential market within refugee camps in East Africa

Citizens in slum areas of Tanzania
6.500.000

Citizens in slum areas of Kenya
4.400.000

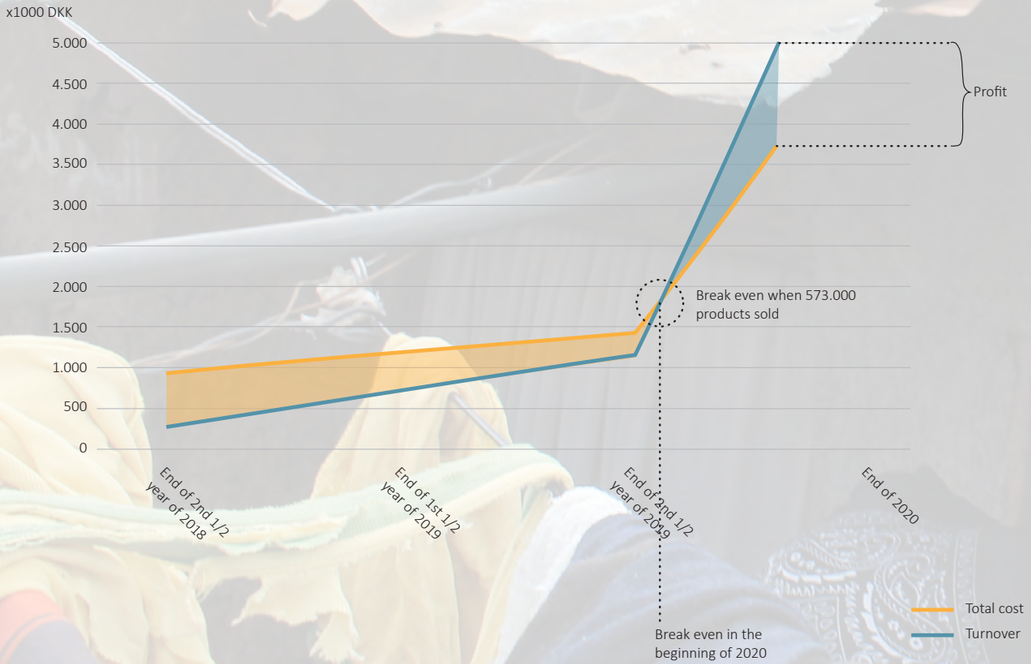
Citizens in slum areas of Uganda
2.500.000

Purchasing price, locals in slums

240 liters of clean water

0,02 DKK / liter of clean water

Break even for sales to NGOs operating in East Africa



Solarsacks is sold to local retailers who resells them to the locals in slum areas. The break even analysis is based on the market of slum areas in Uganda, Kenya, and Tanzania. Break even is based on sales numbers varying from 3%- 35% based on the potential market. Locals in slum areas can purchase SolarSack for 5,60 DKK and can provide approximately 240 liters of clean water. That is 0.02 DKK per liter clean water.

solarSACK

Master thesis, process report
MSc04-ID9
Industrial Design, Aalborg University
Anders Alexander Venning Løcke
Louise Sandahl Ullmann
18.05.2017

TITLE PAGE

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Main supervisor	Christian Tollestrup
Technical supervisor	Mikael Larsen

Number of pages, process report	104
Number of pages, Product report	35
Numbers of worksheets	72
Numbers of other appendices	9

ABSTRACT

More than 47 million people in Uganda, Kenya, and Tanzania do not have access to a safe water source. This leads to 80% of all illnesses being linked to poor water and sanitation conditions. Boiling the water is the most common purification method, but the huge amount of charcoal used, has led to increased deforestation being a threat to nature and wildlife. Another tradeoff is the increased price of charcoal. Therefore, charcoal is both expensive and a limited resource. On the basis of this problem, field studies regarding human behavior, interactions, and water routines have been conducted in Uganda and Kenya. Through ideations, the concept of SolarSack evolved. SolarSack is developed on the basis of the principle of solar pasteurization where heat combined with UV-A and UV-B eliminates bacteria in water, which leads to diseases. The development of SolarSack evolves around research, sketching, prototyping, and testing both in Denmark and in Uganda and Kenya. A business model and a business case are made in relation to SolarSack, and the product is developed to target slum areas and refugee settlements in East Africa.

Anders Alexander Venning Løcke

Louise Sandahl Ullmann

ACKNOWLEDGEMENT

More heads are better than one head. This especially counts for interdisciplinary projects as this master thesis. We are therefore very grateful for all insights, view points, and knowledge that we have received during this project.

Thanks to Ideaal and Access2Innovation for helping us getting started on this project and for the competent feedback.

Thanks to Alex Valerie Omnewu, for helping us create an amazing network in Uganda, and help us get access to Adjumani refugee camp. Thank you for putting us in contact with the right people in slum areas in Kampala and villages of Kumi district.

Thanks to our guides and interpreters in slum areas of Kampala and Nairobi, and in Ngora and Adjumani refugee settlement.

Thanks to all the women that has participated in interviews, observations, and tests.

Furthermore, we would like to thank Aalborg University and foundations for giving us financial support for our field trip to Uganda and Kenya

READING GUIDE

The project consists of a process report, a product report, and technical drawings. Alongside appendices and worksheets which can be found on the accompanying USB.

This report is divided into 5 chapters: Preface, Research, Concept Development, Concept Detailing, and Outro. The report shows the main activities and takeaways of the process, for more insights there are continual references to worksheets. References to external literature are made according to the Harvard Method. Sources are referred to as (writers last name, year) in the main text.

Figure 1: Figure headline

The main text of the figure is inserted here. The texture used will differ from chapter to chapter

Criteria
The criteria is described here. The texture used will differ from chapter to chapter.

TABLE OF CONTENT

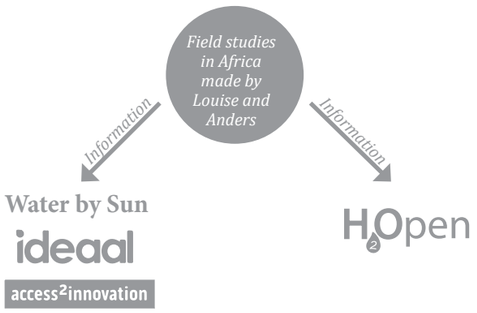
PRE-PHASE

CHAPTER 0

The pre-phase chapter gives a brief of the project background and how the design brief has evolved during the beginning of the project. This includes the project focus and the project frame. A short overview of activities in Uganda and Kenya is described together with the research approach.

Figure 2: Researc

Field studies made in East Africa collects data for the Water by Sun project and the H_2Open project



…pt methods to the context.

…project were enough for a ma… thesis project.

…ure 3: Workshop Ideaal

…eas were sketched on a whiteboard so …y were exposed to all participants

…ct frame…
…esign brief).

… be a part of their
…ruggle and mental

…containers can be
…erly
…ter poured from the wa-
…er can be filtered
… the locals be tout about
…giene
…n a new water container
…e clean water
…w can the water containers be
…asily transported
How can the water be boiled faster
and easier

Because of the immense amount of impressions gathered in the initial research in Africa, the working principle acted more as problems, that if solved, would lead to the wanted value. And not the actual working principle that could solve the problem.

ACTIVITIES IN AFRICA

The field studies are delimited to focus on East Africa, as network is obtained in this area by Ideaal and Access2Innovation. Field studies are conducted in Uganda and Kenya. Most relevant activities are shown in the figure below.

23.02.17: Observations and interviews in Malimila slum

24.02.17: Knowledge sharing with Design Without Borders

29.02.17-02.03.17: Observations and interview in Adjumani refugee settlement

07.03.17: Observations and interviews at production school

07.03.17: Tests, observations, and interviews in Kibera slum

24.02.17: Observations and interviews in Katanga slum

28.02.17: Observations in Gulu

02.03.17 - 04.03.17: Observations and interviews in villages near Ngora

08.03.17 - 09.03.17: Tests and interviews in Malimila slum

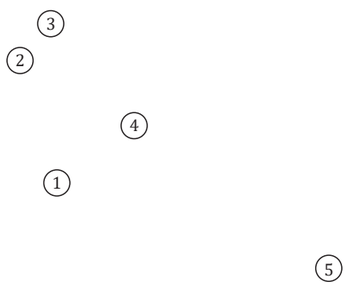
Figure 5: Time line

The time line shows an overview of the order of most relevant activities conducted

As seen on the time line, a great amount of user insights has colored the design process and the research phase. It has been challenging to keep up with all information and insights obtained during the activities. Many user needs have been revealed, both latent and explicit needs, mostly by semi-structured interviews and observations. Other activities have been conducted, but the time line shows the ones that is in relation to users or stakeholders. Being in a different cultural context, one doesn't stop observing and analyzing. So just walking around the streets, observations are made as well.

Figure 6: Map

The map shows the areas where the different activities were conducted



1: Kampala, Malimila and Katanga slum
2: Gulu
3: Adjumani refugee settlement
4: Ngora
5: Nairobi and Kibera slum

RESEARCH APPROACH

Doing field studies in an East African context is very different from a Danish context. The following section describes the research approach and the preparation of the research

Before traveling to East Africa, a meeting with Simone Dyhr Johansen was held. She has a master degree in Product and Design Psychology and has done her master thesis project in Uganda (worksheet 6 - Interview with Simone). She has a great knowledge about user research and interactions in a Ugandan context. This meeting helped us prepare our research so it would fit in an East African context.

INTERVIEWS

The interview setup was, in general, consisting of an interviewer, observant/note taker, interpreter, guide/spokes person, the interviewed person, and audience.
Conducting interviews the interpreter had to translate all questions and answers. It often became a big task to explain to the interpreter how important it is not to rephrase questions, so they become leading questions. In many cases, the guide/spokesperson wanted to answer on the interviewed person behalf. It therefore also became a task to explain the guide/spokes person that the questions were meant for the interviewed person only.
Most interviewed persons were women, and Louise, therefore, conducted most interviews, as the interviewed person would feel intimidated if a male (Anders) were conducting the interview.
When conducting the interviews people nearby was really interested in observing the activities. In some cases, this created a great amount of audience. This could make the interviewed person feel intimidating and afraid of answering some questions. During interviews, the audience had to be told to leave the area.

The people interviewed, had a limited abstraction level, therefore questions had to be rephrased and made tangible.

An example of question not to ask:
"Explain what a perfect water container should be able to do?"

An example of questions to ask:
"Which of the following features would be most important for a water container?". - And when show examples of different features - preferable as illustrations.

Example of questions to ask:
"Which of the following features would be most important for a water container?". - And when show examples of different features - preferable as illustrations.

TESTS

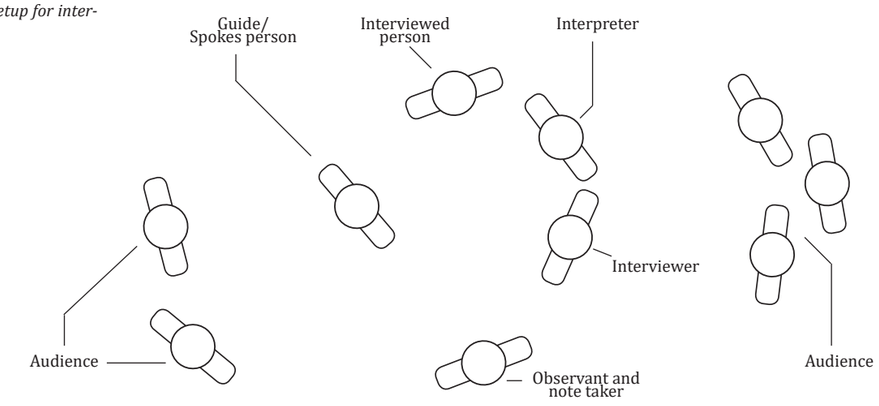
When conducting tests regarding concepts, interactions or principles, it was challenging to make the test setup so that the person did not feel like they were being tested. Some people had a hard time understanding that it was the concept that was being tested and not the person itself. This resulted in persons sometimes trying to answer the question they thought was the "right" answer, instead of just telling their own opinion.

OBSERVATIONS

In many of the areas where observations were made, white people was not a common spectacle. In some cases, this resulted in people stopping what they were doing, but they were quick to take up their work again. Another scenario was also that people were eager to show us their activity.

Figure 7: Interview setup

The figure shows a typical setup for interviews.



CHAPTER SUMMARY

This section shortly summarizes the pre-phase chapter including focus and frame that is making the basis for field studies and user research in Uganda and Kenya.

The background of the project focus and the project theme has its starting point the thermally driven water pump (water by Cun), but changed to focus on how to provide safe drinking water to the users.

Field studies and activities have been planned, to obtain knowledge and insights needed to execute this project.

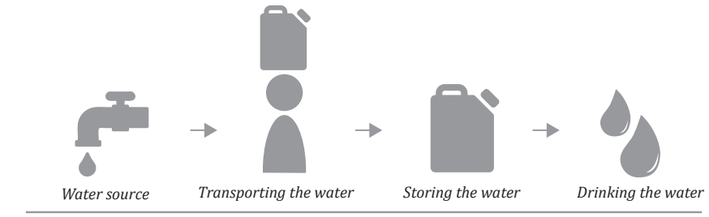


Figure 8: Water cycle

The figure shows a general water cycle, and where in the water cycle focus of Water by Sun and H2Open are.

CURRENT FRAME

What? + **How?** = **Value (experience)**

Making the users feel safe while purifying and drinking water

RESEARCH
CHAPTER 1

The research chapter covers the knowledge obtained through activities in Uganda and Kenya. Desk research regarding water contamination and water purification including consequences are covered as well. The chapter results in a frame that is the basis for the concept development.

WATER CONTAMINATION

This section provides a brief of the water contamination status, what diseases the water contamination causes, and how many becomes ill from contaminated water.

East Africa belongs to that part of the world where most people do not have access to an improved water source. Figure 10 shows how many that do not have access to an improved water source in percent. In numbers, that will be:

- Tanzania: 23,3 million
- Uganda: 8,2 million
- Kenya: 16,7 million

(WHO/UNICEF, 2015) (The World Bank, 2015)

Contaminated water causes diseases that are costly for the society and for the families to treat. In worst case, it will lead to death. The 4th biggest cause of death in East Africa is diarrhea, which is often related to bad water and sanitation conditions (Chigozie, no date).

Diseases that are often caused by bad water conditions are:

- Diarrhoea
- Arcenicosis
- Cholera
- Fluorosis
- Guinea Worm Disease
- Typhoid

The most mentioned diseases when conducting field studies in Uganda and Kenya were diarrhea, cholera, and typhoid.

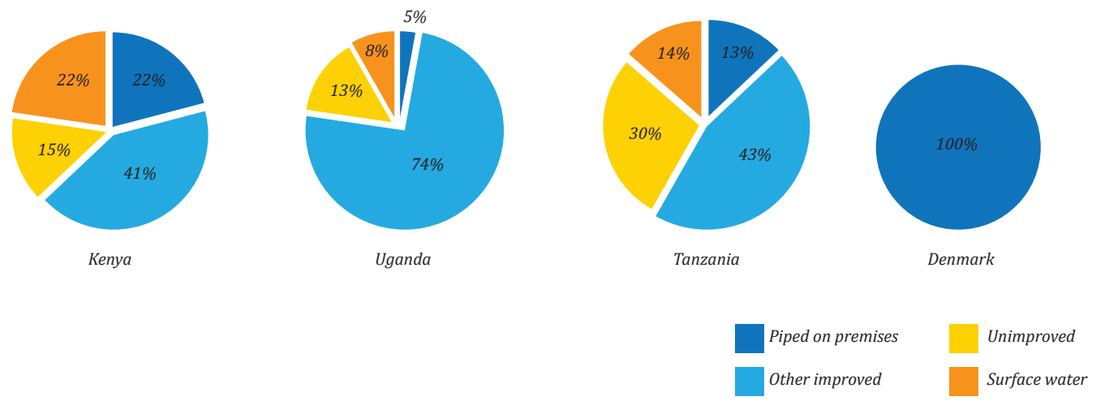
In the rural area, Ngora, a focus group were asked if they have been ill from drinking contaminated water, and as seen in Figure 9, almost everybody raised their hand as a yes.

Figure 9: Hand raise in Ngora

The focus group in the rural area, Ngora, raises their hand if they have been ill from contaminated water

Figure 10: Pie chart

Access to an improves/unimproved water source in Uganda, Kenya and Tanzania (WHO/UNICEF, 2015)



WATER CYCLE

The water cycle consists of five different steps before the water is ready to be consumed. The five different steps are elaborated in this section.

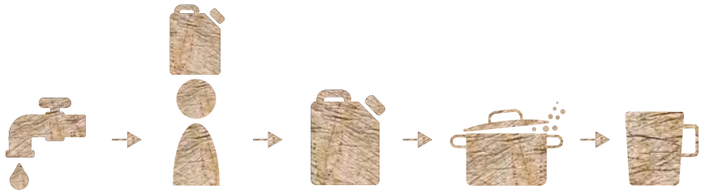


Figure 11: Water cycle

1. Water source, 2. Transportation, 3. Storage, 4. Purification and 5. Storage

THE WATER SOURCE

Many different water sources are observed in Uganda and Kenya, and the water source can be different in slum areas, villages and refugee settlement. Most water sources do not deliver safe drinking water, which can lead to diarrhea if the water is not treated later in the water cycle (Worksheet 29 - Disease and bacteria desk research). In slum areas, the water sources are often close to the sewer, which causes an easy transmission of diseases.

The pipes for water are often in bad conditions and with holes, making the water contaminated (Figure 12). In villages people are often collecting water from the same water holes were cows and goats are drinking, making animal diseases transmit to people.

In many areas, communities have a water pump. However, all pumps observed were only dogged 12-17 meters down in the ground, not making the water safe to drink.

Figure 12: Water pipes

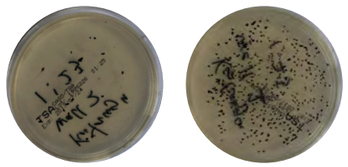
Water pipes for tap water in Kibera slum, Kenya, that is fixed with tape

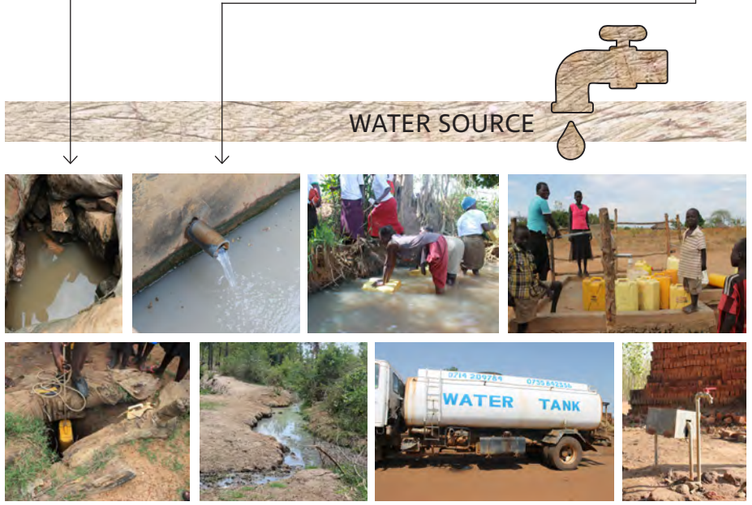
TRANSPORTATION

After the water has been collected at the water source, the water is transported to the household. A household of five persons collects between two and five 20 L jerrycans per day, and the water has to be transported up to several kilometers (Worksheet 31 - Interview with ladies in Kampala slum). Collecting and transporting the water is often a job for women and youths, and the heavy jerrycan is often transported on the head. Some people are making a business of transporting water, as they take a little fee for transporting the water on e.g. a bike.

Figure 13: Bacteria count

Right plate: 332 colonies
Left plate: 20 colonies (The water was right next to the sewer, and many people emptied the water for cleaning in the sewer. It is assumed that the soap has decreased the amount of colonies)





STORAGE

The jerrycan used for transportation is often also used for storing the water until use. The water often becomes even more contaminated when stored in the jerrycans, as the jerrycans are difficult to clean because of the small opening (Worksheet 7 - Water container study).

PURIFICATION

The most common way to purify water is to boil it. This purification method is common in slum areas, and boiling is done using charcoal stoves. In refugee settlements and villages the water is not boiled as they lack access to charcoal and wood (Worksheet 60 - Deforestation and lack of wood).

In refugee settlements, people sometimes receives purification tablets from NGOs, but this is a short term purification method.

STORAGE AFTER PURIFICATION

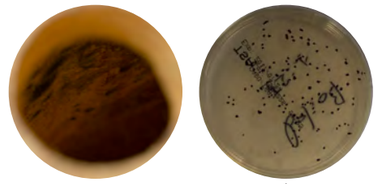
After the water has been purified/boiled, it is stored until it has cooled down or until consumed. The containers used for storing the purified water, is often a plastic container or a clay pot. The advantage of the clay pot is that it keeps the water colder compared to a plastic container. It is observed that people are using individual cups for drinking the water, and not sharing the same cup, or drinking directly from the water container.

OUTPUT

The water cycle shows that there is a contamination risk in all steps before the water is consumed. Therefore, the focus will be on decreasing the contamination at the end of the water cycle, as close to the point where one is drinking the water.

Criteria

The product should purify the water in the end of the water cycle, right before the water are consumed (not at the water source)



WHO PURIFIES WATER?

This section describes three women and their personal water cycle. The three women are respectively from a slum area, a village, and a refugee camp, and according to where they come from, the water cycle differs.

Figure 14: Women

Pictures of the three women used as cases in this section

NAKAMBNE BIRISKA

Living in Katanga slum
37 years old
6 children
A husband
Occupation: housewife and fruit stand
Income: 5000 UGX per day
Uses 4-6 jerrycans per day
(Worksheet 31 - Interview with ladies in kampala slum)

JOYCE FONI

Living in Adjumani refugee settlement
25 years old
3 children, but 2 died of cholera
No husband
No occupation
Uses 3 jerrycans per day
(Worksheet 32 - Interview with people in Adjumani)

Figure 15: Water cycle

The three women's individual water cycles

Nakambne's water cycle

Water is collected from a tap, where she pays 30 UGX (6 DKK) per jerry can

Water is transported in a 20 L jerrycan on the head for approximately 50-100 meters

The water is stored in the jerrycan until use

The water is boiled

The water is poured in a new container. The water cools down before drinking

Joyce's water cycle:

Water is collected from a mechanical well

Water is transported in a 20 L jerrycan on the head for approximately 100-500 meters

The water is stored in the jerrycan until use

Often the water is not being purified, but sometimes NGO's hands out purification tablets

ACEN LUCY

Living in Ngora
26 years old
3 children
A husband
Occupation: house wife
Uses 3-4 jerrycans per day
(Worksheet 32 - Interview with people in Adjumani)

Acen's water cycle:

Water is collected from a water hole

Water is transported in a 20 L jerrycan on the head for approximately 500-2000 meters

The water is stored in a clay pot until the water is being consumed

HIERARCHY

Figure 16 shows the overall social hierarchy observed in East Africa. This structure is approximately the same in slum areas, villages, and refugee camps. The hierarchy structure is very much respected, and people often respect and look up to the persons higher in the hierarchy.

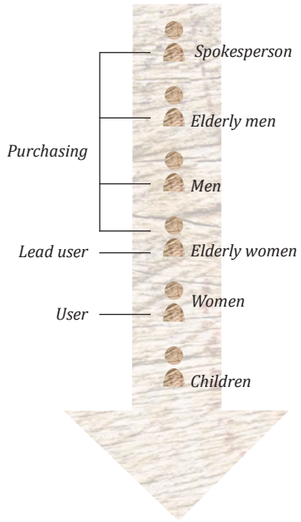


Figure 16:Hierarchy

The figure shows the general hierarchy structure within a community

Due to these observations and insights, the product should target the different people in the hierarchy on different levels:
Men or elderly: The purchaser of the product. How can the man see a benefit in purchasing the product?

Women: The user of the product. How can the product be designed to target the women regarding use and interaction?

Elderly women: The lead user. How can the elderly women be used as an inspiration and role model to other women for using the product?

(Worksheet 22 - hierarchy) (Worksheet 34 - ACH360).

Figure 17:AICA women

AICA womens proudly wearing their t-shirts from ACH360

Criteria
The product should be one-woman-operated

THE USERS VALUES

This section describes the value card sort activity, which was used as a conversation starter, and to obtain insights into the women's values.

Hospital and medical services | *Family and friends* | *Clean water* | *Communication and information* | *Food* | *School and education* | *House or shelter* | *Having a job* | *Transportation*

Figure 18: Value cards

The different cards used for the method, and the ranking of the cards for three different women

The Card Sort method is used as a quick and easy way to spark conversation about what matters to the users. Nine different cards that represent different values were handed over to the interviewed person. The person was asked to rank them in order of what is the most important. Afterward, the person was asked to elaborate on the order. (Ideo.org, 2015).
The method has worked great in an East African context, as it makes it more tangible to the participant. This is in relation to p. 12 - Research approach.
This section shows the output of the activity for three women from respectively a slum area, a village, and a refugee settlement. The activity has been conducted with nine different women, and all results can be seen in worksheet 10 - Value card sorting.

Katanga slum
Name: Nakambne Biriska

Food, work, and family are the most important to her. To have things like access to medical services, education or water purification, one needs to earn money, and the way to do that is by having a job.

Village in adjumani
Name: Acen Lucia

The family is by far the most important. Family and education make one a human being. Transportation is not at all important as God made the original transportation- Legs. So transport is no need for us.

The participants of the activity ended up being both Acen Lucia and her husband. As the husband also was the interpreter, this was hard to avoid. Therefore these answers do not only count for Acen alone, but for her husband as well.

Refugee settlement in adjumani
Name: Regina Lindrid

Water, food, and a house are the basic needs to stay alive. Work is nice to have, because when she can get a nicer house and make her family feel well.
Friends are very good because they help her a lot with cooking and cleaning.

SEMIOTIC STUDIES

Most symbols incorporate some amount of implicit knowledge, a knowledge that is widely different from culture to culture, and therefore not understood the same way by Africans and Westerns.

In Europe, we have a long history of getting information from road signs, telephones and computers, and we have adopted a common language of symbols. As people living in Uganda do not have access to the same products (and symbols) as we do, semiotic studies have been conducted to obtain knowledge of their interpretation of semiotics. Two semiotic tests have been conducted; the second test was modified according to the result from test one.

Symbols the participant did understood (worksheet 15 - Semiotic test)

1. *Jerrycan* 2. *Jerrycan* 3. *Jerrycan*
1. *Spanner* 2. *Spanner* 3. *Spanner*
1. *Machine* 2. *Tap* 3. *Tap*
1. *Check mark* 2. *Right sign* 3. *Check/tick*

Symbols the participant did not understood (worksheet 15 - Semiotic test)

1. *Political party symbol* 2. *Punch* 3. *Thump print*
1. *Floor* 2. *Leaf* 3. *Moon*
1. *Don't know* 2. *Moon* 3. *Circle with cross*

Modified symbols the participant did understood (worksheet 30 - Semiotic test 2)

1. *Boiling water* 2. *Charcoal stove* 3. *Boiling water* 4. *Charcoal stove*
1. *Boiling water* 2. *Boiling water* 3. *Boiling water* 4. *Boiling water*
1. *Stop* 2. *You stop* 3. *Stop* 4. *Don't know*

Criteria
User manuals and instructions should use semiotics that 2/3 users understands.

Figure 19: Semiotics test

Selected symbols and answers form semiotic test 1 and 2.

CONCLUSION ON VALUE CARD SORTING

For most of the interviewed people in Adjumani refugee settlement, water and food are a high priority - higher than in the slums. It was clear that access to clean water and food was limited in Adjumani, and therefore water and food is more valued.

The general impression of the slums is that having a job and earning money is more important than food and water. However, food and water are still crucial to them, but they know that money is needed to be able to buy food and water, and therefore is a job more valuable. Compared to Adjumani, where people did not have a job, and almost no money flow was present in the area, they were used to getting food and water from NGO's and therefore they don't see a job as crucial

Figure 20: Semiotics test 1

Left: Symbols used in semiotic test 1. See answer in worksheet 15 - Semiotic test

Figure 21: Semiotics test 2

Right: Symbols used in semiotic test 2. See answer in worksheet 30 - Semiotic test 2

Figure 22: Conducting test

A participant from Adjumani refugee settlement explaining how she understands the semiotic symbols.

DE-PICTURING

Direct de-picturing of items, e.g. a jerry-can or a spanner is in general understood correctly, but e.g. a rain drop was in all cases misunderstood, as the symbol for a raindrop does not look like a rain drop in "real life". Symbols have to look the same as in "real life."

SCALE

Further implications are their understanding of scale. In some cases, they take the scale of the symbols literally. Therefore, the symbol has to be presented in a context, so it is compared to other symbols making it easier to understand the scale.

CULTURAL PRECONCEPTION

The participants in Uganda has a different preconception of semiotics compared to people in Denmark, and this influences the interpretation of semiotics. An example would be a “thumbs up,” which Danes would understand as "like" or "okay".But in Uganda, the participants recognized it as e.g. a political party, as the thump-up is used as a party's symbol on election posters.

CONTEXT AND INTERACTION

By placing an illustration of a person or a part of a person in relation to the symbol, turns it into a small scene, giving the scale and the way of interacting with the item represented by the symbol.

Criteria

Icons and symbols should be shown in relation to a person, parts of the person or other objects.

COLOR STUDIES

As it is not known if colors is associated with the same way in East Africa, as it is in Denmark, a color test has been conducted to obtain these insights.

Different colors were shown to the participants. The participants were asked different questions, and asked what color they associate with the asked question. e.g. *"What color do you associate with happiness?"*. All answers can be read in worksheet 17 - Color test.

CLEAN, POSITIVE AND SAFE

Blue and white colors are associated with positive things. The participants answered that they associate white with “safety”, “accepted”, and “clean”. Blue is overlapping as it is associated with “clean”, “accepted”, and “happiness”.

DANGER OR NOT ALLOWED

Colors like Black and brown were often associated with dirty. Like known from the European context, "danger" and "not allowed" is associated with red. This is also the participants interpretation. Also, red is used on “stop” and “keep out” signs in Kampala and Nairobi.

FAVOURITE COLOR

As the last question, the participants were asked which color were their favorite color. Most participants answered blue and white. In many cases, their favorite color matched the answer on what they associate with positive things like, "happiness" and "safety".

Figure 24: Interview

Palaya Rosemary Hakim in the Adjumani refugee camp getting asked about what color she associate with a given subject.

Figure 23: Toilet in the slum

A toilet seen in the Malimila slum in Kampala. The blue color is seen on multiple toilets.

Criteria

Colors used, should primarily be shades of blue and white

Figure 25: Water truck

A truck with water for the dry refugee camp. Painted white and blue to represent cleanliness and safety.

AVAILABLE PURIFICATION PRODUCTS

A registration of existing purification products was made before traveling to Africa. The expectations were that some purification products were to be found is Uganda and Kenya, but this was not the case.

Figure 27: Existing products

The three purification products presented to local women and what the women thought the products were used for

Life straw:
For drinking porridge

Filter bucket:
Trash container

Filter bag:
Juice machine

KNOWLEDGE OF PRODUCTS

Selected women were presented with a set of pictures of three different water purification products, with the hope of them having tried the products and comment on how good they are. This, however, were not the case, as no one who saw the products could recognize any of them. Instead, they explained what they thought the products were used for (Worksheet 9 - Locals knowledge of purification products).

OBSERVED PURIFICATION PRODUCTS

The prevalence of the common cooking and boiling process is clearly visible at street level, where charcoal, fire starters, and stoves are sold both in separate small stands and markets.
However, mechanical purification products and purification tablet were nowhere to be found.

Figure 26:Main street

A central shopping street in the Malimila slum in Kampala.

REPAIR AND REPURPOSE

In the context of East Africa, people repair and repurpose anything possible. This, however, might occur as a problem, when applied to a future water purification product. In this case, the wrong repair can result in contamination of water.

In Uganda and Kenya, it was clear to see how the low economy has forced the locals to be creative with their resources.

RECYCLE

Walking the streets of Kampala and Nairobi slums, one would see trash fires burning throughout the day. Garbage like plastic, food, and wood, were burned on the ever burning trash fires. This resulted in a characteristic smell.

Figure 29: Trash fire

Burning trash fire

Figure 28:Sanding machine

A man repurposing a bike to make a sanding machine for sharpening knives.

Figure 30: Cooking stove

A cooking stove made of clay and old bike gears.

Figure 31: Repurposed jerrycan

A broken jerrycan used for fetching water from the well

REPAIR

Throughout the streets, there would be electronic repair shops, repairing everything from fans to mobile phones. And because of the coverage of wood and metal workshops, these would also offer repair on furniture, motorbikes, and cars (Worksheet 8 - Local production and repair).

REPURPOSE

If a product or a component is no longer fit for use, the product is often used in a new context in a creative way. Examples is a broken bike that is reused as a sanding machine, old bike gears used for cooking stoves, and broken jerrycans used for flowerpots or in wells.

OUTPUT

When developing the product, it is important that the product can not be repaired in a way, so that it exposes the water to contamination. If the product brakes it can be repurposed in a new context as long as it is not related to water purification. At some point, the product will be garbage and be burned together with the other garbage. Therefore, it is important that no toxic chemicals will be emitted when burned.

Criteria
If the product brakes, it should be difficult to fix

Criteria
The product must not consist of materials that will emit toxic when burned

COMPETITOR ANALYSIS

Even though not many existing purification products were observed and used in Uganda and Kenya, an investigation of existing purification products is made. The objective is to reveal competitors strengths and weaknesses and to see how to differentiate from the current competitors.

In total eleven products is included in the competitor analysis. Four products are described in this section, and the rest can be seen on page 26.

All product have been avaluated and decribed in worksheet 28 - Market analysis.

Figure 33: Lifestraw

http://eartheasy.com/lifestraw

Figure 34: Real Relief Life Well

http://www.realreliefway.com/en-us/life-saving-products

Criteria
The price per liter clean water should be less expensive, compared to competing products

Criteria
The product should not encourage people to drink directly from

LIFE STRAW

Max capacity:	1,000 L
Capacity per use:	No limit
Purification time:	Seconds
Filter type:	Mechanical
Bacteria retention:	%99.999
Price:	≈ 100 DKK.
Price/L:	≈ 0.10 DKK
Volume when shipped:	≈ 140 cm^3

REAL RELIEF LIFE WELL

Max capacity:	N/A
Capacity per use:	10 L
Purification time:	10 minutes
Filter type:	Mechanical
Bacteria retention:	99.9999%
Price:	≈ 20 DKK.
Price/L:	N/A
Volume when shipped:	≈ 2-400 cm^3

PURIFICATION TABLETS

Max capacity:	25 L
Capacity per use:	1 tablet = 1L
Purification time:	30-45 min
Filter type:	Chemical
Bacteria retention:	99.9%
Consumer price:	≈ 62DKK for 25pc = 25L water
Price/L:	≈ 1,24 DKK
Volume when shipped:	≈ 10 cm^3

PURALYTICS SOLARBAG

Max capacity:	1,500 L
Capacity per use:	3 L
Purification time:	3-6 hours
Filter type:	Solar pasteurization
Bacteria retention:	99.9999%
Filtration:	N/A
Price:	≈ 137 DKK
Price/L:	≈ 0.09 DKK
Volume when shipped:	≈ 50 cm^3

Figure 35: Purification tablets

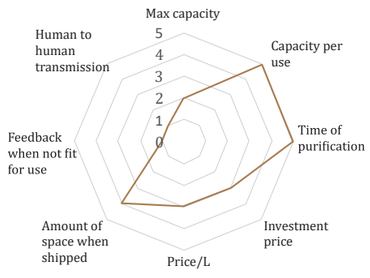
http://all-about-water-filters.com/ultimate-guide-to-water-purification-tablets/

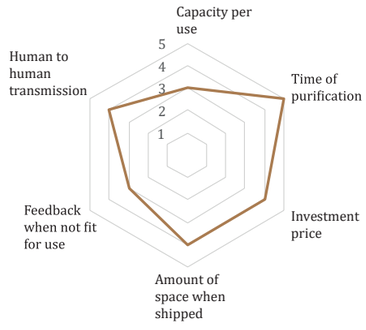
Figure 36: Solarbag

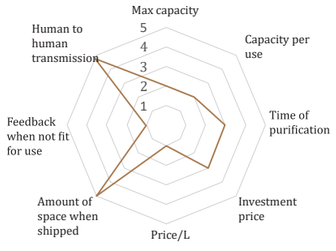
http://puralytics.com/solarbag

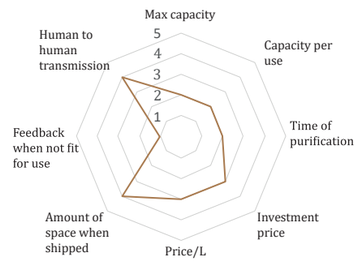
Figure 32: Spider chart

If the product performs well in er certain category it will get 5 points and if the product performs ill it will get 1 point. Spider charts for all analysed product can be seen in worksheet 28a - Market analysis.









MARKET POSITIONING

Figure 37 shows a chart of the competing products and in what degree they approach the market of developing countries or the market of adventure and nature life. The chart is based on own assumptions. Many products for purifying water has been found, but is narrowed down to this eleven products as they are to some extent targeting the market of developing countries. Far most products use mechanical or chemical filtering. However, the Puralytics Solarbag uses another technology (solar pasteurization), but they are aiming for the market within adventure and nature life. They claim that they are within the market of developing countries as well, but their product is costly compared to the competing products.

Figure 37: Market position

The illustration shows how much the different products is targeting developing countries or adventure and nature life

OUTPUT

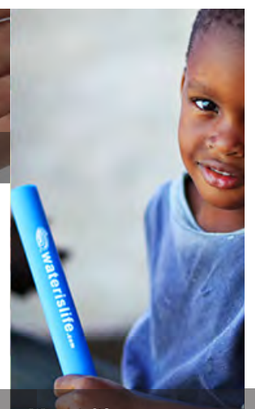
Selected competing products are compared to each other and evaluated according to e.g. price, purification method, capacity, and use. When doing the market analysis, information showed up, telling that the different products are not only committed to target the market of developing countries, but also the western world, including adventure and nature travels. Insight in the competing companies business strategies has also occurred, and can work as great inspiration for the development of the business model later in the process. Business strategies found includes e.g. direct sale to NGO, carbon credits, “buy one, give one”, and micro loans (Worksheet 28 - Market analysis).

Figure 38: Competing products

The figure shows the rest of the products included in the competitor analysis. Descriptions of the products can be read in worksheet 28 - Market analysis

Auro Aquasafe

Life saver jerry can



Water is life straw

Lifestraw Community

Water is Life Buscket

Nazava Water Filter

PURIFICATION METHOD

Four different purification methods are found; Boiling, chemical purification, mechanical purification, and solar pasteurization. Solar pasteurization is chosen as purification method and working principle.

BOILING

Boiling is the most commonly known purification method in East Africa. Approximately 90% boils the water in the slum areas. In Kenya, 18.4 million people use 70 kg charcoal per year, per person. This has great consequences for the forest and nature life. East Africa's 107 million hectares of forest shrank by more than 9 percent to 98 million hectares between 1990 and 2000, and a further 13 percent to 85 million hectares in 2010 due to rampant deforestation (Ligami, 2015). The increased demand for charcoal combined with the increased deforestation results in the prices for charcoal increases. It has also resulted in, that people living in rural areas and refugee camps have to walk long distances to collect wood, with the risk of being attacked from competing for wood collectors (Kuroiwa, 2014). (Worksheet 60 - Deforestation and lack of wood).

Criteria
The product must not encourage to an increased use of charcoal and wood

CHEMICAL PURIFICATION

Most chemical tablets or powder is a one time use and therefore a limited resource. In Adjumani refugee camp people received purification tablets from UN the first few month. Afterward, the UN were out of stock and no more chemical tablets were handed out (Worksheet 32 - Interview with people in Adjumani). Chemical tablets also have some crucial downsides. If used over a lengthy period it might disturb the health. People can develop allergy outbreaks and can be harmful to pregnant women. Chemical tablets also add a bad, bitter taste to the water. Some chemical tablets (mostly chlorine) makes the water become contaminated again if the water is stored for a longer period of time. (Ultimate Guide to Water Purification Tablets, no date)

Criteria
The purified water must not be harmful to the user when the water are consumed

MECHANICAL PURIFICATION

Mechanical purification methods are really efficient but expensive to purchase, Most products using mechanical purification can purify a greater amount of water between 1.000 to 70.000 liters. (Worksheet 28 - Market analysis) This only counts for smaller purification products and not wastewater treatment plants. Even though mechanical purification is efficient, no such product was found in Uganda and Kenya, what makes these products fail, is the high purchase price.

SOLAR PASTEURIZATION

Solar pasteurization uses the heat and UV rays generated by the sun to purify the water. Details about how the method works can be read on page 30. No products using this method were registered in Uganda or Kenya, and when asking around, people were unfamiliar with the method.

SUMMERIZE OF PROS AND CONS REGARDING THE FOUR DIFFERENT PURICIATION METHODS

Figure 39:Purification methods

Examples of how the four different purification methods can look like and pros and cons

+ Well know method

+ Trusted method

- Threat to the environment

- Limited resource

+ Trusted method

- Temporary resource

- Harmful if used for a longer period of time

- Not fit for pregnant women
- Add bad taste to the water

+ Can purify a great amount of water

- Expensive to purchase

- Is rarely seen in Eastern Africa

+ A free and unlimited resource

+ No threat to nature and animal life

- An unfamiliar method

SELECTION OF PURIFICATION METHOD

BOILING

The potential in the boiling method would be to optimize the stoves so that it would be more efficient and use less charcoal. However, the deforestation is increasing, and it would be better not to use any charcoal compared to decrease the amount needed.

CHEMICAL PURIFICATION

There exists a huge variety of chemical purification tablets on the market. The solution space seems limited because of the red market but also because of the project being more a "chemical project" than a design project.

MECHANICAL PURIFICATION

Just as chemical purification, there exists a huge variety of mechanical purification products on the market. The method has great potential and can be used in many different kinds of products and contexts. But being able to compete on design and price will most likely be challenging, this method is deselected.

SOLAR PASTEURIZATION

This method is rarely used in a product design relation, and the potential and solution space seems to be present. It is a less explored method compared to Chemical and mechanical purification. The personal interest for further exploration of the method and the solution space is huge. This purification method is used as working principle.

REFRAMING

The insights obtained through user studies and the selected working principle leads to a reframe of the project:

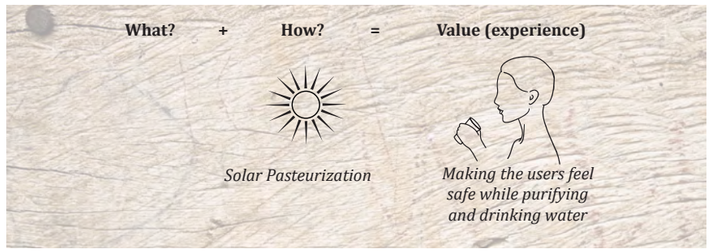


Figure 40: Reframing

The new frame of the project

SODIS

The solar pasteurization method was first describes over 20 years ago, and has been adopted using a 1,5 L PET bottle and named SODIS.
This method has mainly been promoted by an NGO that are promoting the SODIS method in the Philippines.
With the help from the Swish organization, Eawag, they have done research in the method, evaluating on possible benefits and uncertainty.
This a culminated in the "SODIS manual" from which the fundamental knowledge of the method for this project comes from.
(Luzi et al. 2016)

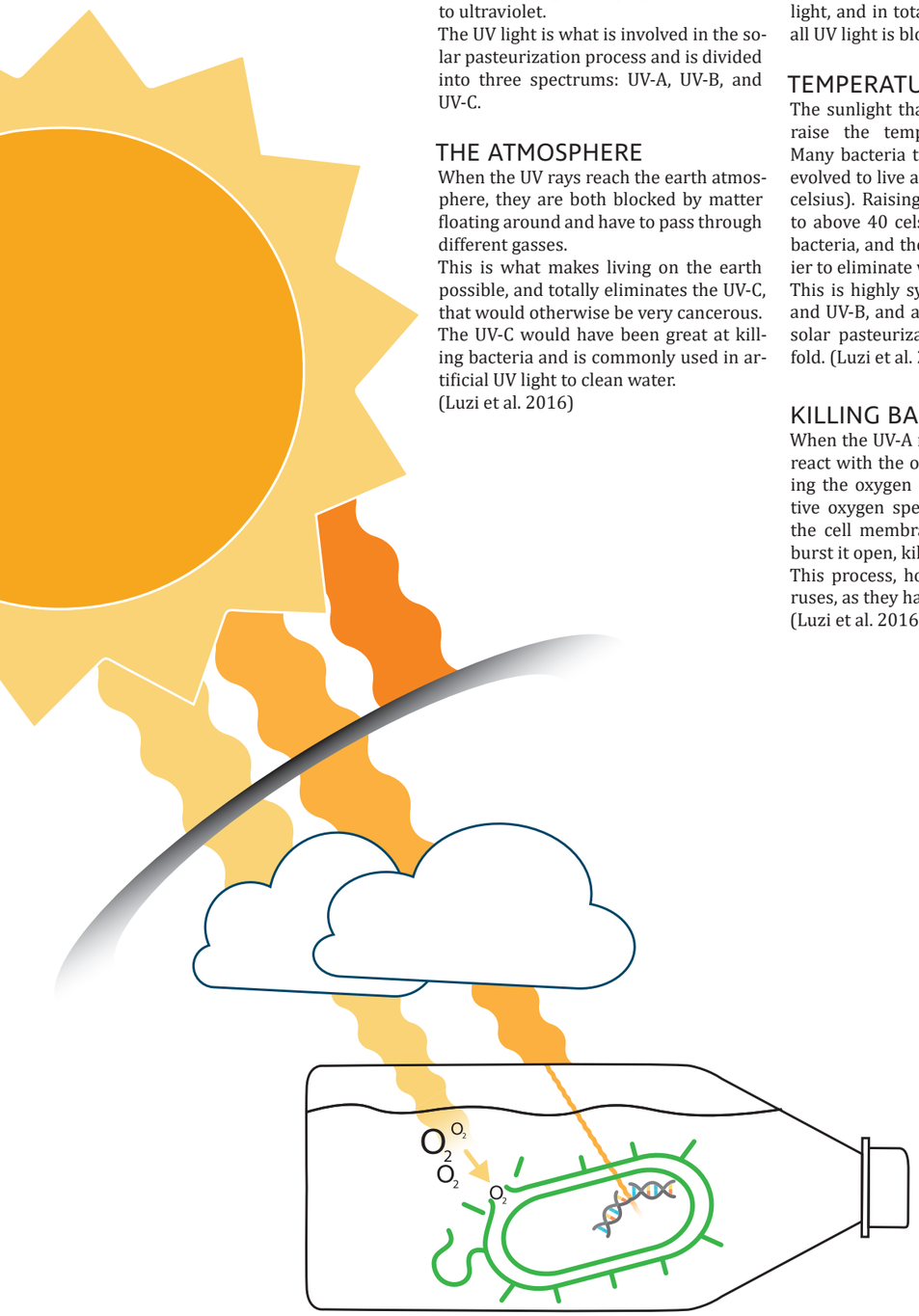
PET BOTTLE

The Polyetylentereftalat, commonly used for the SODIS method, block almost all UV-B from getting to the water, leaving the UV-A to do the pasteurization.
The PET bottle will also discolor from the sunlight and start to block more of the UV-A aswell.
(worksheet 68 - Material)

WORKING PRINCIPLE

Figure 41: UV penetration

Figure showing how the 3 types of UV; UV-A, UV-B and UV-C that are radiated from the sun gets blocked on the way.



The UV rays from the sun are what pasteurizes the water, but the process has multiple sub-processes and is highly dependent on the UV spectrum that ends up in the water.

SUN RADIATION

The light from the sun, contains the full spectrum of light, ranging from infrared to ultraviolet.
The UV light is what is involved in the solar pasteurization process and is divided into three spectrums: UV-A, UV-B, and UV-C.

THE ATMOSPHERE

When the UV rays reach the earth atmosphere, they are both blocked by matter floating around and have to pass through different gasses.
This is what makes living on the earth possible, and totally eliminates the UV-C, that would otherwise be very cancerous.
The UV-C would have been great at killing bacteria and is commonly used in artificial UV light to clean water.
(Luzi et al. 2016)

WEATHER

Depending on the weather conditions, cloud or mist can block parts of the UV light, and in total overcast about almost all UV light is blocked.

TEMPERATURE

The sunlight that gets to the water will raise the temperature of the water. Many bacteria that causes diseases, are evolved to live at body temperatures (37 celsius). Raising the water temperature to above 40 celsius will slow down the bacteria, and the bacteria is thereby easier to eliminate with UV-rays.
This is highly synergistic with the UV-A and UV-B, and at 45 celsius the effect of solar pasteurization is increased threefold. (Luzi et al. 2016)

KILLING BACTERIA

When the UV-A reaches the water, it will react with the oxygen in the water, turning the oxygen into what is called reactive oxygen species, that will attach to the cell membrane of the bacteria and burst it open, killing the bacteria cell.
This process, however, doesn't affect viruses, as they have no cell wall.
(Luzi et al. 2016)

DNA AND RNA DAMAGE

The small amount of UV-B that gets to the water, will directly damage the DNA and RNA in the bacteria or virus, killing them.
(Luzi et al. 2016)

VIRUS

As explained the UV-A works by destroying the cell wall of the bacteria, and because viruses don't have a cell wall, they are not affected by this.
Luckily by far, most water-related diseases comes from bacteria, making it far more important to eliminate bacteria.
However, UV-B destroys some of the viruses. This makes the method accommodate WHO's standards for treated water.
(Luzi et al. 2016)

Figure 42: Lake water

A small lake that the villages would get their drinking water from.
This water is so filled with dirt and organic matter, that the SODIS method will not work with unless the water is filtered.

CHEMICALS

In the slums, the lack of space and maintenance sometimes leads to water holes being contaminated with water from the sewers. This water can contain chemicals as soap and fuel.
These substances can not be removed by solar pasteurization or even boiling, and have to be filtered away.
However, asking the locals in the slum, they stated that they would only use it for cleaning and washing cloth etc. not drinking.

AVAILABILITY

The PET bottle is known by most people, but in reality only found in abundance in the slum areas, where they can gather it from the wealth in the city.
When asking both the people in the rural villages and the refugee camps, they did not know how to purchase these bottles, apart from traveling the long distance to the city.

TURBIDITY

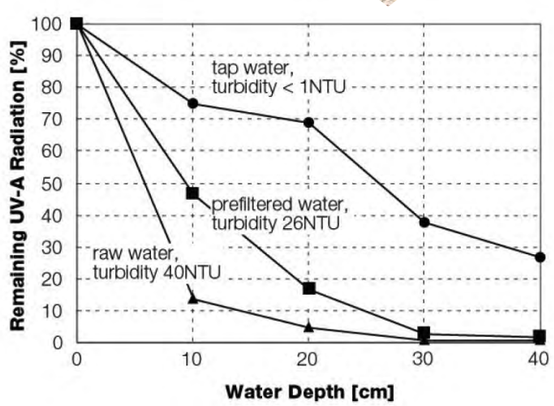
Turbid water, from organic matter or non-organic matter, have a big affect on the effectiveness of the solar pasteurization. Particles can hinder the UV rays from penetrating the water and thereby slowing the process.
Most people gets their water from wells where the water is not turbid, but people getting their water from water hole or similar, have to filter the water before the water can be solar pasteurized.

PENETRATION DEPTH

The depth of the water has an influence of the how well UV-A rays can penetrate the water. A lower water depth allow more UV-A rays to penetrate the water (Figure 44).

Figure 43: UV penetration

Graph showing the penetration of the UV-A over different water depths, and different turbidity.



Criteria
The depth of the water should be maximum 10 cm

REGROWTH

As the SODIS method proclaim to reduce the bacteria by 99.9%, it will still contain a very small amount of bacteria.
Too small to prove any danger to humans, but if the pasteurized water is stored for a long period of time contaminants might grow back. This has been studied in relation to the SODIS method and has shown not to be a problem in this instance, showing no noticeable regrowth 14 days after the sun exposure.
(Luzi et al. 2016)

SAFETY FACTOR

The solar process as recommended by the organization behind SODIS, recommend 6 hours of sun exposure to get the water sufficiently pasteurized to drink.
Based on own experiments (Worksheet 45 - Test of SODIS ½with temperature focus), and data from the SODIS manual (Luzi et al. 2016), the water can be sufficiently pasteurization in 30 minutes with the optimal conditions.
As SODIS recommends 6 house solar pasteurization time, is to account for smaller factors that can influence and hinder the affect of solar pasteurization.

Figure 44: Well

A well in the Katange slum that pour out water that has been contaminated with sewerwater because of broken pipe further back.

OUTPUT

When designing a product using solar pasteurization, it is important to implement factors, that can improve and accelerate the pasteurization process. This includes consideration about:

- The type of material should absorb as little as possible of UV-A and UV-B
- Filtering the water before pasteurization
- The lower water thickness the better pasteurization
- An increased water temperature will speed up the pasteurization time

This has been implemented as criteria

Criteria
Material used should absorb as little as possible of UVA and UVB

Criteria
Material used should not discolor or be damaged when exposed to sunlight for up to 250 hours.

Criteria
The product should accelerate the heat up of the water

CHAPTER SUMMARIZE

A short summarize of the activities described in this chapter is made. All criteria stated throughout this chapter is summarized. The project frame that makes the basis for the concept development is shown as well.

Field studies in Uganda and Kenya have been conducted regarding water contamination. Different water sources have been observed and testes for the amount of bacterial colonies. Water containers, primarily jerrycans, has been studied according to use and contamination. Results showed that the water from most water sources is not fit for drinking. Field studies showed, that boiling water is a commonly used purification method in slum areas, but not in rural villages and refugee camps because of the limited access to wood and charcoal. A lot of products is currently available on the market for water purification, but these products are rarely used in East Africa. Studies about the East African context and culture has been conducted using observations and interviews.

CRITERIA SUMMARIZE

Criteria
The product should purify the water in the end of the water cycle, right before the water are consumed (not at the water source)

Criteria
The product should be one-woman-operated

Criteria
User manuals and instructions should use semiotics that 2/3 users understands.

Criteria
Icons and symbols should be shown in relation to a person, parts of the person or other objects.

Scope
Kenya should be approached as test market

Criteria
Colors used, should primarily be shades of blue and white

Criteria
If the product brakes, it should be difficult to fix

Criteria
The product must not consist of materials that will emit toxic when burned

Criteria
The price per liter clean water should be less expensice, compared to competing products

Criteria
The product should not encourage people to drink directly from

Criteria
The product must not encourage to an increased use of charcoal and wood

Criteria
The purified water must not be harmful to the user when the water are consumed

Criteria
Material used should absorbe as little as possible of UVA and UVB

Criteria
Material used should not discolor or be damaged when exposed to sunlight for up to 250 hours.

Criteria
The product should accelerate the heat up of the water

Criteria
The depth of the water should be maximum 10 cm

CURRENT PROJECT FRAME

What? + **How?** = **Value (experience)**

Solar Pasteurization

Making the users feel safe while purify and drink water

CONCEPT DEVELOPMENT

CHAPTER 2

This chapter is a walktrough the concept development based on outputs from studies in East Africa. The concept development includes both ideations and evaluations with multiple approaches. The development ends in a final concept, where details according to e.g. materials and manufacturing is described in chapter 3.

PROOF OF PRINCIPLE

Even though desk research has been made regarding solar pasteurization, a test is conducted to see how efficient the purification method is in an East African context (Worksheet 45 - Test of SODIS with temperature focus) (Worksheet 43 - SODIS background test).

The test has been conducted in Nairobi, Kenya, where two plastic bags with 0,5 L of contaminated water gathered from Kibera slum is placed on a black and a white background. The result was that a black background raises the temperature by approximately 10 degrees compared to the white background, and thereby accelerates the water pasteurization, which is reflected in the bacterial count. The bacterial count after 90 minutes on a black background showed two small bacterial colonies, this is most likely an error as other bacteria may have accessed the plate when incubating the sample.

Criteria
The product should have a dark colored background.

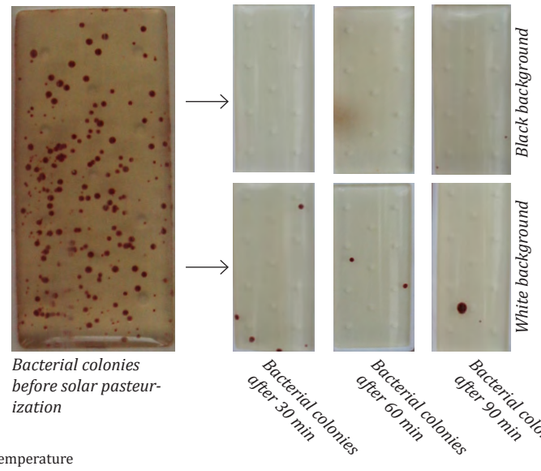


Figure 45:Bacterial count

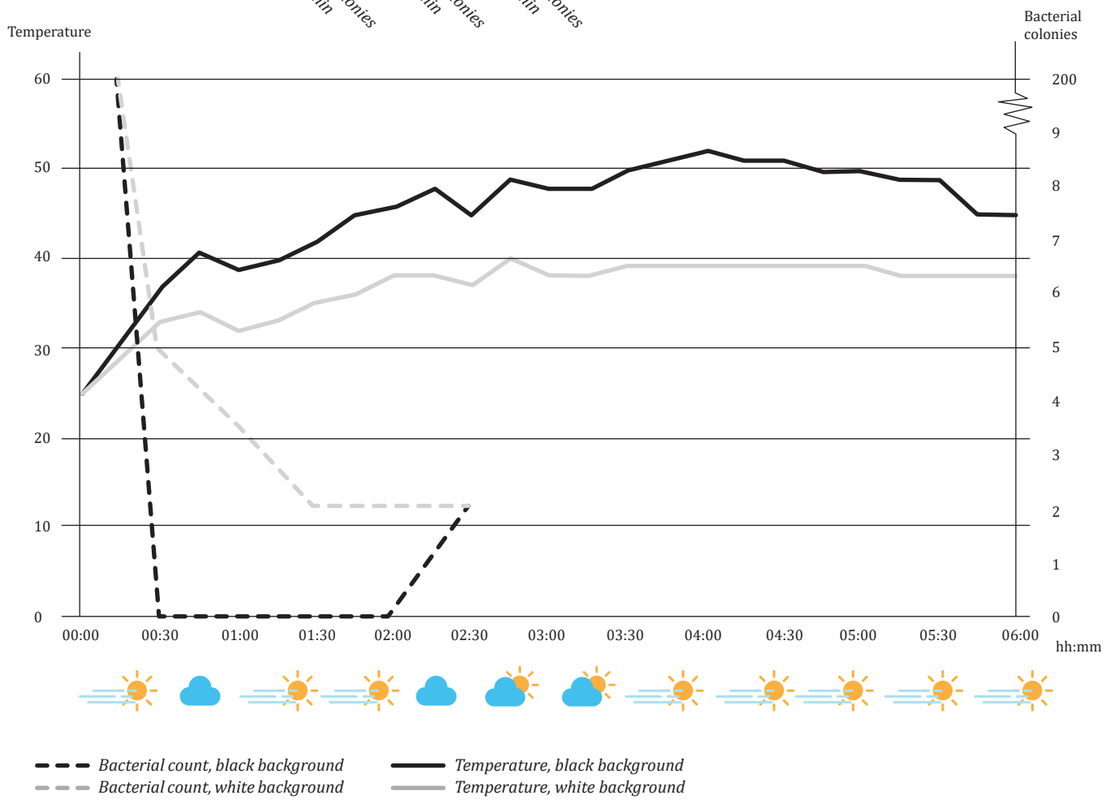
Bacterial colonies after incubation time

Figure 47: Plastic bags

Plastic bags with 0,5 L of water from Kibera slum placed on a white and a black background

Figure 46:Graph

The graph shows the temperature of the water, bacterial counts, and the weather over time



TEST IN SLUMS

As it is possible to do solar pasteurization using PET bottles, a user manual and PET bottles were brought to Malimila slum and Kibera slum to pasteurize water together with the locals.

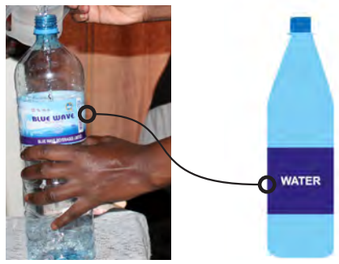


Figure 48:Label

The label on the user manual and on the bottle is too different

The objective of conducting solar pasteurization with the locals is to obtain insights in how the locals interpret user manuals, and to see if they would trust water pasteurization as a purification method.

TEST 1:

Malimila slum, day 1

Water pasteurization was conducted with three different women, individually. The overall understanding of the user manual was tolerable, but with room for improvements. Step 1 was ignored by all participants, as they did not understand that the label should be removed, as the label on the user manual were not corresponding to the label on the water bottle. This confirms our conclusion that they take semiotics literately (page 19). Step 2 was understood by all participants, but there was some doubt about how much water should be poured into the bottle. All participants understood that the bottle should be placed in the sun for 6 hours. But some thought that it should just be placed outside if the sun is shining, and it does not matter if it is in the sun or in the shadows. All participants understood that the method was not fit to use when it is raining or no sun are visible. All participants understood check marks as “great” or “correct” and the X as “not good” (Worksheet 42 - Test of sodis in malimila slum 1).

TEST 2:

Malimila slum, day 2

After the first test, the user manual was redesigned according to the output. The user manual was made in monochrome and colors to see if that would influence the interpretation. Two tests were conducted with the colored user manual and two with the monochrome. The boxy steps made the user manual easier to read. The participants did still not understand that they should remove the label, as it was still not corresponding to the label on the bottle. As the bottle on the user manual is filled with water, all participants understood that the bottle should be full. The rain was removed from step 3, but the participants did still understand that the method was not fit for use if it was cloudy or raining. All participants placed the bottle on the roof as shown in the manual. In this way, the chance that the bottle will be placed in shadows is decreased.

Figure 49: Pruification process

1. Reading the user manual, 2. filling the bottle with water, 3. Placing the bottle in the sun

Figure 50:Roof top

The bottle is placed on a rooftop

There was no significant difference in the interpretation of the colored and the monochrome user manual. After the test, the participants using the monochrome user manual, were presented to the colored user manual and vise versa. They were asked which of the two they thought was the best. The participants using the monochrome user manual chose the monochrome as the best one, and vise versa for the participants with the colored user manual (Worksheet 43 - Test of sodis in malimila slum 2).

User manual from test 1

User manuals from test 2

User manual from test 3

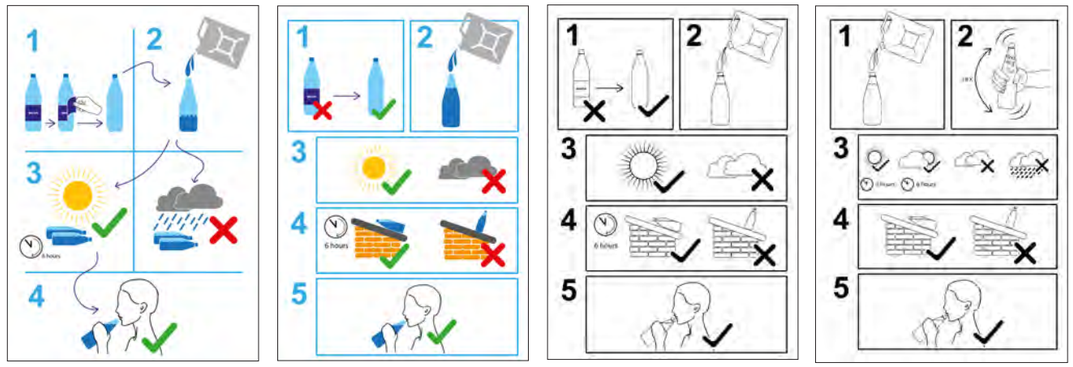


Figure 51:User manuals

The three user manuals used for the tests

TEST 3:

Kibera slum

The first step from test 1 and 2 is removed, and the labels on the PET bottles were removed as well before conducting the test. A new step 2 is made, showing that the bottle should be shaken. Between test 2 and 3 new data showed up, stating that shaking the bottle to make the water more airy would slightly improve the pasteurization process. However, 3/4 of the participants did not understand that the bottle was supposed to be shaken. Step 3 is extended to 4 different weather conditions. Surprisingly, all participants understood water pasteurization conditions for all four weather conditions. On the test day, few clouds were visible in the sky, and the participant was in a little doubt whether or not the bottle should be in the sun for three or six hours (Worksheet 52 - Kibera slum).

The tests are conducted in Malimila, Uganda and Kibera, Kenya, and no significant difference in the interpretation between locals from the two areas was observed.

TRUSTWORTHINESS

Some of the participants felt unsure that the method would work. This is understandable as the purification method lacks feedback on when the water is being purified and when the water is safe to consume. 3 out of 11 participants did not trust the method. Other participants were excited about this new purification method, claiming that they would get more water bottles so that they could purify a lot of water at the same time. It was possible to keep contact with the local guide from Kibera slum. Approximately 3 weeks after the test were conducted in Kibera, the guide was asked if they still use water pasteurization, answering that 3/4 still uses the method including himself.

OUTPUT

There is no significant difference if the user manual is in monochrome or in colors. The symbols on the user manual should look the same as it does in “real life”, to avoid situations similar to when the participants did not understand that they were supposed to remove the label. The lack of feedback makes the users doubt if the method is working and if the water is safe to consume. In some cases, it can be challenging to the users to decide on whether or not the weather are fit for water pasteurization. The areas, including the ground and rooftops is often dirty and unstable, making it challenging to find a suitable spot with no shadows and not making that bottle trill. Check marks and X’s were understood without any problems.

Figure 52: Lady with usermanual

A lady from Malimila making water pasteurization

Criteria

The product should give feedback on when the water is in a purification process or when the purification process is done

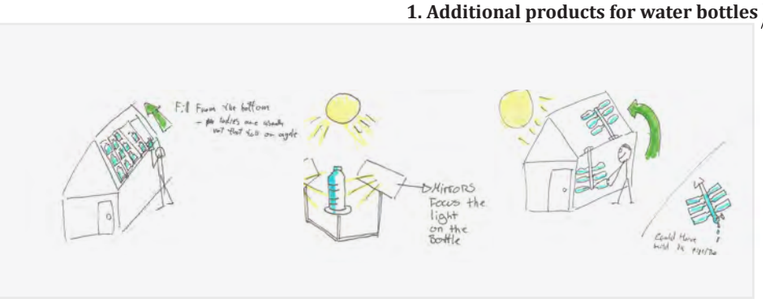
Criteria

The product should be able to be placed on multiple surfaces

IDEATION ON SOLAR PASTEURIZATION CONCEPTS

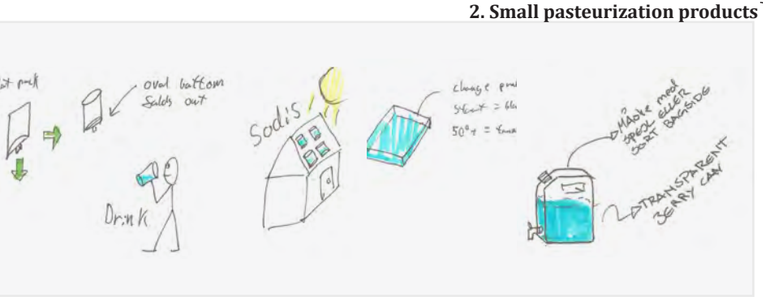
Ideations have been conducted regarding different solutions for water pasteurization. The ideas are divided into four different categories (Worksheet 41 - Ideation on sodis concepts).

1. Additional products for water bottles



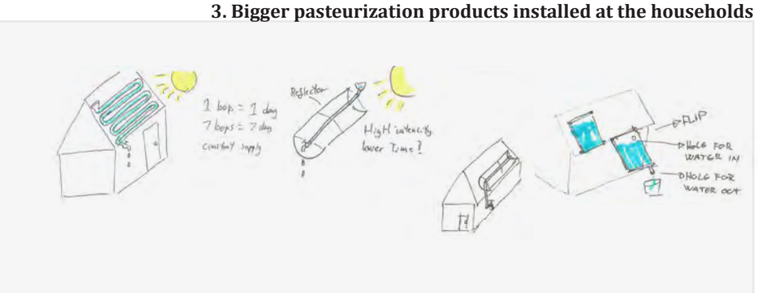
The concepts show how PET bottles can be reused for water pasteurization. The focus is not on reinventing the water bottles, but on the development of additional products that can make it easier and more efficient to pasteurize water with bottles.

2. Small pasteurization products



The concepts do not require bigger installment in any way. Meaning that the products contain less water and at the same time is portable.

3. Bigger pasteurization products installed at the households



The concepts show bigger solar pasteurization installments that are placed at the locals households.
The space around the households is often limited (especially in slum areas). Therefore, the space needed for the installment can be difficult to find. The rooftops are also very different from slum areas to villages and refugee settlements. Also, the condition of the rooftops varies a lot.

4. Bigger pasteurization products installed at the water source

The concepts show how pasteurization can happen at the water source. In this way, the pasteurization is not happening at the individual households, but in small communities consisting of several of households.

DESELECTION OF CATEGORY 3:

Bigger pasteurization products installed at the households

Concepts within this category are deselected as it has a bigger start up cost and maintenance cost for the individual households. Compared to category 4, where the start up- and maintenance costs are split between more people in the community. As the concepts purify a larger amount of water, there is an increased risk of people pouring the water into jerrycans again after pasteurization (and the water is once again contaminated). Concepts within the category requires cleaning, as algae can grow in the containers or pipes, because of the

DESELECTION OF CATEGORY 4:

Bigger pasteurization products installed at the water source

Concepts within this category are deselected as our studies, and existing studies shows that 50% of the water are contaminated (once again) when it is transported and stored In jerrycans. So, if the water is pasteurized at the water source, the water will in many cases be contaminated afterward.

Criteria

The contaminated water should not enter the product the same place as the the exit for the purifyed water

Either category 1 or category 2 will make the basis for further concept development. Pros and cons for the two categories is shown.

CATEGORY 1:

Pros

\+ They bottles exist already and is obtainable

Cons

\- The water comes in and out the same place and increases the change of contamination

\- The PET bottles can be harm full to the user, when used for longer time

\- No feedback is indicating then the water is safe to drink

CATEGORY 2:

Pros

\+ Can be designed for the purpose and the users

\+ Can reduce the chance of contamination as the water doesn't need to come in and out the same place

Cons

\- Development and production costs can make it the product more expensive compared to category 1

Category 2 has been chosen for further development. The solution space will be further investigated.

TRUSTWORTHINESS

To obtain insights in what products, shapes, and styles seems more or less trustworthy to the users, a test is conducted.

Figure 53:Participant

One of the participants placing the six products i prioritized order

Figure 54: Graph

The graph shows how much the different products is interpreted as good for solar pasteurization.

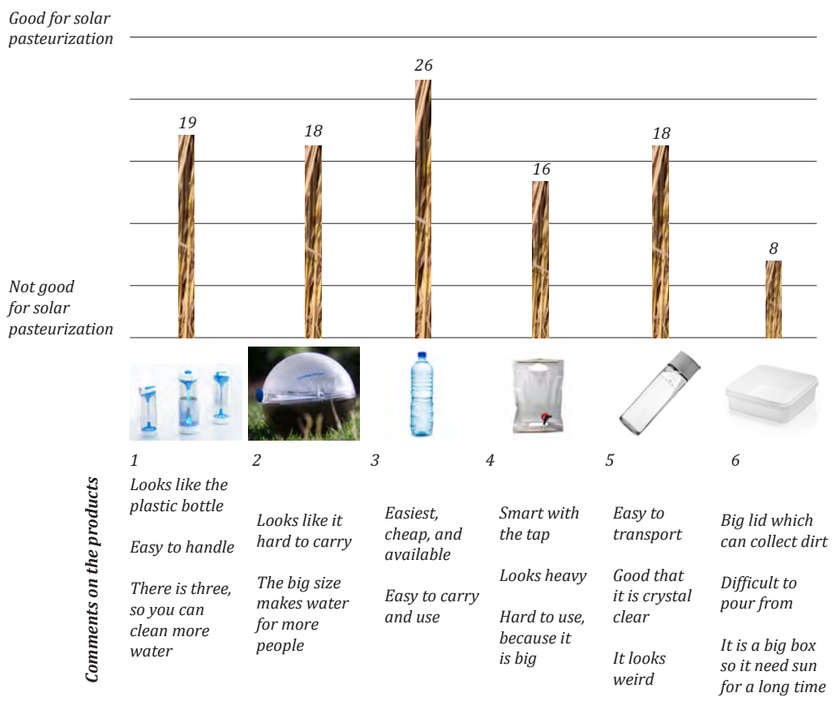
Criteria
The product should be as big as possible without without comprimising the ease of transportation and use

In Kibera slum, after the participants had conducted solar pasteurization with PET bottles (page 36), the participants were presented with cards showing six different products. The products were presented, as they were all fit for solar pasteurization. The participants were asked to prioritize the products according to which ones they think is best for solar pasteurization. The prioritization has been converted into a point system afterward. As seen in Figure 54, the water bottle was selected as the best one. As the participants had just done solar pasteurization with PET bottles, it is assumed that the reason for picking the bottle as the best one, is because they have tried to use the product, and are therefore convinced that this product works. This tells that they quit fast trusts new products if they succeed with it.
Product 1, 2, and 5 scored a second and third prize. Product 1 and 5 is similar to the PET bottle according to shape, and thereby assumed to be more trustworthy. Product 1 contains blue, and from earlier studies (Worksheet 17 - Color test) blue is associated with "clean" and "safety", and thereby maybe making the participant interpret this product as better.

The products were not presented in a scale comparison, making the participants interpret the sizes differently. Especially product 2 and 6 were perceived as a big product.
Some associated a big product as positive, as it could purify more water. Others associated it negatively, as it would be hard to transport and handle. A common thing, where that the participants associated a good product as being able to purify water for many people, without compromising the ease of transportation and use. More information about the test and the results can be seen in worksheet 46 - What makes a product trustworthy.

OUTPUT

The users trust products quite fast if they succeed with it the first time that they use a product. The product should be able to purify a bigger amount of water without compromising the ease of transportation and use.

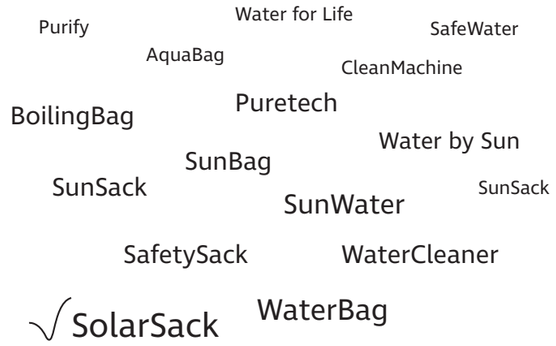


IDENTITY

The product name and the product identity serves to visualize both the values but also what it is. As things are taken literately, the product needs to be named what it is, without being too abstract.
Values it should represent:
Prestige, safety, and purity.

What it is:
A bag, a sack, a water container

What it can:
A boiling machine, a water cleaner



Orange: Represents the power of the sun

Blue: Represents safety, clean, and happiness

LOGO CHOICE

Solar and Sack is connected by a circle, representing the sun. The sun is in a gradient of blue and orange, representing the connection between water and sun and that they work together - not separate.

Product logo in colors

Product logo in monochrome

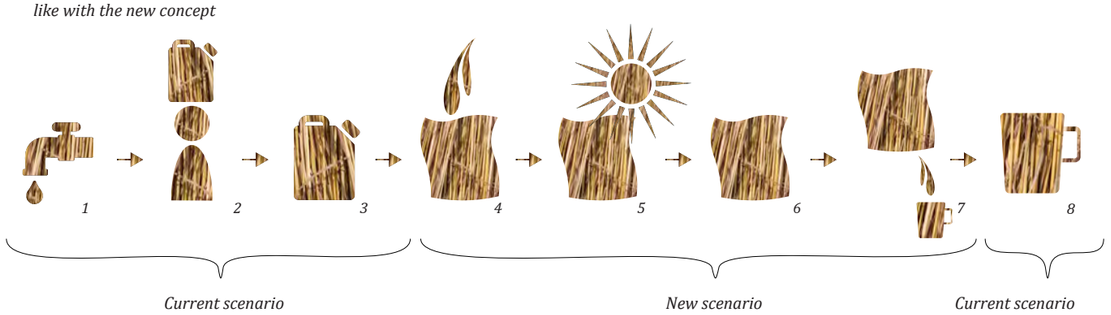
Product logo in monochrome

USER SCENARIOS

Figure 56: Scenario

A user scenario has been made showing the aim of the new water cycle when using the concept.

How the expected user scenario will look like with the new concept



Criteria

When the purifyed water is dispensed, it should not be re-contaminated from the dirt where the product has been placed for solar pasteurization

1. Fetching water from water source
2. Transport water to household
3. Store water
4. Pour water in the product
5. Place the product in the sun for solar pasteurization
6. Cool and store
7. Dispense water
8. The water is ready to be consumed

Llater in this chapter, documentation regarding step 4 - 7, will be elaborated with a focus on interactions, feedforward, feedback, and other details.

Figure 57, Figure 58, and Figure 59 shows examples of household in slum areas, rural villages and refugee settlements and were the product can be placed or not be placed. The places with a check mark are good places for solar pasteurization as no shadows will interferer the purification process. As seen on the pictures, the areas are very dirty. This requires the product being design so that the dirty surroundings can not contaminate the water when it has been purified.

Figure 55: Kibera

Rooftops of Kibera slum in Kenya

Figure 57: Rural village

An example of a house hold in rural villages

Figure 58: Slum

An example of a house hold in Malimila slum, Uganda

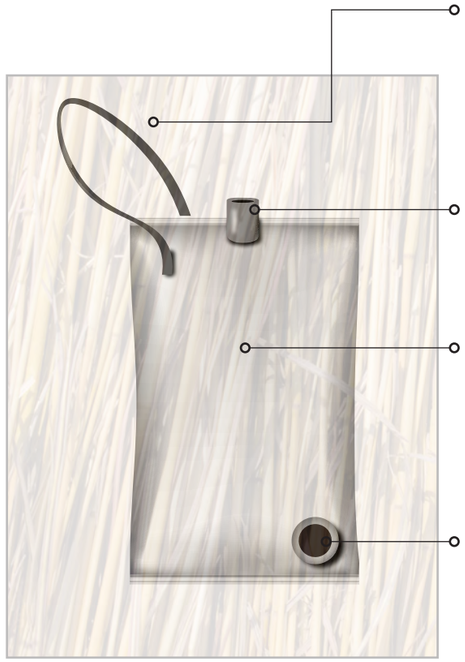
Figure 59:Refugee settlement

An example of a house hold in Adjumani refugee settlement

OVERALL PRODUCT ARCHITECTURE

As a foundation for further concept development, the overall product architecture has been illustrated.

The overall product architecture is seen in Figure 60. The architecture consists of four general elements that serve different functions: Transportation and placement, water entry, water container, and water exit. The form and shape used to show the overall product architecture is not in concordance to how the final concept will look like, but is just showing the basic elements. The four overall elements will be further investigated in this chapter. Off course other elements might appear as necessary later in the process.



Transportation and placement
- *Placement when being pasteurized*
- *Placement after pasteurization*
- *Placement when nor in use*
- *Transportation*

Water entry
- *Interaction*
- *Ease of use*
- *Opening/closing*

Water container
- *Size and shape*
- *Purification feedback*
- *How much water should be stored*
- *Plastic type*
- *Thickness*

Water exit
- *Interaction*
- *Ease of use*
- *Opening/closing*
- *Avoid recontamination*

Figure 60: Product architecture

The figure showing the concept's overall product architecture

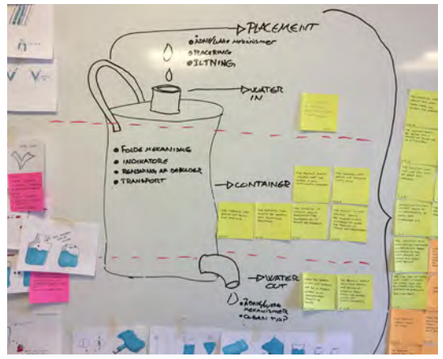


Figure 61: Product architecture

The product architecture drawn at the project team's group room (Figure 60 is a polished version)

IDEATION ON SHAPE

An ideation were made on the basic shape of the product. The ideation were made by sketches.

One of the main criteria of the shape, is that the volume should be transformed from a smaller volume to a bigger one when containing water. This is to avoid air being transported to Africa, as oversea shipping to Africa can be costly. According to NGOs, it would be easier for them to distribute small volume products.

Information about the ideation can be read in worksheet 54 - Ideation 04.04, but a simple description oF the groupings of ideas can be read here:

1. The principle of an ice cube bag. However, This was more of an addition to the bag and will therefore be saved for later integration.

2. Concepts have a plastic inlet and outlet, which works as container and protection for the plastic bag. And by putting one shell in the other, you have the whole container compressed.
But this will involve the hard plastic part being injection molded and afterward welded to the bag in 3D, which is an expensive process.

3. A semi rigid container with ridges for a controlled collapse. Origami inspiration.

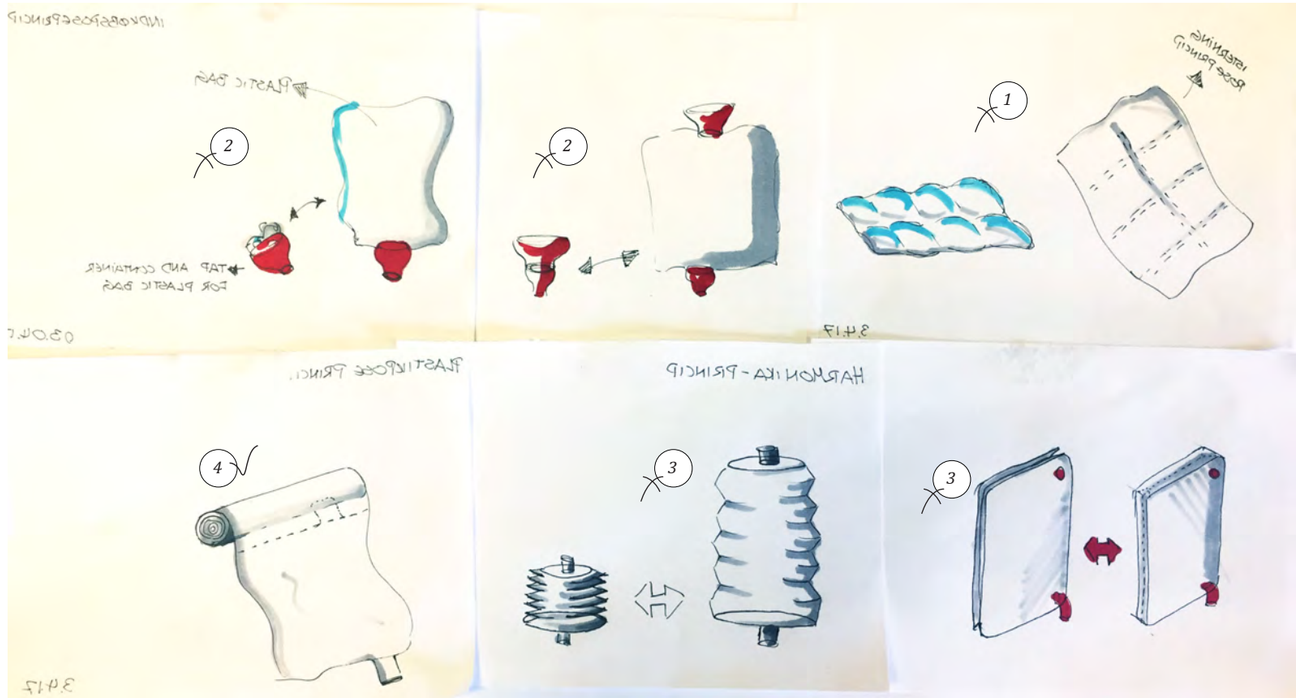
4. The bags are delivered as a roll. Afterward, the bag can be ripped off and filled with water.

SELECTION

Idea 8 is chosen for further development as it does not take up much space during transportation, and the manufacturing principle used is low.

Figure 62: Ideas

The different ideas for the shape of the product



TEST OF SHAPE

As idea 4, page 45, has been chosen for further development, prototypes have been made in two different shapes - A rectangular shape in 200x300mm and in 150x1000mm.

It is not possible to evaluate the shape based on sketches, therefore prototypes were made. To support the manufacturing process used for plastic film, rectangular shapes were chosen, and shapes of round, triangular etc. were delimited. The two rectangular shapes were in great contrast to each other according to the use.

SELECTION

The 200 x 300 mm sized bag is chosen for further development, as it was easiest to handle. (Worksheet 56a - Shape)

Figure 63: 200 x 300 mm

The pictures shows the bag being transported and lifted

200 x 300 mm

LIFTING

The plastic bag felt wobbly when lifted, but manageable.

TRANSPORTING

The plastic bag was transportable yet heavy.

Figure 64: 150 x 1000 mm

The pictures shows the bag being transported and lifted

150 x 1000 mm

The plastic bag were heavy to lift, but manageable. However, it was difficult to place correctly up high.

It was difficult to lift an place the bag on the shoulders due to the shape and weight, but when it was first placed it was easy to carry on the shoulders as the weight were evenly divided on the body. However, when not filled completely, the bag would not have water around the neck of the person, and dig into the skin, hurting.

TEST OF SIZE

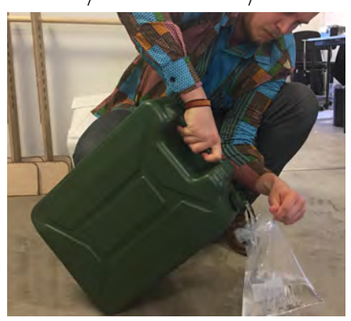
Plastic bags containing five different amounts of liters is tested according to different user scenarios.

Figure 65 shows the different amount of liters tested. From studies regarding trustworthiness, it is known that the users would like the product to purify a big amount of water, without compromising the ease of transportation and use (page 42). The plastic bags is tested in scenarios such as pouring water in the bag, holding the bag in one hand, and lifting the bag up high.

Figure 65:Plastic bags

The five plastic bags containing 2 - 10 litres of water

12 L plastic bag



4 L plastic bag

Figure 66: Pouring water

Water pourd from a jerrycan into a 12 litre bag and a 4 litre bag

The opening of the 12 L plastic bag is wide, making it hard to avoid the opening collapsing when pouring the water. Therefore, two hands are needed to control the plastic bag, which makes it hard to hold the jerrycan at the same time.

The 4 L plastic bag were easier to handle compared to the 12 liter bag. With one hand the user can control the small opening of the plastic bag. Rolling the opening, makes it more stable, and thereby even easier to handle.

Figure 67: Holding bags

Holding the five plastic bags in one hand

Figure 68: Lifting bags

Lifting the five plastic bags up high

Criteria

The product should contain 4 litres of water.

The force needed to hold the plastic bag as seen in Figure 67, is mainly located in the fingers. The bags containing 8 and 10 liters were heavy for the fingers to hold. When the bags were lifted up high, as seen onFigure 68, the bags containing 6 - 10 liters were really difficult to lift as they were heavy and wobbly - not making the user able to get a descend grip on the bags. The bags containing 2 and 4 liters could fit in the hands without feeling wobbly.

OUTPUT

A volume of 4 liters has been chosen, as this is the biggest amount of liters, one can handle without compromising the ease of transportation and use. The opening of the bag should consist of a rigid strip, to make the opening more stable when water is poured into the bag. (worksheet 56b - Prototyping and test of size and shape)

BLADDERS

The four liter plastic bag is prototyped with 1-3 bladders to investigate how it will influence the use and interaction.

The bladders were created by welding lines in the middle of the plastic bags. The plastic bags felt less wobbly with 2 and 3 bladders. As seen in Figure 70, a bag with 2 and 3 bladders were laying straight when held in one hand, compared to the on with one bladder, which was wobbly and bent downwards.

Another benefit of the bladders, is that it keeps the plastic bag more flat, decreasing the time needed for solar pasteurization and accelerated the water to heat up.

OUTPUT

The plastic bag should have three bladders as it makes it more stable and thereby easier to handle and hold. Another benefit is what it keeps the bag more flat. (Worksheet 66 - Bladders)

Figure 69: Plastic bags

The three plastic bags, containing four litres each, with 1 - 3 bladders

One bladder *Two bladders* *Three bladders*

Figure 70: Holding

The three plastic bags held in one hand

One bladder *Two bladders* *Three bladders*

Figure 71: Lifting

The three plastic bags lifted up high

One bladder *Two bladders* *Three bladders*

WATER ENTRY

Sketches has been made representing different ways of letting the water be poured into the product, and how the water entry can be opened and closed

Idea number 1, 2, and 3 all consist of the same principle, of folding the plastic around a rigid strap and fasten the ends of the strap to each other.

Idea number 4 uses the principle of a plastic zip, allowing the bag to be opened at 3/4 sides. This makes the product easy to clean. But as plastic zips often brake easily, the idea is deselected.

Idea number 5 uses the principle of a screw cap, which makes a secure and rigid closing and opening mechanism. However, the screw cap consists of two injection molded parts, which increases production costs. If the product needs cleaning, it can be difficult to use hands or tools to clean inside due to the small diameter of the water entry. Also, this solution does not support the decision of the product being a plastic roll (page 45).

Idea number 6 uses a mechanism where the water can be poured in, but the lid automatically closes when there is a water pressure from inside the bag. This solution minimizes the interaction with the opening. Similar to the screw cap, this solution requires injection molding, which increases production costs. Also cleaning will be difficult because of the small diameter of the opening.

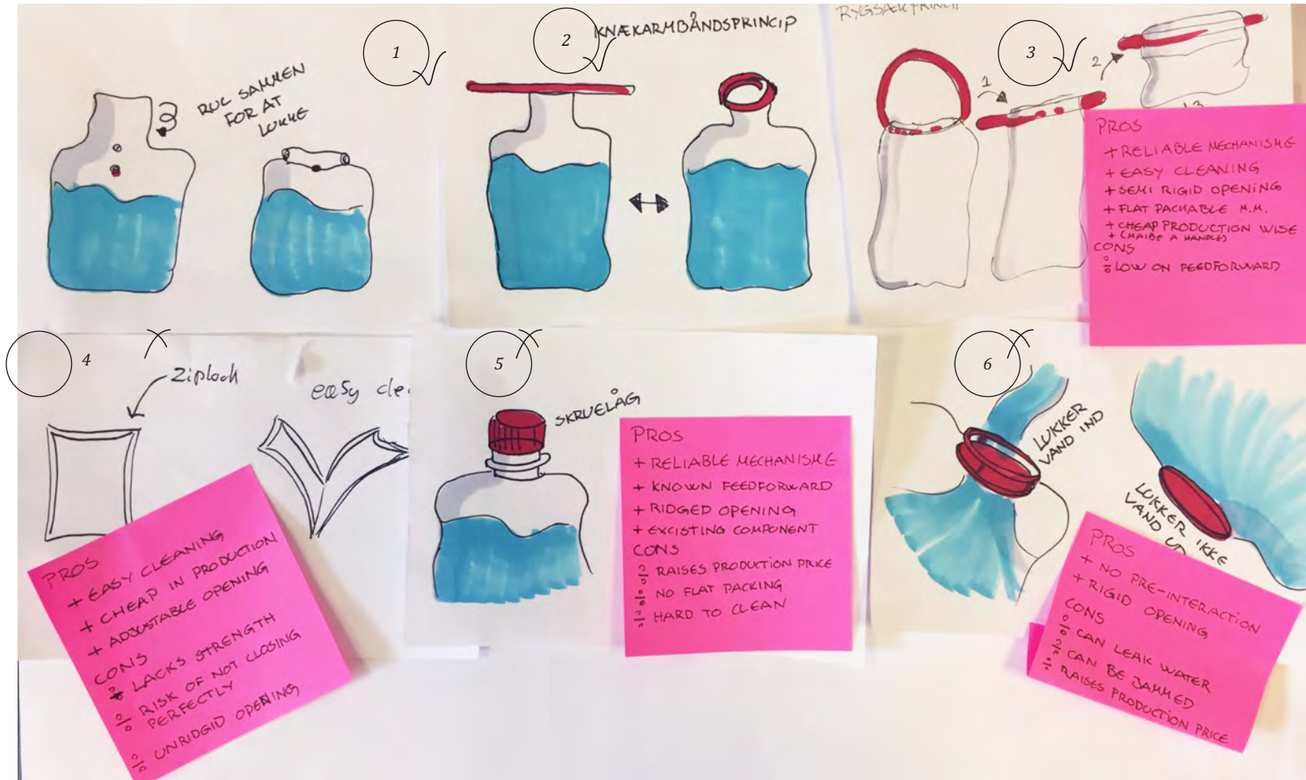
More pros and cons about the different ideas can be read on the pink post-its. More details about the activity can be read in worksheet 54 - Ideation 04.04.

OUTPUT

The product should use the opening and closing mechanism of idea 1, 2, and 3. As the solution do not cover how the two straps are being fastened, this has to be further investigated (see page 52) (Worksheet 54 - Ideation 04.04)

Figure 72: Ideation

Sketches of how the water entry should be opened and closed



LOCKING MECHANISM

The solution from the previous page consists of two straps that needs to be fastened to each other. Different locking mechanisms has been found, and one has been chosen.

Different locking mechanisms that are already used in different contexts is found and evaluated according to the price and the functionality if the locking mechanism is integrated into the product. The placement of the different locking mechanisms on the graph (Figure 73) is based on own assumptions.

The normal hook and loop mechanism has less improved functionalities compared to number 5, but is also cheaper. There will be a risk of it being jammed by sand, but it is assumed that it will happen after the product is no longer fit for purification.

Figure 73: Graph

The different locking mechanism placed in a graph according to price and functionality

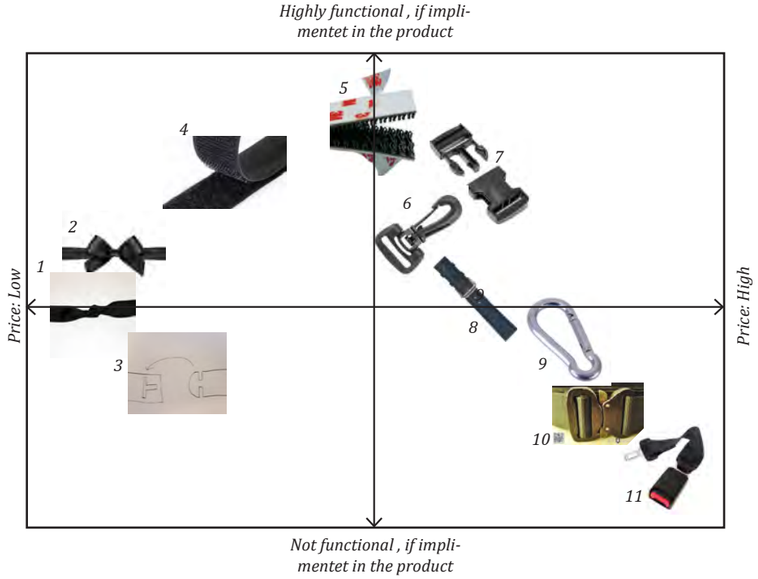
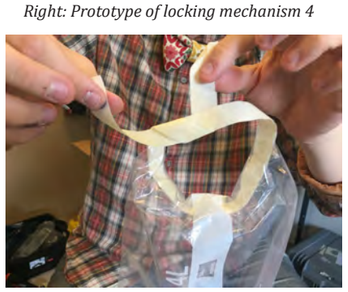


Figure 74:Prototypes

Left: Prototype of locking mechanism 1 and 2
Right: Prototype of locking mechanism 4



OUTPUT

Locking mechanism 4 is evaluated as the most promising solution according to price and functionality. The locking mechanisms have been prototyped. The hook and loop mechanism is chosen as it secures a safe locking each time, and you do not have to relay on the users being capable of tying the right knot. (Worksheet 71 - Closing mechanism).

TRANSPORTATION AND PLACEMENT

A benefit of the choosen water entry is that it can be made as a handle as well. General information about transportation and the placement of the product will be elaborated in this section.

Mentioned on page 52, some worries about the hook and loop getting jammed were described. To eliminate this worry, the hook and loop were rubbed in soil. Figure 77 shows the hook and loop filled with dirt after being rubbed in soil. Knocking a few times on the hook and loop removed the dirt, and the hooks and loops had not lost any of its functionalities.

TRANSPORTATION

The benefit of the water entry is that it creates a handle for transportation (Figure 76). Also, the product can be hung in the handle after purification, making it easier for the users to dispense the water.

PLACEMENT WHEN PURIFIED

As shown on page 43, the product can risk being placed on rough areas containing e.g. stones. The plastic film used should be rigid so that it do not puncture if placed on a stone.

Criteria
The product should be puncture resistant

STORED WHEN NOT IN USE

To give the product the best conditions, would be to let it air-dry if not used. If the product has to be stored over night or for a period of time, the plastic film can be rolled around the handle making the product less exposed to dust and dirt when stored, and it does not take up much space (see Figure 75).

Figure 75:Stored when not used

The product when it is rolled and secured by the handle

Figure 76:Transportation

The water entry creates a handle making the user able to transport the product in one hand

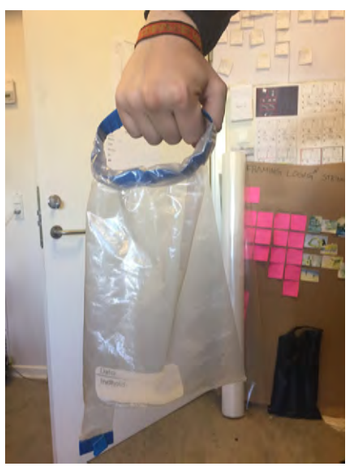


Figure 77: Hook and loops

Top left: The hook and loops after being rubbed in soil
Bottom left: The hook and loops after being knocked on

WATER EXIT

Different ideas of the water exist has been sketched, and evaluated according to criteria.

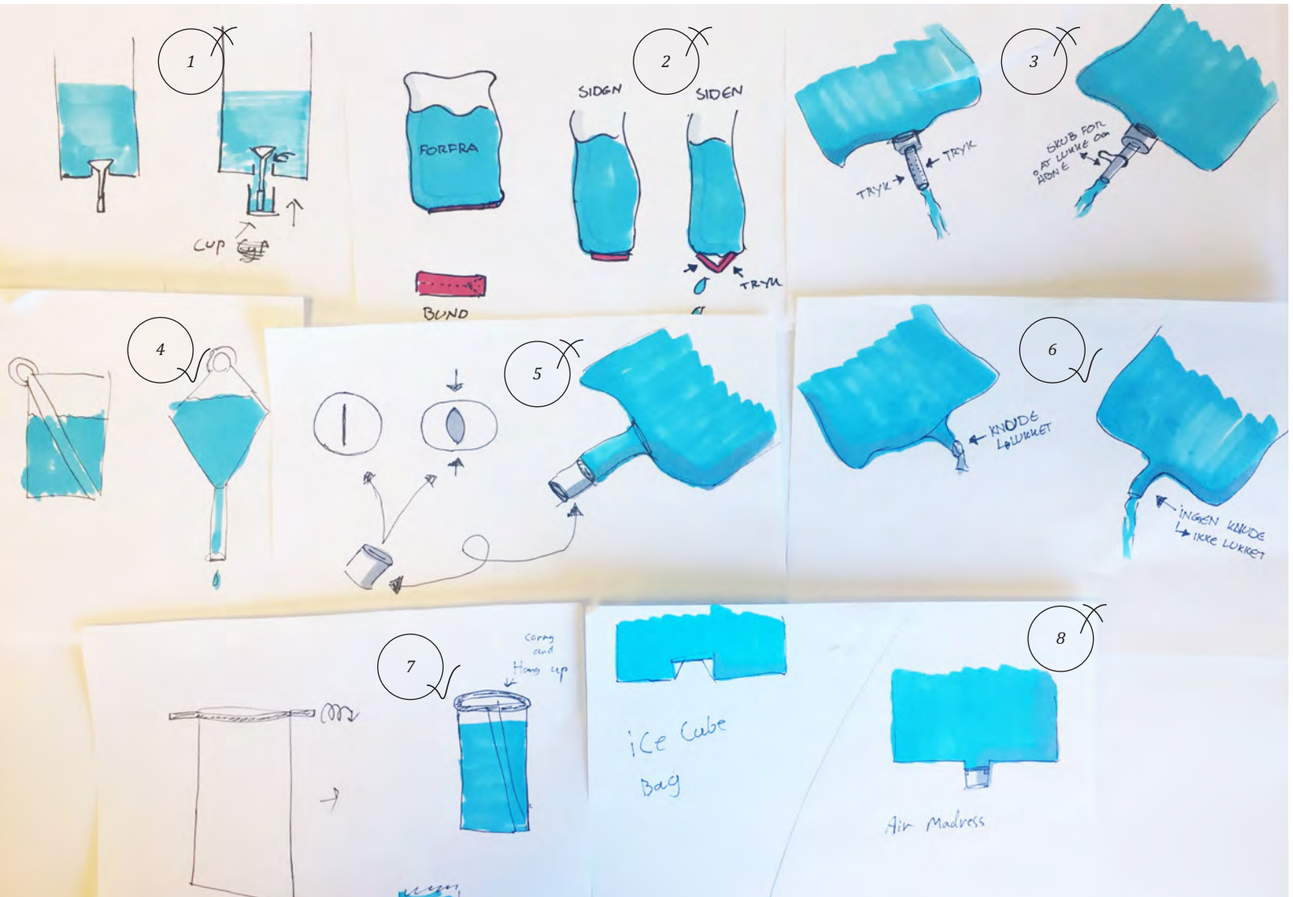
Idea number 1, 2, 3, 5, and 8 all consists of one or more injection molded parts, that will increase the products costs and it will take up more space during transportation. The ideas oppose the decision on that the product should be made in plastic film rolls.

Idea number 4, 6, and 7 consists of a snout were no injection molded parts is necessary, which decreases the production costs. The ideas support the decision on making the product as a plastic film-roll.

Criteria are that the users should not drink directly from the water exit, because of the human to human transmission risk of diseases. The snout's long (straw-look-a-like) form, can maybe tempt the users to drink directly of the product. However, the snout solutions will be prototyped and further investigated, to test functionalities, interactions, and how likely it is that the users will drink directly from the snout.
(Worksheet 54 - Ideation 04.04)

Figure 78: Sketches

Sketches of different ideas for water exits.



PROTOTYPING WATER EXITS

Three different prototypes of the placement of the snout is made and evaluated according to use and interaction

PLACEMENT OF THE SNOUT

To avoid the users placing their mouth on the snout, and drinking directly, prototypes regarding the placement of the snout has been made. The snout's closing is made with screw caps from cola bottles - This is just to secure the water for testing.

Prototype 1 has the snout placed up in the bag, making it difficult to drink directly from the snout, but it also becomes difficult to handle the snout with the hands.

Prototype 2 shows the snout placed in the middle of the bag. This solution makes an obstacle of empty the button of the product for water. A benefit is that the water exit is not in direct contact with the soil when the product is placed on the ground for solar pasteurization.

Prototype 3 shows the snout sticking out of the bag, making it easier to dispense with hands, but also invited the user to drink directly from the snout.

OUTPUT

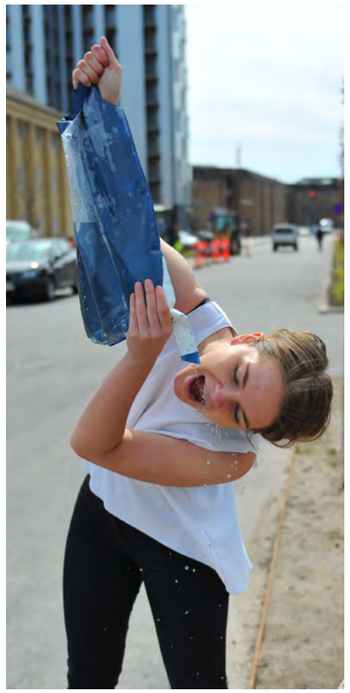
When prototyping and conducting act-it-outs, it became clear that avoiding the users drinking directly from the snout is not a matter of the placement and form of the snout. Having four liters of water, makes the product heavy enough to make it difficult to do so (see Figure 79). It is not possible to dictate how the users should interact with the product, so there will always be a risk that the users will drink directly from the snout.
The solution represented by prototype 3 is chosen because this is the easiest to handle and interact with.

Figure 80: Prototypes

Prototypes of the placement of the snout

Figure 79: Act-it-out

Trying to drink directly from the snout



PROTOTYPING WATER EXITS - OPEN/CLOSE

As it is decided that the snout should stick out in the bottom of the bag, a solution for how to open and close the snout, needs to be developed.

Four different prototypes representing four different opening and closing mechanisms has been made. The solutions are evaluated according to ease of use and the risk of the snout getting contaminated when placed on the ground for purification.

OUTPUT

The prototype representing open/close 4 (Figure 84) is chosen for further development as it has a decreased risk of contamination in the snout, and because this solution where the easiest to interact with. (worksheet 65 - Snout size and shape)

Figure 81: Open/close 1

The snout has two ribbons that can be tied together and thereby close the water exit. Tying and untying multiple times tears the ribbons. It is also difficult to secure that the knot is correctly tied

Figure 82: Open/close 2

The snout is tipped up, and when some kind of mechanism should keep the snout closed.
The water pressure would force water around the bend and out, and therefore the mechanism did not work.

Figure 83: Open/close 3

A reinforcement that also works as a kind of a hinge, makes it easier to secure the water exit for water not running out. The long snout can pick up dirt when the product is placed on the ground for purification.

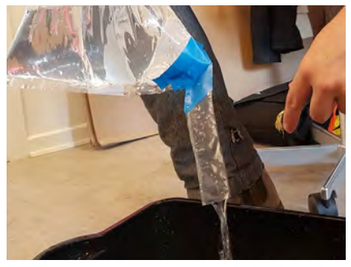


Figure 84: Open/close 4

The prototype is similar to the one above, the only difference is the length of the snout. The snout is made with a reinforcement, making it easier to control, and decreases the change that the snout will pick up dirt when the product is placed on the ground for purification.

KEEPING THE SNOUT CLOSED

The snout is closed by folding it up. A mechanism is needed to secure it that it will not unfold.
Hook and loop fastening, snap buttons, and build in hooks are evaluated, but in the end a simple slit in the reinforcement turned out to be sufficient.
The tip of the snout can be inserted into the slit and will secure that the snout does not fold itself out. (Worksheet 65 - Snout size and shape).

Figure 86: Slit

The pictures show how the snout is being closed using the slit. Left picture shows the water exit when it is opened and the right picture shows the water exit when it is closed

WATER FLOW

Different diameters of the snout have been made to evaluate different water flows. A diameter of 5 mm created a small stream of water, A diameter of 10 mm created a moderate stream of water (Worksheet 65 - Snout size and shape). With this water flow it was manageable to control the water when poured into a cup or container.

Figure 85: Water flow

The picture shows the chosen stream of water.

COLOR CHOICE

The colors used for the product is based upon functionalities, the symbolic of colors, and what colors the users prefer.

Figure 87: Solar pasteurization

Plastic bags containing 0,5L water with respectively a white and a black background being solar pasteurized

Figure 88: Color test

The colors used when conducting the color test

The test of solar pasteurization (page 35), showed that a black background accelerated the heat up time and achieved a higher peak temperature, thereby improves the solar pasteurization. Most users associated black with "dirty" (page 21). As the product is a cleaning/purification product, black will not represent the right value of the product.
Blue and white were associated with "happiness", "safety" and "clean", which is in concordance with the products values.
Using a blue color instead of black, will reflect all blue colors, but absorb all other colors and convert them to energy/heat, as seen in Figure 90. The blue color will absorb approximately 2/3, while black will absorb all colors and thereby generate more heat. The compromise of the blue color is tolerated, as a positive color association is obtained instead.

OUTPUT

A dark blue color absorbs more heat compared to a light blue color. Therefore a dark blue color is chosen as the products background color.

Because of the positive associations to white and light blue, the colors is chosen for user manuals and feedforwards.

Figure 89: Considered colors

The colors that is considered used for the product. Black is delimited.

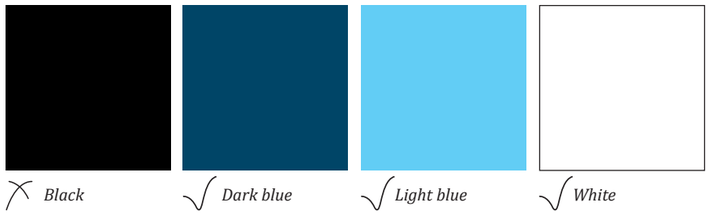
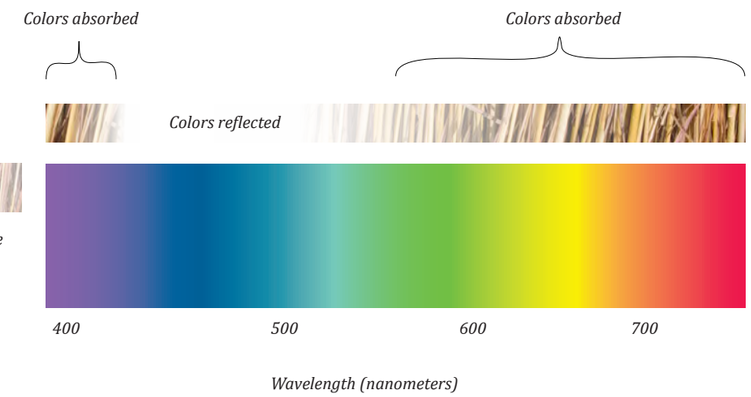


Figure 90: Color spectrum

The visible colors and the once that will be absorbed in the blue color.



FEEDFORWARD AND FEEDBACK

The general use of the product and the trustworthiness of the product, requires feedback, telling the users that the purification process is working as intended.

From conducting solar pasteurization with the locals in slum areas (page 38, it was clear that the users needed some kind of feedback telling them if the whether is suited for solar pasteurization or not.

METHYLENE BLUE INDICATER

When applied to water, the water becomes blue if bacteria is absent in the oxygen in the water. When the bacteria has been killed, the blue color will disappear.

UV ACTIVATED PIGMENT

The pigment is colorless, but when exposed to UV it will change color. The pigment is available in multiple color and can change at wanted UV level.

HEAT ACTIVATED PIGMENT

The pigment can change from one color to another when exposed to heat. The pigment can change colors at different temperatures.

DISCUSSION

The benefit of the methylene blue indicator is that it can actually give feedback when the water is safe to drink, compared to heat and UV activated pigment. However it is irreversible, and the color, therefore, needs to be applied to the water before every single solar pasteurization.
The heat and UV and heat activated pigment can only tell when the pasteurization process is running. As the most important factor is UV exposure, the UV activated pigment is choosen.
(Worksheet 59 - Indicator types, research on indicators.)

OUTPUT

UV activated pigment is chosen to be used to give the users feedback, that the purification process is "running".

Figure 91: Methylene indicator

A blue color that is present when bacteria are present in the water

Figure 93: UV activated pigment

The colors that is considered used for the product. Black is delimited.

Figure 92: Heat activated pigment

A pigment that changes color when exceeds a specific temperature

IMPLEMENTATION OF UV ACTIVATED PIGMENT

The UV activated pigment needs to be applyed to the product in a way so that it provides the user with a feedback that they can understand.

Four different ways of applying the UV activated pigment as visual feedback are suggested.

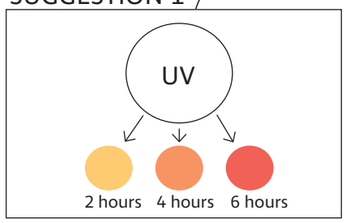
It is important that the user does not alienate themselves from how water pasteurization work, meaning that it is important that they become aware that it is the sun that is the source for purification so that they not overlook crucial risks.
For example if they put the product out for solar pasteurization, and the indicator shows 2 hours, because there is a high level of UV-index, and the user then ignorantly comes back 2 hours later and drink it, without noticing that the weather changed to overcast for the majority of the 2 hours, and therefore not finishing the solar pasteurization.
Therefore an “either or” solution is chosen (suggestion3 and 4). Only one option: 4 hours of pasteurization or not at all. The "fit for purification"-symbol should only appear if the UV index is high enough for the water to be pasteurized within the timeframe (including the later mentioned insuring factors).

From the “user manual test” on page 36, it is known that the users did not have any problem reading and understanding “4 hours”.

Figure 94: Feedback suggestions

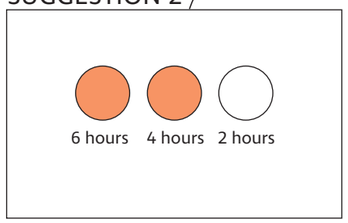
The four different suggestions for how the UV activated pigment should be applied as feedback

SUGGESTION 1



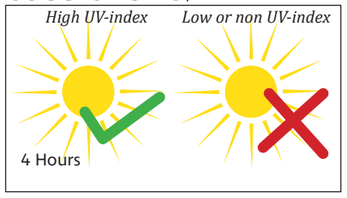
According to the level of the UV-index, the big circle will change colors. If the color of the circles is **yellow** the water should be pasteurized for 2 hours, 4 hours if **orange**, and 6 hours if **red**.

SUGGESTION 2



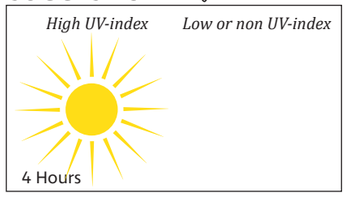
According to the level of the UV-index, between 0 and 3 circles will change color. If the UV-index is low, only the “6 hour circle” will change color and if the UV-index is high, all circles will change color and the water only need solar pasteurization for 2 hours.

SUGGESTION 3



Where suggestion one and two has four different appearances, a third suggestion only has to appearances: Fit for solar pasteurization or not fit for solar pasteurization, marked with a check mark or a X.

SUGGESTION 4



Similar to the third suggestion, this suggestion also have to appearances. If the UV index is fit for solar pasteurization, a sun marked with “4 hours” will appear. If the UV index is too low, no sun will appear.

INSURING FACTOR

Conducting solar pasteurization with users in slum areas (page 36), some users mistrusted the method. The general conclusion is the lack of visual feedback. The common purification method, boiling, is trusted by the locals. Boiling water gives a visual feedback to the users. The users also kept asking "so is it boiling now?" Because of the nonexisting feedback from the water bottle, and because boiling is their only referent point according to water purification.
Therefore The UV indicator needs to be the feedback telling the user that everything is working as it should.

OUTPUT

Figure 95: Boiling water

The boiling process that have both heat, fire, bobbles and steam to indicate that everything is working.

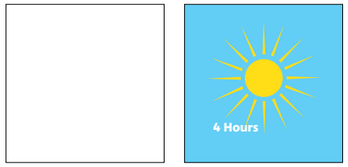
Suggestion 4 is chosen as it gives the biggest change in appearance. To help the users understand that it is the sun that is the source for purification, explanations on weather conditions will be integrated into the user manual (page 62).
(Worksheet 59 - Indicator types, research and ideation)

FRONT SIDE LAYOUT

The purification indicator chosen has to be integrated into the layout of the front side of the product,

Figure 96: Purification indictors

The purification indicator when it is exposed and unexposed to UV



No UV activation

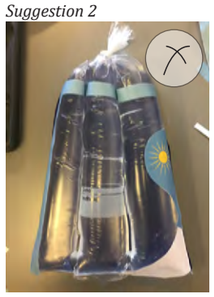
UV activation

To pinpoint that the water is being solar pasteurized (the engine is running), a color change from white to blue will supplement the appearance of the sun symbol. As blue is associated with “clean” and “happiness” (page 56), this color can add a positive association to the feedback when the water is being pasteurized.

Different suggestions for the layout of the front side of the product is made . More suggestions and further descriptions can be seen in worksheet 69 - Front side layout).

Suggestion 1

Suggestion 2



Suggestion 3

Suggestion 4

Suggestion 5

Figure 97: Layout suggestions

Examples of layout suggestions for the front side of the product

Inactive solar pasteurization mode

Active solar pasteurization mode

Figure 98: Selected layout

The selected front side layout when it is exposed and unexposed to UV.

OUTPUT

Suggestion 4 has been chosen, as the matching shape of the reinforced water exit and the indicator spot compliment the form of the bag. A line at the top indicates how much water should be filled in the bag. If the user pours more or less water into the bag, it will have no crucial consequences. If there is too much water in the bag, the bag can not be closed, and the user will realize that some of the water must be poured out again. If less water is poured into the bag, less water will be purified.

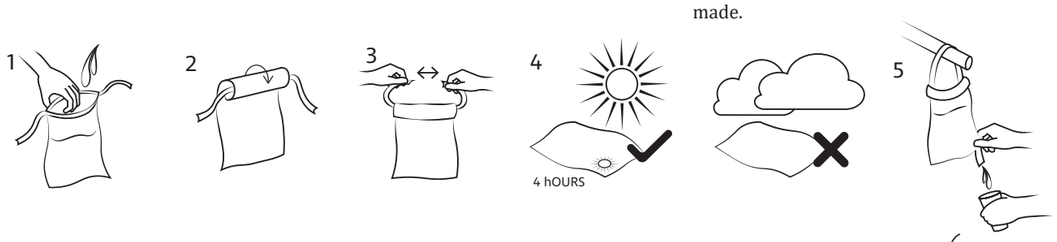
By having color changing pigment around the rim of the bag, the indicator can easily be checked even when the bag is laying on a rooftop.

When the water is being heated up to 30-40 degrees, the water will start to circulate, so the water under the colored spots will be changed during the solar pasteurization time.

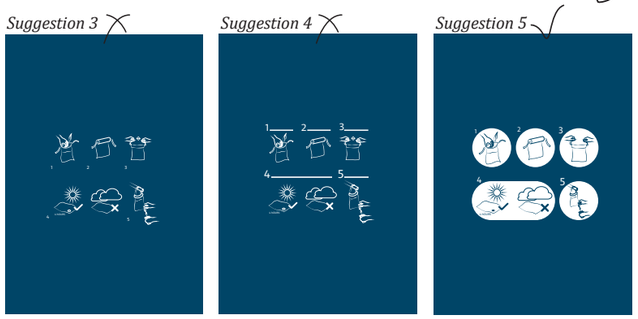
BACK SIDE LAYOUT

The back side of the product contains a user manual, that explains how the product should be used.

The user manual is designed based on the output from the test of user manuals in Malimila slum and Kibera slum (page 36). The result from the test was that the users perceive symbols literately, so the symbols have to look like it does in "reality". Including humans and part of humans in illustrations, makes it easier to understand. Check marks and X's is perceived as "go/good" and "don't". Different suggestions of the back side layout including the user manual has been made.



Suggestion 1 *Suggestion 2* *Suggestion 3* *Suggestion 4* *Suggestion 5*



Suggestion 5.1 *Suggestion 5.2* *Suggestion 5.3*

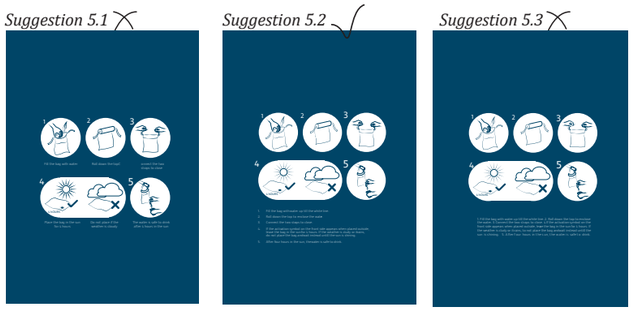


Figure 99: Back side layout

The different suggestions for the layout of the user manual and placement of additional text

Suggestion 5 is chosen, as the circles are in concordance with the rounded shapes on the front side layout (page 60). Also, the white circles separate each step, making it easier to read.

Whether or not adding text, explaining the user manual has been pondered. As East Africa consist of over a 100 different tripes with different languages, this can be difficult. However, many people speak and read English. If a user does not read English, there are spokes persons or other people familiar with English in slum areas and in refugee settlements. The user can approach these people if they need help. However, the text is not necessary to read, as the illustrations explain the same instructions as the text.
If the text is placed on each step of the user manual, the user might feel that it is crucial to know what the text means before using the product. Therefore, the text is placed away from the illustration, choosing suggestion 5.2.

OUTPUT

Suggestion 5 combined with text as bulled points underneath the illustrations is chosen (5.2).

More suggestions for the back side layout can be seen in worksheet 70 - Back side layout

Suggestion 1 *Suggestion 2* *Suggestion 3* *Suggestion 4* *Suggestion 5* *Suggestion 6*

Figure 100: Prototypes

Prototypes of six suggestions for the back-side layout including the user manual and text

Figure 101: Chosen user manual

Below sees the selected placement of the user manual and text, and how it will look when the bag is filled with water

As the product has three bladders, the back side surface will not be a plane surface when filled with water. To see how that will influence the back side layout, prototypes were made. Both text and illustrations are placed differently. Suggestion 6 is chosen, compiling all illustrations and texts in the center of the left bladder. This gave a fairly plane surface to read, without the text getting warped to much, even when filled (Worksheet 70 - Back side layout).

Figure 102: Reference render

A set of renderings of the current idea of the product were made to get feedback at the stutus seminar.
At this point the snout and final graphics were not established.
This gave valuable feedback for developing the final details.

CONCEPT SUMMARY

A prototype of how the concept looks like at the current stage is made, and the different elements of the concept is highlighted and refered back to relevent page sections.

The SolarSack uses the principle of solar pasteurization to produce four liters of clean water in four hours.
The concept is an environmental substitution to boiling water with charcoal.

The concept is a “purification machine” using the sun as fuel. The indicator changes appearance when the “machine is running”, telling the user that the purification process is running. The three bladders stabilize the bag so that it is easier to handle, and to keep the product flat when filled with water, which helps accelerate the solar pasteurization. Light blue, white, and dark blue is associated with "happiness", "clean" and "safety", and the dark blue accelerates heating up the water.

WHAT IS THE PRODUCT?

Is it a bag? Is it a container? - It is a hybrid between both. The concept integrates functions from both a water container and a plastic bag. The concept is based on the principles of a plastic bag as it is delivered in rolls and production wise uses the same principles. However, the development of the concept has increased functionalities and the physical feel of the concept. The concept is stable and rigid and thereby feels more like a container when one interacts with it.

Figure 103: What is it?

The figure shows that SolarSack is a hybrid of plastic bags and water containers

WHAT DOES IT?

It does the same as the most common purification method in East Africa - Boiling. As boiling does, SolarSack produces safe drinking water. The two methods use different purification activators (sun and charcoal) and different products (stove and SolarSack) that is activated by sun or charcoal. But the purification methods provides the same output - Safe drinking water.

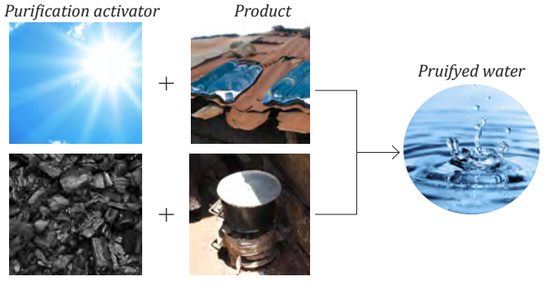


Figure 104: What does it?

Similarities in boiling water with a stove and solar pasteruization with SolarSack

CHAPTER SUMMARY

A short summarize of the activities described in this chapter is made. All criteria stated throughout this chapter is summarized. The current project frame is shown as well.

The principle of solar pasteurization is further investigated and testes. Semiotics and user manuals are tested together with locals in the slums of Uganda and Kenya. Ideations on concepts using solar pasteurization have been made. Investigations according to volume, shape, and size has been made according to the ease of use. The water exit and water entry have been developed according to low production costs and interactions. Feedforward and feedback are developed with the East African context and behavior in mind. Intelligent pigments have been investigated, and UV activated pigment is applied as feedback, telling the user that the "machine is running". A user manual is developed based on solar pasteurization tests in slum areas.

CRITERIA SUMMARY

Criteria
The product should have a dark colored background.

Criteria
The product should give feedback on when the water is in a purification process or when the purification process is done

Criteria
The product should be able to be placed on multiple surfaces

Criteria
The contaminated water should not enter the product the same place as the the exit for the pruifyed water

Criteria
When the purifyed water is dispensed, it should not be re-contaminated from the dirt where the product has been placed for solar pasteurization

Criteria
The product should be as big as possible without without comprimising the ease of transportation and use

Criteria
The product should contain 4 litres of water.

Criteria
The product should be puncture resistant

CURRENT PROJECT FRAME

What? + **How?** = **Value (experience)**

SolarSack

Solar pasteurization

Making the users feel safe while purify and drink water

CONCEPT DETAILING

CHAPTER 2

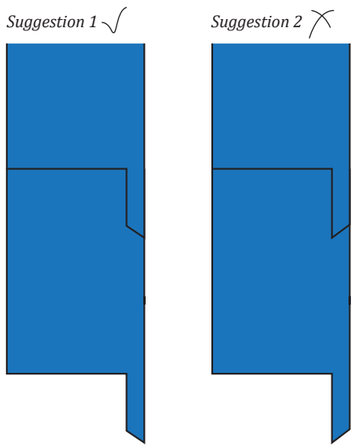
The chapter covers details about the concept with a focus on material, construction, and manufacturing. A business model and a business case is developing, which accounts for e.g. implementation and market position. Financial profit from a business point of view is made, but also a financial profit for the users.

CONSTRUCTION DETAIL

When building the final prototype, from the design specified in the concept development, some small problem surfaced, and for that some minor structural addition were added.

Figure 106: Snout

The figure shows the correlation between the snout's pointy end and the top of the next bag in the roll.



SNOUT END

When testing the closing mechanism, it was hard to get the snout through the slit that secures the closing.
The snout is therefore designed to be pointy, so it is easier to insert in the slit.
The snout can be angled to be pointy at the right or the left side.
The solution with the pointy end to the right is chosen, because it will work with the cut out on the next bag.

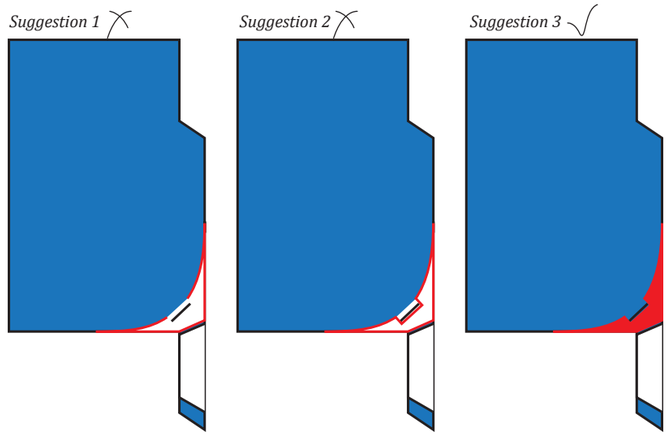
WELDING REINFORCEMENTS

The prototype was first made having a weld running along the outer edge of the reinforcement. This worked, but with the cut out for the slit, water and dirt can be collected underneath the reinforcement, and grow bacteria that will get in contact with the snout when inserted (suggestion 1).
The welding should be in concordance with suggestion 2 and 3, so no dirt can get under the reinforcement.

To strengthen the reinforcement suggestion, 3 is chosen.

Figure 105: Welding area

The figure shows the welding areas for the reinforcements.
The red color indicates the welding area.



LOCKING RIBBON LENGTH

The length of the ribbon was initially though to have the hook and loop fastened right by the side of the bag.
When testing this, with a filled bag of water, it would curl the bag too much, making it unable to lie flat, giving an uneven exposure to the sun (suggestion 1).
Therefore, the ribbon is extended to have 25 mm of ribbon before the hook and loop (suggestion 2).

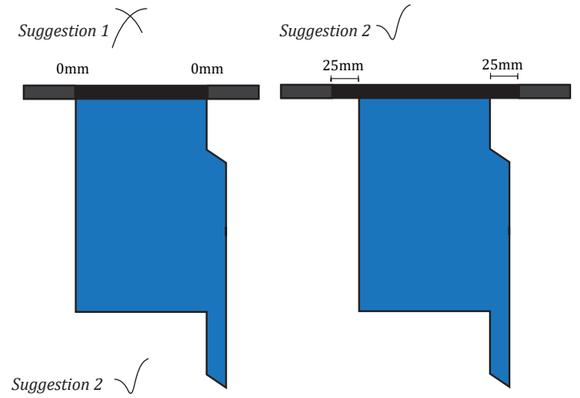


Figure 107: Ribbon length

Left picture showing how the bags curls up when the straps are closed and right picture showing that the 25mm spacing before the hook and loop patch insures that it can lay flat.

CORNERS

To avoid dirt from water being collected in the lower left corner of the bag, suggestions for welding of the corner is made.
Having a filled in the corner will decrease the change of dirt and bacterial growth.
Suggestion 3 is chosen as it has a filled corner, but no extra cutting process is needed.

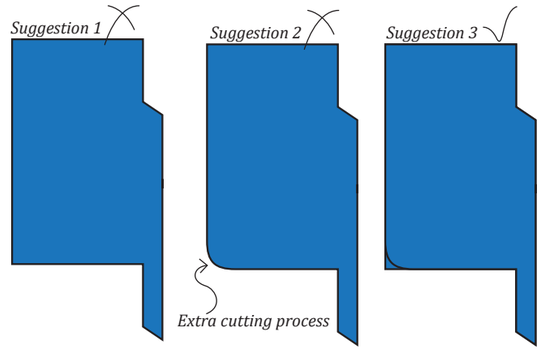


Figure 108: Corners

From left to right: original sharp corner, rounded corner with the left over removed, rounded corner with no material removed

HOOK AND LOOP MATERIAL

Because PE is oil based and especially good at keeping its surroundings from affecting it, it is nearly impossible to glue on. So attaching the Hook and loop fastener, which is commonly made of nylon which can not be welded, is nearly impossible.
The prototype was made by sewing it on, but this was evaluated to be unfit for the final production, due to the lengthy process and the possibility of contaminant build-up in the threads.
With some research it is found that the hook and loop fastener can be made in PE, making thermo welding possible.

Figure 109: Strap material

Showing the hook and loop fastener being attached with sewing.

MATERIAL REQUIREMENTS

Working in such a harsh environment, with prolonged exposure to sunlight combined with getting thrown on the ground and other rough surfaces, the material choice is important to make sure that the pasteurization process is not compromised.

MATERIAL REQUIREMENTS

When choosing materials, the most important factor is not to compromise the effect of the pasteurization process. If the material gets "tired" over time, and thereby cracks or get opaque decreasing the solar pasteurization effect, risking the water being contaminated. The material must therefore not hinder the pasteurization process over time. It is important that the product cracks or in another way brakes, before the material starts decreasing the effect of solar pasteurization.

The second focus is that the material can not ham the user with chemicals or toxics, which is why the pigment should either be separated from the water, or nontoxic.

If the material is burned, it can not emit any toxics.

The plastic type should also be at least as good as the PET bottle, to either have the process be as good or better than the original SODIS.

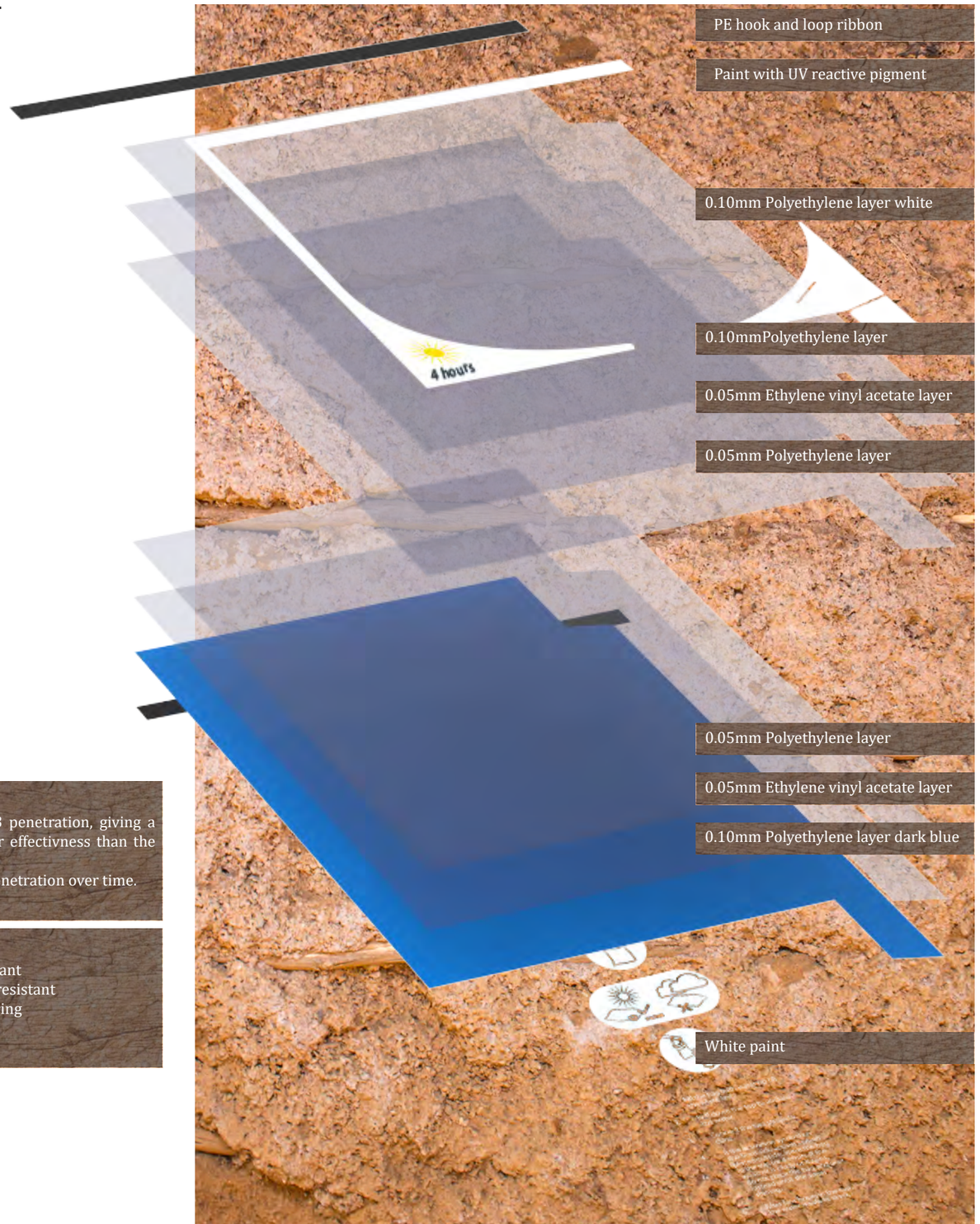
MATERIAL REQUIREMENTS

PAINT
Printable on plastic
UV resilient
One color
Not contaminate the water

FRONT
UV-A and UV-B penetration, giving a equal or higher effectivness than the PET bottle
Maintain UV-penetration over time.

UV REACTIVE PAINT
Last for at least 60 pasteruization cycles.
Change color at UV intensity of 400 W/m² Page 74
Change color in less than 5 seconds

BACK
Puncture resistant
Wear and tear resistant
Dark blue coloring



MATERIAL CHOICE

The chose of materials are based on the requirement.

PAINT
Specified by the manufacturer according to the listed requirements.

THE PLASTIC
Reseach on materials fit for solar pasteurization is found, and this knowledge has been applied to SolarSack.

PET:
Polyethylene terephthalate, PET, used for water bottles, is found to be highly impractical for the solar pasteurisation. It absorbs nearly all UV-B and a large amount of the UV-A, and degrades over time, getting opaque and turning brittle.

PE:
Polyethylene on the other hand absorbs a larger amount of the UV-A, but lets in a higher amount of UV-B which accelerated the Pasteurization process. The downside of PE is that it discolors already after 1-2 days in the sun, and it gets brittle and breaks.

However, when PE is laminated around a layer of ethylene vinyl acetate, EVA, it retain almost all the good penetration features, and gain the UV resilience. This resilience also keeps the plastic from getting brittle and breaking, even with exposure over 5 months (Worksheet 68 - Material).

Figure 112: Parts

A exploded view of the different parts that the SolarSack is made of.

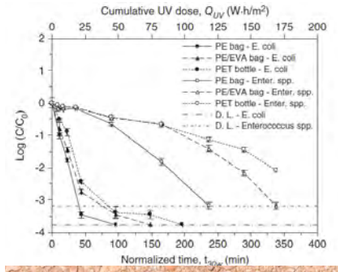


Figure 110: E. Coli reduction

The graph shows the reduction in E. coli over time in containers of various materials.
(Gutiérrez-Alfaro et al., 2016)

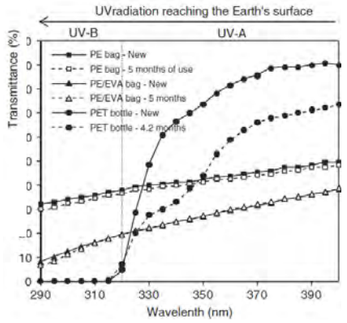


Figure 111: Light penetration

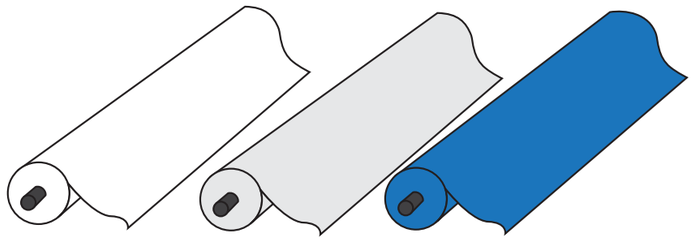
The penetration of light at different spectrum through different materials.
It also shows the loss in effectiveness due to prolonged sun exposure.
(Gutiérrez-Alfaro et al., 2016)

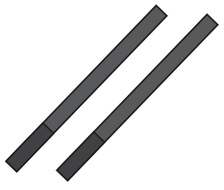
MANUFACTURING

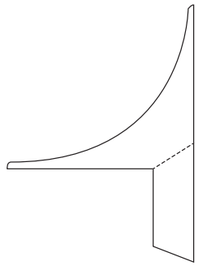
Producing the SolarSack is not like producing a traditional plastic bag, but it uses processes that are known from producing plastic bags, making it possible to produce it at factories that allready have equiptment for traditional plastic bags.

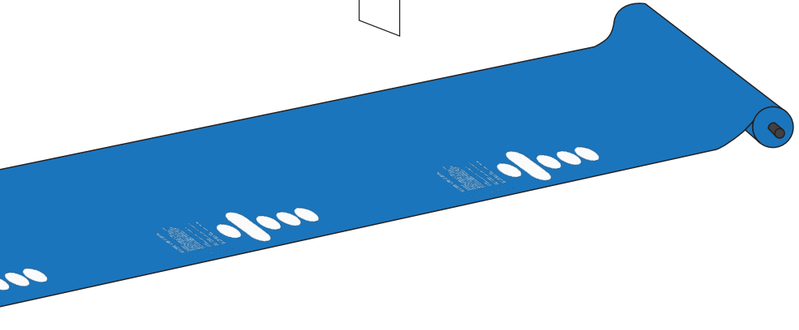
Figure 113: Production steps

Showing material bought and the production steps required to make the SolarSack.









TOLERANCES
The SolarSack is designed from the ground up to be cheap to produce, and the whole product can accept a tolerance of 0,5 mm.

FOILS
For the product 3 different plastic foils are used.
One white PE foil, which is 0.1 mm thick that is used for the reinforcement for the closing mechanism. the other foil is described on page 73.

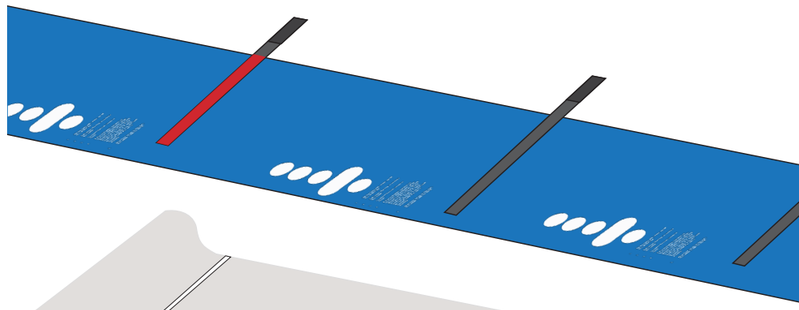
PAINTS
Three paints are used.
A white paint for printing the instruction on the back.
And for the front, a white to blue photochromatic paint is used for the borders, and a white to yellow for the sun symbol.

HOOK AND LOOP STRAPS
The female hook and loop straps are bought pre made.
They have 50mm of the hook and loop, followed by 295mm of only the strap, that will get attached to the rim of the bag.
Made in PE to enable heat welding.

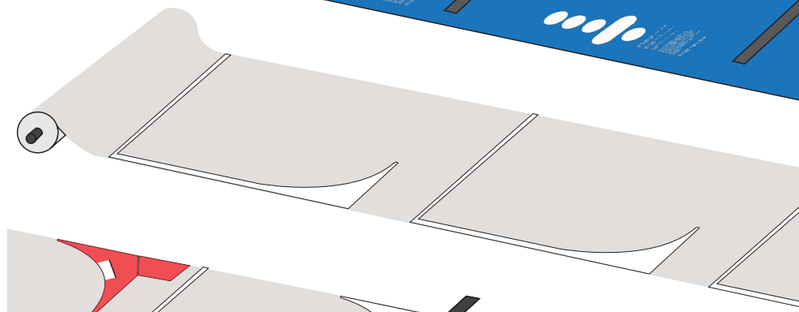
REINFORCEMENTS
As the first part of the production, the reinforcement will be punched from the white foil.
The bend between the two pieces are only perforated, so they are attached together in production.

BACKSIDE PAINT
The instruction manual is printed on the back in twhite paint.

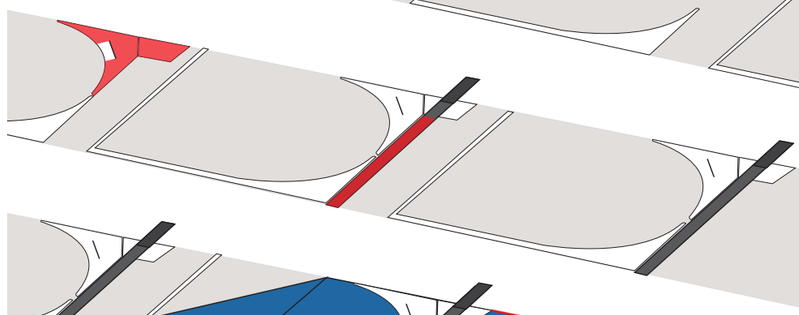
STRAP ATTACHMENT
The hook and loop strap is placed and simultaneously welded onto the outside of the blue foil.
Weld area is shown in red.



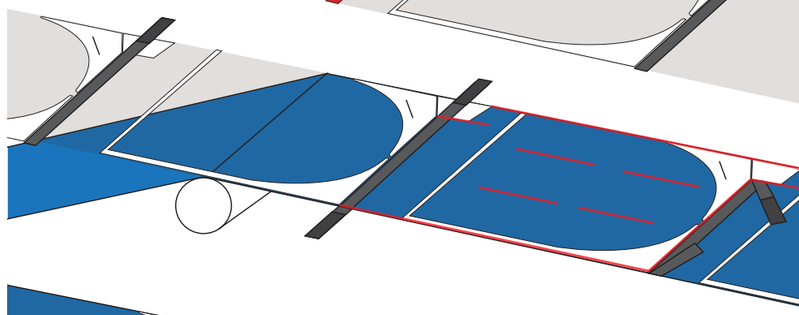
FRONT PAINT
The photochromatic paint is painted on the outside of the clear foil.



REINFORCEMENTS AND STRAP ATTACHMENT
The reinforcement, previously made, is placed and heat welded on.
Afterward, the hook and loop strap is placed and welded on.
Weld areas is shown in red.

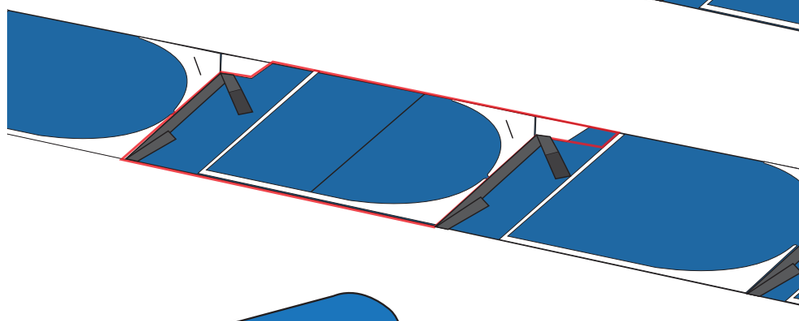


JOINING THE FOILS
The two rolls of foil are now joined and welded together. Note that the blue foil is flipped over.
Weld area is shown in red.

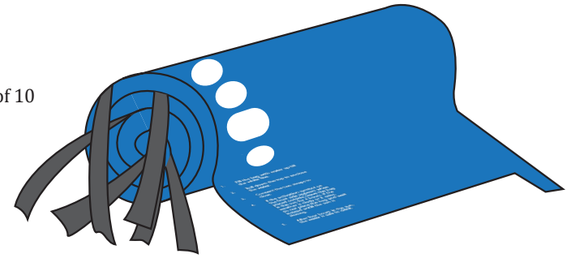


FOLDING THE STRAPS IN
The two straps now have to be folded in, to make space for the cuts in the next step.

PUNCHING THE BAG
The bags can now be punched to shape.
Both removing leftover from the sides, and cutting the perforated cut between the bags so that they can be zipped off later.



ROLLED AND BOXED
The bag can now be rolled into rolls of 10 and boxed, ready for shipping.



PURIFICATION DETAILS

The sun intensity is crucial for the process, and to make sure the SolarSack is placed in sufficient sunlight, the indicator has to switch color at the right intensity, so that the water is sufficiently pasteurized after the recommended time.

UV SPECTRUM

As described in worksheet 68 - material, the wavelength of the light exposure is important. This is not only affected by the material in the bag, but also atmospheric condition e.g. cloud, and depending on the season.

INTENSITY

Calculating a precise intensity for where the process doesn't work is impossible, and have to be a rough estimate, according to out tests.
The test conducted in Kenya, in partly clouded weather shows that even after 60 minutes there was a sufficient reduction in bacteria.
Partly clouded weather corresponds to 400 W/m2, and fully sunny is 700 W/m2 (Luzi et al. 2016)

SYNERGY

Research shows that temperature has a large influence on the process. This effect is especially influential over 45 celsius where the pasteurization rate accelerates exponentially, and at 50 celsius the process is 3 times as effective.
(Luzi et al. 2016)

SAFETY

To account for the varing factors, the recommended exposure time is set to 4 hours, to incorporate the factors describe in the model to the right.

Start
The user fill the bag with the contaminated water, and places it in the sun

1 hour
During this time the temperature is raised to 40-50 celsius and the bacteria and virus are killed by the UV-A and UV-B. Approximately 1 hour.

4 hours
Even though at optimal conditions, the bacteria is killed within one hour, the SolarSack should be placed in the sun for four hours (according to front side feedback, page 62). Three extra hours are a safety facter, as other parameters might influence the solar pasteurization negativily.

Stop
The user can now safely consume the water

Temperature
Because of factors as the wind, or laying on a cold surface the temperature might never reach a higher temperature than 40 celsius.

Turbidity
Water from e.g. a lake can have dirt or organic matter in it, that will block the UV from penetrating the water and pasteurizing the full amount of water.

Scratched foil
The outside of the SolarSack can be scratched so that it is opaque, blocking parts of the UV light.

UV spectrum
Because of seasonal and atmospheric conditions they spectrum might not be optimal for the process.

Weather change
During the exposure time the weather can change to either have less sun, or more wind.

WHEN TO USE SOLARSACK

As the solar pasteruarization is very depended on the sun, statistics is found regardign sun hours.

Figure 117, shows the average daily sun hours in Nairobi, Kenya. SolarSack will however still be able to work in mist or cloudy wether if enough of the UV-A and UV-B can penetrate the clouds. The graph shows that the product can be used every month of the yeat. However, the months with the best preconditions for solar pasteurization are October to April. If it is cloudy or raining, and the solar indicator does not change color, the user will boil the water. Conducting tests in Malimila and Kibera, the participant were asked what they would do if it were cloudy or raining, and they understood that they need to boil the water instead (Worksheet 42 - Test of sodis in malimila slum 1) (Worksheet 43 - Test of sodis in malimila slum 2) (Worksheet 52 - Kibera slum).

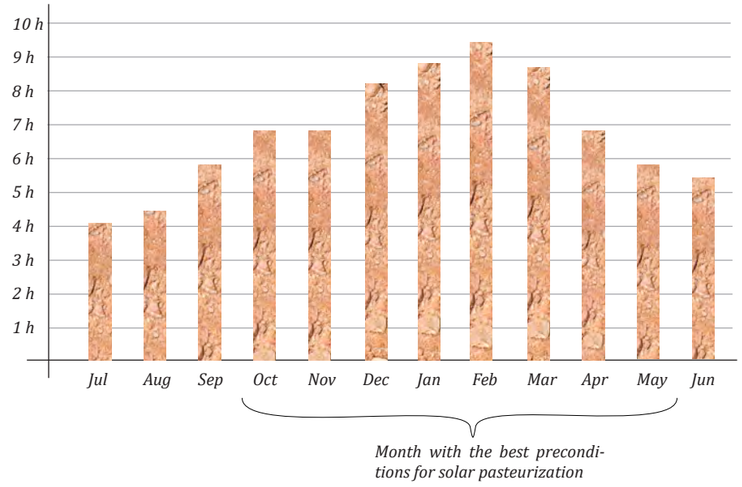


Figure 114: Sun hours

The grapgh shows the average daily sun hours in each month in Nairobi, Kenya

Figure 115:UV-activated pigment

Left: Pigment when not exposed to the sun.
Right: Pigment when exposed to the sun.

Reading about UV activated pigments, makes one curios. UV pigment is bought for tests. The pigment changed from almost colorless to a strong light blue and yellow when exposed to the spring sun in Denmark.

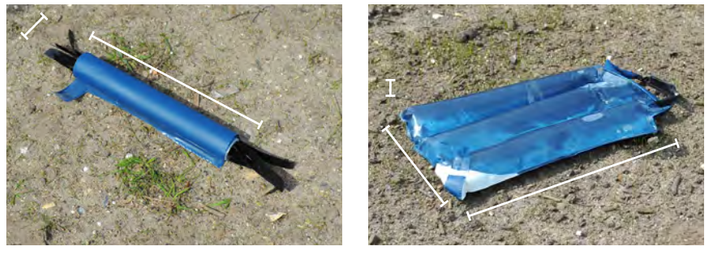
TRANSPORTATION

An estimation of the shipping costs is made, as a container from China to East Africa is not unexpensive, and is therefore needed to be included in the product costs.

A shipping container from China to Africa is approximately 50.000 DKK. Having the product take up as little space as possible during transportation has therefore been integrated. SolarSacks is produced and transported as rolls of 10 bags. A 20 ft container can fit about 180.000 SolarSacks. This volume will increase to 4000cm3 per bag when filled with water. (Appendix: Business case).

Figure 116:Size compareson

The great difference in a rool of 10 bang, and a full bag, achived by having a collapsable product.



Price for 20 ft container from China to East Africa	*50.000 DKK*
Cubic metres in a 20 ft container	*33 m^3*
Cubic meters on a roll of 10 SolarSacks	*0,00147 m^3*
Amount of rolls in 1 cubic metre	*544*
Amount of rolls in a 20 ft container	*17.959*
Amount of bags in a container	*179.592*
Shipping price for 1 SolarSack	***0,28 DKK***

Figure 117: Expected route

The route from production in China toKenya, where is distributed.

PRODUCTION COST

Production cost is estimated according to mass production.

Production costs are based on supervision with lecture Erik Appel Jensen, and later confirmed by Jacob Petersen from Coloplast. Because of relatively cheap production methods, it is assumed that the material price is going to be the biggest costs. SolarSack, is primarily made of PE, and the material cost for PE is approximately 8 DKK/kg. This gives a material cost of about 0,5 DKK per product. As material costs are assumed to be the most expensive post, factor 1,8 is multiplied by the material cost, to estimate the production cost. However, this is only the production cost of producing the bag from plastic film inclusive weldings. Furthermore, the product consists of paint and hook and loops ribbon. Adding the shipping costs will result in a total production cost of 1,65 DKK per product. (Appendix: Business case).

Amount of SolarSacks		*1*	*500.000*
Volume of SolarSack	*cm3*	*64,8*	*34.400.000*
Density PE	*g/cm3*	*0,93*	*0,93*
Weight	*g*	*60,26*	*30.132.000*
Material costs		*0,48 DKK*	*257.796 DKK*
Production costs	*Factor 0,8,*	*0,39 DKK*	*464.032 DKK*
Paint		*0,20*	*100.000 DKK*
Hook and loop		*0,30*	*150.000 DKK*
Shipping costs		*0,28 DKK*	*139.204 DKK*
Total production cost		***1,65 DKK***	***1.064.161 DKK***

Figure 118:Production

A typical set og rolls used in platic bag production.

MARKET POTENTIAL

The potential market is described in this section togehter with delimitation of markets. The different markets/contexts requires different business approaches.

Field studies in East Africa showed that there is three different contexts that primarily lack access to safe drinking water:

- Slum areas
- Rural villages
- Refugee camp and settlement

The population in rural villages is very spread and the money flow is very low. Compared to slum areas, were the money flow is higher and more people live collectively in the slum areas. The main reason is that the slum areas is a part of main cities, and they have access to other job opportunities such as boda boda riders (a taxi scooter) and security guards. The market of slum areas is easier to approach. The money flow in refugee camps is almost not present. They depend on resources from UN. Approaching the different contexts requires different business models. As the market potential is highest in Refugee camps and slum areas, these contexts are approached.

Figure 119:Contexts

The three different contexts found during field studies in East Africa

√ ***Refugee camps/settlement***
- *Limited money flow*
- *Depending on NGOs*
- *Community living collectively*

✗ ***Rural villages***
- *Limited money flow*
- *No help from NGOs*
- *Spread out in smaller communities*

√ ***Slum areas***
- *Present money flow*
- *No help from NGOs*
- *Community living collectively*

Three biggest refugee camps in East Africa
- *Kakuma: 164.000 people*
- *Dadaab: 250.000 people*
- *Adjumani: 222.000 people*

People living in slum areas
- *Tanzania: 6.5 million people*
- *Kenya: 4.4 million people*
- *Uganda: 2.5 million people*

Targeting slum areas and refugee camps in East Africa give more than 14 million potential users. Approaching refugee camps, one needs to approach NGOs and UN, as they are the buyers of the products.

Small shops and stands are everywhere in slum areas selling everyday products such as jerrycans, stoves, charcoal etc. SolarSack will be sold through local retailers in slum areas. Distribution centers will be established near slum areas, where the retailers can buy SolarSack for resale. This will encourage locals to create small business of selling.

RETAILERS

The market of slum areas is apprached by local retailers. This will create small business and encourage local growth.

RETAILERS

Taking small loans is available to people in developing countries. Companies like KIVA, provides small loans for people starting up a small business (e.g. selling charcoal or sew clothe). The loans are without interest and a repayment rate of 97%. To encourage locals to start up small business Locals can become a retailer of SolarSack, but instead of paying the retail price before resail the SolarSacks, they can be offered to pay back the retail price after they have sold their batch of SolarSack. People that can not afford to buy a batch, can now get a chance to start up a small business anyway. To give the retailers a feeling of being a part of an organization they will participate in a one-day teaching program to learn about solar pasteurization and basic sales technique., they will get t-shirts or other branding materials. From studies in Ngora, it was clear that the locals took pride in being a part of an organization (page 17).

RISK

There is a risk that they will not pay back the retail price after they sold the batch, and just "disappear". But similar services like KIVA, has a huge repayment rate, which is hoped to be the same for the SolarSack retail service.

Figure 120: Retail service

An overview of the retail service

Retailer gets an one day teaching program about solar pasteurization and basic sales technique → *Hand out of SolarSacks and marketing material (t-shirts) to the retailer* → *The retailer sells SolarSacks to the locals* → *The retailer pays back the retail price to the distribution center and gets a new batch of SolarSacks*

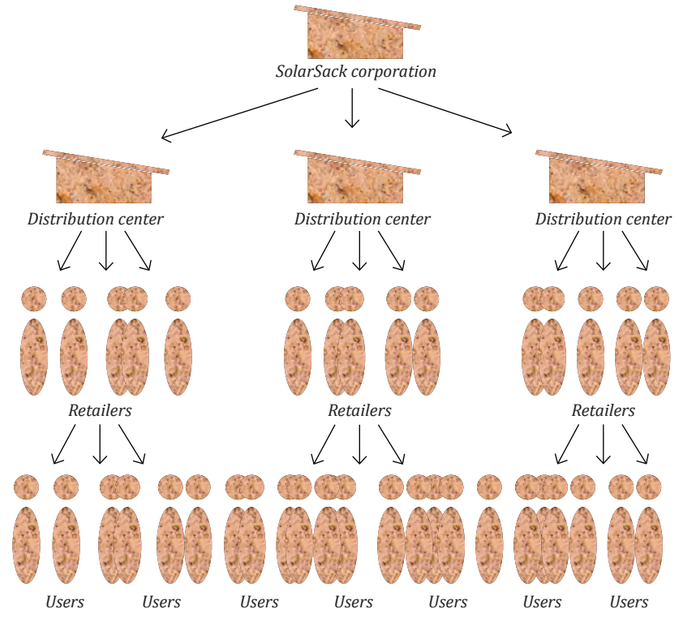


Figure 121: Distribution

The flow of SolarSack, from SolarSacks to the end users.

BUSINESS MODEL

Two business models has been made targeting refugee camps/NGOs and slum areas.

As the product targets refugee camps and slum areas, two different business models are made as the two customer segments needs to be approached differently. However, the two business model is made as similar as possible, not to have too many extra elements in the different building blocks. Looking at the building blocks: Partners, key activities, and key resources, the two business models is alike. The main difference is that the SolarSacks is resold by retailers in slum areas, where distributions centers need to be established. Looking towards refugee camps, SolarSacks is sold directly to NGO's and UN. The business model for refugee camps is assumed to be somehow unstable, as one can not dictate what kind of products NGOs wants to buy, and is either a large sale or no sale. It is, therefore, important to secure a stable business within slum areas in case that no sales to NGOs will happen. This will be elaborated on page 88.
(Worksheet 64 - Business model canvas)

Figure 122: Business model 1

The business model that targets slum areas

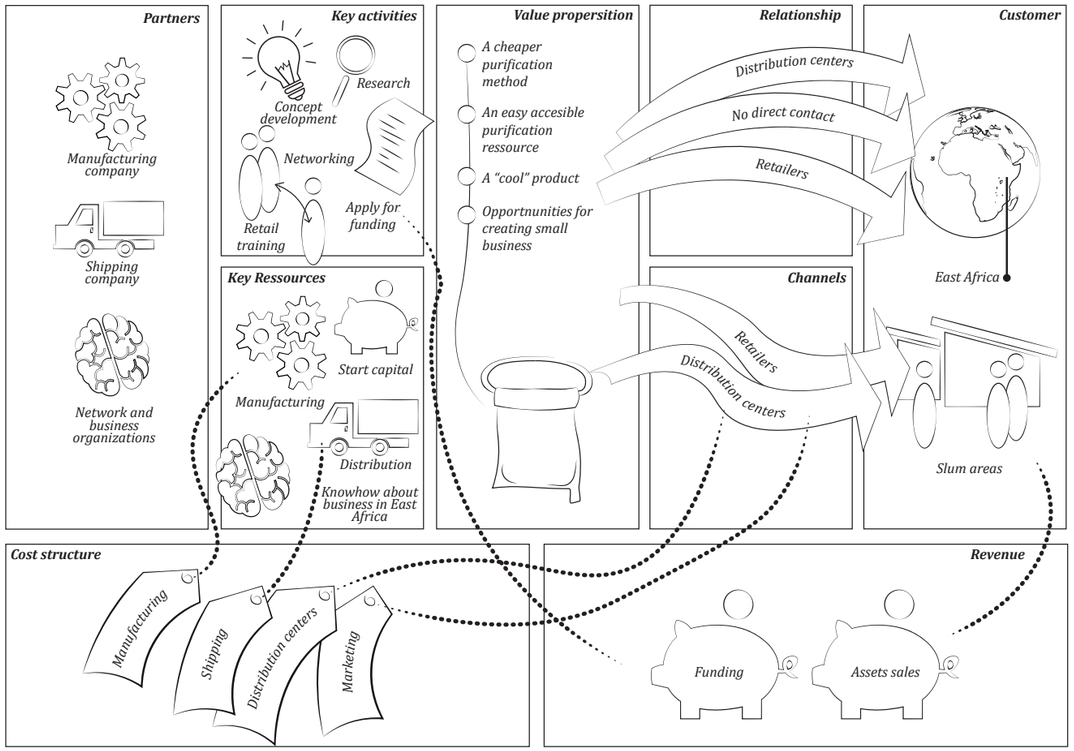
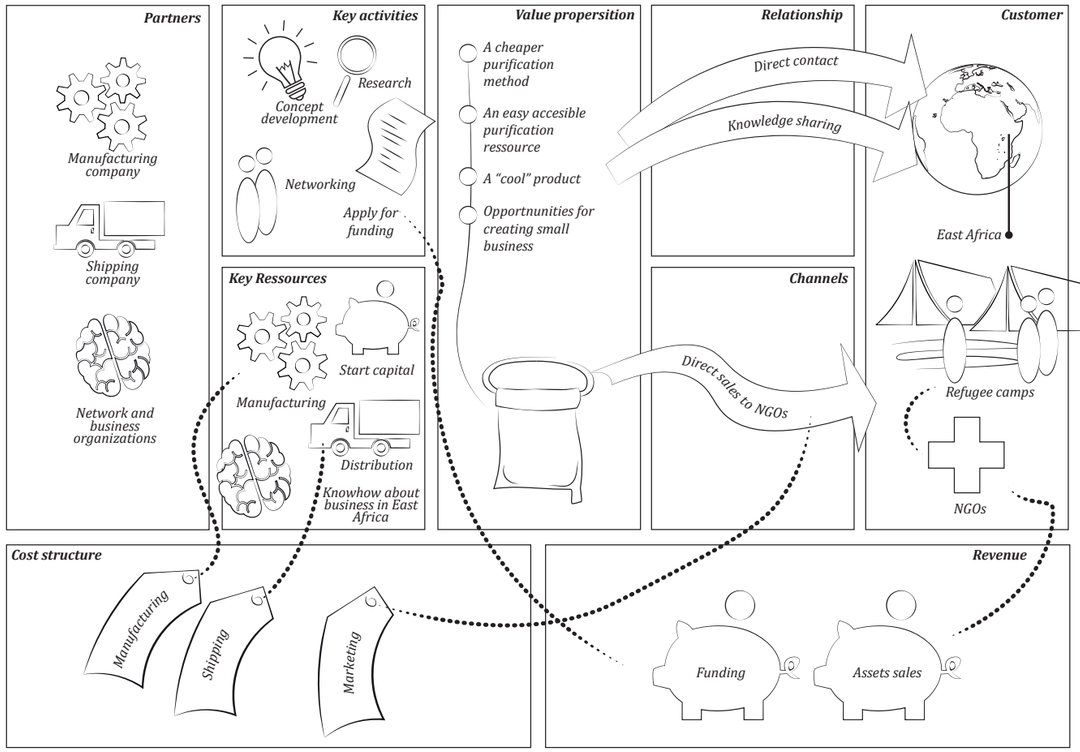


Figure 123: Business model 2

The business model that targets refugee camps/NGOs



GO TO MARKET

An order for entering different areas of slums in East Africa is made. Kibera, Kenya is approached as test market because of its ideal locations

Nairobi, Kenya is one of the growing business locations in Africa, with many start ups and design hubs. A great place to develop network and business. The biggest slum in East Africa, Kibera, is located only 5 kilometers from Nairobi down-town. Kibera is chosen as a test market, as it is easy accessible from Nairobi down-town. After Kibera slum, SolarSack will be distributed to other slum areas in Mombasa and Kisumo, Kenya. Afterward, slum areas in Dar el Salam, Tanzania and Kampala, Uganda will be entered.

The biggest refugee camps are located in Uganda and Kenya, and will be entered through UN and NGOs.

A general decribtion ofbusiness opportunities in East Africa is described in Worksheet 72 - Opportunities in East Africa

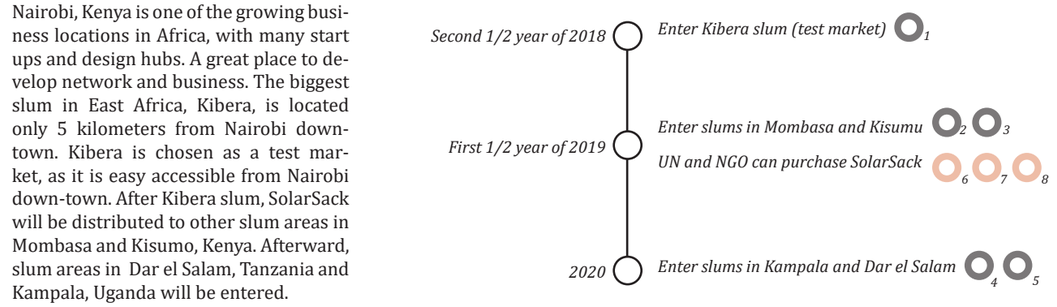


Figure 126: Time line

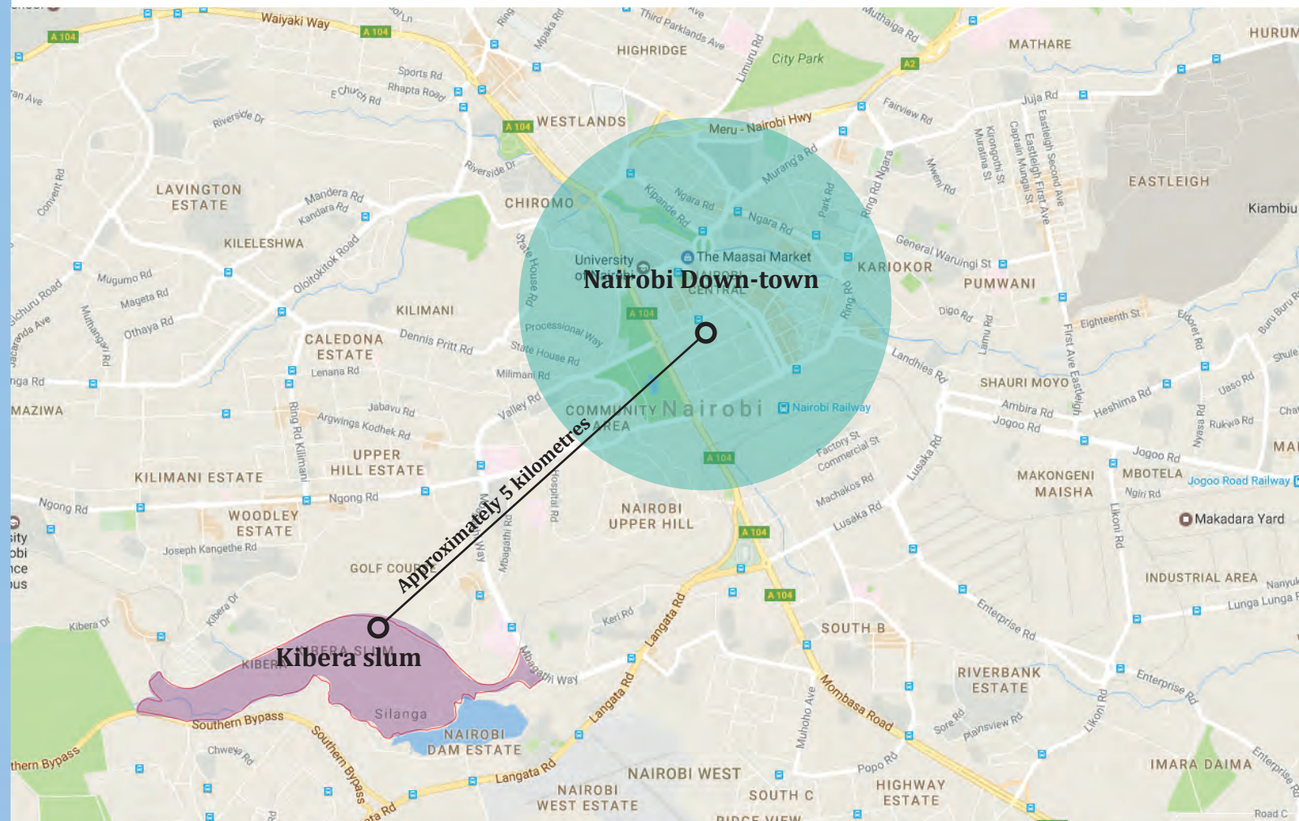
The time line shows the order which the different slum areas and refugee camps are entered

Refugee camps/settlements

Slum areas

Figure 125:Nairobi map

The map highlights the location of Nairobi down-town and Kibera slum



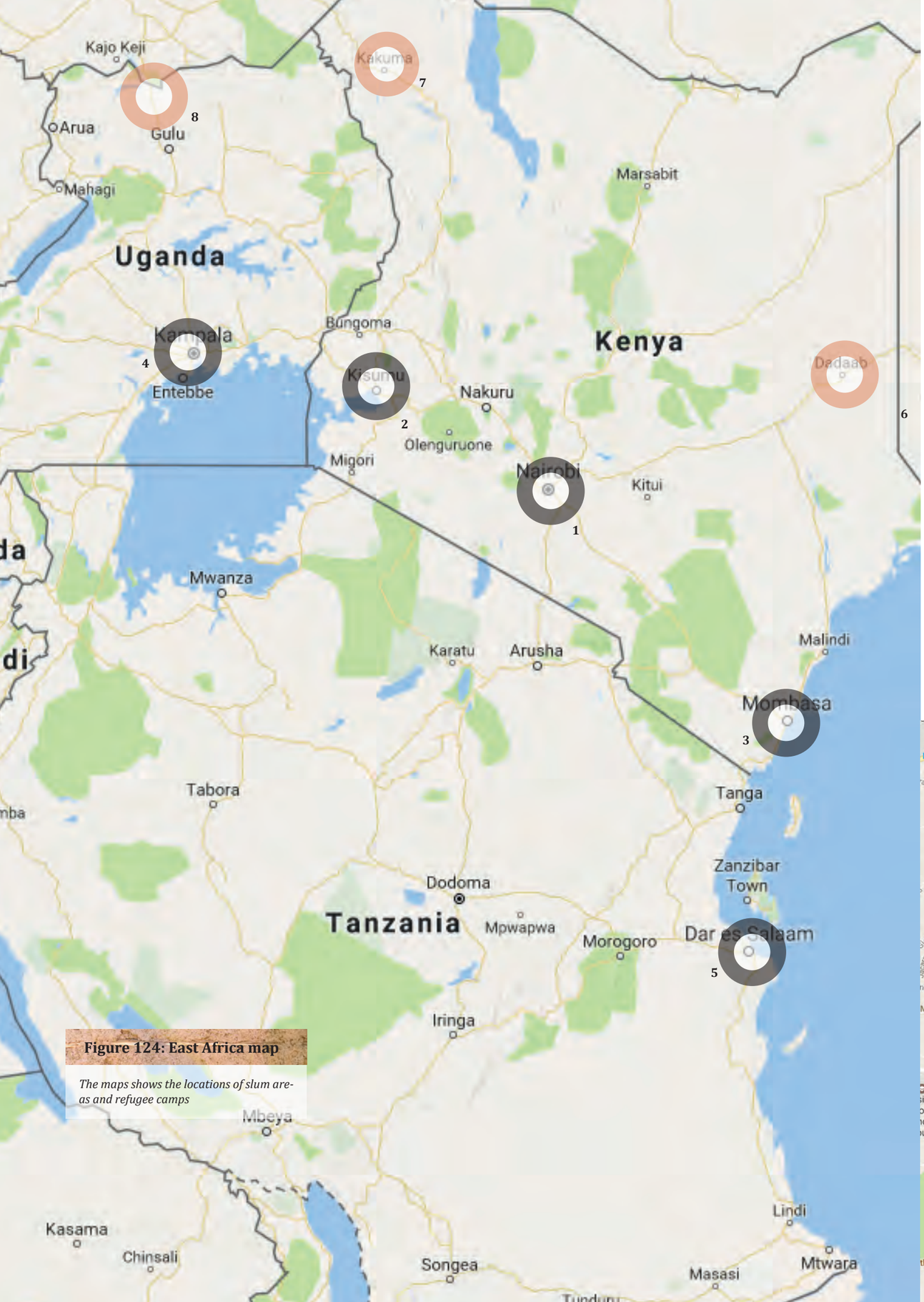


Figure 124: East Africa map

The maps shows the locations of slum areas and refugee camps

BREAK EVEN ANALYSIS

A break even analysis is made based on sales to slum areas.

Sales numbers are estimated on the basis of the go to market strategy on page 83 where Kibera slum is entered first, as a test market. The sales numbers should be considered as sales goals more than expected sales numbers. One SolarSack can be purchased for 5,60 DKK for people living in slum areas. Sales to NGOs will be direct sales, and no retailer is needed. Therefore, the sales price for NGOs is 2,80 DKK.
The break even analysis is made on basis of sales to slum areas, as there is no guaranty that NGOs will purchase the product. The market within refugee camps is also a very unpredictable market, as one can not predict wars, hunger, or catastrophes that will accumulate a stream of refugees. Break even will happen after one year or after about 600.000 SolarSacks is sold. (Appendix: Business case).

ESTIMATED SALES NUMBER IN SLUM AREAS

	2nd 1/2 of 2018	*1st 1/2 of 2019*	*2nd 1/2 of 2020*	*2020*	*2021*	*2022*
Kibera slum	*90.000*	*150.000*	*240.000*	*1.200.000*	*1.680.000*	*2.100.000*
Other slum, Kenya		*108.000*	*180.000*	*720.000*	*1.080.000*	*1.440.000*
SLums in Uganda				*375.000*	*750.000*	*1.125.000*
SLumas in Tanzania				*975.000*	*1.950.000*	*2.925.000*
Total sales	***90.000***	***258.000***	***420.000***	***3.270.000***	***5.460.000***	***7.590.000***

ESTIMATED SALES PRICE IN SLUM AREAS

Sales price		*5,60 DKK*
Sales price, retailer		*5,60 DKK*
Contribution, retailer	*50 %*	*2,80 DKK*
Sales price, SolarSack		*2,80 DKK*
Contribution, SolarSack	*41 %*	*1,15 DKK*
Product cost		*1,65 DKK*

ESTIMATED SALES PRICE TO NGOS

Sales price		*2,80 DKK*
Sales price, SolarSack		*2,80 DKK*
Contribution, SolarSack	*41 %*	*1,15 DKK*
Product cost		*1,65 DKK*

ESTIMATED INVESTMENT

Prototyping	*50.000 DKK*
Development	*30.000 DKK*
Prepare for manufacturing	*500.000 DKK*
Travels	*100.000 DKK*
Total investment	***680.000 DKK***

BREAK EVEN

	2nd 1/2 of 2018	*1st 1/2 of 2019*	*2nd 1/2 of 2020*	*2020*	*2021*	*2022*
Products sold	*90.000*	*258.800*	*420.000*	*3.270.000*	*5.460.000*	*7.590.000*
Sales price	*2,80 DKK*	*2,80 DKK*	*2,80 DKK*	*2,80 DKK*	*2,80 DKK*	*2,80 DKK*
Product costs	*1,65 DKK*	*1,65 DKK*	*1,65 DKK*	*1,65 DKK*	*1,65 DKK*	*1,65 DKK*
Turnover	*251.870 DKK*	*722.028 DKK*	*1.175.028 DKK*	*9.151.285 DKK*	*15.280.127 DKK*	*21.241.056 DKK*
Variable costs	*148.158 DKK*	*424.722 DKK*	*691.408 DKK*	*5.383.108 DKK*	*8.988.310 DKK*	*12.494.739 DKK*
Contribution margin	*103.711 DKK*	*297.305DKK*	*483.985 DKK*	*3.768.176 DKK*	*6.291.817 DKK*	*8.746.317 DKK*

	2nd 1/2 of 2018	*1st 1/2 of 2019*	*2nd 1/2 of 2020*	*2020*	*2021*	*2022*
Investment	*-680.000 DKK*	*-576.288 DKK*	*-278.983 DKK*	*205.002 DKK*	*3.973.179 DKK*	*10.264.996 DKK*
Contribution	*103.711 DKK*	*297.305 DKK*	*483.985 DKK*	*3.768.176 DKK*	*6.291.817DKK*	*8.746.317 DKK*
Remaining	*-576.288 DKK*	*-278.983 DKK*	*205.002 DKK*	*3.973.179 DKK*	*10.264.996 DKK*	*19.011.313 DKK*

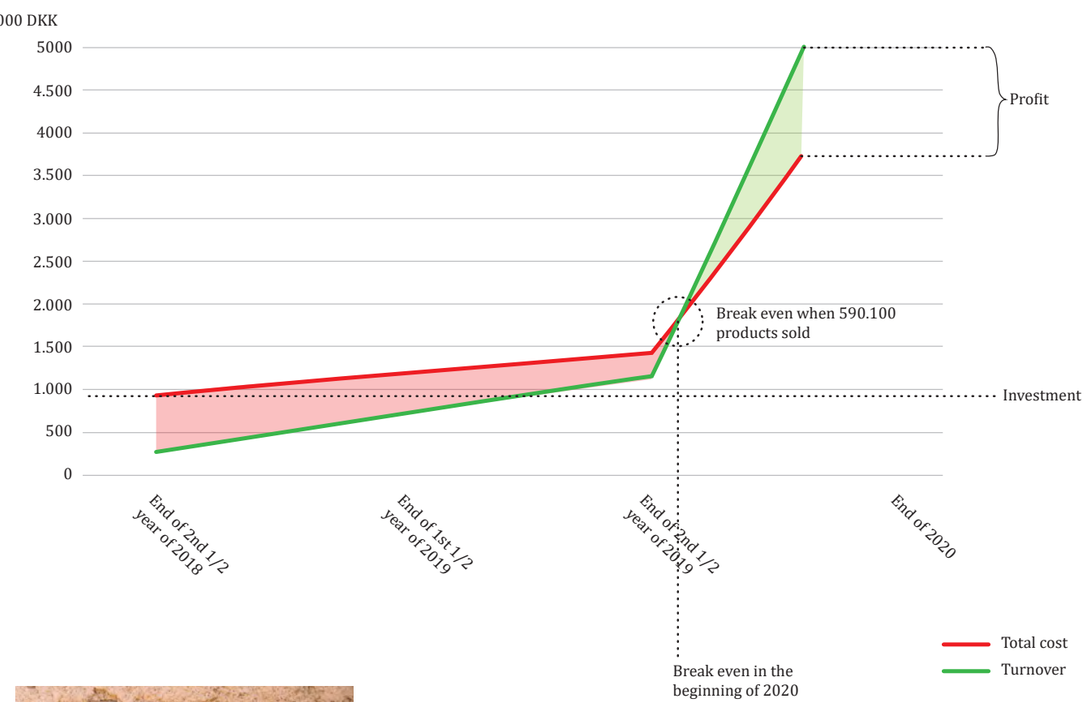


Figure 127: Time line

The time line shows the order which the different slum areas and refugee camps are entered

SENSITIVITY ANALYSIS

A sensibility analysis is made to investigate how different factors can influence the time of break-even and return of investment.

Factors chose that can influence break even, and ROI is:

NO SALES TO SLUM AREAS

What will happen if we do not succeed in the market of slum areas, and no sales to this marked will happen.

MINIMUM SALES PRICE

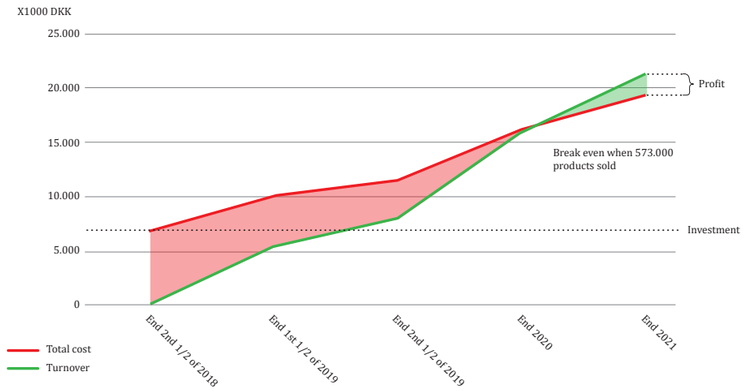
What is the minimum allowed sales price if the break even should happen in 3,5 year

INCREASED PRODUCTION COST

What will happen if the production costs increase by 100%?

Figure 128: No sales in slums

Break even if not product are sold in slum areas, but only to NGOs

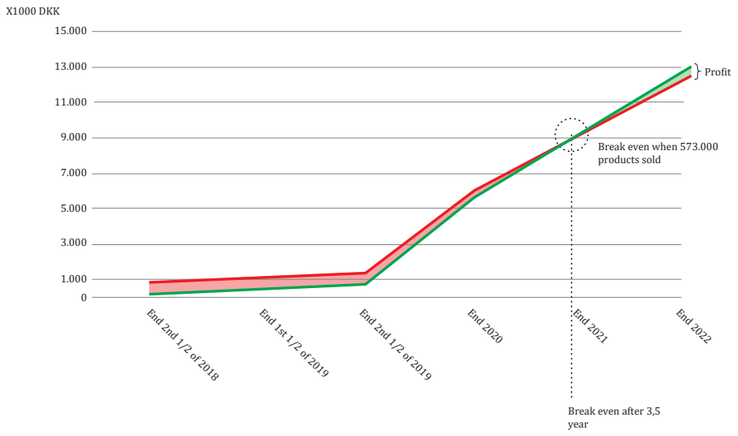


NO SALES TO SLUM AREAS

A break even analysis if made if Solarsack is not able to step in on the market of slum areas, and thereby sales will only happen to NGO's.

The break even analysis shows that the business can survive even without the slum areas as a market. Break even will happen at the beginning of 2021. (Appendix: Business case no sales to slum areas).

ROI in 2022 is 250%



MINIMUM SALES PRICE

If break even should happen after 3,5 year, a minimum sales price is estimated. The minimum sales price should provide the company with a contribution on 0,07 DKK (4%). This will result in a sales price of 3,50 DKK for customers in slum areas and 1,70 DKK for NGOs. (Appendix: Business case minimum salesprice).

Figure 129:Min. sales price

Brake even after 3,5 year, decided by adjusting the sales price

INCREASED PRODUCTION COSTS

If the production costs raise by 100% (without shipping), the total product cost (inclusive shipping) will increase from 1,65 DKK to 3 DKK. If the sales price to NGOs and retailers is not changed, but contribution will be decreased to -0,2 DDK (-8%). So, every time a Solarsack is sold the company will loose 0,2 DKK. This is off course, not good business. As seen on figure X, break even will not happen. (Appendix: Business case production price increased by 100 percent).

ROI in 2022 is -740%

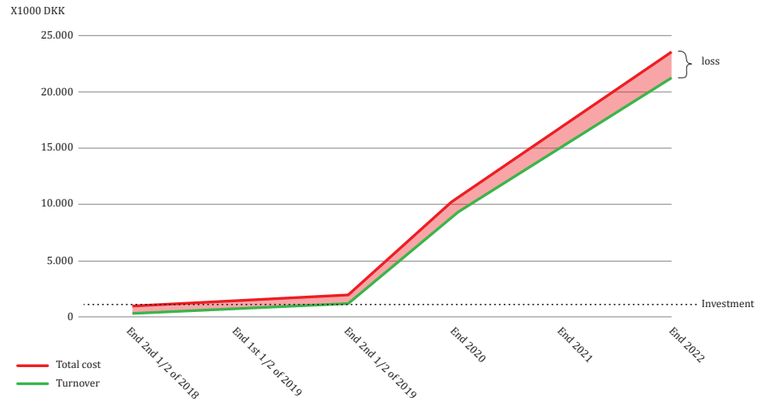


Figure 131: product cost

The grapgh shows that if the production costs is increased by 100%, break even will not happen.

To avoid the situation show in figure X, the sales price needs to be increased. The consequence of increasing the sales price, is that fewer customers will purchase the product. A break even analysis is made on the factors that production costs is increased by 100%, The sales price is increased by 50%, and sales numbers is decreased by 50%.

This will provide a contribution margin of 1,20 DKK (28%), and the sales price will be increased from 5,60 DKK to 8,40 DKK for customers in slum areas. The sales price will increase from 2,80 DKK to 4,20 DKK for NGOs. A consequence of a decreased sales number of 50% would still provide break even in approximately 1,5 year. (Appendix: Business case producion price increased by 100 percent and increased salesprice).

ROI in 2022 is 1520%

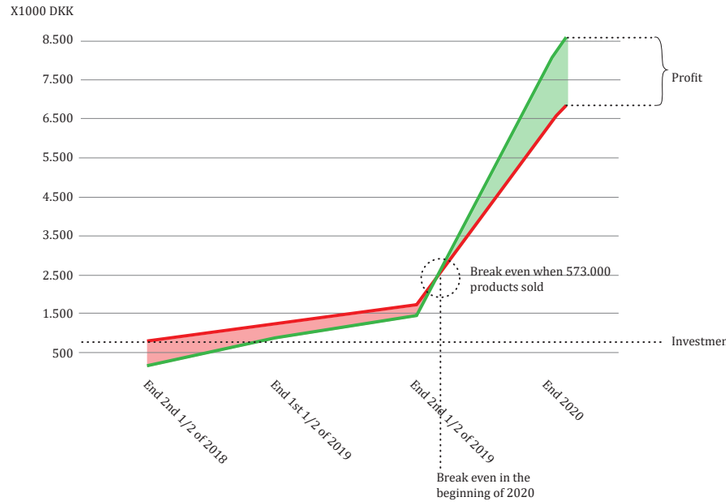


Figure 130:product cost

Break even according to an increased production cost by 100%, increased sales price of 50% and decreased salesnumbers of 50%.

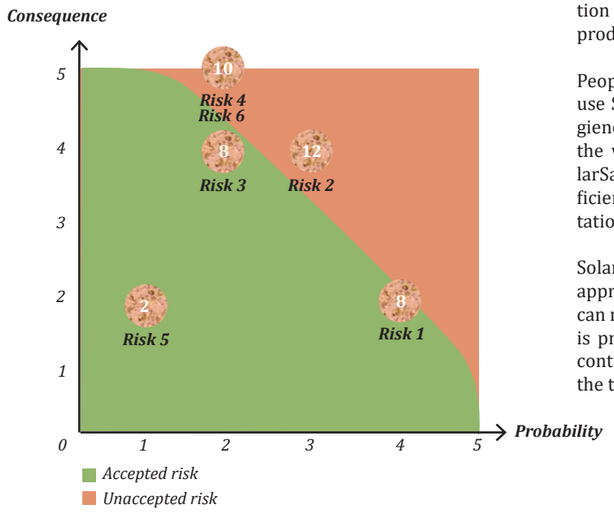
RISK ANALYSIS

A risk analysis is made, to identify what consequences and what properly potential risks are.

Figure 132: Risk graph

Mapping of risk, showing the consequence and probability, and whenever its acceptable or not.

6 potential risks are identified. The risk is rated from 1-5 where 5 is high, and 1 is low. They are rated according to the consequence of the risk and how probably it is that the risk will happen. The rate of the consequence C is multiplied by the rate of the probability P. If the rate, CxP, is higher than 9 the risk should be acted on.



Different measures for is found that can reduce the probability or the consequence of the risk. As seen in figure 132, risk number 4, 6 and 2 is the biggest risks.

As the product is relatively easy to copy, there will be a change that a big corporation with capital will take a copy of the product on the market.

People can still get sick even though they use SolarSack, as bad sanitation and hygiene conditions can cause illnesses. In the worst case, users would blame SolarSack for not purifying the water sufficient which would spread a bad reputation.

SolarSack's lifetime is estimated to be approximately 2 months. However, this can not be decided on before the product is proper tested. This will be done in a controlled test environment, and later in the test market in Kibera slum.

	Risk (what could go wrong?)	***Consequence C (1-5)***	***Probability P (1-5)***	***CxP***	***Measures that reduce probability***	***Measures that reduce consequence***	***Cost of measures***
Risk 1	*NGO will not purchase the product*	*2*	*4*	*8*	*Bribe. However, this is not an approach that is aimed for*	*A break even analysis is made to secure a stable business if no NGOs purchases the product*	*High*
Risk 2	*The product is copied by another company*	*4*	*3*	*12*	*Trademark protection can be bought*	*Obtain a stable market position before competitors gets to copy the product*	*High*
Risk 3	*Plastic bags gets banned*	*4*	*2*	*8*	*redesign the product so it is not within the category of plastic bags*	*Go to another market = e.g. India or West Africa.*	*Medium-high*
Risk 4	*People gets sick after using the product*	*5*	*2*	*8*	*Raise exposure time and UV treashold on indicator.*	*Bad rumours needs to be eliminated*	*Medium*
Risk 5	*Retailer will not pay back the retail price*	*2*	*1*	*4*	*The retailer is not allowed to get a new batch of SolarSacks*	*Crowdsource the foundign through companies like KIVA*	*Low*
Risk 6	*Most products brakes before 2 month*	*5*	*2*	*10*	*Observing the use of the SolarSack in the test market (Kibera slum) and consider if the product need improvements*	*Reduce the advetised lifespan*	*Medium*

CONSEQUENCE ANALYSIS

A consequence analysis is made to identify positive and negative outputs if implementing SolarSack in the East African context.

DECREASING DEFORESTATION

As described on page 28 and in worksheet 60 - Deforestation and lack of wood, the huge amount of charcoal increases deforestation in East Africa and is a threat to nature and wild life. Charcoal is primarily used for cooking and boiling of water. By using SolarSack, users can decrease the amount of charcoal for boiling. Boiling water is still necessary when the weather is not fit for solar pasteurization.

ENVIRONMENTAL POLLUTION

Producing charcoal and burning charcoal leaks carbon dioxide which contributes to environmental pollution. Having machines produce SolarSack will also contribute to environmental pollution, primarily by leaking CO2. The amount of environmental pollution from boiling one liter of water and from pasteurizing one liter of water with SolarSack is not known. But it is assumed that SolarSack will contribute to less environmental pollution per liter water.

DECREASE THE PRICE FOR WATER PURIFICATION

Decrease the price for water purification Using SolarSack, users will be able the Safe 0.6 DKK per jarrycan water purified compared to boiling.

UNEMPLOYMENT AND EMPLOYMENT

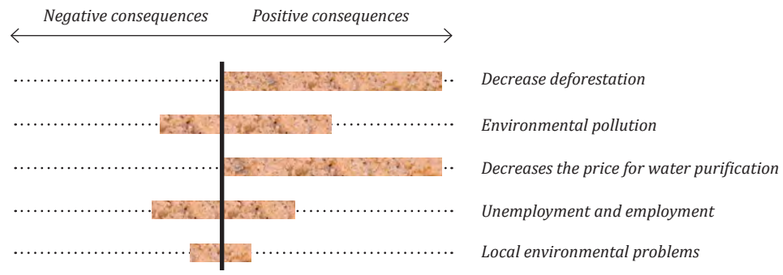
Implementing SolarSack in slum areas, people working with producing and selling charcoal will experience a decreased sale. However, new employment opportunities will arise, as retailers are needed for reselling SolarSacks in slum areas.

LOCAL ENVIRONMENTAL PROBLEMS

When Solar sack is not fit for use and disposed of, it will contribute to the huge amount of garbage that is already present in slum areas.

Figure 133: Consequence scale

Diagram showing the distribution of negative and positive consequences.



VALUE IN CONTEXT

The final price of the product, 5,60 DKK might for some seem low, and for some seem high. To get a better understanding of the value of 5,60DKK in and East African context, products of similar price is found, both for cleaning water, and from the context in general.

WHAT CAN YOU GET FOR 5.60 DKK IN UGANDA

5,60 DKK

240 Liters of purified water.

Availability:
Shops in slums and through NGO'

1,5 bucket of charcoal = 100 Liters of purified water.

Availability:
Shops in slums and villages.

Half a water melon

Availability:
Shops in slums and villages and at markets.

3 Liters of purified bottled water

Availability:
Shops in slums, small and large cities.

1,5 purification tablet = 40 Liters of purified water.

Availability:
Shops in slums and through NGO's

1 meal, Goat skewer

Availability:
Shops in slums and villages and at markets.

Figure 136: Value

Examples of what 5.60DKK can buy in East Africa

Figure 135: Guard job

500 DKK per mounth

Standard job for a male in families that lives in slums

Figure 134: Small foodstand

200 DKK per mounth

Side business for ladies in slums.

CHAPTER SUMMARY

A short summarize of the activities described in this chapter is made.

Decisions on materials and production methods are made in order to accommodate a low production- and material cost, but without compromising the functionality and the solar pasteurization efficiency. Different construction details have been considered in order to support the water purification. A business model and a business strategy are developed with a focus on slum areas and refugee camps, and how the two markets can be targeted. A break-even analysis made that shows break-even after one year. The benefits for the end users is revealed, and what they will gain from the product both financial and value-wise. Potential consequences, both positive and negative, that the product will bring along is identified.

OUTRO
CHAPTER 4

This section covers conclusion and reflections upon the product and the process. Reflections about additional products and scalability are covered as well

CONCLUSION

The project scope started to be about how to secure safe drinking water in East Africa. Field studies are Uganda and Kenya is conducted, and complemented by desk research, the principle used for water purification was decided to be solar pasteurization. The solution aims to be a supplement to the most common purification method in East Africa - Boiling. Boiling the water needs to be decreased in order to decrease the huge deforestation and to provide users with a cheaper purification method.

User studies are conducted in slum areas, rural villages, and refugee camps. Culture, behavior and the water cycle differs in these three areas. The market is narrowed down to focus towards slum areas and refugee camps. In slum areas, the money flow is high enough for the locals to purchase purification products (SolarSacks or charcoal) without any financial support from NGOs or the government. The sales price in slum areas is estimated to be 5,60 DKK.
I refugee camps, almost no money flow is present. The users do not have the financial capacity to buy SolarSacks or charcoal for boiling, themselves. They depend on resources from NGOs and the UN. The SolarSack will be sold to NGOs for 2 DKK per product, which makes Solar sack a great and cheaper alternative to purification tablets, which is the current product that NGOs provides the refugees. Solar sack accommodates criteria for the

The development of SolarSack is based on an iterative process of ideation, prototyping, testing, evaluation, and repeat. The product is developed to accommodate the users need and create a value of the users feeling safe purifying and drinking water. The development has also been function-based according to improve the solar pasteurization process combined with construction choices leading to cheap production and costs.

SolarSack can purify four liters of water in four hours, and can be used approximately 60 times. The SolarSack pasteurize water by the heat of the sun combined with penetrations from UV-A and UV-B that eliminated bacteria that can causes diseases. To let the user know that the weather is fit for solar pasteurization, an indicator made in UV-activated paint gives the user visual feedback on if the weather is fit or not.

SolarSack is in colors of white, light blue, and dark blue. The value based functions are that the colors are associated with "safety", "clean", and "happiness". The functional perceptions are that the dark blue color accelerated the heat up of the water.

Semiotics and user manuals are based on studies and test in Uganda and Kenya.

The product is produced in PE and vinyl foil with a total thickness of 250 microns. The manufacturing processes primarily consist of cutting and welding, which is relatively cheap production methods.

It can be concluded that the developed solution meets the criteria stated throughout this report. Furthermore, it can be concluded that the solution can provide safe drinking water as a supplement to boiling, without encouraging to deforestation and in any way harm user with added chemicals.

SCALABILITY

MARKET SCALE

The concept is designed based on field studies from Uganda and Kenya. Thereby, the product is designed to fit the users of Uganda and Kenya, according to needs, interactions, and general insights. In theory, SolarSack can be used in other location where there is a need for safe drinking water and where the sun rays are strong enough, e.g. India, South America, or West Africa. Even though SolarSack will function in these areas according to Solar Pasteurization, it has to be investigated how the product would work according to interaction, feedback and feedforward and general influencers from the context.

DOWNSCALING THE PRODUCT

The product can be downscaled according to size and the thickness of the plastic film. This will lower the production cost and purchase price, and people with the very lowest income could afford it. However, consequences of using thinner plastic film, is that is more likely to puncture. Downscaling according to size can have the consequence, that if it e.g. contains one liter of water, people would more likely drink directly from the product with their mouth, as the less heavy bag will be easier to manage and drink directly from - this will increase a human to human transmission risk of diseases.

UPSCALING THE PRODUCT

There are also some opportunities in upscaling the product. The product can be highly improved functional wise, by implementing a water filter, that filters out sand and dirt, which will improve the solar pasteurization. An "oxygenation unit" could be implemented, producing more oxygen in the water when poured into the SolarSack. This will accelerate the solar pasteurization process. These two addictions have both been eliminated from the current 4L version but could be integrated into a larger or premium version.

Improved SolarSack could also be sold for nature and adventure trips for people in Europe and America. Though the current SolarSack is fundamentally made for a different context.

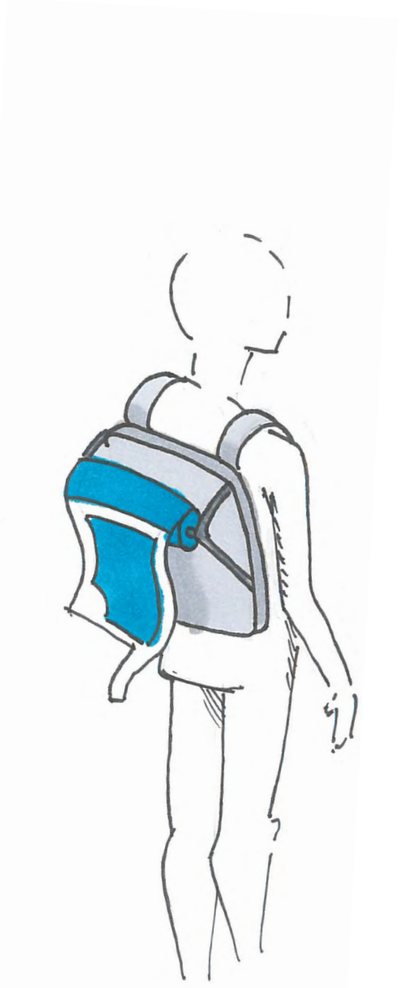


Figure 137: Retail equipment

A concept of a "portable stand" for retailer.

ADDITIONAL PRODUCTS

RETAIL EQUIPMENT

The business model for slum areas is based on reselling SolarSacks using local retailers. Considerations regarding retail products are made, to ease the sale and distribution from the retailer's point of view. This could be small selling stands or portable selling stands/equipment e.g. figure 151.

SOLAR PASTEURIZATION PRODUCTS

It is up to the user to decide on suitable areas for placing the SolarSack for solar pasteurization. If no perfect area for placing the SolarSack is available, a stand for solar pasteurization could be made, like a tree or a frame. The stand could intensify the purification process, store more SolarSacks and provide shadow to cool down the purified water.

As Ugandans and Kenyans are skilled craftsmen when it comes to metal work, this could be implemented in the production of additional products. Instead of distributing additional products produced elsewhere, technical drawings could be handed out to local craftsmen, and based on the drawings produce and selling additional product to the SolarSack. This contributes to the local growth.

REFLECTION-PRODUCT

TEST OF THE PRODUCT IN CONTROLLED ENVIRONMENT

There is no standards or regulation for the design and the efficiency of water filter product. As well, there are no regulations for test setup for testing water filter products. (http://www.thefactsaboutwater.org/water_regulations/Regulations_Filtered_Water). Most products for water purification has somehow been tested in a controlled environment, e.g. at universities. Thereby the product/company receives a certification and a report from the respected university, stating the results and that the product has been tested. This is often used as a guaranty for retailers and customers that the product works properly. SolarSack is designed based on test results from laboratories and universities, and in theory SolarSack will be able to pasteurize water according to these test results. However, SolarSack still needs to be tested in a controlled environment, to confirm that it purifies the water sufficient, as people's health depends on SolarSack.

PRODUCT EVALUATION

The development of SolarSack is based on insights from field studies in Uganda and Kenya, However, the product still needs to be tested in the East African context. This is to test feedback, feedforward, and interactions and reveal possible product improvement. Observations regarding how the product will be adapted to the context, and how the context will influence the general use of the product, needs to be conducted. Is the product used an intended? If not the product needs to be redesign to fit their intentions.

LONGEVITY

We have had issues defining the longevity of the product. Throughout the process, the two team members have had different ideas of the product's longevity, pulling the design in contradictory directions. It has great influence on the design, if the product is intended to be a one-time-use disposable product, or if it should last for a year. To control if the product should be disposable, few-time-use, or last for a longer period of time, criteria regarding this, should be made earlier in the process, stating the product's longevity. There have not been a tangible criteria to evaluate the product's quality of construction on according to the longevity. An example of criteria could be that the product should cost the same price as a bucket of charcoal, but the product should be 5 times as efficient = producing 5 times more water.
Other ways to base evaluations on, could be having the users to state the preferred longevity according to purchasing price.

Another way of working with the quality of the product, could be to develop it in three tracks. One track was the product should be disposal, one where it can be used few times (maybe 50 times) and one where it can be used many times (maybe 500 times). The three concepts (that varies in quality) could when be evaluated according to trustworthiness, price, functionalities e.g.

PLASTIC GARBAGE

Considerations about the disposal of the product and its consequences been a great subject. - This is also influenced by the longevity. To not contribute to the huge amount of garbage disposed of, especially, slum areas, a deposit system could be implemented. The users can return the SolarSack to the distribution center when it is no longer fit for water purification, and trade it for a new SolarSack to a lower price.

A wish would also be to use a biodegradable material, but this will compromise the efficiency of the solar pasteurization.

REFLECTION-PROCESS

THE PROJECT TEAM

The study program has a very interdisciplinary approach, which results in the students of MSc04 being skilled in different design fields. We have tried to take advantage of this, as we are skilled in different fields and with different design approaches. This makes us able to complement each other and cover the different fields within design, from navigating the fuzzy front end to product detailing.

PROJECT MANAGEMENT

A scrum board has been used as the main media for project planning and management. Scrum meetings have been conducted at the start of the day and if necessary in the middle of the day. This has worked great, especially being two team members made it manageable to keep a general alignment between both of us. Worksheets have been used throughout the project, and has worked well as a project documentation. Before traveling to East Africa, worksheets were made for all expected activities in East Africa. This was to secure the necessary knowledge from the East African context.
However, conducting field studies, input from the users and the contexts influences and changes the project frame, and thereby also the worksheet objectives.
Writing the report, it was easy to track activities, objectives, and results when having the worksheets.

RESEARCH APPROACH IN EAST AFRICA

It has been a great experience to challenge our design competencies in an East African context. We have been forced to quickly adapt our approach to design and user research to fit the context. We have been challenged on misunderstandings and misinterpretations, especially when asking very abstractive or reflective questions. This has been a learning by doing research approach, and input and knowledge from an interview have changed the phrase of questions at the next interview. This was possible, as the interviews were semi-structured.

PROTOTYPING

During this project, prototyping as been used for testing and evaluation in a high degree. This has been necessary as the concept requires a great user interaction, and as the concept consists of a flexible material influenced by many factors. Luckily we have been able to prototype in a grateful and tangible material - plastic foil(PE), making us able to do cutting and welding in hand quickly.

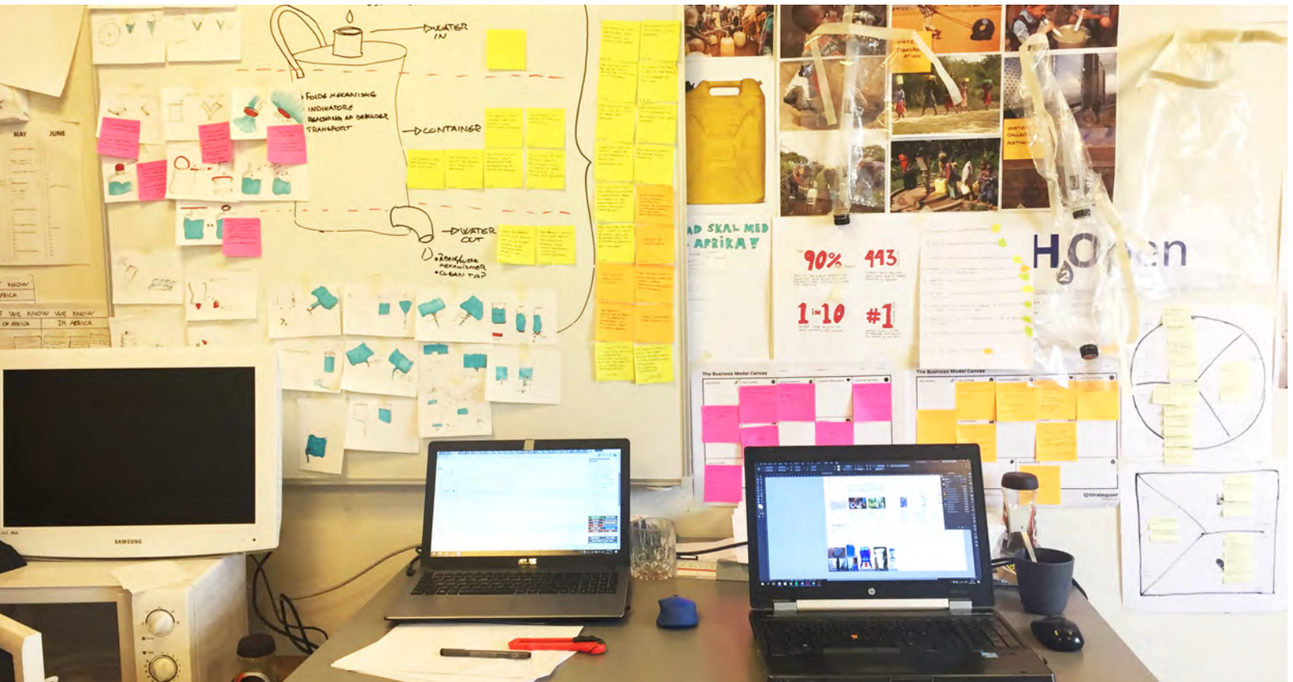
PERSONAL OBJECTIVE AND LEARNINGS

We both found it crucial to find a project theme that we were passionate about, to be able to find the highest possible motivation for the master thesis project. We wanted to apply the competencies obtained the past 4,5 years on a subject that matters to us, and where we felt that we could contribute to solving serious problems. Finding the subject of this project has been a combination of own initiatives and luck.

From our internships at Lego and Ideaal, we have been able to apply skills and approaches to this project. We have also used this master thesis to further develop our individual skills, according to what we want to work with when graduating.

Figure 138: Project wall

One of the two wall used to pin up current inspiration, research, criteria and other info that needed to be quickly accessible



REFERENCES

(Chigozie, no date)
Chigozie, E. (no date) Top 10 Diseases in Africa - Most Deadly. Available at: http://answersafrica.com/diseases-in-africa.html/2 (Accessed: 30 April 2017).

(Gad, 2015)
Gad, M. (2015) Afrikas muligheder – Set i dansk perspektiv. p. 7-9

(Gutiérrez-Alfaro et al., 2016)
Gutiérrez-Alfaro, S., Acevedo, A., Figueredo, M., Saladin, M. and Manzano, M. A. (2016) 'Accelerating the process of solar disinfection (SODIS) by using polymer bags', Journal of Chemical Technology and Biotechnology, (May). doi: 10.1002/jctb.5005.

(Kuroiwa, 2014)
Kuroiwa, Y. (2014) Curbing time-consuming, dangerous searches for firewood, 2014-07-15. Available at: http://www.unhcr.org/news/makingdifference/2014/7/53c53bb26/curbing-time-consuming-dangerous-searches-firewood.html (Accessed: 28 April 2017).

(LIGAMI, 2015)
LIGAMI, C. (2015) 'Index @ Www.Theeastafrican.Co.Ke', China, India, South Africa still classed as developing nations, p. 1. Available at: http://www.theeastafrican.co.ke/news/China--India--South-Africa-still-classed-as-developing-nations-/2558-3002714-fg86v8/index.html.

(Luzi et al., 2016)
Luzi, S., Tobler, M., Suter, F. and Meierhofer, R. (2016) SODIS manual - Guidance on solar water disinfection.

(Nielsen, 2007)
Nielsen, A. (2007) Kenya bugner af forretningsmuligheder, Iværksætteren. Available at: http://www.ivaerksaetteren.dk/flx/artikler/13/kenya-bugner-af-forretningsmuligheder-705/ (Accessed: 30 April 2017).

(Shields et al., 2015)
Shields, K. F., Bain, R. E. S., Cronk, R., Wright, J. A. and Bartram, J. (2015) 'Association of supply type with fecal contamination of source water and household stored drinking water in developing countries: A bivariate meta-analysis', Environmental Health Perspectives, 123(12), pp. 1222–1231. doi: 10.1289/ehp.1409002.

(The World Bank, 2015)
The World Bank (2015) Population, total | Data. Available at: http://data.worldbank.org/indicator/SP.POP.TOTL (Accessed: 30 April 2017).

(Ultimate Guide to Water Purification Tablets, no date)
Ultimate Guide to Water Purification Tablets (no date). Available at: http://all-about-water-filters.com/ultimate-guide-to-water-purification-tablets/ (Accessed: 28 April 2017).

(WHO/UNICEF, 2015)
WHO/UNICEF (2015) Progress on sanitation and drinking water, UNICEF/WHO. doi: 10.1007/s13398-014-0173-7.2.

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