E M U
A BIOCHAR STOVE

Biocharging urban neighborhoods

Diploma project

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Industrial Design

SUMMARY

The project aims at raising the awareness and promoting the use of Biochar. The project has culminated in a cooking stove specifically designed for the “urban farming hub” at Losæter in Oslo, but with the potential of further commercialization. The stove is designed to efficiently gasify any type of biomass or garden waste, while transforming it into charcoal.

As the seriousness of our climate situation is starting to sink in, plans to cut emissions are being set in place. But very few are talking about how we can reduce the huge buildup of gases we already have in our atmosphere. There are very few viable ways of capturing CO2, but biochar is one of them. By storing charcoal made from biomass in our soils, we effectively take carbon out of the natural loop - in that way we are capturing and sequestering CO2 from our atmosphere. In the soil, biochar has several positive attributes that can benefit both the small scale gardeners as well as the industrial farmers.

To reach its potential effect, biochar has to be implemented into larger scale industrial processes and agricultural use. Norway’s compost industry, for instance, has many deep seeded issues that biochar could solve.

But the general awareness of biochar as a carbon-negative technology is still very limited. My project therefore focuses on raising this awareness through an appealing and user friendly biochar stove, developed in collaboration with Andreas Capjon, the “head farmer” at Losæter.

Losæter has a wide reach, both to the potential users of biochar - the growers, but also media and politicians. Losæter is an ideal arena to spread the knowledge and use of biochar - with the stove acting as an educational talkpiece.

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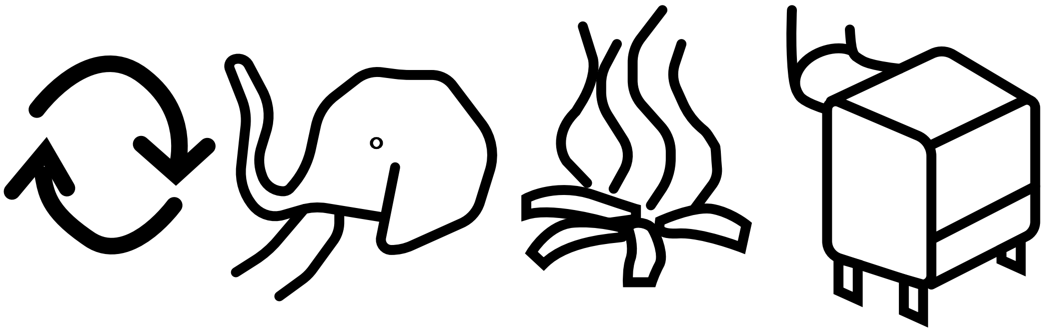
MOTIVATION

My interest in biochar started in the industrial design course “Protohype”, where we were looking at how design could play a role in a more sustainable future.



Sustainability **Kenya** **Indoor cooking** **Biochar Fireplace**

As part of that goal we went on a study trip to Kenya, while there I was investigating the problems linked to indoor cooking with firewood, where smoke was a big health hazard. In relation to this I came across the concept Biochar, which involved a method of producing smokeless fire, but also the byproduct Biochar, which could be used for agricultural benefits.

The project proposal culminated in a biochar fireplace stove that could potentially reduce emissions, to alleviate smog caused by fireplaces in Norwegian urban areas during winter.

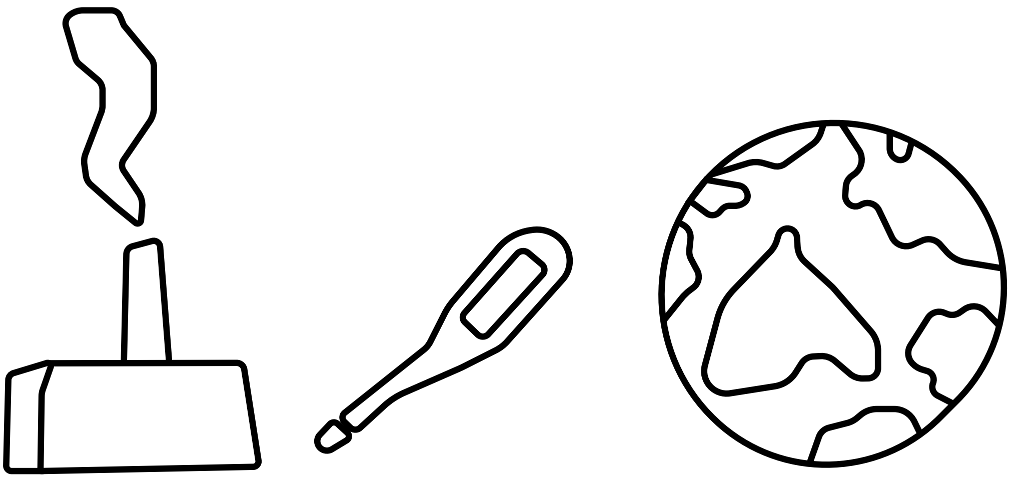
During that project I got a basic understanding of the workings of biochar, but I also knew I barely scratched the surface. So when I decided to work with biochar on my diploma project I wanted to delve into the fundamentals of making biochar, to fully understand it, and to design around these findings.

With biochar being a solution with so much potential, I also wanted to find out *why* it’s so far from implementation here in Norway. And based on that determine how, as a designer, I could influence this.

CHAPTER 1 - BACKGROUND

In this chapter I talk about the current climate situation, and how biochar can be a relevant solution.

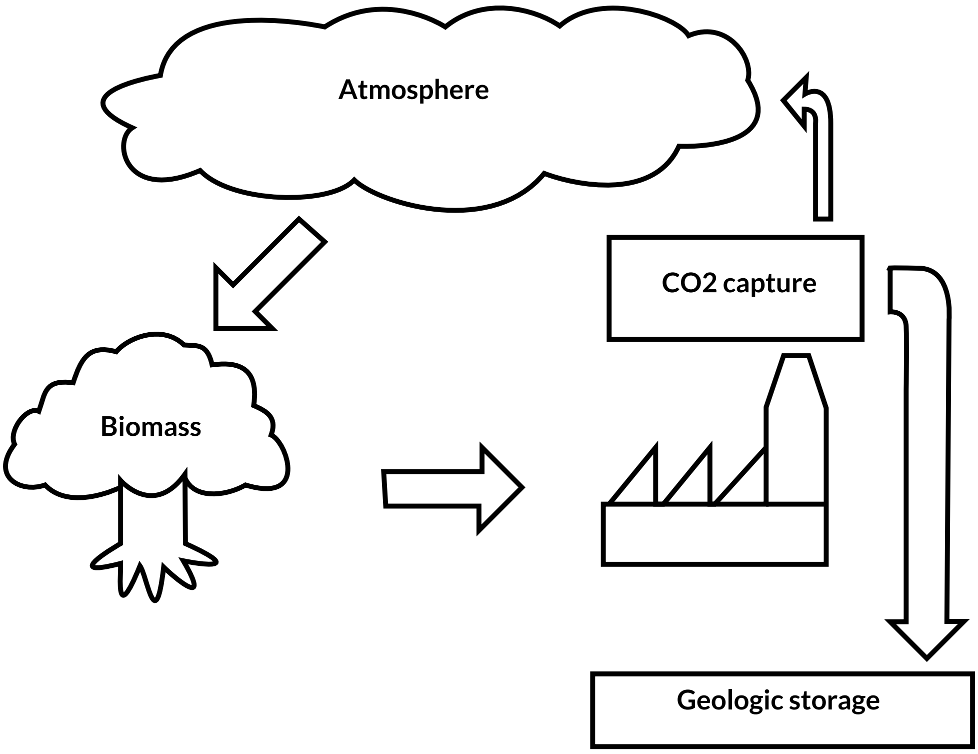
1.1 CLIMATE CHALLENGE



There is a scientific consensus that we are in trouble. CO2 emissions from carbon-based fuel consumption is causing our atmosphere to heat up - which in turn influences the global climate. In spite of our now considerable awareness of the issue the rate of which we emit CO2 is *still* accelerating (Canadell, 2007).

We are already seeing some of the effects of this - accelerated melting of glaciers and the polar ice-caps and the resulting rise of sea-level (NOP, n.d), more extreme storms and droughts and the resulting ecological and environmental destruction(NCA, n.d) .

Additionally there are certain factors that could cause "chain reactions" and escalate the situation even further: 1. When the ocean - which is, contrary to the atmosphere, our biggest CO2 sponge (IAP, 2009) - is fully saturated whith as much CO2 it can hold, our atmosphere will take on the full extent of CO2 emissions. And 2. When the permafrost, which covers 24% of the northern hemisphere (Woodhams, 2016), starts to melt (which it already has) and releases huge methane and CO2 deposits.



So what is being done to deal with this challenge? As previously mentioned, emissions are still accelerating, so apparently not very much is being done.

But what does this really mean? According to Sciences' road-map for staying below 2°(Rockström,2017) it means we have to not only reach a level of *zero* carbon emissions within *this* century - but also implement comprehensive measures of *capturing* large amounts of CO_2.

The suggested method of capturing said amount of CO_2 (5 gigatons/ year) is a concept called BECCS (Bioenergy with Carbon Capture and Sequestration) which is basically a power plant that burns plant-material (biomass) for energy, captures the outgoing emissions and stores them indefinitely in storages underground.

"In the IPCC Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC), BECCS was indicated as a key technology for reaching low carbon dioxide atmospheric concentration targets" (Wikipedia, 2017). However, this kind of storage has also, even by IPCC, been criticized to be a quite costly and risky process with little knowledge of long term consequences (IPCC, no date). My project explores a much simpler and safer way to achieve both what BECCS achieve and simultaneous being able to utilize the stored carbon to improve our precious topsoil i.e. as described in next section, by producing and using Bio-Char.

1.2 BIOCHAR

Adam O'Toole:
As part of my research I have conducted an in depth interview with Adam O'Toole, scientist within Environment and natural resources, soil quality and climate at NIBIO.

Watch attached video titled: "Adam Otoole Biochar"
As Adam states in the video, biochar is the concept of burying charcoal in our soil. Theoretically it works similarly to how the BECCS method would: Trees (biomass) capture CO2, biomass is burned for energy, emissions are captured and stored - making up a carbon negative cycle.

But instead of chemically capturing the emissions, and physically storing them in huge underground depots like the BECCS method would - the emissions are captured and stored in the charcoal.

1.2.2 HISTORY

The use of charcoal in the soil can be dated as far back as to the Amazon indians over 2500 years ago (Wikipedia, 2017)

But they had other reasons for doing it than the climate. Due to the amazons clay-like soil and the rain washing away all of the nutrients in it, it is very hard to actually grow anything there.

The indians countered this by putting high amounts of charcoal, mixed with animal bones, manure and other nutritious matter in the soil.

The charcoal was used to soak up a lot of these nutrients, hold on to them and protect it from the rain wash. This very same soil found in parts of the Amazon jungle, is today known as the Terra Preta (ref), which means Black Soil, and is renowned for its high level of fertility. The terra preta stands as a living example of the potential biochar has for agricultural purposes.

1.2.3 ADVANTAGES & USES

1. One of the core advantages of biochar is that the production of it creates energy, in the form of gas. (More on next page) This means that many energy-dependent and bio-mass related industries could benefit from implementing biochar production into their models - when/if the technology becomes more economic, and biochar gains a market demand.

2. Biochar can be used in many of the same filter-applications as activated charcoal, in some instances (according to Adam O'Toole) biochar outperforms activated charcoal, in regards to absorbency capabilities.

3. A potential widespread use of biochar does include some dangers. First and foremost in terms of managing the biomass and green waste in a sustainable manner. There are also some practical precautions to be had when using the char in the soil. If the char is not fully saturated (or "charged") with nutrients before being put in the soil, it will continue to absorb nutrients from the soil itself, giving inferior yields for up to several seasons. It is therefore pivotal to ensure that the char goes through a nutritious process (ex. mix with compost, dung, filtering uses etc.) before use.

4. Biochar has many uses in animal related scenarios. Research (ref) show that having biochar in feedstuffs improves animal health and prevents common illnesses. It is then also naturally passed into the manure, where it absorbs nutrients for further use.

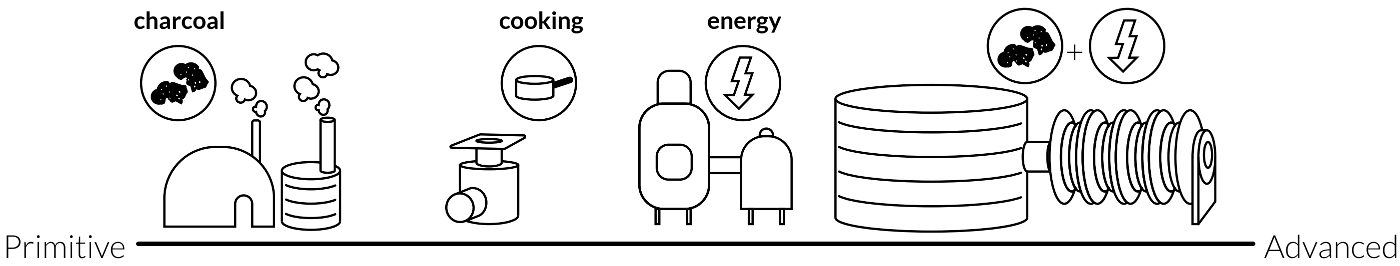
5. As the amazon indians exemplified, having charcoal in the soil makes the soil more resistant against floods. With weather getting more extreme, biochar could act as a powerful security measure for farmers around the world.

6. Biochar does not only hold on to nutrients, it also holds on to water, which it slowly leaks out into soil - making it more water efficient. This can, again, be a protective measure against more extreme droughts. But also a welcoming attribute for both small and large scale growing.

1.2.4 MAKING BIOCHAR- PYROLYSIS

Pyrolysis (pyro: heat, lysis: breakdown) is the driving process behind "gasification" - by driving out all the gases in a material, what is left is carbon, also known as charcoal.

Known methods for obtaining charcoal:



Charcoal Kilns: These come in many shapes and forms, and use the very simple method of "smoking" out the gases.

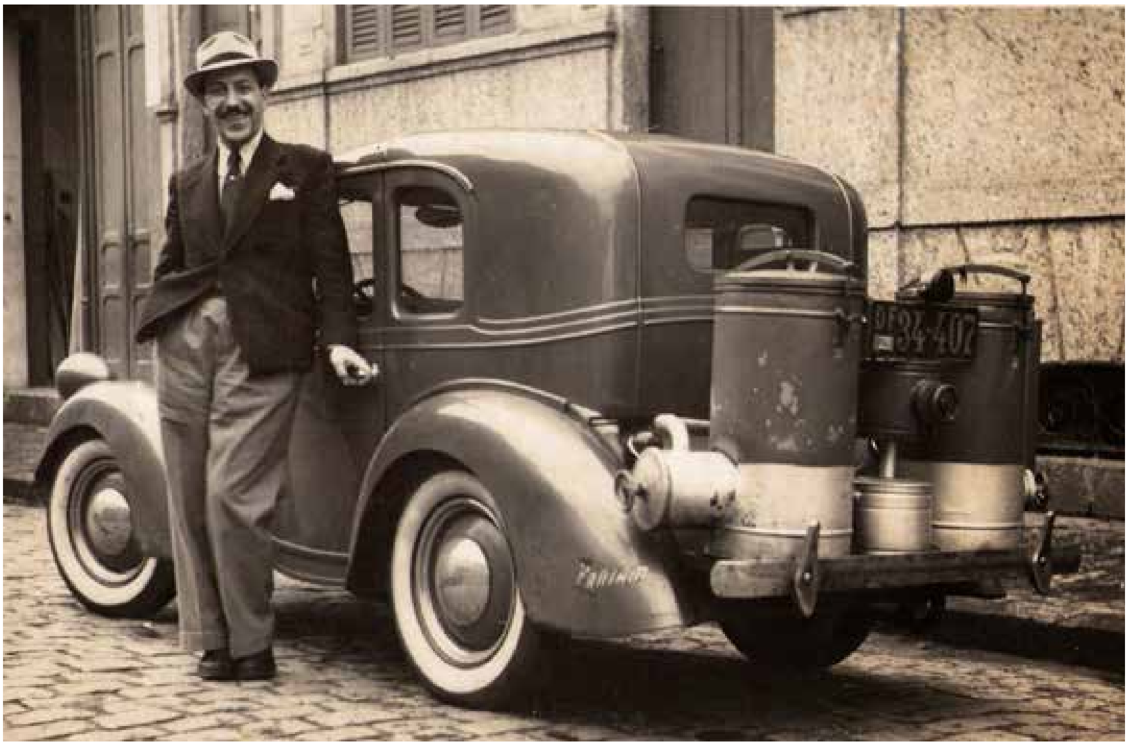
Gasifier stoves Several stoves designed for developing countries use gasification. But none of these/ few exploit the possibility to produce biochar.

Pyrolysis reactors / sin-gas: Uses more complex techniques to collect the gases in pure form

Biochar large scale production: Are still in need of technological advancements to be economically viable.

Gasification happens when organic material is heated above a certain point,(recent studies (ref) imply that biochar made at temperatures above 300 C is more effective) in an close to oxygen free environment, it starts to break down into gas. Under controlled circumstances this gas (methane, carbon-monoxide, nitrogen + carbon-dioxide) can be extracted, and utilized for similar purposes as other flammable gases. When the materials are depleted of gas, you are left with pure carbon, or charcoal, as a byproduct. Primitive pyrolysis methods like charcoal kilns do not utilize the gases for anything, and they come out as smoke. While more complex methods, using reactors for example, the gases are distilled into the more applicable syn-gas, and a secondary byproduct is tar - which can also be utilized. Pyrolysis used to be a more common technology - during world war 2 for example, because of limited oil access, countries like Sweden ran cars on syn-gas using pyrolysis reactors. But for the purpose of making charcoal on a small scale while igniting the gases, there are several rather crude and simple ways of achieving gasification. Many of these methods needs external energy/ heat, but the method I have chosen to focus on, the TLUD, does not need an external heat source.

TLUD, Top Lit Up Draft. Which I found to be optimal because it is a self contained gasification process - the heat/energy needed to pyrolyze the material is created during the process itself.



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Car with syngas reactor. (Gomes, 2011)

The design is said to be invented by the norwegian Paal Wendlebo, and is remarkably simple. It consists of a double layered bucket, with primary air coming in the bottom, and secondary air holes at the top. The bucket is filled with biomass, and lit from the top.
As the fire on top heats up both the metal bucket and the underlying biomass, it sucks in air from the primary air holes and is further accelerated. After a minute or two, the top layers of biomass closest to the flame will start to gasify and feed the flame. As the whole container heats up, the heat from the steel walls will start to gasify the deep layers as well. The now larger amounts of gas will mix with the air, which is preheated while passing through the outer shell, and shoot out the secondary holes as sting flames.

But pyrolysis needs oxygen free environments, so why all the air holes? The air/ventilation is explicitly there to feed mix with the gases and feed the gas flame (like a air gas torch). Because the material/mass is relatively compactly packed, there is never enough space for the lower levels to actually catch fire, instead they gasify.

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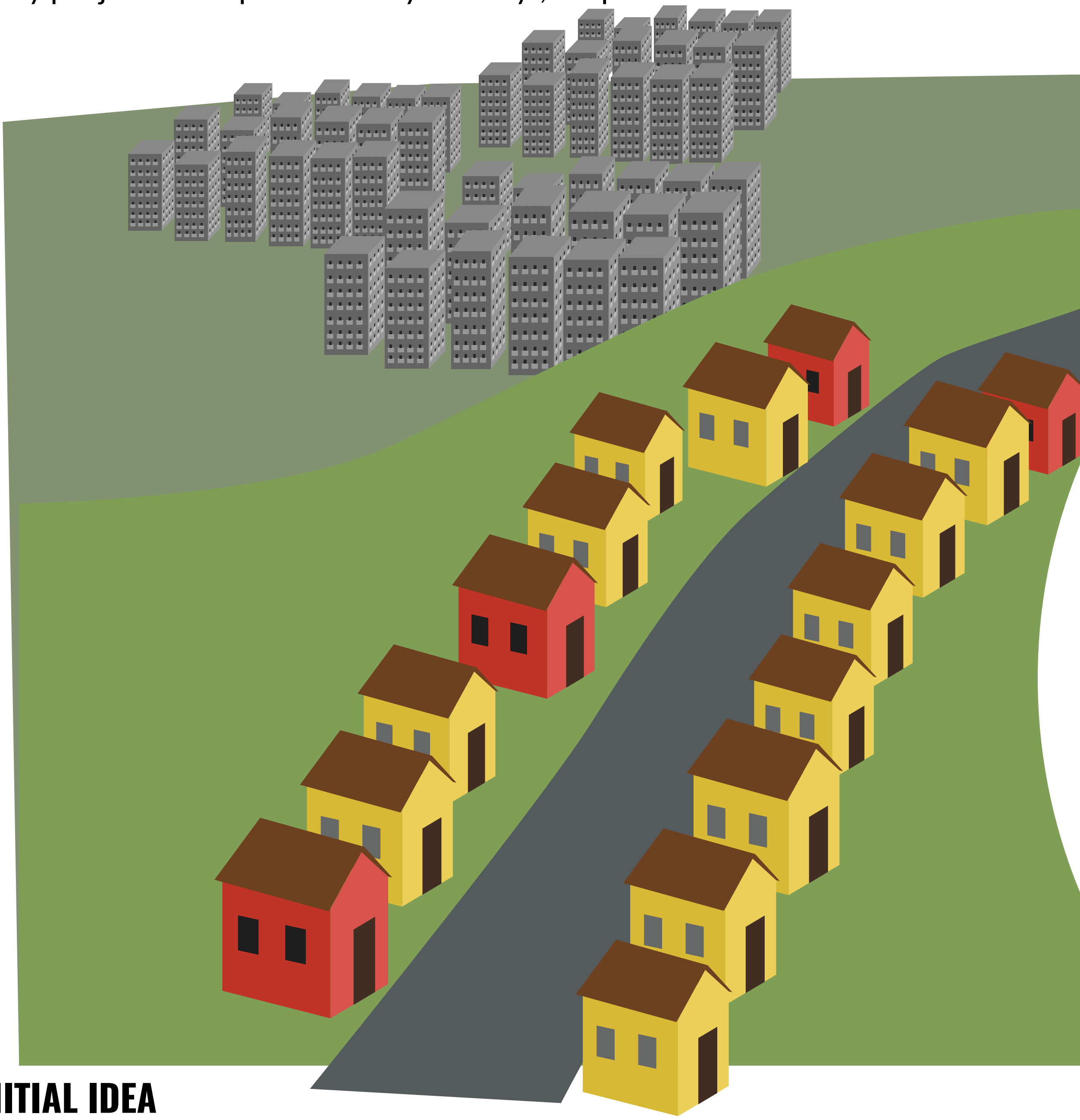
(Anderson,2010).

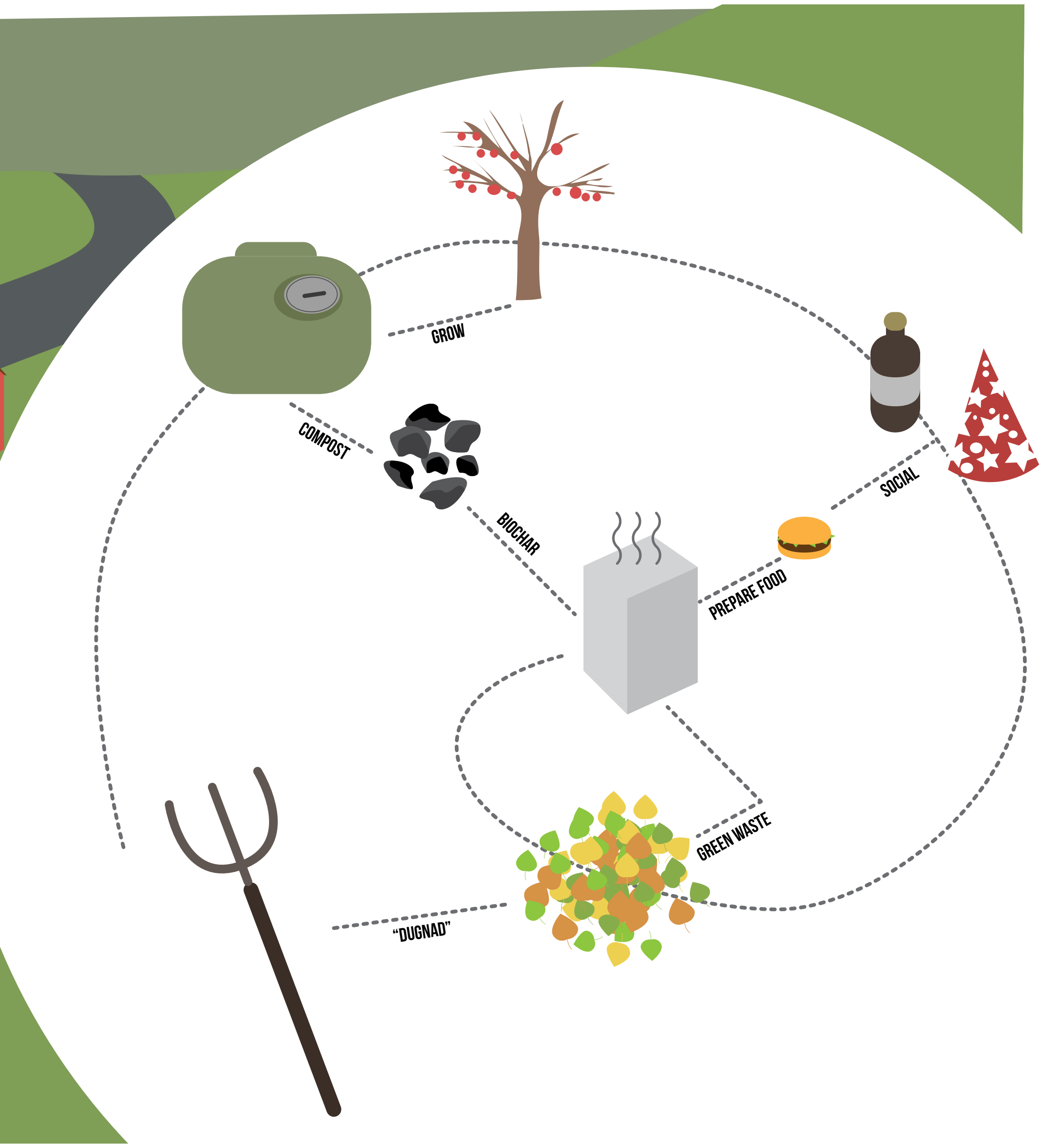
CHAPTER 2 - PROJECT

In this chapter I will introduce my initial project idea, the context of which my project takes place and my activity-, output- and outcome goals.



2.1 INITIAL IDEA

Initially I envisioned a project scope that could maybe have more actual impact in itself. I imagined something akin to a product service system, where I would design a stove that would be in the center of these “biochar recycling hubs” for green neighborhoods. These hubs could include an outdoor kitchen and compartments to separate, store and dry different types of green waste materials(trees,branches,leaves, general biomass) , to be used as fuel for the stove. The collection and handling of the materials would be organized through the quarterly “outdoor cleanups” that are normal for Norwegian neighborhoods /housing cooperatives.



The outdoor kitchen would be a semi-public social space, to be used by everyone in the specific neighborhood, and the stove as such would be designed for ease of use, safety and sturdiness. The hub could also work in tandem with a joint food waste compost situation, where the biochar would also end up.

It will further on in this report hopefully become clear why and how I chose to shift away from this project frame.

2.2 CONTEXT - LOSÆTER

The project is done in collaboration with Losæter, and more specifically Andreas “Bybonden” Capjon, who is in charge of the urban farming activities at Losæter. Andreas has been both my collaborator for this project, as well as my main user. It is through meetings and discussions with him, the user demands in terms of biochar and cooking has been specified.

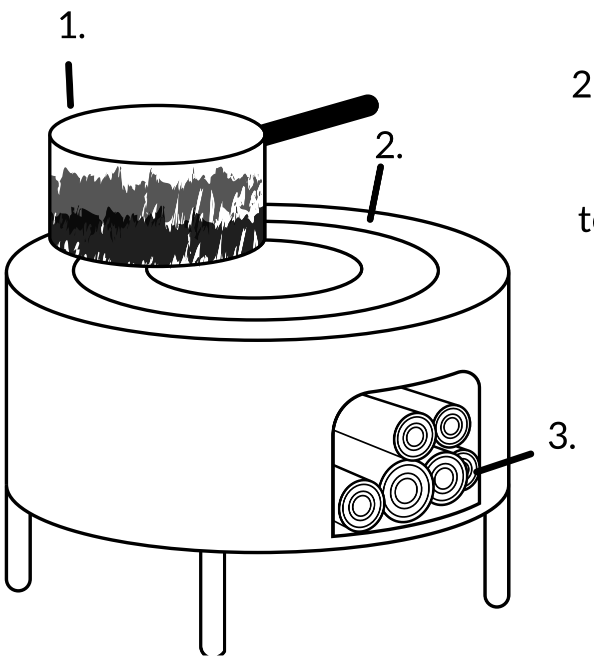
Losæter has a lot of different types of residue materials from the farming activities, as well as getting different types of biological byproducts from different industries, which can all be used as fuel to make biochar - which More about Losæter, Andreas and the context in this video:
Watch attached video titled:
“Loseter_Bybonden_Biochar_Materialsr”

3

Tjodunn (2016).

My stove will replace this cooking stove, and is going to be situated in an outdoor kitchen currently under construction. The stove will be used for cooking during the weekly dinners with up to 70 guests, but also act as an informative/educational talk piece to promote the use of Biochar.

The original stove, a traditional “Takke” stove, has several disadvantages for its particular use at Losæter:

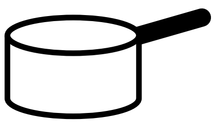


1. Because of its sub optimal combustion a lot of smoke is created, and the cooking utensils gets covered in sot.

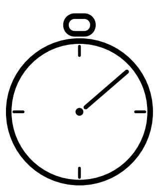
2. The whole stove is made of thick cast iron, which absorbs a lot of the heat. The cooking surface on top is also inefficiently large for its purpose.

3. The stove uses a lot of firewood to keep it hot enough for cooking throughout the dinners. Getting it up to efficient temperatures takes a long time, and it needs to be started about one hour before the dinners start to be efficiently hot

Because neither I or Andreas yet knew any of the exact parameters or workings of my stove, we agreed on some rough requirements it should have, in addition to producing charcoal:

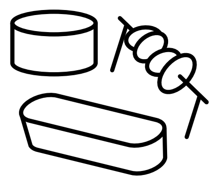


Not sot utensils



Fast start-up

Sufficiently hot for the duration of a dinner



Support different types of cooking

2.3 ACTIVITY GOALS

My initially planned activities for this project where as follows:

- Consult with experts on biochar - theoretical insights

- Consult with users of biochar - practical insights

- Consult with grill/outdoor cooking-hardware producer - technical insights

- Prototyping - Through exploration and rough prototyping arrive at a viable and concrete way of producing biochar/cooking, which will serve as a basis for my concepts and final solution

- User test - Test out said solution at Losæter

- Comparative study - Define the pros and cons of my solution compared to established products.

2.4 OUTPUT GOALS

My initial output goals:

- Functional prototypes

- Visual model

- Report

- Product video and/or Product pamphlet

2.5 OUTCOME GOALS

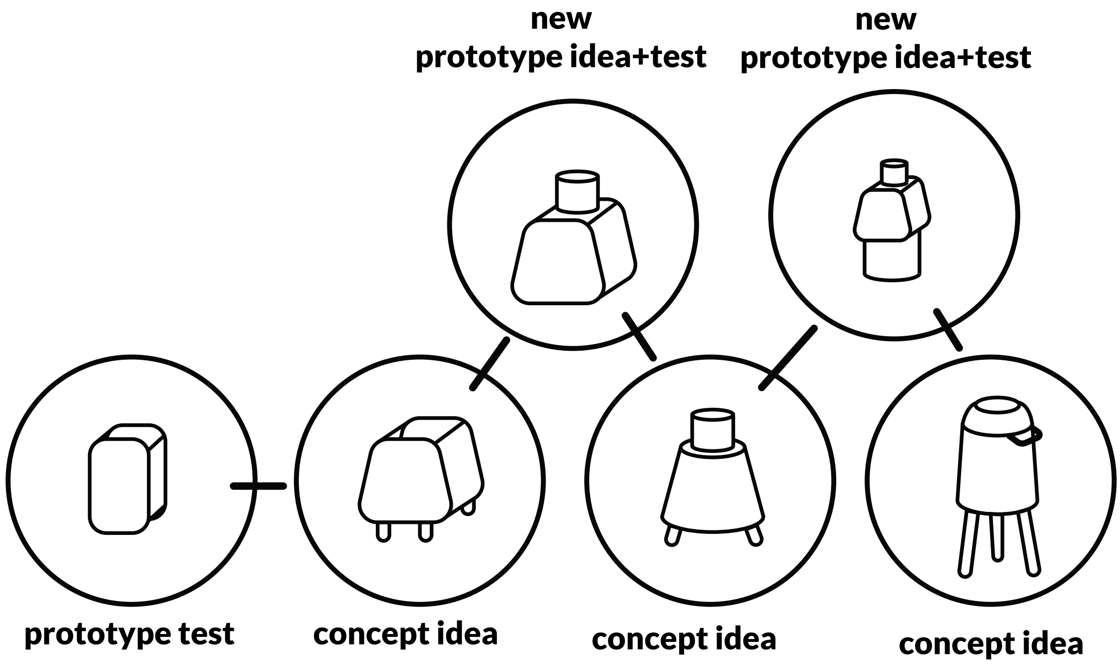
My initial outcome goals were to not only propose a viable way for people to produce and use biochar, but hopefully also a proposal that can promote and spread the knowledge of biochar as a both an important tool to capture emissions as well as a fruitful soil additive. (mer?)

CHAPTER 3 - PROCESS

In this chapter I will go talk about my approach, show how my activity goals were implemented through my process, before evaluating my process.

The concept phase is not presented in a strictly chronological manner, but I am rather trying to highlight some of my main thoughts and iterations.

3.1 APPROACH

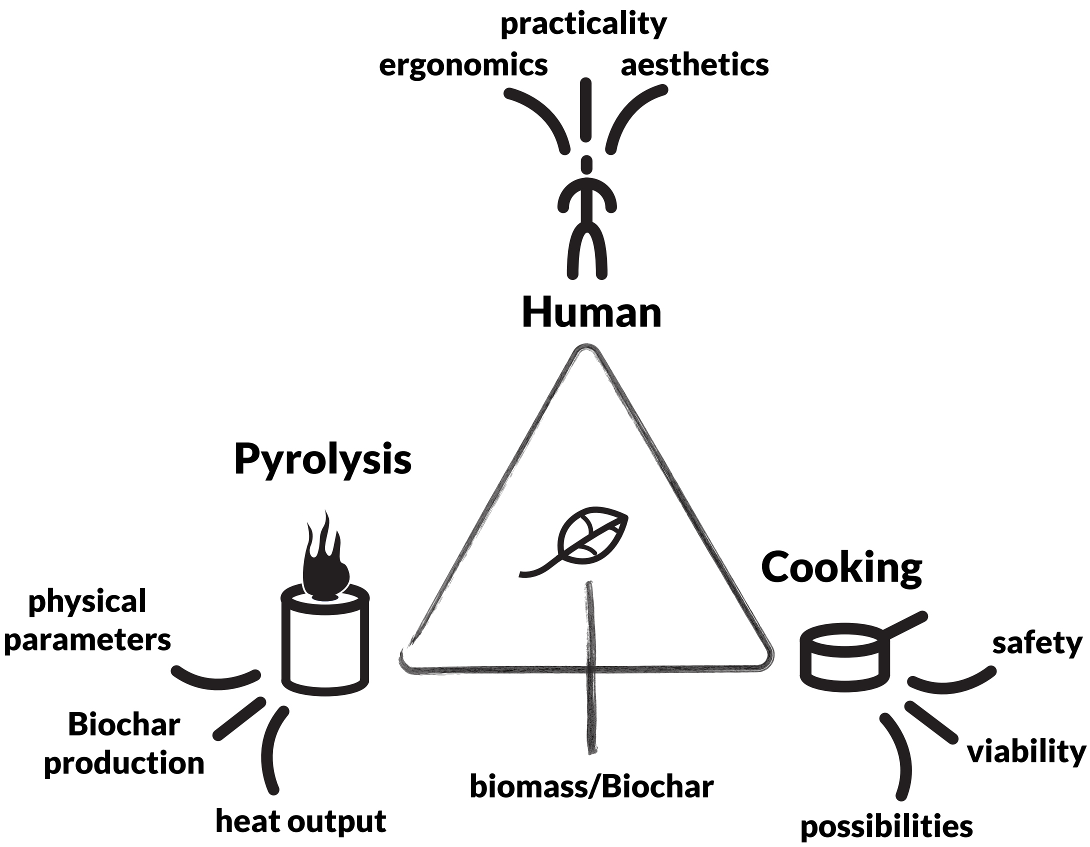


My approach has in some sense been a two-folded process. Through my interviews and desktop research I got the needed theoretical insights to scope my project and project goal.
While my practical insights has originated from exploring and testing different prototypes, and getting feedback on my findings and concepts from experts and my main user Andreas.

My design process has been technically focused and aesthetically focused, and I have worked with functional prototypes and developing concepts based on the prototype findings in tandem, like illustrated.

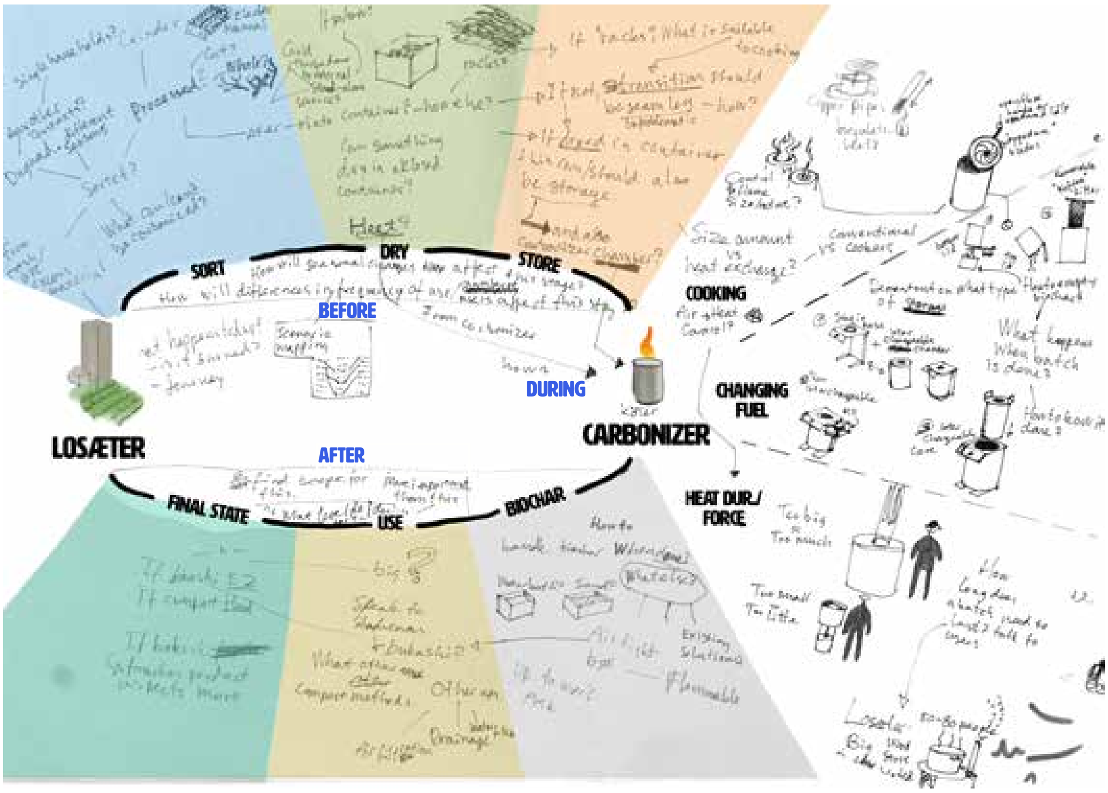
3.1 APPROACH

My design considerations has been centered around these four inter-twining categories:



Where biochar as an end-result is the main motivation, I've tested and prototyped different combustion principles to make biochar, conceptualized around the results , while trying to accommodate for cooking and human factors

3.2 IMPLEMENTATION



In my first meeting with Andreas as well as with Adam, we discussed the different stages to consider. I sketched out a journey map of the stages from before the charcoal is made, during use of the stove and after the charcoal is made.

2.2.1 BIOCHAR STATUS QUO

What is the status of biochar today? How widespread is its use? In what degree has it been implemented? And by whom?

What I found was that discussions about biochar and its future is mostly still contained within the scientific community, lawmakers have yet to really take notice of the potential biochar has as a climate measure.
Most of the active use and production of biochar is being done by the early adopters I call the Grassroot Level. These consist of independent groups/communities that focus on organic farming(ref)(Living Web Farms, Eco Barn). There are also several non-profit initiatives/organizations that focus on promoting the use of biochar (IBI, US Biochar Conference, ThinkGreen), and some for-profit biochar consultancies focusing on helping relevant businesses to implement biochar into their business-models (Wilsonbiochar, Restore Char). Of consumer level biochar related products, there is very little happening but some examples worth mentioning. There are many gasification stoves for developing countries, but very few market the possibility of biochar (the reasons for this will come later). There is an Italian successfully kickstarted gasifier stove, Enki Stove, which is meant for "park" cooking and where biochar is briefly mentioned, but not emphasized in any way.
All Power Labs, the team behind a home energy gasification system (GEK Gasifier), has also garnered some international interest.

On industrial level production of biochar there is a lack of technology economically viable. But there are several examples of larger scale production by individual farms and groups using crude methods. In Equador for instance, medium scale biochar production has created some what of a biochar market.

2.2.1 BIOCHAR STATUS QUO NORWAY

And what about the specific Norwegian context? Being a country very rich in forest and biomass, one would think that politicians here would at least have looked into possible ways of implementing biochar. But as Adam talks about here: ***Watch attached video titled: "Adam Otoole Politics"***

there is still a lack of real interest and commitment from lawmakers,
It's hard to determine at which end the problem lies: Entrepreneurs are not interested because there is no immediate market/demand for biochar, and politicians haven't set in place any measures to create a market (like other green technologies) because they know too little about it.

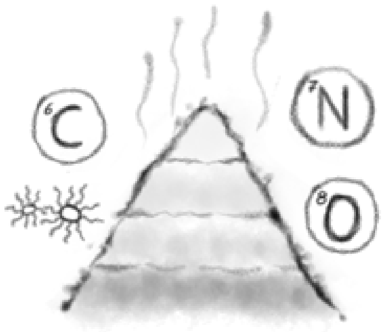
2.2.2 COMPOST

Compost:
An aerobic organic (as opposed to chemical) process where organic matter is broken down by bacteria into a nutritious mass that can be used as a potent additive for plant soil and soil products.

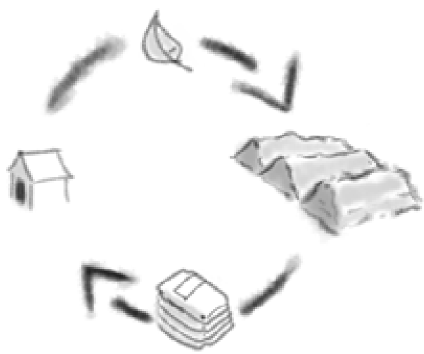
Grønmo compost plant:
Processes 20 tons of material pr. year.
Has material delivery spots spread out around Oslo. Households/ private citizens deliver most matter (70%) while industry deliver the rest.
But industry buy most of the compost back. Strive to make their cycle more local and sustainable. I visited Grønmo to speak to the manager Harald Aanes

I visited Grønmo compost plant mainly for 3 reasons:
1.My initial project idea was based on somewhat facilitating for a biochar/compost situation, so I wanted to learn how you make compost and the processes behind it.
2. I also wanted to learn about the system as a whole, who the users are - which would be the same users, people who needs to get rid of their garden waste. And also how Grønmos' business-model works.
3. Because compost is one of the most fruitful methods of actually getting biochar into the soil, I also wanted to hear what their thoughts on biochar was, and in what particular ways biochar could be relevant for them.

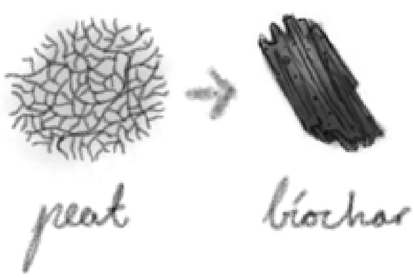
What I learned was:



1.Making a potent compost is hard, you have to manage several stages, materials, temperature, nitrogen/oxygen levels and bacteria - is it too complex to expect most people to be able to do?



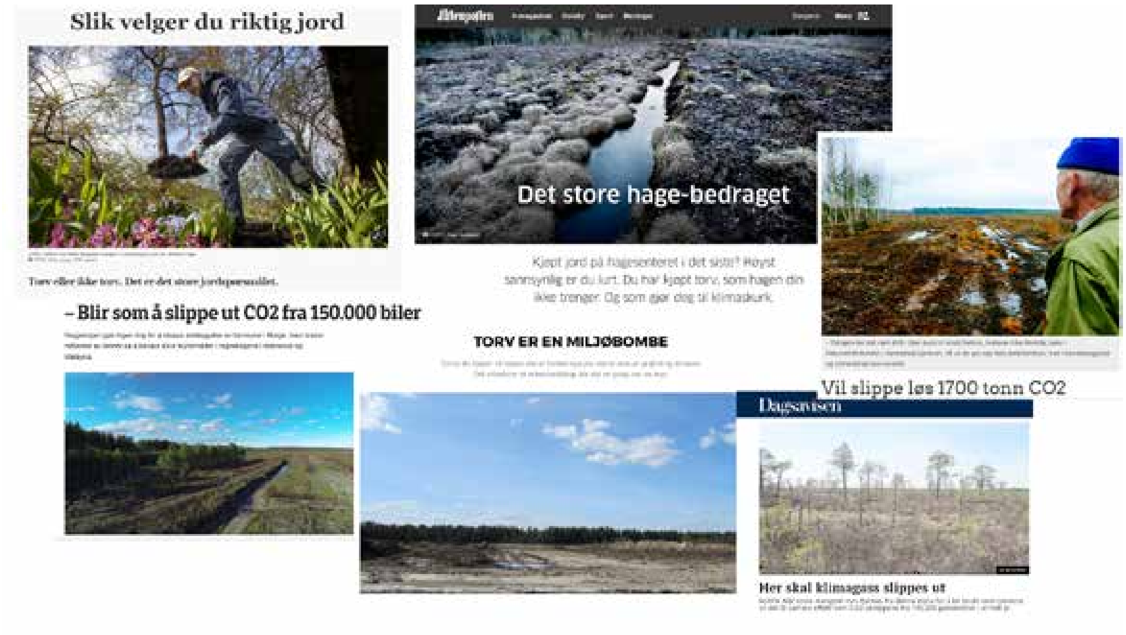
2. Grønmos' system works remarkably well. They have several delivery spots spread across Oslo and a lot of people use them. They continually optimize and improve their system and process, and frankly represent a good example of how sustainable systems can be both profitable and efficient. Is this really a system I would want to disrupt by pushing for a more self dependent system?



3. I learned that biochar has an even more relevant role for the Norwegian compost/soil industry than I previously thought. All compost and soil products made in Norway has what is called torv, or "peat", mixed into it (more on next page). Grønmos own plant-soil product "Tigerjord" has the lowest amount, but some soil-products from other manufacturers have up to 95% peat content. As Harald says in this video: ***Watch attached video titled: "Harald Aanes Compost biochar***

Biochar can act as a direct replacement for peat in soil products.

TORV



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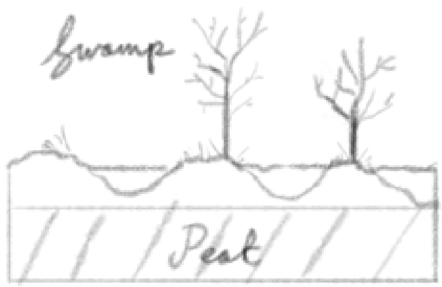
Maybe as a result of people becoming more aware of the environmental effect of the products they buy - the issue with peat has been some what of a controversy in recent years. Peat is used in soil products as a “filler” to give mass,structure and create the wanted pH value. But there are several problems with use of peat:



1. Peat is a non-renewable carbon product. It is essentially partly decayed organic matter, mostly moss, found in the deeper layers of swamps. In the swamps the peat is stable, but once it is excavated from the swamps the peat will decompose and result in carbon emissions.

2. Peat in itself gives no nutrition to the soil, and it decomposes quickly. In practice this means that when you buy and use a peat-based soil product, you will probably have to replace this the next season to have a nutritious soil.

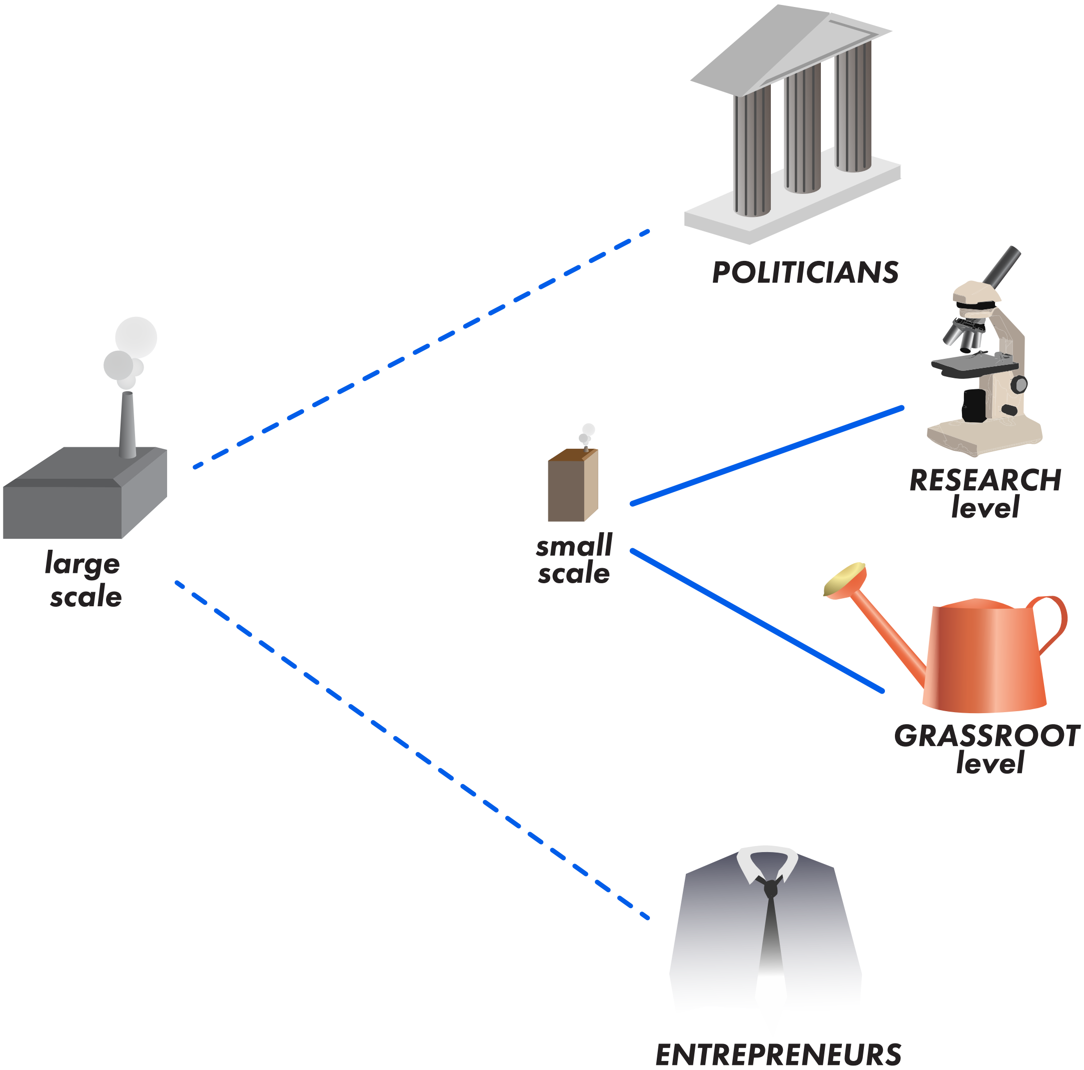
3. The demand for peat has resulted in 1/3 of Norwegian swamps being excavated and ruined, more excavations are also planned. Swamps serve as unique habitats for a plethora of different animal and plant species.

The destructive nature of peat is well known, and the hypocrisies are astounding. Norway invests millions in preserving important swamp areas in Malaysia and Indonesia, while destroying our own swamps(Stenberg & Tomter, 2014). In one example (ref) one part of a swamp is being restored from previous excavation, while another part of the same swamp is being excavated. Peat is also exempt from carbon taxation, the excavation of Jødahlmåsan, which is expected to give a profit of 20 million NOK, would cause carbon emissions totaling at around 100 million NOK if taxed (ref).

So why aren't politicians doing anything to restrict the wide use of peat? The answer right now is that there aren't any replacements. The most talked about viable replacement is coconut fibers, which would have to be imported, and not be any significantly better in terms of emissions. And this is where biochar can play a significant role

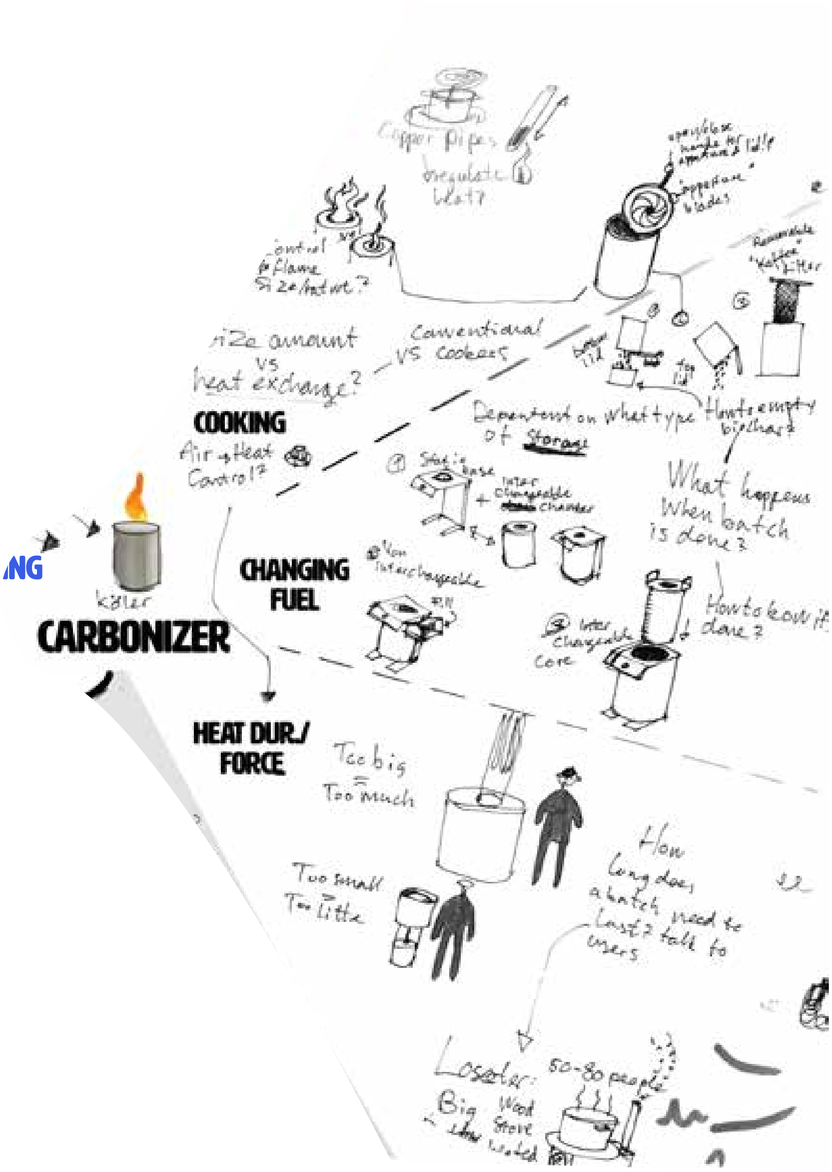
This would be a perfect opportunity for the Norwegian context to both implement biochar industries, and abolish the use of peat. The politicians just have to take notice of the opportunity.

NEW FRAME



My new frame/goal is therefore driven by the agenda of “freeing” biochar from its niche “jail”. As my findings show that its’ biggest obstacle is the mere lack of knowledge of it, and what it can do. The idea of creating a “new” green waste management system with biochar also seems a bit redundant, when it is in fact the established green waste management system that needs biochar the most.

Losæter is an optimal arena to get biochar across to a large portion of the segment that has a need for it - the growers. It is also frequently visited by both media and politicians. The stove can represent what biochar is and its many capabilities.



With the new scope I also shifted my product idea from a large and semi-public outdoor stove, to a smaller more low threshold stove, that can also have potential as a commercial product for "urban" growers.

I therefore chose to strictly design for the "carbonizer" part of the user journey. With focus on ease of use and low threshold functionality coupled with appealing and unique aesthetics. It should be something that grabs attention at Losæter, and sparks curiosity, a talk piece in itself.

2.2.2 BOKASHI

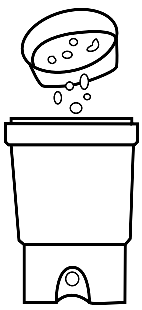
Bokashi is a low threshold compost method, that can be done indoors with no smell, that can seamlessly be used in tandem with biochar.

Askbo, H. (2016)

5

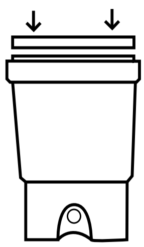
After changing my scope to a solution that was more targeted at individual households, and not so much reliant on a common compost situation, I still had to seek out other suggestions for "final states" for the biochar, if traditional compost would be too complex. Bokashi compost could be just that. It consists of a sealed container with a tap to expel
nutritious liquids that accumulate during the process. Biochar is a optimal sponge for this liquid. By having charcoal in the bottom of the bucket, it sucks up the liquids so the user no longer needs to expel them, and at the same time the biochar is charged with nutrients for the soil.

According to Bokashi Norge, one of the only companies currently selling bokashi kits in Norway, the demand has boomed the last year. Most byers are first-time "composters" and growers. Bokashi be done with any bucket and lid, as long as you have the bokashi-sprinkle (micro-organisms)

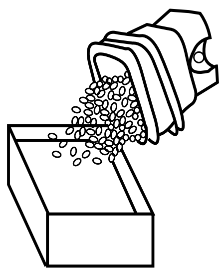


Empty food-waste into the bokashi bucket once a day. Any type of food goes

2 spoons of bokashi-sprinkle per liter foodwaste

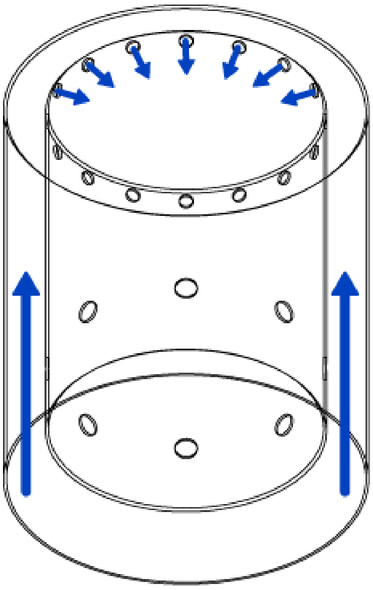


Place the lid and repeat daily until the bucket is full. Then leave it for 2 weeks



Then pour it in and mix it with your plant soil. Mix well and cover it. 3-6 weeks later you have compost soil

TESTING

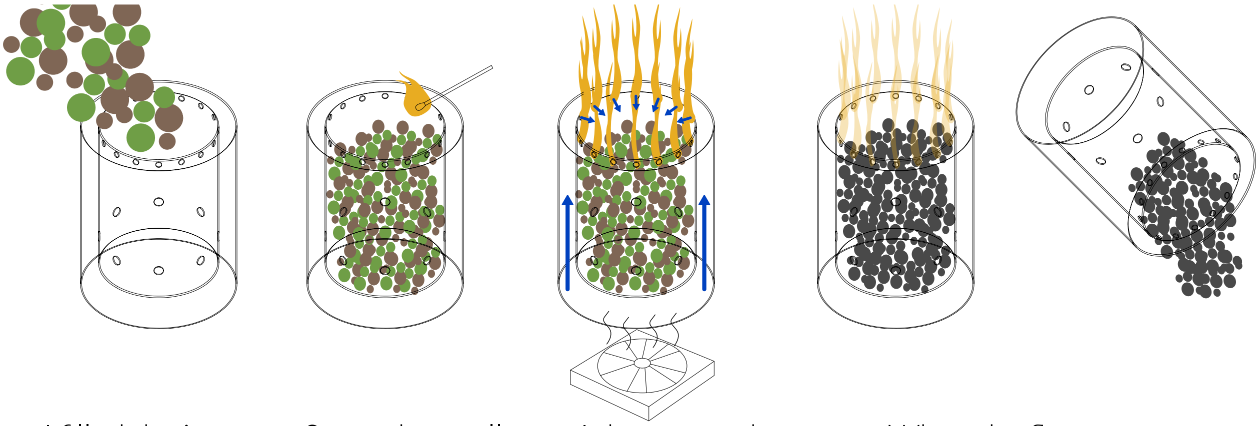


Gasifier stove making has somehow garnered a quite interesting open source “community” online, where stove designs and principles are shared and discussed.

This was a great resource when I built my first test prototype, which was a very simple TLUD stove that I used to make my first “batch” of biochar from some green waste.

Watch attached video titled: "Test 1"
which is my first (successful) trial

How it works:



I filled the inner container with biomass (pellets)

Started a small fire on the top layer using flame accelerator

I then turned on the fan, and few minutes later the gasification start-ed

When the flames shifted "form", about 45min. later the biomass was turned into charcoal.

The setup: For my tests I used 3 differently sized 12V computer fans to see if there was any difference in results, connected to a potentiometer to regulate the voltage. I measured the surface temperatures close to the fire using a high temperature thermometer. I used pure wood pellets to have the exact same fuel parameters.

AESTHETICS

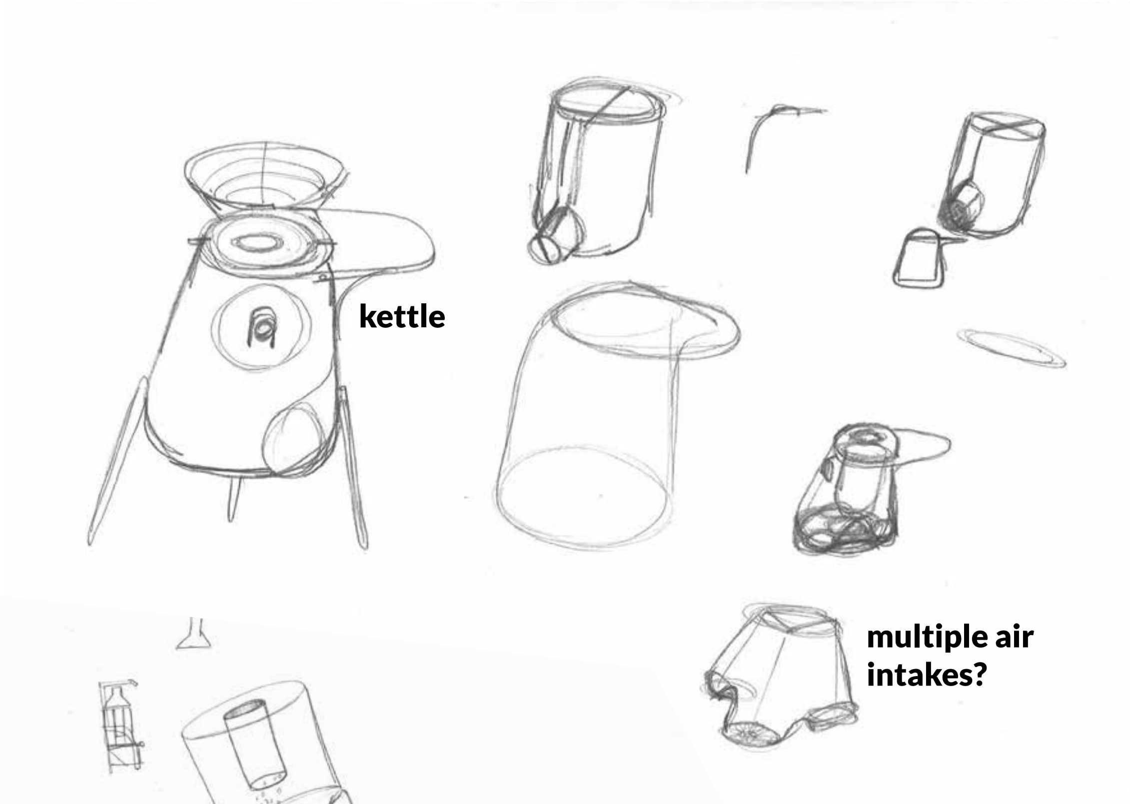
Some of my aesthetic aspirations were:

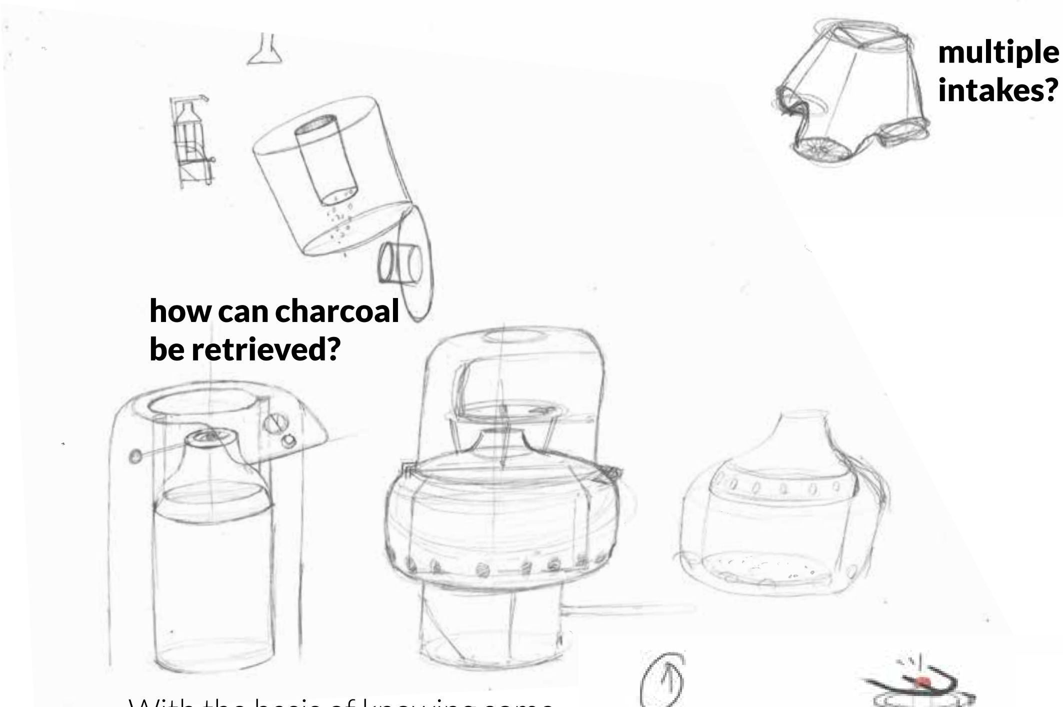
-MATERIAL COMBINATIONS
-“LIVING” MATERIALS
-SOFT MEETING SHARP
-ROUND

With a sparkle of this:

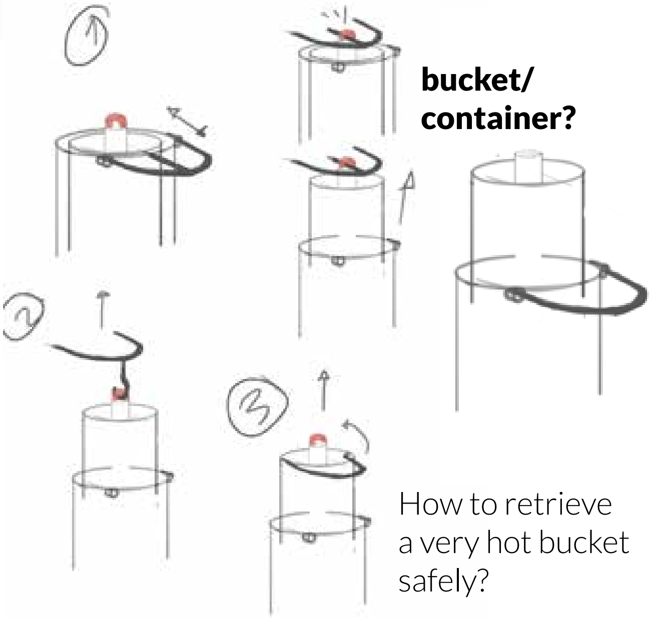
-FLUSH SEAMS
-GROOVES
-SHAPES MEETING

FORM FOLLOWS FUNCTION?

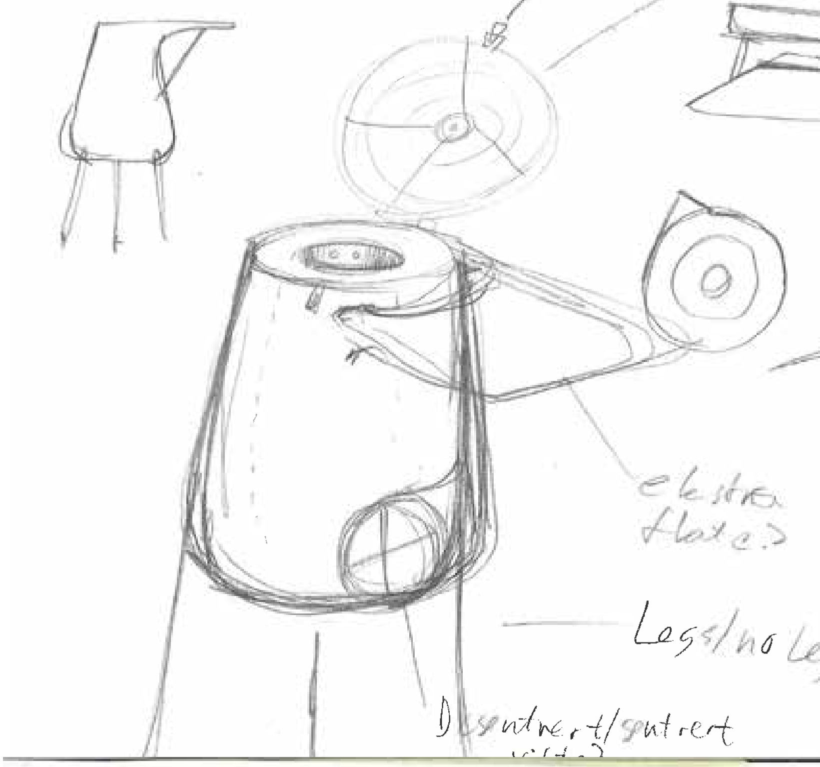




With the basis of knowing some of the technical limitations from the prototypes I ideated around both how certain mechanics could be solved, what shapes that could accommodate the aesthetics and functionality. The TLUD principle limited the design to a barrel shape, I wanted to lift the whole stove up from the ground with legs, it needed an air control interface, a cooking surface for cooking utensils, and maybe most importantly a way to empty the charcoal.

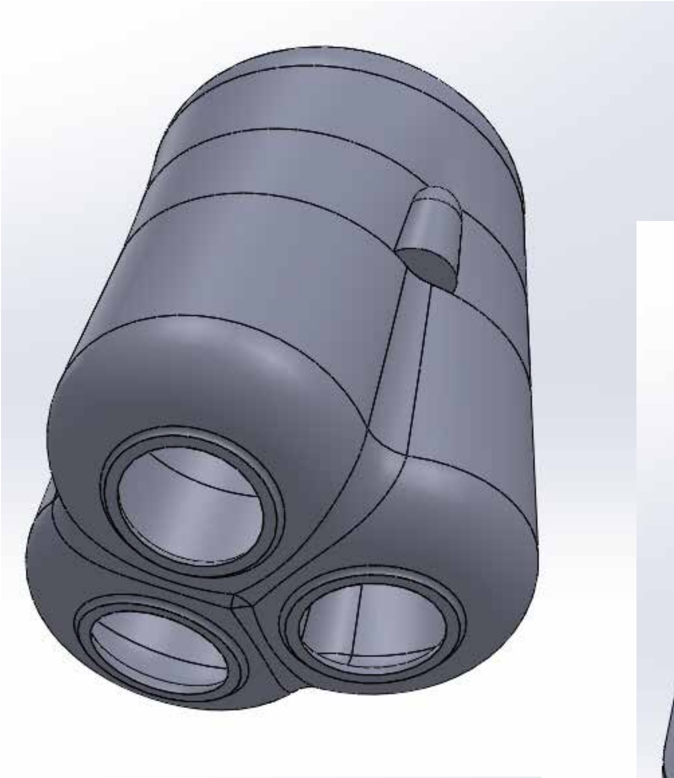


MATERIALITY & SHAPES

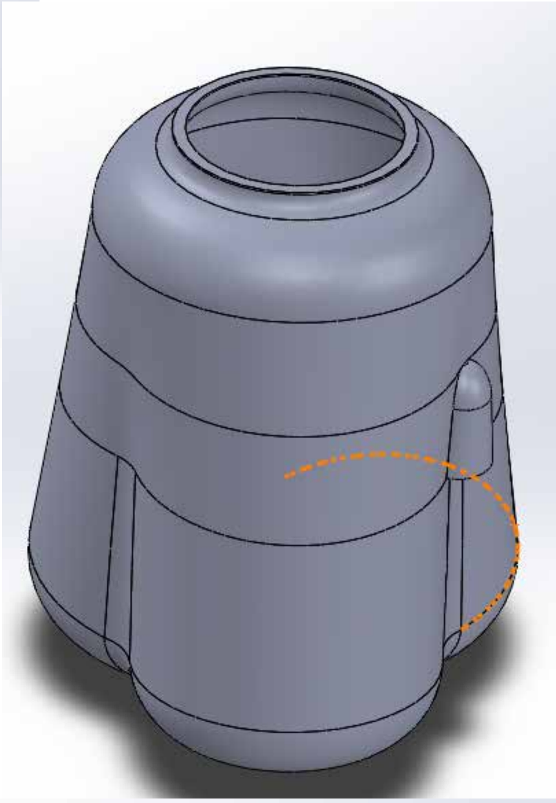


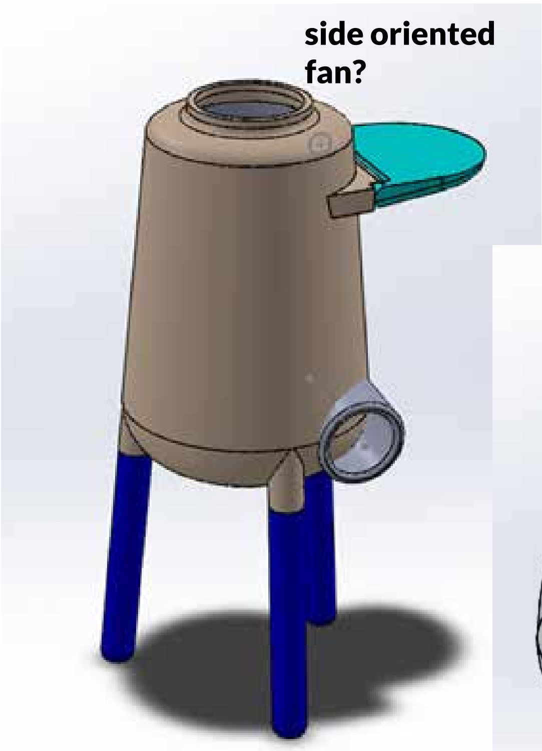
I was looking for ways to make a barrel shape look interesting and beautiful. I quickly leaned towards aesthetics and shapes found in pottery and ceramic objects. It suited the theme and associations of “growing”.

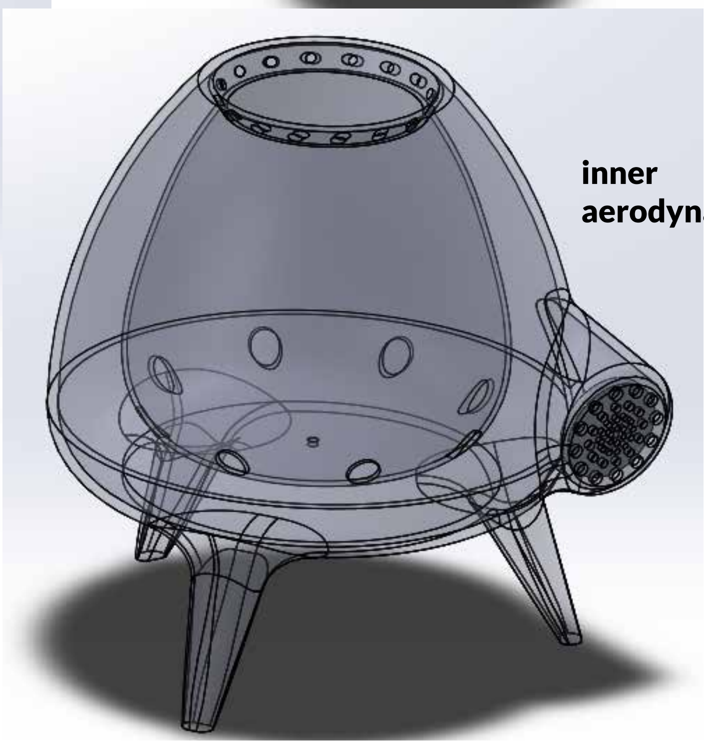
AIR INTAKE + SHAPE



I sooner rather than later explored my ideas in CAD to visu-alize the parts in relation to each other and potentially further prototype



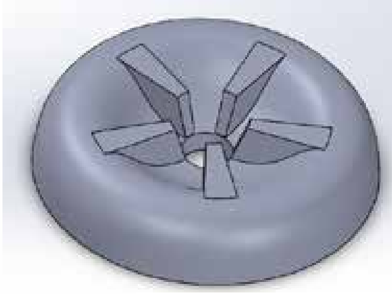




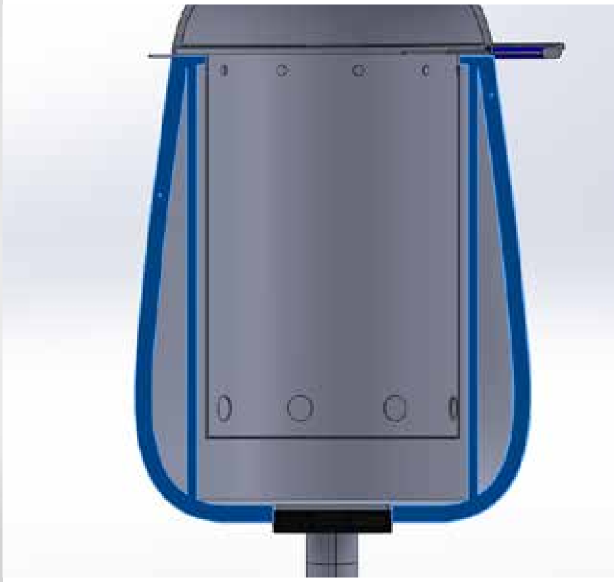
I played with ideas of making inner shapes that could be more aerodynamic, and make the process more efficient. But through further prototyping I concluded that this was not a very deciding factor in that sense.

LID, AIR CONTROL, BUCKET

Kettle stand integrated in lid?



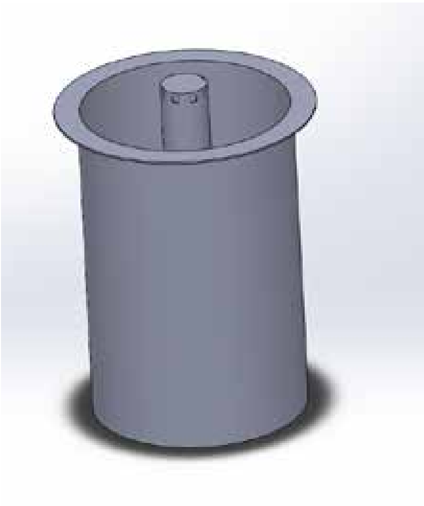
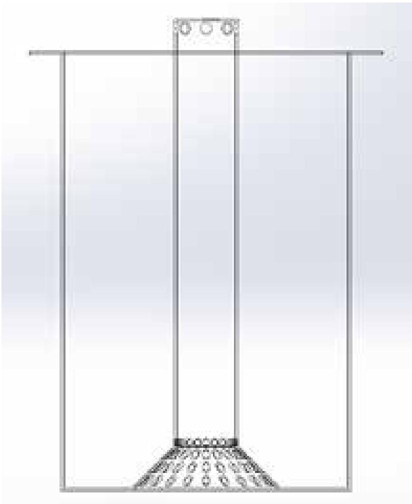
The shape and larger structures started to become more defined. I needed to further define how the lid and kettle stand would function, as well as control the interface



A TLUD is in essence a double layered bucket. I came to the conclusion that separating the layers, with the outside layer being the thick stove shell that could also isolate and contain the heat, and the inside layer being a separate bucket. A gap between them on the inside would let air pass through.

TESTING


The idea of trying to replicate the fire spread found in gas stove muzzles. So that this muzzle could be the only part sticking out from the bucket, and *ideally* give a even flame spread across the kettle/pan.

In this prototype the the fan would push air through a tube going through the middle of the bucket. A cone shape at the bottom of the tube is covered in holes, and the idea was that the upward air pressure would pull gases with it up through the tube before being combusted at the top “nozzle”

Prototype


Result

The prototype was, as shown in the pictures, an utter failure. But I learned a lot about how *not to* do it.

MATERIALS

6

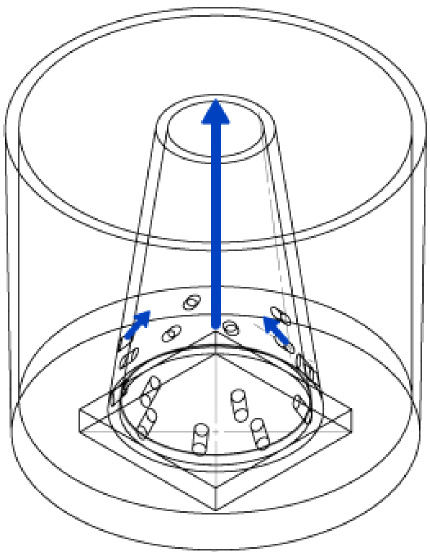
http://cargocollective.com/martabakowskide-sign/Cosmos-concrete

Regarding meterials I was looking for materials that could give a unique look, but still answer to the requirements. The should naturally be stainless steel, but the base/outer shell could be a concrete/cement based material. It would isolate the heat, but heat resistant concrete is quite expensive. It could though also be a more “exotic” material like geopolymer, which is very suited for high temperatures.

COLORS

I was limited by the logic restriction of dark palettes because of coals ability to smear everything with black dirt. Initially I leaned towards having it in the natural color of the material (concrete), gray. But it would become a bit too masculine and tame, so I decided to add a very dark tint of color. Ideally this color would be mixed in with the material to avoid scratching, and extenuate the texture in the material (by not covering it with paint).

TESTING

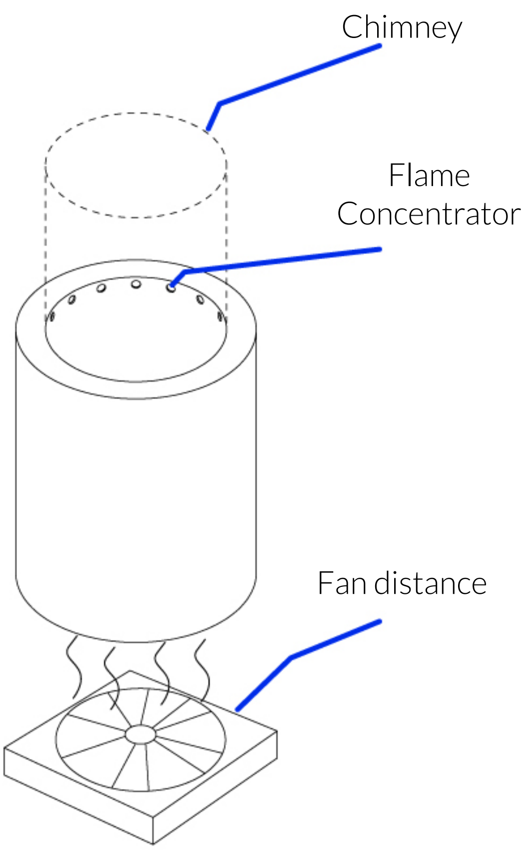


I decided to have try the tube principle again. But instead of going through the work of welding a new prototype just to fail again, I made a mold so I could cast multiple tests in a plaster/chamotte mix. By doing this I could more easily change the parameters without spending too much time building. And to also test a material closer in behaviour to concrete

THE HUNT FOR THE BLUE FLAME

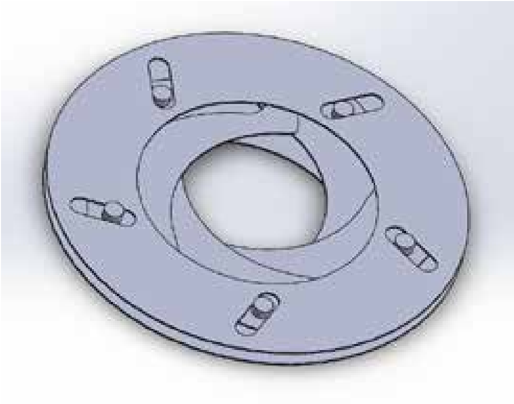
The only way to really ensure a limited amount of sot on the cooking utensils using a flame, is to have a very clean burning flame, meaning that most of the debris are burned off. So achieving a bluish flame was an underlying goal during my testing. After a lot of trial and error I found a good combination of parameters to achieve an efficient *enough* flame.
Watch attached video titled: "Test 3"

As seen in the video, the following parameters ensured the results:

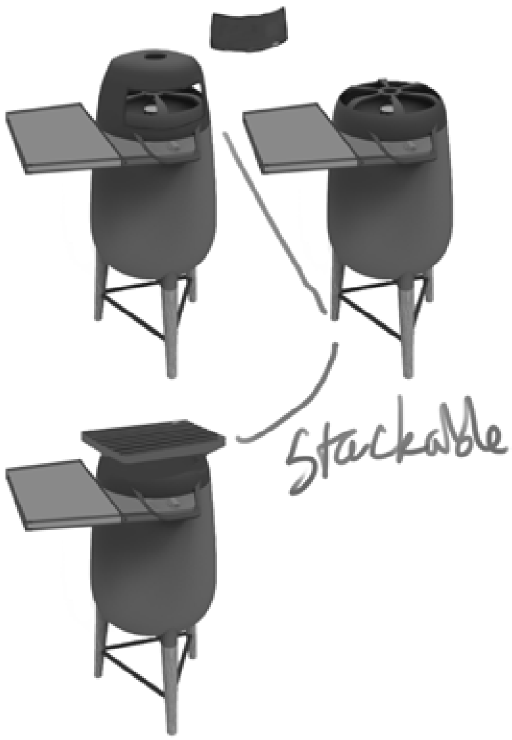


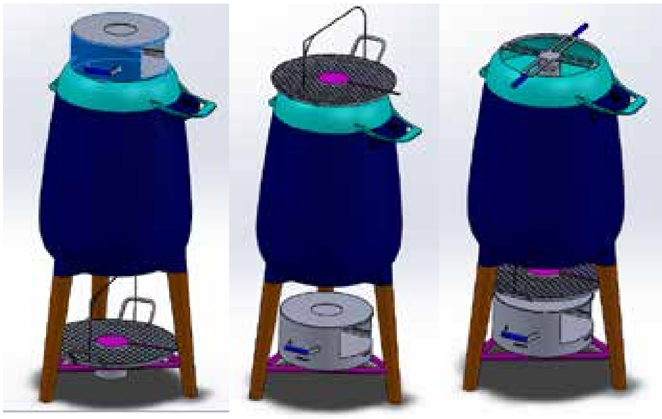
The tube principle was actually more efficient at producing a very hot flame. But after discussing the two solutions with Andreas we decided to go for the conventional TLUD. The reason was the space limitation that the tube gives. You would be limited to certain sized biomass, and char could potentially get stuck

LID+ MODULES

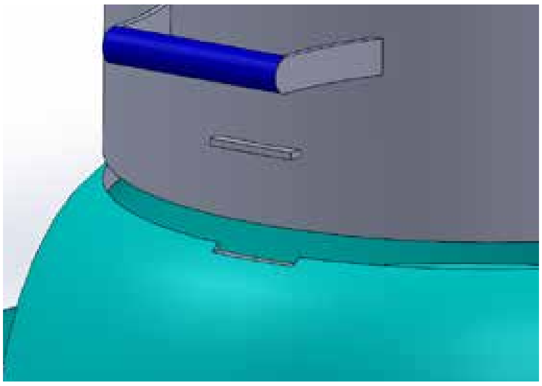


An “aperture blade” type closing mechanism could be used to either open/close the fire concentrator hole to adjust flame spread, or to close off the air-intake at the bottom - to avoid extra lids.



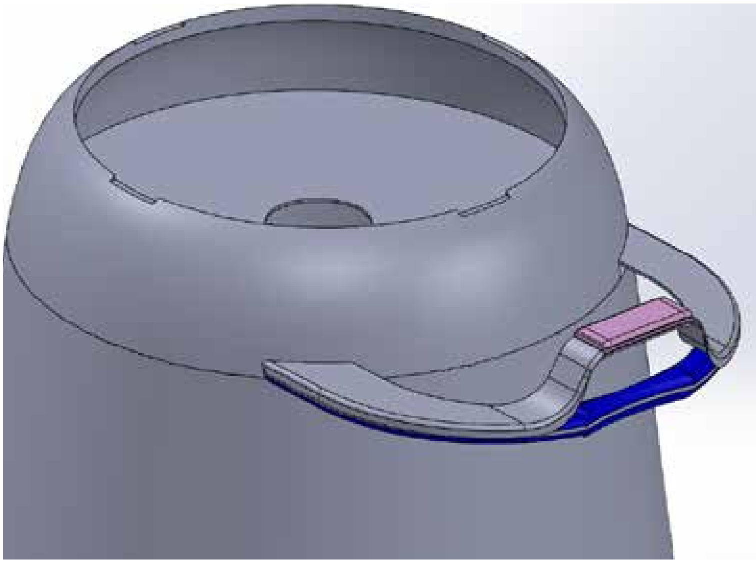


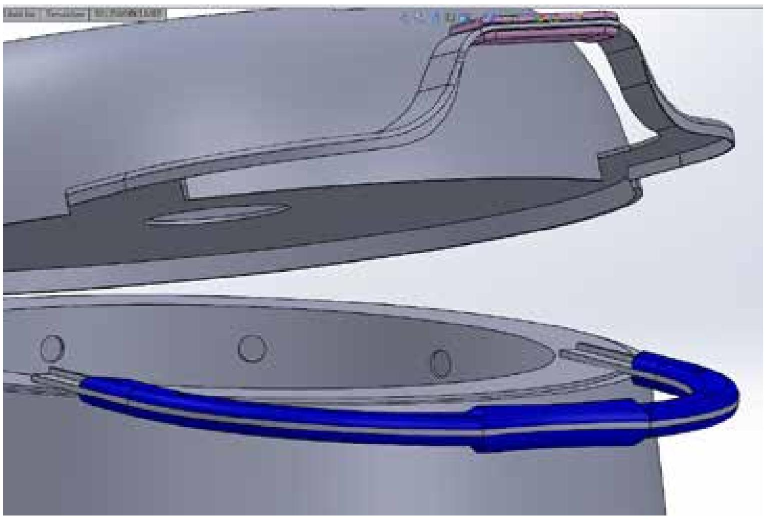
Could the demand for flexible cooking capabilities be met by implementing a modular solution. Where the kettle stand was the standard, but additional modules including a grill and an oven could be put on the stove instead.

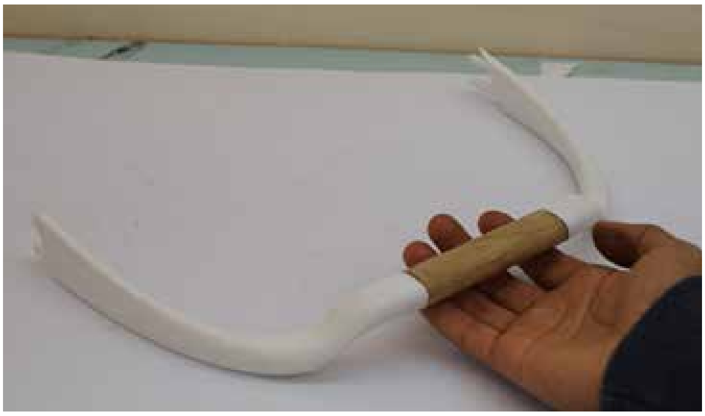


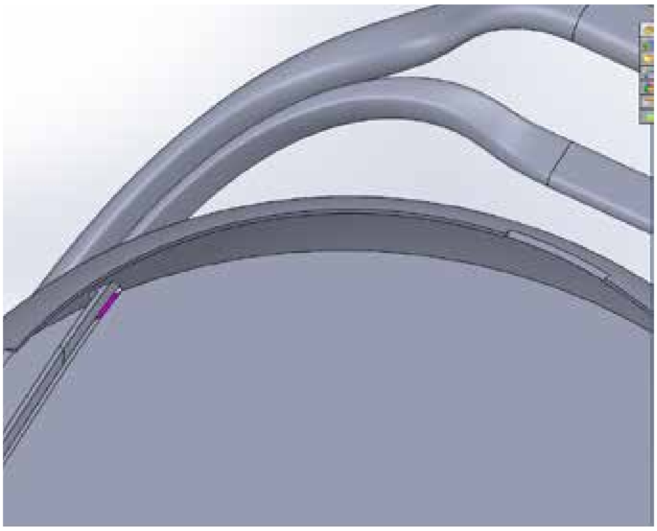
A solution could some insert slits on the lid itself.

HANDLES









MEETING PRIME STOVES

Prime Stoves is a company that produces cooking gasifier stoves, mainly for developing countries like Indonesia, Malaysia and Zambia. Their gasifiers have natural draft (no electric fan), and they produce two models, one for finer and one for cruder materials.


4

I met with Camilla Fulland and Jørund Buen, two of the founders of Prime Stoves to get some insight into:
1. What makes their stove, or similar gasifier stoves competetive?
2. Marketing strategy
3. Who are their users, and what are their biggest challenges with the stove?
4. Why do they not market the possibility of biochar?
5. Discuss my solution.

And what I learned was that:

1. One gasifier is a heavy economical investment for their target group but, in many developing country contexts, it can substitute the use of "stove stacking" (which is the use of multiple stoves/fireplaces for different purposes). Could gasifiers be a substitute for grills on the western market?

2. A lot of educational marketing, introducing and teaching how gasifiers work, and word of mouth.

3. The target group is working class families. The biggest challenge is gasification being a very foreign concept for users who their whole life burned wood in a "campfire" way. A lot of follow up instructional work is needed to ensure that the product is used the right way. Is this threshold maybe lower for a western market?

4. Gasification is a foreign enough concept already. Introducing biochar to the mix would clutter and complicate the message. Even though many users could have good use of biochar for growing, most people see it as waste to not use the energy available in charcoal for heat. People don't want to think about anything else than the cooking happening

5. Camilla and Jørund thought my solution seemed viable, in terms of the technical solution and safety. Using a fan gives a lot of leeway in terms of materials that can be used and ventilation "precision" - but I should not aim to develop the technical solution any further, an expert would be needed to optimize the solution.

COMPARATIVE STUDY - BIOLITE

Optional attached video titled: "Optional Biolite"

Cooking capabilities:

Camping stove
Heat regulation
2 steps
TLUD without gasification **

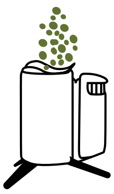
Fuel:

Biomass, changed between every use, duration depending on biomass used (Potentially free)

Mobility:

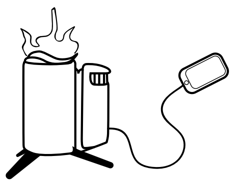
Very portable

Journey:



Fill inner container with any biomass

A fire is started on top of the biomass using lighting fluid, other accelerator. Fan turned on



Small meals can be cooked, and phone/other batteries can be charged

When done, empty the ash / debris

**The inner container is covered in air holes, to let as much air as possible in. This is (probably) to make for a simple combustion of sticks etc. you would find in the woods. The air ventilation makes for a very fast and simple startup, but this combined with the small size hinders gasification happening (too much air).

+

- Portability
- Generates electricity
- Very fast startup

-

- Low heat output
- No windshield blows flame in all directions
- Limited cooking capabilities

COMPARATIVE STUDY - IKEA KLASEN GRILL

Optional attached video titled: "Optional Ikea"

Cooking capabilities:

Grill & Oven
Heat regulation
(3 step up to 250 C)
Heat startup: 5min+

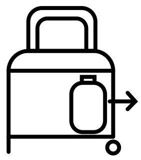
Fuel:

Gas, changed every season at gas stations (1000kr)

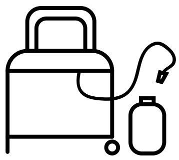
Mobility:

Litmited, has 2 wheels, can be moved over straight surfaces

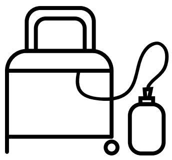
Journey:



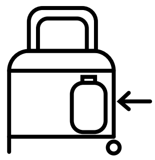
Before use gas canister has to be lifted out from underneath



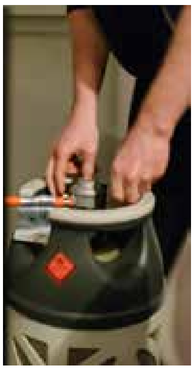
Connecting the gas hose was the hardest part, it took over 7 minutes which I was told was the average time it took to get it right.



Once installed the grill is ready to be used



When done, the hose has to be disconnected (easier than connecting) and can be put back under the grill



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- When connected it functioned correctly.
- Smaller than average gas grill.
- Gas can lasts a whole grill season.

-

- Gas hose almost impossible to connect.
- Low heat output.
- Oven loses all heat if lid is opened.
- Tends to burn food

BIOCHAR STOVE

Cooking capabilities:

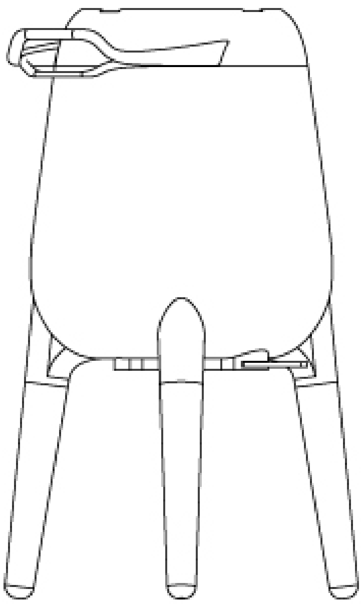
Stove (potential for grill + oven)
Stepless heat regulation
Heat startup: 2-5min

Fuel:

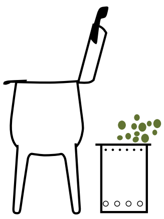
Biomass, changed between every use, duration depending on biomass used (Potentially free)

Mobility:

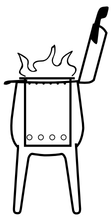
Mainly static, can be moved but not while in use



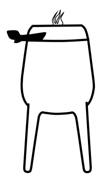
Journey:



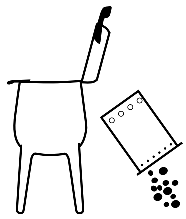
Bucket taken out and filled with biomass (at least 3/4 full)



A fire is started on top of the biomass using lighting fluid, other accelerator. Fan turned on



After between 2-5 minutes of even fire on top gasification will start and device is ready for cooking.



When flame becomes almost invisible gasification is done, biochar can be retrieved, *or* cooking can continue on heat from charcoal.

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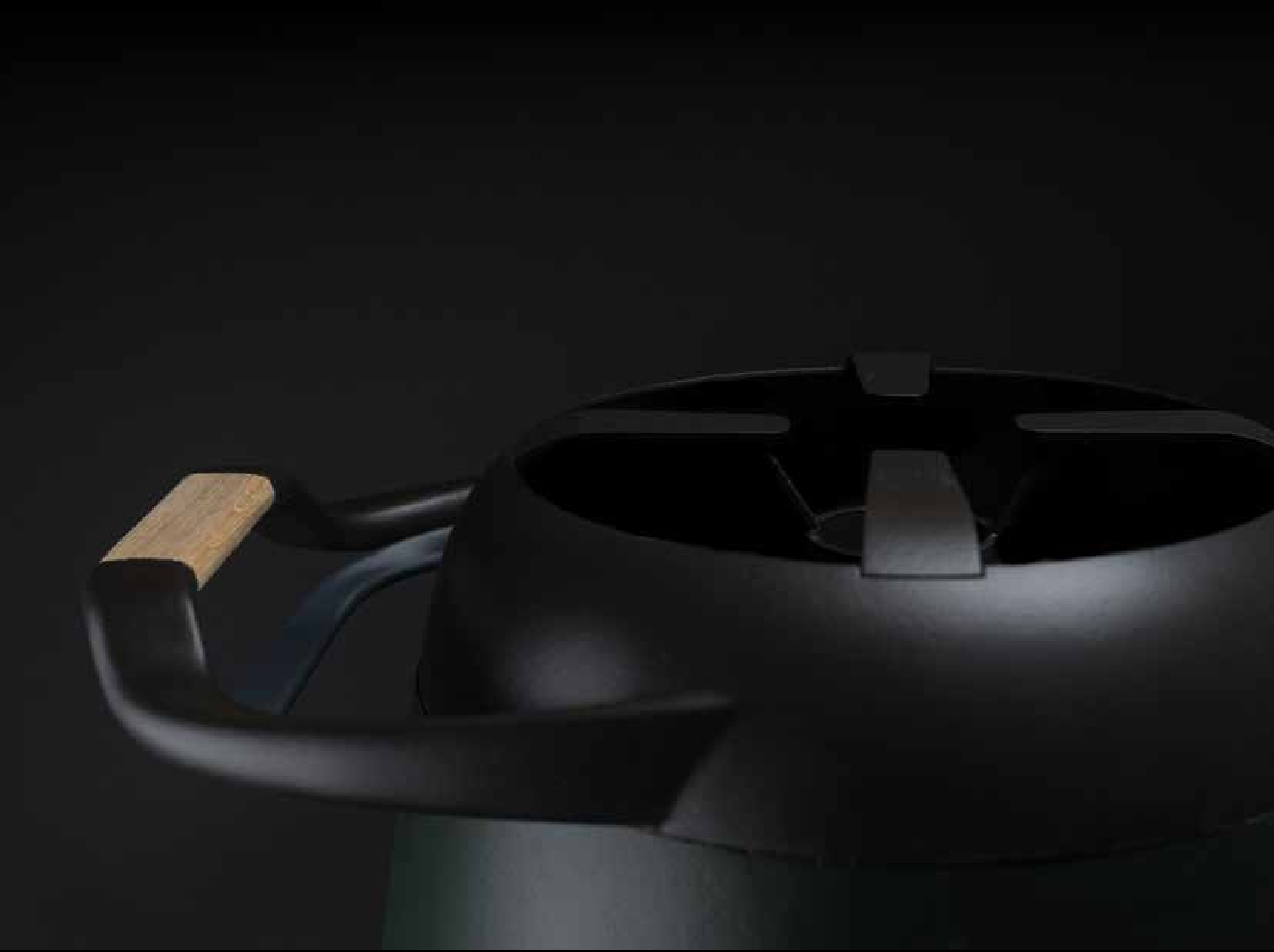
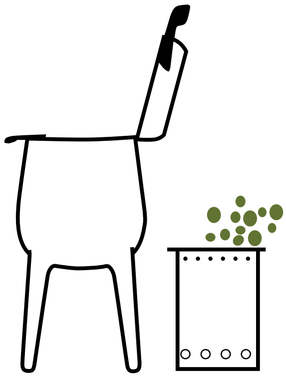
- Fuel is (potentially) free
- Useful biochar byproduct
- Multiple cooking capabilities
- High heat output.

-

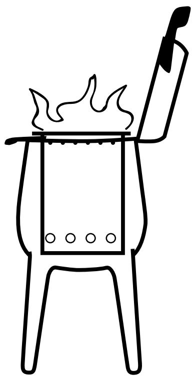
- Inferior heat control on low temperatures
- Low level of mobility
- Charcoal can be dirty/messy
- Many steps from startup to finish

E M U
A BIOCHAR STOVE

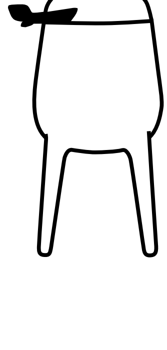


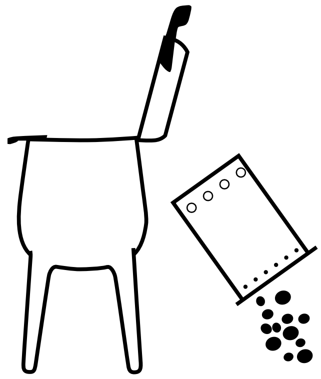



Fill the bucket with biomass, it can be v firewood, pellets or green waste from your garden. Light an even fire at the top layer using lighting-sticks/fluid. Turn on the air and wait 2-5 minutes before closing the lid.

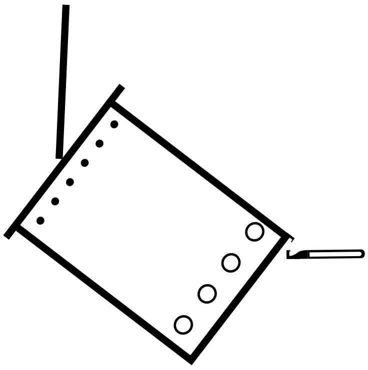


While cooking use the air controller
to adjust the flame heat and intensity

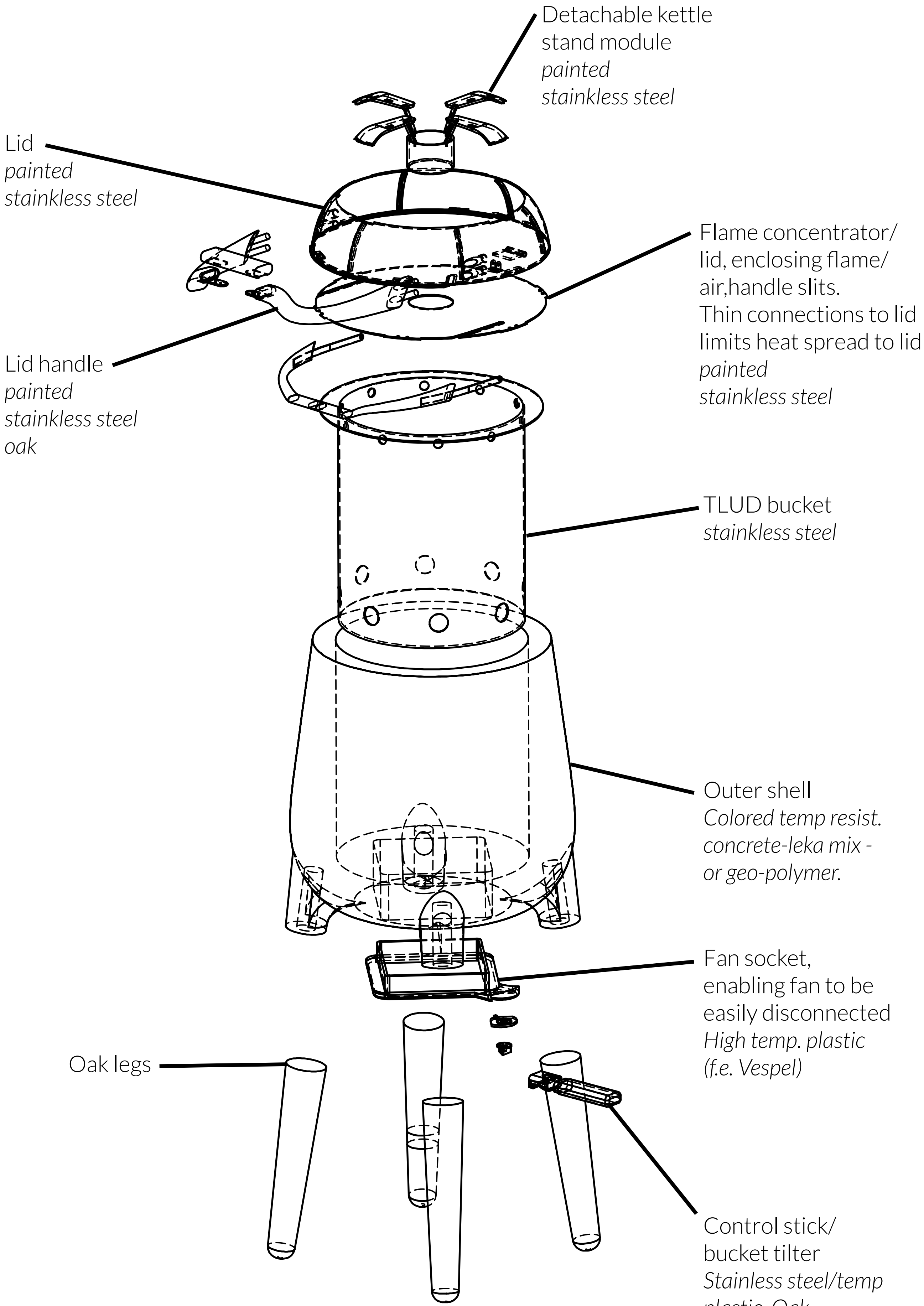




When the flame changes color and transparency, biochar is done. Cooking can continue, or charcoal can be retrieved.



Detach the magnetic control stick to safely tilt and empty the biochar content


Detachable kettle
stand module
painted
stainkless steel
Lid
painted
stainkless steel
Flame concentrator/
lid, enclosing flame/
air,handle slits.
Thin connections to lid
limits heat spread to lid
painted
stainkless steel
Lid handle
painted
stainkless steel
oak
TLUD bucket
stainkless steel
Outer shell
Colored temp resist.
concrete-leka mix -
or geo-polymer.
Fan socket,
enabling fan to be
easily disconnected
High temp. plastic
(f.e. Vespel)
Oak legs
Control stick/
bucket tilter
Stainless steel/temp
plastic, Oak

FURTHER DEVELOPMENTS

There are several parts and aspects that are in need of further development and definition. I have focused on presenting a viable solution in the broader sense, and defined the most important aspects in regards to technical viability, use and safety.
Parts and aspects that definitely further developments are:

1. Closing mechanism on air intake to easily shut air/gas-flow and cut the flame before taking out bucket.

2. Thermo-electric generator, akin to the Biolite. Now the fan is reliant on conventional batteries. Implementation of a thermo-electric generator would alter the bottom part of the shell.

3. Alignment sockets for bucket placement, to ensure that the bucket is inserted in the right specific place every time. To have a uniform inner gap between the bucket and the shell, and to have the bucket handle always align with the slits in the lid.

4. Grill & oven modules are theoretically viable, but would need testing and further definition, I am therefore not presenting these as part of my main proposal.

5. Fan/battery pack connect/disconnect mechanism in fan socket

6. Non-disruptive lid for kettle stand hole

7. Handles to lift the stove. For the Losæter context, the most the stove will most likely be molded into the outdoor kitchen bench, so mobility is irrelevant. But in terms of it having potential as a commercial product, it would need more considerations into mobility, possibly through side handles.

CHAPTER 5 - REFLECTIONS

My process has been a focused in many different directions. Originating from the very big issue our planet is facing, I fought to find a point of entry where I as a designer could feel I contributed.
I had a lot of assumptions going in to this project, especially regarding what I thought would have the most impact. But through investigation and interviews I realized that the problem in some sense lies in the way biochar has been marketed. This gave me a more concrete and limited frame. I could focus on what I feel I know best, which is functionality and aesthetics.

But what went more according to my set plan was my ambition to test and successfully produce functional proof of concepts that I could base my solution on. In hindsight I maybe went a bit far in that direction, and could have settled with my earlier results (which I ended up using anyway). These are areas that would need more expertize, and I have no ambition of doing “engineering” tasks, but I felt that the principles were simple enough for me to handle.
I had plans of producing a 1:1 scale prototype to test at Losæter, but unfortunately time constraints hindered this. Though I felt that my tests gave enough information for me and Andreas to discuss the solution in a meaningful way.

In terms of my design and aesthetic choices I feel I managed to create something that is appealing, and that can garner some attention. I wanted it to spark curiosity, but at the same time give indications of what purpose the product has. I devoted a lot of time to the production of the visual model, which ate some of the priority regarding the more technical aspects. It is not finalized down to every detail, but I do feel I solved the most important parts.

For me this project will continue well in to the summer. We will test more prototypes at Losæter and hopefully find a way to fund the production of a “real” (visual + functional) prototype that can serve its purpose of “Biocharging” Oslo, or not.

This is what Andreas has to say about it: ***Watch attached video titled: “Andreas Capjon Stove”***

CHAPTER 6 - REFERENCES

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