NEST
stove

an efficient oil-heating stove that transfers heat equally

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Faculty of Crafts and Design - Industrial Design

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Nest stove

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Acknowledgement

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I want to thank the engineers and everyone who gave me advice for their time and assistance.

I want to thank my parents and family for their unconditional love and support. You are the reason why I stay strong and the reason why I am here. Love you.

Thank you, everyone.

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1.0 INTRODUCTION.

1.1 Problem

Due to rapid urbanization, climate change, extreme weather, and in search of a better life, many people from rural areas migrated to Ulaanbaatar, Mongolia's capital city. Those people live in the ger district, a form of a residential district, where people set up traditional yurts called ger. Because this district is unplanned, they lack social infrastructures such as water and heat. Therefore, due to the harsh, cold winter in Mongolia, people burn raw coal to cook food and heat their homes. According to the Asian Development Bank (2019), "over 200,000 ger households burn coal and other combustion fuels, accounting for 80% of the city's air pollution."[1]

Everyone has a right to live in a safe and healthy environment. However, people in Mongolia live in a hazardous atmosphere due to the extreme amount of air pollution in the capital city, where they are suffering from health issues just by breathing air. Therefore, my capstone project intends to come up with an eco-friendly solution for the stove that can reduce air pollution and improve the quality of life of people in Mongolia. I will focus on improving the stove that the locals use in their daily life and will design it to be more convenient for the user and safe for the environment.

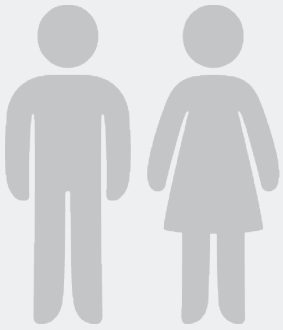
Figure 1.01: Yun Wu & Celia Rong Cui. *Paving the way to sustainable heating in Mongolia.*

1 Mongolia's Ulaanbaatar Breathes Easier After Cleanup of Air Quality. (2022, June 9). Asian Development Bank.

1.2 Target Users

Key Demographics:

- Age: 25-50
- Gender: 60% Female, 40% Male
- Accommodation: Preferably lives in yurt
- Location: Ger district in Ulaanbaatar



Key Psychographics:

- Concerned about outdoor and indoor pollution
- Willing to take action against air pollution but don't know what to do
- Cooks regularly on a stove

Challenges:

- Has limited budget to spend on products
- Finds it difficult to use the current stove and aware of its danger
- Needs affordable, safe, and user-friendly product

1.3 Background

I grew up in Ulaanbaatar, Mongolia, one of the most polluted cities in the world. I remember going to school during a cold winter day and not being able to see my surroundings due to the extreme amount of smog. My school was located near the most polluted area of the city. The hallway used to fill up with smoke and the smell of burnt coal would stink my hair, clothes, and bag. Growing up in that kind of environment made me worry about the health of myself and my loved ones. Air pollution is a long-term killer. You might not notice the change in your body now, but it will damage your health in the future. Therefore, as an industrial design student, I want to contribute my knowledge and skill to come up with a solution no matter the size of the impact.

Figure 1.02: Nogoon Hutuch. (n.d.). *Ger District.*

2.0 RESEARCH.

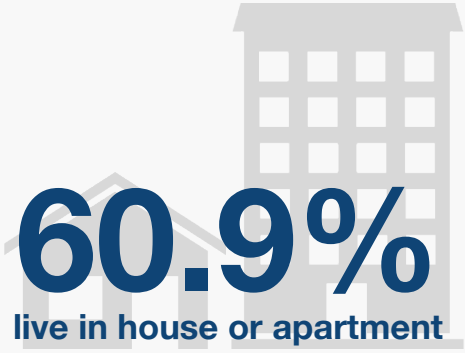
HOW CAN THE AIR QUALITY BE IMPROVED IN MONGOLIA?

Health is a person's most precious treasure. The basis of both human and animal well-being is breathing fresh air. Breathing polluted air can lead to many health risks such as respiratory issues, heart diseases, and lung cancer. Some may not notice the effect instantly but breathing polluted air leaves permanent damage to one's health.

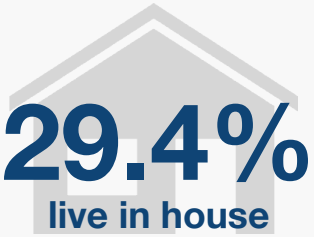
I started my research by pursuing different directions. From searching for an alternative for raw coal to possible insulation improvement in a ger (yurt). After researching possible directions, I have decided to focus on the stove. The stove that the locals use is mainly used for cooking and heating. The problem with the one that they use right now is that it is hazardous for both outdoor and indoor use, complicated to use and aesthetically unpleasant. Even though there are numerous stoves on the market such as electric, ethanol, and wood-burning, most of them are not suitable to use for Mongolian people as they are expensive, considering the average salary that Mongolians get and hard to adapt for use in a traditional ger.

2.1 Statistics

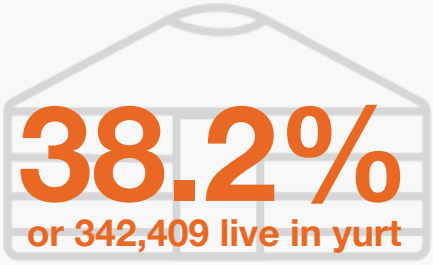
Total number of households in Mongolia: 897,427



60.9%
live in house or apartment



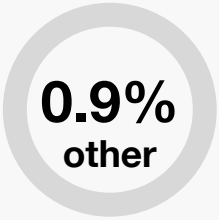
29.4%
live in house



38.2%
or 342,409 live in yurt

More than 80% of the current air pollution in Ulaanbaatar comes from the part of the city known as the ger district. Researchers estimate that at 200,000 gers, approximately 600,000 tons of raw coal was burned for heating during the winter season.[2]

8.4%
have no home



0.9%
other

2 Saygi. (2022, April 9). Air Pollution in Mongolia: Ulaanbaatar is at High-Risk. SfS.

2.2 Current Products

There are two types of stoves that the locals use in their daily life. One is conventional (traditional) stove and the other is improved stove.

Conventional stove

Figure 2.01: Facebook. *Traditional stove*.

Advantages:

- Strong sturdy material that lasts longer
- Heats up quickly
- Cheaper

Disadvantages:

- More waste
- Extra unnecessary steps
- Poor air circulation because it is old
- Emits coal-like odour

Improved stove

Figure 2.02: Tourist Info Center. *Improved stove*.

Advantages:

- Keeps the warmth longer
- Spending less money on coal
- Doesn't emit coal-like odour
- Better design
- Much easier to use

Disadvantages:

- Lid is small so it is difficult to remove ash
- Exposed to fire when cooking (dangerous)

2.3 Interviews & Discussion

Questions

1. What are the advantages of using a smokeless stove over a traditional stove?

2. What are the difficulties in using a smokeless stove?

3. After lighting the stove, how long does it take for a house (yurt) to heat up? And how long it keeps the warmth at home?

4. Smokeless stoves were first introduced as measures against air pollution. Do you think air pollution has decreased?

5. What do you think needs to be improved about smokeless stoves?

6. Have you ever thought of a more eco-friendly option than a smokeless stove? For example, solar panels etc

User A. Improved smokeless stove. Lives in a yurt.

1. It is convenient to use and I think it has a better design than the old one. The old traditional stove was bigger and it takes a lot of space.

2. Might be dangerous. It is hot so we have to be careful. I know that there are a lot of incidents of people suffering from carbon monoxide. Sometimes kids put in too much coal without knowing and it could lead to danger. I always tell my kids to light the stove properly because carbon monoxide is a silent killer.

3. It's pretty quick to heat up and keeps the warmth long enough. I used a traditional stove before and compared to that it works way better.

4. Not sure. It might have decreased but I still see some smoke when I go out.

5. Not sure

6. Yes. The information on environmentally friendly options is a bit limited. Not a lot of people advertise it or recommend it to us, so I can't answer that question. It would be great if we use electricity. But the infrastructure of our city is poor.

User B. Improved smokeless stove. Lives in a yurt.

1. It is convenient to use and I think it has a better design than the old one. The old traditional stove was bigger and it takes a lot of space.

2. Might be dangerous. It is hot so we have to be careful. I know that there are a lot of incidents of people suffering from carbon monoxide. Sometimes kids put in too much coal without knowing and it could lead to danger. I always tell my kids to light the stove properly because carbon monoxide is a silent killer.

3. It's pretty quick to heat up and keeps the warmth long enough. I used a traditional stove before and compared to that it works way better.

4. Not sure. It might have decreased but I still see some smoke when I go out.

5. Not sure

6. Yes. The information on environmentally friendly options is a bit limited. Not a lot of people advertise it or recommend it to us, so I can't answer that question. It would be great if we use electricity. But the infrastructure of our city is poor.

User C. Improved smokeless stove.

1. It is introduced first as a smokeless stove to reduce air pollution. I can't say it was reduced. But the new stove has a better design. The old stove was big and bulky but the new one is smaller and they added some colour.

2. It is much better than a traditional stove. I can't think of anything right now but I'm also not happy with it either. There aren't any better alternatives.

3. It heats up pretty fast and keeps the warmth long enough

4. No. A few days ago, I went to my mother's house, which is away from the city. It was nice to breathe some fresh air. But on my way home, I could see the smog of the city. It was horrible. I am honestly frustrated that we are living in this kind of environment. I am most worried about my kids and future generations.

5. It leaves soot. It would be nice if it doesn't leave anything.

6. No. I'm not sure if there is any eco-friendly option available out there. It's not that I don't want to change into it, I just don't have enough information about it.

User. Traditional stove.

Q: What are the difficulties in using a traditional stove?

A: I used to use a traditional stove before, so use-wise it is not that bad. However, I observed that it produces more waste and requires a lot more steps than the new one. In the morning, during the day, and at night, I must light up. It has poor air circulation because it is old. It occasionally emits a coal-like odour.

Q: After lighting the stove, how long does it take for a house (yurt) to heat up? And how long it keeps the warmth at home?

A: It heats fairly quickly. Heating up probably takes 15 minutes. How much coal you put in will affect how long it will maintain its heat. For instance, I lit it up this morning at 7 and added a small amount of coal at 9. Then one more at 4 PM. The issue is that the traditional stove produces waste since it doesn't entirely burn coal.

Q: How much coal do you approximately use in a month?

A: One sack of coal lasts for 2 days. Also, I use wood and one bag lasts for 2 days as well. Sometimes I like to add cow dung because it smells nice. I don't like coal's odour. Cow dung might be ideal, but it burns poorly and produces ash.

Q: Smokeless stoves were first introduced as measures against air pollution. Do you think air pollution has decreased?

A: No. To be honest, nothing changed as a result of it. I believe it is preferable to stop using coal and look for alternative solutions. There will always be air pollution as long as we burn coal.

Q: Have you ever had any problems with smokeless stoves? Injuries etc.

A: Not really. But I am aware that we have to be extra careful to not burn ourselves. The metal part needs to be sturdy. It's also crucial to regularly replace the old chimney. A traditional stove's ashtray is quite thin, and I believe it should be stronger and thicker. If the chimney is too short, a spark could fall on the yurt's fabric, hence it must be long and tall.

Q: Have you ever thought of a more eco-friendly option than a smokeless stove? For example, solar panels etc.

A: Yes. I wanted to install underfloor heating but people told me it doesn't work for wooden floors. I also have a low-energy heater that I only use during extremely cold weather. It is very convenient. I wish I could use it without burning coal all winter long. I am aware that the government is taking measures to reduce air pollution, such as relocating residents from ger districts to apartments. But some people simply don't like the idea of living in an apartment. I enjoy living in the yurt since it is easier for me to get outside and take care of my garden at home.

Figure 2.03: Asian News. *Ulan Bator, shepherds flee pollution: 'The air is unbreathable'.*

Physician, Environmental Health Scientist (discussion)

Her team has studied the effectiveness of the new stove in comparison to the older, more conventional one. First, they went to the ger district and installed a measurer in the chimneys of both the new and the old stoves. They first measured how much the smoke decreased. Overall, it revealed that the new stove produced 65% less smoke than the old one. Second, the new stove's capability to keep the heat for an extended period was also tested. One measuring device was installed near the stove and the other in the farthest spot of the home. The result was positive. During her research, the majority of people were using the new stove.

When asked why air pollution is not decreasing while the new stove is showing better results, she responded that many people are switching back to their old stoves. Because the new one is more expensive than the old one, some people have sold their new one. Another factor is that the stove's broken parts cannot be replaced. Many chimneys broke, and when people tries to replace them, there were no compatible replacement parts on the market. The new stove has different components than a regular stove. It is hard to find them. And even if they find it, most of them can't afford it. She mentions that poverty also contributes to air pollution.

2.4 Observation

The Mongolian government began replacing the old, conventional stoves with new ones in 2010 and produced a new stove that is believed to be smokeless. Additionally in 2019, the government banned the use of raw coal in favour of “refined coal briquettes” to reduce air pollution.[3] Through observation on how to use the new stove with refined coal briquettes, I noticed some problems with it.

Steps of using a stove:

1. Clean all the ash inside the stove and make it free of residue.

2. Coal can be placed up to a maximum of 60% of the total space of the stove, if more than that, there is a risk of overheating. Coals should be selected as small as possible, and too large or too powdery will affect the complete combustion of the stove.

3. Wood should be equal to 3/1 of the total amount of coal, and it should be fine wood. Light the fire by sticking a piece of paper in the middle of the wood.

4. All the valves should be kept open when the fire is lit, and when the fire enters the coal, top and bottom valves should be closed.

Figure 2.04: Ubcap. Right way of using stove.

Observation notes:

- People should use it in a certain way to not mess it up. For some people, especially kids, this could be very complicated and could put their safety in danger.

- How much coal you put in the stove will determine how long it will maintain its warmth. To use the stove, the user must first add coal and then add wood. To allow the coal to burn, they also must add some paper on top of it.

- The stove is mainly used for cooking and heating. From the observation, the user takes out the lid of the stove exposing themselves to fire. The lid can also get very hot.

- Because the stove is put right in the middle of the ger, there is no protection around it. The chimney also heats up, making it dangerous for people to touch.

3 Saygi. (2022, April 9). Air Pollution in Mongolia: Ulaanbaatar is at High-Risk. SfS.

2.5 Market Research

Through market research, there were many different types of products related to air pollution. One of them is an air purifier called Airee that offers wool as an organic, biodegradable alternative to synthetic filters. According to their research, 80% of air pollutants from combustion are electrically charged. Sheep wool has electromagnetic properties, making it an excellent filter against air pollution. This was an interesting product and maybe there could be a way to use it for the stove. Possibly a filter inside the stove that filters all unhealthy pollutants, including fine dust (PM2.5), volatile organic compounds (VOCs), as well as bacteria and viruses.[4]

Figure 2.05: Airee

Figure 2.06: BioLite. *CampStove 2+.*

Another product was the BioLite stove. According to BioLite, “BioLite creates affordable, durable products that harness surrounding energy to cook, charge, and light daily life for off-grid households.”[5] This product was also interesting as it turns fire into electricity. This gave me some potential ideas for my design.

4 100% Biodegradable Air Purifier. (2022, October 20). Airee.
5 CampStove 2+. (n.d.).

Figure 2.07: Exodraft. *Electrostatic particle filter.*

Exodraft is a Danish owned company that has for over 60 years developed, manufactured and sold chimney fans to control chimney draught. The exodraft ESP particle filter is designed to filter out hazardous and ultrafine particles from the flue gas of your wood-burning stove or fire-place. This is one of the products that I could get inspiration from. The electrostatic particle filter is installed on top of the chimney, where it is coldest, and uses a high-voltage electrode to charge the particles in the flue gas, causing them to collect inside the filter.[6]

This furnace uses a downdraft gasification process and creates syngas that could be used for generating energy. This G4000 is the only outdoor furnace that measures the exhaust and adjusts the air to guarantee the best real world performance and efficiency.[7] This was an inter-esting product and helped me to understand the downdraft gasification process better. This product is built with strong materials to last lon-ger, uses wood as a fuel and is easy to use.

Figure 2.08: Heat Master. *G4000.*

6 Wood Stove Filter - exodraft chimney fans & heat recovery. (2022, June 28). Exodraft.
7 G Series | Wood Burning Furnace Heaters. (n.d.). Heat Master.

3.0 SYNTHESIS.

My research has shown me that there is a need for product improvement to reduce air pollution as well as design a more user-friendly stove.
Insights I got from my interviews:

• Most people have limited information on solar panels or different options than using coal. I think there are not a lot of products available for people living in the ger district. These people have different lifestyles and for some people, it might be hard to afford other options. According to a study, 40% of people's income is spent on heating alone (buying coal, wood, and more). Some people even use cardboard, paper, and tires to light up their stoves.

• Most of the people I interviewed answered dangerous when asked about the issue with new stoves. Dangers can include safety issues like burning and carbon monoxide. According to an article, In the winter of 2019-2020, a total of 2,568 people were poisoned by gas and received medical help.[8] Causes and conditions of registered carbon monoxide poisoning include:

- Stoves are broken or poorly sealed
- Stove and chimney joints are being repaired
- The chimney is sooty
- The ashtray is full
- Misfired fuel
- Short chimneys
- The exhaust valve is closed

Children are most vulnerable to air pollution as they have weaker immune systems compared to adults. Air pollution affects their brain development. The study shows that children grew up in polluted place have 40% damaged lungs than kids grew up in fresh air.

Designing an environmentally and user-friendly stove would help the locals avoid potential risks and will allow them to live in a safe environment.

8 А.Намуун, і. (2022, April 19). 2019-2020 оны өвөл нийт 2,568 хүн угаарын хийнд хордож эмнэлгийн тусламж авжээ. Ikon.Mn.

Figure 3.01: Chimedtseren. (n.d.). *Ulaanbaatar Electricity Distribution Network*.

Figure 4.01: Choijiljav. (n.d.). *Photos Mongolia*.

4.0 BRIEF.

To design a coal-stove with oil filled pipe heaters that will help the people living in the yurt stay warm and reduce the repetition of lighting the stove as a way to improve the air quality in Mongolia.

The majority of people in Ulaanbaatar reside in informal ger districts, where they use coal-stove for cooking and heating throughout the winter. The stove is not only unsafe and difficult to use, but also adds to air pollution.

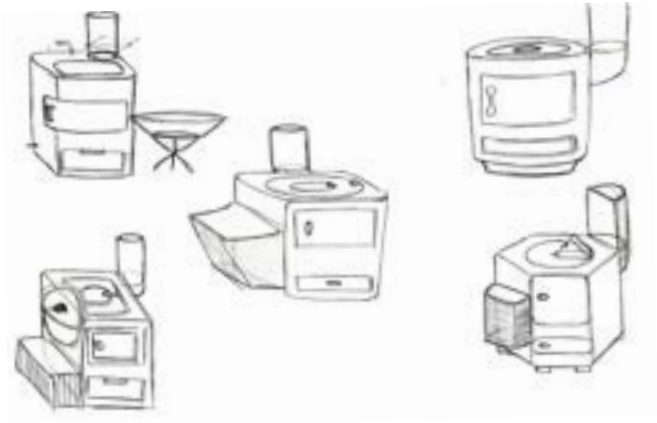
5.0 IDEATION.

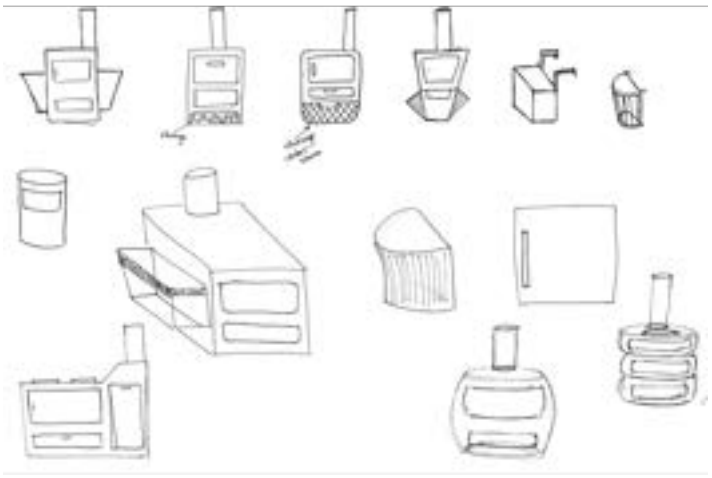
5.1 Moodboard

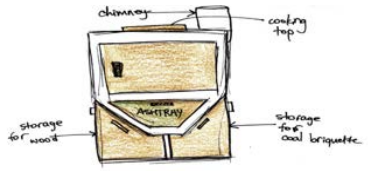
For my moodboard, I mostly chose different designs of stoves that seemed interesting. I focused on form and functionality.

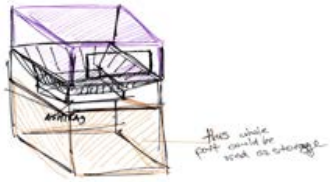
Figure 5.01: Sideros wood stoves. (2017, August 20).
Figure 5.02: Дурслэх урлагийн музейн сан хөмрөгөөс: Монгол тулга. (2021, February 16). *Montsame.*
Figure 5.03: Yurts UK (n.d)
Figure 5.04: Jotul F 45 V2 Greenville Modern Wood Stove. (n.d.).
Figure 5.05: Warehouse, S. (n.d.). Ekol ApplePie Multifuel Wood Burning Stove 4kW Small. *Stovefitter's Warehouse*.
Figure 5.06: Portable Stove. (n.d.).
Figure 5.07: Pinterest.

5.2 Sketches






chimney
cooking top
storage for wood
storage for coal briquette
ASHTRAY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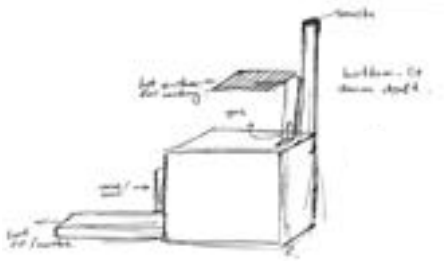
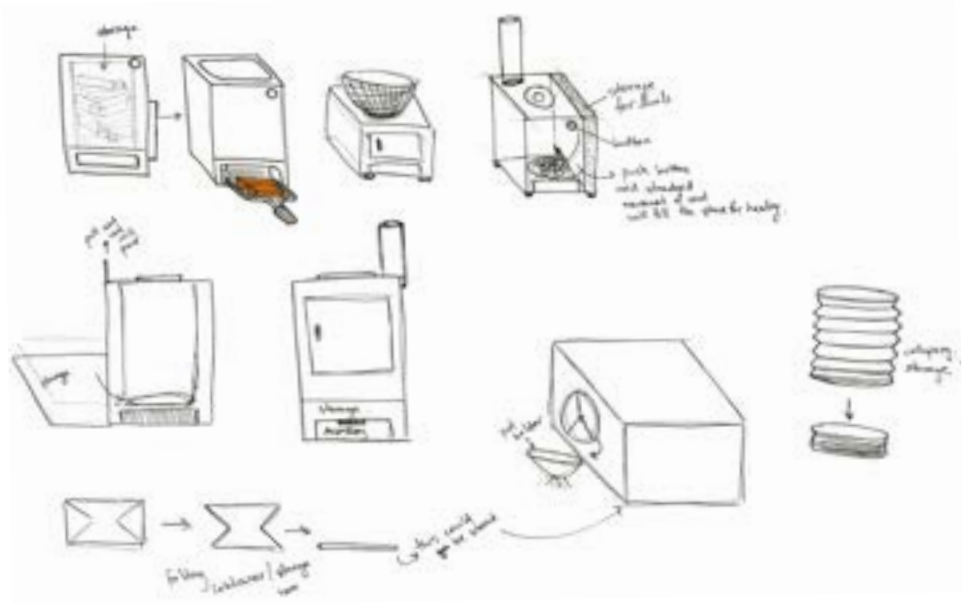
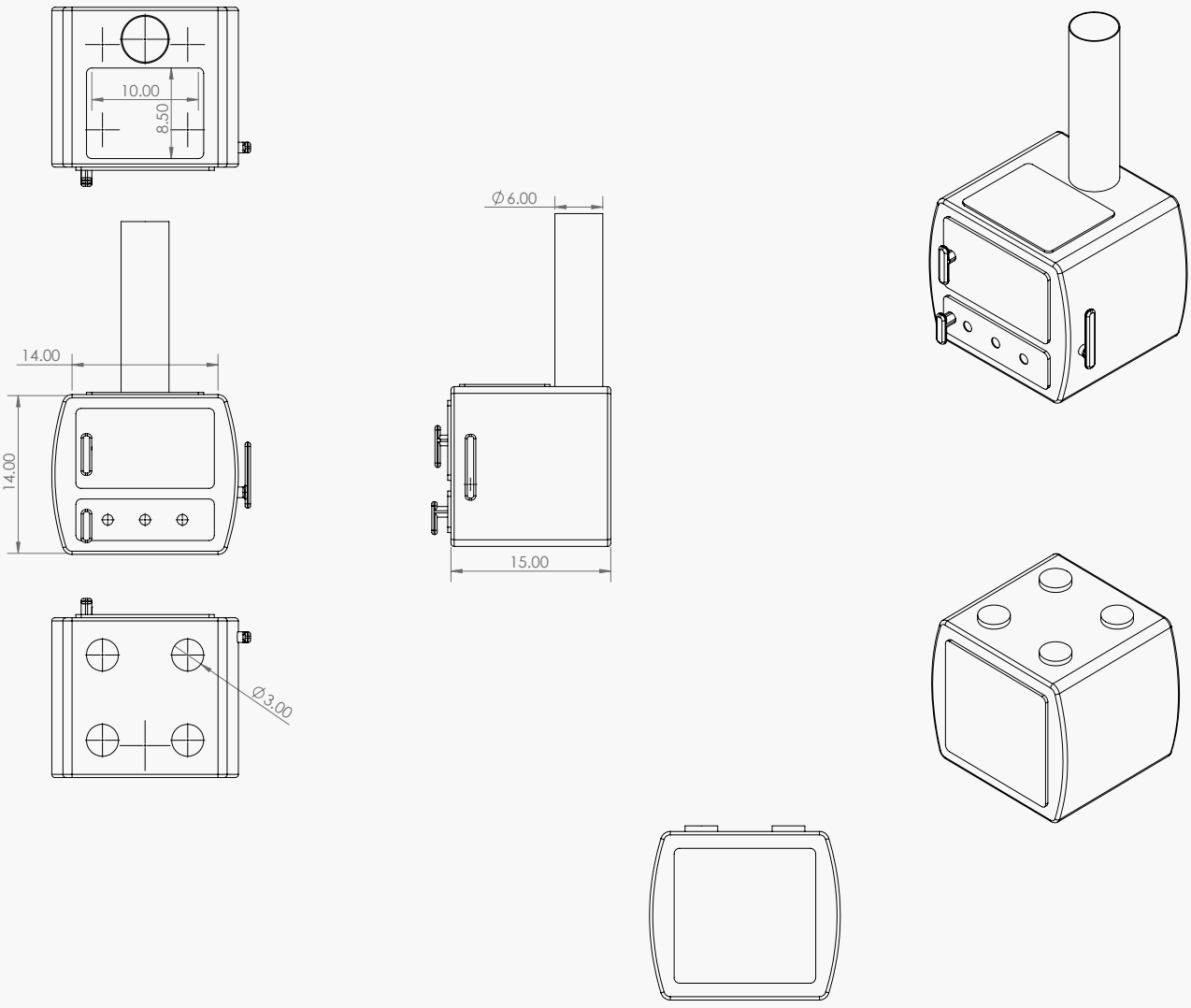


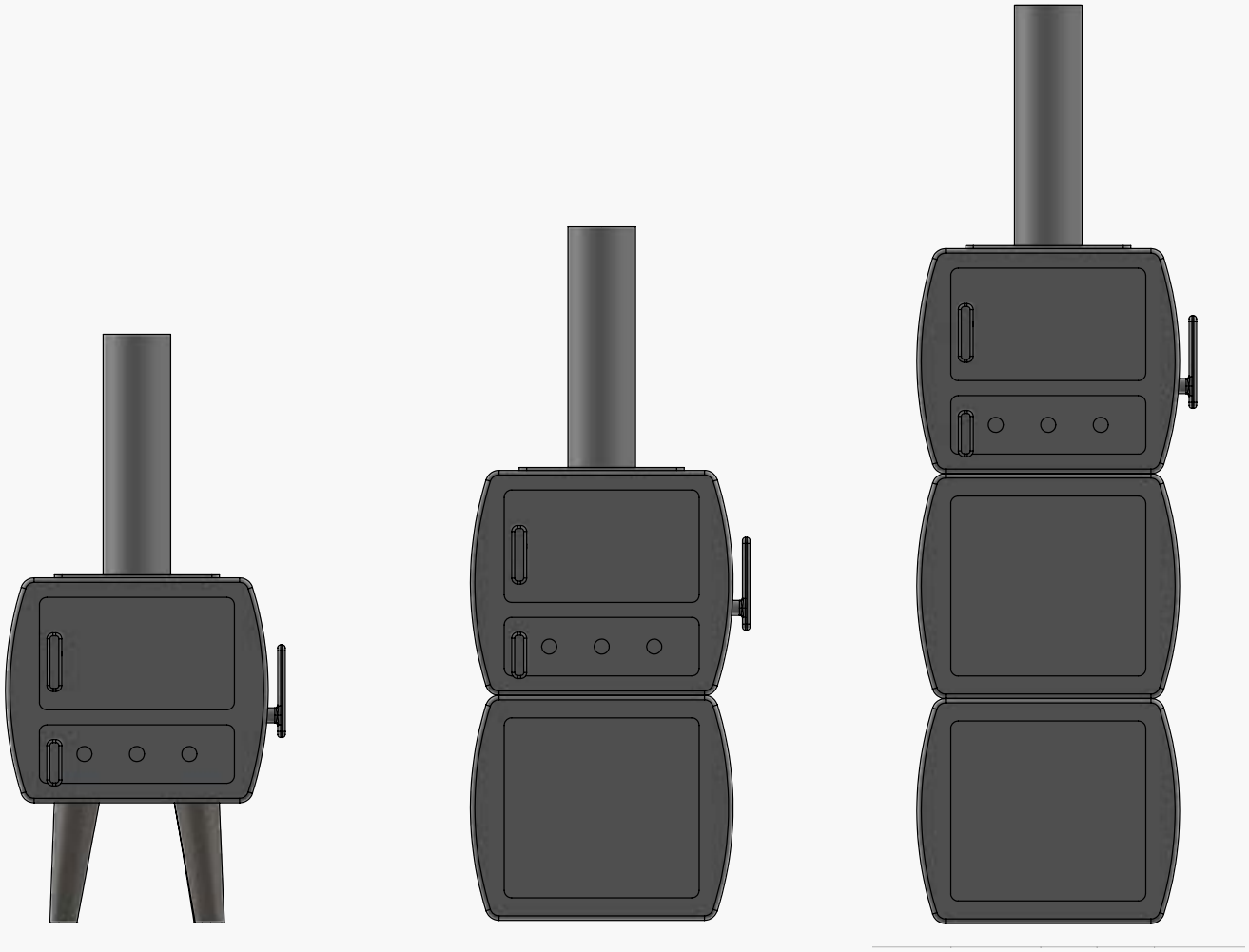


6.0 CONCEPT DEVELOPMENT.

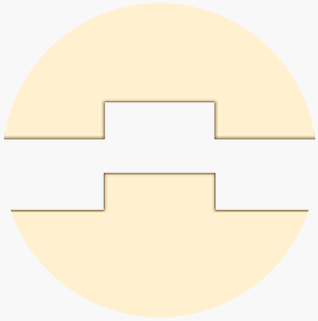
Concept 1: Stackable Stove

This stackable stove concept are for people who want to save space and get more storage. It allows people to customize their stove. The main stove can be used by itself attaching a leg into it. The main stove can be equipped with additional storage components.



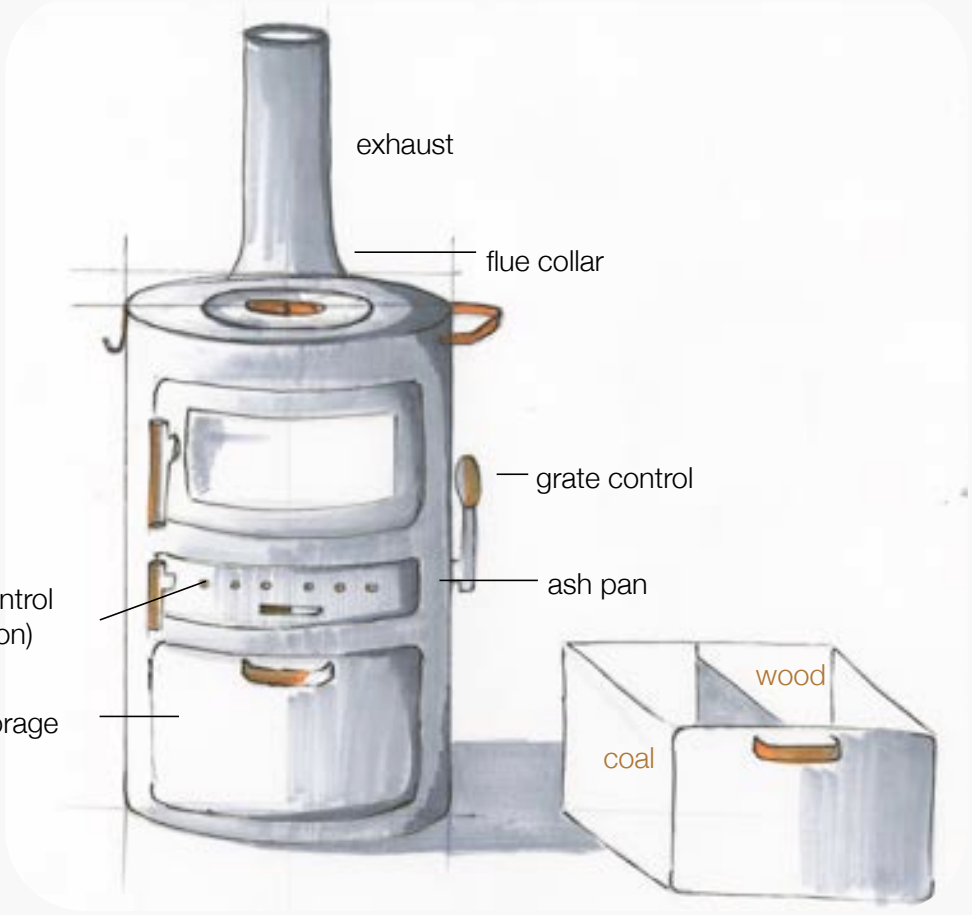


The parts can be attached like lego.



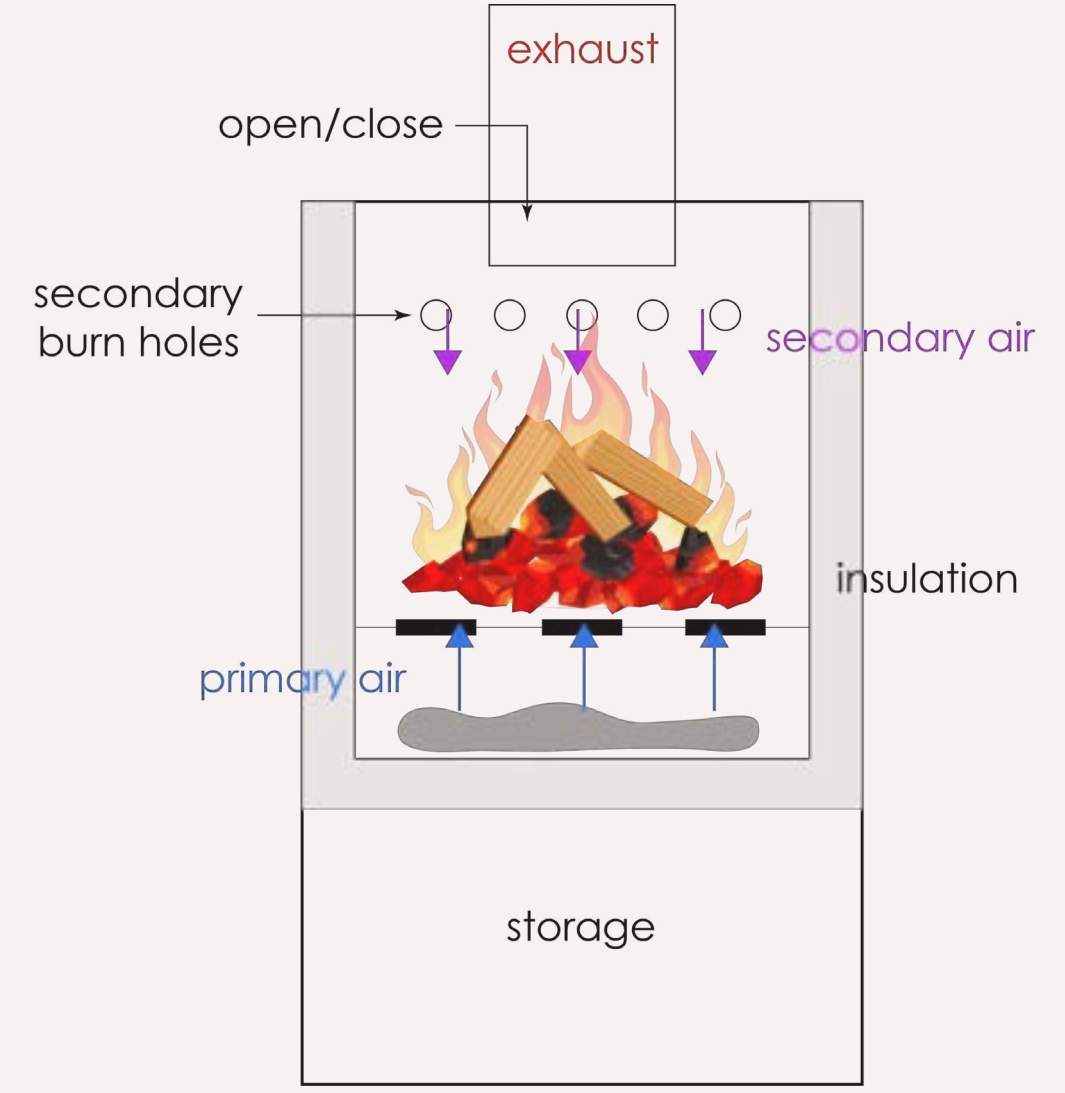
Concept 2: Updraft Stove

This is a concept of a top-lit updraft stove. TLUD stoves are simple to use and quickly warm up a small area. Due to the simplicity of the procedure, TLUD usually allows a simple design for the stove.



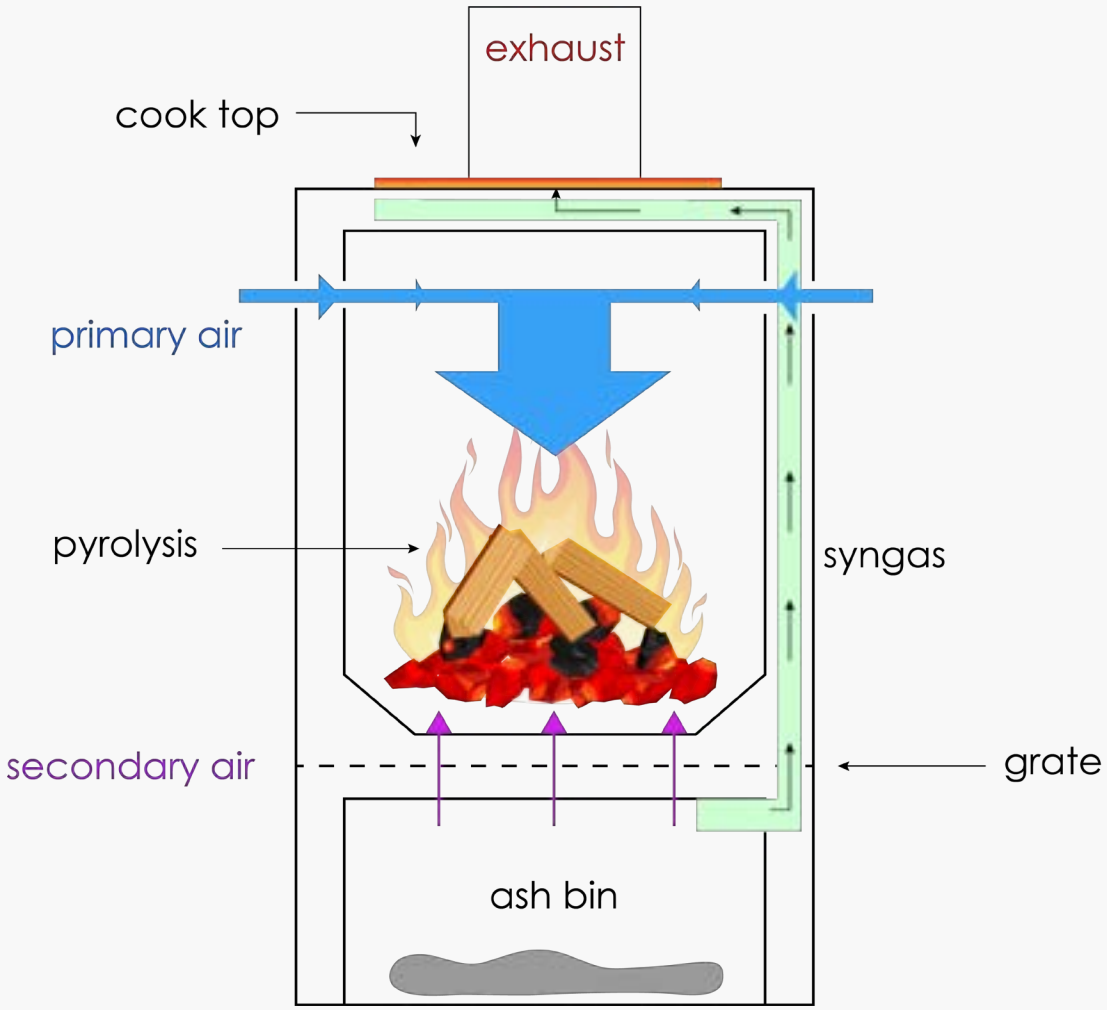
How it works:

The user lights the top layer of the fuel to start the pyrolysis. Once the fuel has begun to burn and gas has begun to form, air begins to enter through primary and secondary air inlets. Fuel moves in opposition to air flow.
The updraft stoves has been the standard for coal stoves for a long time. This stove also includes a storage for coal and wood at the bottom part.



Concept 3: Downdraft Stove

Gasification is an effective process of reacting organic or fossil fuels at high temperature without combustion. It produces significantly lower quantities of air pollution. Downdraft gasification regulates the air intake and produces syngas that is used to generate energy.



In downdraft gasifier stove, both fuel and gas move downward. Both sides of the stove have air valves that let primary air enter from the top. A vortex is then created as secondary, preheated air enters through the air bin. As the gas lowers, it will gather at the bottom and go via a tube to a cooktop where it will heat up. The user will be able to cook without risking their own safety to fire.

7.0 DEVELOPMENT.

7.1 Pain Point

After choosing my three concepts, I decided to narrow down the scope of my project and did more research on it. From my research, I picked up some of the pain points of living in the yurt. Those are:

- Heat escapes through the roof
- Lower ground always stays cold due to lack of insulation
- Heat doesn't transfer to every part of ger
- A more thermally efficient ger uses less fuel, reducing its contribution to both in door and outdoor air pollution.

Therefore, I decided to focus designing a stove for yurt living.

Without oil pipes

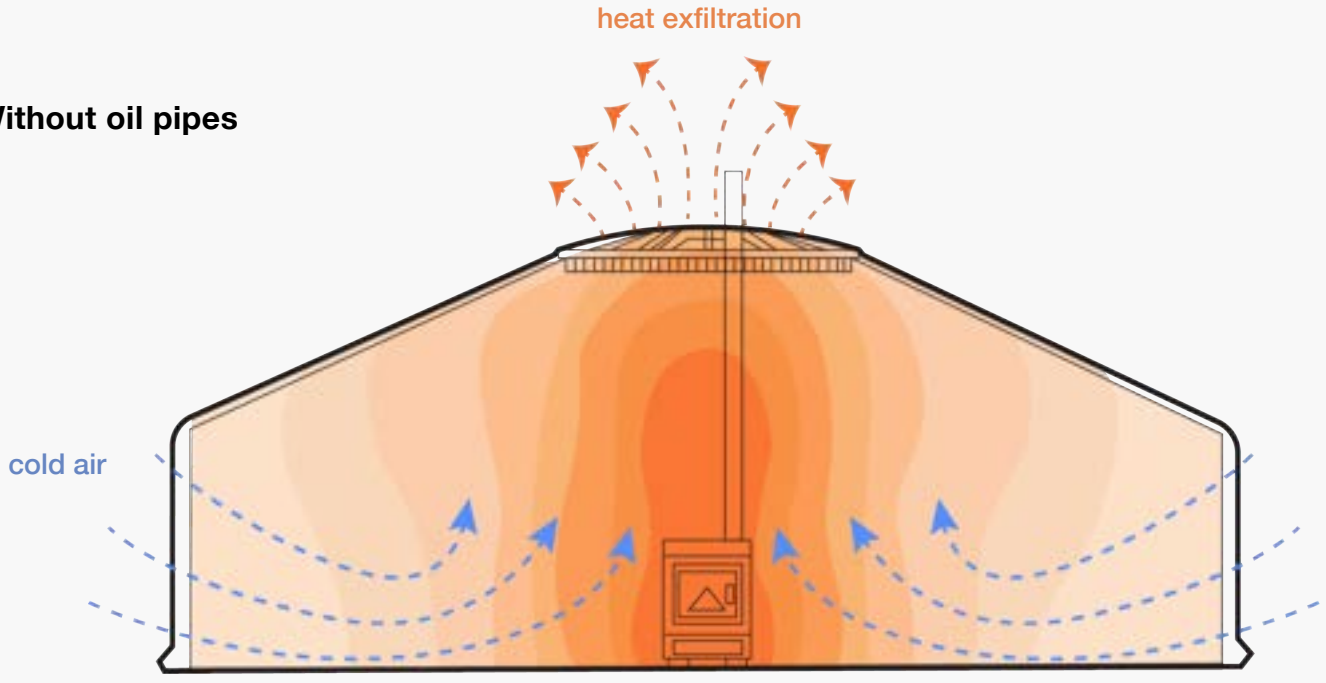


Figure 7.01: Design Recommendations for Ger. (2021, November 9).

Heat exfiltration occurs when hot air is pushed upwards by cold air coming from the lower circumference and the sides of the ger. Heat escapes through and around the roof of the ger.

9 Design Recommendations for Ger. (2021, November 9). Gerhub.

Another thing I found from my research was oil filled heaters. Because of the structure of the yurt, no matter how many times you light up the stove, it is always cold in the lower circumference. Therefore, I have decided to use the oil pipes to block the cold air coming from outside and keep the heat inside the yurt.

Why not water or use glycol solution in water?

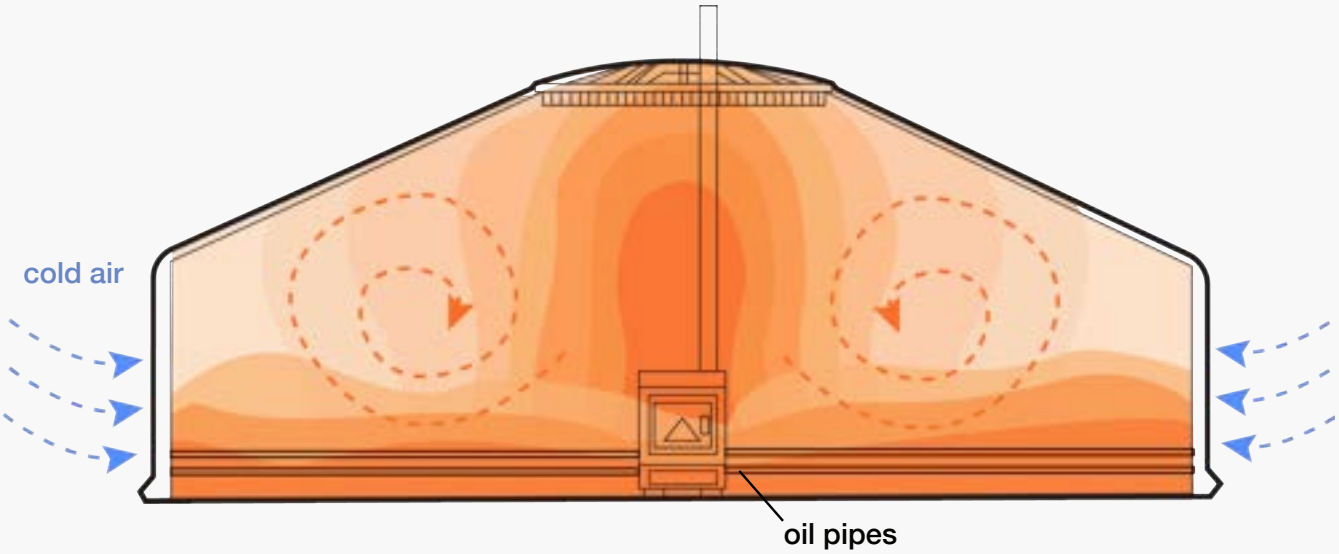
Water or glycolic solution in water is the best possible heat transfer medium to use for heating. But even though it is a good choice, there are some drawbacks. It can be corrosive, contain contaminants. Although adding glycolic solution in water will enhance the boiling and the freezing point, it will reduce the heat capacity.

Therefore, I have decided to go with thermal oil which has a high boiling point and non-corrosive.

Diathermic heat transfer fluid

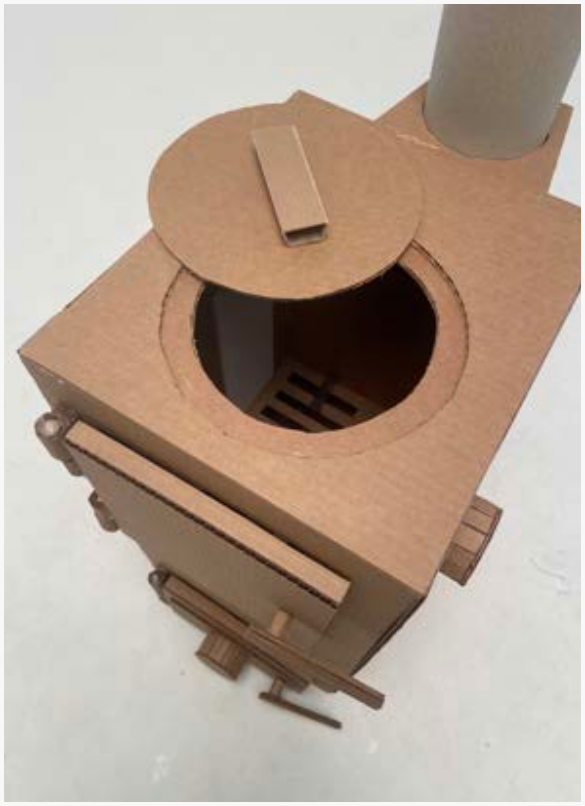
- Heats up fast, and doesn't freeze easily
- Energy efficient
- They retain heat well

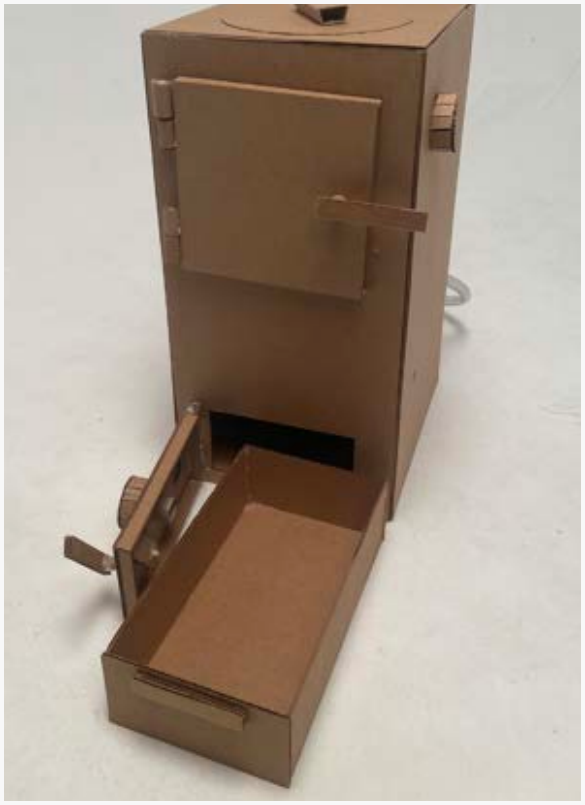
With oil pipes



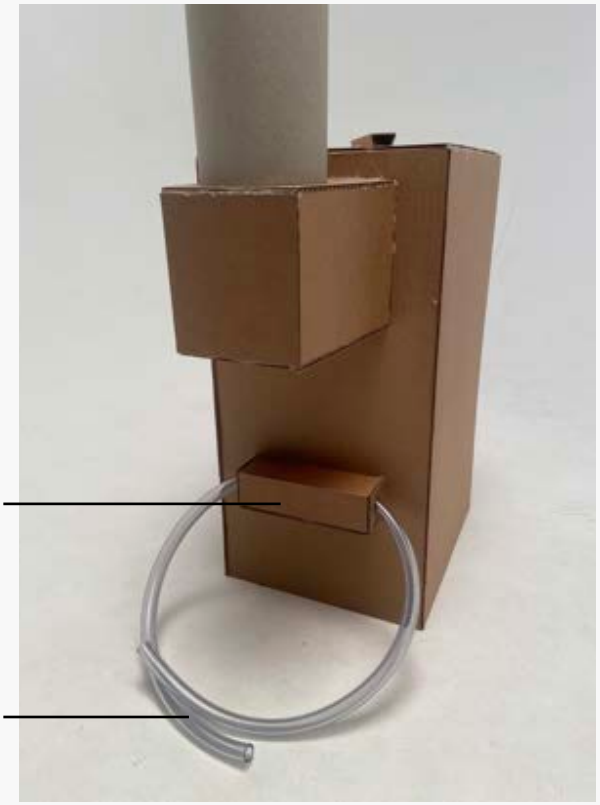
But with oil pipes, it will transfer heat equally to every part of the ger. Especially the lower circumference, keeping the ger warm for a long time. Plus, it will reduce the repetition of lighting up the stove.

7.2 Rough Model





For the rough model, I included all the necessary components such as oil pipe grate, the tubes, the pump, and air flow control.


pump
oil tubes


grate with oil filled tubes

8.0 FINAL DESIGN.

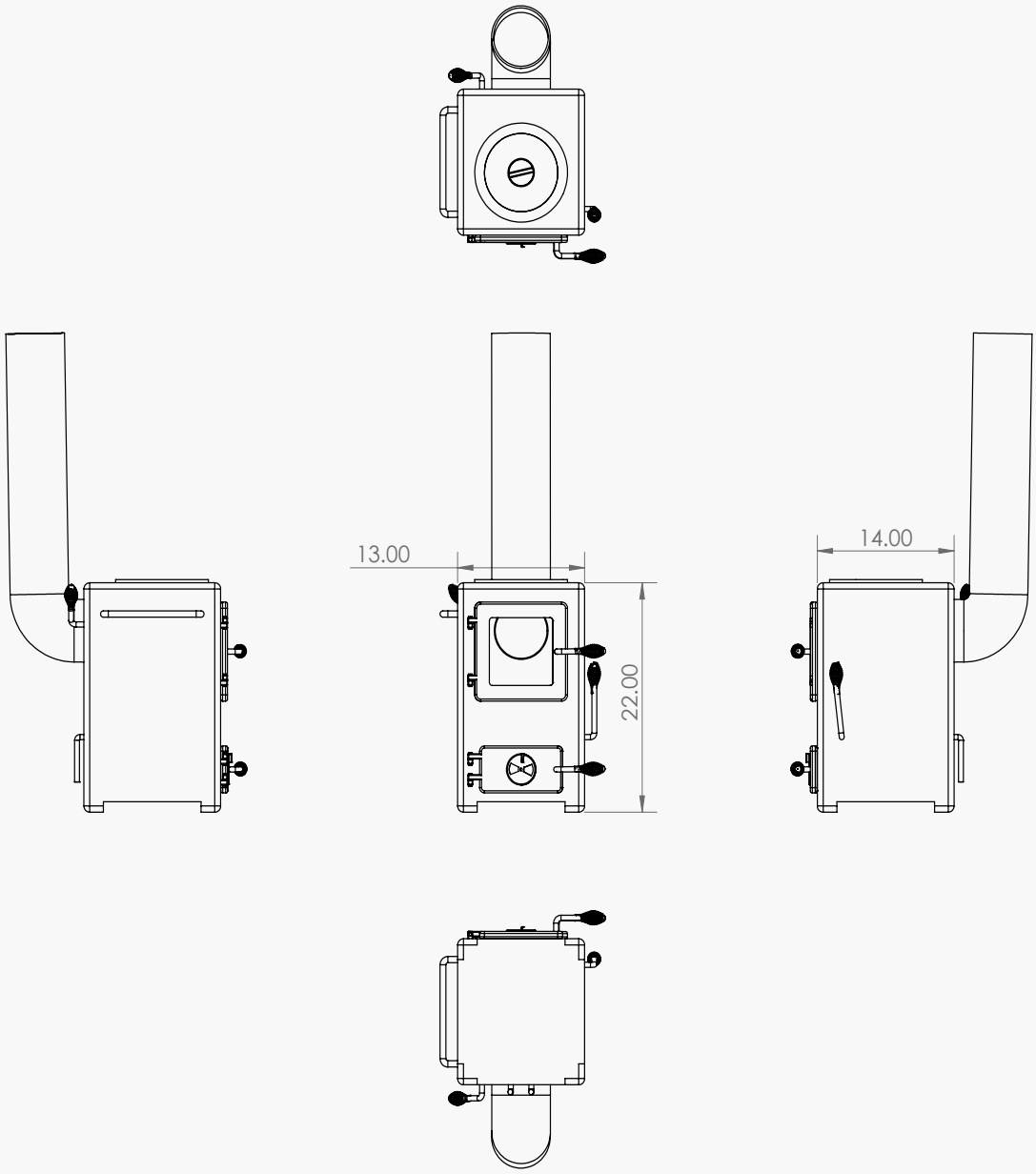
8.1 Renders

For my final concept design, I have decided to use the updraft stove with a combination of oil filled heating tubes in the grate of the stove. This way, it would reduce the frequency of lighting the stove, thus will reduce the air pollution.

Benefits:

- Keeps the ger warm
- Reduces the carbon emissions
- Easy to use

8.2 Dimensions



8.3 Technical Drawing

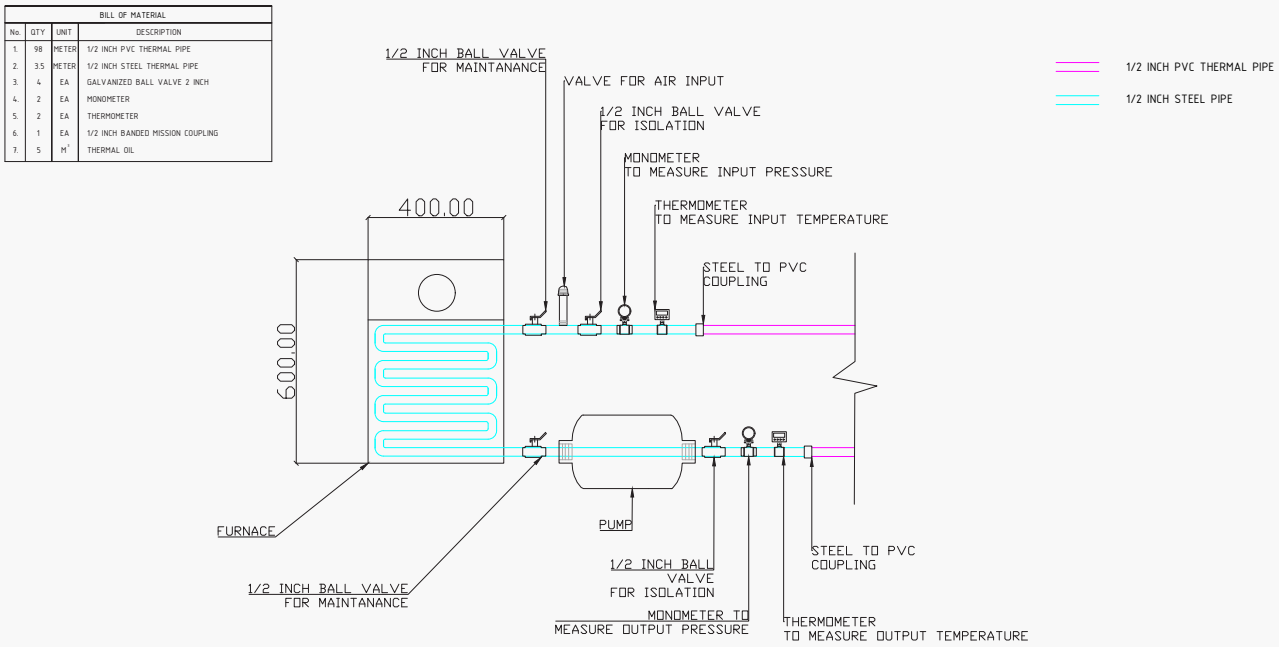


Figure 8.01: Calculations for Nest Stove. Engineers.

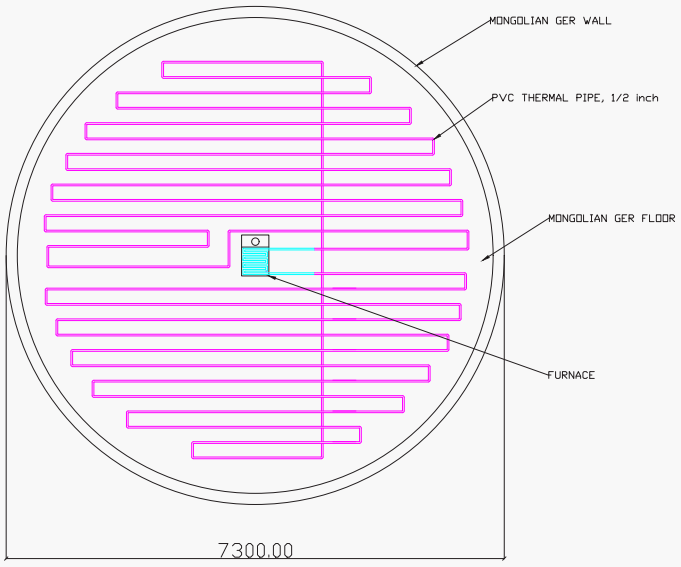


Figure 8.02: Length of oil pipes to install for ger. Engineers.

In order for stove to function properly and for safety issues, there has to be particular valves such as thermometer for controlling the temperatures and monometers for checking the pressure.

These are two diagrams that were drawn by the engineers.

The diagram below shows the right way to put the pipes under the floor of the ger (yurt).

8.4 Calculations

The purpose of calculating heating capacity by balancing the total obtaining and loosing heat is to prove that our heating project is reliable for Mongolian harsh weather condition. Also this calculation shall be base of equipment's selection.

To calculate the thermal balance of a Mongolian ger, we should follow the steps below:

1. Determine the size of the room: Measure the length, width, and height of the room to determine its size in cubic feet or meters.

D1 – Diameter of the "Toono"
D2 – Diameter of the floor
H – Height from floor to "Toono"
h – Height of wall
S1 – Surface of the floor
L0 – Length of the floor circle
V = Volume of the Mongolian ger
Sfloor – Surface of the floor
Swall – Surface of the wall
Sloss – Total surface that heat loses.

a. D1 = 1.82m (From Mongolian ger dimension table)
b. D2 = 7.30m (From Mongolian ger dimension table)
c. H = 2.94 m (From Mongolian ger dimension table)
d. V = 144.1m3 (From Mongolian ger dimension table)
e. Sfloor = π*(D2/2)2 = 3.14*(7.30/2)2 = 41.83m2
f. L0 = 2*π*(D2/2) = 2*3.14*(7.30/2) = 22.92m
g. Swall = L0*h = 22.92*1.6 = 36.67m2
h. Sloss = Sfloor + Swall = 41.83 + 22.92 = 78.5m2

2. Determine the heat loss: Heat loss is the amount of heat that escapes from a room to the outside. Calculate the heat loss by considering factors such as the insulation of the walls, windows, doors, and roof, and the outside temperature.

To calculate the heat loss, we use the heat loss online calculator “Omni calculator”

a. The volume of the Mongolian ger equals 144.1m3
b. The insulation is low
c. The total surface that loses heat is 78.5m2

So the heat loss is approximately, 5309W which is mean 5.309kW.

3. Determine the required heat input: To calculate the required heat input for the room, you need to consider the desired indoor temperature, the outdoor temperature, the heat loss of the room, and the heat gain from any appliances or people in the room.

To calculate the required heat we shall consider the loosing heat with λ coefficient:

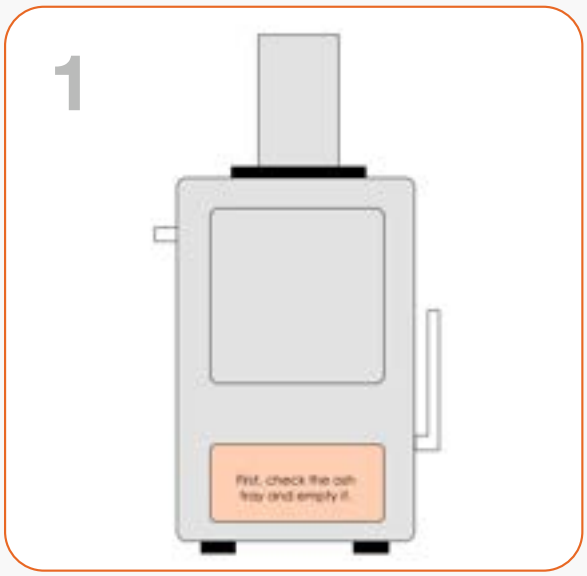
Qincome = λ* Qloss
Qincome = 1.1 * Qloss = 1.1*5.702kW = 5.84kW

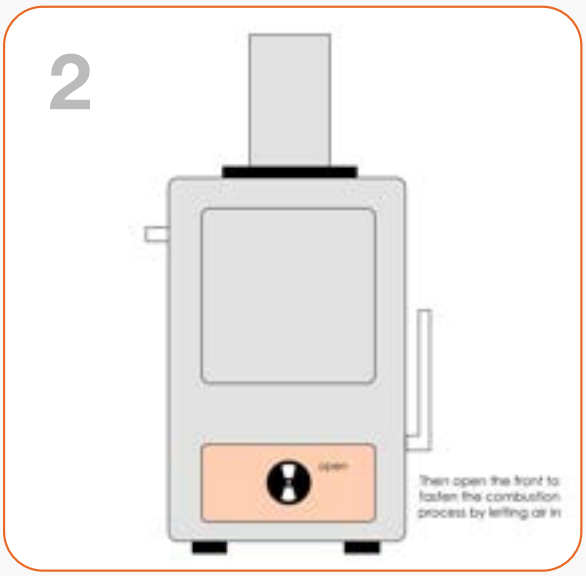
It means, we should heat the Mongolian ger with 5.84kW to hold inside temperature in 20 °C.

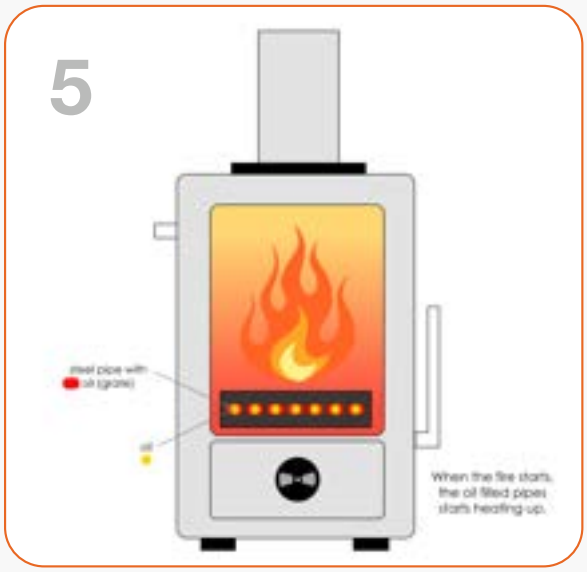
8.5 In Situ

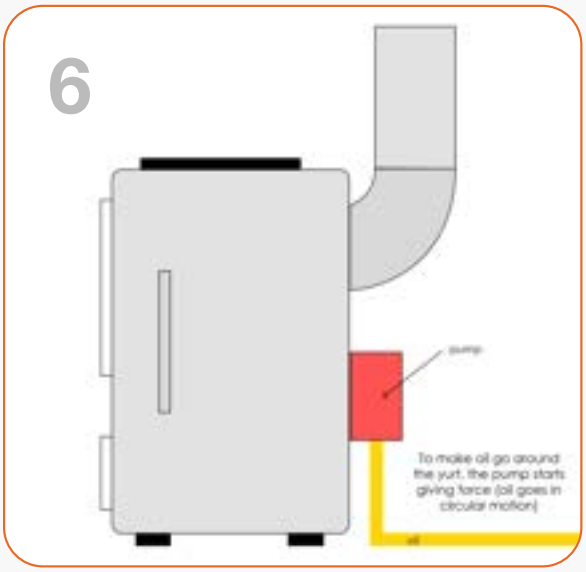
Figure 8.03: Yurt Interior. Adobe Stock
Figure 8.04: Render of Nest stove. Tergel Saikhanbayar

8.6 Storyboard

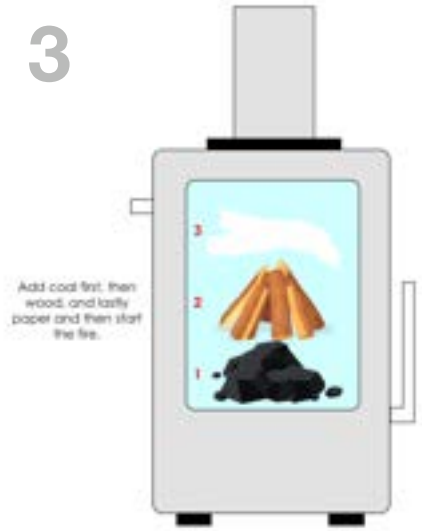




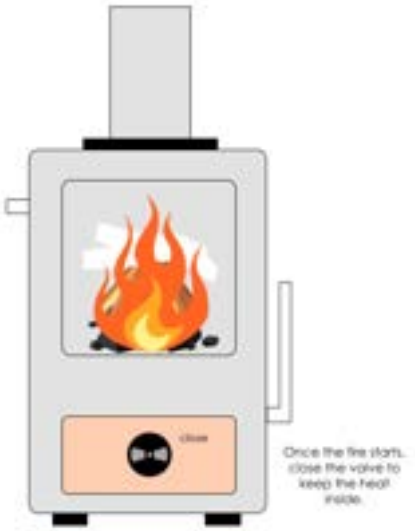




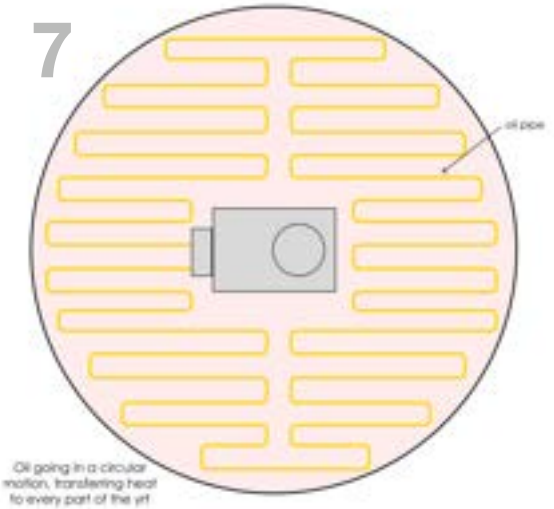
3


3
2
1
Add coal first, then wood, and lastly paper and then start the fire.

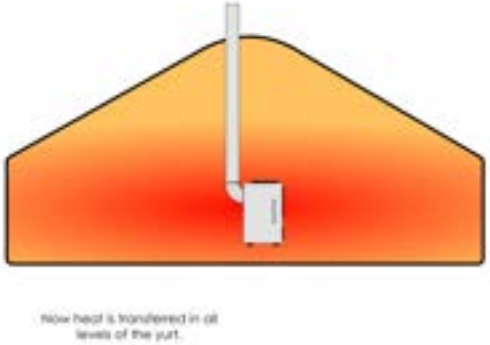
4


close
Once the fire starts, close the valve to keep the heat inside.

7

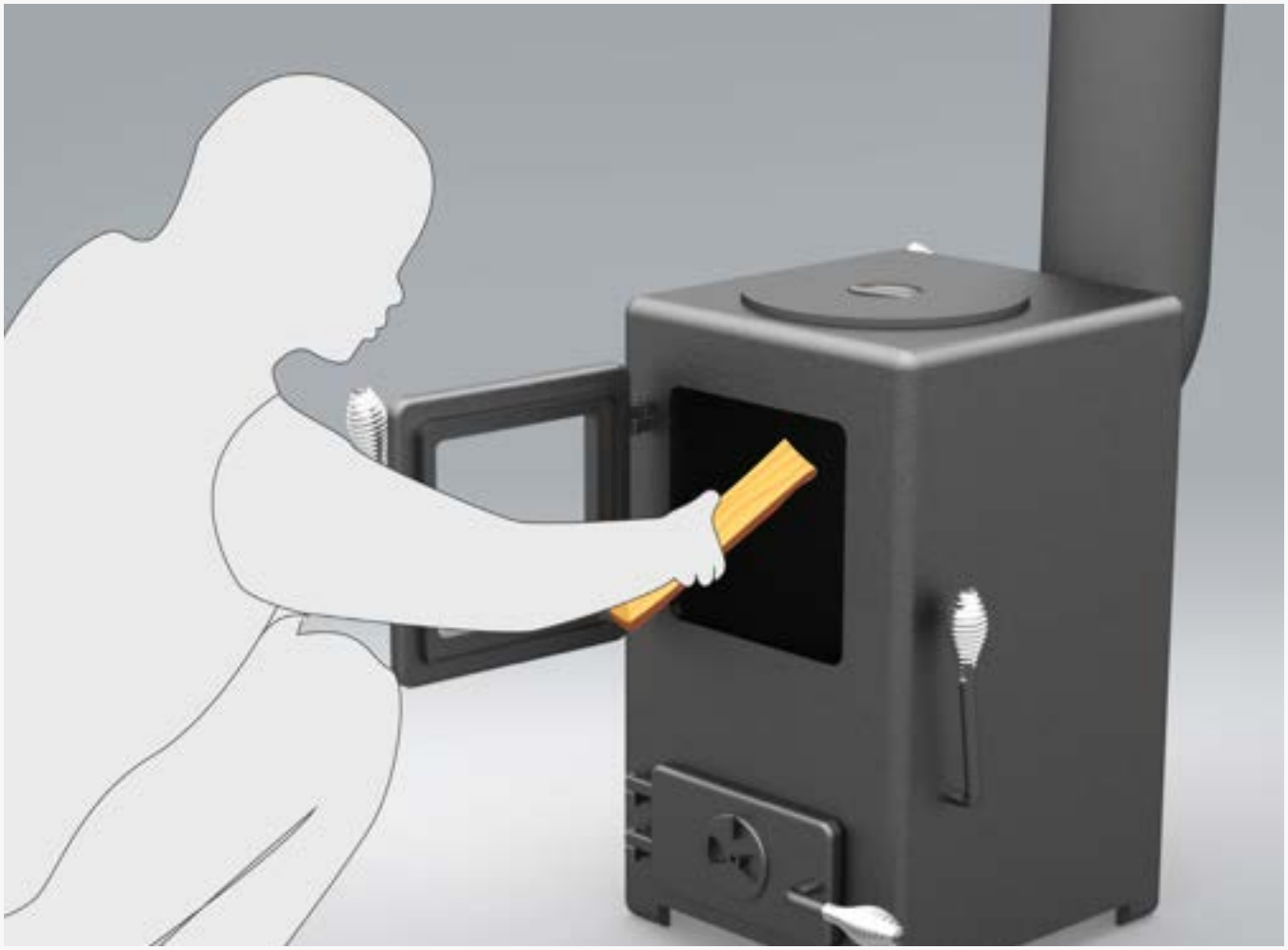

oil pipe
Oil going in a circular motion, transferring heat to every part of the yrt

8


Now heat is transferred in all levels of the yurt.

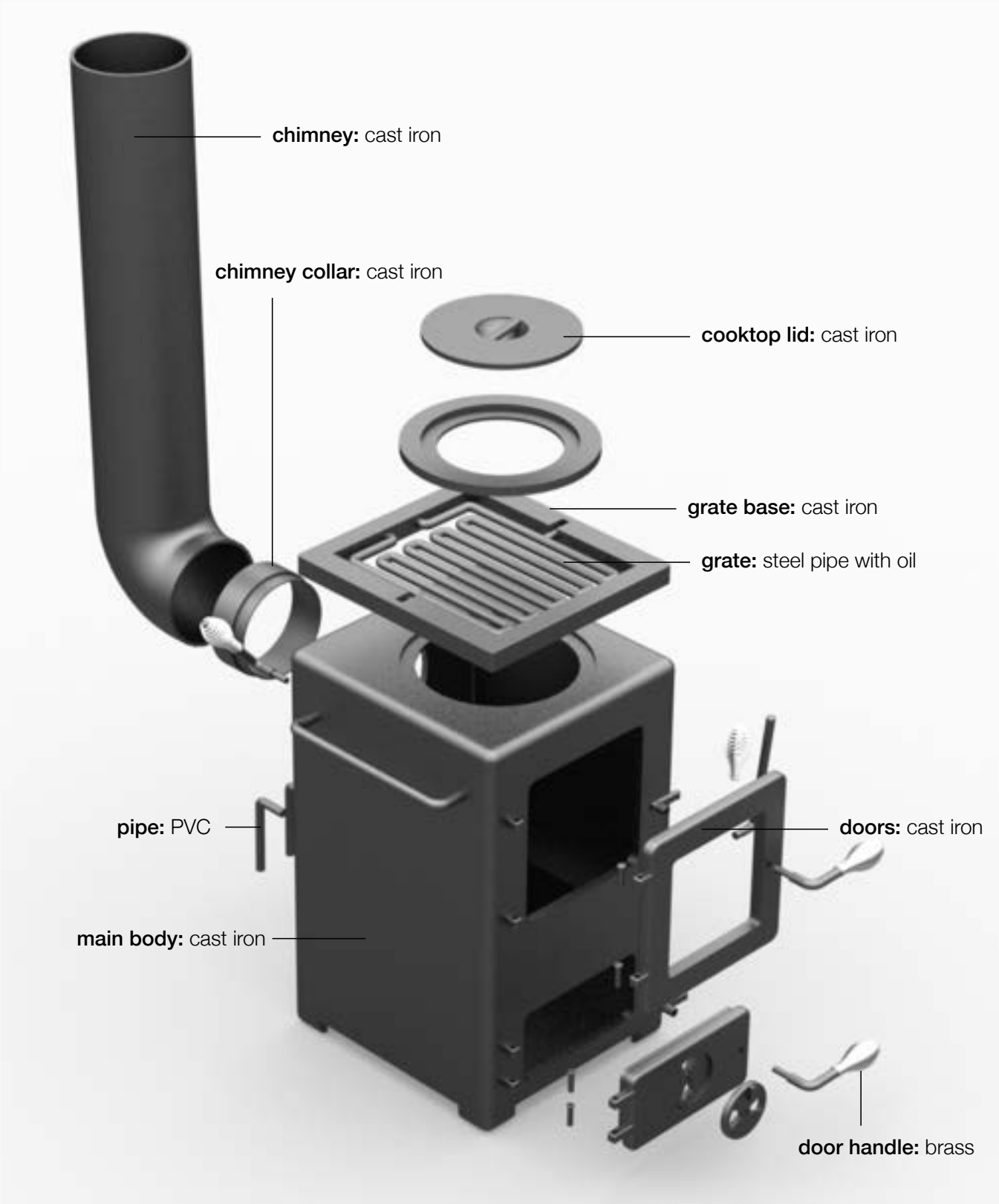
8.7 User Scenario

Remove the lid and place the pan on a cooktop to use the stove for cooking. The heat from the fire will allow the user to cook warm meals.

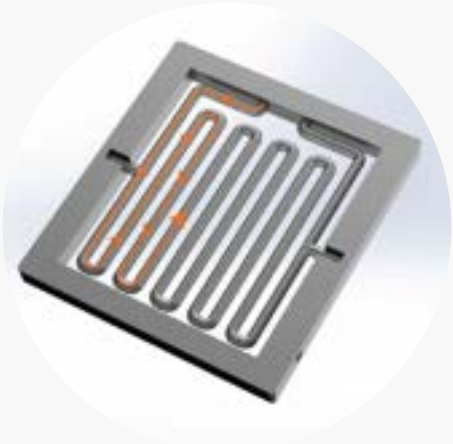


Adding fuel to the fire.

8.8 Materials



8.9 Details



Steel oil pipes

Unlike normal grates, the 1/5 inch steel tubes inside are designed specifically for oil to flow freely in a circular motion.

Floor tubing

The tubes under floor are 1/5 inch PVC tubes that will help the oil to flow around the yurt. This way, the ger (yurt) will keep its warmth for a long period of time.

Pump and tubes

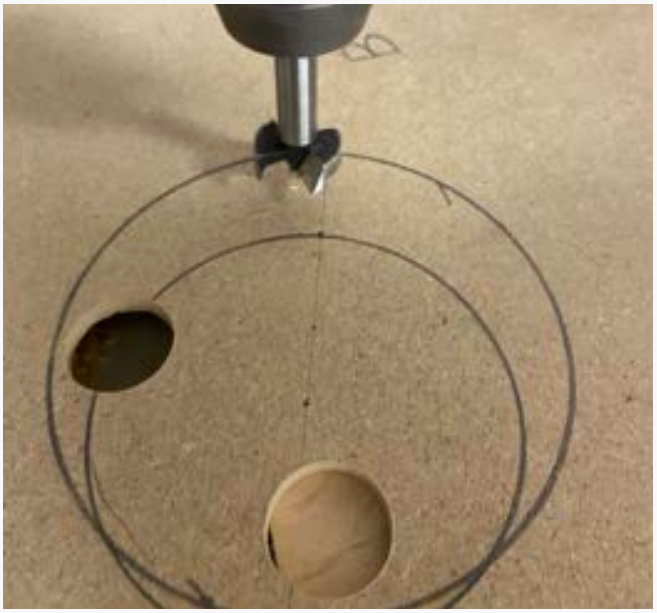
In the back of the stove there will be a pump that will force the oil to flow.

Figure 8.05: Floor Heating. Google Image.

9.0 MODEL MAKING.

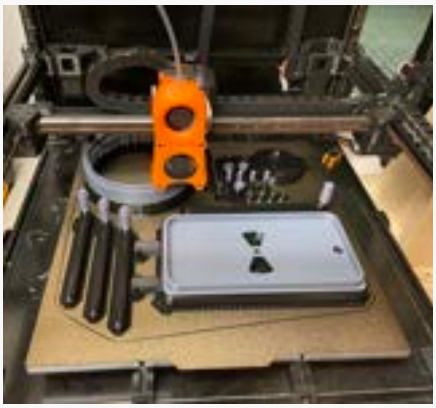
9.1 Main Body Part

Cutting the MDF board for the main body part



MDF board was the best choice for the main body of my stove since it was an appearance model

9.2 3D Printing & Sanding



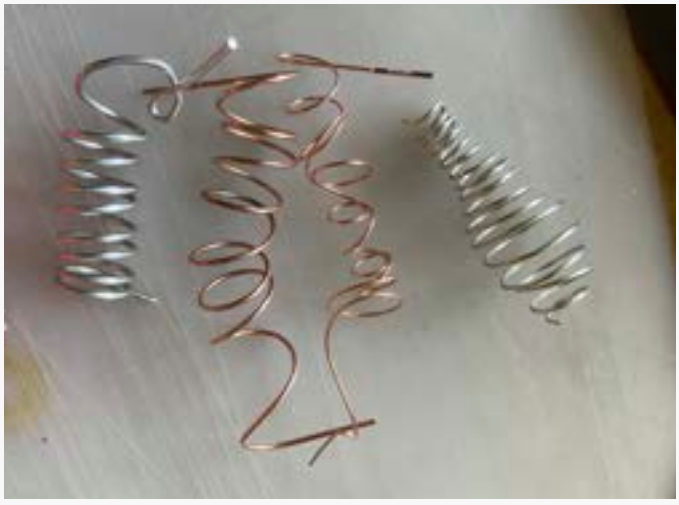
The next step was to 3D print the components.

The design of the stove was with round edges. Therefore, as advised, the corners were 3D printed with extra surface inside for stability.

Adding a rod inside for stability.

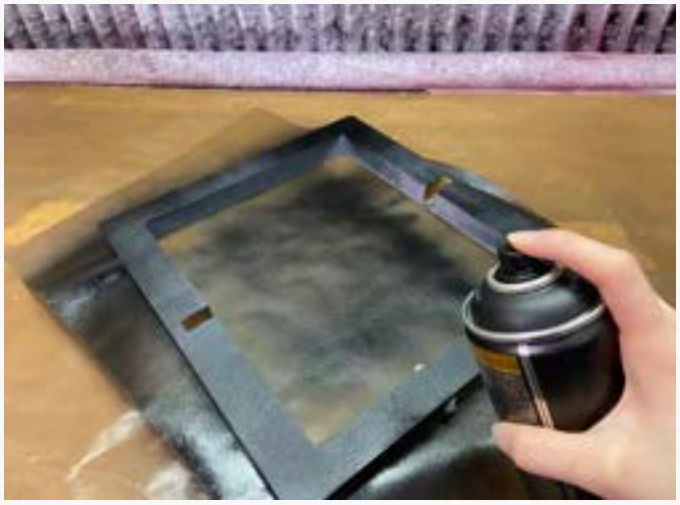
After 3D printing, I put spot putty for smooth surface and sanded them off.

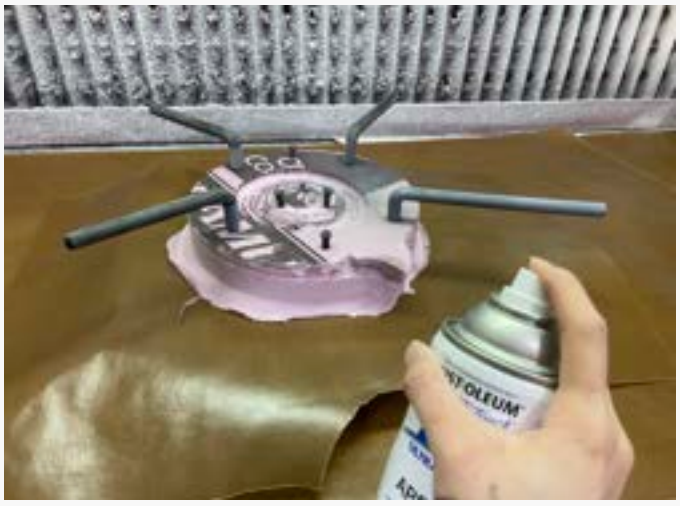
9.3 Handles

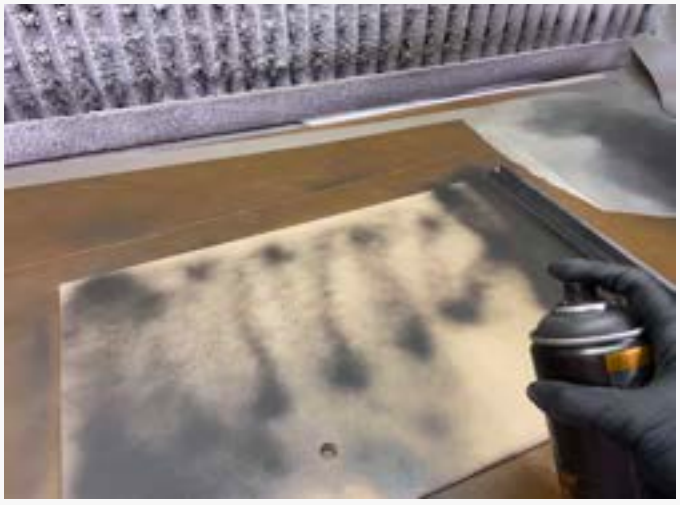


For the handle, I decided to use aluminum coil and shaped it using a dowel.

9.4 Primer

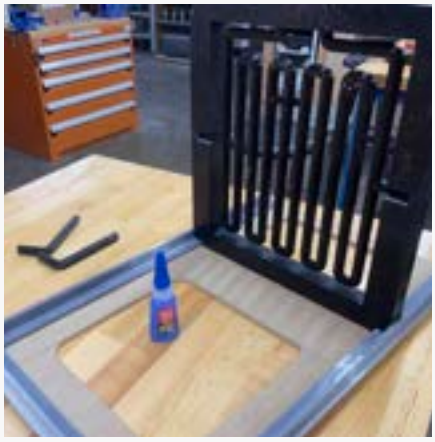






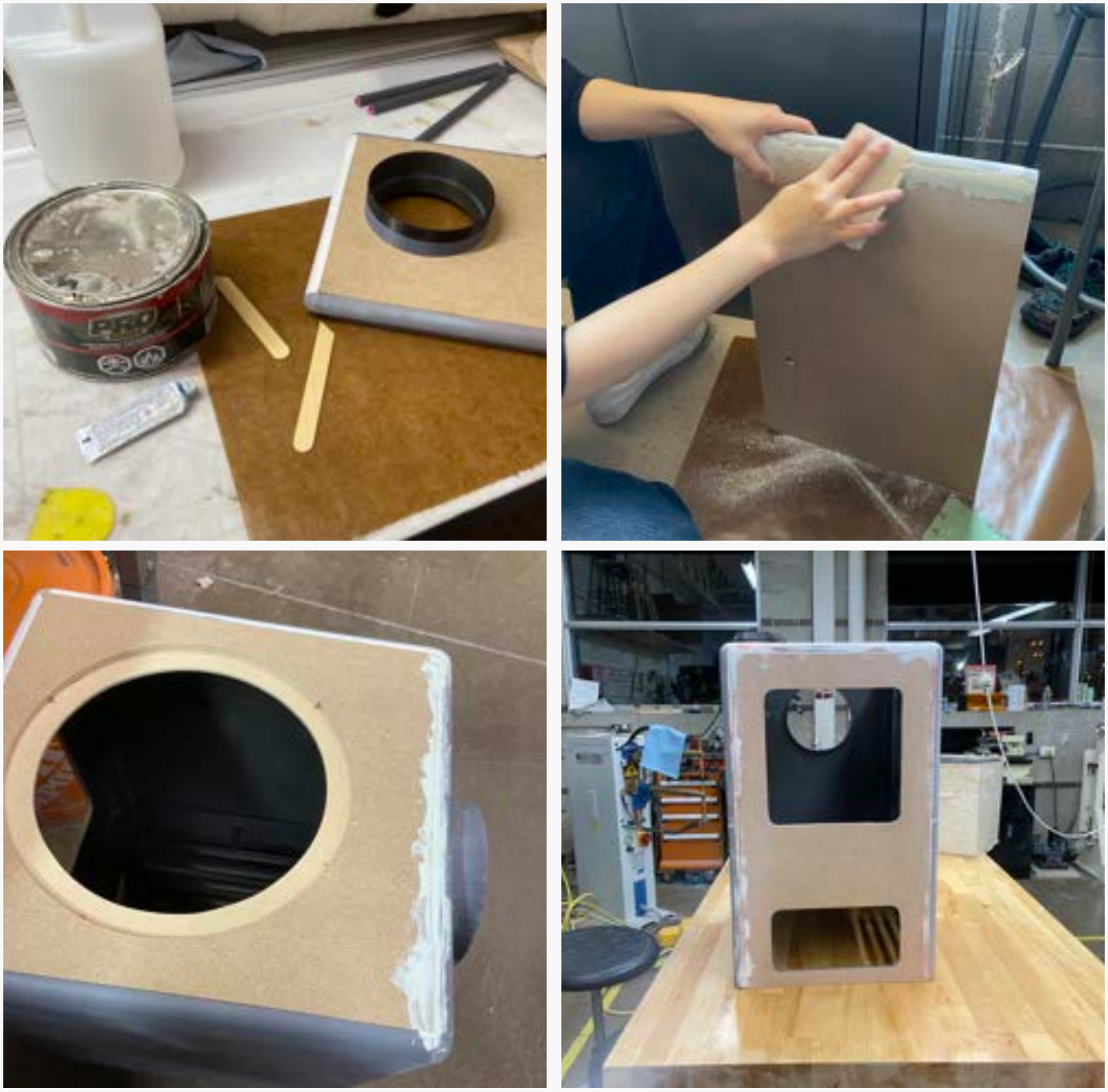
9.5 Assembling Main Body Part

Once all the parts were ready, I glued the corners to the MDF boards.



Then I glued all four sides of the stove.

9.6 Bondo & Sanding



Adding bondo and sanding for smoother surface.

9.7 Painting

More sanding.

9.8 Final Touches



Once all the parts were sanded and painted, I started to assemble them all together.



The last few steps was to add the handles and the legs.

10.0 PHYSICAL MODEL.

11.0 SELF-REFLECTION.

Within the first semester, my focus was to reduce air pollution in Mongolia. From my research, I learned a lot about different ways to reduce them. But the main reason was the use of coal. I tried to find different solutions such as replacing the fuel with a more biodegradable and environmentally-friendly alternative or designing a filter for the current stove. Finally, I have decided to focus on the stove. While the first semester was more focused on research and ideation, the second semester has allowed me to see my project from a different perspective.

I understood that instead of desperately trying to design a stove that doesn't make any pollution, my goal was to reduce it by at least 40-60% because there were many other factors were contributing to air pollution. Furthermore, I narrowed my scope to design a stove for yurt or ger due to the high number of users. From there, I got to learn the real issues with the structure of the yurt and was finally able to go with my final idea.

From this whole process, I learned the importance of being patient and taking quick action when something goes wrong. Even though it was a challenging idea, the thought of designing a useful product for my own country has given me joy and made the whole process more enjoyable.

Figure 8.01: Natural Zone. (n.d.). *Discover Mongolia.*

11.1 Next Steps

This was a very ambitious project and while working on this project, I figured that I had four different ideas within the project. Those were the heating system, the floor design for nomads, the tubing, and the design of the stove. Personally, I would like to pursue the idea of the heating system and the tubing. I believe that these two ideas can be combined into one and will be useful because they can be used for any stove and any type of home, if designed correctly.

One thing I didn't get a chance to do was a test. Therefore, I would like to make a working prototype and test it out in Mongolia during the summer or next year. I believe that this idea can help many people and improve their living conditions. Since my whole purpose was to reduce air pollution and improve the quality of living environment, I would like to continue my journey and make this idea into a reality.

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12.1 Appendix

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Fig 1.02: Агаарын бохирдлын PM 2.5 тоосонцор. (n.d.). www.nogoonhutuch.mn. https://www.nogoonhutuch.mn/a/106

Fig 2.01: Traditional Stove. Retrieved from https://www.facebook.com/104619111515814/posts/d41d8cd9/111094357534956/

Fig 2.02: ТӨСЛИЙН ЗУУХ БУЮУ ДЭЭРЭЭСЭЭ НОЦОЛТТОЙ ЗУУХАНД ГАЛ ТҮЛЭХ. (n.d.). Tourist Info Center. Retrieved from http://www.touristinfocenter.mn/news_more.aspx?NewsID=2293

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Fig 2.06: CampStove 2+. (n.d.). Biolite. Retrieved from https://ca.bioliteenergy.com/products/campstove-2-plus

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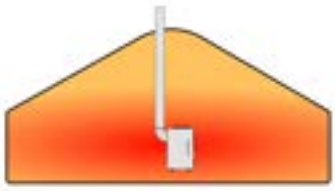
Fig 8.02: Length of oil pipes to install for ger. Engineers.

Fig 8.03: Yurt Interior. Adobe Stock

Fig 8.04: Render of Nest stove. Tergel Saikhanbayar

Fig 8.05: Floor Heating. Google Image.

Fig 11.01: Natural Zone. (n.d.). Discover Mongolia. Retrieved from https://www.discovermongolia.n/about-mongolia/nature-geography/natural-zone



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