

Post Harvest

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1 INTRODUCTION



REALITY STUDIO

Reality Studio is a transformative course offered within the Master's program in Architecture and Planning Beyond Sustainability at Chalmers University of Technology. This educational platform fosters collaborative knowledge creation between universities in Kenya and Sweden alongside various organizations, associations, and authorities. The course emphasizes sustainable development as a crucial global challenge that requires nuanced, local solutions. Through the Reality Studio, students engage directly with local stakeholders in urban areas to develop innovative design and planning strategies to improve health and enhance quality of life. This hands-on approach ensures that projects are sustainable, culturally relevant, and responsive to the specific needs of the communities involved. Participation and interaction with local communities are fundamental to the studio, ensuring solutions are grounded in real-world contexts and challenges.

STUDENTS

The team consists of four Chalmers students: Sylvia and Yuhan are master's students in industrial design, and Xuanjia and Helge are master's students in architecture.



OUR PROJECT

Reality Studio is a transformative course offered within the Master's program in Architecture and Planning Beyond Sustainability at Chalmers University of Technology. This educational platform fosters collaborative knowledge creation between universities in Kenya and Sweden alongside various organizations, associations, and authorities. The course emphasizes sustainable development as a crucial global challenge that requires nuanced, local solutions. Through the Reality Studio, students engage directly with

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UN SUSTAINABLE GOALS

Initially, our given mission was to solve the grain storage problem in Seme village. However, with the time flow, we decided to focus on the drying process instead. Further explanation will be given in the process section. Each year, the studio works on identifying themes connected with UNSDG goals to focus on. Food loss and poverty are the primary themes associated with this project. The theme focuses on decreasing poverty and hunger in the village by increasing the drying process's effectiveness. To the right, you can see the UNSDG goals that we believe are connected to this project.

Goal 1: End poverty

1 NO
POVERTY



Implementation: Free the farmers from conducting repeated and tedious steps in the drying process. They can then focus on activities such as earning an income.

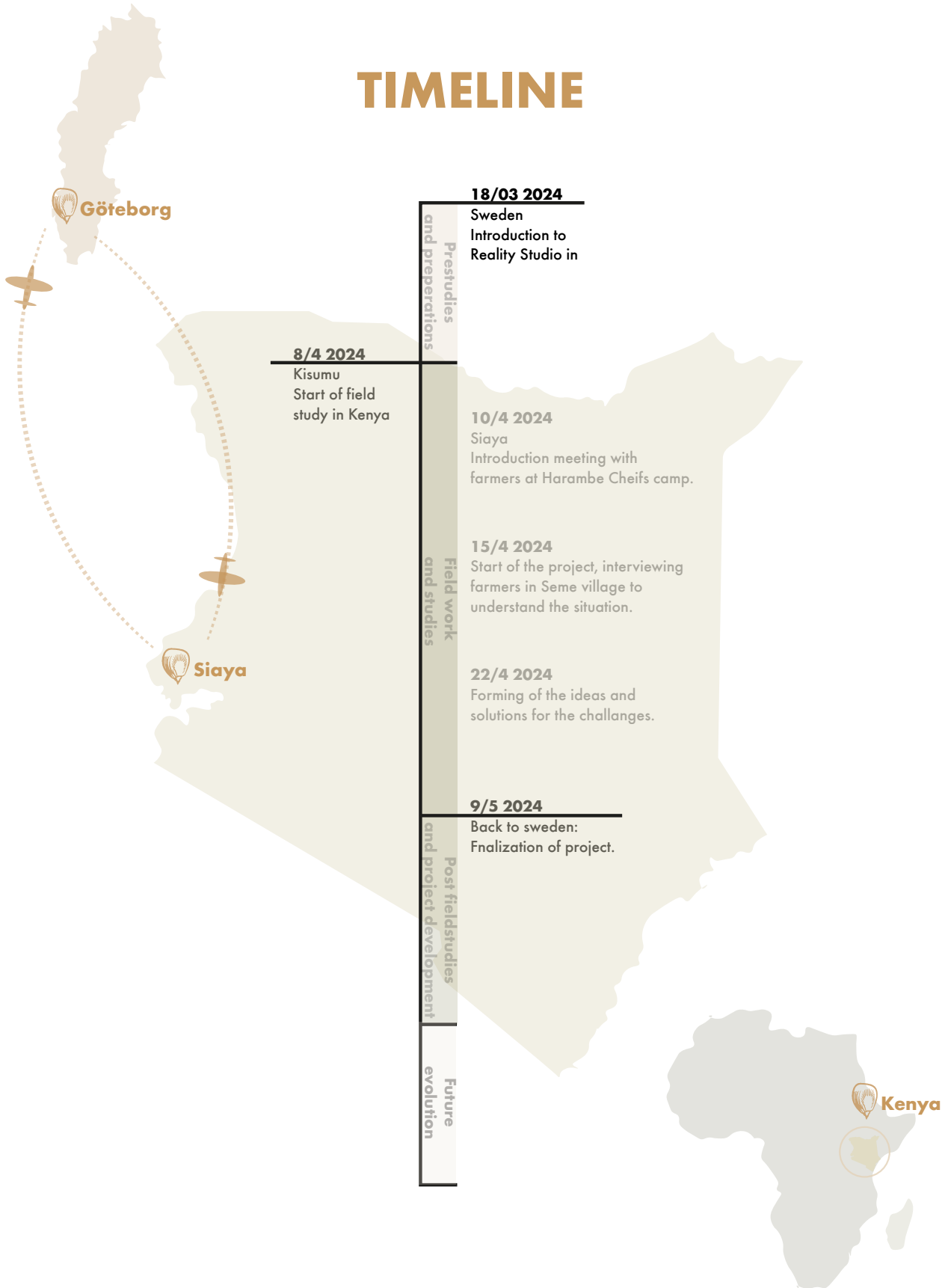
Goal 2: Achieve zero hunger

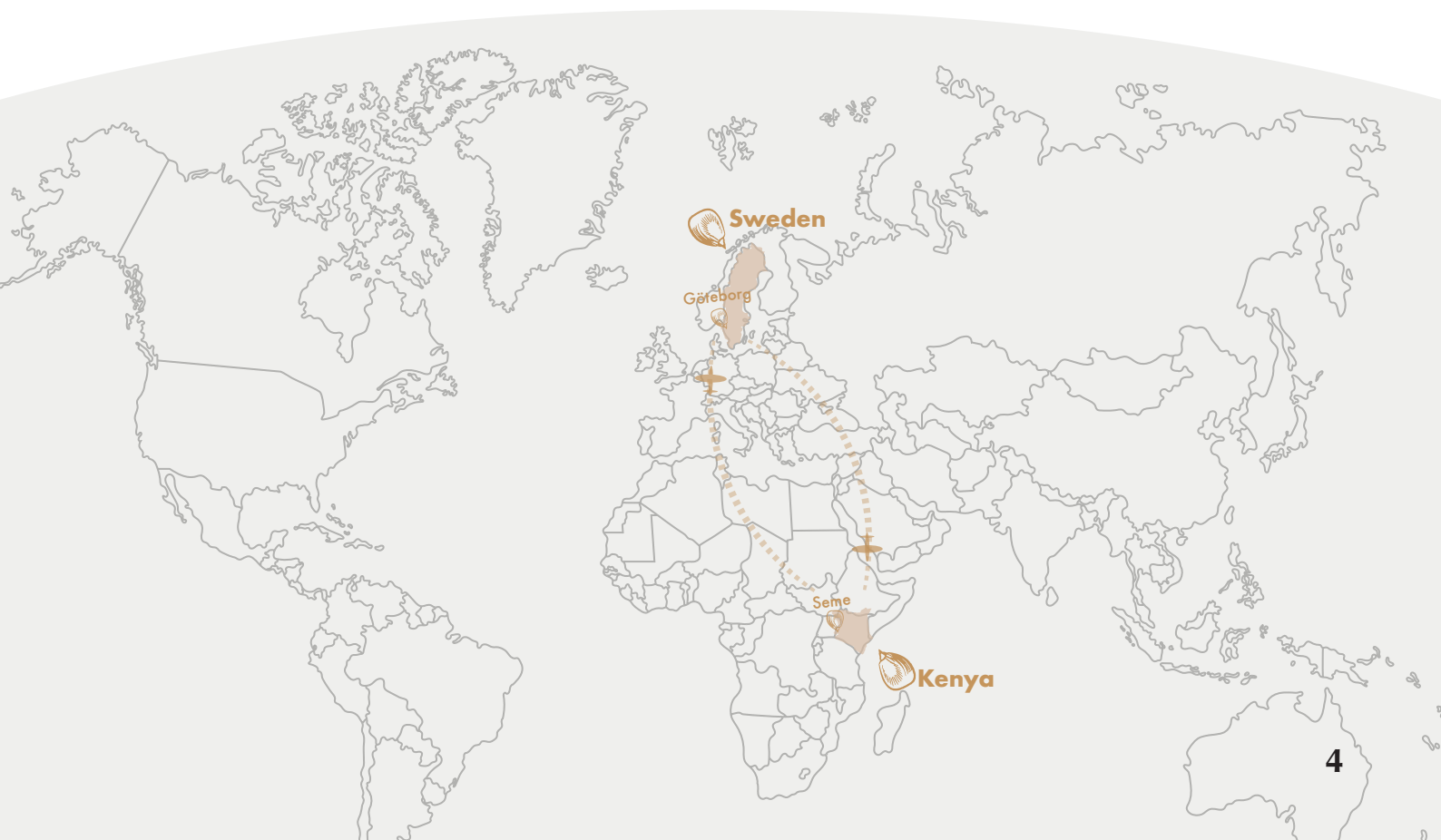
2 ZERO
HUNGER



Addressing the issue of food wastage due to spoilage is a crucial step to reaching "zero hunger." Research and implement methods to extend the freshness and lifespan of harvested crops.

TIMELINE





BACKGROUND

The village and sub-county Seme where we have been working is located just north-east of Lake Victoria, and about 5 km south of the equator. It is a geographically a big village, with a community gathering building called Harambee Cheifs Camp.

According to data from 2019, the sub-county Seme have a population of 122,000 and a areal of 268 km² (City Population, n.d.). This means the area have a density of 450 people /km². For reference Gothenburg have a population density of 3200 inhabitants/km².

Seme, as a lot of parts of Kenya, have a majority of women, and according to locals is this because the men dies sooner for different unknown reasons. This also means that the head of the farm often is a woman. In our case 4/5 farmers we worked with were women.

The main county Seme belongs to is Kisumu, which is also the third largest city in Kenya, with a population of about 1,200,000 people. (Britannica, n.d.)

AGRICULTURE IN KENYA

According to research conducted by Ketiem, P. (n.d.), agriculture contributed up to 30% of Kenya's annual GDP. However, the agricultural sector has not kept pace with the increased demands from rapid population growth. Presently, nearly 1 in every 3 Kenyans (14.5 million) suffer from chronic food insecurity and poor nutrition annually, with approximately 20% of the population not meeting minimum dietary requirements.

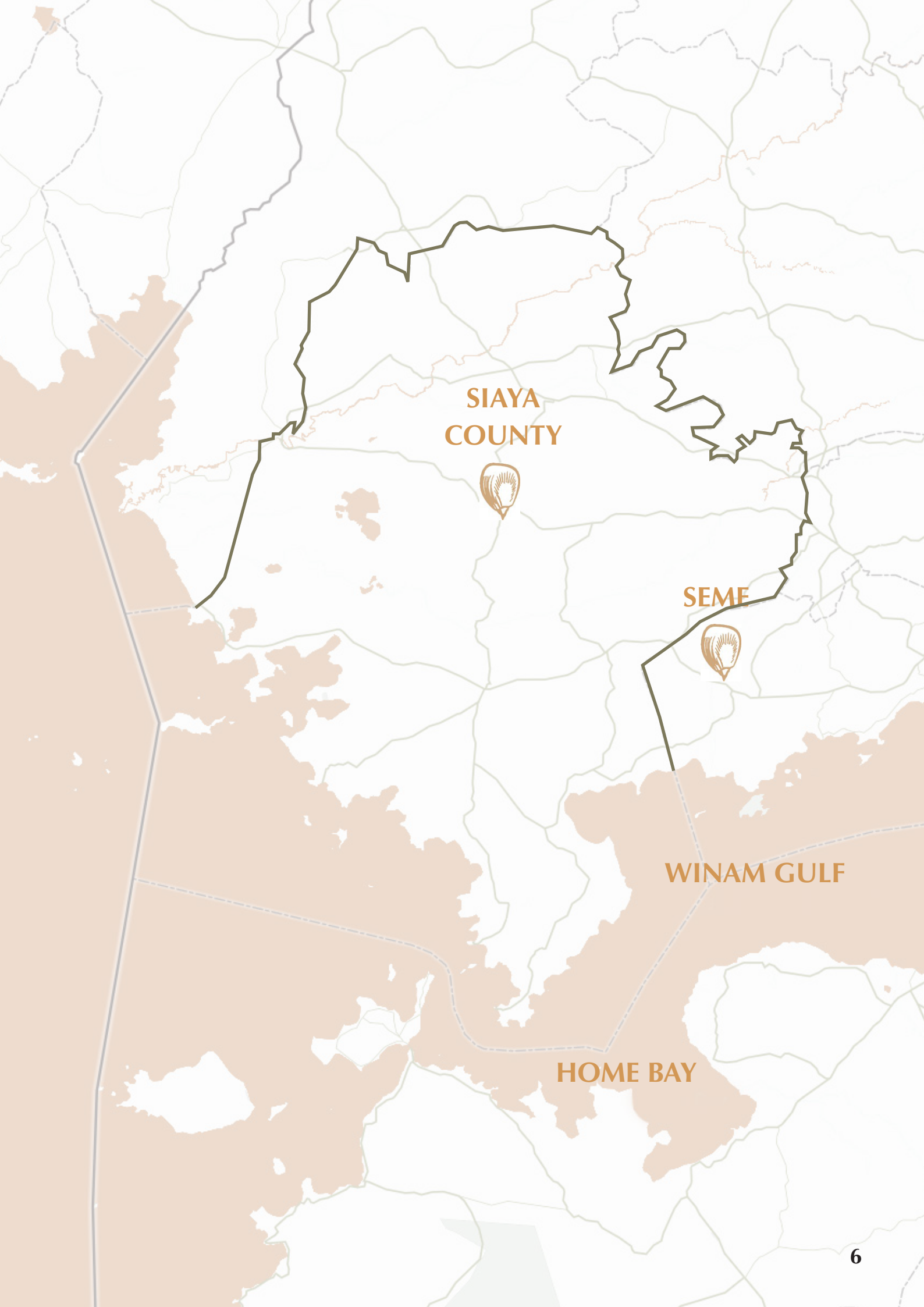
Food production has been declining due to high dependency on rain-fed agriculture, low adoption of technology, frequent pest and crop disease attacks, adverse weather, land degradation, urban encroachment into arable land, and rural-urban migration of the youth. Kenya loses up to 30% of its key cereals annually within six months after harvest (World Bank et al., 2011), leading to significant costs. Post-harvest losses are a major factor in decreased food availability, highlighting the need for loss reduction interventions and policy formulation.

ABOUT MAIZE

Maize, a strategic food security crop, accounts for up to 15% of Kenya's GDP from food crops, which cumulatively contributes 32% of the agricultural GDP. Declined maize production or shortfalls will lead to a food security crisis. In 2008, maize farmers, primarily small-scale, lost up to KES 29.6 billion, with 80% of the losses linked to poor storage and aflatoxin contamination (Ketiem, P. (n.d.)).

ABOUT SMALL SCALE FARMER

A small-scale farmer in Kenya typically manages an area ranging from less than one hectare to about 10 hectares. (Food and Agriculture Organization of the United Nations, 2013) These farmers primarily use family labor for production and focus on the stability of the farm household system. They often produce for commercial purposes and their own family consumption.



**SIAYA
COUNTY**



SEME



WINAM GULF

HOME BAY



2 STAKEHOLDERS & METHODS



STAKEHOLDERS



FARMERS

Due to time constraints, our research focused on five farmers: Margarite, Christina, Jacob, Phinister, and Theresa. These participants were carefully selected to represent a cross-section of the farming community in Sembroader problems faced by the majority of the village's farming population.



APOLLO

During the field study, Apollo, an expert in local handcrafts and agriculture from Seme Village, was indispensable to our research efforts. He functioned as an essential intermediary between the research team and the local farming community.



BUYERS

Customers of the farmer who buy grains can be neighbors, smaller actors in the market, or big corporations who, in turn, resell or use the product to make other products for the market.



FABRICATORS

The people farmers will contact for help regarding the construction of the design outcome. Could be a single person or a larger corporation to produce multiple products.



ONE ACRE FUND

This organization has been offering various services to support smallholder farmers in Africa since 2016. These services comprise, among others, providing access to better farming products like naturally produced hybrid seeds, fertilizers, and storage bags, commonly known as PICS bags, as well as offering better farming technology.



CHALMERS STUDENTS

Students from Chalmers University in Gothenburg, Sweden, are the designers and coordinators in this project.

FARMERS



THERESA

Madam Theresa is a 70-year-old farmer who grows maize, beans, and peanuts. She also raises cows, chickens, and ducks. She farms to sustain herself, though in recent years it has become more challenging due to her age. Transporting water, harvesting, and handling fertilizer are particularly difficult for her. Despite these challenges, she attends communal One Acre Fund meetings, which discuss and provide information about farming techniques. Thanks to these meetings, she does not face the same issues with weevils and theft that other farmers do.

Jacob, 42 years old, has a wife and three young children. Currently, he works in farming, but he previously worked in construction for several years. This experience allowed him to build his own house and undertake various projects around his property. He plans to expand his farm and buy more chickens. Jacob grows a variety of crops, including cassava, sesame, and maize.



JACOB



PHILISTER

Philister is a 43-year-old single mother of three young children. She has a small plot of land where she primarily farms maize and other vegetables to sustain her family's needs. Living in a remote area, access to her home requires walking through small mud paths, making it challenging to transport harvests and materials. However, the close-knit community around her provides reliable support.



CHRISTINA

Christina, a woman in her 40s, has a large family with children ranging from 1 to 18 years old. She has close family members living nearby who help with farming. Christina grows various crops, including beans, peanuts, and millet, but her main crop is maize. She also runs a side business, operating a bar a few minutes away by motorbike. Additionally, she owns donkeys and cows, which she uses for harvesting and fetching water from the river. To earn extra money, she rents out her animals to other farmers.

Madam Odema, a woman in her 70s, works on a farm, planting various crops like millet and beans depending on market demand. However, the main crop she grows to sustain her family's food supply and economic needs is maize. She manages the farming mostly by herself, hiring help only when needed, such as during the harvest season.



MARGARET

METHODS

SITE VISIT: QUALITATIVE INTERVIEWS & OBSERVATION

Qualitative interviews were conducted with five selected farmers in Seme village to gain a more comprehensive understanding of their daily lives and the challenges they encounter. Initially, the interview format was structured, with each farmer being asked an identical set of questions. This standardized approach facilitated the comparison of responses, providing a complete view of the farmers' issues.

As the study progressed, to explore specific claims and clarify particular issues more deeply, the interviews became less structured. This phase included both planned and spontaneous questions tailored to the individual circumstances of each farmer. The interviews were conducted in various settings, including outdoors on the farms and inside the farmers' homes, complemented by meticulous observation.

SUMMARIZE DATA: HTA

A Hierarchical Task Analysis (HTA) is a structured and systematic approach used to dissect and understand the tasks and goals of users within a system. Initially, the overarching goal of the system is identified. This main goal is then decomposed into a series of smaller, manageable subgoals. Each subgoal is supported by specific tasks necessary for its achievement. This breakdown provides a detailed and comprehensive outline of all the steps required to complete a task, thereby facilitating

the identification of potential areas for improvement. Additionally, by presenting this hierarchical map to the farmers, we were able to gauge their understanding and identify any possible misconceptions.

BRAINSTORMING: BRAINDRAWING

To generate a large quantity of ideas, we employed a brainstorming technique known as brain drawing. Starting with selecting a central theme, such as the drying process. In each sketching section, participants will start simultaneously and be allocated 1-2 minutes to sketch a potential solution to the issue. Upon completion of the allotted time, each sketch will be passed to the next participant. Subsequently, the new holder of the sketch could either further develop the existing idea or introduce an entirely new concept alongside it. This process continued until each sketch had circulated back to its originator. Ultimately, participants received their original sketches, now enriched with additional details and ideas. The group subsequently discussed these ideas, exploring the potential for combining them and triggering new inspiration.

REQUIREMENT SPECIFICATION

The requirement specification is a list that gathers the laws, requirements, needs, preferences, and wishes that have been identified. The requirements must be met by the solution, while the wishes and features are only desirable for the product to achieve. Together, the list creates a picture of what the solution should perform. The specification can be used to

choose between different solutions based on how well they meet the requirements and wishes.

allows us to review the recordings if there are any uncertainties, ensuring accuracy and preventing misunderstandings.

LITERATURE REVIEW

Literature review is a method that aims to provide a comprehensive analysis of existing research on a specific topic to help with understanding and decision-making.

USER EVALUATION: INTERVIEW

User evaluation methods, such as interviews, involve directly engaging users to gather feedback on a product or concept. These can include putting the users in a real-use scenarios to assess how users interact with the product. This method provides qualitative insights into user satisfaction, usability issues, and potential improvements by allowing users to express their thoughts and feelings in their own words.

PROTOTYPING

Prototyping involves creating an early version of a product to test its technical mechanisms and usability, confirming the concept's viability. Prototypes can vary from basic mock-ups made from materials like cardboard or paper to advanced functional models.

VIDEO, PHOTOGRAPHING, TAKING NOTES

During site visits, we ensure that at least two people take notes and one person is responsible for photography, aiming to simplify data sorting and analysis later. All interviews are also recorded. This









3

PROCESS

& FINDINGS



<p>18/03 2024 Sweden Introduction to Reality Studio</p>	<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Pre studies and preparations</p>	<h1>Design process</h1>	
<p>8/4 2024 Kisumu Start of field study in Kenya</p>	<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Field work and studies</p>	<ol style="list-style-type: none"> 1 First site visit Qualitative Interview & observation 2 Literature review Litterature review on previous used method of storage, the maize weevil and maize 3 Data analysis Heuristic task analysis, HTA 4 Brainstorming round 1 Maize storage and drying process 5 Literature review 2 Mechanism of maize drying and hermetics bags 6 Brainstorming round 2 Drying porcess 7 Site visit Concept evaluation round 1 8 Brainstorming round 3 Imrovements and iterations on design concepts 9 Site visit 3 Concept evaluation round 	        
<p>9/5 2024 Sweden Fnalization of project.</p>	<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Post fieldstudies and project development</p>		
<p>2025-</p>	<p style="writing-mode: vertical-rl; transform: rotate(180deg);">Future evolution</p>		

STEP1&2 - SITE VISIT&LITERATURE REVIEW



In this phase, we aimed to understand the situation of the farmers more comprehensively. To achieve this, we visited their homes to conduct qualitative interviews and observations, which we recorded on camera. Additionally, we conducted a literature review to gain a basic understanding of previously used storage methods, weevil, and maize.

Comments: We recorded all our interviews, which turned out to be very helpful. Whenever we had doubts, we could go back to the videos to check.

Most of the time, we used a small handheld camera held by one of us at a distance from the participants. This way, we could observe without making them uncomfortable.

However, there was one time when we placed the camera directly in front of the interviewee for better quality. From her body language, it was clear she felt uneasy. I've learned from this experience. In the future, after making sure to inform people before recording and we should maybe also try to be more discreet in filming.

STEP3 - DATA ANALYSIS



After transcribing the interview notes, we began categorizing potential problems. To clarify any uncertainties and ensure comprehensive understanding, we employed Hierarchical Task Analysis (HTA) and created a flow matrix from it. This allowed us to double-check our findings with the farmers, confirming that everything was understood correctly.

During this phase, we also discussed which challenges to prioritize. We decided to focus on storage and drying processes. Storage was initially identified as a primary issue, and drying was of particular interest to our team members. These problems are closely related and offer a potential for a combined solution.

STEP4 - BRAINSTORMING



In this phase, we initiated our first brainstorming round, focusing on the themes of storage facilities and drying processes. Our discussions began in a group setting, sketching out ideas collectively, which paved the way for



individual brainstorming. During the drawing section, we started to have some vital questions about our product. For instance, should the storage facility be sealed or opened? Should the air be cold or hot during the process?

STEP5 - LITERATURE REVIEW II



As we delved deeper into the subject through literature reviews, we discovered valuable insights about PICS bags (Purdue Improved Crop Storage bags) from the One Acre Fund's website, besides finding the answers to the abovementioned questions. Contrary to some farmers' beliefs that these bags lost efficacy after a season or two due to diminishing chemical effectiveness, we learned that PICS bags use a non-chemical storage approach and can last up to three years if handled properly. In Kenya one year have two harvest season. The seasonal income per person in Kisumu is around 139,585 KSh, calculated from the local GDP. Each bag costs about 250 KSh, and a small-scale farmer typically needs about 4 to 6 bags, totaling approximately 1,000 to 1,500 KSh. Since these bags can be used for up to 6 seasons (3 years), the seasonal cost is 170 to 250 KSh, which is about 0.17% of their seasonal income.

Our research revealed a gap in the farmers' understanding of how to use the bags effectively. Many farmers were not

utilizing all three layers of the bags and frequently opened them, allowing air to enter and weevils to thrive. On revisiting the farms, we confirmed our suspicions: the majority of farmers were not following the usage instructions fully, except for one who had no issues with weevils due to her adherence to the provided guidelines.

However, we found that there are two subgroups in our target group. Some farmers already have a storage room, and some don't. Thus, farmers with storage rooms don't have a problem with a lack of storage space, and developing a solution that builds upon the existing storage rooms to prevent weevils is perhaps more suitable and economical. But those who don't have one might want to have a whole new storage facility. We still decided to provide one of the concepts for storage in idea evaluation with the farmers, and the thought was confirmed.

Therefore, with the argument above, we decided to focus on increasing the effectiveness of the drying process.

STEP6 & 7 - BRAINSTORMING II & SITE VISIT II



Each group member conducted individual brainstorming sessions to develop ideas for improving the drying process. They presented these ideas and sketches verbally to three of the five farmers. The farmers preferred one idea, called the "table idea," which was preliminarily chosen as our final concept for further

development. We also created a requirement specification for the concept to clarify the needs of the users before the final round of brainstorming. In the final brainstorming session, the concept of a solar dryer emerged, inspiring two new ideas.

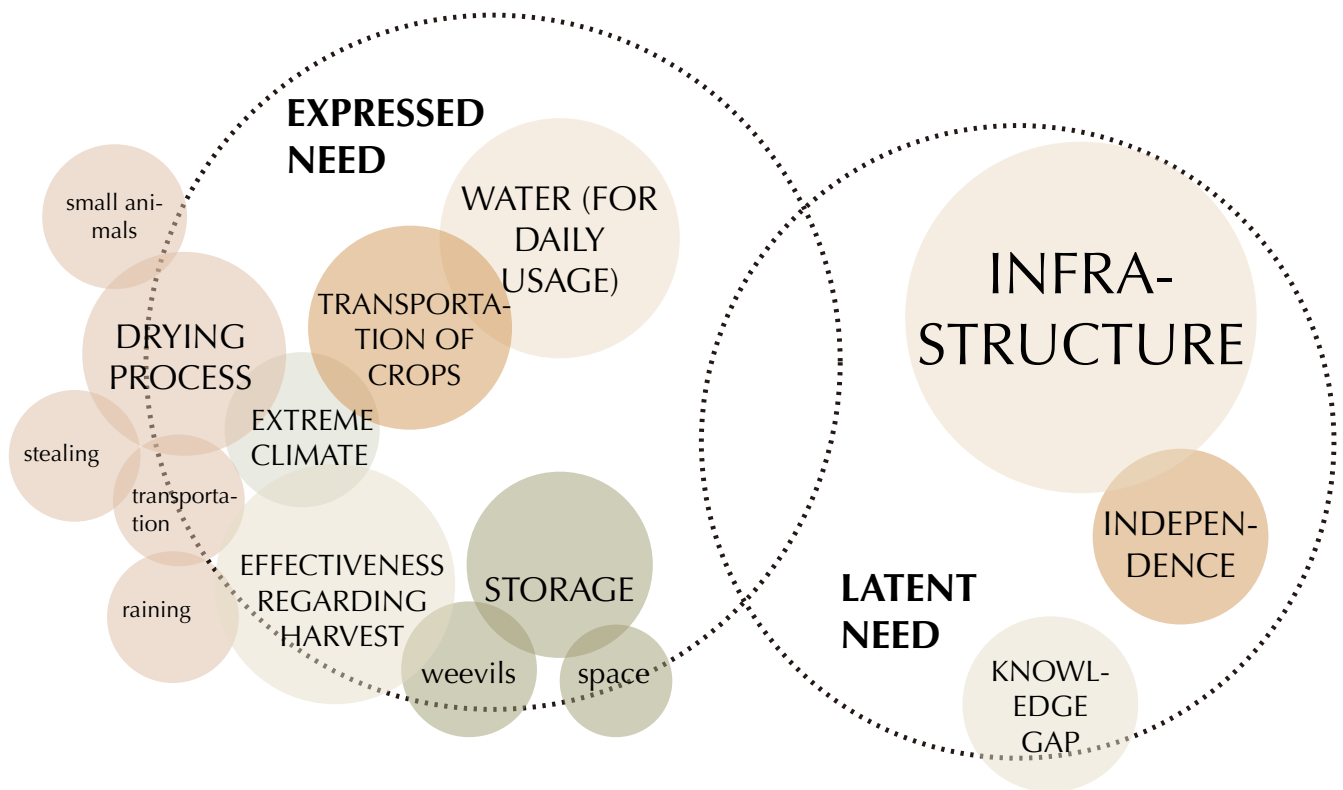
STEP8 - BRAINSTORMING III



We collaborated to refine these two new concepts with the table idea and presented them to the remaining farmers. The new solar dryer idea was more favorable and was chosen as the final concept. This concept was then presented in our stakeholder presentation.

Comments: Preparation time was very limited before the first evaluation round. Various group members made

the sketches at different detailed levels, potentially impacting which concept the farmers found more favorable. Knowing that the sketches were made by different members could also cause the farmers to give positive feedback on every concept. Therefore, the sketches in the second round of evaluation were made by one person, and the author of each concept remained anonymous.



EXPRESSED NEED

STORAGE

Weevils

There are two types of corn: One Acre Fund corn and traditional corn. One Acre Fund corn is more difficult to store because it is less resistant to insects than traditional corn. Therefore, farmers usually choose to keep traditional corn for more extended periods. However, even traditional corn has issues with weevils. The weevil problem is the primary reason we found causing the post-harvest loss.

Space

Three farmers (Jacob, Theresa, and Phlista) said they face significant challenges with their storage capacity. Currently, they store all their grains inside their homes. However, especially during

the harvest season, they often run out of room to securely store the grains indoors, leading to losses from theft. Moreover, they express the need to use the storage space for other purposes.

TRANSPORTATION OF CROPS (FROM FIELD TO HOME)

The crop transportation could be challenging, as the terrain was not always favorable and often lacked paved roads. Additionally, the volume of the crop often necessitated the use of donkeys or motorbikes. Take the donkey as an example; each donkey can carry only two sacks (100 kg) at a time. This capacity is significantly less than the total weight of the harvested crops of 400-600 kg mentioned by the farmers. As a result, a single donkey must make multiple trips, which can be inefficient, or farmers need

to rent multiple donkeys, which can considerably increase costs.

DRYING PROCESS

Transportation (Inside And Outside Farmers' Houses)

Similar problems occur during grain drying and transportation. According to our interviews, farmers can carry a maximum of around 15 kg at a time and do not have efficient tools. They only use their hands and small utensils to scoop the maize. For example, a farmer with 400 kg of maize needs to make 27 trips to carry it all out to dry in the sun. If each trip takes 3 minutes, it takes 80 minutes to carry everything out. Bringing the grain back in the evening to prevent theft and rain takes another 80 minutes. During the harvest season, over 4-7 days, farmers spend 3-4 hours daily on this drying process.

This exhausting process leaves farmers with little time and energy to engage in other activities, such as small businesses, that could generate additional income or simply provide a break from the tiring and stressful harvest season.

Raining

As the farmers stated, depending on the unpredictable climate, the crop could take different amounts of time to dry. Sometimes, rain prevented the grain from drying altogether. If the maize is not dry enough, mold will develop.

As mentioned above, taking all the grain inside is time-consuming, and rain does not wait. Nowadays, people cover the maize with a tarp, but many farmers express that some maize still gets wet.

Additionally, rain can come while the farmer is absent, further complicating the drying process.

Stealing

Nearly all the farmers expressed problems with grain theft. This, along with rain, is one of the main reasons they must carry all the grain indoors at night. The problem is especially severe for those living closer to the road.

Small Animals

During an interview, a farmer was drying some maize on the ground and needed to constantly get up to scare the chickens away from the maize. She expressed that this is a common problem.

EFFECTIVENESS REGARDING HARVEST

Theresa mentioned that during a great harvest season, she had more harvest than she expected, but she didn't have an effective way to harvest them all in time, thus causing a massive loss of harvest.

“During a great harvest season, I could produce one bag of beans, but I could only harvest a half bag in time.”

WATER (FOR DAILY USAGE)

Christina has a big family. Every few days, she must take her donkey to carry six containers of water from a lake about an hour away. This water serves as drinking water for humans and animals, including cows, donkeys, and pigs, and is also used for showering and washing clothes.

Another farmer who expressed the

problem of water supply was Marguerite. She has two 5000-liter tanks that collect water during the rainy season. However, she expressed that the water wasn't enough. Since she doesn't have a donkey, she walks to the lake with a water container carried on her head. She said that she is old and weak nowadays, and collecting water from the lake is tiresome and challenging.

EXTREME CLIMATE

Concern was also expressed about the changing climate, which made every step of the farming process more unpredictable. For instance, entire harvests could be affected by drought or flooding, and rain could also slow down the drying process.

LATENT NEED

INDEPENDENCE

Another significant challenge was the affordability of tools and supplies. The farmers expressed that the seeds bought from One Acre Fund, which usually comprised half of their crop, were sterile, meaning they had to buy new seeds every season. Similarly, the storage bags provided only lasted for three seasons. The farmers expressed a need for independence from these companies.

INFRASTRUCTURE

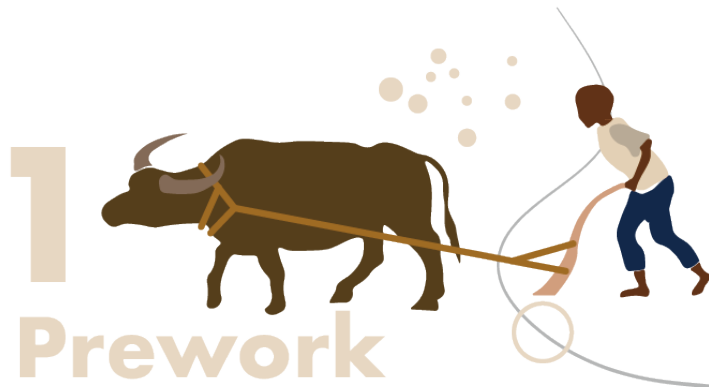
The transportation challenges, especially between the field and farmers' homes, could be translated into a latent need for better infrastructure for transportation and movement around the farms or communal cooperation with shared donkeys or other resources.

KNOWLEDGE GAP

It was found that the farmers have some knowledge gaps. For instance, they were not using the PICS bags, an ideal solution that could solve their biggest challenge with weevils. These bags have been readily available to them for many years. Theresa was a clear example of this knowledge gap; she was the only one who used the bags correctly and followed the instructions. Consequently, she was the only one of the five farmers without problems with weevils.

The farmers mistakenly thought that PICS bags were produced with chemicals applied on the surface and that the chemicals would wear off after one season. However, this was a misunderstanding. In fact, according to Blablabla, PICS bags are non-chemical storage facilities that can be used for up to three years.

FOCUS AREA



DESIGN CRITERAS

SCENARIO 1

Grace woke up at 5 a.m. today. It is the harvest season. For the past two days, she has been busy harvesting maize in the field with the help of two farmers she employed. After returning home, Grace spread all the maize on a big tarp she bought from One-Acre Fund. This season was a productive one; she harvested 400 kg of maize.

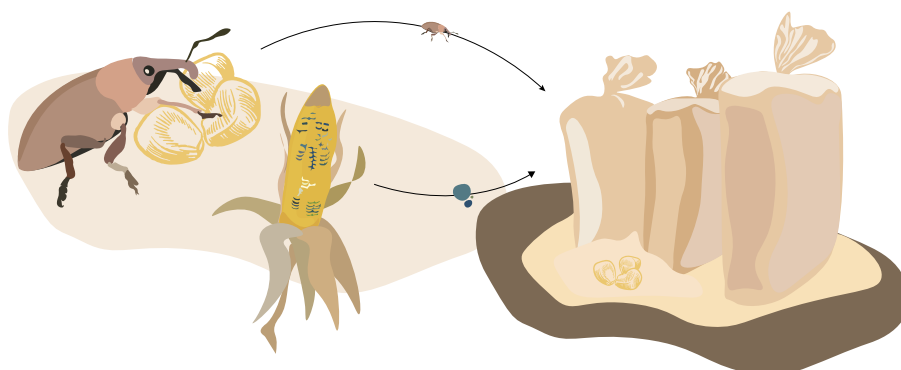
The drying process, however, was labour intensive and exhaustive. Every evening, she had to carry all the maize indoors to prevent theft and rain from damaging the harvest, and the next day, she had to spread it all out again to complete the drying process. Since she can only carry 10 kg at a time and she don't have any additional tool on hand beside the bags, this process was both physically demanding and time-consuming. The chickens were also a challenge, constantly trying to eat the maize while it was drying on the tarps.



SCENARIO 2

The harvest season was over, Grace stored some of her maize waiting for the grain price to rise. Nevertheless, Grace was increasingly worried about the weevils eating her maize. The sound of them gnawing away drove her crazy every time she entered the storeroom. Recently, she tried to spread some of her maize under the sun to kill the weevils, but it started raining while she was still visiting a friend. Because of this the maize got wet, potentially risking a mold outbreak and forcing her to restart the drying process.

Now, she is left with half of her maize wet and the other half infested with weevils. She must devote her entire day to the drying process. If the maize isn't dried properly, all of it will spoil. Grace wishes the drying process could be less time-consuming. She had planned to start a small business to generate extra income, but fear of theft and rain has forced her to stay at the house while the harvest is drying.



REQUIREMENT LIST

MANDATORY REQUIREMENT

- The equipment should be able to collect or generate heat
- The equipment should generate airflow
- The equipment be able to contain maize

DESIRED FEATURES

- The equipment should not taking up too much space while in storage
- The system should be modular, so it can be adopted to different needs
- The drying apparatus should be space-efficient, scaling appropriately to the quantity of grain being dried.
- The lost of grain while conducting drying process should be minimized
- It should prevent grains from being polluted by animals
- It should be able to process >50 kg of grain simultaneously
- One person user friendly
- The equipment should ensure that the gain keep dry during the whole drying process
- The preparation time of using the equipment should not be longer than the traditional way
- Putting the grain into the bag should not take more time than the traditional way
- The drying time should aim to be shorten compare to the traditional way
- Structure should not deteriorate
- It should prevent small animal from eating grain during drying
- It should prevent grains from being polluted by animals
- It should prevent grainstealing
- After the drying process, weeviles should be eradicate from the grain



4 DESIGN OUTCOME



Length
2.5 cm

X

①

⑤

width
2.5 cm

1.5 cm

1.5 cm

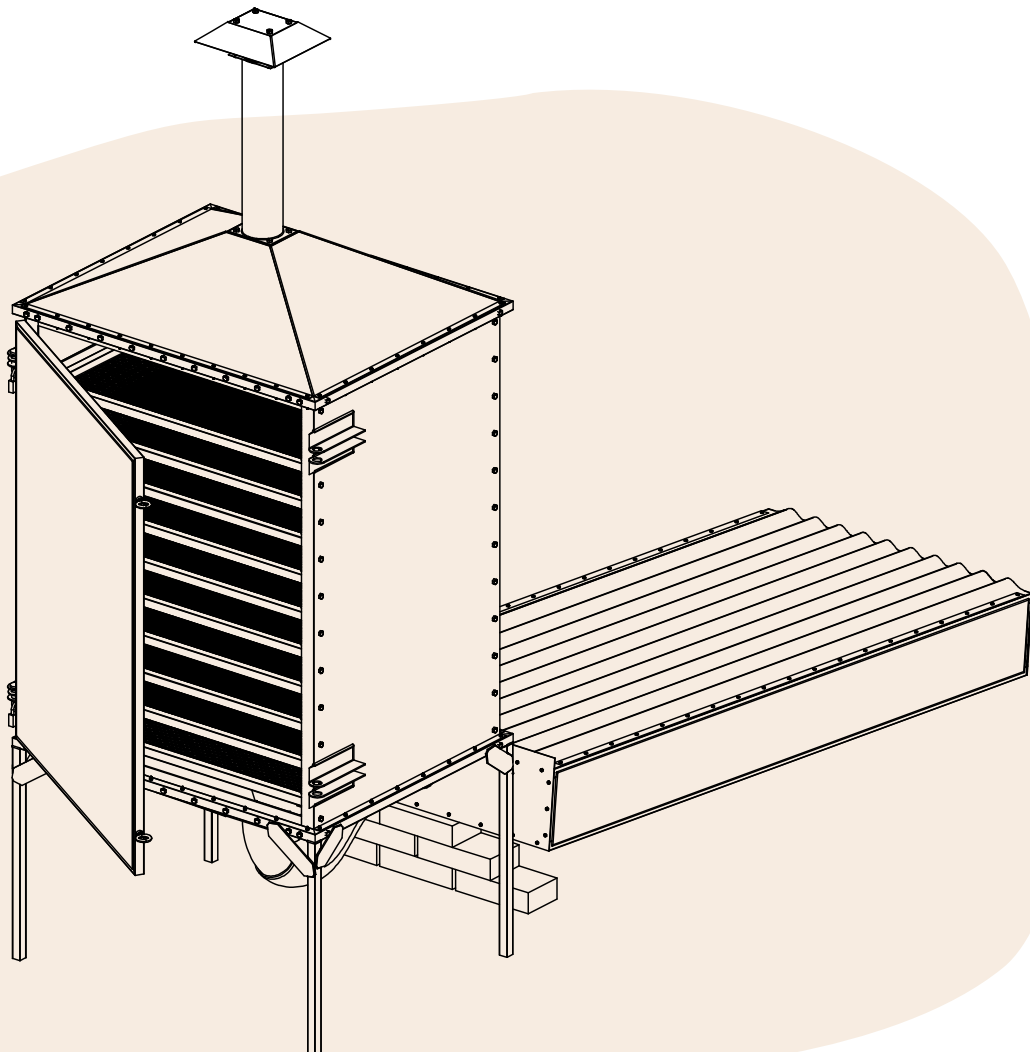
FINAL CONCEPT

The drying tower is a grain drying facility, in this first prototype primarily for maize. Both for drying kernels and the corncob as a whole. It can also dry other grains of similar size, such as beans. Smaller grains like millet require shelves with smaller holes. More testing needs to be conducted, but this could probably be achieved by putting fine fishing net on the shelves.

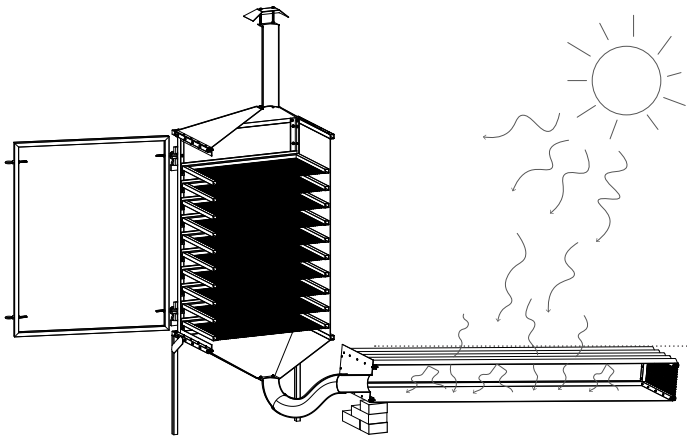
The facility has two main components: the black box and the drying tower. The black box captures heat from the sun and heats up the air, and through the phenomena of hot air rises (stack effect) generates airflow to dry the maize. The drying tower

stores the grain and allows the heated air to flow through, drying the maize. These components are connected by a flexible pipe of choice.

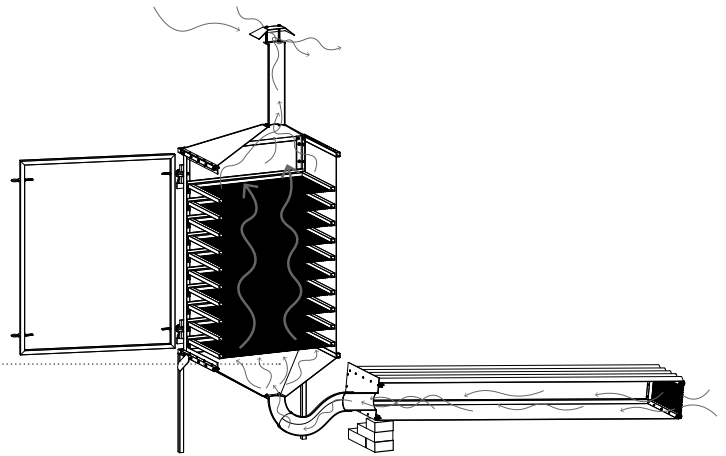
The enclosure allows for a lockable tower door which lets users to secure the grain in the evening or when absent, preventing theft and rain. This system provides users peace of mind, knowing their maize is safe and will dry efficiently. It also frees up time for them to pursue other business opportunities, spend time with family, or enjoy personal interests.



THE MECHANISM OF THE DRYING TOWER



Capturing energy and creating hot air.



Creating natural airflows through the system.

GENERATING HEATED AIRFLOW

The black box is placed at a slight inclined, so its surface is perpendicular to the sun. This allows for maximum exposure, and also water to run off. The inside of the black box is painted black, this is also where the name comes from. The color black is the best at capturing the energy of the sun, and will therefore turn really hot. When the black surface turns hot, it will radiate out energy in the form of heat, which in turn will heat up the air inside the black box.

As the air near the ground is always cooler, the air is also relatively speaking more dry. This is why we have a air inlet close to the ground. Upon entering, the air is immediately heated by the black box. This heated air rises and exits through the higher end of the black box. The warm air then continues to ascend through the tower, passing through all the shelves

where the maize is placed. The moisture of the maize is brought down because the hot air is dryer than the relative moisture content of the maize. Finally the air will exit through the chimney.

So in summary the whole idea is based on the concept of hot air rises and natural ventilation. So in theory this should work, but there are a lot of variables. For example a lot depend on how hot the air will become. It's also important that we only have one air inlet in the bottom and an air outlet in the top, with sufficient height difference between openings, to create the best stack effect.

RELEASING OF MAIZE

Reloading the shelves is simple. It only involves pulling them out and spreading the maize evenly. This could also be done inside the tower if you don't want to carry the shelves with maize on. Nevertheless, there are two ways to release the maize. For a smaller amount, pull out one or a few shelves. For larger quantities, unplug the pipe connected to the black box, place a bag underneath, and pour the maize to the bottom of the drying tower. This allows for the release of all or a significant amount of maize at once.

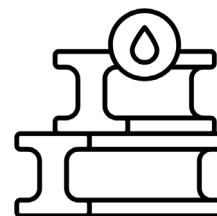
MATERIAL

The choice of material in this version is metal to withstand outdoor deterioration and longevity, but alternative materials that could potentially replace each component have been marked and mentioned in the construction handbook. The idea is to construct the whole structure in metal according to our handbook to have a solid base. This first prototype will then be tested and evaluated. After that other material could be used to try out some prototypes where the structure needs adjustment.

Price

This version, as mentioned before, is the first prototype. This means that materials and details can or should change after testing and evaluation. Based on Swedish material prices from Montano.se, a Swedish seller of metal products, the rough material cost of the drying tower and black box would be 8,000 Swedish kronor, or about 100,000 Kenyan

shillings. This is more than we expected and quite expensive, but we don't think it's unreasonable considering its potential. A new bodaboda (local motorbike), which is common in Kenya and Seme, costs about 150,000 shillings.



THE PROCESS CAPACITY

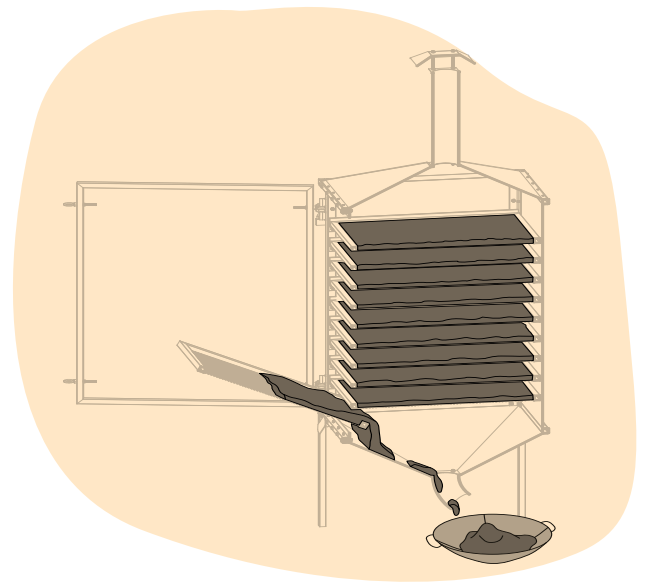
The dimensions of each shelf in the tower are 81x70x2.5 cm, and based on the bulk density of maize at 760 kg/m³, each shelf should be capable of processing a total of 10 kg of maize. The maize should be distributed across 10 shelves. This distribution is based on the carrying capacity of the least physically strong farmer among the five farmers included in our research. This also means that the tower can dry 100 kg at once, the same amount as in one PICS bag.

USING SCENARIO

Some of Grace's maize had been infested by weevils. She now has to re-dry them to get rid of the weevils. In the past, she would have to spend multiple hours every day for at least three days dealing with the infestation, constantly worrying about her chickens eating the maize, anyone stealing her maize or the rain prolonging this tiresome process. However, with the new solar dryer, her life has changed. Yesterday, Grace decided to dry one bag

of her stored maize kernels. She slowly carried them out and placed them evenly on the shelves. Then, she ensured she locked the tower's door before heading to her friend, who lived a few hours away, something that she normally didn't dare to do because of the fear of thieves and unexpected rainfall.

Grace is now free from the stress of all the potential problems. She has peace of mind knowing her maize is safe and drying efficiently. With this newfound freedom, Grace plans to visit her friend in the neighboring village, something she couldn't easily do before. The solar dryer has not only made her maize processing more efficient but also improved her quality of life, giving her more time to spend on her other businesses and time to spend with her family.



How to release maize





5 CONCLUSION



LITERATURE REVIEW

MECHANISM OF DRYING

When food grains containing a certain amount of moisture are exposed to air, moisture moves from the grain to the air, or vice versa, until there is a balance between the grain and the air's moisture.

Moisture Content And Temperature

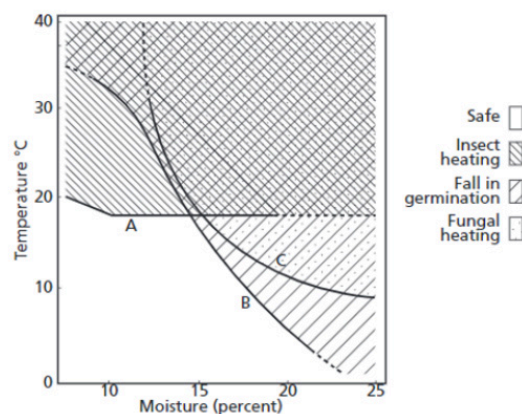
According to Food and Agriculture Organization of the United Nations (2012) unharvested crops face diminishing returns due to shatter losses and attacks by insects, mold, birds, and rodents. Promptly harvesting and cleaning contaminants like dust, straw, and weed seeds are essential to prevent spoilage.

Grain storage success heavily depends on moisture content. High moisture encourages fungal and insect problems, increased respiration, and germination. Lowering grain temperature reduces respiration rates and insect and fungal activity, extending storage life.

Damp or warm spots in grain increase respiration, creating heat and moisture that promote mold and bacteria growth, leading to a self-generating spoilage process. The moisture content and temperature should follow according to graph 1 to ensure safe storage. In Siaya, a county with in a one hour driving distance from Seme village have a yearly average temperature of 23.93 degrees according to Celsius Weather and Climate. (n.d.). Therefore, the storage facility should ideally maintain a temperature slightly cooler than the ambient temperature, specifically below 18 degrees Celsius. The

drying process should reduce the maize's moisture content to a maximum of 15 percent from the initial 18-25 percent at harvest (FAO, 2012)

If dryer for human and animal consumption, you can dry in temperature as high as 120 degree, which will remove 4-5% moisture per hour. If it's for sowing, germinability should be taken in consideration. Heat will kill the life (mecmargroup.com)



Graph 1. Effects in storage at different temperatures

Maize Weevil

The maize weevil is a pest that infests and damages corn, making the maize unfit for consumption. Corn can become infected either in the field or post-harvest, when a female weevil chews a small hole in the corn and then lays a single egg inside of it. After the egg has been laid, a larva will emerge and feed on the kernel until it completes its development, pupates, and emerges from the kernel as an adult beetle, continuing the cycle. The maize weevil is a small beetle recognized by its long, protruding snout.

<https://www.atchison.k-state.edu/docs/>

crops/stored_product_protection.pdf

Mold

Mold is a challenge faced when storing cereal and grain. The mold causes the grain to degrade in quality, causing discoloration, musty sour odors and cracking.

[https://doi.org/10.1016/0168-1605\(88\)90045-1](https://doi.org/10.1016/0168-1605(88)90045-1).

The mold is responsible for producing mycotoxins, which is a harmful compound dangerous for animal and human ingestion. All these factors affect the final price and ability to consume.

[https://doi.org/10.1016/0378-4274\(95\)03599-0](https://doi.org/10.1016/0378-4274(95)03599-0)

Mold is naturally present on mature grains, often already present in the field, and requires specific moisture and temperature levels to germinate and thrive. Without these favorable conditions, the fungi cannot survive; for instance, a low-moisture environment will lead to the fungi's eventual stagnation and possible eradication. To prevent mold growth, it is crucial to maintain a controlled environment with consistently low moisture levels where the grain is stored.

https://www.atchison.k-state.edu/docs/crops/stored_product_protection.pdf

CURRENT METHODS

Mold And Insect

The farmers in Seme village employ various methods to prevent and mitigate mold and insect damage to their crops. One such method is the application of ash. They produce their own ash by burning wood and leaves in their vicinity. This

ash is applied after the grains and cereals have been adequately dried. It can be applied initially, before long-term storage, to prevent potential mold, and also during the storage period if signs of mold are observed. Similar procedures are followed for insects, especially the maize weevil, based on signs of damage or to mitigate infestation.

Additionally, farmers utilize strains of cereal and grain that exhibit greater resistance to mold and insects. However, local strains, while more resistant, are considered less productive by the farmers. Nevertheless, these local strains possess thicker shells, providing enhanced protection against mold and insects. For example, maize kernels from local strains feature thicker shells, and the husks surrounding the cobs are also thicker, offering protection against birds, pests, and airborne mold spores. Although farmers sometimes leave cereals and grains in the field to dry, prolonging exposure increases the risk of damage by pests and mold spores. Therefore, despite the lower productivity, farmers in Seme still use the local grains and cereals.

Drying

According to research conducted by the Food and Agriculture Organization of the United Nations (2012), traditional methods used by farmers for drying grain rely on natural air movement and sunlight to reduce moisture content to a safe level for storage. Natural drying can be divided into three main methods:

- Drying in the field before harvesting.
- Drying in shallow layers, exposed

to sun and wind, on a surface that prevents ground moisture from reaching the produce.

- Drying in or on a structure with open sides to allow air movement through the mass.

MECHANISM OF THE PICS BAG - HERMETIC STORAGE TECHNOLOGY

PICS bags utilize hermetic storage technology, which creates an airtight and moisture-proof environment, effectively isolating the contents from external conditions. This method serves to safeguard stored goods by eliminating unwanted contaminants and maintaining a controlled atmosphere. Commonly utilized in the agriculture industry, particularly for storing dried grains over extended periods, hermetic storage ensures the preservation of aroma, taste, and quality, while also retaining nutritional value. By preventing exposure to insects and mold, this technology protects grains and cereals from contamination.

<https://www.crs.org/our-work-overseas/research-publications/guidelines-seed-storage>

Traditionally, grains and cereals are vulnerable to infestation either in the field or during storage, leading to a decline in quality. However, hermetic technology disrupts the life cycle of molds and insects by creating an environment with minimal gas exchange. Studies have shown that low oxygen levels significantly diminish the vitality of molds and insects. This environment is fostered by the respiration of existing insects and molds within the stored crops.

<https://www.sciencedirect.com/science/article/abs/pii/S016816058890044X>

Despite its benefits, large-scale adoption of hermetic storage faces challenges. One of the major challenges are concerns regarding the economic viability, durability, and longevity of the storage bags. Additionally, there exists a knowledge gap regarding the optimal usage of hermetic storage technology, potentially hindering its widespread implementation.

Efforts to address these challenges, such as improving the affordability and robustness of hermetic bags, as well as providing education on their effective utilization, are crucial for realizing the full potential of hermetic storage in enhancing food security and preserving crop quality.

REQUIREMENT LIST

MANDATORY REQUIREMENT

- The equipment should be able to collect or generate heat
- The equipment should generate airflow
- The equipment be able to contain maize

DESIRED FEATURES

- The equipment should not taking up too much space while in storage
- The system should be modular, so it can be adopted to different needs
- The drying apparatus should be space-efficient, scaling appropriately to the quantity of grain being dried.
- The lost of grain while conducting drying process should be minimized
- It should prevent grains from being polluted by animals
- It should be able to process >50 kg of grain simultaneously
- One person user friendly
- The equipment should ensure that the gain keep dry during the whole drying process
- The preparation time of using the equipment should not be longer than the traditional way
- Putting the grain into the bag should not take more time than the traditional way
- The drying time should aim to be shorten compare to the traditional way
- Structure should not deteriorate
- It should prevent small animal from eating grain during drying
- It should prevent grains from being polluted by animals
- It should prevent grainstealing
- After the drying process, weeviles should be eradicate from the grain



NEXT STEPS

We left our metal solar collector with the farmer. The next step is to construct the tower structure per our handbook and assess the intricate concept for potential improvements. After the evaluation phase, we would be able to address the following questions:

- Is the airflow and the temperature inside the product enough?
- How should they adjust the facility if the effect is not ideal?
- How does rapid temperature change impact the maize inside when sudden rain occurs?
- How much maize is feasible for the equipment to process?
- Is it more efficient and convenient than the traditional way of maize drying?

The collected data should be recorded and further developed in another future project before putting into mass production.

REFLECTIONS

Due to time constraints, the prototype presented was not optimal. Convincing the farmers of the solar dryers' functionality and tailoring the concept to their specific context was a challenge. Concerns were raised about the cost and rebuild ability of the structure after the field trip.

The prototype was made of metal for speed of construction and durability. Although wood was considered, local farmers preferred metal for its long-term resilience. However, the high cost of metal posed a challenge for small-scale farmers. If we had more time, more focus on materials and methods to construct a structure tailored specifically to the farmers in Seme would have been helpful. We are satisfied with our overall time management and planning during the prototyping and design phase. Without the initial time spent on research and data collection, we would not have been able to identify this specific challenge. Comprehensive data collection revealed that the real issue was a knowledge gap rather than a design solution, allowing us to focus on another aspect of post-harvest processing.

While the principle of indirect solar drying is known and the structure is used elsewhere, it has not been tested under the exact same circumstances. Key questions remain, such as whether it is possible to efficiently dry large amounts of grains like maize in these structures, whether it is better than the conventional tarp method used by the farmers today, and if it truly streamlines the drying process and

mitigates theft. Despite these unknowns, we believe this project is a great starting point, and given more time, it has the potential to make a significant difference for the farmers in Seme village and possibly for those in Kenya as a whole.

Because we did not conduct the field study during the harvest season, we might overlook some of the farmers' needs during the problem identification phase. Additionally, missing the harvest season means we are uncertain if our design meets all the desired features. For instance, minimizing grain loss during the drying process is a key requirement that needs measurement using the current drying method, which we cannot perform now.



6 REFERENCE



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7 APPENDIX



LOGICAL FRAMEWORK

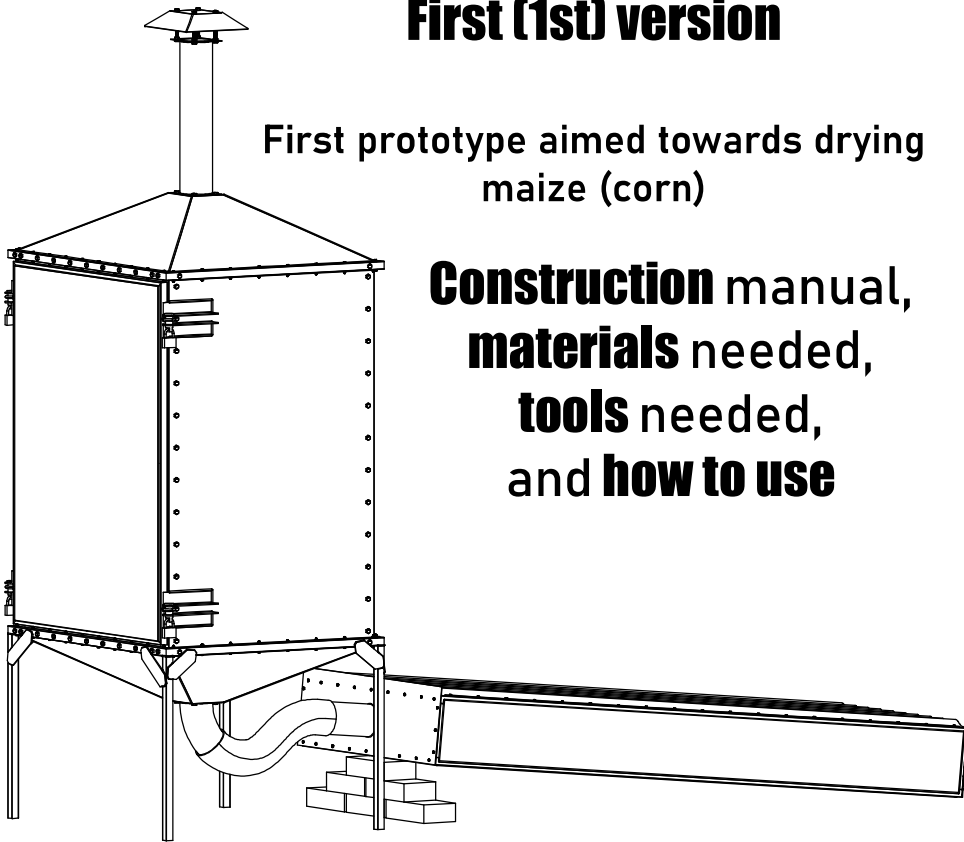
	Project Description	Performance Indicators	Monitoring (Means of Verification)	Assumptions (Risk Assessment)
Overall Objective	The overall objective of the project is to empower local farmers in Seme Village by improving postharvest storage systems. This initiative aims to address and resolve the most pressing storage issues in a phased approach, leading to comprehensive community upliftment.	<ol style="list-style-type: none"> 1.Quantity of crops successfully preserved through improved post-harvest practices. 2.Reduction in post-harvest losses as a percentage of total harvested crops. 3.Increase in the availability of preserved food for household consumption throughout the year. 	<ol style="list-style-type: none"> 1.Data and reports from local governments or village-level sources, including information on community economic development, employment opportunities, and food supply. 2.Field surveys and research, gathering information on agricultural production, livelihoods, and market conditions through interviews with local farmers, community members, and stakeholders. 	
Project Purpose	<p>To reduce the rate of hunger incidence by ensuring that food storage issues are minimized, allowing for sufficient food supplies until the next harvest season.</p> <p>To contribute to poverty reduction by enabling the community to not only meet their basic food needs but also generate extra income through the production and sale of surplus food.</p> <p>To enhance economic well-being for the local community through improvements in physical storage infrastructure and the introduction of advanced technology and methods for better storage practices.</p>	<ol style="list-style-type: none"> 1.quantity of the constructed food storage space, including capacity and durability 2.Improvement in crop quality, such as crop dryness and extended shelf life 3.the quantity and quality of fertilizers used 	<ol style="list-style-type: none"> 1.Data and reports from local governments or village-level sources. 2.Field surveys and research, gathering information on agricultural production, livelihoods, and market conditions through interviews with local farmers, community members, and stakeholders. 	<ol style="list-style-type: none"> 1.weather and climate conditions 2.government policies and regulations 3.access to finance 4.Infrastructure and Access to Resources(transportation networks, electricity, water supply) 5.External Partnerships and Collaboration 6.social and cultural factors(Community attitudes/gender dynamic/Social cohesion and community participation)
Results (Outputs)	<ol style="list-style-type: none"> 1.Longevity of harvest is longer in comparison to before change is made. 2.Less harvest loss due to theft and spoilage. 	<ol style="list-style-type: none"> 1. If the stored harvest maintains its "shelf life" for a significantly longer period compared to before the implemented changes, it can be concluded that the goal has been achieved. 2. A reduction in the incidence of stolen and spoiled harvest produce would serve as another indicator of successful outcomes. 3. An overall increased amount of harvest produce retained would indicate a successful improvement. 	<p>The amount of time that it takes to prepare the harvest from harvest to "ready for long term storage". Or the amount of time the harvest will stay "good" to consume.</p> <p>For example it may take months for corn to sun dry prior to improvement, and if after the improvement it takes x-1 months to completely dry there is a measurable output.</p>	<ol style="list-style-type: none"> 1.The stakeholders, farmers, initiative, ambition and willingness to adapt to the change, try it out. 2.Access to material. 3.Time limitations. 4..weather and climate conditions 5.government policies and regulations 6..access to finance 7.Infrastructure and Access to Resources(transportation networks, electricity, water supply) 6.External Partnerships and Collaboration 7..social and cultural factors(Community attitudes/gender dynamic/Social cohesion and community participation)

Activities	Resources (means)	Costs	
<p>1.Assessment of Needs and Resources(interviews/contact with local suppliers/mapping)</p> <p>2.idea generating(drying techniques/storage method/ fertilizer)</p> <p>3.infrastructure construction</p> <p>4.Market Linkages</p> <p>5.Monitoring and Evaluation</p>	<p>1.Assessment of Needs and Resources</p> <p>-experts/technology/supplies</p> <p>2.Capacity Building and Training:experts(agriculture/architecture)/training handbook</p> <p>3.infrastructure construction:construction materials/experts</p> <p>4.Market Linkages:local community</p> <p>5.Monitoring and Evaluation:local community</p>	<p>no idea...</p>	<p>1.weather and climate conditions</p> <p>2.government policies and regulations</p> <p>3.access to finance</p> <p>4.Infrastructure and Access to Resources(transportation networks, electricity, water supply)</p> <p>5.External Partnerships and Collaboration</p> <p>6.social and cultural factors(Community attitudes/gender dynamic/Social cohesion and community participation</p>

Experimental (Prototype)
Drying Tower
First (1st) version

First prototype aimed towards drying
maize (corn)

Construction manual,
materials needed,
tools needed,
and **how to use**



What is this?

Reality Studio is a course at Chalmers University in Gothenburg, Sweden. Each year, a group of students is tasked with going abroad, and this year, they are going to Kenya. Previous years have visited South Africa, Bangladesh, and Kenya, among other places.

On site, the students collaborate on different projects with local stakeholders, various organizations, associations, and authorities to generate collaborative knowledge sharing. The course and projects emphasize sustainable development as a crucial global challenge that requires nuanced, local solutions.

The papers you are reading now are the practical result of such a project, though we hope this is not the final outcome. Connected to the project is also a project report.

In April of 2024, four students from Chalmers traveled to Siaya, Kenya, to work with local farmers in the village and region of Seme. We had heard beforehand that the farmers needed help with post-harvest solutions, and our aim was to create a design solution through combined knowledge that would solve one or more identified problems.

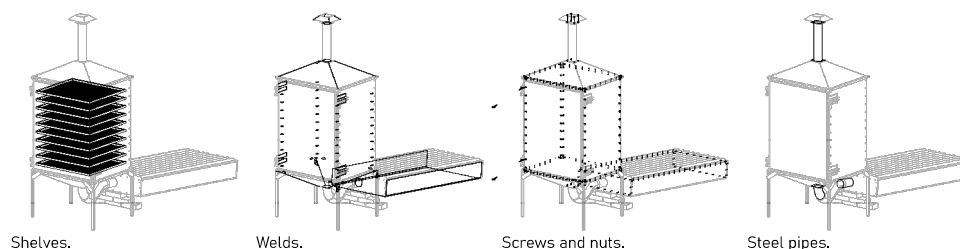
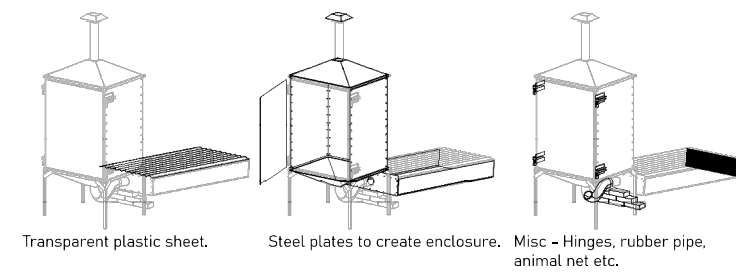
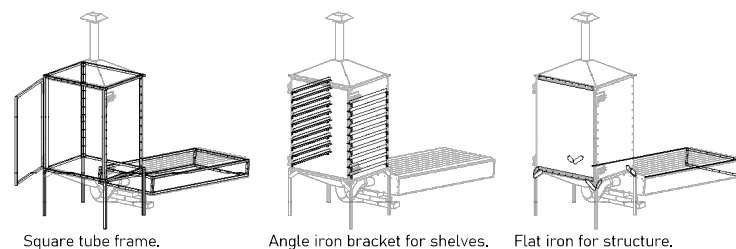
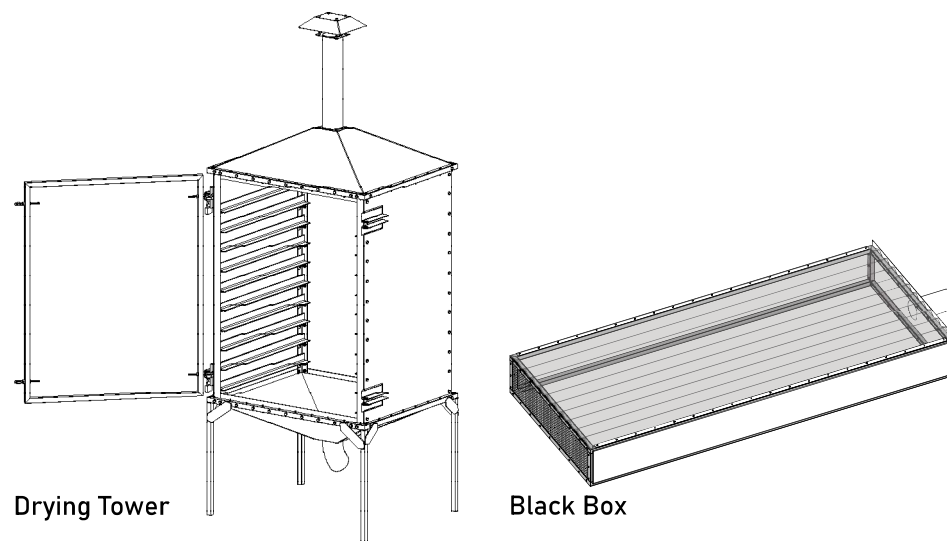
This handbook is about this design solution, something we call a Drying Tower. Connected to the Drying Tower is the Black Box, a heat-generating source.

The idea is simple. We have two parts. One part is where you put grains to dry – the Drying Tower. The other part is to generate heat through the sun's energy – the Black Box. The Black Box's task is simple: it sucks in dry cold air and heats it up to temperatures that will dry the maize to a low moisture content that allows for long-term storage. The Drying Tower's task is to temporarily store the grains while they are left to dry. Simultaneously, the Drying Tower protects the harvest from rain, theft, and animals. The grains can be left unattended in the dryer for days.

We want to emphasize that this is a prototype. It is based on research you can read about in the project report. The principles work, but we are not sure how efficient they will be in this version. The prototype needs to be built and tested in real-world conditions. This is where YOU, the potential user, come in. We want you to build the prototype and try it out! Let us know what works and what does not, what should change and what should stay.

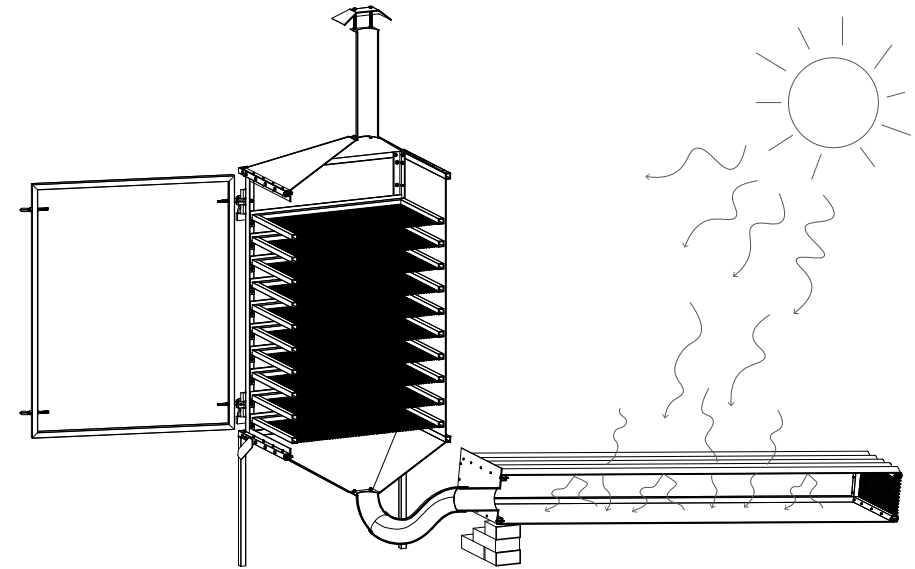
Thank you!

The Students,
Helge Berntsson, Sylvia Xie, Yu-Han Hua, Xuanjia Ye



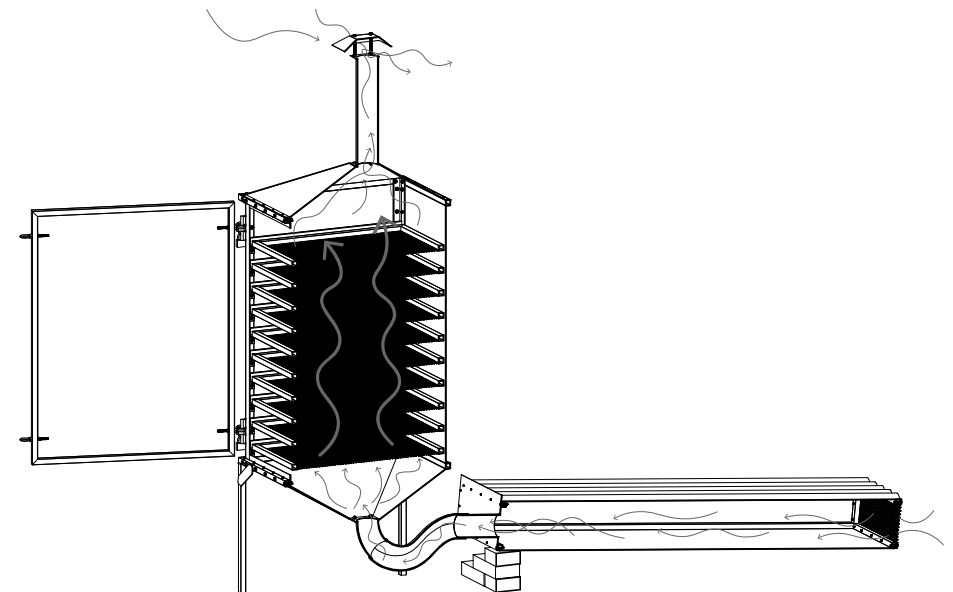
The principals

The dryer works by utilizing two main concepts. The first is to capture the sun's energy by creating a small greenhouse (Black Box). The top of the Black Box is a transparent plastic sheet, which lets the sun's rays through but traps the air inside the box. The color black is the best at absorbing heat, so the inside of the Black Box is painted black (except for the transparent roof). This is where the name comes from. The black surfaces heat up quickly and then radiate heat, which heats up the air.



Capturing energy and creating hot air.

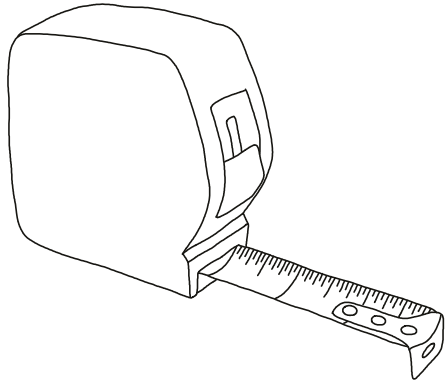
The second concept is the stack effect—hot air rises. This creates the natural airflow needed to pull in dry, cooler air through the bottom inlet and push it out through the chimney. The fast-moving outside air (the wind) also helps to "pull" out the air through the chimney while passing the opening. Combined, this is the concept of natural ventilation.



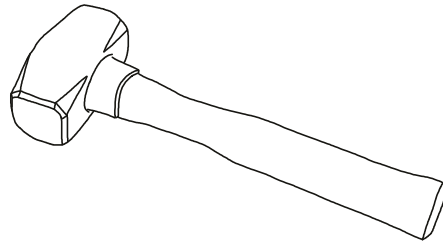
Creating natural airflows through the system.

Tools needed

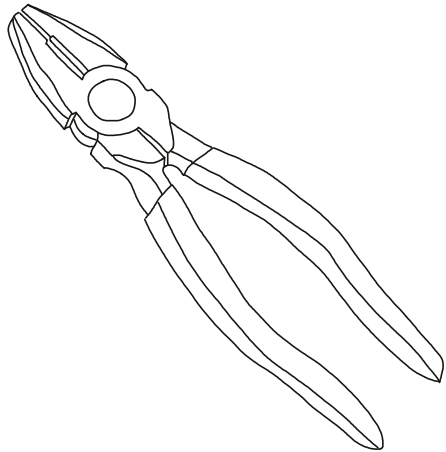
The tools to manufacture and assemble the Drying Tower and Black Box are not numerous or advanced, but you need some expertise. Since everything in this version is made of metal, you need someone who knows how to cut and weld metal to fabricate all the parts. Assembly can be done by anyone.



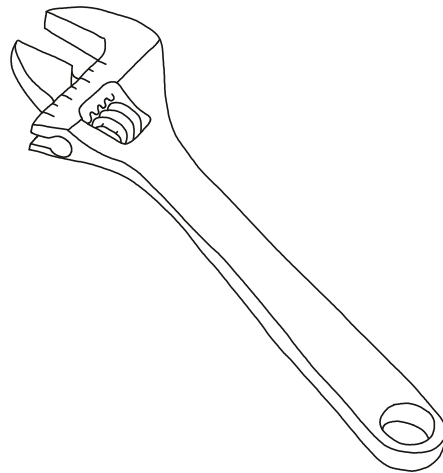
Tape measure



Hammer

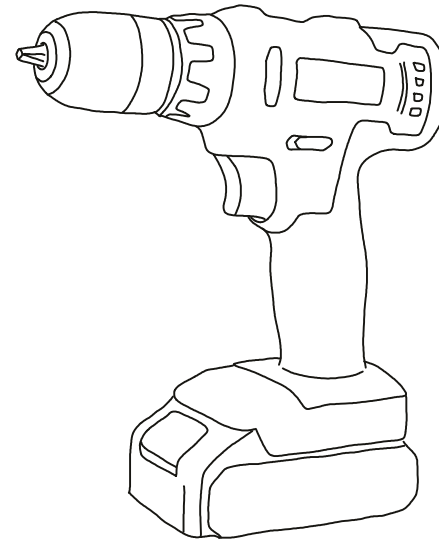


Plyer

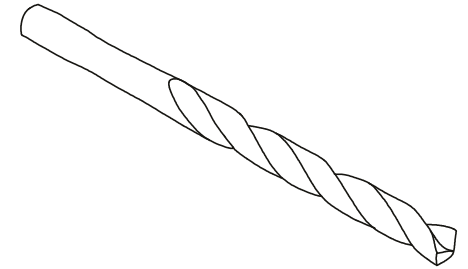


Wrench

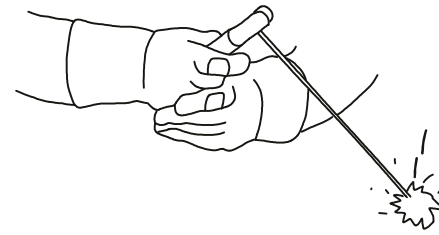
(Pliers and wrenches are just examples of tools that can tighten hex nuts and screws. Two socket wrenches could work just as well.)



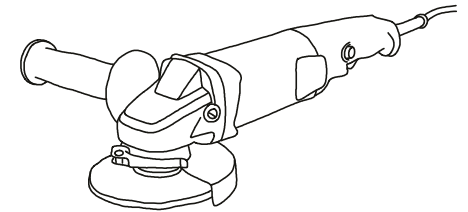
Drill



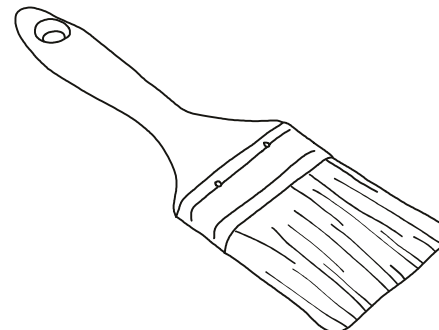
Drill bit for metal
4.5 mm and 9 mm



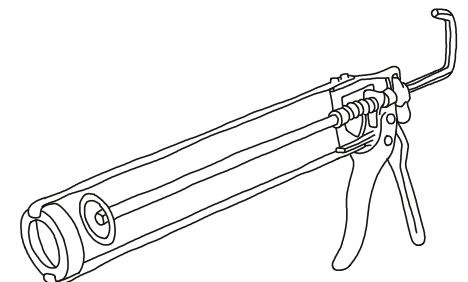
Welding machine



Angle grinder (and/or anything else
that cuts metal)



Paint brush



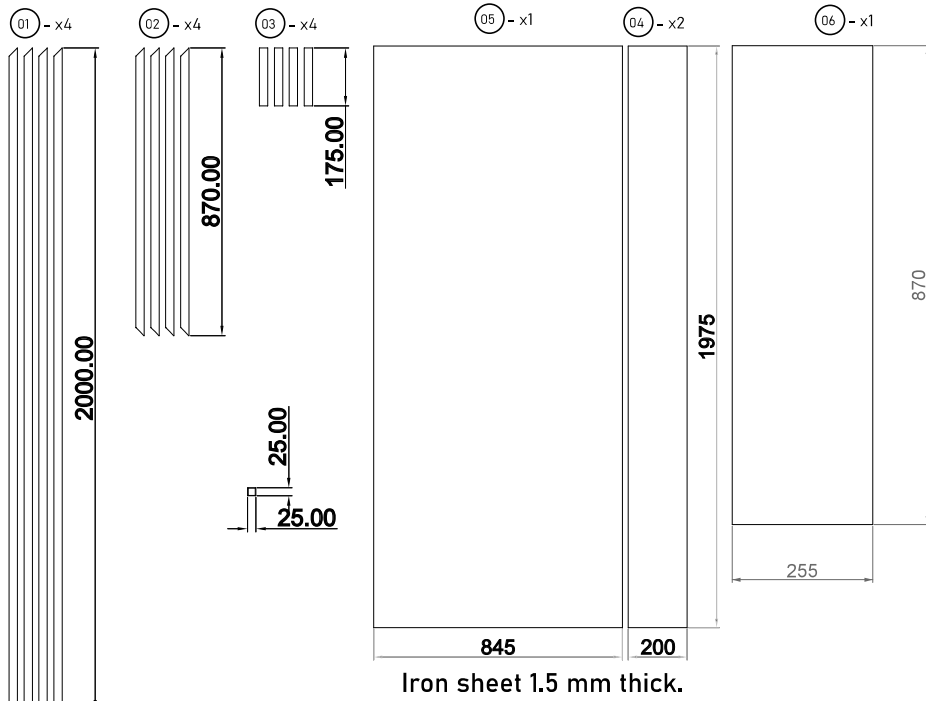
Silicon gun

Raw materials needed

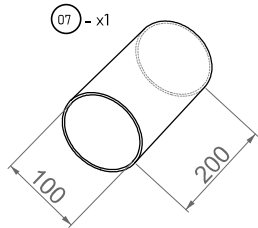
Square tube pipe 25x25x1.5 mm 6m	5	Amount
Angle iron 40x40x3 mm 6m	4	Amount
Metal sheet 2000x1000x1.5 mm	7	Amount
Metal steel pipe straight 100 mm diameter	700	Length (mm)
Metal steel pipe bent 100 mm diameter	150	Length (mm)
Flat iron 25x3 mm 6m	1	Amount
Flat iron 50x3 mm 6m	1	Amount
M4 hex screw 35 mm	158	Amount
M4 hex nut	158	Amount
M8 hex screw 14 mm	80	Amount
M8 hex screw 35 mm	34	Amount
M8 hex screw 100 mm	4	Amount
M8 eyebolt >30 mm	4	Amount
M8 hex nut	130	Amount
Silicon		
Rubber pipe		
Metal Pins	4	Amount
Padlock	4	Amount
Black paint	3	Area (m3)
Transparent plastic sheet 87x2000 mm	1	Amount
Metal net 1000x220 mm	1	Amount

Cutlist of materials

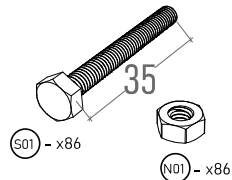
Black Box



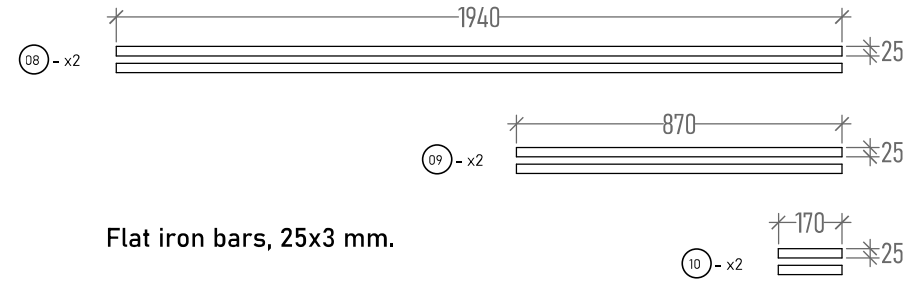
Square tube pipe 25x25x1.5 mm.
Peice 01 and 02 need a 45° cut
in each end.



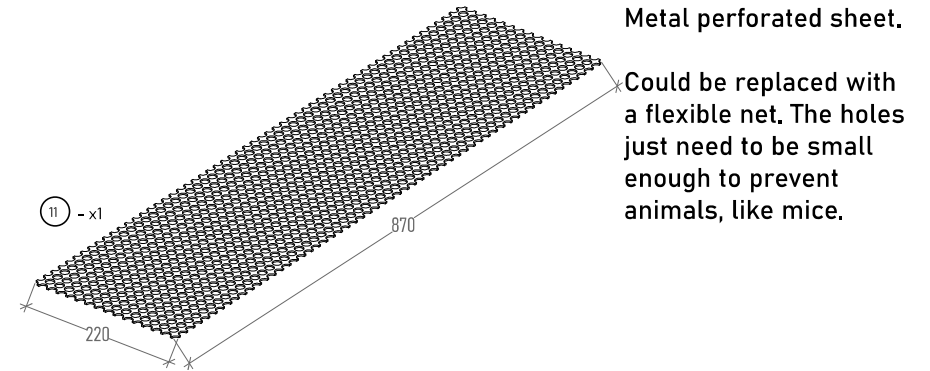
Steel pipe 100 mm in
diameter.



M4 Hex screw and
nut. 35 mm long.



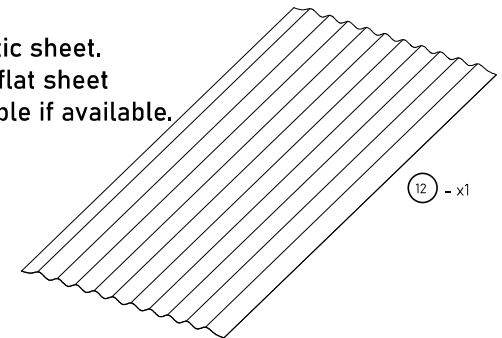
Flat iron bars, 25x3 mm.



Metal perforated sheet.

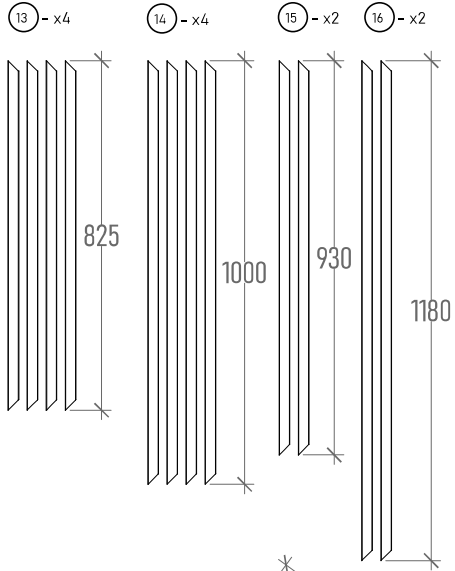
Could be replaced with
a flexible net. The holes
just need to be small
enough to prevent
animals, like mice.

Transparent plastic sheet.
870x2000 mm. A flat sheet
would be preferable if available.

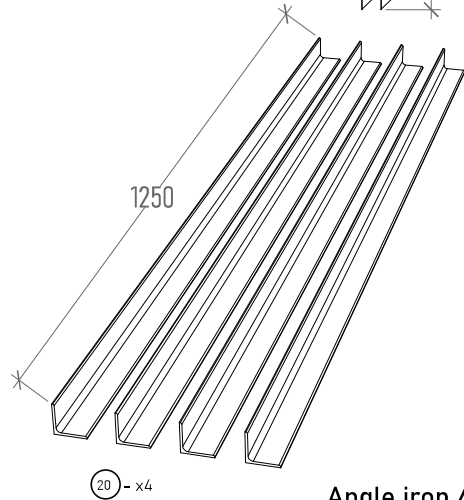


Cutlist of materials

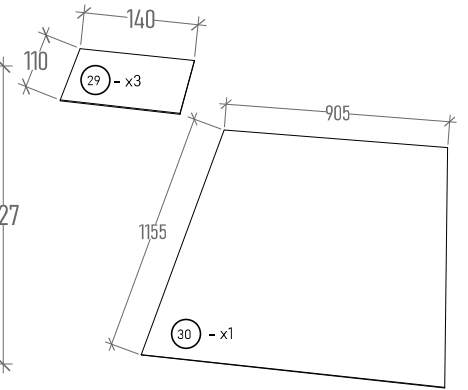
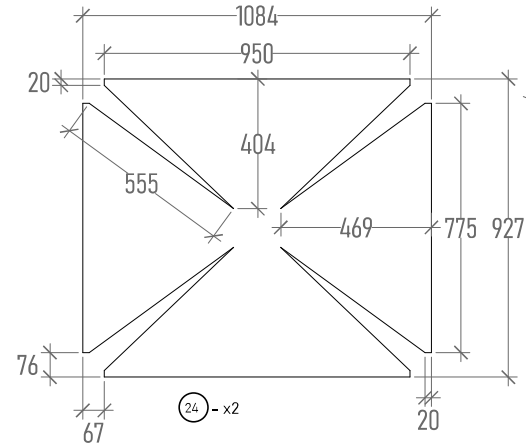
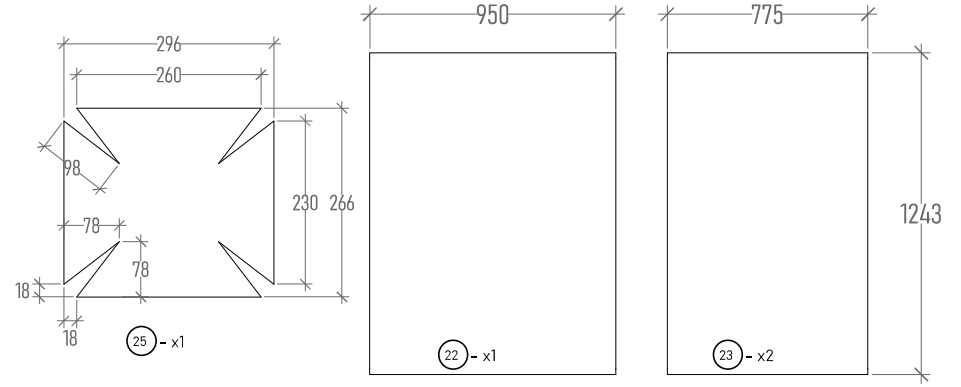
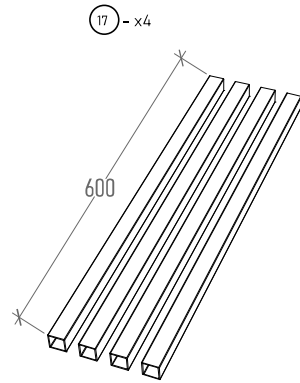
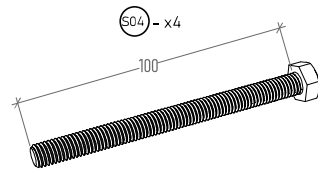
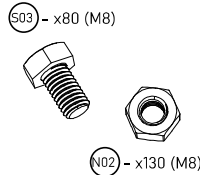
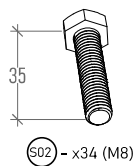
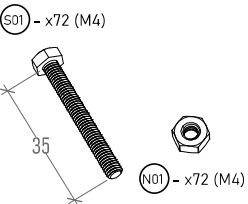
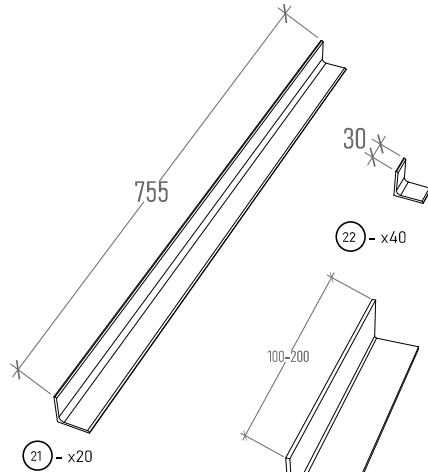
Drying Tower



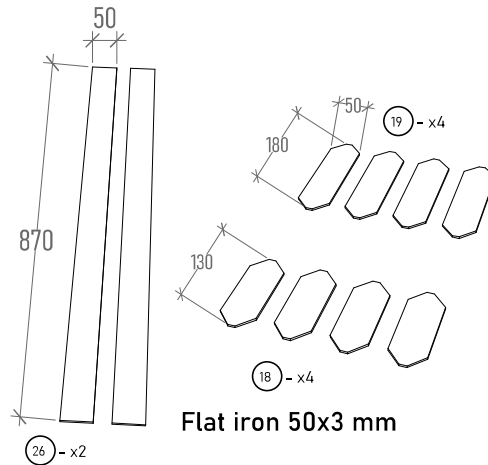
Square tube pipe 25x25x1.5 mm
Peice 13, 14, 15 and 16 needs a
45° cut in each end.



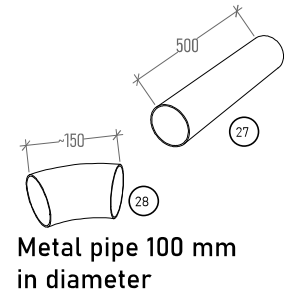
Angle iron 40x40x3 mm



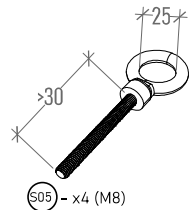
Metal sheet 1.5 mm thick



Flat iron 50x3 mm



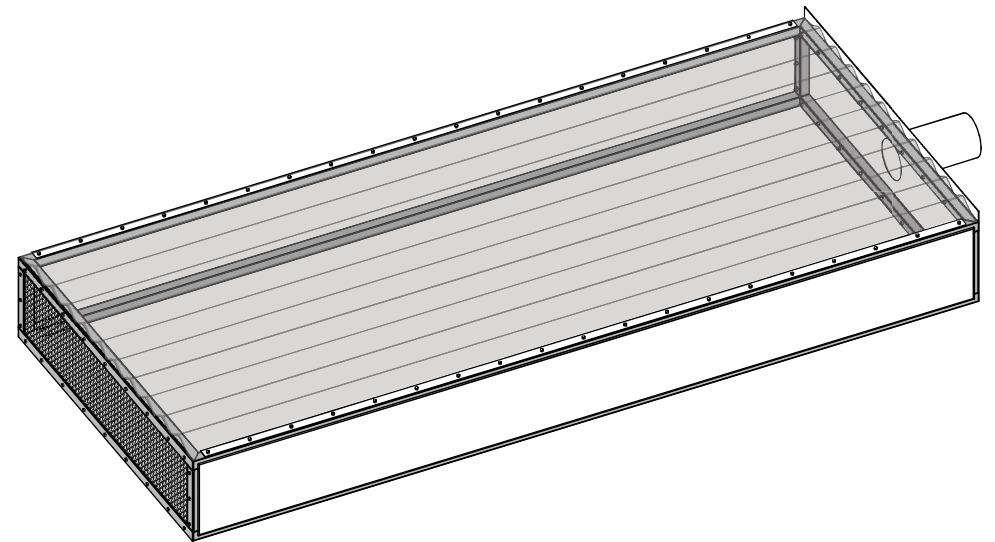
Metal pipe 100 mm
in diameter



Manufacturing

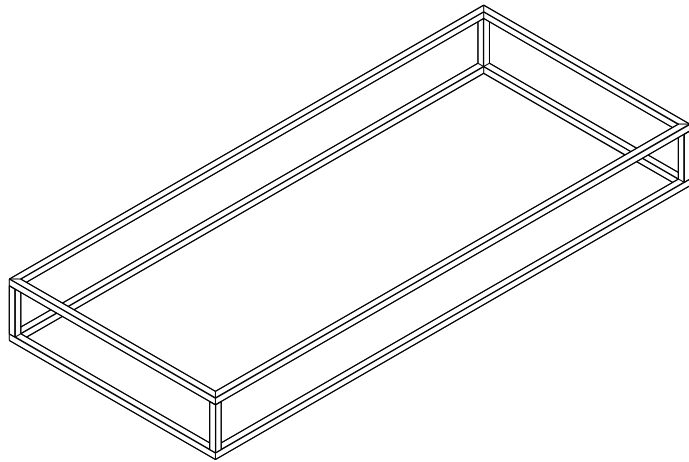
Black Box

Solar Energy Capturing Component
This component generates hot air for
drying grains using natural airflows.



Step 1

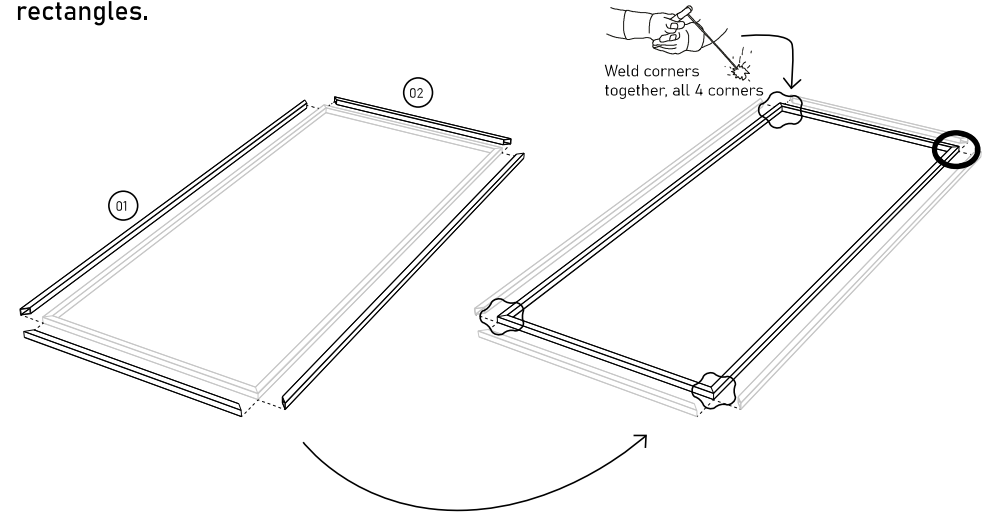
Welding black box frame



A01 - The goal of this step

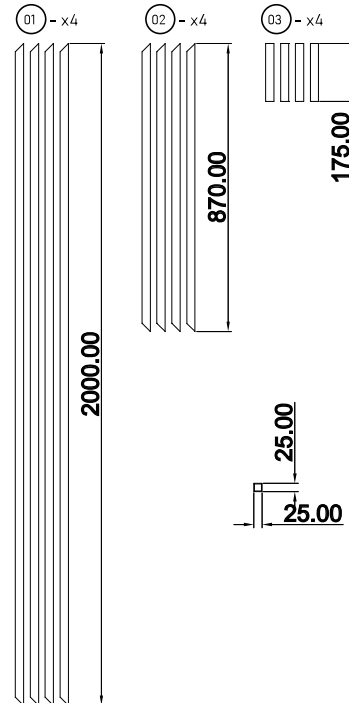
Sub-step 1.1 (x2)

Weld 2x2000 mm and 2x870 mm pieces together. Repeat 1 time. Total of 2 rectangles.



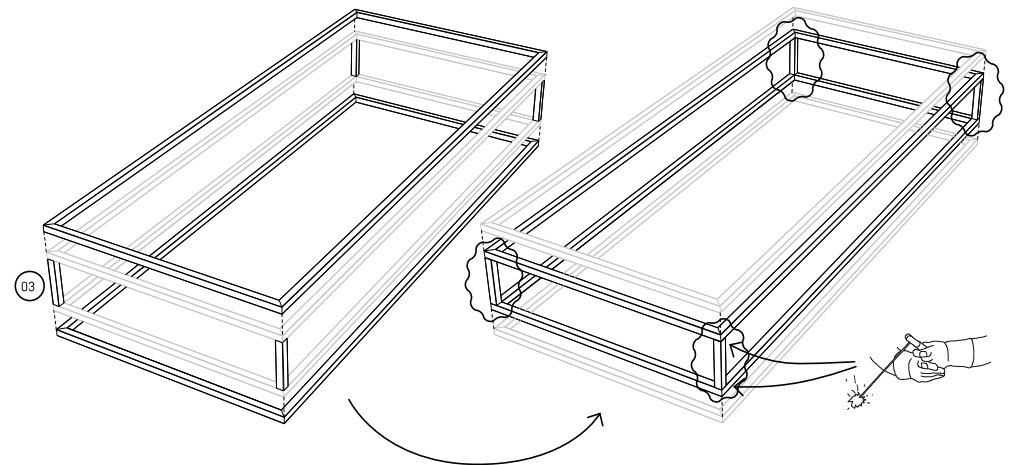
Materials needed

Square tube pipe 25x25x1.5 mm
4x 2000 mm (cut 45° in each end)
4x 870 mm (cut 45° in each end)
4x 175 mm



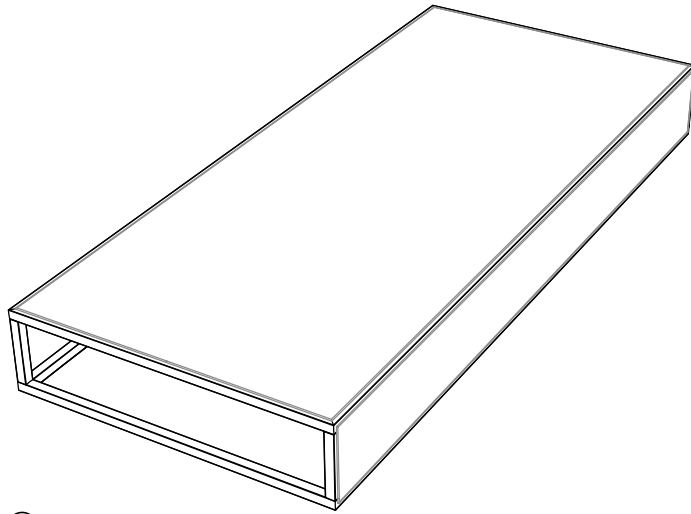
Sub-step 1.2

Weld the 2 made rectangles together to create a box frame.



Step 2

Welding metal sheets to 3 sides.

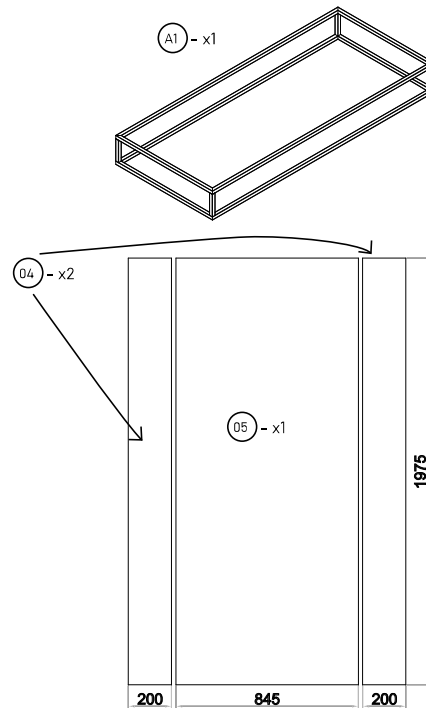


A02 - The goal of this step

Materials needed

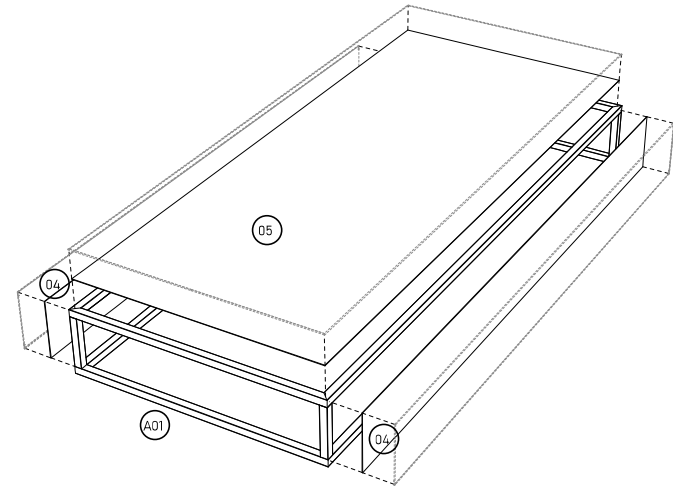
A01 Assembly

Metal sheet 1.5mm
1x 845x1975 mm
2x 200x1975 mm

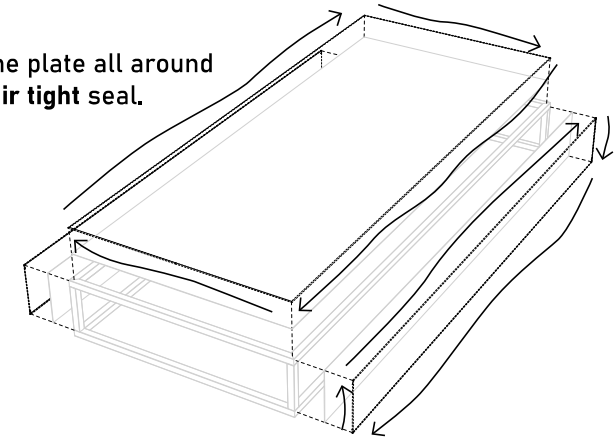


Sub-step 2.1

Weld the 3 metal plates to the frame structure from step 1, A01.

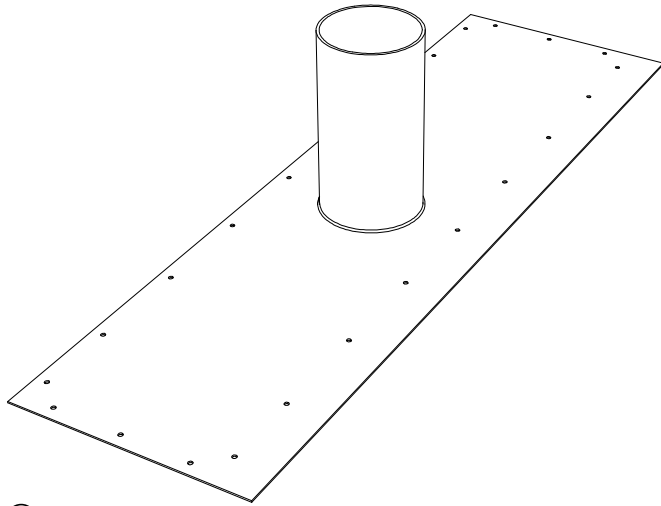


Fully weld the plate all around
to create a **air tight seal**.
All 3 plates.



Step 3

Creating short side sub-assembly

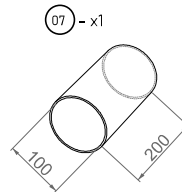
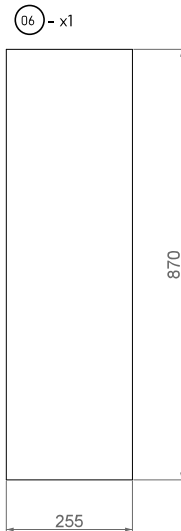


003 - The goal of this step

Materials needed

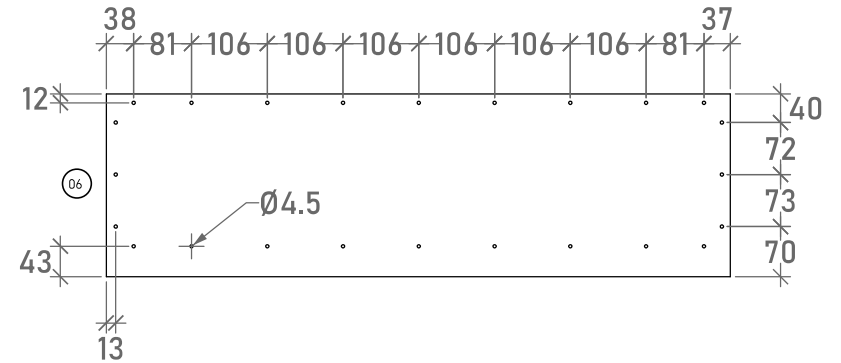
Metal sheet 1.5 mm
1x 870x255 mm

Metal pipe diameter 100 mm
1x 200 mm



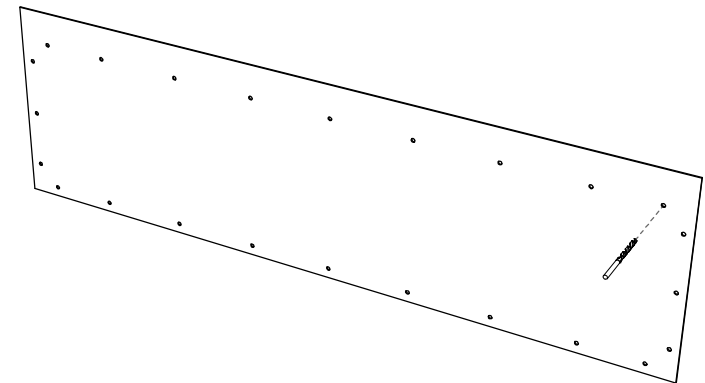
Sub-step 3.1

Mark out all the holes center points.
Mirrored on both sides.



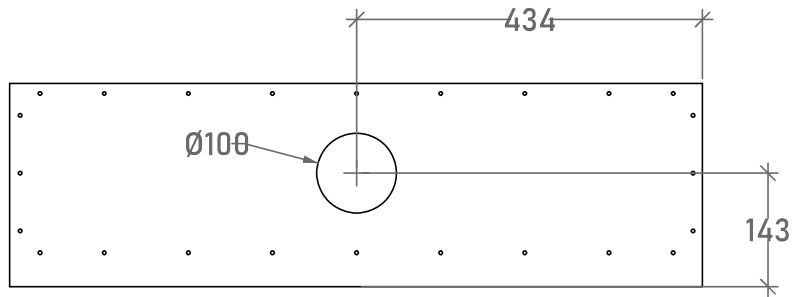
Sub-step 3.2

Drill all the holes. Drill 4.5 mm in diameter



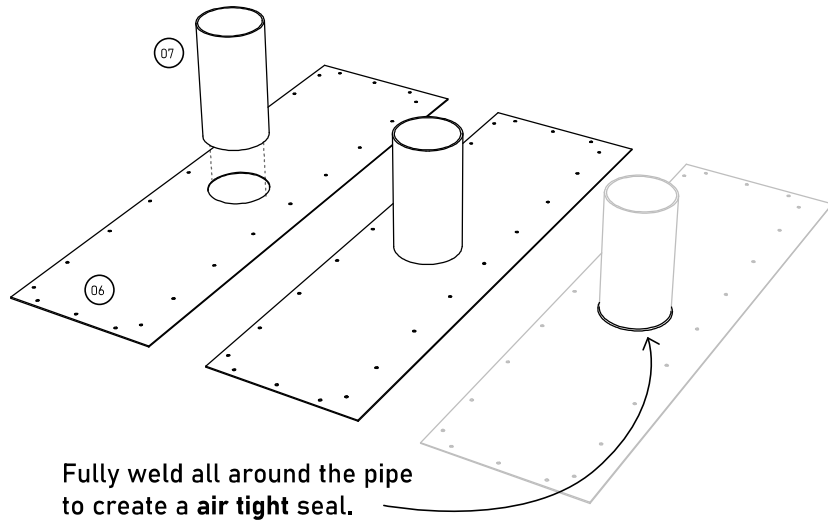
Sub-step 3.3

Mark out center hole and cut it out.



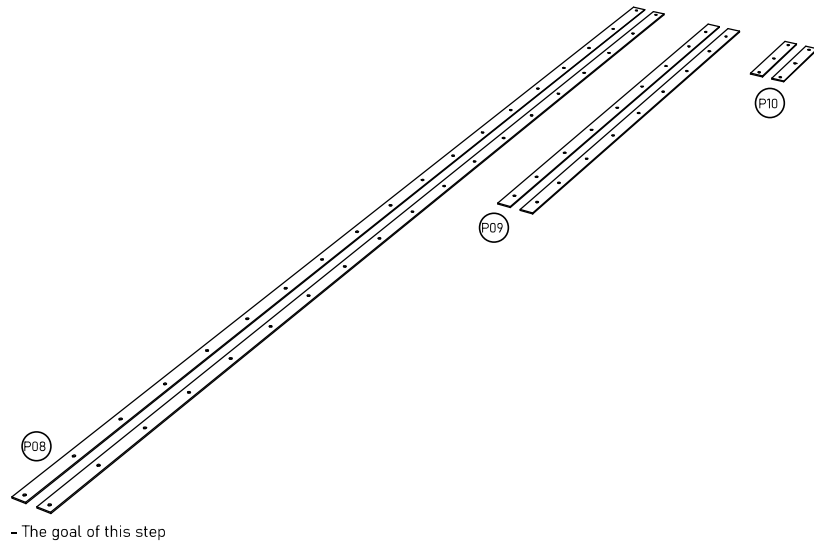
Sub-step 3.4

Weld metal pipe to cut out hole in the metal sheet



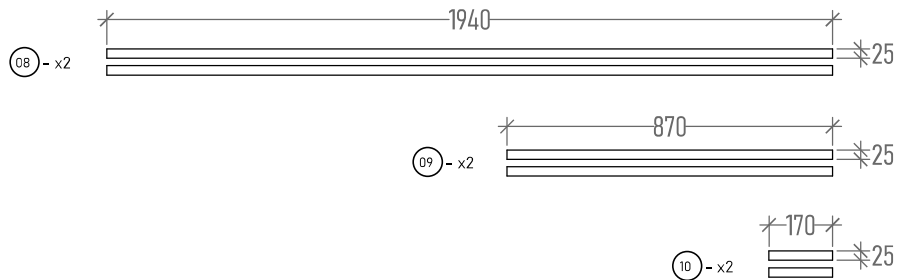
Step 4

Drilling holes in flat iron



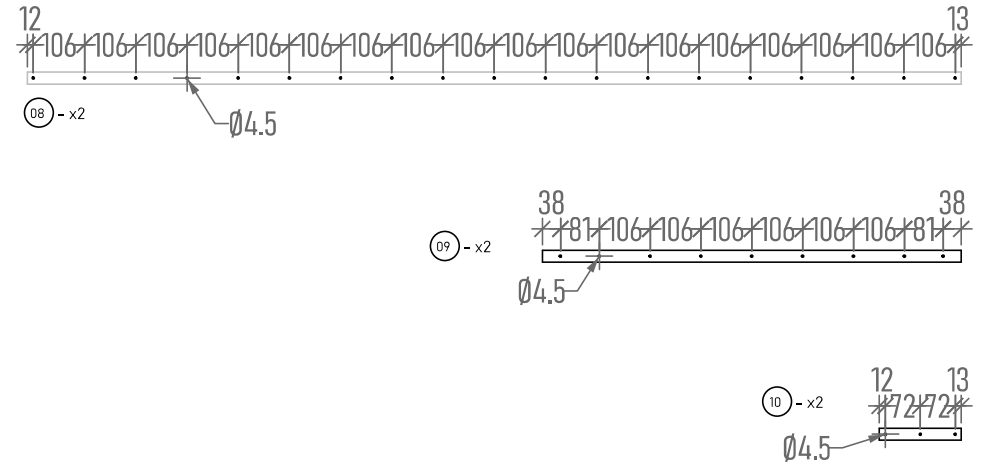
Materials needed

- Flat iron 25x3 mm
- 2x 1940x25 mm
- 2x 870x25 mm
- 2x 170x25 mm



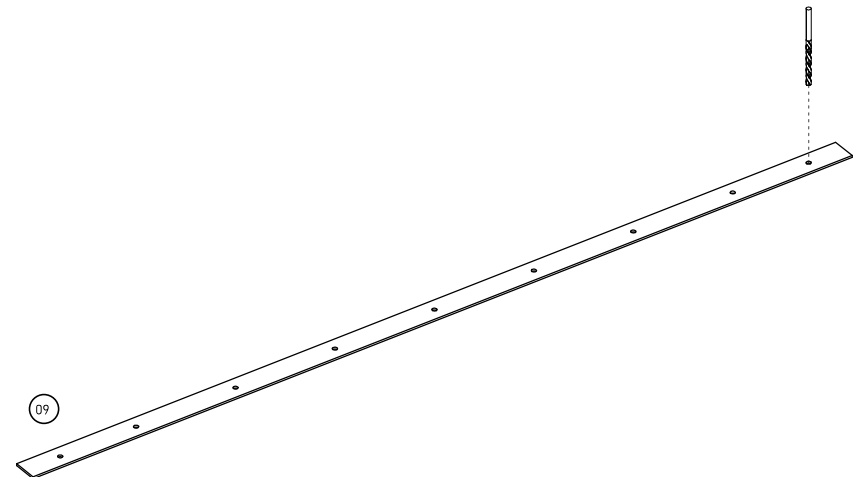
Sub-step 4.1

Mark out all the holes center points.



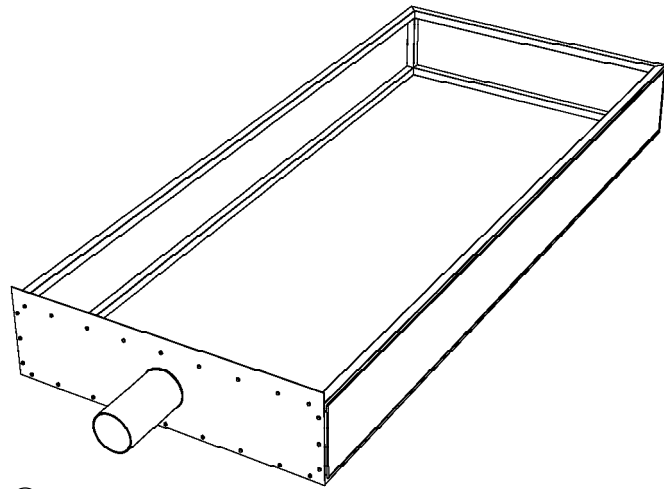
Sub-step 4.2

Drill all the holes. Drill 4.5 mm in diameter. Repeat for all 6 flat iron peices.



Step 5

Mounting step 3 assembly to step 2 assembly



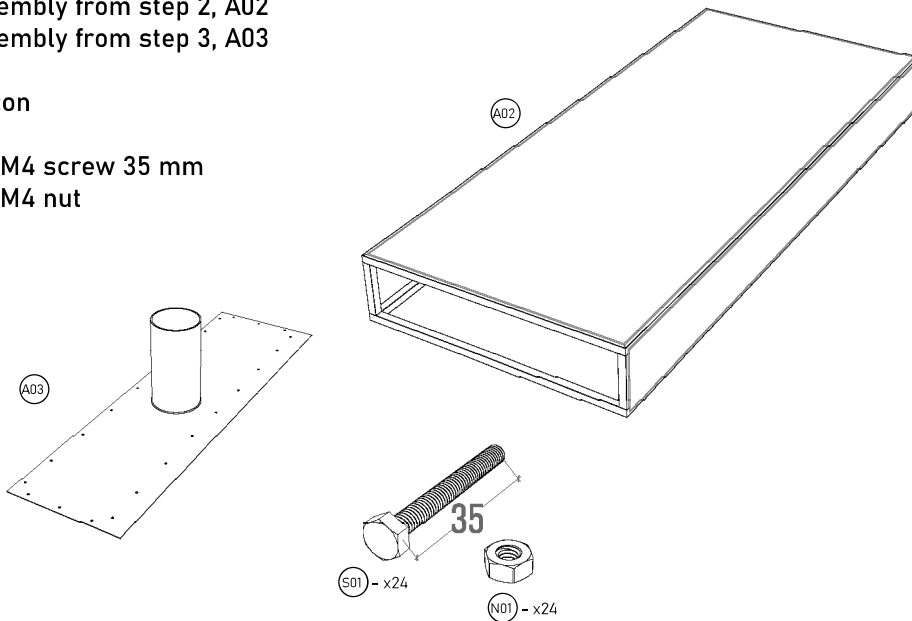
A04 - The goal of this step

Materials needed

Assembly from step 2, A02
Assembly from step 3, A03

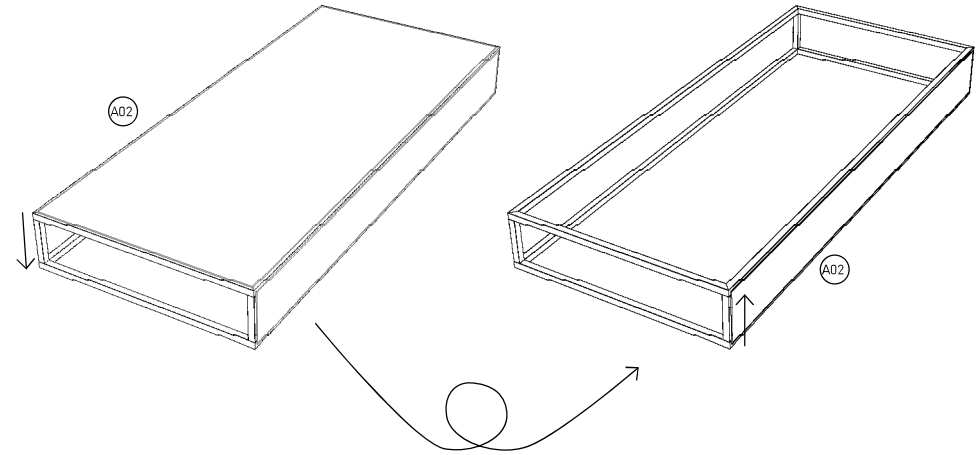
Silicon

24x M4 screw 35 mm
24x M4 nut



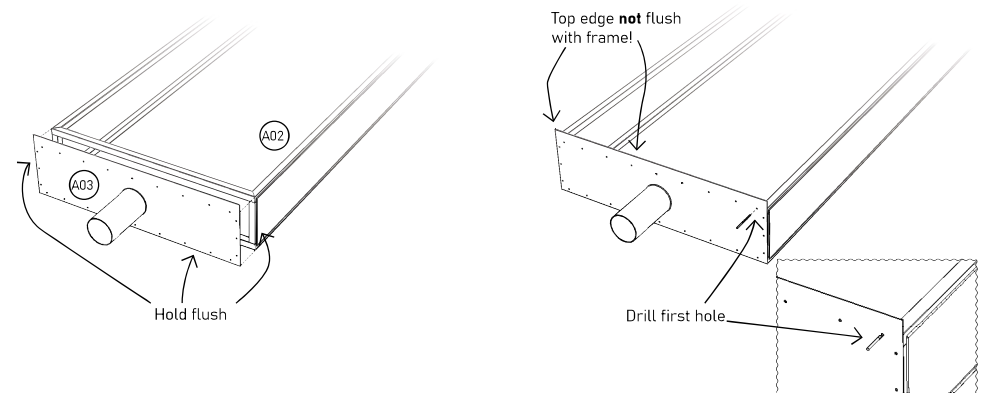
Sub-step 5.1

Flip A02 around. Metal sheet should be place towards the ground.



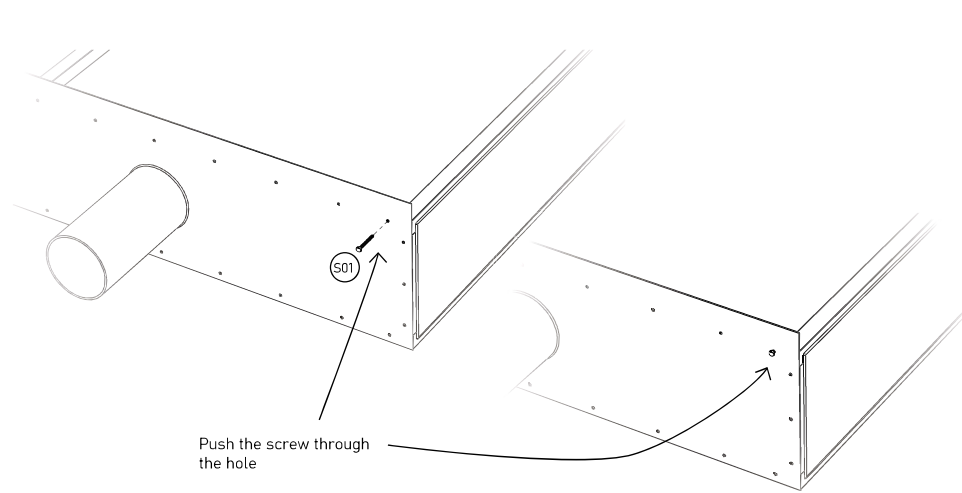
Sub-step 5.2

Hold A03 flush (aligned) with the bottom and sides of A02 and drill the first hole all the way through the square pipe. Plate should stick up above the frame, about 25-30 mm.



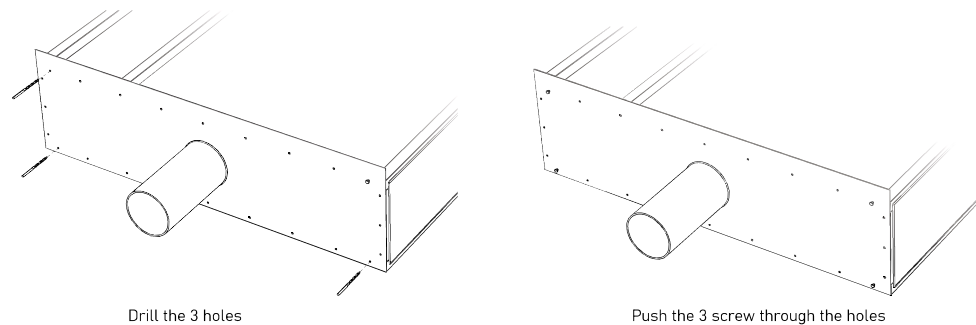
Sub-step 5.3

Put one (1) M4 screw (S01) through the hole. **Don't** put the nut on.



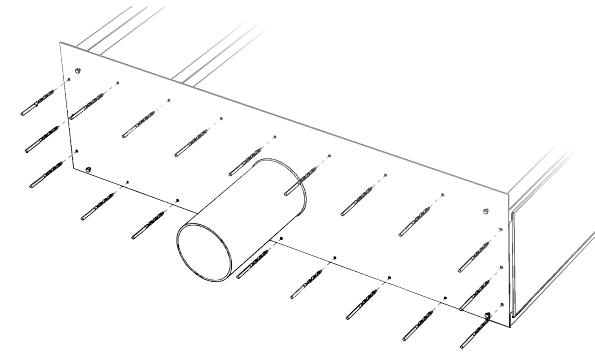
Sub-step 5.4

Drill the other three (3) holes showed in the picture and put one (1) screw through each hole.



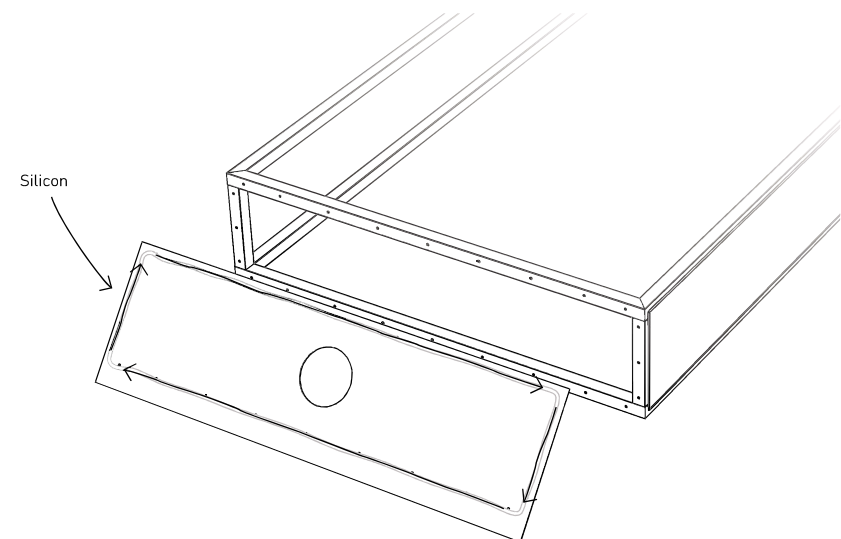
Sub-step 5.5

While A03 is hold in place by the four (4) screws, drill the rest of the holes.



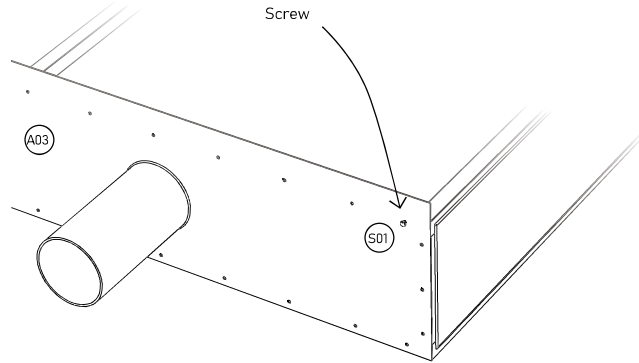
Sub-step 5.6

Remove the four (4) screws and place A03 on the ground. Use silicon to create a seal all around the plate (on top of the holes).



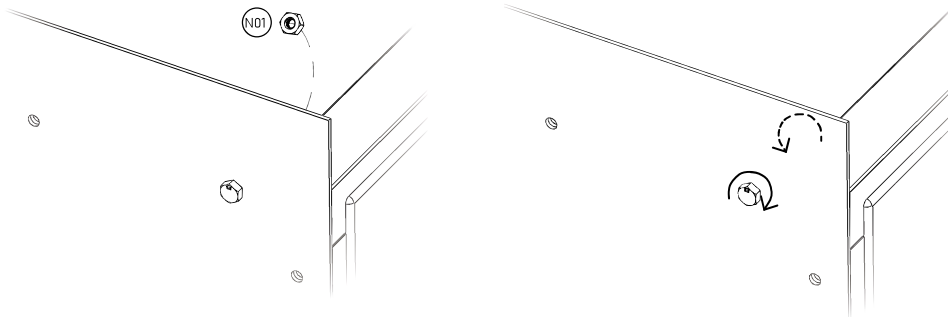
Sub-step 5.7

Remount A03 with the silicon seal to the frame and put the screw (S01) in the hole.



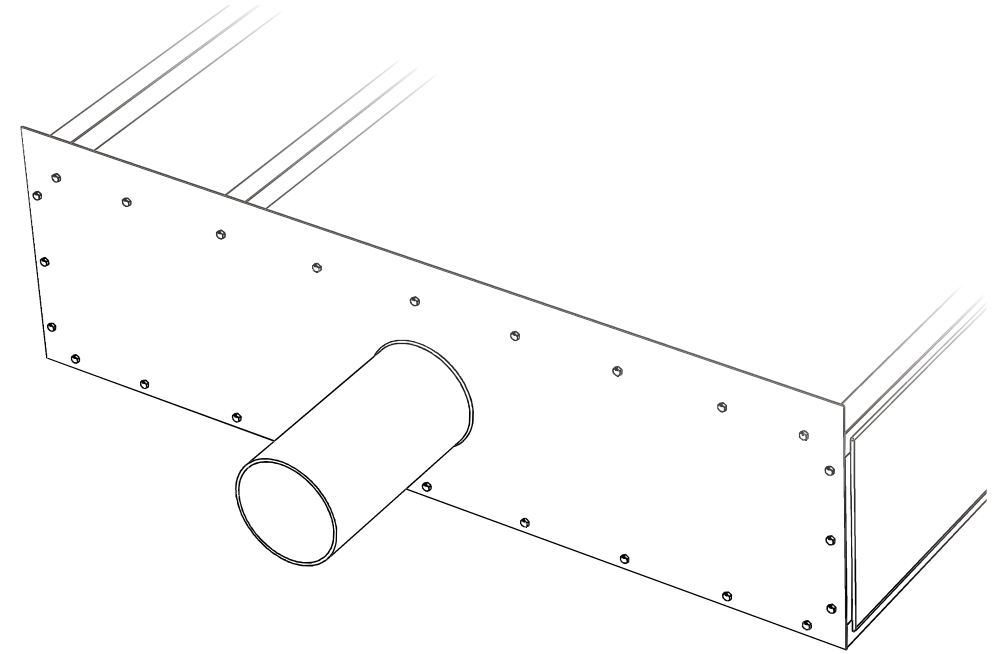
Sub-step 5.8

Put the nut (N01) on the screw and tighten it.



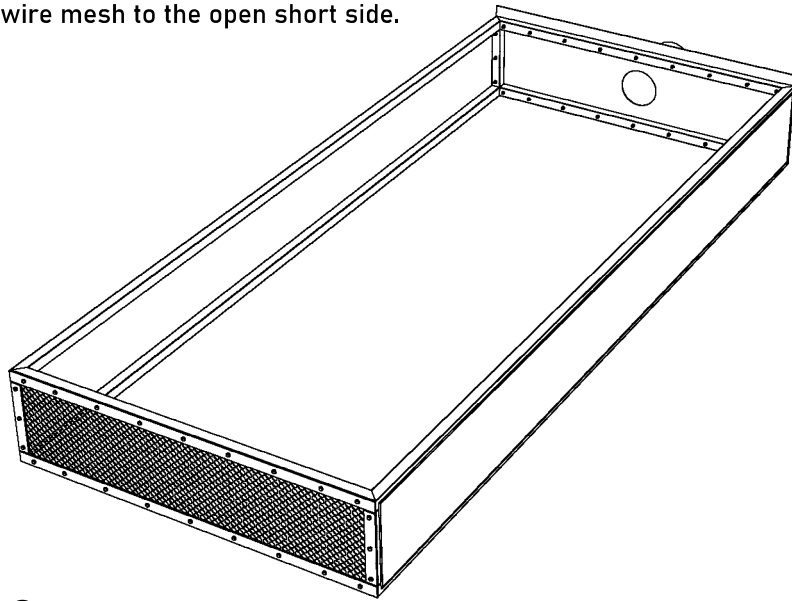
Sub-step 5.9

Mount all the other 23 screws and tighten everything down. This should create a air tight seal all the way around.



Step 6

Mounting wire mesh to the open short side.



A05 - The goal of this step

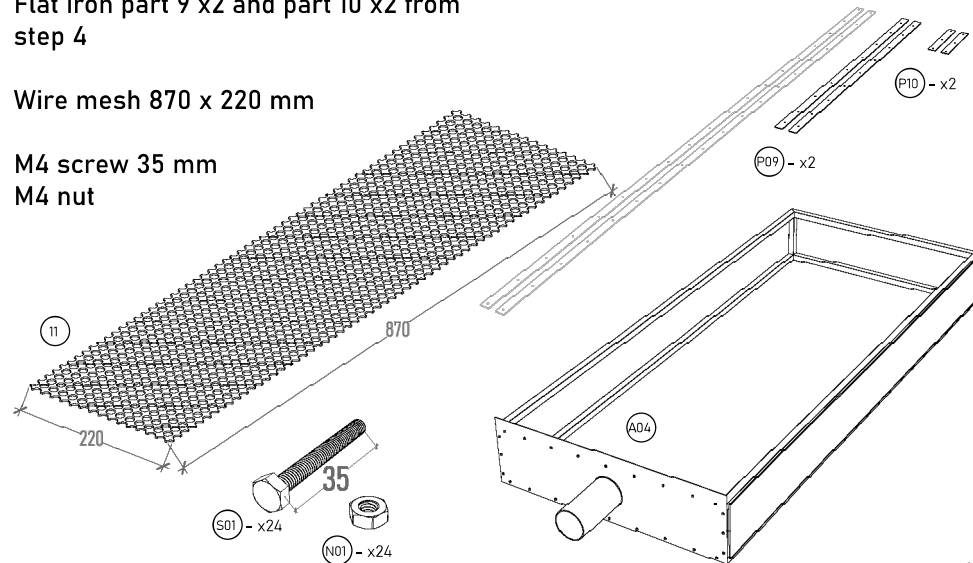
Materials needed

Assembly from step 5

Flat iron part 9 x2 and part 10 x2 from step 4

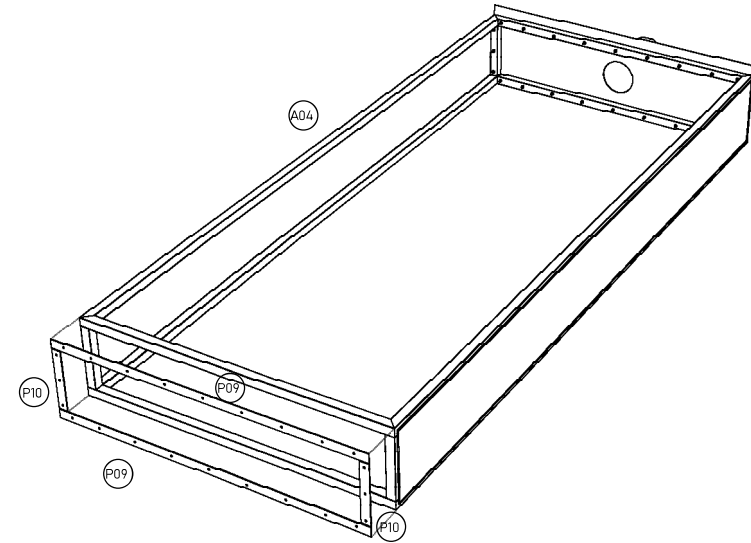
Wire mesh 870 x 220 mm

M4 screw 35 mm
M4 nut



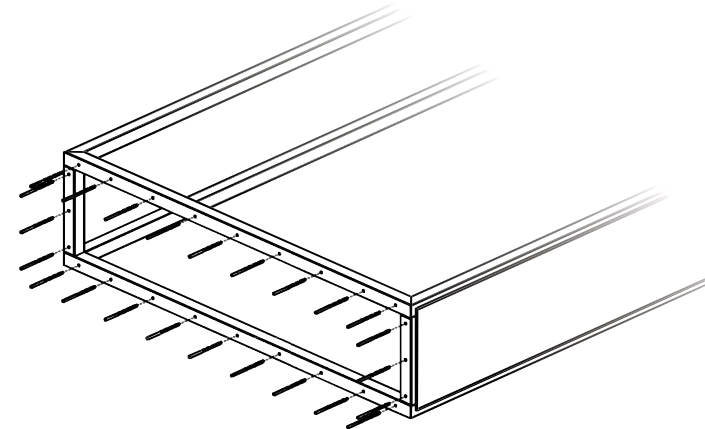
Sub-step 6.1

Flip A04 around and hold up P09 and P10 as showed in the picture.



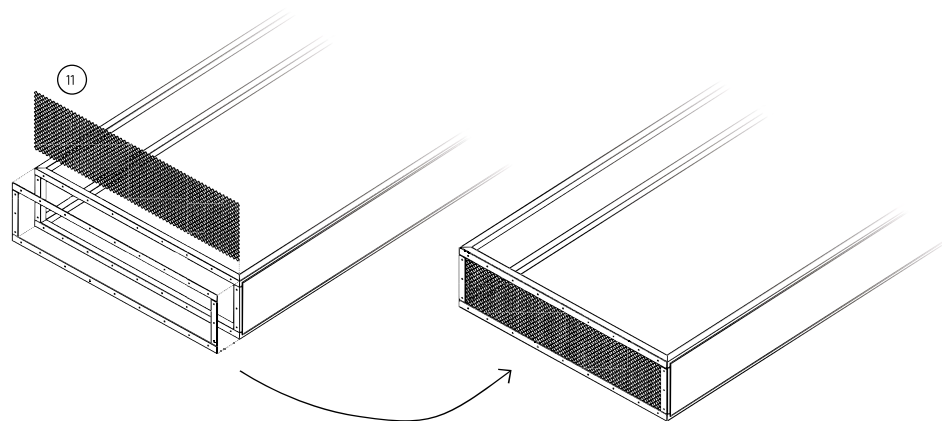
Sub-step 6.2

Drill out all the holes. All the way trough the square tube.



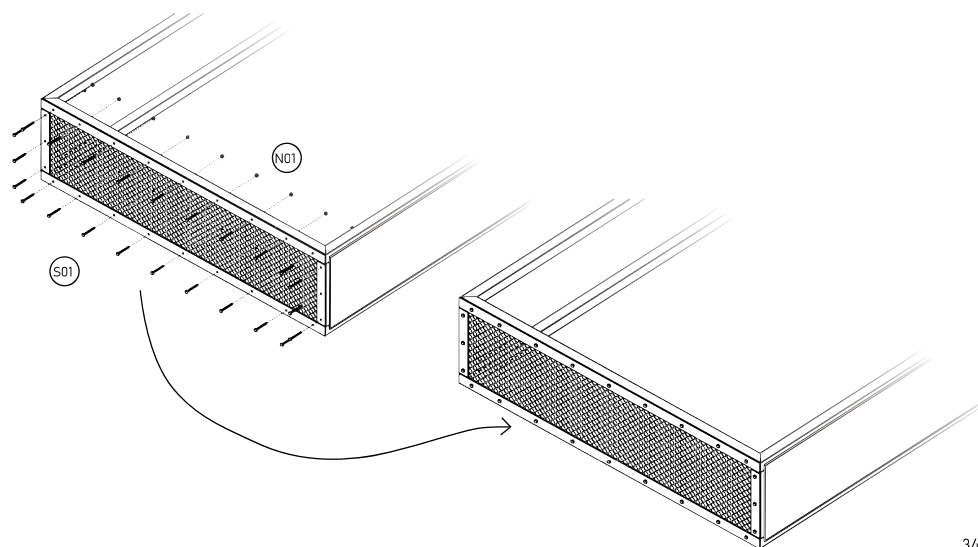
Sub-step 6.3

Place the metal net between the frame and flat iron peices.



Sub-step 6.4

Mount all the screws and tighten the nuts down.



Step 7

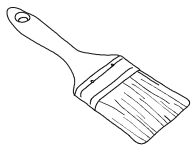
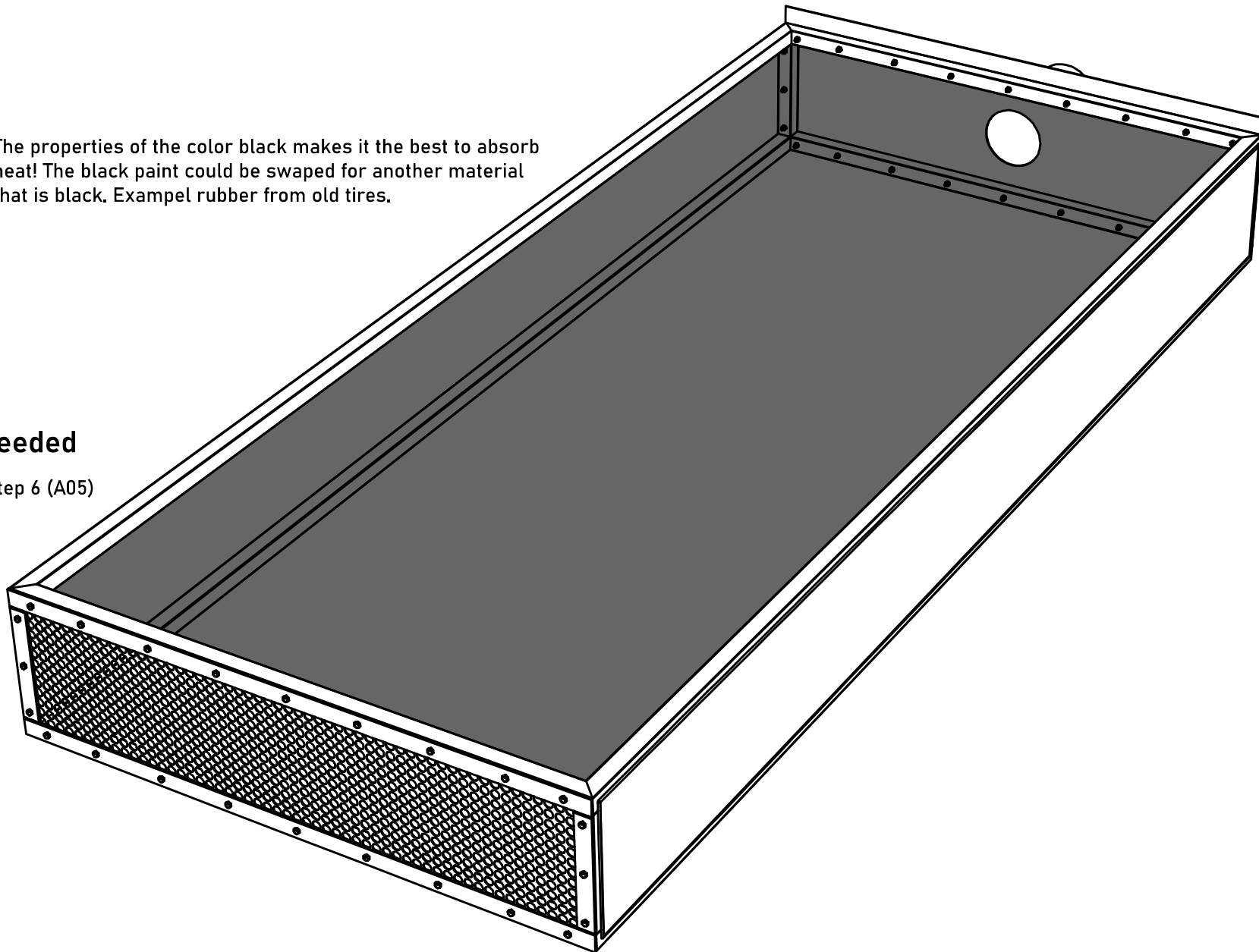
Painting the inside of the black box black.

The properties of the color black makes it the best to absorb heat! The black paint could be swaped for another material that is black. Exampel rubber from old tires.

Materials needed

Assembly from step 6 (A05)

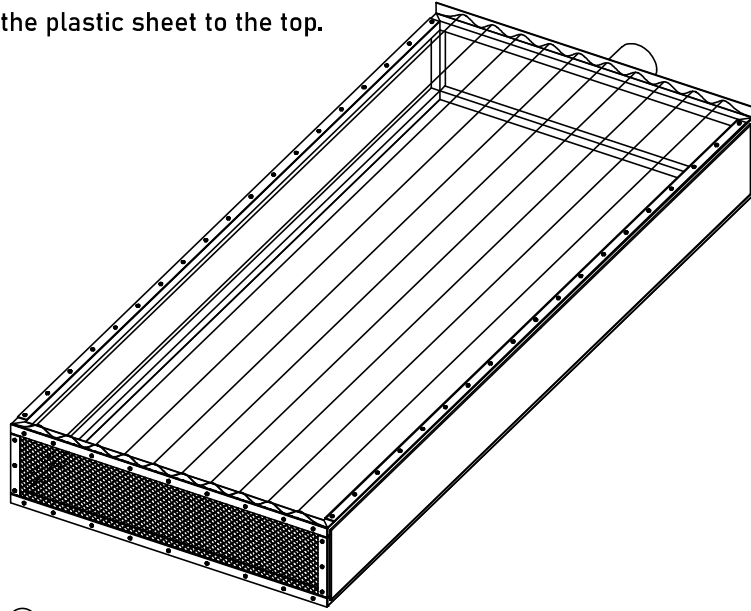
Black paint



Painting

Step 8

Mounting the plastic sheet to the top.



A06 - The complete black box

Materials needed

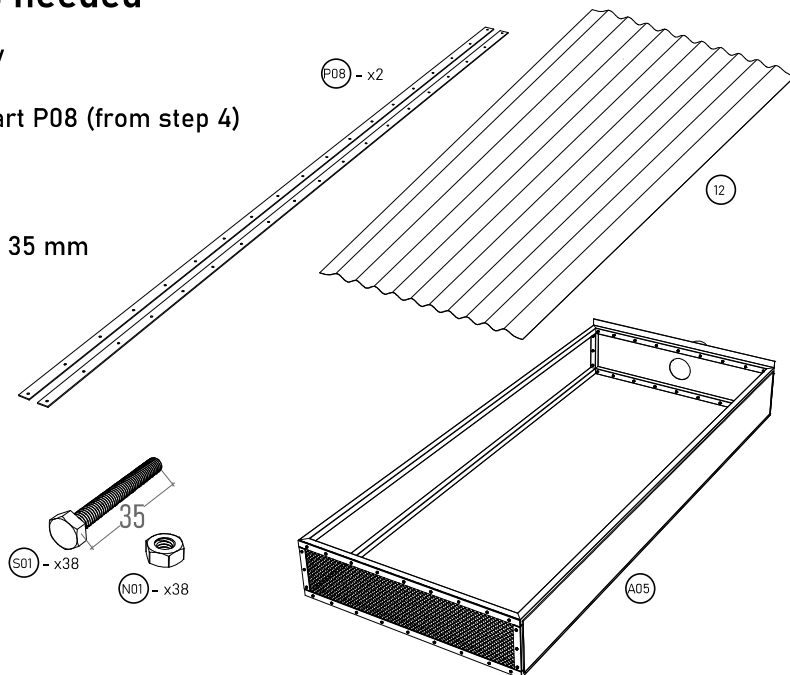
A05 Assembly

2x Flat iron part P08 (from step 4)

Plastic sheet

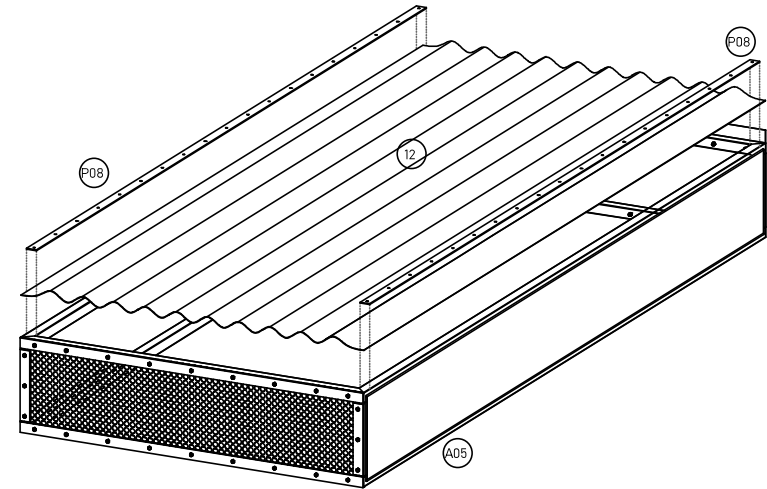
38x M4 screw 35 mm

38x M4 nut



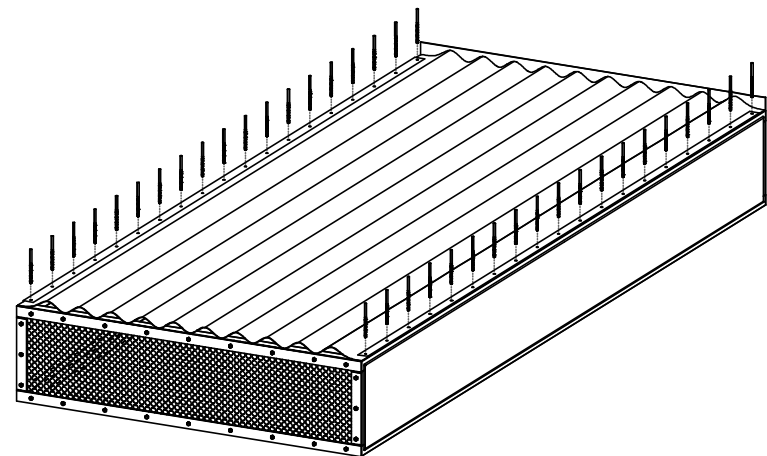
Sub-step 8.1

Place the plastic sheet on the frame, and the flat iron above the plastic sheet.



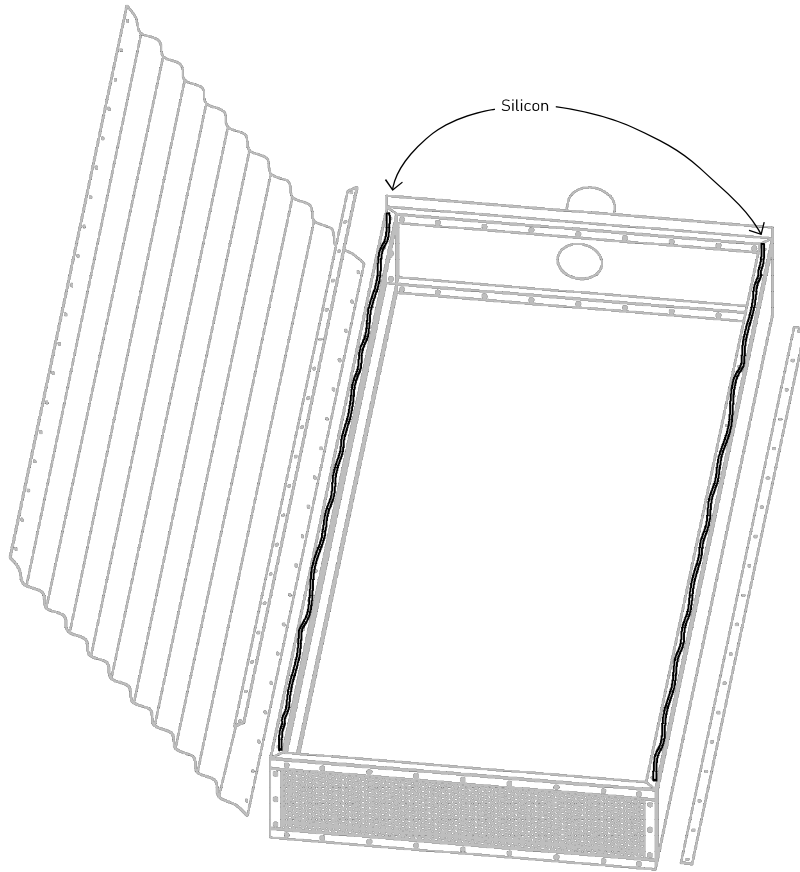
Sub-step 8.2

Drill out all the holes. All the way through the plastic sheet and the square tube.



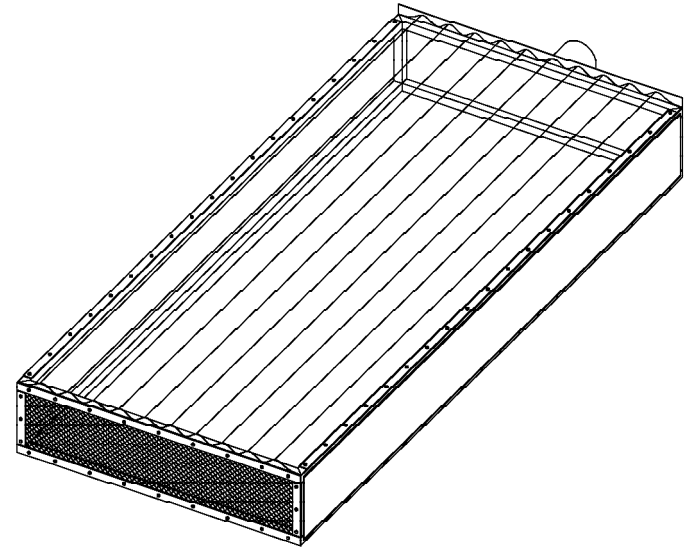
Sub-step 8.3

Remove the plastic sheet and flat iron bars. Put down two (2) silicon lines on each side. This will create a **air tight seal**.



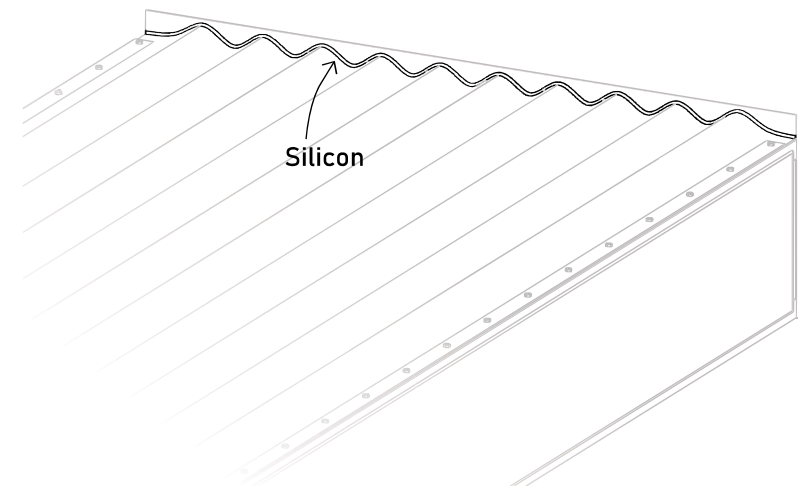
Sub-step 8.4

Put the plastic sheet back on the frame, squesing the silicon. Place the flat iron above and mount all the screws and tighten the nuts down.

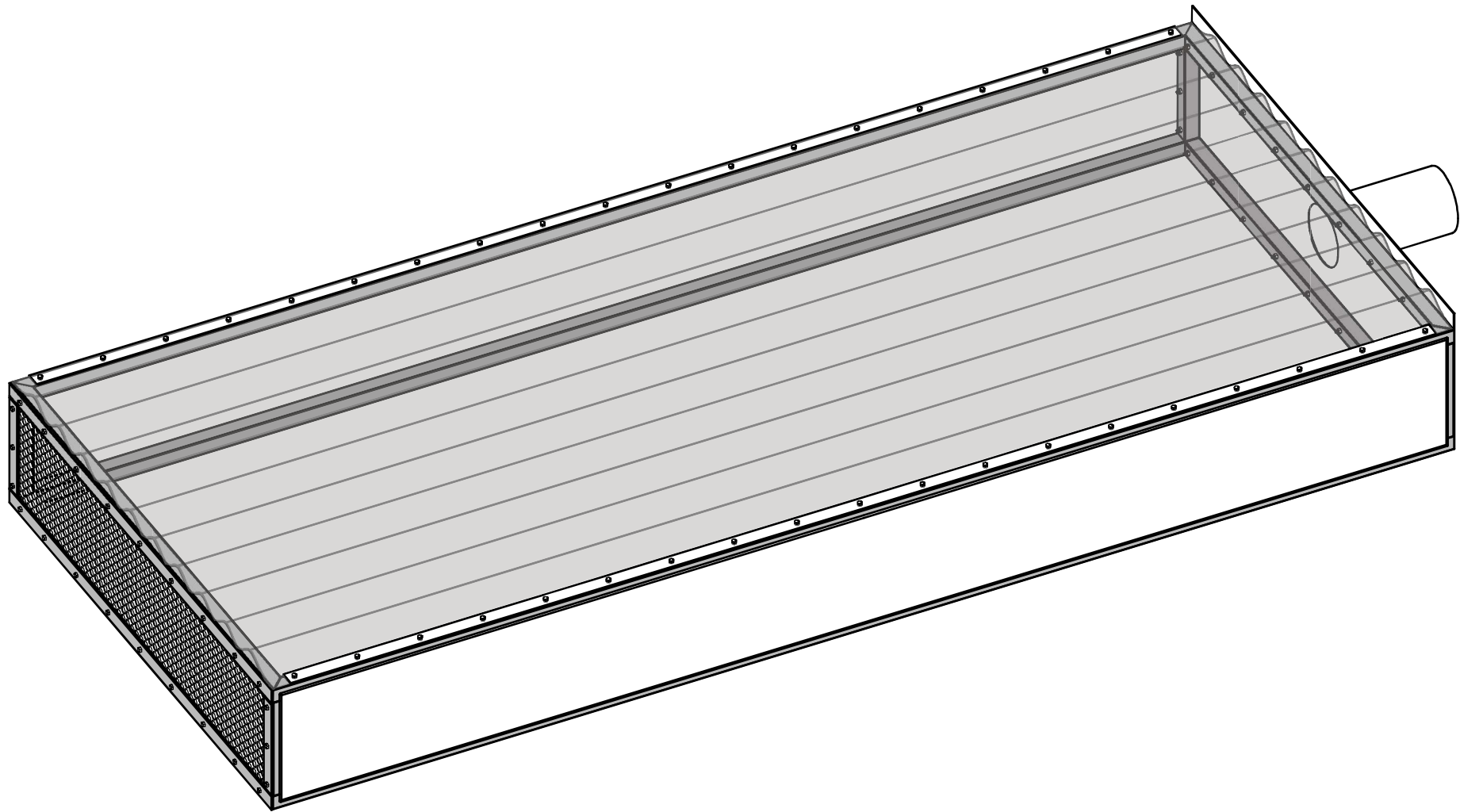


Sub-step 8.5

Steal the plastic sheet to A03 (the metal sheet sticking up) with silicon.



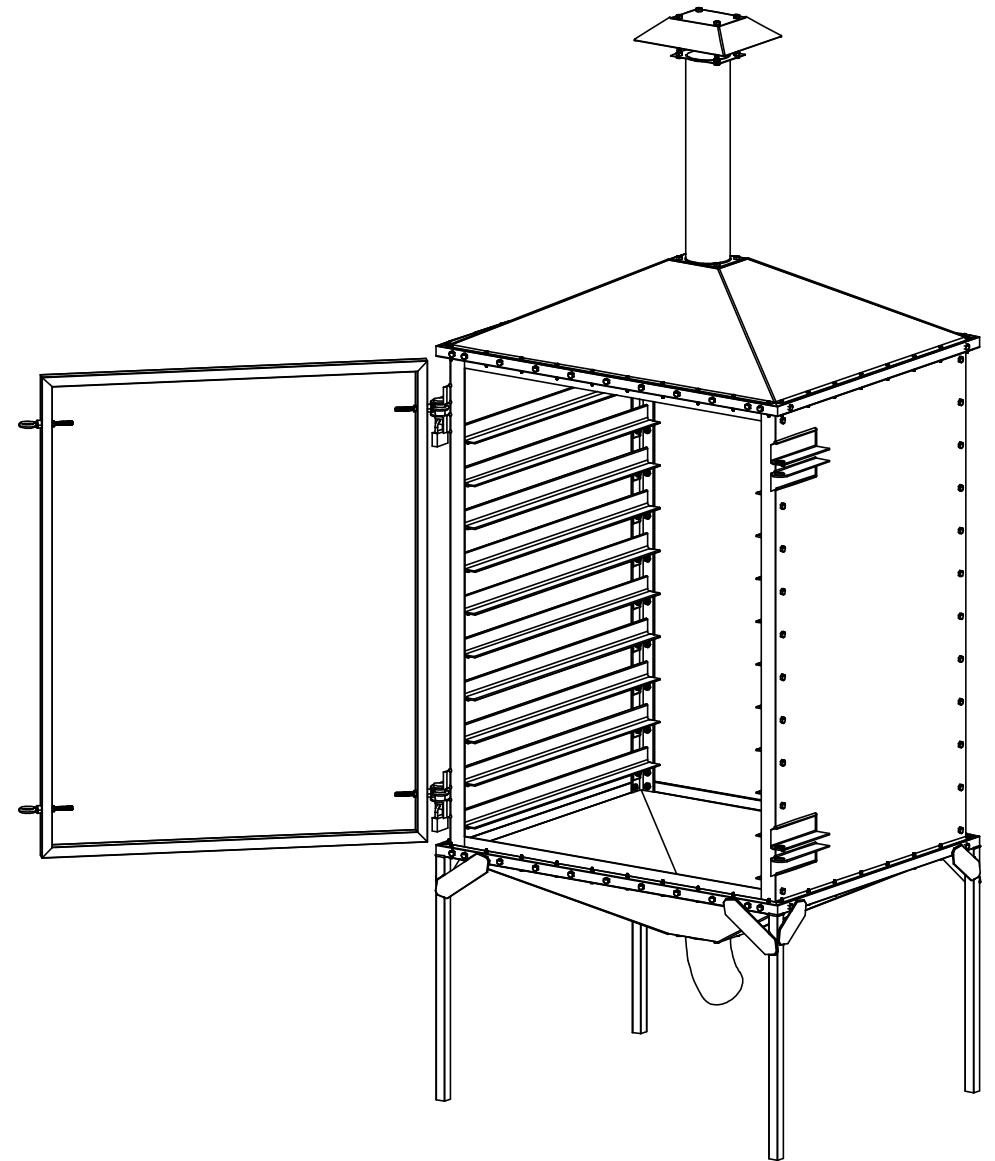
BlackBox done!



Manufacturing

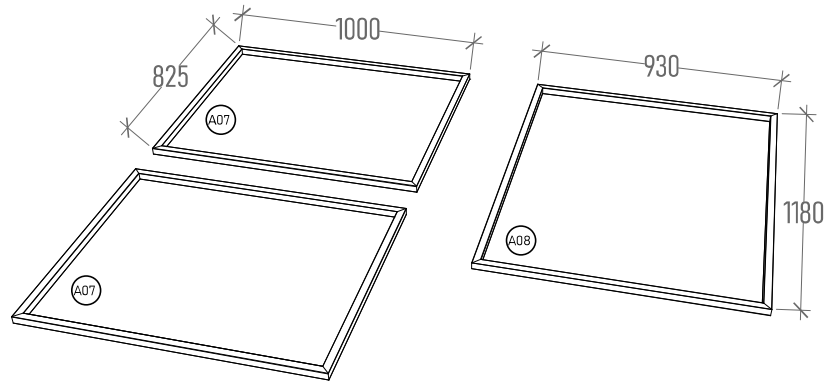
Drying Tower

Drying structure for grains: dries, protects from rain, protects from thieves, and hopefully dries faster than normal methods.



Step 1

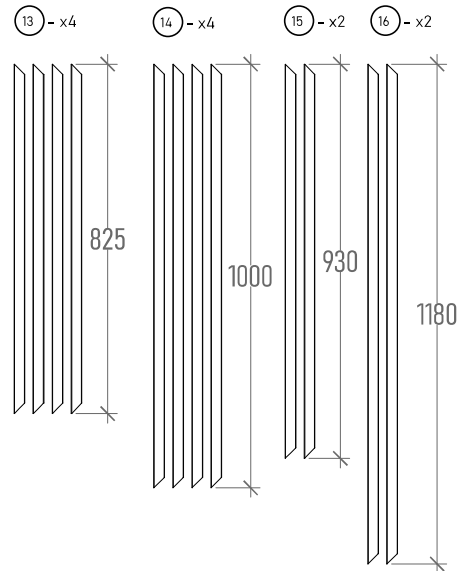
Makeing three (3) rectangle frames.



The goal of this step

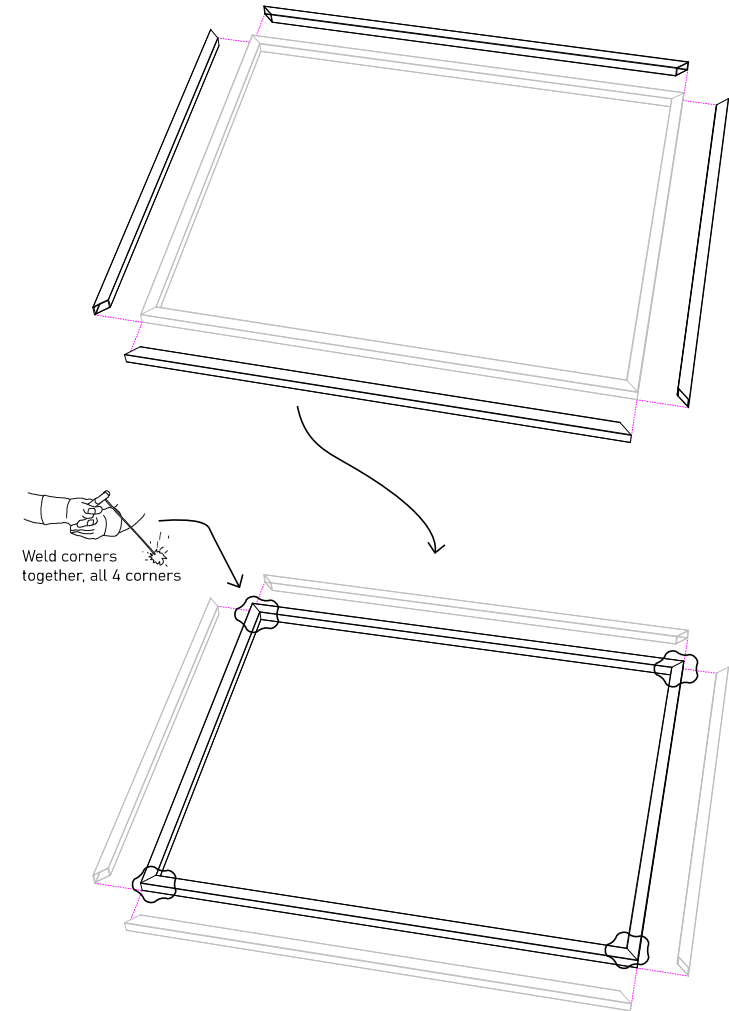
Materials needed

Square tube pipe 25x25x1.5 mm
4x 825 mm (cut 45° in each end)
4x 1000 mm (cut 45° in each end)
2x 930 mm (cut 45° in each end)
2x 1180 mm (cut 45° in each end)



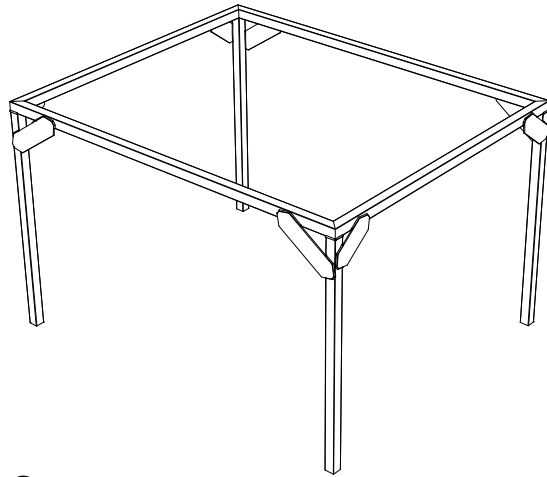
Sub-step 1.1

Weld the 4 square tubes together into a rectangle. Do this for all three rectangles.



Step 2

Making the base for the Drying Tower.



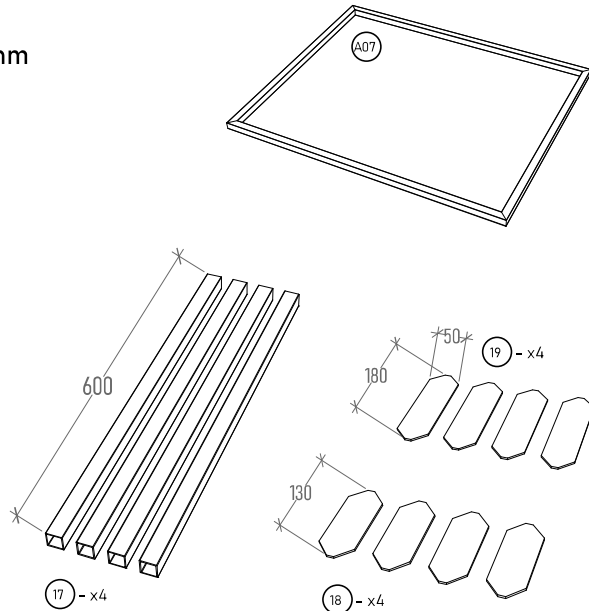
(A09) The goal of this step

Materials needed

Assembly A07

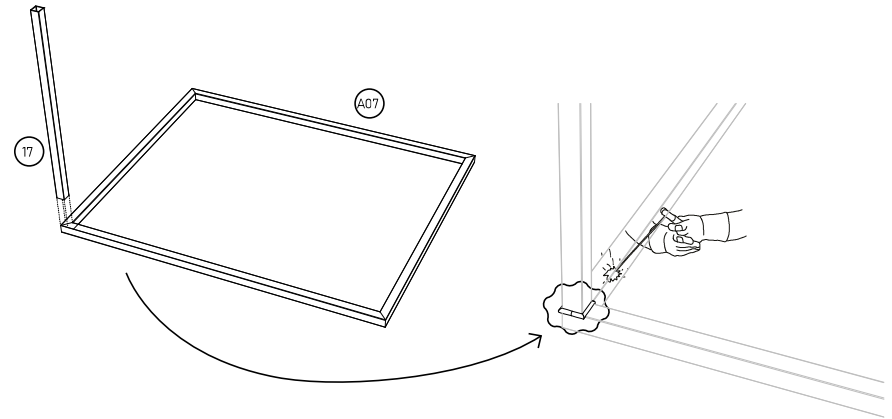
Square tube pipe 25x25x1.5 mm
4x 600 mm

Steel plate 50x3 mm
4x 180 mm (corners cut of)
4x 130 mm (corners cut of)



Sub-step 2.1

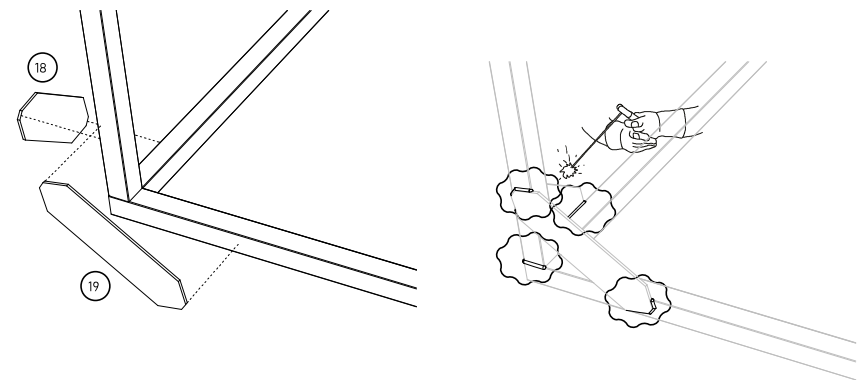
Weld on the table legs. Do this for all four (4) legs.



Sub-step 2.2

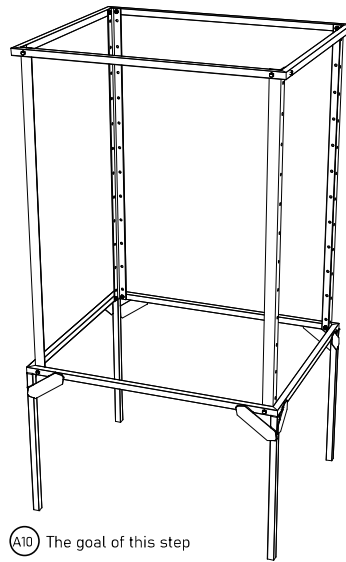
Weld reinforcement brackets to the corners on each leg.

The longer peices should be placed on the long side of the rectangle, and the short on the short side.



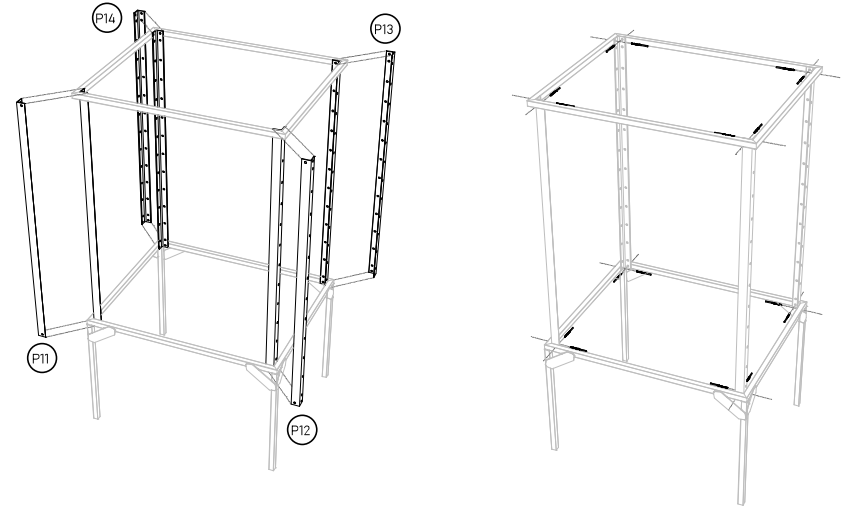
Step 4

Assembling the base structure for the Drying Tower



Sub-step 4.1

Drill out the holes in A07 and A09 as shown in the illustrations. Pay attention to which element is placed where.



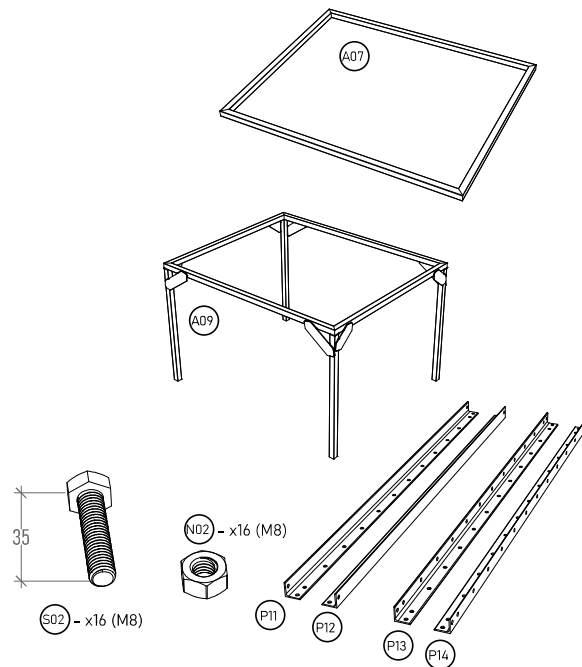
Materials needed

Assembly A07
Assembly A09

Part P11
Part P12
Part P13
Part P14

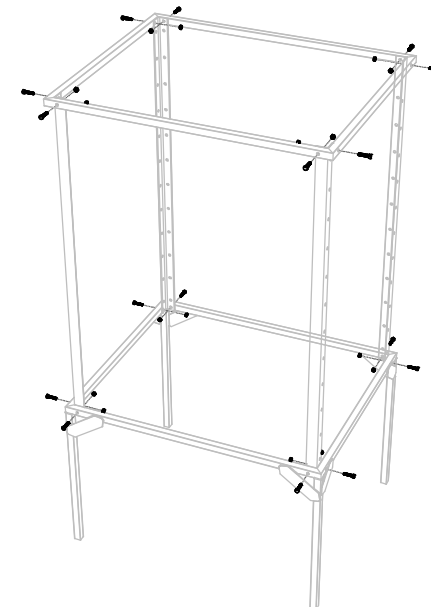
M8 Hex screw
16x 35 mm

Hex nut M8
16x



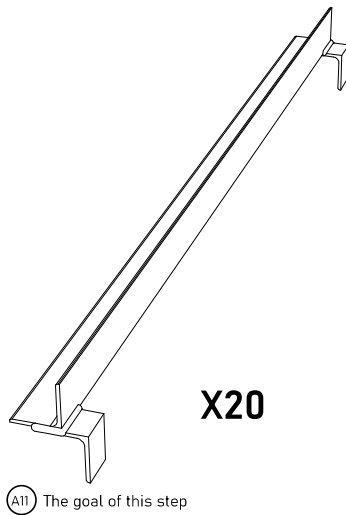
Sub-step 4.2

Screw the pieces together to create the base frame for the Drying Tower.



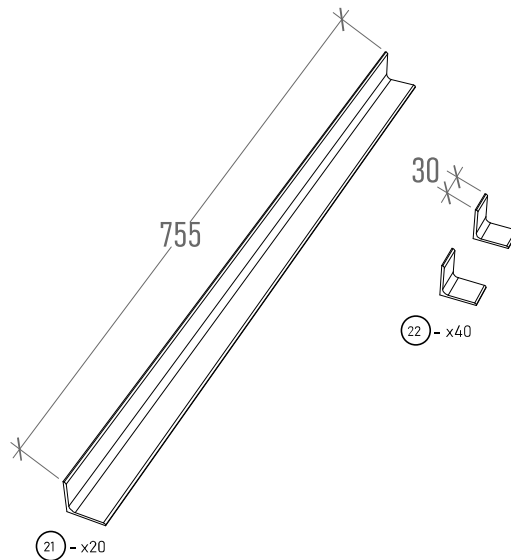
Step 5

Welding shelf brackets together. 20 in total.



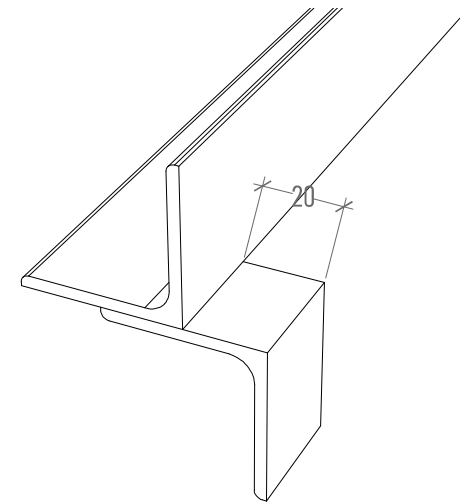
Materials needed

Angle iron 40x40x3 mm
20x 755 mm
40x 30 mm



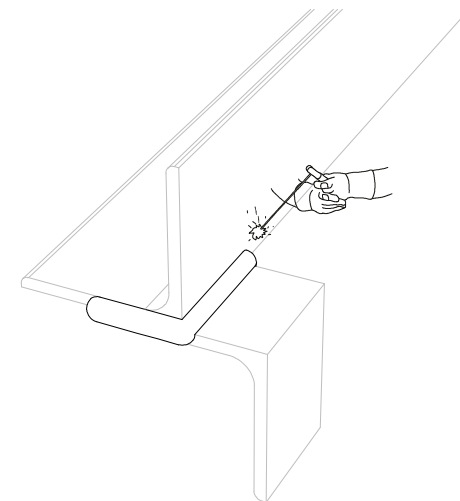
Sub-step 5.1

Place the small peices flush with the ends of the longer peice.
20 mm from the edge. One in each end.



Sub-step 5.2

Weld the three (3) peices together

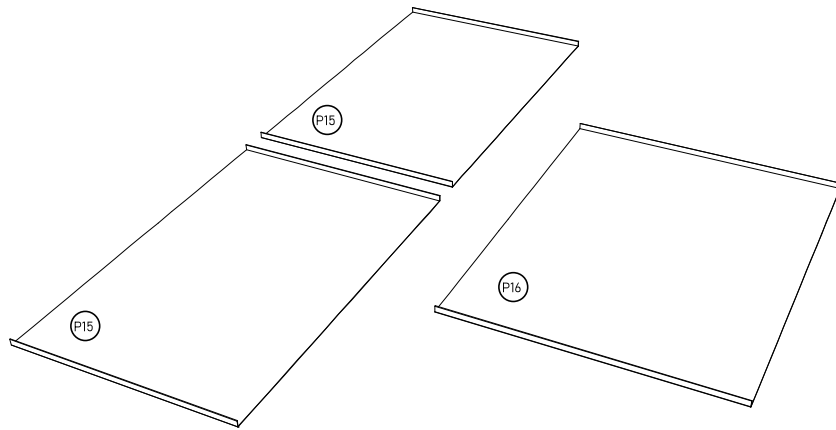


Sub-step 5.3

Repeat 20 times.

Step 6

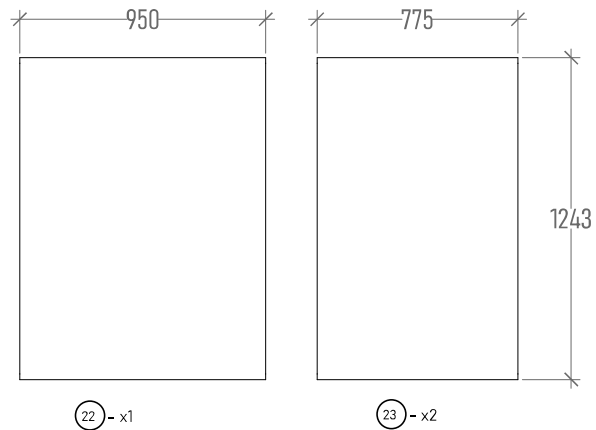
Folding a lip on sheets of metal.



The goal of this step

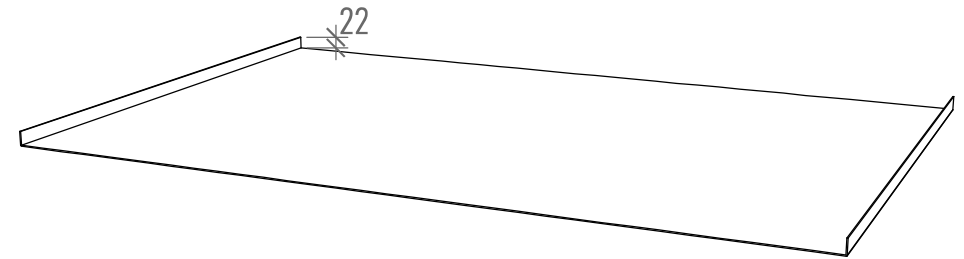
Materials needed

Sheet metal 1.5 mm
2x 775x1243 mm
1x 950x1243 mm



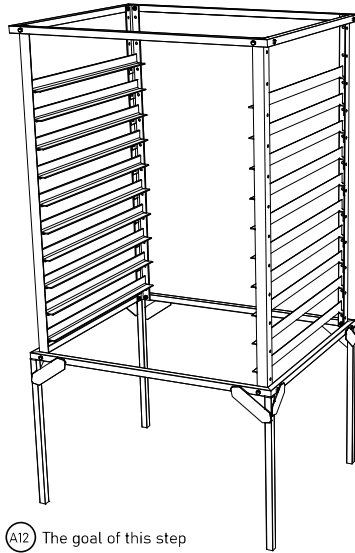
Sub-step 6.1

Mark a line on each side, parallel to the short edges. 22 mm from the edge. Fold the sheet 90 degrees to create a lip.



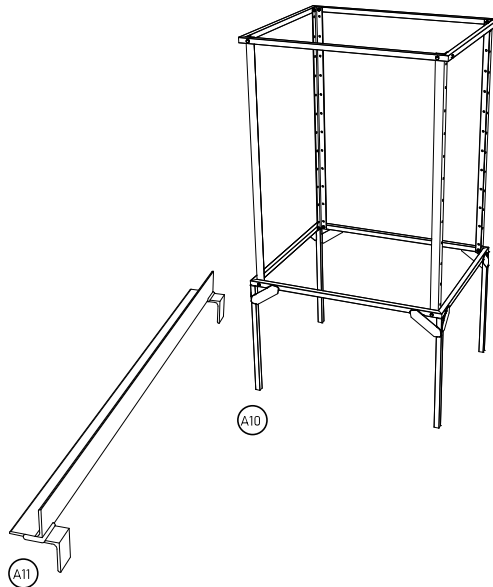
Step 7

Drill out holes in the shelf brackets (A11).



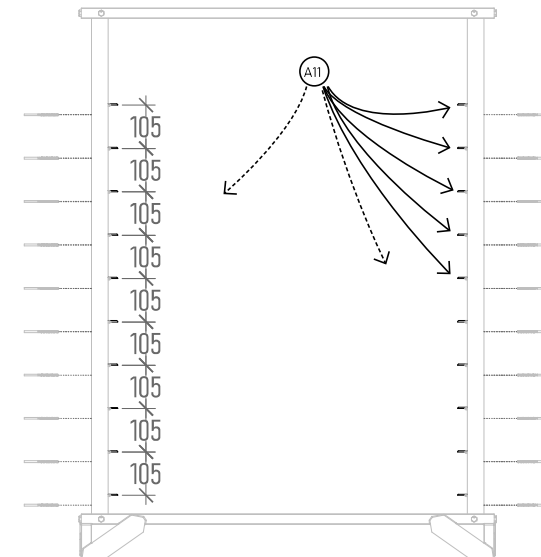
Materials needed

Assembly A10
Assembly A11 x20



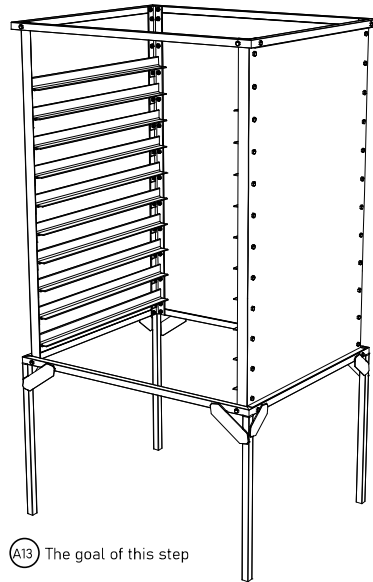
Sub-step 7.1

Mark the locations of the shelf brackets (A11) and drill out all the holes. 9 mm diameter. Brackets are spaced 105 mm apart.



Step 8

Assemble the steel plate walls and shelf brackets to the base structure.



Materials needed

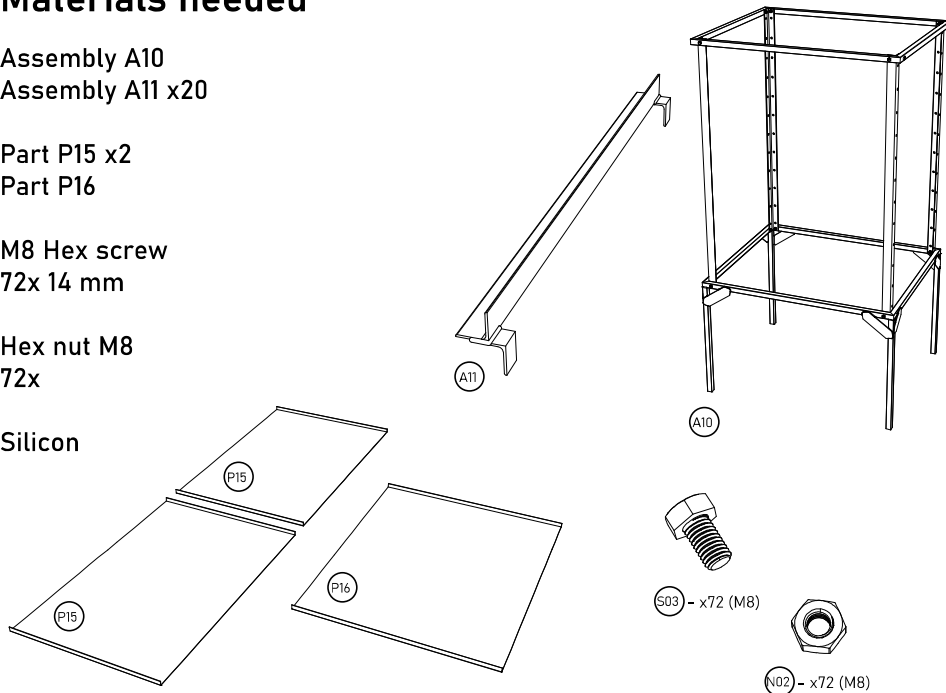
Assembly A10
Assembly A11 x20

Part P15 x2
Part P16

M8 Hex screw
72x 14 mm

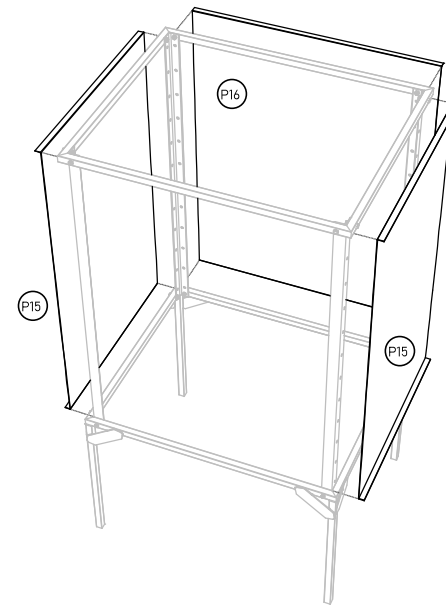
Hex nut M8
72x

Silicon



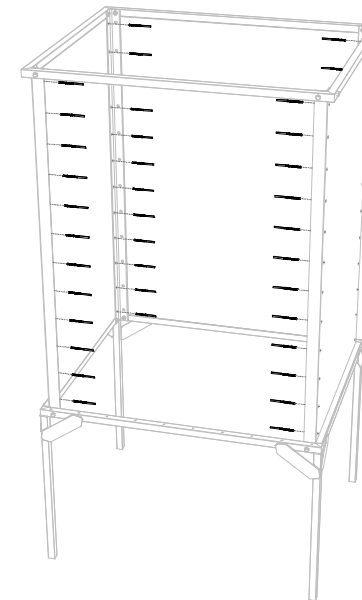
Sub-step 8.1

Place the 3 made steel plate sides on the structure.



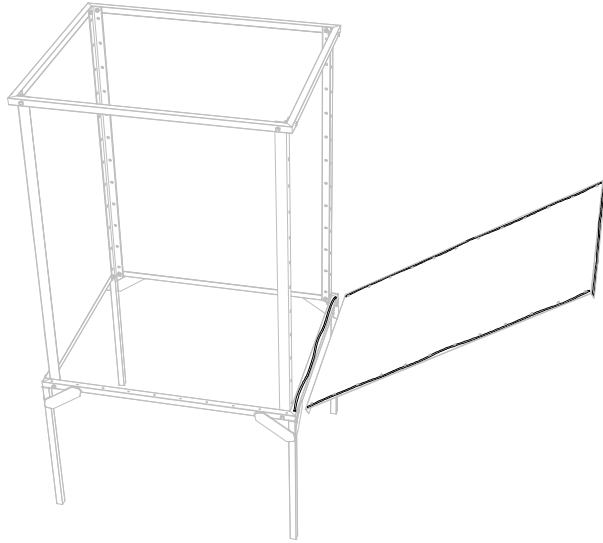
Sub-step 8.2

Drill out the holes on all three sides.



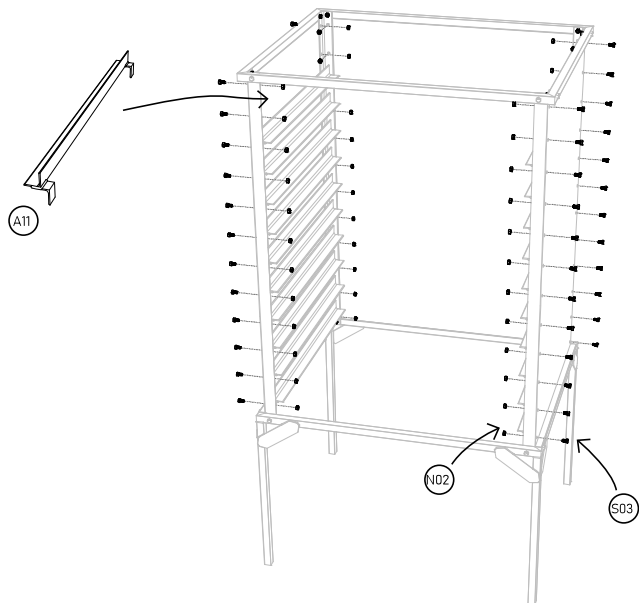
Sub-step 8.3

Put down silicon all around the steel plate to create a air tight seal. Do this for all the sides.



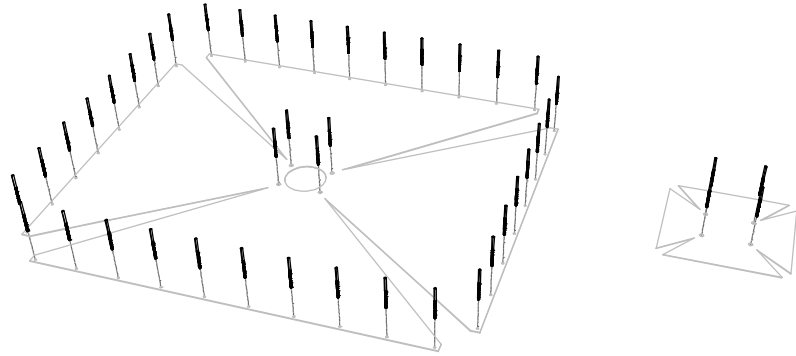
Sub-step 8.4

Screw everything together. Steel plate - structure - shelf bracket



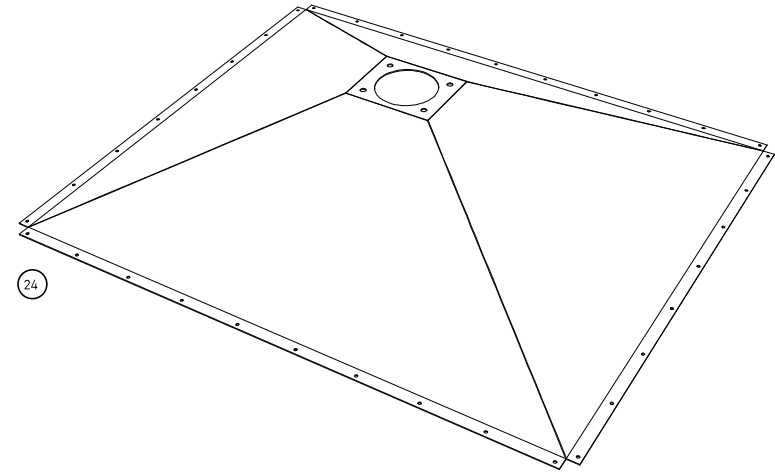
Sub-step 9.3

Drill out all the holes in the 3 parts. Also cut out the big center hole in part 24.



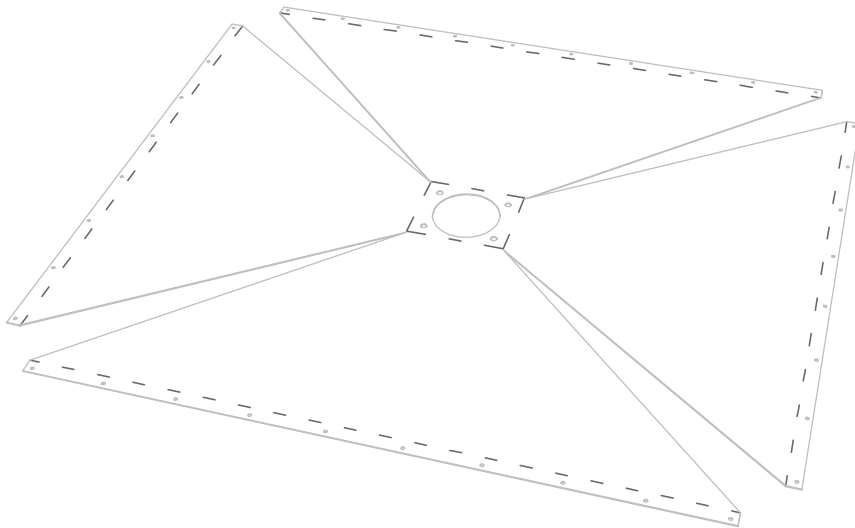
Sub-step 9.5

Folded together.



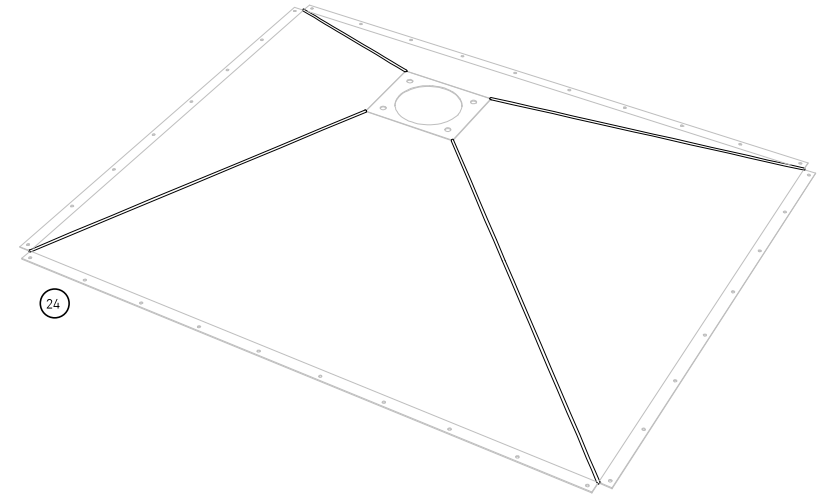
Sub-step 9.4

Fold the metal sheets along the lines illustrated. Will create the form in sub-step 9.5. Same for all three parts, except the smaller part (25) dont have the outer folding lines.



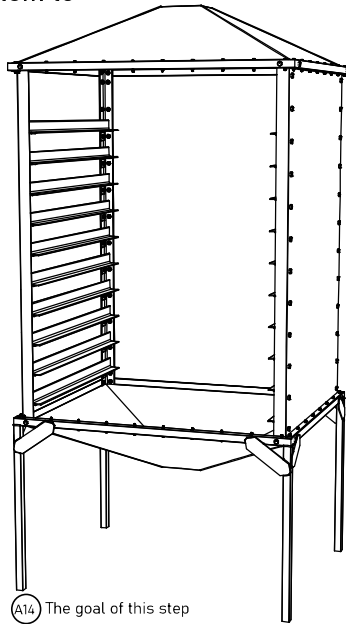
Sub-step 9.6

Weld the liines where the parts meet.



Step 10

Mount the top and the bottom to the structure.



Materials needed

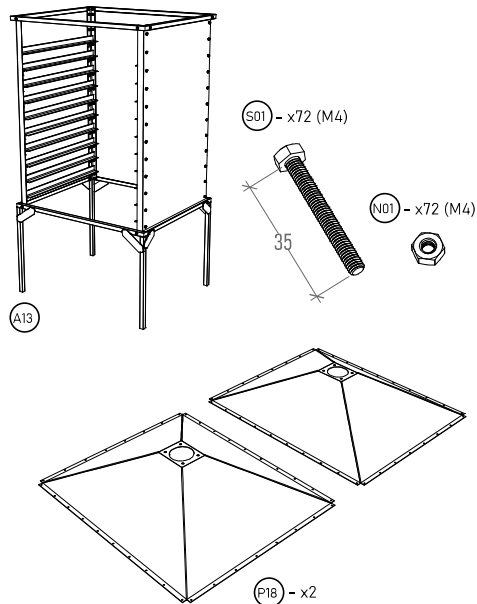
Assembly A13

Part P18 x2

M4 Hex screw
72x 35 mm

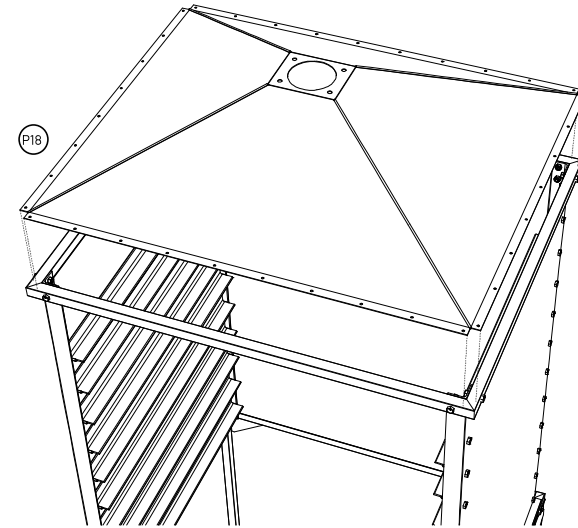
M4 Hex nut
72x

Silicon



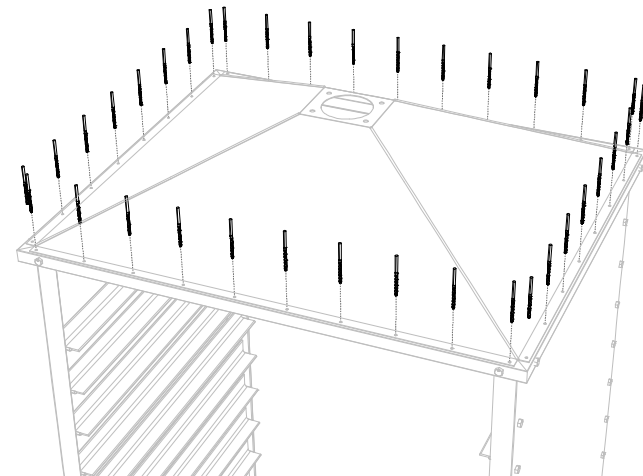
Sub-step 10.1

Place the roof on top of the structure.



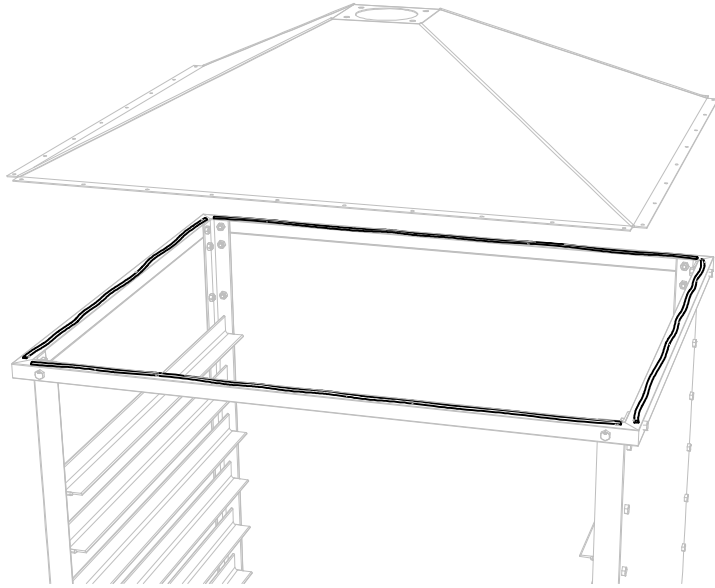
Sub-step 10.2

Drill out all the holes through the square tube. 4.5 mm in diameter.



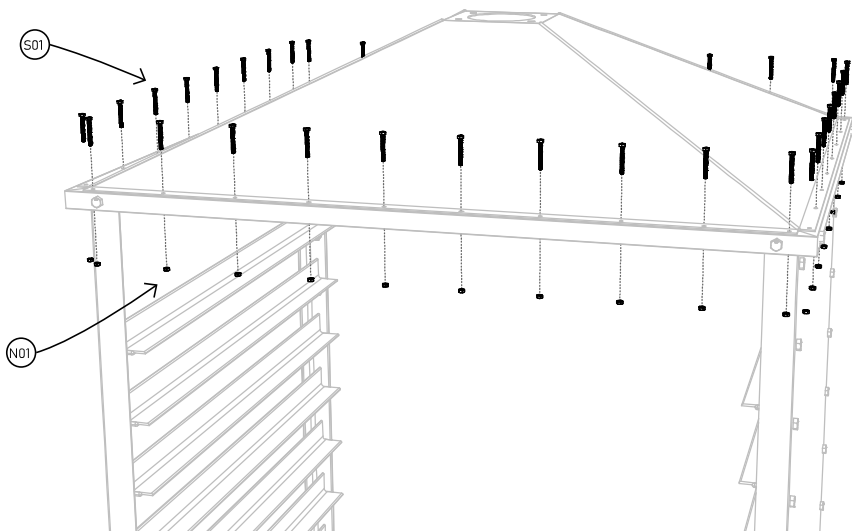
Sub-step 10.3

Before screwin the top roof on, put down silicon to create a air tight seal.



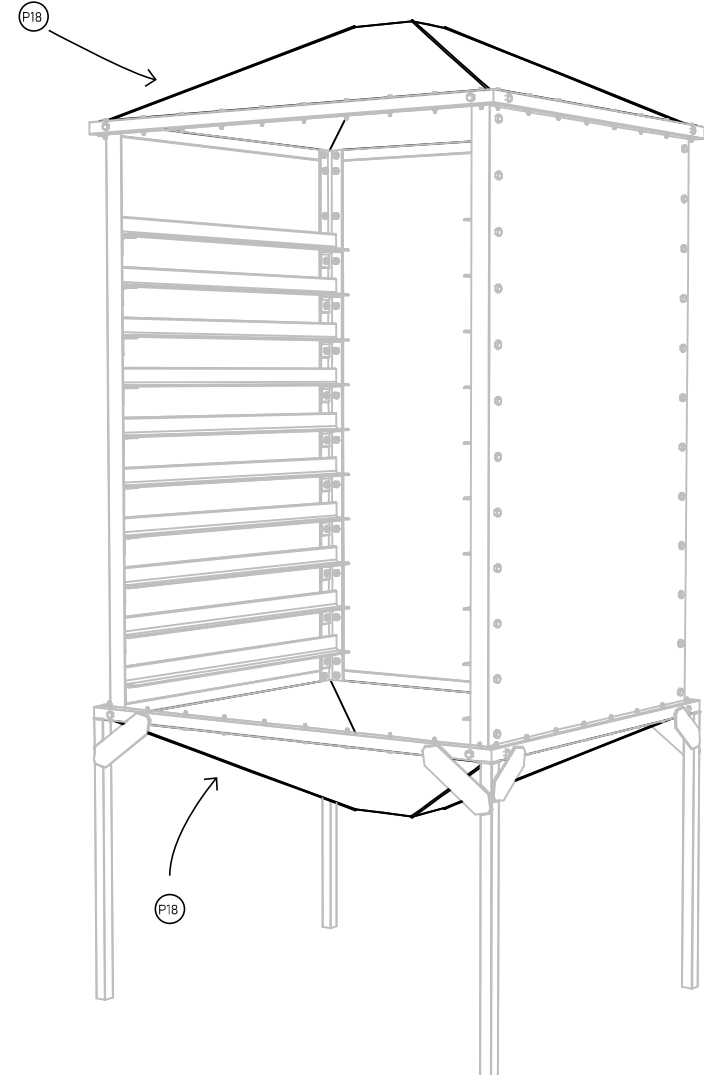
Sub-step 10.4

Screw the top roof on.



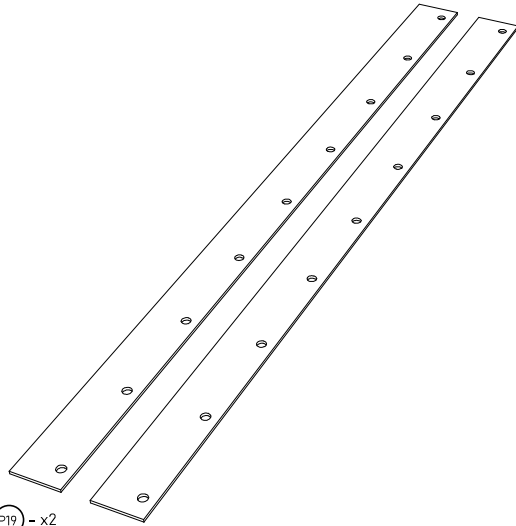
Sub-step 10.5

Repeat 10.1 - 10.4 for the bottom part. Exacly the same, just upside down.w



Step 11

Making two (2) metal plate brackets.

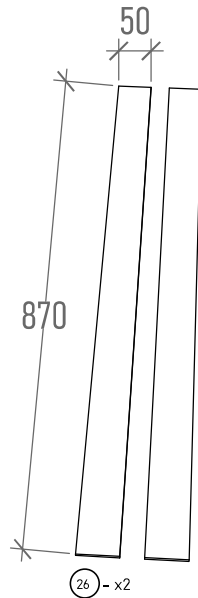


Ⓐ - x2

The goal of this step

Materials needed

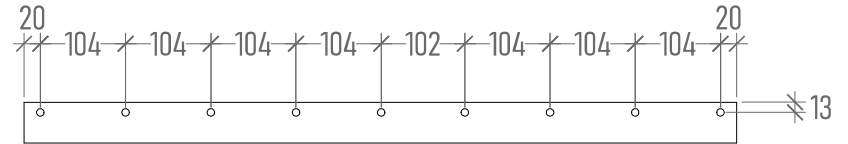
Flat iron 50x3 mm
2x 870 mm



Ⓐ - x2

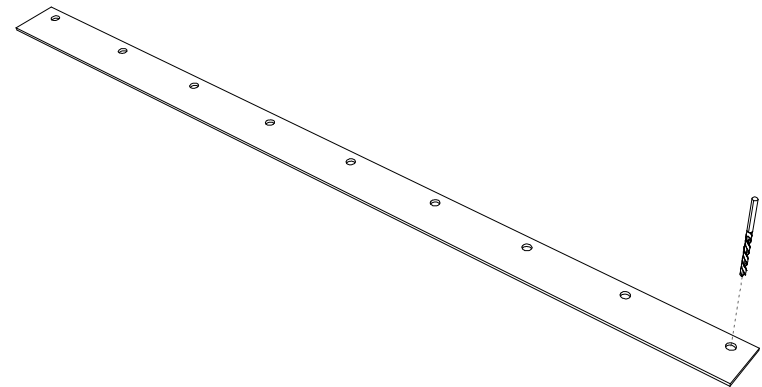
Sub-step 11.1

Mark drill locations. 9 mm diameter.



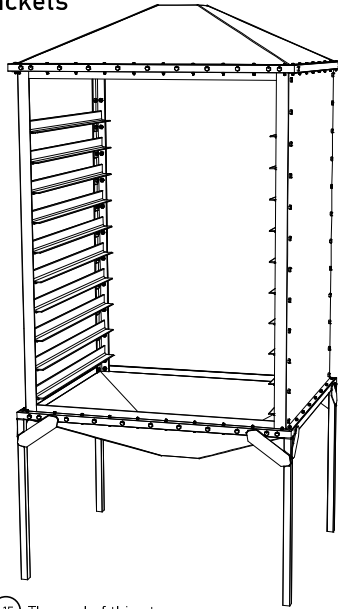
Sub-step 11.2

Drill out the holes.



Step 12

Mount the previously made brackets to the structure.



A15 The goal of this step

Materials needed

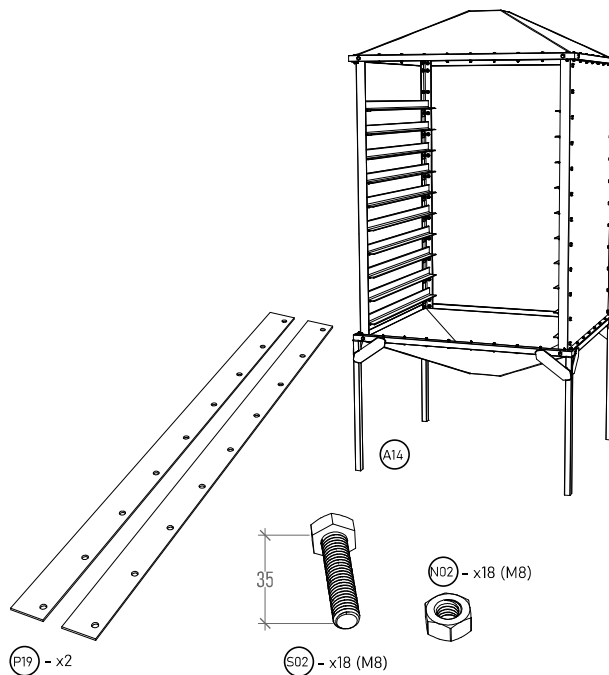
Assembly A14

Part P19 x2

M8 Hex screw
18x 35 mm

M8 Hex nut
18x

Silicon



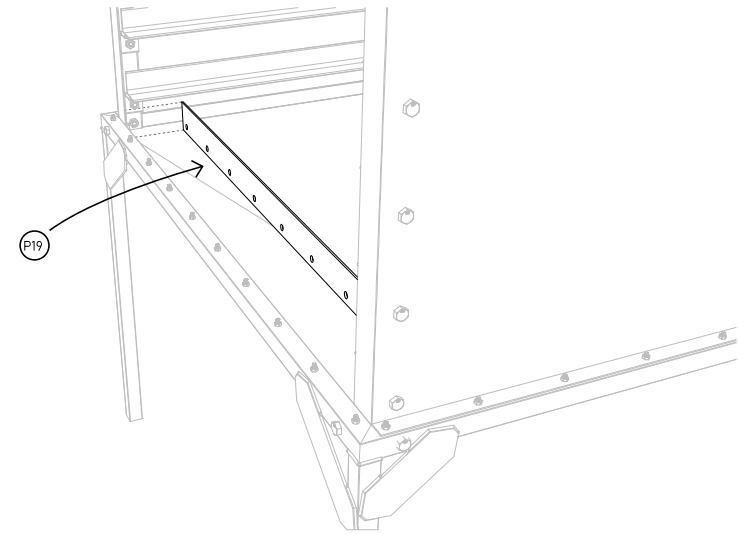
P19 - x2

S02 - x18 (M8)

N02 - x18 (M8)

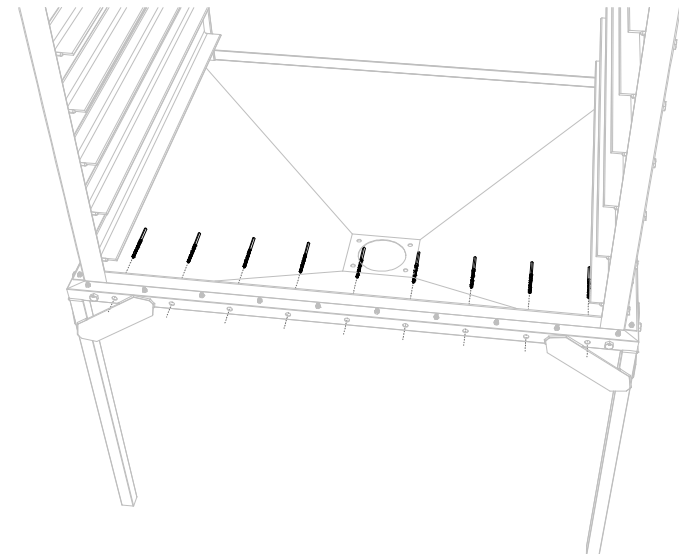
Sub-step 12.1

Place the brackets on the inside of the structure (on the open side).



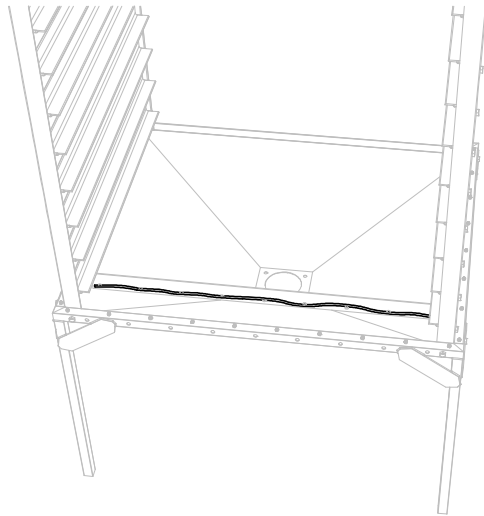
Sub-step 12.2

Drill out the holes, 9 mm diameter.



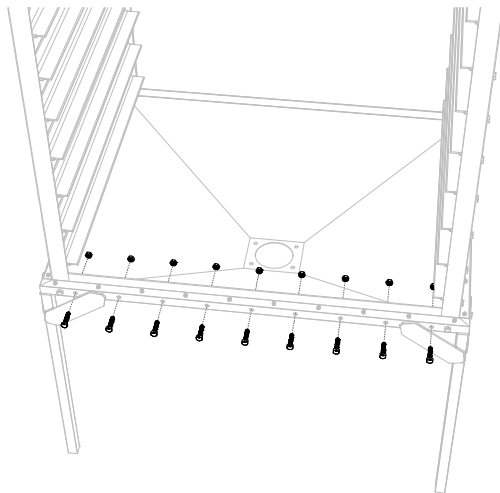
Sub-step 12.3

Put a line of silicon to create a air tight seal.



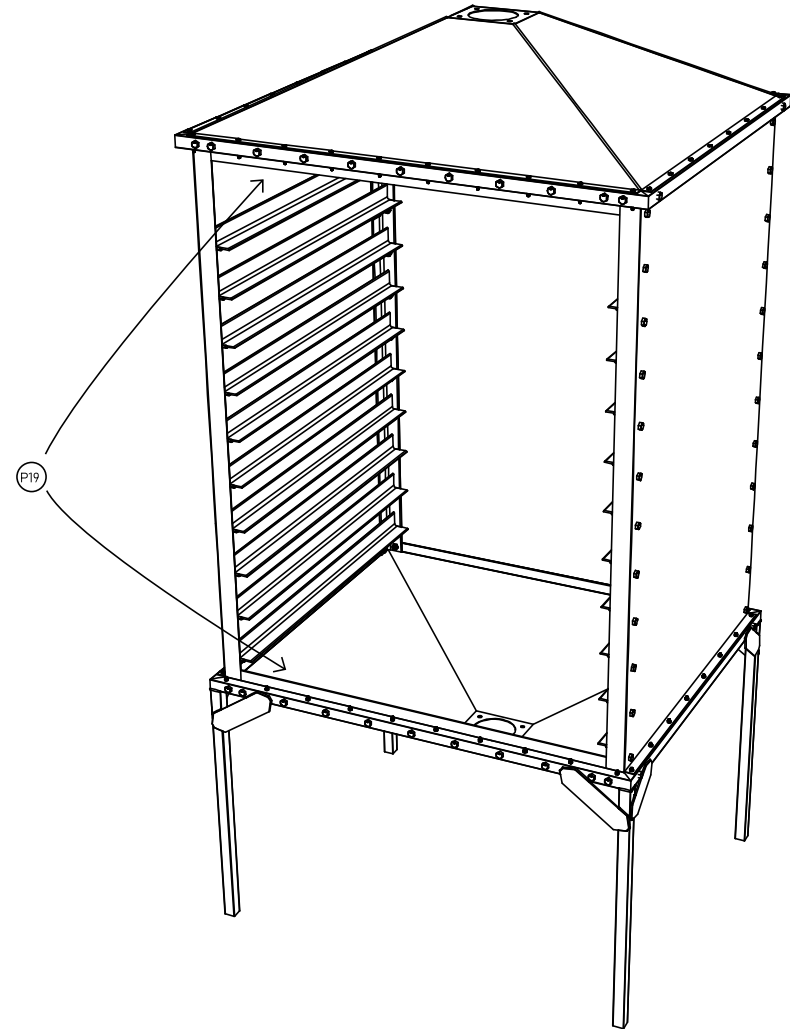
Sub-step 12.4

Mount the steel plate with screws and nuts.



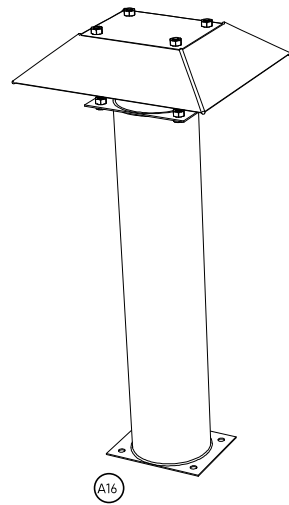
Sub-step 12.5

Repeat sub-step 12.1-12.4 for the top part.



Step 13

Asseby of chimney and bottom air inlet.



The goal of this step

Materials needed

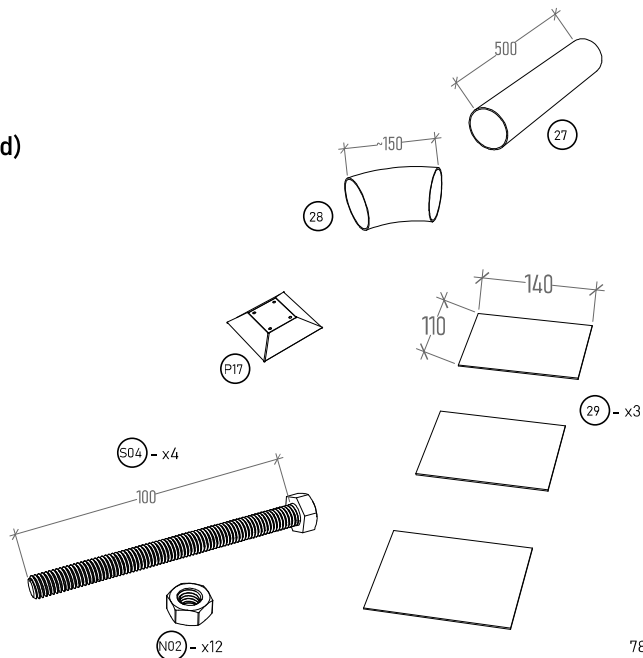
Part P17

Steel pipe 100 mm diamter
1x 500 mm
1x 150 mm (~30 degree bend)

Steel plate 1.5 mm
3x 110x140 mm

M8 Hex screw
4x 100 mm

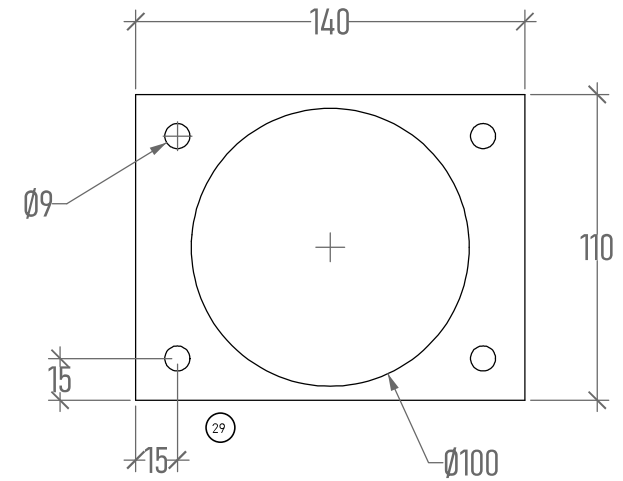
M8 Hex nut
12x



78

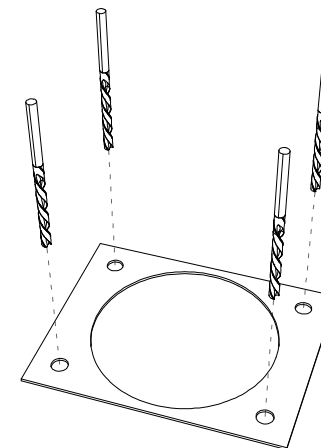
Sub-step 13.1

Mark out holes on all three plates.



Sub-step 13.2

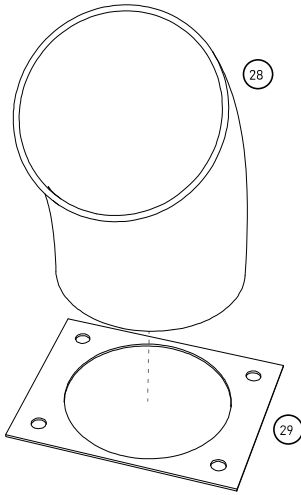
Drill out the holes and cut out the middle bigger hole.



79

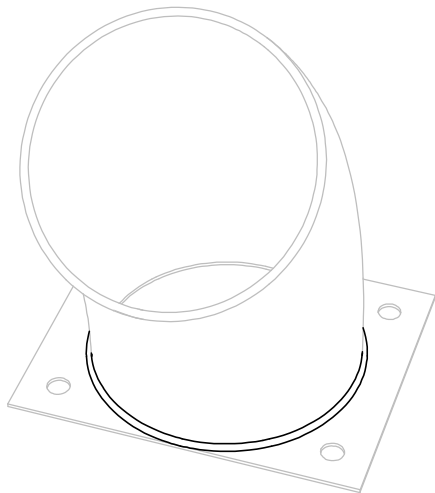
Sub-step 13.3

Place the short bent pipe on one of the steel plates. The bent side should be aimed towards the long side of the steel plate.



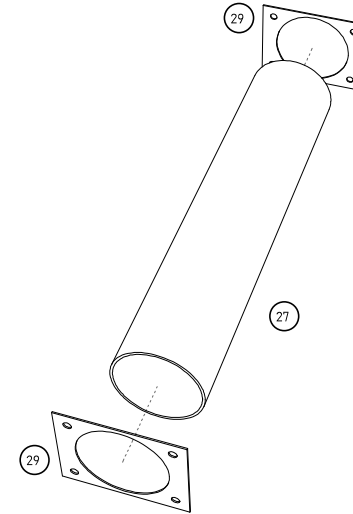
Sub-step 13.4

Weld the pipe and plate together.



Sub-step 13.5

Place the longer straight pipe in between to plates.



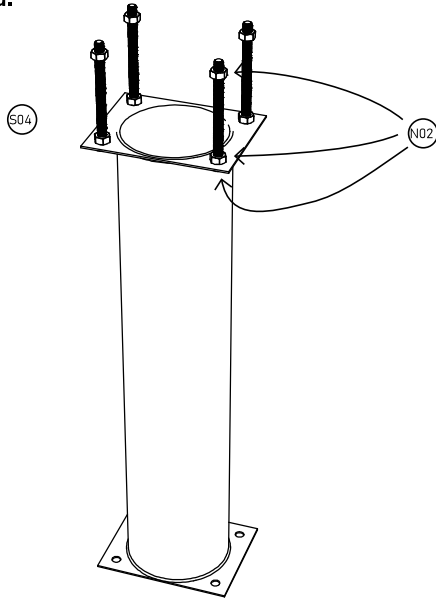
Sub-step 13.6

Weld the three (3) parts together.



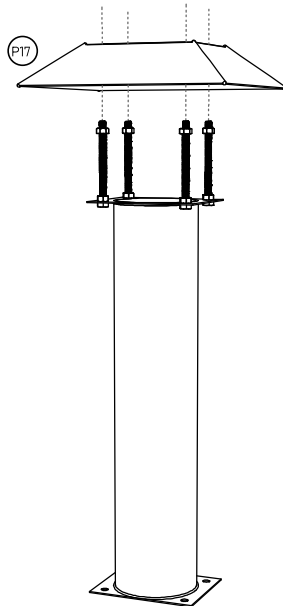
Sub-step 13.7

Mount the long 4 screws in on end of the chimney pipe together with 2 nuts on each as illustrated.



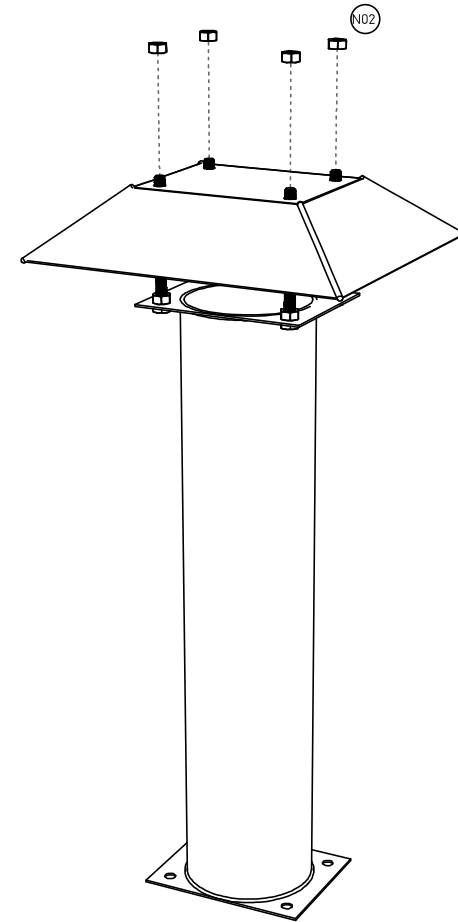
Sub-step 13.8

Place the top cap on.



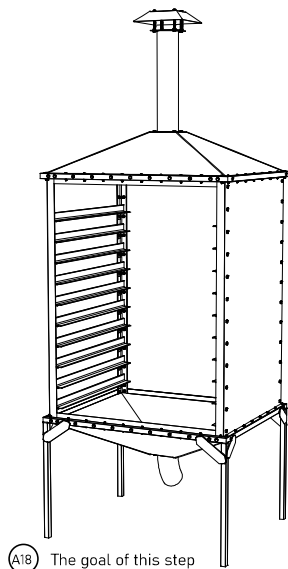
Sub-step 13.9

Screw the last nuts on.



Step 14

Mount the chimney and air inlet to the structure.



(A18) The goal of this step

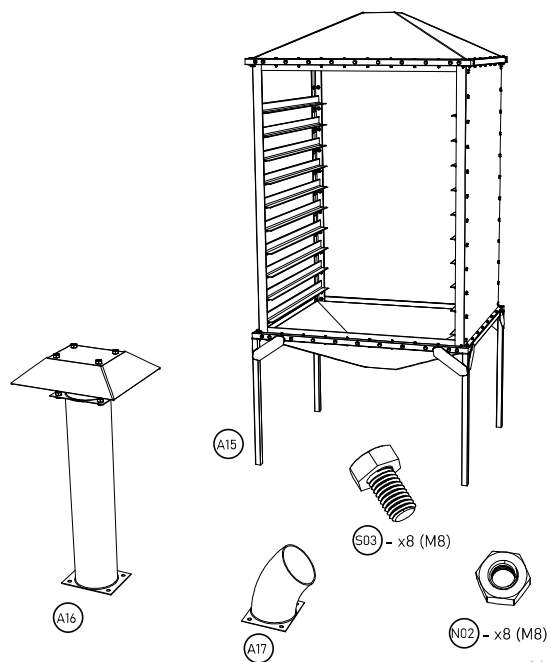
Materials needed

Assembly A15
Assembly A16
Assembly A17

M8 Hex screw
8x 14 mm

M8 Hex nut
8x

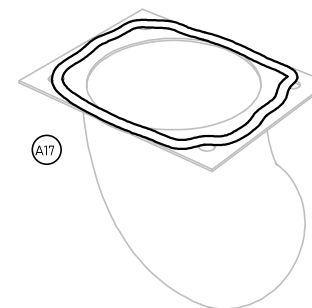
Silicon



84

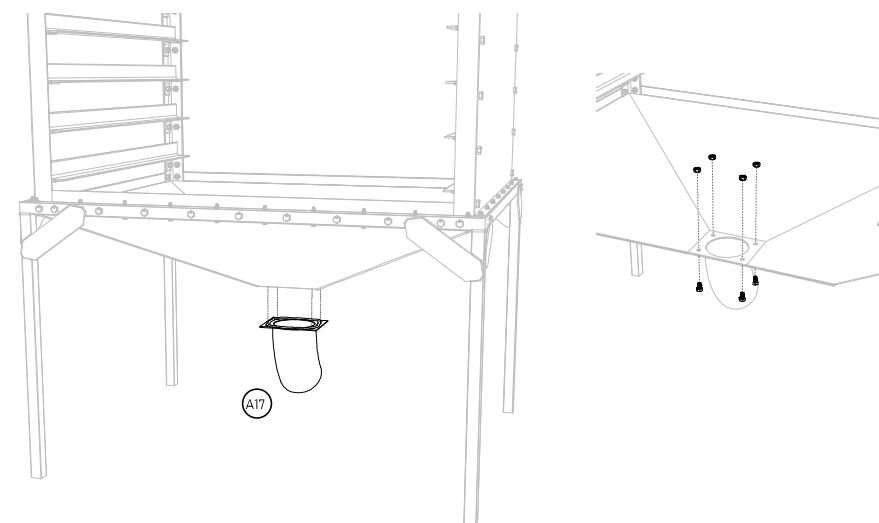
Sub-step 14.1

Put a silicon line on the steel plate.



Sub-step 14.2

Mount the air inlet pipe in the bottom of the structure.



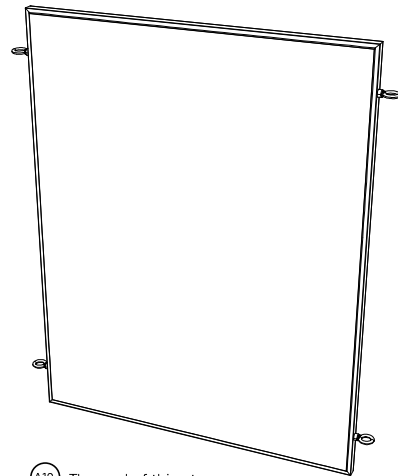
Sub-step 14.3

Repeat sub-step 14.1-14.2 for the chimney on the top.

85

Step 15

Creating the door.



A19 The goal of this step

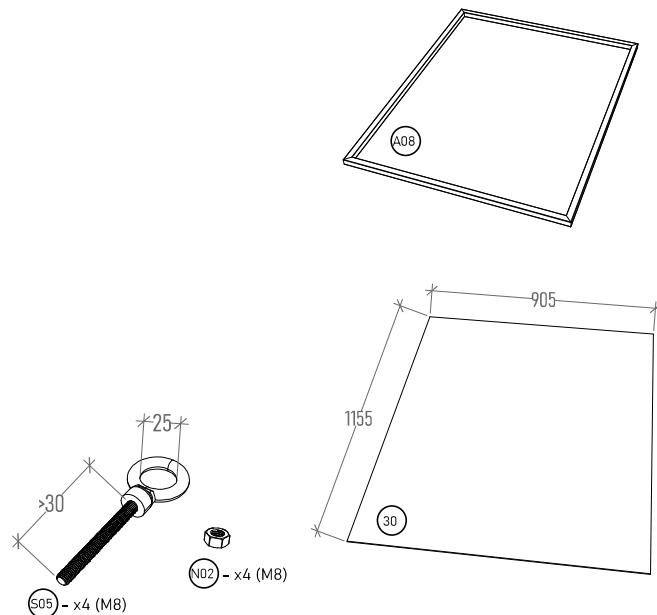
Materials needed

Assembly A08

Steel plate 1.5 mm
1x 1155x905 mm

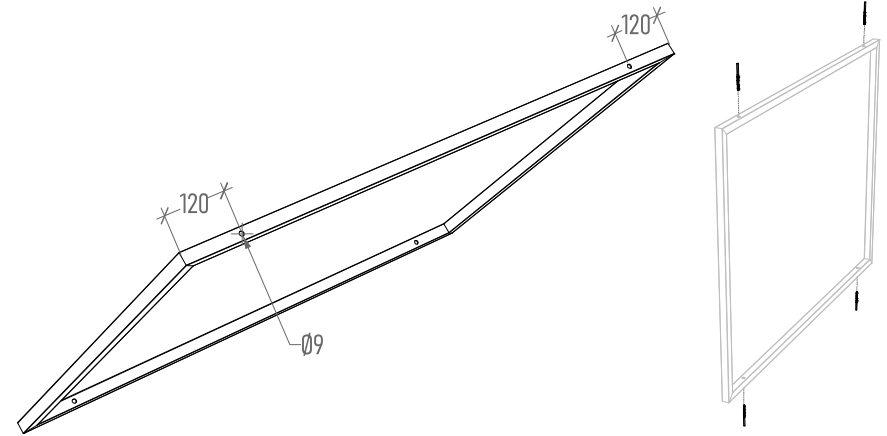
Eyebolt M8
4x >30 mm

M8 Hex nut
4x



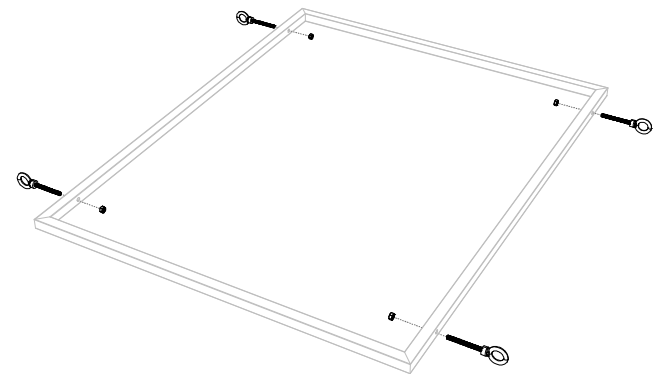
Sub-step 15.1

Mark out the hole locations on the square tube frame. Drill out the 4 holes, two on each long side.



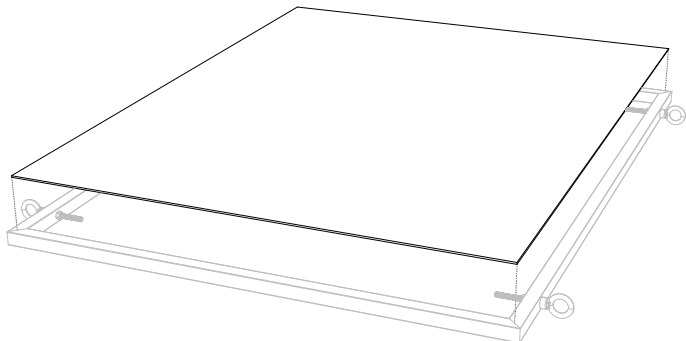
Sub-step 15.2

Mount the eyebolts as shown.



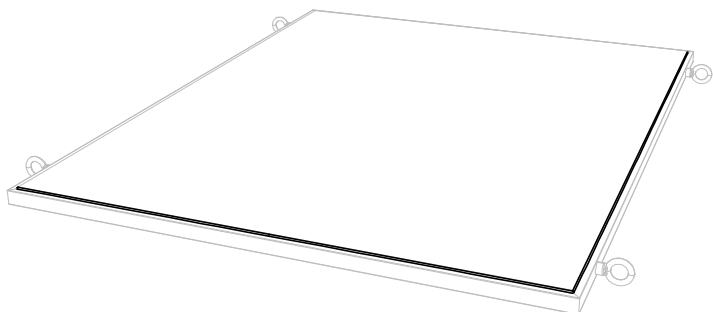
Sub-step 15.3

Place the steel plate centered on the frame.



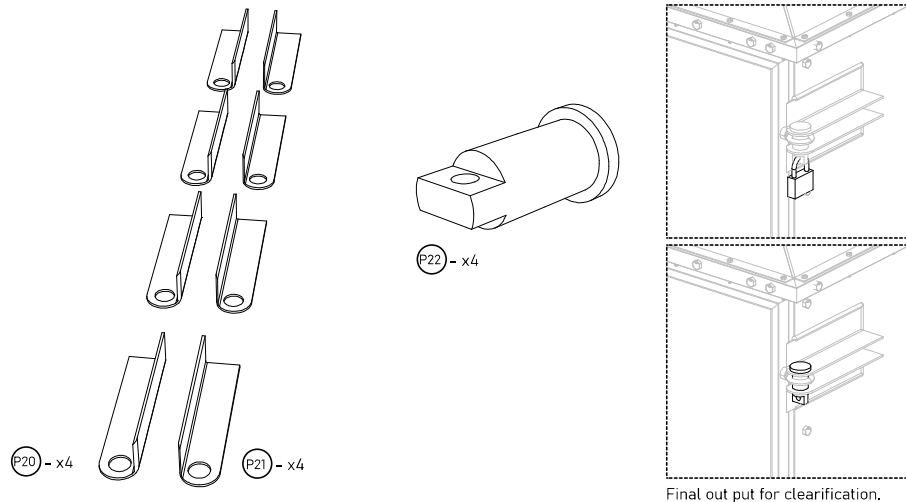
Sub-step 15.4

Weld the steel plate to the frame.



Step 16

Fabricate hinges for the door. This step is only an example. Any other hinge system that can be welded or bolted to the structure and door will work. The only requirement is that the door can be locked to prevent theft.



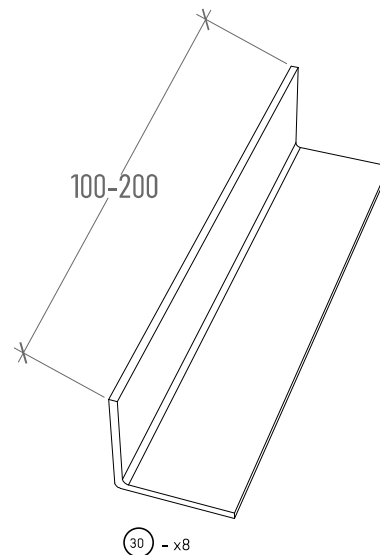
The goal of this step

Materials needed

Metal pin x4

Angle iron 40x40x3 mm
8x 200 mm

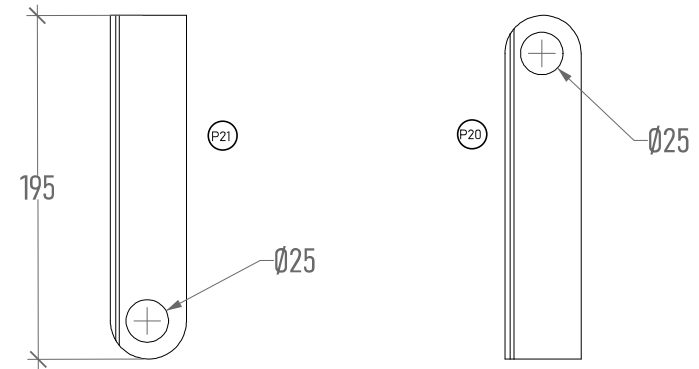
Padlock x4



Sub-step 16.1

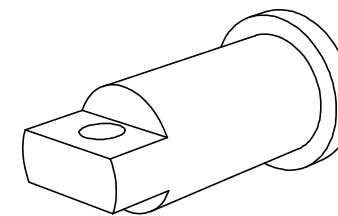
Cut out a hole in the end of the angle iron peicre. Two pairs of 4. Both pairs are identical, but mirrored. The hole size should matched the diameter of the pin in sub-step 16.2.

Round of the corners in the ends where the holes are placed.



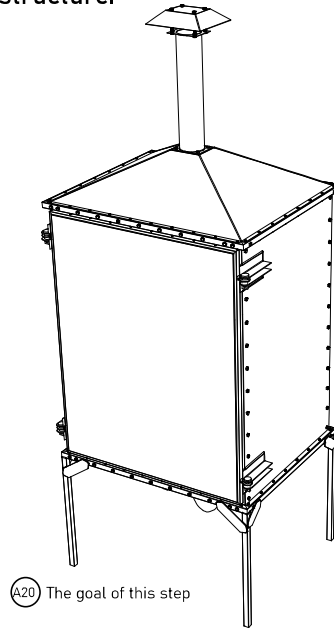
Sub-step 16.2

Create a pin similar to this one. For exampel made out of steel tube. One end should have a stop, and the other one a hole for a padlock.



Step 17

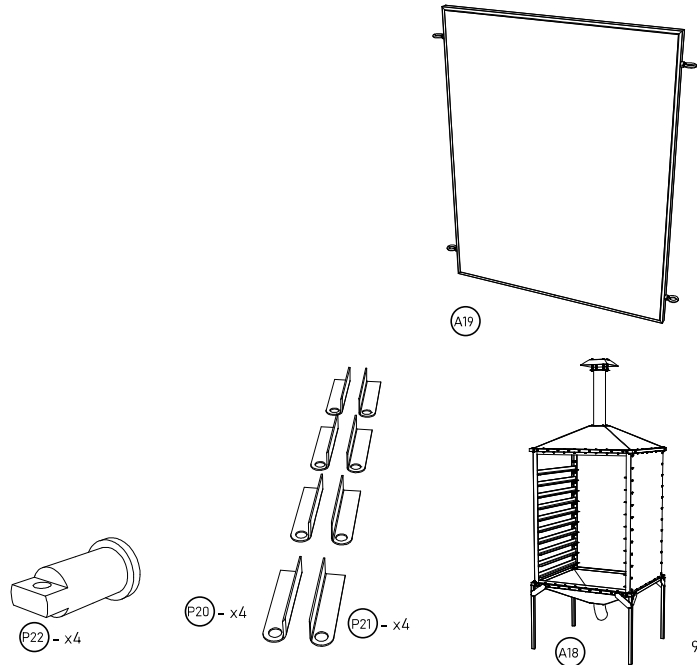
Mount the hinges on the structure.



Materials needed

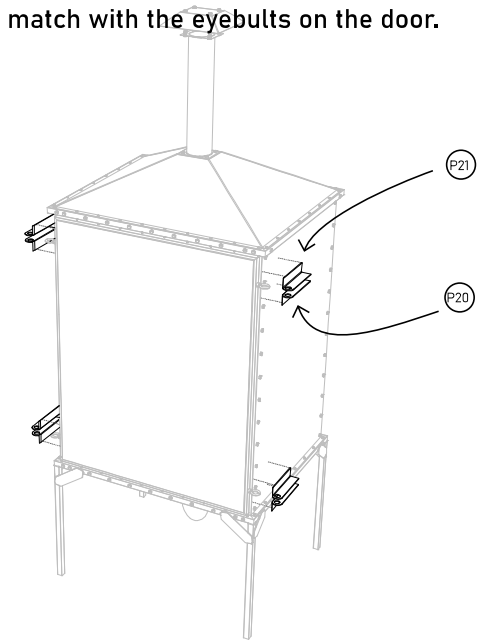
Assembly A18
Assembly A19

Part P22 x4
Part P20 x4
Part P21 x4



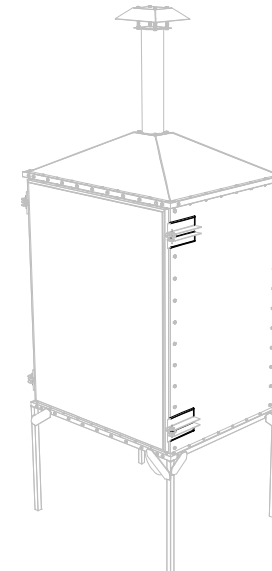
Sub-step 17.1

Place the hinges so they match with the eyebolts on the door.

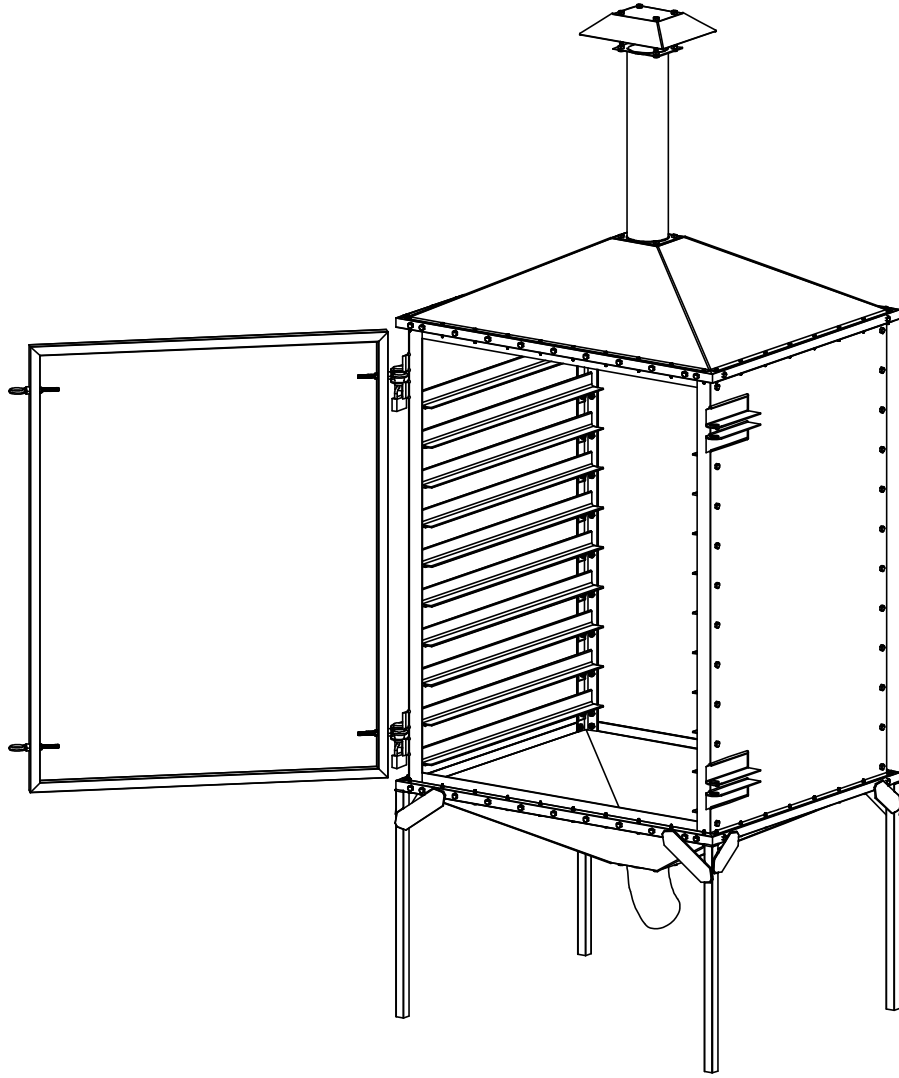


Sub-step 17.2

Weld the hinges to the steel plate on the drying tower.



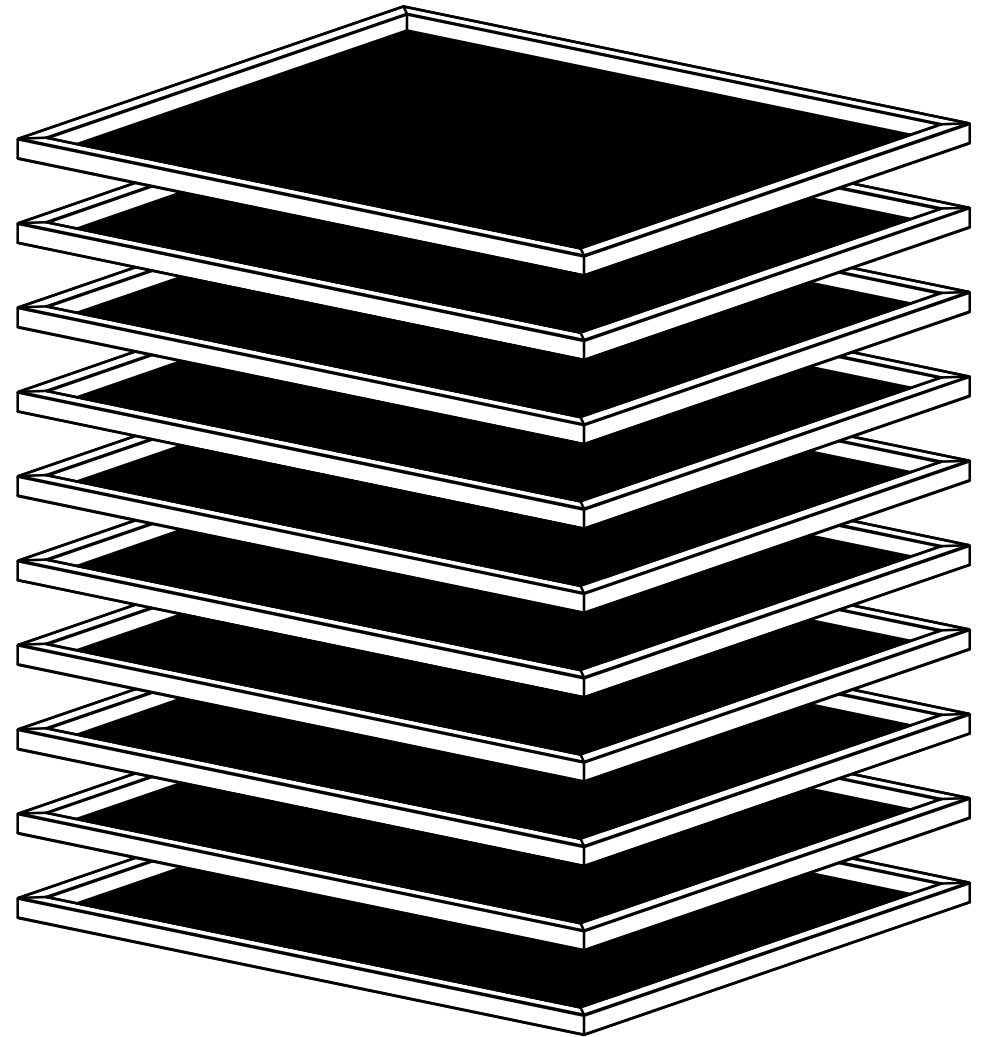
Drying Tower done!



Manufacturing

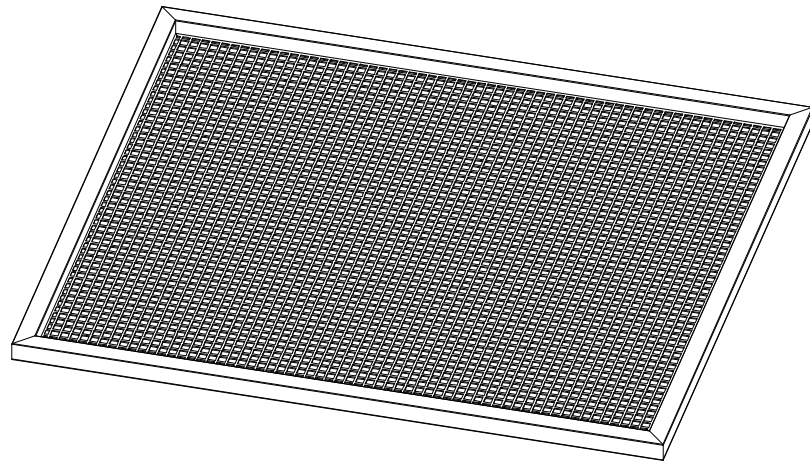
Metal shelves

The steel shelves are optional. The shelves could be made from other materials, such as wood. They just need to have the same width and depth.



Step 1

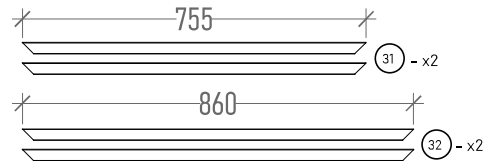
Makeing one (1) shelve.



The goal of this step

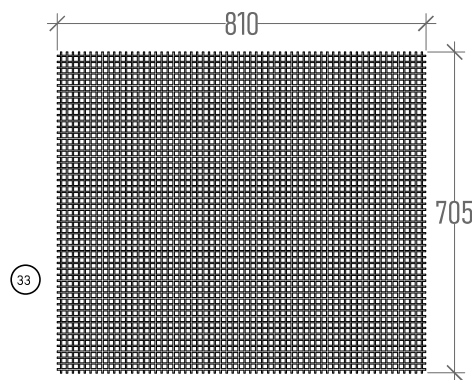
Materials needed (for one shelve)

Square tube pipe 25x25x1.5 mm
2x 860 mm (cut 45° in each end)
2x 755 mm (cut 45° in each end)



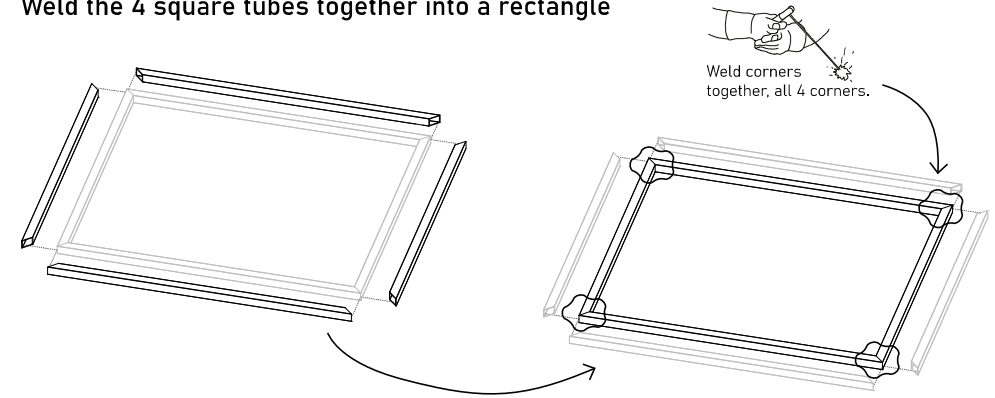
Wire mesh 810 x 705 mm

If you are making the recomended 10 shelves, you need everything x10.



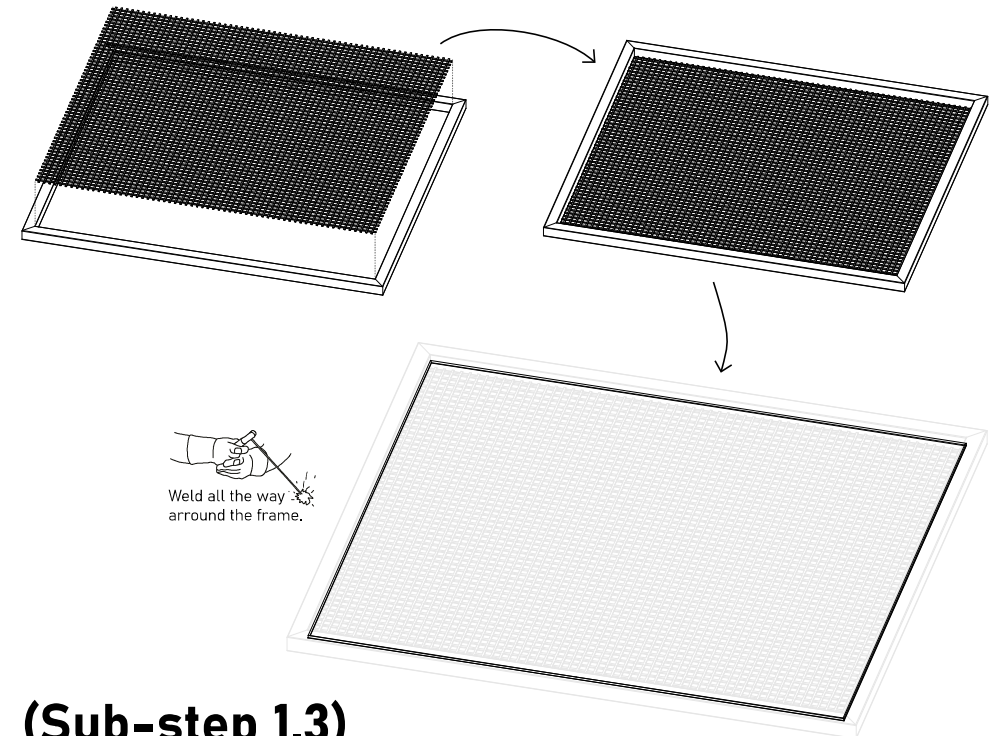
Sub-step 1.1

Weld the 4 square tubes together into a rectangle



Sub-step 1.2

Place the wire mesh inside the metal frame, flush with the bottom, and weld it to the frame.



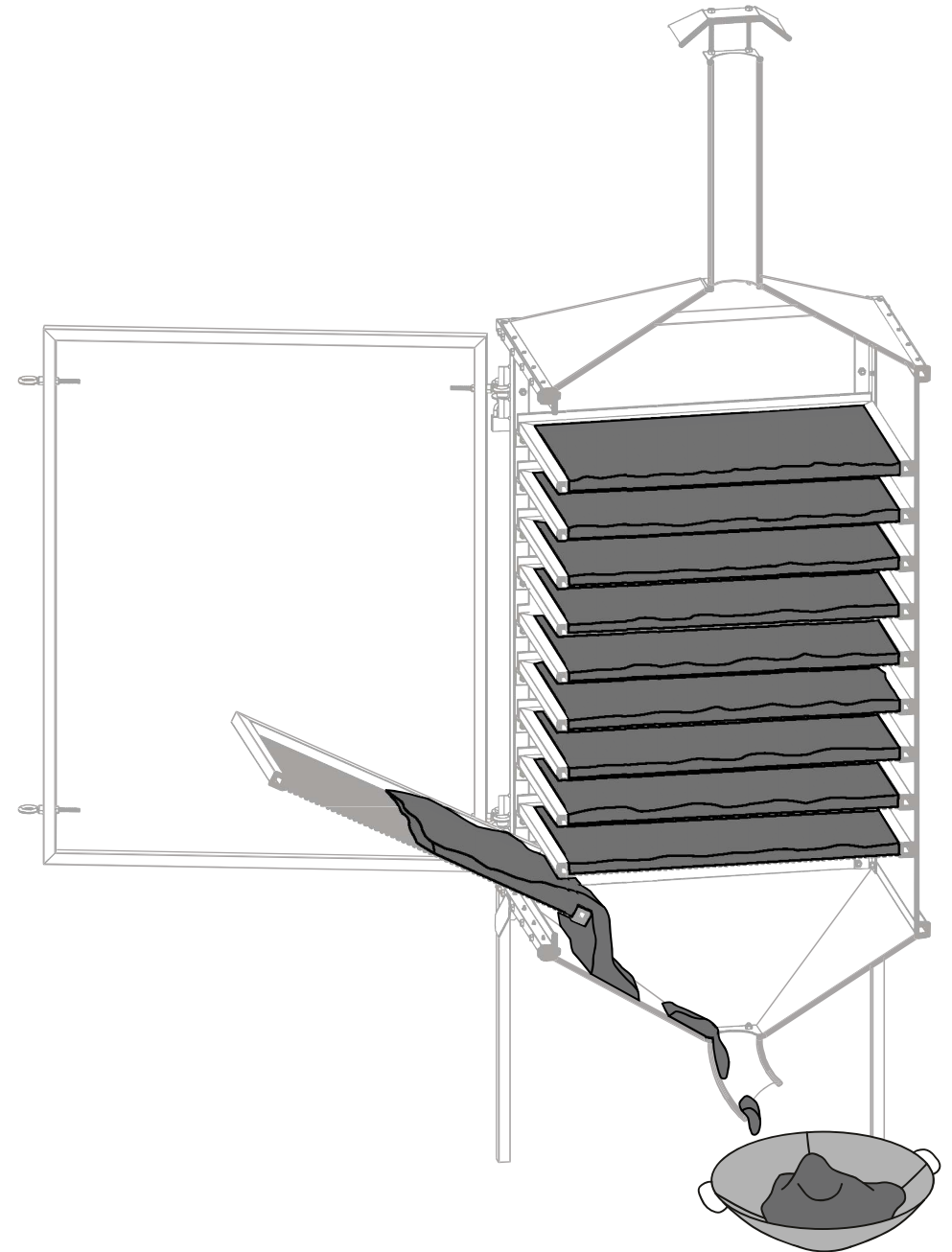
(Sub-step 1.3)

Repeat 10x times.

Tutorial

How to use

The basic ideas illustrated.



Open the door

The hinge system in this version of the drying tower can be opened from both sides, depending on what suits you better. You could also remove the door completely.

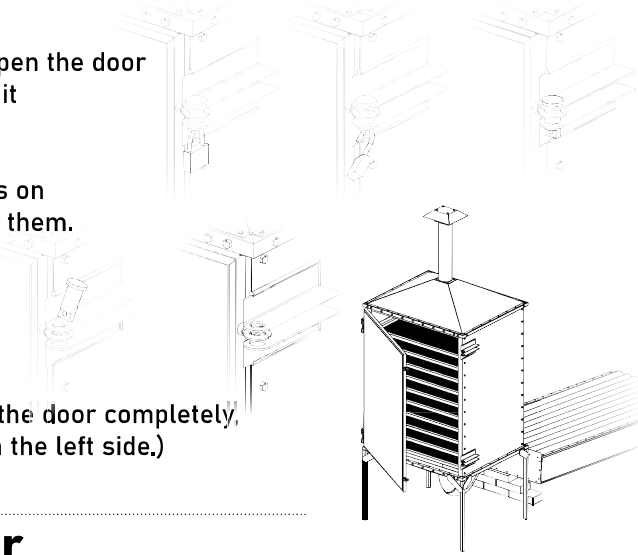
In this example, we will open the door on the right side, pivoting it on the left hinges.

1. Unlock the two padlocks on the right side and remove them.

2. Remove the two pins.

3. Swing the door open.

(4. If you want to remove the door completely, repeat the above steps on the left side.)

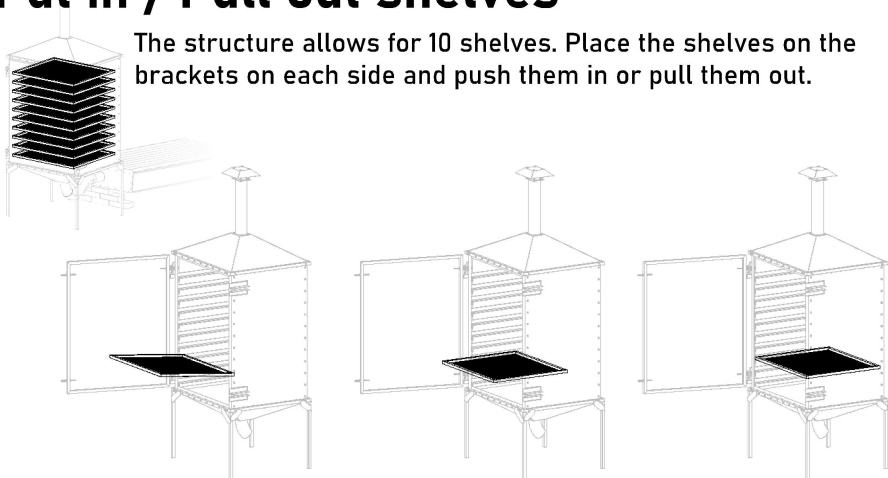


Lock the door

Repeat the steps for opening the door, but in reverse order.

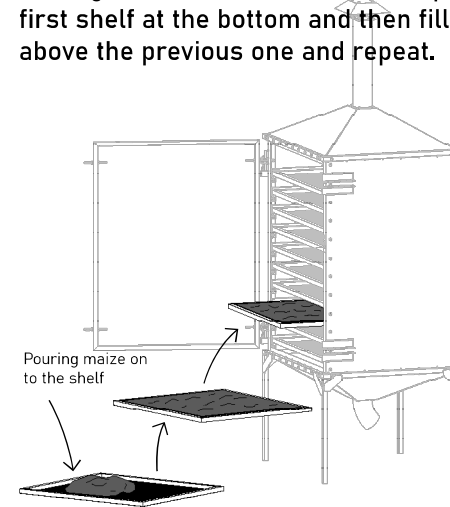
Put in / Pull out shelves

The structure allows for 10 shelves. Place the shelves on the brackets on each side and push them in or pull them out.

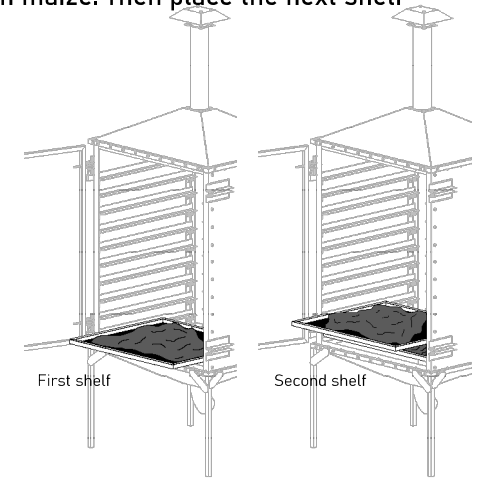


Put maize on the shelves

Depending on what's easiest for the user, you can either put the maize (or any other grain) on the shelves before placing them in the drying tower, or put the first shelf at the bottom and then fill it with maize. Then place the next shelf above the previous one and repeat.



Pour the maize on the shelves first before placing them in the tower.



Place the shelf in the tower and then pour maize on it.

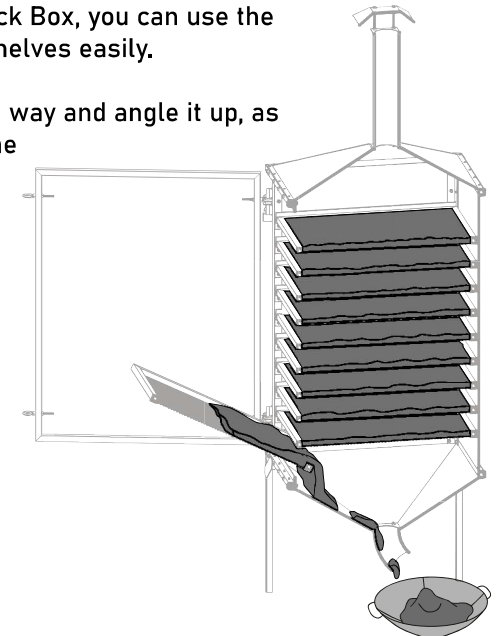
Empty shelves into the bottom (optional)

If you disconnect the pipe from the Black Box, you can use the bottom pipe as a funnel to empty the shelves easily.

Pull out the bottom shelf almost all the way and angle it up, as illustrated in the picture to the right. The grains should now fall off the shelf and down to the bottom of the drying tower and out the pipe. You may need to use your hand to help the last of the maize fall down.

Start with the bottom shelf, then move to the one above it, and so on.

Don't forget to put a basket or bag under the outlet pipe!

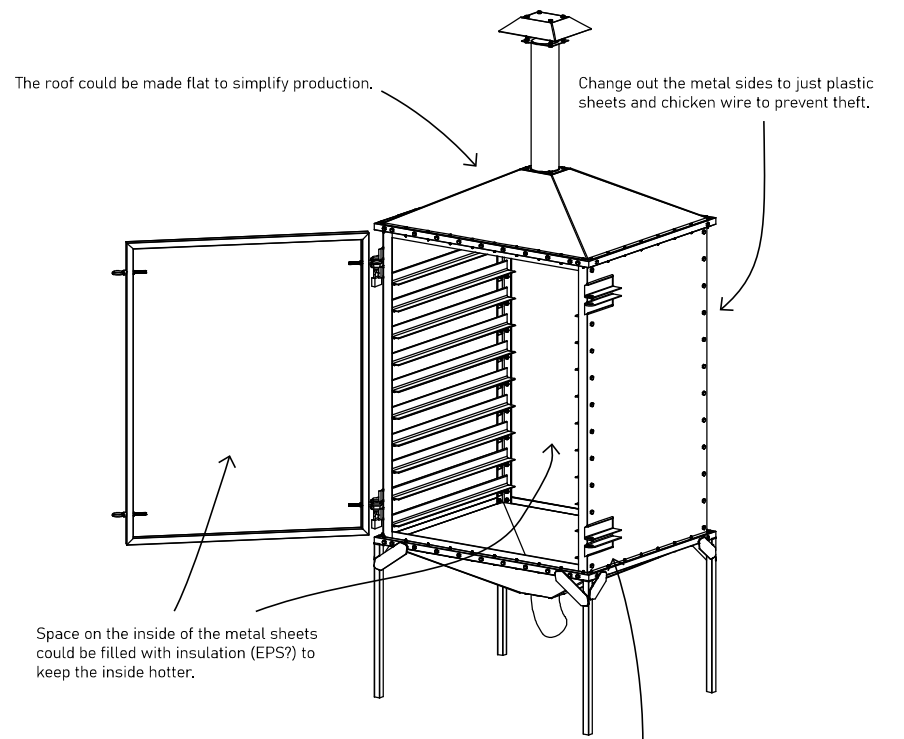


Possible changes

This prototype illustrated in this handbook is made entirely of metal. We know metal is a bit trickier for a normal user to work with since it requires special tools. However, we chose metal for the first prototype because, if you have the tools and knowledge, it's quite easy to build. Metal is also good for the longevity of the structure since it is resistant to weather and similar factors.

Although we want this project to be easily accessible for everyone, both in terms of tools and cost, we have ideas that could be tested to improve the concept and make it cheaper.

Here are some thoughts we have had that might inspire you to experiment:



Whole structure could be made out of wood?

Hinges could be constructed in another way. Maybe you could skip hinges and use a rope to hold the door closed.