CONSTRUCTION MANUAL

SOLAR DRYER

ENERGIESEMINAR - SUMMERSEMESTER 2019

The idea of developing a solar dryer to improve the economic situation of Sudanese date farmers was the beginning of a cooperation project between members of the Arab-German Young Academy of Sciences and Humanities (AGYA), the Environment and Natural Resources and Desertification Institute (ENDRI) of the National Centre for Research (NCR) in Khartoum and the Reiner Lemoine Institut (RLI) in Berlin as well as the Energieseminar at Technische Universität Berlin (TU Berlin).

After having clarified the most important conditions between the leading scientific assistants, the project Solar4Food started in the summer semester 2019 as a project lab organized by students of the Energieseminar. Doing so the project lab not only highlighted the specifics of solar dryer construction, but also approached the topics of development cooperation, gender and low hierarchical organizational processes with a critical perspective. While the project unfolded, the needed theory was gradually developed and translated into organizational practice. The present construction manual can be understood as a result of this collective process.

A solar dryer is intended to enable the controlled drying of food in the best possible hygienic conditions as well as reducing the time needed for the whole drying procedure. Its usage would be conceivable in the drying of fruits, vegetables, herbs, tea, and mushrooms, but also of meat and fish. From the objective to develop a cost-effective, easy to build, resource- and environmentally friendly solar dryer, there were corresponding limitations regarding the selection of the form, the means and the methods of the construction of the dryer. As a first step the students agreed to the development of a tunnel dryer that can be realized with comparatively little effort due to its design and can be adapted to the most varied size requirements of agricultural businesses. The further elaboration of technical details was subsequently left to newly-formed working groups, which exchanged views on the status of their planning as well as feedback in regular consultation with the project group.

After the working groups had developed plans for the realization of the tunnel dryer, it was built on two weekends in June and July 2019 in a workshop on the campus of the TU Berlin. The finished tunnel dryer was provided to Frieda Süd, a neighborhood-based project in Berlin, in the hope that it will be used after its completion.

The construction manual essentially follows the structure of the working groups formed for the development of the single components (1. drying table, 2. frame including gable plate preparations, 3. collector, 4. grid, 5. electronics and associated components, 6. roof) and also contains safety instructions, comments on particular work steps, alternative material proposals as well as a tool and material list. With the mailing of the construction manual, Solar4Food enters its second phase, in which the prototype will be adjusted to the conditions in Sudan and/or further developed, and finally built and tested for usability by the ENDRI in Khartoum.

Workshop safety is everyone‘s responsibility, the following rules have been put in place to ensure the safety of all staff. Please read the safety rules carefully before entering the workshop.

Workshop rules:

- Never work alone in the workshop
- People with any health problems that may affect workplace safety (e.g. medication, epileptic fits) must report these conditions to the workshop staff
- Notify the workshop staff of your arrival
- Wear the correct protective equipment for the tools you are using – ask if in doubt
- Ask how to use the tools safely
- Make sure your work piece is fixed securely before work commences
- Keep leads up off the floor
- Turn the machine off before cleaning it
- Clean up any spills immediately
- Wash hands after using equipment and machinery
- Check that any tools you have been using have been put away in the appropriate spots, cleaned up your work area and notify the workshop staff.

Clothing & footwear:

- Safety glasses and hearing protection
- People that wear glasses should be aware these are not safety glasses, they are only impact resistant and may shatter, safety glasses must be worn.
- All loose clothing (eg shirts hanging out) must be tucked in.
- Safety boots or enclosed shoes must be worn in the workshop. Do not enter under any circumstances without this footwear, there are no exceptions to this rule.
- Long hair has to be tied up including fringes.
- Remove rings and loose jewellery before operating machinery they can be a hazard

First Aid

The first aid regulations should be perestend by the workshop supervisor. Listen carefully and act based on them in terms of any accident.

Fires or other emergencies

Think before reacting to any emergency in the workshop, ensure you are reacting safely before you assist in an emergency. Do not attempt to fight any fire unless you have been trained to do so.

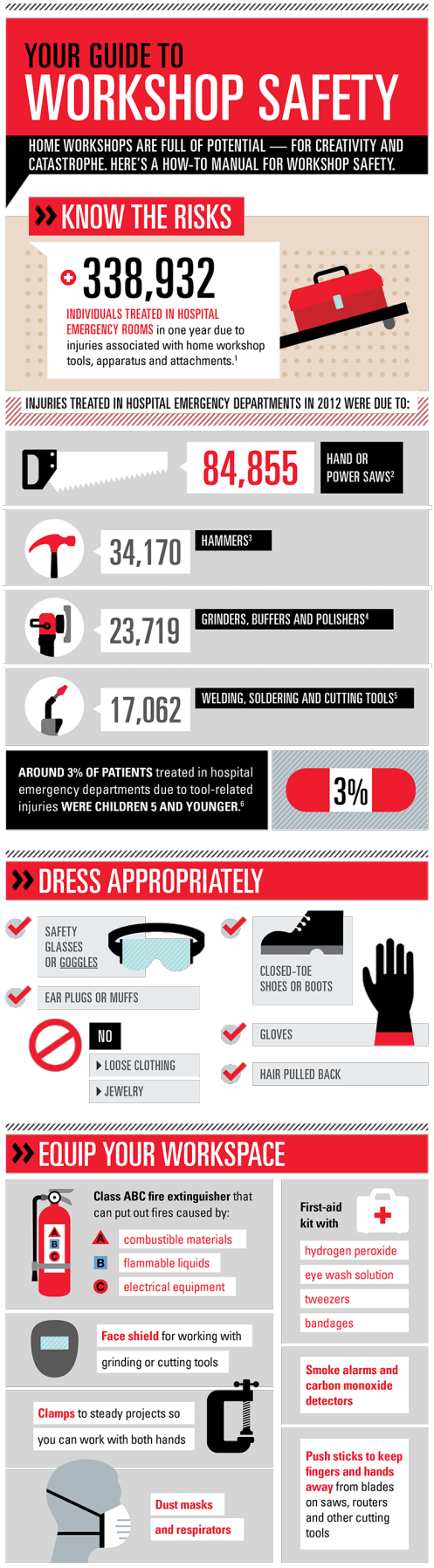
More about rules

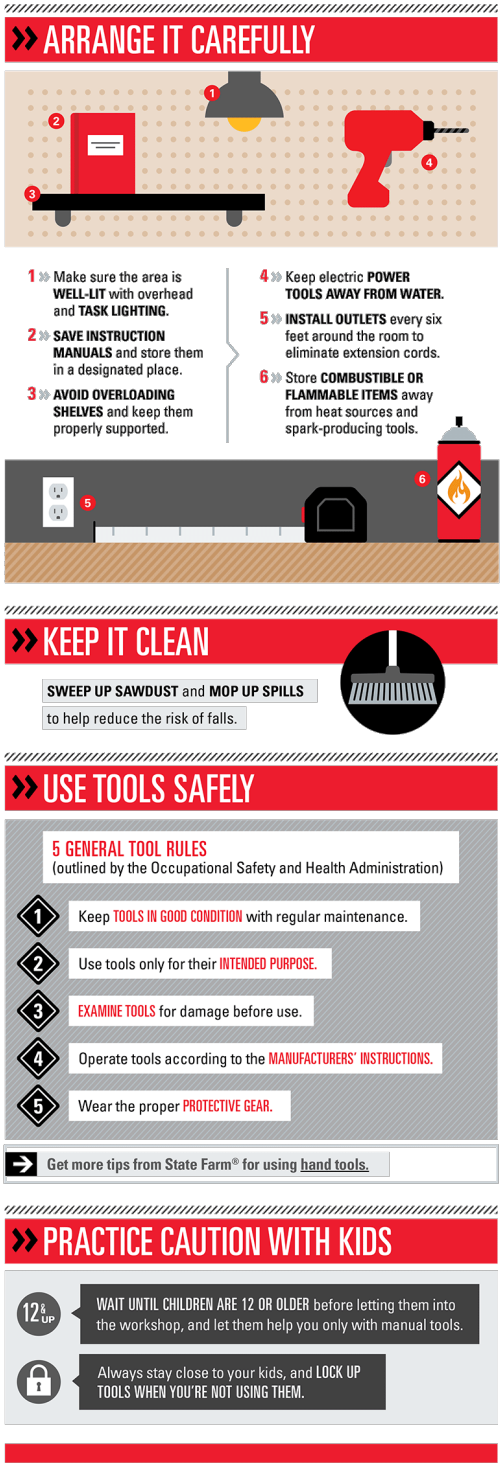
Much more detailed regulations can be found here:

https://www.deakin.edu.au/students/faculties/sebe/abe-students/workshop/rules-safety

http://web.inf.ed.ac.uk/infweb/health-safety/policies-procedures/workshop-safety

[https://i.pinimg.com/originals/16/33/8e/16338e021cdb1f8e9816c188cec44ed2.jpg]





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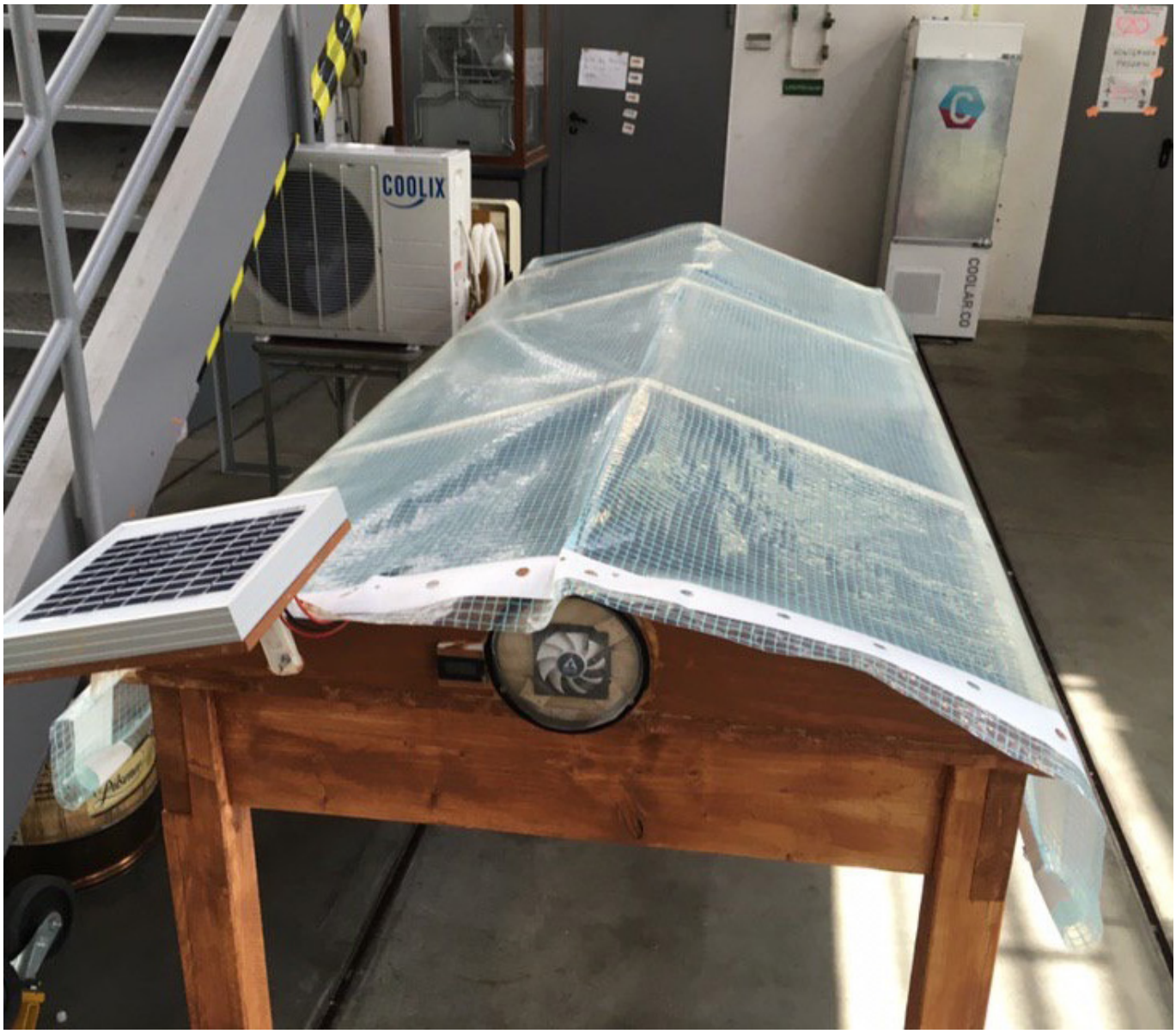


Solar Dryer: A project called Solar4Food started in the summer semester 2019 as a project lab organized by students of the Energieseminar at Technische Universität Berlin Foto by Denis Linsner.

Drying table

Tools:

- Workbench
- Screw clamp
- Circular saw
- Folding rule
- File
- Rasps
- Planer
- Drill + attachments
- Hammer
- Open-end wrench
- Ratchet

Materials:

6 x profile boards (18cm x 96cm x 206cm)
2 x planks (2cm x 20cm x 200cm)
2 x planks (4cm x 20cm x 84cm)
1 x screed (2cm x 20cm x 200cm)
4 x scantlings (90cm x 8cm x 8cm)
4 x screw-on sleeves (81mm x 81mm)
32 x screws (4 Ø)
12 x wood screws (M8 x 150)
12 x washers (12 Ø)
12 x washers (8 Ø)
~ 30 x nails (8 x 45)

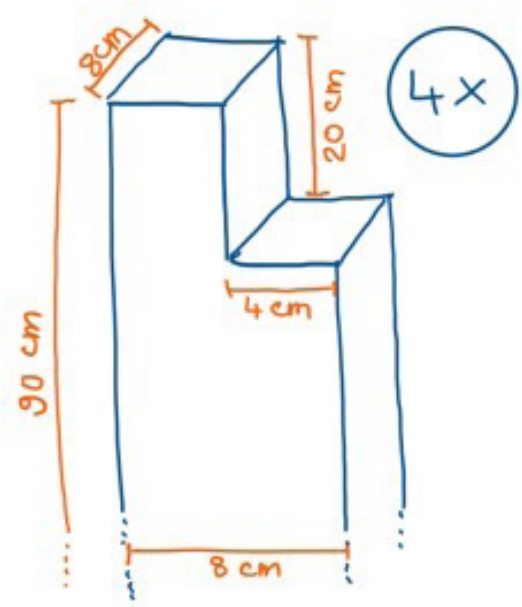
Preparation
1. Draw dimensions on material

2. Fix material on the Workbench with screw clamp and then saw it

3. Preparation of the legs

3.1. Cut the upper ends of the legs with a circular saw, creating a recess for the longitudinal beams (dimensions of the recess: 4cm x 8cm x 20cm)

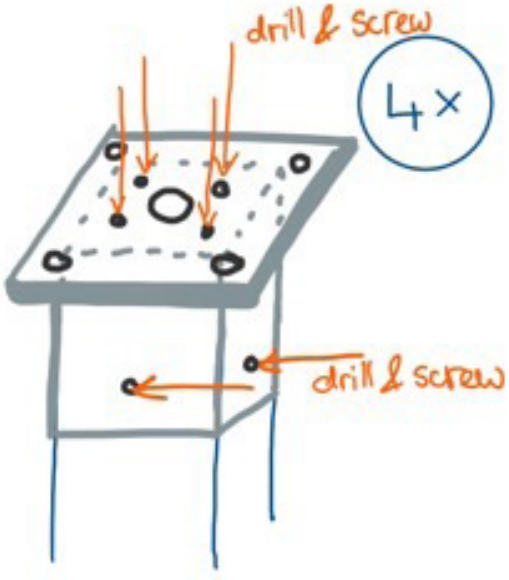
Note: Draw in the dimensions on both sides, as the circular saw does not get through completely.



3.2. Correct, if necessary, bring the legs with a file and rasp to the correct dimensions

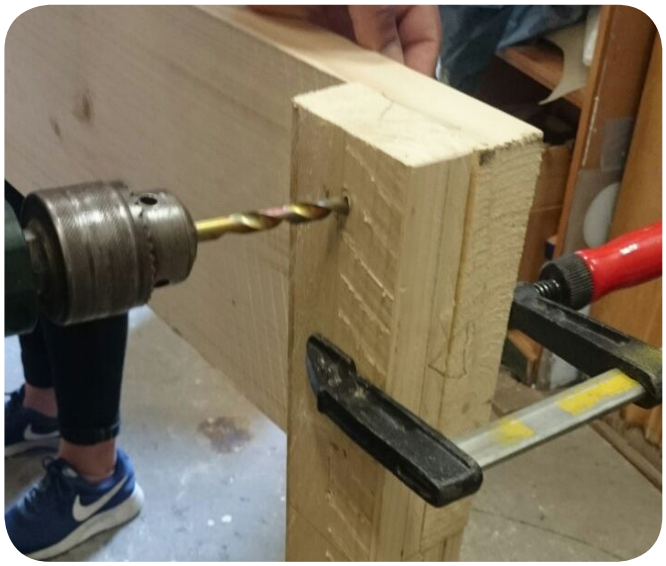
3.3. Pre-drill legs with 3 Ø then drill with 7.5 Ø

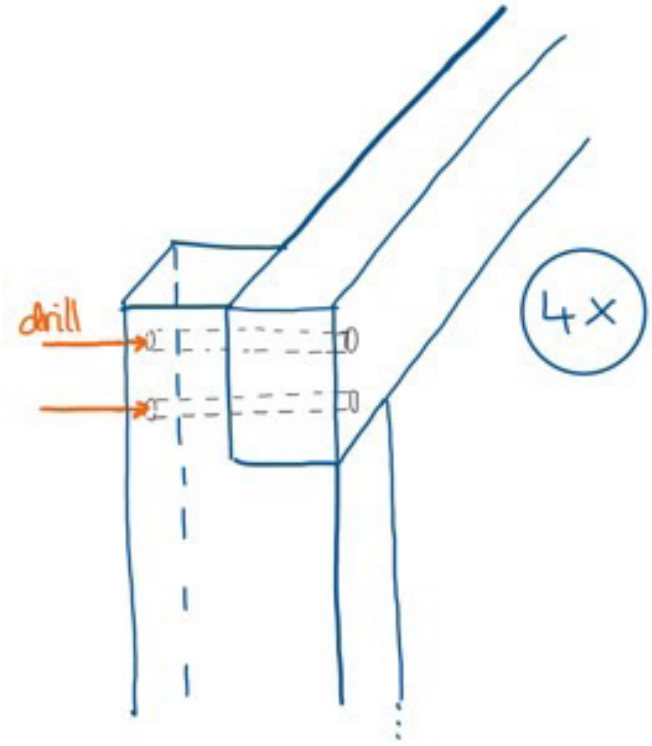
3.4. Fitting the legs in the screw-on sleeves:
Pre-drill with 3.5 Ø and then fasten with 4 Ø screws (8 each per leg)



4. Preparation of the longitudinal beams:
   Pre-drill longitudinal beam with 3 Ø, then drill with 7.5 Ø

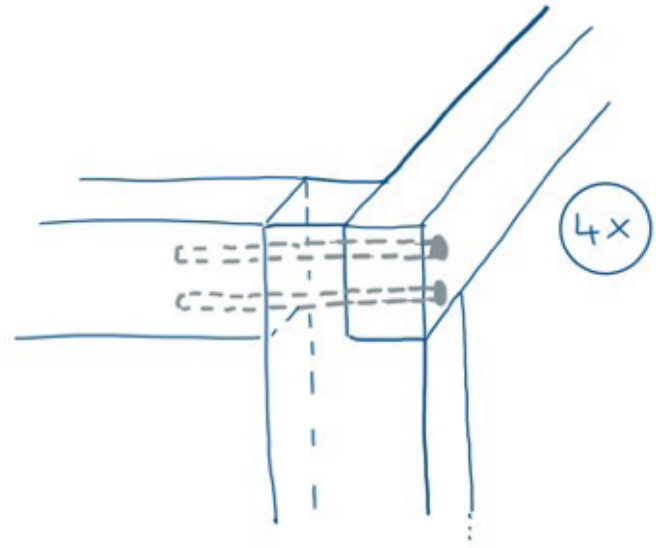
Note: To take holes in the legs, fix these and longitudinal beams with a screw clamp and transfer the drill holes to longitudinal beams (make sure that components are aligned, so that all fits together in the end)





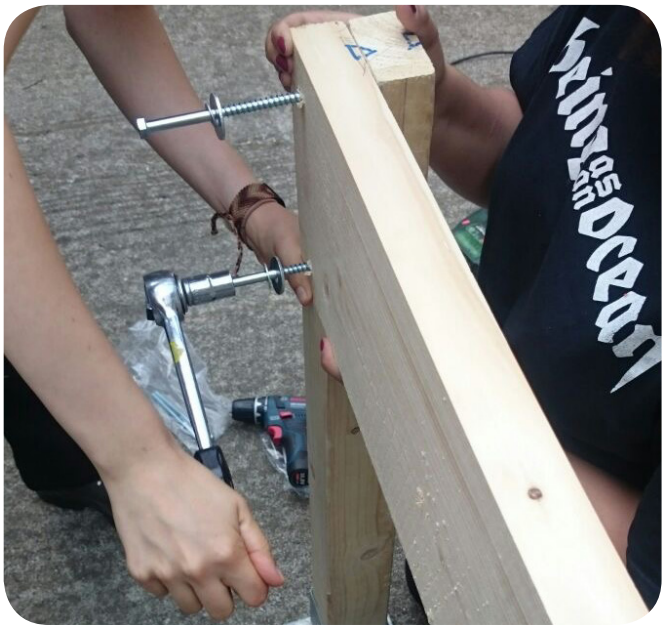
5. Preparation of the crossbeams:
   Pre-drill the crossbeams first with 3 Ø, then with 6Ø drilling attachment

Note: Transfer bores of the legs to the cross-beams again, drill them with 7.5 Ø through the legs (make sure that components fit together)



Assembly

1. Legs and longitudinal beams



1.1. Fasten the longitudinal beam with ratchet and open-end wrench to two legs

Note: Turn the screws in so far that the tip comes out the back

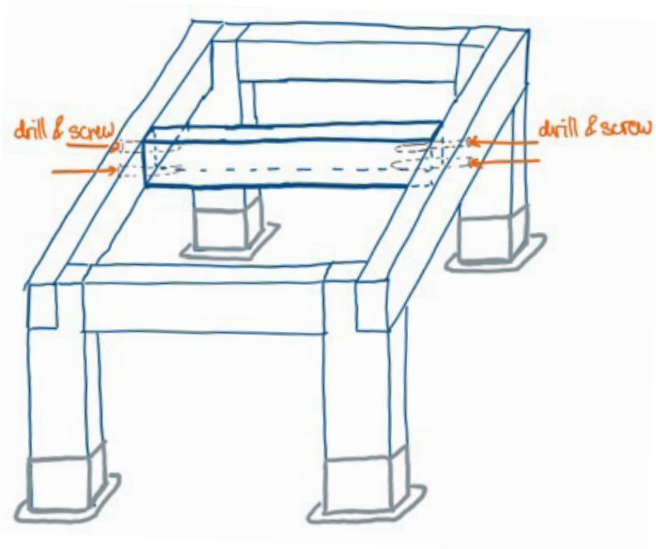
1.2. Repeat for the opposite side

2. Crossbeam

2.1. Continue to fasten the screws from the longitudinal beam into the crossbeam

Note: Make sure that there is no gap between the components

2.2. Fit middle crossbeam and fasten with screws



2.2.1. For this, mark holes on longitudinal beams and pre-drill with 3 Ø, then drill with 7.5Ø

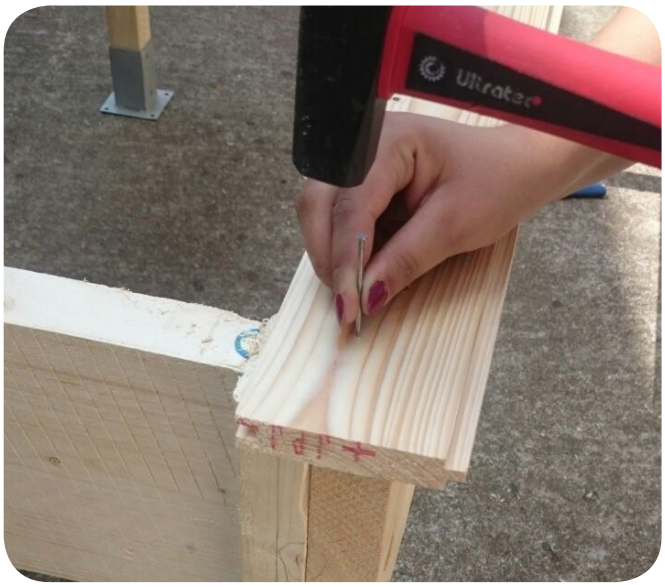
2.2.2. Transfer holes to central cross beam with 6 Ø and drill them in the same attachment size

2.2.1. Fasten central crossbeam with ratchet and wrench

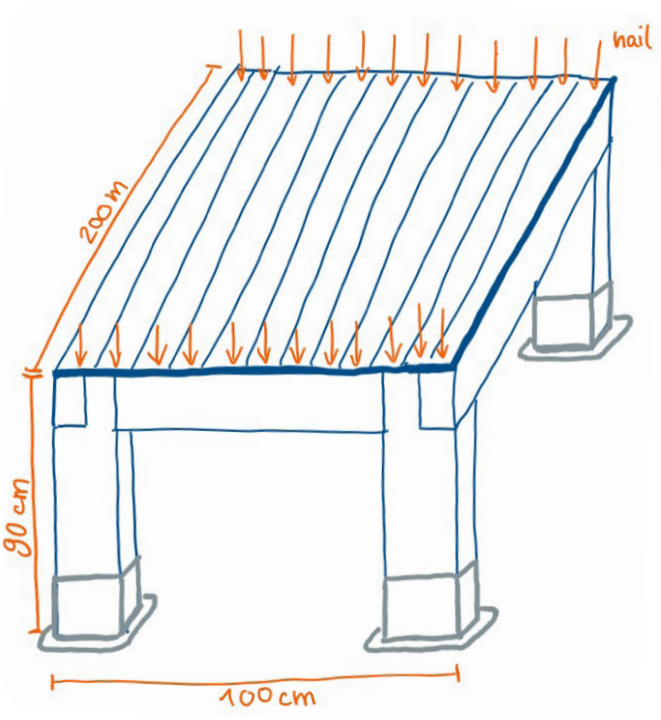
Note: Bring supernatant to the right measure with a rasp and a file.

3. Tabletop

3.1. Fixing a first profile board with a hammer and nails on the long side of the underframe (one nail in each leg and three nails in the longitudinal beams)



3.2. Fit the prepared profiled boards with hammer and an already cut board one after the other and nail them (1 nail per longitudinal beam and 1 in the central crossbeam).



Finalizing work

1. Corrections:
   Fill air-permeable holes and slots with heat-resistant and health-friendly material.

2. Finish:
   For weather protection, coat the outside table area with health-compatible Osmo Bankirai oil.

Frame including gable plate preparations

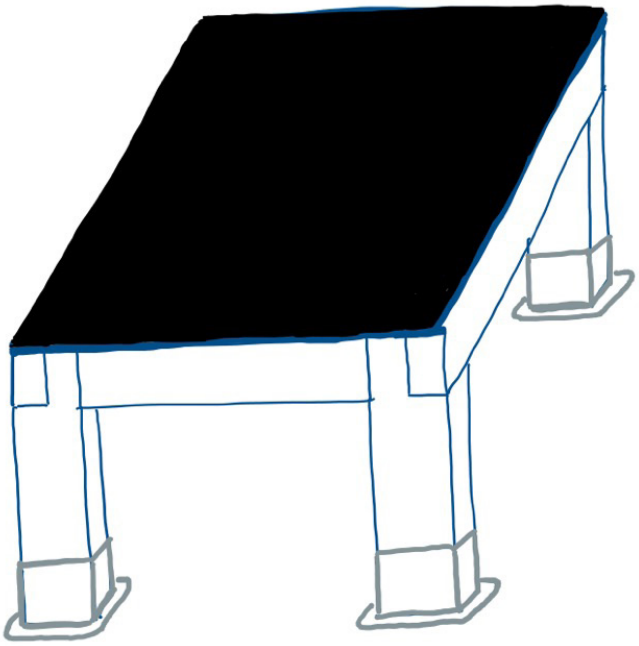
Tools:

- Measuring tape
- Pencil
- Jig saw
- Circular saw
- Drill with 8 mm bit

Materials:

1 x wooden board (1000 x 50mm)
2 x wood slat (2000mm each)
14 x wood screws at least 60 mm long
Foil (1 m^2) (water and heat resistant)
Nails for foil (number at own discretion)
Silicone and silicone press
(kitchen silicone: drinking water neutral, cements and fungicidefree, temperatu-re and grease resistant, notch resistant, highly elastic)

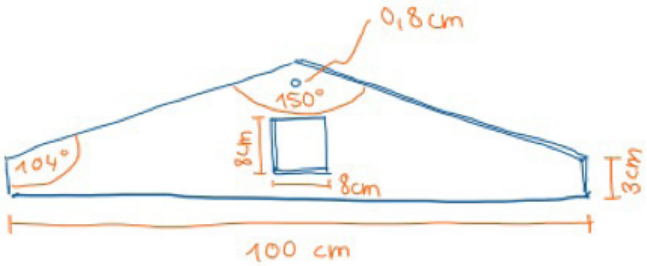
Preparation table
Cover the table top with a heat resistant foil. Secure the foil (underneath frame and grid) on the foundation with nails, number at own discretion, (or staples) where the grid is supposed be placed.

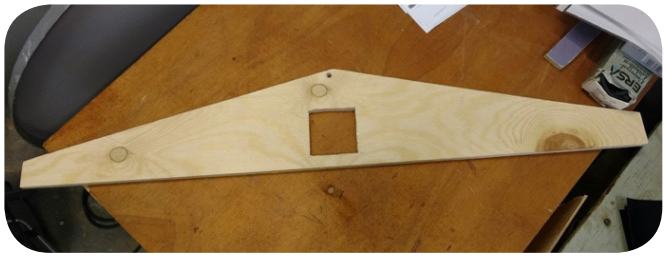


Preparation Frame and Gable Plate
1. Cut the wooden board into the following shape and dimensions. In the following this will be referred to as gable plate.

Note: The measurements seen in the first picture were adjusted to more suitable measurements. The adjustments and improvements were noticed in the aftermath.

2. Align the wood slat/frame and gable plate on the foundation table correctly.





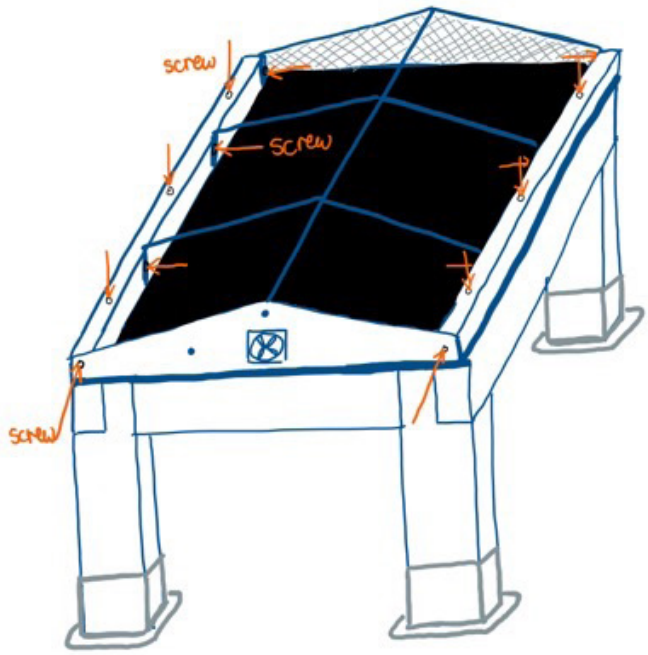
3. Pre-drill holes in the wooden frame from above (see arrows).

4. Drill screws in the wooden frame
To drill the hole use a drill with 8 mm bit.

5. Fasten gable plate and wooden frame with screws.

Note: Drill bit must be one size smaller than actual screw. If no suitable screw length is available, the screw can also be drilled deeper. When pre-drilling, first use one smaller drill size and drill downwards. Second use the same drill size as the head of the screw and drill a small hole (only the surface), this will allow the screw to be sunk deeper.

6. Apply silicone from outside and inside
(so that no air gets lost and insects / beetles cannot enter from outside)

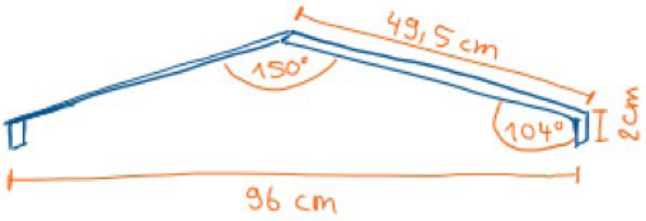


Collector

Materials:

non-toxic, black colour (100ml)
flat iron (20x3mm) for struts:
1416 x 20 x 3 mm
aluminum pole/ ridge pole:
d 0,8 mm, l 2100 mm
Wooden slats for struts:
495 X 25 X 10 mm
wood screws
stainless steel wire
Aluminum square tube
Disc / rubber ring
Foil

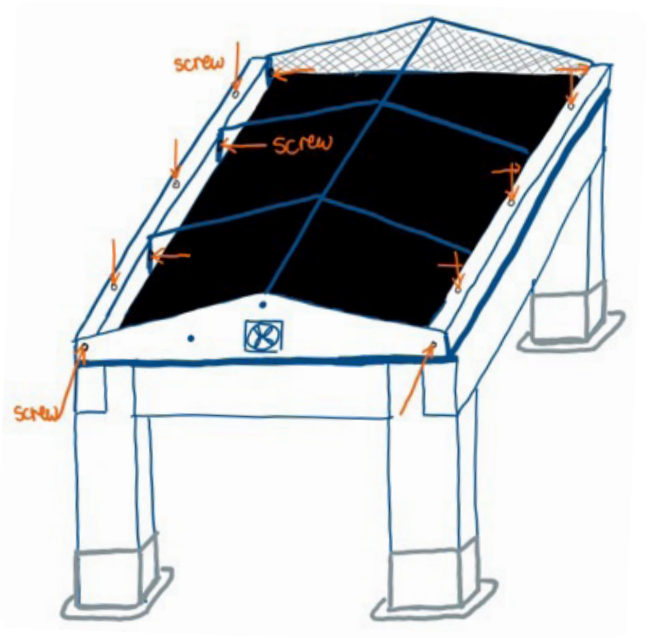
The plate 1000 X 171 X 30 mm is sawn as a pediment. It contains an 8mm hole in the ridge to accommodate the ridge pole and a recess of 8 cm x 8 cm to install the fan. Screw the long side frame parts with the 4.5 mm x 40 mm wood screws from the side to the base plate and the gable to the side of the base plate.



1. The three flat irons are each bent after 20 mm at an angle of 104°. 495 mm after the first kink, there is a second kink with an angle of 150°. After another 495 mm is bent once more with 104°. The easiest way is to record the shape with chalk on the floor and then simply bend all three rods according to the drawing.

2. The small wooden slats of size 495 X 25 X 10, on which the uv-resistant plastic foil rests, are screwed onto the three flat irons. These wooden slats are needed as protection, as the iron in the sun gets so hot that the plastic tarpaulin melts. The plastic sheet is attached on the gable by the iron plate with the aid of a combination of screw, washer and rubber ring.

3. Then the 8 mm diameter aluminum pole is inserted into the hole in the „gable“. With the help of stainless-steel wire, the aluminum pole is attached to every curved flat iron. The small screws are used to attach the small wooden slats on the curved flat iron. The big screws are used to connect everything to the base plate.



4. As a plastic tarpaulin may e.g. a thick uv-resistant greenhouse foil can be used. The tarpaulin is fastened on both sides by means of an aluminum edge profile. This was done using screws and nuts. In order to prevent the plastic sheet to be lifted by a blast of wind two aluminum bars are installed at each side of the plastic sheet. They function as a hanging weight. In this way the gap between the frame of the dryer and the plastic sheet is always closed. Install the plastic sheet to the iron bar as seen in the figure below with the use of screws and washers. Secure the screw with a screw nut. It makes sense to leave the tarpaulin at both longitudinal ends a bit, so that it can not rain into the dryer.

The black painted half of the base plate serves as a collector

Note: Use food grade!

Grid

Tools:

- Cordless Screwdriver
- hammer
- (stapler)

Materials:

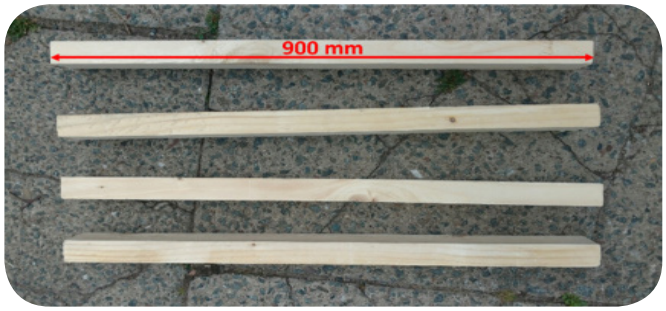
wood lumber 2x 1000 mm
wood lumber 4x 900 mm
12x wood screws (length depending on the dimensions of the wooden slats)
Network / grid (1m2)
wood screws with washer or tacker cartridges

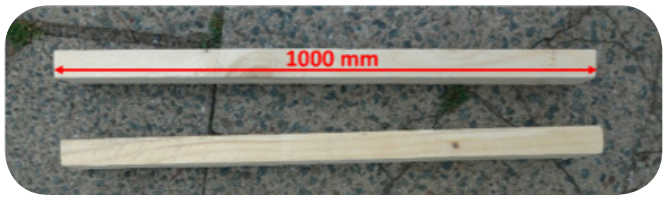
Preparation

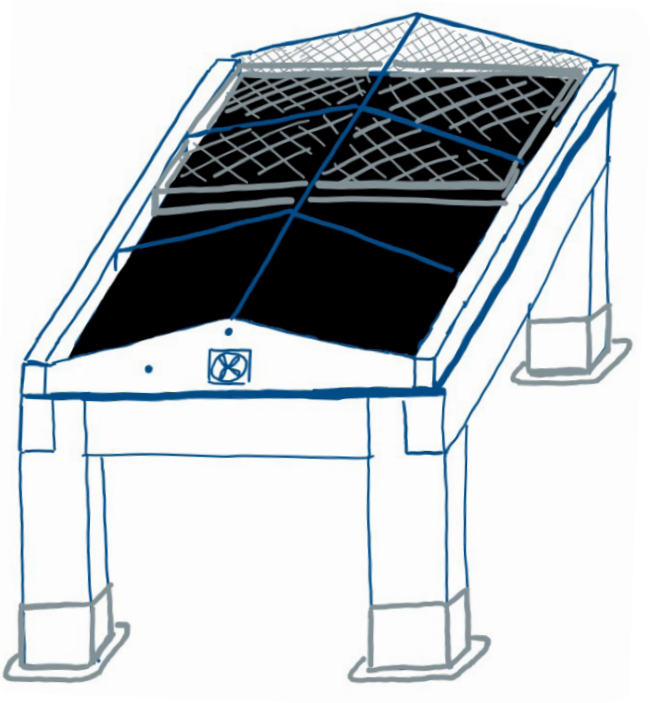
1. To build the rack you will need 2x 1000 (or 1x 2000) mm and 4x 900 mm lumber

2. Saw lumber into pieces 2x 1000 mm long

3. Saw lumber into pieces 4x approx. 900 mm (depending on the wooden frame the step before)

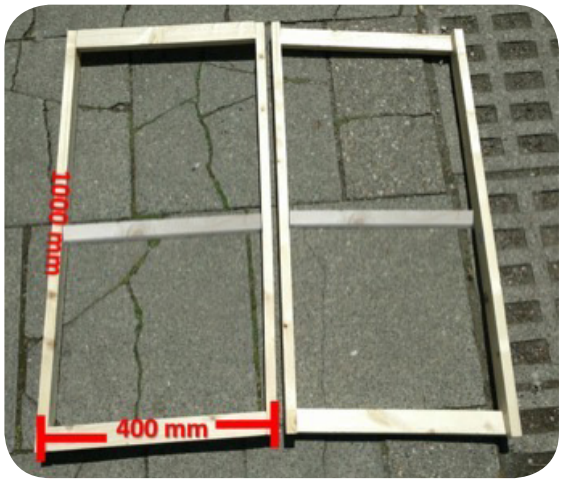


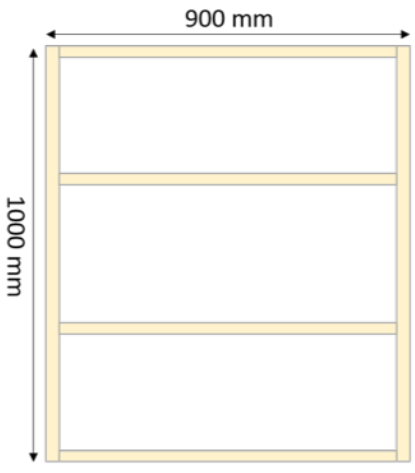




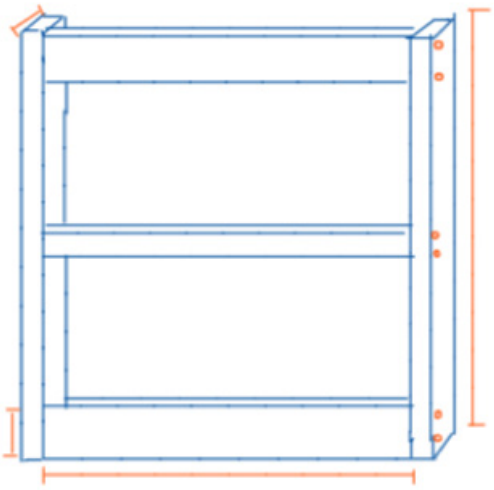
4. Arrange the layout on the floor and pre-drill the holes to avoid damaging the wood

Attention: The pictures on the left do not correspond directly to the description. A better alternative has emerged aftermath (picture on the right).



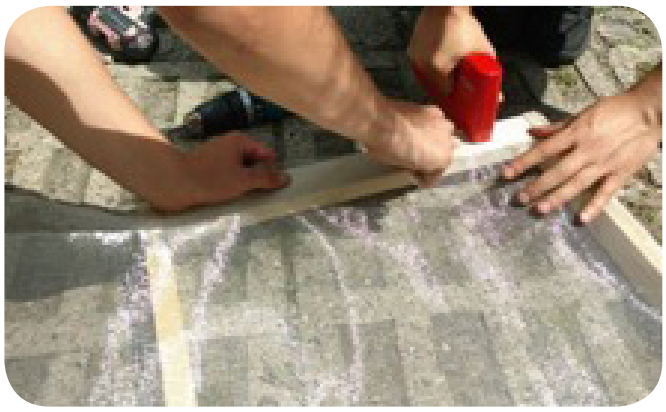


Assembly
1. Connect the lumber as you can see on the draft with two screws per corner or middle piece



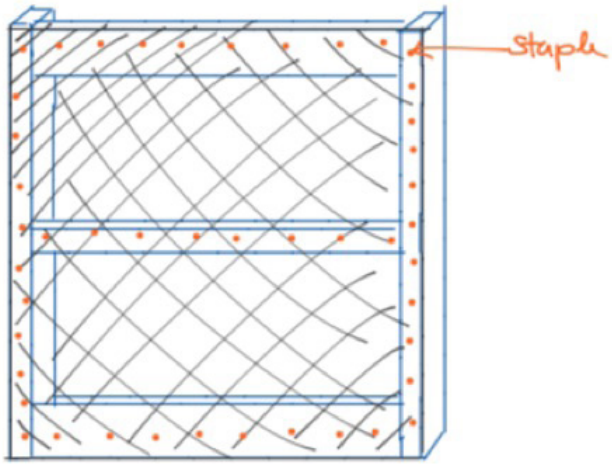
Note: For a good ventilation of the foodstuff make sure the air can pass underneath the mesh trays.

2. Cut the mesh wire and make sure that the mesh wire does not stick out to the sides, because of the risk of injury



3. Install the mesh wire with wood screws and washer (or staples) on the frames.

Note: The stapler can be used. There is a risk that the mesh wire will break or is torn in some places.



Electronics and associated components

Tools:

- Screwdriver
- Cutter

Materials:

Gable plate
Airflow Fan
Small wooden plates
Nails
Electric wire
Chandelier clamps
Switch
Solar panel 5 Watt peak

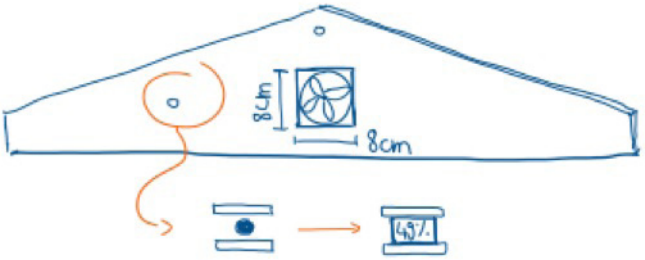
Gable plate (see II.) for fan

1. Plug the fan into the 8 x 8 cm hole of the gable plate. Mind the direction of the airflow of the fan.

2. To fix the fan use small wooden plates and nail them.

Wooden layer for solar panel

Drill a hole big enough to get the sensor of the Hygro-Thermometer through into the gable plate and place the Hygro-Thermometer above. You can fix it with two little bars glued above and under the hole. In that way it's possible to plug the thermometer between them and still get it back out for battery change. By doing that the drill hole will be hidden as well.

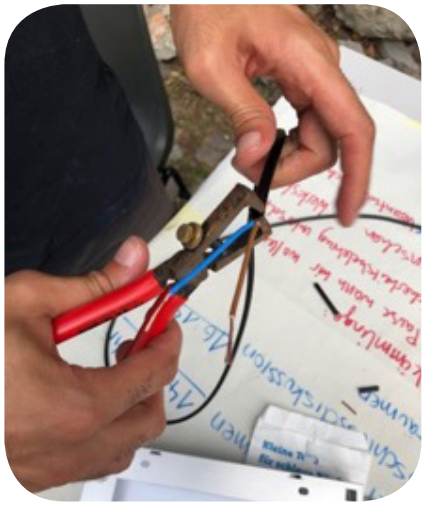


Fixing material for fan, measuring instruments and solar panel

1. Open the cover of the solar module and remove a bit of the isolation from the cable.



2. Connect the cable with the solar panel as shown in the pictures



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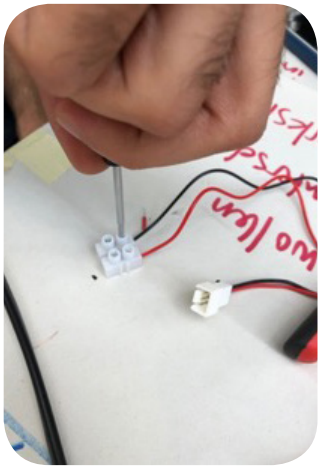



Assembly of the solar panel
1. Use the rest of the wooden plate, to cut a 26cm X 26cm underlay for the solar panel.

2. Drill a hole big enough for the switch into the plate

Note: If there is a hollow space between solar panel and plate, the cables can be placed there.

Also put two nails or screws into the plate, so you can hang/fix the solar module on it.

3. Fix the (mounting) angle with two screws on the panel underlay and drill a hole on the gable plate big enough for one bolt with nut on the gable plate.

With this one bolt with nut it's possible to change the angle of the solar panel anytime.

4. If everything is in the right place, connect the cable coming from the switch with the fan and see if it works.

5. Screw the gable plate on the table and fill the gaps with silicone.

6. Now srew the sieve in front of the fan.

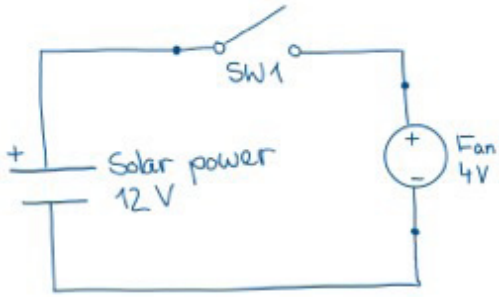
Wiring the Solar Panel and switch
A solar panel with 5W peak is used for this solar dryer. The properties of the solar panel can be found in the table.

The front and back side of the panel is shown in the pictures below. A single pole, single throw switch is used in order to switch on/off the fan.

Cable length	0.9 m
Height	45 mm
Length	270 mm
Width	270 mm
Current	300 mA

Because it is a one-way switch, the current is just controlled by a phase cable (positive cable). The connection joint between fan and solar panel is a 3 pins to 4 pins fan cable adaptor used in a computer motherboard.

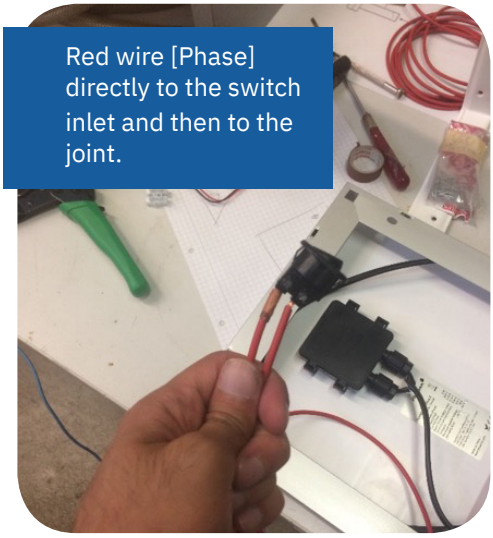
The schematic diagram of the electrical network is shown in the right picture. The step by step instruction guide follows as:



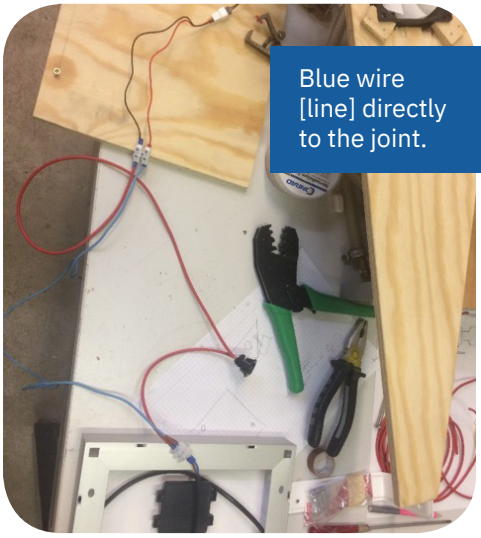
1. Strip the wire with a stripper in order to connect them into the connection box in the back side of the Solar Panel.

2. Open the connection box and wire two cables to the solar panel

3. Connect the phase cable to the switch (inlet) and then connect the outlet cable of the switch and line to the joint



Red wire [Phase] directly to the switch inlet and then to the joint.



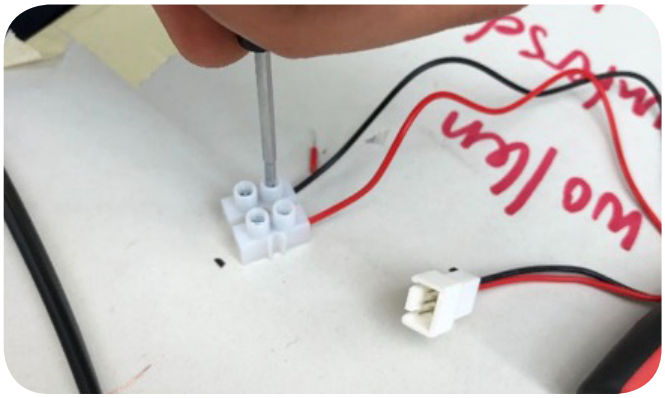
Blue wire [line] directly to the joint.

4. A ¾ is used to connect the Solar Panel to the fan. Because it's a motherboard cable, it's necessary to cut the IDE connector and use the 3pins as it's shown in pictures

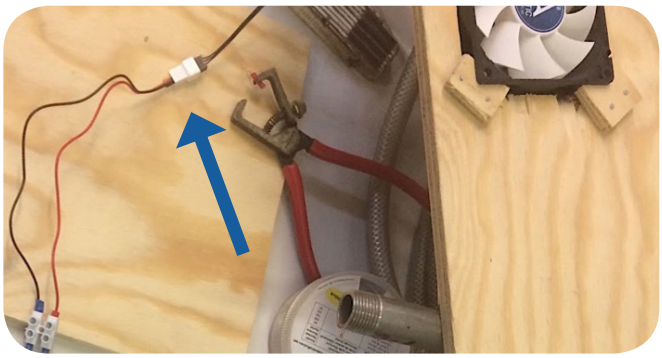
4.1. The 3 pins to 4 pins with IDE

4.2. Cutting the IDE pin

4.3. Connection the wire (after cutting IDE pin) to the joint



4.4. Connecting the fan to the joint



Roof

Tools:

- Circular saw
- Cordless Screwdriver
- Cutter
- Drill + attachments
- File
- Folding rule
- Hammer
- Jig saw
- Measuring tape
- Open-end wrench
- Pencil
- Planer
- Rasp
- Ratchet
- Screw clamp
- Screwdriver
- Stapler
- Workbench

Materials:

6 x profile boards (18cm x 96cm x 206cm)
2 x planks (2cm x 20cm x 200cm), 2 x planks (4cm x 20cm x 84cm), 1 x screed (2cm x 20cm x 200cm), 4 x scantlings (90cm x 8cm x 8cm)
4 x screw-on sleeves (81mm x 81mm),
32 x screws (4 Ø)
12 x wood screws (M8 x 150)
12 x washers (12 Ø)
12 x washers (8 Ø)
~ 30 x nails (8 x 45)
Aluminum pole/ ridge pole: d 0,8 mm, l 2100 mm
Aluminum square tube
Chandelier clamps
Disc / rubber ring
Electric wire
Fan
Flat iron (20x3mm) for struts: 1416 x 20 x 3 mm
Foil
12x wood screws (length depending on the dimensions of the wooden slats)
Foil (water and temperature resistant)
attach nails to foil (number at own discretion)
Gable plate
Litte wooden plates
Nails
Network / grid (1m2)
Non-toxic, black colour (100ml)
Solar panel 5V
Stainless steel wire
Switch
Tacker cartridges or wood screws with washer
Wood lumber 2x 1000 mm
Wood lumber 4x 900 mm
Wood screws
Wooden slats for struts: 495 X 25 X 10 mm

Preparation phase
1. Mark dimensions on slats

2. Saw the slats

Bending flat irons in shape
1. Bend flat irons at 22mm in an angel on 104°

2. Bend again after 495mm (counted from the last kink) with an angle of 150°

3. After 495 mm bend with an angle of 104°

Note: The easiest way is to record the shape with chalk on the floor and then simply bend all three rods according to the drawing.

Tarpaulin and roof/slat construction
1. Saw wooden beams to measurement 495mm X 25 X 10

2. Screw the wooden beams from inside the metal frame:

3. Connect bent iron via screws to the base-plate

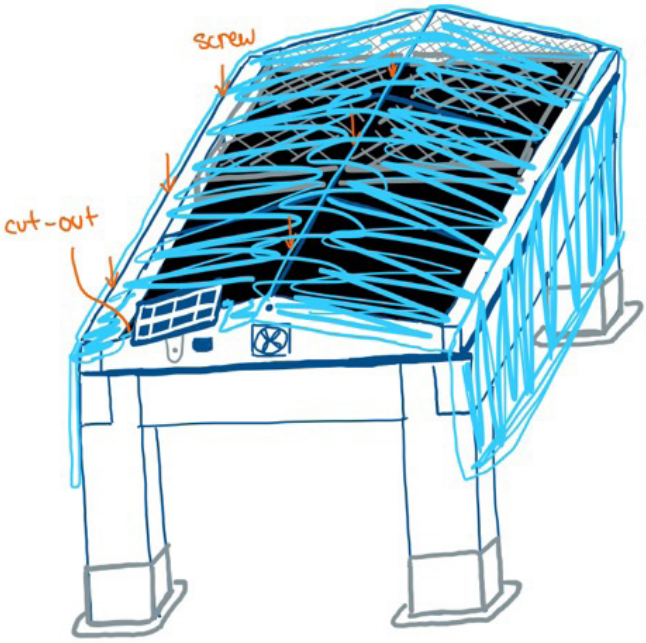
Assembly
1. Slats and bended irons

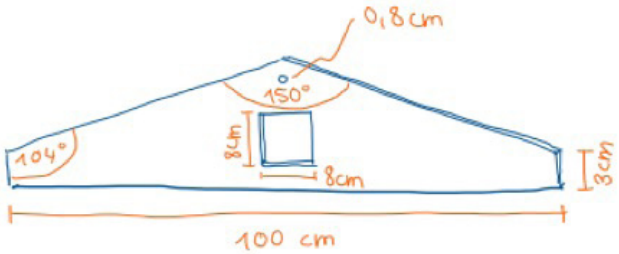
2. Slat construction, gable and frame

3. Insert the aluminum Pol into the 8 Ø hole

4. Fixate it with wire on each bent iron

5. Connect the other components with little screws





Plastic Foil
1. Attach the flat surface with Clamps

2. Hold it tight with small weights

Note: As a plastic tarp may e.g. a thick greenhouse slide can be used. One of the two profiles is an angle, the other a square tube, they were connected with blind rivets. When there is a lot of wind, this clamp rail can be clamped to the frame of the solar dryer with two clamps or screw clamps to prevent the tarpaulin from being opened by the wind. It makes sense to leave the tarpaulin at both longitudinal ends a bit, so that it can't rain into the dryer.