Redesign Disaster:

Water and Energy hub.

P1	P2	P3	P4	**P5**
11/11/2019	08/01/2020	26/03/2020	15/05/2020	**24/06/2020**

Filip Zielinski
Student number 4746376

CLIMATE **CHANGE**

Natural disasters

GLOBAL WARMING

2018: **127** FLOODS

34.2M AFFECTED

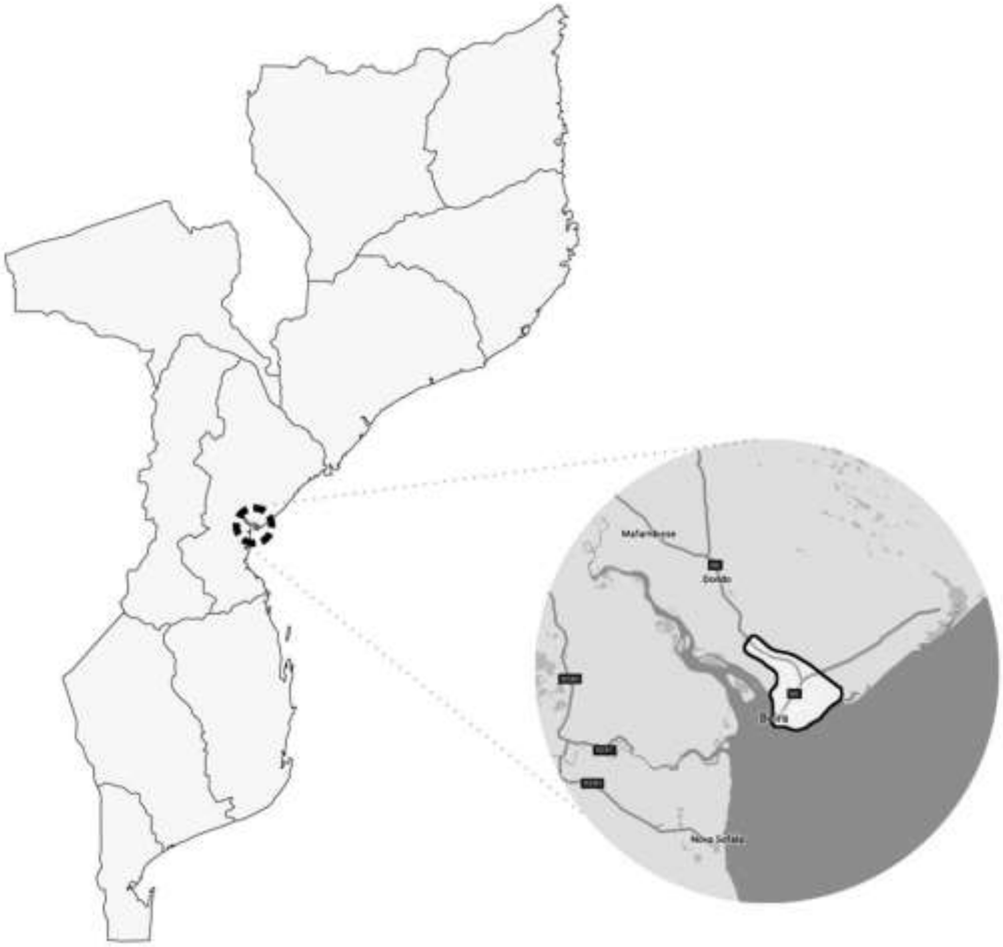
2879 RECORDED DEATHS

(Natural Disasters 2018; CRED, 2019)

CONTEXT **AFRICA**

CONTEXT **MOZAMBIQUE**

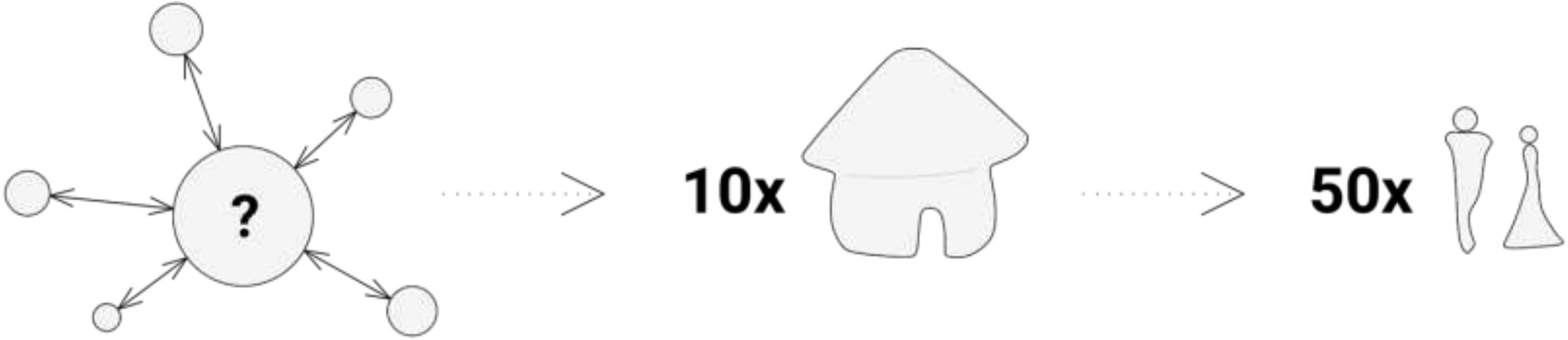
CONTEXT **BEIRA**



PROJECT **IDEA**
Target group

PROJECT **SCALE**

Small community



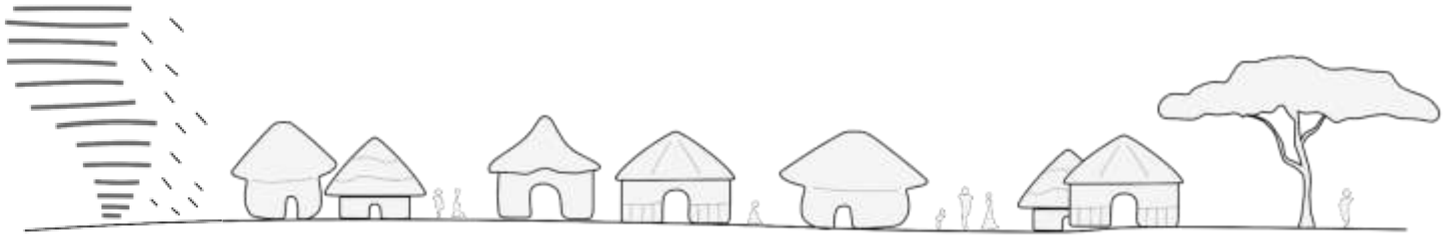
(United Nations, 2017)

Design by Research

PROJECT **CONTEXT**

Climate

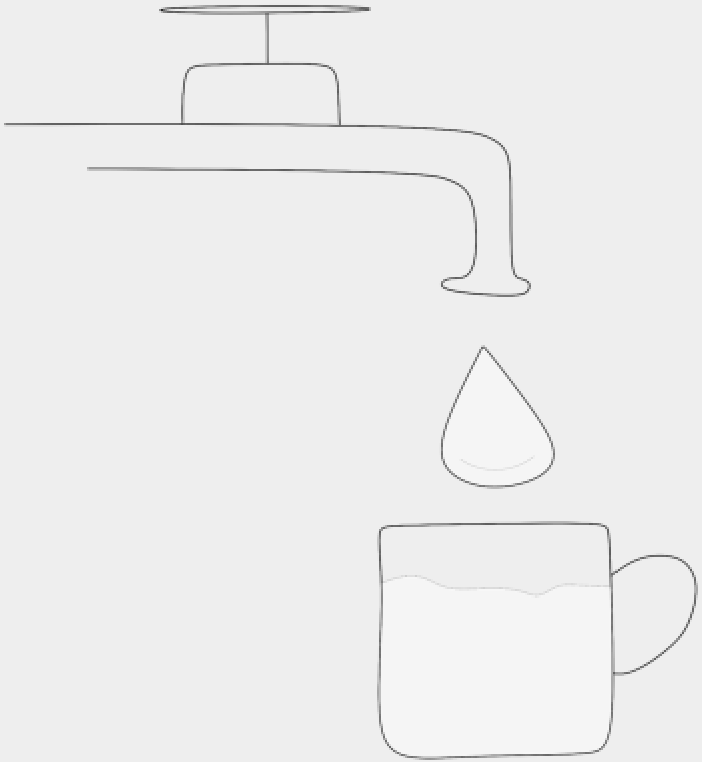
WET NOV-MAY	**20-32°C**	**220mm** MONTH	**2-4m/s** AVERAGE
DRY MAY-OCT	**16-28°C**	**50mm** MONTH	**76%** AVERAGE



(Weather & Climate, 2019)

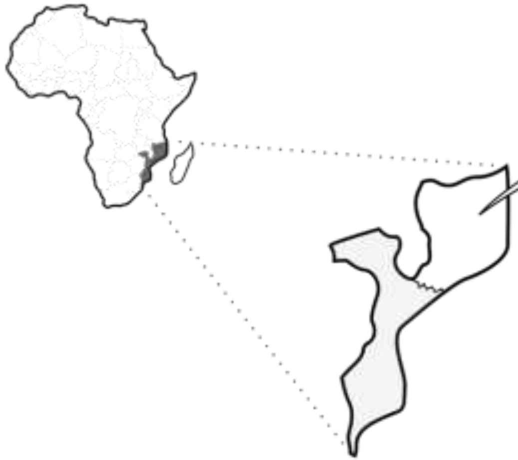
IDAI **CYCLONE**
Facts

(Schofield & Deprez, 2019)



Drinking Water

DRINKING WATER ACCESS



mozambique

49%

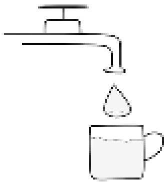
POPULATION
WITHOUT ACCESS
TO CLEAN WATER

13.7M

netherlands

10x

50x



(The World Bank, 2015)

WATER **CONSUMPTION**

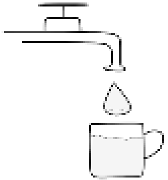
Average consumption of tap water per person (liters/day)

europe

mozambique

10x

50x



(European Commission, Statista, 2014-2015; WHO, 2016)

GUIDE TO **50L PER DAY**

PETS 1L

COOKING 1L

TEETH AND HANDS 2L

DRINKING 3L
WATER/TEA/COFFEE

HOUSE CLEANING 5L
EVERY 2nd DAY

DISH WASHING 9L
1 SINK WASH

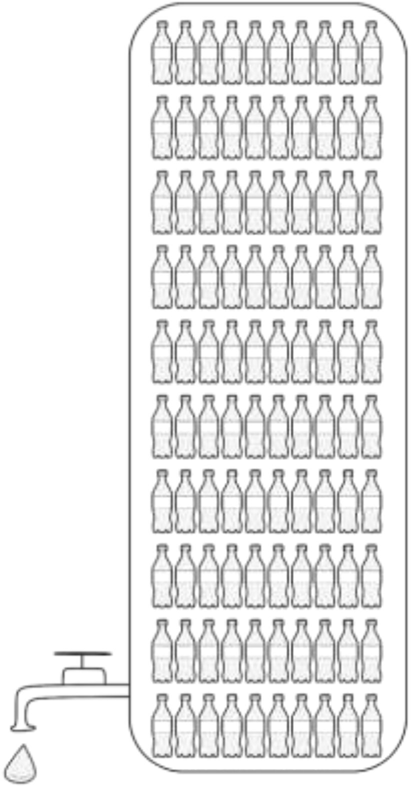
FLUSHES 9L

LAUNDRY 10L
1 LOAD (70L)/WEEK

SHOWER 10L

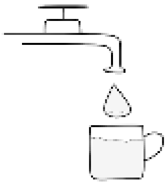
100 BOTTLES

50L



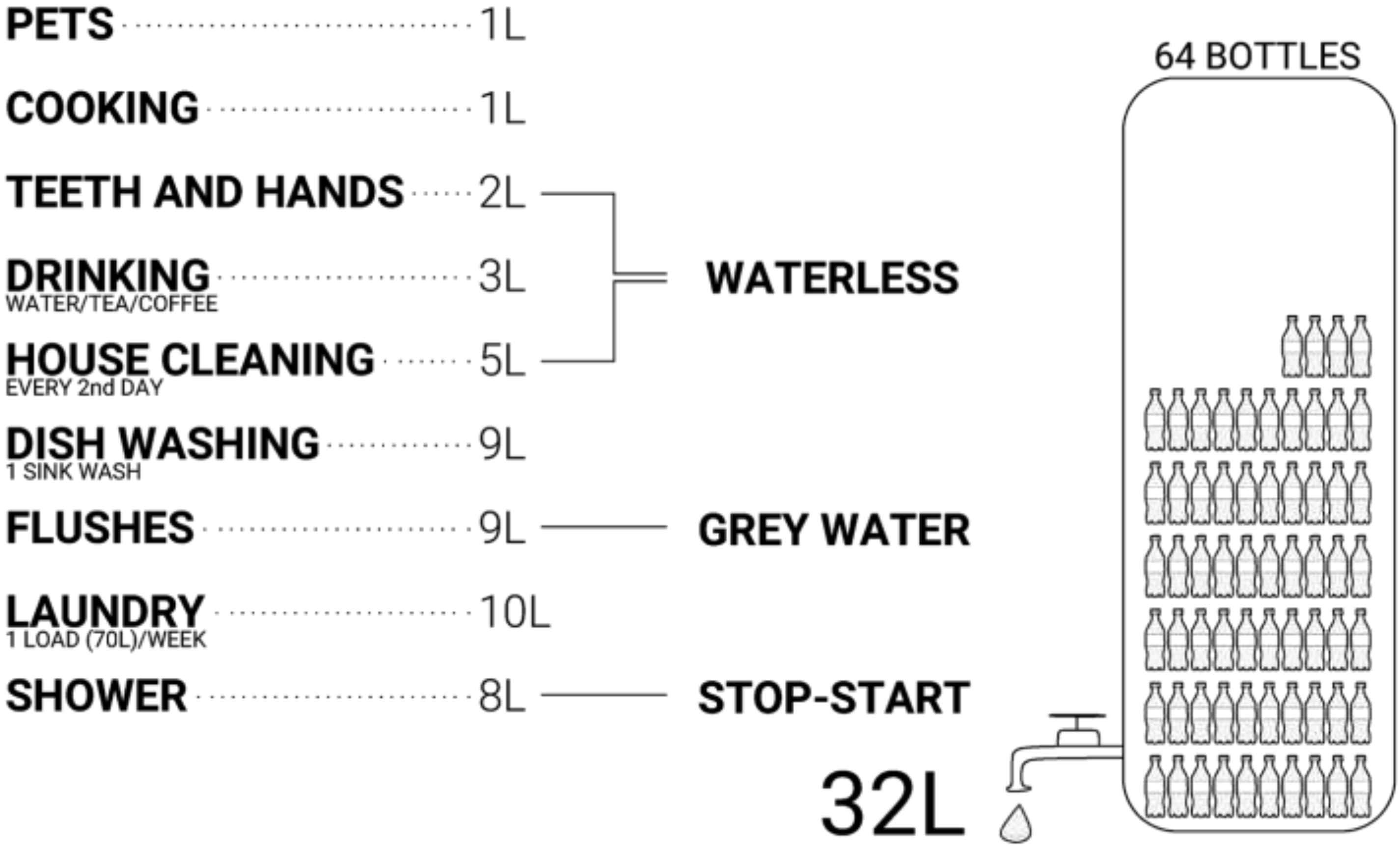
10x

50x

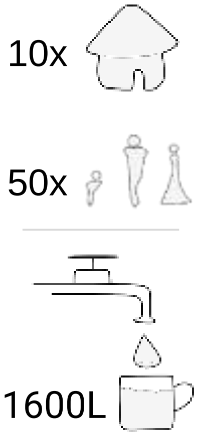


(The Water Research Foundation, City of Cape Town, 2016)

GUIDE TO **MAKE IT LESS**

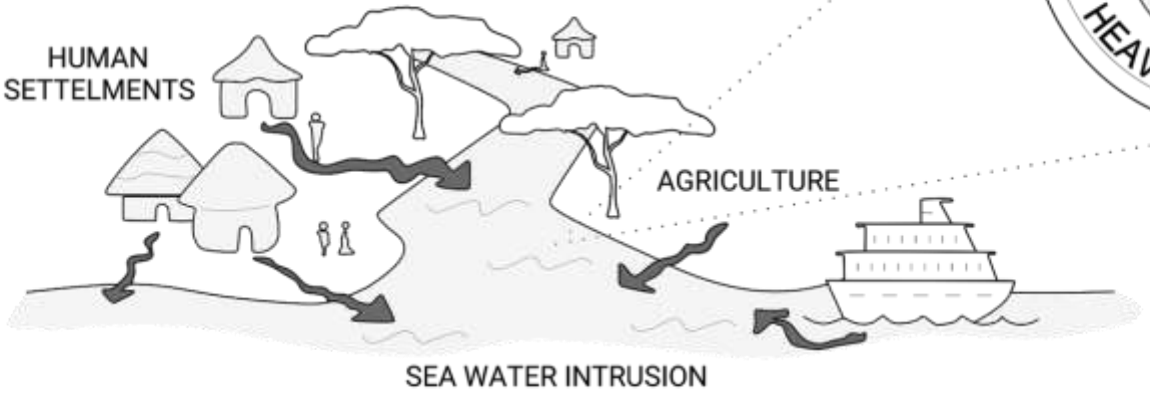


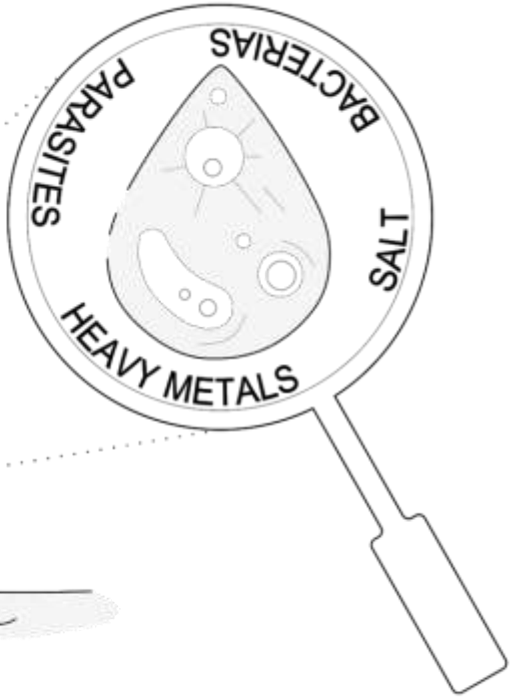
(The Water Research Foundation, City of Cape Town, 2016)



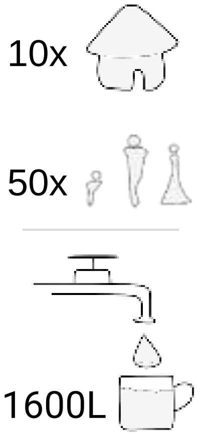
WATER **QUALITY**

USED FOR
DRINKING AND **SANITATION**



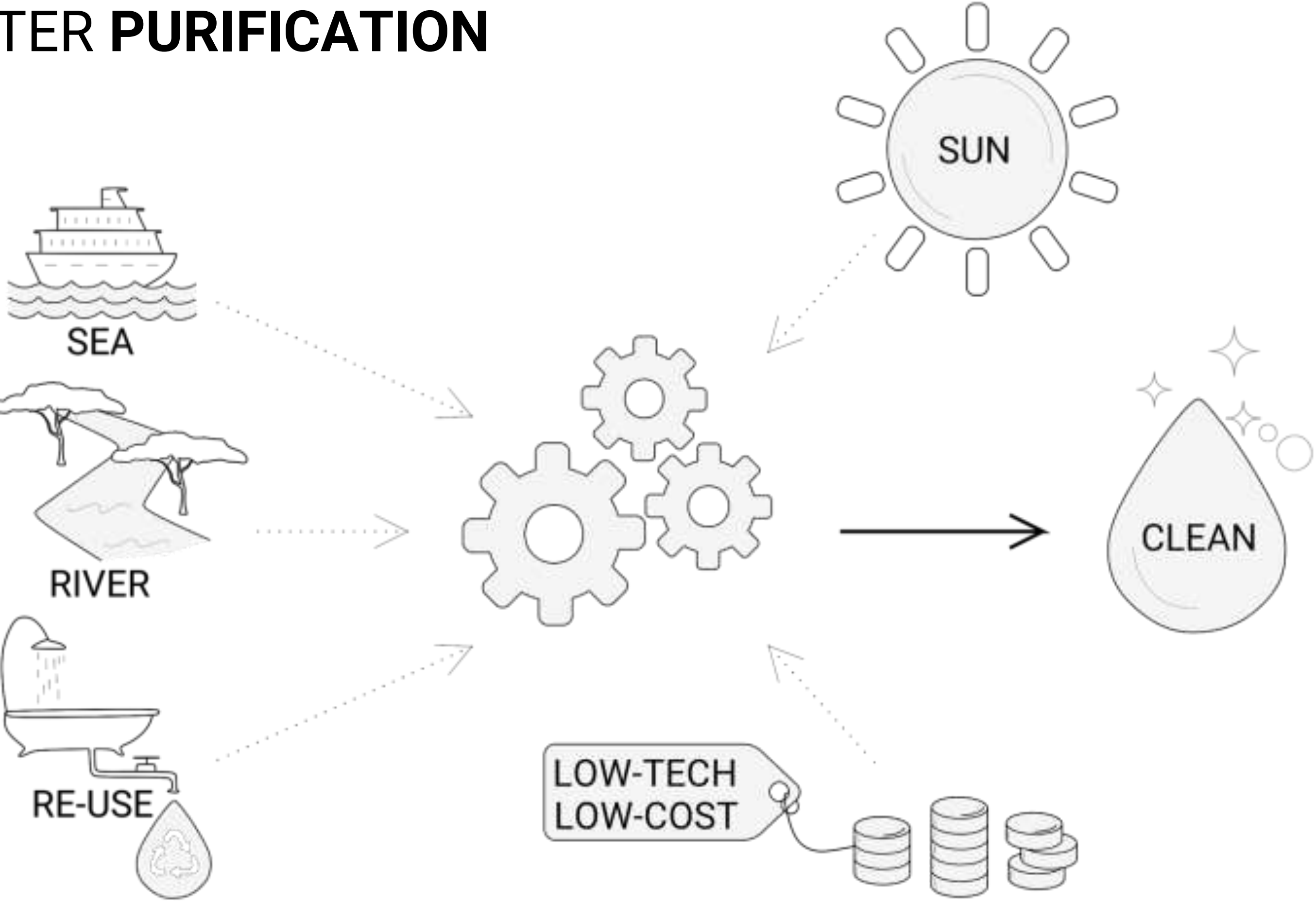


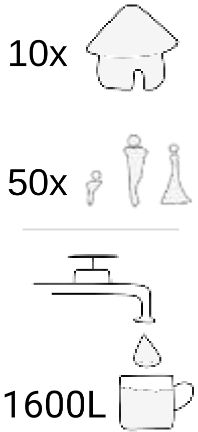
WATERBORNE DISEASES AMONG THE MAIN CAUSES OF **DEATH OF CHILDREN** IN BEIRA



(Water & Sanitation for the Urban Poor, 2019)

WATER **PURIFICATION**

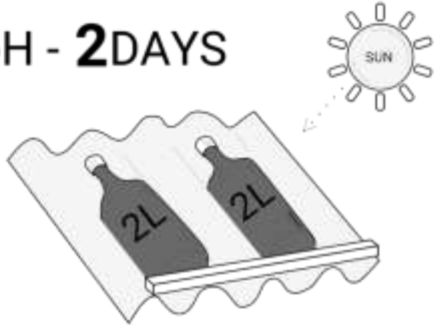




SOLAR BASED SYSTEMS

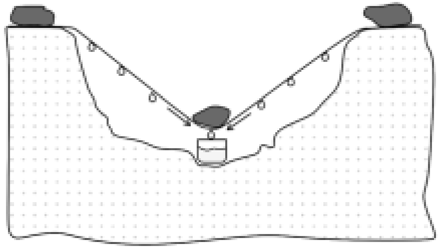
SOLAR DISINFECTION

6H - **2**DAYS



HIGH TEMP **UV-A RADIATION**	**SMALL** SCALE
NEED TO BE **PREFILTERED**	VERY **CHEAP**

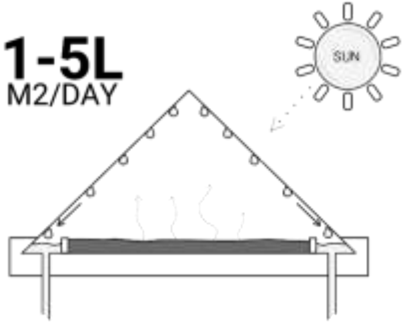
AIR TO WATER



VERY LOW FLOW RATE	DAMAGE **VULNERABLE**
RELATIVE HUMIDITY DEPENDENT	**LOW** TECH

SOLAR STILL

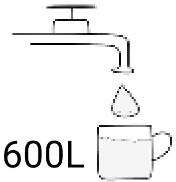
1-5L
M2/DAY



EVAPORATION CONDENSATION	**MIDDLE** SCALE
ANY WATER SOURCE	**LARGE** FOOTPRINT

10x 

50x 


1600L

(Luzi, Tobler, Suter, & Meierhofer, 2016; Saidur et al, 2011)

SOLAR BASED SYSTEMS

SOLAR DISINFECTION

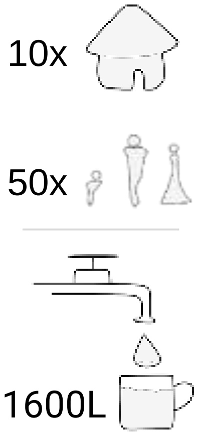
(The Science of Creativity)

AIR TO WATER

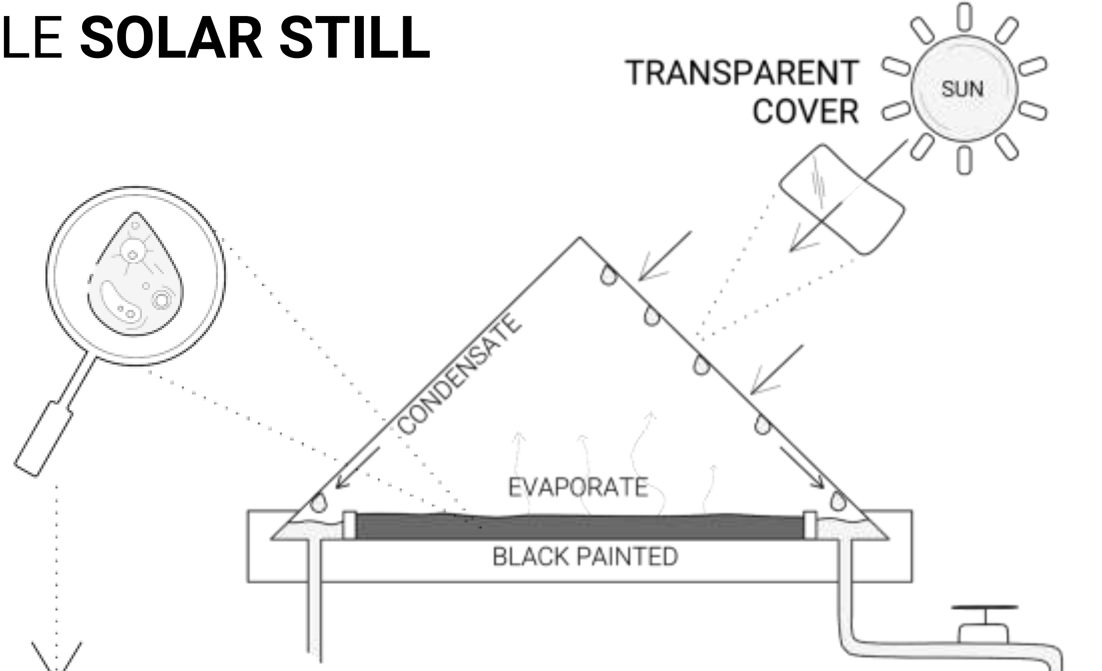
(All 4 Adventure)

SOLAR STILL

(Photo Courtesy Creative Publishing International)

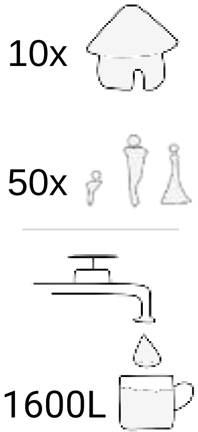


SIMPLE **SOLAR STILL**



~~SALTS~~
~~BACTERIA (E. COLI)~~
~~PARASITES (HELMINTHS EGGS)~~
~~HEAVY METALS~~

1-5L
M2/DAY



(Ali et al, 2011; Ligy, Ramprasad, Krithika, 2019)

OPPORTUNITIES & CHALLENGES

+

LOW-TECH LOW-COST

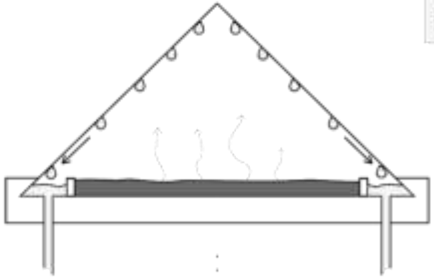
REMOVES PATHOGENS

SOLAR **ENERGY IS FREE**

OFF-GRID SOLUTION

SIMILAR TO **NATURAL HYDROLOGICAL CYCLE**

ANY KIND OF WATER CAN BE FED:
SEA & **RIVER WATER**
GREY WATER & **SEWAGE WATER**



−

NOT VIABLE FOR LARGE-SCALE PRODUCTION

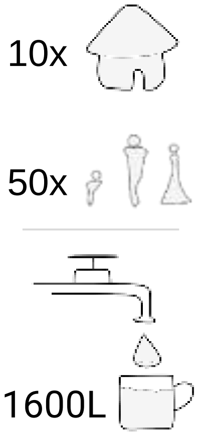
LARGE AREA FOR SOLAR COLLECTION

LOW ENERGY EFFICIENCY SLOW HEATING OF A FULL VESSEL OF WATER

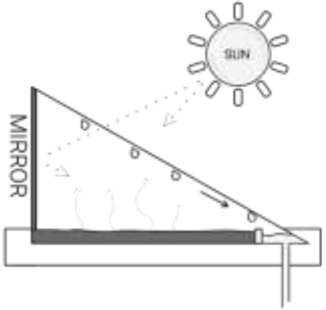
THE NEED FOR **ROUTINE MAINTENANCE**

VULNERABLE TO DAMAGE BY THE WEATHER

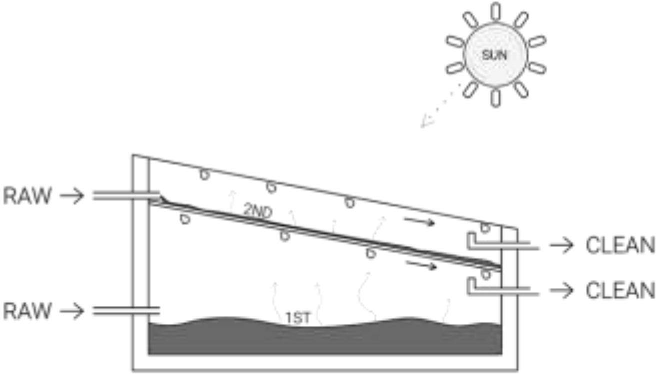
(Cannon & Au, 2008; Ligy, Ramprasad, Krithika, 2019; Shatat & Riffat, 2014)



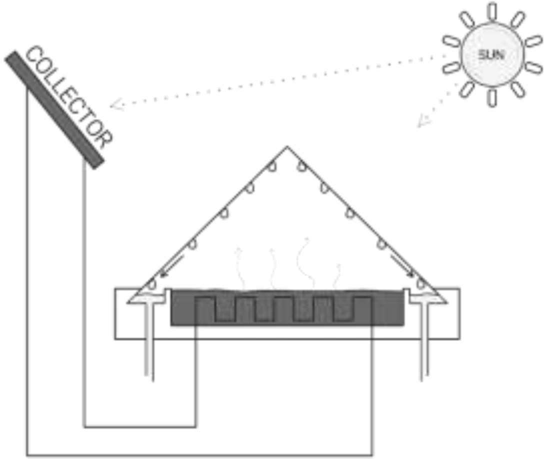
POSSIBLE **IMPROVEMENTS**



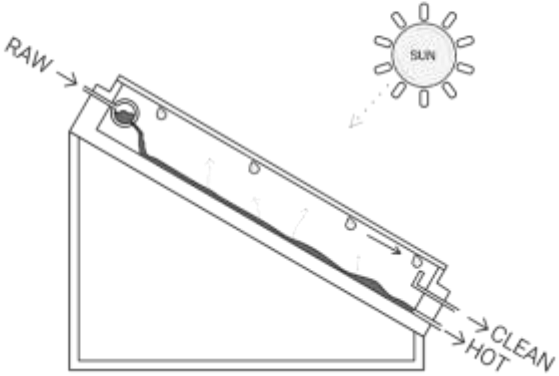
(Al-hayek, Badran, 2004)



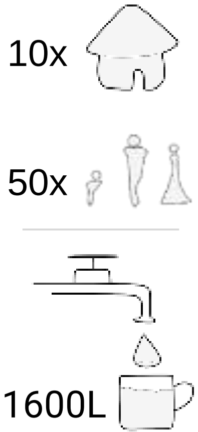
(Adberachid, Abdenacer, 2013)



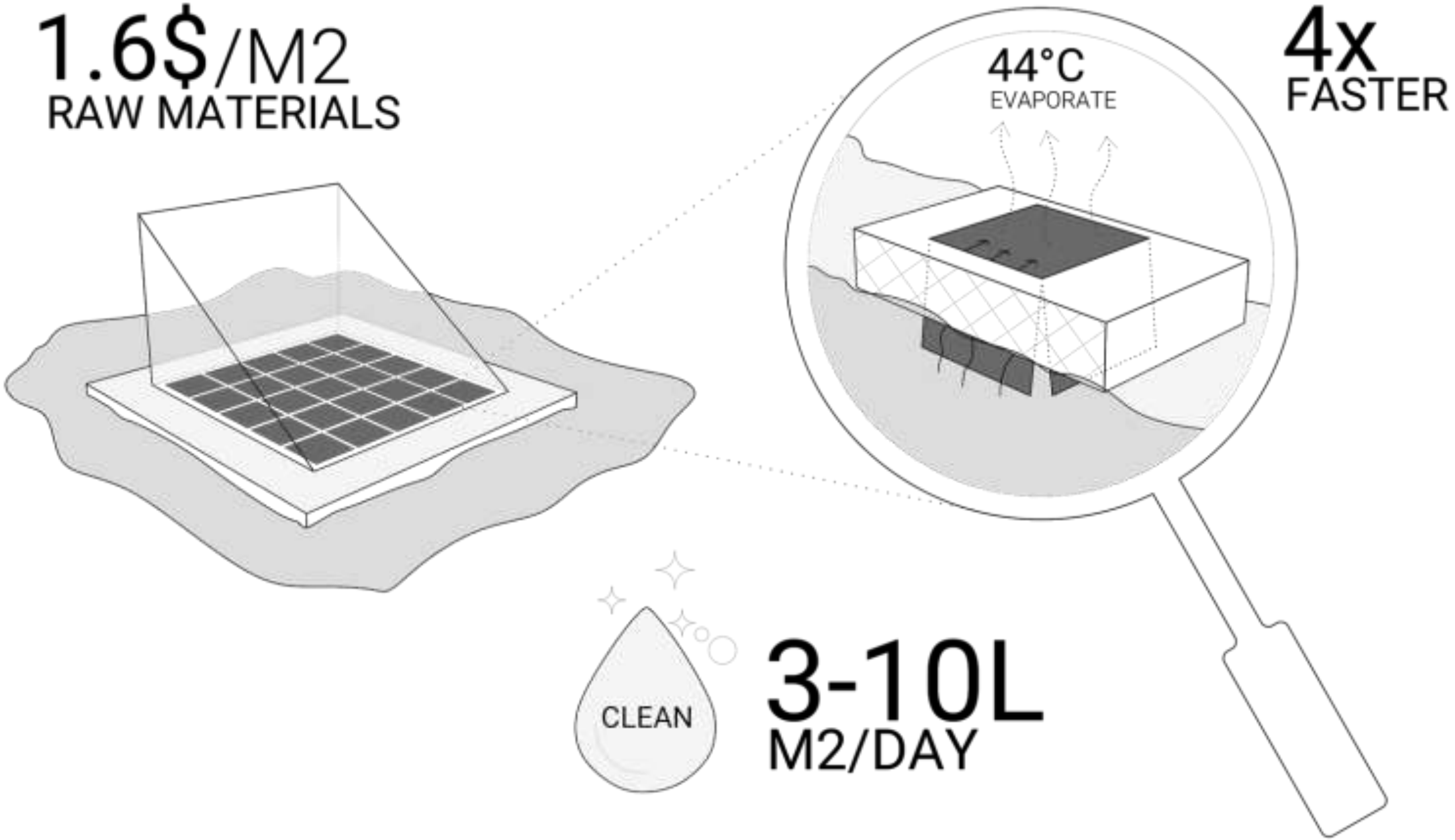
(Manchanda & Kumar, 2015)

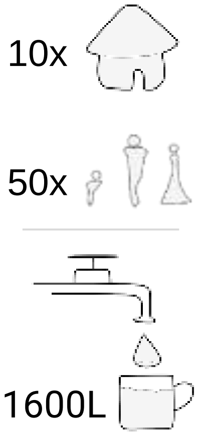


(Ayber et al, 2005)

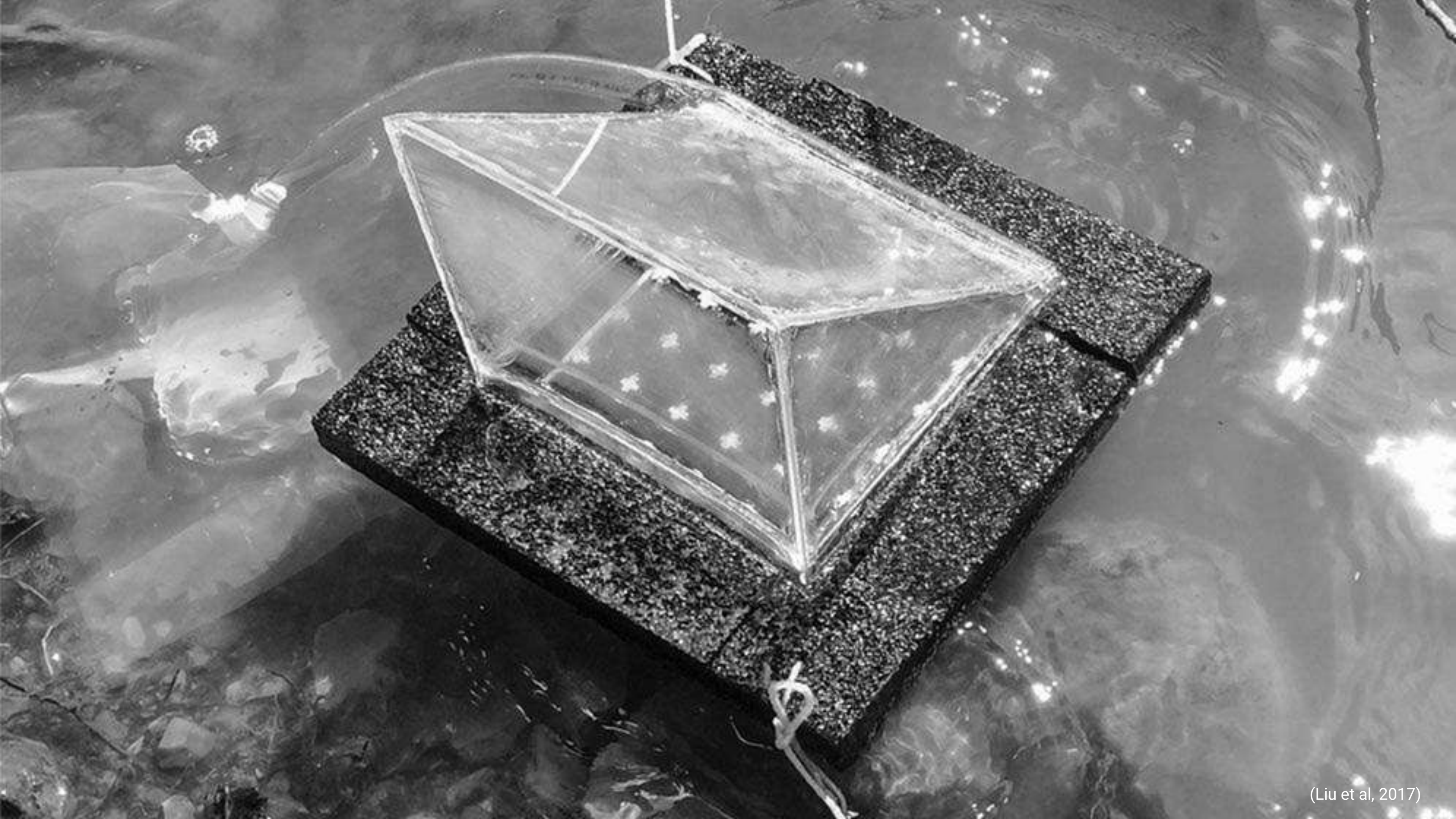


IMPROVED SOLAR STILL



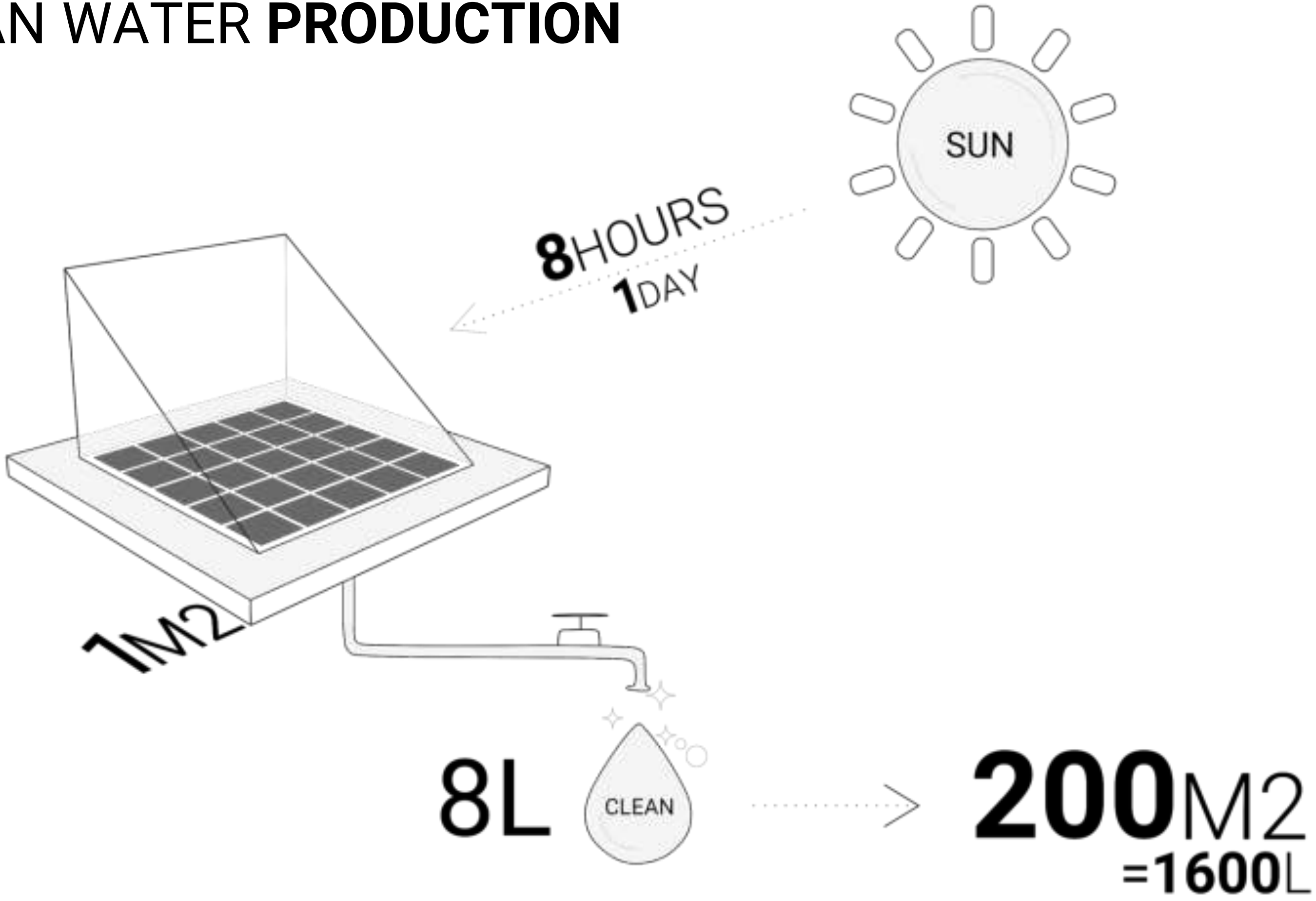


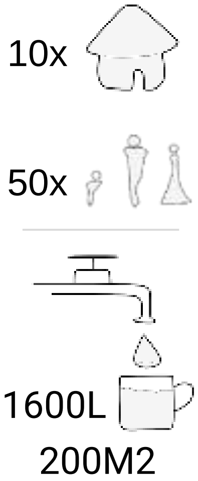
(Liu et al, 2017)



(Liu et al, 2017)

CLEAN WATER **PRODUCTION**





Electricity

ELECTRICITY ACCESS

mozambique

75%

POPULATION
WITHOUT ACCESS
TO ELECTRICITY

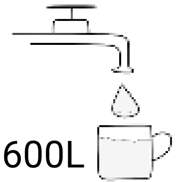
21.8M

netherlands

(The World Bank, 2015)

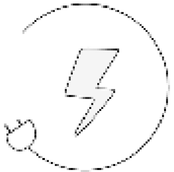
10x

50x



1600L

200M2



ENERGY **CONSUMPTION**

netherlands

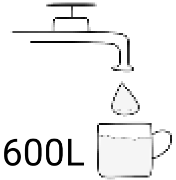
3005kWh/year

(1000-2000kWh/person)

europe

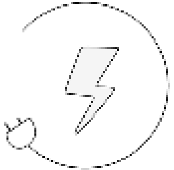
10x

50x



1600L

200M2

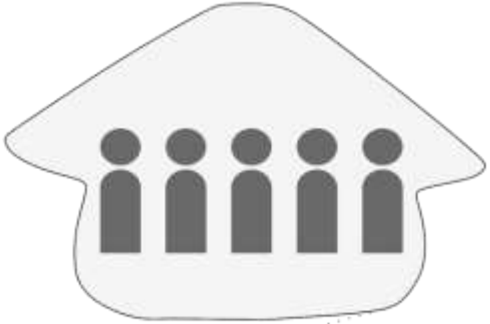


(City Centre Retreat, 2018)

ENERGY **CONSUMPTION**

africa

mozambique



2005: **131**kWh/year

2009: **153**kWh/year

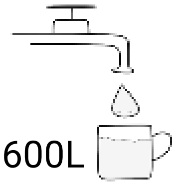
exp. 2020: **235**kWh/year

(26-47kWh/person)

(NationMaster, 2005; Monari, 2011)

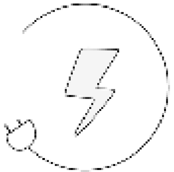
10x 

50x 

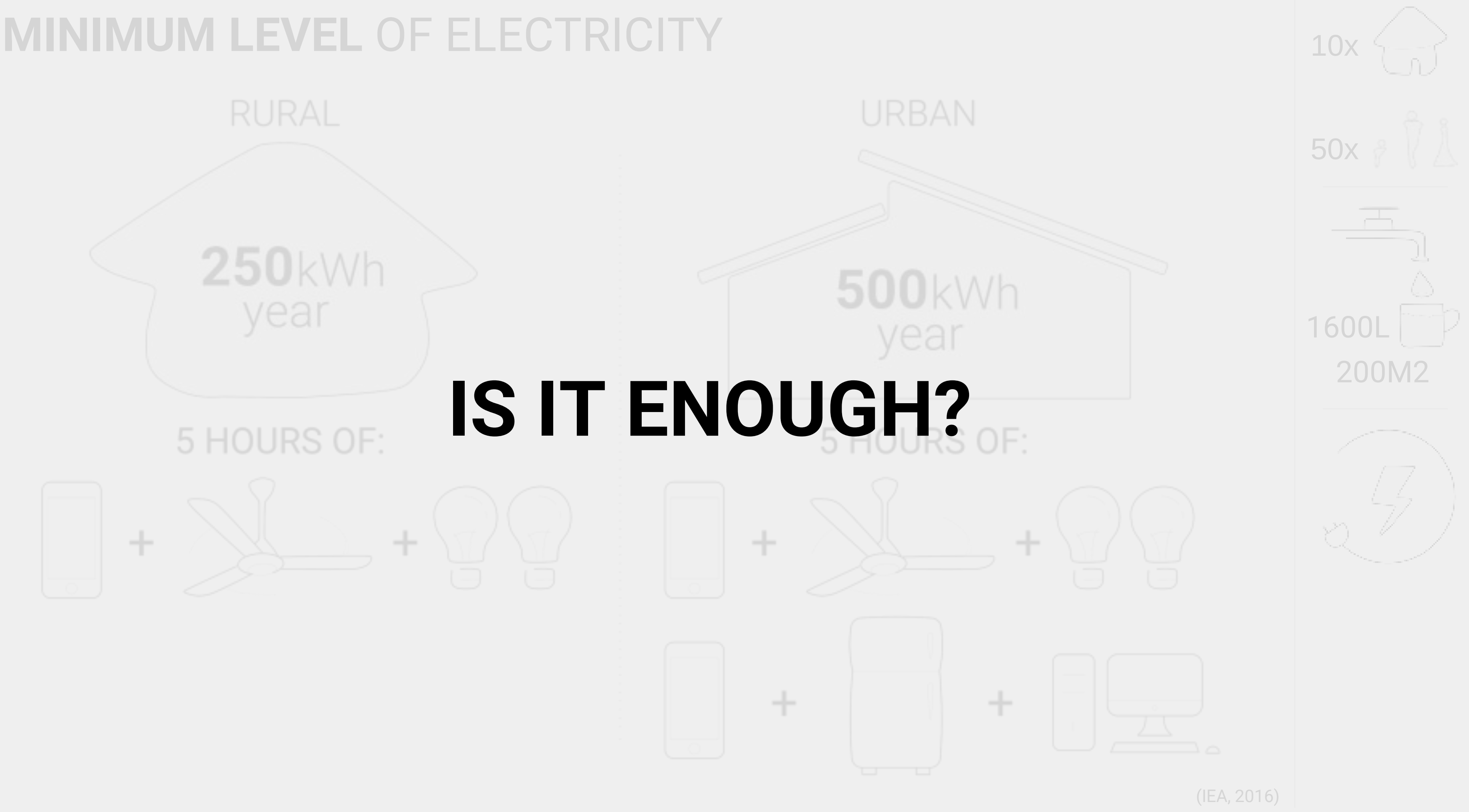


1600L

200M2



IS IT ENOUGH?


MINIMUM LEVEL OF ELECTRICITY
RURAL
250kWh year
URBAN
500kWh year
5 HOURS OF:
5 HOURS OF:
10x
50x
1600L
200M2
(IEA, 2016)

ENERGY **TYPICAL USE**

	WATTS	HOURS/DAY	kWh/DAY
SMARTPHONE	6	1	0.024
CEILING FAN	120	5	0.600
TV	140	3	0.420
COMPUTER	200	5	1.000
FRIDGE	35	24	0.840
ELECTRIC COOKING	1200	0.4	0.480
LED BULB	10	5	0.500
SEWING MACHINE	100	1	0.100
ELECTRIC WATER HEATER	1500	0.5	0.750
DISHWASHER	1500	1	1.500
COFFEE MACHINE	1000	0.2	0.200
LAUNDRY	800	1	0.800

TYPICAL: **3372** kWh/YEAR (13x)

10x

50x

1600L

200M2

ENERGY **OPTIMAL USE**

	WATTS	HOURS/DAY	kWh/DAY
SMARTPHONE	6	1	0.012
CEILING FAN	120	5	0.600
TV	140	3	0.420
COMPUTER	200	5	1.000
FRIDGE	35	24	0.840
ELECTRIC COOKING	1200	0.4	0.480
LED BULB	10	5	0.300
SEWING MACHINE	100	1	0.100
ELECTRIC WATER HEATER	1500	0.5	0.750
DISHWASHER	1500	1	1.500
COFFEE MACHINE	1000	0.2	0.200
LAUNDRY	800	1	0.800

TYPICAL: **3372** kWh/YEAR (13x)

OPTIMAL: **1776** kWh/YEAR (7x)

10x

50x

1600L

200M2

ENERGY **NECESSARY USE**

	WATTS	HOURS/DAY	kWh/DAY
SMARTPHONE	6	1	0.012
CEILING FAN	120	5	0.600
TV	140	3	0.420
COMPUTER	200	5	1.000
FRIDGE	35	24	0.840
ELECTRIC COOKING	1200	0.4	0.480
LED BULB	10	3	0.060
SEWING MACHINE	100	1	0.100
ELECTRIC WATER HEATER	1500	0.2	0.300
DISHWASHER	1500	1	1.500
COFFEE MACHINE	1000	0.2	0.200
LAUNDRY	800	1	0.800

TYPICAL: **3372** kWh/YEAR (13x)
OPTIMAL: **1776** kWh/YEAR (7x)
NECESSARY: **792** kWh/YEAR (3x)

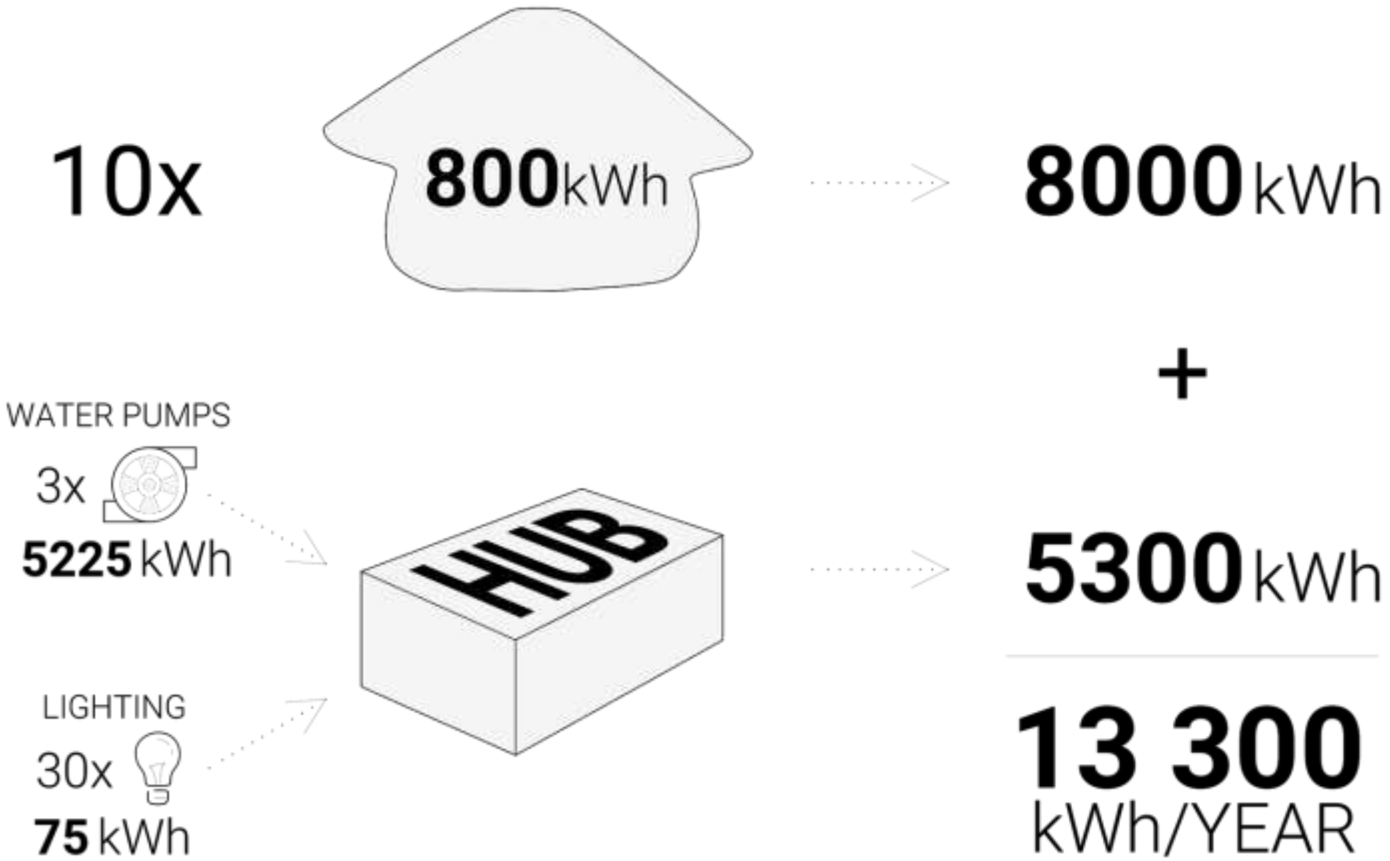
10x

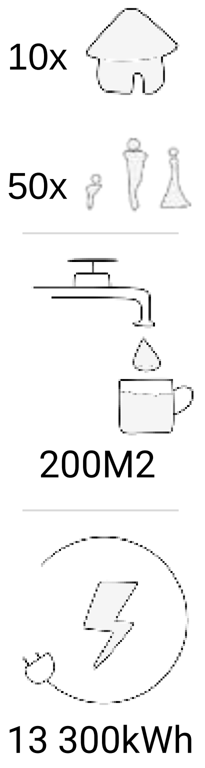
50x

1600L

200M2

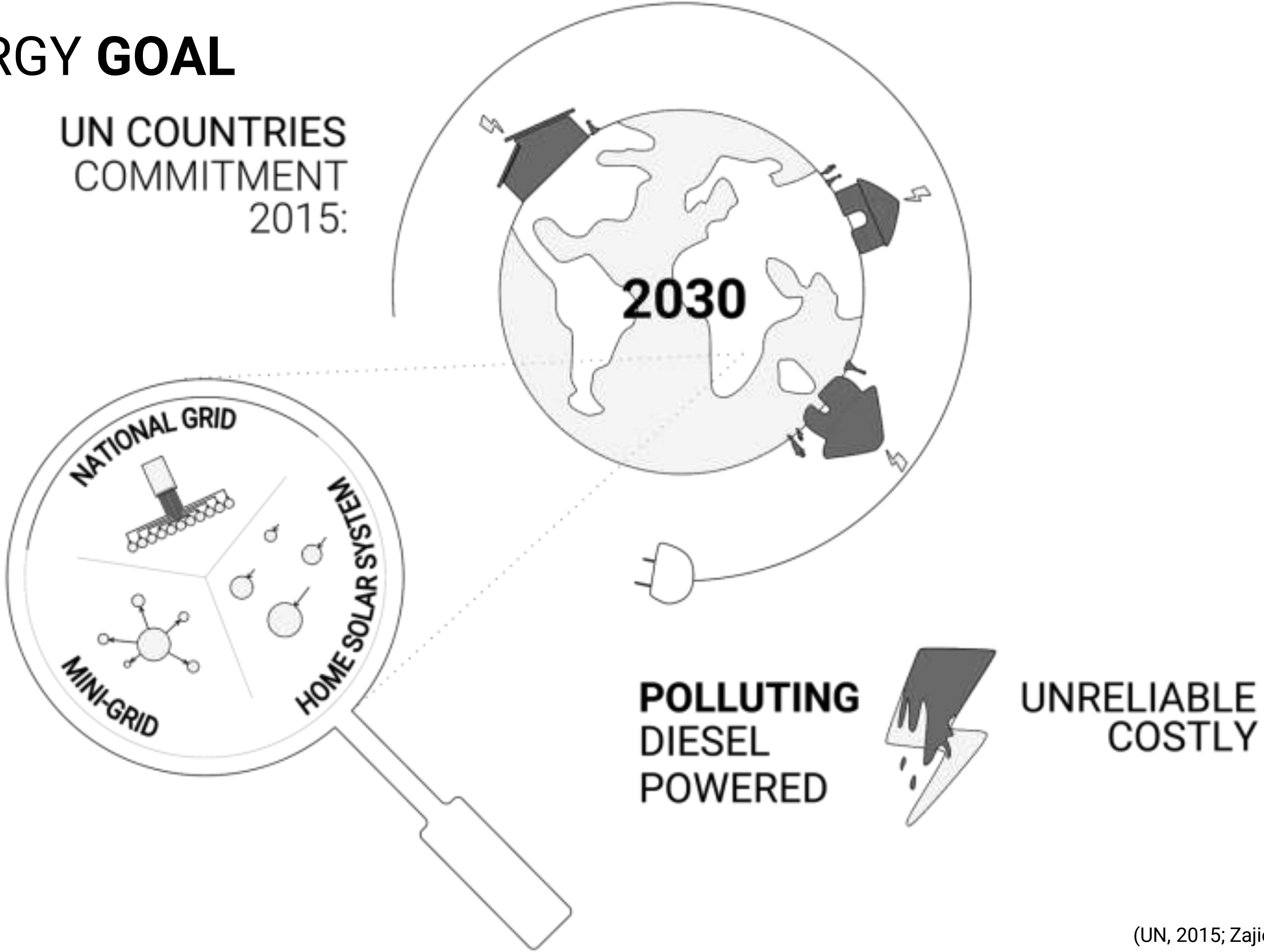
ENERGY **PRODUCTION NEED**





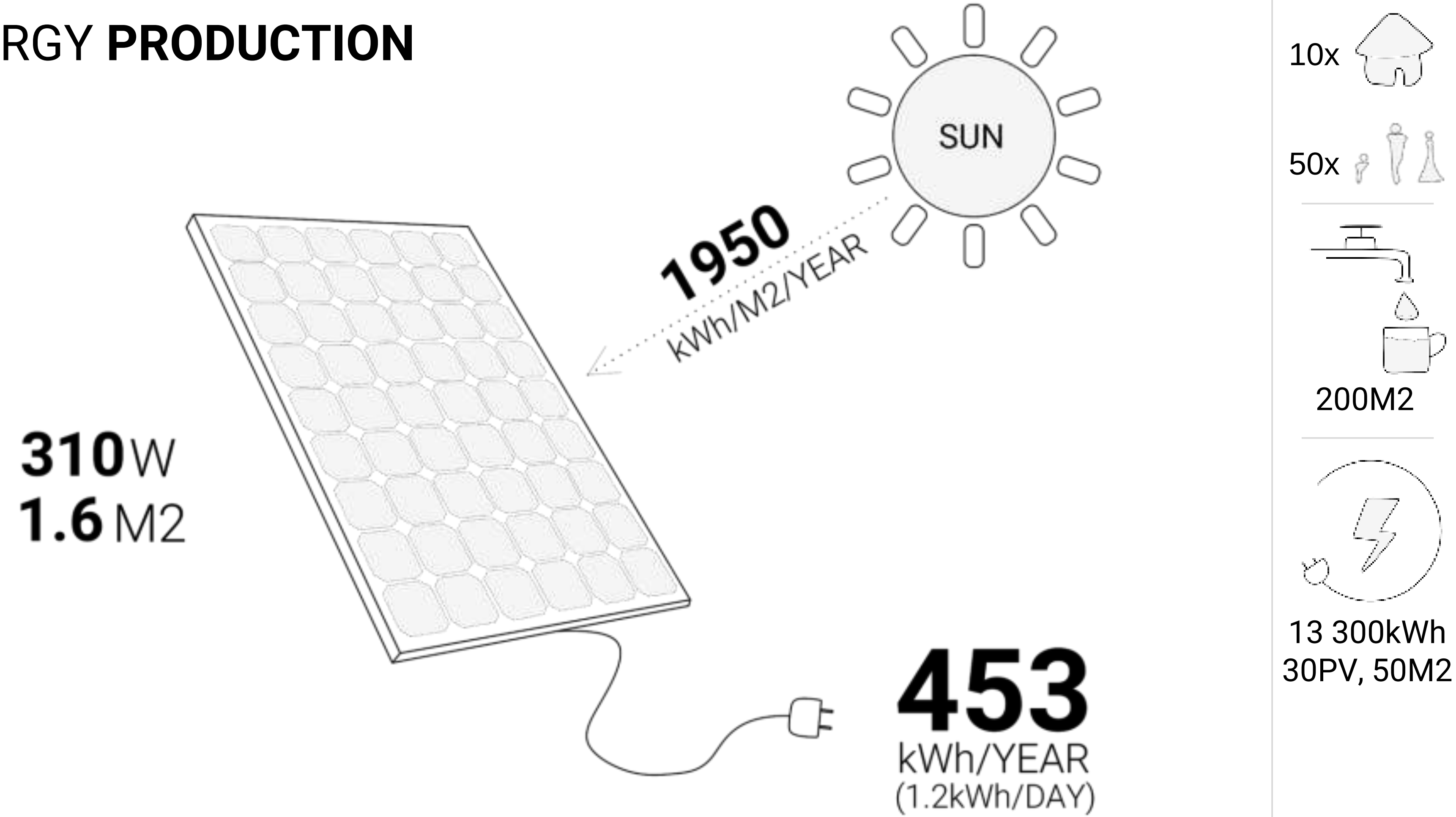
ENERGY **GOAL**

UN COUNTRIES
COMMITMENT
2015:

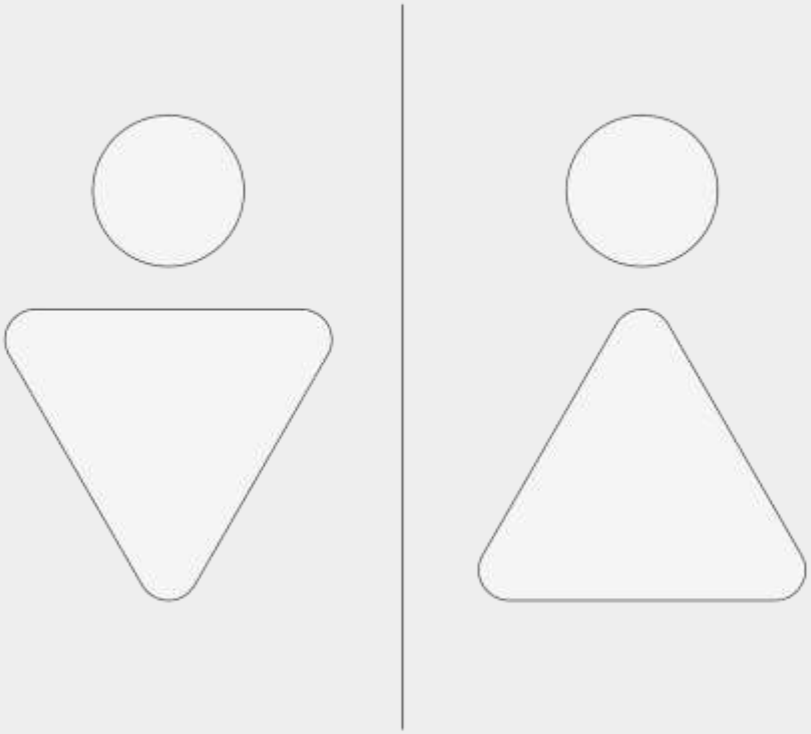


(UN, 2015; Zajicek, 2019)

ENERGY **PRODUCTION**

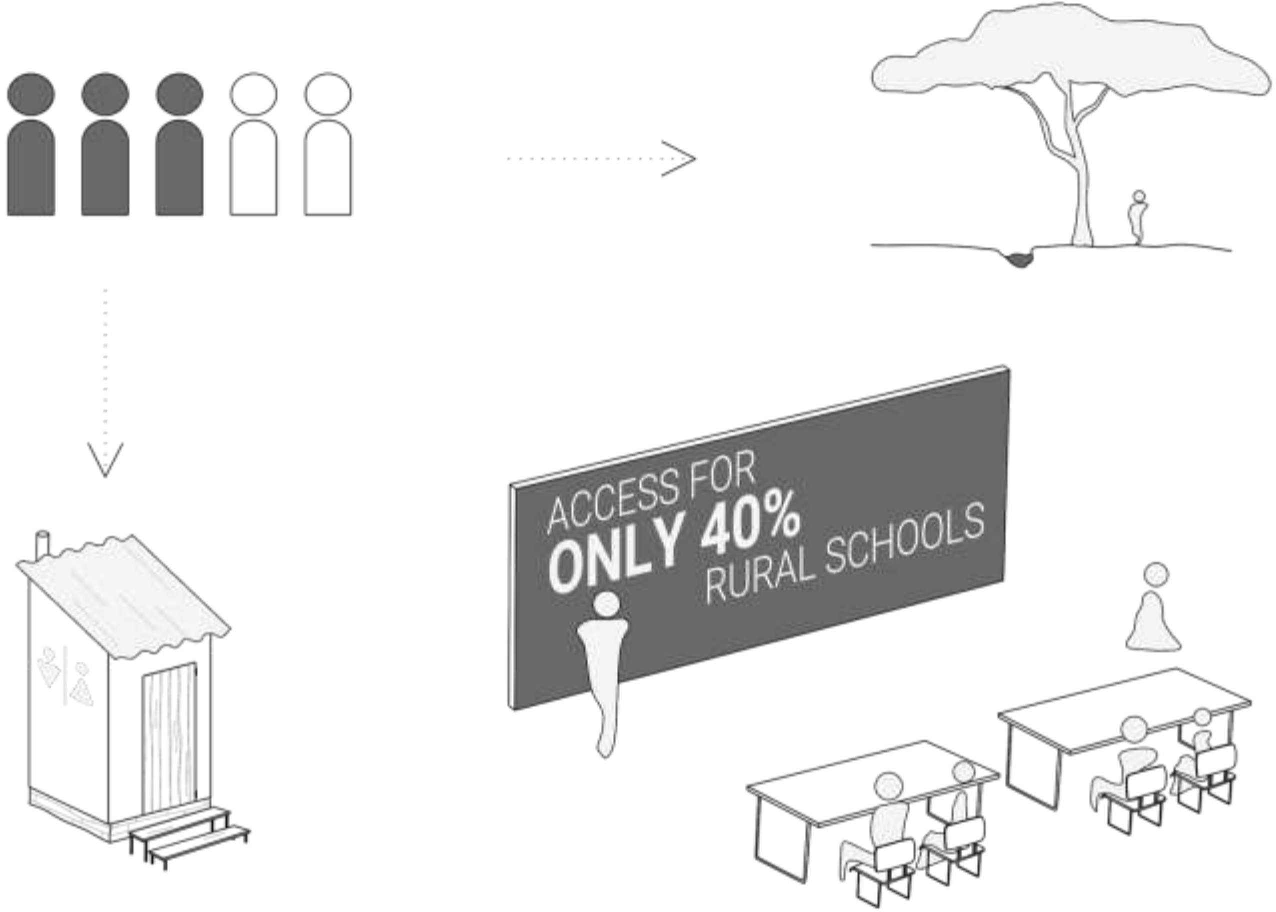


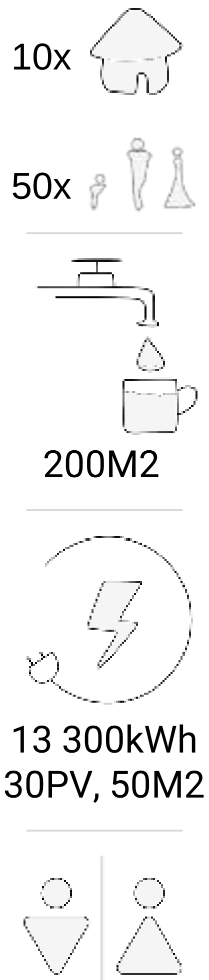
(Cuamba et al., 2006)



Sanitation

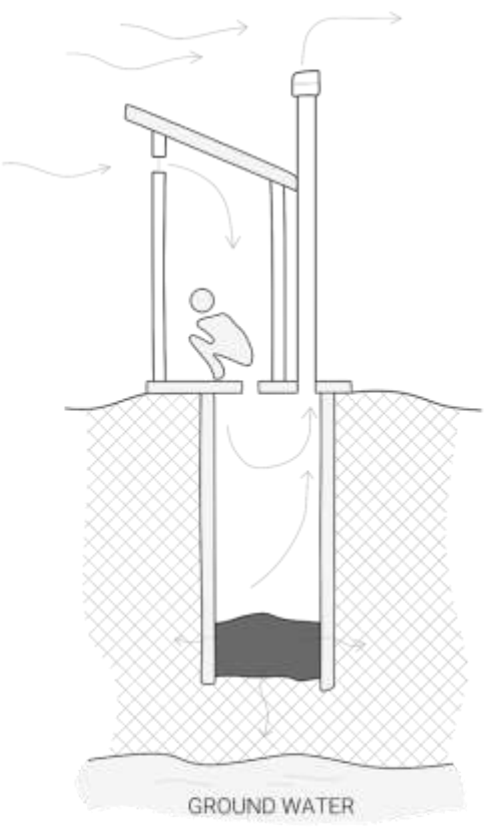
SANITATION OVERVIEW



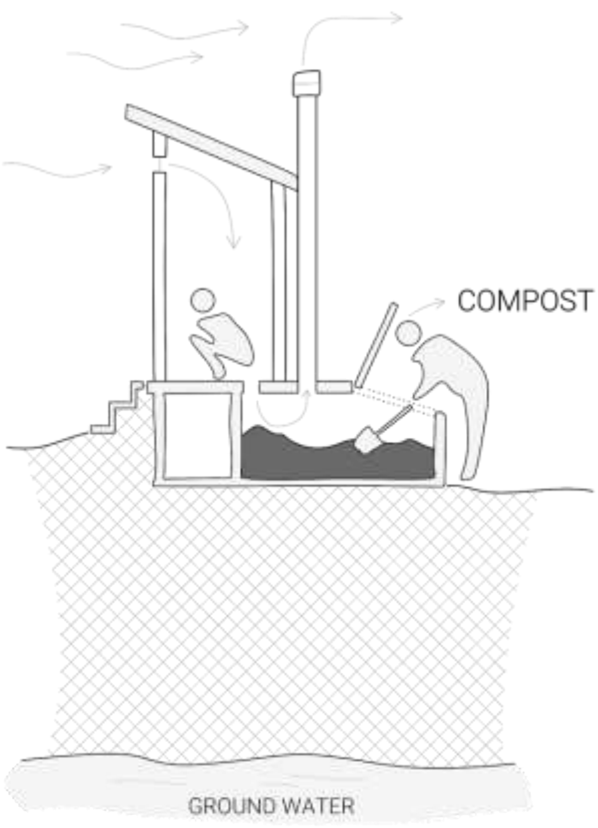


(UNICEF, 2017)

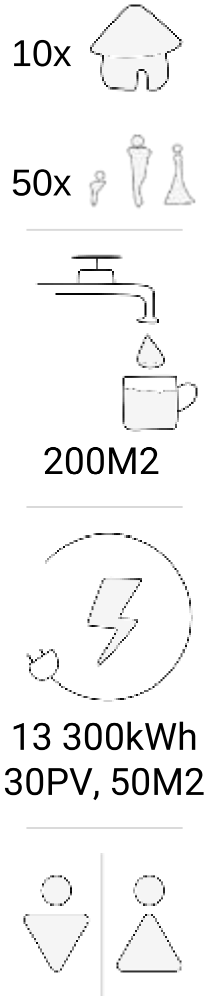
VIP LATRINE



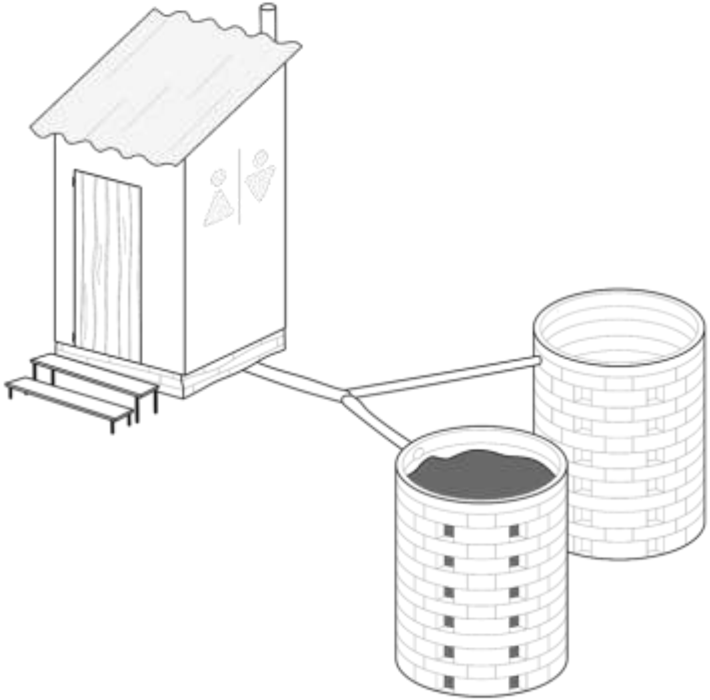
(Shaw, WEDC, 2010)

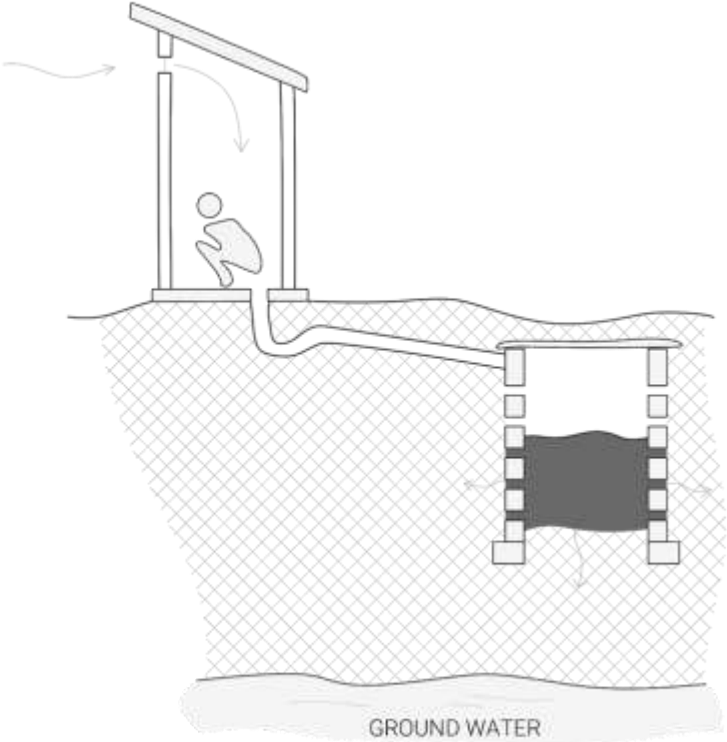


(Jenkins, 2009; Tilley et al, 2014)



TWIN PIT LATRINE





(Tilley et al, 2014)

10x

50x

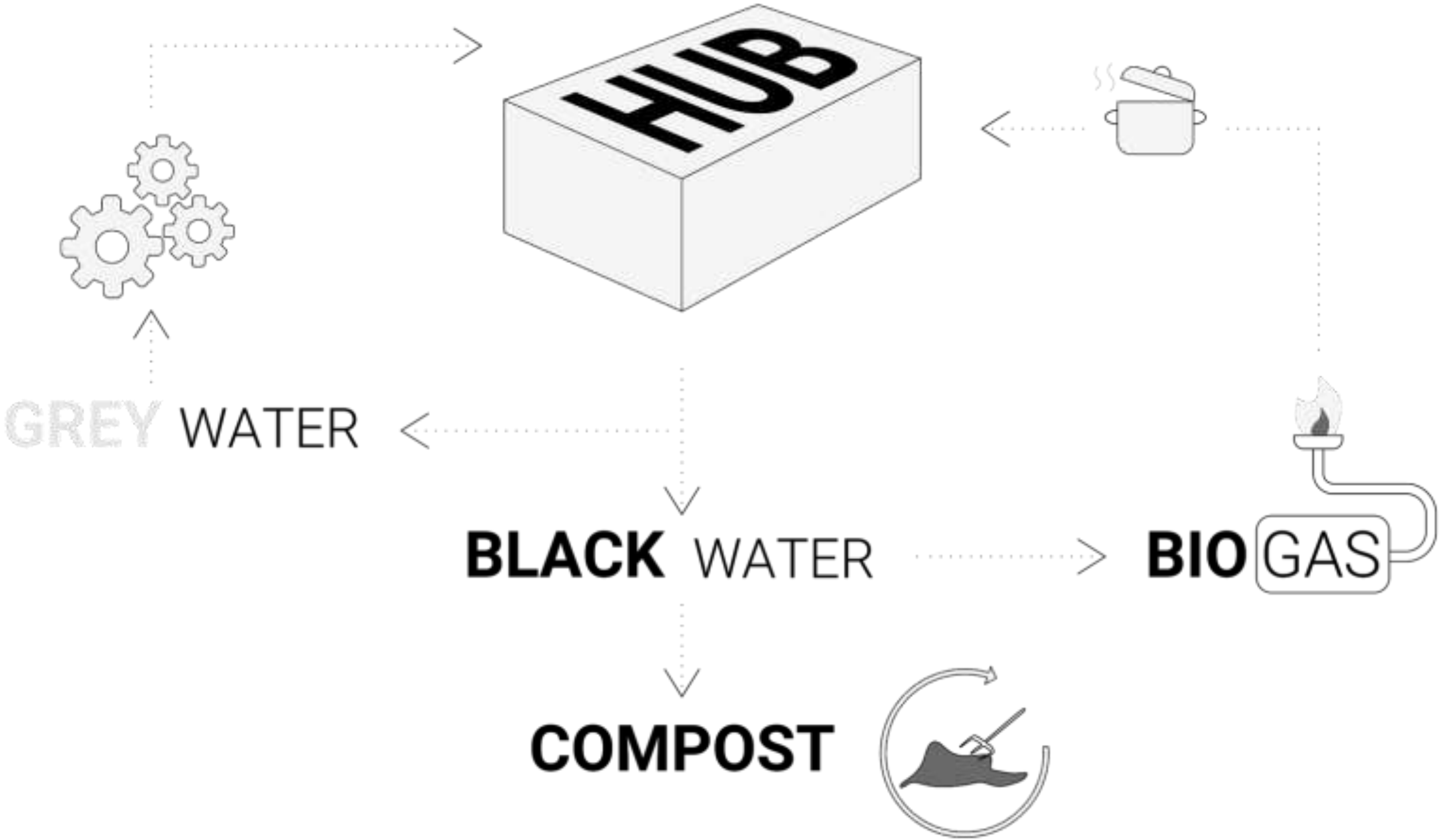
200M2

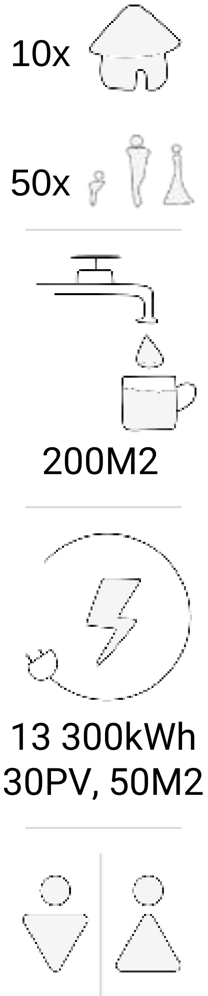
13 300kWh
30PV, 50M2

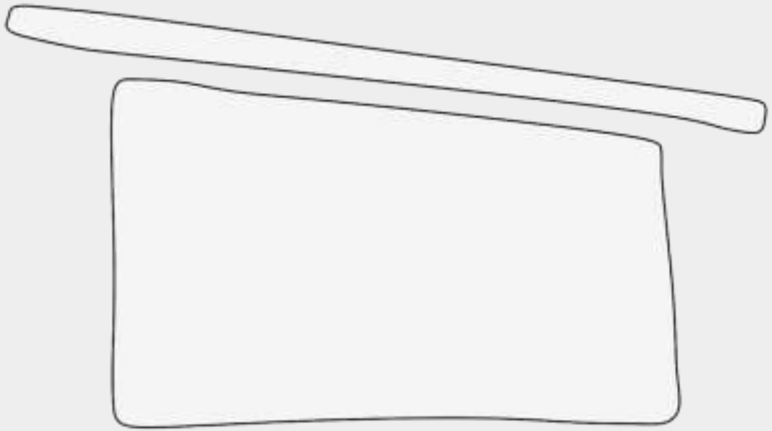

Mozambique, Arup


Mozambique, Kelvin Tembo

SANITATION **STRATEGY**







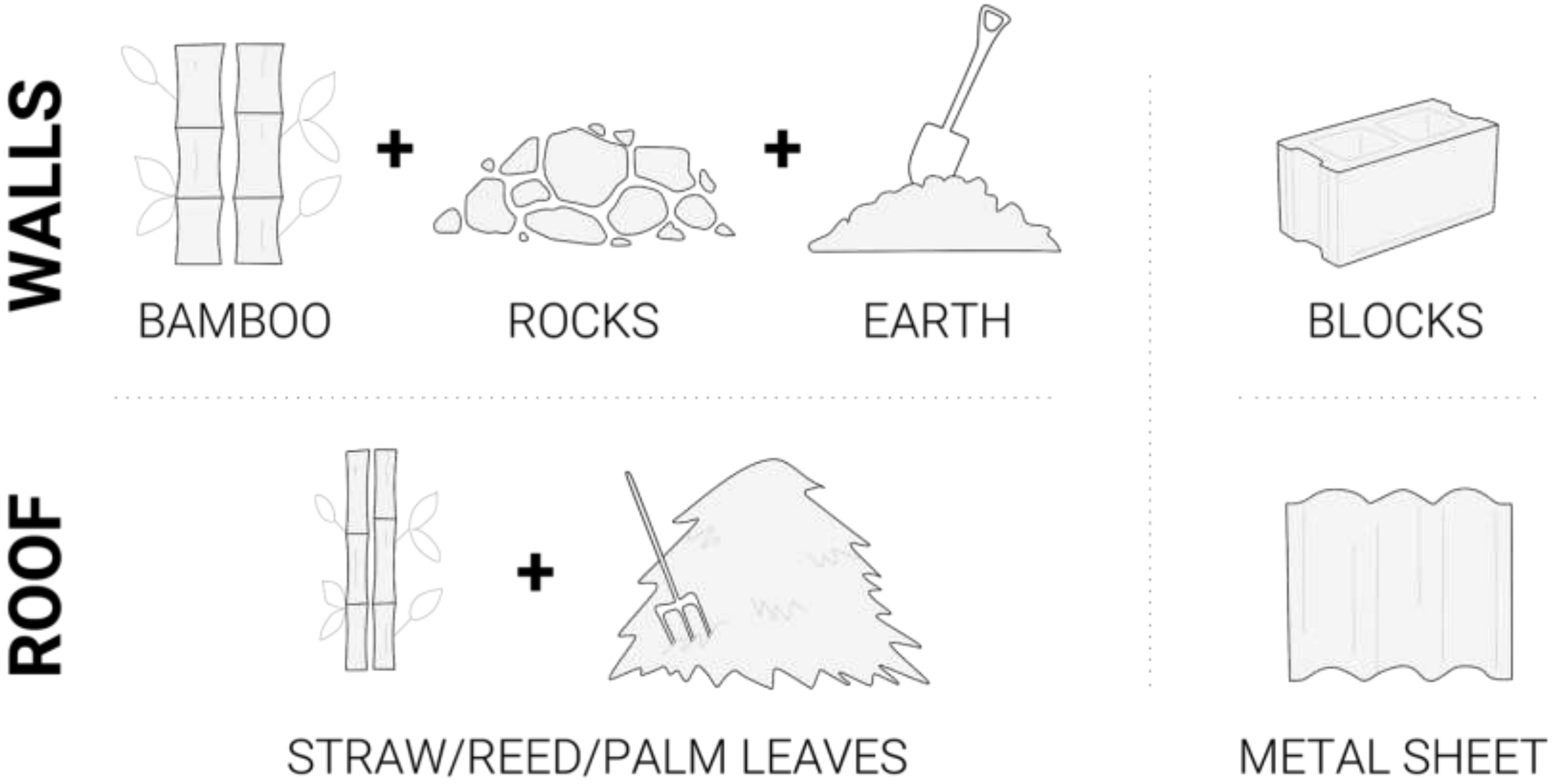
Local Architecture


Mozambique, Fango Nsanje


Mozambique, Betty Muess


Mozambique, Dreams Time

LOCAL MATERIALS



(Schofield & Deprez, 2019)

LOCAL CONSTRUCTION TECHNIQUE

Bamboo, Wood

Yasuyoshi Chiba/AFP/Getty Images

Yasuyoshi Chiba/AFP/Getty Images

LOCAL CONSTRUCTION TECHNIQUE

Rock, Earth

LOCAL CONSTRUCTION TECHNIQUE

Metal Sheet, Straw, Reed


Philip Kleinfeld/TNH


Reuters


Reuters


Intellectual Reserve, Inc. 2019


Balagan Stock, Shutterstock

2009: Educational Building in Govuro, Mozambique.

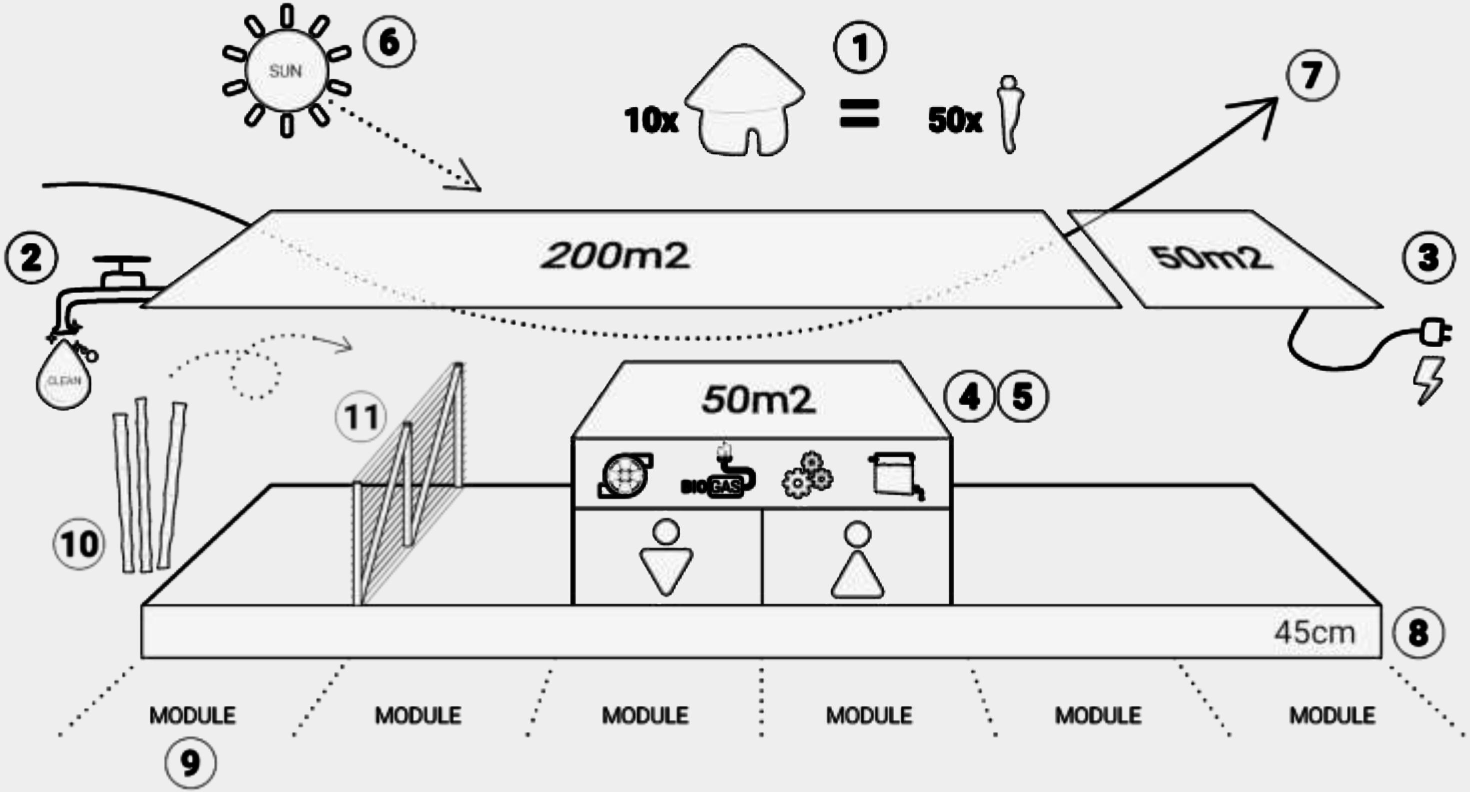
Masterstudents of Bergen School of Architecture

2009: Educational Building in Govuro, Mozambique.

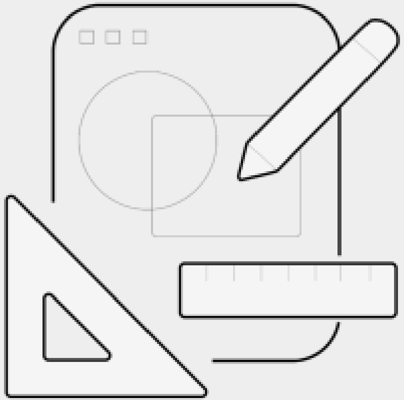
Masterstudents of Bergen School of Architecture

2018: The Econef Children's Center in Kingori, Tanzania

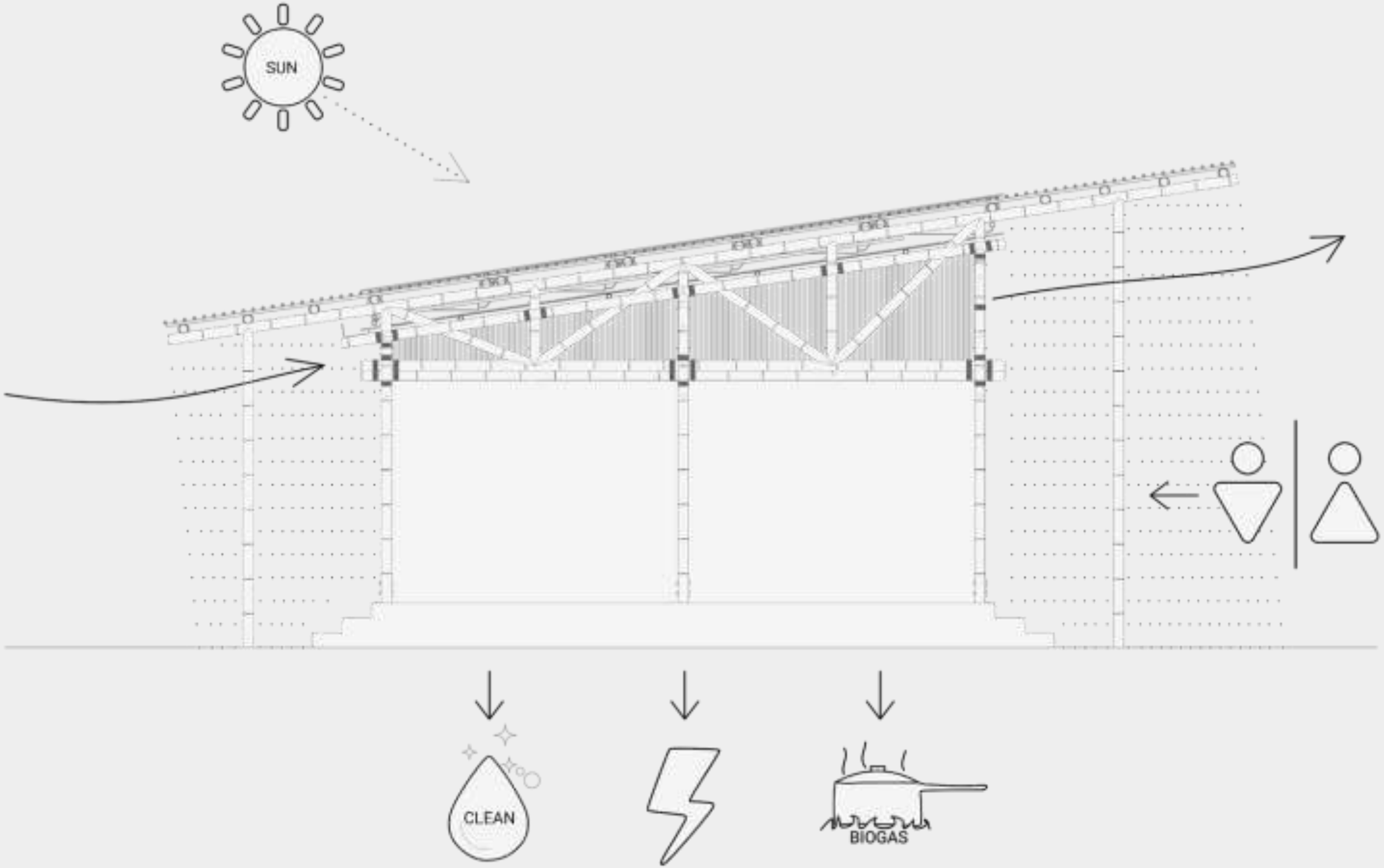
Asante



Design Brief (PoR)



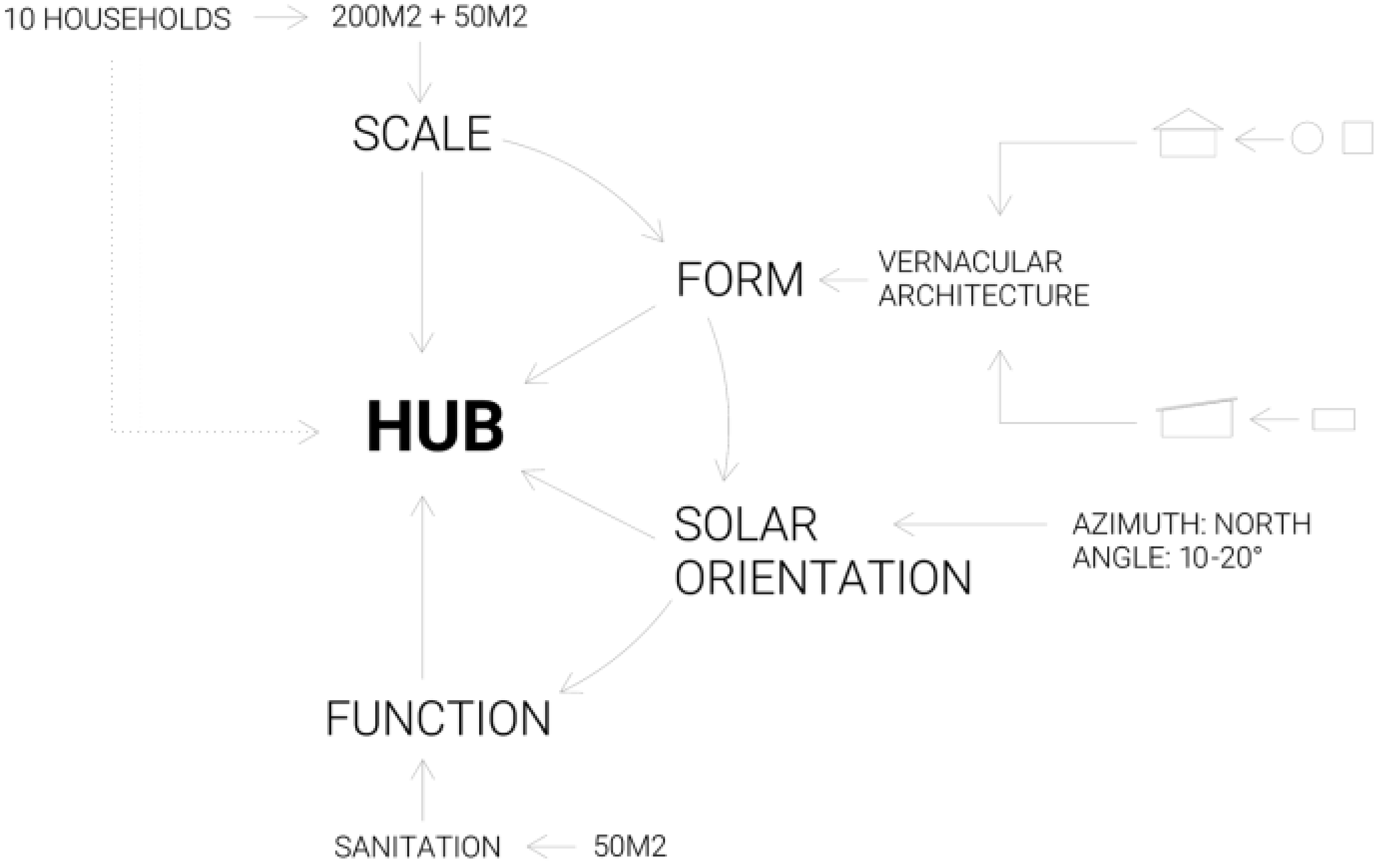
Research by Design



Architecture

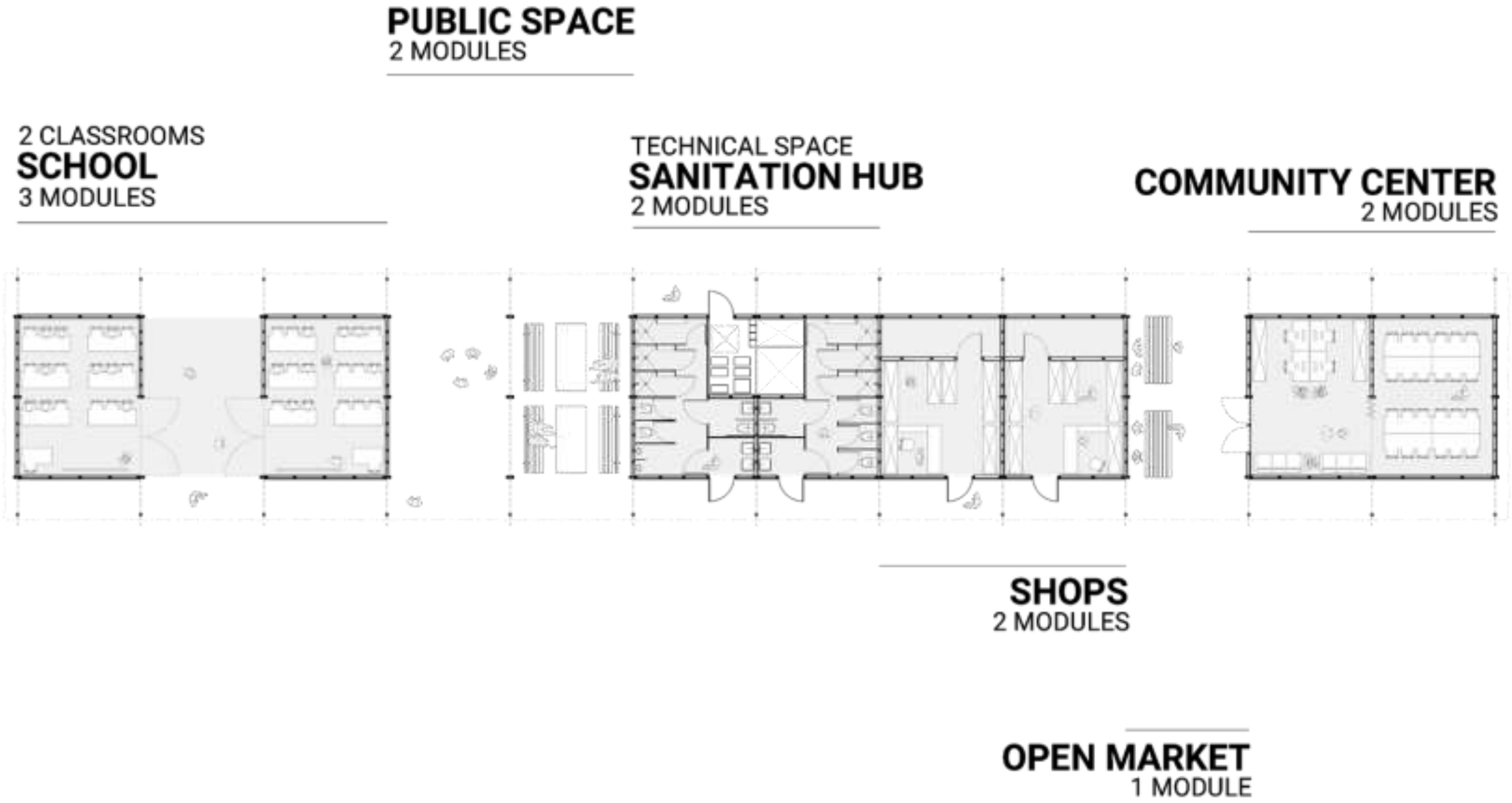
ARCHITECTURE

Form & Scale



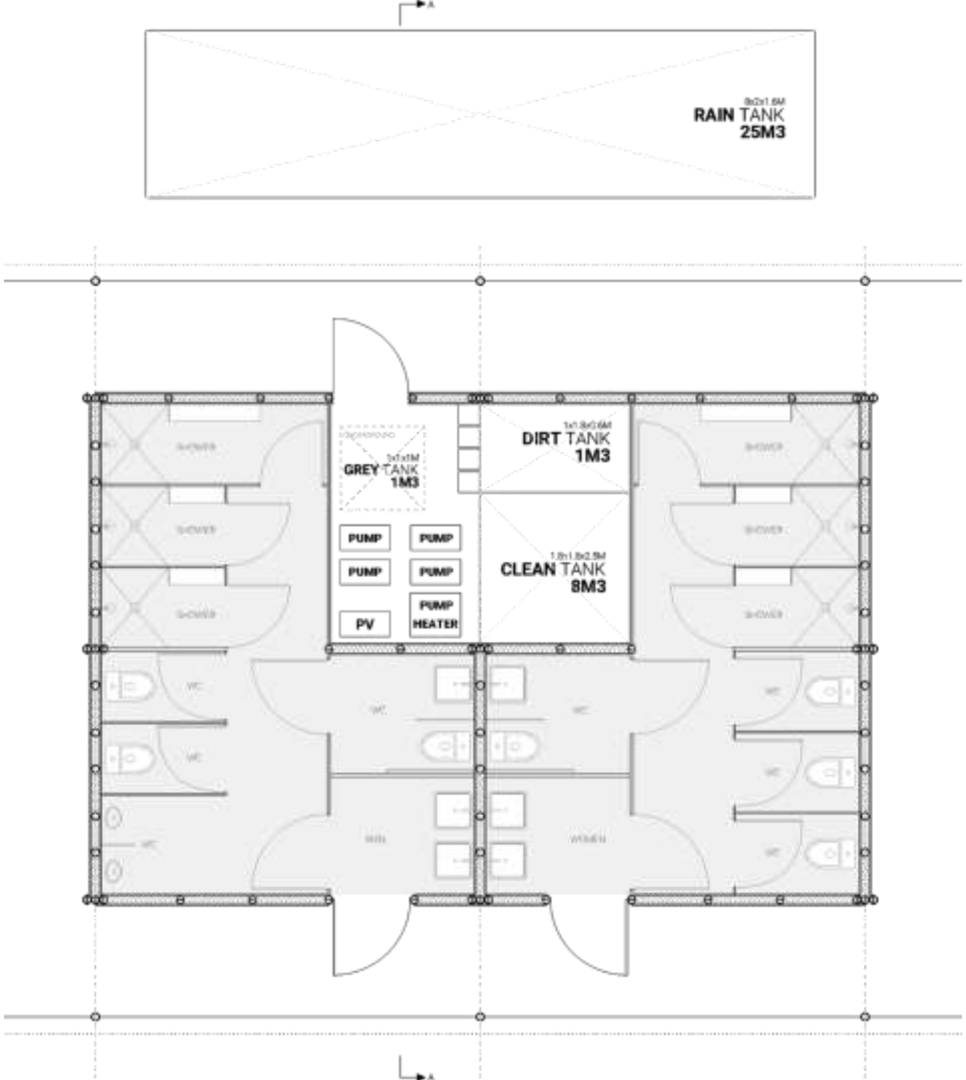
FUNCTIONAL **LAYOUT**

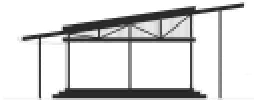
12 Modules



CENTRAL **HUB**

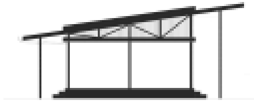
2 Modules - floorplan

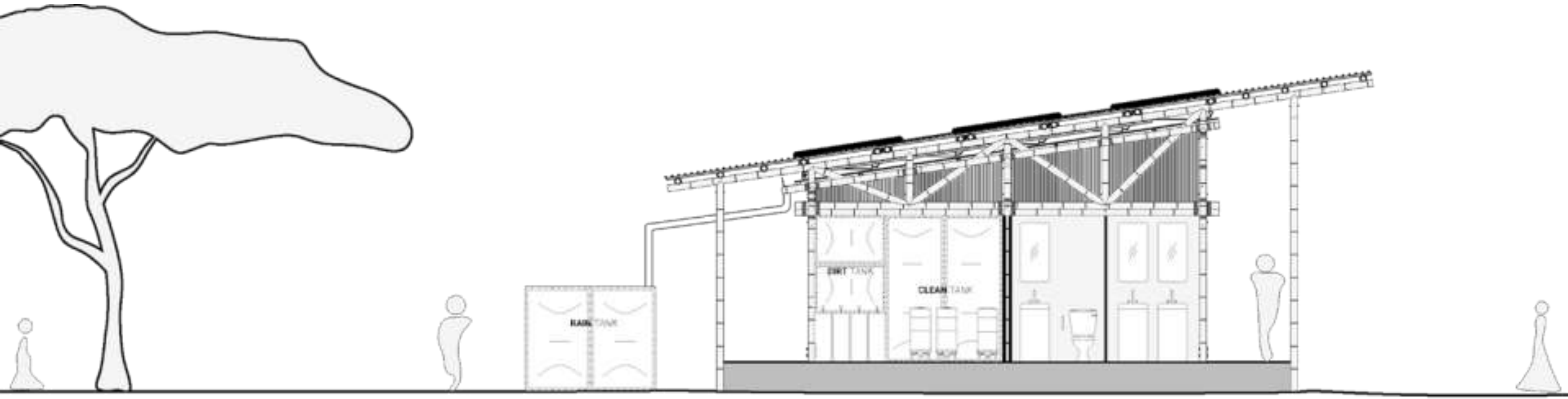




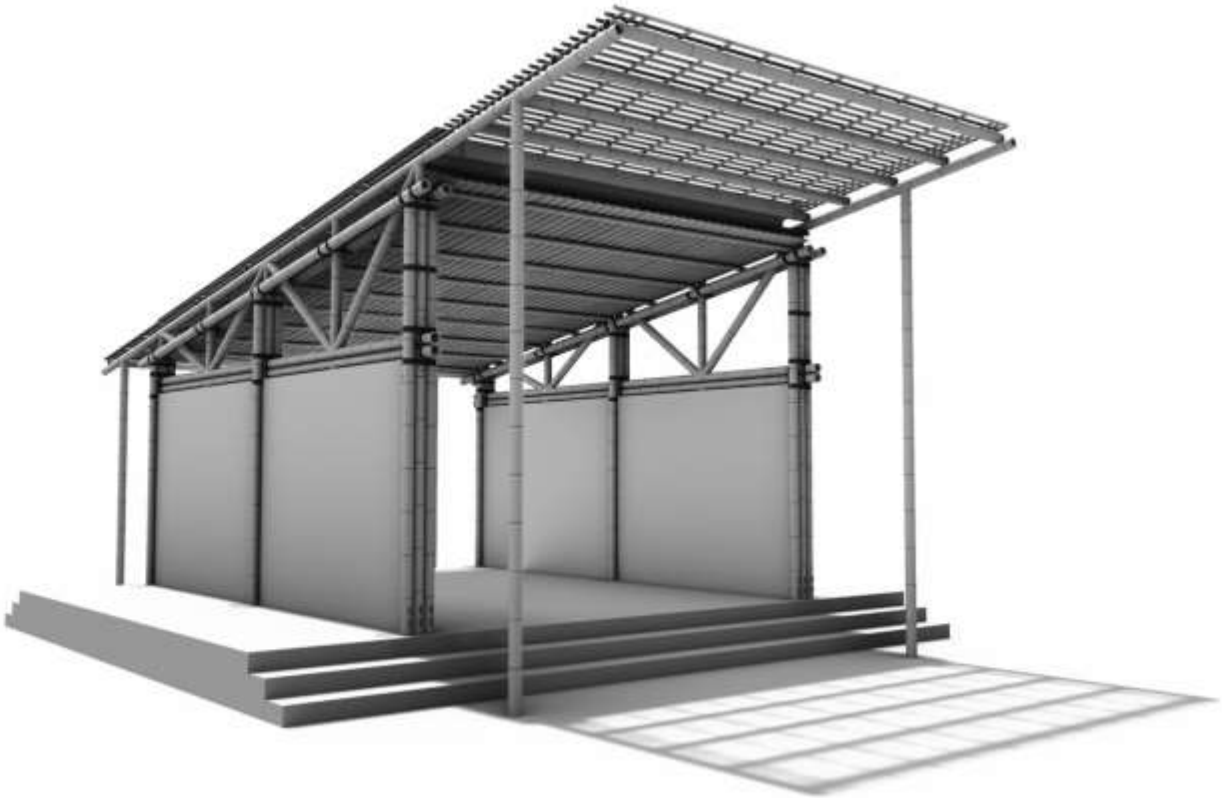
CENTRAL **HUB**

2 Modules - section A-A





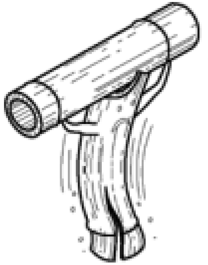
MODULE UNIT



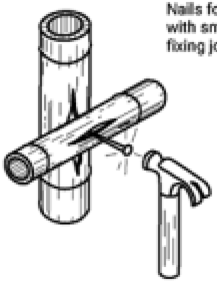
BAMBOO STRUCTURE

Construction principles

DONT USE FOR CONSTRUCTION



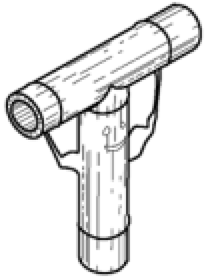
Culms with low compression strength. These include:
1) Young culms less than three years old,
2) Culms which are or have been attacked by insects or fungs,
3) Culms which have flowered,
4) Culms with cracks or which have transversal cuts made by a machete



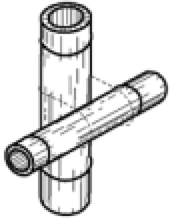
Nails for fixing lateral culms with smaller diameter, or for fixing joints.

USE

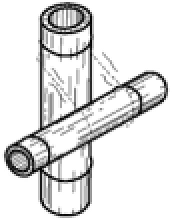
1) Mature culms three years old or older
2) Giant culms with appropriated dimensions and thick walls (more then 9mm)
3) Culms with appropriate joints



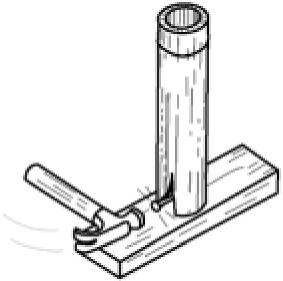
If it is necessary to use nails for fixing small diameter culms (4 to 5 cm) or joints of giant bamboos, it is recommended to open a hole previously with a drill bit sligtelly smaller than the nail's diameter
2) For fixing horizontal and vertical structural members in temporary structures use wire ties, nylon or strong vegetal cords



DONT USE FOR CONSTRUCTION



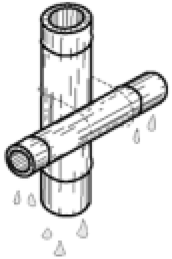
Green bamboos used structurally in permament constructions and tied with wire or ropes. When green culms become dry, they shrink and the ties become free



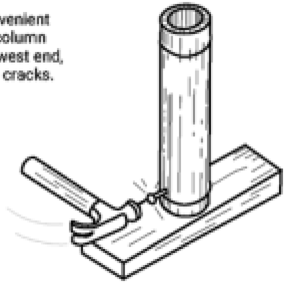
Temporary vertical supports or colums without any node at the lowest end which can cresent cracks at the moment of being fixed.

USE

In this case it is convenient to check frequently the ties, or to use dry culms



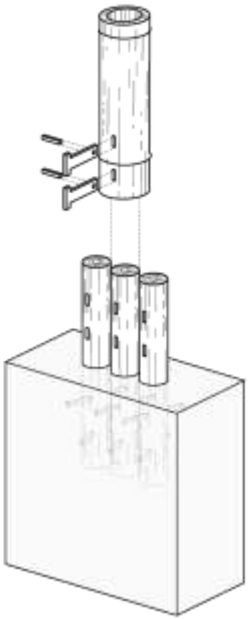
In this case it is convenient that the temporary column has a node in the lowest end, in order to avoid the cracks.

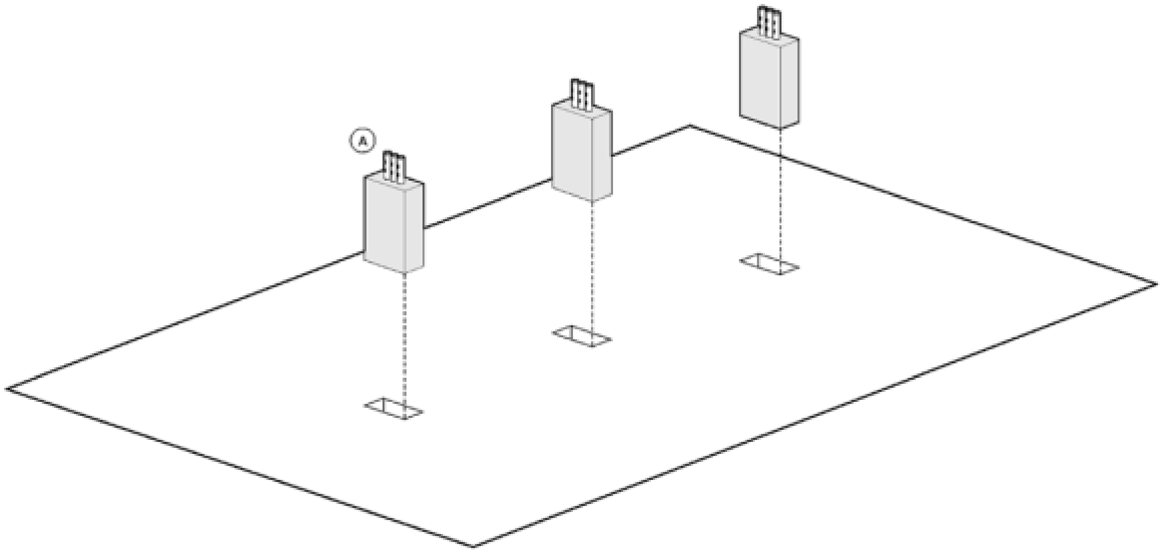


(Hidalgo-López, 2003)

ASSEMBLY STEPS

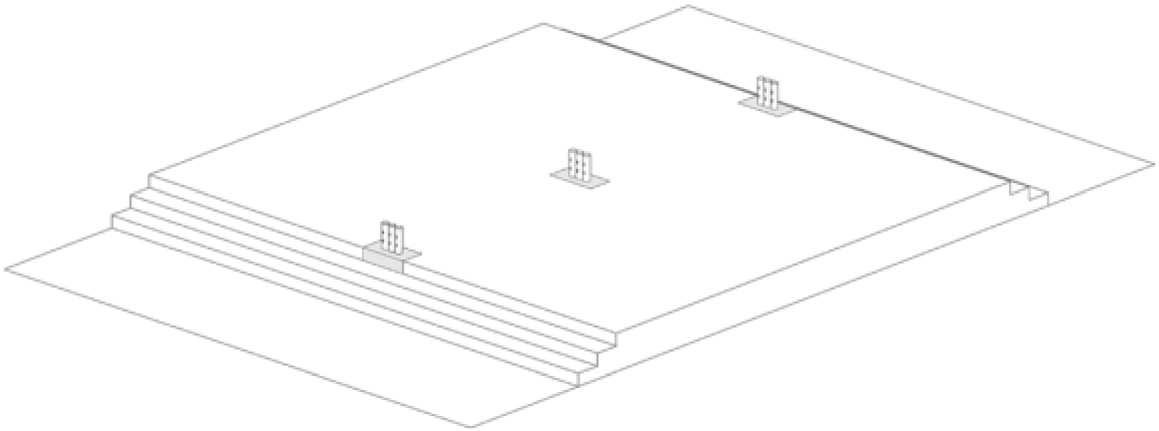
Foundations





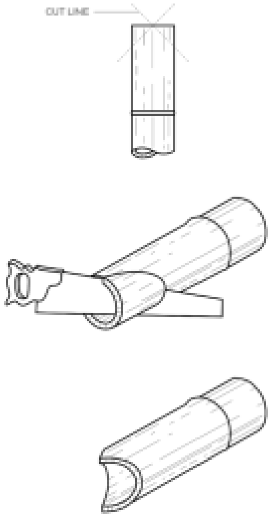
ASSEMBLY STEPS

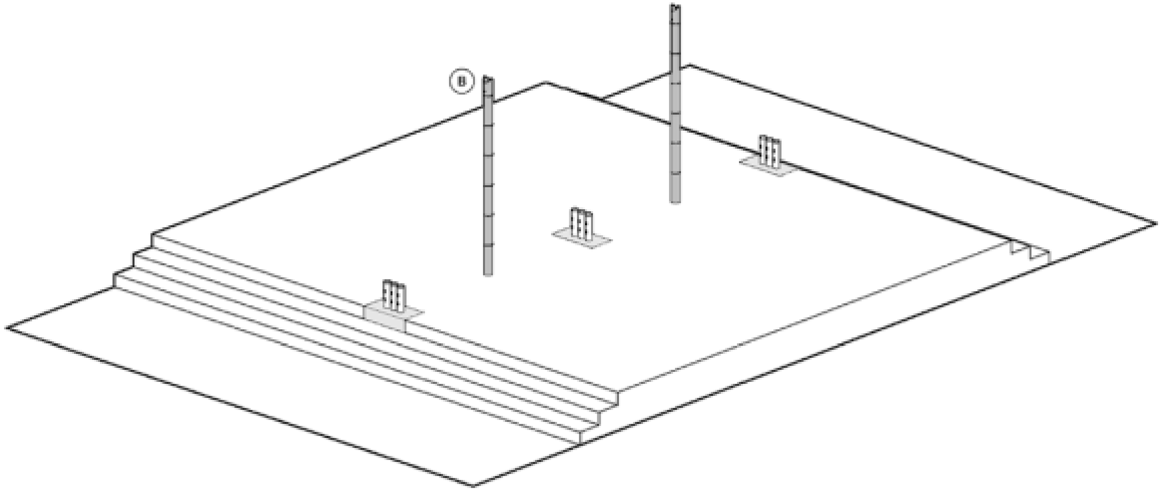
Elevated floor +45cm



ASSEMBLY STEPS

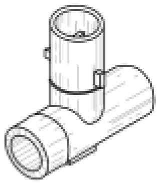
Single-culm columns

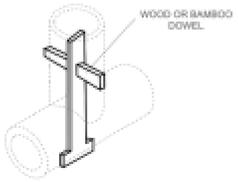


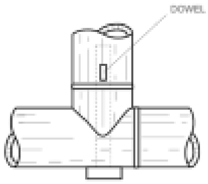


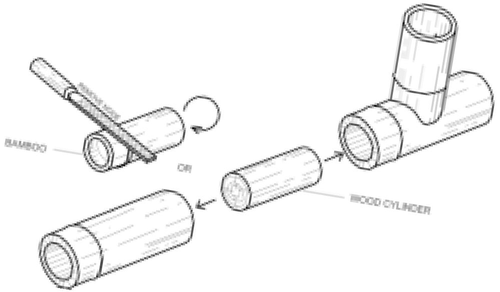
ASSEMBLY STEPS

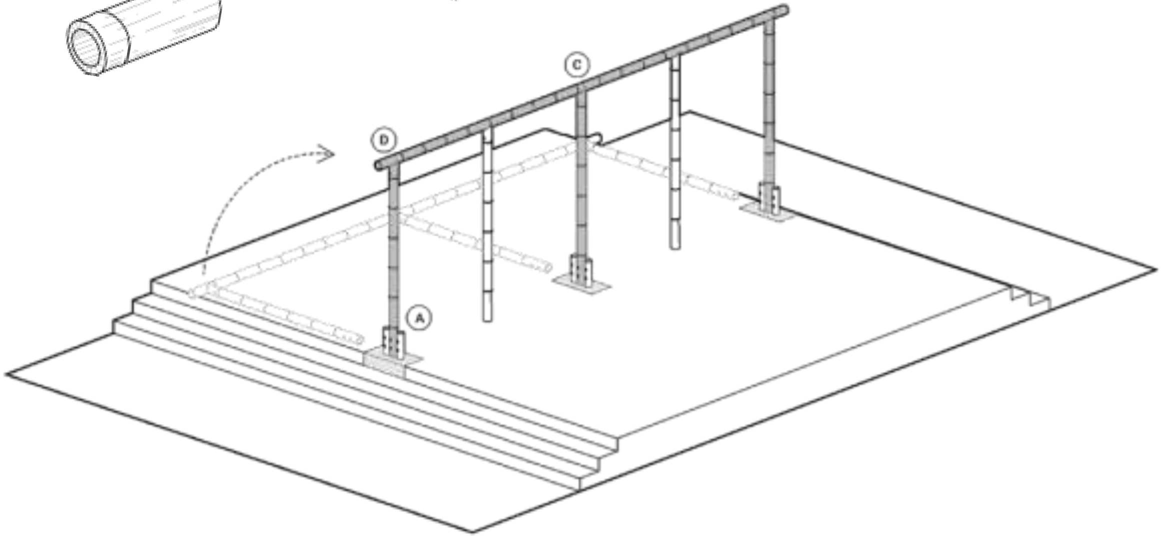
Main frame





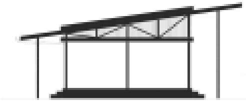


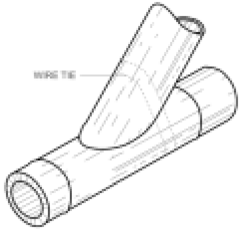


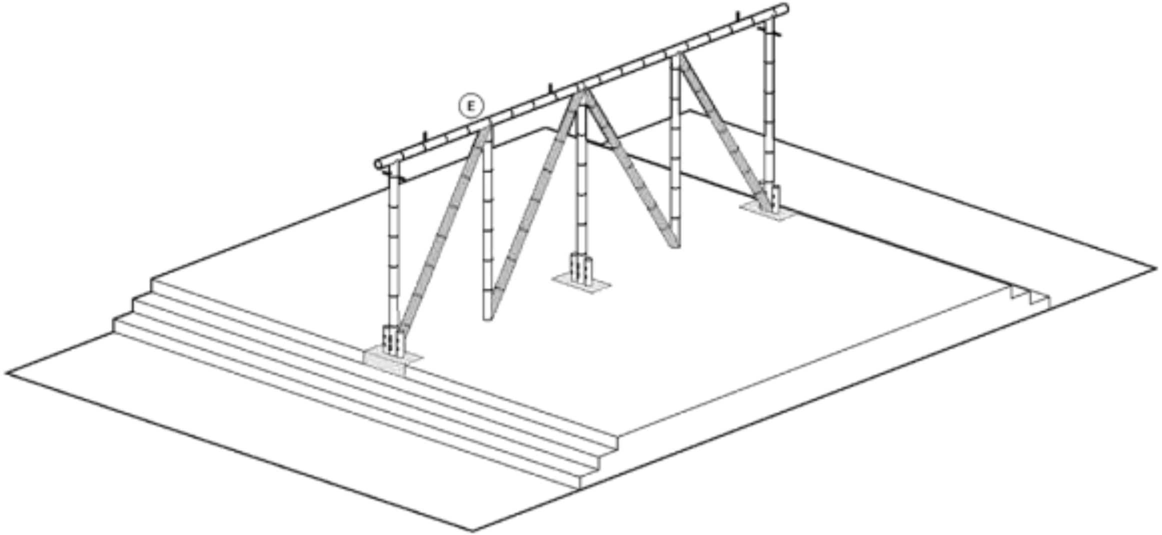


ASSEMBLY STEPS

Diagonals

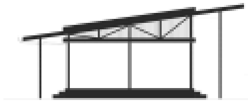


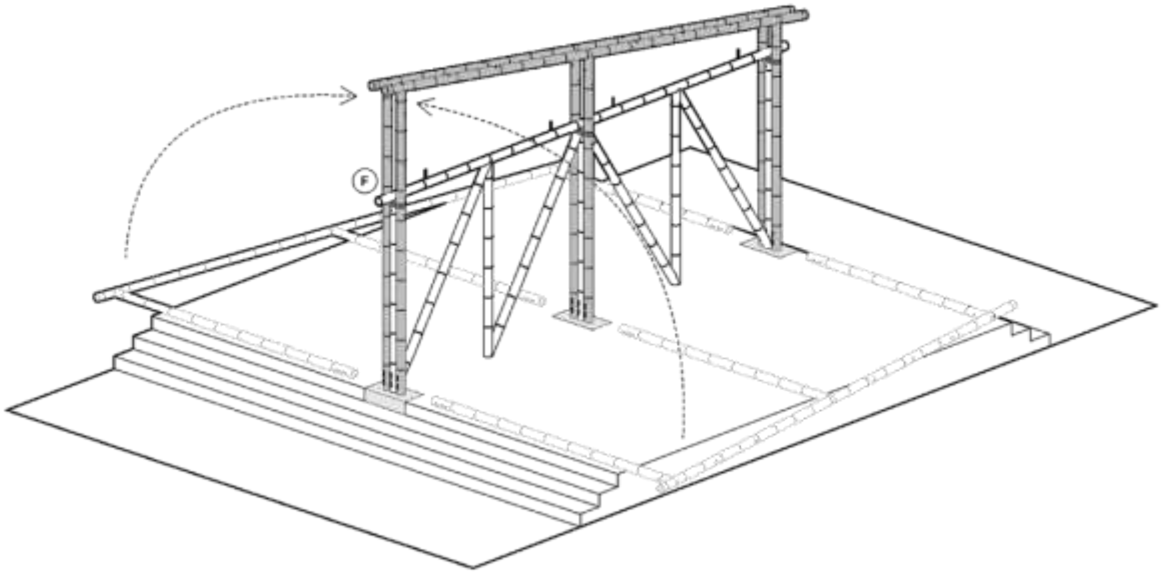




ASSEMBLY STEPS

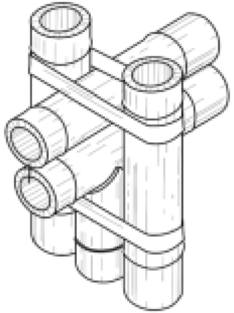
Secondary roof frame

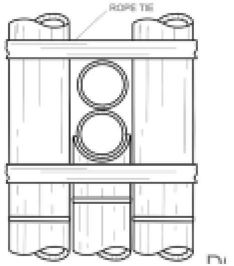


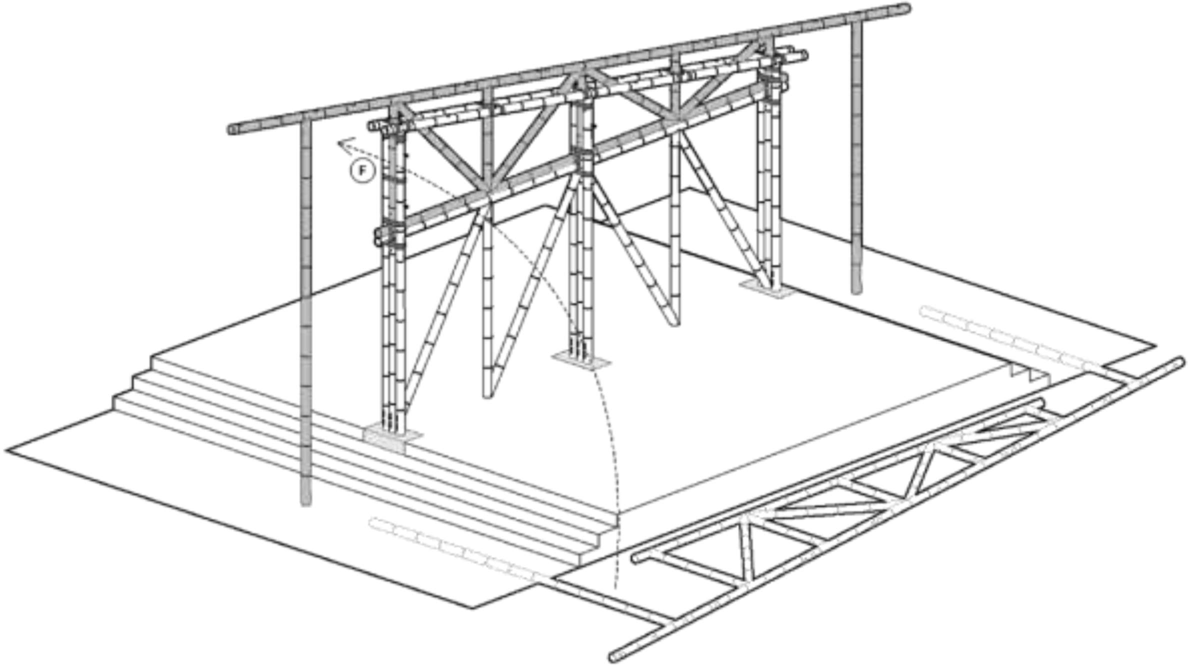


ASSEMBLY STEPS

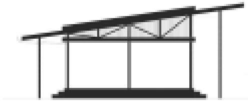
Truss

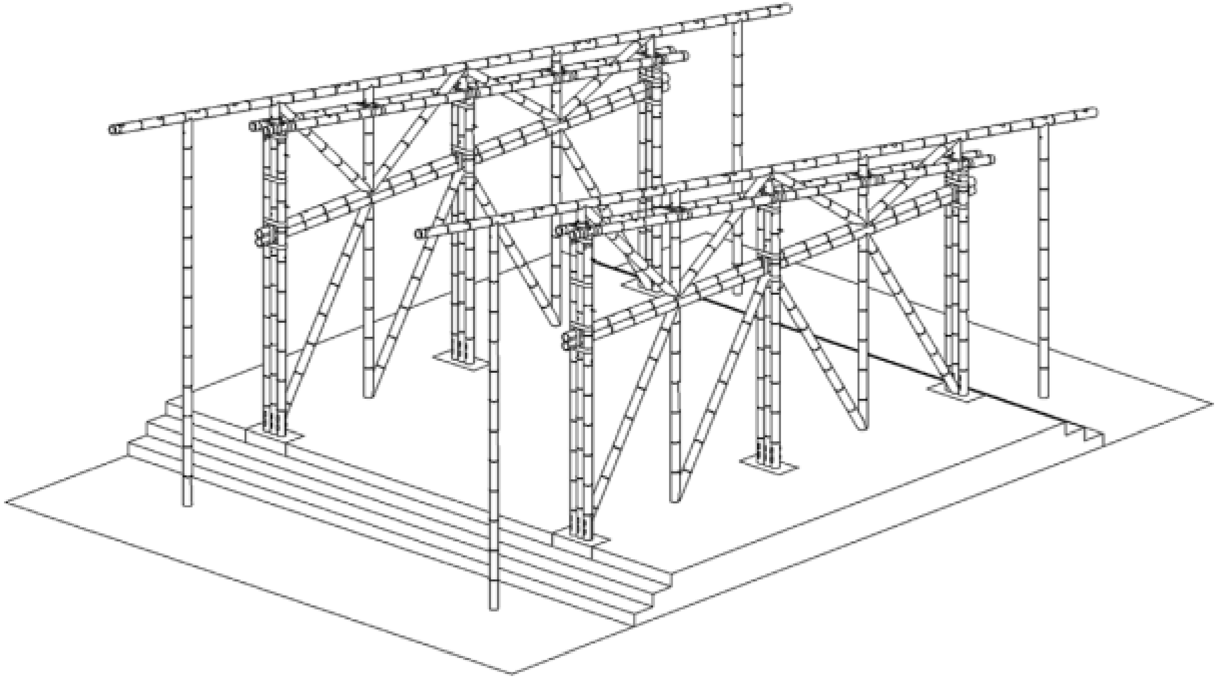






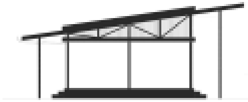
ASSEMBLY STEPS
1 module

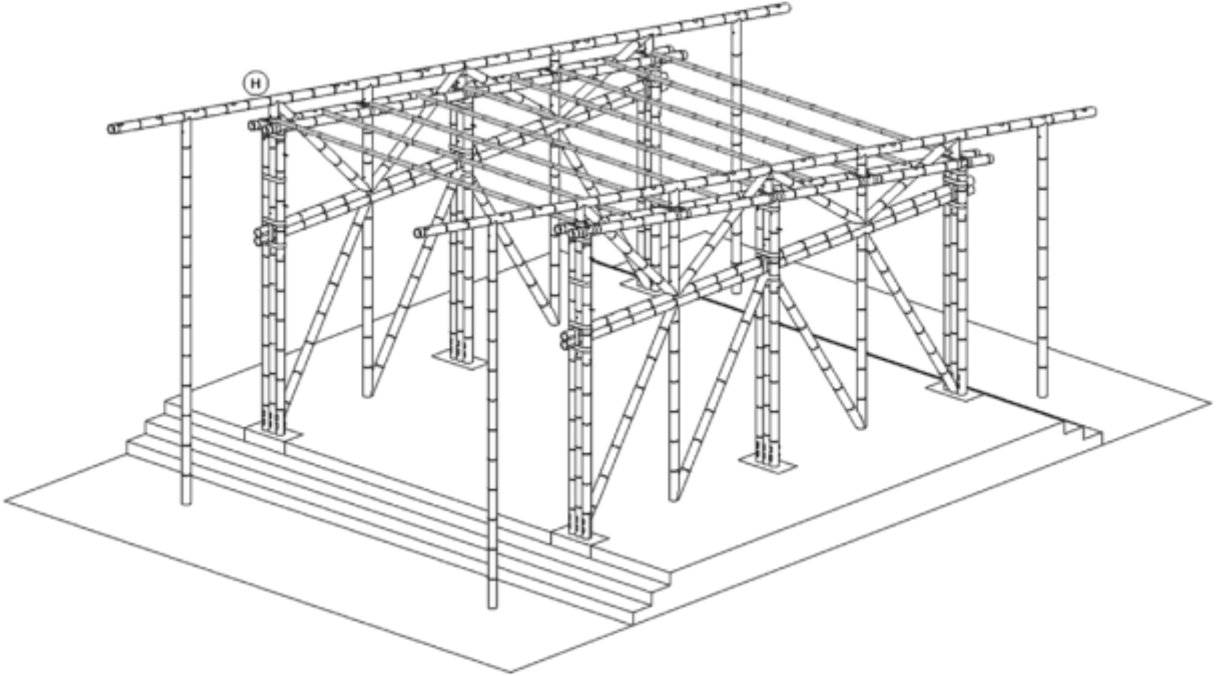




ASSEMBLY STEPS

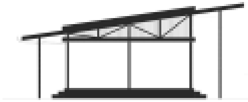
Secondary roof substructure

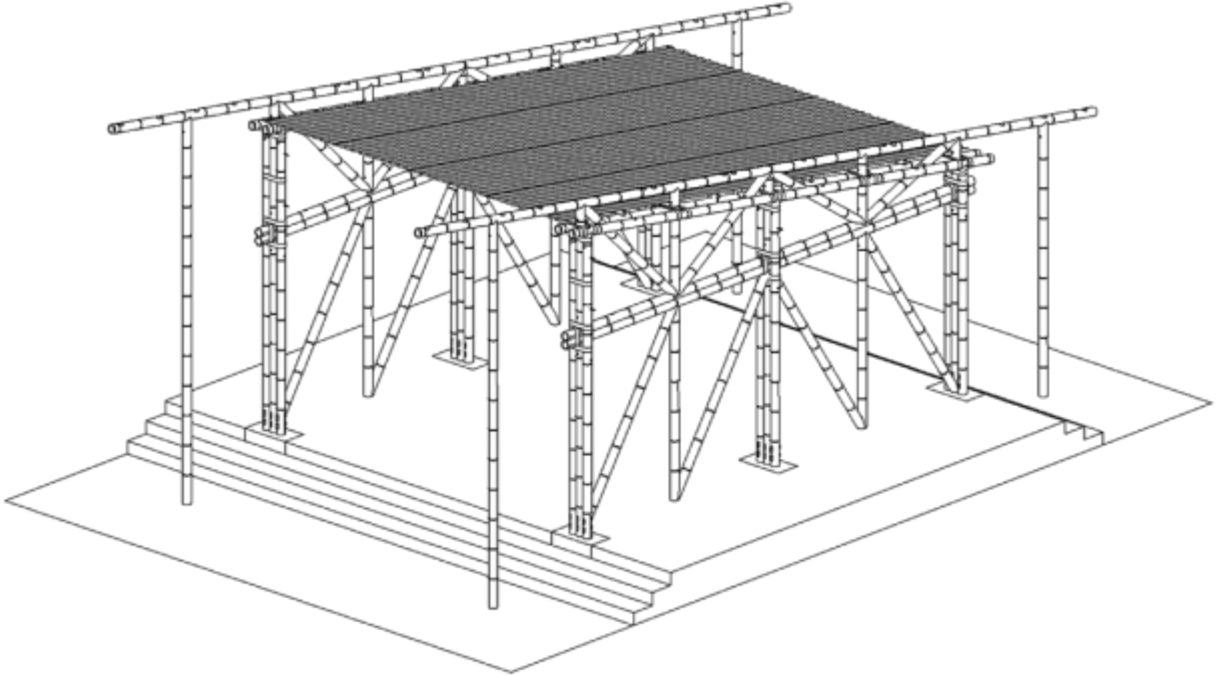




ASSEMBLY STEPS

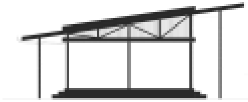
Metal sheet covering

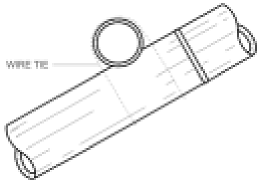


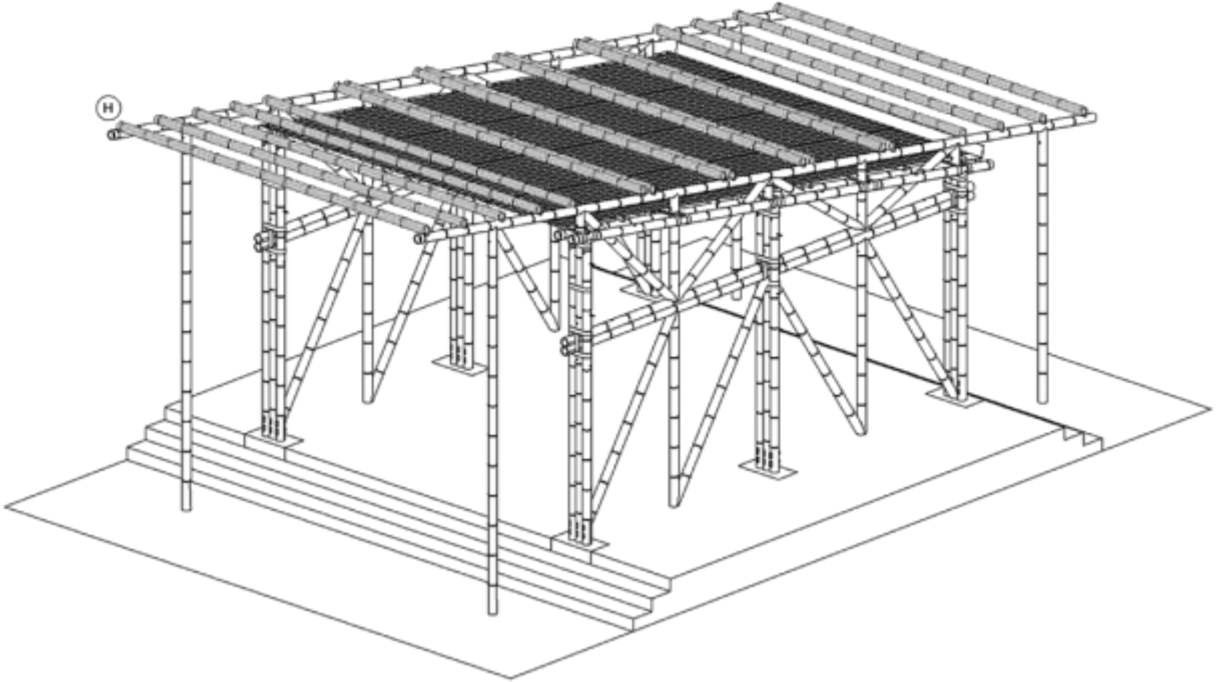


ASSEMBLY STEPS

Main roof substructure - main beams

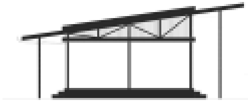


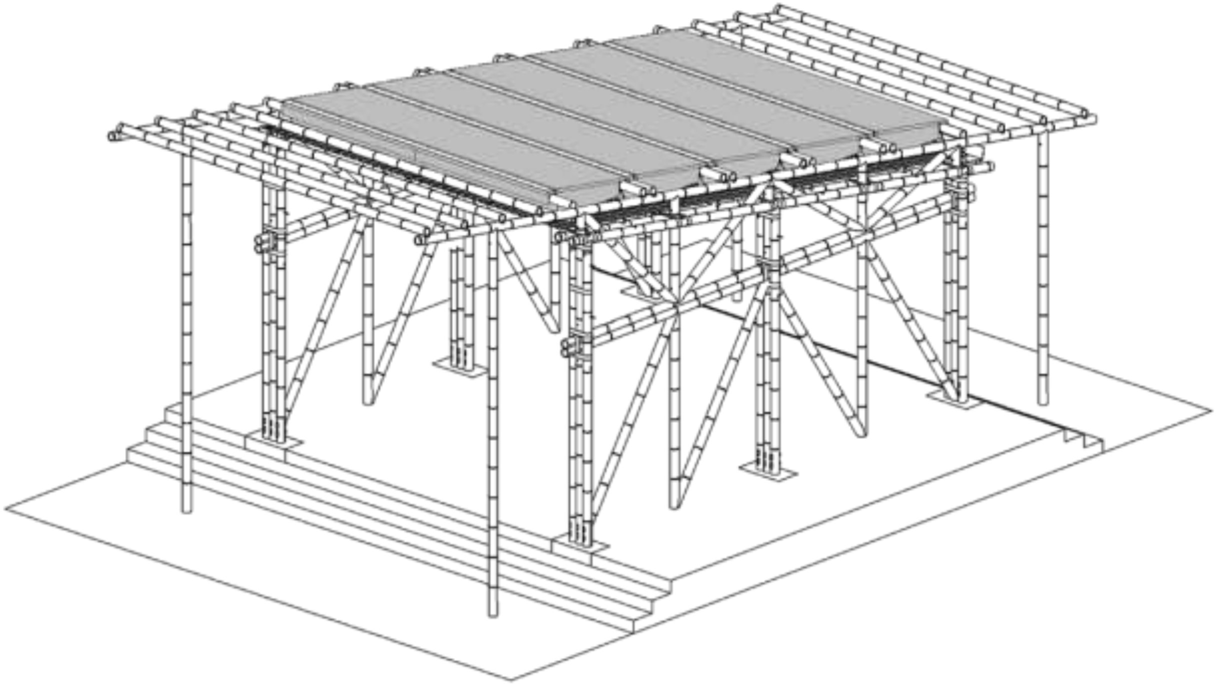




ASSEMBLY STEPS

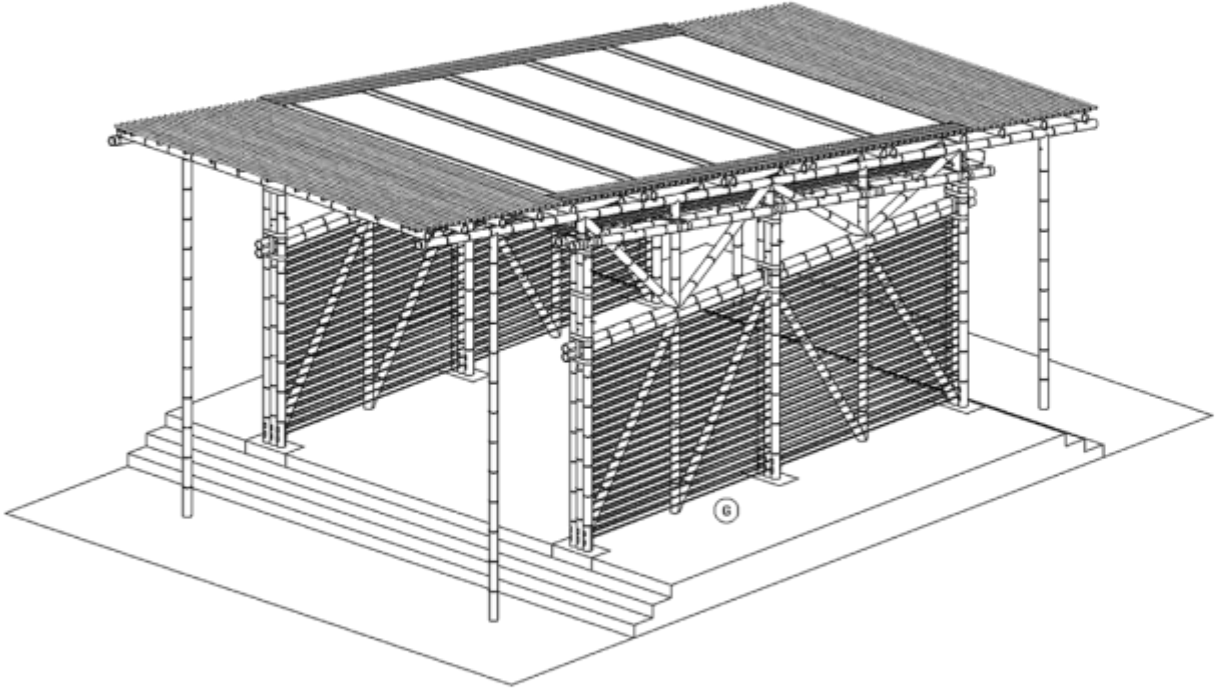
Solar-still units / PV panels

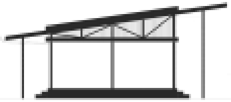




ASSEMBLY STEPS

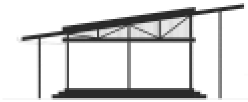
Openwork shading, wall bamboo slats

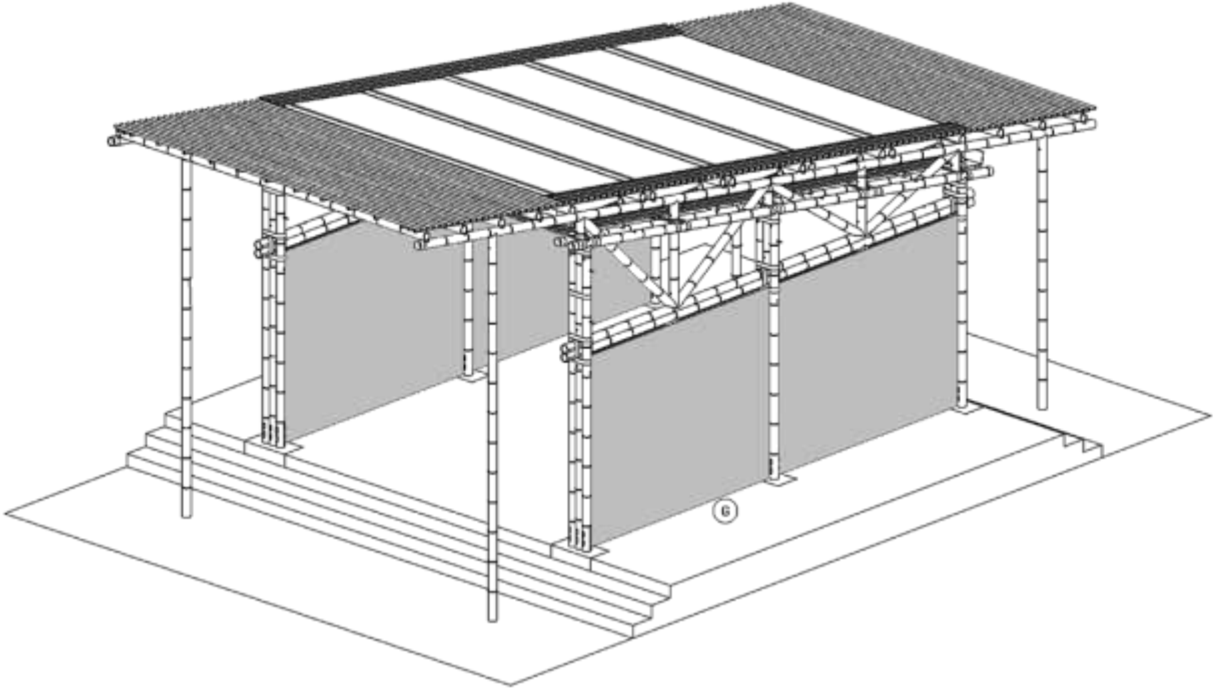




ASSEMBLY STEPS

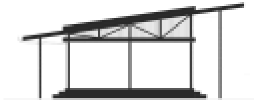
Openwork shading, wall filling & plastering

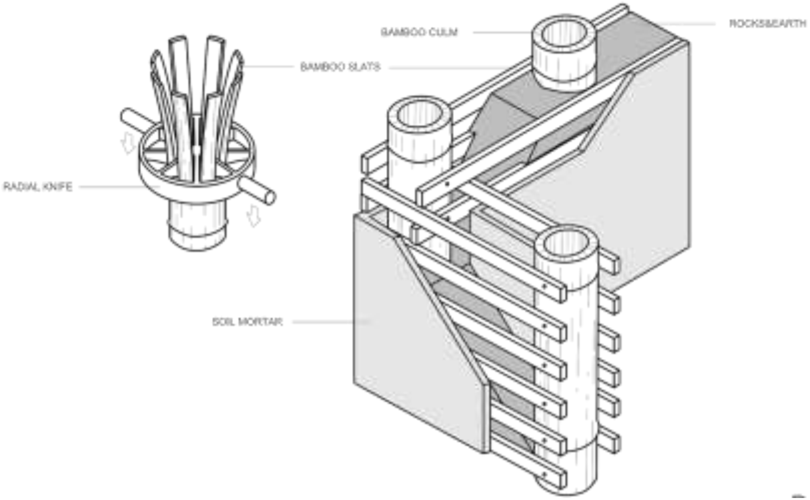


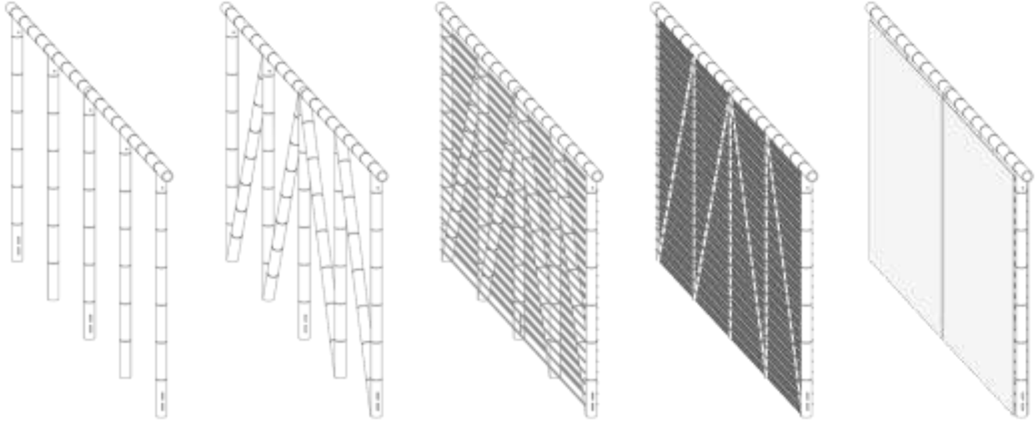


WALL

Local construction technique

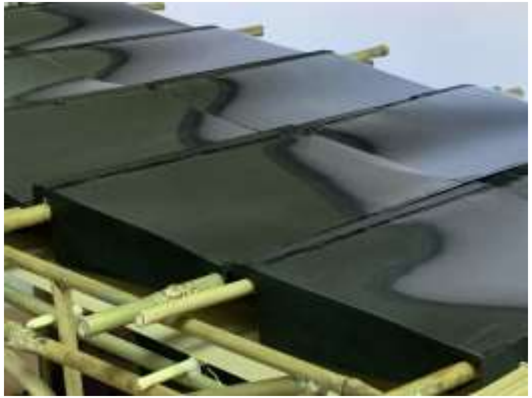






PHYSICAL MODEL

1:10 Maquette

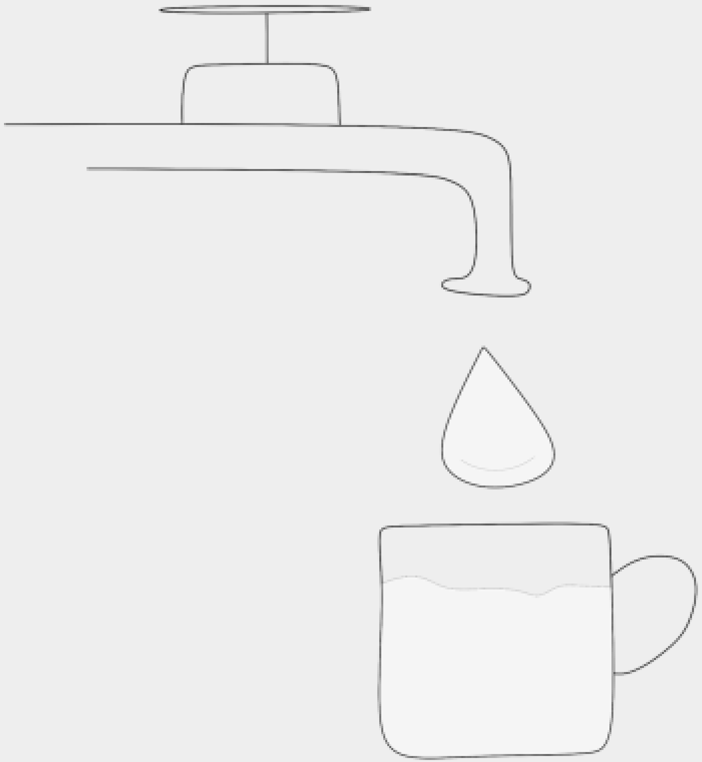


PHYSICAL MODEL

1:10 Maquette

PHYSICAL MODEL

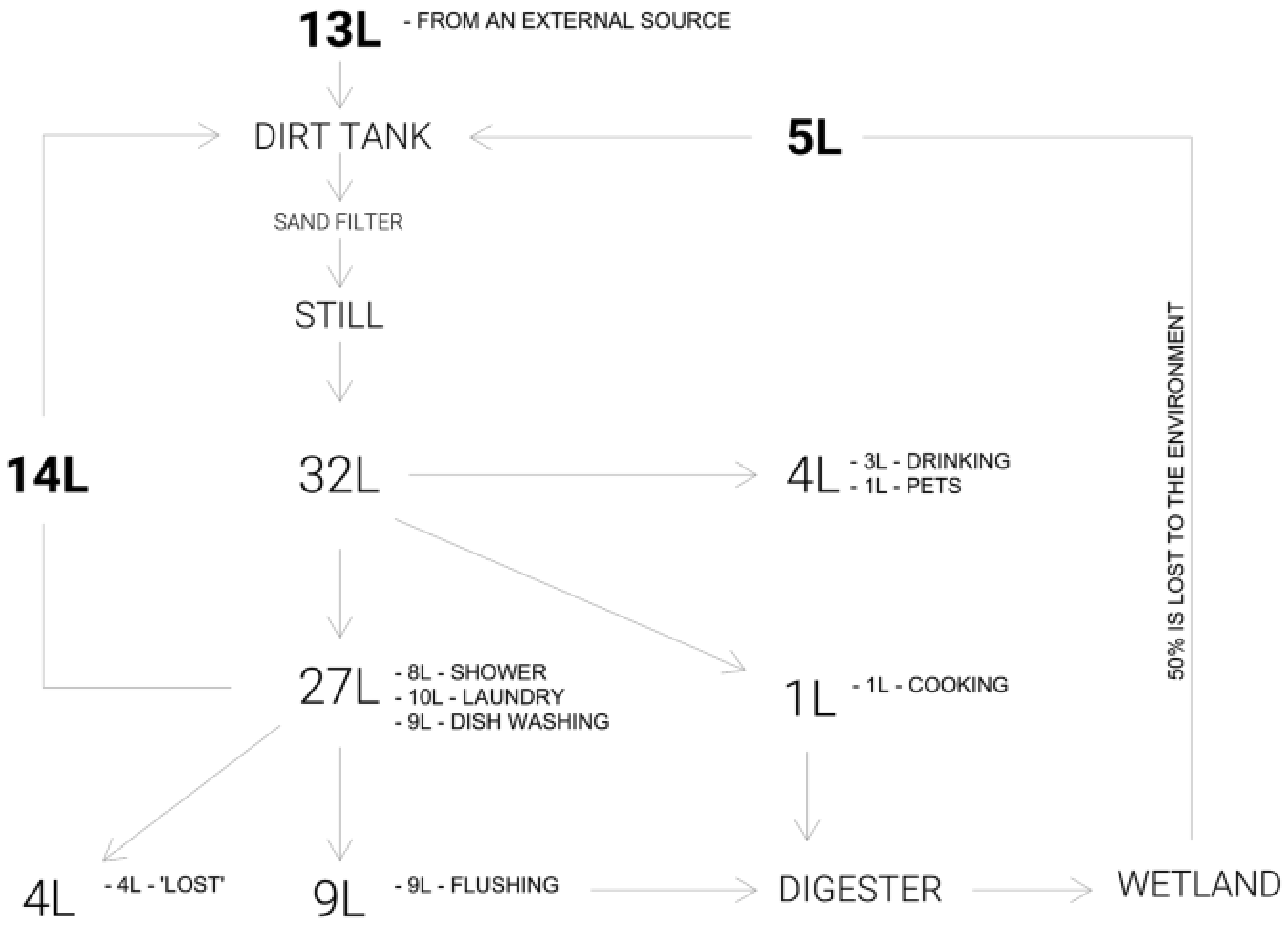
1:10 Maquette



Water System

WATER **FLOW**

Per user



RAINWATER COLLECTION

Main water source

DEMAND FOR WATER FROM EXTERNAL SOURCE

13L x 50PEOPLE = **650L/DAY**

ROOF AREA = **25M2**/MODULE

12MODULES=**300M2**

650x30DAYS = 19 500L

25 000L (RAIN) STORAGE TANK

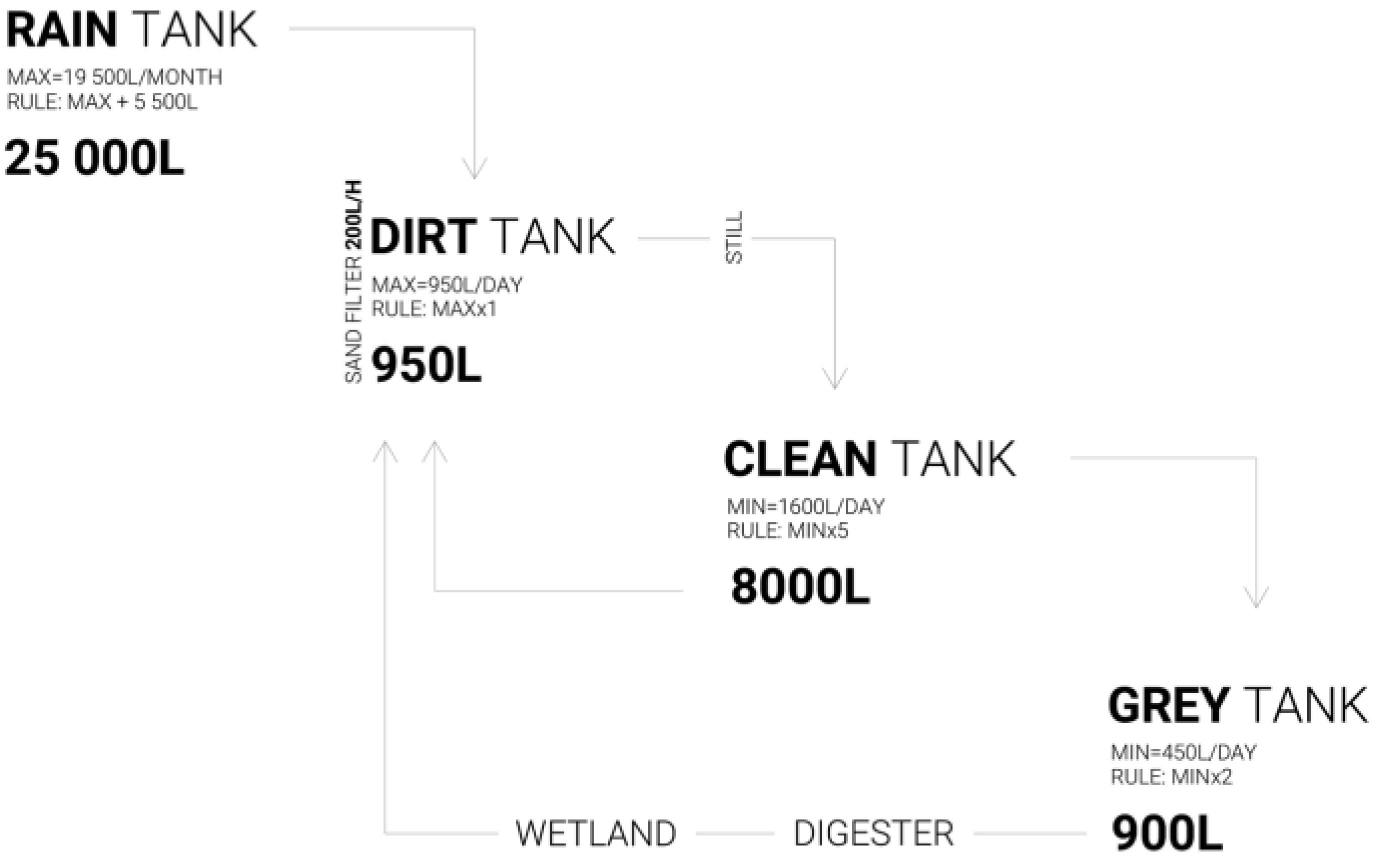
BEIRA AVERAGE PRECIPITATION

MONTH	JAN	FEB	MAR	APR	MAT	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MM	250	300	275	140	85	50	45	40	25	40	110	230
DAYS	11	12	12	8	7	7	8	5	3	5	7	10
L FOR 300M2	75 000	90 000	82 500	42 000	25 500	15 000	13 500	12 000	7 500	12 000	33 000	69 000
L/DAY (1/30)	2500	3000	2750	1400	850	500	450	400	250	400	1100	2300
	RAIN WATER **COVERED**	RAIN WATER **COVERED**	RAIN WATER **COVERED**	RAIN WATER **COVERED**	RAIN WATER **COVERED**	RAIN WATER **COVERED** 5 500L FROM TANK	**6 000L** TO BRING	**7 500L** TO BRING	**12 000L** TO BRING	**7 500L** TO BRING	RAIN WATER **COVERED**	RAIN WATER **COVERED**

(Climates To Travel, 2019)

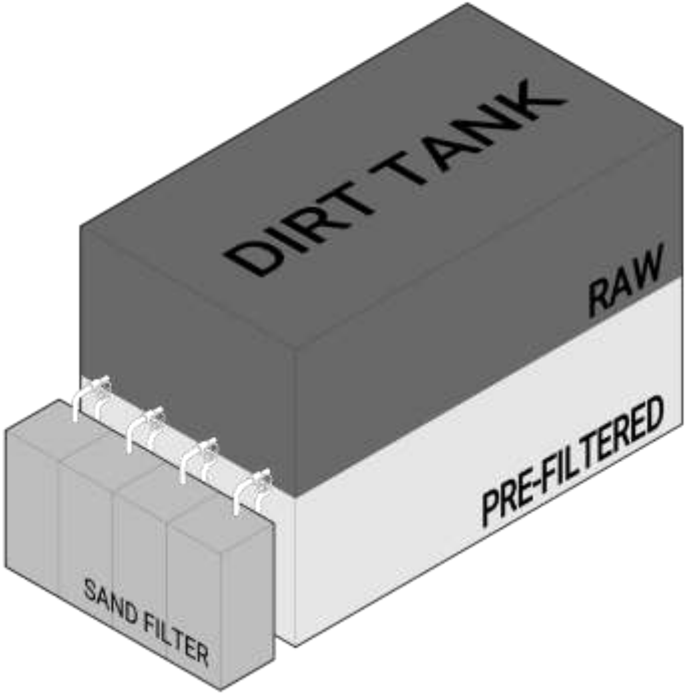
WATER **TANKS**

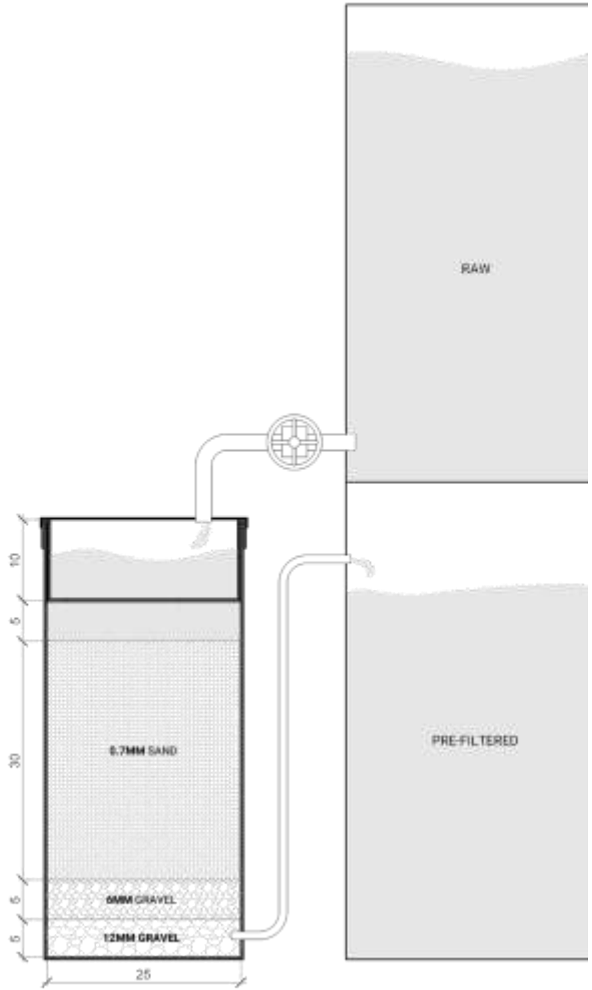
System infrastructure



PRE-FILTRATION

Dirt Tank with Sand Filter

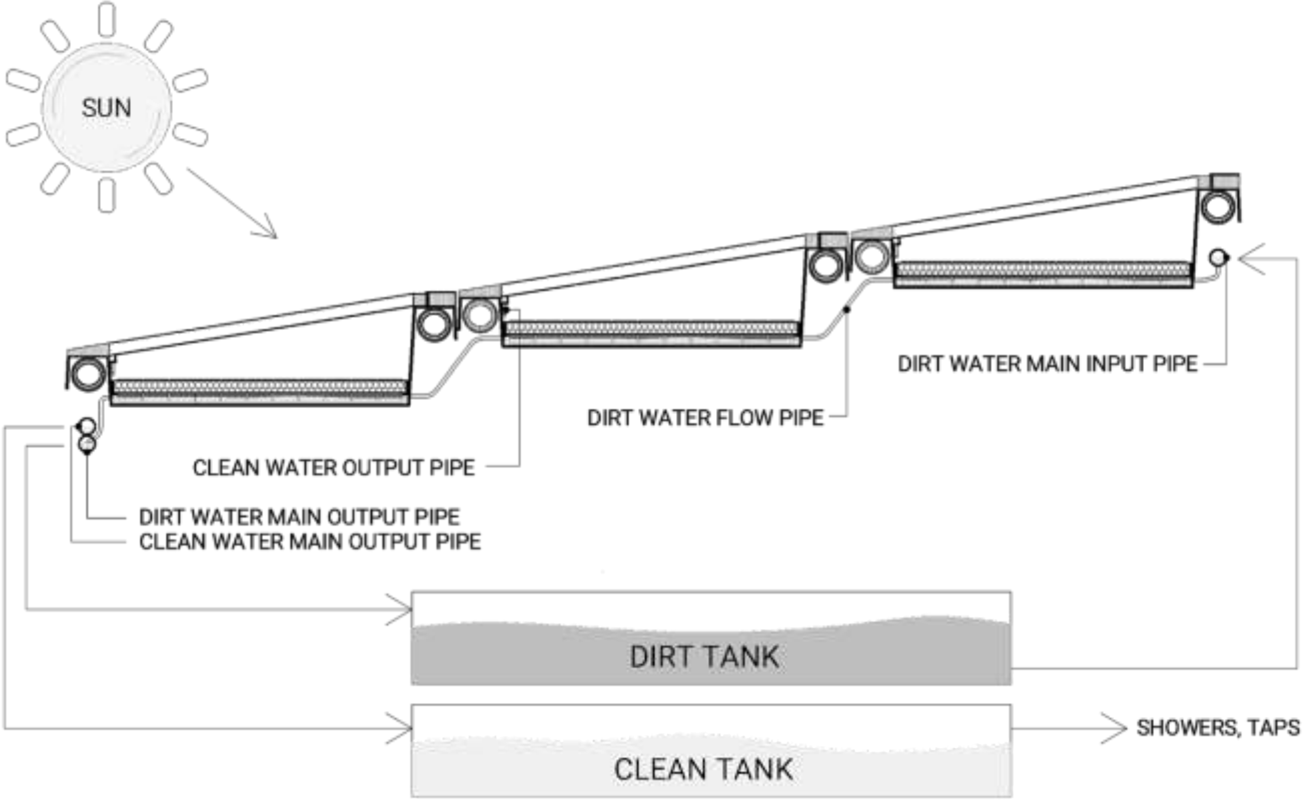




(CAWST, 2009)

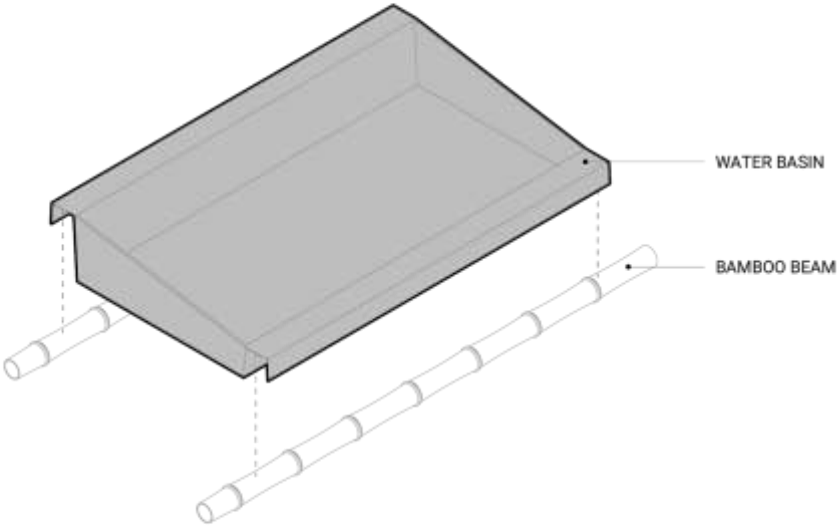
SOLAR-STILL SYSTEM

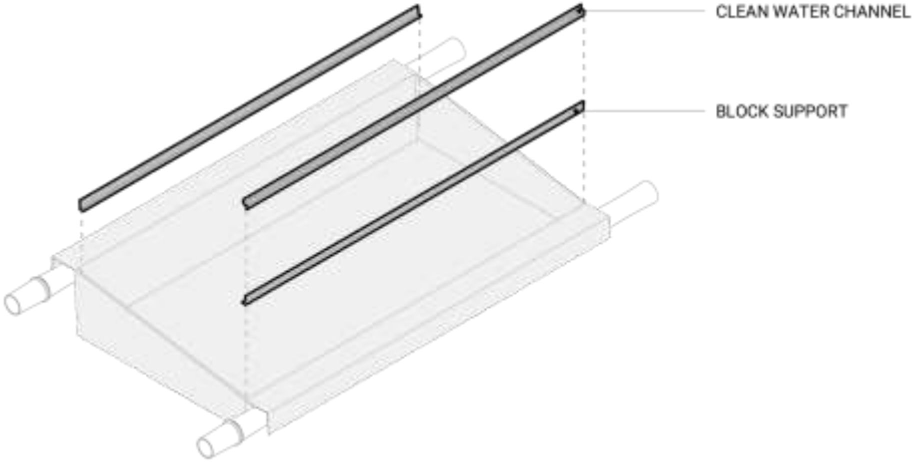
Roof units



WATER **BASIN**

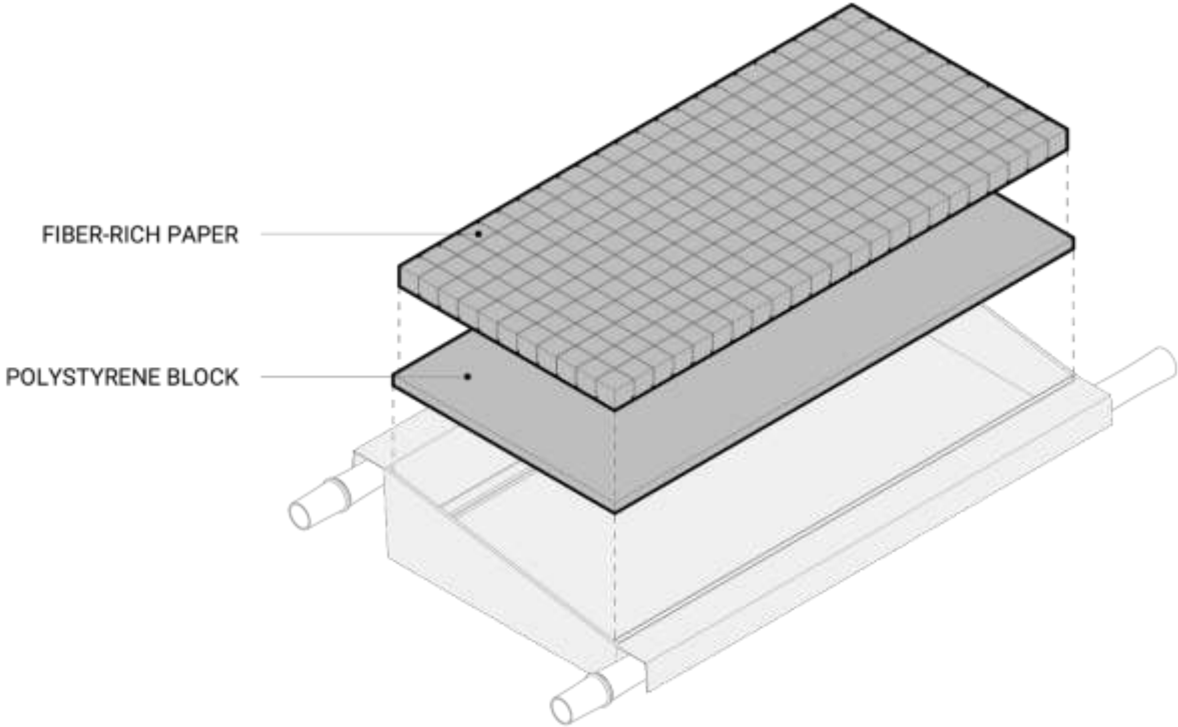
GFRP form





POLYSTYRENE BLOCK

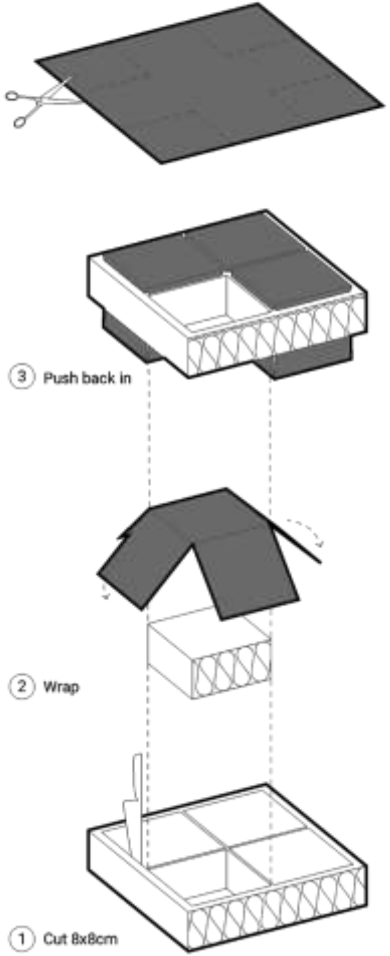
Thermal barrier



FIBER-RICH PAPER

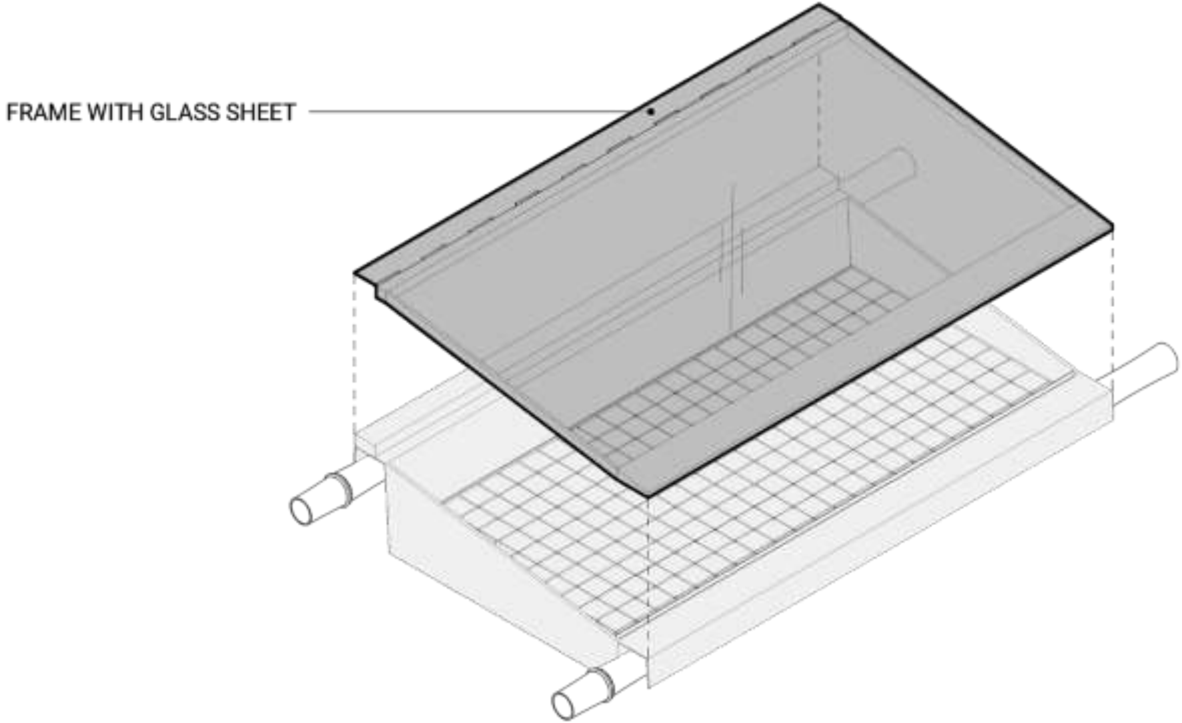
Carbon-coated wipes

SR511 TOKAI Carbon Black



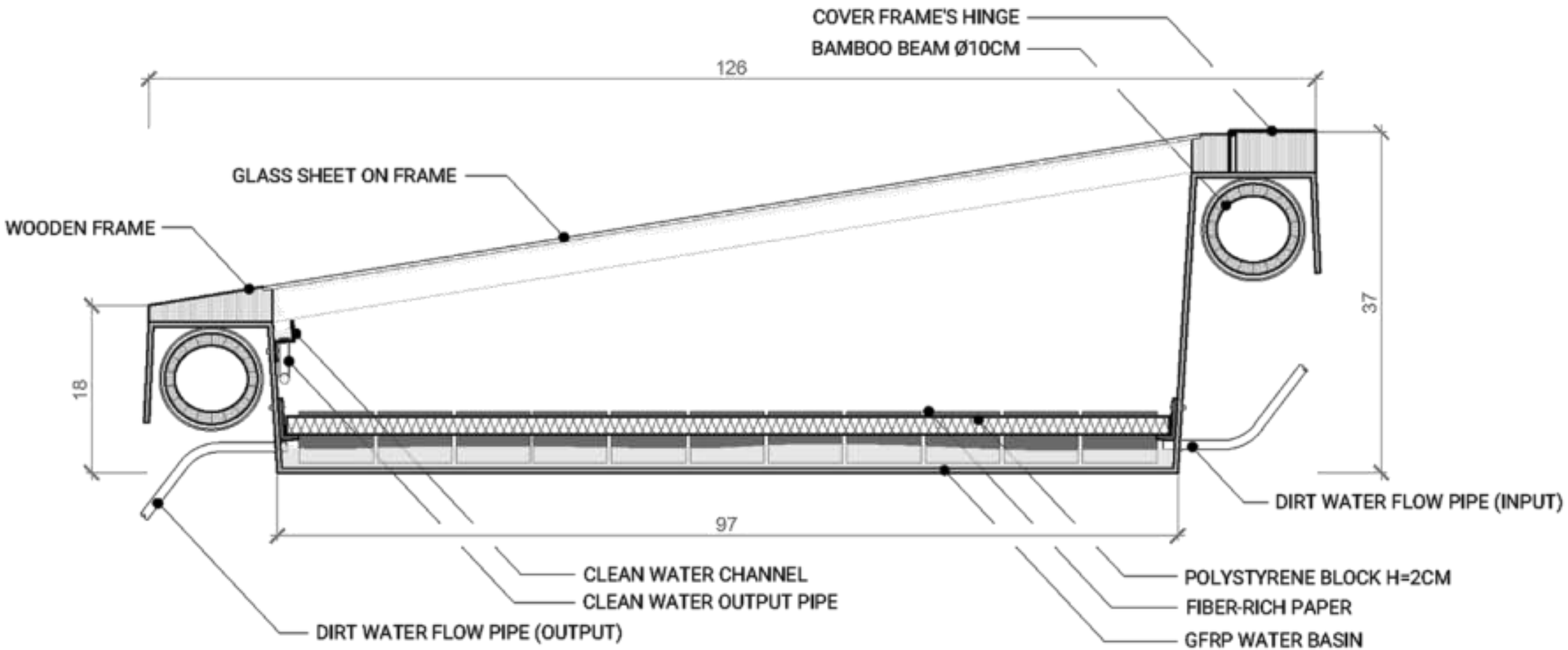
TRANSPARENT **COVER**

Glass panel



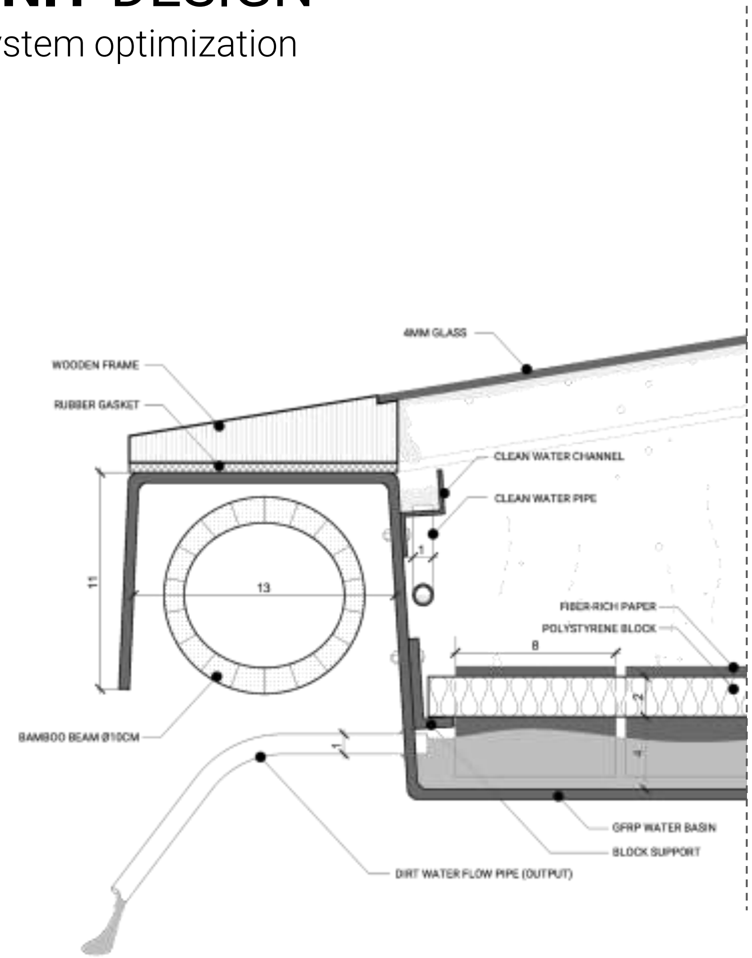
UNIT DESIGN

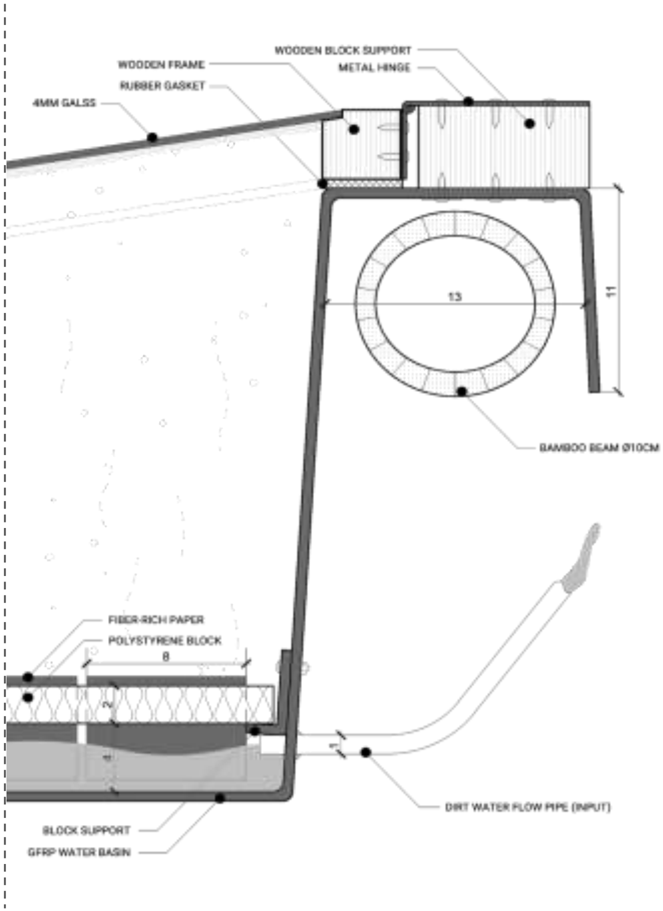
System optimization



UNIT DESIGN

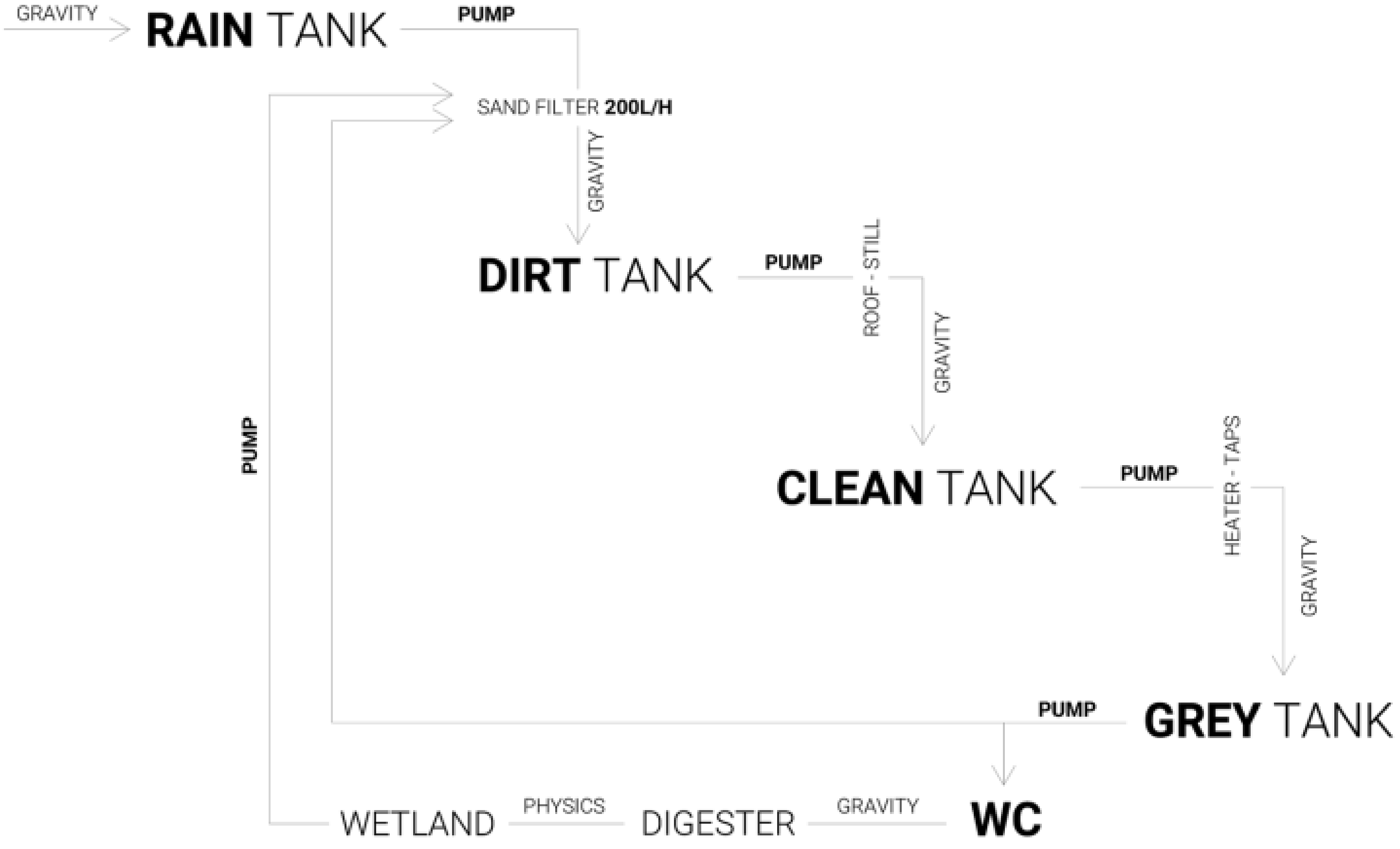
System optimization





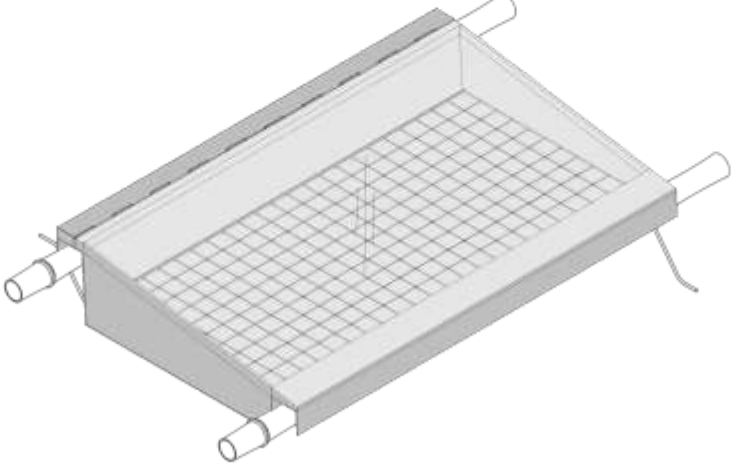
SYSTEM **MAINTENANCE**

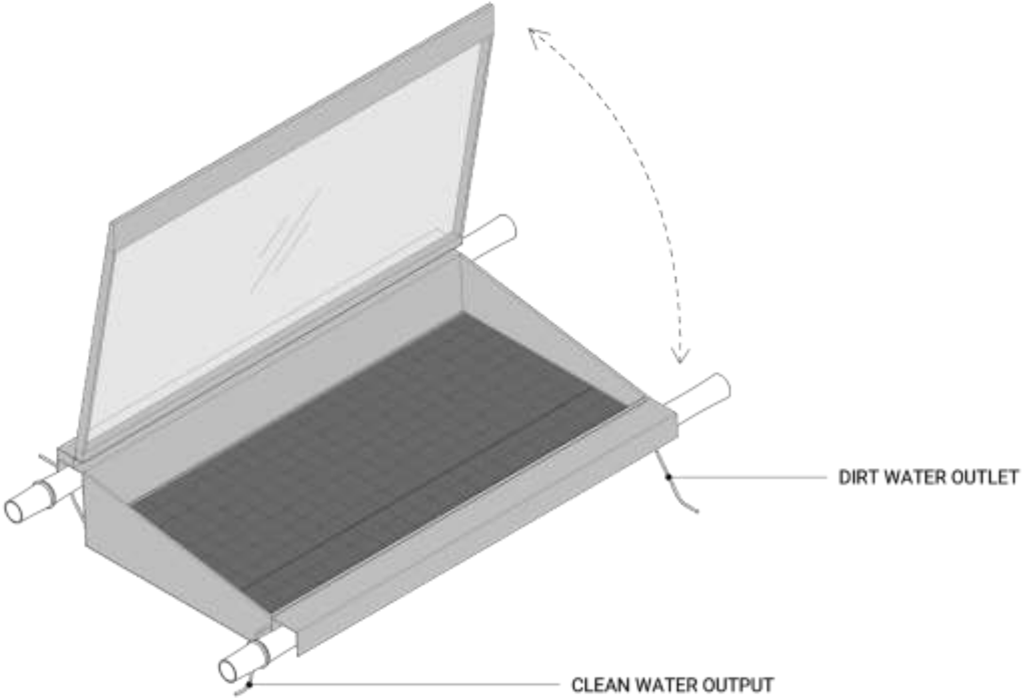
Service-free design



SYSTEM **MAINTENANCE**

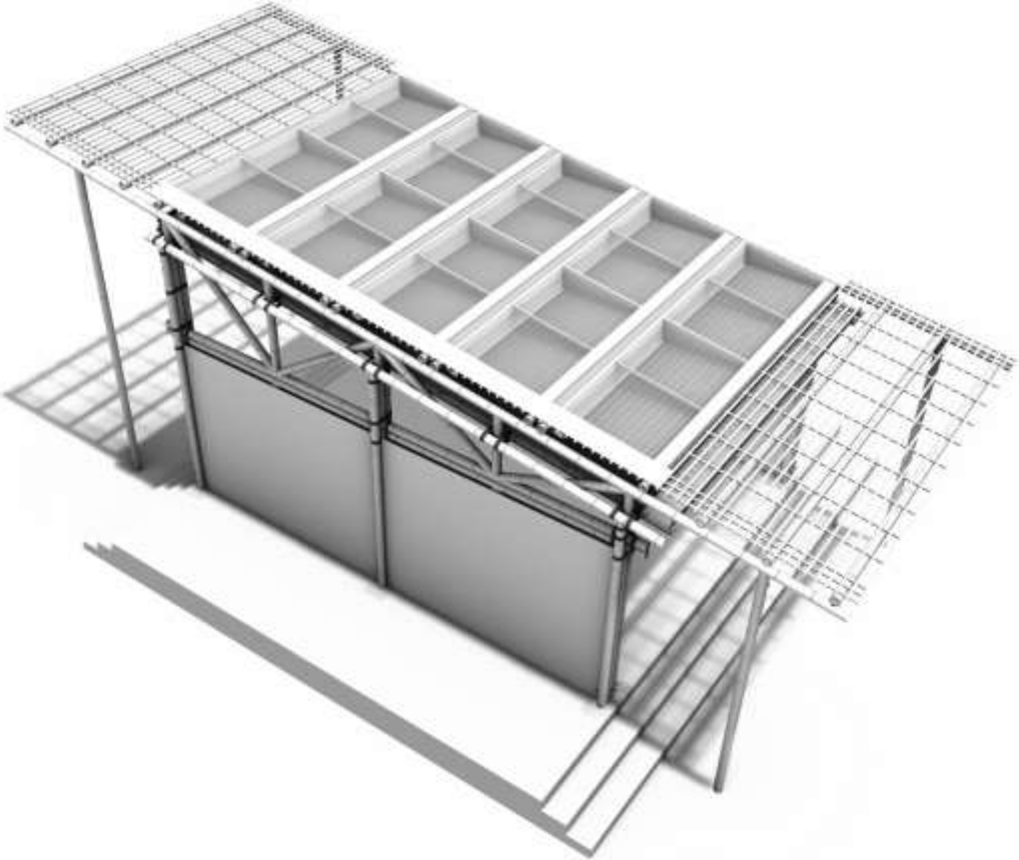
Periodical cleaning





WATER SYSTEM **MODULE**

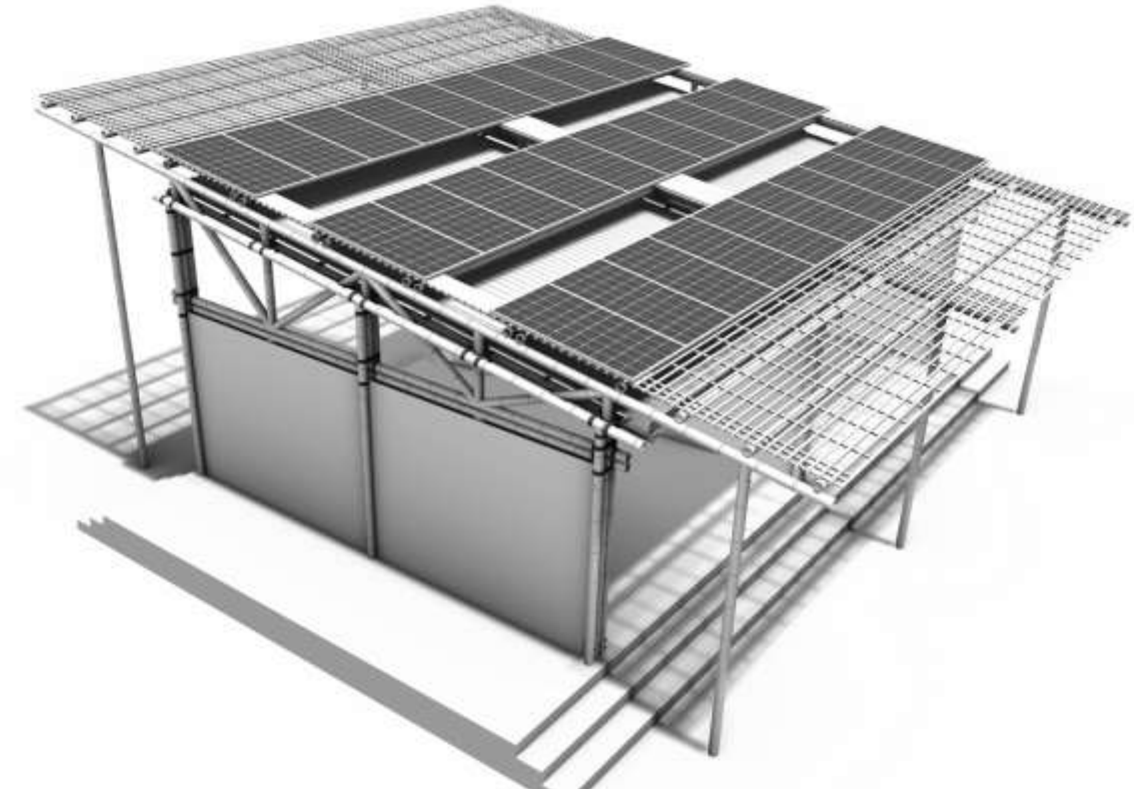
Solar-still roof



Electricity System

ENERGY SYSTEM **MODULE**

PV roof



PHOTOVOLTAICS

Electricity storage

Public HUB	Off-sun hours energy demand
4 Fridges - Shops (12h)	1.70kWh
6 Computers (2h)	1.80kWh
Water pumps (3h)	1.20kWh
Lighting	0.1kWh
	4.80kWh

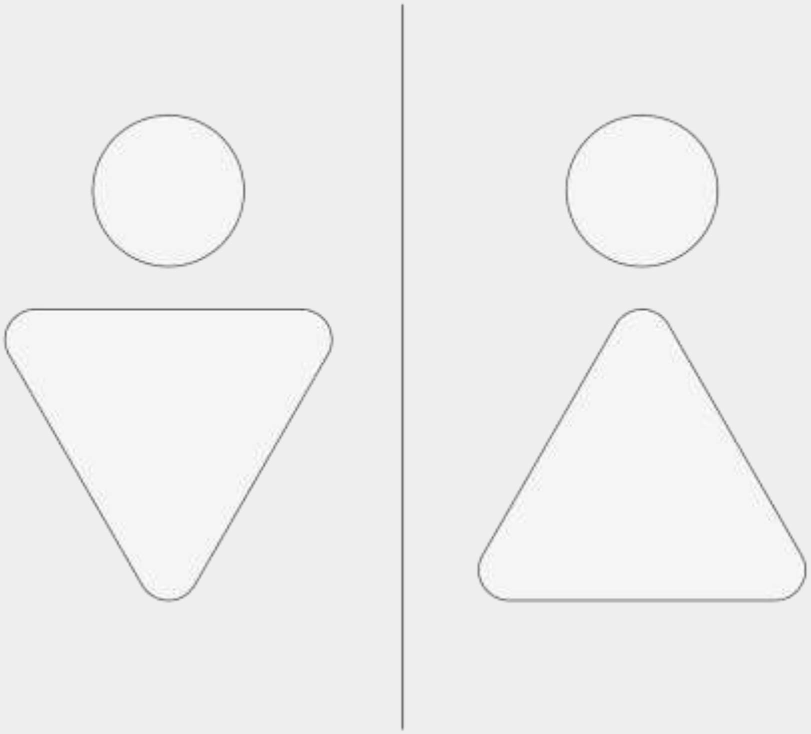
3x

Residential HUB	Off-sun hours energy demand
Fridge (12h)	0.42kWh
Lighting (5h)	0.20kWh
Computer (1.5h)	0.23kWh
TV (1h)	0.10kWh
	0.95kWh/house=9.50kWh/hub
Water pumps (3h)	1.20kWh
Lighting	0.1kWh
	10.80kWh

7x

Car battery 200Ah 12V

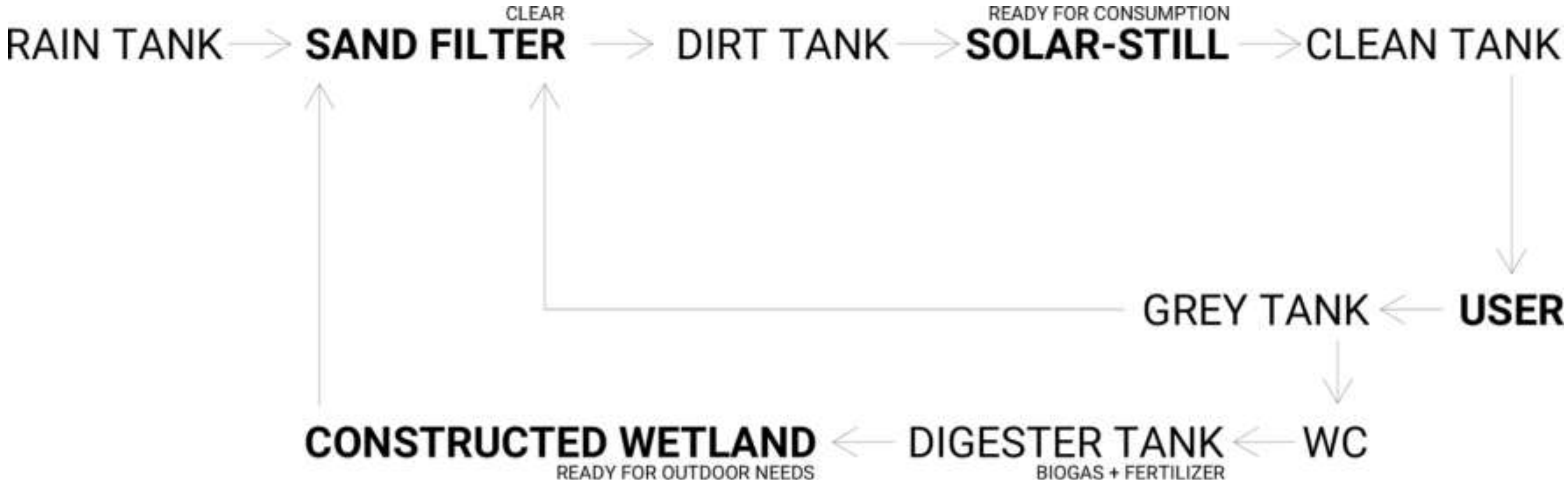
Car accumulator	
P=U*I [W]	P=200*12=2400W=2.4kWh
U - electric voltage	U=200Ah
I - electric current	I=12V
30% loss	2.4*0.7=**1.7kWh**



Sanitation Strategy

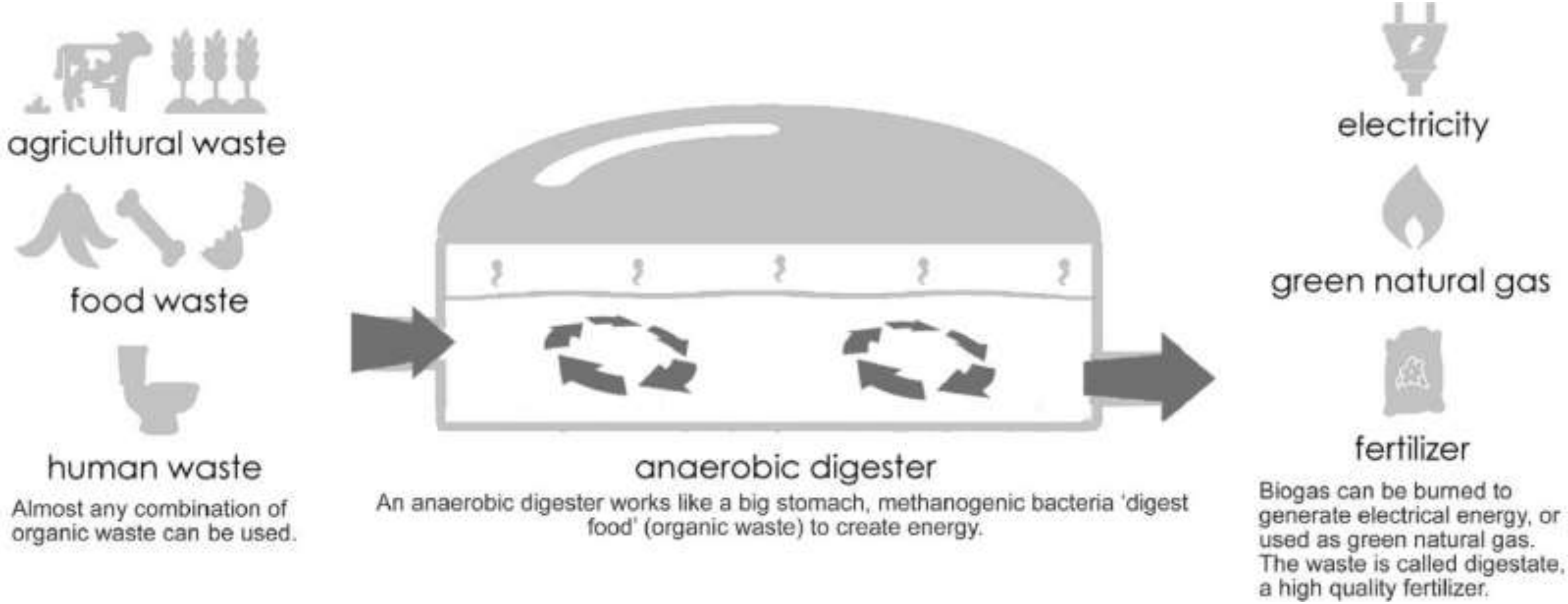
WASTE-WATER **STRATEGY**

Reduce, Reuse, Produce



BIOGAS PLANT

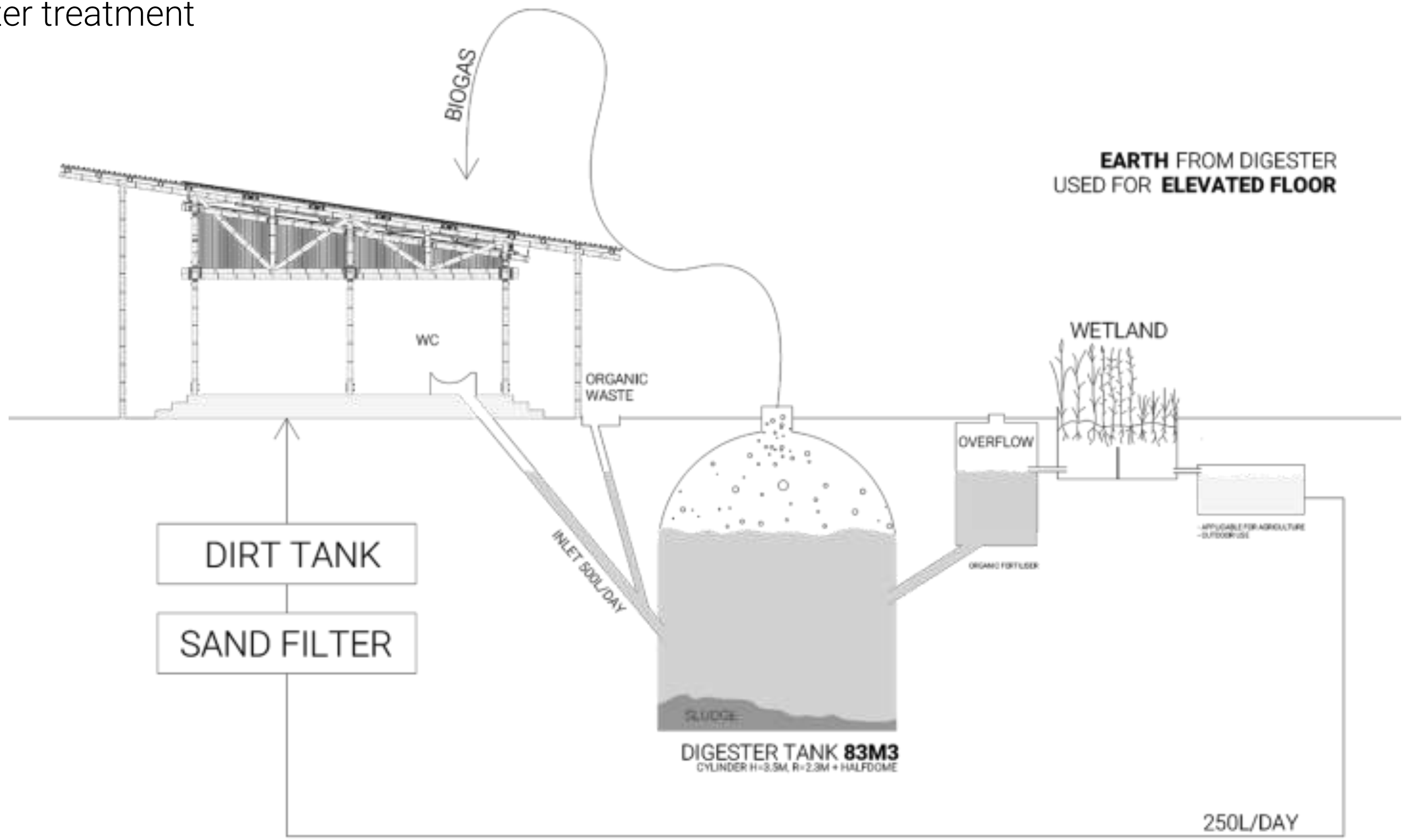
Energy for cooking and water heating



(Polit, 2013)

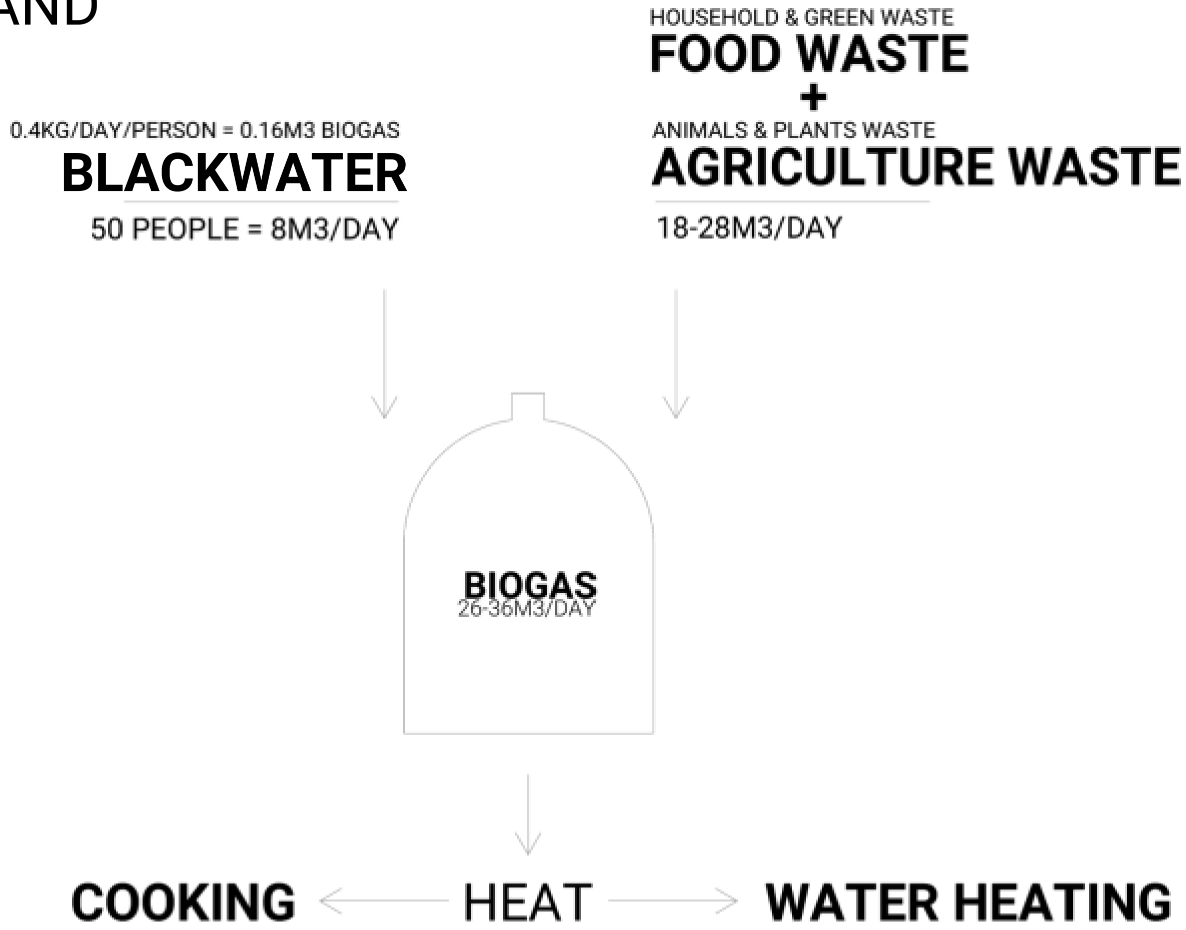
BIOGAS SYSTEM

Blackwater treatment



BIOGAS DEMAND

Plant input & output



(Panjwani, 2017)

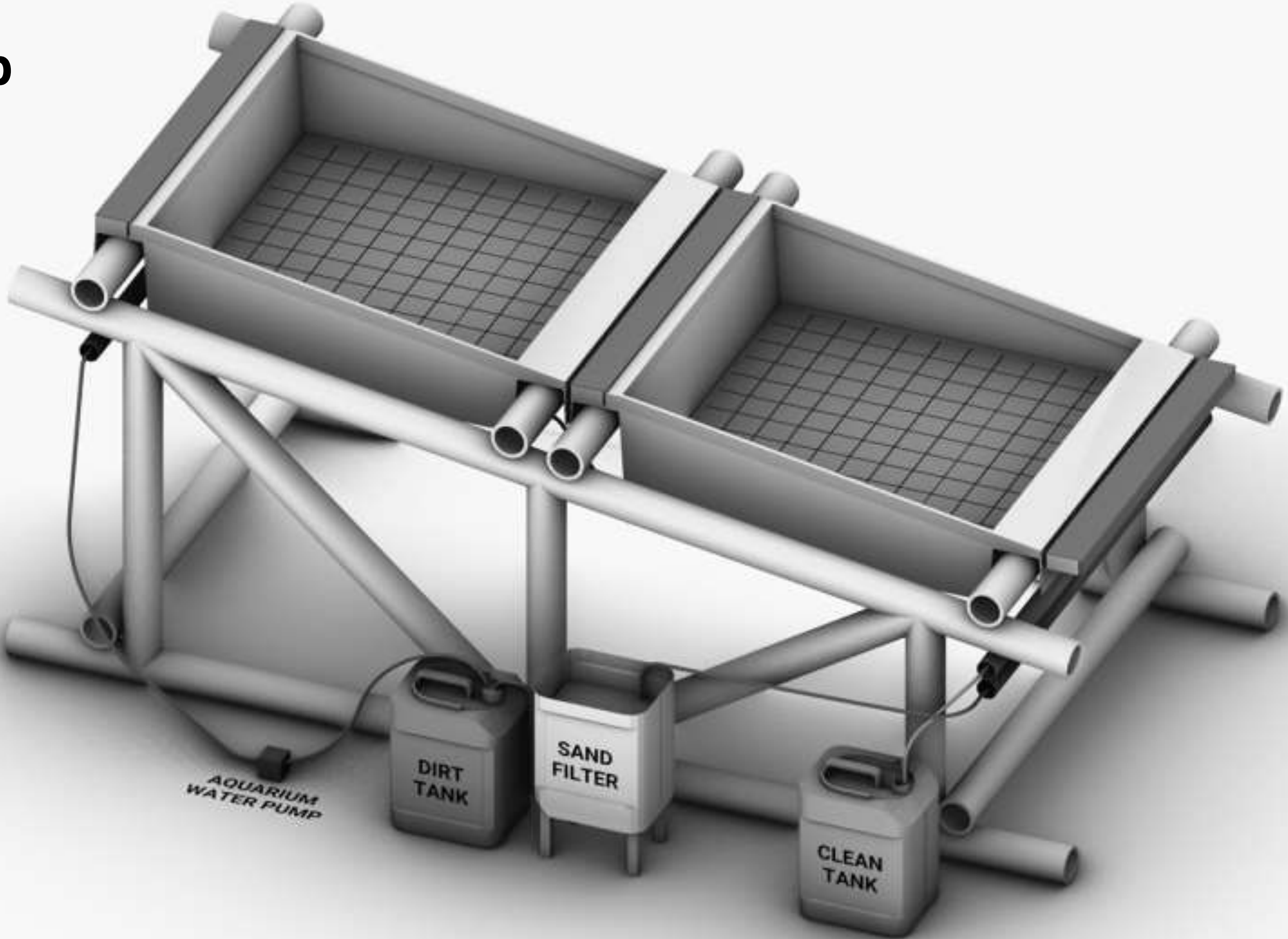
BIOGAS BENEFIT

Life quality improvement

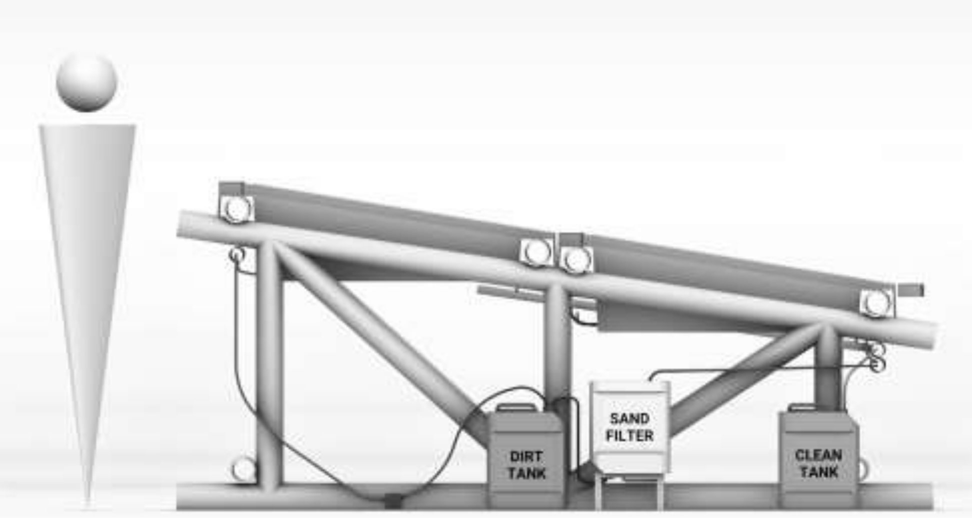
	WATTS	HOURS/DAY	kWh/DAY
SMARTPHONE	6	1	0.024
TV	140	2	0.280
COMPUTER	200	3	0.600
FRIDGE	35	24	0.840
LED BULB	10	5	0.200

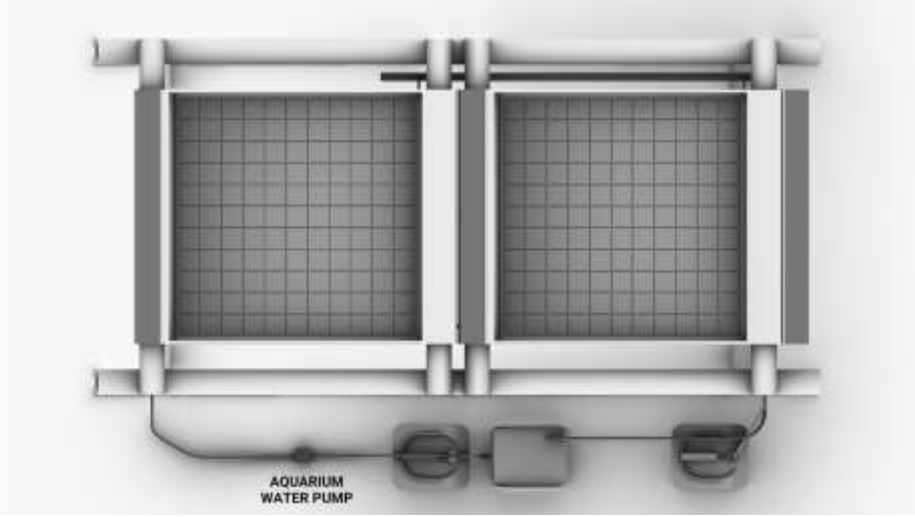
700 kWh/YEAR

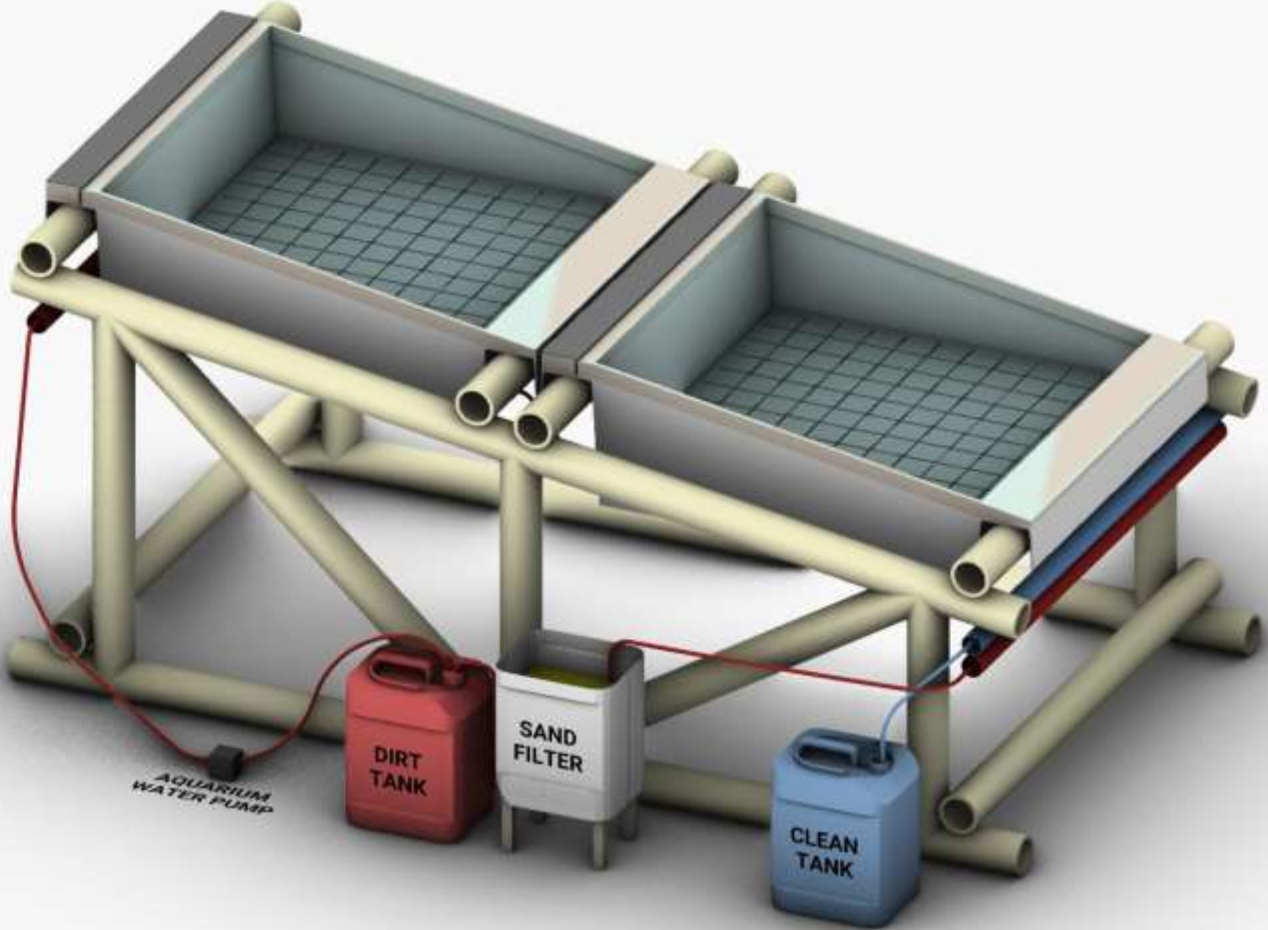
Mock-up



MOCK-UP
Prototyping

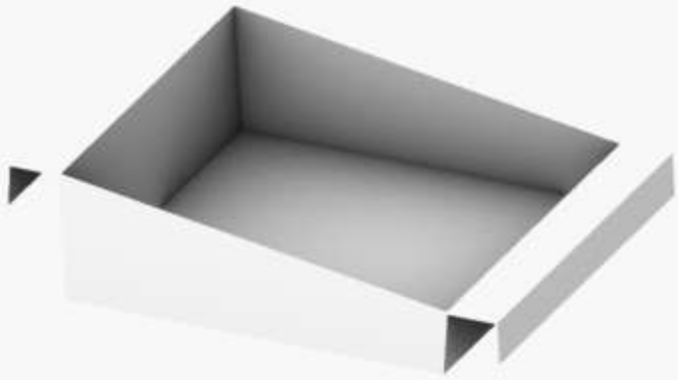


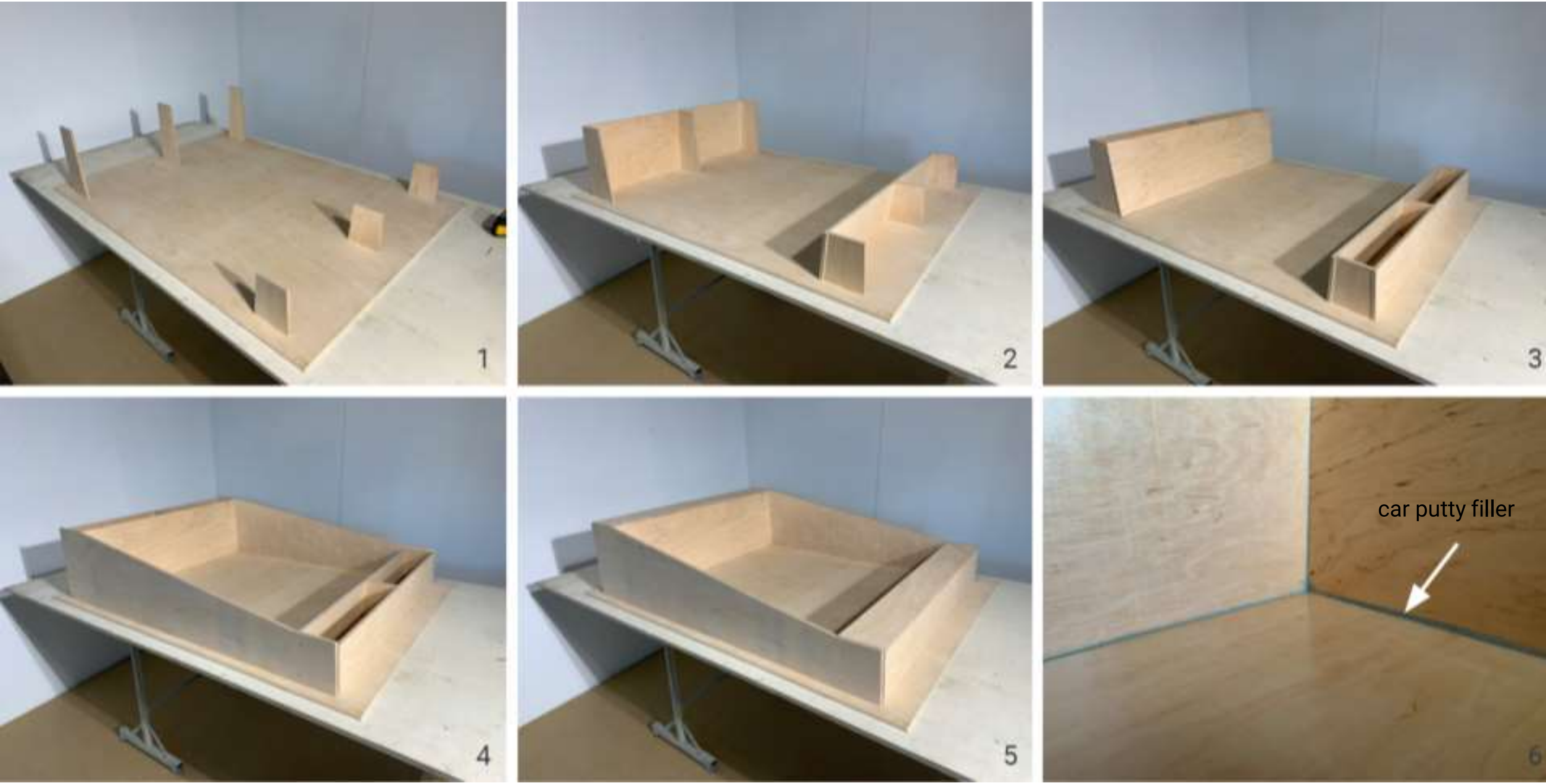



AQUARIUM WATER PUMP
DIRT TANK
SAND FILTER
CLEAN TANK

Water basin

1x1m

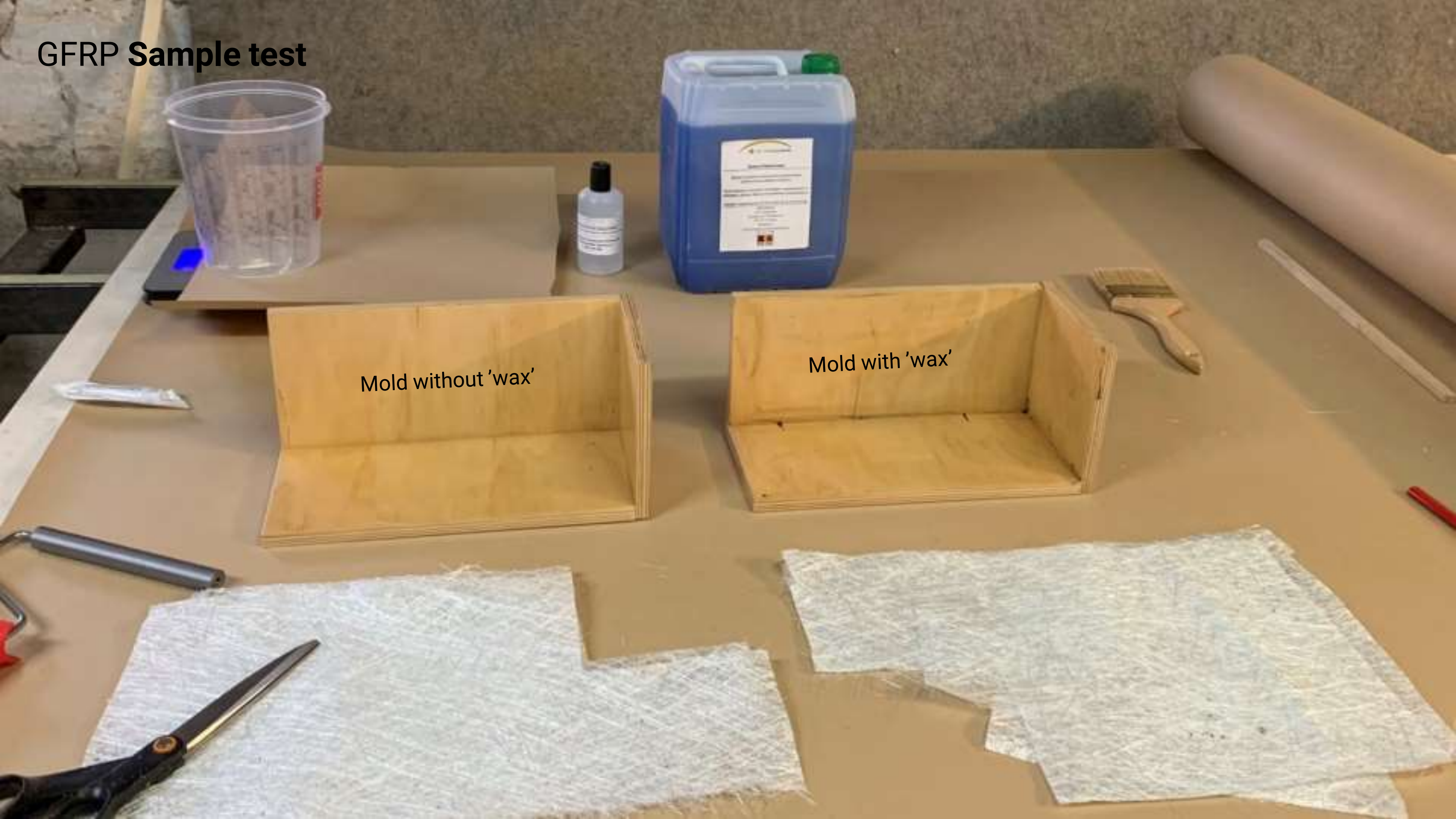



1
2
3
4
5
car putty filler
6

Plywood **Mold**
1x1m

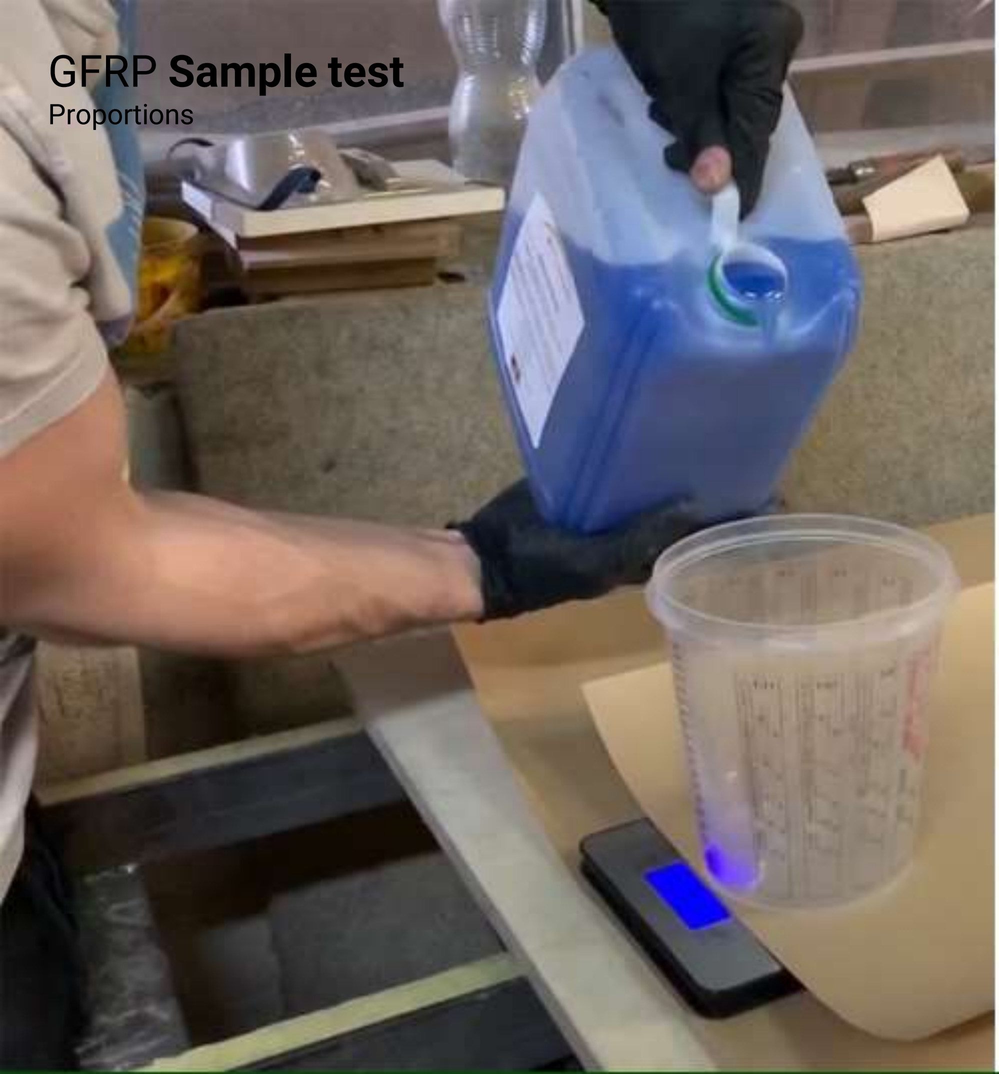
RESIN ON PLYWOOD = 500g/m2
RESIN ON FIBERGLASS (300g) = 650g/m2
CATALYST 1% OF RESIN

GFRP **Sample test**



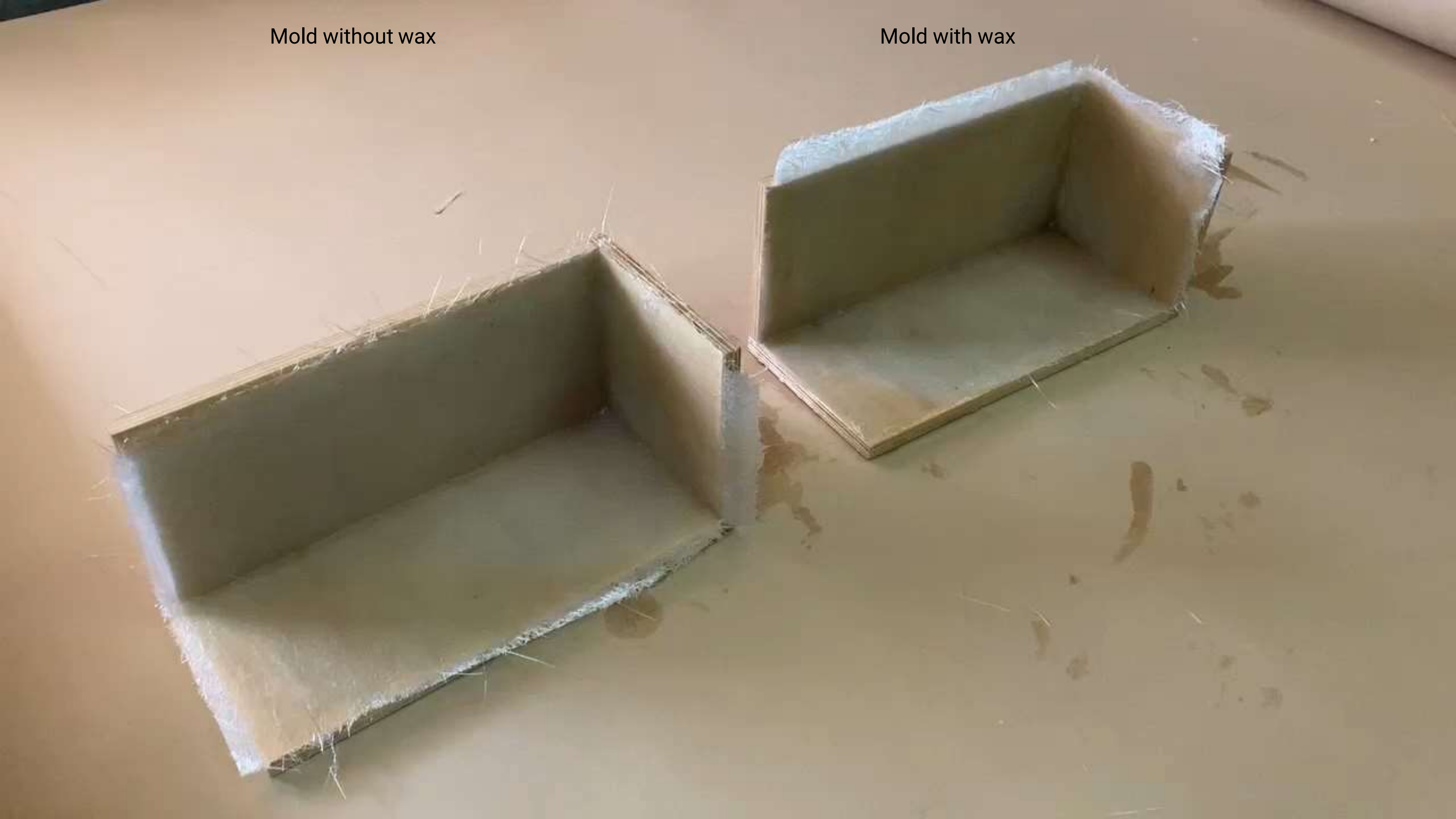
GFRP **Sample test**

Proportions



GFRP **Sample test**

Casting


Mold without wax
Mold with wax

GFRP **Sample test**

Water tightness

Fiberglass mat

Paper cardboard model

Tip: It is always better to buy more material than less…

Water basin **casting**
1x1 GFRP basin

GFRP **Water basin**

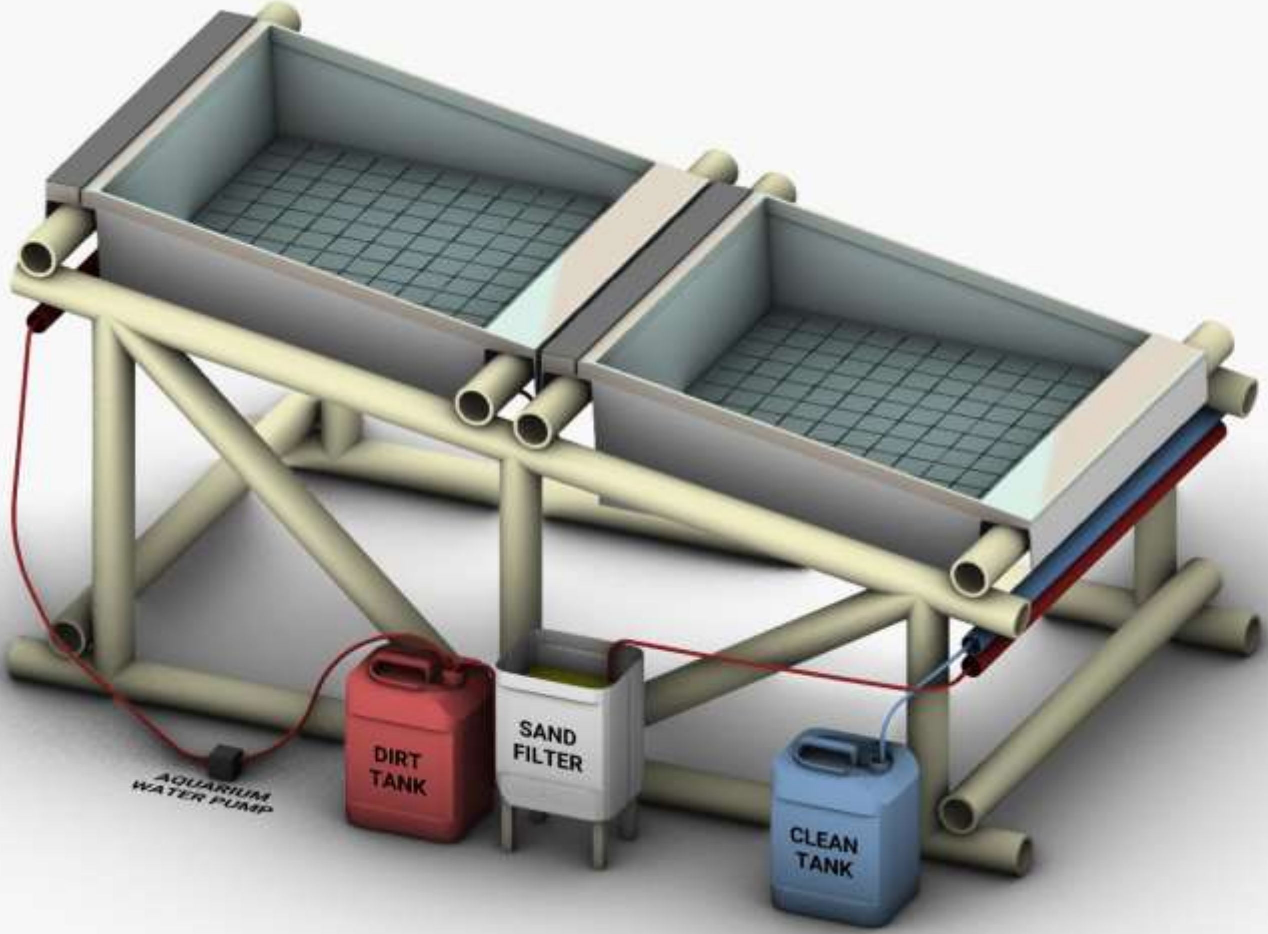
In mold

GFRP **Water basin**

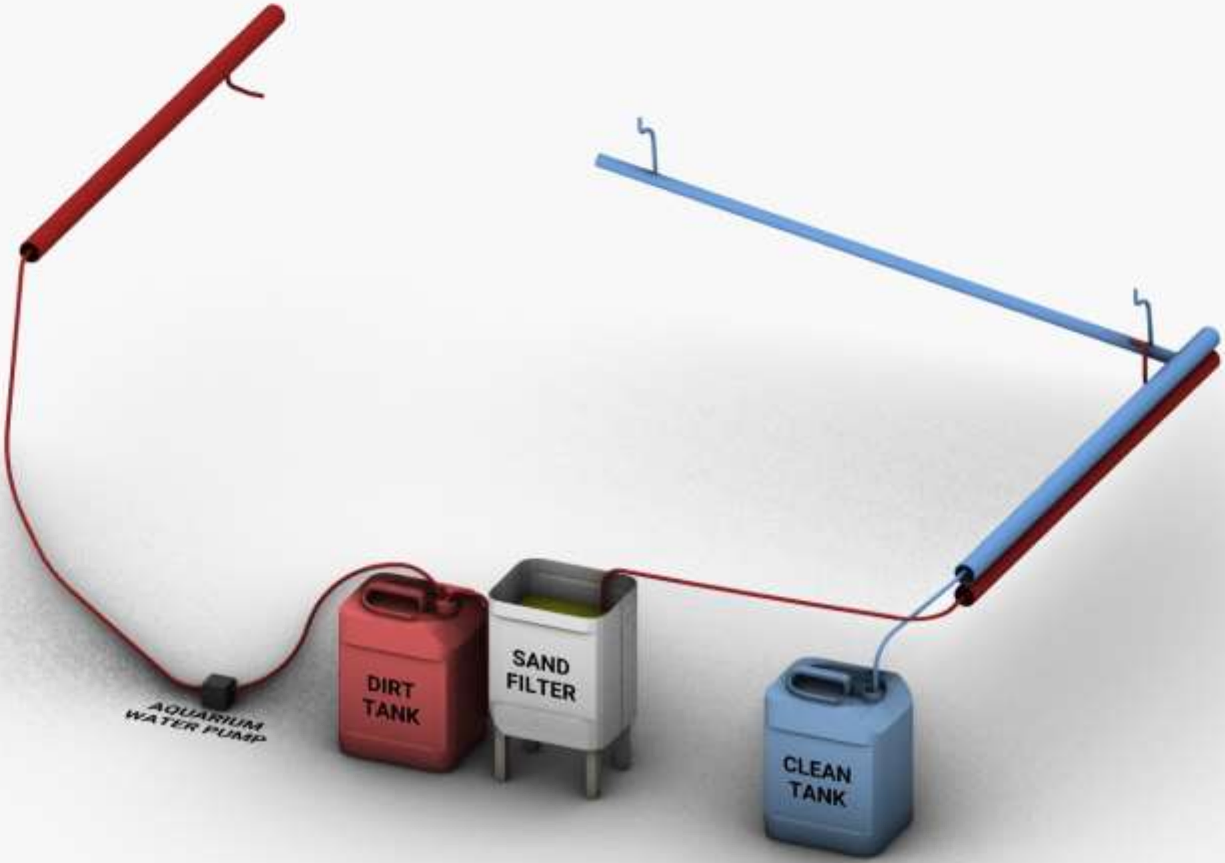
Postprocessing

Surface sanding

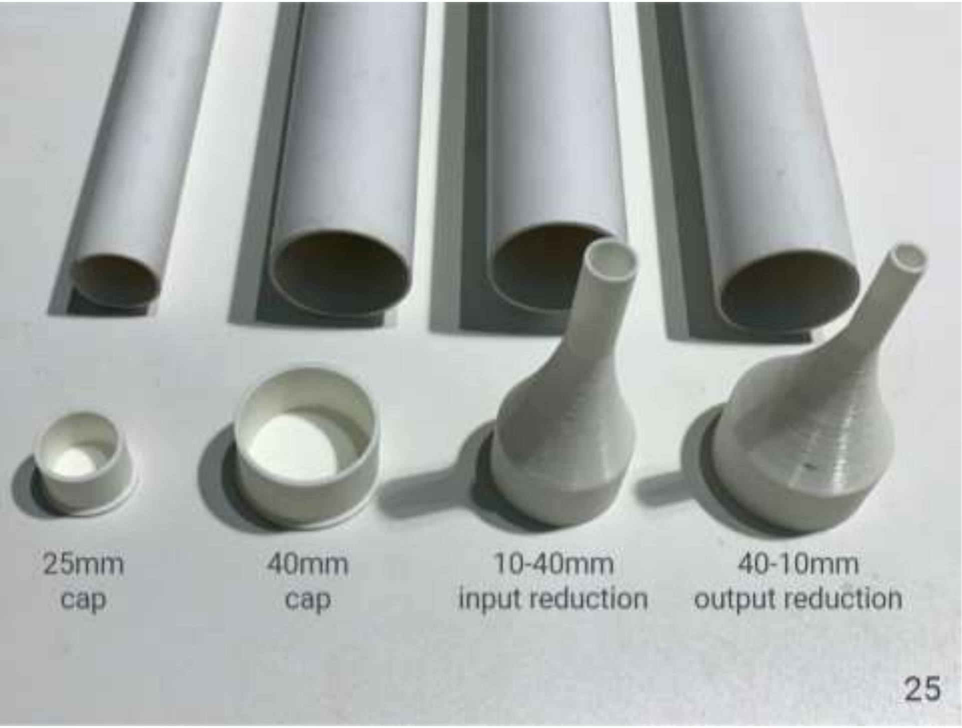
Edge trimming


AQUARIUM
WATER PUMP
DIRT
TANK
SAND
FILTER
CLEAN
TANK

Piping
Water input & output



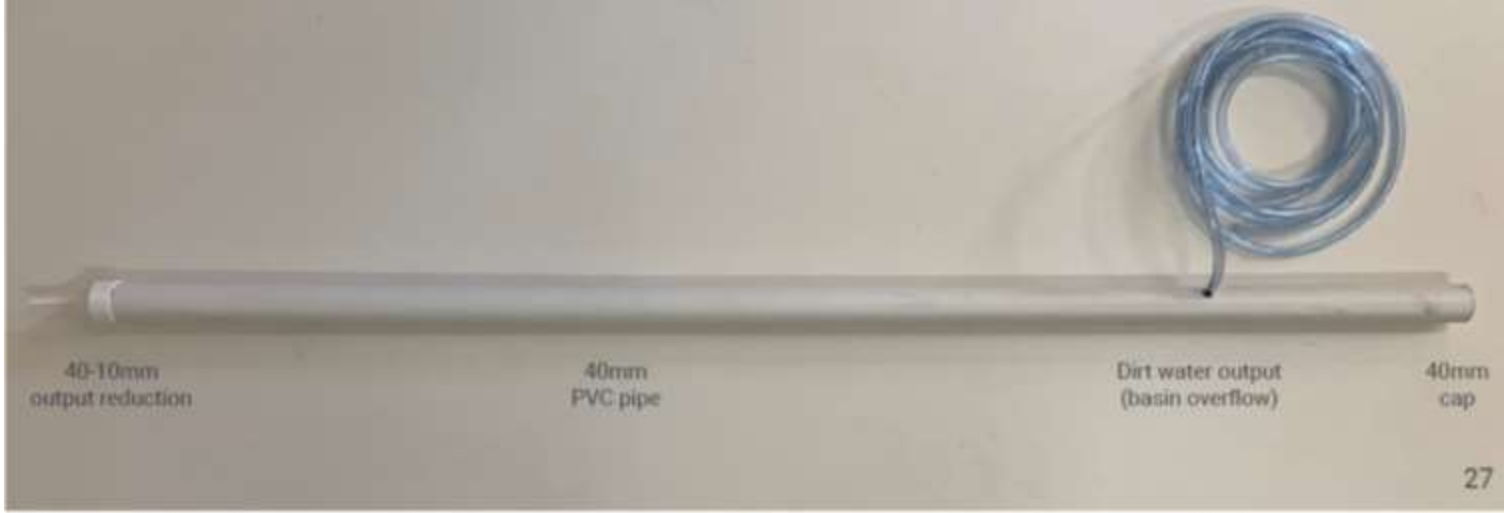
Piping
3D printed reductions



Water **pump**

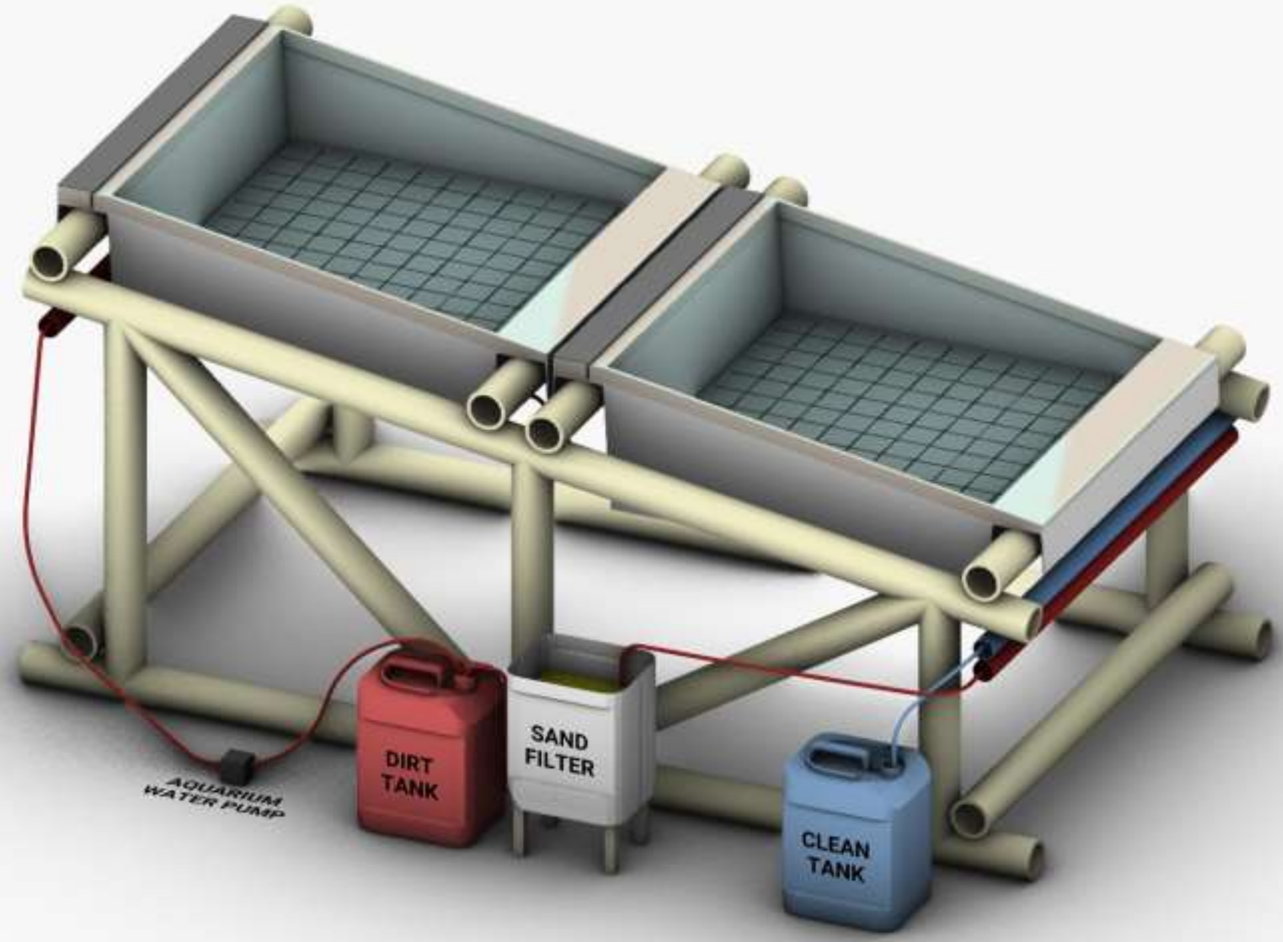
Aquarium pump

Piping
Drilled connections



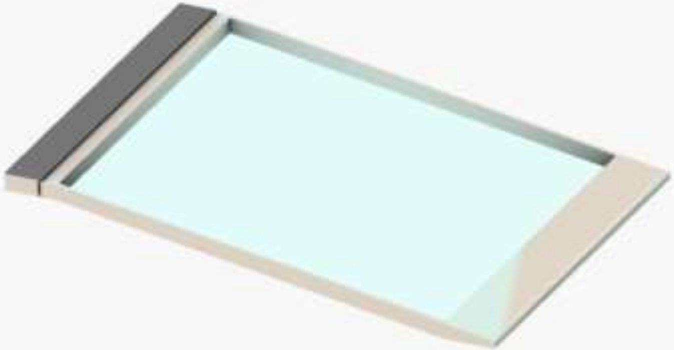
Profiles
Support and water collection

Pipes
Dirt water input & output


AQUARIUM
WATER PUMP
DIRT
TANK
SAND
FILTER
CLEAN
TANK

Transparent cover

Wooden frame with ETFE



WOODEN FRAME

ETFE 150MIC

RUBBER GASKET

TEST 1

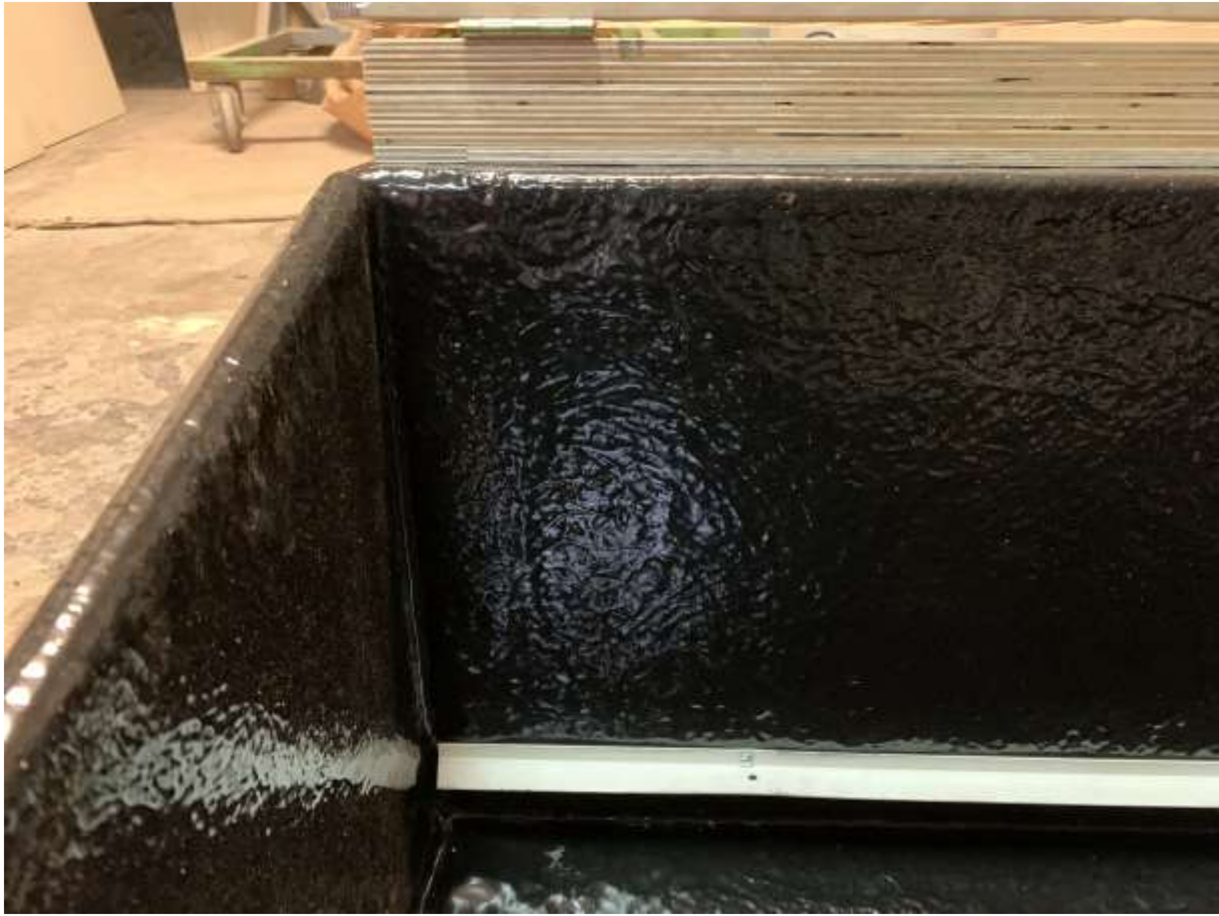
(FAIL 1...)

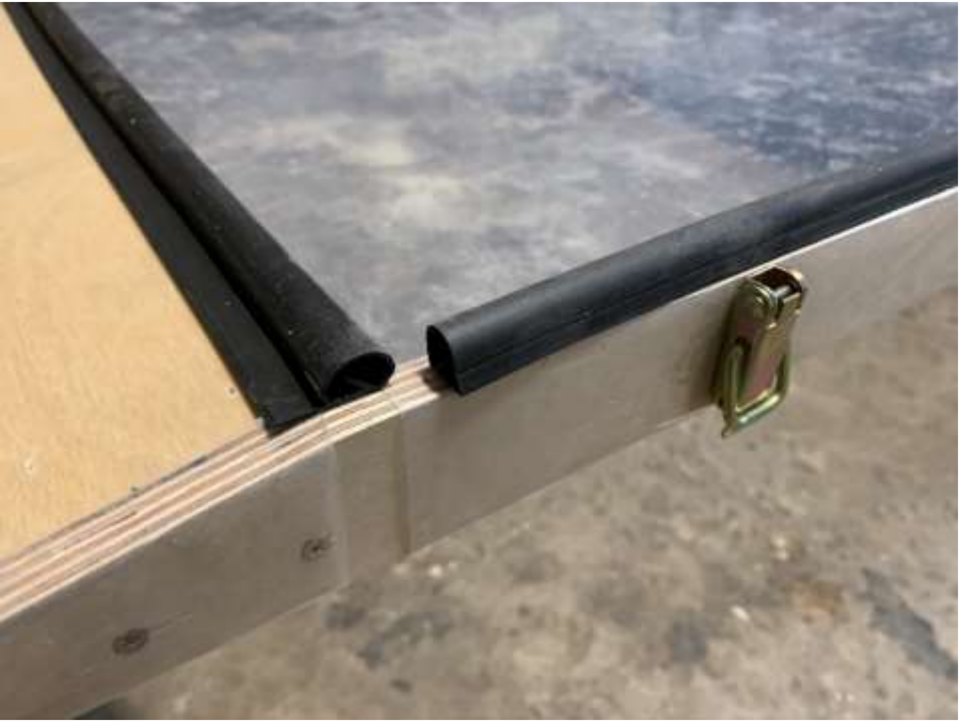
IMPROVISING…

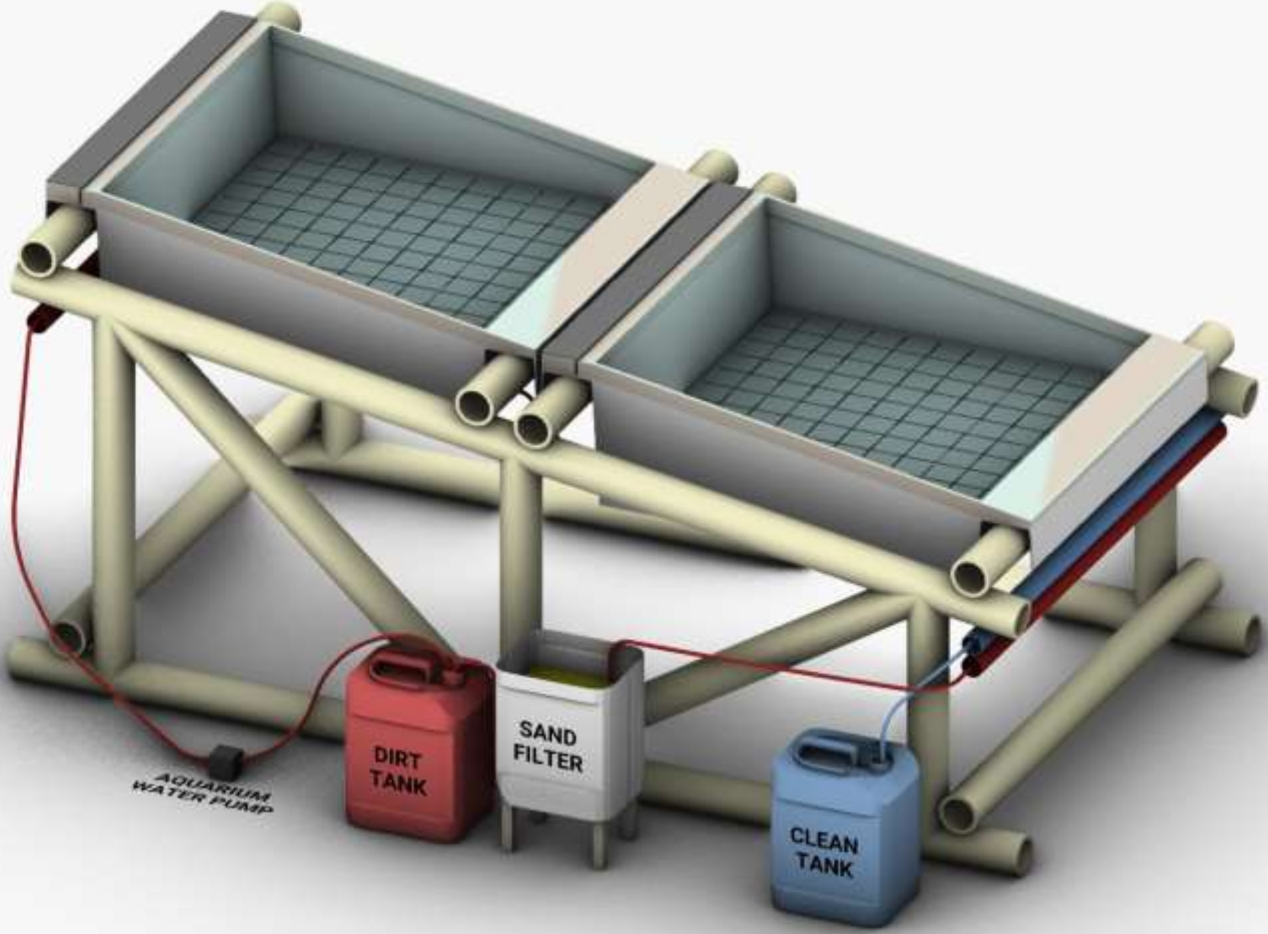
Water basin **topcoat**

Polyester lacquer

+POLYESTER LACQUER



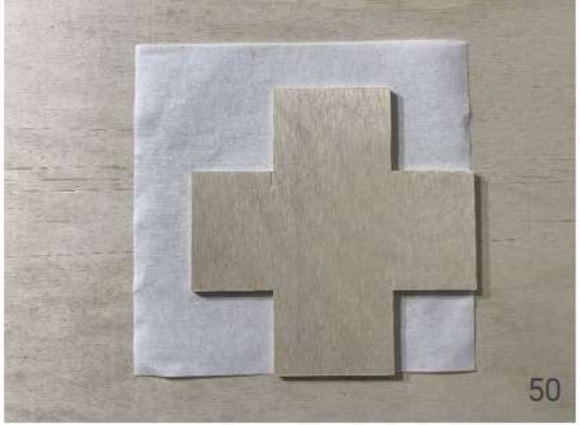


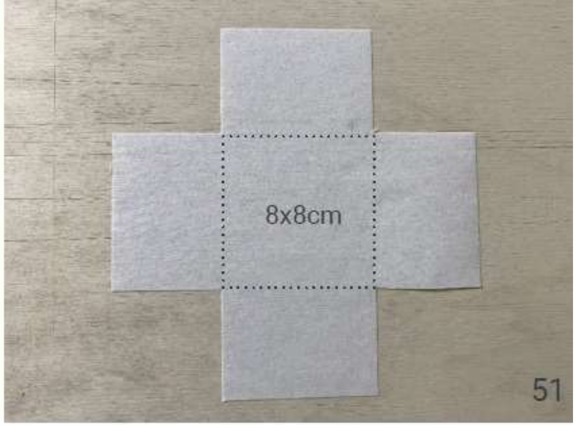


AQUARIUM WATER PUMP
DIRT TANK
SAND FILTER
CLEAN TANK

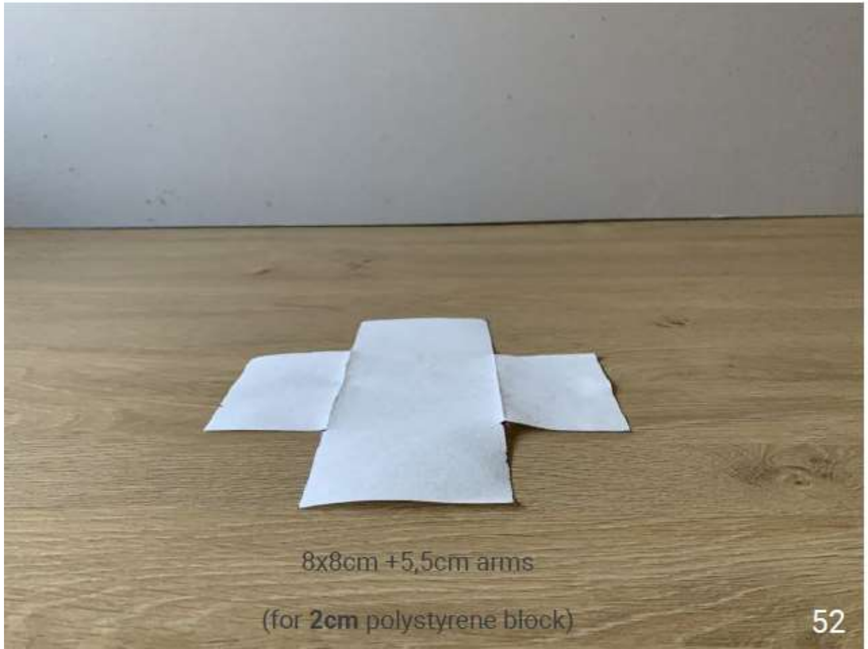
Polystyrene block

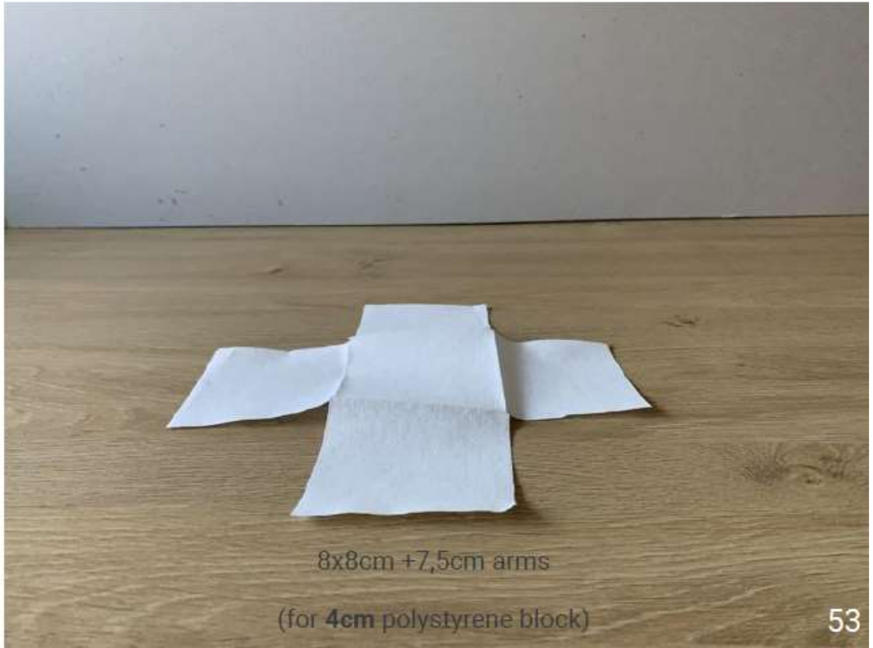
With fiber-rich papers


Texwipe TX609
23x23cm
49


50

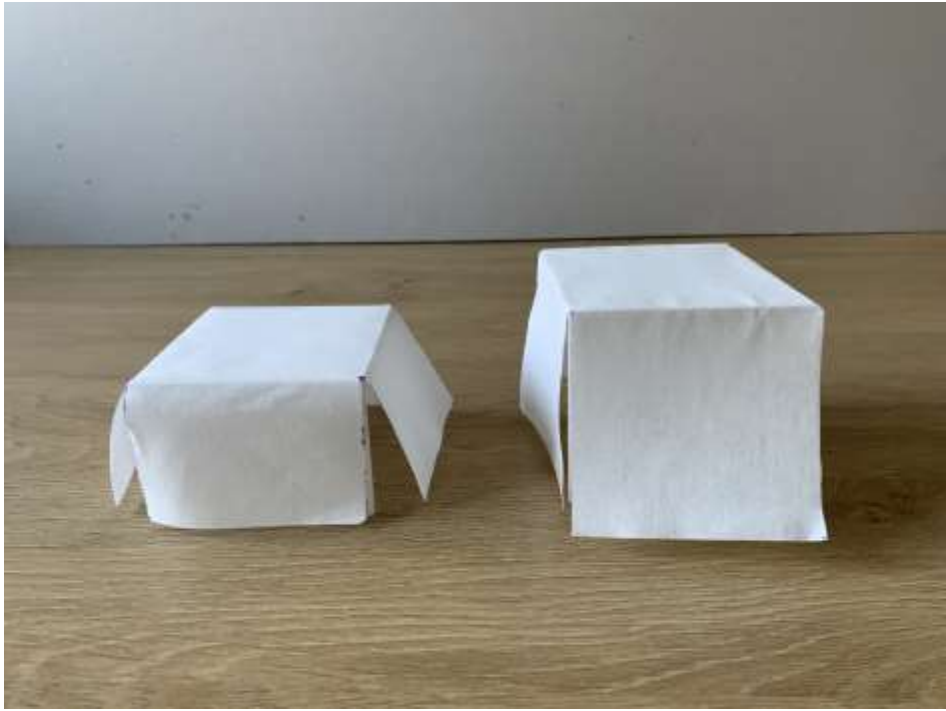

8x8cm
51


8x8cm +5,5cm arms
(for **2cm** polystyrene block)
52


8x8cm +7,5cm arms
(for **4cm** polystyrene block)
53

Wipe **test**

Water performance



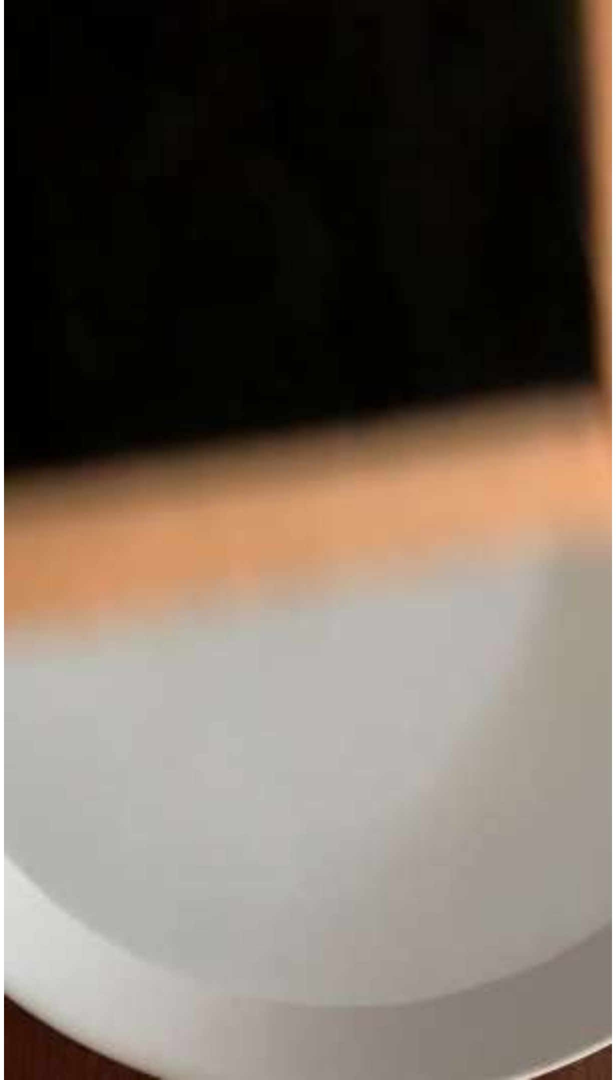
Polystyrene block
Testing

Polystyrene **block**
Cutting

Wipes **coating**

Black powder

2x COATING
NO RINSING



1x COATING
3x RINSING

2x COATING
3x RINSING

+DRYING BETWEEN

Wipes **coating**

242 wipes

4x65 WIPES

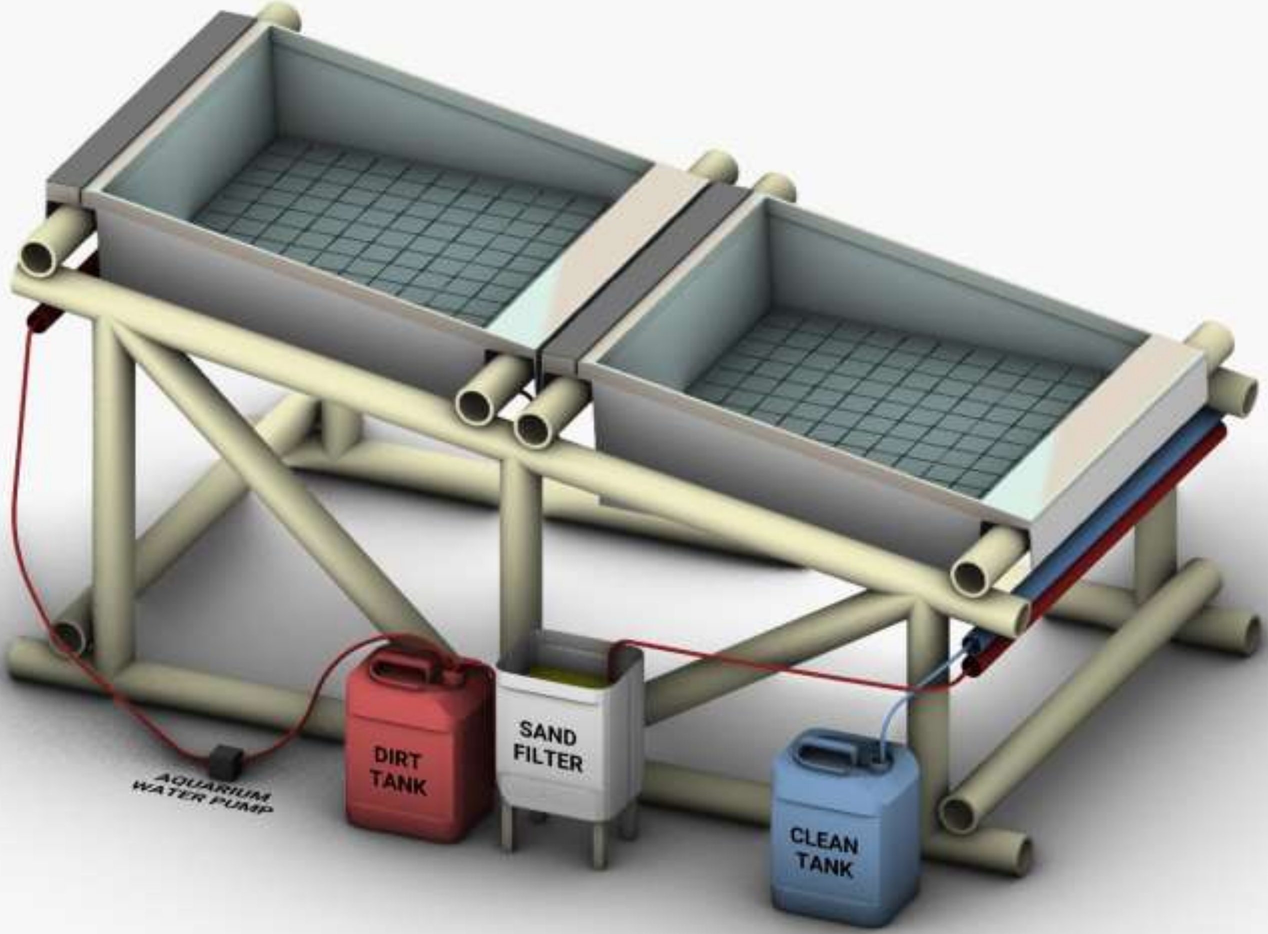
TOP (121 WIPES) 1M2

BOTTOM (TOUCHING WATER)

Polystyrene block with wipes
Water performance

Solar stills

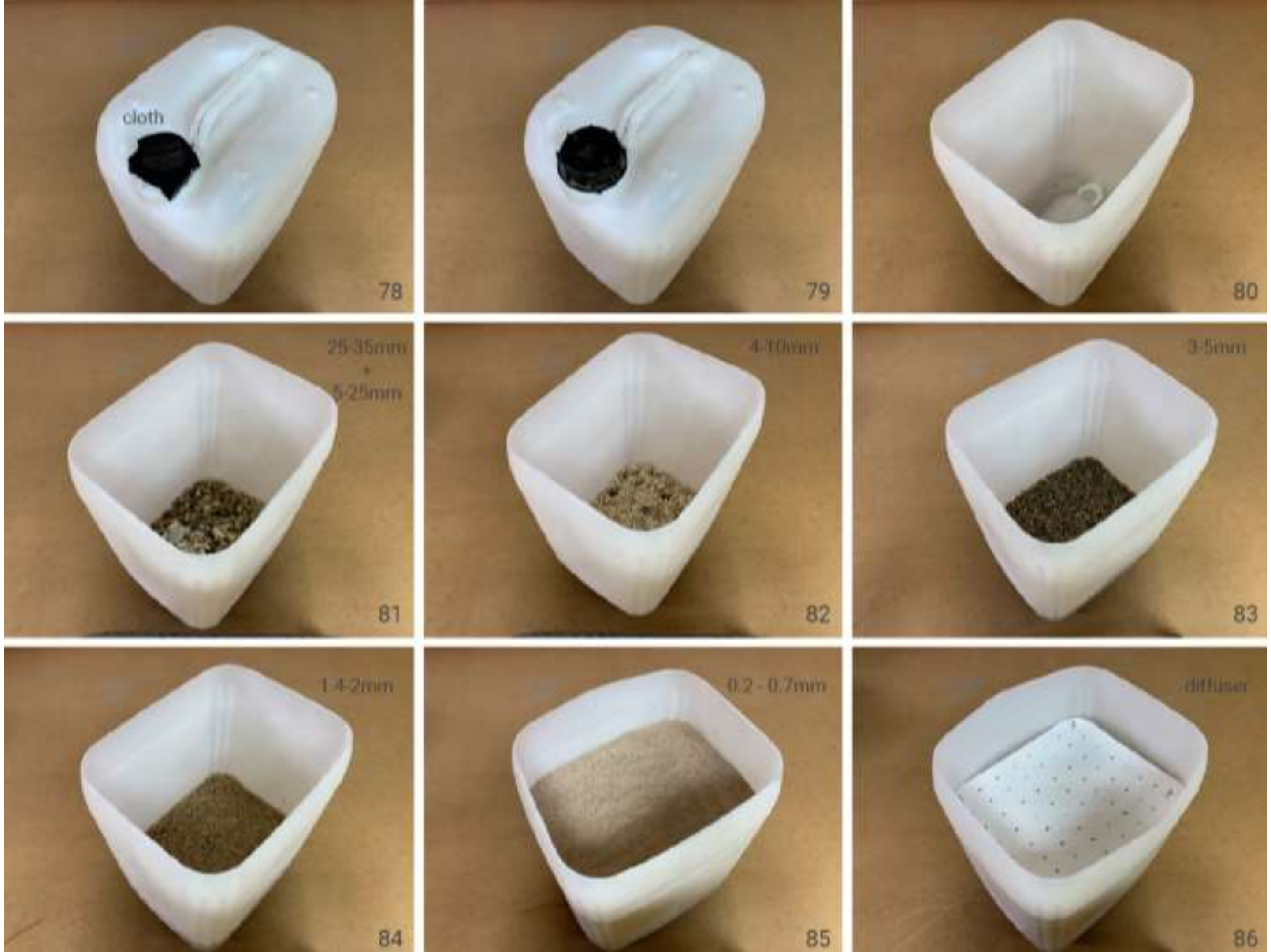
Final units


AQUARIUM
WATER PUMP
DIRT
TANK
SAND
FILTER
CLEAN
TANK

Sand filter

Sand filter

Gravel and sand fractions

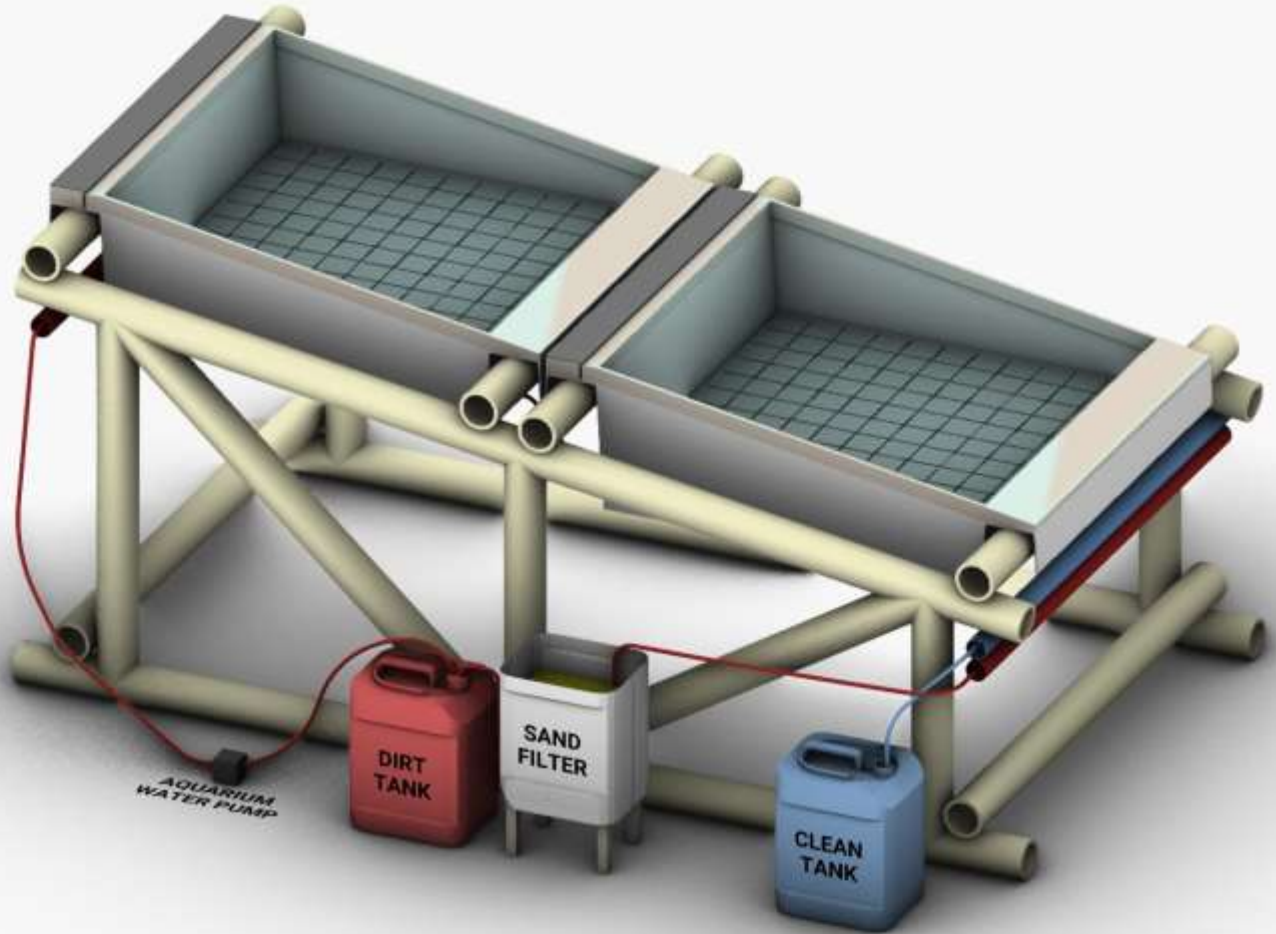

cloth
78
79
80
25-35mm
+
5-25mm
81
4-10mm
82
3-5mm
83
1.4-2mm
84
0.2 - 0.7mm
85
diffuser
86


DIRT WATER
TAP WATER

DIRT WATER

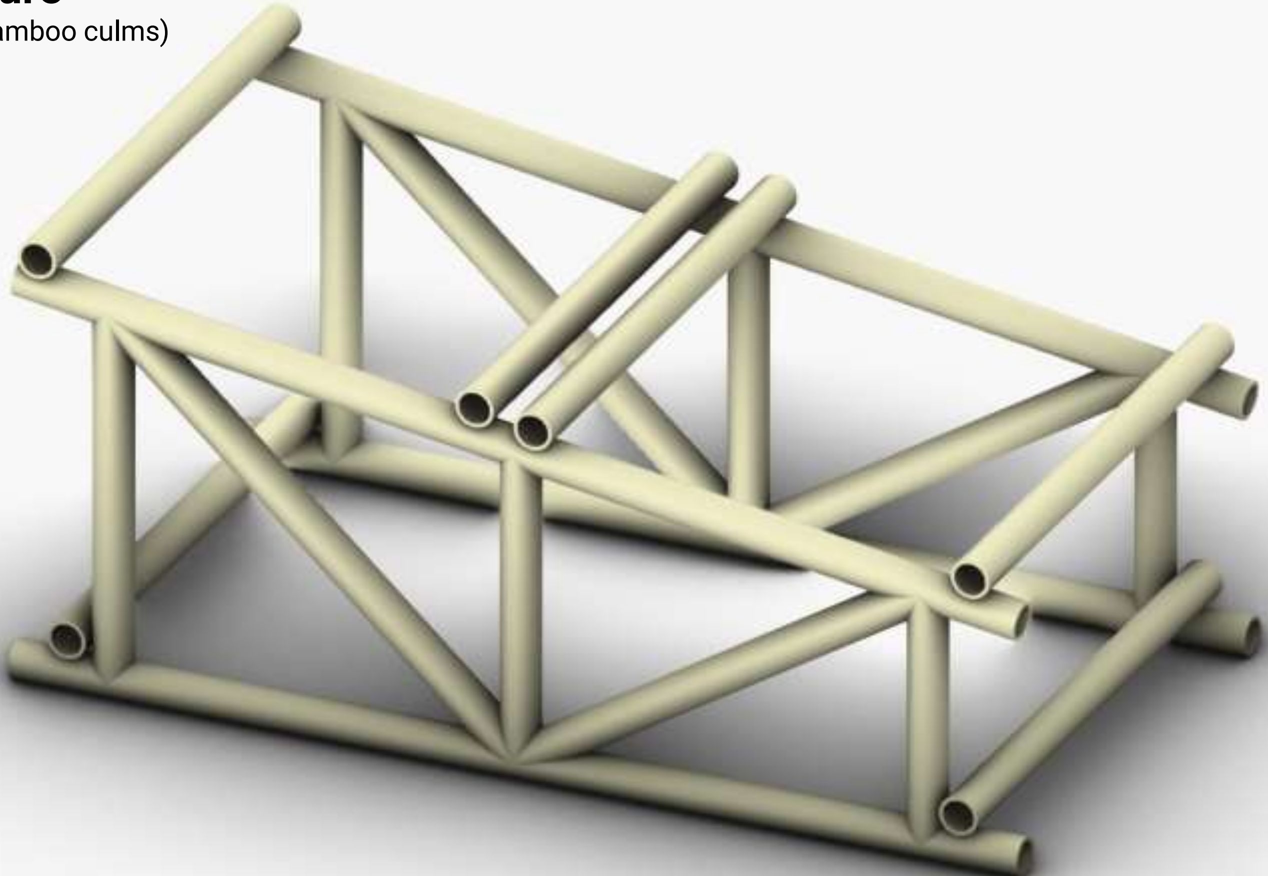
FILTERED
(HIGH PRESSURE)

TAP WATER


AQUARIUM WATER PUMP
DIRT TANK
SAND FILTER
CLEAN TANK

Support structure

Cardboard tubes (as bamboo culms)

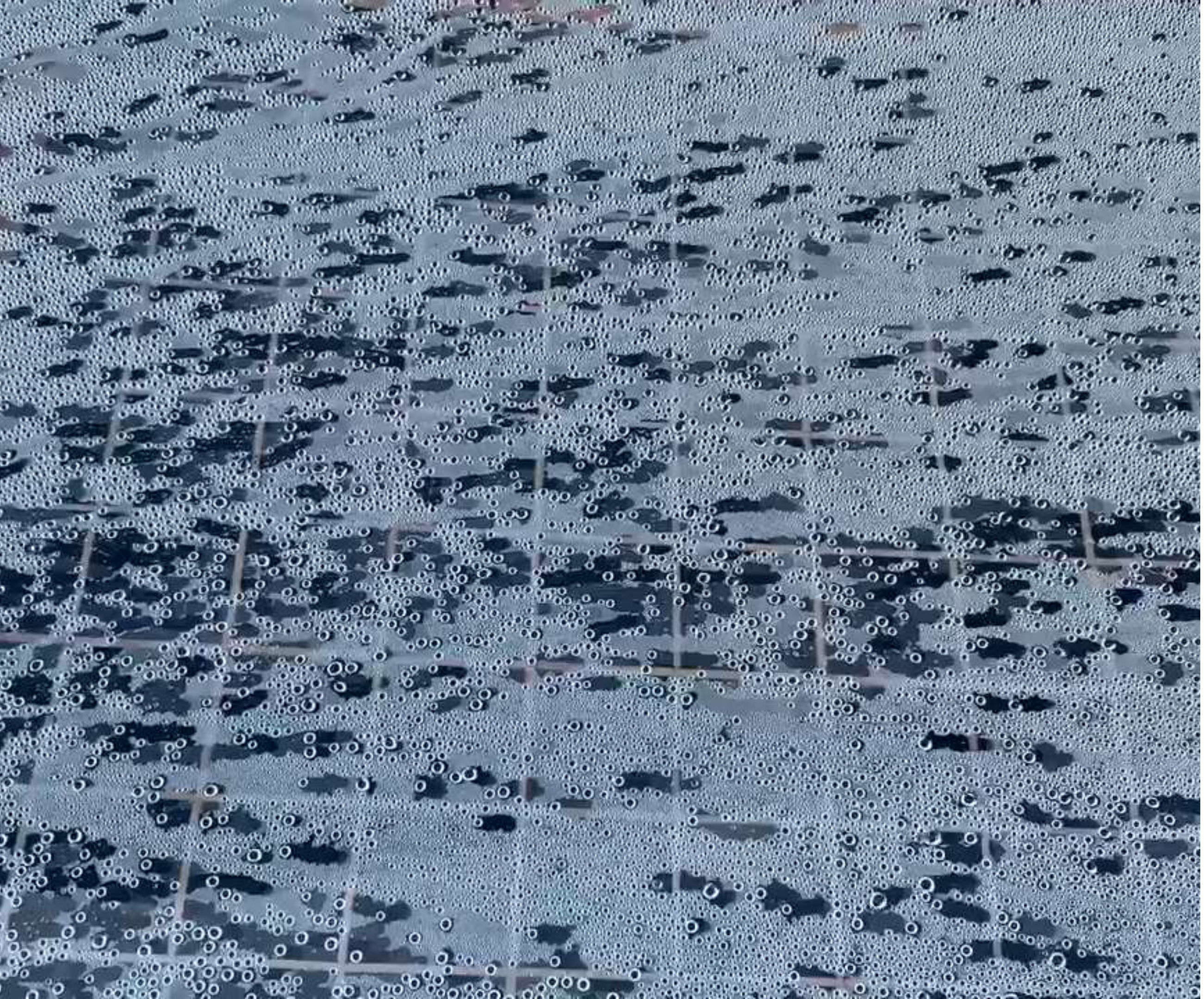


Support structure

Cardboard tubes (as bamboo culms)

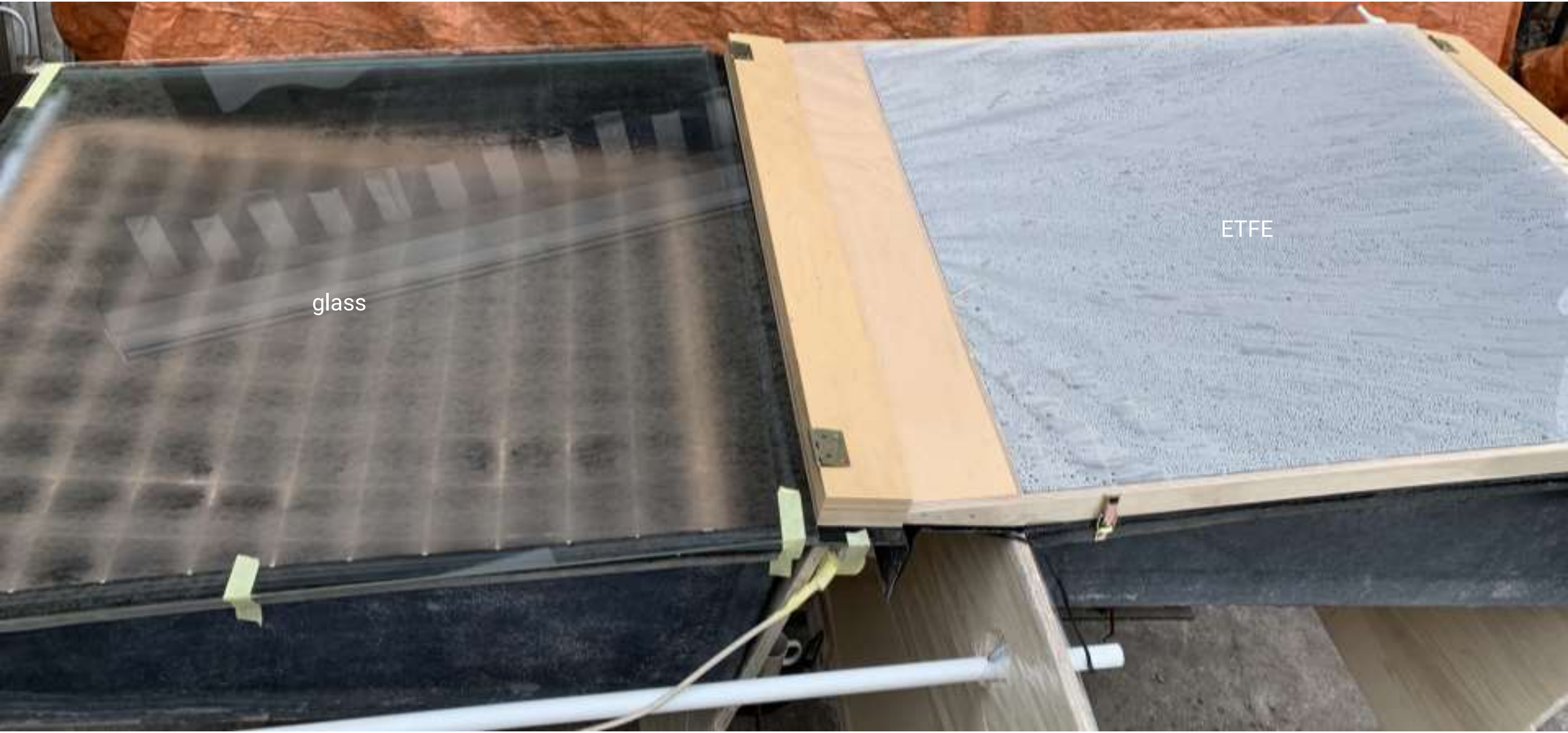
TEST 2

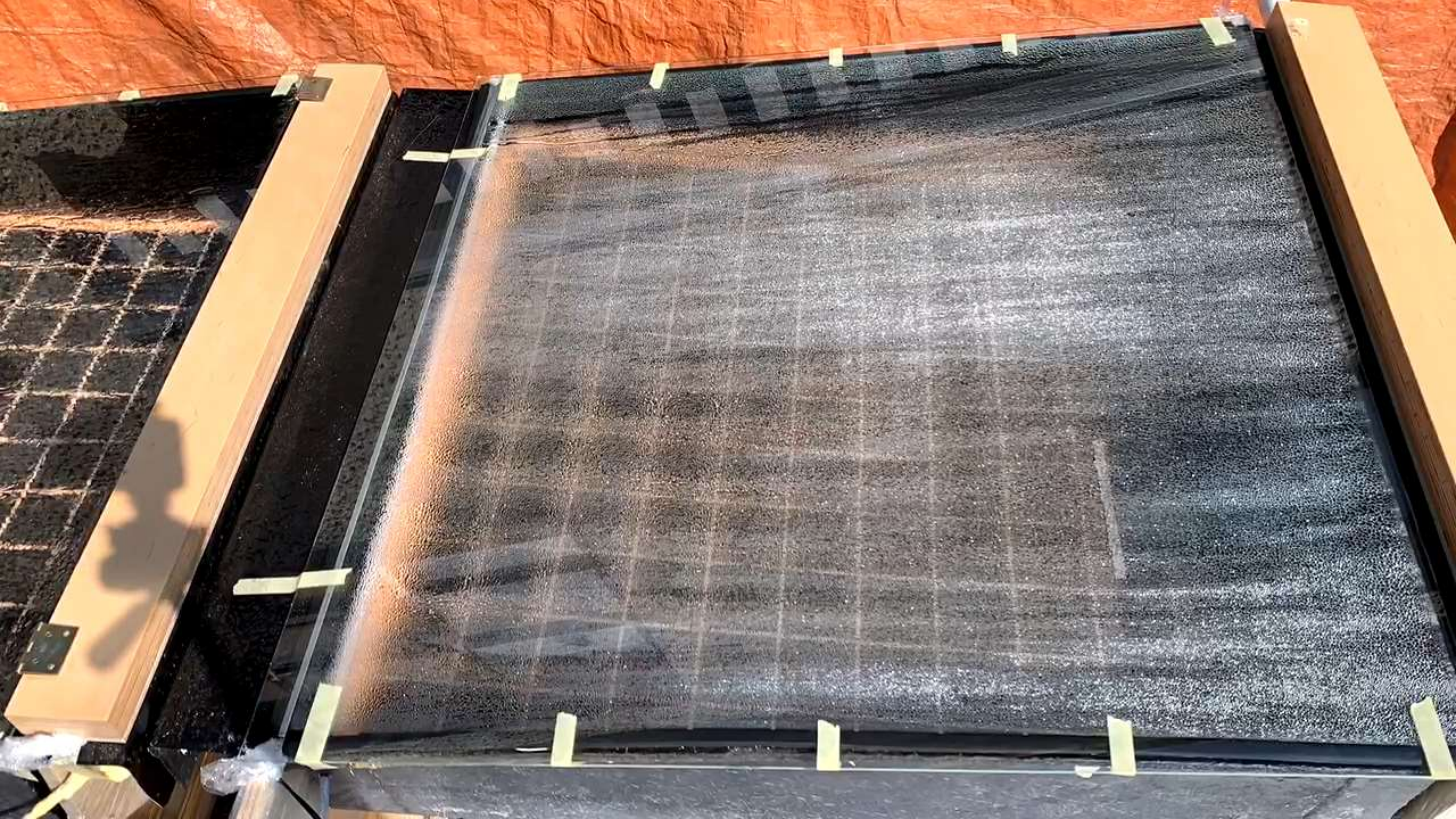
(FAIL 2...)



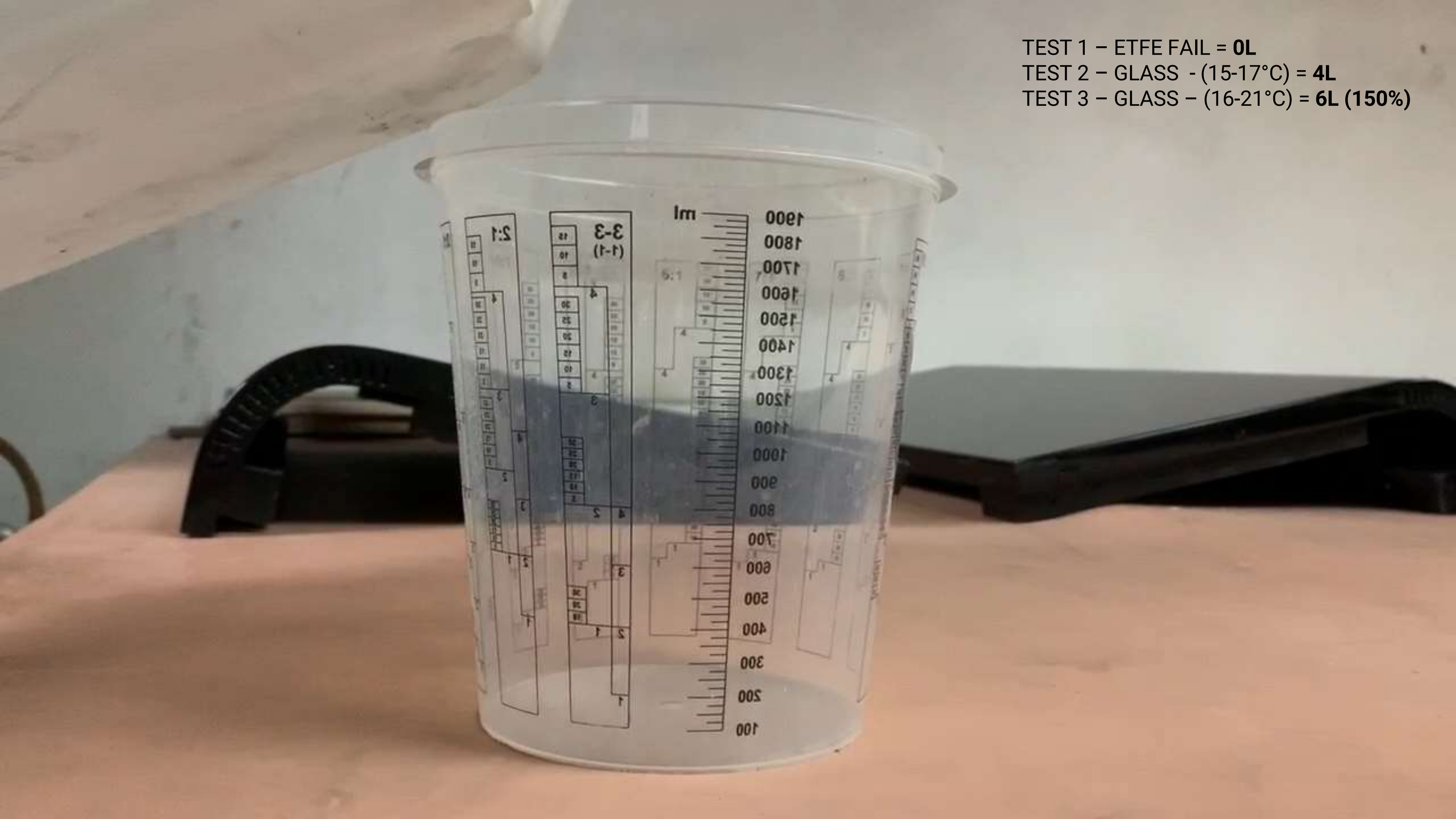

ANGLE CHANGED
STILL NOT WORKING...

Glass improvising





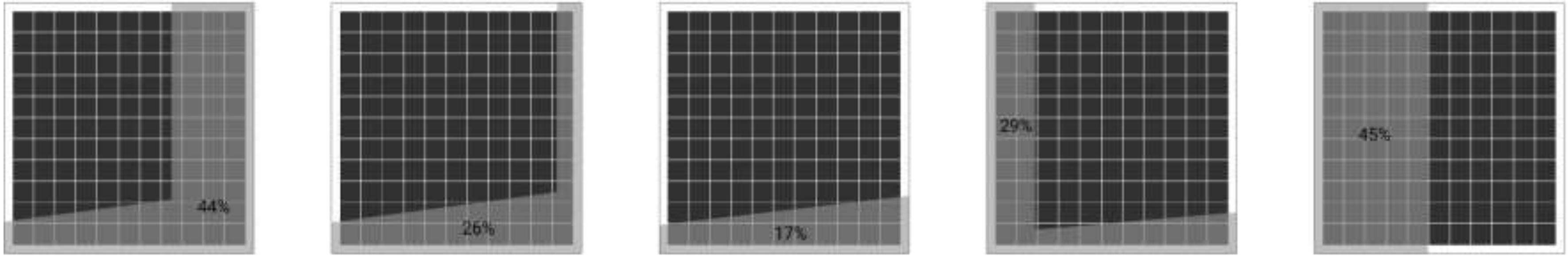
PERFORMANCE TEST


TEST 1 – ETFE FAIL = 0L
TEST 2 – GLASS - (15-17°C) = 4L
TEST 3 – GLASS – (16-21°C) = 6L (150%)

LIMITATIONS

System performance

- Hot climate or summer sun
- No direct sun – air temperature
- +50% while temperature increased by 1-4°C
- No clear sky – no solar radiation
- Improvised glass - leaks
- West orientation and self-shading



10AM, 27.04.2020
Swarzedz, Poland
Altitude: 30°
Azimuth: 123°

12AM, 27.04.2020
Swarzedz, Poland
Altitude: 50°
Azimuth: 161°

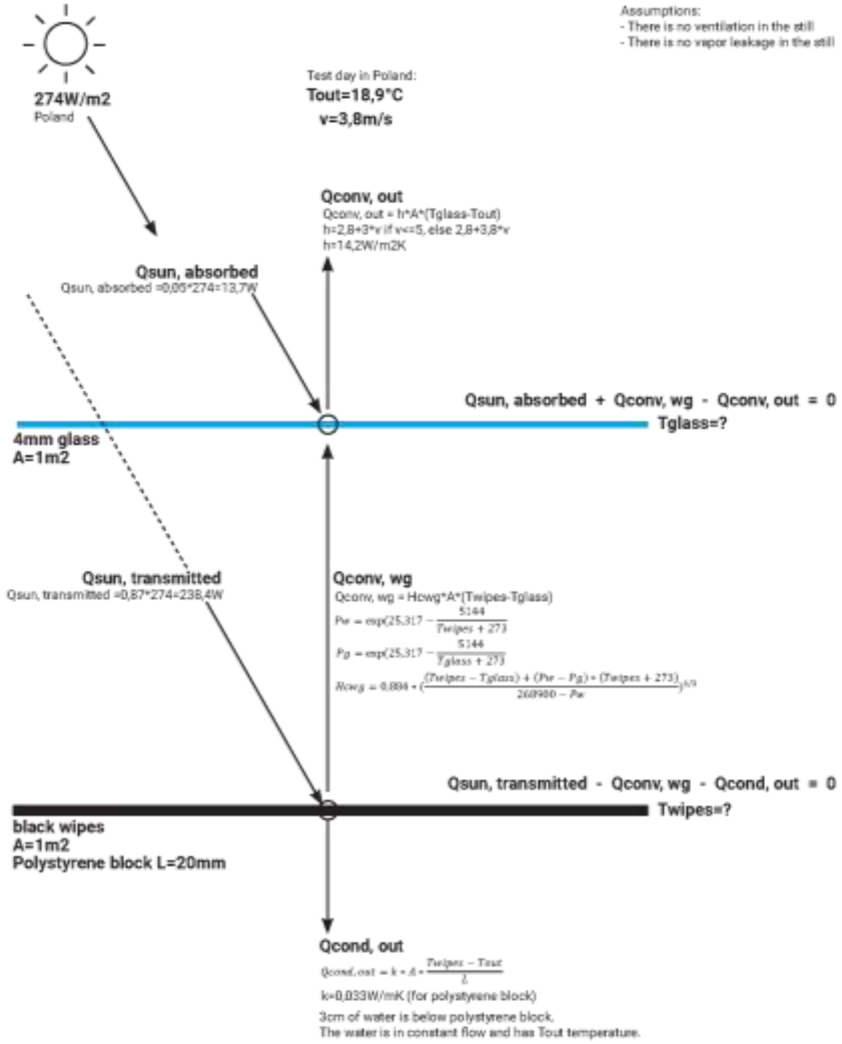
2PM, 27.04.2020
Swarzedz, Poland
Altitude: 49°
Azimuth: 207°

4PM, 27.04.2020
Swarzedz, Poland
Altitude: 36°
Azimuth: 243°

6PM, 27.04.2020
Swarzedz, Poland
Altitude: 19°
Azimuth: 269°

SOLAR-STILL **SIMULATION**

Heat Balance Model



SOLAR-STILL **SIMULATION**

Steady State Model

Qsun, absorbed + Qconv, wg - Qconv, out = 0

$$I * \alpha a + Hcwg * A * (Twipes - Tglass) - (2{,}8 + 3 * v) * A * (Tglass - Tout)$$

$$Tglass = \frac{I * \alpha a + Hcwg * Twipes + 14{,}2 * Tout}{14{,}2 + Hcwg}$$

Hcwg=3,8

Tglass=30,6°C

Twipes=70,8°C

Steady state after 100 iterations

$$Twipes = \frac{I * \alpha t + Hcwg * Tglass + 1{,}65 * Tout}{1{,}65 + Hcwg}$$

$$I * \alpha t - Hcwg * A * (Twipes - Tglass) - k * A * \frac{Twipes - Tout}{L} = 0$$

Qsun, transmitted - Qconv, wg - Qcond, out = 0

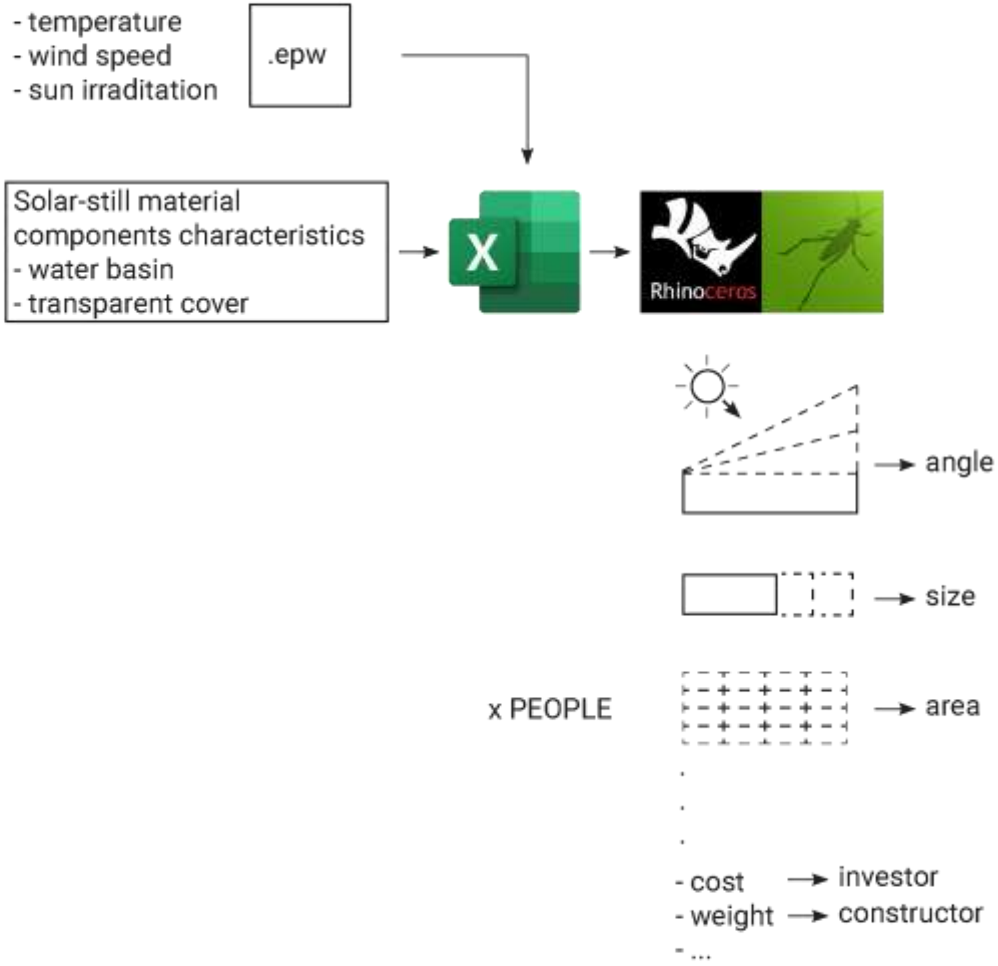
$$Hewg = 0{,}01628 * Hcwg * \frac{Pw - Pg}{Twipes + Tglass}$$

$$Qewg = Hewg * (Twipes - Tglass)$$

$$Mw = \frac{Qewgi}{Lv}$$

SOLAR-STILL **SIMULATION**

Parametric Model

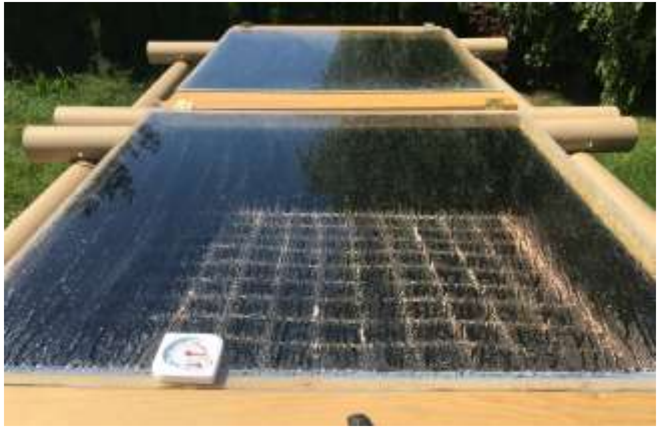


2ND MOCK-UP TESTING

17.06.2020, Cardboard Tubes (Bamboo Structure)

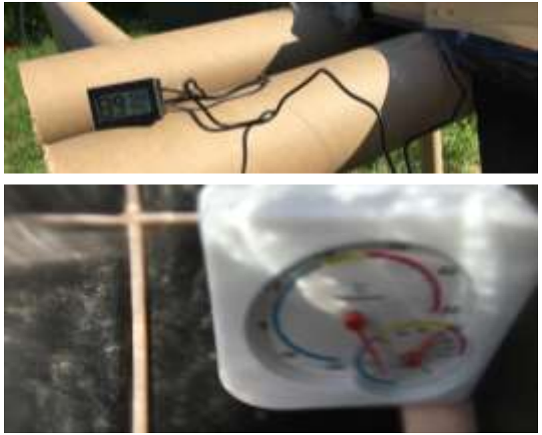






2ND MOCK-UP TESTING

17.06.2020



INSIDE SOLAR-STILL

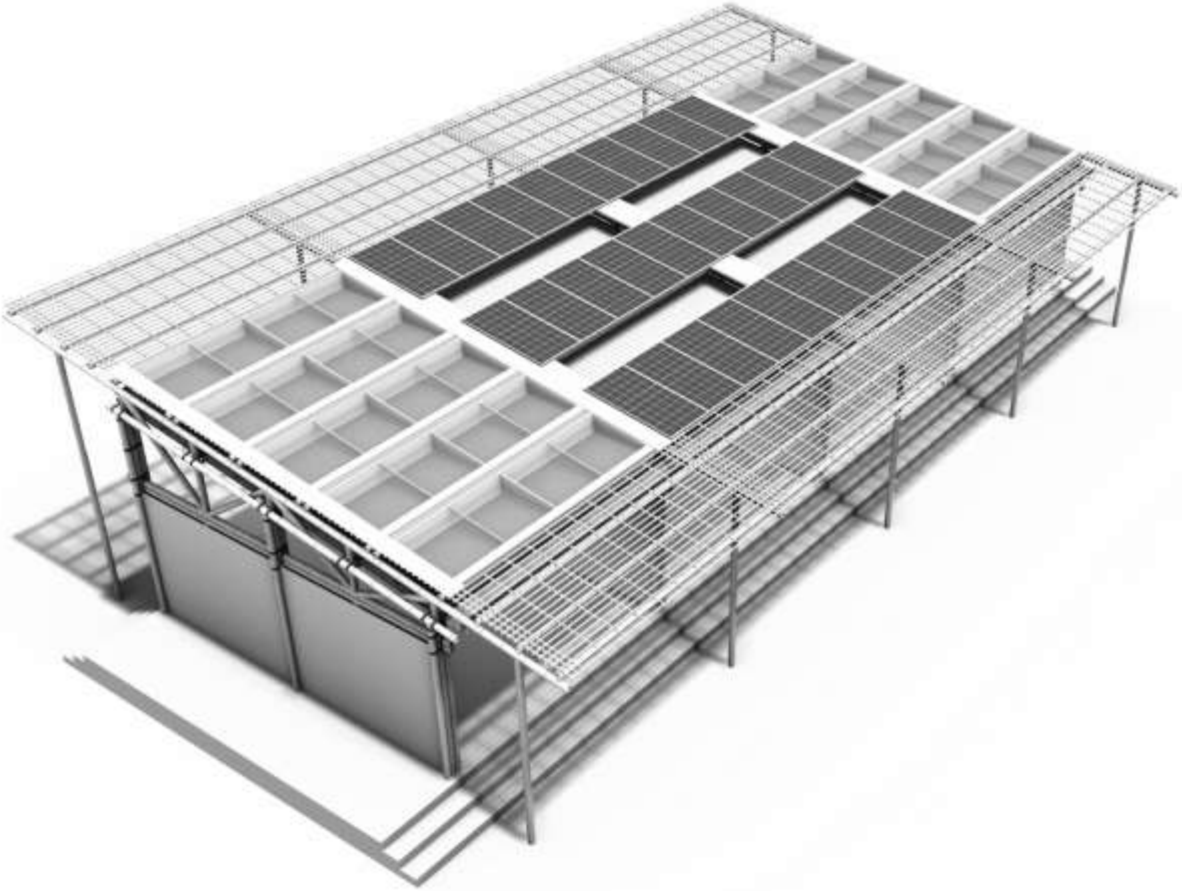
OUTDOOR (SUN)

OUTDOOR (SHADE)

	Inside solar-still		Outdoor (sun)		Outdoor (shade)	
	Hum. [%]	Temp. [°C]	Hum. [%]	Temp. [°C]	Hum. [%]	Temp. [°C]
8.00	56%	53°C	50%	30°C	67%	26°C
12.00	70%	65°C	26%	47°C	55%	26°C
15.00	99%	81°C	24%	50°C	60%	28°C
18.00	99%	55°C	35%	37°C	60%	24°C

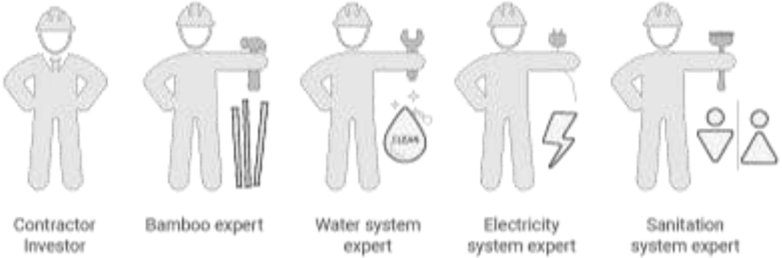
SELF-SUFFICIENT HUB

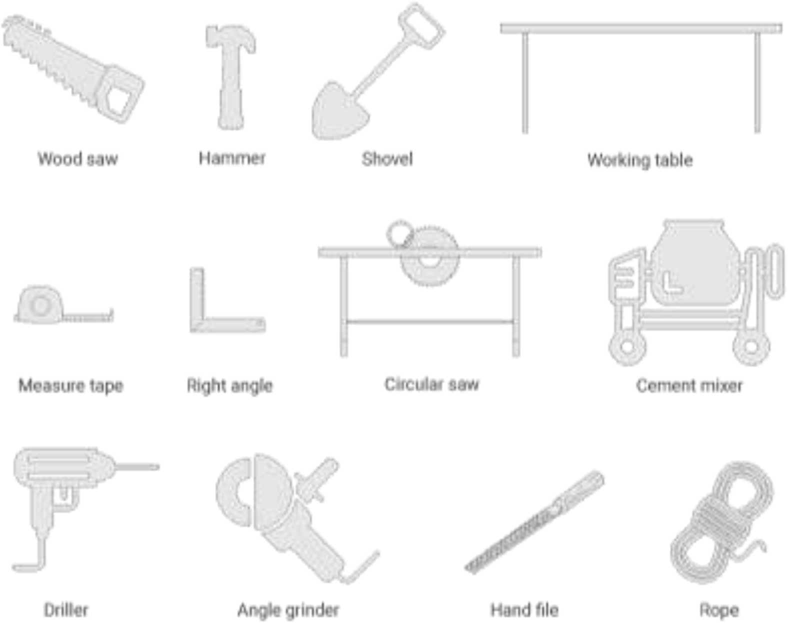
Off-grid system



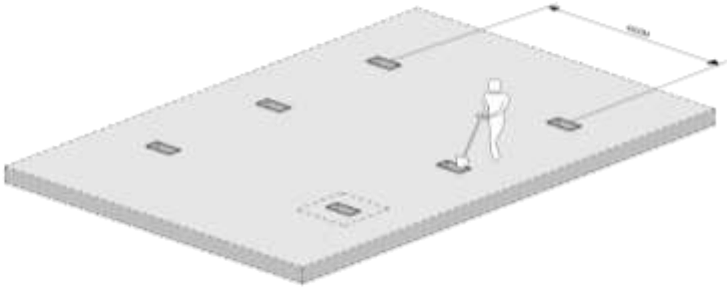
CONSTRUCTION MANUAL

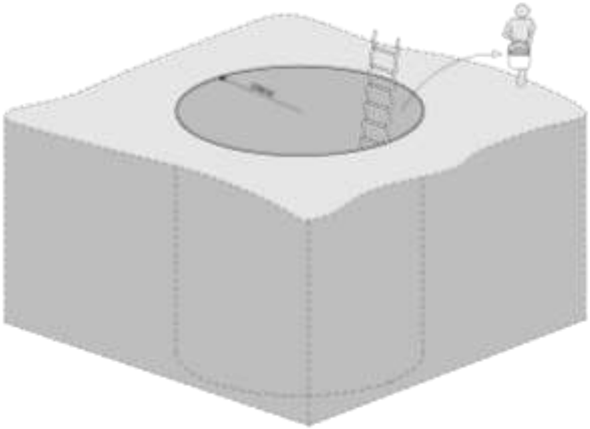
Final Product





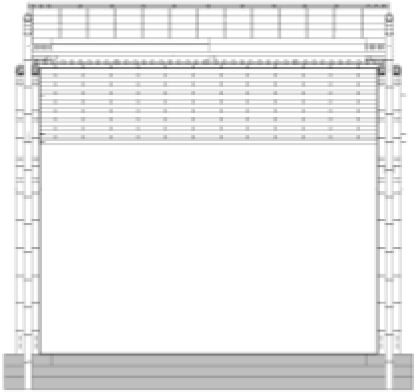
CONSTRUCTION MANUAL
Final Product



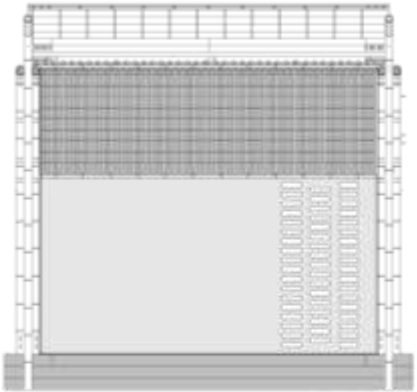


CONSTRUCTION MANUAL

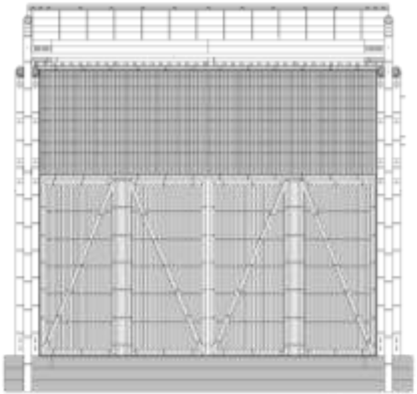
Final Product



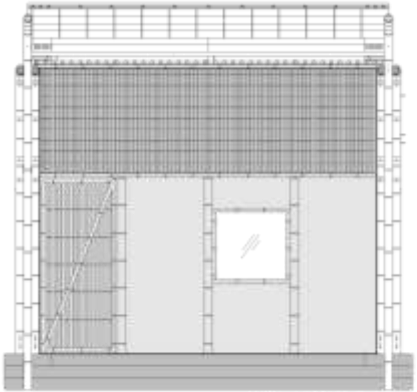
Fully open



Fully closed



Openable



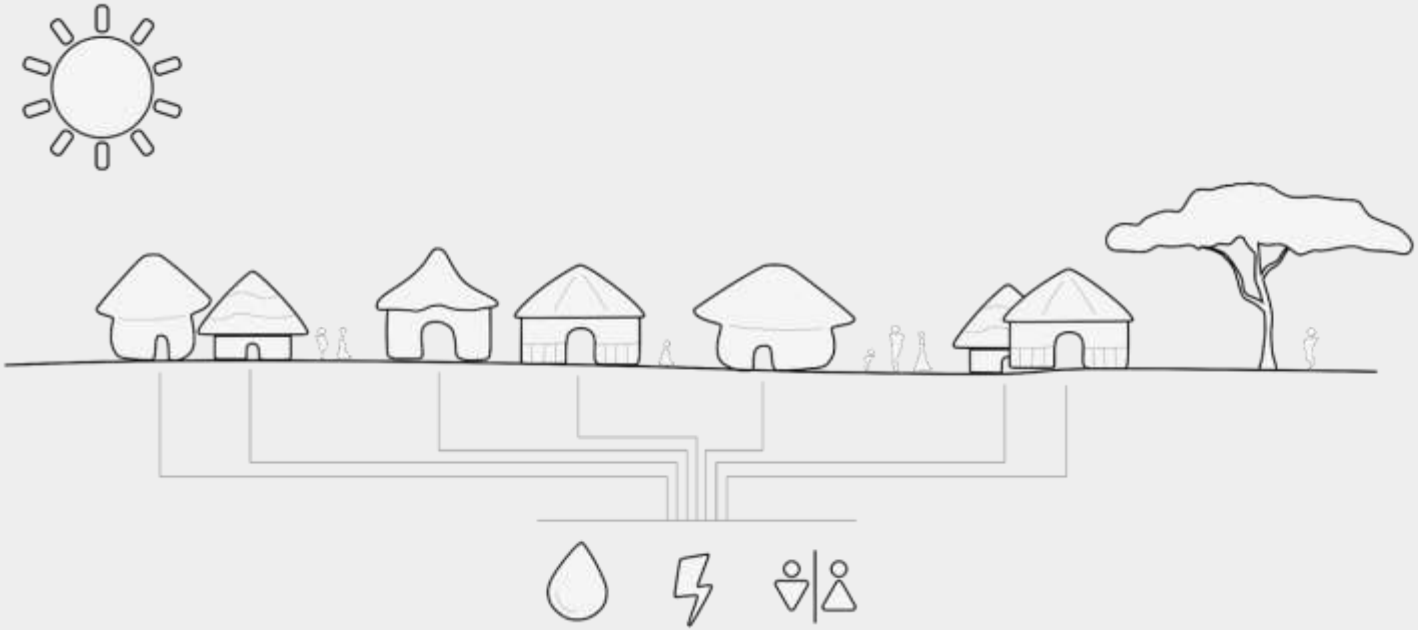
With doors/windows

COST ESTIMATION

One module, One unit

Item	quantity	cost
Foundation	0,97m3 (100€/m3)	97€
Bamboo: Φ10cm Φ5cm Φ3cm	 420m (3,5€/m) 54m (2€/m) 65m (1€/m)	 1470€ 108€ 65€
Metal sheet	14(7,5€/m2)	105€
Gutter	5m (3€/m)	15€
Bamboo mat	14m2(2€/m2)	28€
Ropes	90m (1€/m)	90€
Dowel connection	104(1€)	104€
Optionally	Front+Back walls	226€
		2308€

Item	quantity	cost
GFRP	18m2 (5,5€/m2)	99€
Plywood frame	0,5m2 (12€/m2)	6€
Glass	4m2 (6€/m2)	24€
Silicon	1 (3€/m)	3€
Rubber gasket	6m(0,5€/m)	3€
Hinges	2 (1€)	2€
Toggle latches	2 (1€)	2€
Pipe Φ1cm	1m (0,5€/m)	0,5€
Support PVC profile	4m (0,5€/m)	2€
Collecting PVC profile	2m (0,5€/m)	1€
Polystyrene block	2m2 (2€/m2)	4€
Wipes	13,5m2 (1€/m2)	13,5€
Dying powder	0,3kg (4€/kg)	1,2€
		161,2€



Redesigned Disaster

THANK YOU.