1. LINKS AND RESOURCES

showerloop.org
This is website

showerloop.org/research
Original bachelor's thesis'

showerloop.org/diy
Instructions and design files for Showerloop

showerloop.org/store
This is where you can purchase parts

showerloop.org/community
Community site

on Facebook
facebook.com/showerloop

on Youtube
youtube.com/channel/UCaTOqjcOmjv0xqIp348tH4A

on Vimeo
vimeo.com/user56408233

on Reddit
www.reddit.com/r/showerloop

F lablab.aalto.fi
Aalto FABLAB Digital Fabrication Laboratory.
None of this would be possible without the help of Aalto Fablab!!!

Turbiini Startup Accelerator
A startup center in Vantaa, Finland which has graciously provided us with office space to work on Showerloop and other sustainability projects.

AIRO Island RY
Our soon to be production facility is hosted by A.I. Robotics Island RY. While Showerloop isn't specifically in the field of A.I. we're working with digital fabrication tools like CNC machines and 3D printers with the goal of educating Finns and the world about the opportunities that lie in these but amazing technologies, especially when shared.

OSCEdays
Open Source Circular Economy days 2015 in Helsinki is where we presented Showerloop to the open source community for the first time. Jason was also one of the organizers of the event that year and in 2016.

POC21.cc
Proof of Concept 21. An innovation camp in 2015 that helped Showerloop get some international fame.

Instructables.com

Helsinki Fashion Week
This version Showerloop KIT18 was presented at the HFW2018.

GreenTech Awards
We won the Galileio Wissenpreis GreenTechAward, Berlin 2017. We also got a business loan from the one and only Rea Garvey.
Showerloop at the Helsinki Fashion Week 2018
2. TABLE OF CONTENTS

1. LINKS AND RESOURCES

2. TABLE OF CONTENTS

3. SAFETY INSTRUCTIONS

4. BOM / COMPONENT LIST
   Showerloop Component List

5. SPECIFICATIONS
   5.1. DIMENSIONS Minimum dimensions
   5.2. WATER CONSUMPTION
   5.3. POWER CONSUMPTION
   5.4. REPLACEMENT OF FILTERS & OTHERS

6. MATERIALS & CARE
   6.1. THOUGHTS ON MATERIAL SELECTION, LONGEVITY AND PRODUCT LIFECYCLE
   6.2. VERSIONS.

7. WHAT IS SHOWERLOOP?

8. OPERATING PRINCIPLE AND GENERAL SPECS
   8.1. TAKING A LOOP SHOWER
   8.2. MODES
     8.2.1. Prewash
     8.2.2. ShowerLoop
     8.2.3. Backwash
     8.2.4. Bypass
     8.2.5. Pee / Flush
     8.2.6. Drain

9. ASSEMBLY INSTRUCTIONS.
   9.1. ORDER
   9.2. SECTIONS:
     9.2.1. Pre-filter and pump:
     9.2.2. Valves :
     9.2.3. Filter:
     9.2.4. Uv:

10. PARTS / COMPONENTS / BOM .
   10.1. PREFILTER.
   10.2. PUMP.
   10.3. Valve.
   10.4. FILTER.
   10.5. UV LAMP
   10.6. HEATER.
   10.7. PIPE FITTINGS.
     10.7.1. Plastic quick fit hose connector.
     10.7.2. Brass quick hose connector.
     10.7.3. Other options.
   10.8. ELECTRONICS .
     10.8.1. Backboard size 30x50 plywood 3-6mm
     10.8.2. Power Box / Relay Box
3. SAFETY INSTRUCTIONS

- READ this before using !!!

Please read these instructions carefully before using ShowerLoop. The instructions contain important information which will help you understand the limitations of the technology and also help you get the best out of the system and ensure safe and proper installation, use and maintenance. Keep this manual close so you can always refer to it for j

- The filter captures particles and dirt inside it, the backwash system may help flush out these things but the point is that it doesn't just magically purify water with any contaminants. It was specifically designed for use in showers.

- A short, non-looping or pre-wash is preferable before activating the loop to reduce the overall load on the system and to remove particles, oils, and dirt from the body and therefore from entering the system extending the life of the filtrate (filter material).

- Ultraviolet (UV) light can be dangerous. Never stare at it directly without eye protection or expose it directly to your skin. The UV lamp has an operating time of 6000 hours (of continuous operation) before it's output is reduced by 20%. As a precaution, it is advised to change the lamp after 2 years or 600 hours of operation as lamp usage is likely intermittent and the turning on and off of the lamp will reduce its capacity sooner. Once a suitable sensor becomes available we can reliably determine the lifetime of the lamp.

- Test the GFCI (Ground Fault Circuit Interrupter) on a monthly basis. When the system is connected to 220V AC power but not ON, Press the [T] button and everything should switch off.

- Check the cable glands, electrical boxes, and switches for leaks, holes, water moisture or anything abnormal.

- Check the pump on a monthly basis (according to the manual) but at least open the pump and service it each time the filter is changed (or after flushing the filter).

- Always use a pre-filter before the pump. Any debris will clog the pump and damage it. It won't go off automatically and the friction can cause overheating and possibly even fire.

- Stop the pump when switching modes if possible.

- When activating the system for the first time the AC will release lots of dust and it should NOT be recycled. Flush the system like a normal shower - clear water IN and all water to DRAIN / WASTE WATER for 5-10 minutes/ 50-100 liters. After this, the filter may release dust every now and then (especially when tightening the filter). As long as the particles are small they will not be a problem for the filter and the trace amounts of carbon are not dangerous if consumed.

- Don't operate unless you are nearby (at least for the first 10 hours of operation, reset after maintenance).

- If WET, ONLY use the SWITCHBOARD and ON/OFF button on the power box.

- Attach a power consumption meter / Timer between the power plug and wall socket to measure the operating time of the Filter.

- Log use of the system (see appendix) and report back to Showerloop Headquarters...
4. BOM / COMPONENT LIST

Below is a link to our component list, this includes some specifications and known suppliers. Prices may vary as well as the products. If you're looking for something on ebay and the link is no longer valid try searching for the full name listed.

Showerloop Component List

5. SPECIFICATIONS

5.1. DIMENSIONS Minimum dimensions

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Minimum Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>X (WIDTH)</td>
<td>500 mm (440 mm smallest)</td>
</tr>
<tr>
<td>Y (HEIGHT)</td>
<td>1800 mm (1440 mm smallest)</td>
</tr>
<tr>
<td>Z (DEPTH)</td>
<td>250 mm (230 mm smallest)</td>
</tr>
</tbody>
</table>

Total system weight: 35 kg
Total package weight with extra parts: 42 kg

XXXPICTURE OF THE WHOLE SYSTEM HERE!XXX

*** See component list for dimensions and weights of individual parts ***
*** See 3d model for design files ***

5.2. WATER CONSUMPTION

<table>
<thead>
<tr>
<th>Process</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREWASH</td>
<td>1-5 L?</td>
</tr>
<tr>
<td>SHOWERLOOP</td>
<td>10 L</td>
</tr>
<tr>
<td>BACKWASH</td>
<td>0-5 L</td>
</tr>
</tbody>
</table>

A water and power savings calculator was developed by http://david.mercereau.info/
http://showerloopcalculator.zici.fr/en

5.3. POWER CONSUMPTION

<table>
<thead>
<tr>
<th>Component</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUMP</td>
<td>40W</td>
</tr>
<tr>
<td>VALVES</td>
<td>0.24W</td>
</tr>
<tr>
<td>RELAY MODULE</td>
<td></td>
</tr>
<tr>
<td>SWITCHES</td>
<td></td>
</tr>
<tr>
<td>AC/DC TRANSFORMER</td>
<td>150W</td>
</tr>
<tr>
<td>UV</td>
<td>30W</td>
</tr>
<tr>
<td>HEATER &amp; HEAT LOSS</td>
<td>3000W</td>
</tr>
</tbody>
</table>

12VDC 8A maximum (10A fuse) 100W max. Operating power.
5-24VDC 0.02A
5-12VDC
220VAC to 12VDC
220VAC or 12VDC
220VAC or

Nominal operating power is 150 W max without heating or 60 minutes is 0.150kWh
10-minute shower ~1.3 kWh
30-minute shower 2 kWh

A water and power savings calculator was developed by http://david.mercereau.info/
http://showerloopcalculator.zici.fr/en

5.4. REPLACEMENT OF FILTERS & OTHERS

<table>
<thead>
<tr>
<th>Component</th>
<th>Frequency</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHOWER DRAIN FILTER</td>
<td>DAILY</td>
<td></td>
</tr>
<tr>
<td>PREFILTER</td>
<td>WEEKLY - MONTHLY, INSPECTION, MONTHLY CLEANING. REPLACE AFTER 150 showers</td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>Inspection/Cleaning Schedule</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>------------------------------</td>
<td></td>
</tr>
<tr>
<td>PUMP</td>
<td>MONTHLY INSPECTION &amp; CLEANING (see Pump manual)</td>
<td></td>
</tr>
<tr>
<td>SAND FILTER</td>
<td>2-5 MONTHS</td>
<td></td>
</tr>
<tr>
<td>AC FILTER</td>
<td>2-5 MONTHS</td>
<td></td>
</tr>
<tr>
<td>UV LAMP</td>
<td>1000 hours operating time but rated for 8000 hours continuous operation (see UV manual)</td>
<td></td>
</tr>
<tr>
<td>HEATER</td>
<td>6-12 MONTHS INSPECTION (see Heater manual)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Filter lifetime is still in need of wide scale testing. Most results are estimations based on empirical data from our lab tests and tests with a single showerloop in household conditions. The water from Southern Finland where the hardness of water ranges from 3.0 to 4.5 dH and water quality is good.

### 6. MATERIALS & CARE

#### 6.1. THOUGHTS ON MATERIAL SELECTION, LONGEVITY AND PRODUCT LIFECYCLE

ShowerLoop is a work in progress. Components and materials had been selected in the last 5 years (2012-2017) carefully and under a tight budget. The limitation in resources has been the principal reason why ShowerLoop develop process has taken longer than expected. In consequence, materials had been choose base on longevity, price, availability and utility = sustainability. It's likely that every component could be replaced with something more sustainable, effective, simpler, prettier and cheaper.

Additionally, we limit the suppliers to commonly available hardware stores in Finland which have slightly smaller selections than those in mid-Europe. ShowerLoop applies the Open Source principals, so parts can be interchanged with what is available locally.

That said, many alternatives have been attempted with almost every component and material available, making this last design the best of the best so far. In order to speed up the developing process, we relay in more users fabricating/modifying their own ShowerLoops. We encourage you to find good and sustainable components, as well as suppliers that would allow Showerloop builders to collaborate and ultimately make a super sustainable shower.

#### 6.2. VERSIONS.

Shower some pictures
fig. 1: Showerloop assembled in Hamburg at n55 in 2016. Designed by Jason and Eduard Kobak, assembled by Jason and Timm Wille. Still my favorite one visually and for it’s 1m2 XYZ city structure format, however, it doesn’t have the passive drainage possibilities of future models.

fig. 2: Showerloop at Helsinki Design Museum as part of the Enter and Encounter exhibit on the
7. WHAT IS SHOWERLOOP?

Showerloop is a water filtration system made principally for Showers, allowing you to take showers at a reduced environmental and economic cost. It requires 10 liters of water for a shower of any length* while reducing the amount of energy needed for a nice and warm shower.

How it works is not a mystery! basically, it captures water from the drain which gets sucked through an initial particle filter by the pump before it's pumped through a fabric, sand and activated carbon filter to remove particulates and organic compounds like oils and sweat. The carbon has millions of tiny pores that capture suspended solids and can even trap molecules making the water crystal clear or pure, for the next step - ultraviolet sterilization, to be effective.

The ultraviolet sterilization is done by The UV lamp, it emits UV-C light radiation which breaks up the DNA of bacteria thus sterilizing it. After this, the water can be recycled/reused. Neither term is accurate as recycling is generally more like downcycling. Reusing also is a bit incorrect as a term since the water has been upcycled from it’s ‘dirty’ state. (returning the water as close as possible to its original form with the low-tech materials used). Re-upcycled? UpUsed? Temperature can be maintained with a resistive heater and thermostat to automatically maintain water temperature, though solar heating would be preferable and gas heating is a good option in some circumstances.

The system also uses a series of electro-mechanical ball valves and piping to allow multiple shower modes: Showerloop, bypass (which skips the filters), backwash or back-flush (to clean the filter), pee mode / direct to drain and finally system drain - this allows all the water to be drained from the system after each shower. The blue-grey water can also be stored and used for washing clothes or flushing the toilet. The system runs mostly on 12VDC power except for the UV and heater, though it is possible to have a completely 12V off-grid ready system. Still under development are 1. research on removing soaps and oils, 2. making the shower smarter using sensors, microcontrollers and adding connectivity and programmability to the system, not to mention the 3. overall design, usability, and production process.

Showerloop was officially started as a Bachelor's thesis project in 2012 (though proposed in class on thermodynamics and a business competition in 2010 and). Research on filter dimensions and purification/sterilization were the main facets of the research which can be found here:

https://www.theseus.fi/handle/10024/76148
8. OPERATING PRINCIPLE AND GENERAL SPECS

8.1. TAKING A LOOP SHOWER

The process of taking a shower is as follow:

- Check that all valves are in OFF-position (down)
- Check the pump is switched to zero (counterclockwise)
- Turn ON the system from the control box by rotating the RED ‘emergency switch’ button
- Set the desired heating temperature on the thermostat if it's available
- Activate the Showerloop mode on the switch panel. Normally by activating valves 2, 4 and 5.

Initially, it is recommended to run the shower in 'pee' mode at least once before taking your first shower in order to remove loose filter particles out of the system and not back into the filter.

Afterwards begin to fill the shower with water from your water source of choice. Hot water is preferred. Turn on the pump on the control box (button above the stop button) and adjust the flow on the dial. Stop adding water once around 10 liters has been added to the system. You should have a continuously looping shower now. See the troubleshooting section if things don't look normal at this point.

Step into the shower and enjoy. When you are ready to step out of the shower and turn off the pump. Change the mode into Backwash mode and turn the pump on again. This will pump water into the drain but backwards through the filter rinsing it off a little.

Open all the valves but shut off all other devices since you don’t need them any longer. This will Drain the system of excess water and prepare it for the next shower. After the whole system is drained the system can be shut down. Keeping the system powered to allow for drainage uses a marginal amount of energy (maximum 15 W, though likely it's more like 1.5 W).

The system can also be drained faster by using the pump to build up a pressure in the filter. By closing the output valve but this would require some practice as it's a manual operating.

Getting wet and washing off main dirt particles and possibly applying shampoo. Shampoo and conditioner can also be applied at the end of the shower if possible.

*Draining and cleaning the filter will be automatic in the next model.

8.2. MODES

DIRTY WATER IN > PRE-FILTER > PUMP > VALVES > FABRIC FILTER > SAND FILTER > ACTIVATED CARBON FILTER > VALVES > UV > HEATER > SHOWER HEAD > YOU > <start again>

There must be sufficient water in the system (7-10 liters) to fill the system. Water is prefiltred, pumped to the filter, filtered, sterilized/purified in the UV lamp and reheated before being looped.
8.2.1. Prewash
Ideally, in this mode, you will take the initial shower before activating Showerloop mode to reduce the load on the filters. A pre-wash or navy shower is recommended, essentially taking a really quick shower. Getting wet and washing off main dirt particles and applying shampoo and soap.

8.2.2. ShowerLoop
: PUMP, UV, HEATER, V2, V4, V5
The main mode used to enable the filtering and reuse of shower water.

8.2.3. Backwash
: PUMP, V2, V3, V5
Run this until no water goes out the drain pipe/ the motor has run dry for a moment.
Then run Pee/Flush mode: PUMP, V2, V4
To evacuate all the water left in the system.

8.2.4. Bypass
: PUMP, V1, V2, V5
Run this until no water goes out the drain pipe/ the motor has run dry for a moment.
Then run Pee/Flush mode (see: Pee / Flush)
To evacuate all the water left in the system.

8.2.5. Pee / Flush
: PUMP, V1, V3, V4
Run this until no water goes out the drain pipe/ the motor has run dry for a moment.
Then run Pee/Flush mode: PUMP, V2, V4
To evacuate all the water left in the system.

8.2.6. Drain
: V1, V2, V3, V4, V5
This is, unfortunately, a little bit cumbersome of a process and will be automated. Leave the valves open for 10-30 minutes after you have taken a shower to allow for the filters and pipes to empty of water. For this reason, it’s good to allow for water to drain passively from the system by connecting devices.
9. ASSEMBLY INSTRUCTIONS.

9.1. ORDER
Figure out how you want all the components to be laid out. Lay them out on the ground or on the backboard you intend to use.

Considerations:
The Sand/Active Carbon Filter should be upright with the current design (carbon level on the top of sand). It should run sideways but some important features may be missing: the ability to push bubbles out of the system and filter and passive or gravity draining. So water should always be flowing upwards or sideways (though a slight angle is recommended).

9.2. SECTIONS:
9.2.1. Pre-filter and pump:
The pre-filter and pump intake should be aligned. It doesn't matter if it comes from the left or right but make sure the orientation on both the pump and the pre-filter are correct. Look for the arrows showing the direction of water flow. Ideally, both are positioned at the bottom of the Showerloop. It's not recommended to use angled pipe connectors with filters.

9.2.2. Valves:
Can be split into the top and bottom assemblies.
- Top Assembly: Valves I and II.
- Bottom Assembly: Valve III, IV, V.
Use 5-7 rounds of Teflon tape. This part is a little tricky because with the connectors we are using there's no way to ensure the orientation, except for trial and error. Using plumbing style connections (like with the POC21 version) it's a little easier.

9.2.3. Filter:
The main filter (sand/active carbon) should be installed in the middle of the Showerloop, preferably located over the pump and pre-filter. The orientation of the filter is based on the internal material. The sand is located in the bottom of the filter and the active carbon on the top of the filter. The bottom of the filter is connected to T-branch, located between valves V3 and V4. The top of the filter is connected to the valve V2.

9.2.4. Uv:
Uv is located on top of the showerloop, over the main filter. The recommended installation angle is 45°. The lower connector is connected to the Valve VI. The top connector is connected to the shower head.

Heater
10. PARTS / COMPONENTS / BOM

**fig. 5: General assembly diagram.**

<table>
<thead>
<tr>
<th>Det nr.</th>
<th>Qty.</th>
<th>Name</th>
<th>Ref. number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>PRE_FILTER</td>
<td>LOOP-057</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>PUMP</td>
<td>LOOP-046</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>VALVE</td>
<td>LOOP-060</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>MAIN_FILTER</td>
<td>LOOP-001 - LOOP-009</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>UV</td>
<td>LOOP-052</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>CONTROLLER</td>
<td></td>
</tr>
</tbody>
</table>
10.1. PREFILTER.

The first prefilter stage is the drain itself. This is the first and best line of defense to keep the Showerloop in working order for as long as possible. The drain will keep big size external elements/particles out of the system.

The second stage of the Prefilter is a KIT (as shown), it contains a filter that can be replaced when needed. An easy visual inspection will tell you whether is time to change it (for more info check Maintenance chapter). The kit includes a support, we recommend it for an easy installation and maintenance.

The KIT pre-filter is placed before the pump to capture large particles and prevent them from clogging up the pump and hoses.

The prefilter should be placed horizontally with the transparent chamber facing down and accessible so that you can clean and replace the filter.

NOTE the orientation of the filter. There should markings for IN and OUT (outside of the filter to the center and then up and out). Also, make sure that there isn't anything there.

Use Teflon tape or hemp fiber to seal the connections. L-bends, Male, Barbed connectors can be used.

10.2. PUMP.

The pump is a crucial part of the system, it is the device that ensures the circulation of the water throughout all the components. There are definitely many options to choose from, but through our experience, a self-priming water pressure pump does the job quite well, it should cost at least 60 dollars/euros.

The Pump should be placed after the pre-filter and connect to the T-pipe located between valve V4 and V5. This ensures a good operation of the ShowerLoop modes. It is better to orient the motor housing facing down (as illustration ##) or horizontal so it can be inspected and clean easily. For more information consult the self-priming water pressure pump manual:

SEE SELF-PRIMING WATER PRESSURE PUMP MANUAL
https://docs.google.com/document/d/1uYXIMgoutgRsRaZN4cyekQJQvDxBk9fcLM-2BmzSxSco/edit?usp=sharing

10.3. Valve.

The motorized ball valves are used in combination to activate the various showerloop modes by opening and closing in specific combinations. Ball valves are nice because of their low resistance as the diameter inside the valve is about the same as the hose in a straight line. Solenoids can also work but they generally only flow in one direction, have high resistance, and draw much more power (watts compared to fractions of a watt).

Valve power
On at 6.4V (very slow and weak though)
0.02A
.122 watts per valve
It goes off at 4.5V or less
0.02 A

LINK to the valve documents!!!
10.4. FILTER.

[Image of filter components]

fig. 6: Filter components.

Link to the design files above.
https://drive.google.com/open?id=1l7l9SxWHhkKq-GCmqPPQ-Iw2lWYjYr0T

SEE FILTER MANUAL
https://docs.google.com/document/d/1bDM_z5XQPu2OrFVX3QOyj3mfffK_Ft_fFbqZrGkTmbY/edit?usp=sharing

10.5. UV LAMP

ULTRAVIOLET IRRADIATOR
SEE UV MANUAL

10.6. HEATER.

SEE HEATER MANUAL
https://docs.google.com/document/d/1e7NSEUpV_W2SX7Yeyd1IDjKIwWVAsMepUFc0gqwY/edit?usp=sharing

10.7. PIPE FITTINGS.

Everything has been standardized to use 1/2” BSP (British standard pipe) threads for connecting hoses, valves, pumps, UV, you name it. 3/8” inch might work but I haven’t used it much. Also 3/4” and 1” connections may also
work better to reduce the overall pressure in the system but I have my doubts they would offer significant improvements. 1/2” is a good size because it's common with gardening equipment, is inexpensive and has a good range of quality and standard parts with decent prices. Permanent fixtures with copper/ss pipe or PEX tubing will for sure work but I haven't been able to test them out thoroughly. Since they are an industry standard I see no problems with them except their larger size and cost.

**10.7.1. Plastic quick fit hose connector.**
This is standard for connecting 2 hoses together. It's easy to install and very reliable (no leaking) without the need for tools as it tightening by hand is sufficient. These can be found in any gardening section in a decent hardware store though they cost a lot compared to finds on Ebay.

![fig. 7: Plastic fitting connector.](image)

**10.7.2. Brass quick hose connector.**
This component took a while to find but it's fantastic. Really should be available everywhere. It's got the 1/2” female thread which can also connect to a male-male connector to have both orientations.

**DIAGRAMS**

- Brass T
- Brass Male - Male
- Brass Male - ¼” barbed connector

**10.7.3. Other options.**

PEX tubing
10.8. ELECTRONICS.
COMPONENT 6 AND 7 IN THE ASSEMBLY DRAWING LIST!!!
This is technically outdated, but also a simplified version of the switchboard/power box combination. Instead of using a relay module and trigger each device from it, the switchboard directly triggers the valves and via the minimalistic power box on the right triggers a relay for the pump, UV, and heater. The output from the switchboard is all 12V DC while the output from the power box is 220V AC for the UV and Heater and 12V DC for the pump. The reason this was replaced with the Relay module is that it was both less expensive to produce at small quantities and also provides a visual feedback for the devices. When the device is triggered via the switch a RED LED turns on to show that the RELAY is CLOSED. Wiring the relay module is also simpler.

WHERE IS THE 3D MODEL?
WHERE IS THE CAM FILE?
Attachments? Links?

fig. 8: Plastic fitting connector.
10.8.1. Backboard size 30x50 plywood 3-6mm

Cut the plywood. Round the edges if desired. Lacquer or varnish.

Laser cut baseboard for power box. Plastic may be the better option as wood will likely warp from the humidity and changing temperatures. Hopefully, if the box leaks the wood will reveal it. Acrylic is an available alternative but possibly less sustainable.

Complete baseboard includes 17 pieces, mainly used for organizing electronics during assembly. To help with assembly, we have marked components' positions on the board itself, such as position for a relay unit or cable through-holes.
For assembly, you might need wood glue and sandpaper. After cutting the plywood, gently push all the pieces out (fig. 10). Begin assembly with the terminal block holder. Turn the baseboard upside down, text facing down. Use two holders to attach terminal block holder. Attach eight (8) holders in the middle of the board (fig. 12).
Use two holders to attach cable organizer (marked with text) to the marked location (Fig. 11). Do not apply force, since pieces are fragile to break.

Remove a DC-motor regulator from the protective case. Attach holders (Fig. 13) to the DC-motor regulator before attaching regulator to the baseboard. The smaller holder is located on top of the bigger one (Fig. 14). Attach the component to the baseboard with four M3-screws and nuts as shown in Fig. 15 and 16. Turn the baseboard around marking text facing up.
Proceed with electronics’ assembling.

LASER CUTTABLE FILE
https://drive.google.com/open?id=1Oiyu1M63p1VlhiQVy5KYxs1pycWCMKvNk
**10.8.2. Power Box / Relay Box**

The purpose of the power box is to house the high voltage electronics and to separate them from the user while they are in the shower. Water and electricity can be an intimidating combination even though it's done all the time with washing machines, dishwashers, and jacuzzis. In Finland, we casually through streams of water at electrical resistors while naked in the sauna.

**LIST of components:**

<table>
<thead>
<tr>
<th>Det nr.</th>
<th>Qty.</th>
<th>Name</th>
<th>Ref. number</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>POWER BOX</td>
<td>LOOP-028</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>BACKBOARD</td>
<td>LOOP-029</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>RELAY MODULE</td>
<td>LOOP-032</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>TERMINAL BLOCK (5 pin)</td>
<td>LOOP-033</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>TERMINAL BLOCK (2 pin)</td>
<td>LOOP-034</td>
<td>Use 2 x 2 pin as one 4 pin</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>MOTOR CONTROLLER</td>
<td>LOOP-035</td>
<td>Incl. switch and control buttons</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>FUSE 10A</td>
<td>LOOP-036</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>FUSE 1A</td>
<td>LOOP-037</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>GROUND FAULT PROTECTOR</td>
<td>LOOP-040</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>CIRCUIT BREAKER</td>
<td>LOOP-041</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>KILLER SWITCH</td>
<td>LOOP-113</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>11</td>
<td>CABLE GLAND</td>
<td>LOOP-038</td>
<td>PG7, 7 x white, 4 x black</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>DIN RAIL</td>
<td>LOOP-114</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>AC/DC CONVERTER</td>
<td>LOOP-062</td>
<td></td>
</tr>
</tbody>
</table>
fig.17: Plastic fitting connector.
Begin assembly by attaching relay module (1.) to the baseboard (Fig. 18). The location for a relay module is marked on the baseboard in the middle. The relays should be facing left towards terminal block location (Fig. 19). Secure the relay module with four M3-screws and M3-nuts (Fig. 20). Try not to bend the relay module, as it may break.

![Fig. 18: Relay module (LOOP-032)](image1) ![Fig. 19: Relay module installed](image2) ![Fig. 20: Relay module installed (close)](image3)

Secure the DIN rail (13.) to the baseboard (Fig. 21). The location for a DIN rail is marked on the baseboard, located under the relay module location. Use two M3-screws and -nuts, in addition to washers. The DIN rail should be located directly under the relay module in addition to touching it (Fig. 22).

![Fig. 21: DIN rail with attachments](image4) ![Fig. 22: DIN rail attached](image5) ![Fig. 23: Cutted terminal blocks](image6)

Attach terminal blocks (5) to the baseboard (Fig. 23). Use M3 wooden screws to secure terminal blocks. The 4-pin terminal block is used for connecting AC/DC converter to the fuses. Terminal block is located in the right-top location of the baseboard (Fig. 24). Remaining 2-pin terminal blocks are used for DC-power connection. A 2-pin terminal block for controlling DC-pump is located in the left-down location of the baseboard (Fig. 25). Another 2-pin terminal block is located next to the relay module and fuses (Fig. 26).
Install Ground Fault Protector (9) and Circuit Breaker (10) to the DIN rail (13). Ground Fault Protector should be located on top of Circuit Breaker. The 1-pole of the Ground Fault Breaker should be facing left while 2-pole should be facing right. The Circuit Breaker should be installed such way, that the text written on both components should be easily read without turning baseboard.

10.8.2.1. WIRING...

The process includes wiring AC and DC components. The wiring also includes adding additional components, such as Killer Switch, Fuses, Terminal Blocks, and Pump Controller switches.

General wiring rules are included in the process, covering color pattern for AC/DC components. AC-wiring includes usage of blue, brown and green/yellow wires, where DC-wiring includes red and black wires.

Begin with wiring AC components. Based on standard IEC 60466, phases are brown & neutral is blue. AC Power Cable is connected to Ground Fault Protector (9.). Phases (brown) is connected to the pin 1 of Ground Fault Protector and Neutral (blue) is connected to the N-pin on the same side. The pin 2 of Ground Fault Protector is connected to the Circuit Breaker (10.) by the Phase (brown) wire. The wire is routed between components on the other side of the baseboard. To secure wiring use 2.5mm² terminal crimps (LOOP-074).

Connect the unplugged end of Circuit Breaker to the Killer Switch (11.) with Phase (brown) wire. From Killer Switch the Phase (brown) wire is connected to the Terminal Block marked with 220 AC(+). The wire should be routed through the back of the baseboard. The Neutral (blue) wire is routed from Ground Fault Protectors (9.) pin N to the Terminal Block marked with 220 AC(-). The Power Cable's Ground is connected to the Terminal Block marked with 220 AC(grnd).
Connect Fuse Holders (Fig. 27) to the Terminal Blocks located in the top right of the baseboard. To keep Fuse Holders secured on a baseboard, reroute wires as shown in figure 18. Install 10A Fuse (7.) to the left Fuse Holder and 1A Fuse (8.) to the right Fuse Holder (Fig. 29). On the back side of baseboard, the Fuse Holder with installed 10A Fuse is connected to the Motor Controller (Fig. 30). The Fuse Holder with installed 1A Fuse is rerouted to the Terminal Block marked 12V DC+ on the front side of the baseboard (Fig. 31). From previously connected Terminal Block reroute ground wiring (black) parallel to the Fuse Holders. 10A Fuse Holder –related wire is connected to the Motor Controller (6.) and 1A Fuse Holder -related wire is connected to the Terminal Block marked 12V DC- (Fig. 32).

Jump wire two 12V DC+ marked Terminal Blocks together. Connect both 12V DC+ Terminal Blocks to the Relay Module’s(3.) COM-ports 1 ... 5. Use 1.5mm² terminal crimps (LOOP-074) to secure wiring to Relay Module. Jump wire two 12V DC- marked Terminal Blocks together.

Connect Relay Module’s Pin DC+ to the Terminal Block marked 12V DC+, and Pin DC- to the Terminal Block marked 12V DC-. Reroute two DC wires from Motor Controller (Fig. 33) to the Terminal Block located in the lowest left side of the baseboard marked Pump (Fig. 34).
10.8.2.2. ASSEMBLY...

Begin assembly by connecting Switch and Speed Controller to the Motor Controller (6.) Use picture [XX] as a reference. (note: secure Switch Controller to the Power Box (1.) before connecting to the Motor Controller and use O-ring). Place assembled Baseboard inside the Power Box. The arrow markings should match the position of power box's through-holes, which indicates the correct installation position.

Attach O-rings (LOOP-039) to each Cable Gland (12.). Install and fast secure Cable Glands to the Power Box in marked location (note: black-colored cable glands are used for AC-components, while white-colored are used for DC-components). Don't apply force while securing cable glands, as it may break O-rings. Secure Killer Switch to the marked location.

Attach AC/DC Converter (14.) to the Power Box. The AC-side cable is connected appropriately to the Terminal Blocks (AC+, AC- & GND) located on the baseboard. Two DC-side cables are connected to the terminal blocks together with Fuse Holders: brown cable is connected with the red one and blue cable with the black one (note: you can check the polarity of cables marked on the Converter itself).

Attach UV-light Converter to the Power Box. Cables are connected appropriately to the Terminal Blocks located on the baseboard.

Connect 3-wire Power Plug Cable (LOOP-065) to the Power Box. Peel off protective skin to expose internal wires. Before connecting wires, ensure that ground wire is the longest of all three wires. We recommend cutting ground wire at least 200mm. longer than other wires. Secure wires inside the Power Box. Both phase (brown) and neutral (blue) are connected to the Ground Fault Protector (9.) in the marked sockets. The ground is connected to the Terminal Block marked 220 AC(grnd).
fig.35: Electric Diagram.
Fig. 36: Nikita made this awesome diagram for us.
10.8.3. Switch panel / Control panel

Fig. 37: control Panel diagram.
Top left: AC/DC transformer 150W DC output. Left: Power Box, Right: Switch panel. Right, right: prototype Showerloop mode diode module. LEFT: DIMENSIONS FOR THE 6X TOGGLE SWITCH PANEL (originally for the Motonet/seaworld one, but also works with Biltema)
RIGHT: Dimensions for the boat rocker switch (mm). >Snug fit<

The Control Panel is pretty simple.

input is 12V DC power + and -
The switches open and close the circuit. Each switch has 3 connections,

1: +/PWR/VCC/positive
2: -/ground/negative
3: ACC/accessory/signal

There's a common power cable for all switches and a common ground. The ACC or signal is what's connected to the INPUT of the relay module to power each device.

It could be even simpler with a common ground for everything and the power working as the signal cable and going directly to the device.
This doesn't happen for 2 reasons. First a switch with an LED needs to have 3 connections so the power of the device isn't going directly through the LED, secondly, and more importantly, the switches are used to activate relays and therefore separate the power of the device from the circuit that the user can come into contact with while in the shower. E.g. imagine the 220V heater connecting to the wall socket and all you have is a on/off switch to activate it. If the switch was not properly insulated the current could pass through you and cause electric shock (this is bad). Instead now only low voltage and low current 12V DC 0.01 A power can come into contact with the user.
10.8.3.1. WIRING & ASSEMBLY....

For Control Panel the wiring and assembly simultaneously. Begin the assembly by attaching Switch Board (LOOP-044) to the cover case of Switch Panel (LOOP-043). Remember to attach silicone gasket between switch panel and cover case to remain IP-protectivity. Use four M3 screws and nuts to secure switch panel. Detach all fuse holders from the switch panel.

Cut six approx. 200mm. long wires. Use a crimp tool to attach Female Spade Crimps to each cable from one side. Connect wires by crimps to the switch panel.

Install the 8-pin terminal block inside the Switch Panel Housing (LOOP-043) and secure with the screw to the case bottom. Attach two PG7 Cable Glands (LOOP-038) with 0-rings to the holes drilled in switch panel housing.

Use two 5-meter long, 6-wires Cables (LOOP-066) to connect Power Box to the Control Panel. Peel off protective skin (approx. 100mm. length) to expose internal wires from both sides of the cable. Connect the cable to the terminal block located inside the Switch Panel as shown in the diagram [XX].

When all components are connected, close the case of Switch Panel and secure it properly with four screws included with the case. Connect two previously used 6-wires Cables (LOOP-066) to the Power Box. Push cable through two Cable Glands marked A & B. The marking on the baseboard provides you an information for each switch controlling each valve. Using diagram [XX] as reference connect wires to the relay module and the terminal block accordingly.

10.8.4. Testing.

Before begin testing, make sure that:
- the Emergency Stop Switch is pressed down
- both Ground Fault Protector and Circuit Breaker are switched off
- check for unplugged cables, especially attached to the AC-powered components
- make a visual inspection of all cables' and wires' insulation for exposed copper
- don't touch any visible components while the electronics are powered on (!)
- don't plug or unplug any components/cables/wires while the electronics are powered on (!)

Plug the power cord to the wall socket. Turn the Ground Fault Protector and Circuit Breaker on. Release the Killer Switch. The Relay Module's LED should turn on.

Test the Pump Switch, by pressing it. The LCD display should turn on and 0-value should be printed. Turn the Pump Speed controller in both directions, while the number on LCD display should be changed between 0 ... 100.

Test all switches in the Switch Panel by turning them on and off. The LEDs on Switch Panel should turn on for each switch, while LED on Relay Board should turn on accordingly.

Test emergency shutdown by hitting Killer Switch. All LEDs should be shut down immediately. Test the functionality of Ground Fault Protector by pressing T-button located on the component. The switch should release immediately and the power should turn off.

End testing by pressing the Killer Switch on and unplug the power cord from the wall socket. After a little moment, you may begin connecting Power Box to the Showerloop.
10.8.5. connectors / electrical fittings.

10.8.5.1. JUNCTION BOXES

10.8.5.2. PG7

10.8.5.3. PG11

10.8.5.4. AWG/EU electrical cables

Amps

10.8.5.5. STANDARDS

AWG/EU electrical cables

IP Classifications
7. 11. Q&A

"... why is it necessary to discard the water after use? As in why couldn't the same water be used to shower over and over multiple (hundreds?) of times since it's being purified with each pass?

Best, Frank

> Hey, I'm sure the water can be reused but I'm not sure how often so I don't want to advertise it until I've been able to test and verify the results, something that's been very difficult to do since graduating from university and losing access to the various laboratories that I had at my disposal.

The thing I'm concerned about it still water. Generally, bacteria will begin to form no matter what you do and if there are trace nutrients in the water, which there are, biofilm would start to form on the surface layer/walls of the storage tank. That said I think running the shower X times a day/week/month when not in use would remedy the situation. Also, I think if it's necessary a ceramic filter (much like a membrane filter) and or bubbling ozone through the water would act to sterilize the water. UV would also work but we don't have a holding tank for the water and it's safer/better to use various methods of sterilization to make it super safe/secure – one system goes down or isn't sufficient to deal with some kinda superbug. Chlorine may work but only so and so since it evaporates and would consume the Activated carbon, also I want the system to run on its own without the need for chemicals.

The best long-term option would be solar thermal heating and desalination. Storage tanks for both hot, cold and process or grey water. This way the system runs basically passively. All you need to do is clean the system every now and then. Solar and batteries as storage. The point of the hot water storage is to act as a battery. Maybe a Stirling engine or Peltier elements could work to convert some of it into electrical energy. Is there a loss when it's hot on one side (the hot water tank) and cold (room temp/outdoor temp) on the other side. Wouldn't that be really efficient? or if the efficiency is only like 20% then we're losing 80% of the heat energy to outside. And you need a lot of surface area. Then again maybe a container designed like a heat exchanger/heater could do everything. It would need a way to get cleaned maybe. Maintenance would always be good - but there's a loss in structural strength and simplicity... and of course, there's always wood ovens and stuff like that.

RESOURCES

8. 12. TROUBLESHOOTING

What to do when...
Everything is on but the water isn’t coming out
- Check that all devices have power.

Pumps not working

13. APPENDIX TOC
## 14. Showerloop Usage LOG.

<table>
<thead>
<tr>
<th>Date</th>
<th>User</th>
<th>Duration (minutes)</th>
<th>Water used (liters)</th>
<th>Power used (kW)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.7</td>
<td>testing</td>
<td>5 hours?</td>
<td>50 flushing</td>
<td>?</td>
<td>errors.</td>
</tr>
<tr>
<td>22.7</td>
<td>More testing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
15. REFERENCES, SOFTWARE & OTHER MANUALS

Tutorial: How to crimp connectors, strip wire and use heat shrink. Mjlorton on youtube.
https://www.youtube.com/watch?v=kjSGCSwNuAg

Common plumbing parts with names and pictures

Software we use and Open Source alternatives

Fusion360 (3d models, CNC, printing)
Cura
Prusa Slicer
Tinkercad
OpenSCAD
FreeCAD
SolveSpace
Adobe Illustrator
Gravit Designer
Inkscape
Keynote
Google Docs
Eagle (board design)
KiCAD
Easy EDA (circuit diagrams)
16. Link to the scanned documents here:

MANUALS for other products

Selvarajan, Jason; Holland, Keiran (2013)
https://www.theseus.fi/handle/10024/76148

TESTING FACILITY FOR A WATER RECYCLING SHOWER Master’s thesis
Eduard Kobak (2013)
https://dspace.cc.tut.fi/dpub/bitstream/handle/123456789/22156/Kobak.pdf?sequence=3

16.2. Testing the Efficacy of The Prototype Water Purification System for Shower Water
Mishra, Anup (2015)
https://www.theseus.fi/handle/10024/92876

16.3. Testing different combination of personal cleaning products against activated carbon for Showerloop shower water purification system
K.C., Gaurab (2017)
https://www.theseus.fi/handle/10024/92876