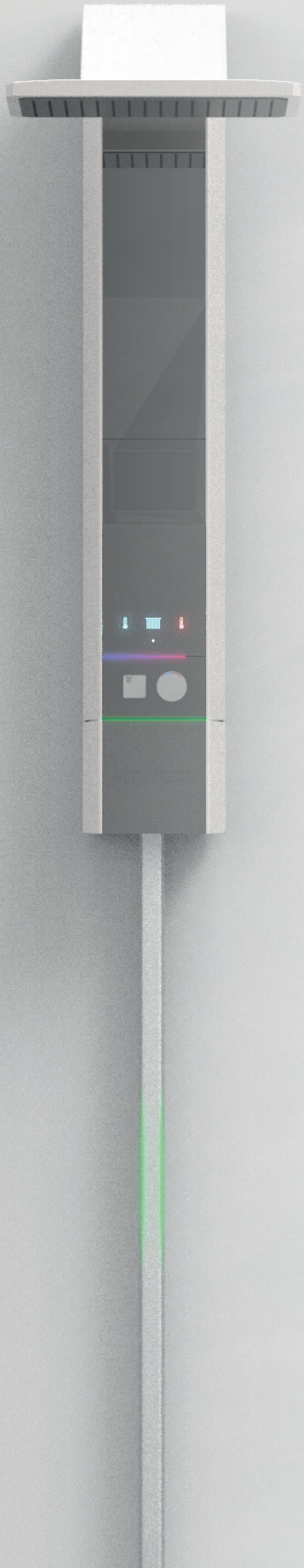
The Elv Shower

The next generation of sustainable products



PRODUCT REPORT

Aalborg University // Industrial Design // MSc04-ID8 // 2017
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THE ELV SHOWER

Elv is created as an reaction to the severe water wastage while showering which is seen in homes. Water which is perfectly fine after being showered in, ultimately gets drained, wasting both water and heat. As a solution to this, Elv sets a new paradigm in sustainable showering by using the normally drained water once again by picking up the cleanest of the water before it hits the drain. The forces of the recirculated water is then used to pick up more water using the Hydro Lift technology, resulting in a truly unique low powered recirculation principle. The water then passes through the Smart Filter, before once again, getting outputted onto the user.

Furthermore Elv builds upon the values of showering by using the recirculated water to enhance the coverage of water, without the added water usage usually associated with this. Providing comforting features which support and enhance the relaxing and therapeutic feeling of the warm water, a value appreciated by many, Elv is truly the next step in sustainable comfort.

By providing a highly competitive product on a otherwise stagnating market, it is believed that Elv will be a significant product for both the water saving segment of users, and the users looking for a higher comforting shower experience.

THE SHOWER EXPERIENCE

Relaxation

The shower is one of the best places to relax and enter a state of comfort. Be it to relax your tired body, to decompress from a stressful day, or just pure indulgence, the shower can do it all.

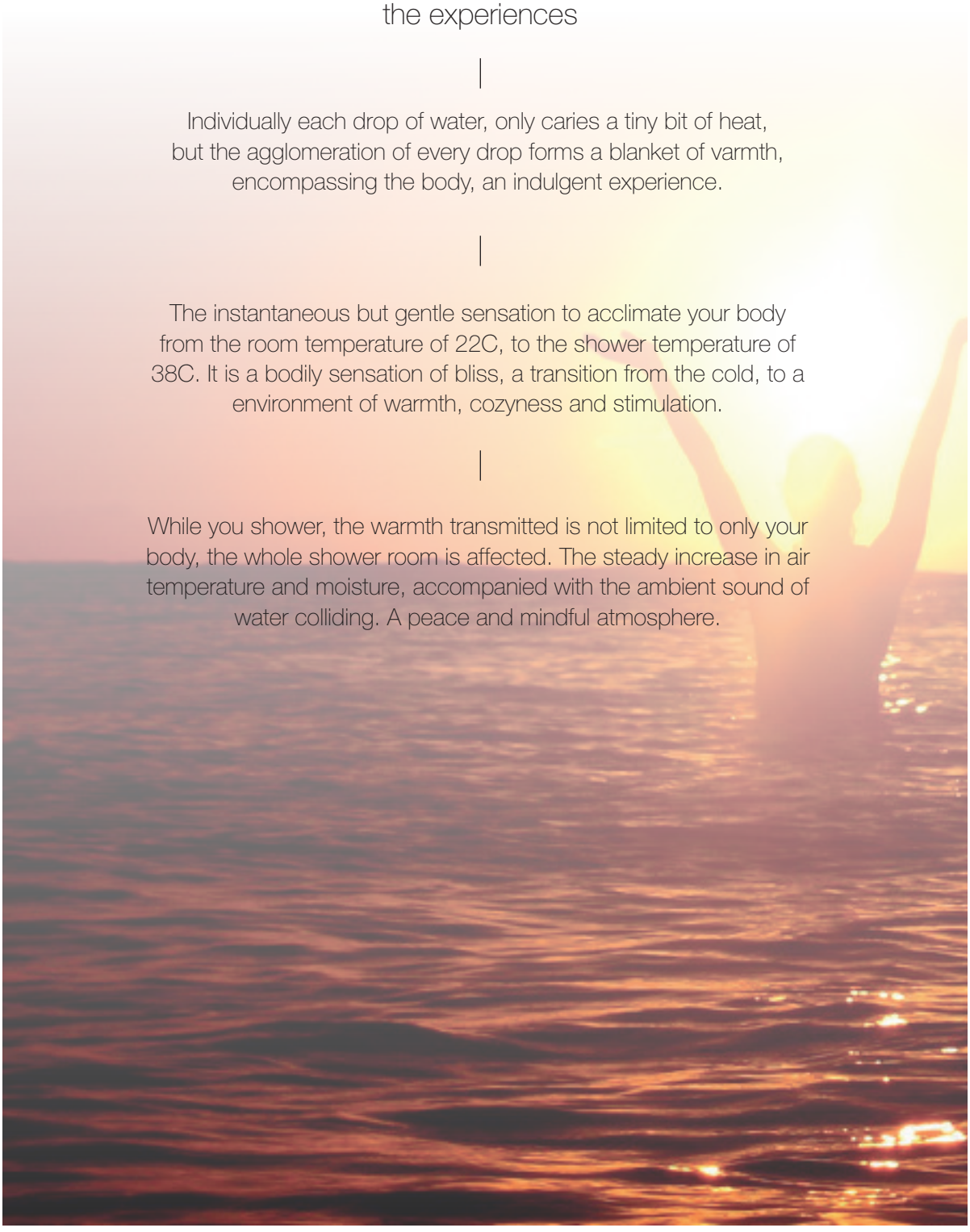
The Core experience to any relaxing shower
is the bodily sensation of **warmth**.

the experiences

Individually each drop of water, only caries a tiny bit of heat, but the agglomeration of every drop forms a blanket of varmth, encompassing the body, an indulgent experience.

The instantaneous but gentle sensation to acclimate your body from the room temperature of 22C, to the shower temperature of 38C. It is a bodily sensation of bliss, a transition from the cold, to a environment of warmth, cozyness and stimulation.

While you shower, the warmth transmitted is not limited to only your body, the whole shower room is affected. The steady increase in air temperature and moisture, accompanied with the ambient sound of water colliding. A peace and mindful atmosphere.

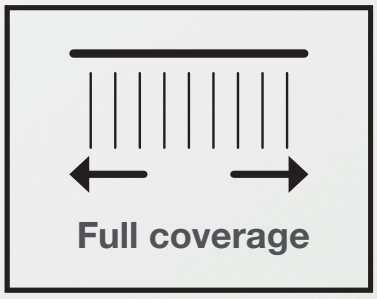


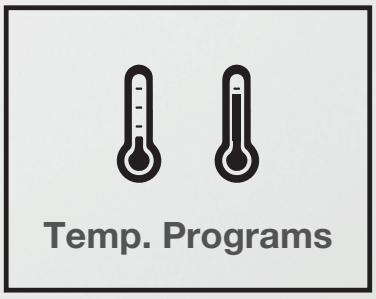
However, the transfer of warmth inevitable requires a great deal of water and energy with current products

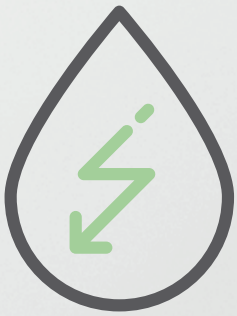
The average comfort shower goer expends up to 300 liters per shower, the same usage as a moderate familiy of four.

And additionally the same energy usage as 4 continuous days of TV usage.

The Elv Shower supports the core experiences of warmth. By providing the **Elv full body coverage**, and the addition of **unique temperature programs**







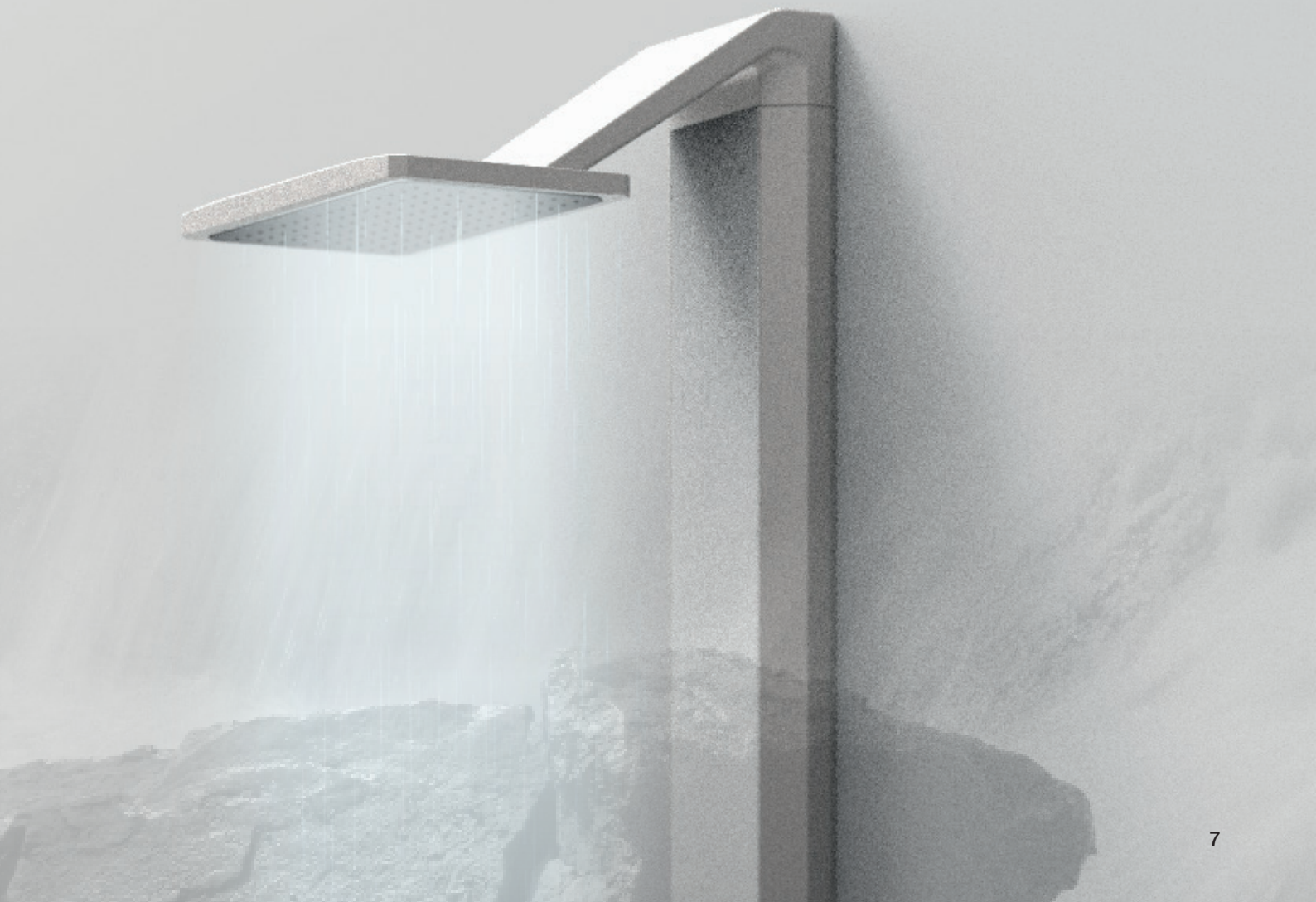
However, It achieves this by channeling the natural properties of fast flowing water to create a **Water Recirculation Shower**, resulting in an all time low energy and water usage. The entry of **Sustainable Comfort**, Indulgence with up to 60% water savings.

The Water Recirculating Shower

Lowers water waste by picking up the cleanest percentage of water, filtering and finally recirculates it to reuse within the shower, to create a high flow rate, with an actual low water usage. However the Elv shower does so in a truly unique way, by the means of two key technologies.

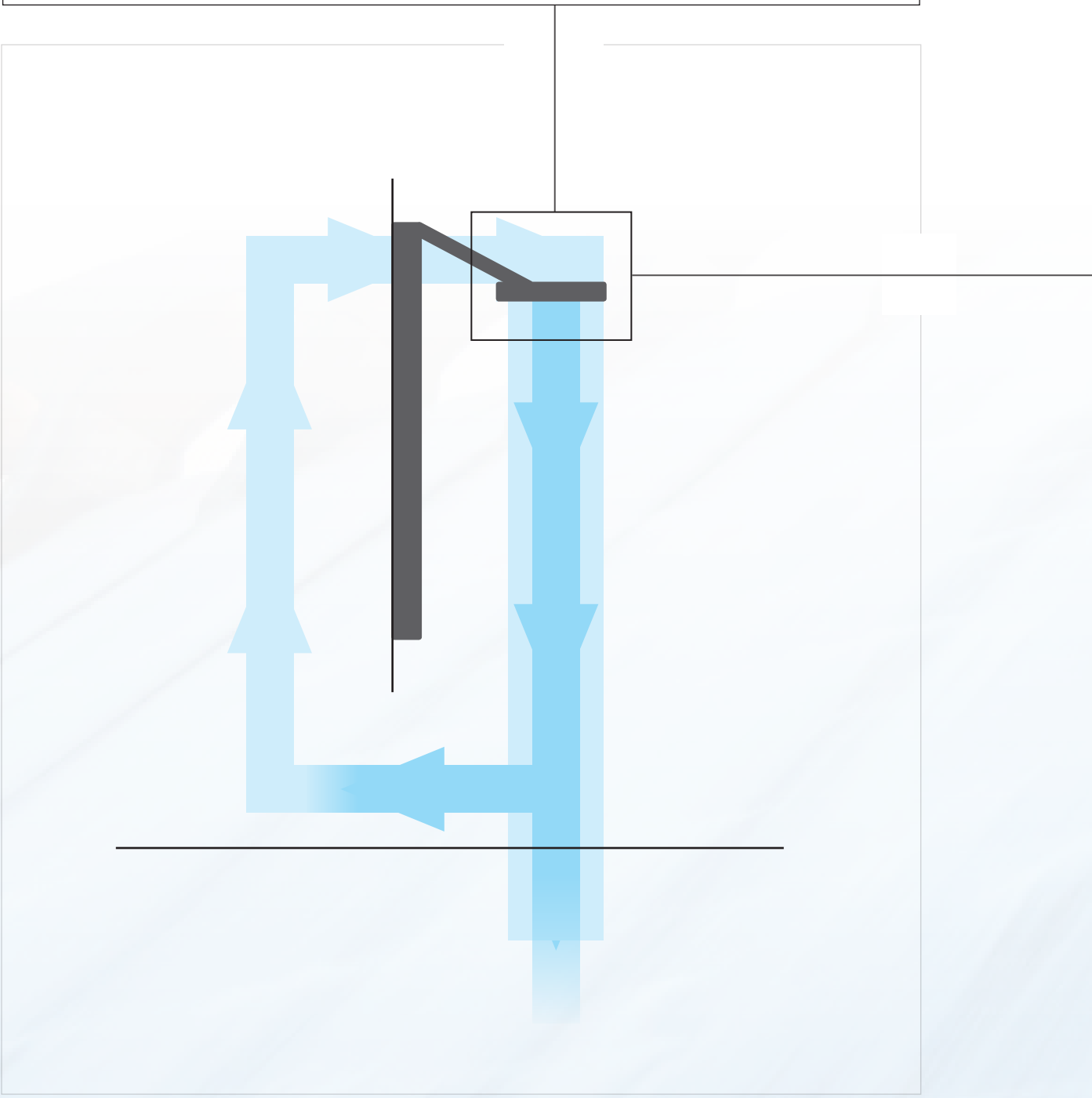
Hydro Lift

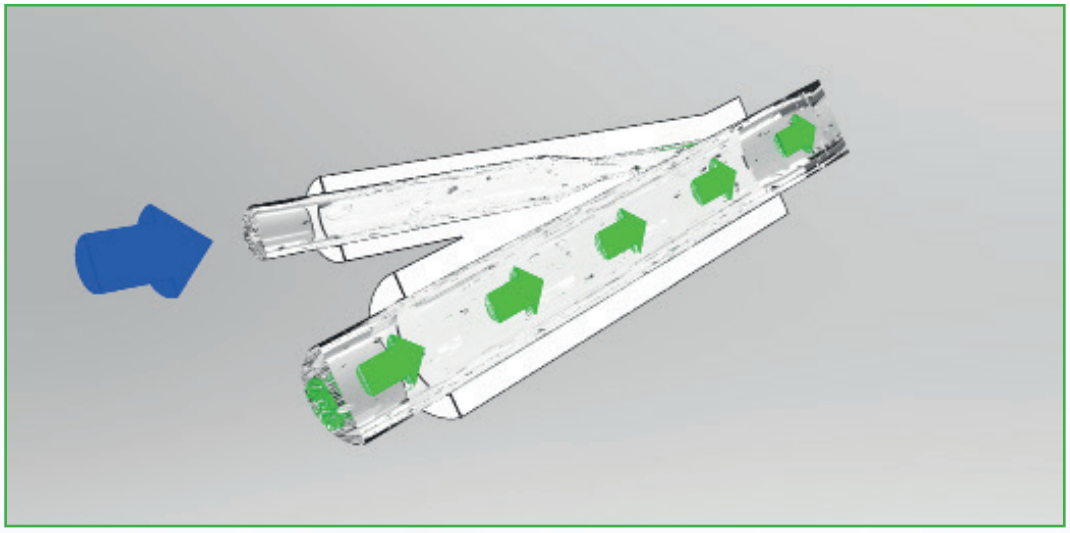
Smart Filter



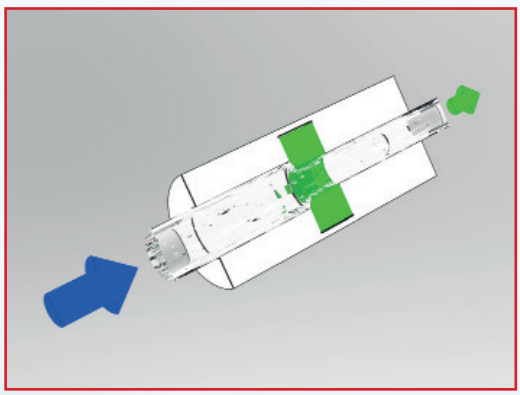
Hydro Lift

The Hydro Lift technology uses the high pressure and fast flow of the internal water stream to generate a circulation loop, reusing up to 50% of shower water.

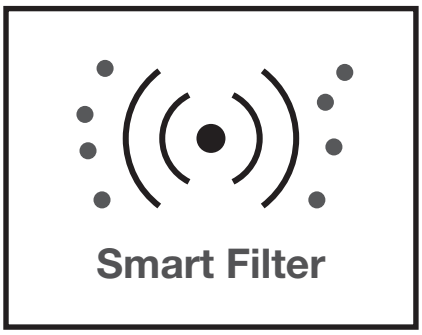




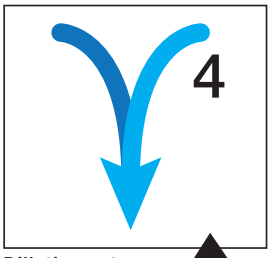
The Hydro Lift is situated inbetween the water flow, close to the showerhead, wherein water passes through a narrower tube section as seen with the blue arrow. The strong jet of water creates a strong suction that is utilized to lift shower water, as shown with the green arrows. The Hydro Lift enables the shower to make the very best use of what is already available, whereas conventional water saving showers are the direct opposite.



The conventional water saving shower, acheives its ability to save water, by using a water restrictor. It restrains the flow rate by narrowing the water tube, creating friction and turbulences, the waters inherent energy is lowered and thereby the flow rate, however the natural energy of the water is wasted, and is not being utilized.



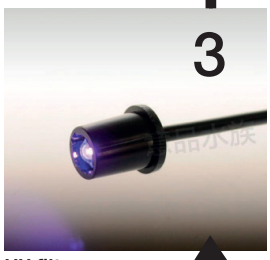
The ELV Smart Filtration
Only selects, filters and circulates the most suitable water, ensuring a very high water cleanliness. It will ensure that no soap is reused onto you, and should you spill a whole bottle of shampoo, the system will detect and immediately stop, and re-initiate once it has dissipated.



Dilluting water

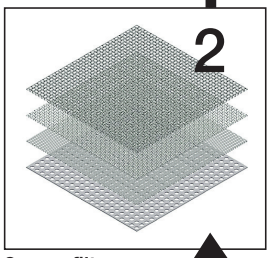
Once the water has been disinfected, it is further diluted into fresh water. Making the few suspended particles spread even further, ensuring that the water is clear.

The remaining shower water is discarded after usage.



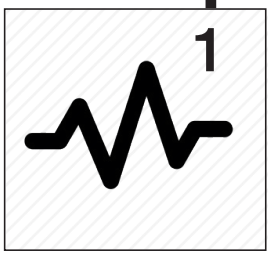
UV filter

The water is lifted up to a buffer tank, wherein all harmful bacteria such as E.coli will be disenfected with highly effective UV-C rays, ensuring that the water is absolutely safe to shower in.



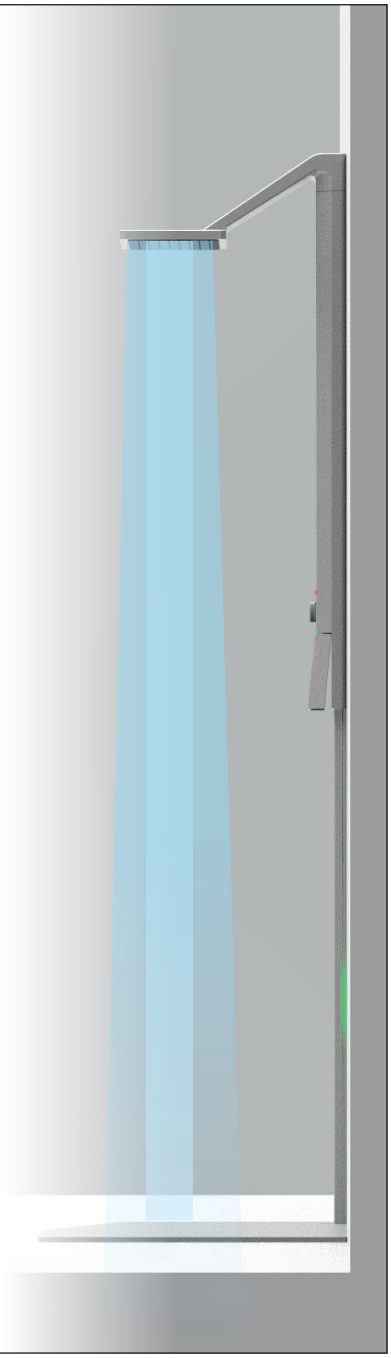
Screen filter

Meanwhile, all rough particles such as hair, or bigger obstactles will be blocked with a mesh filter, that is removable to be cleaned.



Sensor module

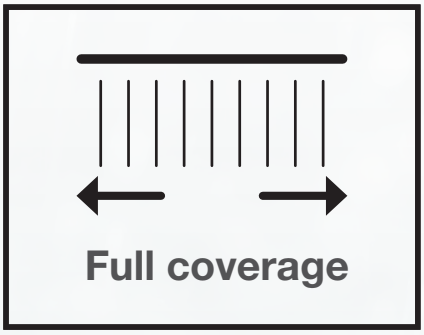
Once water pours down, the quality will be measured, if it meets the acceptable threshold it will be picked up. For instance, soap and dirt will not meet the requirement, thus not be picked up.



The ELV Smart Filtation has a close to perfect detection rate, however the digital system is not able to detect all and everything, furthermore, the perception of what is clean and what is not, is in the eye of the beholder. The Elv shower accomodates this by having a On/Off button. Whenever you are uncertain, or simply want to ensure something is not being recirculated, you can simple turn the recirculation off.

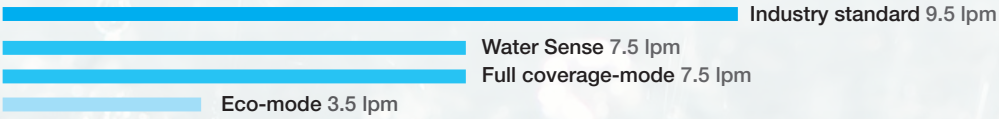
The On/Off button, has a clear visual on/off stage, even in the most misty of showers. It has a big surface of operation, enabling it to be activated very easily with clear tactile feedback, even when facing away, activating it with your elbow.

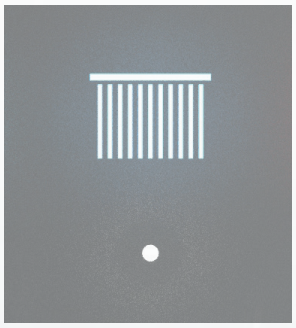
Whenever the recirculation is on, it is clearly shown by the upwards pulsation of light, a digital simulation of upwards pumped water. When it is disabled, so is the pulsating light. The extra layer of feedback, will ensure a clear understand from multiple perspectives.



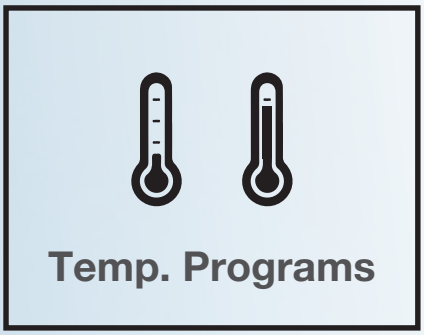
The Elv Full coverage. Indulge in a sumptious water flow with the mere press of a button, the water coverage will extend your shoulders, supporting an experience where you are able to fully relax, no movement is required to get the full benefit of the warm water pouring onto you.

A unique experience, offering a high-end coverage, only seen in luxury products until now, however with an very low actual usage of water, creating sustainable comfort. The experience is enabled by the Hydro Lift, that has two modes, the default eco-mode, that enables water and energy savings up to 60%. And the “on demand” full coverage mode, that is on par with the best conventional water saving showers (WaterSense certification) and significantly lower than the industry standard.





The full coverage experience is enabled by pressing the touch button, a white light will light up upon activation.



The Elv Temperature Programs.
Are features that seeks to support the experience of warmth, temperature is a vital part of this, and two key experiences were identified, the experience of re-entering the shower and of acclimitazation.

The experience of acclimatization

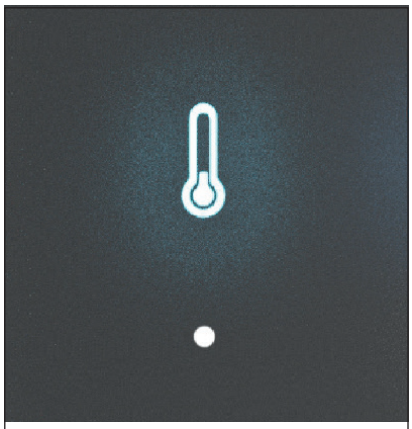
Towards the end of the shower, the warmth has seeped deep into your body, the temperature of your skin and core body has significanlty increased, the differential between the outside environment and your current state are far apart. Ending and leaving the shower, will in no doubt be one of stark discomfort.

This can be alleiviated by being acclimatized to a colder temperature at a very calm pace, matching the bodies rate of acclimatizating to the warmth, making it impalpable. Hence the experience of acclimatization towards a comfortable ending to the shower.

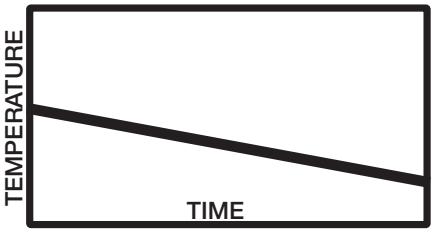
However, this would require high user participation, as it would require the user to constantly decrease the temperature bit by bit, making it have a uncomfortable ending to your shower, the Elv experience changes this.

...Before exiting the shower

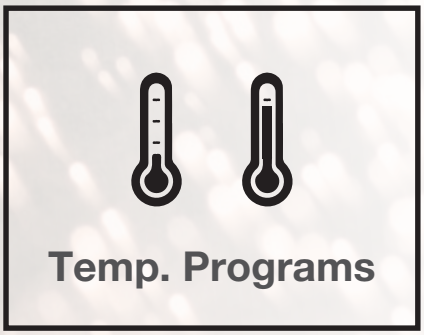
You stand in the shower, and would normally be dredding the thing that is about to happen. You are about to exit the shower.



With three minutes left of your shower, you hit the acclimatization button, which slowly decreases the temperature to match the water temperature to the outside temperature more closely.



Unnoticed, your skin temperature has reached that of outside the shower, and you are now able to exit the shower without being hit by a freezing feeling as normally.



The Elv Temperature Programs.
Are features that seeks to support the experience of warmth, temperature is a vital part of this, and two key experiences were identified, the experience of re-entering the shower and of acclimatization.

The experience of re-entering.
When you first enter the shower, the bodily sensation of transitioning from room temperature to warm water of 38C is blissful, an intense feeling of warmth courses over your skin, and seeps into your body.

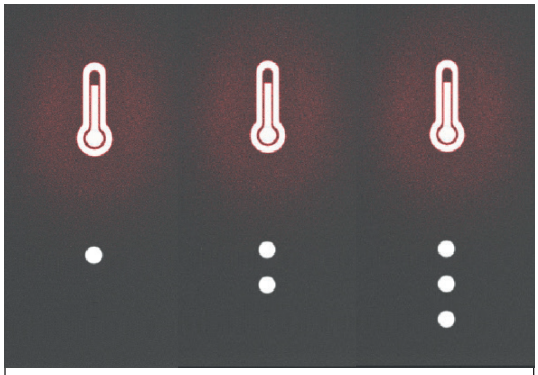
Over time the body acclimates to the warmth, and the feeling dissipates.

However the sensation can be regained, by an instant temperature increase, and repeated multiple times, until a barrier is hit, where the water is too warm.

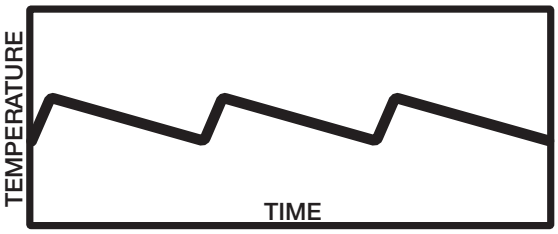
The experience of “re-entering” is a defining experience, but also incredible wasteful in terms of energy usage, the Elv experience changes this.

...In the last five minutes of your shower.

You have washed yourself throughly and simply stand in the shower passively, eyes closed, simply enjoying the warm water. However the feeling of the warmth is slowly fading...



You hit the temperature increase program three times.

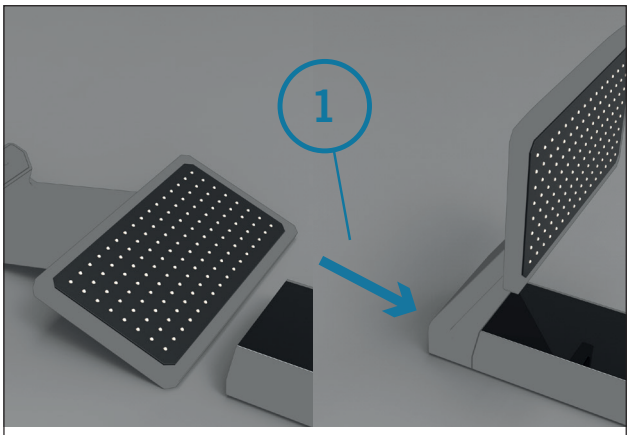


Upon activation, the temperature instantly increases, however instead of maintaining the constant temperature, the Elv program over one minute decreases the temperature, at an pace that perfectly matches the natural acclimatization of your body. Since the program was queued, it will reaccure two additional times, with no user activity.
The benefit, is that a scaldering barrier is never hit, and you are able to do it as many times as you like, and still save warm water compared to the current situation. Queing mulitple pulses of warmth, ensures you are able to immerse yourself in the good feeling.

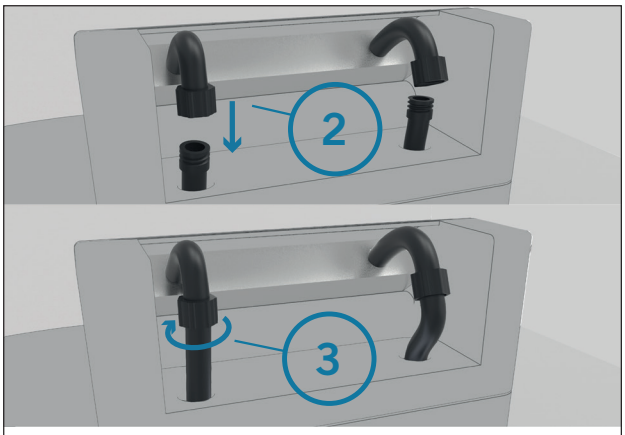
INSTALLATION

All this technology combined into such a neat package calls for a higher power usage, right? Not with Elv. By achieving a ultra low power usage by the use of Hydro Lift, Elv sips so little power that a battery is more than enough for over two weeks of showering on a single charge. As Elv utilizes a battery solution, it means that the installation is done in less than an hour by the user themself, drastically cutting down on the downtime of the bathroom, and the price involved with a professional installation.

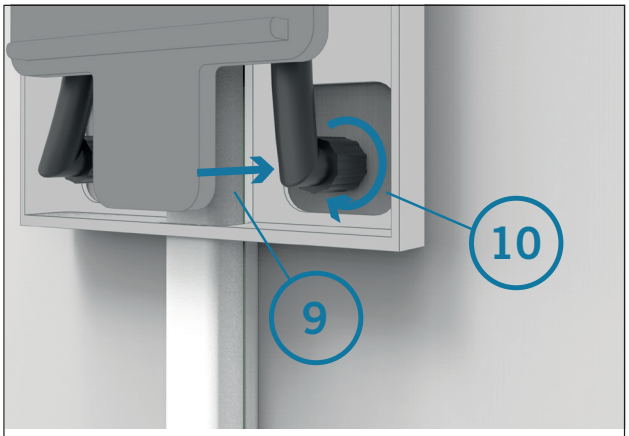
The few competing water recirculating solutions are overly expensive due to the need for a extensive installation done by professionals, as they have to be installed into the flooring and be connected to the AC power grid, things that are both difficult and or illegal to do by the user themself.



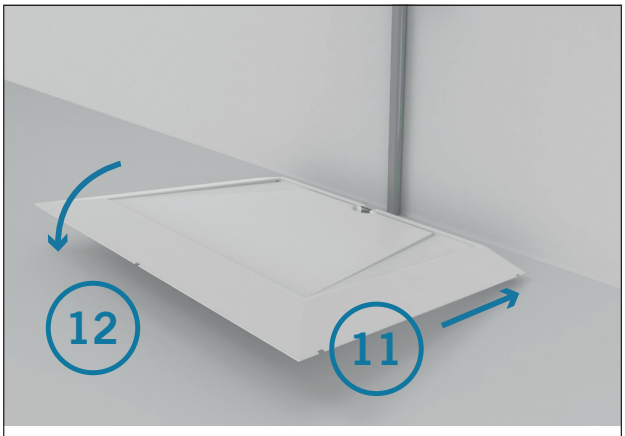
Installing the showerhead
The showerhead is installed by mounting it on the top (1), and fastening it with the included screws.



Installing showerhead tubes
The showerhead tubes is plugged in (2) and afterwards screwed down (3).



Installing the mixer tubes
The included tubes are installed on the mixer outlets (9) and screwed in to secure (10).



Placing the mat
The mat is placed securely against the wall (11) and laid flat on the ground (12).

DISCLAIMER BEFORE INSTALLATION

1. To install Elv properly, the wall should not have variences in the structure, meaning that it should be straight.

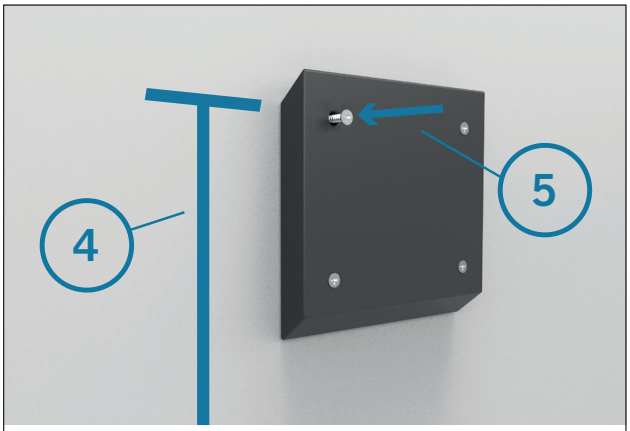
2. Before installing, water needs to be turned off at the mixer connection

3. To install Elv, it might be preferable with support from another individual.

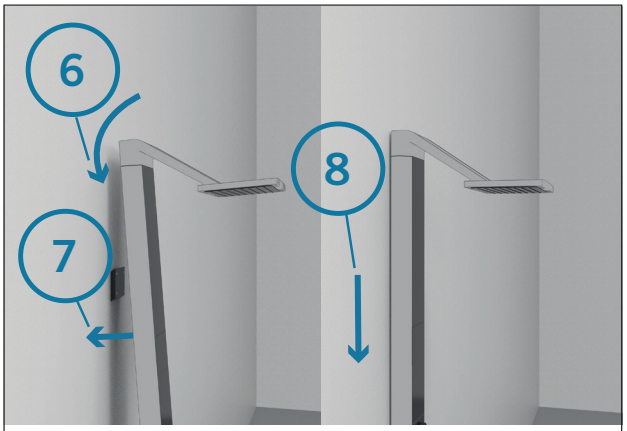
4. The flooring should be mostly flat.

INCLUDED IN THE PACK

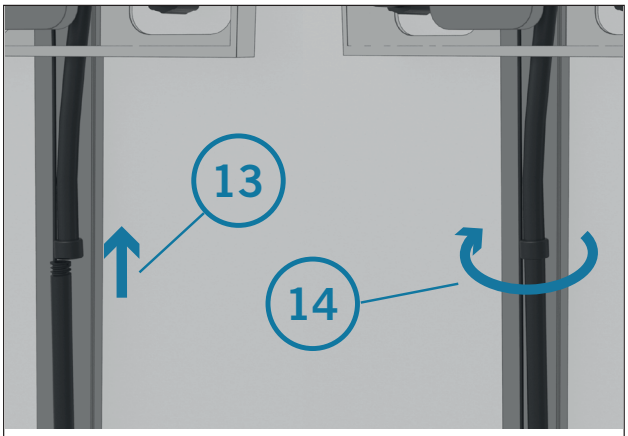
1pcs. Elv Showerhead
1pcs. Elv Body
1pcs. Elv Mat
1pcs. Elv Powerpack
1pcs. Installation bracket
1pcs. Installation screws
1pcs. Powerpack charger
1pcs. Instruction manual
1pcs. Phillips Screwdriver



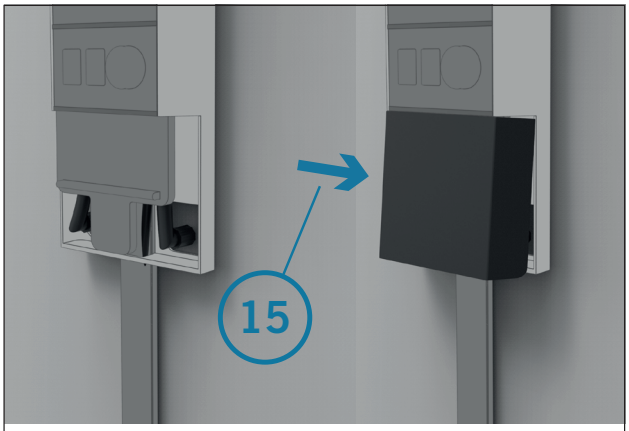
Installing the installation bracket, the height is measured as described (4) and the french cleat is leveled and fastened on the wall with the included screws (5).



Installing Elv on the wall, elv is rotated against the wall (6), and pushed on to the installation bracket (7). Elv is now pushed down to secure the fit (8).



Installing the recirculation tube
The tubes are plugged in (11) and screwed to secure (12).



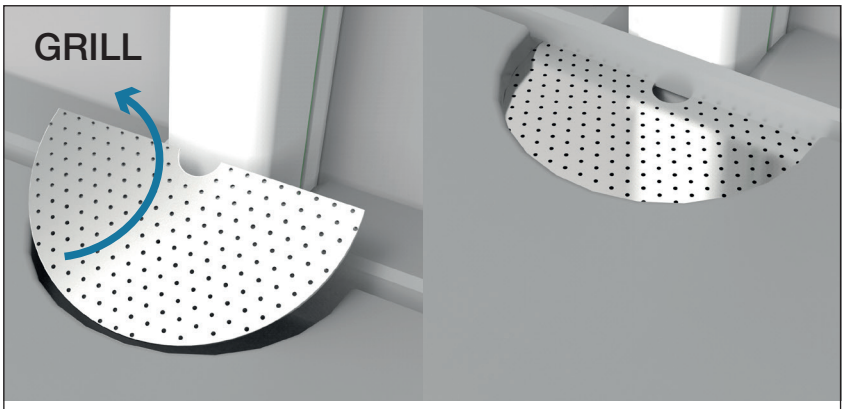
Recirculation button is installed
The button is magnetized and simple clicks on (13).

MAINTENANCE

As with the installation, Elv is as easy to maintain. The filter can be lifted, and can be cleaned for hair and other particles. Furthermore it is adviced to clean Elv through the cleaning program and cleaning fluid each month.

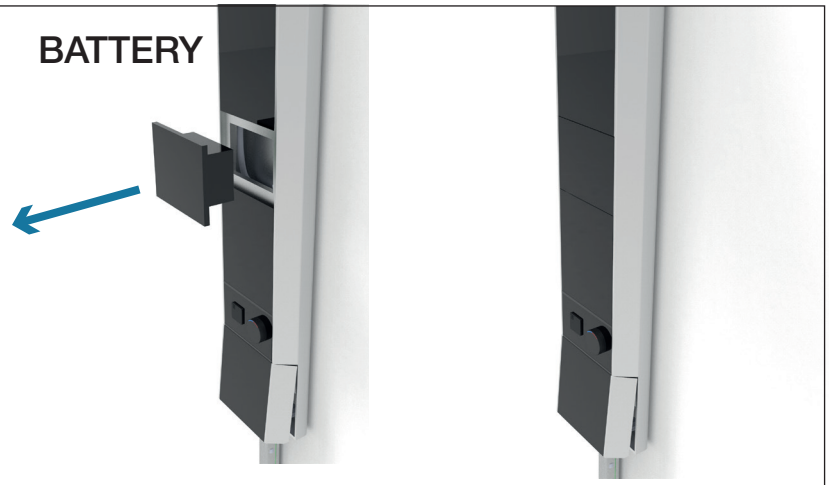
The battery is easily clicked out of Elv when it is time to charge, the screen will display when the battery is running low.

GRILL



The outer grill is easily removed for an easy maintenance, an inner mesh filter with finer mesh must be removed and cleaned once in a while too.

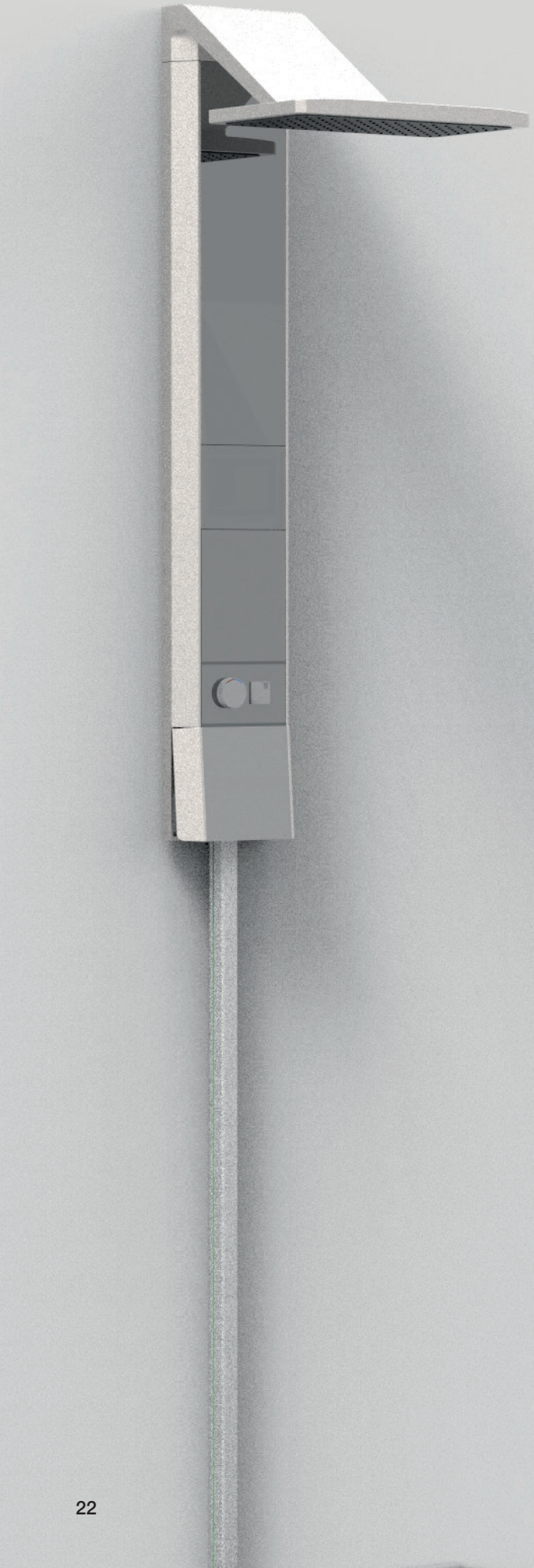
BATTERY



The battery is easily removed for recharging, the battery has power for 14 hours of continuous showering, which equals atleast 2 weeks or up to 1 month of usage. The battery takes 5 hours to fully recharge.

AUTOMATIC CLEANING PROGRAM

Every month, it is advised to descale the product. This is achieved by an automatic cleaning program. While the product is powered off, the descaling agent is poured down the collector cavity. The start button is held down for 10 seconds to initiate the descaling and to throughoutly flush the system. This process may take up to 30 minutes.



BENEFITS

SUSTAINABLE COMFORT

Higher Comfort
The Elv shower supports shower comfort by offering superior coverage and unique temperture features.

Water Savings
Up to 60% water savings compared to the industry standard.

Energy Savings
Up to 60% Energy savings compared to industry standard.

INSTALLATION AND PRICE

The Elv Shower is significanlty more affordable and easier to install than other water recirculating showers.

Ease of Installation
From installation to use, Elv is build with a goal of making it as easy as possible for the user to get started. No need for professional installation.

Affordable
The Elv Hydro Lift and Smart Filtration enables the product to be significantly more affordable.

The Elv Recirculating Shower
Elv is a comforting shower with sustainability as a main driver. Fulfilling three product segments, being the comforting shower and the water saving products therein also the recirculating shower which as of now is not affordable by most users.

Market
To position Elv in the market, it is crucial to see how the competing products are placed, and see how how the users are segmented. Elv is a product delivering several value propositions to the user, and being able to hit a broader market, would potentially mean more units sold.

Elv compared to recirculating products
In the recirculating segment, there are two main competitors, Orbital Systems with a price of 4650 USD (32.000 DKK) and Hamwells E-Shower Blue, with a price of 3200 USD (22.000 DKK). Orbital Systems is primarily focused on saving water, and no additional comfort features are part of the product. Hamwell's try to focus on water saving, being less effective than Orbital Systems, but also include simple feature to increase water output.

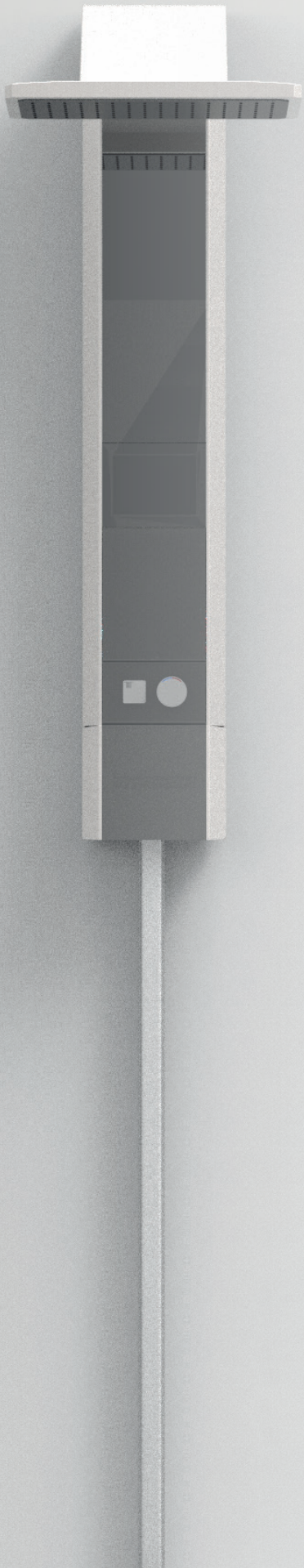
Elv compared to water saving products
The most common product on the market to save water are flow restrictors which are either part of the shower head, or are installed afterwards. By restricting flow, the comfort is usually also being neglected, however with a low price of 200 DKK to 5000 DKK, depending if you buy a restrictor by itself or a complete shower set, the price is low. Elv will not be able to be priced as low as these solutions, however by delivering a more sustainable solution, without neglecting the comfort for the user, it is the perfect solution for users which want a more sustainable product, and still want the comfort which he or she is used to from ordinary shower sets.

Elv compared to comforting products
As comfort product are seen and placed in the higher-end segment of products, they are usually more expensive than water saving products, a trend which can be identified with Hans Grohe (Axor and Raindance series) from a price range from 5.000 to 24.000 DKK. The higher priced product integrate a series of coverage features, meaning that the shower head is normally larger than ordinary showers, however their water usage is proportionally higher, meaning that they are not aimed at water saving oriented users.

Position
By creating Elv, it is possible to combine all three aforementioned product segments into a single product. While it is difficult to compete with ordinary water saving solutions, Elv provides comforting features not even found on the highest end of products meaning that settings a price point higher is justified.

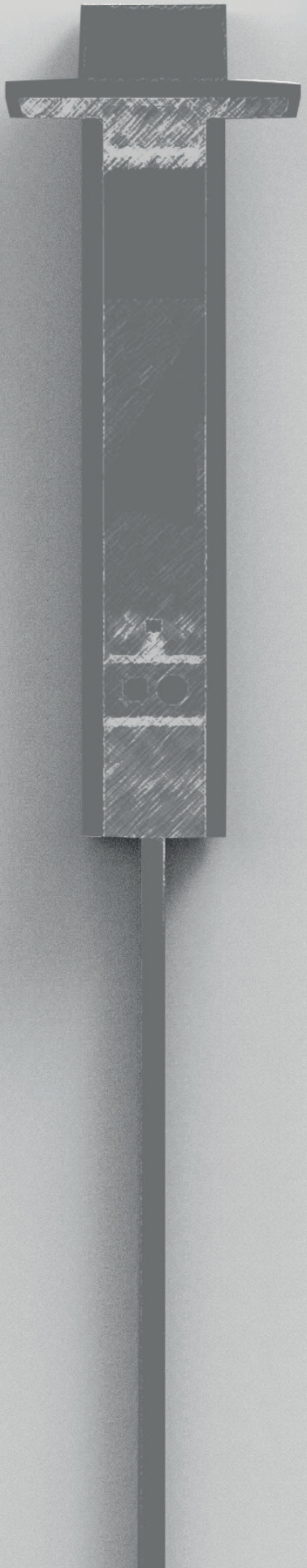
As the comforting products are highly priced, it would be beneficial to compete in this price range while delivering the recirculation features found in the much more pricey solutions from Orbital Systems and Hamwell's. Pricing Elv at 7.999 DKK, means that even compared to inferior comforting products, Elv can be competitive, and being priced three to four times lower than the competing recirculating showers, makes these products available to a broader market.

MSRP: 7.999 DKK



The Elv Shower

The next generation of sustainable products



PROCESS REPORT

Aalborg University // Industrial Design // MSc04-ID8 // 2017
Jacob Terp Christensen // Alexander Sun Petersen

Project title:
Elv - Water recirculating shower

Project theme:
Sustainable shower

Project period:
01.02.2017 - 19.06.2017

Project team:
Team 8, MSc04, Industrial Design
Institute of Architecture and Design,
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01.02.2017 - 01.03.2017

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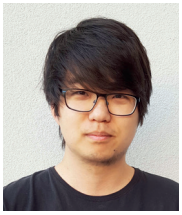
01.03.2017 - 19.06.2017

Technical supervisor:
Mikael Larsen



Alexander Sun Petersen

Jacob Terp Christensen

READING GUIDE
Please read the product report first.
The worksheets and technical drawings are located in the Included USB drive.

ABSTRACT
The project was written over a four month period, during the 10th semester at the Industrial Design education, Aalborg University. Created through both technical solution oriented research and user studies. Wasting water during showering is highly water consuming, hence a solution toward the minimisation of water wastage was conceptualised. Water wastage while showering is a severe result of water getting drained, with only minimal contact with the user, meaning that most of the water is more than adequate for getting used again. To solve this, several products try to limit the water output or manipulate the water in ways which minimize water output, both of which affect the showering experience for the worse, an experience which many users value highly while showering. Elva provides a solution which by recirculating the else drained water, creates a sustainable shower for the water saving segment. Furthermore Elva provides the user with comforting aspects not found on other products, by using the recirculated water to enable for both a higher coverage shower, and temperature features suited for users that value the showering experience as a therapeutic and relaxing activity.

ALIGNMENT

This project emerged from an **observation** that a lot of “clean” water, heat and energy is wasted when showering. This was followed by the line of thought:

> If the water is so “clean”, why do filters even have to be used?” Could filters be ommited if a percentage of “used” water was dilluted in clean water, and directly reused within the shower?

The insight sparked a series of questions and assumptions that formed the starting point and the initial stages of this project, the **Recirculating Shower.**

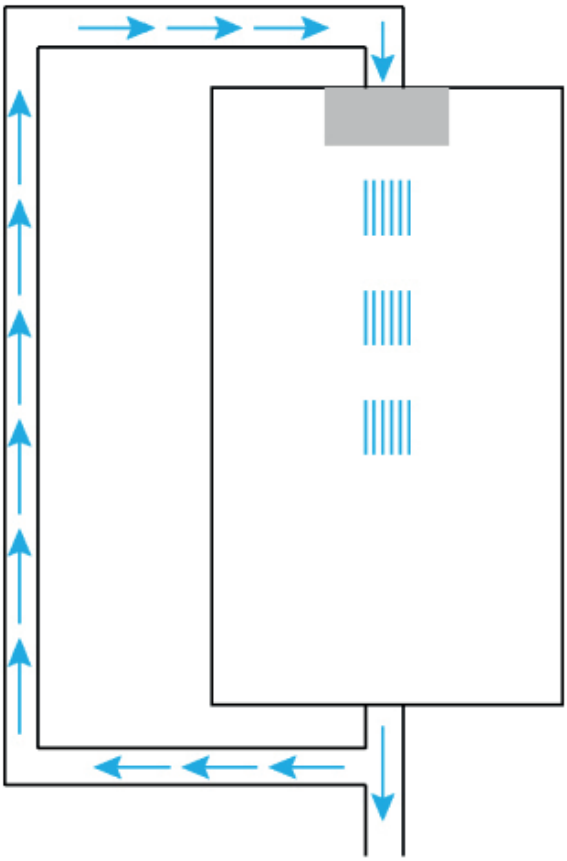


Figure 1: Project description sketch, november 2016

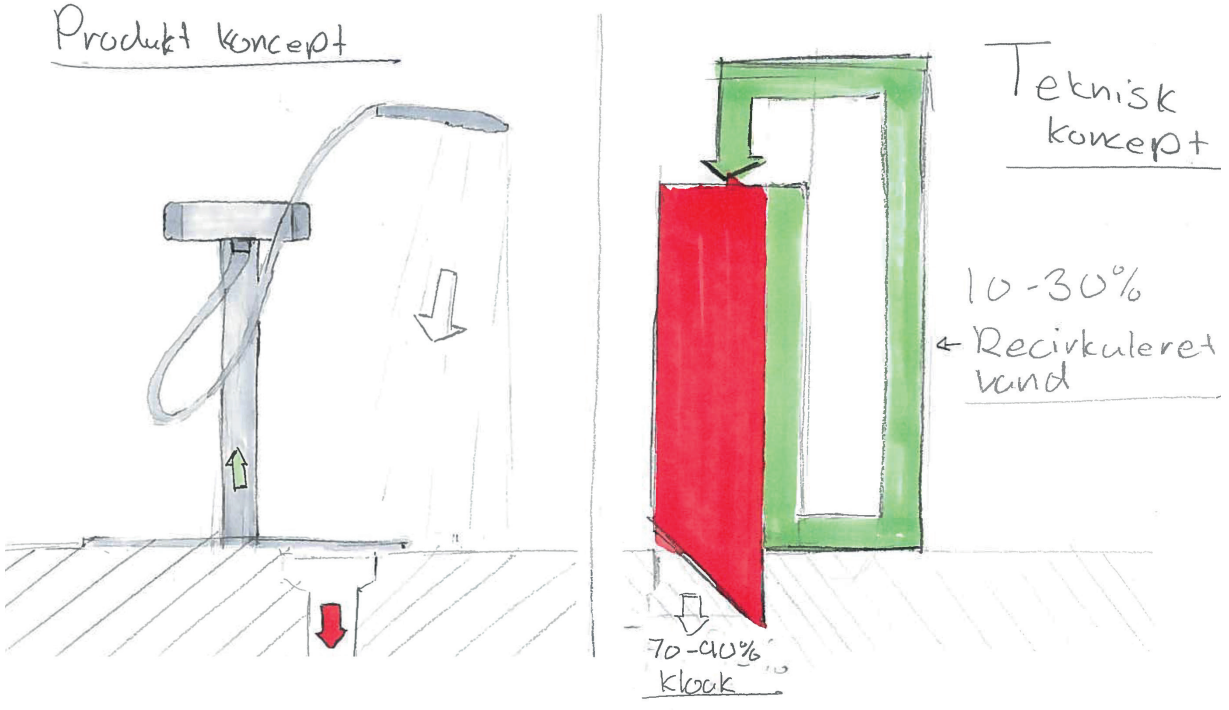


Figure 2: Early sketches, january 2017

THE OBSERVATION

Currently - The Comfortable shower

Showering is a great experience, the water is more than just an activity to clean yourself, it is a recreational activity.

THERAPEUTICAL EXPERIENCE **A RELAXING ACTIVITY** **A REFRESHING ACTIVITY**

Figure 3: Shower Joy

Figure 4: Drain

Currently - The Wasteful Shower

At the same time, showering is incredible wasteful. While you shower, warm water that has just barely touched your body falls down into the drain, water that hardly has been contaminated or spend its heat. The water continues to a water treatment center, where it has to be treated in an expensive and evironmentally harmful process.

WATER WASTE **UNSPENT WATER HEAT** **CHEMICAL THREATMENT**

THE VISION

Figure 5: Bulb

Future - The Recirculating Shower

Now imagine a system, where just as the water falls off the body, immediately picks-up a percentage of the used water, fuses it with fresh water and reuses it to shower within seconds.

The reused water has not been exposed to the contaminated pipes further down the system and still retains it heat, thereby saving both water and energy.

By fusing the relatively clean recycled water and fresh water, it is possible to reach a water solution so clean that expensive filters and futher chemical processes can be omitted.

Thereby establishing our Vision, the recirculating shower.

REUSING SHOWER WATER

OBJECTIVE: What entity is shower water, and what can it be compared to?

GREYWATER

The core principle is to reuse shower water, which by law is classified as greywater. Greywater is wastewater that has not been contaminated by fecal matter and typically is wastewater from washing machines, showers and baths in households. Greywater is typically classified as one entity, as it is collected into one tank, meaning that it is cross contaminated.

It can easily be argued that the cleanliness largely varies in between the sources of greywater, for instance a kitchen sink is exposed to food preparation, household chores and washing dishes. Whereas the shower has a more singular usage, showering. A distinction between greywater sources must be made, this project deals with greywater from showering.

THE RECIRCULATING BATHTUB

Showering in used water might seem offputting, and even associated with being dirty or unhygienic, but consider the usage of bathtubs, which is considered an acceptable method of using water for personal hygeine and recreation. A bathtub is much alike the Elv recirculating shower, in that all the dirt, sweat, skinoil and dead skin shed is diluted into a large body of water, except that it is recirculated... the recirculating bathtub.

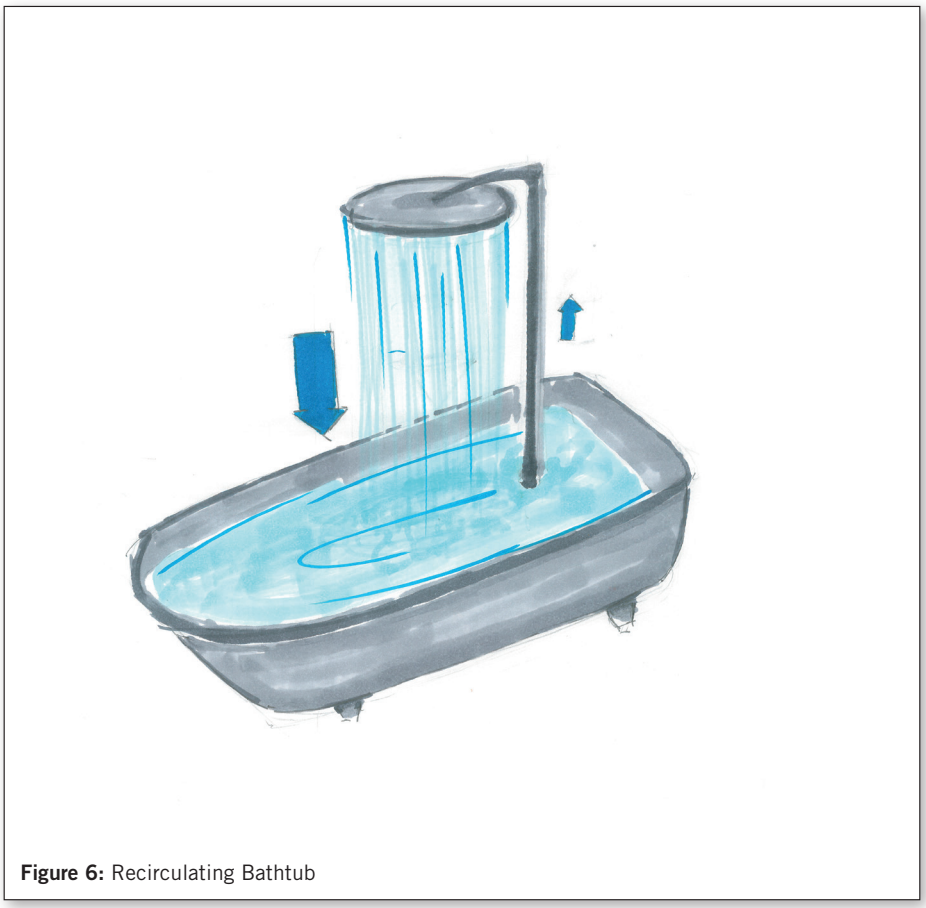


Figure 6: Recirculating Bathtub

WHAT DO PEOPLE THINK OF REUSING SHOWER WATER?

USER QUESTIONNAIRE

To get a better understanding of showering habits, and user impressions of our vision, a online questionnaire was created. The questionnaire included questions relating to time consumption in the shower, whether the shower was used as a recreational area, or only to get cleaned. Furthermore the questionnaire asked directly into our technology and how users felt about using small amounts of recirculated water to shower in.

DO YOU FEEL CLEAN BEFORE YOU ACTUALLY ARE DONE BATHING?

61% Yes, i feel relatively clean before im done showering
39% No, when im clean, im also done showering

DO YOU ENJOY SHOWERING? IS IT RECREATIONAL?

70% Yes, i enjoy showering, it is relaxing
30% No, i only bath to get myself clean

WOULD YOU BE WILLING TO REUSE 10% WATER WHILE SHOWERING

Imagine a percentage of your bath water, for example 10% before it has touched the drain, are recycled with new water (10% recycled water, 90% fresh water). The recycled water before it is recycled has only touched your own body and the floor. The recycled water will be coarsely filtered for hair and other particles.

24,5% Yes, throughout the whole shower
11,2% Yes, after i washed my hair and body
5,1% Yes, after i washed my hair
1% Yes, after i washed my body
13.3% Other.
44.9% No.

4. IF NO, THEN WHY?

38,5% It is a hygenical problem
43,5% I do not like the thought
18% Other

Full Survey [WS1]

Output

The overall consensus was that a large percentage was open to the idea, while others were still uncertain or directly opposing the idea, due to the understanding that the water is “dirty”. Others were welcoming to the idea, but had concerns in regards to when the system is used in scenarios where recirculating water would be unsatisfactory, such as in washing off mud or peeing in the shower etc.

A large part, were opposed due to the understanding, that it is a hygenical problem, If the system could be perceived acceptable like using a bathtub, it can be assumed that some of the group that answered “No, it is a hygenical problem” could be convinced. The group that said outright no, have to be futher investigated, what is the psycological barrier?

CONTEXT

What could the solution differentiate itself with, and what is required to do so, in regards to its closest competitor and the product category in general.

What is the technical challenge to acheive our vision, any possible technical opportunities.

A CLOSE YET DIFFERENT COMPETITOR

OBJECTIVE: If the vision is compared to the closest competitor, are there any immediate market opportunities, and what are the requirements to do so.

A CLOSE COMPETITOR

A close resemblance to our proposed vision was found in **Orbital Systems**, which produces a recirculating shower targeted towards the high-end consumer market and institutions retailing at 32.000DKK. Orbital Systems uses a very complex architecture, including filtration and heating of the used water, to again reintroduce this water to the user. **This solution promises to reuse 90% of the shower water, and the filtrated water is of a very high standard, in instances cleaner than traditional tap water.** Orbital is a premium product at a very high pricepoint, ontop of that significant financial cost, it also has to be installed by a professional and most likely in conjunction with a bathroom renovation, furthering the cost and increasing the barrier for implementation of the product, making it largely unattainable for the general population [WS2]

MARKET POSITION

Is there really a need to filter shower water cleaner than tap water, when using a bathtub is acceptable? By making a shower that filters water minimally, in harsh terms a "recirculating bathtub", **we believe Elv can be more affordable, making it possible to target a usually unattainable techology to the mid-to-low end market (general population)[Figure 7].**

Another opportunity is to make the product easier to implement, which might be possible with Elv, due to a possibly lower product complexity.

The tradeoff compared to Orbital would most likely be a lowered efficency, as it will most likely not be able to recirculate 90% of the shower water, and it will not be able to filter the water to cleaner than tap water[Figure 9].

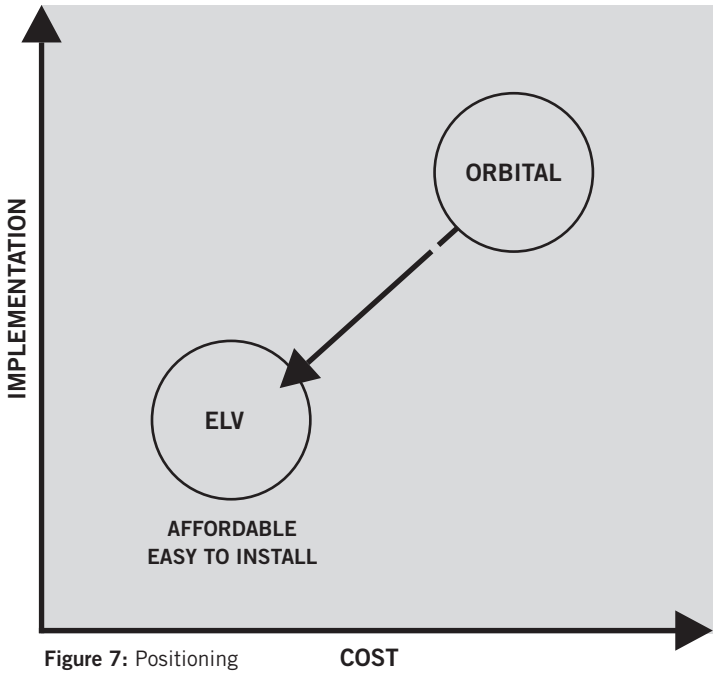


Figure 7: Positioning

Figure 8: Orbital system

Figure 9: Orbital system benefits

MARKET POSITION: WATER SAVING PRODUCTS

OBJECTIVE: What are the baseline and innovative features/products of the current water saving shower market. Compared to their overall working principles, are there any immediate market opportunities.

Water saving products / features

The water saving market is very extensive, the most common are products from the reduce category, a lot of offerings in the form of shower sets, to features can be listed. The most common and state of the art solutions are listed below. [WS3]

Figure 10: Aerator showerhead

Figure 11: Restrictor

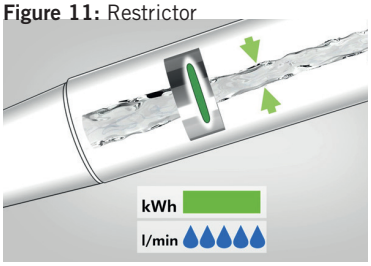


Figure 12: Button restrictor

BASELINE FEATURES

Aerator - By mixing air and water, the water density gets lowered, thereby reducing the water usage, this is often achieved by the venturi effect, and is a common feature intergrated in many showerheads today

Water restrictor - A restriction within the showerhead, that lowers the amount of water ejected out. This is a typical feature intergrated in most showerheads today.

Temp. & flow button - Most showers have a restrictor button, limiting flow-rate and temperature beyond a certain point, the limitation is lifted by presssing while rotating the button.

Figure 13: Nebia, the water atomzing shower

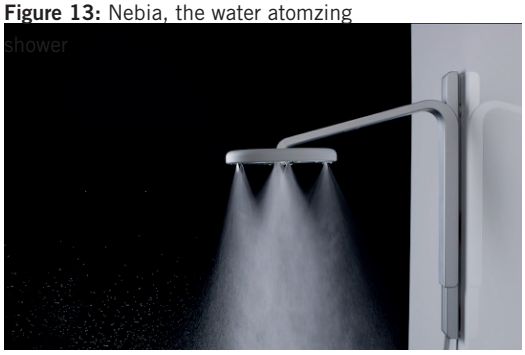


Figure 14: H2O water swirlver

INNOVATIONS

RADICAL

Water atomizer (Nebia) - A nozzle head sprays water into very small droplets, thereby acheving big coverage with little water.

Water swirlver - A nozzle head that makes the water swiwel around, creating the perception of better water coverage, with less water.

INCREMENTAL

Market position

The most common method to save water, is through the principle of directly reducing the water needed to shower, as seen in the baseline features, reaching a water usage between 7,5 and 10 Liters per minute (Lpm)(1), the lower end reaching the diminishing returns in terms how much the water usage can be reduced, without impacting the shower experience too much.

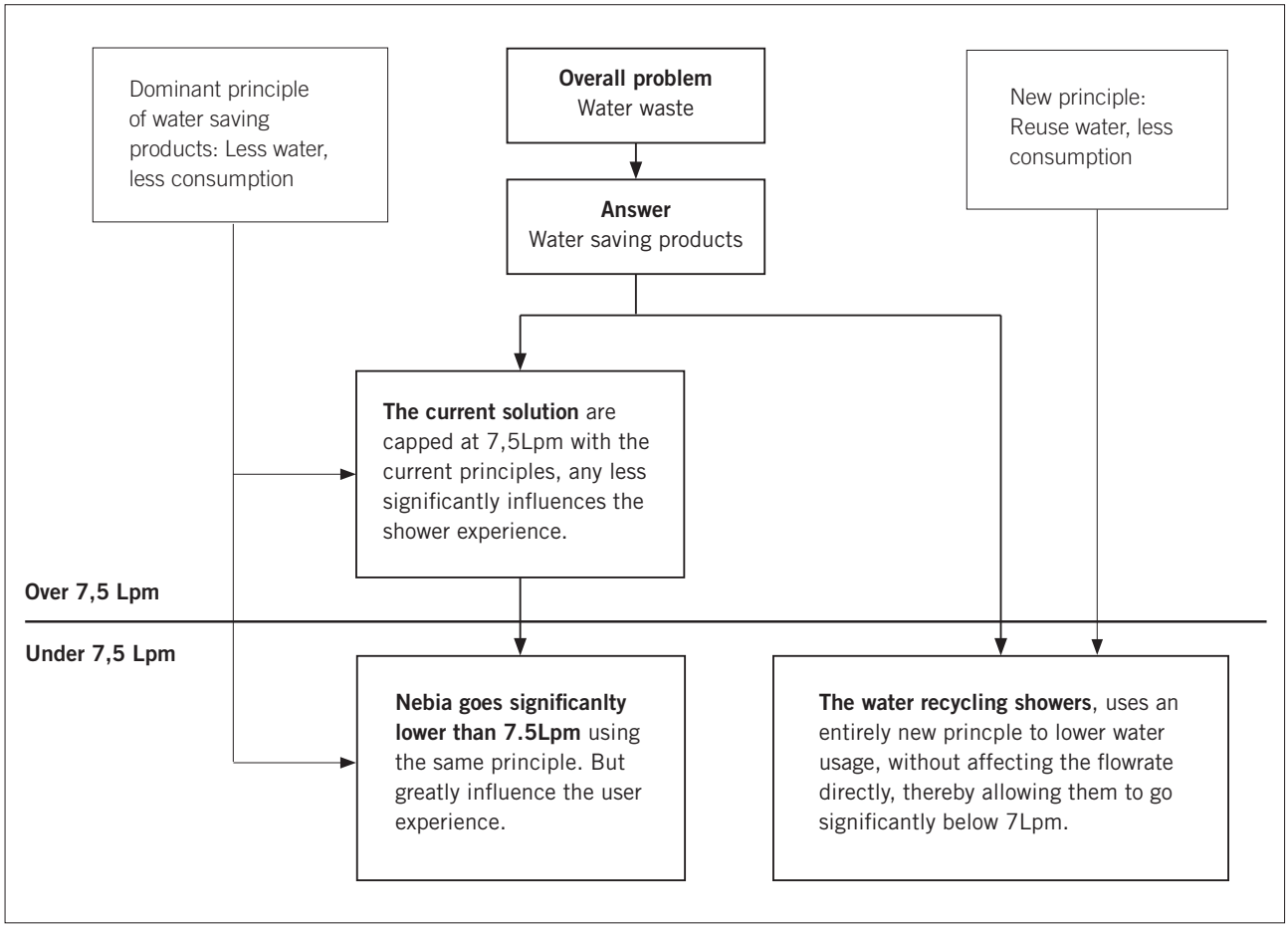
Some solutions attempt to break the barrier, going significantly lower than 7,5Lpm, such as the radical water atomizer, resulting in a significantly lower water usage, however a very different shower experience[Figure 13]. More incremental water saving features attempts to create more comfort with less water, by using a unique water spray pattern, resulting in more coverage with less water[Figure 14].

However, some manufactures attempt to further reduce the water usage by using only baseline features, resulting in a less than adequate shower experience, for instance Figure 15

Figure 15: Water saver showerhead

We believe that by offering a water saving product that is able to go significantly lower than the current 7,5Lpm, and simultaneously not change the shower experience in terms of water flow rate. That we are able to have a position in the market, or rather, that there is space for a product, like the one we envisioned.

Process model: Market position sketch used during most of the project



Output

The benefit of maintaining a high flow while saving water is apparent, however the path to create a water recirculating technology, that is affordable and easy to install, is far away. At this point, we viewed the development of a possible technical solution to be the highest priority, with the reckless notion, “if we manage to do it, then finding an opportunity to use it, should be possible”...

TECHNICAL CHALLENGE

OBJECTIVE: Is it feasable for the team to develop a "new" technology , what are the possible directions and critical issues that need the most attention. A very early technical development was initiated, where solution principles were researched, and tested to make them tangible.

The Elv technology vision

What if: We are able to create a techology, that is able to recirculate water in a way that is **affordable** and **easy to implement.**

Will enable: A product that can save an significant amount of water and secondly, introduces a unique way of being sustainable, to the low-and-mid end consumer market, with unexploited possibilities.

Early exploration

BATTERY OR MAINS POWERED

The recirculation must be powered, a mains powered solution requires to be installed by an electrician, as it has to be connected to the powergrid within the walls, which is likely to require a bathroom makeover.

A battery powered solution could enable for a easier and safer installation as it is placed in Zone 0 in the bathroom where water hits [WS4] and as it upon installation would not require to be connected to the powergrid, it could be installed like a standard shower set, by the user himself. **An overall lower power consumption would greatly benefit a battery powered device, as it would enable a smaller battery and probably less down-time in the form of recharging. Furthermore, working towards developing a low consumption solution could greatly be a great driver towards a more sustainable solution.**

Another distinction is that products that uses the power grid must follow the bathroom standard for high voltage products, whereas a battery powered solution is more manageable. [WS4]

ACTIVE OR PASSIVE PUMP

The shower water has to be circulated. It has to be picked up, lifted up, mixed with clean water, and ejected out of the showerhead. The fluid movement could possibly be achieved by an electrically powered pump, or a passive pump.

A passive pump piggybacks on another source of energy, typically one that is readily available in the given environment. For instance a siphon pump works using gravity and a specific positioning. Whereas an aspirator pump, commonly used within chemistry, uses a strong water flow to generate suction, typically from a sink faucet.

The benefit is a low cost method of pumping, with the consequence of needing specific conditions to work. And the performance is linked to the source of energy, that is often less than controlable.

An electrically powered pump however works independently, the pressure and flow needed can always be acheived by dimensioning the motor and power supply correctly. The disadvantage is the higher power usage.

The benefits of passive pumps are a significant lower power usage, and could be a key enabler in making a battery powered solution and in general a more sustainable product.

HOW TO MIX THE CLEAN AND USED WATER

After the water is lifted, it has to be mixed, or dilluted into the clean water. Three overall methodologies were discussed, with "low power consumption" being in focus.

1. The clean and used water are sprayed out alongside each other and mixed in the air outside the showerhead.
2. The two fluids are mixed inside a mixing chamber, most likely losing part of their pressure, and re-pressureized to be ejected.
3. The two fluids are mixed in motion, the "used water" is forced into the pressurized clean water stream.

The third method seemed the most feasible from two view points; **we wish to properly mix both liquids, to acheive a consistent water quality ejected onto the user, disqualifying method 1.**

The second viewpoint, is the energy needed to mix and eject. The second method, as it stagnates both liquids to mix, would require a rather large motor to re-pressurize the shower water, to be ejected out at the same speed as normally. Whereas **the third method piggybacks on the higher flow rate, however must be bruteforced into the higher pressure clean water.**

The third method, seemed the most go to, as it was likely to have the least power consumption while still acheive a proper mixing, a simple **T-pipe** was proposed to reintroduce the fluid, it could be inserted at a junction of the shower system. **Furthermore it seemed like a tangible idea to test on our own shower.**

T-pipe

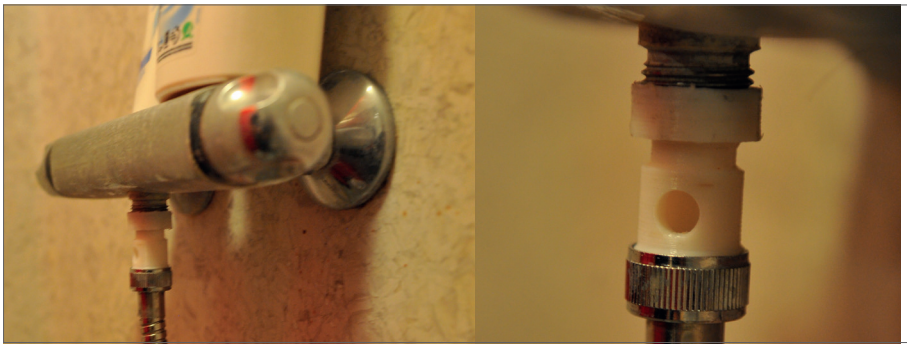


Figure 16: T-pipe tests

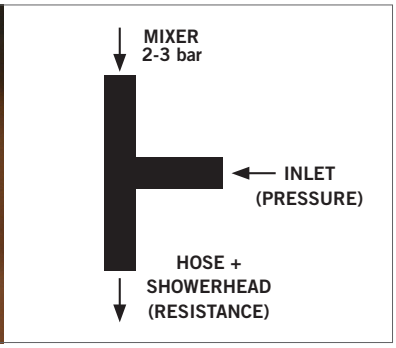


Figure 17: T-pipe resistance

A 3D printed T-pipe was inserted between the mixer and hose[Figure 16], A tube was connected to the inlet, attempting to reintroduce water. **However** It was impossible to re-introduce the water at the intlet, unable to even hold the finger to block the hole, resulting in backflow.

Evaluation: The issue was the high resistance caused by the hose and showerhead, which was unexpected. The inlet pressure must cause more resistance than showerhead and hose, as pressuredized fluid always choses the path of least resisitance, in contrary what happened and caused backflow. The situation is illustrated in Figure 17

Another method, would be to lower the resistance required to re-introduce the used water into the pressurized system. For instance by moving the T-section junction between the hose and showerhead, thereby omitting the hose as resistance. Another method is to lower the pressure exerted by the showerhead, as it seems to cause a lot of resistance, which is most likely due a "restrictor" restraining the water flow, as described on page 12

Output

As a solution principle the T-pipe was a failure, but as a test it helped further the understanding of the technical difficulties. **We managed to locate the critical issue in recombining two liquids**, as of now, it is most likely to require a rather big motor, which would not promote a low power consumption at all. Additionally we gained some insight in where and how to decrease system resistance, which might be very helpful.

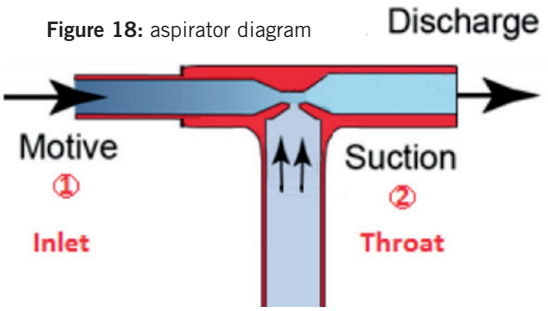
Laboratory aspirator

Basic theory on the working method: At essence, an aspirator looks like a T-pipe, with a narrow section in the middle[Figure 18]. However the narrow section causes a rapid increase of flow rate and simultaneous decrease in pressure (Bernoulli's principle), that creates a vacuum at the inlet. In practice, the data sheets of aspirators were difficult to translate. Most data sheets list that lab. aspirators are able to generate 29.5" Hg vacuum at 30 PSI pressure, but how 29.5"Hg translates into flow rate and water pressure, was very much unrelatable.

The main take away was that a aspirator essentially is a T-pipe with no resistance at the inlet, however it even creates suction and no backlow. A possible enabler for a low powered system.

At this point in the project, no aspirator was available, a few were 3D printed, however all failed, which we later discovered was due to not being primed, a subject that will be discussed later.

Figure 18: aspirator diagram



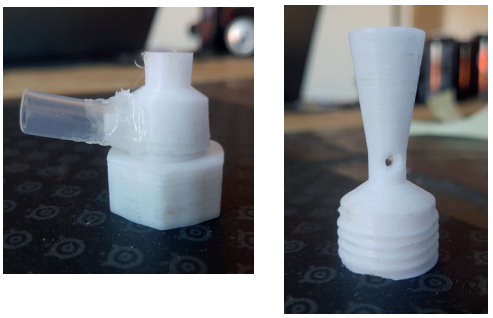


Figure 19: Failed aspirator 3D prints

Output

Once again, the tests were a failure, not due to the solution princple itself, but due to our lacking knowledge. The ability for the aspirator to work as a "T-Pipe with no backflow" was however a driver to continue researching the aspirator.

TECHNICAL DEVELOPMENT

To make a water recirculating shower that has it's starting point in technology that is yet to be developed, means that the system capabilities, limitations, advantages and disadvantages cannot be specified.

Thus the team must develop or rather make it probable that a low cost and easily implemented water recirculating shower is possible, and with that a boundary that can be developed within.

With a limitation, the user-oriented reasearch can be approached while having in-depth knowlegde of what the weaknesses and strengths are.

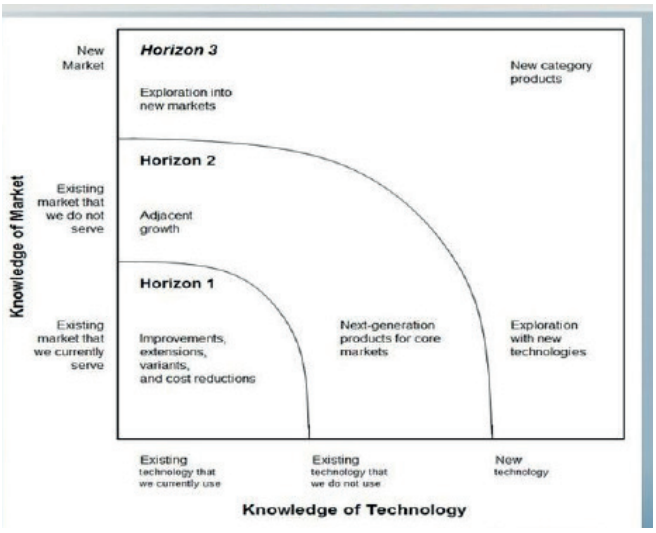
APPROACH REFLECTION

At this stage, developing a technology, or rather the potential advantages in a new technology was the right course of action, which is the opposite of what we traditionally do(starting in user research, and uncovering latent needs).

The logic string in this decision is rather simple.
- Recirculating showers are hardly available for the general public, due to the sky high cost and difficult implementation, due to that, they can be considered a new product category, approaching the "third horizon".
- The change from "high cost and difficult implementation" to "low cost and easy implementation" will undoubly carry very serious trade offs, and consequences, that are unknowns, their effect on the users are unexplored, another characteristic of the third horizon.

With that in mind, the group considered defining the system architecture as the number one priority.

Figure 20: Third Horizon Model (2)



PRIORITIZATION

To define the function that are critical to the creation of the envisioned system, a basic principal structure was created. From the prior research and experiments, the most critical functions to create were defined as the circulation, the mixer and filtration, and were seen as the biggest threats to hinder a low powered and affordable solution.

The aspirator (venturi injector) had the potential to be a easy method of injection, and possible also for the circulation and mixing of the fluid, it alongside the filtration, were prioritized highly.

The question is, can a venturi injector be a driver to achieve a low powered circulation and injection? if so, to what extend and what are the consideration and consequences to using a venturi. The largest majority of resources were spent on exploring the possiblites of the venturi injectors and defining a filtration system.

MAIN FUNCTION - VISION
The main function is to recirculate and filter the "cleanest" percentage of shower water, which is to be reused within the shower itself while showering. The recirculation should be affordable, and support an easy installation.

SUB-FUNCTIONS
(1) Water collection: Collects the otherwise drained water.
(2) Water circulation: Circulates water from the collector to the water output (showerhead).
(3) Water mixer: To mix and inject the used water into the clean water.
(4) Water regulator: To regulate and control the percentage of clean and used water.
(5) Water output: Outputs the diluted water unto the user.
(6) Water filtration: Filters the "cleanest" percentage of water and dilutes it based on cleanliness.

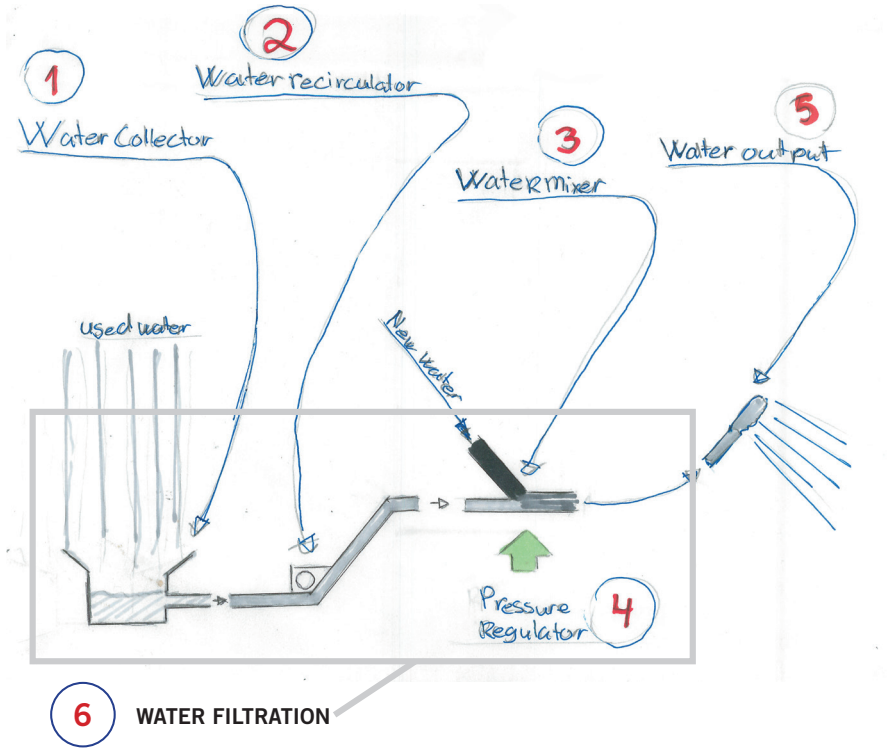


Figure 21: Early principal structure sketch

PROCESS APPROACH

A “Function-means” diagram with inspiration in the Tjavle method was used to explore the solution space throughout all of the technical development. The mandatory design brief was written in the early period of time, which can be found in [WS38]. The currently worked on principles were kept on top of the black line, and the ones that were not worked on, were moved down. A lot of emphasis was put into tests, as we neither are fluid or mechanical engineers, practical tests were the only method to confirm theories that otherwise would remain assumptions.

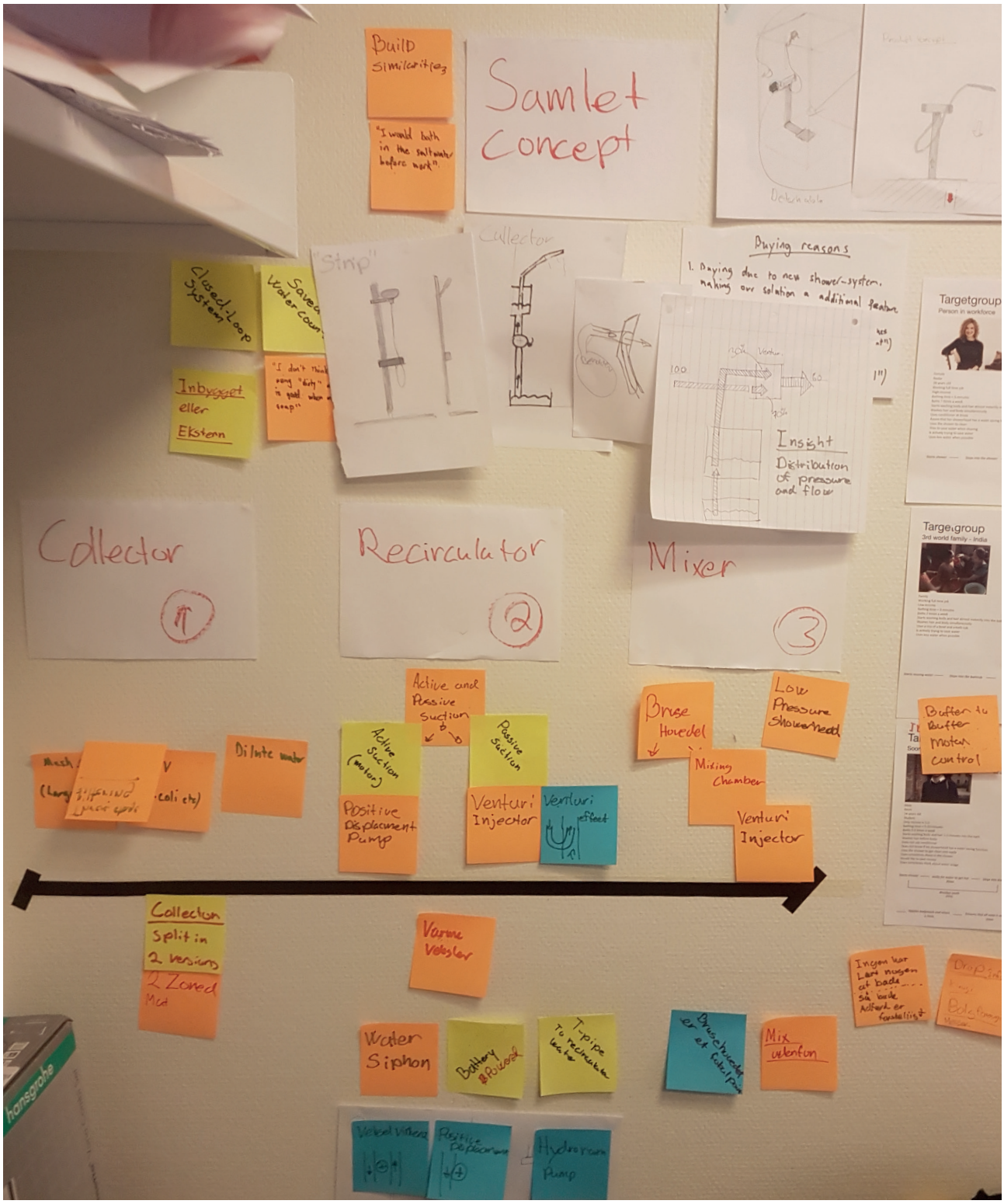


Figure 22: Wall with technical development

HANDS-ON APPROACH

Neither of the team members have any outstanding nor decent knowlegde in fluid or mechanical engineering, thus a more hands on approach was adopted. Both members are however super users with 3D-printers and rapid prototyping. Furthermore both members have basic knowlegde of programming, and one team members has over average competencies in low voltage circuits.

Thus, a lot of functional models were build, and components bought to test, below is a small selection of our fails, and unsuccesful endeavors.

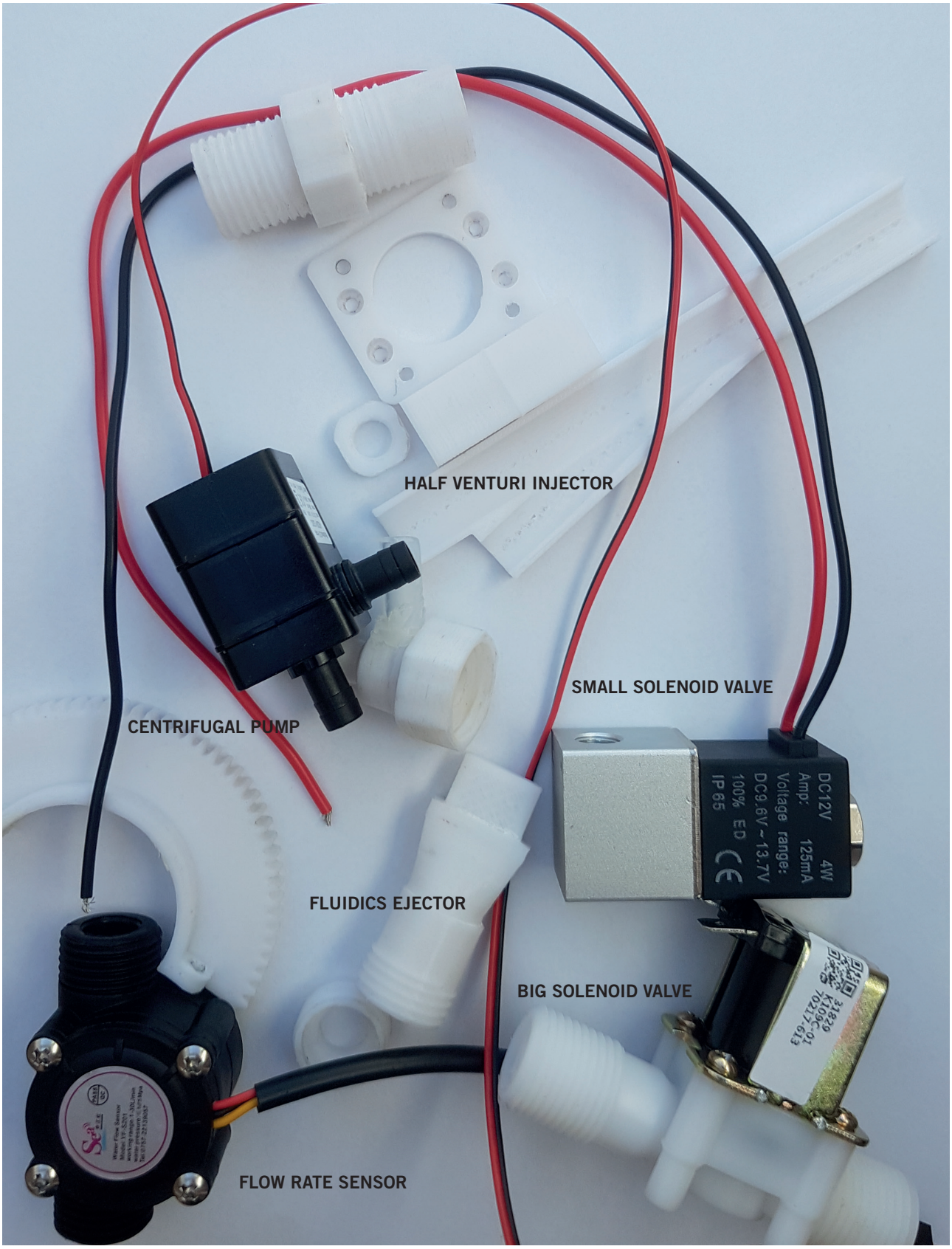


Figure 23: Misc components bought or 3d printed that failed

TESTING THE ASPIRATOR

OBJECTIVE: is to test the aspirator principle and see how much water can be picked up, and how this will affect the usage with an aspirator.

Setup: 3D-printed fittings were made to ensure a tight seal and made it possible to connect the hose and aspirator. For the second test, the showerhead was attached. The suction inlet was connected to a tube, going into a container with water. The thermostate flowrate was engaged fully for each test, and the tempeature was at 38 degrees celcius. [WS5]

Figure 24: Aspirator test setup

Figure 25: Aspirator test results

TEST GROUP: WATER FLOW WITH AND WITHOUT SHOWERHEAD - 60SECS					
	Test 1	Test 2	Test 3		avg.
WITH SHOWERHEAD	7.8	7.9	7.7		7.8
WITHOUT SHOWERHEAD	7	6.8	7		6.933333333
LOST FLOWRATE					0.8666666667

TEST SETUP: WITHOUT SHOWERHEAD - 60SECS					
	Test 1	Test 2	Test 3		avg.
Total output (mL)	5833.4	6407	6500		6246.8
Used water (mL)	1667	1667	1667		1667
Used water %	28.57681626	26.01841736	25.64615385		26.74712916

TEST SETUP: WITH SHOWERHEAD - 60SECS				
	Test 1	Test 2		avg.
Total output (mL)	5000	5217.391304		5400
Used water (mL)	850	782.6086957		840
Used water %	17	16.29166667		15.74074074

CHANGE IN FLOWRATE		
The flowrate neither with showerhead or aspirator was	7,8L/m	(Reference point)
The showerhead alone diminished the flowrate to	6,93L/m	(-0,87 L/m)
The aspirator alone diminished the flowrate to	6,62L/m	(-1,18 L/m)
The aspirator and showerhead dimished the flowrate to	5,2L/m	(-2.40 L/m)

[WS6]

TEST RESULT SUMMARY

The best suction rate, unsurprisingly was without the showerhead, achieving an avg. of ~26% and 1,67L/m, with a total out of 6,2L/m. The suction rate with showerhead achieved an avg. of ~15% and 0,85L/m, with a total out of 5,4L/m. Significantly worse.

TEST INSIGHTS

1. The aspirator was unable to create sufficent suction to lift liquid. As discovered, an aspirator must be filled with water(**priming**) to reach maximum efficiency, whereas without it, is only able to create a mild vacuum.
Priming refers to sqeezing air that is initially inside the system out, as most pumps, and in this case the aspirator, must have water inside to be able to build pressure, the aspirator was unable to “self prime”, and has to be done manually)
In retrospect, this is what made the initial aspirator test fail, and sidetracked the misleading results.
2. An inconsistency in the test results was recorded due to trapped air in the tubes. It became evident afterwards, that low pressure systems are unable to rid themselfs of air bubbles, that causes major water resistence due to friction.
3. A good suction rate of 26% was achieved, but significantly lowered to 16% by an added showerhead, furthermore the total flowrate was lowered to 5,2L/m, losing 2,4L/m. The restrictor within the showerhead, as described on page 12, causes the majority of resistance, rendering the flowrate to be unacceptably low. (Standard showers are sold in 7,5l/m and 9,5l/m versions usually.)

4. The change in flowrate provides some useful insight. The showerhead alone decreases the overall flow rate by 0.87 Lpm, whereas the aspirator lowers it by 1.18 Lpm.

They both restrict the flowrate, however the aspirator makes use of the energy to create suction, whereas the restrictor simply wastes the energy, an interesting perspective.

If the restrictor was removed and replaced with the aspirator, in other words, building the aspirator inside the showerhead, the aspirator should be at the point of least resistance, and be able to work at maximum efficency, making use of the high flowrate instead of wasting it.

Furthermore, a showerhead with less resistance in general would also be benefical.

Test series 1 conclusion

Compared to the initial test, this was widely succesful, the aspirator was able to cover both functionalities, the circulation and injection. However to an far insufficent degree, the performance with the showerhead attached was not acceptable and must be improved. The ability to freely inject a stagnant liquid into a highly pressurized system, and even having it create a suction rate of 26% was promising.

The aspirator seems to be very “integrated” meaning what multiple individual parameters are formed by one input. The output flowrate, suction rate and mix percentage all depend on the “input flowrate”What are the consequences of dealing with such an “intergrated” component?

In summary:
-The venturi must be in the junction of least resistance.
-The showerhead must have low flow resistance.
-The venturi causes friction and lowers the overall flow rate, much like a water saving restrictor.
-The venturi acts like a mixing chamber.
-The venturi is very “integrated” meaning what multiple individual parameters are formed by one input.
-The venturi is able to inject a low pressurized fluid into a highly pressurized fluid.
-The venturi must be primed and air bubbles avoided.

VENTURI INJECTOR DESIGN & TEST

OBJECTIVE: is to design and test different venturi injectors to see how the performance is affected by different designs.

Venturi injector design:

In response to test series one, we set out to design our own venturi injector. We are not fluid engineers, nor are we able to calculate the finer details, the only other viable option was to ask experts or look into other industries. It turns out, there is a community in the US, where injectors are used to extract gold from rivers, with some good DIY resources. The designed venturi follow a set of simple proportions[Figure 26] and was dimensioned to fit the fittings of the thermostat and hose. Two designs we adapted, with reference in [Figure 27], the "most" effective being the Jet Log design, whereas the suction nozzle should be easier to prime. An more indepth explantion can be found in [WS7]

Figure 26: Venturi design, proportions

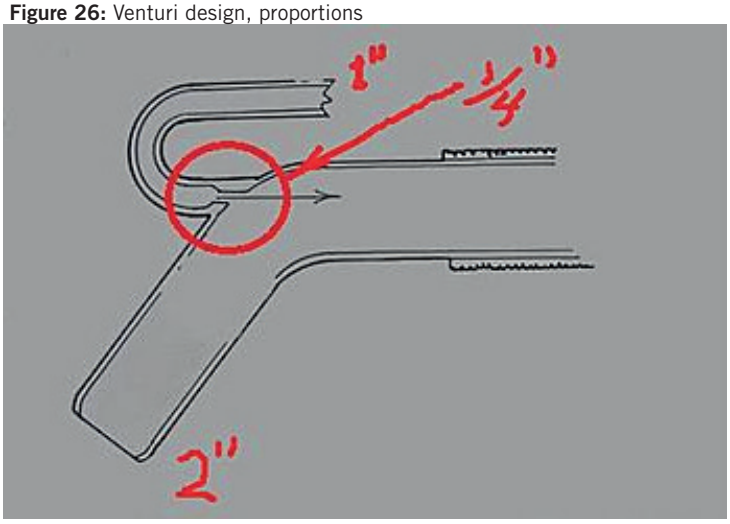


Figure 27: Venturi design, types

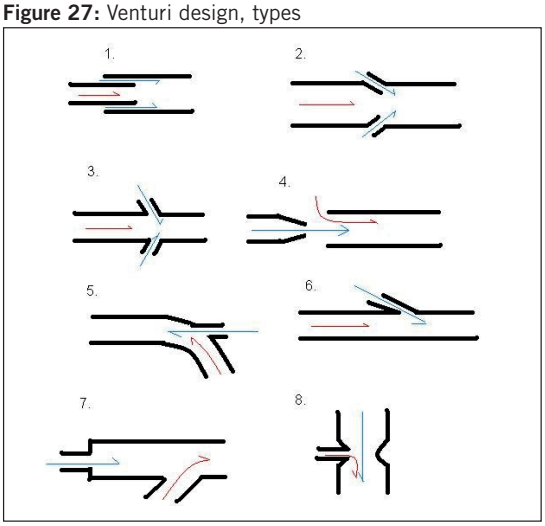


Figure 28: 3D printed suction nozzle design

Figure 29: 3D printed jet log design

TEST SETUP
Both venturi injectors where tested on the same setup as the previous setup, and attached to the very end of the hose.

TEST RESULT SUMMARY
-The jet log delivered a total flowrate of 13L/m of which 7.5L/m was used water and 5.5 fresh water. Amounting to a used water percentage of ~57%.

-The suction nozzle delivered 9,8L/m of which 3L/m was reused achieving a suction rate of ~30 % and an overall higher output by 3 litres than the standard flowrate!

TEST INSIGHTS
1) By increasing the tube diameter inside the venturi compared to the aspirator, from 8mm to 16mm, less friction and a better flowrate could be acheived at lower pressures. However it worsened the ability to lift liquid from the inlet. Meaning that the inlet should suction must be assisted in order work at a good efficency.

The benefits were a significant increase in flowrate and suction rate, up to 100%, and a flow rate of 13L/m which the traditional shower cannot output, while maintaining a low actual usage of water of 7L/m.

2) **Furthermore, a relation between input flowrate and suction rate is non lineare was discovered. Meaning that if one value parameter changes, it does not equal a 1:1 ratio change in the other parameters.**

For instance, if the input flow rate is 7L/m, the suction rate and total output flowrate might respectively be, 50% and 8L/m.

If the input flowrate is halfed, since it is non linare, the suction rate will not be 25%, neither will the output flowrate be 4L/m, it might be 10% suction and 3,5L/m. A depiction of a non-linaer behavior can be seen in Figure 30

The consequence of this is most likely that the flow rate be be kept constant and non adjustable. Which in turn, means a constant suction rate and output flow. Enabling a much simpler system control in terms of water quality and temperature.

An adjustable flow would be very difficult to implement and expensive. And in terms of difficulty, outside the scoop of this project.

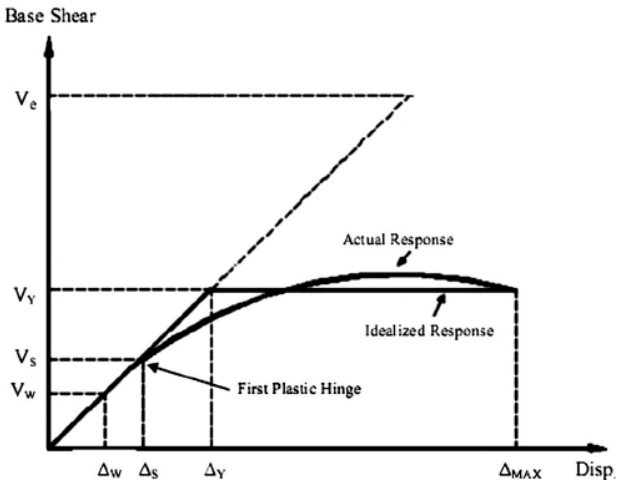


Figure 30: Illustration of non-linear behavior. (3)

Test series 2 conclusion

By now, the benefit of the venturi is apparent, it singlehandely is a driver to create a low powered solution by utilizing the inherent energy of fast flowing water.

However the consequences of using the venturi are severe and system-wide. By fulfilling three sub functions at once, through only one input (input flowrate), renders achieving complete functionality neigh on impossible.

For instance, the mechanical energy unable to fulfill all three functions at once. If a suction rate of atleast 50% and injection is to suceed, it most assuredly is unable to provide enough suction to also lift the liquid from the bottom of the floor to the shower head. As such the system will be assisted by an electically powered pump.

Furthermore, it will require a system control that is able to control the temperature, as the two water streams are of different temperatures, however that will be less of a challenge, since the flowrate is constant. Likewise, the water quality is easier to define, since the dillution rate is constant.

Output

In conclusion, the focus on passive pumps can be considered a succes, as a low powered circulation and injection of fluid was made probable. Furthermore, the team is confident that a venturi injector can be made to specification, within the limitations of a 50% reuse rate, and a maximum of 13L/m, everything inbetween should be a possiblity. However that would require considerable time as it would be trial and error procedure.
The team will move on to deal with the system-wide consequences of using a venturi.

IMPLEMENTING THE VENTURI

OBJECTIVE: is to implement the venturi in a shower architecture.

Assisting the venturi injector

As results show, the venturi injector must be assisted in lifting the liquid, this can be achieved by an electrically powered motor and a buffer tank towards the top, closer to the venturi.
The venturi will draw water from the buffer, whereas the lift motor will supply the buffer with water. **The distance between the collector and buffer is an important factor when dimensioning the lift motor, aswell as the distance between the buffer and venturi when dimensioning the venturi.**
The lift motor can be relatively little, as it only has to match the flowrate of the venturi inlet, meeting little to no resistance. [WS8]

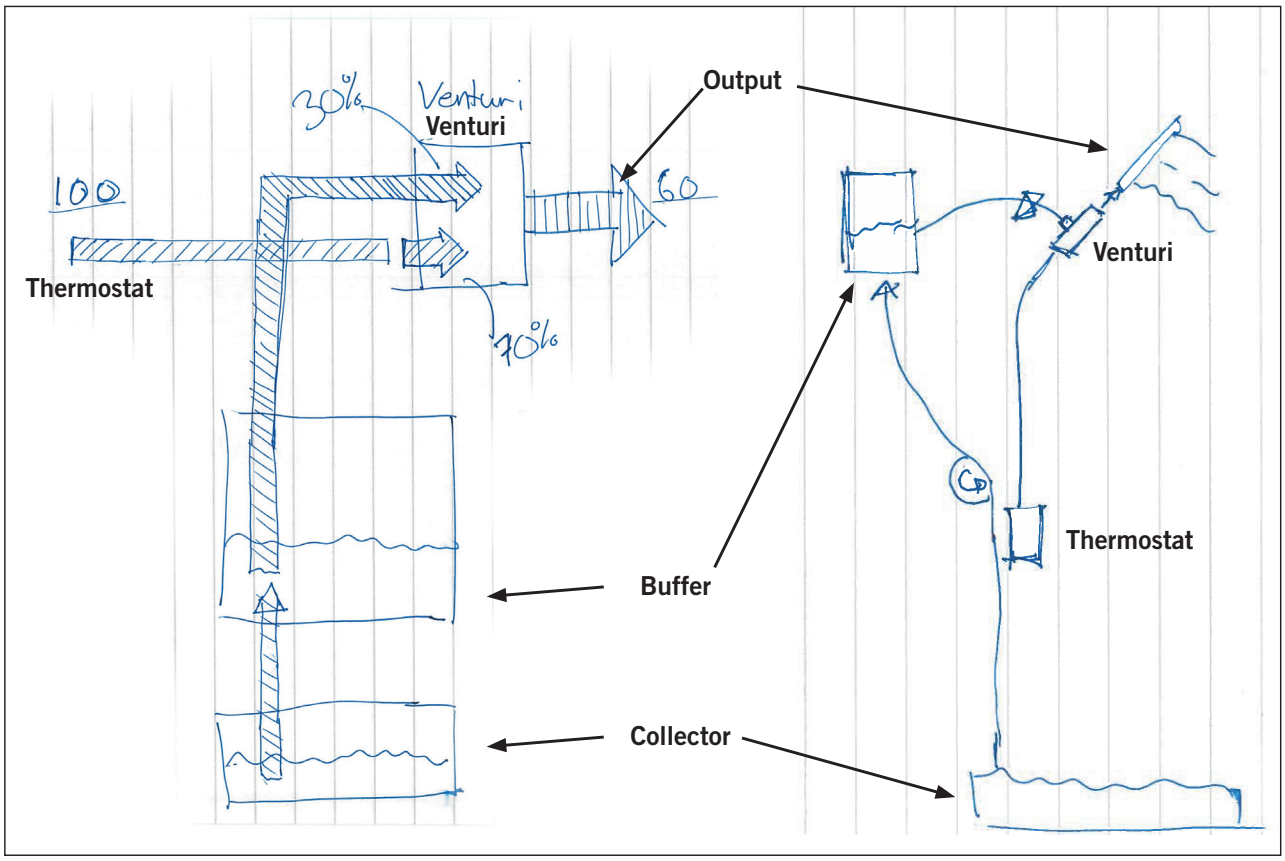


Figure 31: Lift motor and venturi implementation

Output

CONSEQUENCES
The venturi must be very close, or even be besides the showerhead, and the buffer must be close to the venturi. The consequence is that using a showerhead is highly unlikely, the solution must probably be offered in a shower pipe configuration, which in turn is likely to increase product cost.

Venturi regulator

The flowrate through a venturi can be controlled by a simple venturi regulator system, the system works by the principle that a fluid will choose the path of least resistance.

In the Figure 32 below, a venturi injector is connected to a water supply line by the means of two T-sections with a simple ball-valve in the middle. When the ball valve is open, water will flow directly through, as it is the path of least resistance. When the ball-valve is closed, all water will be pumped trough the venturi injector and maximum suction rate is reached. By adjusting the valve, the venturi can be utilized a varying amount, or simply turned on/off, while a flow still is maintained. This is likely to be useful if the used water is to be stopped, but clean water is still needed.
The system can easily be adapted to switch betwen for instance two venturi injectors, as seen in Figure 33, or 2 venturi injectors and a clean water stream, as seen in Figure 34. This might be very usefull, since the flowrate is to be constant, switching between injectors might be an option.

However this would likely require mechanized valves, which adds to the system complexity, more info in [WS9].

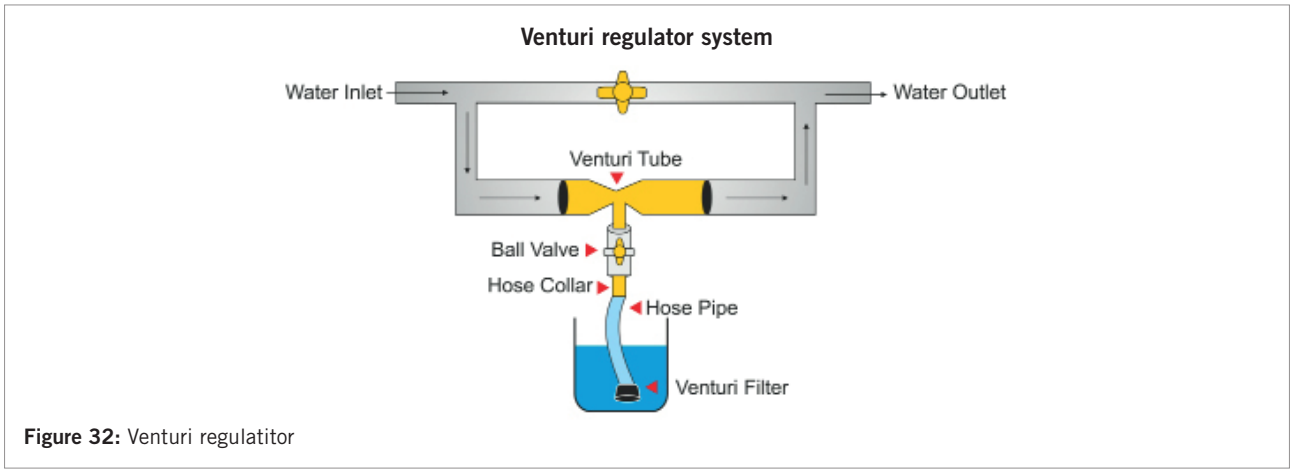


Figure 32: Venturi regulatitor

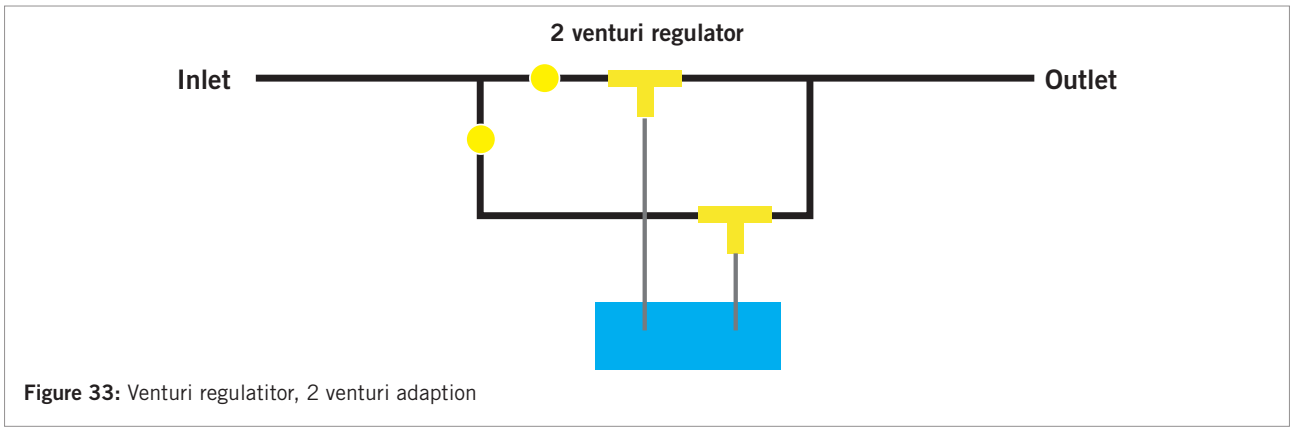


Figure 33: Venturi regulatitor, 2 venturi adaption

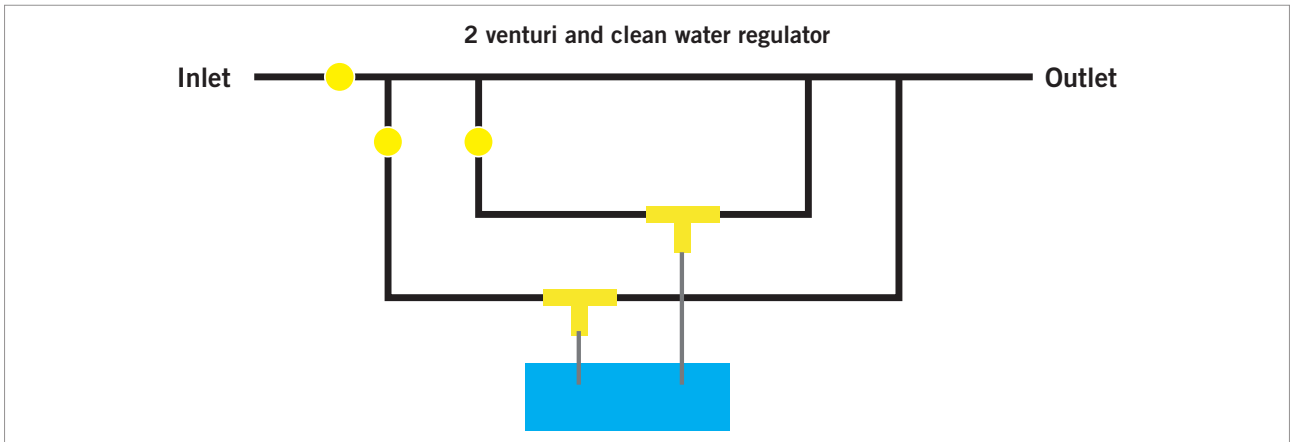


Figure 34: Venturi regulatitor, 2 venturi adaption and clean water adaption

TEMPEATURE CONTROL

OBJECTIVE: Is to develop a temperature control that works alongside the venturi injector.

Venturi temperature control concepts

When the water is ejected out of the showerhead, travels through the air, and hits the floor a lot of heat is absorbed in the air, the user and the floor, as such the used water naturally has a lower temperature. The specific temperature is dependant on a series of external factors, the important ones are as follows:

1. Room temperature and moisture.
2. Air flow, is a window open?
3. Body temperature.
4. Floor material, heat conductivity.
5. Floor heating.

To get a general understanding of the temperature difference, a test was conducted using a thermal camera, and can be seen to the very right.

The combination of external factors create a highly variable temperature on the ejected water, that must be taken into account when combining it with the clean water.

A constant flowrate, simplifies this by a huge margin, as the mixing rate can be kept constant.

CONCEPTS

Three concepts were discussed, however one was rulled out, when it was decided, that the flowrate must be kept constant. Both have have system wide consequences.

A: Heat the reused water. A constant temperature could be achieved, by heating the used water, for instance in the buffer tank.

- Would ensure that the water is at the correct temperature.
- Would not rely on other mechanisms in the system to work correctly, it would simply rely on a heater.

- A water heater uses a huge amount of power, the battery would be drained very quickly. Furthermore it must match the flowrate of the suction, possibly requiring a very large buffer tank or a very strong heater.
- The system is not very responsive, the water can only be heated, however not cooled on demand.

B: Adjust the clean water temperature. A constant temperature could be achieved adjusting the clean water temperature, for instance through the mixer, thereby effectively creating a constant temperature.

- Works independently of the venturi injector, meaning that it is easier to implement.
- Low power consumption, as it utilizes the already implemented functionality of temperature adjustments.

- Requires the temperature control to be automatic, and a thermometer sensors, possibly in a feedback loop.

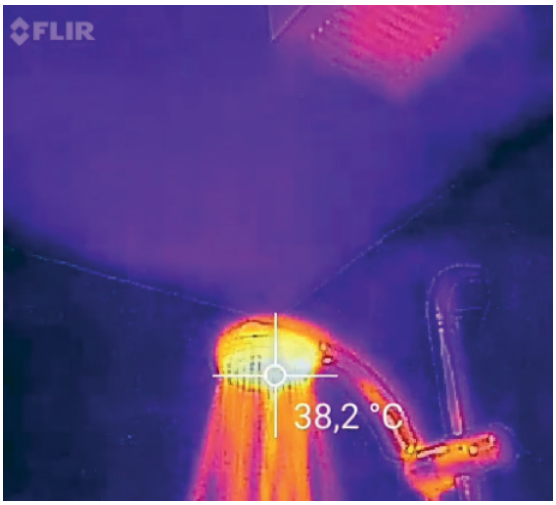
- Could possible affect the final flowrate of the water by a small margin, if temperature adjustments affect the flowrate, which it does in some homes, however mostly to a small degree.

Output

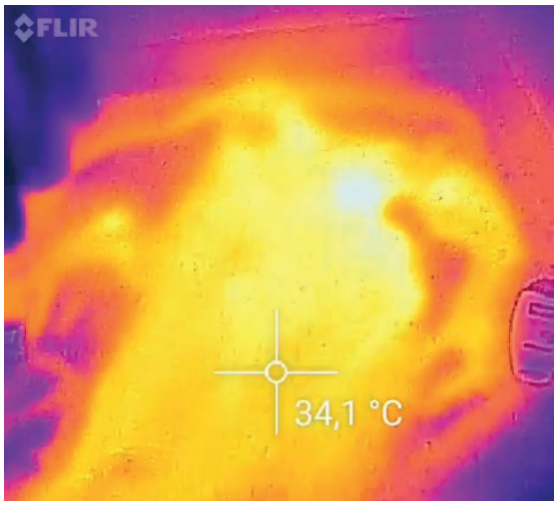
Solution B was chosen due to the low power consumption of the system, and the ablity to build upon already existing components, greatly reducing the technical difficulty.

TEMPERATURE DIFFERENCES IN THE SHOWER AND VARIENCES OVER TIME

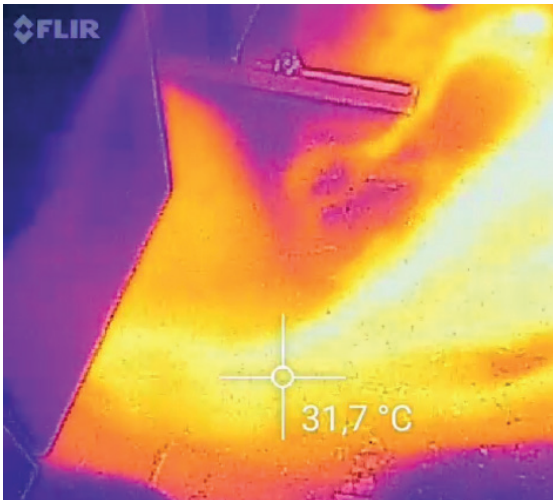
Figure 35: Thermal imaging of bathroom environment



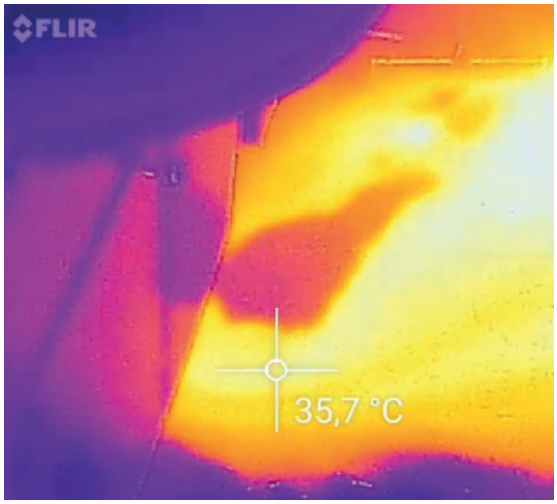
1. The initial temperature at the shower head



2. The temperature of the water at close to the impact area of the water



3. The temperature of the water close to the drain.



5. After ten minutes the floor has heated up, this is the temperature of the water close to the drain, the output temperature is the same.

Results: The tests show that the temperature varied greatly due to the floor heating up after ten minutes, this proves that the water on the floor is not at a fixed temperature, but changes over time. The initial temperature difference, between picture 1 and 3 is 6.5c, however is less than 2.5c by the 10min mark. More in-depth information found in [WS10]. Thermal imaging is explained in [WS11].

The temperature control must compensate for the dynamic change.

Developing the automatic temperature concept

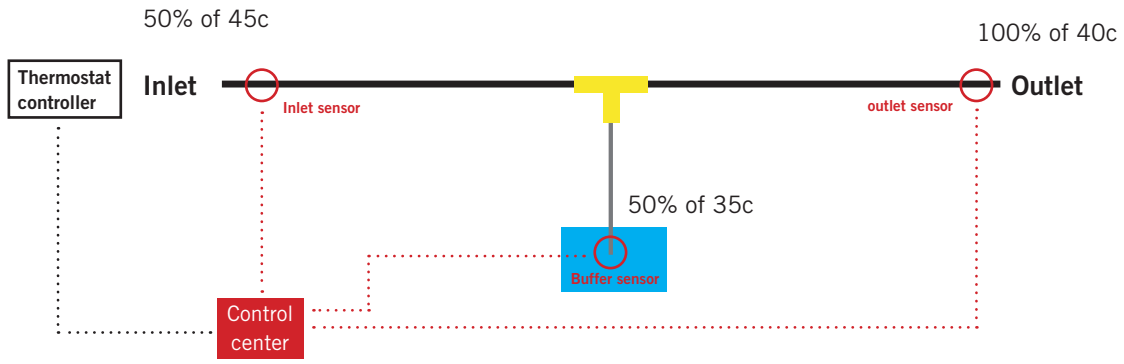
HOW TO BE AUTOMATIC

To be able to automatically adjust the temperature, the system needs a feedback loop and a method to control the temperature by the means of a digital signal.

Feedback loop: Tempature sensors are placed at water output, buffer and thermostat. When the temperature of the buffer is lowered, the mixer will increase the temperature by a calculated amount, and the water output sensor will give feedback to the system whenever it succeeded, or small adjustments are to be made.

The calculation, depends on the temperature differental, and the mixing rate. For instance, lets assume the mixing rate is 50/50, the wished temperature is 40C, and the buffer tempature is 35c. Meaning that the thermostat temperature has to be 45c, in order for the output water to reach 40C. This has been tested in [WS12]. The system is illustrated below [Figure 36].

Figure 36: Temperature feedback loop



Controlling the temperature digitally: To control the temperature digitally, the physical action of turning the dial is controlled by a motor, most likely a stepper or servo motor, wherein the digital signal by the feedback loop is translated into motor movement, this is also called by-wire control.

The consequence of such a system is that it interferes with the manual control, which means that the system control must be layered.

MANUAL CONTROL

To manually control the tempature of a digital system, the physical movement of turning the dial, has to be translated into a analog signal, readable by a microcontroller, this is easily done by a potentiometer or a rotary encoder.

The manual control will set the target tempeature, whereas the automatic control will aim to maintain that temperature.

Output

The temperature control, is rather elaborate, however that is one of the consequences of reusing water. The concept should work perfectly alongside the venturi concept.

If the fluctuations were to be ignored it would create a varying temperature throughout the shower, that which would deviate from the norm. However it would reduce system complexity to remove it.

FILTRATION

OBJECTIVE: The function is to make the shower water usable within the shower partially by dilution, and what else are needed to make the water "fit for purpose", and getting the "cleanest" water.

SHOWER WATER

Tap water is ejected from the showerhead, where the majority hits the user, the remaining directly hits the floor, wall or other obstacles. The water flows down and along the user, until it meets the floor that is sloped towards the drain, wherein the water is funneled towards. The water flows down the drain, where it connects to the sewage pipes.

THE ASSUMPTION:

The water is in contact with three major surfaces, in order: the user, the bathroom environment, and lastly the drain. We assume, that the most severe source of bacteria, and dirty matter is the drain and the pipes connected to the sewage pipes, additionally the area beneath is inaccessible for the user to clean and is able to get cross contaminated by other sources of water.

The shower environment, the walls, floor and other obstacles such as the shower thermostat appear very clean, and are accessible in terms of cleaning. The shower environment, is just as clean as a bathtub's surface, which is viewed as clean and acceptable.

The user, before entering the shower, and along the shower has a varying degree of cleanliness. The team has three assumptions regarding the user cleanliness:

a) We live a more sedentary lifestyle, and are generally more "clean" today than 100 years ago, atleast in Denmark and most of the western world. Getting clean as a daily maintenance task involves washing off sweat, washing oil off your hair, scalp and such.

b) Showering is not only an activity to get clean, it is an opportunity to relax, to soften your hair, to moisten your skin, to get fresh for the morning, to enter a state of mindfulness. In other words, we assume that showering is much more than getting clean. The added activities create a longer shower duration, and a longer interval in which the user appears relatively clean.

c) A bathtub is considered hygienically acceptable. Being submerged in bathtub water is comparable to showering in reused water.

We assume that shower water as it is, can in many cases be considered acceptably clean, atleast as clean as bathtub water. Considering that typically no one would use the bathtub while full off mud, they would lightly shower beforehand, then use the bathtub. The same principle applies for shower water, there will be periods of the shower when the water is cleaner, and we argue that this period is extended considerbly due to the multitude of shower activities beside achieving cleanliness.

VISION

Just as the water falls off the user before touching the drain, the cleanest percentage gets picked up, is minimally filtered and diluted in fresh water, thereafter ejected on the user.

The vision enables us to avoid the drain, thus we are able to circumvent the biggest source of contamination. By picking up only the cleanest percentage, and minimally filtering it, the water should be considerably cleaner than bathtub water.

To define the "cleanest" percentage, as in, what to pick up and not to, we need to define what the minimal filtration is capable off.

SHOWER WATER CONSIDERATIONS

There is two elements which we have to consider.

1) the user perception of what is clean water "this water is not clear, thus not suited to shower in"

2) The invisible, which the user does not see, but which can make them sick, bacteria.

Turbidity, the haziness of the water, to a large extend is how the user gauges water cleanliness, as haziness is associated with unclean water, such as bacteria, and vice versa.

But what is actually required to be filtered? The source of contamination is defined mainly by the user. The water that has been in contact with the user, thus having the slight possibility to contain bacteria which are dangerous, such as E.coli. Additionally it is required by european law to eliminate E.coli bacteria in reused water (4).

Soap, the slight amount of skin oil, dead skin or larger particles such as hair, causes visual inregularities in the water, which as defined impacts the perception of water quality, without actually being dangerous.

Turbidity is the haziness of a fluid caused by particles that are generally not visible to the naked eye, like smoke in air.

FILTRATION CONCEPT

Larger particles:

To circumvent larger particles being recirculated, a filter is needed. As larger particles are usually easy to filter due to being larger than water particles, this filter can be inexpensive.

One of the easiest methods of filtering hair, with low maintenance and still being passive is a **mesh filter**. The filter should be dense enough to filter out hair, sand and larger particles, but not dense enough to restrict water flow. The mesh filter should be positioned as the first filter in the system, allowing for the coarse filtering to happen first, before the water is then sucked up further into the system.

Bacteria:

Due to the small possibility of recirculating dangerous or harming bacteria, a filter is needed to ensure that the recirculated water is completely safe to shower in. As E-coli is dangerous to consume and can spread through the airways, an effective bacteria filtration is necessary, as these bacteria could cause harm if swallowed by the user.

Bacteria filtration can be very complex, mechanical micro filters such as active carbon and sand are able to remove bacteria, however these filters needs to be replaced after continuous use, and can add to the complexity of the system, due to restraining water flow and user replaceability. Mechanical filters are often passive themselves, but require a pump to push the water through the system, indirectly using electricity.

UV radiation (**UV-C**) is used in water purification systems, and is both an effective and cost effective way of getting rid of harmful bacteria. UV filters do not remove bacteria, but disinfects by killing the bacteria. As UV disinfected water is safe to drink, showering should be very acceptable. Being an active solution, power is needed, this is however available due to the battery in the system, two types of UV lights are available, the traditional mercury light and LEDs. Mercury lights are very power inefficient, due to converting power to heat as a by-product, whereas LEDs consume less energy but are significantly more expensive.

Turbidity:

To achieve clear water, an important factor in determining water quality and how the user perceives the water, it is possible to **dilute the water with new water**. This would allow the system to inexpensively lower the water turbidity, and thereby the user would not be showering in dirty looking and smelling water, as the mesh and UV filtration would not single-handedly resolve issues in regards to the water color or odor.

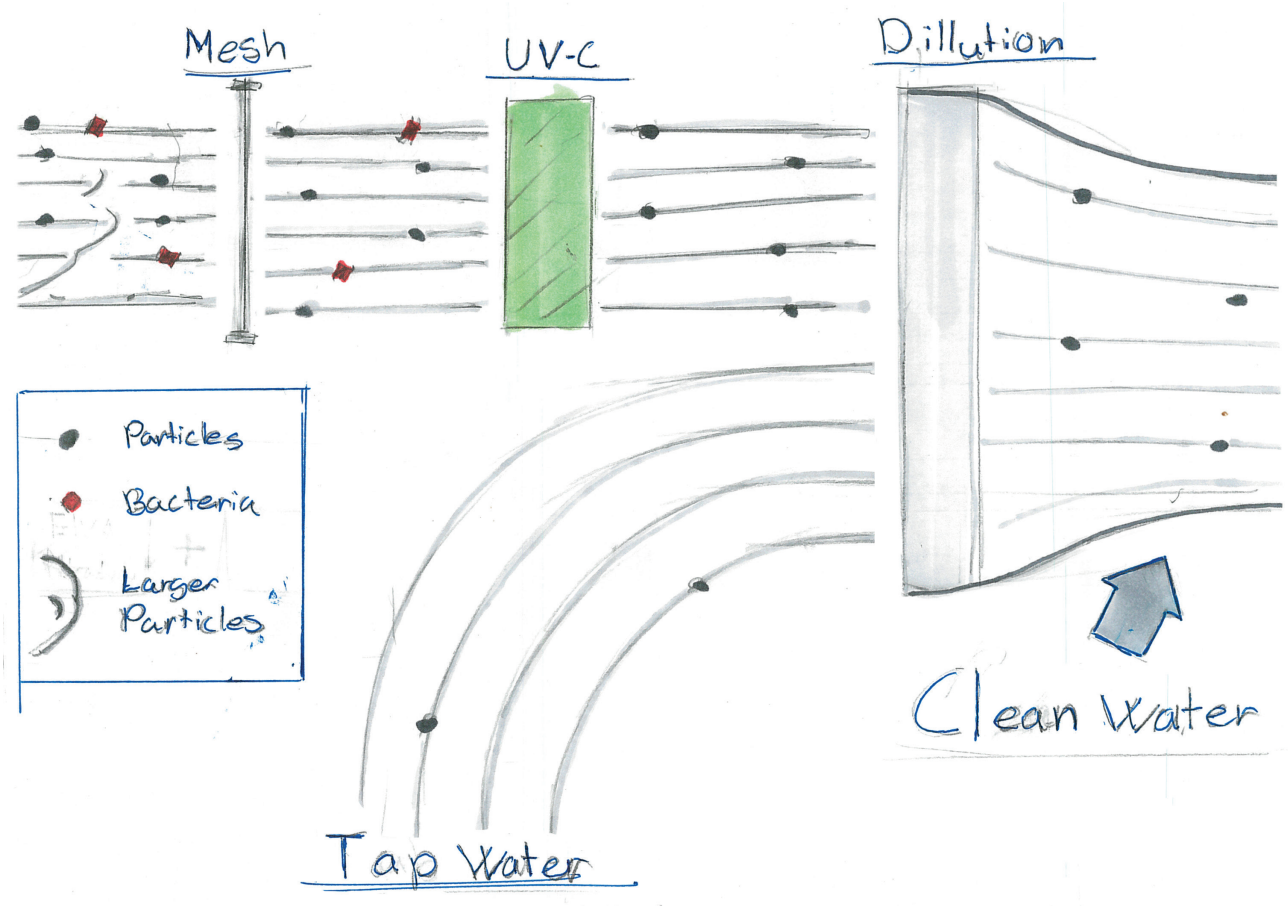


Figure 37: Filtration process sketch

Figure 38: Coductivity test, water

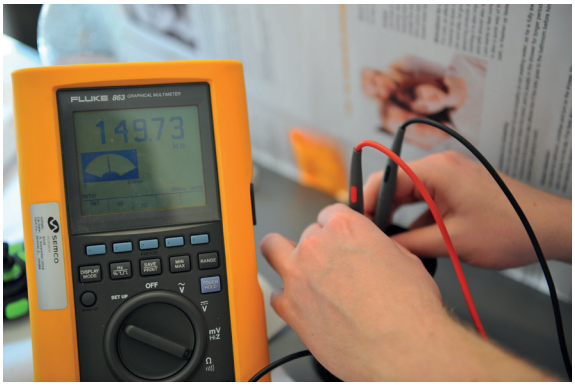
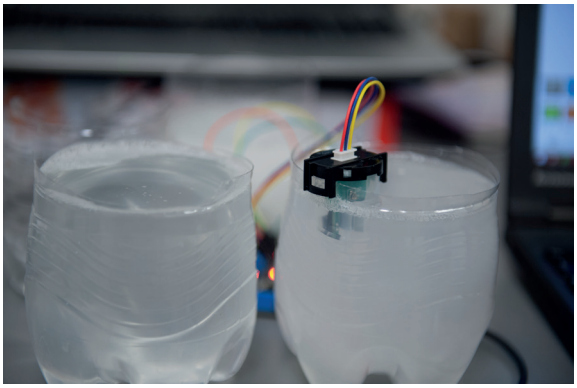


Figure 39: Coductivity test, Pepsi max

Testing for resistance in fluids. To see whether it was possible to differentiate between clear fluids and fluids with a higher density of salt, such as urine, a small test using a multimeter were conducted. The multimeter was set to measure resistance and probes were inserted into both clean water and a fluid with more conductivity (Pepsi Max). The clear water clearly showed more resistance due to the lower conductivity (149 kOhm)[Figure 38] whereas the Pepsi Max showed much lower resistance, meaning a higher conductivity (28 kOhm)[Figure 39]. This proves that resistance can be measured quite easily in a fluid, and can be a probably way of sensoring different fluids. Test setup and resistance explained in [WS13]

Figure 40: Turbidity test, from left to right, in squirts of soap: 0, 1, 2, 5, 20

Figure 41: Messuring the suspended partices with an optical sensor.



Testing for turbidity in water. To see whether we could measure different turbidities in water, a range of five samples were set up, ranging from completely clear tap water to completely soapy water. The turbidity sensor were put into the different samples and a value was read out. This value did not directly relate to a NTU value, so it was difficult to read the exact NTU, however it was made probable that turbidity can be measured in the water, as the different samples read out different values.

CONSIDERATIONS AND CONSEQUENCES

The filtration concept is able to inexpensively filter water, to guarantee that the water is safe in terms of bacteria, and ensure that it is visually appealing by the means of dilution and and remove larger particles by the means of a mesh filter.

The consequence of this type of filtration is its inability to remove solubles and liquids, such as soap, shaving cream or an extreme case like menstruation blood or motor oil. From a hygienic standpoint, soap and shaving cream is not problematic, atleast in small quantities, but the menstruation blood and motor oil should be avoided at all costs. Furthermore, the dilution never removes particles to reduce haziness(turbidity), it merely distributes the already very few harmless particles, such as skin oil and dead skin cells over a larger body of water, thereby making the water more clear. The dilution would be unable to address if an excessive amount of dirty matter is picked up, like a large quantity of mud.

The cleanest percentage can therefore be defined, as a threshold of based on what liquids and solubles should be avoided, and turbidity. The threshold are ensured by combining the result of a few sensors:
Turbidity sensor, to measure suspended particles
Conductivity sensor, to measure the conductivity.

IMPLEMENTATION

The filtration concept and the venturi concept must be combined, the venturi acts as the dillution filter and the buffer tank is the obvious place to intergrate the UV-C filtration. The mesh filter is inserted at the very start of the water collector, which hinders larger particles clocking up the system. **The UV-C must match the suction flowrate, and be dimensioned according to that.**

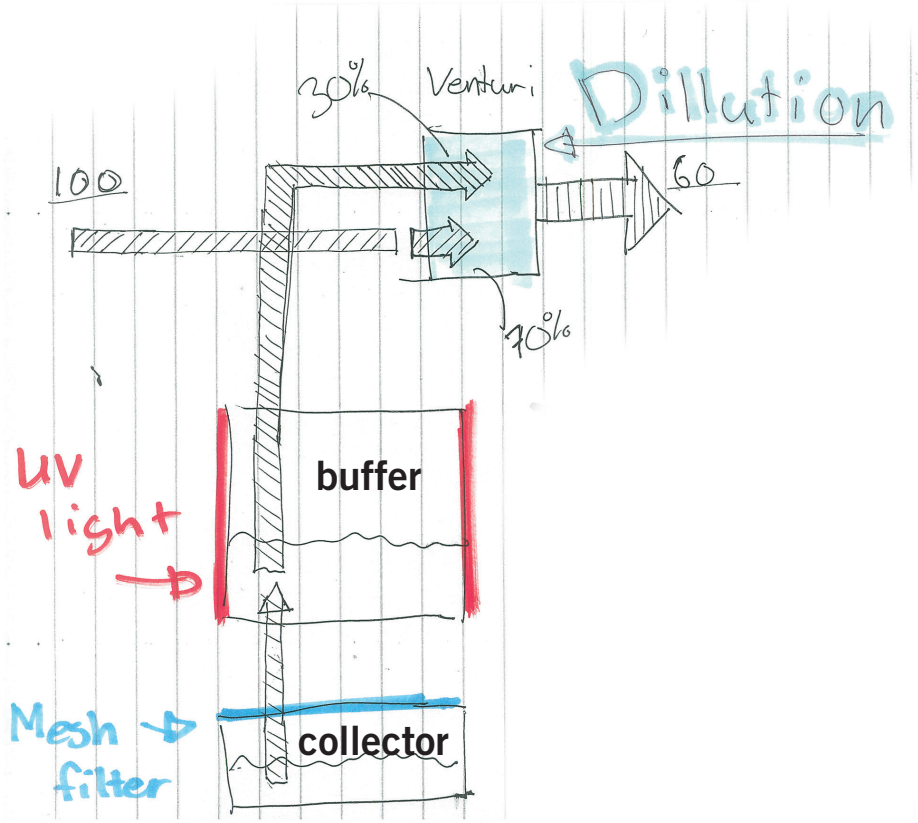


Figure 42: Combined venturi and filtration concept

LAW

The team has an ongoing correspondence with the Danish Environmental Agency (Miljøstyrelsen). In conclusion they informed us, that no current laws exists on the domestic reuse of greywater within showers, however, the general rule is that no E-coli is allowed at all.

The case of reusing greywater within showers is being processed at the moment, they informed us, that it can take a while, the correspondence can be found in [WS14].

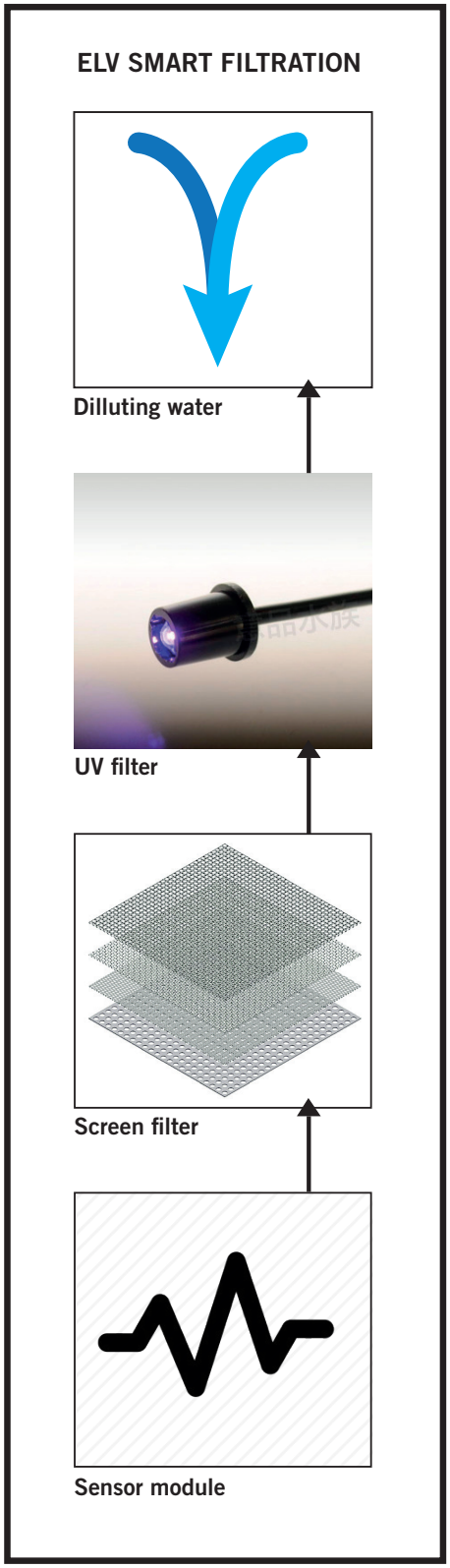


Figure 43: Filtration on a principle level

Detailing

Finally diluting the water with 50% new water will ensure that the NTU value will be cut in half, meaning that the final value is 5 NTU, meaning close to clear water.
See [WS16] for more information and a simple test.

The UV filters purpose is to eradicate dangerous bacteria, ensuring the user wellbeing. The wavelenght needed for this is 254nm, meaning that a series of LED's within this wavelenght is used. The power(watt) depends on the flowrate.
See [WS15] for more information.

The screen filter is dimensioned to restrict hair and larger object to enter the rest of the system, as hair is the thinnest of particles in the system, the screen filter is dimensioned for this. The given screenfilter is chosen to have a hole size of 0.074mm, also called a meshfilter No. 200.
See [WS15] for more information.

The accepted turbidity of the water at the sensor module is 10 NTU, meaning that the sensor should be calibrated for this value.
The reasoning behind this value is described in [WS15]

Output

This concludes the deep dive into filtration, two important aspects were touched upon, the absolute hygiene and the the percieved one. The most critical is the disenfection of E.coli, which has been made probable. The remainder is the percieved hygiene, which we believe has been made probable, by providing the tools to deal with it. It is a matter of adjusting the values up and down, and less importance has been placed in investigating the "best" values, as it in no way posesses a danger, just as a bathtub.

OTHER

OBJECTIVE: Throughout the development, the team dived into other means, as well as the other components. The exploration had some significant impact, or wasted a significant amount of time, they are summerized in this section.

SHOWER SET VS ADDON STRUCTURE

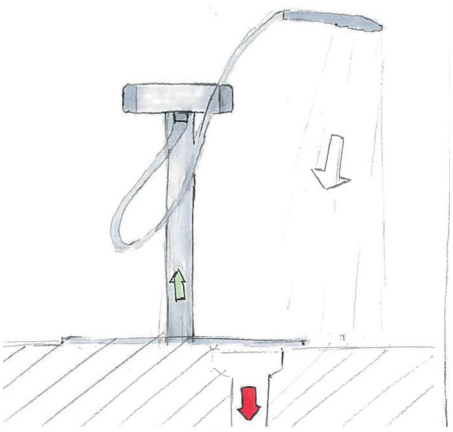


Figure 44: Early sketh, addon

VS

Figure 45: Intergrated product

In the early phase of development, where the technical structure was mostly unexplored, some time was spent in thinking how it could be offered. As a third party addon, a brand specific addon or a whole showerset. Five companies were contacted (Damxia, Hans Grohe, Grohe, Vola and Oras) However they were not interested in Water recycling showers or saw no benefit in supporting a master thesis project [WS17].

In the later stages of development, the team realized that the system would stretch from top to bottom, leaving only one choice, a whole shower set. Furthermore, the team decided it to be an external showerset, rather than a built-in shower set, in consideration of retail cost and installation [WS18].

FLUIDICS NOZZLE

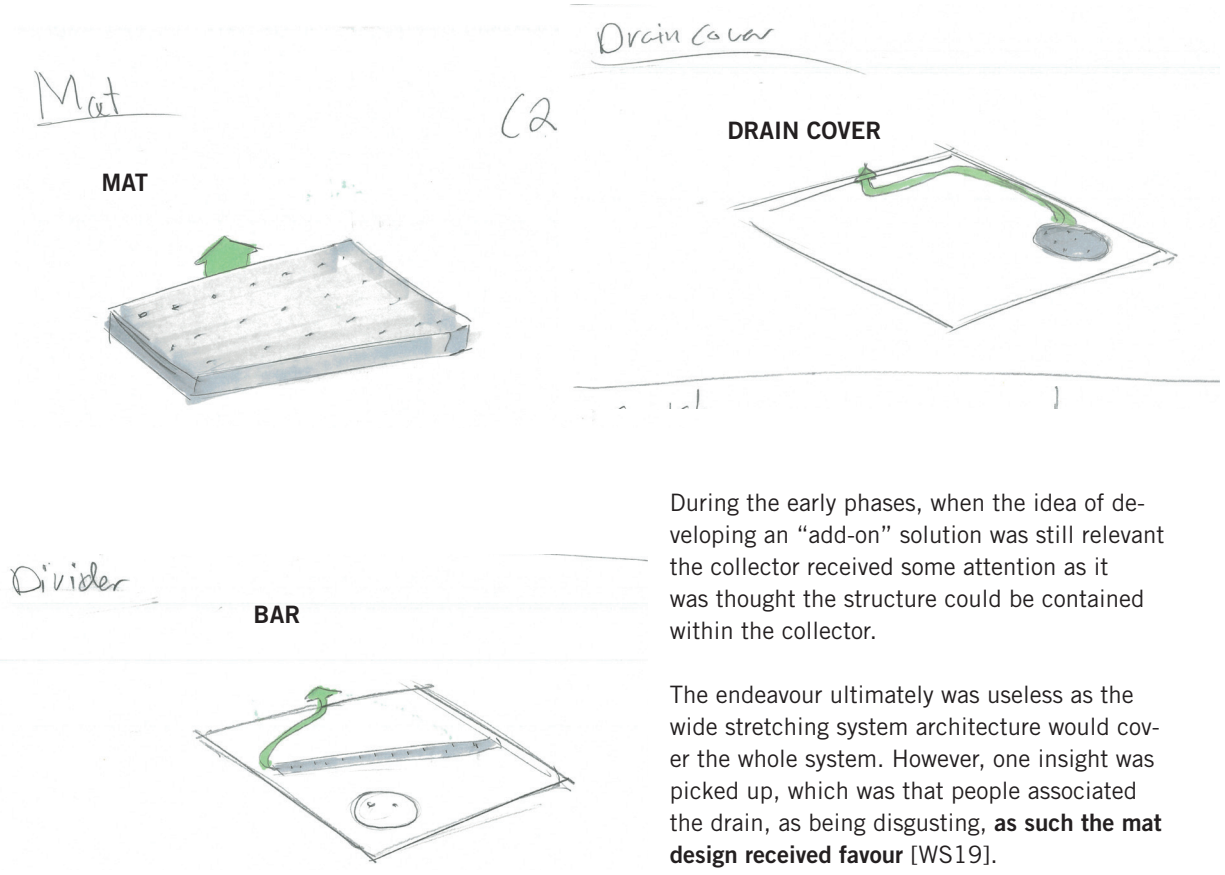
Inbetween the aspirator test and the design of our own venturi injectors, some time was spent researching shower heads.

The principle of creating more coverage with less water, as seen in market research page 12, was explored, as it could negate the big loss of flowrate using the aspirator.

The fluidics nozzle was very interesting, as it is able to create a swirly motion without any internal moving parts. A 3D printed showerhead with 16 nozzles was even modeled and worked perfectly. However due to new info regarding the venturi injectors ultimately rendered it a waste of time.

Figure 46: Fluidics showerhead

SHOWER COLLECTOR



During the early phases, when the idea of developing an "add-on" solution was still relevant the collector received some attention as it was thought the structure could be contained within the collector.

The endeavour ultimately was useless as the wide stretching system architecture would cover the whole system. However, one insight was picked up, which was that people associated the drain, as being disgusting, **as such the mat design received favour** [WS19].

Figure 47: Collector sketches

FLOWRATE RESEARCH

Inbetween the aspirator test and the design of our own venturi injectors, some time was spent gathering the flow rates of other peoples homes, mostly as reference data, to be assured that the injectors would have sufficent pressure to work in most homes, which was the case [WS20].

PRINCIPAL STRUCTURE: ELV

OBJECTIVE: To describe the system method of operation, power usage and the final considerations.

method of operation

1 **.The shower has been initiated**, water is gathered in the collector, where it is coarsely filtered to obstruct larger particles such as hair and is measured in terms of turbidity (haziness), temperature and conductivity
2. Depending on the quality, an amount is by the use of an active pump transferred to the buffer tank.
3. The buffer tank has two purposes, one is to shortly store the water to be UV-C treated to kill harmful bacteria, and secondly to shorten the "lift" distance which is critical to make the venturi injector function at maximum effect. The used water is now in standby, ready to be mixed and ejected.
4. **Meanwhile,** The thermostat is pushing water through a fluid circuit that determines the amount of clean water passing through the venturi injector, or bypassing the injector, effectively controlling the flow passage way with a ball valve. The circuit works with a simple principle, which is that a pressurized fluid will choose the path of least resistance, by closing the ball valve the fluid will be forced to pass through only the venturi injector, or vice versa
5. As water is passing through the venturi injector, a suction is created at the injector inlet, wherein the UV treated water from the buffer container is lifted into the injector, then combined and ejected into the showerhead.
6. As the combined water is ejected through the injector output to the showerhead. **The water has successfully entered the showerhead, and is being ejected onto the user.**

Battery calculations

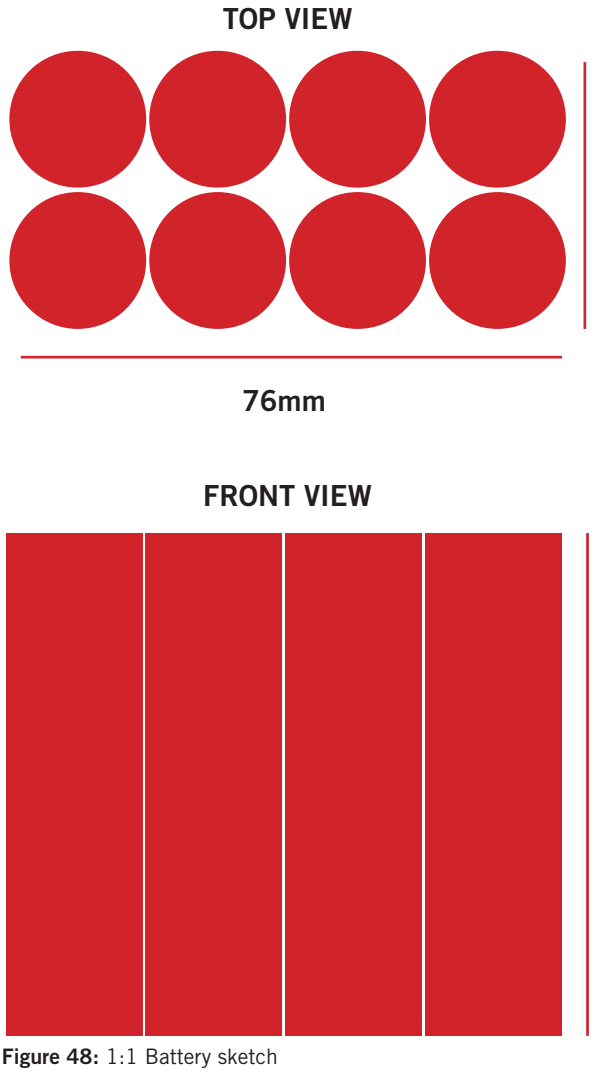


Figure 48: 1:1 Battery sketch

Eight 18650 batteries produced by LG are readily available on most chinese wholesales channels. They are widely used in most battery driven electronic appliences, for instance laptops. A 1:1 illustration can be viewed to the left.

8 High capacity 3400mAh 14.8 Nominal voltage Equals ~12700mAh at 12V, this includes a penalty of 20%, as these batteries must not be discharged below 20% [WS21].

BATTERY CAPACITY		
Total mAh	12732.54054	mAh
COMPONENTS		
Pump	400	mAh
UVC LED's	150	mAh
Turbidity sensor	30	mAh
Conductivity sensor	10	mAh
Others	150	mAh
Total	**740**	**mAh**
	17.20613587	**Hours usage**
CHARGING		
Charging at 12V 2A	5.44	hours

The battery will last ~17 hours, when all components are running at all times. If a user showers 30min every day, the battery will last a total of 34 days. However, the battery will discharge ~20% over one month, rendering the actual usage ~27 days.

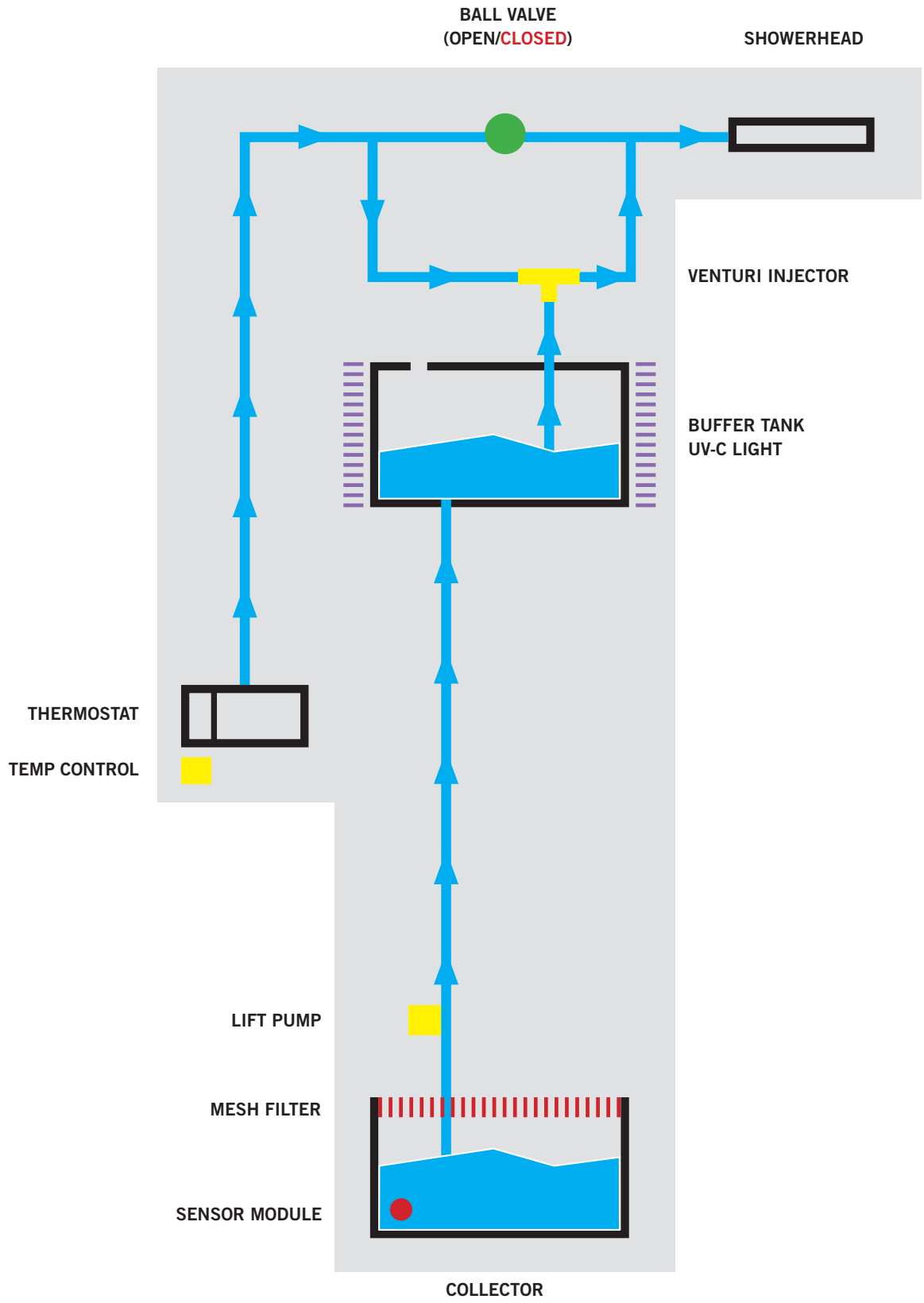


Figure 49: System architecture

Conclusion and delimitation

The early prioritzation of the sub-functions: circulation, mixing of fluids and filtration led the team into two deep dives, the research into venturi injectors, and how to deal with their consequences in implementation, and the research into filtration.

The development can be considered a mild success, as the system at a principle level, is able to claim itself to have acheived a low power usage and is affordable. However since none of the requirement were specified to any metric, the development true sucess or failure is difficult to detemine, however we strongly believe that the prioritization process was strong due to the early research into solution principles and tests.

DELIMITATION
The team has chosen to stop the technical development, as the main goal has been acheived, to make a low powered and affordable system probable. However this means that the team is delimiting itself from further research into two other sub-functionalities, meaning the showerhead and floor collector.

The showerhead and collector are absolutely essential features, however due to time constraints, the team is forced to move on.

System opportunities

Is able to recirculate water at very low power consumption by harnessing the powerful flow rate and pressure of the mixer.
- Is able to achieve a clean water flowrate as low as 3.25 Lpm, while providing a total flowrate of 7.5 Lpm, with a recirculation rate of 50%. Halfing the usage of most standard water saving showers.

- Is able to provide a total flow rate up to 13 Lpm, while only using 5.5 Lpm of clean water, using less water than almost all current water saving products, while providing almost twice the flowrate.

Is able to filter water, inexpensively and at very flow power consumption.
- Is able to disenfect all harmful bacteria by the use of UV-C, notably E.coli
- Is able to make the water appear more clean, by decreasing water haziness by dillution.
- Is able to automatically stop the filtration should an excessive amount of dirty matter enter the water stream, by the means of sensors.

System consequences

Has limitations in terms of controllablity if a steady flowrate, temperature and water quality is to be maintained throughout the shower
- No flowrate adjustability, is locked at one setting.
- No suction rate adjustablity, is locked at one setting.

Filtration cannot remove liquid or solubles, and must be omitted by the means of detection.
- A turbidity and conductivity sensor are unable to detect abselutely everything, it can fail.

Requires an elaborate temperature control mechanism
- The temperature control is digital, and must be controlled bi-wire

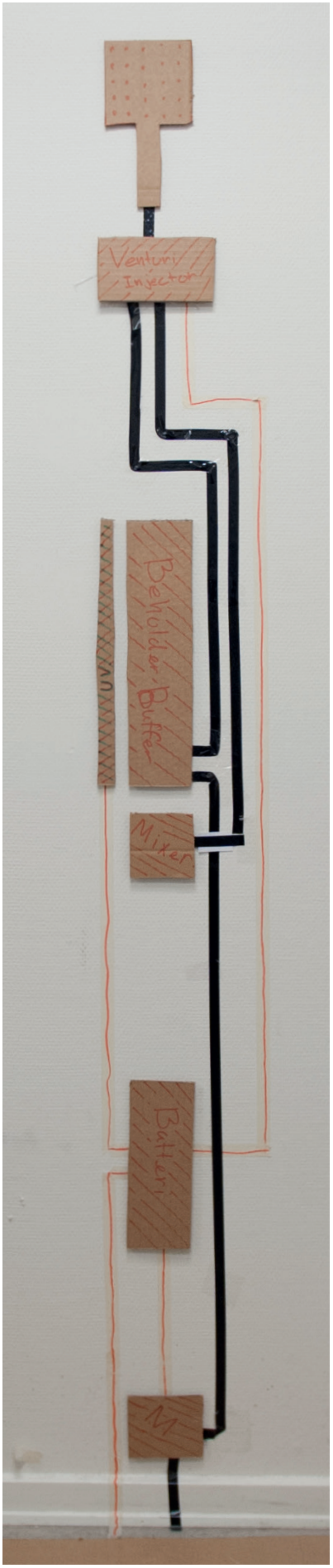


Figure 50: System architecture, component overview

USER EXPERIENCE

Approach process

Transistioning to a user-oriented way of thinking was one of the biggest challenges in this project, as the prior technical development required a very solution oriented approach, where thinking in solutions was fast and efficent. However, while working with users, jumping to conclusions (solution principles), removed our ability to dive deeper, and reach the core insights to set a direction.

The way the team dealt with it, was "seeing" the technical development as a prior experience, like a prior semester course, attempting to create some mental distance from it.

The process of designing the shower experience

The Elv technology is a new entry into the "water saving product" market, with strengths and weaknesses in regards to the user that are yet to be uncovered. How will it affect the user experience when showering, and how can the team make the best of developed technology, while mitigating the weakneses, or even turning them into strengths.

BEHAVIOR AND COPING STRATEGIES

Inherent to a water saving product is that it is able to greatly reduce the usage of water, but we acknowledge, that the incitement and impact of water saving might be a weaker value proposition for western countries where water is in abundance.

For instance, saving water might have a different meaning for an australian citizen where water scarcity is a reality, a loss of a everyday commodity. Compared to a danish citizen, where the incitement of saving water might be due to wanting to live a "greener" way.

Either way, the incitement of saving water, is deeply interwoven with what the users might be willing to sacrifice or trade in order to gain it. As such, it is crucial to have an understanding of what the users success criteria and frustrations when showering is, and how that is reflected in their behavior and coping strategies.

Taking a close look at the users current coping strategies could be a very useful reference point, as coping strategies are weighted actions that are formed from the users behavior in order to fulfill his success criteria, and to some extend are able to give a glimpse in what the users might be willing to accept or even sacrifice to fulfill that succes criteria.

The question is, how will the Elv recirculating shower influence the users behaviors, will it require the users to adapt their coping strategies. If so, what kind of behavior will it support and how will it deal with negative consequences. We need to be extremely aware of this, as we on one hand, might be able to support the users success criteria, but what if it hinders the user in her strategy.

To realise the strength and weaknesses of the product in a given user group, we need to be able to precisely pinpoint what behavior we want to support and the consequences to deal with, thereby forming a direction (handle) for the solution to progress in. To do that, we need to compare the current shower experience with the Elv product structure, step by step.

Choosing a target group

The user group we choose, was a Danish demography, the driver for that choice was purely due to availiblity. To create an in-depth analysis of users, personas, we believed it was essential to be in touch with the users and to be in a relatable culture.

From a solution stand point, we believe the developed technology has immense potential in contries where water might be scarce as a commodity. However from a learning stand point, and our ability to go in-depth, we believe an accesible target group is essential.

PERSONA DEVELOPMENT

OBJECTIVE: To develop and define a group of in-depth personas, in order to define a potential target group and later be able to create a comparison between the the current behaviors and the Elv technology.

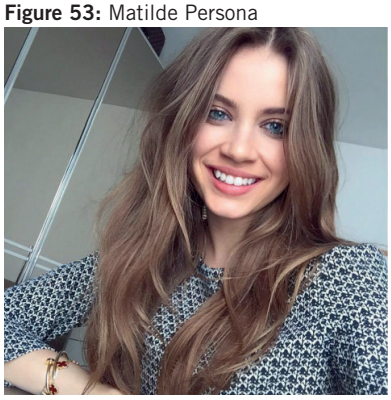
Figure 51: John Persona

John's succes criteria:
To feel clean.
To get ready for work, in terms of apperance.
To relax and feel cozy.

Figure 52: Nicole Persona

Nicoles's succes criteria:
To feel clean.
To keep up appearance, in terms of visual appearance.

Figure 53: Matilde Persona



Matilde's succes criteria:
To feel clean.
To relax and feel cozy.
To upkeep apperance infron of the significant other.

Figure 54: Andres Persona

Andres's succes criteria:
To feel clean before going to sleep.
To relax and feel cozy

Figure 55: Niels Persona

Niels's succes criteria:
To feel clean fast, and progress with his day.

Figure 56: Father Persona

The father of two teenage daugthers's succes criteria:
To limit the water usage of his daughters.

Personas

In order to define a target group, we did not go by age, or other general metrics, but attempted to find diverse people based on their goals inside the showers. Five people were interviewed, in which they were asked to describe their shower experience. A framework was developed in order to process the data, and to create more "Real Life" personas. The persona "Farther of two daughters" was modelled after a interviewee's dad. The main theories were from "Experience economy" by B. Joseph Pine II (5).
The general outline was: What is their state of mind before and when showering? What is their motivation and frustrations when showering? How does that influence their coping strategies, and how is that mirrored in their coping strategies? How is their experienced percieved, are they achieved through active participation, or is it an aesthetic experience. The persona development process material can be found in [WS22].

Output

Out of the six personas, Nicole and Johns where the most throughout, due to a closer collaboration. The first two personas to go in-depth with was Nicole and John was Nicole's due to having a very "technical" shower, and John's relaxing shower, can the Elv technology deal with that?

PERSONA: NICOLE

OBJECTIVE: An in-depth description of her state of mind when showerin, her motivations, frustrations.

ABOUT NICOLE
Nicole is a young lady with semi coarse hair down the lower back, she often has straightened hair and places a lot of importance in appearance. She is single, and therefore does not deem is necessary to not shave legs in the winter, when leg skin is not revealed. She lives with a roommate and the apartment has one shower.

Figure 57: Nicole Persona

SHOWER STATS
Shower time: 20min
(Has the shower disabled for 2min)
Flowrate: 10L/m
Total water usage: ~180L

CONTEXT
Nicole showers in the evening, towards the end of her recreational time before going to bed. She has a traditional shower set and usually the window is open while showering creating a colder environment. She lets her hair dry before going to bed.

MOTIVATIONS FOR SHOWERING
For Nicole showering is a function to uphold her appearance, she considers the shower part of her grooming process in which her hair must be shiny, smooth and easy to straighten, her face is scrubbed to remove impurities and her body is cleaned to uphold hygiene in a efficiently and fulfilling way.

FRUSTRATIONS FOR SHOWERING
Nicole views showering as a grooming process that has to be done, not only for herself, but also for the people around her, going outside without showering, or rather not doing the beautifying processes that she does within the shower is not an option for Nicole. Showering is therefore often viewed as a chore, that she wished she not not have to do.

SHOWER BEHAVIOUR
To make the shower chore more bearable, she turns on music and often sings along. The shower is turned on before she unclothes as it minimizes the transition time, avoiding the cold room.

When she showers, she strives to done as fast as possible while still being very throughout in her cleaning and beautifying activities, she is even willing to compromise her comfort, should it interfere with getting her shower activities done to her standards, for instance she turns off the shower when applying body soap, to be able to throughout lathe her body in soap, without the water washing it off.

Throughout the whole duration of the shower, every minute is filled with a task, and exactly when those cleaning and beautifying activities are completed, she too is done with the shower.

She does not condition her hair everyday, nor does she shave her legs everyday in the summer, she does what is needed to uphold her appearance.

IDEAL EXPERIENCE
-The ideal shower experience for Nicole is one that supports her at completing her shower actives fast as possible, while being very throughout in terms of reaching her goal of cleanliness and appearance.
- She seeks entertainment in the form of music and dance to make it more bearable, the ideal shower experiences, has to keep her entertained to reduce the boredom.

PERSONA: JOHN

OBJECTIVE: An in-depth description of his state of mind when showering, his motivations, frustrations.

Figure 58: John Persona

SHOWER STATS
Shower time: 30min
Flowrate: 12L/m
Total water usage: ~360L

ABOUT JOHN
John is a 32 old guy with a longtime girlfriend, he places importance in appearance, and is a perfectionist that buys brands and quality.

CONTEXT
John lives in an older apartment and wakes up early in the morning to shower due to his girlfriend also needing a shower. The bathroom is normally quite cold due to the lack of floor heating, which is why he does not open a window in the start of the shower, due to the heat loss.

MOTIVATIONS FOR SHOWERING
Showering is a vital part in John's morning ritual and is a way of him freshening up for his daily work routine, and a way of opening his pores for his daily shave. Due to having a girlfriend and a fulltime job with human interaction, it is important for him to look good. Furthermore the shower is a way for him to relax, and a place in which he feels completely comfortable, which he defines as the feeling of running hot water on his body, steam, and the feeling of being in a state of complete relaxation.

The shower is one of his favorite places to relax, making the shower as comfortable as possible he has no hurry to finish quickly, this results in him taking good time when grooming, extending his shower time significantly.

FRUSTRATIONS FOR SHOWERING
As showering is so much of a relaxation activity as a grooming activity, John is very profound in regards to the comfort in the shower. As the bathroom is normally cold when entering, John is often very cold when unclothing, and getting into the shower cannot go fast enough. When it is time to leave the shower, John is hesitating as he knows he is going to lose the comfort once again, leading to him taking longer showers due to the thought: "I don't want to be cold again"

SHOWER BEHAVIOUR
When showering, John uses the first 5 minutes as a relaxation period, where he gets into his comfortable zone. The next 10 minutes is used for his grooming products, and when that is done, he often uses 10-15 minutes to just relax and feel comfortable in the shower. While using the grooming products inside the shower, he does not turn of the water, as he enjoys the feeling of the heated water, instead he leans his head outside of the water stream, such that his body is still in the water stream, this is also possible due to having short hair, which washes out quickly.

When it is time to get out of the shower, hesitation quickly hits, and he often uses a couple minutes more to force himself out of the shower, as he knows that it is colder outside of the shower.
It is very important for John to use the grooming products each day, as he has a high standing job, in which he is expected to look good, this is also why he is shaving his face after each shower..

Ideal experience
-The ideal shower experience for John, would be one where while applying grooming products, would not disrupt his veil of comfort, staying inside the warmth and light water massage of showering.
-When entering the shower, it would be ideal if the room had already reached a temperature, so that when unclothing, John would not feel discomfort due to the cold.
-When leaving the shower, it would be ideal if when exiting John would not feel a difference in temperature, keeping the feeling of comfort from the shower outside of the shower.

Nicole's Shower journey and coping strategy

+ = Strength - = Weakness * = interview insight

Nicole turns on the water beforehand, even before unclothing to make the transition instantly, and turns on music, both to minimize and make the shower "chore" more bearable.
+ The principle of recirculation is able to recirculate a large amount of water, while it heats up.
- The heating process might be slower due to the dillution of temperatures.

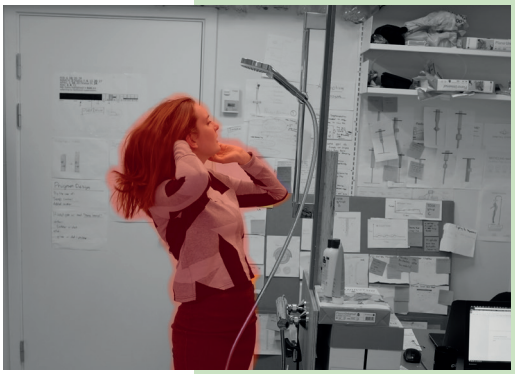
Figure 59: Nicole's journey through the shower

Nicole turns on the shower, while being outside of it.

Nicole wettens her face, to clean off makeup and simultaneously wettens her hair to make it ready for lathering it with shampoo.
* Nicole has a higher expection of cleanliness with her face and the area around, the principle of recirculation might collide with that, if the water recirculated is not sufficiently clean

Nicole wettens her face and wettens her hair throughoutly.

Nicole applies the shampoo while barely being inside the shower, to gain just a bit of warmth while lathering her hair, to make the lathering more comfortable.
She lets the shampoo settle while being half inside the shower.
+ The principle of recirculation is able to save a large amount of otherwise wasted heat and water, as she barely uses the full stream of water to maintain her body heat.



Nicole applies shampoo outside of the water stream.

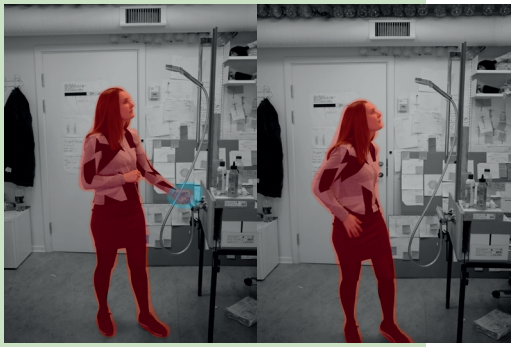
Nicole throughoutly rinses her hair, to remove all soap to progress to the next step of conditioning, requiring her hair to be well washed and soap free.

- The principle of recirculation collides with her current shower coping strategy of getting clean, if the soap is recirculated, as she wouldnt be able to rid herself of it.
- The first rinse of soap, can be considered to be the dirtiest water of the shower, as it within the foam and soapy water, contain all the organic she wishes to wash away, such as body fat and dandruff.
The principle of recirculation collides with her objective of cleanliness, and she might find it off putting.

Nicole rinses her hair

Nicole applies conditioner outside of the water stream. And rinses it off.

*Nicole at times lathers and rinses her hair in shampoo two times before conditioning, in which the same coping strategy applies, although she lets it settle in for a shorter time the second time around.



Nicole turns off the shower, and lathers intimate soap.

Nicole turns off the water, as the water would interfere with her objective of getting the soap lathered proportly, she is willing to sacrifice shower comfort in favor of her cleanliness.

- When the shower is turned off, what happens to the water inside the buffer, will it affect the start up temperature, as its getting colder while waiting, or how will the system handle it.

She washes off the soap, turns off the shower and applies body soap.

Nicole is very methodical, the soap from the prior session must be removed before the body soap can be applied.
- If soap was recirculated, it might increase the time to rinse off soap from the prior session, thereby interfering with her shower efficency.

She turns on the shower and rinses her body.

Nicole takes great care in washing all the soap off.

- The soap colides with the recirculation principle, meaning that she would not feel clean, if the soap was recirculated.

She relaxes in the shower for the last three minutes.

+ The principle is able to reuse a very high degree of water, as she is very passive in this period, and already clean, meaning that the water is very clean.
- what happens to the water after she is done showering, will she use the same water for the next shower? or what if her roomate uses the shower, that might encroach on her sense of cleanliness and her roomates

John's shower journey and coping strategy

Similarities with Nicole
Based on John's activities and his expectations to cleanliness, parallels can be drawn to Nicole's, their coping strategies are pretty much identical. Furthermore they both spends a lot of time on their beutification process, however John differs in his attitude towards the shower as a leisure activity, he considers showering a form of relaxation, meaning that showering has a drastically different purpose than Nicoles shower, and is mirrored in his activites. **We focus on his coping strategies to achieve comfort.**

+ = Strength - = Weakness * = interview insight

As John expects the shower to be warm to his liking before entering, he turns on the shower to acclimatize the room, and heat the flooring due to it being without heating. Furthermore he waits a minute before entering, to ensure that the water is completely heated.
+ The principle of recirculation is able to recirculate a large amount of water, while it heats up.
- The heating process might be slower due to the dillution of temperatures.

Figure 60: John's journey through the shower

John turns on the shower.

Going from the ambient temperature to a warmer temperature is a transition from the daily life to a relaxing environment, and the feeling of the warm water hitting your skin, inducing a feeling of a warmth pleasure quickly heating your body. Therefore he spends five minutes after just having entered, savoring the feeling of warmth, not doing anything but relaxing.
+ The principle of recirculation is able to recirculate a large high amount of water, as he is not rinsing nor doing anything, the water is very clean, as he usually is not in the slighest dirty, as the showering is a beutification process rather, to get ready for the morning.

The principle is highly effective during this time frame, a large amount of water can be saved, by recirculation. However, through the prior tests, it was discovered, that the venturi injectors, were able to output more water, than the current flowrate, allowing for a much higher flowrate. Could that be used to create a more comfortable shower experience? **Could the additional water, that is recirculated be used to create a better comfort experience .**

Check the temperature, goes in and relaxes for 5min.

1. John applies shampoo to his hair, while he tilts his head outside.
2. After one minute, he rinses.
3. Step 1 and 2 are repeated two times, to apply shampoo once more and conditioner.
4. Body shampoo is applied, while being half inside, and rinsed off.

John tilts his head away from the water stream when lathering, doing this, he avoids that the shampoo is rinsed before it has taken effect, however he makes sure not to step out of the shower, due to not wanting to get out of the warmth.

When lathering his body with soap, John steps halfways out of the shower, to ensure that the soap is not rinsed away instantly, ensuring he is able to warm his body while lathering.

Compared to Nicole that opts to turn off the shower two times, John due to priotizing his comfort highly, has chosen to a coping strategy that maximizes his comfort, and lets the water running, using significantly more water than nicole in his cleaning and groming activities.

+ While John applies and waits for the shampoo to to settle, a high degree of water could be recirculated.
Could the additional water, that is recircled be used to create a better comfort experience.

- John's coping strategies put a lot of emphasis on staying inside the warmth, he thereby avoids any big inconsistensies in warmth. The principles and solution principles must avoid any drastic unforseen drops in varmth.

John stands in the shower relaxing for 10 to 15 minutes.

When the beutification process is over, he spends another 10 to 15 passively standing in the shower, just relaxing.
Usually towards the 15 min, since leaving the shower, means leaving the comfortable environment.

+ The recirculation is highly effective, as in the begining where 5 min is spent, except he is even cleaner in this period of time, meaning that the water touching his body, is very clean.
Could the additional water, that is recirculated be used to create a better comfort experience .

*When John is relaxing, he tends to lend himself towards turning up the heat along the way, due to the feeling of acclimatizing himself, while showering, meaning that the temperature of the water is important to him. Furthermore the feeling of the warm water is minimized when the body adjusts to the temperature, loosing the feeling of the warmth enveloping and heating the body, again appealing to increasing the temperature of the water.

Other cases:

Shave legs (Shaving creme)
Menstruation blood
Pee in the shower
Shower sex (fluids)

A worksheet describing more extreme cases can be found in [WS23].

Either of these, would be percieved as unhygenical to be recirclated, and since reusing water is something entirely new for Nicole, she would like to be assured that when either of those are in the water, that the recirculation is off.

Output

Insights

1) Nicoles success criteria for a shower is to get clean, does the principle of recirculation interfere with that? Among her coping strategies to get clean, **the principle of recirculation interferes with her rinsing of hair and body, as she expects to wash out soap after each rinse, which the principle cannot fulfil as it is.**

Futhermore **reusing water is something new for Nicole, she would like to be assured when the recirculation and filtration is working or not. in terms of extreme cases, she would like to be even more assured that the recirculation is off.**

2) Rinsing is an important activity in regards to her success criteria of getting clean, but the principle of recirculation in no way supports that activity, therefore unable to support her motivation to shower more effectively.
Furthermore, all of Nicole's coping strategies to clean and groom herself, the majority of all interaction is between another product (Shampoo, face scrub, body soap etc) and herself. The shower merely provides a means to wetten and rinse, a passive function. **The principle of recirculation seems unable to support Nicole in her objective to get clean more efficient and effective.**

Incitement

Economical or Green:
Nicole showers for around 20min, which amounts to ~180L/m with her shower setup. Which amounts to a total of, using the water prices in Aalborg:

amount used (Liter)	180
freq in year	312
amount of ppl using shower	1
Total water usage in L	56160
total cost of spent water - one year	3216.17088

Made using the spreadsheet found in [WS24]

Her water usage is very high, yet when asked, she was not aware of her water usage. If she was made aware maybe an incentive to save, be it for an environmental or economical reason could be created, although it cannot interfere with her goal of getting clean.
Could she be Informed about her water usage to possibly create a economical or environmental incentive?

Output

Insights

1) As John enjoys the comforting shower experience when being passive in the shower, the principle has great potential to work in this timeframe, due to no soap being expelled into the drain, resulting in the principle being able to reuse a high percentage of water. **The principe could have a high impact by reusing water in a way that supports or enhances his comforting experience.**

2) John tilts his head away from the water stream when lathering, doing this, he avoids that the shampoo is rinsed before it has taken effect, however he makes sure not to step out of the shower. The shower should be able to support a situation where lathering up while being within the shower is possible.

3) When John showers, he has basic expectations, a warm entrance, with a non varying temperature, flow rate and coverage across the shower. The shower has a stable temperature, flow rate and coverage, which as discovered in the prior ideation phase, is a challenge. Furthermore a stable temperature, flow and coverage is likely to be expected by anyone, it just expecially disrupts John's comfort experience.

4) John expects the shower to be warm to his liking before entering, he turns on the shower to acclimatize the room, and heat the flooring due to it being without heating, he waits a minute before entering. Going from the ambient temperature to a warmer temperature is a transition to a relaxing environment, and the feeling of the warm water hitting your skin, inducing a feeling of a warm pleasure quickly heating your body. When it's time to leave the shower, he hesitates and usually ends up staying for longer. **The shower should support or enhance the experience of stepping into and out of the warmer climate.**

5) In an informal inteview conducted after the persona creation and the following ideation section. Inquiring about insight 4, we further gained the understanding that John, while relaxing, turns up the heat along the way, due to the feeling of acclimatizing himself, trying to recreate the feeling of entering the shower. Furthermore the feeling of the warm water is minimized when the body adjusts to the temperature, loosing the feeling of the warmth enveloping and heating the body, again appealing to increasing the temperature of the water.
The shower should support or enhance the experience of acclimatizing, when already in the shower, furthering the experience of increasing the temperature in small increments.

Interestingly, turning up the heat is an action that both team members do too, but never thought about, and neither did John in the first interview. After inquiring study mates, friends and family, it seems like a common yet seemingly hidden behavior.

Incitement

Economical or Green:
John showers for around 25-30min, which amounts to ~300 to 360 Liters in total with his shower setup. [WS24]

amount used (Liter)	360
freq in year	312
amount of ppl using shower	1
Total water usage in L	112320
total cost of spent water - one year	6432.34176

Comfort:
If the shower can increase his comfort experience, that might be an incitement.

IDEATION - RINSING

OBJECTIVE: The objective was to explore the solution space in regards to what we perceived as the most critical consequence: **the principle of recirculation interferes with her rinsing of hair and body, as she expects to wash out soap after each rinse, which the principle cannot fulfil as it is.**
The ideation was used as a quick way to empty and document what we thought of while doing the feasbility study, emptying our heads, before the next study.

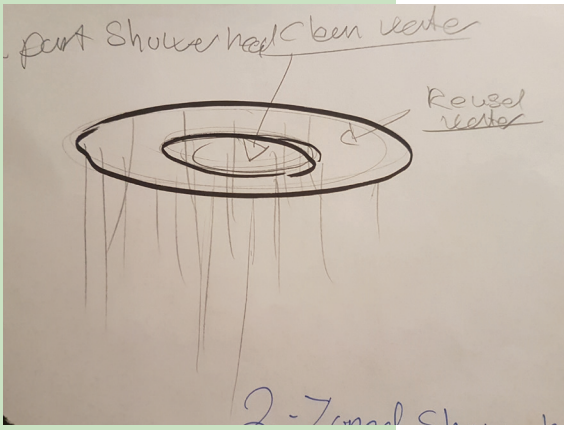


Figure 61: 2 zone shower

(1) TWO-ZONED SHOWERHEAD

A showerhead with two outputs, the middle one hitting the head with clean water, and the outer ring hitting the body with used water
+ Passive, no user interaction
+ Clean water to face
- Locked body position.
- Hair and body are hit with used water, and face if moved.
- Seperated used and clean water, technical issue.
- Heat difference, the used and clean water will have temperaturs, as they are not mixed. A heater is non optional, the power consumption is very high.

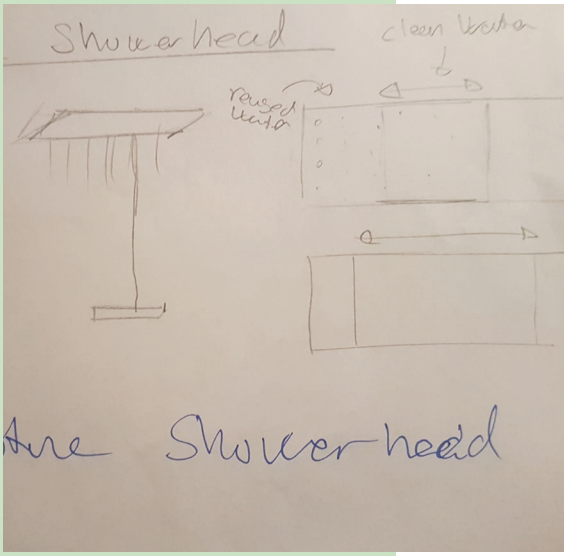


Figure 62: Adaptive shower

(2) ADAPTIVE SHOWERHEAD

An adaptive showerhead which automatically adjusts the coverage depending on the amount of reused water, more reused water, means a bigger surface area which the water outputs from.

Would give Nicole a physical identification when she reuses water, and would give the feeling of “extreme comfort” when clean water runs into the system, due to most of the water getting reused.

+Passive, no user interaction
+Clean water to face
-Heat difference
-Seperated used and clean water, technical issue.
-Very complex system

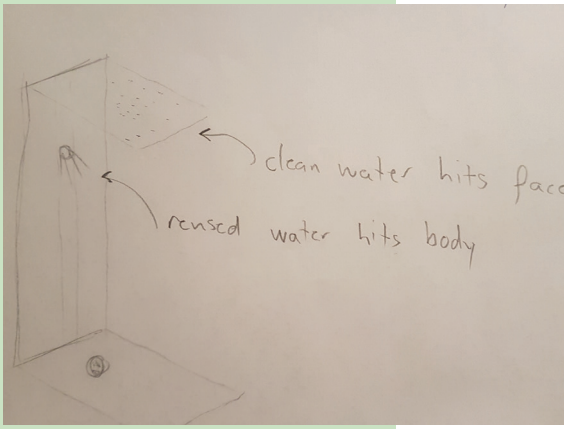


Figure 63: Body nozzle

(3) BODY NOZZLE

A body nozzle which would use mainly reused water, to avoid getting reused water in the mouth and ensure that only new water is used when grooming hair etc.
Would ensure that Nicole would only get used water on her body, and not in her face and to a lesser extend her hair.
+ Passive
+ Clean water to hair and face
- Seperated used and clean water, technical issue.
- Heat difference.
- Directional, only hits one side the body.

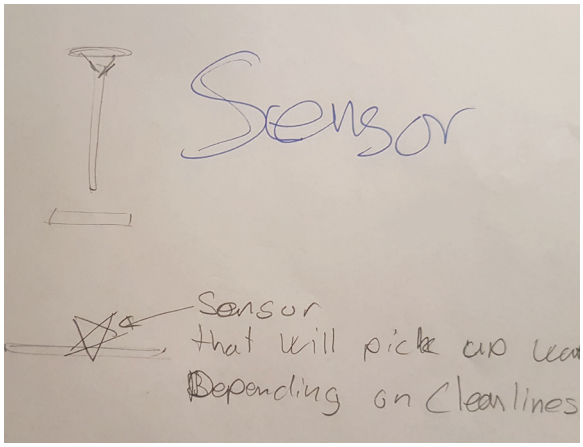


Figure 64: Sensor

(4) SENSOR

A sensor which automatically adjusts how much water is reused based on how much soap is drained.
Would let Nicole shower in clean water, due to the system only collecting the cleanest water, and closing off for soap.
+ Passive.
+ Can reuse the sensor which is already there to detect for filtering.
- Relies on sensor, can be expensive.
- Sensors can not messure percieved cleanliness, that varies on the user. Meaning that the system can "fail"
- Technical challenge

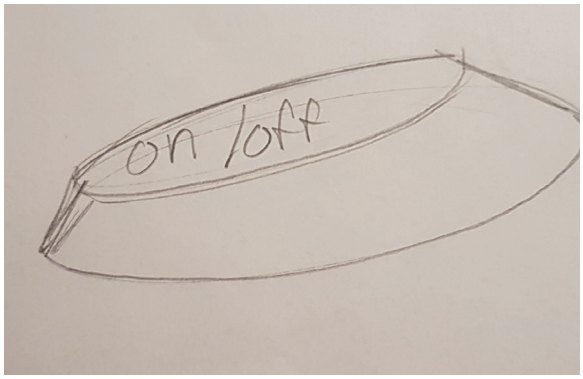


Figure 65: On/Off Button

(5) ON/OFF BUTTON

A button which lets the user turn on and off the reuse of water. A foot controled variant was proposed too.
Would let Nicole control when the system would use used water, and when she wants clean water. Solving the issue of percieved cleanliness, that varies on user to user basis.
+ Hand controlled - easy to adjust.
- Relies on position in shower.

Output

The solution principle 1, 2 and 3 shares the trait of redirecting the reused water, so that the water would not touch the head and face of Nicole. A dilemma was raised, as these would be difficult to implement through the current technical solution, as the venturi injectors inherently mix the fluids. **Separating the two fluids would require a system revamp, which is unlikely, and a huge disadvangage to the approach applied in this project.**
The two zoned shower would support a passive and locked behavior, which is contary to her current high maintenance coping strategies.

Solution principle 4, 5 and 6 are on/off, focused on delivering a way for the user to turn on and of the recirculation, so that the user would be in control of when the output was recirculated water or new water only was used. However the principles pose a technical challenge. When the recirculated water is turned off, what happens to the current flow? Does the flowrate plummet and the tempeature suddenly increase, in other words it will create an inconsistency, that usually are not present in their current showers, that will happen 3-4 times during Nicoles shower. For the above solution principles to work, the system would have to recompensate for the lost flow and temperature, which might be possible with the current system with the proposed venturi regulator.

Solution principle 4, was very interesting as it would allow a relatively "normal" shower in regards to the current user activity, not adding any additonal actions, with the added bonus of being able to use the current sensors. Whereas, solution principle 5 and 6 would require a lot of additional user interaction, and likely require the user to reposition himself a lot in order to reach the button, however the buttons support a very high user control, which might be very useful to tackle extreme case, or to handle the users individual perceived cleanliness.

IDEATION - COMFORT

OBJECTIVE: The objective was to explore the solution space in regards to creating a better comfort experience, based on the insights gained by comparing the Elv principle and John's current shower experience.

Insight 5, the feeling of "re-entering" the shower, was not discovered yet, but rather in an informal interview the following days, in the coming section "Shower comfort".

Furthermore, three ideation sessions where completed, yet only two are shown, due to the third "Support John staying inside the shower" was largely unsuccesful.

Can the additional water be used to improve comfort

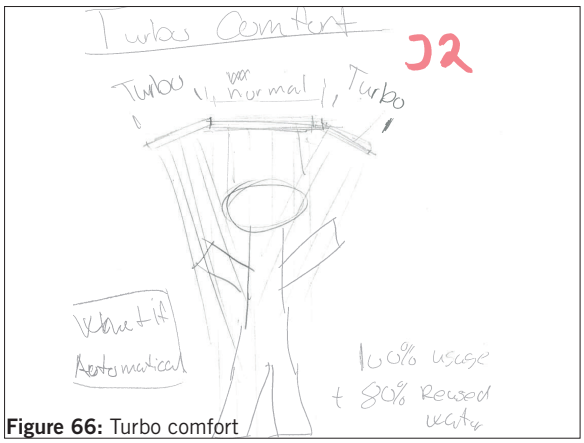


Figure 66: Turbo comfort

(1) TURBO COMFORT

A turbo feature which would enable the extra water to be outputted through extra shower heads.
Would let John get extra coverage through multiple extra output nozzles.
+ Can use the extra collected water.
+ Possible to do automatically.
- Relies on recirculation of water.
- Might affect the sustainability of the product.

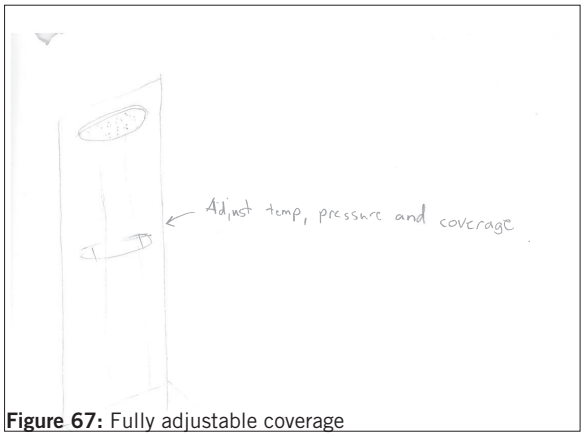


Figure 67: Fully adjustable coverage

(2) ADJUSTING THE COVERAGE

An extra dial for adjusting the coverage of the water.
Would let John adjust the coverage for his personal liking.
+ Can use the extra collected water.
+ High adjustment level.
- Mechanically complex.
- Might affect the sustainability of the product.

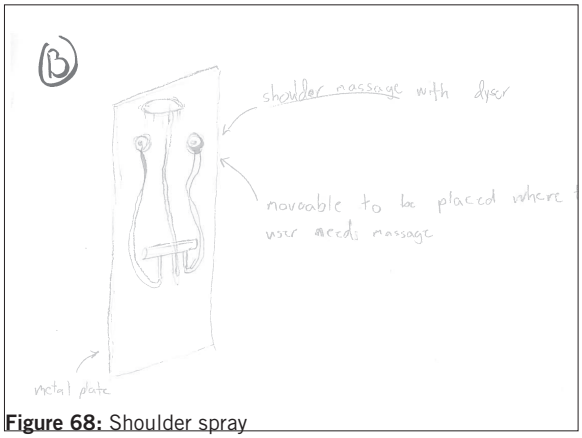


Figure 68: Shoulder spray

(3) MOVEABLE SHOULDER HEADS

Moveable shoulder heads, which can be adjusted in height and width.
Would let John get extra comfort throughout the shower.
+ Can use the extra collected water.
+ Can fit different body types.
+ Can be used as shower heads as well.
- Requires much user interaction
- Might affect the sustainability of the product.

Can the additional water be used to create a better acclitimaztion

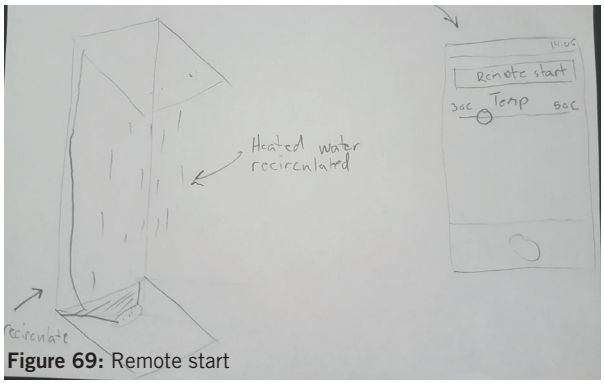


Figure 69: Remote start

(4) REMOTE START

A remote start to start the water before entering, the water would be reused to a high level, meaning that the room would get hot before entering.
Would let John enjoy a warm room when entering.
+ Can be used as a heater
+ Can be started before entering the shower
- Uses more energy, as the water needs to be heated.

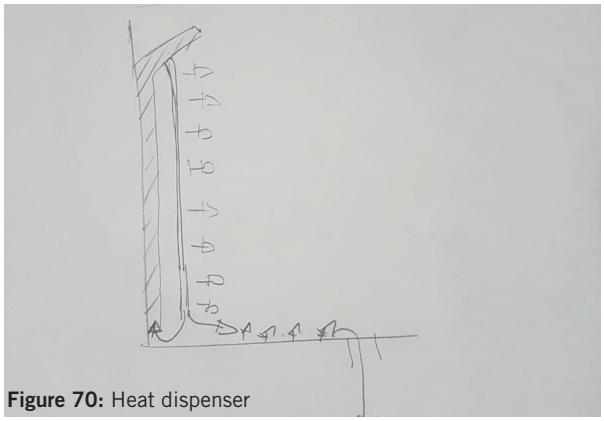


Figure 70: Heat dispenser

(5)HEAT DISPENSER

A heat dispenser, which uses the water to heat the room
Would let John stand in a preheated shower with a heated floor.
+ Floor and room heater.
+ Better acclimatization.
+ Preheats the water.
- No value while showering.
- Uses more energy to heat the water.

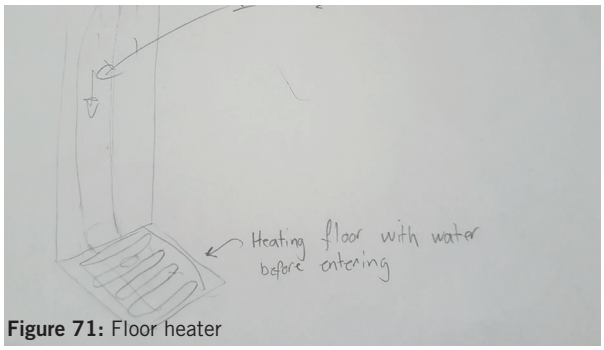


Figure 71: Floor heater

FLOOR HEATING

A floor heater, allowing the floor to get heated before entering.
Would let John stand on a heated floor when entering.
+ Heated floor.
+Better acclimatization.
+ Avoids having to wait for the water to get hot.
- Has to be started before entering the shower.
- No value while showering.

Output

OUTPUT: The first round of solutions (1, 2 and 3) focussed on increasing the comfort, by adding the recirculated water on top of the new water, thus enabling for more water output. While the concepts were promising due to the convenience of using the extra water which is picked up, **the fundamental value of comfort was not clearly identified, the lack of "handles" made the solutions feel inadequate in their argumentation.**

Based on the fact that the solution would be able to recirculate water, thus being able to use water without having to worry about excessive water waste, a series of solutions (4, 5 and 6) were created to effectivily support or enhance the acclimatization in the shower. The concepts were all built around the principle of heating certain areas of the shower, it being the floor, through the floor heating idea or a more complete heating solution, seen with the heat dispenser, which would help heat up the bathroom. The remote start concept came from the insight that John usually turns on the water, and does another activity, while waiting for the water to get hot enough for him to enter. By being able to remote start the shower, John would essentially be able to start the shower, while still in bed, in the morning, and when entering would be met by an already acclimatized bathroom and shower.

No concept stood out as being fundamentally striking in regards to either supporting or enhancing John's passive relaxation state in the shower, and it was obvious that the very core values of comfort was still to be found.

SHOWER COMFORT

OBJECTIVE: A attempt to define what shower comfort is, the experience and the coping strategies, in order to set a boundary in which solutions can be created and evaluated.

Through the use of the personas, and a series of informal interviews with John, an in-depth exploration of the value of "comfort" was conducted. The coping strategies from John were the main benefactors when evaluating what a comforting shower would imply, as John is an avid advocate of using the shower as a comforting and relaxing activity.
By delving into the exploration of comfort, a clearer insight into how a feature could be developed were established and by using John as an initial standpoint, a very throughout analysis could be created due to the coping strategies involved with comfort that John posseses.

Coping strategy

Shower comfort can only be described as an complex experience, that stimulates a multitude of the human senses, the majority are passive, that are gained by just being inside the shower. Two where discovered where the user actively takes initiative to enchance his experience, both which are related with the feeling of acclimitzation, the bodily sensation of increased temperature.

PASSIVE:
The values related to showering which requires no active participation from John.
Under the warm shower.
Being in the shower, passive, feeling the ambient warmth and the water conducting heat to your body, relaxing the tense feeling in your muscles.

Along the shower in an increasingly damp environment.
The feeling of the heated moisture in the air increasing, getting embodied by more and more warmth from the mist/humidity. The inhalation of warm air and the feeling of warm steam embracing your body creating an ambient warmth and humid environment

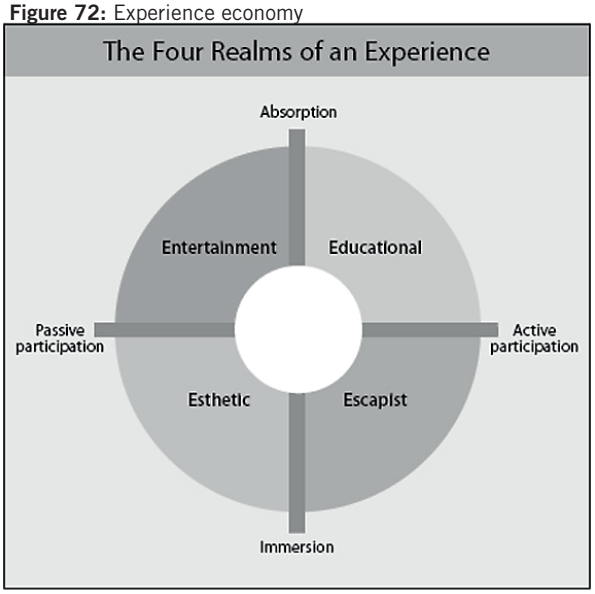
Along the shower in the ambient sound environment.
Being in the shower, passive not doing anything, the ambient sound of water hitting your body and floor is a familiar safe sound inciting a state of mindfulness.

Along the shower in a therapeutical state of bodily relaxation.
Being in the shower, passive, not doing anything with the feeling of the warm water hitting your body as a light massaging experience, the feeling of bodily pleasure and relaxing tense muscles.

ACTIVE PARTICIPATION:
The coping strategies involving active participation from John.
Adjust temperature for initial entering.
Going from ambient temperature to warmer. Acclimatization from cold to warm, the feeling of one's skin being embodied in warmth feels bodily pleasuring. The initial feeling of each drop of warm water hitting the skin.

Higher temperature along the shower.
Getting the feeling of re-entering the shower, due to the temperature rise and the feeling of acclimatization once again. The feeling of one's skin being warmed once again, bodily pleasuring.

Figure 72: Experience economy



Experience Economy Model

BY B. JOSEPH PINE II AND JAMES H. GILMORE (6)

Six comfort coping strategies were identified, four of which were defined as passive and two active. The four passive strategies were indentified as esthetic experiences, an immersive experience that is initiated by cues that the user is exposed to, just by being inside the shower. While the four other strategies are written as individual experiences, in actuality, we believe the combination is what creates the experience, the warm and cozy shower experience. Atleast all have to be present, to what extend or balance is highly variable, due to outside factors. For instance, open windows might create a higher temperature difference and lessen the dampness.

The two active experiences we define as escapist experiences, the user chooses to act, in order to experience the warm and cozy, by transistioning into the shower environment, defined as the four passive esthetic experiences above.

Output

THE CORE EXPERIENCE

Of all six experiences, we believe the sensation of "warmth" is at the very core, it is what directly or indirectly creates the effect of comfort, a large part of what is perceived as comfort. Indirectly by increasing air moisture and making it more warm, or directly conducting heat to the body, increasing the skin and core body temperature, and relaxing the muscles by the means of a light physical massage combined with warmth.

A key element of how warmth is perceived, we argue is the transfer of heat, the conduction of heat of the water to the skin of the user. And we argue it is acheived with multiple methods. Two strategies are seen in the two active experiences. By entering the shower, thereby drastically inducing heat to the body, or recreating the experience of "entering" by increasing the temperature directly in the shower to experience a burst of warmth.

The experience of "re-entering" was very interesting, as it was a direct and tangible method to achieve arguably better comfort. The team saw a great potential in creating a feature which would be able to simulate this feeling. However, as this involves increasing the temperature, thus adding more hot water to the water stream, a potential negative outcome would be the sustainability of the feature, as hot water is more expensive than cold water, and with a feature like this, we would invite the user to increase the temperature, and by that increase the price of the water, which is very counter intuitive to creating a sustainable product.

Direct temperature change is however not the only factor to how warmth is perceived, or rather how heat can be conducted to the body. Adding more water through for instance a larger surface area, meaning a larger coverage of the body, will also increase the heat conducted, while not more intense, but rather more even. The extra coverage of water can be seen as a natural extension to the current shower experience, a way of enhancing the overall experience.

The direction "Adding more, adds more comfort" as defined in the prior ideation was not wrong, the cause was just undefined. The ability to add more water is almost an inherent feature of the Elv recirculating shower, and as such is something the team wants to pursue.

FRAMING

Through the user experience mapping, the team had a much clearer understanding of what consequences the technology had on the user and where it had the most impact.

With that, the team decided to go into the direction of comfort, with a starting point in the two core insights of the the experience of warmth and the consequence of recirculation.

With that, the team was able to set a product vision, and could justify a deep dive into the experience of warmth to expand on the definition and attempt to quantify the experience with metrics.

THE VISION

THE CORE VALUE OF ELV

While Elv has first and foremost been evolved through the vision of creating a sustainable shower set, the insights into Nicole and mainly John, and due to the market being countries alike Denmark, another aspect of the shower experience were found. The comforting features of Elv would elevate it above the competition which focuses mainly on creating a water saving product, and would be able to cater towards a market in which water scarcity is not a issue, and where the comforting aspect of showering is very much a thing. The two values which Elv was to contain, culminated into a combined goal for the product, which was:

BIG COMFORT, SMALL FOOTPRINT

ACHIEVING THE VISION

To achieve the vision of creating Big comfort with a Small footprint, the sustainability should be maintained by recirculating water, and the big comfort should be created through the features.

The next step is to see how these features are going to unfold, and how the key insight into warmth in regards to temperature and added water are further explored to develop a unique comfort feature.

UNIQUE SELLING POINT

Furthermore, it must deal with the consequence of being a recirculating shower. The key insight is the systems inablity to filter fluids and soluables in scenarios that are key to acheiving cleanliness, such as when the user rinses his hair, body or in extreme cases.

A TRUSTWORTHY RECIRCULATION

Output

The vision, by stating the core values of Elv must be a leading star for further development, aswell as a tool to align our work to focus. Further work should also be done in how these specific features will affect the users current coping strategy, how it will fit into their showering experience, and what will be needed to make the transition from their current shower set to Elv as mellow as possible

THE EXPERIENCE OF WARMTH: TEMPERATURE

OBJECTIVE: A deep dive to get a better understanding of what temperature is, and how this can be manipulated to create the experience of warmth.

Controlling the temperature

John's coping strategy of increasing the temperature to create a better comfort experience must be further investigated, can the experience be quantified, what metrics cause the "good" experience? Furthermore, what are the other coping strategies where temperature is used, as a means to create a better experience?

OBSERVING THE USERS IN THE SHOWER

As to get an understanding of how temperature was getting controlled throughout the shower, with the main focus on the temperature increase, a user were observed in the shower. A camera was set up in the shower, and a wireless thermometer were given to the user. The user were instructed to meassure the temperature for each time he changed the temperature, this data was then sent to the receiver which was also recorded, the data was then combined. This allowed the team to gather valuable data on several things, the shower duration, the temperature changes, at what time these changes were occuring, and what the temperature difference was. Furthermore, own conclusive tests were done on the team members as well, these were also documented, and were compared to the outside user.

Duration: 10:50 minutes.
Initial temperature: 35C.
End temperature: 46C.
3 min inbetween temperature minutes with 2-3C.

The user increased the temperature three times throughout the shower, and noted that this was done due to it feeling like he was reentering the shower. He increased a second time due to being what he described, as getting used to the varmth, feeling acclimitized, wanting to experience the feeling again, exactly as with John.

Both team members tested themselves, in the home environment, where both, had the same overall behavior of 2-3 temperature increases of 2~3c.

Another observation was conducted, however he did not fit within our focus of comfort, described in [WS25]

Figure 73: Observing the user and water temperature

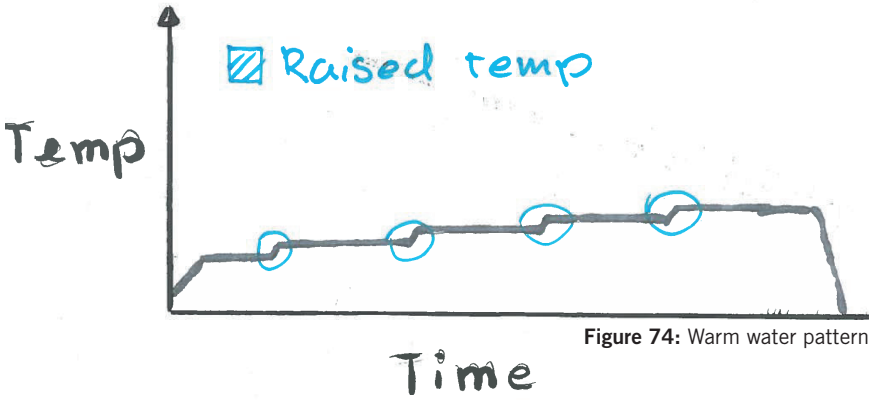


Figure 74: Warm water pattern

While, three user test are non conclusive, it still demonstrates the overall pattern of consecutive temperature increases, as illustrated. The raised temperature is inbetween 2-3c, while the interval inbetween the increases happen when the user gets acclimitized to the increase in temperature.

The sustainable temperature increase

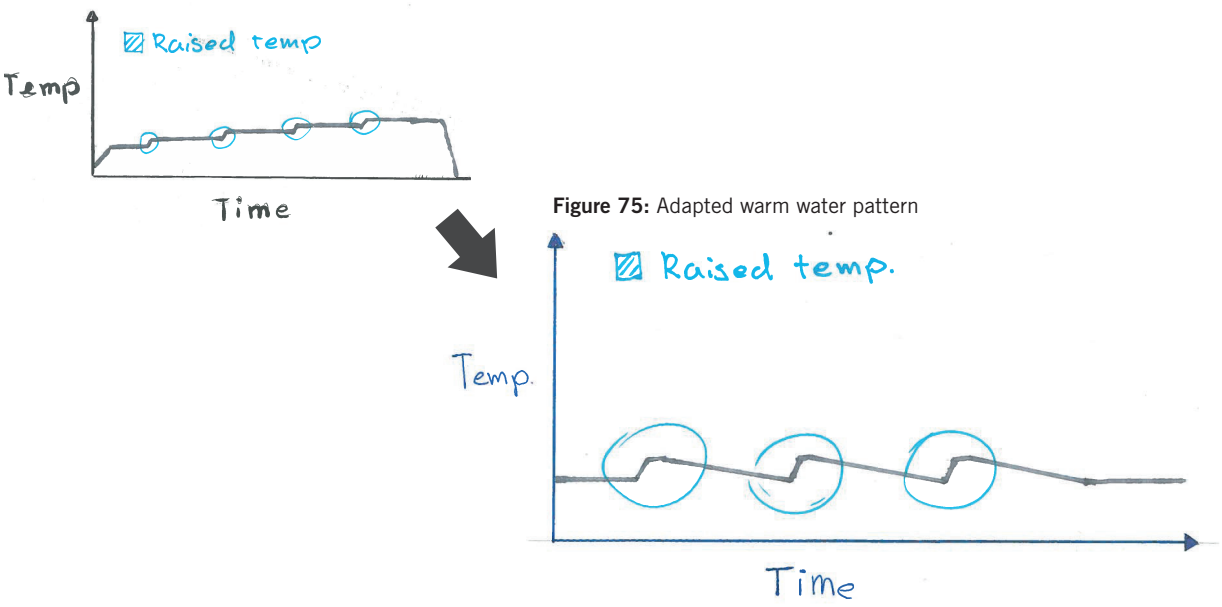


Figure 75: Adapted warm water pattern

The behavior of increasing temperature is problematic in the sense that it is very unsustainable. However while conducting the tests, the idea of matching the users acclimatization was brought up. In other words, when the temperature is increased by 2-3c, the time it takes for the user to get "used" to the temperature is matched by a slow decrease in temperature. Thereby creating the perception of a constant temperature increase, without actually happening. However testing this would not be possible manually, as the user would have to slowly decrease the temperature 2-3c over minutes, making it far to uncontrollable. Furthermore it would not fit within the behavior of comfort, the decrease must be automatic.

TESTING SETUP

To simulate the temperature increase, and the sustainable concept, a precise testing rig was needed, thus an apparatus was build from the ground up to precisely be able to control the temperature with programs that could be initiated with a button, enabling us to conduct experiments with high control. Setup in-depth described in [WS26].

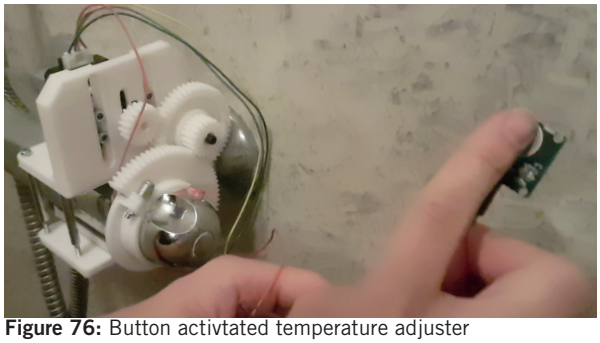


Figure 76: Button activtated temperature adjuster

Test: Sustainable temperature increase

The program emulated an increase in temperature by three degrees within one second, and a decrease in temperature by respectively three degrees over 30 and 60 seconds, the 60 second program was chosen after in-house tests, as it by our perception perfectly matched the acclimitazation rate, however we were aware of the slowly decreasing temperature.
The program was tested on an outside user, that was instructed to treat the button as his coping strategy to increase the temperature, however without the knowlegde of it being slowly decreased over 60secs.
In the end, he noticed the temperature decrease by the third time, but was impressed as he did not notice it the first or second time, and said it was close to neclectable.

Output

The deep dive into the experience of "Re-entering" can be considered succesful, as the experience could be quantified with the metric of a 3c temperature increase. Furthermore, the understanding was expanded by the creation of the "sustainable temperature increase" wherein the experience of being acclimitized could be quantified to a decrease of 3c over 60seconds. While the sample size is small, the team has decided that the insight is well enough documented, to be materialized into a feature.

Through an informal interview a user proclaimed to turn down the temperature with increments in the last 3-5 minutes of his shower, this allowed him to acclimatize towards a goal of reaching the same temperature as the outside environment, meaning that the unwanted feeling of getting out of the shower was dealt with. This was very interesting, as it is one of the main reasonings behind John staying in the shower for a longer time, the feeling of stepping into the cold. However, turning the manual knob manually is non optional, as it directly interferes with his passive state of comfort.

Using the metric of acclimatization from the prior experiment, a program was concieved that at a continuous rate, decreased the temperature, with only one user action. The program was only tested in-house, however, the effect was apparent, it was clearly noticable, that the transition felt more natural, certainly a feature that could support John's shower experience, thus it was included at a swift notice, well knowing that it is less defined.

The common denominator is that both must be automatically controlled to fit within the behavior of comfort. From a technical standpoint, it is one of the strengths of the product architecture, as the techical solution already has an inbuilt automatic temperature controller, and an extended functionality should make it usable.

Program ideation

How could automatic tempeature programs be materalized, an ideation was conducted. How can the automatic feature support the experience of comfort?

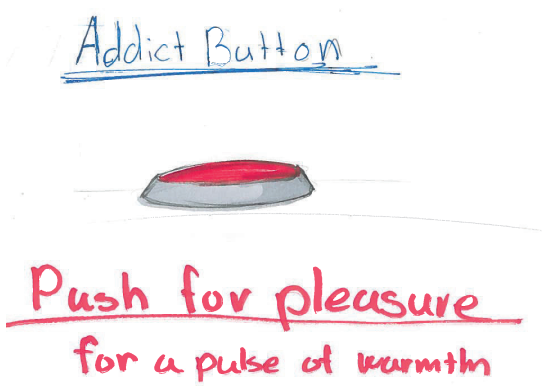


Figure 77: Addict button

THE ADDICT BUTTON
"Addict" button which lets the user get a pulse of increased temperature water on demand.

This might affect the experience of being completely passive in the shower, being relaxed, as the user possible has to turn around before pushing the button, and the pressing it. However as this is a very low tech solution

Furthermore, the button the user interaction is not much different from the current coping strategy of turning the knob.

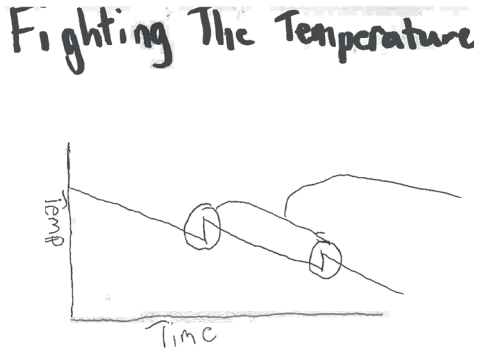


Figure 78: Fight the temperature

"FIGHT THE TEMPERATURE" PROGRAM
Would let the user fight the temperature by automatically decreasing the temperature at a slightly faster rate of acclimitazation, forcing the user to increase the temperature, acheving the experience of re-entering, by fighting his desire for comfort.

This feature might hinder the user in entering a state of passive relaxation, as he is forced to defend it continously.

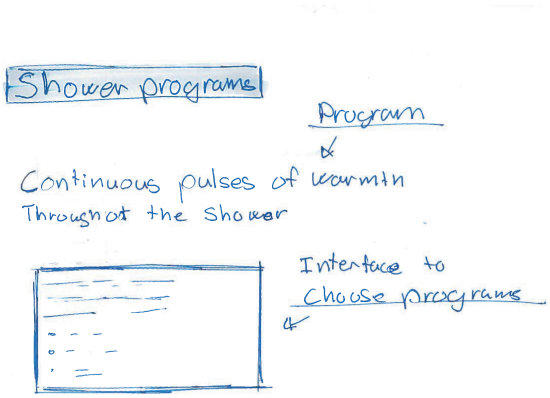


Figure 79: Automatic programs

THE AUTOMATIC PROGRAM

Only needs to be activated once by the press of a button, and would run throughout the shower. It would automatic pulses of warmth, each minute.

Enables the user to be completely passive while activated, supporting his state of comfort, however it also supports the usage of more water, as it can be activated at the very start of the shower, going against the sustainability of the product.

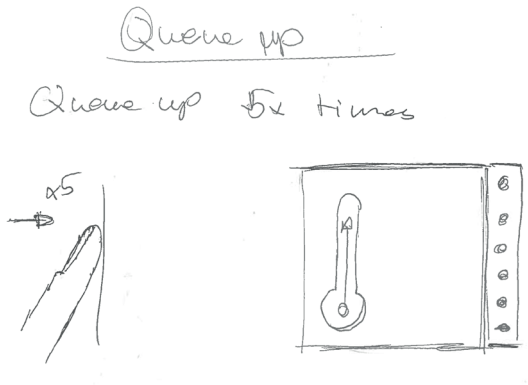


Figure 80: Queue up interaction

QUEUE UP BUTTON

As a middle ground between the addict button and the automatic program, a way of queueing a couple of temperature increases which would be released through a specific time period were considered. The button would allow the user to only be only active once, and get the temperature increase delivered a set amount of times, decreasing the active user interaction needed with the momentary button, but still limit the possibility of having the temperature increase happening throughout the shower, making it more sustainable.

Output

As sustainability is one of the key factors in Elv, we did not want to scrutinize this by enabling the user to completely play against this factor. However, as Elv is also a highly regarded enabler for the passive comforting state, having the user press a button for each time the temperature feature should be used, seemed to go against this passive behavior. The end result was the queue button due to being the middleground between sustainability and interaction.

The acclimitazation feature was not dealt with to the same degree, as we believe the automatization in itself, was enough of a feature for the users.

This concludes the teams research into the temperature features, two features were developed, the “Queue up” button and the acclimitazation feature, however the interaction itself, was not possible to develop at this point, due to not even being aware of the product it is to be interacted with.

THE EXPERIENCE OF WARMTH: MORE WATER

OBJECTIVE: A deep dive to get a better understanding of how more water can create a better experience of warmth. Furthermore, possible combinations between temperature and more water were explored too.

An ideation of how more water could support John's shower journey was conducted in the early phases, however at that time, conclusive metrics on how the different delivery methods affected the shower experience were missing. In fact, we still do, however two overall patterns can be deducted that affect the experience of warmth.

Does the water **create more coverage** through for instance being drizzled over a wider area, thereby hitting more of the body? Or is it water splashes, where a **higher density of water** hits the body?

To get a better understanding of the physical properties comprised with both more coverage and a higher density of water, a series of tests were done through thermal imaging, creating a heatmap and temperature measurements in different instances.

Figure 81: Thermal coverage tests, more yellow or golden equals warmer, the cross hair is not used in this test, ignore it.

Thermal coverage

The thermal coverage of a 7Lpm shower with low spread range was seen how the temperature was distributed on the body. The result was rather telling as the heatmap above illustrates. Both arms and back of the user in the shower was several degrees colder than the torso and head, leading to a big difference in how the warm water was distributed on the body.

This gave insight into why people seem to shuffle around in the shower, as they want their whole body covered with the water at once, but due to the size of the shower head, is unable to do so by standing still.

This shows that a larger coverage very possibly would aid in the experience of warmth, as more heat could be transfered to the body, due to the whole body being covered.

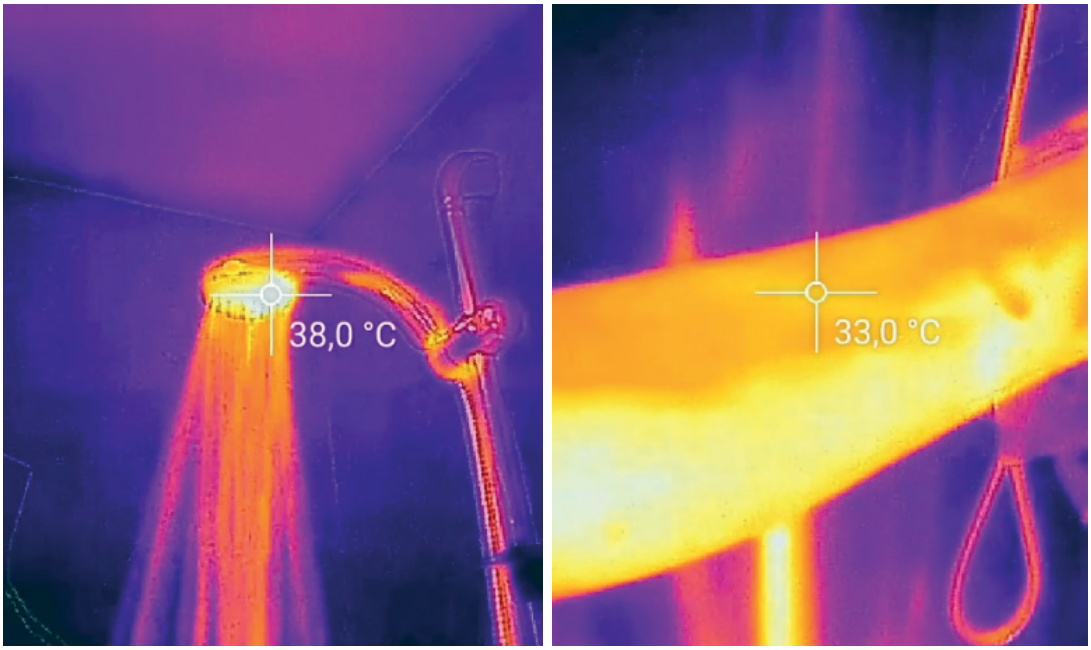
Thermal density

The effect of a higher dense water output was difficult to measure, however a test were done by filling a bucket with water from the shower, and pouring this water on an arm, and comparing it to having the arm under the shower stream using the same time frame, would maybe give a small insight into what denser water would mean to the temperature density on the arm.

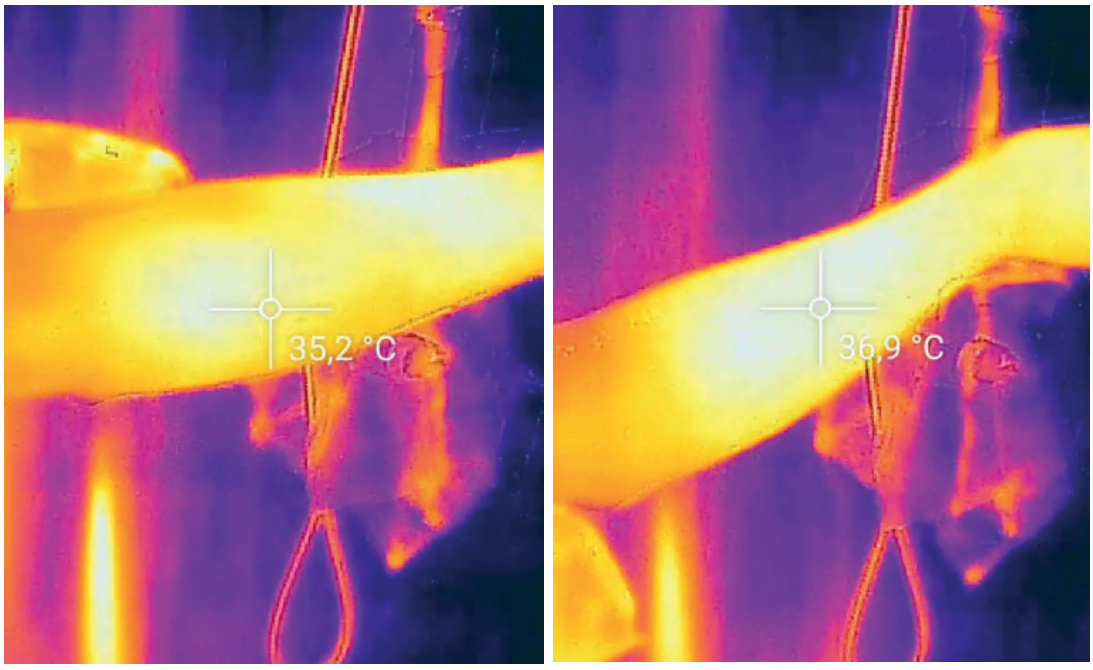
Comparing the normal temperature and water pour results shows that there is a significant difference by almost two degrees, and the heatmap also shows that by keeping the arm in the normal water stream results in a more inconsistent heat dissipation, whereas the pouring of water results in a more even area.

These results point towards the possibility that a higher density, results in a more even temperature distribution and a higher transfer of heat at the given spot of higher density.

Figure 82: Thermal density, use the crosshair



Initial water temperature | Initial skin temperature



Skin temperature with normal shower | Skin temperature after water pour

Output

The tests were limited and held at thermal in showers that were readily available. To build a test setup that was able to give more coverage or density was deemed to resource intensive.

However the tests do conclude that more water is able to increase the transfer of heat by increasing the coverage, or the intensity of heat by coverage. The later essentially acts as a momentary temperature increase in one spot, whereas the first, hits spots that normally are not, increasing the temperature to match the remainder of the body.

A second point is that an increased coverage might be able to support a better state of passive relaxation, as moving around in the shower to average out the body temperature would not be needed.

The delivery method

Based on the previous tests and user observations, a series of possible solution outcomes were created based on both the possibility of delivering a higher coverage of water, and on the possibility of delivering a higher density of water.

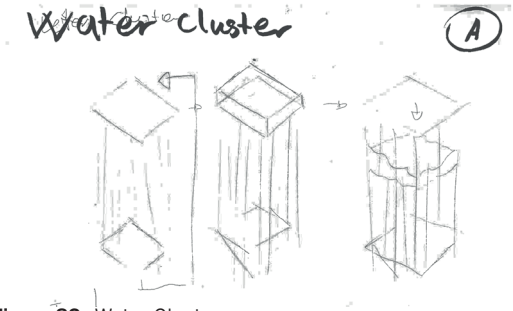


Figure 83: Water Cluster

WATERCLUSTER
A water cluster function, which would store up water, and pulsate higher density water on the user to emulate a higher increase in temperature.

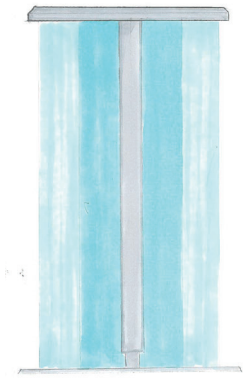


Figure 84: On-demand coverage

ON-DEMAND COVERAGE
On demand coverage, the coverage is increased drastically, switching from the water saving mode to "coverage" or "luxury" mode.

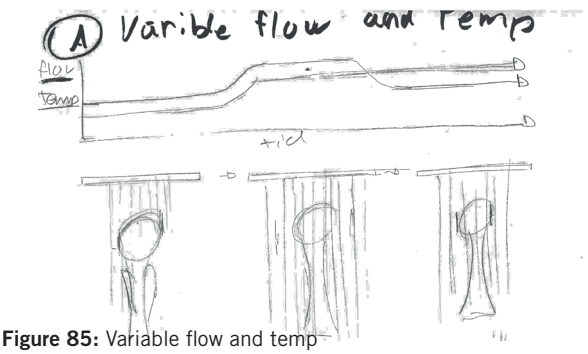


Figure 85: Variable flow and temp

VARIABLE FLOW AND TEMPERATURE
A variable flow and temperature which could give a burst of more water when the temperature was simultainously increased, intensifying the effect of both.

Figure 86: Bigger drops

BIGGER WATER DROPS
Creating higher density water by creating bigger drops, allowing for a possible better heat transfer, thus the feeling of more warmth to the user.

Output

Through the past ideation phase it was difficult to conclude on an exact solution principle that the team wanted to move forward with, as the metrics in how each solution could support the user still remain blurry.

The simplest, in terms of benefit were the “On demand coverage” and the “water cluster” as they can be related to the two thermal tests. Whereas the others, are interesting but difficult to compare without an in-dept study of each principle, which was deemed impossible within the remaining time frame.

Between the coverage and density solution principle, it was chosen to go forward with the coverage solution based on several view points. The user observations pointed towards a common behavioral act which happened throughout the shower, which was the side to side movement, enabling the water stream to hit all areas of the body. The increased coverage could conclusively support the act of less movement, and thereby the state of passive relaxation. Furthermore the average shoulder width was investigated and measured on five users, in which the males had the wider shoulders of 40-45 cm, indicating that this should be the targeted width for the increased coverage.

From a technical view point, the increased coverage is a known high-end market feature, meaning that it is a possible feature. Whereas the “on-demand” part is part of almost all shower heads. This was an important factor, as the increased density feature would be an entirely new feature, requiring very throughout development to even claim that it is a possible feature.

From a market viewpoint, the increased coverage is a known high-end feature, and might be a relatable feature, users see value in, whereas the density feature could be alien, making the users unable to gauge its value. However a lot more unique.

This concludes the experience of the “warmth” deep dive, in total three comfort features were defined, the features that support the users comfort experience.

CONCEPT

With the two deep dives concluded, and the status seminar closing in, the team found it appropiate to formulate the concept of the Elv water recycling shower.

The concept combines the core insights investigated, the technology developed and the ideation processes inbetween to define the main features.

The system must be adapted to facilitate these features.

THE SMART FILTRATION + ON/OFF BUTTON

The major collision between the recirculating shower and users shower behavior was their inability to achieve proper cleanliness if soap was to be recirculated while they rinse their hair and body. The question is, do the users change their current behavior to fit the system, or does the system attempt to accomodate the users current coping strategy as much as possible.

The coping strategy
Rinsing is a coping strategy to remove soap and the dirt within. The activity is considered done when the soap has been sufficently removed. Once done the shower might progress to next step of conditioning, or even the second lathering of shampoo as seen with John and Nicole.

The strategy is at the very core of succesfully acheving cleanliness, making it more difficult or even ignoring it will hinder them in getting clean. Thus, the Elv recirculating shower must support, or atleast not hinder the users in their current coping strategy.

SMART FILTRATION
The systems inability to filter solubles and liquids relies on a sensor module to detect, and stop the recirculaton once unwated liquids, such as soap has entered the water, creating a experience were no additional actions, such as with the traditional shower experience.

However, while the sensors are likely to detect most unwanted matter, it might not be able to for instance detect very clear pee, thus the On/Off button enables to stop the recirculation.

ON DEMAND, RECIRCULATION STOP.
The button is able to handle the users perceived understanding of cleanlines, enabling her/him to turn off the recirculation and having the perception of having complete control whenever any situation of uncertainty is present.

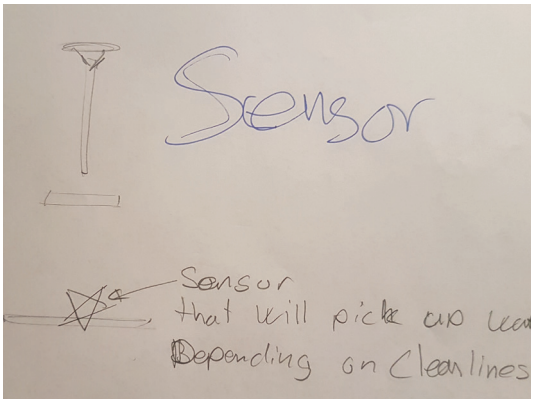


Figure 87: Sensor

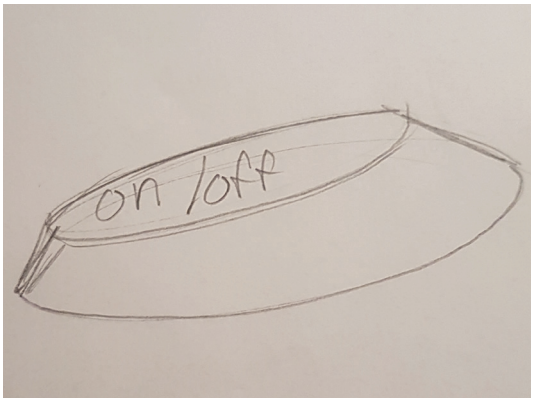


Figure 88: On/Off Button

ECO, COMFORT & CLEAN MODE

The premise of this product is to recirculate water, in order to lower the consumption of water, furthermore it was discovered that the concept is extremly efficent in recirculating water, while the user relaxes. Coupled with the discovery that the venturi injector, when dimensioned a specific way, is able to draw a huge amount of used water, and add it on top of the nominal flowrate, the coverage mode was formulated, to support the experience of warmth.

ELV IS ABLE TO PROVIDE THREE MODES:

Eco-mode: Is the default mode and enables the user to recirculate a percentage of water, lowering the need for new water, satisfying the incitement of saving water and heat, the core of water saving products.
Comfort-mode: Is able to output more water by recirculating a percentage of water, but instead of cutting down on the output of new water, the output remains at maximum, and the recirculated water is then added on top of this, to effectively output more water. However only uses as much water as a normal water saving shower, creating a luxurious coverage at a low usage.
Clean-mode: Is only utilized by the smart filtration and the manual On/Off Button.

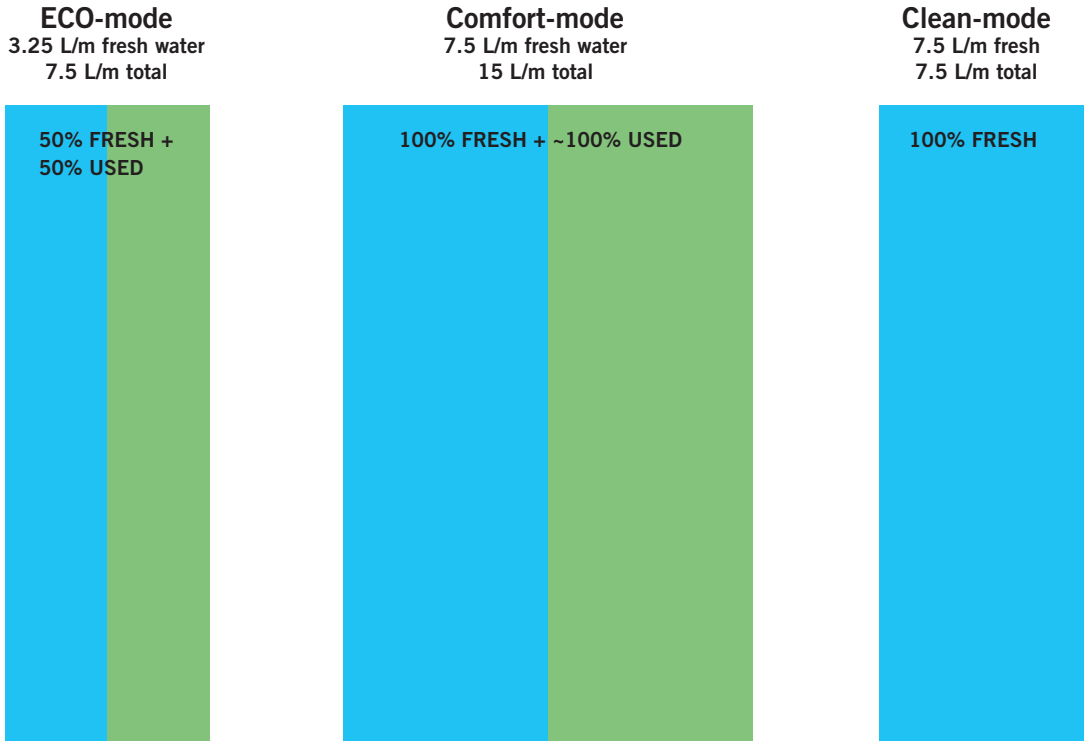


Figure 89: Coverage, left to right: Eco-mode, Comfort-mode, Clean-mode

TEMPERATURE PROGRAMS

As the insight pointed towards warmth as a main value in the comforting shower experience, and manipulating the temperature a method to achieve it. The experience was investigated and culminated into two sustainable temperature programs. Furthermore, the temperature features required automatic control, a function that the system already possesed, and initially thought of as a system weakness.

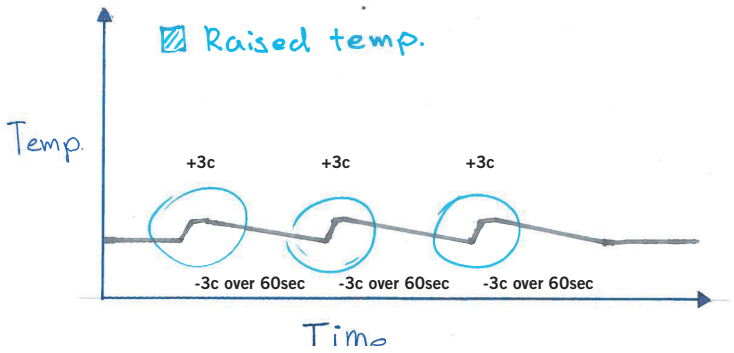


Figure 90: Sustainable temperature increase

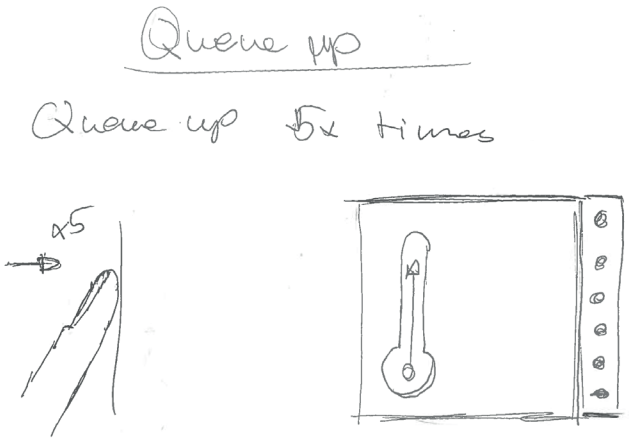


Figure 91: Queue up interaction

The experience of "Re-entering"
Through an interaction, the user will initate an automatic feature, that as the normal experience, provides a sudden spike in temperature, however will very slowly decrease the tempature over time to match the acclimatization of the body, as is the current experience. Thereby returning to the neutral temperature and saving hot water, making a normally very wasteful action, a lot less wasteful.

The queue up interaction
The user is able to queue up subsequent pulses, enabling him to close his eyes, face away or simply daydream while experiencing the pulses of warmth, supporting the users state of passive relaxation.

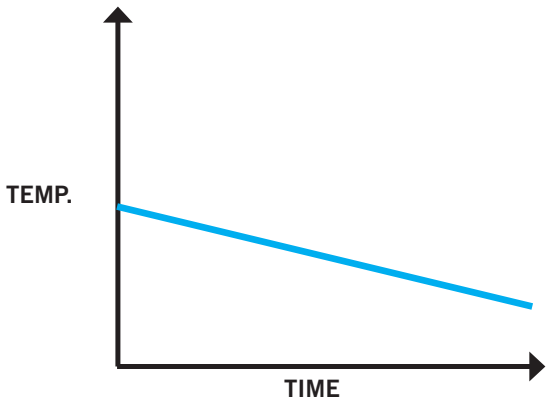


Figure 92: Temperature decrease over time

The experience of "acclimatization"
Through an interaction, the user will initate an automatic feature that very slowly decreases the water temperature, at a rate that matches the bodies acclimatization to warmth.

This enables the body at a comfortable rate, to get acclimatized to the outside environment, creating a transition with no discomfort. See [WS28] for info in regards to this.

TECHNICAL DEVELOPMENT - CONTROL

OBJECTIVE: To adapt and develop the technical structure to be able to fulfill the features, as well as define the functional control method between the different modes.

An updated diagram of the control used to make the delivery methods available were created. For more information in regards to updated system description and system control, see [WS41]

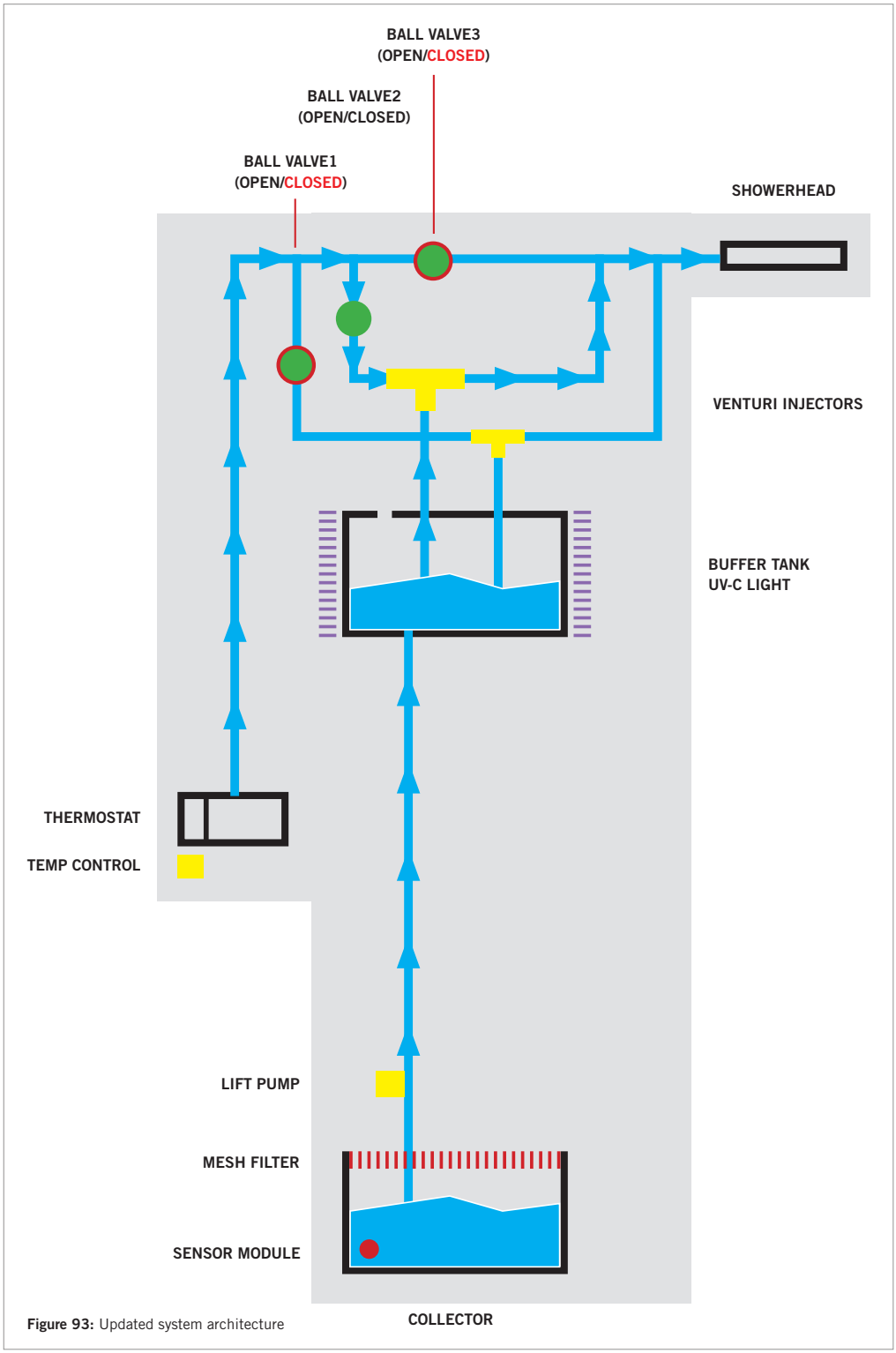


Figure 93: Updated system architecture

INTERACTION DESIGN

Having the product structure and features explored thoroughly, a natural standstill occurred in the process, this was due to the need of finding how the features should be presented for the user, including how the user should understand the functionality of each feature with the appropriate cause and effect, while maintaining a clear and functional interface, ahead of, and while showering.

Furthermore a critical factor was in the ability of being able to present the product as a recirculating shower, meaning that the user should first and foremost be able to decode what the product was capable of, generally as a recirculating shower, and secondly as aforementioned, down to each feature presented through the product.

Focus area

Elv is a water recirculating shower, and has significantly more features than other showers, meaning that it is a different shower experience than an ordinary shower, a set of requirements have been created to deal with this, focusing on how the product is perceived when approaching it, and while showering.

APPROACHING THE PRODUCT:
Meeting the product the first time.
How do we give cues to the user it is a recirculating shower, while maintaining that the product is not alien to the user.

WHILE SHOWERING:
The user is using soap in the shower.
How do we ensure that the user is aware in what state the recirculation is in while showering.

The user has an accident, and the recirculation is unwanted.
How do we ensure that the recirculation can easily and trustworthy be turned on and off by the user.
User understanding of the recirculation, “what is happening when I push this button?”
Getting the user to trust the system fully by being as visual with what is happening in the recirculation.

The user is passive and relaxing in the shower.
How do we prevent too much user interaction, which could affect the experience of being passive?
How do we make the features accessible when they are available?
How is the user aware of what the features encompass? Cause and effect.

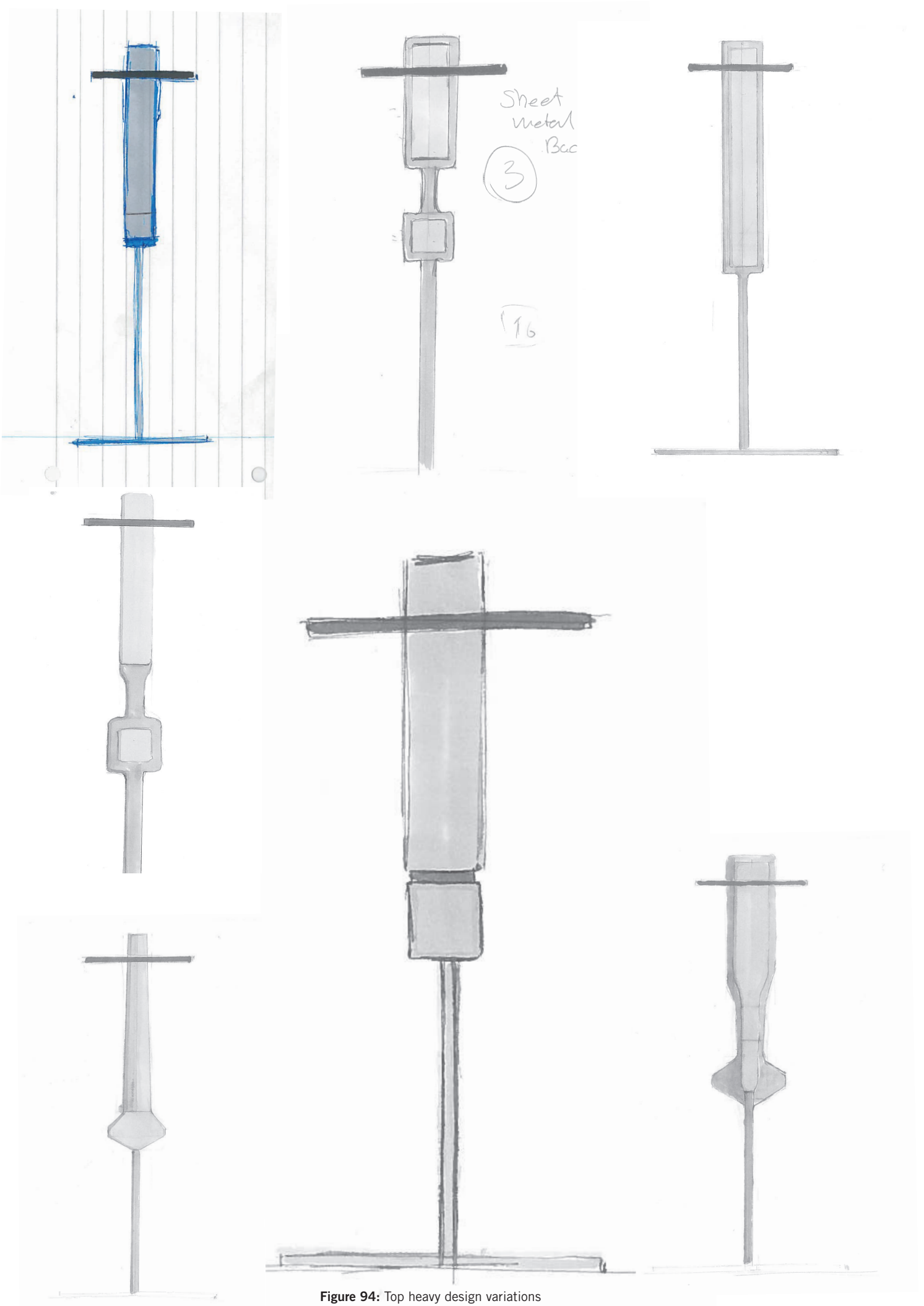


Figure 94: Top heavy design variations

APPROACHING THE PRODUCT

OBJECTIVE: To get a better understanding of what temperature is, and how this can be manipulated to create a better experience throughout the shower.

How does the user understand the recirculation?

As the recirculation is a new feature not found in traditional shower sets, the recirculation might be a wary experience for some users due to them not knowing how the water would get picked up, filtered and outputted once more.

An ideation was conducted, with the intent of investigating visual cues that the shower is a different expeirence, yet not look alien, with the ultimate hope relaying that it is a recirculating shower. To the left, are variations of the chosen design, the principles which it is based on can be seen below, furthermore a physical model was build to get a spartial understanding of the model.

PRINCIPLES

- Use similar hard points as a traditional shower set, thereby creating a sense of familiarity, such as the control placement.

- segment the functional areas on the shower, most importantly the part that would pick up and recirculate the water.

- Top heavy design, creates a natural segmentation, like a straw that is sucking water, giving cues that water is being pumped up.

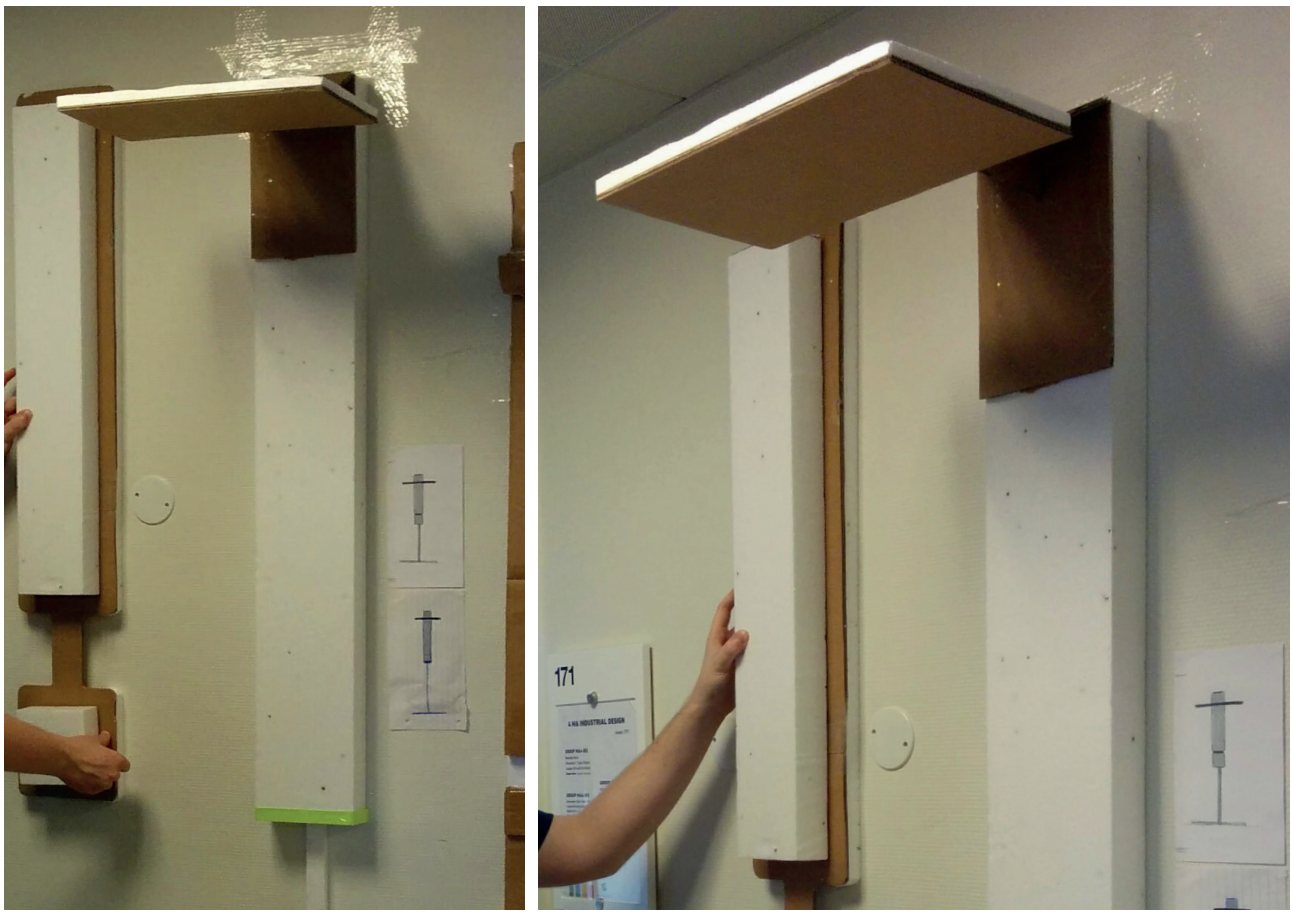


Figure 95: Top heavy design mockup

ON/OFF BUTTON

OBJECTIVE: The overall visual expression was chosen, the on/off button could finally be placed and dealt with.

RECAP:
The user is able to on demand turn off the recirculation, in order to stop and be assured that unwanted matter is not to enter the system and get recirculated. The on off/off button was identified as a necessary coping strategy, partly as a consequence of the minimal filtration method, and as a strategy to deal with extreme situations in [WS23]

WHAT MUST THE INTERACTION SUPPORT?
The coping strategy is a method to avoid a negative event, that would heavily affect their sense of cleanliness. The coping strategy must therefore be able to clearly communicate whenever it is on or off, and the action of going from on to off and vice versa, must be convincing and assuring.

Consider these three interaction stages, how will the coping strategy convey its meaning to the user, in regards to these three parameters:

Action:
What is executed by the user?
Link:
What is the link between the action and the action happening in the product?
Effect:
The reaction, how is this portrayed to the user?

Digital screen with a touchscreen, in which every feature and mode can be controlled digitally.

THE TOUCH SCREEN

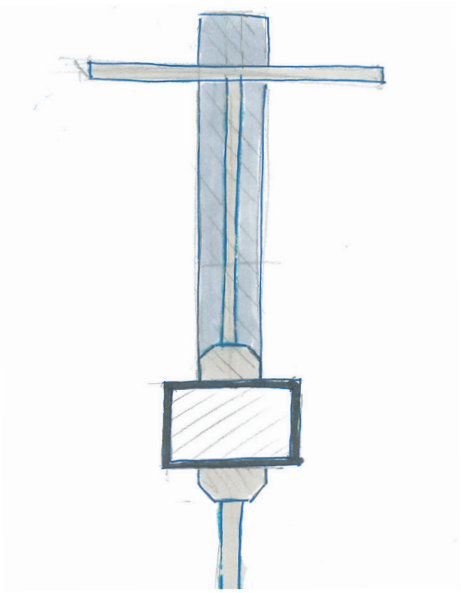


Figure 96: Touch screen

Pressing a button, to activate and deactivate the recirculation

SMALL PRESS BUTTON

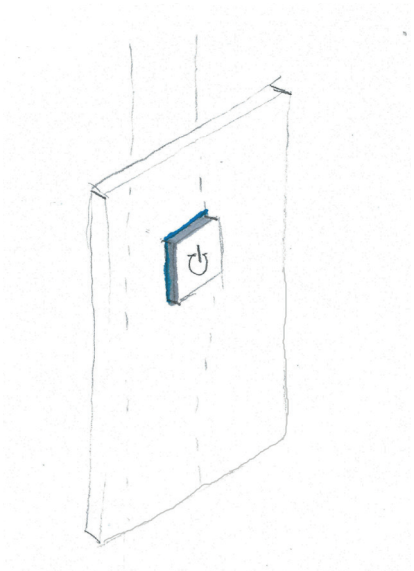


Figure 97: Small press button

A large physical switch, which is easy to hit, no matter the position in the shower. Like a big light switch.

EMERGENCY BUTTON

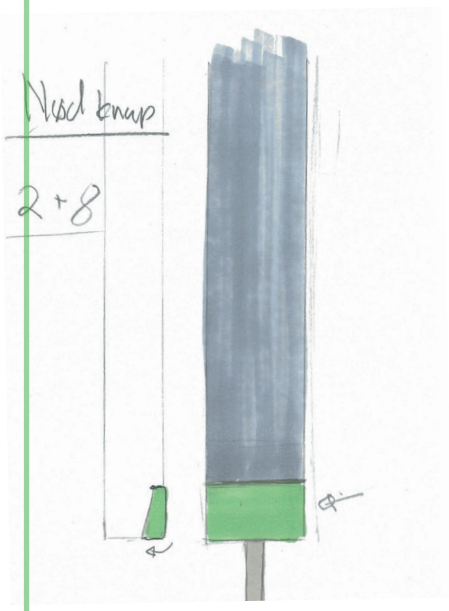


Figure 98: Big button

MORE DIGITAL

USER BEHAVIOR AND CONTEXT

- The shower is misty and water is pouring down, furthermore your eyesight is bad.
- You shower while facing away from the thermostat.
- You shower with closed eyes.
- You move a lot during the shower.
- You have both hands occupied by handling your toddler inside the shower.

IDEATION

An ideationphase was created to explore possible solution towards how the user could activate or deactivate the recirculation, and how these solutions should portray the action, the link and the effect towards the user, while considering the users goal with the coping strategy and the possible user behaviors inside the shower context.

CHOICE - EMERGENCY BUTTON

The physical button provides a clear action in terms of tactile feedback, whenever it is activated or not.

It has an on and off state, indicating whenever it is on or off, and indicating whenever the activation was succesfully switching states.

Allows free movement, unlike the footswitch, that might impair where you move.

Allows multiple ways of activation, with a slap, a shoulder push, or the back of your hand, furthermore its easy to locate and push since it is big.

Simple mechanism, can most likely be made to withstand calcium build-up, water and soap etc.

A foot switch which would allow the user to directly control the recirculation with the foot.

FOOT SWITCH

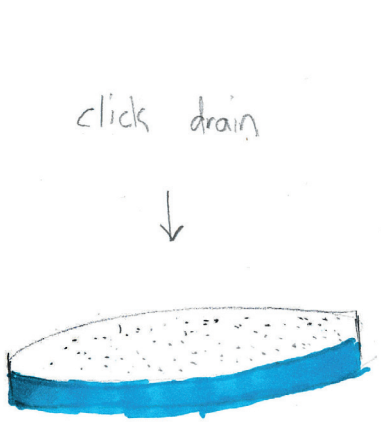


Figure 99: Foot button

Sliding a lever, with inspiration in a ball valve found on many water pipes, which is very common. People might be able to associate with this.

SLIDING TO BLOCK TUBE

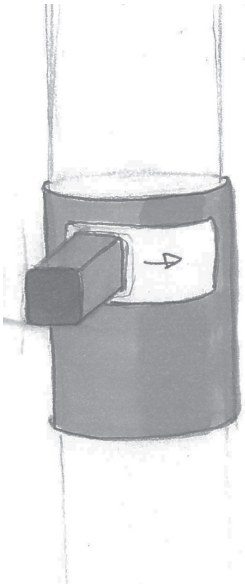


Figure 100: Rotary grip

A Rotating handle with a direct linkage to a gate down the mat

LINKAGE SWITCH

Figure 101: Linkage switch

1. ROTARY KNOB

Figure 102: Rotary button, on

Figure 103: Rotary button, off

2. ON/OFF SWITCH

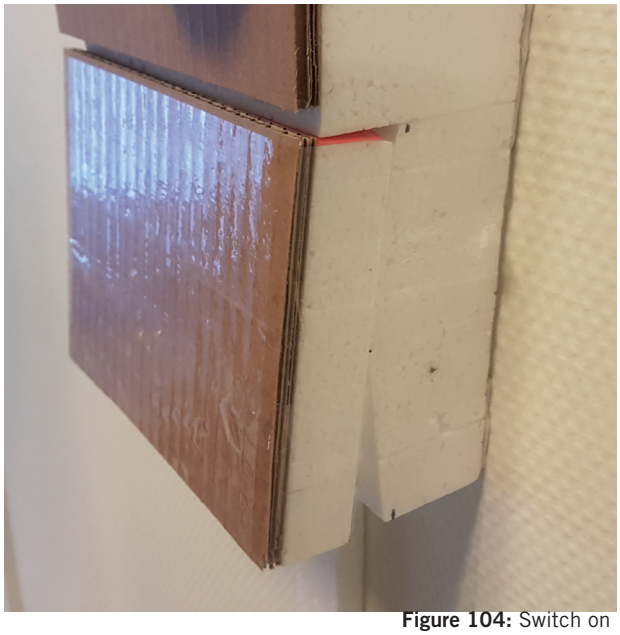


Figure 104: Switch on

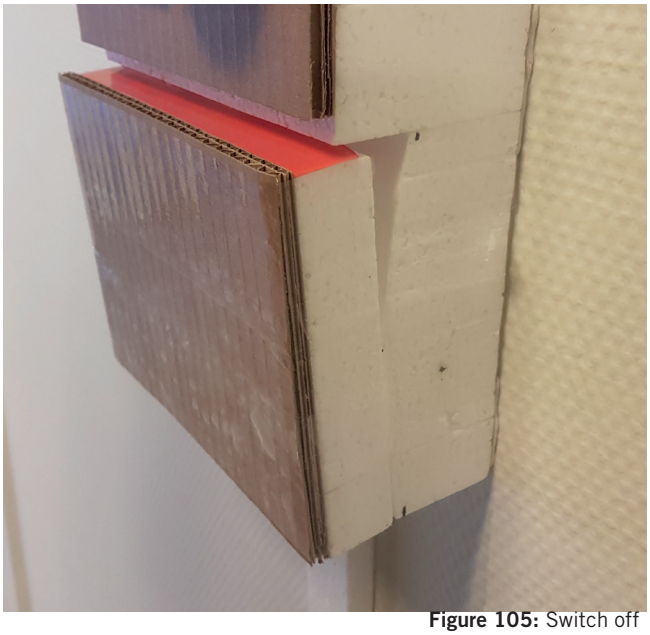


Figure 105: Switch off

3. BALLPOINT MECHANISM

Figure 106: Ballpoint button, on

Figure 107: Ballpoint button, off

DETAILING THE ON/OFF BUTTON

OBJECTIVE: The objective was to test the button with different users, and get feedback on how it felt to use, and to ask whether they would trust the button in critical situations. Would they be able to decode the state of the button with their back against it, and with their front against it?

The overall button concept was defined, a big button. But how do we achieve the claimed parameters of tactility, clear on/off stage, and more importantly, what makes sense for the users. Furthermore, how should we test it with paper sketches? A series of physical models were build.

The models were build trying to associate to common items that share the same purpose. The models were build with real mechanisms, the snappyness was achieved with magnets, and the button mechanism was achieved by intergrating a simple ballpoint pen.

TESTING

All three buttons were exposed to users, the general consensus was that the on/off switch had the most clear indication of the on/off stage in terms of the visual feedback, due to the red top strip and physical transformation, which was very noticable when standing in front the shower.

Another note which was not immediately noticed by the team members, was the sound it made when activated and deactived, which audible indicated that the action had just been done, however as the button is situated where water splashes is common, this might be questionable whether that is a reliable source of feedback for the user.

The rotary knob failed in being easy to activate with for instance the elbow, whereas the other two did very well.

A general issue was that, while they provided a visual feedback, it required the users to be front facing, which cannot be guaranteed.

Output

CHOICE

The switch was chosen for its ability to clealy show its on/off stage, while providing good tactile feedback, however the issue in terms of direction the user is facing in the shower must be adressed.

RECIRCULATION FEEDBACK

OBJECTIVE: How can the link between cause and effect be made more clear to the user?

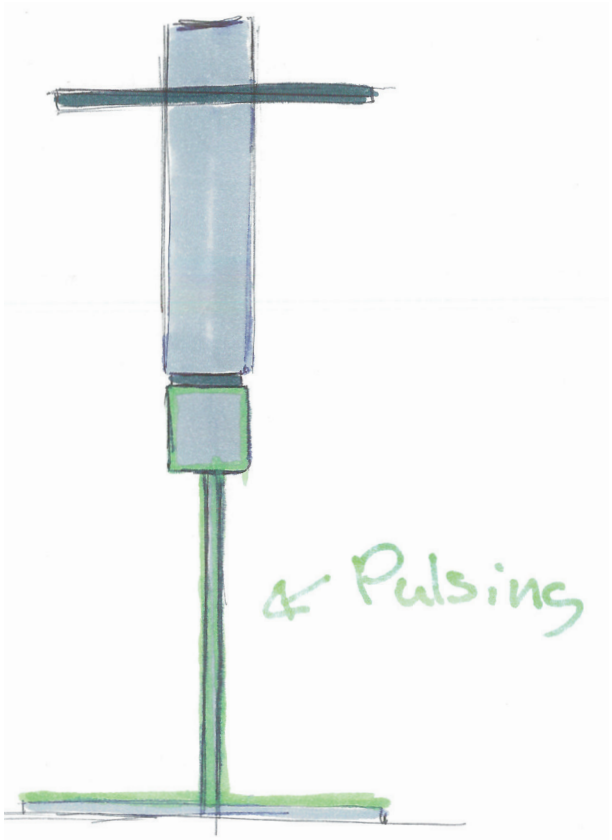


Figure 108: Top heavy design, combined with feedback features

As a continuation of the overall visual expression, how will the design give cues to the mechanism of recirculation.

And as an extension of the on/off button, in terms of how the feedback should be strengthened, and the issue with direction, an ideation was conducted.

Three principles were combined, the digital simulation of water being pumped[Figure 110], being the main driver. It gives a cue that water is being circulated by association.

The on/off button will furthermore also disable the pulsating light, creating another layer of indication, thus another layer of assurance.

By extending down into the mat[Figure 109], it enables the person to look slightly down, solving the issue of the user standing with the back against the product.

The pulsation is limited to the "pumping" segment[-Figure 111], that is linked to the mat, dividing the structure.

A visual indicator located on the collector, allowing the user while looking sligtly downwards to see whenever the circulation is on or off.

FLOOR LIGHT

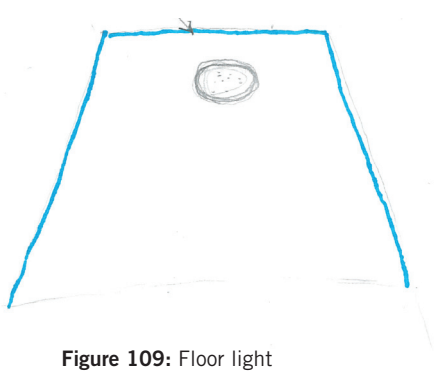


Figure 109: Floor light

Digitally simulating the flow of water when recirculation is on. As the water is hidden, the visual simulation would help understand what is happening when the recirculation is turned on and off.

DIGITAL FLOW OF WATER

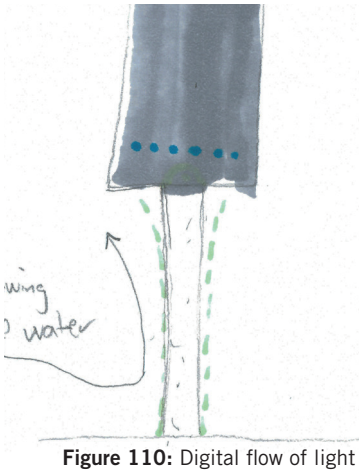


Figure 110: Digital flow of light

A divided system, where all components are individually divided. Being able to understand the system better, if the components are divided into segments, and also being able to see how the water runs from one component to the next and so on.

A DIVIDED SYSTEM

Figure 111: Divided system

Detailing

The switch and overall model were combined with an Arduino controller and LED strips to once again test our assumptions and expose it to users. The feedback given was informative in the sense that people had different opinions. Some users related the light to a landing strip, whereas others understood it correctly as being a visualization of something getting picked up. Other feedback were based on the light, and how fast it was, in which the common concensus was that the speed and light intensiveness should be dialed down. The assumption on user position was correct as some people would stand with their front against the shower, whereas other would have their back against it. Fortunately the LED strip already allowed to be seen even with the back against the system as it would travel throughout the whole length of the mat, thus being visible when the user looks down. The added light strip to the on/off switch would further "segment" the structure visually, and strengthen the feedback, however most of the attention was dragged away with the pulsating light strip. A summary of the informal interviews can be found in [WS29]

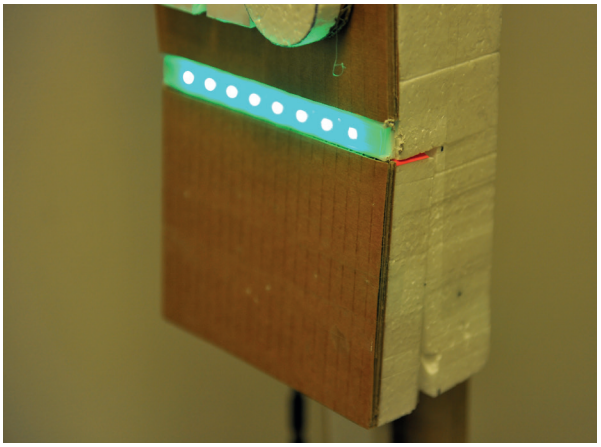


Figure 112: Switch combined with feedback light, on

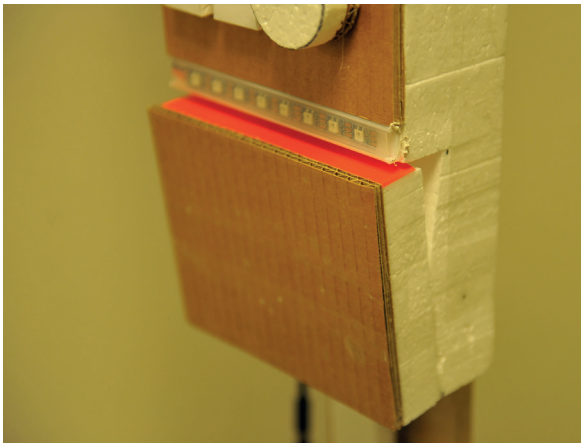


Figure 113: Switch combined with feedback light, off

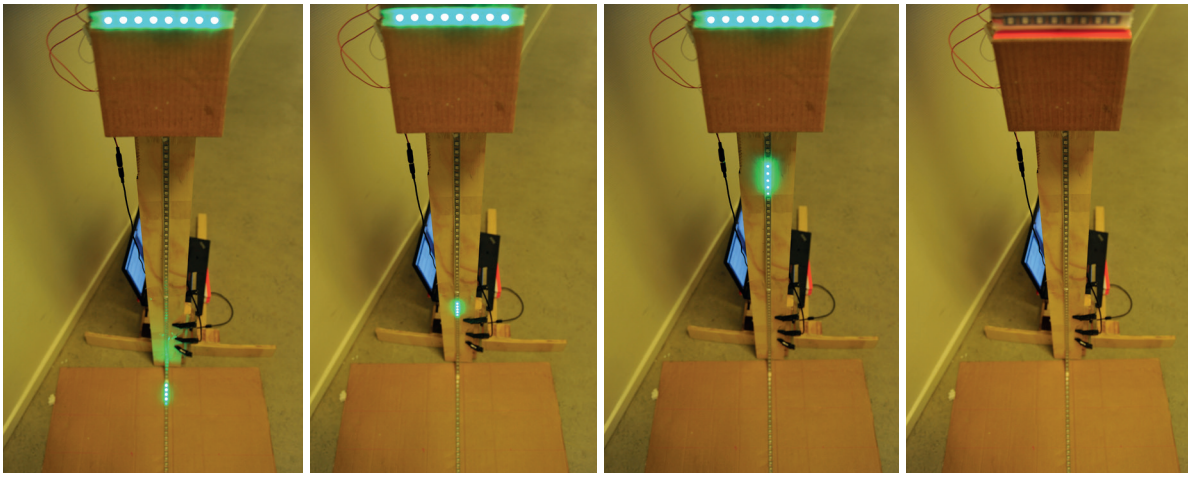


Figure 114: Digital flow of water sequence

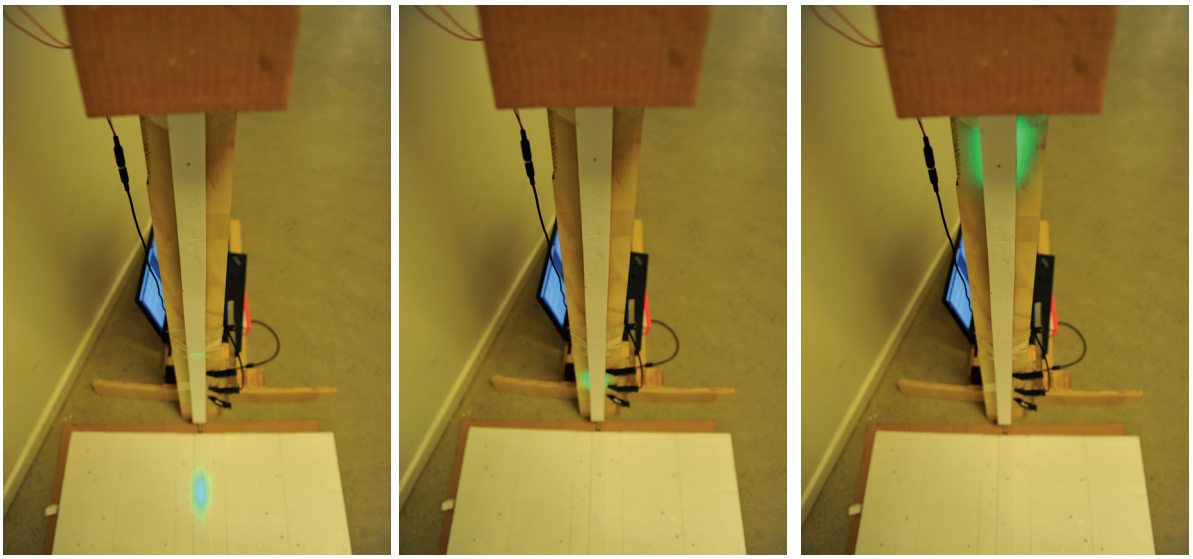


Figure 115: Digital flow of water sequence, damped

INTERACTION LAYERING

OBJECTIVE: How does Elv deal with having significantly more functionalities than other showers?

To not make the product stand out as an completely alien product with several features new to the user, a layering of functions were conceived. This would ensure that the user would not be overflown with options from the get go, which could become confusing for new users, and could make the product look advanced and difficult to use. This was done by **a second layer of interaction** only available when the shower is powered on, hiding the program features till then. The second layer consist of the program features: Comfort-mode, Re-entering and Acclimatization.

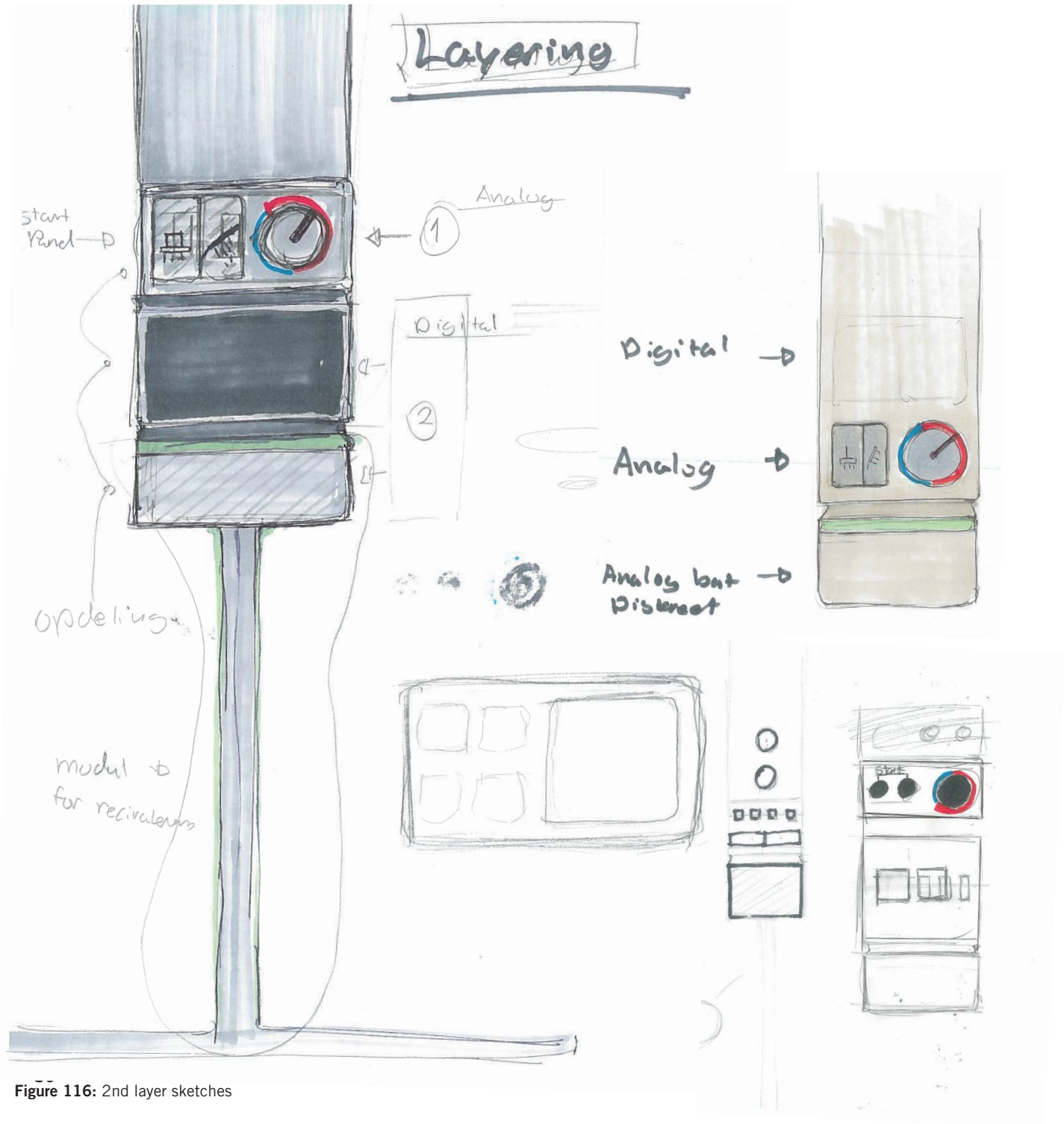
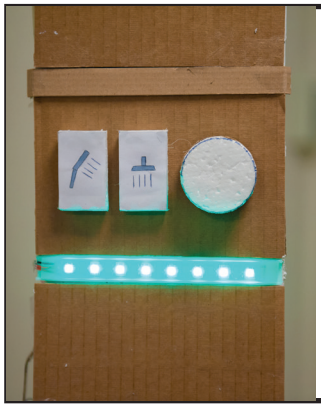


Figure 116: 2nd layer sketches



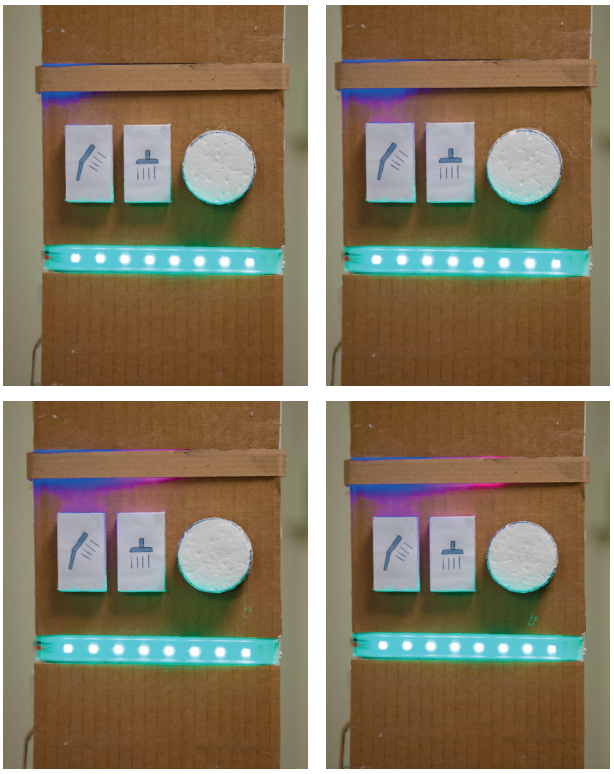
1. START THE EXPERIENCE

PRESS THE OVERHEAD SHOWERHEAD
(OR THE HANDHELD)

2. THE WATER IS HEATING UP

And it is gradually shown that the water is warmed up, ensuring the user that water is warm, even from a distance.

It warms up to the standard temp. of 38C.
This may be customizable.
This process may take some time, it relies on the households ability to deliver warm water.



3. SECOND LAYER

When the water is warmed up, only then will the second layer be shown, ensuring that buttons are shown when relevant, and not in the start where it could confuse the user.

Figure 117: Start up sequence

DETAILING

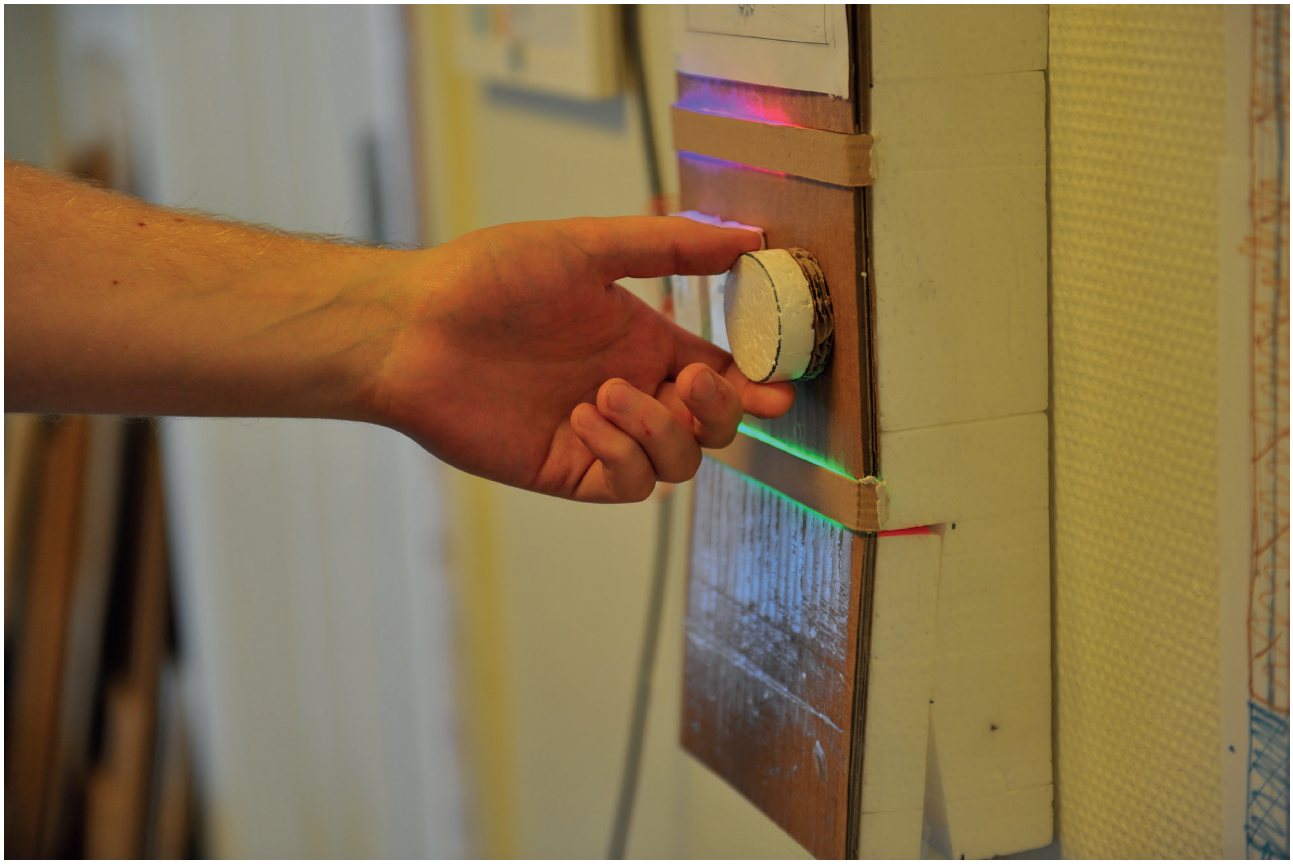
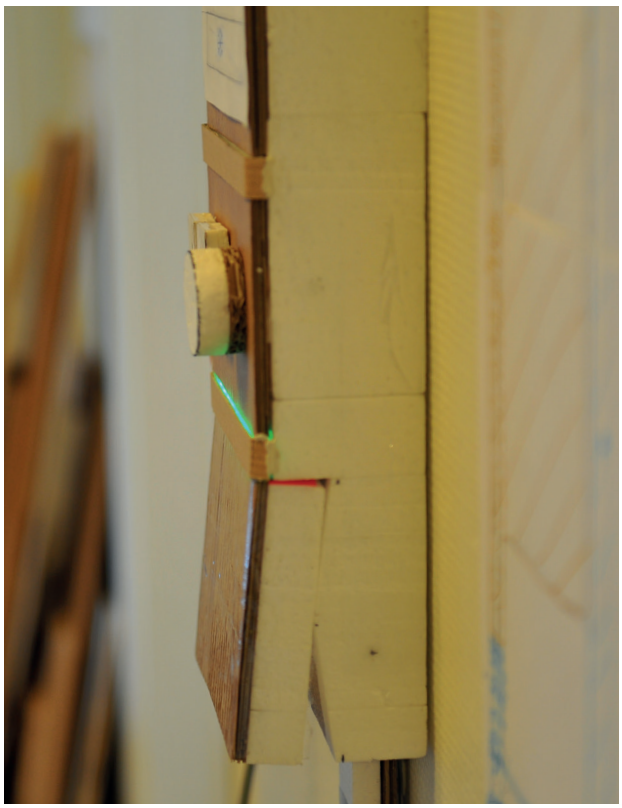
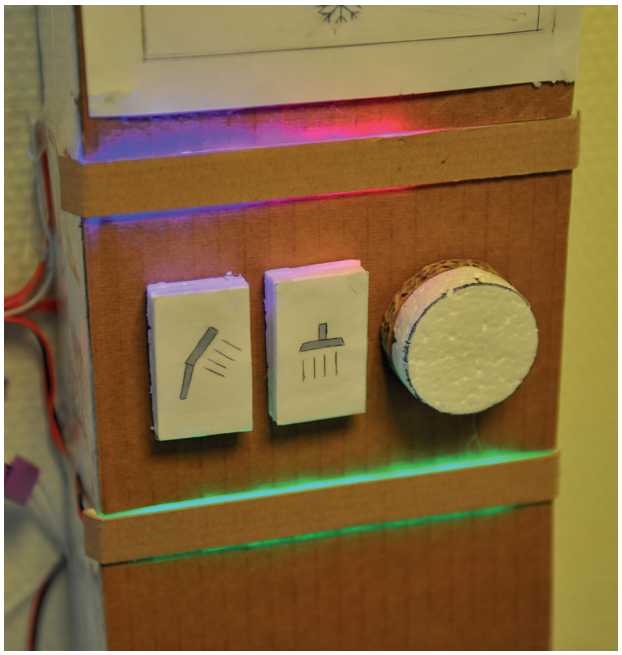
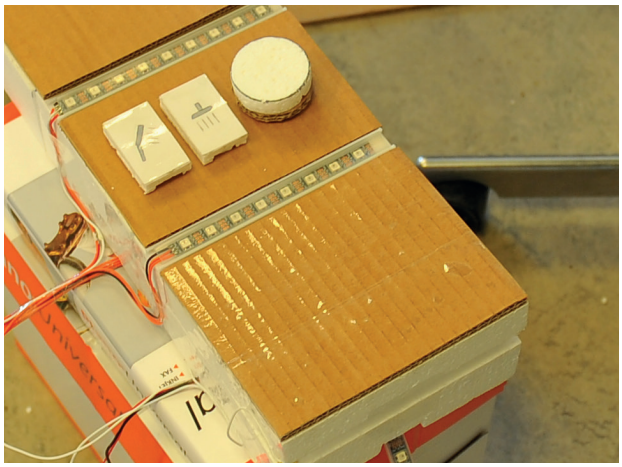
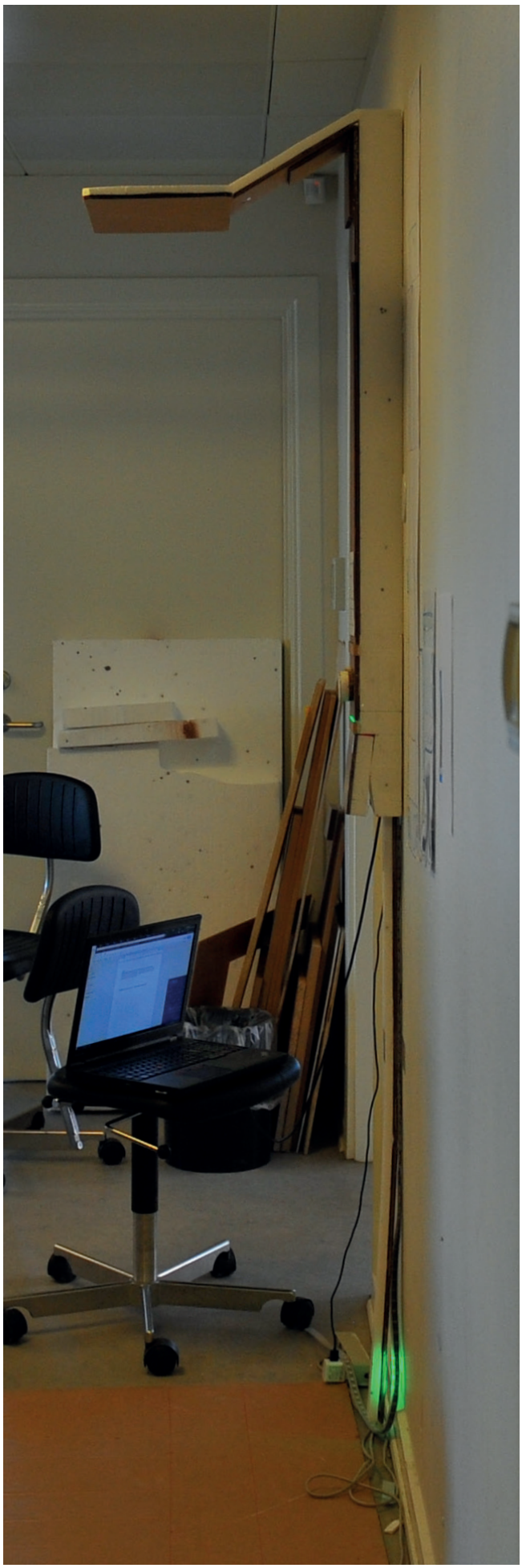


Figure 118: Final mockup, damped lights









FURTHER WORK

OBJECTIVE: The objective was to see how the current state of development was, and how future development should be focussed.

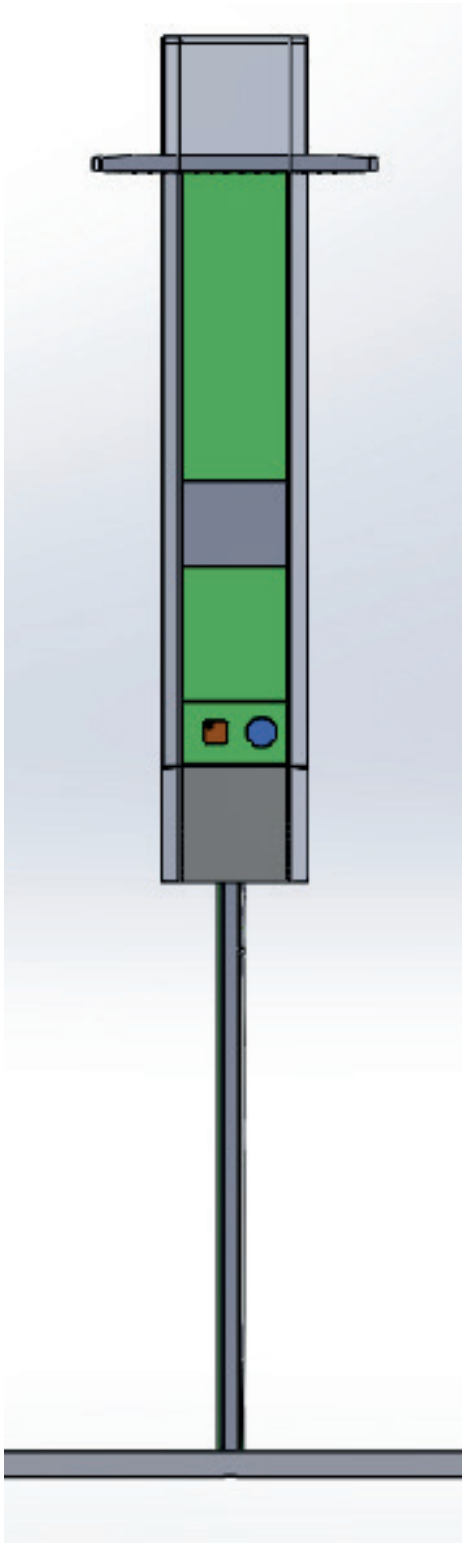


Figure 119: Focus

UP TILL NOW.
The team has focussed on creating a technical viable solution, and has applied this solution to a product which is formed through an in-depth user analysis and testing. The mat and showerhead was delimited early on, as it was of most importance to get the main body, and the technical solution to work. Later on in the process the mat and showerhead creation was thus offset, and it was not deemed justifiable to begin working on these, due to the time constraint. The main body was of main focus due to the technical solution being comparted in this area of the product. However due to the technical development has been relying on physical models, the CAD model was therefore offset late into the project. This also included the mat and showerhead, which off until late was not perceived, other than in some ideation sketches, which meant that their construction was not decided before the CAD model creation were initiated. However, while the CAD model were created, a series of consideration were needed to make the mat and showerhead. Furthermore the second layer of interaction were only shortly touched on. The maintenance and installation of Elv was also conceived in the short while of the CAD creation.

THE INSTALLATION AND MAINTENANCE
The installation and maintenance was considered through the CAD modelling, and has been further explained in the Product report.

Considerations in regards to this can be found in [WS43]

MARKET
The market came as a result of creating the final component list, in which the MSRP could be predicted. The market is described in the Product report, and is further in-depth described in [WS34]

POWER CALCULATIONS
A updated battery calculation were created due to being to more precisely calculate power usage from each component

These calculations can be found in [WS32]

PRODUCTION AND CONSTRUCTION OF MAIN BODY
As the main body of Elv was the main focus, more in-depth production and construction considerations in regards to this, has been created on the next couple of pages.

THE MAT

The mat had a series of considerations in regards to how it should be conceived, and with little focus on how it should be manufactured.

Considerations in regards to the mat can be found in [WS30]
Manufacturing considerations can be found in [WS44]

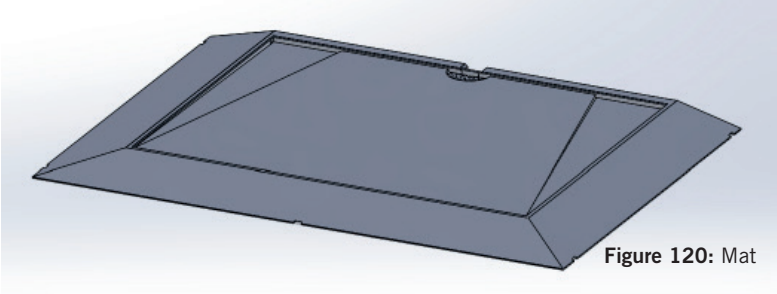


Figure 120: Mat

THE SHOWERHEAD

The showerhead had a series of consideration when created in CAD, furthermore it can be discussed whether it would have been neccesary to look more into the creation, as the venturi system is placed in the showerhead, however it was the belief from the start, that what we did with the showerhead was possible, due to other manufacturers doing the same in regards to coverage.

Considerations in regards to the mat can be found in [WS31]
Manufacturing considerations can be found in [WS45]

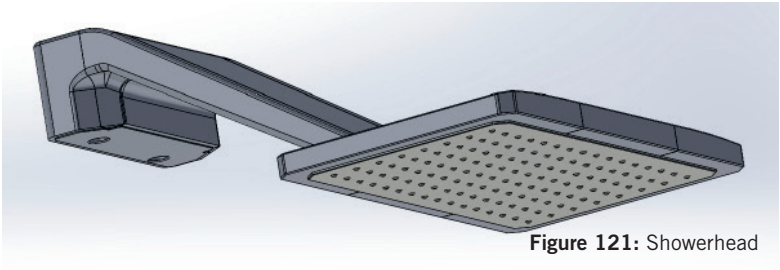


Figure 121: Showerhead

SECOND LAYER OF INTERACTION

The second layer of interaction detailing was mainly created due to the creation of the CAD model, however some consideration were done

Considerations in regards to the second layer of interaction can be found in [WS40]

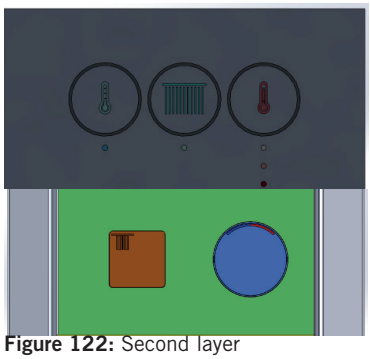


Figure 122: Second layer

CONSTRUCTION - BODY

OBJECTIVE: How the product would be assembled with focus on the main body.

ASSEMBLY

The main body consists of three main modules to facilitate the assembly, an extruded profile with rails, a component tray and lastly the internal components that are mounted onto the tray and slid into the extruded profile, for an easy assembly and repair if needed.

SEALING THE PRODUCT

Considerations

- Sealing against splashing and moisture
- Low amperage battery prevents lethal shock if something should go wrong.
- IP67 sealing to prevent ingress to enter system
- Cut down on seams and holes on the shell to limit the need for rubber sealing etc.
- Outside buttons should be sealed or bought pre-sealed.

See [WS37] for more info in regards to sealing and waterproofing standards.
See technical drawings folder for detailed component list.

Figure 123: Extruded profile

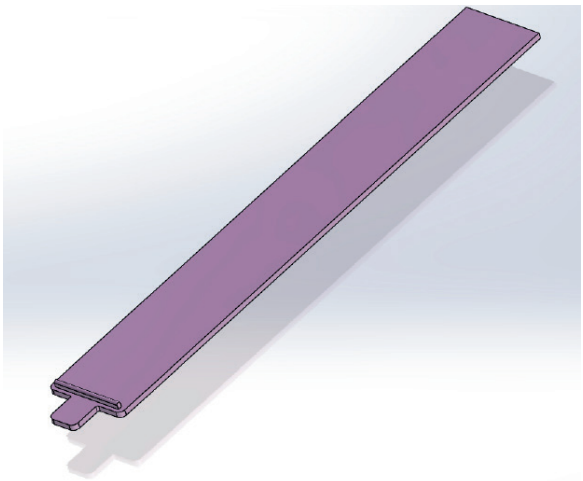


Figure 124: Tray

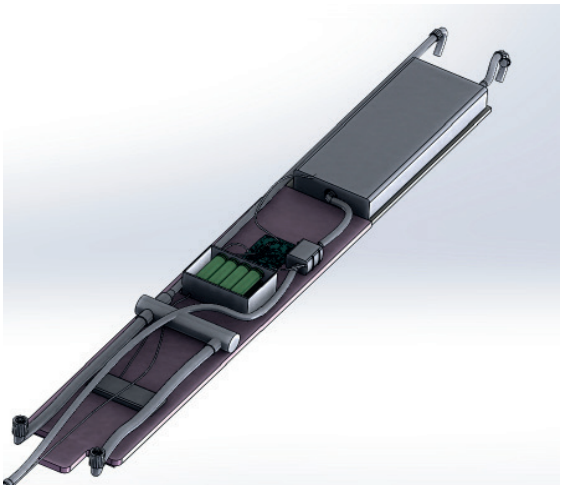


Figure 125: Tray with components

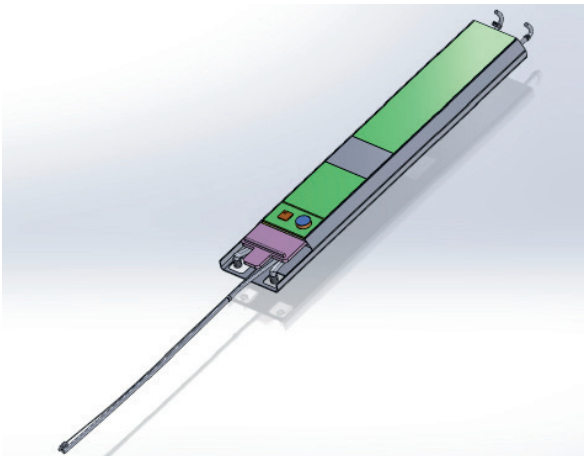


Figure 126: Tray inserted into profile

PRODUCTION - MAIN BODY

OBJECTIVE: The objective is to find how the main body should be produced.

The extruded profile is the structural backbone and should be able to withstand being mounted on the wall and be strong enough to hold the internals. Furthermore it should be a visible part of Elv, and should therefore be produced in a material which would work aestetically with the rest of the materials used.

See [WS46] for other material options

EXTRUSION OF PROFILE

The body is to be extruded in aluminium, which was the material wanted due to the appearance, while being relatively lightweight and rigid. In the extrustion, a set of rails were integrated to make the assembly of the product as easy as possible. The rails and open ended form is furthermore a relatively cheap operation in an extrusion.

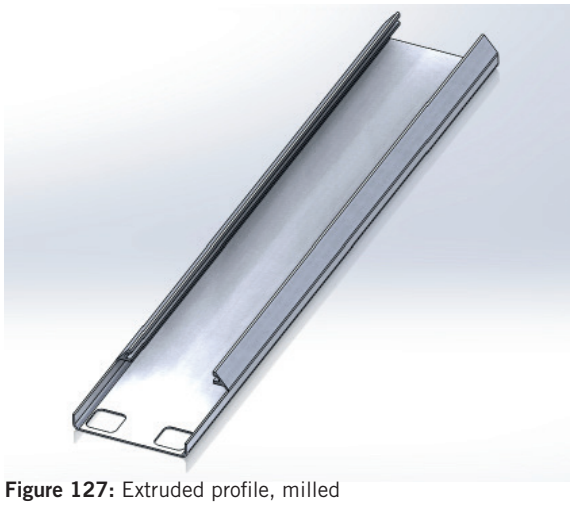


Figure 127: Extruded profile, milled

Figure 128: Cross section

TREATING THE ALUMINIUM

As the aluminium is to be placed in a damp environment with water they might tarnish over time, so it would be beneficial to treat the aluminium with a anodization, both hardening the surface, and making it possible to anodize with several color options, which could be available for the buyer to select from.

MILLING

The lower part of the side walls must be removed to accomodate the big button, and two inlet holes aswell to connect the hot and cold water. This is acheived by two simple milling opperations.

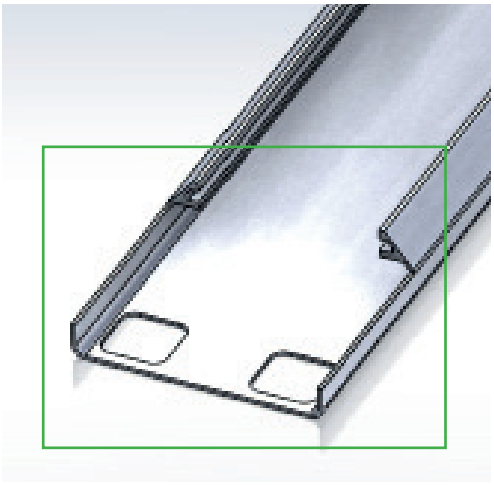


Figure 129: Lower walls

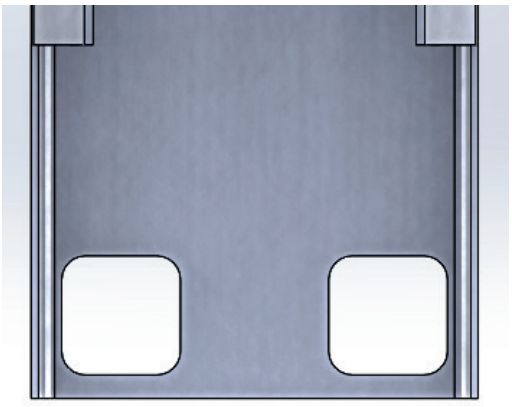


Figure 130: Hot and cold water inlet holes

OUTRO

Conclusion

Did we manage to develop a recirculating shower, that is easier to install and more affoardable?
It was identified that the cost and difficulty in installation was the main barrier in making water recirculating showers unsuitable for the low to mid end market.
The team solved this by creating a battery driven solution, with an extremely low power consumption, and minimal filtration.

We succeded in creating an architecture, with the potential, of being installed by the user themself, as it does not require an electrician. And an arcitecture that bottomline has cheaper componenents. This sets Elv apart from the other recirculating showers, however, the actual implementation or capitalization of those perks, have not been followed through, as the focus had to switch to a more user oriented approach, ending the technical development.

Did we manage to deal with the consequences of being a recirculating shower?
The shower journey of five real life personas were investigated, and three were thoroughly analyzed. The most critical issue indentified that interfered with their shower pattern, was if soap was recirculated, as it would disallow them to achieve cleanliness. And furtermore, the intensive beutification process requires multiple lathe and rinse cycles, disallowing an approach were the shower simply ends with 2 minutes of clean water.

An automatic approach was chosen, as it would minimize additional user interaction, attempting to bring it closer to the traditional shower experience. However the automatic approach brought several consequences. In essense, reusing shower water is as safe, as it is with a bathtub, however what is perceived as safe, is up to the individual users, that fact had to be accomodated in an automatic solution, giving the user the ability to remove any uncertainty and be in control, that was achieved by an on/off button and a very clear feedback.

However, what we solved was the consequences specific to the Elv recirculating shower, enabling the personas to fullfill their current shower experience in the Elv shower, without compromising their ablity to get clean, nor beautify themselves.

We did not solve the larger issue off people shying away from reused water, and the general paradigm that they consider it dirty, although it from a hygenical standpoint is perfectly fine to use, as with a bathtub. The attitude towards reused water can however be pushed by a product like Elv, as it could expose the idea of water recycling showers to the low-mid end market.

Did we manage to create "Big comfort, small footprint"?
Through the aforementioned personas, it has been possible to identify the key factor in shower comfort, the experience of warmth. Furthermore, it was possible, to utilize two unique technical capabilites of Elv, the ability to automatically control temperature, and increase the flowrate, enabling us to create comforting features not found in other shower products.

The value of the temperature programs are well reasoned, however the actual value is yet to be ascertained.

Furthermore the temperature features are well reasoned from the cost standpoint, as they are a extension of an already necessary technical feature, to secure a stable temperature.
Temperature is a dimension that no current shower manufactures use to their advantage. An in-depth study of this phenomena could be a gateway in expanding what shower comfort is, and how it could be enhanced, however this is outside the scoop of this project.

Reflection

Developing a technical solution as industrial designers.
Choosing to develop a technical concept as the starting point was a mix of several factors, a fairly well weighted decision with a bit of personal motivation, the main points we considered are below:

- The knowledge of bathtubs being acceptable and the early questionnaire supported that using a minimal filtration would be possible, lowering the technical difficulty, as the water does not have to meet drinking water requirements.

- A very early effort was made into researching passive pumps and rationalzing the working principles, if the venturi injector would not succeed, other principles could.

- Water. Fluid dynamics and the physics to calculate a system working method, is not possible. However the causality of water, is not much different from an electrical circuit, the cause and effect are easily tested and predicted.

- The motivation to use the prototyping skills gained throughout the last five years as an active tool in development.

The choice was well considered, but the consequences were not. We believe the sequence of going from a heavily

technology dependent and technology driven approach, to a user oriented approach, at large is the critical point of both what succeded, what was detrimental and the most challenging in this project, the considerations are as follows:

+ Having in-depth knowledge of the working method, capabilities, strengths and weaknesses from an early stage in the design process was an immensely helpful framework,- for going indepth with how the water recirculating shower exactly impacts the user.
- On the other hand, the investment of one month of manpower into developing a system architecture fueled an approach where the technology was the driver in most decision making, as the technology could not be abbandoned at this point, narrowing the possible solution space, where a large factor in choosen solution principles was based on their compatibility, rather than their value to the user.
- It fueled an approach where the main goal was to make the best use of an technology. Instead of investigating a latent user problem, and choosing a technology based on that.

Starting with an technology based approach from the start, has had major implications on how resources could be spent in the later phases.
- Spending one month in the beginning at defining the system meant that the remaining two months were prioritized on defining the user experience. Leaving no time for further refinement of the system architecture, or worthwhile detailing. One additional month, or a third team member could have alleviated the issue, or simply better planning.
- Defining a project scope. In the early phases, the project scope was discussed, wherein it was defined, that a solution that encompases a shower set would be far to big an assignment for two people, and that an addon type product might be more appropiate, the design brief touches upon that[WS38]. However through the technical development and the one month investment, it was evident, that the only method to make this technology available, would be to integrate it in a whole shower set. The consequence was that two components, the showerhead and collector, had to be abbandoned in terms of development, in order to move on to the user experience research at a quick pace.

- While working with water to a large degree could be rationalized through tests, expert knowledge should have been sought. The Danish "Miljøstyrelsen" was sought out, however they are yet to finish guidelines on how grey water is to be reused within showers, making it very difficult to define what water quality actually must be achieved. They promised a case would take 4 weeks to process, after several conversations after, it got pushed back, and an answer still awaits after 9 weeks...

Project navigation and decison making
The project, at the very inception was defined by a future vision, a desired market position and lastly the solution principle of being battery driven, thereby setting forth the requirement of being low powered.

Coupled with a fact that the project was initiated with a technical development, meant that at the conclusion of technical development and one month into the project, that the team had no list of requirements, nor a core insight to focus on, but rather a system with a list of opportunities and considerations.

The initial vision was achieved, however the elephant in the room had not been, the fact that the shower reuses water, and that users are apprehensive to that fact. However the problem increased significantly, as the solution developed, brought it's own set of unique challenges on top of being a recirculating shower.

It was challenging to transition to a user oriented approach, as it seemed overhelming to connect all the dots from the user experience to the technical opportunities and weaknesess.

The solution was to focus on one situation and one persona, and step for step measure the user experience and solution principle up against each other. However that approach was not finalized in days, it took weeks to go into proper depth.

The transition was difficult on a mental level, as both team members during their internships, and the technical development, were required to think very solution-oriented. Meaning that problems were answered with solutions, instead of investigating the cause, this was very problematic as it hindered us going into depth with the cause and effect of using a water recirculating shower.

Project navigation and decision making
Throughout the whole design phase, the team defined several specifications, that can be looked up in [WS27]. The specification in the traditional sense of a long list with requirements, was an unsuccesful endeavor as it did not support the development in anyway, they were not put on a wall, nor were they consulted to evaluate. The process of defining them did however function as a tool to align the two team members towards a common goal, or rather to define the enablers and drivers in the project.

The team, mainly used visions, and attempted to define the core drivers for each phase.

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WORKSHEETS

WS1 - Questionnaire
WS2 - Orbital Systems
WS3 - Water saving products
WS4 - Bathroom zones
WS5 - Initial aspirator test
WS6 - Aspirator test results
WS7 - Venturi injector design
WS8 - Lift motor test
WS9 - Venturi regulator
WS10 - Temperature in-depth
WS11 - Thermal imaging explained
WS12 - Mixing waters temperature
WS13 - Resistance tests
WS14 - Correspondence with Miljøstyrelsen
WS15 - Filtration values
WS16 - Testing acceptable diluted water
WS17 - In talks with possible partners
WS18 - Choosing the full shower set
WS19 - Choosing the mat
WS20 - Gathering flow information from other users
WS21 - Battery capacity calculations
WS22 - Personas
WS23 - Extreme cases
WS24 - Incitement calculation spreadsheet
WS25 - User behavior observation in shower
WS26 - Mixer mechanical setup test
WS27 - Design specifications
WS28 - Acclimatization
WS29 - Informal interviews about lighting
WS30 - Collector considerations
WS31 - Showerhead considerations
WS32 - Updated battery calculations
WS33 - Component and production cost
WS34 - Market
WS35 - Mat production considerations
WS36 - Showerhead production considerations
WS37 - Sealing the components
WS38 - Design Brief
WS40 - Second layer of interaction consideration
WS41 - Updated system description
WS42 - Component list and main parameters
WS43 - Installation and maintenance
WS44 - Mat manufacturing
WS45 - Showerhead manufacturing
WS46 - Material choices - Main body

FIGURE LIST

Figure 3: http://www.littlechurchmouse.com/wp-content/uploads/2015/08/ThinkstockPhotos-186306075-600x398.jpg

Figure 4: http://taylorsplumbing.com/content/taylorsplumbing.com/img/site/shower-drain.jpg

Figure 8: http://arizonaenergy.org/News_13/News_Dec13/orbital-systems-shower-3.jpg

Figure 9: https://en.reset.org/files/imagecache/ogimage/2014/02/04/shower-of-the-future.jpg?1491593206

Figure 10: http://www.dhresource.com/600x600/f2/albu/g4/M00/D1/83/rBVaEFfH2fmAI83cAAHJb9fWXeU432.jpg

Figure 11: http://assets.hansgrohe.com/assets/global/hg_ecosmart_showers_730x411.jpg

Figure 12: https://images-na.ssl-images-amazon.com/images/I/415dPBEC2dL.jpg

Figure 13: https://www.wired.com/wp-content/uploads/2015/08/Nebia-half-spray-featured.jpg

Figure 14: https://www.deltafaucet.com/files/live/sites/delta/files/innovations/in2ition/mbackground2.jpg

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Figure 26: http://www.treasurenet.com/forums/attachment.php?attachmentid=1016341&d=1404078506&thumb=1

Figure 27: https://lh5.googleusercontent.com/-19aUOtyHkMA/VQ6epfyxIrI/AAAAAAAAA-w/zIpz3Szr8i8/w376-h373-no/venturidesigns.jpg
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http://4.imimg.com/data4/EW/DO/MY-537032/filter-mesh-250x250.jpg
https://thenounproject.com/term/data/126464/
Figure 51: https://t3.ftcdn.net/jpg/01/06/66/10/240_F_106661066_1azVOQCXy5iSLAOotH9oCwcXJhuKxdWp.jpg

Figure 54: http://www.diarioelpueblo.com.uy/wp-content/uploads/2015/06/AlbisuCarlos.png

Figure 55: http://blog.usabilla.com/wp-content/uploads/benjamin.jpg

Figure 52: http://www.backgroundwallpapershd.com/wp-content/uploads/2014/01/emilia-clarke-celebrity-hd-wallpaper-1920x1080-6458.jpg

Figure 53: https://s-media-cache-ak0.pinimg.com/originals/ef/29/e0/ef29e0acaed0d896d649a2dbf64058c7.jpg

Figure 56: http://i.dailymail.co.uk/i/pix/2017/04/08/14/3F1185C500000578-0-image-a-35_1491656444627.jpg

Figure 72: https://hbr.org/resources/images/article_assets/hbr/9807/98407_C.gif

APPENDIX

MSC04-ID08
GROUP 8
PROJECT ELV

CONTENTS

READING GUIDE

The worksheets that have been directly referred to are located in the first column, other worksheets made during the process, as well as the design brief are located in the second column

WORKSHEETS

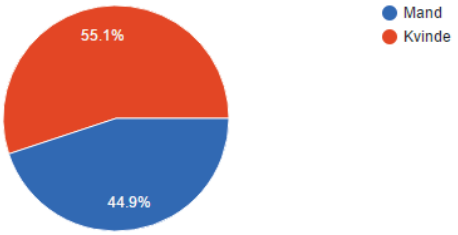
OTHER WORKSHEETS

Objective

The objective is to get an understanding of users general showering habit and their attitude towards reusing water, thus probing the feasability of the "future vision"

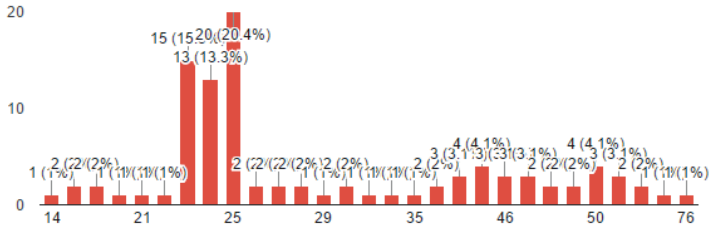
Køn

98 responses



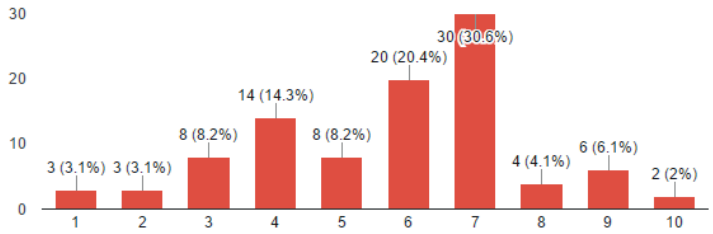
Hvad er din alder?

98 responses



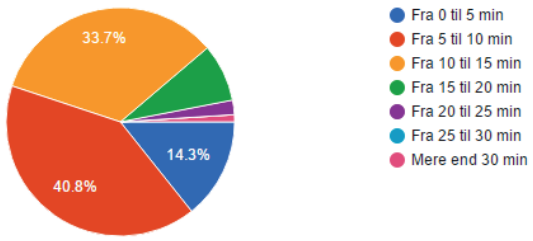
Hvor mange brusebad tager du om ugen?

98 responses



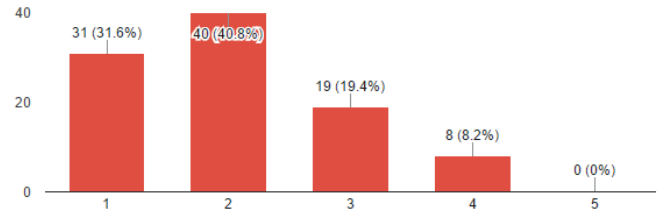
Hvor lang tid bader du?

98 responses



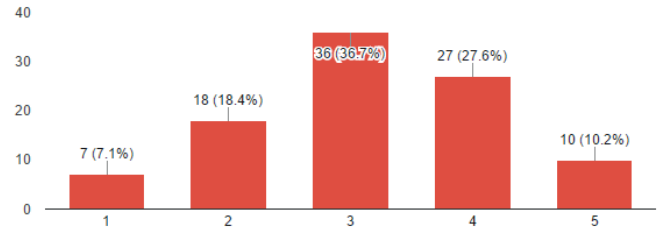
Hvornår begynder du at vaske hår med sæbe?

98 responses



Hvornår starter du med at vaske kroppen med sæbe?

98 responses

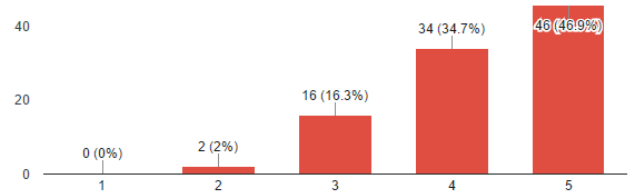


Er der et tidpunkt i badet hvor du føler dig nogenlunde "ren", inden du faktisk er færdig med badet?

98 responses

Hvornår føler du dig ren i brusebadet?

98 responses



Data

The Questionaire can be seen below

Excel format: https://docs.google.com/spreadsheets/d/1N-zhsDzUzl3N37_OE5tUSh1RSUY-BQpLUhB3f3U1vXQk/edit?usp=sharing

The Questionaire itself: https://goo.gl/forms/L52rmGGdFjqsuXhc2

Evaluation

-The results were very promising, as a total of 25% were open to the idea of reusing water, throughout the whole shower. And ~5% were open the idea after washing either their hair or body.

- A large majority said no due to perceiving it as a hygenical problem, whereas some were outright against the idea.
It can be assumed, if the solution was proven to ve hygenical, a large majority could be won over, however the group that answered outright no, require more investigation.

- A large majority think showering is a recreational acticity, supporting the assumption that showering is much more than simply cleaning on self.

Reflection

The questionaire supports the assumptions made, in the “future vision”.

With 25% answering yes, the team has chosen to further progress with the idea.

Objective
The objective is to see how Orbital Systems is placed in the market, what the pricepoint is and what the prerequisites are before buying and using Orbital Systems. Furthermore analysis of the features are done.

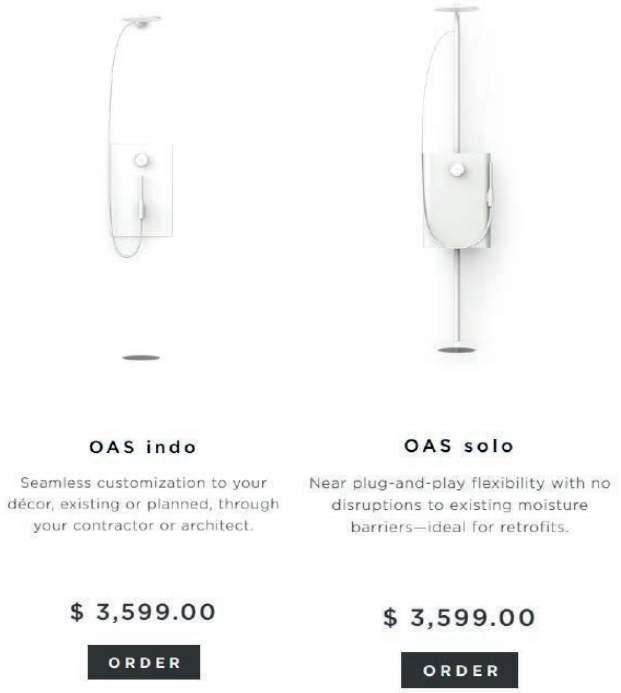
Introduction
To understand the current market, and products with a similar aim of ours, to re-circulate water, an analysis of both closed-loop systems and "open"-loop products such as grey water solutions were created. This will allow us to find a possible gap in the market, in which our solution would fit and be competitive, and it would allow us to identify eventual pitfalls to avoid when creating our own solution.

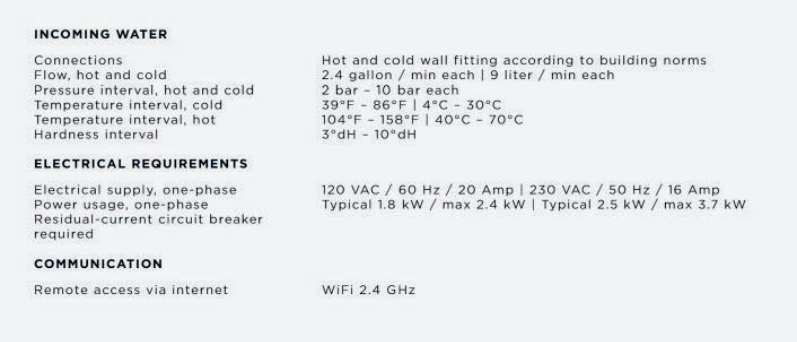
A close resemblance to our proposed solution were found in Orbital Systems, which produces a closed-loop product targeted towards the high-end market and institutions.

Data

Pricepoint
Orbital Systems is a very high-end product with a initial pricepoint of 32.000 DKK (https://orbital-systems.com/store/). This is likely a pricepoint which is outside of the regular shower user, and is truly a premium priced product. Orbital Systems provide to products, one for installing with a renovation of the bathroom, and one which can be retrofitted in the existing bathroom, without the need to renovate. Priced similar, the non-retrofitting version will be more expensive due to having to renovate the shower, or if installed when the house or appartment is build, could be of the same price.

Features of Orbital Systems
- Price: Starting at 3.599 USD excl VAT.
- Cleans 90% of water, they claim it is cleaner than the tap water initially used.
- Can be installed without renovation, but is difficult to install.
- Uses expensive filters that has to be changed at 15.000 and 50.000 liters used.
- Large water and energy savings.
- Filters water to a very high standard, output water is cleaner than the input water.
- Complete system, everything has to bought as a whole.





INCOMING WATER	
Connections	Hot and cold wall fitting according to building norms
Flow, hot and cold	2.4 gallon / min each | 9 liter / min each
Pressure interval, hot and cold	2 bar - 10 bar each
Temperature interval, cold	39°F - 86°F | 4°C - 30°C
Temperature interval, hot	104°F - 158°F | 40°C - 70°C
Hardness interval	3°dH - 10°dH
ELECTRICAL REQUIREMENTS	
Electrical supply, one-phase	120 VAC / 60 Hz / 20 Amp | 230 VAC / 50 Hz / 16 Amp
Power usage, one-phase	Typical 1.8 kW / max 2.4 kW | Typical 2.5 kW / max 3.7 kW
Residual-current circuit breaker required	
COMMUNICATION	
Remote access via internet	WiFi 2.4 GHz

https://orbital-systems.com/store/

Filtration method

Orbital Systems uses a very complex architecture, including filtration and heating of the used water, to again reintroduce this water to the user. The system picks up the water before it reaches the drain and filtrates this using complex filtration, heats the water to the correct temperature, and reintroduces the water. This solution promises to reuse 90% of the shower water, and the filtrated water is of a very high standard, in instances cleaner than traditional tap water.

What they say

- A fixed amount of water usage (5 litres) independent of time showering.
- Saving the world, only 1% fresh water, why use so much of it? SO LITTLE WATER.
- We are all environmentally responsible together.
- Price will be lowered with time.
- Early adopters
- Institutions are buying firstmost

Very little focus on price, this is a product of the future, saving water. “I want to be part of the future, by saving water” “I also save money”

https://www.youtube.com/watch?v=LbkXw1SLeO0

“You can shower as long as you want, guilt free,”

https://www.forbes.com/sites/michaelkanellos/2015/10/12/the-tesla-of-showers/#113fd0987bd1

There, each of the six showers installed saves over 30,000 liters (8,000 gallons) of water and 1600 kWh of electricity each month. A similar installation in Denmark sees a payback in less than one year, and then it is not only water and energy winner, but also a huge money saver.

Users of Orbital Systems

The users of Orbital Systems is identified as being in in the upper range of wealth. As there is both yearly expensives that needs to be covered when using Orbital (filters) and there is the high initial price, to save money is far out in the future when using Orbital. It must be seen mainly as a environmental friendly product, saving water, not thinking about the actual price saving when using the product. The users must be environmental aware and have a good reasoning behind saving water to want to buy into Orbital Systems.

Powering Orbital Systems

Orbital Systems are powered by AC voltage, meaning that the bathroom must contain this somewhere close to the shower area. This also means that there will always be power when needed, as there is no battery to be charged etc.

Evaluation

It is clear that Orbital Systems is a very compelling product, due to the features and the “cleaner than tap water” filtration. The price is however a barrier for many, and can be seen as a hole in the market, as there is a segment of users which want to save water, but can’t buy into Orbital Systems.

Reflection

Placing Orbital Systems in the market, made it possible to see how our product should be placed, and to see what segments would not be able to afford Orbital Systems, and see how we could target out solution.

WS3 - Water saving products

Date: 04/02/17 Written by: Jacob

Objective

The objective was to categorize different ways of saving water, and comparing these to one another. Furthermore it was possible to get a understanding of which product are on the market, and where to position ourselves.

Data

The market were categorized into four categories:

1. Avoid, avoiding using water by ensuring that the user is aware of the time used in the shower.

2. Reduce, reducing the output of the water with different techniques.

3. Reuse, reusing the water already spent once.

4. Recycle, much like Reuse, did not find differences in products.

These four categories are compared, and both the positive and negative values are proposed.

Avoid:

-Using a timer or watch to prevent extensive use of the shower.
-A timer to stop waterflow af a set time.
-Using a bathtub to avoid using more water than a bathtub holds.
-Collective bathing with others to save total water usage.
-User could bath every other day to cut water usage in half compared to bathing every day.

This leads to the following negative values:
--Impacts the experience, not a leisure activity.
--Timed, not affected by the necessary bathing time.

These solutions often relies on behavior of the user, and a behavioral change in the way showering is done.
The showering is changed from “leisure” to a “chore”.

Reduce:

-Using mist as a way of making it feel like more water.
-Reducing the flow of water.
-Aerator to mix water and air, reducing water usage.
-360 degrees showers, to ensure that the user feels clean earlier, reducing water usage.

This leads to the following negative values:
--Affects the feel of the shower, and might affect how you shower
--Technology driven
--Does not affect the shower duration, but reduces the over-all water usage.
--Lessens the amount of water, needed to take a whole bath, and probably offers a different feel of the shower
--The more water that is saved, or reduced proportionally affect how the showering feels.

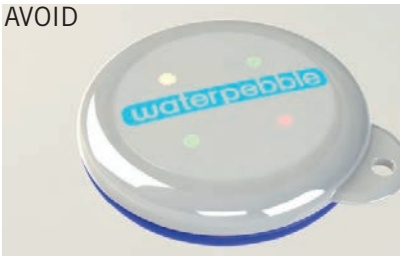
These solutions often affect how the showering feels to the user, and can affect the thought: “am I clean now?”

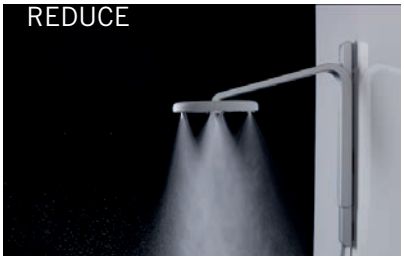
Reuse:

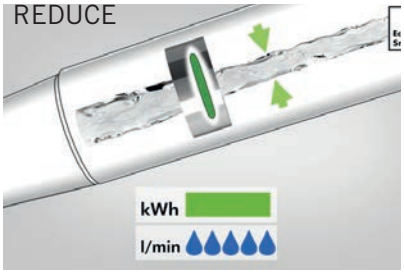
-Apartment wide grey water recycling system, to reuse grey-water where possible.
-Closed loop shower system, where water is reused.
-Manually filing the shower with “used” water for reuse.

This leads to the following negative values:
--Can be expensive.
--Maintainance can be high due to a complex system.
--Can be difficult to implement.

These solutions often relies minimally on user-interaction, as the system is closed loop. Furthermore, it is possible to create this as an direct replacement for the normal shower, and it would be possible to maintain the normal routine and experience of showering. It is also a very effective way of reducing water usage.







Prices were also compared, and the individual functions of the products were listed in the following document:

	Notes	Price		
https://orbital-systems.com	Three models, integrated for new houses, one for a lot of baths and one for adding to an existing bathroom	4600 Euros = 32.000 DKK	High-end	Re-use
https://nebia.com/	Creates steam to lower total amount of used water	400 Dollars = 2750 DKK		Reduce
https://www.deltafaucet.com/design-innovation/innovations/shower/h20kinetic-showers	Makes water fall in pattern to feel like more water	350 Dollars = 2500 DKK		Reduce
Hans Grohe EcoSmart	Reduces water output	3200 DKK		Reduce
http://waterpebbleus.com/	Signals when to get out of shower	15 Dollars = 100 DKK	Low-end	Avoid

Evaluation

It is clear that the cheaper options, such as the Avoid category of products, often affect the shower experience, making it a chore instead of leisure. Furthermore it was very informative to see which products are on the market, and how these differentiate from each other, either by being cheap or very high-end. The market research also clearly showed the shortfalls of each category, and how this related to the user experience or market position.

Reflection

By creating the market research, we enabled us to see in which category we could position ourselves, it being because of the potential in the market, or due to a gap related to price or user experience. As the Reuse category seems to have a gap when it comes to price, and what a common user would be able to pay, it would be very interesting to exploit this gap, and enter the market with a product for a cheaper price, basing itself on some of the same values seen with the other products. Positioning ourselves in the other categories could result in a product which would not directly compete in the category, but would become another solution towards solving the problem. Furthermore it was clear that the Reuse category was the one which had most potential to not affect the user experience while showering.

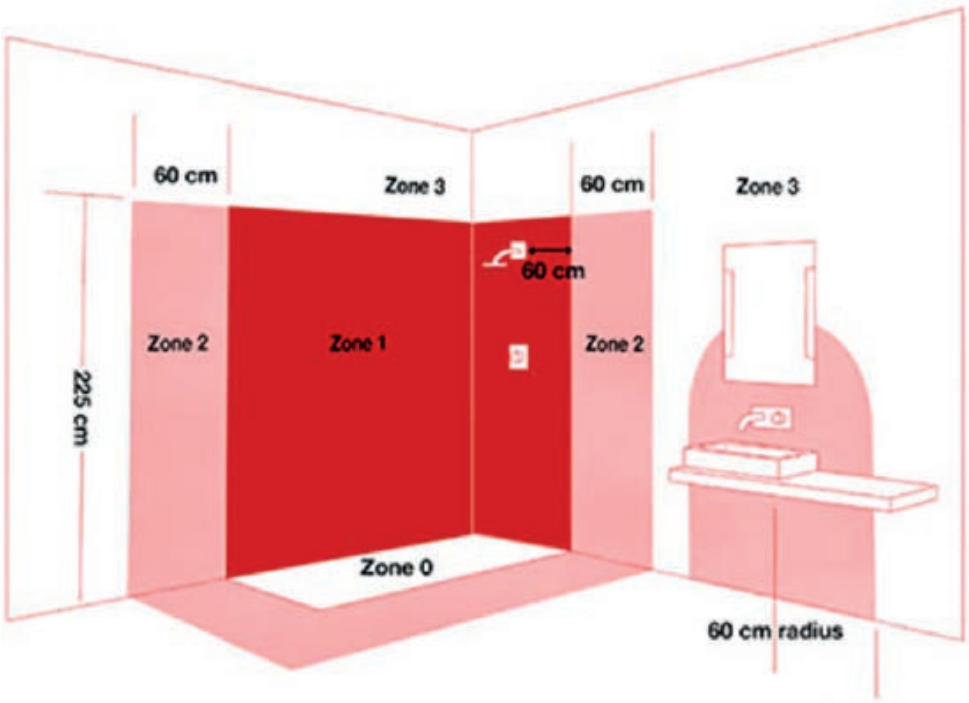
WS4 - Bathroom zones

Date: 22/03/17 Written by: Jacob

Objective

The objective was to find the laws in regards to electrical installations in the bathroom. This was to see how a possible AC solution could work, or whether our solution should rely on a battery.

Data



http://www.jemogfix.dk/fix-det-selv/installationer/vaerd-at-vide-om-badevaerelsesbelysning http://elbogen.dk/badevaerelse/

Zone 0: This is the area inside the shower and bathtub. If there is no shower tub, this is the area 5 cm above the floor. This is the area where direct water splashes and even submersion occours. Only 12V applications must be installed here.

Zone 1: The area above Zone 0. Is basically the area in which the user stand, and with a height of 2.25 metres, meaning the hole wall behind the user when standing in the shower. Only 12V applications must be installed here.

Zone 2: Is the zones just outside the shower, meaning the areas 60 cm outside of the showering area.

Zone 3: Where water is not hitting, by humidity still is a factor.

Placing an outlet in the bathroom.

Placing an outlet in is only legal to do in Zone 3, meaning outside of the normal showering area. If our solution should rely on AC power, the product should be connected in an area which might not be reachable, and the power cable should be long. A way to circumvent this is by getting the shower professionally installed, however this is normally very expensive and would jeopardize the low target price of our solution.

Evaluation

The zone requirements was a very informal research, as it gave insight into how a possible AC solution should be installed, but it also gave insight into how cumbersome it would be, if the user should install the shower themself. Orbital Systems rely on an AC solution, meaning the their "retrofitting" solution should have a cable running into a zone 3 in the bathroom.

Reflection

An AC solution would quickly become difficult for the users to install themselves, due the laws in regards to placements of outlets, and would most likely have to be installed professionally due to this. A battery powered solution sounded like a better solution to fulfill our wish of having a easy and cheap installation, to open up for a larger user segment.
Furthermore it was interesting to know that only 12V applications was allowed to be installed in Zone 0 and 1, meaning that out solution should run only on 12V if it should be installed in these zones.

WS5 - Initial aspirator test

Date: 20/02/17 **Written by: Alex**

Objective

To describe the test setups

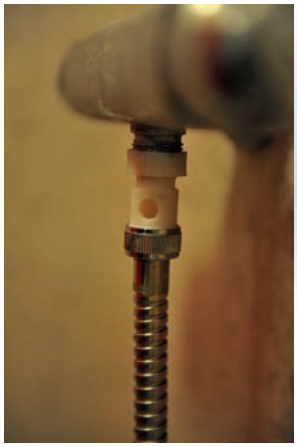
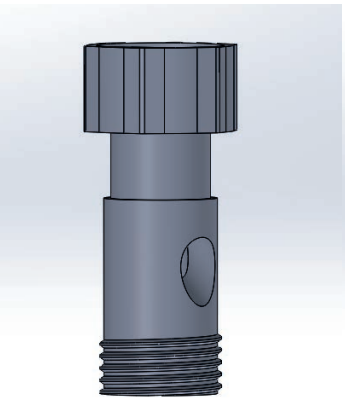
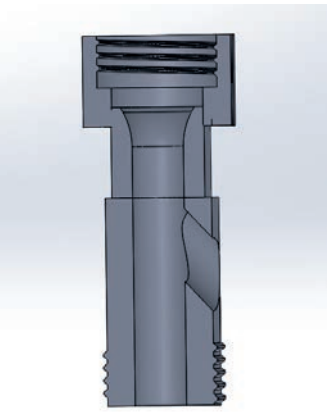
Data

The t-pipe was 3d printed to fit inbetween the thermostat and hose

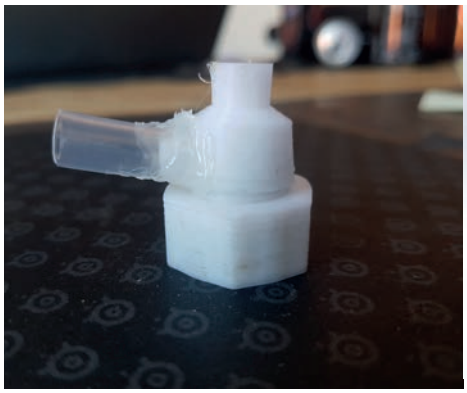
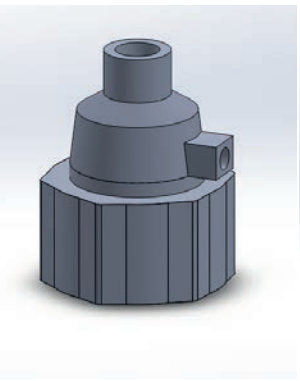
The venturi injector 1 was 3d printed to be fitted direcetly on the thermostat.

The venturi injector 2 was 3d printed to fit at the hose end.

t-pipe

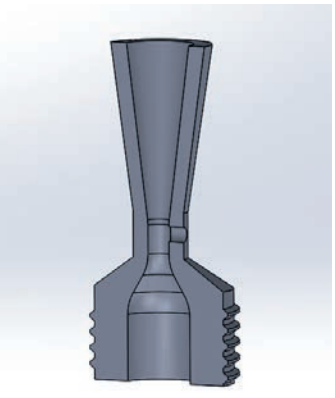




Venturi injector 1


Venturi injector 2



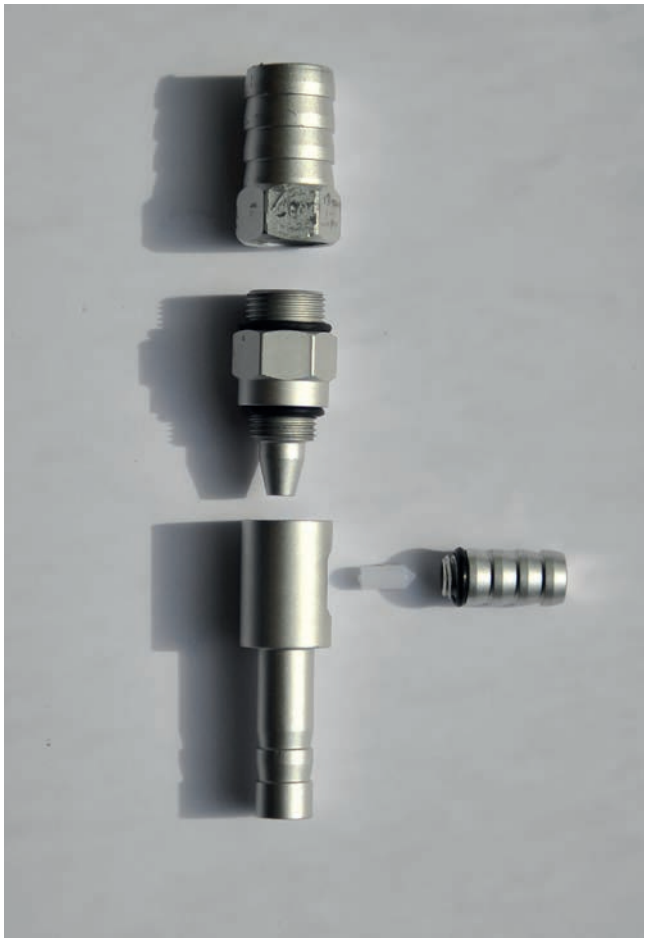


Initial injector test

The aspirator was gotten within the mail and immediately tested. The aspirator was with hand force clamped on the end of a facuet

BOM/assembly

The aspirator compared to the prior 3d printed parts, essentially is the same, except a checkvalve to avoid backflow at the suction inlet. The inlet hole is furtermore very small



Aspirator test 1

The aspirator was fitted to the end of the hose, with a tube connected to the suction inlet goin to a container.
By messuring the water drained from the container, and the total water in the white bucket over 30sec, very precise messurement could be taken,

WS6 - Aspirator test results

Date: 25/03/17 **Written by: Alex**

Data

Green = Fresh water
Blue = Reused water
Brown = Reuse percentage

WITH ASPIRATOR ON HOSE - WITHOUT SHOWERHEAD					
SEC	36	36	36		
	3,500	3850	3900		
	1000	1000	1000		
	2500	2850	2900		
	60	60	60		
	4166.4	4740	4833		
	1667	1667	1667		
	5833.4	6407	6500		6246.8
	1667	1667	1667		
	28.57681626	26.01841736	25.64615385		26.74712916

WITH ASPIRATOR ON HOSE - WITH SHOWERHEAD				
	60	46		30
	5000	4000		2700
	850	600		420
	60	60		60
	5000	5217.391304	86.95652174	5400
	850	782.6086957	13.04347826	840
	17	16.29166667		15.74074074

WITH ASP BETWEEN MIXER AND HOSE - NO SHOWERHEAD		
	30	30
	3000	3000
	220	300
	60	60
	6000	6000
	440	600
	7.333333333	10

WITH ASP BETWEEN MIXER AND HOSE - WITH SHOWERHEAD
30
2500
50
60
5000
100
2

WS7 - Venturi injector design

Date: 25/03/17 Written by: Alex

Objective

Designing our own venturi, suited spefically for the water outlet a thermostat can provide.

Data

Venturi injector design:

In response to test series one, we set out to design our own venturi injector. We are not fluid engineers, nor are we able to calculate the finer details, the only other viable option was to ask experts or look into other industries, we started off with the second option to move forward as fast as possible.

It turns out, there is a small community in the States, where injectors are used to extract gold from rivers are common, and are often designed by experience rather than theory, using simple principles.

By doing a throughout desktop research, both design guidelines and further considerations about venturi injectors were discovered.

Types (The red line is the suction inlet, the greeen is the pressurized water inlet) http://gpex.ca/smf/index.php?topic=10071.0

Design 1 is the most common home-made design for infinity jets. The problem is half the water injected (blue line) is subject to friction of the outer pipe and its energy is wasted.

Design 2 is a much better design, but the constriction is prone to plug-ups. In this case the water injected is forced towards the center where it will do the best job of pushing.

Design 3 eliminates the the constriction. It can be a dual jet, tri-jet or if all the way around, an infinity jet. For the Gould Engineering site, it can be claimed that a tri-jet is almost as efficient as an infinity jet and probably easier to fabricate.

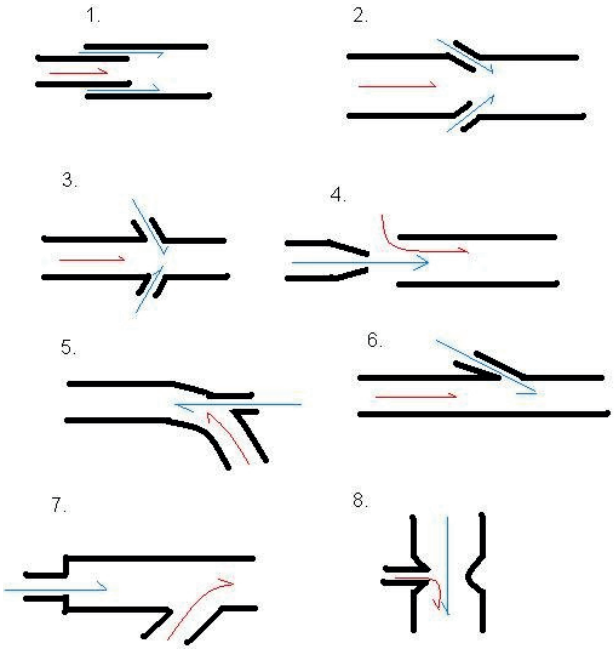
Design 4 is the old hydraulic elevator design. Material is introduced between the nozzle and the pipe. This design can be used for increasing water volume to a washplant. You lose pressure, but you get more water volume than the pump can normally produce.

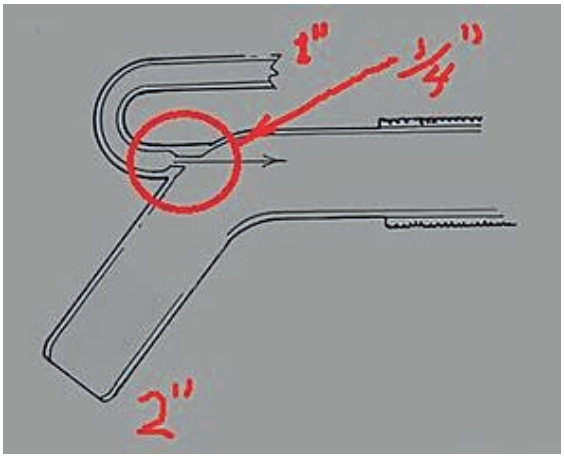
Design 5 is the old stand-by suction nozzle. It has the problem of near-sized getting stuck at the bend. This is plug-up mecahnism is usually reduced by swaging some sort of restriction at the nozzle opening. It is fairly efficient and has the advantage of quick priming.

Design 6 is the log/power jet. The angle is usually somewhere about 11°. Because the of the single injector, it is the least efficient. It has some advantages over a suction nozzle. No second hose to drag around. No unwieldly nozzle to keep in the right orientation. Perhaps most importantly, it is less prone to plug-ups.

Design 7 is the most practical plastic pipe design. It has all the efficiency of the suction nozzle without near the problem with plug-ups. If we run just a wye without the injector restriction, this design works with gravity dredges. Gravity dredges defined as water from farther upstream is piped to the wye and used as the injection water.

Design 8 was thrown in to show a real venturi. Many of you will recognize it as a carburetor. It uses Bernoulli's Principle that restrictions create a low pressure zone draging fuel in from the side port. It is also commonly used for fertilizer injectors in irrigation systems. It has no practical uses for us.





Proportions

The inlet tube must be 1:1, with a narrowing end at 1:4 going into the outlet tube that must be 2:1

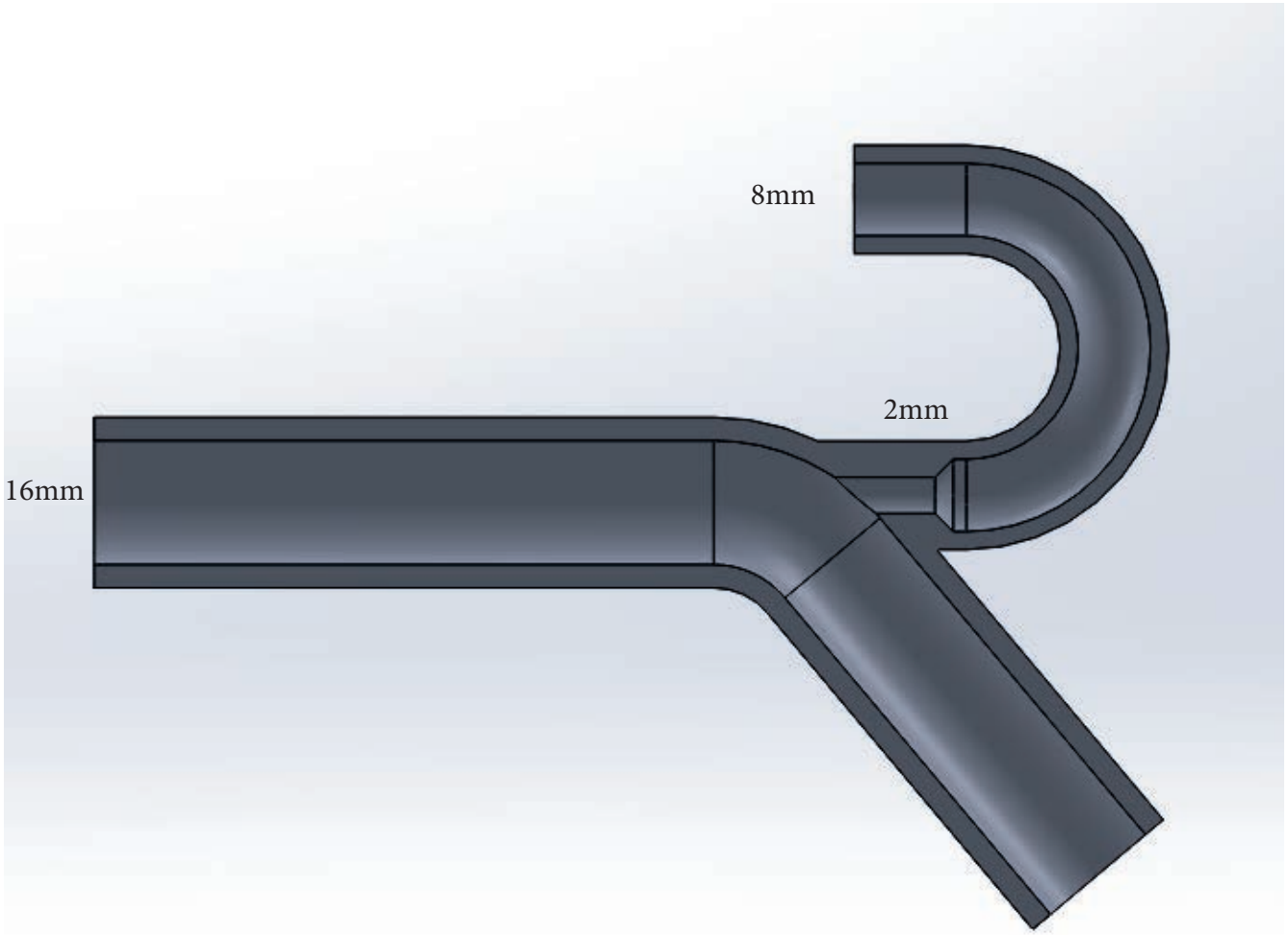
I was gathered, that design 6 is the most powerful, however it cannot be set in series, that does however not impact the usage in showers.

Design 5. was gathered to be the most common

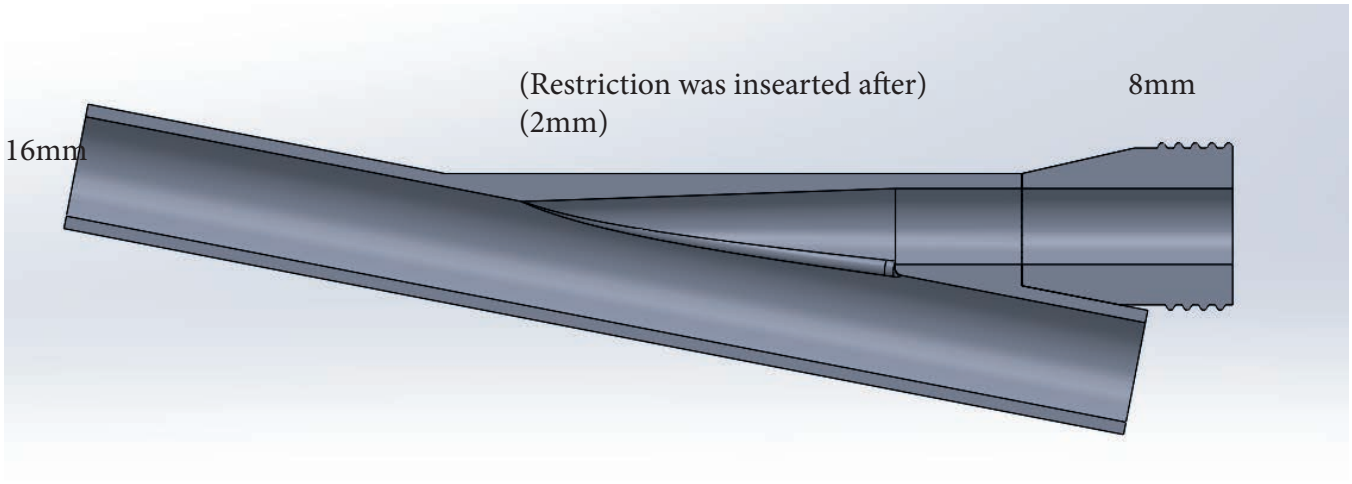
Both designers were adapted according to the above proportions.

The hose outlet is 8mm, that is the 1:1

Design 5



Design 6



WS8 - Lift motor test

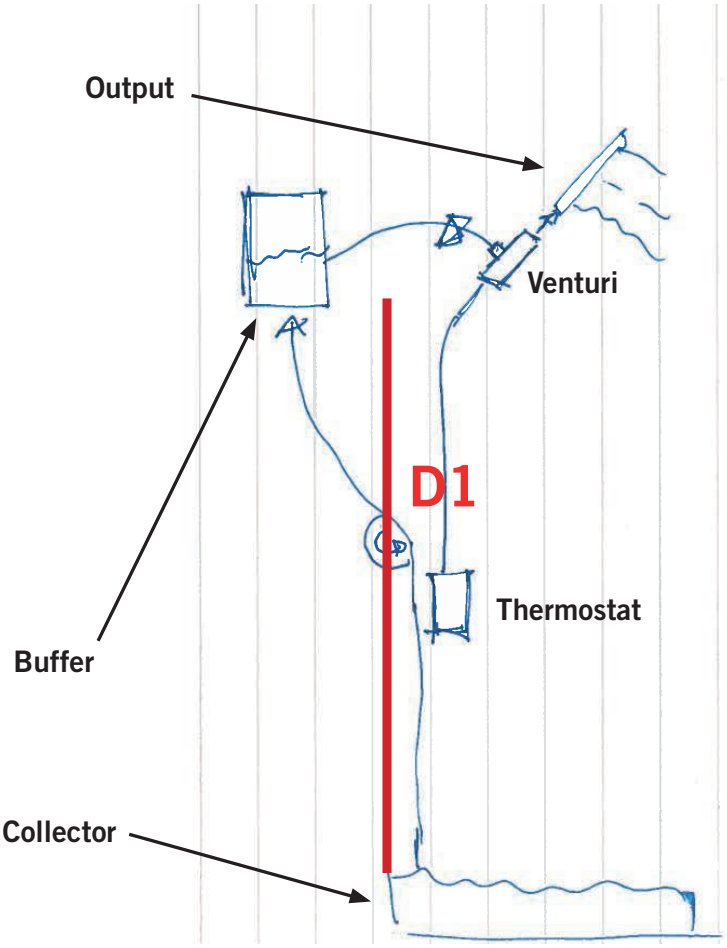
Date: 20/03/17 **Written by: Alex**

Objective

The objective is the detail the lift motor

Data

-The pump must be able to lift fluid up to the buffer tank, at height D1 height.
-The pump does not meet pressure, except what it requires to lift the fluid itself
-The pump must be able to match the flowrate required*
-The pump must be able to withstand water of lesser quality**



** If the total flowrate is 7.5Lpm, and 50% is reused water, then the pump must deliver a flowrate of 3.5 lpm

If the total flowrate is 13 Lpm, and 50% is reused water, then the pump must deliver a flowrate of 6.5 lpm

* This will depend on the filtration, and the resulting water quality.

A simple centrifugal pump was tested, that at 100-150mAh, is able to pump 4 Lpm, scaling up from that point should not be difficult

Evaluation

Lifting the fluid requires very little power, this a little pump, as no resistance is met.

However a centrifugal pump might not be the best choice, as it might be less resistant against dirt, a membrene pump or peristaltic pump is a better choice.

Reflection

The lift pump is not seen as an critical issue, it is a matter of sourcing the right pump.

WS9 - Venturi regulator

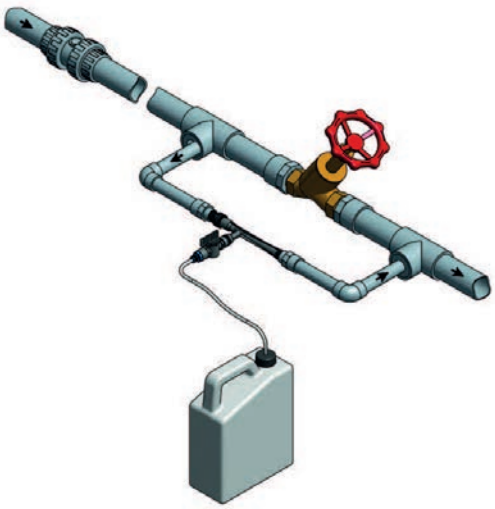
Date: 22/03/17 Written by: Alex

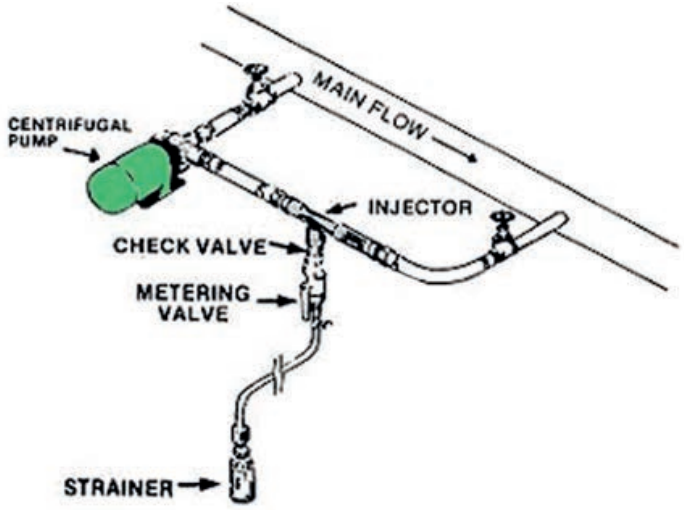
Objective

Describe venturi regulator systems in the fertilizer industry

Data

The venturi injector are used for fertilizer system, a valve system is used to acheive he correct mixing rate.





The system can be adapted as on on/off or mixing rate controller for the shower venturi.

The suction rate and water output can partially be controlled by a venturi regulator system, the system works by the principle, that a fluid will choose the path of least resistance. In the illustration below, a venturi injector is connected to a water supply line by the means of two T-sections with a simple ball-valve in the middle. When the ball valve is open, water will flow directly through, as it is the path of least resistance. When the ball-valve is closed, all water will be pumped trough the venturi injector and maxium suction rate is reached. By adjusting the valve, the venturi can be utilized a varying amount, or simply turned on/off, while a flow is maintained by clean water, this might be very useful if the used water is to be stopped, but clean water is still needed.

WS10 - Temp in-depth

Date: 02/04/17 Written by: Jacob

Objective

The objective is to see how temperature affects different aspects of the shower, it being the floor, or the user themself. Furthermore it will give us insight into how water dissipates heat onto the floor and user.

Introduction

As the system relies on the principle of water and heat, and the properties involved with, flow, heat transfer, heat loss etc. it would be beneficial to be able to measure and get a visual understanding of the water and heat. Furthermore, by being able to visually illustrate water spread and flow, different shower heads can be tested, and the effect of each shower head on the body can be both seen and measured.

To test these parameters, an FLIR One camera is used.

Data

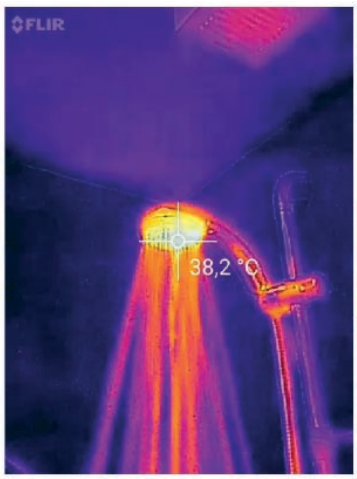
Test setup

The FLIR One is set up in the shower, and is able to record both the heat map and temperatures throughout the shower. The camera is set to record video which then later on can be analysed, and measurements of the temperature can then be recorded.

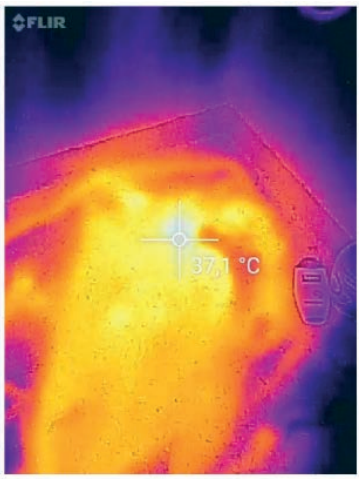
Testing for water loss from shower head to floor:

As the recirculation system needs to ensure that the water has the right temperature when it is reintroduced to the user, the used water is fused with new water which has a higher temperature, ensuring that the output water is at the right temperature.
Measuring the water at the shower head, and at the spot where the water impacts the floor, lets us see the difference and heat loss the water has in the beginning, where the floor is cold, and throughout the shower, when the floor has heated up. This makes it possible for us to make accurate assumptions in regards to heat loss, and how the recirculation system should be tuned to deal with this loss.

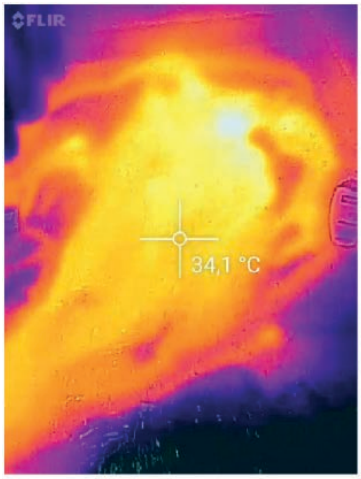
The result was that the loss of heat was around 2-6 degrees, depending on if the floor was cold or heated by the water for a duration of one minute, and how far towards the drain the water had traveled. Interestingly enough, the water did not lose more heat when it had to go from shower head, to body, to floor, so the heat transfer from the water to the body is minimal. Furthermore the temperature decreased when the water flowed towards the drain, however this effect was minimized when the floor had heated up after a while.



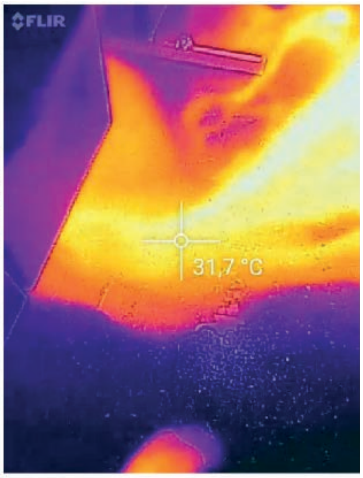
Water temperature at shower head.



Water temperature at floor hot spot.



Water temperature outside of hotspot.



Water temperature close to drain.

Test result

Water temperature at shower head	**38,2C**
Water temperature at floor - Hotspot	**37,1C**
Water temperature at floor - Out of hotspot	**34,1C**
Water temperature at floor - Close to drain	**31,7C**

Testing coverage of water on body

While showering, the coverage of the water and the heat map was analysed. As one of the comfort features of the product relies on the coverage and temperature of water, it was important to look at how the current shower head covers and transfers heat to the body. Creating a heat map throughout the shower, will allow the team to see the water and heat coverage on the body, and see if certain body parts are hit more by water than others.

The testing were done twice on two different users. The results showed that the shoulders are mostly outside of the water stream, and is considerably colder than the rest of the body, the user is therefore also more prone to moving around in the shower, ensuring that the shoulders are also hit by the warm water. The water stream from the ordinary shower head was very focused and did not spread much, this can also clearly be seen, as the torso are completely enveloped in warm water.

The shoulders and arms are not heated as much as torso.

One side is noticeable colder than the other.

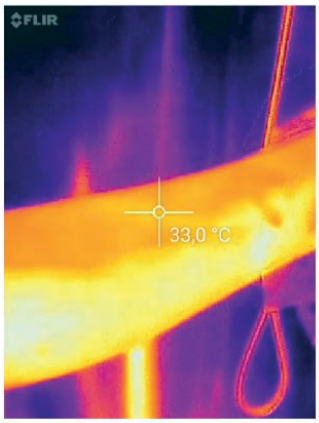
Second user - Same pattern can be seen. Arms are left out.

Testing of pulse with bucket

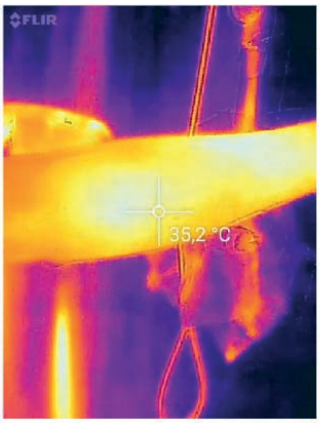
To simulate the feeling of being drenched with higher amounts of water at once, a bucket was filled with water and poured over the user. As the pulse of water is considered to be one of the comfort features in the product, it was necessary to visualize the effect of having larger amounts of water poured on the user had, and also how the temperature was distributed across the body.
The testing would be able to give an indication whether the sudden larger amounts of water makes any measureable difference. As the feeling of more water getting poured is different compared to the normal shower, and as the larger amount of water feels warmer when poured, it would be interesting to see whether the feeling was able to be measured, or whether this is just a imaginary feeling.

The testing showed that it was difficult to fully see how the water had any impact on the showering experience, as the water poured had the same temperature as the water coming out of the shower head, meaning that that there was no noticeable temperature difference to be seen on the heat map. The only difference noticeable was that a larger surface area of the skin was covered immediately, instead of being heated by drops of water, as normal.

The testing was redone to see if the sudden pour of water was noticeable if the user was not inside the ordinary water stream when the pouring of water would happen. The skin temperature of an arm was measured, and was immediately moved into the water stream coming from the shower head, in the meantime a bucket was filled with water, and the arm was removed to simulate the water stream turning off. This showed that the skin was not evenly heated by the water stream, as some areas on the arm were colder than others. When the water from the bucket was poured it was noticed that the heat was much more evenly distributed, and the whole area had close to the same temperature. This result could mean that due to the much more evenly distributed heat on the skin, that the feeling of warmth is more noticeable, therefor making it feel hotter than the ordinary water stream.



Skin temperature and heat map before entering the water stream



Skin temperature after being in the water stream

Skin temperature after being poured with water

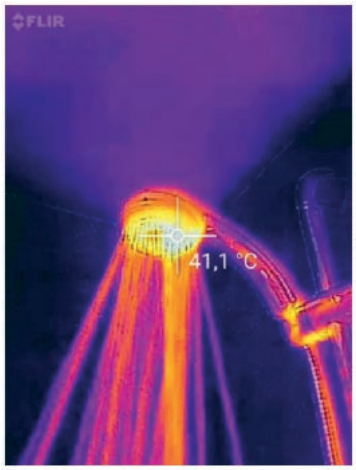
Initial water temperature measured at head

Test result

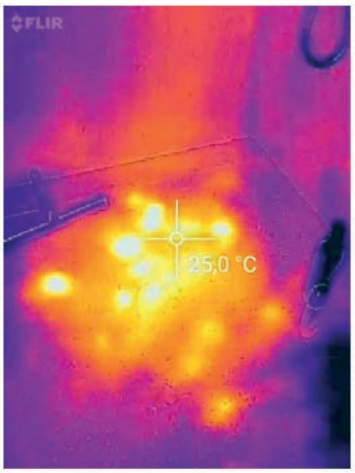
Water temperature at shower head	38C
Before entering water stream	33C
After water stream	35,2C
After dense water pour with bucket	36,9C

Testing of room heating

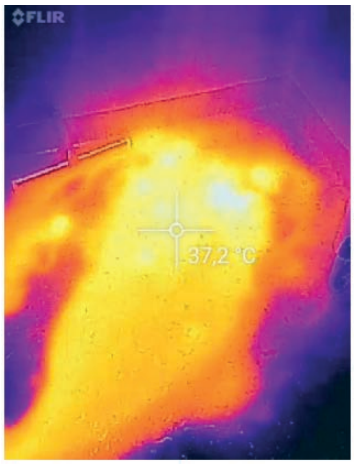
To see how the room would be heated, and how the heat would distribute through the bathroom, the test were started in a unheated bathroom, and the shower were turned on for a duration of 10 minutes, in which the heat map was analysed afterwards.



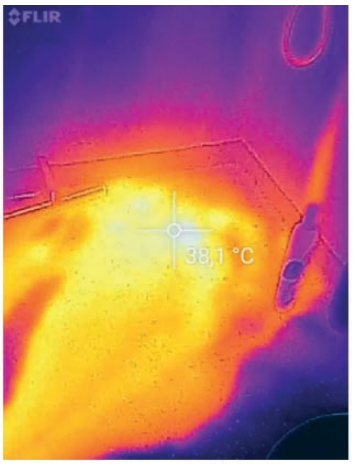
Water temperature at shower head



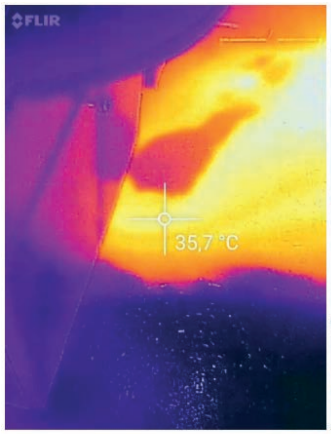
Floor temperature at water start



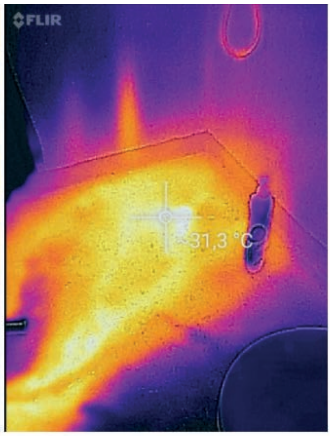
Floor temperature at one minute



Floor temperature at 10 minutes



Water temperature close to drain



Floor temperature three minutes after water stop

Test result

Water temperature at shower head	41,1C
Floor temperature at water start	25C
Floor temperature at one minute	37,2C
Floor temperature at 10 minutes	38,1C
Water temperature close to drain	35,7C
Floor temperature three minutes after stop	31,3C

Evaluation

The temperature had a clear impact on both the floor heating, and how it was dissipated on the user. This shows that we have to take the temperature into consideration when it is picked up at the floor, due to the temperature decreasing. This temperature decrease is however less, when the shower has been running for a longer period, due to the floor heating up.

Reflection

Due to the temperature decreasing when it is picked up, it will be necessary to look at how this temperature difference can be dealt with, whether we should heat it or mix it with new water to compensate for the temperature loss.

WS11 - Thermal imaging

Date: 24/04/17 **Written by: Jacob**

Objective

The objective is to give a short explaination of thermal imaging, and the camera used for the thermal tests.

Data

Thermal imaging functions through IR, the infrared rays which is emitted of objects. This gives a possibility to meassure and create heatmaps of objects, which includes water in our tests.

FLIR One:

The FLIR One is an infrared camera, capable of illustrating a heat map and measure temperatures through a thermal sensor. The camera is connected to a common smartphone, and videorecording and images can be recorded.

On the left is a heatmap of a hand. By creating heatmaps, it is possible to get a much better understanding of different temperature differences in the image, and see how water covers the body, and see how the floor changes thermally along the shower.

WS12 - Mixing water temperature

Date: 25/04/17 **Written by: Jacob**

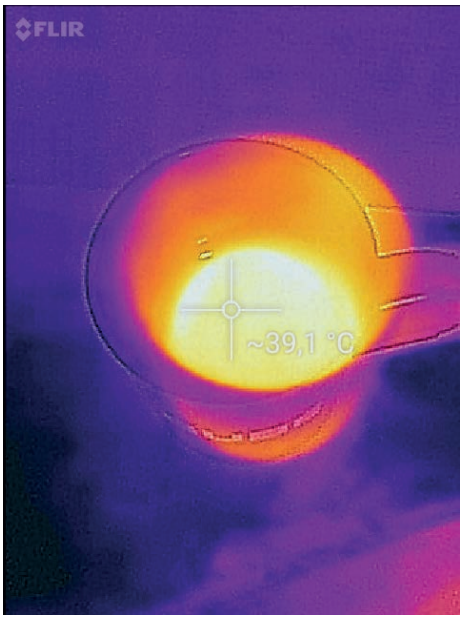
Objective

The objective is to see how the temperature of water is changed when mixing two different temperatures. This is necessary, as we want to mix both the clean water from the mixer with colder water which is recirculated.

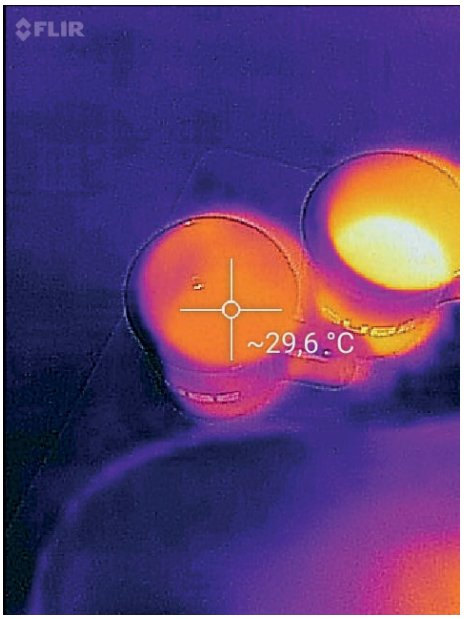
Data

The tests works by having two cups with 100ml water, with a temperature of 35C and 25C, the waters are mixed, and it can be seen that the final temperature is 30C. This proves that mixing water in this way, directly translates to a temperature inbetween.
Furthermore, this can also be calculated:

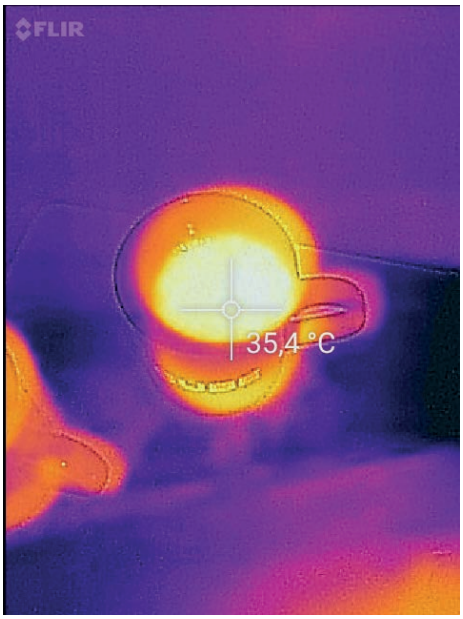
T = (m1c1t1 + m2c2t2) / (m1c1 + m2c2)
Where T is the final temperature, m is the mass of the first liquid, c is the specific heat of the liquid and T is the initial temperature of the liquid.



Water at 40C



Water at 30C



Water mixed at 35C

Evaluation

It can be seen that there is a clear relation to how the water temperature is mixed when two different tempered waters are mixed, this means that mixing the two water (clean and recirculated) should not be a problem.

Reflection

Mixing the water is not a problem, and it is now proven that if we want output water of 40C, and the recirculated water is 30C, we should be mixing in 50C water at a 1:1 ratio.

WS13 - Resistance test

Date: 29/04/17 **Written by: Jacob**

Objective

The objective was to see if the resistance in different fluids was possible to meassure, and if this could be used as a way of filtering out fluids which are unwanted, such as urine.

Test set-up

A multimeter is set-up and the probes are distanced one centimetre from each other in the fluid which is to be tested, the distance is very important, as the resistance increases with the distance from the probes. The resistance is measured on the display and noted down.

Data

Resistance in salty fluid (Pepsi Max)	**28 kOhm**
Resistance in tap water	**149 kOhm**

Evaluation

As can be seen, the resistance is much lower in the Pepsi Max, as it has much more salt. It is very clear that it is possible to see a resistance difference between the tap water and the Pepsi Max, however as Urine is a waste fluid which changes mineral properties depending on how much the user has been drinking, and what he/she has been drinking, the resistance might change. This could be a very cheap way of measuring what the fluid is, however due to the forementioned problems, it could also be very unreliable.

Reflection

Using resistance as a cheap way of filtering fluids could be interesting, however as urine specifically changes properties as mentioned, it might be better to look at how the resistance is different among other products used in the shower, which can then be filtered, as urine would be to unreliable to do properly.

WS14 - Corresponance with Miljøstyrelsen **Date: 07/03/17** **Written by: Jacob**

Objective

Correspondance with Miljøstyrelsen
The objective were to find whether there were any rules in Denmark regarding the means of recycling greywater in the shower.

Data

The data gathered were information regarding drinking water and rules regarding that. Furthermore we got links in regards to greywater and how that can be used while following the rules.

Drinking water:
https://www.retsinformation.dk/Forms/R0710.aspx?id=174907
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1998:330:0032:0054:DA:PDF
http://svana.dk/vand/vand-i-hverdagen/drikkevand/kontrol-af-drikkevand/

Shower water:
http://svana.dk/vand/vand-i-hverdagen/genbrug-af-vand/

Grey water:
http://naturstyrelsen.dk/media/nst/7496661/140304%20Udredning%20om%20brug%20af%20sekundavand%20i%20Danmark.pdf

Evaluation

Through the mail correspondance, it was made clear that there was not clear distinction between grey water used for toilet flushing and showering, this is something they need to discuss internally.

Reflection

As there is no rules set for using grey water as shower water, and as we will only be using water from the same individual which is going to receive the grey water, we believe that there is nothing restrictual holding the project back.

WS15 - Filtration values

Date: 04/05/17 Written by: Jacob

Objective

The objective is to be able to dimension the filtration, specifically the screen filter, the sensory, the UV filtration and lastly the dilution.

Data

The screen filter

The screen filter should filtrate hair and larger particles, to avoid introducing these particles to the system.
As the hair is the thinnest of particles unwanted in the system, this can be seen as the filtration threshold. Human hairs range from a diameter of 17 to 181 µm, however a common human hair can be said to be 100 µm, or 0.1mm thick.
Screen filters is dimensioned by their mesh no. a higher number, meaning a denser hole size, also called an aperture.
The correct mesh no. for our application is No 200, due to the 0.074 mm aperture size, which will filter the hair, without restricting the water flow considerably.

Mesh no. diagram.
http://www.sigmaaldrich.com/chemistry/stockroom-reagents/learning-center/technical-library/particle-size-conversion.html

Hair sizes:
http://hypertextbook.com/facts/1999/BrianLey.shtml

Sensory

The sensory system consist of a turbidity sensor, responsible for measuring turbidity (haziness) in the water, and a resistance sensor, responsible for measuring resistance in the water.

The accepted turbidity in showering water should not exceed 5 NTU, meaning that the water should be close to clear as drinking water. However as the water gets diluted in the end, with a ratio of 50% used water and 50% new water, the accepted NTU at this stage can be double of the outputted NTU. To ensure that this is complied with, the turbidity sensor is calibrated close to this value, and will tell the system when this value is exceeded.

https://www.kjwc.org/water_quality_alerts/turbidity_faq/

The electrical resistance of water changes depending mainly on the saltiness concentration in the water, and the density of other minerals. Some preliminary tests have been done on this.

UV filtration
The UV filtration should eliminate any dangerous bacteria from the water, before it is reintroduced onto the user.

Dangerous bacteria consists of E. Coli, which through the EU regulation should not be found in drinking water, meaning that in a sampling of 100 ml, zero E. Coli bacteria should be found. This should therefor be completely filtered in the recirculation system, and should not be reintroduced onto the user, as the bacteria can be both transferred through the water, but can also be airborne due to the high humidity created in the bathroom.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1998:330:0032:0054:DA:PDF

To eliminate the bacteria in the water, mercury lamps are normally used due to the wavelength of light they emit. The wavelength for destroying bacteria is around 254nm (UV-C) at a specific wattage in relation to how fast the elimination should happen.

https://en.wikipedia.org/wiki/Mercury-vapor_lamp

While mercury lamps are effective, they are also very power inefficient, and due to ELVA using a battery, this is not an option.

LED's has become increasingly available in the needed wavelength, and is much more power efficient, crucial to a battery driven system.

Based on an open source project concerning reusing water(Showerloop), the wattage needed for eliminating the bacteria in a span of seconds is 8W, however this is with the use of a mercury lamp, meaning that the equivalent wattage needs to be found with the use of LED's.
https://docs.google.com/document/d/1SH_oGhC3JrDVmkOrh9ITMHL4rzs_eL7-klx4UQVFZCk/pub

A LED can be said to be 10 times more efficient than a regular mercury lamp, meaning that to create a 8W mercury lamp equivalent with LED's, the wattage should be 0.8W.

As the LED's chosen has an individual output of 0.1W, eight of these should produce the wanted 0.8W.
To be safe, and to take degradation and manufacturing differences into consideration, 20 LED's are to be installed.

By eradicating the bacteria, it is possible to reintroduce the water onto the user.

Dilution
By diluting the used water with new water, the concentration of used water is minimized. This means that the NTU is halved if the dilution ratio is 50/50. Furthermore possible soap remedies will be further diluted.

Evaluation

The filtration has been defined at it is not possible to dimensions the filtrations principles appropriately.

Reflection

The filtration techniques seemed possible, and as such was not replaced with something different. The dimensioning of the sensory and mesh filter made it possible to get a look into the overall look, and how it should be incooperated into the design. Furthermore the UV dimensioning made it possible to calculate power draw.

WS16 - Testing acceptable dilluted water

Date: 08/04/17 **Written by: Jacob**

Objective

The objective is to see how visible soap is when diluted in water. This will give insight into whether user will be able to see the soap when showering, and thereby evaluate whether having soap in the recirculated water is acceptable.

Data

Different kinds of soap was diluted into water. Shampoo and body soap was diluted with different amounts into the same water, and the water was then evaluated, to see whether the soap was visible.

Tab water, completely clear.

One squirt of greenish body soap was introduced to the water. The water was a little more hazy, however it was not directly visible if the water was poured out.

Two squirts of greenish body soap was introduced to the water. The water was now hazy to a level which was possible to see when the water was poured.

A squirt of shampoo was introduced, and the water became completely hazy, which also possible to see when the water was poured.

Evaluation

It became apparent that hazyness has as much with the product to do, as it has with the amount added to the water. The greenish body soap was more hazy than a clear soap, and the small amount of shampoo added made the water completely hazy.

Reflection

As people use different products in the shower, which might also be colored, hazyness is difficult circumvent, however as soap is not dangerous, the turbidity of the water is only a perception, and it would be completely acceptable to shower in the most hazy of water, if it is only soap which has contaminated the water.

WS17 - In talks with possible partners **Date: 12/04/17** **Written by: Jacob**

Objective

The objective was to see if it was possible to collaborate with a possible partner throughout the project, and if so, which partner it should be. Several companies were contacted, which are engaged in showering products already.

Data

Several companies were contacted by email or phone.

Damixa

Damixa was open about a partnership, however as they were not creating any new products at the moment, and the resource budget was very low, it was not deemed relevant for them to work with us. However it was still seen possible that we could chat with them if we had questions. This did not become relevant for the team.

Hans Grohe

Was very open about working with us, and a longer period of mails and phone calls led to a believe that a partnership could function. It was later discovered that the R&D department were placed in Germany, and it was not possible for the team to be a external team, so we had to sit in Germany to work on the project. This was deemed very cumbersome for the team, and it would be difficult due to the need for housing, and due to being isolated from the university in Aalborg.

Grohe

We never got an answer back from Grohe.

Vola

Vola was closed off in regards to the project, as they already had a bunch of architecture teams working with them in collaboration with their master project.

Oras

Oras was also open about the project, however after further explaination of the project, it became clear that they would not be able to contribute to the project in a way that would help the team.

Evaluation

The different companies was mostly open about working with the team, however it became apparent along the way, that it was not clear in what way the companies would be able to help the team. The team was hesistant on having a partnership with a company, if we could not see how it would benefit us.

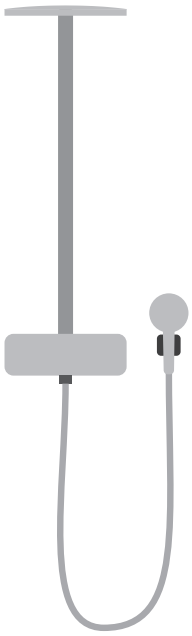
Reflection

The product that the team was to create would not imeddiately fit into any of the companies product portfolios, and there was not technology that the companies had that we would use in our product, meaning that getting information from the companies would be limited down to sales numbers etc. A offer we got from Hans Grohe.

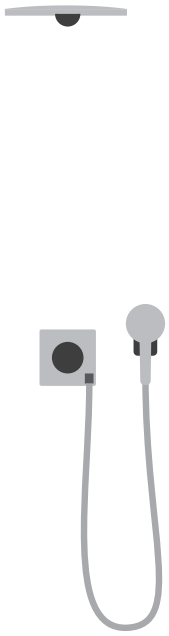
CURRENT SHOWER SYSTEM ARCHITECTURES

The objective is to gain insight into the current shower setups, what are the archetypes and what modules do they consist off, this is valuable, as it creates an understanding of where it might be possible to integrate the ELVIRA technology with the biggest impact, from a point of standarization.

Traditional Shower Set
Based on an independent showerhead, and external mixer, these product are more common, and is placed in the lower end of the price range. The architecture consists of one showerhead, with a hose connecting it to the mixer.
1000 - 7000 dkk



Two shower head set
A higher end shower with two shower heads, one independent, which can be moved freely, and one stationary, which is situated above the user. These products can be acquired within a low and high price point, depending on the brand and quality. The architecture consists of a moveable showerhead, a stationary showerhead, and a mixer connected to both showerheads.
2000- 24000dkk



Wall-intergrated shower set
The highest end shower consisting of a built-in system with two showerheads. This architecture is priced in the higher-end with a need to renovate the wall, which the product is installed in. Due to the product being built into the wall, these showers are usually very covert. The architecture consists of a moveable showerhead, a stationary showerhead, and a mixer connected to the stationary showerhead with a built in hose, and to the moveable showerhead .
3500- 30000dkk

The prices are gathered from billigvvs.dk

OUTPUT

The three architectures are differentiated by the price point and features they incorporate. Architecture 1 and 2 are widely based on the same principals, with an added stationary showerhead being the main benefactor when choosing between the two. Architecture 3 separates itself by being mostly built into the wall, therefore hiding parts from the user. This also requires for a more throughout renovation of the wall, and is mostly aimed for new bathrooms being built, which further increases the price.

The mixer, showerhead and cable are the three most common elements, building the feature within one or more of these three elements would ensure a high coverage. Whereas building it into the overhead showerhead, might provide a feature to an already high-end product, perhaps creating a more attractive product.

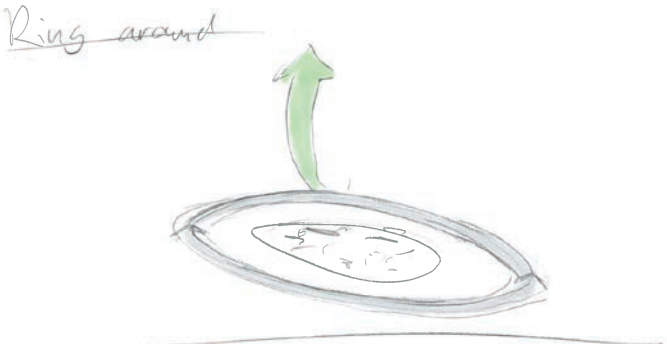
WS19 - Choosing the mat

Date: 29/02/17 **Written by: Alex**

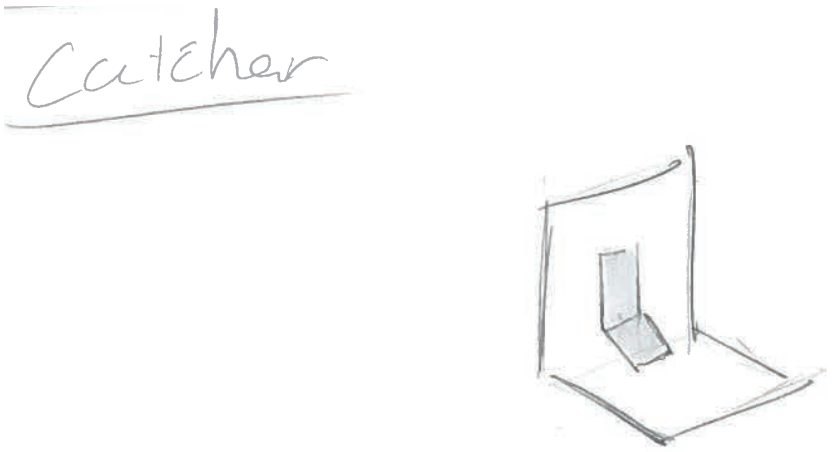
Objective

Evauluation of the collector ideation phase

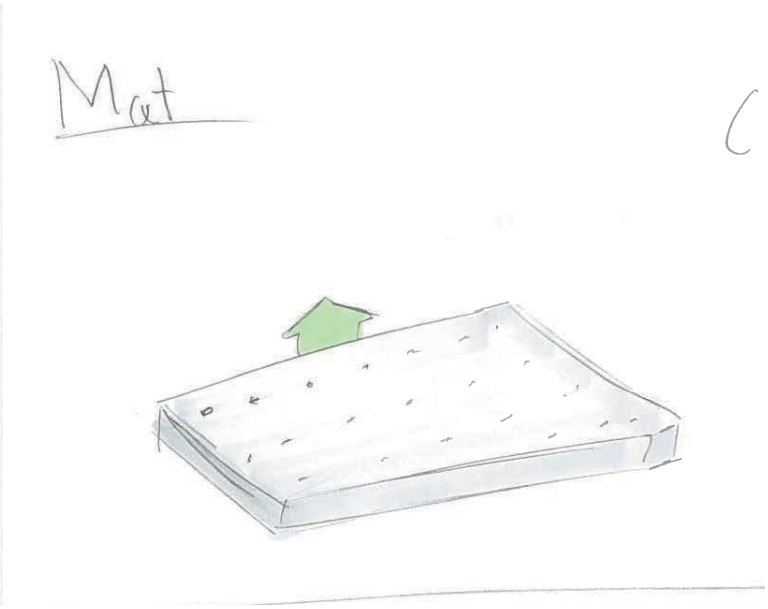
Data



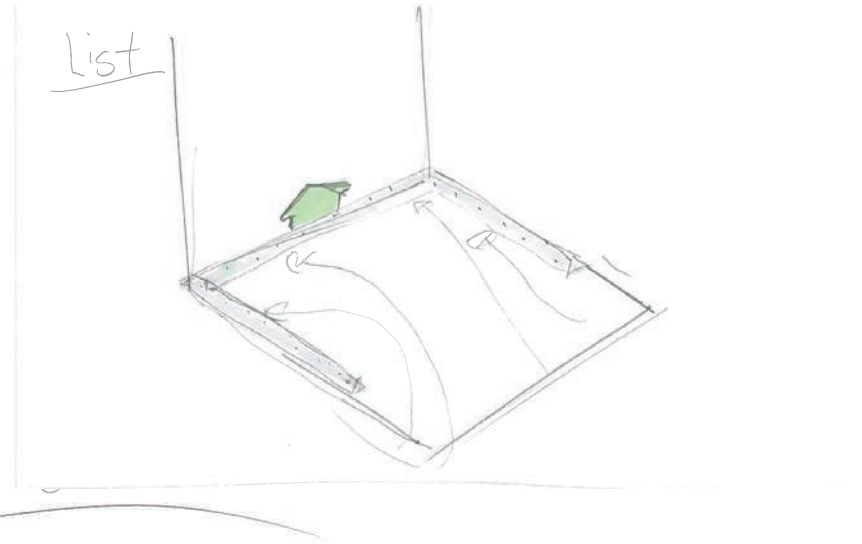
A ring around the drain, it will most likely be able to fullfill the goal of effiency, however the user might have to stand on it, thus blocking it.



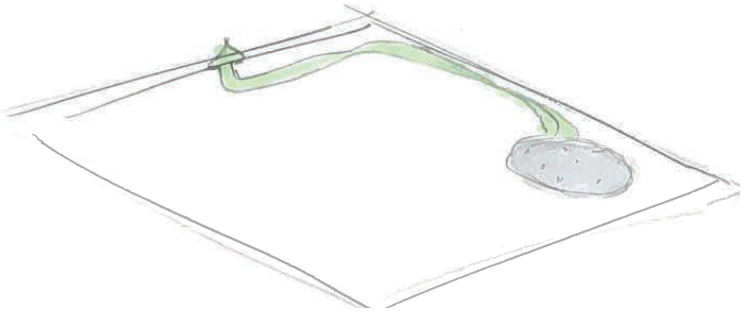
A catcher mounted to the wall, thus no interference on the floor, however it is very questionable that it will be able to collect enough water



A mat that the user can stand on, it is a known design that works

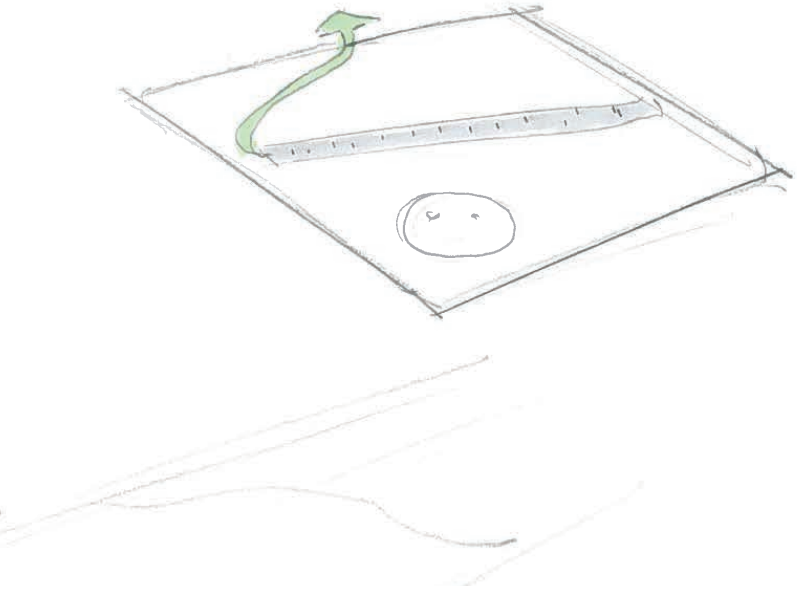


Corner collectors, it is questionable if it will be able to collect enough water, however it will interfere little with the user. Not all bathrooms might have enclosures, and the walls might be furter removed, thus lowering the water collected



Drain cover, will be able to collect enough water, however might be clocked up very often, as the collection point and drain point is the same.

This further raises the point, that the drain and collection point are close, which might be perceived as dirty



Bar across, could possible be able to collect enough water, however it is very questionable.

WS20 - Gathering flow info

Date: 24/02/17 **Written by: Alex**

Objective

The objective is to probe what flowrate people have in their homes, to know if there is sufficent flow rate to feed the venturi injector

Data

Andreas		
6 lpm	36c	With showerhead
4.5 lpm	50c	With showerhead
Stefan		
12.6 lpm	46c	With showerhead
Jacob & Alex		
7	40c	Without showerhead
6.3	40c	With showerhead
Peter		
10 lpm	38c	
John (real life persona)		
12.6 lpm	40c	With showerhead
15.8 lpm	40c	Without showerhead
Nicole (real life persona)		
6 lpm	40c	With showerhead

Evaluation

The flowrates, except one are all well above 7 lpm which was used in the tests.

Reflection

This probe is deemed sufficent for now, to know if enough flow rate is available to feed the venturi.

WS21 - Battery capacity calculations

Date: 08/05/17 **Written by: Jacob**

Objective

The objective was to calculate the estimated battery capacity and power draw from the current solution. This was to ensure that we could create the product as a battery powered solution with an acceptable runtime.

Data

Battery capacity

The chosen batteries were 3400mAh 18650 cells due to their availability, affordability, and due to their proven reliability. The battery pack are created as a 4S4P pack, meaning four cells in series creating the wanted 14.8V normal voltage and 4 packs of these in parallel creating the wanted capacity of 13600mAh.

Battery capacity	
4x	
DISCHARGE IN USE	
Buck converted to 12V 90% ef	
735.1351351	mAh per Volt
2058.378378	mAh at 100%
1852.540541	mAh at 90%
BATTERY CAPACITY	
Total mAh	
Pump	
UVC LED's	
Running LED strip with 5 LEDS	
Indicator LED's x 10	

The 14.8V will be too high for the components used in the solution, and must be converted to 12V. This is done through a Buck converter which ensures that the voltage is kept stable at 12V.

As the cells should never be discharged under 20% capacity, only 80% of the 13600mAh is usable, 10880mAh effectively. As the Buck converter lowers the voltage, the effective capacity increases, however this is only done at 90% efficiency, meaning that about 1850mAh is left from the conversion, which should be added on top of the 10880mAh, making roughly 12730mAh.

Component power draw

As the system was contructed from being low powered from the ground up, the power draw is fairly low at only 740mAh at max usage, meaning when everything is running all the time, which is not the case in most usecases.

This adds up to 17 hours of continous use of the system, before the battery pack needs to be charged.

Evaluation

The battery in the solution would be suitable for 17 hours of continous running, meaning that a person like John would be able to enjoy the shower for 34 days before having to rechage, if he was showering for 30 minutes each day.

Reflection

The total power draw of the systems seems low, however it will be necessary to later look over the solution again, and add eventual new components to see how this will affect the total runtime.

Objective
The object is to document the personas result, which was 6 persona profiles, 5 of based on real personas, and the father was based on an inteview.

Data

NICOLE - THE SOLUTION ORIENTED AND METHODICAL

About Nicole
Nicole is a young lady with semi coarse hair down the lower back, she often has straightened hair and places a lot of importance in appearance. She is single, and therefore does not deem is necessary to not shave legs in the winter, when leg skin is not revealed. She lives with a roommate and the apartment has one shower. Her roommate, and herself has a different opinion of cleanliness.

Context
Nicole showers in the evening, towards the end of her recreational time before going to bed. She has a traditional shower set and usually the window is open while showering creating a colder environment. She lets her hair dry before going to bed.

Motivations for showering
For Nicole showering is a function to uphold her appearance, she considers the shower part of her grooming process in which her hair must be shiny, smooth and easy to straighten, her face is scrubbed to remove impurities and her body is cleaned to uphold hygiene in a efficiently and fulfilling way.

Frustrations for showering
Nicole views showering as a grooming process that has to be done, not only for herself, but also for the people around her, going outside without showering, or rather not doing the beautifying processes that she does within the shower is not an option for Nicole. Showering is therefore often viewed as a chore, that she wished she not not have to do.

Shower behaviour
To make the shower chore more bearable, she turns on music and often sings along. The shower is turned on before she unclothes as it minimizes the transition time, avoiding the cold room.

When she showers, she strives to done as fast as possible while still being very throughout in her cleaning and beautifying activities, she is even willing to compromise her comfort, should it interfere with getting her shower activities done to her standards, for instance she turns off the shower when applying body soap, to be able to throughout lathe her body in soap, without the water washing it off.

Throughout the whole duration of the shower, every minute is filled with a task, and exactly when those cleaning and beautifying activities are completed, she too is done with the shower.

A large part of showering for Nicole is to uphold her appearance, as such she does not do all beautifying activities if they are not necessary.
She does not condition her hair everyday, nor does she shave her legs everyday in the summer, she does what is needed to uphold her appearance.

She showers for around 20 minutes. The only exception being, due to being outside in the cold, a hot shower is an easy way to get warm and cozy, to acclimate from cold to warm which is enjoyable and comfortable, wherein she can shower up to one hour.

Ideal experience
-The ideal shower experience for Nicole is one that supports her at completing her shower activities fast as possible, while being very throughout in terms of reaching her goal of cleanliness and appearance.
- She seeks entertainment in the form of music and dance to make it more bearable, the ideal shower experiences, has to keep her entertained to reduce the boredom.

JOHN - THE PERFECTIONIST - APPEARANCE AND COMFORT

About John
John is a 32 old guy with a longtime girlfriend, he places importance in appearance, and is a perfectionist that buys brands and quality.

Context
John lives in an older apartment and wakes up early in the morning to shower due to his girlfriend also needing a shower. The bathroom is normally quite cold due to the lack of floor heating, which is why he does not open a window in the start of the shower, due to the heat loss.

Motivations for showering
Showering is a vital part in John's morning ritual and is a way of him freshening up for his daily work routine, and a way of opening his pores for his daily shave. Due to having a girlfriend and a fulltime job with human interaction, it is important for him to look good. Furthermore the shower is a way for him to relax, and a place in which he feels completely comfortable, which he defines as the feeling of running hot water on his body, steam, and the feeling of being in a state of complete relaxation.

Due to not having to hurry in the shower, he puts a lot of effort into making the shower as comfortable as possible, avoiding discomfort by turning of the shower. Furthermore as the shower is one of his favorite places to relax, he has no hurry to finish quickly, this results in him taking good time when grooming, extending his comfortable period.

Frustrations for showering
As showering is so much of a relaxation activity as a grooming activity, John is very profound in regards to the comfort in the shower. As the bathroom is normally cold when entering, John is often very cold when unclothing, and getting into the shower cannot go fast enough. When it is time to leave the shower, John is hesitating as he knows he is going to lose the comfort once again, leading to him taking longer showers due to the thought: "I don't want to be cold again"

Shower behaviour
As John does not want feel the cold when unclothing, he turns on the shower, letting it heat up the room a little, before removing his clothes. This lets him go from a comfortable state in clothes, to a less uncomfortable state unclothed. While showering John enjoys every bit, due to the comfortable feeling of the water, and uses a great time making sure that his shampoo and conditioner has had effect on his hair. Furthermore he uses soaps to clean his body, in which he is very thorough. As he wakes up early, he does not have to hurry, meaning that he can comfortably enjoy the shower, which he does.

When showering, John uses the first 5 minutes as a relaxation period, where he gets into his comfortable zone. The next 10-15 minutes is used for his grooming products, and when that is done, he often uses 10 minutes to just relax and feel comfortable in the shower. While using the grooming products inside the shower, he does not turn of the water, as he enjoys the feeling of the heated water, instead he leans his head outside of the water stream, such that his body is still in the water stream, this is also possible due to having short hair, which washes out quickly. When it is time to get out of the shower, hesitation quickly hits, and he often uses a couple minutes more to force himself out of the shower, as he knows that it is colder outside of the shower. It is very important for John to use the grooming products each day, as he has a high standing job, in which he is expected to look good, this is also why he is shaving his face after each shower.

Before showering John uses time to find just the right product suited for him, and while in the shower, he uses time to read the back of the bottles to ensure that he is using the products rights.

Ideal experience
-The ideal shower experience for John, would be one where while applying grooming products, would not disrupt his veil of comfort, staying inside the warmth and light water massage of showering.
-When entering the shower, it would be ideal if the room had already reached a temperature, so that when unclothing, John would not feel discomfort due to the cold.
-When leaving the shower, it would be ideal if when exiting John would not feel a difference in temperature, keeping the feeling of comfort from the shower outside of the shower.

MATILDE - APPEARANCE, CLEANLINESS AND COMFORT

About matilde
Young lady with coarse blond hair down the lower back, she places importance in appearance both to herself and the people around her, especially her boyfriend. She lives together with her longtime boyfriend.
She is very conscious about cleanliness.

Motivations for showering
For Matilde showering is a therapeutic, the warmth and light massage makes a pleasant experience and leaves her in a state of comfort. She also considers shower an absolutely necessary task to uphold her visual appearance and cleanliness, but she is not rushed, as the activities themselves happen under the comfort of the shower.

Frustrations for showering
Matilde has long and coarse hair which makes lathering up a rigorous and difficult task, it requires her to turn off the water to properly lather it up both her hair and body, as the water stream would hit her hair and body and wash out the soap before fully lathering up. She only turns off the shower one time, but has to lather up both her hair and body leaving her without the comfort of the shower for a prolonged time.
Rinsing requires her to handle to showerhead to reach every nook and cranny, to wash all soap out, disrupting her shower comfort.

Shower behaviour
Matilde steps into the shower, turns on the water, spends 5 minutes just to wetten her hair properly, she is not rushed in doing so, as the feeling to acclimatize from cold to hot is very comfortable and refreshing.

She has condensed all activities that require her to turn off the shower into one block, choosing to have a prolonged time without warm water, instead of multiples times, enabling her to have two longer periods of shower comfort. Between lathering up her hair and applying body soap, she likes to slightly turn on the shower for a short time to wash her hands in between, as well as in between washing her feet or face, as she believes that increases her cleanliness.

Two times a week, before showering she applies an aroma oil to her body, that gives a pleasant smell throughout the shower and after, heightening the comfort while showering. She does not condition her hair everyday she does what is needed to uphold her appearance, distributing tasks over the week.
She baths for around 30min.

Ideal experience
-The ideal shower experience for Matilde is one where she can fulfill her beautifying and cleansing tasks without leaving the veil of warmth and light massage that the shower provides, will still completing her tasks fulfillingly
-A shower that supports her to complete her tasks more effortlessly, lowering her own participation, making the shower do the work, while she can stay in her therapeutic state.

ANDRES - THE CLEAN AND COMFORTABLE

About Andres
Andres is 27 years old with very short hair. He has a girlfriend, but they are yet to move together. He places a high importance in cleanliness for himself, rather than the people around him.

Context
Andreas likes to shower before going to bed because, he would under no circumstances go to bed sweaty or just a bit dirty, as it would dirty his bed sheets. Andreas usually spends his evening gaming, reading or other recreational activities.

Motivations for showering
For Andres showering is a evening ritual, that is integral to his own perception of cleanliness. He finds the process of showering very comfortable, the feeling of acclimatization from cold to hot is a pleasant sensation, Making him want to savor it more and not want to leave it. In other words, when he first started showering and feels warm and comfortable, he would like to stay that way, thereby extending his shower time

Frustrations for showering
Andreas finds the task itself to shower annoying, it cuts time of his afternoon time before going to bed. After having entered the comfortable state of showering, he finds it frustrating to leave the shower too, leaving the varm and coziness.

Shower behaviour
Andreas has a basic shower scheme, he does what is necessary to clean himself, he shampoos ones and washes his body in one go, he often takes down and handles the showerhead to thoroughly scrub his body. The cleaning process is not very long, but majority of time is spent dazing off and enjoying the warmth and light massage, extending his showering time significantly.

Andres showers for 20min.

Ideal experience
-The ideal shower experience for Andres is one in which he can stay inside the comfort of warmth of showering while cleaning himself.
-The ideal shower does not frustrate him, when he has to leave the shower.

MICHAEL - THE QUICKY

About Michael
Michael is a 24 year old student with girlfriend. He prefers effectivity and is a guy with a tight schedule.

Context
Michael lives in a student apartment with his girlfriend, however Michael is usually up early, as he goes to the gym before heading off to the university. The shower is unheated, however, it is small. Due to the almost daily gym activities, Michael often uses the showers at the gym facilities after training.

Motivations for showering
For Michael, showering is a task that has no other value than getting clean, either after training or as a result of feeling dirty.
Showering is a task which he finds just needs to get done, before more important tasks can be done throughout the day. Showering is sometimes done with his girlfriend, due to the intimacy involved.
Showering is usually done as quickly as possible to not interfere with other plans for the day, which his grooming products reflect, meaning that his appearance is a non issue, but the feeling of being clean is valued.

Frustrations for showering
Michael places great value in the effectiveness of the shower, ideally cutting of as much time as possible in the shower. However this is not always possible due to not feeling clean immediately. Furthermore showering can at times feel like a chore to him, especially when he is training in the gym for several days in a row.

Shower behaviour
Before Michael steps into the shower, he turns it on to make sure not to step into a cold shower. He unclothes and when entering, quickly wettens his hair and body. He applies the same soap in his hair as on his body and quickly rinses it off. While in the shower, he has no problem stepping outside of the waterstream, to make sure that his grooming products work as effectively as possible. When done he quickly steps outside of the shower and dries himself with a towel. He might also shave his face if necessary.

The shower usually takes 5-7 minutes.

Ideal experience
-The ideal shower experience for Michael is one which by being fast can buy him more time for other duties, enabling him to spend time where he think it matters more.

LARS - THE FATHER WITH EXPENSIVE DAUGHTERS

About Lars
Lars is a 46 year old father and husband. Having two teenage kids and a full time job. He tries to save money where possible.

Context
Lars lives in a house with his family, and works a full time job from early in the morning. His two kids are both in gymnasium. The house only has one bathroom, meaning that the whole family has to share one shower. Lars leaves early and is usually the one taking the first shower, as he has to prepare things for work. His kids then come next, and at last his wife. The shower has floor heating but is normally not heated when he enters the bathroom.

Motivations for showering
For Lars, an effective shower is a good shower, he values his time in the shower, however he does not waste water by just standing in there, doing nothing. As he has a job and wife, he grooms everyday, however he does not put extra effort into using the grooming products to its fullest, as he finds it a waste of water. As he showers in the morning it is also important that he does not use more time than necessary as his kids and wife should also be able to use the shower. Lars wants to feel completely refreshed when going to work, which is why the shower is also a quick way of freshening up, this is also why he sometimes takes a colder bath, to freshen up faster.

Frustrations for showering
When Lars uses the shower he puts empathy on not wasting water, as he is fully aware of how much water his shower is using, and the cost of this. His kids does not follow this trend, and is usually in the shower for longer periods of time, without thinking about water usage.
Furthermore this behavior also affects him if the kids goes to the bathroom before him, meaning that he sometimes does not have time for a shower before going to work.

Shower behaviour
Lars enter the bathroom, unclothes and turn on the shower. He enters the shower, and uses the grooming products he finds necessary to feel clean and ready for the day. If he feels drowsy he will at times turn on colder water, as it help him become awake.
When leaving the shower, he quickly dries and opens a window to let out the steam, before the kids get into the bathroom.

When the kids shower, they use 20 minutes each, as they both have appearance standards that needs to be met before going to the gymnasium.

Ideal experience
-If his kids had a better water saving mentality
-If he could get freshened up without the need for cold water
-Monitor his kids shower activity, such as water usage, which could then be presented for the kids.

Objective
The objective is to investigate matter that must be filtered or avoided by deselction.

Data

Solubles:
Solubles are currently washed down the drain when the user uses soap and shampoo in the shower or when shaving cream are used while shaving.

Rinsing hair:
Shampoo and soap - If recirculated, shampoo and soap will be be re-introduced in the waterstream, meaning that this will come down on your head, maybe resulting in a unpleasing experience.
Furthermore the soaps might cause problems in the system due to the disolvement in the soaps, which could cause rubber gaskets etc. to fail over time.

Re-circulation should prevent water with an NTU of over xx to get recirculated, meaning that it should either regulate water intake or stop re-circulating all together.

Shaving:
Shaving cream - With a larger amount of hair in the shaving cream, the re-circulation might plug the mesh filter, due to the shaving cream getting sucked into the system.
Furthermore the shaving cream could introduce irritation in eyes if circulated.

Re-circulation should stop completely, to prevent shaving cream completely, and to prevent possible plugging of the mesh filter.

Being dirty:
Oil - With larger amounts of oil, the system could become contaminated and plastics could fail in the long run, due to the corrosive effects.
Furthermore the oil could cause irritation to the user.
Re-circulation should stop completely, as there is no filter to prevent intake of this.

Liquids:
Currently the user is used to being able to pee and bleed in the shower, due to this going down the drain, furthermore, peeing is not done at a specific spot in the shower, as all water is going towards the drain.

Peeing:
Accidental urine - If re-circulated, the urine would be recirculated on to the user, causing discomfort, and distrust to the product.

Re-circulation should be stopped completely, either automatically or manually by the user in a quick manner.

Aware urination - If re-circulated, the urine would be recirculated on to the user, causing discomfort, and distrust to the product.

Could have areas which are safe to urinate in, as that area would not be re-circulated
Re-circulation should be stopped completely, either automatically or manually by the user in a quick manner.

Blood:
Menstruation blood and wounds - If re-circulated, would create discomfort for the user.

Re-circulation should be stopped completely, either automatically or manually by the user in a quick manner.

Particles:
Currently the user is expecting that dirt are washed down the drain, however hair might limit or clog the drain, meaning that this has to be maintained.

Being dirty:
Dirt and sand - If recirculated would contaminate the system, and could cause harm if passing the mesh filter, due to use of pumps, which could fail due to sand and dirt build-up.

Mesh filter should filtrate this completely, such that eventual dirt is close to non-existing in the system. Else Re-circulation should completely stop.

Rinsing hair:
Loss of hair - If recirculated could quickly clog the mesh filter, and could prevent clean water to pass through.

Mesh filter should filtrate this completely, if mesh filter is clogged, the system should stop re-circulating the water, and the filter should be cleaned by the user before re-circulation can continue.

Others:

Tissue:
Toiletpaper - If re-circulated, the meshfilter would quickly be clogged, limiting or stopping the recirculation.

Re-circulation should be stopped completely, and the toilet-paper should be removed manually by the user.

Other paper - If re-circulated, the meshfilter would quickly be clogged, limiting or stopping the recirculation.

Re-circulation should be stopped completely, and the toilet-paper should be removed manually by the user.

Larger objects:
Plastic bottles - If re-circulated, would stop or limit the system from re-circulating water.

Re-circulation should be stopped completely, and the object should be manually removed by the user.

Evaluation

By compilating extreme cases by inteviewing the real life personas, and by desktop research, lot of of extreme cases where discovered.

Reflection

These cases must be taken into account when detailing the filtration system

WS24 - Incitement calculation spreadsheet **Date: 05/03/17** **Written by: Alex**

Objective

The objective is to calculate the financial incentive of John and Nicole

Data

https://docs.google.com/spreadsheets/d/1tTAYjXgWGiFRCUKNsUCe_gWIwYxMcreiydHZvAwFIec/edit?usp=sharing

John

COLD water price per liter	0.0412	Product lifetime in uses	5000
Varm water is xx% more expensive	1.6	Product lifetime in years	16.02564103
Ratio % of warm water used	0.65	Earning before lifetime ends	43541.2
Shower water price	0.057268	avg. earnings per year	2716.97088
amount used (Liter)	360		
freq in year	312		
amount of ppl using shower	1		
Total water usage in L	112320		
total cost of spent water - one year	6432.34176		
saved amount	0.5		
Water saved in L	56160		
yearly savings	3216.17088		
product cost	8000		
paid itself in x years	2.487430021		
paid itself in x months	29.84916025		

Nicole

COLD water price per liter	0.0412	Product lifetime in uses	5000
Varm water is xx% more expensive	1.6	Product lifetime in years	16.02564103
Ratio % of warm water used	0.65	Earning before lifetime ends	17770.6
Shower water price	0.057268	avg. earnings per year	1108.88544
amount used (Liter)	180		
freq in year	312		
amount of ppl using shower	1		
Total water usage in L	56160		
total cost of spent water - one year	3216.17088		
saved amount	0.5		
Water saved in L	28080		
yearly savings	1608.08544		
product cost	8000		
paid itself in x years	4.974860042		
paid itself in x months	59.69832051		

WS25 - Shower observation

Date: 14/04/17 **Written by: Jacob**

Objective

The objective was to see what behaviors different users had in the shower, and how their coping strategies ensured that they had the wished for shower experience.

Data

Test setup:

A camera was setup in a public shower at the university, and a thermometer in a cup was given to the user. Outside of the bathroom, the receiver and a camera was set up to record temperature fluctuations. The user was instructed to fill up the cup at the entrance in the shower, each time he/she changed the temperature and at the end of the shower when it was time to leave.

User 1

Results:

Initial temperature before entering: 35C
Temperature increments: 38-39C after 1:50 minutes
End temperature: 46C

Turns up the temperature with approx. 3 degrees with various time intervals. Turns up the heat for the end of the shower.

User 2

Results:

Initial temperature before entering: 40C
Temperature increments: 38C after 2:30 minutes
18C after 3 minutes later
12C after 1:30 minutes later
End temperature: 12C

Turns down the temperature with about 2:30 minutes in-between.

User 3

Results:
Initial temperature before entering: 38C
Temperature increments: 41C after 4 minutes
44C after 4 minutes later

End temperature: 44C

Turns up the temperature with approx. 3 degrees with various time intervals. Uses four minutes to relax in the start, then turns up to 41C and applies soap, then shampoo, conditioner. This takes four minutes, and then he turns up the temperature to 44C for the remainder of the shower, in which he relaxes (4 minutes)

Informal interview Alexander Kjær:
Showers in hot water, however he gradually turns down the shower towards the end of the period. This is to acclimatize himself to the temperature outside of the shower

Showers for 5-10 minutes

Evaluation

By observing the users we also saw a user turning down the temperature quickly in the end of the shower, this was when asked to freshen up, and get ready for the day. By analysing the user behavior it was also interesting to see that some the increase in temperature happened with close to the same time in between.

Reflection

By analysing the temperature behavior in the shower, it is possible to get an image of how the solution could cope towards these coping strategies.

WS26 - Mixer mechnical setup test

Date: 13/04/17 **Written by: Jacob**

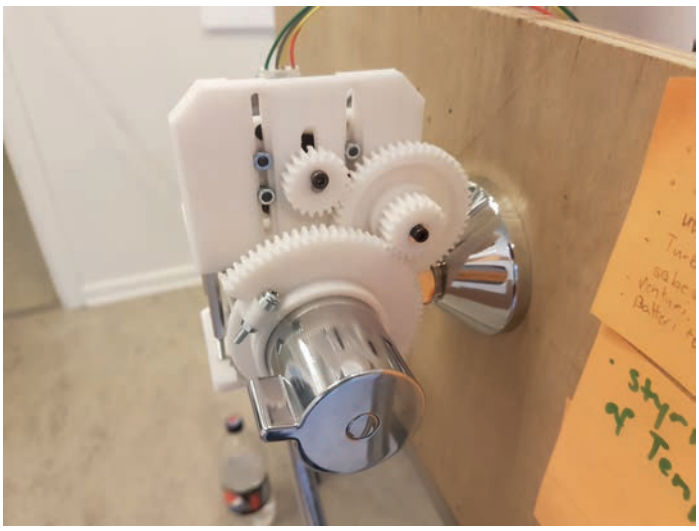
Objective

The objective was to test different "programs" by using a programmable microcontroller to adjust the temperature along the shower with a push of a button.

Data

Test setup:

A microcontroller was programmed to adjust a steppermotor which was geared and mounted on the teams showerset. The stepper would be able to adjust the temperature dial very precisely and very slowly if needed. The gearing was 3D printed to make up for the large torque needed to adjust the temperature dial, and to also enable for a very slow rotation of the dial. The stepper was initially a NEMA 14 motor, but was later changed to a NEMA 17 to make sure the torque could be handled by the motor. The test rig was mounted on the shower set, and the microcontroller was programmed to run a program by the push of a button. This program was easily adjustable in the code. The first program emulated turning up the temperature quickly, and slowly over one minute turning it down to the initial temperature.



Evaluation

By creating a setup which could adjust temperature through code was an amazing thing, as it allowed us to created programs which did different things without user interaction. This also allowed the system to be used with user which was unaware of the program, and could tell us about the experience without needing to adjust the temperature themselves.

Reflection

The test setup opened up for the program feature on the solution, as it made it possible to emulate programs, allowing the team and other users to experience temperature adjustments with user interaction.

Objective
Is to document the specifications made throughout the project

Data

TECHNICAL SOLUTION REQUIREMENT

The filtration system should be able to minimally filter shower to an acceptable standard. The filtration should function in 3 stages:

-A Mesh filter that is able to remove hairs and bigger particles.
    -The mesh size must be able to remove obstruct hairs
    -The mesh size must obstruct bigger object that could block the recirculation
-An UV filter that eradicates harmful bacteria.
    The UV filter must be strong enough to ALL e-coli bacteria in filter quickly flowing water
-The diffusion filter is able to mix the reused water source based on turbidity to reach solution with an acceptable turbidity level.
    -The diffuse filter is able to measure water turbidity of the yet to be diffused water.
    The yet to be diffused water is mixed based on the turbidity with clean water to reach an acceptable water turbidity.
    -The two sources of water must be thoroughly mixed

The solution must be easy to install.

-One person is able to handle the installation from start to finish (from buying to installation)
-Can be installed by a novice person, with a limited toolbox available, comparable to a normal showerset. (no need for an electrician)
-Can be installed without any prior remodelling of the bathroom, you should be able to swap the old with the new one.

The solution must have a low power consumption to accommodate the usage of batteries.

-The solution is battery powered
    -The proportion between power usage and battery size must be able to give at least one week of usage (equivalent to a family of four, where every family member uses the shower for 15min each day for 7 days, totalling 420 min. Or 7 hours of constant usage.
    -The power usage must be kept to a minimum to keep cost and size of the battery as small as possible.
-The overall power usage must not exceed the saved energy by recirculation
-The battery is rechargeable and easy to maintain in terms of recharging

The recirculation is able to provide at least an average of 30% reused water throughout the shower.
The recirculation pump(s) must are able to feed enough fluid, to reuse an average of atleast 30% of the shower water. The pump(s) must be able to peak at atleast 50% to account for downtime when the recirculation is less effective.

EXPERIENCE SOLUTION REQUIREMENTS:

The solution must have a feature that is able to on demand give the bodily sensation of re-entering the shower.

-The feature is able to provide an incremental temperature rise by up to 3 degrees.
-Must be sustainable and adopt the same principles of saving water as in accordance with the vision.
-Must be an unique selling point.
-The interaction is intuitive.
-Must provide a clear indication of when the "comfort" feature is enabled or disabled.
-Adjustable to user patterns.
    -Accommodate size of temperature raise.
    -Accommodate when temperature changes are needed.

The solution must be able to provide clean water when rinsing body and hair.

-The recirculation must be paused/disabled when the water has a high content of soap.
-The interaction requires little or no user participation.
-The solution must provide a clear indication (experience nudge) of when the re-circulation is enabled or disabled.
-The recirculation is able to be paused/stopped by the user to accommodate extreme situations.

The solution must have a feature that is able to deliver a more encompassing shower coverage, by the means of recirculated water.

-The feature is able to provide a better transfer of heat, by the means of better water coverage in spread and/or density
-The feature is able to provide an alternative mode, that is more luxurious and sumptuous in terms of coverage, by the means adding reused water to increase flow rate.
-Must be an activatable feature.
-Must clearly indicate when enabled or disabled

The solution should be able acclimatize the user to the outside.

-The feature is able to slowly acclimatize the user to the colder environment after showering
-The feature must be activatable.
-Adjustable to unique user patterns.
-Accommodate different temperature changes.
-Accommodate when temperature lowering are needed.

SEMOTICS

The first collision - The solution must in the first meeting tell that it is different from a everyday shower set, that it is a shower where you are to expect something different, while maintaining a sense of familiarity.
Must give a clear impression that it is a shower set.
Must give an impression that water is to be recirculated.
Must have a clear method of operation, that has a sense familiarity

In use - The solution must illustrate the causality of using recirculation
The consequences of misuse must be apparent, and the impact and cause.
The damage done by misuse and how to reverse is easy is indicated how to do.

All the buttons and actions that the user has access to must be responsive in several ways.
Must have a tactile feedback, incase vision is obstructed.
After execution of the button press, the effect must be immediate.
The buttons are difficult to misfire.

SEMOTICS REQUIREMENTS

Before entering:

The shower must have familiar traits from an ordinary shower-set.
- Placement of functionality (method of operation)
- The main element and functionality of the shower is visible.
- Visual elements

Give a cue that this is a recirculating shower
- Functional wise
- Visual wise

The mat should clearly indicate its use
- Why it is placed as it is
- Recirculation

The flow, direction and end-stop of the water should be visible.

The shower should allow for a curtain, or be able to be installed in a cabin.

When entering:

The shower must have a clear division between the categories of actions
- The temperature, flow, comfort and stop button should be memorable and easily

distinguished between each other.
- (tactility, placement, visuality etc)

The interaction between the user and interface must have a clear sense of causality (cause and effect).
- The interaction has a clear feedback that it is enabled and disabled

The interactions should be focused in one area, and in torso height while being in clear line of sight.

When showering:

The shower must have interactions that are clear to distinguish, locate and use in a misty and rainy environment.
- Must be distinguished for users with bad sight (no glasses in shower) and

accommodate uses that like to have their eyes closed while showering (opening and closing eyes can be disorienting for a while after opening the eyes)

The comfort features should standout and satisfying to use, tieing up the pleasureable experience with a memorable user interaction.

The shower should clearly indicate when the re-circulation is engaged or not.

The stop button must be assuring, clearly indicating that the recirculation is immediately turned off.

Must have a feature to easily reverse should a undesirable soluble get dissolved and pumped up.

The mat should clearly indicate its use while showering, and why it is placed as it is.
- The flow of water when recirculating.
- The flow of water when not recirculating.

OTHER:

Same experience when a new user enters the shower, meaning that if buttons is depressed by another user, this button should not be depressed when the new user is entering.

WS28 - Acclimitazation

Date: 20/04/17 **Written by: Jacob**

Objective

The objective was to see how users used the temperature to acclimatize to the outside environment.

Data

The users:

The acclimatization happened in two different instances, first with User 2 when observed, in which the user turned down the temperature rapidly. This was done to both get a fresh splash of water and waken up, and to ensure that the environment outside of the shower would not feel really cold, when it was time to end the shower.

The second user was asked in an informal interview, whether he turned up the temperature along the shower, this was something he did, but he also added that he liked to turn down the temperature in small increments in the last 3 minutes of the shower, as this would allow him to exit the shower without freezing due to the temperature difference which is normally there.

Evaluation

Turning down the temperature was not something the team was aware of happened, and especially not for the reasons described. It was very interesting to see that turning down the temperature to acclimatize the body to the outside temperature was a coping strategy for at least one of the users.

Reflection

Turning down the temperature to acclimatize was a feature which could be incooperated into the solution if it was deemed important enough. As we want to cut down on the user interaction with the product, having a automatic program to slowly decrease the temperature could be a nice feature for the solution.

WS29 - Informal interviews about light

Date: 01/05/17 **Written by: Jacob**

Objective

The objective is to see how the user would interact with the product when first approached, and to collect information on how they perceive the features of the product, and whether they understand to use the controls, such as turning on the product, adjusting temperature and turning on/off the recirculation. This will give the team an understanding of possible flaws with the current button layout and functions, or possible scenarios which has not been played out before, which could inflict the final solution.
Furthermore this will show how the solution collides with their current coping strategies, and how the product could be changed to better suit the individual shower behavior.

Data

Initial approach

The user will be asked to explain the three main interaction surfaces, what they believe is the function of each, and how it is operated, the three interaction surfaces are the showerpipe and shower head selection buttons and the temperature dial.

Tilde:
The initial approach began with the user walking on top of the mat as expected, and correctly identifying the button for starting the product, the shower pipe button was selected.

Jesper:
The user would approach the product and stand outside of the shower while turning on the water, and would adjust temperature accordingly to what he was used to.

Sum-up:

The most prominent areas of interest that were mentioned by the users were that they both selected the button when turning on the product, and did not try to dial the temperature control first. This could be due to the temperature indication not showing up before the either the showerpipe or shower head selection button was pushed.

When starting the product

The user will be asked to start the shower and go through the series of actions which are done in the user's normal shower routine, turning it on, adjusting temperature etc.
Tilde:
The user would start the product by pressing the shower pipe button, however she noted that the temperature dial might be confused being a "On" button as well, due to usually turning on a shower by a dial. The shower was turned on and the temperature was adjusted accordingly, however it was noted that she was standing outside of the shower at this moment, as she normally feels the temperature before entering. She then stepped inside the shower and started wetting her hair, in which she was standing with her back against the dials, this also meant that the controls were out of reach, if she did not turn around to use them. She then turned off the water to soap in.

The user was now introduced to the recirculation button, and the principle of recirculation, and immediately turned it off, as she did not want soap to be picked up. The sensors were then explained, and she turned on the recirculation again.

The user was then put in a scenario in which she did not want to have something recirculated, and her immediate reaction were to hit the button, however she noted that looking at the button when turning it off was important for her, as she did not solely rely on the sound or feeling of the click.

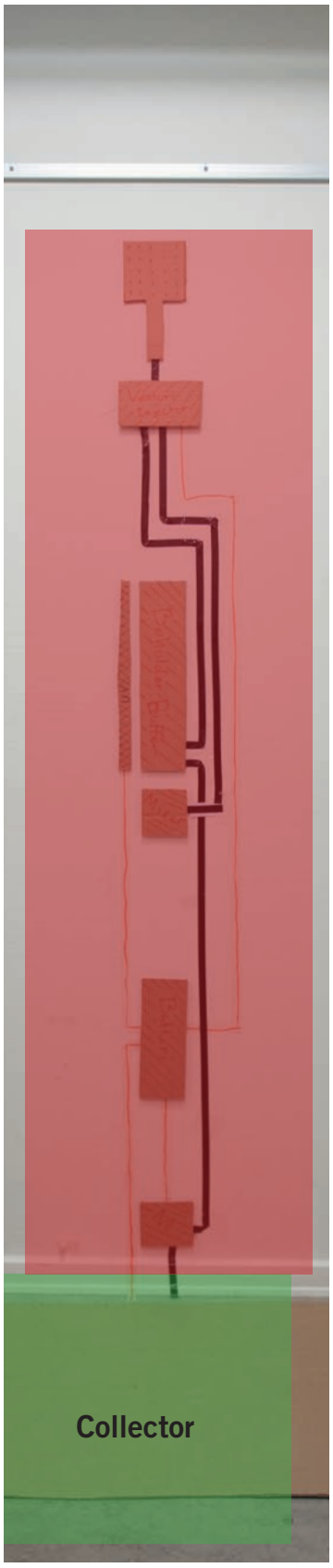
The user noted that the light was noticeable, however the recirculation button could be forgotten to be either turned on or off, if she was tired in the morning etc. And that the recirculation light might help remember to either turn it on or off.

The second layer of interaction with buttons was then introduced. Her immediate reaction to the buttons was that the "Coverage" button, meant more water, the "increased temperature" button meant floor heating, and the "cool down" button meant that she would get an ice cold shower immediately.

Jesper:
He would turn on the shower by clicking the shower pipe button and would then enter the shower. The user noted that the recirculation button might be thought of as a "On/Off" button.

COLLECTOR

OBJECTIVE: The objective was to describe the current state of the collector, the thoughts behind, and how the the future development of the collector should be focused.



The first link in our recirculation is the collector. The collector was simple defined as something that should funnel the water towards the pickup, and was not as important for the project, as the main body of Elv. However it can be discussed whether the collector is of most importance, as it is the first criteria that has to work, for the rest of the system to work, because if there is no water to be picked up, then there is no recirculation.

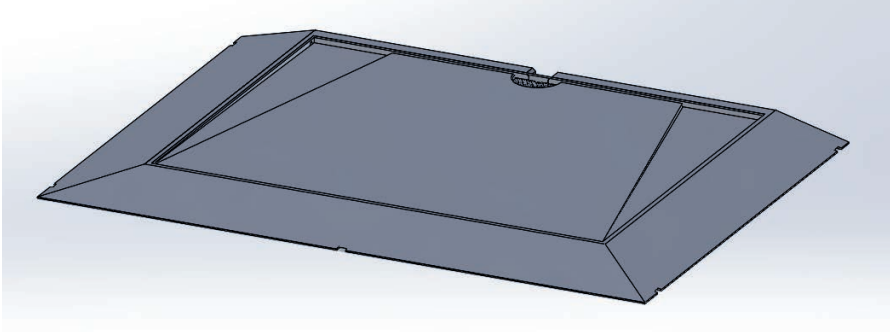
However, some considerations in regards to the collector were made, some of which are listed here.

Considerations

- The collector was dimensioned for the width and lenght of a person.
- Environment considerations was not considered, such as how the mat should fit into a shower cabin etc.
- The height of the mat were made to minimize the change of tripping.
- The side slopes were made to ensure easy mounting and unmounting on the mat, as people move around in the shower.
- The only water flow considerations were the sloping of the water funnels, which needed to funnel the water to where it will be picked up.

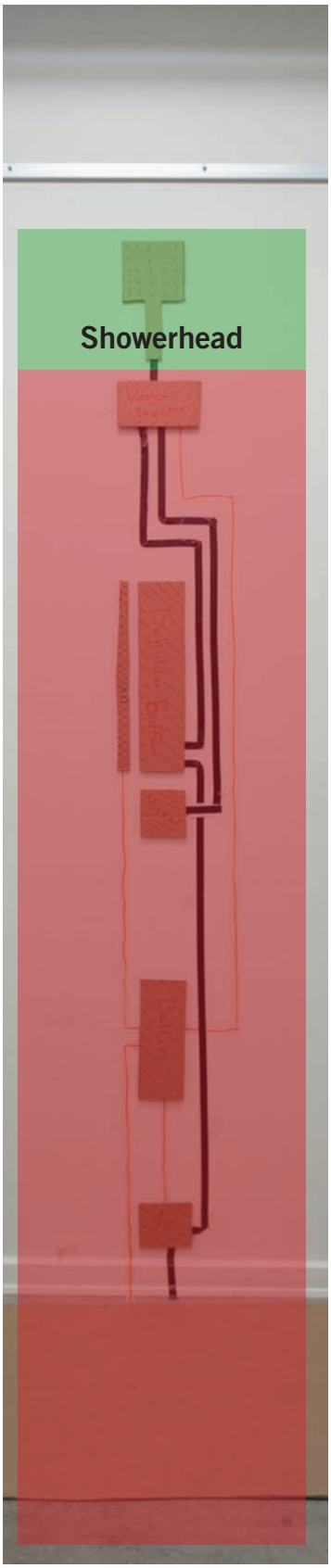
Figure 1: First mat mockup

Figure 2: Dampened mat



SHOWER HEAD

OBJECTIVE: The objective was to describe the current state of the shower head, and which considerations was integrated, in which ones that lacked.



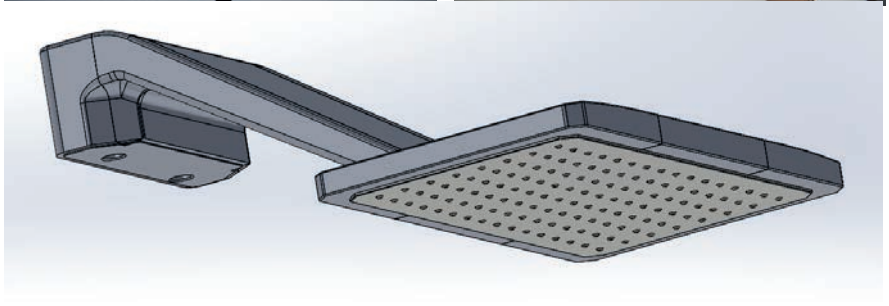
The shower head was not in focus throughout the project, due to the insignificance it had for the development of the recirculation. Furthermore it was not perceived as an important factor, as it in the start only had to output the recirculated water onto the user, and could therefore be rather "dumb" in the sense that no technology had to be integrated. This however changed later down the line, where the showerhead also became housing for the venturi system, however the showerhead were not directly formed after this, and just became an afterthought. However, some considerations in regards to the shower head were made, some of which are listed here.

Considerations

- The shower head has been dimensioned in the width to cover a body, but the lenght is still unknown.
- The shower head has not been tested to see how the coverage feature would technically work, however as the ability to change the coverage on other shower sets are already possible, it has been deemed possible for our solution as well.
- The nozzles has not been dimensioned to ensure for the right pressure and coverage of water.

Figure 3: Early showerhead mockup

Figure 4: Final mockup showerhead



WS32 - Updated battery calculations

Date: 11/05/17 **Written by: Jacob**

Objective

The objective was to calculate the updated estimated battery capacity and power draw from the current solution. This was to ensure that we could create the product as a battery powered solution with an acceptable runtime.

Data

Battery capacity			
4x		6800 mAh at 12V	
		Battery efficiency 80%	
		5440	mAh effective
		10880	mAh
DISCHARGE IN USE			
Buck converted to 12V 90% efficiency			
735.1351351	mAh per Volt		
2058.378378	mAh at 100% efficiency		
1852.540541	mAh at 90% efficiency		
BATTERY CAPACITY			
Total mAh		12732.54054	mAh
Pump		400	mAh
UVC LED's		150	mAh
Running LED strip with 5 LEDS		100	mAh
Indicator LED's x 10		200	mAh
Turbidity sensor		30	mAh
Resistance sensor		10	mAh
All		890	mAh per hour worst case
		14.30622533	Hours usage
CHARGING			
Charging at 12V 2A		5.44	hours

The updated battery calculations shows that the solution now draws 890mAh. This results in a total runtime of 14 hours, again if the everything is running all the time, which is would not do in a normal user scenario.

Evaluation

The updated battery calculations made the runtime go down 3 hours, however 14 hours is still a long time before having to recharge, and is still inside the realm of what the team would accept.

Reflection

The updated battery calculations are very rough calculations, which means that it might vary due to other factors, such as temperature decreases and increases affecting the batteries, and wattage specifications being wrong on the manufacturer pages.

WS33 - Component and production

Date: 11/05/17 **Written by: Jacob**

Objective

The objective was to calculate the total price of the components found in the solution, both internally and externally.

Data

Internal components

BATTERY PACK		system voltage	12V	
Individual cells				
18650 cells				
1 cell 3.7V 3400mAh		Price per cell at 1	2	USD
11.1	V	Boosted to 12V	3cells	
or				
14.8	V	Regulated to 12V	4 cell	
Booster board	https://www.aliexpress.com/item/10pcs-Boost-Buck-DC-DC-Adjus			
1.4	USD			
Voltage regulator	https://www.aliexpress.com/item/10pcs-LM2596-LM2596S-ADJ-F			
0.6	USD			
Charging/discharging protection and balancing of cells				
https://www.aliexpress.com/store/product/4S-8A-12-8V-LiFePO4-BMS-PCM-PCB-I				
8	USD			
Price for raw components		3cell		
21.4	USD			
Price for raw components		4cell		
24.6	USD			
Sealing, shell estimate				
5	USD			
Battery pack total price				
26.4	3cell			
29.6	4cell			
Motorized ball valve X2				
https://www.alibaba.com/product-detail/Electric-Actuator-Motorized-Brass-Ball-Valv				
7	USD			
14				
Pump				
https://www.alibaba.com/product-detail/Electric-Mini-Submersible-Pump-Brushless				
2	USD			
UVC				
https://www.alibaba.com/product-detail/275nm-Germicidal-UVC-LED-for-Water_60				
20	USD			
Sensors				
Turbidity sensor	https://wholesaler.alibaba.com/product-detail/Turbidity-sensor-liqu			
6.5	USD			
Resistance probe	https://wholesaler.alibaba.com/product-detail/100CM-stainless-st			
2	USD			
Etc				
Controller				
5	USD			
Control of flow?				
10	USD			
Internal Component list total				
89.1	**USD**			

The internal components was priced at around 90USD. These prices do fluctuate due to different resellers, so this is only a rough estimate. The internal components consists of everything that needs to be there to make Elv function inside. However there is still some uncertainties such as the price for some of the non-standard components such as the buffer tank etc. This will further increase the price.

Evaluation

The total component price was 102.35 USD, however as previously mentioned, this might increase due to the non-standard components which needs to be there for the product to work, such as the buffer tank.

Reflection

This was a rouch estimate on the component prices which will give a standpoint on how much the total product will cost in raw components.

Objective

The objective is to see how Elv can be targeted on the market, and what price would be considered acceptable by the target group which are aiming at selling to.

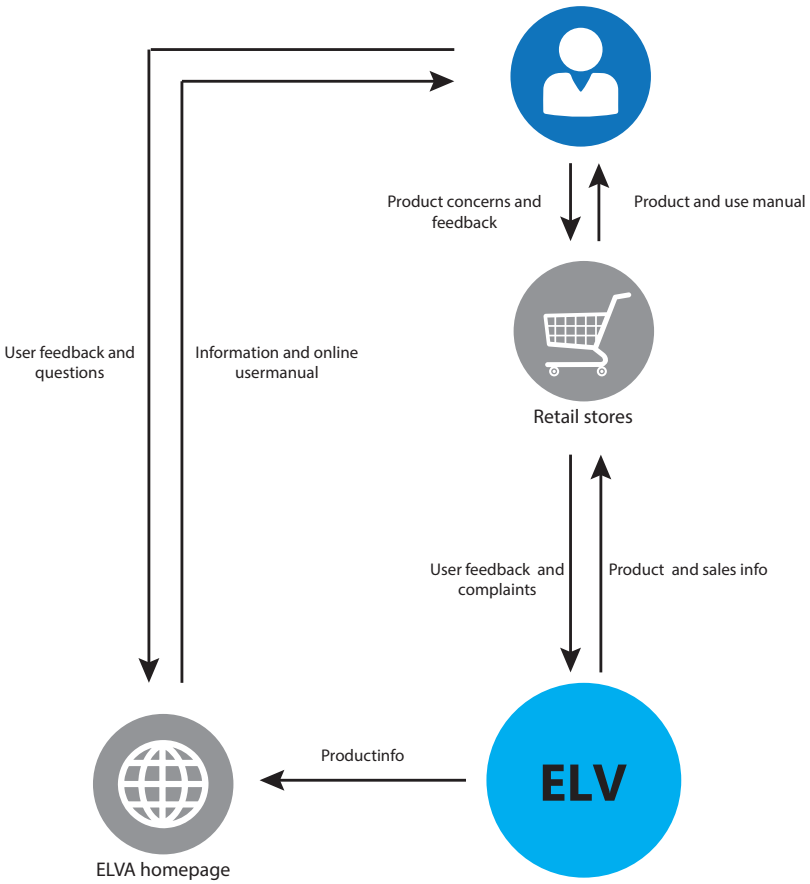
Business plan

The business plan was created on a basis of illustrating the actor network, business canvas, thereof also the distribution chain, and possible sales outlets.

Actor network

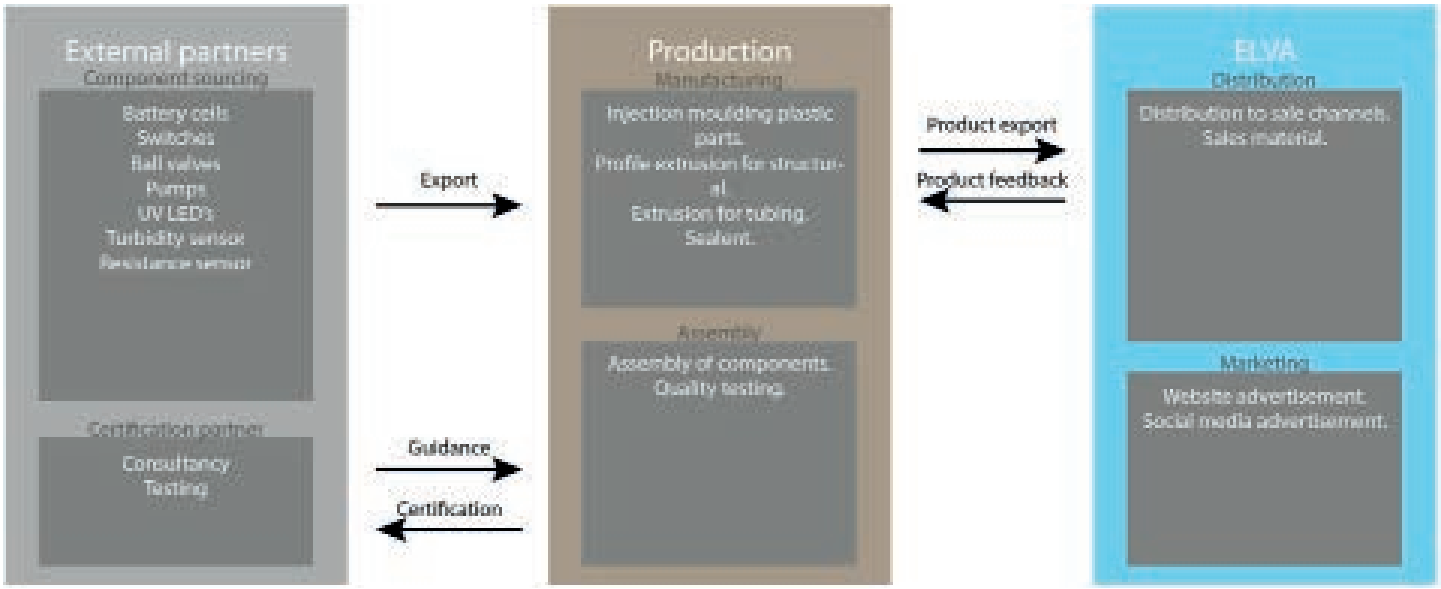
The actor network illustrates possible sales outlets, the backflow of information from these outlets, which could help provide insight into customer satisfaction and possible improvements on later iterations of ELVA, it being production revisions or product advancements in the form of additional ELVA products down the line.

The product is mainly to be sold in retail stores which sell shower products, furthermore, a online store has been deemed unnecessary, and overly complicated due to the necessary warehouse and excessive marketing due to ELVA being a completely new brand, unknown to the users.



Distribution chain

While most of the components in ELVA can be sources from distributors in China, some parts are prefered to be bought from their representative manufacturers, such as the battery cells, which is manufactured by LG in Japan. The distribution chain will illustrate where the parts will come from, and what ELVA will do production wise.



Business model canvas

The business model canvas will frame the current product development, illustrating key partners and revenue.

Key Partners

A manufacturing partnership is necessary to avoid cost involved with setting up manufacturing facilities etc.

Key Activities

The key activities for ELVA is to further improve the product and through active partnership with the manufacturing partners to improve on the cost of production. Furthermore an ongoing product development should ensure to create new product on behalf of feedback from the current product on the market.

Key Resources

Production is outsourced, and key components are imported from various distributors in China and Japan. In the further development of ELVA, an increased importance in the development is needed due to manufacturing costs and component development.

Value propositions

The value proposition is to create a product which can go in and replace the current shower solution for most users. In this given moment the cost is not justifiable for some users, however further development and optimization of production and component cost will be able to lower the overall price, opening up for a broader market with cheaper "budget" solutions based on the same principles of recirculating water.

Channels

The distribution channel is mainly through retail stores, due to the convenience of not needing warehouses and the marketing from ELVA can be minimal. Further products from ELVA could be distributed through own outlet channels, either from an online store or through dropshipping from the manufacturer itself.

Customer Relationships

As of right now, no direct communication between the customer and ELVA is conceived, however with future product development, it can become very relevant due to the use of sensory which could possible measure how much water is saved, which then can be displayed on the product or through an App, or through a customer profile on the homepage. Further communication between the customer and ELVA is mostly through the retailer, however if the product is to be sold through an online shop in the future, feedback can be done through social media or the like.

Cost Structure

The production of the injection moulding and extrusion is the most expensive, as the mould and profile elements are the most expensive. The electrical components are rather cheap, only the batteries being the main expense.

Customer segment

Due to the relative high price compared to ordinary shower sets on the market, it is not possible to catch the complete market, however the price is much lower than similar products which has the same objective, of recirculating water. Furthermore ELVA adds a whole range of comforting features not found on other products in the same category, meaning that the customer segment is also expanded to the user wanting a more advanced and comforting shower.

Revenue Streams

The main revenue is through the direct sale of the product, however different mats could possible be selectable by the customer, due to constraints in the bathroom. Furthermore future products can be sold to possible existing customers already in the ecosystem, or to new customers, due to ELVA being a more know product, thus creating more interest when a new product is released.

Sales number

Based on the early questionnaire, in which 25% of the asked people would happily shower in recirculated water, it can be assumed that this number still holds true, and could be heightened due to the added features and more concrete product, compared to what they were presented with.
This gives reasoning to believe that out of the 25%, a percentage of those will have the economic ability to buy ELVA, however, as the possible customers might not buy the product on release, due to it being a not so ordinary product, the first year sales is expected to be lower, increasing after two years due to the publicity and the market position being more fixed. These are however optimistic assumptions based on a best-case scenario, in which ELVA will sell, and no bad publicity is released due to failures or customer dissatisfaction.

Production cost per unit - Estimate

Electrical components cost
95 USD - 650 DKK

Manufacturing cost
Plastic moulding mat - 25 DKK a piece

Plastic moulding misc - 25 DKK a piece

Extrusion of profile - 200 DKK a piece

Misc - 400 DKK a piece

Total 1300 DKK

Due to being an estimate, total cost would will probably be closer to 1500 DKK in rough component prices.

Marketposition

To position ELVA in the market, it is necessary to look at two different segments of product, as ELVA is both a water recirculating and saving product, but also a comfort oriented product.

Water saving products come in many variances, from small flow restrictors which can be had for 200 DKK to higher end product which combines several ways of saving water, priced at up to 15.000 DKK, such as the Hans Grohe Axor series.

In the recirculating segment, there are two main competitors, Orbital Systems with a price of 4650 USD (32.000 DKK) and Hamwells E-Shower Blue, with a price of 3200 USD (22.000 DKK). Orbital Systems is primarily focused on saving water, and

no additional comfort features are part of the product. Hamwell's try to focus on water saving, being less effective than Orbital Systems, but also include simple feature to increase water output.

By positioning ELVA at a price undercutting both Orbital and Hamwell's, it is believed that the product can be very competitive on the market, however this also depends on the marketing for the product.

In the comforting segment, there is a greater deal of products on the market, namely from Hans Grohe, Grohe and others.

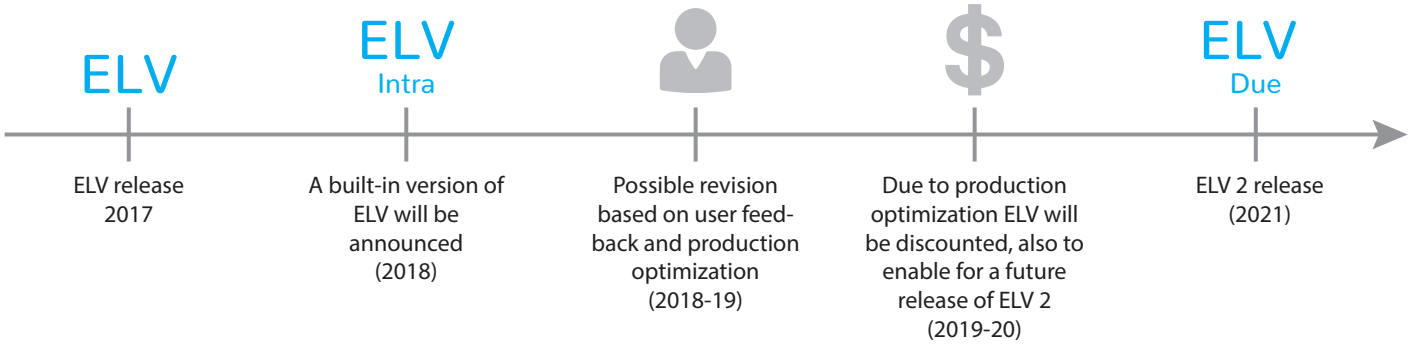
Hans Grohe offers their most premium products (Axor and Raindance series) from a price range from 5.000 to 24.000 DKK. The higher priced product integrate a series of coverage features, meaning that the shower head is normally larger than ordinary showers, however their water usage is proportionally higher, meaning that those are not aimed at water saving oriented users.

While water saving and comfort in the same product is not available today, it might open up for a new and larger user segment, combining both the user willing to buy a comforting shower, such as those buying high-end Hans Grohe shower sets, and those who buy with a sole purpose of saving water, but still want a comforting shower, which until now has not been possible in the same way, without having to buy into the ecosystem of Orbital Systems.

Positioning ELVA, undercutting the recirculation segment of products, and positioning ELVA in the middle of the comforting product would be ideal, to both be competitive with the water saving segment by delivering a very compelling principle, especially at the price range, and be competitive in the comfort segment by delivering a set of comfort features not found in other products.

The target price for ELVA is 7.999 DKK MSRP.

Future roadmap for ELVA



If ELVA is successful, it would be beneficial to see how the future of the product could unfold. While the product is positioned as a stand alone product for replacing the ordinary shower, a possibility is also to be able to build in the product into the wall. This is seen with many luxury showers, and is a common sight in newly build houses. Supporting this tendency would possible broaden the market towards the higher end segment which expect their new shower to be built into the wall.

As the electronics in ELVA are responsible for the controls in regards to filtration, it would also be possible to give the customer a possibility of updating ELVA if the filtration level are found to be a little off by further testing. Furthermore this also opens up for the possibility that the user can tweak these values themselves, meaning that they can customize the shower experience to their liking.

The second evolution of ELVA is to include fixes from user feedback and would possibly include a cheaper and more sophisticated filtration and sensory system, as the components could be custom produced and the sensory system is still to be explored more in depth, to see if there are a possibility to measure more parameters in regards to the water, which could improve the user experience even more.

OUTPUT
By releasing ELVA, it is expected that the competition will release competing product, therefore it is important to keep developing ELVA through revisions, and keep competing when the competition announces their products. By discounting ELVA down the line, it is believed that it can be competitive even with competing products.

WS35 - Mat production consideration

Date: 06/05/17 **Written by: Jacob**

Objective

The objective is to get a rought understanding of how the mat could be produced, however as the mat has not been in focus, the production has not been discussed very much.

Producing the mat

The mat should be produced in a plastic, due to the very limited conductivity ability of the material, meaning that the mat will not feel ice cold in the morning, as aluminium or other metals would do.

Due to the mat being submerged in water, the material should not absorb moisture, however there is no need for any UV protection, due to it not being in direct sunlight.

As the mat does not need any electronics installed, there is no need to take warping into consideration, either from use or from degradation in the material.

Alkalis and acid may be used in the shower, meaning that the material should be able to withstand this.

ABS fulfills all the criteria, and is easy to both produce and cheap. Furthermore it can be rubber coated, which could be useful as a safety measure for the user, when he or she stands on it.

Injection moulding the mat would be a possibility as it is not very complex and does not have any extreme cavities which would require for a more expensive mould.

Evaluation

Producing the mat should not be a problem as it is a completely passive part, meaning that there are no components inside. This also means that the mat is basically just something the user is standing on, which funnels the water down to the collector.

Reflection

If the mat were to include components, such as the pump or something else, there should be more focus on how the material would function in cold and hot water, due to warping, and also on how it should be produced, due to the need for more cavities or mounting of the components.

WS36 - Showerhead production considera- **Date: 06/05/17** **Written by: Jacob**

Objective

The objective is to get a rought understanding of how the shower head could be produced, however as the shower head has not been in focus, the production has not been discussed very much.

Producing the shower head

The shower head should be produced in either plastic (ABS) and be chrome plated or it should be casted in a aluminium which is then nickel or chrome plated to ensure corrosion resistance and impact resistance.

As the shower head includes complex geometry with a hollow core, it would be beneficial to have a split seam in the middle when produced, and afterwards welded or glued together. And as the venturi is to be installed in the shower head, this might be installed before the splits are glued or welded together.

The output nozzles on the shower head should be produced in silicon, as it is both resilient to water and can be cleaned easily if calcium should clog them.

Evaluation

As the shower head includes the venturi system, producing it can be a little more complex. However it should be possible to split the shower head in the middle, and produce the top and bottom by themselves, and then glue or weld these together, ensuring it is watertight.

Reflection

The shower head is a important part of the shower, however due to the limited focus, the production knowledge in regards to this is still very limited. Future investigations into how it can be produced should be made.

WS37 - Sealing the components

Date: 07/05/17 **Written by: Jacob**

Objective

The objectives was to find how the product should be sealed to avoid water damage and to avoid that the components are destroyed. The product is situated in the shower and should therefore be sealed accordingly.

Sealing the product

As the product is situated in the bathroom, and water is expected to be splashed on the product, it needs to be sealed. By using a low amperage battery, we assure that there is no risk of a lethal shock when showering, even if water ingress has found its way into the product. To prevent ingress, a proper sealing is necessary, however to reduce the places where sealing is needed, a construction with less seams and larger unobstructed surfaces are desired. The physical buttons should be sealed, and the potentiometer, as these are physical moving buttons, which will break down over time, if water gets in. Fortunately most components, such as potentiometers and buttons can be found pre-sealed, so the biggest area of focus should be on making the shell of the product sealed.

IP rating

The product should be sealed to a IP standard, which is a standard for sealing against dust and water. The IP rating of 67 was chosen as it secures against dust and short amount of submersion in water, which would probably not happen, as the product is not submerged in water but is only splashed on with water. The IP rating is higher than what is actually needed, this is only to ensure that the product will hold up to extreme cases, such as if the product would be submerged in water.

https://www.electricalcounter.co.uk/ip-rating

http://www.resourcesupplyllc.com/PDFs/WhatDoesIP67Mean.pdf

http://www.rogerscorp.com/documents/2201/designtools/Technical-Design-Guide.pdf

Furthermore, it will be beneficial to make the product as seamless as possible to ensure that no ingress can enter seams in the product, and this will also make sealing the product easier and cheaper.

As the components are all DC, and run at a low amperage, a electrical shock should not be able to happen, if the sealing is penetrated with water, and furthermore the components should not immediately be destrouyed as again it runs on 12V.

Another way of ensuring that the product will work for a long time is to seal each component individually. This would allow to have a perforated structure, to ensure that moisture could escape, and still have the components run. This would be considerable more expensive, and heat from the components should be taken into consideration.

As the only thing the user are able to remove is the battery pack, for charging it, sealing the product should not be difficult, as it only becomes increasingly more difficult if sealing is applied on removable parts.

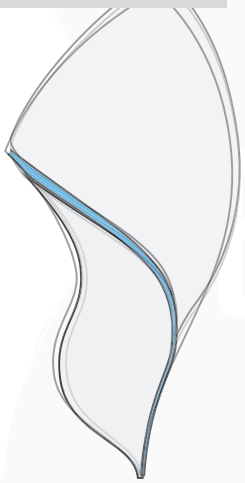
Evaluation

Sealing the product should not be much of a problem, as the only removable part is the battery pack. The chosen IP rating of 67 is to ensure that the product can be submerged for a short while, which will probably never happen.

Reflection

Sealing a product is a complex matter, and should be researched more in-depth in the future, as water and electronics do not go hand in hand, and is of most importance to keep out of the system.

WS38 - Design Brief



ELVA

The most Sustainable Shower

Group 8
Jacob Terp Christensen
Alexander Sun Petersen

DESIGN BRIEF

ELVIRA

Vision

We want to develop a shower that takes sustainablity to the next level, a product that celebrates the high quality of water and makes the very best use of it. ELVIRA will be the benchmark for sustainable showers, it will inspire and empower a more responsible usage of water.

Currrently - The Wasteful Shower

While you shower, warm water that has just barely touched your body falls down into the drain, water that hardly has been contaminated or spend its heat. The water continous to a water treatment center, where it has to be treated in an expensive and evironmentally harmful process.

Water waste

Unspent water heat

Chemical threatment

Future - The Recirculating Shower

Imagine a system, that just as the water falls off, immediately picks-up a percentage of the used water, fuses it with fresh water and reuses it to shower within seconds.

The reused water has not been exposed to the contaminated pipes further down the system and still retains it heat, thereby saving both water and energy.

By fusing the relatively clean recycled water and fresh water, it is possible to reach a water solution so clean that expensive filters and futher chemical processes can be omitted. Thereby in the truest sense, creating the most sustainable shower.

Mission

Develop a recirculation system, that takes a percentage of shower water and reuses it. The product must be accesible and affordable by the single consumer or family and uphold the recreational and leisurely use when showering.

PROJECT OVERVIEW

This project emerged by an observation that a lot of “clean” water and heat energy is wasted when showering. This was followed by the thought: “if the water is so “clean” why do filters even have to be used?” Could filters be ommited if a percentage of “dirty” water was dilluted in clean water? The insight sparked a series of questions and assumptions, that formed the narrative of this project, **the Recirculating Shower.**

Questions and assumptions:
If expensive filters can be omitted, both lowering cost and product complexity, could that materialize into a market potential?

Does this carry a hygenical risk if done “right”?, a bathtub is practially the same, and that is considered acceptable. Rather, is this mostly a phycological issue? what steps can be taken towards that.

- can the percentage of reused water scale with the water cleanliness?
- can only the “cleanest” water be picked up and reused?
- what is the threshold, what is acceptable?

Bottom up approach
This project from its very inceptions was based on the narrative of creating a filterless recirculating shower. At current it is a mere narrative, it has to be developed into a technical concept alongside a strong framing. While investigating for opportunities in regards to the market, and the bussiness oppotunities as project.

The design brief, will attempt to answer some of the assumptions and questions we asked outselfs.

DISPOSITION

PRINCIPLE STRUCTURE: ELVIRA

The objective is to identify the technical structure of the narrative and to define a set of hardpoints, as to further the exploration of recirculating water

The concept is defined by a wish to recirculate a percentage of water while showering. Four hardpoints can be defined, which together form the technical basis. The first of the four components is used to collect the water, and is used as a filter for hairs or bigger particles, which is undesirable to recirculate, the water is then needed to be recirculated, such that the used water is again moved up, until it reaches the water mixer, which then mixes the used water with the new water. This water is then transferred to the water output, which pours on to the user

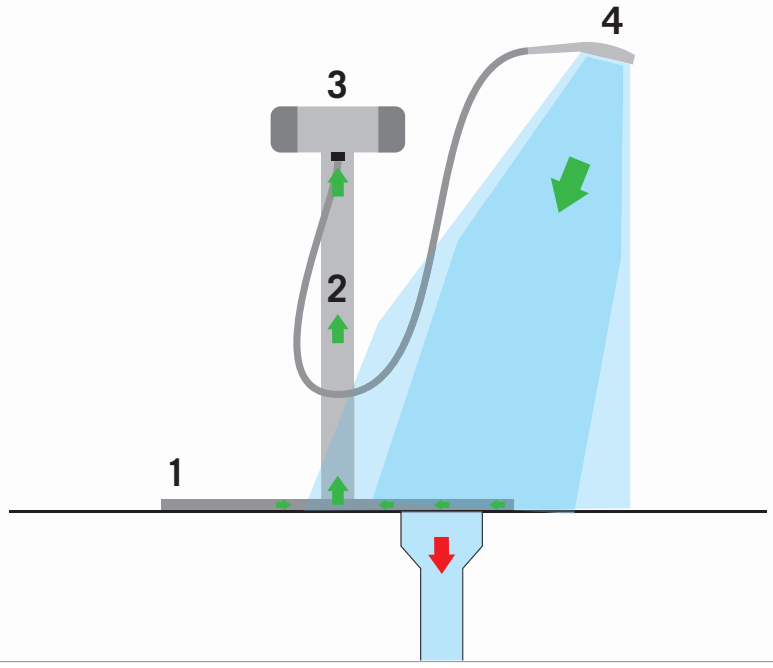
The four hard points:

1. THE WATER COLLECTOR
Used to collect part of the else drained shower water. Is placed strategically where most used water can be collected.

2. THE RECIRCULATOR
Used to recirculate the water collected by the water collector. This is used to pump up the water to the next part.

3. THE WATER MIXER
Used to mix the reused water with the clean water, the water mixer can be positioned at different areas on the shower, where the mixing would be the most efficient.

4. THE WATER OUTPUT
This is where the recirculated water is ejected, this could conviniently be done in the shower head itself, or it could be done at another place, if necessary.



OUTPUT

Four hardpoints were defined, that each describe essential componenents in a recirculation system. Each hardpoint represent a feature that has to be developed and this principle structure will allow us to do so in a more directed manner. The figure, is a quick rendition of a possible implementation, where a simple mat was the collector. The sketch, was one of the initial ideas made even before project kickoff to probe if the technical difficuly was within our reach.

INSIGHT - THE FILTERLESS SHOWER

The objective was to expose the narrative of the recirculating shower to a broad consumer base and secondly to obtain knowlegde about shower habits.

USER QUESTIONNAIRE

To get a better understanding of showering habits, and user impressions of our technology, a questionnaire was created. The questionnaire included questions relating to time consumption in the shower, whether the shower was used as a recreational area, or only to get cleaned. Furthermore the questionnaire asked directly into our technology and how users felt about using small amounts of recirculated water to shower in.

DO YOU FEEL CLEAN BEFOE YOU ACTUALLY ARE DONE BATHING?

61% Yes, i feel relatively clean before im done showering
39% No, when im clean, im also done showering

DO YOU ENJOY SHOWERING? IS IT RECREATIONAL?

70% Yes, i enjoy showering, it is relaxing
30% No, i only bath to get myself clean

WOULD YOU BE WILLING TO REUSE 10% WATER WHILE SHOWERING

Imagine a percentage of your bath water, for example. 10% before it has touched drained, are recycled with new water (10% recycled water, 90% fresh water). The recycled water before it is recycled has only touched your own body and the floor. The recycled water will be coarsely filtered and second hair.

24,5% Yes, throughout the whole shower
11,2% Yes, after i washed my hair and body
5,1% Yes, after i washed my hair
1% Yes, after i washed my body
13.3% Other.
44.9% No.

4. IF NO, THEN WHY?

38,5% It is a hygenical problem
43,5% I do not like the thougt
18% Other

OVERALL SURVEY STATS

Gender:
100 participants
55% men / 45% women

Age group:
Ages vary between 14 to 76yo.
50% are between 23 and 25yo.

Shower frequency:
30% take seven showers a week
20% take six showers a week.
12% take more than seven a week.
38% take less than six a week.

Shower time:
33% shower 10 to 15min
40% shower 5 to 10min
14% shower 0 to 5min
13% shower 15min+

OUTPUT

Based on the online questionnaire, in which close to 100 participants answered questions in relation to showering habits, the overall consensus was that a large percentage was open to the idea, while others were still uncertain or directly opposing the idea of showering in small amounts of recirculated water. It must be said that no benefits of showering in recirculated water were showcased in the questionnaire, meaning that some users might not know the reasoning behind using our technology.
The questionnaire was spread through Facebook, meaning that most answers were done by people on our own age-group. However small amounts fluctuated in age, and we were able to get answers from people younger and older than ourselves.
Compared to our assumptions, the questionnaire revealed that some people simply were opposing the idea of recirculating water due to the consensus that the water is “dirty”. Others were welcoming to the idea, but had concerns in regards to when the system is used in scenarios where recirculating water would be unsatisfactory, such as in washing off mud etc.
If the system could be perceived as hygenical, or rather acceptable like using a bathtub, it can be assumed that group that answered “No, it is a hygenical problem” could be convinced. The group that said outright no, have to be futher investigated, what is the psycological barrier?
Furthermore it gave us insight in how long the average person uses in the shower, and whether hair and body was washed simultaneously or separately.

CURRENT WATER SAVING CATEGORIZES

The sustainable shower products/features can be categorized into three groups, each with a distinct approach and tradeoff. All categories were investigated, as one product often contains multiple sustainable features, that work independently or as a combination. Making it crucial to investigate, as it might provide an oppotuniy to combine ELVIRA with multiple features

1. AVOID

Products or features that avoid the wastage of water, by typically by restraining the length of a bath, or avoid the bath altogether.
Tradeoff: In order to save water, this type of product often attempts to dictate or change the users behavior. Often dimishing the "wellness" aspect of showering

2. REDUCE

Products or features that reduce the amount of waste water, by lowering the amount of water needed to shower.
Tradeoff: The reduction in water often impacts how the shower is felt, by either directly reducing the amount of water, or by a technology, creating the perception of better water coverage.

3. REUSE

Products or features that reuse water, to lower the amount of waste water. The reuse of water involves treating "used".
Tradeoff: Recycling water requires expensive filters, that need to be maintained and the products have a difficult implementation

OUTPUT

ELVIRA is within the Reuse category of products, it would be neccesary to seek out products in or close to this category, such that a comparison and benchmarking can be established, comparing ELVIRA to its competitors. Futhermore, an investigation into the broader market for saturation and opportunities to stand out, among the other water saving features will be conducted.

COMPARING THE CLOSED LOOP SYSTEMS

The objective is that based on the current water saving solutions, a close resemblance to our concept were found. Both products have been defined as "closed loop" reuse products. Orbital Systems produces a product with a value proposition close to ours, and a comparison would allow us to know how to position ourselves in the market.

ORBITAL SYSTEMS SHOWER

- Price: Starting at 5.295USD.
- Cleans 90% of water, they claim it is cleaner than the tap water initally used.
- Can be installed without renovation, but is difficult to install.
- Uses expensive filters that has to be changed at 15.000 and 50.000 liters used.
- High water and energy saving
- Filters water to a very high standard, output water is cleaner than the input water.
- Complete system, everything has to bought as a whole.

ELVIRA SHOWER

- Price: TBD - Affordable by the target group
- Cleans 30% of water.
- Should be able to be installed without renovation and easy to install.
- Uses a cheap filter that filters out hair and larger particles.
- Moderate water and energy saving.
- Filters water to a "Fit for purpose level" of cleanliness.
- Is adaptable to fit the current bathroom, can be bought as an extension to the existing shower.

OUTPUT

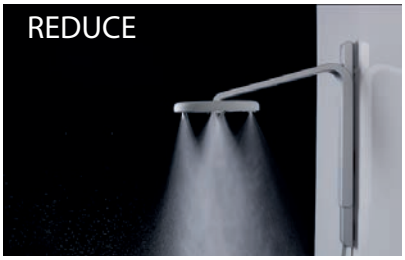
Comparing the closed loop systems from Orbital Systems and ELVIRA, it is clear that Orbital Systems target the high-end consumer market and possible institutions, with a "do-it-all" solution for a premium price. Furthermore it can be discussed whether cleaning water to a higher standard than normal bath water, and thereby using more expensive filters, is a sustainable solution, compared to cleaning water to a level that is "fit for purpose" requiring less intensive filtering. Orbital Systems has created a product that cleans a great amount of water, compromising with the use of expensive filters, and premium features, such as an app and intelligent heating. It would be nearly impossible for a familly of four to recuperate the the cost in saved water and break even and unreachable for a single person or a group of two. Orbital is a complete system, and while it does not necessarily require renovation to install, it requires a major revamp of the bathroom. It would probably be bought for new buildings, when the showerset or bathroom is to be renovated, associating additional cost and a barrier of implementation to the product.
A product that positoned itself to the broader market, by offering a product that has a lowered cost and implementation barrier. Possible a product where a student or a family of four could break even within years, could be a possible blue ocean within the reuse category. That market position plays to ELVIRA's strength, as the use of "fit for purpose" water, requiring less filtering and thereby a more affordable solution for a broader market. A lower barrier of implemention could be achieved by offering an "addon" product, or simply a showerset that is easy to install.

CURRENT WATER SAVING PRODUCTS/FEATURES

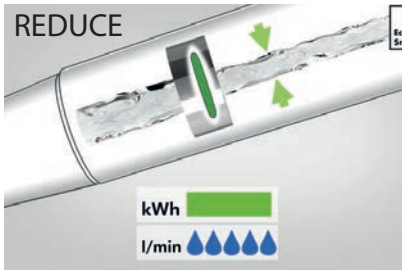
As the market is saturated with products targeting water saving, and as most solutions can be used in series with each other, to further save water, it can be beneficial to look at how these product solutions could benefit ELVIRA, and how these solutions embody the visual feedback towards the user, creating a sense of "I save water", or whether the solutions are hiding the features.

TIMER - A simple waterproof timer that will indicate when your shower-time is over.

WATER SWIRLER - A nozzle head that makes the water swiwel around, creating the perception of better water coverage, with less water.



WATER ATOMIZER - A nozzle head sprays water into very small droplets, thereby acheving big coverage with little water.



WATER RESTRICTOR - A restriction within the showerhead, that lowers the amount of water ejected out. This is a typical feature intergrated in most showerheads today.

AERATOR - By mixing air and water, the water density gets lowered, thereby reducing the water usage, this is often acheived by the venturi effect, and is a common feature intergrated in many showerheads today

CLOSED LOOP RECYCLERS - Water is collected in a bottom tray, filtered and reused. The solutions are very complex and require expensive filters.

FINDINGS

The **aerator and water restrictor** are widely employed by most manufactuers, as they provide a good effect with little effort, as they often can be implemented through standardized components, that can be added to virtually any system. The featurs are by no means delighers to most consumer, but rather a baseline for water saving shower heads.

Products that affect the water delivery to the body, such as the **water swirler and atomizer** to a high degree influence how the showering is felt, which might create a uncertainity if the shower experience is gimped or maybe more pleasurable. Furthermore the innovations are highly visible, or rather front facing which might be useful for branding and to stand out amongst the competitors. Both the swiwel and atomizer are located within the shower head

The **timer** is almost exclusivey seen as a stand-alone product, often very affordable but rarely seen. The assumption is, that the products in the AVOID category, are in contrast to the current market meta that promotes showering as recreational and refreshing activity, a timer would be detracting from that experience.

The closed loop recyclers at current are large scale features, that encompass the whole shower setup, from the showerset to even the cabinet. As such, these systems are extremely expensive, have a high-cost implementation and additionally are very complex as they require hightech filtering and maintence. Yet the principle to reuse water within a closed loop stands out, as a sustainable feature, as it directly saves water, recovers heat and lowers the chemical wastage, without impacting the shower experience.

OUTPUT

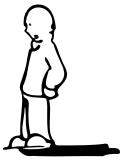
There is a great amount of products on the market, to either prevent water waste or to limit the water used when showering. Common among them is that they can work in series with each other, meaning that a aerator can be used in combination with a water restrictor etc. Furthermore it is clear that there is a lot of companies producing water saving products, however most are low cost solutions, which is already becoming the norm, integrated into new products, without any customer intervention, and with a lack of user recognition. A fairly unsaturated market is however surfacing with the introduction of closed loop recirculators, however the seemingly scarce product selection in this category is targeted towards the high-end market, with effective but expensive solutions. This category is accessible and we believe that there is a place for a product targeted towards the mainstream market, enabling for water saving at a reasonable price.

BUSINESS CANVAS: VALUE PROPOSITION & CUSTOMER SEGMENTS

The objective is to create an overview of the value propositions which our solution is going to fulfill, and categorize the customer segments and the values the solution will be targeting towards each of these.

The value propositions is the values which enables for the solution to have a space on the market.

- Minimizes water usage
- Saves energy
- Cost savings
- Minimizes chemical drainage
- Enables the user to have a positive environmental impact
- Enables the use of water "Fit for purpose"
- Enables for a low/mid-end market



The customer segments are created to be able to categorize different end-user needs and desires. Furthermore it is possible to create extreme users, making sure to be aware of a large range of end-users. At last it is possible to map what needs and desires are meet with out solution ELVIRA

THE ENVIRONMENTALIST

WHO ARE THEY?

- Very aware of the environment and how he impacts it.
- Is very progressive when new solutions towards a sustainable future is created.
- Does not think to much about the cost of "saving the environment".

ELVIRA ENABLES FOR...

- Makes it possible to use less water, thus saving the environment
- Creates a feeling of "I save the world"
- Does not contaminate the underground with chemicals

THE FRONTRUNNER

- A frontrunner when new technology is created, needs what is new!
- Keeps up to date with new technology and how this could affect his daily life.
- Aware of cost/benefit

- New technology.
- Makes it possible to say that he has the newest solution towards a sustainable shower.

THE MONEY SAVER

- Very aware of cost saving, and where it is possible to save money.
- Is very aware that he needs to save money in the long run, before considering buying.
- Does not think to much about "saving the environment"

- Makes it possible to create a cost saving solution.
- A lower price means that the cost saving benefit will occour earlier.

OUTPUT

Based on the Business canvas, it is possible to categorize three customer segments which would be potential customers of ELVIRA. The three categories are extremes in that sense that customers can be a mix of some or all of the above examples. It it very clear that making a product aimed at all customers could limit the possibility of making a concrete solution, due to having to fulfill all needs. Preferable, a ranking of which customer segment is our primare, second and third target group could be established, enabling for a more specific product development, targeted first and foremost at one target ground.

WATER USAGE: SCALE OF THE PROBLEM

The objective is to obtain information about the usage of water and the cost, to have a basis for calculating the benefit of reusing water.

The water usage in Denmark is plentiful, due to the quality of the water and the non-concern of scarcity of water. The average person in 2015 used **106** liters of water each day, whereas a person with low or high usage respectively uses **80** and **200** liters of water each day[http://www.sbi.dk/miljo-og-energi/gronne-regnskaber/gront-regnskab-for-boliger/nogle-tal-2015].

Baths and personal hygeine is the largest percentage, totalling up to 50% of the total water usage.
The water expenditure when showering are highly dependent on the equipment and durration of the shower. The **average shower is 12min**, whereas a water-saving showerhead typically outputs ~**5 liters per minute** and a non-water-saving shower head might use up to **10 liters per minute**,

The average water spent when showering in Denmark is about **40 liters,** as not anyone showers everyday. A high usage might result in **100 liters per day**, whereas a low usage might result in only **30 liters per day**. In addition to the water usage, is the cost of heating the water, which adds about **60% cost to the base water and drainage tax.**

A rule of thumb, is that the average shower in Denmark cost between **5 and 10dkk**, depending on the equipment the user has.[http://nyheder.tv2.dk/nyheder/article.php/id-70766581%3Ausynlige-priser%252C60062] The water cost per cubic meter, including drainage tax fluncuates between **42dkk to 65dkk** depending on the location in Denmark.

KEY FINDINGS
Families in Denmark do nothing to share water between members, the usage of shower water is doubling with each member.

CALCULATING WATER USAGE
A spreadsheet, to calculate the anual water expenditure of a student and a family of four has been calculated.
Spreadsheet:
(https://docs.google.com/spreadsheets/d/1tTAYjXgWGiFRCUKNsUCe_gWI-wYxMcreiydHZvAwFIec/edit?usp=sharing)

The reference numbers used:
- 57dkk for water heated to 40deg.
- The base cost was 41,2dkk, where the cost of heating has been added.

STUDENT
Peter showers 12min six days a week. He has a basic water saving showerhead, that ejects 6 liters per minute.

Annual shower water usage: 22464 liters
Annual water cost: ~1200dkk

FAMILY OF FOUR
Each family member showers 10min six days a week, the family has a very good showerhead, that ejects 5 liters per minute.

Annual shower water usage: 62400 liters
Annual water cost: ~3500dkk

OUTPUT

The usage of water is highly variable, the showering habit, equipment and number of persons showering are key.
Student or family, the anual water expenditure is enormous, and scale quickly by the number of users.
The family of four expend most water, but one could assume, that the shower equipment gets weared down faster.

WATER REUSE: COST-BENEFIT

The objective is to obtain insight in what can be saved by recycling a percentage of water, what is the cost benefit.

WHAT IF (30%)
an average of 30% was reused during the shower, what would that result in?

STUDENT
Reused shower water anually: 6739 liters
Water cost saved anually ~360dkk

FAMILY OF FOUR
Reused shower water anually: 18720 liters
Water cost saved anually: ~1050dkk

WHAT IF (30%)
The product has a lifetime of 5000 uses, and the product costs 1500dkk, how long would it take to recover the cost, how much would they earn before the product is weared down, and how many years would the poducct last. how much would the student or family earn, how many years would be product last, before breaking.

STUDENT

1500dkk paid itself in:	**3,8 years**
Product lifetime:	**16 years**
Earned per year:	**292dkk**
Earned in product lifetime	**4600dkk**

FAMILY OF FOUR

1500dkk paid itself in:	**1,3 years**
Product lifetime:	**4 years**
Earned per year	**697dkk**
Earned in product lifetime	**2800 dkk**

WHAT IF (50%)
an average of 50% was reused during the shower, what would that result in?

STUDENT
Reused shower water anually: 11232 liters
Water cost saved anually ~643dkk

FAMILY OF FOUR
Reused shower water anually: 31200 liters
Water cost saved anually: ~1750dkk

WHAT IF (50%)
The product has a lifetime of 5000 uses, and the product costs 1500dkk, how long would it take to recover the cost, how much would they earn before the product is weared down, and how many years would the poducct last.

STUDENT

1500dkk paid itself in:	**2,3 years**
Product lifetime:	**16 years**
Avg. earned per year:	**550dkk**
Earned in product lifetime	**8800dkk**

FAMILY OF FOUR

1500dkk paid itself in:	**0,8 years**
Product lifetime:	**4 years**
avg. earned per year	**1765dkk**
Earned in product lifetime	**5568dkk**

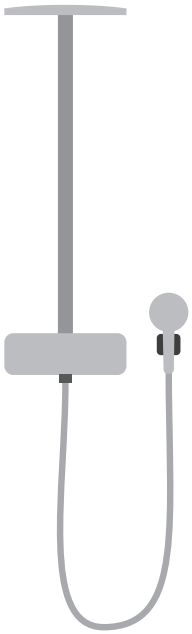
OUTPUT

A enormous amount of water can be saved and a sizable amount of money, the cost benefit aspect is very much dependent on the total percentage reused.
If the product costs 1500dkk, even the student is able to recooperate the cost within a reasonable amount of time. The product cost and lifetime are all assumed, but enable us to play with the cost/benefit, the relation between product cost and lifetime, which is a valuable metric when developing technical solutions. A longer lasting product will result in better payout for the user.

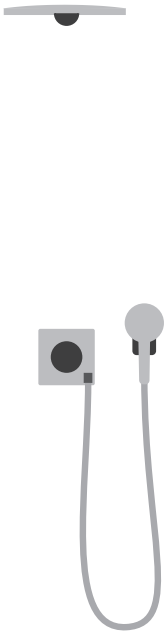
CURRENT SHOWER SYSTEM ARCHITECTURES

The objective is to gain insight into the current shower setups, what are the archetypes and what modules do they consist off, this is valuable, as it creates an understanding of where it might be possible to integrate the ELVIRA technology with the biggest impact, from a point of standarization.

Traditional Shower Set
Based on an independent showerhead, and external mixer, these product are more common, and is placed in the lower end of the price range. The architecture consists of one showerhead, with a hose connecting it to the mixer.
1000 - 7000 dkk



Two shower head set
A higher end shower with two shower heads, one independent, which can be moved freely, and one stationary, which is situated above the user. These products can be acquired within a low and high price point, depending on the brand and quality. The architecture consists of a moveable showerhead, a stationary showerhead, and a mixer connected to both showerheads.
2000- 24000dkk



Wall-intergrated shower set
The highest end shower consisting of a built-in system with two showerheads. This architecture is priced in the higher-end with a need to renovate the wall, which the product is installed in. Due to the product being built into the wall, these showers are usually very covert. The architecture consists of a moveable showerhead, a stationary showerhead, and a mixer connected to the stationary showerhead with a built in hose, and to the moveable showerhead .
3500- 30000dkk

The prices are gathered from billigvvs.dk

OUTPUT

The three architectures are differentiated by the price point and features they incorporate. Architecture 1 and 2 are widely based on the same principals, with an added stationary showerhead being the main benefactor when choosing between the two. Architecture 3 separates itself by being mostly built into the wall, therefore hiding parts from the user. This also requires for a more throughout renovation of the wall, and is mostly aimed for new bathrooms being built, which further increases the price.

The mixer, showerhead and cable are the three most common elements, building the feature within one or more of these three elements would ensure a high coverage. Whereas building it into the overhead showerhead, might provide a feature to an already high-end product, perhaps creating a more attractive product.

OPPORTUNITY MAPPING

The objective is to define future opportunities in regards to how the product is offered, is it a total solution or merely an addon. And what are the business and design oppotunities in regards to us as a project group.

INDEPENDENT PRODUCT

Stand Alone

The stand alone product, would be defined by a product which could be added to the bathroom as an independent product, and could be seen as an accessory to the bathroom. This product could then be installed independently from the shower, as a way of saving water while showering.
This would allow for a design which could be separated from existing shower products in the bathroom, and could allow for a broader design exploration, due to not being restricted to fitting existing products on the market.
Choosing this product type would allow for the group to create a product which could be situated in all bathrooms, however this would also limit the possibility of integrating the product into an existing shower, creating a more integrated architecture. Due to the nature of this, cooperating with an existing company would deem less relevant, as the product wouldn't need to fit into an existing product range.

"Add-on"

The add-on would function as an add-on for the existing installed shower, and should be able to be installed on most showers. This product could be designed to fit an existing shower head, mixer or elsewhere, depending on where saving water would be most effective and doable.
As the product would need to be designed to fit a large amount of showers, designing the product would require it to be "neutral" in design, and wishfully fit most existing shower designs.
Working as an add-on it would be possible to make the product work in parallel with the shower, and create a more integrated architecture. As the product needs to be added to existing showers, it could be beneficial to cooperate with an existing shower company, as it would allow us to create a product which would fit their range of products, and also fit most other products on the market.

Independent product

The independent product would consist of a completely new product or system, consisting of a redesigned mixer, shower head, hose, or all combined. This architecture would allow for a very integrated solution, and could result in the most efficient product. However, due to it being a completely new product, the user must replace their old solution with this, and the cost would probably be higher.
The design, would as the stand alone product type, be independent, and would not have to follow an existing product range. This would allow for full control of the appearance and would allow for changes to how a mixer looks and behaves etc. The design could also consist of retrofitting our technology in an existing product on the market, making the exterior design represent the existing product closely.
Choosing to work with this product type could result in a completely integrated solution, in which the group has full control of the design and construction throughout the product. Furthermore collaborating with a company would benefit due to their knowledge about showers. Retrofitting the product would call for a cooperation with a shower company, due to the need for an existing product to be retrofitted with our technology.

INTERGRATED PRODUCT

OUTPUT

The three product opportunities are defined by the type of product, the application and possibilities when seen from a design and business perspective. The scale and possibilities were defined to seek out product opportunities in where out technology could be materialize. Furthermore ranging from the completely independent product to a integrated solution, it is clear that the reasoning behind company cooperation increases when the product becomes a solution aimed towards existing products, while product complexity varies according to whether the product is a add-on for existing products, or a completely independent system, meant to replace the existing shower system completely.

A choice cannot be taken, as it heavily depends on the actual implemention of the technology, and how the components are scattered in the system. If all functionality can be concentrated in a few modules it might be possible to make an addon, if not, it might be better to make a more intergrated product. The important aspect is to be aware of this, as it might be a parameter to choose a concept later on.

WS40 - Second layer considerations

Date: 07/05/17 **Written by: Jacob**

Objective

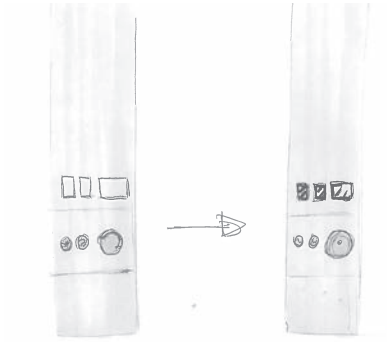
The objective was to find how the second layer could be created in a way that would be easy for the user to understand.

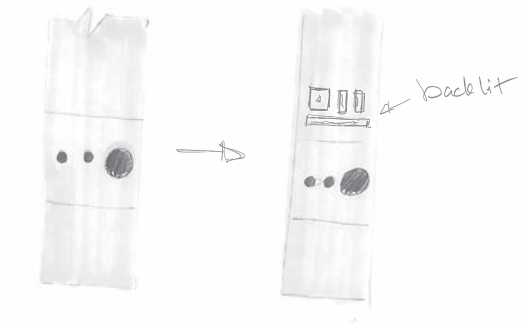
Reason behind the second layer

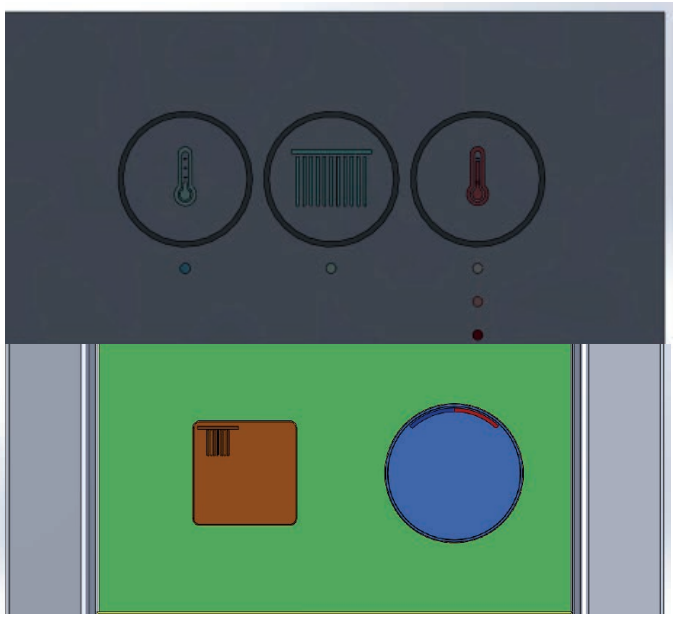
The second layer was built around the idea of presenting the feature to the user, when they made sense, and when they were available. Through the development of Elv, a great focus were put on which features should be available to the user, and when they should be presented. A lesser degree of focus were put on how these features should be presented on the product, how the pictograms should look, and how the user would perceive this, this was also apparent when users questioned what the different buttons did, and when some users guessed completely wrong when asked. Some work were put into how the buttons should be set up, and different variances were sketched.

Pictograms

The initial pictograms were mostly created as a way to differentiate the buttons on the sketches, to make it easier to understand by the team members, and these pictograms continued on in the project without second thoughts. It was lastly when the CAD model were created that the pictograms were revised.







Evaluation

The second layer was created very late in the process and different interactions were not tested with users. This can be seen as the final concept were created on behalf of the teams own opinion and not what was understood by the users. Furthermore the pictograms were not considered more than the bare minimum and could be revised if needed.

Reflection

Testing the final interaction would be beneficial as it is of great importance, as the user needs to understand it to use it. However due to time constrains this has not been deemed possible, and should probably be done in the future.

TECHNICAL DEVELOPMENT - CONTROL

OBJECTIVE: To adapt and develop the technical structure to be able to fullfill the features, aswell as define to the functional control method between the different modes.

Updated Overall system description

1. **The shower has been initiated**, water is gathered in the collector, where it is coarsely filtered to obstruct larger particles such as hair and is measured in terms of turbidity (haziness), color and temperature and conductivity.
2. Depending on the mesurements, water is transfered up by an active pump to the buffer tank.
3. The buffer tank has two purposes, one is to shortly store the water to be UV-C treated to kill harmful bacteria, and secondly to shorten the "lift" distance which is critical to make the venturi injector function at maximum effect.

4. **Meanwhile,** The thermostat is pushing fresh water through a series of valves, the state (closed/open) of each valve will detemine one of three paths the water can take:

(Clean-mode) It passes directly into the showerhead, ejecting clean water.
(Eco-mode) The injector passes through the eco-venturi, ejecting a determined mix of clean and used water equivalent to a normal flowrate.
(Comfort-mode) It passes through the comfort-venturi, adding constant percentage of used water ontop of a normal flowrate, achieving an increased flowrate.

5. As water is passing through one of the two venturi injectors, a suction is created at the injector inlet, wherein the UV treated water from the buffer container is lifted into the injector, then combined and ejected into the showerhead.
6. As the combined water is ejected to the showerhead, **water is being ejected onto the user.**

System control - Valves

By controlling the 3 valves, the flow can be redirected to acheive the "Off mode", "Eco-mode" and "Comfort-mode", by precisely controlling the valves, a relatively smooth transisition between the modes in terms of flowrate should be available.

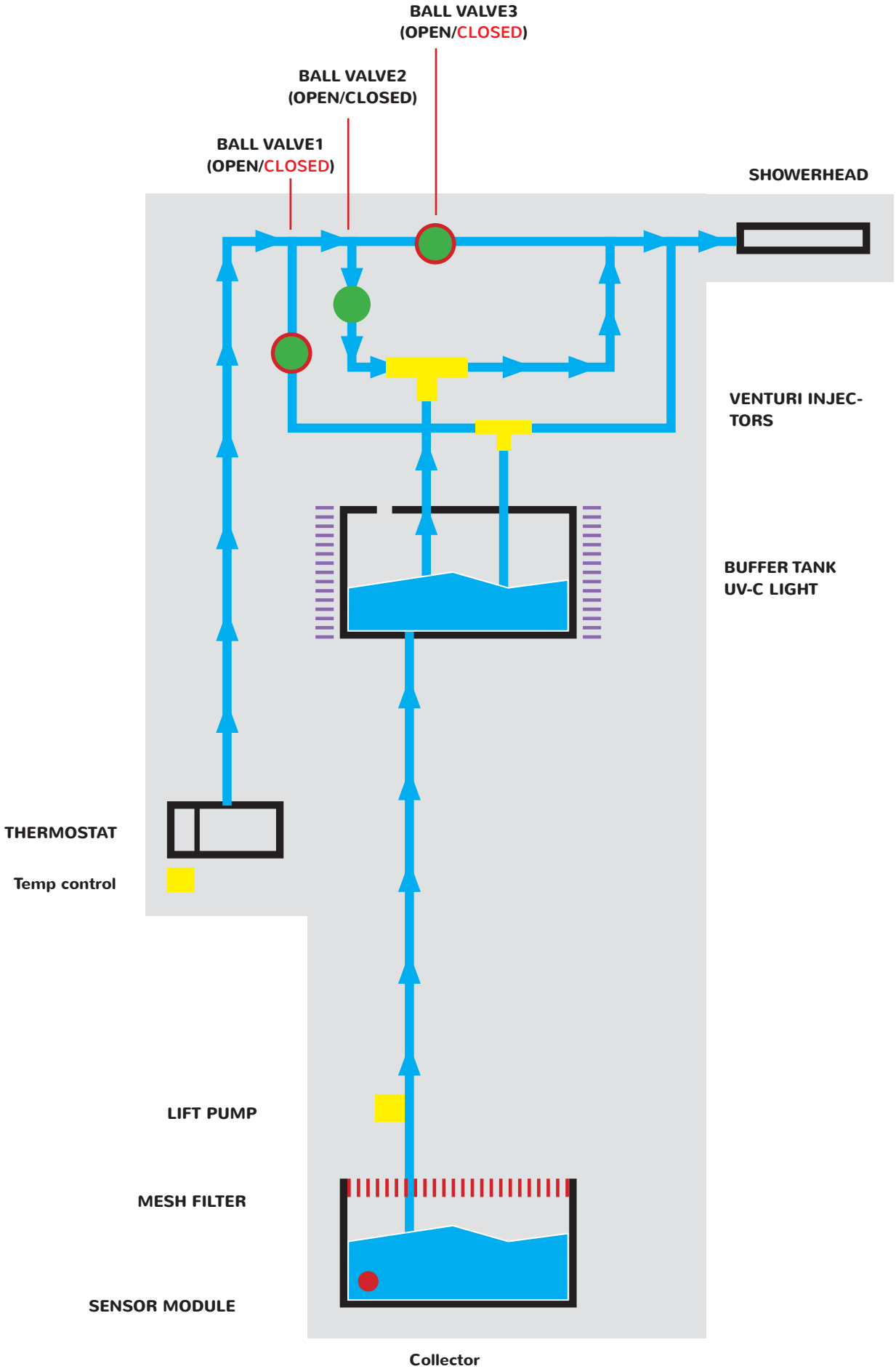
Control operative:
a) The automatic soap dectection, will switch between eco-mode and clean-mode.
b) The automatic soap dectection, will switch between comfort-mode and clean-mode, if comfort-mode is enabled.
c) If the buffer tank is empty (in case no water can be picked up) it will switch to clean-mode.
d) The On/Off button when pressed will always, regardless of what mode is enabled, change to clean-mode.

Valve combination:
The system is currently in Comfort, as seen in the right hand illustration.
Off-mode = Valve1(open), valve2(closed), valve3(closed)
Eco-mode = Valve1(closed), valve2(open), valve3(closed)
Comfort-mode = Valve1(closed), valve2(closed), valve3(open)

System control - Limitations and consequences

-The system has no adjustable flow control, only a on/off flow button. Hans Grohe offers several of their high-end showers with no adjustable flow, it might be seen as a luxury feature, like a start button in cars. Furthermore, it was observed that very few actually adjust the flow while showering, however this is only a claim, and cannot be backed up data.

- The system must be offered as a shower pipe configuration (overhead showerhead, non removable). Furthermore many shower pipe configurations offer a handheld showerhead as an option. The configuration, the right-hand illustration has no such support at the moment, however it would only require a diverter, which is no issue, except that it would only output clean water.


BALL VALVE3
(OPEN/CLOSED)
BALL VALVE2
(OPEN/CLOSED)
BALL VALVE1
(OPEN/CLOSED)
SHOWERHEAD
VENTURI INJEC-
TORS
BUFFER TANK
UV-C LIGHT
THERMOSTAT
Temp control
LIFT PUMP
MESH FILTER
SENSOR MODULE
Collector

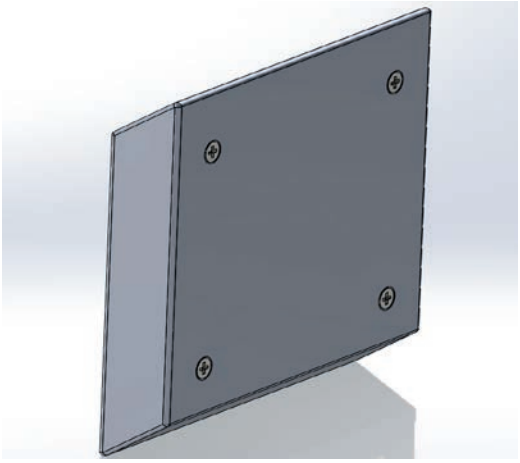
INSTALLATION AND MAINTENANCE

OBJECTIVE: The objective was to make sure that the product could be installed by the user, and what this involves.

Installing Elv

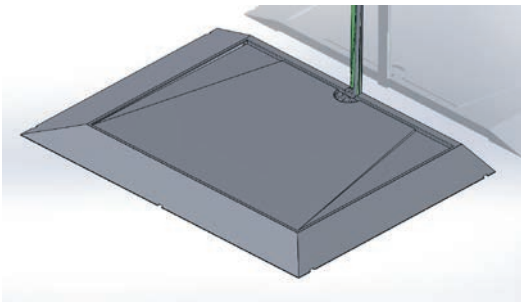
It was very important that Elv could be installed by the user themselves and without the need for a friend to help, without needing professional installation, as is the case with the competing products. This developed as series of requirements in regards to how the product should be designed, delivered and how many steps is needed to install.

Furthermore as Elv uses a battery as power, the installation is much less complex than if it was AC powered due to not needing a electrician to install the outlet for the product. Consideration were made to each of the parts, to help the user install Elv by themself.



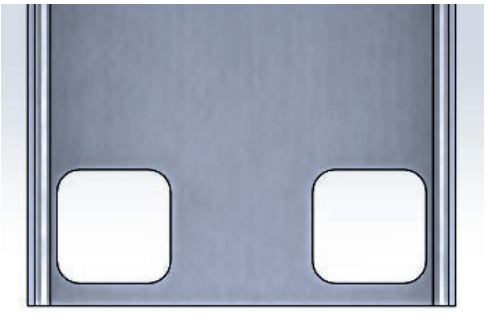
The wall mount

- Mounted in the right height on the wall.
- Should ease the rest of the installation by supporting the main body, when it is installed on the wall.
- Installable by one person.



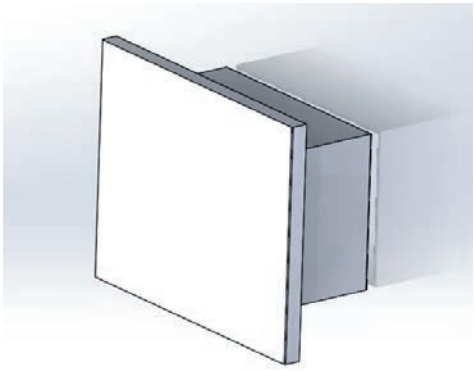
The mat

- Slim to be flatpacked.
- Easily installed by the user with a tube for recirculation.
- Easily lifted for cleaning.



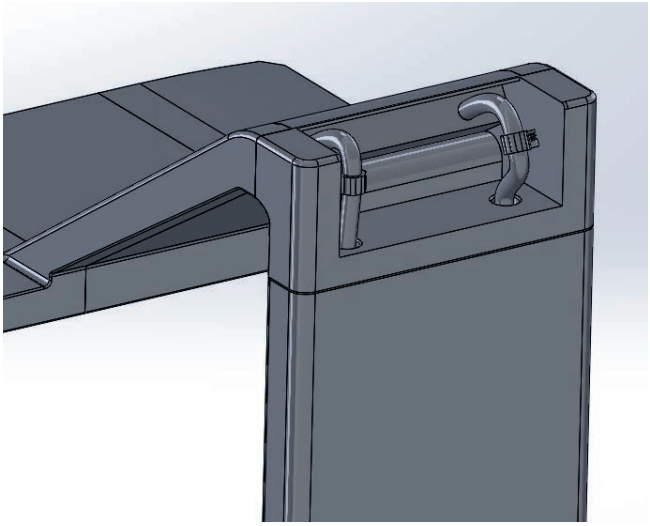
The frame

- Has holes for mounting the inlet tubes at a STANDARD of 150mm distance.
- Inlet tubes can be installed after Elv is mounted on the wall.



The battery pack

- Replaces the normal AC installation required.
- Makes installation of Elv legal to do by the user themself.
- Easily removed to charge.



The shower head

- Detachable to enable the product to be flatpacked.
- Easily attached by the user with to tubes.

Maintenance of internals

- The system should have a cleaning system to clean internals.
- Access to the drain in which cleaning fluid can be poured.

Output

The installation of Elv was very important, as it would be the first thing the user should do after buying the product, the first barrier before use. This is also why the component layout is created as it is, as connecting a large amount of tubes and electrical connectors could confuse the user. It is clear that by using a battery, the installation has become much less complex, and this is also the reason to why the installation is as easy at it is.

WS44 - Mat manufacuring

Date: 08/05/17 **Written by: Jacob**

Objective

The objective is to see how the mat could be manufactured.

Manufacturing the mat

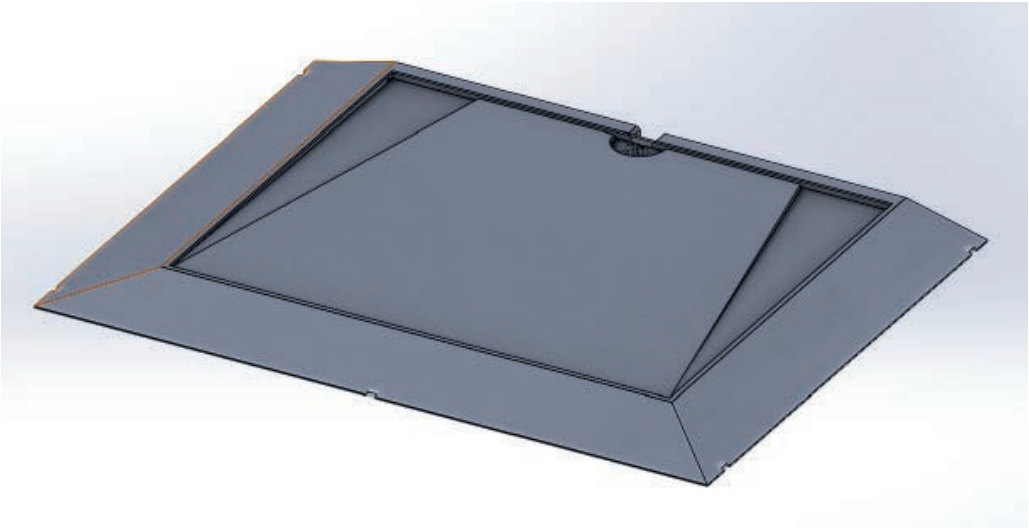
As the mat does not have any electrical components embedded, and is simply a “dead” part, meaning that it is just something the user stands on, the process of producing the mat is not considerable difficult. The mat could be produced in the following ways:

Injection moulding: The mat should easily be able to be injection moulded as there is no difficult cavities in the form. The only cores that would need to be placed, is for the drainage holes in the side of the mat. Furthermore the form already has a form of draft angles due to the slopes, meaning that it would be beneficial to eject the form with the slopes oriented in the right way.

Rotation moulding: The mat could be rotation moulded as again the tolerances needed is not critical.

Considerations

- Produced in plastic due to the complexity and low conductivity, meaning that it won’t become as cold as a metal.
- Does not need to be UV protected, but should not absorb moisture.
- Should withstand acid and alkalis.
- ABS would fulfill these criteria.



Evaluation

Due to the simplicity of the mat, there is a range of moulding techniques that can be used to produce the mat. Furthermore it can be considered whether the mat should be hollow to use less material, in which blow moulding could be a technique to create a hollow core.

Reflection

As the mat has not been in focus throughout the project, the production consideration are very limited, however some consideration were made, however finding the most suitable production method has not been done.

WS45 - Showerhead manufacuring

Date: 08/05/17 **Written by: Jacob**

Objective

The objective is to see how the showerhead could be manufactured.

Manufacturing the showerhead

As the showerhead includes the venturi system, but otherwise is only there to eject water, several production methods are available.

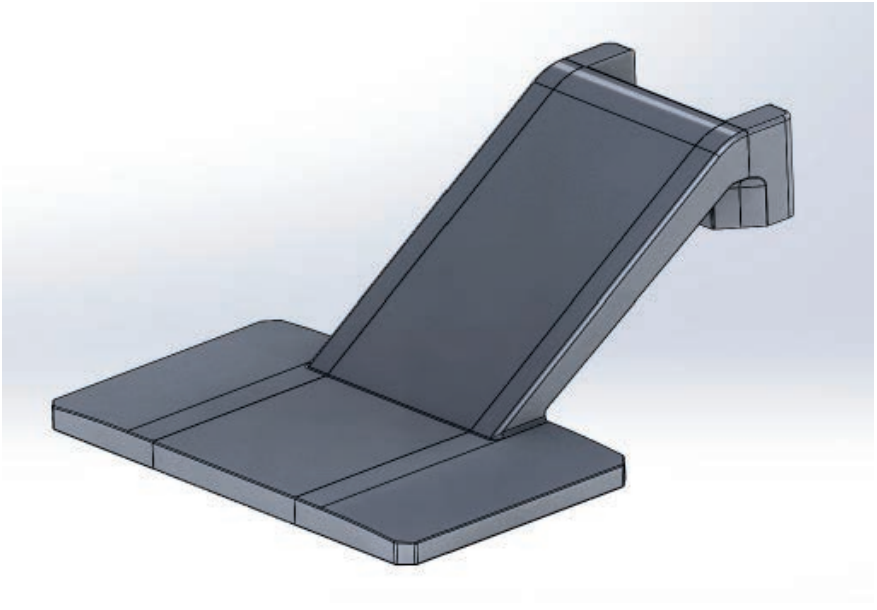
Injection moulding: If the showerhead is produced in plastic, it could be injection moulded, however as it is hollow, it could be beneficial to split the head in the middle, and mould each part and then glue those together. The showerhead is a fairly complex form, and splitting it would make the mould both cheaper to produce and be easier to mould. After this the showerhead should probably be chrome plated to maintain the look wanted in the shower.

Rotation moulding: The showerhead could be rotation moulded as if it was split, the two parts could be in the same mould, and could afterwards be glued or welded together.

Blow moulding: The showerhead could be blow moulded as it is hollow, this would allow for the form to be created in one part, not needing to be split in the middle.

Considerations

- Produced in plastic or metal and be chrome plated.
- Split seam to make production easier, due to hollow core.
- Venturi should be able to be installed.
- Nozzles produced in silicon due to calcium clog up.



Evaluation

As the shower head is a bit more complex due to the hollow core, the manufacturing should probably be looked into more, as to be able to chose the manufacturing process specifially for this task.

Reflection

The showerhead has not been much of a focus for the team, and the production considerations is therefor lackluster. The only specifics in regards to the showerhead is the width of it, which is needed to cover the whole body of the user.

WS46 - Main body manufacuring

Date: 08/05/17 **Written by: Jacob**

Objective

The objective is to find which material would work the best for the main body of Elv, as it both has to be strong, to support its own weight, and still feel nice to the touch.

Materials

The body of Elv can be produced in various materials, and due to the extrusion of the profile should also be fairly cheap to produce.
The materials considered are ABS and Aluminium.

The ABS is very easy to extrude, and is very resistant to soap and other alkalines found in the shower. ABS is very non conductive, and would not feel cold in the morning, however due to rigidity of the material it might squeak due to the size of the body. Furthermore the material can be very "non-premium" looking making the product feel cheap.

Aluminium is a more premium feeling material and can be anodized to the wanted color. However, it is also very conductive, and can be cold to the touch in the mornings. Aluminium is easily extruded, so it would not be a problem to produce. The rigidity of aluminium could come in favor as the material would not squeak and would be very strong when installed on the wall.
The aluminium would feel more premium to the user, and as most showers today rely on being produced in a metal, either nickel plated or stainless steel, the feeling is very much a concern, and is of high regard. This is also why aluminium has

Evaluation

The chosen material is aluminium which should be anodized due to the environment it is in. Furthermore the anodization will give options in regards to different colors being used.

Reflection

As it has been chosen to produce the body in aluminium, it should be considered how thick the material should actually be, as this would cut down on the material use. Furthermore it is still unknown how aluminium reacts to temperature changes over a longer period, and how anodization would hold up to alkalis. This should be reseached further in the future.

OTHER WORKSHEETS

WS - Project theme decision

Date:28/11/16 **Written by: Alex**

Objective

Initierende brainstorm
To find an overall direction to look, hopefully ending with a project theme, through multiple short brainstorm sessions over a period of 1 month, from november to december.

Data

1. Tag system, til rejsende folk (Tagge ting, og swippe telefon over taske, har man glemt noget?) Tyveri

2. Digitalisere farver og tekstur, plasktiktyper redskab

3 .Wearable clothing, make it smarter.
Handsker, fylder for meget, nøglering
Hue
Trend nøglering

4. Indkøbsnet

5. Tandbørste, hyNoise cancelling panelergienisk?

6. Postkasse notifier

7. hydroponics

8. Skruetrækker, finde den rigtige bitstørrelse
Skruetrækker der måler torque ved udskruening, og som tilpasser sig til målt torque ved indskruening

9. Inddørs grill
Sous wide, immersion cooking

10. Genbrug af badevand til at bade

11. Nye elektriske biler gør det svært for blinde at høre dem, kan man lave noget som kan notificere dem, hvis en bil kommer kørende, når de vil over vejen?

12. Et smartere vejkryds system. Nye biler bliver mere intelligente, kan de kommunikere med signalering i kryds, så man får et bedre flow af trafik?

Evaluation

The brainstorm yielded some interesting directions on where to futher research. The brainstorm was mostly focused in the solution space, looking at possible product categories, that might be good for a starting point for futher research.

Reflection

It was chosen to look at “the reuse of bath water” as a starting point, because of an informal discussion about an phenomen we both observed personally, which was that, that a lot of shower water, that doesnt seem dirty is going down the drain, giving us the “what if” the used shower water was reused to shower in again, as it was not very dirty.

WS - Initial project framing (1dec, 2016) Date:01/12/16 Written by: Alex

Objective

Inititial project direction (part of the project description hand in, 1dec 2016

To explore the potentials of reusing shower water.

Data

Brainstorm - potentials
To further develop a direction, a running brainstorm consisting of potential solutions has been performed. This is to both explore a possible project heading and product outcome, thereby giving an insight in what areas to research and what technical challenges to expect.

Water pickup system
While you shower, warm water that has just barely touched your body falls down into the drain, water that hardly is contaminated or spend its heat. Now imagine a system, that just as the water falls off, immediately pick-up percentages and reuses it to shower within a seconds and possibly fuses it with new shower water.

The reused water has been not exposed to the the contaminated pipes further down the system and still retains it heat, thereby saving both water and energy. By fusing the relatively clean recycled water and fresh water, it might be possible to reach water solution so clean, that expensive filters can be omitted (the percentage of recycled water, to new water being a key factor, maybe a variable system)

Water cleanliness, what is acceptable?
Wastewater that has not been contaminated by fecal matter is coined greywater, and typically has its source from sinks, washing machine, showers and baths in households. All types of greywater are often put in the same category, but we argue, that the cleanliness largely varies.
For instance, the interaction by a sink, might be food prep, washing hands, or even household cleaning, therefore the properties vary a lot, where as a bath exclusively is for showering.

By only recycling shower water and making the distinction, we might be able to create a much more specialized system, possibly at a very good price. The next question would be, what part of the shower water has to to be filtered to be considered acceptable (Perception of clean varies). Shower water largely contains soap, organic matter (dead skin and hair) and a mix of dirt and sweat, soap is very hard to filter out, and would require a larger processing plant, whereas it might be possible to filter out larger particles relatively easy. Would soapy water be acceptable for users? If so, would it be more suitable for some phases in the shower than others, or could it be beneficial to dilute it with fresh water.

Perception of water cleanliness, manual or automatic control possibilities
Perception of water cleanliness for showering, certainly varies both within the same household and most definitely between a rich and poor environments. For instance, we if take water cleanliness by a scale of how many percentages of recycled water is diluted with fresh water, some might find it acceptable to reuse 50% others 20%. Another consideration is the shower patterns, there will be a phases with especially soapy water and very clean water, and the ratio of recycled, would vary depending on those phases.

Imagine a shower faucet with a third rotary knob that could control the percentage of recycled water, giving the consumer control and maybe inciting a sense of satisfaction “wow in this bath i recycled 50% of the water”. A manual system could possibly reduce the technical difficulty of development and maybe be a very cheap solution.

An automatic system possibly high-end, would be able to sense water cleanliness and adjust water ratio accordingly. Removing control from the user might be beneficial for children, institutions and such, where the users don’t understand the concept of saving money or helping the environment, or users that have no familiarity with the system, and therefore understanding how to use it, a “smart bath”

Centralized or decentralized system
A centralized greywater plant in households, connects all greywater outlets to one filtering plant and almost certainly requires to be implement when the house is built as seen in zero emission housing. Exploring the possibility of small decentralized systems with the intent of reducing the barrier of entry is very interesting, a product that would require no change in infrastructure, easy to implement and maybe even DIY.

Imagine a water saving system, that could be picked at Imerco, installed in half an hour and had a clear business proposal. What are the delighters in a industrial product made consumer grade?

Passive pickup system
Use the already existing water pressure, to passively pick up water, thereby omitting motors and such. For instance use a water aspirator commonly used in laboratories (an aspirator uses a high water flow rate to proportionally sized vacuum).

Approaches to saving water
The above topics are mostly concerned with recycling and reclaiming water that would otherwise be lost. The advantages is that the bathing experience, or rather the way water hits your water and such remain the same and we believe a closed loop water technology might have a big potential for scalability.

the opposite would be to limit the amount of water used and thirdly to create an environment that encourages lower water usage. Water atomizers for instance limit water usage to a high degree, but create a totally different bathing experience, think Buckmeister Fuller's Fog Gun https://www.gwern.net/fog-gun

Evaluation

The above started as an initial research, but ended up
as a throughout investigation on possible potentials,
touching up many different aspects, albeit a bit chaotic.
but explains our current thoughts very well.

Reflection

The reuse of bathing water open up for some very interesting disscussions and posiblities.

It proposes a technical system that works VERY differently to conventioal greywater systems. In a normal greywater system, all the water would be filtered very throughoutly, because water from different sources are mixed, but if the system is closed loop, a shower, that only reuses showerwater from the same bath, it might be possible to NOT filter the water as much, thereby proposing the technical solution of a greywater system for showers only, that can omit expensive filters.

THE CURRENT TECHNOLOGY, Greywater systems are VERY expensive, and require an implementation that has to be done by proffesionals, very expensive and a time consuming implementation, if it has to be retro fitted into older houses. It can also be built into new houses, that too is very expensive and has to be preplanned.

A NEW TECHNOLYGY that omits big filters and makes it closed loop, would make it possible to offer a greywater system for the shower, that both could possibly could be cheap and easier to implement, possibly removing two MAJOR barriers.

BUT, the REQUIREMENTS to the system is that it has to be cheap and easy to implement.

ENABLING us to offer a unqiue solution to saving water within shower systems.

implementing A NEW TECHNOLOGY that reuses water might challenge the perception of water cleanliness, from a hygenical and physiological standpoint. Using a bathtub is acceptable, using a towel multiple times is too, but reusing shower water while it might be hygenically sound, is outside what is normally done, breaking the usual behavioural pattern. Making it nessercy to investigate water cleanliness from A HYGENICAL STANDPOINT, ASWELL AS FROM A BEVAVIORAL STANDPOINT.

A system that reuses water, in terms of functionality has to transport water from A to B, TECHNICAL SOLUTIONS to do so, in a way that would follow the requirements of being cheap and easy to implement were briefly ideated, starting the initial investigation how possible TECHNICAL PRINCIPLES.

lastly, other water saving aproaches were disccussed, initiating the investigation into OTHER POSSIBLE METHODS TO SAVE WATER, IN TERMS OF COMPETITORS AND OTHER TECHS.

The potentials seem vert promising, with plenty to work on, we have decided to choose this theme for our project.

WS - Idea bords

Date: 20/01/17 **Written by: Alex**

Objective

The objective is to provide a way to gather ideas before the actual project kickoff. Three categories(boards) were made.

1: Technical principles
The objective was to explore the possible technical principles and solutions needed to get our initial concept to function.
Furthermore it was necesary to explore the technical principles, to get a intial understanding of the components needed to get a working prototype.

2: Product Direction
The objective was to map how the product could be offered.

3: Insights/Assumptions
The objective is to provide a space to set down assumptions/insight that are made throughout, "what if's" and "If that is X, then we expect it results in Y"

Data

TECHNICAL principals

The initial technical principles were divided into three main areas:

1. The way of powering the system if it was an active system.

2. The suction method, active or passive.

3. How the used water should be fused with new water.

As the initial idea was that the system could not rely only on passive components, without a need for power, a way of creating this power was explored. Initally both battery and AC outlets were considered due to not knowing how much power draw the system would end up taking. The AC solution were however not favored due to the complexity, and the observation that few bathrooms have outlets in the shower area, furthermore the installation would probably require professional installation if AC power were to be used. The battery was a reliable way of getting power, however the power draw might be to high for a battery to be feasible.

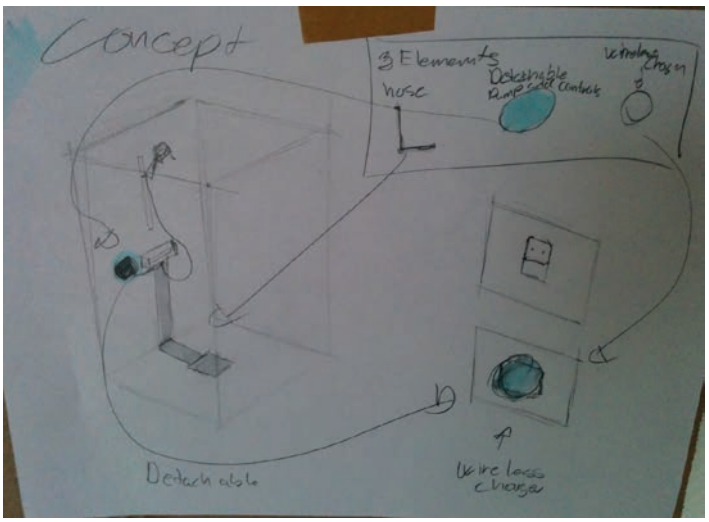
The suction method could either be active or passive, however the passive system would rely very much on the pressure and flow of water, whereas the active solution could be made to accomodate all types of shower, not needed to worry about flow and pressure of water.

Fusing the water is necessary as we want to mix the old water with a percentage of clean water. The initial idea was to create a T-pipe, simply making it possible to introduce old water into the stream of new water.

Evaluation

The solution was heading towards using a battery, as this would allow the user to install the system themself, avoiding a complicated installation due to AC power restrictions. However it can be necessary to use AC power, if the power draw is to high for a reasonable sized battery.
The suction method is still very much a thing which needs to be tested, as this is such a important function of the concept, and needs to function without fail.

Fusing the water with a T-pipe was tested, and the result was that it was incredible difficult to fuse the water, as the pressure of the used water had to be higher than that of the clean water, this meant that passive suction was very difficult to imagine, as the passible solution we had explored were with very little pressure and flow, not able to win over the clean water pressure and flow.



Reflection

It was very important to test some of the technical principles as these lead to quick realizations in regards to fusing the water, and if passive suction would be possible. This lead to us seeking new ways, and exploring whether our passive method of sucking up water could be different, this needs to be tested further.

DIRECTION BOARD

Product type, what the product could be offered as, what would be easiest to implement, what would be cheapest etc. Stand-Alone……Addon……Integrated (or could it be a bathroom accesory)

If the product was offered as a stand alone, it could
be sold and marketet from from a third party company, maybe a startup, it should be easy to add on the exisiting product structure."

If the product was offered as an addon, that a producer of shower equipment could use as a addon feature. Imagine a addon with an compatibality of 80% that had the water recirculation feature.

IF the product was offered as a intergrated product, it would be a total solution like a shower set, it could for instance be a new product line for a company, it would require to design the whole set., but it might be easier to get a unifed visual expression and technical structure.

Where to place ourselfs, scale "market framing"
$$----COST-BENEFIT---- "ECO"------ Save the world

What value could we offer, the value proporsition on a scale.

Institution or bolig foreninger, might be very interested in it, from a money perspective.

The normal family, might be able to see the cost benefit, as in, if i buy this, i would be able to break even after a year or so, and thereafter save some money, with the added benefit of using less water, which is good for the environment.

Is it the ECO guy, that is willing to pay for a solution that supports the environment, maybe willing to pay a premium or go through more inconvienses.

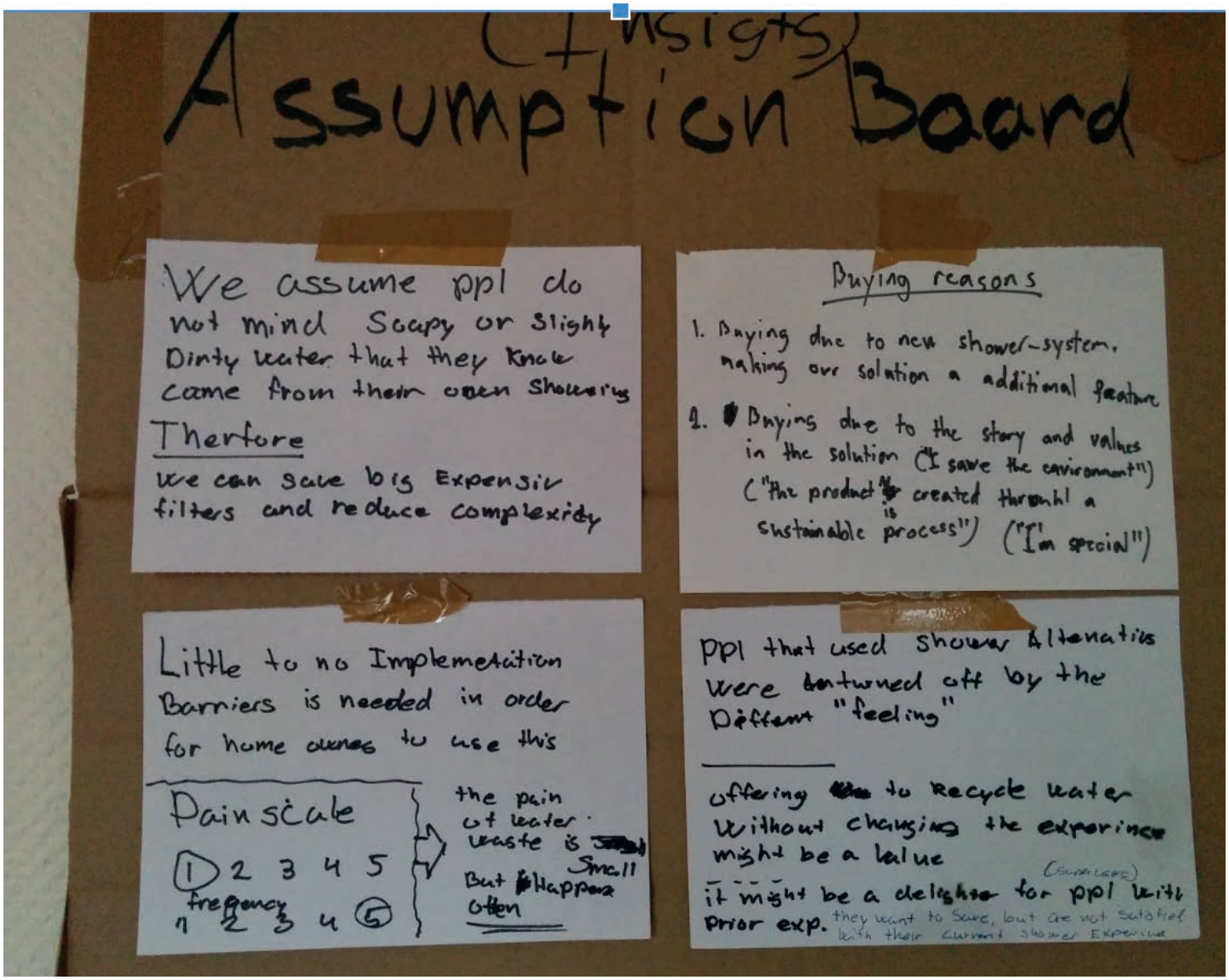
Is it a produc that is used for areas with water scacity, do we create a "save" the world product.

Reflection

How could the technology, the recirculating shower be offered? what are the benfits in terms of making it cheapest and easiest to implement, that would depend on how the technical structure would be defined, it might be needed to make an intergated product to make it work, maybe an addon is possible to make. We need to futher explore the solution space to see how the technical solution shapes up to be.

What target group, is our product aimed at, is it regions where water is scarce, is it areas where water is very expensive, and using as little as possible is important, or is it the westeren world, where we could adress a quality of life issue. Offer a shower that makes you "feel better" by saving water. Or maybe the familiy, could save some money.

It would be needed to research the various cultures, what is their relation ship to water.



Reflection

Through the assumptions, we are able to list down some requirements, which for instance would be an easy implementation, but how the implemention defined as?

We assume, that people would not mind slightly soapy water, if they know the origin, this needs to be tested.

We assume that two buying reason exist, we need to talk to sales persons, what are the reasons

We assume, the current solutions that save water, in some way or the other negtively impact the shower experience by offering less water, wheres our current solution would not

WS - Touchpoints while showering

Date: 02/03/17 **Written by: Alex**

Objective

Explore touchpoints in a shower, normal usage, special cases etc.

Data

Touch points
Normal usage
Lather hair with shampoo
Rinse hair

Lather body with soap
Rinse body

Wash face
Rinse face

Apply conditioner to hair
Rinse conditioner ‘

Wash the genital area with ph-neutral soap

Removal of dead skin with hemp sponge
Removal of hard skin with rasp

Adjust the water temperature multiple times during the shower
Adjust the water flow rate multiple times during the shower

Letting the water get warm and run for a prolonged time without going into the shower yet.

Sometimes
Cold shower
Hair cure
Shave face

Washing toddler
Pee
Brush teeth
Shave legs
Cut nails
Menstruation blood
Clearing nose in bath

Rarely
Wash dog
Throw up in bath
Wash plants to get dust off
Pour fish tank water down the drain
Pour cleaning water down the drain
Bathroom cleaning with hard chemicals
Onani
Kneppe

To be assigned
Aroma terapi som påføres før bad, smøres på krop
Songer
Tømmer afløb hver anden dag
Frisere hår inden bad, for at minimere hår i afløb
River løse hår ud og hænger dem på væk

Evaluation

Based our own personal experience and interviews asking them to describe their shower procedure, a list of touch point and 4 timelines where gathered.

all four had a standard shower set, architype 1

Reflection

The list of touchpoints and timelines have given us an inital understandng and reconfirm the two archetype of showers, the fast shower and the recreational shower.

Furthermore it gives a good look at the touchpoints woman go through some things to consider.

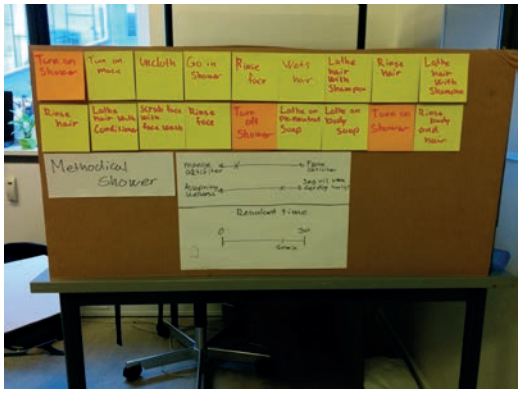
WS - User mapping

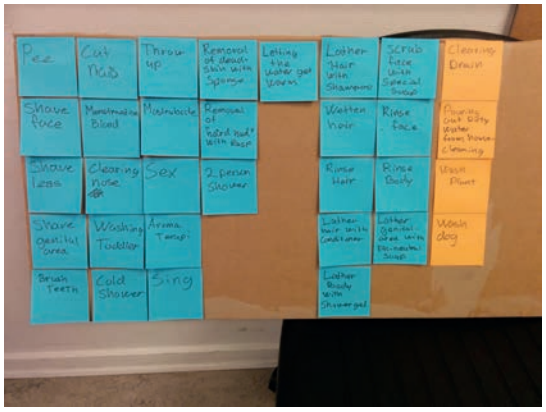
Date: 02/03/17 **Written by: Alex**

Objective

To put the shower touch points, timelines into a system

Data





Evaluation

The first move was to define one kind of shower, that we termed the methodical shower, a shower in which there are many activites, which take a long time, therefore the shower takes a while, but the main objective was to get them done. This could be evauluated on two scales, the amount of tasks and if the shower was for mainly enjoyment or just to get clean.

After that we had some informal disscussion with some fellow class mates, where we discussed their “entry points” to showering, in which it was made cleaer that, the shower very much depends on what the objective is, and what tasks are done in the shower.

It is clear, that each person has a set of things to do, depending on what the objective is, very much like habits, so different typs of entry points were defined. The entry point to showering.

Depedning on that, a lot of different activites can happen, which we coined touchpoints, we also made a board with that.

Lastly, we discovered, that every person will take different kind of showers, but the dispositon of the person will greatly detemind to how many activites are performed and when a shower is for enjoyment or a labourious task. Which are yet to document.

so the relation is:

Entry point (objective) -> shower activites that can fulfill that, which also depends on which tools they have available.

Reflection

The touchpoints are listed, and indicate there is a lot of different ways of approaching the shower.

There are entry points, touchpoints and then the “washing program they set together.

SUPERVISION:

The information explain what they could do, but not the experience in accordance to a person type. We just explain there are a lot of ways to shower but with no focus.

We can also not define what “the good shower is” because that is very individual, to do that, we need to tie each “washing program to a specific persona.

The post it way of doing it is very 2 dimensional, we it does not tell 3 dimensional information.

A persona would be, what kind of person it it, what his state of mind is, what his behavior is based on that, for that he will have a preference for the way he showers, or a washing program. Based on the supervison, we need to delimit ourslef, but to do that, we first need to discover specifically what a good shower is, for different person, based on that the person will have some expections the the shower, can the principle of recirclulation cover that? what are the consequences, and how could this princple support the shower in achieving a better shower?

after that, where can our product princple have the biggest impact, that would be our first place do go very deep.

WS - User mapping nicole

Date: 14/03/17 **Written by: Jacob**

Objective

The objective was to create a complete user mapping of Nicole, which is one of our personas. The user mapping involves Nicole's shower reason, her timeline, coping strategies and understanding of the most ideal shower. This will create a frame for the team, to both focus further idea development and a specific requirement specification.

Data

Nicole's current coping strategies:

Nicole's current coping strategies is a series of actions she does inside the shower, to ensure that her shower experience is as she is used to. This includes when she is preparing to enter the shower, how she soaps up in the shower, avoid uncomfortability in the form of cold, and how she copes with getting completely clean. As Nicole is a very effective user in the shower, ensuring that each task is done correctly, her coping strategies affects this.

Before entering the shower Nicole does the following actions:
Turns on the shower - To ensure that the water gets hot.
Turns on the music - For entertainment, showering is a chore.
Removes her clothes

When she has entered the shower, Nicole cleans her face, and wettens her hair, it is now time for shampoo, this is handled by **tipping her head away from the waterstream, so that the waterstream still hits her body, while applying the product.**
She then washes this out, she does this twice.
The same is done with the conditioner, however the waiting time in which she stands with her head tipped, is greater.

When soaping up her body, she steps outside of the water stream for the entirety of the period it takes to soap up, this means that she can't maintain the comfort, due to being outside of the water.

Our principles effect on her current coping strategies:

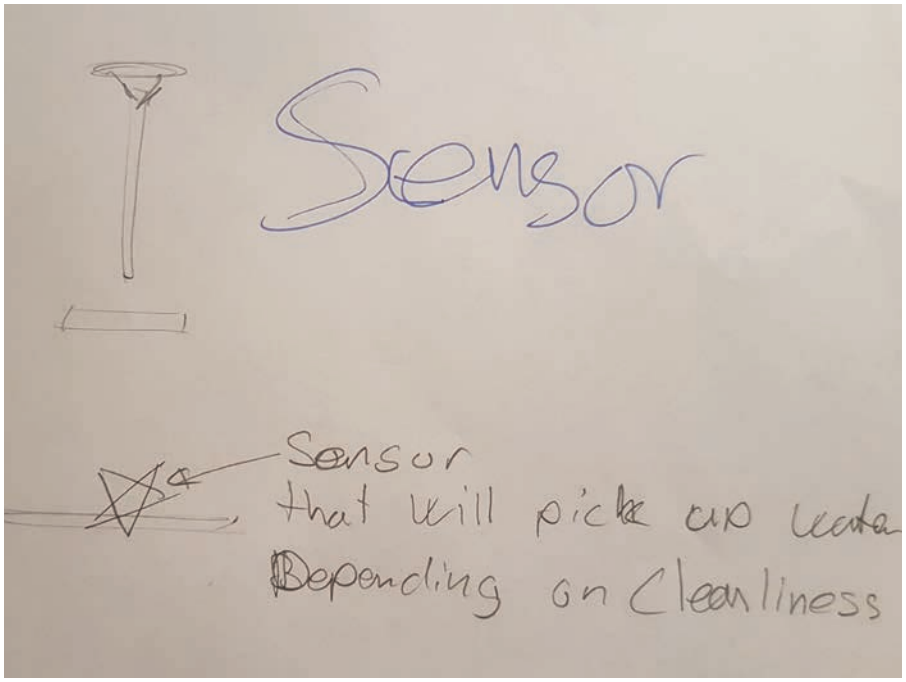
Our concept is built mainly around the principle of reusing water, following this it is limited in forms of which functions we can present to the user when showering. As Nicole is very objective oriented, in which she is fulfilling a handful of actions with specific coping strategies, there is a limited time where our principle can work, due to most of her activities involving soap, limiting or stopping the effect of reusing. Furthermore Nicole is very specific about being completely clean, and has a range of activities ensuring that she is and feels clean, this further limits the principles possibilities, due to it resuing "dirty" water.

Ideation process

An ideation process of 20 minutes each were conducted on the two main benefactors which are a part of her daily shower, and the consequence which our principle has on these; **the feeling of cleanliness** and **the effective shower.**

The feeling of cleanliness:

Sensor



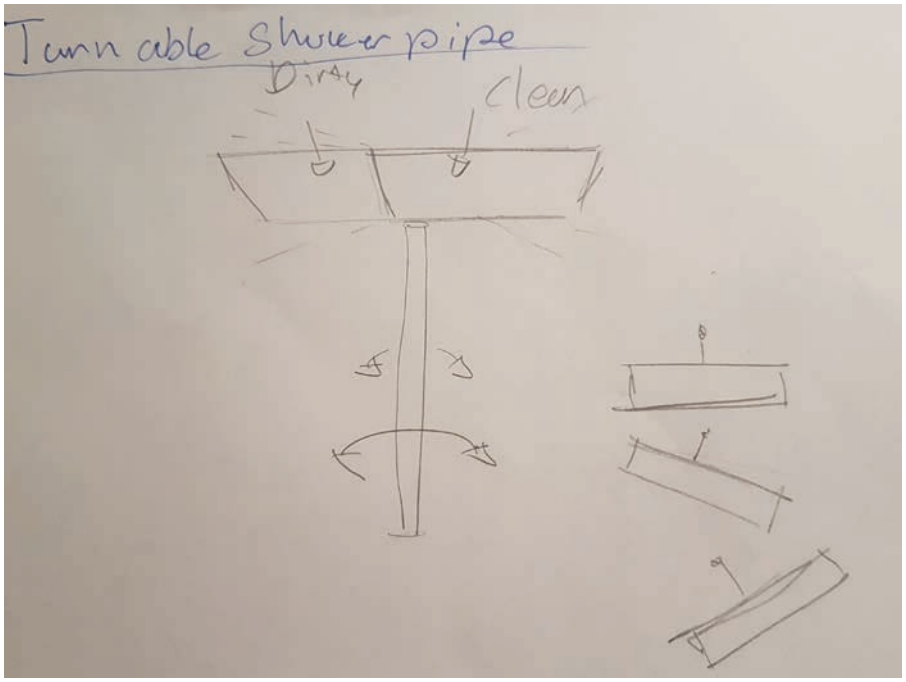
A sensor which automatically adjusts how much water is reused based on how much soap is drained.

Would let Nicole shower in clean water, due to the system only collecting the cleanest water, and closing of for soap.

+ Passive
+ Can reuse the sensor which is already there to detect for filtering

- Relies on sensor, can be expensive
- Can fail

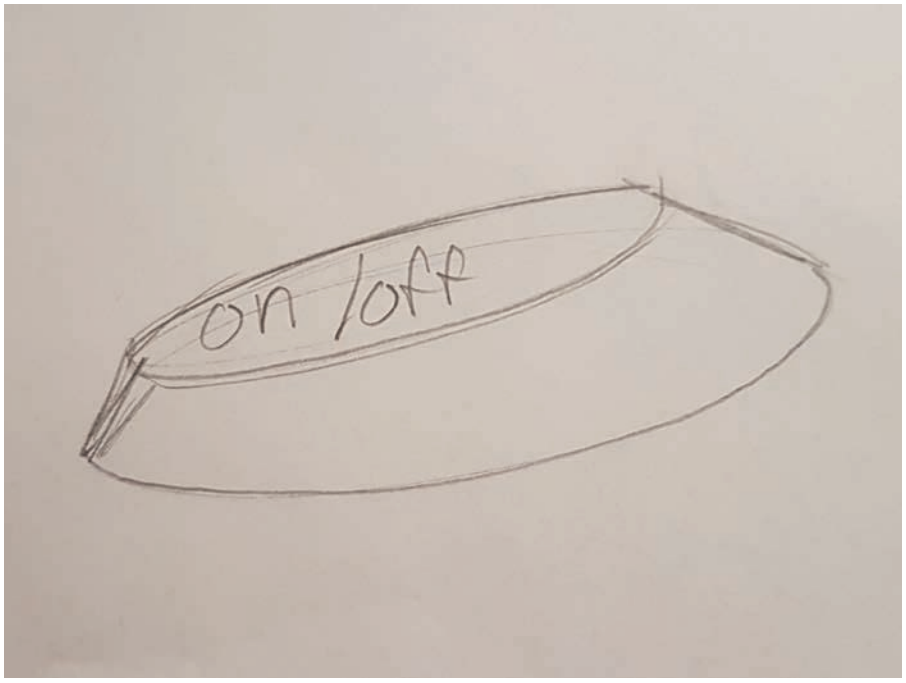
Turnable showerpipe



A turnable showerpipe which can adjust the flow of clean and used water.

Would let Nicole adjust the showerhead, such that in a whim, she would shower with completely clean water, and in another shower with used water.

On/off button



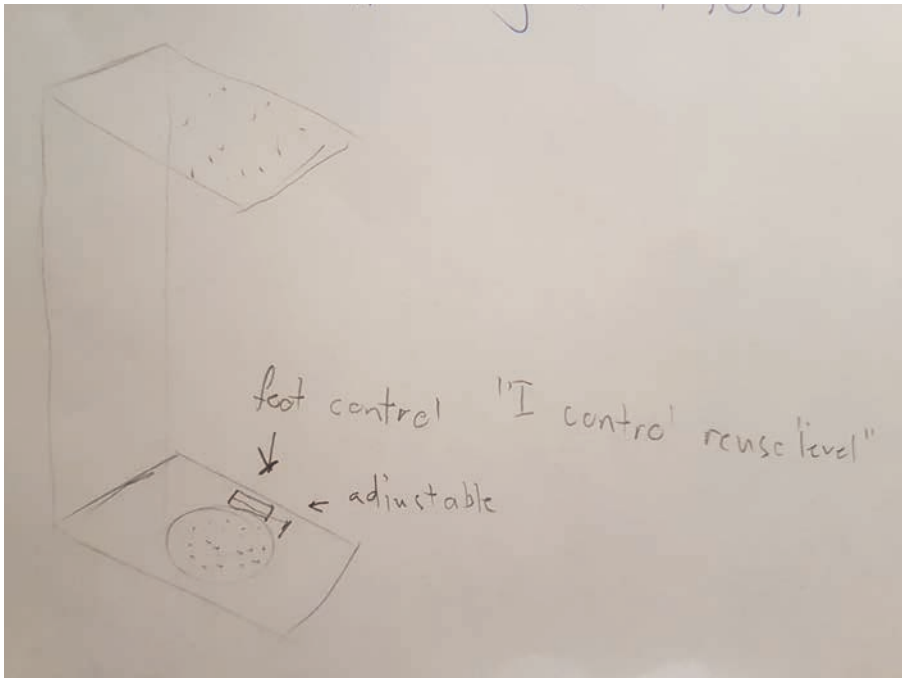
A button which lets the user turn on and off the reuse of water.

Would let Nicole control when the system would use used water, and when she wants clean water.

+ Hand controlled - easy to adjust.

- Relies on position in shower.

Adjustable foot control



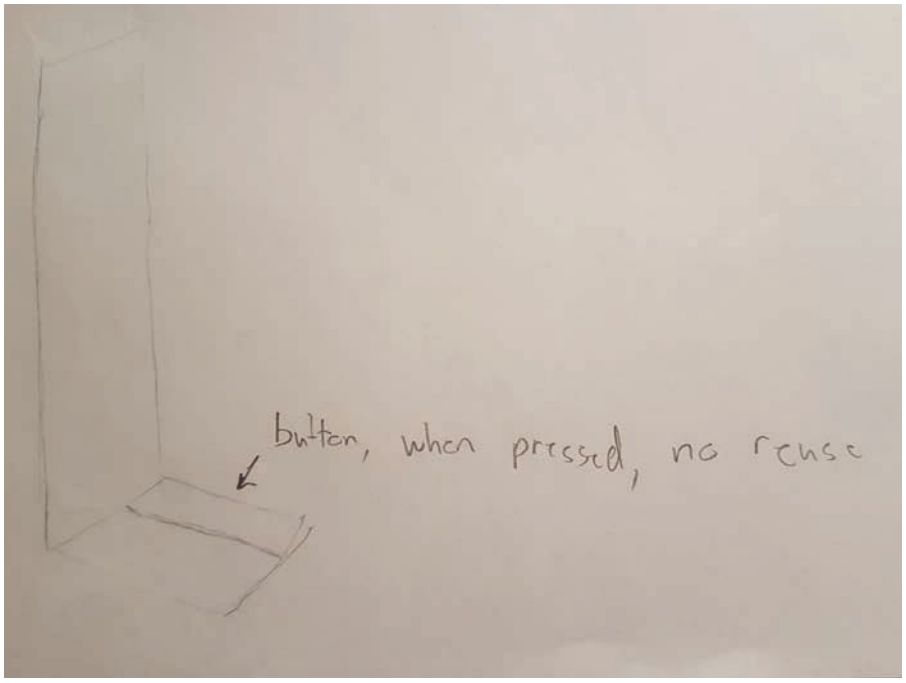
A reuse level adjuster with foot control, to control how much water is reused with the foot.

Would let Nicole control when the system would use used water, and when she wants clean water.

+ Does not rely on position in which the user stands

- Weird way of controlling, can get in the way

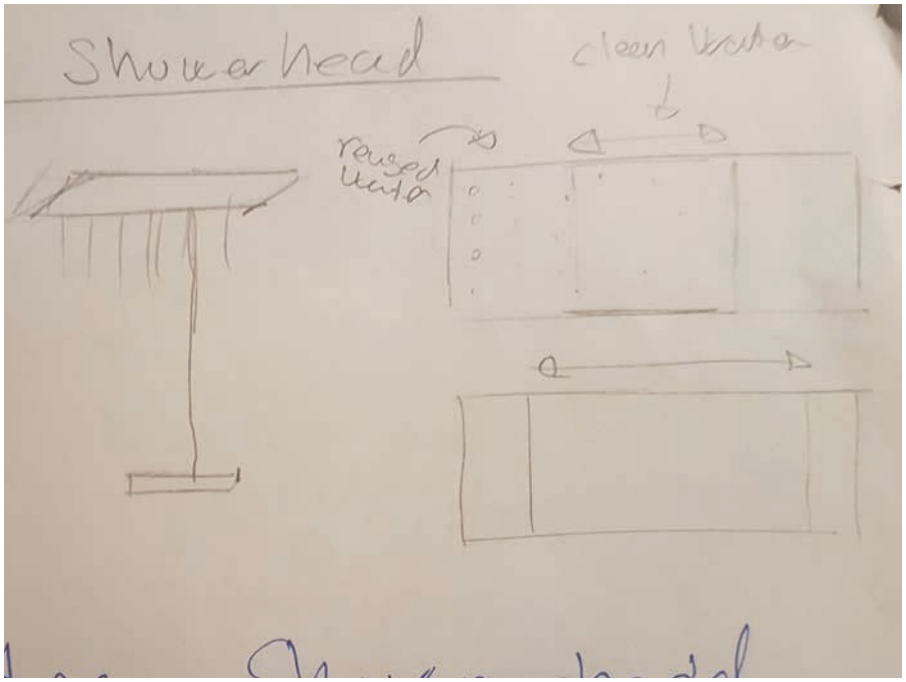
Foot button



A button which turns of the reuse function. The user would just stand on that part of the mat, if he/she does not want to reuse water.

Would let Nicole control exactly when she wants reused water.

Adaptive showerhead



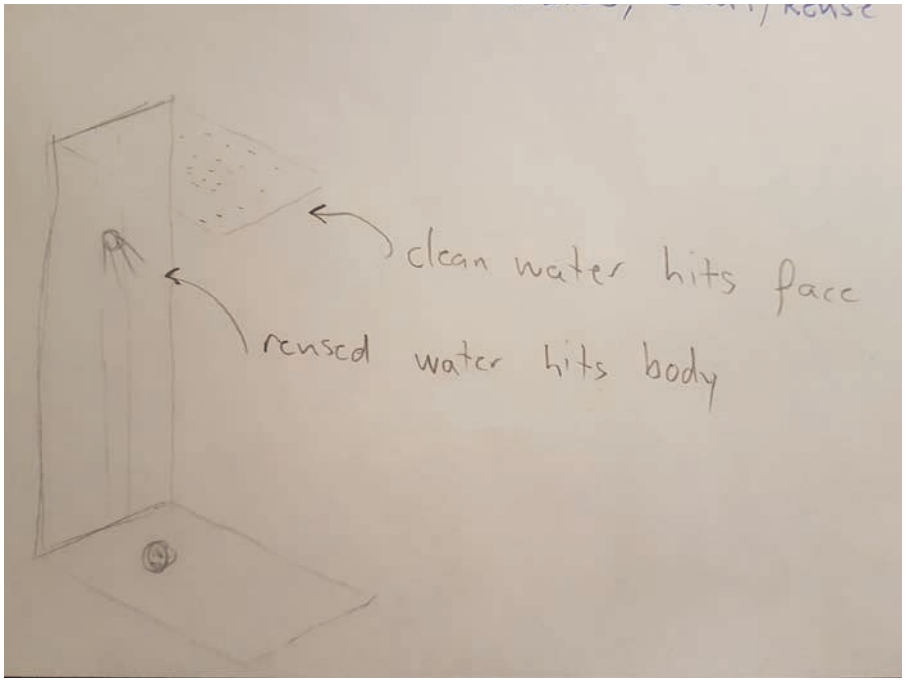
An adaptive showerhead which automatically adjusts the output depending on the amount of reused water, more reused water, means a bigger surface area which the water outputs from.

Would give Nicole a physical identification when she reuses water, and would give the feeling of “extreme comfort” when clean water runs into the system, due to most of the water getting reused.

+Passive, no user interaction
+Clean water to face

-Heat difference, due to new and used water
-Complex system

Body nozzle



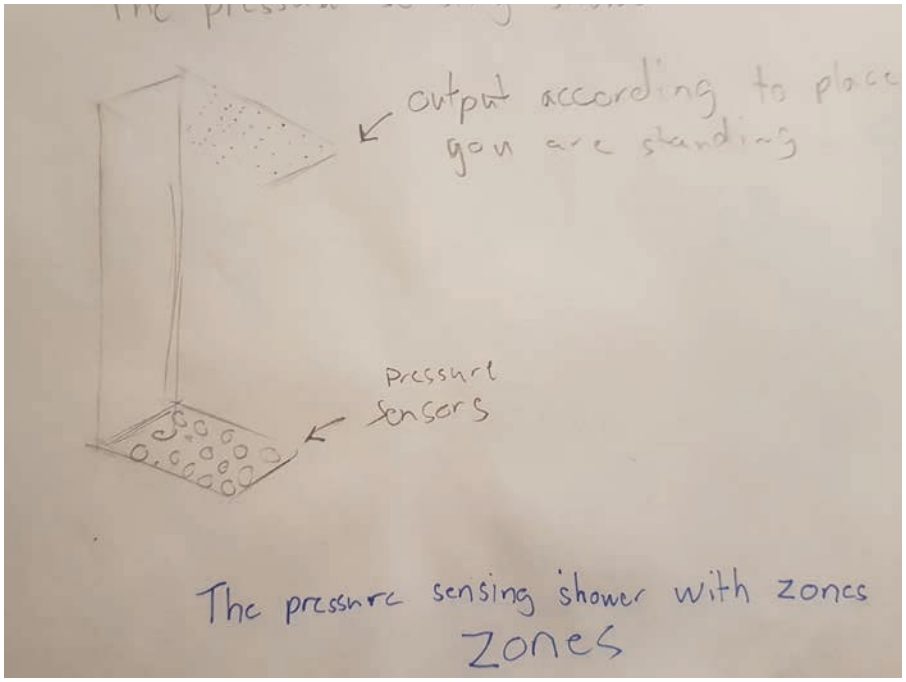
A body nozzle which would use mainly re-used water, to avoid getting reused water in the mouth and ensure that only new water is used when grooming hair etc.

Would ensure that Nicole would only get used water on her body, and not in her face and hair.

+ Passive
+ Clean water to hair and face

- Body still receives dirty water
- Mostly comfort, as it does not help clean-liness

Pressure sensing shower with zones

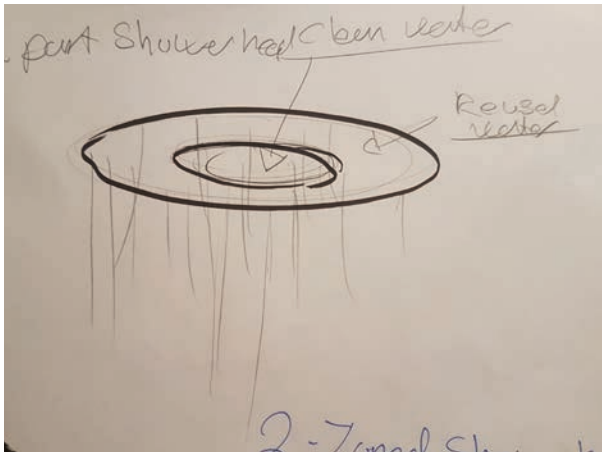


A mat with pressure sensors, which would allow the system to know where the user stands, and control how the water hits the user.

+ Does not rely on position in which the user stands

- Weird way of controlling, can get in the way

Two-zoned showerhead



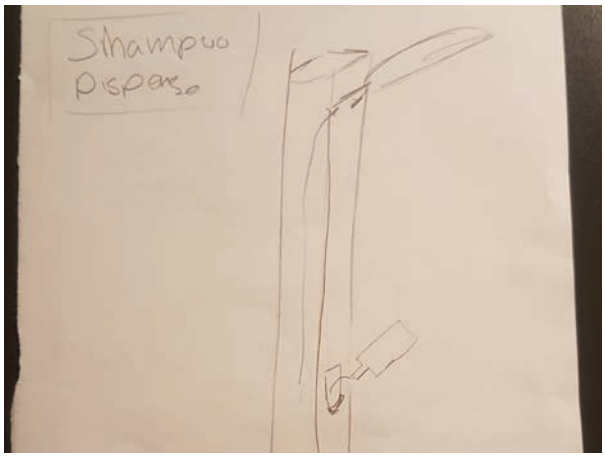
A showerhead with two outputs, the middle one hitting the head with clean water, and the outer ring hitting the body with used water

+ Passive, no user interaction
+ Clean water to face

-Hair and body are hit with used water, and face if moved.

Effectivity

Shampoo dispenser



A way of dispensing shampoo into the shower, such that the user does not need to apply the shampoo or soap manually.

Would allow for Nicole to not having to manually lather her hair with shampoo, possibly making her showering more effective.

+ Less user participation

- Is not standard

Evaluation

The first ideation were based on the two benefactors, cleanliness and effectiveness.
Due to Nicole being very aware of the cleanliness in the shower, it was very difficult to imagine a situation where she wants to reuse water, and where our system is able to reuse water, due to the shower constantly being filled with soap, as she has no “passive” state in the shower, meaning that her shower are filled with active participation, in the form of applying shampoo, conditioner, soap etc. This means that she either expects clean water, due to having to rinse herself from soap or shampoo, in which our principle would not work, due to not wanting to recirculate shampoo.

The ideation of how we could create a more effective shower experience for Nicole, ended in a very short process, due to the realization that it would be very difficult to enhance or replace the active participation, which includes lathering with shampoo or soap. However as Nicole is a very effective oriented user, it would be beneficial if her shower could be more effective, resulting in a shorter shower etc.

In the end, it was concluded that it would be difficult to enhance her shower experience, however the product could be adjusted to fit into her current shower situation, and coping strategies, to avoid creating a bottleneck if the same shower situation is used with our product.

Reflection

The ideation phase for Nicole showed that our principle would not allow for better coping strategies, due to it being built around reused water, not suitable for Nicole and her shower experience. This however allows for a requirement specification to be created based on what our solution should do, and not do.

WS - User mapping john

Date: 02/03/17 **Written by: Alex**

Objective

Usermapping - John

The objective was to create a complete user mapping of John, which is one of our personas. The user mapping involves John's shower reason, her timeline, coping strategies and understanding of the most ideal shower. This will create a frame for the team, to both focus further idea development and a specific requirement specification.

Data

John's current coping strategies:

John's current coping strategies is mainly aimed at creating a comforting experience for himself, and to ensure that he becomes ready for the day with social interaction on his job. This means that John showers for a long time, as he is both through a beatification period, and a relaxation period in the end of the shower. His coping strategy to achieve this is by getting into the shower early in the morning to avoid being late, he also makes sure the water temperature is exactly the right temperature before entering. The first period of his shower is the beatification period, where he ensures as little as possible to be without the warm water, meaning that he only tips his head outside of the shower when lathering his hair, instead of stepping out completely, this ensures that his body is still kept warm. When applying soap to his body, he does not step out of the water stream, instead he applies soap multiple times, to ensure that it has taken effect. When the beatification period is over, he usually stand in the shower for 10 minutes relaxing.

Before entering the shower John does the following actions:
Turns on the shower - To ensure that the water gets hot.
Removes clothes

When he has entered the shower, John lets the water steam up, and wettens his body, at times he uses a long time in this state as a relaxation period. When it is time for shampoo, he tips his head away from the water stream, and applies the shampoo. This is done twice, before applying conditioner, which is done in the same way.

When soaping up his body, he does not step outside of the water stream, but applies multiple times, if the soap is washed off to quickly.

Our principles effect on his current coping strategies:

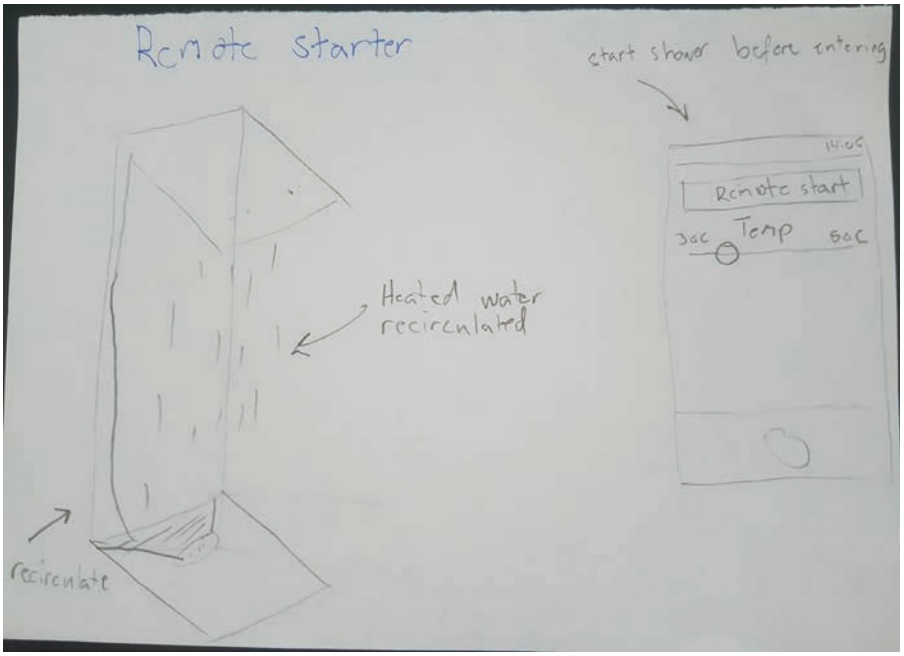
Our concept is built around the principle of reusing water, mainly when limited or no soap is used in the shower. When John uses his products, such and soap and shampoo, the principle of recirculating the water is limited or would not work. However when John has his relaxation periods where he is passive, without the use of products, the principle would be working with best effect.

Ideation process

An ideation process of 20 minutes each were conducted on the two main benefactors which are a part of his daily shower, and the consequence which our principle has on these; **the feeling of acclimatising** and **a way to be more inside the water stream.**

Acclimatising:

Remote start



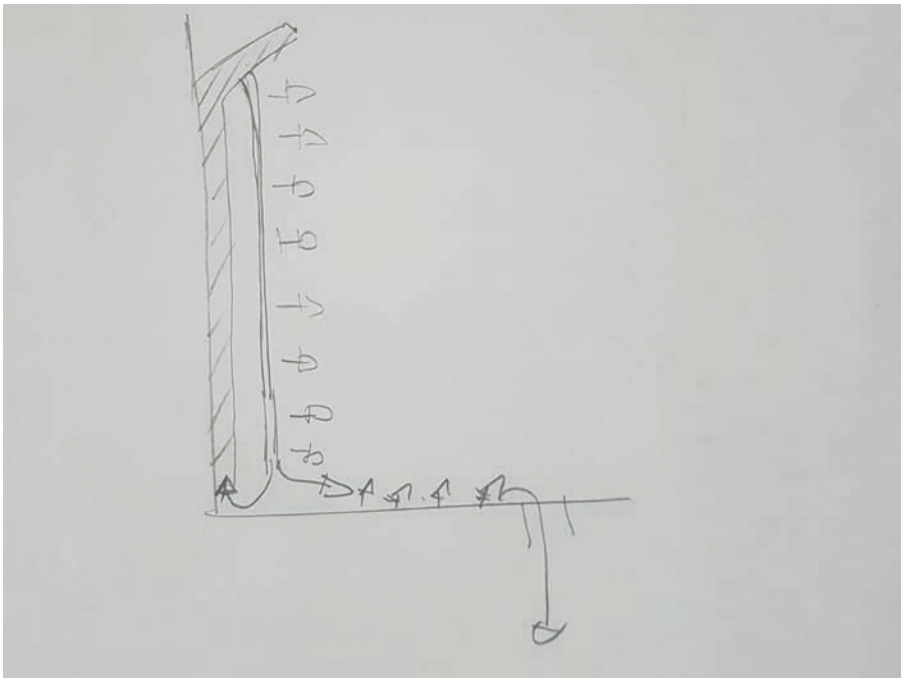
A remote start to start the water before entering, the water would be reused to a high level, meaning that the room would get hot before entering.

Would let John enjoy a warm room when entering.

+ Can be used as a heater
+ Can be started before entering the shower

- Uses more energy, as the water needs to be heated.

Heat dispenser



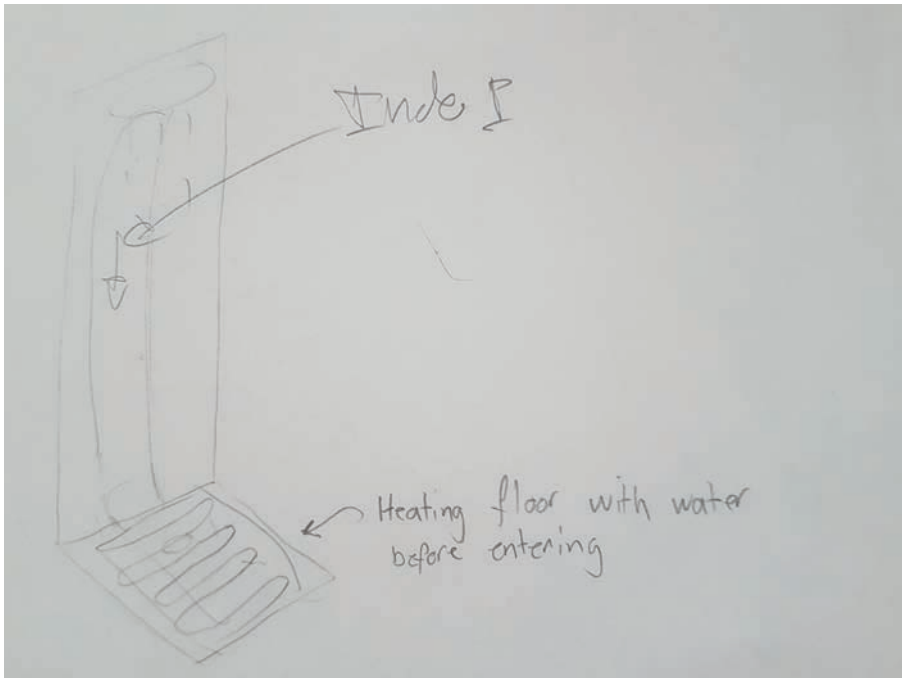
A heat dispenser, which uses the water to heat the room

Would let John stand in a preheated shower with a heated floor.

+ Floor and room heater.
+ Better acclimatization.
+ Preheats the water.

- No value while showering.
- Uses more energy to heat the water.

Floor heating



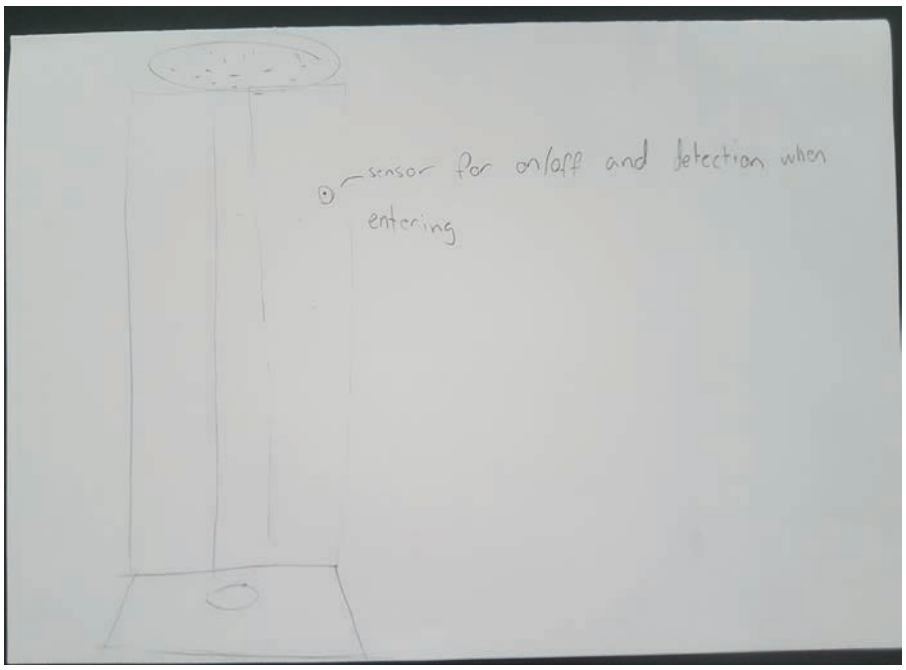
A floor heater, allowing the floor to get heated before entering.

Would let Jogn stand on a heated floor when entering

+ Heated floor.
+Better acclimatization.
+ Avoids having to wait for the water to get hot.

- Has to be started before entering the shower.
- No value while showering.

Automatic on when entering

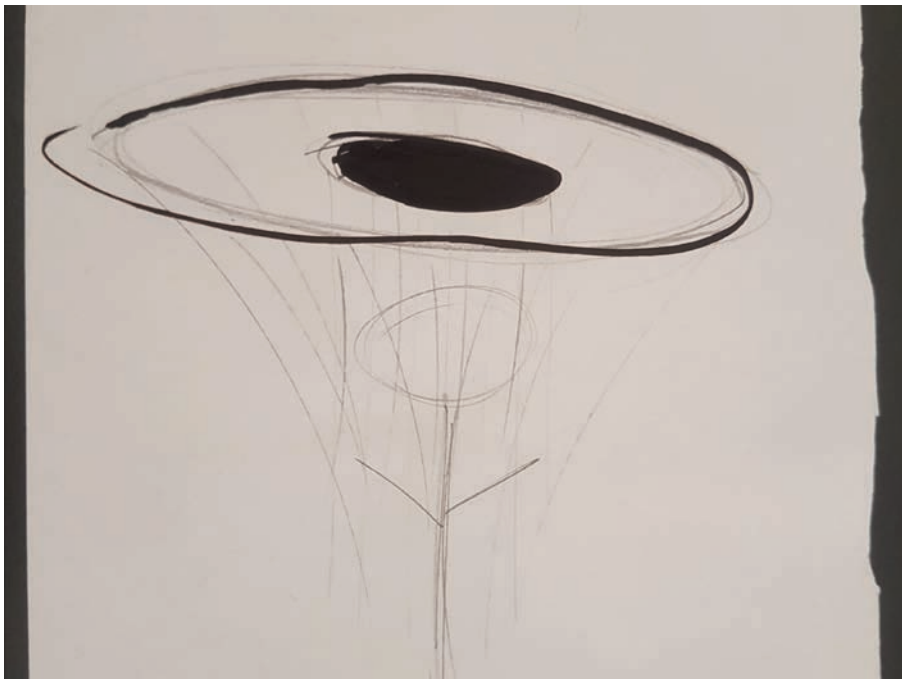


A sensor which automatically turns on the shower, when entering the room.

+ The sensor can be used for multiple things.

Staying inside the water stream:

Shower orbit



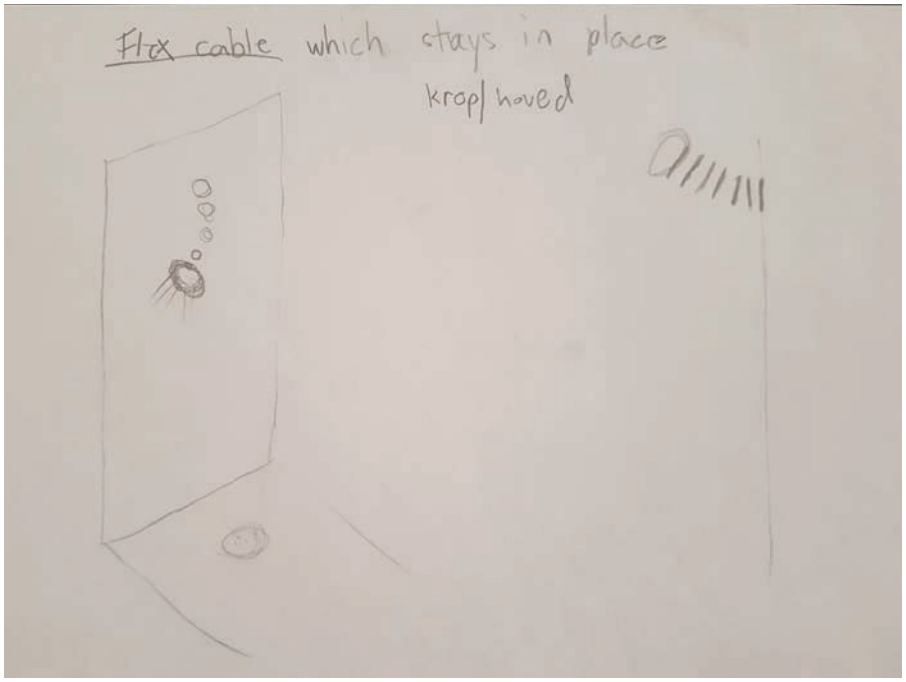
A shower orbit which have sections where water can be turned off.

Would let John be able to stay in the shower when lathering shampoo, as the “head” section could be turned off. Water would still hit the rest of his body.

+ Full coverage.
+ Can turn off the middle section, so John does not have to tip his head outside of the water stream.

- The user has to stay inside the “Orbit”, he is locked in one position.
-Uses a large amount of space.

Flexible shower head



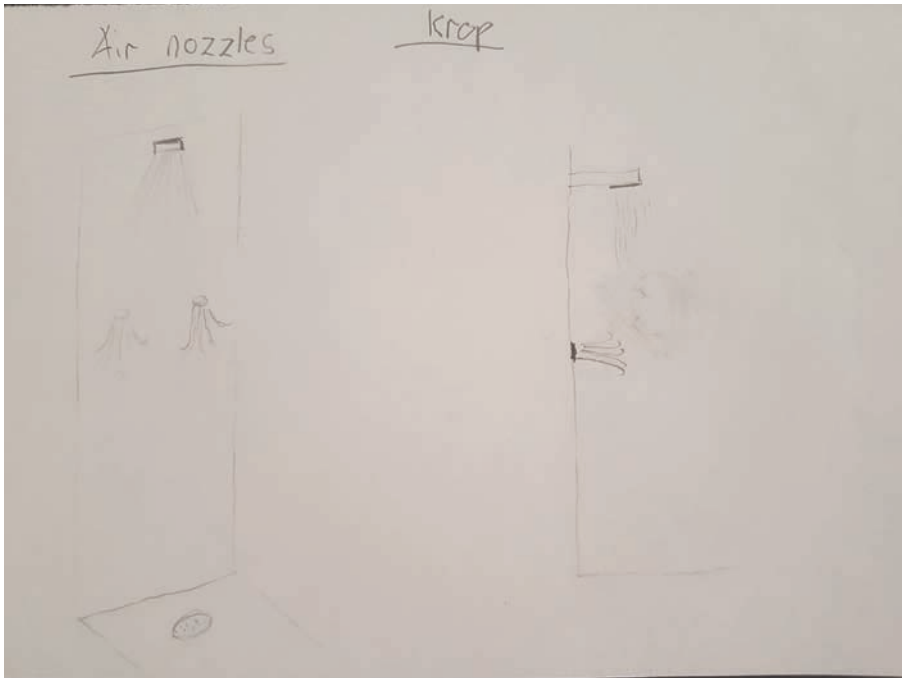
A flexible shower head which can be moved around and be locked in a wished position

Would let John place it away from his head and aimed only at his body when lathering shampoo, as to avoid to tip his head away from the water stream.

+Adaptive for multiple position.
+Selective, you choose where the water hits.

-Flex is often seen as cheap.
-User participation is needed.

Air nozzles



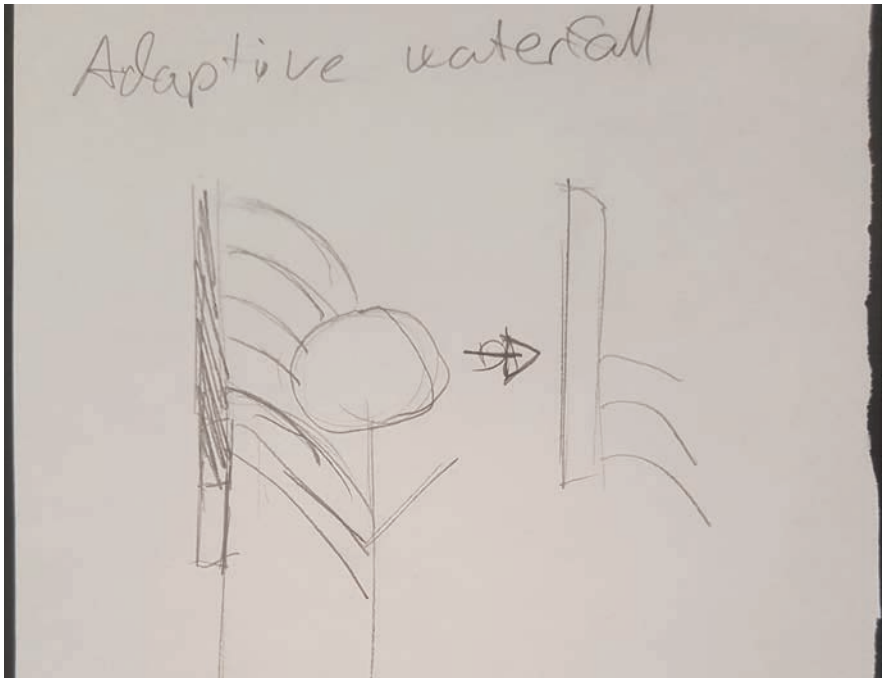
Air nozzles which would push away the water where it was unwanted.

Would let John select where he wanted water to hit. And would allow to lather body with soap, but still keep head in water stream.

+ Get water on head, and avoid it on the body.

- Could be loud.
- High-tech, does not know if it will work.

Adaptive waterfall

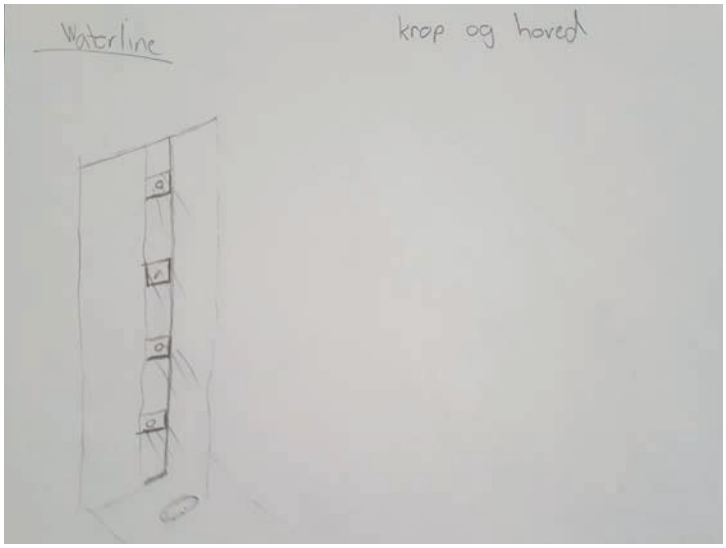


An adaptive waterfall, which could adjust the height of the water stream, to allow for only getting water on the body.

+ Directional.
+ Choose if you want to wash hair or body.-

- Big
- Directional

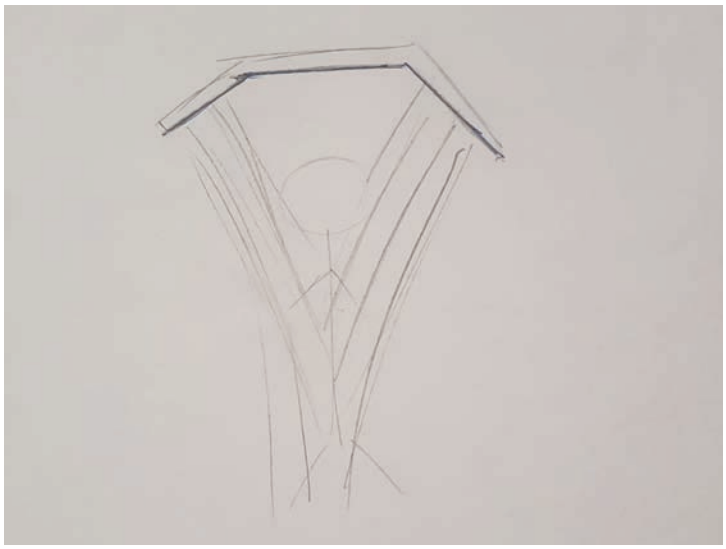
Multiple nozzles



Multiple nozzles which could spray water where needed.

+Adaptive for multiple position.
+Selective, you choose where the water hits.

Three zone shower



Multiple nozzles with zones which could create more coverage or turn off water if not wanted on head.

+Adaptive for multiple position.
+Selective, you choose where the water hits.

Evaluation

The ideation phase was based on John's two main benefactors, being the feeling of getting acclimatized, and staying inside the water stream.
As John enjoys his passive relaxation period in the shower, and generally being very relaxed in the shower, it was important to look at how we could support or enhance this feeling. As to give John a better comfortable feeling in the shower, the ideas were focussing on being able to stay inside the shower, where he before had to tip his head outside or compromise in another way. Furthermore John turns on the shower in the beginning as to make sure the water temperature is corrent before entering, and to slowly heat up the floor, this was also a part of the ideation, in how this could be supported or done better.

The ideation phase was fairly quick, and ended with multiple ideas which was very similar, this is due to our common understanding of what would be feasible to create and the primare problem of "staying inside the shower" is not a problem which is directly solvable by an idea, but other things could play it, which we are not aware of yet.

In the end, it was concluded that many of the ideas had potential, however as "comforting" phase of John's shower is where he is mainly passive, the ideas which are focusing towards where he is using products, such as when he has to lather up his hair, might now have much potential, however in the areas where he is passive, he is not using soap, meaning that our solution of recirculating water would be the most effective, and with a high potential.

WS - User mapping comfort

Date: 15/03/17 **Written by: Jacob**

Objective

Usermapping - Comfort

The objective was to elaborate on the definition of "comfort" when used in correlation with how three of our personas are experiencing and concedes comfort.

Data

To elaborate and conceive on the definition of "comfort", a common denominator between our personas was that they were all living in Denmark, therefor with the same cultural values, these being:

Water is some of the cleanest in the world
Water scarcity is not a problem
There is nothing restricting the user from getting clean/hygienic

A set of parameters were set for how comfort could be either affected by either our solution being a showerset and context parameters, being things in the environment.

The product parameters were as follows:

Water Temperature
Waterflow
Coverage
Angle of water impact
Type of waterflow, laminate, small droplets, big droplets

Which could be affected by our solution

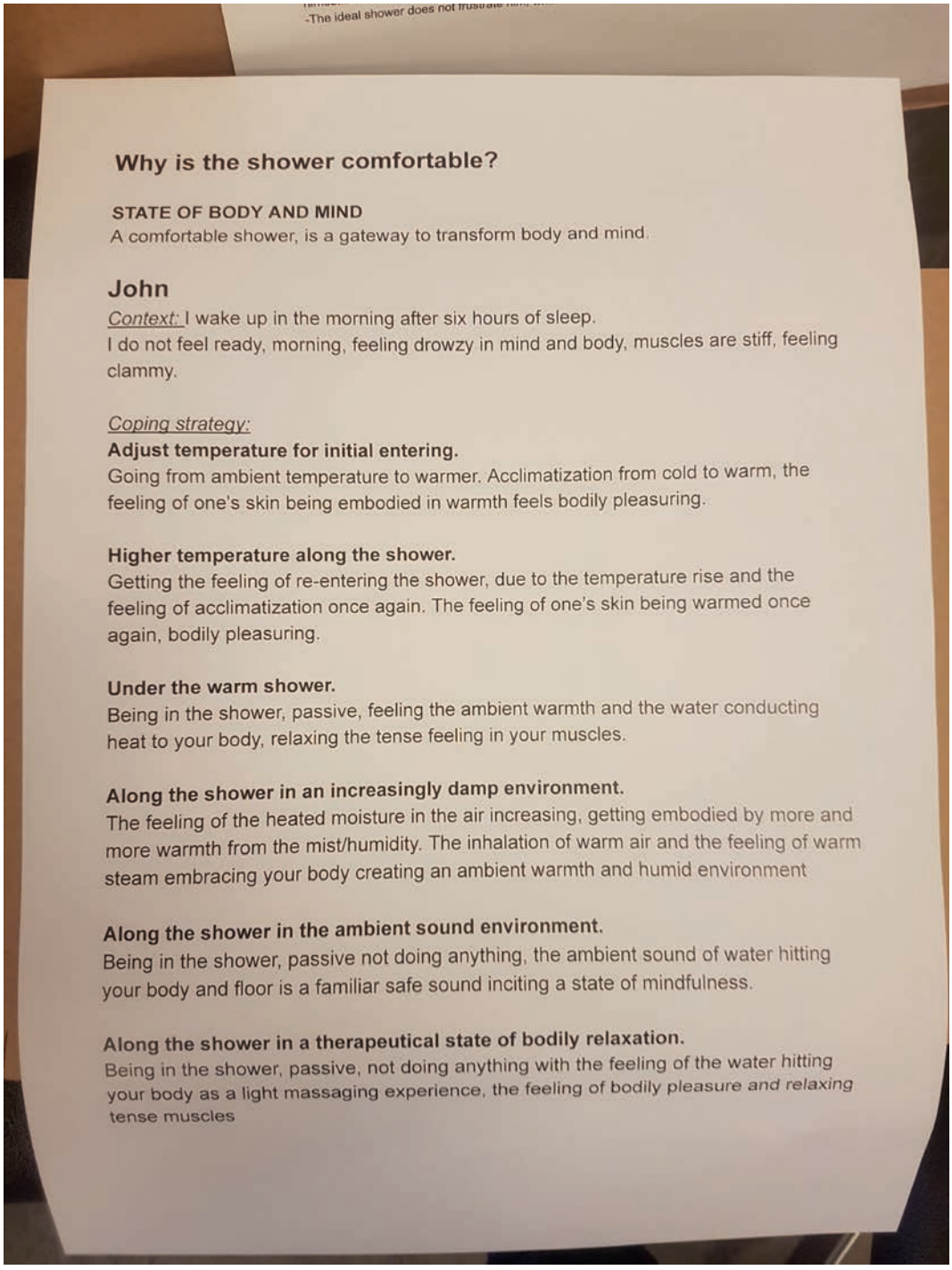
The contextual parameters were as follows shown on the right:

- Sound
  - Ambient
    - Ventilation
    - From outside
  - Water
  - Music
    - Control
    - Non-control
- Light
  - From lights
    - Dampening
  - From outside
- Temperature
  - Ambient
    - In the room
    - In the floor
      - Cold to the touch?
  - In shower
  - Draft
    - From under door
    - From outside with window open
- Flooring
  - Hard
  - Soft
- Where is your products placed?
  - Cupboard
- Smell
  - From drain
  - From Toilet
  - From outside
  - From products
    - From shampoo, soap
    - From aroma oil
    - Perfume
- Humidity
  - Climate
  - Seasonal
  - Prior shower
  - When in bathroom and shower is turned on

This was a baseline and a foundation for their experiences and values in the shower.

The primare user was John, due to his seemingly mixed shower experience, which involves both an very active part (lathering shampoo, soap etc.) and a very passive part (relaxing), making John a very versatile user.
From John, a context was presented:
I wake up in the morning after six hours of sleep.
I do not feel ready, morning, feeling drowzy in mind and body, muscles are stiff, feeling clammy.

And through that coping strategies for how John would create a comfortable experience for himself.



Evaluation

Based on the "comfort" values for John, it was clear that it was an area which we had not touched enough upon, due to new discoveries in regards to why John does what he does in the shower. This was especially clear when it was discovered that John would turn up the heat along the shower, which again was done due to the feeling of acclimatization, a experience which can be very addicting, meaning that it wants to be experienced again and again.

Reflection

Based on the values created, a specification requirement can be made, this allows the team to exactly pinpoint where we can tweak, change or simply allow for an exact experience in the new solution.

Supervision with Christian Tollestrup 15/03/2017

Based on the previous work, and in continuation of the work done up till this point, it was decided that group should continue elaborating on these values, to get a clear understanding of what and why these "comfort" enducing things happens in the shower, furthermore it would be possible to create a requirement specification based on these values, and previous observations.
Based on the requirement specification it will be possible to explore the solution space, preferable by solving one specific requirement at a time, then combining two requirements, solving these together, and so on, allowing for a very systematic approach towards solving the solution.

WS - Valve types

Date: 03/04/17 **Written by: Jacob**

Objective

The objective is to find what valve to use to block the water flow in our system

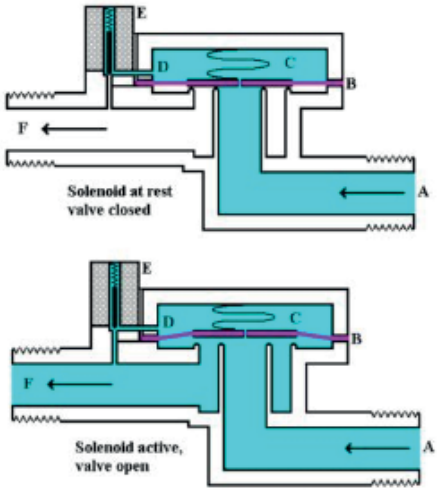
Data

Solenoid versus motorized ball valve.

As the system requires a way to block water, both Solenoid valves a
motorized ball valves have been researched.
Solenoid valves work by closing and opening a small gap by magnet
ing a spring, which opens and closes a plunger. This also means tha
a typical solenoid is very quick to perform its action, down to millis
onds. However as the gap is very small, the water flow is also restric
which in our system would be critical, due to heavily depending on
water flow to utilize the venturi effect.

Full bore solenoid valves does not restrict water flow, however they
much bigger in size, and would be inconvenient to use in our syster

Motorized ball valves function by having a small servo rotate a ball,
which either closes or opens an opening. This means that very little
if any restriction in flow occurs, however the actions of opening and
closing is slower than a solenoid valve.

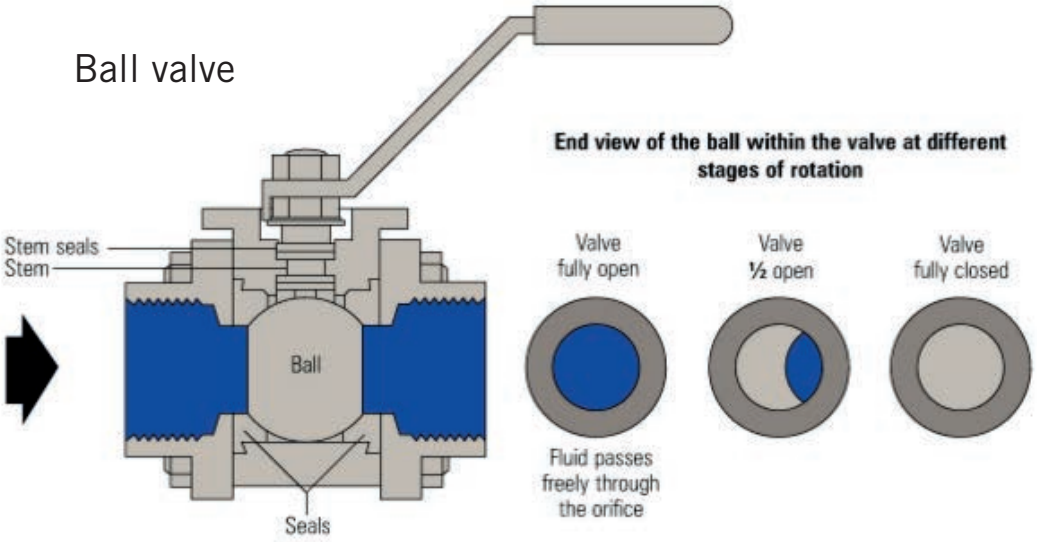


A - Input side
B - Diaphragm
C - Pressure chamber
D - Pressure releif conduit
E - Solenoid
F - Output side

Solenoid

Output:
As it is very critical not to restrict water flow in our system, a motori
ball valve is prefered. However, most of these are bigger physically than
solenoids, and requires higher wattage. The slower action of the ball
valve might have complications later on, however as of right now, there
is no critical issues with this.

Ball valve



WS - Water Threatment

Date: 15/02/17 **Written by: Jacob**

Objective

The objective is to get an insight in what treatment is necessary in water, when it has to be used for showering, and considerations for what our product has to comply with.

Data

As our concept is reusing water before it hits the drain, we do not have to think about bacteria related to drainage. As the new water is clean, we do not have to think about bacteria related to that either, this means that the focus should be on the used water, due to it having been in contact with the body, thus having the possibility to contain bacteria which are dangerous in quantities. Furthermore, turbidity, which is the density of volume in the water, making water less clear, is a important factor when considering showering comfort for the user, as cloudy water might throw of some users, even though it is safe to shower it.

As the water might contain larger particles such as hair, and bacteria such as E.coli, a filtering system has to be in place, as to ensure that the user is not discomforted or in danger of getting infected. The filters are as such:

Mesh filter: A filter with a rather rough filtering, removing hairs and larger particles from the water, this also ensures that the rest of the system is not getting clogged up with hair, preventing the system to run efficiently, ss the mesh filter is to be placed in the start of the system.

UV filtering: Most bacteria is not dangerous, however E.coli is to be prevented, thus needed for a filter to remove these. UV light (UVc) is a effective way of destroying the DNA of said bacteria, preventing it from reproducing or spreading in the system, removing the chance for the user to get infected.

Due to the mesh filter not removing skin oil and the like, it is necessary to fuse the used water with new water, this is to prevent discomforting for the user, and to ensure that the turbidity of the water is kept to a minimum.

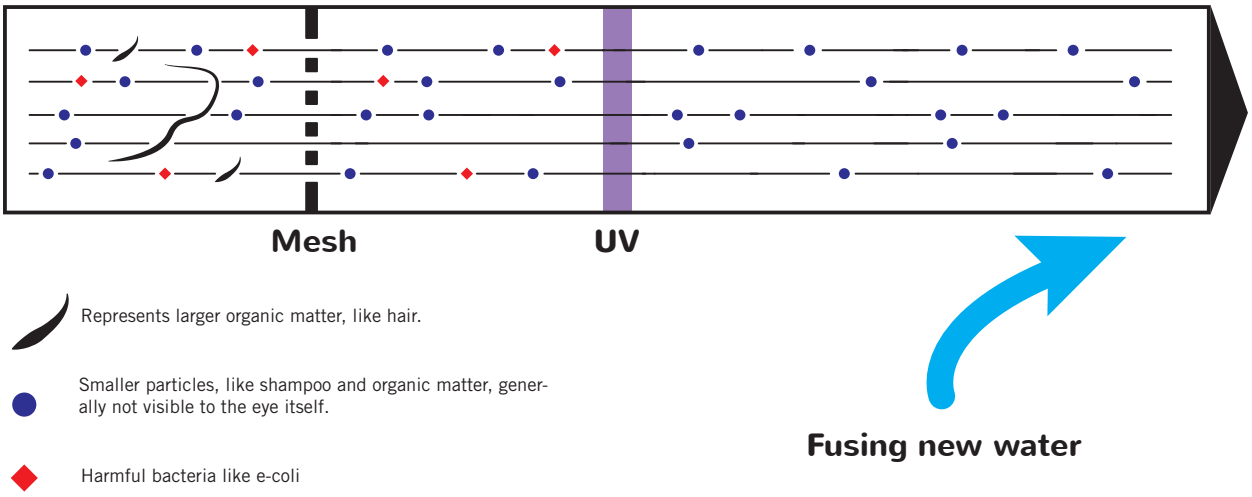
Links:

https://phc.amedd.army.mil/PHC%20Resource%20Library/Ultraviolet%20Light%20Disinfection%20in%20the%20Use%20of%20Individual%20Water%20Purification%20Devices.pdf

http://www.epa.ie/water/wm/bathing/bw_quality/

https://phc.amedd.army.mil/PHC%20Resource%20Library/Ultraviolet%20Light%20Disinfection%20in%20the%20Use%20of%20Individual%20Water%20Purification%20Devices.pdf

http://www.epa.ie/water/wm/bathing/bw_quality/



Evaluation

Our system needs to filter three things, larger particles, bacteria and skinoil and others, which the mesh filter does not filter. There is two elements which we have to consider, the user perception of what is clean water "this water is not clear, thus not suited to shower in" and the more critical part, which the user does not see, but can make them sick, bacteria. There is a difference in what the user perceives as clean to shower in, and what is actually clean enough, this is mostly defined by the turbidity of the water.

Reflection

It is clear that the research done on water filtration and bacteria needs to be dived into, there needs to be testing of the water to ensure that our solution filters it enough for showering purposes.

WS - Inital target group

Date: 14/02/17 **Written by: Jacob**

Objective

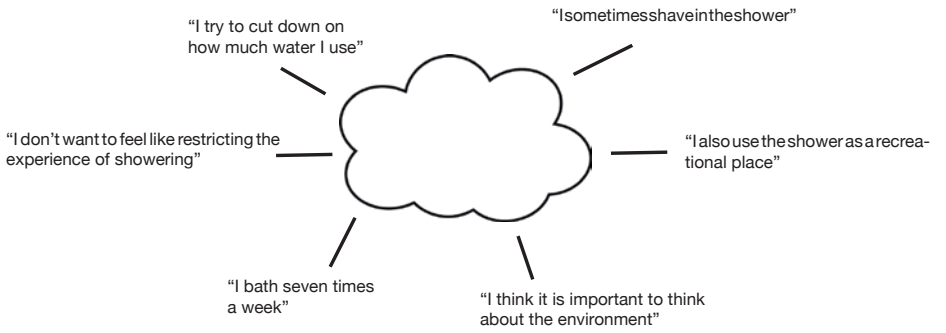
The objective is to find three different target groups in which our product can be targeted. Furthermore it would allow us to map a bathing experience for each group.

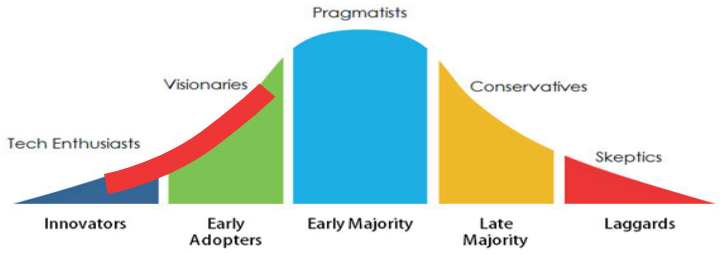
Data

Targetgroup

Soon-to-be-done student

Male
Kevin
24 years old
Student
Only income is S.U.
Bathing time = 5-10 minutes
Baths 5-6 times a week
Starts washing body and hair 1-3 minutes into the bath
Washes hair before body
Does not use conditioner
Does not know if his showerhead has a water saving function
Uses the shower to get clean and ready
Does sometimes shave in the shower
Would like to save money
Does sometimes think about water usage





Starts shower — *waits for water to get hot 20sec* — *Steps into the shower* — *Dampens himself 1min* — *Applies shampoo and rinses 1min* — *Applies shampoo and rinses 1min*

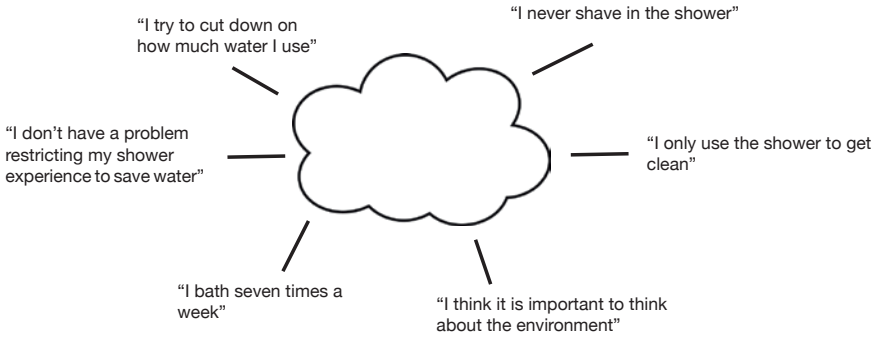
Brushes teeth 2min

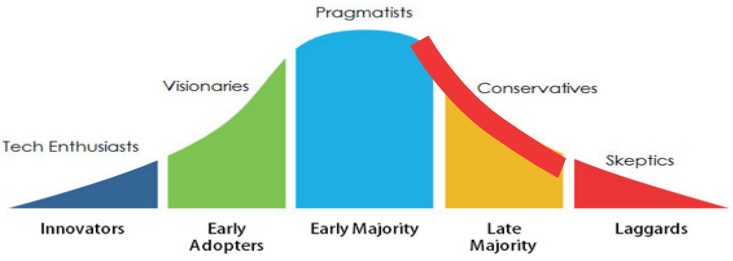
Applies bodywash and rinses 1.5min — *Ensures that all soap is washed off 2min*

Targetgroup

Person in workforce

Female
Nadia
38 years old
Working full time job
High income
Bathing time = 5 minutes
Baths 7 times a week
Starts washing body and hair almost instantly into the bath
Washes hair and body simultaneously
Uses conditioner at times
Aware that her showerhead has a water saving function
Uses the shower to clean
Tries to save water when shaving
Is actively trying to save water
Uses less water when possible



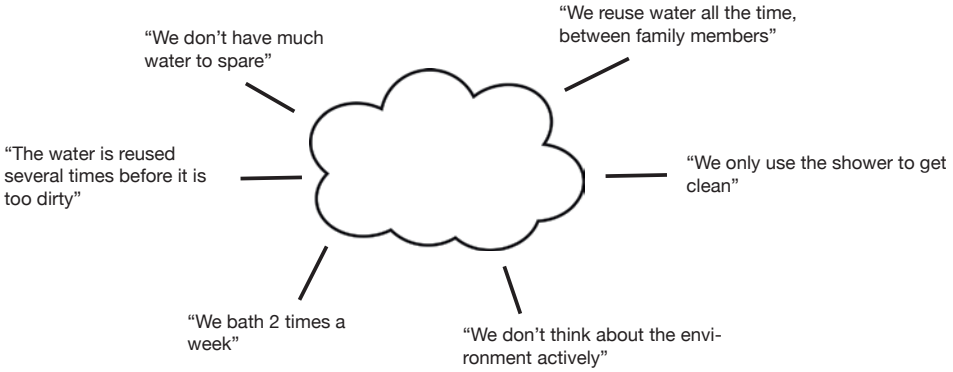


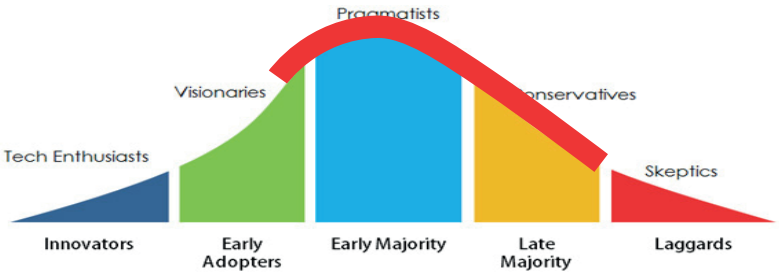
Starts shower — *Steps into the shower* — *Applies shampoo & bodywash and rinses 1.5min* — *Applies shampoo and rinses 1min* — *Steps out of shower*

Targetgroup

3rd world family - India

Family
Working full time job
Low income
Bathing time = 3 minutes
Baths 2 times a week
Starts washing body and hair almost instantly into the bath
Washes hair and body simultaneously
Uses a mix of a bowl and a bath tub
Is actively trying to save water
Uses less water when possible





Starts reusing water — *Steps into the bathtub* — *Applies soap to hair and body 0.5min* — *Rinses body and applies water with bowl 1min* — *Steps out of shower*

Evaluation

Based on the targetgroups, which were created based on the following assumptions: The student would like to save money, and would like our product. The person in the workforce, does not consider money to be a problem, but would like the "save" the environment, and would like our product. he 3rd world family would like our product due to the water saving feature, as water is scarce.
A assumption surrounding their bathing ritual were created, and a adoption curve were created as a means of telling when the targetgroup would accuire the technology/product.

Reflection

The three target groups were a great way of finding how our solution would solve some problems which users have, however it is also a very broad market, going all the way from "I don't want to go down in water usage" to "we don't have enough water" meaning that our solution should span very far to satisfy all groups. We need to cut down, and restrict the market, as to be able to create a more focussed product.

WS - Tjavle process

Date: 25/02/17 **Written by: Alex**

Objective

The objective was to setup a board in which we could document and a visual aid in investigating the different componenents. The tjavle structure is based on the component structure defined in the product architecture.
It functions a way, to explore the solution space, to be knowlegdable within the field, wherte we must be able to say that it is possible to make, if not a pivot would be needed.

This inital tjavle is based on very first requirements of building a system that is cheap and easy to implement for the user. Where few user interactions a descriped, this is to a high degree a tjavle to develop a system that can fulfill the requirements, a crash course, that turned us from novices to "experts" since a lot of research into the inner workings of showers was required.
The tjavle to a very high degree, was coupled with a lot of experiments, as the a technical structure was desired to be devoped very quikckly, where experiments can provide quick verification cycles.

Data

The overall concept, is a gathering for, concept ideas, concerning the whole structure, partly made up on the principles below. Below are the 3 components and the post its princples to fulfill the functionality.

Evaluation

All current principles, from concept v1, current concept and the technical principles were transfered over.

The structure was dived in to 4 categories, one overall, that is a gathering of concept of the overall idea.

the three other are the actual principles that stand alone or make up the above concept, the black line indicate what currently is in focus and being researched.

Reflection

This is very much a board that is developing every day, each category is being developed as you can see.
This is also a gathering of all princples from day one.
each category is very much in flux, the boards are a way were fleeting thoughts can be documented, as such this board changes a lot.

at the time this is documented, a concept for the princple structure has been decided on, the post its over the black line are the princples in focus, and were chosen on the basis on creating a solution that is cheap, uses least power and would be small enough to pack into a solution that would be easy to implement.

COLLECTOR

FUNCTION
The gather water from the floor / catch it
Contain the first filtration, a screen/ mesh filter

Contains sensors, that decide what to pick up or not

CONSIDERATIONS
The main problem is maintenaince, as it might gather up a lot of dirt and hair and the user interaction, the users feet might interfere with it.
Secondly is that, the drain and the floor might be asociated with being dirty, so there might be some warriness.

From a technical standpoint, it has to be placed in a position that can gather up enough water.

What if people pee or shave legs, what then?

PRINCIPLES
Centralized collector
Dencentralized collector
2 zoned collector

REQUIREMENTS
Has to be able to psysically catch enough water, for the required percentage.
Has to be easy to maintain
Should not gather up dirt in crevices, or trap dirt inbetween the flor and collector.

DEVLOP A COLLECTOR THAT DOES NOT COLLECT DIRT AND IS HYGENICAL, IT MUST BE PERCIEVED AS CLEAN

RECIRCULA-

FUNCTION
To transfer water from the collector to the mixer.
Contains the second wave of filtration, the UV filtration

CONSIDERATIONS
The recirculater has the function to carry the water, from the very bottom to the shower head most likely, where the least pressure to recombine the two streams is needed. So the recirculator is stretches throughout the whole product, and it has to provide enough pressure, but the shower pressure is very high, so recombining to streams might be difficult, as the recirculator has to provide enough pressure, so a lot of care has to be taken, in developing a system where that is minimized, as it would save a lot of motor power, therefore both size, cost and energy cost of the product. The size might be essential, as it might be an important factor that decides how easy the product is to handle and how bulky it is.

Secondly is that the recirculator has to house the second stage of filtration the UV germicidal irradication, so the water has to pass through an area that can do so.

A lot of inital importance was placed in this component, as it is central to ferry the water up and provide it to be recombined, where a lot of technical difficuluty could be seen, as the solution idealy would have to use as little power as possible, because the product would have to be battery driven, as defined in the prior concepts, because not many showers have the outlet, and if they did, it would have to be hooked up by a certified electrician, if the product uses 230v, high voltage a lot more stric regulations have to be followed, so we place very high importance in making it battery driven.

Trough inital tests, it was tried how easier it would be to recombine new water to the stream. A shower operates on 2-3 bar, so it is acutally very difficult, the least pressure, was discovered and very logically at the very end of the output. The shower heads, often have regulators in them, contricting the flow of water, if that is removed, even less resistance is met. So recombining the water in the shower heads might be the smartest, from a technical stand point. Time was too invested in researching passive solutions as it might for once help recombine the waters and reduce the energy used to power the system.

PRINCIPLES
Active motor
Passive motor
- Aspirator
- Siphon
- Venturi injector
  - Power jet
  - Water Aspirator
  - Suction nozzle

battery powered
T-pipe
Heat exchanger

REQUIREMENTS
Must be able to lift the water from the collector to the mixer, and provide enough pressure to recombine to two streams of water in the mixer.
Must use as little power as possible.
Must be able to be maintained, the pipes that is.
Should recombine the water streams, at the point with least pressure to do so, as to save energy to do, and therefore a smaller motor.
Smaller is good.
Must be able to pick up and reuse the water quick enough, to retain the water heat.

DEVLOP A RECIRCULATOR THAT CAN DO IT WITH AS LITTLE POWER AS POSSIBLE AND AS SMALL AS POSSIBLE

MIXER

FUNCTION
To recombine the two waters, and possible eject it through the shower head, possible be the showerhead.

CONSIDERATIONS
The showerhead, in many ways is the very focus of showers, it contains a lot of functionality, that the mixer must be able to cope with, as it is very likley that the mixer and showerhead will be combined.

The showerhead is often the module, where a lot of water saving features are incorporated, as the showerhead deals with how the water is delivered to the body, and how much, so beside the mixer, it has to house a lot of other functions, most likely.

The mixer from a techical standpoint has to mix the two waters, which can be very difficult, as the pressure from the used water stream, in a conventional system has to be stronger than the resistance in the outout which is the showerhead, else it will run reverse, which is why, it would be valuable with a showerhead that does not apply a lot of pressure on the system.
Furtermore, if the pressure to recombine the two water sources could be lowered, it would lower the energy req, therefor possible a smaller motor.

Once again, a lot of effort was placed into either creating a low pressure showerhead, or a passive recombiner, like an aspirator, that also has the functionality of pulling water, which might work party to support the reciruclationg unit.

The mixer and recirculator were looked at, at the same time till now, as they must support each other.

PRINCIPLES
Passive recombiner
- Aspirator
- Siphon
- Venturi injector
  - Power jet
  - Water Aspirator
  - Suction nozzle

Valve system
mechnical mixers

Low pressure showerheads
- Water deliver systems
  - Normal stream of water
  - Droplets
  - Swirwly water

MIXING OUTSIDE OR INSIDE

REQUIREMENTS
Must recombine water in a way that can fullfil the rquired percentage
Must do so, in a way that requires as little power as possible
Must fit within a showerhead
The componenent must be able to adjust the percantage of used water.
Must not cause backflow

MUST THROUGTTLY MIX THE WATERS IN A WAY THAT REQUIRES THE LEEAST PRESSURE POSSIBLE

CURRENT CONCEPT

Evaluation

This tjavle has been ongoing for 3 weeks so far. Where the end result is a current concept.

This tjavle has been accompained by 5 experiments, where different key princples were tested. Which all will be described in separate worksheets. (atleast 100 hours of 3d printing)

The result is a tjavle, that while not very expansive, is very detailed in the prinples explored, as they we tested and confirmed, for that different key functionalites were verified one by one, leaving us with a working structure, with small amount on princples to fall back on, to adjust the current concept how needed.

This tjavle structure marks the end of the first phase, based on the inital specification on creating an affordable and easy to implement system.

Reflection

The tjavle structure, and the contents, have us a very throughout understanding of how the fucntionality could be acheived, and by making experience, it was not only assumptions but a reality, thereby we are able to say, atleast one structure can do what we desire, and that is enough for now, as it removed a lot of our worry, of it not being possible.

On the same token, it also opened up a lot of discussion and also very indepth with our technical superviser, where we are able to work with critical junctions from the VERY start of this project, which we find very valuable, as it will help us creating a working proof of concept.

The next move is to userfy this product, and to define what the exact purpose is.

WS - Benchmarking

Date: 07/03/17 **Written by: Jacob**

Objective

Benchmarking - Others vs Elva. The objective is to benchmark the products on the market compared to the user experience and the water saving.

Data

Nebia

The ultimate in water saving - Cutting down on water output extremely
Affects shower experience in following ways:
Low water amount - Makes the shower feel less effective, soap is harder to wash off, rinsing while shaving legs takes longer.
Affects the quick (in and out) user, who needs an effective shower. This might also mean that the user is in the shower for longer, than with a normal shower.

Possitive impact in following ways:
Very effective in water scarcity areas.
Very effective for the "money saver" user, which would gladly compromise on the showering experience to save money

This is a completely different experience than a normal shower.

Flowrate: 2.84L/m Price: 2750 DKK

H2OKinetic

Uses swirling water to simulate a larger water output - Makes it feel like you are using more water
Affects shower experience in the following ways:
Does not really save much water compared to other products, but does make the user feel like he is hit with more water.

Possitive impact in following ways:
Effective as a way of using less water if you are used to the feel of a high flowrate.
Effective to cover a larger area due to the swirling.

Simulating more water, however the water saving is minimal

Flowrate: 9.50L/m Price: 2500 DKK

Aerator

Introduces air in the water, restricting water output
Affects shower experience in the following ways:
Is louder due to the airstream.
Affects the user a little when soap is rinsed.

Possitive impact in following ways:
Is a cheap way of saving water
Can be used to effectively cut down on water, without affecting the user experience much.

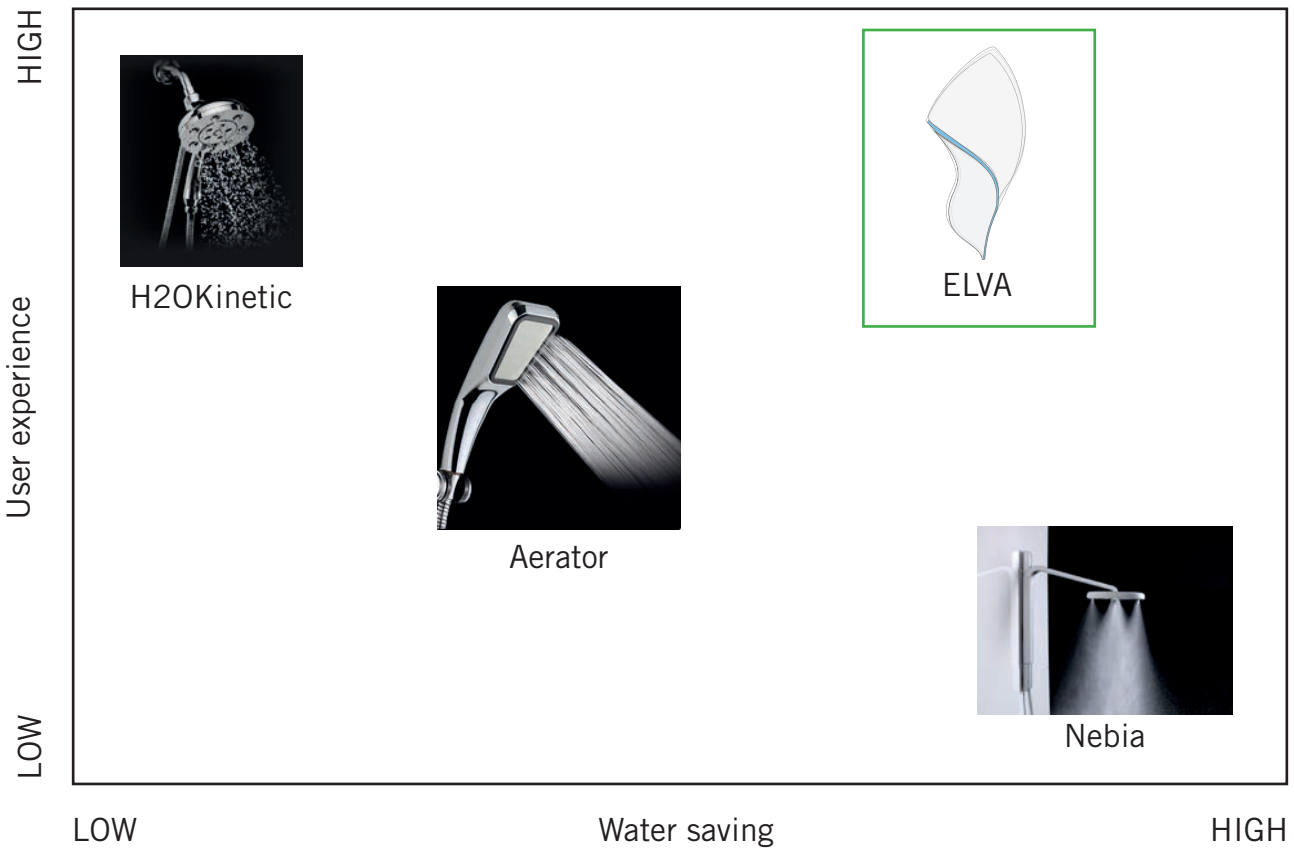
Flowrate: xL/m Price: 300 DKK

Evaluation

The benchmarked products are all selling themselves as new ways of showering, whether it is by saving water, or simulating more water and using a little less water. However there is a pattern shown, that if you try to save water by outputting less water, the user experience will be affected, this is shown by the extreme product Nebia, which heavily limits the water output by creating mist, which in return affects the user experience. However if the user experience is a non issue for the user, Nebia is a excellent product.

Reflection

Based on the benchmark, there is a unavoidable problem with outputting less water as means of saving water, because by limiting the flowrate, the user will experience less water, which again can affect the shower experience, this is why Elva does not limit the flowrate, and even makes it possible to output more water than traditional showers, effectively using the same water.



WS - Process models

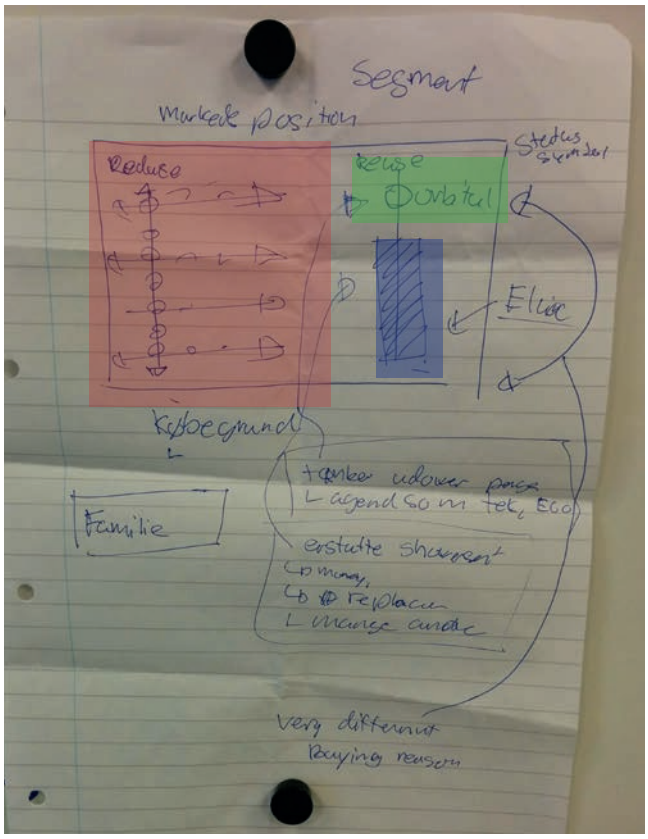
Date: 29/02/17 **Written by: Jacob**

Objective

The objective is to externatize some of the decisions taken in the process to paper, to 1. get a common understanding of important junctions in the process, and to document these junctions. and lastly, as tool to discuss how we should proceed, how do we confirm what is assumed and how to do build on that.
The models were also made as an aid, in the transition from a process mostly dominated from the technical standpoint, and a way to document and get a common understand what the current frame is right now, initiating a structured user-centered approach.

Data

Market position model:



Market position model(Vertical/horizon):

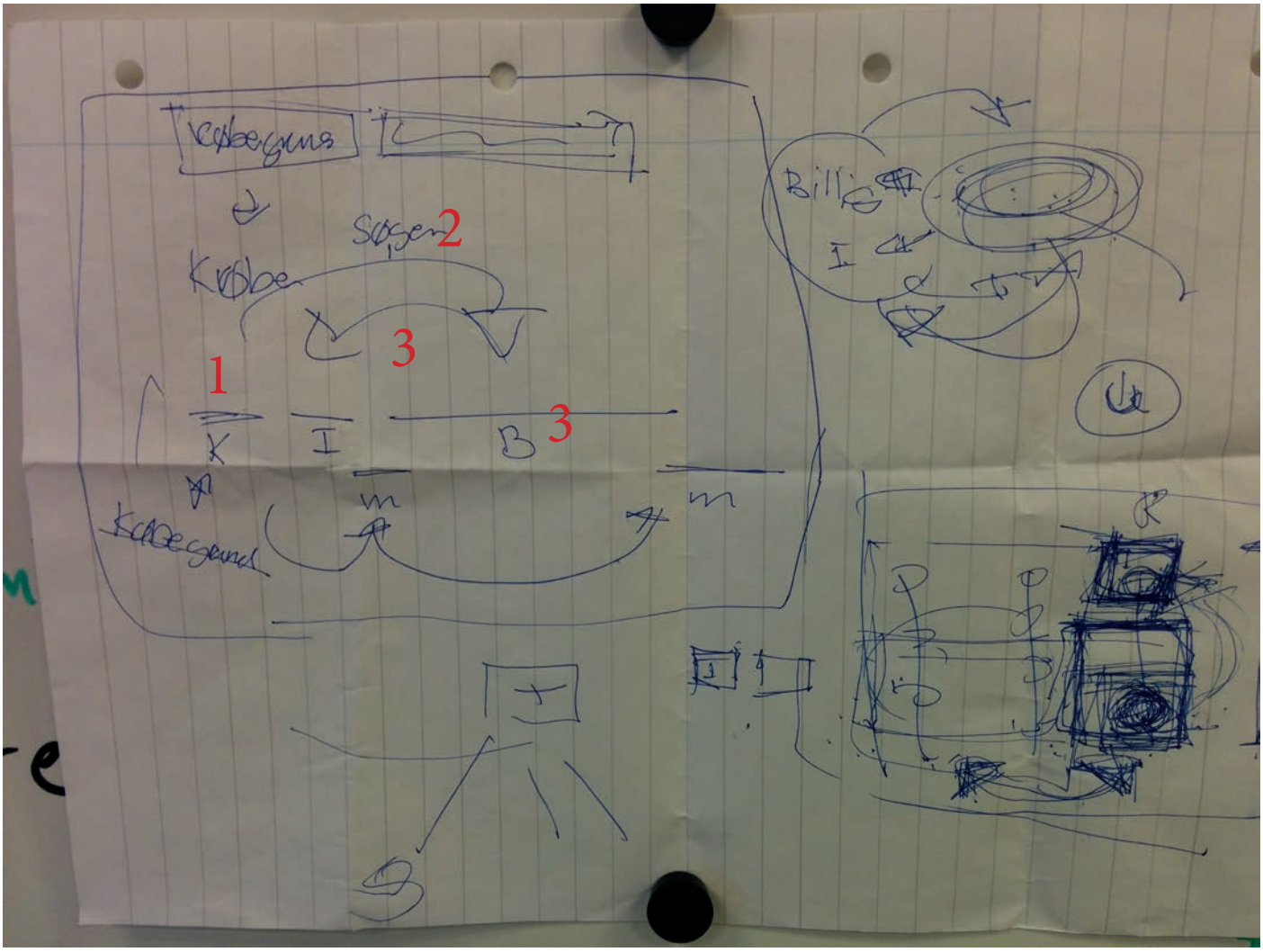
The current market is dominated by “Reduce” products, both low and high end products are offered in a wide range of offerings, very much creating a market where both the vertical and horizontal segments are hard to enter. (red)

An up and coming segment are the “Reuse” products, the first big comercial entry is Orbital, which by itself only is one product series, so this product segment is very much still developing. Orbital is a very high end product with a price tag at 37000dkk,(green) and very much is a luxury item. that pricewise, competes with the highend reduce products, and in general attempts to compete with the highest end product in comfort and wellness.“A water saving luxury” experience.

Elva, wants create a product entry in the low to mid segment within the “reuse” segment. The only specifics being, that the product is affordable and easy to implement, as allowed by the developed technical structure. But aside from that, the value proporsition has yet to be developed. How do we want to position ourself in relation to the low to mid reduce segment. The low to mid segment, has a wide range of products that offer different things, how do we create a product that can compete with that. (blue)

Market vision “ We want to create a product, that appeals to the common user that , when he has to replace his shower set, he would buy Elva over other showers, the question is, what does the end user desire?” We want to create a product, that is not niche, it has to be mass market consumer, so we have to design a product in accordance with the common users buying reason.

What are those reasons? assumptions incomming
My showerset is old and doesnt work anymore, time to buy a new one
My water bill and usage is too high (my daughters use too much water), time to buy a water saving product.
etc etc.



User timeline

The users have a buying reason and are looking to buy a product (1), they are looking for a product that can fulfill their needs, but they do not know how the product performce, they are searching for indications (2), that fullfill their needs, if they find a match, they will see a reason to buy it (3)

The point is, the users do not actually know, how the actual usage will be in the "use" fase (4), as they cannot use it. So the buying reason and what they desire when it is in use, might not be the same, or rather what they "think" they need, might not fulfill their exact needs.

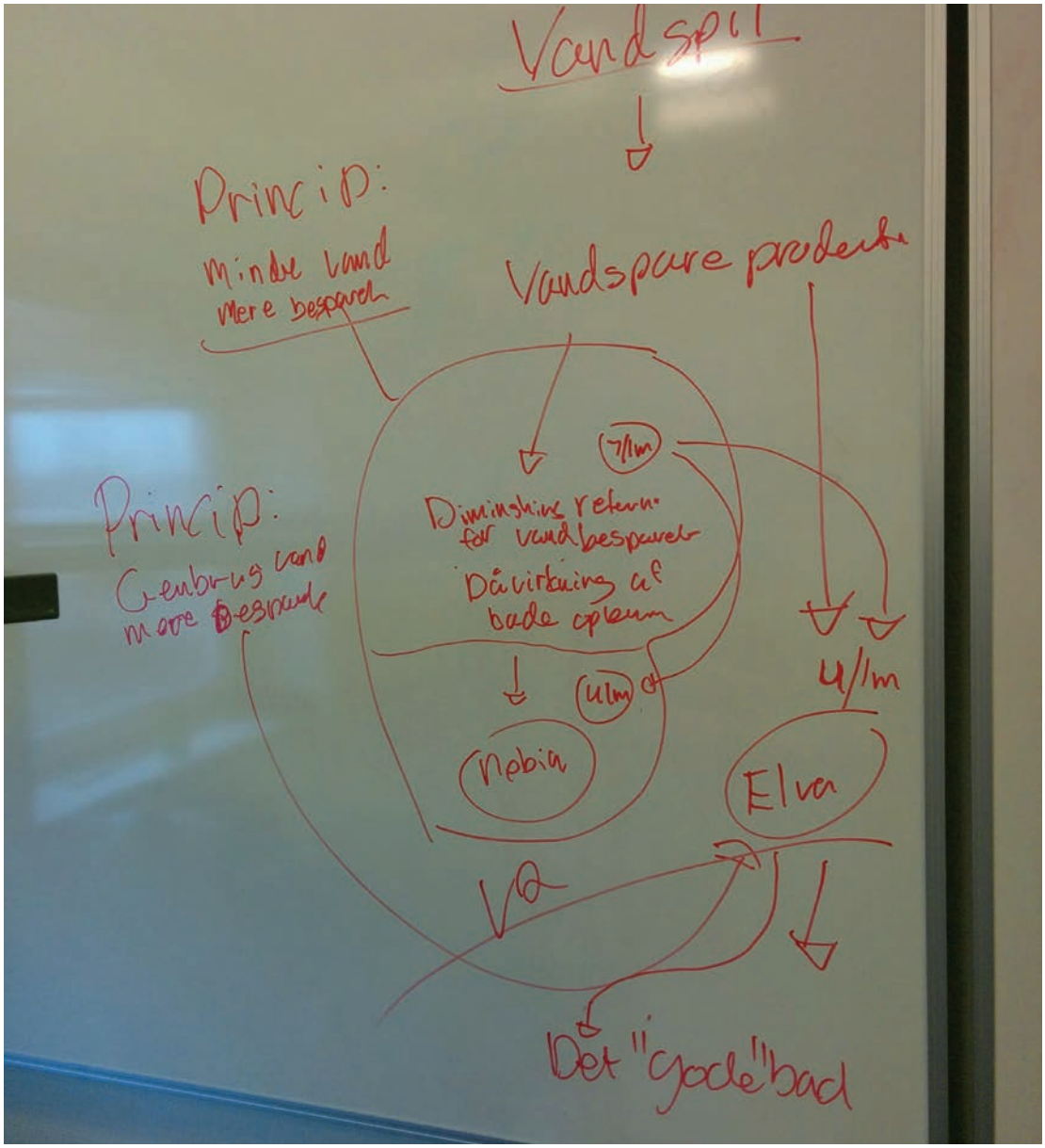
How can Elva incite users to buy it over the competitors, how can it give the needed "indicators for users to buy it over others, so, what features would support those buying reasons? and are there certain combinations that coud suprise/delight the user.

Should it indicate, that it is very good at saving water? or maybe that it is good at saving water, while upholding a wellness experience.

Is it the visual expression, that it must fit within their current interior.

Is it a two layed decison, first it has to be a very good water saving product, then maybe the shower that can get a person clean the fastests??

To define this, we need to define what value proporsition users are searching for, what is important in a bath for them, and what are the outside factos? (visual expression, easier maintenance) etc etc.



Current frame

The current frame is that, water wastage is commom problem that is acknowledged, therefore, a huge array of water saving products exists on the market.

Most of these product, use the principle of "reducing" the water needed to shower, thereby saving water. Almost all current product incoorprate such a feature, and market themself as water saving. But the principle has, and for many years met a diminshing return, if the water amount, is futher reduced, it will severely impact, the shower experience. For instance, the current limitation is abut 7.5/lm, that is a very good, a peak water saving shower product, that is able to deliver a traditional shower, that does not impact the behavior of the user. Wheras, if the principle is user to futher decrease the water usage, like NEBIA, to about 3/lm, is severely impacts and changes the experience, as only uses 3l through water dust to clean the user, a very different experience, arguably very good, in its ability to save water for either money or if water is a scarcity, but vastly changes the user experience, which might not be apealing, if neither of the former are strong drivers.
. So the current "reduce" products are capped at 7.5lm(or 2 gallons per min), further reduction will create a vastly different experience,

We believe, there is space in the market for products using new principles, that can surpase the current limitation without affecting the user experience too much. The reuse category, the principle of, reusing water and thereby saving water.
This type of shower, does not reduce the amount of water needed to shower, rather it takes a portion and reuses it, there adding water, instead of reducing, giving it a much bigger potential to go beyond 7.5lm, without impacting the shower experience.
but current product are very expensive and thereby inaccesible for the common user, ELVA will provide that ability, it will surpass the current limitation of 7.5L per min, and bane the way for a new type of shower in the market.

To do that, we need to fit the principle of reuse into the current paradigm of showers, how can we provide a shower expeirence with close authenticity to the current showers, that is the first order. (How can we fit the principle of reuse, into a product that common users would buy)

The next is to, what are the potenials of the principle, to provide a "better" shower, and what is the definiton of a good shower?

WS - Battery technology

Date: 06/03/17 **Written by: Jacob**

Objective

The objective is to find the right battery technology for our application. Furthermore, price and discharge power has to be considered.

Data

Three types of battery technologies have been considered, each with specific weaknesses and strenghts.

Lithium Polymer (Li-Po):

- High output (amperage output)
- Low weight
- Dense
- High charge rate

- Wears if discharged to much
- A very reactive chemical process if punctured
- Expensive

Norminalvalue: 3.7V

Lithium iron phosphate (LiFePO4):

- Chemical safe
- Self shutoff when discharged, reduces wear
- Easily packed
- Self contained
- Low price

- Fairly heavy
- Not so dense
- Expensive

Norminalvalue: 3.7V

Nickel–metal hydride battery (NiMH):

- Cheap
- High output (amperage)
- High cycle eate

- Wears if discharged to much
- Discharges fast by itself
- Low charge rate

Norminalvalue: 1.2V

Our solution needs:

- Should be removable
- Should be rechargeable
- Should not be too heavy
- Should be able to sustain a high load
- Should have low charge protection
- Should be safe for the user.
- Should have a low charge of 12V

Evaluation

It can be beneficial to find the right battery, for the right application, this means that there is a set of parameters which is necessary for the battery type to withhold. Furthermore the batterypack must not be too expensive, if it has to be changed in the future.

Reflection

As all batteries is capable of driving the system, the cost is the main factor in this, and recycle amount. LifePO4 cells is some of the most used battery types, and is used in the industry already, furthermore it is an selfcontained fairly cheap solution. Most cells of this type is 2600mAh, so creating a 12V battery, means four cells in series. This needs to be regulated not to go pass 12V, as four fully charged cells would have a voltage of around 16.8V.

WS - Buying reason for Orbital Systems

Date: 14/02/17 **Written by: Jacob**

Objective

The objective is to find the reasoning behind buying Orbital Systems, from a private homeowner/student perspective and institutional perspective. The value propositions need to be defined.

Data

As a price of 37.000DKK, the product is very expensive for most private homeowners and students, also the cost/benefit is unclear and far in the future, if the product is used in normal homeowner or student scenarios. If used in institutions, it is clear that the cost/benefit is much clearer due to the sheer amount of showers the product is going through.
There is two seperate target groups for the product, the private use and public use, the first being the common consumer, and the second being institutions etc. These two groups have seperate values towards buying and using the product.

The private use:
- Saving water, thereby saving the environment.
- Being an early adaptor of new technology.
- We should all be environmentally responsible.
- I can shower completely guilt free.

The public use:
- Due to a large amount of uses, the product will pay for itself in a couple of years.
- We can be frontrunners, and set a standard for tomorrow's environmental perception.

Due to the price of Orbital Systems, the firstmost buyers are the institutions, due to the clear cost/benefit of the product.

Video of Orbital Systems TEDx:
https://www.youtube.com/watch?v=LbkXw1SLeO0

Forbes: https://www.forbes.com/sites/michaelkanellos/2015/10/12/the-tesla-of-showers/#113fd0987bd1

"There, each of the six showers installed saves over 30,000 liters (8,000 gallons) of water and 1600 kWh of electricity each month. A similar installation in Denmark sees a payback in less than one year, and then it is not only water and energy winner, but also a huge money saver."

Evaluation

The buying reasons for private and public use is different, however some values, such as, being a front runner for new technology can at times be the same. The private user, which we target with our solution, is a very rough outline of the actual values which they want from a product, this also means that it is important to dive deeper into the segment, and even split the private user into different users.

Reflection

Concluding on the observations, it is clear that it is important to look further into why the user should buy our product, as this might be completely different, compared to why they would buy Orbital Systems. We are segmenting ourselves in a complete different pricebracket, thus also targeting a different user, which again might have a different set of values, which he/she expects from a shower set. Due to the differences in values across our target group, it can be beneficial to create a example of a low, mid and extreme user of the product, to further analyse different buying reasons and values for each user in the private segment.

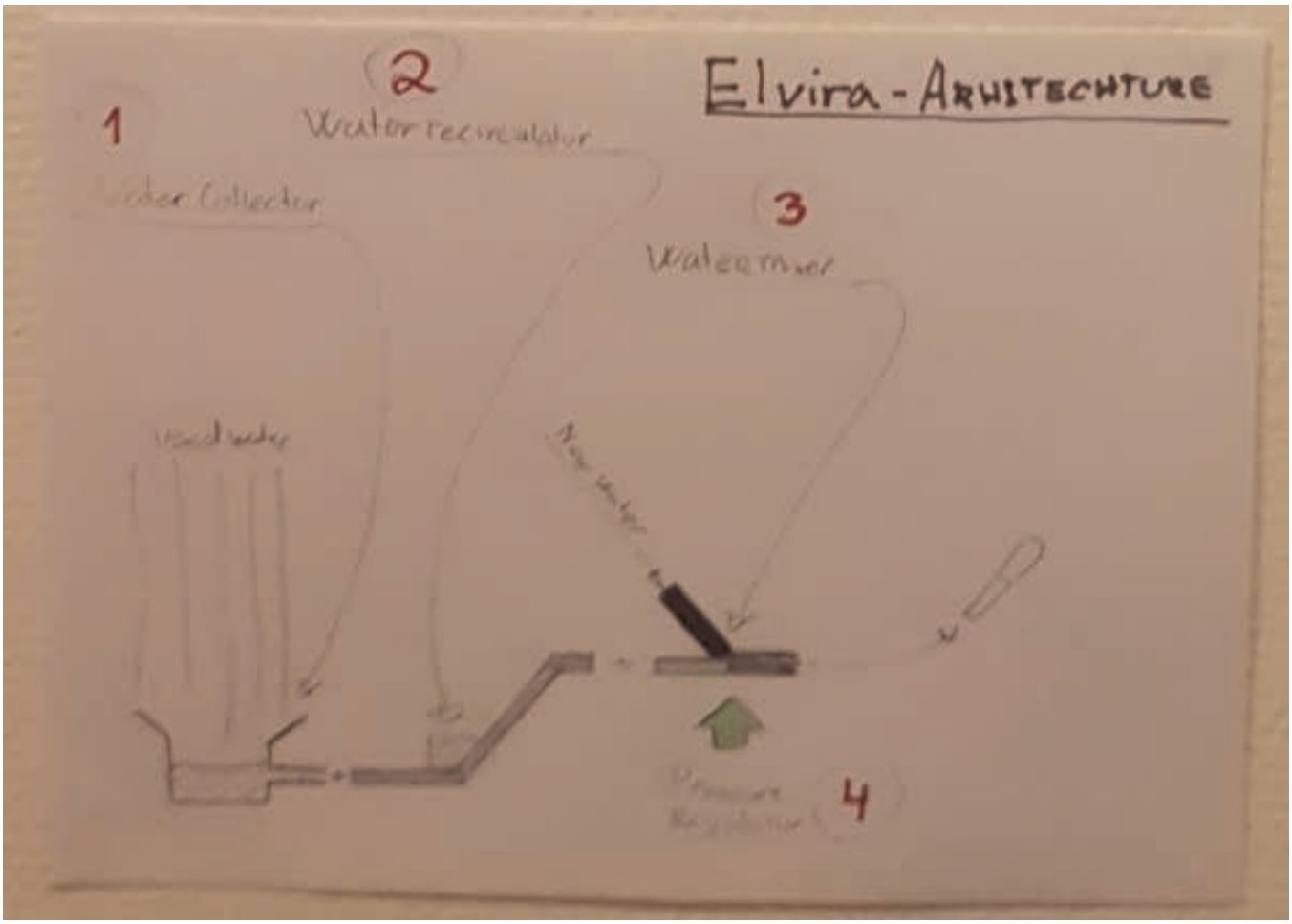
WS - Elva product architecture

Date: 07/02/17 **Written by: Alex**

Objective

Based on concept v1 and the current concept and the currenn technical principles, an initial principle stucture fo elvira is to be developed, the objective is to create a componentent(funcionality) structure, where each one can be developed in depth and explored, thereby dividing the task. (tjalve)

Data



Evaluation

four functionalities were identified as the initial structure, each constitute a functionality to create the recirculating shower. It is only based on the functionality of transporting water from a to b and lastly defusing the water.

The diffusion stage is currently at the end of the hose, as it was discovered prior that it might be the easiest way to recombine water due to pressure being lowest at that point, this might be subject to change, as in, the interconnectivity of the functionalities might change.

Reflection

This will be the base for a structured exploration of the technical solution, a tjavle function / middel tree.

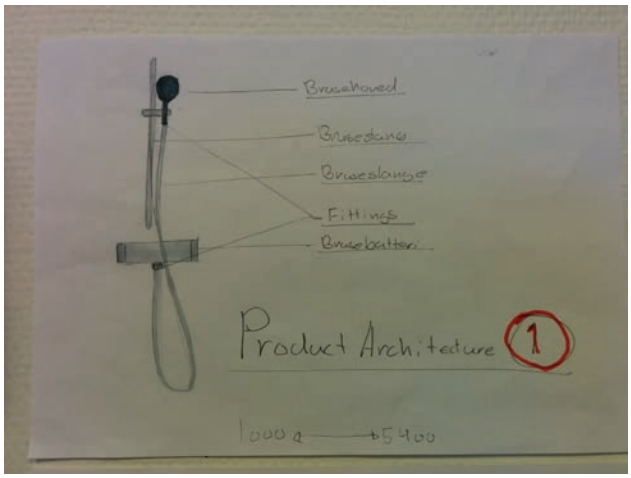
WS - Conventional product architecture

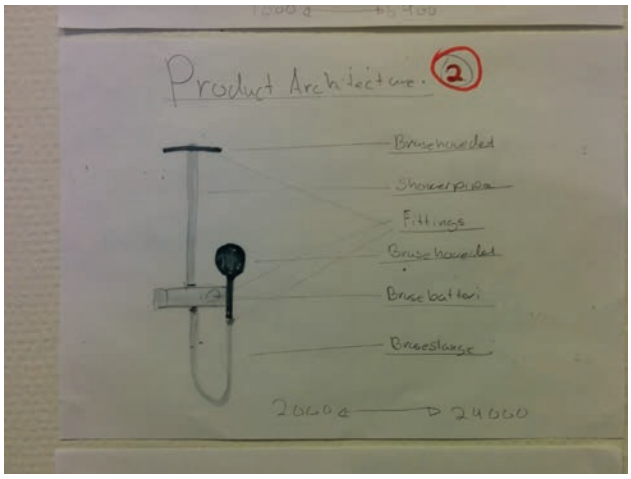
Date: 11/02/17 **Written by: Alex**

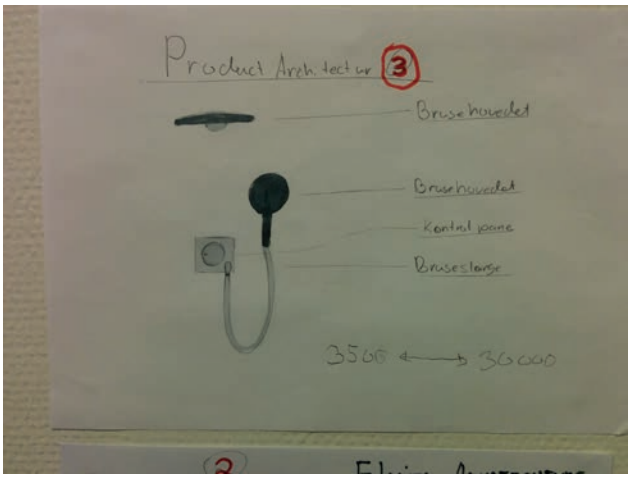
Objective

To define the structure of currently retailed showers, and to create a distinction between the different types, what are the different proporties.

Data







Evaluation

Structure one, the normal shower set is the most basic and genrally the least expensive, structure two is often significantly more expensive. and structure 3 is the most expensive, as it reguires remodelling of the bathroom, therefor also harder to intergrate.

The easiest to intergrate would either be 1 or 2, whereas 3 would be the most “exclusive” solution.

Reflection

This will work as a reference to current product structures, and what standard componenents therein, a common way to adress the current structures in the team and to refer too.

The architure definition will be helpful to define the overall structure of elva, and will be the next step to define.

WS - Water saving spreadsheet

Date: 02/02/17 **Written by: Alex**

Objective

To gain an inital understanding of water prices and the usage of a household, and what could be saved if a percentage of water was reclaimed.

Data

Google sheets:
https://docs.google.com/spreadsheets/d/1tTAYjXgWGiFRCUKNsUCe_gWIwYxMcreiydHZvAwFIec/edit?usp=sharing

Evaluation

The first section calculates the water cost, and what it would cost if mixed with hot water, wherein it was discovered that hot water, is 60% more expensive.

The second section, calculates the total amount water and money spent on water in one year, based on the liters used per bath, freqeuncy of showering and amount of ppl in the household. It was discovered, that each person in a household, double up the amount of used water, no diminsing return. The frequency would often be capped at 365, being the factor that is least variable, and the amount of ppl in a household often is between 1 and 4, but the amount of water used is highly unpredictable, as persons shower very differently, an avg value might be able to be calculated, but if a household with a person uses 200L per shower, whereas the avg person uses 75L, that would double up the water and cost, so applying avg metrics would not be correct, it has to be defined in low, avg and high use casses.

the third section, decribes the anual saving if a percetage of water is saved.

The fourth section calculates break even depending on the sales price. The water usage, percentage and sales price form this estitmate. On nornal usage and a sales price of 3000, the saved water percentage is 30%, the product can be repaid within a very reasonable amount of time, ~2 years and even less if for high users.

After 2 years, the product will payback, depending on the product lifetime, which section 5 describes, which currently is set to “amount of uses” if the product is able to survive 6000 uses, which is a conservative estimat, the product will earn a sizeable aount of money.

Reflection

Money, is clearly one very important aspect for deciding what is affordable. But what are the key factors, is it the sales price? is lower better? how does a low price impact perception of quality?

Does the ability to break even increase the affordablity? and even the ability to earn money, how does that influence the sales price, could be price be higher, if you would be able to earn it back?

How do we inform uses about these metrics, if they do not know, what can be saved, they cannot see the benefit in breaking even.

These are questions, we think are central to being affordable? but when is affordable a value for the user? when the product is bought? or when the product is used?
and what does affordable mean, in relating to the want to “save money”

WS - Current concept 10 feb.

Date: 10/02/17 **Written by: Alex**

Objective

The objective is to find out whether the concept is to be focused on being a completely stand-alone product, or if it should be combined with the traditional shower hose and head.

As the concept could go two ways, either being combined with the already installed shower hose and head, or a completely stand-alone product, both concept directions were considered. The addon product would result in a solution suited to fit an already installed shower set, which would allow us to create a less complex system, again, probably making it cheaper. As the stand-alone solution would mean a more integrated product structure, allowing us to create a product with a higher possibility of integrating more features. Also, as the system needs power, the addon product would still need forms of powering, meaning a battery or AC input.

A product structure is possible to realize, and can be categorized into four parts:

1. The water collector, which collects the used water

2. The pumping element, which pumps up the water to the rest of the system

3. The recycling element, which introduces the old water with the new.

4. The dispenser, used to dispense the mixed water onto the user again, a shower head.

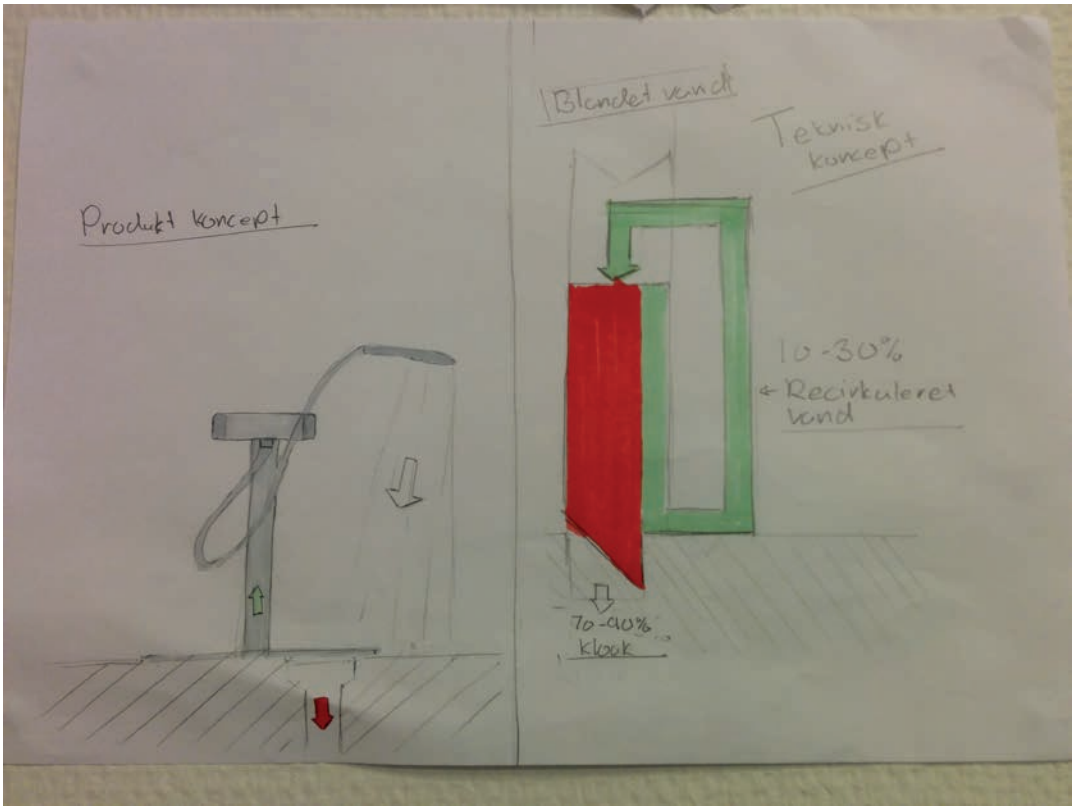
This product structure is showing the basic functionality of how the water should be moved, and mixed, further components can be added in the future.

Evaluation

Due to the complexity of the solution, a addon might not be the right outcome for the project, as there is a range of components that need to work. The stand alone concept gives us the possibility to create our own shower product structure, without having to consider how a traditional mixer would work with the new product. Furthermore considerations regarding where the water is mixed is done, whether it should be done in the showerhead or before the shower head, the decision is affected by what our prototyping shows, as it depends heavily on how effective each solution is, due to our wish for a low power usage

Reflection

Creating a stand-alone solution is considered to be the best way to go, and allows us to work closely with getting all the components to work. Furthermore this allows us to design the product, without having to take other mixer designs into consideration.



WS - Idea bords

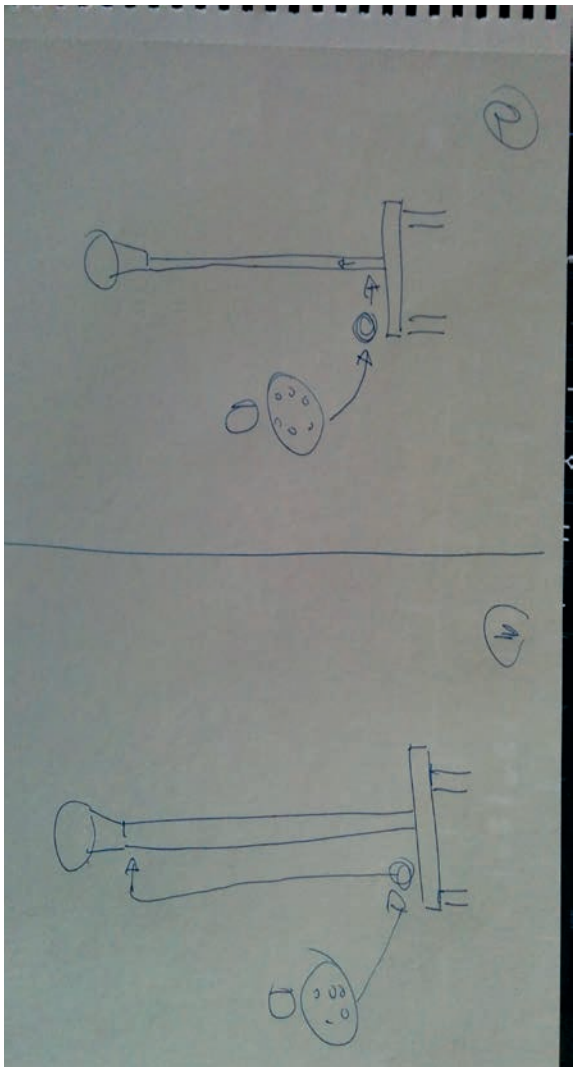
Date: 05/02/17 **Written by: Alex**

Objective

The objective was to test out and validate the introduction of a T-pipe in the system, to introduce water into an existing flow.

Data

To test out the concept, a CAD model with threading for installing between the mixer and hose were created, in this middle piece, a hole were created, making it possible to test whether we could introduce water in the existing water flow. The model were 3D printed and tested between the mixer and hose, and between the hose and showerhead.



Evaluation

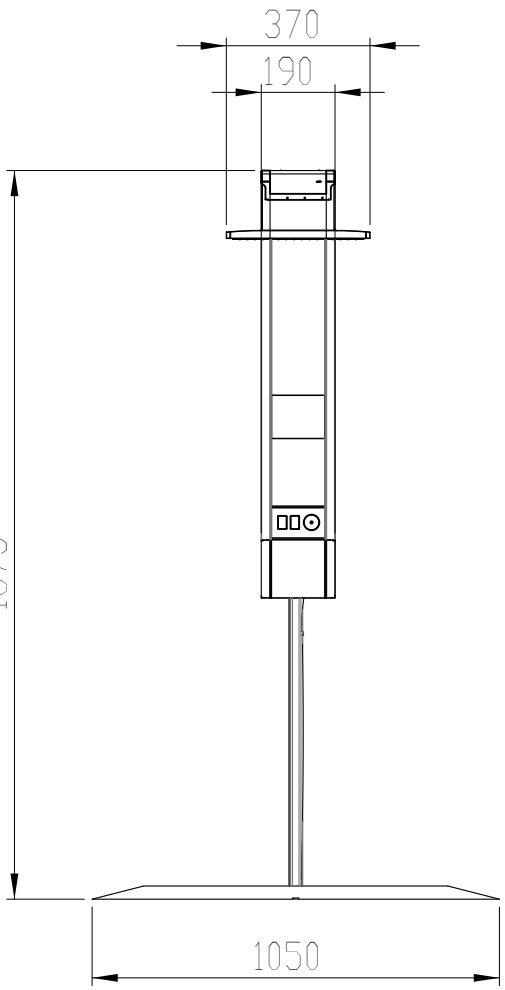
Reintroducing water with the T-pipe ended up being very difficult, due to the pressure in the hose. As water seeks the least resistance, more water went out the T-pipe hole therefore making it difficult to introduce water in the same hole, this could probably be sorted if a large pump were used to pump the water into the hole with a higher pressure than that coming out of the mixer. The T-pipe were also tested between the hose and showerhead, which resulted in less pressure needed to introduce water, but still with a need for a big pump. It was concluded that the difference between the placement of the T-pipe resulted in a resistance difference of the water, so when the water went to the showerhead, the resistance of the hose had already been overcomed.

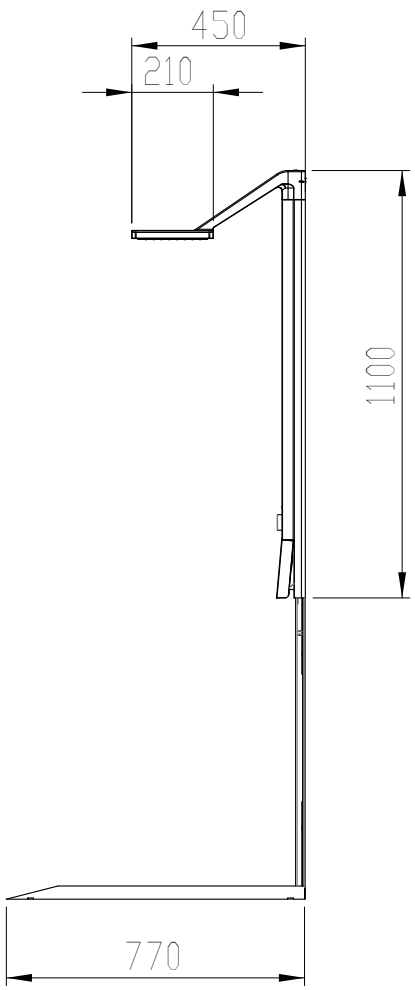
Reflection

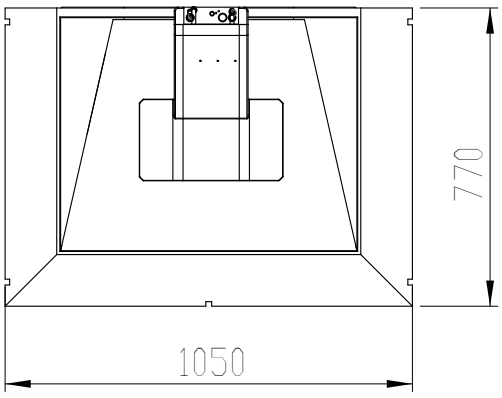
As the pressure was so high at the hole on the T-pipe, it was concluded that a larger pump was needed, this again would draw more power, and it is a very ineffecient way, due to forcing used water into a pressurised stream of new water. Instead of using a T-pipe we will have to look into other methods of introducing water into the new stream.

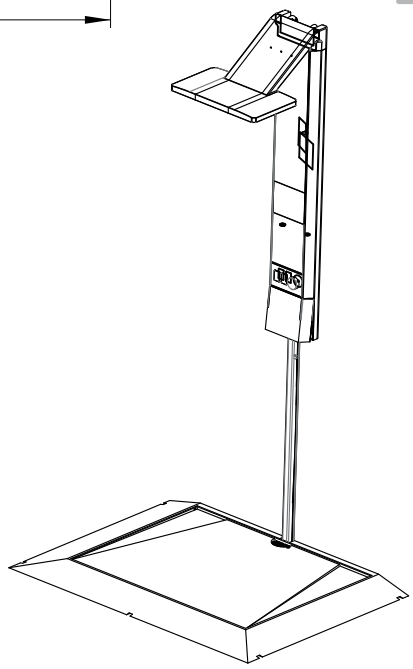
TECHNICAL DRAWINGS

MSC04-ID08
GROUP 8
PROJECT ELV









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Author: MSc04 ID 8	Date: 10.05.2017	
	TITLE: NON-EXPLODED	
MATERIAL:	DWG NO. 0015	A4
	SCALE:1:20	

Reading guide

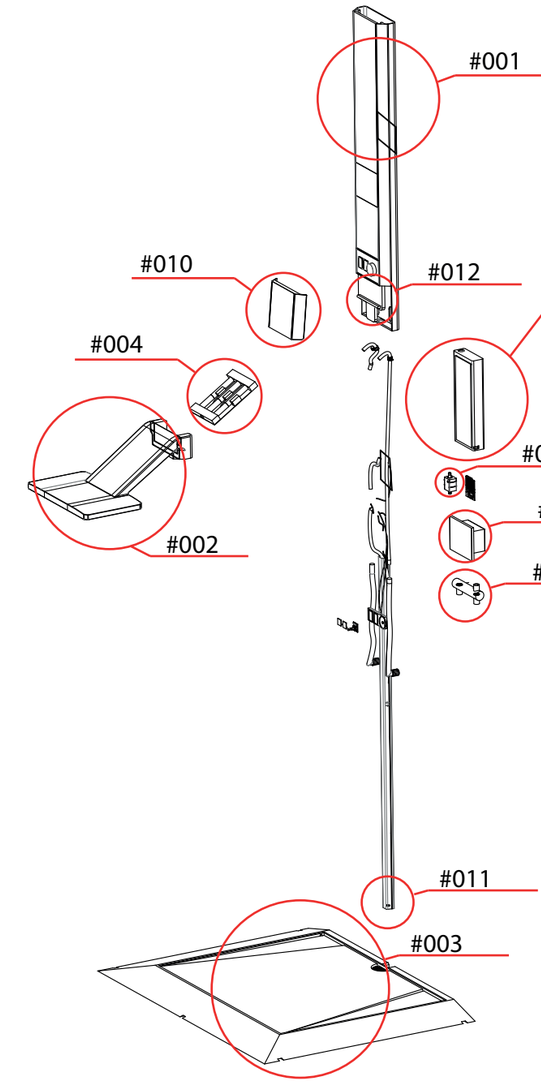
A BOM lists the components and their respective sales channel and price. Component hyperlinks can be found in the following spreadsheet:

https://docs.google.com/spreadsheets/d/1tTAYjXgW-GiFRCUKNsUCe_gWIwYxMcreiydHZvAwFIec/edit?usp=sharing

Following an exploded view of Elv comes a series of technical drawings going in-depth with dimensioning and tolerances. Some of the technical drawings only display main dimensions due to the part not having been focussed on in the project.
The technical drawings were created on behalf of the current state of Elv. **The drawings marked with green are newly designed components/parts for Elv. The drawings marked with blue are those which are standard parts, which have not yet been found, but is believed to be available, but should be dimensioned close to the technical drawing specification.**

BOM

ID	DRAWING NO.	UNITS	PRICE PIECE USD	PRICE TOTAL USD	COMPONENT	WHERE TO BUY
INTERNAL ELECTRONICS						
#001		8	2	16	18650 Battery cell	Alibaba
#002		1	0.6	0.6	Voltage regulator	Aliexpress
#003		1	8	8	Charging circuit	Aliexpress
#004		3	7	21	Motorized ball valve	Alibaba
#005	#005	20	1	20	UVC LED's	Alibaba
#006	#011	1	6.5	6.5	Turbidity sensor	Alibaba
#007	#011	2	1	2	Resistance probes	Alibaba
#008	#007	1	2	2	Pump	Alibaba
#009		1	5	5	Controller	Alibaba
#010		1	2	2	Wiring	
INTERNAL OTHERS						
#011	#004	2	2	4	Venturi injectors	
#012	#006	1	5	5	Buffer tank	
#013	#009	1	10	10	Mixer	
#014		1	5	5	Tubing	
#015		12	1	12	Tubing fittings	
		1	5	5	Misc	
EXTERNAL ELECTRONICS						
#016		2	2	4	Showerhead and pipe button	Alibaba
#017		3	0.1	0.3	Touch switches	Alibaba
#018		1	1	1	Rotary encoder	Alibaba
#019		1	1	1	Switch for recirculation	Alibaba
#020		3	2	6	LED Strips	Alibaba
#021		1	5	5	Battery charger	Alibaba
EXTERNAL OTHERS						
#022	#003	1	10	10	Mat	
#023	#002	1	15	15	Showerhead	
#024	#012	1	10	10	Tray for components	
#025	#001	1	20	20	Outer shell	
#026	#010	1	2	2	Recirculation button shield	
#027	#008	1	3	3	Enclosure for battery pack	
#028		1	2	2	Mesh filter for mat	
#029	#013	1	5	5	Mounting bracket	
#030		4	0.1	0.4	Screws for mounting bracket	
				208.8	USD	



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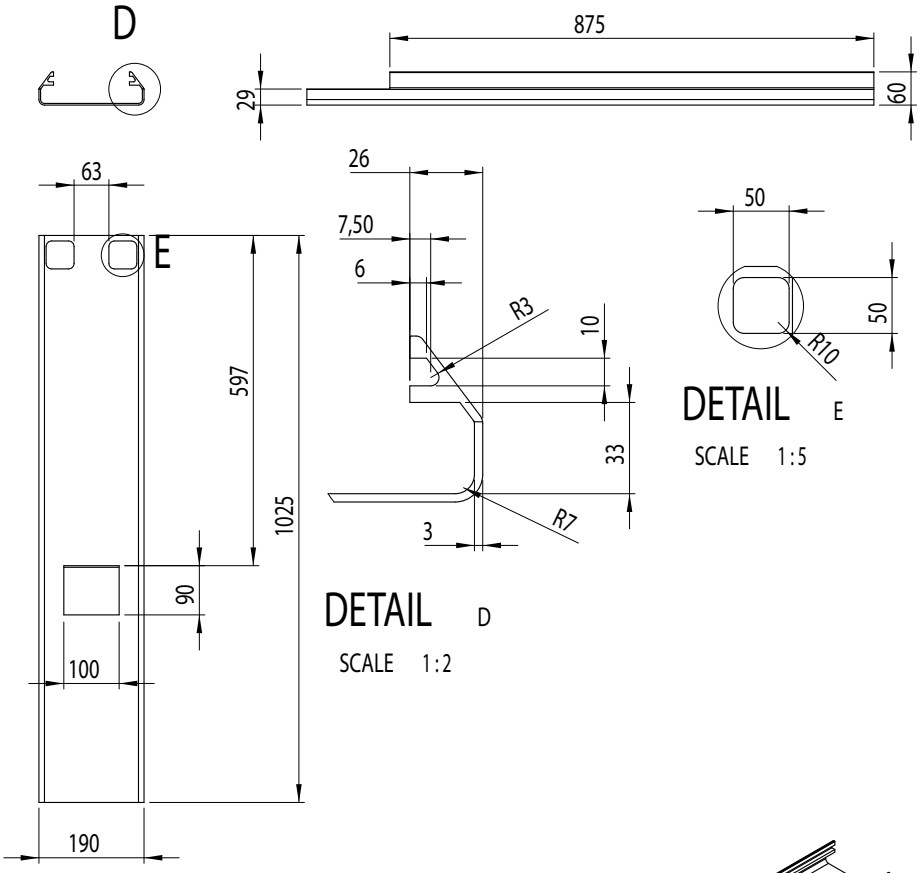
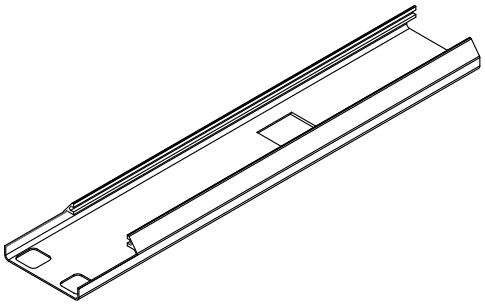
Author: MSc04 ID 8	Date: 10.05.2017
	TITLE: EXPLODED
MATERIAL:	DWG NO. 0014 — A4
	SCALE:1:20





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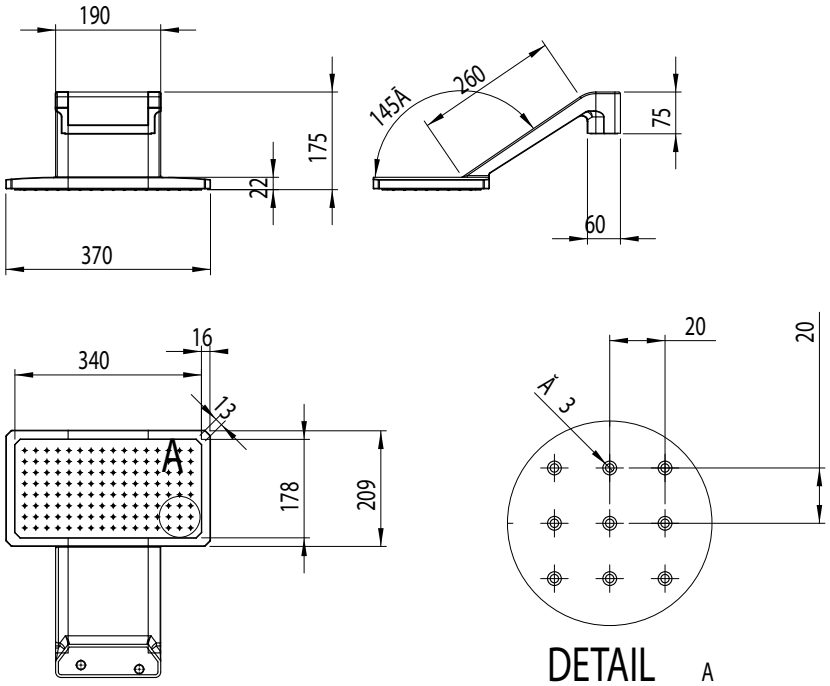
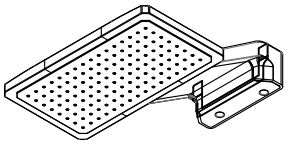
Author: MSc04 ID 8	Date: 10.05.2017	
	TITLE: Shell	
MATERIAL: Aluminium	DWG NO. 001	A4
	SCALE:1:20	



DETAIL A

SCALE 1:2



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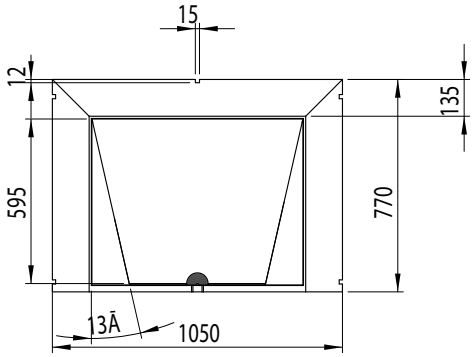
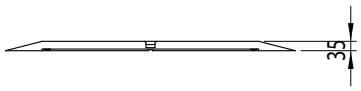
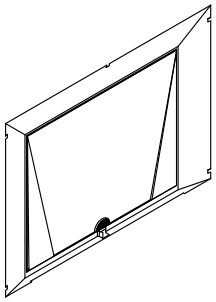
Author: MSc04 ID 8	Date: 10.05.2017	
	TITLE: Showerhead	
MATERIAL: Aluminium/ABS	DWG NO. 002	A4
	SCALE:1:10	







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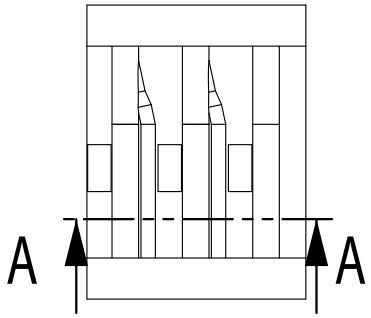
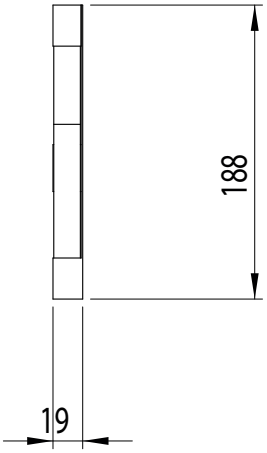
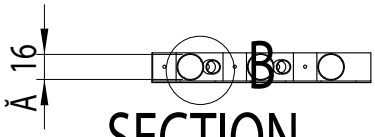
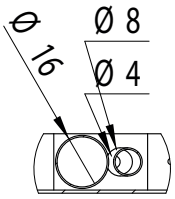
Author: MSc04 ID 8	Date: 10.05.2017	
	TITLE: Mat	
MATERIAL: ABS	DWG NO. 003	A4
	SCALE:1:20	





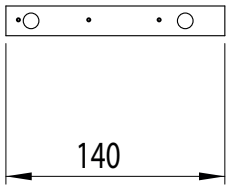


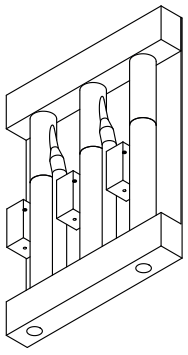
SECTION A-A



DETAIL B

SCALE 2:5





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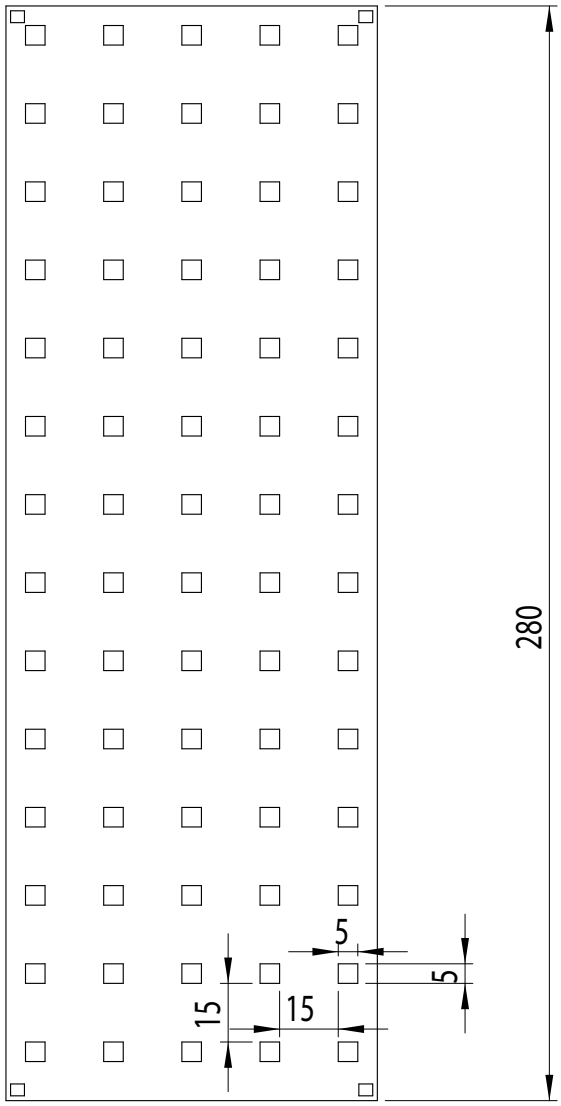
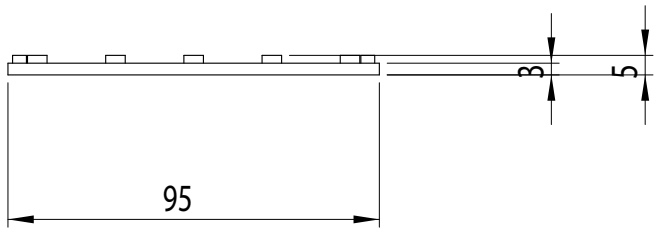
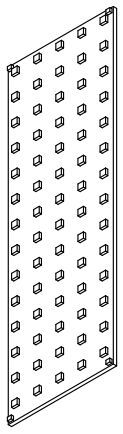
Author: MSc04 ID 8	Date: 10.05.2017	
	TITLE: Venturi system	
MATERIAL: ABS	DWG NO. 004	A4
	SCALE:1:5	







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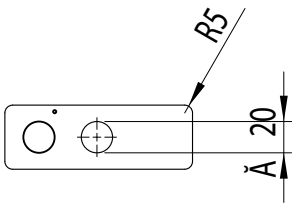
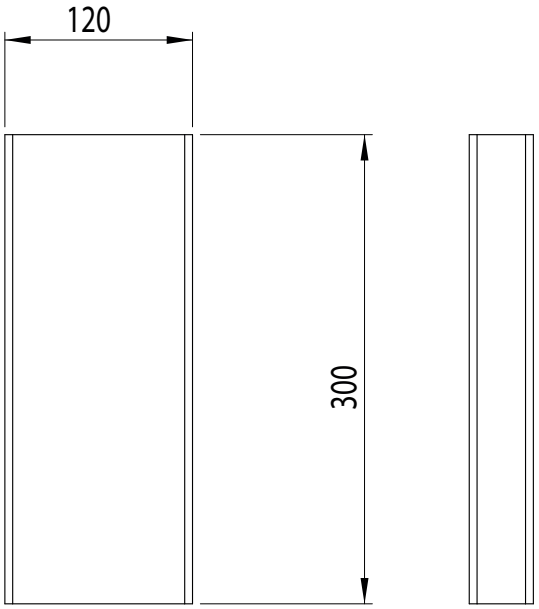
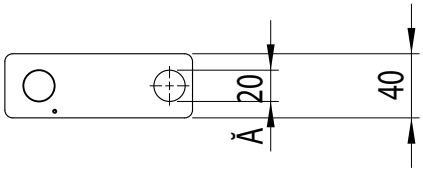
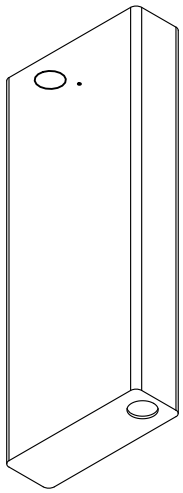
Author: MSc04 ID 8	Date: 10.05.2017	
	TITLE: LED Panel	
MATERIAL:	DWG NO. 005	A4
	SCALE:1:2	









Projection: 	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: Smooth TOLERANCES: LINEAR: Not tolerance decided maesurements DS/ISO 2768-1 m ANGULAR: Not tolerance decided maesurements DS/ISO 2768-1 m	
Author: MSc04 ID 8	Date: 10.05.2017	
	TITLE: Buffertank	
MATERIAL: ABS	DWG NO. 006	A4
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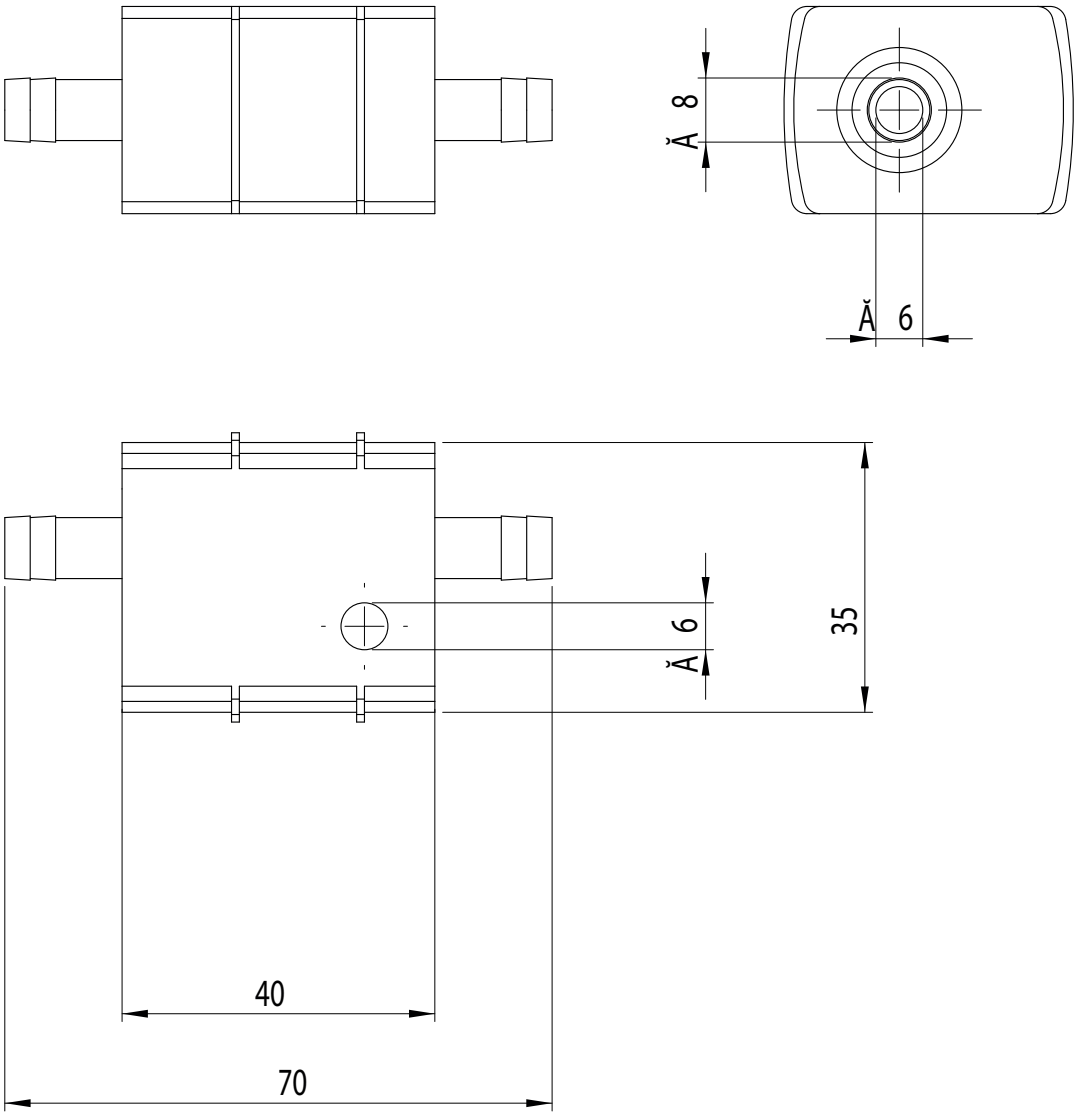

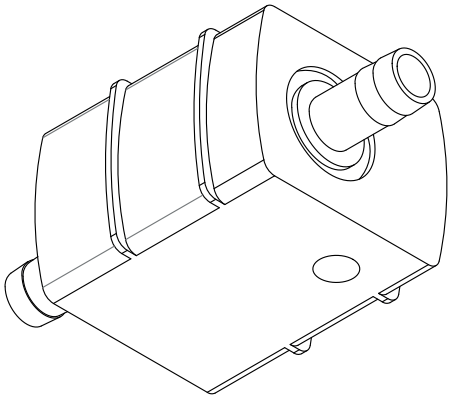

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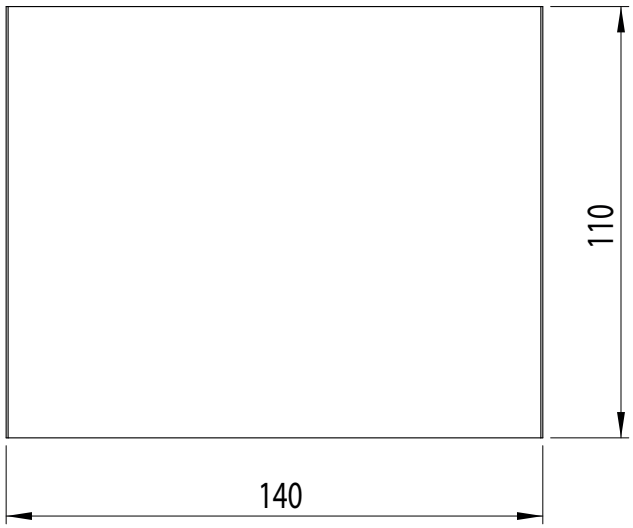
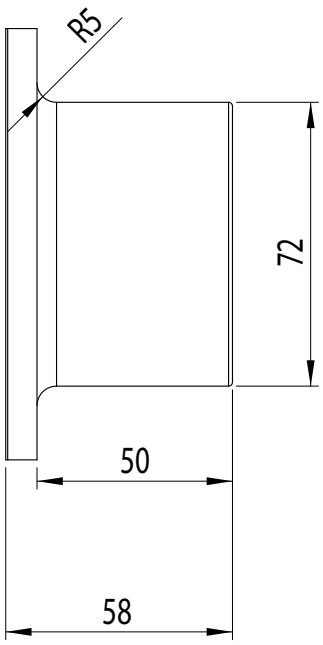
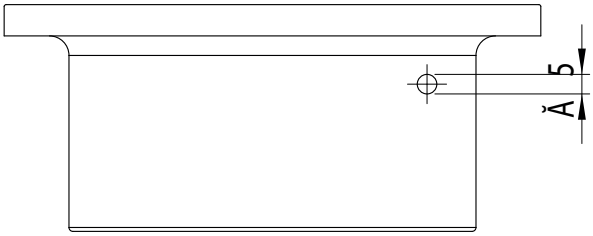
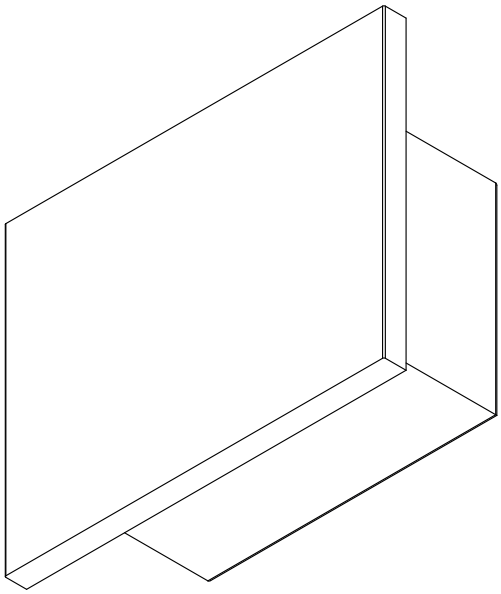
Author: MSc04 ID 8	Date: 10.05.2017	
	TITLE: Pump	
MATERIAL: ABS	DWG NO. 007	A4
	SCALE:1:1	

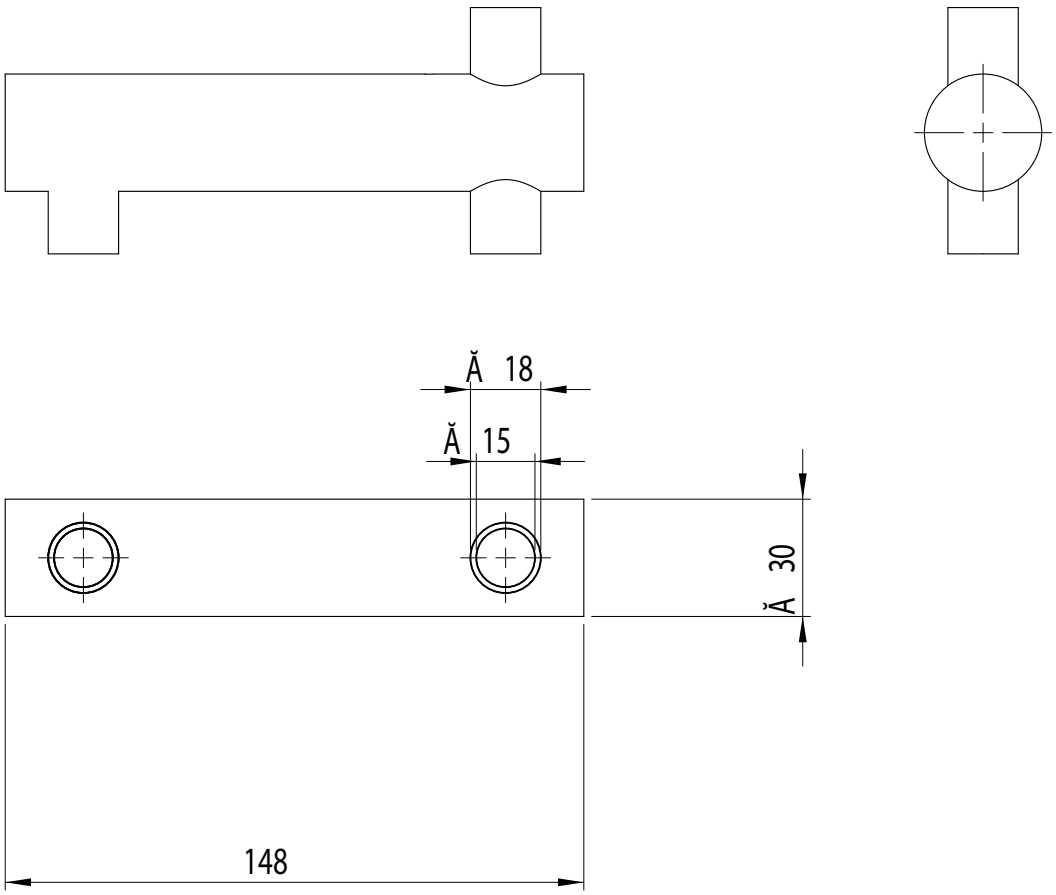


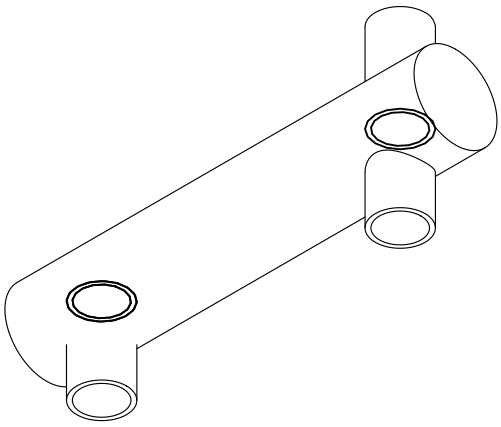




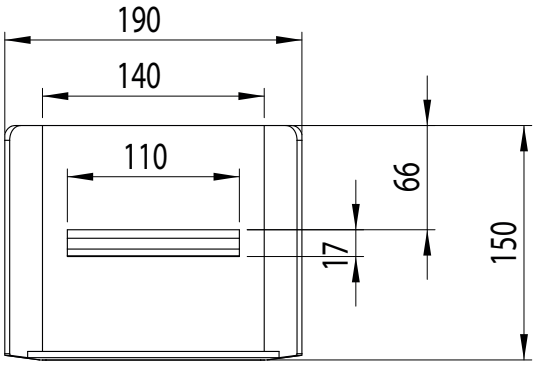


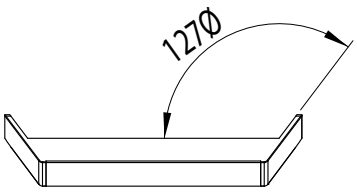
Projection:	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: Smooth TOLERANCES: LINEAR: Not tolerance decided maesurements DS/ISO 2768-1 m ANGULAR: Not tolerance decided maesurements DS/ISO 2768-1 m	
Author: MSc04 ID 8	Date: 10.05.2017	
	TITLE: Battery	
MATERIAL: ABS	DWG NO. 008	A4
	SCALE:1:5	

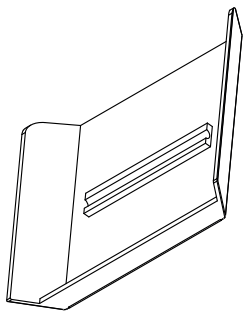




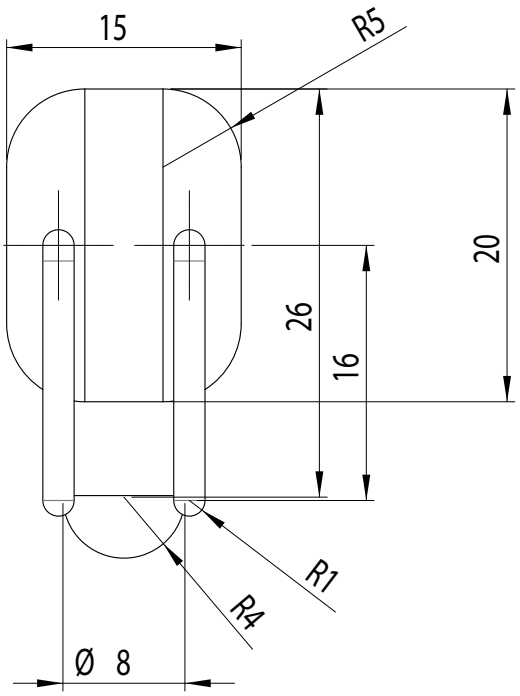
Projection:	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: Smooth TOLERANCES: LINEAR: Not tolerance decided maesurements DS/ISO 2768-1 m ANGULAR: Not tolerance decided maesurements DS/ISO 2768-1 m	
Author: MSc04 ID 8	Date: 10.05.2017	
	TITLE: Mixer	
MATERIAL: SS	DWG NO. 009	A4
	SCALE:1:2	

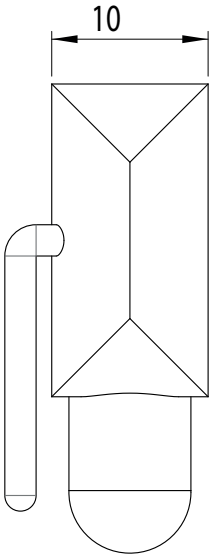


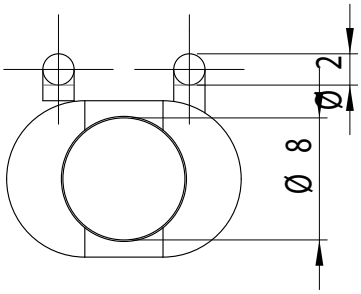


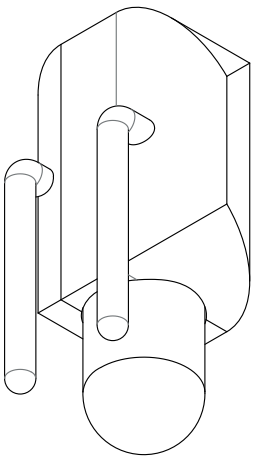


Projection: 	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: Smooth TOLERANCES: LINEAR: Not tolerance decided maesurements DS/ISO 2768-1 m ANGULAR: Not tolerance decided maesurements DS/ISO 2768-1 m	
Author: MSc04 ID 8	Date: 10.05.2017	
	TITLE: Mixer	
MATERIAL: Aluminium	DWG NO. 010	A4
	SCALE:1:5	

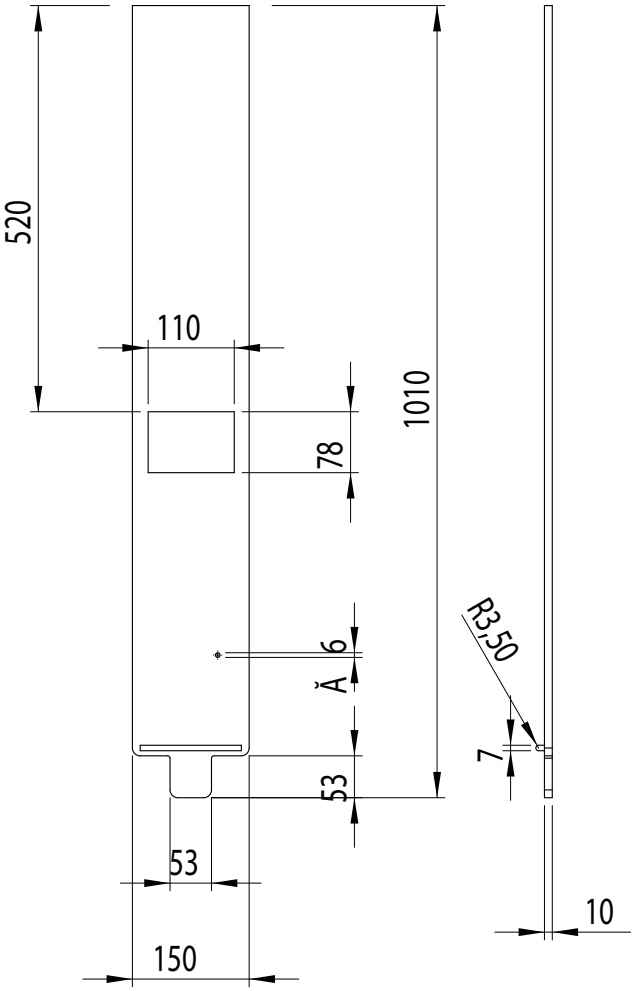


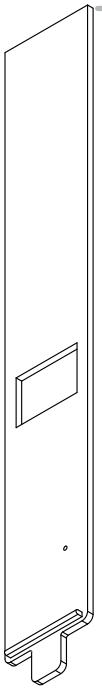




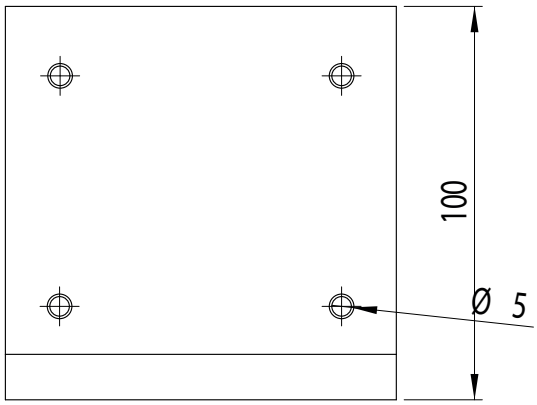


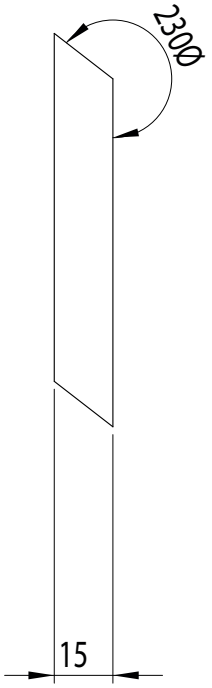
Projection: 	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: Smooth TOLERANCES: LINEAR: Not tolerance decided maesurements DS/ISO 2768-1 m ANGULAR: Not tolerance decided maesurements DS/ISO 2768-1 m	
Author: MSc04 ID 8	Date: 10.05.2017	
	TITLE: Sensor box	
MATERIAL: ABS	DWG NO. 011	A4
	SCALE:2:1	

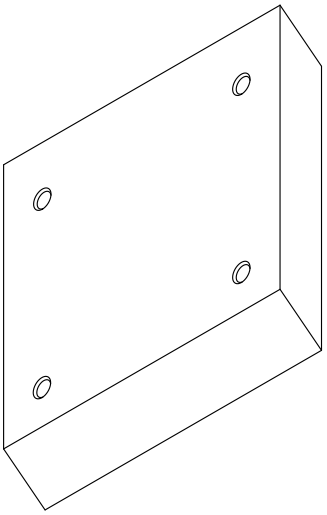




Projection:	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: Smooth TOLERANCES: LINEAR: Not tolerance decided maesurements DS/ISO 2768-1 m ANGULAR: Not tolerance decided maesurements DS/ISO 2768-1 m	
Author: MSc04 ID 8	Date: 10.05.2017	
	TITLE: Tray	
MATERIAL: Aluminium	DWG NO. 012	A4
	SCALE:1:20	







Projection:	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: Smooth TOLERANCES: LINEAR: Not tolerance decided maesurements DS/ISO 2768-1 m ANGULAR: Not tolerance decided maesurements DS/ISO 2768-1 m	
Author: MSc04 ID 8	Date: 10.05.2017	
	TITLE: Mounting bracket	
MATERIAL: ABS	DWG NO. 013	A4
	SCALE:1:2	