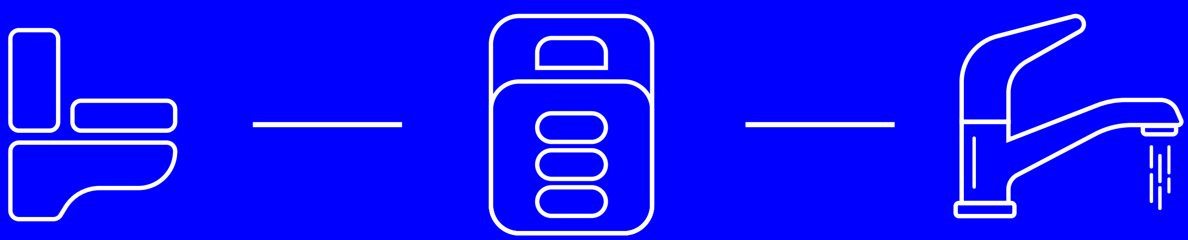
A DIPLOMA IN INDUSTRIAL DESIGN

YW™ - YOUR WATER

Design Thinking for Future Water Treatment

BY ZANE CERPINA



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THE OSLO SCHOOL OF ARCHITECTURE AND DESIGN

YW™ - YOUR WATER
Design Thinking for
Future Water Treatment

A diploma thesis by Zane Cerpina, Spring 2019
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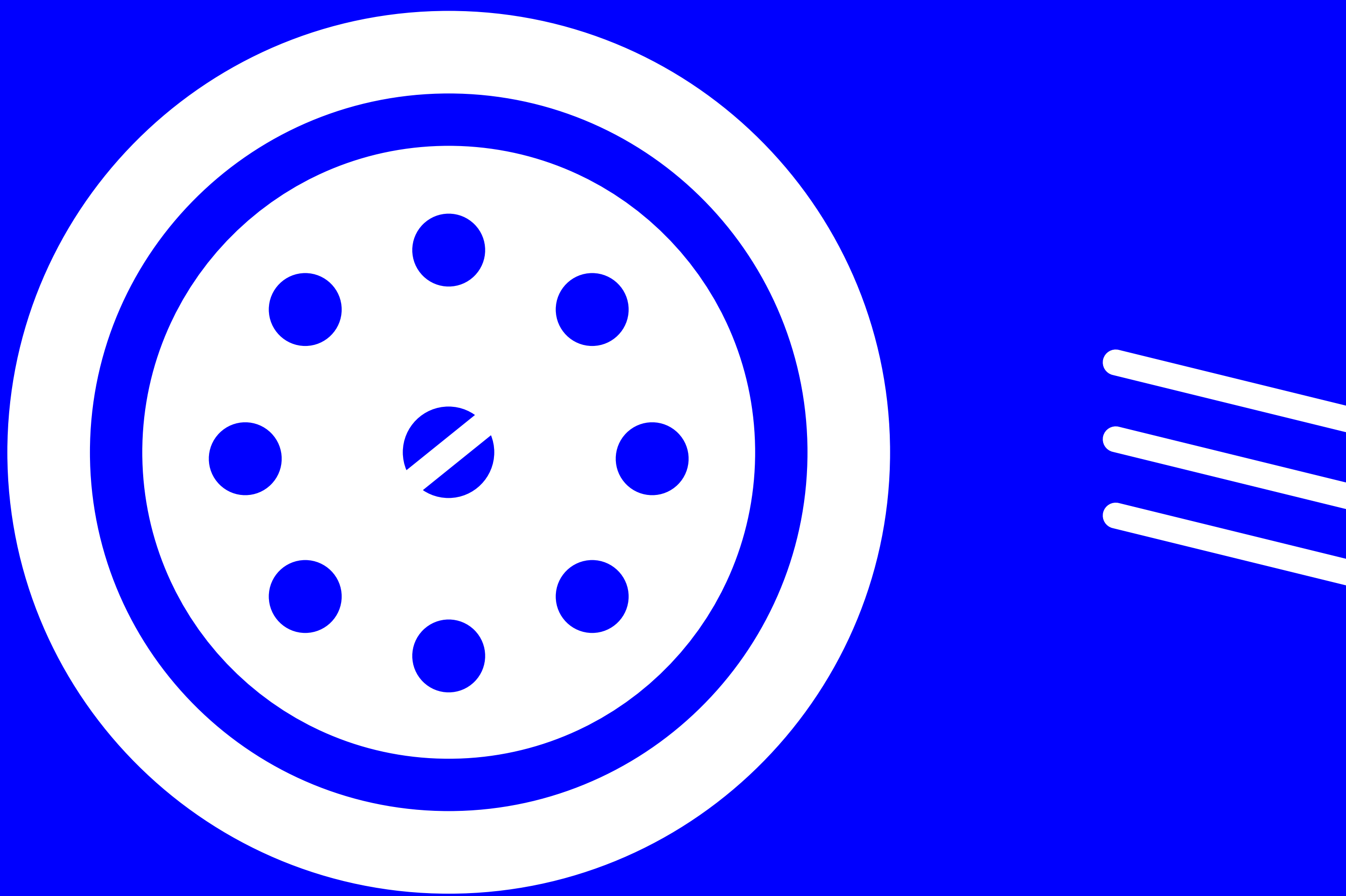

1. INTRODUCTION

1 INTRODUCTION

YW™ - Your Water is a speculative industrial design project developed for the Master's degree diploma at The Oslo School of Architecture and Design during the spring semester 2019.

The YW™ project explores the potential of speculative industrial designs to evoke critical reflection about present ways of living while offering radical solutions and exploring alternative future scenarios.

Now the Earth has entered a new geological epoch - the Anthropocene, in which humans have become a major geological force on a planetary scale. (Crutzen, 2002) In this new age, we are pushing the Earth System into more unstable and unpredictable environmental conditions. Due to the rapid global population and economic growth over the past two centuries, we are also drawing on massively greater use of natural resources than before. (Steffen et al., 2011) Urbanization, pollution and climate change are also crucial factors overwhelming nature's ability to provide the global population with the essential functions and services. (UN, 2018) Global freshwater resources are at a critical risk. The recent cases of water-related crises around the world are strong evidence of this.

In 2018 the world experienced the most significant water crisis in modern history as Cape Town in South Africa with its 3.8 million population was about to entirely run out of water. More than ten megacities and countless urban environments around the world face a similar future. While the growing global population will require 50% more freshwater by 2050, only 20% of global wastewater is currently treated before discharged back into the environment.

This globally important issue lacks both the public's attention and involvement to ensure freshwater security and minimize the risks of water-related crises around the world.

The YW™ project aims to radically challenge the way the public perceives, thinks of and gets involved in the increasing water scarcity in the age of the Anthropocene. The project investigates the potential environmental and socio-economical benefits of recycling all household wastewater locally and deliberately through a visible process within every urban household.

The final result is an industrial design proposal of a modular household wastewater treatment system: YW™ - Your Water. It allows its users to recycle their wastewater, including black and grey water, into clean drinking water and valuable secondary by-products such as sustainable energy, phosphorus, microalgae biomass, and oils.

The YW™ project is explorative and experimental. The speculative design thinking behind it is tested through action-based research and public interventions.

At the outset of the project I formulated two main research questions:

i) How can speculative industrial designs raise individual awareness of the global increase in water scarcity?

ii) What if household wastewater recycling becomes part of our daily lives and a valuable renewable resource for wastewater by-products, such as clean water, energy, and nutrients?

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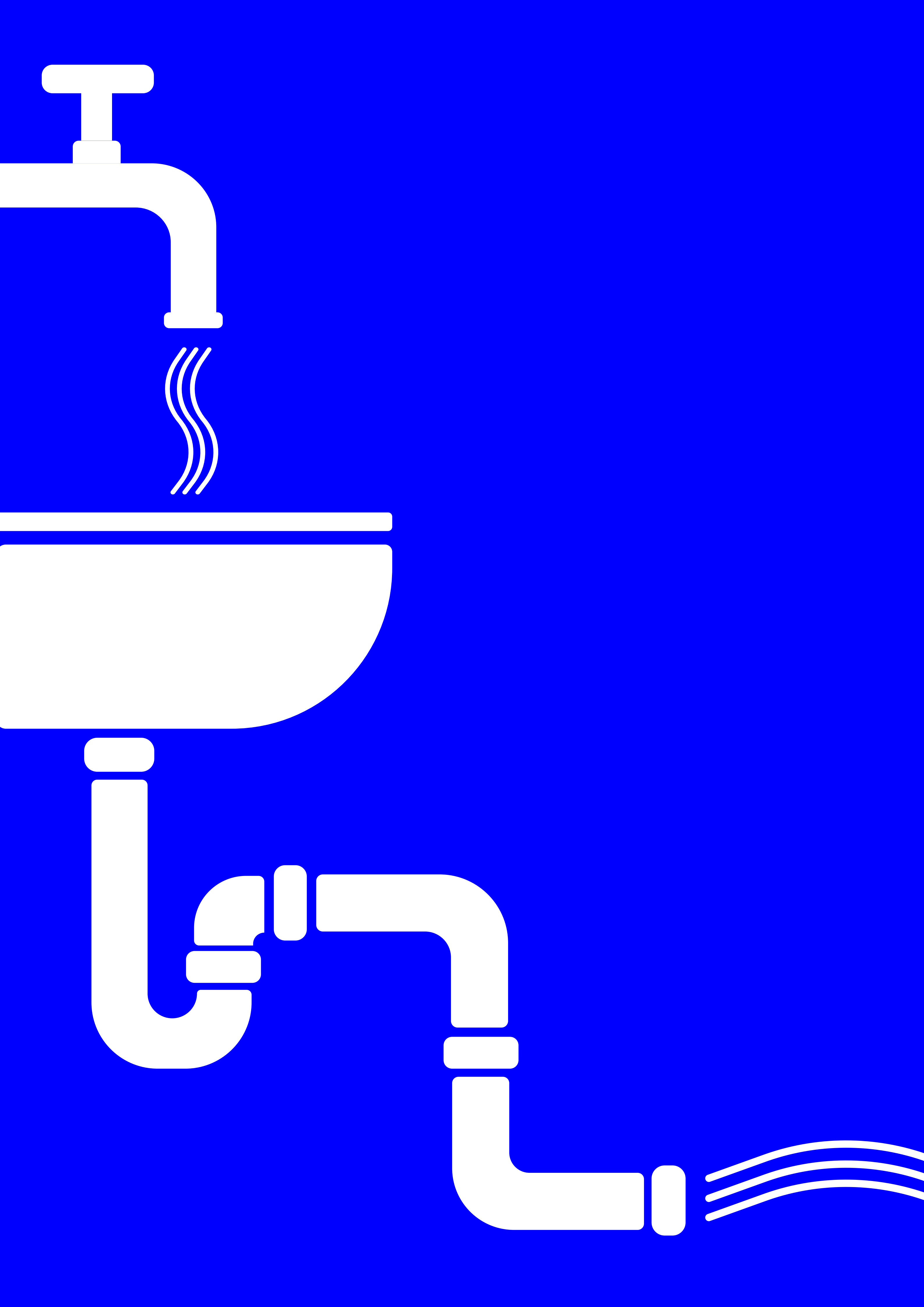


2. BACKGROUND RESEARCH: THE TROUBLESOME HISTORY OF WASTEWATER

This chapter contains the background research and findings that fueled the project's initial intention to raise the public's awareness of the increasing global water scarcity in the Anthropocene. The research started by uncovering the history, current state, and future forecasts concerning freshwater management in the increasingly urbanized world.

2.1 BRIEF HISTORY OF FRESHWATER MANAGEMENT

2.1.1 HISTORY OF WATER TREATMENT

Humans have taken extensive measures throughout the history to find clean drinking water, dating back to prehistoric times (Baker, 1948) when its quality was assessed through taste, smell, and appearance. (Vuorinen, Juuti, Katko, 2007)

The first archeological evidence of water treatment goes back to 4000 BC. At that time, it appears that the main focus was to improve the aesthetic qualities of water. The earliest written documentations of water treatment methods have been found in ancient Sanskrit and Greek writings (around 4000 BC), documenting the attempts to improve water quality by using simple methods such as boiling, heating the water under the sun, and filtering through gravel and sand. More recent archaeological evidence shows drawings of water clarifying apparatus on the walls of Egyptian tombs from 15th to 13th century B.C. (See image 1) (Jadhav, 2014) (freedrinkingwater.com)

Image 1. Purification device by Ancient Egyptians. An image found on the wall of a tomb

2.1.2 BEGINNINGS OF WASTEWATER TREATMENT

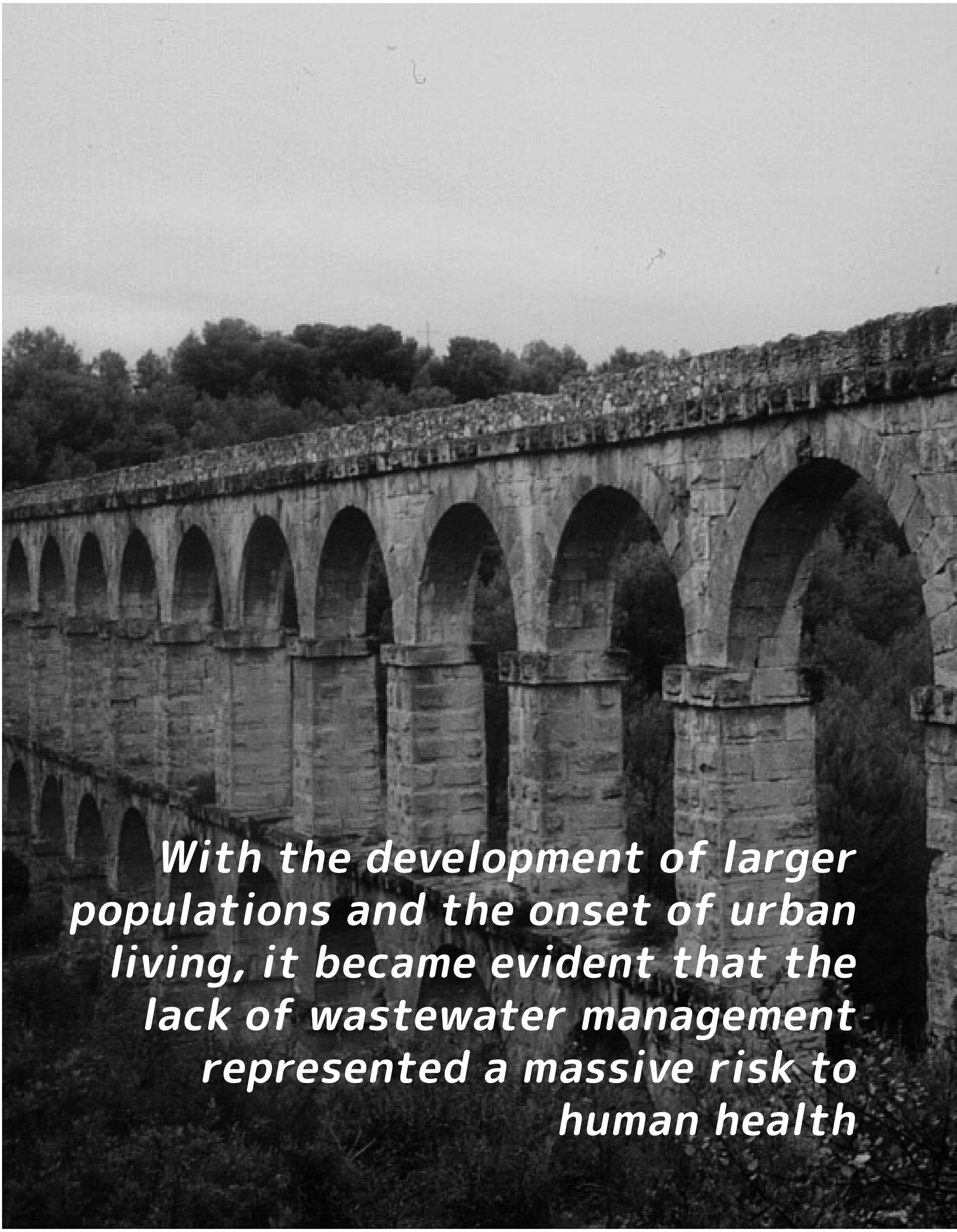
With the development of larger populations and the onset of urban living, it became evident that the lack of wastewater management and sanitation represented a massive risk to human health. This quickly led to the development of wastewater management in the cities.

The Mesopotamian Empire (3500–2500 BC) was the first civilization that started to connect houses to wastewater drainage systems. Around the same time, such a system was also built in the Indus Valley in South Asia, where it became prohibited to discharge wastewater on streets without a basic treatment. (Lofranoa, Brown, 2010)

However, the beginnings of the modern wastewater management systems are usually referred to Ancient Greece and Rome (300 BC to 500 AD). The Greeks started to use water channels to collect public wastewater for irrigation of fields outside the cities. Their system was further advanced by Romans (300 BC) who managed the complete water cycle from collection to disposal through large aqueducts and urban plumbing channels. Romans also practiced basic wastewater treatment before discharging wastewater from baths. (Lofranoa, Brown, 2010)

After the collapse of the Roman empire, their sanitary approach became largely dysfunctional due to its high dependence on effective government and protection by the army. (Cooper, 2001)

This contributed to slowing down the progress of freshwater management in Europe.



With the development of larger populations and the onset of urban living, it became evident that the lack of wastewater management represented a massive risk to human health

2. Roman aqueduct near
Tarragona, Catalonia, Spain.

2.1.3 MODERN CENTRALIZED WASTEWATER MANAGEMENT

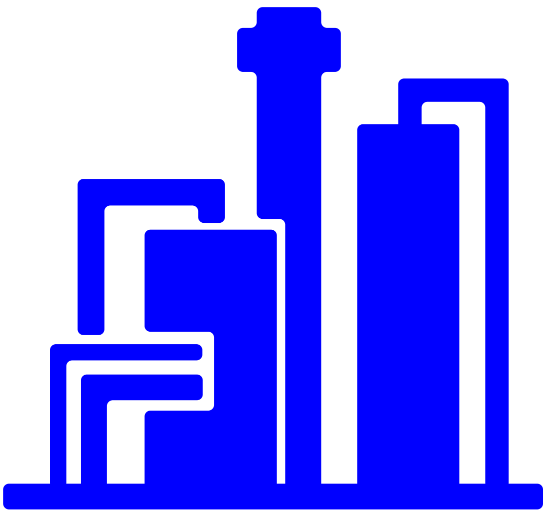
With the growing amounts of produced wastewater in the new industrial cities, the approach of public sewer systems was once again recognized as an urban necessity starting from the 1750s. The main goal was then to minimize the death rates related to waterborne diseases (cholera, typhus) that often occurred due to the lack of sanitation. (Cooper, 2001)

Since the end of the 19th century, centralized wastewater treatment systems became the conventional way to manage domestic wastewater, (Hophmayer-Tokich, 2006) and are now widely applied in well-developed urban environments. (Cooper, 2001)

At present, wastewater in developed countries is mostly collected through centralized systems consisting of large pipeline networks, (sewerage) which transport it at long distances to one or several treatment plants (off-site wastewater management). The treated wastewater (effluent) is usually then discharged into natural water bodies. The treated effluent may also be used for beneficial purposes, and in this case, it is referred to as reclaimed water. (European Environment Agency, 2018) Centralized treatment systems are usually owned and fully maintained by government agencies to collect and treat wastewater for the whole community. (Sharma, Sharma, 2018)

Although centralized wastewater treatment systems are advantageous for many reasons, they also pose concerns due to their negative impact on the environment. For example, large pipeline infrastructures is a threat to the environment, in case of pipeline failures. Damaged pipes are common due to aging pipeline systems and are hard to locate. These centralized systems are also overall energy-intensive and expensive to both construct and operate. (Hendrawan, et al., 2013)

To gain a deeper understanding of these issues, the next section will explore the present water-related crises in urban environments around the world.



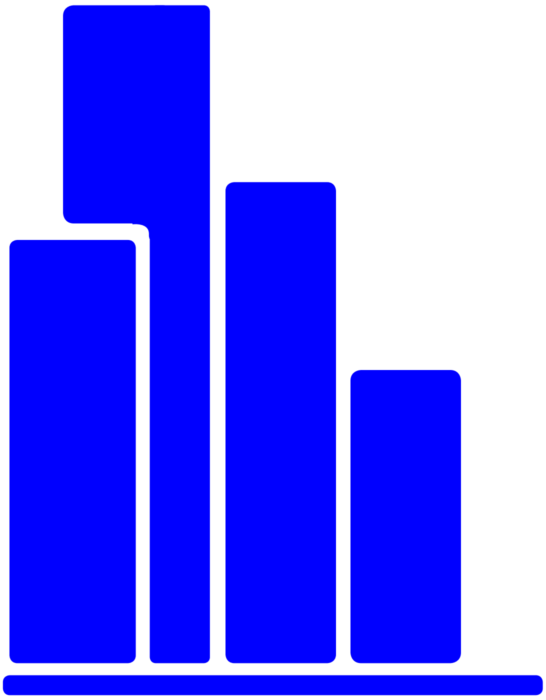
3. Advanced wastewater
treatment plant in USA

2.2 WATER SCARCITY IN URBAN CONTEXT

Despite the long history of freshwater management, and the development of modern conventional centralized wastewater treatment plants, cities around the world are currently encountering more severe freshwater scarcity threats than ever before.

2.2.1 MORE CITIES - LESS WATER

In 2018 the world experienced the most significant water crisis in modern history as Cape Town in South Africa with its 3.8 million population was about to entirely run out of water. Also known as "Day Zero," it was the biggest drought-related municipal water failure in modern history. Cape Town's water crisis was averted by rainfall in the last seconds but has affected the whole city. Cape Town currently keeps a 105-liter water limit per person a day. (City of Cape Town, 2019)



Cape Town is only one of the examples showing the immense threats of water scarcity under the pressures of urbanization and climate change. More than ten global megacities face a similar future, struggling to provide the necessary amount of freshwater to their populations. The major megacities under the most water scarcity threats currently are: São Paulo, Bangalore, Beijing, Cairo, Jakarta, Moscow, Istanbul, Mexico City, London, Tokyo, Miami. (bbc.com, 2018) Also, 21 large Indian cities are projected to entirely run out of groundwater by 2020, only to increase the current amount of 200.000 deaths every year due to the lack of clean drinking water. Another example is China, where in the past 25 years, 28.000 rivers have disappeared across the country. (Parton, 2018)

The significant amounts of natural resources require densely by densely populated areas is one of the major reasons for the current crisis. By 2050 the global demand for water is expected to grow by 55%; with most of this demand in cities. (OECD, 2012) The growing demand for freshwater leads to the world's freshwater sources being drained faster than they can be replenished through natural processes. (Smedley, 2017)

This calls for an increased focus on wastewater recycling and reuse of effluent water.

By 2050 the global demand for water is expected to grow by 55%; with most of this demand in cities

-OECD, 2012

Cityscape of Shanghai, 2018

2.2.2 LACK OF WASTEWATER TREATMENT

The growth in global freshwater demand accordingly leads to an increase in the global production of wastewater. All of the wastewater produced requires adequate collection and treatment. (UN Water, 2015)

Untreated wastewater can be both a massive issue for the environment and a significant health threat to the world's growing population that continue to concentrate in large cities.

According to data by the United Nations, up to 80% of the wastewater generated globally is discharged without any treatment. (WWAP, 2017) It is mostly the cities in the developing countries that lack infrastructure for wastewater treatment. On average in the poorest third world countries, only 8% of water undergoes treatment of any kind. (ibid, p. 2-10) A large number of urban city households in these countries still discharge wastewater directly on the streets.

Lack of sanitation increases the risks of diseases such as malaria, cholera, diarrhea. Leading to almost 80% of diseases in developing countries being waterborne, causing more than 3 million early deaths every year.

It is not only the third world countries that need radical improvements in wastewater management. Also, in the developed countries, 30% of wastewater is still discharged without treatment. It is estimated that 30 million European citizens are not connected to a centralized wastewater treatment system. (European Environment Agency, 2018)

In comparison to the third world, developed countries, including Europe are more likely to have the resources to improve the situation of freshwater management and treatment. This is crucial to address, due to 80% of drinking water in Europe coming from rivers and groundwater - sources that are extremely vulnerable to threats posed by over-exploitation, pollution, and climate change. (European Environment Agency, 2018)

With the freshwater resources being at increased risk, it is important to investigate the individual patterns of freshwater use in urban households.

2.2.3 INCREASED FRESHWATER CONSUMPTION

The global demand for freshwater for households is increasing both due to the population growth and the high freshwater consumption per capita.

In Europe, the freshwater consumption greatly varies from country to country. The average freshwater consumption is 144 liters per person per day. (European Environment Agency, 2018) While the lowest consumption is in Slovakia (60 liters per inhabitant per day) (EurEau, 2017), and one of the highest is in Norway, with the Norwegian citizens taping 179 liters every day. (Statistics Norway, 2018) This greatly exceeds the minimum consumption required to meet basic human needs (50 liters per person per day). (Brown and Matlock, 2011)

The freshwater consumption in the individual households could be greatly reduced by increasing water-use efficiency such as implementing more efficient approaches of wastewater management and treatment. According to calculations by Woo, if an average city recycled all its wastewater, it could reduce the freshwater requirement by 60%. (Woo, 2016)

The increasing global freshwater consumption, not only requires more freshwater to satisfy the demand but it also leads to a higher energy use by the freshwater sector.

2.2.4 ENERGY CONSUMPTION

Depletion of the global freshwater resources is not the only issue concerning the current trends of freshwater use. Large amounts of energy are daily wasted on the lack of water-use efficiency. The energy consumption by the whole water sector is estimated to be 4% of global consumption, mostly in the form of electricity. This equals to all the energy used by Australia in a year. (International Energy Agency, 2016) Approximately half of this (2% of the world's total energy consumption) is used directly for collecting and treating wastewater. (State of Green, 2016)

The mapped patterns and future forecasts point to the global freshwater resources being at immense risk. This requires global attention and collective action.

2.2.5 GLOBAL FOCUS ON FRESHWATER SECURITY

Due to the increased global threats, freshwater security in recent years has become an important focus area for many projects and organizations on an international level. For example, Sustainable United Nations Development Strategies Group has set the "Availability and sustainable management of water and sanitation for all" as one of the Sustainable Development Goals (SDGs). (UN, 2018) Freshwater management and its use are also marked as one of the Planetary Boundaries not to be overstepped in order to ensure a livable environment on Earth. (Rockström, et al., 2009) According to the UN, the provision of drinking water, treatment, reuse of wastewater, and water-use efficiency are the main areas of focus and necessary improvement. (UN, 2018 p. 10)

Large scale sustainability-focused organizations are starting to recognize the global threats of water scarcity. The next important step is to raise public awareness.

2.2.6 LACK OF PUBLIC'S AWARENESS

The research has uncovered many issues concerning the current approaches and trends of managing and using global freshwater resources both on a national and individual level.

The high individual household freshwater consumption and the dependence on government-run large scale centralized freshwater management systems point to the lack of the public's awareness towards the increasing global water scarcity.

The freshwater scarcity has direct threats to individual wellbeing and health. Therefore, society must be part of the discussion and assessment of the current conventional ways of freshwater and wastewater management.

2.2.7 FROM CENTRALIZED TO DECENTRALIZED SYSTEMS

As shown earlier, centralized wastewater treatment systems have become the conventional way to treat wastewater around the world. The study has also pointed to the massive environmental impact of centralized wastewater treatment approach. This requires an investigation of alternative ways of treating wastewater.

RECONSIDERING DECENTRALIZED SYSTEMS

In recent years, the advances in wastewater treatment technologies, in combination with the global water scarcity threats and the global interest in water reuse, have increased the interest in decentralized wastewater treatment systems. Decentralized wastewater treatment (on-site management) refers to the process of the wastewater being collected, treated, and disposed or reused close to its source. (Hophmayer-Tokich, 2006)

ADVANTAGES

According to the research, there are several advantages associated with the implementation of decentralized wastewater treatment systems in comparison to centralized systems:

1) Lower costs in the long term (eliminates large expensive collection infrastructure);
2) Less environmental damage in case of a system failure;
3) Increased reuse opportunities;
4) Reclaimed water is cheaper (costs of wastewater and reclaimed water transportation are eliminated);
5) No minimum water consumption required to run the system; (Morel and Koottatep, 2003)
6) It is a modular system, therefore the technological advancements can be implemented gradually; (Hophmayer-Tokich, 2006)
7) It is more climate-resilient; (Bernal, Restrepo, 2012)
8) Requires fewer resources and therefore is more sustainable;
9) Can facilitate recovery of various by-products;
10) Can be implemented accordingly to the population growth; (ibid)

DISADVANTAGES

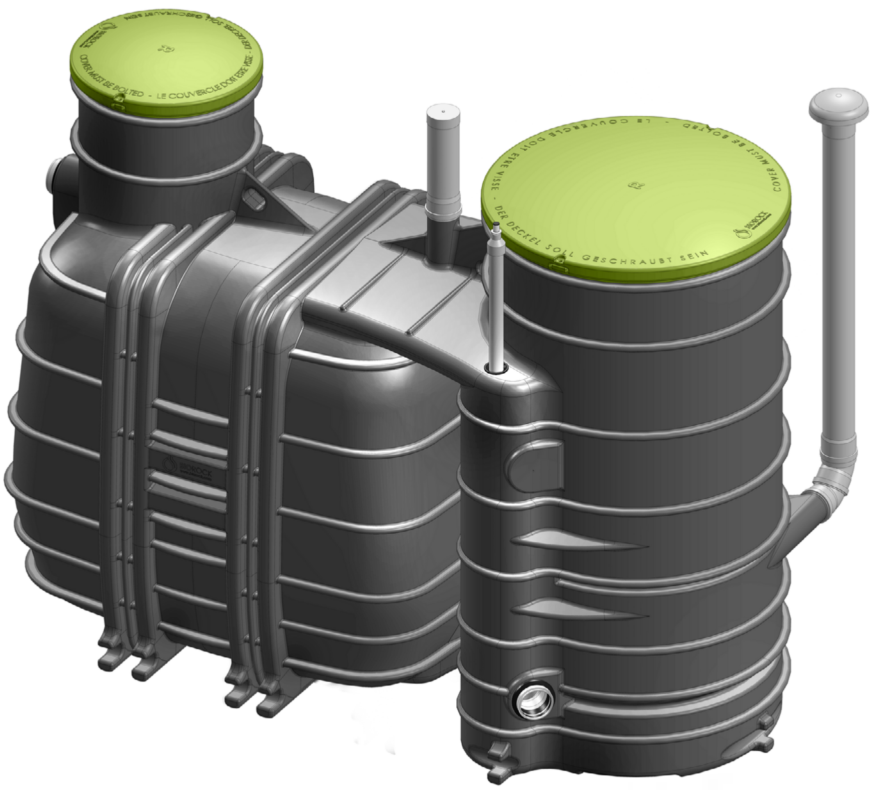
However, the findings also show that building, operating, and maintaining many small on-site systems might be more expensive than one central system.

Research also shows that to make decentralized systems more viable the greywater should be separated from blackwater. This can be done by collecting fecal waste through a process that does not require water. This could reduce household consumption of water by 20%. (Nelson, 2005) To consider decentralized systems a beneficial solution, such on-site systems need to be highly efficient, provide advanced wastewater treatment, as well they should be easy to operate by users and low in costs. (Wilderer, Schreff, 2000)

PRODUCTS IN THE MARKET

There are several small scale wastewater utilities available in the market that offer on-site wastewater management, treating the household wastewater to a quality that is safe to discharge in the environment.

These often modular systems are typically referred to as “packaged sewage treatment plants,” and allow to increase the quality of treated water by upgrading the system gradually. This treatment follows the same principle used in large sewage treatment facilities only on a smaller scale. Smallest systems offer to recycle water for a household of 1-3 people. These systems vary in size, smallest available in size of aproximetly 2 cubic meters. (biorock.co.za)



4. Household wastewater treatment plant by Biorock company

2.3 WASTEWATER - AN UNTAPPED RESOURCE

Until the 1970s all the wastewater collected through municipalities was discharged back into the environment after undergoing a basic treatment. Since then wastewater reuse gradually became a more common practice, often forwarding the recycled wastewater for non-potable use (agriculture or industry). (Chapman, 2005)

SOURCE OF FRESHWATER

The reuse of recycled water is becoming increasingly important due to the massive growth of the global freshwater consumption and the increased threats of water scarcity. Most importantly, reuse of wastewater can provide an alternative and sustainable source of freshwater, minimizing the risk of water crises and increasing water efficiency on a global level.

The advancements in treatment technologies now allow to treat the wastewater to a standard of safe and clean drinking water. Moreover, drinkable water is not the only by-product that can be extracted. Other recoverable by-products include energy and organic as well as inorganic materials. New technological and scientific discoveries are making resource recovery from wastewater not only feasible, but also environmentally sustainable on a scale that has yet to be fully explored. This makes the wastewater one of the most underestimated resources we have. One example is the possible harvesting of free energy from wastewater.

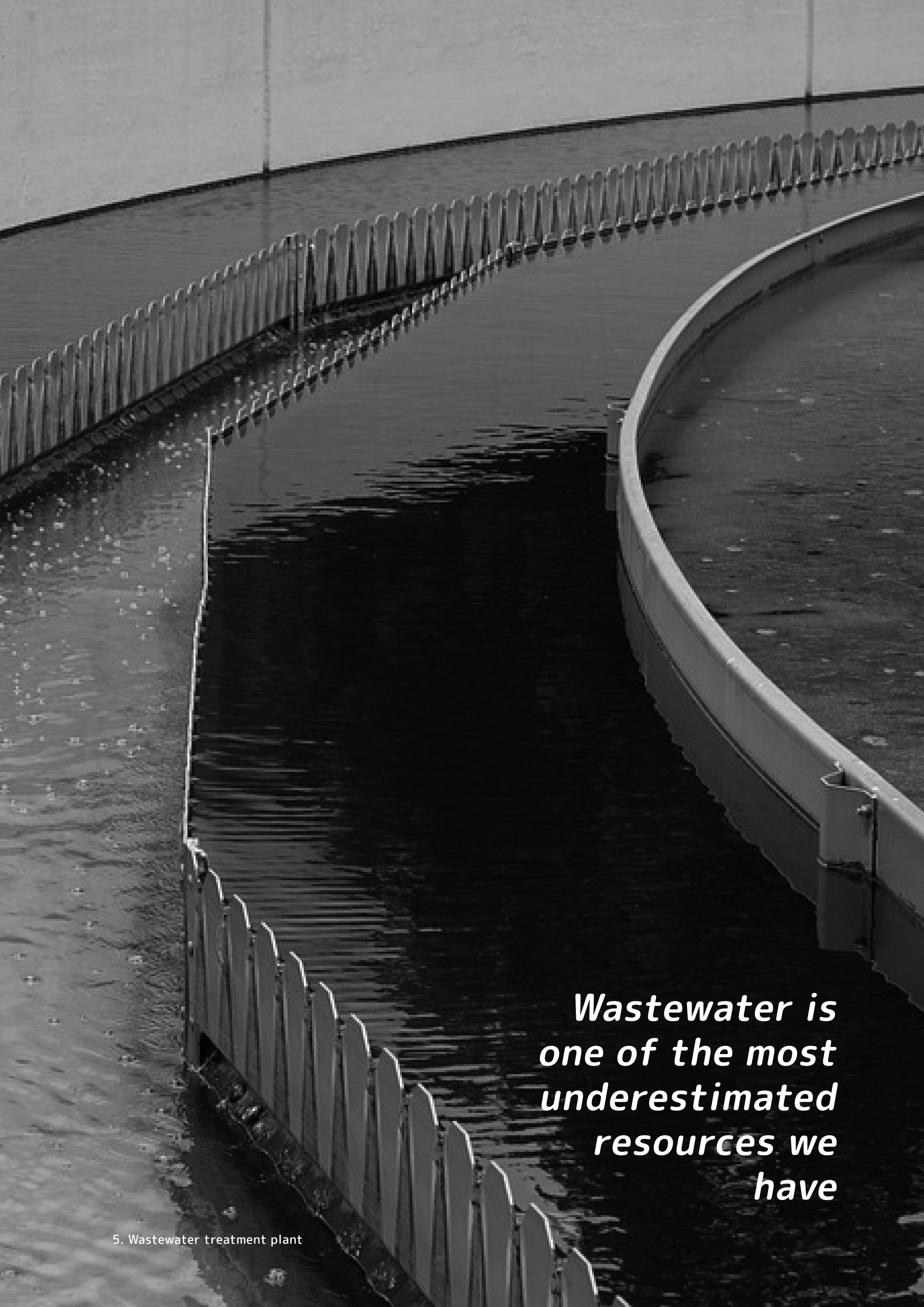
SOURCE OF FREE ENERGY

Wastewater from shower drains, dishwasher and laundry water, especially the warm and hot wastewater, is currently a lost source of free energy. The energy consumption and carbon emissions involved in freshwater management could be decreased, for example, by extracting the thermal energy inherent in wastewater while it is close to its source. (Oesterholt, Hofman, 2014) The heat loss through a sewer is estimated to be 40% of the total heat loss of a modern house. (ibid) It is estimated that Americans flush 350 billion kilowatt-hours of energy into the sewers each year. (FEMP, 2005) That is enough to power 30 million homes.

SOURCING ORGANIC AND INORGANIC MATERIALS

Both greywater (from taps, shower, household appliances) and blackwater (from the toilet) contains various organic and inorganic materials that can be recovered and reused. For example, nutrients (e.g., nitrogen, potassium, phosphorus), rare metals, and oils. 20% of the world's manufactured nitrogen and non-renewable phosphorus is contained in domestic wastewater. (Puyol, et al., 2017) Household wastewater is also a suitable medium for growing microalgae - a natural water filter that can remove wastewater nutrients. The microalgal biomass can be further turned into fertilizer or energy. (Wurrocheke, et al., 2016)

As shown earlier, decentralized wastewater recycling technologies is an advantageous approach to facilitate the recovery of clean water and other by-products. With the increasing need for water reuse and water-use efficiency, closed loop systems are a beneficial approach.



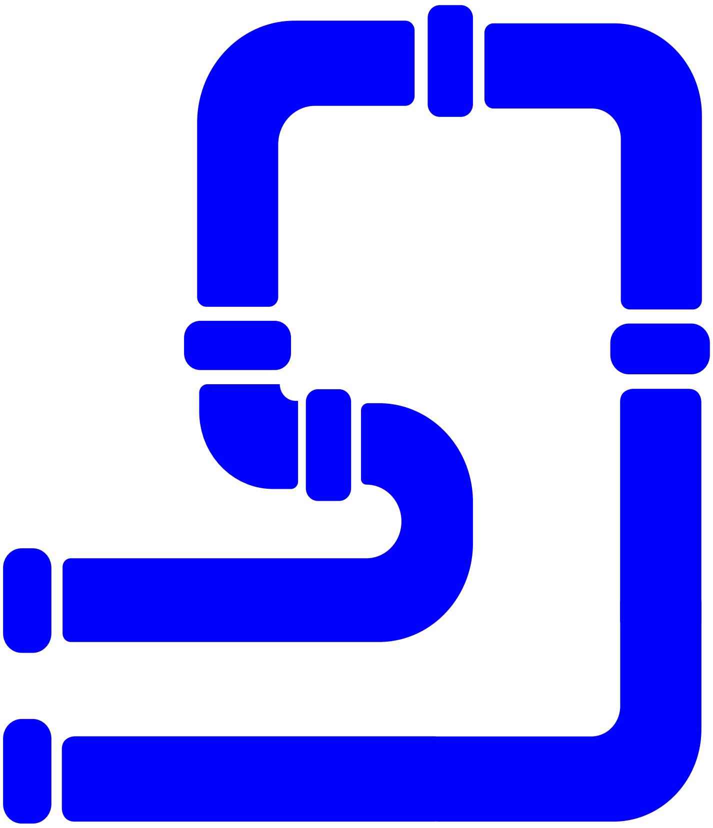
5. Wastewater treatment plant

2.4 TOILET-TO-TAP WASTEWATER RECYCLING

"The truth is that all water is being recycled over and over—no water on earth is truly pristine"
- Ghernaout, 2017

Climate change, pollution, and the increasing global demand for freshwater are overwhelming nature's ability to continuously provide the global population with necessary clean and safe drinking water.

Therefore, wastewater recycling for potable use (drinkable use) is significantly growing in importance. Such an approach for direct use after treatment, with no recharge through natural aquifers, is often referred to as "toilet-to-tap" water recycling.



The toilet-to-tap water recycling is similar to the conventional wastewater treatment approach, however, to reach the water quality for drinking, additional steps after the primary, secondary, and tertiary treatment are required.

These usually include: 1) microfiltration, to remove some of the viruses and bacteria, 2) Reverse Osmosis, using filters through which only water molecules can pass through, 3) and disinfection by ultraviolet (UV) light, that breaks down any organic substances to make the water perfectly safe for drinking. (Borgenproject.org, 2017)

Toilet-to-tap wastewater recycling might be an obvious answer to true sustainable freshwater management, however, very few projects have implemented this promising approach.

2.4.1 TOILET-TO-TAP PROJECTS

GOVERNMENTAL PROJECTS

The world's first centralized toilet-to-tap water recycling system for direct potable use was implemented in Windhoek, in Africa already in 1969. Today, the Goreangab wastewater plant provides 35% of cities 300.000 residents with 41000 liters of clean and safe drinking water every day. (Ghernaout, 2017)

Another success story is the city of Singapore, which began the initiative NEWater in 1998. Currently, Singapore has three treatment facilities that provide 80 million liters of clean drinking water recycled from secondary sewage. (Covey, 2017)

Another example is the Los Angeles city that revised its "Toilet to Tap" project after it was both initiated and abandoned in 1990. (Grenoble, 2009)

COMMERCIAL PROJECTS

There are also a few commercial projects and companies that are currently investing in research to bring the closed-loop water recycling for potable use into individual households.

In 2018, The Ohio based Tangent Company announced its project "Watercycle" - an on-site system for small buildings with a capacity of 1892 liters. They have been running a similar system in private housing since 2014. (cleveland.com, 2018)

Canadian based company "Newterra" has also has announced an initiative to create a system for households with a capacity of maximum 2271 liters per day. (newterra.com, 2018)

With many new toilet-to-tap initiatives on the way, it is relevant to explore not only their economical and technological feasibility but also include the socio-cultural perception of reusing wastewater.

6. Wingoc employee inspecting effluent at the New Goreangab Water Reclamation Plant

7. People tasting water purified by Newterra demo system

2.5 WASTEWATER: AN IDEA HARD TO SWALLOW

"In all the ages of water, wastewater has been considered filthy."

- Lofranoa, Brown, 2009

This study has highlighted the closed-loop, toilet-to-tap wastewater recycling as a potentially viable alternative that is both more efficient and sustainable compared to conventional wastewater treatment plants.

However, the research points out that the small number of implemented toilet-to-tap systems around the world appears to be due to more psychological than practical reasons.

The study by Po, shows that the idea of reusing recycled wastewater, especially for direct potable use, is "hard to swallow." Therefore such proposals often encounter strong community opposition. (Po, et al., 2003) Several projects across the world have been stopped due to public opposition. For example, in Redwood City, California, a proposed water reclamation project was closed down because of occurring protests by a group of citizens in 2002. (Ingram, et al., 2006) Research shows that the public's perception of wastewater reuse has been recognized as the main aspect towards the success in any water reuse projects. (Po, et al., 2003)

DISGUST FACTOR

According to research by CSIRO, the "disgust factor" or the psychological barrier is often the most crucial element against the reuse of water. Recycled water is often associated with raw sewage, therefore perceived as filthy and unsafe to drink.

WASTEWATER SOURCE MATTERS

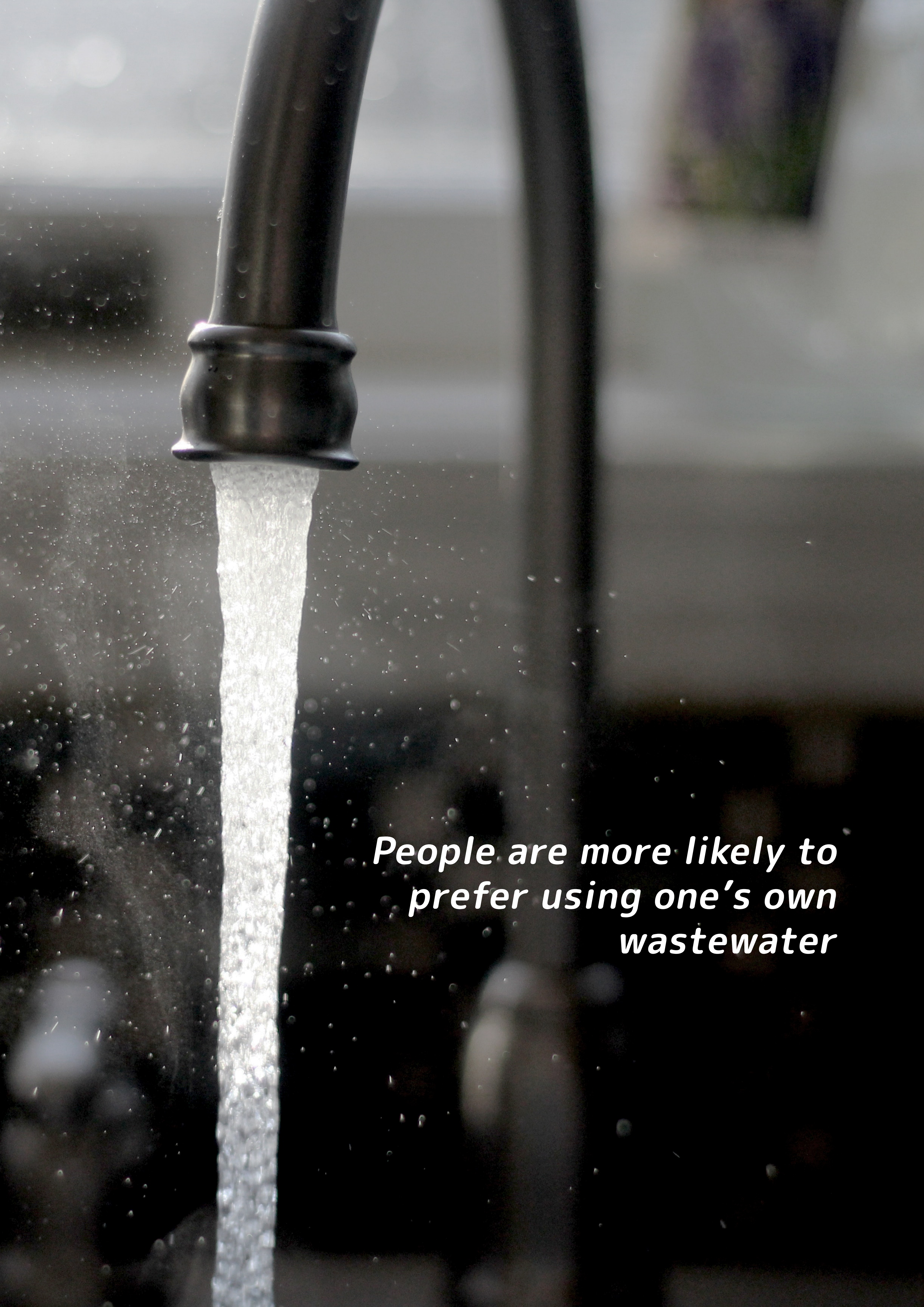
The water source is also a critical element in the public's acceptance. For example, people are more likely to prefer using one's own wastewater, then wastewater derived from other public sources.

NEED FOR ENVIRONMENTAL AWARENESS

People already living in water-scarce areas have a higher acceptance of wastewater reuse. However, a sense of responsibility for the environment and sense of partaking in solving these issues can be a decisive factor as well.

BENEFITS & OTHER ASPECTS

The general public perceives the recycled water as of lower quality; therefore, it is expected to be cheaper. Other important factors are i) awareness of potential benefits; ii) trust level in the authorities; iii) understanding of the technology; iv) socio-demographic groups (people over age 50, are more likely to oppose these alternative systems); v) the perceived sense of control over the quality of the received recycled water. (ibid)



People are more likely to prefer using one’s own wastewater

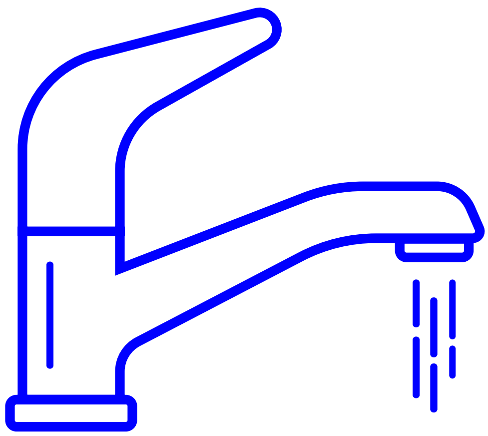
2.6 SUMMARY

Despite the long history of wastewater and freshwater management, the cities around the world face more significant water scarcity threats than ever before. Due to the rapid global population and economic growth, in combination with climate change and pollution, we are overwhelming nature's ability to fulfil the increasing demands for freshwater.

The research has uncovered several disadvantages and environmental threats connected to currently conventional centralized wastewater treatment systems, pointing to a need for a radical change in the complete cycle of freshwater management.

In order to radically improve the global freshwater security, the water-use efficiency must be increased, the amounts of untreated wastewater eliminated, and the water reuse and resource recovery from the wastewater must be set as a standard procedure of wastewater recycling.

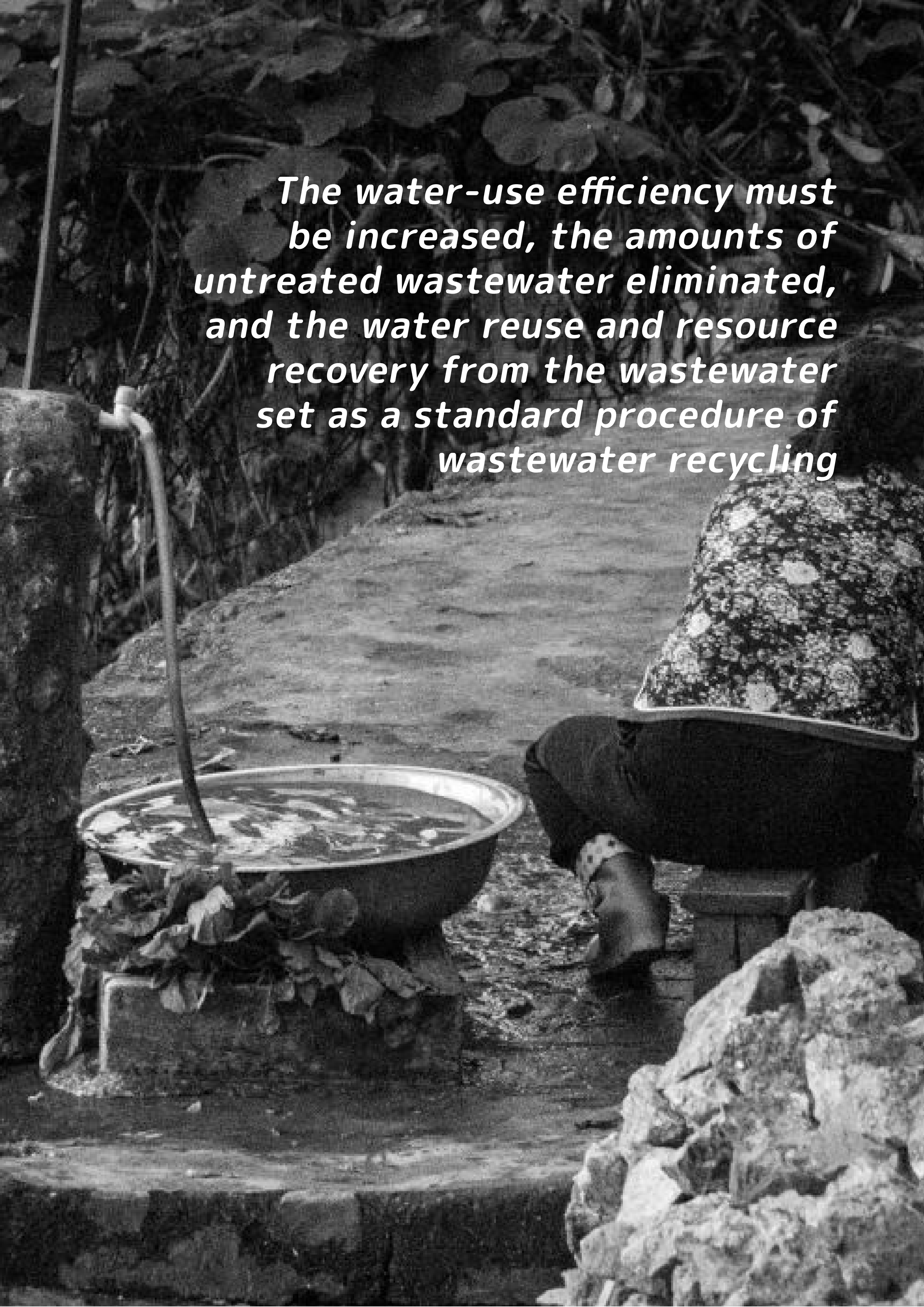
This study has discovered the potential benefits of decentralized, on-site water recycling systems. Toilet-to-tap wastewater treatment for direct potable use shows great potential to eliminate the main issues connected to conventional wastewater treatment plants while directly involving the general public in the freshwater management process. Toilet-to-tap systems are still rare both on governmental and individual household level. Historically this has been primarily due to the public's opposition towards reusing wastewater.



The research insights also point to the lack of the public's awareness and involvement in resolving the issues connected to increasing global water scarcity. The high average freshwater use per capita in European households is one of such indicators. The complete control over the whole freshwater cycle by governmental agencies, might be one of the reasons why the general public has little knowledge of the situation.

The public's awareness is an important link to increase the individual involvement and the political pressure to solve this problem on a global scale. These immense issues can only be resolved by large scale political, societal, and ideological change.

To achieve this, the project will apply a design methodology that can raise awareness and evoke critical reflection towards this global issue. The following chapter will provide an overview of the chosen methodological approach.



The water-use efficiency must be increased, the amounts of untreated wastewater eliminated, and the water reuse and resource recovery from the wastewater set as a standard procedure of wastewater recycling

3.METHODOLOGY

This chapter explores the potential of speculative designs to raise awareness and evoke critical reflection towards globally complex and important issues. Action-based research will also be explored as a relevant tool to gain insights from the public as well as test ideas and concepts in practice.

3.1 SPECULATIVE DESIGN

Typically, the design's task is to solve small issues by implementing functioning practical solutions. However, in the Anthropocene, the contemporary eco-political and social issues are increasingly growing in complexity, interconnectedness and are often hard to grasp due to their large scale. The current times of crises, require to think and act future-focused while staying critical of our present time issues. Therefore this section of the report explores speculative design as a useful design methodology that can provide designers with the necessary tools to evoke radical change.

WHAT IS SPECULATIVE DESIGN

Ivica Mitrović defines speculative design as a "Critical Design practice that comprises or is in relation to a series of similar practices known under the following names: Critical design, design fiction, future design, anti-design, radical design, interrogative design, discursive design, a design, adversarial design, futurescape, design art, etc." (Mitrović, 2015)

Anthony Dunne and Fiona Raby, who coined the term "Critical Design", further specifies the characteristics of speculative design methodology in their book "Speculative Everything" as follows: speculative design "thrives on imagination and aims to open up new perspectives on what are sometimes called wicked problems, to create spaces for discussion and debate about alternative ways of being, and to inspire and encourage people's imaginations to flow freely. Design speculations can act as a catalyst for collectively redefining our relationship to reality." (Dunne and Raby, 2013, p. 2)

SPECULATIVE DESIGN AND ALTERNATIVE FUTURES

According to Dunne and Raby speculative designs often speculate on how things could be. This design approach often evokes critical discussion and reflection on current ways of living, societal processes, values, and ideologies, while allowing us to imagine both desirable and undesirable futures. Therefore this design branch can be seen as a useful method to spark discussions and pose questions about topics that in times of crises urgently need public attention. (ibid, p. 43) In order for these designs to evoke the intended discussion, they often start with a "what if" question. These designs are also often by necessity provocative and intentionally simplified. (ibid, p. 3)

CHALLENGES WITH SPECULATIVE DESIGN

While the speculative design has many values when it comes to approaching global and complex issues that often do not have straightforward, practical solutions, there are also drawbacks to consider when working with this design methodology.

Speculative designs can be dismissed as art, because they are often fictional, and can seem too unrealistic. (ibid p. 88) Therefore, the speculative design is often criticized by the design community and the commercial sector. (Tran, 2019) Taking this into consideration, Dunne and Ruby continue by stating that the power of critical design depends on its balance between challenging issues that are not already well known while designing in a way that connects these topics close to everyday life.

Based on the discovered strength of speculative designs when closely relating to everyday life, and the potential weakness of it being dismissed as art, the next section will explore how can action-based research potentially strengthen the experience of speculative designs.

3.2 ACTION BASED RESEARCH

This section explores action based research as an experimental approach and a useful tool to test ideas and concepts, while collecting insights from the target audience.

The term 'action research' was introduced by psychologist Kurt Lewin to design social experiments in the 1940s. (Kemmis, McTaggart, 2007) To define this research approach, Kemmis developed a simple model to describe the typical action research process, in which there is at least one cycle consisting of four steps: plan, act, observe and reflect. (Fridered, 1992)

This method is often used to collect qualitative data and gain insights from individuals in their natural environments.

To achieve this the researcher sometimes becomes fully immersed in the experiment setting. For example, using role-playing and false identities to hide the intention of the research. (Ibid, 2008). Therefore, it is important to acknowledge that action based research can involve a certain level of deception to gain the desired research results.

3.3 SUMMARY

This chapter explored relevant methodological approaches that have the potential to evoke critical discussions and raise awareness about global issues on a personal level.

The study uncovered that speculative designs are often intentionally simplified and provocative to communicate the main intended message. Therefore, this approach is relevant to reach the main goal of this project - raise the public's awareness and involvement in the increasing water scarcity around the world. Speculative design methodology also provides a framework to show alternative futures that could be achieved by implementing radical solutions.

Based on this, speculative industrial design has been defined as the primary design approach in this project. In order to test the developed ideas and design concepts, the project will use action based research method to bring speculative design concepts closer to everyday life through staged public experiences.

TM

4 YW™ YOUR WATER

4.1 CONCEPT DEVELOPMENT

Cities around the world face more significant water scarcity threats than ever before. These immense issues can only be resolved by large scale political, societal, and ideological change. However, right now, the global water scarcity crisis lacks both public awareness and involvement, especially in developed countries, where water scarcity is not yet visible.

Most of the wastewater in developed countries is recycled through centralized wastewater treatment plants. This globally conventional approach, however, poses an immense negative impact on the environment. It also makes the freshwater-management related issues invisible to the general public living in modern urban households. The general public receives clean drinking water in the household and after flushes the used water down the drain, without any awareness of its management.

The research has uncovered the potential benefits of toilet-to-tap wastewater recycling, which would allow to increase the water-use efficiency, decrease the amounts of untreated wastewater, and implement water reuse and advanced resource recovery from wastewater. This opens up a wide range of possibilities for developing urban wastewater treatment solutions through industrial designs.

The radical idea of decentralized closed-loop wastewater treatment as a solution to problems posed by currently conventional centralized wastewater treatment plants has led to the development of the YW™ - Your Water concept.

YW™ - Your Water is a speculative industrial design object that aims to raise the public's awareness of the increasing global water scarcity in the urban environments around the world.

The research has provided a basic understanding of the complex wastewater treatment process and the interconnectedness of the practical, technical, environmental, political and socio-cultural aspects that are part of both the problem and the potential solutions. The chosen methodology of speculative design allows to simplify this complex issue and the technology behind the potential solution. Therefore, the project focuses on presenting a provocative and radical design that can evoke reflection on current ways of wastewater management while exploring alternative future scenarios of wastewater treatment.

The project proposes a radical solution - to implement the full process of wastewater treatment within the house, and recover clean drinking water directly at its source.

4.2 THE YW™ SYSTEM

YW™ - Your Water is a modular household-size wastewater treatment system that recycles wastewater at home. YW™ turns black and grey water into clean drinking water. It also extracts valuable secondary by-products such as energy and nutrients that would be otherwise lost. Save energy by powering YW™ with the additional thermal energy produced from recycled wastewater.

There are several benefits that the implementation of such industrially produced household appliances could have both on a personal and global scale.

Firstly, it is an environmentally friendly and sustainable solution. Such a household appliance would increase water-use efficiency and water reuse. The elimination of centralized wastewater systems would decrease the environmental impact, such as pollution in case of water-pipe failure, energy use needed to run the treatment plants as well as the resulting carbon footprint - a common issue of conventional wastewater treatment plants.

This would also allow for the wastewater treatment being implemented gradually in growing cities, making people independent from the centralized system, and giving more stable water-security in case of extreme scenarios.

If wastewater treatment and water reuse became an everyday process of every urban household, it would raise the public's awareness and understanding of the importance of sustainable freshwater cycle.

THE MARKET FOR YW™

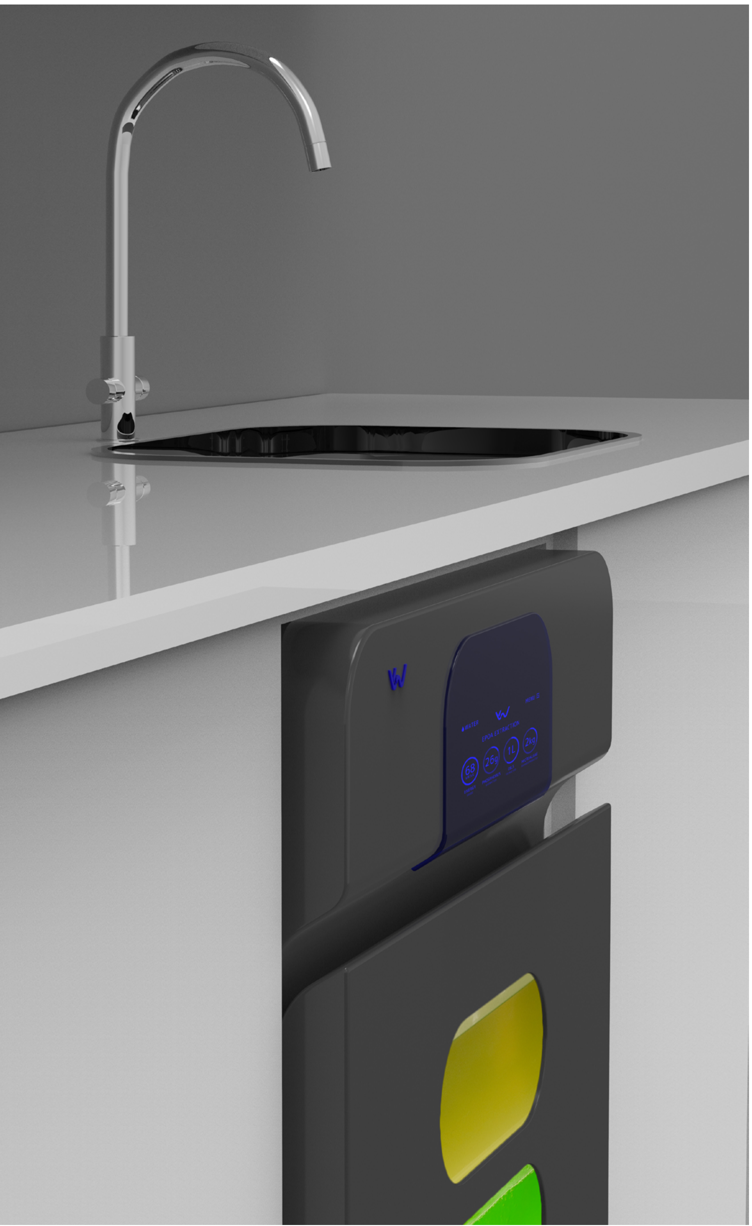
YW™ has a global market, as the freshwater scarcity is one of the most severe global crisis to continue to affect the world.

With 80% of the world's wastewater currently discharged in the environment without any treatment, and the freshwater related issues projected only to increase, the world will be looking for radical ways to resolve these issues. Even Europe still has 3 million citizens that are currently not connected to a centralized wastewater system.

4.3 FINAL CONCEPT

YW™ - Your Water is a modular household size wastewater treatment system - it recycles wastewater at home. YW™ turns black and grey water into clean drinking water. It also extracts valuable secondary by-products such as energy and nutrients that would be otherwise lost. Save energy by powering YW™ with the additional thermal energy produced from recycled wastewater.

With YW™ you will recycle up to 90% of household wastewater, including the wastewater from your washing machine, dishwasher, shower, tap and toilet - all through one in-house equipment.



With YW™ no wastewater leaves your house, eliminating the environmental risks of secondary pollution and reducing the carbon footprint that is common in currently conventional wastewater treatment plants.

YW™ is the essential water management tool in the age of the Anthropocene, ensuring maximum water efficiency and reuse that is a crucial element towards sustainability in growing urban environments from developed to third world countries.

YW™ is a modular household appliance, allowing our customers to choose the right size and functionality matching the particular household type and daily water usage by its residents.

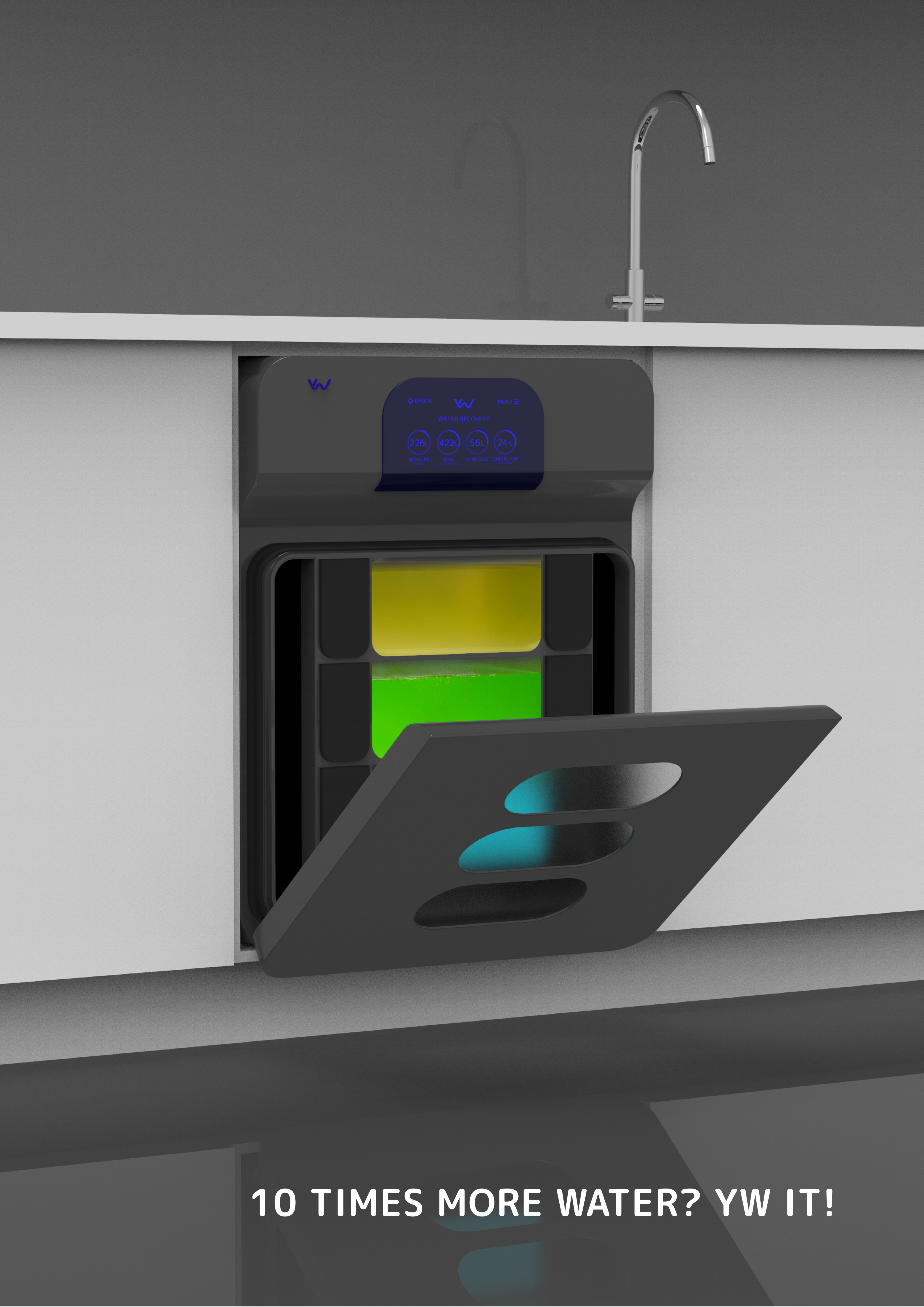
YW™ is the new generation technology making the toilet-to-tap water cycle the new standard towards clean environment and sustainable use of natural resources. With

YW™ makes water recycling real and raises awareness of wastewater as a valuable resource.

On average the water consumption in Europe is 144 liters per person per household everyday. With a population of 700 million that equals 100.8 million cubic liters. YW™ will reduce it by 90 percent.

YW™ saves lives. Millions of lives. Almost 80% of diseases in developing countries are connected to water causing more than 3 million early deaths. Every 17 seconds there is a child dying from diarrhoea.

YW™ will nearly eradicate all the transmission of diseases through water consumption.


EPOPA
MENU
WATER RECOVERY
226L
RECYCLED
TODAY
422L
TOTAL
IN THE SYSTEM
56L
TO RECYCLE
24°C
TEMPERATURE
ON AVARAGE
10 TIMES MORE WATER? YW IT!

4.4 YW™ PRIMARY FUNCTIONS

4.4.1 RECOVERING WATER

The primary function of YW™ is to recover clean and safe drinking water from grey and black household wastewater. Research has shown that this can be done through a closed-loop toilet-to-tap wastewater recycling process. Firstly, wastewater is treated to a quality that would usually be discharged back to the environment after undergoing the process through a conventional wastewater treatment plant. The main steps of this treatment process are:

Preliminary treatment;
Primary treatment;
Secondary;
Tertiary treatment;

After, the water enters a three step process to treat the water to a quality of drinking standards:

Microfiltration;
Reverse osmosis;
UV light sterilization;

4.4.2 EXTRACTING BY-PRODUCTS

The background research has shown the potential to recover various by-products from wastewater. The approach of speculative design allows to show the potential of many technological solutions all in one design. Based on the findings, project will also showcase some of the less known extractable by-products, besides clean water: electricity, phosphorus, oils, and microalgae biomass. Similar to the decentralized wastewater treatment systems available in the market, YW™, through its modular system **“E-P-O-A”** offers to choose between the different add-on units:

E-Module extracts thermal energy from warm and hot wastewater.
P-Module allows to recover the valuable and non-renewable phosphorus.
O-Module extracts oils that can be used for saponification.
A-Module is a micro-algae bioreactor, producing valuable biomass.

4.4.3 PRODUCT VARIATIONS

The YW™ concept was developed as a modular wastewater treatment utility, applicable to various-sized households and customer needs. For the purpose of thought experiment, the following are three different available product sizes.

YW™ MINI

FOR SINGLE PERSON HOUSEHOLDS

Dimensions (mm): 400 x 300 x 300
Household size: 1 resident
Maximum wastewater capacity per day: 200 liters per day
Empty unit weight: 50kg

YW™ MEDI

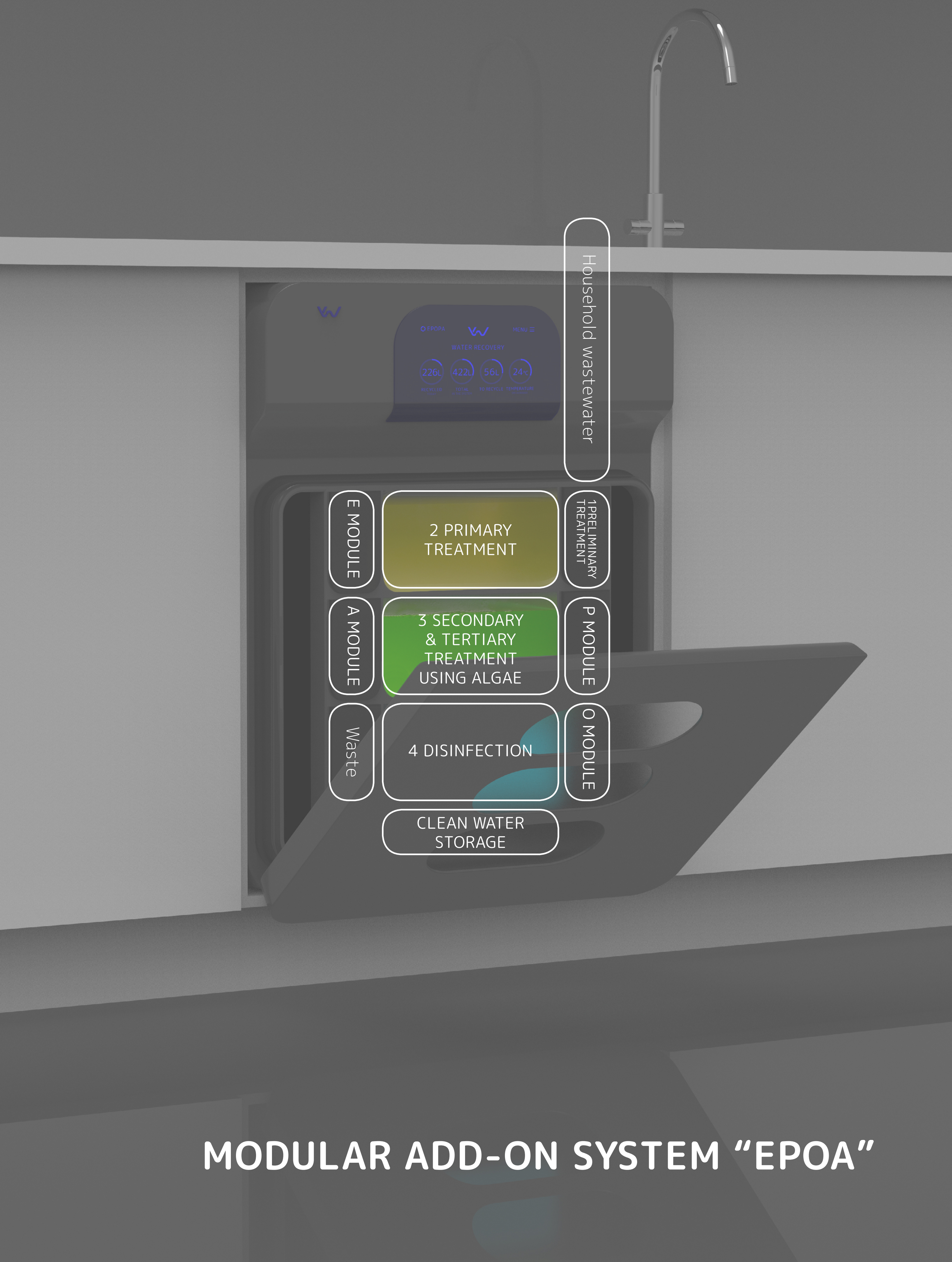
FOR SMALL HOUSEHOLDS

Dimensions: 600 x 550 x 850
Household size: 1-3 residents
Maximum wastewater capacity per day: 600 liters per day
Empty unit weight: 90kg

YW™ FAM

FOR FAMILY HOUSEHOLDS

Dimensions: 1000 x 550 x 850
Household size: up to 5 residents
Maximum wastewater capacity per day: 1000 liters per day
Empty unit weight: 120kg



MODULAR ADD-ON SYSTEM “EPOA”

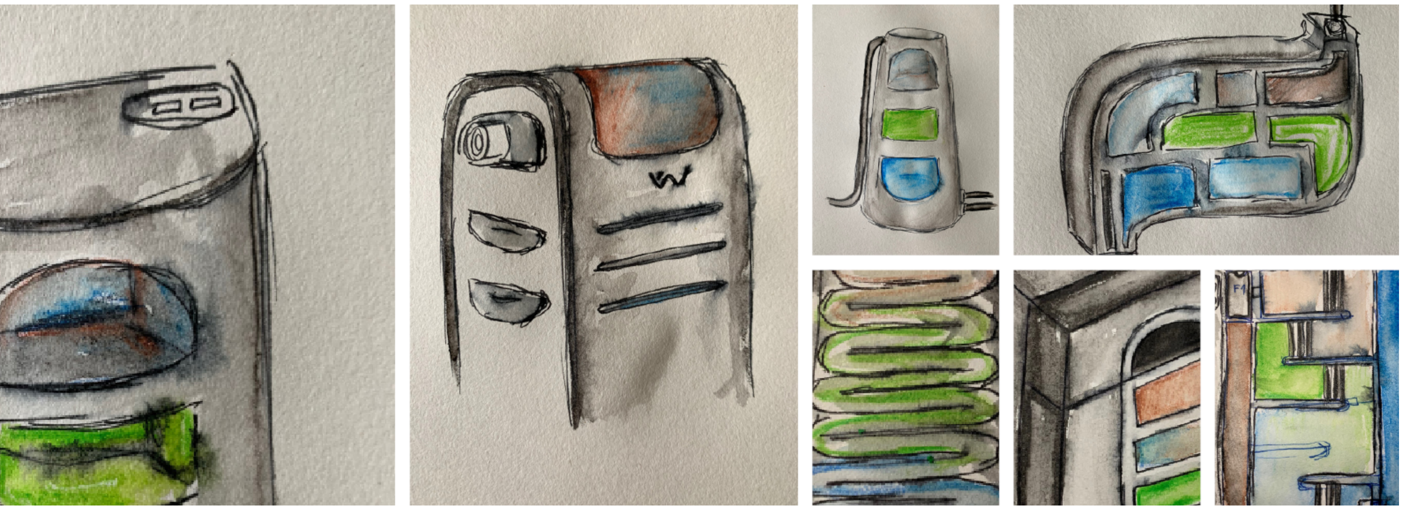
4.5 DESIGN PROCESS

YW™ was created through an iterative process of sketching and developing a series of design variations through a 3D modeling software.

The final design is created intentionally minimalistic, yet communicating important functions such as control panel functions and see-through windows showing the main process of water recycling. YW™ is made to be an unobtrusive, yet decorative and desirable utility to have.

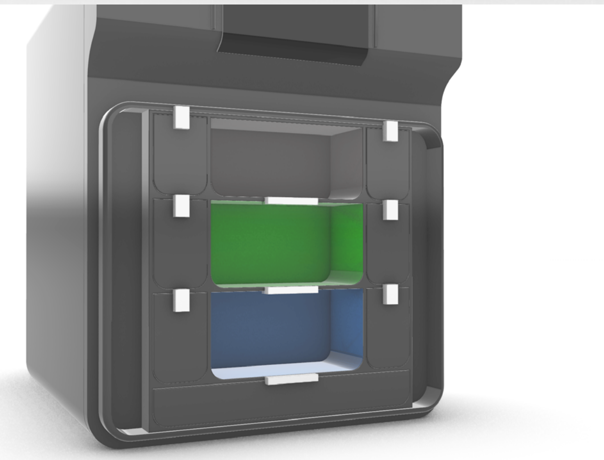
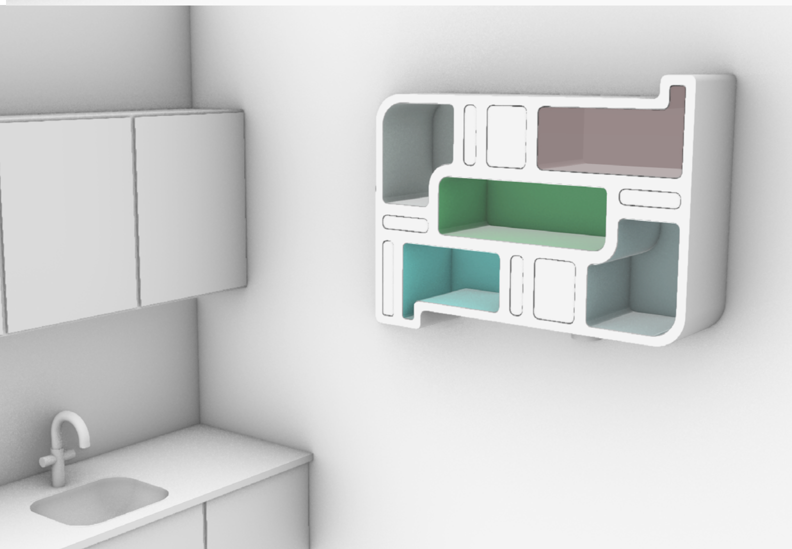
The design follows the size and form of a conventional household utility such as the dishwasher or the washing machine. The YW™ product is intended to be placed within the household in a similar manner. A suggested location is in the kitchen as part of the kitchen inbuilt set, for example, besides the sink. This is a natural location to place the machine as it is a point of water in- and outlet.

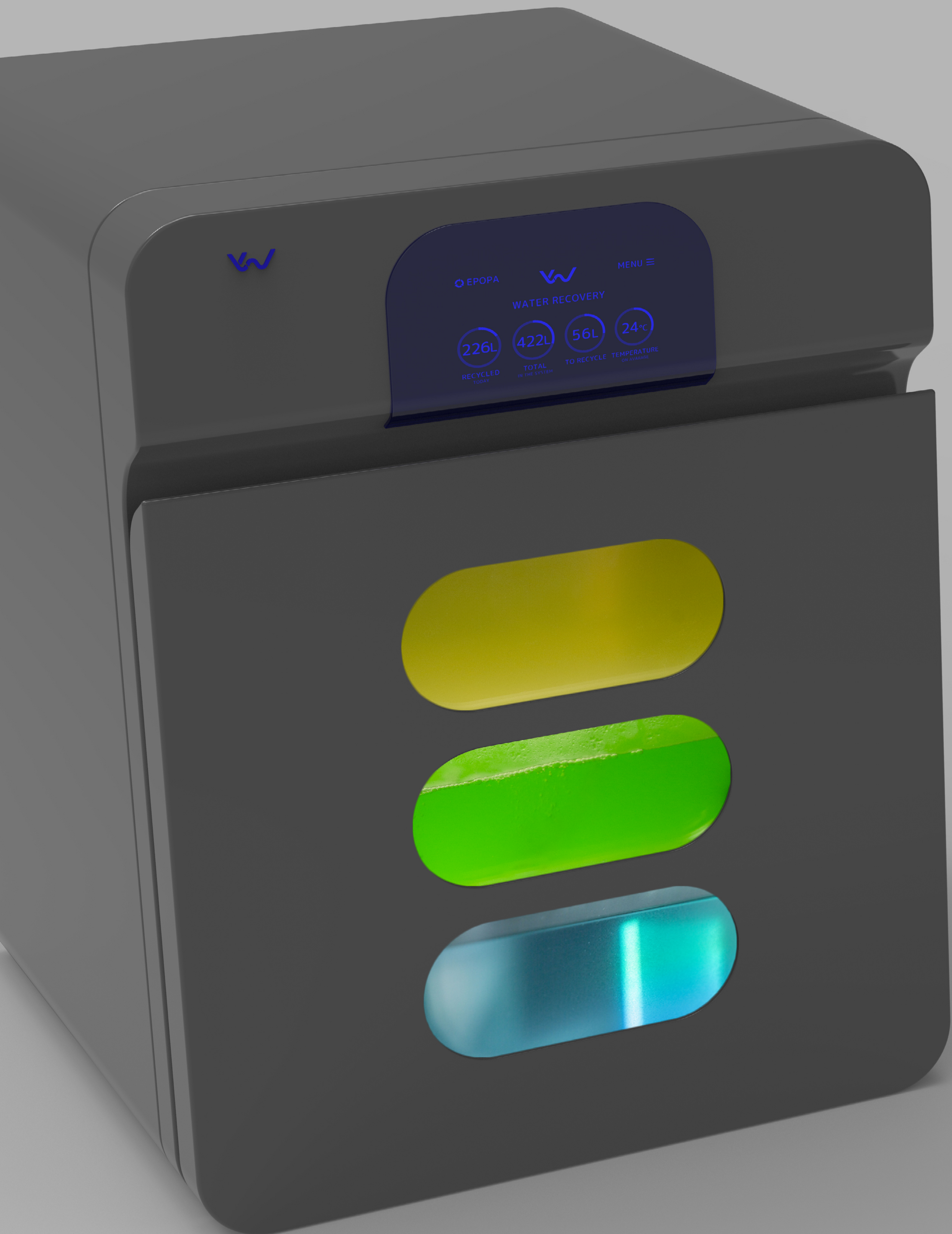
The modular inside system is presented in a simplified manner in renderings. It is created only for illustrative purposes and potential discussion.



Early design sketches





EPOPA
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IN THE SYSTEM
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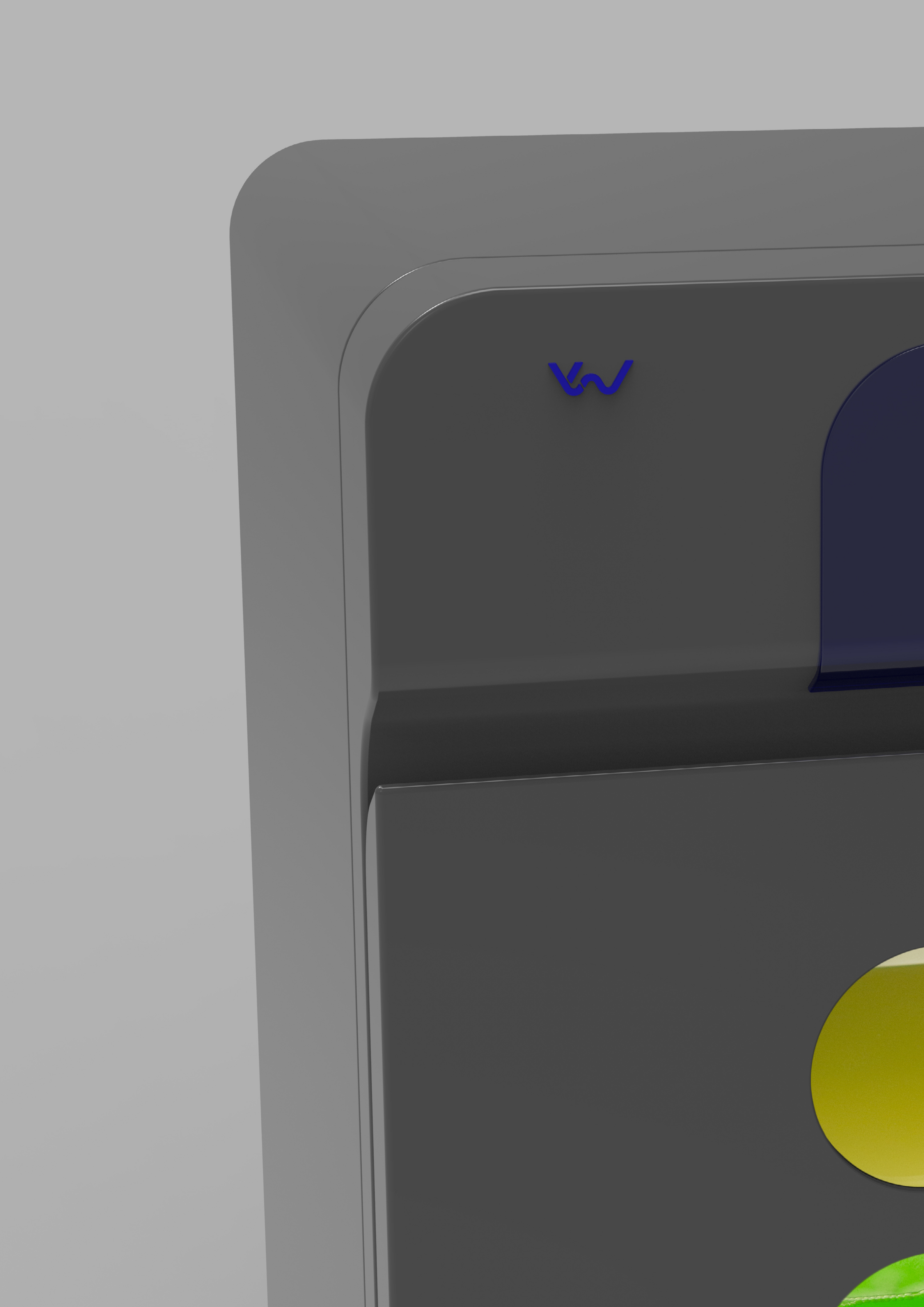
TO RECYCLE
24°C
TEMPERATURE
ON AVARAGE

YW™ - YOUR HOME SOLUTION TO WASTEWATER

RECYCLE WASTEWATER INTO CLEAN DRINKING WATER AND VALUABLE SECONDARY BY-PRODUCTS SUCH AS SUSTAINABLE ENERGY, PHOSPHORUS, MICROALGAE BIOMASS, AND OILS.


WITH YW™, WATER RECYCLING BECOMES A DELIBERATELY VISIBLE PROCESS IN EVERY HOUSEHOLD ACROSS THE WORLD.




EPOPA
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422L
TOTAL
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56L
TO RECYCLE
24°C
TEMPERATURE
ON AVARAGE

4.6 FINAL PROTOTYPE

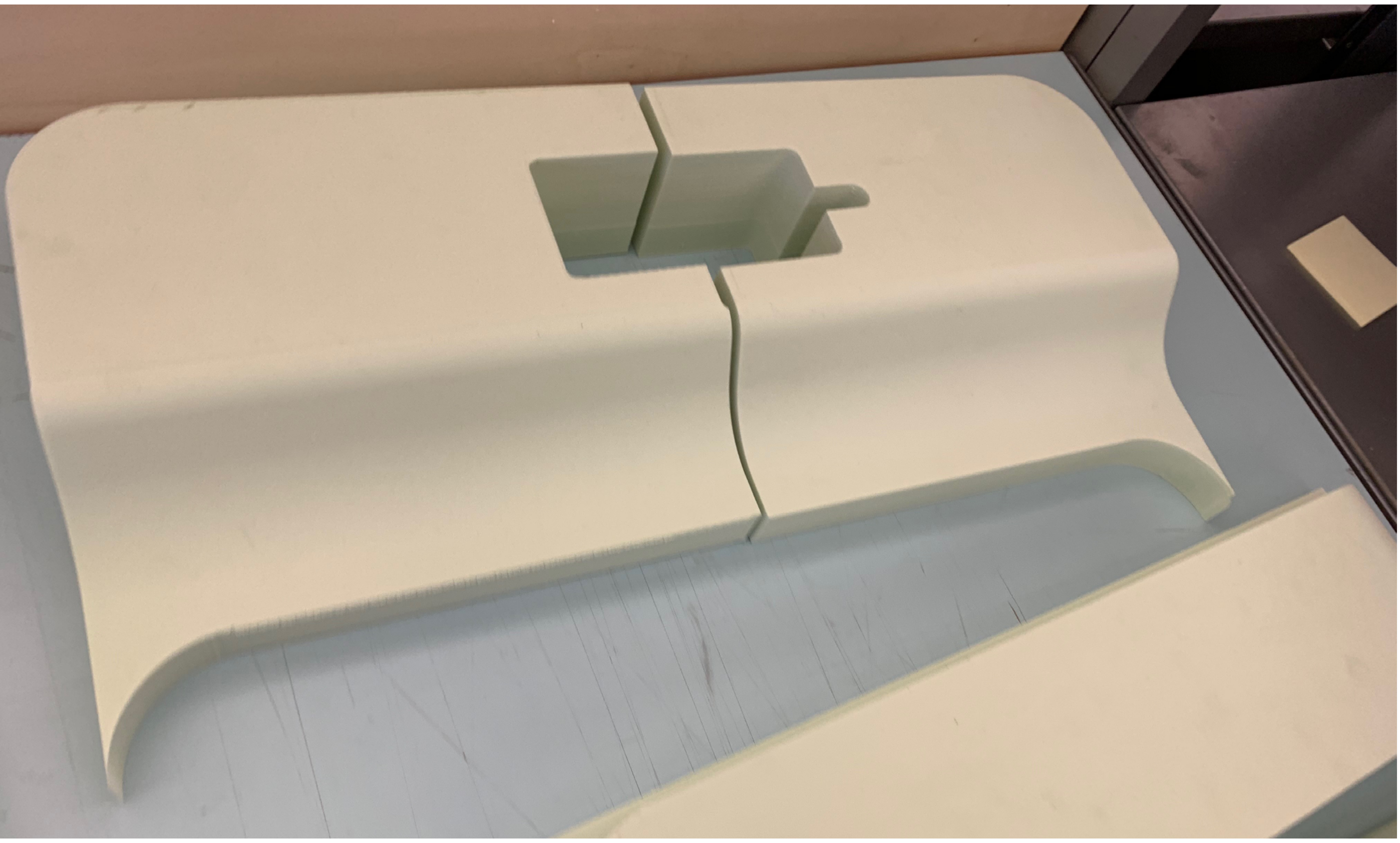
One of the project goals was to create a 1:1 size product prototype for the diploma project deliveries. For practical reasons, only the front part of the YW™ product was built, including the front display and the front door. The system was shown only in renderings, both for practical reasons and in order to focus on the design object as an exploration of speculative design methodology.

The final physical prototype was created by milling and assembling several parts into one object. The model was sanded, painted, and covered with a clear coat spray paint to mimic a visual look of industrially mass-produced products.

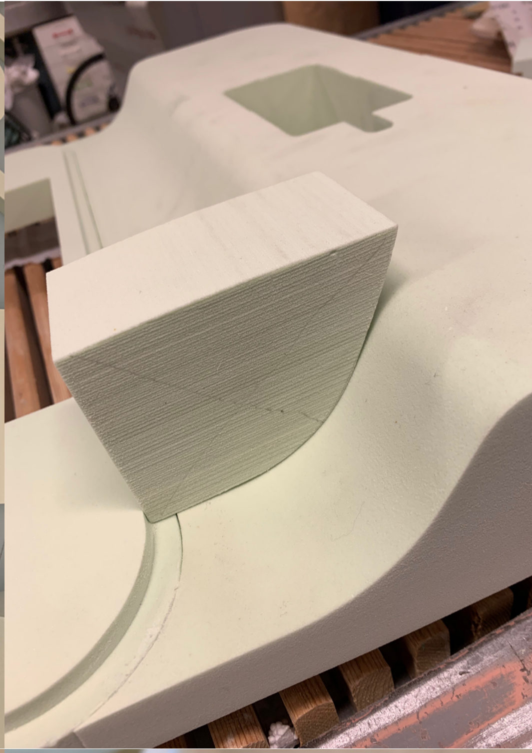
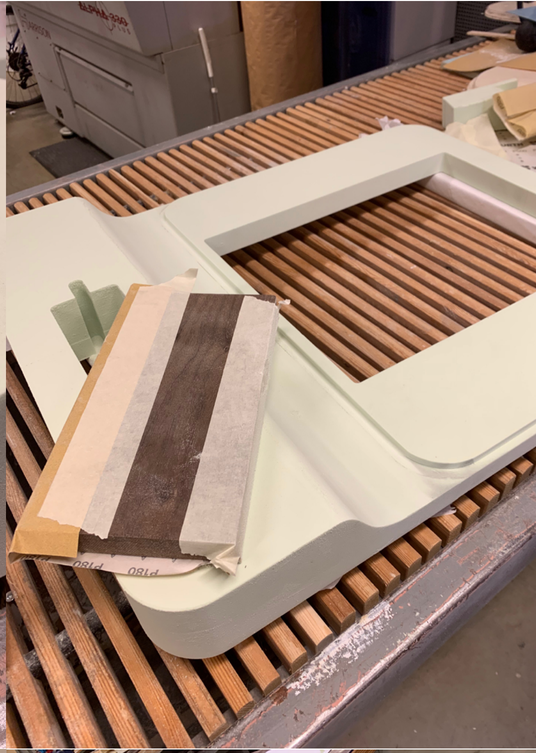
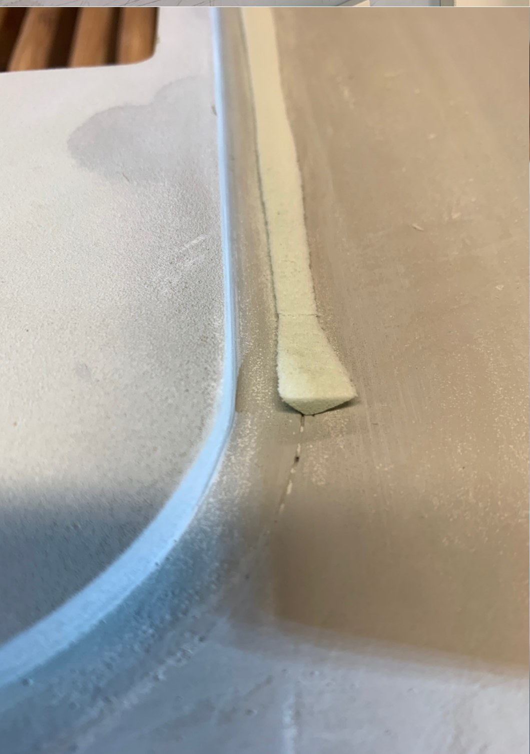
The details shown in the physical prototype include a touchscreen dummy, created by hiding a phone display (that loops a video) behind blue translucent acrylic glass.
The touchscreen display shows the basic functionality of the device in a simplified manner.

The three clear water containers that are visible through the three front windows show the wastewater recycling through three phases: 1) wastewater primary undergoing the primary treatment 2) wastewater going through microalgae filter 3) recycled water going through the last phase of UV disinfection.

Monocolored dark grey is the choice for the final physical prototype, in order to be in strong contrast and highlight the three front windows.



Milled model parts before assembling





L KKBOKS
LEGG DELENE SOM SKAL
LAKKERES SÅ NÆRT
LAKKBOKSEN SOM MULIG


OKBINDERIET
Johnsen
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LEGG DELENE SOM SKAL
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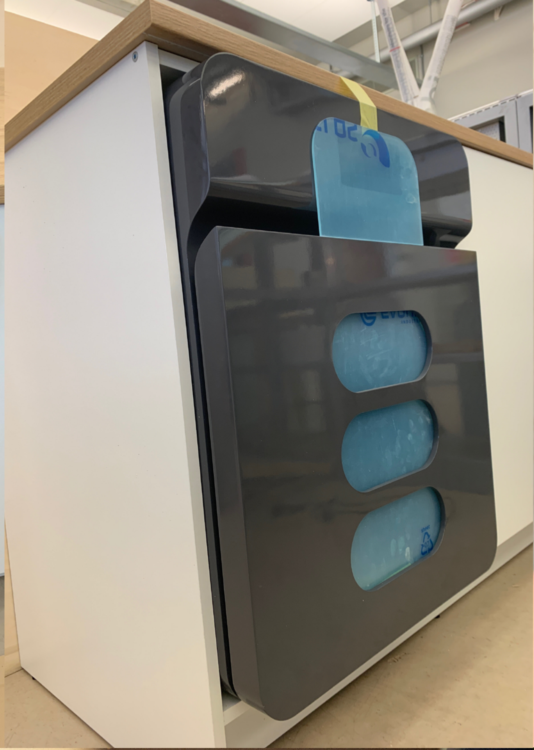
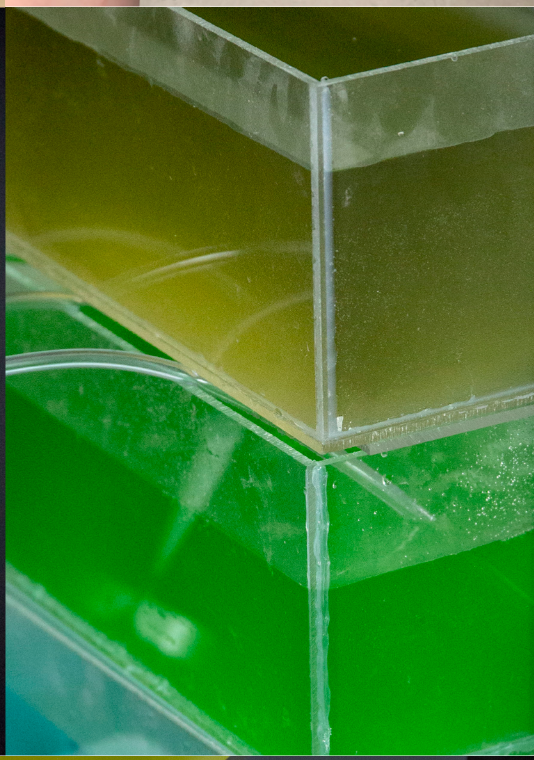


4.7 VISUAL IDENTITY

Based on the role of narrative in creating speculative designs, and the project's intention to stage a public intervention using the developed concept, YW™ was created as an already established product and brand in the market. Therefore, to strengthen the YW™ concept and the alternative future scenario it aims to communicate, it was essential to build a strong and consistent branding. The developed visual identity consists of a logo, color palette, and a set of illustrations that visually explain the basic functionality and applicability of YW™.

DESIGN CHOICES

The design choices taken to develop the visual identity were based on three main aspects of the YW™ product:

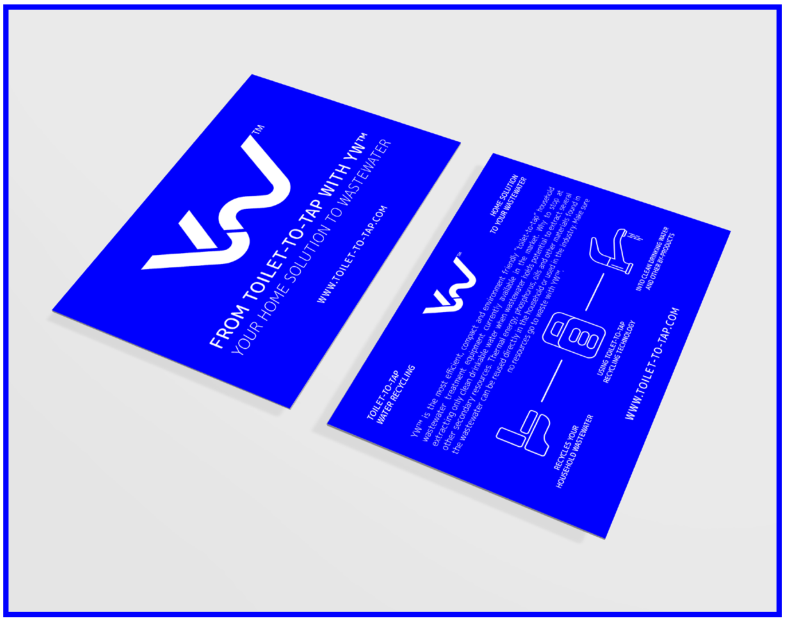
i) it recycles water (blue color for visual identity; a logo that represents flow);
ii) it is an industrial product and company (simple logo); iii) it is a radical and bold innovation (strong blue color for the logo and visual identity); iv) the overall branding stands out from other companies offering wastewater solutions

LOGO

The design of the YW™ logo was finalized two weeks before the NSB group changed their name to VY, which also came with a new branding of using the two letters in a distinctly similar manner then YW. Concerning the relatively small size of Norway and the few nationally known logos, it was of concern that people might draw relevance to the two logos. However, by the time YV was announced, the YW™ logo was already incorporated in all the project material; therefore it was decided not to change the direction of the brand identity.

IMPLEMENTATION OF THE VISUAL IDENTITY

The developed visual style was used to create a set of advertising material to be used as part of the public interventions and the final AHO Works Exhibition. This material included a website, flyers, posters, label tags, and business cards.



Flyer (105x148 mm)

Business card (55x90 mm)

Front page of the YW™ website

DID YOU ALREADY HEAR ABOUT TOILET-TO-TAP AT AHO?

5 PUBLIC INTERVENTION: TOILET TO TAP AT AHO

Designing posters for the public experiment at AHO

5 PUBLIC INTERVENTION: TOILET-TO-TAP AT AHO

The background research uncovered that people are likely to agree that water reuse is a necessary action towards sustainable resource management. However, often, such projects face public opposition once proposed for large scale implementation. Therefore, action based research was chosen as a potentially valuable approach to test the developed concept.

Through staging public interventions, the aim was test the public's acceptance towards using the toilet-to-tap system, from the scenario - as if it had already been implemented in their everyday urban environment. The experiments aimed to render the developed alternative future scenario physically tangible and personal. If the experiment were to succeed, it was expected to gain insights such as: Would they believe the implementation of the system? How would people react? Would they have any concerns? Would they change their drinking behavior? Would they see benefits? Moreover, would this situation make them reflect on the global water scarcity issues?

Three text variations for tags to be distributed as part of the intervention at AHO

5.1 PLANNING

The public intervention was chosen to be executed within the AHO building, to have as much control of the environment and the audience as possible.

This lead to planning an intervention "AHO - the first public institution in Norway to implement the toilet-to-tap wastewater recycling system." The initial plan was to stage the intervention on a scale of the entire AHO building, allowing me to reach an audience of 1000 people, and to gather an extensive amount of qualitative and quantitative data.

In order to make the campaign more realistic, it was decided to discuss the possible involvement and support from the AHO in the experiment. This was imagined through a confirmation email sent out to the students and staff or a post on the website informing about the bold step AHO has taken.

TOO HARD TO SWALLOW FOR AHO

AHO would not let to execute the experiment on a scale of the entire building. The main concerns were the perceived use of deception in the project and the potential implications this might cause, such as students switching to drink bottled water instead of tap water, or causing unwanted external publicity.

The school agreed to allow a much smaller scale intervention at two locations within the AHO: i) Design Department floor and ii) the recently opened South wing. I was also offered a confirmation email sent out to the staff and students at the Design Department by one of the professors.

Preparing the printed material for the experiment

“Toilet-to-tap at AHO” campaign
tag in on of the AHO’s toilet

5.2 PROCESS

Accordingly the experiments were executed as a poster and label-tag campaign at the two locations at AHO. The posters were placed near the water taps in the kitchens, informing about the newly implemented system, while the tags were hanged on the wastewater sources (the taps in the toilets and kitchens). The Design Department was informed about the implementation of toilet-to-tap as promised, however, due to the misunderstanding by the person sending out the email, it stated me as the person behind the project and revealed my contact details. This was not intended according to the initial plan, and therefore, I expected the experiment at the second location to be likely perceived as a student stunt.

The experiment lasted three days (29/04 - 01/05). It was revealed through another set of posters on the last day, informing people about this being a social experiment and thanking their participation in conversations.

"Toilet-to-tap" becoming part of the AHO environment for three days

5.3 RESULTS: COLLECTED DATA

The downscaling of the experiment gave an opportunity to talk to fewer people than initially expected. However, according to rough calculations, almost 90 people in total experienced it. The poster campaign also attracted 39 people to visit the YW™ website. As the website was only announced through the AHO-inside campaign, this can be seen as a direct sign of general interest amongst AHO students to find out more about YW™. During the three days, 18 informal conversations were conceived with people from both locations. The responses varied; however, there were several interesting patterns.

SOUTH WING GOES TOILET-TO-TAP

In the South Wing of AHO, I played the role of either "a design student assigned by YW™ or "a representative from the YW™ company" to collect the customer feedback about using the toilet-to-tap system.

Some participants were questioning the eligibility of YW™'s implementation at

AHO. They were unsure if this is a part of a student project or it is a real system implemented. The main suspicions of this being a stunt were evoked due to the lack of workers present at the building in the past months; as well as the website lacking more technical information about the product. Even if people considered it to be a stunt, they admitted they would be very impressed and positive if it was real.

The participants who believed the implementation of the system at AHO, were convinced about the safety and necessity of such system, if it has been already implemented in a public building. All the participants wanted to know more about the technical and practical functionality of it. Most of them were also interested in the actual environmental impact of closed-loop water recycling more in detail.

DESIGN DEPARTMENT GOES TOILET-TO-TAP

Due to my contact details sent out to the Design Department through the email, the intervention failed to some extent. Therefore, at this location, I rather chose to have conversations about the design methodologies and design thinking the YW™ project is using.

Most of the conversations at the Design Department evolved around the speculative design methodologies and action based research as a tool to test ideas and concepts. I discovered a lot of support and positive attitude towards experimental design approaches. Several participants analyzed the experiment and how it has been executed. People who had seen the website and read the posters, noted the high quality of the branding and how the website is making it believable.

5.4 RESULTS: SUCCESS EVALUATION

Even if the experiment changed its nature during the process, both tests gave valuable insights into how people perceived the toilet-to-tap water recycling in Norway. This action based research approach also allowed to evaluate the developed concept, its strengths, and weaknesses, as well as to evaluate this type of user testing method.

Based on the conversations, it became evident that people in Norway are likely to trust the decisions made by governmental institutions. This points to a potential acceptance and positive attitude towards assessing and changing the current approach to wastewater management.

The discussions also revealed the lack of awareness of the environmental impact of inefficient water use and need for water reuse even in countries under a relatively low water stress, such as Norway. However the experiment seemed to raise this awareness and lead to self-reflection about the lacking knowledge. Opposite to what expected, the toilet-to-tap wastewater reuse didn't seem to cause as much opposition as discovered through background research.

5.5 FINAL PRESENTATION: AHO WORKS

The AHO Works Exhibition is the final presentation of YW™. The main goal of this event is to showcase all the elements developed as part of the project: i) the design concept and narrative, ii) the physical prototype, iii) branding and visual identity.

Choosing the AHO building as the setting for the public interventions ensured that the majority of people exposed to the "Toilet-to-tap at AHO" campaign are likely to also see the exhibition. This allows me to create another opportunity for reflection for the previously included audience.

Based on my experience from exhibiting at the Stockholm Design Week, as part of the third semester, I chose to present the YW™ project using similar aesthetics to be found at design fairs: creating a visually defined space to show the product.

The YW™ concept is created to fit in a typical urban household; therefore I chose to implement the product in a ready-made kitchen unit. With this strategy, I aimed to make this speculative design concept easy to imagine in one's own kitchen.

It was also essential to show the developed brand identity, as it has been a large part of the project. Hence, I chose to print the business cards and create a large scale 3D logo to be displayed on the wall behind the product.

Creating YW™ logo for the AHO Works Exhibition

Detail of the final
YW™ prototype

6 DISCUSSION
7 CONCLUSION
8 FUTURE OUTLOOK

6 DISCUSSION

YW™ was developed to explore the industrial designs potential to raise public awareness in wastewater management in the age of water scarcity in the Anthropocene. The project focused on a specific area within the freshwater cycle - the household wastewater management. This chapter discusses the main insights and outcomes from the conducted background research and the design process in order to evaluate the project success.

6.1 THE FUTURE OF WATER

It is clear that without water, there are no cities. With the current trend to hide the complexity of wastewater pipes under the cities and place its recycling facilities far behind the city walls, it is hard to make the wastewater and related issues visible and thinkable by the general public who use this system.

The cities are one of the most critical locations concerning the water crisis in the future. However, cities can also be seen as an important terrain for sustainable innovation and radical change, not only through the implementation of new technologies, but also for the development of new societal values and ideologies.

Based on the conducted background research and the gained insights through public interventions, I see the future of wastewater management as a very important and promising area for industrial designers.

There might not be one perfect solution to wastewater management in the increasingly urbanized world, and it might not be the centralized or decentralized systems that can solve all the issues. A hybrid approach will greatly contribute to a real world solution with a substantial increase in capacity.

However, with the projected increasing water scarcity in the global mega-cities and the lack of adequate quantity of freshwater sources, it is self-evident that the water efficiency and upgrade of used technologies to recover resources will be the key factor of success. Based on the research I also believe that closed-loop systems and on-site water management can radically decrease the environmental impact and potential water scarcity from many perspectives. However, technological testing and research on advanced wastewater management is still in its early phase.

6.2 DESIGN PROCESS AND OUTCOMES

The process of this diploma semester has been exciting and insightful both in terms of explored topics and in experimentation with what can speculative design be used and useful for.

One of the main outcomes of this diploma project was to develop a design concept and to create a physical prototype of the final product. Due to the complexity of the chosen topic and the advanced technologies involved, I chose to follow the speculative design approach and developed a simplified concept in order to focus on the central message of the project. This gave me the freedom to develop a more minimalistic design than it would be required if I was to make the product highly realistic with the currently available technologies.

An essential part of this project was the exploration of and experimentation with the chosen methodologies: speculative design and action based research. The design became a sort of a "black box" for a variety of possible technical solutions and future scenarios. I see this as a successful outcome concerning the set project goal to explore and test the potential of speculative industrial designs. Based on the issues with organizing the public interventions at AHO, and the insights gained from the experiment, I also consider the YW™ to be successful in provoking and thus stimulating the audience into personal reflection concerning the current state and the future of wastewater management.

Poster informing about the experiment

7 CONCLUSION

YW™ is a speculative industrial design project that aimed to raise awareness of and propose a radical solution to wastewater management in the growing urban environments around the world.

My main inspirations for this project were the catastrophic global issues connected to the water scarcity in the Anthropocene and the lack of critical reflection towards the currently conventional ways of freshwater management in developed countries.

I started the research by uncovering the problematic areas in the centralized off-site management of wastewater. I then discovered the potential benefits of decentralized and closed-loop wastewater recycling utilities, such as toilet-to-tap systems for indirect and direct potable use.

I then acknowledged wastewater as the most unappreciated resource we have. A resource that holds potential not only to recover clean drinking water, but also energy and organic and inorganic by-products.

Based on the research, I created the YW™ concept - a proposal for a modular household-size wastewater treatment system - that recycles wastewater at home. YW™ is a design solution that turns black and grey water into clean drinking water. It also extracts valuable secondary by-products that would be otherwise lost.

With YW™ I aimed to incorporate the gained knowledge on technological, scientific and practical solutions to wastewater management that could increase the efficiency of water use and decrease the environmental impact of wastewater recycling (including pollution, carbon emissions, and energy use).

The YW™ concept was presented to the public and tested using public interventions. I used this action based research approach to uncover personal reflections on the topic and to make the proposed solution experienceable in an everyday environment.

I constructed two public interventions at the two locations within the Oslo School of Architecture and Design. I staged a campaign titled "Toilet-to-tap at AHO" that informed the students and staff about the newly installed system. The first location was used to gather insights about the public's perception, concerns, and reflection of drinking reclaimed water. The second location was used to discuss the project from an intellectual viewpoint to analyze the used design methodologies.

During both experiments, I noticed that the people I talked to started to reflect on their lack of knowledge about these issues, and gave their thoughts not only about the YW™ product but also the state of freshwater management in Norway.

Through the use of action based research, I gained insights that allowed me to evaluate if I reached the initially set project goals. This also helped to finalize the concept and the design.

Based on the insights gained through the informal conversations and discussions, I find the project to be successful in making important wastewater issues thinkable through the YW™ concept and the proposed future scenario experienceable through the staged public interventions at AHO.

In conclusion, I have met the initially set project goals and developed a hybrid speculative industrial design concept, that proposes a radical solution to wastewater management in the urban environments. I also believe the project has succeeded in raising awareness of the water scarcity through the chosen design methodology.

8 FUTURE OUTLOOK

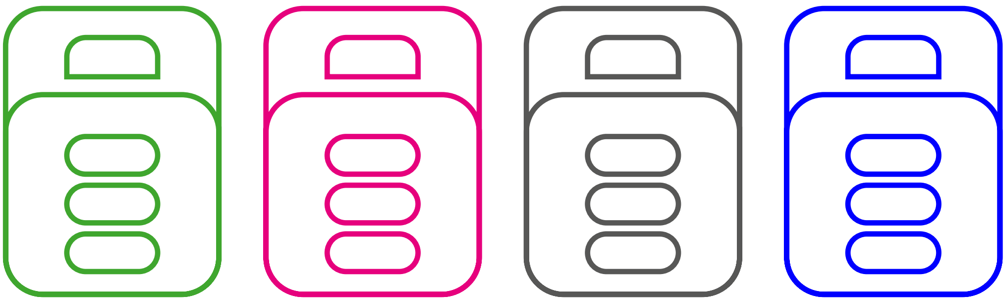
The YW™ project contributed to raise the public's awareness about the increasing global water scarcity and evoked critical reflection towards toilet-to-tap wastewater recycling as a potential radical solution.

In addition to the achieved project goals and the developed design proposal, the project has showed a more positive feedback towards toilet-to-tap water recycling then initially expected. This can be seen as a positive sign towards potential personal involvement in managing the world's most unappreciated resource - wastewater.

The success of this speculative industrial design project, points to the potential for further development, that could lead to designing a viable product for the market. In that case, the next phase should be more in-depth research and technical development of the system.

The YW™ project aims to continue to evoke discussions during the AHO Works Exhibition not only about the design solutions to wastewater management, but also about the value of making alternative future scenarios experienceable through critical and speculative design approach.

This experimental and exploratory project, also is created to inspire and encourage other design students and designers to work with hybrid design methodologies and use creative ways to test their concepts and design thinking.



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