Group one

Miljøpunkt Loop 2

Pipe-in-Pipe solution

"Gain from the drain"

62990 Innovation Pilot Summer Edition 2020

Group one

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1 Executive summary

This report is the documentation of Group One's work on the Miljøpunkt case from DTU's Innovation Pilot course of the summer edition 2020. Through research the group found a potential in collecting the rainwater in the Inner City of Copenhagen. This potential matches the case due to the following quote from the case description:

"Can a possible solution involve other climate-friendly concepts/technology, e.g. Re-use / use of rainwater..."

The group formed the following innovation question / problem statement to guide the innovation process:

"How can we gain from the drain?"

Through a thorough innovation process, the group created a solution that answers this question. The solution is a pipe-in-pipe system that comes in various sizes and holds between 20 and 30 liters of water in just a 2m pipe. It also features a tap for draining the water for usage.
The group also created a realizable business model and collected interviews with people stating that they want to buy the solution, e.g.:
"I Love the idea, Why hasn't anyone thought of that before?.....Window cleaners and the cleaning personnel for the stairs can also use it." - Emma Giorgi, Jewelry designer, Store Kongensgade
These interviews alongside observations and research proves that the solution can make the market at a realistic price setting of 2000DKK with a direct marketing strategy targeting stores/shops, cafés, restaurants and housing associations.

Contents

2 Introduction

In the following report we will show how we researched and developed a solution that hopefully will help on the UN sustainability goals number 6 and number 12. With these two sustainability goals in mind we wanted to take the rainwater that can cause floods in the Inner City of Copenhagen and turn it into useful water for watering plants, in order to greenify the city.
The case behind the project is given by the NGO Miljøpunkt Indre By and Christianshavn that wanted a way to greenify the Inner City of Copenhagen. We will throughout the report discuss Miljøpunkts involvement in the project.

Figure 2.1: UN goals for sustainable development

The product itself is a pipe in pipe solution that is attached at the end of the downspouts to collect rainwater, using less space compared to a traditional rainwater barrel. We will walk you through each individual part in our solution and will cover means of target group, production, size, coating and pricing. We got to this solution through speaking with several citizens and business owners in the Inner City during the multiple iterations of prototyping, with focus on human centered design.
All the quotes in this report are translated to english from danish as accurately as possible for easier understanding.

2.1 Background

We are a group of six students at DTU from various study programmes as seen below:

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The project is made in collaboration with Miljøpunkt Indre By and Christianshavn during the course 26990 Innovation Pilot (Summer edition 2020). Miljøpunkt provided a case that each member of the team chose to work with for Loop 1, when starting the course and before meeting each other. Afterwards the team then chose to work with Miljøpunkt again for the second stage of the course (Loop 2). From Loop 1 we had found out that taking care of the plants in the Inner City was not as big a problem as we initially thought, so we chose to take another direction, while still keeping our first collected empirical data in mind.
In Loop 2 we noticed that the case mentioned, that getting water to the potted plants, was a problem and therefore we came up with the following innovation question:

How do we gain from the drain?

3 Problem Owner

In this section we will present an analysis of the problem owner, Miljøpunkt, and what channels the organization has.

Miljøpunkt Indre By and Christianshavn is a small NGO which is self-owned by a fund and founded in 2008. It is a center for counseling and support for local environmental community work. They have a 1,5 million, [1]. budget a year with only a few paid workers and mainly use voluntary labour to meet their goals. They therefore have a lot of resources available to support their work, but also leaves them vulnerable.
The founding of Miljøpunkt was encouraged by the municipality of Copenhagen and we believe this gives them some sort of influence. As the municipality encouraged the organization they must have the same goals and therefore a willingness to support Miljøpunkt.

Miljøpunkt has four main focus areas; Clean air, Recycling, Less noise and Greenifying, where Greenifying is the focus of the case we work with.
Within this focus area Miljøpunkt has different initiatives. They have created a catalogue describing different species of plants well suited for facades, and the needs of the different plants. They have also created an easy form on their website, which should enable their users to easily apply to the authorities to establish facade plants. Furthermore they arrange monthly meetings open for everyone to join where the subject could consist of which plants are good to have inside and outside or a common bike ride through the city to give inspiration on how beautifully planted facades can be a reality.
These arrangements are a contribution to their main focus, which is to help others realize their projects by using their government contacts and creating connections between other organizations and groups of people who work within their scope.

Regarding Marketing channels they mainly use their own website and their facebook page where an activity calendar is shared, containing previous projects, running projects and things going on. Furthermore the location of the office in the city center, on Rainbow Square, right next to City Hall and Tivoli, which gives them easy access to be noticable and attract and inspire new customers.

4 Project background

In this section we will describe the case set from 'Miljøpunkt Indre By and Christianshavn', what their challenge is and what kind of outcome they seek, as well as a description of how we see the case. Miljøpunkt Indre By and Christianshavn has an agenda of encouraging citizens, businesses and restaurants to take part in greenifying the city. Miljøpunkt has already created a catalogue that shows different types of facade plants suitable for different conditions, and how to apply for allowance at the City Hall.

The challenges they have noticed are that sometimes it is not easy to plant directly in the soil due to the presence of pipes and wires. Furthermore maintenance is a big problem especially in the summer months as the plants need a lot of watering and care. Many of the plants are in pots and therefore need much more watering to stay alive.

Miljøpunkt is interested in finding a solution that would help businesses and citizens in making the city greener and to plant more plants in the urban space. A solution that they could easily adopt and inspire others to use as well. If possible this solution could also have a climate friendly function integrated e.g. reuse of rainwater, use of solar energy etc.

All in all the case presented was:

"How to develop concepts and solutions that will enable and entice citizens and businesses to plant more plants in the Inner City of Copenhagen?"

The key points we noticed from the case were that maybe the essentiel problem was not to plant the plants, but actually finding an easy way to maintain them.

4.1 Vision

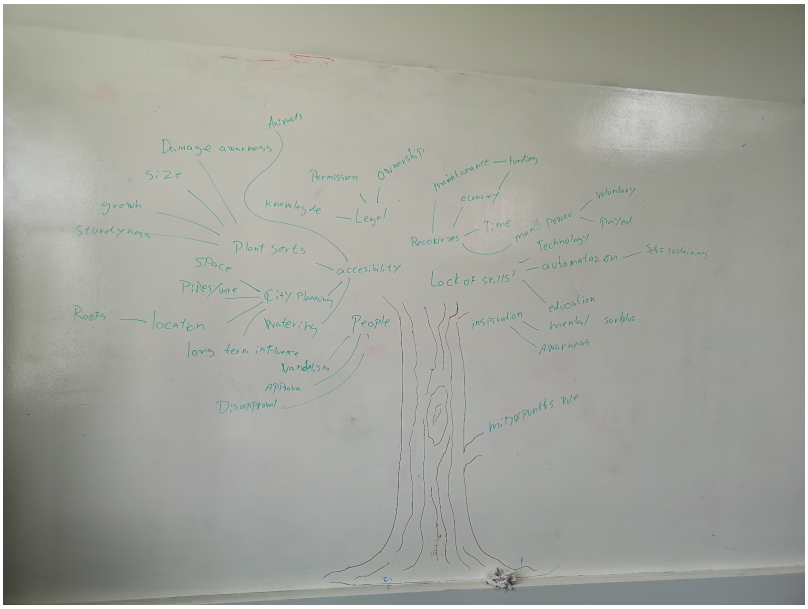


Figure 4.1: Questiontree

From examination of the case we used a questiontree and created our vision for this project;

"How do we gain from the drain?"

The meaning of our vision is that we wish to use the rainwater that floods the Inner City of Copenhagen and use it to water the plants in the same area.
How we have developed a solution that releases this vision will be described in the following sections 5 and 6.

5 Design

In this section we will guide you through our whole journey of creating our solution. We will lead off by defining our Target Group through using Market Segmentation Variables. Then involve our users in a direct User Research.
In order to give a clear overview of the stakeholders involved in our project, for future corporations, we have created a Stakeholder analysis.
Second Last we will make a Value Proposition, to define what value our solution should carry to meet the needs of our customers. And thereby we close the design chapter by showing our prototype, what we have tested and how experts and users have experienced our solution.

The section is key to gain an understanding our process and how our vision came to life. So be ready to get engaged and enjoy your ride.

5.1 Target group analysis

To specify the target group, we have conducted a target group analysis using the market segmentation variables [2] which is shown in the table below 5.1:

Demographic variables
• 25 years or older
• Stakeholder in:
  ○ Housing cooperative (Andelsforening)
  ○ Owners association (Ejerforening)
  ○ Tenants association (Lejerforening)
• Owner / CEO of
  ○ Stores/Shops
  ○ Cafe or restaurants
	Geographic variables
	• Copenhagen
	• Inner City
	• Christianshavn
	• Backyards
	• Facades with plants

Psychographic variables • Green thinking • CSR/image • Environmentally conscious • Green washing	**Behavioristic variables** • On average the plants need around 1L per plant. • People need to water their plants multiple times a week

Figure 5.1: Segment

We chose to exclude B2C (business-to-consumer) and B2G (business-to-government) to narrow down the market and to focus on stores/shops, cafes, restaurants, housing cooperatives and owners/tenants associations (B2B). It can then be concluded that the target group is citizens in the Inner City of

Copenhagen (typically over 25 years old), who are stakeholders in housing associations or owns/runs a store/shop, cafe or restaurant. With this defined target group, a marketing and advertising strategy can be chosen.
We have chosen to use direct marketing to address the target group directly. This can for example be done by mailing (physical post) or calling the stakeholders of the stores/shops and housing associations.

5.2 User research

In this section we wil present how we gathered empirical data.

During our previous field research study from loop 1, in the Inner City of Copenhagen, Christianshavn and Nørrebro, we found that knowledge about caretaking and plant species was not a main issue for the store owners and citizens, but rather unwanted fluids and work hours. Therefore we chose to focus on identifying difficulties related to the plants without specifying a topic in advance. Aiming to discover and define problems in greenifying without asking leading questions.

Several store owners said that they did not really experience problems in relation to the plants, but that the fetching of water for their plants was time consuming. When asked if there was anything they were missing in the city, one answer that stuck with us was *"If there was something in the streets, that you could fetch water from, it would be a lot easier to take care of the plants. That would make it easier for everyone to take care of their plants"*.
This matched our vision – *"To gain from the drain"*. After benchmarking and evaluating existing solutions we became curious about why none of the potential users we had talked to were using these solutions. We made a sketch of an alternative solution, modified our test design and interview guide, and then went back again. A

When asking whether they used rainwater – *"what for"* or *"why not"* – most said that they just had not thought about it. When asking if they could think of solutions from which they could gain from the drain, the main concerns were authorization, price, space, visibility, and volume. We were surprised to find that vandalism was not as big a concern as authorization from the landlord and the local authority, Københavns Kommune.

We presented three solutions – two existing and the sketch of our own, see the pictures below. 5.2.

(a) Rainwater container (b) Rainwater barrel (c) Pipe-in-pipe sketch

Figure 5.2: Solutions for rainwater collection

After informing the store owners of our findings regarding authorization and the prices of the solution, the main concerns were volume and space. They preferred our solution because it is less visible, has easier adaptability and because of the volume it offers.
We experienced a great willingness to pay for solutions like these and many expected the solutions to be a lot more expensive than they are.

5.3 Stakeholder analysis

In the following model we will present a short analysis of the key stakeholders, and what advantages and disadvantages they will encounter if they become a part of the project in some way and what actions we will take to make them satisfied in the future corporation.

Stakeholders	Advantages	Disadvantages	Action
Housing cooperatives and owners/tenants associations	-They get free water and can possibly avoid water damages, -They can have a good environmental consciousness when using the water	-The solution isn't free -It can't be used to water edible plants -It may have to be used only as a supplement	-We need to market our product to them and show them the advantages of it. - We could offer them to participate in a spread on Miljøpunkts website and Facebook profile and thereby be an inspiration to others.
Miljøpunkt	-They take one step towards their goals. -They can get their name out in public as a part of the project.	-They might have a financial loss	- Miljøpunkt can be used for funding and is very willing to invest in green initiatives that fits within their scope.
Miljø- og Teknikforvaltningen	-The flow of water in the sewer systems is delayed. - It is free to them	-There might be some extra paperwork that has to be done if there is a large amount of containers installed	-We need to have the municipality on our side, and Miljøpunkt can help us with finding the right gatekeeper to keep our project afloat.
Production unit	-They get more work and therefore money	-They will be forced to make something cheap because we work with a relatively small profit margin	-We need to find someone willing to produce our product if we make a large order.

(M.L Attrup, J.R Olsson, 2008, S.124-130)

Figure 5.3: Stakeholder analysis

5.4 Value Proposition

In this section we will describe how we have defined the value of our product by using the "Value Proposition Canvas", [3]. In order to understand the boxes in the canvas, we have used different colours of "stickers" for easy visualization. Therefore a reference will be made in parentheses defining which colour of sticky note are mentioned and thereby which box is referred to. We hope this gives a clear understanding of the process of making the canvas.

The "Value Proposition Canvas" has been used to identify why the customer should buy our product, and gives a clear overview of the customers needs and how our product can meet these needs and create value to the customer.

The Canvas, 5.4, is divided into two boxes. On the right side we have the customer who possesses "jobs" (yellow) and has "pains" (orange) and "gains" (green) related to these jobs. On the left hand side we have our product with "product and services" (purple), the "pain relievers" (blue) and "gain creators" (pink) of the product. Between the two boxes are made lines that show how the product meets the customers needs and what value it gives to the customer.

We have acknowledged the main problems (jobs) for our customer is

- Watering plants
- Maintenance of plants

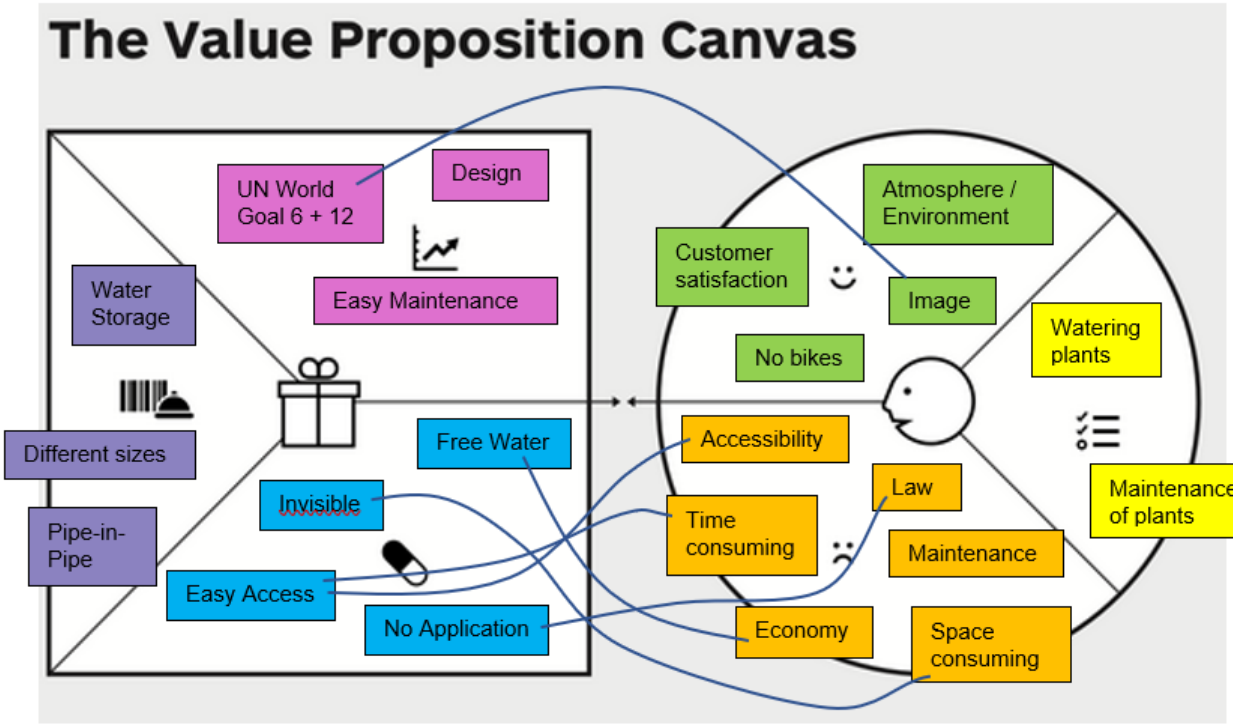


Figure 5.4: Value proposition

Through the "Value Proposition Canvas" we can conclude that our solution compliments many of the pains the customer has and that many of the customers gains related to the jobs are dependent on things the product does not directly affect.

5.5 Prototype and testing

We will now present our prototype, how it is made and how we tested it as well as results.

The prototype of our solution is made out of two acrylic pipes, to make it easier to visualise and evaluate the inner function of our solution. At the bottom a water tap is mounted, but the designed cleanout function was not deemed necessary for the prototype and testing of it.
To test the prototype we placed it under a gutter and simulated rain with a waterhose to test the overflow function and whether leaves and others would follow the overflowing water and leave the water compartment, 5.5a. Afterwards we did the test again with sand and dirt to examine the effects of accumulated dirt, 5.5b.

(a) Leave overflow test (b) Dirt test (c) Circulation test

Figure 5.5: Prototype tests

We discovered that the overflow of water worked perfectly, that soaked leaves settled at the bottom and dry leaves floated, but only some of the dry leaves followed the overflowing water and disappeared. It is important to note that leaves and sticks rarely occur on tall buildings and most likely will not become a problem in Copenhagen.
When we filled sand and dirt into the pipe the waterflow in the tap lowered, but the dirt floated with the water out of the tap. After a while the flow had cleaned a passage in the dirt in the pipe which

allowed for an increase of the waterflow. Of course the amount of dirt/sand we used in this test is more than what will accumulate over several years, 5.5b.
To visualise the circulation in the water, when the overflow is active, we apply a highly concentrated colour, 5.5c. Here we could see that circulation only occurs in the top of the pipe, which might influence the growth of algaes in still water if the water is not used for a longer period of time.

5.6 Prototype feedback

We will now present the feedback given on our product from both experts and users. The experts and users have been a part of the developing process and impacted our development and iterative process. They have been consulted in different phases of the process - from the sketch phase to the prototype phase. The users, presented here, have been interviewed while being shown the prototype.

5.6.1 Eksperts

The experts we have consulted during the development process are listed below, 5.6. Only key points given from their side will be mentioned and explained how we have taken this into consideration.
In general all mentioned volume, clogging of dirt, and possible frost damages as key points we should consider when developing the solution.

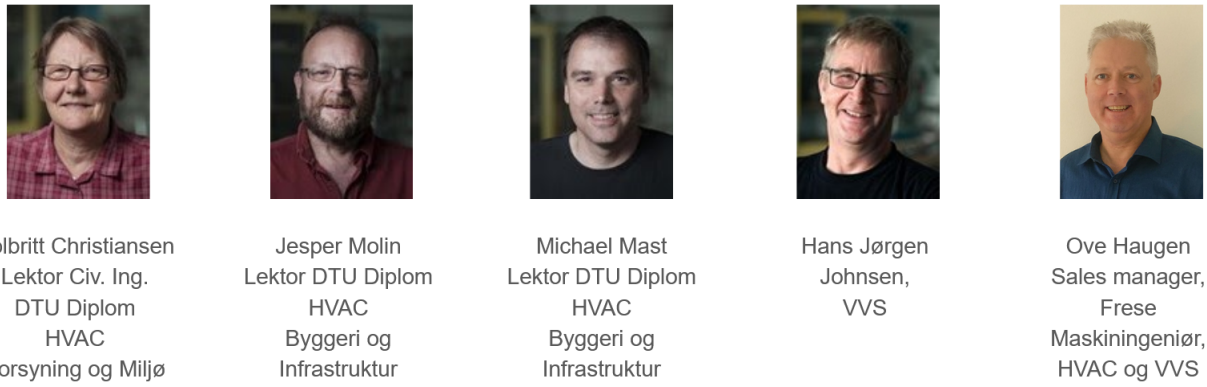


Figure 5.6: Overview of experts interviewed for prototype feedback

Solbritt Christiansen, Lektor Civ. Ing. DTU Diplom

"I believe it is a very good idea with good prospects. Remember to check that your product has something that similar competitors do not have. And make design a key factor, as Copenhagen City Hall loves to implement things that will enhance the beauty of the urban space, e.g. like the trash cans. You can check out the project "Fole Haven" for more inspiration."

Jesper Molin, Lektor DTU Diplom

"I think it is a good solution. It should create no problems with clogging of the system, as water would naturally run along the pipe edge, and dirt would enter the center. To optimize the storage volume you could look into the Wavin UV product, as the inner pipe could then be decreased to 56mm in diameter. Also check the rainwater filters and see if you should implement it into the product. You could also look into combining the solution with a direct link to facade plants. And most importantly remember to make a solution where everything works perfectly and with low maintenance for the customer."

Hans Jørgen Johnsen, engineering assistant and VVS

"Even in the city center where leaves and others do not get into the gutter, algaes will alway grow in still water. It's therefore important that you come up with a solution for cleaning at the bottom of the pipe, even if you filter the water at the top of the pipes."

Ove Haugen, Sales manager, Frese

"My main concern is the weight of the solution. Not making it stick to the wall, but making sure that the weight of it does not drag down the gutter and causes damage especially in solutions with greater volume."

Through the above mentioned comments we came to the conclusion that our system should not hold the Wavin UV function as this would be too expensive to implement. A rainwater filter could be an add on for further developments but will not be included in the first line of product. We have focused on design, how to avoid clogging and frost damages, and ensure easy implementation in the city landscape along with easy maintenance.

5.6.2 Users

In order to confirm that there is a market for our product we visited over 30 shop owners around Inner City. We started by asking them how they watered their plants and where they get their water from. Then we presented drawings of our idea and asked them what they think about our concept, and asked them if they would be willing to pay about 2000 DKK for this solution.

Emma Giorgi, Jewerildesigner, Store Kongensgade.

"I Love the idea, Why hasn't anyone thought of that before?.....Window cleaners and the cleaning personnel for the stairs can also use it."

Nikolai, Responsible for sustainability, Hotel Phoenix, Bredgade.

"I think it's brilliant, we just use tap water.... We think a lot about sustainability and we have a

large roof terrace with a lot of plants and it would be nice to water them with rainwater."

Diana, Florist, Green by Sinding, Grønnegade.

"I think it's a great idea, we use a lot of tap water and this could be a wonderful alternative"

Kendt Lauridsen, KENDT Design, Nansensgade.

"I love it, I could see it for me on every street corner, then everyone could water the plants, which will indirectly greenify the City." "It would really make it easier for me, to water my plants. I have to walk through my shop to get water multiple times, and it would be much easier when I am away, to get people to help me."

Figure 5.7: Kend outside his store

Our prototype concept test showed us that many liked our concept and thought it would be great to have it installed. The price estimate at 2000 DKK was a fair price, but many said: *"if it goes higher up, they would have to think more about it." 2000 DKK is a fair price and small enough to make a fast decision".*

6 Our solution - technical description

In this chapter we will present the technical design of our solution, we will walk through the capacity, cleaning, production method and how it will be installed.

Our solution consists of five parts which can be produced individually and then be assembled on site when needed. All the parts will be produced in mild steel and then coated, except the valve, which we will discuss later.

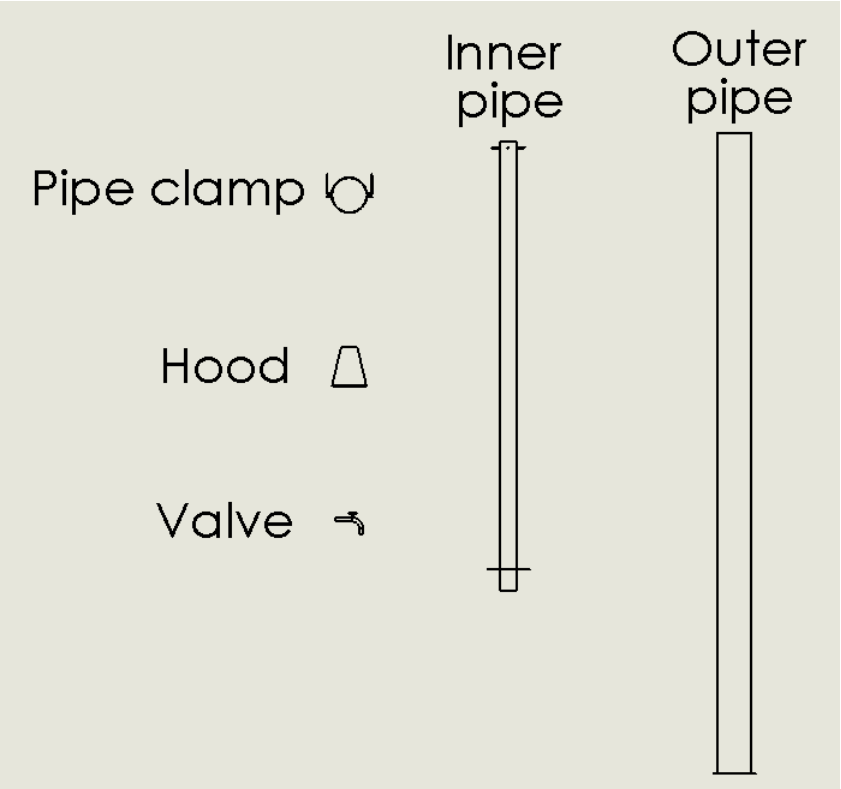


Figure 6.1: Solution parts

6.1 Pipe clamp

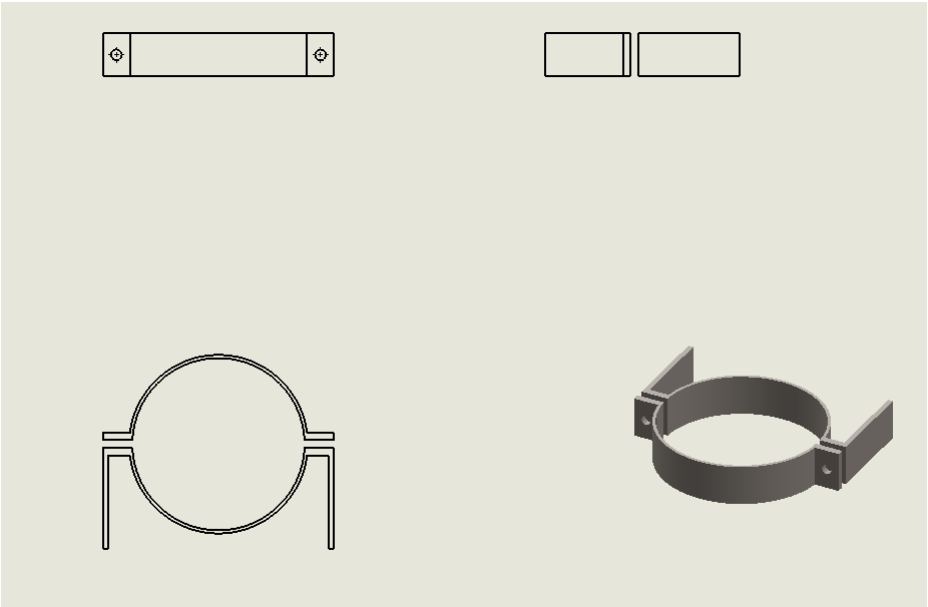


Figure 6.2: Pipe clamp

The pipe clamp is produced in four parts, two legs that will be welded to the back of the U-shaped iron and the front U-shaped iron. The two parts are then bolted together with hot dip galvanized M10 bolts to ensure that the construction does not fall down no matter what. The dimensions of the pipe clamp are greater than the actual need to ensure that it does not break under any circumstances.

6.2 Hood

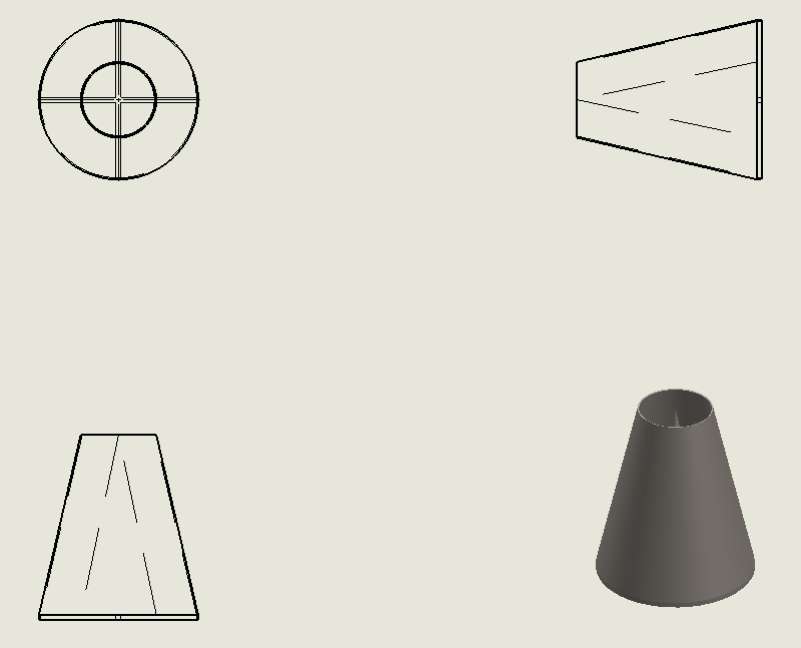


Figure 6.3: Hood

The hood is made from two conical milled pieces which are welded together on a cross that allows leafs to pass without getting caught. The inner conical piece spreads the water so it hits the side of the outer pipe and runs down the side. This is useful as the water wont fall through the inner pipe immediately. Because of this function the space between the two pipes is filled before overflowing. The top of the hood can vary in size after which size of drain it needs to be connected to and can easily be made bigger if needed.
The hood is attached to the outer pipe with self tapping screws that can be removed easily if needed.

6.3 The valve

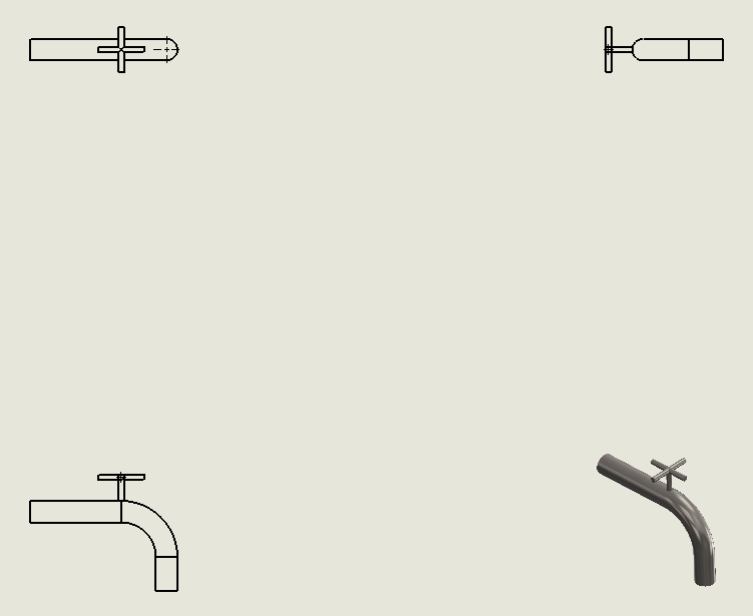


Figure 6.4: Valve

We want to deliver our solution with a basic valve, but we will attach it with a standard ” fitting so that it easily can be changed if there would be any need or desire to do so.

6.4 Outer pipe

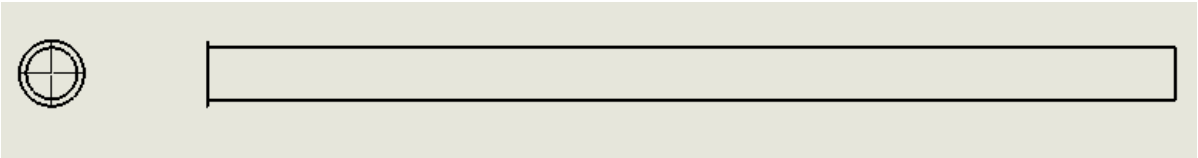


Figure 6.5: Outer pipe

The outer pipe consists of the pipe itself and the flange at the bottom. The flange is made as small as possible in order to keep the solution less space consuming, while still being big enough to hold a rubber gasket.

6.5 Inner pipe

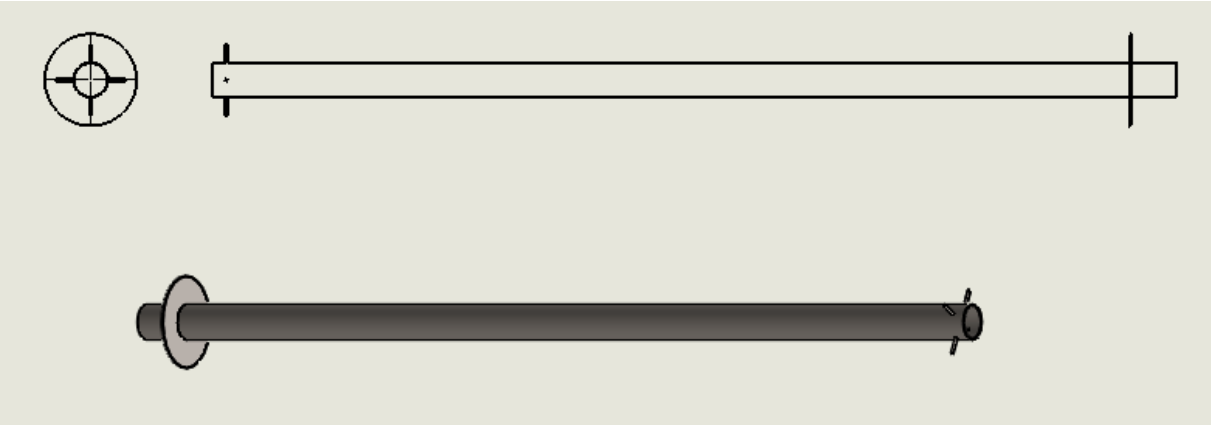


Figure 6.6: Inner pipe

The inner pipe is very similar to the outer pipe except it has four spacers at the top that keeps it centered while still making it possible to pull it down for cleaning, also see 6.9.

6.6 Coating

To ensure a cheap and lasting product we have chosen to hot dip galvanize our solution.

Figure 6.7: Coating

We have chosen this kind of coating over a normal galvanization because of the better protective properties. If the customer chooses it, it is possible to paint over the coating if they think it fits better to the area it is placed in.

6.7 Capacity

Through the process of designing the product, we have made several calculations with regards to the capacity/volume of the space between the inner and outer cylinder/pipe. Using equation 1:

$$Volume = Outerpipe - Innerpipe = (\pi \cdot r^2 \cdot h) - (\pi \cdot r^2 \cdot h) \quad (1)$$

The calculations is as follows in table 1 with typical pipe dimensions, the one marked in green is the prototype:

Inner pipe, mm	Outer pipe, mm	L/m	L per 2m	L per 3m
76	100	3,3	6,6	9,9
76	110	5,0	9,9	14,9
76	140	10,9	21,7	32,6
76	150	13,1	26,3	39,4
76	200	26,9	53,7	80,6

Table 1: Calculation for different pipe solutions

The dimensions of the solution can be seen on the drawing below:

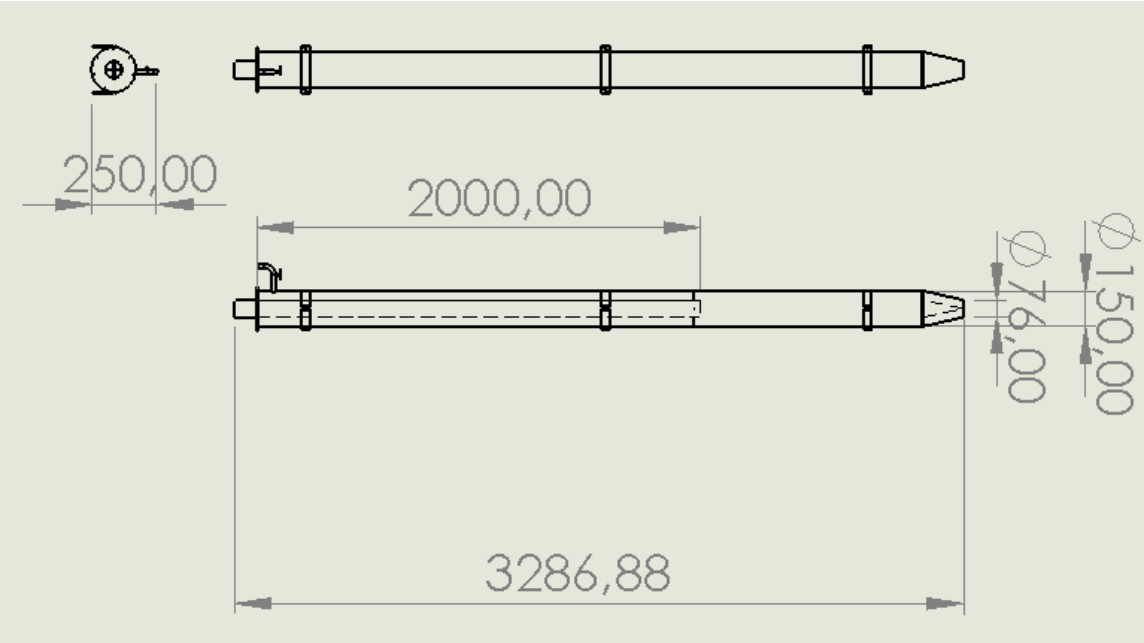


Figure 6.8: Solution dimensions

6.8 Cleaning

If the space between the outer and inner pipe gets clogged with various unwanted dirt it is possible to loosen the bolts holding the inner and outer pipe together in order to create a space for cleaning.

The inner pipe weighs around 10kg and it is therefore possible to easily drop it down and clean it, lift it up and then bolt the pipe shut again.

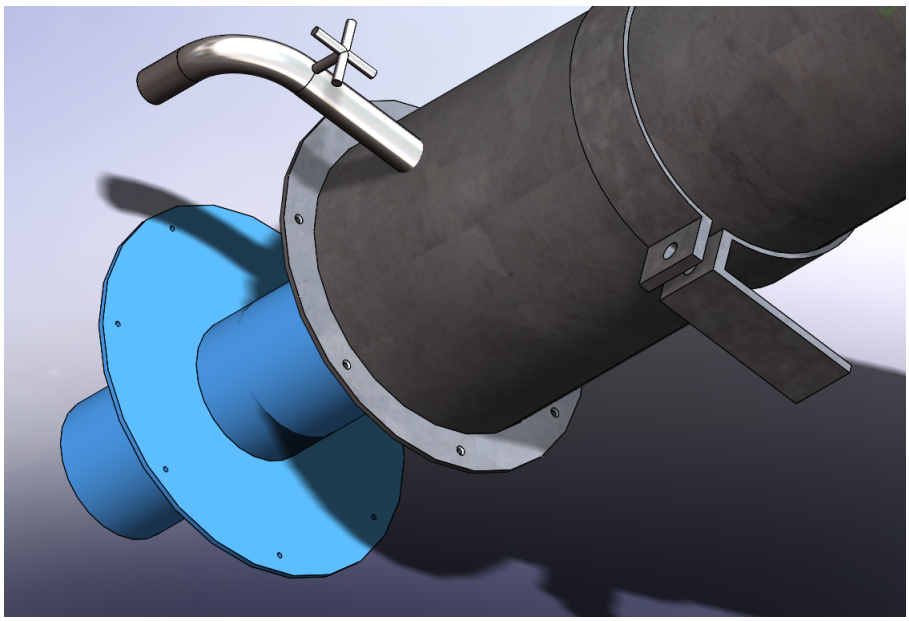


Figure 6.9: Cleaning solution

6.9 Legality

In this paragraph we will look through specific legal issues that have to be obliged to follow in order to install our product.

The following quotes are all translated from the municipality's guide to collect rainwater. C.

"There are no requirements or rules from the authorities. The individual citizen can connect the rainwater container on the drain and use the water directly for watering. If the drain has previously been connected to the sewer, the sewer must be plugged and Copenhagen Energy must be informed. Plugging the sewer must be carried out by an authorized plummer.
Installations where rainwater is used for edible plants must meet the requirements for water quality in the Executive Order on water quality and supervision of water supply facilities. (Cf. §5, subsection 1 on washing and §5, subsection 2 on watering). The water must, amongst other things, be checked for microbiological parameters and live up to the requirements for drinking water."

It can be concluded that it is legal to mount and to collect rainwater with our solution, but if the water is going to be used for watering edible plants, there are other things to consider. This is further specified in the quote below:

"When collecting rainwater you have to be aware of the materials used for the roof and gutter surface. Some surfaces will pollute the water with pollutants, which means you will not be able to reuse the water for watering edible plants. It however can be used for any other types of plants. The specific surfaces consists of:

- Zinc and Copper
- Asbest, also known as Eternit. These are usually on buildings pre 1988
- Asphalt roofing which contains bitumen. After a couple of years the roof does not contain the pollutant anymore."

We have also looked through the general norm "Bygningsreglementet" but found no noticeable requirements to installing the product, as it will only take place in the same spot as an already existing pipe. It is also to be noted that most drainage pipes do not connect directly to the sewer, and therefore do not need to be connected by an authorized plummer.

7 Economic perspective

In this paragraph we will go through the process of determining the price of our solution and create a business plan. We will look into aspects of customer relationship, market potential and cost structure.

7.1 Price determination

To determine a realistic price the three C's of pricing [2] has been taken into consideration:

- Costs
  - The cost of manufacturing is estimated to 1500DKK. This is based on a quick estimate given by a blacksmith and might be higher if we cannot produce the product in-house. It takes into account the price of materials, processing and work hours.
- Customer
  - When interviewed, the target group estimated the worth of the product to 2000DKK which we interpret as the price they see fit for such a product.
- Competitors
  - The cost of the closest equivalent products from competitors is around 2000DKK, [4]. E.g: 5.2

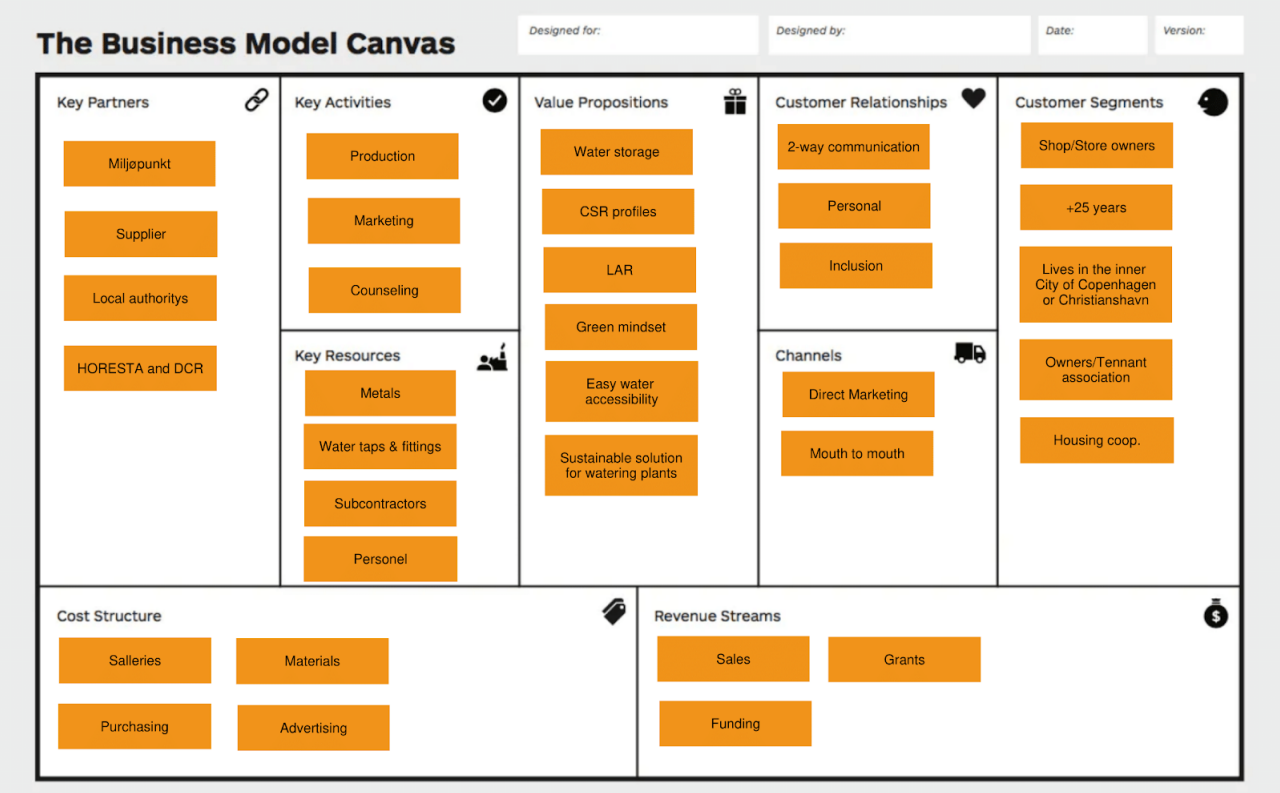
Based on the variables above, multiple pricing strategies are relevant:

- Cost-plus pricing
  - Calculated costs plus a mark-up
- Competitive pricing
  - The price is mainly based on the competitors. Value-based pricing
- Value-based pricing
  - The price is mainly based on how much the customers believe the product is worth E.g: 5.2

Since the three C's are so close to each other the outcome of the pricing strategies above will be the same. **The price should be 2000DKK with a 25% profit margin.**

7.2 Business plan

Our business model is documented by the business model canvas below:



The business model canvas [3] is a visual summary of all the key building blocks in our business model. It contains key details about our target group, marketing strategy, value proposition and stakeholders. With all these building blocks taken into consideration the business model and pricing of 2000DKK is deemed realistic.

8 Discussion and Prospect

Our Concept has overall been embraced by everybody we have shown it to, but it is far from a finished product. We saw that the user, and hereby shop owners, think it is a great idea. We have not had contact with any property owners in the Inner City which makes our data biased by users and that is an important segment data we are missing. Many property owners are businessmen, or large investment corporations, with profit in their minds could be a potential challenge when having to convince them to invest in our concept, because 'what value would they benefit from it'. Some of them could use it in their CSR profile if they have one, but apart from that it is difficult to see their gains. An advantage is that it is relatively cheap to install, so if we can nudge the tenants to demand it from landlords, the owners can easily and cheaply fulfill these demands.

Some roofs, gutters and downspouts are toxic and therefore its not allowed to use the water for watering edible plants. Cleaning our system is something which could be optimized. It could turn out to be troublesome or problematic to actually take out the whole inner pipe in order to clean it. An option could be fastening part of the inner pipe directly to the outer pipe. This would require a second flange and rubber gasket to keep it shut at the intersection, but would increase the risk of a leak. We have also considered making a cleaning hole from which you could flush the pipe with water to clean the sides of the bottom when it is taken out.

Some of the buildings in the inner city are listed and have special demands for how they should look, therefore we need to examine these demands further. Also we could use Miljøpunkt connection with the municipality to make it possible for building owners to use our solution, before we start manufacturing. When looking at the sustainability goals it is not clear how much the solution actually would help. The pipe's limited capacity is its downfall, but the size of the solution would make it possible to install many places and thereby collectively collect a lot of water.
In relation to further development it would be relevant to look into different opportunities in filtering. Implementing a filter could make the solution fitted for watering of edible plants and drinking.
Furthermore creating module options, for easier extension or replacement of parts of the solution would be evident as well as looking further into the possible problem supporting the solution to avoid it dragging down the gutter. We evaluated that Wavin UV would be too expensive to implement, despite the benefits of it in relation to the volume of the water. Creating a cheaper solution with the same overall functionality would be an evident prospect. Not only could it mean that more water could be stored in the pipe, but the air-poor water could potentially limit algae growth too. Nevertheless an option for treatment of algae growth and the effects of these in still water should be examined further.

The price of the product is hard to determine precisely. The price a factory puts on a product can vary after demand and the method of production. On the other hand if we buy too much we would have to have some kind of storage for the units, which adds in new depths to the determination and realisation.

9 Conclusion

Through a thorough research and innovation process, we have successfully created a solution that shows how it is possible to gain from the drain. The solution is a pipe-in-pipe system that comes in various sizes and holds between 20 and 30 liters of water in just a 2m pipe. It also features a tap for draining the water and to fill up a watering can.

We have furthermore created a realizable business model and collected interviews and observations which proves that the solution can make the market.

10 References

[1] Miljøpunkt Indre By Christianshavn. *Årsberetning for det lokale miljøarbejde i 2018 for Miljøpunkt Indre By Christianshavn*. URL: `https://www.kk.dk/sites/default/files/edoc/Attachments/23152485-32246423-1.pdf`. (accessed: 21.08.2020).

[2] Elnora W. Stuart Michael R. Solomon Greg W. Marshall. *Marketing: real people, real choices*. 9th edition. Pearson, 2008, pp. 204–217. ISBN: 978-9063693275.

[3] Y. Pigneur A. Osterwalder. *Business Model Generation*. John Wiley Son, 2010. ISBN: 978-0596804176.

[4] Føtex. *Pure regnvandstønde*. URL: `https://www.foetex.dk/produkter/pure-regnvandstoende/100347741/`. (accessed: 21.08.2020).

Appendices

A Testdesign

Vi vil gerne undersøge hvorfor folk ikke benytter sig af regnvand og hvis de gør hvordan de så gør det.

Benytter du dig af regnvand?

- hvis ja, hvordan?
- hvis nej, hvorfor ikke?

Har du nogle ideer til hvordan det kunne løses?

Hvilke udfordringer ser du i følgende løsning?

- Vis informanten den ene løsning efter den anden og forklar konceptet.

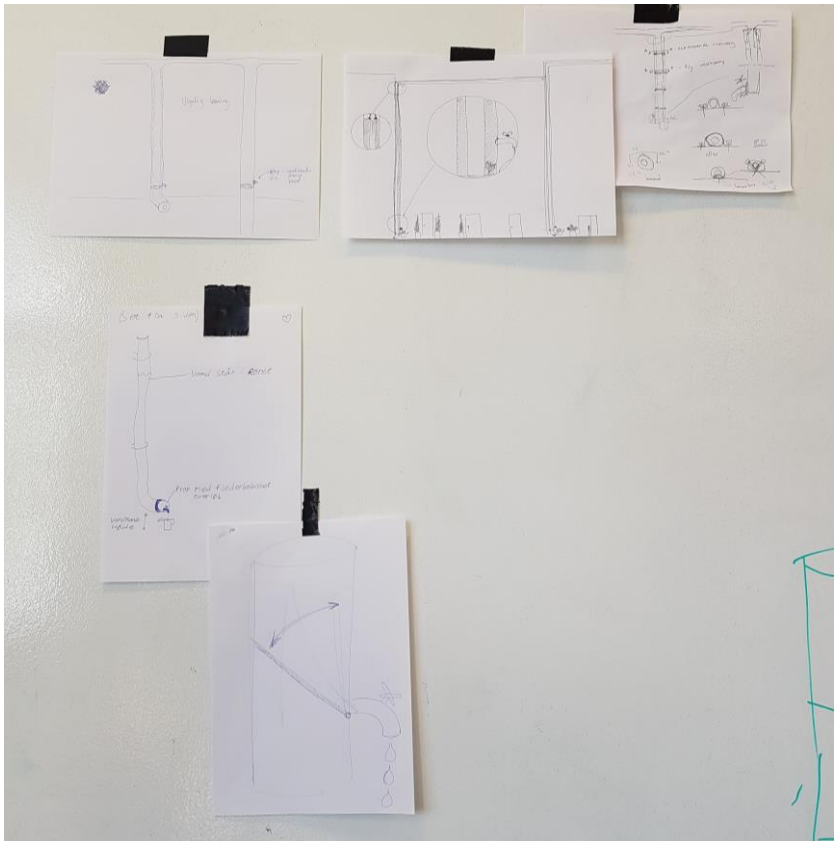
  Hvad er sådan en løsning hver hvis du skulle købe den? kvalificeret bud...

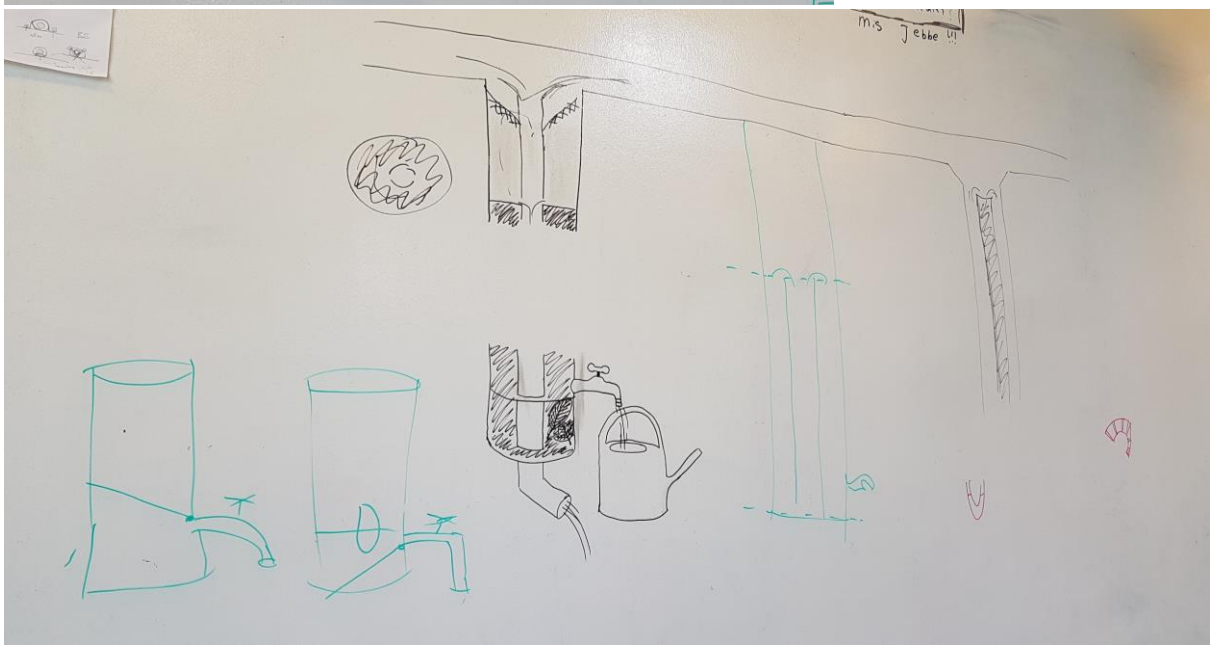
Svar på undersøgelse findes i dokument: Test Phase B

B Test phase

Test phase Loop 2

Løsningsforslag

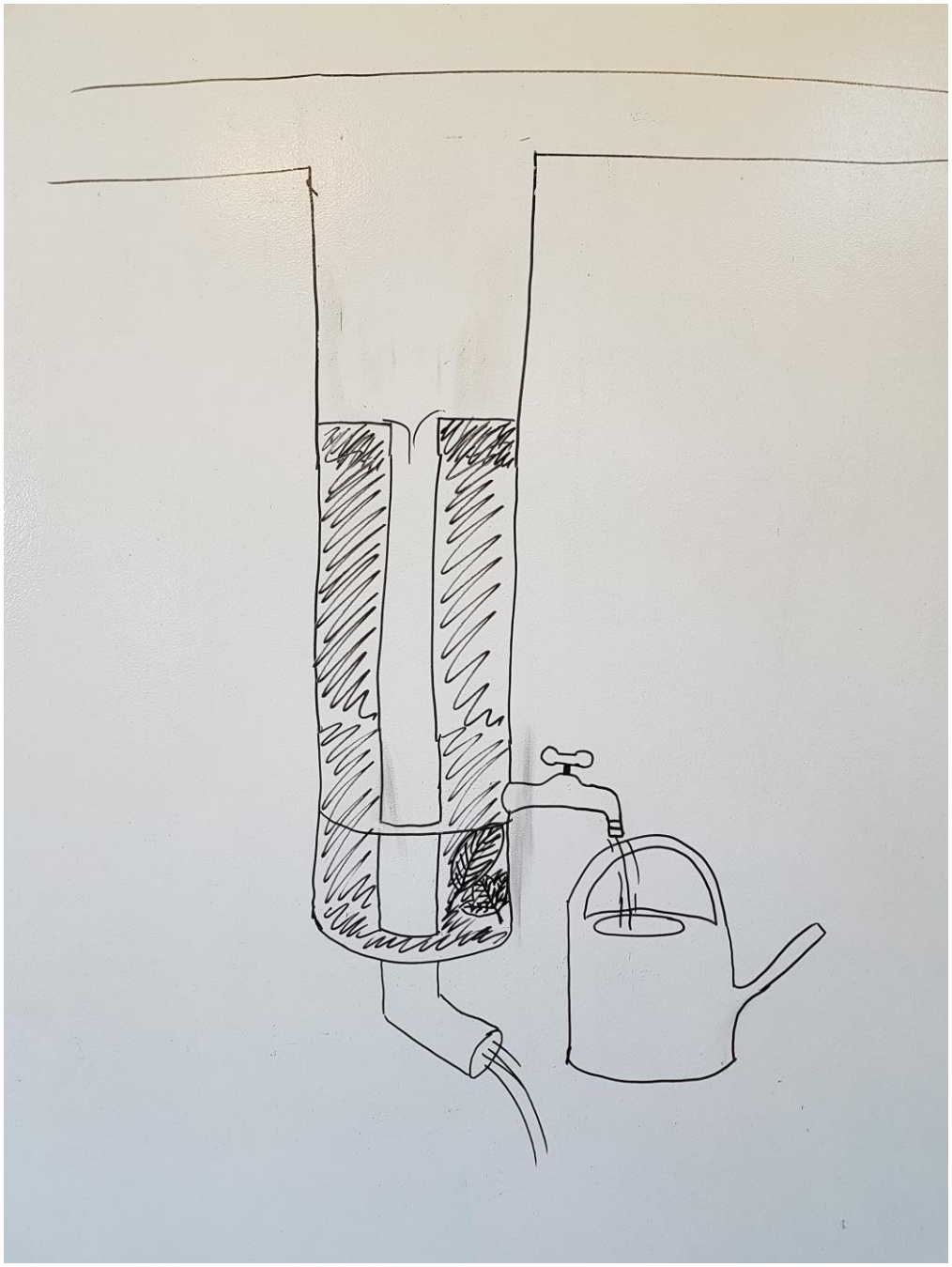




Indsamling af emperi
Test design - skitser på papir og vis til folk
Vise eksisterende løsninger til folk
Snakke med installationslektorer

Løsninger på markedet

Vores forslag



Observation

Nyhavn

- Business model
    - worth it?
    - 0 kr m 5000000kr profit

- Er motiveret
    - problem m ejerne
    - flere tusind kr.
- Brug for meget volume
- Baggård
- Synlig vs. **Usynlig** (flest vil gerne have usynlig)
- Lejere vs. **Ejere**
- Villighed til at betale (gårdhave)

Nørrebro

- Forkert målgruppe - lejer sig ind.
- Lejere vs. **Ejere**
- Bekymring for kommunen - stationære ting
- Volumen for lille
- Tagrender inde i riller - kan være problem pladsmæssigt
- Space issue
- Uvidenhed om lovgivning
- Information uoverskueligt
- Volumen
- Bekymrede for kommunen, ikke hærværk

Christianshavn

- Stor variation af nedløbsrør
- Mindste nedløbsrørs dimension
- Nederste del af tungt metal
- Ejere, foreninger og baggårde
- 7-8 forskellige ejerforeninger i én baggård
- Volumen
- Manglende information
- Samlinger - stor forskel på cases
- Svært med en universel løsning
- Rensebrønd
- Ingen høje træer - blade i tagrender ikke problem
- 15-18 m høje bygninger

Interviews Eksperter

Michael Mast - Lektor DTU Diplom, HVAC, Byggeri og Infrastruktur

- Rensning - indsæt bundventil til tømning

- Frost om vinteren kan være problem. Men måske materiale afhængig - lav forsøg for at tjekke.
- CO2 omkostning i produktion (miljø)
- Plads - Kommune/lovkrav
- Hærværk
- Flere aftap så enkelte etager kan bruge den til vanding af fx. altankasser
- Undervisning
- Behov - er det til parken eller 5 potter??

Jesper Molin - Lektor DTU Diplom, HVAC, Byggeri og Infrastruktur

Innovation: Projektleder for "Laboratorium for grønne tage"
tlf. 31362414

- Tjek filtre til regnvand - mener plastmo har lavet nogle.
- Vand løber langs yderkant at rør, tunge ting (sten, skidt) løber naturligt i midten. Derfor ser løsningen med rør-i-rør ud til at kunne fungere rigtigt godt
- Problem - vinter - frost. Tror ikke det er materialebestemt.
    - Indfør evt. en automatisk ventil.
    - Bedre med en løsning der fungerer 100% - vil folk gerne betale for
- Tjek Wavin UV system. Indvendig tagnedløb 56mm. Undertryk i rør - vand suget nedad/vandret i rør. https://www.youtube.com/watch?v=YJKMlKPuqjg
- Montage - evt. lav standard mål 6m som monteres nemt ved at save stykke af, indsætte, montage med muffe/dut etc.
- Flere modeller alt efter ambitionsniveau
    - tykkelse af rør
    - størrelse
- Kombiner med:
    - facadevægge
    - grønne kiler i nedløb
    - grønne nedløbsrør (tjek online - mener der findes sådan en løsning)
    - selvvanding
    - Klik system (beholder)
    - Faskiner / Gro rockwool
- Gro Rockwool (bruges af planteskoler) opsamling af vand
- Synes generelt at det er en god og spændende ide!

Solbritt Christiansen - Lektor, Civ. ing. DTU Diplom, Forsyning og miljø

- Tagbelægning (forurening) kan være problem. Men hvis man ser bort fra dette….
- Lav løsning hvor design er key factor
    - pænt at se på

    - Kbh kommune går ind for smukke ting - skraldespande etc. der pryder bybilledet
    - nemt måde at score point på
- Mængder: Tjek SBI anvisning (vandinstallationer) ang. hvor meget vand pr. m2 tag
- Reproducerbart
    - mål og str der passer
- Vandalisme kan være et problem
- Rensning kan være problem
- Volumen
    - tænk ikke på at redde hele verden men i stedet på det man bidrager til
- FOLE haven (Køgevej) - sender materiale på mail
    - Marina Bergen
    - Samler regnvand fra tagnedløb
    - kører det i ledning under fortov
    - fører over til et 3m. højt reftehegn med beplantning
    - bruger særligt rockwool til at holde på vandet til planterne
    - skaber
        - udnyttelse af regnvand
        - et rum til folk
        - samvær
- Brug Miljøpunkt - kan de bidrage med kontakter, forhandling af ide, hvem man skal tage fat i hos kommunen for at kunne slå igennem med produktet
- Har produktet noget som de andre løsninger ikke har?
- Præsenter helt sikkert produkt for Miljøpunkt
- Synes generelt at det er en rigtig god ide

Valg af løsning: Rør-i-rør

Steps

- Proto
- Markedsanalyse
- Undersøg tekniske midler
    - Wavin (sug effekt - 56mm rør) Se produktblad i Loop 2 samt video https://www.youtube.com/watch?v=YJKMlKPuqjg
    - Plastmo - filtre til regnvand - hvirvel filter (https://www.regnvandstanken.dk/produkt/hvirvelfilter-til-regnvandstank/)
- udregn forskel volumen på str. af rør

Voluminer

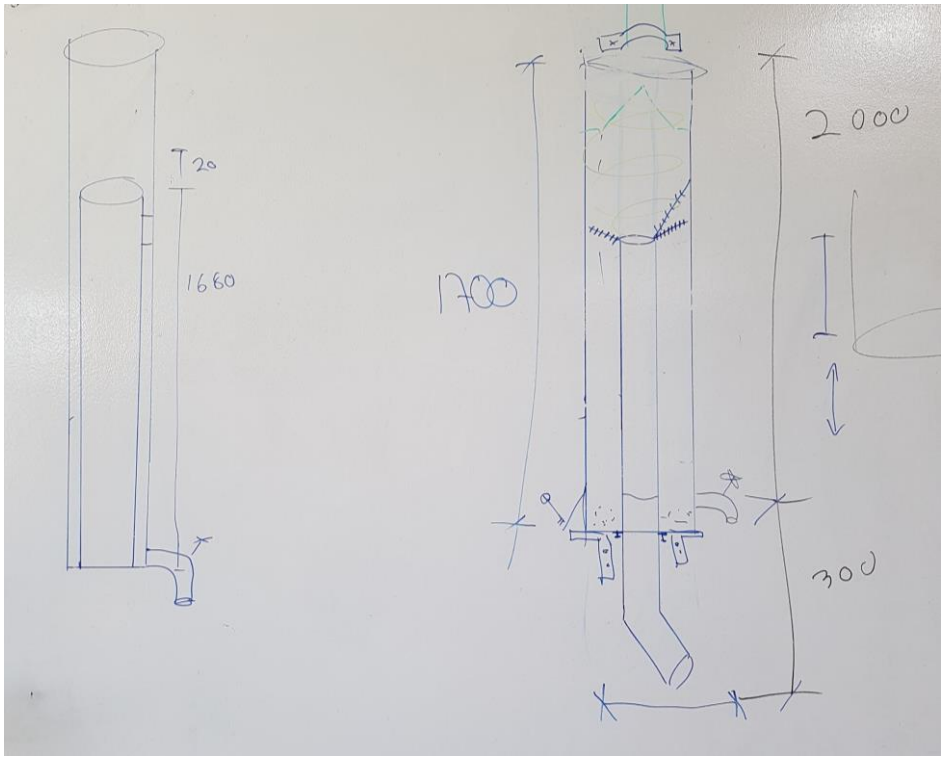
Baseret på standardmål

Type	Indre dia [m]	Ydre dia [m]	Volumen [L/m]	Vol. pr. 1,68 m [L]	Vol. pr.5,68 m [L]
Zink	0,076	0,100	3,3	5,5	18,7
Plast	0,075	0,110	5,1	8,6	48,9
Plast	0,075	0,160	15,7	26,7	151,7
Plast	0,075	0,200	27,0	45,4	257,9
???	0,076	0,150	13,3	22,3	126,7

Plastrør (PP) forekommer i standardmål: 110, 125, 140, 160, 180, 200mm

Design

Alle mål er i mm. Længde Indvendigt rør 1680mm, udvendigt 1700mm = 20mm overløb.



Inspiration

Tudstykke

C Vejledning til spildevand

København Kommune

Opsamling og anvendelse

December 2011

Københavns Kommune

Opsamling og anvendelse

December 2011

Ref.: Opsamling og anvendelse

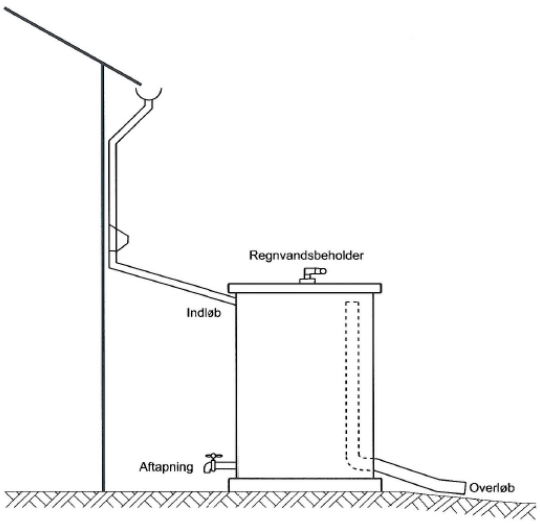
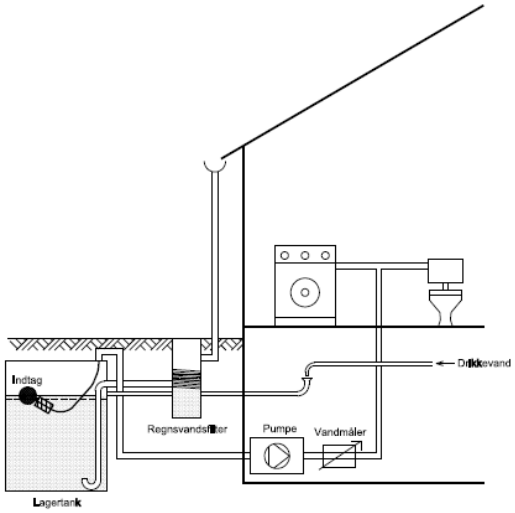
Udarbejdet af:
- Rambøll Danmark A/S
- Erling Holm ApS
- KU, Skov og Landskab
- DTU Miljø
- Orbicon A/S

Indholdsfortegnelse

1. DATABLAD

Opsamling og brug af regnvand sker normalt på to måder:

a) Tagvand opsamles i en beholder til havevanding
b) Tagvand filtreres og opsamles i en lagertank, hvorfra det pumpes til toiletter og maskiner for tøjvask.

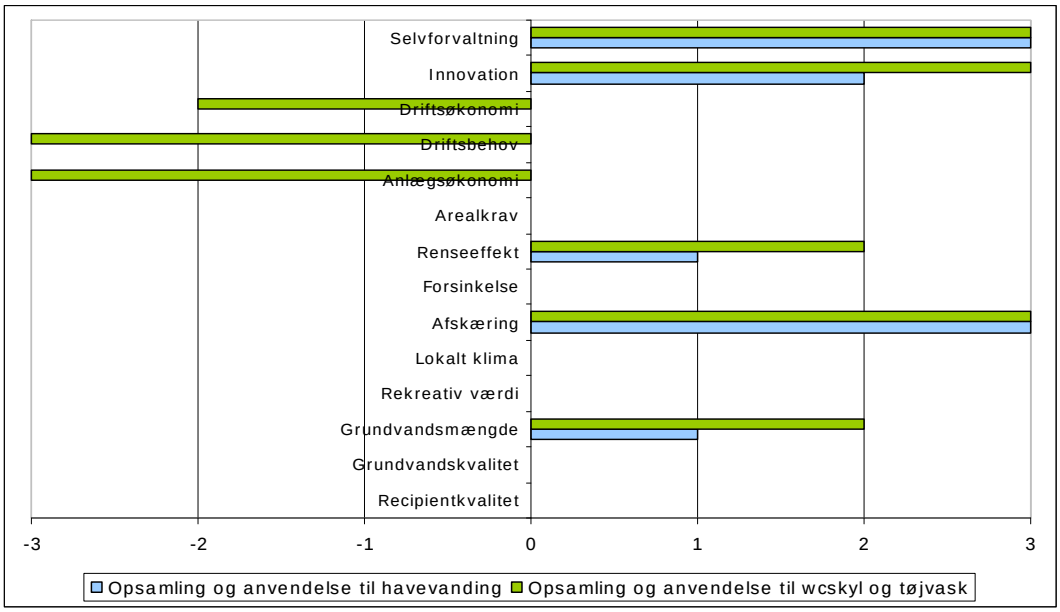
Opsamling til havevanding	**Opsamling til wc-skyl og tøjvask**
	

Begge former for opsamling kan anvendes ved enfamiliehuse, etageejendomme, erhvervsejendomme mv.

Ved metode a) kan vandet anvendes til havevanding.

Ved metode b) kan vandet fra egnede tagflader med tegl, beton og skiffer anvendes til toiletskyl og tøjvask. Vandet kan desuden bruges til vask af biler, maskiner mv. samt til forskellige former for vanding på fx idrætsanlæg og boldbaner. Der må kun anvendes regnvand, som er opsamlet på egnede tage. Der må aldrig anvendes regnvand opsamlet andre steder, som f.eks. fra veje og pladser.

Væsentligste egenskaber		a)	b)
	Reduktion af vandvolumen	Høj	Høj
	Reduktion af intens regn	Høj	Høj
	Fjernelse af suspenderet stof	Middel	Middel - høj
	Fjernelse af kvælstof	Lav	Høj
	Fjernelse af tungmetaller	Lav	Lav
	Fjernelse af oliestoffer	Lav	Lav
	Fjernelse af pesticider	Lav	Lav
	Landskabelig værdi	Ingen	Ingen
Drift og vedligehol	a)	Rensning af tagrender og nedløbsrør	
		Tømning af beholderen om vinteren	
		Inspektion og rensning af evt. filtre samt beholdere	
	b)	Rensning af tagrender	
		Inspektion og rengøring af lagertank, sandfangsbrønd og regnvandsfilter	
		Tilsyn og vedligehold af pumper og styresystem	
Fordele	a)	Erstatter brug af drikkevand	
		Nem og billig at installere og vedligeholde	
	b)	Erstatter brug af drikkevand	
		Kalkfrit vand til toiletter og vaskemaskiner, der mindsker sæbeforbruget.	
Ulemper	a)	Ingen rensning af vandet	
	b)	Kræver en del tilsyn og pasning af anlægget for at sikre vandkvaliteten	
Økonomi	a)	Lave omkostninger til anlæg og drift	
	b)	Rentabelt i nybyggeri. Kan være en dyr løsning i eksisterende byggeri	



Samlet vurdering af opsamling og anvendelse af regnvands egenskaber som LAR-metode i forhold til afledning af regnvand til fælleskloak. Hvor der ikke er angivet nogen værdi, er metoden vurderet at have samme egenskaber som den nuværende afledning af regnvand.

2. OPSAMLING TIL HAVEVANDING

2.1 Generel beskrivelse

2.1.1 Opbygning og funktion

Regnvand fra taget ledes via tagrende og nedløbsrør til en beholder, der er koblet direkte på det enkelte tagnedløb. Beholderen anbringes for det meste på jorden, men den kan også være gravet helt eller delvist ned. For at undgå, at der samles blade og andet bundfald i beholderen, kan der anbringes et grovfilter, inden regnvandet løber ned i beholderen.

Nær ved bunden er beholderen forsynet med en hane, hvor vandet kan aftappes til en vandslange eller en vandkande. Beholderen kan også være forsynet med en lille dykpumpe, så regnvandet pumpes ud til havevanding eller kobles på et drypvandingsanlæg i et drivhus.

Udløbet fra beholderen bør ikke være placeret helt i bunden, hvor der ofte samles bundfald, som let kan stoppe hanen. Dette gælder især, hvis der ikke er anvendt et grovfilter før beholderen.

Nogle tagmaterialer kan afgive stoffer til regnvandet. Regnvand fra følgende tage bør derfor ikke bruges til at vande køkkenhaver med spiselige afgrøder, men kan godt bruges til vanding af blomster og andre planter:

- tage og tagrender af zink og kobber
- tage med asbest. Eternittage fra før 1988 indeholder næsten altid asbest.
- tage med tagpap, som indeholder bitumen. Forurenende stoffer fra tagpap frigives dog mest i de første år, efter at taget er lagt.

Regnvandsbeholderne kan være lavet af træ, metal, plast (polyethylen) eller andre materialer, som er modstandsdygtige over for sollys. Der kan også bruges større såkaldte palletanke, men de er ofte vanskelige at passe ind i omgivelserne og kan være klodsede at se på. Beholderne skal have et tætsluttende låg, så insekter, snegle mv. ikke kan kravle ned i beholderen.

Med mindre beholderen isoleres eller graves ned til frostfri dybde (ca. 80 cm) er der risiko for at evt. vand i beholderen fryser, og at beholderen sprænger. Regnvandsbeholderen bør derfor være tømt for vand om vinteren.

I perioder med meget nedbør vil beholderen ofte blive fyldt. Den skal derfor forsynes med et overløb. Vandet fra overløbet kan blot løbe ud på jorden eller ledes til beplantninger, der kan tåle meget vand, se f.eks. metodebeskrivelsen om Regnbede. Hvis vandet fra overløbet, løber ud over jorden tæt på en bygning, skal der være mindst 20 ‰ fald på jorden væk fra huset for at undgå, at vandet trænger ind i bygningens fundamenter.

2.1.2 Krav fra myndigheder

Der er ingen krav eller regler fra myndighederne. Den enkelte borger kan koble regnvandsbeholderen på tagnedløbet og bruge vandet direkte til havevanding. Hvis tagvandet tidligere har været tilsluttet kloakken, skal denne afproppes, og Københavns Energi skal orienteres. Afpropning af kloakken skal udføres af en autoriseret kloakmester.

Anlæg, hvor der anvendes regnvand til spiselige afgrøder, skal opfylde kravene til vandkvalitet i Bekendtgørelse om vandkvalitet og tilsyn med vandforsyningsanlæg. (Jf. §5, stk. 1 om vaskning og §5, stk. 2 om vanding). Vandet skal således bl.a. kontrolleres for mikrobiologiske parametre og leve op til vandforsyningskravene for drikkevand.

2.1.3 Renseeffekt

Der sker ikke nogen væsentlig rensning af regnvandet, når det opsamles i beholdere. Der sker dog en sedimentation i beholderen, som kan fjerne små mængder af suspenderet stof, tungmetaller, PAH'er og eventuelle pesticidrester. Når regnvandet bruges til havevanding, sker der en rensning både ved optag i planter og ved filtrering gennem jordlagene.

2.1.4 Landskab og beplantning

Regnvandsbeholdere står ofte synligt udendørs, og der findes forskellige muligheder for at indpasse beholderne i omgivelserne. Der kan f.eks. vokse planter op ad dem, så de på den måde glider ind i haven, eller de kan placeres i kombination med anden "inventar" som f.eks. terrasser, havemøbler og legestativer, eller afskærmes bag f.eks. et flethegn, se figur 2.1.

Figur 2.1 Eksempel på afskærmning af opbevaringsbeholder i en privat have

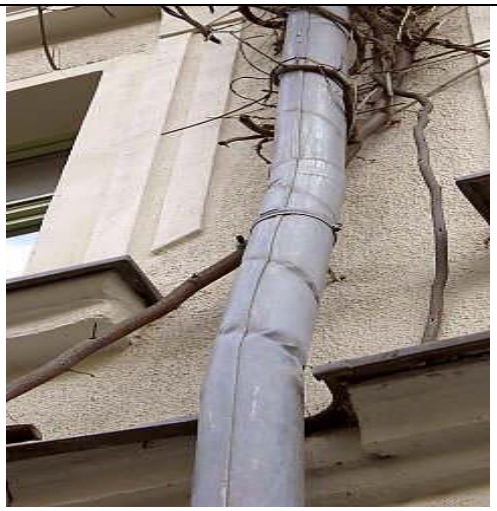
Tæt buskads, espaliertræer og hurtigvoksende slyng- og klatreplanter er velegnede til at skjule opsamlingsbeholdere. Samtidig skygger planterne, så vandet i beholderen ikke bliver varmet op af solen.

Særligt til private haver er der mange plantearter og -sorter at vælge mellem. På offentlige arealer begrænses valget til planter med et lille plejebehov. Ofte vil arter, som hører naturligt hjemme i Danmark, være bedst egnede. I nogle områder kan der endvidere være behov for at skabe sikkerhedsmæssig barriere, så børn ikke leger på eller med regnvandsbeholderne. Her vil buske med torne være egnede.

Nogle slyng- og klatreplanter har stængler, som kan ødelægge nedløbsrør og andre dele af anlægget. Følgende arter kan derfor ikke anbefales:

- Arkitektens Trøst (Polygonum aubertii)
- Rådhusvin (Parthenocissus tricuspidata "Veitchii")
- Efeu (Hedera helix)
- Blåregn (Wisteria sinensis /floribunda/frutescens)

Hvis disse planter benyttes for at opnå en hurtig begrønning af en stor flade, skal det sikres, at opbindingssystemet slutter mindst 1,5 m fra nedløbsrør og andre rør.



Figur 2.2 Nedløbsrør deformeret af blåregn (Wisteria)

Eksempler på velegnede slyng- og klatreplanter er:

- Vildvin (Parthenocissus inserta/vitacea)
- Diverse clematis (Clematis viticella /diversifolia /tangutica /montana /vitalba)
- Krybende benved (Euonymus fortunei Coloratus/ Radicans)
- Humle (Humulus lupulus)
- Klatre-Hortensie (Hydrangea anomala/ petiolaris)
- Almindelig Gedeblad (Lonicera periclymenum)
- Klatreroser (Rosa spec.)
- Brombær (Rubus fruticosus)
- Vinterjasmin (Jasminum nudiflorum)

Figur 2.3 Nedløbsrør dækket af storblomstret clematis, sandsynligvis af sorten "The President" (Foto: Papilio, www.mein-schoener-garten.de)

2.1.5 Begrænsninger for anvendelsen

I tabel 2.1 er opsamling af regnvand til havevanding vurderet i forhold til en række lokale faktorer, som kan begrænse, ændre eller påvirke anlæggets udførelse og drift.

Faktor	Påvirkning af anvendelse
Grundvand	Ingen
Jordbundsforhold	Ingen
Pladsforhold/arealkrav	Ingen væsentlige krav. Beholderne optager meget lidt plads
Forurening i jorden	Ingen

Tabel 2.1 Oversigt over forhold, der kan påvirke eller begrænse anvendelsen af anlægget til opsamling af regnvand til havevanding

Regnvandsbeholderen skal placeres, så overløb fra beholderen ledes væk fra bygninger. Der skal være et fald på minimum 20 $^{o}/_{oo}$ på jorden væk fra huset.

2.2 Anlægsdele

Et typisk anlæg til opsamling af regnvand direkte fra et nedløbsrør består af følgende:

- Beholder på 400–600 liter, inkl. tætsluttende låg og hane.
- Grovfilter til montering på nedløbsrør eller på rør mellem nedløbsrør og beholder.
- Rør og fittings mellem nedløbsrør og beholder
- Rør og fittings til overløb
- Fliser eller andet fundament for beholderen. Fundamentet skal kunne klare trykket fra en vandfyldt beholder på 400-600 kg. Hvis der skal kunne fyldes en vandkande fra aftapningshanen, skal beholderen være hævet over jorden.

Figur 2.4 viser en typisk regnvandsbeholder i en parcelhushave.