Innovation Report

Loop 2

MILJØPUNKT
AGENDA 21 · FOR ET BÆREDYGTIGT KBH

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For a greener Copenhagen

Byggeri og infrastruktur

Elektroteknologi

Process og innovation

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Executive summary

The city of Copenhagen is aiming to be a leading green city and increase the amount of plants throughout the city, this however is proving to be challenging to implement in a dense urban environment. The organization Miljøpunkt provided a case with the agenda on how to make Copenhagen more green, for the course Innovation Pilot at DTU.

Green Builders, a team of five engineering students, worked with the problem definition through the six week summer course. Through research and interviews with the community of Copenhagen, we noticed a trend: The community agreed that an increase in plants throughout the city would be well taken but were often discouraged to contribute themselves.

Green Builders goal is to implement a solution for the city administration of Copenhagen that is sustainable, requires low or no maintenance by the community and can fit into the urban scene of Copenhagen. Through using the urban space inventory in the city, specifically the iconic "Københavner bænk" and trash bins, we could achieve our goal.

We designed four prototypes which were implemented as the concept Green Urban Focus (GUF). These prototypes are add-on modules to the existing benches and bins throughout the city. It was vital for us that we could use the existing inventory in order to save material and provide a more sustainable solution.
On a 1 km walk through the inner city of Copenhagen, we encountered 27 bins and 43 benches, thus implementing our solutions to these will visually increase the amount of plants significantly throughout the city.

Through prototype tests on Fiolstræde in Inner Copenhagen, we received positive feedback from more than 50 people. They believed our solution provided a much needed green touch to the city and it was nice that the existing inventory solutions could be utilized.

Green Builders has decided not to create a company to produce GUF, but instead to provide the city of Copenhagen and other relevant stakeholders with technical drawings of our design. In order to give a realistic price estimate for implementation of the module based solution in Inner Copenhagen, we obtained a rough price estimate from Gladsaxe Klip & Buk.

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Contents

Executive summary 2
Acknowledgements 3
List of figures 5
List of tables 5
Introduction 6
Loop 1 7
Loop 2 8
Reframing 8
Solution development 8
Information searching 10
Surveys 10
Observations of urban space inventory 12
City administration 13
Plant experiment 13
Prototypes 15
Prototype description 15
Test of prototype and feedback 18
Concept screening 21
Advantages & Disadvantages 22
Business 23
Business partners and target audience 24
Economy 25
Further work 26
Prototype alternatives 26
Soil composition 27
Next steps 27
Conclusion 29
Bibliography 30
Appendix 31

List of figures

Figure 1 - App GreenCPH 7
Figure 2 - Folder 7
Figure 3 - Needs-metric matrix 9
Figure 4 - Plant solutions on Christianshavn 11
Figure 5 - Multibæltet 15
Figure 6 - Lågmodulet 15
Figure 7 - Rygmodulet 15
Figure 8 - Sidemodulet 15
Figure 9 - Prototype, bench 18
Figure 10 - Prortotype, trash bin 18
Figure 11 - Prototype, backrest 18
Figure 12 - Concepts 21
Figure 13 - Concepst screening 21
Figure 14 - Prices of prototypes 25
Figure 15 - Multibæltet, alternatives 26

List of tables

Table 1 - List of urban space inventory 12
Table 2 - Plan experiment 14
Table 3 - Advantages and disadvantages of prototypes 23

Introduction

We, Green Builders, are a group of five engineering students with different fields of study. Through the course Innovation Pilot we have worked together as one unit to come up with our solution to the case defined by Miljøpunkt.

The case was presented by Marianne Spang from Miljøpunkt Indre by and Christianshavn, with the agenda of making Copenhagen more green and sustainable. Miljøpunkt is funded by the city administration, as well as other funds and stakeholders, with an interest in developing green solutions around Copenhagen. The city of Copenhagen is aiming to be a leading green [1] city and increase the amount of plants throughout the city.

During the presentation Miljøpunkt promoted - Clean air, Less noise, Green city and More recycling - as their four main focus areas. From their own research Miljøpunkt believes that some of the main challenges are the lack of time and/or resources to maintain plants around the city. They expressed that planting in soil is proving to be difficult due to the underground layout of pipes and cables.

Miljøpunkt therefore enticed the students to explore possible challenges and opportunities, to develop a solution that will enable and entice the citizens and businesses to plant more plants in the inner city of Copenhagen.

Our project was divided into two loops (loop 1 and loop 2), where we could either work two different cases, or the same case. In either case, in each loop we had to find the innovation question and all the way to a finished solution. We decided to continue with the same case in both loops.

Loop 1

In loop 1 the case presented by the organization Miljøpunkt, was to increase the amount of plants and trees in the central part of Copenhagen and Christianshavn.
Green builders as a group took on the task to find a solution for the case.

A question tree was used to narrow down the problems and help set up survey and interview questions.
The survey materials were distributed through various social media. Furthermore we made semi-structured interviews of citizens and shopkeepers in the area near Ørstedsparken, Nansensgade, Strøget and Læderstrædet.
The results of the investigations showed that the problem was a lack of easy accessible local regulations of plant establishment.
It was pointed out that citizens and companies were familiar with a long and complicated application phase, thus in many cases completely avoided the attempt to plant.
In loop 1 we decided that the product should include both citizens and shopkeepers, in order to increase the focus of a greener city and to establish a sense of ownership of the green areas.
Based on our collected data, we created our innovation question:

"How can we encourage citizens to take ownership and inspire the local communities to create a greener Copenhagen, by providing the necessary guidelines for establishing plants."

Our proposed solution to Miljøpunkt consisted of two parts. An App "GreenCPH" with several features, such as a product catalogue, "Adopter en plante" and an interactive map over the green areas in the capital. The second part was a folder to spread awareness of the App and Miljøpunkt. See Figure 1 and Figure 2 and Appendix A.

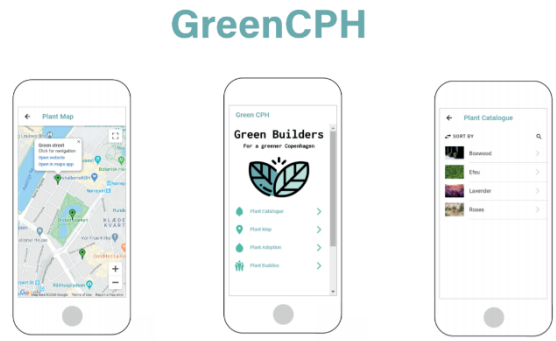


Figure 1 - App GreenCPH

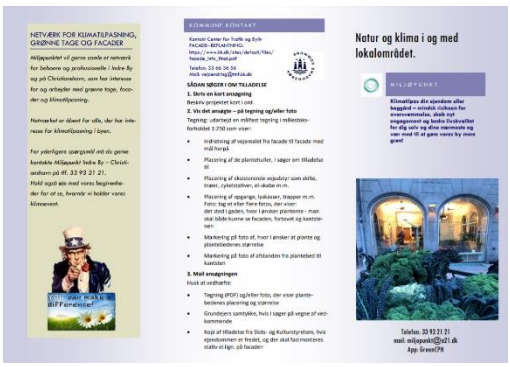


Figure 2 - Folder

Loop 2

In this section we will go through our overall process in loop 2: reframing our data from loop 1, gathering of new information, developing and testing our prototypes of our concept Green Urban Focus (GUF).

Reframing

In order to see if we had overlooked other possible problems in the first loop during our information-gathering phase, we reframed our problem definition.
We reevaluated the core of the problem and to create a new point of view.
By using different methods as the 5 whys, 4 C's and the Anti-problem, we broadened our mindset in order to find a different angle to the case.
This did not lead us to any specific new angles, we therefore took a different approach, in which we worked with our current knowledge and tried to look at possible solutions and worked our way back.

We looked at different solutions, like event based solutions but also the branding of Miljøpunkt itself. In order to properly reframe and through further discussion with the facilitators, we went back to defining "what is green?" and discussed whether we should go for a sustainable or visual green solution. The group decided to take a look on how to implement more plants in the urban space and started a discussion of who the target audience should be.

Through the interviews we conducted, we noticed that we often were met with an uncertainty around laws and restrictions on planting around the city. This was applicable for both citizens and shopkeepers around Inner Copenhagen.
Since we encountered these problems regarding laws and restrictions, we started to discuss whether the city administration should be our target customer, so that we could get around these uncertainties from our informants and still implement a green solution in the urban space.

Solution development

We took a walk in Inner Copenhagen, to look for potential ways to involve the city administration in increasing the plant population around the city. During the walk we noticed that the urban space inventory was highly represented throughout the city, but without a green touch. We observed the type and numbers of existing urban space inventory in Inner Copenhagen, and shifted our focus from getting the citizens in the city to plant, to taking advantage of existing and unused space.
This led us to our innovation question of loop 2:

"How can we sustainable contribute to a greener Inner city, by use of the existing urban space inventory?"

We chose the two most represented types of inventory, “Københavner bænk” and the round trash bins, see Appendix B, in order to have the highest impact on the urban landscape. We investigated the market for potential competitors with existing green solutions in the urban space through desktop research. There exist different bench and trash bins versions with plants, but they all have the plant solutions as an integrated part, see Appendix C.
Before developing prototypes we created a needs-metric matrix in order to easier validate if we fulfilled the customer needs in the solution we would develop.

	Bench Garbage can Customer Requirements Need / Engineering Characteristics Metric	1 Plug and play	2 unit manufacturing cost	3 Material strength	4 Green value	5 Placement	6 Multifunctional	7 Material choice	8 Sensors
1	Should be easy to throw out cigarets						x		
2	Functionality					x	x		
3	Plants should not be in the way of sitting area					x	x		
4	Sustainable							x	
5	Pretty to look at				x			x	
6	Be difficult to vandalize			x					
8	Easy to install	x							
7	Last a long time			x					
9	Low maintanence			x				x	x
10	Injury safe					x		x	
11	Affordable for the city		x					x	
12	Should be possible to add pant						x		
13	Visible as a garbage can				x	x	x	x	
14	Room for slogan 'ren kbh'						x	x	

Figure 3 - Needs-metric matrix

During the 2-weeks break we performed a qualitative plant experiment to examine the well known problems with pouring alcohol and urinating into plants. We wanted to examine the possibility of a specific soil composition by use of microorganisms to address these challenges, see section Further work.

The purpose of our solution was determined by brainstorming and through needs-metric matrix as:

- Easy maintenance
- Embellishment
- Multiple functions
- Durable solutions
- Easy implementation
- Add-on for existing urban space inventory

We constructed prototypes in cardboard with focus on the design and functionality. The prototypes formed the basis of the concept idea GUF. In order to validate and evaluate the concept we went out among citizens testing a setup of all prototypes.

During the test phase we performed two different types of tests; direct approach and observing human behavior. This was done to evaluate if the concept had the wanted effect and impact on the citizens.
By **direct approach** one group member was sitting at the bench, watching people passing by. As they stopped to take a picture or comment on the prototype, the group member actively addressed them about their opinion of the prototypes and if they liked the setup, this started a dialogue and we could gather information.
By **observing** the human behavior - meaning no group member on the bench - we observed that many people stopped to take pictures and others turned their head to see the add-on solutions when passing by.

From the test, a list of advantages and disadvantages was created in order to validate our product. From the list we saw potential for design optimizations of the prototypes in order to fit the concept best as possible to the city administrations.

Information searching

This section describes which different inquiries have been done throughout the project in loop 2. Descriptions of which interviews and observations have been made, as well as which informants we have been in contact with to support the development of our project.

Surveys

In the reframing of the project in loop 2, we decided to gather new empiri through an online survey and conversation with people on the streets of Inner Copenhagen. The purpose was to examine the opinion of citizens, shopkeepers and civic associations regarding a green city. We wanted to find out how much interest they had when it came to active participation due to maintenance and how much value they thought the green areas gave them on a daily basis. We were interested in their experience of having plants at home or plants in the urban space, both the challenges and positives they had experienced. We wanted to examine these things in order to find out what it will take for them to become more motivated to increase the green planting in the

urban space. In Appendix D, the questions for the surveys in the street are shown. Beside this we made questions for the online survey[1] to Marianne's network.

We went to interview people on the streets on Christianshavn, since our informants in loop 1 were mainly from the inner city. We wanted to see if the opinion was the same between neighbourhoods. We could not find many people who had the time to talk to us, mainly due to bad weather. From the online survey we received 9 answers and 10 from the street.

Both in the interviews and the online surveys, we found problems which corresponded to the empirical data gathered in loop 1, which where:

- maintenance
- urine and beer being poured into the plants
- long and complicated application phase
- local restrictions
- space suitable for plants above ground

The fact that the informants mainly faced similar problems, confirmed that the problems were not geographically dependent, but the few number of informants meant that continuing with the citizens/shops/civic associations as the user-target, would perhaps be problematic to gather enough evidence, giving the short period of time.

This acknowledgment led us to talk about what we had observed in our walks around Inner Copenhagen and Christianshavn during our search for people to interview. We saw that Christianshavn was better to use the empty space and had more quirky solutions when it comes to adding green in the urban space, Figure 4.

We decided to focus on the inner city, and see if we could figure out a way to implement plants in the urban space, with the city administration as the target customer.

Figure 4 - Plant solutions on Christianshavn

[1] https://docs.google.com/forms/d/1tW-0KNB56RtyUjGoiZQHw0JmMMNrn5OGXck3Ly2T6jc/edit

Observations of urban space inventory

Based on our decision we went for a walk in inner Copenhagen from Rådhuspladsen to Nørreport, a rute of approximately 1 km, for observing and documenting both the different urban space inventory and numbers. We observed, Table 1, show the selection of inventory, the full list are available in Appendix G:

Type of inventory		**Amount**
	"Københavner bænk"	43
 	Round trash bin with existing add-ons	11
	Round trash bins	16

Table 1 - List of urban space inventory

From these observations we decided to focus our solution to the "Københavner bænk" and the round trash bins shown in Table 1 based on the large number of observations.
We observed 43 "Københavner bænke" and 27 round trash bins, which indicated that these two inventories are well represented.
Therefore we decided to work with developing prototypes for these two types of urban space inventory in order to have the highest impact in the city.

City administration

In order to make sure that we are allowed to add items to the urban city inventory, Green Builders contacted the Copenhagen city administration, the department, “Teknik og miljøforvaltningen”, with knowledge about the urban space inventory.This was done with purpose to know which rules are applied for the different types of urban space inventory and to know about the possibility of implementing new solutions to the existing inventory.
In a conversation with senior advisor Jacob Hartmann from the city administration we were told:

“Hvis et projekt er realistisk, og med en ordentlig argumentation for dets bidrag til Københavns overordnet grønne plan, samt en fornuftig økonomisk scope, så er det muligt at lave forslag der vil blive taget til overvejelse og muligvis implementeret til byrumsinventaret”.

This confirmed the relevance to continue development of the prototypes and making them suitable for the city's existing urban inventory.

Plant experiment

In order to examine the problems regarding urine and alcohol in the plants we performed a 2-week experiment. The purpose of the experiment was to investigate the plants well-being when they were exposed to different liquids. These issues, which we have been informed of, are related to the nightlife of the city, where cans of beer have been emptied, or people urinating in the plants. Therefore we sat up a test, where all plants were the same species, in order to document how the plants were affected when they only were watered with:

- Water,
- Sparkling water,
- Water with a low concentration of water (200 gram/L),
- Water with a high concentration of water (500 gram/L) or
- A dilution of 5% alcohol.

This was done in order to point out the problematic components from drinks and beers when they have been poured into plants.
During the test, two plants were used for every type of liquid, in order to have a control plant of each different liquid.
The plants were watered every third day with 20mL solution and placed in a sunny spot, but not directly in the sun.

Table 2 shows the results of the test period.

Liquid / Date	**20th of July**	**23th of July**	**27th of July**	**30th of July**
Water	*Colourful flowers and buds*	*Colourful flowers and buds*	*Colourful flowers and buds*	*Few withered buds*
Dilution of alcohol ~ 5%	*Colourful flowers and buds*	*Withered buds*	*Withered buds*	*Withered buds, started to collapse*
Sparkling water	*Colourful flowers and buds*	*Colourful flowers and buds*	*Colourful flowers and buds*	*Colourful flowers and buds*
Water w. high conc. of sugar	*Colourful flowers and buds*	*Colourful flowers and buds*	*Mouldy soil*	*Mouldy soil, small flies were observed*
Water w. low conc. of sugar	*Colourful flowers and buds*	*Colourful flowers and buds*	*More buds and fresh leaves*	*More buds and fresh leaves*

Table 2 - Plan experiment

From Table 2 it can be concluded that if plants are exposed only for liquids containing a high concentration of sugar or a little alcohol it will affect the plants ability to survive. If plants only are exposed for a low concentration of sugar, the plant is able to survive due to sugar being used as fertilizer, but a high concentration of sugar will seem like poison for the plant. The environmental impact shows that the plants were able to survive with only water, but the environment is harsh and a small amount of fertilizer has a positive effect when the plants are blooming.

In order to investigate solutions to different types of vandalism, such as emptying a bottle with alcohol and urine in the plants. Green Builders contacted two associate Professors with knowledge within biochemistry and organic chemistry.

This experiment could be continued in order to examine how to deal with these problems in the city, but based on lack of time and resources this is recommended as future work with the project.

Prototypes

In the following we will describe the prototypes, the physical test, feedback from users and advantages & disadvantages.

Prototype description

During observations in Copenhagen, Green Builders noticed that the widely spread urban space inventory around the city was bland and could benefit with some plant solutions. Some of the most widely spread urban space inventory are the iconic "Københavner bænk" and trash bins, see **Fejl! Henvisningskilde ikke fundet.**. Therefore Green Builders decided to go with four prototypes, which functions as add-ons for these two types of inventory. This creates a more sustainable solution, as the city does not need to replace their urban space inventory with completely new.

We came up with the concept Green Urban Focus (GUF), which consist of the following four prototypes:

- "Lågmodulet"
- "Multibæltet"
- "Sidemodulet"
- "Rygmodulet"

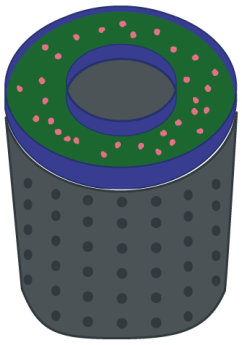


Figure 6 - Lågmodulet

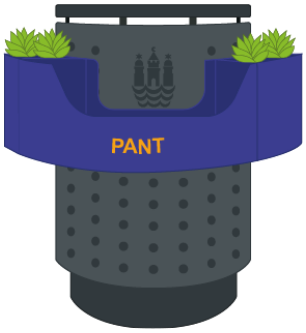


Figure 5 - Multibæltet

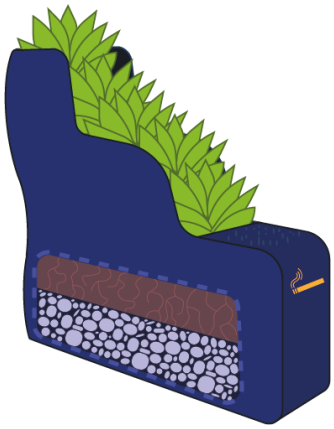


Figure 8 - Sidemodulet

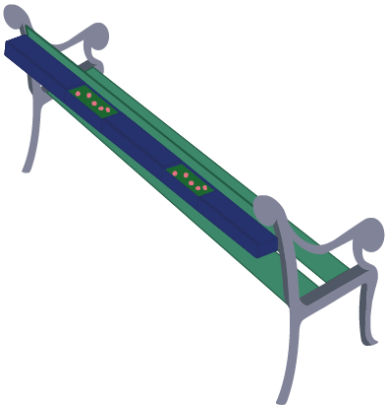


Figure 7 - Rygmodulet

All four prototypes will contain plants which will create a more visual green city. The finished products will be steel solutions, making them robust and match the design of the existing bins and benches. In all prototypes excess water will be drained through drain holes.

“Lågmodulet” is a module for the trash bins. It is designed to have a sedum plant solution. The sedum will be fastened with a plant net, thus making sure that the plants will not fall out when the bin is being emptied. A unique soil composition of pumice and soil would be a great absorbent and will release water to the plants when needed, and thereby reduce the need of maintenance.

“Multibæltet” is a module based system, which includes a plant module with low maintenance plants and a bottle module. These modules can be selected individually to which they best suit the different locations around the city. There can be up to four modules attached at the same time. In Figure 5, a setup of one bottle module and two plantmodules is shown. The size of the modules makes it possible to advertise Copenhagen or events around the city.

- The **plant module** is made in two sizes, so it is possible to have a plant module instead of a bottle module, thus adding flowers all the way around the trash bin.

- The **bottle module** is an attachment to avoid people putting bottles in the bin and thereby providing a more hygienic handling of empty bottles. The curved design of the module, is making the bottles visible and accessible for those who could use them. The size of the module is also larger than the existing solutions. This ensures that larger bottles also can be placed.

“*Sidemodulet*” is a module for the iconic “København bænk" placed at the side of the bench. Green Builders have designed a low maintenance plant module that will not interfere with the design of the bench. The module is designed to follow the curves of the bench. In order to avoid cigarette buts being thrown on the ground or being placed in the plants, the module is implemented with a disposal unit for cigarette buts. This unit is placed in the front of the module and is marked with a cigarette icon. The disposal unit is also able to be reached from a seated position on the bench.

“Rygmodulet” is placed on the backrest of the bench, without interfering with the original design. The module will be a closed bar along the whole backrest with two open areas for plants. There is a narrow opening along the module, functioning as a rainwater intake. The plants best suited for this module are smaller plants, similar to the sedum used on the “lågmodul”, to avoid annoying people sitting on the bench.

Plants

We have tested the following plant solutions for our prototypes and propose a similar setup for the city administration.

- **“Lågmodulet”** will have a sedum solution in order to minimize the maintenance.
  The solution is similar to those used on roofs, it is resilient to extreme drought, therefore making it the optimal solution for this project.
- **“Multibæltet”** has more volume for a soil composition, making it more versatile in terms of plant compositions. We made a combined solution with sedum and small rose bushes to add some color. The soil is a mix of pumice and nutrient-rich soil and to minimize the maintenance of the plants we propose a bottom layer consisting of pumice.
  The pumice will absorb water and release it to the plants when needed.
- **“Sidemodulet”** has a large volume similar to “Multibæltet”, therefore making it a more versatile product in terms of plant compositions. The soil is a mix of pumice and nutrient-rich soil and to minimize the maintenance of the plants we propose a bottom layer consisting of pumice.The pumice will absorb water and release it to the plants when needed.
- “**Rygmodulet”** has a slim design and we propose a sedum solution similar to “Lågmodulet” to keep the maintenance of the plants at a minimum.

These plant setups can be customized to suit the city's wishes in terms of plant and/or colour composition.
Whether or not the proposed plant solutions cause more or less maintenance can not be concluded without further tests.

Gardener - Expert knowledge

By consulting with Søren from Byggros we could narrow down the range of plant solutions most suitable for our prototypes. We had some criterias based on the collected data from interviews, observations and tests that we wished to meet:

- Low maintenance
- Drought resilient
- Urban embellishment

His advice for us, based on the data we provided him with, was a pumice layer in the bottom half of both “Multibæltet” and “Sidemodulet” with a drain hole to prevent excess water from overflowing. A soil solution from their company which is a mix of pumice and nutrient-rich soil to secure the best conditions for the plants. This composition and the volume of the plant modules, will allow the customer to select from a wider variety of plant solutions.
His suggestion to “Lågmodulet” and “Rygmodulet” was their sedum solution for roofing, due to its drought resilience and its ability to stay colourful throughout the season.

These suggestions were based on a criteria setup where low maintenance, functionality, and high exposure were the main focuses. This can be altered to suit other preferences.

Test of prototype and feedback

We wanted to test all our prototypes in order to know how the citizens would respond to the prototypes and to observe their behaviour. We found a location on Fiolstræde behind Vor Frue cathedral where we knew lots of people would pass by during the day. Our four prototypes were then implemented on a bench and a trash bin. The prototypes were filled with details such as bottles, small flowers, soil and pumice in order to illustrate the purpose and functions of the setup. Pictures are shown below.

Figure 10 - Prortotype, trash bin

Figure 11 - Prototype, backrest

Figure 9 - Prototype, bench

Feedback

By standing beside the setup or sitting on the bench one group member at the time, we were able to receive feedback from the citizens, who stopped to take a closer look or a picture. With this method we were able to receive feedback from bypassing citizens who showed interest in the project.

We spoke to around 50 people, some came in pairs or larger groups, which represented all genders and all ages, but mostly people of 30-70 years old.

Everyone who gave us feedback of the prototypes expressed an attraction of the green solutions and the flowers implemented on the urban space inventory. An older woman who sat on the bench expressed that she was attracted by the flowers and would rather sit next to some flowers which gave her something pretty to look at. The lady was not the only one who expressed the pleasure of seeing something green being added to the urban spaces. One person thought it was too much if all four products were implemented at once, on all the benches and trash bins in the city. Several people of the older generation were concerned for theft, vandalism and destruction. A man who was late on his way to work, stopped to take some pictures. He pointed out that the citizens' sense of ownership of the "Københavner bænk" and other urban space inventory was an important factor that reduced the vandalism.

Transients who used the bottle module said it had some great functions, a larger deposits room than usual, it seemed more robust and that it was nice to combine both functional- and flowers modules. The combination of multiple functions also made some informants emphasize that it should not make the maintenance work more difficult. Many thought the idea of using the already existing urban space inventory for flowers, was a brilliant idea and described it as:

"*pænt*"
"*dagens højdepunkt*"
"*hyggeligt*"
"*et godt initiativ*"
"*var med til at gøre inventaret pænere*"
"*sjove løsninger*"

Even though it only was low fidelity prototypes, people thought it fitted nicely to the design of the urban space inventory. We also experienced some people who asked when the idea could be implemented and seemed excited to tell and show the ideas to their acquaintances.

Observations

We also had an interest in observing if transients and users paid attention to our solutions, and to observe their interaction with it.

In order to make these observations, we took position at a bench around 20 meters away to observe. We did observations of all who passed by which was represented by all ages and genders. We observed many people using the module for bottles and cans, sizes ranging from

small cans to 2 L bottles were placed there. Even some of the collectors of bottles paid attention to the setup of flowers, though some just overturned the flowers when rummaging through the trash bin.

Many transient people turned their heads and paid a lot of attention to the prototypes, and even more stopped to have a closer look. Surprisingly many of the younger citizens stopped to take several pictures even if they were in a hurry and some of them even took their time to give feedback. The setup received a lot of attention from families with children who passed by, to have a look at the flowers while using the trash bin easily and effortlessly.

From these conversations and observations we concluded a positive result of the implementation of the prototypes, and confirmed the design had a visual effect as an eye catcher of the urban space inventory. The design functions were clearly understood by the citizens and serval were enthusiastic of the beautification of the already existing inventory. We had a feeling that citizens were open and positive of the ideas, and despite the concerns of vandalism many expressed that they wanted the solutions implemented right away.

The test period was 7 hours during the day, which means we have not tested during the night, therefore we are not able to assess the behavior of the citizens and ascertain how the inventory is treated during both day and night. In order to determine if the design and plant solution is satisfying, a functional prototype of the final products must be implemented for a longer period of time in order to examine any problems with durability and maintenance.

Concept screening

In order to compare the solutions to each other, and make a decision based on whether or not to continue with them, we evaluated all prototypes individually through a concept-screening, see Figure 13, based on our collected data from interviews, observations and tests.

Every module is defined as a concept named from A to D, Figure 12.

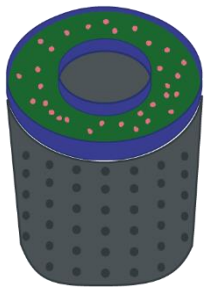
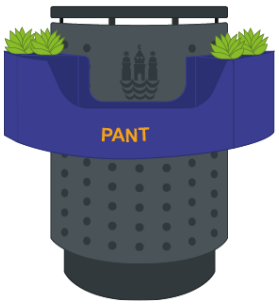
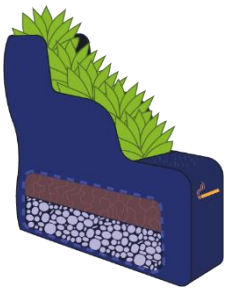
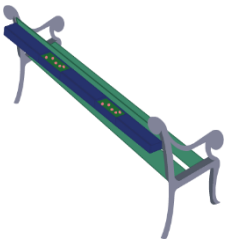
A	B	C	D
			

Figure 12 - Concepts

In the concept-screening, Figure 13, the selection criterias, corresponds to the metric in Figure 3. The criterias has been prioritised based on importance and each concept got a score (s) and the importance (i) for an operational product, ranging from 0-5, where 0 was when the criteria was not met at all, and 5 when it was delivered perfectly. The total score of the concepts is summarised and ranked, in Figure 13.

		Concepts							
Selection Criteria	**Importance**	A		B		C		D	
		s	i	s	i	s	i	s	i
Plug and play	100%	4	4	5	5	4	4	3	3
unit manufacturing cost	60%	4	2.4	2	1.2	3	1.8	4	2.4
Material strength	80%	5	4	5	4	5	4	5	4
Green value	80%	5	4	4	3.2	4	3.2	2.5	2
Placement	100%	4	4	5	5	4	4	3	3
Multifuntional	45%	0	0	4	1.8	4	1.8	3	1.35
Material choice	80%	5	4	5	4	5	4	5	4
Sensors	20%	0	0	0	0	0	0	0	0
Net Score			22.4		24.2		22.8		19.75
Rank			**2**		**1**		**3**		**4**

Figure 13 - Concepst screening

Advantages & Disadvantages

Based on the physical test as well as observations from the group during the design- and test phase, different advantages and disadvantages were discovered, Table 3

One of the major advantages with the solution is the ability to customize the amount of green solutions at each location. GUF adds colour and embellishment to the area and supplies a solution to prevent trash in the streets.

"Lågmodulet"	
Advantages	Disadvantages
Easy to mount on the top of the bin The sedum plants on the top will remain while the bin is emptied No maintenance on the sedum plants Caught the citizens attention A tendency that the trash bin was treated more gently by bottle collectors	More weight than the original solution Plants are prone to vandalism
"Multibæltet"	
Advantages	Disadvantages
Easy to attach on the bin A large module for bottles which fits up to 2 L bottles Available area on the side to brand Copenhagen or events Adjustable to each bin, depending on the available free space around the bin Customisation of modules, for flowers, bottles or cigarettes Caught the citizens attention	Advertisement has to be customized to fit Plants are prone to vandalism

The maintenance of the flowers is kept on a minimum	
"Sidemodulet"	
Advantages	Disadvantages
Easy to mount on the bench Citizens can place the cigarette buts in the slot instead of throwing it on the ground Caught the citizens attention The maintenance of the flowers is kept on a minimum	The cigarette disposal unit is not in optimal position, while sitting at the bench Plants are prone to vandalism
"Rygmodulet"	
Advantages	Disadvantages
Easy to mount on the backrests Does not interfere with the original design of the bench	Small and difficult to see from the front of the bench Plants are prone to vandalism

Table 3 - Advantages and disadvantages of prototypes

These prototypes were low-fidelity prototypes, and from the list above it is possible to improve the design, before making a more permanent solution. We will discuss this further in Further work.

Business

In this section, we explain how far we will take GUF and the different involved parties it will take to get the product implemented in the urban scene.

Green Builders is not going to start up a business and produce GUF ourselves. We decided to develop the technical drawings, which the city administration or a manufacturer of urban space inventory can buy the rights to.
This decision is based on multiple factors:

- Implementation of new inventory/items within the urban space, requires a regular tender process. This process takes time, resources and network - which we do not have.
- Veksø are the current supplier of urban space inventory to the Copenhagen city administration.
- GUF is created to fit the existing urban space inventory, produced by Veksø, therefore selling to them would be more beneficial for all parties involved.
  Veksø has the capabilities and resources to produce and sell GUF to the city administration.
- We do not wish to be a competitor to Veksø.

From this point of view it makes sense to stop our business case on the level for production of technical drawings.
In order to get to the level where we can sell our technical drawings, we still need to test and develop more. In order to communicate the purpose of GUF, we created a video pitch[2], which we can send to interested parties.

Business partners and target audience

The target audience we are trying to reach is the city administration of Copenhagen, especially "Teknik og Miljøforvaltningen", with our solution. We do not aim to limit the target audience to Copenhagen, we hope our solution can raise awareness of "a green touch" in the urban scene in other large cities in Denmark and other countries

The main caretaker of the plant maintenance will be "Vej og Park", who already are taking care of emptying bins and cleaning the urban areas throughout Copenhagen. Through our research and discussions with the local residents, we suggest that the caretaking could be overseen by local institutions and communities. This provides these institutions and communities, with a possibility to take care of plants and help the city of Copenhagen to maintain their green areas.

In order to produce the products we propose a production collaboration with Veksø. Veksø are the main supplier of urban space inventory for the city of Copenhagen and the company who designed the "Københavner bænke" and trash bin. They will be in charge of material choice and production.

For plant suppliers we suggest Byggros. They are a provider of landscaping solutions in urban and park environments. They also provide sedum solutions for green roofs and walls, to which we suggest to use as plant composition for our modules.

[2] https://www.youtube.com/watch?v=qFsGKCoHcM8

Economy

In order to get a realistic price estimate, which could be presented for the Copenhagen city administration, we contacted a local company, Gladsaxe Klip & Buk. The price estimates are applicable for a purchase order of 10.000 units, see Appendix E.

The prices shown Figure 14, is applicable for the purchase of each unit, and does not include the soil composition and plant combination.

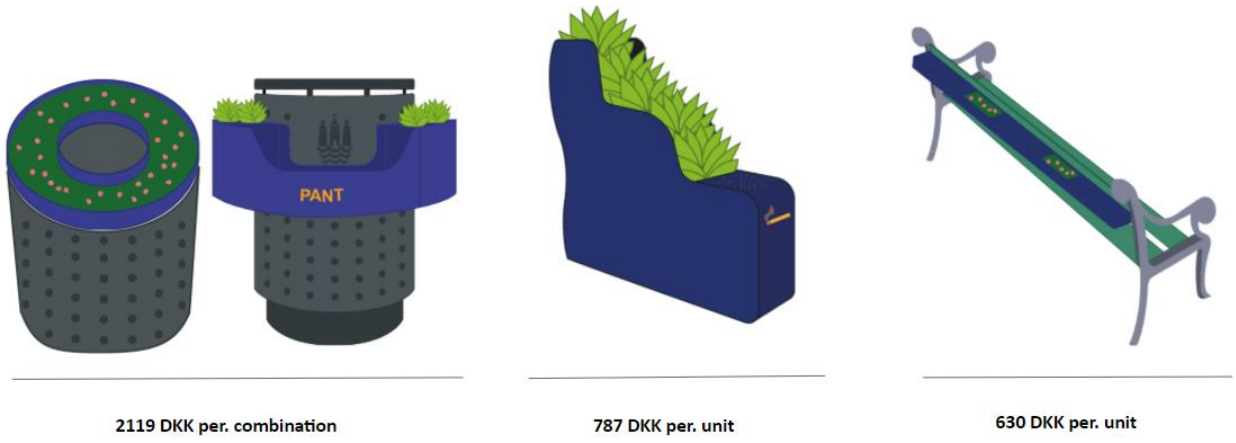


Figure 14 - Prices of prototypes

The final cost for the city administration is expected to be within the same range but it depends on a competitive tendering. The city administration must obtain prices for purchase, fitting, maintenance, soil composition and plant solution.

Further work

In this chapter we will discuss what alternatives we see to our solutions and the pros and cons of them. We describe what we need to do in order to get to a point where the technical drawings are done, and lastly which other solutions we can see as being interesting to test and implement in GUF.

GUF could be implemented in many cities in Denmark making it a versatile product suitable for the urban environment. In some cases it will require minor alterations to GUF to fit some cities urban space inventory, something the model based solution GUF provides.

Prototype alternatives

"Multibæltet"

In Advantages & Disadvantages we mentioned how one of the disadvantages of "Multibæltet" is that it covers the green CPH advertisement. In order to take this into consideration, we came up with an alternative version, Figure 15, where the posters can be placed in an angle.

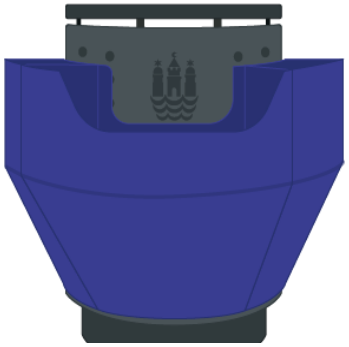


Figure 15 - Multibæltet, alternatives

The city could also use the space for advertising for events or rent out the space for commercials.

The disadvantages of this solution would be the increased price in manufacturing. Instead, it might be more advantageous to spend the money on adjusting the current posters to fit the smaller space on "Multibæltet".

"Lågmodulet"

In Concept screening we mention the possibility of an alternative version of "Lågmodulet" where instead of an add-on, it is created as the lid for the trash bins. This would mean that all the lids would have to be removed and exchanged with this alternative version, if the city administration wishes to add green to the trash bin lids. By creating a built-in version for the lid, it would be possible to add a small mechanism that can help open the lid, making it easier for the maintenance worker to avoid work-injuries.

The alternative prototypes are only quick ideas, and have yet to be refined and tested in order to conclude if they improve our solution or not.

Soil composition

In the city the plants are exposed to vandalism such as urine and alcohol during the night. In terms of biochemistry it is interesting to figure out how the alcohol and urine affects the plants and its growth potential.
We investigated the possible solutions for the soil composition to take care of this problem. By use of bacterias, the organic compounds will be converted to a usable product which benefits the plants and thereby reducing the maintenance cost.

The environment in the soil must be aerobic to ensure suitable living conditions. Drain holes in the side of the modules must prevent water saturation as this would affect the aerobic processes, the diffusion of air will be much slower and can lead to a harsh environment.
Different methods can be used, implementing a mixed culture of bacteria or by use of a specific bacteria.

- By implementing a mixed culture with different species of bacteria, natural selection will ensure the strongest bacteria will survive within the condition while the rest will go extinct. Before these cultures are ready to implement it is of high significance to perform controlled experiments in a lab in order to ensure the bacteria which survive is not harmful to humans or have bad side effects.
- The bacteria Microcystis aeruginosa, strain NIES-843 is a fresh-water gas-vacuolated, bloom-forming cyanobacteria which can survive in cold to tropical climates. M.aeruginosa is capable of transforming urea (from urine) into both N and C sources [2] in the metabolic process. The metabolism has an optimal operation in alkaline condition with a pH value between 7.5 to 9.5

Next steps

We have at this point tested our low-fidelity prototypes, with a focus on the visual, and received a lot of encouraging feedback.
A more advanced prototype should then be constructed, and by permission of the city administration, a test over a longer time period (for example a month) should take place, in order to evaluate the citizens behavior and use of GUF in the urban space.
A higher involvement of the city administration will be required in order to ensure we meet any requirements they might have when it comes to emptying the trash bins and maintaining the urban space.
Individual research regarding the possibility of getting the local communities, such as schools/institutions and scouts, to take care of the plants.
Looking into the possibility of renting out commercial space on the modules and if the money from that could help pay and maintain GUF could also be looked into.

Furthermore, we see an interest in taking a closer look at implementing one or more of the following ideas

- A sensor that registers the volume of trash in the bin and sends a message to the waste disposal employee when it needs to be emptied.
- A sensor that automatically closes the lid inside the bin making it harder to overfill the bin.
- A humidity sensor that registers the humidity optimising the maintenance of the plants.

Conclusion

Green Builders recommends implementation of the concept GUF to the existing urban space inventory in Inner Copenhagen. With these add-on products the city administration would be able to make a noticeable embellishment of the urban scene. By adding plants, the inventory will become more visible and accommodating, as well as appear more attractive to the citizens. By developing plant modules for the "Københavner bænk" and trash bins there is a risk that vandalism will occur.
Therefore we recommend a test performed in various places around the inner city for a longer period of time. This should be done in order to collect more data regarding how the citizens accept and interact with the new designs of the inventory, what kind of maintenance level is required, and examine if any other problems may occur.

Drought resistant plants are recommended within each module in order to prevent a large demand of water and maintenance. These plants will be best suitable for surviving in a harsh environment. To give the plant the best living conditions a mixed soil composition is suggested, which consist of a mixture of pumice and nutrient-rich soil.

The current developed prototypes are not completely resistant due to being exposed to alcoholic liquids and urine. The methods that should be dealing with these problems should be further examined in order to make the concept more able to thrive. The concept GUF is developed in order to gain the citizens a sense of ownership in an attempt to prevent vandalism.

We decided not to make a business out of GUF, but to create the technical drawings and make a one-time sell of these. We see an idea in selling either to the city administration of Copenhagen or Veksø (manufacturer of urban space inventory).
To get an overview of the cost to produce GUF, we got a price estimate of each module from Gladsaxe Klip & Buk, based on 10.000 units.

- "Lågmodulet" + "Multibæltet" 2.119 DKK
- "Sidemodulet" 787 DKK
- "Rygmodulet" 630 DKK

Considering everything, GUF poses an optimal solution to our innovation question, receives positive feedback in the field and embellishes the city.

Bibliography

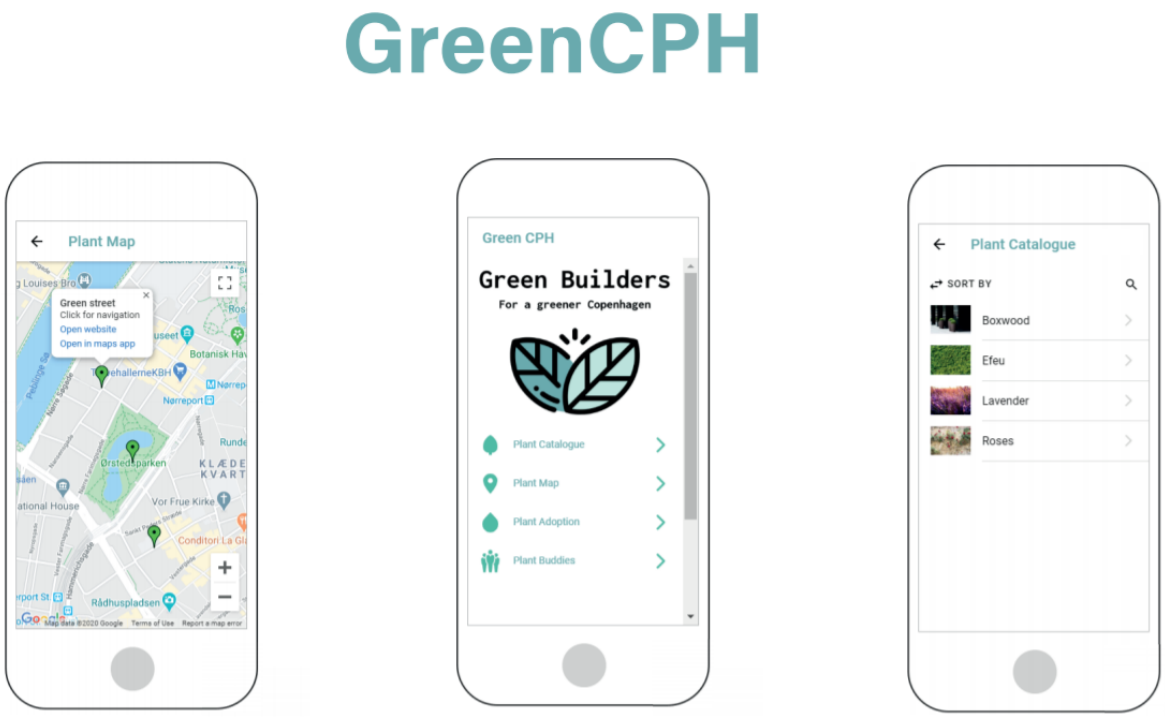
[1] "Et bedre København." [Online]. Available: https://www.kk.dk/etbedrekbh?page=1. [Accessed: 03-Aug-2020].

[2] L. E. Krausfeldt, A. T. Farmer, H. F. Castro Gonzalez, B. N. Zepernick, S. R. Campagna, and S. W. Wilhelm, "Urea Is Both a Carbon and Nitrogen Source for Microcystis aeruginosa: Tracking 13C Incorporation at Bloom pH Conditions," *Front. Microbiol.*, vol. 10, no. MAY, p. 1064, May 2019.

Appendix

A: App mock up and folder

App mock-up



Folder

NETVÆRK FOR KLIMATILPASNING, GRØNNE TAGE OG FACADER

Miljøpunktet vil gerne samle et netværk for beboere og professionelle i Indre By og på Christianshavn, som har interesse for og arbejder med grønne tage, facader og klimatilpasning.

Netværket er åbent for alle, der har interesse for klimatilpasning i byen.

For yderligere spørgsmål må du gerne kontakte Miljøpunkt Indre By – Christianshavn på tlf. 33 93 21 21.
Hold også øje med vores begivenheder for at se, hvornår vi holder vores klimaevent.

KOMMUNE KONTAKT

Kontakt Center for Trafik og Byliv
FACADE--BEPLANTNING:
https://www.kk.dk/sites/default/files/facade_info_final.pdf

Telefon: 33 66 36 56
Mail: vejaendring@tmf.kk.dk

SÅDAN SØGER I OM TILLADELSE

1. Skriv en kort ansøgning
Beskriv projektet kort i ord.

2. Vis det ansøgte – på tegning og/eller foto
Tegning: udarbejd en målfast tegning i målestoksforholdet 1:250 som viser:

- Indretning af vejarealet fra facade til facade med mål herpå
- Placering af de plantehuller, I søger om tilladelse til
- Placering af eksisterende vejudstyr som skilte, træer, cykelstativer, el-skabe m.m.
- Placering af opgange, lyskasser, trapper m.m.
  Foto: tag et eller flere fotos, der viser: det sted i gaden, hvor I ønsker planterne - man skal både kunne se facaden, fortovet og kantstenen
- Markering på foto af, hvor I ønsker at plante og plantebedenes størrelse
- Markering på foto af afstanden fra plantebed til kantsten

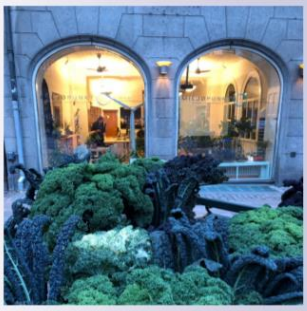
3. Mail ansøgningen
Husk at vedhæfte:

- Tegning (PDF) og/eller foto, der viser plantebedenes placering og størrelse
- Grundejers samtykke, hvis I søger på vegne af vedkommende
- Kopi af tilladelse fra Slots- og Kulturstyrelsen, hvis ejendommen er fredet, og der skal fastmonteres stativ el.lign. på facaden

Natur og klima i og med lokalområdet.

MILJØPUNKT

Klimatilpas din ejendom eller baggård – mindsk risikoen for oversvømmelse, skab nyt engagement og bedre livskvalitet for dig selv og dine nærmeste og vær med til at gøre vores by mere grøn!



Telefon: 33 93 21 21
mail: miljopunkt@a21.dk
App: GreenCPH

Grøn by, Renere luft, Klimatilpasning og Bæredygtighed

Foto: Sabine Buurgaard Sørensen.

København har masser af liv – her bor mennesker, drives erhverv og kommer mange besøgende. Miljøpunktet arbejder for renere luft til borgerne, ved at fremme brugen af cykler i Indre By og på Christianshavn.
Træer, grønne tage, facadebeplantninger og anden grønt bidrager til et godt miljø, klima og bæredygtighed, dette højner byens kvalitet og medvirker til gladere og sundere borgere.

Planteløsninger

Løsningerne til lokale åndehuller er mange.
I denne baggård til Studiestræde er facaderne dækket af Efeu.

Foto: Det Juridiske Fakultets, baggård

Ved at danne grønne oaser i byen skabes levesteder for både dyr og planter, hvilket bidrager til en øget biodiversitet.

Foto: Teglgårdstræde 11

Ved denne boligforening er der valgt stokroser som facadeløsning.
Derved bidrager de som forening til et grønnere billede.

I Studiestræde hvor pladsen er trang er der skabt en løsning som passer til det smalle indgangsparti. Denne løsning består af stokroser.

Foto: Studiestræde13

Foto: Teglgårdstræde 9

Forskellige planteløsninger kræver forskellige vedligeholdelse alt fra lille beskæring til her hvor der skal skæres oftere, dette skal overvejes ved den valgte planteløsning

Foto: Nansensgade 61

Her er den grønne løsning inkorporeret i dagligdagen. Det grønne tag over skraldespandene bidrager til en forskønnelse af gårdmiljøet.

GreenCPH - App

- **Produktkatalog med visualisering**
  Visualisering af mulige planteløsninger af din facade, i virtuel reality (VR)
- **Kort**
  Guide til åndehuller og/eller især specielle planter
- **Løberuter—marguritrute**
  Grønne ruter til gang og løb
- **Adopter en plante**
  Bidrag til grønnere København ved egen mini kolonihave fællesskab
- **PlantSaver**
  Informer folk om hvorvidt planten trænger til gødning/vand
- **Køb et træ**
  Bidrag til forøgelse af træer i København ved hjælp af crowdfonding

B: Urban space inventory

Trash bin in Inner city

The iconic “Københavner bænk”

C: Competitors

	https://bit.ly/2Q6jSSv	https://bit.ly/32ahP5u	https://bit.ly/3l1VCz9	https://bit.ly/34armfD
				
Integrated flowers	✓	✓	✓	X
Suitable for urban space	✓	✓	✓	X
Add-on	X	X	X	X

	https://bit.ly/34e6Tqk	https://bit.ly/324OxW6	https://bit.ly/3aBojhM	https://bit.ly/34iaEuL
				
Integrated	✓	✓	✓	✓
Suitable for urban space	✓	✓	✓	X
Add-on	X	X	X	X

D: Survey on the street

Borger:

- **Hvor grøn** synes du København er? Både når det kommer til klima og planter i bybilledet.
- Hvad vil du **se mere af** i det grønne bybillede?
- Hvad **betyder** et grønt København for dig?
- Hvad ser du som **udfordringer** i forhold til et grønnere København?
    - Hærværk
    - Pladsmangel
    - Folks adfærd
- Hvilke **fordele** ser du ved et grønnere København?
- Hvad kan **motivere** dig til at **bidrage** til et grønnere København?

- Sorterer du dit affald? Hvad gør du med affald som ikke har en specifik skraldespand? Såsom tøj, dåser med undertryk eller større glas ting

- Har du grøn beplantning ved din bolig?
- Hvem **vedligeholder** det?
- Oplever du nogle udfordringer ved at have planter selv?
- Hvad kunne motiverer dig mere til at have flere planter hjemme?

- Tænkt scenarie: Så hvis du havde lyst til at lave beplantning ved din bolig, hvad ville dine første step være?

Forretninger:

- Hvorfor har du valgt disse **planter**? Hvem **vedligeholder** beplantningen?
- Hvilke **udfordringer** ser du i forhold til beplantning ved din forretning?
    - Hærværk
    - Pladsmangel
    - Folks adfærd
- Hvordan kan det være i valgt at have planter - Hvad bidrager planterne med til jeres forretning?
- Hvordan **sorterer** I jeres affald?
- Kan I komme af med alle former for affald ved jeres containere? eller skal I selv forbi den lokale genbrugsstation?

Boligforening:

- Har i lavet nogle **grønne tiltag** i jeres forening? Hvis ja, hvilke tiltag og hvordan startede i projektet?
- Hvor stor en **interesse** oplever i fra boligejerne til deltagelse i vedligeholdelse og etablering af grønne områder?
- Hvor ser du der kunne været et muligt areal for jer som forening at have planter?

Hvordan foregår **affaldssortering** i foreningen?

E: Price estimate

Price_estimate_Gladsaxe_Klip&Buk.pdf

F: Final version of prototype

G: Urban space inventory list

Type of inventory		Amount
	“Københavner bænk”	43
	Round bench	12
	round trash bins	16
	round trash bin with existing add-ons	11

	Square trash bin	9
	Lampposts	20
	Areas with chicanes	10
 	Trash bag	42