Breman flow

The next step for ecologically sustainable ventilation in the renovation industry

A master's thesis Integrated Product Design, for Delft University of Technology, Industrial Design Engineering, in collaboration with Breman Schoorsteentechniek

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SUMMARY

This report describes the process of designing a ventilation concept for the renovation industry. The project is in collaboration with Breman Schoorsteentechniek, an installation company located in the Netherlands. The initial brief was kept vague on purpose and described a project in which I was to find a way for Breman, to make their products more recognizable on the market. At the time, Breman was starting to rebuild their companies vision with ecologically sustainable intentions.

The initiation of the project became a search for what the vision for this product should be. Next to a small analysis of the current workflow, a trends and development research was conducted. This resulted in core movements for the year 2030 in the fields of: sustainability, construction industry and general world developments. These were then used to communicate a proposed world vision and were discussed with the board members of Breman. From these meetings three ideas where generated. After consideration of the core movements and the initial aspirations of the project, the direction of ventilation in renovation was chosen.

After a short transition from this general vision to the design phase, I constructed a model in which I could order my decisions. The model made that the overall design stayed consistent and that gaps in the argumentation for the concept could be determined. Concluding from this model, I designed a component based product. This product consists of a full central ventilation system with integrated IoT functionality. A distinction was made between a full fletched version and a budget version. I implemented the product in a virtual space, to offer a more tangible impression of the product.

With the conclusion of the design phase, I continued to a small evaluation phase. The virtual space visualisations where used in meetings with experts on different levels of the ventilation industry and the field of plastic injection molding. The gained feedback on the feasibility, desirability and viability of the concept was then used in combination with left over insights of the project, to write recommendations for Breman. As a conclusion to the project, the initial brief is reflected upon. The final result is Breman flow, the next step for ecologically sustainable ventilation in the renovation industry.

INTRODUCTION

In this introduction I would like to sketch an overview for you, the reader, on the background of this project. First, graduating. This project and report serve as a quality check before I will start working as a designer. This means that the project was of a research nature. Certain mandatory topics were explored for the graduation project's checklist

Second, a short introduction to Breman. Breman is an installation company that operates in the Netherlands and incidentally in neighbouring countries. The company consists of different departments across the Netherlands that function independently from each other. This project has been carried out in collaboration with Breman Schoorsteentechniek. This department is responsible for coming up with solutions in the area of flue gas technologies and produces a part of these solutions themselves. From here on out, I will use "Breman" when talking about Breman Schoorsteentechniek, unless otherwise specified.

Next follows a short, global overview of the process behind the project. The process behind a design project is rarely chronological. This was also the case for this project. However, to provide some insight into the different steps that were taken, it has been described chronologically.

The project started with a project brief: a summary of a meeting with the different parties involved in which the direction of the project and its boundary conditions were decided. The project brief can be found in appendix A.
After that the (scientific) research part: one of the required parts of the graduation assignment. This part is used to learn about the context and industry of the assignment. This part can also be used to create time within the project to investigate technological developments or specific phenomena within the context.
Within the framework of the research, the designer and the company, a vision is created. This vision can be changed throughout the project but will remain mostly consistent in its core. The system that is created from this vision is made by answering questions such as: How will we achieve this vision and what purpose does the overarching system serve? This keeps the project at a high abstraction level, making sure the solution does not necessarily have to fit within existing boxes.
Because of the abstraction level during the design of the system, there was the possibility to design a system, service or product or a combination between them. It was important in this project to keep the result as open as possible and avoid specifying what result was preferred. This process resulted in a product as the end result of this project.
The product has been validated by performing small tests. These tests, together with parts of this report such as the discussion, are used for recommendations on how to improve the product and what the next steps for Breman could be. Finally, as a result of the design process, the thesis presents a conclusion about the project and a product concept.

As the last part of this introduction, a short disclaimer. To keep this report concise, yet still use it as part of the assessment for the graduation assignment, the report is a combination of process and results. This means that certain project details are only partially described in the report or appendices. Stray tracks for example, which naturally occur in a design process, have been documented to a lesser extent or left out. Design methods have been moved from the report to the appendices and the research phase has been condensed to its main conclusions.

Figure 1: TU Delft, the faculty of Industrial Design Engineering.

Figure 2: The facade of Breman Schoorsteentechniek.

Figure 3: A small impression of the products Breman Schoorsteentechniek provides, in this case: the outdoor LWP.

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ASSIGNMENT CONTEXT

At the start of this project and report, it is important to know the context of the project. Breman is looking for the next step for their company. They are asking questions such as: "where is the market going and how can we react to this?". Next to that, Breman notices that their company is recognised for their norms and values, cooperativeness, high quality products and customer friendliness. However, the products that they make are not yet associated with them. This is partly due to the nature of the industry that Breman operates in. The contractor determines the type of installation that is used in a building, while the resident experiences it. The buyer and the user are therefore not the same people. Breman also has to work with other parties such as municipalities and project developers. An overview of the parties Breman currently has to work with and the datastreams in their current workflow can be found in appendix B.

Next to improving the conveyance of Breman's qualities to the end users, the decision has been made within Breman to be energy positive by 2025, in both their production and within their cooperation as a whole. For this, internal processes will have to change, but more relevant to this project: their products and production need to become more sustainable.

With the combination of these subjects and the different parties within this project (Breman, counsellors from the TU Delft and me as graduee), a project brief has been drafted. This brief contains the design assignment and the framework that this assignment will be executed within. The full brief can be found in appendix A. Below, a summary.

What I will design:
"Through the integration of: internal and external user research, research in sustainability and branding, I will design a strategy concept for Breman that will show their brand values. These values contain at least circularity within the company and a recognizable form language."

The research and designs should lead to the following:
The envisioned product/product-service/productsystem makes the intentions of the company visible to partners and customers. With this solution the company can further develop a healthy workflow for the industry with their partners. Additionally this new strategy can be expanded to not only inspire contractors and architects, but also to inform the end user of the products on how to adapt to a sustainable society.

The framework of the project was, at the time of the project brief, still in its fuzzy front end phase. This was mostly due to two causes. Firstly, conceptually thinking of the future was still new to Breman and secondly, I was not yet acquainted enough with the industry. The to be researched subjects and the envisioned result did offer enough footing to start the project. Together with the counselling team, associates from Breman and the TU Delft, it was decided to frame the project as a concept design.

Breman wants to lead in the market instead of reacting to it. By placing a point on the horizon I want to facilitate this for them. To create a well-founded concept for this, I will first need to get acquainted with the world of the future. Originally, the project was set to be envisioned for 2030. During the project however, this has been adjusted to 2025. Because of the orienting nature of the research part and with it the relevance of the timeline, the projection for 2030 has been kept as the result of the first phase of the report. The method I used to create an image of the future contains elements of the ViP method.

RESEARCH PHASE

During the research phase, I started by finding and analysing trends and developments to get an idea of the world of 2030. These are compiled in visualisations: three visual representations and an expected use scenario on buying a house in 2030. Based on these results, three idea directions manifested. By deconstructing the three idea directions, I identified specific drivers (term derived from the ViP method, indicating motives and drives) of the future that fit Breman and combined them into a vision for the future world of 2030. Through discussions with Breman and the background acquired during this phase, a new brief for the second phase of the project was formulated.

EXTRAPOLATIONS AND THE WORLD'S EXPECTATIONS.

A way to visualize the world of 2030 is to first analyse current trends and developments. A full list of the found trends and developments can be found in appendix C. In appendix C, there is a small explanation for each trend and development with references to the sources found in the bibliography. To summarize: the most relevant, clustered main conclusions for this project are the following:

Products are becoming product services. Customers pay for a service instead of owning the product that provides that service. This phenomenon expresses itself in the construction industry, in rentable or collective use of products like washing machines, but also the non-owning of a house.

Production process overhauls in the construction industry. Increasing efficiency is always a driving factor for industries. A focus on sustainability is added to this factor. An increase in women and elderly workers in the construction industry resolves some of the labor shortage. However, this target group has different needs than the current employees in the industry, both physically and mentally. Providing another factor for the production process overhauls.

Hyper personal production parts. An increase in scale and processable materials of additive manufacturing (3D printing) makes for cheaper personalisation. Translated to the construction industry, this results in a higher possibility of personalizing builds but also structural optimization. In turn, this gives the possibility for more passive design strategies. Special designs could be made for specific temporary houses.

Central hubs are used to collect and distribute products, services or data. Products are collected and distributed autonomously. Data is stored in collective networks. Services can be coordinated on different scales. An example is, a scenario where neighbourhoods produce and distribute their own electricity or clean their own water.

New buildings are made to grow or shrink with its inhabitants. Both to grow and shrink with the composition of the families, the composition of the population age and cultural differences. A high level of adaptability and modularity is needed for this development. Owning space, instead of a building or a room, contributes to this development.

Products are measured not only by quality but also by their story. Products which are proudly produced locally are the norm, and craftsmanship is a central mark for brands.

The best way to reach people is the new "mouth to mouth" advertisement. Mouth to mouth advertising is becoming digitized. An example would be social media feeds where you are informed or enticed by trusted people or groups. Brands turn from logos to people. Virtual companions help people through their days, and help them make decisions.

The world is living from home. More and more offices are shutting down because the need for them declines. Better facilitation for working, sports/ working out and shopping from home are needed. Adaptability and modularity are essential in making small spaces suitable for these multiple uses.

The amount and integration of connected devices in homes is increasing. Products are operated from a personal device and those that are not connected are connected through semi-connectivity (wifi plugs for example).

Boycotting of non-inclusive and non-sustainable companies. To maintain a healthy relationship with the public opinion, companies have to be transparent about their supply chain and production ethics.

With an increase in activities at home, a response creates itself in the need for human contact. The decrease of offices and the increase of services that come to your home (groceries, clothes) make for less social interaction, so people grow more lonely. Contact is done more through video calls and less face-to-face.

The world I envision for 2030 contains the above-mentioned features. These features are roughly visualized in the following three collages. The visual representations are divided into three search areas: inhouse living, houses, and construction industry. These visuals are used to convey an overview and general feel of the future within the relevant areas.

Figure 4: A small indication of the visualisations. Full sizes with short descriptions are on the following three pages.

IN-HOUSE LIVING 2030 (WIP)

A big focus on the flexible use of areas. Different uses can happen simultaneously. More awareness among people to live healthy, both physically and emotionally.

HOUSES 2030 (WIP)

Sustainable housing with more attention to circularity and modularity. Integration of natural materials and greenery. These buildings will be simple and functional to improve scalability.

CONSTRUCTION INDUSTRY (WIP)

An industry in motion. Some parts develop faster than others, as will companies. Integration of technology and a diversification of the demographic.

USER JOURNEY

With the knowledge of the trends, I put myself in the shoes of customers in 2030. What do they think, what are their aspirations and what choices do they come across? All of this is projected on the journey they take to get a place of their own in 2030. The journey is somewhat on the bright side of the future. This is intentionally chosen. It shapes the scenario into a plausible, but also desired future state of society.

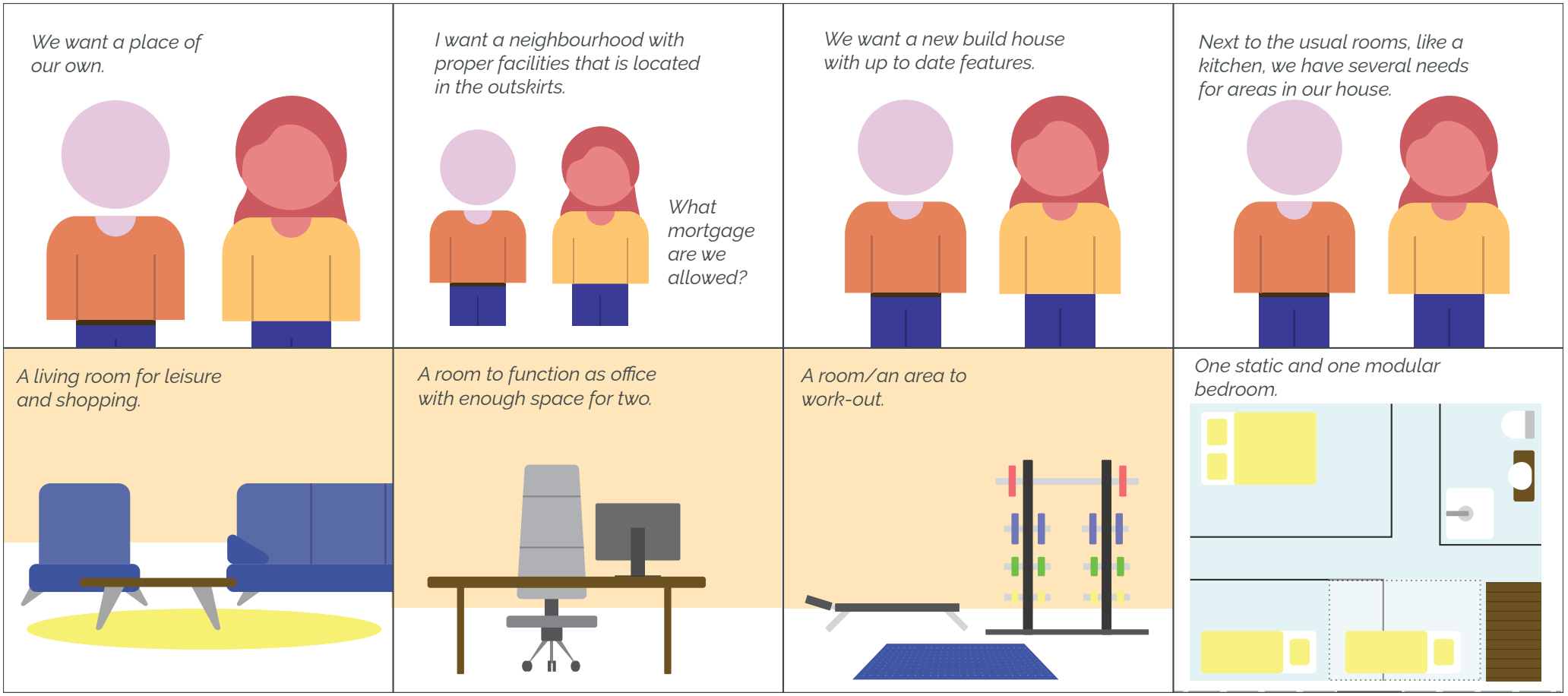

Figure 5: A fictional scenario visualising the current state of the market. What are the needs and questions that these people have? Continuation on the next page.

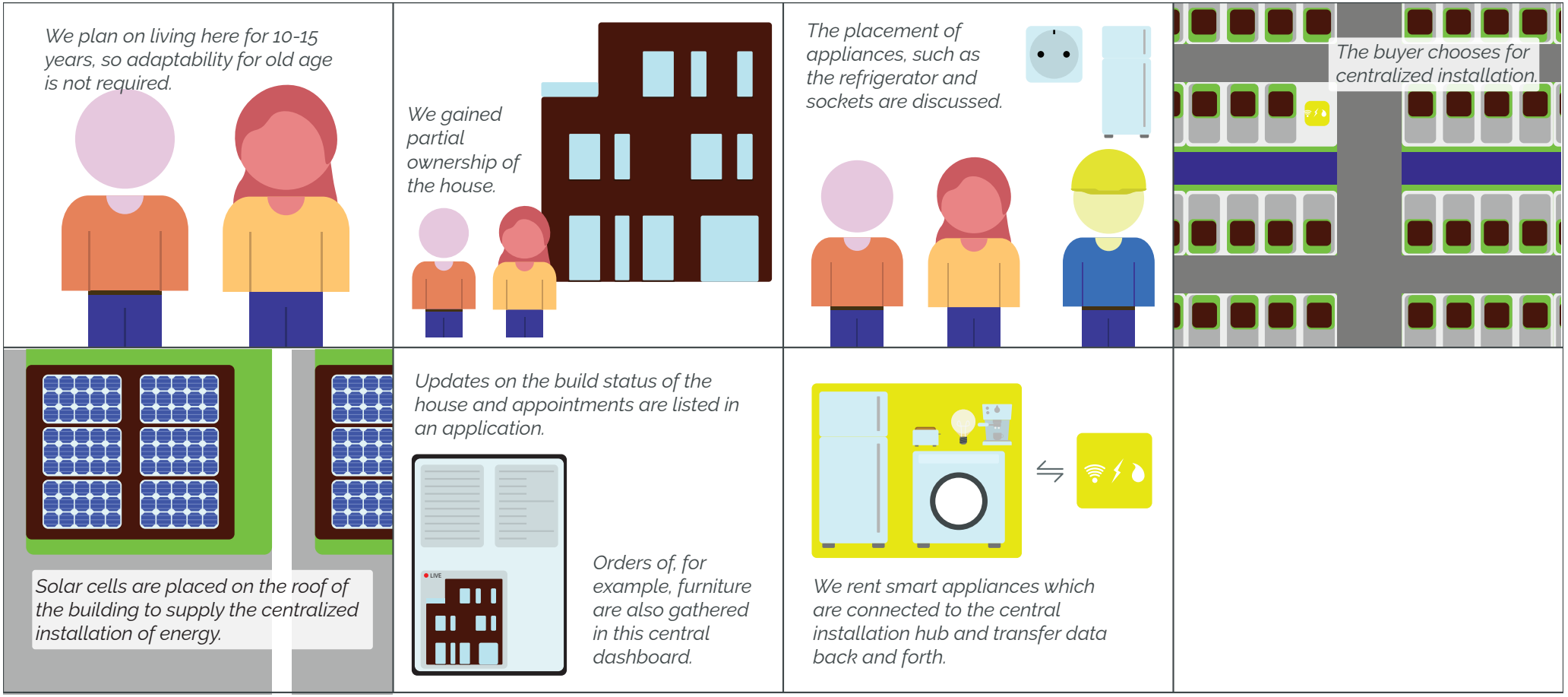

Figure 6: Continuation of the scenario

Concluding from the scenario, the future customer is much more involved in the building process. Partial modularity is a wish and areas of the house need to be adaptable to multiple scenarios. Centralized installation is needed for this adaptability and has the additional benefit of reducing some of the costs of living. Products, and the house alike, are all services. This means that the customer is only the owner of personal belongings. Other products are converted to their service counterparts. Not a dryer, but the need for dry clothes. On top of that, smart devices may optimize, for example, power usage and product lifetimes.

DRIVERS OF THE FUTURE

In a meeting in which Breman was introduced to the world vision of 2030, the discussion was started about how this vision aligned with their own vision. During the conversation several interesting opportunities were opted. From these opportunities I crafted three rough idea directions. A full description of the idea directions and elaborations for this chapter can be found in appendix D. In short, the three idea directions are the following:

A rentable modular bathroom module.
- Adapt to the multipurpose style of living.
- Users could transform their bathroom into a spa-like module.

Living as a service.
- Customer's rent installations and products from Breman.
- Opens up possibilities for increased energy and material efficiency.

Passive renovation.
- Counter movement to the increased technology in houses.
- Make old houses more ecologically responsible.
- Breman could lead the market and become an expert in the field of ecologically responsible renovation.

From this point forward, I assume that the three proposed directions are in line with the envisioned future and the capabilities and aspirations of Breman for 2030. To concretize this underlying vision, I distill the drivers from the ideas. The question asked is: What are the underlying motives of these ideas and why do these ideas resonate with Breman? This results in drivers which can be combined into a common vision from which to design from. There is some overlap in drivers between the different ideas, an overview of the resulting drivers can be seen below in figure 7.

	A modular bathroom	Living as a service	Passive renovation
The need for modular/multipurpose houses	x		x
The adaptation of smart products on lease contracts	x	x	
Installation companies at the start of the building process	x		x
A call for ecological responsibility	x		x
An emphasis on mental healthcare	x		
A shortage in housing.	x		x
A shift towards a relevance based market		x	
An ever growing need for convenience		x	
Acceptance of AI assistance based product/service/systems		x	
Developments towards small collective initiatives		x	
A countermovement to the increasing technologies in homes			x

Figure 7: An overview of the drivers for each idea direction.

CONCLUDING VISION

The drivers give an impression of what the future looks like. The resulting expectation on how people react and how we want them to react to this future is the vision of this project and the conclusion of this part of the project. By combining three small descriptions of the drivers, see appendix E, I came to the following world vision of 2030:

> "In 2030 the main focus will be on ecologically responsible housing, while coping with the housing shortage. Houses will be made modular or passive. The consumer wants help in transitioning towards sustainable housing solutions. The consumer prioritises convenience over ownership, looking for leasable options and flexible solutions. Convenience is added as well by companies who create collective solutions, which could be positioned locally. Within the construction industry, Breman operates as an innovative facilitator among their partners. From this new position, Breman will guide the market and the consumer in how to transition towards being ecologically responsible."

A timeline, figure 8, was constructed to give some sense what this concluding vision could mean for Breman, The reasoning behind this timeline can be found in appendix F.

2020 - current

- Executive party
- Convey craftmanship
- Wellbeing of their employees

2025 - transition

- Ecologically responsible
- Emphasize on craftmanship and employee wellbeing
- Join and help partners in their innovation projects

2030 - future

- Ecologically responsible
- Help their partners to develop towards sustainable products
- Increase efficiency and streamline processes
- Facilitating/consulting position

Figure 8: A timeline for Breman, with short descriptions of where to be in the transition at that specific time.

CONCLUSION OF THE RESEARCH PHASE

Based on the vision and the found research, a discussion with Breman on the product was held. In turn, the discussion led to the following conclusion about the research phase. An elaborated explanation about the contents of the meetings with Breman can be found in appendix G.

The concept of a ventilation system redesign that can be implemented in existing buildings resonates the most with Breman. This direction came as a continuation of the idea direction of passive renovation. The ventilation redesign would also enable me to create a form family/branding for Breman to show them the possibilities of a strong brand identity in their products.

The quality of indoor climates in a lot of buildings needs an upgrade in the coming years, making ventilation integration in existing buildings a highly relevant topic for Breman. Next to this business case, it would also fit in with the ecologically responsible aspects that Breman aspires to have. Through this product they can help private contractors and partners within the industry alike with the improvement of sustainability within buildings. However, in the end it is still installation technology, holding on to the core strength and the essence of the company.

In the second phase of this project the focus shifts towards this integration of ventilation in existing buildings. Through various thought processes (which can be found in appendix G), the results of the research phase are combined into the following vision:

Together with Breman I want to create a new focus for the future within the area of ventilation. With this focus, we want to offer an ecologically responsible solution to residents of a standard terraced house. This solution will help the resident with becoming aware of ventilation and sustaining a healthy climate in their home. Next to that, the solution will help Breman to invest in relevant drivers of the future and position themselves as an innovative and helpful company.

Figure 9: An impression of the "standard" terraced house I will be designing for.

DESIGN PHASE

In the design phase part of this report I will explain the product and the different components. I will start with a short, global explanation of the method that I used to get to the product and shortly explain what this product entails. After that I explain the different components used in the product in detail. I elaborate on their functionalities, aesthetics, materials and production methods. To conclude this phase, I give an overview of the full interim concept.

DESIGN INITIATION: LEVELS MODEL

During the design phase, I kept going back and forth between details and overall concepts. All these ideas were designed with the vision and the background knowledge in mind of the research phase. To get to the essence of the ideas and to construct a conclusive story, I rearranged my ideas into a level model. This model has become the foundation of the design and the root of the decisions made. An explanation of the model and the decisions made on the different levels can be found in appendix H and I respectively.

The product that resulted from this model is a modular, retrofitted MVHR system for the standard terraced house in the Netherlands. The product is aimed at helping a large number of people renovate their homes for a more ecologically sustainable future. Since it should be implementable by many customers, it also has to be economically feasible. This subject is on the edge of this project's scope, however a small addition is made to this topic by adding budget counterparts to the design components. On top of that, only implementing the parts that are needed in the desired configuration, establishes cost effectiveness on a system level as well.

PRODUCT COMPONENTS AND SPECIFICATIONS

In this chapter I will specify the components and their requirements. I start where the air from outside is sucked in and go through the components up to the actual air distribution in the rooms. In figure 10, the components are visualized in a schematic manner to give an overview of the overall system. The greyed out areas indicate what is out of scope for this project.

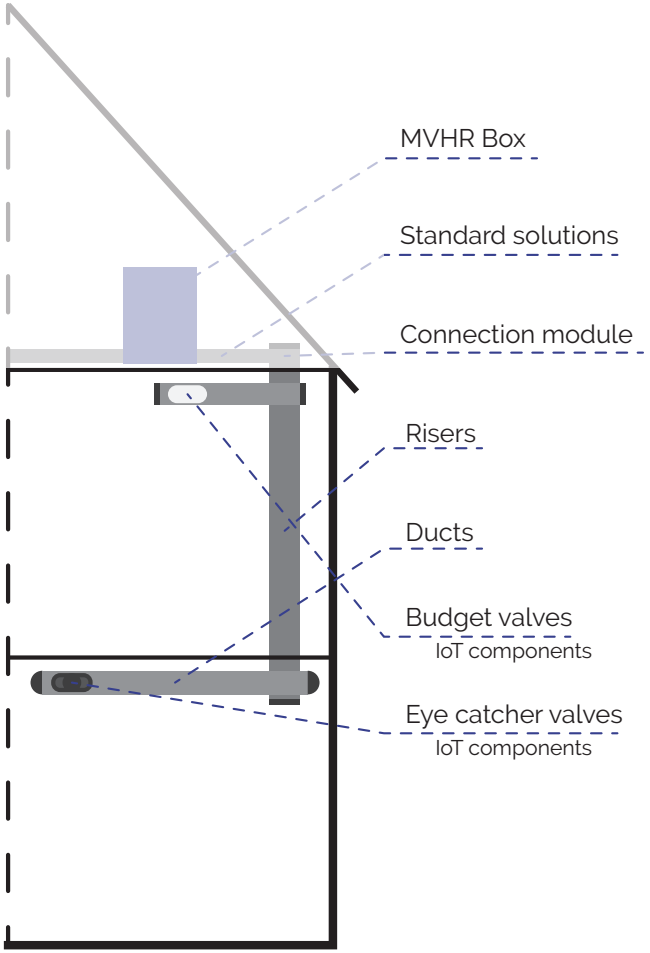

Figure 10: An overview of the main components of the product, to give a basic understanding of the overall system.

The MVHR unit, IoT components (in general, as well as in the valves) and the applications are connected to the design, but are not within the scope of the project. These components are not the essence of the product. However, they are needed to complete the full picture and are therefore presented in this report. Most of these components are discussed shortly and only have rough estimations regarding dimensions and functionality.

A MVHR UNIT

The MVHR unit is an integral part of this design. It is a ventilation unit that transfers the heat from the polluted air into the fresh air. There are a lot of different MVHR units available on the market. Even though their functions are roughly the same, their orientation and configuration varies. Due to the MVHR unit being out of scope for this design, it is assumed that Breman either uses the MVHR unit that is available at the residence, or partners up with another company to have a standard go-to unit.

Figure 11: a MVHR unit of the brand J.E. StorkAir. The position of the in- and output tubes differs between brands.

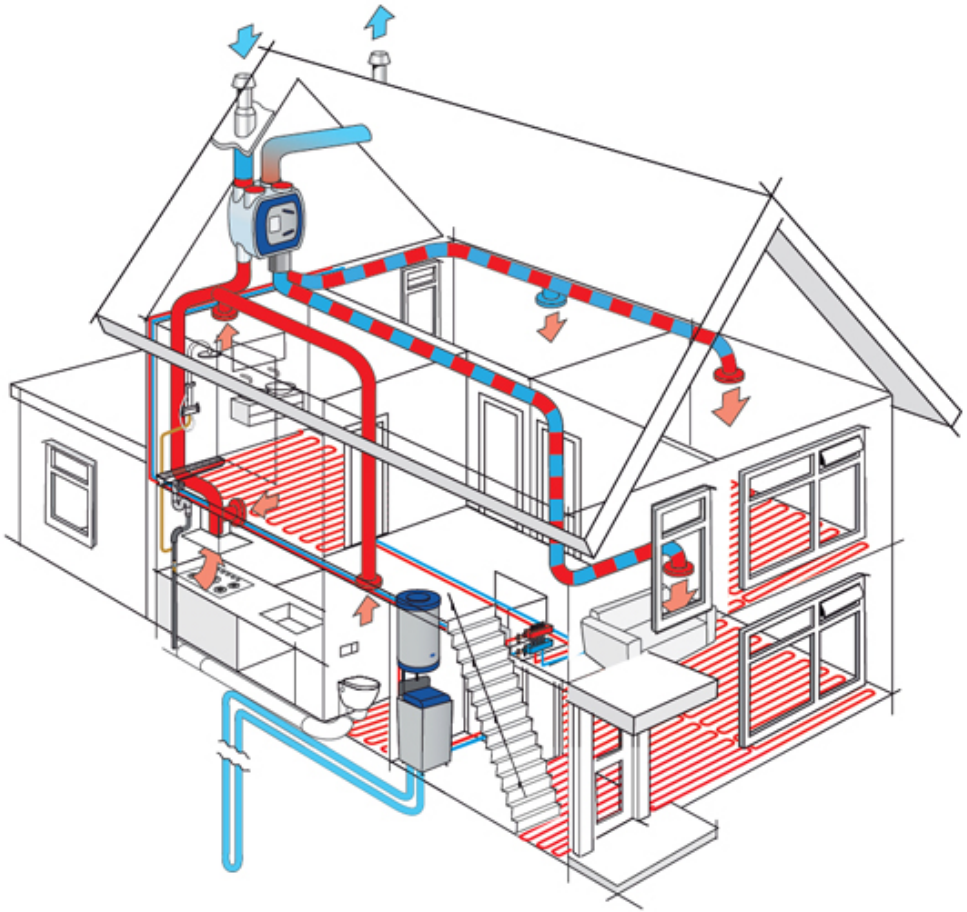

Figure 12: A general impression on the main functionality of a MVHR system.

As will become evident in the riser and valve components, the vision for this product is for it to be exposed to the view of the user. However since the MVHR unit and black box are outside of the daily view of the user I decided to refrain from introducing extra components for their connection to the risers. On top of that, within the industry, mechanics already have solutions for these current situations in the attic. Keeping these current solutions would lower the learning curve of installing the system, as well as probably lower the cost of the overall system. When available, the knee walls should be used to cover up some of the standard solutions. This would take up less effective space, as these spaces are often just used for storage.

To connect the standard solutions to the riser, the same part can be used as the connection of the riser to the air ducts, described in the riser chapter.

Figure 13: A preview of the riser to air duct connection part.

Figure 14: An impression of the "allowed" messiness of the standard solutions. These are not in view, so the installation is entirely up to the mechanic on site.

RISER

The risers function as transportation method for the clean and polluted air between the different floors. These risers are arranged in a certain pattern to maximize adaptability to different layouts of the standard terraced house. The general spaces (the placement of the inside walls) are the same for most cases, however there are variations in layout. To allow for maximum flexibility while obstructing as little living space as possible, I have chosen to place a supply and an exhaust riser in each corner of the house, see figure 15. The risers are placed in the corner of the rooms with the different risers on two different walls, see figure 16. The full reasoning behind these choices can be found in appendix J.

The most common way of producing continuous profiles would be extrusion molding. Therefore the main riser parts are extruded. A logical choice for the material would be aluminium. Breman is already familiar with this material and has the means to process aluminium. On top of that, aluminium is commonly used in this production process and it can be recycled indefinitely.

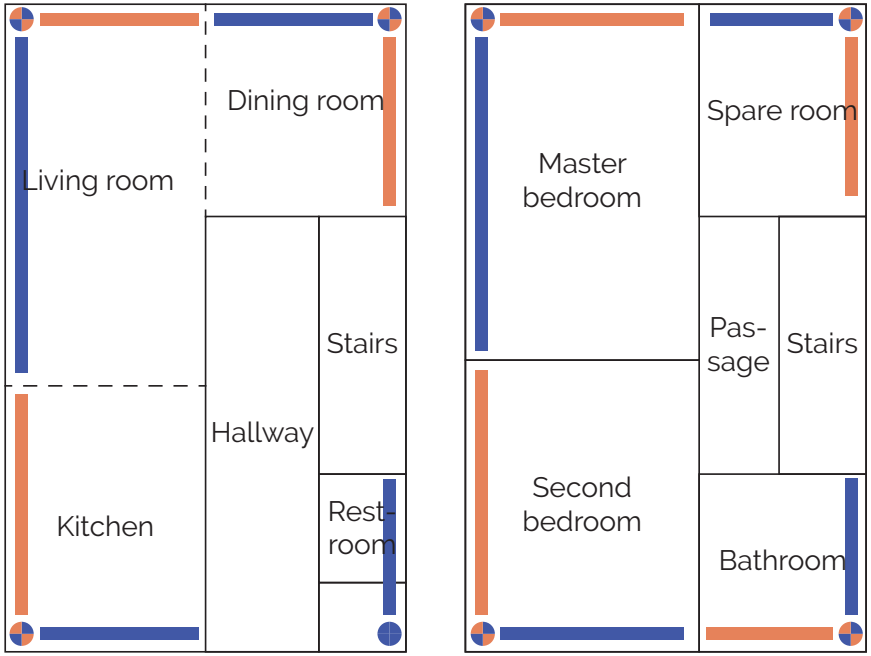

Figure 15: An example of a floor plan of a terraced house, with a configuration fit for all the possible ventilation options. Blue is exhaust, orange is supply.

Figure 16: A render of a corner with both an exhaust and a supply riser.

PROFILE DIMENSIONS

The profile of the riser is based around several topics. First of all, the air flow. I estimated that the cross section of the profile should have the same area as a standard riser. This standard dimension makes for a system that conforms to the regulations made for standard situations. The standard ventilation pipe used as a riser is 10 [cm] in diameter, resulting in an area of 79 [cm^2]. In extreme use cases, this area could lead to an increase in noise within the product. For example, when a multipurpose room is transformed from a home office to a workout place, the volume of air through the ducts is increased significantly. However, in these situations, extra noise is tolerable due to the activities and standard conditions (loud machines and music). In current extreme situations (you turn on the ventilation in the bathroom or toilet), this increase in volume is already accepted by the user.

As I will explain later in this report, the form language of this product is built out of rectangles with modifications. With this in mind I made a table with probable ratios of height and width of the profile, to experiment with. I visualized these aspect ratios in figure 17.

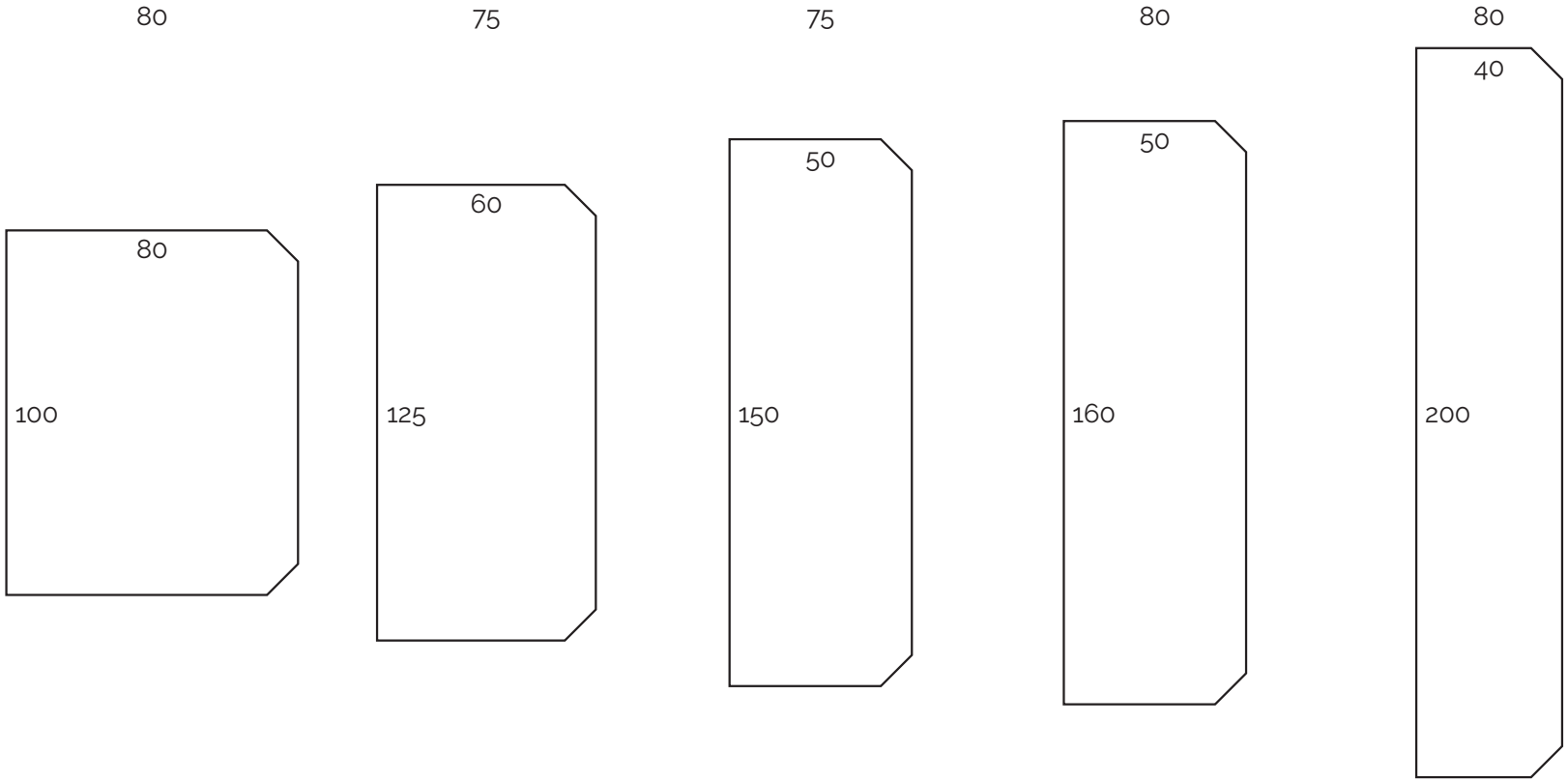

Figure 17: Profile proportions with side lengths in [mm] on the corresponding edges and the resulting area in [cm2] above

With a larger depth, the total product comes further into the room, resulting in obstructing more effective space. The flat back of a rectangular profile compensates for this slightly. The flat back is desirable as well, simply because it avoids hard-to-clean areas.
A smaller depth makes for a larger width and a more intrusive product in sight. To balance the cons of both sides, I settled in the middle with a profile with a width of 16 [cm] and a depth of 5 [cm]. The width of this part is quite high, however, as will be discussed in the duct chapter, I added small 1 [cm] chamfers on the side of the profile to make it feel less obtrusive. The loss of area created by this falls within the slight margin created by the profile dimensions. The final profile can be seen in figure 18 and 19.

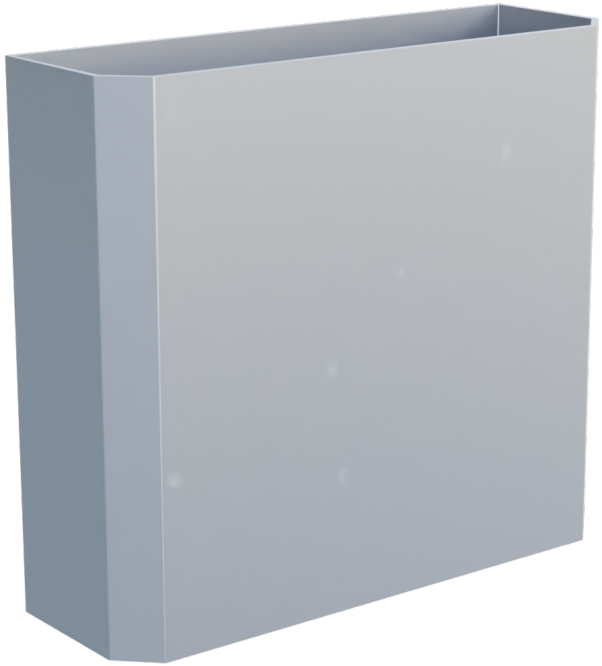

Figure 18: A three quarter view of the riser upright.

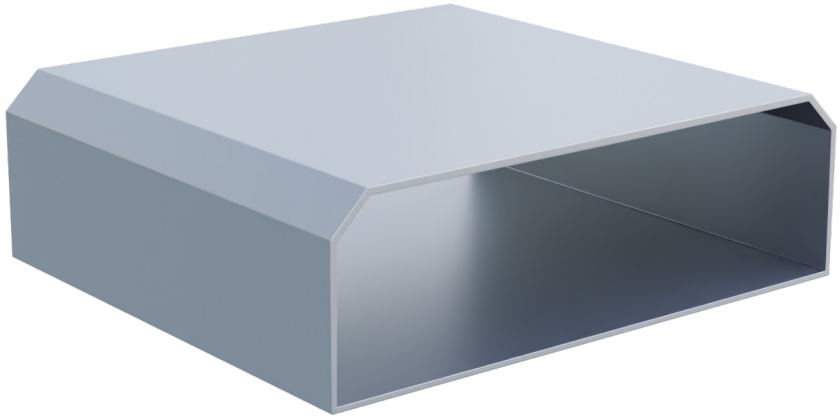

Figure 19: A three quarter view of the riser on its back.

CONNECTION TO THE AIR DUCTS

The connection of the risers with the air ducts is a separate component. This separate part ensures the correct installation of the components, reduces the amount of improvisation needed from the mechanic and provides a consistent image of the product. The connection has a hole in the front and connects on the top and bottom to the cover plate and normal riser respectively, see figure 20. The connection part with the hole is 139 [mm] in length and is produced by the extruder. A short aluminium pipe (~10 [mm]) is welded on the front hole (at Breman or at the extruder), which in combination with a rubber ring makes for an air tight connection with the air duct. An airtight connection from this connection part to the riser has not been designed yet. Rectangular ducts do exist, so there are solutions, however within this project these are yet to be considered. The connection from the top of the connection part with the cover plate is considered reasonably air tight.

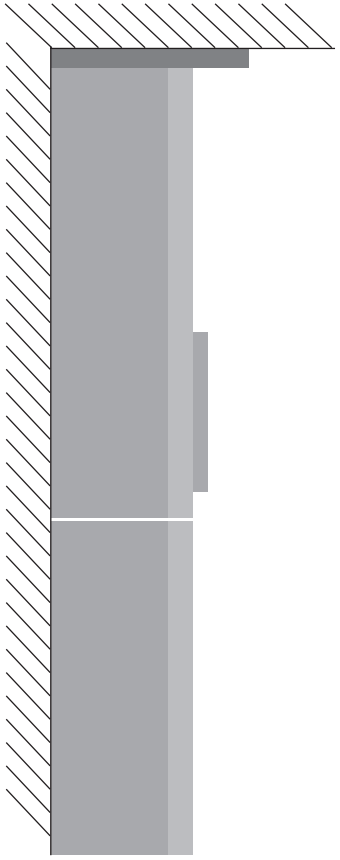

Figure 20: An overview of the connection part in between its neighbouring parts. On top it connects with the ceiling and the cover plate, on the bottom it connects with a standard riser.

Figure 21: A three quarter view of the connection part.

RISER CAPS

The risers need to be capped air tight at the top and the bottom of the stack. As I discussed previously, there is a distinction made between normal components and budget counterparts. However, these riser caps are mostly out of the view of the user and are therefore designed primarily for their function. The caps located on the attic are shut with a plastic impact insert cap (figure 22). These can be mass produced with injection molding and should be produced in solely dark gray, to reduce costs. The inside of the riser might need some ribs to provide extra material to bite into. The caps on the bottom of the system are made out of a aluminium and plastic combination, visualized in figure 24. The aluminium L-profile pieces are screwed into the plastic. These can later be used to attach the cap to the riser and also keep the rubber ring in place. The plastic caps can be injection molded in white or black, while the L-profile is a standard aluminium extrusion.

Figure 22: Plastic impact insert cap in a dark gray colour.

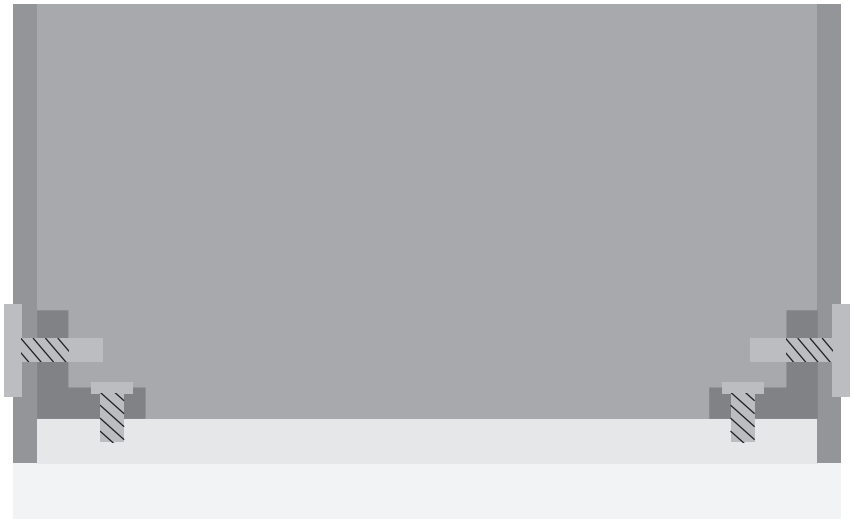

Figure 23: A cross section of the plastic-aluminium cap inside a riser.

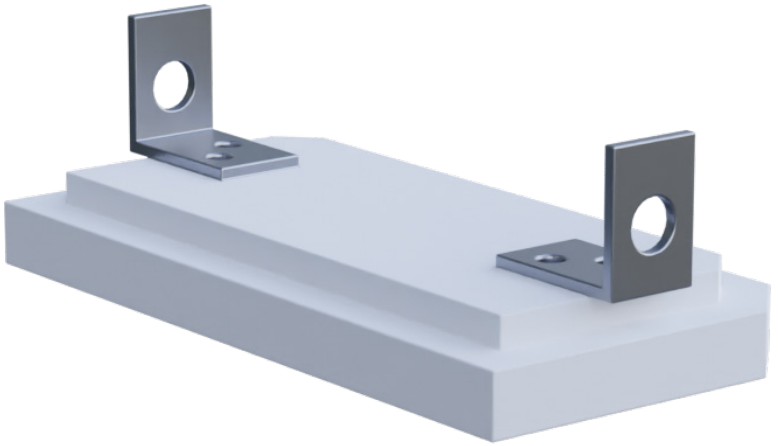

Figure 24: Plastic, aluminium combination cap

COVER PLATES

To be able to displace the air to the different floors the risers go through the ceilings of the house. Since the houses are built before the implementation of the product, these passages need to be made during installation. Because the profile of the risers is not a circle, while a drill is, there should be a margin for installation and a cover to tidy it all up. In figure 25, a top view of the situation is visualized. In this figure, the cover is made semi-transparent to show the drill holes. It is advisable to place standard pipes in these holes to prevent the air from leaking into the ceiling. In the area of the riser profile, there are still several(yellow) floor parts visible. Whether or not this loss in capacity is critical in the system is not further researched. The cover plate is mounted to the floor or ceiling using two bolts, attaching the riser firmly to the wall. The cover plate is laser-cut from an aluminium sheet. The bolts' holes are cut with the laser as well and are countersunk to make sure the cover plate is completely flush on the top when installed.

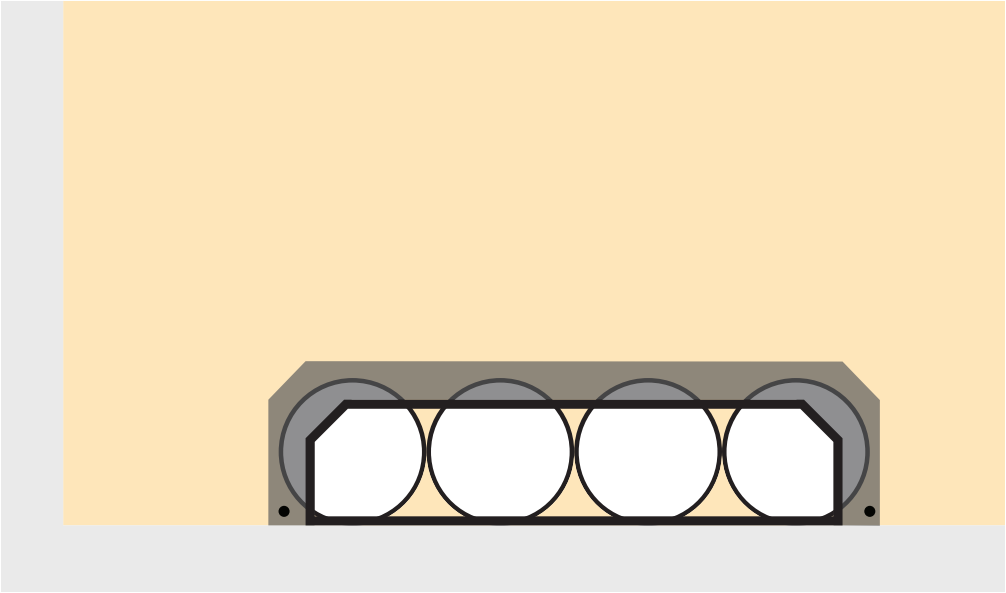

Figure 25: A schematic top view of the passage situation.

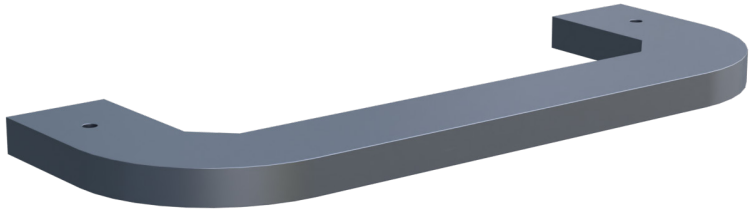

Figure 26: A three quarter view of the riser cover plate.

AESTHETICS

Throughout the chapter I discussed several aesthetic considerations. To conclude this chapter, there are several additional thoughts on the aesthetics of the risers. Overall, the vision for this product is to convey a healthy climate, which could be translated to a calm image. The design has to fit a large scale of interiors and is therefore envisioned to have a low-key image. The combination of these two interpretations translates to a minimal design.

It is established that the risers are of less visual importance than the ducts and the valves. However they do provide the visual cue for people how the air currents are situated. Therefore I chose to not cover them up and keep the metallic colour. This is also in line with the pureness of the system, resulting in no main hidden elements, not even the colour. The risers are kept straight to not interfere with the architecture of standard homes, but blend into it. As the risers are of lesser importance to the visual concept, the risers placed behind the ducts make sure they do not interfere with the horizontal direction of the product.

DUCTS

The air ducts distribute the air, provided by the risers, throughout the floors. These ducts are placed in front of the risers along the walls of the rooms. The reason why the ducts are positioned in front of the risers is further discussed in the aesthetics part of this chapter. Due to the configuration, every room has the option to have a supply duct and an exhaust duct.

PROFILE DIMENSIONS

Similar to the risers, the ducts have a rectangular shape. However, since the proportions of the riser felt too wide, I had to tweak the profile. The height (previously the width, but the duct is positioned on its side relative to the risers) was too large and made the design feel heavy. The before mentioned chamfers helped, but it still felt too bulky. To balance the profile I added a slight arc to the back of the profile. Because of the extra depth created by this arc, the height could be reduced. The resulting height of the profile is 140 [mm], 20 [mm] lower than the riser. The depth of the curved part is 22 [mm], with a resulting depth of 66 [mm], only 6 [mm] deeper than the riser. The riser is not adjusted to these proportions as the flat back of the profile is beneficial for its placement and purpose. The final profile of the duct can be seen in figure 27.

To match the riser the ducts are also made out of aluminium extrusions. The slightly more complex profile should not be a problem. An argument could be made about the back of the duct. Since these can be seen, but are closely to the wall, the surface finish is of lesser importance. To further nullify this problem an option could be to add ribs to the back of the profile, illustrated in figure 28.

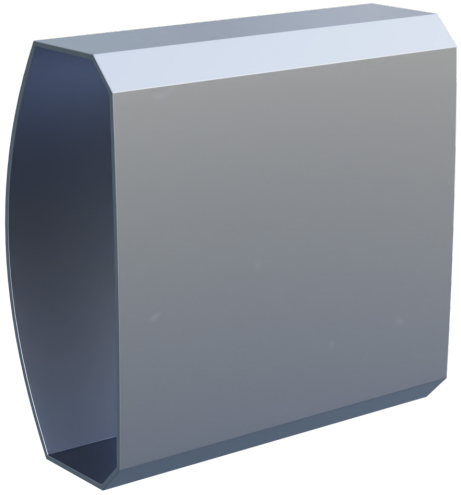

Figure 27: The final duct profile in a three quarter view

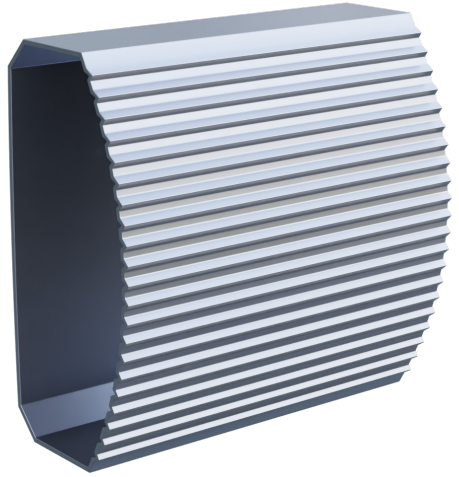

Figure 28: The addition of ribs to the back of the profile removes the visibility of surface imperfections.

CONNECTION TO THE RISER

The duct counterpart of the connection between the duct and riser, see figure 29, is based on the profile of the duct without its curved part. There is a 100 [mm] diameter pipe welded to the back of the part. This pipe slides into the pipe that is situated at the front of the riser connection part. The connection ensures that the ducts are always situated 120 [mm] from the ceiling.

The sides of the connection parts have flanges which cover the open endings of the air ducts. These are welded on the part as well, with the weld edges falling in the chamfers of the riser's profile. One side of this connection part is capped, which will be later discussed when describing the duct cap. The other side is connected to the duct. Similar to the riser, the airtightness of the connection part has not been researched.

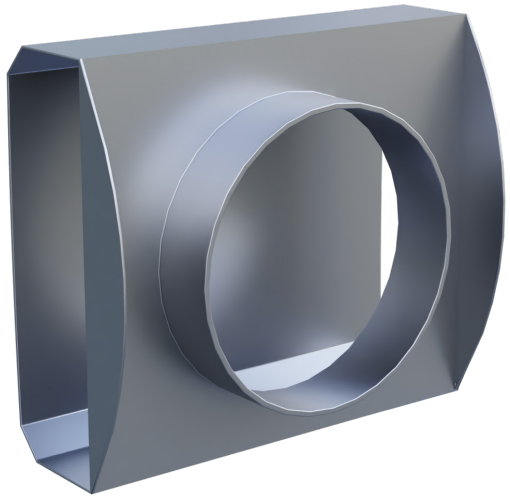

Figure 29: A three quarter view of the connection to the riser

DUCT CAPS

The caps of the ducts come in several variations. This is due to the design vs budget point made earlier on. The main objective of these caps is to seal the ducts and amplify the aesthetic vision of the product. In the budget solutions the functional objective is most important, however it should not detract from the aesthetic vision.
There is a budget cap and a fancy cap. The budget cap, see figure 30, can be pushed into the duct in the same manner as the plastic riser caps. The plastic cap protrudes 10 [mm] from the duct and is injection molded. The budget caps work using a similar principle to their respective riser caps. The inserted part of the cap could be detailed with ribs (not visualized in the figures). These ribs would provide extra area and grip for the cap.

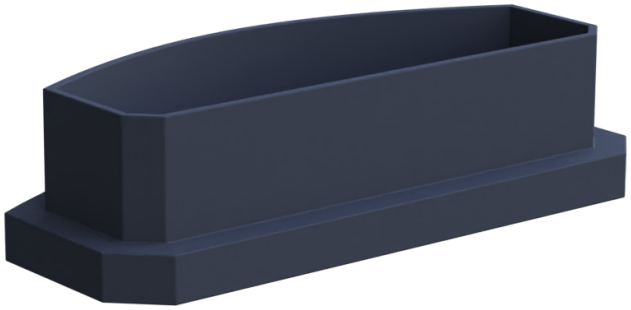

Figure 30: A three quarter view of the budget duct cap

The other cap type is a more stylised cap, see figure 31, meant for the design version of the product. This cap is similar to the duct profile but has a rounded end to be more in line with the design of the duct. The same method of production and installation as the other cap applies. The cap is coloured black or white to keep a clean and calm image.

Figure 31: A three quarter view of the normal duct cap

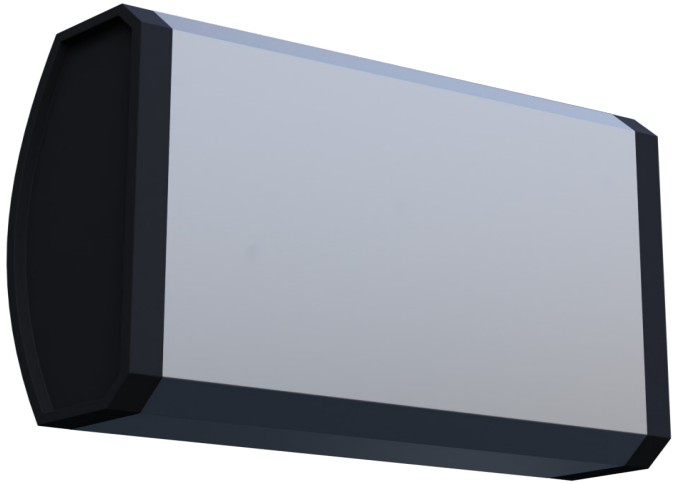

Figure 32: An overview of the budget caps on a duct

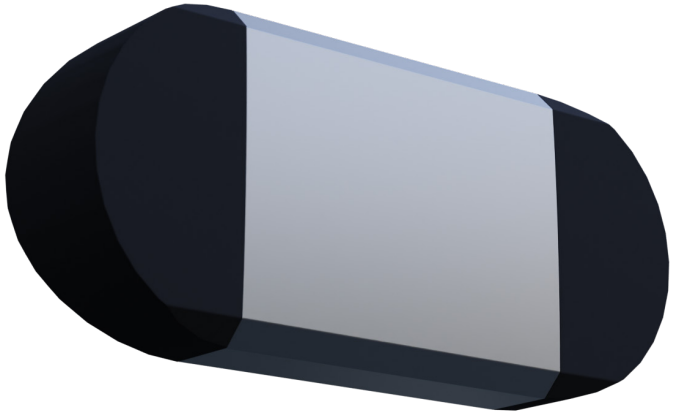

Figure 33: An overview of the normal caps on a duct

CONNECTION TO THE VALVES

A specific duct component is used to connect the valves to the duct. This duct component has the same profile as the ducts overall but has a 100 [mm] round hole in the front side, see figure 34. On this hole a 100 [mm] diameter piece of pipe is welded to attach to the valve. With the addition of this part, the hole will be manufactured in the factory, increasing quality and consistency. This reduces the amount of improvisation needed during the installation.

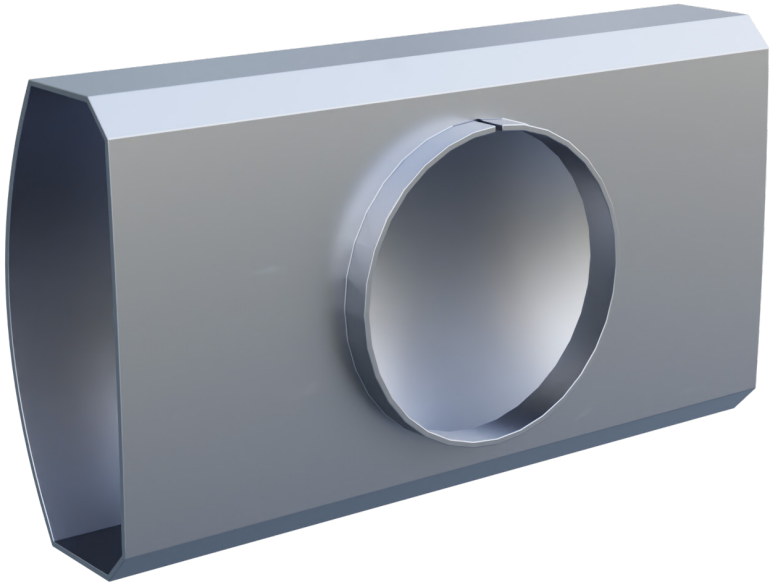

Figure 34: A three quarter view of the normal duct cap

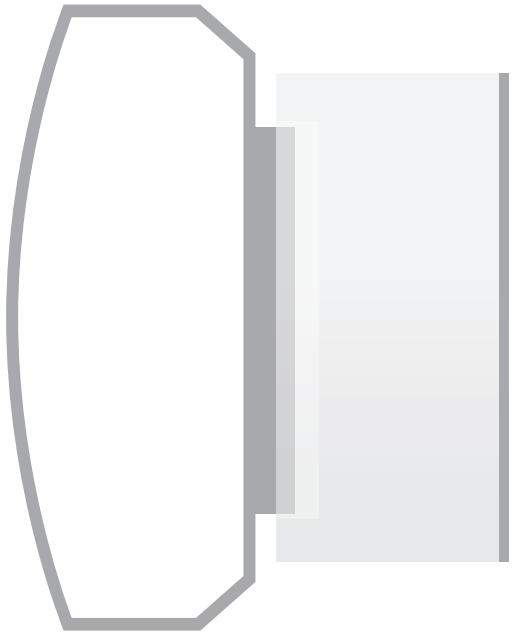

Figure 35: Side view of the connection with the budget valve

COVER PLATES

Similar to the riser, cover plates are used to seal possible holes that are made when the duct has to go through a wall. This cover plate consists of two parts split through the middle of the shortest side, see figure 36. These plates are laser cut from a 2 [mm] thick aluminium sheet with holes for the screws. The screw holes are countersunk for a smooth finish after installation. The cover plates are screwed into the wall. To get the duct through the wall, two separate duct parts are used with their connection hidden within the wall. The cover plates do not have to be made air tight since the air that can escape through the remaining cracks in the walls is insignificant and the air ducts are sealed airtight already.

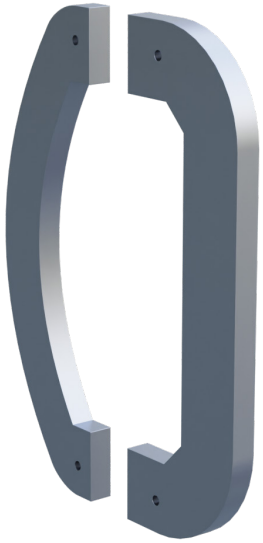

Figure 36: A three quarter view of the two cover parts, separated

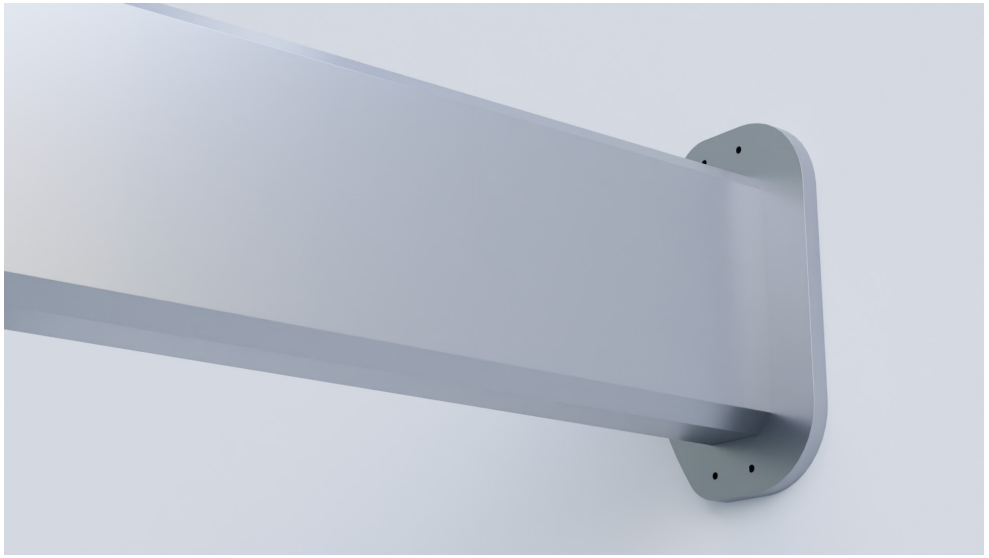

Figure 37: General impression of how the covers look in context.

SUSPENSION PARTS DUCTS

To hold the ducts in place, several suspension parts are used. These suspension parts are connected to the back side of the duct to make it look like the duct is floating. A spacer is needed per 500 [mm] duct. The spacer is welded onto the backside of the duct. An attachment ring is screwed into the wall. The spacers lock into these rings with a small screw or rod to secure them. During installation the duct is held against the wall to mark the placement of the rings and drill the correct holes. After the rings have been installed the duct can be slid into place. By tightening the screw or rod in the ring, the spacers are held tight and the duct is suspended.

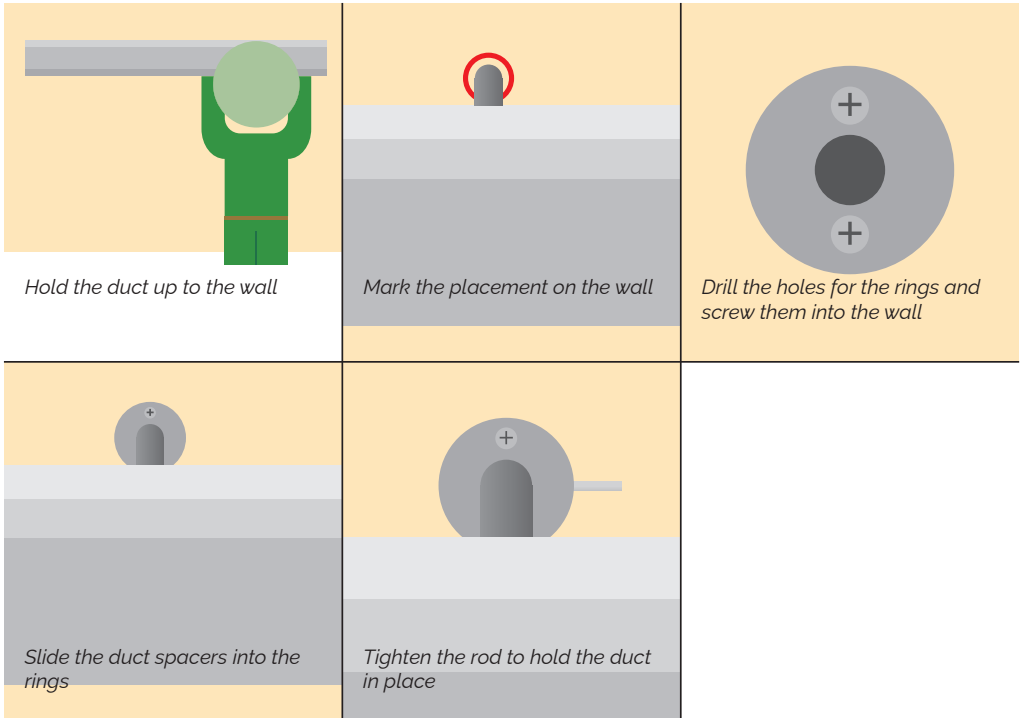

Figure 38: A quick guide on what the installation of the duct would look like.

Figure 39: A visualisation of the full assembly of suspension parts. The rod in the middle would be fixed to the duct before assembly.

AESTHETICS

A distinguishable feature of this product is the crossing air flows. In figure 40 the connection between the different parts is illustrated and clearly shows the different streams and the hierarchy between the elements. The main view of the product is in line with the architecture, it integrates and strengthens the long straight lines of the room.

To provide some visual interest (and optimize the area) the back of the duct is rounded. Combined with the chamfered front the overall duct is less bulky and therefore less intrusive. In order to keep the envisioned low-key image, the front of the duct is not altered in any way.

In an effort to further emphasize the healthy climate image, the association with floating and lightness was integrated into the product. The set of mounting points to the wall keep the floaty nature of the ducts intact and amplify it.

As is the case with the risers, the ducts also maintain their metal colour. Maintaining an honest design, and staying true to the vision of not covering elements up.

Figure 40: The intersection between the riser and the duct visualized.

VALVES

The valves function as the supply and suction of the air in the rooms. By using IoT components the valves can be controlled and data about the air quality of the house can be collected. This provides extra functionalities for the user and ensures the quality of the system. Similar to the duct caps the valves also come in different variations to serve both the purpose of a more budget and a more design version of the product.

BUDGET VALVES

The budget valves are mainly functional without detracting from the aesthetic vision that has been created throughout the rest of the design. The supply and exhaust valves look identical. The backside of the valve has a 100 [mm] round hole that can be slid onto the duct connection. The valve can be removed from the duct to provide access to the backside of the valve. Firstly, this is useful when cleaning the valves. Secondly, this provides access to the battery cavity, for the battery that is used for the IoT components. The housing is big enough to fit all the IoT components (the IoT components specifically will be explained later on).

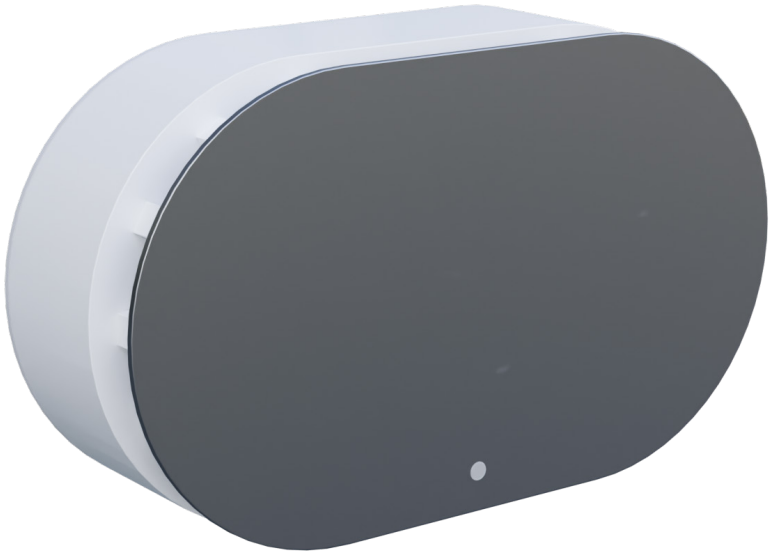

Figure 41: Front view of the budget valve.

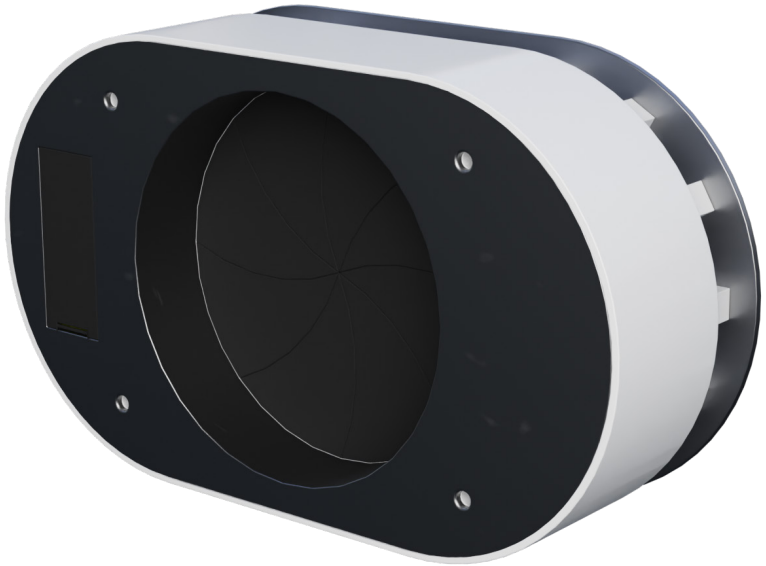

Figure 42: Back view of the budget valve.

The housing consists of an injection molded plastic part, two metal plates and two parts purchased from third parties.

Starting off with the injection molded housing. As this is concept design, the main consideration is in the reproducibility of the part. Therefore I designed the elements to be releasable on one axis. This makes for cheaper molds and lowers investments (figure 44, next page). The elements in the back are indications of where IoT components could be situated. These elements can be enclosed by walls on the back of the body (simplified to only the IoT components in the figures, for a sense of dimensions). These created slots could also be designed as snap fits for a more rigid end product. The four round screw hole pillars connect the backplate to the housing, sealing the IoT components away from the air streams. By using screw holes, instead of snap fits, the product remains dismountable and provides a higher repairability. The tube on the back is to keep the iris in place and seal the connection. The front of the housing has several spacers on which the metal plate can be attached. Four spacers have holes in them for a friction connection with the metal front plate.

The first metal plate has four cutouts with various functionality. The four small round cutouts are for the screw attachment to the housing. The cutout in the middle is to provide the air flow for the valve. On the inside of this cutout, a metal pipe is welded to keep the iris in place. The cutout on the left side is for the insertion of the battery compartment. By making only the battery compartment accessible, the chance of users unknowingly sabotaging the IoT elements decreases.

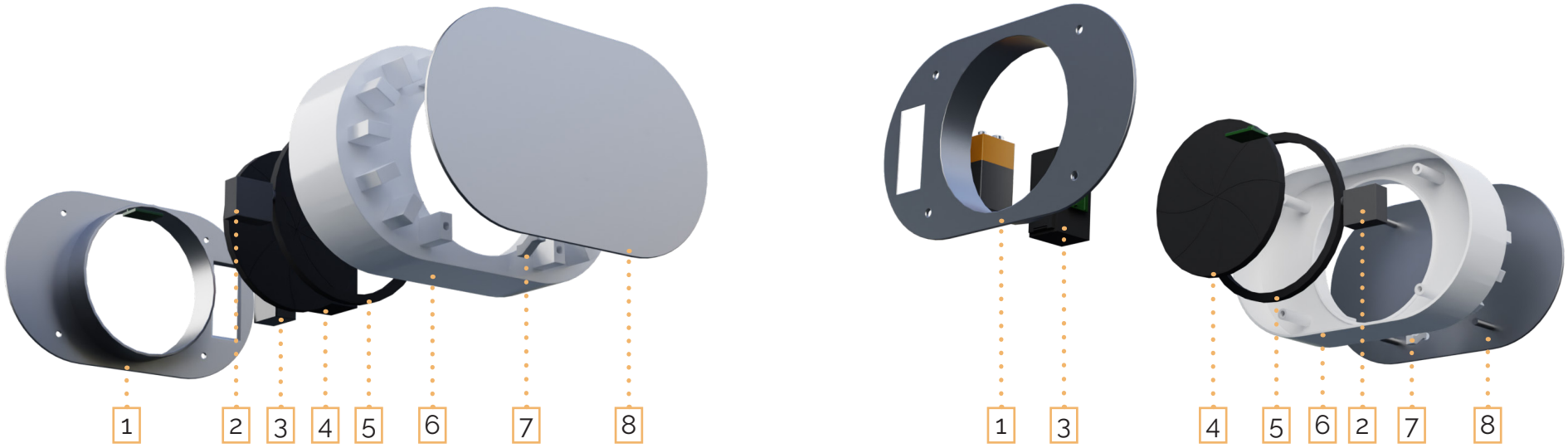

Figure 43: Exploded views of the budget valve with the most important elements labeled. ***[1]*** *Backplate,* ***[2]*** *Servo iris,* ***[3]*** *Battery compartments,* ***[4]*** *Iris blades,* ***[5]*** *Iris fixation ring,* ***[6]*** *Main housing,* ***[7]*** *Light,* ***[8]*** *Cover plate.*

The second metal plate is a simple cutout with a small round hole in the bottom. This hole functions as a passage for the indicator light. On the back of the plate four rods are welded, which in turn fit into the four holes in the spacers of the main housing.

The first part bought from third parties is a battery compartment, to give the user access to the battery. The second is the iris.

The actual fixation of the iris is loosely determined by the tubes on both sides of the element. However additional detailing and experimentation is required to make this feature fully feasible.

The direction of the in- or output of the valves provides a non obtrusive airflow, as illustrated in figure 45. The valve is finished with a cap on the front. In this cap a small light is integrated to give visual feedback to the user on the status of the valve.

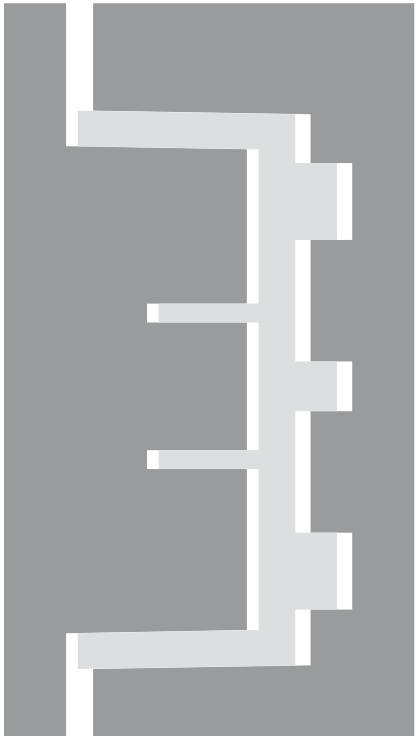

Figure 44: Simplified cross section of the molds of the main housing.

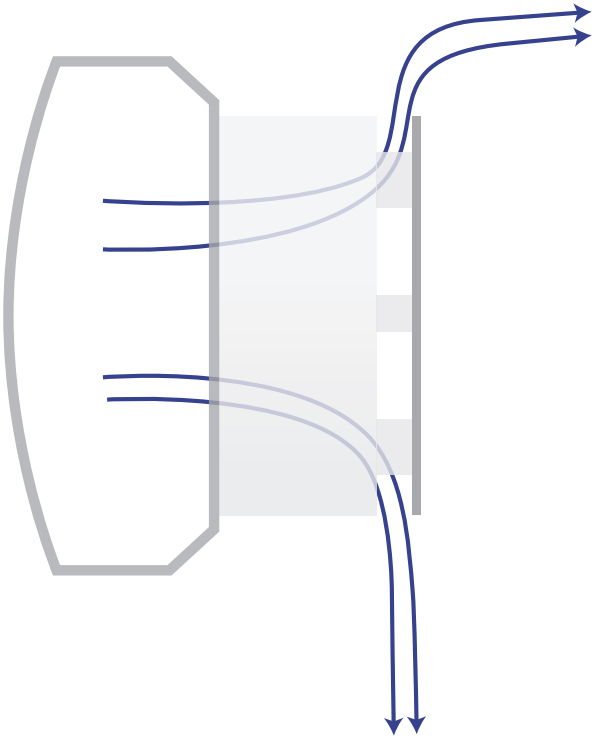

Figure 45: Cross section of the duct and the valve, with the indication of the presumed air flow.

AESTHETICS

The overall appearance of the budget valve is kept neutral. With this basic valve, function is most important. The shape is a result of following the existing form language and combining this with the needed dimensions for the features. I chose a white housing for the injection molding part, as it combines well with the metal colour and maintains a calm image.

The front plate's metal colour creates contrast with the valve itself, but integrates in the whole picture, preventing the valve from becoming too much of a standalone element. The valve fits inside the space between the chamfers of the duct for the same reason. With the minimal interruption of the sight lines, the valve stays to the foreground of the hierarchy without compromising the overall shape of the product.

The visible passageways for the air could have been covered by a cloth membrane. However, to stay true to the pureness philosophy, the cloth was removed for the final iteration. The open nature of the valves makes it so that the user can even see the airflow from certain angles.

Figure 46: General impression of the budget valve in context.

EYE CATCHER VALVES

The eye catcher valves for the design version of the product are not only more expressive in form, but also have slightly more functionality. The valves can be rotated to face a different direction and create a different airflow. This is useful when trying to create the optimal airflow or for adaptation by the user to a different use scenario. More emphasis has been put on expressing the different functionalities of the supply and exhaust valves through their design. The valves also have a clear visual cue on what setting the ventilation is set to. Overall, the eye catcher valve puts more emphasis on making the user aware of ventilation. Throughout the project many ideas and iterations where made on this subject. In figure 47, an impression of such a thought process is shown. The resulting valves are described in the rest of this chapter.

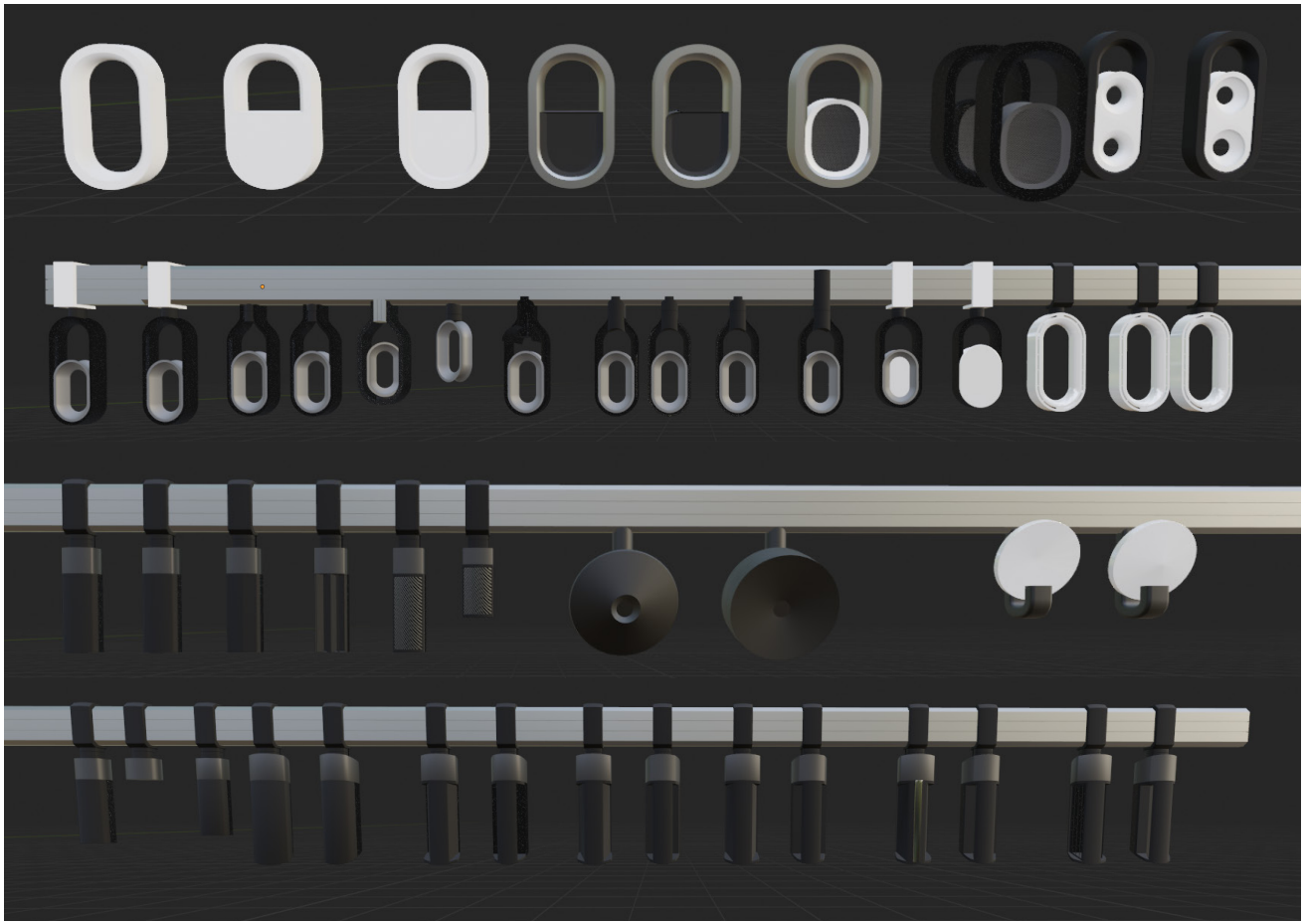

Figure 47: An impression of the iterations and explorations which can be found in appendix K.

The supply valve

The supply valve consists of three injection molded plastic parts, an extrusion profile and three parts purchased from third parties.

The first injection molded part is the outer shell of the valve. This shell is mounted through the side of the profile and sits in between the chamfers of the duct. A small space has been left on the top and bottom, to counter that it would never sit perfectly on the bend. The long snapfits in the inner ring connect the part to the extrusion profile. These snapfits are inset relative to the outer ring of the part, to hide the imperfections of the cutout in the extrusion profile.

The outer shell has two functions: storage of larger IoT components and opening up the possibility of a z-axis rotation. The middle of the outer shell has a hole in the shape of the rotational cross section of the blow-in head. By using the cross section of the shape, the two parts remain airtight when using different rotations.

The blow-in head of the valve is split in the middle, dividing it in two separate parts. I did this to eliminate the need for a third part, a back cap, and to reduce the complexity of the mold in general. The front shell and the back shell only need to house the air speed sensor and the servo for the iris. These parts will be clamped inside the housing when assembling the part (this is assumed and not shown in the figures). The division line is placed in the middle due to producibility, but has the benefit that it only shows when the head is actually turned. As an upside to this, it gives the design more direction, as it now has a "neutral" rotation state.
The backside of the head is a continuation of the round shape. However, this shape is terminated by a backplane situated on a distance determined by a 30 degree rotation angle. This results in a maximum rotation angle of 60 degrees, without compromising the air tightness of the head. The back of the head is curved inwards, with large fillets, to obstruct the airflow as little as possible.

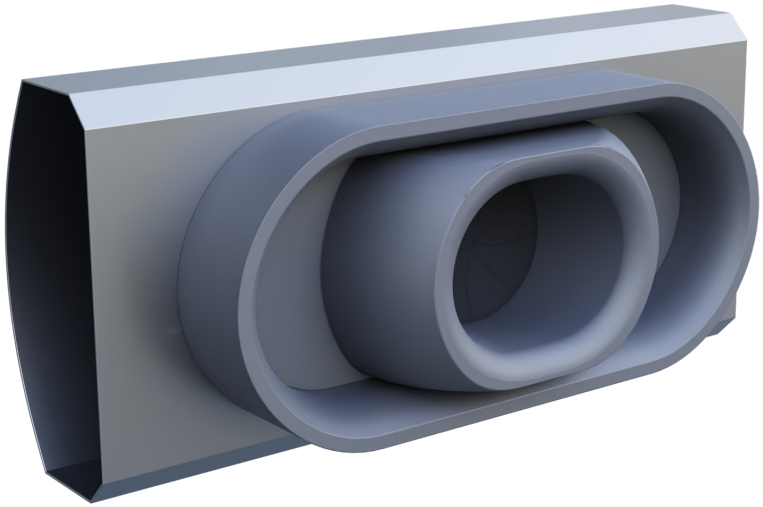

Figure 48: Front view of the supply valve.

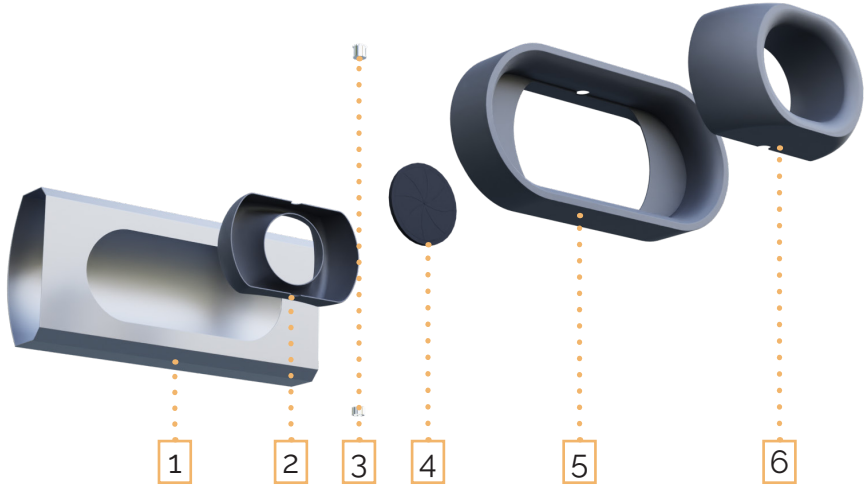

*Figure 49: Exploded view of the supply valve with the most important elements labeled. **[1]** Duct with cutout, **[2]** Back shell blow-in heads, **[3]** Low: hollow axis, high: servo rotation axis, **[4]** Iris, **[5]** Main housing, **[6]** Front shell blow-in heads.*

The extrusion profile is a modified piece of duct. This duct has a cutout with a small inset relative to the shape of the outer shell part. The extrusion is 50 [mm] wider than the outer shell leaving some room on both sides to let the design breath.

The first part bought from third parties is a rod/axis connected to a servo motor. This part will be connecting the top holes of the parts. The servo would be situated in the outer ring, while the fixation would be clamped in the blow-in head.

The second part bought from third parties is also a rod, but this time for the bottom holes of the parts. This could be a simple tube. Its main functions are: to complete the z-axis (guiding and providing stability to the rotation) and as a port for wiring.

The third part bought from third parties is a similar iris to the iris used in the budget valves. This iris is clamped in between the two housing parts of the blow-in head.

The exhaust valve

To balance the design of the supply valve a counter, exhaust valve was designed. The exhaust valve consists of an injection molded plastic part and a part purchased from third parties.

The exhaust valve does not need the added functionality of a rotational head. Therefore the part was kept simple and mainly follows the design of the supply counterpart. The back of the housing is snapped into the extrusion profile similar to the supply part. The iris is clamped between the opening and the extrusion profile. The space left in between the housing and the extrusion profile can be utilized for the IoT components.

The extrusion profile is a duct with an extra hole in the middle. It also has two slits to connect the snapfits.

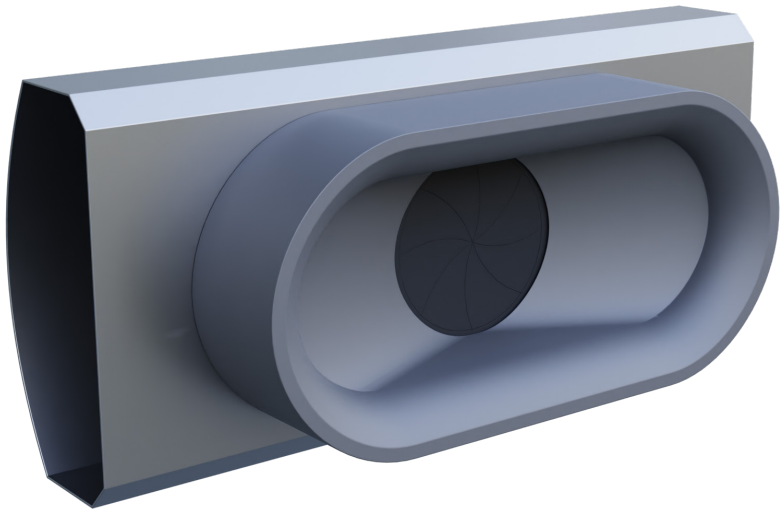

Figure 50: Front view of the exhaust valve.

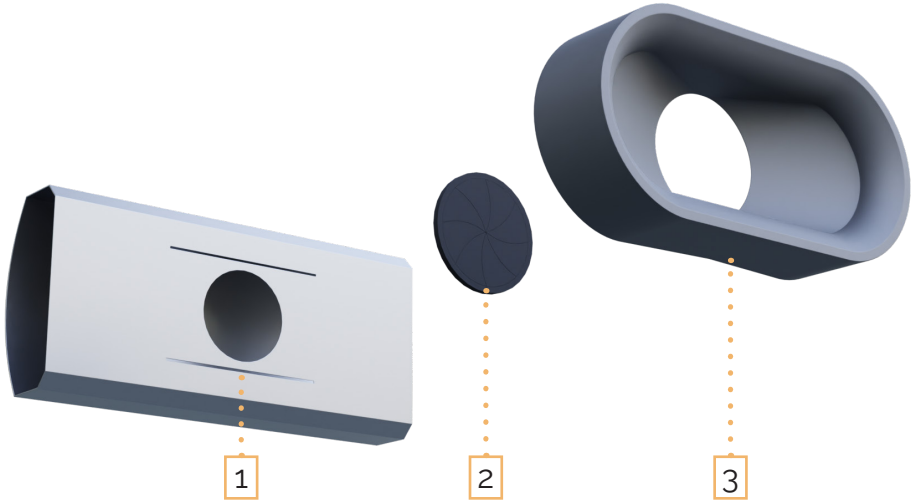

*Figure 51: Exploded view of the exhaust valve with the most important elements labeled. **[1]** Duct with cutout, **[2]** Iris, **[3]** Main housing.*

AESTHETICS

The eye catcher valves are more expressive in their design. They emphasize the functionalities of the ventilation system and provide the possibility for the user to be more expressive in their design choices.

The outer shell and the outside ring of the supply valve and the exhaust valve respectively follow the overall shape of the duct. It integrates seamlessly into the shape of the ducts with the rounded caps, but also integrates well with the simpler cap option. These valves' silhouette is relatable to the budget valve as well, making it a form family instead of separate elements.

The supply and exhaust valves are similar, but have distinctive functional differences. The shapes suggest inhaling and exhaling, which makes the user subconsciously aware of the function of the different valves. The somewhat concave and convex shapes also link into each other, strengthening the idea that something happens between the two valves when on opposite sides.

Figure 52: A comparison between the valves, with reference pictures of the envisioned association.

Figure 53: A supply valve in the context of the living area. All designer variants are used for this system and are implemented in white.

Figure 54: A supply valve in the context of the living area. All designer variants are used for this system and are implemented in white.

Figure 55: An exhaust valve in the context of the living area. All designer variants are used for this system and are implemented in white.

IOT COMPONENTS

By adding IoT components, the efficiency of the system is increased, a level of flexibility is added to the system and the installation/setup is easier. An example of what this added functionality could do can be seen in the envisioned use scenario in figure 56 and 57.
The addition of IoT components enables the product to regulate and adjust itself and allows the user to set zones and use scenarios. This makes the system adaptable to the home without removing the control from the user. The system will also be able to provide information about the air quality of the house and efficiency of the system to the user to create more awareness about ventilation. This data could also be used by Breman for optimisation of the system, if privacy regulations allow it.

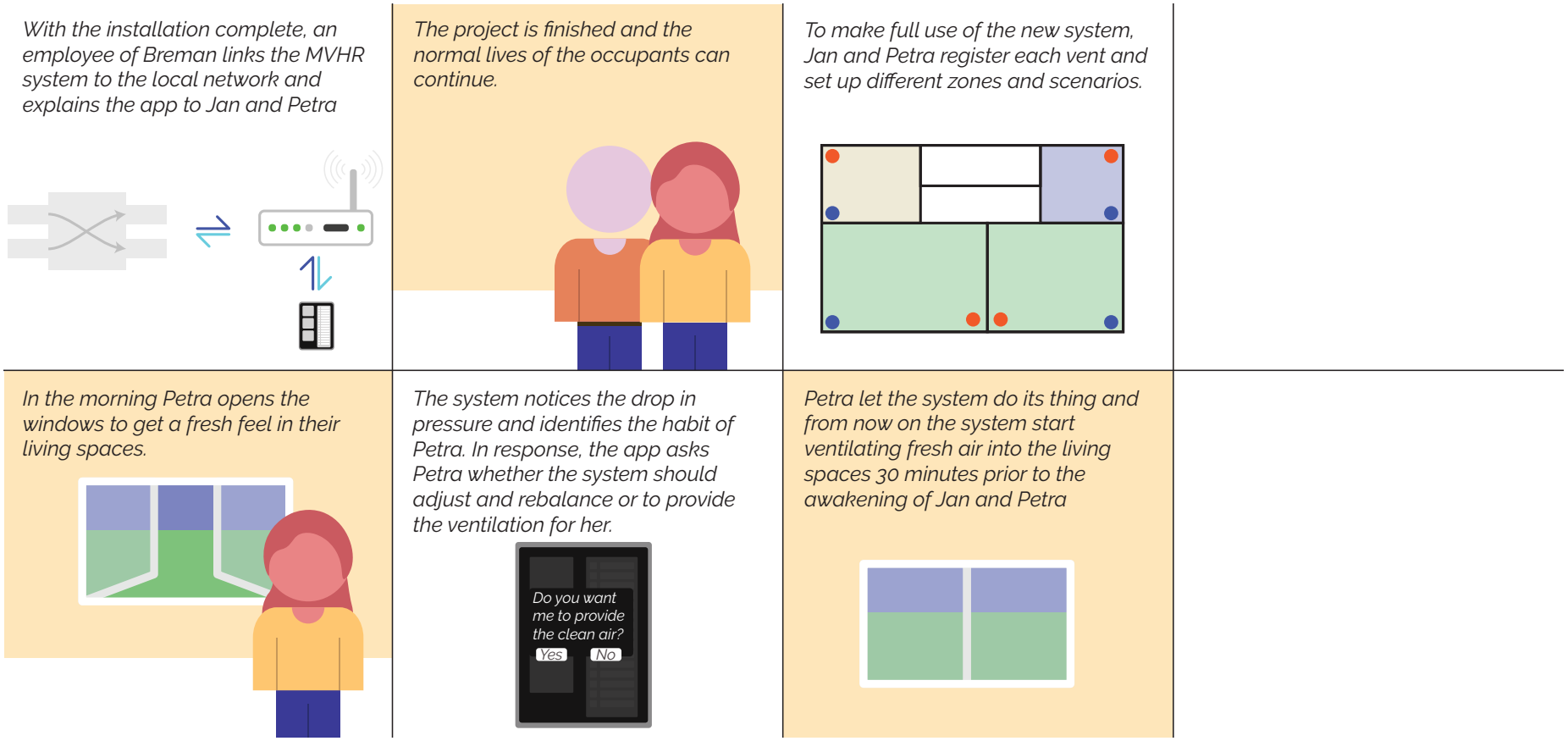

Figure 56: An use scenario of different envisioned applications of the IoT.

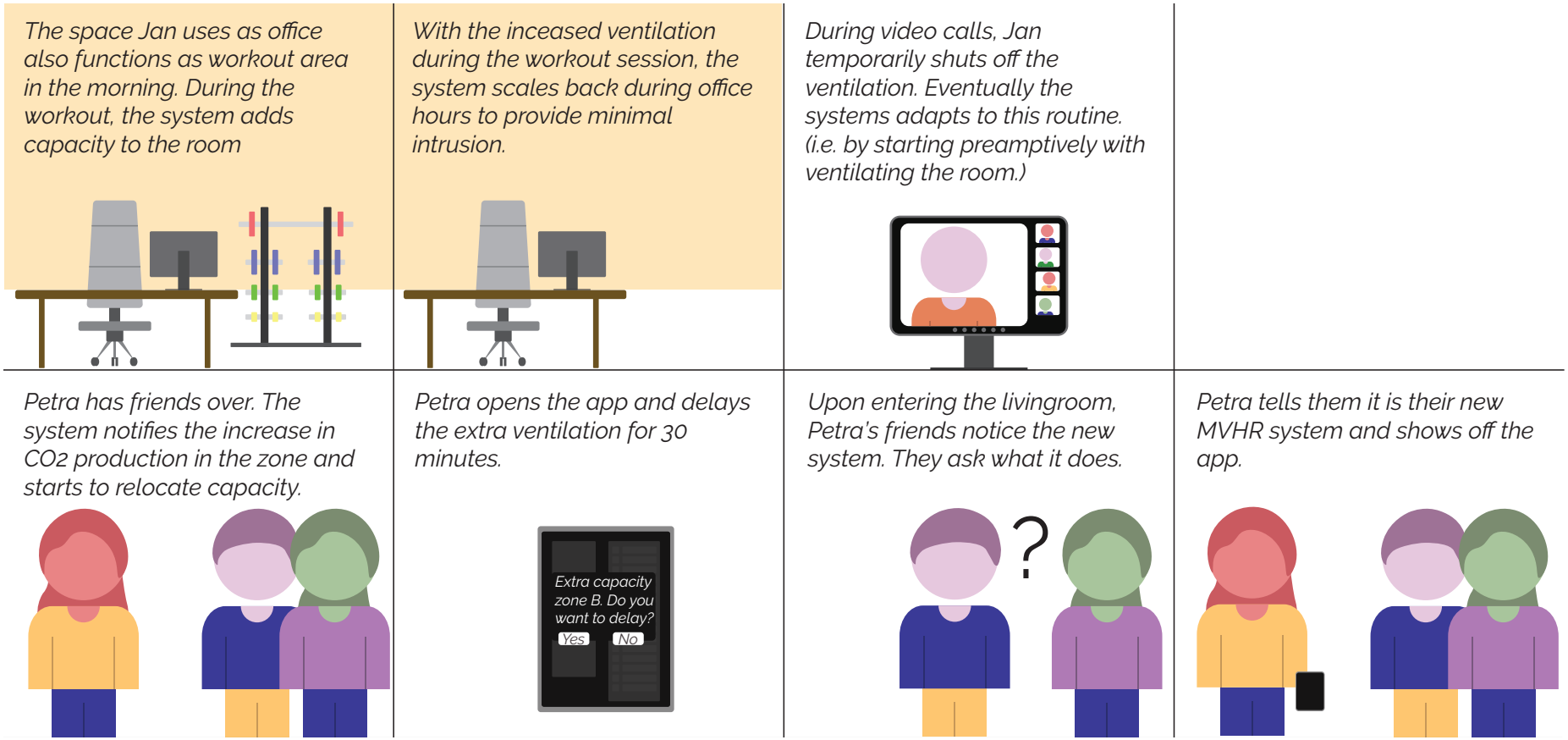

Figure 57: Continuation on the envisioned use scenarios.

The following sensors and actuators are added to the system:

- An air speed sensor measures the speed at which the air passes through the valve. This sensor is implemented in the exhaust and the supply valves.
- An actuator/servo motor rotates a disc inside the valve, regulating the capacity. This sensor is implemented in the exhaust and the supply valves as well.
- A CO2 sensor measures the air quality and approximates the amount of CO2 in the room. Most CO2 sensors measure air quality as a whole and can measure the moisture as well. This sensor is only used in the exhaust valve.
- A wifi module is used to connect the valve to the local network of the user.
- A small light is added to the budget valve to indicate its status.
- A battery is used to power these components within the valve.

APPLICATION

With an application the user will gain control over and insight into the system. The application supports the basic functionalities of the IoT system. This means that the user will be able to control the settings of the ventilation, connect different valves and create different zones and use scenarios. The user is also able to look at the statistics of the system and get an overview of these statistics over the months.

INTERIM CONCEPT

Following the discussed designed elements, I present the interim concept Breman Flow.

The interim concept functions as a milestone to start validating and to initiate the next design loop. This design freeze is needed to prevent everlasting design cycles. Figure 58 to 62 are indications of what a “regular” installation looks like. In this manifestation of the product, the standard MV installation is offered (exhaust in wet areas) with the addition of supply in several living areas. The spare room is labeled multifunctional. Only the most important areas are shown in the report, renders for the additional rooms can be found in appendix K.

Figure 58: An impression of the living room with the budget valves installed.

Figure 59: An impression of the living room with the budget valves installed.

Figure 60: An impression of the kitchen with the budget valves installed.

Figure 61: An impression of the master bedroom with the budget valves installed.

Figure 62: An impression of the master bedroom with the budget valves installed.

EVALUATION PHASE

In the evaluation phase part of this report I will go through several meetings with experts on different aspects of the product. A discussion is added with additional thoughts on the product and the process. The evaluations and suggestions are compiled into a recommendations chapter for Breman as a guide for the next steps to be taken. The evaluation phase is concluded with the answer on the question the brief asked and a final overview of all the product components.

EVALUATION

In search of validation on the interim concept, I had several meetings with experts, in which I presented the concept and decisions, relevant to their expertise areas. These meetings serve as an evaluation of the concept as well as feasibility, desirability and viability checks. Additionally, the nature of these meetings shifted towards creative sessions, in which new solutions and suggestions manifested. Therefore, this chapter functions not only as a validation test, but also as a reference to these solutions.

CEZAR DE JONG & MARTIJN ROOK (PRODUCTION, FEASIBILITY)

Cezar de Jong and Martijn Rook are the product development duo of Breman Schoorsteentechniek. Cezar has a strong sense for developing concepts, while Martijn specializes on the details. With a combined 35 years of experience, they have great knowledge of the construction industry.

Their first reaction to the product was that overall, the aluminium parts of the product can be manufactured. They agree that the elements should be manufactured at third parties, resulting in catalog based elements. However, some of the elements and their production could be optimized.

Cezar and Martijn mentioned that the two profiles, of the risers and the ducts, could be combined into one extrusion profile. Combining the profiles lowers the production costs and reduces the amount of molds necessary. To still keep the risers different from the ducts they suggested using the back of the profile for the former and the front for the latter.

Due to the profiles no longer being round, Cezar and Martijn raised the question about what would happen to the airflow and primarily the sound this airstream would produce. They also wondered what the airflow would be in the connection parts between the risers and the ducts.

As there is a space between the ducts and the wall, Cezar and Martijn wondered whether there would be a build up of dust, cobwebs, etc. behind the ducts. Currently the space on top of the duct and between the duct and the wall, seem hard to clean. Cezar and Martijn do agree that, since the valves are no longer placed against the ceiling, there will be no hard to clean black marks on the ceiling. On top of that, any dirt or grease on the product can be easily wiped off.

To avoid the need of an additional mechanical operation to the ducts, Cezar and Martijn suggested changing the connection points, that are welded to the ducts, into a slit in the back of the extrusion profile. This way, a u-profile could be attached to the wall to which, in turn, the duct could be attached. Using a u-profile would also simplify the installation process and reduce the amount of parts. As a continuation of the simplification of the installation process: in the current solution the mounting points could align awkwardly with the architecture (mortar joints). On top of that, consistently installing the mounting points level, will in practice prove difficult. The result would be that the product is installed skewed or improperly. The u-profile would however, remove the floating image the ducts currently have. To retain this image, the u-profile could be manufactured with cutouts.

Cezar and Martijn advised against fixing the risers solely with the cover plates. They mentioned that in current installation processes finishing elements, such as the cover plates, are installed last. This would mean that the risers would remain floating until the end of the installation. On top of that, they could imagine that there would not always be enough material

around the riser for the cover plate to be screwed into. In that case solely glueing the cover plate down would be the only option, which would not fixate the riser enough. Instead they suggested connecting the riser to the wall with screws through the back of the riser. Screws are currently used to attach certain parts of ventilation systems as well, so it should not impact the airtightness of the product.

Since the floor heights can differ from house to house, Cezar and Martijn suggested creating modular lengths of the riser. On top of that, they suggested inserting the risers through the ceilings instead of using a connection piece between the risers on the different floors. This does mean that the hole that has to be made through the floor and ceiling becomes more complicated. They expect that a specific tool will be designed to create this hole, due to the projected scale of the renovation market. To connect the different riser parts, they suggested a two sided impact insertion piece, as illustrated in figure 63.

To make the installation and finishing of the product even more straightforward, Cezar and Martijn advised to turn the duct and riser caps into impact insertion caps. This way they can be installed with just a mallet. Negative pressure, as is present in the exhaust ducts and risers, tightens the caps. In the supply ducts and risers, the pressure is minimal (30 / 40 [Pa]) and will not cause the caps to pop out of the ducts or risers. By adding ridges, the grip of the caps can be increased even more.

Cezar and Martijn compared the costs of the product to the current way MVHR ventilation is built into existing houses. They expect the overall price of the product to be lower than existing solutions. The production costs will be higher, but this is compensated by the easy and fast installation.

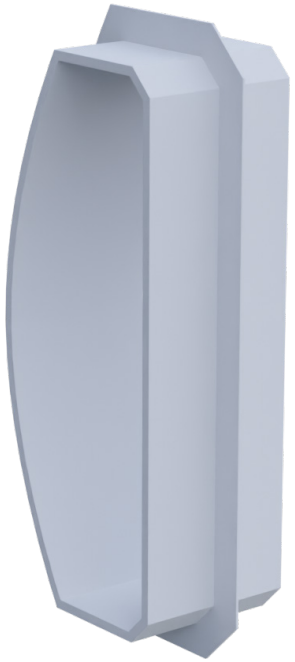

Figure 63: A suggestion of the part described by Cezar and Martijn.

CONCLUDING VALIDATIONS PRODUCTION & INSTALLATION

- Generally speaking, the aluminium parts are producible.
- Product elements should be produced at third parties.
- Mounting to the wall should be done with a profile instead of individual points.
- The risers should not be mounted to the wall solely with the cover plates.
- The solution of the multiple holes through the floor is possible, however alternatives need to be explored.
- Change the mounting method of the caps to impact insertion
- The expected overall price of the product is estimated to be lower than existing solutions.

MARK SPRENKELS (MARKET, VIABILITY)

Mark Sprenkels is the manager of knowledge centre Energy Transition at Breman Installationgroup and has been working in the installation branche since 1986. He has a thorough understanding of the installation market and is in close contact with housing associations.

Mark Sprenkels' first reaction to the concept was fascination about the rectangular ducts and risers, as the current market is stuck using round ducts. Mark Sprenkels notices an increased demand of MVHR installations, as it increases comfort for the user and reduces energy costs. However, when a MVHR ventilation system has to be built into an existing building, it is oftentimes an invasive procedure. Mark Sprenkels agrees that with the solutions found, concerning shape and installation, the amount of adaptations to the building seems to be reduced. His overall impression is that the elements in sight are calm and pleasant to look at.

Mark Sprenkels mentions three pillars for creating solutions for housing associations, with which the renovation industry can become more ecologically responsible. The three pillars are: affordability, manageability and scalability.

Affordability mainly has to do with investment and ease of installation, which translates to lower costs.

Manageability has to do with stability of the system and the amount of maintenance needed. On top of that, it also has to do with where the raw materials are sourced and the circularity of the product elements.

Scalability has to do with being able to upscale the production of the product elements and an easy and fast installation.

Based on these three pillars, Mark Sprenkels evaluated the product.

AFFORDABILITY

Mark Sprenkels mentioned that, currently there are still little properly working and affordable solutions for ecologically responsible housing. Therefore, housing associations make little movement towards sustainability. The products on the market are still too expensive or the housing associations do not have enough budget available. Adjustments to the budget can take years before they are implemented. More money will become available in the coming years, since the housing associations are currently looking at their budgets.

For housing associations overall costs are the main concern when deciding on solutions. If a product has a feature that is only beneficial for its residents, but makes the product significantly more expensive, the housing association will not be incentivised to buy it. Housing associations do appreciate all in guarantees, low maintenance or included maintenance, but in the end they want the overall costs to be as low as possible.

As far as the overall costs are concerned, Mark Sprenkels mentioned that the product should be compared, not to the existing solution of a full renovation (in order to install a MVHR system), but to other future ecologically responsible alternatives. It should not only be compared on affordability, but also on manageability and scalability.

He estimated that the full product could be sold for a price between €15.000 and €20.000, including a heat pump or other gasless system. By compensating for the more expensive (but advanced) product with a basic heat pump, the overall product can become competitive with its alternatives.

The initial higher cost of a MVHR can be justified by lower energy costs, which creates an incentive for homeowners to buy the product. For housing associations however, this does not matter as they do not pay the electricity costs, removing the benefit for a large target group of the product.

Mark Sprenkels does not see a need for a leasable system among housing associations. They have the ability to get cheap loans and prefer to control their own financing.

By adding IoT and making it so that the system can set itself up, which currently is a high intensity task, the costs of the product are reduced.

As a reaction to the modularity and the ease of installation, Mark mentioned the possibility of carrying out the installation by non-mechanics. For example: a DIY'er, people with a less technical background or even students. This will likely reduce the overall cost of the product.

MANAGEABILITY

Rental houses, which make up a good portion of the target houses, change owners (mutates) quite frequently (4-5 years). On top of that, current residents could change their interior during their residency. The product however, will stay on the wall for 20 - 25 years, seeing different residents. It is therefore important that the walls of the home stay adaptable to the residents preferences, even after the product is installed. Mark Sprenkels foresees issues with painting or wallpapering these walls after the product has been installed. The calm and modest form language, combined with greyscale colours do feel fit for a wide array of houses.

Additionally, the mutation time could be used by the housing association to install the product in between owners. This way the residents do not experience the inconvenience of the installation and Mark foresees that residents will classify the product as part of the house.

Mark Sprenkels advised to clean the inside of the ducts and risers every 6/8 years. This is also becoming a standard for housing associations. Especially in the exhaust ducts grease builds up in the first 1.5 to 2 meters of the duct. Currently they use two methods for cleaning. The first method is using a brush that they insert into the valve. The second method is using a powder that is blown into each valve individually (one at a time) and blown through the system to the roof, where it is blown into the air or collected. The powder method is becoming the standard. At least one of these cleaning methods should be applicable to the product.

Mark Sprenkels advised against wireless connections, as they are prone to malfunction. In the construction industry he noticed a slow movement back towards wired connections.

SCALABILITY

With the envisioned, simple installation, the amount of people that are able to install the product increases. Mark deemed this as beneficial, since there is a shortage in manpower in the industry.

Mark Sprenkels stated that the IoT controllability is desired in general. This creates the possibility for less to no ventilation in the areas without residents or little activity. More ventilation capacity can be sent to when and where there are more people or more activity.

The resident should only have to set up the IoT and app once. Preferably, this should be done using a guiding interface, such as is present when setting up a smartphone.

ADDITIONAL THOUGHTS

Mark Sprenkels has concerns about the amount of sound the product will create and the speed with which the air travels through the product. It is essential for the users not to experience discomfort or they will actively sabotage the product to remove this discomfort.

By removing potential discomfort such as from sound, excessive energy use or unwanted air streams, the chances of the product getting actively sabotaged are decreased. Opening a window, and therefore sabotaging the product, is not an active sabotage but more part of the habits of the user and ignorance in relation to ventilation.

Mark Sprenkels mentioned that, currently, residents (partially) plug valves when they experience unwanted airstreams. This shows that a valve with the extra functionality of a movable air stream, is desired by the user.

The feedback loop of the app that signifies sabotage of the product can be experienced as intrusive, Mark Sprenkels mentions. The user does not want to get pop up notifications about them opening a window and therefore sabotaging the product. Mark Sprenkels also thinks that a part of the control that is added in the app is unnecessary and that the focus should be on a carefree product.

CONCLUDING VALIDATIONS MARKET

- There is a need for MVHR installation solutions for renovation.
- The amount of adaptation of the building needed for the installation is reduced.
- The market is opening up to ecologically responsible solutions.
- Offering a budget version next to a more elaborate version, offering more possibilities, is justified, as overall costs are most important to the target market.
- The simple installation will provide a competitive edge.
- The higher investment of a MVHR installation can be justified by its reduced energy cost.
- Leasable constructions are not in demand in the target market.
- IoT and its benefits are welcome in the industry and could reduce costs (mainly in maintenance).
- The shortage of manpower is evident and the product offers a plausible solution.
- The calm and modest form language, combined with greyscale colours do feel fit for a wide array of houses.
- Wired connections should be considered for the stability of the product.
- The users of the product can set-up the IoT systems by themselves.
- Residents actively sabotage their ventilation when experiencing discomfort.
- A valve with the extra functionality of a movable air stream, is desired by the user.
- The feedback loop of the app that signifies sabotage of the product can be experienced as intrusive.

JOS OBERDORF (INJECTION MOLDING & DESIGN, FEASIBILITY)

Jos Oberdorf is partner and designer at npk design and professor at the TU Delft. His many years of experience as a designer makes him knowledgeable on all aspects of mass producing plastic products.

Overall Jos Oberdorf was positive about the producibility of the injection molded parts, as well as the product in general. He agreed that using an iris mechanism to close off the air supply would be the best solution. Throughout the meeting the emphasis was on the eye catcher valves. Several changes mentioned in this subchapter are edited into the documentation in the previous chapter about the eye catcher valves. This is due to the eye catcher valves being developed, while the remainder of the design was frozen and in a validation stage.

As far as the eye catcher valves were concerned, Jos Oberdorf found the black outer edge to be too close to the chamfers of the duct profile. He wondered whether these edges needed to be this big and stated that the areas between the outer edge and the iris inside has no function. He also mentioned that the connection between the duct and the valve is not optimal as there could be imperfections in the hole that is cut into the duct. This would create slits for the air to pass through and an overall imperfect look. Jos Oberdorf suggested making the hole in the duct smaller than the outer edge of the black part and adding an additional, smaller, ring inside of the profile, see figure 64.

When asked about the producibility of the supply eye catcher valve, Jos Obderdorf agreed with splitting the blow-in head into two parts. He added that the back of this part could be made similar to the front, going from the pill shape to the circle that is necessary to install the iris. He also mentioned that the back could be closed off similar to the front and the iris and IoT components could be inserted through the split of the two parts. This way no extra part is needed to cap the part and no dust can gather in these parts.

Jos Oberdorf did raise the question of how much the air flow would be limited by the valves, and especially the blow-in head of the supply valve, protruding into the duct.

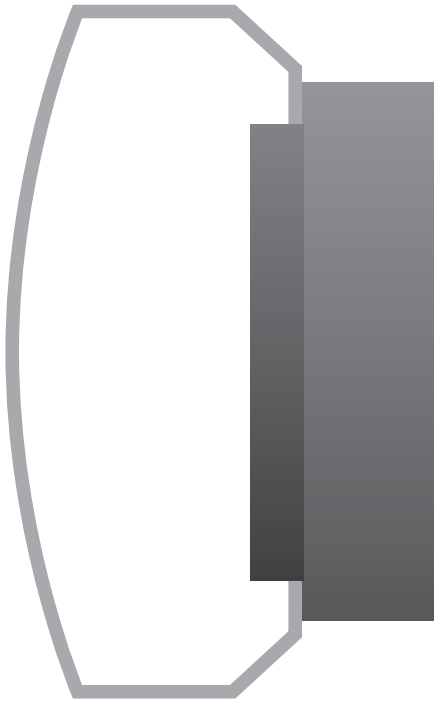

Figure 64: An illustration of the part described by Jos Oberdorf

When asked, the look of the eye catcher valves reminded Jos Oberdorf of an eye as well. He mentioned that this could be caused by the space between the blow-in head and the outer ring. He thinks that by reducing the contrast between these parts, the eyeball effect could be diminished.

Since all the parts of the eye catcher valves will be made with injection molding, draft angles will be necessary on all the parts. These draft angles will have an influence on the fit of the different parts but also on the overall look. Edges that, in the front view, seem to line up will not necessarily in reality, since their surfaces will have an angle to them.

CONCLUDING VALIDATIONS INJECTION MOLDING AND DESIGN

- The injection molded parts seem to be producible.
- Overall the eye catcher valves seem to close to the edges of the duct
- The connection between the duct and the valves should be reconsidered to minimize inaccuracies and air gaps.
- The blow-in head of the supply valve should be produced in two parts.
- The amount of capacity loss due to the valves protruding into the duct should be investigated.
- The necessary draft angles for injection molding will significantly change the overall look of the valves.

JEROEN GEELHOED (VISION, DESIRABILITY)

Jeroen Geelhoed is director strategy and market at Breman Installation group. Jeroen has been advising in strategy and vision building for various companies, for more than twenty years. He is closely involved in the reorganization of Breman and their vision as a whole.

Jeroen Geelhoed's first impression was that he could imagine it to fit in a wide variety of interiors. On top of that, he thought it was a smart decision to focus on making existing houses more ecologically responsible. He clearly understood the modularity of the product and its benefits for adaptability and the ease of installation. Next to the positive feedback, Jeroen Geelhoed also shared possible improvements and elaborations on the product.

The past year, Breman has seen a rise in demand for better ventilation in schools. Due to the pandemic, the terrible ventilation situations in schools have been brought to attention. Since Breman wants to start focussing on this market, Jeroen Geelhoed wondered whether this product could also be implemented in the renovation of schools.

Jeroen Geelhoed has been working with Breman the past six months to reevaluate their strategy. They made the choice to be actively involved in the energy transition. They want to look at the whole life cycle of their products and connect all the sister companies. This way renovation becomes part of the design process and they have therefore started to create a vision on housing renovation. This product would fit perfectly in this new strategy and vision.

The noise the product would create was something Jeroen Geelhoed was worried about. He did agree with the statement that more noise is allowed when more ventilation is required. However, since the risers and ducts are stacked on top of each other he foresees a possible noise disturbance created by the air having to go around a corner. To counter this he mentioned a research in which the noise in corners was investigated. The result of this research was that an oddly shaped profile outperformed a perfect bend. In an effort to find the optimal noise minimisation of the product, this research could be retrieved for further investigation. On top of that, to avoid the corner from the duct to the valve as a whole, he suggested moving the valves to the end of the ducts, replacing the duct caps.

Jeroen Geelhoed put forward the idea of possible integration of the product with the interior. He suggested integrating for example curtains into the product. He agrees that this multifunctionality is not something for Breman to do on their own, but would be something they could do with partnering companies.

The idea of a leasable product resonated with Jeroen Geelhoed. Being able to refurbish or recycle the product after, for example, 15 years in use was something that appealed to him. He could see this happening, for example to reduce the costs of the product for social rent houses. With small adjustments the system could be made to fit a different house.

[redacted]

CONCLUDING VALIDATIONS VISION

- The product fits a wide range of interiors.
- The product seems easy to install with its modularity.
- The product could possibly be used for renovation of school buildings.

[redacted]

- Noise created by the system is still a point of attention.
- Integration with the interior elements, such as curtains, would be possible.
- A leasable product seems appealing to Breman.

RECOMMENDATIONS

I have several recommendations for Breman about the continuation of the project. These recommendations are on one hand based on the evaluation with the different experts. On the other hand, during the design process I came across several limitations of the product, as well as some general improvements. These could not be implemented within the timespan of this project, so I share my thoughts on them here. The recommendations are divided into three groups. The first group consists of adjustments to the product that should be explored before, or during the first prototypes. The second group consists of tests and research that should be done to validate the remaining principles regarding feasibility and desirability of the product. The third and last group consists of possible elaborations on the product and opportunities when scaling up.

PRODUCT ADJUSTMENTS

Throughout the project, several adjustments to the product were suggested. These suggestions are described below.

Connection of the duct to the wall.
Suggestions on this part would be to add ribs to the back of the duct profile. These ribs could connect to a u-profile on the wall. Added costs of a more complex extrusion profile should be weighed against improved ease of installation.

Glueing the cover plates instead of screwing them in place.
Removing the structural element of the cover plates, but improving the ease of installation. However, a new part has to be added to function as fixation of the riser to the wall. The cover plate could also be offered in baseboard-like materials.

Connection of the riser to the wall.
Following up on the new part to function as fixation of the riser to the wall. A possible solution could be, by adding extra geometry to the back of the riser which could in turn clamp into a wall-mounted (u-)profile. Keeping a blind image, but also allowing the riser to be fixated early in the installation process.

Inserting the risers through the ceiling and floor.
The risers could also be inserted through the floor. This is worth exploring because it would add strength to the product, while also adding in a few centimeters of slack in the risers. This could be beneficial as the standard lengths would be made incremental (as the increments would fall into the slack length). However it does raise some questions like: How is the hole drilled and how are the horizontal ducts consistently placed on the same height. On top of that, the risers would not be resting on the floor anymore, so they should be fixed in the vertical direction in some way.

Convert the product to wired connections.
Within the extrusion profiles there is the option to integrate channels for wiring. However, connection parts would get more complex. Wiring could also be integrated in the suggested mounting u-profiles.

Remove the feedback loop of the app and reduce the complexity of controlling the system.
The forever debate between control and autonomy within systems. A balance needs to be found between the system regulating itself, while still making the user feel in control.

Connecting the different riser or duct modules with an impact insert cap.
As visualized in the evaluation with Cezar de Jong and Martijn Rook, an impact insert cap could be used to connect the different modules. Such a solution would be beneficial for the flexibility and ease of installation. Airtightness and overall look when implementing this should be considered.

TESTS AND RESEARCH

To develop the product, there are fundamentals that should be researched. Suggestions of topics for these researches are described below.

The amount of noise disturbance through the channels.

Air tightness of the system.

User research on the appearance and desirability of the product.

SCALE-UP/PRODUCT ELABORATION POSSIBILITIES

Throughout the conversations about the product, several scale-up possibilities and elaborations on the product arose. These pointers are described below.

Make the product as easy to install such that it could be done by other people than just the installer.

The product could be built in, in the period between two owners.

The full product could be sold for between €15.000 and €20.000, but should include a heat pump or other gasless system.

Create modular lengths of the riser, to make the product easier to install in different houses.

Integrate parts of the interior, such as curtains, into the product.

Make the ducts and risers cleanable using the standard cleaning methods.
A suggestion of a solution for the brushing method would be the following. The impact insertion caps could be removed to gain access to the duct. The minimal length to the wall may have to be adjusted for the tool that is used. Next to the cap removal, the valve holes in the budget version of the product could also be used.

A suggestion for the powder cleaning is in combination with the IoT components. Within the app a cleaning routine could be implemented. It notifies the user in which valve to insert the powder, putting its light on, while closing all the others. The user verifies that the powder has been inserted and the cleaning starts. This process is repeated for all valves. The benefit would be that the user themselves can do this, with a low chance of errors. After the cleaning is done, the system reverts to its ventilation setting.

Cover the air exits of the budget valve with a membrane / textile cover to reduce chances of filth and for a possible higher-end look.

Consider ways or solutions for repainting or wallpapering the home after the product has been installed.

Evaluate the effect of the draft angles on the appearance of the injection molded elements.

Reevaluate or add a configuration to fit more houses.

CONCLUSION

In this conclusion, I answer whether, and how I managed to complete the task that was formulated in the project brief. To conclude this project as a whole, I share two final images, one of the product in context and one with an overview of all the designed product components.

CONCLUSION OF THE BRIEF

The brief was formulated as followed:

What I will design:
"Through the integration of: internal and external user research, research in sustainability and branding, I will design a strategy concept for Breman that will show their brand values. These values contain at least circularity within the company and a recognizable form language."

The research and designs should lead to the following:
The envisioned product/product-service/productsystem makes the intentions of the company visible to partners and customers. With this solution the company can further develop a healthy workflow for the industry with their partners. Additionally this new strategy can be expanded to not only inspire contractors and architects, but also to inform the end user of the products on how to adapt to a sustainable society.

The what I will design part of the brief is loosely answered in this report. The project shifted away from the sustainability and branding aspects in order to make way for more general research about the future. The concept that is presented in this report does offer a strategy concept to Breman which is in line with their aspired brand values. The form language of the concept is recognizable, but it is not specifically linked to Breman. Further steps have to be taken on this subject. Circularity is briefly touched, but gave way for more general sustainability topics.

Continuing to the what the research should lead towards. The envisioned concept product clearly shows the intentions of the vision of Breman. The workflow with their partners has not necessarily been directly impacted. It has been researched within the first phase, but was considered out of scope for the rest of the project. However, the workflow of the installer has been improved, which could in turn lead to better workflows among their partners. The aspiration to inform and educate users on how to adapt to a ecologically sustainable future has been woven into several parts of the design.

Overall the response of the different divisions (within Breman), I presented the concept to, was positive. The company is looking for ways to innovate in an ecologically sustainable manner, while also improving their corporate structure. I am confident this product could tie these together. The result can be a starting point for Breman, to fulfill their future goals.

Figure 65: An overview of all the designed components of Breman flow.

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APPENDICES

TU Delft

Personal Project Brief - IDE Master Graduation

Breman, a circular brand identity? project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 08 - 09 - 2020 08 - 03 - 2021 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

The project is situated around the personality of Breman, a installation company in the Netherlands. Their job is to provide and renovate installations for construction. The company provides services and products, which can be visible or hidden within the building. Breman is in the transition of becoming an energy positive company. However to get to this stage and convey this to the customer a redesign of their current portfolio and workflow is in order.

This new vision needs to consider the companies interests, but also stakeholders like: project developers, contractors, architects and the eventual buyers of the buildings.

Currently the workflow is as follows: The project developer request the architects to draw a building. The contractor then searches for parties to facilitate the different parts of the build. Breman gets asked to participate in the project and facilitates the installation part of the build. They have to adjust to the other parties and custom make the parts for each project.

Sustainability is a term that is used quite loosely in the industry. However Breman indicates a strong will towards changing to a responsible company. The communication and services Breman provides, are themed with sustainability aspects. The industry is not fully adapted to this point of view yet, but is seemingly open to it.

On the other side of the scale of customers of Breman are private individuals(particulieren). In this market the aesthetics of especially the visible parts are extra important. Currently Breman does not have a clear visual style or image for their products. The custom work they make for private individuals is currently not specifically recognizable as Breman products, nor as sustainable products.

Quick look at what the parties value and main opportunities and limitations:
The following parties are identified: The company itself, project developers, contractors, architects, buyers of the houses and private individuals. The following is an estimation of what the parties value the most.

Breman: Want a proper brand image to compete with and want to improve the healthiness of their company.
Contractors: Want the best price/quality ratio while still selling their properties without problems.
Architects: Want the building constructed as close to what they designed.
House buyers: Want a good looking building without any flaws and proper construction.
Private individuals: Want quality products and something special to show off.

The opportunities for this assignment would be the willingness towards change of the company. With the right direction they could not only be sustainable themselves but also show their partners and customers how they can be sustainable as well.

Limitations for this project are first and foremost, breaking the habits of the industry. The workflows and the people working with them are conservative and might not be willing to do a little extra to change their current ways. The design therefore needs to not only convey the brand values of Breman but also motivate their partners towards sustainability.

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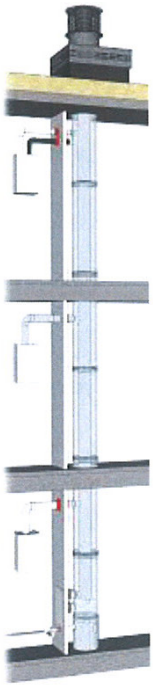


image / figure 1: Example of a CLV system, currently produced by Breman.

image / figure 2: Ventilation shafts on the roof of the building. In the background the header of a chimney.

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

To stay up to date and get back on top of the market, Breman needs to compete on more than quality and price. This added value will come through brand values in the shape of circularity, standardization and form language. The designed features should be applicable in at least one of the workflows of the company. Further value can be added through guidance of house owners in sustainability.

The limitations of the problem lie with the industry and the capabilities of the company. The industry is not adapting fast enough to the growing need of sustainability. Part of the objective is to make the partners within the industry realize how to optimize the current construction workflow for the improvement of sustainability.

The main focus of this project will lie with the facility which produces their products, Breman Schoorsteentechniek. Research/interviews will be done with other facilities to make sure the design stays in line with Breman as a whole. However the other facilities will be of lesser importance in the final design.

Danger within this project lies within the amount of work that can be done. As the process is fuzzy at the start, there is no real indication where the design will go. I have to keep track of my time and go to the next design phase as stated in the GANTT chart.
It is important to keep in mind that this project is IPD oriented and therefore I have to cut some corners on the marketing and legal areas.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

Through the integration of: internal and external user research, research in sustainability and branding, I will design a strategy concept for Breman that will show their brand values. These values contain at least circularity within the company and a recognizable form language.

The envisioned product/product-service/product system can make the intentions of the company visible to partners and costumers. With this solution the company can further develop a healthy workflow for the industry with their partners. Additionally this new strategy can be expanded to not only inspire contractors and architects, but also inform the eventual consumer of the products how to adapt to a sustainable society.

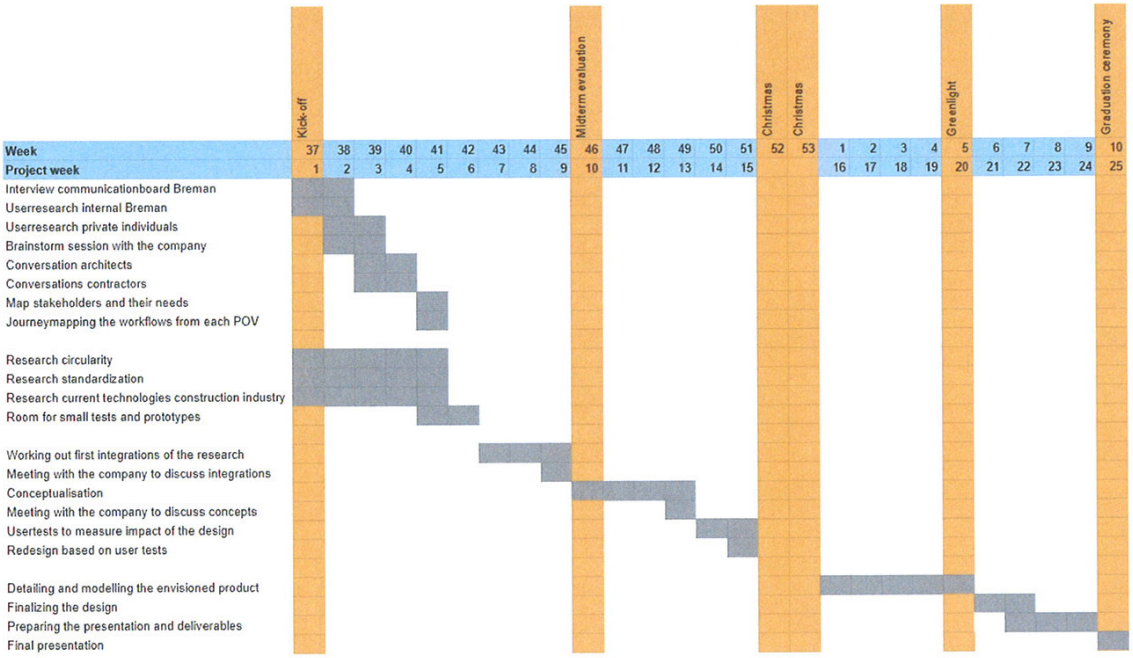
Initials & Name M.C. de Wilde Student number 4448235

Title of Project Breman, a circular brand identity?

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 8 - 9 - 2020 8 - 3 - 2021 end date



Initials & Name M.C. de Wilde Student number 4448235

Title of Project Breman, a circular brand identity?

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

Most importantly, I want to design in a way that matters. That should always be the first requirement of a design in my opinion. When I got into contact with Breman and they explained to me what they are trying to do and the challenges they are facing, I realized this is an opportunity to design in a meaningful way. The matter or meaning in this case would be to improve the sustainability and healthiness of the construction industry.

With this project I want to show that not only on a TU assignment level my branding competences are sufficient, but also when applied in the industry. Furthermore I want to add depth to the design that I do for companies. In the case of Breman the challenge lies in embracing circularity. This is a great opportunity to deepen my knowledge in this area of expertise and apply it in the design process. It is also an opportunity to expand branding to not only a product or product service but optionally to a product system.

FINAL COMMENTS

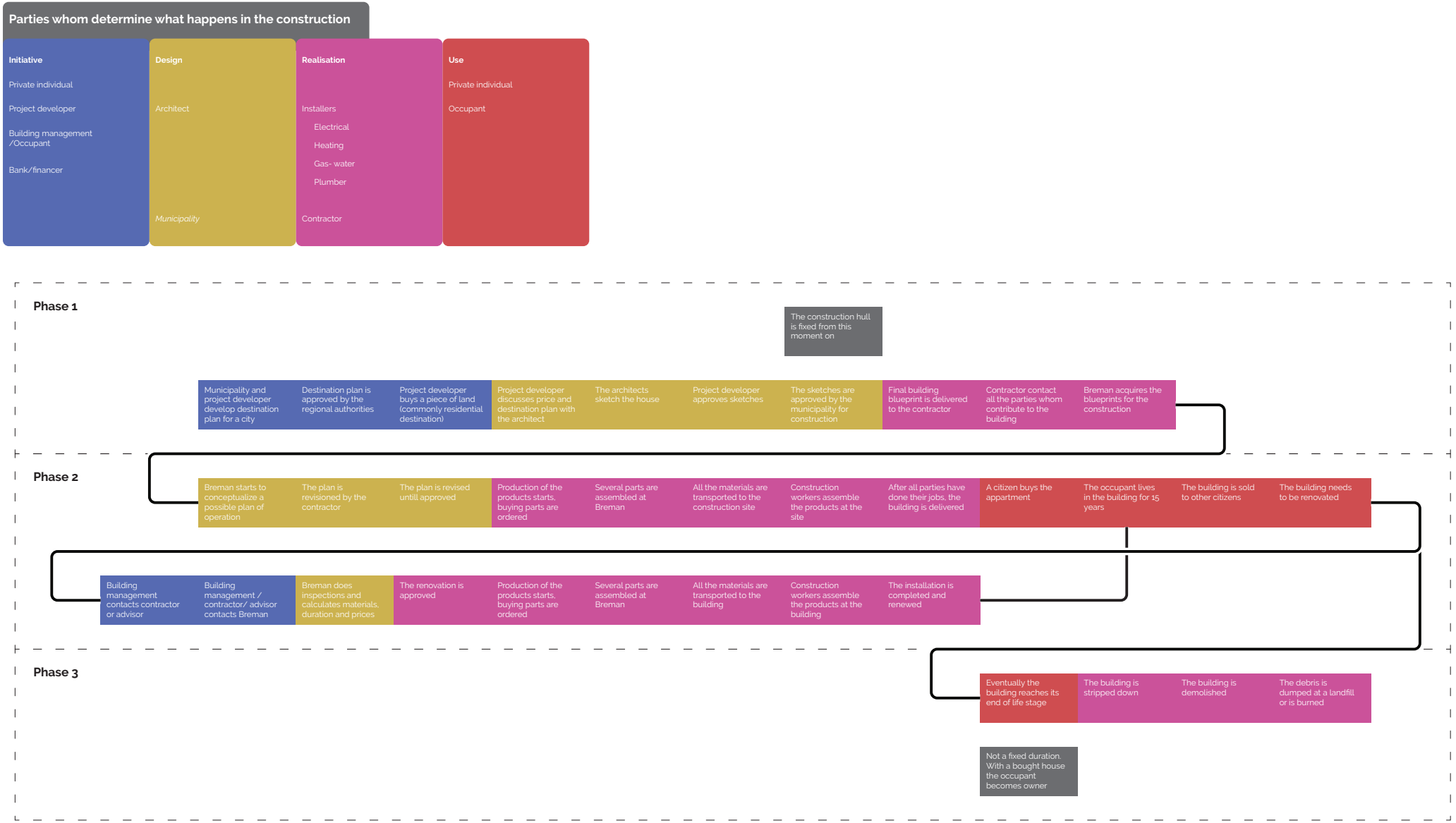
In case your project brief needs final comments, please add any information you think is relevant.

Due to physical limitations this will be a part time graduation project. This results in 32 hours a week, which results in a 5 week delay of the project.

Initials & Name M.C. de Wilde Student number 4448235

Title of Project Breman, a circular brand identity?

APPENDIX B: CURRENT WORKFLOW BREMAN



APPENDIX C: FULL LIST OF TRENDS AND DEVELOPMENTS

Construction:

Modular construction
"Modular construction is a process in which a building is constructed off-site, under controlled plant conditions, using the same materials and designing to the same codes and standards as conventionally built facilities – but in about half the time. Buildings are produced in "modules" that when put together on site, reflect the identical design intent and specifications of the most sophisticated site-built facility – without compromise." (Modular Building Institute, n.d.)

Relocatable houses
Several examples of these self sustainable, relocatable homes are found in the market today. While still in a development state the first buildings are being placed with a positive response. (Modular Building Institute, n.d.), (BuildinG, n.d.)

Building information modelling (BIM)
BIM is a reformation of the traditional building process. It aims to improve the management and generation of digitized physical and functional characteristics of places. These include tools, technologies and contracts. Example would be a database of building parts of the manufacturer, which are available to the architect at the moment of designing the house.
This leads to an optimized workflow with fewer iterations and inefficiencies.

Repurpose building shells
Currently mostly old buildings shells are reused to preserve heritage and give these spaces purpose again(Needs source). However what if the buildings are constructed with multiple uses during its lifetime in mind. Office buildings can be repurposed to appartments and reverse based on demand. Apartment floors can be divided into commonrooms and private rooms and grow with the growth of the family (Needs source).

Increase in construction management software
Due to companies everlasting search for efficiency and the increase in size of the construction projects there is a need for managing companies properly. Combined with the multitude of parties involved in the construction of a building software is needed to keep everything streamlined and organized (Technavio, n.d.).

Labor shortage
The labor shortage in the Dutch construction industry was created during the last economical crisis. 75.000 jobs disappeared, but with the current rebuilt state of the industry a labor shortage was created (CoBouw, 2018).

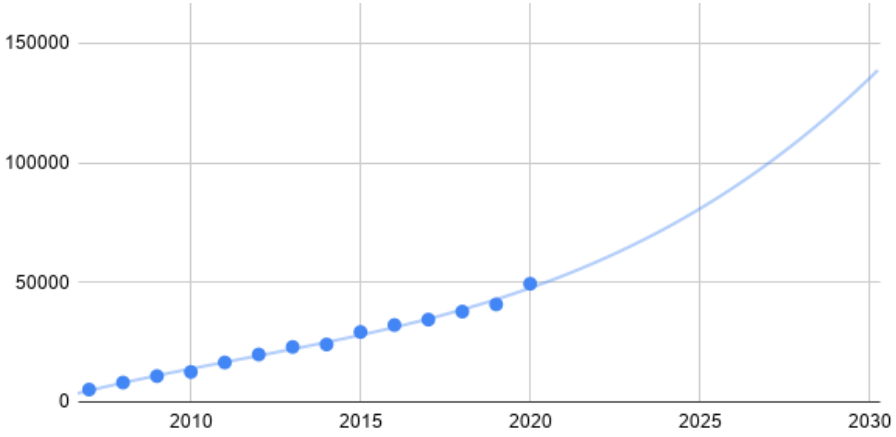
Fluctuating virgin material costs
The market of virgin materials is fluctuating at a high rate (Djukanovic, 2018). It is influenced by supply and demand, but also political matters (Djukanovic, 2019). Lowering in virgin materials can lead to increased stability of material costs.

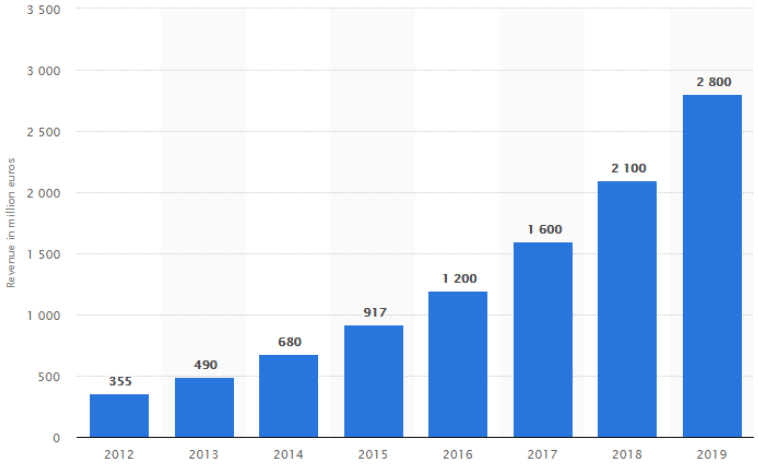
Buildings can increase in value while money inflates
Basically real estate can be used as an investment. Whether it is to rent the building or to just invest in estate and later sell it with a profit, generally the price of real estate is increasing (Delmendo, 2020). A shift towards product service of building modules might change this perception or profitable real estate. However if building costs decrease, current homeowners "lose" this value. Meaning that the current generation would not be able to sell their homes without taking considerable losses.

Multi functional homes (work, play, shop, sport)
Even before the current Covid-19 state of the world, working from home was increasing in the Netherlands (NL Times, 2019). It does however ask for different facilities from the spaces than for normal living tasks (Luthra, 2020). Further multifunctionality within homes are for example sport, shopping and playing (Angus & Westbrook, 2020).

Sport
“The busy schedule and long hours of working, crowded fitness centers, and problems regarding vehicle parking have resulted in an increasing number of consumers actively inclining towards home workouts.” ((Mordor Intelligence LLP, 2020))

Shop
Internet businesses are growing. Both in size and in numbers. These indicate that there is more online shopping which would lead to more shopping from home. Underneath is a graph of the revenue of Bol.com (one of the largest online retailers of the Netherlands) and an estimation of their revenue in million euros for 2030. Takeaway would be that the revenue estimation will grow to three times its current size.



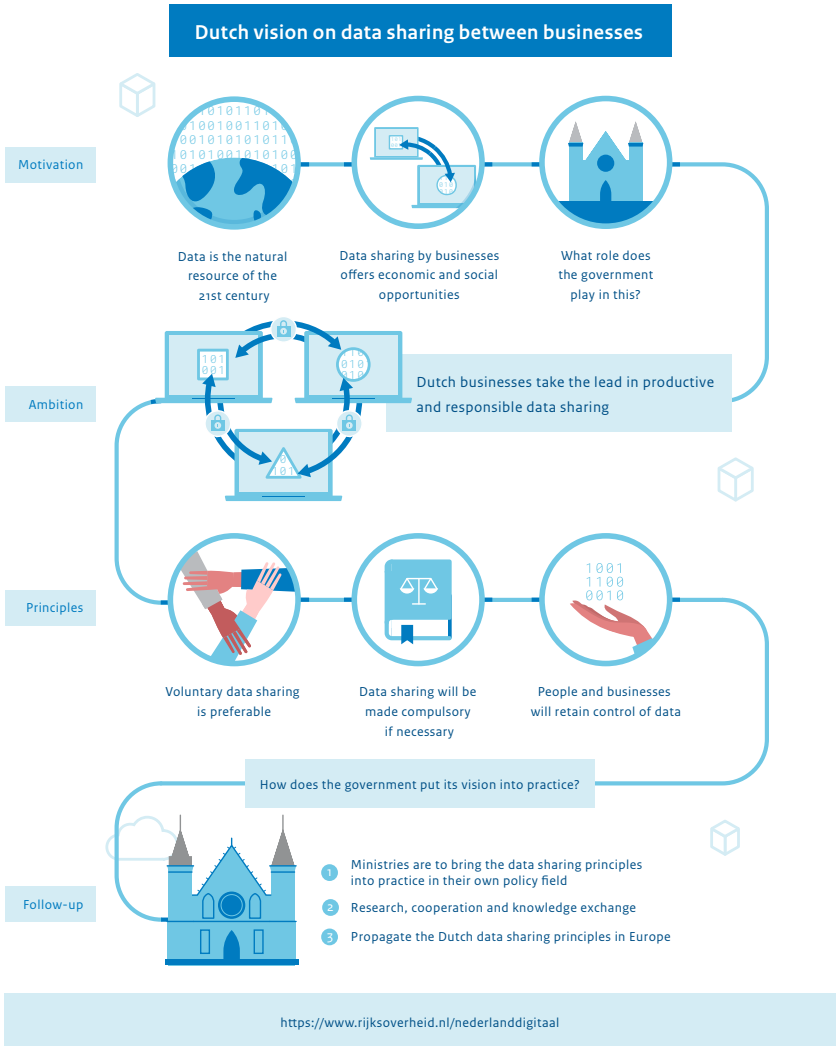


Original data from Statista (Best, 2020).

Increased use of drones in construction
Drones can take over human tasks, do them faster and more efficient. This reduces costs and timespan (Wingtra, n.d.). Most use cases are mapping areas, tracking progress and identifying problems in earlier stages (Drone Deploy, 2018).

Mobile camera and AI to perform measurements

Data sharing (central database)
The Dutch government is enticing industries to become accustomed to data sharing. The goal is responsible exploitation of the social and economic opportunities of data sharing between businesses (Dutch Government, 2019)



Prefabrication systems

On site automation

Within this trend the possibilities for on site automation is explored. Use cases can include the integration of stand-alone or single task construction robot technology into networked machine systems. This is to improve the material flow and organization on site(Bock & Linner, 2016). Automation would also be an answer to the labor shortage (McKinsey & Company, 2019).

A robotic bricklayer would be another example of automation of repetitive, less skill intensive tasks (Forestell, 2020).

Exoskeletons improve working conditions

Extra strength, relief of joints and overall improved working conditions (Thilmany, 2020). The experimentation of exoskeletons in the medical industry are currently adapted by the construction industry. Multiple applications are: Power gloves, back support, arm and shoulder support, crouching and standing and full body exoskeleton (Forestell, 2020).

New collaboration tools

With the increase in data and the increasing complexity of construction projects, new collaboration tools are needed to facilitate these processes (Rhumbix editorial staff, 2020). Companies like Autodesk are developing software which enables data sharing between different parties without sharing sensitive information of businesses (Autodesk, 2020).

More women and elderly in construction

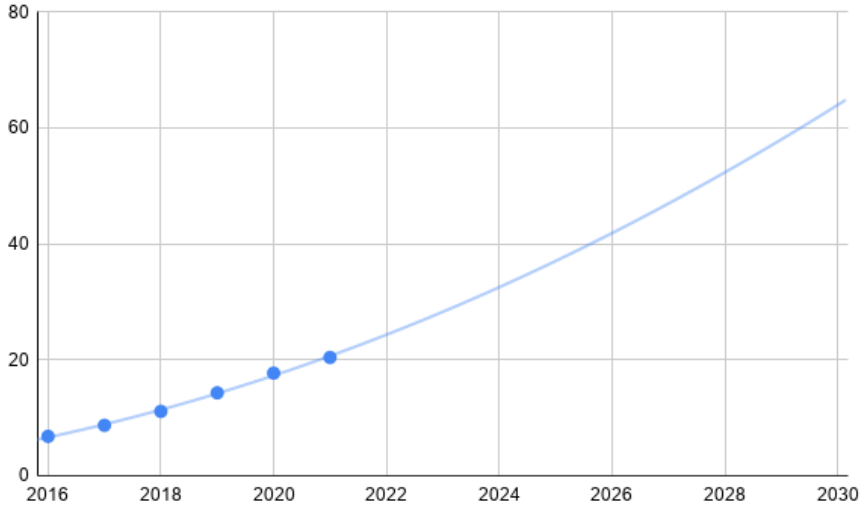
With the labor shortage, an increase in elderly (percentage)(Source) and more working women (OECD, 2017), the trend is clear. The construction industry needs to facilitate these “new” groups within their workforces. Practical but also social problems will occur when

these groups are integrated more into the industry (Astor & Onsalo, 2017). Examples are early or irregular hours, sexual harassment, shared toilets on worksites, safety equipment (Comer Construction, INC, n.d.). However these groups can also add value, the experience of elderly (CIOB, 2015) and attention to detail of women (Comer Construction, INC, n.d.).

Ownerless home living
The initial costs of circular buildings are higher. More complex connections are an example of increased costs at a build. However in the circularity models there is a "rest value". This rest value can counter some of the higher initial costs, making it more of an investment than just a pricier product. However, this does mean that the building's shell remains in the ownership of the investor.

Technology:

Mobile data speed:



https://www.statista.com/statistics/371894/average-speed-global-mobile-connection/

Smart city developments
Smart cities use the many sensors in modern day products. Think of smart LEDs or infrastructure mapping of transport and parking developments (KPN Redactie, 2019). The six domains on which a smart city can manifest are: economy, environment, governance, living, mobility and people (Internet of things Nederland, 2015).

Smart contracts (blockchain)
(Cong & He, 2018)

VR/AR in building design
VR and AR are technologies which are years in the making, but are reaching the construction industry due to lower costs and higher capabilities. These tools are used to guide construction workers and prevent mistakes during the building process (Souza, 2019). It also helps to envision constructions before they are realised and is therefore a tool to convey certain ideas before they are tangible (Matter Port, n.d.).

Virtual companions
The acceptance of VR and AR technologies is rising and therefore connecting with/through it is as well (Mattin, 2019). An increase in loneliness and a will to connect is countered by the development of virtual companions (Narvis, 2018). These companions can do a range of things due to developments in AI.

3D printing custom parts (increase in building material useability)
Making highly personal products is often associated with 3D printing or other additive manufacturing. However these applications are on a smaller scale. Current developments are being made to make a wider range of materials available for additive manufacturing. Combined with a larger scale this makes its entry into the construction industry (IAAC, 2017).

Digitized society
General trend from the last century. More and more things are developed towards digital products, services and systems (Schat, 2013) (Farinato, 2020).

Autonomy
The integration of robotics and digitized systems are widespread, but how these systems and robotics are operated is in full development. With the rise of neural networks, machine learning and other AI programs, the capabilities of these systems grow (Owen-Hill, 2018). Better autonomy means less men required for operation and wider applications of the systems (Digital Governance, 2018). Most known is probably the driverless cars, but logistics and autonomy within production chains are available much sooner (Grolms, 2020).

Mobile education
The internet holds all the information about almost everything. However getting to the essence of this information is a tiresome task. App developers are providing a middle way. Selected information and education on the fly. People look for ways to learn, but want to do so in between tasks or while traveling for example (Mohammedi et al., 2020). Small, fast parts of information instead of full courses (Lafleur, 2020).

Strategic big data
With all the digitized systems and the monitoring of choices and behaviour data is collected in enormous amounts. The data these systems produce can be used to predict behaviour (Big data framework, 2019), test effectiveness of products/services/systems and help in optimizing problems (Mazzei & Noble, 2019).

Smart homes
Homes become increasingly more connected. Applications are accessible through people's personal devices and can communicate with each other (Edmonds & Chandler, 2008). In future homes these could communicate with external parties to further the convenience of living (Akkerman, 2016).

Deep learning (neural networks, evolved, AR)
As earlier discussed these developments are used to power trends like autonomy (Heckerson, 2017). These developments are possible because of the ever growing capacity of processors and the decrease in their costs (Bain, 2020). The increase in complexity and accessibility, paired with the decrease in costs make these technologies wider applicable.

Sustainability:

The 17 Sustainable development goals for 2030 of the United Nations:
Overall the united nations have 17 sustainable development goals for 2030. Whenever you are looking for things to improve on personal or professional context, this is a good place to start (United Nations, n.d.).

Sustainable awareness
This trend is central to the whole sustainability topic. The amount of information that can be found on sustainable developments and ecological initiatives are proof of its significance. More companies and people are searching for sustainable alternatives to their non sustainable lifestyles/processes.

Need for clean air
Improved air quality is something that is overlooked at the moment, but is getting more attention (Global wellness summit, 2018). Combined with the trend of an increase in activity in homes, the quality of living needs to be upgraded. One of the factors for this quality is the quality of the air we live in. Think of humidity control, CO2 control and filters against pollen based allergies (EPA, 2018).

Eco shaming
Comes from consumers and is faced against companies or groups of people who have less regards for nature (Trendwatchers, 2020). For example flights are shamed on social media platforms (Trendmonitor, 2019). But also companies who maintain the use of plastic bags (Thelen, 2019).

Passive design
Whether it is for cost savings, ecological health or an improvement in quality and comfort, passive design is on the rise (Crayon Design, n.d.). The principle for passive design is designing in a way that minimizes or removes active elements in a product entirely. For homes this results in homes with less heating and cooling for example. In a passive product/house the electricity for example is all generated by the product itself. It's self-sustainable and independent of other facilities (Daniel, 2020).

Product service systems (Stay responsible for your product)
Moving away from the traditional make product, sell a product and moving towards selling a service with a product as a main feature (Lombardo, 2019). Not selling tires, but selling kilometers. Not selling heaters but warmth. The company stays responsible for the whole loop of the product and the user rents it from the company (Aubertin, 2019).

Eco friendly materials : Self healing concrete, 3d graphene, light emitting concrete, solar cell film (McPherson, 2019).
Materials with reduced impact on nature are sought-after. Some do it for positive advertisement, others for ecological reasons, but the demand leads to supply. Therefore there is a rise in eco friendly materials and their developments will continue. These new materials lead to new products possibilities and better alternatives for future designs (Zitzman, 2020). Other materials seek to improve on the negative aspects of materials like PV cells that generate power from rain (Trekker group, 2016).

Electric transportation
Combined with several other trends, the need for non fossil fueled transportation is quite obvious. An estimated half of public transportation is already powered by electricity (Shell, n.d.) and electric cars are becoming more common as well (ABB, n.d.).

Vertical gardens
From a boring wall to a garden. Companies are specializing on padding sides of buildings with greenery (Ambius, n.d.). Both on the outside, but also on the inside. Improving work conditions and air quality within buildings (Vertical gardens, n.d.).

Green roofs
Same principle as vertical gardens but on the roofs. Has ecological and financial benefits (Green deal groene daken, 2018).

Cradle to cradle design
Waste=food is the main objective of this method. From the start of the development the whole lifecycle of the product is analysed. The discarded materials/products should be a source for a new product or process. Minimizing the overall ecological impact of the product (Mosa, 2017).

Society

Age composition 2:1 elderly:working adult --> 3:1 | 50% of population 50+
The demographics of the Netherlands are changing. The composition of the age 50 years ago was fewer than 1 in 3 adults was older than 50 (CBS, 2014). This ratio will increase towards 1 in 2 adults with an age over 50 (CBS, 2014). In turn this leads to less working adults and more elderly to take care off (PWC, n.d.). It also means we need to develop systems in which these older adults can still help out in parts of society.

Population of the Netherlands grows from 17.17M to 17.5M in 2039 then declines.
The population is growing mainly due to an increase in immigration (CBS, 2020). The birth factor has been declining for multiple years. It is expected that in 20 years the growth slowly reaches its maximum (United Nations, 2019).

Internet virality
Virality on the internet is at an all time high. Through platforms like TikTok, Instagram and Youtube people find their entertainment and education. Trends on these platforms have a major impact on how target groups behave (think for example about the BLM movement, which was sparked through Twitter). These virality platforms need to be dealt with carefully. It can help a company grow but also lead to a boycott. However it is not ignorable anymore since so many of the population are connected to it and get their information through these platforms.

Hyper personalisation
Personalisation is nothing new and most customers have grown to expect it. However with the increase in data and analysis speed even more services can be offered in an increasingly personal way (TheNextWeb, 2019). Manufacturing processes like 3D printing also make hyper product personalisation possible. Think about shoes specifically made for your 3D scanned feet (Bremer, 2020) (in a few years maybe even in real time).

More women and elderly in industries
Due to the increase in elderly (EIB, 2017) and working women (Bouw kroniek, 2019), industries have to be ready for a new work environment. Adapting to different workflows and new compositions of workforces can be a challenge for companies. However specifically in the construction industry, with it's labor deficit, adapting to these new workgroups might prove interesting.

Hyper relevance (not just affordability and convenience)
Hyper relevance comes down to the constant feedback loop of services current customers have (Hull, 2018). For example: Currently the user is subscribed to Netflix. However he keeps seeing the advertisements of other streaming platforms. With the amount of information and feedback found on the internet the user can decide every moment whether he wants to continue using Netflix or wants to swap to another service. In other words, it is not the affordability and/or convenience that forces the decision, but whether a specific service has what the user at that moment needs. Therefore the service needs to be most relevant at every given moment.

Need for mood enhancement, relax, stress/anxiety relief (mental health care)
More than 15% of the Dutch population suffers from a kind of anxiety disorder (Ritchie & Roser, 2018). The traditional stress relief products like alcohol are being replaced by natural, more healthy alternatives. They want outcome-based products that address their mental wellbeing needs, that prevent stress and help them sleep better (Angus & Westbrook, 2020).

Lasting urbanisation
The trend we see for many years now is the increase in people living in cities (Impact initiatives, 2019) (CBS, 2019). At the moment there are no indicators for this to stop or even slow down.

Globalisation
Globalisation can be divided into multiple areas: economical, technological, institutional and cultural
While the Dutch open economy makes for easy trades over the whole world, technological advancements make the world smaller and smaller (CBS, n.d.). On cultural areas it is an effect from the growing immigration ratio relative to the declining birthrate. Therefore the ratio of foreign to Dutch cultures is increasing towards foreign cultures. However on institutional grounds different cultures clash and friction builds.

Immigration
As stated in the changing demographics of the Netherlands, immigration remains to grow (Statistica research department, 2020). With the steady economy and the internationality of Dutch companies this is not expected to slow down.

Flexible mobility (convenience, car sharing)
People want tailored mobility with real time updates for adjustability. It needs to be seamless, quick and the most economical option (Angus & Westbrook, 2020).

Burn out generation
While burnout statistics are lower in the Netherlands relative to other countries (Tipnis-Randive, 2019) it remains growing at an alarming rate. In the past 20 years the numbers have doubled and are expected at this rate to affect 25% of working adults in 2030 (Arbo unie, 2019).

Subscription box services
Think about food, beauty accessories, razor blades or underpants. An increasing list of products and services come in the shape of subscription box services. People are getting used to this manner of consuming and grow more accepting of such a lifestyle.

Acceptance of robots and AI
People are positive towards robots in the industry, but robots in their households get a negative response (Nitto, 2017). However the amount of AI applications like voice assistants are growing (Mathe, 2020), which suggests an acceptance of society towards AI integrated systems.

Self health diagnostics, also preventive instead of healing
People tend to self diagnose their health. Googling their symptoms or using apps to determine what is wrong (Bennet, 2018). As this need is dangerous, it is also an opportunity. People need reliable advice when they tend towards these practices.

Cultural storytelling, authenticity and craftsmanship
Backgrounds of products/services/systems, companies or people in general are coming to the foreground. Movements like Black Lives Matters signify this for people for example. The story behind things are being told and are considered as extra value. Consequently authenticity and craftsmanship has increased in value as well. Smaller companies fully focussed and founded on these qualities are the manifestation of these trends.

Transparency and openness of companies
Companies increase the transparency of their supply chains and company structures. In the past years it has become important for customers how these things are handled within companies and provide additional conditions for customers whether they buy at certain companies.

Support local communities (local production)
The increase in smaller local companies and the need for authenticity also leads towards more support for “the little man”.

APPENDIX D: DRIVERS OF THE FUTURE EXPANDED

A more detailed look at the three idea directions:

A modular bathroom. Gaining energy positivity from a bathroom module. Adapting the multi purpose style of housing, combined with the need for relaxation at home, the bathroom could function as a spa-like module as well. The idea is to produce a box with movable connections, so it is installable in a newly built house as well as in a renovated house. The investment would be at the side of the builders/Breman and the module would be rentable for the customer.

Living as a service. An initiative Breman started thinking about a while ago was Breman as a service. The initiative would imply that all the installations Breman provides wouldn't be bought by the customer, but instead would be a service the customer rents. The notion was that everything could be serviceable, not in the sense of maintenance but in the sense of providing services instead of products. The consumer would like warmth in the house, but how the warmth is provided is not important.
Combining these thoughts became living as a service. Not only installation, but also things like white goods and internet connections. LAAS could help with the regulation of energy and other resources within a society. Balancing resources where needed and therefore opening up possibilities with increased efficiency would fit into the envisioned ecologically sustainable brand Breman wants to be.

Passive renovation. Throughout the pitch at Breman I showed and talked about examples of passive building. It was noticed that a counter movement on the whole "increased technology in houses" was inevitable. On top of that, not all houses are newly built but a large portion of living houses are renovations of old buildings. Breman foresees a large demand for solutions for these renovations. People want to be more ecologically responsible, but don't know how or are scared of the costs. Combining the statements above, the idea direction of passive renovation is born. In this, Breman would be the knowledge centre on how to renovate with limited or completely without active technology. In doing so, Breman could lead the market and the citizens in how to renovate responsibly and in the process Breman becomes an expert in this field.

DRIVERS PER IDEA DIRECTION

Drivers behind a modular bathroom are: the need for modular/ multipurpose houses, the adaptation of smart products on lease contracts, installation companies at the start of the building process, a call for ecological responsibility, an emphasis on mental healthcare, a shortage in housing.

Drivers behind living as a service are: the adaptation of smart products on lease contracts, a shift towards a relevance based market, an ever growing need for convenience, acceptance of AI assistance based product/ service/systems, developments towards small collective initiatives

Drivers behind passive renovation are: a shortage in housing, a countermovement to the increasing technologies in homes, a search for pureness, a call for ecological responsibility, looking to nature for answers (mimicry), the need for guidance in the ecological transition, installation companies at the start of the building process.

APPENDIX E: CONCLUDING VISION CONSTRUCTION

To construct the vision I started off with three small descriptions of the future's house market, the expectations of consumers and collective initiatives (in the context of the house industry).

The house market will be determined by two main drivers: ecologically responsible and the house shortage. Newly built and renovated houses both maintain relevance. Within the newly built buildings there are two options: modular adapted builds and/or passive construction methods.

The consumer expects an energy positive house. They are limited in their knowledge on ecological impact and ask for help. Consumers prioritize convenience over ownership. The possibility to lease and exchange white goods and domestic appliances is self-evident for people. The consumer expects areas in their houses to have multiple purposes. A part of the consumers is looking for technology-free solutions, from either a cost perspective or the search for a more pure lifestyle.

Collectives are shifting towards hybrids. They are evolving from on one side national/regional and on the other side family size, towards neighbourhood size. Collectives like these need investors who invest in the product, and in turn provide the service to the consumers. A big part of these collectives will be driven by AI/big data operated systems to manage fluctuating offer and demand. This increases efficiency of resources and improves profitability for all parties involved.

The combination of these three descriptions lead to the following world vision of 2030.

"In 2030 the main focus will be on ecologically responsible housing while coping with the housing shortage. Houses will be made modular or passive. The consumer wants help in transitioning towards sustainable housing solutions. The consumer prioritises convenience over ownership, looking for leasable options and flexible solutions. Convenience is added as well by companies who create collective solutions, which could be positioned locally. Within the construction industry, Breman operates as an innovative facilitator among their partners. From this new position, Breman will guide the market and the consumer in how to transition towards being ecologically responsible."

APPENDIX F: TIMELINE EXPLANATION

To get some sense of where the world stands and where Breman stands in relation to the general vision I constructed short indications of where the drivers from last chapter might stand on short, middle and long term. In the paragraph below I discuss how Breman as a brand could evolve towards these future developments. The resulting timestamps are not the main focus of this project and should be seen as suggestions rather than thoroughly researched statements. They function as indicators and as a way to make the vision more tangible. All in all, these concluding timestamps are a short exploration of the brand Breman and its implications on the product design in the design phase.

TIMESTAMPS FOR BREMAN AS A BRAND

2020: Where is Breman now?
Breman is an executive party. They have to adapt to what is constructed. Breman is part of the development stage but is mostly involved in the eventual installation. Their main focus is on conveying craftsmanship: "Breman, well planned"(Breman, goed plan) is the current slogan of the company. Within the company there is a focus on the wellbeing of the employees, their so-called Breman DNA.

2030: Where does Breman want to go?
Looking back at why Breman resonates with the ideas from the brainstorm session I got a sense of what Breman is looking to become. As mentioned earlier in the chapter:
Breman is looking to become an ecologically responsible organisation. Additionally Breman wants to help their partners and the users of their products to develop towards sustainable lifestyles. This includes initiating and/or participating in initiatives which develop a sustainable future. Next to that, Breman is looking for opportunities to be more efficient in their current activities and streamline their processes.

To add to that brandvision: from a market point of view, combined with the development of other companies and the strengths of Breman it is highly advisable to take on a facilitating/ consulting position. Breman should focus on the installation in future builds and pick up related problems during meetings, but refrain from becoming a construction company. This would ensure the prolonged existence of Breman products in future buildings, but would prevent Breman from competing with big construction companies. Breman has obtained some knowledge and partners in the sustainability and IoT industries. These expertises are used to give a more complete service to the customer and industry partners and have a better understanding of the field they are operating in.

2025: How does Breman transition?
Breman should aim to be ecologically responsible, both in material use, and care for their employees. They should continue to emphasize on the Breman DNA formula, but also elaborate on it. Being clear to the partners and the market, that Breman is an innovative facilitating company. To convey this market position Breman should join and help partners in their innovative projects. A rule of thumb could be: to have 20% of the profits of the company consist of products/services/systems that are no older than 3 years.

APPENDIX G: TRANSITION TO THE DESIGN PHASE

With the information gathered in the first phase, the design phase, or phase 2, can be started. The framework around and the criteria of the project have been further discussed and determined within this phase. The concluding objective of the research phase is as follows:

I will design a ventilation system that is integratable in existing houses. Ventilation in- and outputs, channels or panelling to cover them and potentially a redesign of the MVHR box. To further frame the assignment: The technical bits and pieces of the system will, for the most part, be considered black boxes. Meaning, elements like for example: the actual heat recovery system and IoT solutions will be assumed to function and will only get a standard dimension in the design.

To get to a more abstract level after the focus of the first phase a conversion has to be made to get from the conclusion of the first phase to the start of the design phase. This abstraction level will ensure more out of the box solutions and with it can lead to better solutions.

To get to the more abstract level I ask myself broader questions, for example: what is ventilation and what does ventilation mean to the user? This is done since a MVHR system does not necessarily have to be the best solution to solve the ventilation issue. The goal of this project is to provide clean air in a home with minimal energy loss. An MVHR system is only a possible manifestation of this.

From this mindset and with the idea direction of ventilation in renovation in the back of our minds, questions and discussions have been formed, with amongst others Breman and design experts, about what this ventilation product would entail. These discussions added additional boundary conditions to the to be designed system.

One of the issues that arose was that the users do not really know what a ventilation system does or how it works. An example of this could be seen when mechanics from one of the sister companies of Breman arrived at a home and discovered that the ventilation had been unplugged. The residents mentioned that they had experienced draft and had turned the ventilation off. After this, bad smells wouldn't go away and the residents did not realise that they had sabotaged their own ventilation.

To play into this unconscious incompetence of the user, awareness has become a point of attention. The question to ask with this is: How do we make the user aware of ventilation and the function of ventilation. To answer this, I first ask the question: What is ventilation? Ventilation is the displacement of air and even more so the renewal of air. This is what the user expects from their ventilation system.

Next to this, Breman mentioned that setting up and fine tuning of a balanced system, such as a MVHR system, is difficult and therefore takes time and expertise. The scope of this project has been set to standard terraced houses. There are about 8 million terraced houses in the Netherlands of which 4 million are low-rise (As stated by Cezar de Jong). These houses need to become more ecologically responsible by 2030 mandated by regulations of the EU. This means that a renovation system needs to be installed and fine tuned quickly. Next to the large amount of houses that need to be renovated there is also a shortage of workers in the building industry. This emphasizes the need for a quickly installed and fine tunes system.

Breman has the drive to help customers, users and industry partners with innovating and wants to contribute to solving problems and be part of the solution. They would like this attribute to show in the new system.

These additional boundary conditions, combined with the drivers from the research phase and the main motives of Breman resulted in the following vision:

Together with Breman I want to create a new focus for the future within the area of ventilation. With this focus, we want to offer an ecologically responsible solution to residents of a standard terraced house. This solution will help the resident with becoming aware of ventilation and sustaining a healthy climate in their home. Next to that, the solution will help Breman to invest in relevant drivers of the future and position themselves as an innovative and helpful company.

APPENDIX H: LEVELS MODEL EXPLAINED

In this appendix, I will show you the steps made to make this model. The main goal of this tool is to give insight into the decisions made. However, this tool is also useful to find gaps in the foundation of the design. It can also be used to find inconsistencies in the design. When using this model it is good to keep in mind that levels and statements are dynamic and can be tweaked. During the design process requirements may change or views may need to be adjusted. Eventually this leads to a conclusive story, where all the parts fall into their own place and have a clear path of origin.

The model itself consists of various levels and relations between these levels. Decisions can be traced back through these different levels, grounding every decision in the vision. The model is divided into two parts: a top (more abstract) part and a bottom (more tangible) part. The combination process is the bridge between these two parts. Every level has a question it asks of the statement or manifestation on that level. This question is described under the level name. These questions help me as a designer to check whether or not I have the result in the correct level. Each time I generated an idea I mirrored it with the model, looking for connections with the levels to find the reason why that idea resonated with me within this project. Sometimes this led to nothing or I found out that the essence would not line up with the model. So several ideas were put on the side, maybe they could be of later use, but most of these are not relevant for the project.

In the example following this section I will explain the model at the hand of a component. In this explanation I will touch on the different levels and how they are connected. I also give insight in my thought process and the results. However, to keep a concise report I decided to move the decisions of the top part of the model to the appendices. The thought processes found in the top part of the model will not be discussed further. The decisions made on these levels can be found in appendix I. After the example I dive straight into the different components and their specifications. Moving forward to the example, I want to give a peek into the thought process behind the risers.

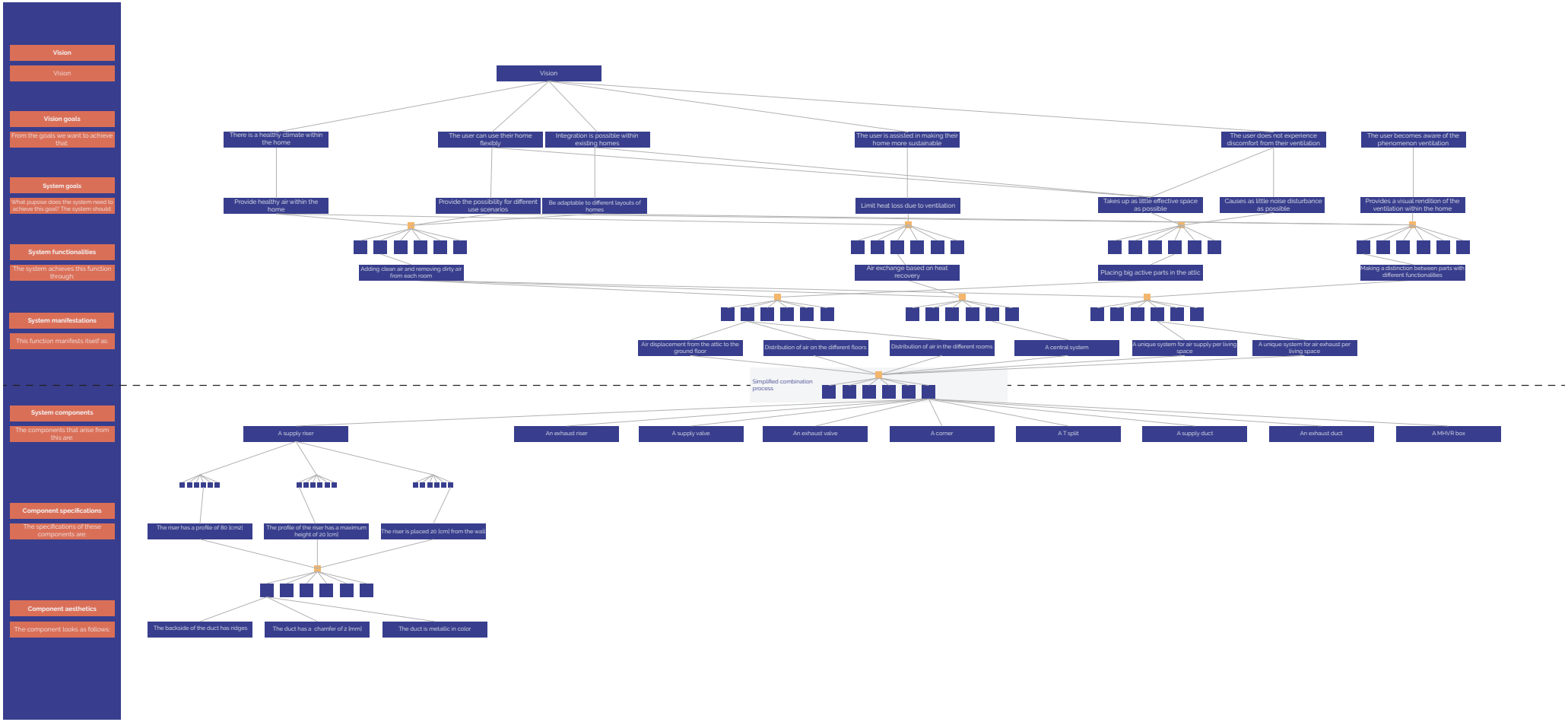
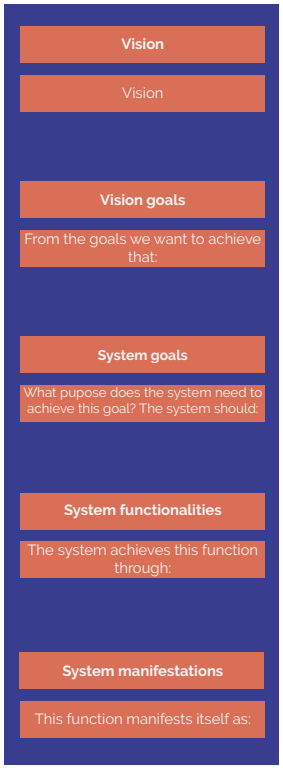
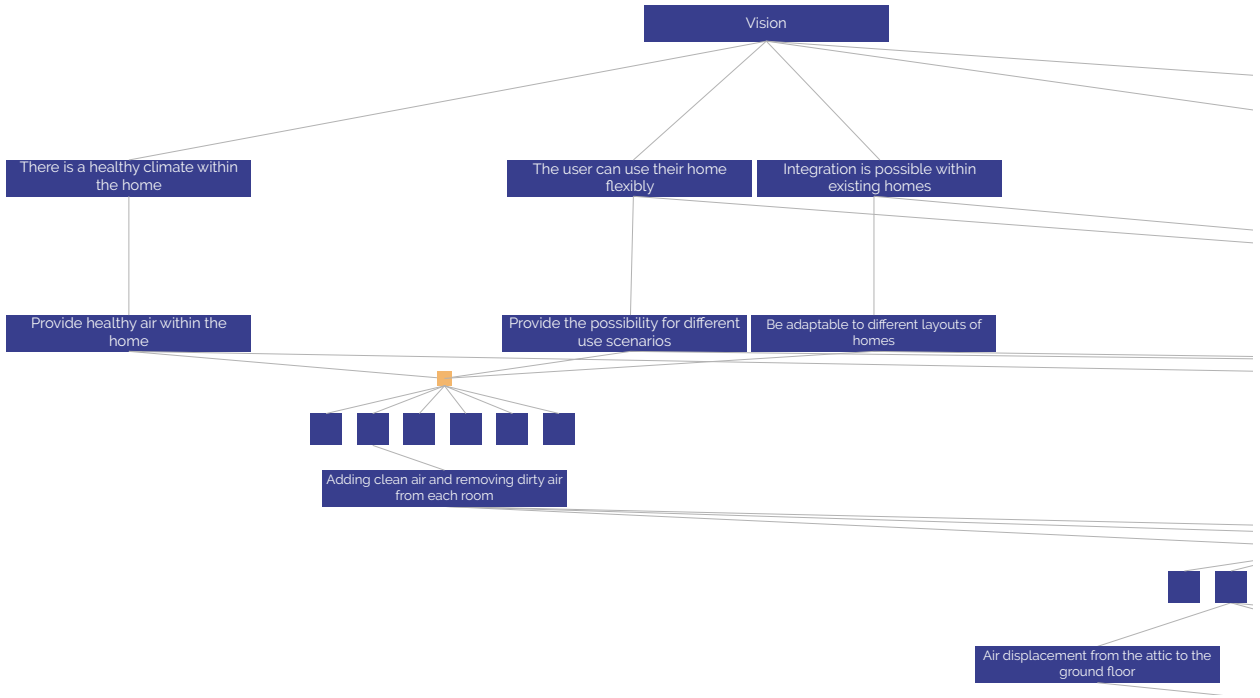


Figure 66: An overview of the model largely filled in for the risers



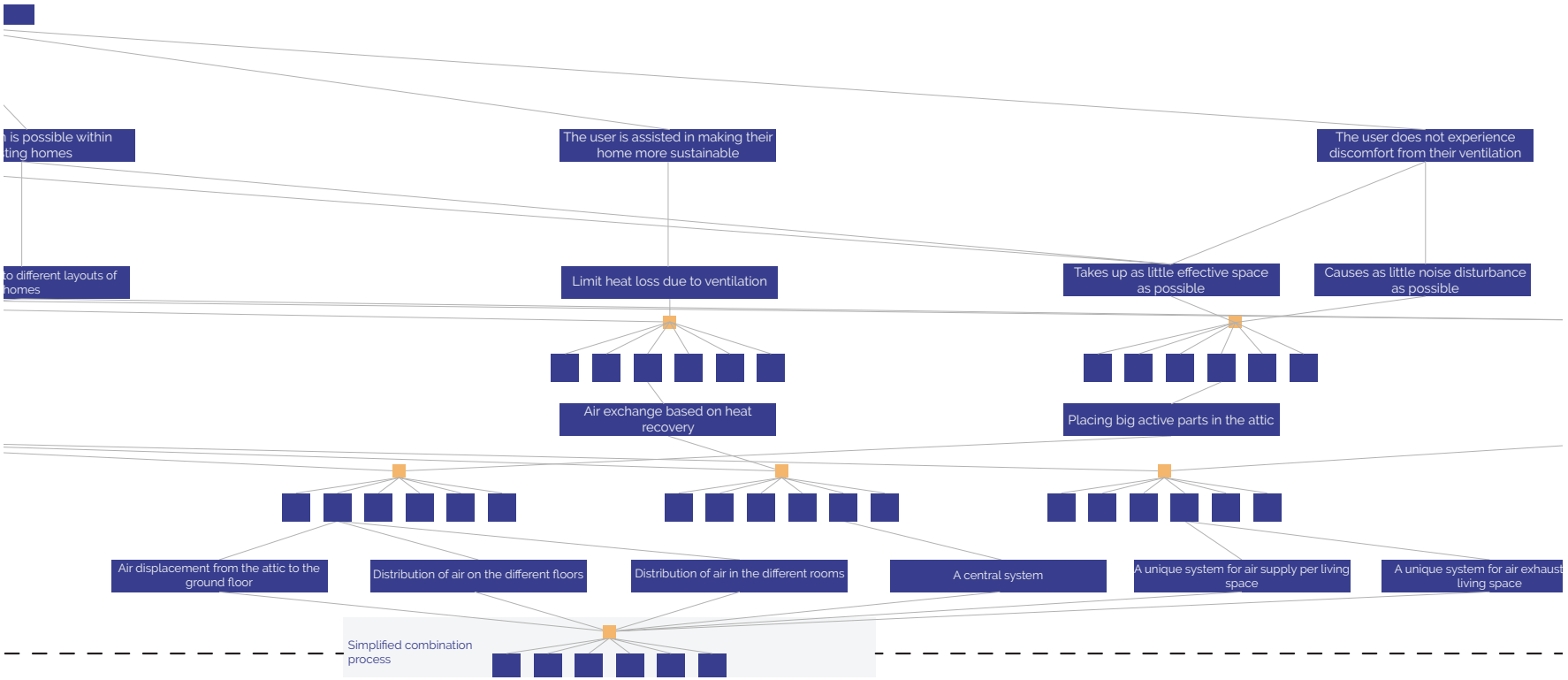


The model starts with the vision. From this vision I distilled the goals that this vision inherits. In this example the vision goals are split into 6 parts. However these are still vision goals, so the question arises: what purpose does the system need, to fulfill this goal? This results in system goals. To accomplish these system goals, that part of the system needs a distinct function. So, what functionality does this part need to complete its purpose. This is where the decisions start. There can be multiple solutions to make a part complete its purpose. In this case the purposes of the system are: The system has to provide clean air to the residence, the system has to offer possibilities for multiple use cases and the system has to be adaptable to different layouts of the residence. Eventually this led to the decision to give this systempart the function of supplying clean air and suctioning dirty air in individual rooms. However in this particular case the thought process was not as linear as I describe it. To show the dynamic nature of this model I want to give you insight into how this decision came to be.

I started off with the system functionality of supplying clean air and suctioning dirty air. I knew the essence of this idea was grounded somewhere in the “providing healthy environment within the residence” parts of the vision. Next to that I distilled the vision goals: inside the residence achieve a healthy climate and the user should be able to use its home in a flexible manner. With these two levels in mind I found that I was missing a layer. A translation between the goals of the vision and the goals of the system. After making this discovery I found the reasoning to be much

smoother. My vision goal of wanting a healthy climate inside the residence translated to the system goal of providing clean air in the residence. Which was further combined with different system goals to start the discussion on whether the initial system functionality was the correct solution. In the discussions with for example my counseling team, other experts or other people in general I discovered that this system functionality might not be the whole picture. Closely related to the vision goal of flexible use of the residence was the goal of maximum integration in existing buildings. Translated to their respective system goals they state that the system has to offer the possibility of different use cases and the system has to be adaptable to different layouts of the residence. Adding the three goals together there are different functionality solutions possible to fulfill these goals. In this case I chose the most general one and thus the conclusion is that the system achieves these goals through the supply of clean air and the suction of dirty air in individual rooms.

Through this process I realised that in this example there were three goals (instead of two) that combined into this function. These goals are then later used in different combinations and as part of extensions to form other system functions.



To continue with the example, I arrive at the system manifestation. One or several system functionalities come together and are evaluated on how they could form a piece of the puzzle. In the example I combined the supply of clean air and the suction of dirty air in individual rooms with the placement of noisy and big elements away from the user. This combination led to the decision to position the ventilation unit itself in the attic. Therefore the product needs to move air from the attic to the different floors and rooms. These detailed functions, or system manifestations as I call them, are the building blocks for the actual components of the product. Because of the decision to move air throughout the building from the attic, the choice for a central ventilation system has become logical. Despite being on the same level, the choices made, influence each other constantly. This is also part of the dynamic nature of this process.

That concludes the top part of the model. All these system manifestations are funneled into the center of the model. Through this funneling, multiple decision processes are used to convert the information of the top part to components for the bottom part. For example: The product needs to move air from the attic to the ground floor. There are dozens of ways to do this, for example: make holes in the ground, use pipes, add fans to staircases or add some kind of outside hamster tubes to displace air towards different floors.
These HKJ's as we call them in our education, or "how-tos" can result in maps with random solutions to the problem. The maps help to visualize and to communicate the ideas and make sure these ideas are not only living inside the designers head.
Eventually, in the problem of the air displacement, I chose to add a component to provide this manifestation to the product. Due to the type of company Breman is and wants to be and overall feasibility of the project, this component results in risers which provide an air displacement between the floors.

To wrap this example up, a summary of the process from bottom to top: In the product I end up with a riser component. This riser is needed because I want to utilize a central system with most of the big and noisy elements out of the user's way, in the attic. Additionally, I want to be able to supply clean air and suction dirty air in individual rooms. I need this functionality in the product, because I want the product to provide clean air in a building, but I also want people to be able to use their homes flexibly. Next to that, a main objective is to help people in the energy transition. Therefore, I want this product to be implementable in a standard house with the possibility of variation in the layout of these houses. As you can see, the component ties all the way back into the vision.

As this was only a short example for the risers, a full list of the resulting decisions made on the top levels can be found in appendix I. These relate through one or multiple connections with each other and lead to a list of components which embody the end product.

APPENDIX I: DECISIONS ON THE DIFFERENT LEVELS

Vision

Together with Breman I want to create a new focus for the future within the area of ventilation. With this focus, we want to offer an ecologically responsible solution to residents of a standard terraced house. This solution will help the resident with becoming aware of ventilation and sustaining a healthy climate in their home. Next to that, the solution will help Breman to invest in relevant drivers of the future and position themselves as an innovative and helpful company.

Vision goals
From the goals we want to achieve that:

There is a healthy climate within the home

The user can use their home flexibly

Integration is possible within existing homes

The user is assisted in making their home more sustainable

The user does not experience discomfort from their ventilation

The user becomes aware of the phenomenon ventilation

The user feels in control over the ventilation in their home

The user is guided in correctly ventilating their home

The installer can adjust to the customer's needs

System goals
What purpose does the system need to achieve this goal? The system should:

Provide healthy air within the home

Provide the possibility for different use scenarios

Be adaptable to different layouts of homes

Limit heat loss due to ventilation

Take up as little space as possible

Cause as little noise distrubance as possible

Provide a visual rendition of the ventilation within the home

Avoid improvised solutions during installation

React to the ventilation need of the user

Avoid active and unconscious sabotage of the ventilation system

Be easy to set up

Provide the possibility for the user to control the system

Be minimal in the expressivity of the elements

Provide an optimal airflow

Be able to use standard solutions for parts that are not in sight of the user

System functionalities
The system achieves this function through:

Adding clean air and removing dirty air from each room

Air exchange based on heat recovery

Placing big active parts in the attic

Placing elements on the floors in such a way that they take up as little effective space as possible

Placing the elements on the floors without interrupting or covering existing architecture

Making a distinction between parts with different functionalities

A standard configuration which, through the use of standard components, can be adapted to every variation of layout of the house

Offering flexible ventilation capacity

Minimal amount of passes through ceiling and walls

Creating enough distance between the supply of clean air and exhaust of dirty air

Self regulation of the system

Automatic set-up after installation

Giving the user insight into the status of the system

Providing the installation company with information about the status of the system (privacy)

Providing flexible, preventive (remote) maintenance

Provide the possibility for the user to change the ventilation

Taking the user along on understanding the ventilation in their home

A minimalistic formlanguage

Reducing complexity that is caused by adding flexibility to the system

Collection data about the different use areas

Minimising the interaction of the user with the system during install

System manifestations
This function manifests itself as:

A central system

A unique system for air supply per living space

A unique system for air exhaust per living space

Distribution of air on the different floors

Distribution of air in the different rooms

Air displacement from the attic to the ground floor

Placement of the elements on the floors against the outer walls of the building

A flexible location for the supply of clean air

A flexible location for the exhaust of dirty air

Integration of sensors and actuators into the system

Elements controlled by an external medium

Consultation with the client about the locations of the connections

A visualisation of the data collected through the sensors

Possible data feedback to the installation company (privacy)
The possibility to create the longest distance between the supply and exhaust air streams

The aversion of different airstreams crossing in the elements with different functions

Closures for ends and unused connection points

A gradation in the expressivity of the elements

An element that regulates the supply and exhaust of the central system

An element that connects the active ventilation element to the rest of the system

An element that connects standard solutions with the system elements

An element that closes holes made through floors, ceilings and walls

An element to connect the system to the walls of the building

Covering up elements that contribute to the awareness of ventilation to a lesser extent

An installer that installs and sets the system up

The ability for the user to create different living zones and use scenarios in those zones

System components
The components that arise from this are:

A supply duct

An exhaust duct

A duct cap

A duct cover plate

A duct suspension part

A supply valve

An exhaust valve

An exhaust rotation element

A connection part for the valves

A cap for the valve connection parts

A corner

A T-split

A suppy riser

An exhaust riser

A MVHR box

A |blackbox|

Connection modules for the standard solutions

IoT components

An application

APPENDIX J: RISER CONFIGURATION THOUGHT PROCESS

The risers function as transportation method for the clean and dirty air between the different floors. These risers are arranged in a certain pattern to maximize adaptability to different layouts of the standard terraced house. The general spaces (the placement of the inside walls) are the same for most cases, however there are variations in layout. In figure 67 you see the plain blueprint and figure 68 and 69 display two common layouts.

These layouts may seem similar, however from a ventilation standpoint they are vastly different. From a traditional point of view dirty air is suctioned from “wet” spaces. Most commonly, these wet spaces are the bathroom, the toilet and the kitchen. The supply of clean air could be done through natural ventilation. The suctioned rooms create a negative pressure, which the surrounding rooms can fill through the gaps under doors. This creates an airflow through the building. Clean air can also be mechanically pumped into the residence. The common choice is to provide the clean air in living areas (living room, bedroom) or traffic areas like hallways.
With this in mind I add the functionalities in the different rooms in both situations. The spare room is considered an office/workout space.

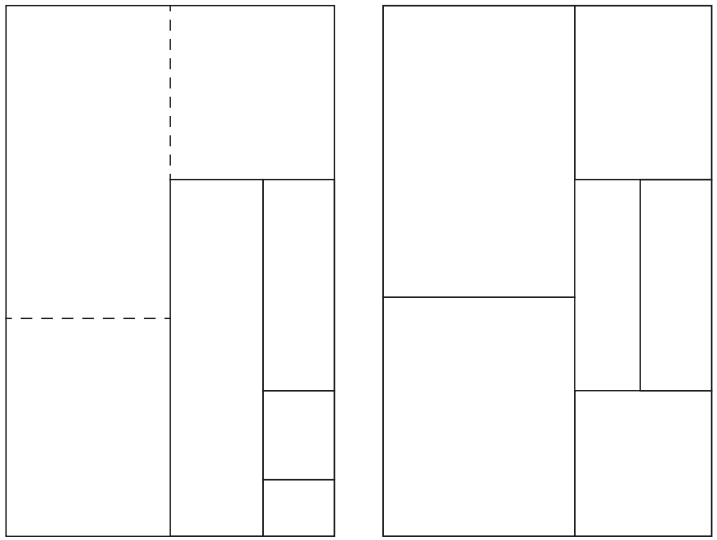


Figure 67: A blueprint of the ground (left) and first floor (right) of a terraced house without layout

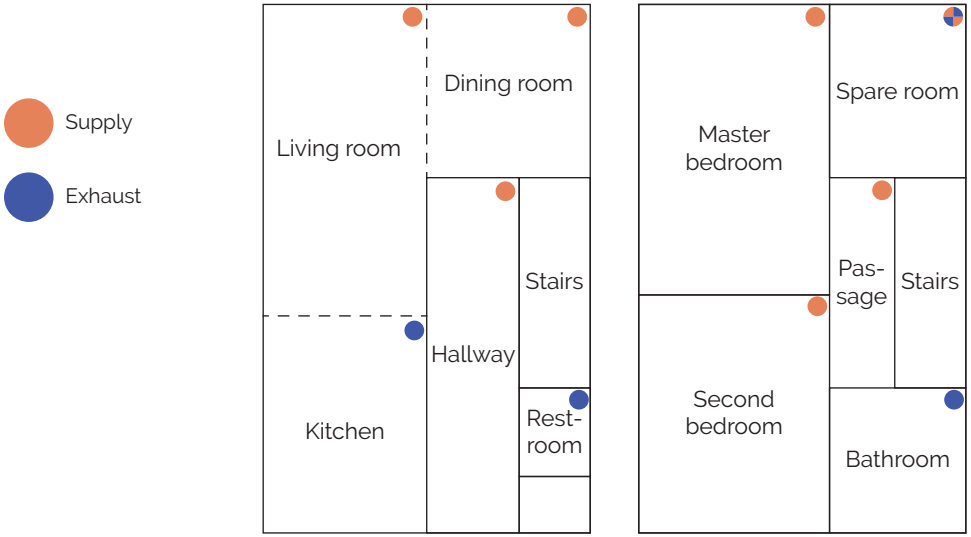


Figure 68: A blueprint of the ground (left) and first floor (right) of a terraced house with the kitchen in the front

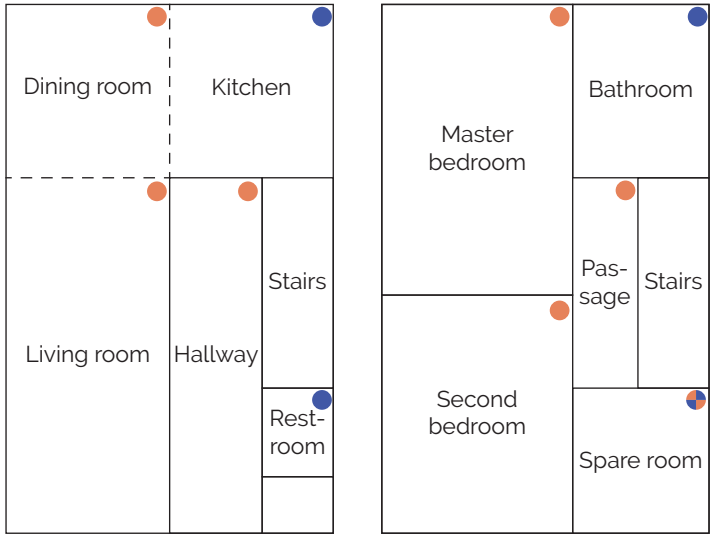


Figure 69: A blueprint of the ground (left) and first floor (right) of a terraced house with the kitchen in the back

Overlap these two maps and it is clear that with only two plausible layouts the amount of flexibility required is already high. Combining this with the vision in which I want to provide a system that is ready for multiple used spaces, I decided to consider every room to need both airflows. This would be the extreme situation for this system, but such a configuration would make variation possible. The configuration can then be adapted to the envisioned use of the owner of the house. Only implementing the needed parts and omitting the other parts. Shortly continuing on this topic. The product is aimed at helping a large number of people renovate their homes for a more ecologically sustainable future.
Next to the variation and flexibility that it requires, it also needs to be economically feasible. This subject is on the edge of the scope of this project, however a small addition is made on this topic by adding budget counterparts to the design components. On top of that, only implementing the parts that are needed from the configuration, establishes this cost effectiveness on a system level as well.

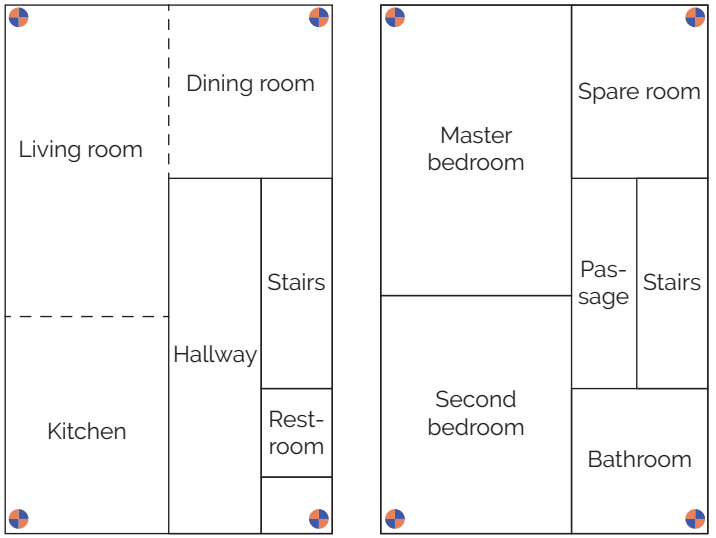


Figure 70: A blueprint with the riser locations.

Regarding the still numerous possibilities on how to tackle the flexibility problem, I wrote down requirements for the system.
The air flow needs to be visible and the product has to be integratable into an existing home. However I want to use as little effective space as possible and it should not be obtrusive. The obtrusive part sounds like an aesthetic problem, but should also be considered in this configuration phase. Therefore a contradiction emerges: I want people to realise what the ventilation does and make it visible, but at the same time, I do not want to be pushy with the elements of the design. To further add balance and visual direction to the product I added different levels of priority to the components and their appearance. The risers have a low priority and therefore it is not crucial for this part to be in the spotlight.
To maximize space efficiency and prevent the risers from interfering with living space on the first floor the risers are placed towards the walls. Because of the lesser importance of the risers for the awareness of the user, this efficiency can be increased by placing the risers in the corners of the building, without undermining the vision behind the product.

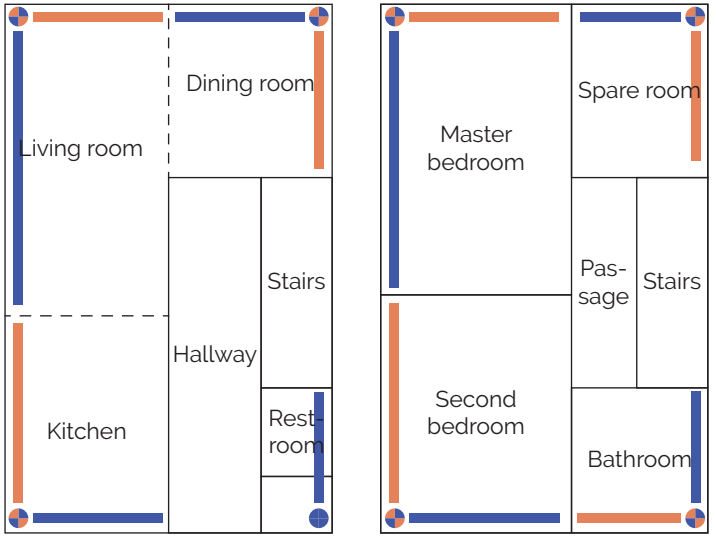


Figure 71: A blueprint with the resulting possible valve locations.

The configuration of the risers still has several degrees of freedom. Options such as a use of concentric risers (a traditional approach) or two rectangular risers (the rectangular profile is discussed later) in front of each other, see figure 72 and 73, are not feasible as they would take up too much effective space. The concentric risers would need to have a total diameter of 140 [mm], instead of the 100 [mm] diameter of a standard ventilation pipe. The effective area it would take up is at least 140 [mm] from each wall. On top of that, using concentric risers would eliminate the visual cue that there are two different air streams, reducing the clarity to the user of what ventilation does.
Considering non absurd proportions the depth of the rectangular risers would be around 50 [mm]. As I will discuss later on, the air ducts are placed in front of the risers. The rectangular risers stacked in front of each other would therefore result in a combined depth of around 200 [mm].

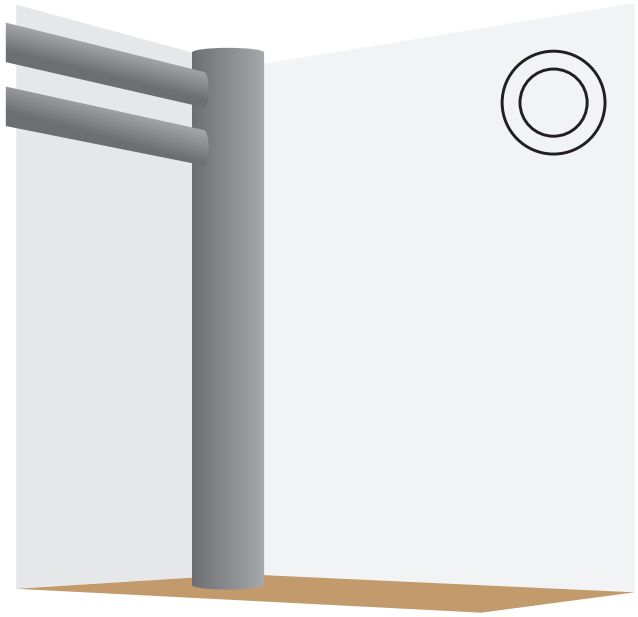


Figure 72: A concentric riser is used to provide both exhaust and supply air flows.

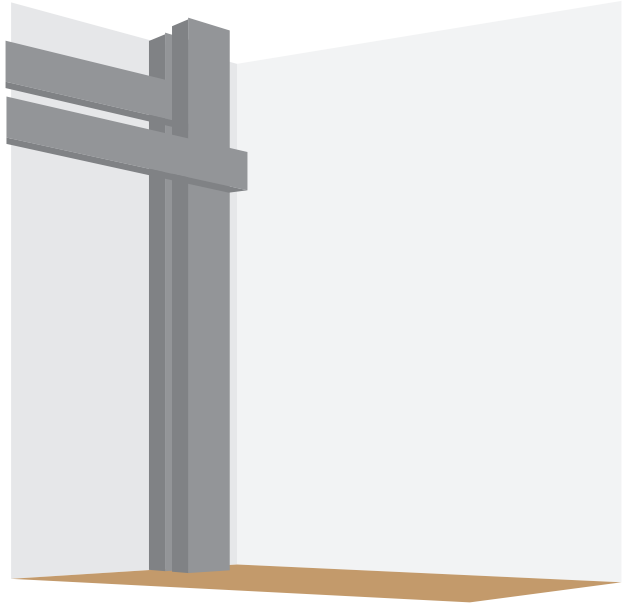


Figure 73: The risers are stacked on top of each other, the air duct can be placed under each other in this configuration.

Concluding from these two examples, I made the decision to use two separately placed risers. This can be done by placing them next to each other on the same wall, see figure 74, or in the corners on the two different walls, see figure 75. Both of these options have advantages and disadvantages, but keep the overall depth around an acceptable 100 [mm].
Placing the risers next to each other on the same wall creates a visually heavy block on the wall. This configuration also makes it more difficult to create diagonal airflow within rooms. To be able to still have the longest airflow, an extra corner/bend component has to be added.
Placing the risers next to each other on the two different walls can result in issues with window coverings placed on the front or back of the building.

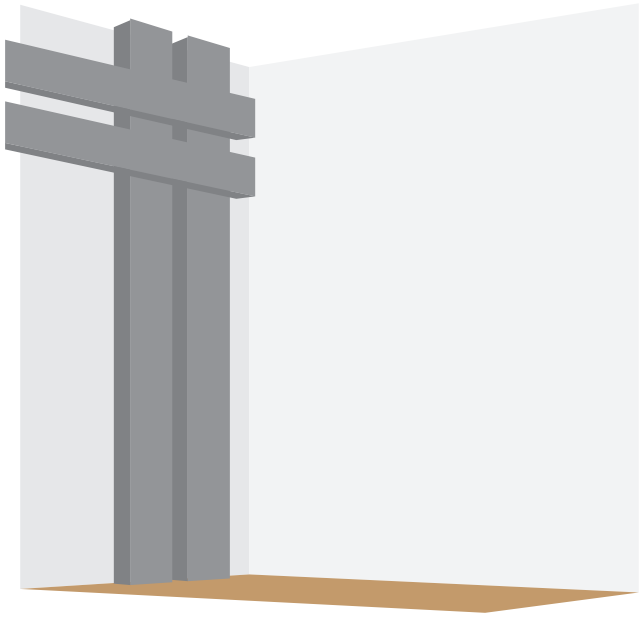


Figure 74: Both airflow on the same wall.

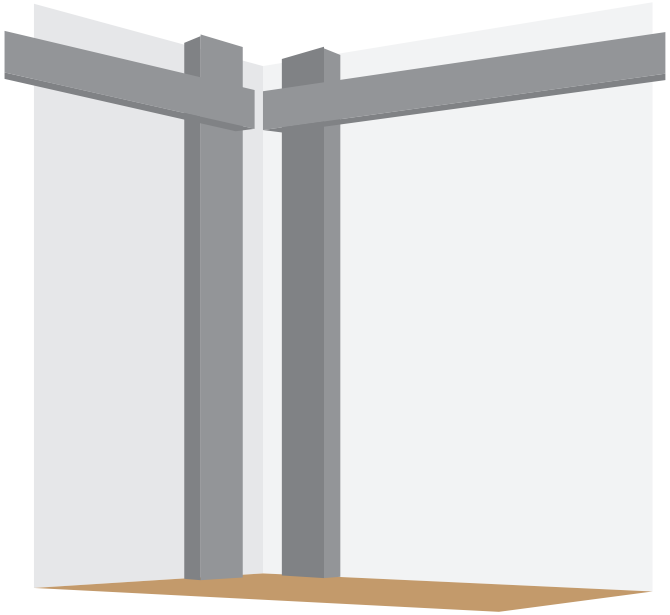


Figure 75: Each airflow on a different wall.

For the remainder of this project I adapt the second option: two risers on the two walls. This option has superior ventilation functionality, less intrusive aesthetics and I expect it to be better applicable than the other option. However since this is going to create problems with a significant amount of cases, Breman could add the other variation to the product as I will discuss later in the discussion chapter.

APPENDIX K: RENDERS OF THE INTERIM CONCEPT IN ADDITIONAL ROOMS

Figure 76: An impression of the restroom with the budget valves installed.

Figure 77: An impression of the bathroom with the budget valves installed.

Figure 78: An impression of the multi purpose room with the budget valves installed.