A STUDY AND DESIGN ON

SUSTAINABLE TECHNOLOGIES FOR HOUSES AND SOCIAL INTERACTION

A study and design on sustainable technologies for houses and social interaction

CONFIDENTIAL

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Abstract

Recently, winning gas in the north of The Netherlands has resulted in earthquakes, damaging houses in its surroundings. This resulted in sustainability becoming an important topic in building houses. Developments are happening in ways of using electricity and heat instead of gas that would fulfil the same purpose. A lot of new products that support sustainable living for going gasless are appearing. The project has been performed externally. The company provided a concept house design, where the first goal was to visualize and choose sustainable technologies that would fit the house design. Research within sustainable technologies has been performed in products, where a selection has been made of products that could be used for the concept house design. The houses will be placed in a cohousing setting. Another part of the project involved the design of the area around the houses, where a community feeling should be present and people are communicating with one another. This, because it positively influences the physical and mental health of humans. The second goal is to design for social interaction without imposing, to make the interaction occur in a most natural way.

A technology roadmap has been created for an overview of sustainable products and how fast they are evolving. This helped in making a first selection of sustainable products. A morphologic chart, assessment of sustainable technologies and placement within graphs resulted in an overview and selection of five concept directions for selecting sustainable products for the house. Further expert interviews and feedback resulted in the selection of one set of products. For the social part, a literature review has been performed in what factors can encourage people to form a community, and how nature and the concept of sharing contribute to a successful communal space. This provided design propositions to use for the concept design for the surroundings of the houses. More research about types of social interaction, social areas and influence on people's behaviour gave insight on how to design for social interaction. Additional qualitative research has been performed in the form of a brainstorm, visitation of a cohousing community and an interview with a Tiny house resident. This, to gain a better understanding about what happens within a community and how this feeling can be designed for.

The result of the assignment is a selection of sustainable technology products for the concept house, together with an appealing surrounding that contains factors to promote social interaction and creates the desired community feeling. The design is evaluated by an expert, who provided feedback on the concept design together with future design recommendations.

Keywords: sustainable, technologies, social interaction, community, cohousing.

Acknowledgement

I would like to thank design company D'Andrea & Evers Design for giving me the opportunity on contributing to the project 2Elephants. Tom Evers and Tim van Leipsig both have provided their experienced eye on the process which I am grateful for. Furthermore, I would like to thank all the experts who gave their opinion on my work with feedback that has been proven very useful. Furthermore I would like to thank Wouter Eggink, for his coaching from the University of Twente and sharp feedback on my work. I really appreciated the approach of planning the next meeting directly after the last one. Thank you for your time and quick responses by mail. Last but not least I would like to thank Viktor Klassen, who was a graduate at D'Andrea & Evers in the same period. We had good talks project related or unrelated and has been a good companion.

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Overview

This thesis presents a master assignment on researching and designing a cohousing community that is running (mostly) on sustainable technologies and where a community atmosphere is present. Because winning gas has recently resulted in earthquakes in the north of The Netherlands, alternative materials are tried to be found for gas. This, together with a house shortage in one- to two person household has brought this assignment to live. Because sustainable technology forces people to think in a more collective way, it promotes collectivism and could mean a diminished individualism within our society. The social interaction within the community should be designed for in order to make the threshold lower for people to search for contact.

In this thesis, the project is introduced first, whereafter research is performed about sustainable technologies and products. A choice of products is made that fit to the concept house, resulting in a concept of chosen technologies. Furthermore research is performed in order to design for the social interaction in the community. The chapters Ideation and Conceptualization follow, which results in a concept. Thereafter a chapter is dedicated to the Evaluation of the concept, followed by a Discussion & Conclusion, based on the gained insights and results. Lastly, a personal opinion is given about the technological and social part of the project.

1. Introduction

1.1 Context of project

1.1.1 University of Twente

This thesis is a product of a graduation project. The University of Twente provides the opportunity to graduate as a MSc of Industrial Design Engineering. The track coordinator of Human Technology Relations, Wouter Eggink, will function as a coach throughout the whole graduation project. Throughout the project, knowledge and facilities within the University can be used. The University will provide a guiding and supportive role within this project. The graduation project will take up to nine months.

1.1.2 D'Andrea & Evers Design

The design agency where the project is running is called D'Andrea & Evers. It is a design company that is existing for over twenty-five years, located in Enter. Luigi D'Andrea and Tom Evers are the company owners. They started the company together and are still running the company up to this day. Tom presented a project, called 2Elephants. The graduation project will cover a part of project 2Elephants, due to the project size. Tom Evers will be project leader of the graduation project and coach of the process. Tim van Leipsig will be the contact for unprejudiced opinions about the graduation project.

1.1.3 Project 2Elephants

Project 2Elephants is a big project that plays into the need for affordable spaces, flexible spaces, modular homes and having a mixed community (D'Andrea & Evers, 2018). The design question for 2Elephants is: "How can we create ***avant garde***, ***adaptable***, ***customisable***, ***sustainable***, ***community-oriented***, ***human*** and ***smart spaces*** to live, work, study, play, produce, etc?" (D'Andrea & Evers, 2018). The aim is to create something that is different from the containers that are often used nowadays or the tiny homes that seem so ideal but often lack a feel of luxury. They are often combined with sustainable technologies, where non-appealing objects are visible, such as fans (figure 1).

Figure 1: Company building (rooftop) and house (left side) installed with fans on the outside.

Project 2Elephants should in the end offer modular one – to two-person households that contain sustainable technologies, which are (mostly) hidden and where a community atmosphere is present.

1.1.4 Present state of the project

At the moment, there are multiple house designs and interior designs. One house design can be found in figure 2, where the door is located on the right side in the picture. It will give an idea about a possible layout of the house. The layout can be seen as a basis. It can be adjusted, based on where the door to the outside world will be placed.

Figure 2: Interior layout of house (D'Andrea & Evers, 2018).

The basic house shape and location of the door could play an important role in the future. No pre-determined choice is made for one particular house layout. This will be determined when it becomes necessary to pursue one house layout to make the graduation project more tangible.
A basic structure of a platform is designed in an earlier stage (figure 6). The idea is to put houses on top of the platform, and sustainable technologies underneath. A second function of the platform is to let people interact with the platform, promoting social interaction.

The contribution of the graduate is to provide a set of sustainable technologies, suitable for the houses that are being designed and to create insight in how the technologies are placed inside the platform or house. Second, to make a design for the platform where people can interact with each other, promoting social interaction amongst residents and creating a community feeling.

The design question of 2Elephants on how to create avant garde, adaptable, customisable, sustainable, community-oriented, human and smart spaces to live, work, study, play, produce, etc. is explained in more detail below and how it is accounted for.

The avant garde is represented in the way the houses are shaped. They have a slight taper, which creates a playful shape from the in-and outside that will influence how you perceive the room in perspective. Because the houses are slightly tapered (figure 3), this also creates opportunities to play with the setup of the houses in a new neighbourhood. The house covers around 31,5m² and is five meters high.

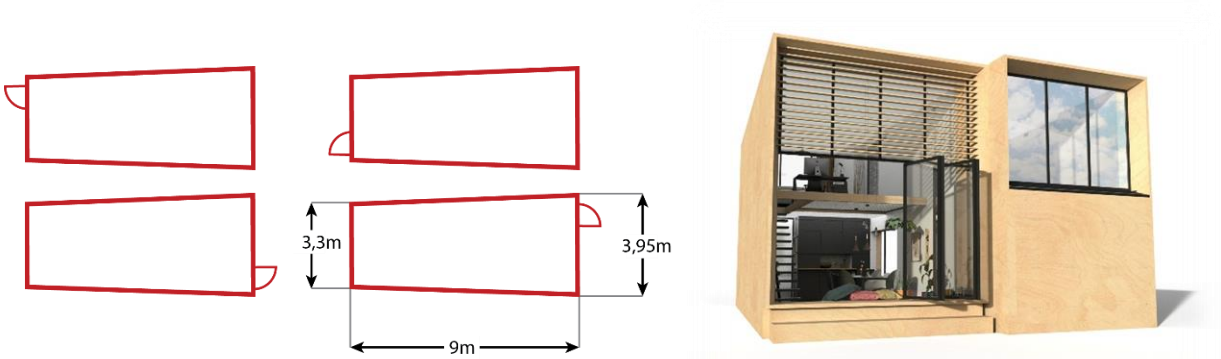


Figure 3: House layout with door orientation (left) and front and back of house (right) (D'Andrea & Evers, 2018).

The avant garde and sustainability effect is represented in how parts of the house can be folded open for easy (dis)assembly. The black box on the second floor is the funnel for all the wiring and tubes (figure 4).

Figure 4: Exploded view of attachable and foldable parts (D'Andrea & Evers, 2018).

The houses are adaptable and customisable because they can be put on top of each other up to a number of four houses. The houses can shift from each other, as long as the funnels are connected, due to all the tubes and wires that need to go from the platform to the house. This way the houses can be shifted to the front and back, while remaining enough room for all the tubes and wires to come through. Figure 5 shows what this would look like. It is a schematic side-view section cut. The red area on the right is the space for wiring and tubes, where the red line within the lighter red area can be used as tunnel.

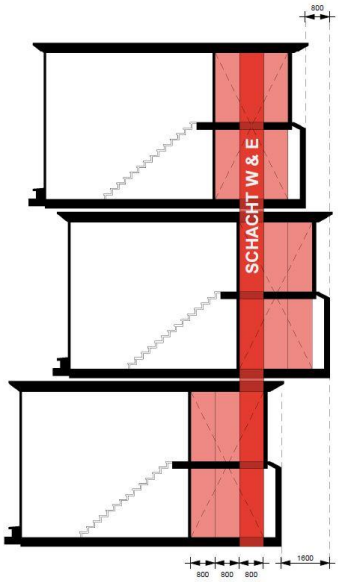


Figure 5: Stacked houses with funnels for wires and tubes (D'Andrea & Evers, 2018).

In research and design within this project, sustainability plays an important role. With respect to the platform this means ideally using materials and technologies that are considered sustainable. Sustainable technologies means having technology that is more efficient than regular products in

energy consumption and that will provide a step closer to living energy neutral or off-grid. They are often connected to nature directly or indirectly (collecting sun heat, wind, etc.

The houses should make use of sustainable technologies implemented inside a platform. This platform will normally be located on the ground. It consist of horizontal oriented, concrete beams that will be levelled inside the ground. On top of these beams some (in the example three) spacers are set, where on its turn wooden beams are placed horizontally. The wooden beams' orientation is perpendicular to the concrete beams. Figure 6 depicts the basic construction of the platform.

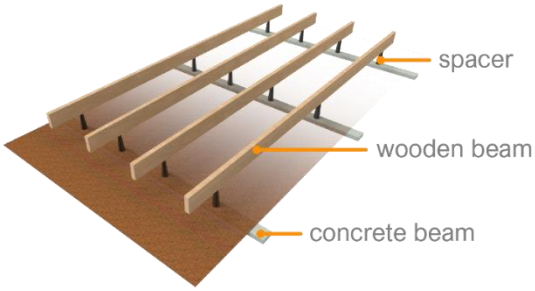


Figure 6: Basic construction platform.

The wooden beams create a division of three areas, where the left and right sides are for placing technology and the middle can function as a crawlspace. The crawlspace is needed for maintenance of the technology. The height of the platform should be around 70 – 100cm. This is not fixed yet.

The platform should induce more than only masking the technologies and saving space inside the house. In order to make the platform more useful, it could contain features for useful interactions (e.g. parking a bike, storing products, post, etc.) that could lead to social interactions. This could help shaping a community, which is an important aspect within the project.

The goal is to create a community atmosphere where a natural form of socialization is present and people care for each other, communicate, adapt and have a 'we do it together' attitude. For the design of the surroundings of the houses, a possibility could entail the introduction of certain features that could enhance or promote this goal. The platform could function as a mediator to promote the social interaction between residents.

In order to get to that goal certain constraints need to be defined along the graduation project. One of them being the main location, that could have an influence on the choice of sustainable technologies and a different approach in designing for the social part, because of culture differences. If 2Elephants will be realised, the first houses will be built in The Netherlands first. So the chosen location is the Netherlands, whereas a more specified place will be selected on a later point in time, to design for the social part. Also, because of the available timespan and research that needs to be performed, it is most interesting to use The Netherlands as starting point.

1.2 Significance of project

1.2.1 Transition to gas-free houses

The main needs of a person in order to be able to live inside a house are electricity, water, ventilation and gas (heat). However, the latter is subject to change. In The Netherlands new houses are built without gas connections. In 1959 people found the largest gas field of Europe in Groningen, making accessibility to gas easy and appealing. Sixty years later a problem emerged with extracting gas from the area. "Earthquakes began damaging homes around the Groningen field (as gas is extracted, the ground subsides). Production has therefore been cut to nearly half of the level in 2013." (Morris, 2017). The Dutch Government decided that requests for new constructions from the 1st of January 2019 entails that the houses cannot get a gas connection and instead should think about a (geo-) thermal pump or sustainable city heating networks which either generate heat directly or use excess

heat from the industry (Vulpen, 2018). The goal is to use 100% renewables for households in 2050 in The Netherlands (Morris, 2017).

1.2.2 Housing shortage

According to ABF Research there is a big shortage of households in The Netherlands. ABF Research is a company that calculates the shortage of households in The Netherlands. The calculation at the 1st of January 2017 shows a statistical shortage of 3.3% households, which comes down to approximate 255.000 houses (Abfresearch.nl, 2018). This means there are a lot of houses that will need to be build the coming years. But apparently the current approach of tackling the problem has not worked out so far, as the headlines about household shortages keep appearing (Blijie, 2018).

1.2.3 Housing waste

On the contrary, the government tries to demolish 6.000 houses a year in Detroit, U.S. Why? Because abandoned buildings lead to a decreasing local economy, lower property values and is associated with higher rates of crime and unemployment. According to Lamore, Berghorn and Syal (2018) this all leads to more people leaving the location, resulting in an area where nobody wants to live in. They tell that in 2012 the U.S. had reached a record of 7.4 million abandoned homes. While the U.S. tries to cover this problem by demolishing 300,000 houses a year, it created 169.1 million tons of construction and demolition debris. This represents about 22% of the U.S. solid waste stream, which is huge. The article talks about changing the mind-set and to think about a change of perspective. They say: ”As with any paradigm shift, the most challenging issue is to change current mind-sets. People need to leave behind a “build it, use it, demolish it” perspective and replace it with a “plan it, design it, build it, use it, deconstruct it, and reuse the materials” view. “ (Lamore, Berghorn and Syal, 2018). The latter is the kind of mindset that is honoured during the 2Elephants project.

1.2.4 Collectivism

Sustainability plays a big role, which is a highly discussed subject at the moment. The social part of looking after each other and creating a community is a strong concept whereas trends towards collective approaches emerge, that needs people to think as a collective instead of individuals. The possibility of creating sustainable energy is rising in popularity as people are making money on it. It creates a lot of job opportunities and triggers to let people think on a more collective level than individualistic (Beres, 2017).

Conclusion

The project is important because it could play into the household shortage, promoting a social environment to a more collective society, realising minimum waste during- and after the build, while promoting the trend towards a more sustainable world.

1.3 Assignment

The assignment is defined as follows, based on the provided information of D’Andrea & Evers: To come up with a concept design for the platform, where most sustainable technologies are build inside the platform and where the platform helps facilitating social interaction amongst residents, creating a community atmosphere.

The graduation assignment, can be divided into two categories. One being about the technological part and the other about the social part of the design. Because they can be seen somewhat separate from each other, the report is divided in this way as well.

1.3.1 Technology

As earlier stated, the goal for the technological part of this assignment is to make a selection of sustainable technologies that is suitable for the 2Elephant concept houses.

In order to do so, research will have to be conducted about what sustainable technologies there are. This could involve desk research, expert meetings, company visits, etc. After having a database of sustainable technologies, a selection will have to be made. There could be multiple selection- or assessment methods needed in order to get to a selection of concepts to choose from, such as roadmaps, creating graph overviews, feature ratings of products and expert opinions, etc.

As a start within this topic, the following research question has been formulated:

- *What technologies regarding sustainable housing installations are available, and which should be implemented into the sustainable house/ platform?*

The first research question should help tapping into knowledge about sustainable technologies and perform a selection and application sustainable technologies for the concept houses of the 2Elephants project.

1.3.2 Social aspects

As earlier stated, the goal for the social part of this assignment is to create social interaction amongst residents of the 2Elephants houses, by facilitating useful interactions with the platform that would create a community atmosphere.

In order to design for the social interaction, research will have to be conducted about what types of social interaction exist. Specifically in a cohousing setting, there are different ways of interacting. If the types of social interactions become clear, this can also help with designing the facilities of the platform, together with how they should be located amongst the platform. In order to prevent aversion against social interaction, when implying it too much (assumption), research will have to be performed about what people need as personal space. What spaces should be private and what should be communal or public.
In order to answer these questions the following research question is formulated:

- *How to design for social interaction within a cohousing setting, where a community atmosphere is desired, without imposing?*

The second research question should help to gain knowledge about cohousing itself, social interaction, social cohesion and in the end what to design for a community to promote social interaction while creating a community atmosphere.

The final deliverable will be a design of the platform within the context of a designated area, where selected technology is installed within the platform and is equipped with features, promoting social interactions that fits the area of a community atmosphere. A video-rendering will be made from the social part to show what it could look like, when people live there and walk about the area.

1.3.3 Project planning

The project will be performed over a timespan of about nine months. The full planning can be found in figure 7 and can also be seen in Appendix A for a bigger version. About half of the time will be delegated to research, whereas the other half will be spent on ideation, design and conceptualization. The planning can be interpreted flexible, while a design process can go back and forth throughout the timeline and can be altered through time.

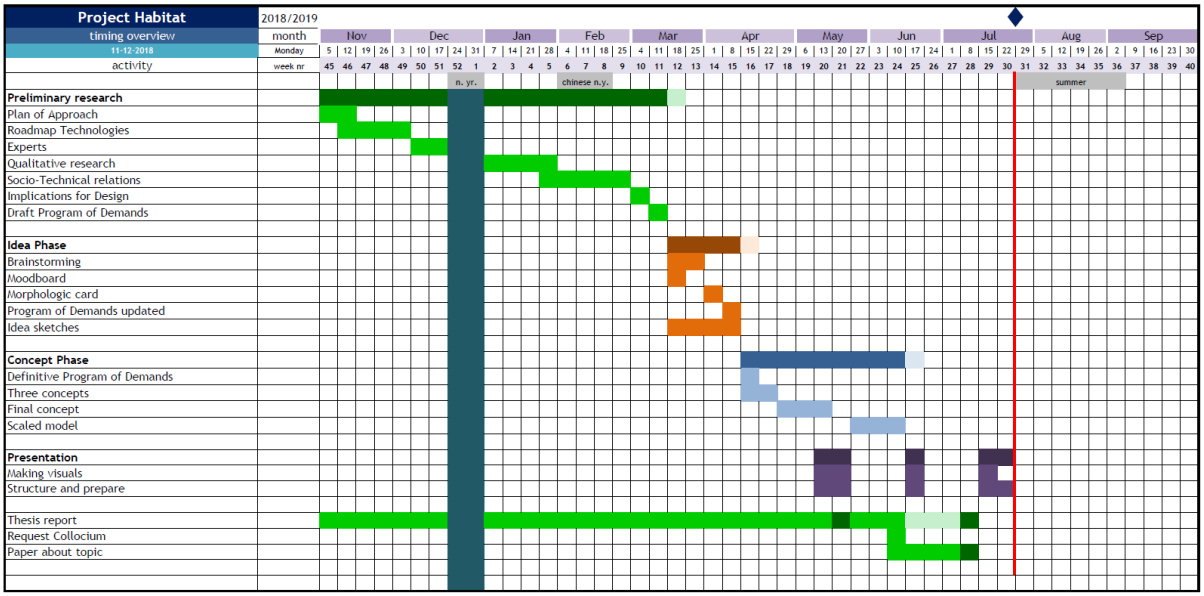


Figure 7: Initial project planning.

1.3.4 Stakeholders

The project consists of several main stakeholders (figure 8). The first one is D'Andrea & Evers Design themselves. They are responsible for designing the in- and outside of the houses, selecting sustainable technologies for the houses and designing the space around it to promote social interaction and a sharing environment.

De Groot Vroomshoop is a big company that builds houses. They have the resources and space to produce prototypes and the first series of the houses for the 2Elephants project. Vikram Mordani is the initiator and investor of the project. He sees a lot of potential in the concept and wants it to be realised. The architect makes sure that the buildings are aesthetically pleasing and that everything is structurally doable. Maurice Beijk is a sustainability expert and is involved during the whole project as informative advisor on selecting technologies that are going to be installed for the houses of the project. He has already performed multiple projects in the past, where sustainable houses were build, which makes him a valuable asset in the chain. This is why he will also attend meetings for the project. The involvement of a company that is specialized in installation techniques will be advised, for installation of the technologies and an expertise opinion on how to tackle this. Which one is not clear yet.

Figure 8: Stakeholders project 2Elephants.

2. Technology research

Various types of research will be conducted in order to provide design implications that could be usable for the design of the platform. Because the technologies used for the sustainable households have a big impact on the design, research on this topic will be performed.

The goal of Technology Research is to gain insight into sustainable technologies that will help defining concepts by combining certain technologies.

2.1 Research

The goal of this research is to gain insight into what technologies and products with regard to generating electricity, creating heat inside the house or ventilating the air are existing, what is new, and what is coming in the future. This, to end up with a selection of products that will fit the platform and provide the residents of their needs. First electricity, heat and ventilation will be researched, where electricity and heat are going to be researched in depth. This, because it is not feasible to research every aspect in depth within the given timeframe. In the end, multiple selections of products will be made, to provide concepts that can be elaborated on to fit the platform. In order to create clarity about what stage a product is in and to make a first selection of the products, a roadmap should be made. Because the project should be feasible within 5 years (D'Andrea & Evers, 2018), only products that are in their concept phase, entering the market or already on the market will be used for making concepts. Because the Design Agency has interest in new developments as well, products that are in their early phase are researched and are considered as added knowledge. The final product combination could be chosen by making a morphologic chart, to create an overview and a clear selection based on different perspectives.

2.1.1 Research topics

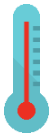
The topics electricity, heat and ventilation were the starting point for this research. However, along the way other factors became important as well, such as cooling, water and storage of electricity/water. Their importance is explained underneath, and how to cope with the topics in relation to research. This is why the explanation of the topics underneath are about all the topics mentioned previously, but not processed in the roadmaps presented later on in this chapter.

The most important factor is having water. Article 6.14 of the Dutch Government states that a connection to the drinking water supply network is obligatory, although using water from this network isn't (Rijksoverheid.bouwbesluit.com, n.d.). Water is an obvious primary need, however, because it is easy accessible and not seen as much of a problem as e.g. having sustainable energy, this topic will not be researched in depth. In the design of the platform, the connection for the water network should be accounted for. Thereby, is it important to think about how residents will get hot/cold tap water.

Internet is also an important factor that people cannot live without these days. However, desk research (Appendix B) into ways of providing internet shows that it can be easily provided without having to implement anything inside the platform. This is why the topic is considered unimportant for the design of the platform. For now, a connection for internet will be added, but it probably will not be a necessity anymore within a few years.

A sewage system consists of a network where the municipality will offer to connect to (Tinyhousestechum.nl, n.d.). It is possible to have the inhabitants dispose their sewage themselves as they do with Tinyhouses, however the Habitat concept should provide more convenience and luxury to the inhabitant (D'Andrea & Evers, 2018). So for the design of the platform this implies that there should be accounted for a connection to the general sewage system.

Electricity is a topic that is considered important for the inhabitants and is researched in depth. As we learned, new houses in The Netherlands have to be build gas-less in the near future and people are searching for ways to make their houses more sustainable by using their own generated electricity. The ultimate goal is to generate enough electricity to be self-providing and create a so-called carbon-neutral home.



Heat is a primary need for humans, when looking at the pyramid of Maslow (Mesaroș, Cioruța, & Coman, z.d.). In depth research will be performed about technologies and products that provide heat for heating the house.

Ventilation is a bit different from the rest. If houses don't have ventilation, mould will start to grow on moisty areas. Ylva Poelman, expert in Biomimicry provided insights into biomimicry solutions regarding energy, heat and ventilation. This input is used to find different ways of ventilating the house, not only by implementing products, but also by using features of nature and/or constructions derived from nature. This is interesting, because it could also have influence on the final looks of the outside of the platform. Several collages are made and some products are found regarding ventilation. These can be seen in Appendix C.

An important factor is being able to cool the house when the inside temperature gets too high. There are different ways to cool and are partly dependent on the type of heating and ventilation that is selected for the house. Some products can heat and cool, so then both are covered within one product.

Because the platform probably will have some volume, it is interesting to think about what product could be stored within the platform. This would be partly dependent on the selection of products/concept, whether this would be electricity or buffering of water.

2.1.2 Categorisation of desk research

While performing research, four clear sub-categories emerged when looking at electricity and heat. These are obtaining, storing, managing and combinations of these three. It felt logic to split them into these sub-categories, which resulted in a clear overview and start for a database of technologies/products.

Next to electricity, heat and ventilation, there are also product systems that cover one or more of these categories in one product. Therefore a row with all-in-ones has been added to the list.

The first overview looks as follows:

- Access to electricity
    - Obtaining electricity
    - Storing electricity
    - Managing electricity
    - Combinations of obtaining, storing and/or managing electricity

- Access to heat
    - Obtaining heat
    - Storing heat
    - Managing heat
    - Combinations of obtaining, storing and/or managing heat
- Ventilation
- All-in-ones – Electricity and/or heat and/or ventilation

2.1.3 Results

The full research on the topics listed above can be found in Appendix D. An example is given in figure 9. While performing research, multiple experts were advised to share information about new sustainable technologies. These experts were respectively: Maurice Beijk (expert on sustainable technologies together with experience in building sustainable homes), Raul da Silva (expert on sustainable technology developments) and Rob Kuijstermans (expert on Phase Changing Materials (PCM's)).

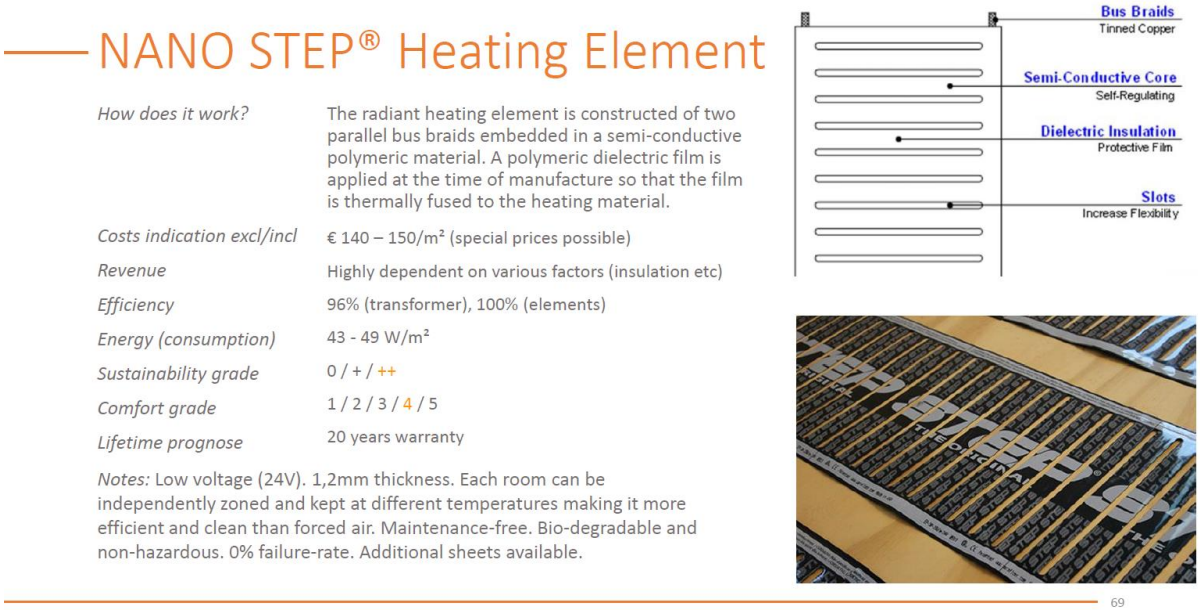


Figure 9: Example from Technology Research; NANO STEP Heating Element.

Every technology or product has certain features that is tried to gain insight into, in order to be able to assess them on these features at a later point. Those features are respectively about: how the product works, cost indication, revenue, efficiency, energy (consumption), sustainable grade, comfort grade, lifetime prognose and notes that are interesting for the technology or general remarks. Every page provides one or two pictures to show the technology and/or product. Sometimes certain aspects of a technology wasn't available, or the company of the product did not reply for elaborate information. Because of these limitations, it made the assessment more tough than envisioned. Sometimes products showed a percentage of a feature as a comparison, or a website made a comparison between products, which could help filling in the blanks to know something about a certain feature. This way, something could be said about the technology. The features where no information was found, have been left blank and have been assessed based on its other features in comparison to the other technologies. The latest version of the database can be found in Appendix D.

2.2 Assessment

'Sustainability' and 'comfort' will be assessed through a grading system, in order to be able to say something about the product or technology regarding these topics.

Factors that were considered grading 'comfort' are: visual perception, noise, feeling, fuels, convenience and assisting software. Grading is performed with a 1 – 5 rating system, where a score can be given from 1 = poor to 5 = excellent.

Grading:

- 1 = Poor
- 2 = Fair
- 3 = Average
- 4 = Good
- 5 = Excellent

Factors that were considered grading 'sustainability' are: recyclability, type of energy source (fossil fuels, sun, wind, temperature), materials, location, transportation, life expectancy, part replacement, efficiency and comfort.

Grading:

- 0 = overall not very sustainable
- + = reasonably sustainable
- ++ = very sustainable

Every researched product and/or technology has been assessed on its sustainability- and comfort grade, only if it's in the Visual/Concept or Production/Product stage and not if it is in the Discovery/Research phase. As mentioned earlier, the discovered research within that area are for the knowledge of the design agency. As they remain unsure of succeeding, they are not taken into account for the concept. The grading helps to generate a quick overview of two important factors. On a later point in the process it could help making a selection for a technology that will or will not be implemented in a concept. All the content is processed in an excel sheet, to generate a quick overview. The sheet can be found in Appendix E. The sheet also shows the reasoning behind every grading of sustainability and comfort.

The next step is to process everything into roadmaps in order to create more clarity about all the found products and technologies, and to make a first selection of products to pursue.

2.3 Technology Roadmaps

Because a lot of information is gathered about (new) sustainable technologies/products, and to converge for having a first selection of products to work with, a technology roadmap will need to be created. Important are: at what stage a product is and how fast it is developing. Different ways of conveying the same information will be explored, to see what creates the most clear overview and good readability in order to work with it. The roadmaps that have not been used can be found in Appendix F1.

For every sub-topic a Technology Roadmap has been generated to gain insight into the stage where technologies and products are located regarding the topic and how fast they are developing. This is where it came in handy to have the topics separated to create clear overviews. Every sub-topic has been researched and the outcome is separated into the stage a certain technology/product is (mostly) in at the moment. These stages are respectively the Discovery/Research, Visual/Conceptual

and Production/Product stage and are located on the x-axis. These stages are used to generate an overview per topic and how fast the product and/or technology is developing. The y-axis represents the technologies and products related to the topic. The roadmaps have been validated together with experts within sustainability, named Maurice Beijk and Raul da Silva. Maurice has over 20 years of expertise within sustainability.

The final Technology Roadmaps can be viewed in Appendix F2. One is represented in figure 10.

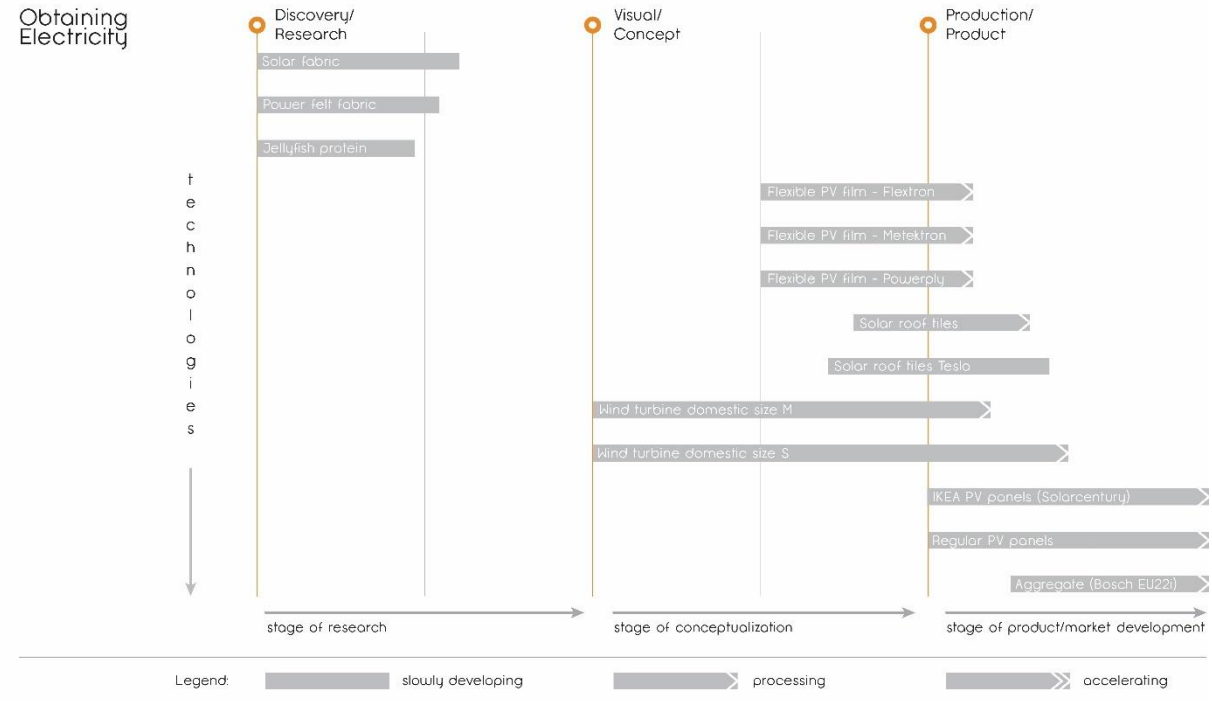


Figure 10: Technology Roadmap Obtaining Electricity.

The technologies/products that are within the stage of research are discarded for the rest of the methods that help in selecting technology for the concept. At this moment all products that are within the stage of conceptualization or product/market development are considered valid options to use for the selection of products for the concept.
Because there are still a lot of options to consider, a morphologic chart will be made. The morphologic chart can provide a structured overview of products within a certain category, such as obtaining electricity or storing heat, etc. From there, choices could be made and start making concepts.

3. Conceptualization

In this chapter, a method needs to be defined to make a selection of products to converge to several concepts. A morphologic chart could provide this. However, more methods might need to be used in order to get to the desired outcome.

The goal of this chapter is to end up with a chosen concept for sustainable technologies, where it is clear how the technology will fit the platform.

3.1 Morphologic chart

The morphologic chart will be used as a tool to select technologies for the platform. The goal is to make a selection of products that could be used within every house and platform.

At first a morphologic chart will be generated that separates every aspect (energy – obtaining, energy – storage, etc.) and categorizations of products (NANO-material, photovoltaics (PV), etc.). This morphologic chart can be found in figure 11.

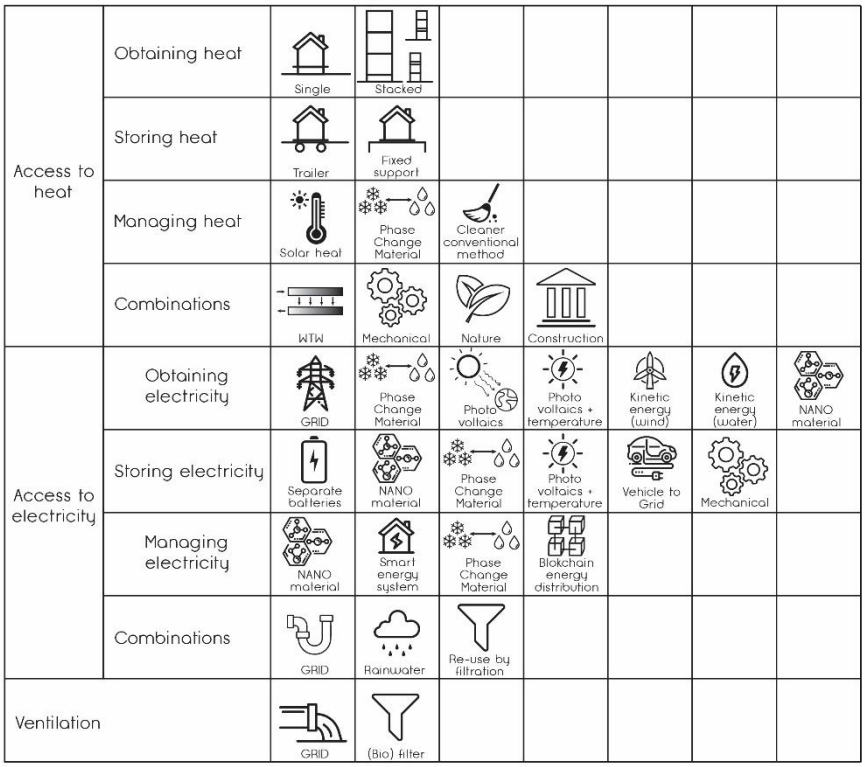


Figure 11: Morphologic chart, aspects separated.

It results in a very big, generic morphologic chart (Appendix G1) that is not useable because it is too general in the selection and too broad for the aspects to choose from.

The insight it gave is that the morphologic chart needs to have the specific products displayed in order to work, as some products covered multiple aspects. Because the products need to be compatible with each other and provide enough heat, electricity or ventilation, this means that it is not as simple as connecting the dots. Because the distinction between obtaining, storing and managing electricity, heat or ventilation complicate the process of making choices, those rows are merged together again. This results in a morphologic chart with heat, electricity, ventilation and combinations/optional as main overview. The new morphologic chart is depicted in figure 12 and can be found in Appendix G2 for a bigger size.

Heat	Solar collector flat panels	Solar collector vaccum tubes	Rocket stove 5	Biomass boiler	NANO step heating element	Regular floor heating	Electric floor heating	PCM Autarkis	PCM panels	Air-air heating pump	Air-water heating pump	Water-water heating pump	Ground-water heat pump
Electricity	GRID	Flexible PV film - Flextron	Flexible PV film - Metektron	Flexible PV film - Powerply	Solarteg roof tiles	TESLA roof tiles	Nemoi wind turbine	PV panels	IKEA PV panels				
Ventilation	Mechanical WTW	Nature	Construction	Conventional mechanical									
Combinations/ optional	JAGA ventilation and heating	PV/T panels	PV/T + central heating	iCEM all-in-one	Tankless water heater								

Figure 12: Morphologic chart, aspects combined.

Product Graphs

Five important demands listed in the List of Demands, provided by D'Andrea & Evers, are: fast revenue, high efficiency, high sustainability, high comfort and low investment costs of the sustainable technologies. These demands will be used as guideline for making the first concept directions. There will be elaborated on what these demands as concept directions mean at a later point in this chapter. In order to be able to make choices within the morphologic chart, eight graphs are made to gain insight into revenue, efficiency, sustainability and comfort with respect to investment costs. This, because investment costs were valued as high importance, due to the fact that at a later point, the concepts would be presented to potential investors. This resulted in four graphs based on technologies for heat, and four based on technologies for electricity. The goal of the graphs is to easily select, for instance, the most sustainable technologies for a concept with high sustainability. The next-highest choice could become an optional choice, to assist or replace another component, or function as a 'safety factor' if a product would be displaced in the graph it still would appear in the optional sector. One graph about products that have a relation to heat is displayed below in figure 13. The x-axis represents the relative investment cost and the y-axis represents the relative efficiency of the products. The other graphs can be found in Appendix H.

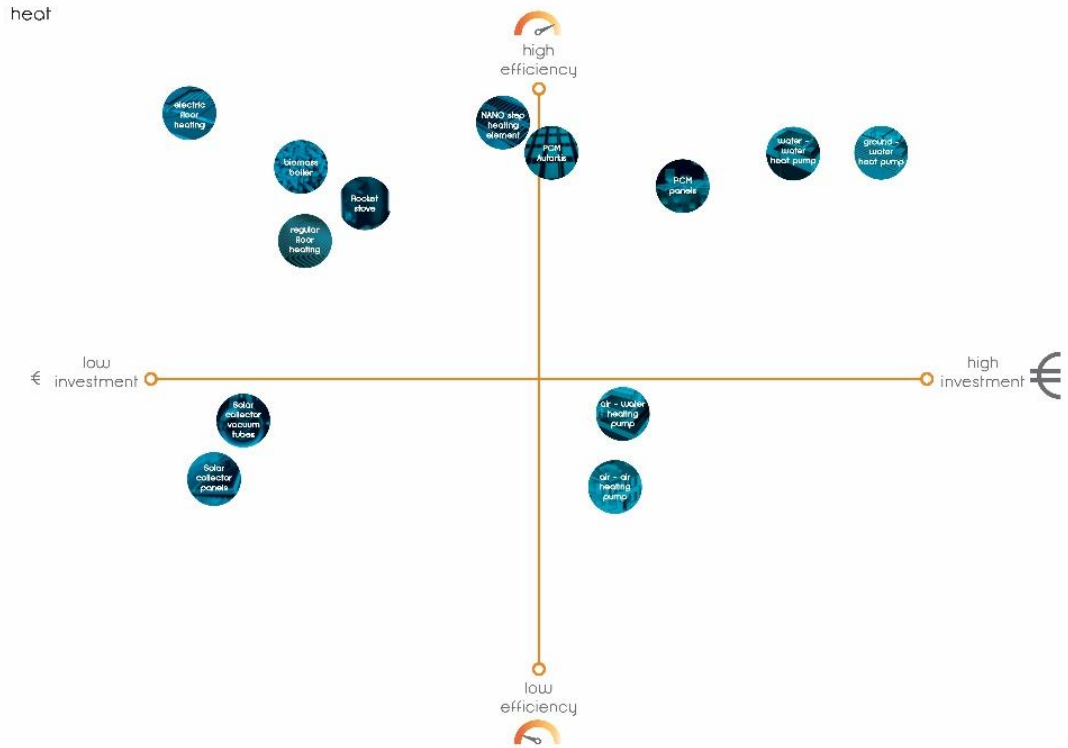


Figure 13: Overview product placement 'investment – efficiency' graph.

Once the graphs are filled in, the choices in the morphologic chart can be in sync with the best outcome of the graphs earlier made. The morphologic charts can be filled in, based on the five perspectives. As mentioned earlier, a choice will be made, together with optional choices. Furthermore will a rough estimated price be introduced for comparison between concepts and negative, positive and general remarks about the chosen products. One example is displayed below in figure 14. The blue dots are the choices, connected with a blue line. The optional choices are the dotted blue circles. On the right the positive, negative and general remarks are listed, and above the morphologic chart, the price and concept perspective are highlighted. All the other morphologic charts can be found in Appendix G2.

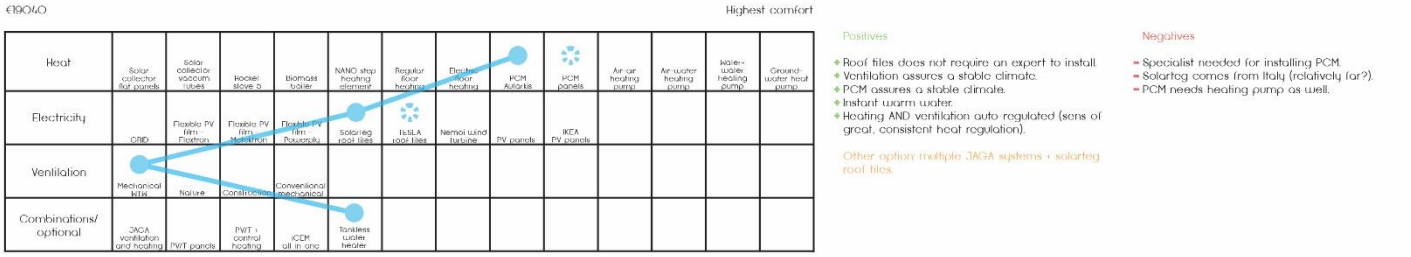


Figure 14: Morphologic chart 'highest comfort'.

3.2 Five concept directions

As earlier stated, the perspectives for conceptualization are respectfully: fastest revenue, highest efficiency, highest sustainability, highest comfort and low(est) investment. Fastest revenue is about selecting products that claim to have the fastest revenue in comparison to the other products. Highest efficiency is about how efficient a product can produce a desired outcome. Such as how efficient electric floor heating is converting energy into heat, or how efficient solar panels produce electricity from solar energy. However, this also has its downsides, whereas electric floor heating seems like it is very efficient, although it will consume a lot of energy to produce the desired heat. Highest sustainability is about which products scores the highest on the assessment about how sustainable the product is. The same counts for comfort. Low(est) investment is about what products are the cheapest to buy in relation to their competitors. An overview of the choices has been made to clearly show the choice of each different perspective, which is depicted in figure 15.

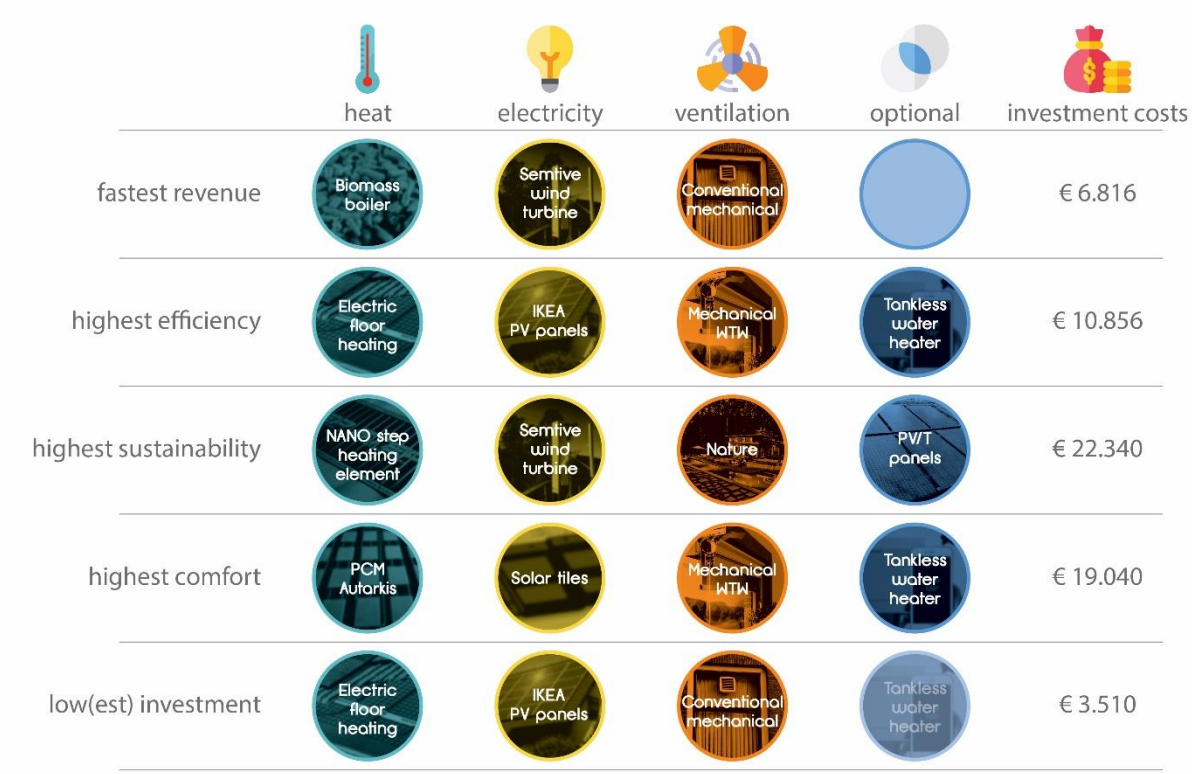
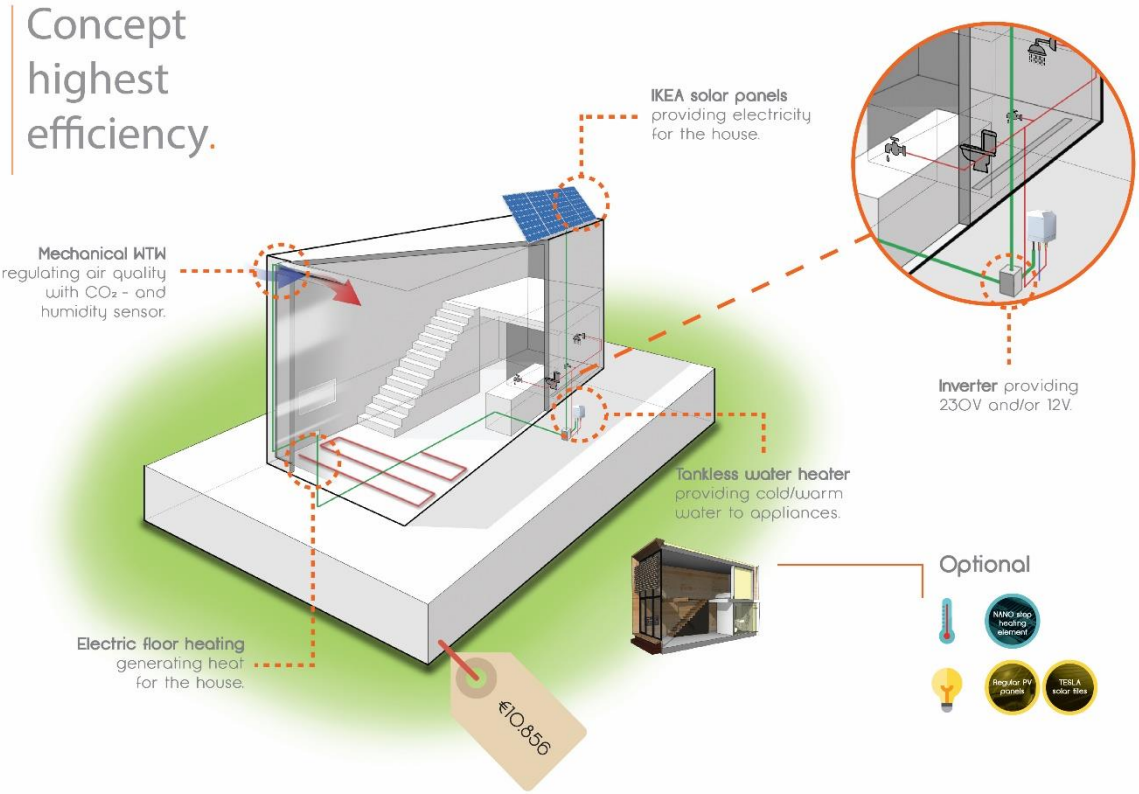


Figure 15: Overview choices of products from different perspectives.

Because everything has been theoretical so far, it felt that it was needed to visualize these choices in order to gain insight into the relation of the technology to the house and/or platform. Do the (optional) choices make sense? Is it complete? What is missing? What is located inside the platform and/or inside the house? The concept drawings can be found in figure 16. All the upcoming concept drawings can be found in Appendix I for a bigger size.



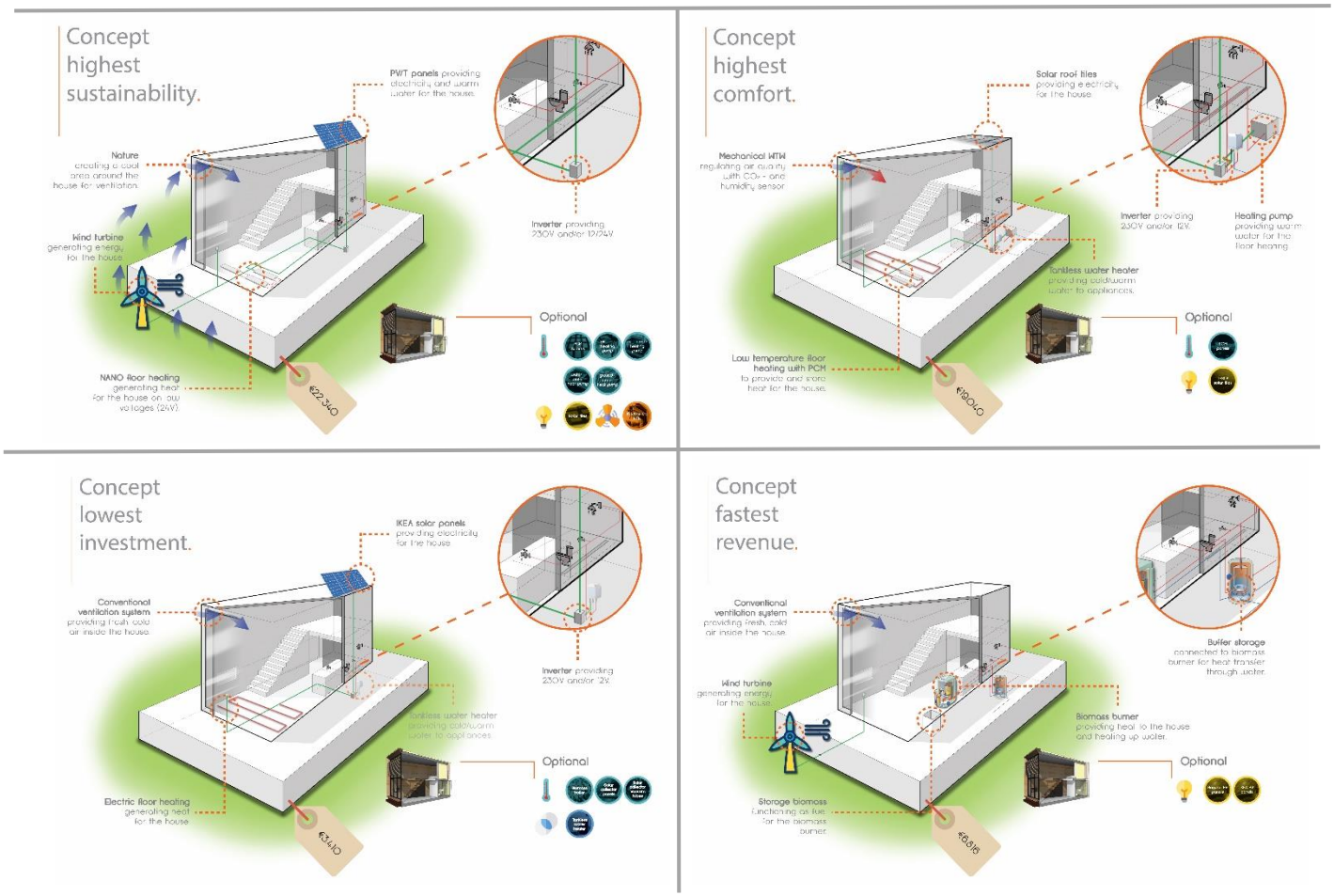


Figure 16: Concept drawings highest efficiency, -sustainability, -comfort, lowest investment and fastest revenue.

3.3 Concept evaluation

The concepts have been discussed and evaluated with different expert parties. This, to gain insight in order to be sure that all the needed sustainable products is accounted for and complete. A presentation with the visuals were made, together with a bit of a background story to give some background information. The following companies have been visited for feedback: De Groot installation technique Hengelo (22-02-2019), Van Dam Installation company Rijssen (26-02-2019), Vennegoor Installation BV (27-02-2019), Maurice Beijk (27-02-2019) and Duurzaam (t)huis Twente (01-03-2019). There is no documentation of this, because the researcher felt like it could limit the freedom of speech of the experts.

The first thing that became apparent from all the meetings is that everybody has their own opinion on what it should mean to live sustainable. Is it about being energy-neutral, or is it about using as little energy as possible, etc.

Secondly, it also became clear that several products or combinations are not suitable for the house. For instance, you do not want a house that still has a conventional ventilation system or biomass boiler, because this affects the EPC (Energetic Performance Coefficient) -value. This is a measurement system to define the energy efficiency of a building (Rvo.nl, n.d.). If a plan to build a house would go beyond a certain value, it cannot be build due to the lack of energy efficiency or sustainable technologies. This means that different choices should be made in order to be able to build the house. In this project it will be taken into account, but no calculation will be made whether

it will pass, due to the limited data available to make a valid calculation. However, the EPC will disappear and a new measure system will be used for buildings build from the 1st of January 2020, called BENG (Bijna Energie Neutrale Gebouwen). The NTA 8800 is the method to define if a building meets the BENG requirements or not (Lente-akkoord, 2019). New requirements will be set that license applicants need to meet. If you want a good EPC value for a building, you would for instance like to have a heat recovery system for your ventilation and no conventional system anymore. So then the option to choose for a conventional system would become obsolete.

Last but not least, it became apparent that some things weren't accounted for that should be in the next step. For instance, cooling became an interesting topic, because once the house is warm, how to make sure the heat can also leave the building? How can you cool in summer? Another topic is to think about how to get warm water, where a difference can be made between warm water for possible floor heating and warm water for consumption.

3.4 Three concept directions

In general, three new concept directions emerged, based on the feedback of the experts. These concept directions are taken as design visions. The previously performed method of choosing products that suit a certain perspective the best and combining them, does not work to its full extent, because everything is connected or interdependent to one another. Sometimes one product is needed in order to have another product (e.g. a heating pump and floor heating). A new selection of sustainable technologies will be made for the new concept directions, while tapping more into the gained knowledge from the Technology Research. The three concept directions are called:
All electric, Low consumption and Collective system.

The all electric concept emerged from conversations on the most efficient concept, where everything is electric. Also, several installation companies and experts think that this concept has a promising position for the future, because of the trend towards gas-less houses. Furthermore are solar panels widely accepted and used by residents, which provides 'free' electricity. In the sustainable world an all electric concept has products that are only electrically powered. However, it would be interesting to take it to the next level and have no water at all for heating as well. This could diminish the amount of maintenance needed and would save labour hours when building the houses.

Low consumption emerged from the philosophy that we have been living incredibly wealthy over the last decades, and that we should shift towards a society that needs to learn to use less of everything and cope with what is available. Maybe us, people, have to give in some of our luxury in order to do good. This could, for instance mean showering for 5 – 10 minutes instead of 15 – 20 minutes. Or put on a sweater when it's getting cold in the room instead of cranking up the heat.

The collective system is a solution that presents technology that is used collectively instead of every house having its individual system. This means that for instance storage of warm water in one big tank will provide warm water for a longer period of time because it is not split into parts. This also means that if one person would shower for 30 minutes, it could mean that someone else is not able to shower that day. So it could also have an impact on a social level.

Another interesting aspect within sustainable living is the government. People can create great ideas about sharing energy directly to each other's neighbour and provide each other of needed electricity etc. However, the government would always demand you to let it flow through the GRID as we know it, otherwise no taxes would be paid over the electricity. So there is also politics in play within this area.

3.5 Three concepts

For the three concepts, a new overview is created to show what technologies are implemented in each concept. This makes it easy to see the differences and similarities in between the concepts. At the same time, a dot can be visible, which shows whether a technology should be installed within the platform or in/on the house. The overview can be found below in figure 17.

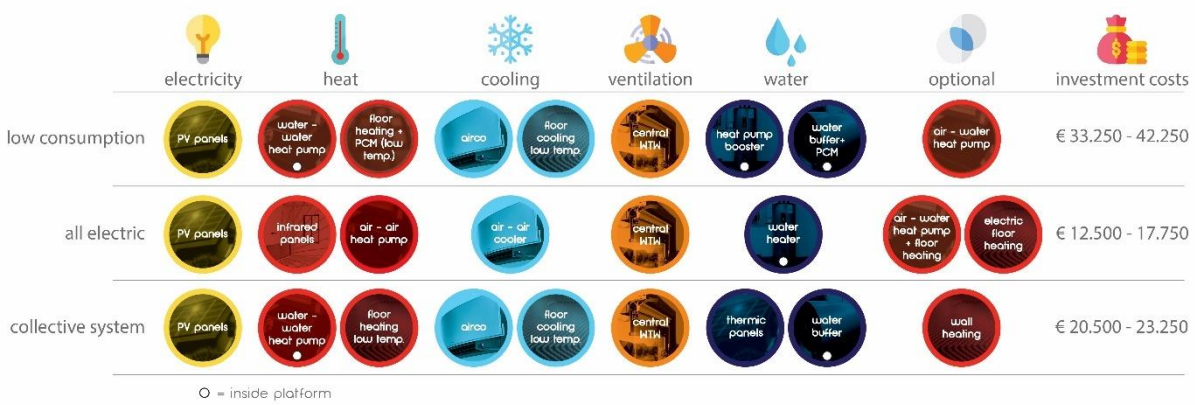


Figure 17: Overview concept ideas with chosen technologies.

As it might be visible, there is quite a price increase in comparison to the last overview. This is due to the expansion of factors that are taken into account such as technology for cooling the house and providing warm water, together with multiple products that can provide heat in a different way. A 15% margin is added for installation costs. The concepts are explained in more detail below.

The drawings of the houses are updated in relation to the new selection of products. Each drawing shows the products that are selected for a concept, a description of what it does, optional products with their up- and downside in comparison to the already implemented product and a small story of what the concept is about and price tag. The placement of products are not always exactly how they would be placed in reality. Sometimes they were placed elsewhere to maintain a clear overview within the drawing.

3.5.1 Concept idea 1: All Electric

The all electric concept is a concept that exists of only electricity-powered products. The concept does not have a heating system that runs on water.

Photovoltaic (PV) panels and the electricity grid will provide the electricity demand. An inverter will transform the electricity from direct current (DC) to alternating current (AC) where necessary. A battery storage option is provided within the platform, however this would be a future possibility. At this moment storing electricity from PV panels is still not interesting enough (high expenses, batteries too small). The air – air heater/cooler provides heat or cool air when needed. Additionally, when sitting in the living room (the front) infrared panels could provide radiant heat if desired. Nature around the house will provide a cooler climate in summer, which can help bringing the inside temperature down. A centralised heat exchanger with CO_2- and humidity sensor will provide ventilation without losing too much heat. A separate water heater will play into the demand of the resident that is in need of hot/cold water.

Optionally two different ways of heating could be applied as well, being electric floor heating or an air-water heat pump + floor heating. The latter would be a heating system with water again, however it felt important to show the difference of electric heating and water heating, together with the difference in efficiency and investment costs. An air-water heat pump could be up to four times more efficient, but the overall investment costs would rise. The electric floor could be added if investors think it would be nice to have heat from the floor as well, because heat from the infrared panels will be blocked if another object is above the object that needs to be heated. For instance, when someone would sit at the dining table, the legs will not feel the heat of the infrared panel, because it is blocked by the table.

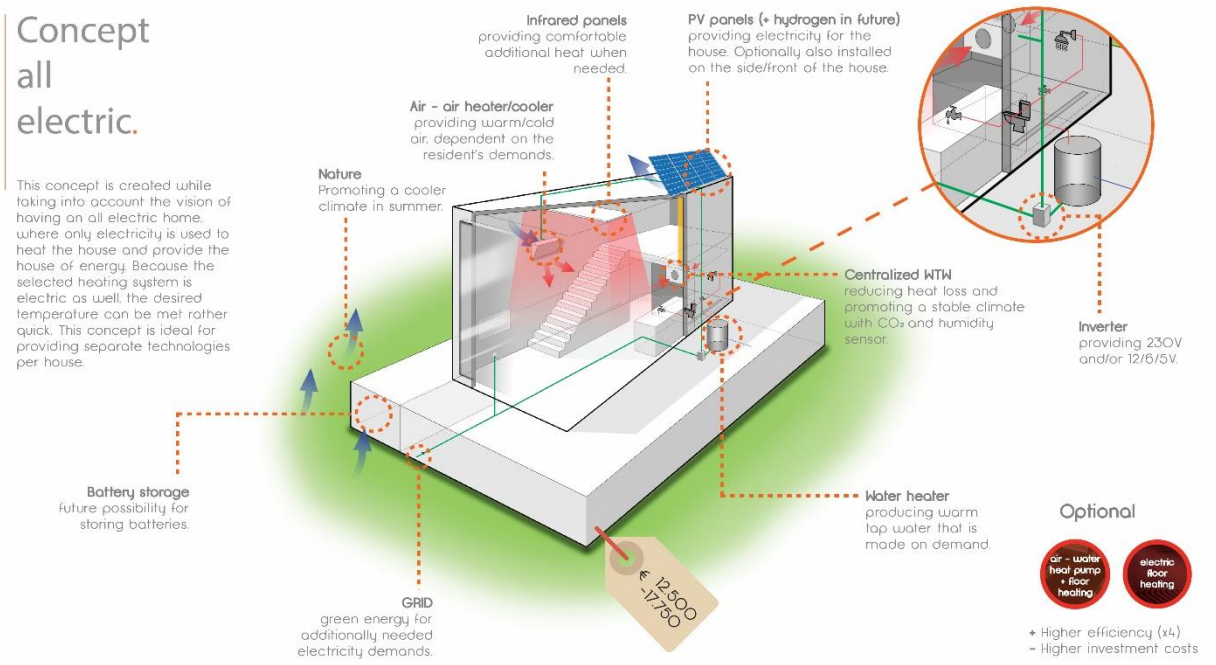


Figure 18: Concept drawing all electric.

3.5.2 Concept idea 2: Low consumption

In this concept extra attention has been payed to select the most efficient technologies and maintaining a stable climate inside.

In this concept PV panels and GRID will provide the houses of electricity. In this concept the PV panels are optionally also installed on one or more sides of the house, instead of the roof only. An inverter will transform the electricity from DC to AC where necessary. A battery storage option is provided within the platform, however this would be a future possibility. The water-water heat pump provides warm water for the floor heating and also warm water for tap water. Warm water other than for heating up the house can be stored in water tanks with Phase Changing Materials (PCM's). The PCM keeps the water on a higher temperature for a longer period of time. Because water-water heat pumps get less efficient when the water temperature needs to rise significantly, a different product is taking care of this; the heat pump booster. The floor heating is a low temperature heating system, so a relatively low temperature will create the same heat a regular heating system would. A low temperature floor heating system needs more time to get to the desired temperature, but the inside temperature will also be quite consistent. Together with PCM above the floor heating, heat can be stored when the inside temperature reaches a certain temperature that is above the average desired temperature. An air conditioner will provide cool air when desired. Nature around the house should also promote a cooler climate inside in summer. The centralised heat exchanger with CO_2- and humidity sensor will provide ventilation without having to lose too much heat. Optionally the water-water heat pump could be replaced by an air-water heat pump. Despite the less efficient system, it is the most efficient system to apply after the water-water heat pump and reasonably cheaper. Because one side of the house will be full of glass, the orientation of the house is also of importance. This could save 2-3°C that is needed to heat, according to Duurzaam (t)huis Twente. The PCM can also store this heat if the temperature would increase too much, and release that heat again when the outside temperature is decreasing.

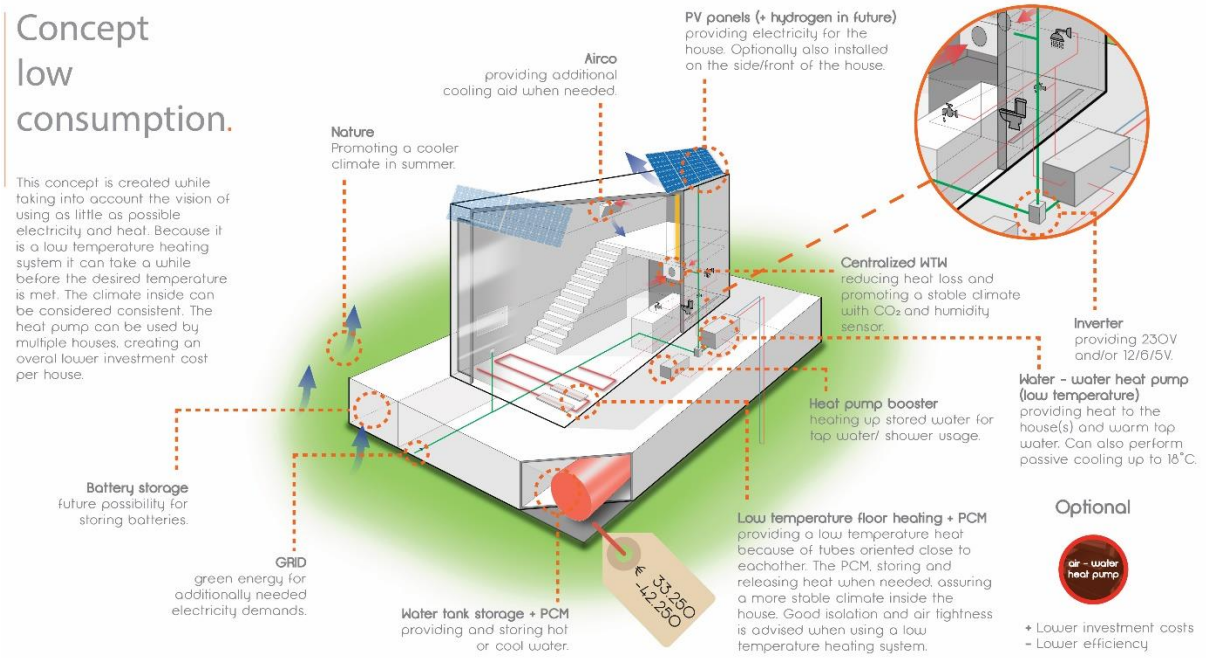


Figure 19: Concept drawing low consumption.

3.5.3 Concept idea 3: Collective system

The concept with collective use as principle is focussed on having collective resources to use.

This concept has a lot of similarities to the concept of low consumption, when looking at the selected products. They both have a water-water heat pump, a centralized heat recovery ventilation system, air conditioning, water buffers, etc. However, the approach is way different. It does not have the PCM's, which saves money for this concept. Instead of only having PV panels, thermal panels are added as well. These panels can provide and store hot water to use on a later time of the day. Because a lot of hot water will be generated, it could also be an option to have wall heating installed. There is a separate tank buffer for storing the heated water of the thermal panels. Maybe that water can also provide for different goals that can facilitate in the social part.

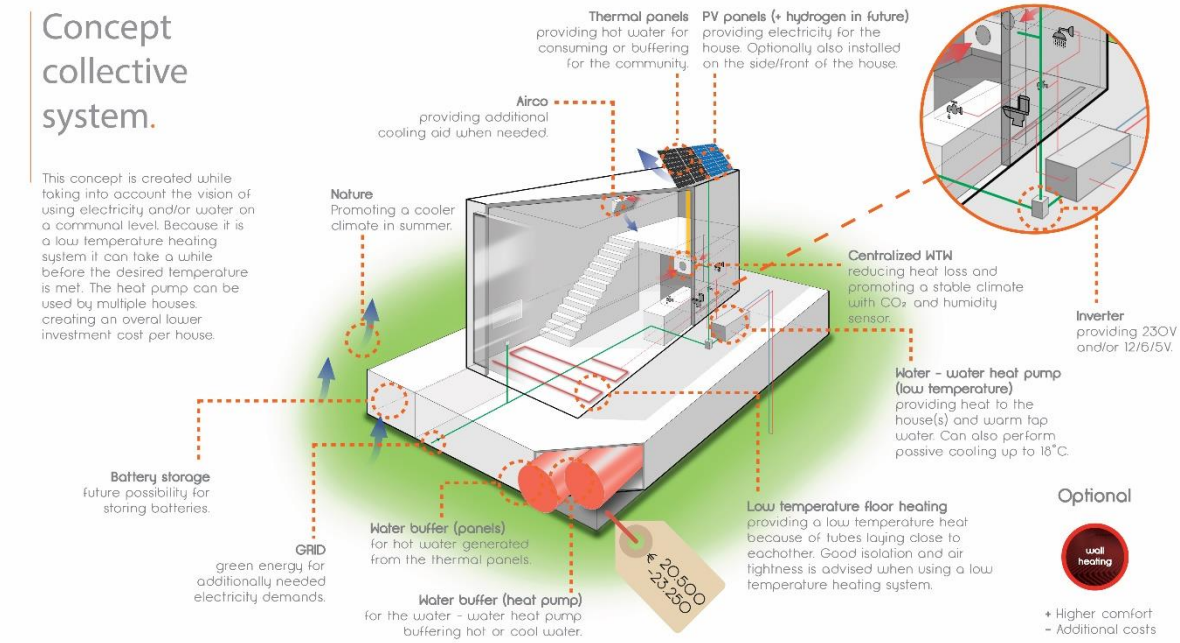


Figure 20: Concept drawing collective system.

3.6 Two concepts

The three concept ideas will be discussed with Tom, because they will be displayed in the presentation for investors as well. In the discussion with Tom, things are discussed as: how things would work together, if it is complete, what the storage space should offer, and the optional products to display. A quick brainstorm together could provide new insights, as iteration on the presented concepts. Lastly, a concept choice has to be made. The idea is to present the new iterations after the discussion and brainstorm, to let the design agency choose which concept should be pursued as base for the rest of the project.

In the previously presented concept drawings, the products might not always have had the right scale, so in order to make the concepts more reliable, a selection of products will be made to integrate in the two concepts. These will function for getting insight into basic dimensions, how it would fit the structure of the platform and how everything is structured. This will give an estimation if everything would fit within the platform structure.

In the discussion/brainstorm it became clear that there was a preference for the All Electric and Low Consumption concepts to elaborate on. Because the Low Consumption and Collective system concept show similarities and the Collective System could easily be integrated into the Low Consumption concept, it has been put aside. So the choice has been made by D'Andrea & Evers to pursue the concepts All Electric and Low Consumption.

Another topic was about the function of buffering of water. Because buffering of water had been considered more interesting to pursue than buffering of electricity. The original products that would be used for buffering water would be replaced with a design of a box that D'Andrea & Evers would like to put on the market themselves. This also counts for a version where a heat recovery system is installed. This buffer should be a rotation-moulded part and will look somewhat as depicted in figure 21.

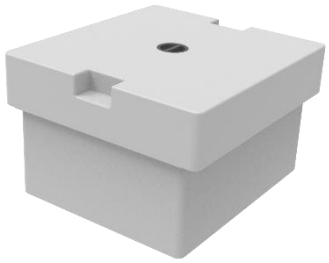


Figure 21: Water buffer design.

The new created overview of the two concepts looks as follows, where a way of buffering water is added as a separate topic, together with some changes of products:

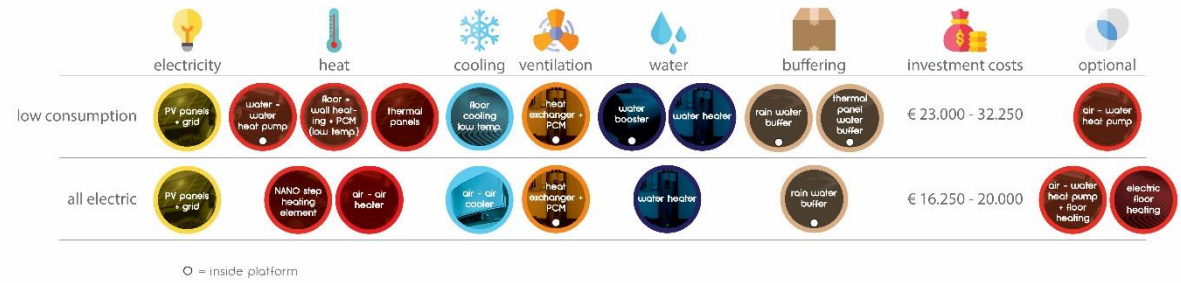


Figure 22: Overview two concepts with chosen technologies.

The next step would be to find products that correspond with the overview shown above. The products that have been selected and processed in the concepts can be found in Appendix J. The chart shows what product it is, what price it costs and the source of where the information has been advised. The prices are estimated, while using the known measurements of the concept house of 2Elephants. This can provide a rough price estimation. The products are visualized together with the platform structure and can be found in figure 24 and 25. The products are located right under the house. In figure 23 a top view can be found where the relation of the platform to the house is shown. This, to create clarity about where the products are placed.

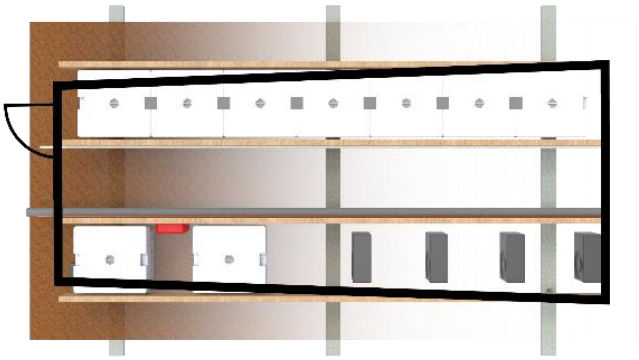


Figure 23: Platform structure with products and house silhouette relation.

The parts are located in such a way that maintenance can be performed on them, if necessary. For instance, the inverter (red) is hung onto the beam, facing towards the mid path. The spacers, together with the height of the beam cover a height of 70cm. If necessary, more height could be created if the final selected products would become bigger than initially calculated. In the all electric concept, the water – water heat pump is a component that cannot fit the platform or lay horizontally, due to the heat buffer that is installed within. Therefore, the choice is made to place it somewhere from the rest, so the platform doesn't need to increase in height. However, if this concept would be chosen as a starting point for the platform design, it has to be taken into account.

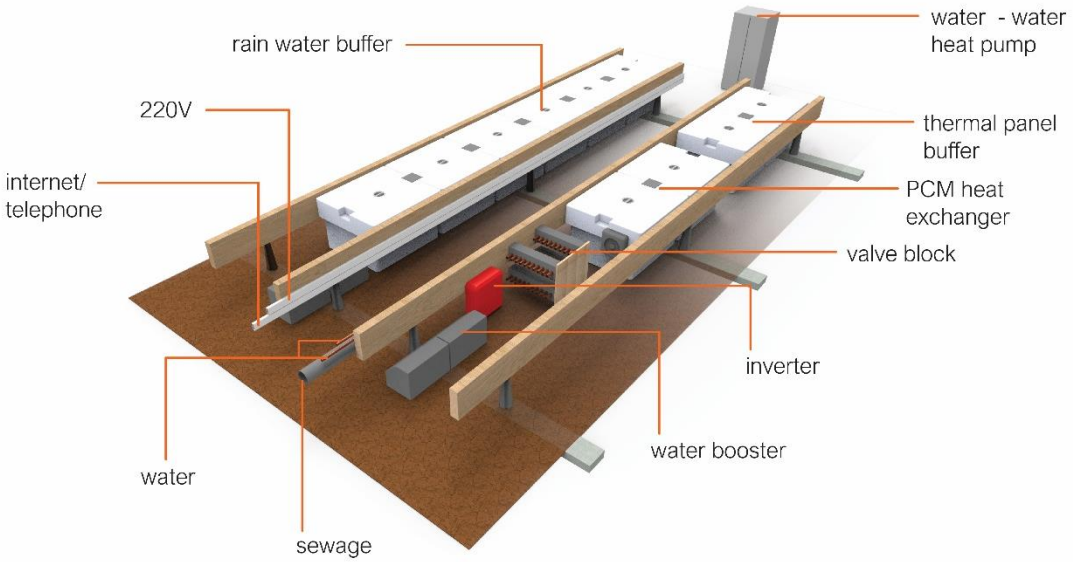


Figure 24: Concept low consumption with products and platform structure.

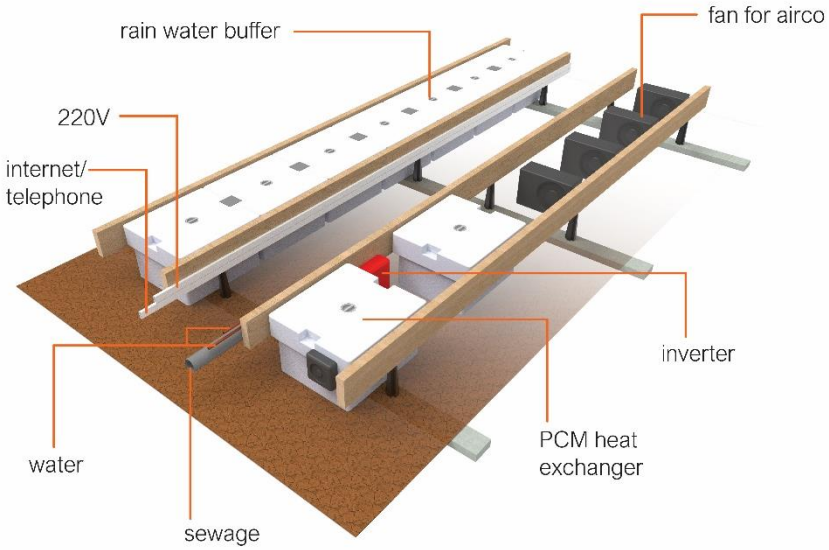


Figure 25: Concept all electric with products and platform structure.

Now that the dimensions of products and basic design of the platform with products are clear, the next step is to combine it with the drawings of the concepts, combining the platform concept together with the house. This, to create a complete overview, where the wires and tubes are depicted and to let D'Andrea & Evers make a choice between concepts. The images created will also be used within the presentation for the investors.

This time, the choice had been made to show the real products within the drawing, to make it more realistic and tangible for the investors. The tubing and wiring is also shown within the drawing, to show that the wires can go through the funnel. The drawings are depicted in figure 26 and 27. It is a concept drawing, so for a check closer to reality, it should be drawn in 3D and combined. However, because this is beyond the scope, it is left out. For now the general assumption is made that it will fit.

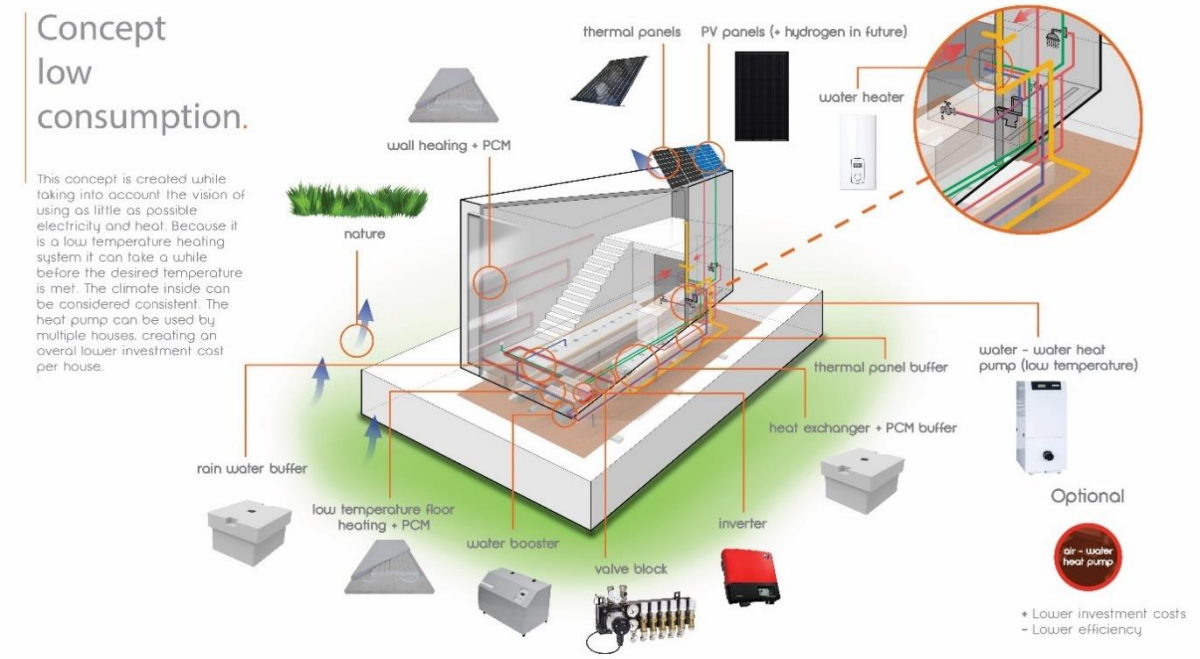


Figure 26: Concept Low Consumption.

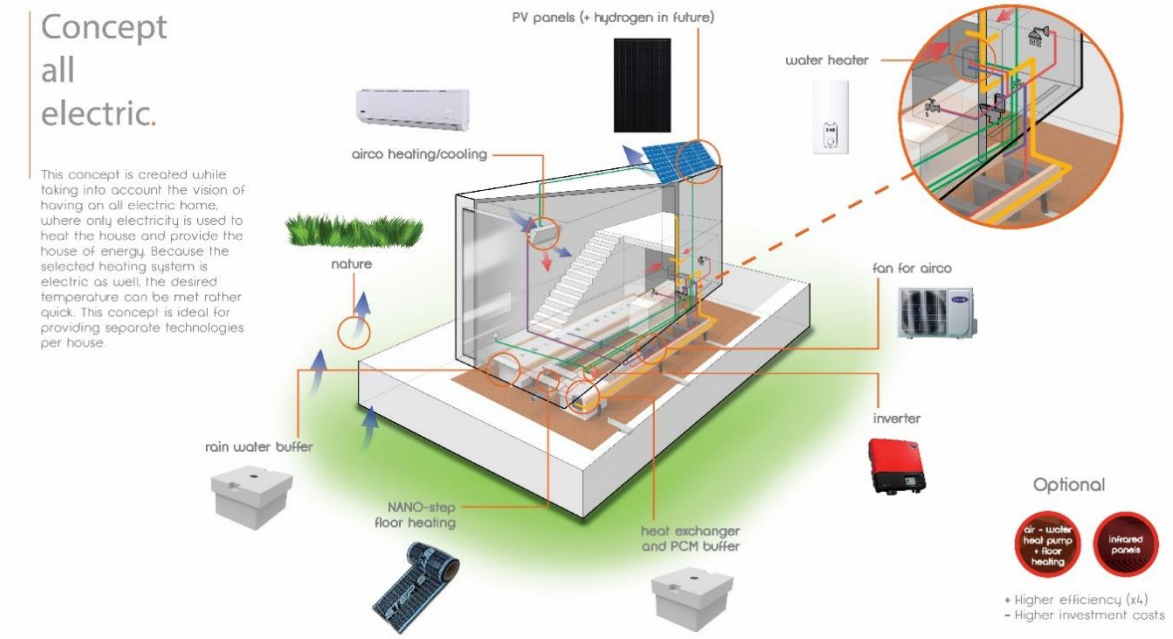


Figure 27: Concept All Electric.

The concepts have been discussed with the Design Agency and the concept that has been chosen to pursue is the All Electric concept. Why? As a first argument the average investment price is considerably lower. This has to do with the amount of products that are within the concept. Thereby, will fewer products lead to less labour hours needed to install products, which leads to a faster building time. Because there is no water needed to heat or cool the floor, this means that this can save maintenance costs needed in the future and makes the overall concept more reliable. The water pump that is present in the low consumption concept could not be placed within the area meant for sustainable products. This would also mean that a solution would need to be found to merge it together with the platform, while maintaining accessibility for maintenance. With the choice of the All Electric concept there is complete design freedom for the platform. In the end the question remains to what extent the low consumption concept would really consume less than the All Electric concept, whereas the latter contains way less products.

4. Social aspect

The challenge within the social part of the project is how to approach the design for the platform, that should promote social interaction amongst residents. How can this interaction start to exist in a most natural way, or for the least, let the resident feel like it exists in a natural way?

4.1 Introduction

In this project a big question remains: Why there is such an urge to create housing concepts that promote social interaction or social support? Tom Evers claims that in countries other than The Netherlands it is a given demand of people nowadays, a need that is not fulfilled yet.
Additional information had been advised, to create a better understanding about this. An interesting finding is that the positive influence of social interaction and support on human beings can work on a physical and mental level. This has already been established by hundreds of studies (Umberson & Karas Montez, 2010). It can affect our immune system positively, lower the occurrence of depression, stress and anxiety (Hebiofeedback.co.uk, 2012). Another source stated that poor social support has been linked to depression and loneliness (Cherry, 2018).

With focus on the concept design, the platform should induce more than only masking the technologies and saving space inside the house. To make it more interesting, the platform could function as a mediator to promote social interaction between residents. It should contain features for useful interactions (e.g. parking a bike, storing products, post, etc.) that could also lead to social interactions. The goal is to create a community atmosphere where a natural form of socialization exists, where people care for each other, communicate, adapt and have a 'we do it together' attitude. For the design of the surroundings of the houses this means that certain features have to be introduced that can enhance or promote the desired goal.

In this part of the design the biggest challenge is to create something where people will not feel forced or have to be forced for social interaction, while still trying to stimulate social interaction in the design. The desired outcome of the assignment would be an environment, where people live in harmony, look after each other, have social interactions, share things and maybe organize something amongst the residents who live there themselves.

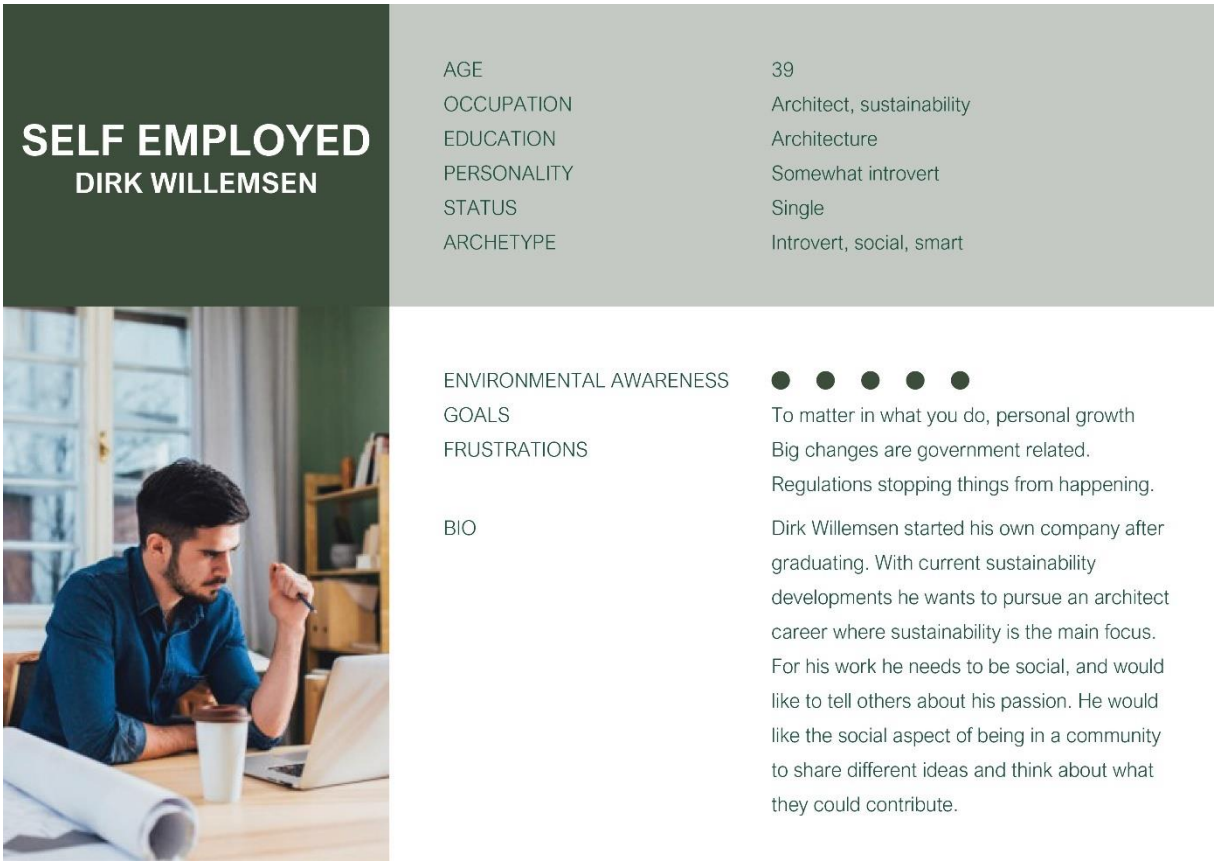
4.1.1 Target group

In order to identify the future residents, a target group will be defined. The main target group to design for are one to two-person households. This, because the houses themselves offer space for one- to two persons. Because the design of the platform is something that will be around/close to the houses, the group can be divided further in people who stay at home and people who are often away from home. The design of the platform would be most interesting for the people who are often close to/at home, because there is a higher chance that they will make use of the area and socially interact with another resident from the community, rather than with someone who is always gone. Because work is a big factor in people's life determining if they are at home or not, another split has been made. The division between stayers and non-stayers can be divided into five groups: Student, Employed, Unemployed, Self-employed and Retired. For instance, a self-employed person can work at home, while a 'normal' employed person is out for most of the time during the day. This is also the reason why a division between workers and non-workers would not suffice. In the design the focus should be on the home-stayers, whereas the non-homestayers should not be excluded, but also not be the primary target group.

One – two person households	
Stayers (focus)	**Non-stayers**
Self-employed	Employed
Retired	Students
Unemployed	

Table 1: Division of target group to design for.

In order to get acquainted with the groups, personas will be made in order to gain knowledge about every group. The persona could become useful or important at a later stage of the design process, more than identifying who is going to live in the new houses. The persona are defined as: Student, Employed, Unemployed, Self-employed and Retired. In order to gain information about the personas, a survey has been conducted beforehand. The data could then be used to fill in the persona. The survey gave insight into their environmental awareness, their goals, frustrations, needs and social abilities. The survey had 48 respondents in total. The results of the survey can be found in Appendix K. All personas can be found in Appendix L. An overview is shown in figure 28.



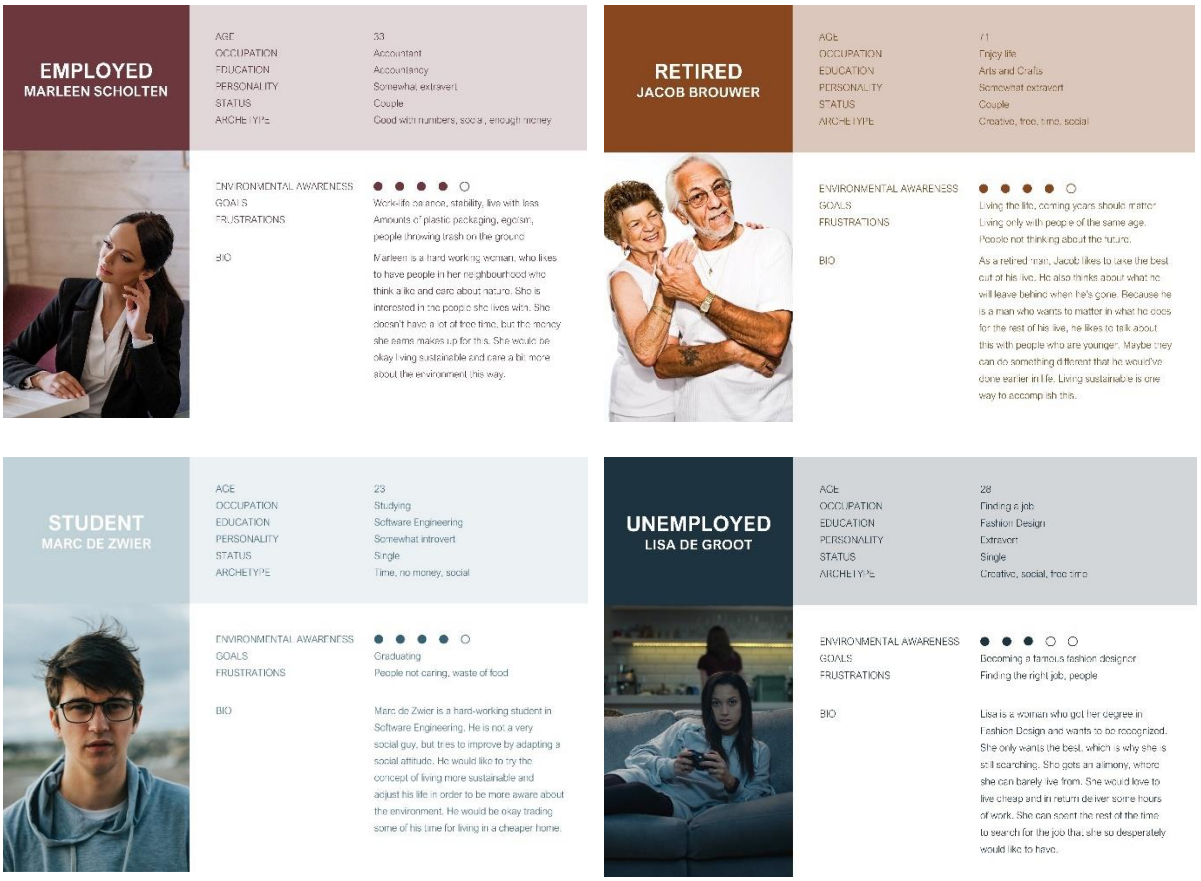


Figure 28: Persona examples: self-employed (top), employed (left middle), retired (right middle), student (right bottom) and unemployed (right bottom).

The survey didn't provide much new insights other than providing information for making the personas. However, it did lead to the realisation that every persona would have their own reason to live within the community that is tried to be design for. This could be derived from people describing their future goals and tapping into common knowledge. The self-employed people could (partly) decide to live there for sharing projects or conversations, possibly leading to new projects. The employed could do it in order to get more social contacts other than the friends and colleges that he/she already knows. Furthermore it was found that employed people sometimes would like to start a new study. This makes it interesting to start talking with the students. The retired people could live there in order to have some sort of social cohesion and hopefully experience the opposite of loneliness. The unemployed people who are in search of a job could lobby within the community that could lead to a new job.

4.1.2 Location

In order to make the design for the platform with the houses and surroundings more tangible, a location should be selected. Every different location would probably induce a different design approach. Maurice Beijk knows someone within a housing corporation that could provide a place that is in need of a new destination. The corporation is called WBO Wonen and is located in Oldenzaal. Joris Sprangers provided a place where the concept design can be placed hypothetically. The assigned location contains a plot that has no destination yet. The corporation is curious what this concept could bring to the neighbourhood. In paragraph 4.3.1.1 more information is presented about the neighbourhood through qualitative research.

4.2 Research

In this chapter several topics will be researched. The first one being the types of social interactions that exist and how they can relate to the design of the platform. The second being product influence on behaviour. What kind of influences are desired for designing the platform and with what facilities they can be coupled. The third topic is about social interaction within a cohousing setting. What can promote social behaviour in these settings. The fourth being a literature review to gain insight into what factors support in forming a community and how nature and sharing can contribute to a community atmosphere within the shared space and service/product, in order to promote community forming in and/or around the buildings.

The gathered insights from this research should provide certain propositions for the design of the outside and surroundings of the platform. Therefore a question is formulated: *What factors can encourage people to form a community, and how can nature and the concept of sharing contribute to a successful communal space?*

4.2.1 Platform – social interaction

There are a lot of factors that could be taken into account when designing the platform, such as: safety, water management, how to cope with the space when people need to settle, etc. The focus of the design for the platform space within this assignment is on promoting social interaction. Research is performed to gain a better understanding of what kind of social interactions can be distinguished and what they mean. This can help name certain social interactions to various facilities the platform should provide.

Social interaction can be separated into two sectors. Passive and active interaction. Passive interaction covers the unintentional ways of interaction. Unintentional in the way that someone didn't intend to come across a person, but meet and have social interaction with each other. As an example this type of interaction can present itself in a hallway or a bicycle parking spot.

The active interaction covers the intentional ways of interaction. This can on its turn again be split into formal and informal ways of interaction. With formal interaction one can think of meetings that are necessary to have, where an appointment needs to be made for. With informal interaction, one can think of it as having a coffee with a friend or neighbour, or playing cards.

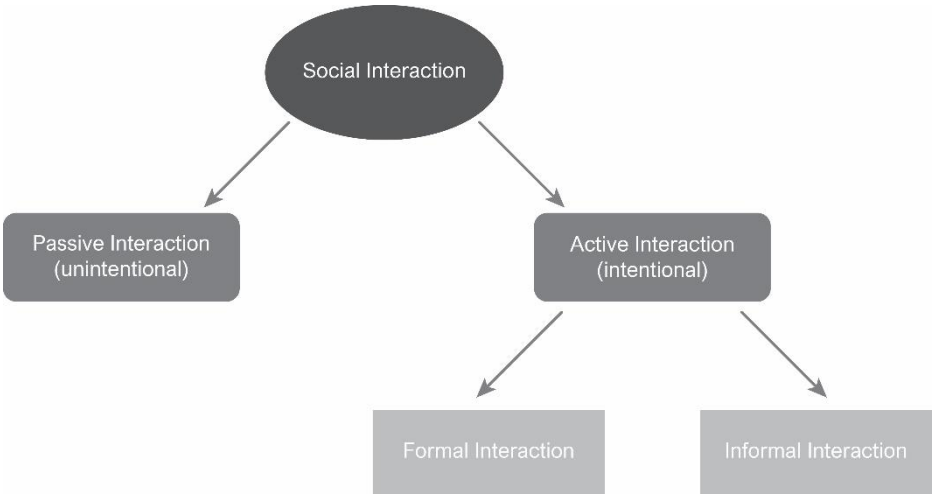


Figure 29: Types of social interaction (Bouma, Poelman, & Voorbij, 2010).

4.2.2 Social areas

For the design of the platform, it is important to take various kind of social areas into account. These areas are often found within cohousing and are respectfully: private area, semi-private area, communal area and public area.

The division between private, semi-private, communal and public area are partly derived from Bouma, Poelman, & Voorbij (2010). Private is somewhere, where nobody else can enter without permission of the person sitting in the area. The area is not for everybody accessible and one can think of a lock that is needed in order to access the area. In the drawing of figure 30 blue rooms represent the private areas. The semi-private area is the area that is accessible or usable for some of the people who share the same semi-private area. It can be seen as an area between private and communal. It is a place of which only a selected group within the cohousing situation can enter or is destined for. The area is often shared with a few people. The yellow rooms represent the semi-private areas. A communal area, is the area that is open to everyone within the cohousing. This area is represented in the colour grey. Lastly, the public area is open to everyone and can be used by everyone, represented in the green colour.

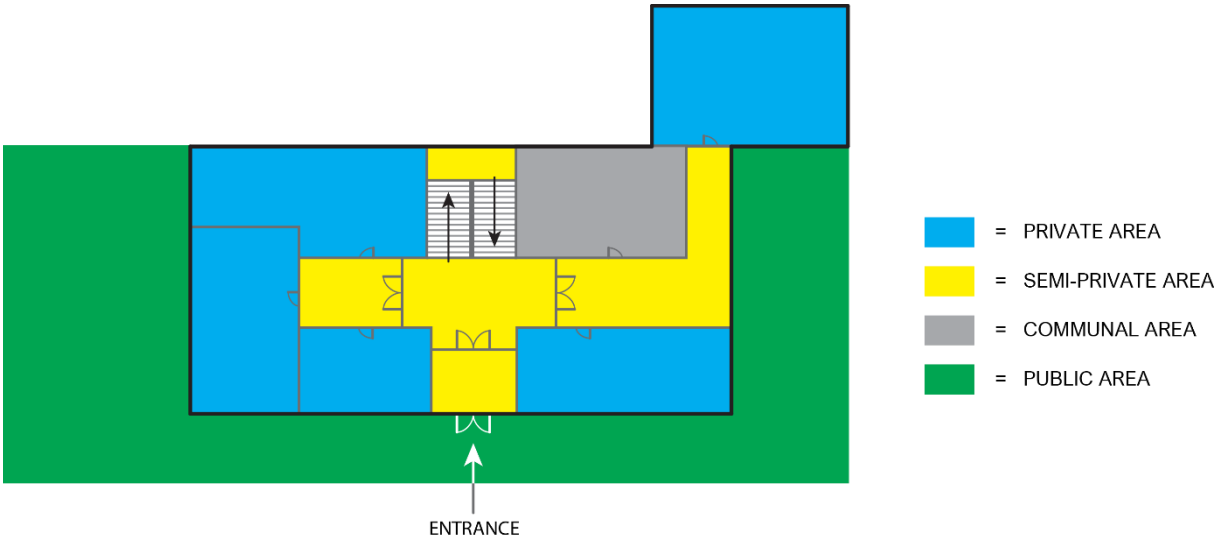


Figure 30: Division of different areas.

It is hypothesized that passive interaction can lead to active interaction. For instance, when a residents speaks often casually about the weather when placing the bicycle or getting the mail and a click between two persons emerges. It could lead to someone saying: “Hey, shall we drink a cup of coffee this week?”. Which would mean a shift from passive to active interaction. When tapping into personal experiences, this shift is something that has happened in life more than once.

Before starting the design of the platform, an overview is created about what type of interactions from previous research could emerge at what facilities/areas on the platform. It is not meant that all these points should also be implemented inside the platform but it provides a clear overview about what type of interaction can be linked to what facility or area of the platform. The overview can be viewed in Table 2.

Passive Interaction	Formal Interaction	Informal Interaction
Car parking	Meetings	Inside house
Bicycle parking		Private area
Mail point		Semi-private area
Communal area		Communal area
Semi-private area		
Waste point		

Table 2: Facilities and areas, divided under passive and active types of interaction.

4.2.3 Product influence on behaviour

In the design the social interaction should be promoted. In order to facilitate this, one has to think about how to trigger this interaction. When it comes to influencing people's behaviour in a certain way, the theory of Tromp, Hekkert, & Verbeek (2011) can assist. They divide the way of how a person's behaviour can be influenced in four categories, being: decisive, persuasive, coercive or seductive (figure 31).

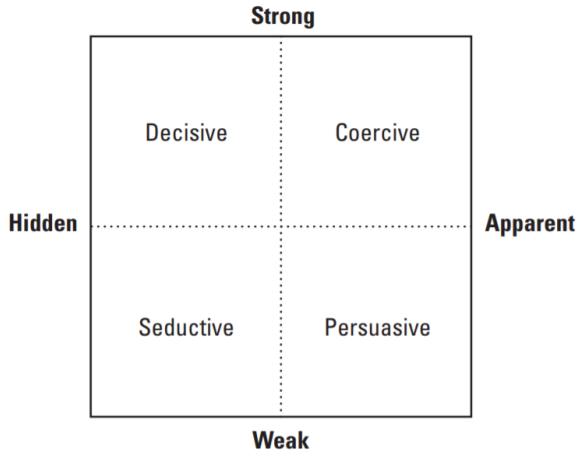


Figure 31: Product influence on behaviour (Tromp, Hekkert, & Verbeek, 2011).

The graph shows the degree of salience on the x-axis and degree of force on the y-axis.
The 2Elephants concept is the opposite of creating a community where someone would like to show off the sustainable way of living and show all the techniques that make this possible (apparent), other than trying to conceal it and make a nice place out of it (hidden). Therefore the choice is made to promote social interaction in a most subtle way as well, because it suits the overall concept. In a decisive approach, people could feel like they make choices themselves, whereas they might actually not do this fully. How the types of influences are perceived by people who interact with their environment can differ from the viewpoint of the designer. For instance a product can be designed in a more decisive way, whereas it is perceived as seductive by the user.

By having some facilities on central locations, where residents would have to go, the chance becomes higher that a form of passive interaction will start to exist. Thinking about how people could move about the platform and the possibility to steer the direction in which they would walk could help bumping into other people more often. Seducing people to a place that they would like, separate from their home might be hard, but as a designer the most you can do is try to make it as appealing as possible. It is nevertheless a weak force with a hidden apparel. The Decisive way has a more strong force, but remains hidden. A designer can influence the design to make people behave in a way that is desired. When the bicycle parking spots are located at a certain point, the chance is

high that they will use these spots to park their bikes and not elsewhere. The way people move and what people do around a certain space can be somewhat defined in that way.

4.2.4 Social interaction

The environment where residents will live is on itself already promoting social interaction (Torres-Antonini, 2001; Williams, 2005; Brenton, 1998). For instance, a common area can facilitate social interaction. If that area is a room which is situated centrally and easy accessible, more residents will use the facility (Williams 2005). Bouma, Poelman & Voorbij (2010) present three variables that are considered important to think about when designing for a community. The first variable being, to create the opportunity for contact between residents. Creating these opportunities can lead to a passive form of social interaction which could grow to an active form of interaction. The second variable being the proximity of the apartments. No concrete amount is mentioned, but it is assumed that a certain balance should be accounted for in the design. As third variable an appropriate space to interact is considered important (Fleming, Baum et al. 1985). No concrete measurement is mentioned, but apparently a certain physical distance has a positive influence on the wellbeing of the habitants. On the contrary is the chance of meeting one another greater, when people are brought closer to each other. This on its turn can help forming a friendship between people or creating social interaction (Abu-Gazzeh 1999). The word 'appropriate' is subjective, whereas everybody can have their own take on what is considered appropriate. In the main thought line it is good to account for.

Another perspective on discovering how to promote social interaction is about how to prevent conflicts from happening. Putnam & Pool (1987), Brenton (1998), Meltzer (2005) and Williams (2005) state that conflicts are often related to the perception or interference with people's personal goals, aims and values. A community works better, or has been found to work better if there are people who share the same goals, aims and values. Like-minded people. Another important aspect for having social interaction within the community is to have residents that are socially able. If not, people might still just keep everything for themselves, locking themselves up in their own homes or distancing themselves from the rest. However, even when cohousing communities are designed with variables or principles stated earlier, this is not a guarantee for people starting to socialise in a community (Bouma & Voorbij 2009).

4.2.5 Literature review

A literature review has been performed, in order to find design implications that could improve the feeling of belongingness and promote social interaction. The research outcome could be used in the design for the platform concept design.

The found implications are quoted below. The full paper can be found in Appendix M. The list below presents all implications that one could take into account when designing for a social space. However, not all things have to- or should be implemented in the concept.

"Design propositions derived from literature:

- Communal space should provide the right services, goods or connection to existing economic and social networks (Buildings and spaces: why design matters, 2006)
- Balance between restorative qualities and social aspect (Stoltz & Schaffer, 2018)
- Nature reflecting important values of the residents (Gineikiene, Schlegelmilch, & Auruskeviciene, 2017)
- A place where you can meet and socialize (Buildings and spaces: why design matters, 2006)
- Let the residents feel like it's 'theirs' (Gineikiene, Schlegelmilch, & Auruskeviciene, 2017)
- Allotment and forest garden can provide a sense of place (Stoltz & Schaffer, 2018)

- Creating opportunities to have positive and pleasant contact, so they get to know each other (Mellor, Stokes, Firth, Hayashi, & Cummins, 2008)
- Interacting with nature (Shinew, Glover, & Parry, 2004) & (Keniger, Gaston, Irvine, & Fuller, 2013)
- Sharing a service (+product) (Bardhi & Eckhardt, 2012) & (Liem, 2015)
- Choose between B2C or C2C. Depending on how much people trust each other (Hartl, Hofmann, & Kirchler, 2015)
- Management or efficiency of the product service should be in the background (not the main factor or goal) (Light & Miskelly, 2014)
- Expressing important values of the resident, reflected by nature (Gineikiene, Schlegelmilch, & Auruskeviciene, 2017)
- Let the residents help design their own neighbourhood (Stoltz & Schaffer, 2018)
- Physical and mental interaction with a public place will create a sense of belonging (Peters, Stodolska, & Horolets, 2016)

Important elements for 'designing in inclusion' are (Worpole & Knox, 2007):

- Including all age groups and social groups in ideas for the public space
- Encourage a strong sense of local distinctiveness
- Looking at evolving a range of spaces with different security regimes, including 'light touch' regulation
- Successful public spaces should build on the large degree of self-regulation of public behaviour that already exists" (Ubbens, 2019).

Once a concept is defined, the design implications that are represented in the concept will be linked back to the literature research. This makes it possible to show in what way certain design implications are accounted for in the concept. Other parts of research that will prove their usefulness in the concept will be referred back to as well.

4.3 Ideation

There is a general impression that sufficient information has been gathered to start the ideation process. Before starting the design, information should be gathered about the location to design for. This will be conducted through qualitative research, as well as getting familiar with communities and how they work on a social level, and how they cope with things such as privacy, sharing and common areas.

An interview with a Tiny House resident will be performed, to get familiar with the social dynamics within a community and how they cope with things such as privacy, sharing and common areas. A visitation to a community in Enschede has the same intention. The community is called 'De Wonne' and offers a place for people who are having a hard time in their life, thinking about not having a house once a person is just divorced etc, or someone who lost their job and cannot pay the house anymore, becoming temporarily homeless. De Wonne can provide these people a place to get a new job or search for a new house and leave the place again to make place for new people.

After more information is gathered, first several house positionings will be explored within the given area to explore what set-up would be interesting to pursue for the rest of the design process. Secondly, the platform will be defined around the houses. What area should the platform cover, and discover what this would mean for completing the rest of the area.
Lastly, a collage will be made for inspiration on how to dress up the platform and how to cope with area's between and around the houses/platform.

4.3.1 Qualitative Research

4.3.1.1 Location

Before a design can be made for the community, a location has to be assigned where to design for. This location is a place in Oldenzaal, Netherlands that is in need of a new purpose. The location is given by WBO Wonen. The area will be used to play with different orientations of the houses and providing a design, where the characteristics of the location will be taken into account as well.

A meeting (05-03-2019) with Huub van Uum from the municipality of Oldenzaal has been organized, to gain more insights about the area. From this conversation several things were discovered that can be taken into account when designing the community outside part.

The area where the allotment is located, is called Glinde-Hooiland. The people who are living in the neighbourhood are of age, as are the houses. The houses are from around 1960 and have been updated once, but are beyond saving to make it future proof. This is why they will replace the houses and want to build new houses. The project is called 'Blokje om'. People can choose to live inside the newly build houses or move to a different location. The houses are built very quick (around eight weeks) so they can move in again as fast as possible. The location is close to the supermarket and city centre. There are quite some sport facilities in the neighbourhood, such as a sport complex, football field, swimming pool and a sport hall. There are some green areas but they are not that big. The municipality stated that they would like to have more people diversity in the neighbourhood, so the 2Elephants concept neatly fits the vision of the neighbourhood.

Figure 32: Location in Oldenzaal to place the concept.

Another discussed topic was about general developments and the difference between young and old attitudes towards an ownership vs. sharing economy and their experiences with somewhat similar projects. There is a noticeable shift towards not owning a good, but using the service or product to achieve a certain goal. One example is that the older generation would like to buy a car, whereas young people would like a way to go from A to B. The older generation wants to buy a house, whereas young people have the desire to sit comfortable and warm. It is a different way of thinking, more focussing on what you want to achieve. The municipality observes a shift from possession that is gradually becoming less important, where the experience becomes more important.

Huub van Uum claimed that it is important to keep in mind that if the decision would be made to make a new road through the assigned location, that it should be a continuous road. If it's an ending road it has a higher chance of becoming a ghetto-ish place, because a dead end creates more opportunity for people to hang in the area in a negative way. If it would be a continuous road, the chance is higher that someone will come past a spot, making it subject to higher social control.

4.3.1.2 Brainstorm

A brainstorm has been organized on 01-05-2019. Expert Joris Sprangers from WBO Wonen was present at the brainstorm as well. He could provide an expert view on environmental psychology and how to take into account the wellbeing of residents. The first topic was a general brainstorm about what factors could promote social interaction amongst residents. Another topic was about how to be private or how people perceive privacy. This on its turn has been used to think about how to create private areas for residents in a pre-determined setting. Another topic that has been discussed is sharing of products and services. The presentation of the brainstorm can be found in Appendix N1. Another discussed topic was about a right approach in organizing the concept of sharing and what it would mean to the residents? The physical outcomes of the brainstorm are photographed and can be found in Appendix N2. A few things became apparent:

Expert Joris Sprangers states that there are five rules which provides the basis for someone's surroundings.

The first one: being in control of your living environment. If someone would undergo music nuisance, the person should be able to close a window, or if there are a lot of people in front of your house you should be able to close the curtains. Having the possibility to change your living environment for the better and being in control about what you can do is important, otherwise someone could feel helpless, resulting in a decrease of the overall wellbeing.

The second one being: stimuli need to have meaning. If someone encounters negative stimuli, such as the smell of burned food or loud house music, this is not beneficial for the wellbeing of a person. If someone smells the fresh scent of rain with mud or hears a piece of music that reminds that person of a happy moment, these have a certain positive meaning.

The third one is about the need for an own territory. People want to have their own place that they can go to if they want. As an example someone doesn't feel like seeing anyone at a moment of time. Or just knowing that there is a place to go to where you won't be disturbed. This shows also the importance of designing for a private area.

The fourth one would be having contact with the natural environment. This is an extra confirmation of the previously mentioned aspects in paragraph 4.2.5 that nature could provide positively influence the wellbeing of a person.

The fifth and last is the need for change. Change of the environment or surroundings. This can help in keeping the communal area 'alive' and interesting to visit over and over. Of course a balance should be considered. It should attract people's interest, while its should not scare them away because it would be always different and they don't know what to expect. This is an important point to bring along the project for recommendations about the design. Some things can be or even have to be permanent, but the design should provide the possibility to change objects in the area.

In order to take into account the wellbeing of the resident, there is a correlation between the amount of stimuli and wellbeing of a person. The graph of this correlation can be found in figure 33. The stimuli can be triggered by sound, visual representations, scent and feel. If someone's wellbeing

would deviate from the top of the curve, it is likely that someone is going to actively work on their wellbeing until they are back to the top.

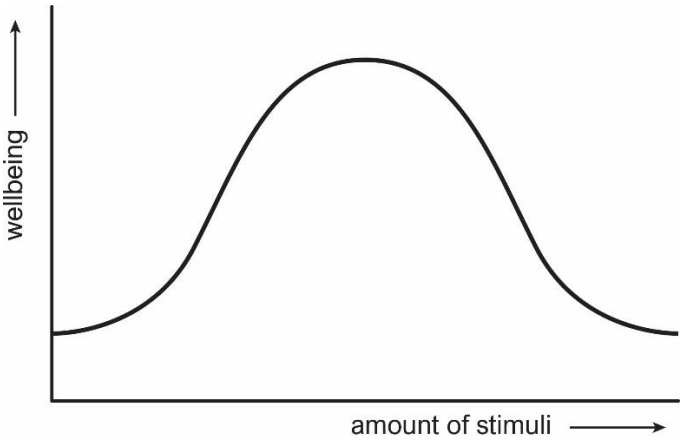


Figure 33: Correlation between wellbeing and amount of stimuli on a human being.

When someone is on the left side of the graph, that person will probably search for more stimuli. If someone is sitting inside with the curtains closed, that person would probably open the curtains or sit outside where more stimuli will lead to an optimum activation level. This also links back to the need for change or being in control.

If a person receives too much stimuli, there will be a point where someone will start to search for a location where the amount of stimuli will be diminished to feel well again. This insight makes it clear that a separate place should be provided that can function as a place of solitude.

When it comes to sharing, there are certain things that an external party should arrange and what residents should arrange internally. When people are unburdened of things, there is less tension amongst people. This will make easier to search for social interaction. A person is okay with sharing its drill five times, but after a certain time people will start hesitate to give or ask for the drill. A mobile app called Peerby is a third party that can provide people of a product that someone wants to loan. Peerby is the mediator between the person who loans the products and the one who gives the product to loan. Because the third part can be held responsible if the product will break, when loaned, it can make the threshold lower for someone to loan a product. Daan van Berg, attendant of the brainstorm claims that the responsibility has shifted. This makes it interesting to think about involving a third party for the community that could take care of things that people would need, such as a power tool or getting something fixed, etc.

For social interaction in general it would be good if new people are introduced, getting to know one another and building a general level of trust.

When thinking about privacy and social interaction, it is hypothesized that people first need a private space as a safe zone in order to step to the outside. At least, it might be easier for a person to socially interact when they know there is a private space where they can come to rest or deflect certain stimuli.

4.3.1.3 Telephone interview and visitation ‘De Wonne’

Because it is not fully clear how things like privacy, sharing products or having something mutual - like a store - are handled, the choice had been made to interview an inhabitant who lives in a Tiny

House community in Kleinhuizen. They have a strong sense of community and in the interview some prepared questions were asked, and some were improvised during the conversation. The prepared questions and given answers can be found in Appendix O1. The main thing learned is a confirmation of what Joris Sprangers had stated as well. That if someone within the community gets responsibilities that also matter to the other residents, it gives a certain power, which results in an imbalance of power. This can lead to frustrations amongst resident. The interviewed Tinyhouse resident stated that it was about the payment of the houses. The interviewed person would rather do it himself but this was how it had been arranged for now.

A second interview has been conducted in the form of a visit to 'De Wonne' in Enschede. The questions and answers of this research can be found in Appendix O2. De Wonne is a place in Enschede which exists from four people at the moment. They are living there permanently. De Wonne is a sanctuary for people whose life is going downhill at the moment, and can find their way back while living in De Wonne. They don't take people in who are still on drugs for or are experiencing mental issues. Only if they are starting or want to start a way upwards in life, they can get a place there. As mentioned earlier, it can be as simple as a couple that divorced and the man or woman needs a place, to save money in order to find a new house.

Figure 34: De Wonne.

De Wonne was an interesting place to visit because they had a thrift shop next to their building. The curiosity emerged on how they arranged things for the shop and whether it was a succeeding concept. They are open two days a week, and some people volunteered to help in the thrift shop. However, they are also often dependent on people doing voluntary work for De Wonne. When the guide told about the shop, it became clear that there were more issues on the matter to keep the shop running, than that it flourished and they really got something out of it. This confirms the fact that involving a third party for such arrangements can be beneficial to avoid unnecessary tension within a group.

In de Wonne people had a small room, which made the researcher wonder how they cope with privacy. The guide told that De Wonne has a lot of communal rooms, that are often empty. So people can retreat in a room when they feel the need to.

When the guide was done with the tour, she and the researcher were talking about what would be the thing that connects people. The resemblance between Tiny house residents and people who would live in the new design of the 2Elephants project. Of course like-minded people came to the surface, which was also found in the literature review. However, another word that is interesting to mention is vulnerability, which is seen as an interesting finding from the interview and visit to De Wonne.

It is hypothesized, that when people adopt a vulnerable attitude, they create a certain openness for social connectedness. With the tiny house they are vulnerable in the way the residents live with the amount of electricity they can use, or the amount of square meters they have inside their houses. For the to-be-designed concept it means about the same as for the tiny house resident. People will live in a small house, that will have them forced to go outside quicker than when someone would own a big house. This is why a private space somewhere around the house should be accounted for. If the residents adopt a vulnerable attitude, and when the design stimulates social interaction to a certain extent, the chance of the desired outcome of people talking with each other, communicating and looking after each other should grow.

Conclusion

The qualitative research gave insight into the hypothesis that people that adopt a vulnerable attitude, creates the potential of a higher chance of social connectedness. Vulnerable in the way how people are limited in their resources and/or living area. However, if the concept would limit the residents in their water or electricity usage, this also means it would influence the luxury feel of the concept.

4.3.2 Positioning houses

Because the concept houses can be placed in various ways inside the designated location, multiple setups will be made. In the end one setup will be chosen by assessment.

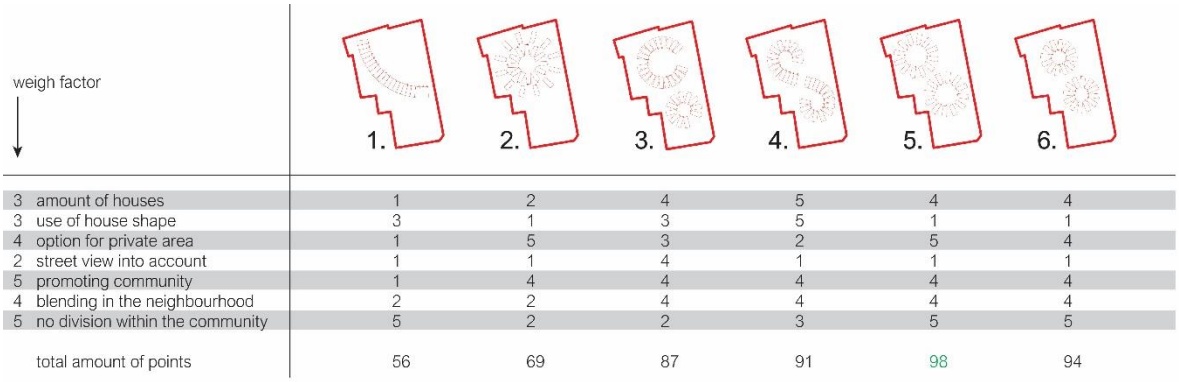
With the given measurements of the concept house, multiple options are explored in how to orientate the houses within the given area. Tom Evers provided a file with a house that should be used as a starting point. Therefore this house has been chosen to pursue through the rest of the ideation and conceptualization as well (figure 35).

Figure 35: House top view to pursue.

Sketches have been made of different house set-ups because it triggers a different way of thinking about what should be implemented. This is why they have been used for sketching and filling in the designated area. The sketches can be found in Appendix P.

Every time a different setup of the houses were made, it provided different insights resulting in a variant of ideas. It triggered different thought patterns, which otherwise might not have come to the surface. As an example the fifth design in figure 36 shows great potential for creating something in between the houses that could maybe be implemented. With concept 4 it is interesting the focus tends to go more in what should come within the designated area, rather than what should come in between the houses.

Because of the shape of the house, linear lined houses are not that interesting. Therefore a pre-selection is made to assess. All variations can be found in Appendix Q.



weigh factor		1.	2.	3.	4.	5.	6.
3	amount of houses	1	2	4	5	4	4
3	use of house shape	3	1	3	5	1	1
4	option for private area	1	5	3	2	5	4
2	street view into account	1	1	4	1	1	1
5	promoting community	1	4	4	4	4	4
4	blending in the neighbourhood	2	2	4	4	4	4
5	no division within the community	5	2	2	3	5	5
	total amount of points	56	69	87	91	98	94

Figure 36: Assessment of placement building possibilities.

The houses have been assessed based on the following aspects:

Amount of houses: How many houses will be placed within the house set-up design?
Use of house shape: How well is the peculiar shape of the house used in the placement of the buildings?
Option for private area: How much and how easy does the placement of the buildings provide options for a private area?
Street view into account: To what extent is the street view taken into account with the placement of the building?
Promoting community: How well does the placement of the buildings create a sense of community?
Blending in the neighbourhood: How well do the buildings blend into the neighbourhood, considered heights?
No division within the community: Do all people have equal spacing, equal ground around the house, could there be a natural ranking or division amongst residents because of it?

The weigh factor has been defined based on the importance of the aspect, validated by Tom Evers.

The assessment aspects got a weigh factor to show the importance of each aspect. The weigh factor is multiplied by the score of the aspects, which results from left to right in 56, 69, 87, 91, 98, 94. This means that house set-ups 3, 4, 5 or 6 would be almost equally interesting to pursue. However, because the area for a private area, people having the same space around the house is found important, design 5 will be pursued in the following design process. Thereby is the concept of having two separate, but same circles as set-up found most interesting, because it makes it fair to the residents that everybody owns the same kind of space. The winning design can hopefully provide interesting options in the future design process.

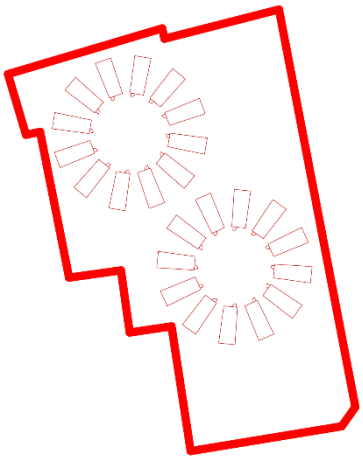


Figure 37: Winning design, number 5.

4.3.3 Platform variations

Now that the orientation of the houses is clear, the next step is to define the platform. How big should it be and what does that mean? How will it influence the location of the house placements? How big should the platform become? An answer will be found to these questions in this paragraph.

Five different design iterations have been made, while playing with the size of the platform and whether the two circular shaped house setups should be connected in between by the platform or not. The iterations are depicted below (figure 38).

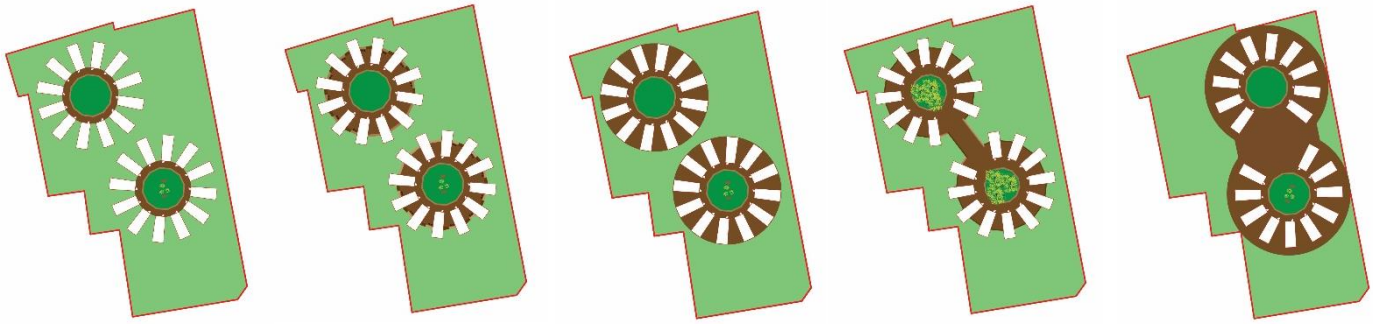


Figure 38: Iterations of platform.

While playing with the platform, the pattern of the houses didn't change. However, with the last (most right) iteration a little shift took place in the orientation, which seemed like a more efficient way of dividing the space. While iterating on the area of the platform around the houses it became clear that an area bigger than the houses itself could help making central places for certain facilities as parking the bike, whereas an area smaller or within the houses could result in more individual facilities or use. A connection between the two circles could facilitate in making it one community instead of having two 'islands'. Another shift that has been made is to open up the two circles in order to prevent the two circles of becoming two separate communities.

Marcus & Francis (1998) state that activities and facilities should be visible from the sidewalk in public spaces. This statement created the awareness that for certain areas the opposite might be desirable: to have a piece of ground that is *not* visible for the public, so that people will not access it, because it is not meant for them.

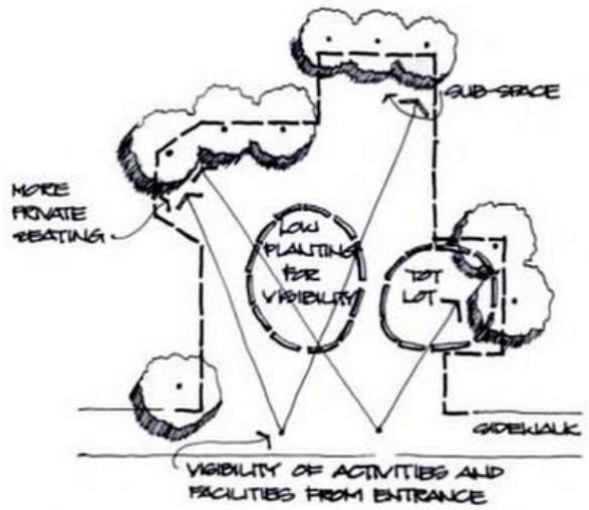


Figure 39: Visibility of activities and facilities from entrance (Marcus & Francis, 1998).

The last iteration on the most right of figure 38 shows a piece of ground on the left, that could function as a place that should only be used by people who live on the platform. The platform hinders partly the visibility of that area for the public from the street, making it less likely for them to access that part. The two circular shaped platforms are connected, because it is hypothesized that a physical connection would probably also induce a more social connection between the people living on each circle, rather than having them separated. The extra space around the house could function as a private/semi-private area. While the sustainable technologies are located directly underneath the houses, it should still be accessible for maintenance. Furthermore could the extra space around the platform facilitate certain functions around the platform. From the different iterations, this design iterations would also provide the greatest freedom in how to design for the private, semi-private, communal and public spaces.

Considered all the benefits this set-up could offer in contrast to the other iterations, the choice has been made to pursue the iteration that is displayed below (figure 40).

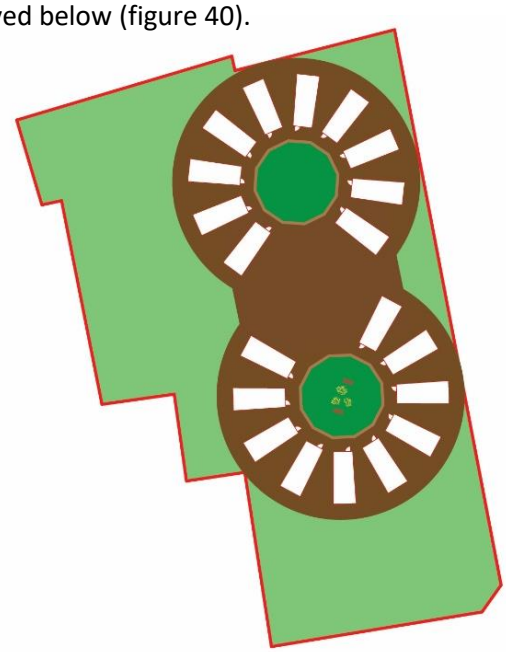


Figure 40: Chosen iteration as main starting point.

4.3.4 Collage

To get inspired for designing activities and/or facilities for the platform, a collage has been made. It triggered to think about what could be possible to do with the platform.

Figure 41: Collage ideas for platform.

Some ideas gave inspiration that could be used in the concept later on, like a hatch to get to the technologies, lying underneath. Another one is to make slots on the side of the platform in order to have the option to park bicycles.

5 Conceptualization

First, a concept will be generated in a 2D view. However, this view gets too limited when, for instance, two things are on the same place but at a different height. So when a general idea is created in 2D, the next step would be to start putting everything into 3D and design while making the 3D model.

5.1 2D to 3D concept

Things that have been accounted for within the 2D sketch are: a parking lot for cars and bicycles, a building for the 3rd party, a green area for the public space, a green area for the residents, a garden for the residents, a communal area within the platform, a place for post mail, a building for sharing products, a building for garden accessories, an object that will separate people's private area and a place to sit and enjoy the view. These things have been defined based on what a person needs outside the house and what relates to the concept and is found as inspiration. The outcome is depicted in figure 42.

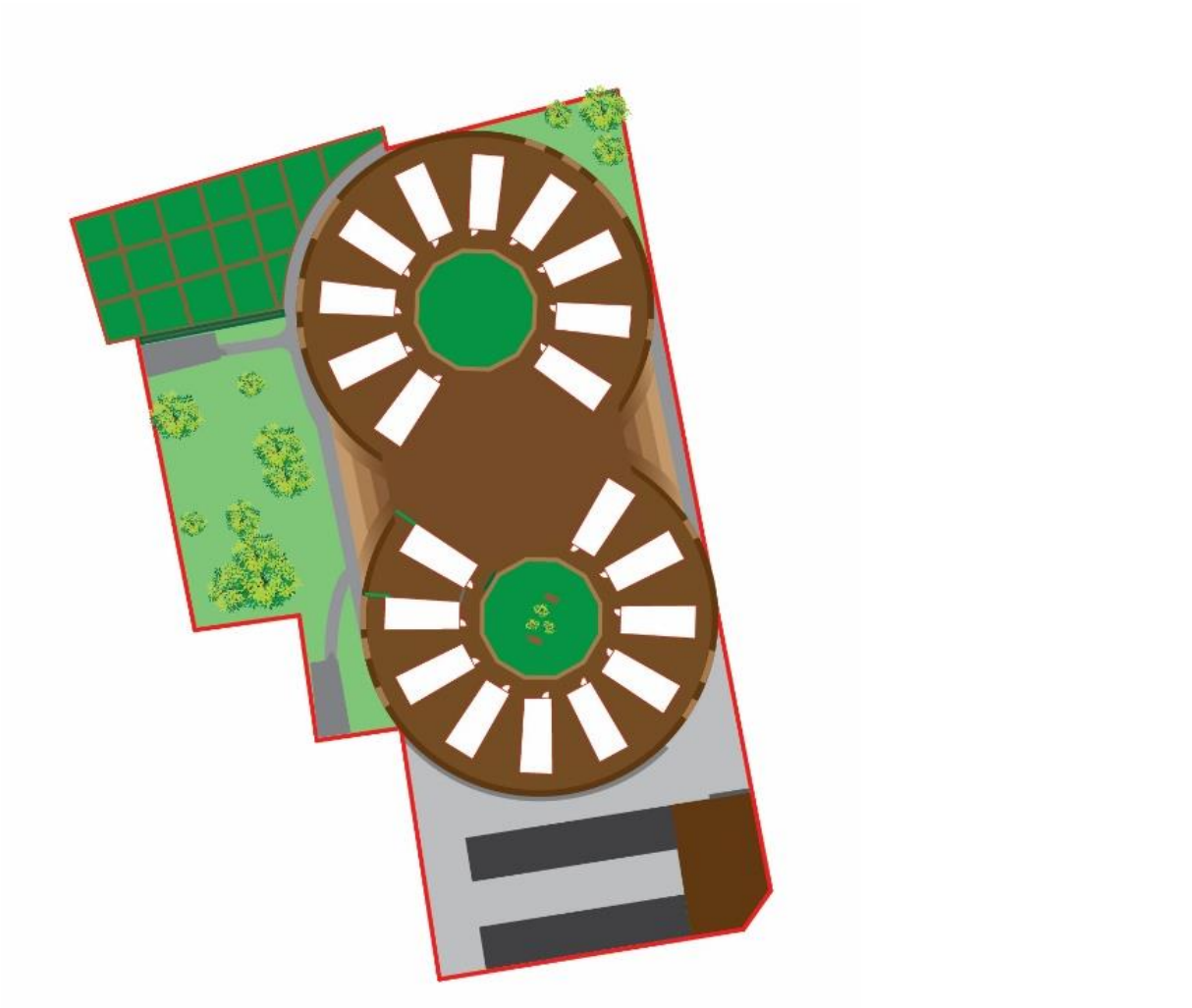


Figure 42: 2D top view of the concept.

Pictures have been attached to aspects of the drawing to make the concept more understandable. It makes the concept more tangible and can provide a certain visual reference (figure 43).

Figure 43: 2D top view of the concept with images for reference.

At this stage the switch from 2D to 3D has been made, to make it even more realistic and tangible. In 2D sometimes things are possible that aren't in 3D and the other way round. One example is that 2D limits the depth from a top view, which is crucial within this project.

5.2 Detailing

In this chapter the detailing of the concept will be described. It will become more clear of what will be implemented in the platform of the final concept and why and how it links back to earlier conducted research.

For a lot of features measurements will have to be advised. The ramps next to the stairs need a certain width, so e.g. people in wheelchairs can manoeuvre on it. Another one is the bicycle stand. If a compact system is desired, what should be the distance and height difference for each bike? For the mailbox, what are minimum and maximum heights for the person who delivers the mail. What is a common height for stairs? What are general sitting heights? How big should a parking lot be and what should be the space around it to be able to manoeuvre the right way? These might not directly have a social relation, but it makes the appearance of the concept a whole lot more realistic. They will be researched and accounted for in the concept.

When a first concept had been defined, it was evaluated with Tom Evers. The outcome was that all the facilities were accounted for. However, the way they were executed could improve visually when looking at the overall experience the user would have. Therefore it had been advised by him to make an inspirational collage that would communicate the materials, shapes or ideas for the next iteration of the concept. The collage can be found in figure 44.

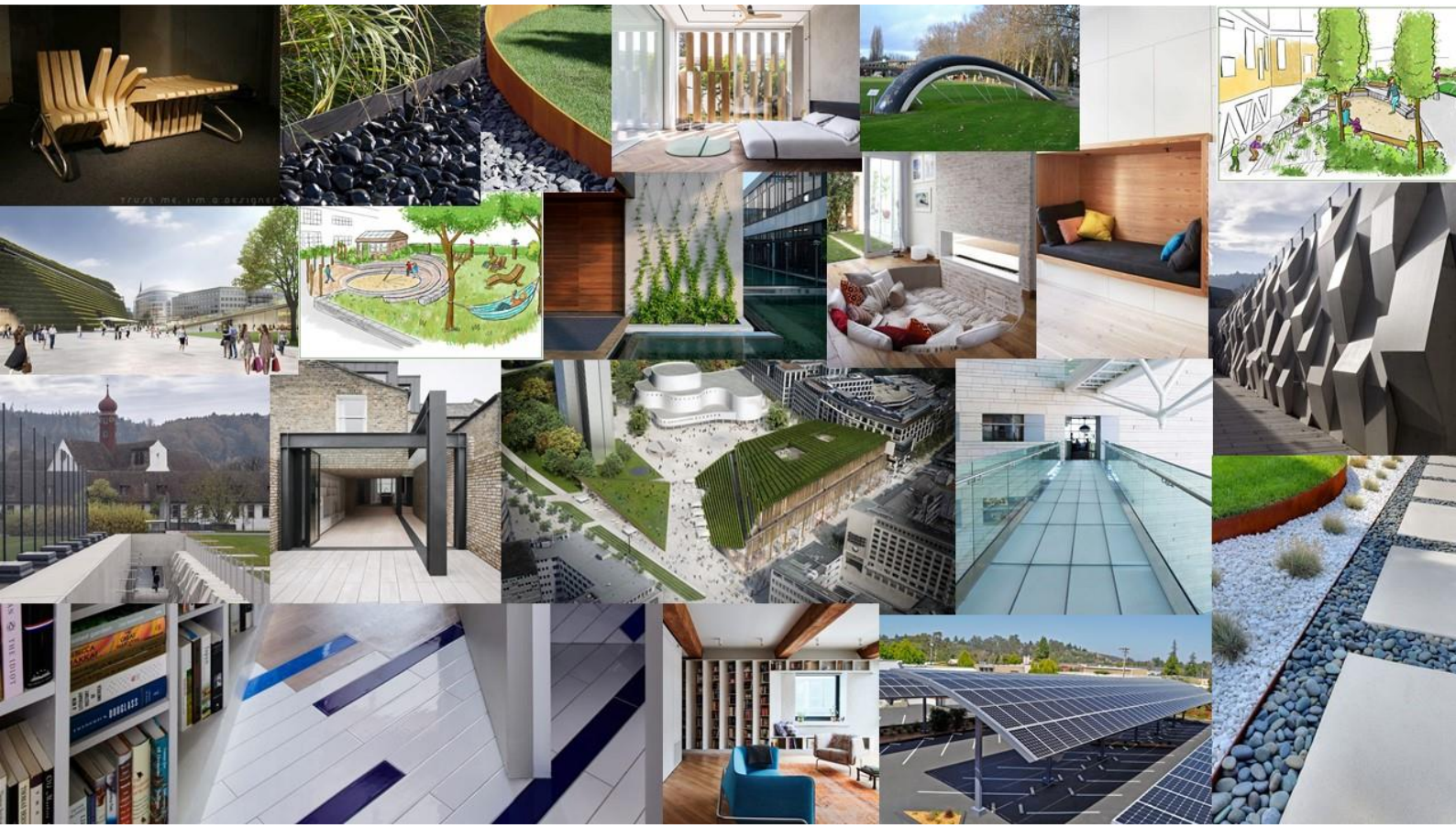


Figure 44: Inspirational collage.

A 3D model has been made in a 3D CAD program (SolidWorks) and realistic images (renders) have been created with help of Lumion, a 3D architect program. In order to explain the concept together with the matching research, the concept will be explained with these images. The renders can also be found in Appendix R.

First, a concept sketch is shown of the overall concept (figure 45). Second, a top view is depicted to have a general understanding of what the concept in total looks like and how the areas can be divided in private, semi-private, communal and public areas (figure 46). Thereafter details are highlighted, where the explanation of the platform and its surroundings follows after. Lastly, the link to the implemented technology will be covered.

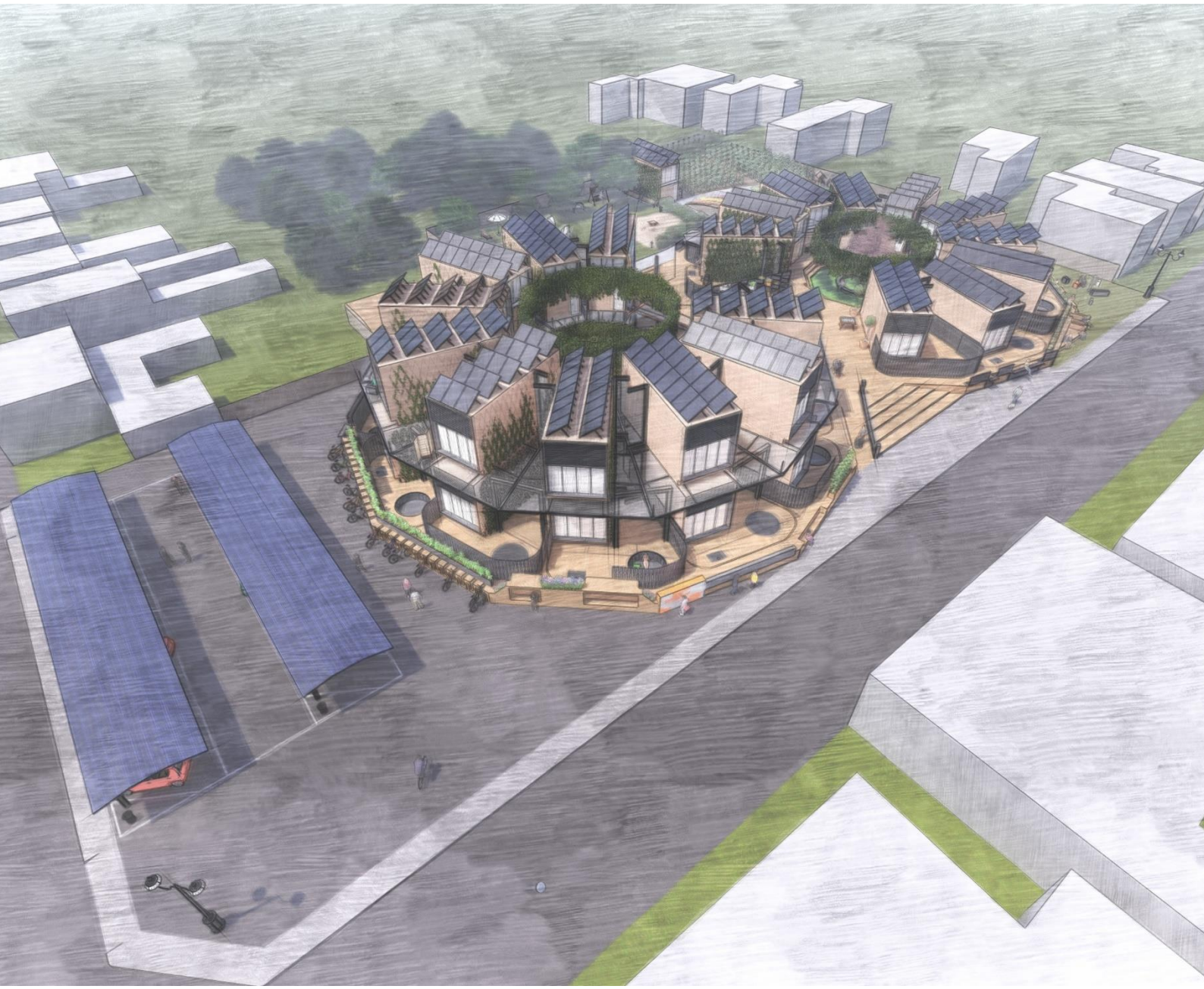


Figure 45: Concept sketch.

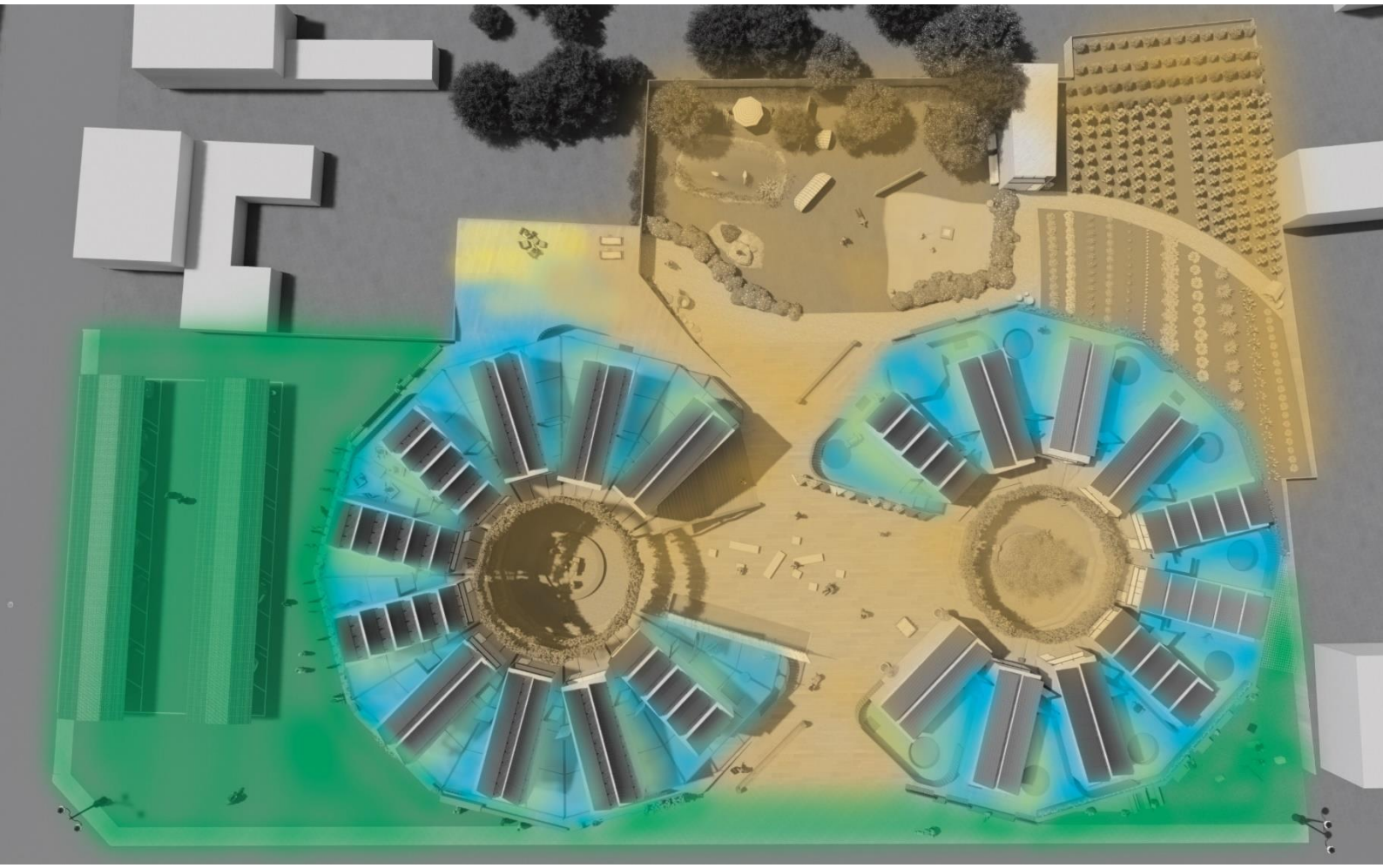


Figure 46: Top view with colour-coded areas. Private (blue), semi-private (yellow), communal (orange) and public (green).

The blue area depicts the private space, the yellow area depicts the semi-private space, the orange area depicts the communal space and the green area depicts the public space. Mainly, the areas around the house, with exception of the front of the house can be used either private or semi-private. This depends on how people arrange this themselves with the moveable wooden fence. If the residents would like privacy they can shut it or split it to whom they would like to distance themselves (the public or neighbour). If neighbours would decide to share both private areas, this creates a more open area in general which results in a semi-private area. In the concept the placement of the houses should provide enough distance, while still keeping it cosy and promoting this in the centre of the circular shaped oriented houses (Bouma, Poelman, & Voorbij (2010). The common area of the platform is positioned centrally and is easy accessible. This makes it highly likely that residents will make use of it (Williams, 2005). The wooden fences (figure 47) create the option for someone to decrease stimuli. It also makes them in control of their own environment, which has a positive influence on the wellbeing of a resident according to expert Joris Sprangers. Each house is placed differently from its neighbour, which could induce the feeling of residents feeling like it is their own house, distinctive of that from the neighbour (Gineikiene, Schlegelmilch, & Auruskeviciene, 2017).

Figure 47: Moveable wooden fences, directed to the liking of the resident, making the area more private or open.

In the concept multiple facilities have been centralized because it is hypothesized that this can increase the possibility of two or more people meeting each other. The unintended social interaction is stimulated this way. Facilities one can think of is: post mail, package delivery spot, bicycle parking spot, car parking spot and communal areas to meet on the platform or in the garden.

Figure 48: Facilities that create the opportunity to socialize on/around the platform.

The picture on the right bottom shows some furniture that is placed randomly. Residents have the opportunity to place it as they like. Joris Sprangers claims people have the need for change, where this area would be perfect to facilitate in. This on its turn would have a positive influence on a residents' wellbeing. As can be seen, there are multiple places to meet and socialize. The parking lot (top right of figure 48) shows one row of cars in the same colour and one that isn't. The idea behind this is that the red cars represent GreenWheels, a car renting company. It suits the philosophy of the residents and mindset of nowadays, where owning something isn't always desired anymore.

Another opportunity for sharing products (Bardhi & Eckhardt, 2012) & (Liem, 2015) is implemented into the concept. An extension of the platform that gradually increases in height, provides space for shared use. As an example, it could contain folding chairs for when someone would give a birthday, or tools for the garden (figure 49).

Figure 49: Extended platform for sharing products within the community.

Another facility that could promote sharing or arrange things within the community is a third party. They could be responsible for garden maintenance, platform maintenance, or be used as a 'neutral' party when someone wants to get something done in the area. A third party can prevent conflicts or tension between residents by making the life easier of people. Because spaces around the houses itself isn't very big, a party with thirty people would not fit behind the house. Someone could ask the third party for permission on doing it on the grass field. Then the third party could maybe facilitate in letting everyone know that a resident would like to have a party and if someone would have questions they can contact the resident directly. The third party could also facilitate in interests or hobbies of the residents. If someone would have a flat tire or needs something fixed, maybe a resident who is a mechanic or carpenter could help a fellow neighbour. In this way people use resources from close by. The third party would be physically distanced from the rest of the houses, but within the communal area. Therefore it is placed in the garden, where the building also functions as a divider between the garden and allotment garden (figure 50).

Figure 50: Third party building.

The garden is a place where people can come to if they would like to change the environment more drastically and decrease the amount of stimuli. The garden provides different sitting areas and dividers, which people could use to limit their stimuli even more. The garden provides a sitting area around the water. This pond could be used as water buffer for the platform, when rain is falling and needs to be drained somewhere. The allotment garden can be used to grow own fruit or vegetables. Residents can pick their homegrown Christmas tree that can be planted back afterwards, diminishing the overall Christmas stress of picking the perfect tree. People within the community could use the communal garden for own use or to start up a small shop and sell their own stuff, on which they can buy new objects for the platform. The third party could help facilitate this (formal, active interaction). Because of the mental and physical interaction with nature and platform, a sense of belonging is created. In the overall concept it is tried to keep a balance between the restorative qualities and options for social interaction (Stoltz & Schaffer, 2018).

Figure 51: Garden and communal garden.

On the platform one wall is a waterfall. This waterfall could just be a waterfall, but in line of making nature reflecting important values of the resident it could also communicate something (Gineikiene, Schlegelmilch, & Auruskeviciene, 2017). Maybe it represents the amount of water that is stored in the water buffers underneath the platform or how well the residents are coping with their electricity or water usage. The waterfall can also facilitate in reducing undesired sounds from the street or surroundings. Because it is such an eye-catcher it is hypothesized that it could also function as a conversation starter. This makes it easier for people to start having social contact that could make the step towards an informal interaction easier (Mellor, Stokes, Firth, Hayashi, & Cummins, 2008).

Figure 52: Garden and allotment garden.

In order to influence the behaviour of the residents (Tromp, Hekkert, & Verbeek, 2011) living on the first floor, the choice has been made to make the space on the front side not too big. This will force people to go downstairs when they don't want to sit around the house. It gives a higher chance of getting them merged together with the ground level. It prevents possible group forming. The ivy on different levels are placed, so people won't look directly inside eachothers bedroom. It should not become too dense, in order to have light still coming through (figure 52).

Figure 52: First floor balcony.

The hatch behind the house can be opened when maintenance on technology needs to be performed. Figure 53 shows a resemblance of how the technology would fit the platform. Of course the copper tubing and sewage system would be connected, whereas in this image it is depicted differently.

Figure 53: Placement of technology underneath the platform.

Something that hasn't been accounted for in the physical concept is social interaction in the digital form. However, it is imaginable that a form of social media within the community might be a starter for residents to have passive interactions on another level. Maybe by influencing the frequency of contact digitally, the probability of passive interactions becoming active interactions could increase.

5.3 Concept Evaluation

In order to evaluate to what extent the concept would fit the neighbourhood and be successful, an evaluation will be performed with the earlier contacted expert Huub van Uum (municipality Oldenzaal). The evaluation will cover how the concept would fit the neighbourhood, and his overall feedback on the concept.

5.3.1 Preparation

In order to prepare the evaluation, 3D renderings have been made in Lumion (architect rendering program) in order to explain the concept, while visualized in a most realistic setting as possible. Furthermore questions have been prepared regarding the overall concept, the green areas, balances between aspects, social aspects and people being in control. In order to introduce the concept, a few aspects of the ideation had been highlighted together with renderings of the final concept, providing handles to start the conversation. The questions together with their answers can be found in Appendix S.

The evaluation with Huub van Uum took place on the 18th of June, 2019.

5.3.2 Positive feedback

In general, Huub van Uum thought the concept looked authentic, renewing, that it was well thought-through with a nice philosophy that suits the norms and values of the present. Behind a lot of design aspects a piece of research had been included to support why it is there and a reason behind the placement of an aspect. He claimed that the concept provided a strong balance between the opportunity of meeting and retreating as a resident. The place would offer a balanced stimulus, which felt like it was almost a vacation retreat. This was meant in a positive way. He stated that he saw himself walking around on bare feet, or just retreated in the garden to rest and relax. The third party service was essential in his opinion. The options the platform provides in altering a personal situation was balanced and he thought it was important for people's wellbeing. According to Huub van Uum a lot of communal area has been integrated in the concept, which suits the philosophy of people today. They want a place where people can come to rest and meet others. He said it could also contribute in reducing loneliness, which is becoming a bigger and bigger problem The concept is doing this, without putting a stamp on it. The playful way of placing the houses makes people feel like they have a unique house.

5.3.2 Room for improvement

Some remarks the expert provided are summarized hereafter. He thought it would be interesting to open up the platform for public use as well. This could improve the connection from the community to the neighbourhood. Another remark was that he felt like more green should be implemented in/on the platform and around the houses. The latter serves also a purpose. One of them being noise reduction. The other is about reducing heat during summer. Because the houses would probably become warm in the summer, it should be accounted for. Also because cooling a space takes more energy than heating up a space. An aspect he missed was about the context of the 3rd party and what role they play and what role the residents would play. The last remark he had is that maybe a different location would suit the concept. Because the garden is reasonably big, he thinks it would fit better at a place more to the edge of the city. Because the current location is close to the city centre it doesn't fit in the area there. The neighbourhood is quite traditional with suiting residents

5.3.3 Design suggestions

The suggestions presented below are design suggestions derived from the feedback of expert Huub van Uum. These suggestions can help in taking the next step within the concept.

Future design suggestions:

- Placement of concept to the edge of a city or suitable neighbourhood.
- Think about the platform as a public space instead of a communal space and how this would change the design.
- Provide more green areas in the platform and around the houses for cooling and noise reduction.
- Create more clarity about what a third party could facilitate and what people could provide for each other.

6 Discussion & Conclusion

This thesis covers two main topics. One being sustainable technology-related, the other social interaction related. The movement towards sustainable technologies in households has started because the use of gas will disappear due to problems with winning gas. Furthermore, is the project playing into the need for one-to two person households and reducing waste in the way the houses are constructed, build and deconstructed for future use.
The social part shows relation to the shift of using sustainable technologies, whereas the importance of collective thinking has become more important. This would mean a shift from an individualistic society to a more collective-thinking society. Furthermore would social interaction or - support positively influence the physical and mental status of a person.

6.1 Technological part

The research question for the technology-related questions was: '*What technologies regarding sustainable housing installations are available, and which should be implemented into the sustainable house/ platform?'*. In answer to that, desk research had been performed to gain insight into what technologies are researched, which are conceptual or almost entering the market and which are already on the market. In the end a selection of products had been made that fits the housing concept of 2Elephants. However, it is possible that other existing products - that have not been found within the time limits of this thesis – exist, which could lead to different technology choices for the house. Because sustainability in relation to households is such a trending topic, speculative almost every day new products emerge.
The choices that have been made, was made on that point of time with as much as gained knowledge possible. While making the selection of products the usefulness of the morphologic chart became doubtable. In hindsight it has proven to be useful as a tool to clearly show what choices have been made in the end. However, when factors of the morphologic chart tie together or some combinations cannot be made together, it makes the morphologic chart less useful than envisioned in the beginning. Thereby is the choice of technology never right or wrong, as it has been noticed that every expert has his/her own opinion/vision about what would be the best way to approach it. Another factor that came into play that has not been accounted for in this thesis is politics and their influence. Because everything is new within sustainable households, the law still has to find its way within this topic. However, idyllic thoughts such as sharing free collected electricity directly with your neighbour is still far away, as the government would like people to pay taxes over it. This gave insight that the government is preventing this idyllic thought from happening. It had been explained that it has to do with taxes on itself and that it's not as simple as getting rid of gas. There is a whole financial factor that is playing along as well. The feedback sessions with experts on the concepts proved most useful for the development of ending up with concept that would work. The created database of sustainable technologies could be adopted by D'Andrea & Evers in order to add new technologies in the future. This way they can keep up with new developments and if another project for the company would require insights regarding this topic, they wouldn't have to start from zero.

6.2 Social part

The research question for the social related question was: '*How to design for social interaction within a cohousing setting, where a community atmosphere is desired, without imposing?'.* In answer to that, literature review has been performed on how to improve the feeling of belongingness and social interaction, which is considered crucial for creating a community. This, together with additional research on types of social interaction, social areas and approaches for influencing people's behaviour together with qualitative research on people living in a community, visit of a

community and brainstorm about how to design for private areas and sharing products and/or services. This all helped to start designing the platform around the houses and design the area on and around the platform. The design of this concept is related to The Netherlands. However, when the houses would be placed somewhere else, this could also mean that other technologies would be selected, due to different weather circumstances. Also the social interaction within a different culture would differ from that of the Dutch people, which means a different approach for the design of the social part.

In the end the persona didn't prove useful, as designing for social interaction is approached more generic than specific in this concept. Aspects found to design for social interaction, taking into account the wellbeing of people and influencing people's behaviour through design were never specific about a certain target group. This is why the persona haven't been used extensively throughout the project. However, it helped creating insight of people who would want to live there, having their own motivation for social interaction. In the end it is more important that people share the same mindset and vision.

The literature review covered different aspect to design for communities and how 'nature' and 'sharing' can contribute to a successful communal space. More factors should be researched in order to gain more insights into design propositions in designing for a community. As an example, one topic addressed is 'safety'. "How to create a communal space where people feel save? ".

Within this research a lot of design implications are presented which are physical. Because a lot is happening nowadays digitally, it could be interesting to conduct research on what factors could facilitate in creating a community on a digital level. Of course everybody is familiar with big players such as Whatsapp and Facebook where people can create groups to talk. It would be interesting to research what influence these groups digitally would have on the group forming in real life. Also, would it be interesting to perform research into other digital platforms that could facilitate or support a community.

Within the design the role of a third party has been described roughly. However, the role of this third party hasn't been described very precisely. This, because it could be seen as a new topic of research into what a third party should facilitate for a community. What would people need from the third party or what should they provide or not provide as a service? The third party should be included into the community to a certain extent, but also not too much so people won't think they are biased in certain matters concerning residents, as with the example of the Tinyhouse resident.

Another topic where more research could be conducted in, is the role that residents should play within the community in relation to their hobbies or interests. Should it be exposed, so that people within the community can ask them for their expertise in a certain area, or should something like that start to exist naturally. Would it be better for residents to maintain their own community or let someone else take care of it? Those are questions that have been remained unanswered, but could contribute to the overall concept created in this assignment.

Last but not least, the whole concept of designing for social interaction is considered a topic that is sometimes hard to grasp. People are still people and in the end they will decide how they will use the space and if it will be used as intended by the designer. This makes it also a very interesting topic to research into and to find hints that can help future designers create a successful communal area. Hopefully research performed within this assignment can accommodate in this matter, where more research into the topic will only help creating stronger concepts for the future.

With respect to the design, the evaluation of it with an expert provided valuable insights. The importance of green around the house had been emphasized again, because nature has a cooling effect on the house, whereas materials such as stones or metal store and radiate heat. If possible, the best option is to have nature around the house. Also because it takes more energy to cool a house than to heat it up. An interesting remark mentioned from the expert is that he thinks the

concept would fit better at the edge of a city, rather than near the city centre. He said this because of the current situation of the neighbourhood, but also because of the amount of green, which he also loved. The researcher disagrees of his statement, because he thinks people tend to move towards green areas within the city. Developments are happening in Hengelo, where a discussion is going on about what the city centre should offer: forest or metal building structures. A lot of people would like a forest-like centre, or at least more green. Maybe a movement towards more green nearby or in the city centre is desired. Or maybe there should not be any city centre at all and live in suburbs, making everything more localized.
The answers to the main research questions provided insights that helped to get to the final concept. The concept could facilitate in promoting social behaviour and there is balance between green/non-green areas and options for people to retreat or meet.

7 Personal view

In this chapter a personal view of the researcher/designer is presented. It is, to show the personal opinion on the technological and social aspect of project 2Elephants.

7.1 Technological

I think it is important to think about how to live sustainable and also to gain knowledge about this topic regarding current developments. Within the 2Elephants project I think it is interesting to think about technologies that could be implemented within the platform and house. The platform creates the opportunity to get rid of the visual or (partly) auditory annoyances that some technologies might give. As an example the fan system for an air-water heat pump is one of those systems. This is not the first project that wants to introduce one- to two-person houses that are sustainable. I think the strength of this concept will be in the platform, where you can 'hide' certain aspects and attach, detach or alter surfaces in order to create interaction with the platform as well.

There is a lot of negative news and critics stating that heating pumps or batteries are not as efficient or sustainable as they appear. I think that not every product is as sustainable or efficient as some companies say, however it's a transition to something better. Maybe the in-between solutions aren't always the best, but I think it is great that there is a lot of attention for the environment and a transition happening towards a more sustainable way of living. It put me to a point where I would like to live sustainable as well and enjoy of all the benefits that it will give to nature and me.

7.2 Social

The social part is an interesting and challenging topic. People are unpredictable and everybody is different. This makes it also hard to design for social interaction. There are structures that can work in one community but wouldn't work in others. Because there is also so much that you can take into account for designing social interaction, this makes it a tough challenge. I could relate to the setting that was needed to create, but that it is hard to create such a setting. The hardest part is that you cannot control everything in your design. People will make a choice in the end whether they will use what you placed somewhere or won't. The only thing the designer can do is promote the interaction in order to make it more appealing or seductive to use a bench or space that promotes in meeting people. Everybody will have their own reason to enter such a community and I think it is a good thing to have a shift towards a world where people start to look more after each other again. I feel that the fast moving technology industry is sometimes also taking its toll by creating more individualism and social bubbles, where a lot of interaction - that normally would've been physically face to face - becomes something that is done via facetime. Of course there is also a big upside, where people who live far away can use it as a tool to have a connection, while physically is not possible. Everything has its ups and downs, and I think it is important to find a balance again, between what you should do physically or electronically. Connect more to your environment and surroundings again, because in the end we live on this earth together.

7.3 Valuable insight

The most valuable insight that this project has given is that people need to change their way of thinking ('omdenken' in Dutch). Not only in the way in how we use energy, what we do with it and the amounts, but also in the way we are coping with space and food. Doing things differently, with a different mindset, creating a new way of living. If one is limited to their energy and needs to charge a car, charge it while visiting a company or parked in the city. If an available space would be smaller than people are used to, use it differently. Think about other possibilities and try to make it work in a different way. If your birthday is in December and you have a small house, rent a place or delay your birthday up to a nice hot summer day to do it outside. Food is mentioned as well, because food can

also be about keeping it local, where locals provide for their own area. If more people would think collaboratively about how to deal with the previous mentioned topics, and how to live together in a different setting, the I believe this could have a great impact on how we live tomorrow.

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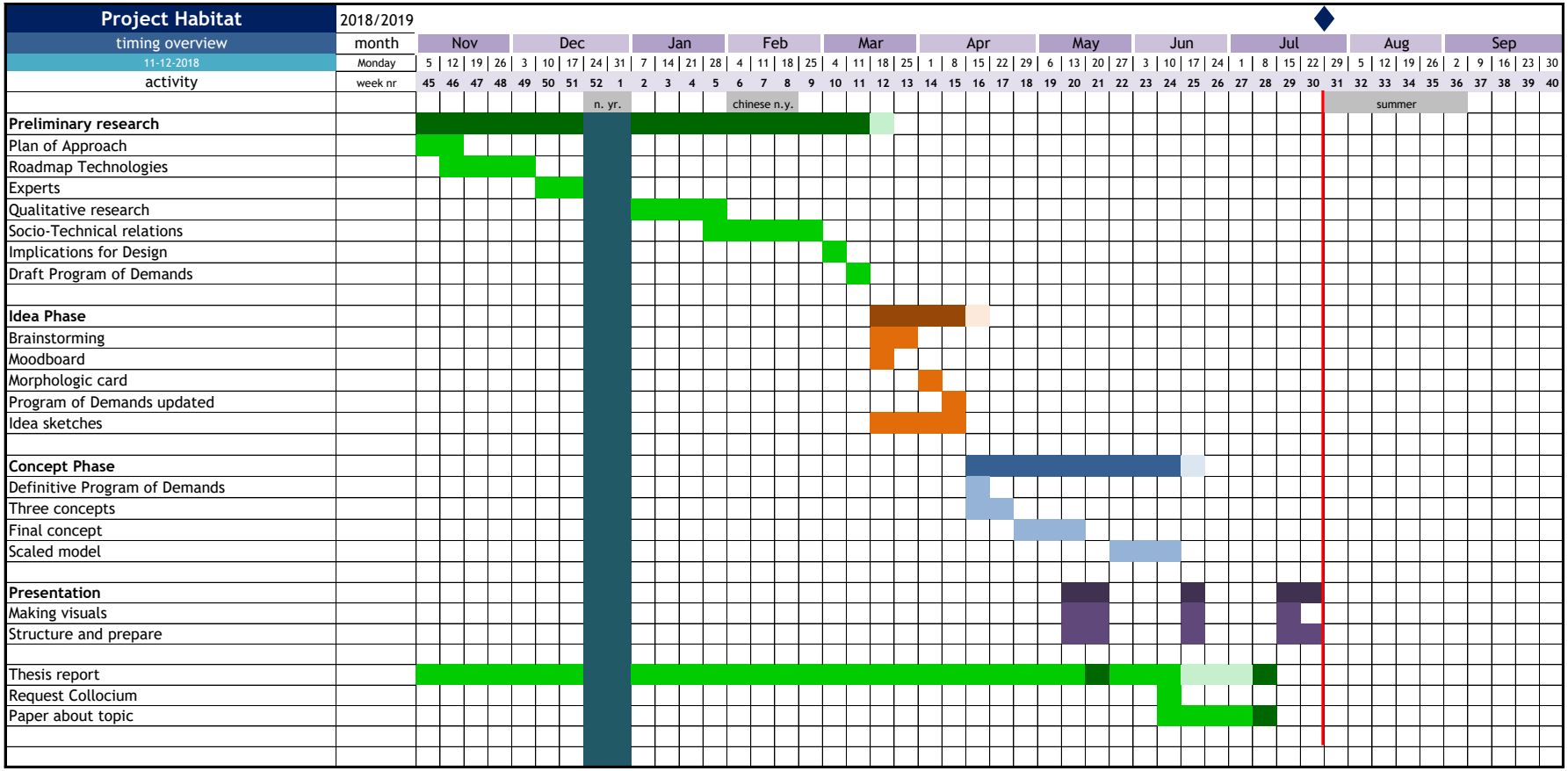
Appendix


APPENDIX
VINCENT UBBENS

APPENDIX A

PROJECT PLANNING

Project planning for the thesis assignment.


Project Habitat
2018/2019
timing overview
month
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
11-12-2018
Monday
5 12 19 26 3 10 17 24 31 7 14 21 28 4 11 18 25 4 11 18 25 1 8 15 22 29 6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19 26 2 9 16 23 30
activity
week nr
45 46 47 48 49 50 51 52 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
n. yr.
chinese n.y.
summer
Preliminary research
Plan of Approach
Roadmap Technologies
Experts
Qualitative research
Socio-Technical relations
Implications for Design
Draft Program of Demands
Idea Phase
Brainstorming
Moodboard
Morphologic card
Program of Demands updated
Idea sketches
Concept Phase
Definitive Program of Demands
Three concepts
Final concept
Scaled model
Presentation
Making visuals
Structure and prepare
Thesis report
Request Collocium
Paper about topic

APPENDIX B

PROVIDING INTERNET

Deskresearch performed into options of having access to internet without standard cable.

Marjoleininhetklein.com. (2017). *Tiny House off-grid internet opties – Marjolein in het klein*. [online] Available at: https://www.marjoleininhetklein.com/2017/01/22/tiny-house-off-grid-internet-opties/ [Accessed 6 Dec. 2018].
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APPENDIX C

COLLAGES VENTILATION

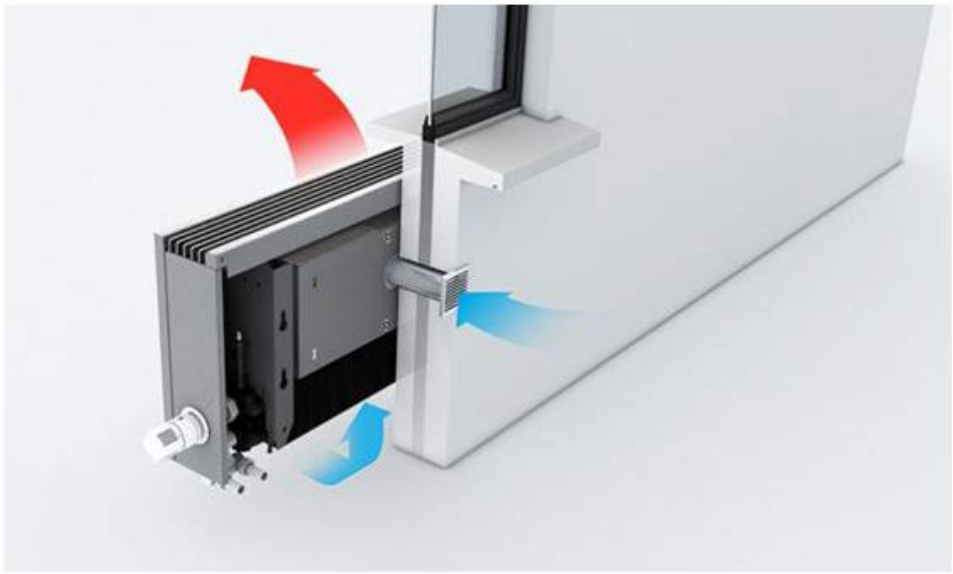
Collages about different ways to ventilate a house.

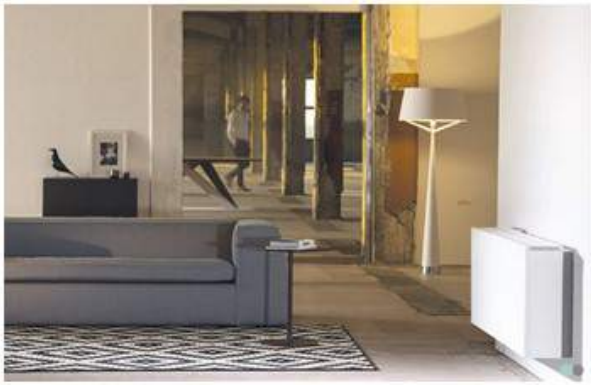
Ventilation by nature

Ventilation by construction

Ventilation (conventional)

Ventilation + heating JAGA in ‘s Hertogenbosch





APPENDIX D

RESEARCH OF SUSTAINABLE TECHNOLOGIES AND PRODUCTS

Every technology or product has certain features that is tried to gain insight into through deskresearch, in order to be able to assess them on these features at a later point. Those features are respectively about: how the product works, cost indication, revenue, efficiency, energy (consumption), sustainable grade, comfort grade, lifetime prognose and notes that are interesting for the technology or general remarks. Every slide provides one or two pictures to show the technology and/or product.

Thadani, R. (n.d.). *Latest Developments in Technology*. [online] Techspirited. Available at: https://techspirited.com/latest-developments-in-technology [Accessed 17 Dec. 2018].
(Thadani, n.d.)

Content

Discovery/Research, Visual/Conceptual and Production/Product Phase for the following categories:

Access to energy
- Obtaining energy
- Storing energy
- Managing energy
- Combinations of obtaining, storing and/or managing energy

Access to heat
- Obtaining heat
- Storing heat
- Managing heat
- Combinations of obtaining, storing and/or managing heat

- Ventilation
- All-in-ones - Energy and/or heat and/or ventilation

Access to energy

Obtaining energy

Discovery/Research phase

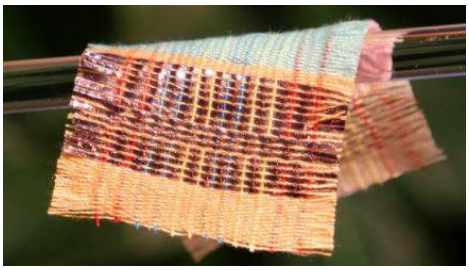
Access to energy – obtaining energy

13

Solar fabric

How does it work?	This fabric is a flexible, breathable and lightweight material. Fiber-based triboelectric (friction) nanogenerators, along with wire-shaped solar cells made of polymer fibers, were woven in with strands of wool to create the material.
Costs indication excl/incl	Relatively cheap material
Revenue	
Efficiency	
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: Fabric can be integrated into various cloths, curtains, tents and so on. Piece of 4x5cm generated 2 volts in one minute with movement and solar energy on a cloudy day.



14

Jun Chen, Yi Huang, Haiyang Zou, Ruiyuan Liu, Changyuan Tao, Xing Fan, and Zhong Lin Wang, “Micro-cable structured textile for simultaneously harvesting solar and mechanical energy,” (Nature Energy, September 12, 2016). http://dx.doi.org/10.1038/nenergy.2016.138

Irving, M. (2016). *Power-generating fabric harvests energy from sunlight and movement*. [online] Newatlas.com. Available at: https://newatlas.com/solar-wind-fabric/45414/ [Accessed 16 Nov. 2018].

(Irving, 2016)

Power Felt fabric

How does it work?	This fabric consists out of nanotubes which are positioned and locked within plastic fibers. With thermoelectric (temperature difference to electric voltage) power conversion, a charge can be given when a temperature difference is present. Additionally, mechanical noise can provide energy.
Costs indication excl/incl	
Revenue	
Efficiency	
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: Vibration of mobile (mechanical noise) could charge your phone as well. Looks like a normal fabric. Re-use lost energy in the form of heat.

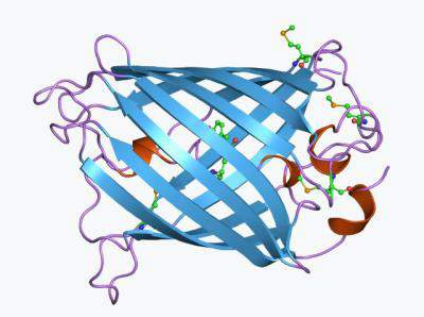
15

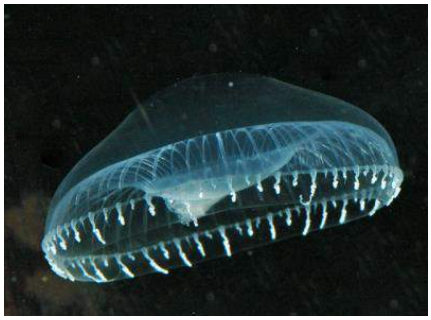
Thomas Edison Muckers. (2013). *Feel the Power, with Power Felt!*. [online] Available at: http://www.edisonmuckers.org/feel-the-power-with-power-felt/ [Accessed 16 Nov. 2018].
(Thomas Edison Muckers, 2013)
16-11-2018

Jellyfish protein

How does it work?	Green Fluorescent Protein (GFP) from the jellyfish called 'Aequorea Victoria', applied to aluminum electrodes and exposed to ultra-violet light generates power measuring in the "tens of nano-amperes."
Costs indication excl/incl	
Revenue	
Efficiency	
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: Biological fuels could enable further research into bio-nanotechnologies that require no external fuel or electrical current to continue functioning. If it could be scaled up, it could become very interesting.





16

Picture: En.wikipedia.org. (n.d.). *Green fluorescent protein*. [online] Available at: https://en.wikipedia.org/wiki/Green_fluorescent_protein [Accessed 16 Nov. 2018]. (En.wikipedia.org, n.d.)

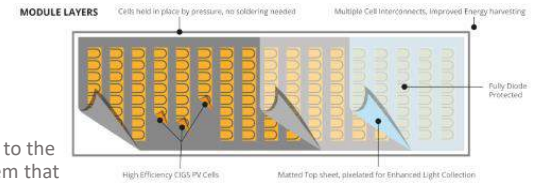
Philips, G. (2015). *8 Unbelievable New Ways of Generating Electricity*. [online] MakeUseOf. Available at: https://www.makeuseof.com/tag/8-unbelievable-new-ways-generating-electricity/ [Accessed 16 Nov. 2018].
(Philips, 2015)

Visual/Conceptual phase

Access to energy – obtaining energy

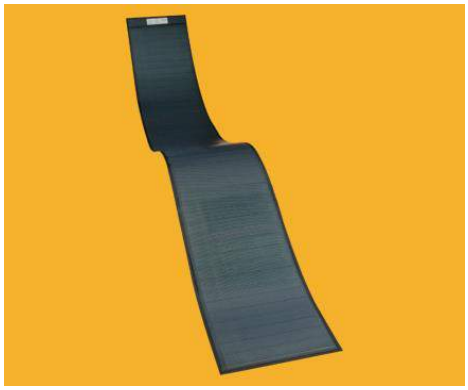
17

Flexible PV film - Flextron



How does it work?	FLEXTRON is a 'peel & stick' module with integrated solar cells. Modules are attached to the approved substrate to create a roofing system that can be installed in the same way as a conventional roof. The PV cells convert light into usable energy.
Based on the 360 watt version:	
Costs indication excl/incl	Bates estimated BIPVCo's solar roofing is around 10 to 15 percent more expensive than traditional silicon panels would be for the same capacity.
Revenue	
Efficiency	Up to 17%
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	5 years product, 10 - 25 years performance

Notes: Building Integrated Photovoltaics (BIPV), teflon coated self-cleaning top sheet, superior thermal degradation and lightweight (3kg/m²), modules can be sold independently or with a roof system as a package. Additional sheets available. Solliance in Eindhoven has a similar product.



18

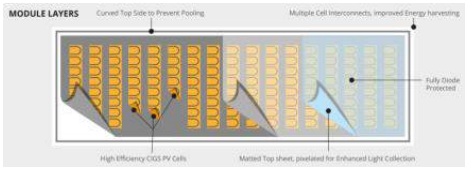
BIPVco. (n.d.). *BIPVco Photovoltaic Products*. [online] Available at: https://www.bipvco.com/products/ [Accessed 19 Nov. 2018].
(BIPVco, n.d.)

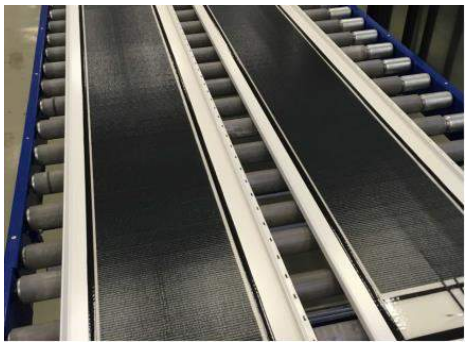
solarsysteem, S., samenwerking, U. and NL, F. (n.d.). *Solliance | Thin film solar research*. [online] Solliance.eu. Available at: https://www.solliance.eu/nl/home-nl/ [Accessed 21 Nov. 2018].
(solarsysteem, samenwerking and NL, n.d.)

Flexible PV film - Metektron

How does it work?	Metektron is a standing seam roofing product with integrated solar cells. Factory applied PV cells are integrated directly onto the approved pre-painted steel to create a roofing system that can be installed in the same way as a conventional roof.
Based on the 130 watt version:	
Costs indication excl/incl	
Revenue	
Efficiency	Up to 17%
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	5 years product, 25 years performance

Notes: Lightweight (2-2,9 kg/m²), modules can be sold independently or with a roof system as a package, no ballast, penetrations, racking or installation required which reduces the investment costs. Additional sheets available.





19

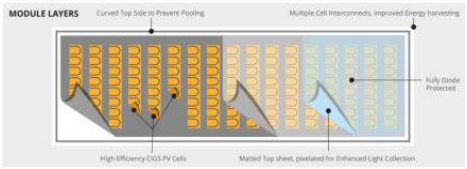
BIPVco. (n.d.). *BIPVco Photovoltaic Products*. [online] Available at: https://www.bipvco.com/products/ [Accessed 19 Nov. 2018].
(BIPVco, n.d.)

solarsysteem, S., samenwerking, U. and NL, F. (n.d.). *Solliance | Thin film solar research*. [online] Solliance.eu. Available at: https://www.solliance.eu/nl/home-nl/ [Accessed 21 Nov. 2018].
(solarsysteem, samenwerking and NL, n.d.)

Flexible PV film- Powerply

How does it work?	Roofing product with integrated solar cells. Factory applied PV cells are integrated directly onto the approved single ply membrane to create a roofing system that can be installed in the same way as a conventional roof.
Based on the 370 watt version:	
Costs indication excl/incl	
Revenue	
Efficiency	Up to 16,1%
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	5 years product, 10 - 25 years performance

Notes: Lightweight (2-2,4kg/m²), roof needs minimum slope of 3°, mechanical fixing or by using adhesive. Additional sheets available.



20

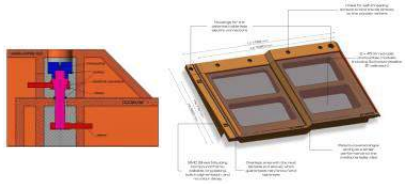
BIPVco. (n.d.). *BIPVco Photovoltaic Products*. [online] Available at: https://www.bipvco.com/products/ [Accessed 19 Nov. 2018].
(BIPVco, n.d.)

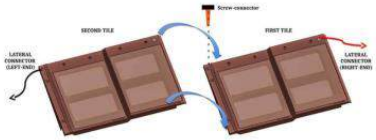
solarsysteem, S., samenwerking, U. and NL, F. (n.d.). *Solliance | Thin film solar research*. [online] Solliance.eu. Available at: https://www.solliance.eu/nl/home-nl/ [Accessed 21 Nov. 2018].
(solarsysteem, samenwerking and NL, n.d.)

Solar roof tiles

How does it work?	Solarteg produces solar panels inside roof tiles. Because of their patented technology no wire is needed to connect the solar tiles. (See image) The conducting screw connector is connecting one tile to the other.
Costs indication excl/incl	/€212,50/m² (ex work and shipping) = €6.693,75 for 31,5m²
Revenue	
Efficiency	15,2 -15,6 %
Energy (consumption)	0,128 kWh/m² (128W/m²) (delivery)
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	25 years warranty on manufactering flaws

Notes: Two services in one, roofing and providing a sustainable solution. 17-45° angle roof, color can be changed. Additional sheets available.





21

SOLARTEG. (n.d.). *Technical details - SOLARTEG*. [online] Available at: https://www.solarteg.it/en/solar-tiles/technical-details/ [Accessed 19 Dec. 2018]. (SOLARTEG, n.d.)

Solarteg roof tiles

Solar roof tiles- Tesla

How does it work?	The tiles are made with technologies and processes to support Building Integrated Photovoltaics (BIPV). Each roof tile (0,078m²/tile) is made from thin layers of quartz, making it robust.
Costs indication excl/incl	€ 204,87/m²*31,5 = € 6.453,41 for 31,5m²
Revenue	
*Efficiency**	*Tesla claims to have done it with about 98% of the
Energy (consumption)	efficiency of regular solar cells in solar panels.
Sustainability grade	0,153 kWh/m² (12W/tile) = 4,846kWh for 31,5m²
Comfort grade	0 / + / ++
Lifetime prognose	1 / 2 / 3 / 4 / 5
	A lifetime warranty for the panels ∞

Notes: More robust than regular roof tiles, Unlike other solar products, Tesla systems are designed to collect up to 98 percent of the solar energy that traditional arrays collect. The unique type of louvered glass tile works in much the same way as window blinds by reflecting sunlight to appear opaque while still absorbing the rays of the sun. 30 years warranty on electricity and weather resistance.

22

Tesla.com. (n.d.). *Tesla Solar Roof*. [online] Available at: https://www.tesla.com/nl_NL/solarroof [Accessed 19 Nov. 2018].
(Tesla.com, n.d.)

Aram, M. (2017). *What We Still Don't Know About Tesla's Solar Roof*. [online] Greentechmedia.com. Available at: https://www.greentechmedia.com/articles/read/what-we-still-dont-know-about-teslas-solar-roof#gs.RzJQNUM [Accessed 22 Nov. 2018].
(Aram, 2017)

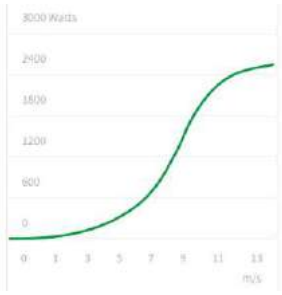
Sendy, A. (2018). *Are the Tesla solar roof tiles worth it?*. [online] Solar-Estimate. Available at: https://www.solar-estimate.org/news/2018-11-06-are-the-tesla-solar-roof-tiles-worth-it [Accessed 22 Nov. 2018].
(Sendy, 2018)

Lambert, F. (2018). *Tesla patent reveals secret behind its solar roof tile's camouflage capacity*. [online] Electrek. Available at: https://electrek.co/2018/05/07/tesla-patent-secret-solar-roof-tiles-camouflage/ [Accessed 24 Jan. 2019].
(Lambert, 2018)

Wind turbine domestic size M

How does it work?	The helix-shaped blades catch wind, which will make the top part spin which creates energy. The Nemoi turbine uses a vertical axis, because of the efficiency of operation at low wind speeds.
Costs indication excl/incl	€ 5.615,64
Revenue	1 – 7 years (dependent energy usage, wind, etc.)
Efficiency	
Energy (consumption)	2,4 kWh (2400 Watt) at maximum speed
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	40+ years, 20 years warranty

Notes: Smaller size wind turbine for off-grid purposes available, producing 600 Watt and is priced at €2.776,67. Easy installation, takes one screwdriver. Max speed gives 38db (whisper). Starts providing enery at windspeeds of 3 mph.



23

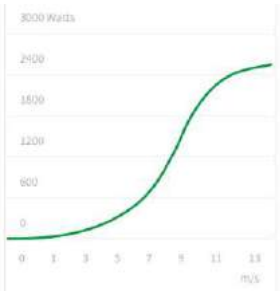
Semtive. (n.d.). *Buy - Semtive*. [online] Available at: https://semtive.com/buy/ [Accessed 26 Nov. 2018].
(Semtive, n.d.)

Renewsable.net. (2017). *This Mini Wind Turbine Can Power Your Entire Home in a Gentle Breeze*. [online] Available at: https://renewsable.net/2017/07/09/mini-wind-turbine-can-power-entire-home-gentle-breeze/ [Accessed 20 Dec. 2018].
(Renewsable.net, 2017)

Wind turbine domestic size S

How does it work?	The helix-shaped blades catch wind, which will make the top part spin which creates energy. The Nemoi turbine uses a vertical axis, because of the efficiency of operation at low wind speeds.
Costs indication excl/incl	€2.776,67
Revenue	1 – 7 years (dependent energy usage, wind, etc.)
Efficiency	
Energy (consumption)	0,6 kWh (600 Watt) at maximum speed
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	40+ years, 20 years warranty

Notes: This turbine is smaller and is meant for off-grid purposes. Provides 12/24V power.



24

Semtive. (n.d.). *Buy - Semtive*. [online] Available at: https://semtive.com/buy/ [Accessed 26 Nov. 2018].
(Semtive, n.d.)

Renewsable.net. (2017). *This Mini Wind Turbine Can Power Your Entire Home in a Gentle Breeze*. [online] Available at: https://renewsable.net/2017/07/09/mini-wind-turbine-can-power-entire-home-gentle-breeze/ [Accessed 20 Dec. 2018].
(Renewsable.net, 2017)

Production/Product phase

Access to energy – obtaining energy

25

IKEA PV panels (Solarcentury)

How does it work?	Every solar panel has its own optimizer, which adds up to 5% of extra energy production within its lifespan. A monitoring app lets you gain insight into the panels' status and controlling it.
Costs indication excl/incl	€ 3.159,49/2496 (installation included)
Revenue	13 years
Efficiency	
Energy (consumption)	994 kWh a year
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	12 inverter, 25 optimizers, 25 panels (warranty)

Notes: Worldleading company in solarpanels, works with IKEA, the inverter uses normally 350V, but when the solar panels are creating no electricity the inverter will reduce itself to the amount of panels. (12 panels = 12 volts).

26

Ikea.com. (n.d.). *Zonnepanelen bij IKEA | Zelf schone energie opwekken - IKEA*. [online] Available at: https://www.ikea.com/nl/nl/zonnepanelen.html [Accessed 21 Nov. 2018].
(Ikea.com, n.d.)

Solar Century Ikea NL. (n.d.). *Omvormer - Solar Century Ikea NL*. [online] Available at: http://ikea.solarcentury.com/nl/omvormer/ [Accessed 20 Dec. 2018].
(Solar Century Ikea NL, n.d.)

Regular PV panels (average)

How does it work?	Solar panels connected in serie with inverter. This is a representation of the average solar panel system for a two person household.
Costs indication excl/incl	€ 6.274/5.185 (instal. incl) (€ 4.407,25 w.o.)
Revenue	8 years
Efficiency	15% - (22%)
Energy (consumption)	2930 kWh a year production with 13 panels
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: Polykristallijne zonnepanelen zijn vaak iets goedkoper. Het gaat hierbij over een verschil van circa 10%. Hierbij speelt de kleur van het frame een belangrijke rol. Vaak willen mensen die mono kristallijne zonnepanelen kopen ook een zwart frame zodat een mooi zwart vlak ontstaat. Om het frame zwart te krijgen wordt het aluminium zogenaamd geanodiseerd. Dat is één van de redenen van de hogere prijs.

27

Zonnepanelen-info.nl. (n.d.). *Kosten zonnepanelen 2018 - overzicht | Zonnepanelen-info.nl*. [online] Available at: https://www.zonnepanelen-info.nl/zonnepanelen/kosten/ [Accessed 20 Dec. 2018].
(Zonnepanelen-info.nl, n.d.)

Murmson, S. (2017). [online] Sciencing.com. Available at: https://sciencing.com/average-photovoltaic-system-efficiency-7092.html [Accessed 21 Dec. 2018].
(Murmson, 2017)

zonnepanelen.net. (n.d.). *Mono of poly zonnepanelen | Zonnepanelen.net*. [online] Available at: https://www.zonnepanelen.net/verschil-mono-en-poly-zonnepanelen/ [Accessed 23 Jan. 2019].
(zonnepanelen.net, n.d.)

Aggregate (Bosch EU22i)

How does it work?	A 4 stroke engine with diesel/benzine as fuel (depending on the model), which will use the produced energy to provide people from electricity. The Bosch EU22i is an example aggregate to get an indication.
Costs indication excl/incl	€ 1.184,21/1.499,99
Revenue	
Efficiency	
Energy (consumption)	1,8 – 2,2 kWh (1800 - 2200 Watt)
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	2 years warranty

Notes: Makes a lot of noise (55-58 dB) and has a special way in how you should connect your appliance to it. It is for outside purposes due to CO2 emission. Heavy (21 kg). Optional to connect aggregates for more power.

28

Bostools.nl. (n.d.). *BOSTOOLS.NL | Honda EU22i inverter benzine generator*. [online] Available at: https://www.bostools.nl/aggregaten/inverter-aggregaten/honda-eu22i-inverter-benzine-generator?gclid=CjwKCAiAo8jgBRAVEiwAJUXKqEm9d_em88V5BPaXmoUS-Ym1QTcGZyGyjKe5Qg8O7zNckIlZR7lnRhoCXdcQAvD_BwE [Accessed 13 Dec. 2018]. (Bostools.nl, n.d.)


Obtaining Energy
Discovery/ Research
Visual/ Concept
Production/ Product
technologies
Solar fabric
Power felt fabric
Jellyfish protein
Flexible PV film - Flextron
Flexible PV film - Metektron
Flexible PV film - Powerply
Solar roof tiles
Solar roof tiles Tesla
Wind turbine domestic size M
Wind turbine domestic size S
IKEA PV panels (Solarcentury)
Regular PV panels
Aggregate (Bosch EU22i)
stage of research
stage of conceptualization
stage of product/market development
Legend:
slowly developing
processing
accelerating

Access to energy

Storing energy

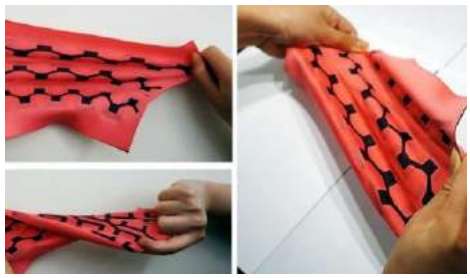
Discovery/Research phase

Access to energy – storing energy

Flexible bio-battery

How does it work?	This textile oriented bacteria-powered bio-battery is based on the paper based bacteria. Microbial-based power studies are performed to see if we can use bacteria to store energy.
Costs indication excl/incl	
Revenue	
Efficiency	
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: These textile-based biobatteries exhibit stable electricity-generating capability when tested under repeated stretching and twisting cycles. With eye on wearables, sweat generated from the human body can be a potential fuel to support bacterial viability, ensuring the long-term operation of the microbial fuel cells.

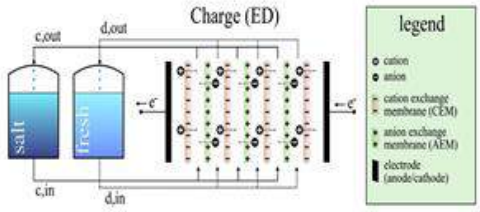


33

News - Binghamton University. (2017). *Scientists create stretchable battery made entirely out of fabric - Binghamton News*. [online] Available at: https://www.binghamton.edu/news/story/925/scientists-create-stretchable-battery-made-entirely-out-of-fabric [Accessed 16 Nov. 2018].
(News - Binghamton University, 2017)

Blue battery

How does it work?	At times when surplus energy is available, electrical energy is used to migrate salt ions against the salinity gradient from a low to high salinity (fig. 1) and the battery is charged. At times when additional electricity is required, the process is reversed by mixing fresh and salt water, generating electricity and discharging the battery.
Costs indication excl/incl	
Revenue	
Efficiency	
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	



Notes: salinity = zoutgehalte. Making use of natural materials, li-ion contains rare materials, blue battery is a sustainable energy storing system that is environmentally safe, cost-effective and applicable in flat terrain. Size of Olympic swimming pool can power 200 houses which converts to 125.000 liters for one house.

34

Van Egmond et al. 2017. The concentration gradient flow battery as electricity storage system: Technology potential and energy dissipation. The Journal of Power Sources 325: 129-139.

Picture: WUR. (2017). *Science: Large scale energy storage using salt and fresh water*. [online] Available at: https://www.wur.nl/en/newsarticle/Science-Large-scale-energy-storage-using-salt-and-fresh-water.htm [Accessed 16 Nov. 2018].
(WUR, 2017)

Power to Ammonia to Power

How does it work?	When there is excess energy, the energy is used to bond nitrogen with hydrogen molecules in an electrochemical cell to create ammonia. When energy needs to be released the ammonia is burned which results in nitrogen and hydrogen.
Costs indication excl/incl	
Revenue	
Efficiency	50-60%
Energy (consumption)	8.7-10.3 kWh kg-1 ammonia (consumption)
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: No carbon in the process. It's a circular process. The goal is to provide more stability in the grid. With this technique it should be possible to store energy for a longer period of time. Most technologies are expected to be available by 2020-2025 to realize the process.

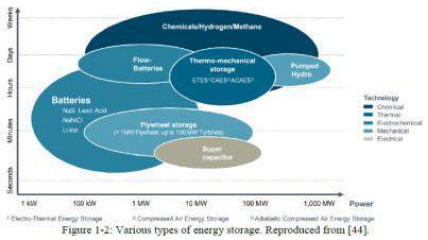
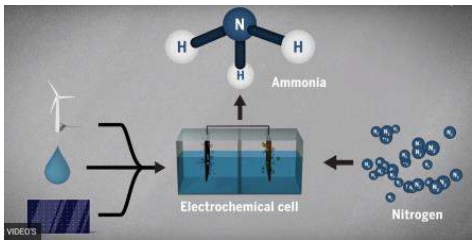


Figure 1-2: Various types of energy storage. Reproduced from [44].



35

Rouwenhorst, K. H. (2018). *Power-to-ammonia-to-power (P2A2P).* Enschede: University of Twente.

(Rouwenhorst, 2018)

https://www.youtube.com/watch?time_continue=127&v=eLMfRZGagfE

Electrolysis hydrogen

How does it work?	The li-ion batteries store energy retrieved from e.g. solar panels. The battery comes with a transformer which probably will be used to store and use the energy again.
Costs indication excl/incl	€...
Revenue	...
Efficiency	....%
Energy (consumption)	2.673 kWh storage
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	...

Notes: 7,14x1,6 m. Launching around 2020.

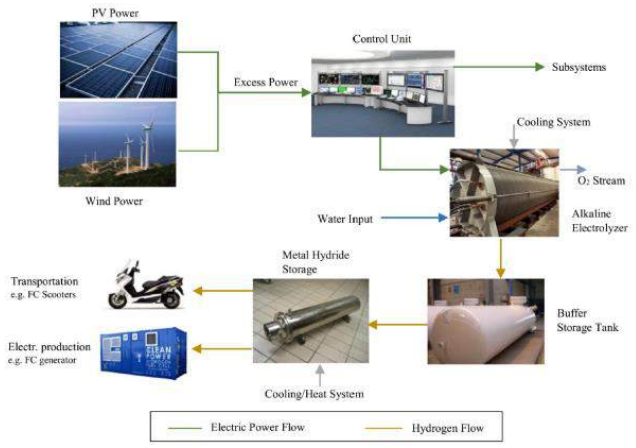
36

Lambert, F. (2018). *Tesla's new Megapack to debut at giant energy storage project in California*. [online] Electrek. Available at: https://electrek.co/2018/12/15/tesla-megapack-debut-giant-energy-storage/ [Accessed 21 Dec. 2018].
(Lambert, 2018)

Christian, J. (2018). *New details about Tesla's gargantuan "Megapack" power storage unit*. [online] Futurism. Available at: https://futurism.com/the-byte/new-details-teslas-gargantuan-megapack [Accessed 21 Dec. 2018].
(Christian, 2018)

Electrolysis hydrogen

- Alkaline electrolyzer for production hydrogen
- 2020
- Very large amounts of hydrogen can be stored in man made underground salt caverns of up to 500,000 m3 at 200 bar (2,900 psi), corresponding to a storage capacity of 167 GWh hydrogen (100 GWh electricity). In this way, longer periods of flaws or of excess wind / PV energy production can be leveled.



37

Kavadias, K. A., Apostolou, D., & Kaldellis, J. K. (2018). Modelling and optimisation of a hydrogen-based energy storage system in an autonomous electrical network. *Applied Energy*, *227*, 574–586. https://doi.org/10.1016/j.apenergy.2017.08.050 (Kavadias, Apostolou, & Kaldellis, 2018)

Energystorage.org. (n.d.). *Hydrogen Energy Storage | Energy Storage Association*. [online] Available at: http://energystorage.org/energy-storage/technologies/hydrogen-energy-storage [Accessed 23 Nov. 2018]. (Energystorage.org, n.d.)

Redox flow battery

How does it work?	The li-ion batteries store energy retrieved from e.g. solar panels. The battery comes with a transformer which probably will be used to store and use the energy again.
Costs indication excl/incl	€…
Revenue	…
Efficiency	….%
Energy (consumption)	2.673 kWh storage
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	…

Notes: 7,14x1,6 m. Launching around 2020.

38

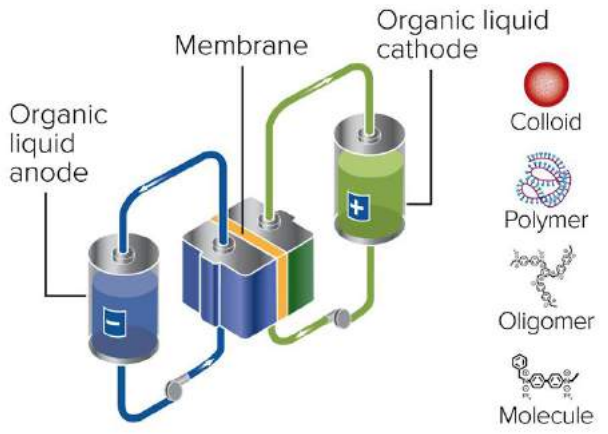
Lambert, F. (2018). *Tesla's new Megapack to debut at giant energy storage project in California*. [online] Electrek. Available at: https://electrek.co/2018/12/15/tesla-megapack-debut-giant-energy-storage/ [Accessed 21 Dec. 2018].
(Lambert, 2018)

Christian, J. (2018). *New details about Tesla's gargantuan "Megapack" power storage unit*. [online] Futurism. Available at: https://futurism.com/the-byte/new-details-teslas-gargantuan-megapack [Accessed 21 Dec. 2018].
(Christian, 2018)

Redox flow battery

Ion exchange occurs through the membrane separator when the electrolytes undergo reduction and oxidation (redox) and in turn can store large amounts of energy, perfect for tying into the grid.

Redox flow batteries are suitable for energy storage applications with power ratings from 10's of kW to 10's of MW and storage durations of 2 to 10 hours



39

Atwell, C. (2018). *6 Promising Energy Storage Options to Tie into the Grid*. [online] Power Electronics. Available at: https://www.powerelectronics.com/alternative-energy/6-promising-energy-storage-options-tie-grid [Accessed 15 Nov. 2018]. (Atwell, 2018)

http://energystorage.org/energy-storage/technologies/redox-flow-batteries

Liquid Air Energy Storage

How does it work?	The li-ion batteries store energy retrieved from e.g. solar panels. The battery comes with a transformer which probably will be used to store and use the energy again.
Costs indication excl/incl	€...
Revenue	...
Efficiency	....%
Energy (consumption)	2.673 kWh storage
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	...

Notes: 7,14x1,6 m. Launching around 2020.

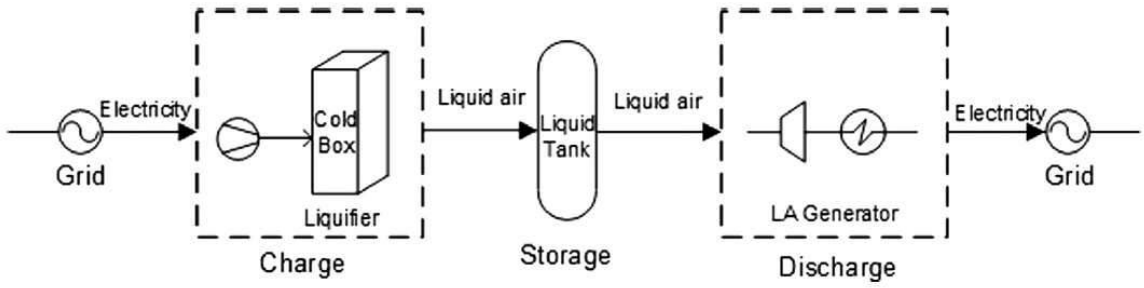
40

Lambert, F. (2018). *Tesla's new Megapack to debut at giant energy storage project in California*. [online] Electrek. Available at: https://electrek.co/2018/12/15/tesla-megapack-debut-giant-energy-storage/ [Accessed 21 Dec. 2018].
(Lambert, 2018)

Christian, J. (2018). *New details about Tesla's gargantuan "Megapack" power storage unit*. [online] Futurism. Available at: https://futurism.com/the-byte/new-details-teslas-gargantuan-megapack [Accessed 21 Dec. 2018].
(Christian, 2018)

Liquid Air Energy Storage

Storing energy by liquifying air



41

Xie, C., Hong, Y., Ding, Y., Li, Y., & Radcliffe, J. (2018). An economic feasibility assessment of decoupled energy storage in the UK: With liquid air energy storage as a case study. *Applied Energy*, *225*, 244–257. https://doi.org/10.1016/j.apenergy.2018.04.074
(Xie, Hong, Ding, Li, & Radcliffe, 2018)

Visual/Conceptual phase

Access to energy – storing energy

Energy Vault

How does it work?	This energy vault stores and releases energy by stacking and unstacking concrete cylinders. It is a six-armed crane that stacks concrete blocks with cheap and abundant grid power, and drops them down to retrieve electricity when needed.
Costs indication excl/incl	Low cost solution
Revenue	
Efficiency	90%, although questioned by experts
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	30 – 40 years

Notes: Operational around 2020. Mechanical storage. More mechanical energy storages launched but never made it, making this concept also questionable.

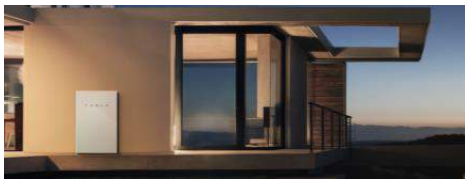
43

Spector, J. (2018). *Can Newcomer Energy Vault Break the Curse of Mechanical Grid Storage?*. [online] Greentechmedia.com. Available at: https://www.greentechmedia.com/articles/read/energy-vault-stacks-concrete-blocks-to-store-energy#gs.lFFEsmc [Accessed 16 Nov. 2018].
(Spector, 2018)

Tesla powerwall

How does it work?	The li-ion batteries store energy retrieved from e.g. solar panels. An app can give you insight into where your generated energy went. The battery can be used as emergency back-up or if there are off-grid intensions, but for that additional hardware is needed. What exactly is remained unknown.
Costs indication excl/incl	€ 6.114,6/7.740 (incl additional hardware of €740)
Revenue	
Efficiency	90%
Energy (consumption)	13,5 kWh storage
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	10 years warranty

Notes: Scalable up to 10 powerwalls. Pre-order available.



44

Tesla.com. (2018). *Tesla Powerwall*. [online] Available at: https://www.tesla.com/nl_NL/powerwall [Accessed 19 Nov. 2018]. (Tesla.com, 2018)

Tesla megapack

How does it work?	The li-ion batteries store energy retrieved from e.g. solar panels. The battery comes with a transformer which probably will be used to store and use the energy again.
Costs indication excl/incl	
Revenue	
Efficiency	
Energy (consumption)	2.673 kWh storage
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: 7,14x1,6 m. Launching around 2020.

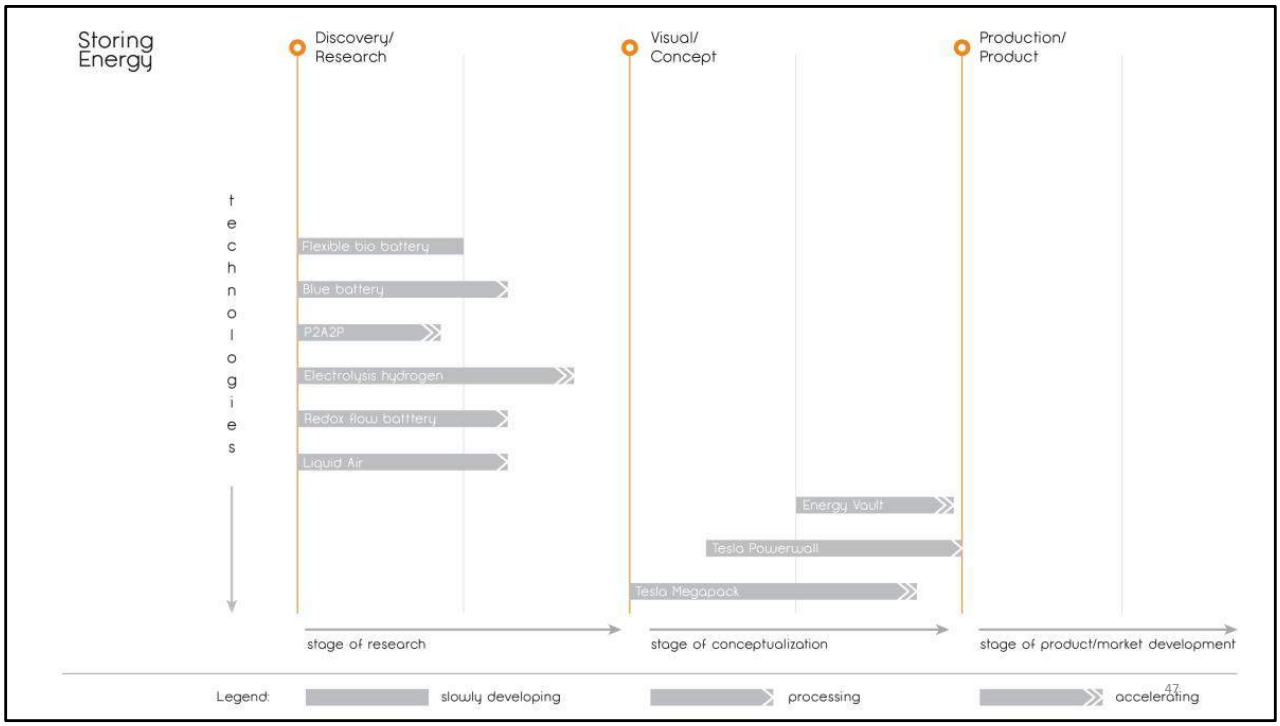
45

Lambert, F. (2018). *Tesla's new Megapack to debut at giant energy storage project in California*. [online] Electrek. Available at: https://electrek.co/2018/12/15/tesla-megapack-debut-giant-energy-storage/ [Accessed 21 Dec. 2018].
(Lambert, 2018)

Christian, J. (2018). *New details about Tesla's gargantuan "Megapack" power storage unit*. [online] Futurism. Available at: https://futurism.com/the-byte/new-details-teslas-gargantuan-megapack [Accessed 21 Dec. 2018].
(Christian, 2018)

Production/Product phase

Access to energy – storing energy


Storing Energy
Discovery/ Research
Visual/ Concept
Production/ Product
technologies
Flexible bio battery
Blue battery
P2A2P
Electrolysis hydrogen
Redox flow batttery
Liquid Air
Energy Vault
Tesla Powerwall
Tesla Megapack
stage of research
stage of conceptualization
stage of product/market development
Legend:
slowly developing
processing
accelerating
47

Access to energy

Managing energy

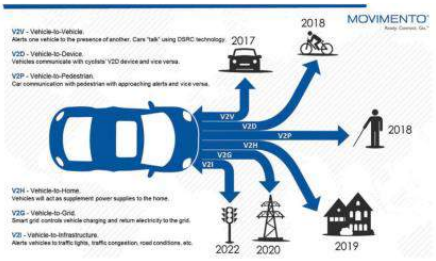
Discovery/Research phase

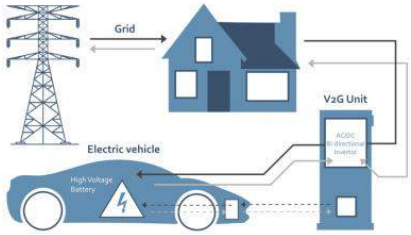
Access to energy – managing energy

Vehicle to Grid (V2G)

How does it work?	"Vehicle to Grid (V2G) communication is a system in which Electric Vehicles (Evs) communicate with the power grid to return electricity to the grid or throttle the vehicle's charging rate."
Costs indication excl/incl	
Revenue	
Efficiency	
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: Upcoming technique, first signs of trials are present.





50

Alam, M. (2016). Embedded Systems Engineering. *EECatalog*, 10-13.
(Alam, 2016)

Picture: EVConsult. (n.d.). *Cashing in with your electric car with V2G-technology - EVConsult*. [online] Available at: https://www.evconsult.nl/en/cashing-in-with-your-electric-car-with-v2g-technology/ [Accessed 27 Nov. 2018].
(EVConsult, n.d.)

https://www.researchgate.net/figure/Architecture-and-the-operation-procedure-of-the-automatic-vehicle-parking-system_fig2_242630611

Visual/Conceptual phase

Access to energy – managing energy

51

LO3 Energy- Exergy

How does it work?	Exergy™ is a distributed ledger system that functions across grid-connected hardware, a token system for transactive energy, and a foundation that advances market design and technology in tandem. Exergy generates, controls and secures the data required to enable price as a proxy for control and optimal operation of electric power systems.
Costs indication excl/incl	
Revenue	
Efficiency	
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: Share and transact energy between eachother, using existing grid infrastructure. A prototype of the Exergy blockchain architecture is already operational in the Brooklyn Microgrid (BMG), a peer-to-peer energy market project supported by LO3 Energy and the community it serves. Additional paper. Community, transaction between smart grid and 'normal' home are made possible via blockchain technology. Use technology of someone that produces energy. Could also function if the main grid fails during storms, cyberattacks etc.

52

LO3 Energy. (n.d.). *The Future of Energy | Blockchain, Transactive Grids, Microgrids, Energy Trading | LO3 Stock, Tokens and Information | LO3 Energy*. [online] Available at: https://lo3energy.com/ [Accessed 15 Nov. 2018].
(LO3 Energy, n.d.)

Production/Product phase

Access to energy – managing energy

53

Access to energy

Product combinations of obtaining, storing and managing energy

54

Discovery/Research phase

Access to energy - combinations

55

Visual/Conceptual phase

Access to energy - combinations

56

Solpad – Home (grid-tied)

How does it work?	This version of the solpad has a 300W solar panel. The product contains: the photovoltaic solar panels, inverter, charge controller, and batteries are all contained in the same package. This makes that the products needed downstairs become less.
Costs indication excl/incl	No indication available yet
Revenue	
Efficiency	
Energy (consumption)	1 kWh storage per panel
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: On the market second half of 2017, now available via construction companies (e.g. BAM!). Meant to power an entire house, and can be easily expanded depending on the energy need. I.c.w. SolControl, the user can manage and gain insight in their energy usage.

57

Pyper, J. (2016). *Meet SolPad, an Integrated Solar-Plus-Storage Solution Fresh Out of Stealth Mode*. [online] Greentechmedia.com. Available at: https://www.greentechmedia.com/articles/read/meet-solpad-a-truly-integrated-solar-plus-storage-solution-fresh-out#gs.RzPbJ40 [Accessed 15 Nov. 2018].
(Pyper, 2016)

Polat, E. (2017). *SolPad Announces the All-in-One Solar Power System - The Green Optimistic*. [online] The Green Optimistic. Available at: https://www.greenoptimistic.com/solpad-announces-one-solar-power-system-20170124/#.W_aKIOhKhPZ [Accessed 22 Nov. 2018].
(Polat, 2017)

Solpad.com. (2019). *Solpad | The Future of Solar+Storage is here...*. [online] Available at: http://solpad.com/ [Accessed 18 Jan. 2019].
(Solpad.com, 2019)

Solpad – Stand-alone (off-grid)

How does it work?	This version of the solpad has a 72W solar panel. This mobile version includes the inverter, control systems, and a WiFi hotspot all in one device. AC and DC energy delivery.
Costs indication excl/incl	€ 965,62/1.222,31
Revenue	
Efficiency	
Energy (consumption)	600 wH battery
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: Will launch after the Solpad Home, didn't meet the initial deadline in 2017. Still not on the market.

58

Pyper, J. (2016). *Meet SolPad, an Integrated Solar-Plus-Storage Solution Fresh Out of Stealth Mode*. [online] Greentechmedia.com. Available at: https://www.greentechmedia.com/articles/read/meet-solpad-a-truly-integrated-solar-plus-storage-solution-fresh-out#gs.RzPbJ40 [Accessed 15 Nov. 2018].
(Pyper, 2016)

Solpad.com. (2019). *Solpad | The Future of Solar+Storage is here...*. [online] Available at: http://solpad.com/ [Accessed 18 Jan. 2019].
(Solpad.com, 2019)

Production/Product phase

Access to energy - combinations

59

Heating

Obtaining heat

Discovery/Research phase

Heating - obtaining

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Visual/Conceptual phase

Heating - obtaining

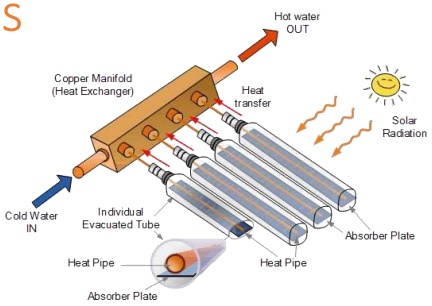
Production/Product phase

Heating - obtaining

Solar collector – vacuum tubes

How does it work?	The prisma pro 24 tubes creates hot water by concentrating sunrays, which can be used to heat the house or use directly in combination with a solar boiler and storage unit. A special reflector gets the maximum heat from the collected sunrays.
Costs indication excl/incl	€ 990 – 1.070/1.257– 1.355 (€750 average*)
Revenue	Up to 10 years (estimation)
Efficiency	66,8 %
Energy (consumption)	2500 kWh a year (1417 kWh average for 2,5m²)
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	15-20 years (vacuum tubes)

Notes: Tubes can be replaced individually, available in smaller sizes. Additional sheets available. Lighter than flat panels, not filled with water.
* Installation not included.



Direct, sloping and diffuse light directions

64

zonnecollector, R. (n.d.). *Het rendement van een zonnecollector*. [online] Zonnepanelen-weetjes.nl. Available at: https://www.zonnepanelen-weetjes.nl/zonnecollector/rendement-zonnecollector/ [Accessed 21 Nov. 2018]. (zonnecollector, n.d.)

2-Improve. (n.d.). *Prisma Pro 24 CPC Zonnecollector 2943 Wp vermogen*. [online] Available at: https://2-improve.com/winkel/heatpipes-2/prisma-pro-24-cpc-zonnecollector-met-2943-wp-vermogen/ [Accessed 21 Nov. 2018]. (2-Improve, n.d.)

En.wikipedia.org. (n.d.). *Solar thermal collector*. [online] Available at: https://en.wikipedia.org/wiki/Solar_thermal_collector [Accessed 22 Nov. 2018]. (En.wikipedia.org, n.d.)

Prisma Pro. (n.d.). *Prisma Pro 24 CPC zonnecollector - Prisma Pro*. [online] Available at: http://prisma-pro.nl/prisma-pro-24-cpc-zonnecollector [Accessed 19 Dec. 2018]. (Prisma Pro, n.d.)

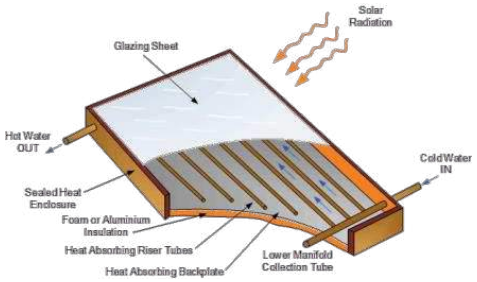
Alternative Energy Tutorials. (n.d.). *Evacuated Tube Collector for Solar Hot Water*

System. [online] Available at: http://www.alternative-energy-tutorials.com/solar-hot-water/evacuated-tube-collector.html [Accessed 7 Jan. 2019].
(Alternative Energy Tutorials, n.d.)

Solar collector – flat panels

How does it work?	Solar radiation is absorbed by the dark backplate of the panel. Cold water comes in, smaller tubes are distributed through the panel, absorbing the heat resulting in a hot water as output.
Costs indication excl/incl	/€2.000 – 4.000 (€550 average w/o installation)
Revenue	4 - 10 years
Efficiency	<66,8% (how much exactly not clear)
Energy (consumption)	1306 kWh for 2,5m²
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	20-30 years (document)

Notes: Less efficient and cheaper than vacuum tubes. Solar boiler needed to store water and keep it at the same temperature. Not as efficient as vacuum tubes, due to their flatness.



65

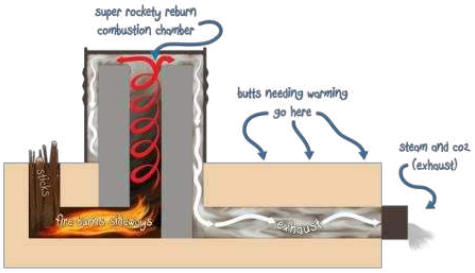
Alternative Energy Tutorials. (n.d.). *Flat Plate Collector for use in Solar Hot Water Systems*. [online] Available at: http://www.alternative-energy-tutorials.com/solar-hot-water/flat-plate-collector.html [Accessed 7 Jan. 2019].
(Alternative Energy Tutorials, n.d.)

indiamart.com. (n.d.). *Glazed Flat Plate Collector*. [online] Available at: https://www.indiamart.com/proddetail/glazed-flat-plate-collector-15857374633.html [Accessed 7 Jan. 2019].
(indiamart.com, n.d.)

Rocket stove- Lite

How does it work?	This stove uses eco briquettes or wood to heat the room. Because rocket stove utilizes complete combustion, it reduces stench and creates more heat on the same amount of fuel than conventional systems. Thereby, it's CO_2-neutral.
Costs indication excl/incl	€ 758,4/960
Revenue	
Efficiency	87%
Energy (consumption)	12 kW (Wood pallets)
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: The amount of CO_2 from burning fuels is the same as when it would rott in the forest. However, now the energy of the material is used. For rooms up to 25m². On the top something can be heated.



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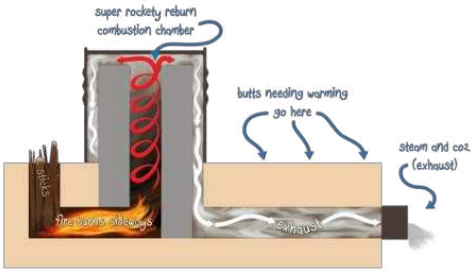
http://rocketstove.store/onze-modellen/ (04-12-2018)
http://rocketstove.store/hoe-het-werkt/ (04-12-2018)

info [apestaart] rocketstove.store
0624199866

Rocket stove- 5

How does it work?	This stove uses eco briquettes or wood to heat the room. Because rocket stove utilizes complete combustion, it reduces stench and creates more heat on the same amount of fuel than conventional systems. Thereby, it's CO_2-neutral.
Costs indication excl/incl	€1224,5/1550
Revenue	
Efficiency	89,3%
Energy (consumption)	7 kW (Wood pallets)
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: The amount of CO_2 from burning fuels is the same as when it would rott in the forest. However, now the energy of the material is used. For rooms up to 40m². On the top something can be heated.



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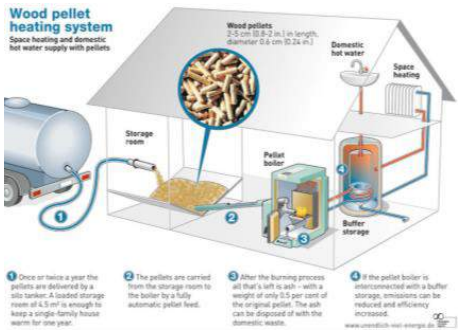
http://rocketstove.store/onze-modellen/ (04-12-2018)
http://rocketstove.store/hoe-het-werkt/ (04-12-2018)

info [apestaart] rocketstove.store
0624199866

Biomass boiler

How does it work?	An efficient way of burning wood for creating heat inside a room or heating water for a heating system or usage/consumption.
Costs indication excl/incl	/€1.000 (30 – 33 cents/kg wood pellet)
Revenue	6-7 years (approximation)
Efficiency	90-93 %
Energy (consumption)	2,7 - 6,17 kW (up to 3900 kilo / year)
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: Example product (artel pelletkachel) heats up to 30m². Fossil fuels used for chopping and transporting wood where the wood pallets come from make it a little less sustainable. Storage for wood needed (takes space).



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Energiebesparendoejenu.nl. (n.d.). *Biomassaketel: stoken op hout*. [online] Available at: https://www.energiebesparendoejenu.nl/alle-verbeteropties/biomassaketel/ [Accessed 30 Nov. 2018].
(Energiebesparendoejenu.nl, n.d.)

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(FilterFabriek.nl, n.d.)

Debruijnagri.nl. (n.d.). *Hout Pellets*. [online] Available at: https://www.debruijnagri.nl/site/hout-pellets [Accessed 7 Jan. 2019].
(Debruijnagri.nl, n.d.)

Energymyway.co.uk. (2018). *Domestic Biomass Boiler - Woodchip Boiler - Pellet Boiler*. [online] Available at: https://www.energymyway.co.uk/products/domestic-

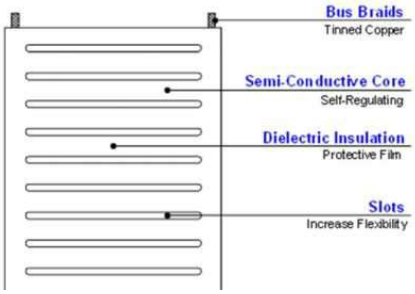
boilers/ [Accessed 7 Jan. 2019].
(Energymyway.co.uk, 2018)

Greenmatch.co.uk. (2018). *Pros and Cons of Wood Pellet Boiler | GreenMatch*. [online] Available at: https://www.greenmatch.co.uk/blog/2015/02/pros-and-cons-of-wood-pellet-boiler [Accessed 18 Jan. 2019].
(Greenmatch.co.uk, 2018)

NANO STEP® Heating Element

How does it work?	The radiant heating element is constructed of two parallel bus braids embedded in a semi-conductive polymeric material. A polymeric dielectric film is applied at the time of manufacture so that the film is thermally fused to the heating material.
Costs indication excl/incl	€ 140 – 150/m² (special prices possible)
Revenue	Highly dependent on various factors (insulation etc)
Efficiency	96% (transformer), 100% (elements)
Energy (consumption)	43 - 49 W/m²
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	20 years warranty

Notes: Low voltage (24V). 1,2mm thickness. Each room can be independently zoned and kept at different temperatures making it more efficient and clean than forced air. Maintenance-free. Bio-degradable and non-hazardous. 0% failure-rate. Additional sheets available.



69

Theperfectheat.com. (n.d.). [online] Available at: https://www.theperfectheat.com/technology [Accessed 15 Nov. 2018].
Theperfectheat.com. (n.d.). [online] Available at: https://www.theperfectheat.com/products-applications/residential-floor-heating [Accessed 15 Nov. 2018].
Theperfectheat.com. (n.d.). [online] Available at: https://www.theperfectheat.com/learning-center [Accessed 15 Nov. 2018].

(Theperfectheat.com, n.d.)

Regular floor heating

How does it work?	Hot water flows through the tubes, giving its radiant heat towards the floor. This creates a comfortable lower temperature and cooler, upper temperature.
Costs indication excl/incl	/€1.000 (approximately)
Revenue	10-15 years
Efficiency	Quite efficient (low temperature-heating)
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	Depends who is offering

Notes: Subject to leakage. With floor heating, a comfortable temperature is perceived at a lower temperature. Better air quality than houses with radiators.

70

Vloer&Verwarming.nl. (n.d.). *Kosten vloerverwarming 2019 - overzicht | Vloer&Verwarming.nl*. [online] Available at: https://www.vloerenverwarming.nl/kosten-vloerverwarming/ [Accessed 11 Jan. 2019].
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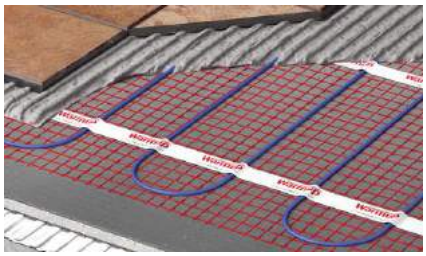
(Verbouwkosten, n.d.)

Eigenhuis.nl. (n.d.). *Vloerverwarming*. [online] Available at: https://www.eigenhuis.nl/huis-duurzaam-maken/energiehuis/vloerverwarming [Accessed 11 Jan. 2019].
(Eigenhuis.nl, n.d.)

Electric floor heating

How does it work?	Temperature is regulated by a thermostat. The wires are heated up purely with electricity. The wires radiate heat through the floor.
Costs indication excl/incl	/€350 (approximately)
Revenue	10-15 years
Efficiency	Up to 100%
Energy (consumption)	150W/m²
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	Depends who is offering

Notes: With floor heating, a comfortable temperature is perceived at a lower temperature. Better air quality than houses with radiators.



71

Vloer&Verwarming.nl. (n.d.). *Kosten vloerverwarming 2019 - overzicht | Vloer&Verwarming.nl*. [online] Available at: https://www.vloerenverwarming.nl/kosten-vloerverwarming/ [Accessed 11 Jan. 2019].
(Vloer&Verwarming.nl, n.d.)

Verbouwkosten. (n.d.). *Vloerverwarming - Verbouwkosten | 2018*. [online] Available at: https://www.verbouwkosten.com/verwarming/vloerverwarming/ [Accessed 11 Jan. 2019].
(Verbouwkosten, n.d.)

Eigenhuis.nl. (n.d.). *Vloerverwarming*. [online] Available at: https://www.eigenhuis.nl/huis-duurzaam-maken/energiehuis/vloerverwarming [Accessed 11 Jan. 2019].
(Eigenhuis.nl, n.d.)

Arconell.nl. (n.d.). *Alles over Arconell elektrische vloerverwarming, kostenvergelijking met CV vloerverwarming*. [online] Available at: http://www.arconell.nl/watuwetenoverele.html [Accessed 23 Jan. 2019].

(Arconell.nl, n.d.)


Obtaining Heat
Discovery/ Research
Visual/ Concept
Production/ Product
technologies
Solar collector - flat panels
Rocket Stove - Lite
Rocket Stove - 5
Biomass boiler
NANO-STEP
Regular floor heating
Electric floor heating
stage of research
stage of conceptualization
stage of product/market development
Legend:
slowly developing
processing
accelerating

Heating

Storing heat

Discovery/Research phase

Heating - storing

Visual/Conceptual phase

Heating - storing

Production/Product phase

Heating - storing

Heat-gaining house

How does it work?	A concrete wall contains tubes filled with glycol, to withdraw heat from the wall. In this house a heating engine will extract the thermal energy from the closed glycol-circuit, which is directed to a boiler for e.g. floor-heating.
Costs indication excl/incl	
Revenue	6 years
Efficiency	Up to 45% nota difference with conventional CV's
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: The house is located in Delden. 'Bouwbedrijf Janssen de Jong Bouw' made the house possible.

*

77

Warmtepomp-weetjes.nl. (2018). *Brine-Water Warmtepomp Toepassing Gesloten Bron*. [online] Available at: https://warmtepomp-weetjes.nl/soorten/brine-water-warmtepomp/ [Accessed 30 Nov. 2018].
(Warmtepomp-weetjes.nl, 2018)

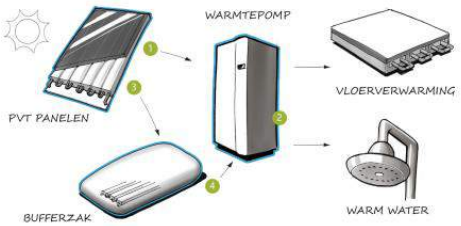
De Groene Dagobert. (2013). *Warmtewinwoning - De Groene Dagobert*. [online] Available at: http://groenedagobert.nl/warmtewinwoning/ [Accessed 8 Jan. 2019].
(De Groene Dagobert, 2013)

Ingenieursbureau Gadella. (n.d.). *Eerste WarmteWinWoning opgeleverd in Delden | Ingenieursbureau Gadella*. [online] Available at: http://www.ibgadella.nl/eerste-warmtewinwoning-opgeleverd-in-delden [Accessed 8 Jan. 2019].
(Ingenieursbureau Gadella, n.d.)

Solarfreezer

How does it work?	Excessive energy, collected with e.g. solar panels is stored into buffers that change phase to store - and later on - release the energy. Water is inside the buffer and a cooling liquid can extract the heat from the water.
Costs indication excl/incl	
Revenue	
Efficiency	
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: A good isolation of the house is needed, including the floor isolation.



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Solarfreezer.nl. (n.d.). *Homepage*. [online] Available at: https://www.solarfreezer.nl/ [Accessed 10 Jan. 2019].
(Solarfreezer.nl, n.d.)

Heating

Managing heat

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Discovery/Research phase

Heating - managing

80

Visual/Conceptual phase

Heating - managing

81

Production/Product phase

Heating - managing

Heating

Obtaining, storing and/or managing heat

83

Discovery/Research phase

Heating - combinations

84

Visual/Conceptual phase

Heating - combinations

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Production/Product phase

Heating - combinations

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Tankless Water Heater

How does it work?	This tankless heater by Heatworks uses graphite electrodes and electronic controls to increase the energy state of the water molecules, so they move faster. Kinetic energy turns into heat. (Ohmic Array Technology*). Provides instant, on demand, hot water.
Costs indication excl/incl	/€697,29 (retail price)
Revenue	Within 4 years
Efficiency	99%
Energy (consumption)	6,2-24 kW
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	6 year warranty full unit exchange, 4 year extended

Notes: Tankless water heater. Heats to the temperature you want (app).
*Patents: 7,817,906,B2; 8,861,943,B2; 9,587,853,B2. **Interested in partnership!** Contact details in speaker notes.

https://www.youtube.com/watch?time_continue=1&v=TcsoYWC4xKQ

87

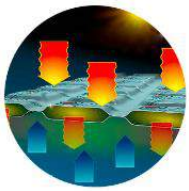
MyHeatworks.com. (n.d.). *MODEL 3 Tankless Electric Water Heater Specifications*. [online] Available at: https://myheatworks.com/pages/model-3-specs [Accessed 26 Nov. 2018].
(MyHeatworks.com, n.d.)

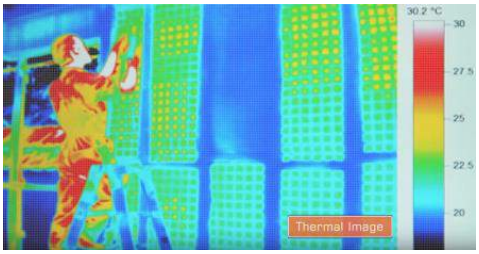
Contact: https://myheatworks.us11.list-manage.com/subscribe?u=fb83e2409b6112bd3f6cd611e&id=4e265a3aa3

Phase Changing Material (PCM) panels

How does it work?	Segmented pieces of PCM are embedded in a sheet of paper. The gel begins to melt at a certain temperature (e.g. 20 °C) With Q24 the maximum temp is 24 °C. So it stores energy between 20 -24 °C. When it becomes under 20 °C the PCM releases heat.
Costs indication excl/incl	/€115/m²
Revenue	
Efficiency	Reduces heating and cooling loads from 40 to 80%
Energy (consumption)	153 Wh/m²
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5 → mss 4, hangt af van revenue
Lifetime prognose	87 years (up to now)

Notes: Additional fire protection (21 minutes). Biodegradable, made from plant materials. Neutral Carbon-footprint. 1 m² = 3 kg. Meant for ceilings and walls (upcoming). The PCM consists of Derivatives of fatty acids, fatty alcohols, esters, emulsifiers, thickening agents and proprietary cross linkers.
~~Active vs. passive systems available.~~





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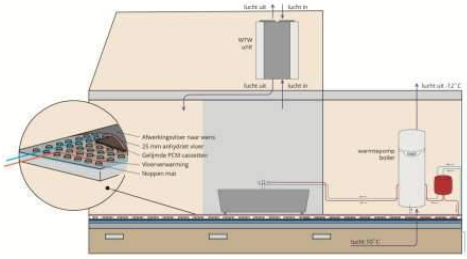
Phasechange.com.au. (n.d.). *BioPCM | Product*. [online] Available at: http://phasechange.com.au/product#toggle-id-6 [Accessed 21 Nov. 2018]. (Phasechange.com.au, n.d.)

(Hamada, Nakamura, Ochifuji, Yokoyama, & Nagano, 2003)

PCM Autarkis

How does it work?	This PCM contains a water + salt-based substance, which will start storing energy at a certain temperature by liquifying. When it releases heat, it crystallizes again. The substance is held in a HDPE shell and can be released if necessary.
Costs indication excl/incl	/€105/m²
Revenue	
Efficiency	97%
Energy (consumption)	240 Wh/m² vloer
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	year warranty full unit exchange, year extended



Notes: Combinated with a (cheap) 3,5 kW heating pump which will provide the house with enough heat and warm water. The system can be delivered together with a WTW (warmtewinning systeem) to optimize a constant inside temperature. For heating AND cooling. Additional sheets available. https://www.youtube.com/watch?v=ZM4Ha7-IY3o

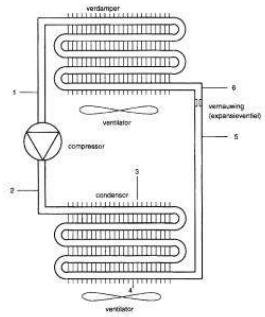
92

Orangeclimate.com. (n.d.). *PCM voor de woningbouw*. [online] Available at: https://www.orangeclimate.com/nl/ocautarkis/producten/woningen [Accessed 8 Jan. 2019].
(Orangeclimate.com, n.d.)

Air – Air heat pump

How does it work?	A ventilator blows warm air on tubes filled with a cold liquid. The cold liquid absorbs the heat and evaporates. A compressor increases the pressure, and therefore the temperature. The hot damp heats up and air is pulled from around the hot tubes resulting in a warm airstream.
Costs indication excl/incl	/€4.000 – 7.000
Revenue	9 – 10 years
Efficiency	Not very effective in winter for heating
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: Can heat as well as cooling. Cannot be connected to existing heating systems inside the house. Suitable for small spaces, one general space. Easy installation. **Feels more suitable for renovation of houses.**
Example product for efficiency, lifetime prognose etc?



Centraal lucht/lucht warmtepomp voorbeeld (komt in ons land nagenoeg niet voor in woningen)

93

Interieurdesigner. (n.d.). *Warmtepomp: Werking en soorten warmtepompen*. [online] Available at: https://www.interieurdesigner.be/bouwen-verbouwen/detail/warmtepomp-werking-en-soorten-warmtepompen [Accessed 9 Jan. 2019].
(Interieurdesigner, n.d.)

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(Warmtepomp-info.nl, n.d.)

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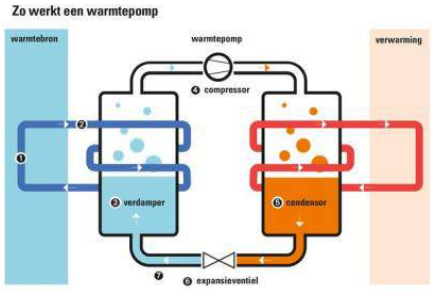
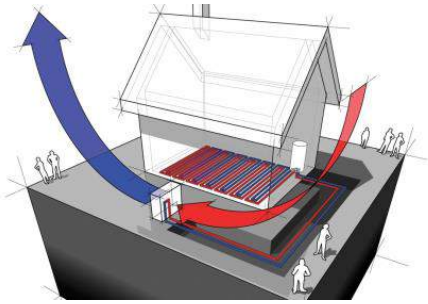
(Warmtepomp-info.nl, n.d.)

Air – Water heat pump

How does it work?	A ventilator blows warm air on tubes filled with a cold liquid. The cold liquid absorbs the heat and evaporates. A compressor increases the pressure, and therefore the temperature. The hot damp heats tubes for consumable water or floor heating. After that it condenses and the valve takes off the pressure.
Costs indication excl/incl	/€4.000 - 7.000
Revenue	10 – 20 years
Efficiency	Dependent on outside temperature
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: No deep ground digging needed (handy for modularity). For every heating pump system **the two biggest factors for revenue are the purchase price and mounting costs together with the expected savings on the energy bill.**





94

Interieurdesigner. (n.d.). *Warmtepomp: Werking en soorten warmtepompen*. [online] Available at: https://www.interieurdesigner.be/bouwen-verbouwen/detail/warmtepomp-werking-en-soorten-warmtepompen [Accessed 9 Jan. 2019].
(Interieurdesigner, n.d.)

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(Warmtepomp-info.nl, n.d.)
Picture: van Gerven, M. (2017). *Maak kennis met de warmtepomp - Vereniging Eigen Huis*. [online] Eigenhuis.nl. Available at: https://www.eigenhuis.nl/besparen-op-energie/warmtepompen-en-zonneboilers/maak-kennis-met-de-warmtepomp [Accessed 27 Nov. 2018].
(van Gerven, 2017)

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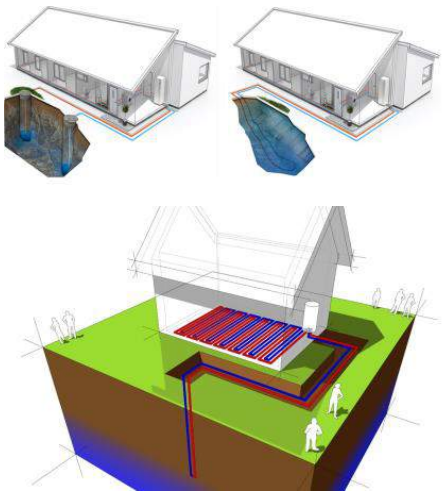
(Vaillant.nl, n.d.)

Water- Water heat pump

How does it work?	Heat is extracted from ground water. This heat is upscaled through a heat exchanger to useable energy to heat your home or tap water. When the energy is extracted, the cold liquid in the tubes will go through the cycle again to get heated.
Costs indication excl/incl	/€15.0000 (drilling excluded)
Revenue	15 – 20 years
Efficiency	Highest efficiency of heating pump techniques
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: The deeper the water in the ground, the deeper they have to drill, the more it will cost. Cooling also possible with the same system. Different ways to have the same system is to have a cold and hot water buffer. A buffer is needed, because the system isn't as efficient throughout the whole day.



95

Interieurdesigner. (n.d.). *Warmtepomp: Werking en soorten warmtepompen*. [online] Available at: https://www.interieurdesigner.be/bouwen-verbouwen/detail/warmtepomp-werking-en-soorten-warmtepompen [Accessed 9 Jan. 2019].
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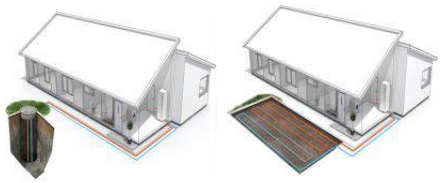
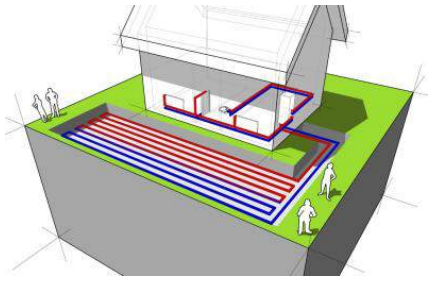
(Eltechno, n.d.)

Ground – Water heat pump

How does it work?	Heat is extracted from geothermal temperature differences. This heat is upscaled through a heat exchanger to useable energy to heat your home or tap water. When the energy is extracted, the cold liquid in the tubes will go through the cycle again to get heated.
Costs indication excl/incl	/€10.000 – 25.0000 (drilling excluded)
Revenue	15 - 20 years
Efficiency	
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: Vertical system is going deeper, resulting in a more stable energy source. Horizontal system is cheaper for digging. In winter the vertical system is more efficient. With a horizontal system you cannot plant anyting above it. Vertical system, not clear in advance how far they will need to dig.





96

Interieurdesigner. (n.d.). *Warmtepomp: Werking en soorten warmtepompen*. [online] Available at: https://www.interieurdesigner.be/bouwen-verbouwen/detail/warmtepomp-werking-en-soorten-warmtepompen [Accessed 9 Jan. 2019].
(Interieurdesigner, n.d.)

Warmtepomp-info.nl. (n.d.). *Warmtepomp: informatie & prijzen 2018 — Warmtepomp-info.nl*. [online] Available at: https://www.warmtepomp-info.nl/ [Accessed 27 Nov. 2018].
(Warmtepomp-info.nl, n.d.)

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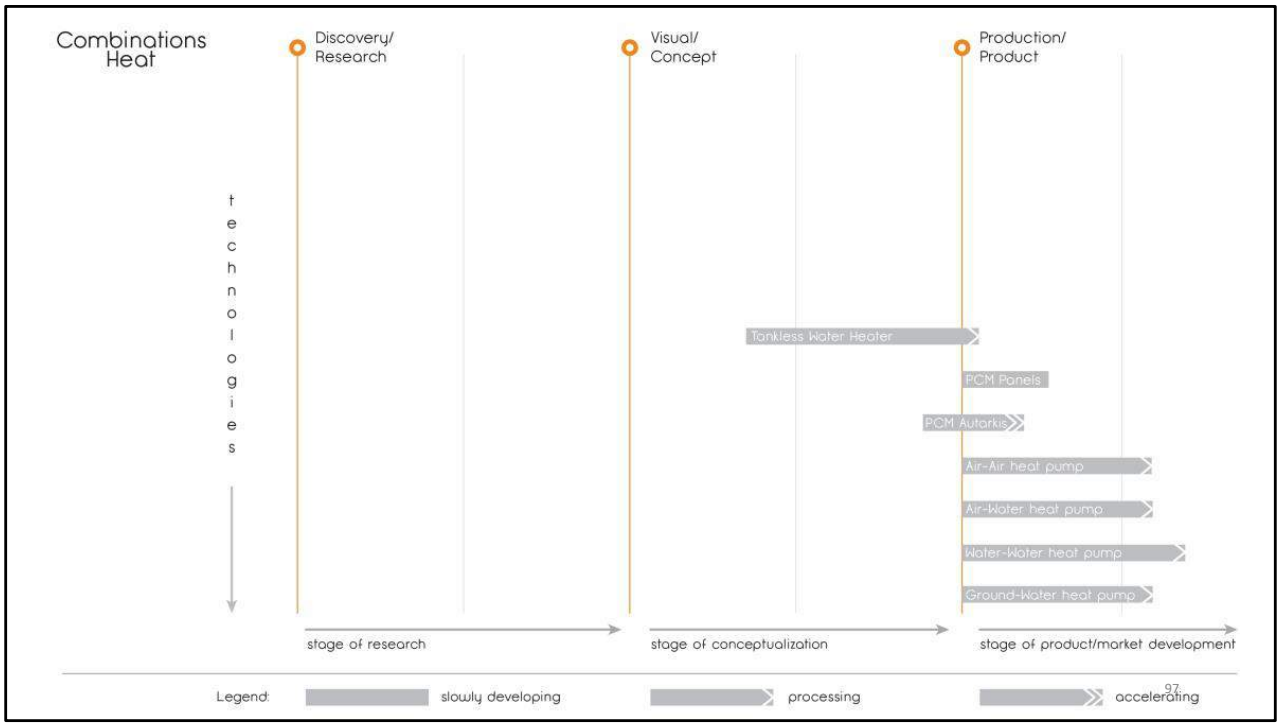
(Eltechno, n.d.)


Combinations
Heat
Discovery/
Research
Visual/
Concept
Production/
Product
technologies
Tankless Water Heater
PCM Panels
PCM Autarkis
Air-Air heat pump
Air-Water heat pump
Water-Water heat pump
Ground-Water heat pump
stage of research
stage of conceptualization
stage of product/market development
Legend:
slowly developing
processing
accelerating
97

Ventilation

Discovery/Research phase

Ventilation

Visual/Conceptual phase

Ventilation

100

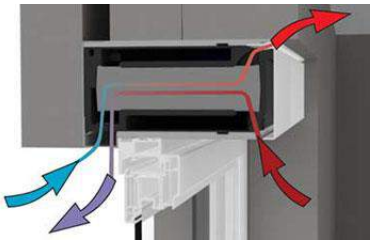
Production/Product phase

Ventilation

Mechanical WTW

How does it work?	Aluminum housing with a unit that holds a ventilator, heat exchanger and heat recovery system. They can blow 15 – 75m³/hour. This can be adjusted with a remote (or humidity and CO_2 sensors in the future). It is also possible to cool with this system by creating only one airstream.
Costs indication excl/incl	€1.500/€1.899/meter (CO_2, humidity sensor) + unit
Revenue	Regular grid is €150 - 250/meter
Efficiency	82 – 86%
Energy (consumption)	0,2 – 0,4 W/m³/h
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	10 years warranty

Notes: The air coming inside or going out is flowing through a filter. This can hold very fine dust or pollen. No air-channels needed, resulting in lower construction costs. Filters can be changed easily. Ventilation on the rooms of your own choice. Sheet available with all the options.



102

Windows4u.nl. (n.d.). *Kozijnen voor optimale isolatie en passief wonen*. [online] Available at: https://www.windows4u.nl/home/passief-wonen [Accessed 13 Dec. 2018].
(Windows4u.nl, n.d.)

Decentralized heat recovery

How does it work?	Filthy air flows through a very fine-meshed ceramic heat accumulator, which extracts heat from the air and given to the air from outside entering the house. The ventilator contains lamella to close the opening if the system is shut down.
Costs indication excl/incl	Only for rooms up to 60m³
Revenue	
Efficiency	Up to 97%
Energy (consumption)	3,61 Watt
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	

Notes: The heat recover system is placed in the room that needs to stay on the right temperature and can be mounted on walls with a thickness from 12 – 47cm. No ventilation channels needed for the spaces that need to stay warm. Noise 20 dB (3 meter distance) and 11 dB (1 meter distance). Outside it is 42 dB (DIN EN 20140).

MOTOR ECO

103

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(Rattanart.n.my, n.d.)

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(Carnahan, n.d.)

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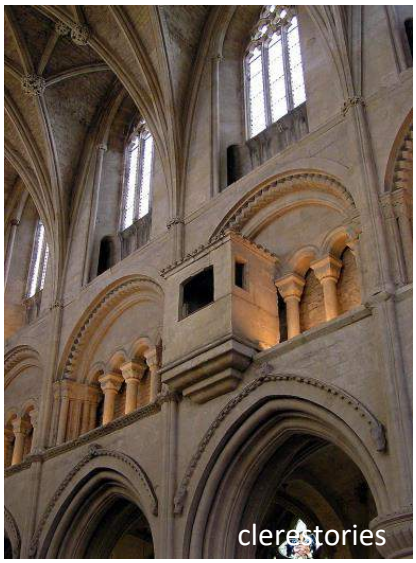
(Lynn, 2015)

Ventilation by construction



One Green Planet. (2013). *10 Natural Ventilation Tips For Your Home*. [online] Available at: https://www.onegreenplanet.org/lifestyle/10-natural-ventilation-tips-for-your-home/ [Accessed 10 Dec. 2018].
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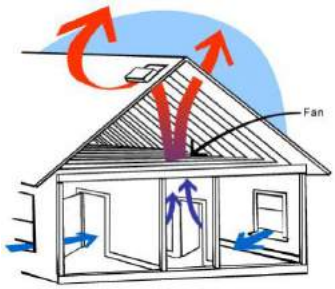
(Aw-arch.com, n.d.)

Ventilation (conventional)



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(Ggdhaaglanden.nl, n.d.)

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(Ventilatiesysteemabcd.nl, n.d.)

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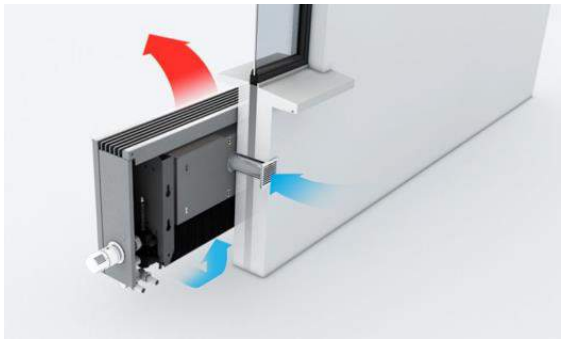
(Toolkit Duurzaam Erfgoed, n.d.)

Ventilation + heating JAGA in ‘s Hertogenbosch


http://www.jaga.nl/

All-in ones

Energy and/or heat and/or ventilation

SUSNANO (1/4) – Photovoltaic

How does it work?	NANO paste that can be applied ('printed') onto smooth surfaces. The photovoltaic coating can capture energy with the slightest light rays, even in low light intensities and shadows.
Costs indication excl/incl	
Revenue	
Efficiency	
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	30 years (approximation)

Notes: >1mm thickness, no problems with overheating, can be integrated in any environment considering functionality and the visual aspect, homogeneous surface, evenly disperced, environmental-friendly. Additional sheets available.

114

zonnecollector, R. (n.d.). *Het rendement van een zonnecollector*. [online] Zonnepanelen-weetjes.nl. Available at: https://www.zonnepanelen-weetjes.nl/zonnecollector/rendement-zonnecollector/ [Accessed 21 Nov. 2018]. (zonnecollector, n.d.)

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En.wikipedia.org. (n.d.). *Solar thermal collector*. [online] Available at: https://en.wikipedia.org/wiki/Solar_thermal_collector [Accessed 22 Nov. 2018]. (En.wikipedia.org, n.d.)

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SUSNANO (2/4) – Battery coating

How does it work?	The battery coating for storing energy has no predefined shape and is even unrestricted. The stored energy can be used for heat or electricity. The coating equals a self-contained system which can save and provide energy.
Costs indication excl/incl	
Revenue	
Efficiency	
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	30 years (approximation)

Notes: Can be printed on any smooth surface, produced via a modified silkscreen process, homogeneous surface, evenly disperced, environmental-friendly. Additional sheets available.

115

zonnecollector, R. (n.d.). *Het rendement van een zonnecollector*. [online] Zonnepanelen-weetjes.nl. Available at: https://www.zonnepanelen-weetjes.nl/zonnecollector/rendement-zonnecollector/ [Accessed 21 Nov. 2018]. (zonnecollector, n.d.)

2-Improve. (n.d.). *Prisma Pro 24 CPC Zonnecollector 2943 Wp vermogen*. [online] Available at: https://2-improve.com/winkel/heatpipes-2/prisma-pro-24-cpc-zonnecollector-met-2943-wp-vermogen/ [Accessed 21 Nov. 2018]. (2-Improve, n.d.)

En.wikipedia.org. (n.d.). *Solar thermal collector*. [online] Available at: https://en.wikipedia.org/wiki/Solar_thermal_collector [Accessed 22 Nov. 2018]. (En.wikipedia.org, n.d.)

Viessmann

SUSNANO (3/4)– Luminescent

How does it work?	Converts energy into light with NANO material.
Costs indication excl/incl	
Revenue	
Efficiency	96%
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	>20 years (approximation) = 50.000 hours

Notes: 2/1000 mm, various colours and shapes can be implemented, when printed on smooth surfaces, possibilities to flash and/or dimm, homogeneous surface, evenly disperced, environmental-friendly. Additional sheets available.

116

zonnecollector, R. (n.d.). *Het rendement van een zonnecollector*. [online] Zonnepanelen-weetjes.nl. Available at: https://www.zonnepanelen-weetjes.nl/zonnecollector/rendement-zonnecollector/ [Accessed 21 Nov. 2018]. (zonnecollector, n.d.)

2-Improve. (n.d.). *Prisma Pro 24 CPC Zonnecollector 2943 Wp vermogen*. [online] Available at: https://2-improve.com/winkel/heatpipes-2/prisma-pro-24-cpc-zonnecollector-met-2943-wp-vermogen/ [Accessed 21 Nov. 2018]. (2-Improve, n.d.)

En.wikipedia.org. (n.d.). *Solar thermal collector*. [online] Available at: https://en.wikipedia.org/wiki/Solar_thermal_collector [Accessed 22 Nov. 2018]. (En.wikipedia.org, n.d.)

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SUSNANO (4/4)– Self-heating

How does it work?	This self-heating NANO coating uses energy to create a warm layer on a smooth surface.
Costs indication excl/incl	
Revenue	
Efficiency	100%
Energy (consumption)	
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	>20 years (approximation)

Notes: This NANO coating doesn't require any maintenance, very efficient and can be applied where is needed (floor or wall). Covering 25% of a room the room temperature can be 21°C with an outside temperature of -10°C. Additional sheets available.

117

zonnecollector, R. (n.d.). *Het rendement van een zonnecollector*. [online] Zonnepanelen-weetjes.nl. Available at: https://www.zonnepanelen-weetjes.nl/zonnecollector/rendement-zonnecollector/ [Accessed 21 Nov. 2018]. (zonnecollector, n.d.)

2-Improve. (n.d.). *Prisma Pro 24 CPC Zonnecollector 2943 Wp vermogen*. [online] Available at: https://2-improve.com/winkel/heatpipes-2/prisma-pro-24-cpc-zonnecollector-met-2943-wp-vermogen/ [Accessed 21 Nov. 2018]. (2-Improve, n.d.)

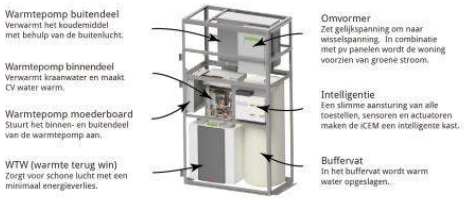
En.wikipedia.org. (n.d.). *Solar thermal collector*. [online] Available at: https://en.wikipedia.org/wiki/Solar_thermal_collector [Accessed 22 Nov. 2018]. (En.wikipedia.org, n.d.)

Viessmann

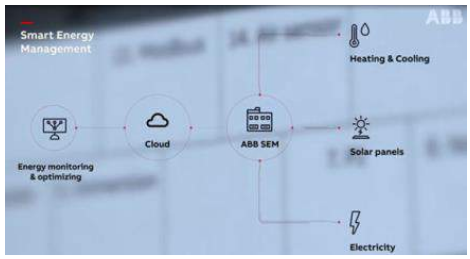
iCEM



How does it work?	A module that exist of an air-water pump for warm water, a WTW-unit for ventilation, a boiler for warm water and thermal storage, an inverter and a combination of a control and monitoring system.
Costs indication excl/incl	€11.900/14.400 (ex PV panels)
Revenue	15 - 20 years (see talk notes)
Efficiency	3,8 (heat), 1,8 (water) SPF situational
Energy (consumption)	3,8 (heat), 1,8 (water) SPF situational
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	15 years technical lifetime (€465/565 a year)



Notes: 10 years warranty if subscription is met (performance). 12 months for product warranty. NOM (Nul Op de Meter) guaranteed. Out- or inside option possible. Additional sheets available. Applied in Herveld, NL.



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SPF (Seasonal Performance Factor) is ook een indicator, zoals COP, om het rendement te kunnen bepalen van een warmtepomp. Het enige verschil is dat COP wordt berekend aan de hand van nominale voorwaarden (bijvoorbeeld een constante brontemperatuur van 10° Celsius), terwijl SPF het gemiddelde rendement berekent van een volledig stookseizoen. SPF houdt rekening met mechanische, elektrische en thermische verliezen en is daardoor een nog betere maatstaf om warmtepompen te kunnen vergelijken.

Hoe wordt aandacht gegeven aan comfortbeleving als het gaat om luchtstromen, koudeval en installatiegeluiden?
De ventilatie unit opereert vrijwel geruisloos voor wat betreft inblaaslucht en machinegeluid. De warmtepomp zal geluid produceren maar door een buitenopstelling
zullen de bewoners daar binnen geen hinder van ondervinden. Met slimme algoritmes wordt de inzet van de warmtepomp op vol vermogen zoveel mogelijk voorkomen.

New.abb.com. (n.d.). *SEM - Woningbouw producten | ABB*. [online] Available at: https://new.abb.com/low-

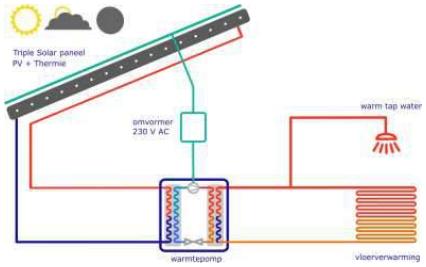
voltage/nl/producten/woningbouwproducten/sem?gclid=CjwKCAiArK_fBRABEiwA0gOOc0I7KXnkQydua1FvPrNypsZS7LT0-DEUHwsWnp29hBHS4Q7jGMgCeBoCgZ8QAvD_BwE [Accessed 15 Nov. 2018]. (New.abb.com, n.d.)

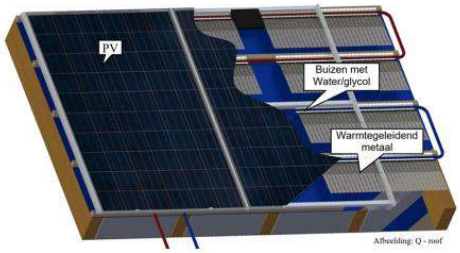
Factory Zero B.V. (n.d.). *iCEM-buitenoplossing - Factory Zero B.V.*. [online] Available at: https://factoryzero.nl/icem_buitenoplossing/ [Accessed 19 Dec. 2018]. (Factory Zero B.V., n.d.)

“Wat betreft de terug verdiend tijd is het niet zo eenvoudig eigenlijk moet je de gasrekening van de bewoners nemen daar we die niet meer nodig hebben en daarop het verschil nemen tussen het extra elektra verbruik (1200kWh) door onze unit en de besparing op gas. Dit is het bedrag wat je terugverdiend kan je terugrekenen in tijd op basis van prijs € 11900. Wanneer je zonnepalen gaat toepassen gaat dit natuurlijk veel sneller en efficienter want bij panelen met 300waatpiek heb je maar 4 panelen nodig om onze unit energie neutraal te maken.”

PV/T + central heating

How does it work?	Panels on the roof are connected to the heating pump. The pump uses energy from the air and energy from daylight and energy from sunlight to provide warm water and heat the house. Triple solar panels can work at night and in winter as well.
Costs indication excl/incl	€ 25.000
Revenue	15 – 20 years
Efficiency	
Energy (consumption)	3.500 Wp (= 3.000 kWh) of solar panels
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	Low energy loads during 25 years, garanteed energy production and little maintenance





Notes:
Works in summer, winter, on the north- or south-side of the roof, but not as efficient on every side. 30° angle is optimal. PV/T weighs 12-14 kg/m².
Meant to deliver high amount of electricity.

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Warmtepomp-weetjes.nl. (2018). *Brine-Water Warmtepomp Toepassing Gesloten Bron*. [online] Available at: https://warmtepomp-weetjes.nl/soorten/brine-water-warmtepomp/ [Accessed 30 Nov. 2018].
(Warmtepomp-weetjes.nl, 2018)

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(Triple Solar, n.d.)

PV/T panels

How does it work?	Water inside the panel gets heated and is used for consumable water, the solar rays are converted to energy with the PV part.
Costs indication excl/incl	/€ 8.000 – 16.000
Revenue	10 - 25 years
Efficiency	
Energy (consumption)	3.500 Wp (= 3.000 kWh) of solar panels
Sustainability grade	0 / + / ++
Comfort grade	1 / 2 / 3 / 4 / 5
Lifetime prognose	30 years warranty

Notes: Works in summer, winter, on the north- or south-side of the roof, but not as efficient on every side. 30° angle is optimal. PV/T weighs 12-14 kg/m². Meant to deliver high amount of electricity.

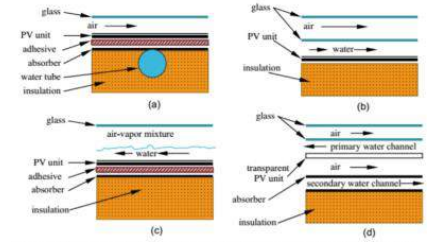
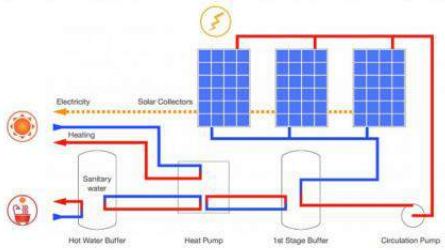


Figure 6 Structure of different types of PV/T collectors (a) sheet-and-tube PV/T, (b) channel PV/T, (c) free-flow PV/T and (d) two-absorber PV/T [20].



120

Zonne-paneel.net. (n.d.). *Hybride zonnepanelen: soorten en info*. [online] Available at: https://www.zonne-paneel.net/hybride-zonnepanelen/ [Accessed 28 Nov. 2018]. (Zonne-paneel.net, n.d.)

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(Zonne-paneel.net, n.d.)

Smartclima. (n.d.). *Solar PVT Panel manufacturer-exporter China*. [online] Available at: http://www.smartclima.com/solar-pvt-panel [Accessed 28 Nov. 2018]. (Smartclima, n.d.)

Products.newformenergy.ie. (n.d.). *Welcome to Newform Energy Ireland a forward thinking renewable energy company*. [online] Available at: http://products.newformenergy.ie/photovoltaic-thermal-pvt.php [Accessed 10 Jan. 2019].
(Products.newformenergy.ie, n.d.)

Öner, İ. V., YeşiLyurt, M. K., Yilmaz, E. Ç., & Ömeroğlu, G. (2016). Photovoltaic (PVT) Solar Panels, *2*(12), 5.
(Öner, YeşiLyurt, Yilmaz, & Ömeroğlu, 2016)

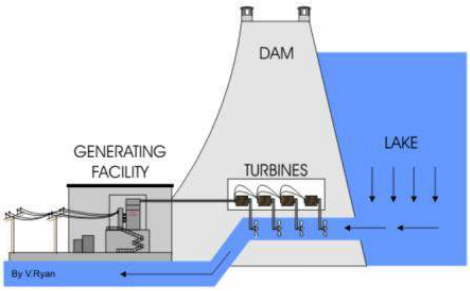

Combinations
Energy
Heat
Ventilation
Discovery/
Research
Visual/
Concept
Production/
Product
technologies
NANO Photovoltaic
NANO Battery coating
NANO Luminescent
NANO Self-Heating
ICEM
Triple solar
PVT panels
stage of research
stage of conceptualization
stage of product/market development
Legend:
slowly developing
processing
accelerating

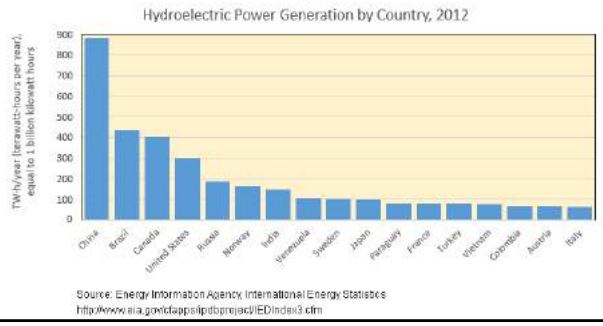
Bigger energy suppliers

Technologies that were not found fully suitable for concept Habitat, but for the complete overview is enclosed separately.

Hydro

- Hydropower represents about 17% (International Energy Agency) of total electricity production.
- First hydroplant to power a lamp in 1878





Pica: Mbogo, M. (2018). *Angola takes lead in Hydropower plant capacity*. [online] Construction Review Online. Available at: https://constructionreviewonline.com/2018/05/angola-takes-lead-in-hydropower-plant-capacity/ [Accessed 30 Nov. 2018].
(Mbogo, 2018)

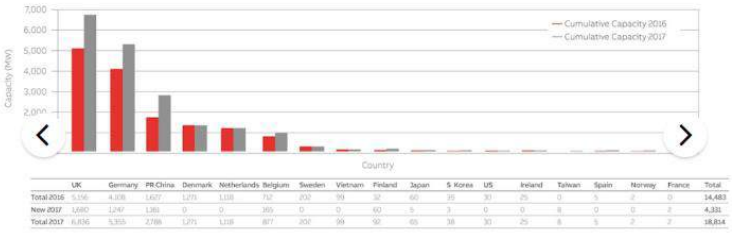
GIF werking hydrodam: https://gifer.com/en/BbvH

Perlman, H. (2018). *Hydroelectric power and water. Basic information about hydroelectricity, the USGS Water Science School.*. [online] Water.usgs.gov. Available at: https://water.usgs.gov/edu/wuhy.html [Accessed 30 Nov. 2018].
(Perlman, 2018)

Wind turbines

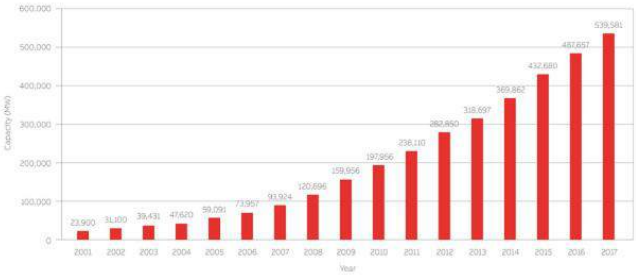
- Annual growth of 13% over 5 years
- 540GW in 2017
- 1887 first electricity-generating turbine

- Generating sound for domestic purposes not ideal



	UK	Germany	PR China	Denmark	Netherlands	Belgium	Sweden	Vietnam	Finland	Japan	S Korea	US	Ireland	Taiwan	Spain	Norway	France	Total
Total 2016	5,196	4,108	1,607	1,271	1,118	712	202	99	32	60	35	30	25	0	5	2	0	14,483
New 2017	1,640	1,247	1,181	0	0	165	0	0	60	5	3	0	0	8	0	0	2	4,331
Total 2017	6,836	5,355	2,788	1,271	1,118	877	202	99	92	65	38	30	25	8	5	2	2	18,814

1/2 3a Installed offshore wind capacity worldwide: Cumulative offshore wind capacity by country 2016 versus 2017.



02 Global cumulative installed wind capacity 2001 to 2017.

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Krontiris, A. and Sandeberg, P. (2018). *HVDC technology for offshore wind is maturing*. [online] New.abb.com. Available at: https://new.abb.com/news/detail/8270/hvdc-technology-for-offshore-wind-is-maturing [Accessed 30 Nov. 2018].
(Krontiris and Sandeberg, 2018)

APPENDIX E

EXCEL OVERVIEW

All the technologies/products have been assessed on its sustainability-grade and comfort-grade. The excel sheet shows the technologies/products and in which phase of development they are currently. Furthermore it shows how the product or technology works, costs, revenue, efficienct, energy delivery/consumption, grade of sustainability and comfort, lifetime prognose and notes of how the assessment came to the rating it received. Some boxes have a certain color because the company of the product had been contacted but did not respond back.

	Technology	How does it work?	Costs indication	Revenue	Efficiency
Discovery/Research					
	Solar Fabric	This fabric is a flexible, breathable and lightweight material. Fiber-based triboelectric nanogenerators, along with wire-shaped solar cells made of polymer fibers, were woven in with strands of wool to create the material.	Relatively cheap		
	Power Felt	This fabric consists out of nanotubes which are positioned and locked within plastic fibers. With thermoelectric power conversion, a charge can be given when a temperature difference is present. Additionally, mechanical noise can provide energy.			
	Green Fluorescent Protein (GFP)	Green Fluorescent Protein (GFP) from the jellyfish called 'Aequorea Victoria', applied to aluminum electrodes and exposed to ultra-violet light generates power measuring in the "tens of nano-amperes."			
Visual/Conceptual					
sales@bipvco.com	Flexible PV film - flextron	FLEXTRON is a 'peel & stick' module with integrated solar cells. Modules are attached to the approved substrate to create a roofing system that can be installed in the same way as a conventional roof. The PV cells convert light into usable energy.			Up to 17%
sales@bipvco.com	Flexible PV film - metektron	Metektron is a standing seam roofing product with integrated solar cells. Factory applied PV cells are integrated directly onto the approved pre-painted steel to create a roofing system that can be installed in the same way as a conventional roof.			Up to 17%
sales@bipvco.com	Flexible PV film - powerply	Roofing product with integrated solar cells. Factory applied PV cells are integrated directly onto the approved single ply membrane to create a roofing system that can be installed in the same way as a conventional roof.			Up tot 16,1%
	Solar roof tiles - Tesla		€ 6.453,31		
	Solarteg solar roof tiles	Solarteg produces solar panels inside roof tiles. Because of their patented technology no wire is needed to connect the solar tiles. (See image) The conducting screw connector is connecting one tile to the other.	€212,50/m² (ex work and shipping)		15,2 - 15,6%
sales@semtive.com	Nemoi domestic size wind turbine M	The helix-shaped blades catch wind, which will make the top part spin which creates energy. The Nemoi turbine uses a vertical axis, because of the efficiency of operation at low wind speeds.	€ 5.615,64	1-7 years	
Production/Product	Nemoi domestic size wind turbine S	The helix-shaped blades catch wind, which will make the top part spin which creates energy. The Nemoi turbine uses a vertical axis, because of the efficiency of operation at low wind speeds.	€ 2.779,67	1-7 years	
solarcentury gemaild op con	Solarcentury IKEA PV panels	Every solar panel has its own optimizer, which adds up to 5% of extra energy production within its lifespan. A monitoring app lets you gain insight into the panels' status and controlling it.	3.159,49/2496	13 years	

not pursued	Aggregate	A 4 stroke engine with diesel/benzine as fuel (depending on the model), which will use the produced energy to provide people from electricity. The Bosch EU22i is an example aggregate to get an indication.	€ 1.184,21/1.499,99		
	Regular PV panels (average)	Solar panels connected in serie with inverter. This is a representation of the average solar panel system for a two person household,	€ 6.274/5.185 (instal. incl) (€ 4.407,25 w.o.)	8 years	15-22%

Energy delivery	Energy consumption	Sustainability	Comfort	Lifetime prognose	Notes
					Fabric can be integrated into various cloths, curtains, tents and so on. Piece of 4x5cm generated 2 volts in one minute with movement and solar energy on a cloudy day.
					Vibration of mobile (mechanical noise) could charge your phone as well. Looks like a normal fabric. Re-use lost energy in the form of heat.
					Biological fuels could enable further research into bio-nanotechnologies that require no external fuel or electrical current to continue functioning. If it could be scaled up, it could become very interesting.
		+	4	Product: 5 years Performance: 10-25 years	Assuming the flexible material is aesthetically prettier than the conventional panels and actually could add value, the only downside would be it produces too little energy to provide enough energy for the whole house. For sustainability it has one + , because it provides a good opportunity of being more sustainable, but the product itself is likely not recyclable.
		+	4	Product: 5 years Performance: 25 years	Assuming the flexible material is aesthetically prettier than the conventional panels and actually could add value, the only downside would be it produces too little energy to provide enough energy for the whole house. For sustainability it has one + , because it provides a good opportunity of being more sustainable, but the product itself is likely not recyclable.
		+	4	Product: 5 years Performance: 10-25 years	Assuming the flexible material is aesthetically prettier than the conventional panels and actually could add value, the only downside would be it produces too little energy to provide enough energy for the whole house. For sustainability it has one + , because it provides a good opportunity of being more sustainable, but the product itself is likely not recyclable.
0,153 kWh/m²	-	++	5	A lifetime warranty for the panels, 30 years warranty on electricity and weather resistance.	These roof tiles are interesting, because they show novelty as there is no difference between conventional panels and the Tesla panels. Because they also create a fair amount of energy and have a very high life expectancy, they are considered very sustainable
0,128 kWh/m²	-	++	5	25 years on manufactering flaws	Quick installation and color can be adjusted to house, material around pv part is recyclable
2,4 kWh	-	++	4	20 years warranty, 40 years lifetime	Although the producer claims the turbine to be soundless, multiple products could create some annoyance. Easy installation. Produced in US
0,6 kWh	-	++	4	20 years warranty, 40 years lifetime	Although the producer claims the turbine to be soundless, multiple products could create some annoyance. Easy installation. Produced in US
994 kWh / year	-	+	4	12 inverter, 25 optimizers, 25 panels (warranty)	Easy access, new tech making it more efficient, easy maintenance and monitoring.

1,8 - 2,2 kWh	Benzine/Diesel	0	1	2 years product warranty	Using fossile fuels to get the energy, makes loads of noise, can only be used outside, heavy, requires your attention
2930 kWh /year with 13 panels	-				

	Technology
Discovery/Research	
	Flexible bio battery
	Tesla megapack
	Blue battery
	Power to Ammonia to Power
Visual/Conceptual	
	Energy Vault
	Tesla Powerwall

How does it work?
This textile oriented bacteria-powered bio-battery is based on the paper based bacteria. Microbial-based power studies are performed to see if we can use bacteria to store energy.
The li-ion batteries store energy retrieved from e.g. solar panels. The battery comes with a transformer which probably will be used to store and use the energy again.
At times when surplus energy is available, electrical energy is used to migrate salt ions against the salinity gradient from a low to high salinity (fig. 1) and the battery is charged. At times when additional electricity is required, the process is reversed by mixing fresh and salt water, generating electricity and discharging the battery.
No carbon in the process. It's a circular process. The goal is to provide more stability in the grid. With this technique it should be possible to store energy for a longer period of time. Most technologies are expected to be available by 2020-2025 to realize the process.
This energy vault stores and releases energy by stacking and unstacking concrete cylinders. It is a six-armed crane that stacks concrete blocks with cheap and abundant grid power, and drops them down to retrieve electricity when needed.
The li-ion batteries store energy retrieved from e.g. solar panels. An app can give you insight into where your generated energy went. The battery can be used as emergency back-up or if there are off-grid intensions, but for that additional hardware is needed. What exactly is remained unknown.

Costs indication	Revenue	Efficiency	Energy delivery	Energy consumption
			2.673 kWh	
		50-60%		8.7-10.3 kWh kg-1 ammonia
Low cost		90%		
€ 6.114,6/7.740 (incl additional hardware of €740)			13,5 kWh storage	

Sustainability	Comfort	Lifetime prognose
		30 - 40 years
		10 year warranty

Notes
These textile-based biobatteries exhibit stable electricity-generating capability when tested under repeated stretching and twisting cycles. With eye on wearables, sweat generated from the human body can be a potential fuel to support bacterial viability, ensuring the long-term operation of the microbial fuel cells.
7,14x1,6 m. Launching around 2020.
Salinity = zoutgehalte. Making use of natural materials, li-ion contains rare materials, blue battery is a sustainable energy storing system that is environmentally safe, cost-effective and applicable in flat terrain. Size of Olympic swimming pool can power 200 houses which converts to 125.000 liters for one house.
Notes: No carbon in the process. It's a circular process. The goal is to provide more stability in the grid. With this technique it should be possible to store energy for a longer period of time. Most technologies are expected to be available by 2020-2025 to realize the process.
Operational around 2020. Mechanical storage. More mechanical energy storages launched but never made it, making this concept also questionable.
Scalable up to 10 powerwalls, pre-order available

	Technology
Discovery/Research	
	Vehicle to Grid (V2G)
Visual/Conceptual	
	LO3 Energy - Exergy

How does it work?
“Vehicle to Grid (V2G) communication is a system in which Electric Vehicles (Evs) communicate with the power grid to return electricity to the grid or throttle the vehicle’s charging rate.”
Exergy™ is a distributed ledger system that functions across grid-connected hardware, a token system for transactive energy, and a foundation that advances market design and technology in tandem. Exergy generates, controls and secures the data required to enable price as a proxy for control and optimal operation of electric power systems.

Costs indication	Revenue	Efficiency	Energy delivery	Energy consumption	Sustainability

Comfort	Lifetime prognose	Notes
	garantie	
		Upcoming technique, first signs of trials are present.
		Notes: Share and transact energy between eachother, using existing grid infrastructure. A prototype of the Exergy blockchain architecture is already operational in the Brooklyn Microgrid (BMG), a peer-to-peer energy market project supported by LO3 Energy and the community it serves. Additional paper. Community, transaction between smart grid and 'normal' home are made possible via blockchain technology. Use technology of someone that produces energy. Could also function if the main grid fails during storms, cyberattacks etc.

	Technology
Visual/Conceptual	
Obtaining, storing and manag	Solpad - Home (grid-tied)
	Solpad - Stand-alone (off-grid)

How does it work?
This version of the solpad has a 300W solar panel. The product contains: the photovoltaic solar panels, inverter, charge controller, and batteries are all contained in the same package. This makes that the products needed downstairs become less.
This version of the solpad has a 72W solar panel. This mobile version includes the inverter, control systems, and a WiFi hotspot all in one device. AC and DC energy delivery.

Costs indication	Revenue	Efficiency	Energy delivery	Energy consumption
no indication			1 kWh storage per panel	
€ 965,62/1.222,31			0,6 kWh storage per panel	

Sustainability	Comfort	Lifetime prognose

Notes
On the market second half of 2017, now available via construction companies (e.g. BAM!). Meant to power an entire house, and can be easily expanded depending on the energy need. I.c.w. SolControl, the user can manage and gain insight in their energy usage.
Will launch after the Solpad Home, didn't meet the initial deadline in 2017. Still not on the market.

	Technology
Production/Product	
	Solar collector - vacuum tubes
	Solar collector - flat panels
	Rocket stove - Lite
	Rocekt stove - 5
	Biomass boiler
	NANO Step Heating Element
	Regular floor heating
	Electric floor heating

How does it work?

The prisma pro 24 tubes creates hot water by concentrating sunrays, which can be used to heat the house or use directly in combination with a solar boiler. Special reflector get the maximum heat from the collected sunrays.
Solar radiation is absorbed by the dark backplate of the panel. Cold water comes in, smaller tubes are distributed through the panel, absorbing the heat resulting in a hot water as output.
This stove uses eco briquettes or wood to heat the room. Because rocket stove utilizes complete combustion, it reduces stench and creates more heat on the same amount of fuel than conventional systems. Thereby, it's CO_2-neutral.
This stove uses eco briquettes or wood to heat the room. Because rocket stove utilizes complete combustion, it reduces stench and creates more heat on the same amount of fuel than conventional systems. Thereby, it's CO_2-neutral.
An efficient way of burning wood for creating heat inside a room or heating water for a heating system or usage/consumption.
The radiant heating element is constructed of two parallel bus braids embedded in a semi-conductive polymeric material. A polymeric dielectric film is applied at the time of manufacture so that the film is thermally fused to the heating material.
Hot water flows through the tubes, giving its radiant heat towards the floor. This creates a comfortable lower temperature and cooler, upper temperature.
Temperature is regulated by a thermostat. The wires are heated up purely with electricity. The wires radiate heat through the floor.

Costs indication	Revenue	Efficiency	Energy delivery
€ 990 – 1.070/1.257– 1.355 (€750 average*)	Up to 10 years (estimation)	66,80%	2500 kWh a year (1417 kWh average for 2,5m²)
/€2.000 – 4.000 (€550 average w/o installation)	4 - 10 years	<66,8% (how much exactly not clear)	1306 kWh for 2,5m²
€ 758,4/960		87%	7 kW power
€1224,5/1550		89,30%	12 kW power
/€1.000 (30 – 33 cents/kg wood pellet)	6-7 years	90-93%	2,7 - 6,17 kW
€ 140 – 150/m²	Highly dependent on various factors (insulation etc)	96% (transformer), 100% (elements)	-
€1.000 approximately	10 - 15 years	Quite efficient (low temperature-heating)	
/€350 approximately	10 - 15 years	Up to 100%	

Energy consumption	Sustainability	Comfort
-	+	3
-	+	4
Wood pellets	0	2
Wood pellets	0	2
Wood pellets	0	3
48,43 W/m²	++	4
	+	4
150W/m²	+	4

Lifetime prognose	Notes
15-20 years (vacuum tubes)	Small discomfort might be experienced in the appearance of the solar collector, sustainability has a + due to its sustainable purpose, but 'bad' materials like copper and aluminium, black coating might be hard to remove, having to change tubes makes it subject to waste. Needs a bigger expansion barrel
20-30 years	Small discomfort in appearance, very robust in comparison to vacuum tube solar collectors
	Sustainability got a relative bad mark because it uses wooden pallets to generate heat. Because the heat will be dispersed from one central point, it could take a while before the whole room is heated. Thereby it is assumed that the type of heat is not always desirable.
	Sustainability got a relative bad mark because it uses wooden pallets to generate heat. Because the heat will be dispersed from one central point, it could take a while before the whole room is heated. Thereby it is assumed that the type of heat is not always desirable.
20 years warranty	Sustainability got a relative bad mark because it uses wooden pallets to generate heat. The discomfort is that you have to fill up the storage of pellets and carry with heavy quantities of wood, it takes a lot of storage and burns a big quantity of wood / year.
20 years warranty	Little hassle to install, comfortable feeling (radiant heat), no maintenance, Energy efficient, efficient heating elements, bio-degradable and non-hazardous. 0% failure-rate. Company located in America.
Depends who is offering	Subject to leakage. With floor heating, a comfortable temperature is perceived at a lower temperature. Better air quality than homes with radiators.
Depends who is offering	Very efficient, needs loads of energy, although the investment costs are relatively low, gives a nice radiant heat, no maintenance, is not very sustainable in the usage of materials, but does not need additional products other than energy to generate heat.

	Technology
Production/Product	
	Tankless Water Heater Heatworks
Contacted on website form	Phase Changing Material (PCM) panels
	PCM Autarkis
	Air - Air heating pump
	Air - Water heating pump
	Water - Water heating pump
	Ground - Water heating pump

How does it work?

This tankless heater by Heatworks uses graphite electrodes and electronic controls to increase the energy state of the water molecules, so they move faster. Kinetic energy turns into heat. (Ohmic Array Technology Patents: 7,817,906,B2; 8,861,943,B2; 9,587,853,B2). Provides instant, on demand, hot water.
Segmented pieces of PCM are embedded in a sheet of paper. The gel begins to melt at a certain temperature (e.g. 20 °C) With Q24 the maximum temp is 24 °C. So it stores energy between 20 -24 °C. When it becomes under 20 °C the PCM releases heat.
This PCM contains a water + salt-based substance, which will start storing energy at a certain temperature by liquifying. When it releases heat, it crystallizes again. The substance is held in a HDPE shell and can be released if necessary.
The system exists of an in- and outside unit. The outside unit pulls air inside. This air is heated to the desired temperature with help of cooling gas, which is heated with the compressor. This gas gives its energy to the air, which is then sucked by the inside unit that enters your home.
A ventilator blows warm air on tubes filled with a cold liquid. The cold liquid absorbs the heat and evaporates. A compressor increases the pressure, and therefore the temperature. The hot damp heats tubes for consumable water or floor heating. After that it condenses and the valve takes off the pressure.
Heat is extracted from ground water. This heat is upscaled through a heat exchanger to useable energy to heat your home or tap water. When the energy is extracted, the cold liquid in the tubes will go through the cycle again to get heated.
Heat is extracted from geothermal temperature differences. This heat is upscaled through a heat exchanger to useable energy to heat your home or tap water. When the energy is extracted, the cold liquid in the tubes will go through the cycle again to get heated.

Costs indication	Revenue	Efficiency	Energy delivery	Energy consumption
/€697,29 (retail pr	4 years	0,99		6,2-24 kW
/€115/m²			153 Wh/m²	
/€105/m²		0,97	240 Wh/m² vloer	
/€4.000 – 7.000		Not very effective in winter for heating		
/€4.000 - 7.000	10-20 years	Dependent on outside temperature		
€15.0000 (drilling	15-20 years	Highest efficienct of heating pump techniques		
€10.000 – 25.000(	15-20 years	Highest efficienct of heating pump techniques		

Sustainability	Comfort	Lifetime prognose
++	5	6 year warranty full unit exchange, 4 year extended
++	5	87 years
++	5	
++	3	
++	4	
++	4	
++	4	

Notes

This product is graded with high comofort, because of the low investment costs, small dimensioned heater, with durable technology, which is modular. Because it can heat energy by using the product water and its high efficiency its rated very sustainable.
The long life expectancy, together with the nature-based ingredients and bio-degadability makes it a very sustainable product. When looking at comfort, it is easy to install when you are building new houses, not difficult, optional active or passive regulated panels and creates an overal nice consistent temperature inside.
The product is creating heat in a more sustainable manner, and is better than conventional heating systems. It doesn't need a lot of alteration to the house in order to function. The product blowing heat can however be apparant in the room that has to be heated. The system probably would need an extra heat source in winter and because it is not conceiled, it is a bit in your face.
The air-water system together with solar panels can be a full-providing system
Together with PV panels a house can be self providing in energy and heat for the whole house. The investment costs are however way higher than an air - air or air - water system. The efficiency is high and can be set up, so it only uses natural energy sources.
Together with PV panels a house can be self providing in energy and heat for the whole house. The investment costs are however way higher than an air - air or air - water system. The efficiency is high and can be set up, so it only uses natural energy sources.

	Technology
Discovery/Research	
	SUSNANO - Photovoltaic
	SUSNANO - Battery
	SUSNANO - Luminescent
	SUSNANO - Self-heating
Production/Product	
wilfried@factoryzero.nl	iCEM
	PV/T + central heating
	PV/T panels

How does it work?
NANO paste that can be applied (‘printed’) onto smooth surfaces. The photovoltaic coating can capture energy with the slightest light rays, even in low light intensities and shadows.
The battery coating for storing energy has no predefined shape and is even unrestricted. The stored energy can be used for heat or electricity. The coating equals a self-contained system which can save and provide energy.
Converts energy into light with NANO material.
This self-heating NANO coating uses energy to create a warm layer on a smooth surface.
A module that exist of an air-water pump for warm water, a WTW-unit for ventilation, a boiler for warm water and thermal storage, an inverter and a combination of a control and monitoring system.
Panels on the roof are connected to the heating pump. The pump uses energy from the air and energy from daylight and energy from sunlight to provide warm water and heat the house. Triple solar panels can work at night and in winter as well.
Water inside the panel gets heated and is used for consumable water, the solar rays are converted to energy with the PV part.

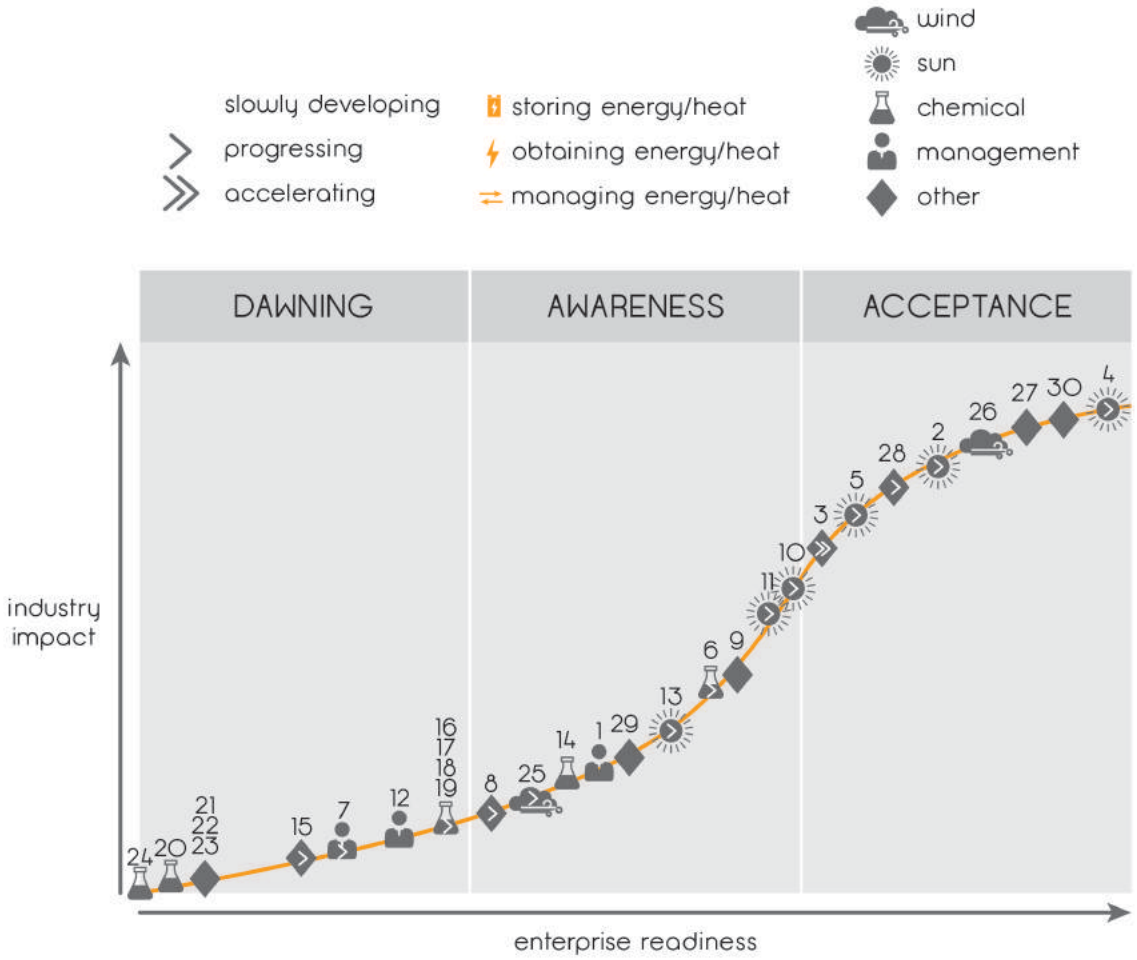
Costs indication	Revenue	Efficiency	Energy delivery	Energy consumption	Sustainability
		96%			
		100%			
€11.900/14.400	15-20 years	>95%	3,8 (heat), 1,8 (water) SPF situational		+
€ 25.000	15-20 years		3.500 Wp(= 3.000 kWh) of solar panels		+
/€ 8.000 - 16.000	10 - 25 years		3.500 Wp(= 3.000 kWh) of solar panels		+

Comfort	Lifetime prognose	Notes
	30 years	>1mm thickness, no problems with overheating, can be integrated in any environment considering functionality and the visual aspect, homogeneous surface, evenly disperced, environmental-friendly. Additional sheets available.
	30 years	Can be printed on any smooth surface, produced via a modified silkscreen process, homogeneous surface, evenly disperced, environmental-friendly. Additional sheets available.
	>20 years (50.000 hours)	2/1000 mm, various colours and shapes can be implemented, when printed on smooth surfaces, possibilities to flash and/or dimm, homogeneous surface, evenly disperced, environmental-friendly. Additional sheets available.
	>20 years	This NANO coating doesn't require any maintenance, very efficient and can be applied where is needed (floor or wall). Covering 25% of a room the room temperature can be 21°C with an outside temperature of -10°C. Additional sheets available.
4	15 years technical lifetime	10 years warranty if subscription is met (performance). 12 months for product warranty. NOM (Nul Op de Meter) guaranteed. Out- or inside option possible. Additional sheets available. Applied in Herveld, NL.
4	Low energy loads during 25 years, garanteed energy production and little maintenance	Works in summer, winter, on the north- or south-side of the roof, but not as efficient on every side. 30° angle is optimal. PV/T weighs 12-14 kg/m². Meant to deliver high amount of electricity.
4	30 years warranty	Works in summer, winter, on the north- or south-side of the roof, but not as efficient on every side. 30° angle is optimal. PV/T weighs 12-14 kg/m². Meant to deliver high amount of electricity.

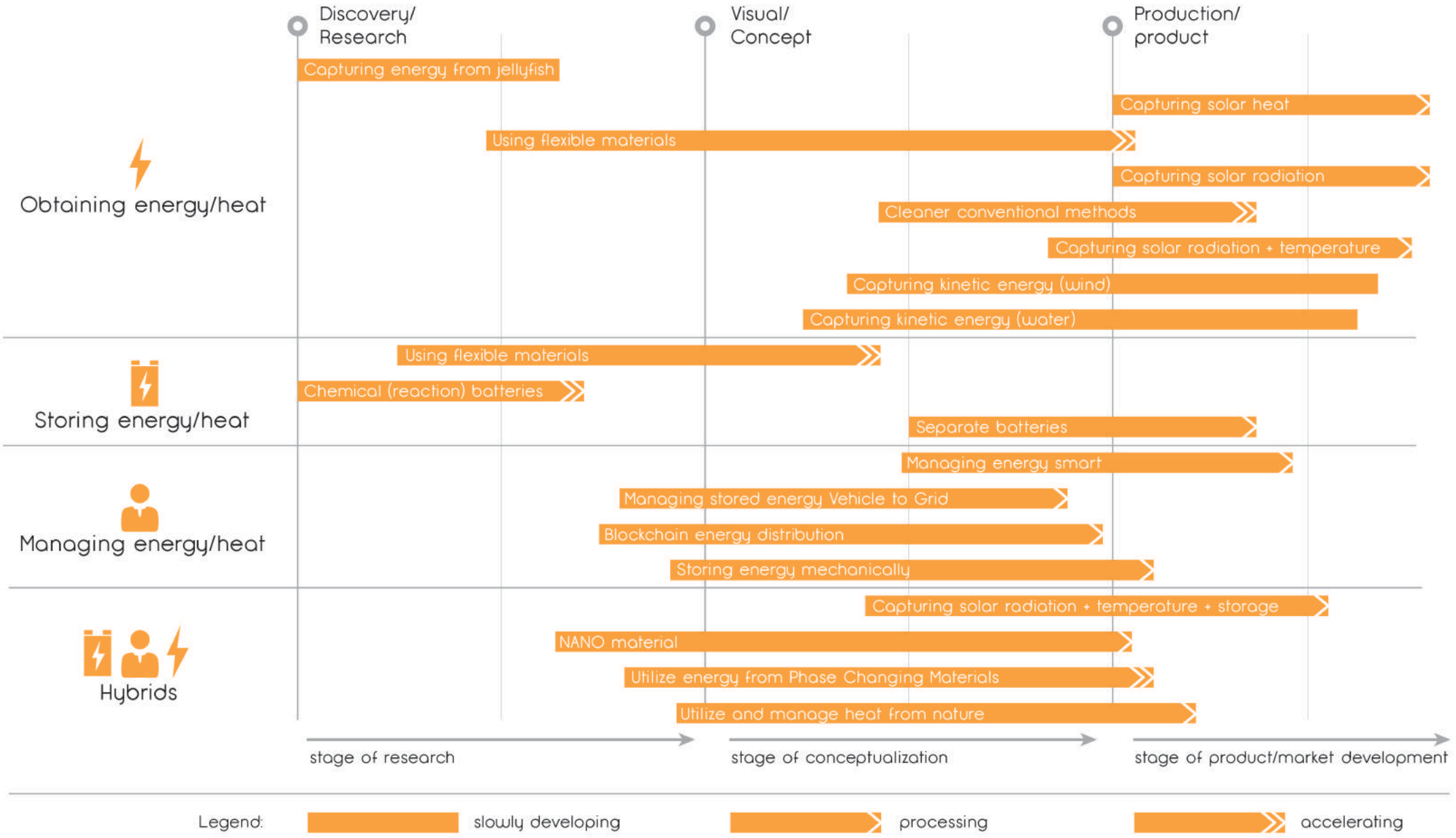
APPENDIX F1

FIRST GEN. ROADMAPS

Roadmaps that have been generated to get to the desired outcome. The roadmaps found in this appendix are the ones that have been discussed in order to get to the final roadmaps in Appendix F2. The roadmaps were discarded, because they were packed with information, making it too complex as an overview for extracting the right information.



1. Smart Energy Management (SEM)
2. Sun Collector
3. Central Heating Pump
4. IKEA PV panels
5. PV/T panels
6. Phase Changing Materials (PCM)
7. Vehicle to Grid (V2G)
8. Energy from waves
9. Powerwall
10. Flexible PV cells
11. Solar roof tiles
12. LO3 Energy - Exergy
13. Solpad Home + stand-alone
14. Nano paste
15. Energy Vault
16. Electrolysis Hydrogen
17. Redox flow battery
18. Blue battery
19. Liquid Air storage
20. Power to Ammonia to Power
21. Solar fabric
22. Flexible battery
23. Power Felt
24. Liquifying jellyfish
25. Nemoi wind turbine
26. Wind turbine
27. Hydro energy
28. Biomass boiler
29. Rocket Stove
30. Aggregate

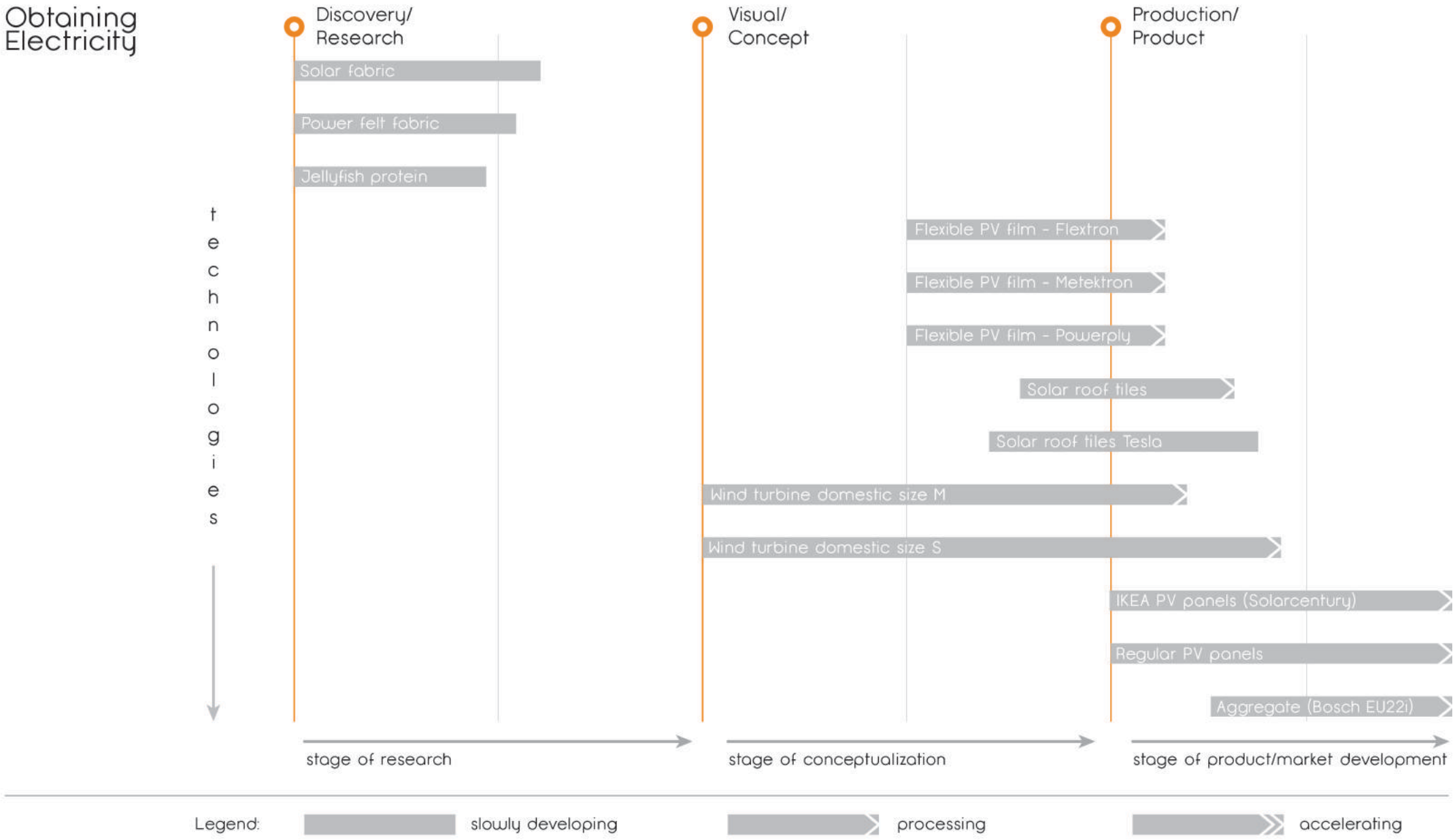

Discovery/
Research
Visual/
Concept
Production/
product
Capturing energy from jellyfish
Capturing solar heat
Using flexible materials
Capturing solar radiation
Obtaining energy/heat
Cleaner conventional methods
Capturing solar radiation + temperature
Capturing kinetic energy (wind)
Capturing kinetic energy (water)
Using flexible materials
Chemical (reaction) batteries
Storing energy/heat
Separate batteries
Managing energy smart
Managing stored energy Vehicle to Grid
Managing energy/heat
Blockchain energy distribution
Storing energy mechanically
Capturing solar radiation + temperature + storage
NANO material
Hybrids
Utilize energy from Phase Changing Materials
Utilize and manage heat from nature
stage of research
stage of conceptualization
stage of product/market development
Legend:
slowly developing
processing
accelerating

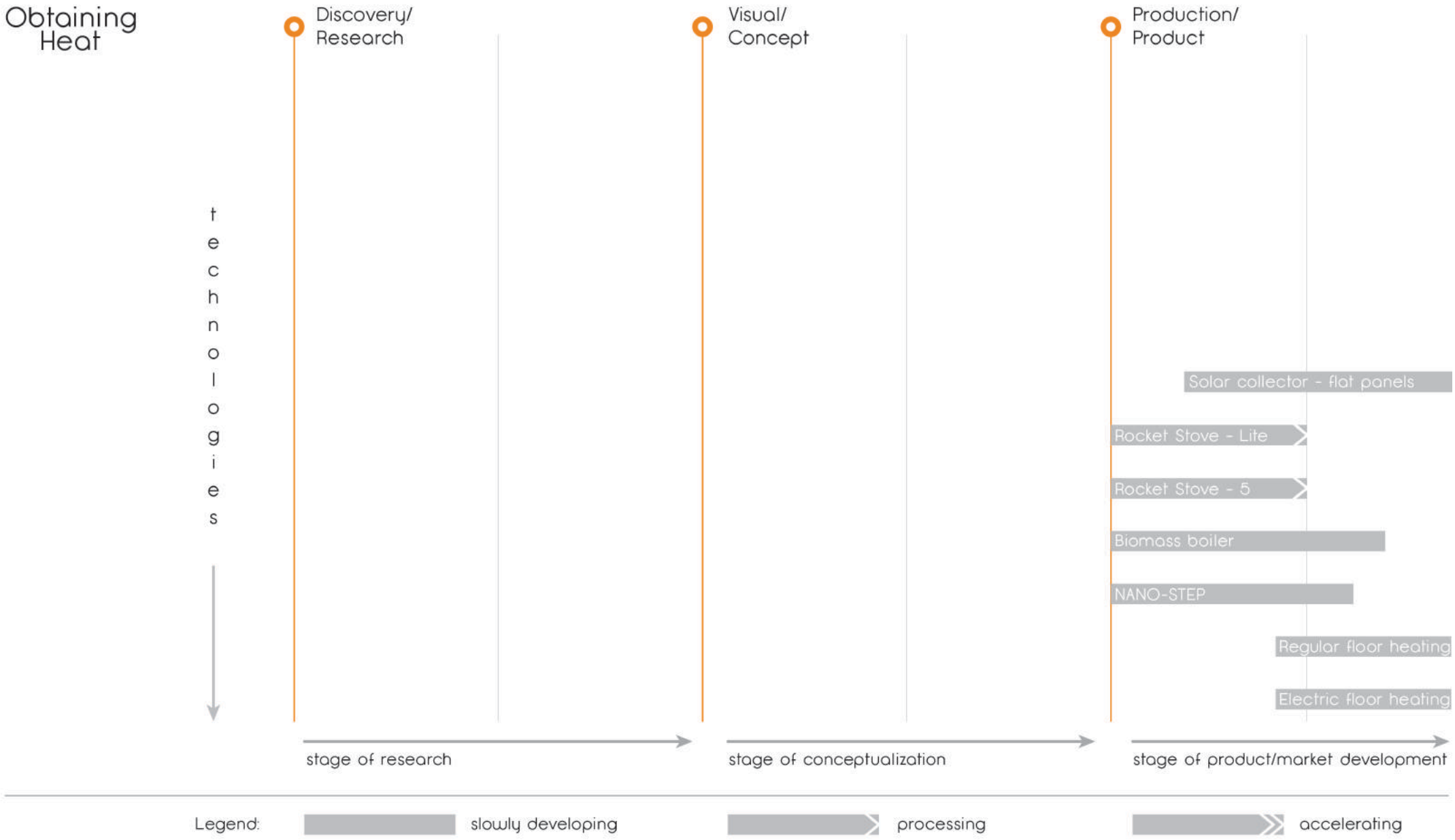
APPENDIX F2

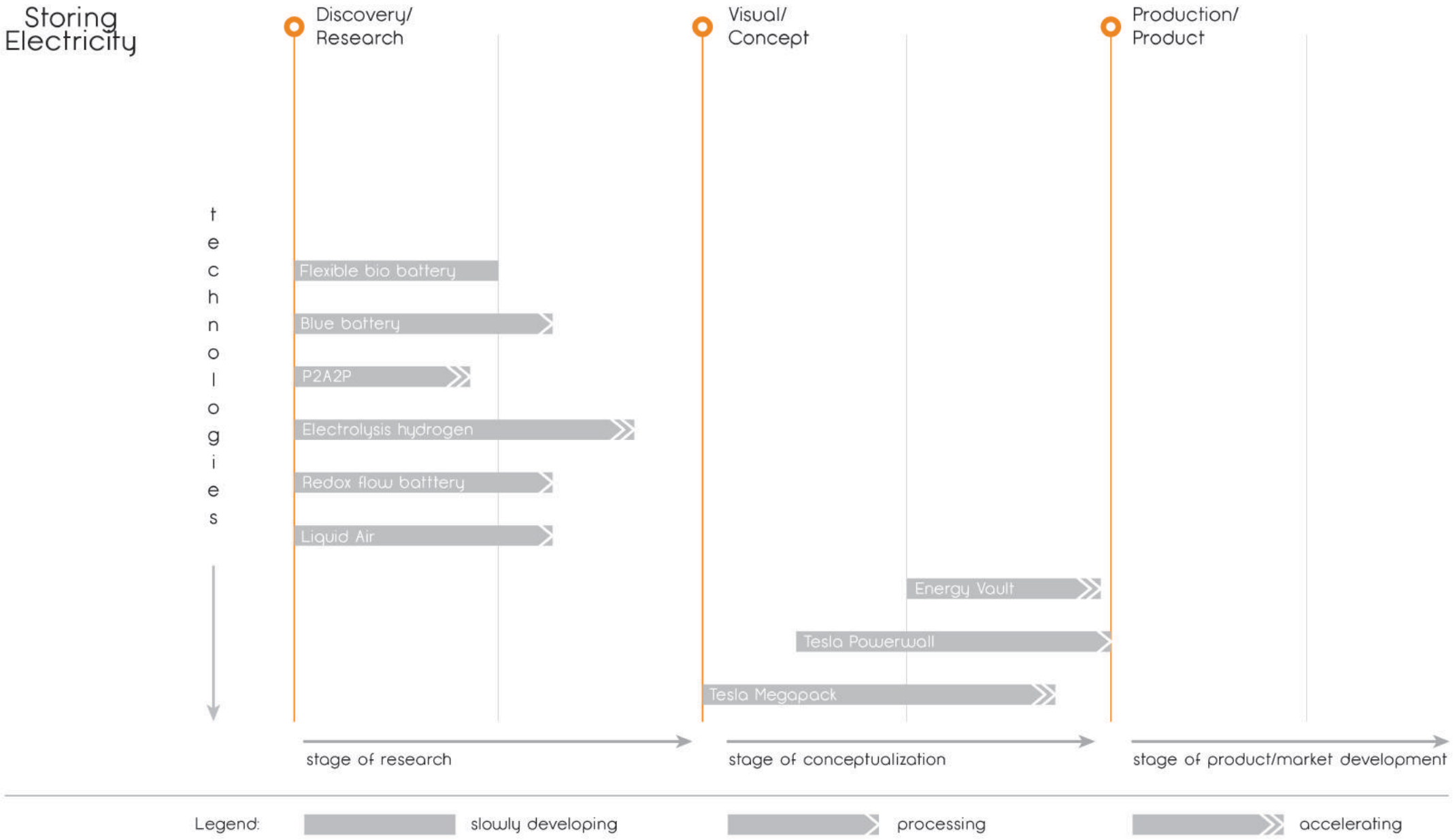
FINAL ROADMAPS

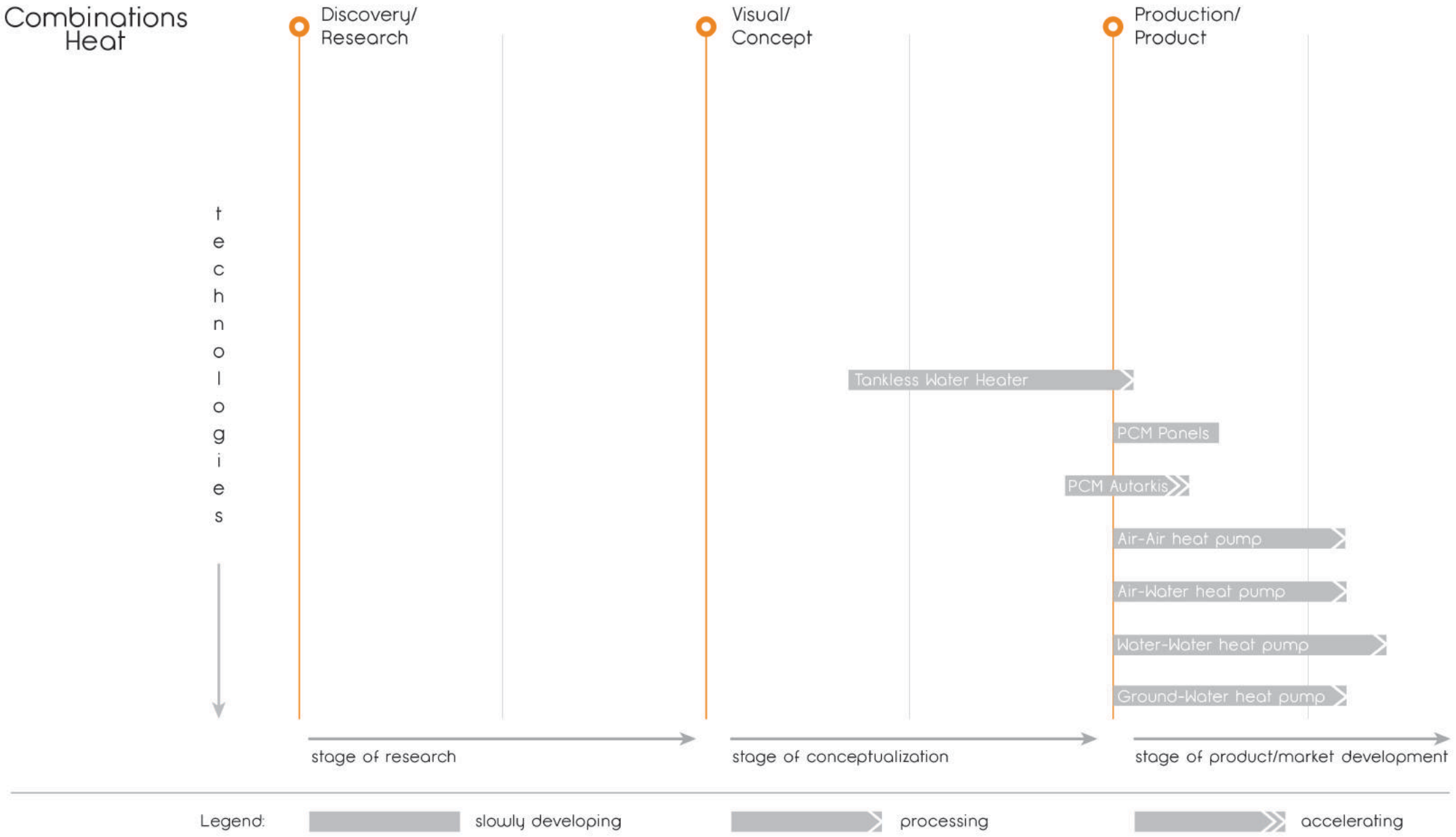
The roadmaps show the products and technologies on the y-axis and the stage of development on the x-axis. It shows how fast the product or technology is processing in the development stage.

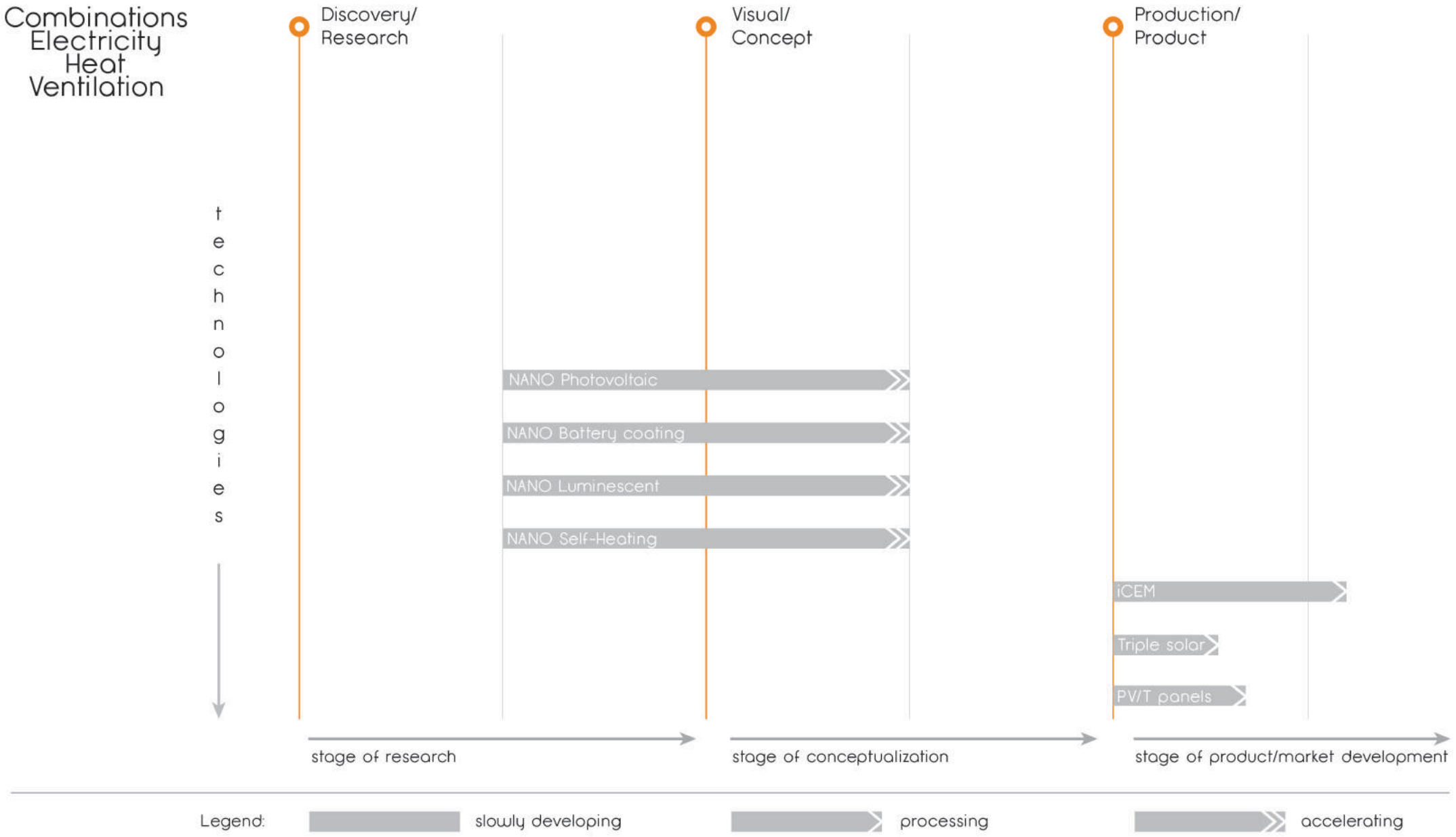
Obtaining Electricity




Obtaining Heat
Discovery/ Research
Visual/ Concept
Production/ Product
technologies
Solar collector - flat panels
Rocket Stove - Lite
Rocket Stove - 5
Biomass boiler
NANO-STEP
Regular floor heating
Electric floor heating
stage of research
stage of conceptualization
stage of product/market development
Legend:
slowly developing
processing
accelerating


Storing Electricity
Discovery/ Research
Visual/ Concept
Production/ Product
technologies
Flexible bio battery
Blue battery
P2A2P
Electrolysis hydrogen
Redox flow batttery
Liquid Air
Energy Vault
Tesla Powerwall
Tesla Megapack
stage of research
stage of conceptualization
stage of product/market development
Legend:
slowly developing
processing
accelerating

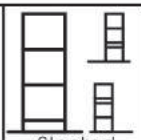
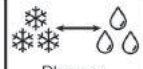
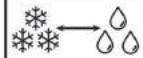
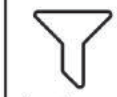

Combinations
Heat
Discovery/
Research
Visual/
Concept
Production/
Product
technologies
Tankless Water Heater
PCM Panels
PCM Autarkis
Air-Air heat pump
Air-Water heat pump
Water-Water heat pump
Ground-Water heat pump
stage of research
stage of conceptualization
stage of product/market development
Legend:
slowly developing
processing
accelerating


Combinations
Electricity
Heat
Ventilation
Discovery/
Research
Visual/
Concept
Production/
Product
technologies
NANO Photovoltaic
NANO Battery coating
NANO Luminescent
NANO Self-Heating
iCEM
Triple solar
PV/T panels
stage of research
stage of conceptualization
stage of product/market development
Legend:
slowly developing
processing
accelerating

APPENDIX G1

FIRST GEN. MORPHOLOGIC CHARTS

Morphologic Charts that have been generated to get to the desired outcome. The charts found in this appendix are the ones that have been discussed in order to get to the final Morphologic Charts in Appendix G2. The charts were discarded, because they were categorized in a way that it was not usable for making concepts out of it.

Access to heat	Obtaining heat	 Single	 Stacked					
	Storing heat	 Trailer	 Fixed support					
	Managing heat	 Solar heat	 Phase Change Material	 Cleaner conventional method				
	Combinations	 WTW	 Mechanical	 Nature	 Construction			
Access to electricity	Obtaining electricity	 GRID	 Phase Change Material	 Photo voltaics	 Photo voltaics + temperature	 Kinetic energy (wind)	 Kinetic energy (water)	 NANO material
	Storing electricity	 Separate batteries	 NANO material	 Phase Change Material	 Photo voltaics + temperature	 Vehicle to Grid	 Mechanical	
	Managing electricity	 NANO material	 Smart energy system	 Phase Change Material	 Blokchain energy distribution			
	Combinations	 GRID	 Rainwater	 Re-use by filtration				
Ventilation		 GRID	 (Bio) filter					

APPENDIX G2

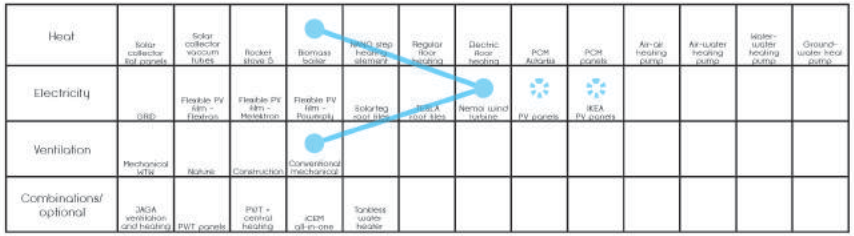
FINAL MORPHOLOGIC CHARTS + CHOICES

The Morphologic Charts show the product choices for each concept direction with a total of five, being: fastest revenue, highest sustainability, highest effiency, low(est) investment and highest comfort. The blue dots are the choices, connected with a blue line. The optional choices are the dotted blue circles. On the left the positive, negative and general remarks are listed, and above the morphologic chart, the price and concept perspective are highlighted.

Morphologic chart
now - half year

€6816

Fastest revenue



Positives

- Collaborative place for getting woodpallets could lead to social behavior within the community.

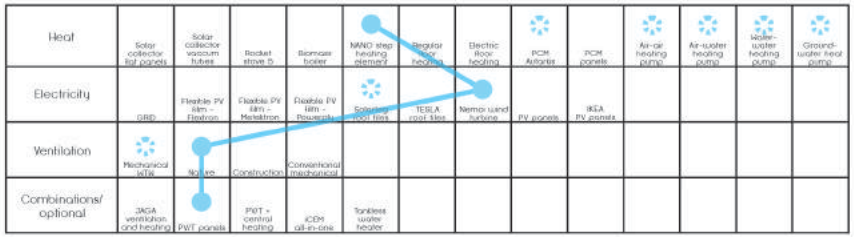
Extra electricity with PV panels (revenue of 6 years in general).

Negatives

- Conventional ventilation system creates higher energy consumption.
- Storage for wood pellets needed.
- Wind turbine is not producing enough energy on its own.
- Turbine produces sound (36dB) at max speed. This is comparable with hard whispers.

€22340 incl. install PV panels, ex install electric floor

Highest sustainability



Positives

- No water for heating the house.
- PWT delivers extra amount of energy and hot water.
- Low voltage floorheating.
- Opportunity to heat up separate parts of the house.
- NANO-step is maintenance-free, biodegradable and non-hazardous.
- PWT provide warm water.

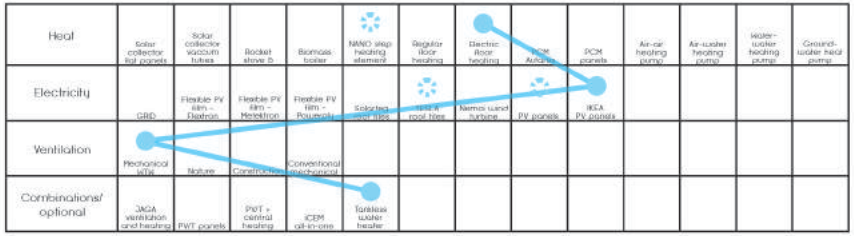
Mechanical WTW supports sustainable ventilation by reducing the amount of energy lost through ventilating.

Negatives

- Windturbine not sufficient on its own.
- Nature can provide cooling, but therefore a direct connection to the outside is needed.
- PWT panel is heavy, so the roof should be able to hold the weight.
- Turbine produces sound (36dB) at max speed. This is comparable with hard whispers.
- Wind turbine is not producing enough energy on its own.

€10856 excl install floor, incl install PV panels

Highest efficiency



Positives

- Water is only needed for consumption, not for heating.
- Instant warm water.
- Monitoring solar panels, push for CC?
- Almost none heat loss due to WTW ventilation.

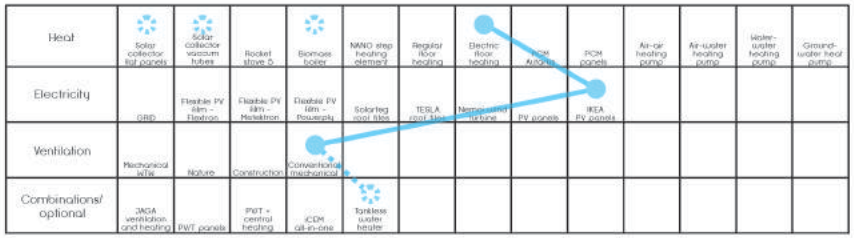
Other solution with almost the same high efficiency: NANO step + TESLA tiles + mechanical WTW + Tankless water heater.

Negatives

- High energy usage (floor).

€3510 - 4210 ex conventional ventilation, excl install floor, incl install PV panels

Low(est) investment



Positives

- Cheap.
- No water needed for heating the house.
- Radiating heat.
- Optimizers per panel.
- Monitoring panels, push for CC?

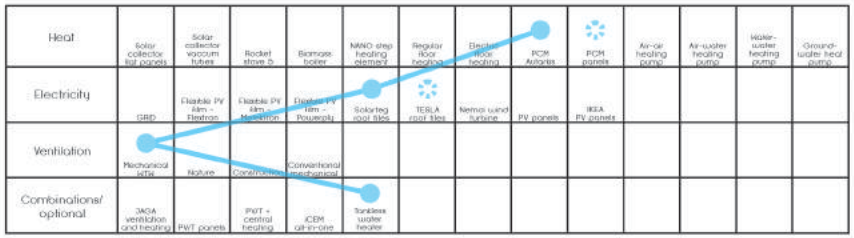
Floor heating on both levels?
Biomass boiler as extra/other option as heat source (revenue unknown).
Tankless water heater might be a more expensive solution than other conventional ways of getting water.

Negatives

- Conventional ventilation system will have a big influence on the energy/heat consumption.
- High energy usage (floor).

€19040

Highest comfort



Positives

- Roof tiles does not require an expert to install.
- Ventilation assures a stable climate.
- PCM assures a stable climate.
- Instant warm water.
- Heating AND ventilation auto-regulated (sens of great, consistent heat regulation).

Other option: multiple JAGA systems + solarteg roof tiles.

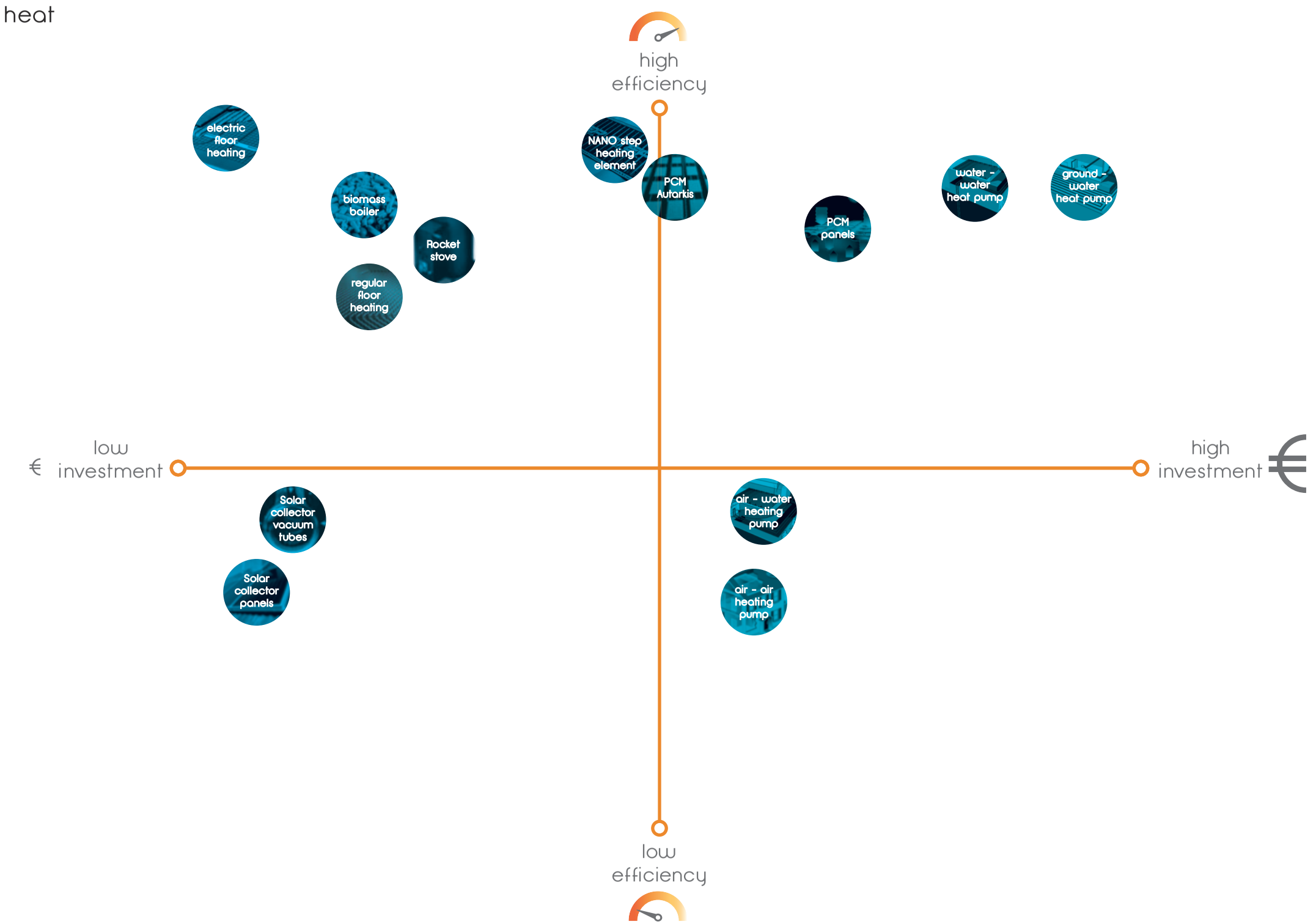
Negatives

- Specialist needed for installing PCM.
- Solarteg comes from Italy (relatively far?).
- PCM needs heating pump as well.

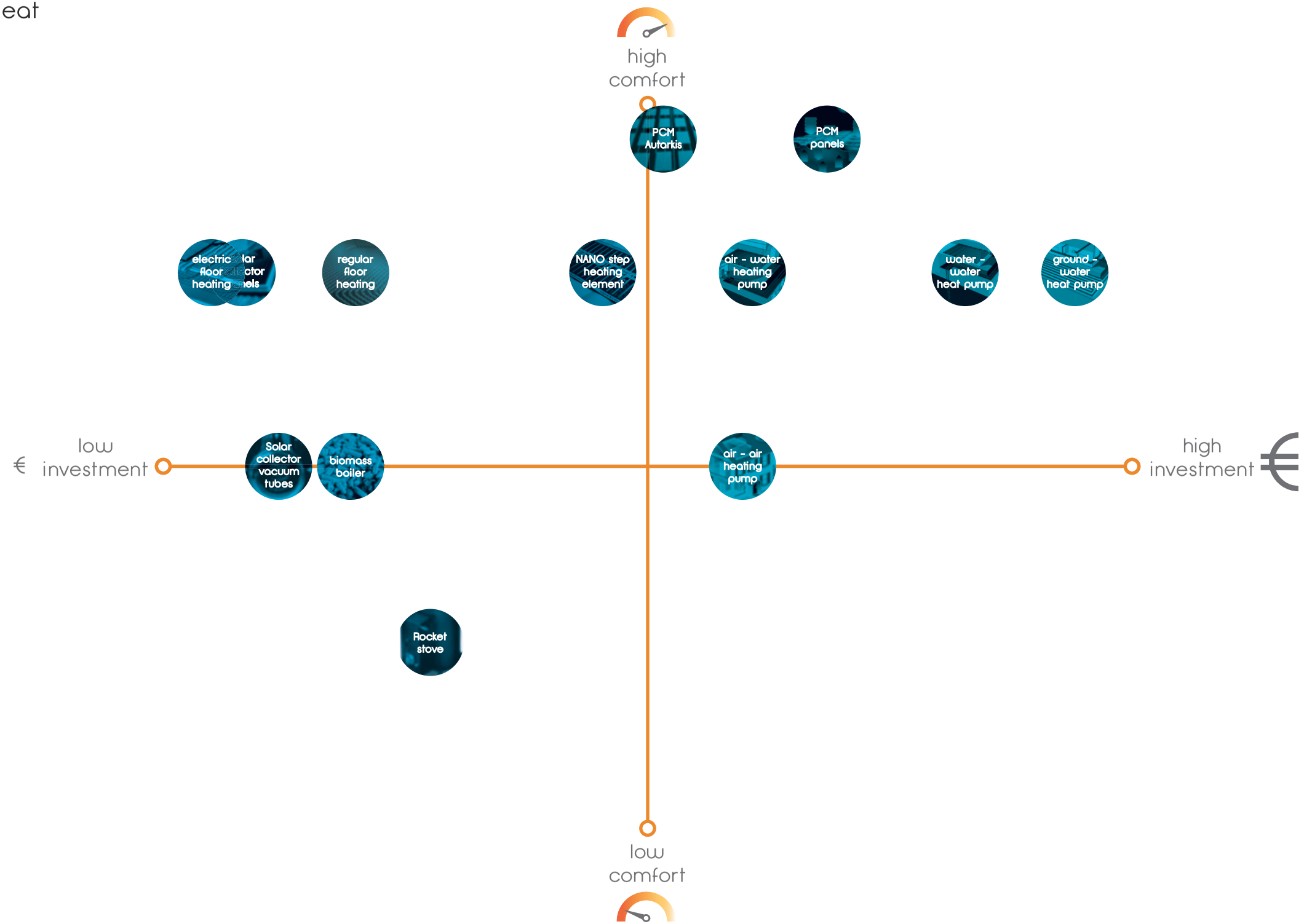
APPENDIX H

PRODUCT GRAPHS

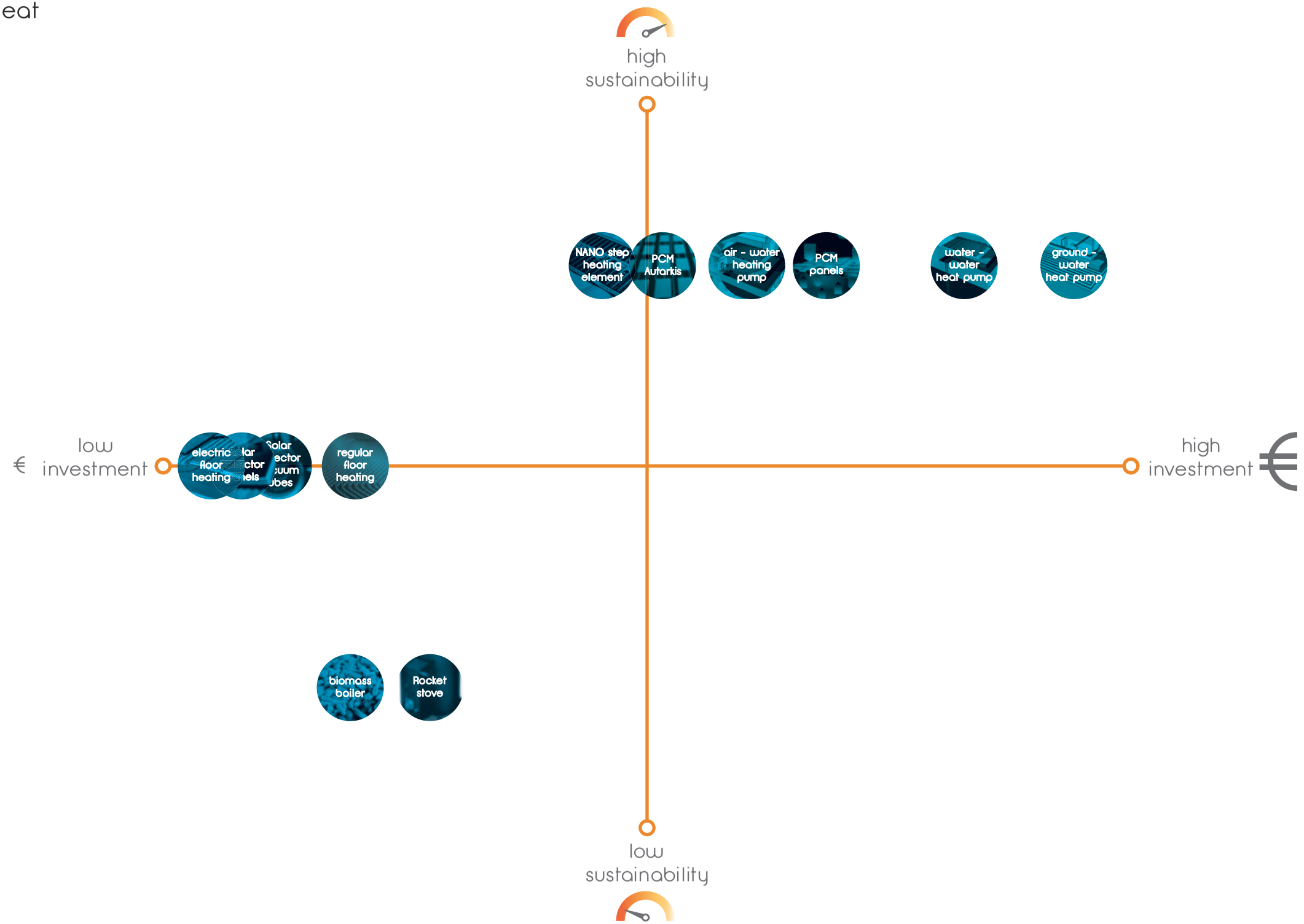
This appendix contains four graphs based on technologies/products for heat and four based on technologies/products for electricity. The x-axis always represents the relative investment cost and the y-axis represents the relative efficiency, comfort, sustainability and revenue of the products.


heat
high efficiency
low investment
high investment
low efficiency
electric floor heating
biomass boiler
Rocket stove
regular floor heating
NANO step heating element
PCM Autarkis
PCM panels
water - water heat pump
ground - water heat pump
Solar collector vacuum tubes
Solar collector panels
air - water heating pump
air - air heating pump

heat


high comfort
low comfort
low investment
high investment
PCM Autarkis
PCM panels
electric floor heating
regular floor heating
NANO step heating element
air - water heating pump
water - water heat pump
ground - water heat pump
Solar collector vacuum tubes
biomass boiler
air - air heating pump
Rocket stove

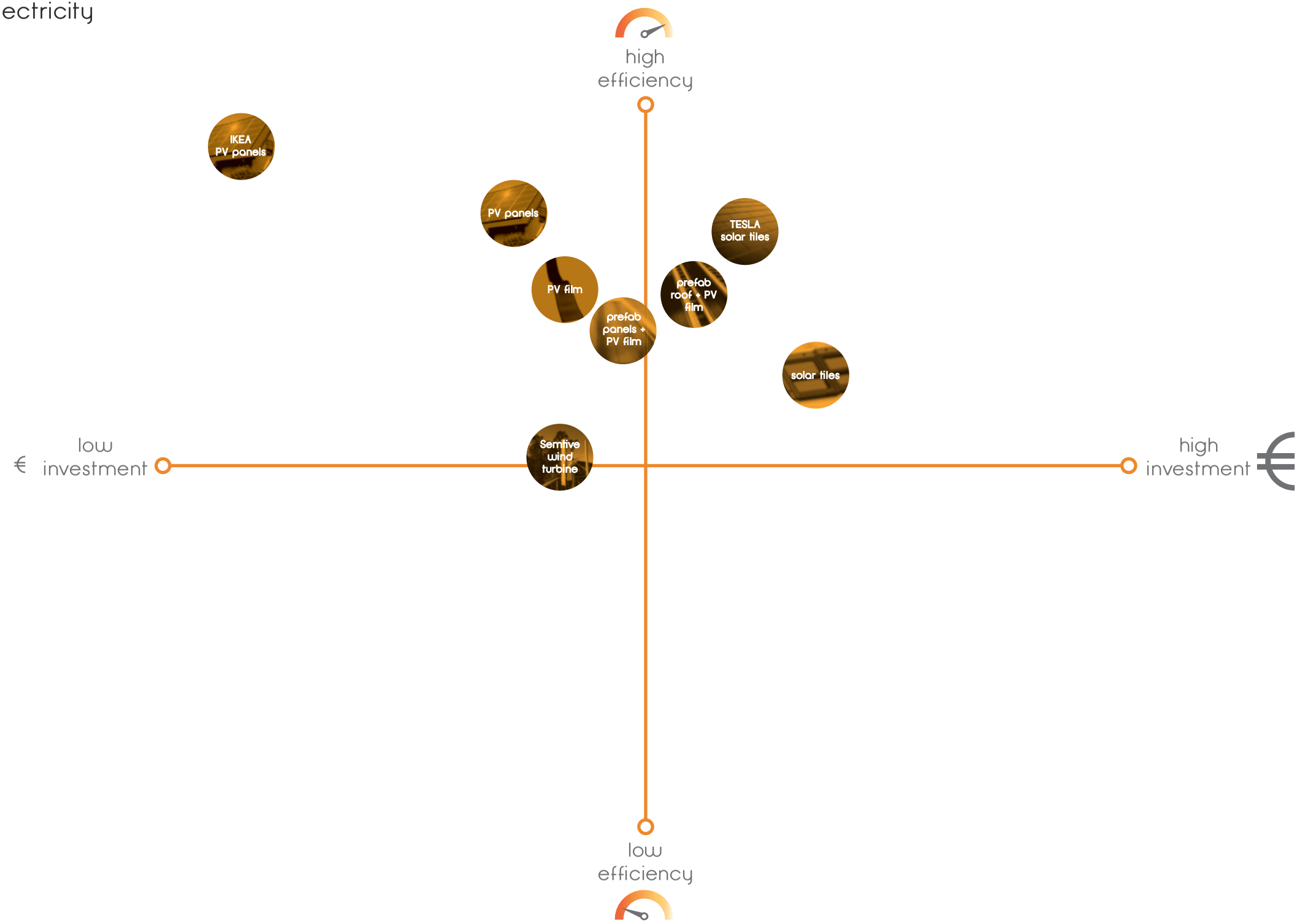
heat


high
sustainability
low
investment
high
investment
low
sustainability
NANO step heating element
PCM Autarkis
air - water heating pump
PCM panels
water - water heat pump
ground - water heat pump
electric floor heating
regular floor heating
biomass boiler
Rocket stove

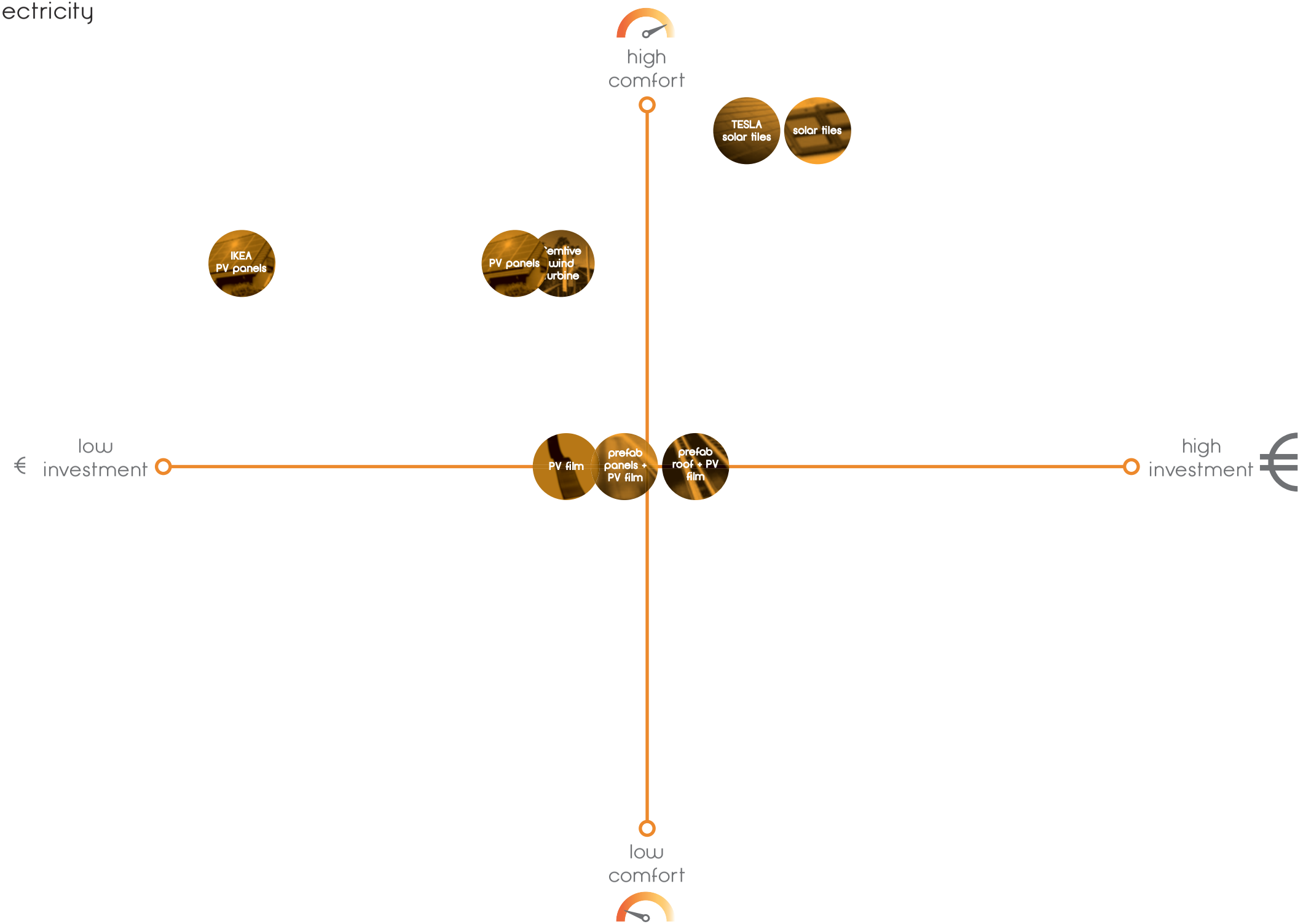
heat


fast
revenue
slow
revenue
low
investment
high
investment
biomass
boiler
Solar
collector
panels
NANO step
heating
element
PCM
Autarkis
Rocket
stove
PCM
panels
Solar
collector
vacuum
tubes
air - air
heating
pump
electric
floor
heating
regular
floor
heating
air - water
heating
pump
water -
water
heat pump
ground -
water
heat pump

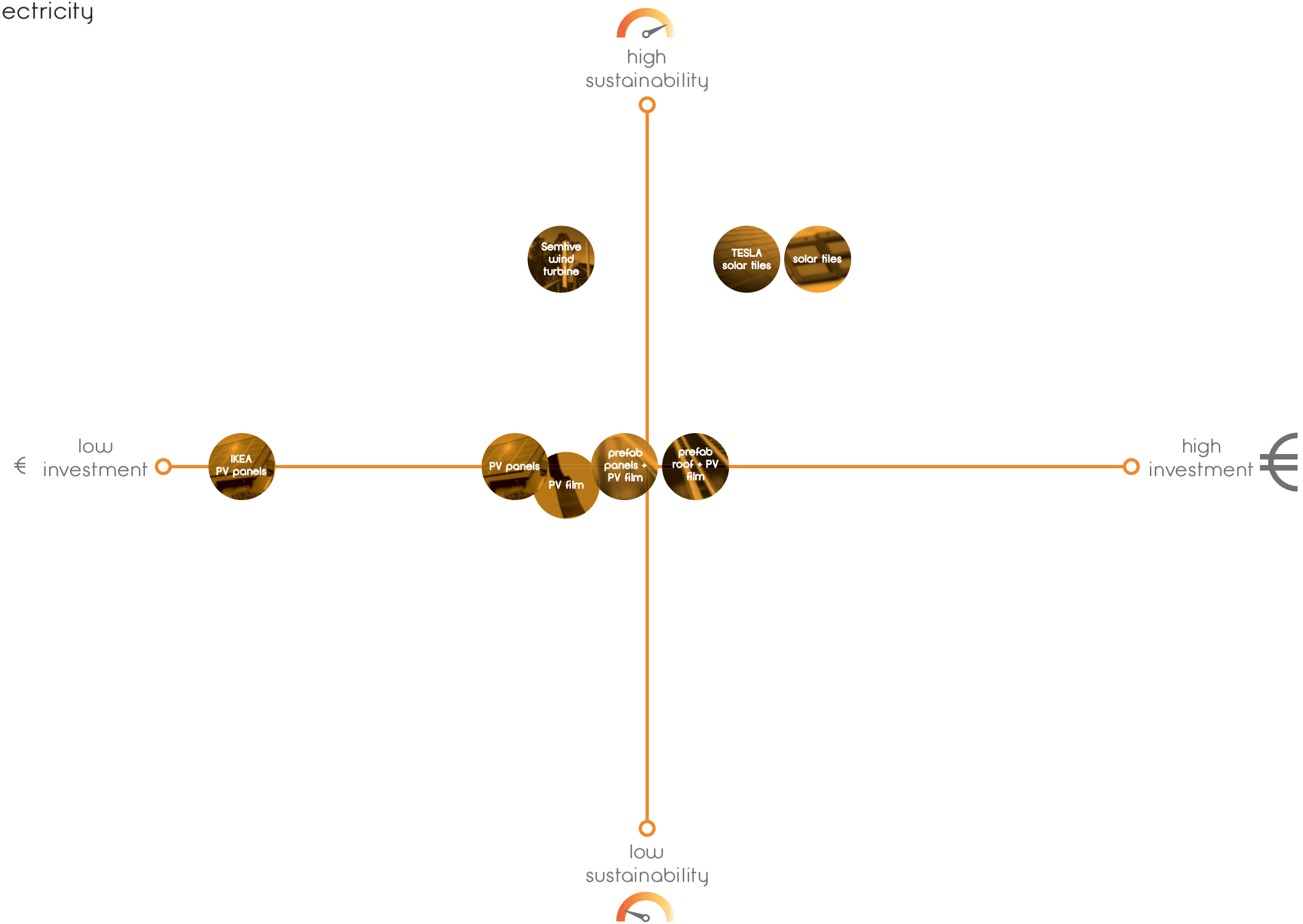
electricity



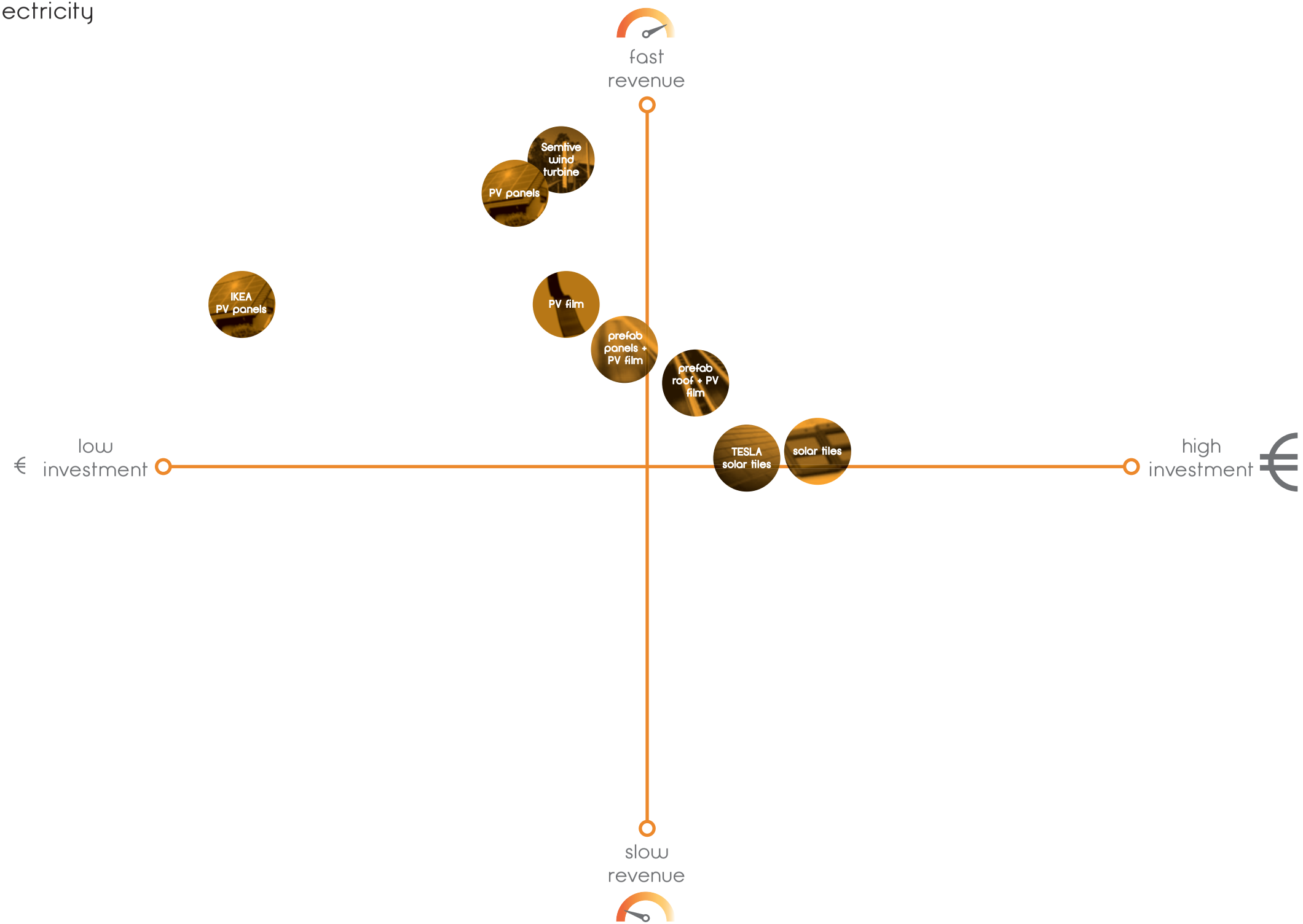
electricity



electricity



electricity



APPENDIX I

CONCEPT DRAWINGS

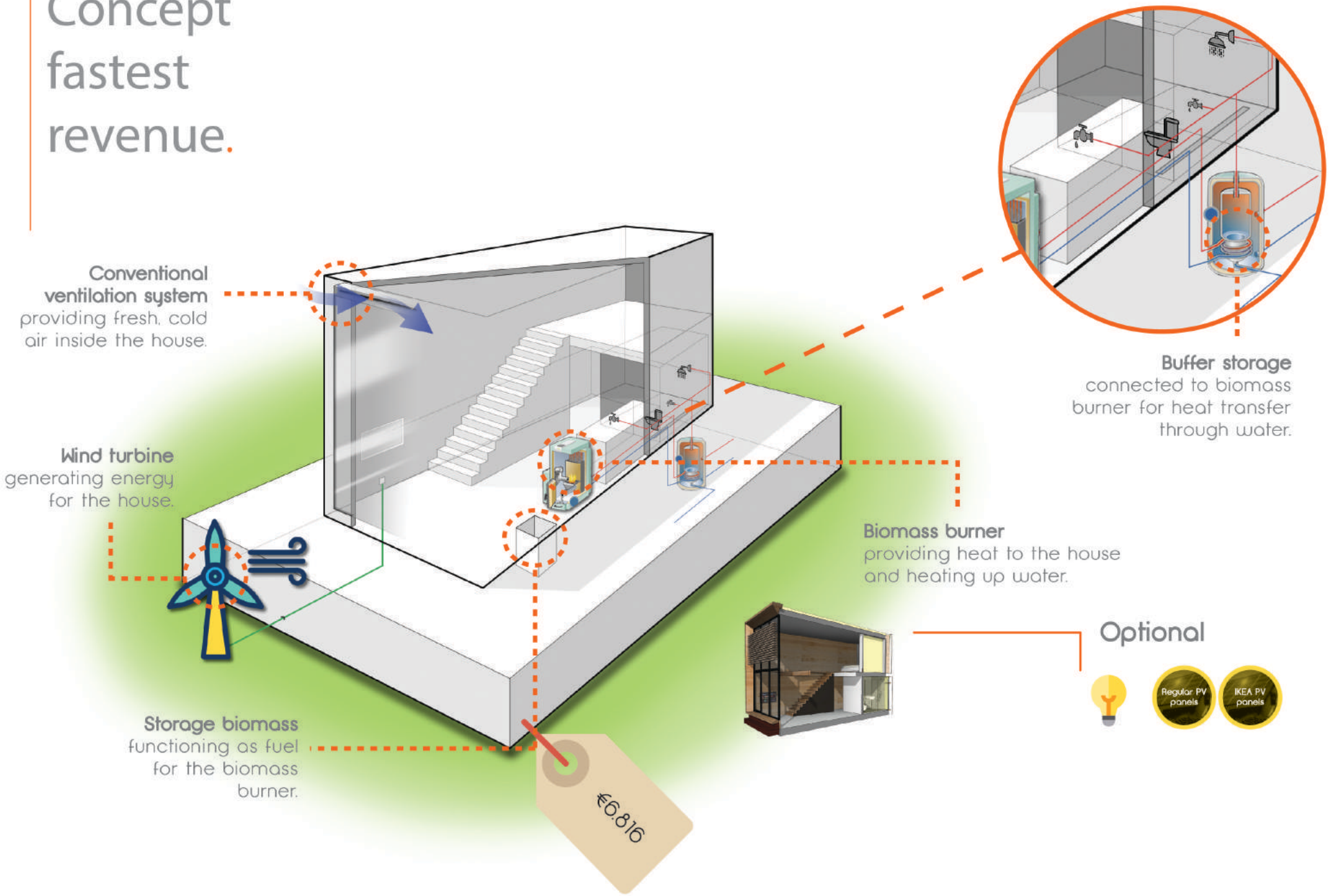
Drawings of the five concepts fastest revenue, highest sustainability, highest effiency, low(est) investment and highest comfort.

Drawings of the upfollowing three chosen concepts: low consumption, all electric and collective system.

Drawings of the two concepts to pursue, being low consumption and all electric.

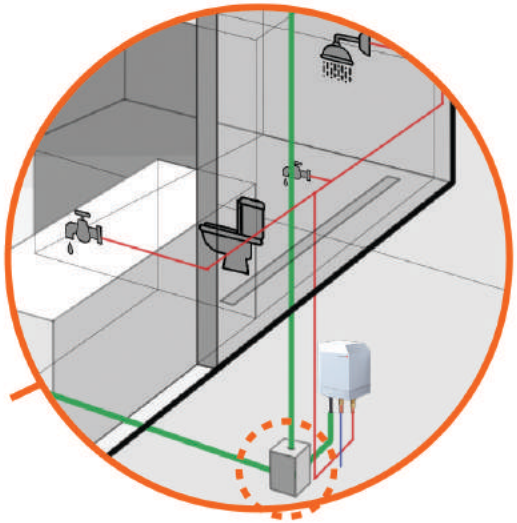
	heat	electricity	ventilation	optional	investment costs
fastest revenue					€ 6.816
highest efficiency					€ 10.856
highest sustainability					€ 22.340
highest comfort					€ 19.040
low(est) investment					€ 3.510

Concept fastest revenue.

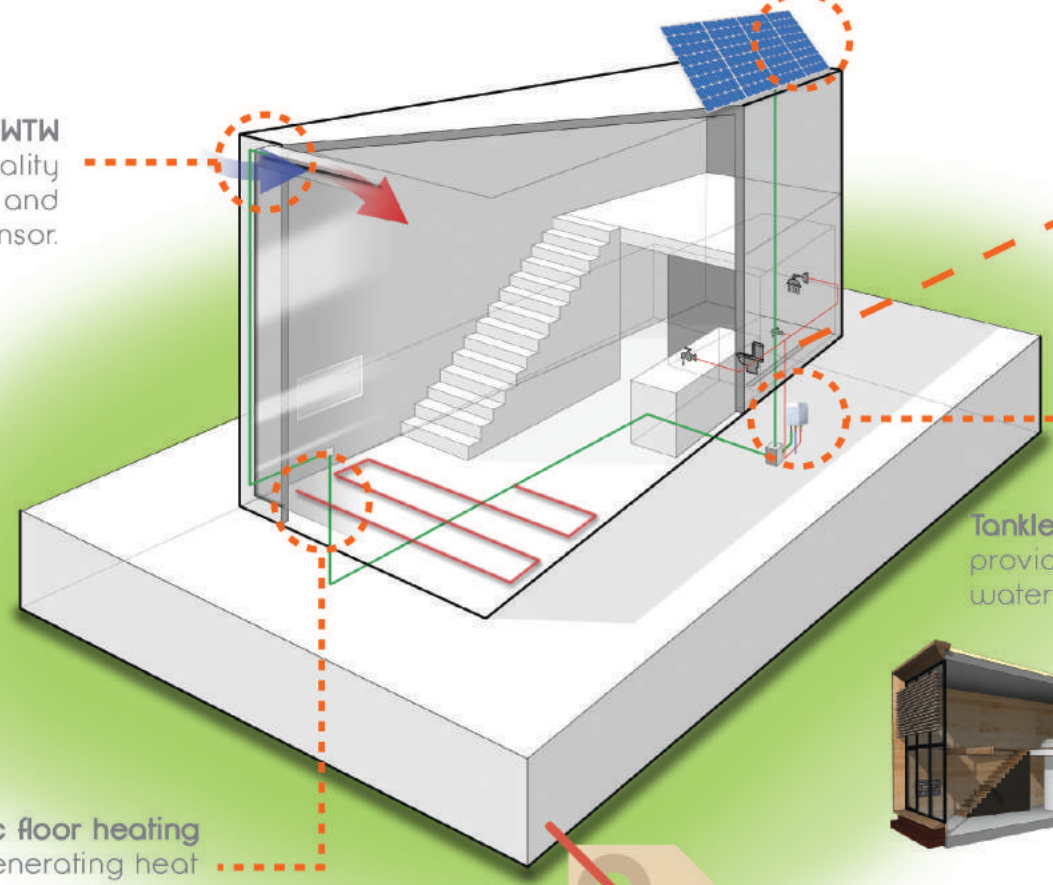


Concept highest efficiency.

IKEA solar panels
providing electricity for the house.



Mechanical WTW
regulating air quality with CO_2 - and humidity sensor.



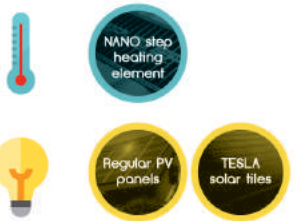
Inverter providing 230V and/or 12V.

Tankless water heater
providing cold/warm water to appliances.

Electric floor heating
generating heat for the house.

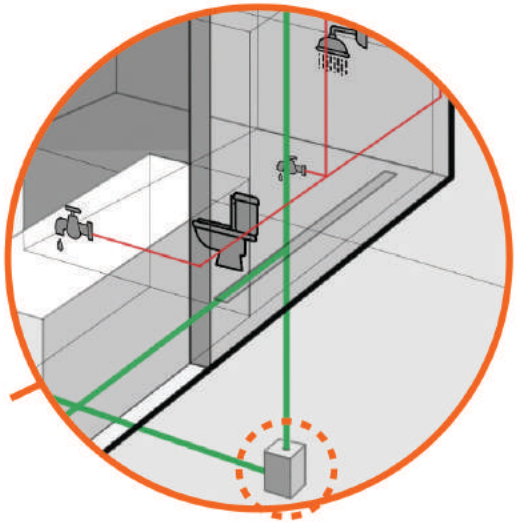
€10.856

Optional



Concept highest sustainability.

PV/T panels providing electricity and warm water for the house.



Inverter providing 230V and/or 12/24V.

Nature creating a cool area around the house for ventilation.

Wind turbine generating energy for the house.

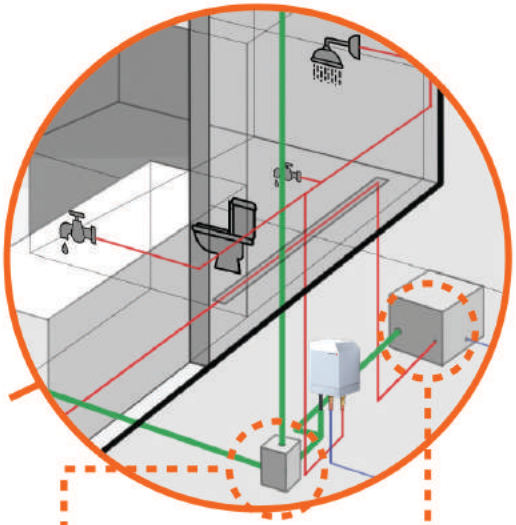
NANO floor heating generating heat for the house on low voltages (24V).

€22.340

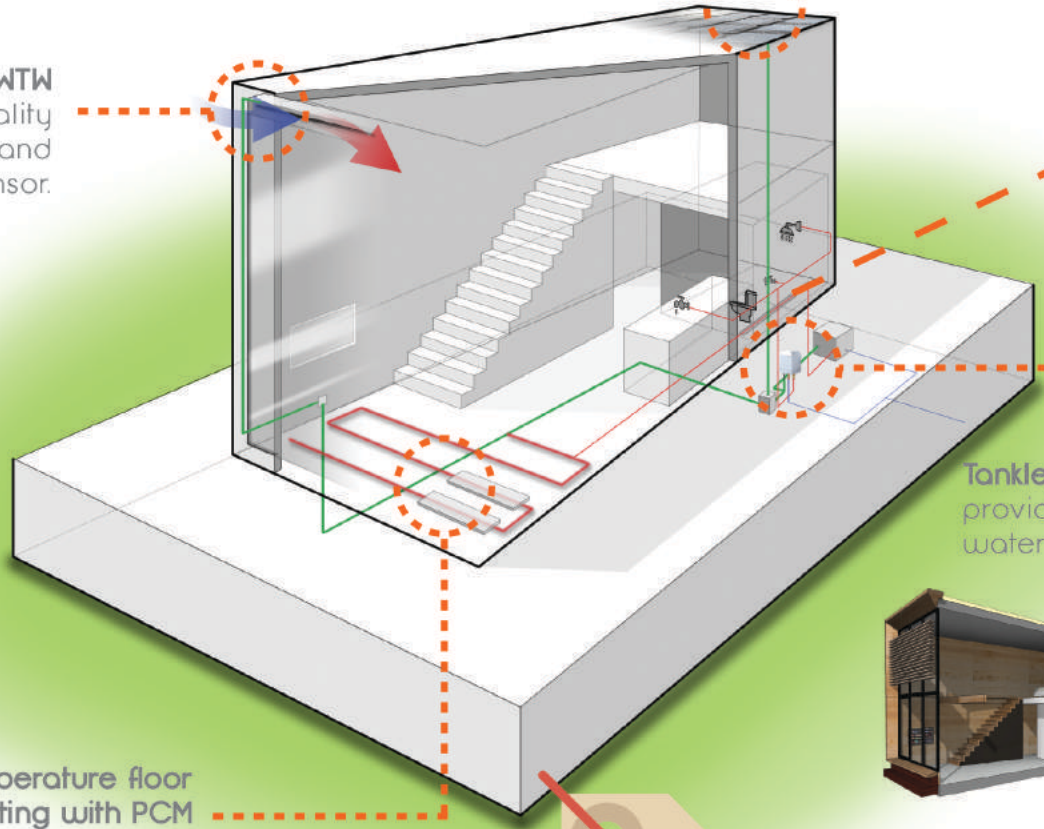
Optional

Concept highest comfort.

Solar roof tiles
providing electricity for the house.



Mechanical WTW
regulating air quality with CO_2 - and humidity sensor.



Inverter providing 230V and/or 12V.

Heating pump
providing warm water for the floor heating.

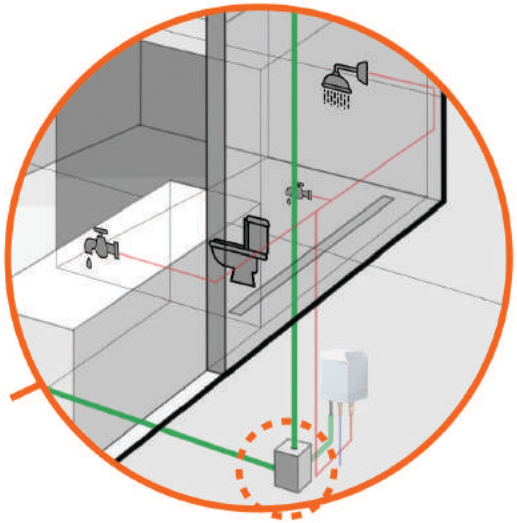
Tankless water heater
providing cold/warm water to appliances.

Optional

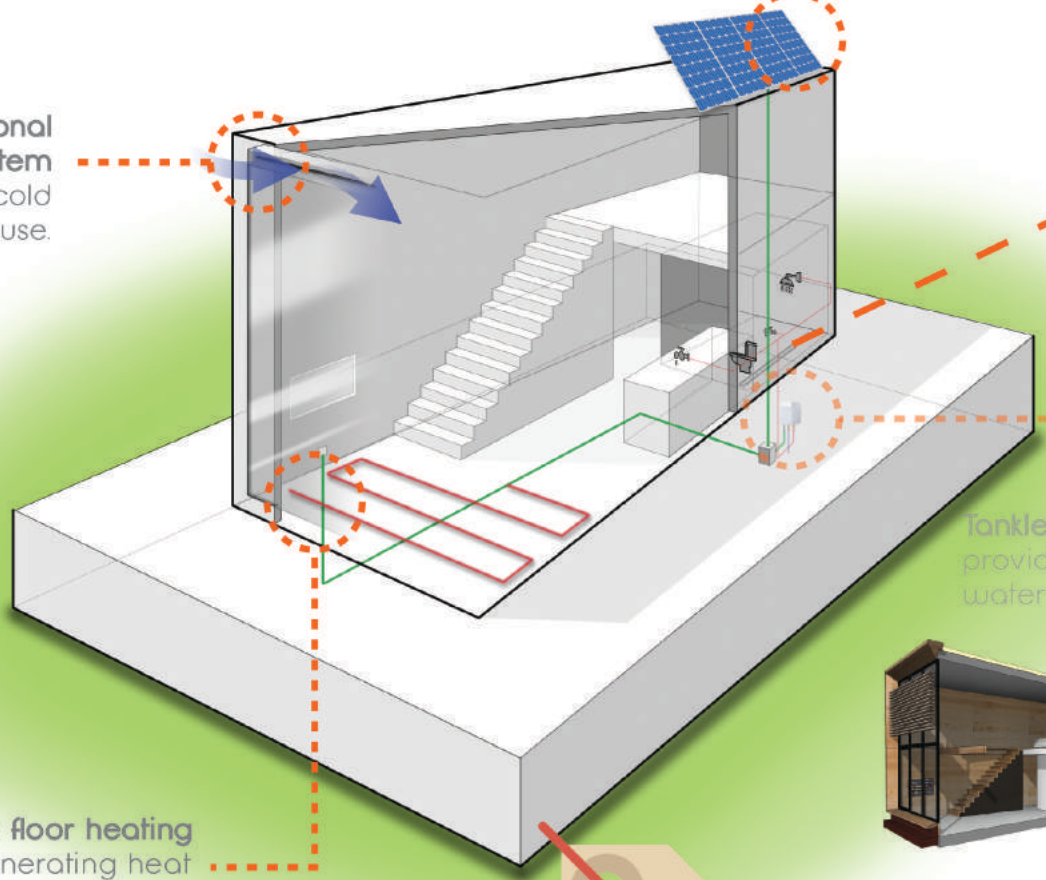
Low temperature floor heating with PCM
to provide and store heat for the house.

Concept lowest investment.

IKEA solar panels providing electricity for the house.



Conventional ventilation system providing fresh, cold air inside the house.



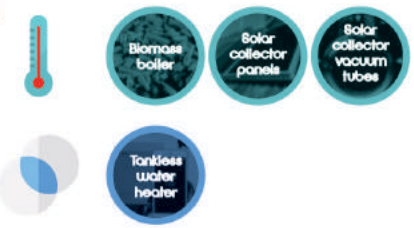
Inverter providing 230V and/or 12V.

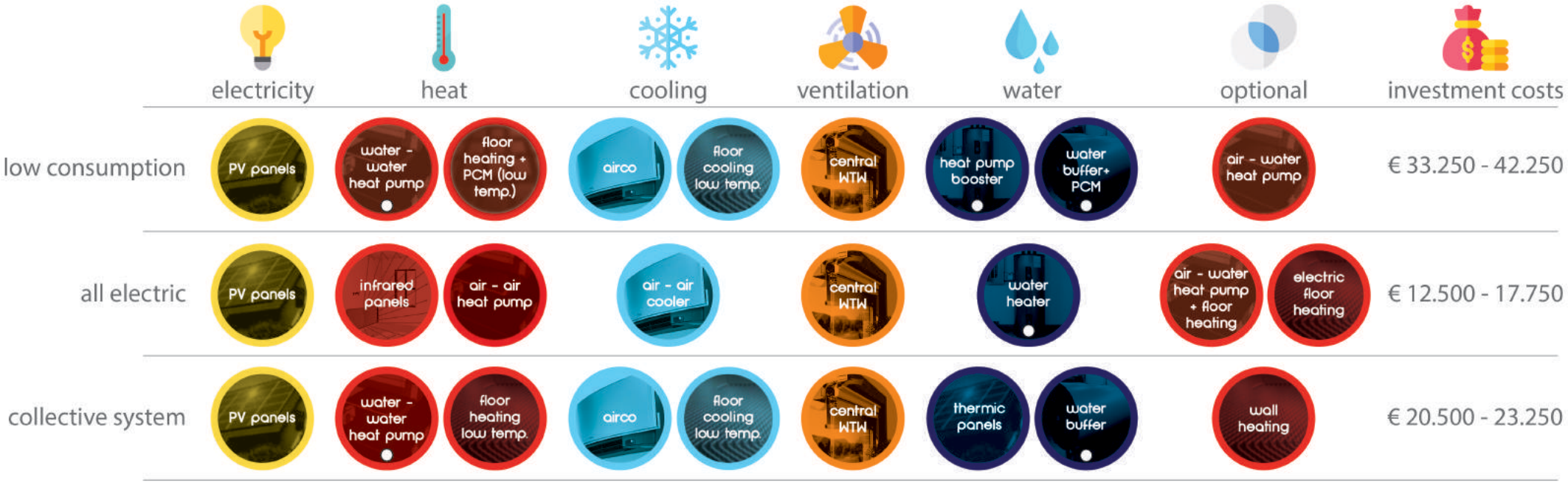
Tankless water heater providing cold/warm water to appliances.

Electric floor heating generating heat for the house.

€3.410

Optional




electricity
heat
cooling
ventilation
water
optional
investment costs
low consumption
PV panels
water - water heat pump
floor heating + PCM (low temp.)
airco
floor cooling low temp.
central WTW
heat pump booster
water buffer+ PCM
air - water heat pump
€ 33.250 - 42.250
all electric
PV panels
infrared panels
air - air heat pump
air - air cooler
central WTW
water heater
air - water heat pump + floor heating
electric floor heating
€ 12.500 - 17.750
collective system
PV panels
water - water heat pump
floor heating low temp.
airco
floor cooling low temp.
central WTW
thermic panels
water buffer
wall heating
€ 20.500 - 23.250
O = inside platform

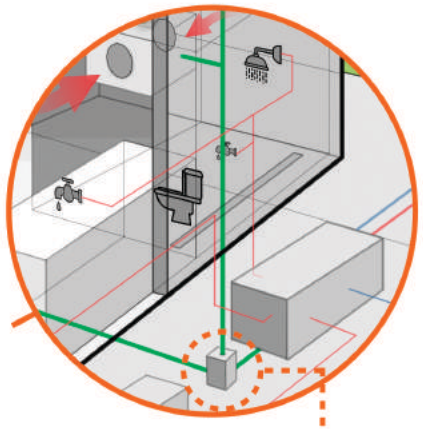
Concept low consumption.

This concept is created while taking into account the vision of using as little as possible electricity and heat. Because it is a low temperature heating system it can take a while before the desired temperature is met. The climate inside can be considered consistent. The heat pump can be used by multiple houses, creating an overal lower investment cost per house.

PV panels (+ hydrogen in future)
providing electricity for the house. Optionally also installed on the side/front of the house.

Airco
providing additional cooling aid when needed.

Nature
Promoting a cooler climate in summer.



Centralized WTW
reducing heat loss and promoting a stable climate with CO_2 and humidity sensor.

Inverter
providing 230V and/or 12/6/5V.

Water - water heat pump (low temperature)
providing heat to the house(s) and warm tap water. Can also perform passive cooling up to 18°C.

Heat pump booster
heating up stored water for tap water/ shower usage.

Battery storage
future possibility for storing batteries.

GRID
green energy for additionally needed electricity demands.

Water tank storage + PCM
providing and storing hot or cool water.

€ 33.250
- 42.250

Low temperature floor heating + PCM
providing a low temperature heat because of tubes oriented close to eachother. The PCM, storing and releasing heat when needed, assuring a more stable climate inside the house. Good isolation and air tightness is advised when using a low temperature heating system.

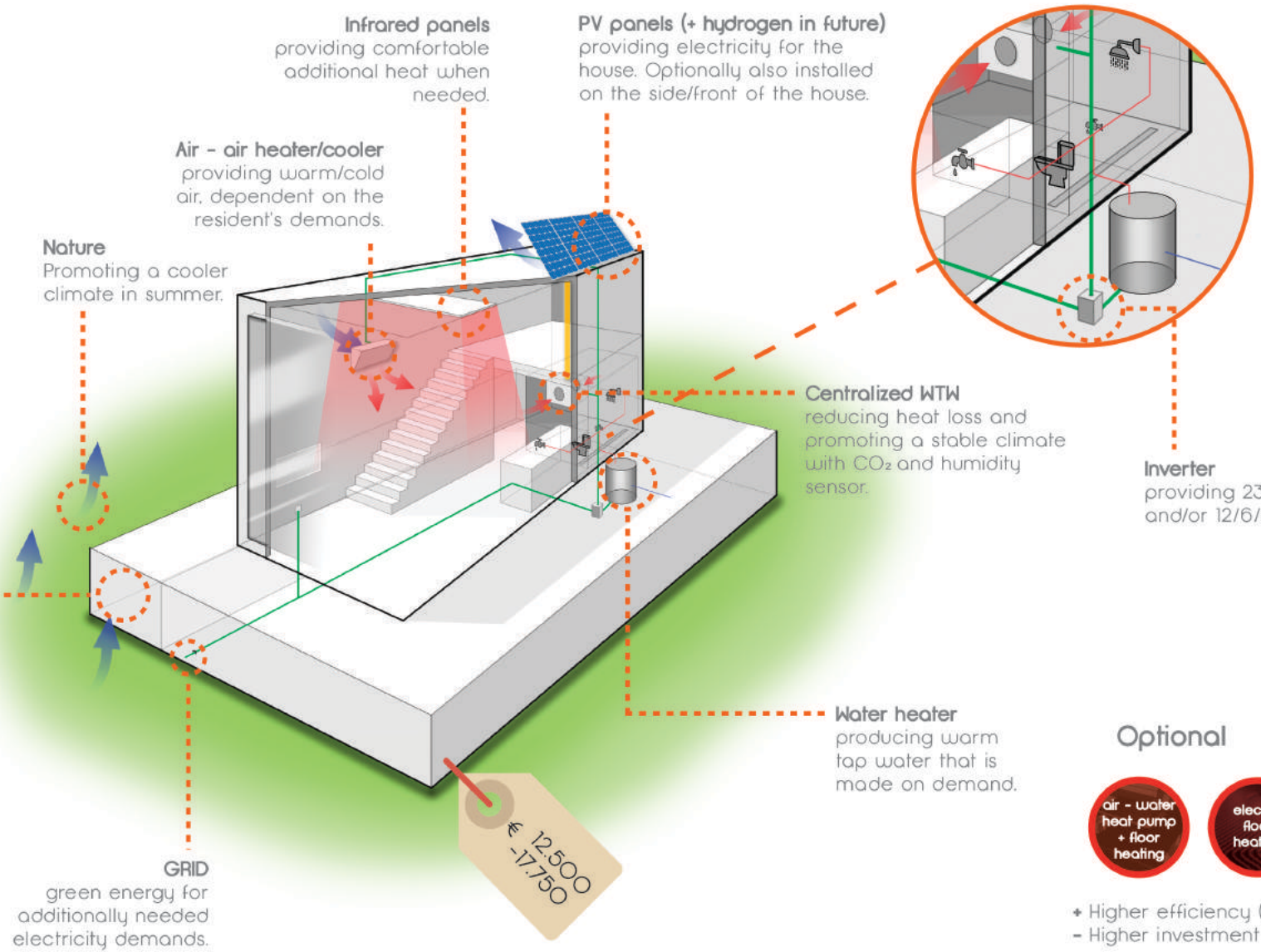
Optional

air - water heat pump

+ Lower investment costs
- Lower efficiency

Concept all electric.

This concept is created while taking into account the vision of having an all electric home. where only electricity is used to heat the house and provide the house of energy. Because the selected heating system is electric as well, the desired temperature can be met rather quick. This concept is ideal for providing separate technologies per house.



Optional

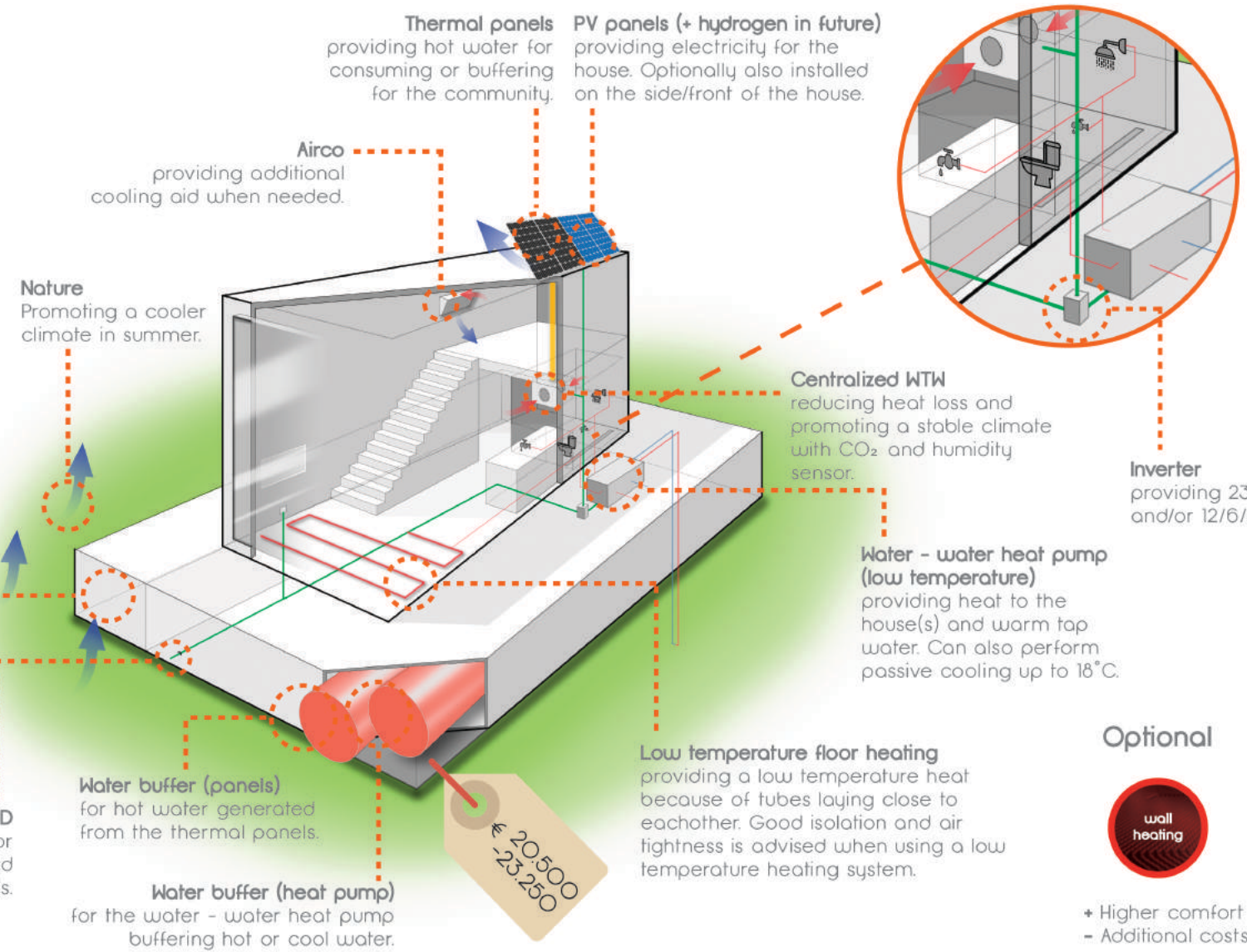
air - water heat pump + floor heating

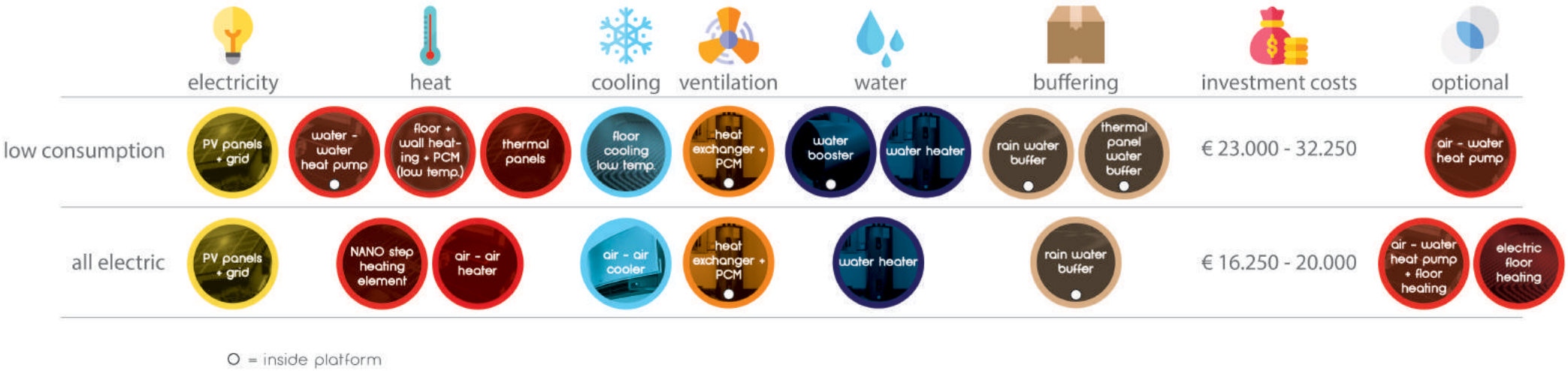
electric floor heating

\+ Higher efficiency (x4)
\- Higher investment costs

Concept collective system.

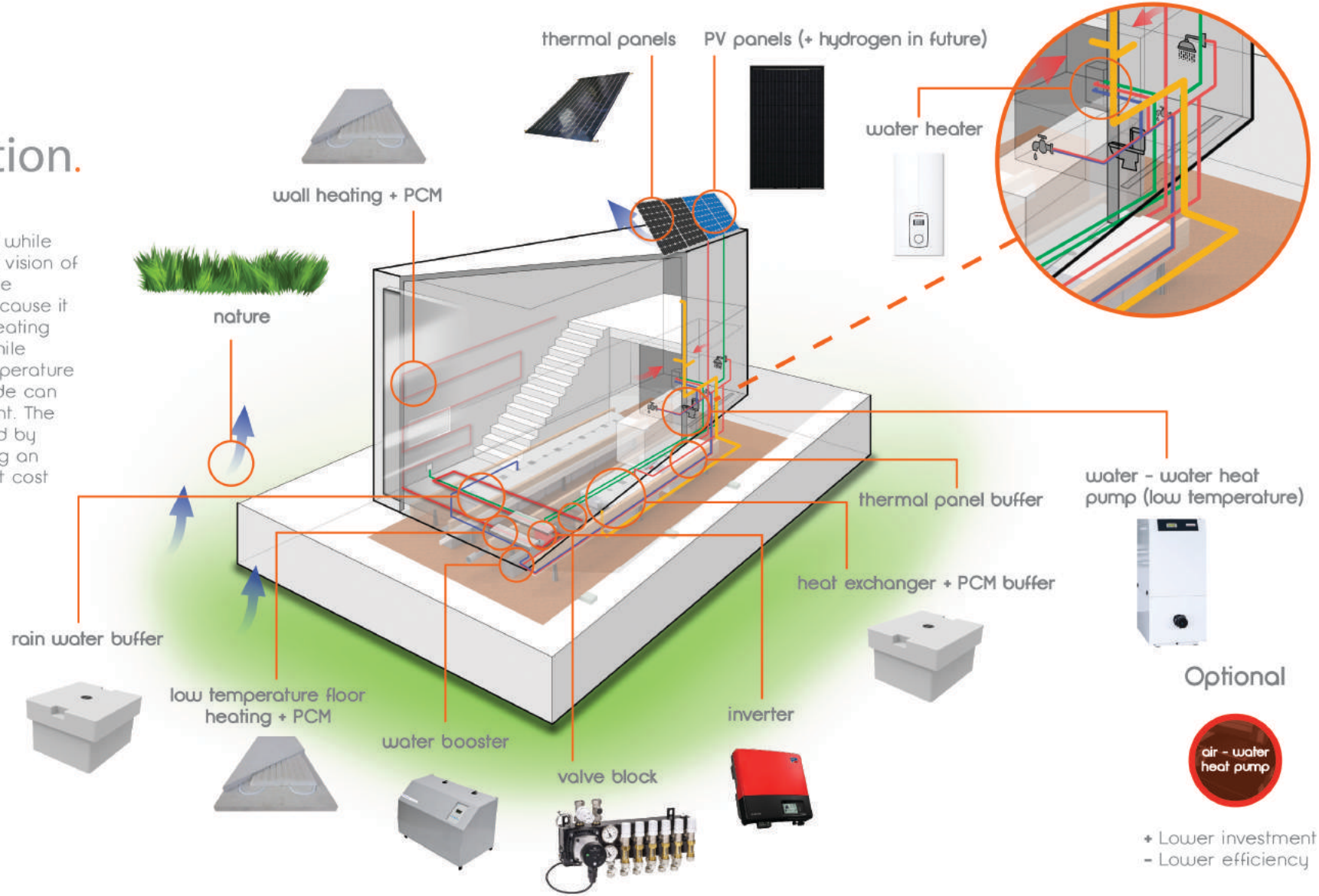
This concept is created while taking into account the vision of using electricity and/or water on a communal level. Because it is a low temperature heating system it can take a while before the desired temperature is met. The heat pump can be used by multiple houses, creating an overal lower investment cost per house.




electricity
heat
cooling
ventilation
water
buffering
investment costs
optional
low consumption
PV panels + grid
water - water heat pump
floor + wall heating + PCM (low temp.)
thermal panels
floor cooling low temp.
heat exchanger + PCM
water booster
water heater
rain water buffer
thermal panel water buffer
€ 23.000 - 32.250
air - water heat pump
all electric
PV panels + grid
NANO step heating element
air - air heater
air - air cooler
heat exchanger + PCM
water heater
rain water buffer
€ 16.250 - 20.000
air - water heat pump + floor heating
electric floor heating
O = inside platform

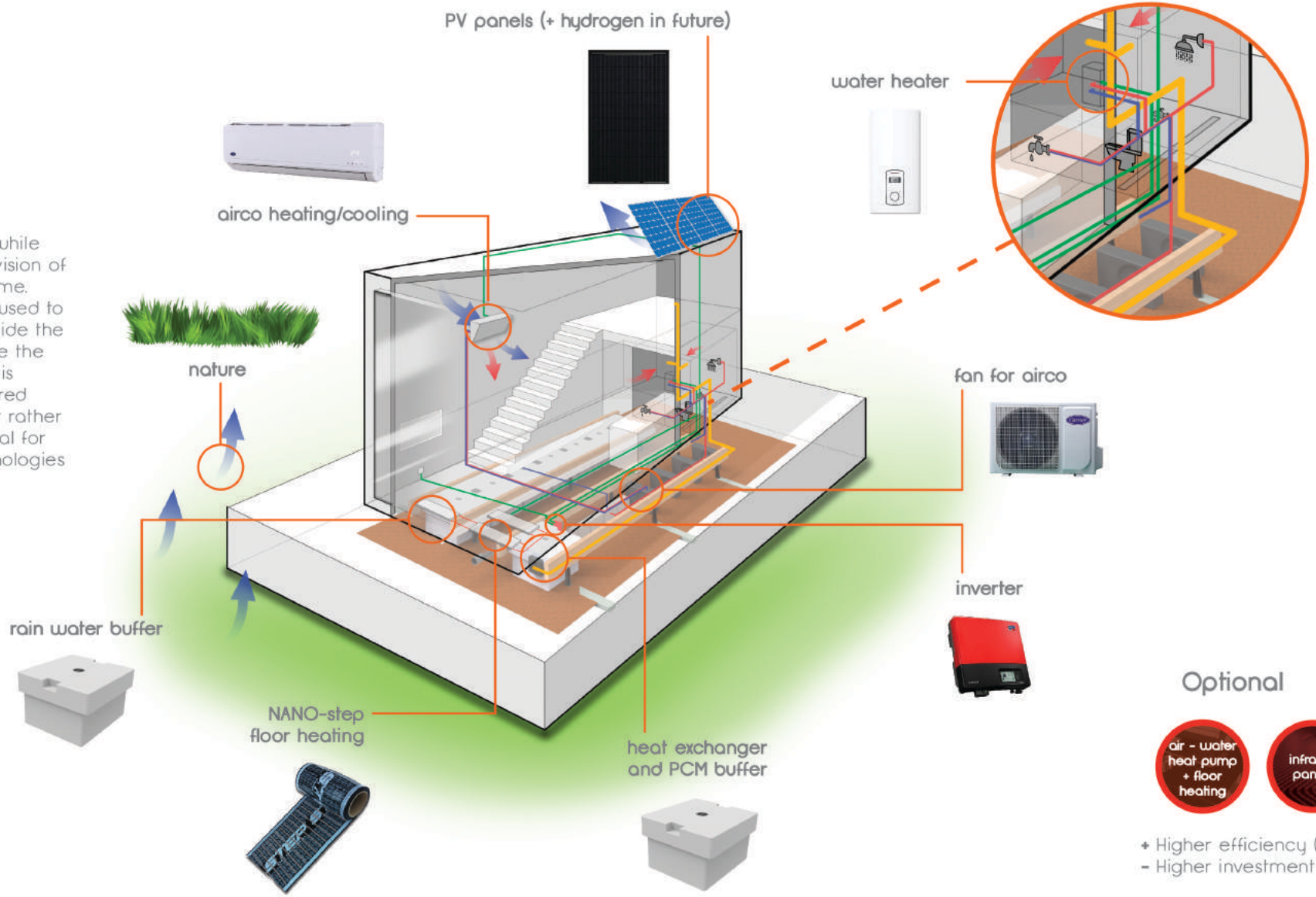
Concept low consumption.

This concept is created while taking into account the vision of using as little as possible electricity and heat. Because it is a low temperature heating system it can take a while before the desired temperature is met. The climate inside can be considered consistent. The heat pump can be used by multiple houses, creating an overal lower investment cost per house.



Concept all electric.

This concept is created while taking into account the vision of having an all electric home. where only electricity is used to heat the house and provide the house of energy. Because the selected heating system is electric as well, the desired temperature can be met rather quick. This concept is ideal for providing separate technologies per house.



Optional

air - water heat pump + floor heating

infrared panels

\+ Higher efficiency (x4)
\- Higher investment costs

APPENDIX J

PRODUCT SELECTION

A product selection for the two concept directions low consumption and all electric. The name of the product, the price and source are displayed in a table. The source also helped for having measurements to design the 3D model of the technology together with the platform structure.

Low consumption

Product	Price	
15 Solar panels + inverter	€4000	https://www.zonnepanelencentra.nl/20-zonnepanelen-295-wp-dmegc-dm295-m156-60bk-omvormer-sma?gclid=Cj0KCQiAn4PkBRCDARIsAGHmH3dkCu_ujtp289P6twlBTm10laII2V9teyhlwoI49ZRHDak8tGrlBnkaAlUyEALw_wcB
Water heater	€475/piece, €950 total	https://www.boilermarkt.nl/Doorstromer/Stiebel-Eltron-doorstroomboiler-DHB-E-18kW-LCD-25A-236744/
Water booster	€2000 - 3000	https://www.ithodaalderop.nl/producten/warmtepompen/waterwater/booster-warmtepomp
Thermal panels	€550/panel ; 5 pieces = €2750	
Water -water heat pump (18 kW	*€14.250 / 5 houses = €4750*	https://www.nibe.eu/nl-nl/producten/warmtepompen/water-water-warmtepompen
Water – water heat pump (24 kW)	*€17.750 / 7 houses = €2550*	
Water – water heat pump 60 kW	*€26.500 /16 houses = €1650*	
Water -water heat pump	€1650 - €4750	
Floor + wall heating + PCM	Around 105/m^2. Only floor is around €3350 (105*31,5) With wall this comes down to 105*70 = €7350	
Rain water buffer	€150/unit * 6 = €900	
Thermal panel water buffer	€150/unit *2 = €300	

Heat exchanger + PCM	€2.000*2 = €4.000	
Price ex installation	€19.900 - €28000	
Installation + 15%	€2985 and €4400	Price ex installation * 1.15
Total price	€23.000 – €32.250	Lowest price, without wall heat + pcm

All electric

Product	**Price**	
15 Solar panels + inverter	€4000	https://www.zonnepanelencentra.nl/20-zonnepanelen-295-wp-dmegc-dm295-m156-60bk-omvormer-sma?gclid=Cj0KCQiAn4PkBRCDARIsAGHmH3dkCu_ujtp289P6twlBTm10laII2V9teyhlwoI49ZRHDak8tGrlBnkaAlUyEALw_wcB
NANO STEP warm floor 24V	€145/$m^{2,}$ 145*31,5 = €4.567,5	https://www.theperfectheat.com/technology
Air – air heater/cooler	€1250 – €2000	https://www.koelklimaattechniekwebwinkel.nl/a-41025127/carrier-airconditioning/carrier-wandunit-42qhf012ds-38qus012ds-3-5kw/ https://www.aircosuper.nl/LG-PC09SQ-Standard-Plus-Dual-Inverter-Airconditioning
Water heater	€475/piece, €950 total	https://www.boilermarkt.nl/Doorstromer/Stiebel-Eltron-doorstroomboiler-DHB-E-18kW-LCD-25A-236744/
Heat exchanger + PCM	€2.000	
Rain water buffer	€150/unit * 7 = €1200	
Price ex installation	€14000 - €14750	

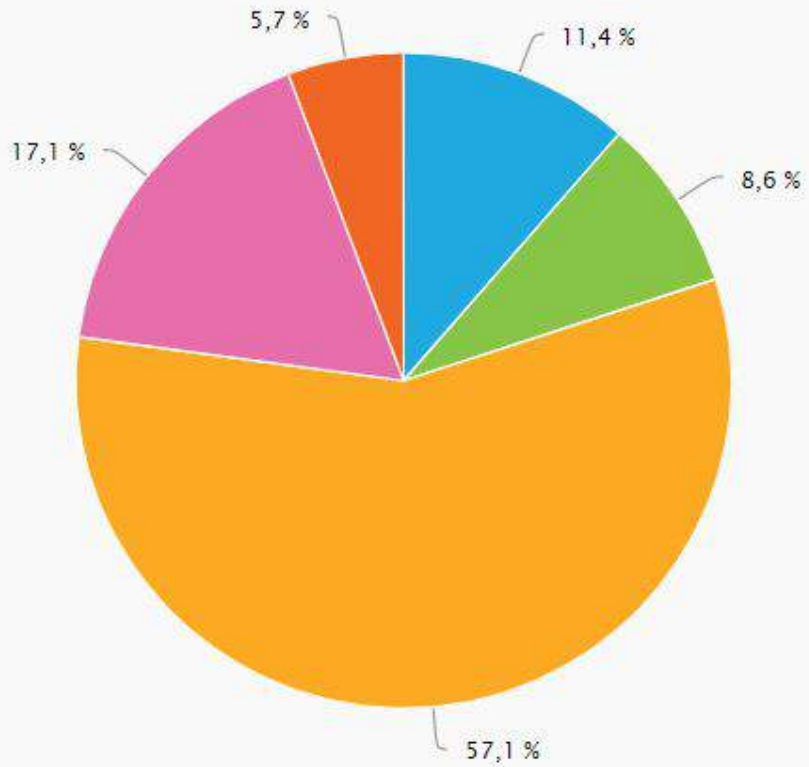
Installation + 15%	€2100 and €2250	
Total price	€16.250 - € 17.000	

APPENDIX K

SURVEY RESULTS

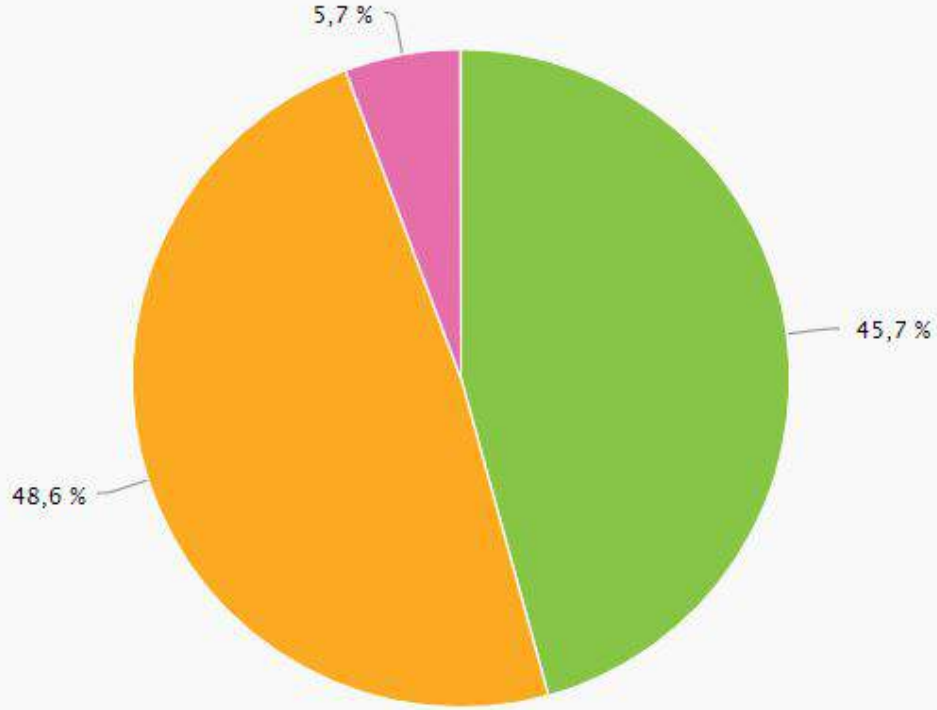
A survey has been spread in English and Dutch for people to answer to get more knowledge about them for filling in the persona (Student, Employed, Unemployed, Self-employed and Retired). The survey gave insight into their environmental awareness, their goals, frustrations, needs and social abilities. The survey had 48 respondents.

1 Welke omschrijving past het beste bij jou?



#	Antwoord	Antwoorden	Ratio
●	Student	4	11,4 %
●	Werkloos	3	8,6 %
●	Werkend	20	57,1 %
●	Werken voor jezelf (e.g. ZZP)	6	17,1 %
●	Gepensioneerd	2	5,7 %

2 Wat is je leeftijd?

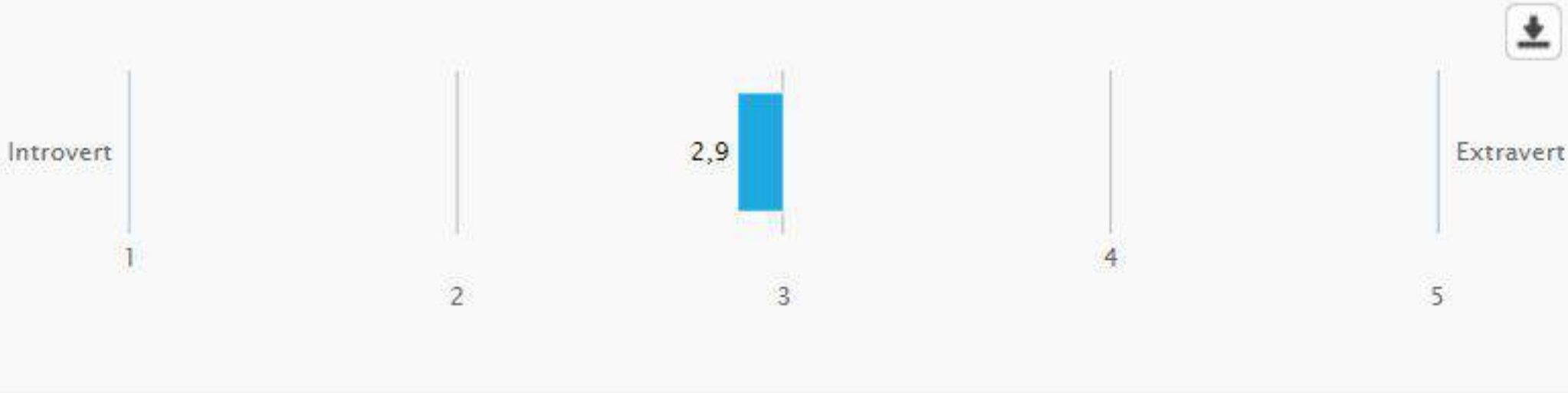


#	Antwoord	Antwoorden	Ratio
●	< 20	0	0 %
●	20 - 40	16	45,7 %
●	40 - 60	17	48,6 %
●	60 - 80	2	5,7 %
●	> 80	0	0 %

3 Wat is je hoofdberoep of bezigheid?

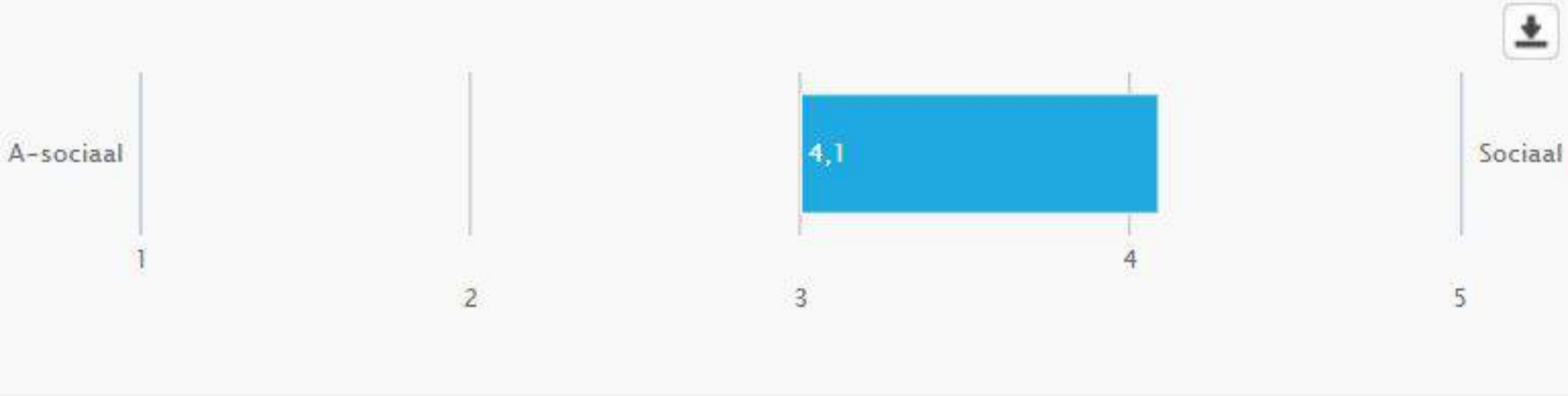
- Verpleegkundige niv4 en in opleiding tot HBO VP niv6
- Coach, secretaresse
- Treinen rijden
- Kassiere
- Ingenieur
- conducteur ns
- Access Bars Facilitator
- Managementassistent
- E-commerce
- Student International Relations
- Assistent
- Verkoopmedewerker
- Afstuderen
- Verkoopster (2x)
- Kapster
- Pleegzorgbegeleider
- Mechanische engineer
- Communicatie
- Genieten van het dagelijkse even ik was wijk ziekenverzorgende
- Docent
- Ik geef gastlessen
- All round storings monteur
- Muziek
- Ondersteunend begeleider
- Huisvrouw
- Dans docent
- Coach (2x)
- Studeren
- Huismoeder
- Engineer
- Zorg
- Fysiotherapeut
- Secretaresse

4 Hoe zou je jezelf omschrijven?



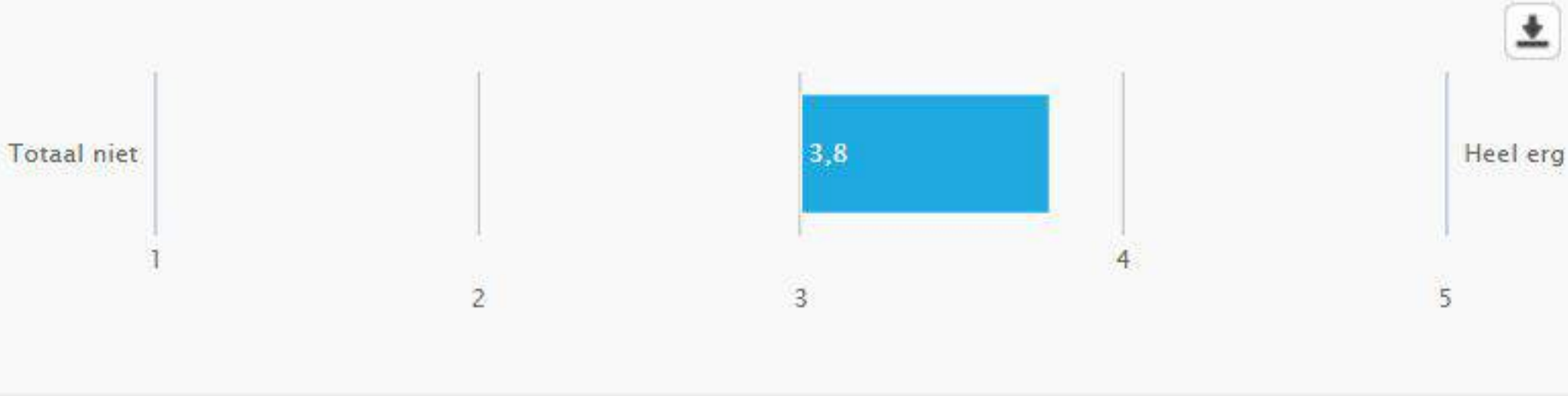
	1	2	3	4	5	
Introvert	1 (2,9%)	9 (25,7%)	19 (54,3%)	6 (17,1%)	0 (0%)	**Extravert**

5 Hoe zou je jezelf omschrijven?



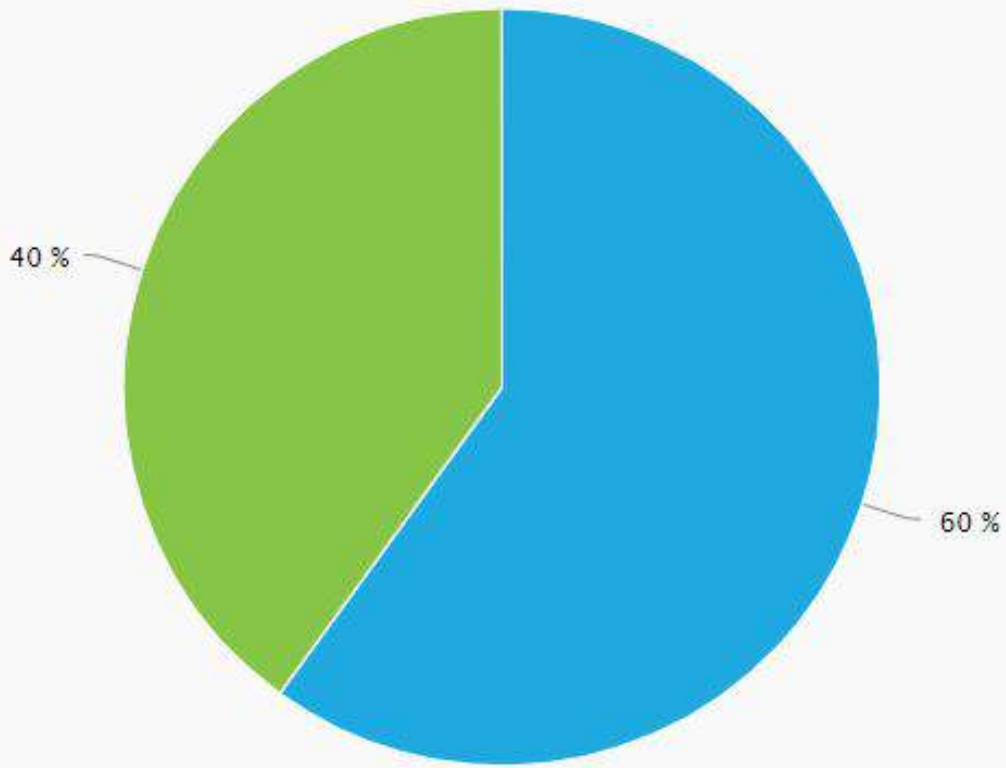
	1	2	3	4	5	
A-sociaal	0 (0%)	2 (5,7%)	1 (2,9%)	24 (68,6%)	8 (22,9%)	**Sociaal**

6 In hoeverre help jij mee aan een verduurzaamde wereld?



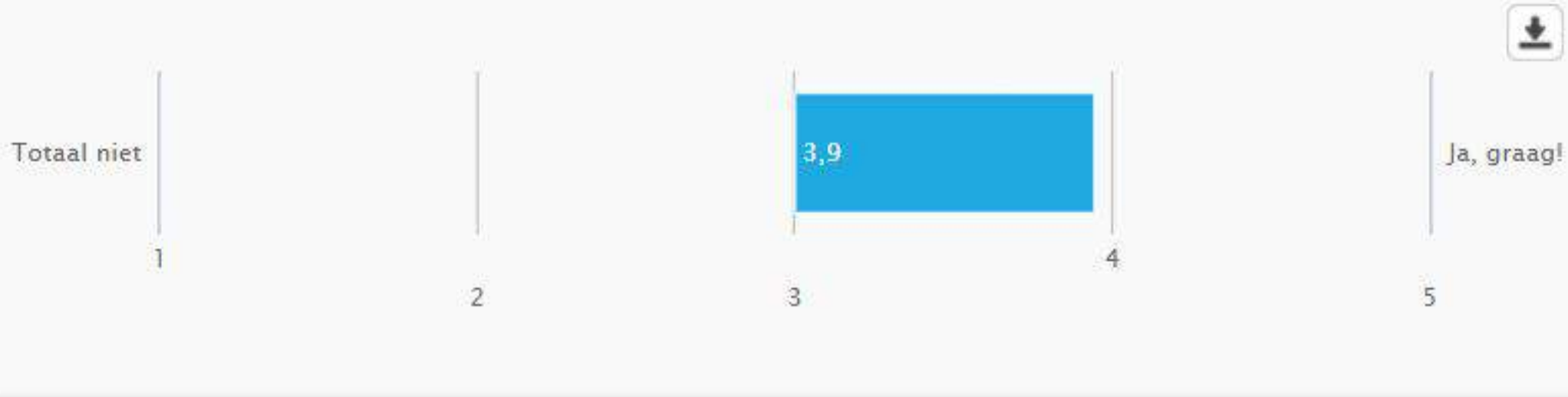
	1	2	3	4	5	
Totaal niet	0 (0%)	2 (5,7%)	10 (28,6%)	17 (48,6%)	6 (17,1%)	**Heel erg**

7 Zou je anders willen leven, waarbij je meer nadruk legt op het milieubewustzijn?



#	Antwoord	Antwoorden	Ratio
●	Ja	21	60 %
●	Nee	14	40 %

8 Zou je duurzaam willen wonen?



	1	2	3	4	5	
Totaal niet	0 (0%)	1 (2,9%)	10 (28,6%)	14 (40%)	10 (28,6%)	**Ja, graag!**

9 Wat zijn je doelen in het leven op dit moment en/of de toekomst?

Mijn HBO diploma halen, zorgen voor een veilige en goede toekomst voor mijn kinderen.

Zingeving

Studie

Op dit moment zou ik graag de curses honden en kattenbesluit willen volgen. Dit bereid mij voor op de toekomst om meer te gaan doen in het werkveld. En natuurlijk zou ik in de toekomst graag samen met mijn vriend (;) ;) ;)) willen gaan wonen in een pravhtig boerderijtje wat niet anders kan zijn dan duurzaam.

Balans vinden inkomen/plezier

Verhuizen, energie neutraal wonen, meer werken en muziek maken

Emigreren

Om af te studeren, en aangenomen te worden bij Buitenlandse Zaken.

Vaste baan bij Katten Academie ;) Mijn passie kunnen blijven uitoefenen en ik wil gewoon een keertje op vakantie :(

Afstuderen, orienteren naar een baan, toekomstig duurzaam wonen, vrienden dichtbij

Een fijn leven hebben, genoegen nemen met minder materiaal

Huisje boompje beestje

Combi van werk voor werkgever en zzp. Doen wat ik doen kan voor de natuur.

Persoonlijke ontwkkeling

Slim wonen

Weer gaan studeren

Mensen bewuster leren omgaan met zichzelf. Zo creeren we betere wereld.

Verbeter de wereld, begin bij jezelf

Bewuster leven

Schuldenvrij de maand doorkomen

Gezin, stabiele basis

Gezondheid

Helpen bij ouderen

Meer tijd doorbrengen met vrienden en leuke dingen doen

Gelukkig zijn. Gezond zijn.

Nu een beetje genieten van het leven

Een eigen huis kopen

Vakantie

Gewoon lekker doorleven

Zonnepanelen, energiebesparing, slimme woning

Vast contract krijgen en een uitdagende baan met toekomst

geen doelen

Mijn huidige leven voort kunnen zetten

Goedlopende praktijk hebben

Leuke baan

10 Wat zijn frustraties waar je tegenaanloopt met focus op sociale interactie, duurzaamheid en milieu?

Niet veel

N/A

Egoïsme, onverdraagzaamheid, onbewustzijn van de noodzaak voor het zorgen voor onze aarde.

Geen frustraties

Veel onduidelijkheid en weinig onderzoek

Afval op straat

Het vele plastic in de supermarkt (om alle groentes/ fruit bijv)

Dat ze in Nederland er veel om geven.. Terwijl de winst meer in het buitenland te behalen valt

Wil wel heel veel, maar weet niet altijd hoe

Veel mensen hebben wel het bewustzijn, maar denken dat wat zij zelf bijdragen geen effect heeft op het grotere geheel en doen daarom niet alles wat ze zouden kunnen doen.

De overheid haar geldklopperij >:(

Ik zie dat veel mensen hun afval gewoon dumpen, zich absoluut niet bezig houden met de natuur om ons heen.

Geld is altijd de winnaar :-(

Regeltjes

De prijs, mijn kosten.

Duurzaamheid

Facebook soms storend, uitslag verkiezingen

Onduidelijk, elke gemeente weer anders met recyclen

Grote veranderingen moeten van bovenaf, overheid, komen. Anders gebeuren er geen grote veranderingen

Zwerfafval, weggooicultuur, voedselverspilling

Mensen in m'n huis ken ik niet. Mensen denken veel aan zichzelf als het gaat om milieu

tegenwerking overheids instanties

Lastig

Niet iedereen is even tolerant en begripvol naar de ander

Vervuiling naruurgebieden

Teveel gebruik van plastic gebruik.

Geen (3x)

Niet realistisch

Het effect van eigen handelen in relatie tot het grote geheel

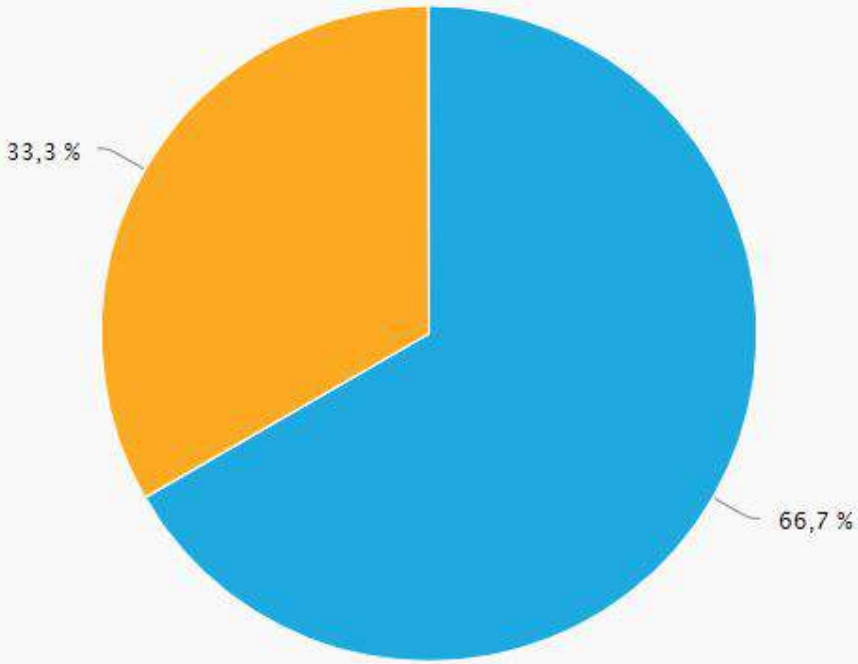
Gebrek aan respect en verkwisting

Mensen zijn uit verbinding aan het raken door sociale media

Nog steeds teveel onnodig verpakkingsmateriaal

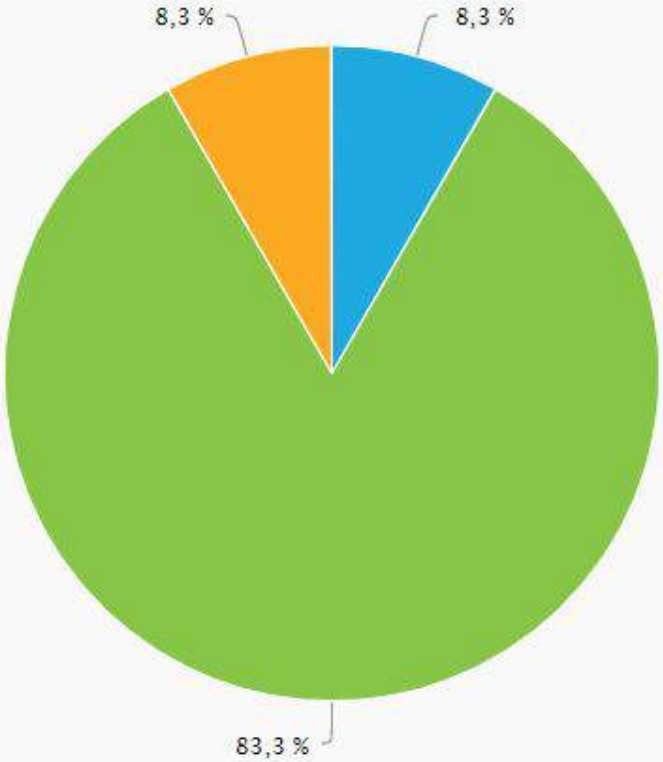
Er ligt veel verantwoordelijkheid bij bedrijven- heb je weinig invloed op. Koopgedrag van mensen is ook erg belangrijk, maar dat is het creeeren van een ander bewustzijn en heeft tijd nodig

1 Which description suits you the best?



#	Antwoord	Antwoorden	Ratio
1	Student	8	66,7 %
2	Unemployed	0	0 %
3	Employed	4	33,3 %
4	Self-employed	0	0 %
5	Retired	0	0 %

2 What is your age?

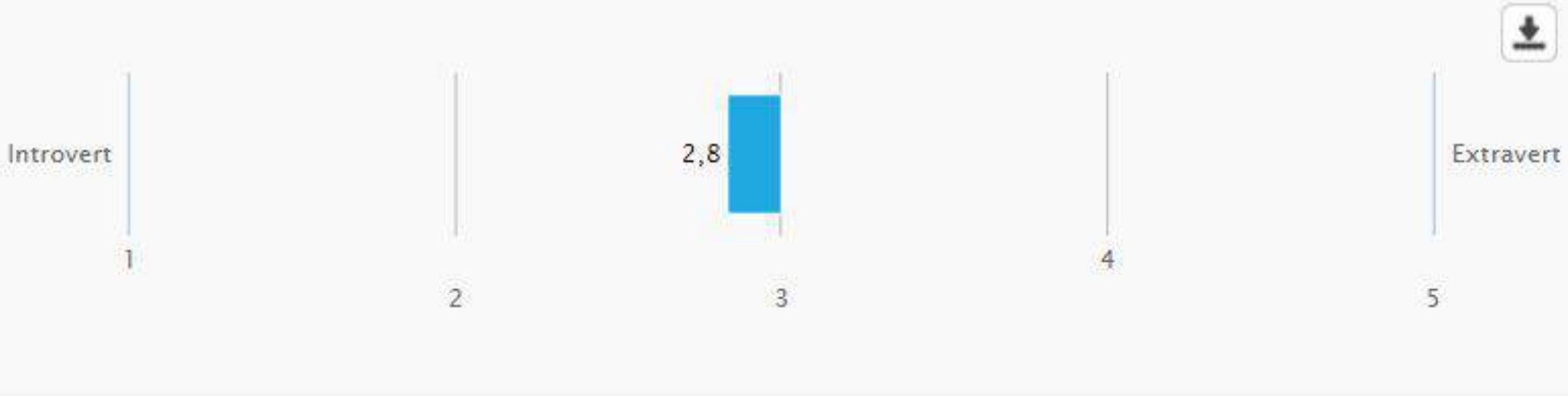


#	Antwoord	Antwoorden	Ratio
●	< 20	1	8,3 %
●	20 - 40	10	83,3 %
●	40 - 60	1	8,3 %
●	60 - 80	0	0 %
●	> 80	0	0 %

3 What is you main occupation?

Student (4x)	Work, beeing mom, studie	Project manager IT	Student in Industrial Design Engineering with part time jobs
student	Study	:	Lecturer
Film kijken, dieren verzorgen, werken en school			

4 How would you describe yourself?



	1	2	3	4	5	
Introvert	1 (8,3%)	4 (33,3%)	3 (25%)	4 (33,3%)	0 (0%)	**Extravert**

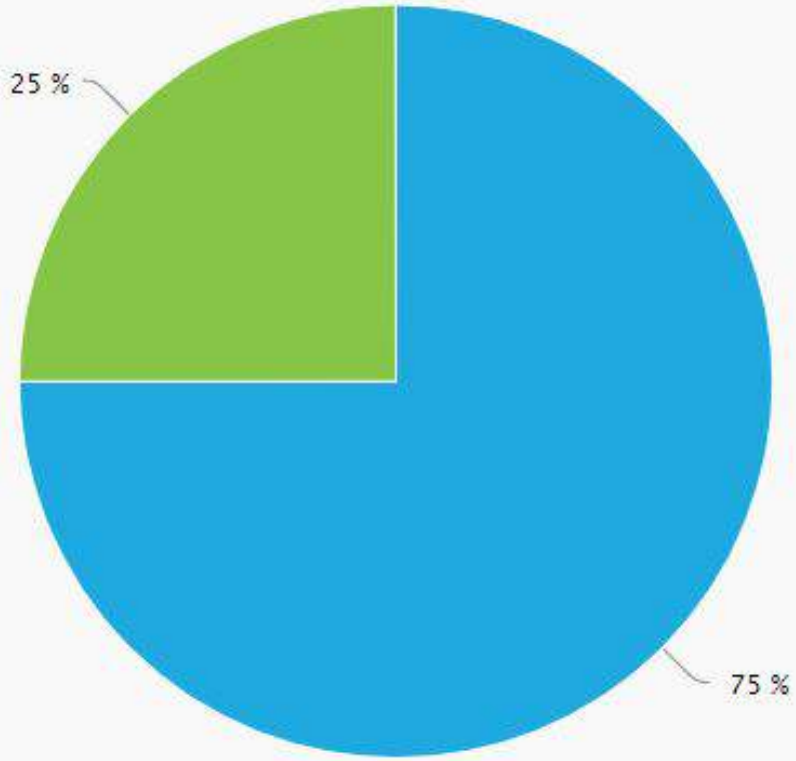
5 How would you describe yourself?

	1	2	3	4	5	
Anti-social	1 (8,3%)	2 (16,7%)	2 (16,7%)	5 (41,7%)	2 (16,7%)	**Social**

6 To what extent do you contribute to a sustainable world?

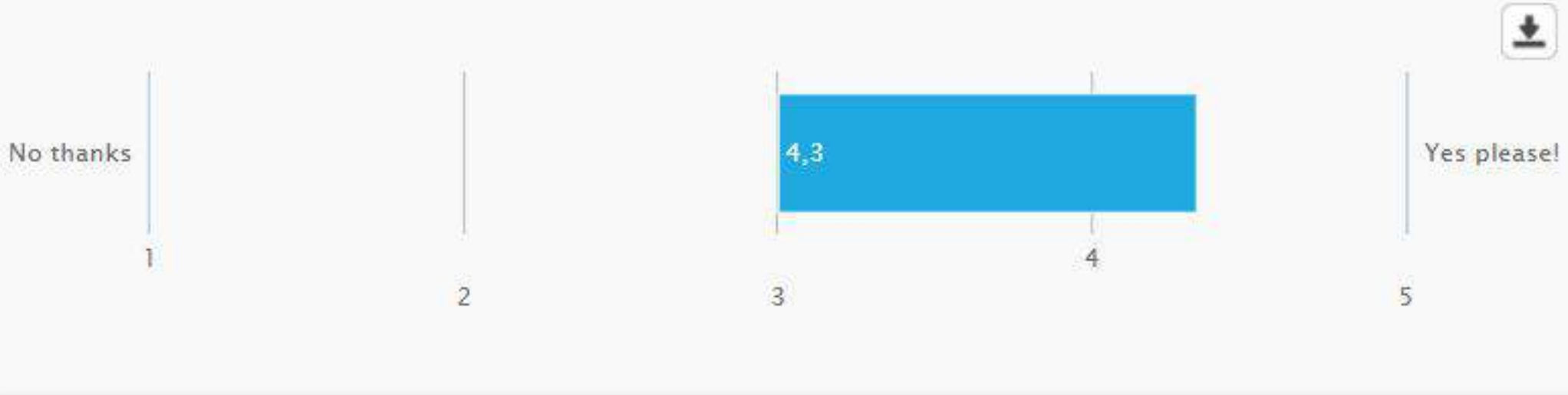
	1	2	3	4	5	
Not at all	2 (16,7%)	1 (8,3%)	4 (33,3%)	5 (41,7%)	0 (0%)	**A lot**

7 Would you like to live differently, emphasizing more on environmental awareness?



#	Antwoord	Antwoorden	Ratio
●	Yes	9	75 %
●	No	3	25 %

8 Would you like to live sustainable?



	1	2	3	4	5	
No thanks	0 (0%)	1 (8,3%)	0 (0%)	5 (41,7%)	6 (50%)	**Yes please!**

9 What are your goals in life at this moment and/or the future?

graduating	End studie, job higher up, to management niveau.	Keeping talent in the twente region	Manage my workload and do well
Degree, find career, build network	Get my degree	finish my studies	.
Finishing my masters	Gelukkig zijn	Good work-life-balance	Private

10 What are your inner frustrations with regard to social interaction, environment and sustainability?

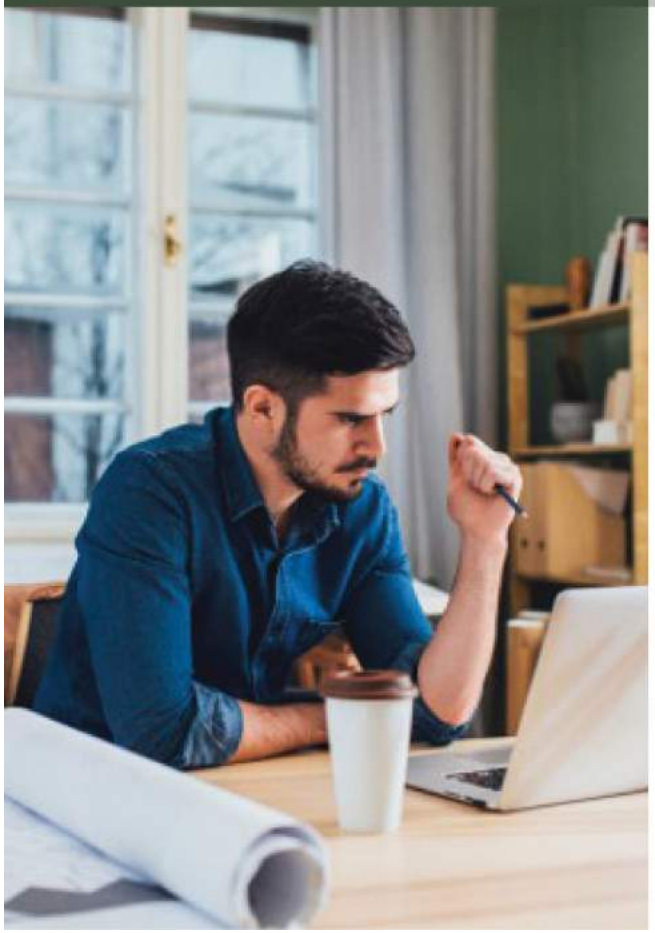
Not enough activity from the government	To much plastic in the supermarket. The rush ,we, people have...	The government does not put solar panels on all their roofs	I am awkward in social situations, I would like to be more sustainable but I feel like a) I don't have time and b) I am not sure what is sustainable and what is a trend anymore
People not caring or not believing the news	not doing enough	.	
Ignorance (2x)	All the negativity	😄	
Te veel gevaar voor de nederlandse bevolking, door open grenzen.			

APPENDIX L

PERSONAS

Personas: Student, Employed, Unemployed, Self-employed and Retired. Defined with data from the performed survey.

SELF EMPLOYED
DIRK WILLEMSEN



AGE	39
OCCUPATION	Architect, sustainability
EDUCATION	Architecture
PERSONALITY	Somewhat introvert
STATUS	Single
ARCHETYPE	Introvert, social, smart

ENVIRONMENTAL AWARENESS ● ● ● ● ●

GOALS

To matter in what you do, personal growth

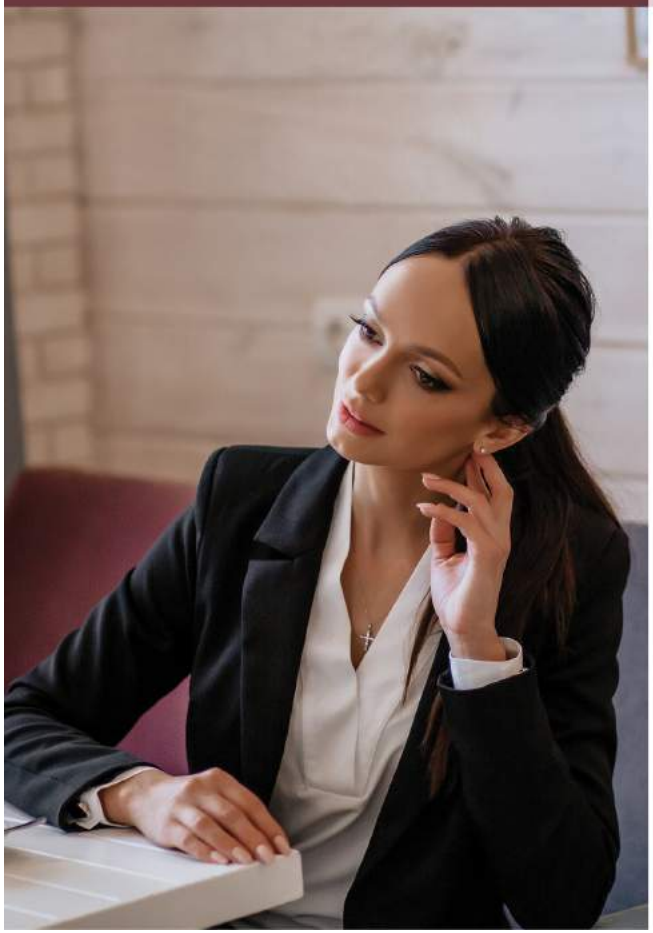
FRUSTRATIONS

Big changes are government related.
Regulations stopping things from happening.

BIO

Dirk Willemsen started his own company after graduating. With current sustainability developments he wants to pursue an architect career where sustainability is the main focus. For his work he needs to be social, and would like to tell others about his passion. He would like the social aspect of being in a community to share different ideas and think about what they could contribute.

EMPLOYED
MARLEEN SCHOLTEN



AGE	33
OCCUPATION	Accountant
EDUCATION	Accountancy
PERSONALITY	Somewhat extravert
STATUS	Couple
ARCHETYPE	Good with numbers, social, enough money

ENVIRONMENTAL AWARENESS	● ● ● ● ○
GOALS	Work-life balance, stability, live with less
FRUSTRATIONS	Amounts of plastic packaging, egoïsm, people throwing trash on the ground

BIO

Marleen is a hard working woman, who likes to have people in her neighbourhood who think alike and care about nature. She is interested in the people she lives with. She doesn't have a lot of free time, but the money she earns makes up for this. She would be okay living sustainable and care a bit more about the environment this way.

RETIRED
JACOB BROUWER

AGE	71
OCCUPATION	Enjoy life
EDUCATION	Arts and Crafts
PERSONALITY	Somewhat extravert
STATUS	Couple
ARCHETYPE	Creative, free, time, social

ENVIRONMENTAL AWARENESS ● ● ● ● ○

GOALS

Living the life, coming years should matter

FRUSTRATIONS

Living only with people of the same age.

People not thinking about the future.

BIO

As a retired man, Jacob likes to take the best out of his live. He also thinks about what he will leave behind when he's gone. Because he is a man who wants to matter in what he does for the rest of his live, he likes to talk about this with people who are younger. Maybe they can do something different that he would've done earlier in life. Living sustainable is one way to accomplish this.

STUDENT
MARC DE ZWIER

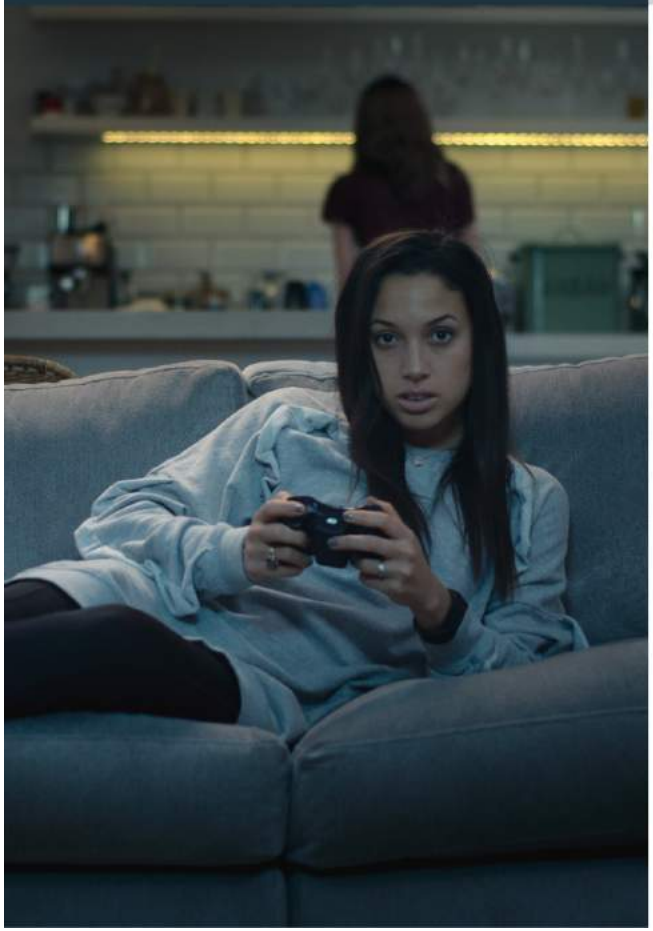
AGE	23
OCCUPATION	Studying
EDUCATION	Software Engineering
PERSONALITY	Somewhat introvert
STATUS	Single
ARCHETYPE	Time, no money, social

ENVIRONMENTAL AWARENESS	● ● ● ● ○
GOALS	Graduating
FRUSTRATIONS	People not caring, waste of food

BIO

Marc de Zwier is a hard-working student in Software Engineering. He is not a very social guy, but tries to improve by adapting a social attitude. He would like to try the concept of living more sustainable and adjust his life in order to be more aware about the environment. He would be okay trading some of his time for living in a cheaper home.

UNEMPLOYED
LISA DE GROOT



AGE	28
OCCUPATION	Finding a job
EDUCATION	Fashion Design
PERSONALITY	Extravert
STATUS	Single
ARCHETYPE	Creative, social, free time

ENVIRONMENTAL AWARENESS	● ● ● ○ ○
GOALS	Becoming a famous fashion designer
FRUSTRATIONS	Finding the right job, people

BIO

Lisa is a woman who got her degree in Fashion Design and wants to be recognized. She only wants the best, which is why she is still searching. She gets an alimony, where she can barely live from. She would love to live cheap and in return deliver some hours of work. She can spent the rest of the time to search for the job that she so desperately would like to have.

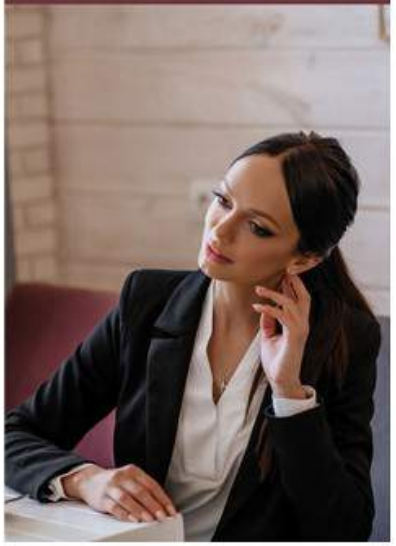
RETIRED
JACOB BROUWER

Behoeftes
Sociale interactie
Privé ruimte buitenshuis
Vrij van zorg
Buurschap
Vakantie

STUDENT
MARC DE ZWIER

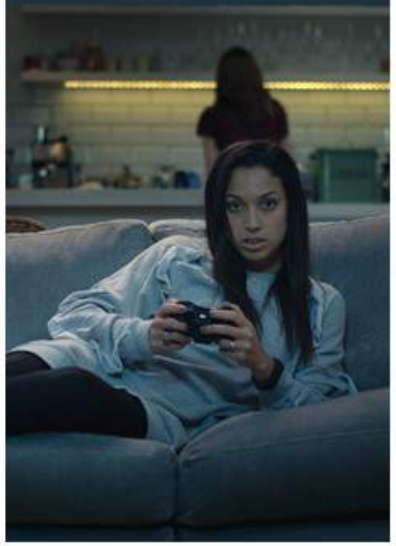
Behoeftes
Goedkoop wonen
Vrijheid in doen en laten
Gemeenschappelijke ruimte
Meer geld
Afstuderen
Delen

EMPLOYED
MARLEEN SCHOLTEN



Behoeftes
Minder werken
Stabiliteit in het leven
Mensen ontmoeten
Gemeenschappelijke ruimte
Privé ruimte buitenshuis
Persoonlijke ontwikkeling
Opnieuw studeren

UNEMPLOYED
LISA DE GROOT



Behoeftes
Sociale interactie
Privé ruimte buitenshuis
Delen
Gemeenschappelijke ruimte
Werk
Bewust leven

SELF EMPLOYED
DIRK WILLEMSEN

Behoeftes
Privé ruimte buitenshuis
Bij huis
Zingeving
Goed lopend bedrijf

APPENDIX M

LITERATURE REVIEW

This document contains research, conducted for this MSc Industrial Design Engineer graduation project. The project ran at D'Andrea & Evers. The research is about how to encourage people to form a community. Furthermore, research has been performed on how nature and the concept of sharing can contribute in designing a successful communal space. All the topics have been researched by performing literature review on the topics. The document provides design propositions derived from the performed research for designing successful communal spaces.

UNIVERSITY OF TWENTE.
Faculty of
Engineering Technology

Industrial Design Engineering
Collected publications
programme homepage: utwente.nl/ide

Design propositions for communal spaces within communities through research

Vincent G. P. Ubbens

Human-Technology Relations

Graduation date: July 12, 2019

This document contains research, conducted for a MSc Industrial Design Engineer graduation project. The project ran at D'Andrea & Evers. The research is about how to encourage people to form a community. Furthermore, research has been performed on how nature and the concept of sharing can contribute in designing a successful communal space. All the topics have been researched by performing literature review on the topics. The document provides design propositions derived from the performed research for designing successful communal spaces.

community; sharing; nature; communal spaces

1. Introduction

2050 is a special date, set by the government in The Netherlands. They want to reduce the greenhouse gases, like CO_2 to a minimum (80-95% less than in 1990). This, due to recent developments where winning gas results in earthquakes, damaging homes in the surroundings. In 2050 almost every energy supply should provide sustainable energy [1]. This resulted in the Dutch government deciding that requests for new constructions from the 1st of January 2019 entails that the houses cannot get a gas connection and instead should think about a more sustainable way of receiving energy [2].

A graduation project for the design agency D'Andrea & Evers lead to research that will be elaborated on in this paper. The whole project is about designing modular, sustainable one- to two-person households that can easily be build up and broken down, to respond to the high demand of households and to change the mindset and way on how houses are built currently. As a part of that project - the graduation project - a platform should be designed, which holds sustainable technologies that are providing the overall needs of the residents for the household (e.g. heat, electricity, ventilation, etc.). The households are around 31,5m² and can stack up or under the platform with a maximum amount of three buildings. Figure 1 shows a schematic front view of the idea. The platform and/or area around it should promote social connections between residents. Therefore, it is interesting to think about ways to include the surroundings of the community in some way by sharing products or services. The households look distinctive and support sustainable living.

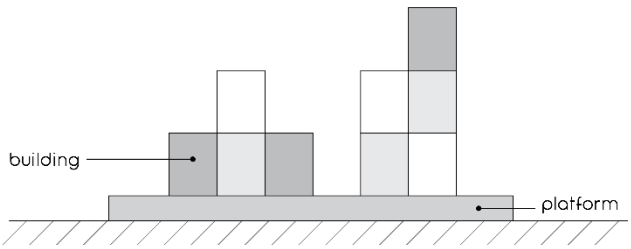


Figure 1.; Schematic front view concept.

In order to promote community forming in and/or around the buildings, research is performed to gain insight into what factors supports in forming a community and how nature and sharing can contribute to a community atmosphere within the shared space and service/product. Nature, because that is why sustainability is such a big topic right now, and within the project. Sharing because there is a noticeable shift currently from owning goods to accessing or sharing in combination with services. [3]

These insights should provide certain propositions for the design of the outside and surroundings of the platform. Therefore the main research question is formulated as follows:

- What factors can encourage people to form a community, and how can nature and the concept of sharing contribute to a successful communal space?

The next chapter will elaborate on the main question. The third chapter of this paper will propose a design idea for the communal space together with the design propositions found in the literature review.

2. Literature review

The first research question is divided into subcategories that are relevant to the project. They are arranged into paragraphs, being: community, nature and sharing. The first chapter will elaborate on how to promote social cohesion, creating a sense of belonging and in overall create a community. In the second paragraph 'nature', the goal is to gain insight into what positive influences nature can bring to the community and people themselves. The third paragraph is about sharing. What does sharing mean, what positive influences can it bring and what service and/or product helps creating a social, communal space.

2.1. Community

It is important to understand how to create a community or how to stimulate the feeling of being a community. What people need to feel in order to become a community and feel a sense of coherence. As a first, a design can stimulate this feeling. Creating a sense of coherence and meaning is important for people's wellbeing [4].

That meaning is (partly) already created by living sustainable. In order to function in a group, one should first determine their social identity. They do so by categorizing themselves into social groups consisting of people with whom they are similar or different [5]. In this case it is about people who are similar-minded (or different from the rest). As an example, residents of Tiny Houses also hope to get in contact with people that share the same interests and ways of living [6]. When a group strongly feels something is 'theirs', a sense of commonality emerges [7]. It is hypothesised that this feeling could be stimulated by allowing the residents of Habitat decide what the communal space should look like. As an example, a phone on itself is not expressing as much of an individual, but with a phone case someone can already express themselves as 'me' rather than 'mine'. The communal space should feel like 'theirs' and express 'them'. This way they have the opportunity to express themselves through the design.

When creating a place where local residents can meet and socialize, a sense of pride and belonging within the community is triggered [8]. Belonging means acceptance as being a member or part of something [9]. A sense of belonging is not only important for shaping a community, but also for the individual. It can create a feeling of social connectedness, but also suppress negative feelings like social isolation, loneliness and alienation. Belongingness is about having positive and pleasant contacts with people that are no stranger to someone [10].

In order to get to know one another, the communal space should provide the opportunity to have contact with the locals and make new connections. One way to achieve this is to dress up the communal space is by implementing nature. This is a relative obvious option to consider, due to the fact that the design project is all about sustainability. Thereby, interacting with nature can lead to beneficial effects on social cohesion (among other things) [11 & 12]. Therefore, it is interesting enough to research what role nature could play within the community, to the surroundings and how nature can positively influence the community forming.

2.2. Nature

An overemphasis on creating communal spaces results in sterile spaces that are not used when it lacks the right services, goods or connection to existing economic and social networks [13]. Nature could provide in certain services and goods, which should fit within the context and its surroundings.

Green spaces are not merely for stimulating a community. It can support salutogenic effects, where the focus is on the stimulation of a person's health and well-being instead of focussing on the things that give negative influences. As an example, aesthetic appreciation is one of them, but hard to make visible in studies on this matter. However, it is also important to induce a certain balance between restorative qualities and the social aspect [4]. Keniger et. al. show a variant of examples of nature and its beneficial effect on the social aspect. This effect can occur at an individual, community and even national scale. The effects mentioned are: facilitated social interaction, enabling social empowerment, reducing crime rates, reducing violence, enabling interracial interaction, social cohesion and social support. [12] These are all effects that can be considered important for creating a nice neighbourhood and fostering a social community.

Nature can also provide other useful, more tangible products. For instance edible items from nature. The more ways of interacting with nature we can experience by using different senses, the more we can relate to nature. Allotment gardens and forest gardens that function as community gardens can provide a sense of place [4], hence, community. Nature could reflect important values that residents hold on to and strengthen the self-identity by symbolizing the self [7].

2.3. Sharing

It is assumed that a connection amongst residents of the community and its surroundings could be established by offering a service and/or product for sharing. This, because communication has to take place in order to use the service and/or product. When thinking about offering a product/service from the community, it could be something that is access-based or shared ownership-based.

Access-based products or services are not necessarily promoting prosocial behaviour. It can be used without social interaction. It could be something that is only interesting for one person. Sharing is about something where multiple people can be involved. One cannot share on its own [14]. As an example, John Doe can access a car via a service. John can achieve the goal of using the car all by himself, whereas sharing would probably involve asking people when or if the car is available on a certain day, maybe calling who has the car at that moment when John also might need it, etc.

Liem [15] came up with a 3-dimensional graph to show the relation between type of experience, type of offering and mode of ownership. This graph can be advised in figure 2. It shows that both partially owned or shared ownership share the same type of experience (utilitarian), but not the type of offering.

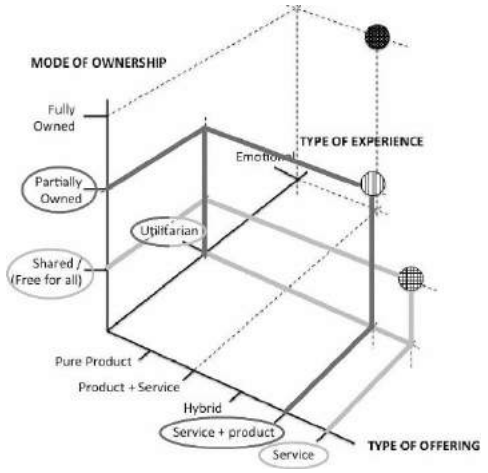


Figure 2.; 3-Dimensional Experience – Offering – Ownership Framework [15].

if someone would like a shared mode of ownership, this could best be performed by creating just a service according the graph. Public transport is such an example. Taking the train, using the service of going from A to B, without (partially) owning the train itself.

In the case of a partially owned mode of ownership, this could best be performed by creating a service + product where the service is the most important factor (so not a product + service). The product is merely there to support or provide the service. As an example let's take the company Swapfiets. It is a company where you buy a membership, which gives you access to a bike. For the time being, it is your bike, up onto the moment the membership expires and you need to give it back. The main service is also to get you from A to B, but the consumer keeps the product that provides this service. Thereby will their service also help the consumer if the main service cannot be performed anymore, by providing a new bike or fixing the one you have. If the bike is not needed anymore is can be used by someone else.

If a product or service would be part of the community or neighbourhood, it is important to think about the consequences and what people do or don't like to have as responsibility, sanctions that come with it and management of the system. When creating something where the emphasis is not on the management or efficiency of the product/service, this could support

contributing to the community and sharing behaviour [16]. However, as a designer it is important to think about the management and how people would like things arranged. If there is a lack of trust amongst people but they share the main goal, people are willing to contribute to a sanction system [17]. For instance, if someone wants to sell his/her laptop for a certain amount of money, there has to be a mutual trust, because one has to send the product and wants the money, whereas the other wants the product and transfers money. Which transaction should go first? What if someone does not get the promised good? There should be a sanction system in that case. Therefore, it is important to have trust amongst the people of the community in a consumer (insider) to consumer (in-/outsider) relation. Otherwise there is a shift needed to a business to consumer model. In the case of a business to consumer model the company can take responsibility in solving issues regarding distrust amongst community members [17].

3. Insights

This chapter will provide a general idea insight and the design propositions derived from the literature review.

3.1. Approach

When designing for the communal space a choice can be made whether to design something different for every location, design multiple options and let the residents choose or let the residents come up with their own idea for the area.

The most ideal approach for stimulating social interaction is to let people think about it themselves and come up with something unique, which they have to arrange themselves and build from a budget. But on the other hand, it could also be the case that no resident feels like taking initiative and they might rather choose from pre-selected options. Another reason to facilitate an open approach is that it could lead to an opportunity for residents in creating a social connection, and a reason to facilitate a service (+ product) within the communal area. It can give people a reason to go to the communal space and the socializing could occur by itself.

Skjelvik et. al. researched companies that facilitate services and/or products for sharing. These are respectfully: car sharing, places for sharing goods (product swap or take), house renting/couch surfing, general workplaces for companies (conference, meeting, presentation, etc.), Sharing energy/water to a company nearby, sharing smaller goods, within and expanding the community [18].

Figure 3.; Collage possibilities sharing service (+ product).

3.2. Design propositions

There is more to designing communal spaces than picking nice objects or making it appealing. In order to create a successful communal space, it also relies on people adopting, using and managing the space [13]. People make places, not the other way round. In order to clarify the design propositions derived from this research, they are listed below.

4.1. Literature review

Design propositions derived from literature:

- Communal space should provide the right services, goods or connection to existing economic and social networks [8]
- Balance between restorative qualities and social aspect [4]
- Nature reflecting important values of the residents [7]
- A place where you can meet and socialize [8]
- Let the residents feel like it's 'theirs' [7]
- Allotment and forest garden can provide a sense of place [4]
- Creating opportunities to have positive and pleasant contact, so they get to know each other [10]
- Interacting with nature [11 & 12]
- Sharing a service (+product) [14 & 15]
- Choose between B2C or C2C. Depending on how much people trust each other [17]
- Management or efficiency of the product service should be in the background (not the main factor or goal) [16]
- Expressing important values of the resident, reflected by nature [7]
- Let the residents help design their own neighbourhood [4]
- Physical and mental interaction with a public place will create a sense of belonging [19]

Important elements for 'designing in inclusion' are [13]:

- Including all age groups and social groups in ideas for the public space
- Encourage a strong sense of local distinctiveness
- Looking at evolving a range of spaces with different security regimes, including 'light touch' regulation
- Successful public spaces should build on the large degree of self-regulation of public behaviour that already exists

5. Discussion

During literature research, sharing and nature were researched as topics, that have relations to creating a community or a sense of belonging to a group. This resulted in multiple design proposition. Further research could dive deeper into a more complete overview of different factors that could help triggering this desired outcome. It is hypothesised that it could be stimulated by allowing the residents of Habitat decide what the public/communal area should look like.

The statement is made that letting people decide what should be placed in a public or communal area should be up to the residents. This would be the ideal case, if everybody entrusts one another. As also found, if there are trust issues amongst people, they might not come up with a design at all and the space is left empty. Therefore, a good suggestion might be to let people choose between certain designs, so they still have some degree of freedom, but not everything open and some guidance.

It is assumed that a connection amongst residents of the community and its surroundings could be established by offering a service and/or product. Elaborate research should point out if this really is the case.

Some research papers were about public spaces rather than communal spaces. The to-be-designed area could become a public space, but a communal space as well. This could mean that certain propositions might only work for the public spaces and not necessarily communal areas.

This literature research covered a part about how to create a successful communal space, while creating a community atmosphere. The topics 'sharing' and 'nature' have been researched. A follow-up topic where research could be performed is 'safety' in order to gain more insight into different factors that can help for creating a community atmosphere or successful communal space. A follow-up research question could be: "How to create a communal space where people feel save?"

There are a lot of factors that can help in order to make the design for a communal space work. However, it is not only the design that should fit, but also the people and what they would like to share with the world. To show their extended selves and who they are.

6. Conclusion

The literature review provides a lot of design propositions that are listed for creating a successful communal atmosphere with nature and the concept of sharing. Furthermore, multiple factors are discovered that can encourage people in forming a community.

Further research in safety could provide more design propositions for creating a successful communal area.

7. Concept design

Some of the design propositions implemented in the concept of the project are: the physical and mental interaction, creating opportunities for pleasant and positive social interaction and a place where you can meet and socialize and interacting with nature. An impression of the concept is displayed below.

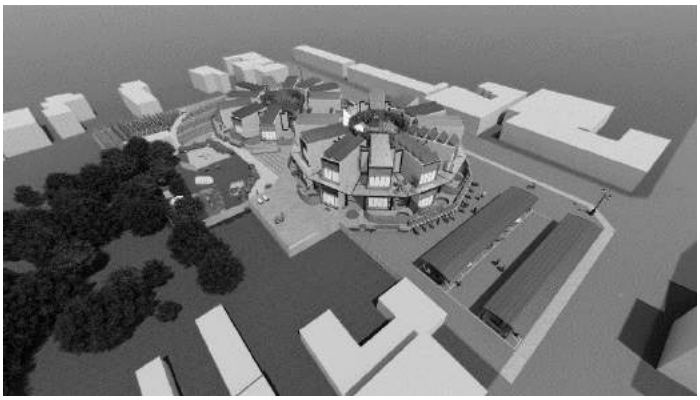


Figure 4.; Impression of concept with implemented design propositions.

8. Acknowledgements

I would like to thank the design agency, D'Andrea & Evers, for giving me the opportunity to contribute to this project.

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APPENDIX N1

BRAINSTORM PRESENTATION

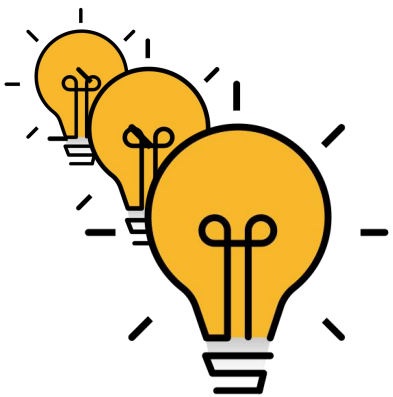
The presentation that is used for performing the brainstorm. Topics that were covered are: privacy, sharing of products and services and ideation on how to facilitate this.

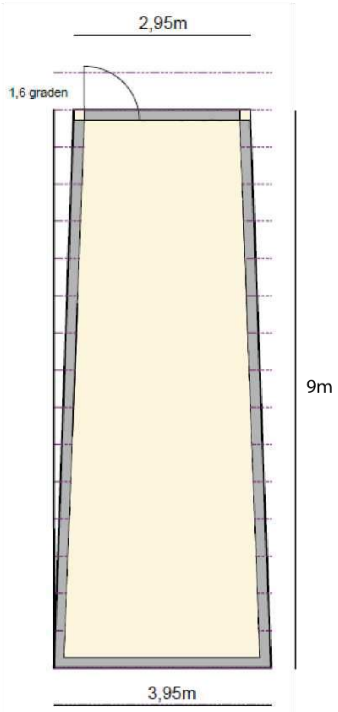
Brainstorm

Privacy en het delen van producten en diensten

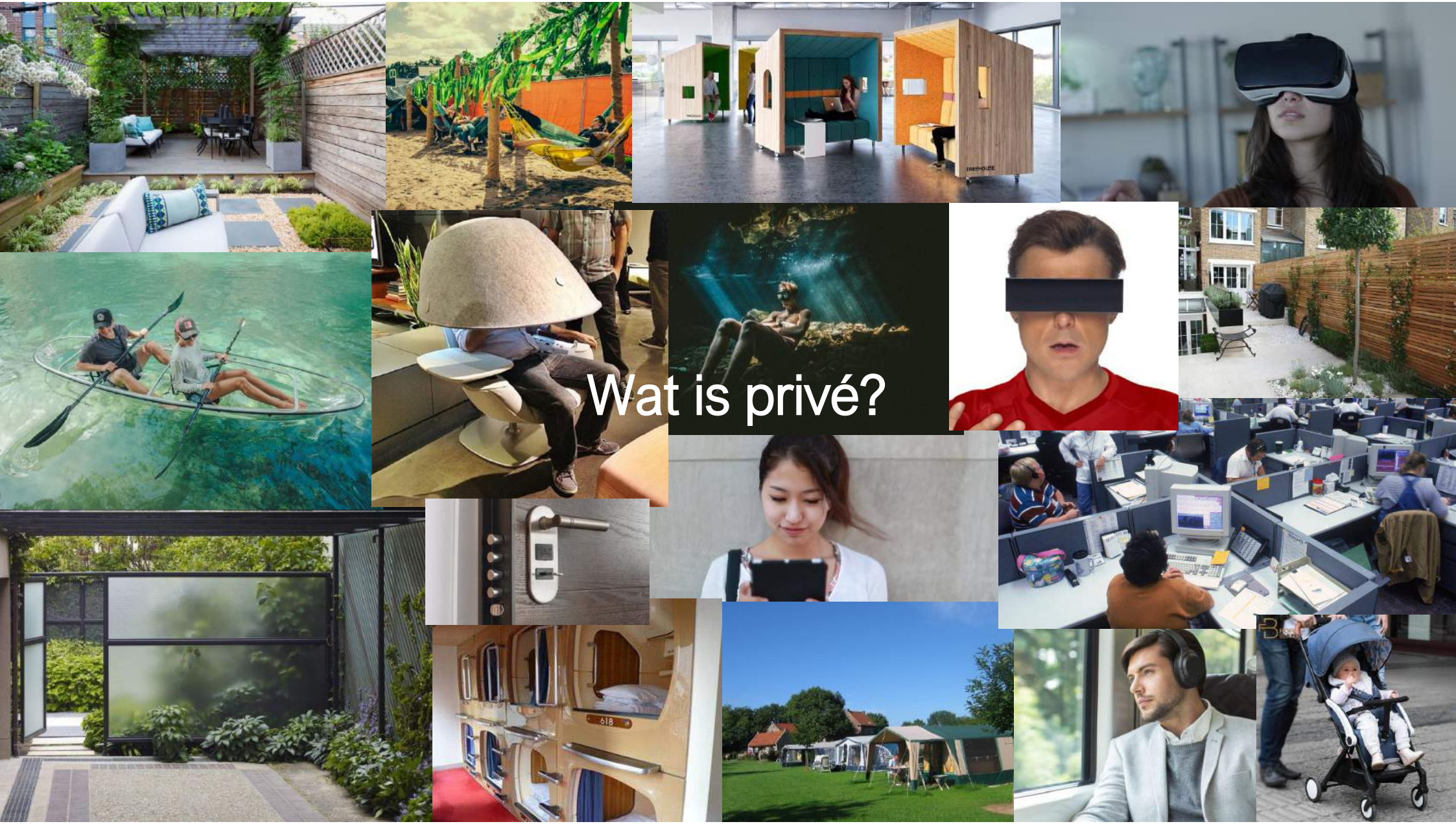
Indeling brainstorm

- Algemene ideatie
- Privé ruimte creëren
- Introductie bewoners
- Sharing - Producten
- Sharing - Diensten

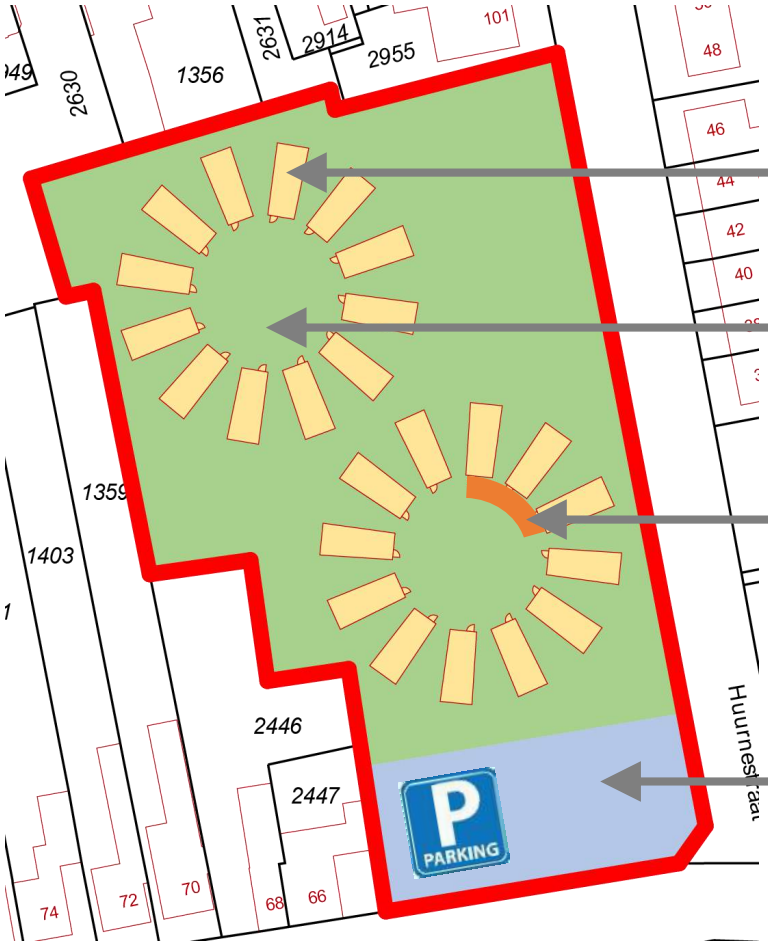



2,95m
1,6 graden
9m
3,95m

Hoe kunnen we het socialiseren, voor elkaar zorgen, communiceren, en een ‘we doen het samen’ houding stimuleren?


Wat is privé?

Zones



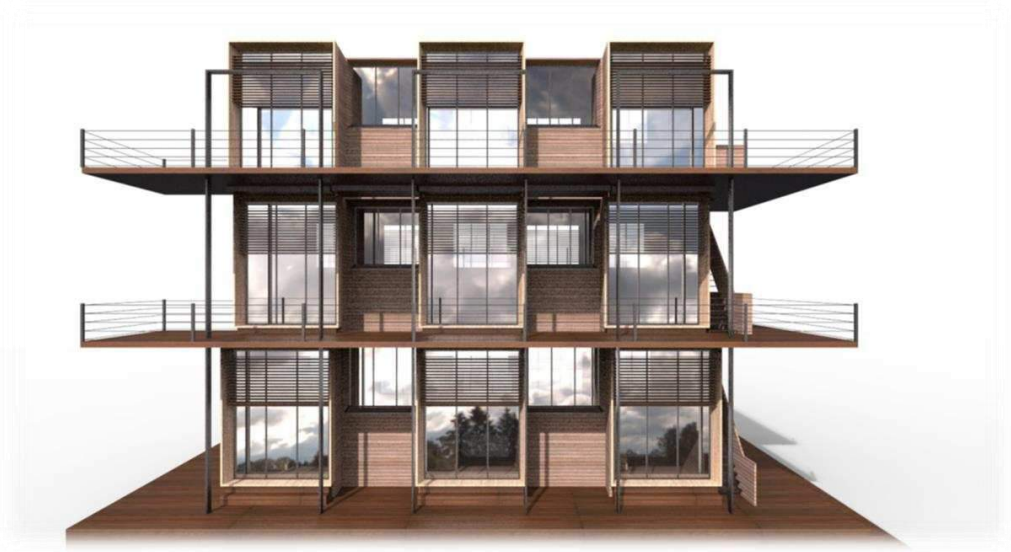
Privé zone
(1-2 personen)

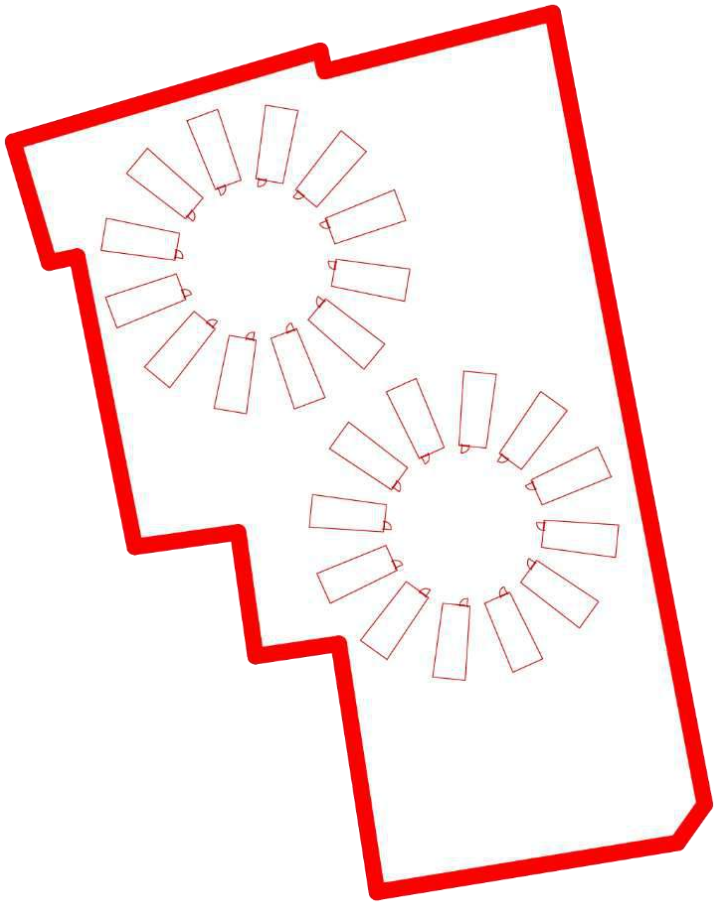
Community zone
(groepsverband)

Semi - privé zone
(tussen privé en
community)

Publieke zone
(open to anyone)

Hoe kunnen we een privé ruimte buitenshuis creëren, binnen de gegeven opzet?





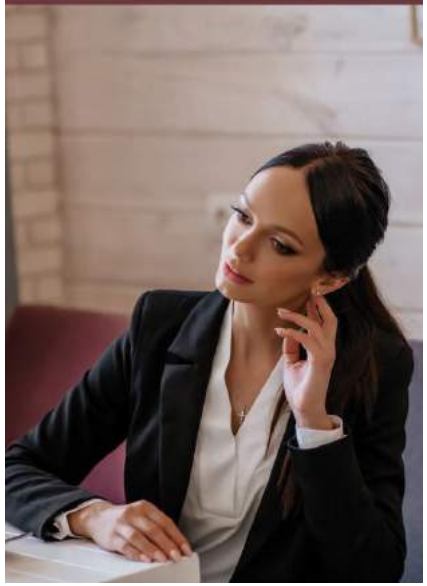
RETIRED
JACOB BROUWER

Behoeftes
Sociale interactie
Privé ruimte buitenshuis
Vrij van zorg
Buurschap
Vakantie

STUDENT
MARC DE ZWIER

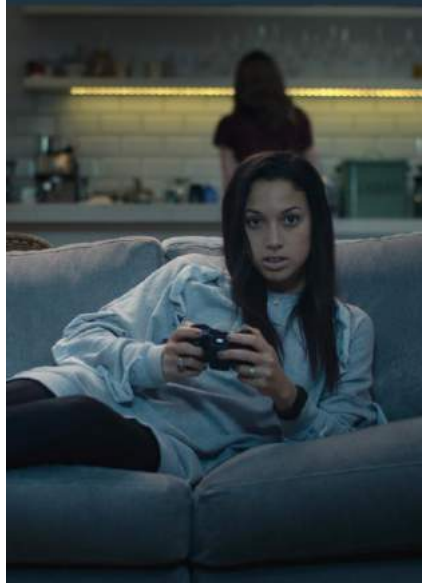
Behoeftes
Goedkoop wonen
Vrijheid in doen en laten
Gemeenschappelijke ruimte
Meer geld
Afstuderen
Delen

EMPLOYED
MARLEEN SCHOLTEN



Behoeftes
Minder werken
Stabiliteit in het leven
Mensen ontmoeten
Gemeenschappelijke ruimte
Privé ruimte buitenshuis
Persoonlijke ontwikkeling
Opnieuw studeren

UNEMPLOYED
LISA DE GROOT



Behoeftes
Sociale interactie
Privé ruimte buitenshuis
Delen
Gemeenschappelijke ruimte
Werk
Bewust leven

SELF EMPLOYED
DIRK WILLEMSEN

Behoeftes
Privé ruimte buitenshuis
Bij huis
Zingeving
Goed lopend bedrijf

Sharing – product

- Per huis
- Collectief hok
- Publiekelijk

Food, eigen share-kast

Iemand moet koken en heeft nog wat spulletjes in huis, maar mist nog wat ingrediënten om een volwaardige maaltijd te maken. Hij/zij loopt even rond om te kijken wat mensen in hun eigen kastje hebben gezet en pakt eruit wat nodig is. De maaltijd is compleet.

Hoe weet je dat er iets in de kastjes zit, iemand haalt alles uit de kastjes, niemand stopt er wat in, mensen stoppen er afval in, etc.

buurtkastje

Party-products, collectief hok

Iemand geeft een feestje en wilt graag extra spullen hebben omdat diegene zelf gelimiteerd is in de hoeveelheid opslag in huis. Gelukkig is er een collectief hok binnen de community waar iedereen producten kan lenen wanneer nodig.

Producten zijn nog bij iemand anders, gebroken/stuk (bij iemand anders/bij jou), verkocht, etc.

Vervoer, publiekelijk toegankelijk

Een oudere man wil zijn boodschappen doen maar er is niemand die hem op dat moment daarmee kan helpen. Hij kan de Greenwheels auto pakken om het alsnog zelf te doen.

Er is geen GreenWheel, de auto start niet, de dienst is buiten werking, hoe te voorkomen dat hem dit niet nog een keer overkomt of wat is een alternatief met respect naar sociale interactie?

greenwheels

Sharing - dienst

- Voort wat hoort wat (1 op 1)
- Verdeling taken (groep)
- Valuta (publiekelijk)

powerpeers
share your energy

BlaBlaCar

SnappCar®

Voort wat hoort wat (1 op 1)

Een bewoner X doet zwaardere taken voor een andere bewoner Y die dat zelf liever niet meer doet. Ze hebben afgesproken dat bewoner Y de pakketjes aan zal nemen als tegenprestatie.

Bewoner Z ziet het en wilt ook wel pakketjes droppen, bewoner Y wilt niet een pakhuis worden. Hoe krijg je evenwicht in taken tussen bewoner Z en X?

Verdeling van taken (groep)

Bewoner A helpt mensen met elektra, bewoner B houdt de omgeving schoon, bewoner C neemt pakketjes aan en bewoner D onderhoudt de gemeenschappelijke tuin.

Iedereen binnen de community moet iets uitvoeren. Hoe ga je verdelen wie wat doet en hoe is dit eerlijk? Als de één iets meer doet, moet dat beloond worden?

Valuta (publiekelijk)

Een bewoner verbruikt niet zoveel energie. Daarom kan diegene de opgewekte energie, die hij/zij niet gebruiken, via Powerpeers delen met de buren. Hiervoor krijgt diegene iets terug.

Met wat voor valuta worden ze terugbetaald? (geld, community currency) En wat voor invloed heeft dit op het sociale gedeelte? Moet je alleen delen binnen de community of juist niet?

SnappCar®

powerpeers
share your energy


COMMUNITY

APPENDIX N2

BRAINSTORM PHOTO'S

Photo's of the results generated in the brainstorm session.

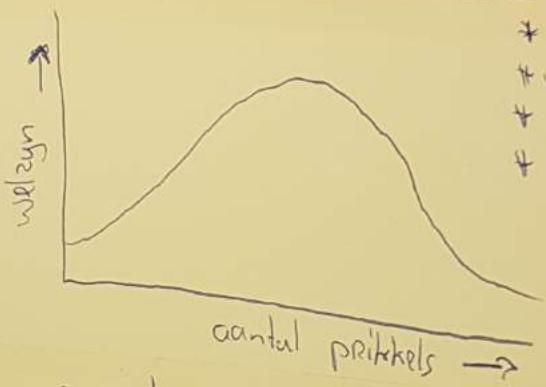

STIMULEREN
Negatieve kenze
Gezamenlijk Groen Tuin
kamp vuur spot
GEZAMENLIJKE RUIMTE
Veiligheid
SHARING SPACES
een 'nieuwe' kerk
Platform for Communication
1 UNIT LEEGLATEN COMMUNITY RUIMTE
uitLEENpUNT
Give Community a common task
RUIMTE van elkaar
1 mooi uitzicht punt?
Common activities → Team Bonding
activiteit = attractiviteit
GATHERING FOOD:
GATHERING WORK!
Post unit
Sharing Platform
Community Daycare
Shared Activities
Food Classes
beperkte mogelijkheid om in de omgeving in te kunnen grijpen
OFFICE SPACE


PRIVÉ
dingen kunnen doen die anders niet zouden kunnen
je afsluiten voor de rest
niet toegankelijk voor iedereen
VISUEEL "uit 't zicht"
GEEN GEDWONGEN VERPLICHTING
Volledige privacy
GEEN BEHOEFTENIS
EIGEN RUIMTE
GEEN REGELS
SAMEN GENIETEN
Alleen zijn
Geen inkijk in huis/tuin
vrij uitzicht
Jezelf kunnen zijn
Full Control - Sound - Interaction
Clear distinction between private + shared
SAMEN ↕ ALLEEN
Doen wat je wilt Kunnen je wilt
Unieh huis vs Allemaal hetzelfde huis
Apart van de rest
Zelf Voorzienend
Geen 'last' van anderen om je heen
In je eigen 'wereldje' zijn
OP JUISTE AFSTAND
In je eigen 'bubbel'

Basis voor omgeving

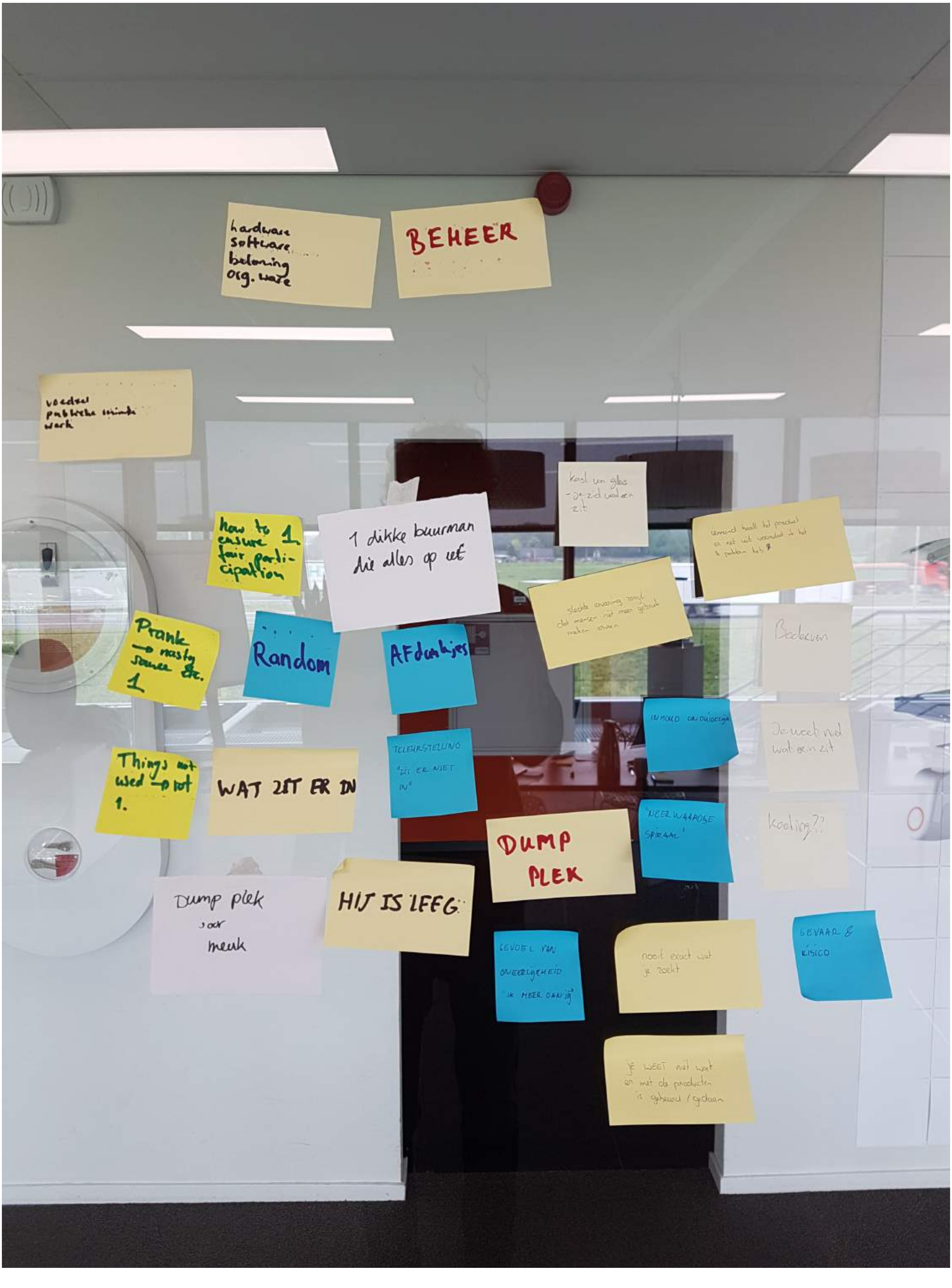
* "In control" over de woonomgeving
* Prikkels moeten betekenis hebben
* Behoefte aan eigen territorium
* Contact met de natuurlijke omgeving
* Behoefte aan verandering

optimaal activatieniveau



* auditief
* visueel
* geur
* tast

* afscheid kunnen nemen van de omgeving
* "good fences make good neighbours"



hardware
software
beloning
org. ware
BEHEER
voedsel
publieke
werk
how to ensure fair participation 1.
1 dikke buurman die alles op eet
kast van glas
Prank → nasty sauce etc. 1
Random
AFdankjes
Bedekken
Je weet niet wat er in zit
TELEURSTELLING
"ZIT ER NIET IN"
Things not used → rot 1.
WAT ZIT ER IN
"NEERWAARDSE SPIRAAL"
koeling?
DUMP PLEK
Dump plek voor meuk
HIJ IS LEEG
GEVOEL VAN ONGELIJKHEID
"IK MEER DAN JIJ"
nooit exact wat je zoekt
GEVAAR & RISICO
JE WEET niet wat er met de producten is gebeurd / gedaan


STIMULEREN
Financial or time benefits
win / win
Introduce People to each other
Gezamenlijk Groen Tuin
GEZAMENLIJKE RUIMTE
Veiligheid
SHARING SPACES
Platform for Communication
UITLEENPUNT
Give Community a common task
RUIMTE van elkaar
1 mooi uitzicht punt?
Company activities → Team Bonding
een 'nieuwe' kerk
GATHERING FOOD:
GATHERING WORK:


Financial
OR
time benefits
PRIVACY first / social = benefits
win / win
Introduce People to each other
ontzorging

APPENDIX 01

QUESTIONS & ANSWERS TINYHOUSE

Questions had been prepared for the interview with a Tinyhouse resident. The answers to these questions can be found in this appendix. The interview has been performed in Dutch, because of the native language of the resident.

Interview with Tinyhouse resident Frank Hooijer 01-05-2019

A telephone interview with Frank Hooijer has been performed, who is a member and resident of the Tinyhouse community in Kleinhuizen, Nieuwegein. The interview has been performed in Dutch.

Algemeen

- Hoe ben jij/zijn jullie erbij gekomen om dit te doen en bij hen aan te sluiten?
  Tinyhouse Utrecht deed mee aan een wedstrijd van een projectontwikkelaar. Voor een bepaalde tijd zochten de ontwikkelaars een invulling voor een terrein voor twee jaar. Die hebben ze gewonnen en kwamen zo op de plek waar we nu zitten, een andere plek moet nu gevonden worden om straks heen te verhuizen.

- Wat zorgde ervoor dat jullie in Kleinhuizen wilden komen wonen?
  Ze zochten nog twee of drie bewoners toendertijd om het gebied 'vol' te hebben. Dit is Frank geworden samen met zijn vriendin. Er waren tien plekken.

- Hoe regelen jullie alles? Wordt dit intern of door een externe partij geregeld? Intern, wie zorgt voor wat?
  Het liefste regelen we alles zelf, niks extern, alles intern houden. De stichting van Tinyhouse Utrecht zal bij de volgende locatie ook op het terrein wonen, zodat mensen evenveel verantwoordelijkheid kunnen dragen. Op dit moment is er geen inzicht in de financiën. Er zou een centraal potje zijn van waar het geld heengaat van de huur. Een gedeelte daarvan is loon voor het bestuur. Er zou ook een potje komen voor het volgende terrein maar hebben geen idee hoeveel dat is. Om dat soort dingen duidelijker te hebben willen ze alles zelf in eigen hand houden. Ze voelen zich er niet fijn bij dat het een businessmodel van iemand is. Er is op dit moment gebrek aan transparantie. Ze steken het nu in eigen zak, want hebben verder geen kosten aan het stuk grond. Ze zien liever een potje waarmee ze iets kunnen voor de volgende plek. Daarbij is het een vertrouwenskwestie. Het creëert een machtsverhouding die niet hoeft. Ze missen de sleutels om volledig onafhankelijk te zijn, maar die sleutels liggen nu bij het bestuur. Die is verder ook gedistantieerd van de community. Voor de volgende plek gaan ze buiten de stichting om een nieuwe plek proberen te vinden.

- Hoe bepalen jullie wie er wel/niet in de community terechtkomt?
  Er was een bijeenkomst georganiseerd, waarbij twintig stellen aanwezig waren. Drie bleven hiervan over. Na de informatie avond moest je een klein bedrag overmaken zodat ze konden zien dat je écht geïnteresseerd was, en toen mochten Frank en zijn vriendin op het veld komen. De mensen die er woonden vroegen wat Frank en zijn vriendin konden bieden aan de community als toegevoegde waarde. Een paar dagen later kregen ze te horen dat ze gekozen waren. Daarna zijn ze begonnen met bouwen van hun Tinyhouse.

- Wat gebeurt er als er frictie ontstaat tussen twee partijen?
  Dan moeten ze dat uitpraten, anders niet. Er is nog niks ernstigs voorgevallen waardoor de groep uit elkaar is gevallen.

- Hebben jullie een commissie aangesteld o.i.d. voor algemene zaken? (aanspreekpunt voor media, verdeling van taken, mensen die beslissen over bepaalde taken).
  Alles is verdeeld. Er zijn wel commissies voor bepaalde dingen, klinkt officiëler dan het is. Onderhoud van het terrein, zoeken naar het volgende terrein. Iedereen zit tenminste bij één

commissie en maximaal twee commissies. Dit zijn de commissies die er nu bestaan: Agrarisch voor de moestuin, bouwvakkers, locatie, party people, pr en communicatie en zwerfafval.

- Hoe vinden jullie het dat een Tinyhouse community zoals Kleinhuizen zoveel aandacht krijgt, voelt het dan niet als een soort attractie?
  We willen mensen laten zien hoe het anders kan. Elke maand organiseren we een open dag, om bekendbaarheid in de buurt te vergroten. Mensen uit de buurt weten niet dat we daar wonen en vinden het vaak leuk, uniek en knap. We hebben het gevoel dat we daarin verplicht zijn om het bekendheid te geven. Ook mensen die bezig zijn met bouwen komen graag, om inspiratie op te doen. Er zijn nu nog 250 Tinyhouses in Nederland.

- Wat haal je er zelf uit om zo te leven?
  Kijkend naar deze locatie is het groen en alle natuur om je heen. In contact staan met de natuur. Zodra je er woont ga je direct minder gebruiken van alles. Zo wordt het bijvoorbeeld een soort spelletje om zo lang mogelijk te doen met een gasfles. Het geeft rust in je hoofd. In een Tinyhouse kun je leven met weinig spullen, dus er is veel overzicht. Dat helpt ook om het huis makkelijk schoon te houden. Het wordt vrij snel een zootje, maar binnen 5 minuten heb je alles weer op z'n plek gelegd, en dat het zo weinig tijd kost is heerlijk. Het is een kwestie van omdenken en creatief denken.

Privé

- Wat hebben jullie privéruimte buitenshuis? Hoe belangrijk is dit voor jou?
  Aan één kant van het huis hebben we een soort hekwerk 20 meter van het huis af, voor het huis hebben we een rivier en een grote boom. Appelbomen staan er bij ons eigen moestuintje en gezamenlijk moestuintje. Mensen uit de buurt mogen uit de moestuin producten halen, waarmee we als community een hand willen uitsteken dat andere mensen ook mogen genieten van het terrein. Verder is alles open in de omgeving. Afbakenen is niet nodig, waarom zou je dat willen? Het ligt eraan welke houding je aanneemt of je uitstraalt of mensen je gaan storen of met rust laten. Als je lekker een boekje zit te lezen bij je huis zullen ze je niet direct gaan storen.

- Hoe kennen jullie elkaar of leren jullie elkaar kennen binnen de community? Gezamenlijke activiteiten of bij toeval elkaar steeds tegenkomen? Waarom denk je dat het klikt binnen de community?
  We organiseren wel eens een barbecue en de open dagen organiseren doen we ook soort van gezamenlijk. Achteraf drink je dan eens een borreltje en kom je zo meer met elkaar in contact. Vergaderingen over wat er moet gebeuren in de omgeving en binnen de community helpen hier ook aan mee. Klusdagen worden georganiseerd om bijvoorbeeld iemand zijn waterleiding in te graven voordat het begint te vriezen. Je helpt elkaar gewoon, daar hoeft niets tegenover te staan. Dat is burenliefde.

- Staan jullie huizen ver van elkaar af en hoe positioneer je huis ten opzichte van de ander?
  We hebben ongeveer 3000m^2 grond per huisje, De huisjes staan heel ver uit elkaar, dus rondom het huis hebben we 40 meter dat er niks is.

- Zien jullie de sociale controle als iets positiefs of negatiefs en waarom?
  Positief, je woont in een dorp, maar voelt niet zo. Het zijn allemaal een bepaald type mensen, de oudste is nog geen 50. Je moet ook met een bepaalde mind-set zo gaan wonen. Zeker

omdat het om een tijdelijke locatie gaat. Je moet wel avontuurlijk ingesteld zijn. Je moet niet bekrompen zijn.

Delen

- Delen jullie producten van elkaar? Zo ja, wat zoal? Hoe is dit ontstaan? Heb je ideeën wat je nog meer zou willen delen?
  Nee, is nog niet de plek voor. Alles is tijdelijk dus alles wat je zou willen kan nog niet gerealiseerd worden. Een centrale overdekte plek maken was één van de ideeën, maar is nu niet haalbaar. Een centrale werkplek zou ook handig zijn.

- Hebben jullie ook producten (fiets/auto) die jullie delen met elkaar? Zo ja, hoe regelen jullie wie wanneer de auto kan gebruiken? Wie de auto schoonmaakt, het onderhoud uitvoert, etc.?
  Het is wel makkelijk om de auto van elkaar te kunnen lenen. Ligt ook meer aan de instelling van de persoon. Doordat je de buren kent krijg je beter contact en ben je ook minder bezwaard om een gunst te vragen. De grasmaaier, kruiwagen en gereedschap leen ik wel van de buurman. Aankloppen en vragen, zo simpel is het.

- Zou je meer interactie willen met de buurt?
  Ja hoor, alles natuurlijk in goed overleg. Je woont op een redelijke afstand van de buurt, dus het is niet voordehand liggend dat je gebruik gaat maken van het terrein. Interactie wordt ook gestimuleerd via de moestuin of open dagen. Zo organiseren we een zomerfeest evenement met muziek en eten die voor de hele buurt toegankelijk is gesteld.

APPENDIX O2

QUESTIONS & ANSWERS DE WONNE

Questions had been prepared for the visitation of ‘De Wonne in Enschede’. The answers to these questions can be found in this appendix.

Visit ‘De Wonne’ Enschede 03-05-2019

De Wonne is a community that takes in people who had a setback in his or her life. This can be something as a person that wants to gets its life on tracks after being addicted, or someone who has gone through a divorce and is temporarily homeless. A condition in order to be able to stay there, is that the person needs to be clean already when entering and that they can get extra help and guidance from someone who is specialized with these kind of situations. The community receives a lot of products, mostly because of their thrift shop. They get food from an ecological supermarket (Ecoplaza) and the local market, that would otherwise go to waste.

General

- Who lives there?
  People who are experiencing a temporary setback and who can go to no other place. Through time people can try to pick up their lives again while living in De Wonne and have to move outside once they are able. People from outside can come and join dinner on regular times. Every night there is room for three homeless people that can sleep inside.

- How do you manage everything internal, who takes care of what?
  Within De Wonne a core-team takes care of the necessary things, in order to keep everything up and running. There is a division amongst task for the people who are living inside De Wonne. These are task as being hostess of the day, cook, taking care of the dishes or gardening, etc.)

- How do you determine who can or cannot join the community?
  It depends on who submits. A lot of submissions cannot be handled, because people are still too far from rehabilitation or would need a stronger guidance to get rid of their addiction before they are able to join De Wonne.

- What happens if friction start to exist between two sides?
  The sides will talk with each other about it and hopefully it results in a peaceful outcome. There are examples where the police was involved or lawsuit.

- Do you have a commission for things such as media, people who determine the tasks that need to be performed or division of the tasks in general?
  No, the core-team takes care of those things mostly.

- What do you (one of the core-team members) get out of it to live inside De Wonne?
  There is more than just having a nice house, a good job and money. Something that can make you ‘grow’ mentally. This is possible by helping each other and being there for other people.

Private

- From what perspective do you look to the fact that you are somewhat closed off from society?
  The space De Wonne offers gives people the space needed to rest and get their lives back on track.

- Does De Wonne provide a private area outside the house?
  The people from the core-team who permanently live inside De Wonne have bigger apartments, where they have their own private room. De Wonne is a big building and offers for people who are staying over enough rooms that are often empty where they could sit and find peace and quiet if they would like to. This is nice for them, while their own rooms have limited space. It has a bed, bureau, closet and bathroom. Only from a few months on they also provide wifi inside the room.

- How do people get to know one another within the community?
  It is something that starts to happen naturally. This could happen because of their dependency or that people take on a vulnerable attitude. Thereby does the one who lives inside De Wonne also responsibilities once he or she said 'yes'. People also tend to look for social contact themselves, otherwise they would have never submitted a form or started to look for such a community in the first place.

Sharing

- How do you arrange who is standing when in the thrift shop, etc?
  There are some ex-residents or current residents that will be busy with that. It changes once in a while. It depends on who is free at the time it is needed in the shop.

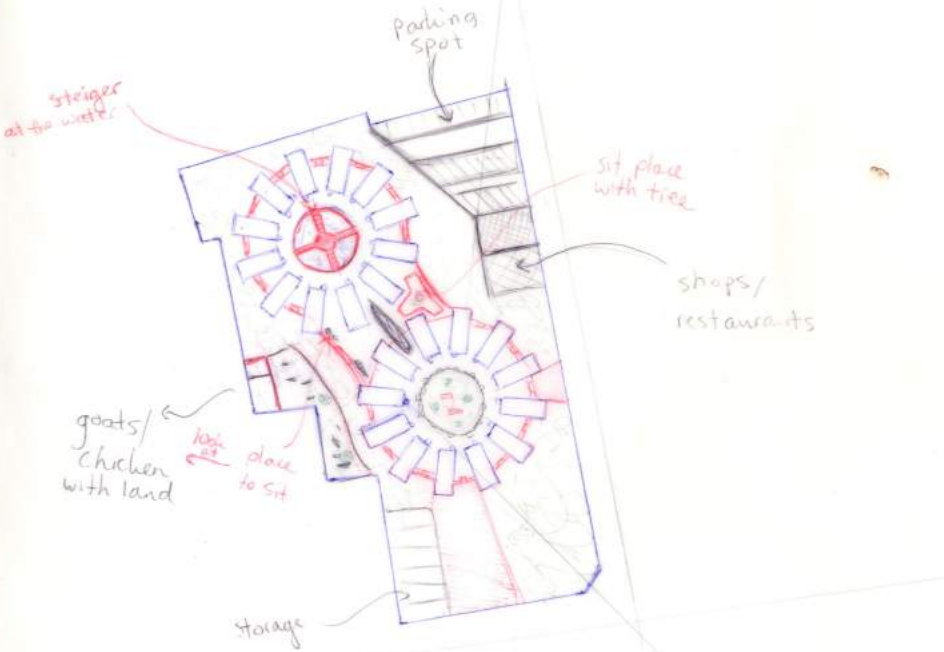
- Who arranges what for the shop?
  De Wonne receives items, selects what is usable and a few people will help selectin who have their own sector to cover.

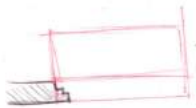
APPENDIX P

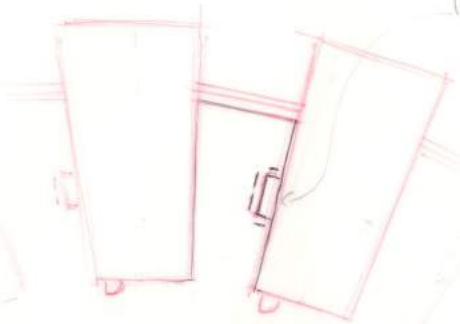
SKETCHES HOUSE SETUPS + ASSIGNED FACILITIES

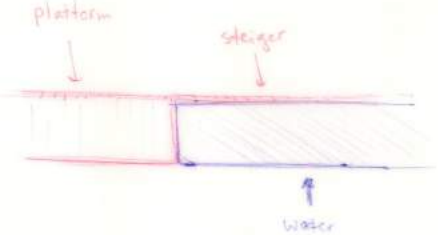
Sketches have been made of different house set-ups because it triggers a different way of thinking about what should be implemented. This is why they have been used for sketching and filling in the designated area.

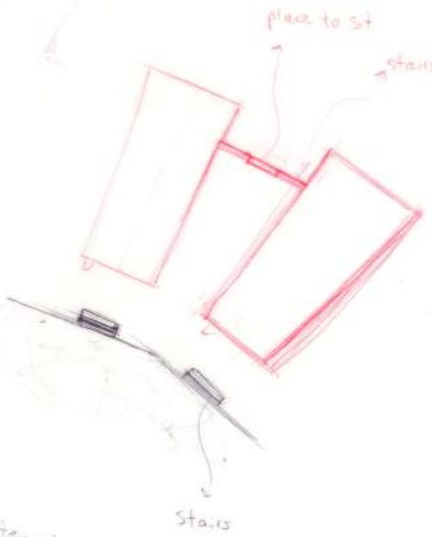
The peanut community

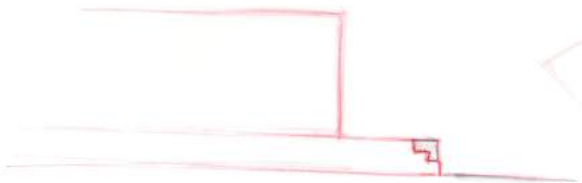


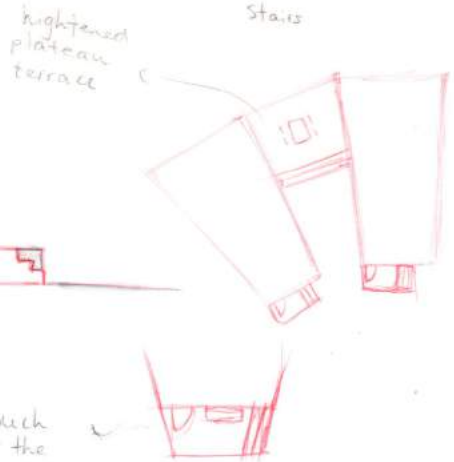




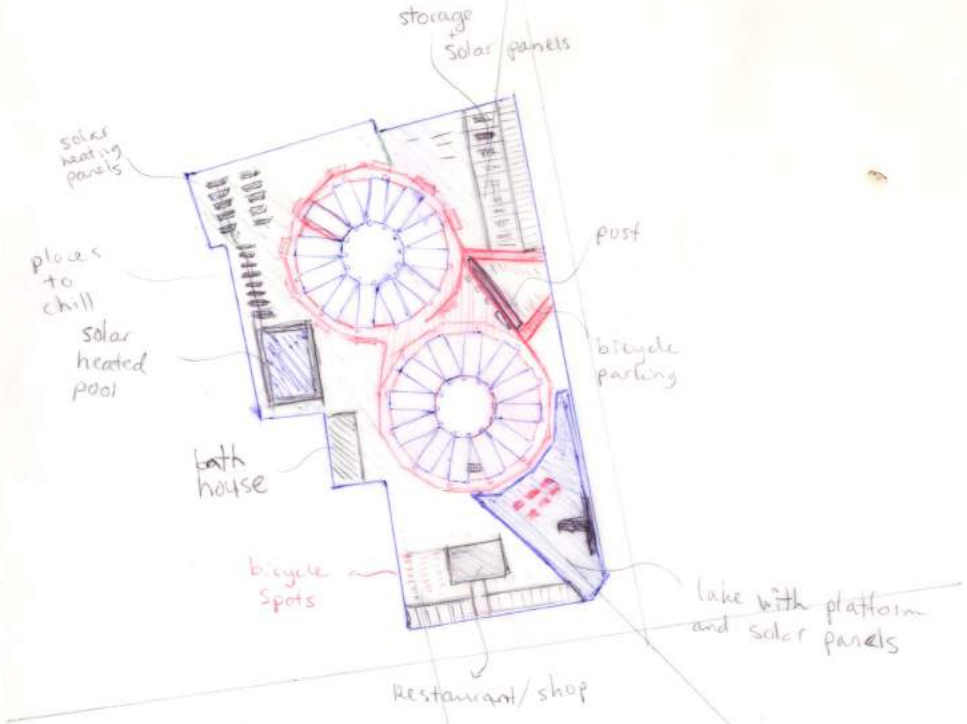


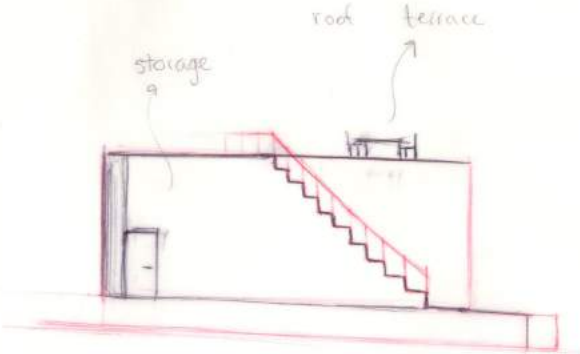


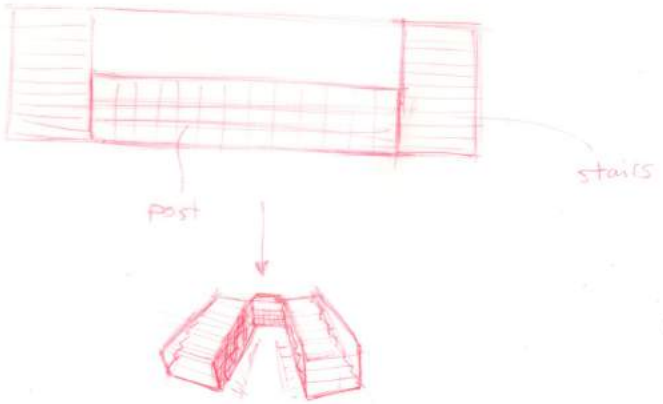




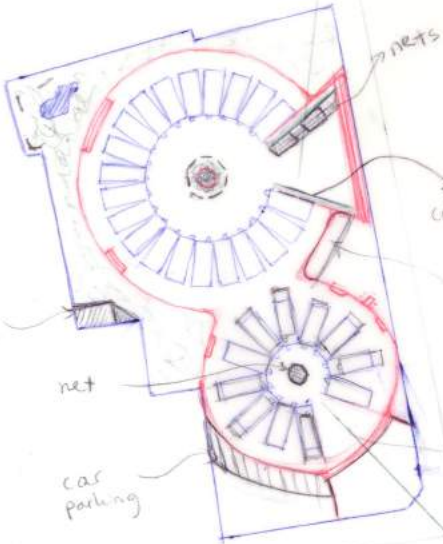
08/04/2019

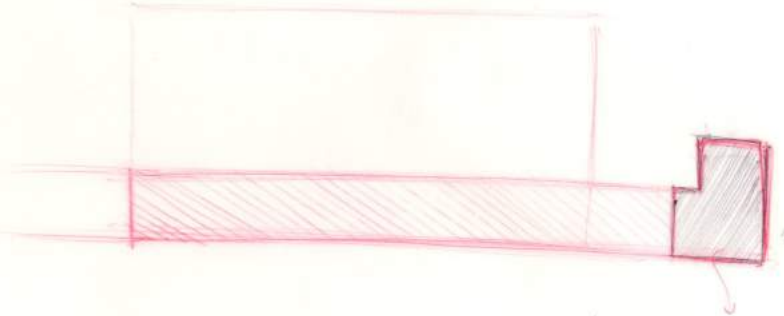

storage + solar panels
solar heating panels
places to chill
solar heated pool
bath house
bicycle spots
post
bicycle parking
lake with platform and solar panels
Restaurant/ shop

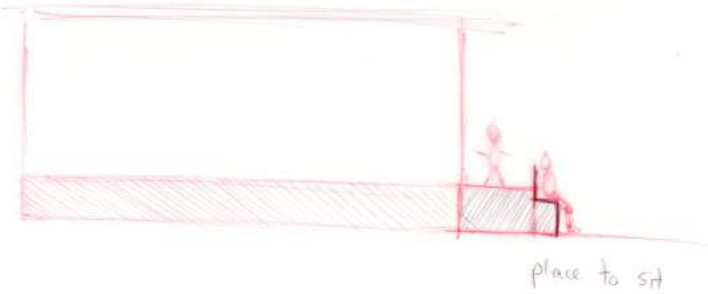

roof terrace
storage

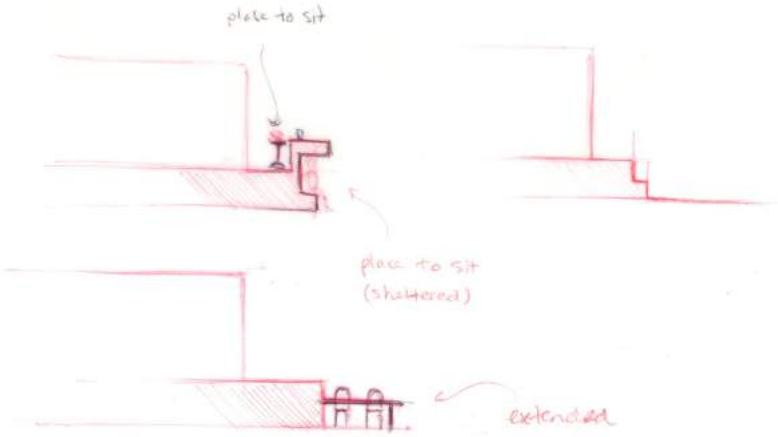

stairs
post

08/04/2019

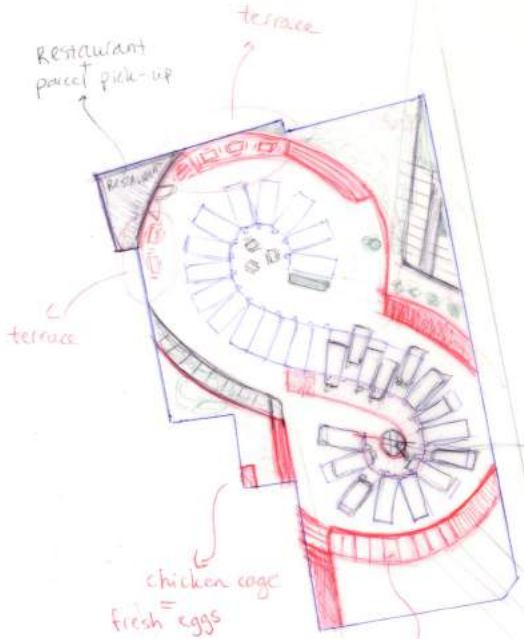

nets
commercials
bicycle parking
two layered
toppenhok + opslag
net
car parking

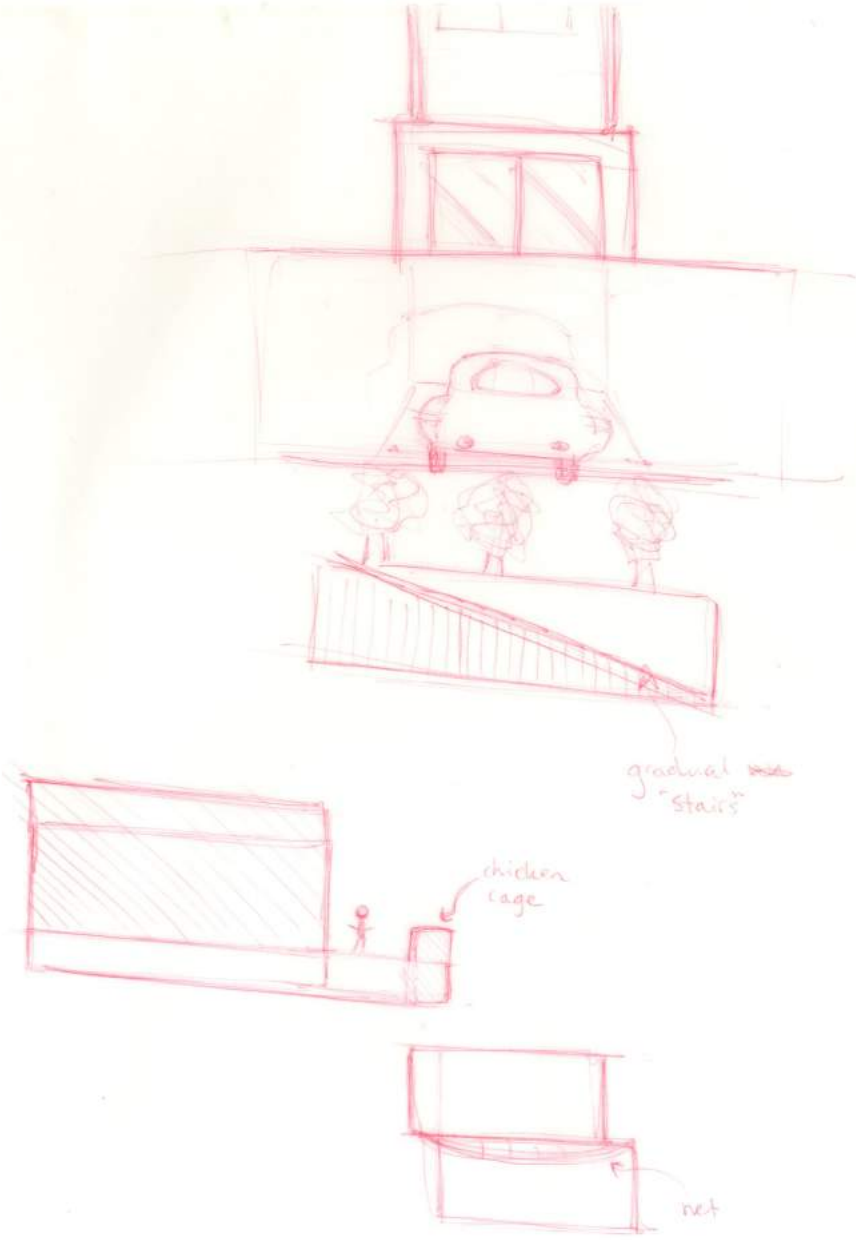

(sharing) storage + bicycle


place to sit

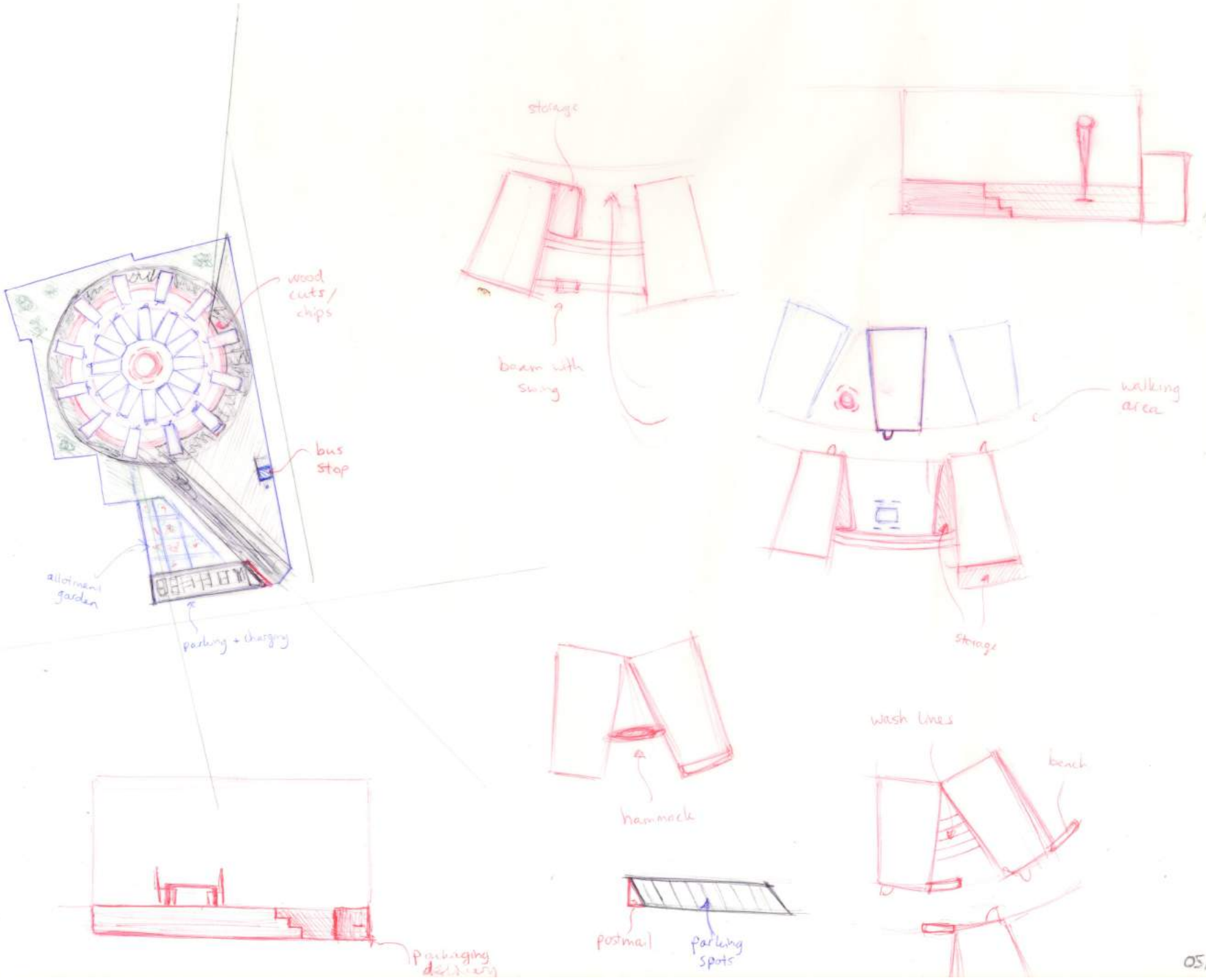

place to sit
place to sit (sheltered)
extended table

03/04/2019


Restaurant
parcel pick-up
terrace
terrace
chicken cage
fresh eggs
also possible to partly integrate inside the platform
car / bicycle parking
net

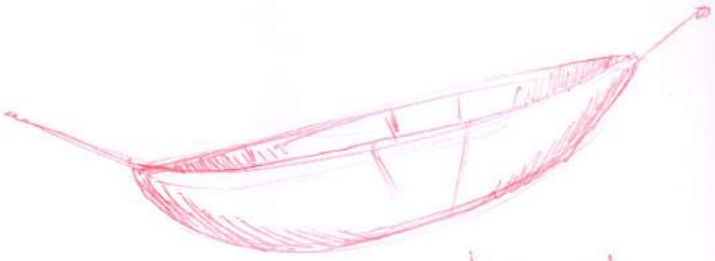

gradual "stairs"
chicken cage
net

05/04/2019

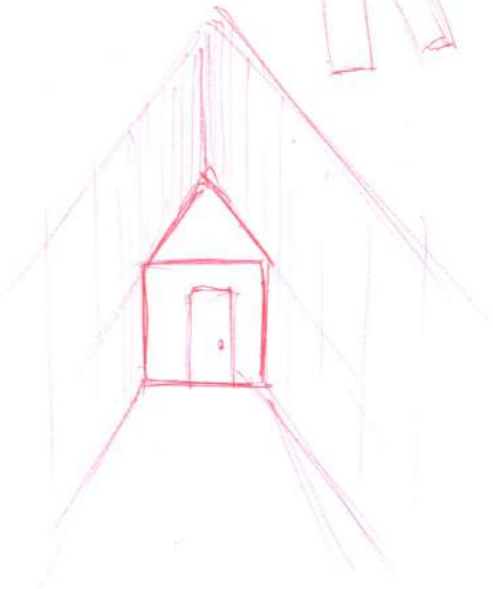

wood cuts/ chips
bus stop
allotment garden
parking + charging
storage
beam with swing
walking area
storage
hammock
wash lines
bench
postmail
parking spots
05/04/2019

In between buildings

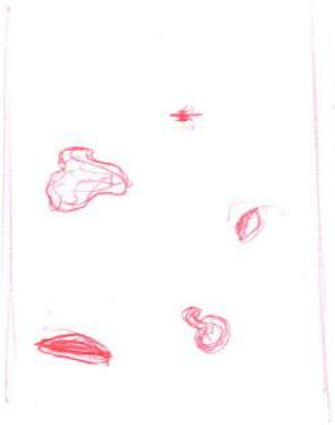
washing line



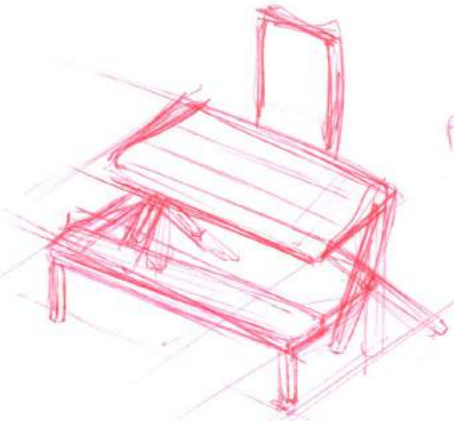
hammock



storage



climbing wall



place to sit (on height)

Greens

bicycle mount

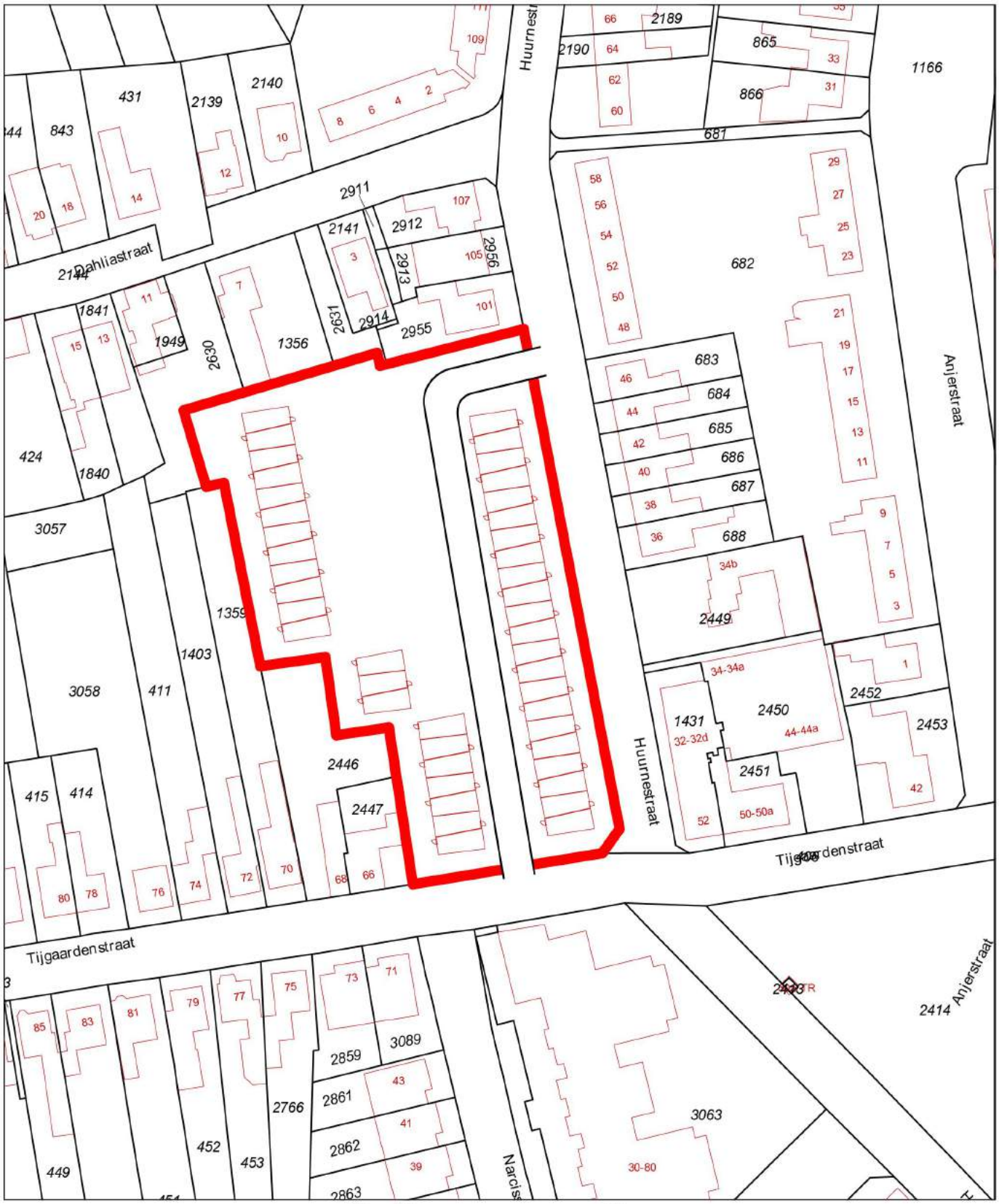
APPENDIX Q

HOUSE SETUP VARIATIONS

A study on house setup variations within the designated location in Oldenzaal.

Uittreksel Kadastrale Kaart

Uw referentie: Huurnestraat 73



0 m 10 m 50 m

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12345 Perceelnummer

25 Huisnummer

Vastgestelde kadastrale grens

Voorlopige kadastrale grens

Administratieve kadastrale grens

Bebouwing

Overige topografie

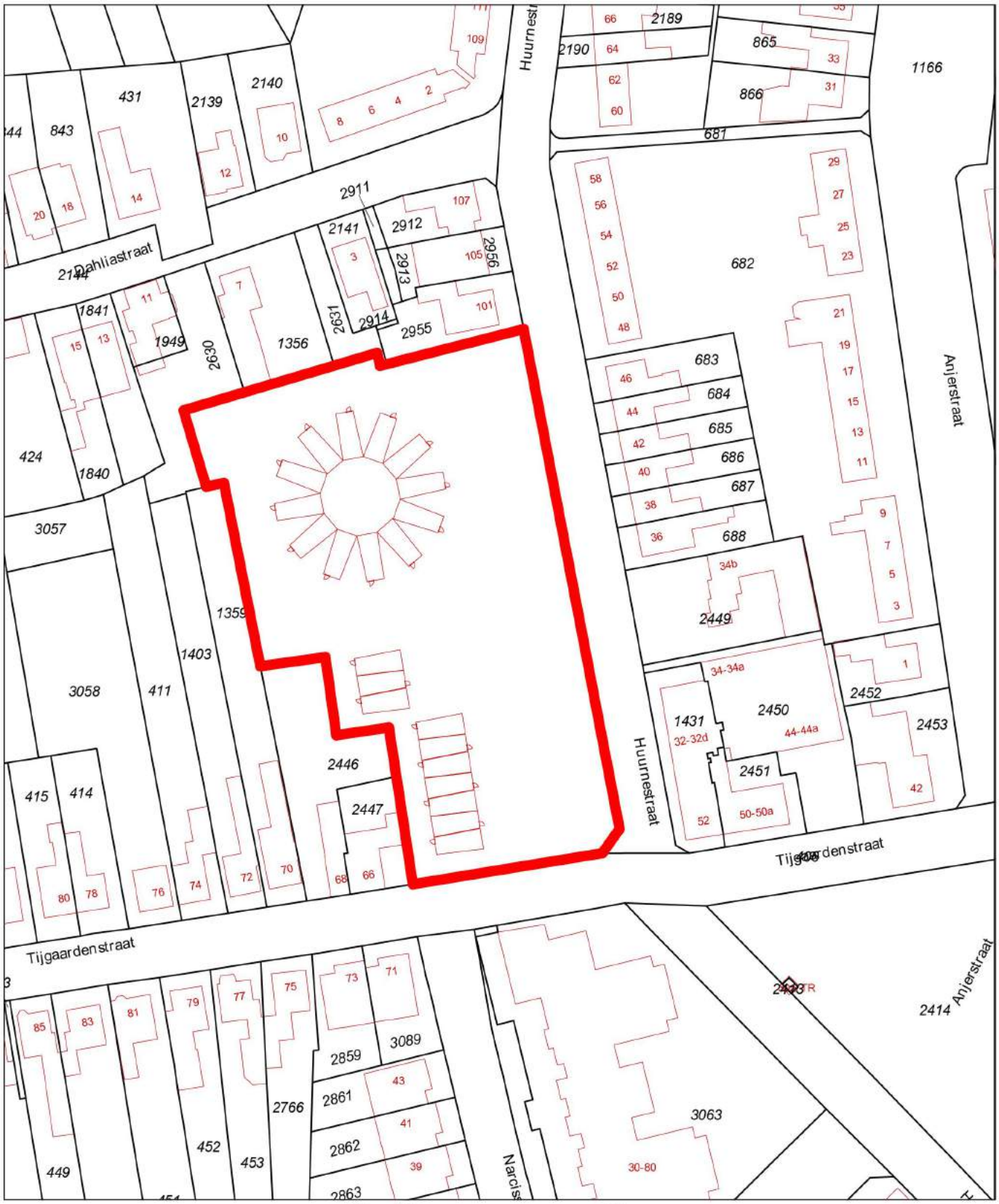
Voor een eensluidend uittreksel, Y, 8 februari 2019
De bewaarder van het kadaster en de openbare registers

Schaal 1:1000

Kadastrale gemeente	Oldenzaal
Sectie	C
Perceel	407

Uittreksel Kadastrale Kaart

Uw referentie: Huurnestraat 73



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12345	Perceelnummer
25	Huisnummer
	Vastgestelde kadastrale grens
	Voorlopige kadastrale grens
	Administratieve kadastrale grens
	Bebouwing
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Kadastrale gemeente	Oldenzaal
Sectie	C
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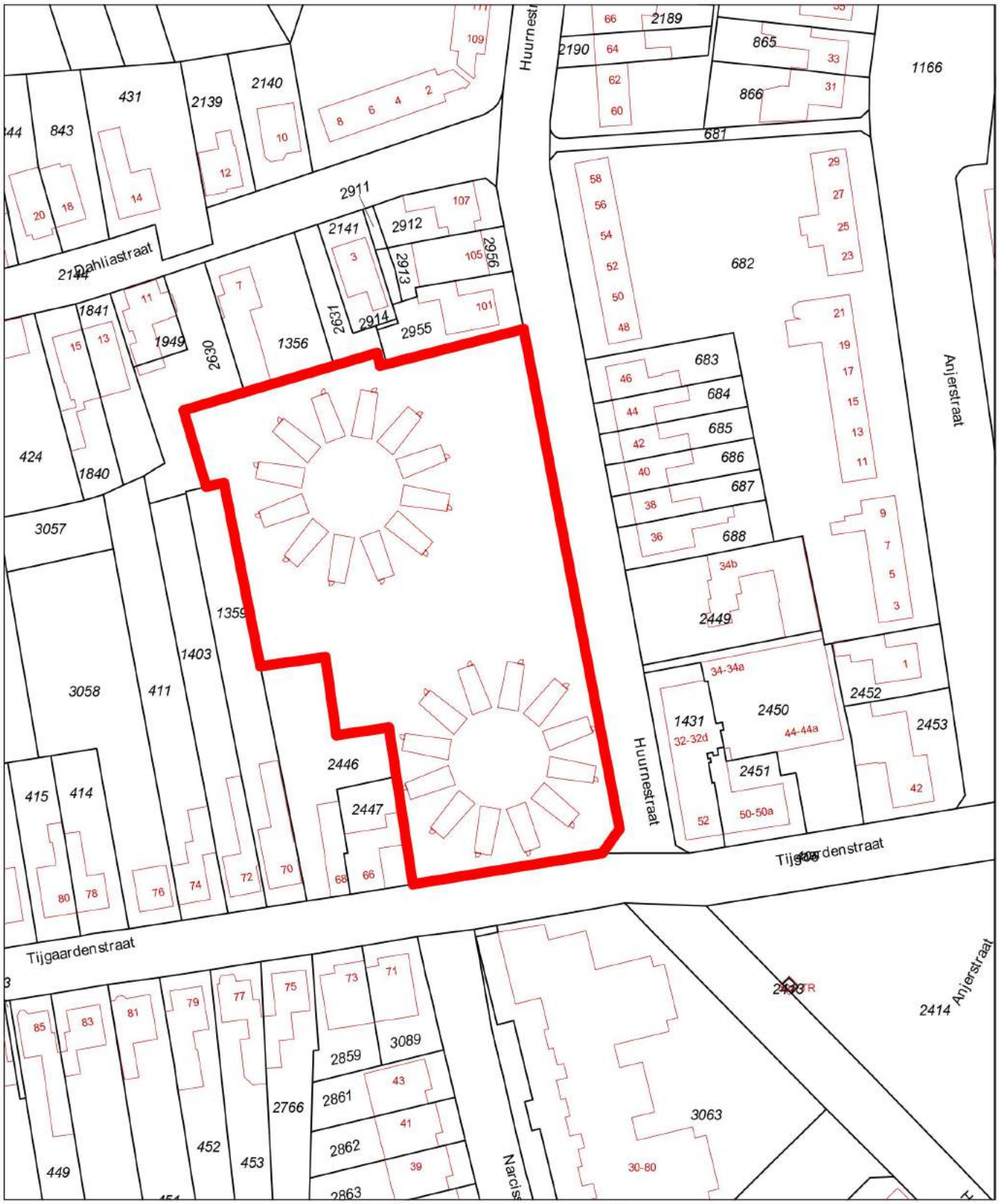
Uittreksel Kadastrale Kaart

Uw referentie: Huurnestraat 73



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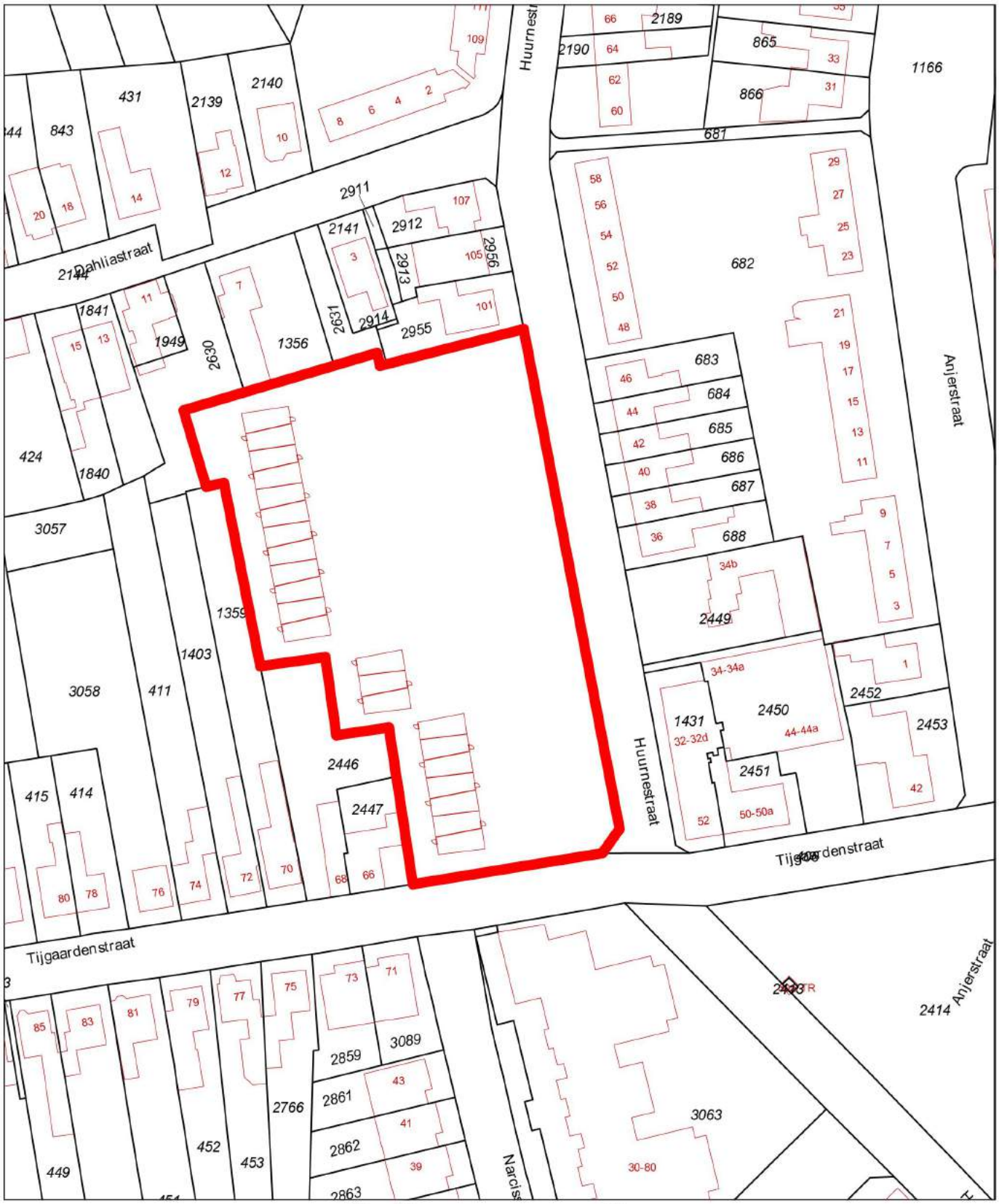
Uw referentie: Huurnestraat 73



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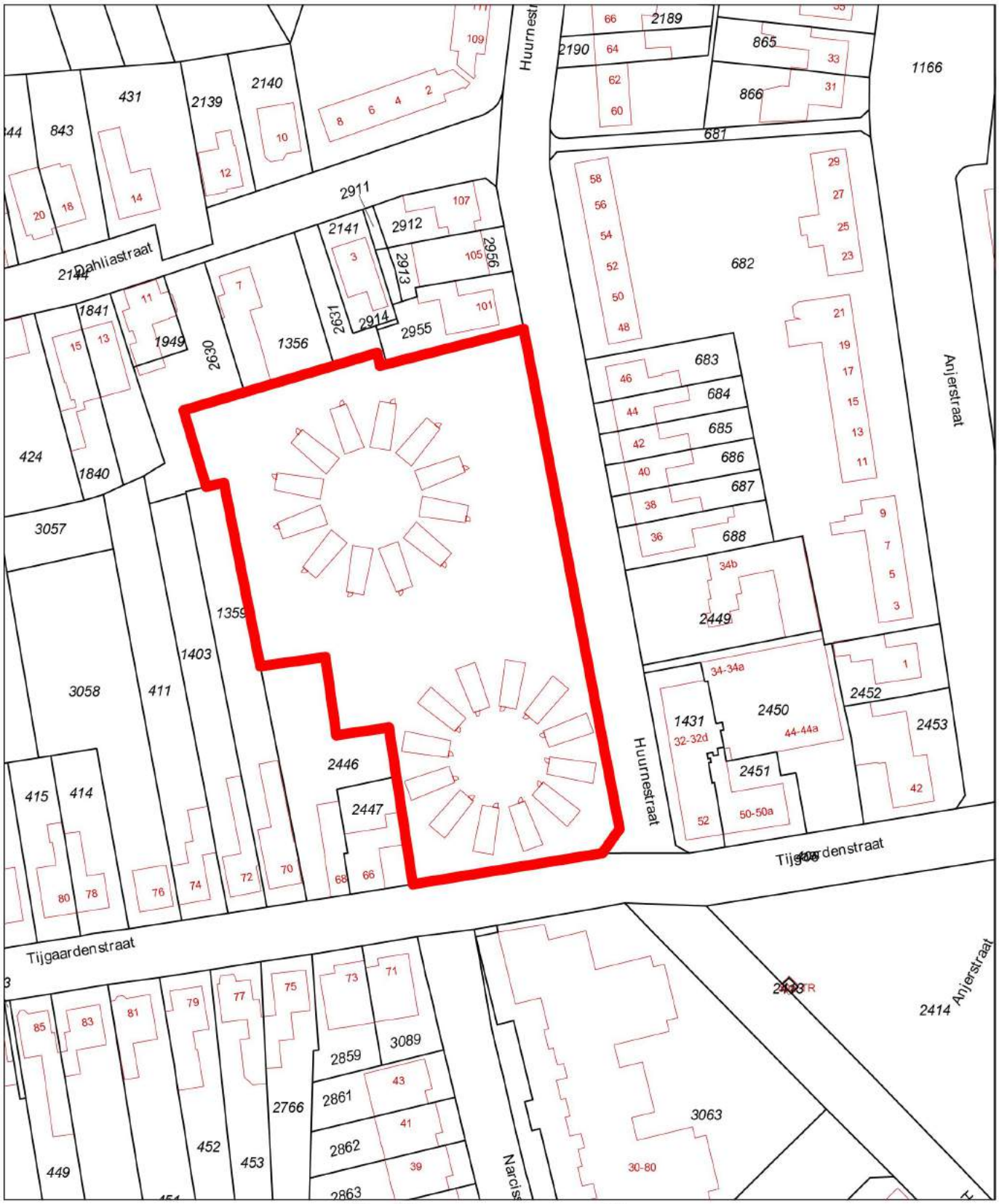

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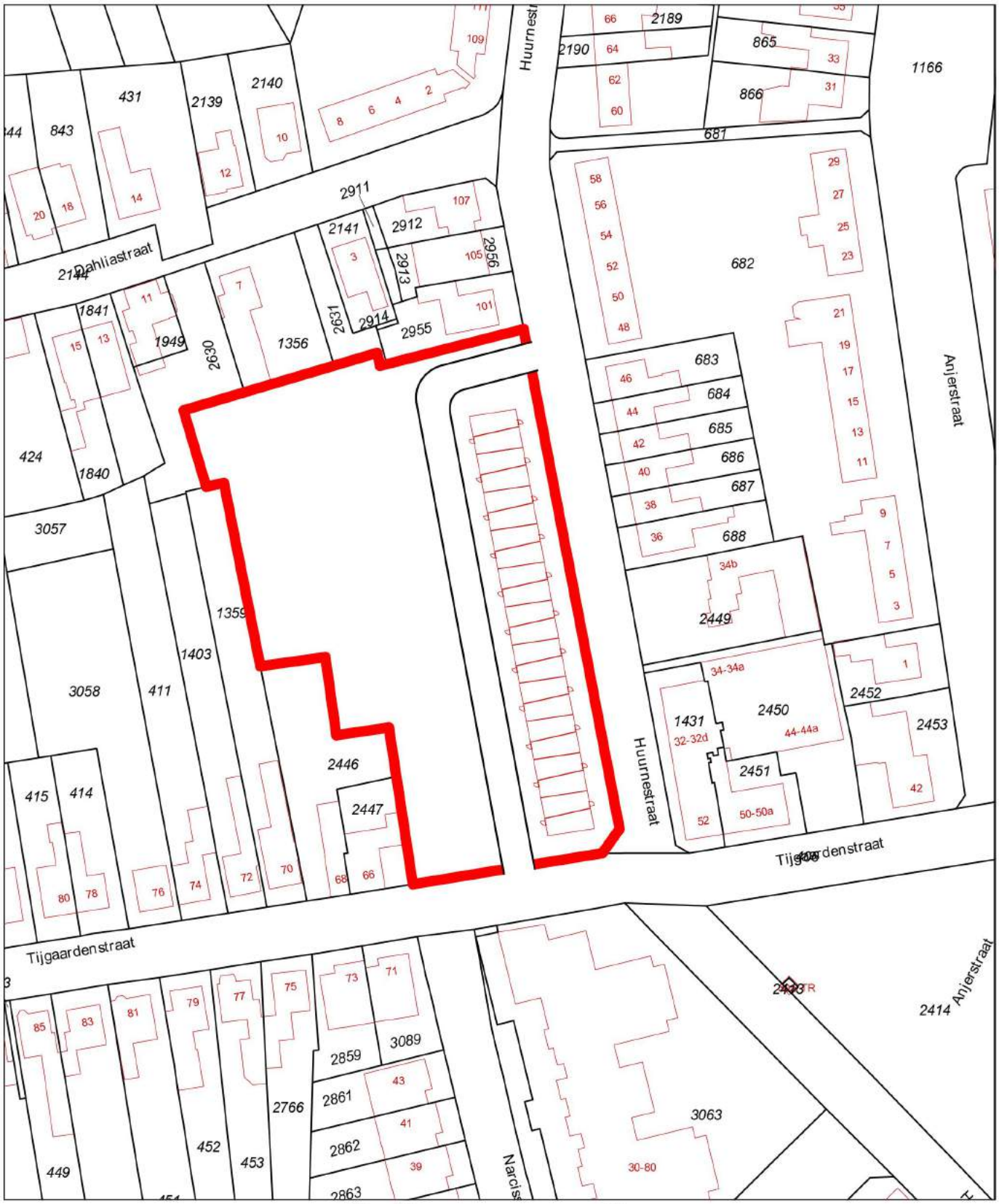

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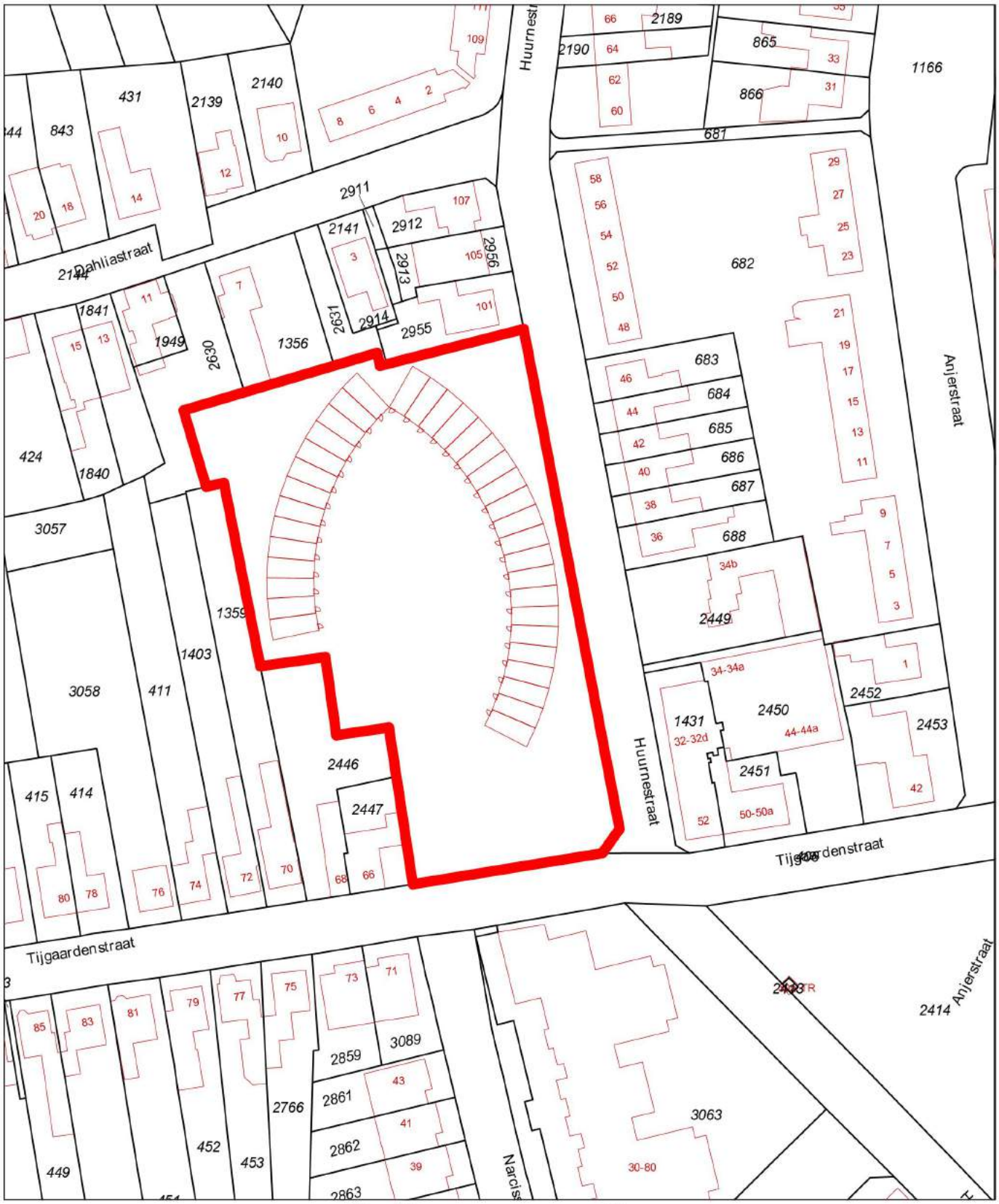

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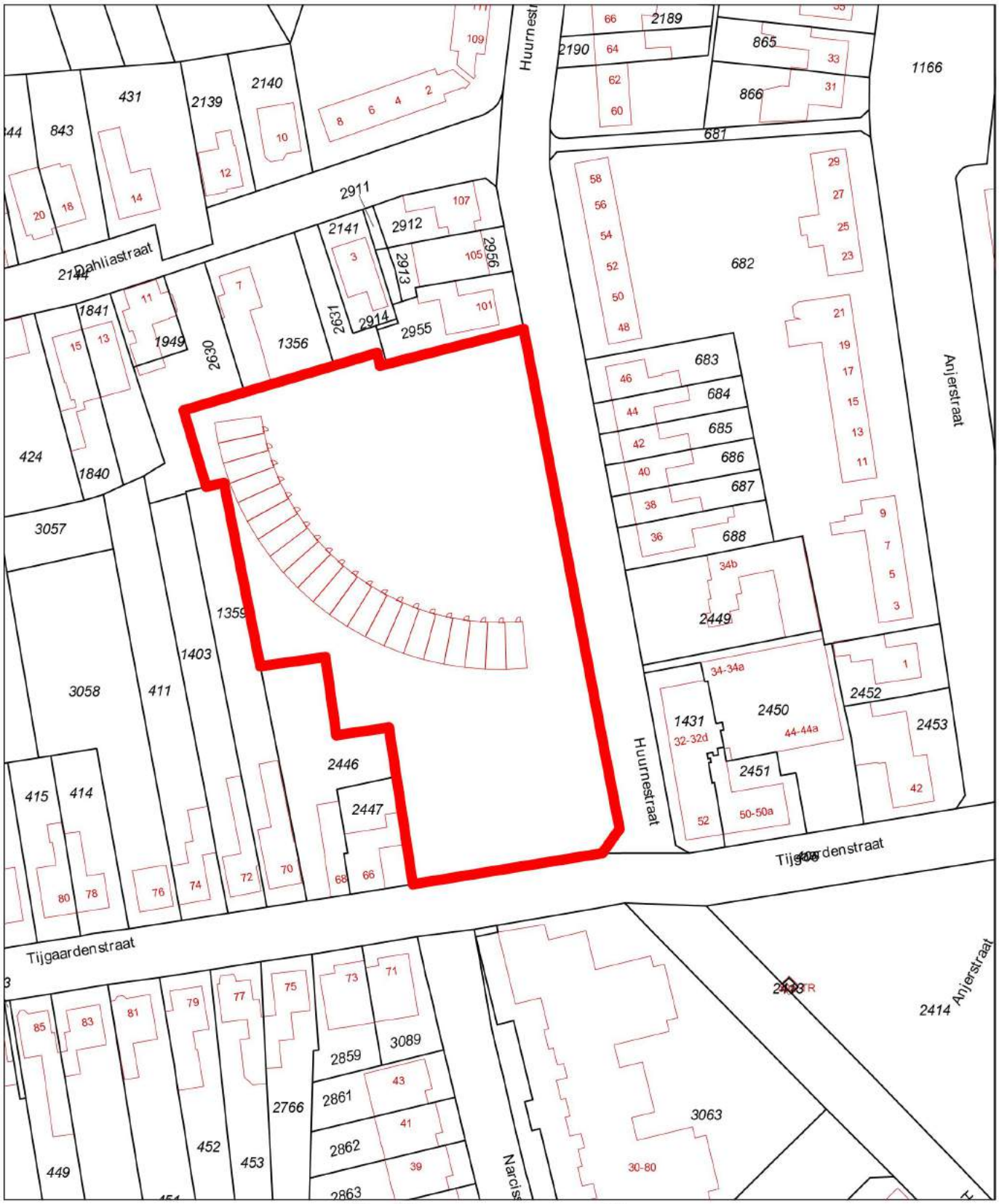

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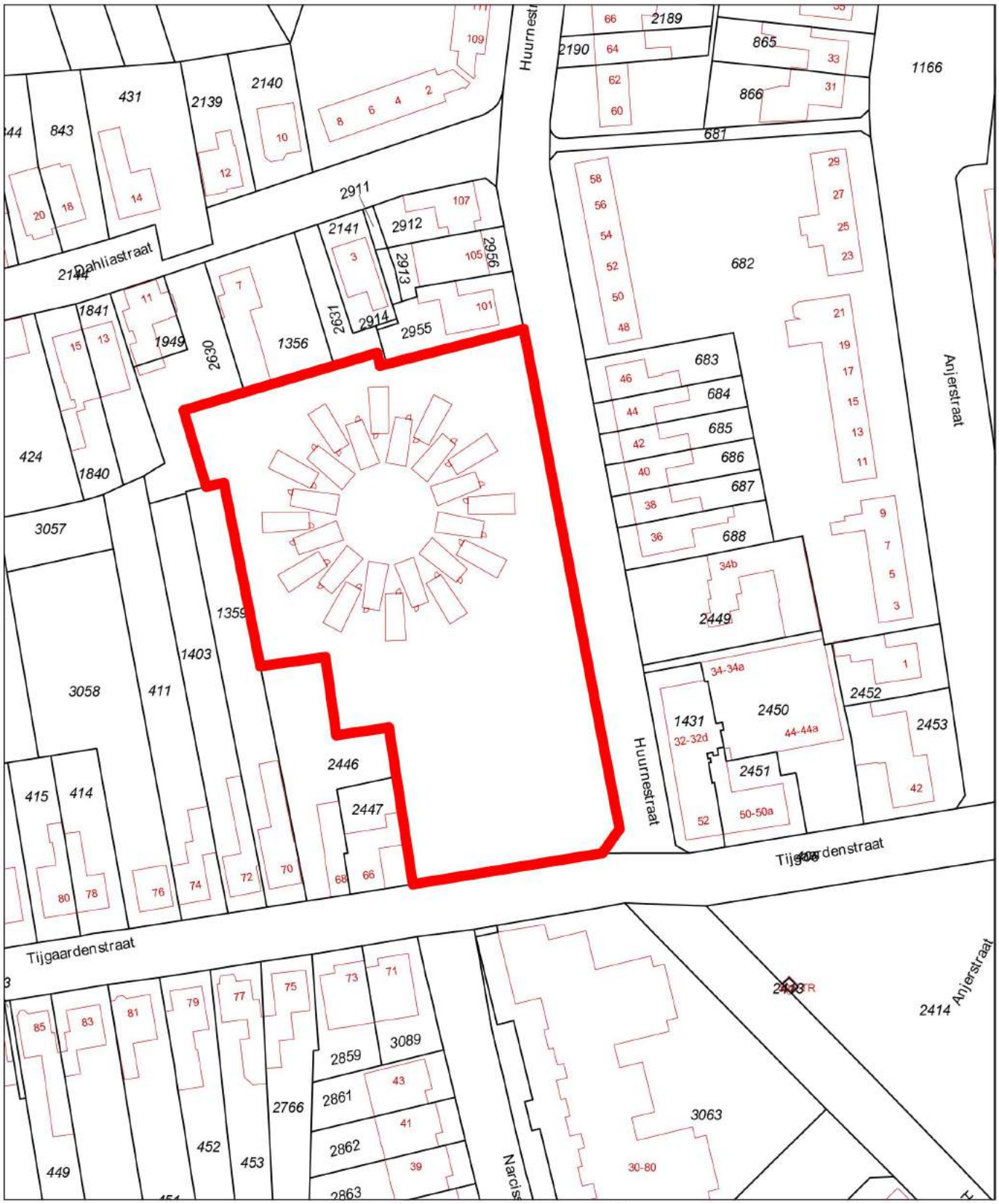

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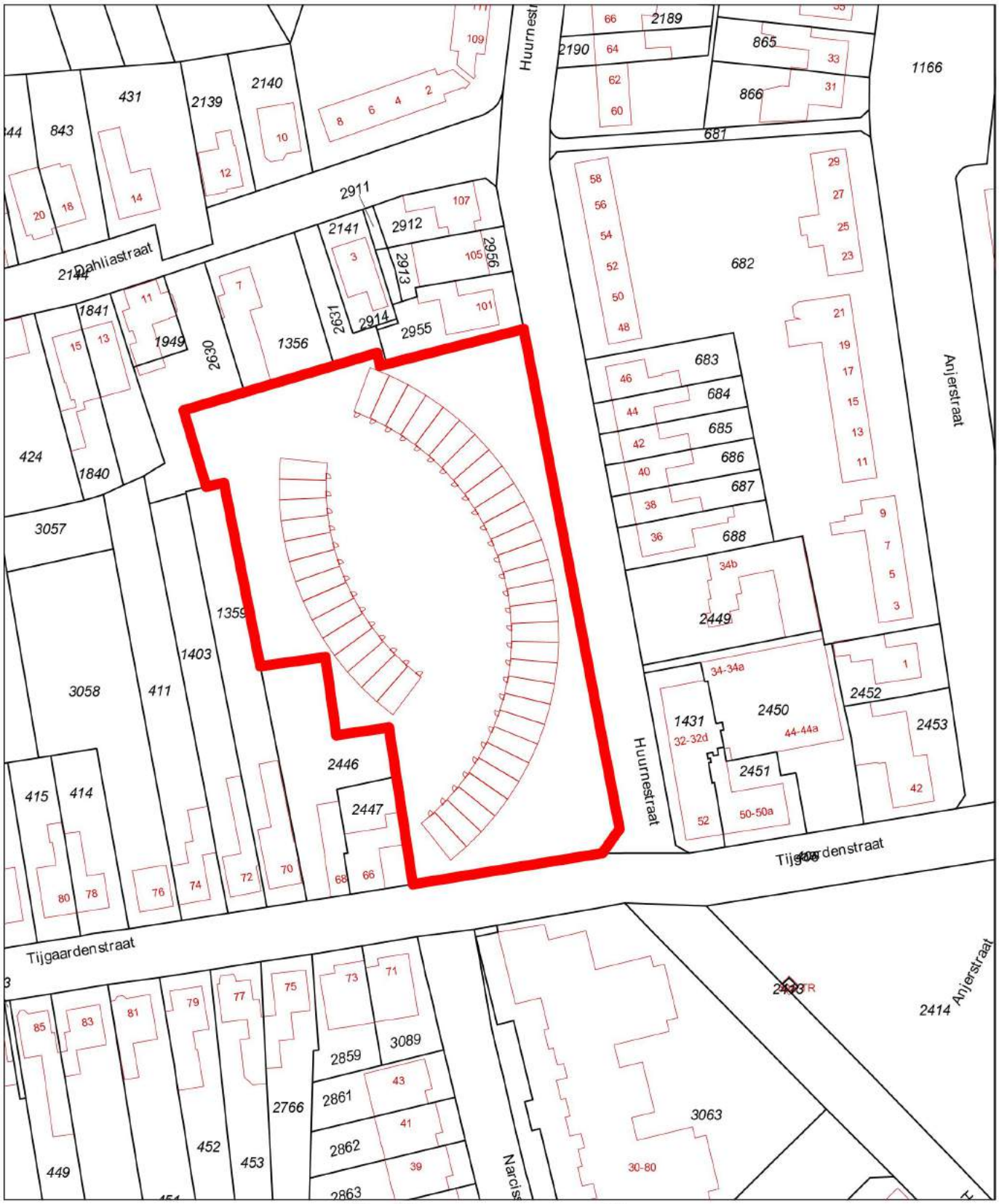

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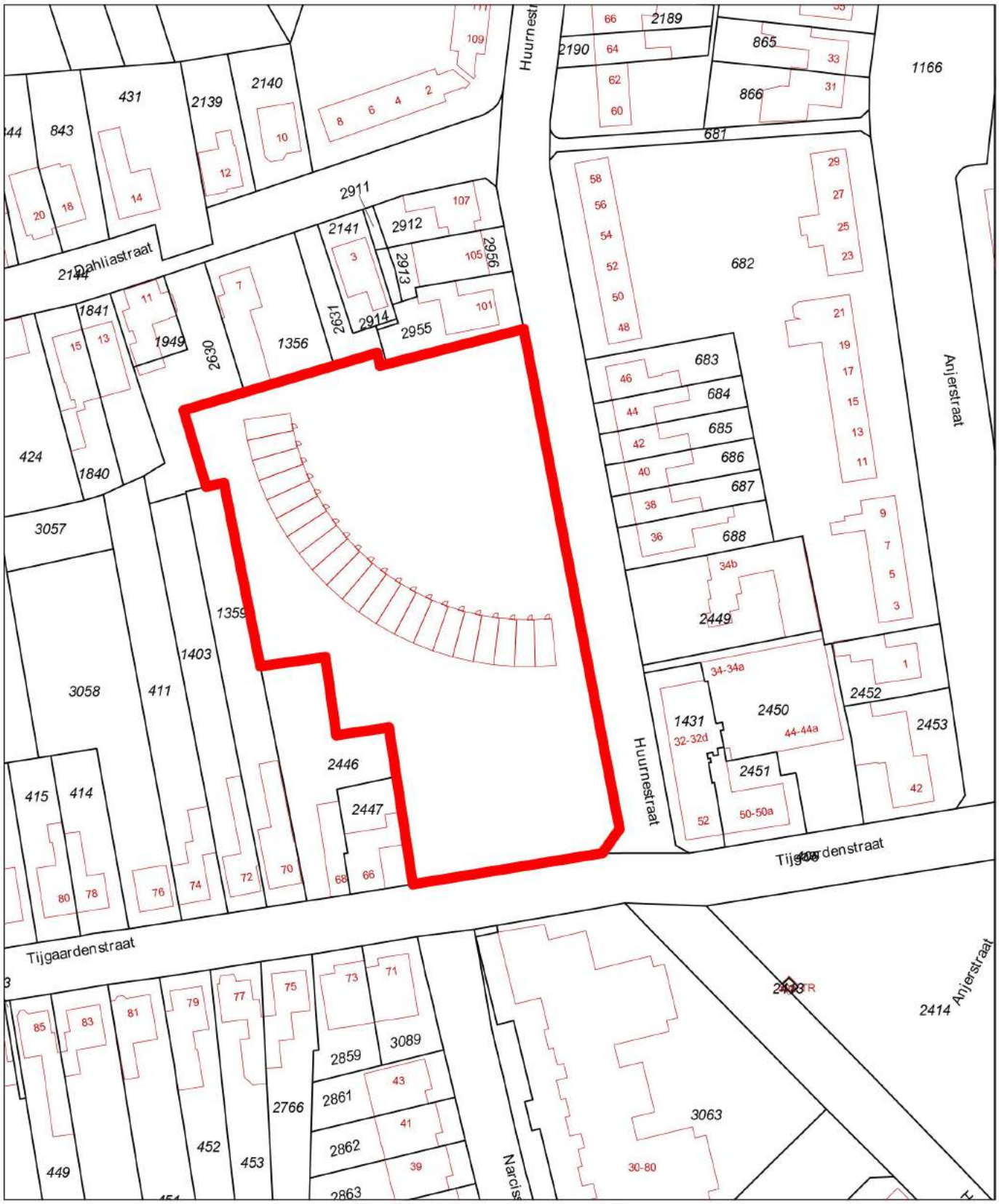

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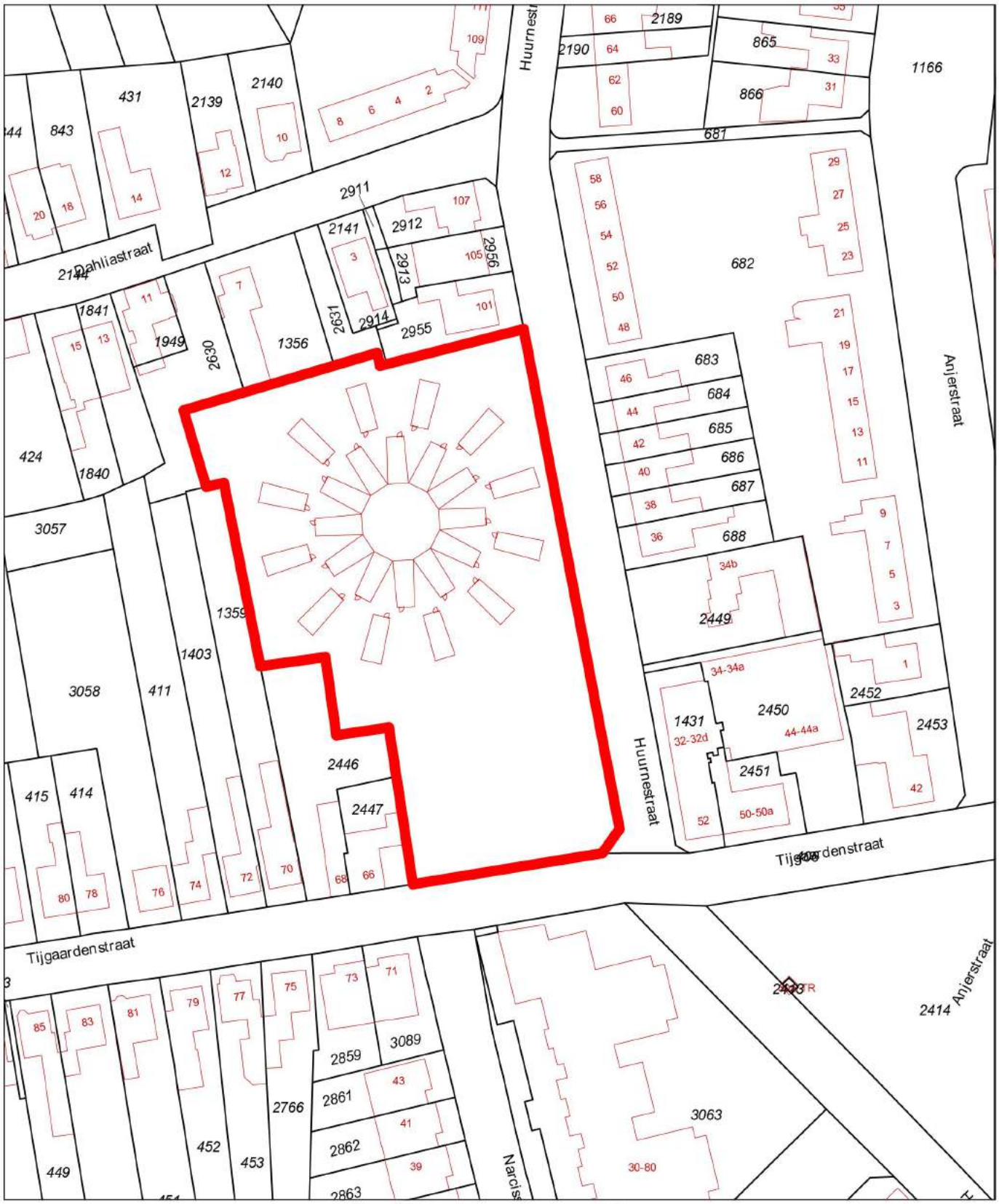

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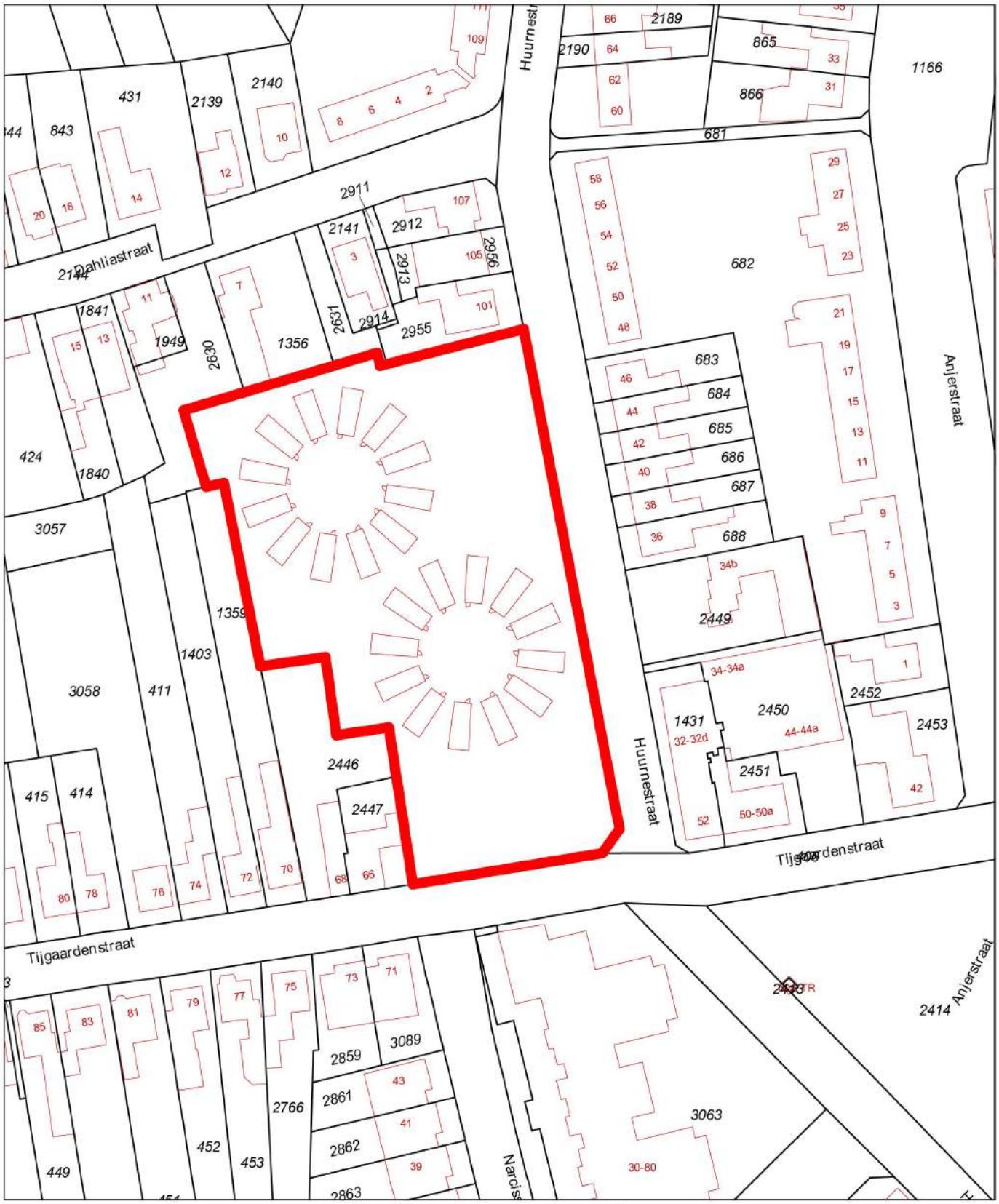

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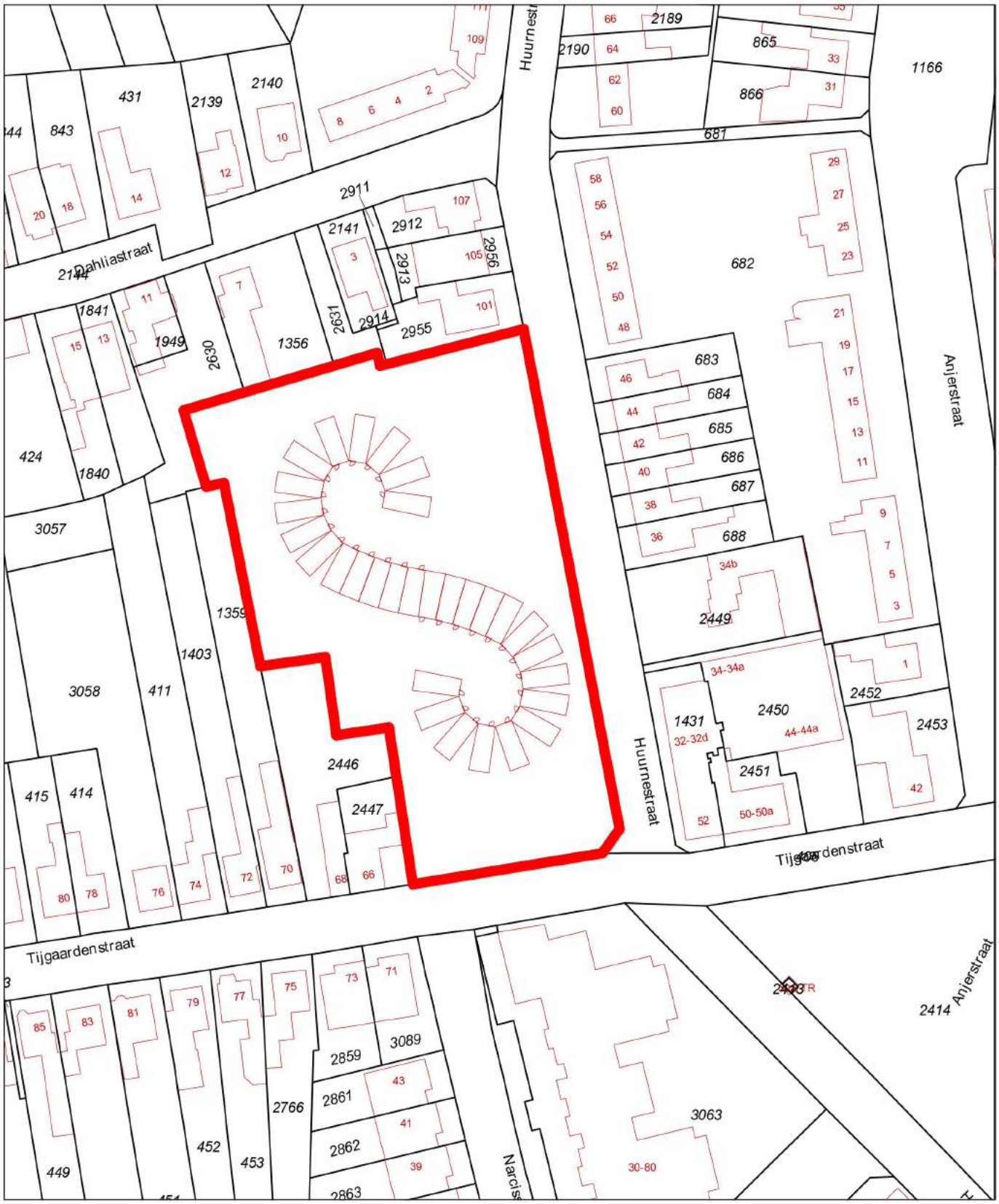

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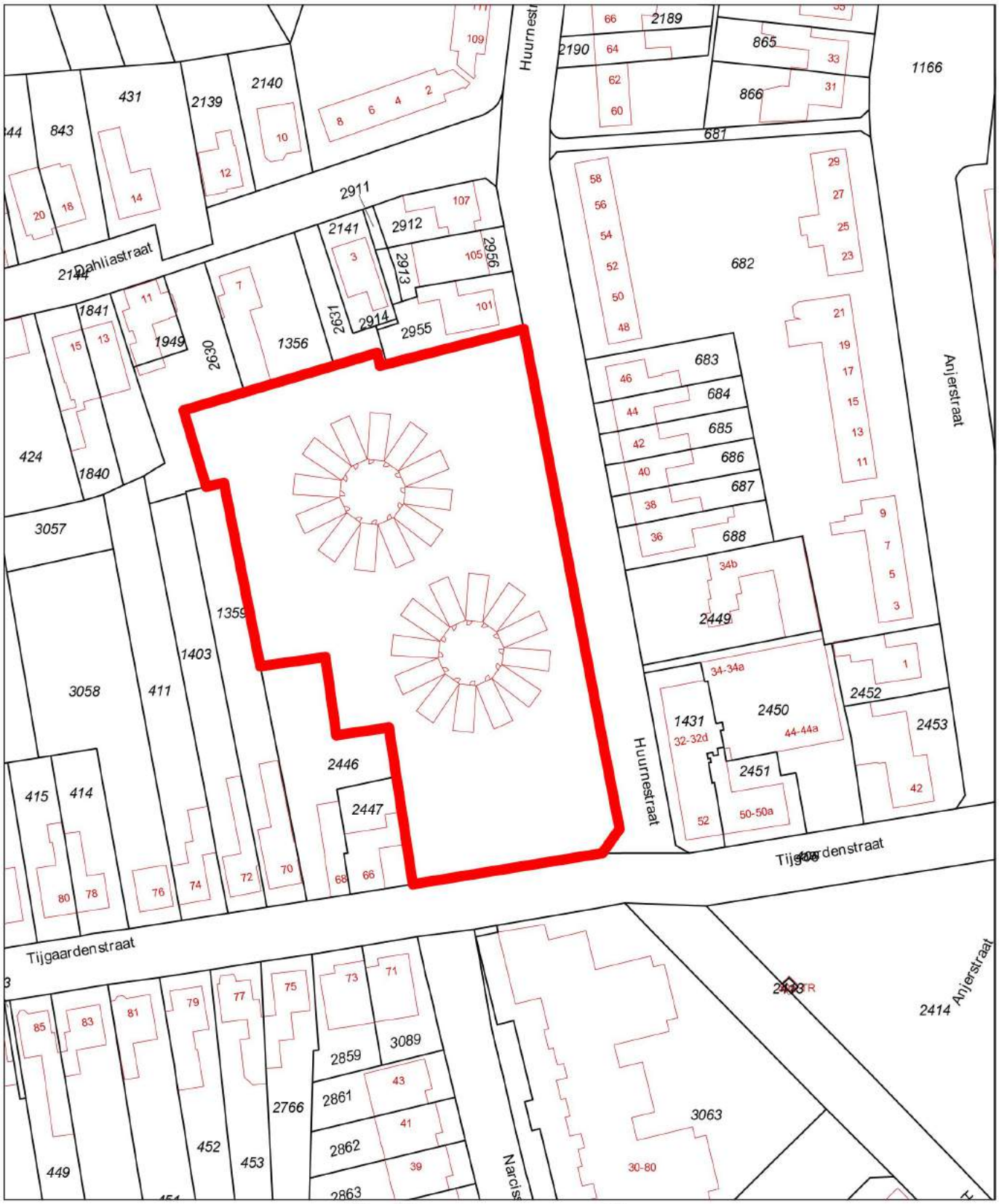

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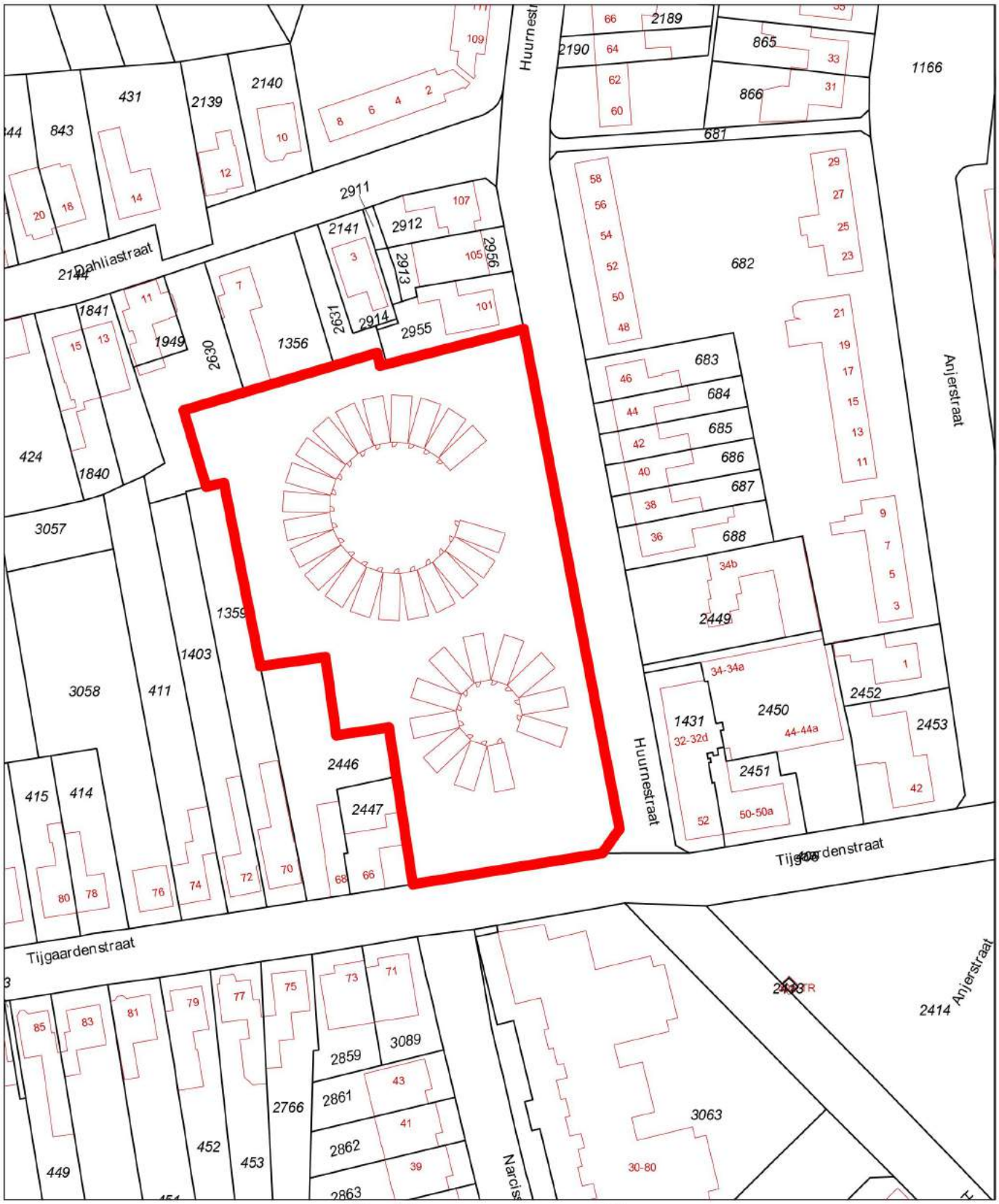
Uw referentie: Huurnestraat 73



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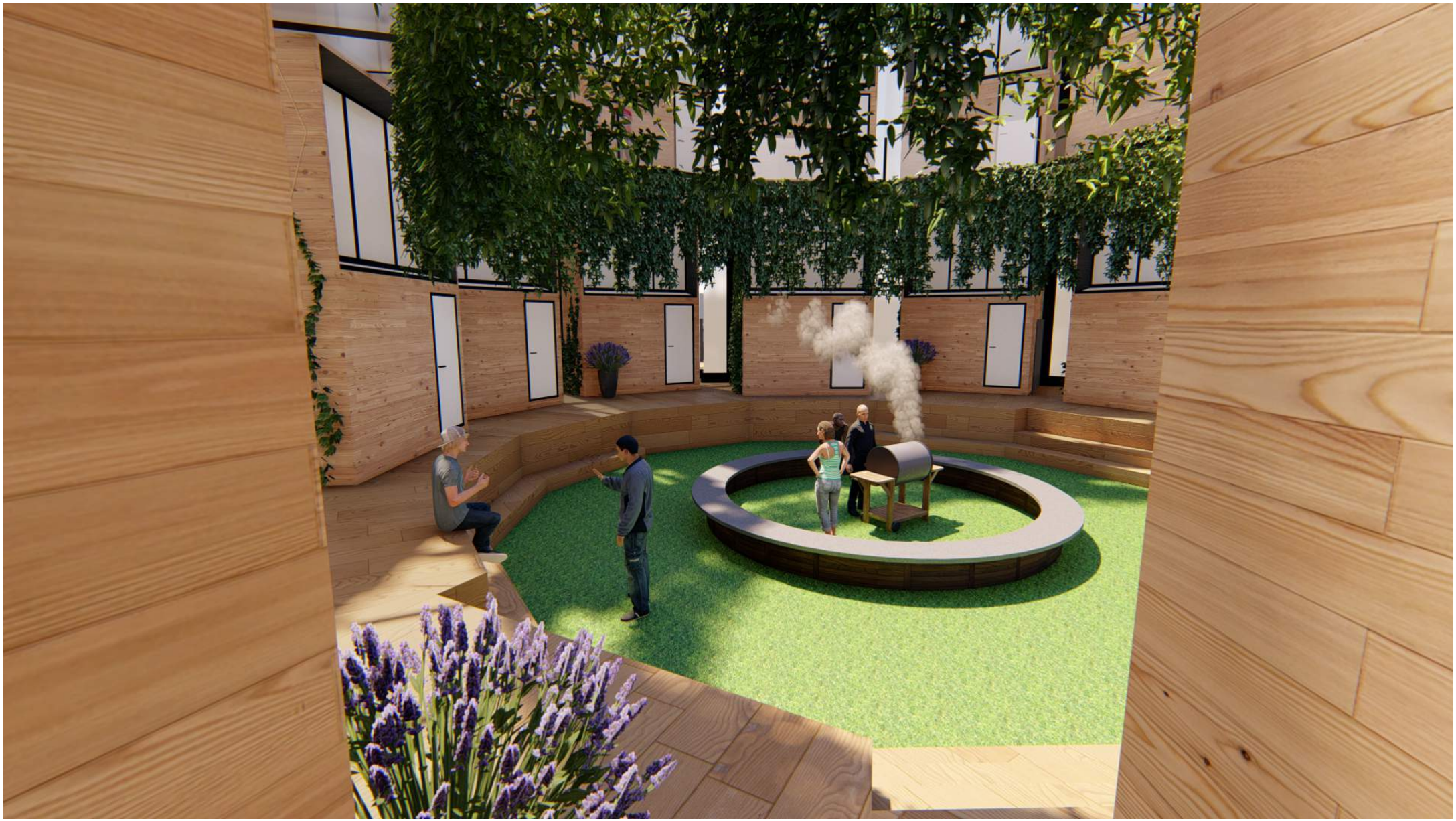
APPENDIX R

CONCEPT RENDERINGS

Renderings have been made to communicate the concept as clear as possible. The images can be found in a reasonable size on the next page.



APPENDIX S

QUESTION & ANSWERS EVALUATION

Questions had been prepared for the evaluation with Huub van Uum (municipality Oldenzaal). The answers to these questions can be found in this appendix.

Evaluation with Huub van Uum, municipality Oldenzaal (18-06-2019)

First the concept has been explained to Huub van Uum to get a complete idea about the concept. Thereafter, the evaluation took place, with questions prepared beforehand. The answers typed are the answers Huub van Uum presented to me while talking.

General questions:

What do you think about the concept in general?

"Authentic, renewing, giving a holiday-vibe, well thought-through, nice philosophy, projects the norms and values of this age. I can also see a representation about yourself in how you explain the concept and how I would see you as a person."

What do you think about how the area is divided in general?

"There is a strong balance between the opportunity to a resident to retreat or meet. With meeting it can be just the presence of being somewhere and seeing people walking by or really make a talk. Again, it gives a holiday-vibe which makes it attractive to seek for a spot outside the house."

What do you think of the houses?

"It looks modern. Playing with the space in the different levels is nice, the placement of the houses provides a playful and casual feeling. Everybody's own house has something unique, through the way how it's oriented and situated."

What do you think of the platform?

"As an example, the first thing my wife wanted when we bought a house was to make a deepened surface in the ground. It is perspective improving. Another example is that in Oldenzaal a new neighbourhood is located that focusses on playing with different heights between buildings."

What do you think about the balance of green/non-green areas?

"The amount of green in/on the platform could be improved. Also because nature can provide a cooling effect of the house. Also, cooling will become a more and more important topic with regard to global warming, while cooling takes up more energy than heating up a place."

What is your first impression about the atmosphere it creates?

"Pleasant, holiday-feeling, balanced stimulus, being in control of the stimulus. I can imagine walking out of my home with bare feet over the platform, sitting in the garden somewhere for a place that provides a resting effect."

In depth:

To what extent are restorative qualities met?

"Good, however it is always somewhat dependent on the co-residents that live within the same area. But if they share the same mindset it should not be a problem."

To what extent can people expres their identity in a way?

"Good, the sitting elements in the middle provide the opportunity for playing with them, in the garden people can express themselves of who they are, and via unintended social interaction between people."

What do you think about the service that provides 3rd party services?

"Essential for the concept, the space should be maintained well and everything around it has to be arranged. Who is maintaining the garden or keeps the solar panels and top of the roof clean, etc. To have the opportunity for the residents to fall back on someone. The norms and values present when a new resident enters the community, should be held. The 3rd party could provide this."

What do you think about the shared part connected to the platform?

"It is nicely done. I think it should be open to everyone within the neighbourhood."

What do you think about the garden area?

"A nice area to retreat and come to rest. Green provides calmness for the people."

What do you think about the garden area's in the platform?

"Good for noise reduction. Essential for a pleasant inside climate of the house. It provides a way of privacy and heat reduction."

What do you think of the flexibility where people can re-structure objects once a while?

"The moveable walls provide the option for concealing or opening up, depending on a person's situation/preference."

Are people having enough/too much options for being in control?

"Enough, in balance. They have the opportunity to provide their area with more or less stimuli. If the people are like minded, it should also not become a closed off community."

Is there enough/too much contact with nature?

"Within the designated area there is. However, the green setting would become even stronger when places on the edge of a city rather than close to the centre. The neighbourhood is build traditionally, where traditional people live. This fresh new concept wouldn't fit and the question would be if the people around it would appreciate it."

What do you think about the territory private/semi-private/communal and public?

"A lot of communal area, which suits the philosophy of people today. Big houses with garden are becoming more and more rare. People want a place where they can come to rest and meet each other, which this concept is about."

What do you think about the fact that social interaction is promoted in a most subtle way?

"Very good, loneliness becomes a bigger and bigger problem. This concept is a subtle way of doing something about that, without putting a stamp on it."

What are points that can be improved?

"Heat management around the houses, implementing more nature around them. More green within the platform (his opinion) and it would be ideal on a location more on the edge of a city."

What should the next concept definitely contain that this one misses?

"Context about whether people are living here, or if they provide something for the community. Would the garden, for instance, be maintained by the 3rd party or the people within the community? Or would they take turns every year? How to make use of people's interests, hobbies or skills, etc."

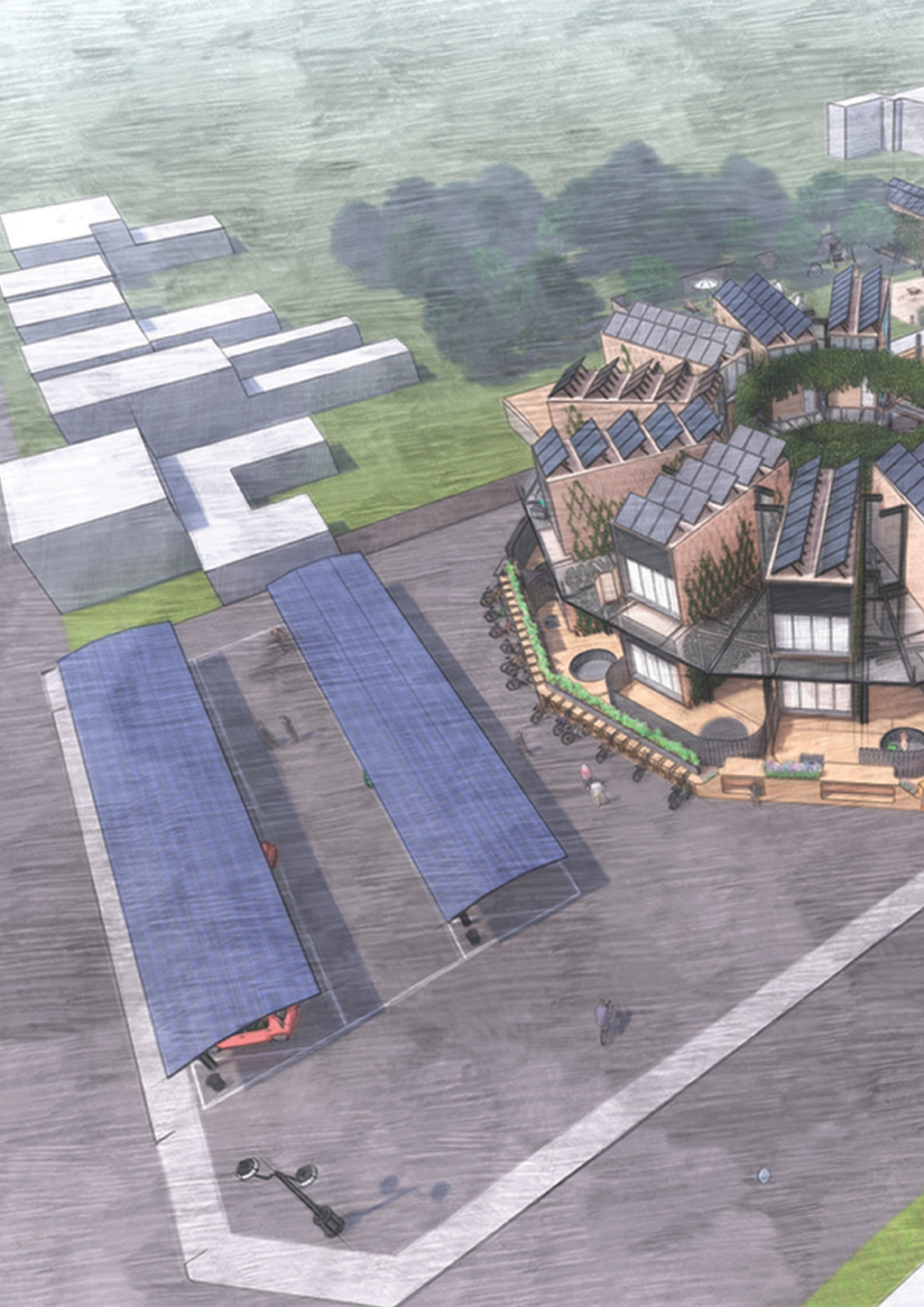
Remark

A sidenote that came to surface was about 'Maankwartier' in Heerlen. It is a project of an artist who claims that heights make people remember. So people have to climb up to 10 meters in order to get to the living area (see Figure below).

Figure 1: Maankwartier in Heerlen (Buchholz, 2015).

Source:

Buchholz, J. (2015). *Heerlen | Maankwartier - Stedenbouw*. [online] Stedenbouw. Available at: https://www.stedenbouw.nl/artikel/heerlen-maankwartier/ [Accessed 18 Jun. 2019].



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Design propositions for communal spaces within communities through research

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Graduation date: July 12, 2019

This document contains research, conducted for a MSc Industrial Design Engineer graduation project. The project ran at D'Andrea & Evers. The research is about how to encourage people to form a community. Furthermore, research has been performed on how nature and the concept of sharing can contribute in designing a successful communal space. All the topics have been researched by performing literature review on the topics. The document provides design propositions derived from the performed research for designing successful communal spaces.

community; sharing; nature; communal spaces

1. Introduction

2050 is a special date, set by the government in The Netherlands. They want to reduce the greenhouse gases, like CO_2 to a minimum (80-95% less than in 1990). This, due to recent developments where winning gas results in earthquakes, damaging homes in the surroundings. In 2050 almost every energy supply should provide sustainable energy [1]. This resulted in the Dutch government deciding that requests for new constructions from the 1st of January 2019 entails that the houses cannot get a gas connection and instead should think about a more sustainable way of receiving energy [2].

A graduation project for the design agency D'Andrea & Evers lead to research that will be elaborated on in this paper. The whole project is about designing modular, sustainable one- to two-person households that can easily be build up and broken down, to respond to the high demand of households and to change the mindset and way on how houses are built currently. As a part of that project - the graduation project - a platform should be designed, which holds sustainable technologies that are providing the overall needs of the residents for the household (e.g. heat, electricity, ventilation, etc.). The households are around 31,5m² and can stack up or under the platform with a maximum amount of three buildings. Figure 1 shows a schematic front view of the idea. The platform and/or area around it should promote social connections between residents. Therefore, it is interesting to think about ways to include the surroundings of the community in some way by sharing products or services. The households look distinctive and support sustainable living.

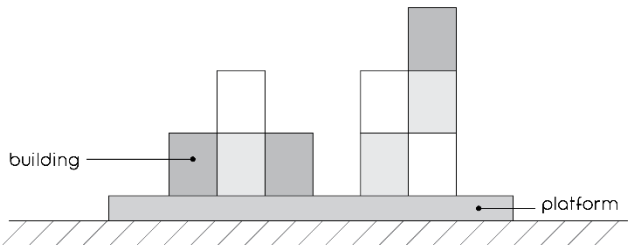

Figure 1.; Schematic front view concept.

In order to promote community forming in and/or around the buildings, research is performed to gain insight into what factors supports in forming a community and how nature and sharing can contribute to a community atmosphere within the shared space and service/product. Nature, because that is why sustainability is such a big topic right now, and within the project. Sharing because there is a noticeable shift currently from owning goods to accessing or sharing in combination with services. [3]

These insights should provide certain propositions for the design of the outside and surroundings of the platform. Therefore the main research question is formulated as follows:

- What factors can encourage people to form a community, and how can nature and the concept of sharing contribute to a successful communal space?

The next chapter will elaborate on the main question. The third chapter of this paper will propose a design idea for the communal space together with the design propositions found in the literature review.

2. Literature review

The first research question is divided into subcategories that are relevant to the project. They are arranged into paragraphs, being: community, nature and sharing. The first chapter will elaborate on how to promote social cohesion, creating a sense of belonging and in overall create a community. In the second paragraph 'nature', the goal is to gain insight into what positive influences nature can bring to the community and people themselves. The third paragraph is about sharing. What does sharing mean, what positive influences can it bring and what service and/or product helps creating a social, communal space.

2.1. Community

It is important to understand how to create a community or how to stimulate the feeling of being a community. What people need to feel in order to become a community and feel a sense of coherence. As a first, a design can stimulate this feeling. Creating a sense of coherence and meaning is important for people's wellbeing [4].

That meaning is (partly) already created by living sustainable. In order to function in a group, one should first determine their social identity. They do so by categorizing themselves into social groups consisting of people with whom they are similar or different [5]. In this case it is about people who are similar-minded (or different from the rest). As an example, residents of Tiny Houses also hope to get in contact with people that share the same interests and ways of living [6]. When a group strongly feels something is 'theirs', a sense of commonality emerges [7]. It is hypothesised that this feeling could be stimulated by allowing the residents of Habitat decide what the communal space should look like. As an example, a phone on itself is not expressing as much of an individual, but with a phone case someone can already express themselves as 'me' rather than 'mine'. The communal space should feel like 'theirs' and express 'them'. This way they have the opportunity to express themselves through the design.

When creating a place where local residents can meet and socialize, a sense of pride and belonging within the community is triggered [8]. Belonging means acceptance as being a member or part of something [9]. A sense of belonging is not only important for shaping a community, but also for the individual. It can create a feeling of social connectedness, but also suppress negative feelings like social isolation, loneliness and alienation. Belongingness is about having positive and pleasant contacts with people that are no stranger to someone [10].

In order to get to know one another, the communal space should provide the opportunity to have contact with the locals and make new connections. One way to achieve this is to dress up the communal space is by implementing nature. This is a relative obvious option to consider, due to the fact that the design project is all about sustainability. Thereby, interacting with nature can lead to beneficial effects on social cohesion (among other things) [11 & 12]. Therefore, it is interesting enough to research what role nature could play within the community, to the surroundings and how nature can positively influence the community forming.

2.2. Nature

An overemphasis on creating communal spaces results in sterile spaces that are not used when it lacks the right services, goods or connection to existing economic and social networks [13]. Nature could provide in certain services and goods, which should fit within the context and its surroundings.

Green spaces are not merely for stimulating a community. It can support salutogenic effects, where the focus is on the stimulation of a person's health and well-being instead of focussing on the things that give negative influences. As an example, aesthetic appreciation is one of them, but hard to make visible in studies on this matter. However, it is also important to induce a certain balance between restorative qualities and the social aspect [4]. Keniger et. al. show a variant of examples of nature and its beneficial effect on the social aspect. This effect can occur at an individual, community and even national scale. The effects mentioned are: facilitated social interaction, enabling social empowerment, reducing crime rates, reducing violence, enabling interracial interaction, social cohesion and social support. [12] These are all effects that can be considered important for creating a nice neighbourhood and fostering a social community.

Nature can also provide other useful, more tangible products. For instance edible items from nature. The more ways of interacting with nature we can experience by using different senses, the more we can relate to nature. Allotment gardens and forest gardens that function as community gardens can provide a sense of place [4], hence, community. Nature could reflect important values that residents hold on to and strengthen the self-identity by symbolizing the self [7].

2.3. Sharing

It is assumed that a connection amongst residents of the community and its surroundings could be established by offering a service and/or product for sharing. This, because communication has to take place in order to use the service and/or product. When thinking about offering a product/service from the community, it could be something that is access-based or shared ownership-based.

Access-based products or services are not necessarily promoting prosocial behaviour. It can be used without social interaction. It could be something that is only interesting for one person. Sharing is about something where multiple people can be involved. One cannot share on its own [14]. As an example, John Doe can access a car via a service. John can achieve the goal of using the car all by himself, whereas sharing would probably involve asking people when or if the car is available on a certain day, maybe calling who has the car at that moment when John also might need it, etc.

Liem [15] came up with a 3-dimensional graph to show the relation between type of experience, type of offering and mode of ownership. This graph can be advised in figure 2. It shows that both partially owned or shared ownership share the same type of experience (utilitarian), but not the type of offering.

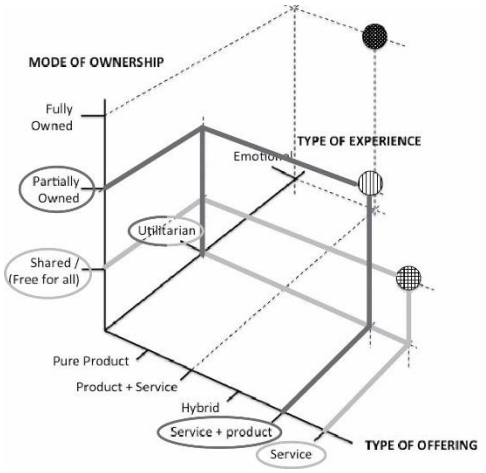

Figure 2.; 3-Dimensional Experience – Offering – Ownership Framework [15].

if someone would like a shared mode of ownership, this could best be performed by creating just a service according the graph. Public transport is such an example. Taking the train, using the service of going from A to B, without (partially) owning the train itself.

In the case of a partially owned mode of ownership, this could best be performed by creating a service + product where the service is the most important factor (so not a product + service). The product is merely there to support or provide the service. As an example let's take the company Swapfiets. It is a company where you buy a membership, which gives you access to a bike. For the time being, it is your bike, up onto the moment the membership expires and you need to give it back. The main service is also to get you from A to B, but the consumer keeps the product that provides this service. Thereby will their service also help the consumer if the main service cannot be performed anymore, by providing a new bike or fixing the one you have. If the bike is not needed anymore is can be used by someone else.

If a product or service would be part of the community or neighbourhood, it is important to think about the consequences and what people do or don't like to have as responsibility, sanctions that come with it and management of the system. When creating something where the emphasis is not on the management or efficiency of the product/service, this could support

contributing to the community and sharing behaviour [16]. However, as a designer it is important to think about the management and how people would like things arranged. If there is a lack of trust amongst people but they share the main goal, people are willing to contribute to a sanction system [17]. For instance, if someone wants to sell his/her laptop for a certain amount of money, there has to be a mutual trust, because one has to send the product and wants the money, whereas the other wants the product and transfers money. Which transaction should go first? What if someone does not get the promised good? There should be a sanction system in that case. Therefore, it is important to have trust amongst the people of the community in a consumer (insider) to consumer (in-/outsider) relation. Otherwise there is a shift needed to a business to consumer model. In the case of a business to consumer model the company can take responsibility in solving issues regarding distrust amongst community members [17].

3. Insights

This chapter will provide a general idea insight and the design propositions derived from the literature review.

3.1. Approach

When designing for the communal space a choice can be made whether to design something different for every location, design multiple options and let the residents choose or let the residents come up with their own idea for the area.

The most ideal approach for stimulating social interaction is to let people think about it themselves and come up with something unique, which they have to arrange themselves and build from a budget. But on the other hand, it could also be the case that no resident feels like taking initiative and they might rather choose from pre-selected options. Another reason to facilitate an open approach is that it could lead to an opportunity for residents in creating a social connection, and a reason to facilitate a service (+ product) within the communal area. It can give people a reason to go to the communal space and the socializing could occur by itself.

Skjelvik et. al. researched companies that facilitate services and/or products for sharing. These are respectfully: car sharing, places for sharing goods (product swap or take), house renting/couch surfing, general workplaces for companies (conference, meeting, presentation, etc.), Sharing energy/water to a company nearby, sharing smaller goods, within and expanding the community [18].

Figure 3.; Collage possibilities sharing service (+ product).

3.2. Design propositions

There is more to designing communal spaces than picking nice objects or making it appealing. In order to create a successful communal space, it also relies on people adopting, using and managing the space [13]. People make places, not the other way round. In order to clarify the design propositions derived from this research, they are listed below.

4.1. Literature review

Design propositions derived from literature:

- Communal space should provide the right services, goods or connection to existing economic and social networks [8]
- Balance between restorative qualities and social aspect [4]
- Nature reflecting important values of the residents [7]
- A place where you can meet and socialize [8]
- Let the residents feel like it's 'theirs' [7]
- Allotment and forest garden can provide a sense of place [4]
- Creating opportunities to have positive and pleasant contact, so they get to know each other [10]
- Interacting with nature [11 & 12]
- Sharing a service (+product) [14 & 15]
- Choose between B2C or C2C. Depending on how much people trust each other [17]
- Management or efficiency of the product service should be in the background (not the main factor or goal) [16]
- Expressing important values of the resident, reflected by nature [7]
- Let the residents help design their own neighbourhood [4]
- Physical and mental interaction with a public place will create a sense of belonging [19]

Important elements for 'designing in inclusion' are [13]:

- Including all age groups and social groups in ideas for the public space
- Encourage a strong sense of local distinctiveness
- Looking at evolving a range of spaces with different security regimes, including 'light touch' regulation
- Successful public spaces should build on the large degree of self-regulation of public behaviour that already exists

5. Discussion

During literature research, sharing and nature were researched as topics, that have relations to creating a community or a sense of belonging to a group. This resulted in multiple design proposition. Further research could dive deeper into a more complete overview of different factors that could help triggering this desired outcome. It is hypothesised that it could be stimulated by allowing the residents of Habitat decide what the public/communal area should look like.

The statement is made that letting people decide what should be placed in a public or communal area should be up to the residents. This would be the ideal case, if everybody entrusts one another. As also found, if there are trust issues amongst people, they might not come up with a design at all and the space is left empty. Therefore, a good suggestion might be to let people choose between certain designs, so they still have some degree of freedom, but not everything open and some guidance.

It is assumed that a connection amongst residents of the community and its surroundings could be established by offering a service and/or product. Elaborate research should point out if this really is the case.

Some research papers were about public spaces rather than communal spaces. The to-be-designed area could become a public space, but a communal space as well. This could mean that certain propositions might only work for the public spaces and not necessarily communal areas.

This literature research covered a part about how to create a successful communal space, while creating a community atmosphere. The topics 'sharing' and 'nature' have been researched. A follow-up topic where research could be performed is 'safety' in order to gain more insight into different factors that can help for creating a community atmosphere or successful communal space. A follow-up research question could be: "How to create a communal space where people feel save?"

There are a lot of factors that can help in order to make the design for a communal space work. However, it is not only the design that should fit, but also the people and what they would like to share with the world. To show their extended selves and who they are.

6. Conclusion

The literature review provides a lot of design propositions that are listed for creating a successful communal atmosphere with nature and the concept of sharing. Furthermore, multiple factors are discovered that can encourage people in forming a community.

Further research in safety could provide more design propositions for creating a successful communal area.

7. Concept design

Some of the design propositions implemented in the concept of the project are: the physical and mental interaction, creating opportunities for pleasant and positive social interaction and a place where you can meet and socialize and interacting with nature. An impression of the concept is displayed below.

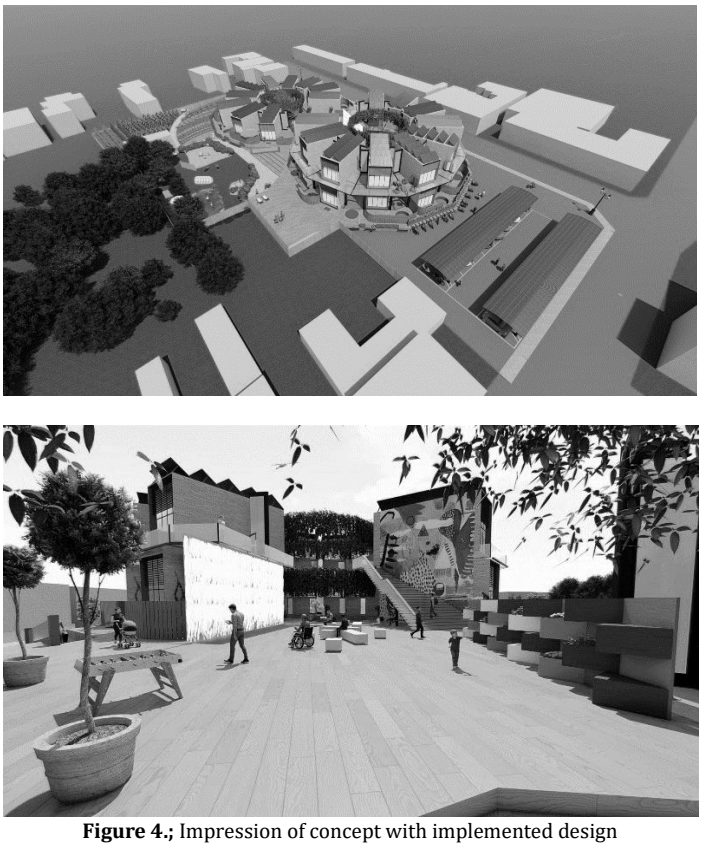

Figure 4.; Impression of concept with implemented design propositions.

8. Acknowledgements

I would like to thank the design agency, D'Andrea & Evers, for giving me the opportunity to contribute to this project.

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