Resourceful Affordability

Research Report

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Preface

The journey of creating this thesis on affordable housing using diverse resource principles has been both enlightening and transformative. Having done limited work on housing design during my bachelor's studies, I wanted to fill this gap through this studio with the aim of furthering my understanding on this topic. What I found was that while I achieved this goal, I also achieved a deeper understanding on other topics such as the Dutch polder, landscape architecture and sustainable building practices. This studio has changed my approach to architecture in using the constraints you're given to innovate.

I would like to thank my tutors Olv Klijn, Ruurd Kuijlenburg and Alejandro Campos Uribe for their insightful feedback and support that helped with the development of this project. I was challenged to explore new perspectives and push boundaries of my creativity, making this one of my most rewarding projects; their constructive critique was invaluable in bringing this project to fruition.

I would also like to thank everyone who contributed to my research findings. There were lots of emails exchanged with different architecture firms and archives to get all the data required to execute this thesis.

Additionally, I would like to thank my family, friends and partner for their emotional support during my studies. Their constant encouragement provided me with all the motivation I needed to get through all the long hours.

Ultimately, my thesis stands as a testament to all the collective support of everyone involved and I am grateful to be able to contribute this work to the architectural field.

Research

Introduction

Problem Statement

Globally, there are many countries facing a housing crisis. In the Dutch context, this is due to the fact that access to housing is limited. This can be attributed to population growth, a lack of space (Lalor, 2022), and stagnation of construction because of new nitrogen regulations (Capital Value, 2020). This, however, is not a new issue in following the fluctuation of housing supply. Historically, there have been times when housing had to be constructed swiftly. A scarcity of housing caused by mass destruction during World War II, as well as a building ban for the five years succeeding the war (Dogger & Veltman, 2011), meant that housing was hard to find. To relieve the crisis, approximately 100,000 dwellings were erected per year (Dogger & Veltman, 2011). Typically, the structure of these dwellings were made from materials such as concrete and steel. Facades were often made from spruce, and typically rotted and needed to be replaced. Many of these buildings have been demolished, or are planned to be demolished due to their subpar quality (Pandomo Makelaars, 2022). Overall, this was a resource approach that prioritised speed and affordability over quality and sustainability.

This housing shortage minimises access to affordable housing. This is most specifically a problem for the large number of people who fall into the gap where they earn too much to qualify for social housing, but earn too little to rent in the free sector (Boztas, 2023). The average price per square metre per month in the private sector is €17.10 (Pararius, 2023), whereas, in the social sector, it's €6.24 per square metre per month (van Deursen, 2023; Vijverberg & Jones, 2005), which demonstrates the vastness in the gap between the ability to rent in the free sector. There are also other expenses that these people have to incur in the

long term. Renting in the free sector means rent increases are allowed to be higher than in the social sector. In 2023, the legal maximum rent increase in the free sector was 4.1% (Government of the Netherlands, 2023), while it was only 3.1% (Lieven de Key, 2023) in the social sector. Free sector renters have less legal help than people renting in the social sector; they only have access to the Rent Tribunal ("Huurcommissie") in the first six months of occupation, while social renters have permanent access (I Am Expat, 2023). The free rental sector also has only 14% of the housing stock, whereas the social sector has 28.7% of the housing stock, increasing competition for housing in this sector. The combination of these factors ultimately makes it very difficult for people who fall into this gap to rent any kind of housing.

The topic of resource usage lends itself to providing affordable housing, however, this is a topic that has very limited research, specifically in combination with sustainability principles. Since certain resource principles are under-used (circularity, bio-based) there is very little researched in combination with affordability.

The problems the country is fac-

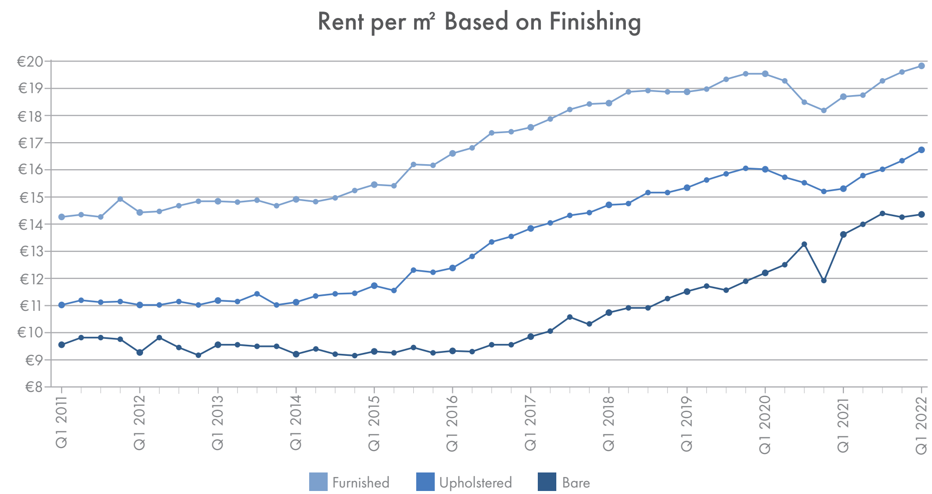

Fig. 1. Adapted from Realstats (2021). Graph of rent per m2 per finishing type.

ing with affordable private sector housing as well as the research gap, lends itself to making the main focus of this study to determine whether there is a more resource-central approach to designing dwellings - specifically for people who are in the gap between social housing and being able to rent in the free sector - that makes a dwelling more affordable to this target group. Given the inefficient solutions to this problem in the past, the aim of this study is to utilise resources in a manner that still prioritises speed and affordability, but also quality and sustainability. This leads to the research question:

"Which resource implementation principle is the most successful in the creation of housing that is considered to be affordable?"

Concepts

The main theories governing this research are principles that focus on architecture from a material perspective, as well as its response to this from an economic perspective. This lends itself to themes centred around the management of resources, including industrial ecology, resource implementation principles and examples of this. To consider architecture from an economic perspective, the principle of housing economics is introduced, as well as the principle of affordability implied in this report.

Industrial ecology is a principle based on means by which sustainability can be rationally approached; it is a system's view focused on the cycle of materials (Kapur & Thomas, 2004), whereby the entire system is evaluated, rather than in isolation (Mitra, Elhaj, & Rahman, 2023). This principle is important in the evaluation of the sustainable use of materials, as well as in designing with materials in a systems approach.

The concept of a **resource implementation principle** forms the backbone of this study. This new term is used since no single overarching term groups these resource principles together in this way. It refers to an overarching theme of approaching sustainability regarding materials. In this instance, it concerns different approaches in material execution, such as cradle-to-cradle, open buildings and modularity. On the other hand, it also focuses on the choice of materials, such as bio-based, and locally sourced materials. The main objective of each principle differs, as is briefly outlined below, and further researched in individual chapters.

The **Cradle to Cradle** approach is based on a literature study of the book of the same name, Cradle to Cradle: Rethinking the Way We Make Things (McDonough, W.;

Braungart, M, 2002). The basic principles of this approach are that when resources reach the end of their use, they are re-used, regenerated or remanufactured; it deviates from the typical linear economy, whereby resources are used and discarded.

Group builds, translated from the German word “baugruppen” and similar to a building co-operative, focus on the ideology of building a dwelling as a joint venture. With this concept, groups with a common vision develop and finance a building collectively (Rinne, 2019). These typically result in affordable, community-based projects.

Modular housing is based on assembling as much of the dwelling as possible off-site, to limit the amount of time spent assembling on-site. It lends itself to quicker construction (Cameron, 2007), as well as demountability ease (Cameron, 2007), whereby modules of the building are mechanically fixed and easily removed as a whole.

Bio-based materials are materials derived from organisms, such as wood, sheep wool, etc (HLM News, 2021). These materials are thus renewable, and therefore more sustainable to use than traditional, non-renewable building materials such as concrete, steel and bricks.

The **locally sourced resource** approach is centred around the concept that materials, and ultimately design, are focused on what is available locally. This has a positive environmental impact due to fewer emissions from transportation to the site, as well as the possibility to reuse local resources.

To relate these resource implementation principles to affordability, a comprehensive definition of housing in an economic sense is provided, thereafter affordability in the context of the article is defined.

Housing economics as a principle, concerns itself with the quantitative value of a house in the market, which thereby allows for ratios and

trends to be applied to its value (Kingsbury, 1941). This principle becomes of use when assessing the affordability of a dwelling qualitatively, as it allows for comparison. This principle bases itself on the evaluation of housing from a consumer’s perspective, whereby “lumber, labor [sic] and land” (Kingsbury, 1941, p. 356) are not considered. In this research, these aspects will be considered, however.

Affordability, as briefly mentioned above, is variable according to consumer perspective. In the context of this research, it is related to people who are above the maximum income required for social housing, but typically earn less than the average required to obtain a rental house in the free market. In quantitative terms, this is considered anywhere between the highest rental amount in social housing, €808.06 per month, and the average rental price in the free market, €1255.00 (Veul, 2023).

The combination of the entire framework provides a foundation to which the research question can be applied, in this case, a comparison between resource implementation principles and affordability.

Methods

To conduct this research and ultimately answer the research question, certain methods will be used, which includes a literature review, case studies, quantitative analysis, as well as qualitative analyses if data is insufficient, ending with a comparative analysis.

A literature review is used to gain a greater understanding of certain topics. Initially, it was used to define the context of the research question by providing data-based evidence for the problem statement, as well as identifying a research gap. This method is also used in the Resource Principles chapter, whereby resource implementation principles are researched in greater depth to understand and extract the main principles around which they revolve. The Case Studies chapter also relies greatly on this method to research and ultimately, understand the design choices of each project.

The Case Study chapter also uses a case study as a methodology, which will be used to gain a greater understanding of the projects that represent each resource principle. This will involve many steps, including an analysis of the architect and their general design approach, a context analysis involving geographic-specific insights, and a building analysis which involves a plan analysis, elevation and materiality analysis, an overview of construction, and three details with a focus on the resource principle.

A qualitative analysis will be used as a method to gain more insight into the case studies in the case that there is insufficient public data available. This includes methods like interviewing architects, as well as fieldwork where applicable.

Once the case studies and qualitative analyses have sufficient data, a quantitative analysis will be executed in the Analysis chapter, whereby Indicator Based Sustainability Assessment Tool for Affordable Housing Construction Technologies (Wallbaum, 2011) is used as a tool to analyse the affordability of each case study. This tool entails giving a score to each case study in respective topics - such as initial construction costs, labour intensity, and durability - and calculating the total average for each case study.

Once the quantitative analysis is completed, a comparative analysis will be executed in the Conclusion chapter to determine the reasoning for the scores, as well as ensure the resource ideology with the highest score, is relevant to the site of the project.

Using all these methods, design principles will emerge, creating the foundation of a project. The design of this will be based on principles further established using the literature review methodology. Once the case studies are analysed, and comparative analysis is completed, an affordable option for the resource ideology will become apparent, which the design will utilise as its main focus.

Resource Principles

Bio-Based Materials

Bio-based materials, also referred to as biomaterials, are materials composed of renewable, living sources. For architectural purposes, this includes materials such as timber, sheep wool, straw, hay, hemp, clay, cork and earth (HLM News, 2021).

Biomaterials typically have a lower carbon footprint due to their carbon sequestration and typically, a lower level of processing (Lecompte & Picandet, 2022), however, certain materials, such as hempcrete, typhaboard, etc., still require additives, making them less carbon friendly than unprocessed bio-based materials (Yadav & Agarwal, 2021). Biomaterials also reduce environmental impacts. Since biomaterials are renewable, the use of them reduces dependence on non-renewable sources, as well as having lower life cycles (Yadav & Agarwal, 2021). These materials have great thermal properties; thermal comfort can be obtained with less energy consumption (Bourbia, Kazeoui, & Belarbi , 2023)

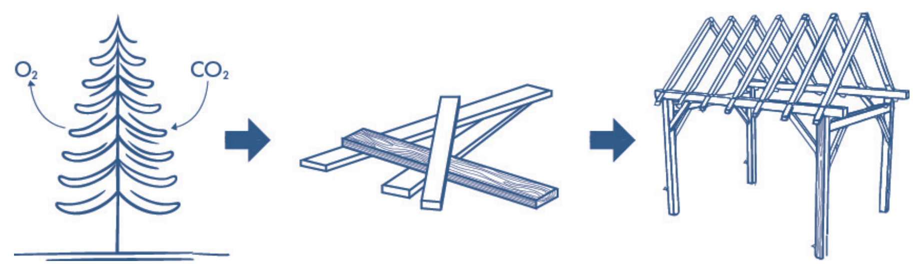

Fig. 2. Bio-Based Resources Diagram

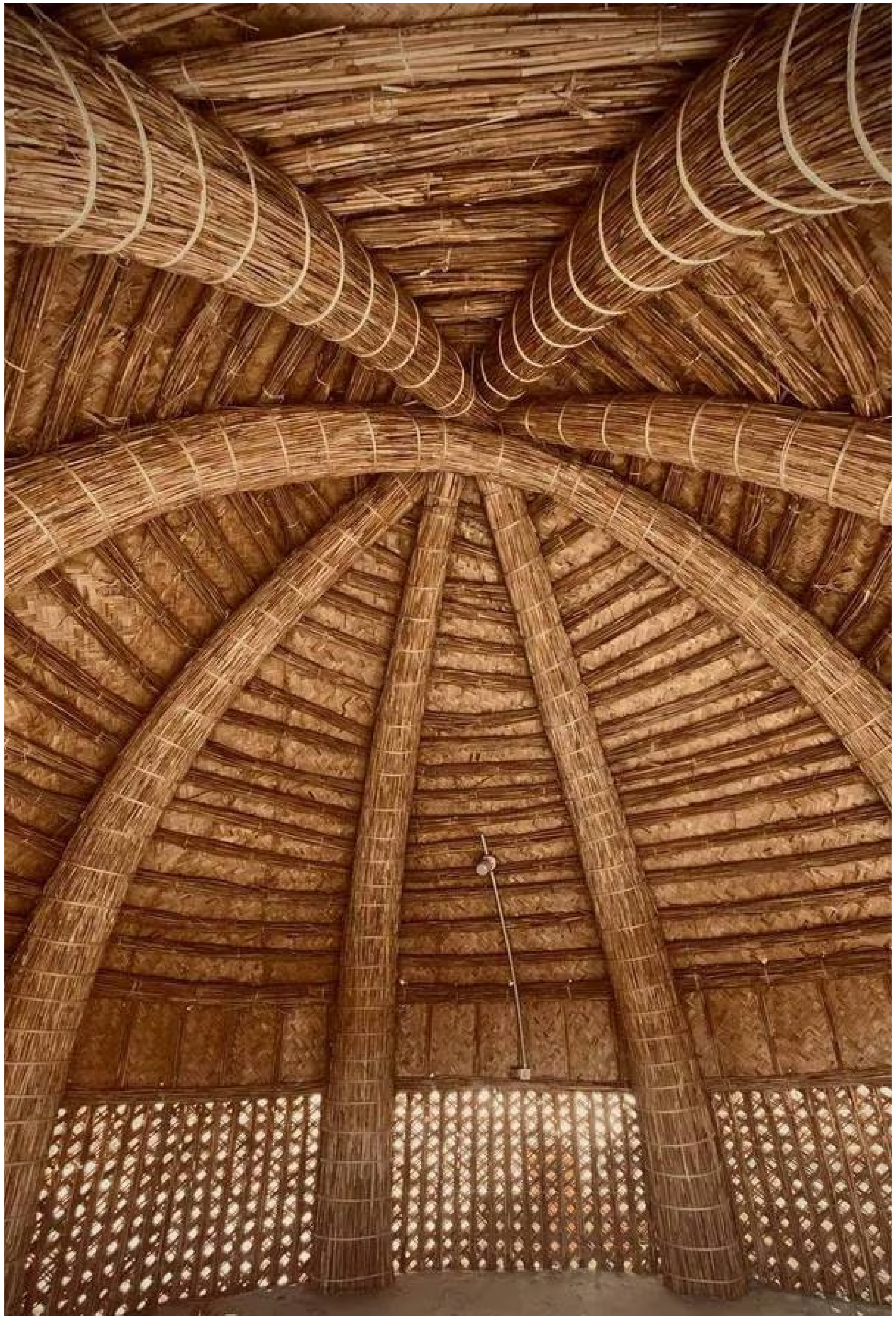

Fig. 3. The Tigris River Protector NGO (2022). Reed Architecture in Iraq

Despite these advantages, currently, only 12% of the building stock globally uses bio-based materials, which can be attributed to its inadequate regulatory framework, unaffordability, and limited mechanical strength. At present, the regulatory framework for biomaterials is restricted; the detail of regulations for traditional building materials is far greater than that of bio-based materials (HLM News, 2021). These materials are also typically more expensive than materials from non-renewable sources (HLM News, 2021), hindering use and innovation of these materials. Most biomaterials at current are used for insulation due to their thermal properties, which leaves a gap for biomaterials with mechanical properties that can compete with traditional building materials (Yadav & Agarwal, 2021).

Overall, these materials offer a suitable solution for lowering embodied carbon in the built environment, however, the expense of these materials is limiting their usage in the field, thus an affordable solution, is an important step to increase their usage.

Cradle to Cradle

Cradle To Cradle, a term coined by Walter Stahel in 1976 (Mohajan, 2021), is a model developed by McDonough and Braungart, made famous by their publication Cradle to Cradle: Remaking the Way We Make Things in 2002. The basis of the model is that resources are utilised in a circular way; resources are no longer depleted at the end of their use, but rather re-used or transformed.

Currently, the construction sector relies heavily on a linear economy; buildings are constructed with new materials, then demolished and disposed of as waste. A circular economy, as proposed with the cradle-to-cradle model, details that the waste from old buildings, is used in new buildings, and then re-used again at the end of their lifespan. For this to be achievable, materials are assessed based on their health, reusability, embodied energy, water usage and social responsibility (Cradle to Cradle Products Innovation Institute, 2011). This approach to material usage means that fewer resources are required in the building sector,

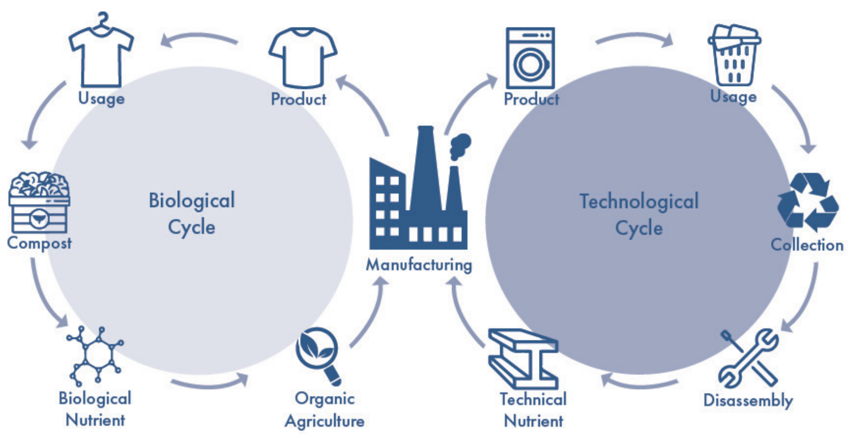

Fig. 4. Cradle-to-Cradle Diagram

minimising greenhouse gas emissions from materials production. This approach also minimises material waste, as well as ensuring that materials that are disposed, have minimal toxins that could compromise environmental quality (Mohajan, 2021).

This model is currently minimally used, due to multiple factors including complexity with implementation, potential price increases and regulatory barriers. The application of cradle-to-cradle principles in the built environment requires additional planning in material acquisition, as well as in the design of the project in suiting requirements for disassembly (Bakker & Wever, 2010). It is generally also the perception that cradle-to-cradle materials are more expensive. While they are on average 20% cheaper (Braungart, 2018), it limits the use of this model by developers.

The usage of the cradle-to-cradle model has multiple positive benefits for the environment, and the study of ease of usage, as well as affordable options and implementation into building codes, would promote the usage of this model.

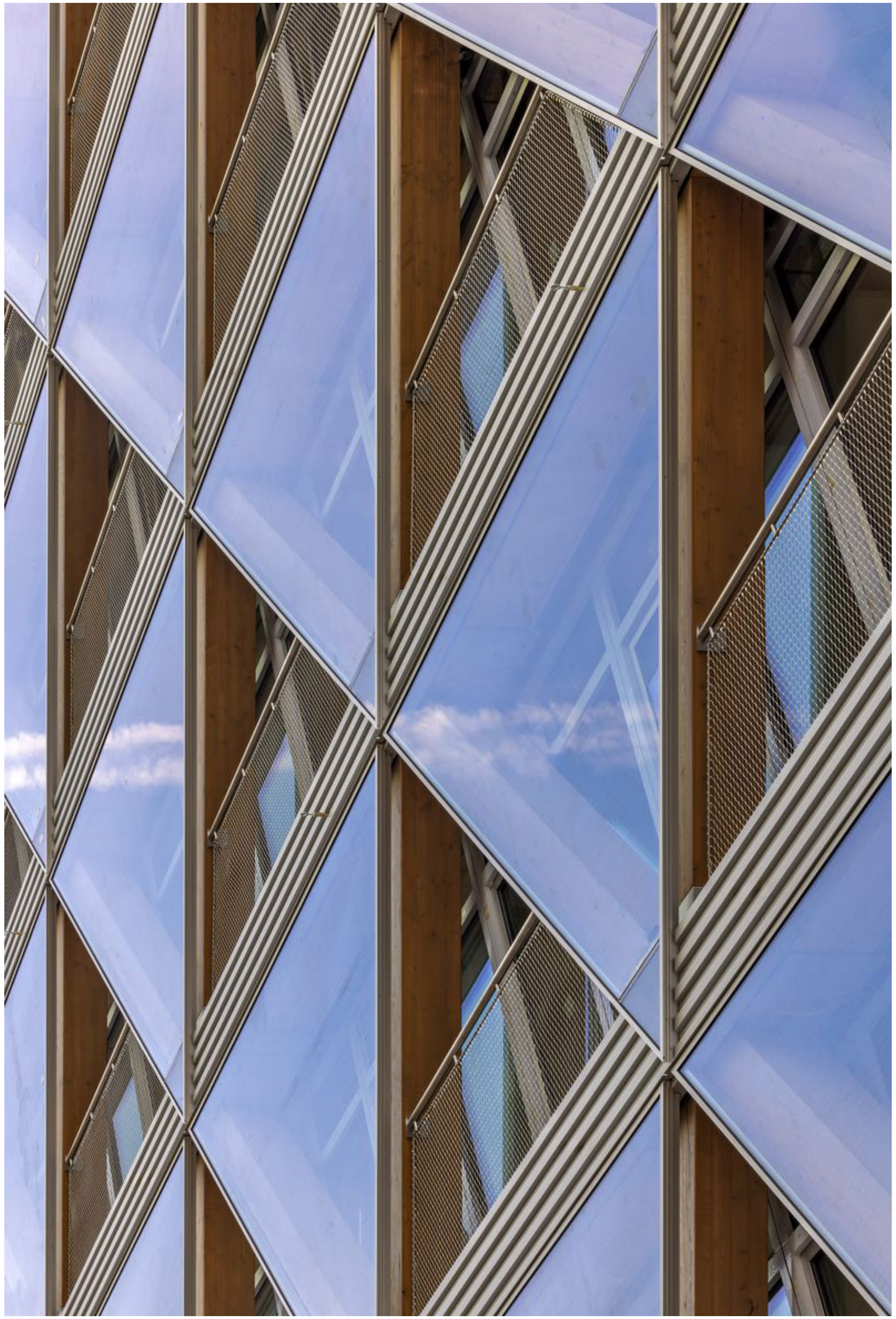

Fig. 5. Richter, R (2023). Photograph of the Façade of The Cradle.

Local Resources

The usage of local resources in architecture refers to using resources obtained from the area in which the house is built. This varies for every project and requires research into the resources locally found in the site of the project.

From a sustainability perspective, local resources minimise the carbon footprint of construction due to a smaller distance travelled to get the resources to the site (Pizzol, Weidema, Brandão, Osset, & Lesage, 2017). From an aesthetic perspective, local resources also tend to aid in blending the project into its surroundings; historical buildings in the area tend to be made from these resources too (Vellinga, 2003). Additionally, the use of local resources has economic advantages. Investing in these resources is good for the local economy through job creation, as well as minimising dependency on importing materials (Kibert, 2008).

The use of local resources is currently not a principle that is emphasised in construction today. Due to purchasing in bulk and econo-

Fig. 6. Local Resources Diagram

Fig. 7.

mies of scale, local resources are typically not the most affordable alternative for material sourcing (O'Brien & Nigg, 2008). On top of this, the availability of materials depends greatly on the site of the project; projects in populated areas are more likely to find availability of local resources in their proximity (O'Brien & Nigg, 2008). Finally, building codes are not always receptive to the use of local resources. The quality of standard imported materials is known, and thus easier to implement in construction, making the quantification for building codes more difficult for local resources.

Local resources offer many advantages besides the known sustainability advantages, however it is the lack of standardisation of these materials that limits their use in conventional building practices.

Modular Housing

Modular housing refers to a dwelling made from pre-assembled components. The size of these components varies based on different factors desired in a project such as flexibility, construction time and level of modularity desired.

The main advantage of this construction type is that it's typically lends itself to being an affordable construction method. This is due to lower labour costs and carry costs from shorter construction times (Smith, 2017). Additionally, the additional planning required for this construction method ensures fewer materials are wasted, as well as a more predictable analysis of the cost (Hartman & Neumann, 2018). Modular design can also be a sustainable option. Due to reduced material waste and energy usage in a factory, the environmental impact is lessened. On top of this, this method of construction also enables easier reusability at the end of a building's lifespan (Azhar & Carlton, 2015).

This is a construction method used more often than other resource principles today, however there are certain restrictions that limits its usage. There is a negative perception towards modular housing, whereby on-site construction is viewed as a higher quality construction method (Aghimien, Oke, Oseghale, & Efeovbokhan, 2018). An additional perception is that modular design offers limited flexibility when compared to traditional construction methods due to the limitation to the module sizes (Smith, 2017). This construction method is also complex in the co-ordination of transport and assembly of the project; more planning is required prior to construction (Hake & Hegazy, 2010).

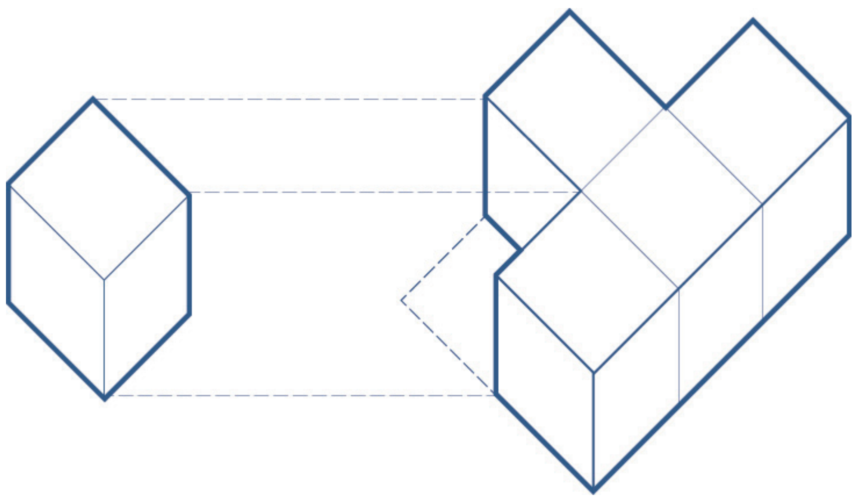

Fig. 8. Modularity Diagram

Modular construction is an affordable, as well as sustainable method of construction. The preconception of this approach is what limits its further use in the present.

Fig. 9. Pasco Photography (2023). Photograph of a U-Build Modular Home

Group Builds

The group build is a German collaborative housing concept whereby a group of people design and construct a building with the goal of inhabitation. With this resource principle, the inhabitants pool their resources together, such as finances (including a profit or loss made on the development), materials and responsibilities.

There are many social advantages to developing housing in this way. It offers personalisation and a sense of control of the environment because inhabitants are responsible for designing their individual homes (Brown, Smith, & Jones, 2019). It also provides a sense of community since the development of the dwellings is done with the inhabitants' future neighbours (Baugruppe, 2015). This is also an affordable form of development, due to the reduced market cost and lack of developer profit (Rinne, 2019). These developments are also typically built with the goal of sustainability in mind, specifically in factors such as energy and material usage (Böhm & Osterwald, 2017).

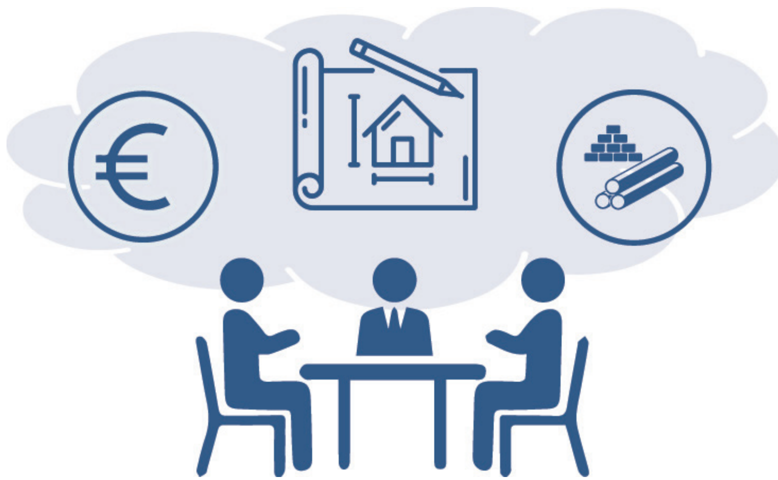

Fig. 10. Group Build Diagram

Fig. 11. Wrage, G (2013). Exterior of Grundbau und Siedler

While this form of development offers multiple advantages, there are shortfalls that offer potential reasoning for its minimal usage globally. While the financial benefit of this development type is high, there are also risks involved. Financing is required by multiple parties, so there is a risk that the project may not be completed due to single individuals in the collective (Rinne, 2019). Land prices also affect the financing, whereby desired locations are typically expensive, so projects such as these may be placed in less desired neighbourhoods (Latzke, 2020). This is also a complex development type. The time and effort required to plan a project of this type exceeds that of a traditional project (Rinne, 2019), and the chances of conflict between inhabitants is also a consideration when dealing with a complex project.

Currently, a traditional development may be favoured due to minimised complexities, however the financial and sustainable gains of a project with this development type cannot be ignored.

Case Studies

The case studies representing each resource utilisation principle were chosen on the basis that the case study was mainly a representation of a single resource utilisation principle, that the case study had sufficient data available, and they were built with the aim of being affordable.

In order to make a fair comparison on the affordability of a resource principle, it is imperative that the design of the case study mainly focused on one principle. In certain case studies, other resource principles were used to make the main principle achievable, which is a factor that will be considered in concluding which principle is the most affordable.

The availability of data is important for the quantitative analysis, as well as the case study itself. In order to use the framework for the quantitative analysis, data such as the price per square metre of the project will need to be obtained. For this to occur, the architects have to be available for questioning, or the data has to be readily available. Because of this, I have mostly chosen case studies from small-scale architecture firms, since they are typically more responsive to questions.

In order to ensure a fair representation of the principle, all case studies are chosen based on their appeal to affordability. There are shortcomings to this approach, as more affordable case studies may exist, however all the case studies chosen have mentioned affordability as a driver of their design.

Overall, in choosing the case studies in this way, the aim is that the resources will be represented in a fair way to ensure the result will be accurate in this way.

Bio-Based Artist Residency

Bureau SLA

Fig. 12. Adapted from bureau SLA (2023). Photograph of Peter van Assche.

Architectural Background

Bureau SLA is an Amsterdam-based, small-scale architecture firm. All of their projects are in the Dutch context, so the typology of their buildings is one that blends itself into the Dutch context. This is achieved using pitched roofs in low-density projects, as well as materials such as bricks and wood cladding. This firm mostly concerns itself with housing projects, as well as public building projects. The combination of these two specialisations, means that a focus in most of their works is encouraging a strong sense of community. They also focus on ensuring sustainable developments in different ways, such as experimenting with principles of circularity, like recycled plastic façade materials and renting materials to be used again, and as is the focus for the case study, the usage of bio-based materials. The firm is featured in many publications, and has won many prizes, and specifically won a Job Dura prize in 2022 for the Bio-Based Artist Residency project.

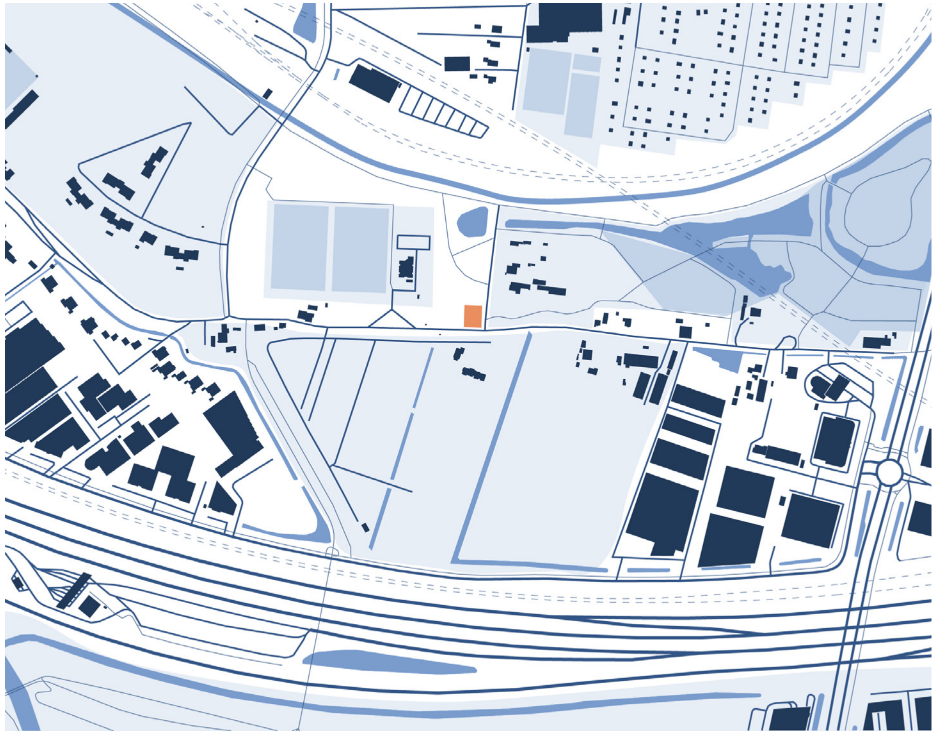

Fig. 13. Site Plan of Bio-Based Artist Residency

Contextual Analysis

The Biobased Artist Residency (2020) is situated in Charlois, Rotterdam. This is an area south of the centre of the city, characterised by mid- to low-density housing. This neighbourhood has two large parks, and the north of the neighbourhood is situated along the Nieuwe Maas river.

This house was commissioned by Theaterstad Amsterdam (Bureau SLA, 2023), which is an organisation that invests in cultural activities. This means that this house is to be accessible for artists across the country, which, due to the highway's proximity, it is by car. Despite the dwelling's situation in Rotterdam, it is relatively inaccessible from the centre of the city, which is unavoidable if aiming to reach the house with public transport.
The house's location near the high-

way, as well as industrially used railways, means that this area is characterised by its industrial activity. Apart from an industrial program, the peri-urban nature of this area, means plots are generally larger, so farming also takes place. These two programs form the backbone of the atmosphere of the area. Overall, the combination of these two programs, contribute to making the surroundings of the house very low density.

Apart from the built environment, the dwelling itself is situated in the Drechterweide park. This park is covered in trees, which gives the immediate surroundings of the dwelling a forest feel. Apart from the dense forestry the park provides, the railway tracks and roads are typically lines with trees, too.

Overall, the surrounding's characteristics combine to give the dwelling a slow-paced, rural, peaceful atmosphere.

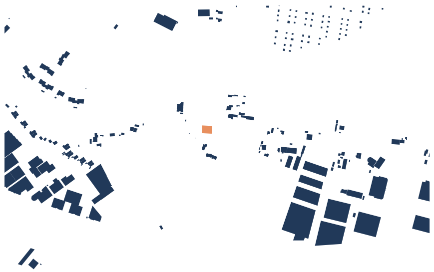

Fig. 14. Morphology

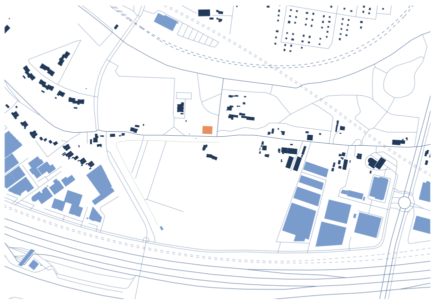

Fig. 15. Program: Industrial vs Farm

Fig. 16. Transportation Around Site

Fig. 17. Greenery Network

Fig. 18. Verrecht, J. (2023). Photograph of biobased artist residency

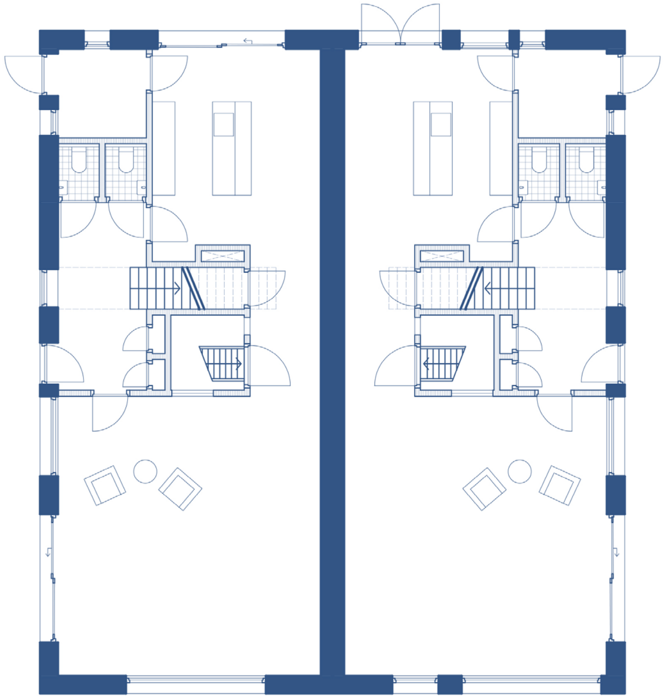

Fig. 19. Ground Floor of Bio-Based Artist Residency

Architectural Analysis

This dwelling is intended to a temporary work-stay residence, which offers artists a different environment to work and live in (Prins, 2021). As a further specification of this program, the architects wanted for this residence to be a place where a sense of community can develop (Prins, 2021). To achieve this, the ground floor is intended to be large and open, so that the space's layout can be configured by the residents. This also leaves ample room, intended for hosting and practising small plays. This side of the house - the most public side - faces the most public part of the lot: the dike. Here, it's made to be as though the passersby are spectators of the performances that occur here. With this being the largest space in the house, it has been given clear hierarchy and defines the character of the build.

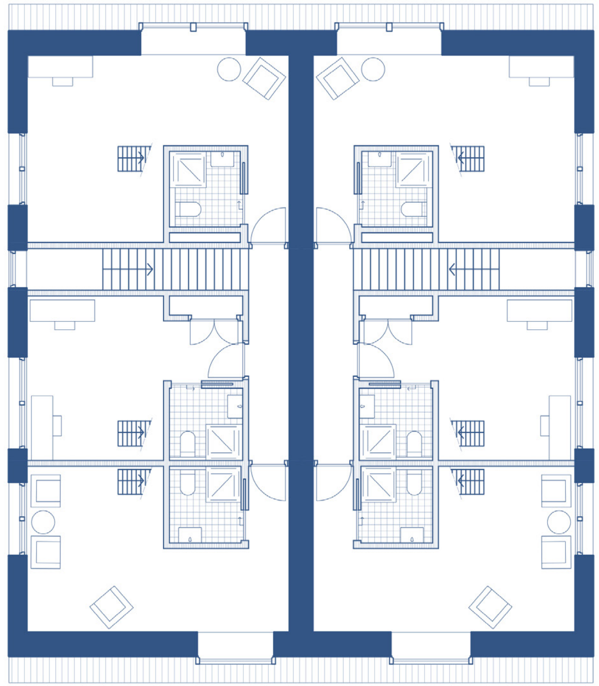

Fig. 20. First Floor of Bio-Based Artist Residency

In contrast to the openness of the ground floor, the first and second floors offer privacy for the residents. A skylight placed on the top of the staircase, accessed from the main entrance, guides the residents to a corridor where they can access their individual rooms. Each resident is given their own bathroom, desks and living room set-up. This space was designed in a way that the resident can also work and live in these rooms, yet individually, in juxtaposition to the ground floor. A lofted bedroom is further separated from this space, and becomes a place designated with the single function of rest, which sets it apart from the duality of functions in the rest of the house. Overall, an important feature brought about by the degree of publicness featured in the ground floor, is an increasing privacy, and mono-functionality in the verticality of the dwelling.

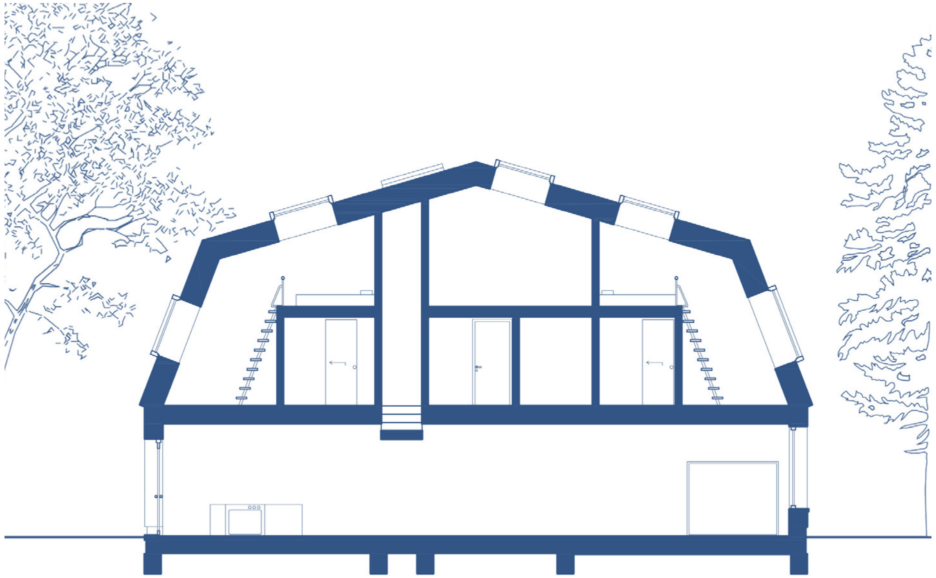

Fig. 21. Section of Bio-Based Artist Residency

The dwelling is divided into two separate, identical residences, with the same layout, however each residence has its own identity due to the flexibility of the ground floor, but most importantly, the placement of openings. The building is mirrored in its interior, as well as the openings on either side, however the front and back façade lack the same symmetry. Since neither symmetrical sides of the house will be seen at the same time, the facades have a randomness that juxtaposes the symmetry of the area's farmhouse typology on which this dwelling is based. This, in turn, reflects the openness that occurs on the inside of the dwellings, and upon which the entire project revolves around.

Cradle to Cradle
PIT Lab
DOOR Architecten

Fig. 22. Adapted from Young Media (2020). Photograph of Karin Dorrepaal and Saskia Oranje.

Architectural Background

DOOR Architecten is a small-scale, Dutch-based architecture firm founded by Karin Dorrepaal and Saskia Oranje in 2014. Their focus is mainly on the urban and architectural scale, with most of their completed projects being large-scale projects, such as apartment buildings and office complexes.

This firm concerns itself with circularity. This means, they aim to use Stewart Brand's layer model as a basis for every design, as well as their own circular materials toolbox and rules (DOOR Architecten, Onze aanpakken, 2024). They are also interested in other circular concepts, such as adaptable dwellings for changing households and growth from within a building as a dynamic whole. This firm has also won multiple awards, and was a finalist in the Circulist Award in 2022. Overall, they aim to showcase their experimentation with circularity in the studios offices and housing, PIT Lab.

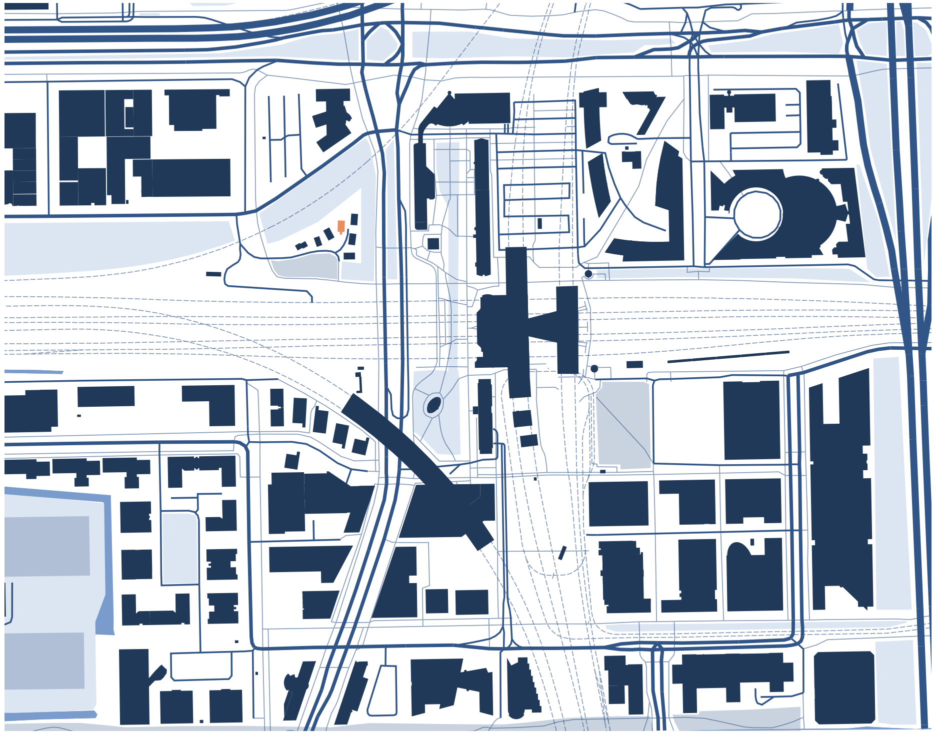

Fig. 23. Site Plan PIT Lab

Contextual Analysis

PIT Lab is located in the Sloterdijk, which is part of the Bos en Lommer district of Amsterdam. The PIT Lab forms part of the "De Tuin van Bret", which is a circular office park for entrepreneurs located next to Amsterdam Sloterdijk Station.

The program of this area is largely business oriented with various high-density office buildings as well as low-density industrial parks following the highway and railways. There are also various high-rise hotels, mainly catering to businesspeople. Recently, more high-rise residential buildings are being erected in the area. Overall, this area is incredibly dense and business centric.

Because this area is so business-oriented, it is very accessible by all means. Amsterdam Sloterdijk Station is a five minute walk

from PIT Lab, which is a large station that provides access to various big cities in the Netherlands. The site is also situated next to the A8 highway, which means the site is accessible by car as well.

The green network is very limited in Sloterdijk. Most green networks follow main transportation routes and appears seldomly within the city block. Because of this, the greenery that De Tuin van Bret provides is easily noticeable as an outlier.

The situation of PIT Lab within a business district provides many advantages such as ease of accessibility. PIT Lab also stands out a lot because of its positioning in this area; it is lower density than the surrounding buildings and biodiversity is present in this site when this isn't the norm for most of this neighbourhood.

Fig. 24. Morphology

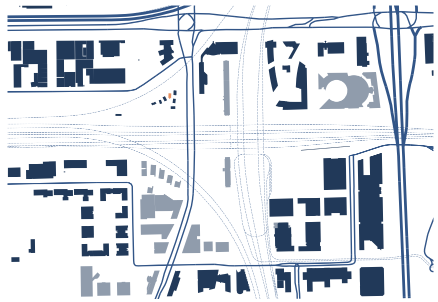

Fig. 25. Program: Offices vs Accommodation (Housing and Hotels)

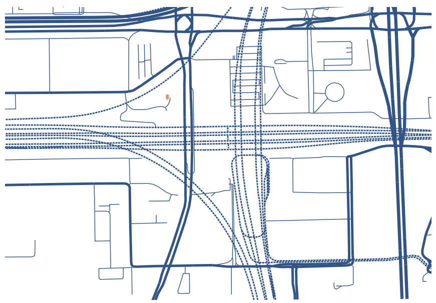

Fig. 26. Transportation Around Site

Fig. 27. Greenery Network

Fig. 28. Door Architecten (2021). Photograph of PIT Lab

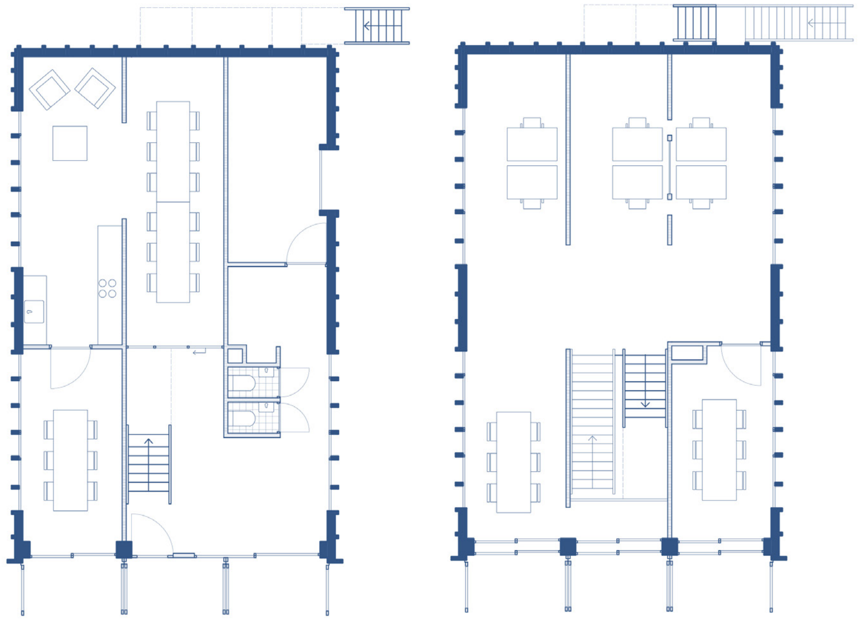

Fig. 29. Ground Floor (Left) and First Floor (Right) of PIT Lab

Architectural Analysis

The PIT Lab is DOOR Architecten's current office and a project that is an experimentation in circularity principles. This design is a result of collaboration within the office, and since it is a continuing experimentation, it is often changing in its design. These changes include a later addition to the rooftop, whereby a smaller shipping container was placed to house the staircase, and a roof was added to house solar panels and shelter their garden. This project is also used as an experiment on what works within the office, and what changes could be made to future office designs. Overall, the use of circularity as a leading project concept aids these ideas in its dynamism.

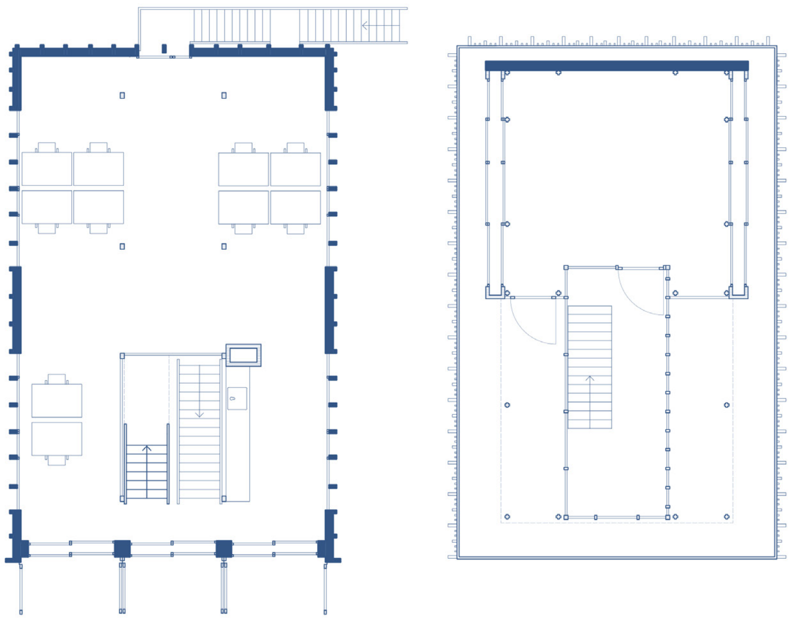

Fig. 30 Second Floor (Left) and Rooftop (Right) of PIT Lab

Three shipping containers are used on each level as the main structural element. The use of shipping containers means that demountability is easier with mechanical connections, and that the interior walls, ceilings and floors were provided; all that is required is insulation, services and coverings. The interior walls were then opened where required, and plumbing shafts as well as staircases were also opened. The difference of the floorplan in each level, shows the relative flexibility of a space like this, and how this can easily be transformed to a dwelling typology as well.

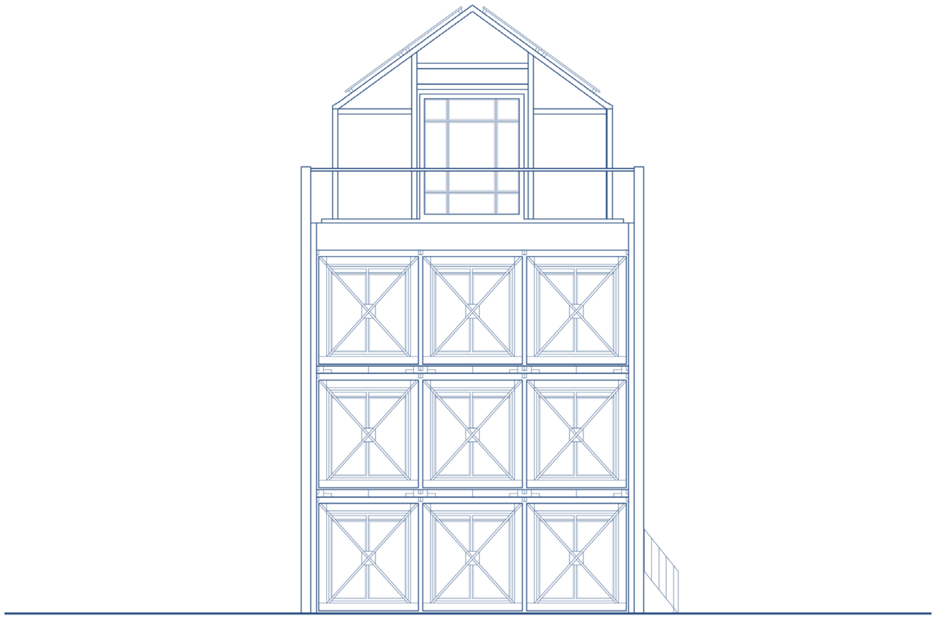

Fig. 31. Elevation of PIT Lab

The main circularity principle of re-use of elements is depicted, and highlighted with its vibrant colour, on the façade of this building. The shipping container doors used in this project offer multiple uses. Large, floor-to-ceiling windows are placed behind the doors, which means the doors can be closed to offer thermal comfort year round. DOOR Architecten are also experimenting with an urban agriculture smart façade module that would work behind these doors. The module would be fit with watering mechanisms as well as sensors that detect light, humidity and temperature. The doors can then be opened based on the weather and the plants preferences for light, humidity and other factors.

Local Resources
Ban-sur-Meurthe House
Studiolada

Fig. 32. Adapted from Bolomey, J (2022). Photograph of Christophe Aubertin.

Architectural Background

Studiolada is a French architecture firm based in Nancy, and was founded in 2009 by Christophe Aubertin, Agnès Hausermann, Benoit Sindt and Xavier Géant (Studiolada, 2024). This small-scale studio mostly focuses on architectural and urban projects, however most of their completed projects are either small-scale, private dwellings, or public buildings such as libraries and healthcare buildings. An inherent ethos of this studio is the aim to preserve and respect the environment in their projects. To achieve this ambition, the firm ensures it familiarises itself with urban and building scales before the execution of a project. The firm also focuses on the usage of local resources to minimise their carbon footprint. Studiolada has won many awards, such as a wood construction prize in 2023 for the Ban-sur-Meurthe House, but the most prestigious is the lauréat des Albums des Jeunes Architectes et Paysagistes from 2014, which is an award received by the French ministry of culture.

Fig. 33. Site Plan of Ban-sur-Meurthe House

Contextual Analysis

Ban-sur-Meurthe House is located in a valley in Ban-sur-Meurthe-the-Clefcy, Grand Est in France. The dwelling's surroundings are very rural and forestry oriented, which made the design of a locally-sourced, timber-centric house possible.

This dwelling is located in a very remote region in France. Since it's a rural landscape, the dwellings are very low-density, with most of the land allocated to forestry. Many of the dwellings themselves belong to foresters or wood craftsmen.

Because of the location's remoteness, the dwelling has very limited accessibility. There is only one main road through this area, with smaller, winding mountain roads connecting to this road. There are very few footpaths, and the footpaths that do exist were made to be used by foresters.

Very little land in this area is developed; there is an extensive green network in this area. However, due the agricultural nature of the greenery, all the trees are the same evergreen species. The biodiversity in this area actually comes from the open fields where many different species of low-lying plants are growing.

Overall, this area has an extensive network of greenery, a lot of which is forestry related. The dwellings themselves belong mostly to people in this trade, which makes the location for a locally-sourced timber-based house ideal in the attempt at affordability.

Fig. 34. Morphology

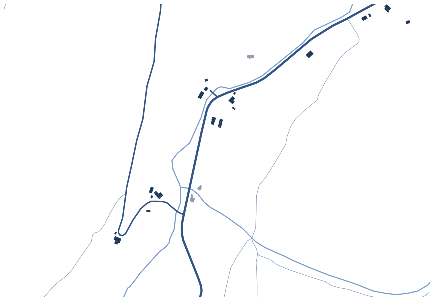

Fig. 35. Program: Farms vs Residence Only

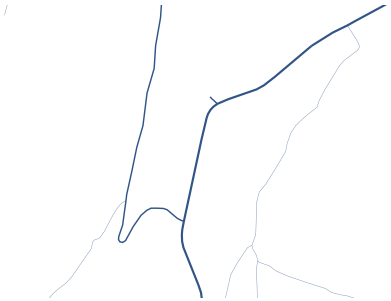

Fig. 36. Transportation Around Site

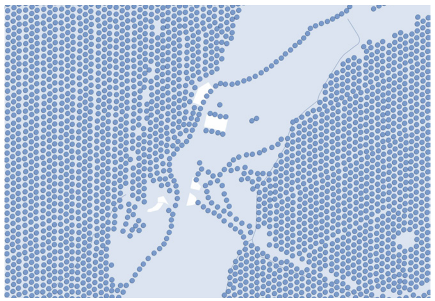

Fig. 37. Greenery Network

Fig. 38. Mathiotte, O (2022). Interior Photograph of Ban-sur-Meurthe House.

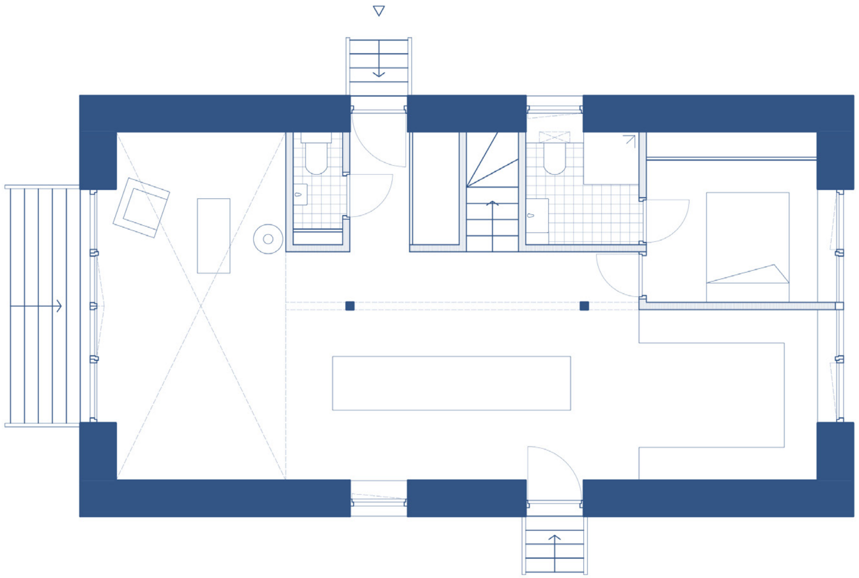

Fig. 39. Ground Floor of Ban-sur-Meurthe House

Architectural Analysis

This house is designed as a private residential project, which is intended to house a family. The floorplan and shape of this dwelling is quite simple, however in the themes of this dwelling, the complexity arises. A recurring theme in this dwelling, is how the local sourcing of materials, shaped the architecture into what it becomes. An example of this, is the use of straw as insulation. The size of the house is a product of the size of the straw modules required; the straw dictated the size of the structural grid, and in turn shaped the building as a whole.

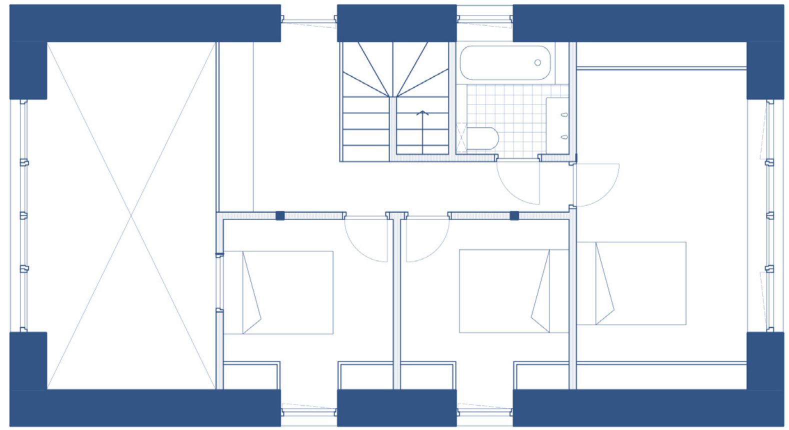

Fig. 40. First Floor of Ban-sur-Meurthe House

A leading principle for this dwelling is the use of wood and local materials. The structure, wall finishings and furniture were crafted from wood. This is due to the fact that this ensures the architects are aware that this is being sourced in proximity to the site to limit the footprint from transportation of this dwelling. The use of wood for everything has certain limitations that required clever solutions. An example of this, is the use of diagonal beams to re-enforce the wooden structure (Pintos, 2022). Shadow and form were also experimented with in this dwelling to provide interest in this monolithic construction. The wood and sourcing thereof, is a driving factor in this design, where wood is showcased in its peak form and manipulated by local craftsmen.

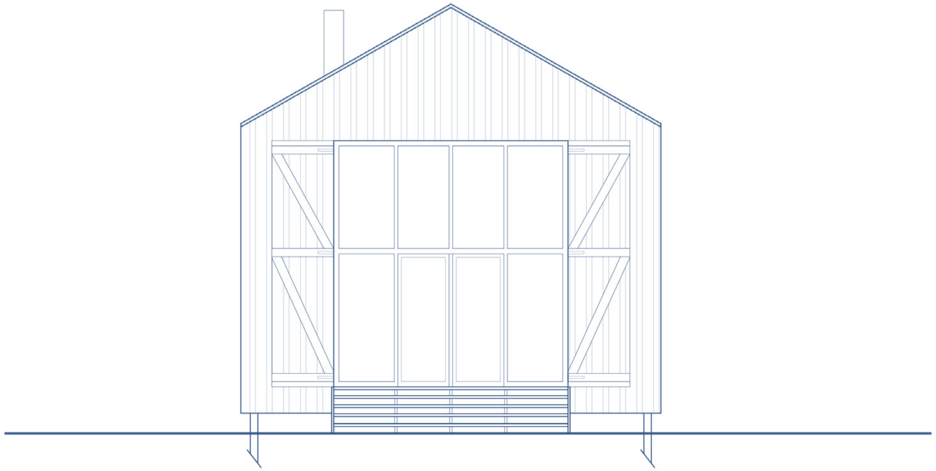

Fig. 41. Elevation of Ban-sur-Meurthe House

The exterior of this dwelling is an attempt to blend into its location. In order to limit the footprint of the dwelling on the ground, the house is lifted onto concrete blocks. These blocks are then made earthquake-proof due to the location. This gives the impression that the house is floating amongst its surroundings. The verticality and materiality of the cladding replicates the use of Douglas in similar farmhouses in the area (Pintos, 2022).

The use of a gable roof, blends the house into the hills behind it. The covering of the windows using vertical slats is an attempt to mimic the rockfaces in the mountains behind the dwellings, as well as providing solar shading. Overall, this house uses typology and transparency to blend into its surroundings.

Modular Building
The Kwikset House
Charles and Ray Eames

Fig. 42. Adapted from Eames Office, LLC (1949). Photograph of Charles and Ray Eames

Architectural Background

Charles and Ray Eames are an American-based couple, famously known for their furniture designs, as well as their contributions to modernism in architecture. The couple focused on issues of affordability with a motto to "make the best for the most for the least" (Eames, as cited in Cowan, 2017), which is a concept that can be seen in projects such as their Case Study developments for "Arts and Architecture, as well their proposal for the Kwikset House. The couple also focused on designs that are easy to assemble, as seen in their furniture designs, as well as in their experimentation with modularity in their Kwikset House. Materiality also played an important role in their designs, such as the focus on plywood usage in their early designs, and industrial and wartime materials used in their Case Study iterations. Ultimately, it was principles such as these, that gained them recognition in their designs and won them a Royal Gold Medal for architecture.

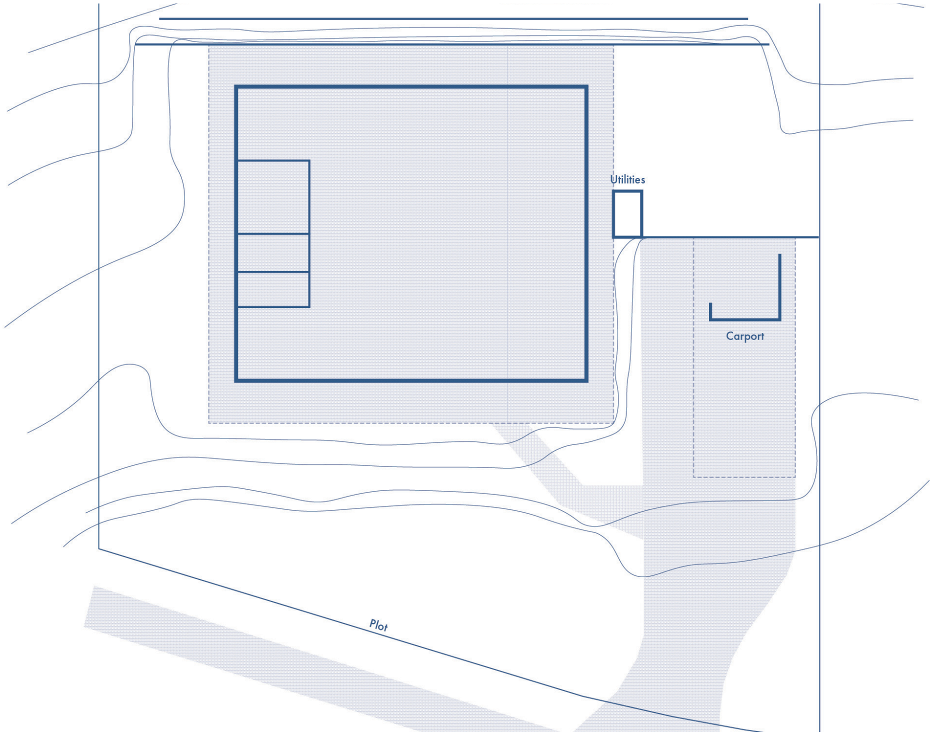

Fig. 43. Original Site Drawn for the Kwikset House

Contextual Analysis

The Kwikset House was designed to be a mass produced house that could be applied anywhere, however with the original drawings, a plot and site were designed. The plot itself was depicted on a hill, potentially to show the flexibility of this house and potential placement of retaining walls. A carport and utility room are also depicted which have not previously been portrayed in the standalone plan drawing of the Kwikset House. While the physical site was lightly designed, the historical context is more telling than the physical site for this case study.

This house was designed at the end of the Second World War. Because of the Great Depression and the war, there was a decrease in the construction of homes (FultonCountryHistorian, 2017). The end of the war also meant many

veterans were returning home and seeking homes (FultonCountryHistorian, 2017). Additionally, the economy in the United Stated saw unprecedented growth, which meant a large portion of the population became urbanised and were moving to cities (Freeman, 1999). The combination of these factors led to a housing crisis, where it was estimated that 1.5 million houses would need to be constructed over the span of ten years to relieve the pressure on the housing market (Eames Office, 2021). This historical context led to the development of a project that could be mass produced in an affordable way to provide a quick fix for this market.

Fig. 44. Eames, C; Eames, R (1951). Photograph of Kwikset House

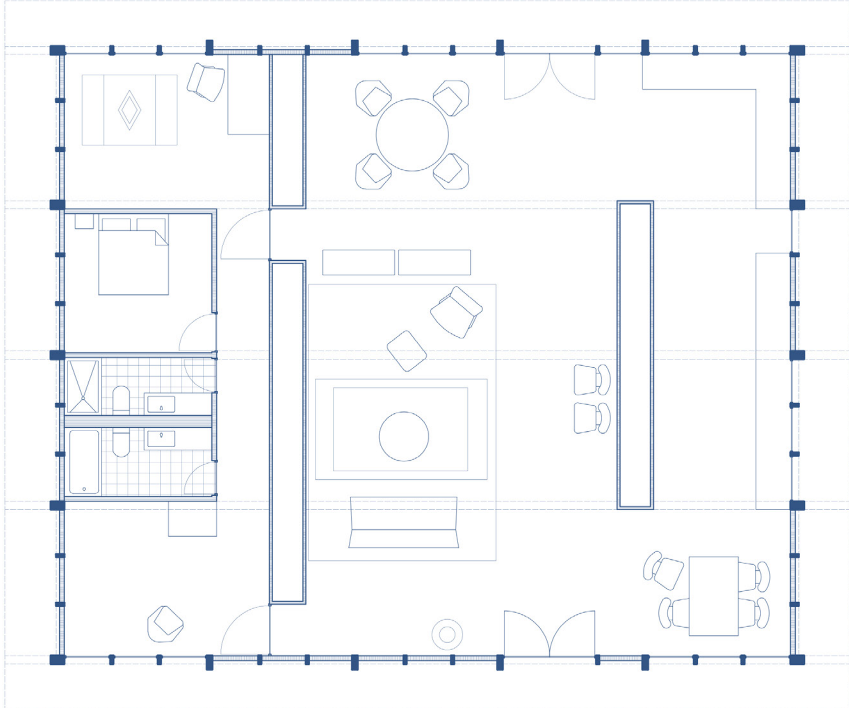

Fig. 45. First Proposed Floorplan of Kwikset House

Architectural Analysis

This house is designed to be a mass-produced solution to the housing crisis in the post-war period. The overall size of the building was determined by what could be made using $8,000. For this project, Charles and Ray Eames worked with Kwikset, a USA-based lock company (Koenig, 2010). Kwikset would provide for the mass-production of this dwelling, which solves issues presented in Eames' previous modularity experiments, namely Case Study House No. 8 and 9 (Budds, 2021). This means that every iteration of the Eames house would be the same size, regardless of household sizes and financial situation, due to the mass-produced nature of this dwelling to keep it affordable.

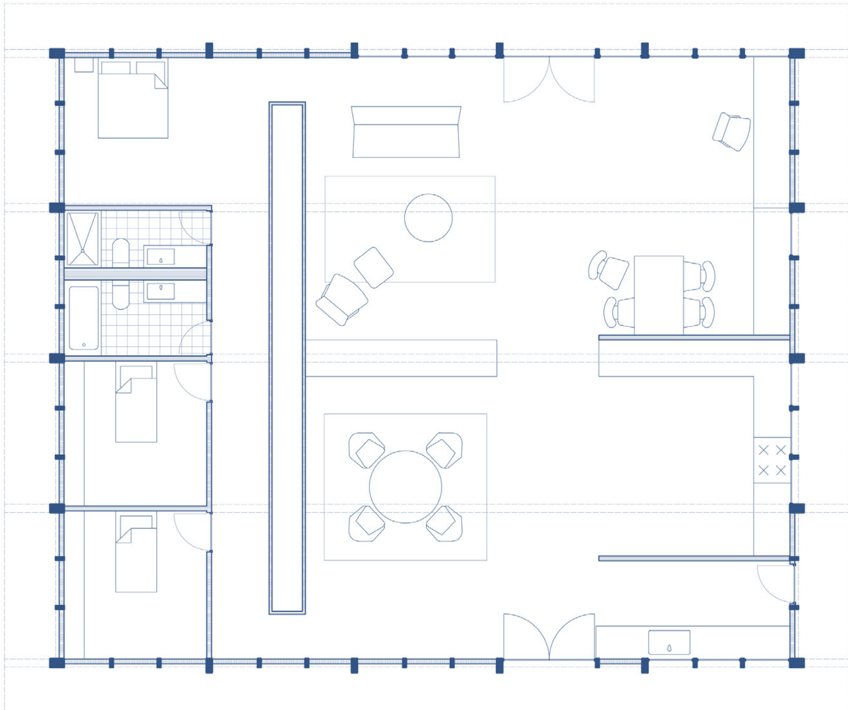

Fig. 46. Second Proposed Floorplan of Kwikset House

As can be seen in the difference of the two floorplans shown, the house is intended to be fully configured by the residents. The goal of this concept is that the dwelling is split by movable, space defining elements such as bookshelves and closets. The bathrooms and bedrooms are to be placed in the same side of the dwelling, and are intended to be entire modular boxes that are placed in the dwelling. Thereafter, the façade composition is decided per household based on the individual preferences, and the climate where the building is placed. These variations ultimately showcase the "Eamesian" concept of interactive, standardised elements (Koenig, 2010) that can be configured in a way that suits the resident's needs.

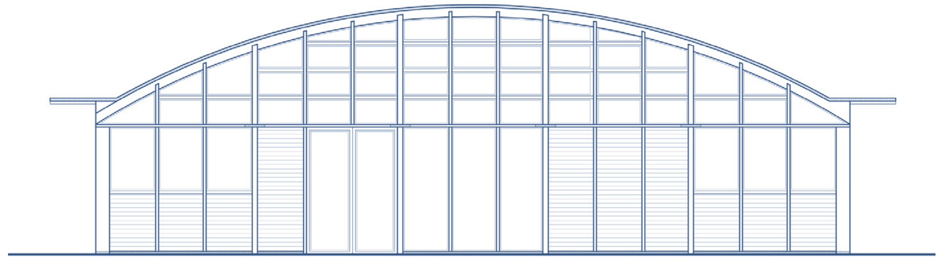

Fig. 47. Elevation of Kwikset House

The shape of the dwelling is what sets it apart from previous modularity iterations. Charles and Ray Eames' ethos for these houses was that they should be "inexpensive and factory built, with a slick look that would make anyone want to move in " (Eames, as cited in Budds, 2021). This concept is present in the façade of this dwelling, where an atypical curved roof appears. This curved roof also adds appeal to the dwelling, where rooms are divided, but no longer concealed. This alters the pre-existing notion of what a room is, and features the more modernist interpretation of planning, presenting the open concept floorplan. The roofline is what sets this building apart from others, and ultimately makes it the aesthetically pleasing dwelling into which people would like to move.

Group Builds
R50-Cohousing
Heide & von Beckerath

Fig. 48. Adapted from Senkrechstarter (2014). Photograph of Verena von Beckerath (Left) and Tim Heide (Right)

Architectural Background

Heide & von Beckerath is a small-scale, Berlin-based firm, founded by Verena von Beckerath and Tim Heide in 1988 (Heide & von Beckerath, 2024). A majority of this firm's completed projects consist of large-scale housing projects, with a few small-scale private dwellings, and public buildings such as galleries. Part of the ethos of this firm is participating in projects of different scales and fields, which is seen in their interest of urban design as well as interior design. On top of the various scale levels, this firm is research driven; they participate in conceptual studies, as well as collaborating with different field studies. This firm has also won awards for their designs, such as the Urban Living Award for the R50-Cohousing. Overall, this firm is characterised by their interest in various scopes, a theme present in the R50-cohousing project, which sets the design of this dwelling apart from the usual.

Fig. 49. Site Plan of R50-Cohousing

Contextual Analysis

R50-Cohousing is located in the Kreuzberg district in Berlin. During the Cold War, this district was one of the poorest in Berlin, but since the 1990s, the area is known as a more artistic, culturally-diverse neighbourhood in Berlin.

The Kreuzberg district has many noticeable areas of interest such as Checkpoint Charlie. Within the site drawing, the Berlin Jewish Museum and the Berlin National Gallery can be seen. Apart from this, this area is mostly monofunctional residential buildings, with a small monofunctional business-centric area to the North-East; there are very few combined functions near the site. Most of the buildings are between five and eight storeys high, which makes this a high-density area.

The greenery network is very extensive in this area. Because most buildings are high density, there is more open ground space, which is typically used for greenery and trees. The medians for main roads have grass and trees, which makes the area feel very green. Additionally, there are many parks and sport parks in close proximity to the site.

Because R50-Cohousing is close to the centre of Berlin, it's quite accessible by public transport. There is a subway line leading to the centre a 15 minute walk from the site. Additionally, there are bus-lines.

Overall, the neighbourhood that R50-Cohousing is located is considered to be desirable neighbourhood as further explained with its extensive greenery and transportation network. The group build principle provides the inhabitants with an affordable way to live in a desirable location

Fig. 50. Morphology

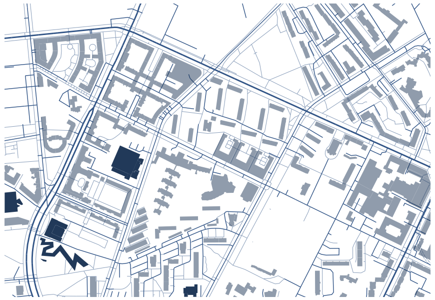

Fig. 51. Program: Institutional vs Residential

Fig. 52. Transportation Around Site

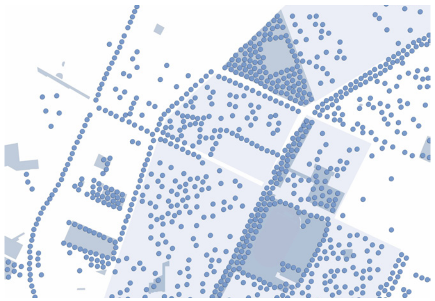

Fig. 53. Greenery Network

Fig. 54. Alberts, A (2013). Photograph of R50-Cohousing Balconies

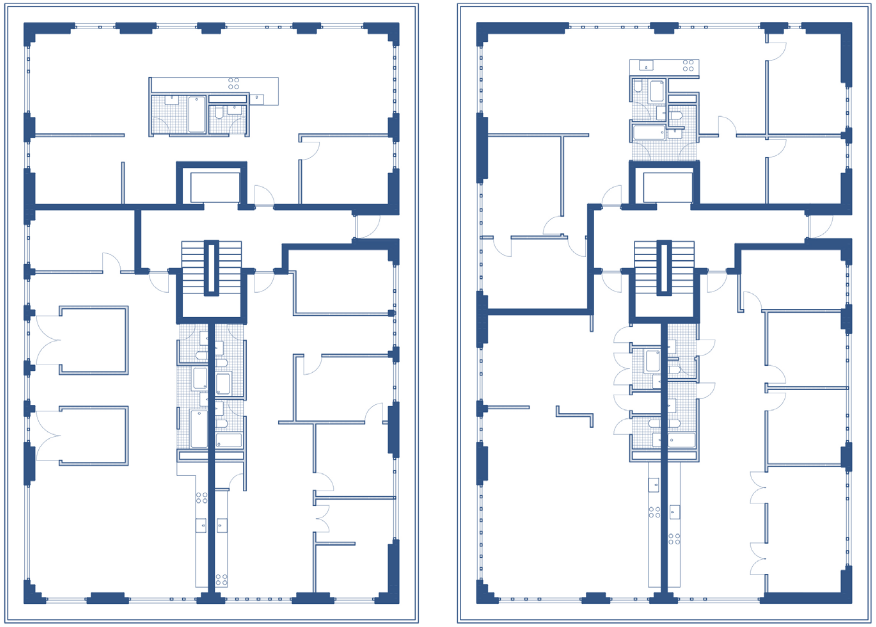

Fig. 55. Floor 4 (Left) and Floor 5 (Right) of R50-Cohousing

Architectural Analysis

This building is a residential project. Each floor has 3 apartments, and in total, the building has 19 apartments, and one studio. The basement and ground floor make up part of the urban fabric, where they both serve public functions for both the residents and surrounding neighbourhood. The basis of this building's design is that each resident sat with the architects and negotiated the requirements for their individual apartment. Collectively, the residents sat with the architects to discuss an architectural language that could be used for the entirety of the building. This was an intensive process, however the outcome was one that all residents were happy with (Heide & von Beckerath, 2013).

Fig. 56. Floor 7 (Left) and Floor 8 (Right) of R50-Cohousing

The structure of the building is an important factor in making the building how it is today. The structure was designed to be its minimum dimensions, and determined the approximate sizing of each apartment. Thereafter, other fixed elements were designed, such as the access and service cores, also affecting placement of entryways, bathrooms and kitchens. The façade of the building is independent from the structure, so that regardless of apartment planning, the façade can be arranged appropriately. Overall, the use of the structure in this way along with this concept ensures happiness within the residents about their living situations, as well as affordability and flexibility, guaranteeing a longer lifespan.

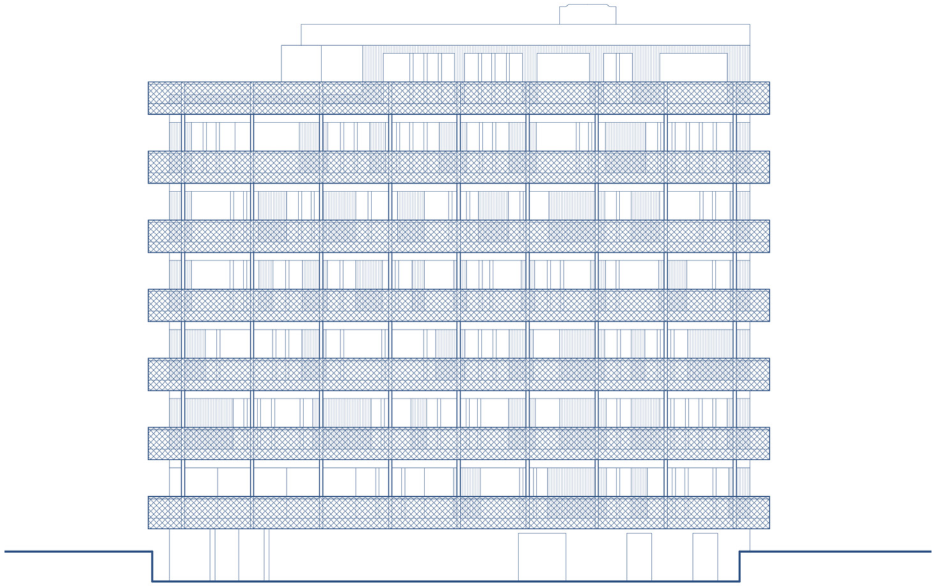

Fig. 57. Elevation of R50-Cohousing

The façade in this building is a representation of what occurs inside. The variation of modular wood elements, mixed with variation of window sizes and placement, showcases that the internal use is not a fixed one, and was decided by the individual (Heide & von Beckerath, 2013). The balcony wrapping around the entirety of the building reflects the social cohesion and trust required to make a project like this feasible, where everyone gets to choose the sizes and types of spaces they will have. Altogether, and with the same language used, the façade wraps into a cohesive whole that depicts the social values of this building.

Analysis

Framework

To assess the affordability of the case studies, a framework will be used that details construction in an affordable and sustainable way, as utilised in the article Indicator Based Sustainability Assessment Tool for Affordable Housing Construction Technologies (Wallbaum, 2011). This framework assesses affordability on a scale of zero to ten based on a certain set of criteria as discussed below. The framework has been adapted to accommodate certain changes such as turning costs from dollars to euros, as well as taking inflation into account.

Initial Construction Costs

This indicator ranks the cost of construction. This includes all materials, as well as labour costs. The framework as used in the study is based on American values and has been adapted. All projects were calculated to the cost in 2024 using inflation rates.

Initial Construction Costs (€/m2)	Rating
< €600	10
< €900	8
< €1200	6
< €1500	4
< €2000	2
Data not found	0

Table 1. Rating based on construction costs adapted from Indicator based sustainability assessment tool for affordable housing construction technologies, by H. Wallbaum, 2012, Ecological Indicators, 18, p. 353-364. Copyright © 2011 Elsevier Ltd.

Requirements of the Production and Construction Processes

This indicator is mostly focused on the labour required in the construction process. It ranks labour in terms of the skillset required to make a dwelling, from least skilled being the most affordable, to most skilled being the least.

Requirements for Construction	Rating
Unskilled labour, low tech tools	10
Unskilled labour with short training, local skills	8
Unskilled labour with intensive training, skilled labour	6
Advanced skills or tools required	4
Very advanced skills or tools	2
Data not found	0

Table 2. Rating based on level of labour from Indicator based sustainability assessment tool for affordable housing construction technologies, by H. Wallbaum, 2012, Ecological Indicators, 18, p. 353-364. Copyright © 2011 Elsevier Ltd

Time Schedule

This indicator focuses on the amount of time required to construct the project, based on principles of prefabrication, supply chains and management.

Time schedule	Rating
Erection of 100m2 < 4 weeks	10
Erection of 100m2 < 8 weeks	8
Erection of 100m2 < 12 weeks	6
Erection of 100m2 < 16 weeks	4
Erection of 100m2 > 20 weeks	2
Data not found	0

Table 3. Rating based on time frame adapted from Indicator based sustainability assessment tool for affordable housing construction technologies, by H. Wallbaum, 2012, Ecological Indicators, 18, p. 353-364. Copyright © 2011 Elsevier Ltd.

Economy of Scale

Mass production of certain technologies has the ability to increase the affordability of the project, which is ranked using this indicator.

Economy of Scale	Rating
Immense price reduction potential	10
High price reduction potential or large-scale approach	8
Price reduction potential or mid-scale approach	6
Minor price reduction potential or small-scale approach	4
No significant price reduction potential	2
Data not found	0

Table 4. Rating based on economies of scale from Indicator based sustainability assessment tool for affordable housing construction technologies, by H. Wallbaum, 2012, Ecological Indicators, 18, p. 353-364. Copyright © 2011 Elsevier Ltd.

Durability

The more durable a building and its resources are, the fewer resources that will have to be consumed rebuilding to the original quality, which is what this indicator evaluates.

Durability	Rating
> 50 years	10
> 40 years	8
> 30 years	6
> 20 years	4
< 20 years	2
Data not found	0

Table 5. Rating based on durability adapted from Indicator based sustainability assessment tool for affordable housing construction technologies, by H. Wallbaum, 2012, Ecological Indicators, 18, p. 353-364. Copyright © 2011 Elsevier Ltd.

Maintenance Requirements

If more maintenance is required, it generally requires more costs and resources. This indicator takes this into account due to its effects on affordability.

Maintenance Costs	Rating
Seldom interventions	10
Interventions of low skill and cost level	8
Average interventions of medium skill and cost level	6
Very frequent interventions	4
Intervention of advanced skill and cost level	2
Data not found	0

Table 6. Rating based on maintenance costs adapted from Indicator based sustainability assessment tool for affordable housing construction technologies, by H. Wallbaum, 2012, Ecological Indicators, 18, p. 353-364. Copyright © 2011 Elsevier Ltd.

Modularisation and Flexibility

Modularity and flexibility incorporated into the design of the dwelling, allow the inhabitants to make changes without further costs or resources.

Modularisation and Flexibility	Rating
High flexibility in case of change of use	10
High modularisation	8
Medium modularisation/medium flexibility	6
Low modularisation	4
Low flexibility in case of change of use	2
Data not found	0

Table 7. Rating based on modularisation potential adapted from Indicator based sustainability assessment tool for affordable housing construction technologies, by H. Wallbaum, 2012, Ecological Indicators, 18, p. 353-364. Copyright © 2011 Elsevier Ltd.

Recyclability and Demountability

The ease at which the building's main components can be demounted (originally demolition) or recycled is evaluated in this indicator.

Recycling and Demountability	Rating
Low demountability effort	10
Low recycling effort	8
Medium degree of recycling and demountability effort	6
High demountability effort	4
High recycling effort	2
Data not found	0

Table 8. Rating based on ease of demountability adapted from Indicator based sustainability assessment tool for affordable housing construction technologies, by H. Wallbaum, 2012, Ecological Indicators, 18, p. 353-364. Copyright © 2011 Elsevier Ltd.

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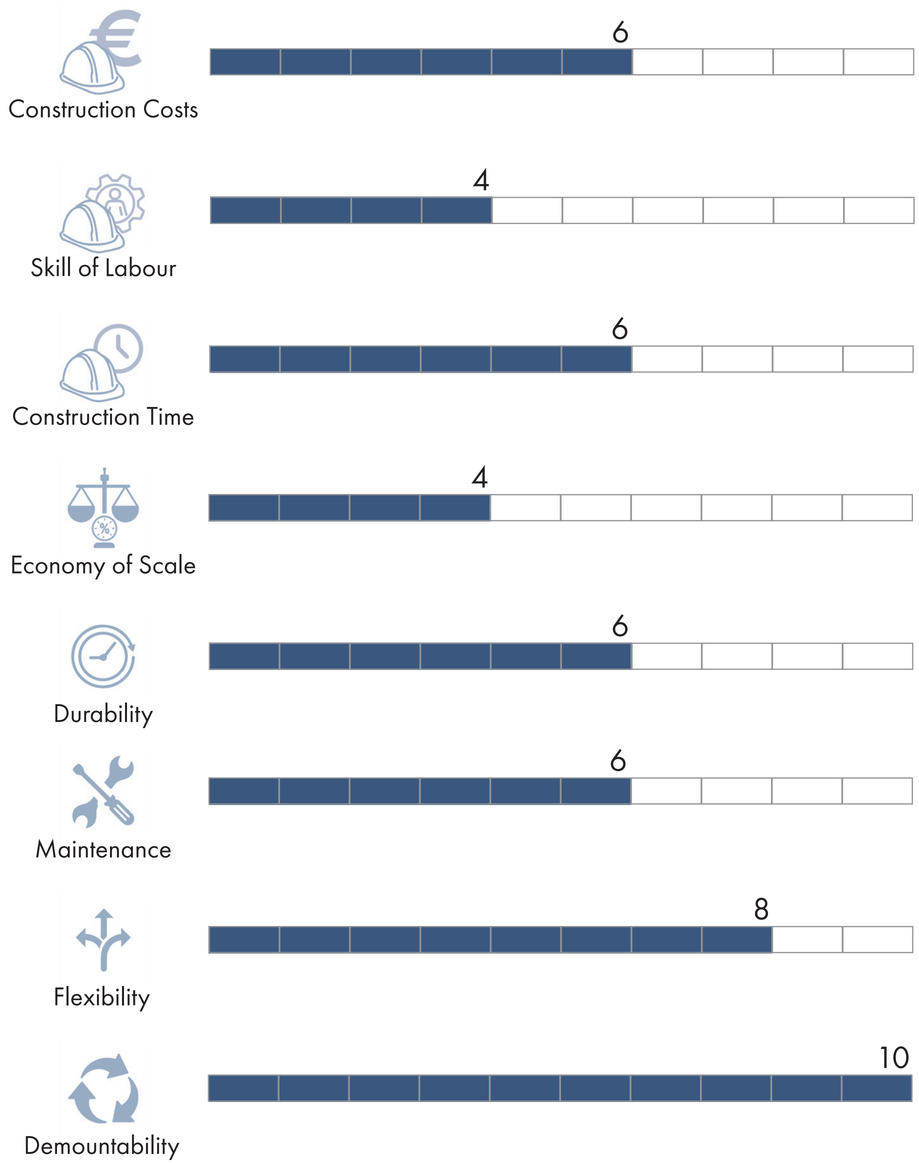
Bio-Based Artist Residence



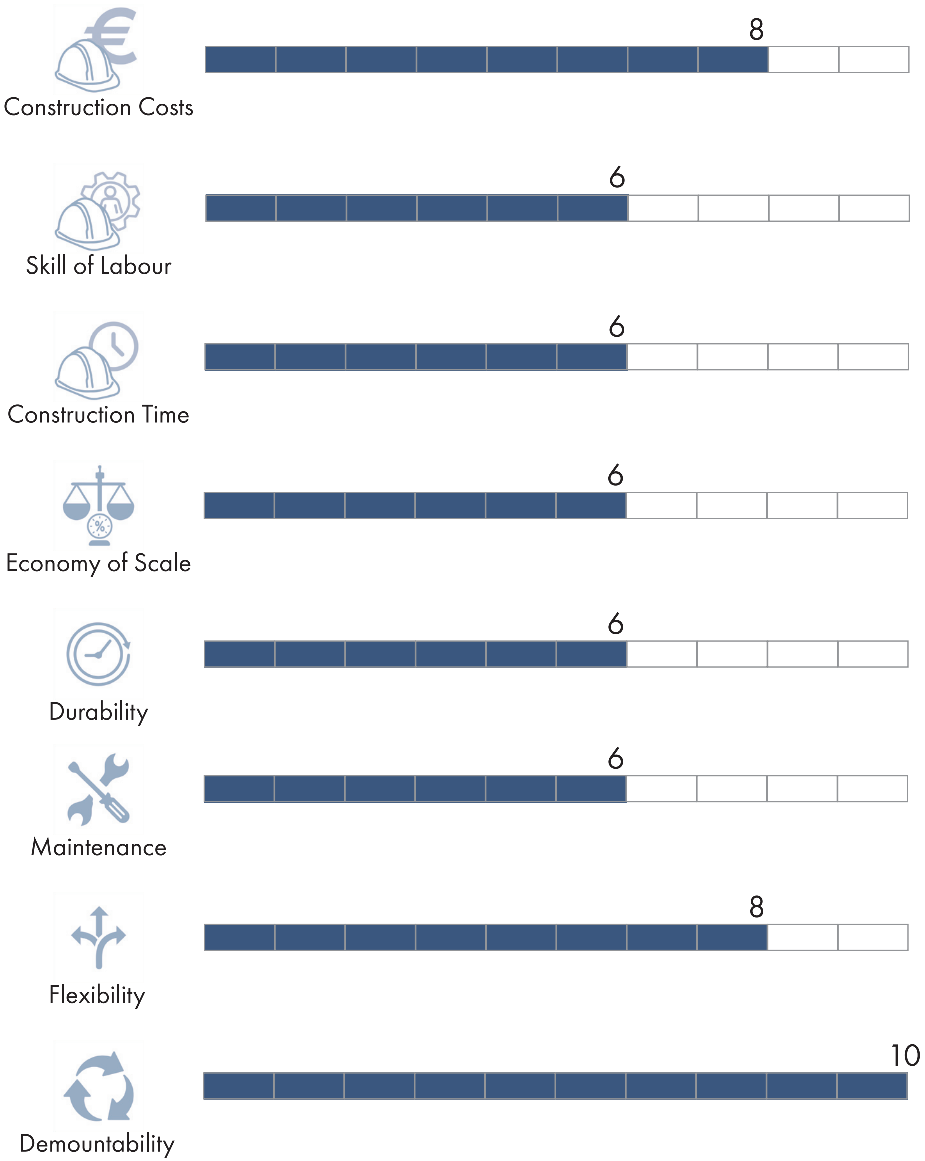
Despite the preconception that bio-based materials are expensive, this case study shows this is not always the case with a score of 6,25 out of 10, ranking it the third most affordable option.

To achieve an affordable design, the construction of this dwelling includes a prefabricated system, which reduces construction time and the associated labour costs. Because of this system, the flexibility of the building was increased due to the simple construction methods whereby the house can be altered easily. The building's most influential factor is its ease of demountability and recycling. The dwelling was designed to be completely demounted with the use of mechanical fastening. Clay plaster is used as a surface finishing, because in combination with the hemp structure, it ensures a vapour-open indoor climate. This means fewer installations are required to regulate air quality within the home. While the use of passive systems was not a measured criterion, it further affects the dwelling's affordability.

The largest downfalls of this case study are the limited mass-production this building technique has, as well as the specialised labour required to construct such a dwelling. This building was not designed with mass-production in mind, so most elements were designed specifically for this dwelling. A potentially massed-produced factor is the use of the prefabricated hemp building blocks. Since hemp is a new building material, it typically requires specialised labour. However, due to the prefabrication of the structural elements, the specialised labour was limited. These two factors received the lowest scores for this case study but did not receive the lowest score overall due to its construction potential.

Ultimately, considering the use of sustainable, new materials, this case study displays construction techniques that aid in making expensive materials, affordable.

PIT Lab



Cradle to Cradle is an affordable resource principle showcased in this design, as this case study receives a score of seven out of ten, ranking it the second most affordable option.

The biggest cost reduction factors for this project are its modularisation and flexibility and complete demountability, which overall attributed to its low construction costs. Since this project was designed using re-used shipping containers, it's a very flexible design whereby new shipping containers can be used as an extension. Expansion has already been done in this project, whereby an addition to the roof was made by adding a shipping container as a closed stairwell to provide rooftop access. The re-use of materials also aided in the low construction costs, as elements such as windows were donated to the project from demolition sites. This project's biggest affordability factor is its ability to be completely demounted. PIT Lab was designed with mechanical fixings to ensure all materials can be

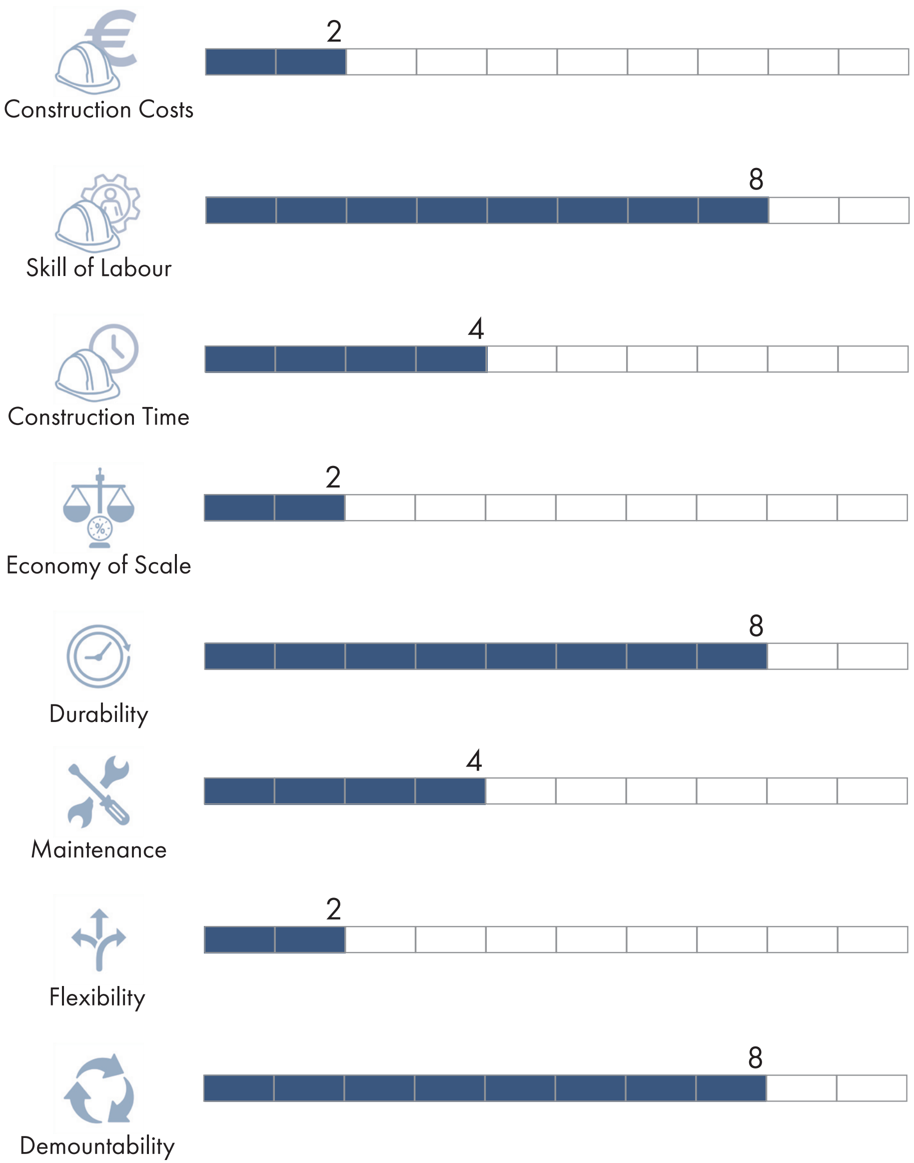
ings to ensure all materials can be

re-used in future if their lifespans permit, which dramatically increased the score for this project.

The largest drawback of this principle is its limited durability. Because elements are re-used, typically the lifespan is decreased. This is especially prevalent in the windows, where they are estimated to need to be replaced in the next ten years, which is a shorter lifespan than if new windows were used. Additional maintenance is also required to ensure elements are up to standard, and this ultimately affected the time schedule for this project despite the use of modular systems such as the shipping containers.

While this is a very affordable resource principle due to its flexibility and demountability, specific attention should be paid to the durability and additional maintenance of re-used materials in order to make this principle even more affordable.

Ban-sur-Meurthe House



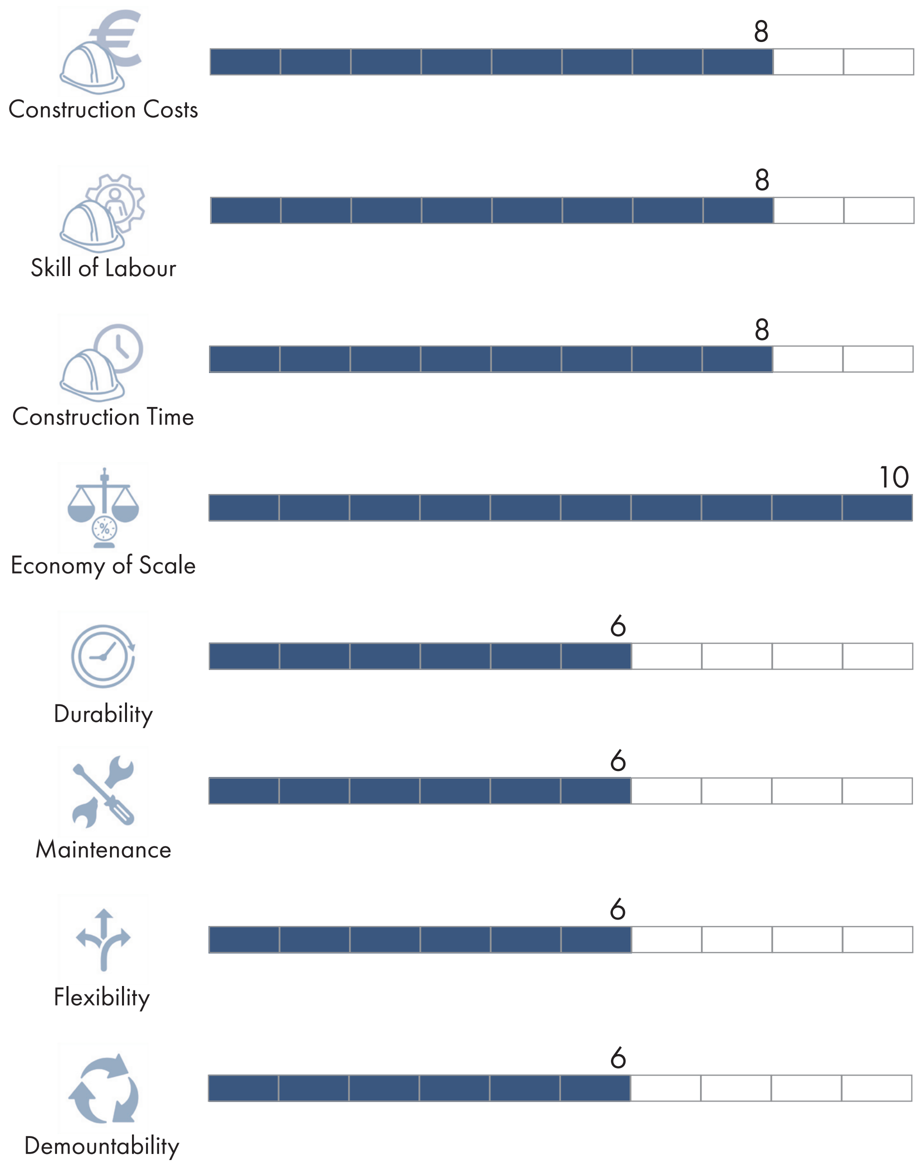
The use of local resources has the connotation of being expensive, which is a connotation that is upheld in this case study. Ban-sur-Meurthe House received a score of 4,75 out of ten, ranking it as the least affordable option.

This dwelling utilises the factors of ease of recycling as well as long durability to its advantage in providing an affordable alternative. The use and design of wood in this dwelling ensures easy recyclability. The foundations also consist of single cinder blocks so are also easy to demount. Due to the quality of the craft and upkeep of this dwelling, it is a durable construction. The employment of local labour to construct the dwelling also contributes to lowering the costs of construction, because of the typically lower labour level associated with the employment of local labour.

A characteristic of locally sourced resources is that economies of scale are typically not applicable to them; small businesses produce lower quantities of products, which increases price. It is also assumed, however, that local resources require lower transportation costs, and could provide an affordable alternative to mass-produced materials. However, in this instance, the resource sourced in this area of France is wood. Because the house is predominantly made from wood, skilled craftspeople (who still ranked high due to their localness) were hired to provide various expressions using wood, which required additional construction time, making it unaffordable. Additionally, the design of this dwelling does not take flexibility into account, so any expansions made to the house require additional costs.

While this case study proved to be an unaffordable option, certain design considerations can be taken into consideration to make it so. From this case study, it has been learnt that to ensure an affordable, locally sourced design, additional characteristics are to be considered, such as modularity and construction time.

The Kwikset House



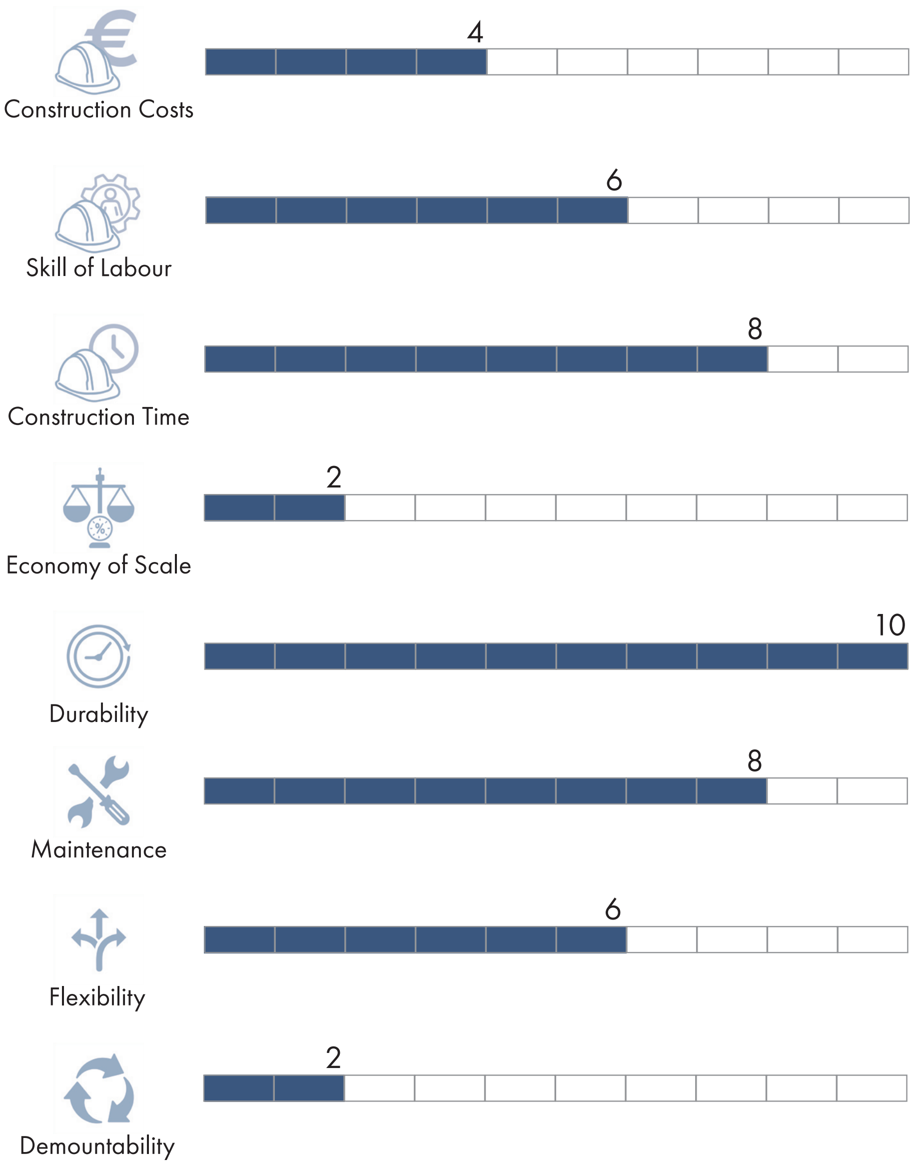
The usage of the principle of modularity aids in the creation of affordable housing, as The Kwikset House is the most affordable dwelling with a score of 7,25 out of ten.

The affordability of this dwelling is mainly attributed to its ability to be mass produced, as well as other factors such as low construction costs and labourer skill levels, as well as a short construction time. The aim of this dwelling's design was to be mass produced by the lock company, Kwikset, which solved the biggest issue of affordability in previous design iterations. Because this dwelling was sold as a package, construction times were also very short, further increasing affordability. The use of simple, wood construction, meant that the skill of labour constructing the dwellings did not have to be very high. The combination of these factors meant the construction costs of this dwelling were very low.

The drawbacks of this project were that the design was not very flexible, as well as the project not being demountable. The project consists of a large house, where interior modules can be placed as desired. This means that the interior design of this dwelling is very flexible. If more space is required than the original plan dictates, it would be difficult to add, given the square design and roof shape. The design was also not detailed to be demounted. Despite the construction of this project being done with timber, all elements are nailed together, which makes it easy to demolish, but limits its demountability and decreases affordability.

Overall, modularity is a principle that is easy to implement in a design, and has drastic effects on the affordability of a dwelling. With the implementation of principles such as demountability and flexibility, this principle is the most attainable to achieve affordability.

R50-Cohousing



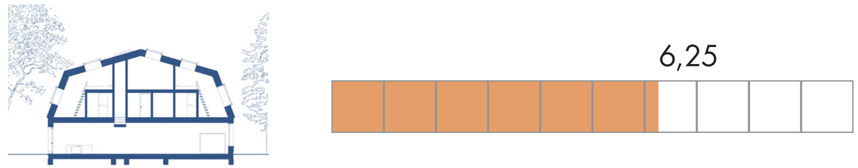
Despite group builds having the title of being a very affordable building method, this project ranked fourth with a score of 5,75 out of ten.

This project's most affordable factors are its rapid construction time, low maintenance requirements, and mostly its durability. Additionally, this type of construction requires minimal maintenance, with the exception of the wooden clad façade. The structure of R50-Cohousing was built with concrete, which attributes to its durability. Due to the use of prefabricated concrete elements, the construction time for this project was swift. The construction costs of this apartment building were affordable, however, the project scored low due to the vast public spaces included in the construction costs.

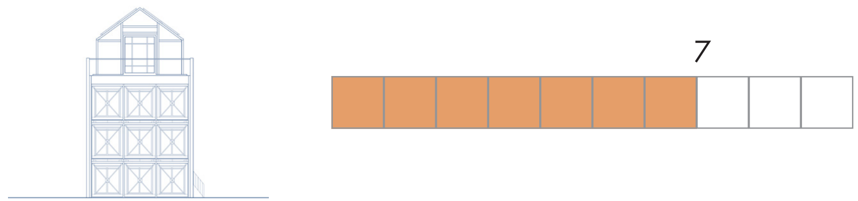
The economy of scale and recyclability were the lowest scoring criteria for this dwelling. The use of concrete decreases the potential for recycling, and due to the manner of construction, demountability is also not an option for this project. The project is quite flexible in the sense that many apartment sizes and configurations were realised with the development, however, the exterior of the building is quite fixed, so sizes are also relatively rigid. The skill of labour required for concrete constructions is not necessarily high, but it requires construction workers with training.

Overall, the durability acquired from the materialisation of the project aids in increasing its affordability. The drawbacks of this method, however, are the higher construction costs from sharing construction costs of public spaces, as well as limited demountability from choice of materials and construction methods.

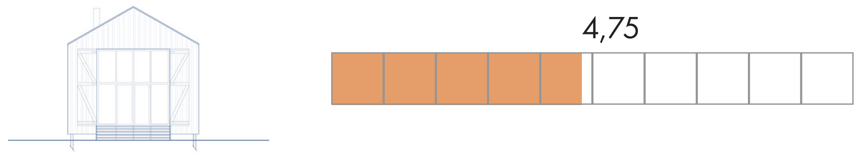
Discussion



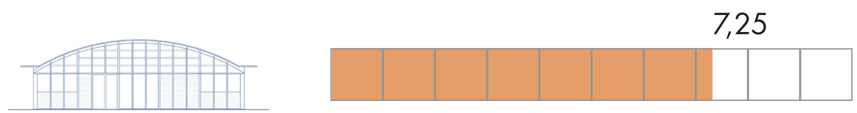
Bio-Based Artist Residence



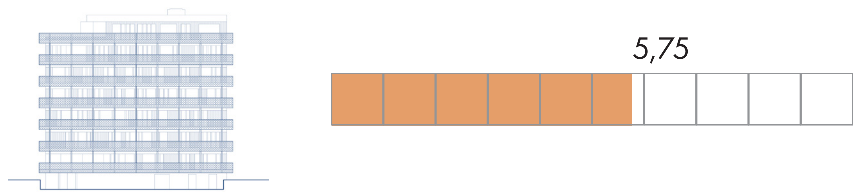
PIT Lab



Ban-sur-Meurthe House



The Kwikset House



R50-Cohousing

The research conducted shows that modularity is the most affordable resource principle based on the chosen case studies, and using local resources is the most unaffordable option.

Modularity, represented by the Kwikset House, received the highest score of all principles. Kwikset House was designed to be a mass produced house, which is not a guaranteed characteristic of modularity. Because of the mass-produced nature of this design, the scores for skill of labour and construction time were also high, however these are still considered to be characteristics of modularity. The combination of these factors means that construction costs are kept low, which gave this project the highest score. While The Kwikset House is an example of modularity, the specifics that make it most successful in achieving affordability are not a characteristic of designing modularly, which is something that should be taken into consideration when designing with this principle.

The very limited research in this matter does show a similar outcome to what is achieved with this study. Modularity is used often as a means of making a project more affordable, as is the re-use of materials as is done with Cradle-to-Cradle. The usage of local resources is typically a more expensive option, especially in a rural context similar to that of Ban-sur-Meurthe House. Contrary to the research, however, is that group building is not an affordable option, ranking second to last in this research. Group building is considered to be a futuristic approach to building whereby residents share the costs of construction, making it a lot more affordable than standalone houses. In this research, it scored poorly, mostly because of the material choice of this particular case study, which severely decreased the case study's score in demountability and economies of scale.

Bio-based materials are typically considered to be more expensive than traditional, inorganic materials, which in this study, is not the

case, due to a moderately high score for the bio-based artist residence. Based on research into bio-based materials, when considering the use of these materials, people generally only consider the upfront costs, which as seen in this case study, are usually quite high. As shown with this research, these costs can be offset through design by using demountable, prefabricated elements which decreases construction time and makes a project more flexible.

Most surprising of all, however, is the fact that local resources scored the lowest of all resource principles. Historically, this was the method all housing was built with, however, since more materials are mass produced due to the industrialisation of the building sector, it has become more affordable to source materials from further away. This is especially the case in rural areas, such as the site of Ban-sur-Meurthe House. As a result of the lack of economies of scale, the construction costs for this case study were very high.

Overall, the outcome of this research generally follow the trends set by previously executed research. The results are partly dictated by characteristics that the resource principles have, but should not be viewed in isolation, as the specifics of the case studies also affected the outcome.

Conclusion

This research was initiated by the housing crisis in which access to affordable housing is very limited for people wanting to rent in the free rental sector. Additionally, the use of resources, especially sustainable ones, are not often linked to being part of the solution to this problem. To solve this, the question of "which resource implementation principle is the most successful in the creation of housing that is considered to be affordable?" was posed. Through the evaluation of case studies, it has been discovered that modularity is the most efficient principle in achieving affordability.

This finding provides insights into how to evaluate case studies on affordability in a simple way, the outcome of which provides a means of achieving affordability with a focus on a single construction method. The evaluation method specifically is of importance in the field of architecture where case studies are typically looked at for inspiration before the commencement of a design. This method provides a simple way to extract characteristics of what makes a design successful with a focus on affordability. With the repetition on a set of case studies, a clear set of characteristics on affordability can be achieved. Ultimately, the most important takeaway of this research is the methodology, which, if further researched could be helpful in the research of affordability using case studies.

While the method used to determine the most successful resource principle was effective, there were certain limitations. Firstly, the case study was used to represent a resource principle, however, oftentimes, the evaluation assessed both the characteristics of the case study, as well as the characteristics of the principle itself. This means that the success of the resource principle cannot be attributed in isolation, but should be viewed in the context of the case study as well. Similarly, certain resource principles exist mostly in a theoretical context – such as cradle to cradle – which means there were very limited case studies available to represent the principle. Additionally, for simplicity, each of the criteria for evaluation had the same importance when in reality, certain measures have a lesser effect on affordability. Ultimately, this could have affected the results.

These shortcomings in the research could be improved by the incorporation of a more qualitative approach. The qualities of the case studies are missed in the pursuit of a link to affordability, when this could justify the costs themselves. As an example, this was the case for certain case studies where high craftsmanship was given priority over affordability, which justifies the extra expenditure due to an increased lifespan. The inclusion of this, would give a more rounded interpretation of the results.

Overall, the simplification of construction methodologies into resource principles was the biggest downfall of the research executed, whereby overarching affordable characteristics were possibly missed in pursuit of the relation to a resource principle. However, the outcome and method used provided a realistic answer to the research question, on top of providing insights that can be used for a clear set of guidelines in achieving affordable housing.

Design

Fig. 58. Adapted from ZUS, Flux and Sweco (2022). Map of Proposal for Midden-Delfland

The topic of this studio was based upon the ZUS, Flux and Sweco proposal for Midden-Delfland. This proposal was made as one of five strategies for the Dutch Deltas in the year 2120 as part of the Redesigning Deltas movement.

The issues intended to be solved that are prominent in the Netherlands, as well as Midden-Delfland, are soil salinisation, and greenhouse gas emissions from peatland drainage. Soil becomes salinized due to extensive groundwater extraction, which lowers the water table, and allows saline water to rise. This has detrimental effects for agricultural use of land because of lower crop yields from high salt levels. Biodiversity is also decreasing due to an increase of salt-tolerant species (ZUS, Flux, & Sweco, 2022). Additionally, draining the peatlands for agricultural usage emits vast amounts of carbon dioxide.

The solution strategy for these issues is to use bottom up planning principles, where certain land uses are allocated based on the soil and water conditions of an area. The strategy for peatlands to reduce emissions and soil salinisation is to terminate the extraction of water from this soil type, and allow these areas to flood. This will be managed by an extensive network of "boezems" that will be built, as seen in Figure 59, to prevent other soil types from being flooded too. Where arable soil types are, resources are to be grown. Specific areas are also allocated for biodiversity to thrive.

Ultimately, the aim of this proposal is to make Midden-Delfland a "green lung" where resources are produced, biodiversity thrives and issues of salinisation and carbon emissions from peat are solved.

The main strategy focused on in the choice of site from this proposal, was the transportation of

Fig. 59. Map of Boezems

Fig. 60. Affected Farmland

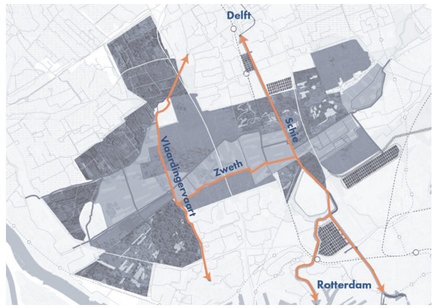


Fig. 61. Transportation Possibilities

Fig. 62. Chosen Site

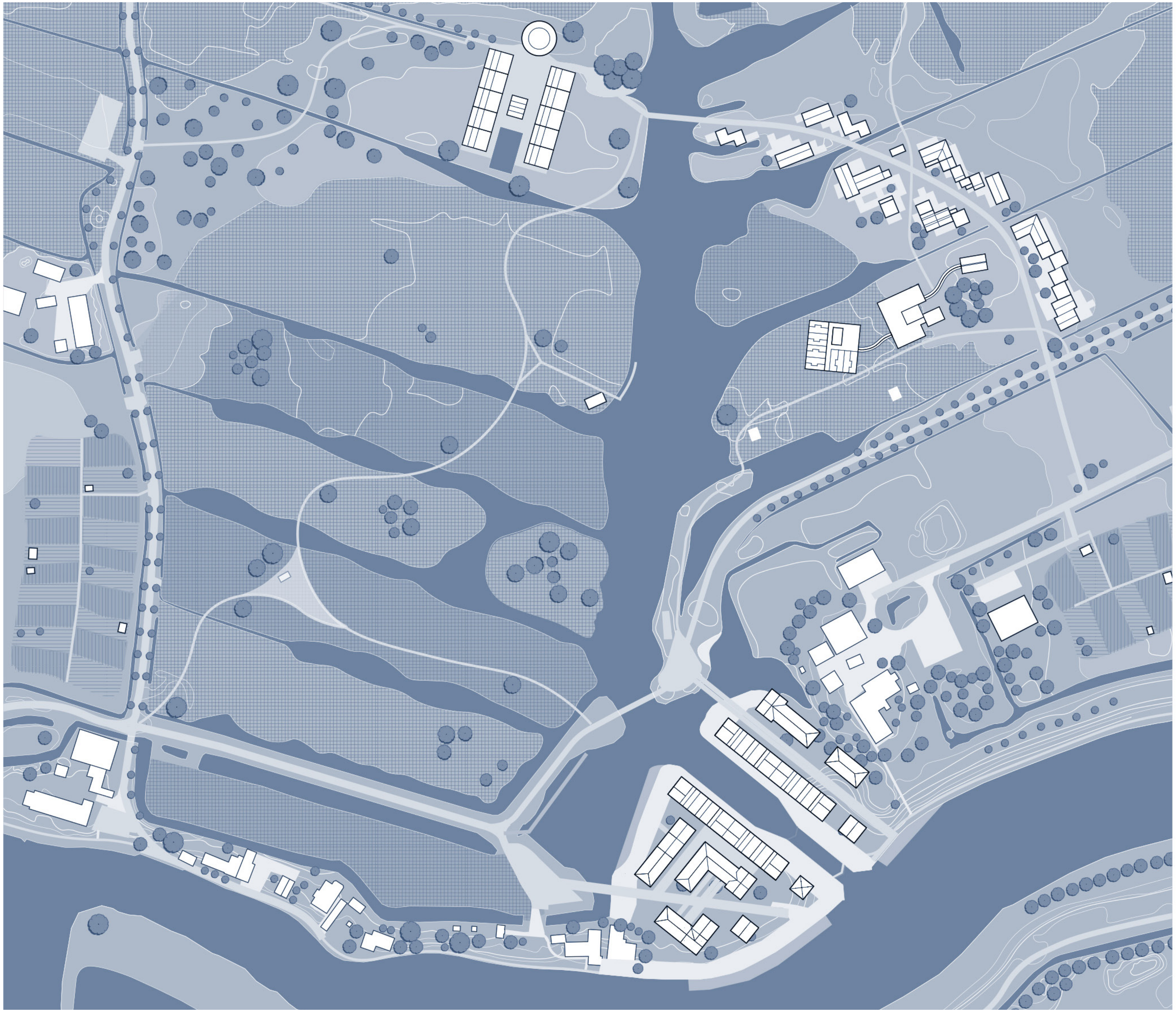


Fig. 63. Group Masterplan

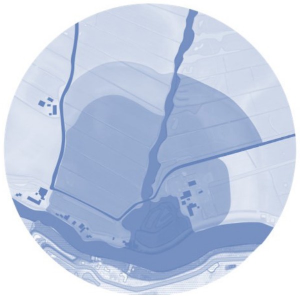


Fig. 64. Degree of Publicness

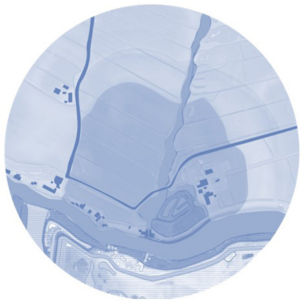


Fig. 65. Degree of Activity

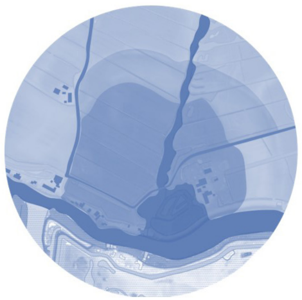


Fig. 66. Degree of Density

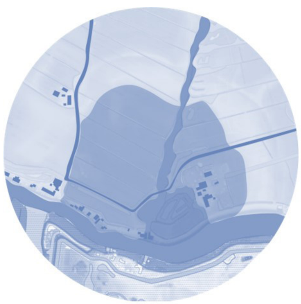


Fig. 67. Degree of Heaviness

resources via waterways because of reduced reliability of roads from flooding. This is why we chose a site that can easily access both Delft and Rotterdam for the trade of building resources. However, in designing our own masterplan we found issue with the construction of certain “boezems” from a resource perspective; the construction of the Zweth “boezem” requires approximately 300000m3 of soil. To circumvent this, we decided to keep the Zweth and Schie at a lower level as they are now, and create a lock between the Vlaardingervaart and the Zweth so that both waterways are still accessible by boats. Since this becomes a stop for boats already, we made the area at the lock a resource intensive area where resources are stored and processed.

The rest of the masterplan is based on using soil as a driving factor for design, similar to the proposal for Midden-Delfland. The site chosen has a tidal inversion ridge, which deposited layers of sand. Because sand is sturdier to build on in com-

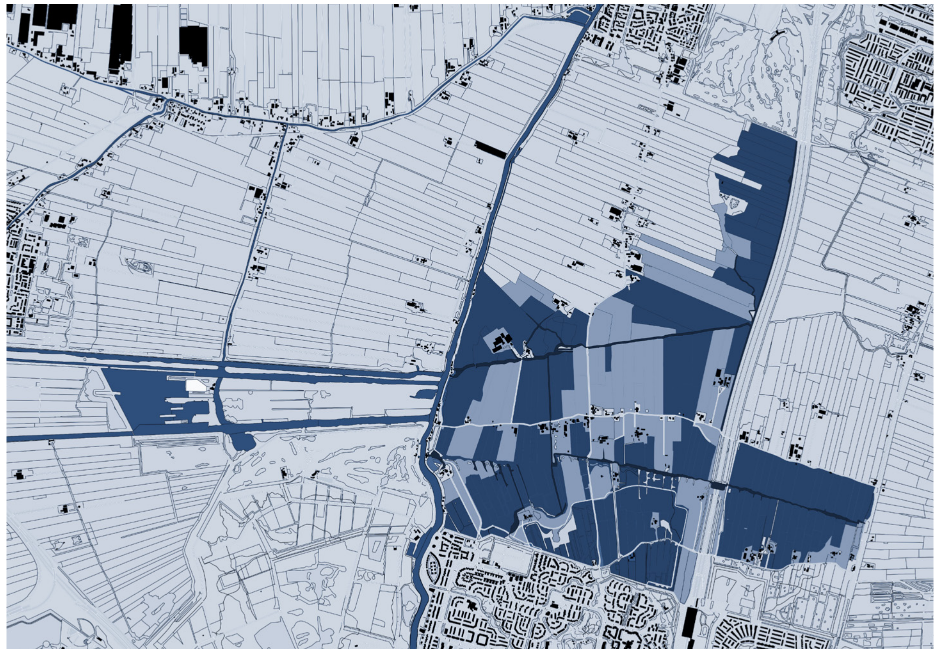


Fig. 68. Wet (Dark Blue) vs Dry (Light Blue) Farming

Fig. 69. Wet (Dark Blue) vs Dry (Light Blue) Farming Zoomed In

Fig. 70. Change in Farmlands

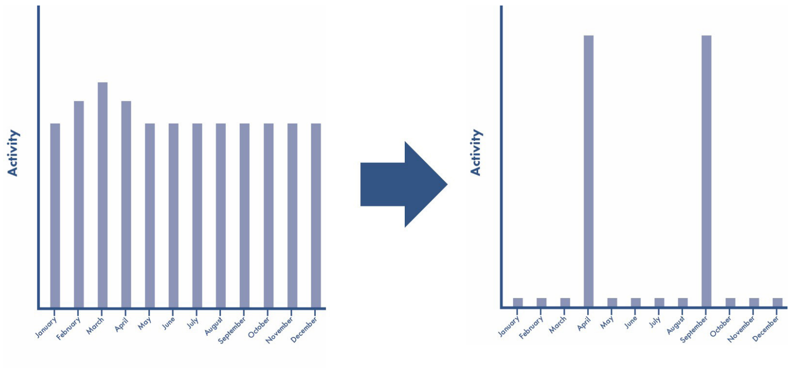


Fig. 71. Change in Farmer Activity Levels

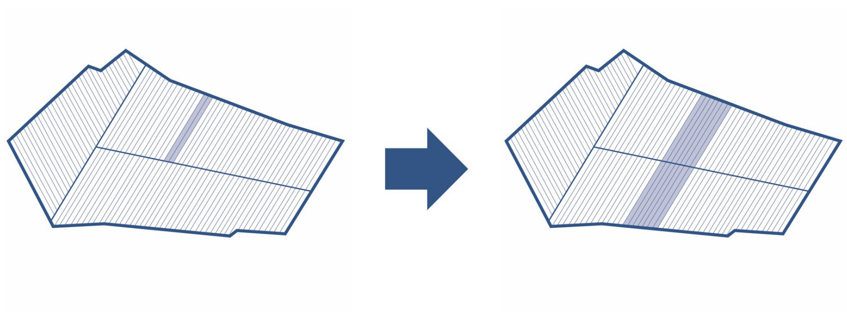


Fig. 72. Change in Farmer Land Ownership

parison to peat, and because the inversion ridge is high enough to avoid the flooding in this area, the rest of the dwellings are placed here.

In addition to using soil types to decide on the placement of dwellings, we also propose for a new farming type, where different crops are grown based on soil types. This would create a new landscape, where crops aren't planted based on land allocation as they are now, but rather based on wet and dry soil types as seen in Figure 68 and 69.

Similarly, the basis of my own proposal relies heavily on a new type of farming. Currently, a lot of the land in Midden-Delfland is used for livestock. This is an intensive farming practice that relies on a lot of land and labour. Since the land in the chosen site is mostly flooded, it is no longer a suitable habitat for livestock, however it is an ideal place for the production of building resources. This type of farming is less intensive than livestock farming; a lot less land and labour is required for similar profit yields, so more land can then be owned by individual farmers. Ultimately, farming becomes a more passive way of making income than it is currently.

Because of this shift in the method of farming, this site becomes an ideal place for a new type of community. Looking at care farms for inspiration, it became apparent that certain crops can be managed by communities instead of farmers. Because of this new opportunity, my project relies on farmers leasing plots of land for a community to live on in exchange for their services on the land. Since farming will be a more passive activity, these communities will have to work on the land a maximum of four times a year harvesting and planting crops. Ultimately, the farming of resources makes these dwellings a lot more affordable.

While this new model is very favourable in helping communities live affordably, it sets certain re-

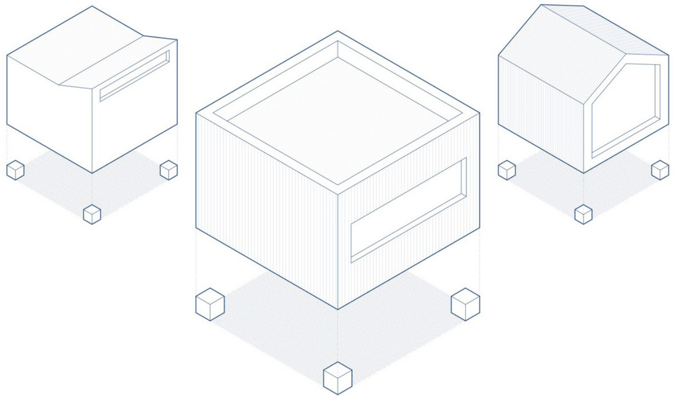


Fig. 73. Temporal Restriction: Demountable Modularity

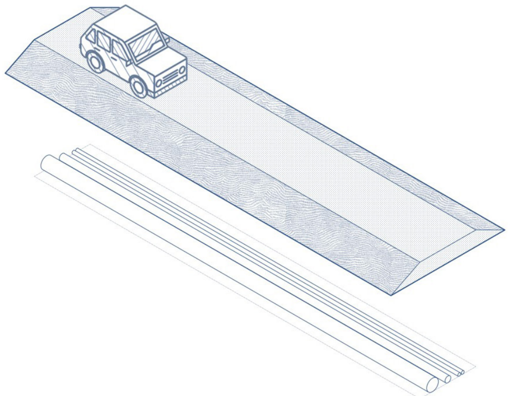


Fig. 74. Temporal Restriction: Impermanent Road

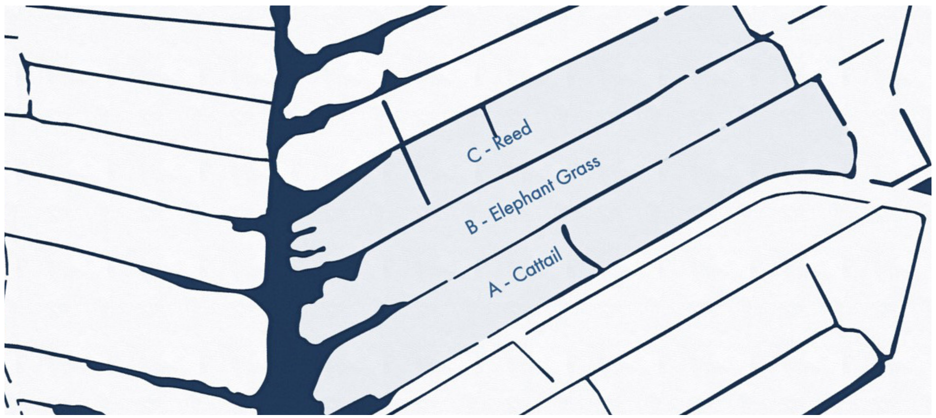


Fig. 75. Financial Restriction: Crops Farmed to Calculate Maximum Plot Size

strictions that drive the design into being what it is. These restrictions are mostly based on making this model as favourable to the farmer as possible. The first set of restrictions are based on temporality, whereby any construction made on the farmer's land should be demountable. Additionally, the farmer's profit should not be diminished, whereby the maximum land size to be occupied is based on what the farmer would pay a seasonal worker to work on that land.

To ensure the construction is temporary, this development will be demountable. All buildings will be demountable, and the road for the site will be made from compressed sand, to ensure ease of removal and lessen the impact on the land. Similarly, the footprint of the foundations will be created to be as minimal as possible; a pile foundation is used to do so.

To ensure the construction on this land does not diminish the farmer's profits, crops were chosen and the value of which was compared to the salary of a farmhand and reflected on the land. The crops chosen for this site had to satisfy the criteria of being a building resource, easy to maintain by being used as a crop in care farms as well as being suitable to be grown in wetlands. To satisfy this criteria, cattail, elephant grass and reed were chosen. The profit of which is €0,26/m^2 a year for cattail, €0,47/m^2 a year for elephant grass and €0,40/m^2 a year for reed. If the farmer hires a seasonal worker for 8 weeks a year at €3700 a year, the maximum land size would then be 962m^2 for the cattail settlement, 1739m^2 for the elephant grass settlement and 1480m^2 per year for the reed settlement.

To reflect this area on the landscape, a module size was chosen. The module size of 1.5m x 3m was chosen with the criteria that it should fit the smallest unit in a house, namely the bathroom. This was then portrayed on the land to its maximum area, as seen in Figure 76. Then, the existing road designed in the group masterplan was

Fig. 76. Maximum Plot Sizes

Fig. 77. Plot Sizes Optimised to Road

Fig. 78. Plot Sizes Optimised by Structural Grid

removed from this area, as well as modules too far from this road as seen in Figure 77. To prevent too high resource usage for the foundations, the grid was further optimised to 3x3m. Additionally, holes were put in the maximum area to ensure houses didn't fill the entire block which would limit daylight and air quality. This ends with a final plot plan as seen in Figure 78.

This plot plan was then physically made in the landscape, where it becomes a pre-provided deck that inhabitants can build their dwellings on. This means that the farmer provides the construction and foundations, and inhabitants only have to build their dwellings on top. This was set as a deck to use bio-based materials and be demountable, while not being ground level so that inhabitants can look over the heightened road.

With the foundations and basis of construction set in place, the inhabitants will then have a catalogue of housing types to choose from. For this project, I chose to focus on housing types for non-traditional housing configurations to test the feasibility of this plan with more complex arrangements. I designed five separate housing types, namely a studio, two types of co-living houses with different amounts of shared spaces, housing for divorced families and housing for a muti-generational family. Then, with the housing types to choose from, the inhabitants of an area would come together and design and arrange the masterplan themselves.

Fig. 79. Blank Deck as Basis To Be Built Upon

Studio

The studio, the most traditional housing type of those designed, is approximately 36m². This dwelling was made to be inhabited by a maximum of two people, which meant it was quite challenging fitting all necessities into this unit.

The biggest priority when designing this unit was to ensure the bedroom area still had a level of privacy, with the bathroom easily accessible by both the private and public spaces within the home. This was done by placing the bedroom the furthest from the entrance, behind the bathrooms. This also meant that the bathroom is accessible from the more public spaces within the home, while creating privacy and ease of access from the bedroom, which is a strategy

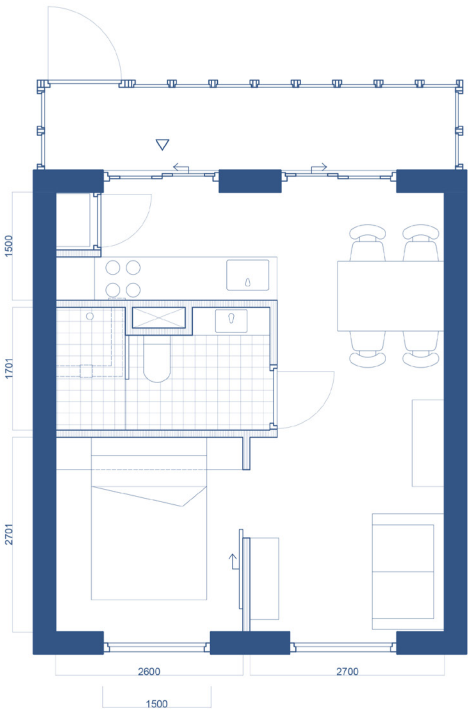


Fig. 80. Floor Plan

repeated in all designs.

Since the dwelling is so small, the intention was to make the home feel spacious by use of ample light. This was done with large sliding glass doors as a means of accessing the house (with a greenhouse to prevent wind from entering the house), a clerestory window to ensure the high ceilings aren't dark, as well as large windows in the bedroom and living room.

Overall, the design of the studio carefully balances the need for privacy and a sense of spaciousness within a compact footprint, ensuring a comfortable living environment for the occupants.

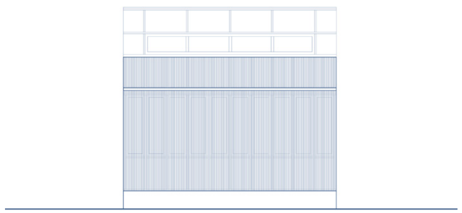


Fig. 81. North-West Facade

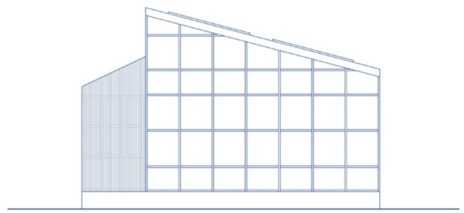


Fig. 82. North-East Facade

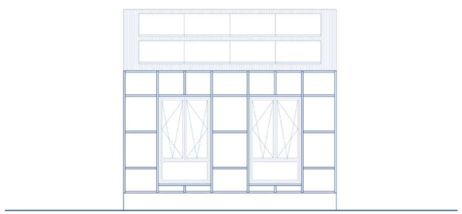


Fig. 83. South-East Facade

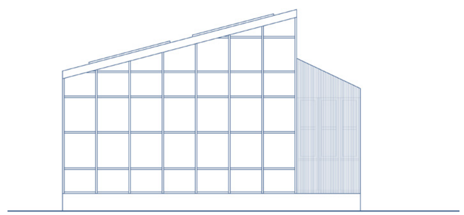


Fig. 84. South-West Facade

Studio: Building Technology

The construction of these dwelling was driven by two main goals: sustainability and affordability. To ensure the dwellings were built sustainably, the aim was that they should be designed in a demountable way, with the prioritisation of bio-based materials. The focus for affordability came from the outcome of the research; the Kwikset House was so successful because of its mass-produced nature.

The foundation of the deck is made from timber piles on concrete extenders, with a concrete foundation wall at the perimeter to provide stability. The wood used for the deck is Ipe, which is a class 1 wood that lasts between 50 – 70 years. This wood is typically more expensive, but the investment into its durability offsets the upfront costs.

For these dwellings, a timber platform frame structure was chosen. This structure type is largely bio-based and is typically made with nails that can easily be replaced with screws to make it demountable. This structure also consists of units stacked on top of each other which suits the design approach well in its flexibility. This also means mass-produced wood sizes are used due to the shorter length required, even in double storey units, which also makes the transportation undemanding.

Because of the atypical way of building (a preconstructed foundation), a new method of building the homes had to be used. The structure of the homes is constructed, within which the insulation is placed to ensure the dwellings stay dry. Because insulation cannot typically be walked upon, a demountable floor system (WoodyFix) is placed on the subfloor, upon which the demountable underfloor heating system is laid. This means the houses are constructed slightly above the deck.

The main principles governing the

façade was using mass-produced materials in dimensions that are mass-produced. All dwelling types are given different expressions by experimenting with different methods of displaying these materials. In the studio type, dark fibre cement boards are used and accentuated using stained battens.

Some dwellings also have greenhouses. These are typically constructed when there's not a separate entrance into the house to prevent wind from entering. These greenhouses use cheap materials and are intended to be very simply built. An example of this is the use of door hinges and gate locks to make the windows openable.

To ensure the dwellings are comfortable to live in, underfloor heating and cooling is provided, as well as ventilation measures. The heating and cooling in this unit is provided from a district geothermal heat pump. Each settlement is provided with a heatpump that has thermal storage and is provided electricity by solar power. Heating and cooling is supplied to each unit using a direct exchange whereby the pipes carrying the heat are the underfloor heating pipes. Ventilation is achieved by mechanical extraction of the indoor air, with trickle vents providing fresh air into the dwellings.

In conclusion, the construction of these dwellings successfully integrates sustainability and affordability through the use of bio-based, demountable materials and mass-production techniques. The innovative design ensures durability and flexibility, while the incorporation of modern heating, cooling, and ventilation systems guarantees comfort and energy efficiency.

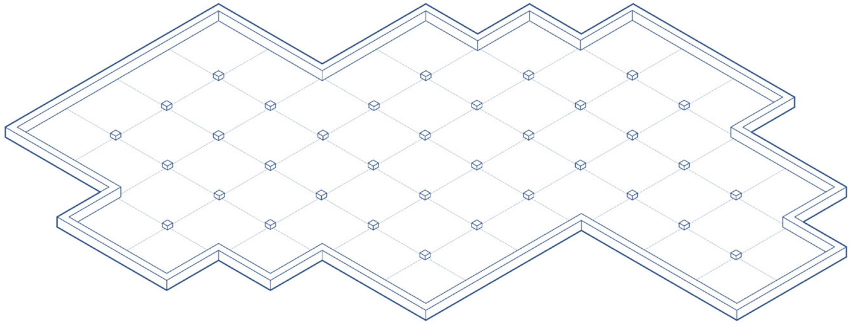


Fig. 85. Foundation of the Deck: Foundation Wall and Piles

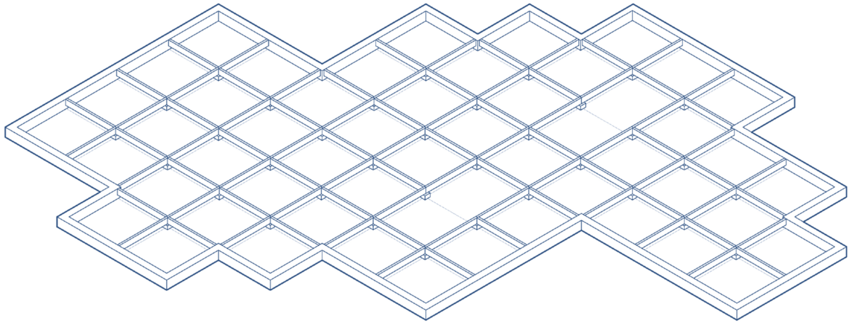


Fig. 86. Foundation of the Deck: Beams

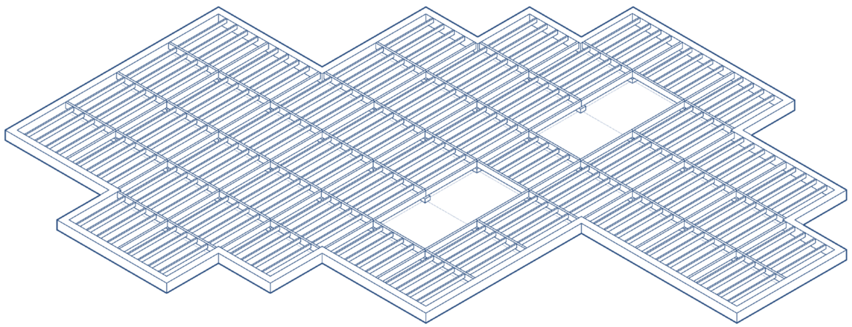


Fig. 87. Foundation of the Deck: Floor Joists

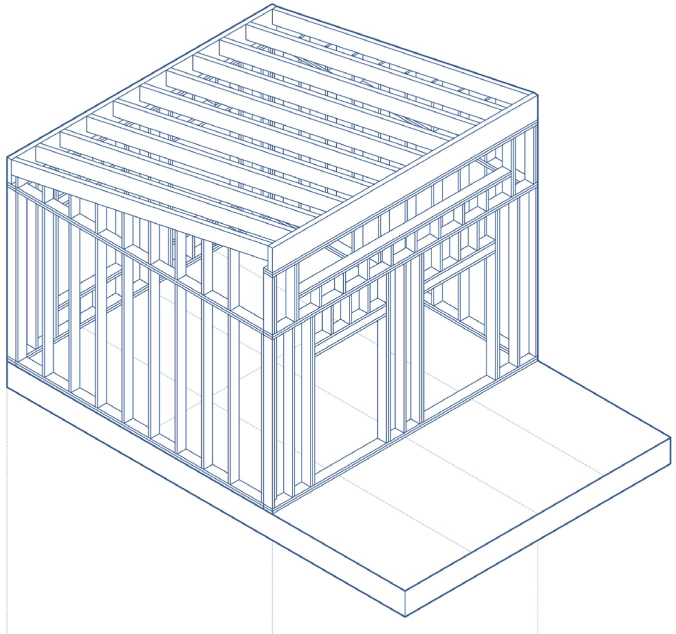


Fig. 88. Studio Structure

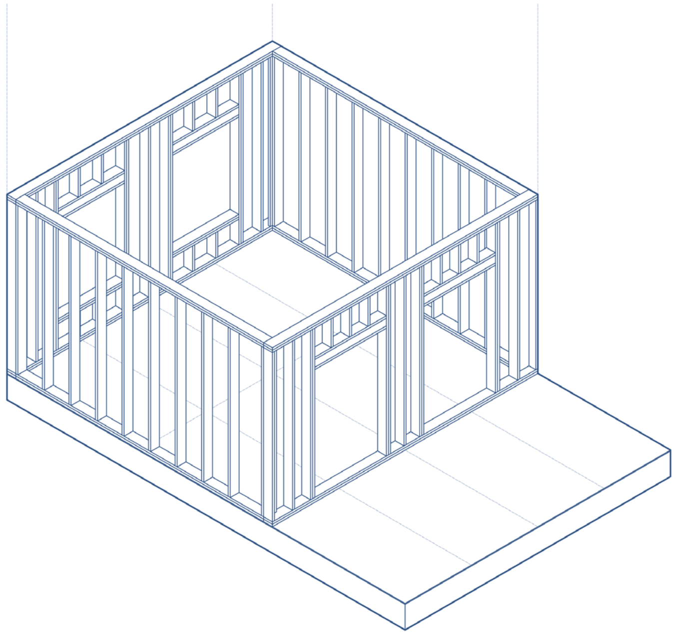


Fig. 89. Structure of Studio if Studio Duplicated Above

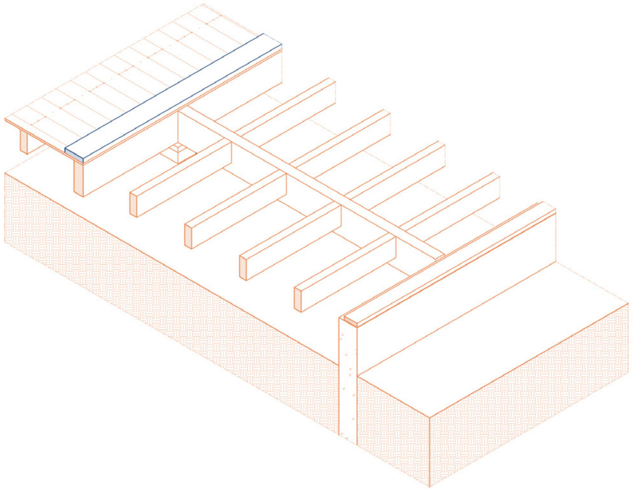


Fig. 90. Isometric of Ipe Wood Use

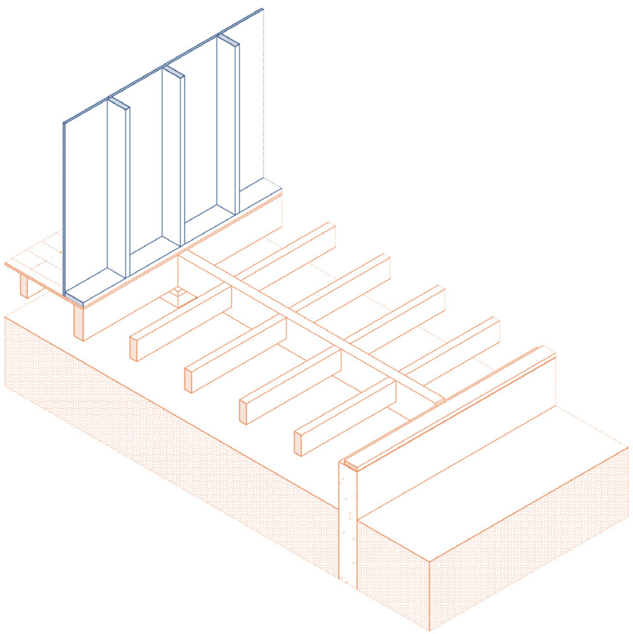


Fig. 91. Isometric of the Basic Facade Structure

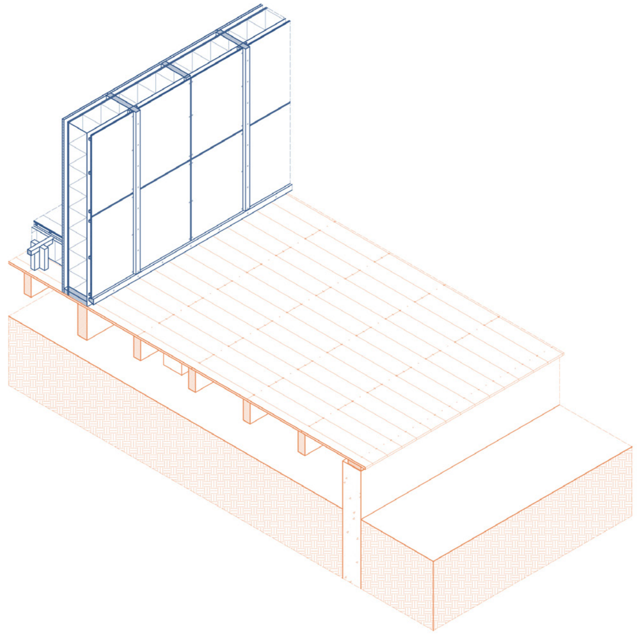


Fig. 92. Isometric of the Facade

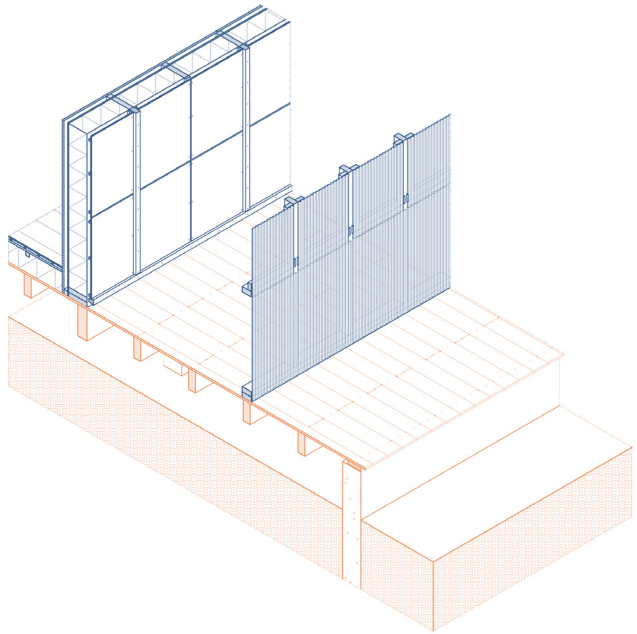


Fig. 93. Isometric of the Facade and Greenhouse

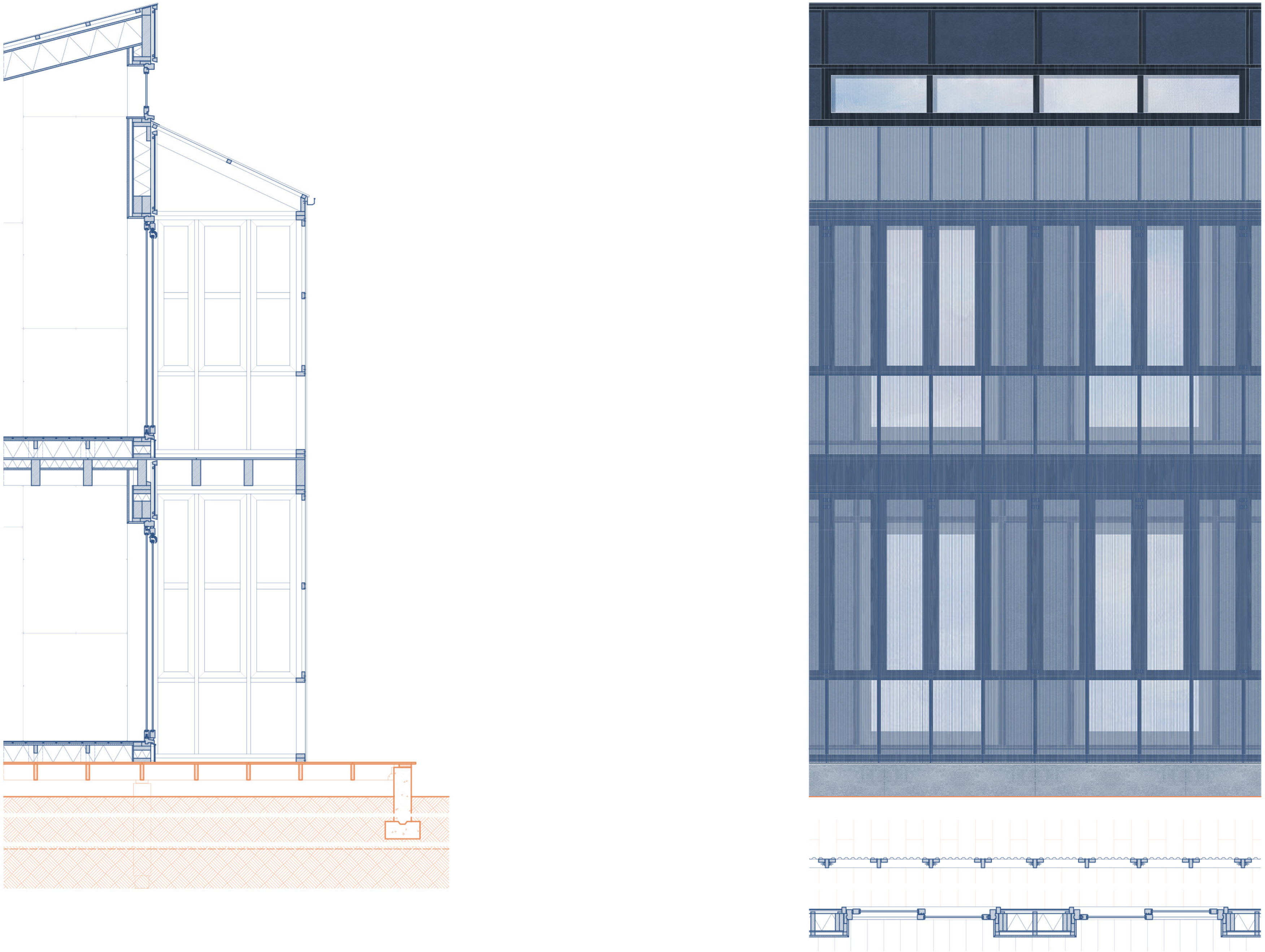


Fig. 94. 1:20 Section (Left), Elevation (Top Right) and Plan (Bottom Right)

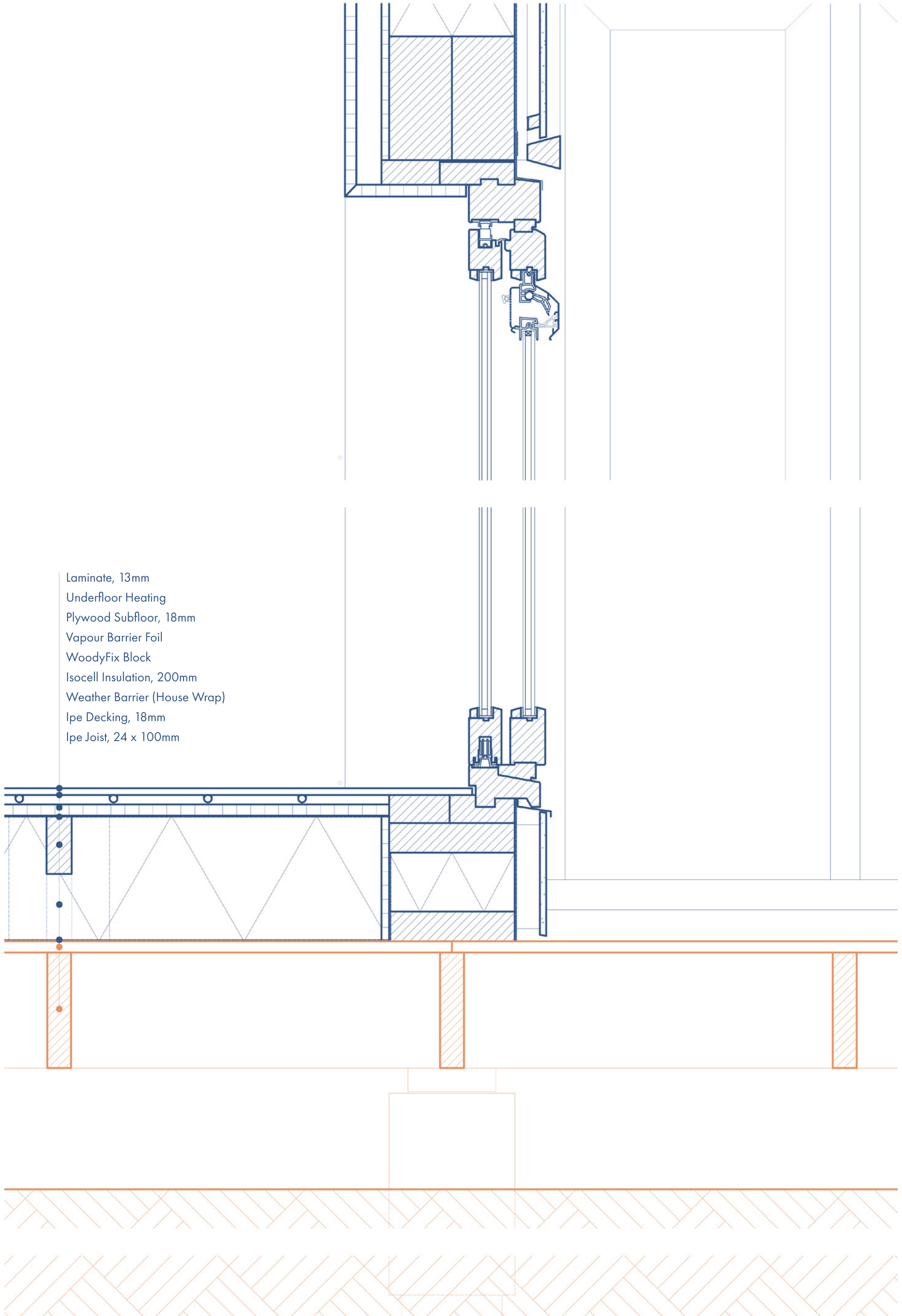


Fig. 95. 1:5 Section of the Floor and Sliding Door

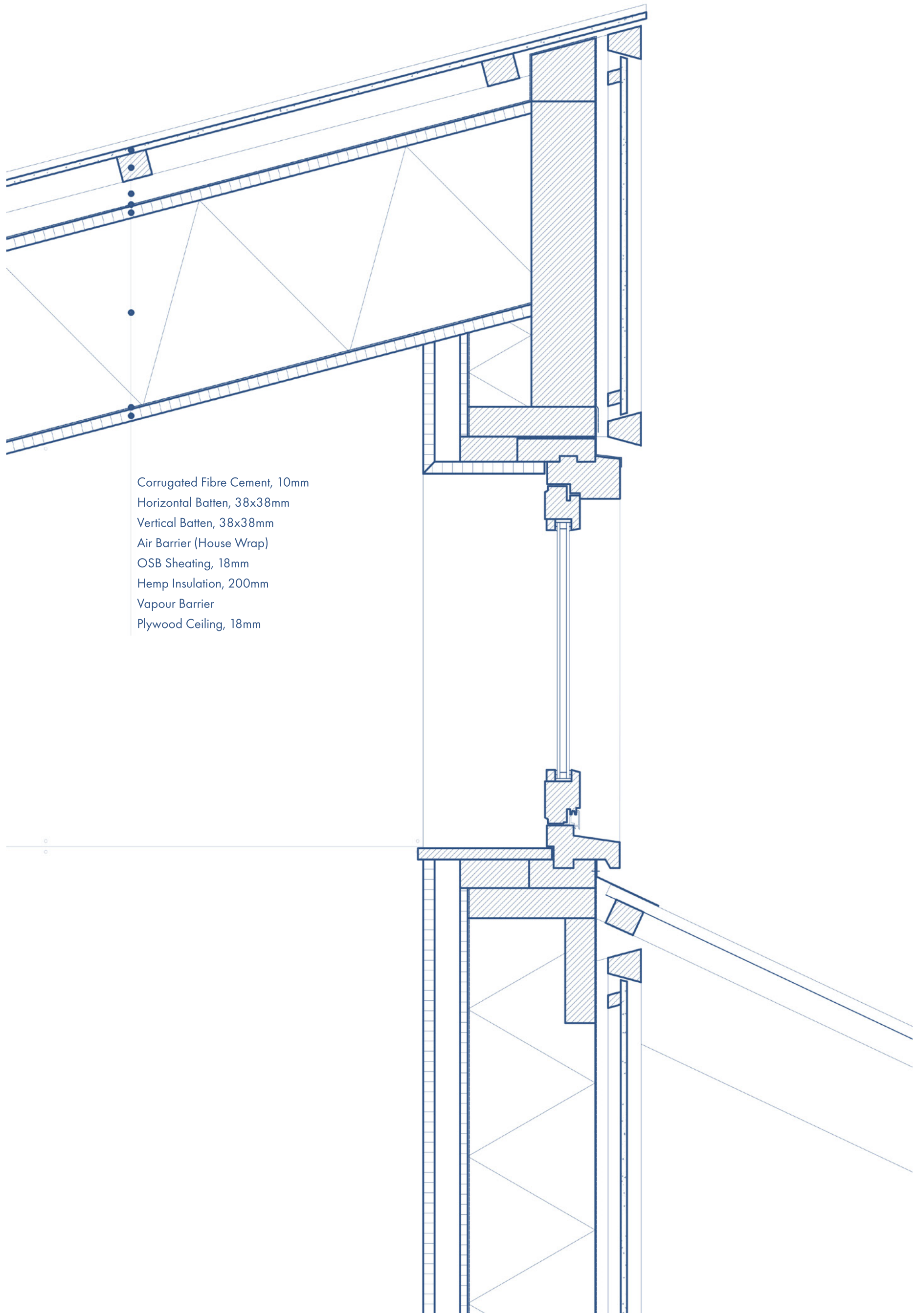


Fig. 96. 1:5 Section of the Roof and Clerestory Window

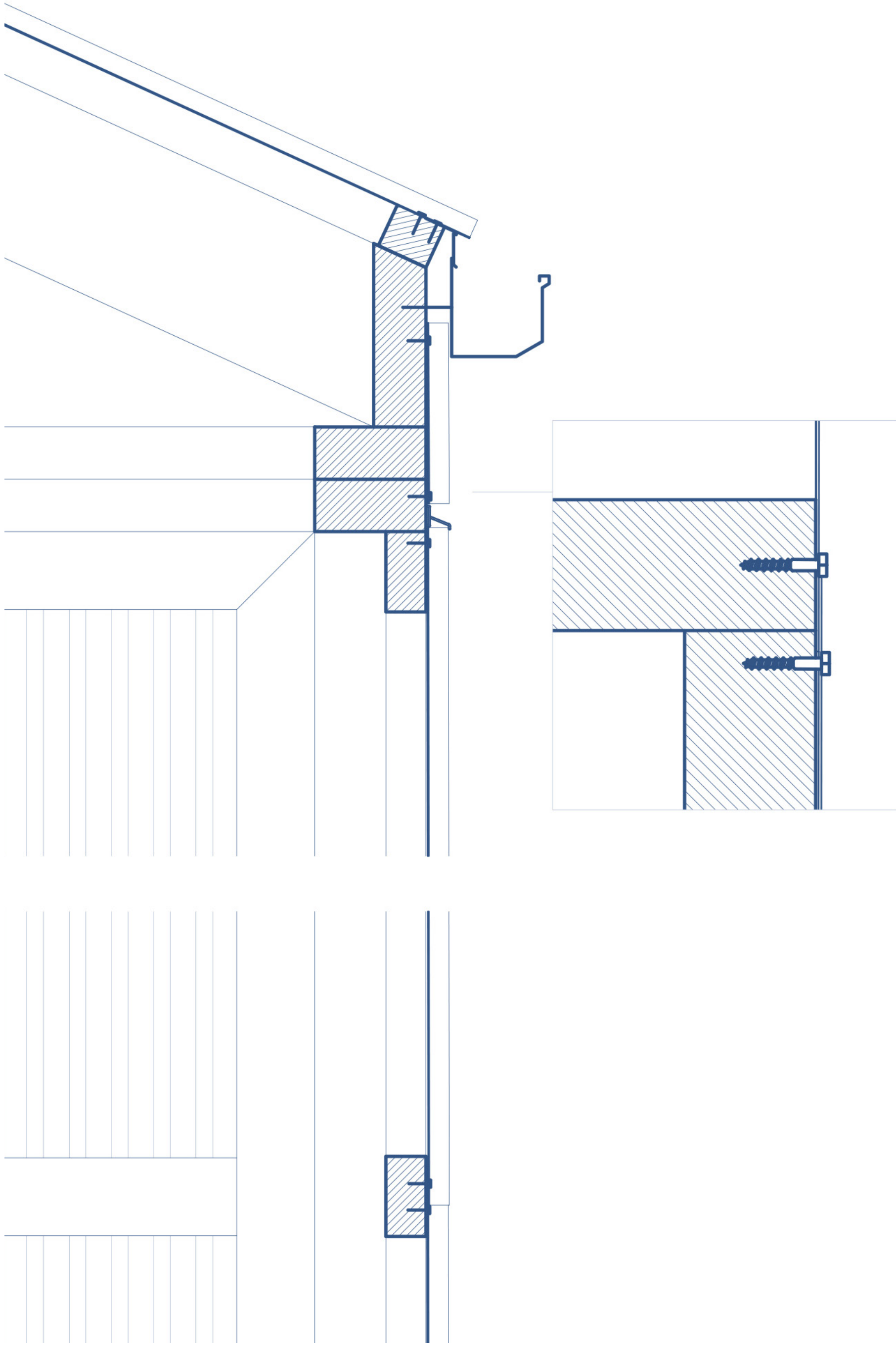


Fig. 97. 1:5 Section of the Greenhouse

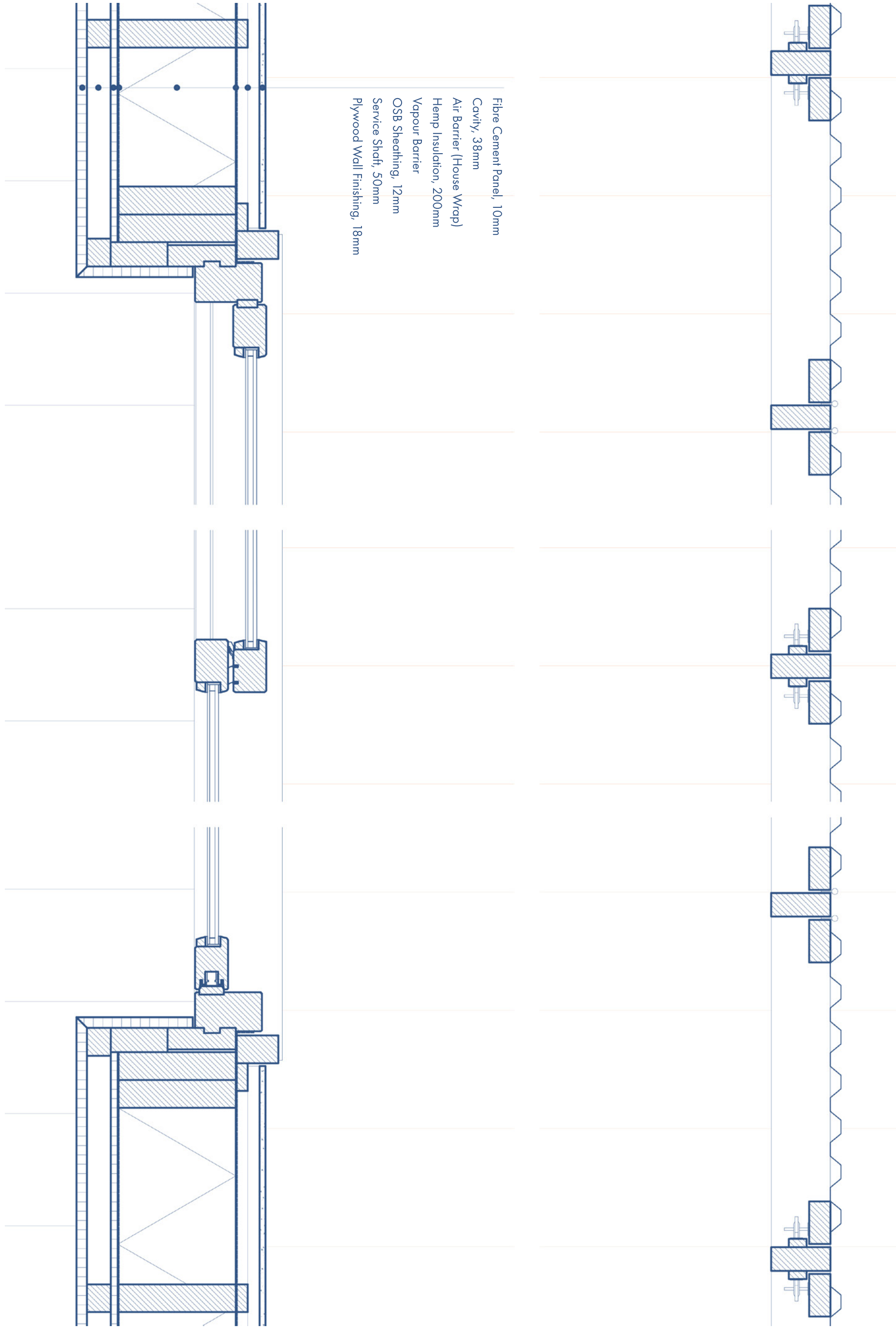


Fig. 98. 1:5 Plan of the Sliding Door and Greenhouse

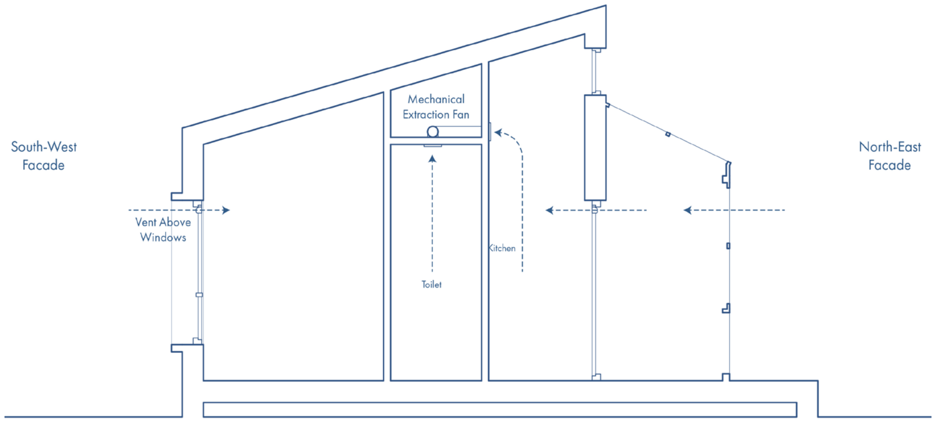


Fig. 99. Diagram of Ventilation System

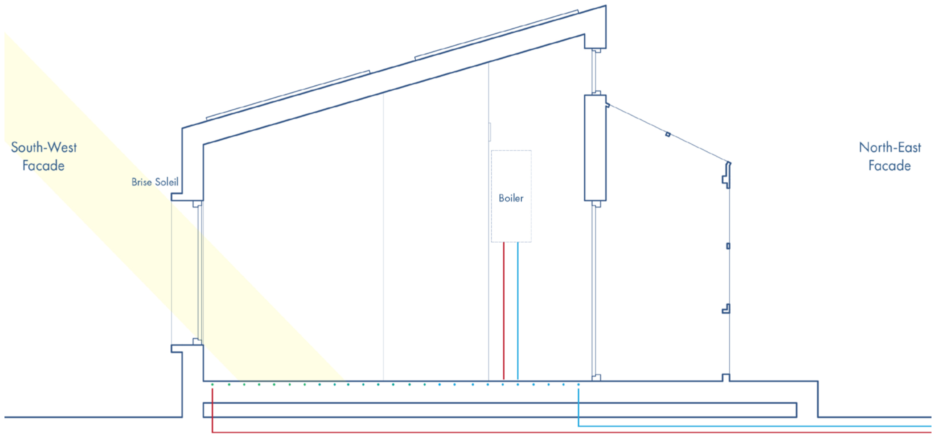


Fig. 101. Climate Diagram: Summer

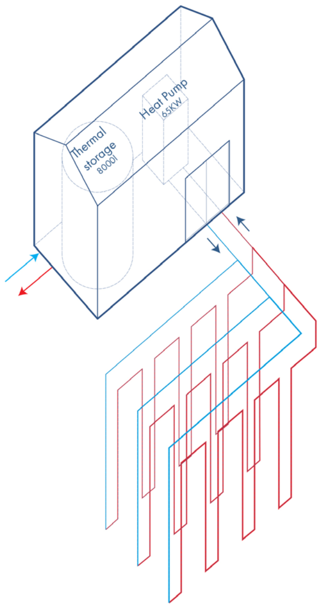


Fig. 100. Isometric of the Basic Facade Structure

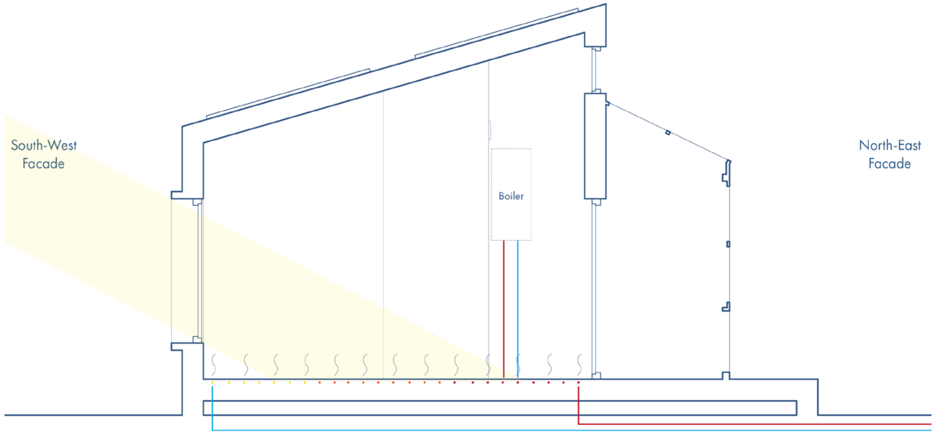


Fig. 102. Climate Diagram: Winter

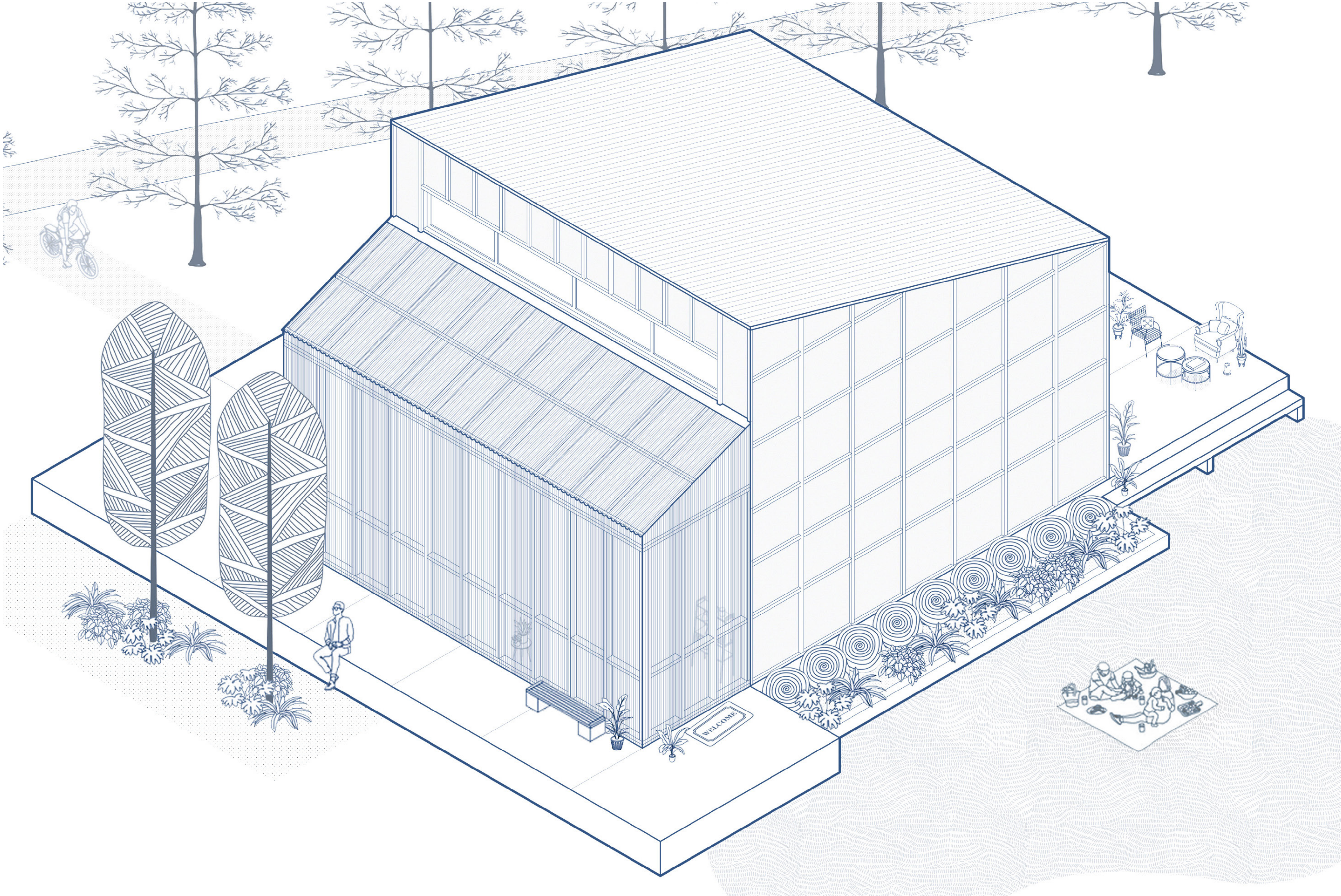


Fig. 103. Isometric

Co-Living Type 1

Co-living type one is a housing type intended for two different households of a maximum of two people to live in. It's 72m² and all amenities are shared; the only private room is the bedroom.

The priority when designing this housing type was for it to feel as though the inhabitant's privacy does not have to be sacrificed despite sharing a home. Because of this, all rooms were designed to be closed off. This is apparent in the bathroom, where the sinks, shower and toilet are all in separate rooms. The kitchen and living room can also be closed, in case roommates would like privacy while in certain rooms. Because of this, access to the bedrooms can be done through the open bathrooms

Fig. 104. Floor Plan Type 1 (Left) and Floor Plan Type 2 (Right)

without using the other, closed off rooms.

The exterior of this house is designed with simple wood panelling and a pitched roof. This dwelling type was designed in this way to be more reflective of the farmhouses in the surroundings, with their monolithic appearance and pitched roofs.

Ultimately, this housing type is designed in such a way that it maintains privacy despite being located in a shared environment. The exterior design draws inspiration from the traditional farmhouses, while housing a modern co-living concept.

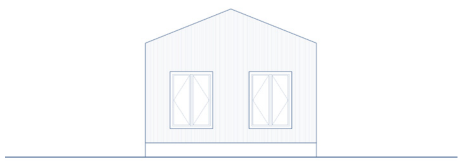


Fig. 105. North-West Facade Type 2

Fig. 106. North-East Facade Type 2

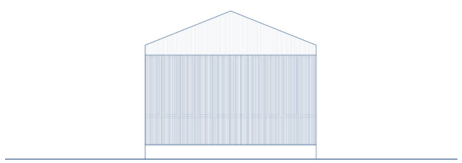


Fig. 107. South-East Facade Type 2

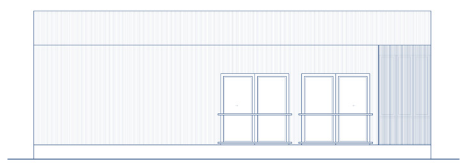


Fig. 108. South-West Facade Type 2

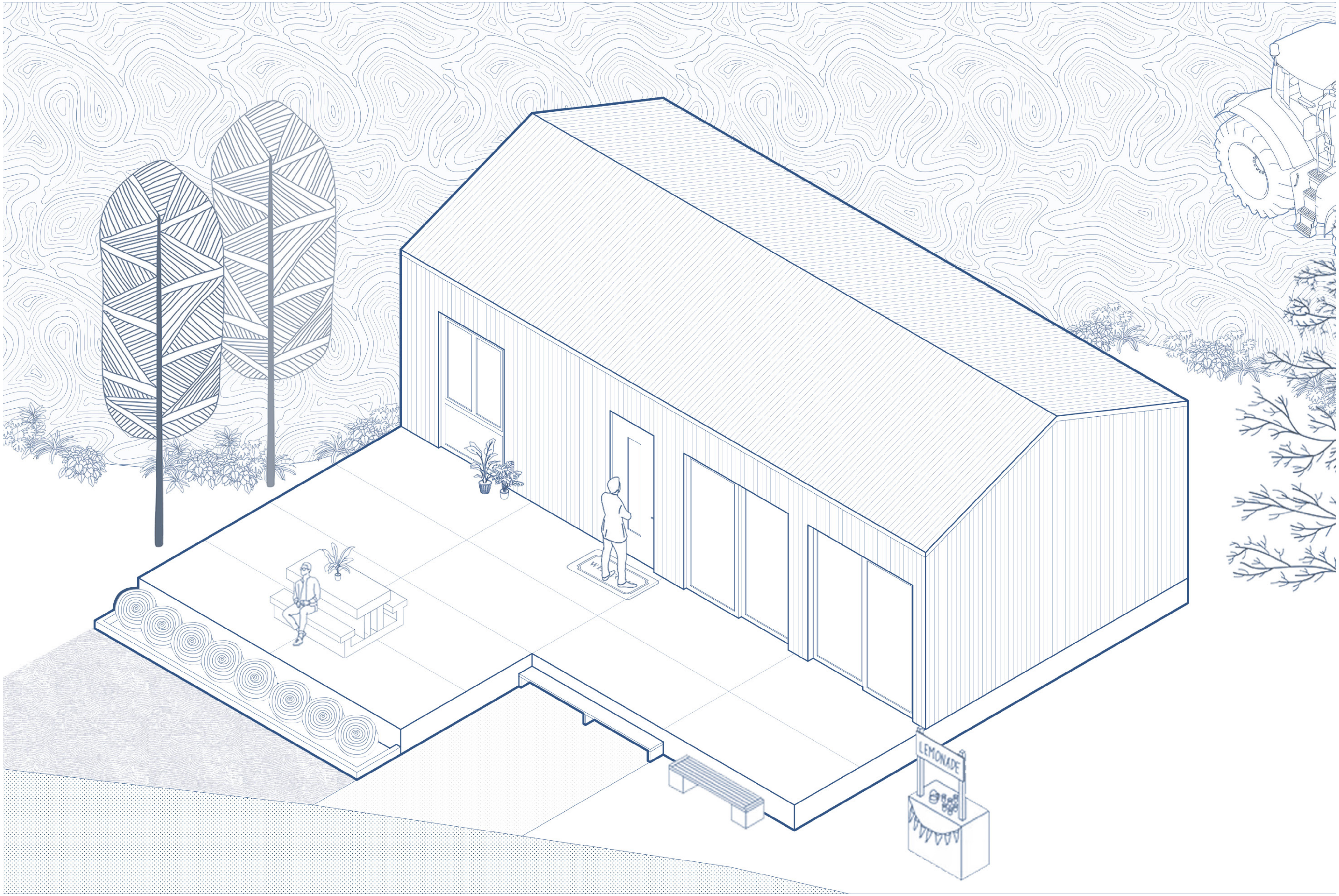


Fig. 109. Isometric Type 1

Co-Living Type 2

Co-living type two is a $67,5m^2$ housing type intended for two different households of a maximum of two people to live in. It differs from co-living type 1 in that the only shared rooms are the kitchen and the greenhouse.

This housing was designed to provide households their own private spaces, such as the living room, bathroom and bedroom, while sharing a kitchen. This dwelling was designed specifically with senior citizens in mind. Typically, these are smaller households with limited social interaction. It's typically quite difficult cooking for a small household as food is sold in large quantities and occasionally goes to waste, so this housing type was designed to combat this issue,

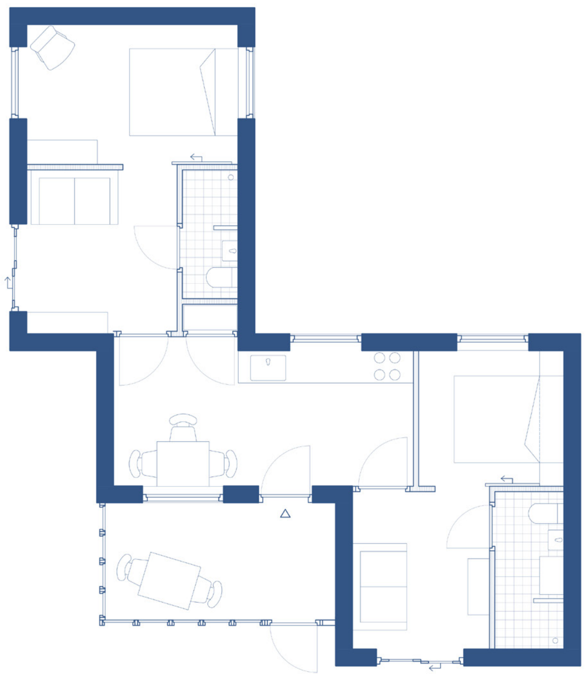


Fig. 110. Floor Plan

while providing the inhabitants a chance to socialise.

The exterior of this dwelling was made to appear to be a reflection of what is within: two individual units with a shared kitchen. To express this, the two more private units have a separate architectural language to that used for the kitchen.

Overall, this housing type provides a solution to the challenge of cooking for small households while encouraging social interaction. The exterior of the dwelling reflects the ability to have both private and shared spaces of the two distinct households.

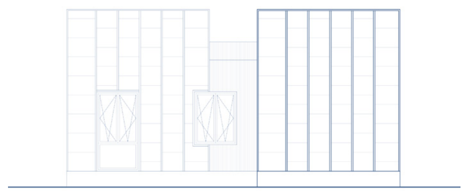


Fig. 111. North-West Facade

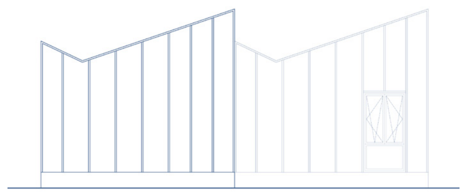


Fig. 112. North-East Facade

Fig. 113. South-West Facade

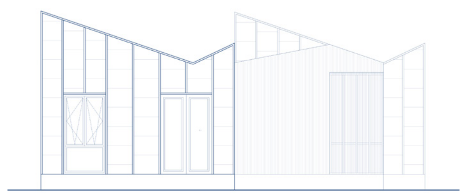


Fig. 114. South-East Facade

Fig. 115. Isometric

Divorced Housing

The divorced housing type is intended for parents who have separated, but still share custody of children. This type ensures the parents can live in proximity to each other, but still have their own separate homes with a child's bedroom that can be accessed by both. This type is intended for two households with a total area of 108m², with one unit being 52m², the second unit being 42m², and the shared bedroom being 13m².

The priority for this household design was to ensure the two households could be separated as much as they would like. Similarly, it was also imperative that the shared child should have privacy while having easy access to both homes from within the dwelling. This was accomplished by a shared hallway that can be closed in such a way that the different houses could be separated completely. From this hallway, the child's room has it's own door which provides them some privacy.

The façade of this dwelling is designed with two separate designs that come together to form one coherent building as a reflection of the family type within.

This design ensures both parents have their own spaces while maintaining proximity for the child's benefit. The layout and dual façade provide flexibility and privacy while symbolising the unified, individual nature of the separated units.

Fig. 116. Floor Plan

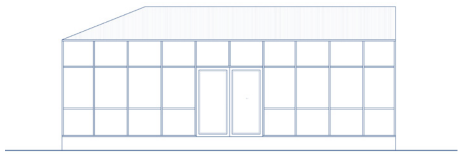


Fig. 117. North-West Facade

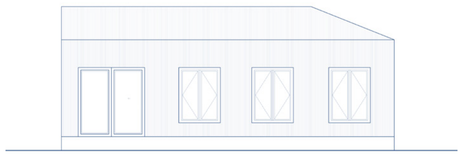


Fig. 118. North-East Facade

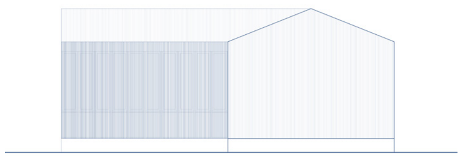


Fig. 119. South-East Facade

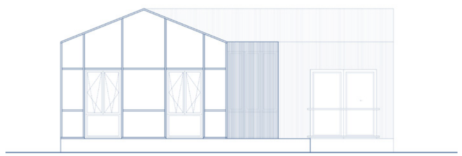


Fig. 120. South-West Facade

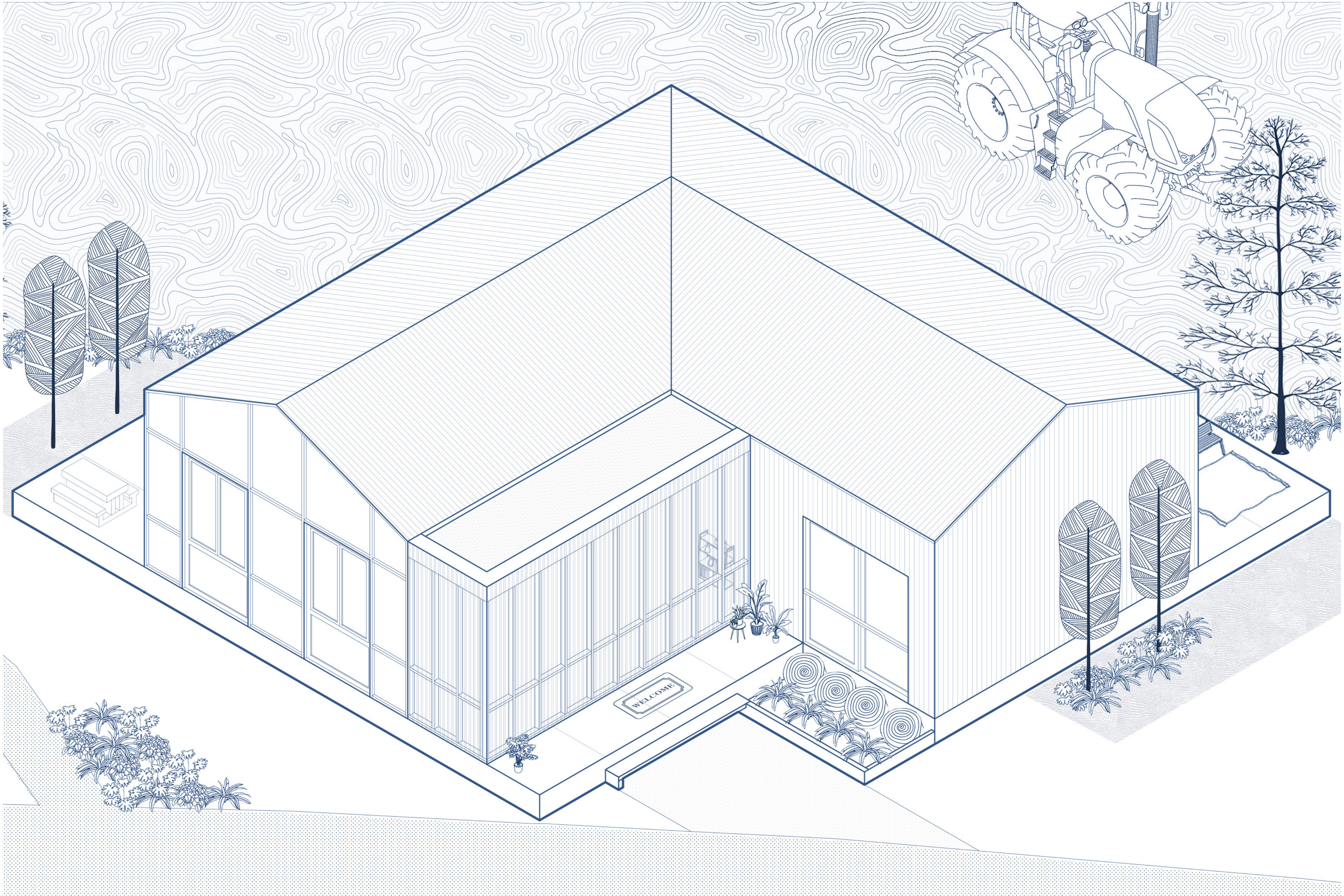


Fig. 121. Isometric

Multi-Generational Family

This housing type is the largest at 180m2. This type is intended to be for families of different generations that would like to live together, specifically a household of a maximum of two people, with a household of a maximum of six people.

This housing type differs from the other co-living types in that the public space is favoured over the private spaces in terms of size. This is meant to be a housing type that promotes socialising with family in the shared kitchen, dining room and outdoor seating upstairs, rather than spending time in the individual units. To create this effect, the upstairs is given a lot of space and windows in comparison to the spaces in the units. The units were designed with the bedrooms taking the most space, and the living and dining room using less space due to the vast sizing of the rooms upstairs.

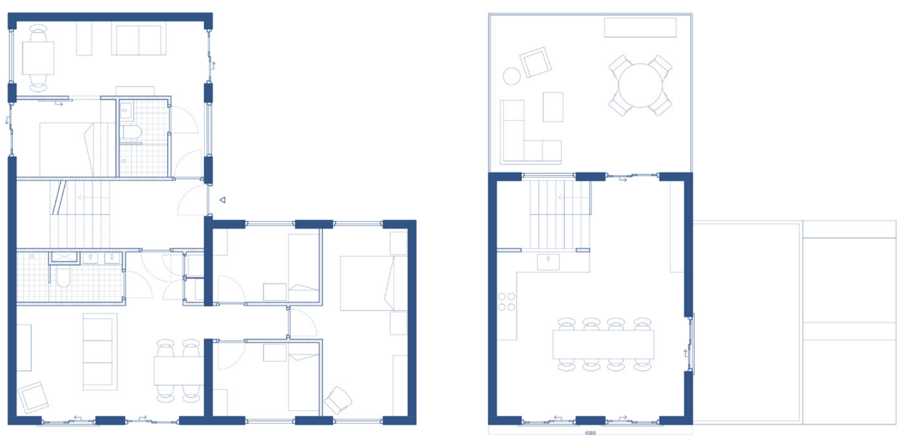


Fig. 122. Ground Floor Plan (Left) and First Floor Plan (Right)

The façade was designed with two different architectural languages in an attempt to balance the shape of the dwelling. The smaller private unit is given one language, while the family unit as well as the public space is given another. This is to symbolise the interconnection of the two units within this housing type.

Overall, this housing type promotes socialisation between families. The facade is designed to replicate the interlinking of the families within, driven by such a design.

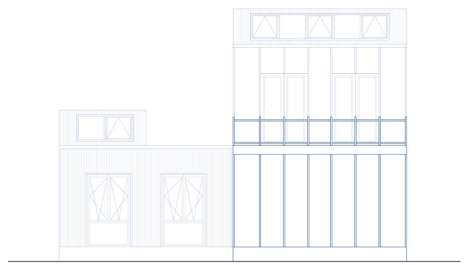


Fig. 123. North-West Facade

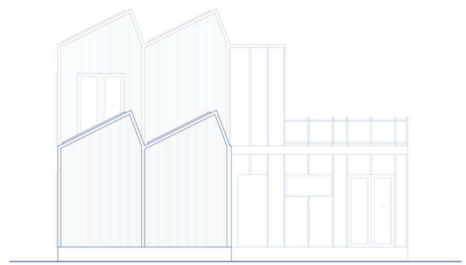


Fig. 124. North-East Facade

Fig. 125. South-East Facade

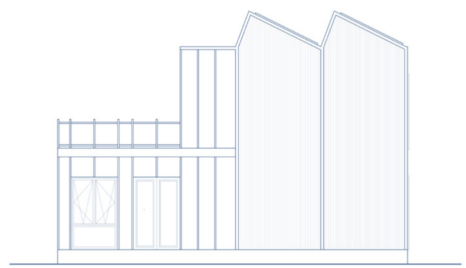


Fig. 126. South-West Facade

Fig. 127. Isometric

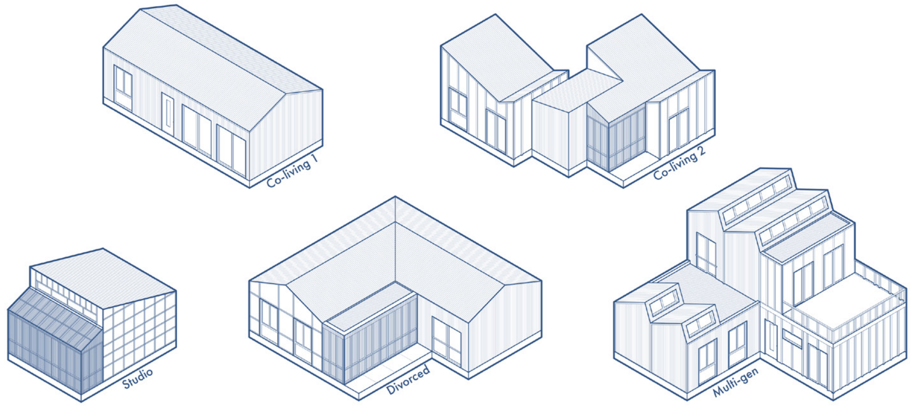


Fig. 128. All Housing Types

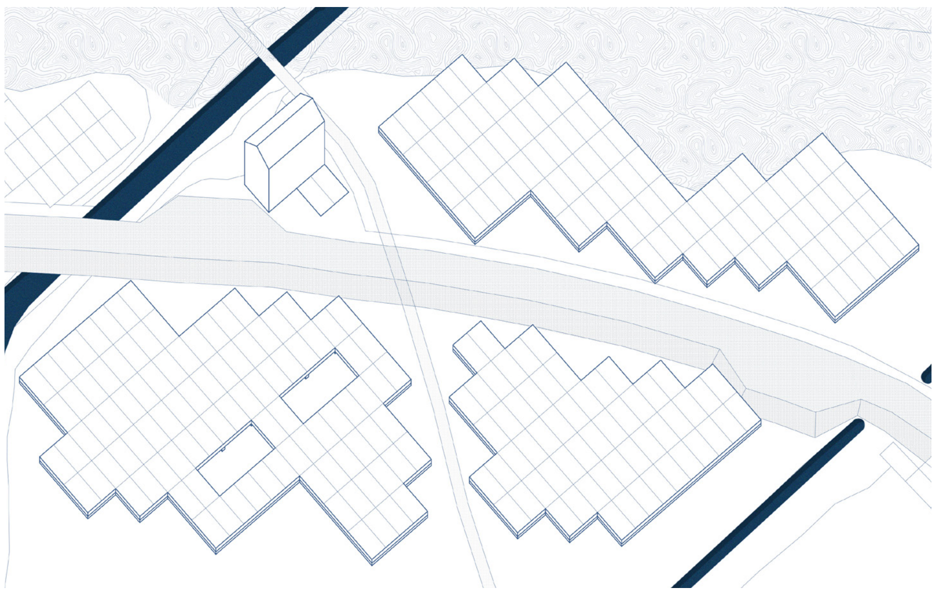


Fig. 129. Unbuilt Deck

With all the housing types discussed, the masterplan would be developed in the same manner as a group build. All inhabitants would choose a housing type based on their needs and would discuss with the other inhabitants where to place their dwellings to form the masterplan themselves. In this case, five housing types were designed where in an ideal scenario, there would be multiple homes to choose from, similar to the Small Homes Service by Robin Boyd.

The masterplan for this project was designed in such a way as to accommodate as many housing types as possible. This was also done in a way that the left over parts of the deck have some privacy that can be used as private balconies with large public spaces where all houses are accessed from. The masterplan also shows how the project would work if housing types are stacked. In this case, there is an access core as well as a gallery to access all units.

Similar to the proposal for Midden-Delfland, this project is executed in a bottom up way, where the masterplan is a result of the circumstances around it. The plot choice and orientation of the project is a result of the soil and the farmer's profit becomes the base of the masterplan.

Ultimately, the design of this project is executed in a manner that it uses the circumstances governed by the proposal for Midden-Delfland to its advantage. A new farmer type provides land and a foundation where different family types are accommodated in a flexible way that solves the issue of affordability well. The construction of these dwellings is also done with affordability in mind by using the results from the research and ensuring buildings are easily constructed, demountable and use materials that are mass-produced but still bio-based. Overall, this project provides comfortable housing in an affordable way using a new ownership principle.

Fig. 130. Final Masterplan

Combination

Reflection

My research takes place in the Advanced Housing Design master's studio. The studio concerns itself with redesigning the Dutch Deltas in a way that integrates water in its planning and design. Additionally, I was assigned to focus on resource usage as the main focus of a group masterplan. My individual research concerns itself with identifying if there is a resource utilisation principle that is most successful in achieving affordable housing, which is a principle I focused on in the design of my project.

My way of working is a very logical one; I always aim to quantify my research as I find working with numbers is easier to manage. To achieve this, my research was conducted by selecting case studies to represent a resource principle. Thereafter, the case study was evaluated with specific criteria to determine which principle is the most affordable. This approach was useful in determining a most affordable principle in that it provided a method to quantify affordability using more factors than fordability using more factors than the price per square metre. It also provided a method to architecturally evaluate a dwelling in comparison to the affordability.

While this approach was useful in many ways, it has drawbacks. Firstly, great stress is placed on the case study to represent the resource principle. Certain resource principles are very theoretical, so they have very few case studies to represent them. The evaluation criteria can also be misleading in that each criteria is assigned the same importance when in reality, this would not be the case. Despite these drawbacks, I found that this method of working makes complex scenarios easy to understand and conclusions were easy to draw from the data I had.

The outcome of this research influenced my design in that it provided a resource strategy that I could focus on while designing. I aimed to incorporate this strategy in all scales of my design. I also aimed to incorporate other resource principles in a similar method to the ones used in the case studies to make typically unaffordable materials, more affordable. My project also changed my research constantly in that I initially intended on researching ways to make affordable rental housing. However, the design of my masterplan raised a new way of constructing, and with this, I had to adapt my research to finding different resource principles that would make building housing more affordable.

The main feedback I received for the design of my project was based on creating a storyline that ran through all scales of my project. I had a clear idea of events that would lead to the design, however the implications of these events kept changing until a succinct story emerged. My design is centred around a new kind of farming emerging from a new water climate in the future. However, the implications of this changed constantly, where different concepts of modularity were explored and different masterplan implications emerged. Overall, the clarity of this helped in the further designing on a small scale as I had a clear set of ideas and constraints to follow in the design.

In this way, my project relates to

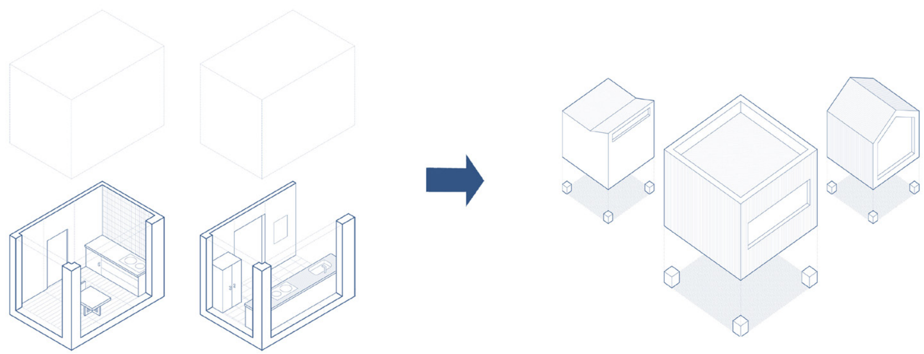


Fig. 131. Adaptation of Modularity Concept After Feedback

the studio in that it uses water as a guiding principle in many aspects. The masterplan is designed around altering the ZUS plan where our design is to be located. The ZUS plan requires new water systems, which we have removed because of a wasteful use of resources. Because of this, the masterplan is centred around a lock used for transporting resources on the waterways. Additionally, my own project is located on a sand bank so as not to get flooded. In an overarching way it also relates to the study of Architecture in that it focuses on issues that may be prevalent for future Dutch architects. It provides a solution for the way we deal with water and designing in areas that are deemed unworthy to develop on, such as swampy peatlands.

I find that my work is transferable because of these links. In the future, the Netherlands will have a very different waterscape than it does today. Within my project, I tried to find opportunities from the adaptations that would have to occur. The flooding of the polders to prevent excessive carbon outputs means that a new kind of farming would have to emerge. Within my project, I found an opportunity that involves creating affordable housing from these new farmers. I find that this line of thinking in a constantly evolving world creates new opportunities and the evolution of housing that could be applied in reality.

To move forward and continue the development of this project, I would like to further improve the representation of building technology products of my design by representing them in a physical model as I find the method of making models further helps the understanding of the construction. I would also like to further integrate my design into my research within my thesis report. I find that writing the entire thesis as a single story including the design will help me gain more insights into any links or discrepancies that I can then adjust.

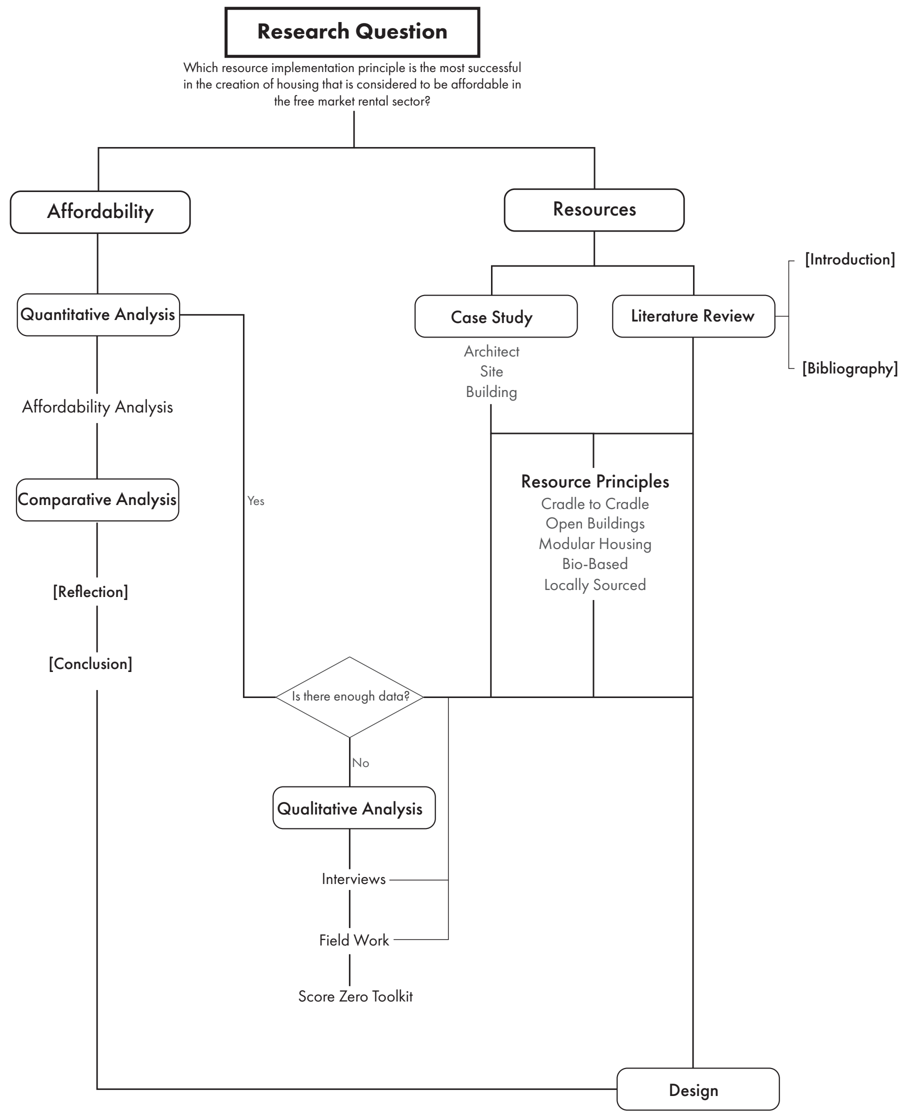


Fig. 132. Research Method

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Appendix

Bio-Based Artist Residence

Evaluation Figures	
Construction costs (€/m²)	1008,07
Construction time (days/100m²)	60,48
Durability (years)	> 30

Table 1. Data used for the evaluation of Bio-Based Artist Residence. The construction costs and construction time data is from Bureau SLA, personal communication, February 29, 2024. Durability is estimated based on material lifespans.

PIT Lab

Evaluation Figures	
Construction costs (€/m²)	842,56
Construction time (days/100m²)	71,64
Durability (years)	> 30

Table 2. Data used for the evaluation of PIT Lab. The construction costs and construction time data is from DOOR Architecten, personal communication, January 16, 2024. Durability is estimated based on data from Schipper Kozijnen. (2018, June 7). PIT Lab - DOOR architecten (genomineerd VKG Architectuurprijs 2018 categorie nieuwbouw) *[Video]. YouTube. https://www.youtube.com/watch?v=LgDFGIYOPug*

Ban-sur-Meurthe House

Evaluation Figures	
Construction costs (€/m²)	1763,67
Construction time (days/100m²)	95,8
Durability (years)	> 40

Table 3. Data used for the evaluation of Ban-sur-Meurthe House. The construction costs and construction time data is from Ban-sur-Meurthe House *by Studiolada, 2022, (https://www.studiolada.fr/mi/ban-sur-meurthe). Durability is estimated based on material lifespans.*

The Kwikset House

Evaluation Figures	
Construction costs (€/m²)	605,65
Construction time (days/100m²)	52,3
Durability (years)	> 30

Table 4. Data used for the evaluation of The Kwikset House. The construction costs are calculated to euros with inflation based on the original price data from What Would It Take to Build This 'Lost' Eames House? *by Diana Budds, 2021, (https://www.curbed.com/2021/12/kwikset-house-eames-modular-design.html). Durability is estimated based on material lifespans.*

R50-Cohousing

Evaluation Figures	
Construction costs (€/m²)	1457,28
Construction time (days/100m²)	53,76
Durability (years)	> 50

Table 5. Data used for the evaluation of R50-Cohousing. The construction costs and construction time data is from Heide & von Beckerath, personal communication, February 20, 2024. Durability is estimated based on material lifespans.