DESIGNING ARCHITECTURE FOR REUSE & RECYCLING

AAHM01, Degree Project in Architecture, LTH, 2018

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TABLE OF CONTENTS

INTRODUCTION

Abstract 1
Foreword 2

BACKGROUND

Global warming and finite resources 3
The benefits of a circular economy 6
Designing for disassembly 8
Recycling and reusing 9

REFERENCES/INSPIRATION

ICEhouse 11
Upcycle house 12
Brighton waste house 13
C2C Family house 14
Other sources of inspiration 14

PROJECT DESCRIPTION

Project background 15
Program 16
The aesthetic and the residents 17
The row house context 17
The window wall exercise 18
Design parameters 19
The cycle of wood within the project 20

PROJECT DESIGN

Result & comments 21
Plans, section & Elevations 25
Cut perspective overview 30
Build order & details 31

CONCLUSION

Reflection & further development 39
Final remarks 40

SOURCE REFERENCES

Text references 41
Image references 42

INTRODUCTION

ABSTRACT

The building industry has a negative effect on the environment by contributing greatly to the greenhouse effect, wastage and the depletion of materials. This project explores through the design of a house how architects can battle some of these problems and contribute to a more sustainable future. To accomplish that we should design for reuse and recycling to use our resources more effectively and reduce the negative impact on the environment. Therefore the project partly uses second-hand materials and is constructed with reusable components where suitable and when not materials that can at least be recycled. That way the resources used when building the project are not wasted. In addition to using the right materials the components are put together in ways so they can be easily assembled and taken apart to be reused, avoiding adhesives, nails, casting and other permanent connections. By leaving joints, connections and fasteners visible and accessible maintenance and deconstruction is made easier and faster. The design of the house features this as part of its charm and shows how designing for reuse and recycling can add to the architectural expression.

FOREWORD

The reasons why I decided on the subject of designing architecture for reuse and recycling are several. I thought it would be a good opportunity to find out more about construction while dealing with a current subject that might become an important part of the future of architecture, but I was also intrigued about how you could base an architectural design on how you put something together and what that might look like.

There was so much I wanted to do and incorporate in the project when I started it. However I realised that I needed to limit the area of focus in order to have a clearer path and to have a core concept I could look back to when unsure about design decisions and the next step. I settled on the core concept being the design for reuse but throughout the design process I discovered just how many different aspects you have to consider and compromise about when designing for disassembly and reuse. Very durable materials with long life spans might sound like the perfect choice when designing for disassembly/reuse, but that is not necessarily the case. There are a lot of aspects to consider such as where the material is from, how it is made and recycled, its flexibility of uses from project to project, etc. Many of the questions can also be asked about the fasteners which will join the different components and depending on the material might need to be more detailed and expensive to produce. This complicated things and made me uncertain what the best options were and that has been the story throughout my design process.

My philosophy has been to design this project as if it would actually get built. Considering cost and environmental impact in addition to core concept in a much more detailed scale than I have ever done before. Something which I think resulted in more of a focus on research, materials and construction details, which left aesthetics and spatial qualities come as an after thought of that. For good and for worse. It lead to a simpler and perhaps more classic design than what I had imagined in some aspects but much more complex when it comes to other. The project has been a journey of learning and a lesson in compromise and I hope to showcase the result and the thoughts that lead to it in the following pages. Enjoy.

BACKGROUND

GLOBAL WARMING & FINITE RESOURCES

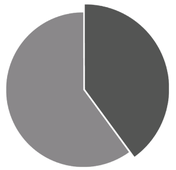
Why would we want to design for reuse and recycling? Because it can be part of a solution to the Earth's environmental problems and the way we create things now are not sustainable in the long run. In Sweden during 2014 about 70% of all greenhouse gas emissions came from new constructions and refurbishments. This shows that the building industry has a massive impact on our environment and in the diagrams on the following page you can get an idea of just how big a part the building industry and property sector play.

Constructing and demolishing buildings also creates a lot of waste and very little is recycled. Partly because it is hard to disassemble parts the way things are constructed, using adhesives and permanent joiners, and partly because materials used are hard to recycle in one way or another. Concrete for example is hard to recycle because it is usually cast on site and will need to be broken in order to be removed when demolishing a building, and the broken concrete has very limited uses as a recycled material. Bricks on the other hand can be reused but it is time and energy consuming to save the bricks when tearing down buildings, and depending on what they are bonded with a lot of bricks might be useless despite the effort.

A bulk of the problems discussed above could be addressed with designing buildings for disassembly, enabling the removal of a building without demolishing it and losing resources in the process. It would be big steps towards a more sustainable future since the building industry is such a major contributor to greenhouse gas emissions and waste. If something can be reused or recycled more efficiently not only will we save a lot of resources but it will also result in less energy consumption, which in turn leads to a decrease in emissions of greenhouse gases.

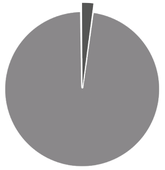
IMAGE 1

THE BUILDING INDUSTRY GLOBALLY

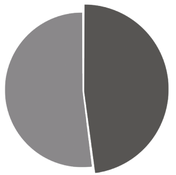


USES 40% OF ALL MATERIALS PRODUCED

IS RESPONSIBLE FOR 35% OF THE WORLDS WASTE



CEMENT ALONE CONSUME 2% OF ALL ENERGY PRODUCED GLOBALLY



BUILDINGS USE 48% OF ALL ENERGY PRODUCED (8% OF THAT IS FOR CONSTRUCTION)

THE BUILDING INDUSTRY & PROPERTY SECTOR IN SWEDEN

19% GREENHOUSE GASES

11% NITROGEN OXIDE

25% PARTICLES

30% ENERGY USAGE

17% HEALTH HAZARDOUS CHEMICAL PRODUCTS

4% ENVIRONMENTAL HAZARDOUS CHEMICAL PRODUCTS

33% WASTE

Source references:

HEATING, COOLING, LIGHTING, SUSTAINABLE DESIGN METHODS FOR ARCHITECTS third edition by Norbert Lechner
http://www.boverket.se/sv/byggande/uppdrag/vagledning-om-lca/

Designing for reuse and recycling would also solve another problem, the depletion of materials. It goes hand in hand with waste from demolition ending up on a landfill, where the materials will be lost. If the materials are lost but the demand for the product is alive, raw materials need to be sourced, draining the finite natural resources. Planet Earth does not have infinite amounts of resources, and it is not only oil that is at risk of depletion. In the upper diagram to the right you see a list of the materials that risk reaching depletion if the current trend continues. It is still not realistic to do space expeditions in order to mine the future materials we may need, so a better alternative is to become much more efficient at recycling. However the word recycling might be too broad of a term for what we are after. Most of the industry recycles in one way or the other, but most of the time it is a matter of trying to save the most valuable part, wasting the rest, or recycling for the reason of branding. A recycled product is not necessarily more sustainable. If the recycling process needs more energy than what new production does or demands hazardous substances it cannot be seen as sustainable. There is a big difference between just recycling a part of something and letting the rest go to waste than trying to account for every detail and keeping as much value as possible. A good way to do that is to design the product so that at the end of its lifecycle all of its materials can be fed directly into making new products and that any by-products created is seen to and put to use. This concept of trying to create closed production loops is a large part of circular economy, which will be explained in more detail in the following pages.

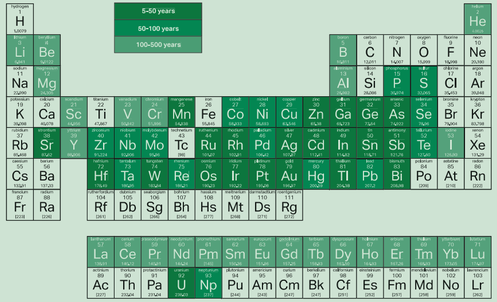


Diagram: Years remaining until depletion of known resources.[16]

This diagram is an reinterpretation of an original owned by Ellen MacArthur Foundation

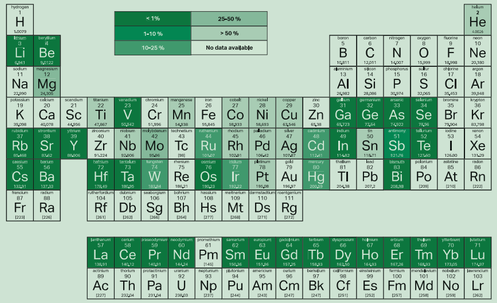


Diagram: Current recycling rates of known resources.[16]

This diagram is an reinterpretation of an original owned by the Ellen MacArthur Foundation

IMAGE 2

THE BENEFITS OF A CIRCULAR ECONOMY

In nature almost everything plays a part in a cycle, and even spoils are taken care of and contribute to something else. As an example plants take nutrients from the ground in order to grow but is then consumed by animals which when they die feed decomposers such as worms, insects and mushrooms that enrich the earth with soil nutrients for the plants, finishing the cycle. This natural cycle is sustainable and could in theory go on forever without complications. However most synthetic products are not part of such a cycle and therefore creates a waste of resources and pollution. Circular economy is the idea that you create sustainable cycles for manufacturing products much like how things work in nature, meaning that all parts and spoils are taken care of and find another use. Making changes to something more sustainable rarely happens unless there are laws put in place or there is a beneficial incentive for it. The incentive for changing to a circular economy is the promise that there will be profit from it in the future when the manufacturing cycles are in action. Material cost will be saved, since materials will be recycled from old products into new ones, and the industry will be less vulnerable being partly its own supplier.

The diagram to the right illustrates the different steps in a linear value chain, showcasing that there are few cycles, most of the products end at the land fill and the production results in pollution and detrimental impacts on the environment.

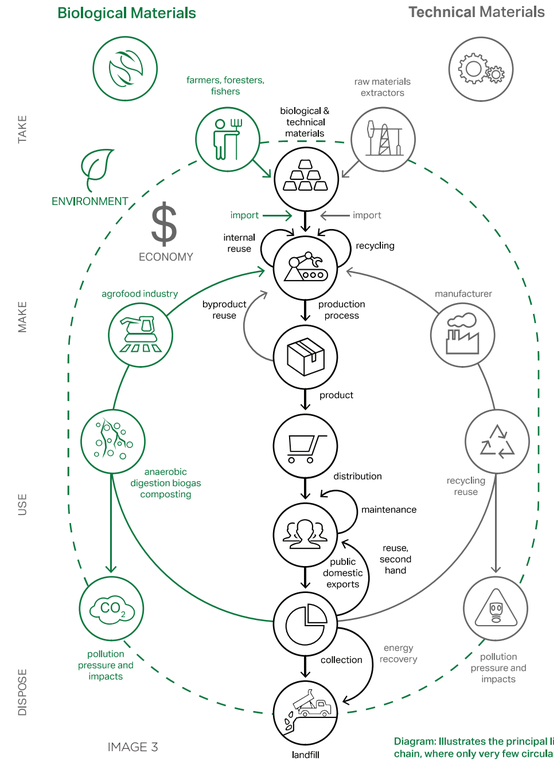


IMAGE 3

Diagram: Illustrates the principal linear value chain, where only very few circular flows can be identified for concrete, steel and timber.

This diagram is an reinterpretation of an original from the report 'Scoping Study to Identify Potential Circular Economy Actions'

Compare that to the diagram to the right which show a circular value system where all by-products are fed back into the manufacturing chain and the little leftovers are used as energy before the landfill, trying to utilize everything to the limit. In order to manage this kind of system the manufacturer has to create a system where it is possible. They have to have an awareness of what the product contains, invest in ways to reuse and recycle used products and gather or receive the used products in some way. The last part can be tricky but can be fulfilled with having resellers receive used products and sending them back or/and have the manufacturers pay for direct shipping to their factories. An incentive might be necessary for the consumers to send the used products back, but that could be managed through discounts on future products for example. The process of changing to a circular economy system becomes easier by corporations working together with other local manufacturers, because one corporation's leftovers might be useful to others. By open communication between different manufacturers they can pick up what would be waste from each other and a circular economy could be made possible. Creating these manufacturing cycles would not only limit waste as seen in the diagram, but would also lead to a more optimized production where all parts are accounted and used to their utmost limit, saving resources. This way the manufacturers become part suppliers as well, which would inform them about the properties of the materials they handle and create a more conscious mindset about what materials are used and what can be reused and recycled, since it would be in their best interest both economically and for the environment.

In short circular economy is a proposed system where manufactured products are made as part of a cycle to create a more sustainable industry and economy.

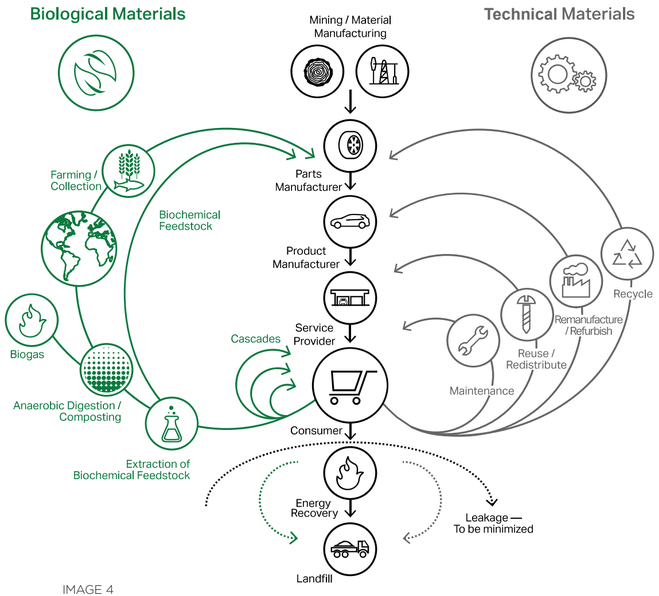


IMAGE 4

Diagram: The system diagram illustrates the continuous flow of technical and biological materials in the value circle. There are four circles of value creation. The diagram comprises a plethora of different terms that are integral to understand the different activities that contribute to a circular economy.

This diagram is an reinterpretation of an original owned by the Ellen MacArthur Foundation

DESIGNING FOR DISASSEMBLY

To design for a circular economy is to design for reuse and recycling, meaning designing for disassembly. If something can be disassembled the parts that the product consists of are much easier to reuse, but that by itself is not enough. If the materials in the product are composites or alloys that are hard to separate, cast in very specific shapes, glued together, have unique fasteners, etcetera, it severely restricts the possibility to recycle or reuse the parts because the applications become very limited or the recycling become too complex and/or not worth the effort. To design for disassembly one should use common, non-permanent fasteners to join components together such as screws, bolts, etc. This is to ensure that you can disassemble the product easily and reuse the components again after the product's lifetime. When talking about a product's lifetime it should be obvious that products wear out, fall out of trend or get damaged and that it is very useful if it is possible to separate different components of different materials in order to recycle them, and a lot of manufacturers do this. However when designing and constructing buildings this is given little thought and it is often difficult to separate materials, so that they can be reused, when demolishing the building. There are several reasons for this, such as that buildings are seen as more permanent than other products, it is faster using nail guns instead of screws, and wall papers, plaster, facade materials, insulation, etc. are often applied directly on top of walls which results in damage to the material when removed. By using reversible methods, limiting the amount of different fasteners that are used and the different means of construction and having a concrete plan on how to disassemble the building, it becomes easier.

Other considerations to enable easy disassembly are access and visibility to fasteners. It is easier and faster for the construction workers to disassemble a project that has fasteners that are in plain sight and easy to reach. If the construction have layers hiding connections and the order of disassembly is very specific, it becomes more complicated and takes more time.

IMAGE 5

RECYCLING AND REUSING

Moving towards a circular economy within the building industry there is a need to retrieve materials from demolished buildings and finding new use for them. Malmö Återbyggdepån works by gathering what would be waste materials directly from sites or from hand overs by people, then sorting, quality checking, preparing and reselling them. Their work makes it so that products are given a second life, saving material and energy in comparison to using newly produced items. There are some risks with using second hand materials, such as that there usually is no guarantee left that it will perform as intended or that it might perform worse than newly manufactured products. The material might also be superficially damaged and have an unwanted appearance, or there might not be enough in stock for what you need. Since places like Malmö Återbyggdepån relies on unwanted materials there is no way for them to have a reliable stock of different materials. Their stock depends on what they have at the moment and therefore it differs greatly from one moment to the next, though there are some materials that are a lot more common and usually in stock, such as bricks and roofing tiles. However designing with what materials are available at the time can ensure a unique look for each building while reducing the strain the building industry has on the environment. It just takes more effort and planning.

In my design I worked with many of the different materials and products Återbyggdepån offer to see how someone can use second hand material in new constructions. These are listed on the following page.

INTERIOR DOORS & DOOR PART OF WINDOW WALL

CUT STONES FOR THE GARDEN AREA AND ITS STAIRS

WASH BASIN & TAP FOR BATHROOM

WINDOWS PART OF THE WINDOW WALL

INSULATION FOR THE SUSPENDED FOUNDATION

SINK WITH TAP FOR THE KITCHEN

BRICKS CUT AS TILES FOR THE BATHROOM

BRICK ROOF TILES

CERAMIC TILES FOR THE KITCHEN

REFERENCES/INSPIRATION

ICEHOUSE by WILLIAM MCDONOUGH + PARTNERS

ICEhouse was designed with reconstruction in mind in order to follow cradle to cradle and circular economy principles. The ICEhouse is built by assembling smaller metal components into an outlying truss system that holds up the wall and roof. Not only does it make for easy construction and disassembly but having the structure as the outermost layer it also informs how it's constructed and makes the structure accessible. The fasteners are common and in plain sight to benefit the idea of the building being able to be disassembled, moved and reconstructed at different locations. ICEhouse is made of four main materials: aluminum, polymer, aerogel, and Nylon 6, which are all either cradle to cradle certified or in the process of being so.

ICEhouse by William McDonough + Partners and McDonough Innovation

IMAGE 6

ICEhouse, close-up of the structure and its fasteners

IMAGE 7

UPCYCLE HOUSE
by LENDAGER ARKITEKTER

While the Upcycle house does not use cradle to cradle design it uses a lot of recycled/upcycled materials in its design resulting in lower CO_2-emissions in production. The CO_2 reduction has been 86% compared to a benchmark house.

The house consists of several upcycled materials, which are waste materials/products that have been processed to something of higher quality or/and value. One such material are OSB panels that cover large parts of the walls and floor. The panels are made by pressing together wood chips that are bi-products from various production sites. This is usually done with glue to make for a stronger material, but not in this case, which keeps the material pure wood, meaning that it can be composted or burned for energy without fear of releasing any hazardous substances into the environment.

Upcycle house by Lendager Arkitekter

IMAGE 8

Kitchen of Upcycle house by Lendager Arkitekter

IMAGE 9

BRIGHTON WASTE HOUSE
by BBM SUSTAINABLE DESIGN

An experimental project using several waste materials/products in its design. A variety of different products have been used as insulation in the project, such as: video cassettes, tooth brushes and jeans. The facade is old carpet tiles with the bottom facing outward. While being experimental the project shows a finished building built with solely waste materials and how that shapes the building in a unique manner.

Brighton Waste House by BBM Sustainable Design IMAGE 10

First floor interior of Brighton Waste House IMAGE 11

C2C FAMILY HOUSE by JOUKE POST,
FRIDO NIEWAMERONGEN & ARCONICO ARCHITECTEN

The materials chosen for the project are almost exclusively environmental friendly and cradle to cradle certified. Even though the project might not have been designed with a focus on disassembly it has several details such as the railing and roof support that works in that regard.

Cradle to cradle family house by Jouke Post, Frido Nieuwamerongen and Arconiko Architecten IMAGE 12

OTHER SOURCES OF INSPIRATION

A lot of the inspiration has been had from industrial or temporary buildings, since those are often designed with a focus on functionality and cheap, quick construction. One such example is a café situated in a slope that I encountered while on a ski trip in Les Arcs. The building show cased its components, joints, fasteners and was probably designed so that the components could easily be transported to such an isolated area and quickly constructed.

Example of non-permanent joint from a café in Les Arcs, France

PROJECT DESCRIPTION

PROJECT BACKGROUND

In the early stages of the project I quickly settled on making a two stories house in a row house context. There were primarily three reasons why; I had never designed anything in that context before, sharing walls save material and it is more efficient to build than a free standing house. There is also an argument to be made that building row houses is a good idea to avoid sprawls since they can be made denser, but you still offer personal gardens and customisation of the exterior. The idea of a row house project that uses second hand material resulting in different exteriors along the body of the row house is to me interesting.

With these restrictions I started the design of the house and at the start of the project there were mainly three approaches that I considered starting to work with. One was to design the project in clear directional layers outside to inside such as in the case of ICEhouse mentioned in the previous pages. Constructing this way in a building with more than one floor would however risk a cold bridge since the second level would have to penetrate the insulating walls in places to be connected to the load bearing outer structure.

The second was to have an inner structure to build all the wall layers on and then have a separate load bearing structure for the second level. This option would make for easy construction since it would be built layer by layer, except for the second level which would be constructed The columns however would obstruct the already limited floor space.

By limiting the length the upper floor needs to span, columns can be avoided and the floor can fasten directly into the walls. This is the third option and what I finally settled for. It demands that the walls are load carrying and easy to attach to, something that will be expanded on in the build order chapter of this thesis.

PROGRAM

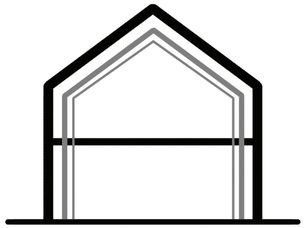
Design of a two storied house in row house context, complete with living room, kitchen, bathroom, two bedrooms and another bedroom on ground floor with flexibility as an office or storage.

The design should enable the reuse and/or recycling of the majority of building components.

Construction and disassembly should be simple and straight forward to ease the process.

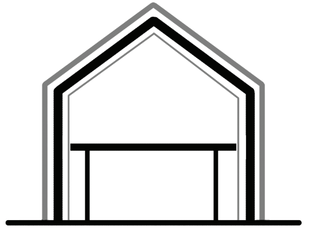
While not a priority economical aspects should be considered

OPTION 1



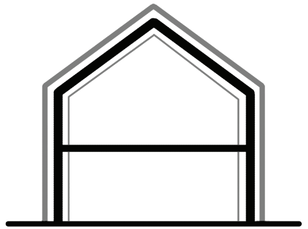
Outer structure carries walls and second level

OPTION 2



Load bearing middle structure with unified interior layer and separate structure for carrying second level

OPTION 3



Load bearing walls, carrying second level and separated interior layers

LOAD BEARING STRUCTURE

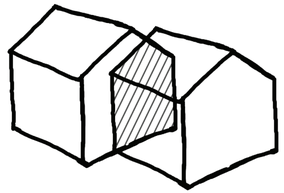
THE AESTHETIC AND THE RESIDENTS

With the project being a comment on designing for reuse and recycling, it was important that the proposal was plausible. If the design would be too expensive or too difficult to construct it would defeat the purpose of designing for reuse and recycling. Therefore the design was kept simple and the focus was put on the arrangement of things, the construction and the materials. Wall to wall the ground floor is just ten meter long and six meter wide, lengths that was the result of modular building components and limiting the size of the project in order to keep it fairly compact. With just six meter of a span to bridge it was possible to have ordinary wooden beams carry the upper floor. The beams are attached to walls by metal fasteners and clearly visible from the ground floor. They are a large selling point of this idea that the construction of the building is visible and on display as part of the aesthetic. The ventilation tubes are another part on display and can be seen on both floors. There was also the idea that the wiring and pipes could be on display, directly attached to the wooden walls in clear lines as a sort of ornament but that level of detail was not reached. These almost industrial elements are contradicted with the more refined wooden elements used in this project and as a bridge between the two is the oriented strand boards with their rough texture.

This fairly unique building with this background about being designed a certain way to work towards a more sustainable building industry is sure to attract a certain kind of residents. Though the project is no designed with a certain kind of resident in mind more than a family situation it is very accommodating to customisation. Both walls and floor are wood after all, so attaching shelves, benches, or what not can easily be done just by a few screws. The south facing window wall is also a great place to grow a lot of plants behind. With three separate rooms and a lot of common space it could even be shared by friends instead of a family. I think that a strength of the project is its flexibility.

THE ROW HOUSE CONTEXT

As mentioned earlier the project is placed in a row house context, it is designed to share part of its west and east wall with neighbouring houses to save material and building time. However as I imagine it each part of the row would be built separately. Using second hand material there is limited inventory which makes it difficult to design a larger complex with it, but it is kind of a missed opportunity. If I would have designed for the row house as one single structure designed for reuse it could have lead to some very interesting results, but since I wanted to delve into the build order I think it might have been good that I limited myself to one part. There is however a lot of potential to further the project by looking into how it would look designing with the row house context in more focus. Such as what would be standardised for each part and how you could design in order for each part to be able to use second hand material to make itself unique.



THE WINDOW WALL EXERCISE

Designing the window wall for the project was a good experience to learn what challenges there is from using second hand building components. I started looking at windows with the idea in mind that they could be assembled together to make a window wall, and I found several windows all with the same paint job, most likely from taken from the same origin, that could work. To get some idea of what quality I was dealing with, which sometimes is difficult to assess when it is second hand. I tried asking for information but the staff did not know. In the end I made my own evaluation by checking how many window panes they had, how damaged the frames were and if the glazing were solidly attached to the frames. In addition to the frame and glazing being in good shape every window I chose to use had at least two layers of glass, to ensure some sort of insulating property, and they were all of the same frame thickness to make it easy to assemble them. I mapped which sizes were available and which could open or not and then began designing the window wall. That several of the windows were the same size helped out quite a bit. I placed some of the windows that could open at the top for the possibility to open during hot days to create natural ventilation. The window wall would be constructed by screwing the windows together, frame to frame (they were all wood), with insulation stuck between them to reduce the possible draft and then have skirting boards cover the gaps.

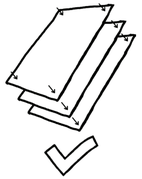
My experience using second hand products in my design lead me to realise two important things to consider when designing with the intention of using second hand components, mainly inventory and quality. Inventory is what limits you, and also what enables you, but in most places that sell second hand inventory is not listed and therefore you will have to go treasure hunting yourself, which can be a great inspiration. About quality the best way is to not use the product somewhere where lacking quality would be disastrous, in the case of my project the window wall is facing south so even during winter the sun will warm the windows quite a bit, and during summer, the top ones can be opened for natural ventilation and are shaded by vines.

DESIGN PARAMETERS

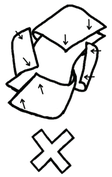
The key parameters in the design can be seen to the right and was a good reminder throughout the design of the project. They mostly deal with ensuring that the building components would be able to be detached and reused. Starting from the top of the page, to design in simple layers means that there should be a clear logic to how things are put together in order to make construction/disassembly not only possible but easier and faster.

Using fasteners that are reversible and joiners that can be detached deals with how you connect different building components. The fasteners and joiners should be non-intrusive on the materials, to leave it in as good of a condition as possible for reuse. It is also good to use as few different types of fasteners and joiners as possible to prevent the need of changing tools during construction or disassembly.

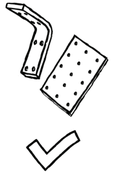
To keep materials pure and whole, means to keep the material useful for future reuse. The reuse of a material is limited if it is stained, damaged or cut. However since wood is used a lot in this project and in varying grades, even if the materials are cut the leftovers can be used somewhere else, such as wood chips are both used in OSB and as insulation.



DESIGN IN SIMPLE LAYERS FOR EASY CONSTRUCTION/ DISASSEMBLY

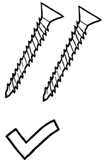


NO WRAPPING LAYERS APPLIED IN MANY DIFFERENT WAYS



USE FASTENERS THAT ARE REVERSIBLE

NO DAMAGING/ PERMANENT ADHESIVES



USE JOINERS THAT CAN BE DETACHED

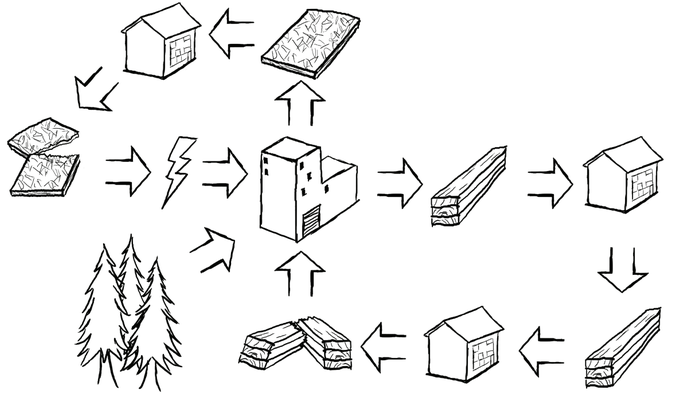
NO NAILS/ PERMANENT JOINERS

KEEP MATERIALS PURE & WHOLE

LIMIT DAMAGE/ PERMANENT CHANGES TO MATERIALS

THE CYCLE OF WOOD WITHIN THE PROJECT

Wood is a very common material in Sweden and the country is a big manufacturer of it. It is also part of a natural cycle and the industry works towards sustainable production. The project being situated in Sweden, makes wood a local material and together with the ability to efficiently recycle it, makes it a suitable material for the design. Wood is used throughout the project for different purposes, such as structural beams, facade material, interior walls and flooring. These different purposes have different demands on the wood, for example the structural beam requires a high standard, while the flooring is OSB (oriented strand boards), consisting of wood chips. The idea is that, for example, if a beam has lost some of its structural properties with age that it could be downcycled and still used in the project as something else. Even if it's not possible in the same project, creating a demand for the downcycled products could reduce the waste of material.



The diagram represents wood's lifecycle as part of the project, first as wooden beams, being reused in different projects and when deteriorated returned to the manufacturer and recycled into OSB for another project and finally as energy at the end of its lifecycle

PROJECT DESIGN

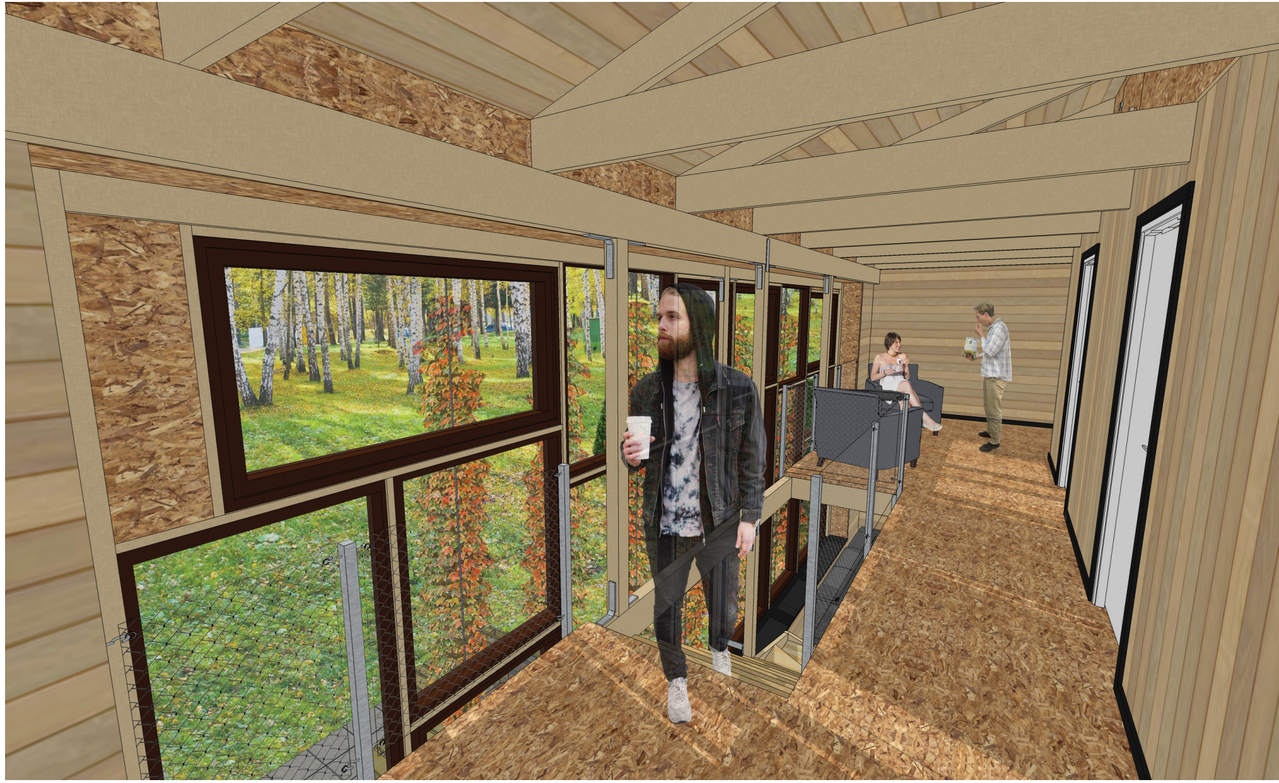
RESULT & COMMENTS

The final design would blend in smoothly in most villa areas, showing that designing for reuse and recycling can still make for familiar aesthetics. However when looking closer the design gives away its purpose. Screws, bolts and fasteners are visible and easy to access, materials are chosen to suit the intention of reuse and recycling, which combined with some second hand materials lead to a unique design. The most notable part are the window wall facing south consisting of second hand windows from Återbyggdepån. It ensures that the living room and kitchen receives plenty of daylight, and during the summer it is shaded by seasonal vines climbing steel wires attached to the facade, to protect the building from heat and the glare of the sun. The outdoor area is paved by second hand stone tiles and the balcony is designed with metal components for easy disassembly and can be attached directly to the facade for easy construction. Indoors you are met with two different wood textures, the planks covering the walls and the rougher texture of the OSB floor. The structural beams are clearly visible and so are the metal fasteners connecting them, screw heads are not hidden and the ventilation pipe is in clear sight on the first floor. With the interior walls being solid wood and only attached to the floor and walls with screws the walls could be moved/removed without too much effort to make the rooms on the upper floor smaller or larger. Above the bedrooms on the first floor there is space for storage as well as built in closets in the hallway leading to the balcony. Moving in to the bathroom you are met with a different material, brick tiles from Återbyggdepån and a bottle wall made with used bottles and concrete functioning as a window.

The house is designed with the idea of limiting different building components to a minimum, so most components are repeated throughout the project and vary very little in size. This is to ease construction and disassembly but also to ensure that if the house are disassembled the components would be able to be used in a different context.

In front of the south facade during a nice summer evening

Kitchen and hallway on the ground floor

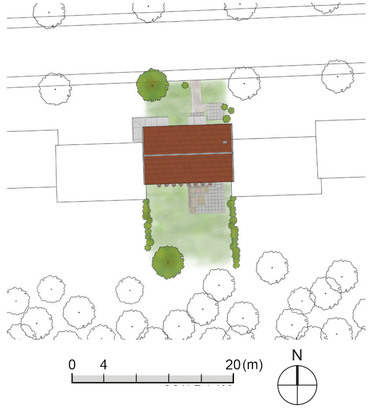


First floor hall way with a great view through the second hand window wall

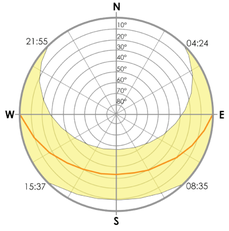
The bathroom with the bottle wall window

PLANS, SECTION & ELEVATIONS

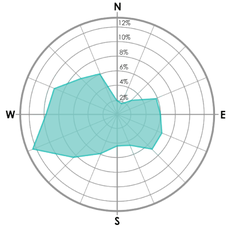
The site of the project is fictional but the data of the environment is taken from the weather conditions of a site in Malmö, Sweden. With the building being situated as it is, the garden has sun most of the day and the balcony during summer evenings. The living room, kitchen and common space gets the most daylight being situated towards the south while the bedrooms are kept cool during the summer being situated to the north.

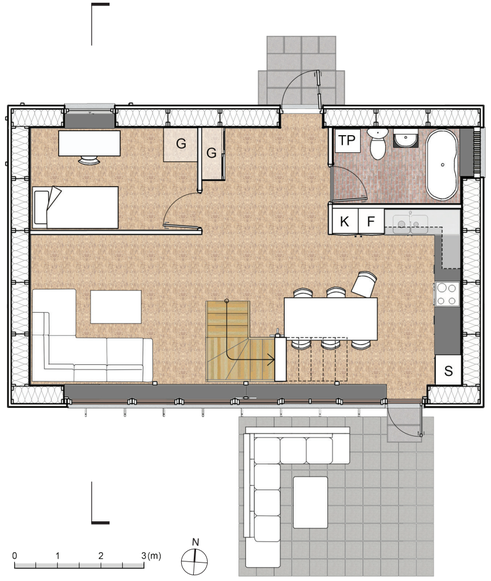


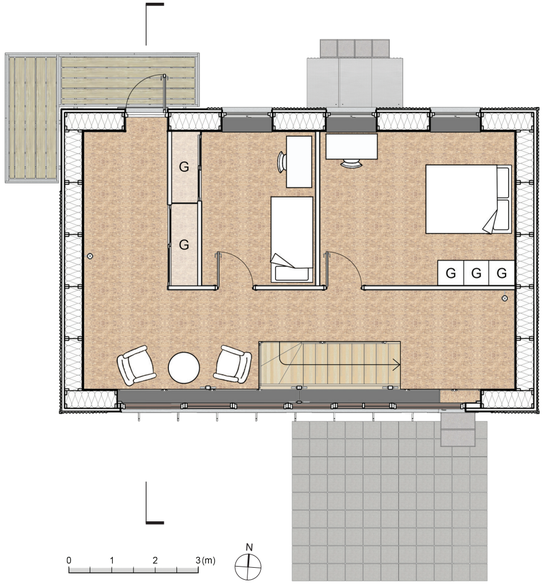
SUN

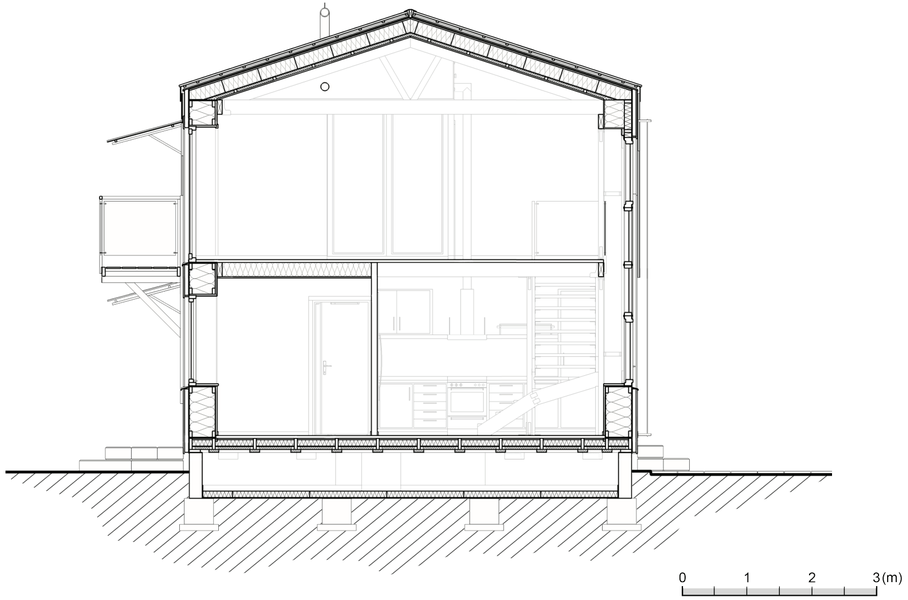


WIND





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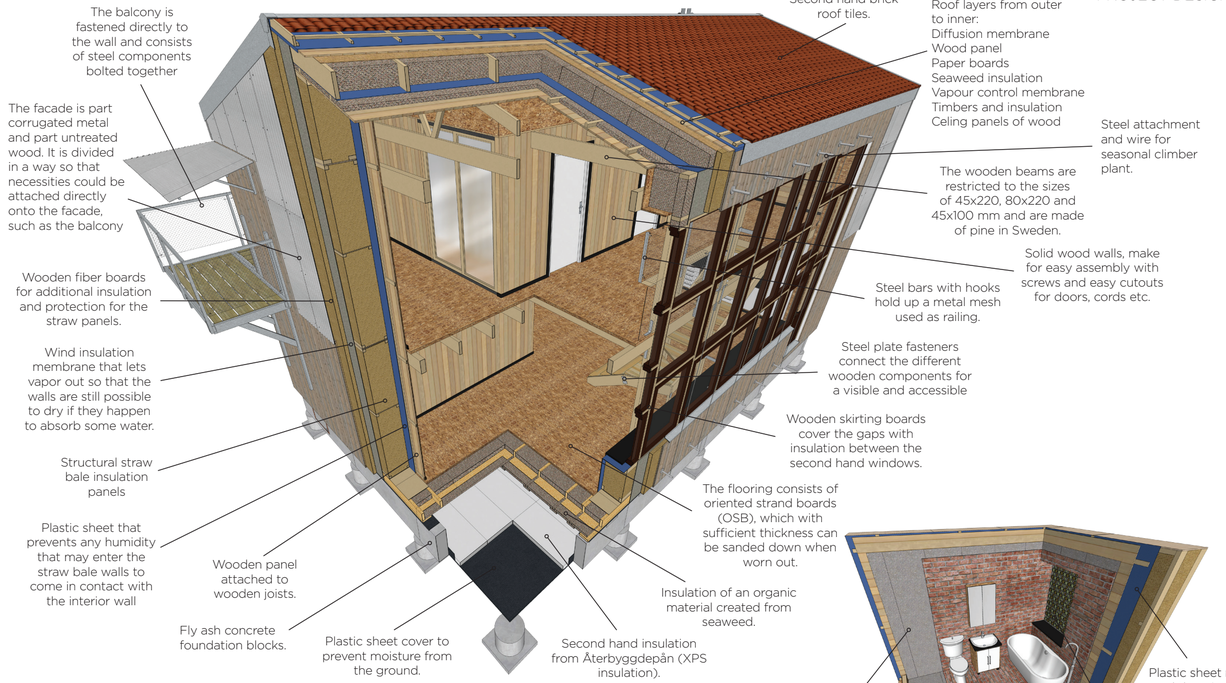
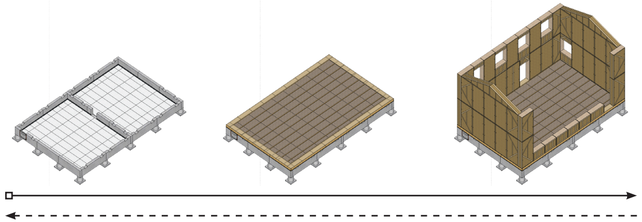


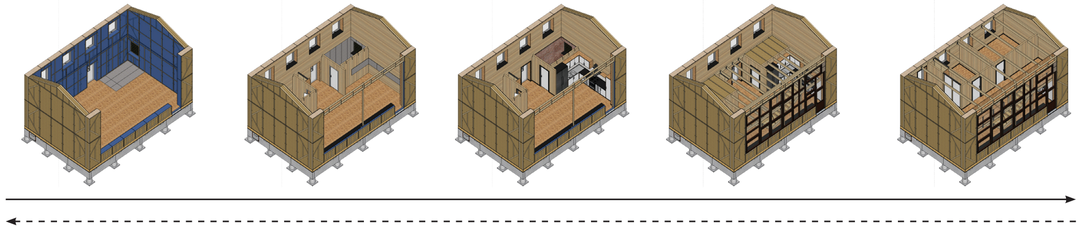
CUT PERSPECTIVE OVERVIEW

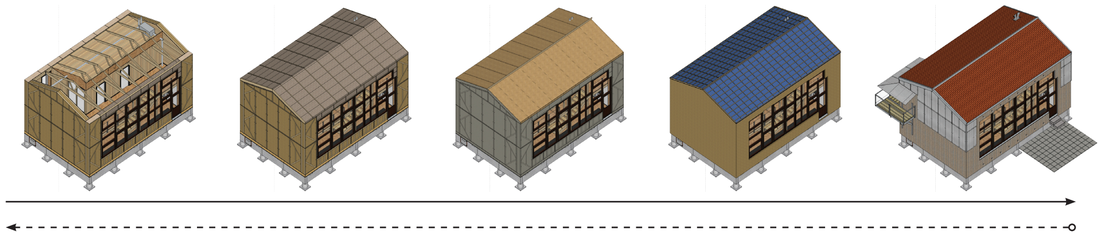
To get an overview of all the layers and parts here is a cut perspective with labels and notes about the different components.

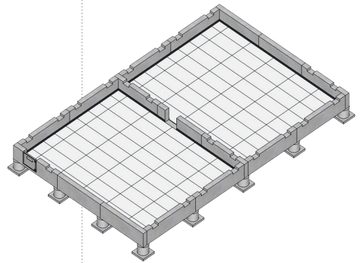
BUILD ORDER & DETAILS

This section will deal with the order of how one could build the design, with the disassembly simply being it in reverse. There will also be some additional information regarding some of the details of the project.









In the first step foundation blocks are placed & ground insulation installed.

Concrete is something that generally can not be reused, but it is possible if you cast parts and use reversible joinery as in the case in image 13, which is a prototype developed by Martin Ravnsbæk and Hans Nicolai Søndergaard. You can further reduce concrete's environmental damage by using fly ash concrete. Fly ash is a waste material gathered from filtration of coal combustion, and can be mixed with cement for a good concrete. This uses a waste material that would otherwise be released in the air or put in a landfill.

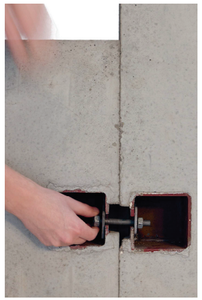
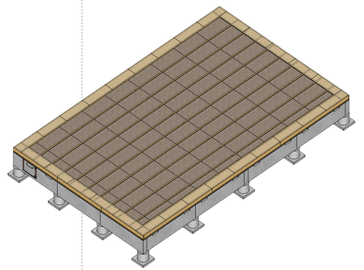


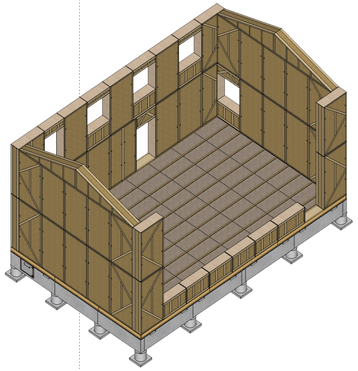
IMAGE 13



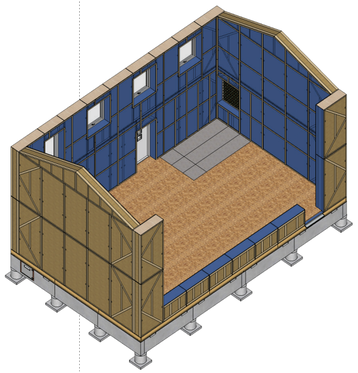
Second step consists of adding floor joists and insulations to create the structure for the walls and floor to be placed on. Seaweed insulation is a great, organic insulating material that can be recycled and is environmentally friendly in its production. It is cradle to cradle certified and made in Denmark which is close to Malmö.

IMAGE 14

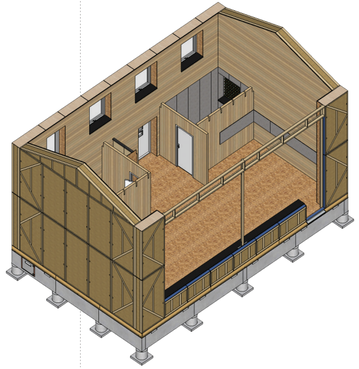
Then the straw bale panels are assembled on top of the base to make the structural wall. A straw bale panel, is compressed straw in a wooden frame, working not only as an insulating material but structural as well, making it easy to add layers on. They are easily assembled simply by screwing them together, which also makes it possible to take them apart without damage to the material. This makes them ideal for this kind of project which aims to reuse most building components. The material is cradle to cradle certified, meaning it can be recycled efficiently and has low if any impact on the environment. Consisting of straw and a wooden frame it could be manufactured locally, even though it is not currently made in Sweden but in Lithuania



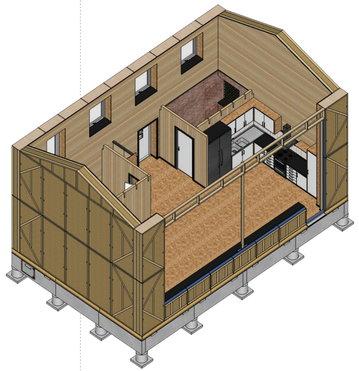
Floor, doors, windows and a water proof layer is then added. The water proof layer is to avoid condensation inside of the wall. Backerboards are added as flooring in the bathroom to avoid water damage.



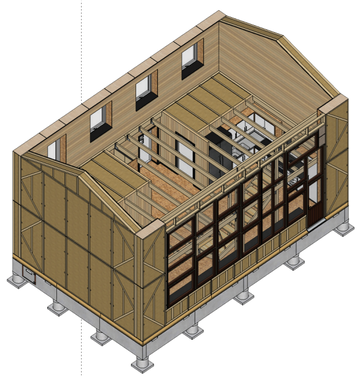
The interior wall panel is attached and interior walls and doors are added, as well as support for the window wall. Backerboards are added on the walls inside of the bathroom and also where kitchen will be. Solid wood are used for the interior walls, making it possible to just screw them directly into the floor and walls, and to make any needed cutouts easily.



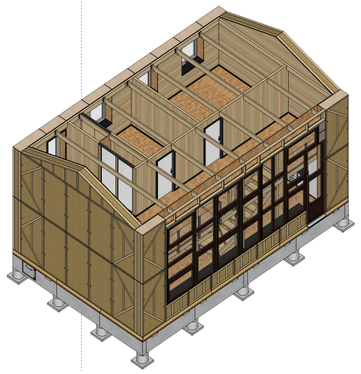
Skirting boards and kitchen added. The sink and kitchen tiles are second hand from Återbyggdepån, as well as the brick tiles for the bathroom finish.

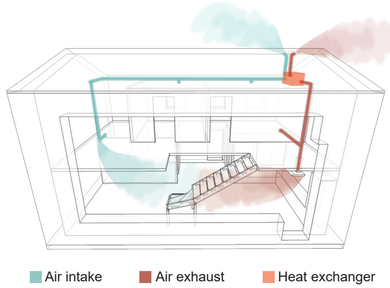


The ceiling for the two rooms on ground floor is added and wood chips are put on top as a light sound dampener. At the same time beams to support the upper floor are installed and the window wall constructed. The window wall consists of several different sized second hand windows of good condition from Återbyggdepån in Malmö.

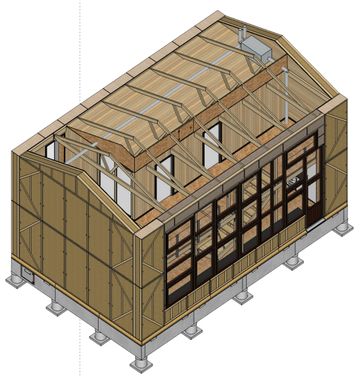


In this step the upper floor is added with interior walls and supporting beams for the trusses.

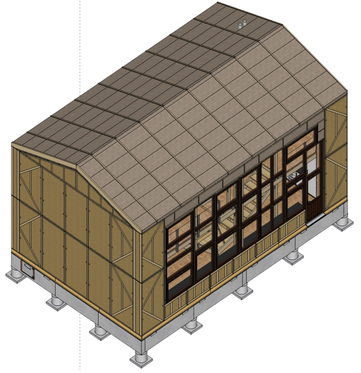




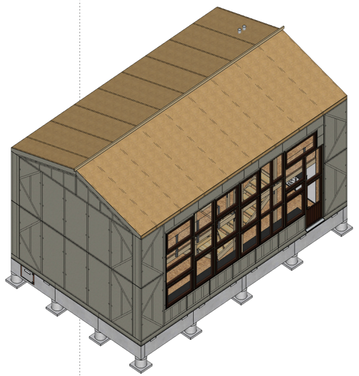
Then the roof trusses, ventilation pipes and room ceiling are installed. Then the space above the rooms are closed off by a thin wall to be used as storage and hide the heat exchanger. How the ventilation is intended to work is demonstrated in the diagram to the left.



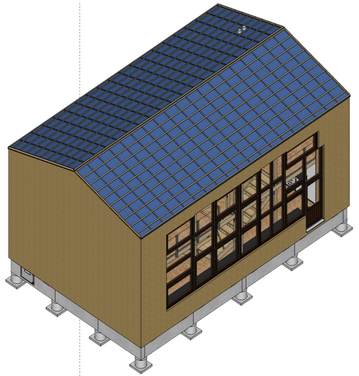
Ceiling boards and roof insulation installed and with that most of the interior layers are done so that the building can be packaged.

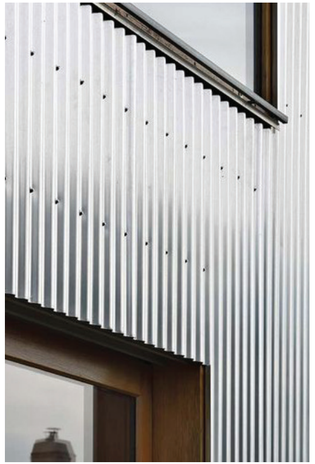


Wind insulation membrane and roofing felt are added. The wind insulation membrane can still let vapor out so that it is possible for the walls to dry if water would get inside.



Water proof layer for the roof and framework on top to fasten the roof tiles on. On the facade a layer of wood fiber is added for additional insulation.

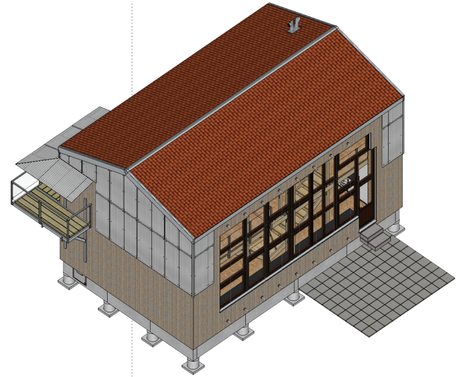




Reference picture of a corrugated steel facade

In the final step garden tiles, balcony, exterior facade, roof tiles, chimney, wires for the climbers and the roofs above the balcony and entrance are built.

The exterior facade consists of two materials; corrugated steel attached with bolts and pine wood. Steel is good as material as it is possible to recycle all of it into a new product and it is not uncommon to appear at second hand retailers. Pine wood grays as it weathers which goes well with the steel and is manufactured locally in Sweden. The two facade materials gives the project a more interesting look and show that the exterior can be a patchwork of different materials, even though in this case it is only two. Part of why I avoided using only the corrugated steel was because I wanted to fasten the balcony directly on the facade and show case fasteners and joiners because of the philosophy of the design.



CONCLUSION

REFLECTION & FURTHER DEVELOPMENT

I believe that in the end I finished with a design that accomplished most of what I set out to do, but if I have any regrets it is that the exterior looks kind of bland and does not speak a lot about the philosophy of the project, even though it is somewhat shown from the north facade by the balcony I think I could have done more if I were perhaps bolder. I would also have liked to show more of the ideas I had of the interior, show casing joiners, fasteners, ventilation, electronics and pipes, stuff that is usually hidden away, but I learned that showing those small things demands another scale and is very time consuming and therefore the priority fell in favor of the over all expression. For further development what was mentioned could be something that would make the project speak more for itself, something I believe it needs a but if help with right now. I would also have liked to develop the project further in its context, meaning how is the row house constructed to be efficient to build, disassemble and to enable reuse.

FINAL REMARKS

When working on the project I have tried to the best of my abilities to make rational decisions in the design so that the project is kept realistic. This has been important throughout the process since the project is supposed to be a comment on designing sustainable, and if the project is something different in reality then the point is lost. By trying to live up to this standard I found myself often getting lost in details that in the end had little relevance to the project or did not even deserve an inclusion in the material presented. In the end I found myself excluding material for a clearer picture, and can not help think that a lot of the time used has been mulling over choices and details that when showcasing the project are too minor to even include. However by working that way and through designing the different layers in my project I feel like I have learned a lot about construction and what comes after the concept drawings in regards to planning. I feel like I have been reminded about all the different aspects to consider when designing architecture and why the design and planning of a building often is a cooperation between many professions. In that regard I am happy in my decision of thesis project though there is much I wish to improve on. Would I do it again I would have prioritised differently, and given the project more of an architectural focus. Making this degree project has been an enormous learning experience, which I hope will assist me in my future endeavours. I hope that you who have taken time to read this thesis found something of interest and would like to thank you for taking your time.

SOURCE REFERENCES

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SEAWEED INSULATION
https://www.c2ccertified.org/products/scorecard/seaweed-insulation

IMAGE REFERENCES

FRONT PAGE - Fasteners
https://newwalls.as-creation.com/en/wallpaper_search/470408.html

IMAGE 1 - Waste from building
https://www.alba.info/en/waste-management/trade-and-industry/waste-from-building-dismantling-and-demolition.html

IMAGE 2 - Building a circular future - Depletion and recycling of known resources
https://issuu.com/3xnarchitects/docs/buildingacircularfuture page 27

IMAGE 3 - Building a circular future - Linear value chain
https://issuu.com/3xnarchitects/docs/buildingacircularfuture page 219

IMAGE 4 - Building a circular future - Value circle
https://issuu.com/3xnarchitects/docs/buildingacircularfuture page 208

IMAGE 5 - Building a circular future - Guidelines on designing for disassembly
https://issuu.com/3xnarchitects/docs/buildingacircularfuture page 77

IMAGE 6 - ICEhouse, Davos, Switzerland - Photo by Brady Johnson
http://www.mcdonoughpartners.com/projects/icehouse/

IMAGE 7 - Building a circular future - ICEhouse frame element
https://issuu.com/3xnarchitects/docs/buildingacircularfuture page 53

IMAGE 8, 9 - Upcycle house by Lendager Arkitekter - Photos by Jesper Ray
https://www.archdaily.com/458245/upcycle-house-lendager-arkitekter

IMAGE 10, 11 - Brighton Waste House by BBM Sustainable Design - Article by Hattie Hartman
https://www.architectsjournal.co.uk/buildings/brighton-waste-house/8666191.article

IMAGE 12 - C2C family house by Jouke Post, Frido van Nieuwamerongen and Arconiko Architecten - Photo by Jeroen Musch
https://www.dezeen.com/2017/02/14/first-cradle-to-cradle-house-netherlands-xx-architecten-rconiko-architecten/

IMAGE 13 - Concrete prototype developed by Martin Ravnsbæk and Hans Nicolai Søndergaard - Photo by GXN
https://issuu.com/3xnarchitects/docs/buildingacircularfuture page 98

IMAGE 14 - ECOCOCON straw bale panel
http://www.ecococon.lt/english/straw-houses/building-proces/