OLD INTO NEW

A TRANSFORMATION OF AN INDUSTRIAL BUILDING

© Viktor Bienek
Master Thesis Spring 2022
Examiner Paula Femenias
Supervisor Walter Unterrainer

Chalmers School of Architecture
Department of Architecture and
Civil Engineering

Gothenburg Sweden
Contact Viktor.bienek@gmail.com

ABSTRACT

I have always liked the idea of former industrial buildings being used for communal purposes. That's what they were built for in the first place. So, if it can't be a factory anymore, what about transforming it into architecture for the local community, such as co-housing, a cultural centre, or something similar? Something that the community benefits from. The number of vacant factories, warehouses, and mills in the rural area of Sweden is still high. Spinning mills, paper mills and other industrial buildings were often built near rivers, which served as an energy source. With an industry, society began to build up, which was mostly dependent on the factory economy.
Today, many industrial buildings and former factories are abandoned, or used for a temporary purpose. They are omnipresent and often go unnoticed, but they exist as a valuable resource and offer a great opportunity for community projects that could enrich the lives of many.

This thesis looks at a particular former spinning mill in Alafors, a community in the rural area of Gothenburg. The factory area consists of several buildings and has been partly developed in the past. However, the current concept is unclear, but the municipality and the property owners see great potential for further development.
A new concept focuses on a mixed-use that creates synergies within the factory site, but also beyond its boundaries. With appropriate new functions, financial risks are spread and lead to resilience for future happenings. New functions can feed off each other, making a scheme more attractive to all users and giving it long term vitality.

An evidence-based design proposal focuses on one building specifically and displays improvements in its environmental impact through an iterative design approach. This was performed through different design tools. Architectural qualities, such as functionality, proportion and materiality, have been investigated through literature, interviews, and design experiments.
The outcome of this thesis is an appropriate new architectural programme for the former spinning mill in Alafors that includes all aspects of sustainability. Social, ecological, and economical.

ABOUT ME

ABOUT ME

VIKTOR BIENEK

A strong believer in the ability of architecture and research combined with design thinking for strengthening our societies and having a positive effect on the world.

EDUCATION

September 2020 - June 2022
M.Sc. Architecture at Chalmers University

March 2014 - September 2017
B.Sc. Architecture at BHT Berlin

WORK

February 2018 - July 2020
Junior Architect at CCM Berlin

ACTIVITES

May 2017 - June 2020
Technical drawing at André Bednarczik Art Gallary

SPECIAL THANKS TO

Walter Unterrainer, my supervisor, who was always a great help to develop my idea and accomplish this thesis.

Paula Femenias, my examiner, for the great feedback and encouraging me to develop my ideas.

Anders Andén & Katharina Bodén who have introduced me to the site and provided me with all the necessary information.

Ylva Frid for introducing me to the Not Quite collective and showing me around the former paper mill in Fengersfors, which has become my case study in this thesis.

Alexander Hollberg for providing the Life Cycle Assessment tool to me and helping me with questions.

All interviewees, Barbro Sundstrom, Maria Sexton, Sofia Jönsson, Birgitta Lundquvist and Emris Bodén, for your time and for helping me with all the questions I had.

Familie and Friends, who always cheered on me and were available when I needed them!

TABLE OF CONTENS

TABLE OF CONTENTS

INTRODUCTION

MOTIVATION

There is a big value in derelict buildings that policy makers, urban planners and property developers often don't see at the first glance. The idea of economic value tends to dominate when dealing with buildings that face restoration or even demolition.

From personal experience, I know that buildings with cultural values are generally well-liked by people and play an important part in a community's identity. Unused buildings or such with a transitory purpose are common and sometimes go unrecognised, but they are a valuable resource that can strengthen a whole community after a transformation.
Furthermore, I am convinced about the benefit of remodeling existing structures as it leads to more circularity and therefore a decrease in the carbon, energy and water footprint.

I am really motivated to increase the sustainability of a project by giving it a new meaning which is controlled by Life Cycle Assessment (LCA). LCA can be used as an effective tool to evaluate the building's environmental footprint, but is still a niche in the construction industry and is often seen as too expensive to be implemented into the design phase. Therefore, this thesis is also a demonstration of how such design tools can support the reduction of carbon emissions and lower the environmental impact of a project.

RESEARCH QUESTION

HOW CAN A **TRANSFORMATION** OF AN EXISTING **INDUSTRIAL BUILDING** ENHANCE THE THE QUALITY OF LIFE IN ITS LOCAL TOWN?

AND HOW CAN DESIGN TOOLS OPTIMISE THE OUTCOME IN ITS **ENVIRONMENTAL PERFORMANCE**?

METHODS & CONCEPT

METHODS

The outcome of this thesis is an evidenced-based design transformation for an old factory building and an appropriate new architectural program for its location site in Alafors. Therefore, the process is divided into three different parts.

Investigation, Iteration & Transformation

The starting point of this project was to identify local characteristics and demands. This was done with a site analysis, a case study, literature and interviews, which have built the foundation for a new architectural programme.
The design part is an iterative process for one chosen building, where the finding from experimenting with design tools are translated, iterated, and evaluated.
Finally, the transformation of the site and the evidenced-based design outcome are summarised and demonstrated in form of illustrations and architectural drawings.

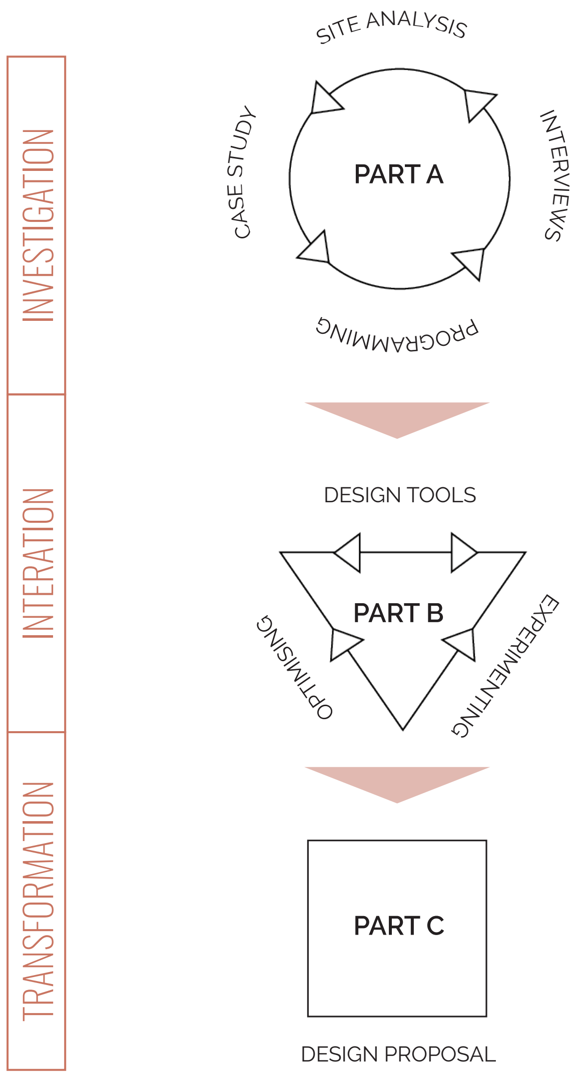
RESEARCH FOR DESIGN

Site analysis
Interviews
Literature

RESEARCH BY DESIGN

Case study
Modeling
Experimenting (material, daylight & form)
Life Cycle Assessment

CONCEPT



APPROACH & DELIMITATIONS

APPROACH

SOCIAL

This thesis proposes a new architectural programme for the former spinning mill in Alafors, located in the rural area of Gothenburg. A further approach is the investigation of synergies between the architectural proposal, the local community and beyond.
The outcome was performed by interviewing locals and architects, the analysis of a case study and a literature review.

Example: What values do the locals see in the former spinning mill? What is missing in the area and what new functions could take place in the transformation? What synergies can be created?

ECOLOGICAL

This thesis compares different design strategies regarding the material selection, energy supply, daylight covering, and shape. The outcome will be an evidence-based design with a reduced ecological footprint performed by selected design tools.

Example: How much emission can be saved by transforming such a building? What strategies can help us to reduce the energy demand during operation?

ECONOMICAL

The new architectural programme looks at economic models that lead to more resilience for future happenings.

Example: How can the new architectural concept support its local community and also generate financial resilience for the future?

DELIMITATION

DESIGN

All design decisions follow basic principles and are done based on estimates. However, there has not been any detailed calculation by a qualified structural engineer.

While this thesis proposes a new design for two buildings on the factory site, the main focus lies on building A, which is also evaluated through a Life Cycle Assessment.

LIFE CYCLE ASSESSMENT

LCA models are always simplified versions of reality, and they must be handled as such. As it is described in a paper by Matthew Eckelman: „all models are wrong, but some are useful." We should not expect that LCA results will provide exact information on the absolute carbon footprint of a product. LCA models are only as good as the data that is used as a background for the calculation. It is vital to understand how the tool works, and that minor changes regarding the study period or the included life cycle stages will lead to a major change.

Prices for products vary worldwide, especially in a time where inflation and global conflicts lead to shortages and delivery bottlenecks. Therefore, a Life Cycle Cost (LCC) Assessment was not included in the project and the focus is mainly on the building's energy and carbon emissions.

THEORY

LIFE CYCLE ASSESSMENT

WHAT IS LIFE CYCLE ASSESSMENT (LCA)?

LCA is used in the construction industry as a tool to measure the energy and emissions of a building throughout its life cycle. Minimising energy consumption and CO2 emissions is an important contribution to the fulfilment of climate objectives. The life cycle is divided into different stages: from raw material extraction, manufacturing/assembly, transportation and distribution, use, maintenance, and disposal/recycling.
Evaluating the environmental impact of a building helps us find opportunities to reduce it already in an early design phase (Goldsteijn, 2020).

WHY IS LIFE CYCLE ASSESSMENT IMPORTANT?

Buildings have a significant impact on the worldwide total natural resource and energy consumption. The constructions industry accounts for nearly 40% of the yearly emission in the world (Global Status Report, 2018). We need to act on this issue and reduce the environmental impact of the construction industry.
Therefore, concentrating on design principles like choosing low-impact materials, and reducing the energy demand during the operation phase, will help to lower the environmental impact of a building. This is especially important in an early design stage, as early choices have the greatest impact on a building's life cycle.
(Zhang, Wang, Hu, & Wang, 2017).
Today, numerous LCA tools for the compilation of buildings-related emissions throughout the life cycle are available on the market, such as CAALA.

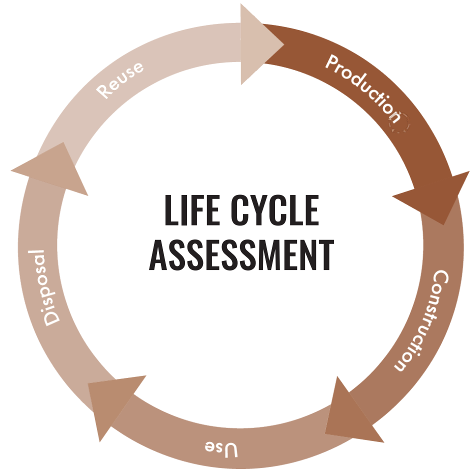


Figure 1. Life Cycle Stages

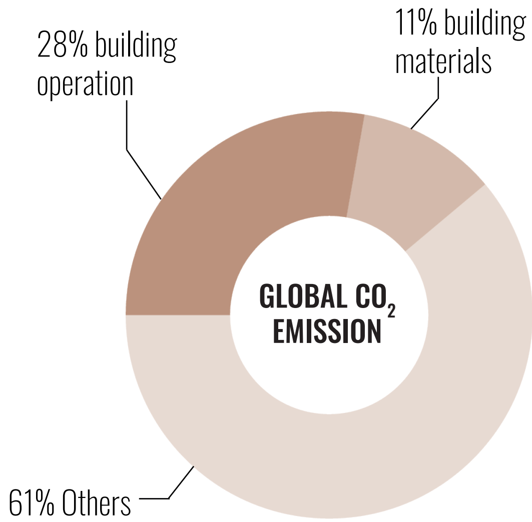


Figure 2. Global CO_2 emission (Global Statut Report, 2018)

LIFE CYCLE ASSESSMENT & CAALA

EMBODIED IMPACT VERSUS OPERATIONAL IMPACT

The building's impact can be divided into two main fields, embodied impact and operational impact. Operational impact describes the CO_2 emission emitted through energy use, while embodied impact describes the emission from materials (Fig.3) (Sartori, Hestnes, 2007).
The main energy consumption arises during operation, whereby the operational energy demand depends mostly on climate conditions. For example, buildings in extreme climatic regions require more operational energy to meet the heating and cooling demands. The reduction of operational energy is often achieved by using more materials (e.g. insulation) and thereby increases the percentage of the embodied impact (Menzies, Turan, & Banfill, 2007).

Furthermore, the choice of materials has a significant influence on the embodied impact of a life cycle. For example, cross-laminated timber (CLT) chosen in place of concrete can reduce the embodied emission by around 60% (Spear, 2019). There is also the circular economy module, which can be included into the Life Cycle Assessment. This module provided information beyond the building life cycle. This means that the benefits of disposal and recycling of materials are taken into account. However, this stage is a speculation and often not included in a building's LCA.

COMPUTER-AIDED ARCHITECTURAL LIFE CYCLE ASSESSMENT (CAALA)

CAALA is a design tool that is created specifically for architects to optimise their designs at an early stage and to reduce the environmental impact of a building. The tool includes Life Cycle Costs, energy demand, and CO_2 emissions all combined in one software. CAALA includes the stages A1-A3 (Production), B4 (Replacements), B6 (Operational energy usage), C3 (Waste processing), C4 (Disposal), and D (Recycling potential) (Fig.4). The tool incorporates both embodied impact and operational impact, but also gives the option to display module D, which takes into account the benefits even beyond a building life cycle (Hollberg, 2017).

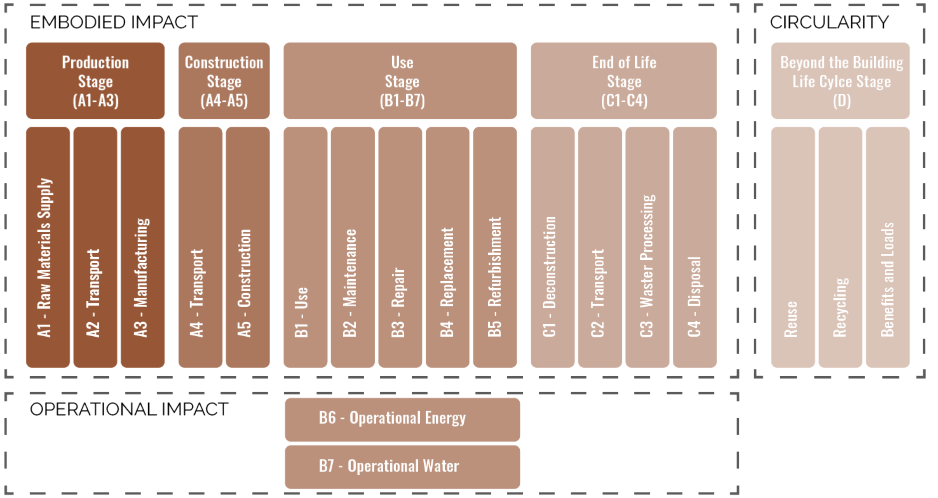


Figure 3. Building life cycle stages (Overbey 2021)

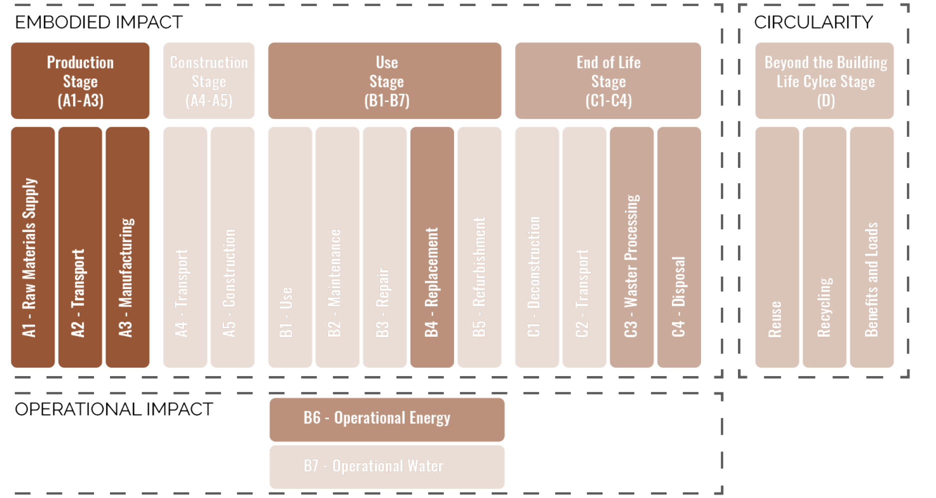


Figure 4. Selected life cycle stages in CAALA

LIFE CYCLE ASSESSMENT & CAALA

HOW DOES CAALA WORK?

CAALA works as a plugin and needs a simplified 3D model to start any calculations. The building elements are divided into those affected by thermal losses during operation (Layer A) and those that are only relevant for embodied energy from the materials (Layer B). During the operation of a building, thermal losses are influenced by all exterior building components (Fig.5). All other building parts are not vital for heating loss and only affect the embodied impact of used materials (Fig.6). The designer may then simply change individual elements such as insulation performance, material lifespan, or material thickness, and then see the impact of their design decision displayed directly in a figure. Depending on the type of construction project, the level of thermal bridges and airtightness can be included. Moreover, heating and ventilation systems should also be included for a more precise outcome.

Because electricity demand varies between different functions, the user's electricity needs to be entered manually.

The lifespan can be changed from 1-to 100 years (CAALA, 2020). Since the tool calculates with german standards, it is necessary to change these in the settings if the project is located in a different country.

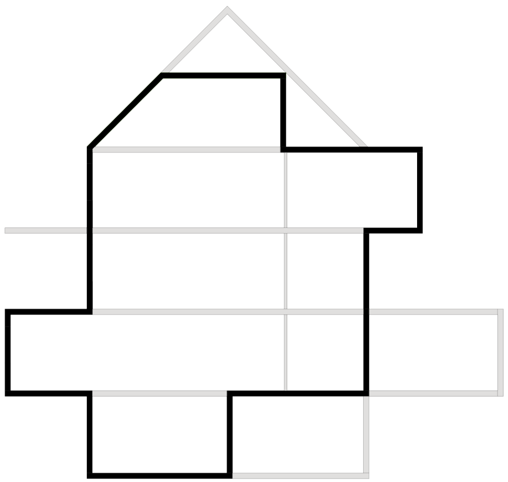


Figure 5. Thermal envelope (Layer A)

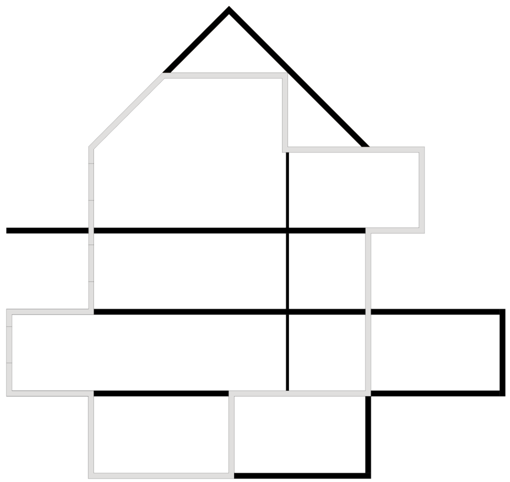


Figure 6. Other building parts (Layer B)

A TENDENCY AND AN ANSWER

The many phases of a building's life cycle account for different amounts of environmental impact. In the past decades, the operational energy use has been decreased, whilst the embodied energy impact has increased. Therefore, design and material choice have to be optimised in relation to the energy use to improve the ecological footprint of our buildings.

WHAT IS GLOBAL WARMING POTENTIAL?

Global Warming Potential (GWP) was developed to allow comparisons of different greenhouse gases that contribute to global warming. The larger the GWP, the more that a given gas warms the Earth compared to CO_2. For example, methane gas has a GWP of 21, meaning that 1kg of methane is 21 times as powerful as CO^2.

The environmental impact of the design proposal in this thesis is displayed in GWP.

CASE STUDY

NOT QUITE

INTRODUCTION

For a better understanding of existing solutions and to study the effect of change in a transformation project, a case study of a similar project was part of my investigation.
The personal contact with involved architects, city planners and locals residents has convinced me that transforming existing structures has potential. All information and data from this case study were collected through interviews and a site visit.

THE SITE

The site of the Not Quite collective is located in Fengersfors, a village situated in the municipality Åmål that belongs to the region of Västra Götaland. The former paper mill Fengersfors Bruk was transformed into a cultural centre for the local community in 2002. The newly developed site allows artists and craftsmen of various kinds to have their studios and workshops in the remodeled buildings. The new cultural centre has become a meeting place for the locals and in a short time made itself known as one of the new main tourist destinations in the region. The combination of art and crafts, with good options for coffee and lunch, has proven to be a successful concept. Moreover, its rural location creates synergies, and a close relationship with the local community which makes this example a successful transformation project of an abandoned industrial building.

Figure 7. Site map of Fengersfors Bruk

SUMMARY OF NOT QUITE

Fengersfors town: 345 inhabitants (2010)

Former paper mill

Area (NFA): 20,000m²

Consists of 13 different brick buildings

Today transformed into a cultural centre with workshops, bakery, exhibition and a boutique shop

Operated by the Not Quite collective since 2002

Members: 70 (10-15 active on site)

Figure 8. Not Quite

Figure 9. Site plan

Figure 10. Café

THE SITUATION TODAY

The Not Quite collective has about 70 members, but only 10-15 actively use the site each day. As a member, you are allowed to use the spaces and sell crafts and other goods at the local boutique shop. Members also host courses, workshops, and participatory events. The place is also used for exhibitions and all kind of performances.
The creative environment and the feel of the old factory make for a special place. Over the years, Not Quite has become a very popular regional tourist destination with about 20,000 to 30,000 visitors every summer.
However, the growing interest and steady development led to a significant increase in the value of the place and as a consequence, the property owners decided to sell it in 2017. Thereby, the future of the Not Quite community is unclear. The collective, which only rents the place, started "The New Plant" project in cooperation with the architect Ylva Frid. The aim is together with public actors, businesses, and private individuals to save the future of the Not Quite collective together with public actors, buisnesses and private individuals (Frid, 2022).

SUMMARISED INTERVIEW WITH YLVA FRID

Architect & Project Manager of Not Quite

Q: In what way did sustainability take a role in the development of the site?

A: [...] The project has become sustainable because the people had very limited financial resources. So, people who were involved in the project needed to be very clever and careful in how they used the resources. And that, I think, is sustainability. There was never a vision or a specific strategy that people followed, but you can look back and extract things that could be seen as a sustainable strategy, but it was never originally part of a concept.

Q: How important is a financial model and are there any opportunities to receive funding?

A: [...] We were also part of an EU research project that was about how you could develop circular economic models for heritage buildings. This has become important since the amount of public funding is decreasing everywhere. Before, you had much more public initiatives that helped to own, maintain and develop places like this. Today, it has become vital to develop your financial foundation without disturbing the cultural heritage that you want to preserve. That takes a lot of time to investigate and we have a lot of ideas, but it is hard to take the next step without owning this place, because that would increase the value of the property.

Q: Why is it that Not Quite is not owning the place already?

A: Culture creates a lot of value, but also rises the price of the property itself, and this gets problematic when you consider buying the place. [...] And right now, the asking price is too high.

Q: What is the next step and are there any further development plans for the factory site?

A: [...] I have also worked on a development plan for the factory area, with things like accessibility and including the parts that are still abandoned but it's tricky when you don't own the place. [...] Because the more you develop the more you raise the value of this place and if you want to buy something, you don't want to raise the value. Because then you have to pay more. So, we are a little bit stuck here with the development process.

Q: What would be your advice to someone who wants to develop a project like Not Quite, a cultural centre for a smaller Swedish community?

A: Think about a timeline. If you use Not Quite as a reference, things happened step by step. Maybe not everything needs to be done at once. There could be strategic functions that should be there first and things can then be developed organically by the residents and people who use the place. [...] Cultural activities are often non-profitable but they are very appreciated. However, profitable functions like housing can subside the less profitable functions. This also leads to a more resilient situation.

LEARNING

The site visit and the interviews with users and planners of the Not Quite collective have helped me to understand the complexity of such a transformation project. Some of the findings can be summarised as follows:

ORGANIC DEVELOPMENT

Often a small budget is enough and the site will develop organically when people start to use it.

VALUE

Cultural use often increases the value of a location.

NON-PROFIT

Cultural is a great asset to a community and should be non-profitable. However, other functions on-site, like housing, can be used to subsidise cultural activities and make a project more economically resilient.

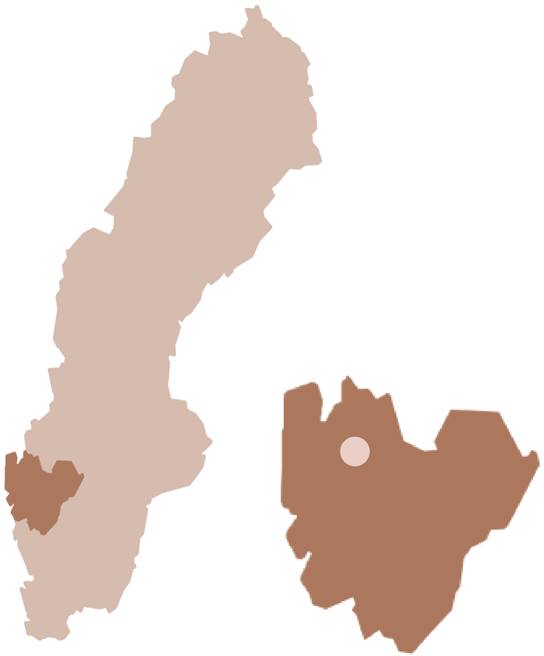
Figure 11. Exhibition hall

Figure 12. Workshop

Figure 13. Smithy

PART A

THE SITE



LOCATION

The former spinning mill is located in Alafors, which is part of the urban area Nördinge-Nol in Ale municipality and belongs to the region of Västra Götaland. Alafors is situated approximately 25 km north of Gothenburg. The whole area of Nörding-Nol is well connected to the infrastructure system and easy accessible by car. However, to get there with public transportation, people have to switch from train to bus. This makes it more complicated if you don't have access to a car, or are too young to drive.

CLIMATE

Around Gothenburg, the summer can be comfortable, but often cloudy. The winter is often long, cold and can be very rainy and snowy. Over the course of the year, the temperature typically varies from -3˚C to 21˚C and is rarely below -12˚C or above 26˚C. On average, it has about 11 rainy days and 143 hours of sunshine a month (Weather Spark, 2022).

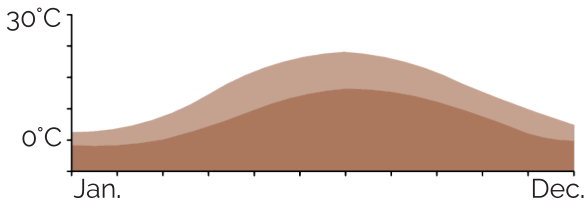
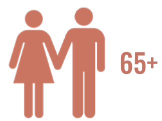


Figure 15. Average min. and max. temperature in Gothenburg, Sweden

DEMOGRAPHICS

Alafors has experienced a steady increase in its population the last decades. In 2020, the town was inhabited by 1.850 people.
Approximately 385 inhabitants are 65 or older and 43 of them are receiving home care on a daily basis. There are also around 412 children between the age of 0 and 18 resident in the town (Statistics Sweden, 2022).

972 (1960)
1.850 (2020)



385 (2020)

412 (2020)

SERVICES

The site (former spinning mill)

Leisure time (food, fitness, etc.)

Education

Under development (housing)

FIRST FINDINGS

A site visit and first interviews with residents have indicated that the community of Ale is lacking cultural activities and people often need a car to experience culture and social activities further away. The opportunity of having such services nearby seems to be highly appreciated.

ALAFORS HISTORY

Before the spinning mill was built, Alafors cultivated only a few scattered farms where agriculture and handicrafts were practised. But with the spinning mill and its industry, society began to grow. Housing for the workers was built around the factory as people moved in. In the beginning, it was mostly outcasts who worked in the factory, while they lived in rented rooms during the week and returned home to their families on weekends.

In the 1860s, primarily young women began to settle and work for the spinning mill. This also meant that houses and schools began to be built and a functioning infrastructure became vital for Alafors. More people began to move in and started their businesses, and various shops were built.
Today, a lot reminds us of the past, like residential buildings, shops, schools, and street names. Many of these buildings are still in use. The „Ahlaforsskolan" is still used for teaching children and the old post office is used as a residential building (Municipality of Ale, 2022).

THE FORMER SPINNING MILL

The construction of the Alafors Spinneri began in 1854 and was initiated by traders from Gothenburg. The location of the factory was carefully planned based on the abundant supply of water, which was common back in the day as lakes and streams around the area were used for the steam engine. In 1855, the construction was completed and the factory was put into operation. Despite the depression in the 1860s, the spinning mill did well and managed to double the production of spun cotton yarn.

In 1889, the company had liquidity problems. As a result, the company was acquired and changed its name to Alafors Nya spinneri AB. Moreover, the factory built an electricity plant as a complement to the gas plant (which powered the lights) and hydropower, which was more reliable.
In March 1905, the factory burned to the ground. The fire started in machine warehouses that were affected by overheating. However, the workers had to help build the new factory, which was just completed one year later, in 1906.
During the First World War, production fell due to a shortage of raw materials and the factory had to close for a whole year. After the end of the war in 1918, the company had major financial problems that were solved thanks to a banking company.

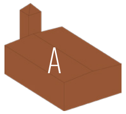
However, additional problems came up when the products did not sell due to lower demand. Therefore, the working weeks were shortened to 4-5 days instead of 6 days.
Despite the setbacks, a new spinning mill and a colour weaving mill were built on site in 1919. A year later, the company also expanded and bought a spinning mill located in Mölndal.
In the following years, the company was doing well and the productivity was stable. However, in the 1950s, the company started to struggle financially and the director of the factory changed multiple times. (Almedahlsföretagen genom tiderna, 1946).
The factory was closed in 1966. With the work being shut down, a more than hundred-year epoch went to the grave. However, the factory itself has not been empty since it closed down. In the beginning, it was various small companies that rented premises, such as a car workshop and a paint company. Other rooms have been used as rehearsal rooms for local rock bands. In the mid-1990s, associations also began to move into the old premises and 26 small micro apartments for younger adults as well as a theatre have been developed. It was also during this period that Ahlafors Breweries moved in. Today, the place is mainly used for temporary purposes, which gives great opportunity to improve the space by further development (Ahlaforsbryggerier, n.d).

Figure 16. 1890

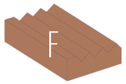
Figure 17. 1916

Figure 18. 1931

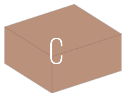
BUILDINGS ON SITE



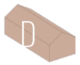
- Former weaving factory
- 4 floors
- Used for storage today



- Former weaving building
- 3 floors
- Consists of a gym and space for storage



- Former weaving factory
- 4 floors
- Partly developed.
Consists of a brewery,
- home care office, a theater and micro apartments



- Former office building
- 1 floor
- Used for storage today

CULTURAL HERITAGE?

The factory site is not documented as cultural heritage. That gives a lot of opportunities for transformation but also comes with the risk that investors can buy the property and allow them to do whatever they want.

EXISTING ARCHITECTURE

Today, the factory site at Alafors consists of 3 main brick buildings and a small office building. Building A (built in 1854 and rebuilt 1905-1906) consist of a four-story cotton mill with an adjoined sprinkler tower.
Building C (built 1918 and extended with the 3rd and 4th storeys around 1926) is also a four-story factory building but with a basement. Building F is a two-storey building with a saw-tooth roof. However, the roof has been extended to provide one extra floor for more storage space (built 1896-98 and extended roof built 2011).
Due to the poor condition of the masonry, the chimney was demolished in 2003.
The factory site has a lot of features that make it interesting from an industrial heritage point of view. The environment preserved at Alafors today largely reflects a very typical cotton industry environment from the early 20th Century and the transition from the steam engine to electric power. Alafors gives a relatively homogeneous impression in terms of age. Probably no other textile industry site in western Sweden today can present the classical building components, high multi-storey spinning mill buildings, low weaving mill building with a saw-tooth roof, steam plant and cotton warehouse in such an educationally clear way.
From an international perspective, the environment at Alafors is also interesting. Its architecture and the whole concept of the site are strongly influenced by the English industry. For example, it bears a strong resemblance to similar facilities around Manchester, the capital of the cotton industry. These types of buildings were then spread all over the world by machine exporters and some of them are still used for their original purpose. (Andén, 2006)

Figure 19. Building A

Figure 22. Building A, boiler room

Figure 25. Building A, storage space

Figure 20. Building F

Figure 23. Building F, storage space

Figure 26. Building F, gym

Figure 21. Building A & C, back yard

Figure 24. Building C

Figure 27. Building D

CONDITION OF THE BUILDINGS

• There is no active heating system and insulated walls in Buildings A, D & F

• The former boiler room is in bad shape and should be demolished in the near future, however, bricks can be reused for other parts.

• The load-bearing structure of all buildings is in good shape and can be reused in a transformation project.

• All windows are double glazed and still in an acceptable condition. They should be sustained to save costs and materials. However, to achieve an adequate U-value with existing windows, interior windows that function as a double layer should be added.

• Building F has an extended roof to provide an additional story for more storage space. The appearance of this construction interferes with the original shape of the saw-tooth roof. A new proposal will consider a dismantling of the extended roof. Roof construction and metal sheets could be reused for other new parts.

INTERVIEWS

As part of my investigation, the contact with local residents and stakeholders was vital to learn from practice and not only from academia. The aim was to understand the different perspectives of property owners, architects, municipalities, city planners and locals.
Therefore, several interviews were held as they helped me to answer my questions and inspired me to think out of the box.
This helped me shape my design and create a new architectural programme for the Alafors factory site.
For simplification, the shown interviews have been summarised into key comments that are relevant or making design decisions.

The Interviews were practised via Zoom/ Teams, e-mail or personal contact.
(Interview recordings can be found digital, URL is listed in the reference list).

Barbro Sundstrom (Former head of the municipal planning office in Ale) & **Maria Sexton** (Town planner in Ale)
2nd February 2022, TEAMS

• More people are moving to the municipality of Ale & Alafors

• More housing planned in Alafors

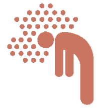
• lacking of cultural activities available in and around Alafors

• Many people in Ale & Alafors work in Gothenburg

• Lack of working space and opportunities for small businesses to rent in Alafors

• Most of the youth centres have disappeared because of economic problems

Sofia Jönsson (Former local, Chalmers architecture student)
3rd February 2022, personal conversation



• Missing local places to meet and socialise for children and teenagers

• Younger adults often move to larger cities

Katharina & Emris Bodén (Property owners)
February 2022, e-mail contact

• There is a day care service for elderly located in Building C

• There is great demand for storage in Ale

• Any form of housing and working space is very appreciated in a new design proposal

• There is a brewery located in Building C which seeks an options to sell its product locally

Birgitta Lundquvist (Planning Secretary of Ale)
16th February 2022, ZOOM

• Many of the elderly between 65 and 90 live alone and suffer from loneliness

• There is no alternative to retirement homes and home caring service in Ale

• New housing concept for the elderly are highly appreciated

• Ale has a shortage of rooms in retirement facilities. Many elderly use the home care service as they need support

SUMMARY

After finishing the site observation and interviews, the next step was the brainstorming process. With the knowledge and answers, I filtered the most important parts and started to map out new appropriate functions as well as the best potential spaces for these. The outcome is shown on the next page.

PROGRAMMING

CHOICE OF BUILDING

Because buildings C and D are partly developed and in operation, the new proposal only focuses on buildings A and F. Building A consists of storage space and building F has a gym and more storage space. There are no development plans made in this proposal for buildings D and C as building D functions as a small office building and building C has been developed in the past and consists of some micro-apartments, a brewery, and a conference hall.

CHOICE OF NEW FUNCTIONS

The new architectural programme is a response to the needs of the community and offers new functions of what residents and city planners see as a great asset to Alafors. It also takes into account the potential synergies that can be created by this project.
One approach was to think of an economically sustainable concept, where different functions can feed off each other and guarantee economic resilience. This is especially needed when thinking of cultural activities that are often less profitable and are dependent on financial support.
However, cultural activities are a great asset to a community for all age groups. It often enriches the lives of many and can reduce frustration and criminality among youths. The talk to locals has uncovered the need for such function in this area. There have been youth centres around, but most of them have closed because of economic problems.
Today, there is no such service near Alafors and locals must use the car or public transportation in

Therefore, a new cultural centre with these functions is a great opportunity to act on those demands. Building F offers a great location for such cultural activities as its open space and large outdoor area make it a great environment to suit a variety of different functions.

As part of the economic model, housing and working space are used to generate money that can then subsidi cultural activities on site.
Since it was clear from the interview, that there are upcoming conventional housing projects in this area, I aimed for a more social housing concept that benefits the elderly community, like a co-housing concept where the elderly can move into apartments and share common spaces.
Moreover, the contact with city planners convinced me to also think of a town's economy in such a project and the benefits of creating working space for small businesses and locals who often travel long distances to get to work. This is especially important when we want to reduce the pollution caused by commuting and enable a better working environment in smaller towns. Therefore, the mixed-use of co-working, together with co-housing, will be situated in building A.

Finally, the existing functions in the two buildings, which mainly consist of storage and a small gym, will also be part of the new programe. The existing gym is kept, because it is regularly used by the locals. However, most of the storage space has been moved to create space for the new design.

SITE PLAN & CONCEPT 1:1000

1 **BUILDING A**
Co-housing (19 apartments)
Co-working
Storage

2 Parking & shared electrical vehicles

3 **BUILDING F**
Youth centrum
Workshop
Gym
Exhibition hall
Restaurant

4 Outside area for youth centre

5 Shared outside space

6 **BUILDING D**
Office & administration

7 **BUILDING C**
Housing (26 micro apartments)
Theater
Conference hall
Brewery

8 New housing, 13 apartments (under construction 5/2022)

SYNERGIES

The term synergy stands for cooperation and interaction between two or more operators. In this new architectural programe, it was part of the design process to investigate possible cooperation between new and existing functions.

The illustration shows created synergies between different function as well as how the local community can benefit from the new transformation of the factory site.

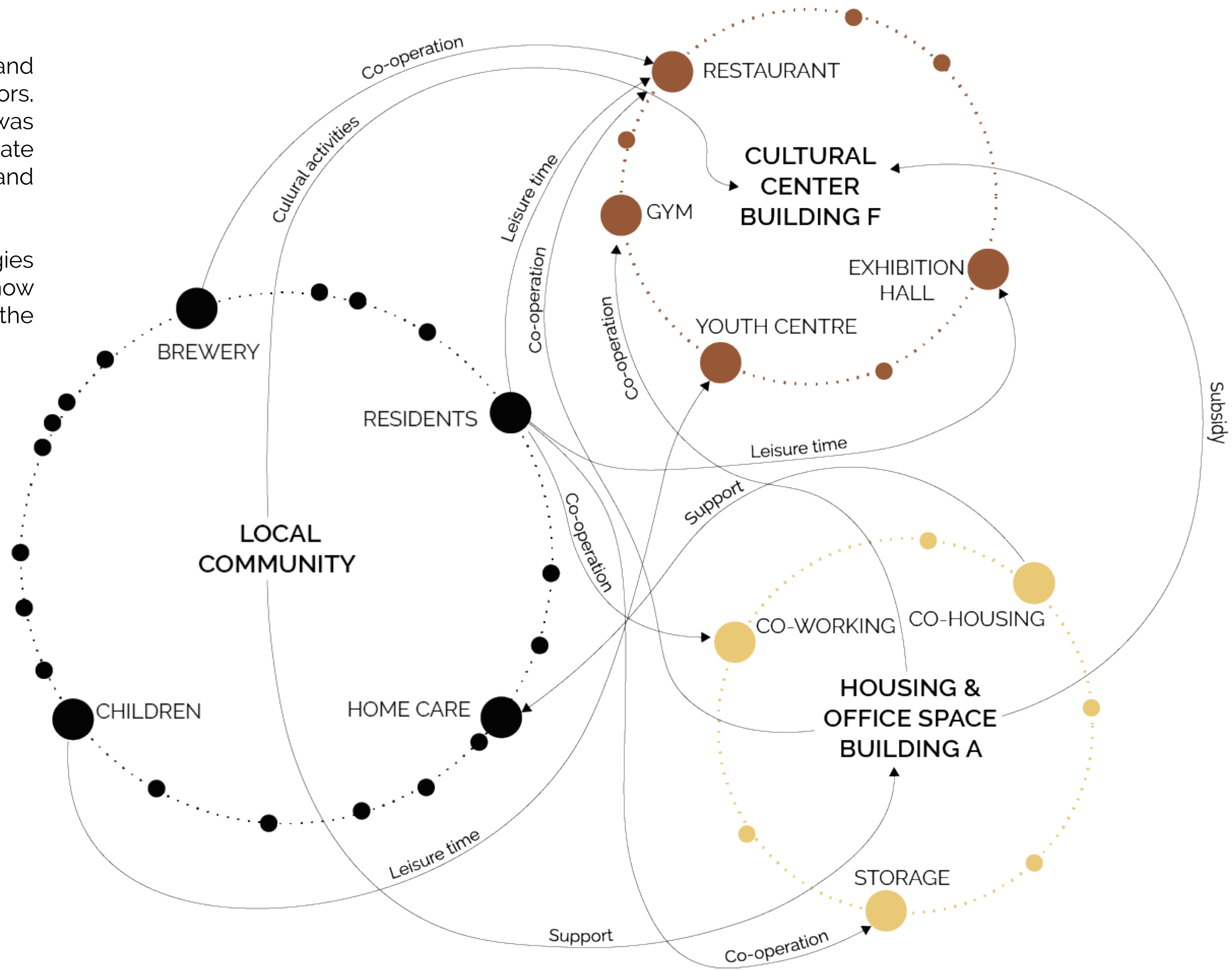


Figure 28. Synergies between exisiting and new functions

PART B

REUSE

When compared to conventional building projects, a transformation project with an existing structure being reused has a significantly lower ecological footprint. Transforming existing buildings uses energy and materials more efficiently and reduces waste because new materials don't need to be created, nor older demolished materials disposed of.
The saved materials and forgoing of all demolition expense makes a transformation project also very cost-efficient and sustainable economically. This becomes even more relevant in a time where inflation and global conflicts lead to material shortages.

The „greenest" buildings are the ones that already exist. (Elefante 2007). By reusing building structures, the designers prevent the production of new materials as existing materials are be used for the new project.

The existing building materials in Building A (steel, concrete and bricks) account for around 1,.200t CO2, which all can be preserved by reusing the existing structure. However, the transformation into housing and office space requires new materials that need to be produced and which are estimated to produce about 590t CO2 emission.

Preserving existing structures also has a social component. In communities with historical architecture, reusing those structures is a form of historical preservation. It restores cultural sites that would otherwise only be used for temporar purposes or demolished to make space for new buildings.

THE OUTCOME FOR BUILDING A

Reusing the existing structure saves approximately 1,200t CO2 in materials compared to a fully newly constructed identical design project.

1200t CO2 emission equals approximately the amount of carbon preserved in 1100 hardwood trees.

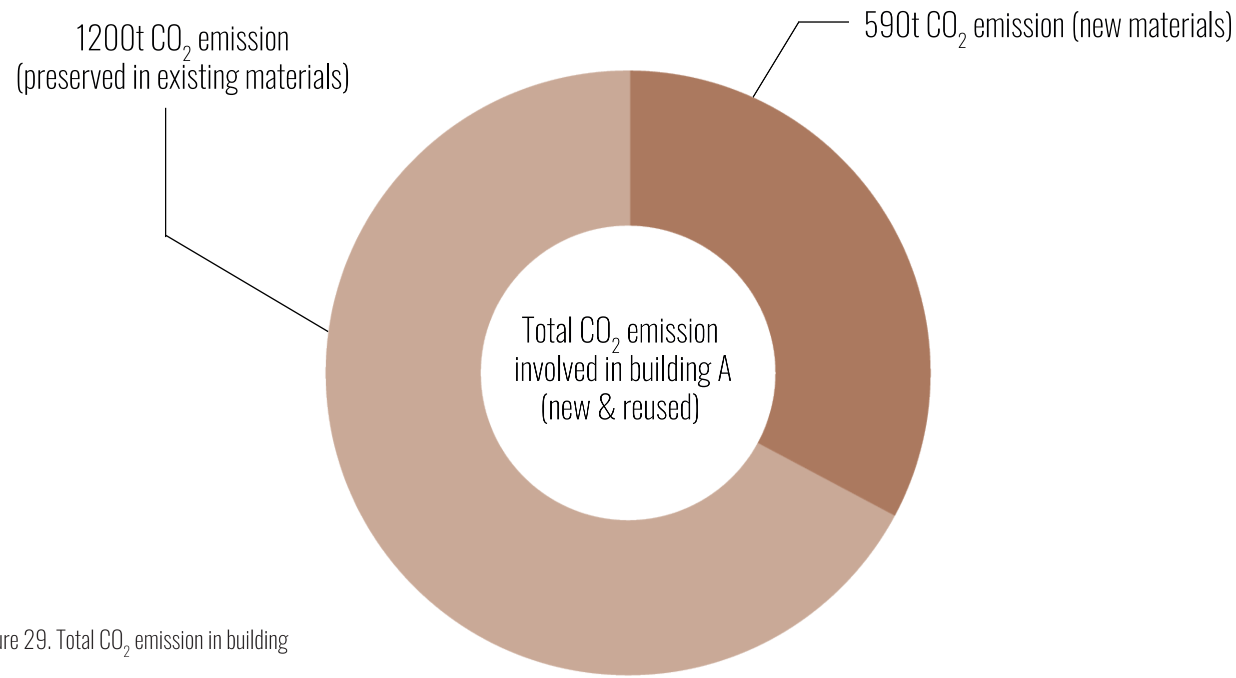


Figure 29. Total CO_2 emission in building

FORM EXPERIMENTS

A compact volume leads to a smaller area for heat losses, which is useful to operate a building more efficiently. However, the width of a building also makes it hard to allow a proper daylight situation and ensure appropriate architectural qualities in the inner core of the building. Especially with functions like housing and working space, this issue had to be addressed.
Therefore, some design decisions were made in the beginning to improve the daylight situation and provide some indoor and outdoor connections. This was vital to continue the design phase where the focus was to ensure an appropriate environment for an elderly co-housing community and office space for co-workers.

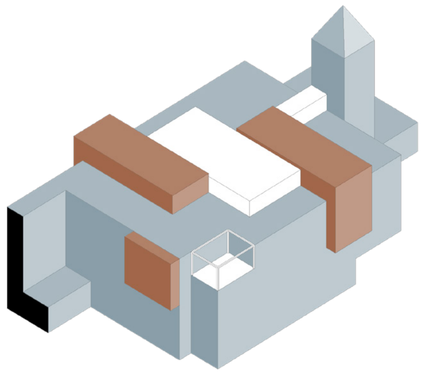


Figure 30. Atrium

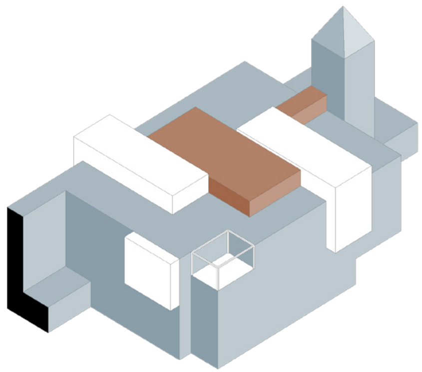


Figure 31. Apartments

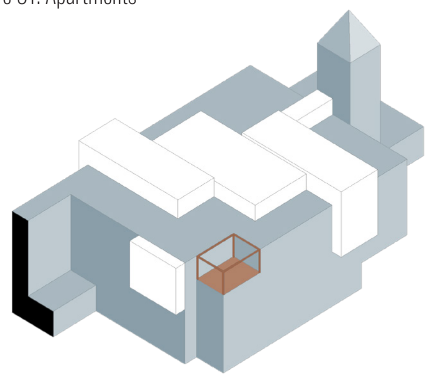


Figure 32. Terrace

ATRIUMS

Two atriums and a `light balcony´ have been cut out along the structure lines. This led to a loss of potential space for further apartments, but increased the indoor qualities significantly. The cut outs are a shared spaces and function as communication spaces where residents can meet, work and relax.

APARTMENTS

Additional apartments in light weight construction have been added to the rooftop. These flats have individual small terraces and are connected directly to the common space. A diversity in apartments offers options for different demands.

TERRACE

The terrace has been added directly to the common space to create some connection to the outside for the residents

DAYLIGHT

The observation was made for an analysis of the daylight condition in building A. The outcome shows a good daylight distribution on each floor and the improved daylight situation in the centre of the building caused by added atriums.
The overall good daylight situation helps to reduce the use of artificial light and therefore saves energy during operation.
However, allowing too much light or solar radiation into a space can have a negative effect, resulting in heat gain and offsetting any savings achieved by reduced artificial light. This means energy is needed to cool down the building.
A daylight factor of 8 or higher is an indicator of overheating. To prevent this from happening in my design proposal, shading elements have been implemented in the design proposal. (shading element - page - 48)

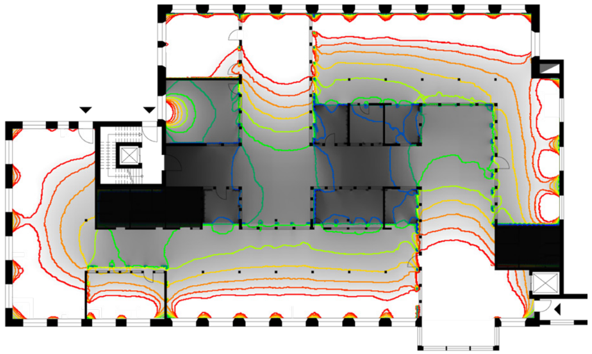


Figure 33. Daylight analysis 1st floor

DAYLIGHT FACTORE SCALE

- 8
- 7
- 6
- 5
- 4
- 3
- 2
- 1

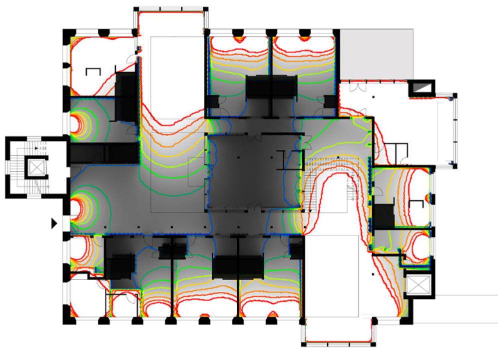


Figure 34. Daylight analysis 3rd floor

The 1st floor consists of two larger offices. The simulation confirms that there is good daylight along the facade where people will likely be sitting during work hours.

The 3rd floor consists of a co-housing community for seniors. The outcome of the simulation confirms a good daylight situation in the apartments and also proves the increased daylight in the inner located space caused by the atriums.
The centre located common kitchen has a daylight factor below 1, however, this is less of a problem since the kitchen is mainly used for cooking.

MATERIALS

The GWP value between materials can vary significantly. As the value of steel is very high, wood, for instance, has a negative value in its GWP. This is due to its ability to take up carbon dioxide during its growth and store it throughout its use as a building material. Other than CO2 emissions, the CO2 take-up results in a negative GWP. Therefore, timber is a good alternative to conventional materials like concrete and steal, if the design is supposed to have a low environmental impact.
For new building elements, the primary materials used for this design have been organic materials. This led to a significant reduction in the GWP (A1-A3) of the new design proposal.

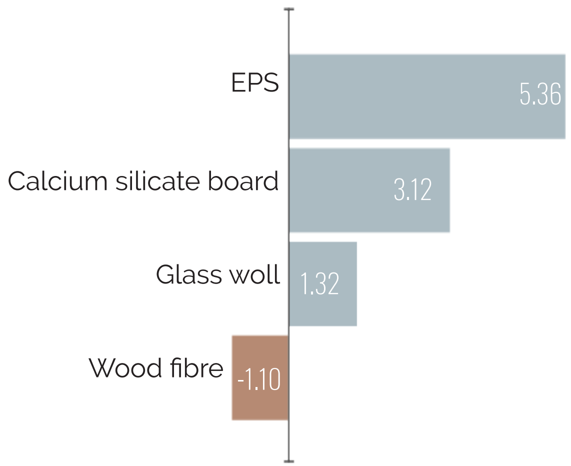


Figure 35. GWP kgCO_2 eq/kg (stage A1-A3)

This graph (Fig. 15) gives an example of the masses of some materials that have been used in the design proposal for Building A. All new building parts are planned to be constructed with timber, which has a positive effect on the GWP outcome.

The U-value of the building envelope has been improved by adding insulation to the existing system. This has reduced the heat losses and therefore, lowered the GWP during operation. However, thermal bridges are unavoidable and the airtightness of such a transformation project is not as good as a fully new construction.

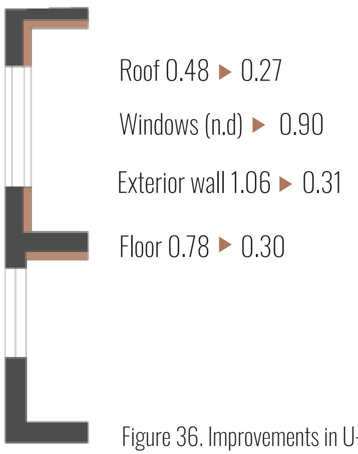


Figure 36. Improvements in U-value

However, sometimes the properties of a material are vital for a certain situation and don't allow designers to only look at the materials with the lowest environmental impact. For retrofitting the existing exterior brick walls, calcium silicate boards have been a good choice, because they are water absorbent, diffusion open, lightweight and easy to install from the inside (Fig. 5).

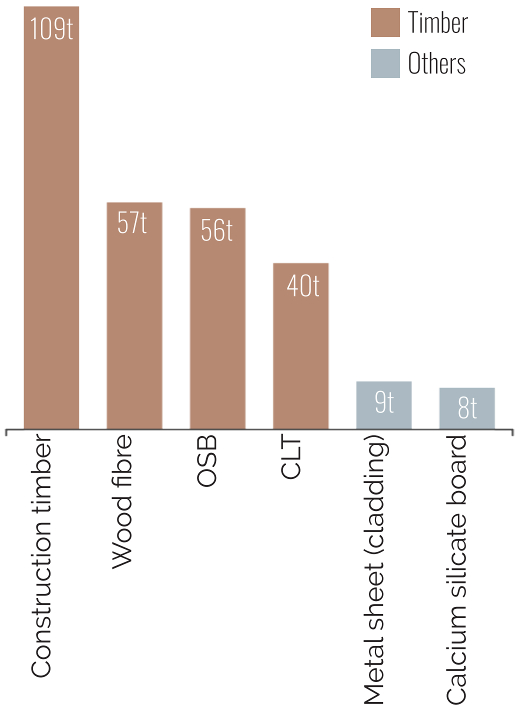


Figure 37. Masses of materials usedin new design

HVAC

The main purpose of an HVAC system is to heat, cool and ventilate a building. This is vital to provide good air quality and thermal comfort for the building users.
The energy demand and environmental impact of an HVAC system can vary significantly between different options. Also, the efficiency of those systems has improved in the past. It can be assumed that this trend continues, and future HVAC systems will run even more efficient and sustainably.

HVAC SYSTEM FOR BUILDING A

Heating system: Electrical heat pump with ground probes.

Ventilation system: Mechanical ventilation with heat recovery plus natural ventilation on warmer days.

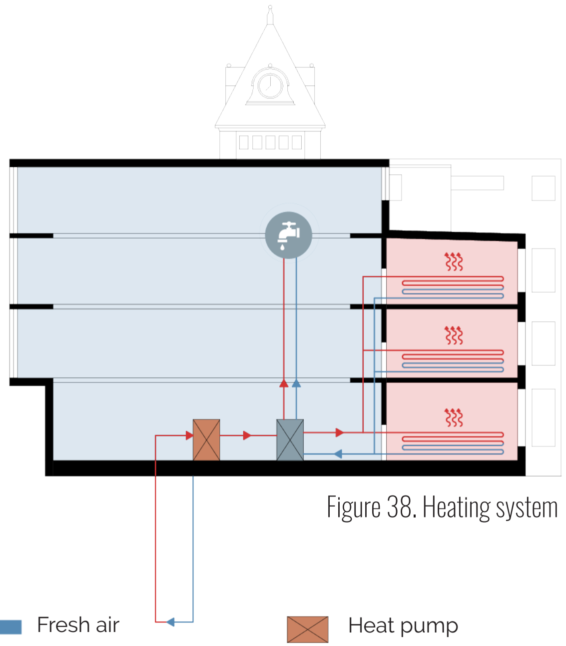
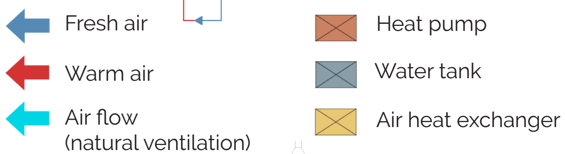


Figure 38. Heating system



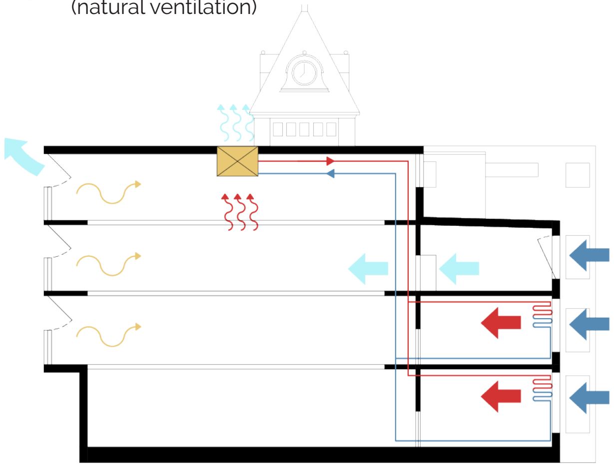


Figure 39. Ventilation system

While the apartments and common space are heated, the corridors and the atrium are not. It is assumed that the solar gain and the interior waste heat ensure an adequate indoor temperature for the unheated spaces.

The building is supplied with a thermal heat pump connected to a geothermal probe, which then distributes through a water tank warm and cold water to the system as well as to the floor heating system.

The mechanical ventilation heat recovery system uses pre-warmed air that is stacked in the upper part of the atrium. This comes from solar radiation and absorbed heat from people, electrical devices and other heat losses that move up as warm air is lighter than cold air. The heat is then used to let warm water circulate through the air inlets to pre-warm the incoming fresh air.

In the warmer months, the apartment and atrium windows can be opened to ensure an airflow for natural ventilation. This reduces the energy demand for cooling and therefore has a positive effect on the GWP.

ENERGY DEMAND

The energy demand of a building consists of the user's electricity consumption and HVAC system. While the user's electricity demand is influenced by individual behaviour and electronic devices, the HVAC electricity demand can be influenced by the chosen system and our design decisions.

THE ASSUMED ELECTRICITY HARVEST & DEMAND

Demand: 217.300kwh/a

Harvest: 105.000kwh/a

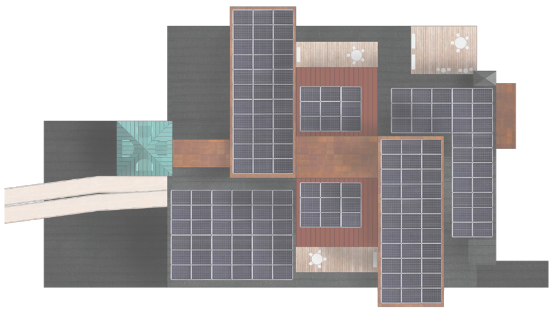


Figure 40. Building A roof with 915 m² solar panels on the roof

The user's electricity consumption differs slightly between co-housing and co-working. In this LCA, it is assumed that co-housing consumes 30 kWh/m²*a
and co-working 25 kWh/m²*a (Mata, É. ; Sasic Kalagasidis, A. ; Johnsson, F. 2013). Which in total means a consumption of 130,600 kwh/a for Building A.

The overall electricity demand is approximately 220.000kwh/a. The possibility of installing 915 m2 solar panels on the roof allows the system to harvest around 105.000kwh/a, which covers almost 50% of the demand. However, the system does not harvest a constant amount of electricity during the year (Fig. 41). While in the summertime, the system can fully cover the electricity demand, the winter months will require additional electricity from the power grid.

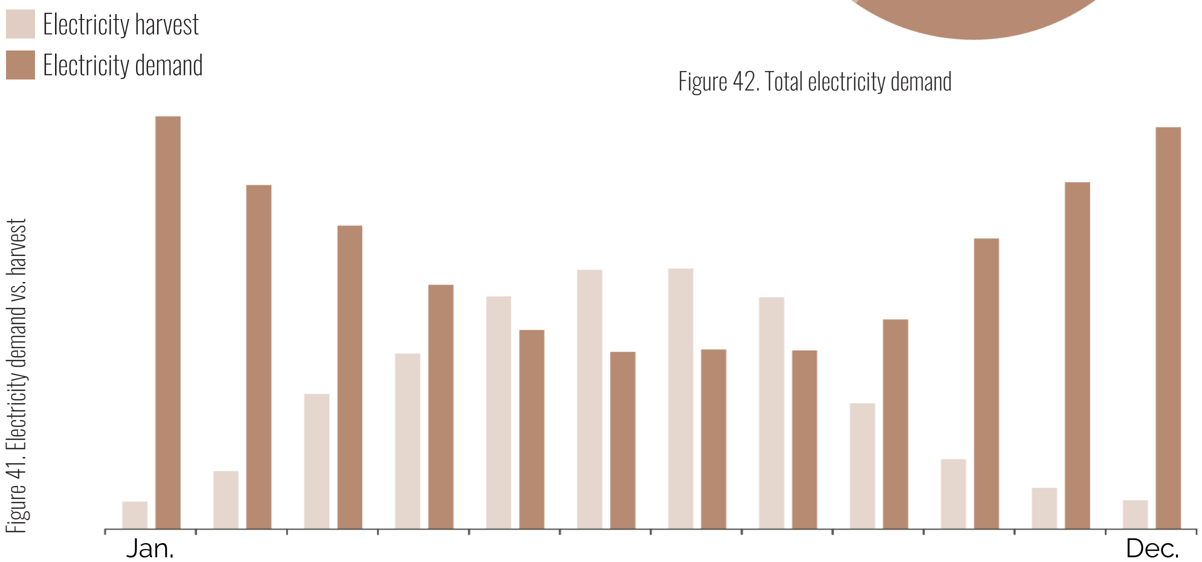


Figure 41. Electricity demand vs. harvest

The HVAC systems consumes a high amount of electricity that needs to be taken into account when looking at the overall electricity consumption. The building demands approximately 86.700kwh/a for operating the HVAC.

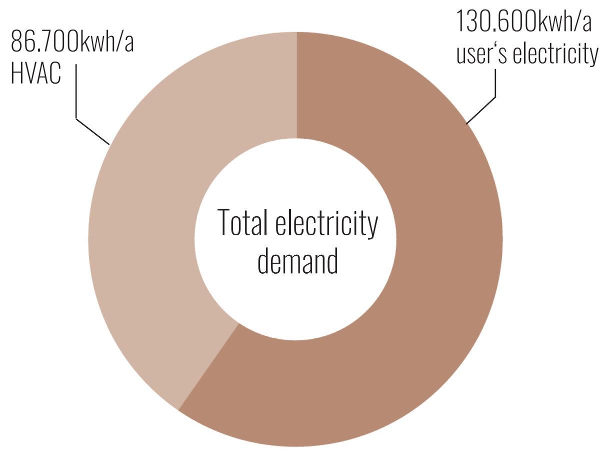


Figure 42. Total electricity demand

LIFE CYCLE ASSESSMENT

The displayed Life Cycle Analysis looks at a study period of 100 years. However, it should be considered that CAALA calculates with current data regarding energy production, climate data and energy demand. These data are likely to change in the future.

GLOBAL WARMING POTENTIAL

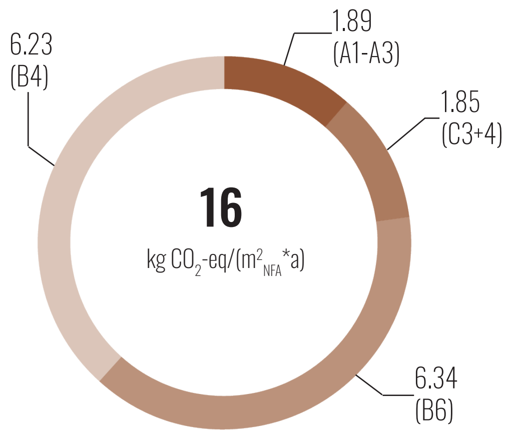


Figure 43. Global warming potentail displayed in stages

PRIMARY ENERGY DEMAND

47 kWh/(m$^2_{AN}$*a)

The Primary Energy Demand has turned out to be quite successful compared to the national average for Swedish properties, which is 96kWh/m² for a muilti-family dewelling (Mata, Sasic, Kalagasidis, Johnsson, 2013). This can be explained by the compact building, a high porpotion of window surface that allow enough solar gain and an efficient HVAC system.

The graphs start with a certain GWP, since materials need to be produced (A1-A3). The leaps in the graph can be explained by maintaining (B4) windows and solar panels, etc., that need to be replaced every 30 years. During operation, the building has a constant energy consumption (B6) which explains a steady growth in its GWP during lifetime. The End of Life (C3+4) also increases the GWP as it is assumed that the building will be demolished after 100 years.

SCOPE

To understand and compare the results of a Life Cycle Assessment better, it is important to mention the parameters that have been entered into the tool.

- Selected life cycle modules: A1-3, B4,B6, C3-4
- Study period: 100
- Thermal bridges: 0.05W/m²K
- Air tightness: n50 = 4h-1
- Electrical heat pump: CO2-Intensity factor was set to 0.15, energy mix (Swedish standard).
- Mechanical ventilation: Heat recovery factor was set to 0.7

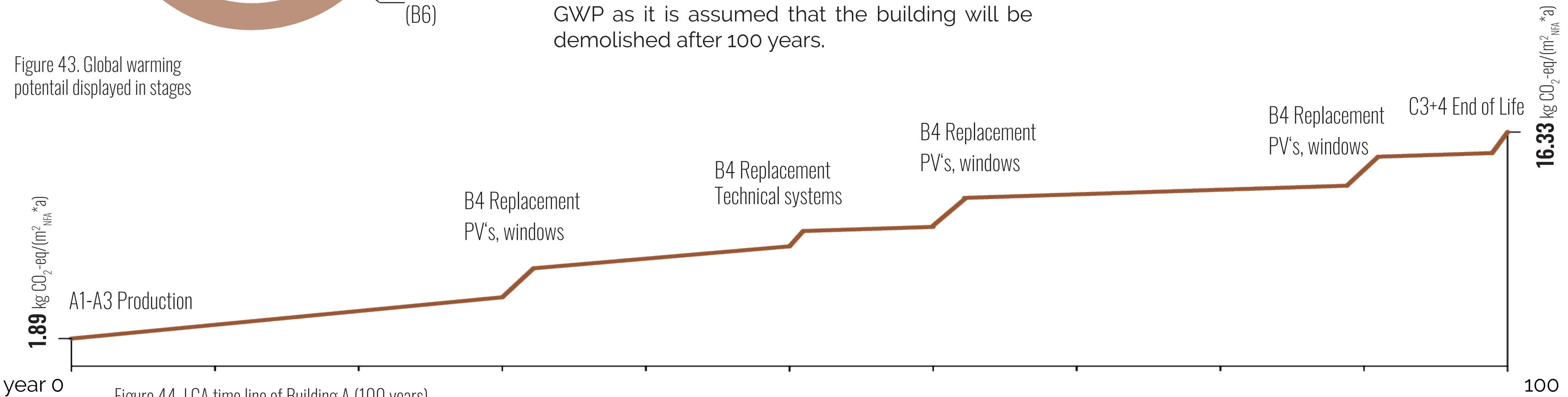


Figure 44. LCA time line of Building A (100 years)

PART C

BUILDING A

NEW SITUATION

FLOORS: 5

NFA: 3,400 m²

NEW FUNCTIONS:

- Co-housing(NFA) 1,670 m²
- Co-working(NFA) 1,080 m²
- Bicycle room(NFA) 75 m²
- Storage 1,950 m³

INTRODUCTION

Building A was built in 1854 and is the oldest building on the site. After a fire burned down the factory, it was rebuilt a year later in 1906. The building is built on a slope and connected with building C. The upper floors are connected by two bridges and allow entry to the building from a path that goes up the slope. Since closure of the factory in 1966, the old brick building has changed both in terms of function and appearance. Today, the building is mainly used for storage and needs restoration and renovation. However, its original function is still well known by the people living in Alafors.

THE TRANSFORMATION

The new transformation combines the concepts of co-working and co-housing in one place. Some of the storage space can fit into the ground level, so the upper floors can fulfill the new functions. The co-working space, located on the first floor, consists of two larger offices and some shared working space. The co-housing is situated on the upper floors and consists of 19 apartments and shared common spaces.

The existing building structure is meant to be kept, as details like the exterior brick wall and the industrial facade with its red windows tell the history of the building. Whenever a brick wall needs to be demolished, as it is necessary for the old boiler room, the bricks can be used in other parts of the building.

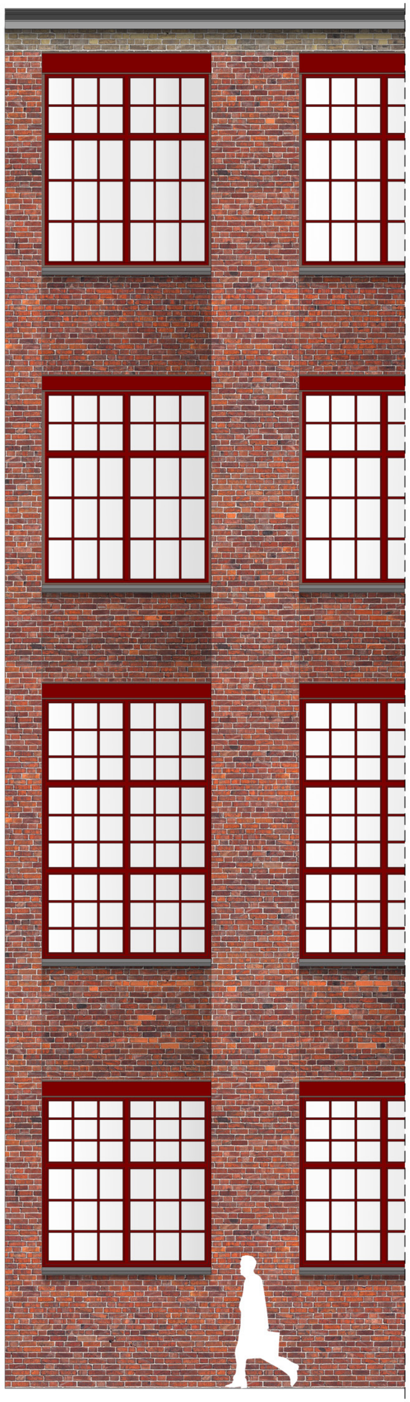
The biggest change made to the building is the two atriums added to the structure, which open up the interior space and creates a possibility of interaction between the users. The lively atmosphere generates a feeling of connection, which is appreciated by everyone willing to socialise and interact with other residents. Another two apartments are added to the rooftop, creating a more diverse selection of apartments for the co-housing community. The old sprinkler tower has been reactivated and belongs now to the common area.

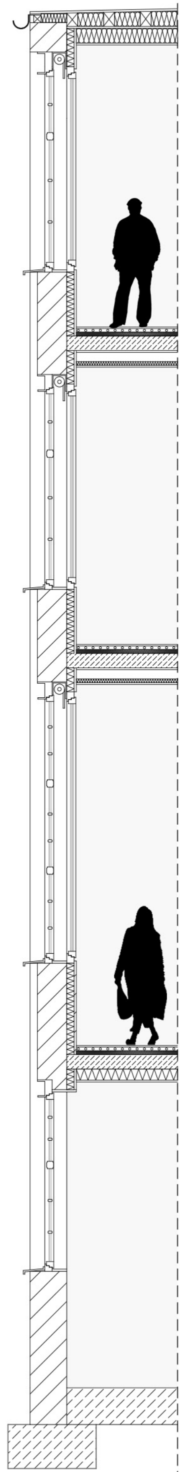
VISION

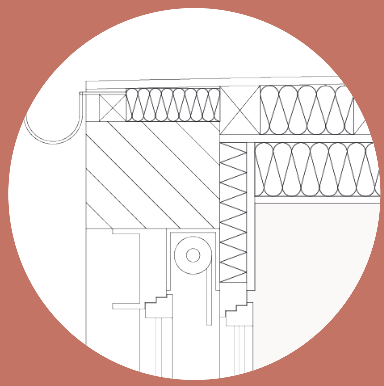
Figure 45. View from south west

Figure 46. First floor - Co-working in the atrium

FACADE SECTION 1:100

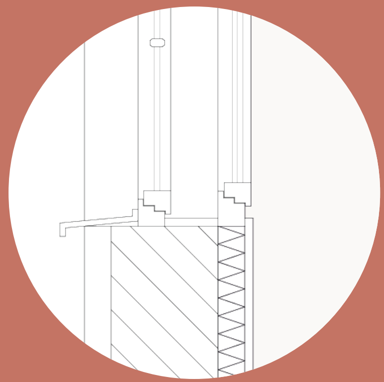






ROOF

- Roofing felt
- 3cm OSB
- 15x15 cm wooden beams, saw dust
- 3cm OSB
- 20x20cm steal beam, cellulose
- 3cm acoustic wooden board

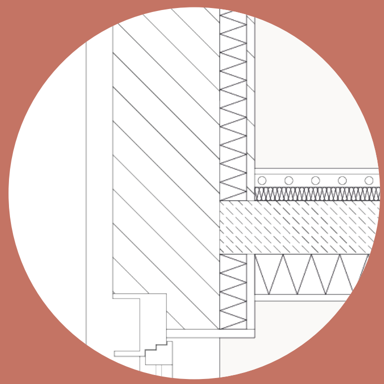


WINDOWS

- Window, double pane
- Shading element
- Window, tripple pane

EXTERIOR WALL

- 50cm brick wall
- 10cm calcium silicate board
- 3cmclay plaster



FLOOR TO UNHEATED SPACE

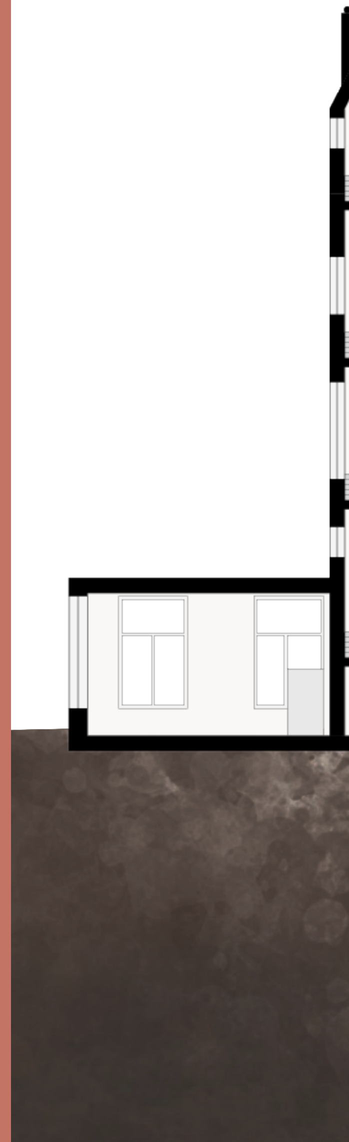
- 1cm flooring
- 3cm gypsum board, floor heating
- 5cm acoustic insulation
- 20cm concrete slab
- 15cm cellulose
- 3cm OSB

FACADES 1:250

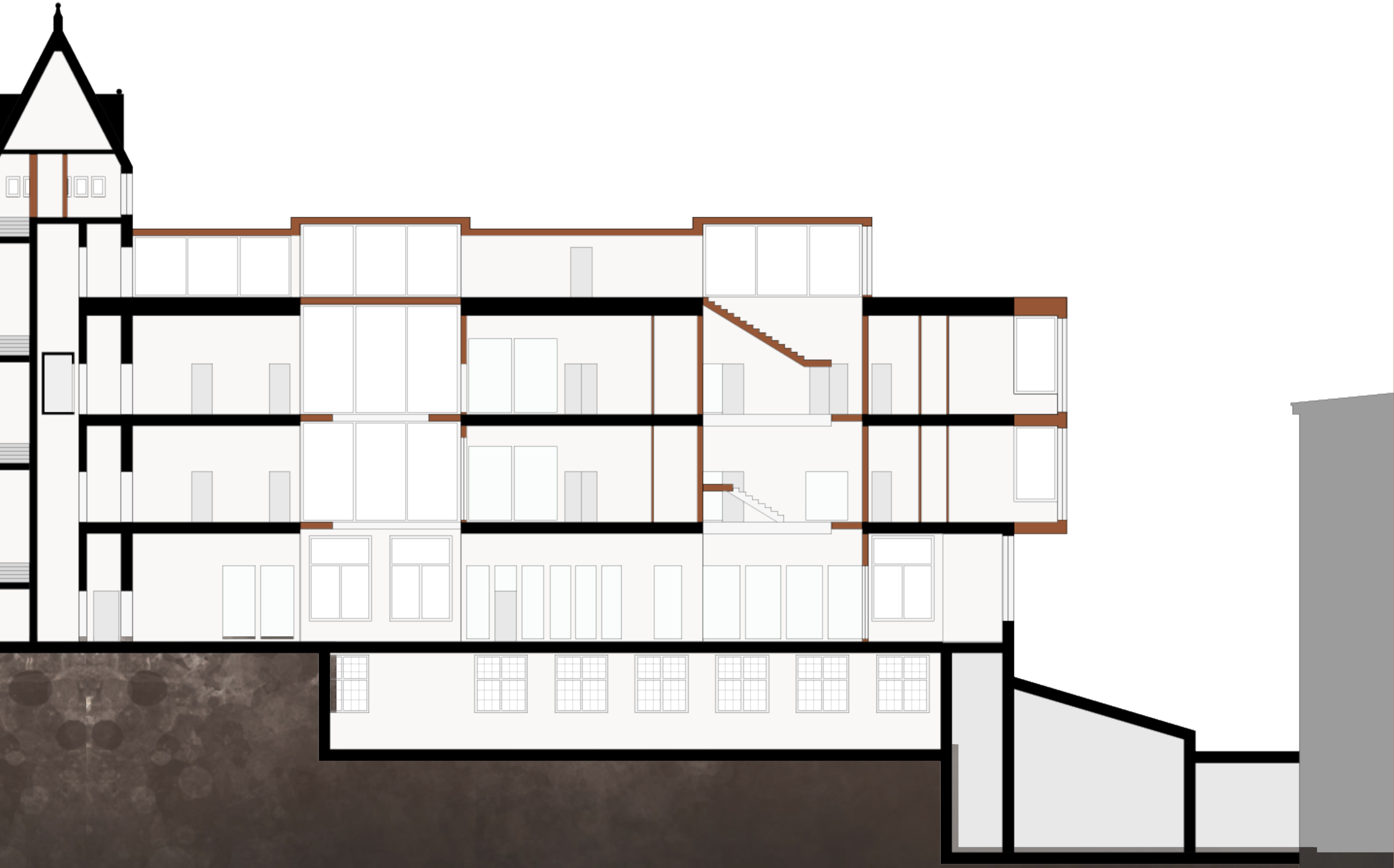
FACADE - NORTH EASTS

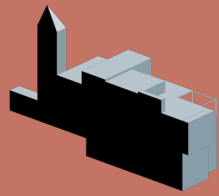
FACADE - NORTH WEST

SECTION 1:250



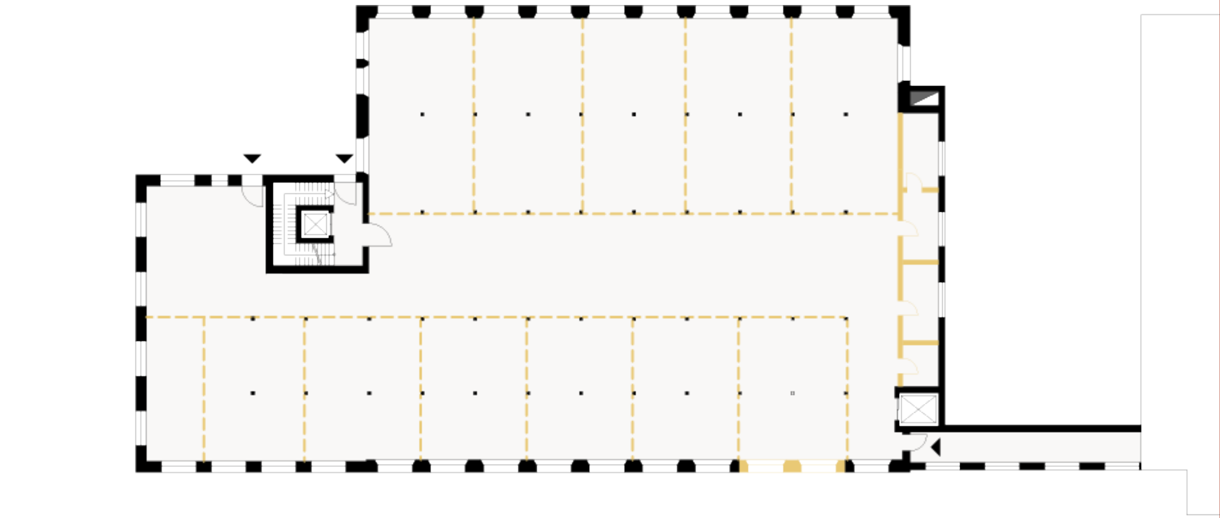
SECTION



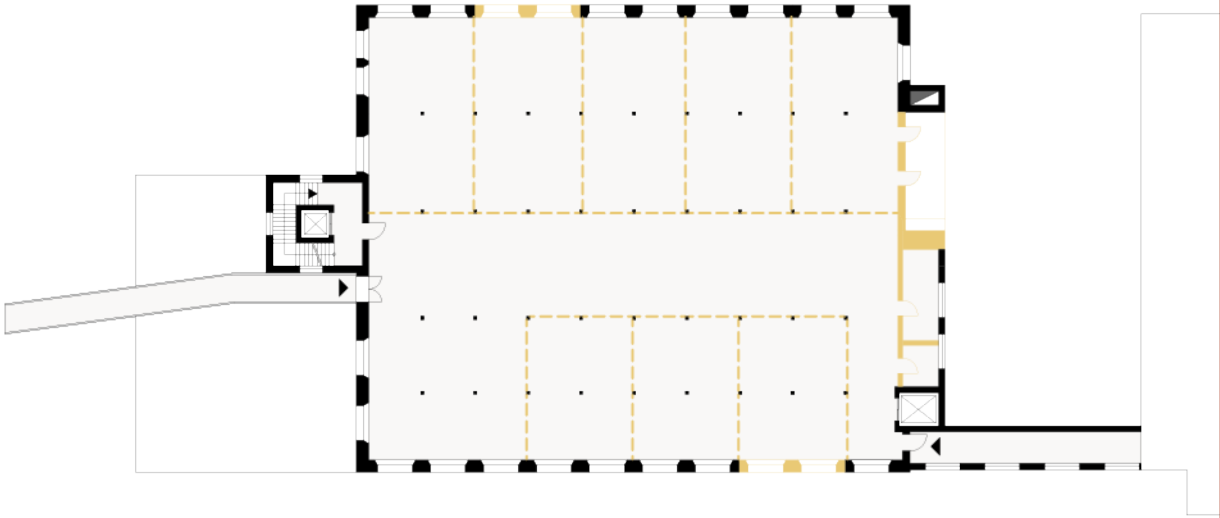


DEMOLITION PLANS 1:500

SECOND FLOOR



THIRD FLOOR

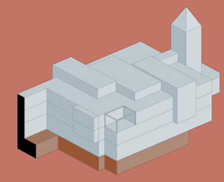


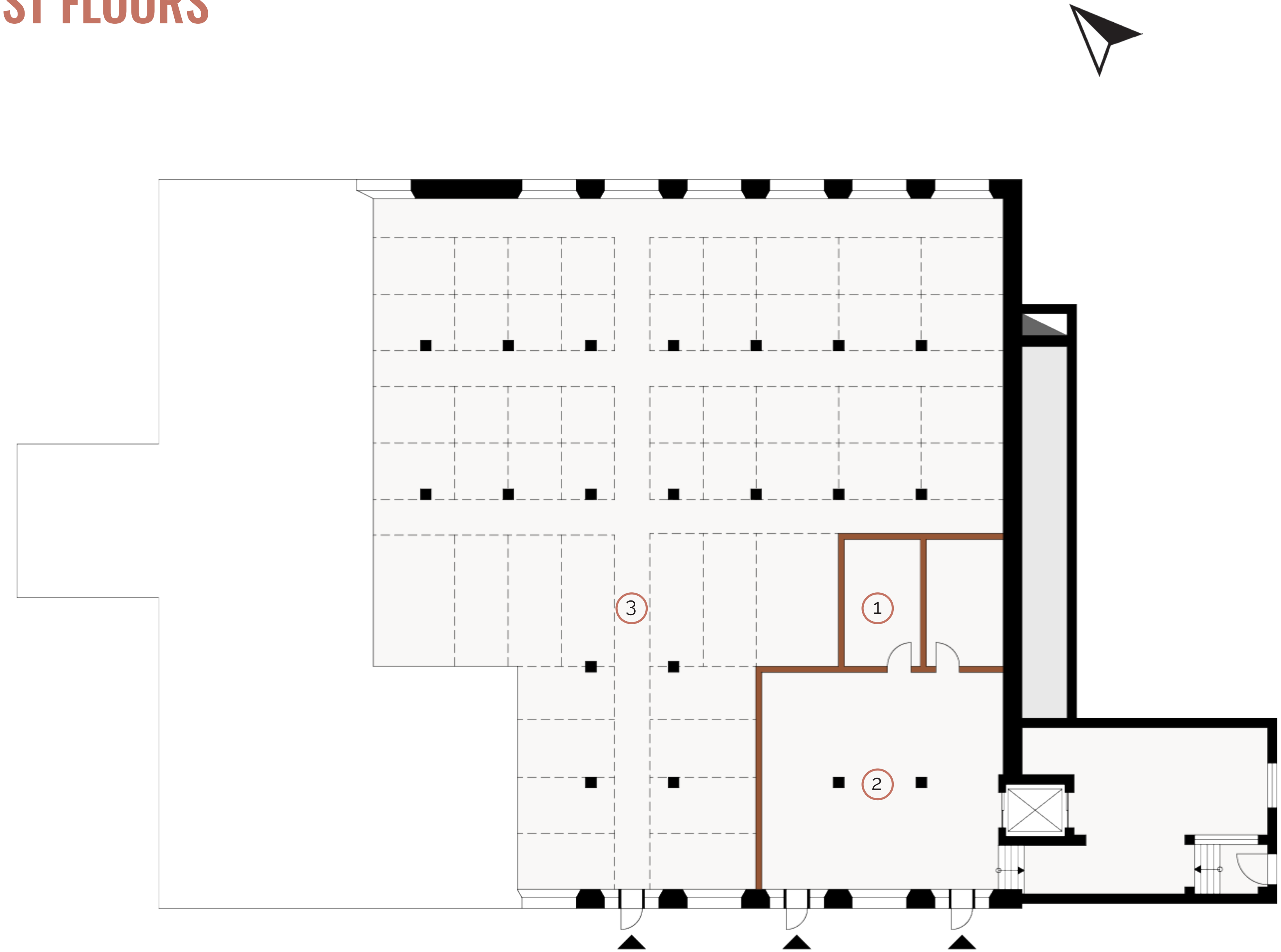
Demolition

Existing structure

FLOOR PLANS 1:250

FIRST FLOORS





1 Technical room

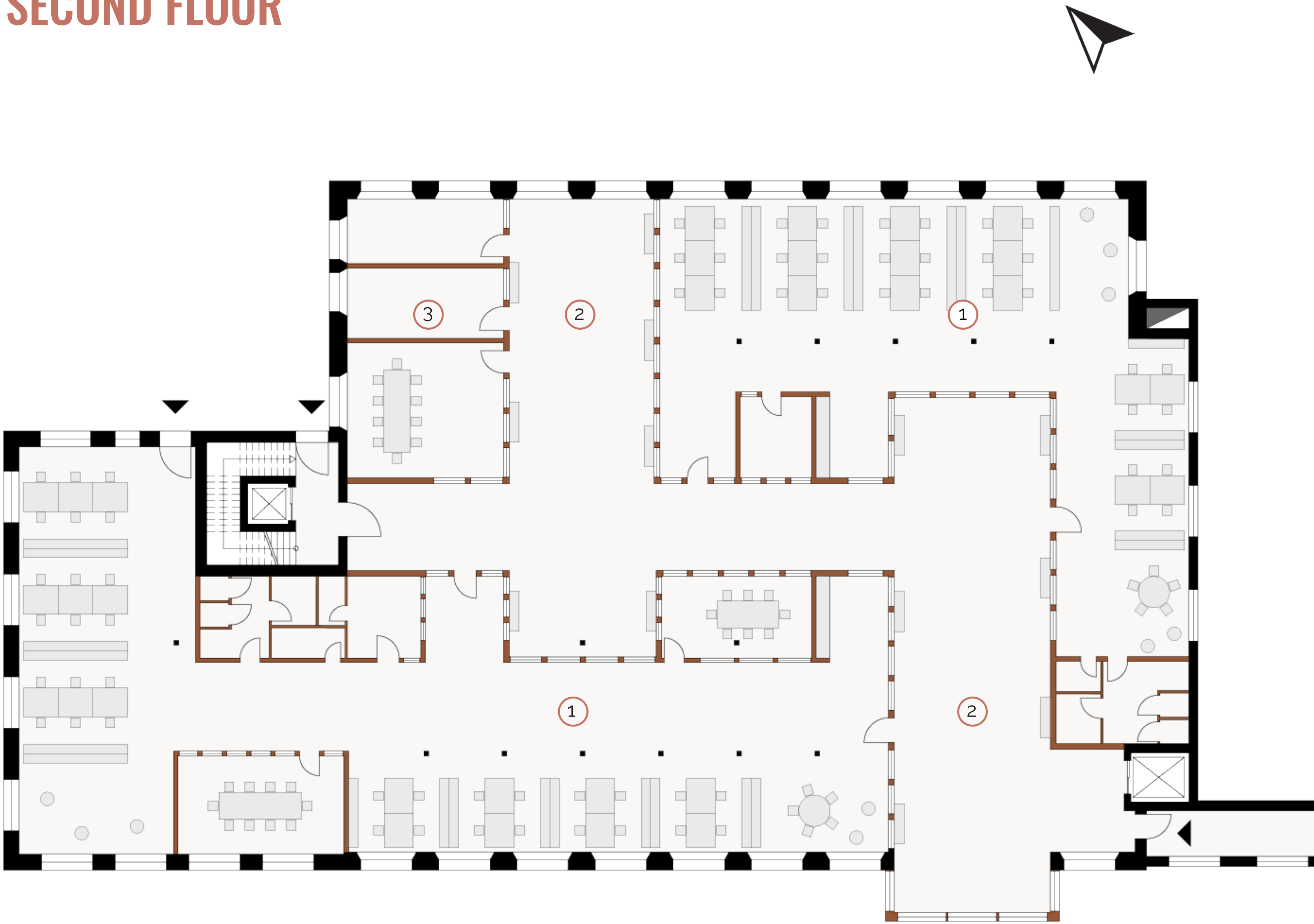
2 Bicycle room

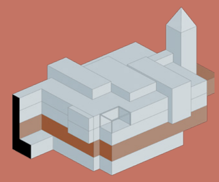
3 Storage space

New construction wood

Existing structure

SECOND FLOOR



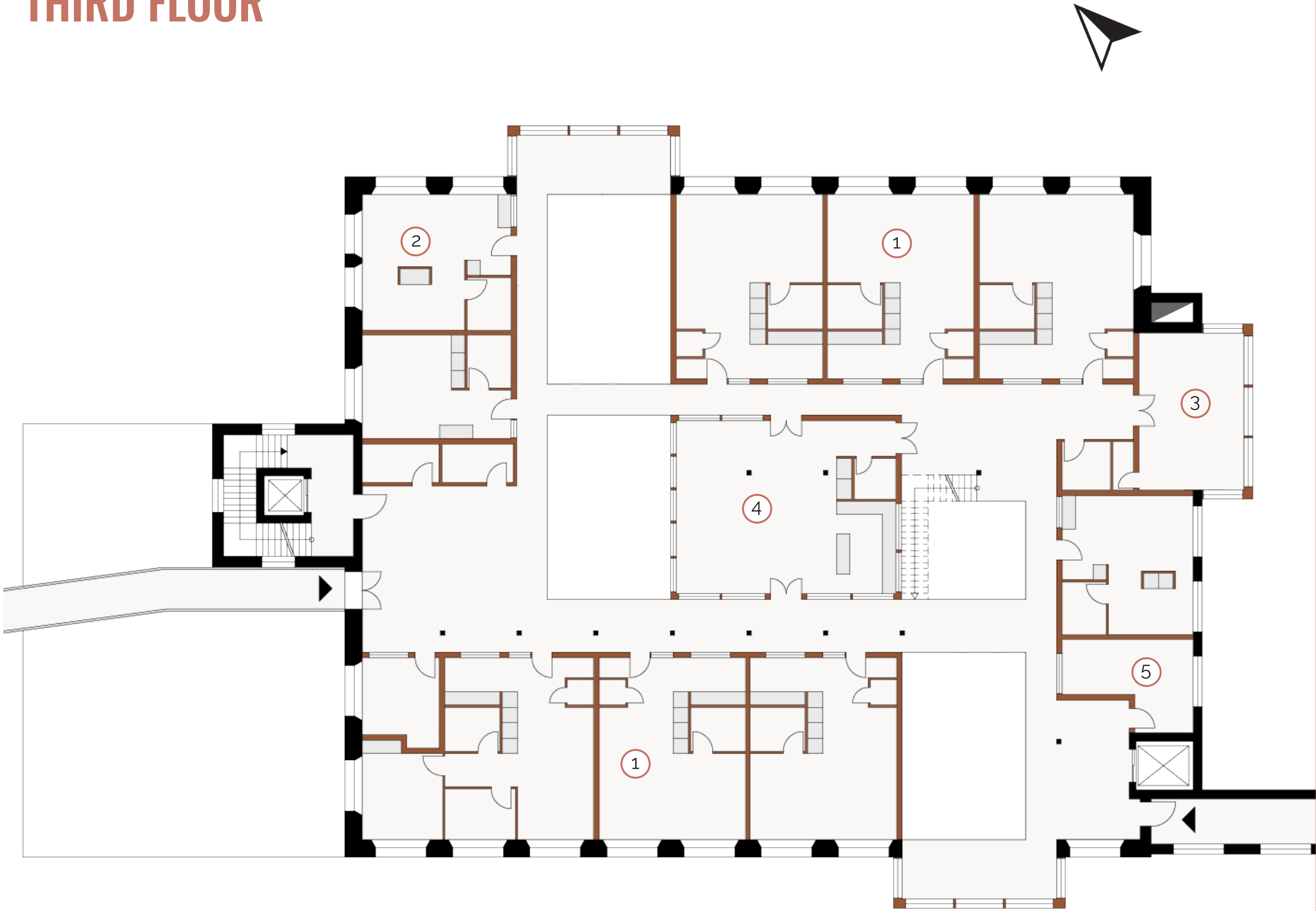


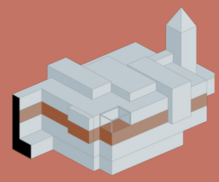
1 Co-working space

2 Atrium

3 Conference

THIRD FLOOR





1 Apartments A 52 m²

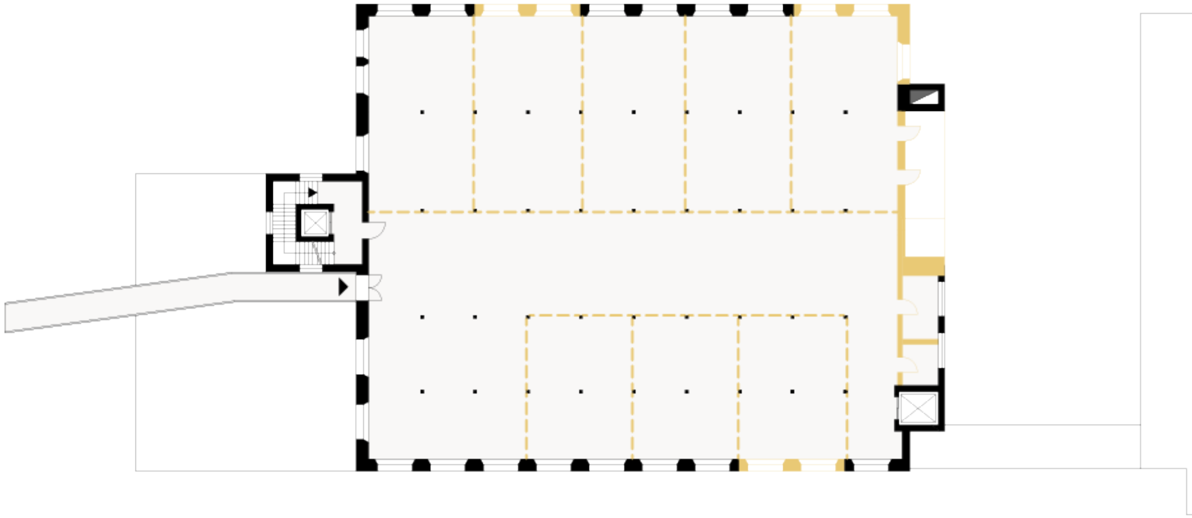
2 Apartments B 36 m²

3 Common space

4 Shared kitchen

5 Laundry

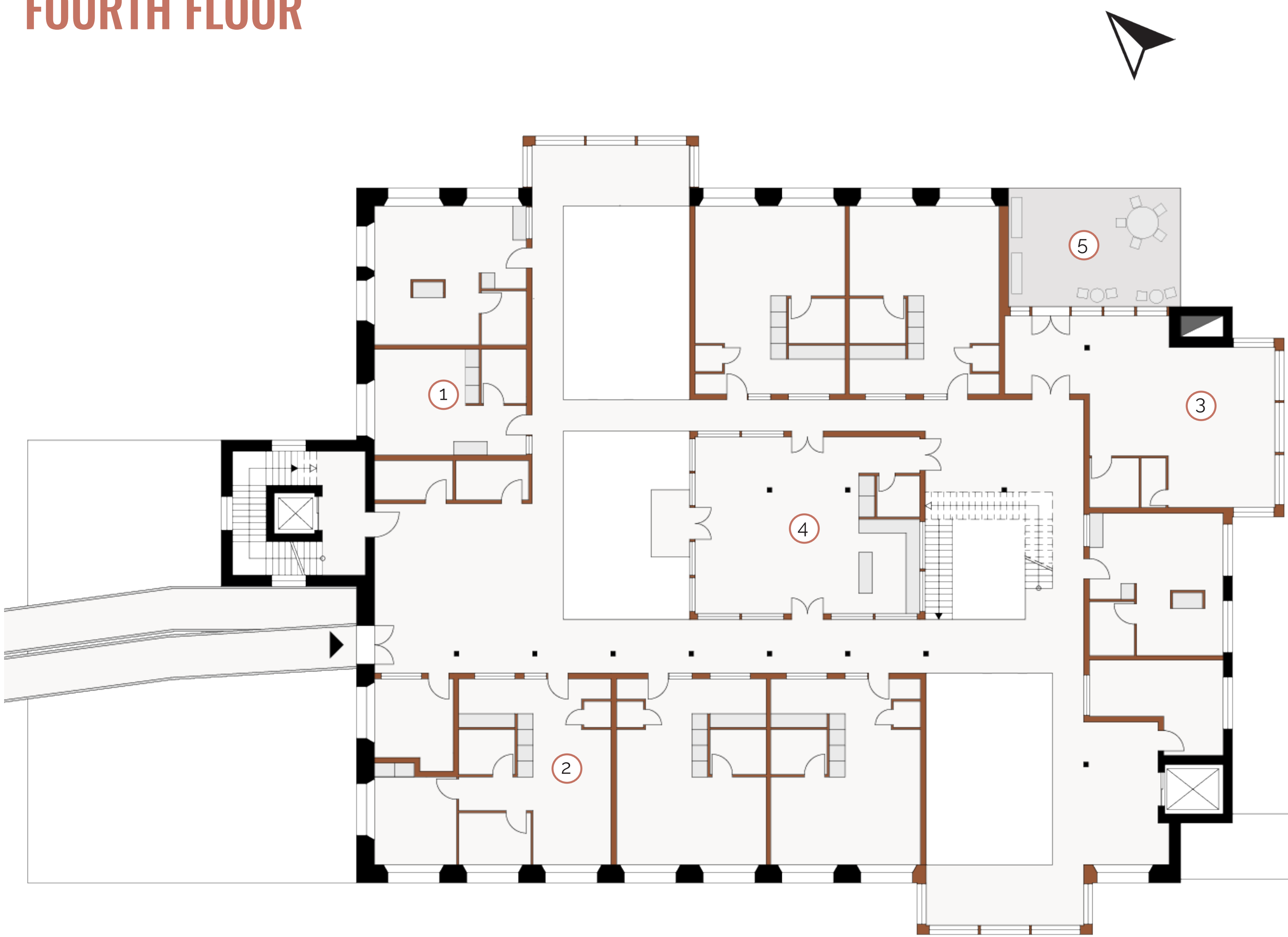
FOURTH FLOOR

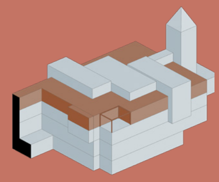


Demolition

Existing structure

FOURTH FLOOR





New construction wood

Existing structure

1 Apartments C 28 m²

2 Apartments D 64 m²

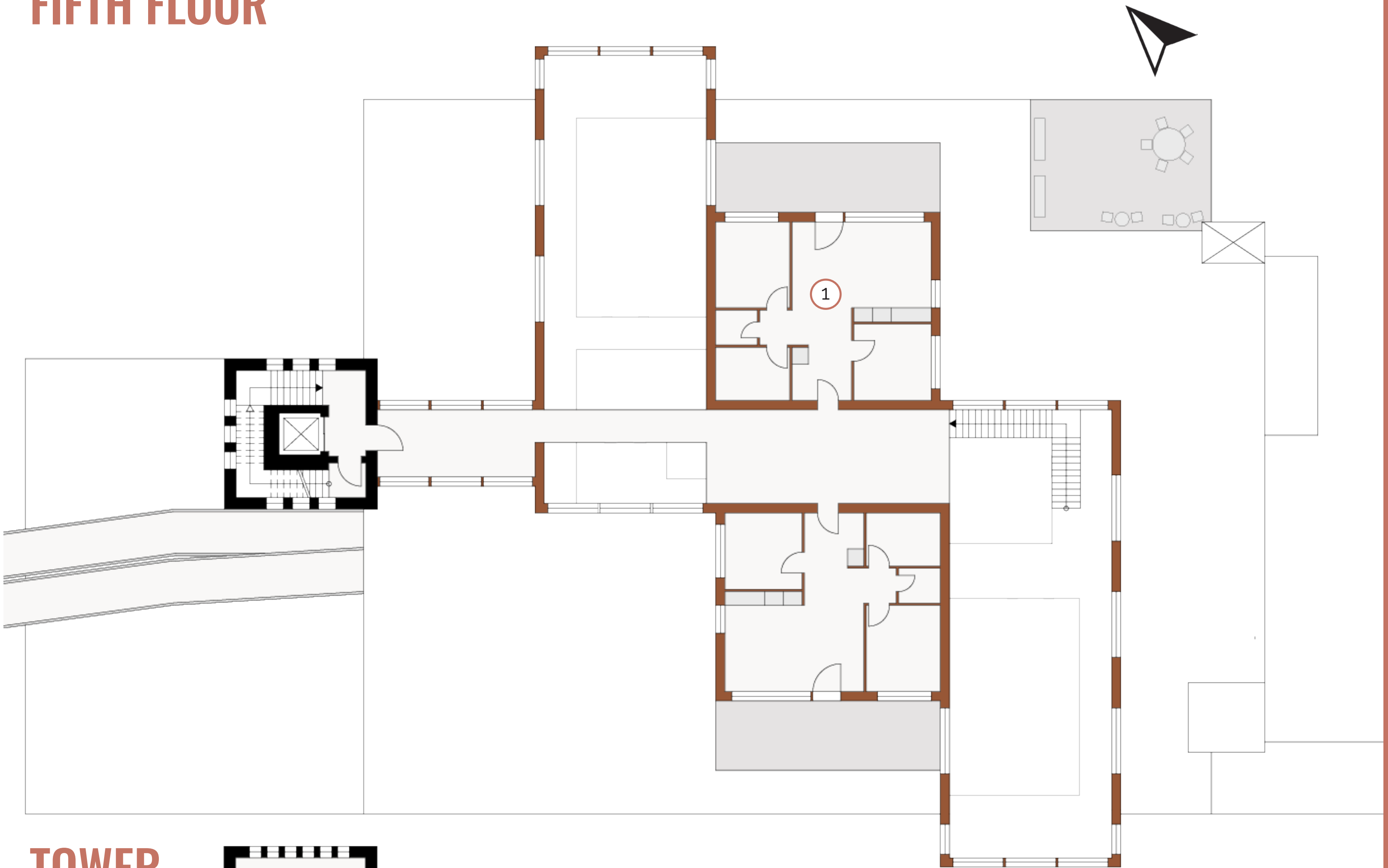
3 Common space

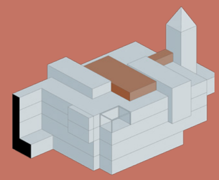
4 Shared kitchen

5 Terrace

58

FIFTH FLOOR

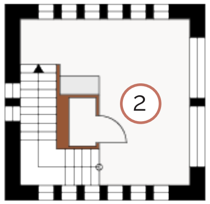




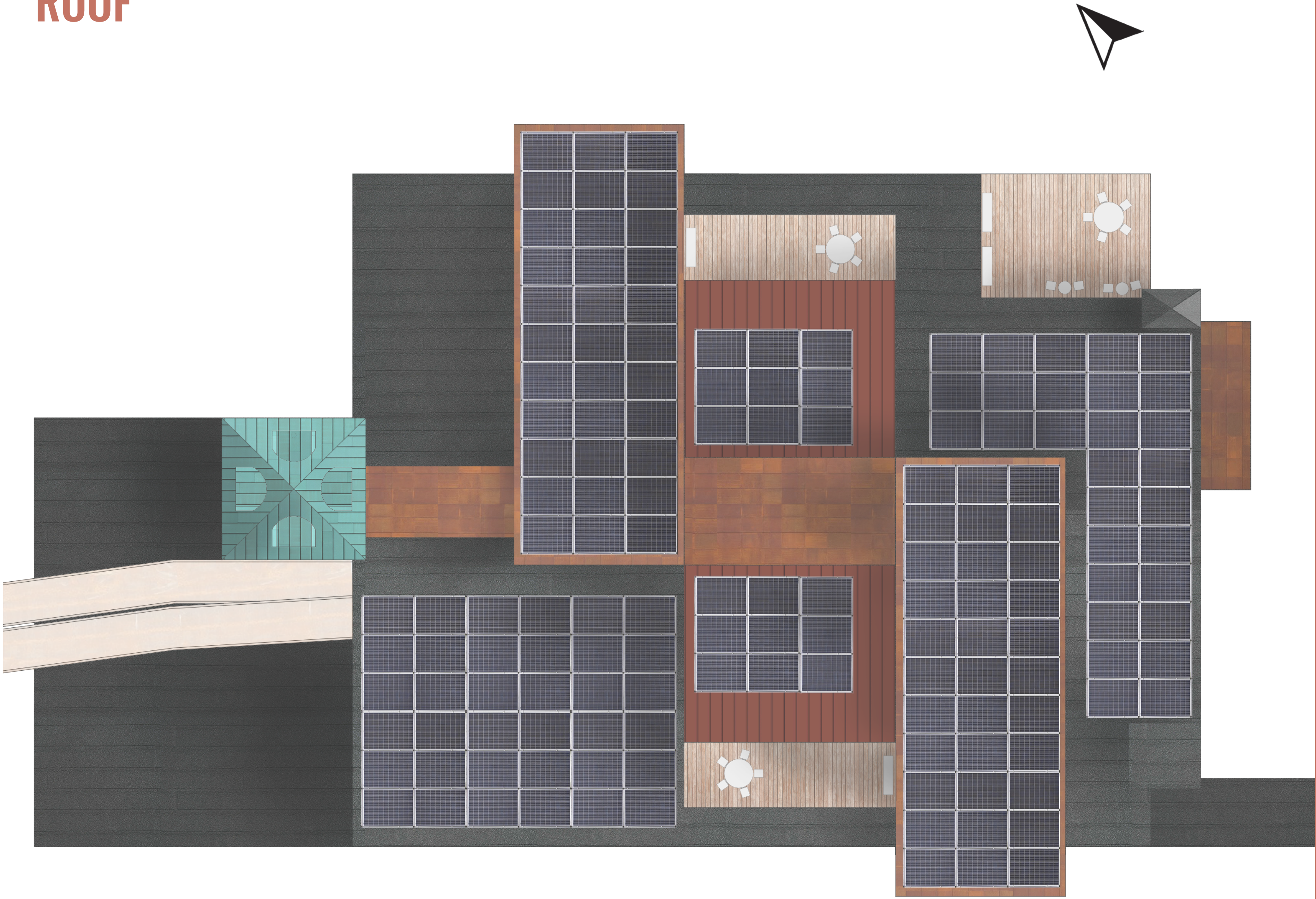
1 Apartments
E 64 m²

2 Common space

TOWER



ROOF



BUILDING F

NEW SITUATION

FLOORS: 2

NFA: 1,650 m²

NEW FUNCTIONS:

- Youth centre(NFA) 460 m²
- Restaurant(NFA) 480 m²
- Exhibition hall(NFA) 330 m²
- Gym(NFA) 240 m²
- Workshop(NFA) 75 m²

INTRODUCTION

Building F was built in 1896 and used to have a saw-tooth roof. The building is also connected to Building C, which makes it possible to reach building A by staying inside.
Today, the former weaving building consists of a community gym and rentable space for storage. To host more storage space, the roof was extended in 2011.

THE TRANSFORMATION

The new proposal turns the whole building into a cultural centre that offers a variety of activities to the community.
The created meeting place consists of a restaurant, exhibition hall, gym and a youth centre. The restaurant is located on the ground floor where residents and locals can have a meal or grab a beer from the local brewery. Moreover, the outside area offers enough space for events and a sitting area.
Close to the main entrance, two rentable rooms can be used for rehearsals or workshops.
The gym on the ground floor will be kept with only minor changes made to the locker rooms.
The youth centre and exhibition hall are settled on the upper floor.
Although there is a great demand for storage, the space will move partly into the ground floor from building A. However, the space is limited and cannot fit all.
The most significant change done to the building is the dismantling of the extended roof. This approach to the roof structure might be a slightly bigger intervention than necessary, however, it makes the changes to the interior visible to the outside and gives the building back its old identity.
Moreover, the saw-tooth shape with added skylights enables a better daylight situation for the exhibition hall and the youth centre on the top floor.

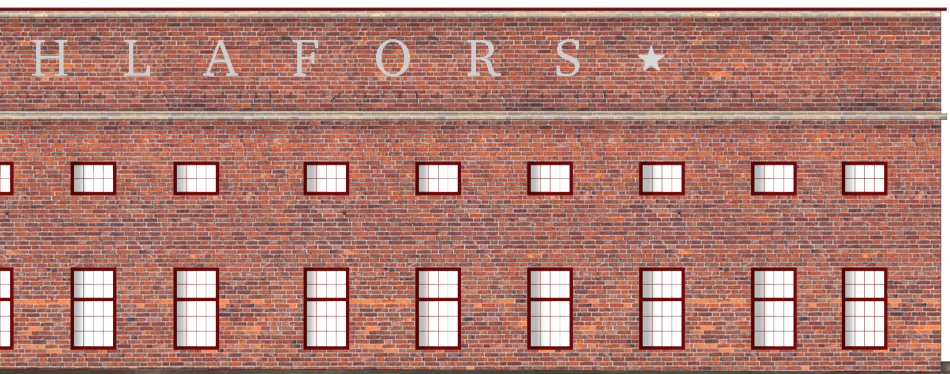
Materials from the dismantled roof can be reused in another part of the site transformation. For example, metal sheets can be reused as the cladding for the new atriums or apartments in building A.

FACADES 1:250

FACADE - NORTH EAST

FACADE - S

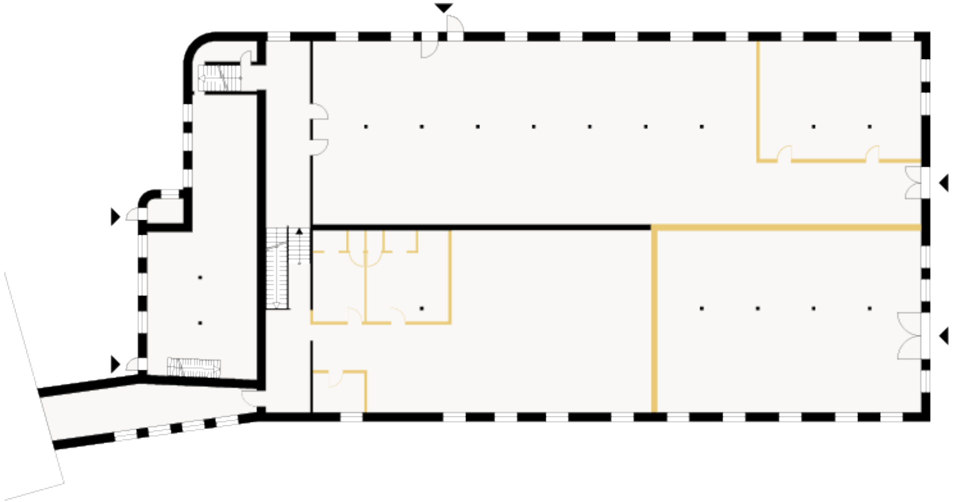
SOUTH EAST



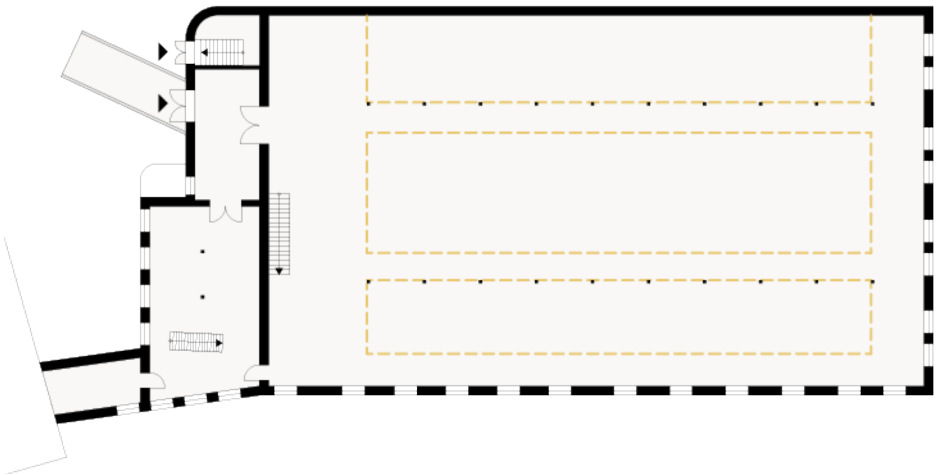
FACADE - NORTH WEST

DEMOLITION PLANS 1:500

FIRST FLOOR



SECOND FLOOR

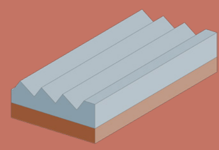


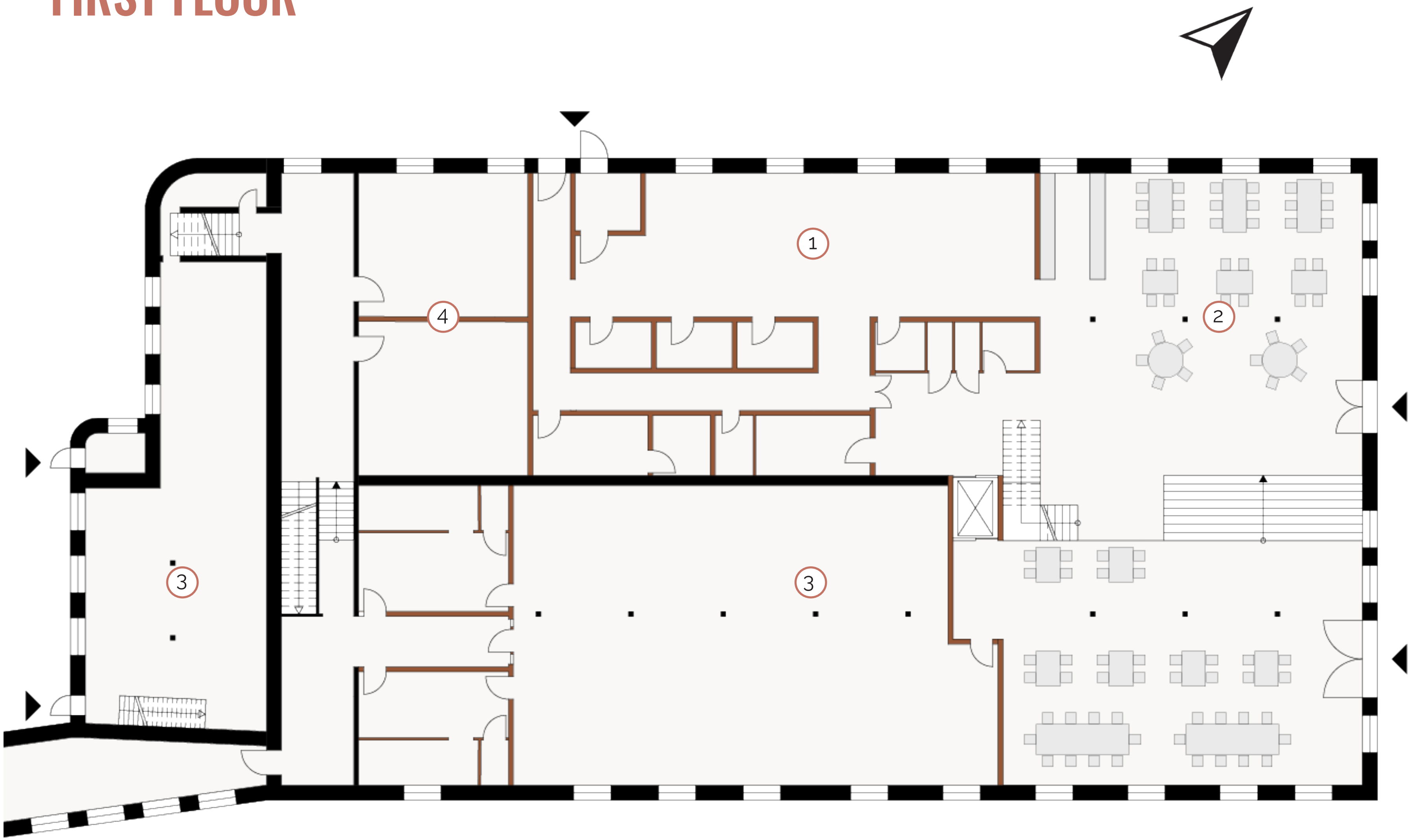
Demolition

Existing structure

FLOOR PLANS 1:250

FIRST FLOOR





1 Kitchen

2 Restaurant

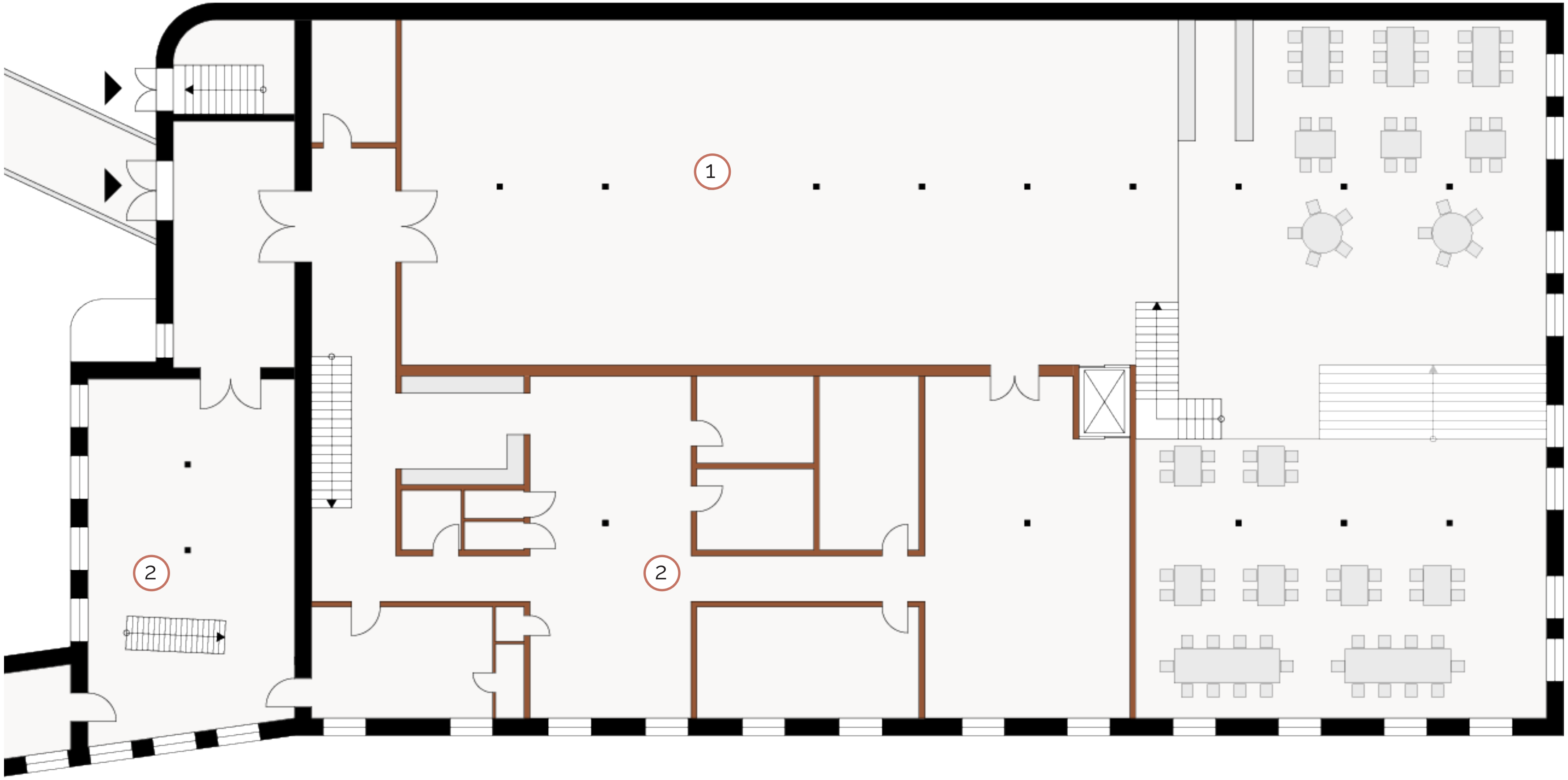
3 Youth centre

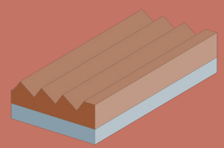
4 Work shop

New construction wood

Existing structure

SECOND FLOOR

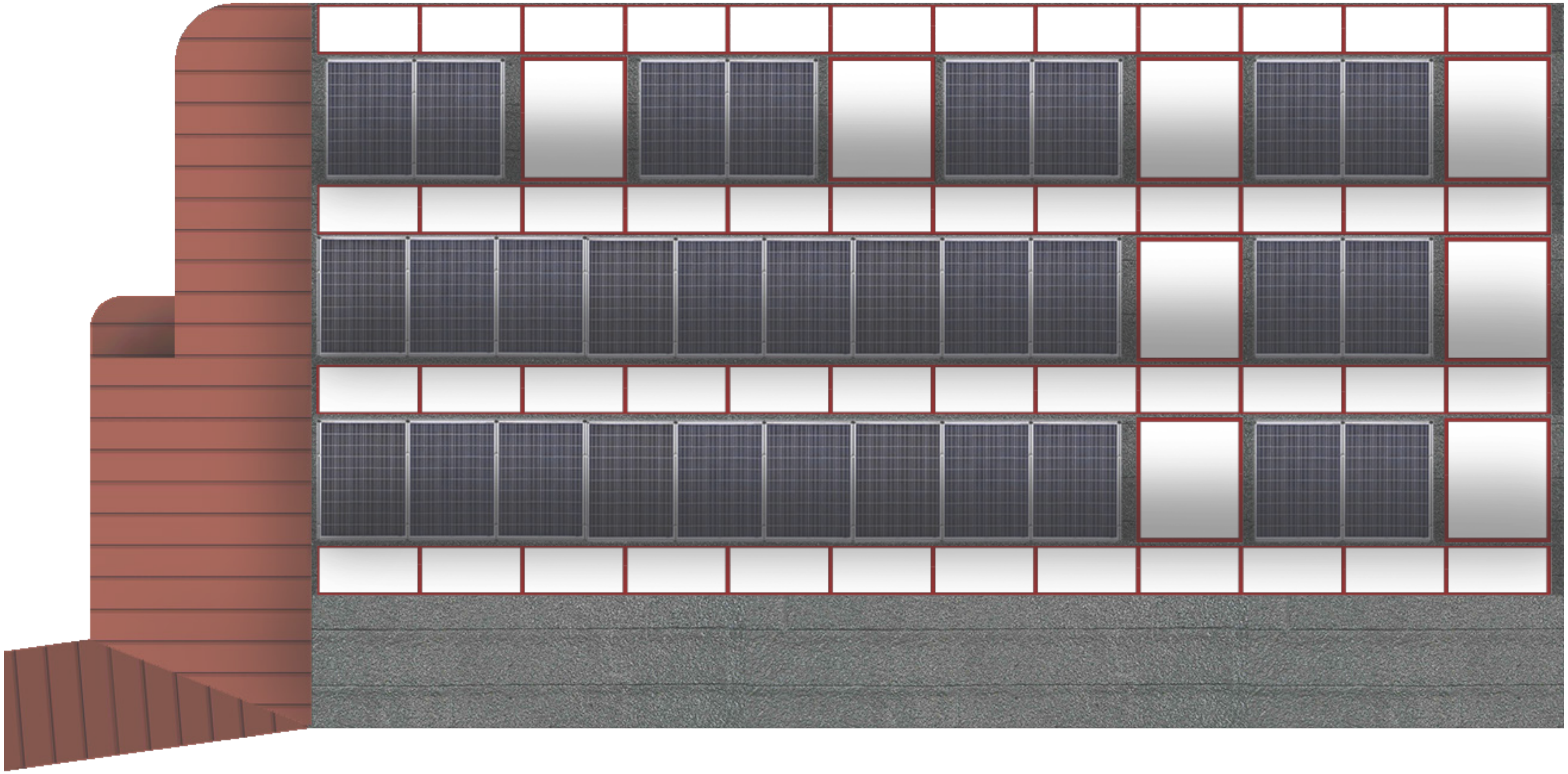




1 Exhibition hall

2 Youth centre

ROOF



LEARNING & RECOMMENDATION

LEARNING & RECOMMENDATION

With this thesis, I address different obstacles in a rural transformation project, however, it should not be interpreted as a complete or unquestionable summary. Moreover, it should be seen as inspiration that gives a direction for further investigations in the field of transformation and life cycle assessment. There are some findings I want to share with everyone interested in this direction of architecture.

WORK TOGETHER WITH PEOPLE

Involve the people in the early design process if possible. It was very helpful to have interviews with different stakeholders to understand the local situation. Moreover, it was also very interesting to experience all the different views and interests of everyone involved in such a project.

CAN WE TRUST THE DATA?

Design tools like CAALA are a great indicator in an early design phase when the aim is to reduce the environmental impact of a project. However, they are only as valuable as the data that goes into them and I experienced how minor changes lead to a huge difference in the outcome.
In addition, life cycle assessment is still a niche, but I am convinced it will become mandatory for all kinds of construction projects, not only newly constructed buildings. Therefore, the accuracy and handling of future software are likely to become better over time, which will make it more attractive to implement them in a design.

LIFE CYCLE ASSESSMENT AND ITS STUDY PERIOD

The study period of a life cycle assessment is always speculation, as the tool uses current data regarding energy production, climate and energy demand. These factors are very likely to change in the future. This should be considered when looking at the results. However, the outcome is still an indicator of what changes lead to an improvement and reduce the environmental impact, and that's what I used the software for.

USE MATERIALS WITH A LOW ENVIRONMENTAL IMPACT

The use of renewable resources is key to reducing CO_2 emissions. I mostly used wood in my project, as wood binds CO_2 during its growth but also prevents much worse emissions from alternative materials like steel, concrete and composites. This has helped to reduce the environmental impact of my project significant.

THINK OF THE HVAC SYSTEM

The HVAC system had the greatest impact on my life cycle assessment. It is important to understand the long term impact of such a system and therefore should get a lot of attention in the design process.

FINAL THOUGHTS

Had I had more time, I would have presented a more detailed outcome. For instance, some of my CAALA experiments are not presented in the booklet, and the level of detail in my final design was limited because of time. However, I am quite satisfied with the outcome, and I enjoyed the process and the finalisation of this paper. In the future, I will strive to keep working in the field of sustainable architecture and will hopefully achieve my personal goal to work with transformation projects. Finally, I thank everyone who has read my thesis and I really hope this topic makes you curious about investigating this field further.

REFERENCES

REFERENCES

LITERATURE

Laura Goldsteijn. (2020). Life Cycle Assessment (LCA) explained. Retrieved 2022/03/01 URL: https://pre-sustainability.com/articles/life-cycle-assessment-lca-basics/

Global Status Report. (2018) The building sector. Retrieved 2022/4/3 URL: https://architecture2030.org/why-the-building-sector/

Zhang, Y., Wang, J., Hu, F., & Wang, Y. (2017). Comparison of evaluation standards for green building in China, Britain, United States. Renewable and sustainable energy reviews, 68, 262-271.

Sartori, I., & Hestnes, A. G. (2007). Energy use in the life cycle of conventional and low-energy buildings: A review article. Energy and buildings, 39(3), 249-257.

Menzies, G. F., Turan, S., & Banfill, P. F. (2007). Life-cycle assessment and embodied energy: a review. Proceedings of the Institution of Civil Engineers-Construction Materials, 160(4), 135-143.

Dr Morwenna Spear (2019). Wood in Construction in the UK: An Analysis of Carbon Abatement Potential, (p3, Main Findings), February 2019

Hollberg, A., Lichtenheld, T., Klüber, N., Ruth, J. (2017). Parametric real-time energy analysis in early design stages: a
method for residential buildings in Germany. Energy, Ecology and Environment, Volume 3, pages 13–23

CAALA (2021). CAALA software. Caala GmbH. Retrieved 2022/3/1 URL: https://caala.de/fveatures

Frid Y. (2017). Personal Conversation 2022/02/16
Statistics Sweden (2022). Population statistics 2022. URL: https://www.scb.se/en/finding-statistics/statistics-by-subject-area/population/

Weather spark, (2022). Weather data. Retrieved 2022/02/23 URL: https://weatherspark.com/y/71566/Average-Weather-in-Göteborg-Sweden-Year-Round

Municipality of Ale (2022). About Alafors. Retrieved 2022/02/16 URL: https://ale.se/kommun--politik/fakta-om-kommunen/ales-historia.html

Ahlaforsbryggerier (n.d). Ahlafors Spinneri. Retrieved 2022/03/4 URL: http://www.ahlaforsbryggerier.se/bryggeriet/ahlafors-spinneri/

Andén A. (2006). Site report & history of Alafors from 2006

Evertherm (2021). Retrieved 2022/05/07 URL: https://en.evertherm.se/post/sa-nar-du-energikraven-som-mojliggor-markanvisning

Mata, É., Sasic Kalagasidis, A., Johnsson, F. (2013) Energy usage and technical potential for energy saving measures in the Swedish residential building stock. Energy Policy, vol. 55 pp. 404-414.

FIGURES

The figures, photos or drawings not found in this list, are either authors own, received from personal communications or exports from used softwares.

Figure 2, Global Status Report. (2018) The building sector. Retrieved 2022/4/3 URL: https://architecture2030.org/why-the-building-sector/

Figure 3, Overbey D. (2021). Life Cycle Stages. Retrieved 2022/3/13 URL: https://www.buildingenclosureonline.com/blogs/14-the-be-blog/post/89547-lca-stages-matter-when-tracking-embodied-carbon

Figur 7, 8 & 9, Not Quite Event (2021). Online photo collection. Retrieved 10/03/22 URL: https://www.notquite.se/#&gid=1&pid=2

Figure 15, Alafors spinning mill (1990). Photograph. Received through personal conctact 2022/1/28 from Andén A.

Figure 16, Alafors spinning mill (1916). Photograph. Retrieved 2022/02/23 URL: https://www.prismavg.se/exhibits/show/ahlafors-spinneri-spinner-vida/item/1514

Figure 17, Alafors spinning mill (1931). Photograph. Retrieved 2022/02/23 URL: https://www.prismavg.se/exhibits/show/ahlafors-spinneri-spinner-vida/item/1514

SOFTWARE USED

CAALA GmbH (2021). CAALA PRO (v1.21.5.25) [Computer software]. https://caala.de/

VELUX Group (2021). VELUX Daylight Visualizer BETA 3.0.22 [Computer software]. https://www.velux.com

INTERVIEWS

Interview can be reviewed online by using following URL's:

https://drive.google.com/drive/folders/1sYOpJzcamWFueRaB3Zr3KnriaVBYG_rn?usp=sharing

CHALMERS
UNIVERSITY OF TECHNOLOGY

Master Thesis Spring 2022

Chalmers School of Architecture
Department of Architecture and Civil Engineering

Architecture and Planning Beyond Sustainability