La machine à fabriquer

A good city has sustainable industry

Thesis Book
Fall Semester 2023
Nathan Boder

Abstract

In this Master of Architecture thesis, two major themes converge: the return of production to the city and the temporary storage of carbon through timber construction. The aim is to bring a tangible intervention into the heart of the industrial zone of Bern's Güterstrasse.

The initial exploration focuses on the significance of the industrial zone in the city center. Inspired by the plea of Dieter Läpple, a German sociologist, the study highlights the positive economic, sustainable and social impacts of bringing production back to the city. It also undertakes to address the major climate challenge by proposing an innovative solution for the temporary storage of carbon, while complying with Swiss standards such as the SIA.

The architectural proposal embodied by the "Machine à fabriquer" harmoniously combines these two axes. It intensifies production through the creation of dedicated spaces, and encourages social integration through creative infrastructures such as a café, equipped workshops and a multi-purpose hall. It is in the choice of spatial design and materials that this project responds to environmental concerns.

In this way, Güterstrasse becomes the stage for an industrial renaissance, where economy, sustainability and social concerns are intertwined. This proposal emerges as a possible example that respects the past while adapting to today's needs, thus opening up promising prospects for the future of this industrial area.

Thesis Book Fall Semester 2023

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Content

1 Introduction

The development of this Master's thesis takes place within a framework set up by HSLU Lucerne and FHNW Muttenz for the autumn semester 2023. The general theme is "Feed The City", with an urban industrial site in the Mattenhof-Weissenbühl district of Berne selected as the site of intervention. The focus is on the issue of sustainable food supply. However, the growing pressure of residential areas in industrial zones, and the migration of the latter away from the city center, is also an underlying theme of the given topic.

The research presented in this paper addresses two topics. On the one hand, this thesis focuses on the future perspective of the industrial zone in an urban environment. The path chosen is the return of the production to the heart of the city, generating significant benefits not only for the economy and the climate, but also on a social level. On the other hand, this study takes into account the climate crisis and the major challenges it poses. This is addressed in particular through the issue of carbon and biogenic carbon accounting, which raises the challenge of designing carbon-negative buildings.

Last but not least, it also consists of developing an architectural project. This is addressed as a case study that implements the principles set out above for a city that is both productive and sustainable.

Art. 23 Industrie- und Gewerbezone IG[1]

1. Die Industrie- und Gewerbezone IG ist für Produktions-, Reparatur- und Lagernutzungen bestimmt.

2. Zulässig sind ferner die zu den Nutzungen gemäss Absatz 1 betrieblich erforderlichen Büroräumlichkeiten, Forschungsstätten, Wohlfahrtseinrichtungen und Wohnungen.

3. Ladengeschäfte, Gaststätten und Freizeiteinrichtungen, die den örtlichen Bedürfnissen dienen, sind gestattet.

Bauordnung der Stadt Bern (Stand: 28. September 2023)

1 Translation : Art. 23 Industrial and manufacturing zone : 1. The industrial and manufacturing zone is intended for production, repair and storage uses. 2. Furthermore, the office premises, research facilities, welfare facilities and dwellings required for the uses in accordance with paragraph 1 are permitted. 3. Shops, restaurants and leisure facilities that serve local needs are permitted.

1.1 An industrial zone in the city

The intervention site is located in the center of Bern. More precisely, it is less than two kilometers from the second-busiest railway station in Switzerland. The area is zoned for industrial activities and is therefore suitable for the secondary sector. This contrasts with the presence of many federal administrations and corporate headquarters. A study of the city's land-use plan reveals that the Güterstrasse and Weyermannsstrasse industrial zone is like an island, or more precisely, an industrial peninsula, in the heart of the city. Most of the surrounding area is devoted to residential development, to the large complex of the Insel Hospital and the Bremgarten Cemetery, which border the Weyermannsstrasse.

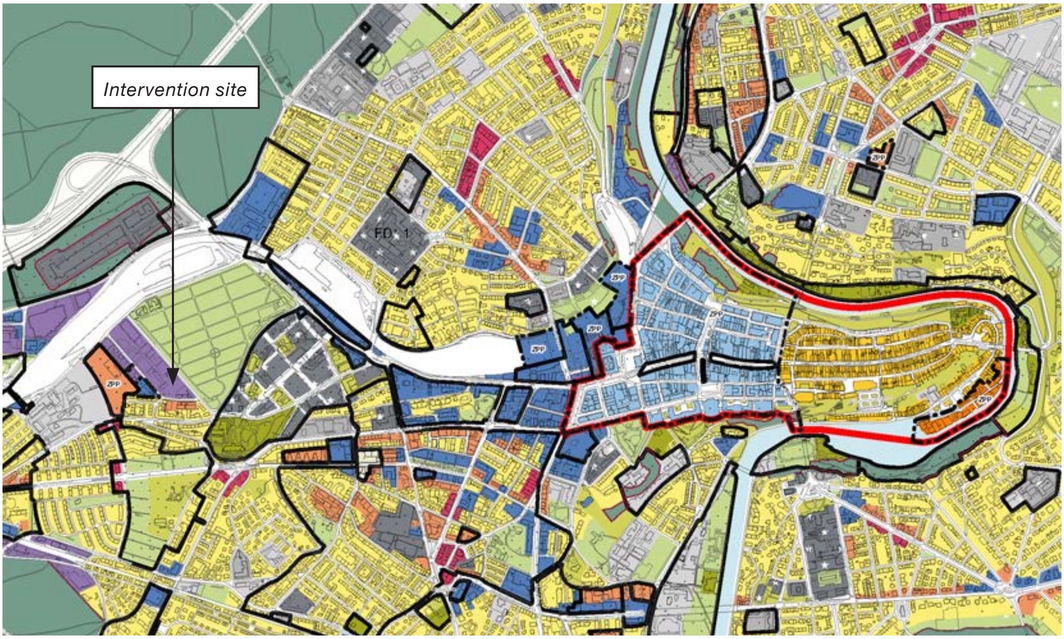


Fig. 1. Land-use plan (Nutzungszonenplan) of the city of Bern. Stadt Bern 2023.

The city of Bern is not as legendary as Basel or Zurich when it comes to industry. However, it is important to emphasize that this type of activity was much more prevalent in the city in the past. In terms of surface area, the industrial zone (IG) in the city center has been reduced by half since 1976, according to the city's land-use plan. This reduction can be attributed to the very high demand for residential and commercial space, the transition from a secondary to a tertiary economy, and the relocation of companies to reduce costs and nuisances for residents. In the case of Bern, the VonRoll area serves as an example of this. Where steel was once processed into railway equipment, now houses a university campus and a residential complex.

This leads us to question the future of the Güterstrasse industrial area. Based on current trends, it seems the time has come to transform the industrial areas into a mixed residential and commercial zone, similar to what was done in the southern part of the Güterstrasse: residential buildings with shops on the ground floor now replace the former incineration site. This change in the northern part of the site was also politically motivated in 2016, with a red-green motion[2] calling for the final takeover of one of the last industrial sites of the city center.

Fig. 2. Aerial view of the VonRoll Area in 1938. Bundesamt für Landestopographie (2019).

Fig. 3. Aerial view of the VonRoll Area in 2023. Bundesamt für Landestopographie (2023).

2 Motion number 2016.SR.000168 from the Stadt Bern : Interfraktionelle Motion SP, GB/JA! (Peter Marbet, SP/Franziska Grossenbacher, GB): Arealentwicklung Güterstrasse-Weyermannsstrasse an die Hand nehmen.

Fig. 4. Map showing the evolution of industrial areas in the city of Bern based on the 1976 and 2023 land-use plans of the city of Bern.

Fig. 5. Aerial view of the the former waste incineration site. Swissair Photo AG (1995).

Fig. 6. Aerial visualization of the settlement project Holliger. Holliger (2023).

2 The productive city

In June 2022, the city of Bern presented a strategy[3] to support the role of the industrial zone[4] in the city of Bern. This paradigm shift didn't come out of nowhere. In fact, it was the logical continuation of a reflection begun by a movement in favor of a return of production to urban centers. In 2016, Dieter Läpple published a statement in Bauwelt magazine[5]. Beyond the economic aspect, the motivations for such a change are social. In a society that is built around employment in the sense that social integration is achieved through it, it is essential to have a diversified range of jobs in order to provide work for both highly skilled and low-skilled people. The result is a much more resilient economy in times of turbulence.

Dieter Läpple draws economic comparisons between U.S. and German cities. While U.S. cities utilized globalization to outsource production to emerging countries, German cities were slower to transition to a tertiary economy[6]. Consequently, German cities maintained a robust industrial base in the city center and are now considered models in this regard.

It is important to emphasize that these are urban industries, but not the industries of the past, such as the chimney industries or the large production complexes inherited from Fordism. These new industries take the form of a mix of small and medium-sized enterprises that respond to individual and local needs. These changes in production are made possible by the evolution of the equipment, especially with Industry 4.0. Additive manufacturing with industrial 3D printers can meet a specific customer demand quite efficiently.

It involves a rethinking of the production system that allows small quantities to be produced on demand and at low cost. With new technologies, the future of production will be where the consumer is, as Dieter Läpple points out.

3 Stadt Bern 2022. Strategie «Zukunft Werkplatz Bern», Juni 2022.

4 An area intended for production, repair and storage.

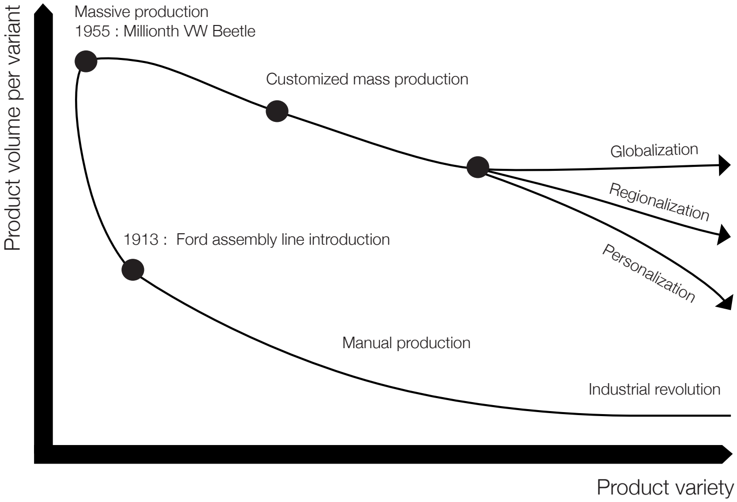
5 Läpple, D. 2016: Produktion zurück in die Stadt. Ein Plädoyer, Stadt Bauwelt, 211, 35.2016, S. 23–29.

6 Focus on service activities rather than the production of physical goods.

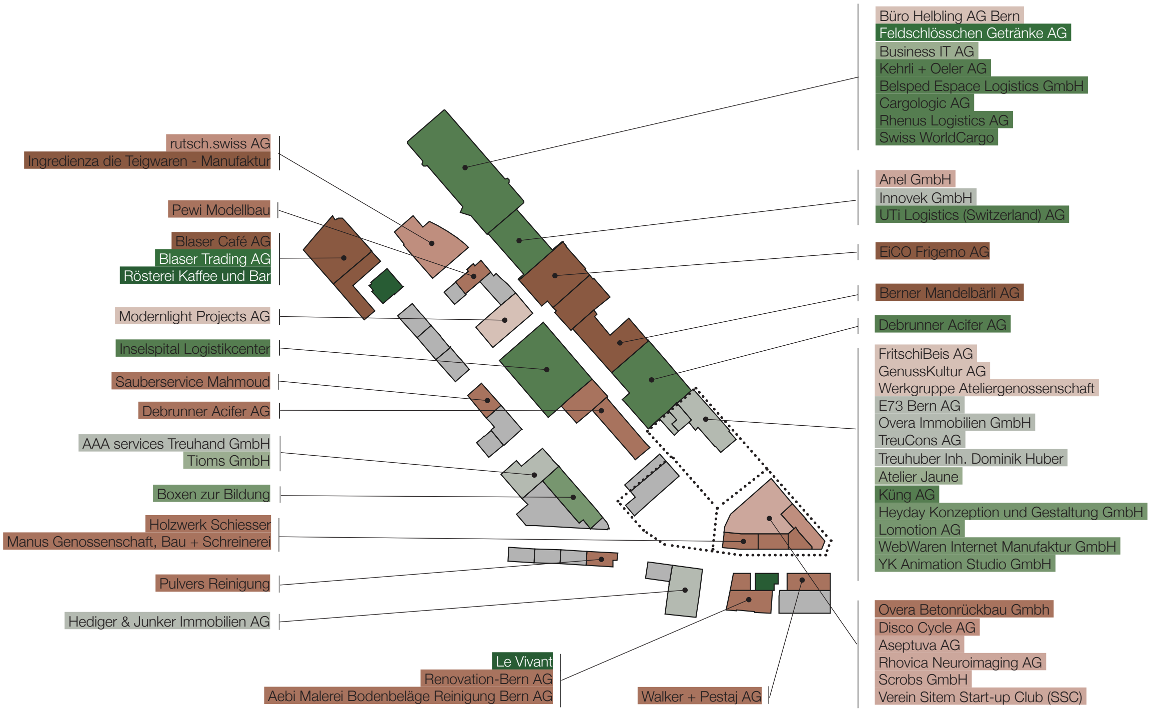
The development potential of an industrial zone in the city center is therefore both tangible and necessary. The reasons mentioned here are economic and social. This change must also take place for environmental reasons. In particular, to reduce transportation by producing locally, but also to produce more sustainably. As Nina Rappaport points out in her book "Vertical Urban Factory"[7], it's easier to verify a company's environmental commitment when it's close to us.

Finally, it's not just a matter of industrial production technologies or the characteristics and constraints of the production site (in the city or out of the city, local or global). It is also about changing demand, as shown in the diagram below. The Industrial Revolution took place at the end of the 18th century. The economy shifted from an agrarian form to the large-scale production of manufactured goods. Improvements in the production chain followed, with Ford's first assembly line in 1913. A period of mass production began, culminating in the production of the millionth VW Beetle in 1955. From then on, product diversity took over, a trend that continues to this day, with the customer's desire to influence and participate more and more in product design.

Fig. 7. The evolution of production (based on the graph by S. Jack Hu, 2013).



7 Rappaport, N. (2015, January 1). Vertical Urban Factory. Actar. p.440



2.1 The existing businesses on the site

Fig. 8. The existing businesses on the site.

- Food processing
- Construction
- Maintenance and repair
- Medical

- Design and planning
- Finances and real estate
- IT support
- Audio-visual production

- Logistics and transport
- Food distribution
- Restaurants

Güterstrasse and Weyermannsstrasse host 55 companies, with 37% in the secondary sector and 67% in the tertiary sector. Food-related businesses constitute 15%, including food processing,[8] food distribution,[9] and restaurants.[10]

Regarding the buildings on the intervention site, the emblematic building at the intersection of Güterstrasse and Weyermannsstrasse is home to 7 companies, 3 of which are in the construction sector, a bicycle repair shop, and 3 medical start-ups. The hipped-roof building at Weyermannsstrasse 28 is home to 13 companies, mainly in the service sector.[11] The use of the hangar at 21 Güterstrasse is related to the AVIA gas station, which is scheduled to disappear.

8 Blaser Café AG, Ingredienza die Teigwaren - Manufaktur, EiCO Frigemo AG, and Berner Mandelbärli AG

9 Blaser Trading AG and Feldschlossen Getränke AG

10 Rösterei Kaffee und Bar and Le Vivant

11 Like architects, graphic designers, audiovisual production

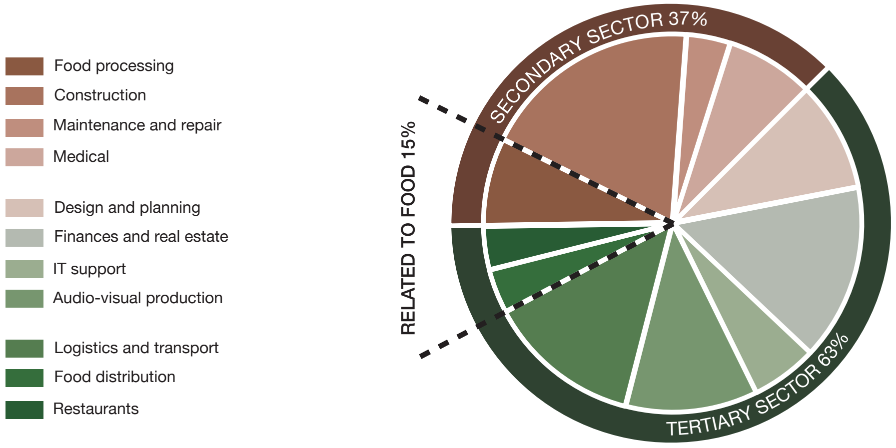


Fig. 9. Analysis graph of existing businesses on the Güterstrasse and Weyermannsstrasse industrial site.

At first sight, the site appears diverse in terms of companies, but it's crucial to consider job density relative to surface area. The graph only accounts for company presence, not surface area or job numbers. Making the ratio of surface area to jobs is a key for understanding business impact. For instance, logistics yields 1 job per $100m^2$, industry/crafts 1.5 jobs, technology production 2 jobs, and office activities 3 jobs per $100m^2$.

Employment promotion suggests that priority should be given to job-generating activities. However, given the high prevalence of office activities in the city of Bern, it is suggested here to give way to production-oriented activities in order to diversify jobs and the economy. Moreover, the current representation in terms of company presence of this type of activity on the Güterstrasse site is only 37%. This is essentially an industrial zone and deserves to be enhanced as such.

Conversely, the logistics sector, with its limited impact on employment and with usually less significant impact[12] for local residents, should also be limited.

12 A significant impact may be felt when workers feel a sense of pride in contributing to the development of a particular product. For example, the Güterstrasse site is sometimes described as the home of Mandelbärli. The creation of a remarkable product strengthens the sense of belonging and gives special meaning to what is produced.

2.2 The "made in Zürich Initiative"

The return of the production to the city, or at least the promotion of this activity in the urban context, is not just a theoretical notion addressed in architectural literature or political agendas. It's also taking concrete action in Zurich, for example, with the "Made in Zurich Initiative."

Founded in 2018, this association has grown rapidly, with approximately 50 member companies in 2019 and a total of 156 member companies today in 2023. Its aim is to strengthen the role and visibility of the urban production sites in Zurich by promoting synergies between its members. It brings together companies of all sizes involved in production, assembly, repair or maintenance, as well as individuals, companies or institutions that support urban production in the city. This concept is presented as an added value for the city, as underlined by this extract from the association's statutes[13]:

> *"Wir sind der Meinung, dass eine lebendige Stadt aktive Produzierende braucht und verstehen den Produktionsstandort Stadt Zürich als Anreiz und Verpflichtung zu Nachhaltigkeit, Innovation und Exzellenz."*[14]

Fig. 10. "Made in Zürich Initiative" logo.

Architecturally, Markus Freitag, one of the founders of the initiative, wants to promote collaborative factory building. His vision[15] is of a large hall where all kinds of small manufacturers could work in well-designed and well-connected spaces.

13 Made in Zürich Initiative (2023, march). Statuten des Vereins «Made in Zürich Initiative». Retrieved November 2023 from https://www.madeinzuerich.ch/_files/ugd/391c46_729f08ff6d4747d38c41dd96471c3493.pdf

14 Translation : We believe that a vibrant city needs active producers and see the city of Zurich as a production site as an incentive and commitment to sustainability, innovation and excellence.

15 Freitag & Frochaux (2019, October). Freitag : rester en ville à tout prix. Tracé : La Ville Productive

2.3 Architectural references

2.3.1. Noerd by Rothen Architektur

Forced to leave their temporary hall at the Maag Areal to make way for new residential and commercial development, Freitag was looking for a new production facility.[16] Unfortunately, they couldn't find an existing hall in the city that fit their budget. With an urban location in their DNA, they had to build a new building. Together with Aroma (a company producing three-dimensional communication concepts), they were the first two tenants for whom the St. Gallen-based investor Senn developed this new 18'907m^2 complex, which can accommodate up to 30 companies and create around 500 jobs.[17]

Located in an industrial zone in the north of Zurich, the volume occupies the entire plot on the ground floor with the production hall for Freitag and Aroma. The upper floors, spread out in two C-shaped buildings, house offices and workshops.

The innovative aspect of this project is the initial desire to host a significant number of companies. However, the project differs from Markus Freitag's vision in that the production hall on the ground floor has been designed and built exclusively for Freitag and Aroma. The spaces available to other companies are flexible in their layout, but do not offer the services required for real production (volume, transportation of goods, etc.).

16 Freitag & Frochaux (2019, October). Freitag : rester en ville à tout prix. Tracé : La Ville Productive

17 Wüestpartner (2019, December). Etude économique du PALM : adéquation de l’offre foncière et immobilière avec les besoins des entreprises. p. 114. Retrieved November 2023 from https://www.vd.ch/fileadmin/user_upload/organisation/spei/fichiers_pdf/20191216_Summary_SPEI_PALM.pdf

Fig. 11. View of Binzmühle-strasse at night. Senn (2011).

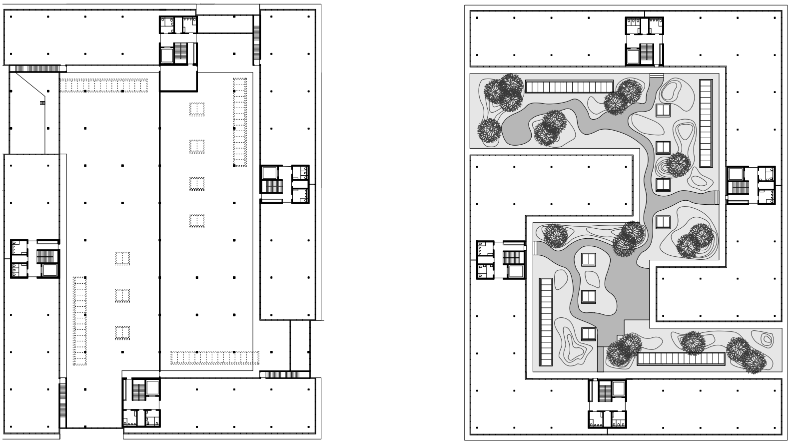


Fig. 12. Plan of the ground floor and of the upper floors. Tracés 10/2019.

Fig. 13. View of the Freitag production hall. Senn (2011).

2.3.2. Gewerbebau by Graser Troxler Architekten

This project, designed by Graser Troxler Architekten, is closer to the vision of Markus Freitag presented in the previous chapter on the "Made in Zurich Initiative." In fact, according to the architects, the project consists of a layering of ground floors thanks to the use of freight elevators directly connected to each production unit.

This project won the competition in 2020 for one of the plots of the Zwhatt site in Regensdorf (10km from Zurich). It proposes a minimalist intervention with a structure made up of a series of load-bearing elements. Made entirely of reinforced concrete and metal, the building is 80m long, 20m deep and 25m high. The future users of this vertical factory were unknown at the design stage. The aim was to create a building with a high degree of adaptability and divisibility. This project is innovative in that it proposes a stack of production halls, a "true" vertical factory in the literal sense of the word, as verticality also means a reference to the city.

As part of the "5. Aachener Tagung Identität der Architektur zum Thema Raum," architect Jürg Graser presented this building[18] and also addressed the issue of sustainability:

> *"Ich glaube, wir sind uns alle einig, dass Energie und CO_2 zu den bestimmenden Themen der Zukunft gehören, dass die Stadt eine Ressource ist, dass viel weniger neue Gebäude gebaut werden sollten und dass Dinge wiederverwendet werden sollten."*[19]

Unfortunately, the explanation in the presentation that follows this awareness of the situation points out that the advantages of this project in terms of architectural sustainability lie solely in the visible positioning of the technical installations under the slabs...

18 Gewerbebau Regensdorf. Graser. (2023, March). [Video]. Youtube. Retrieved November 15, 2023, from https://www.youtube.com/watch?v=-qwLSHgYhlTQ

19 Translation : I think we all agree that energy and CO2 are among the defining issues of the future, that the city is a resource, that far fewer new buildings should be built and that things should be reused.

Fig. 14. Cross-section presented on the competition board. Graser Troxler (2020).

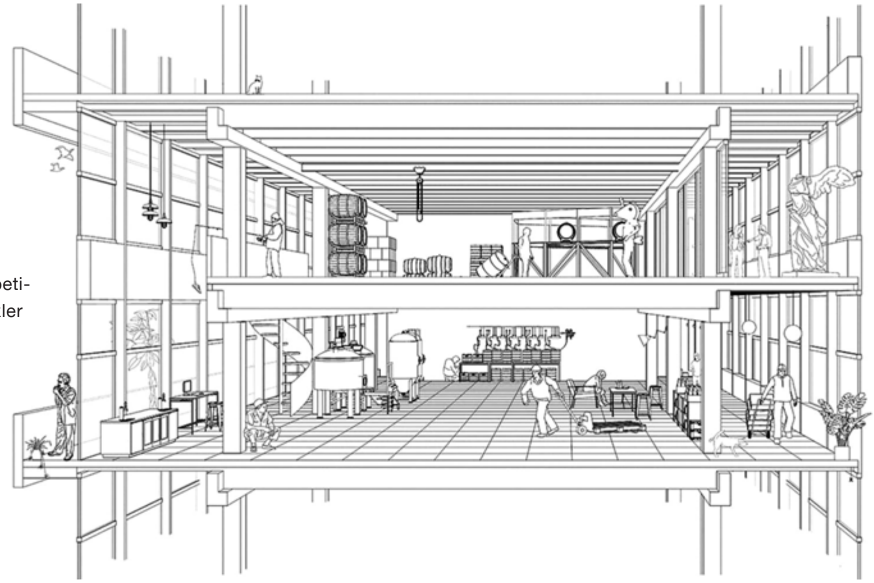


Fig. 15. Typical floor plan. H&B Real Estate AG (2023).

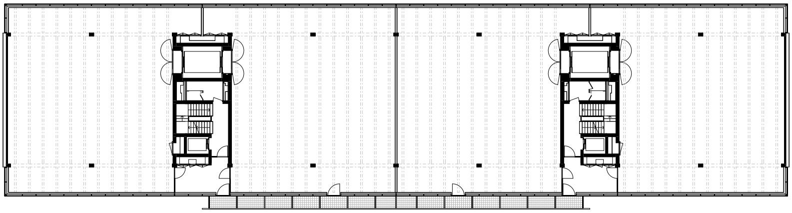


Fig. 16. Model of the building structure. Graser Troxler (2020).

*“**It is not enough** to build today in a way that enables buildings to be reused in 50 or 100 years.*
***It is not enough** from now on just to combine homogeneous materials in such a way that they can be separated from each other again without destroying them.*
***It is not enough** to record the materials used in a property register so that in 50 or 100 years they can serve as a repository of reusable material.*
These are all valuable investments in the future, but they do not change the fact that we need forceful and effective measures right now :
***Right now, we must** stop replacing existing buildings with new ones.*
***Right now, we must** pay attention to the grey energy in our buildings.*
***Right now, we must** stop constructing new buildings with nothing but new building materials.*
***Right now, we must** employ all our inventiveness and all our creative energy to ending the present squandering of raw materials and to drastically reduce the volumes of waste entering landfills!”*

Barbara Buser
Bauteile wiederverwenden (2021)

3 The climate emergency

As Jürg Grasser pointed out at the Regensdorf Gewerbebau presentation: "Wir sind uns alle einig, dass Energie und CO_2 zu den bestimmenden Themen der Zukunft gehören." Today, it is imperative to achieve effective and efficient results. It is no longer possible to delegate this task to others, and this starts with a rapid take-up of these issues, particularly here in an academic context where economic, programmatic and regulatory constraints are not as restrictive as in a real-world application.

As Barbara Buser has been pointing out since the late 1990s, "It's necessary to rethink"![20] The Swiss construction sector generates 17 million tons of waste per year.[21] The fight against global warming is the most important challenge of our time, which is why this topic is an essential part of this Master's thesis. According to the United Nations Environment Agency, the buildings contribute to 37%[22] of the global greenhouse gas emissions linked to human activity.

Barbara Buser's message (see left page) serves to lay the groundwork for the approach to the architectural project of this master thesis.

As this approach is very wide, the focus chosen for this project is to take into consideration the existing substance and to pay attention to the gray energy emitted during the construction.

20 Massmünster, M., Stricker, E., Brandi, G., Sonderegger, A., Angst, M., & Buser, B. (2021, August 19). Bauteile wiederverwenden.

21 Ibid. (p.15)

22 "*When including estimated CO2 emissions from producing buildings materials of around 3.6 GtCO2 (i.e. concrete, steel, aluminium, glass, and bricks), buildings represented around 37 per cent of global CO2 emissions in 2021.*" United Nations Environment Programme (2022). 2022 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Retrieved November 2023 from https://wedocs.unep.org/bitstream/handle/20.500.11822/41133/Building_Construction_2022.pdf

3.1 Carbon Storage Project

The subtitle "Carbon Storage Project" is taken verbatim from the technical report[23] that presents the status of different methodologies for accounting biogenic carbon. It was produced by ETH Zürich to help the city of Zurich define a valid path for the development of a climate-neutral city.

Fig. 17. One cubic meter of wood captures one ton of CO_2. proHolz Austria (2022).

Biogenic carbon refers to the mass of carbon fixed in biogenic materials (plant or animal fibers). Quite simply, $1m^3$ of wood contains approximately 1 ton of CO_2-eq. This material is therefore considered a CO_2 sink due to its ability to temporarily store carbon.

As wood engineer Andreas Burgherr pointed out during a presentation on sustainable buildings in Zurich, the stakes in the construction industry are high.[24] Half of all CO_2 emissions from buildings are linked to their construction, and the other half to their use (heating, for example). This represents approximately 20% and 20% of the global emissions. In comparison, the aviation sector is responsible for 3% of global emissions. As Andreas Burgherr says so well:

> *"Jetzt machen wir einfach eine kleine Rechnung auf. Wenn wir uns um 10% verbessern, dann haben wir mehr erreicht, als wenn wir nie wieder fliegen würden."*[25]

As architects, our proposals can have a significant impact on the CO_2 emissions emitted during construction. The wood industry, in particular, has adopted this as its mantra: choose wood to reduce the carbon footprint. But what if we took it a step further? To take the title "Carbon Storage Project" literally: to imagine a building as a carbon storage facility, in other words, a building with a negative CO_2 balance.

23 ETH Zürich, Pittau, Habert, & Savi. (2022, May). Carbon storage project.

24 Andreas Burgherr. (2023, January). Einblicke: «Nachhaltig bauen mit...». Schweizer Baumuster-Centrale Zürich. https://www.youtube.com/live/zdlF06YEPN8?si=mem0EmFoG-Nf2A9u

25 Translation : Now let's do a little math. If we improve by 10%, we will have achieved more than if we never flew again.

3.2 The construction material pyramid

Inspired by the food pyramid, the Royal Danish Academy's CINARK (Centre for Industrialized Architecture) has developed a pyramid of building materials. This meaningful representation makes it clear what the environmental impact of a material is.

The unit used is GWP (Global Warming Potential) which gives a CO_2 equivalent per m^3 in kg. These equivalents are used to standardize the value of different substances that are harmful to the climate. For instance, CINARK explains that 1kg of methane has approximately the same effect as 25kg of CO_2 when emitted into the atmosphere. GWP is also commonly used to represent the carbon footprint of a product.

Unsurprisingly, one particular category of materials stands out from the pyramid, or rather forms its base: vegetal fiber-based materials have a negative value.

Fig. 18. The construction material pyramid. CINARK (2019).

GWP (kg CO_2 eq / m^3)

Module A1-A3

3.3 The Swiss version of the pyramid

In order to approach this topic in accordance with the current Swiss regulations, it is necessary to refer to the SIA 2032 standard entitled "Graue Energie - Ökobilanzierung für die Erstellung von Gebäuden."[26] In this work, the objective is to focus on the ecobalance of a material in order to obtain a carbon emission value in relation to its volume, in the same way as the Danish pyramid. In the following sub-chapters, certain conditions need to be clarified, in particular the consideration of the whole life cycle, the calculation methods and the chosen data version. These different parameters can contribute to significant variations in the results.

It is important to note that the biogenic carbon content has only been included in Swiss ecobalances since April 2022, following the update of the KBOB list. However, this is not the only change: the data is also updated to bring the theoretical values closer to reality. To illustrate the impact of this update, the following example was presented in a post[27] on the website of a timber construction company: According to the old database, a square meter of glulam wood emitted 40kg of CO_2-eq/m^2. Under the new database, it now emits only 24kg of CO_2-eq/m^2, and benefits from the biogenic carbon stored in the wood, which means an additional deduction of 153 kg of CO_2-eq/m^2. The material itself has not changed, but its carbon footprint has gone from 40 to -129 kg of CO_2-eq/m^2 after the KBOB list update.

26 Translation : Green Energy - Life Cycle Assessment for the Construction of Buildings

27 Timber Structures 3.0 AG. (2022, June). KBOB list updated. Retrieved November 2023 from https://www.timbatec.com/en/aktuelles/meldungen/2022.06.13-KBOB-Daten.php

3.3.1. The life cycle of a material

The European standard SN EN 15804[28] defines the various stages of the life cycle in the form of different modules: A1-A3 are the production stages, A4-A5 are the construction process stages, B1-B7 are the use stages, and modules C1-C4 are the end-of-life stages. The European standard also includes module D, which includes benefits and loads, such as the potential for reuse, recovery and recycling. Unlike the German "Ökobaudat" standards, the SIA does not include this last module in its 2032 standard.[29]

Section 2.1.3 of the present standard (SIA 2032) even states that only the modules A1-A3 (production phases), B4 (replacement phase) and C1-C4 (end-of-life phases) are included, while the phases A4-A5 (construction phases) are partially neglected in the ecobalance defined by this standard. The use phases (B1-B7) are not included. Finally, section 2.2.1.1 of the standard summarizes what is involved in the determination of the ecobalance of a material:

> *"Die Bilanzierung eines Baustoffs umfasst alle Stoff- und Energieströme in der Herstellungs- und Entsorgungsphase des Baustoffs."*[30]

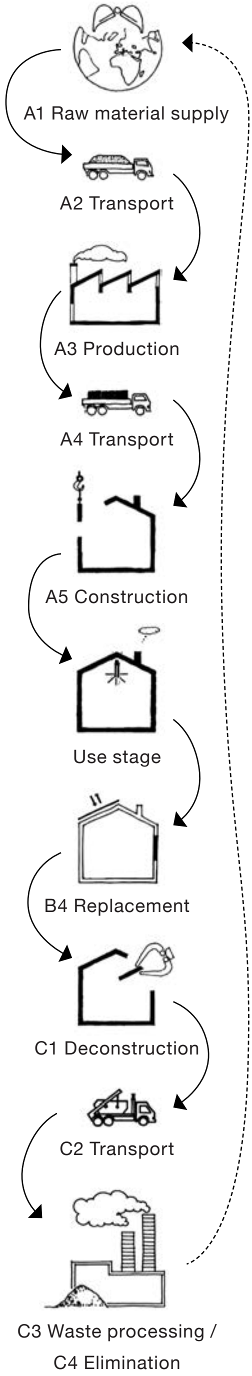


Fig. 19. Illustration of the construction life cycle. (based on the graph of the SIA 2032)

28 SIA 490.052+A2 : SN EN 15804+A2:2019 : Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products

29 *"Wenn das Modul D (Belastung oder Vorteile aus der Wiederverwendung, Recycling, externe Gewinne) z.B. thermische Verwertung eingerechnet wird, behält das Holzprodukt einen negativen CO2 Wert. Bei der Schweizer Methode wird dieses «Modul D» nicht eingerechnet."* Timber Structures 3.0 AG. (2021, August). Zusammenfassung des Berichtes zur Treibhausgasbilanzierung des Holzdeckensystems aus Brettsperrholz der Firma Timber Structures 3.0 AG (TS3). Retrieved November 2023 from https://www.ts3.biz/media/docs/downloads/Treibhausbilanzierung-CSD.pdf

30 Translation : The accounting of a building material includes all material and energy flows in the production and end-of-life phases of the building material.

3.3.2. Annualized or absolute values

The depreciation period, or period of use of building components, allows the environmental impact of a building to be assessed on an annual basis.[31] In principle, a load-bearing structure is depreciated over 60 years, façade cladding over 40 years and flooring over 30 years, to give just a few examples.[32] It's important to stress that this theoretical duration is given according to the type of element, and not according to its materiality.

For the purposes of this work, we will use an absolute value. In fact, annualized values are very useful to take into account the lifetime of the building. However, it remains theoretical because the length of time the building will be used is basically unknown. We must act now. The climate crisis must be solved today, and CO2 emissions must be accounted for today. It's not about smoothing out our emissions over the next 60 years.

It would also be tempting to consider only A1-A3 production values, such as the Danish pyramid. However, here too, we have to pay today for the future emissions induced by our present actions. The method and calculations used here are therefore based entirely on the indications given in SIA 2032 edition 2020.[33]

31 SIA Zürich. SIA 2032:2020 : Graue Energie – Ökobilanzierung für die Erstellung von Gebäuden. (p.14 chapter 3.1.2).

32 Ibid. (p.26 appendix C9).

33 Ibid.

3.3.3. Values, formulas and results

KBOB,[34] the Swiss Federal Coordination Office for Construction is responsible for compiling life cycle assessment data for the construction sector. The list "Ökobilanzdaten im Baubereich"[35] is freely accessible. The tab dedicated to building materials provides a detailed list, including greenhouse gas emission values. For each material, a total is given that it is the sum of the value representing the emissions related to production (A1-A3) and those related to disposal (C1-C4). A column is dedicated to the value of the biogenic carbon content (since April 2022), but it is not included in the previous total. Moreover, the unit is different: it is expressed in kg C, whereas the previous values were expressed in kg CO_2-eq. Finally, all these values have to be related to the volumetric density of the material.

The value of biogenic carbon needs to be converted before it can be added to the emission values. As explained in the "Carbon Storage Project" report,[36] the calculation of carbon sequestration is based on the atomic weights of carbon and oxygen. CO_2 is proportionally composed of 1 part carbon to 2.67 parts oxygen. So the mass ratio between 1 mole of CO_2 and 1 mole of C corresponds to 3.67kg/kg.

For solid timber, the KBOB list indicates the following values:

Mass density : 436kg/m^3
Greenhouse gas emissions Total : 0,288 kg CO_2-eq
Greenhouse gas emissions Production : 0,244 kg CO_2-eq
Greenhouse gas emissions Disposal : 0,044 kg CO_2-eq
Biogenic carbon content : 0,450 kg C

34 KBOB : Koordinationskonferenz der Bau- und Liegenschaftsorgane der öffentlichen Bauherren

35 KBOB. Ökobilanzdaten im Baubereich (IPB 2009/1:2022, Version 4). https://www.kbob.admin.ch/kbob/fr/home/themen-leistungen/nachhaltiges-bauen/oekobilanzdaten_baubereich.html

36 ETH Zürich, Pittau, Habert, & Savi. (2022, May). Carbon storage project.

The equation for calculating the amount of CO_2 contained in $1m^3$ of a bio-based material (S_{CO2}) given in the ETH Zürich report is as follows:

$$S_{CO2} = \rho_0 \text{ x } CC \text{ x } 3.67$$

ρ_0 corresponds to the density of dry biomass. In the absence of information, the moisture value (MC) for forest products can be counted as follows: MC=20% for interior applications, MC=15% for floor coverings and MC=10% for bio-based panels and insulation materials.

$$\rho_0 = \rho_{MC\leq 25} \text{ x } ((100 + 0.45 \text{ x } MC) / (100 + MC))$$

The calculation to obtain the amount of CO_2 contained in $1m^3$ of solid timber is as follows:

$$\rho_0 = 436 \text{ x } ((100 + 0.45 \text{ x } 20) / (100 + 20)) = 396.033 \text{ kg/m}^3$$

$$S_{CO2} = 396.033 \text{ x } 0.45 \text{ x } 3.67 = 654.048 \text{ kg } CO^2\text{-eq/m}^3$$

The total greenhouse gas emission value for $1m^3$ of timber still needs to be multiplied by its mass density:

$$0.288 \text{ kg } CO_2\text{-eq x } 436\text{kg/m}^3 = 125.568 \text{ kg } CO_2\text{-eq/m}^3$$

Finally, the CO_2 balance of solid timber can be calculated as follows:

GWP *= Total* greenhouse gas *emission - Biogenic carbon content*

$$125.568 \text{ kg } CO_2\text{-eq/m}^3 - 654.048 \text{ kg } CO_2\text{-eq/m}^3$$
$$= \underline{\mathbf{-528,48 \text{ kg } CO_2\text{-eq/m}^3}}$$

3.3.4. The discussion around the biogenic carbon deduction

It's crucial to stress that, for the time being at least, biogenic carbon storage in construction cannot be directly subtracted from the emissions attributed to construction. This distinction is simply explained by the fact that CO_2 is stored rather than eliminated. It would be potentially released if the timber were to be burnt at the end of its life cycle.

However, this carbon storage is very important, as shown in the study "Klimapositives Bauen: Ein Beitrag zum Pariser Absenkpfad"[37] :

> *"Der Einbau von biogenen Materialien in Gebäuden hat jedoch eine Verzögerung der klimarelevanten Emissionen zur Folge, da das CO_2 während der Gebäudenutzung gebunden bleibt. Diese Dauer kann durch Wiederverwendung, Kaskaden- und Kreislaufnutzung zusätzlich verlängert werden. Dies ermöglicht, die Speicherzeit für die Entwicklung besserer Technologien zur Sequestrierung von CO_2 und zu effektiveren Reduktionen zu nutzen, was als positiver Aspekt zu werten ist."*[38]

Finally, the Swiss CO_2 Act[39] is another point in favor of accounting for biogenic carbon. Article 14 reads as follows:

> *"Timber used in construction may be counted as a carbon sink."*

37 Nova Energie Basel AG, Basel. (2021, November). Klimapositives Bauen: Ein Beitrag zum Pariser Absenkpfad. (p.82 chapter 5.3.4).https://espazium.s3.eu-central-1.amazonaws.com/files/2022-01/211106_Bericht_Klimapositives_Bauen.pdf

38 Translation : However, the use of biogenic materials in buildings delays the release of climate-relevant emissions because the CO_2 remains sequestered while the building is still in use. This period can be further extended through reuse, cascade and circular use. This makes it possible to use the storage time to develop better technologies for CO_2 sequestration and more effective reductions, which is a positive aspect.

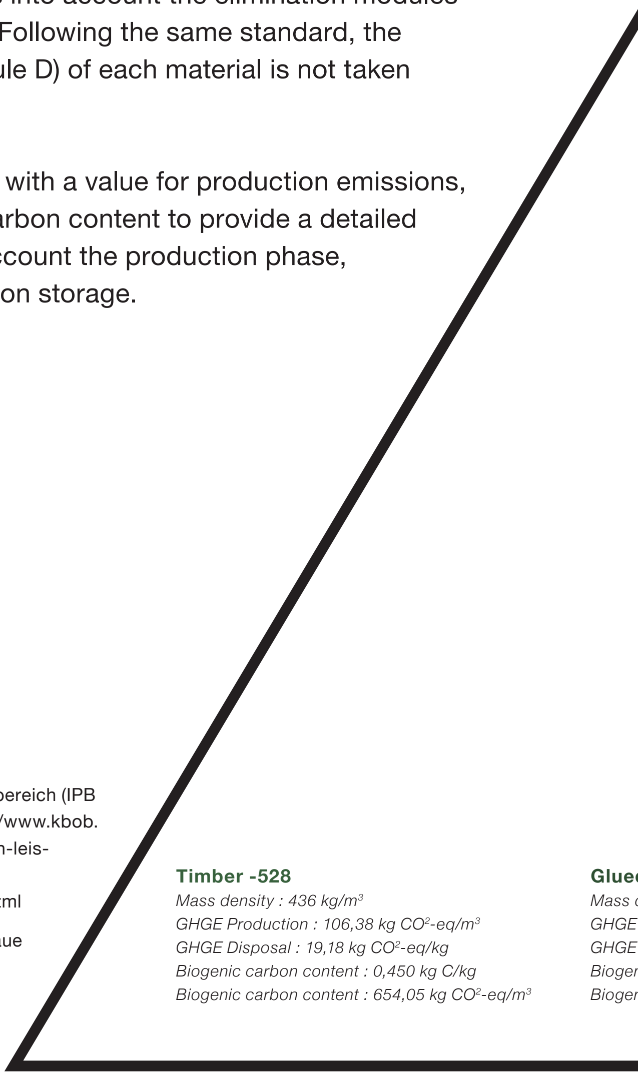
39 Federal Act on the Reduction of CO2 Emissions (January 1, 2013). Retrieved November 2023 from https://www.fedlex.admin.ch/eli/cc/2012/855/en

3.3.5. The Swiss pyramid in numbers

A detailed pyramid has been developed on the basis of the information contained in the KBOB list.[40] This representation is a selection of the materials needed to construct the structure of this project, such as wood and concrete, as well as those used for insulation, such as straw and wood fiber. It also includes essential flooring components specially adapted for industrial use and glazing to allow light in. Finally, it includes galvanized steel for railings and aluminum for window frames.

The principle is similar to the Danish pyramid, but this time the material score also takes into account the elimination modules according to SIA 2032.[41] Following the same standard, the recycling potential (module D) of each material is not taken into account.

Each material is detailed with a value for production emissions, disposal and biogenic carbon content to provide a detailed calculation taking into account the production phase, disposal phase and carbon storage.



40 KBOB. Ökobilanzdaten im Baubereich (IPB 2009/1:2022, Version 4). https://www.kbob.admin.ch/kbob/fr/home/themen-leistungen/nachhaltiges-bauen/oekobilanzdaten_baubereich.html

41 SIA Zürich. SIA 2032:2020 : Graue Energie – Ökobilanzierung für die Erstellung von Gebäuden

GWP (kg CO_2 eq/m^3)
Module A1-A3 + C1-C4

Galvanized steel 35'222
Mass density : 7'850 kg/m^3
GHGE Production : 35'168 kg CO^2-eq/m^3
GHGE Disposal : 54,95 kg CO^2-eq/m^3

Reinforced concrete 288
Concrete : Mass density : 2'300 kg/m^3
GHGE Production : 204,70 kg CO^2-eq/m^3
GHGE Disposal : 29,90 kg CO^2-eq/m^3
Steel : Mass density : 7'850 kg/m^3
GHGE Production : 6068,05 kg CO^2-eq/m^3
GHGE Disposal : 94,20 kg CO^2-eq/m^3
RC (proportion of steel 71 kg/m^3) :
GHGE Production : 257,73 kg CO^2-eq/m^3
GHGE Disposal : 30,48 kg CO^2-eq/m^3

Aluminum window frame (opening size) 132
GHGE Production : 117 kg CO^2-eq/m^1
GHGE Disposal : 14,9 kg CO^2-eq/m^1

Underlayment cement 222
Mass density : 1'850 kg/m^3
GHGE Production : 197,95 kg CO^2-eq/m^3
GHGE Disposal : 24,05 kg CO^2-eq/m^3

Underlayment anhydrite 182
Mass density : 2'000 kg/m^3
GHGE Production : 156 kg CO^2-eq/m^3
GHGE Disposal : 26 kg CO^2-eq/m^3

Clay plaster 59
Mass density : 1'800 kg/m^3
GHGE Production : 36,00 kg CO^2-eq/m^3
GHGE Disposal : 23,40 kg CO^2-eq/m^3

Insulated double glazing (opening size) 44
GHGE Production (24mm) : 40,70 kg CO^2-eq/m^2
GHGE Disposal (24mm) : 3,60 kg CO^2-eq/m^2

Straw bale (insulation) -255
Mass density : 215 kg/m^3
GHGE Production : 20,64 kg CO^2-eq/m^3
GHGE Disposal : 0,00 kg CO^2-eq/m^3
Biogenic carbon content : 0,368 kg C/kg
Biogenic carbon content : 275,85 kg CO^2-eq/m^3

Fiberboard wood (insulation) -117
Mass density : 148 kg/m^3
GHGE Production : 93,68 kg CO^2-eq/m^3
GHGE Disposal : 13,61 kg CO^2-eq/m^3
Biogenic carbon content : 0,436 kg C/kg
Biogenic carbon content : 224,97 kg CO^2-eq/m^3

d laminated timber -506
density : 439 kg/m^3
Production : 125,11 kg CO^2-eq/m^3
Disposal : 21,51 kg CO^2-eq/m^3
ic carbon content : 0,446 kg C/kg
ic carbon content : 652,70 kg CO^2-eq/m^3

Cross laminated timber -480
Mass density : 436 kg/m^3
GHGE Production : 141,70 kg CO^2-eq/m^3
GHGE Disposal : 34,88 kg CO^2-eq/m^3
Biogenic carbon content : 0,449 kg C/kg
Biogenic carbon content : 652,60 kg CO^2-eq/m^3

Oak mosaic parquet -525,86
Mass density : 700 kg/m^3
GHGE Production : 418,75 kg CO^2-eq/m^3
GHGE Disposal : 27,25 kg CO^2-eq/kg
Biogenic carbon content : 0,389 kg C/kg
Biogenic carbon content : 971,86 kg CO^2-eq/m^3

3.4 Reduction prior to the compensation

So far, this work has focused on the compensation of carbon emissions by the biogenic carbon present in the organic materials. However, it is clear that in terms of building design, the first strategy to adopt is to reduce the greenhouse gas emissions generated during the construction process.

The SIA 2032[42] proposes key guidelines in three main ways. First, reducing quantities through surface sobriety and efficiency, compacting volumes, limiting underground construction, and using simple structural systems. Second, minimization of embodied energy and greenhouse gas emissions through judicious choice of construction methods and materials. Thirdly, the separation of systems, ease of maintenance, adaptability and minimal use of technical installations promote durability and longevity.

In a summary sheet,[43] the "Klimapositives Bauen" study also presents its recommendations. These include the need to overcome misconceptions and have the courage to set clear goals, act accordingly, and take responsibility for the environment and future generations. Again, renunciation or reducing the intervention to a minimum is one of the best strategies for reducing greenhouse gas emissions during the construction phase. Ultimately, it is about building with recyclable materials, reusing existing structures and components, and using biogenic building materials. The latter not only contain carbon, but generally have a smaller carbon footprint.

42 SIA Zürich. SIA 2032:2020 : Graue Energie – Ökobilanzierung für die Erstellung von Gebäuden

43 Nova Energie Basel AG, Basel. (2021, November). Faktenblatt. Klimapositives Bauen: Ein Beitrag zum Pariser Absenkpfad. https://pubdb.bfe.admin.ch/de/publication/download/10767

3.5 Additional considerations

The ambition to develop a thesis project with a negative carbon balance, as described in chapter "3.1 Carbon storage project," is somewhat controversial and gives rise to many questions and misunderstandings. This is particularly sensitive in the current context, where carbon offset projects are frequently subjected to critical examination, sometimes exposing their misleading nature. At the same time, methodologies and standards related to the topic, particularly the accounting of biogenic carbon, continue to evolve. Navigating this complexity is no easy task.

It is also important to note that it will not be possible to build exclusively with wood in the coming years. Efforts will have to be made in all sectors, especially to reduce emissions from concrete.[44] The amount of wood that can be used in the construction sector is closely linked to the growth of our forests. As the study for "Klimapositives Bauen"[45] points out, Swiss forests are managed sustainably, which means that what is harvested must at least be compensated for by regrowth. The Helvetic forests still have considerable potential for use without harming biodiversity. The timber construction sector can and must be developed further.

In the second chapter of this work, entitled "The Productive City," one of the objectives was to promote local production to encourage a more sustainable approach. Wood construction lends itself well to this initiative. Particularly when processing is kept to a minimum, using mainly solid wood. This corresponds to a low-tech approach toward the construction of buildings. This not only contributes to a positive impact on the climate, but can also stimulate the local economy where the construction takes place, and then have social benefits.

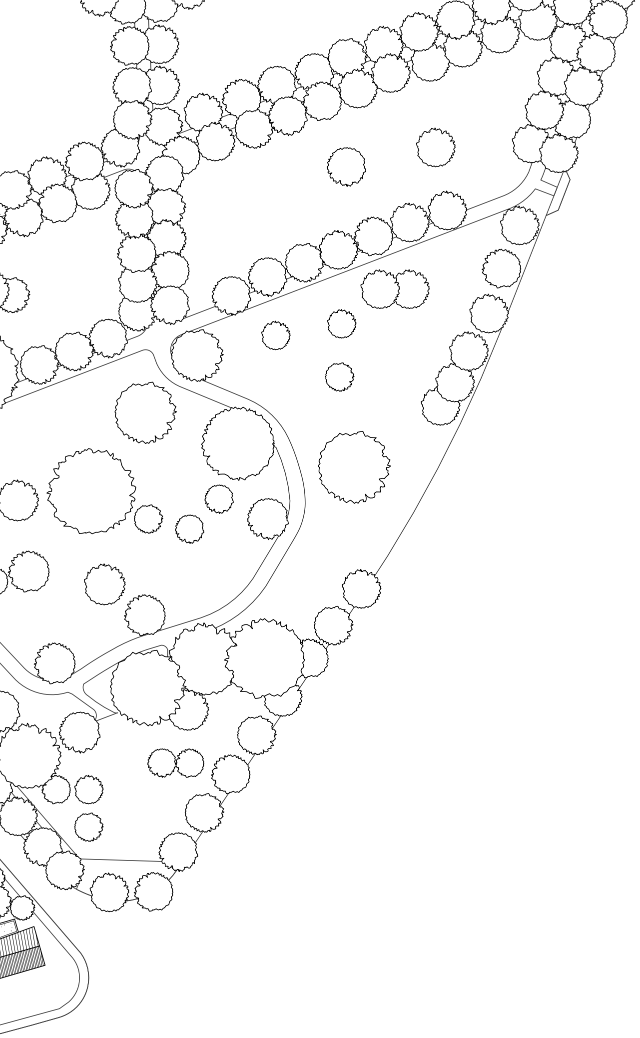
44 "6 to 8 percent of man-made CO2 emissions worldwide are attributable to cement" The Fedral Council. Concrete as CO2 trap – right at the plant. https://www.admin.ch/gov/en/start/documentation/media-releases.msg-id-98159.html

45 Nova Energie Basel AG, Basel. (2021, November). Klimapositives Bauen: Ein Beitrag zum Pariser Absenkpfad. (p.84 chapter 5.3.4.3).https://espazium.s3.eu-central-1.amazonaws.com/files/2022-01/211106_Bericht_Klimapositives_Bauen.pdf

4 La machine à fabriquer

4.1 Plans of the project

Fig. 20. Situation plan N



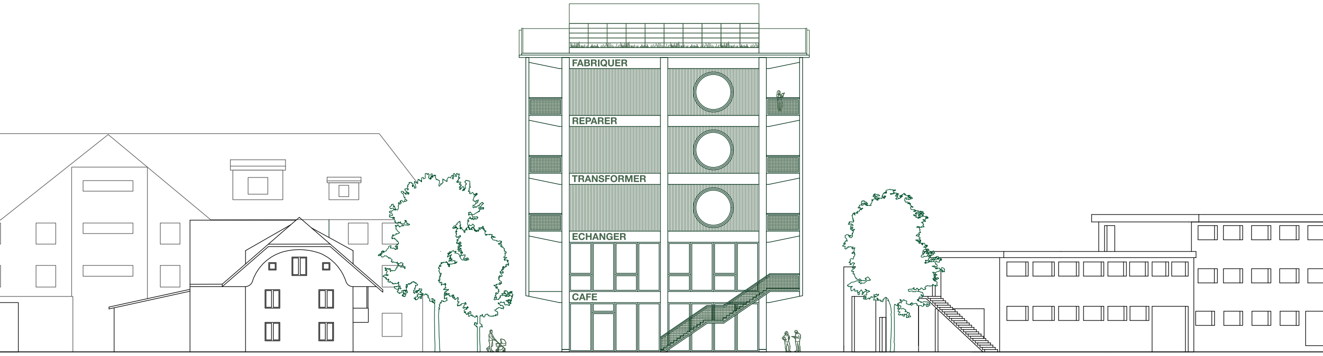


Fig. 21. Southwest façade

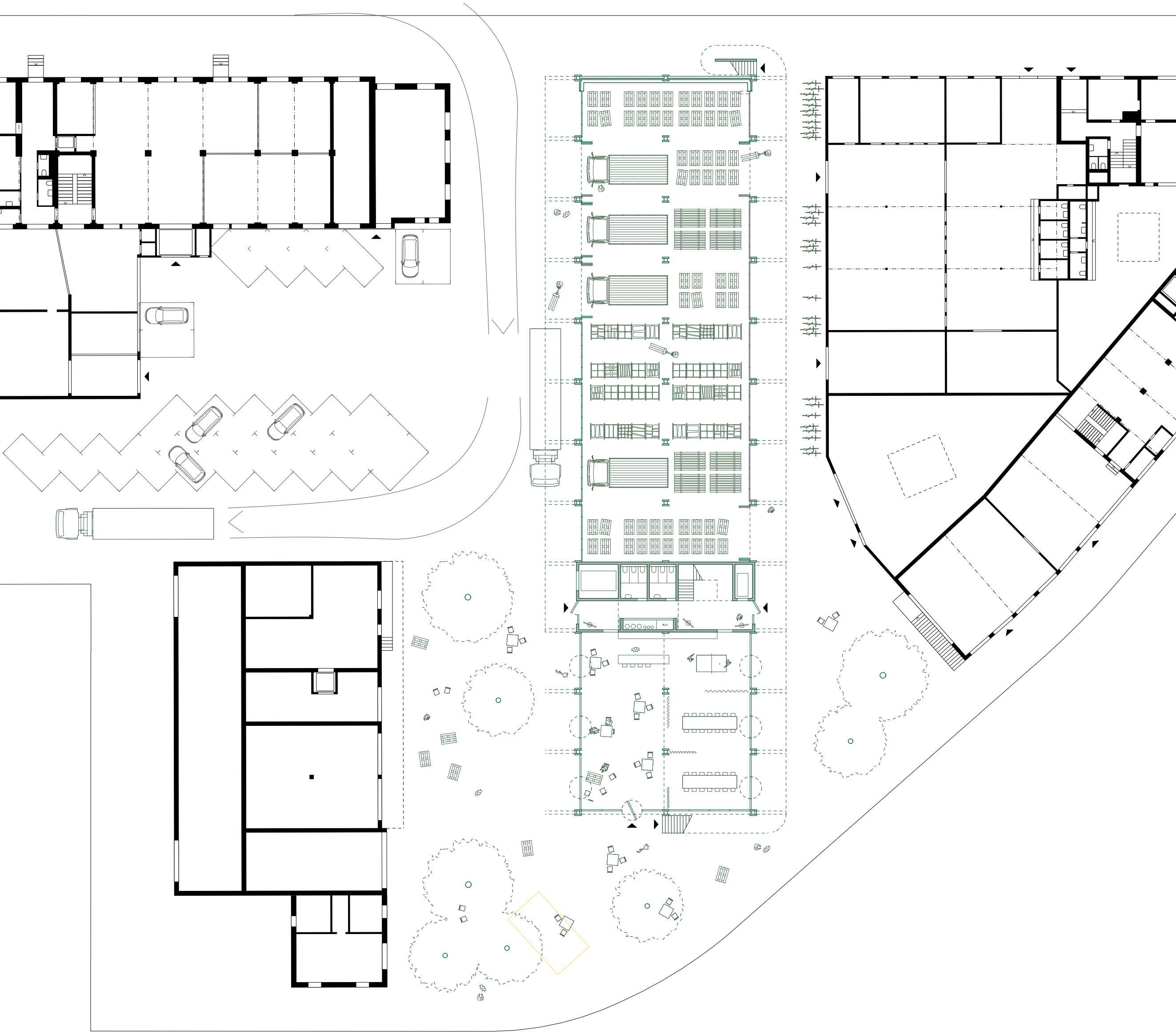


Fig. 22. Ground floor

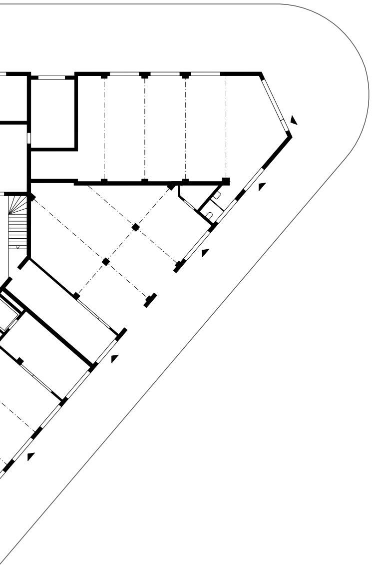


Fig. 23. Southeast façade

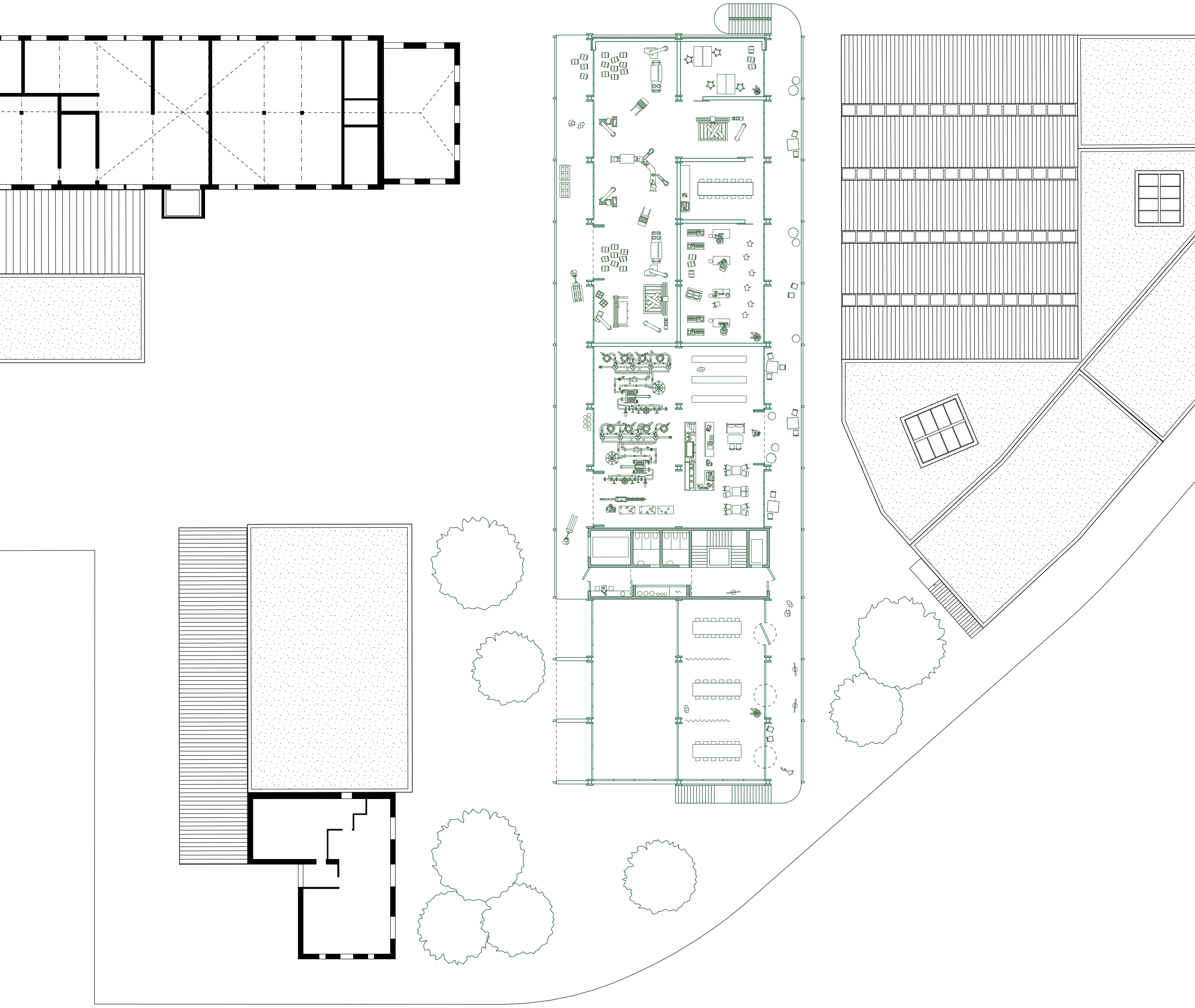
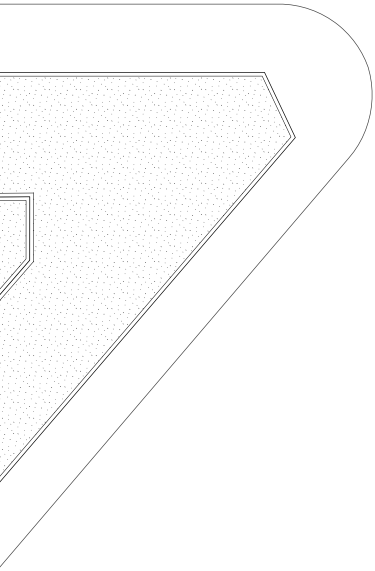


Fig. 24. First floor



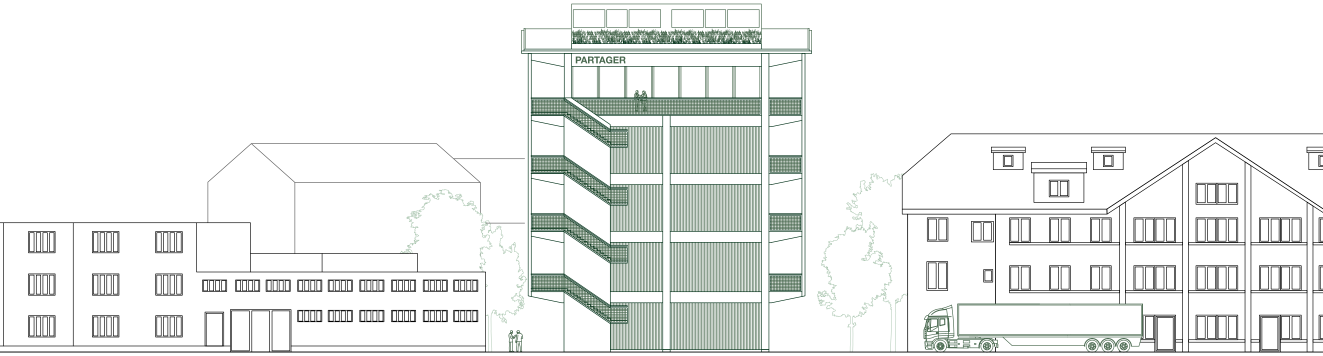


Fig. 25. Northeast façade

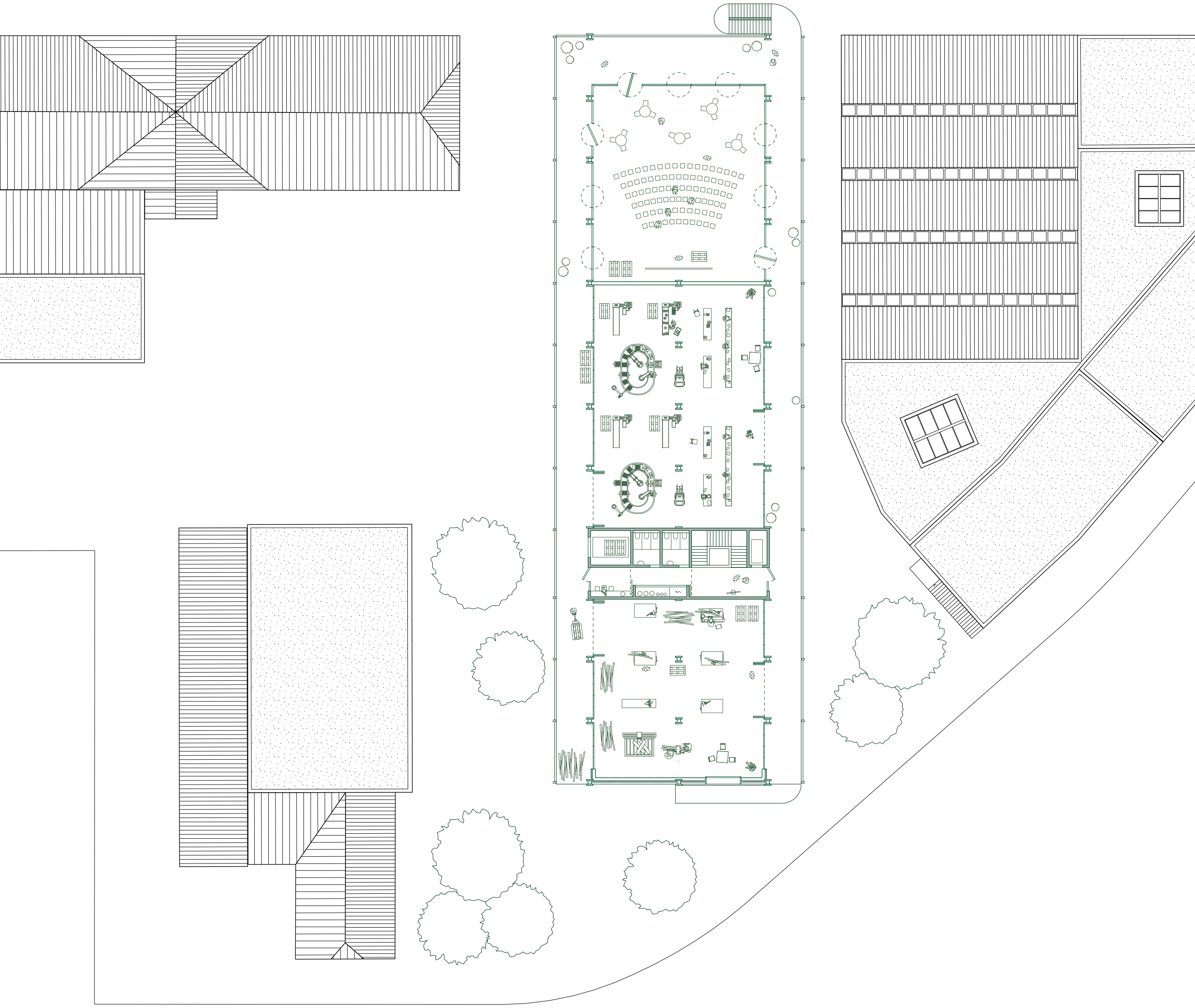


Fig. 26. Last floor

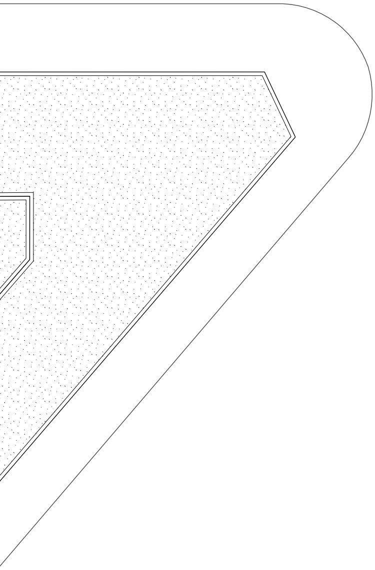


Fig. 27. Northwest façade

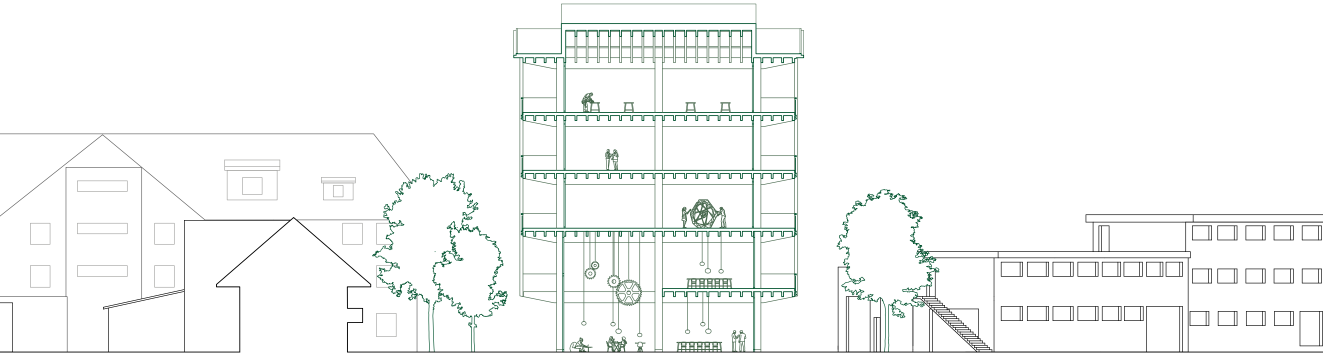


Fig. 28. Transversal section

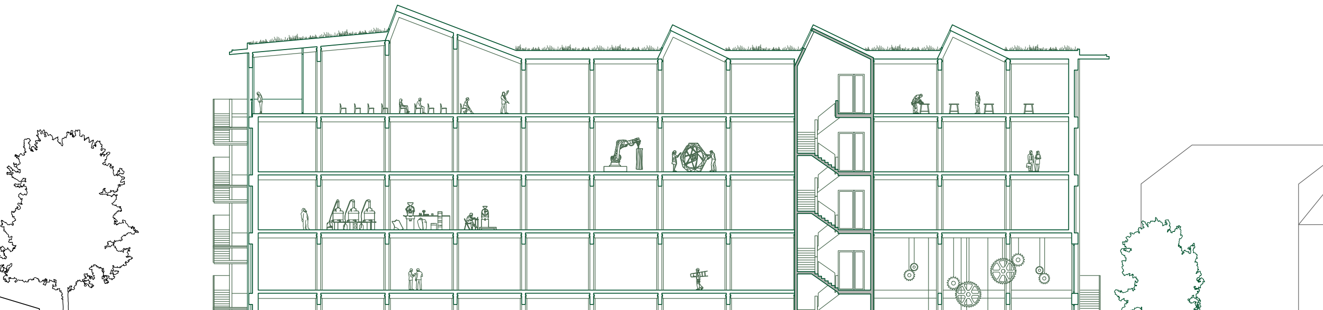


Fig. 29. Longitudinal section

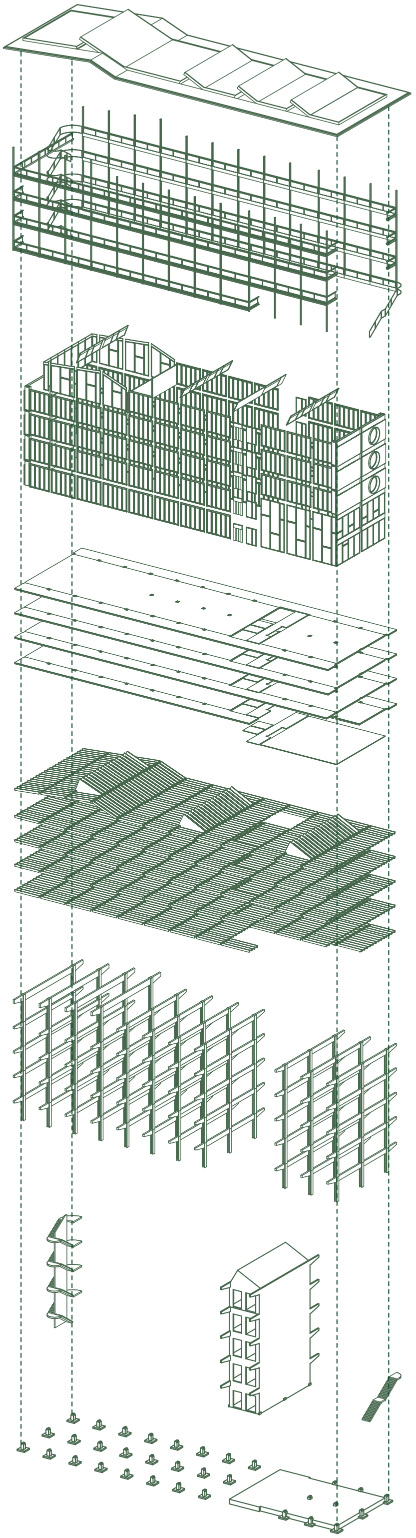


Fig. 30. Exploded axonometry

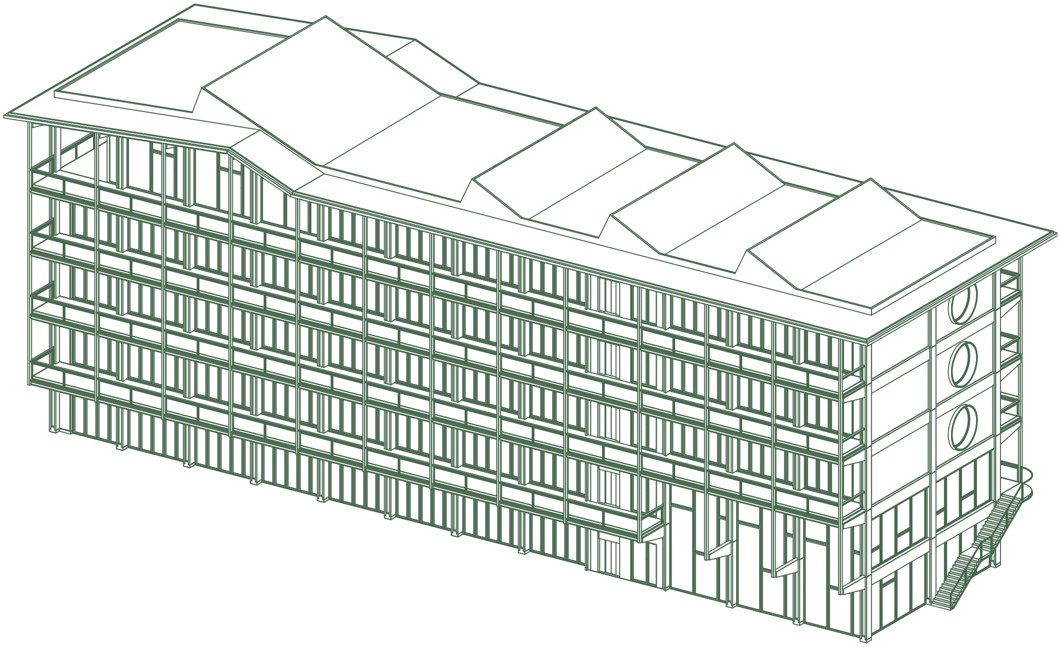


Fig. 31. Unexploded axonometry

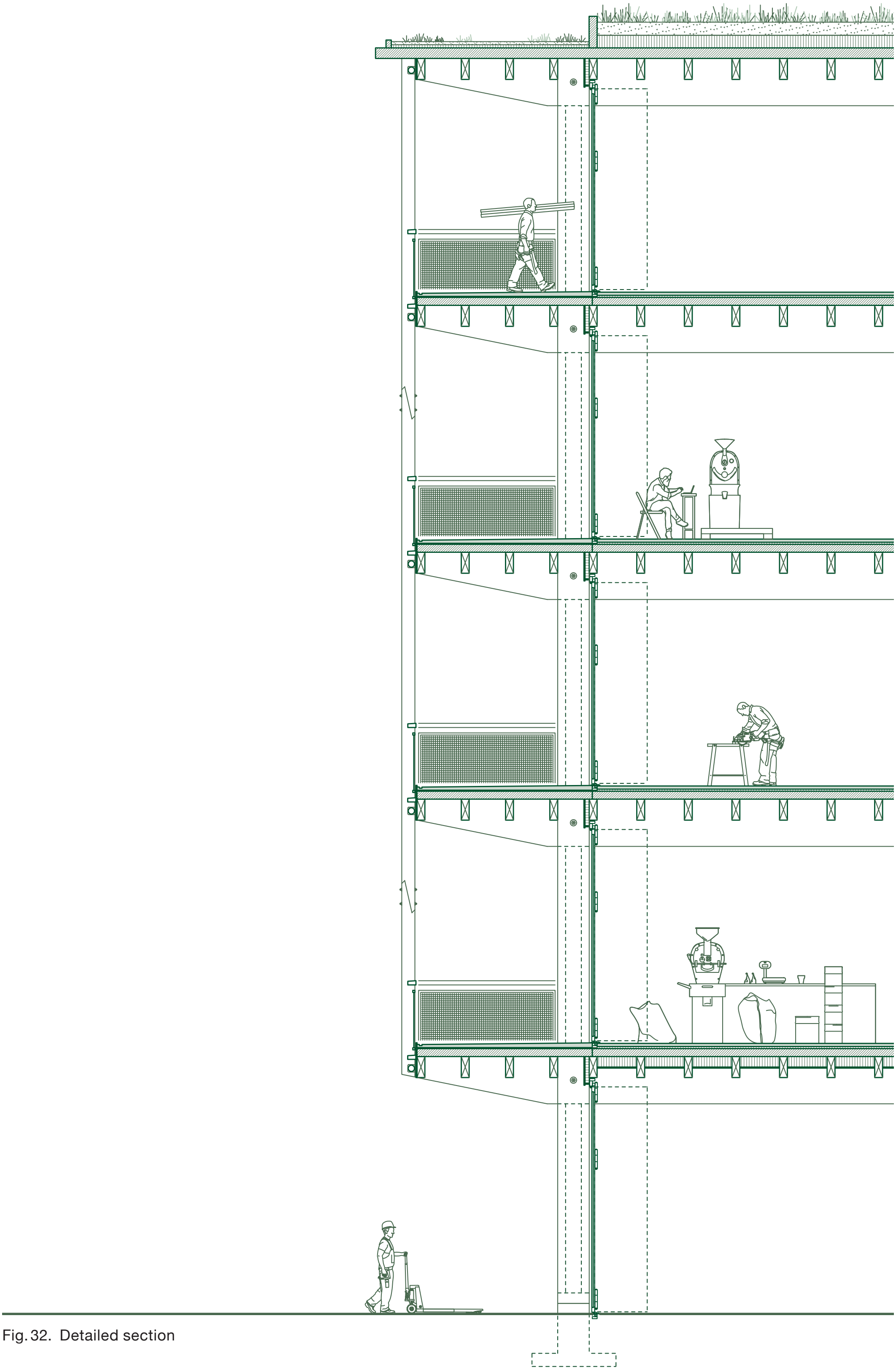


Fig. 32. Detailed section

4.2 Visualizations of the atmosphere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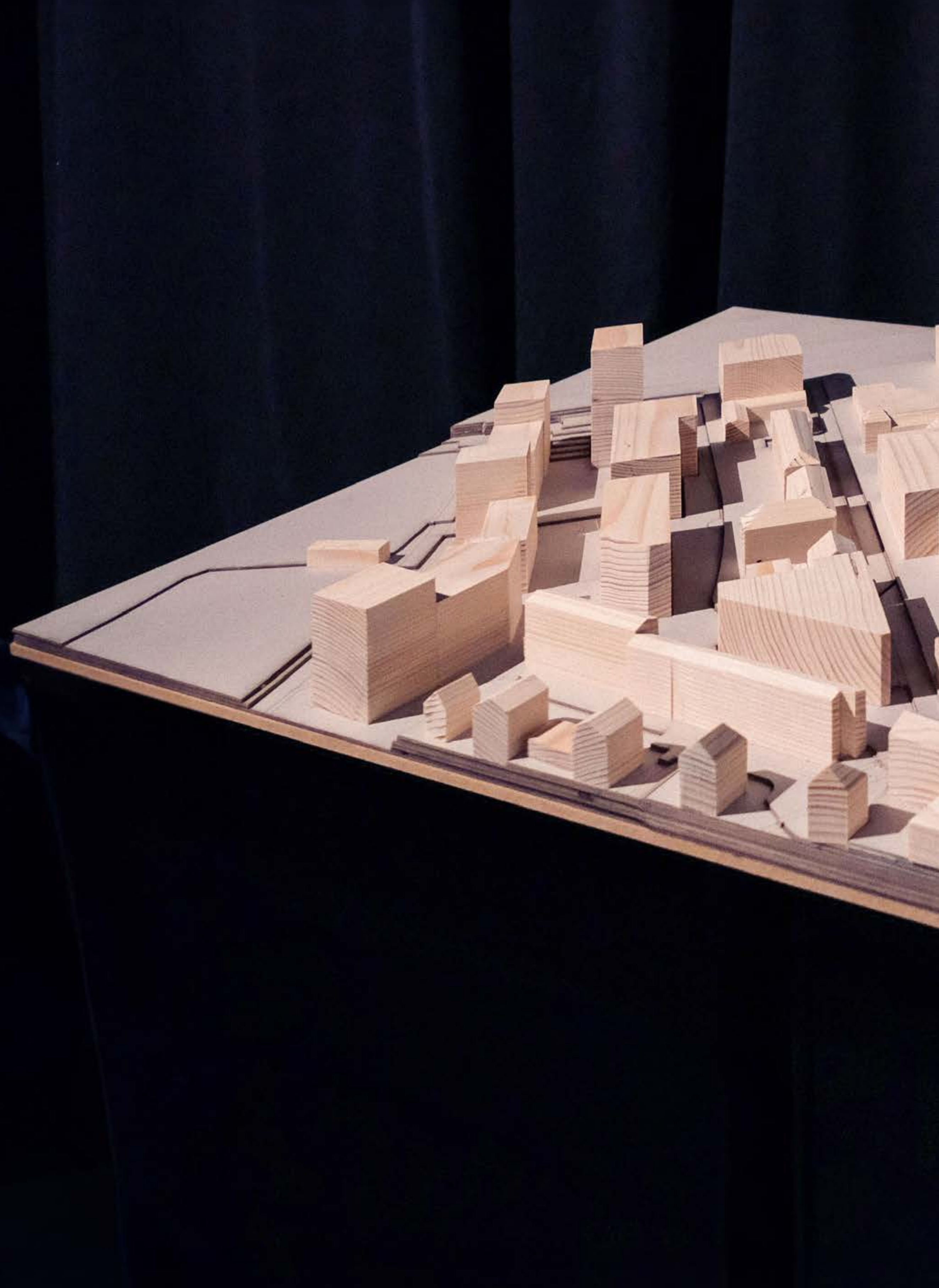
bau +
schreinerei
LIVE,
WORK,
CREAT


FABRIQUER
REPARER
TRANSFORMER
ECHANGER
CAFE


Feed The
Architekturen fü

4.3 Photographs of the models

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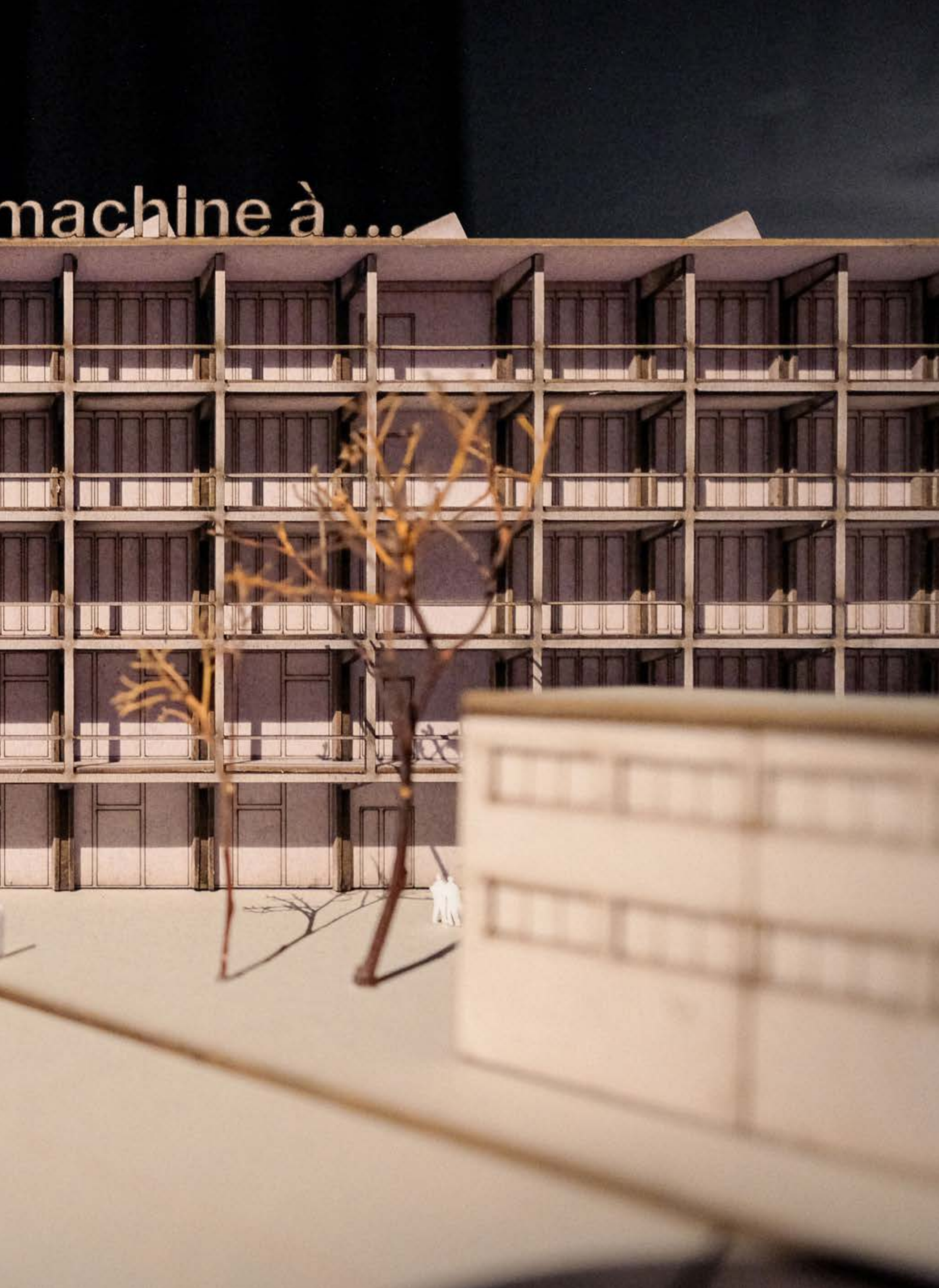

machine à ...


REPARER
TRANSFORMER
ECHANGER
CAFE

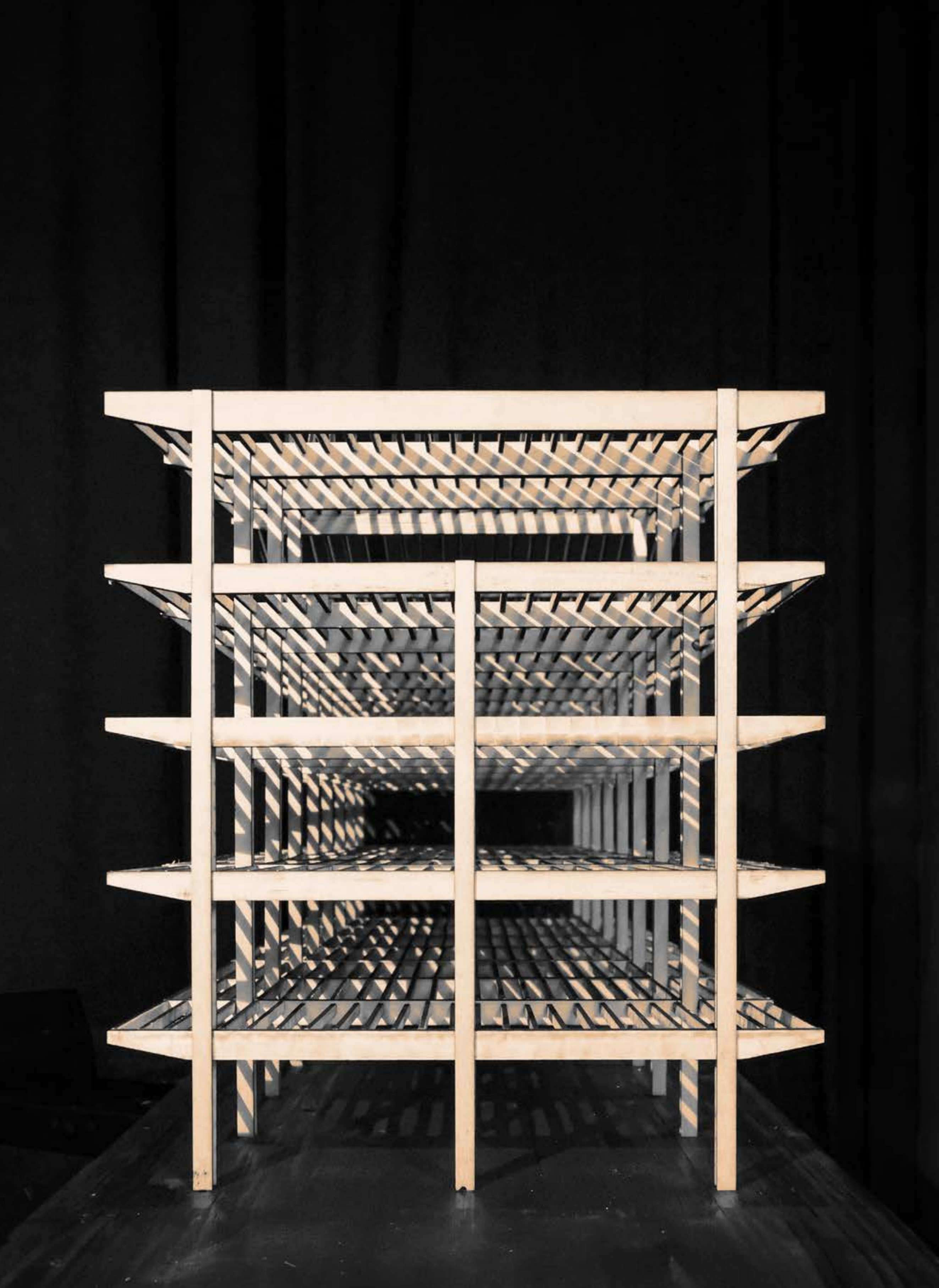


Fig. 45. The walk to "la machine à fabriquer" from downtown Bern.

4.4 Nature of the project

The atmosphere of Güterstrasse, once dominated only by the seductive aroma of roasted coffee, will soon be impregnated with a new scent: that of freshly cut and worked wood. An olfactory metamorphosis that will coincide with the birth of a bold project: la machine à fabriquer.

This imposing wooden structure embodies the fusion of two profound aspirations. On the one hand, it embodies the desire to bring production back to the heart of the city, and on the other, it presents itself as a carbon storage infrastructure with a view to significantly reducing greenhouse gas emissions.

Inspired by the ideals of Dieter Läpple, the vision of "la machine à fabriquer" follows his plea, published in Bauwelt in 2016, to reinvent the urban economic fabric of the city of Bern. The aim is to take full advantage of the benefits of bringing production back to the city, by stimulating the economy by making infrastructure available to small and medium-sized businesses, by improving the sustainability of production by promoting local production, and on a social level by creating diversified jobs, particularly in terms of skills.

Beyond its economic role, this structure is also a possible way to play it's part in reducing the colossal carbon emissions of the construction industry. Not only does it seek to minimize greenhouse gas emissions at every stage, it also offers an innovative approach as a true carbon storage facility. A vision in which the preservation of new structures becomes a necessity to prolong this storage effort as long as possible.

Much more than a building, "la machine à fabriquer" embodies a discreet revolution in the urban landscape. Each piece of wood becomes a fundamental element in the fight to preserve our planet.

4.5 Urban intervention

On the historically charged site of Güterstrasse, the urban intervention was designed to respect the existing structure. Far from radical demolition, the strategy adopted embraces the richness of the existing structures, preserving them while adding new vitality through the insertion of a new volume.

The decision to preserve the existing buildings stems from the simple fact that they are solid and sturdy, bear witness to the history of the site, and vibrate with a communicative energy fueled by the bustling activity of the businesses that occupy them. The intervention does not erase the past, but rather inscribes itself as a new page in the book of the site's industrial development, a harmonious continuation alongside the vestiges of the 20th century. It's a strategy that favors tabula plena over tabula rasa, avoiding the all-too-common easy option of demolition.

Far from simply filling the existing void, the new volume is subtly integrated into its surroundings, weaving specific connections with each situation. To the northwest, wide spaces between the new volume and existing buildings form a delivery loop, facilitating the flow of trucks. To the northeast, along Weyermannsstrasse, it tacitly adopts an alignment with the existing buildings, marking a unified built front towards the Bremgarten cemetery. To the south-east, it is almost set back from the triangular volume that marks the corner of Weyermannsstrasse and Gütterstrasse. This narrow space is free of motorized traffic and dedicated to pedestrians. To the southwest, along the diagonal of Güterstrasse, open spaces emerge from the triangular geometry of the site and become meeting places close to the nearby "Holliger" residential area.

This intervention composes with the past, dialogues with the present and sketches the contours of a future that gives each building a certain autonomy in this ever-changing urban constellation.

Fig. 46. Site model 1:500 close-up view.

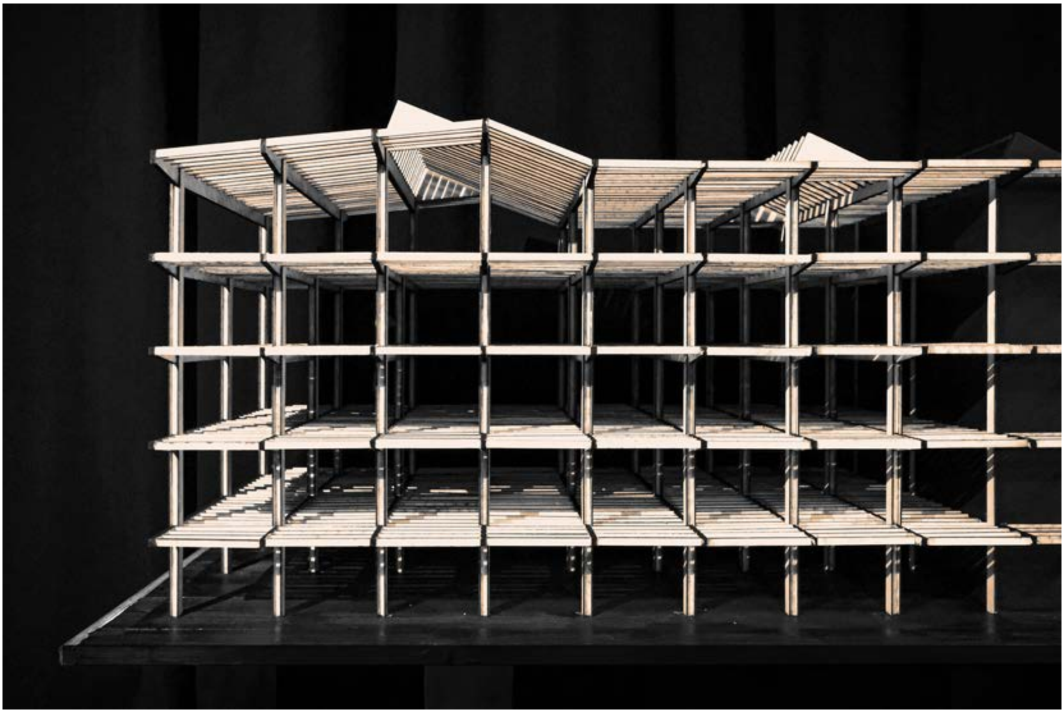


Fig. 47. Structural model 1:50 close-up view.

4.6 Structure

With sustainability at the heart of the equation, the choice of timber construction is a natural one. However, this choice is put to the test when it comes to multi-story industrial construction. The challenges lie not only in the much heavier loads compared to other sectors such as housing or offices, but also in the need for a more extensive structural grid to prevent vertical elements from becoming obstacles to the use of space. The construction of "la machine à fabriquer" required a delicate balance between a simple, traditional construction, on the one hand, and an elaborate, innovative construction on the other.

The simple, traditional approach is intended to be environmentally friendly and accessible to a wider range of craftsmen. This is due to the smaller dimensions of the elements, which make them easier to manufacture, transport and install. In contrast, the more elaborate and innovative approach uses wood that has already been processed in the factory, particularly in the production of glulam beams and cross-laminated timber flooring. However, this approach limits the number of craftsmen capable of producing these components, and installation becomes more complex due to the increased size of the parts. The development of this structure was aimed at finding a compromise between these two approaches, symbolized by the 5.5 m long frame, considered traditional, and the 8 m long frame, which requires the use of glulam.

The peculiarity of "la machine à fabriquer" also lies in the flexibility of its structure. The spaces must be able to adapt to changing needs. The use of external walkways for the circulation of people and goods, in addition to the size of the structural grid, guarantees the flexible use of the volume. The top floor, due to its particular position, benefits from greater flexibility, allowing the creation of more generous spaces.

Ultimately, this wooden structure gives the building its identity, transcending its simple status as a structure. The repetition and structural density of wood can be seen throughout the building. Despite its industrial character, the space is vibrant and welcoming.

4.7 Users

Although the future occupants of the building are not known at the design stage, it is essential to establish a range and criteria. In the first instance, the main target group is small and medium-sized businesses, to take advantage of the inherent flexibility of the structural framework, but also to take advantage of the circulation system in the form of walkways. This architectural selection aims not only to optimize the use of the building, but also to encourage a diversity of activities, a source of economic resilience and production diversity, and thus a wide range of skills required.

By favoring local production, different user profiles emerge. Construction professionals, with a focus on renovation, may consider space in this building as the headquarters for their business. A woodworker, for example, could operate a workshop equipped with his own machinery or shared with others. This would allow him to carry out off-site work such as renovating doors, windows and furniture.

From a food perspective, "la machine à fabriquer" could house a complete production line. For example, the production of a soy sauce would begin with a wheat and soy storage area, followed by an area dedicated to equipment for soaking, cooking, pressing, and fermenting the preparation. A bottling and storage area would also be provided. As for some parts of this infrastructure, or more simply for the reception of visitors, they could be shared with the other food producers present in the building. This welcome synergy would create a unique experience for visitors and strengthen links between producers.

The innovation sector could also find its place, with companies using advanced technologies such as industrial 3D printers. The idea of a shoe designer producing bespoke models on site is entirely appropriate. Similarly, companies in the medical field could work closely with the Insel Hospital, for example, to produce customized medical prostheses using 3D printers.

Finally, recycling, processing and repair businesses could thrive here, using the city as a rich source of raw materials. Creative artisans could breathe new life into existing textiles or materials, contributing to a vibrant circular economy. An example is the company "Rework," which offers clothing collections made from second-hand clothes, which are cut and sewn into new products.

The building, conceived as a fertile breeding ground, offers a space conducive to the development of diverse production, rooted in tradition or resolutely contemporary, all in harmony with local needs and climate.

Fig. 48. The heart of the logistics square.

4.8 The propulsion system

Like any mechanical entity, "la machine à fabriquer" needs an engine, a system that propels it in the desired direction. In this context, that direction is the transformation of the City of Bern into a good city with sustainable industry.[46] As has already been mentioned several times, this requires us to focus our efforts on fundamental areas: the economy, sustainability and social issues. This machine embodies a promising synergy where these values are inscribed in its DNA. For a deeper understanding of this engine, let's break it down into three key elements.

46 This statement refers to the subtitle of this work, "A good city has sustainable industry. To contextualize, this subtitle is an adaptation of the title that has been used on several occasions in publications dealing with the productive city. In particular, it was used in the exhibition "A good city has industry - Atelier Brussels" in 2016, as part of the Rotterdam International Architecture Biennale. It was also the title of the editorial in the magazine Bauwelt 35 in 2016, written by Kaye Geipel. In this thesis, the term "sustainable" has been added to emphasize the need to make the industry compatible with the challenges of the climate crisis.

Fig. 49. Meet someone at "la machine à café".

4.1.1 La machine à café

At the heart of the project is a vital element: the creation of a café. This social space is open to all. Imagine a place that opens at the crack of dawn to offer energizing beverages to early risers, and stays open until nightfall to satisfy those who have become absorbed in their exciting work and have forgotten to eat. It would be a dynamic place, offering everyone the opportunity to meet someone and exchange ideas over a coffee break.

This is what the café is all about: a meeting place. From a first informal meeting, where individuals briefly share their activities, a fruitful collaboration can develop, giving life to ideas that only take full shape when these minds meet. This collaboration is not left to chance; it is actively encouraged. For example, employees are encouraged to bring people together simply by chatting with customers.

Events are also organized in adjoining rooms, such as Pecha Kucha brunches, where anyone can share their ideas in a 6-minute, 40-second presentation. The goal is to encourage the exchange and creation of new ideas. It also welcomes people at the beginning of their creative process, with the opportunity for guidance from more experienced individuals.

Finally, the café's strategic location within the project is no coincidence. It works closely with the meeting place on the southwest side of the site, giving it a certain dynamism. Wrapped in a glass façade, the café is a constant shining light on this square, and when the weather is good, it extends to the entire surrounding space. The square serves as a forecourt for the café, reaching out to the adjacent neighborhoods.

4.1.2 La machine à transformer

Located on the floor above the café, the second driving force behind the machine takes the form of fully equipped workshops that offer everyone the chance to learn new skills. The idea is to provide spaces for courses that introduce different manufacturing techniques, or simply to give free rein to those who want to develop their own project. These spaces are open to everyone and take a different approach to traditional training courses such as apprenticeships or higher education. Self-taught learning is possible, as are courses more akin to those offered by community centers, such as how to make a wooden chair or a coat for the winter season.

Imagine a bright, inspiring space, equipped with all the necessary machines and tools, ready to welcome creative minds from all walks of life. These workshops are divided into three specialized areas: woodworking, textile work, and a fablab with 3D printing and laser cutting machines. They are not just workspaces, but incubators of ideas where everyone is encouraged to explore, experiment, and create.

Whether a novice wants to learn the basics or an expert wants to hone their skills, these workshops are designed to meet everyone's needs. What's more, these spaces are designed to foster collaboration and sharing. Group work sessions are encouraged, allowing participants to share their skills and inspire each other. The instructors, chosen for their expertise and passion, are there to guide and support each learner on his or her journey.

In short, these workshops are much more than traditional classrooms. They embody a dynamic and accessible spirit of learning that offers everyone the opportunity to develop their skills, stimulate their creativity, and contribute to a thriving, productive community.

Fig. 50. Bring an idea to "la machine à transformer".

Fig. 51. Share new ways of producing in "la machine à partager".

4.8.1. La machine à partager

The third element of this propulsion system takes the form of a multifunctional space on the top floor. Essential to the overall operation, this space represents the culmination of the production chain, and its elevated position encourages the public to explore the entire building, transforming this exploration into an inescapable ritual of passage. This room is dedicated to the exchange of experiences through the organization of events on the theme of production.

This generous space benefits from a widening of the structural framework thanks to its location under the roof. Moreover, the shape of the roof reacts and stands out as a sign visible from afar. Bathed in natural light during the day, it transforms into a luminous beacon at night thanks to its three glazed sides. The adjacent terrace provides an outdoor space where participants can share their impressions of the event over a nightcap while enjoying the panoramic view over the vegetation of the Bremgarten cemetery.

This multifunctional space is designed to host a variety of events, from inspiring lectures and film screenings to public presentations of the activities at the heart of "la machine à fabriquer". Of course, the room will also be available to the users of the site, such as for end-of-year dinners.

In conclusion, the multi-purpose room is not just a physical place, but rather a megaphone for the ambition to strengthen the presence of production in the city. It makes visible to everyone this new form of industrial revolution, which is in the process of delicately reclaiming its rightful place in the heart of the city.

5 The place of production in the city

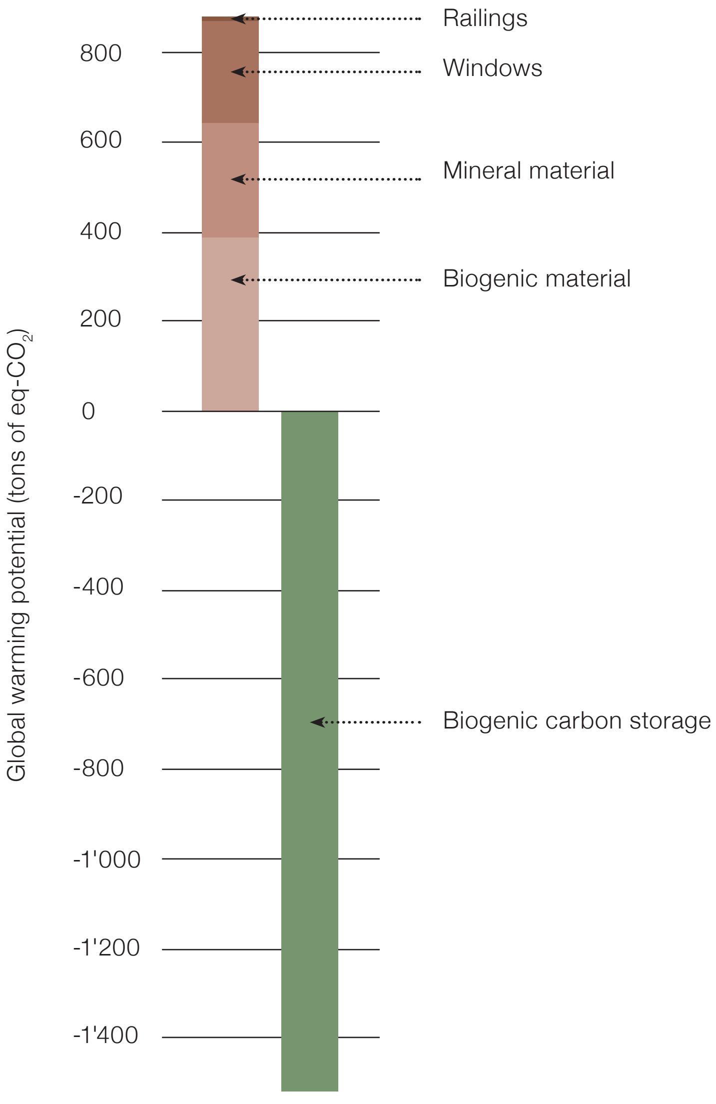
This study highlights the crucial importance of bringing production back to the city, mainly because of its social impact on the integration of the entire population. The aim is to avoid urban segregation resulting from the specialization of activities, where only highly qualified people employed in the federal administration would find their place and the means to live in the city of Bern. Dieter Läpple's statement[47] has a broader scope and also highlights the monofunctional conception of cities. He emphasizes the tendency of politicians to deal with problems individually, without considering the whole. Currently, cities are fragmented in their functions, with distinct commercial, residential, and industrial zones, despite the progressive dissolution of functional, spatial, and temporal separations in our lifestyles. As the German sociologist emphasizes, it is imperative to develop urban structures adapted to these new forms of living and working, thus facilitating the conciliation of work, leisure and family life.

In this thesis, the approach adopted is to densify the industrial zone in order to compensate for the reduction of areas dedicated to this function in the city of Bern. The Güterstrasse has the great advantage of having a variety of places in the vicinity, including the new "Holliger" district, the hospital complex, the cemetery park, and the proximity of public transportation. This diversity provides a unique opportunity to increase production at this location. On a citywide scale, however, it is essential that functional boundaries be progressively softened to offer greater diversity, and that policymakers find ways to reconcile these different uses. As a result, we can expect a reduction in commuting, a more regular use of space and infrastructure, and the avoidance of dormitory cities that are completely deserted during the day, to illustrate the point.

Technological advances such as Industry 4.0, changes in consumer behavior, and environmental concerns give hope that production can once again be compatible with a presence in the city center.

47 Läpple, D. 2016: Produktion zurück in die Stadt. Ein Plädoyer, Stadt Bauwelt, 211, 35.2016, S. 23–29.

Finally, it is crucial to emphasize that in our Western society, where social integration often occurs through work, the importance of these infrastructure and their vital role in our societies should not be underestimated. Architecture, as proposed here, can provide an appropriate interface for urban production. It is imperative, however, that politics give it the space it needs to be implemented.


Railings
Windows
Mineral material
Biogenic material
Biogenic carbon storage
800
600
400
200
0
-200
-400
-600
-800
-1'000
-1'200
-1'400
Global warming potential (tons of eq-CO_2)

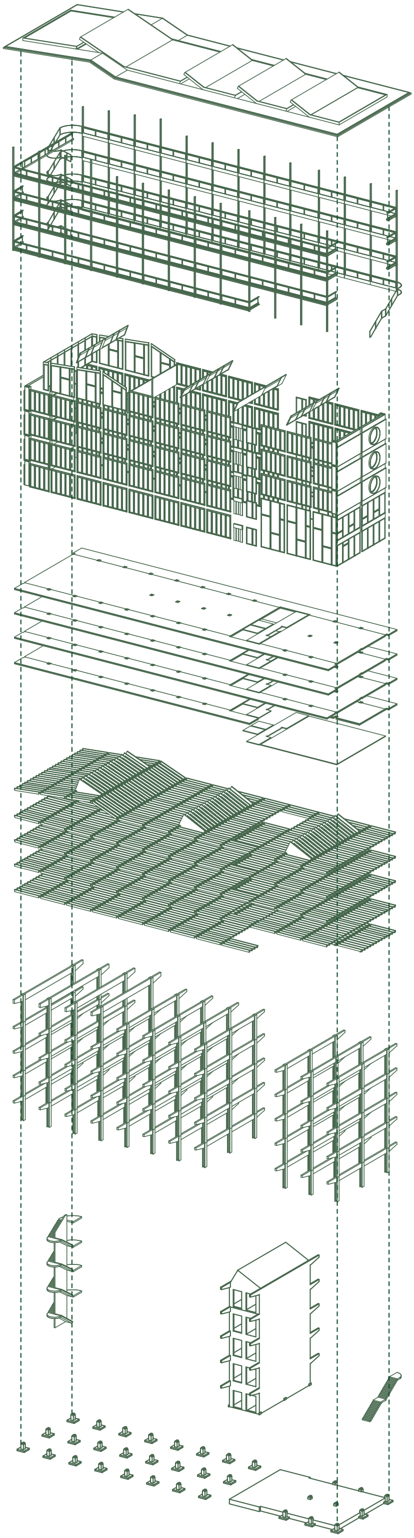
6 Carbon storage application

Throughout the project development process, decisions had to be made in the knowledge that each of these choices could have a direct impact on the emissions generated by the construction of the building. The desire to achieve a negative carbon footprint was crucial in guiding and justifying certain decisions, in particular the decision not to propose an underground construction.

It was also a question of finding the right balance in the use of materials that emit significant amounts of carbon. Concrete is used only where it is structurally essential and for fire protection. Metal is chosen for its ability to protect wood from the elements, but also for its physical properties in assemblies and for railings along fire escapes. Finally, glass is used for its remarkable ability to provide light and views.

No materials have been used in a forced manner, thus avoiding excessive use of natural fiber materials that could have been used in a disproportionate manner to increase the building's carbon storage capacity. Instead, it's important to use each material sparingly, treating them all as scarce resources.
In the end, the building's biggest achievement is a number:
1'531 tons of CO_2 temporarily stored in the building.

Fig. 52. Graph illustrating the carbon balance of « la machine à fabriquer » project (left page)



Roof
Fiberboard wood (insulation) = 172.5m^3
Cross-laminated timber = 162.4m^3

Facade elements and railings
Massive timber = 38.9m^3
Galvanized steel = 0.33m^3

Walls, windows and doors
Fiberboard wood (insulation) = 142.0m^3
Straw bale (insulation) = 128.4m^3
Massive timber = 106.0m^3
Clay plaster = 14.5m^3
Windows and doors (opening size) = 1'308m^2

Flooring
Cross-laminated timber = 787.2m^3
Underlayment anhydrite = 234.2m^3
Fiberboard wood (insulation) = 198.6m^3
Underlayment cement = 162.3m^3
Oak mosaic parquet = 39.0m^3

Wooden secondary structure
Massive timber = 463.1m^3
Cross-laminated timber = 7.9m^3

Wooden primary structure
Glued-laminated timber = 435.4m^3
Massive timber = 55.7m^3

Concrete core and stairs
Reinforced concrete = 512.0m^3

Foundations
Reinforced concrete = 117.8m^3

6.1 Detailed figures

Fig. 53. Presentation of different quantities considered in the calculation (left page).

Here are the details and results of the calculations based on the material quantities shown on the left. As shown, this includes an important part of the elements that should be implemented for the construction of such a project. However, due to the difficulty of taking them into account, the following items have not been included (non-exhaustive list):

- Metal fittings for wood construction
- Vapor barriers, bituminous sheeting and metal flashing
- Gravel, topsoil and solar panels on the roof
- Technical equipment

The figures presented here give an indicative idea of the impact such a project can have, but would need to be further refined to ensure they are representative.

Material	**Quantity** (m^2 or m^3)	**Production** (tons eq-CO_2)	**Disposal** (tons eq-CO_2)	**Biogenic** (tons eq-CO_2)	**Total** (tons eq-CO_2)
Cross-laminated timber	957,5m^3	135,68	33,40	624,86	-455,79
Massive Timber	663,7m^3	70,60	12,72	434,09	-350,77
Glued-laminated timber	435,3m^3	54,47	9,36	284,16	-220,33
Fiberboard wood	513,1m^3	48,07	6,98	115,43	-60,38
Straw bales	128,4m^3	2,65	0,00	35,42	-32,77
Oak mosaic parquet	39,0m^3	16,34	1,06	37,93	-20,52
Clay plaster	14,4m^3	0,52	0,34	0,00	0,86
Galvanized steel	0,3m^3	11,67	0,02	0,00	11,69
Underlayment cement	162,2m^3	32,12	3,90	0,00	36,02
Underlayment anhydrite	234,1m^3	36,53	6,09	0,00	42,62
Insulated double glazing	1308,0m^2	53,24	4,71	0,00	57,94
Aluminum window frame	1308,0m^2	153,04	19,49	0,00	172,53
Reinforced concrete	629,8m^3	162,32	19,20	0,00	181,51
Total (tons eq-CO_2)		**777,24**	**117,27**	**1531,90**	**-637,39**

Fig. 54. Table showing the results of the quantity-based calculation.

7 Conclusion

The realization of "la machine à fabriquer" transcends architecture as a bold intervention, revealing itself as a statement in favor of a more sustainable and integrated urban future. Inspired by Dieter Läpple's innovative vision, this wooden structure embodies a potential fusion between local production, the reduction of greenhouse gas emissions, and the preservation of economic and social fabric.

The approach adopted for the intervention in the area of Güterstrasse, by preserving and revitalizing existing structures, testifies to the desire to preserve history while harmoniously integrating the new industrial era. The structural flexibility and the diversity of spaces created by the machine offer a fertile ground for a variety of businesses, stimulating economic resilience and a diversity of skills.

This proposal goes beyond simply offering an infrastructure waiting to be occupied, and also introduces concrete tools to guarantee the realization of its objectives. From the conviviality of the café that encourages informal encounters, to the equipped workshops that offer spaces for learning and creation, to the multifunctional space that serves as a focal point for sharing experiences, each element contributes to rooting production in the heart of urban life.

This approach underlines the importance of reintegrating production into the city in order to avoid social segregation and promote the harmonious coexistence of urban functions. In this way, Güterstrasse becomes a tangible example of how architecture can play a crucial role in creating balanced, sustainable cities.

The careful choice of materials and construction processes, guided by the quest for a negative carbon footprint, illustrates a concrete commitment to sustainability. "La machine à fabriquer" thus becomes a symbol of architecture's ability to respond to environmental challenges while fostering innovation and creativity.

In a world where the concepts of production, economy and sustainability are constantly evolving, "la machine à fabriquer" proposes a holistic and inspiring vision for the future of industry in an urban environment.

Finally, from a more personal point of view, this Master's thesis in Architecture embodies for me a personal exploration of solutions to future challenges that are and will be my daily bread. It was an opportunity for me to work and build on values that are important for me.

Sustainability and social issues are an integral part of my daily commitments. This project was an opportunity for me to put them into practice and to test them. My goal ist to create a hopeful perspective that evokes a positive and necessary change in the way we conceive our built environment. Today, I'm convinced that we can and must overcome the great challenge of the climate crisis, but it will require a redoubled effort in each and every one of our actions.

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9 List of Figures

10 Declaration of originality

I hereby confirm that I am the sole author of the written work:

La machine à fabriquer
A good city has sustainable industry

and that no help was provided from other sources as those allowed. All sections of the paper that use quotes or describe an argument or concept developed by another author have been referenced, including all secondary literature used, to show that this material has been adopted to support my thesis.

Nathan Boder

Lucerne, 12.01.2024