TRANSFORMATION OF AN EXISTING ABANDONED WARE-HOUSE TO AN OFFICE BUILDING

Master thesis

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SCUOLA DI ARCHITETTURA URBANISTICA INGEGNERIA DELLE COSTRUZIONI

Politecnico di Milano

School of Architecture, Urban Planning, Construction, Engineering

Master Thesis in Architecture

December 2019

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Acknowledgment

I would like to express my very great appreciation to my professor, Dr. Paolo Debiaggi, for his patient guidance and continuous support.

I would also like to thank my caring and supportive husband for his love and understanding.

Finally, I am particularly grateful to my two gorgeous, delightful little boys who give me the strength for becoming a strong, educated mother.

ABSTRACT

Recently, the reuse of abandoned industrial zones is receiving considerable attention, especially by national institutions due to its importance in urban transformation, historical and heritage preservation, and economic aspects.

The following thesis is focused on the transformation of an abandoned industrial site to an office building in the Pero district. In the introduction chapter, the history and urban transformation of the Pero district have been studied. Subsequently, some case studies are provided to show their strategies toward reuse and regeneration of the abandoned buildings. The case studies are classified in terms of their design approach and type of interventions. In the next chapter, passive design methodology and Passivhaus principles have been studied. Finally, the documentation and drawings of the conducted project are provided.

Introduction

In the following chapter, Pero district, characteristics, history, and It's urban Transformation have been studied. Furthermore, some information on the topic of the deindustrialization process and postindustrial territories in Milan have been provided.

2.1 Pero District, Characteristics, History and It's Urban Transformation

Pero is one of the municipalities of Milan located 9 kilometers northwest of the city (Figure 1). It has 11343 residents and is situated between the municipalities of Capoluogo and Rho. It is connected with the underground metro line (M1) to the city center of Milan. Pero is located along the Statale del Sempione street and crossed by the Olona River.

2.1.1 Pero and Direction of North-West

The territories surrounding Milan are very ancient as a construction, and they are structured by directions. There are six routes in Milan area, each with its own different identity, of a geographical, historical, cultural, and figurative nature. Each testifies differently to the settlement's strategies of the civilizations that have stratified over time and propose different intertwining between original characters and external influences, tradition, and modernity, localism, and cosmopolitanism. The northwest direction - "the great axis that leads to the Cisalpino Airport and will link Milan with the whole land" - and the north-east line - "the great axis that will connect Milan with Monza, with the residential areas of Brianza has undoubtedly always been the directions of privileged expansion of the vast metropolitan body.

The director of the Sempione directs towards the historical productive basins of the textile clothing and mechanics related to the settlements of Busto Arsizio, Legnano, Gallarate, Castellanza, while the north-east towards the basins of the lower Brianza characterized by the sectors of automotive mechanics, chemical-textile, of the piece

Figure 1 *Municipality of Pero (the picture is illustrated by author)*

Figure 2 *Olona River in Pero* [1]

1. http://rho.milanotoday.it/pero/tentato-suicidio-olona-7-marzo-2016.html

of furniture, electromechanics, and iron and steel industry (Arese, Cesano Maderno, Varedo, Desio, Lissone, Monza, Sesto San Giovanni).
The northwest direction appears as that prevalent from the structural point of view in the Milanese geography, oriented towards the dry plain - seat of the early Lombard industrialization - and towards the Alpine passes.

The existence of a road that connected Mediolanum to the banks of the Verbano was intuited and traced by the German historian Theodor Mommsen already in 1877, based on numerous archaeological finds found along the course of the Olona river, which indicated as certain the Roman road that from Milan, exiting from Porta Vercellina, reached Verbano passing through Pero, Rho, Pogliano, Parabiago, and Legnano, then to Busto Arsizio, Somma Lombardo up to Sesto Calende. After passing the Ticino, it continued towards Arona and Domodossola, from where, past the Simplon pass, it reached the Canton of Valais and Lake Geneva (Switzerland).

The construction of State Road n.33 - called "del Sempione" from the name of the Swiss town south of the pass, Simplon - was ordered by Napoleon Bonaparte in 1800, as part of the very long corridor that was to connect Milan to Paris.
The Simplon axis has played a strategic role in the historical formation of Milan as a city exchanging distance, giving this sector of the city a vocation to directionality and long-term exchange between city and territory. Vocation which is now maintained and confirmed, as the new, large Milan Trade Fair was added along the Simplon, adding to the existing trade fair system.

2.1.2 Pero Population

From 1950 to 1970, the city faced a cycle of immigration from south and northeast to Pero and also an increased rate in birth. From 1970 there was a decrease rate of immigrants from the south and northeast and a decrease in the increased rate of delivery. From 1990 started another cycle of immigration from abroad (Africa, East Europe, etc.) still in action, but the increased rate of birth tends to keep low. Due to this high immigration, the countryside and especially the municipalities close to Milan, start to urbanize. Consequently, spontaneous settlements and economic and popular cooperative buildings raised but without any regulation regarding the urbanization process.

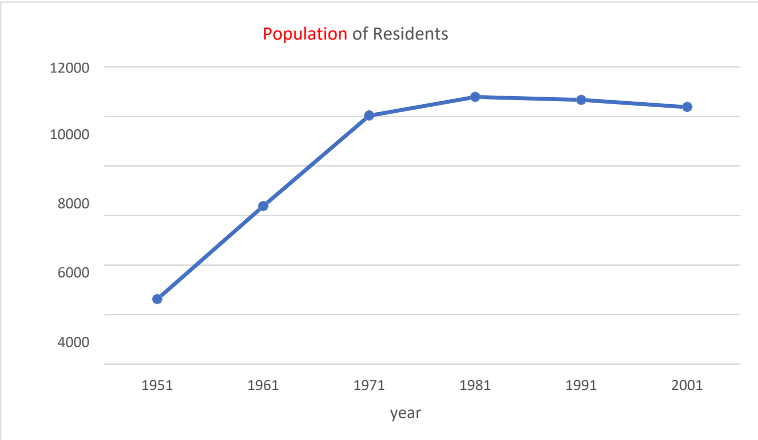


Figure 3 *consimenti Istata (2001 dati provvisori)*

2.1.3 Morphology and Characters of the Territory

Located on the border between the high dry plain and the low flooded plain, the Rhodense area is lapped by the upper limit of the resurgence zone, called "Dei Fontanilli." The analysis of the settlement system shows how the northwest quadrant is characterized by the superposition of a double matrix, one linked to the axis of the Sempione (and to the Olona) and the Varesina (and therefore to the commercial potentialities of the "road"), the other to the agricultural settlements that develop towards the Magentino and the Novara

2.1.4 History, Transformation from Agricultural Territory to Great Industry

Pero territory in the past had agricultural vocation Thanks to the abundance of water (a first irrigation canal had already been built that fed with the waters of the Olona) and fertile lands, in the fifteenth century many Milanese nobles moved to the Rodense territory and built sumptuous palaces mostly destroyed today. At the end of the 1940s, Pero was a small village in which agricultural activity was still significant, considered by the Milanese as one of the most backward countrysides.

The abundance of waterways and the position along the Sempione state road, as well as the considerable proximity to Milan and the system of road and rail connections, favor the development of Pero as an industrial center in the 20th century. As a result, the territory faced a significant transformation from agricultural reality to great industry. The appearance of the region changed because of the establishment of large production centers and especially manufacturing industries in the chemical (in particular oil) sectors. Agricultural areas gradually began to make room for small and medium-sized companies, which were followed by substantial production complexes such as the Rho-Pero petrochemical hub, one of the significant suppliers of petrol and diesel and hydrocarbon storage in the area.

The Rho-Pero refinery, the industry that dominated the area and the horizon of the entire region, was for years a tremendous industrial reality that produced, directly or indirectly, employment and support for the economic development of part of the Country traditionally characterized by a strong entrepreneurial vocation.

Its construction, in the south-east appendix of the municipal area of Rho, but in fact as a close urban relevance of Pero, dates back to the early Fifties, and the productive activity was started in 1953 by the Condor Company.

Being a typical "labor-saving" industry, Condor has never required much labor. At the time of its maximum expansion, the refinery was able to process 4.5 million tons of crude oil per year and was fed by an oil pipeline from Genoa. The most considerable expansion took place in the 1960s when the construction of systems for the production of lubricant bases made it a complete cycle refinery, which, due to its size, technological characteristics, and geographical location, was able to satisfy the demand for petroleum products. In those years, the refinery directly occupied more than five hundred employees and played a leading role in the growth of a diversified and highly qualified branch, firmly integrated with the refinery's activities, contributing with the consequent positive effects on the development of the area.

In 1974, following the acquisition of Shell Italiana by ENI, the refinery became an essential component of the Italian Group's refining system. In 1992 the refinery was closed as part of a plan to rationalize ENI's refining activities, imposed by the profound changes that occurred in the national and international oil scenario and by the consequent crisis that happened in this sector. With the cessation of industrial activity, the problem of environmental recovery of the refinery site was posed for its use adapted to the needs and coherent with the development objectives of the surrounding area.

The presence of large production centers has been the origin of the great territorial transformations. In some cases, the rapidity of the changes that have affected the municipalities has generated the disorderly growth of the settlements, especially concerning the suburbs that grew close to the large industrial centers. In other cases, the concentration of chemical and pharmaceutical industries has constituted a severe environmental risk for the territory. Inevitably the presence of a high number of harmful or dangerous establishments generates - or has generated - strong social tensions. A phenomenon closely related to the industrialization of the centers is undoubtedly constituted by the entry of numerous immigrants from Southern Italy and the Veneto, in conjunction with the expansion of the offer working.

If, in the presence of manufacturing industries, the tertiary sector and the production of services are replaced in the last twenty years, the reference territory is still characterized by the presence of smaller production settlements spread throughout the region.

Figure 4 *Rho-Pero Refinery* [2]

2. http://www.ordinearchitetti.mi.it/it/mappe/milanochecambia/area/23-fieramilano-rho-e-opere-connesse/cronologia

2.2 Deindustrialization process and postindustrial territories in Milan

In the 1980s, the generalized crisis of large industries begun, which also involved the entire national territory. After initial dismay for the strong social and economic impact that this reorganization has produced (concentration, delocalization, closing and consequent contraction of jobs), local administrations have begun to set urban planning policies aimed at considering the presence of brownfield sites as a useful resource for overcoming structural and infrastructural delays that most of them suffer.

In terms of outward characteristics, the abandoned industrial areas present extraordinary features of centrality and accessibility due to the more classical direction of urban growth. In other words, they have significant positional rents that favor convenience and interest in private investment. On the other hand, the decommissioning of areas creates numerous problems for interested municipalities. First, related to the urban decay that follows the abandonment of one or more buildings, Second, associated with the transformation of the quarters born and grown around the large factories, due to the change in commuting flows.

Dealing with the disposal of areas, therefore, requires integrated and non-sectoral interventions. Since the nineties, this new approach has been favored by the departure of some European programs which, in addition to providing funds for the start-up and implementation of urban renewal and redevelopment projects, have forced the Italian urban culture to deal with the need to carry out public-private operations characterized by complex objectives: the certainty of time, economic planning, the cohabitation of a new qualified residence (public and private) with some social services, the need to imagine the protection and promotion of new economic functions, from crafts to advanced research.

Figure 5 *1988. Documento direttore aree industriali dismesse del Comune di Milano* [3]

3. http://www.pim.mi.it/archivio-cartografico/104_milano_documento_direttore_aree_ind_dismesse_1988/

Case Studies

In this chapter, some case studies are classified and analyzed by their design approach and their type of intervention. The relationship between old and new masses are also investigated.

3.1 Classifying Case Studies

Before jumping into studying similar cases to the study context, several classifications are presented to investigate deeper the cases and classify them into different categories.

3.1.1 Design Approach

Several mini-diagrams are generated by the author to create different scenarios in terms of new interventions (Figure 6). There are five design techniques showing basic attitudes towards proposed modifications.

The first case is about keeping the same form without adding to or eliminating any element from the original structure. The main intervention occurs in interior spaces. The second one is called box in a box where the new mass in inserted inside the original mass without any change in the initial state of the form. The third technique is defined as an addition when a new volume is introduced to the existing structure. The fourth scenario is called elimination in case an element or a part of the volume is eliminated. Finally, the fifth diagram describes the combination of addition and elimination.

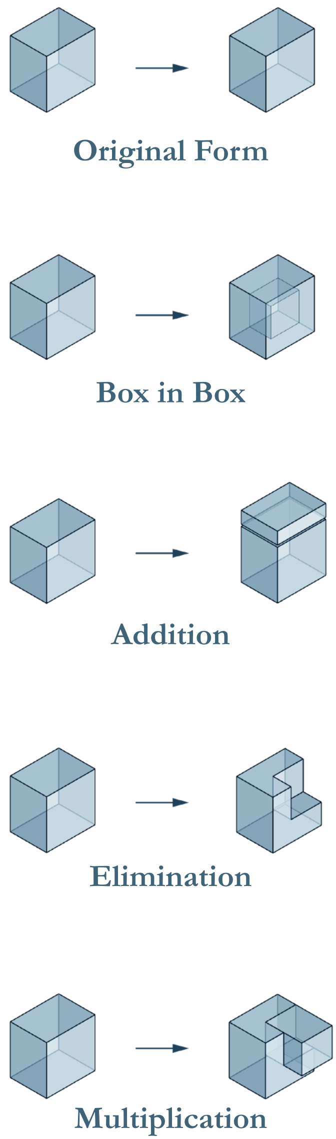


Figure 6 *Diagram of Design Techniques illustrated by the author*

3.1.2 Relationship Between New and Old Masses

In addition to the previous scenarios, a group of schematic diagrams is represented according to Edward T. White's Path Portal Place (Figure 7). These diagrams indicate the interventions concerning the site and its connection to the existing structure.

These intervention categories are as follows: corner, wall, gate, hat, new face, joint, transition, bridge, skin, new interior, umbrella, boundary, infill, feature, glue, roof, underground, divider, alignment, misalignment.

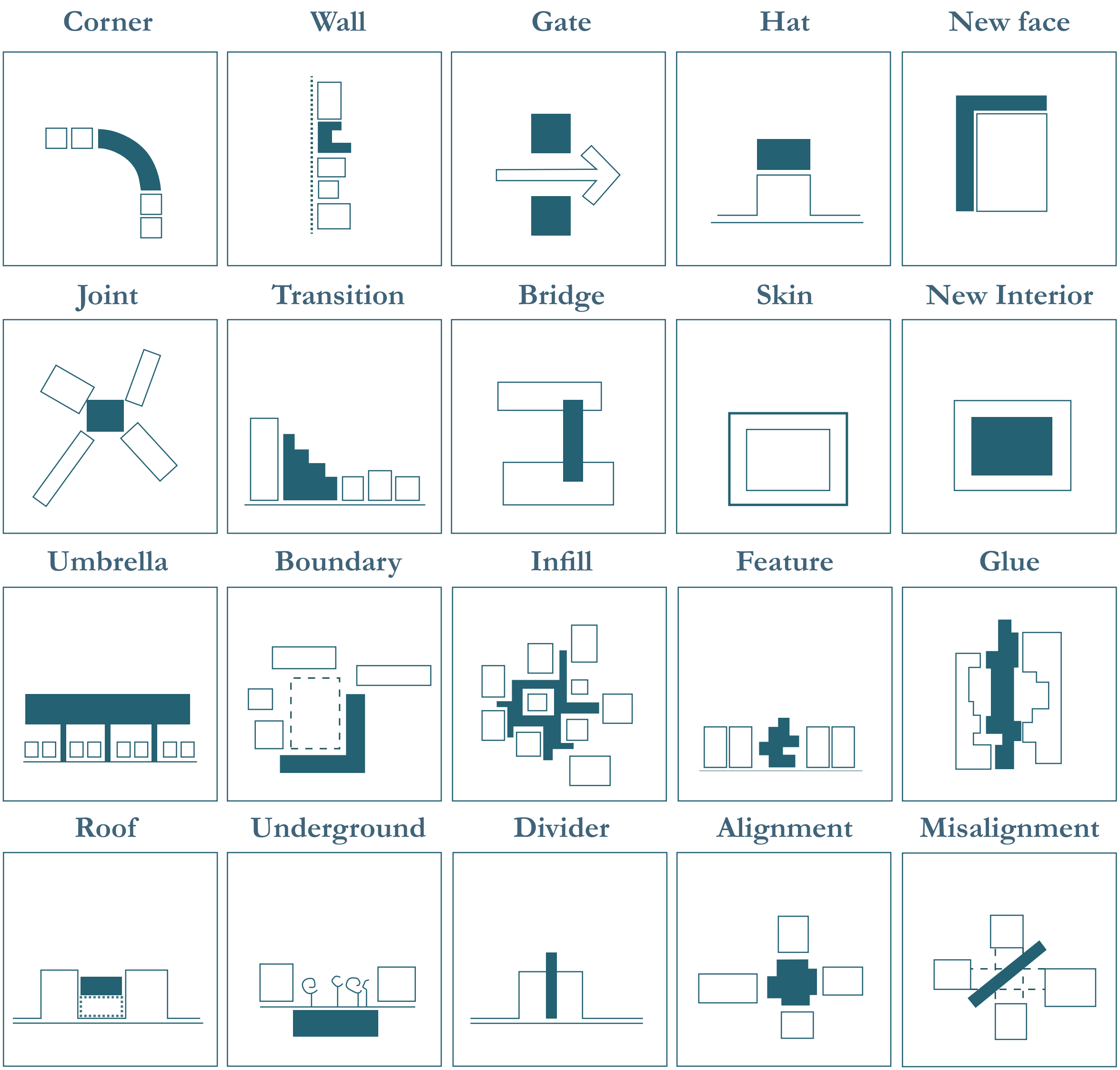


Figure 7 *Formal Relationship Between New and Old Masses* [4]

4. White, Edward T.(1999). Path Portal Place: Appreciating Public Space in Urban Environments.

3.1.3 Type of Intervention

6.

three main categories of building reuse developed by researchers are intervention, insertion, and installation as defined below:

Installation – The new masses exist independently respect to the old masses, and they are situated within the boundaries of the existing building. Although they may have similar language to the present structure, their design is not necessarily the same. Furthermore, removing these installations does not influence the existing building.

Insertion – The added volume independently suited precisely to the existing envelope and is built to fit and placed within the confines of the old masses.

Intervention – The new structure is entirely integrated with the existing building, and it will become part of it. Due to this significant transformation, the old structure is no longer exist independently.

According to the research done by Fisher-Gewirtzman 5, a diagram is attached to these three categories ranging from the most integrated relationship to the most detached relationship, as illustrated in (Figure 8). Furthermore, a ranking system from one to ten is introduced to show the degree of transformation.

5. Fisher-Gewirtzman, D. (2016, January). Adaptive Reuse Architecture Documentation and Analysis.

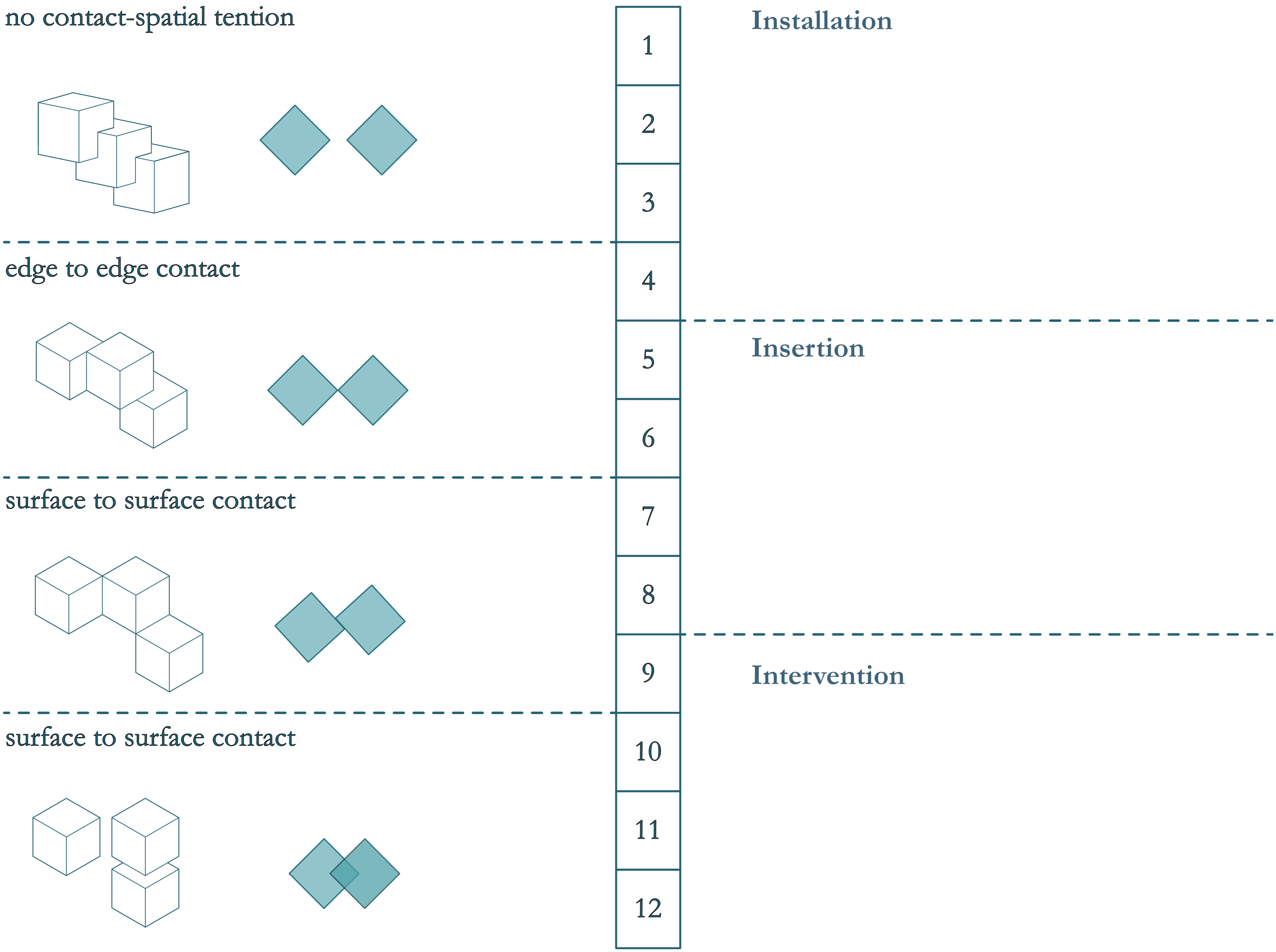


Figure 8 *The extent of transformation of an existing building, including the three categories/ strategies, four diagrams that illustrate the physical application, and a numeric scale that links the two measures* [5].

5. *Fisher-Gewirtzman, D. (2016, January). Adaptive Reuse Architecture Documentation and Analysis.*

3.2.1 Technopole for Industrial Research Shed #19 / Andrea Oliva

Location: Reggio Emilia, Italy

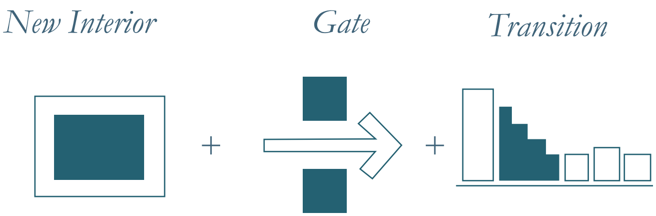
Program: Transformation of a factory to technopole

Gross floor area: 3600 m2

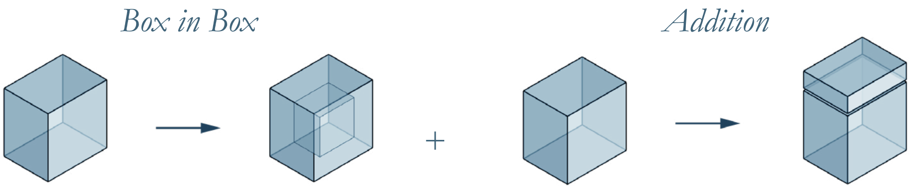
Architect: Andrea Oliva Architetto

The project is a transformation of a factory to technopole. The Shed is now a Technopole for industrial research in agriculture, food, environment and energy, and for improvement and development of biological, agricultural and food resources, and mechatronics [10].

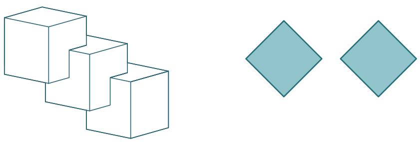
Relationship Between New and Old Masses:



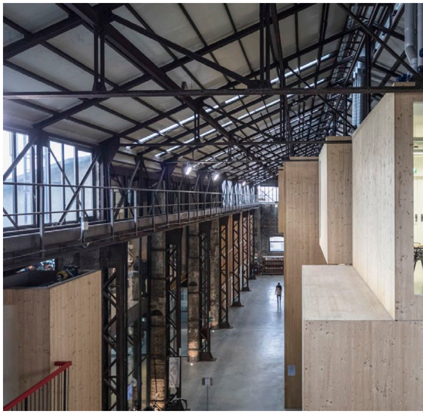
Design Approach:



Type of Intervention: *No Contact-Spatial Tention (Installation)*



7. https://miesarch.com/work/1135



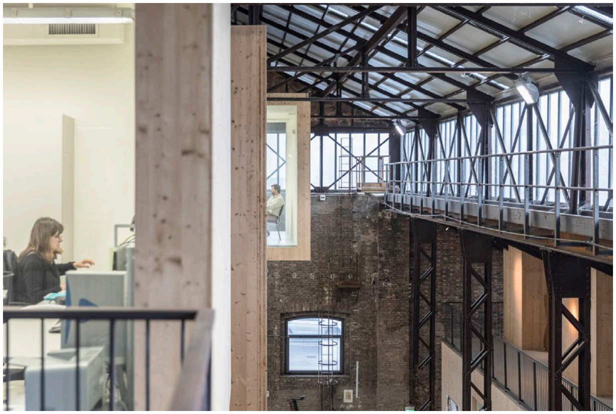



Figure 9 *Initial state before renovation process (source: Archdaily website)*

The memory of labor sounds, smells, machines, process waste, and people are an essential part of industrial architecture sites and buildings.

Figure 10 *Facade after renovation (source: Archdaily website)*

The refurbishment project understands and respects the core beauty of the original building and tries to keep the sound of machines and laborers existed in the building's roots.

Figure 11 *Old structure (source: Archdaily website)*

Shed n.19 consists of large roofing, whose figurative and typological features are expressed through the shape of the empty and confined space; for this reason, to be consistent with the original structure, space subdivision is realized through structurally and thermally independent modules. As a consequence, the available area is incremented, and the public space inside is improved.

Figure 12 *New structure following original shape (source: Archdaily website)*

Space has been subdivided through distinctive modules in terms of structural, thermal, and material features. The building adjusts to contemporary requirements while keeps it's industrial heritage and historical values. This project seeks to turn a deteriorated area into a public space and present new ways of manufacturing. A sequence of open, semi-enclosed spaces and passages are provided to establish a two-way relationship between past and future, between interior and exterior, between building and landscape, between private space and public space.

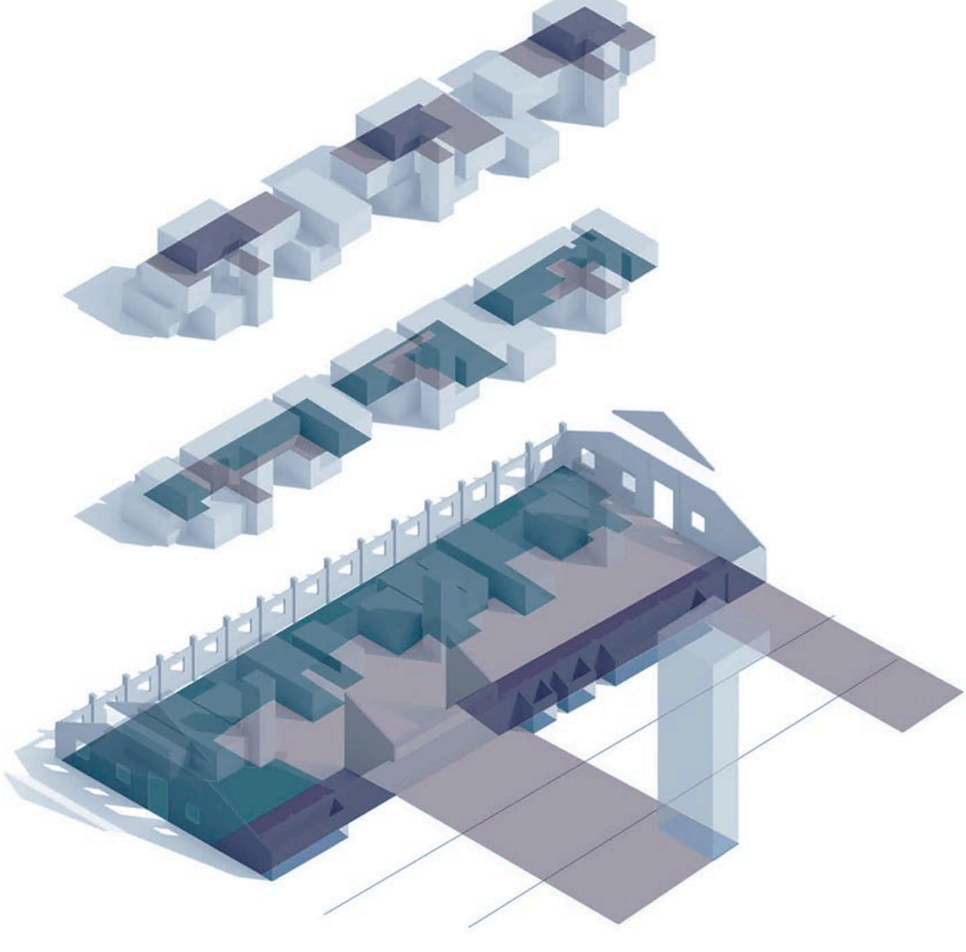


Figure 13 *Interior space showing modules (source: Archdaily website)*

Figure 14 *Interior space (source: Archdaily website)*

Figure 15 *Interior space (source: Archdaily website)*

Figure 16 *Interior space (source: Archdaily website)*

Conserve

Intervention

Innovation

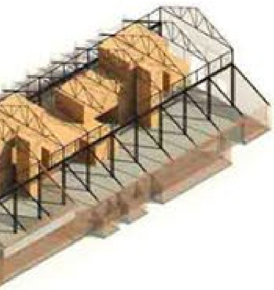


Figure 17 *Interior space (source: Archdaily website)*

Figure 18 *Interior space (source: Archdaily website)*

Figure 19 *In the process of renovation (source: Archdaily website)*

Figure 20 *Exterior facade (source: Archdaily website)*

Conserve

Intervention

Innovation

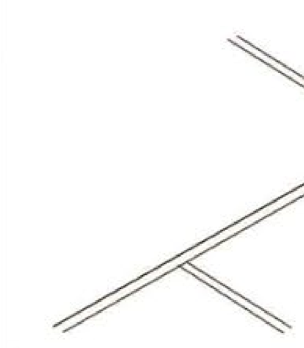
Figure 21 *Interior space (source: Archdaily website)*

Figure 22 *Exterior facade (source: Archdaily website)*

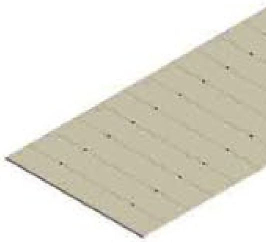
Figure 23 *Before intervention (source: Archdaily website)*

Figure 24 *After intervention (source: Archdaily website)*

Conserve



Intervention



Innovation

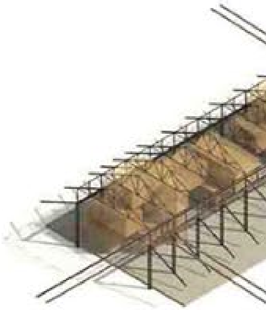


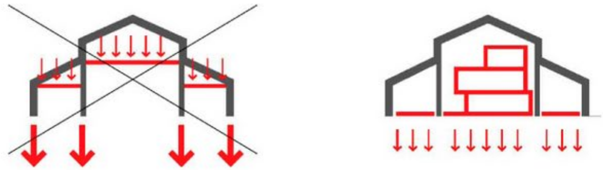
Figure 25 *Interior space after intervention (source: Archdaily website)*

Figure 26 *After intervention (source: Archdaily website)*

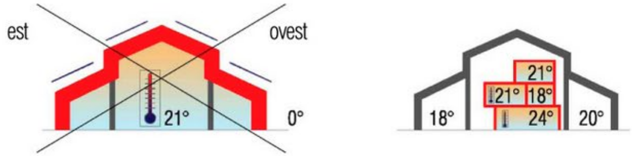
Figure 27 *After intervention (source: Archdaily website)*

Figure 28 *After intervention (source: Archdaily website)*

Structural Aspects

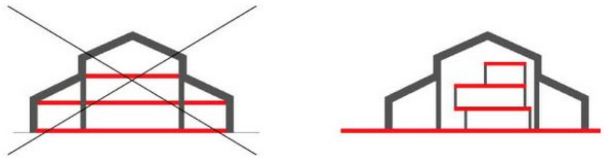


Comfort and Environmental Sustainability

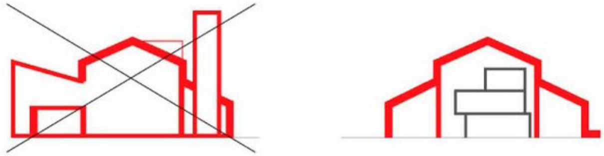


Functionality and Flexibility of Spaces

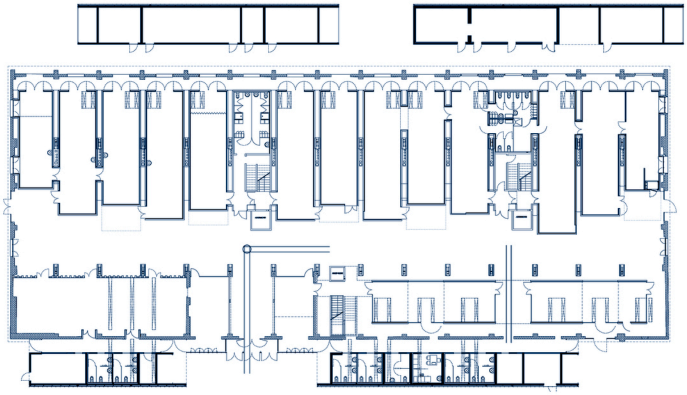
Quality of Relations



Memory



Ground Floor



First Floor

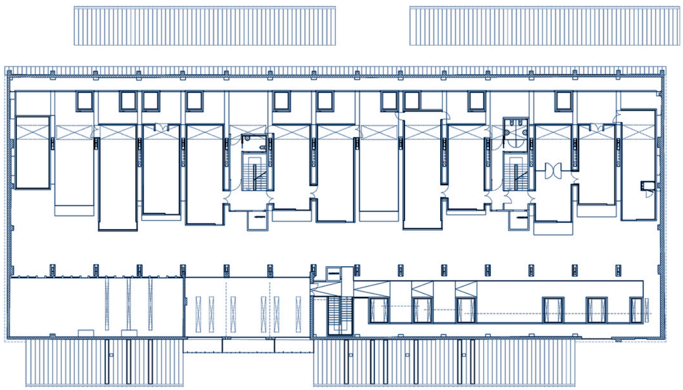


Figure 29 *Details of intervention (source: Archdaily website)*

Figure 30 *New and old masses (source: Archdaily website)*

Second Floor

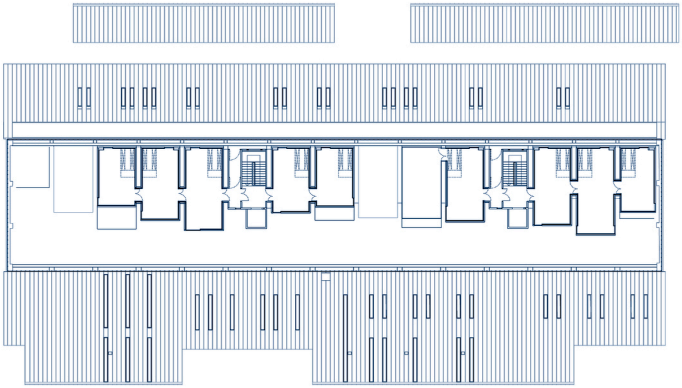
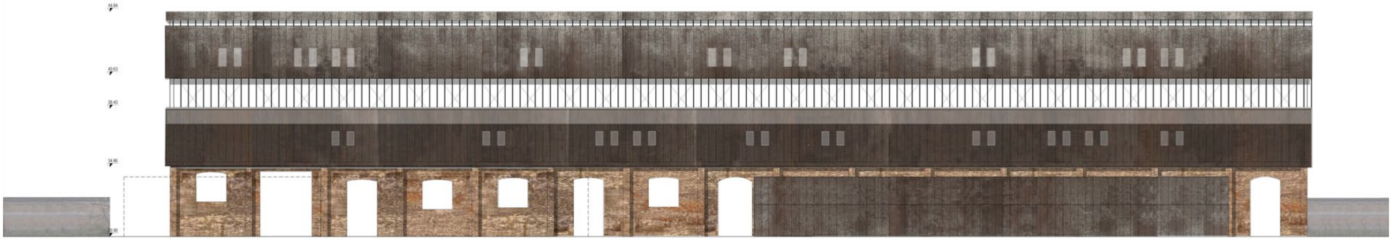


Figure 31 *Detail of intervention (source: Archdaily website)*

Figure 32 *Detail of intervention (source: Archdaily website)*

West Elevation

East Elevation



Section

South Elevation

North Elevation

3.2.2 Joolz Headquarters / Space Encounters

-Location: Amsterdam.NL

-Program: Transformation from factory to office

-Gross floor area: 1600 m2

-Architect: Space Encounters

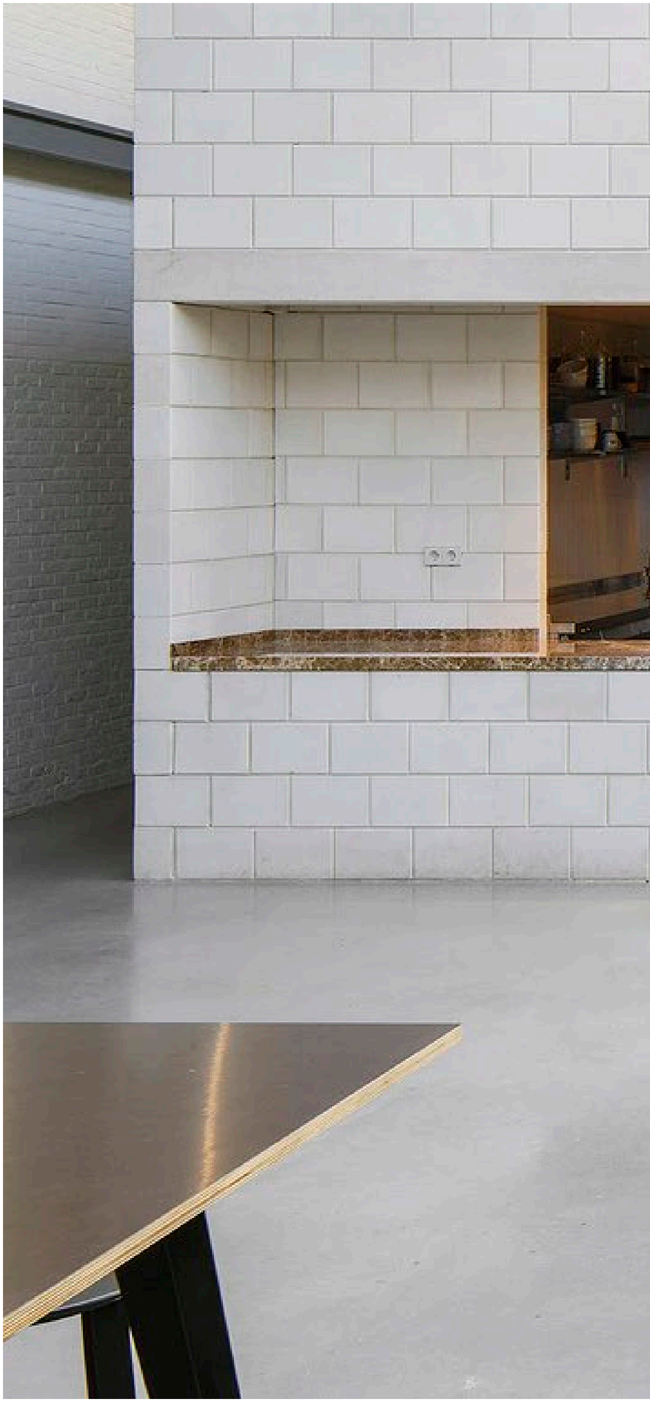
The project is a transformation of a former machine factory building into an office building. It is situated in Amsterdam-Noord area.

Relationship Between New and Old Masses:

New Interior

Design Approach:

Box in Box



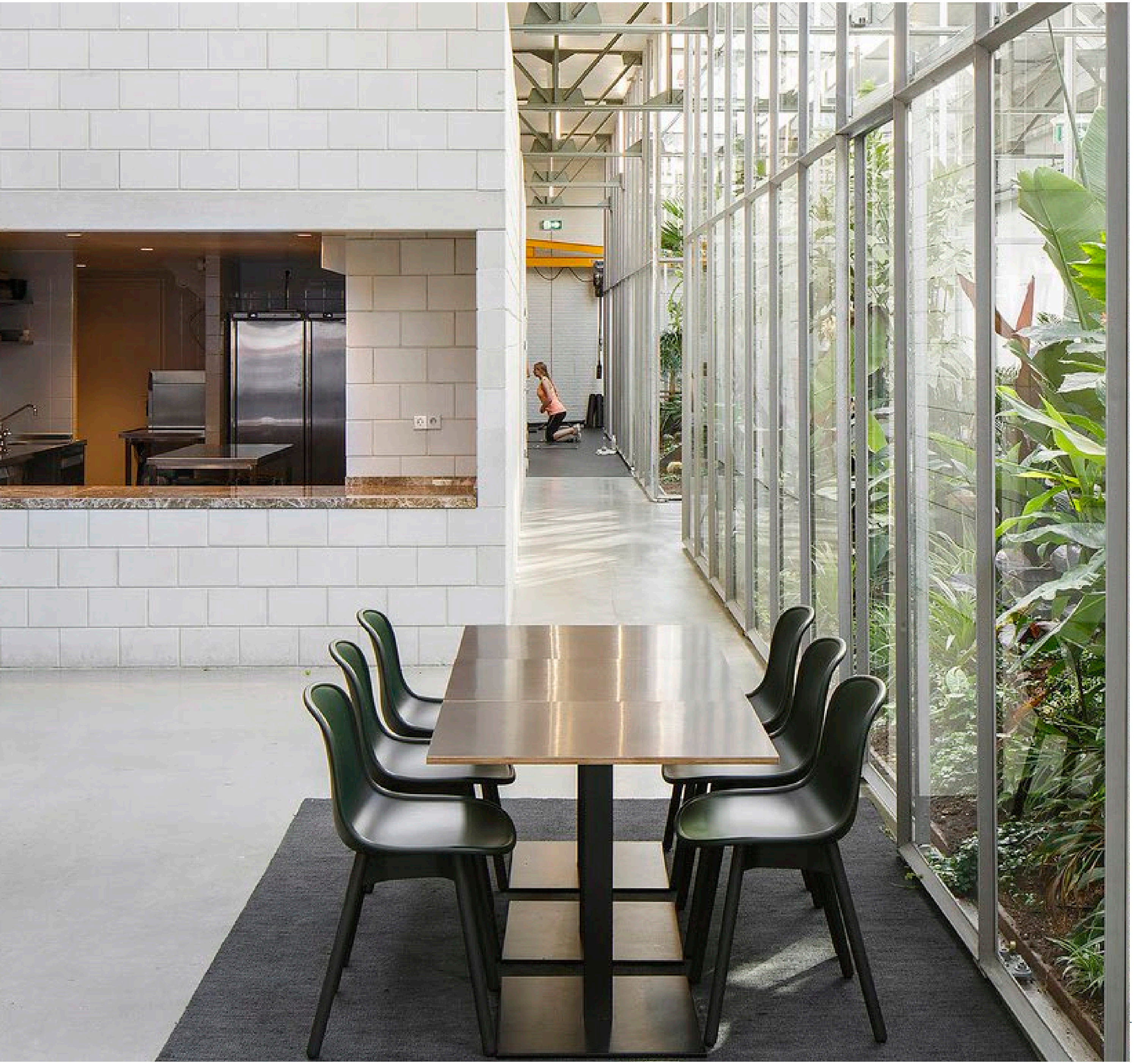


Figure 33 *old openings in the former facade* [7]

In its initial interior condition, offices were blocking the hall from view from a passerby. The architects decided to remove all the walls on the ground floor, in order to make the hall visible from the street view.

8. https://www.yellowtrace.com.au/space-encounters-joolz-hq-amsterdam/

Figure 34 *New large openings in the office facade (Source: Archdaily Website)*

Subsequently, large openings fitted with angled glazing are made in the office buildings facade. They ripped out the exterior roller doors and windows and kept just the brickwork to hold the place together.

Figure 35 *Interior space before intervention showing existing skylights* [8]

The main interventions are three gardens full of trees and plants. These gardens are extruded from and aligned to the existing skylights. They follow precisely roof light's shapes and outlines to demonstrate the current state of the structure.

9. https://www.yellowtrace.com.au/space-encounters-joolz-hq-amsterdam/

Figure 36 *Three interior gardens (Source: Archdaily Website)*

Besides improving the internal climate, the employees have more pleasant choices to get rid of the daily routine. Benches situated among the plants mean the greenhouses can act as meeting rooms.

Figure 37 *Interior space before intervention showing existing skylights* [8]

The architects split the space into two corridors utilizing mentioned three glasshouses.

10. https://www.yellowtrace.com.au/space-encounters-joolz-hq-amsterdam/

Figure 38 *Three interior gardens (Source: Archdaily Website)*

A double-height space, which is a seating area, is set on one side of the greenhouses. There are a white blockwork box housing toilets and a cafe with a marbled countertop In the center of this area.

Ground Floor

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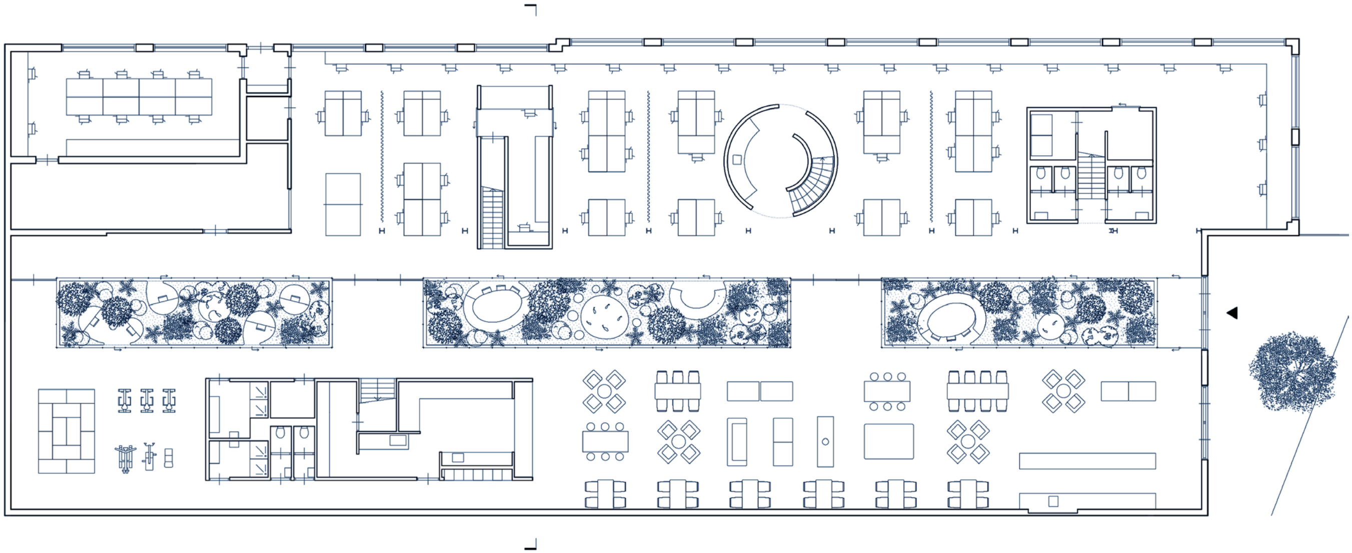
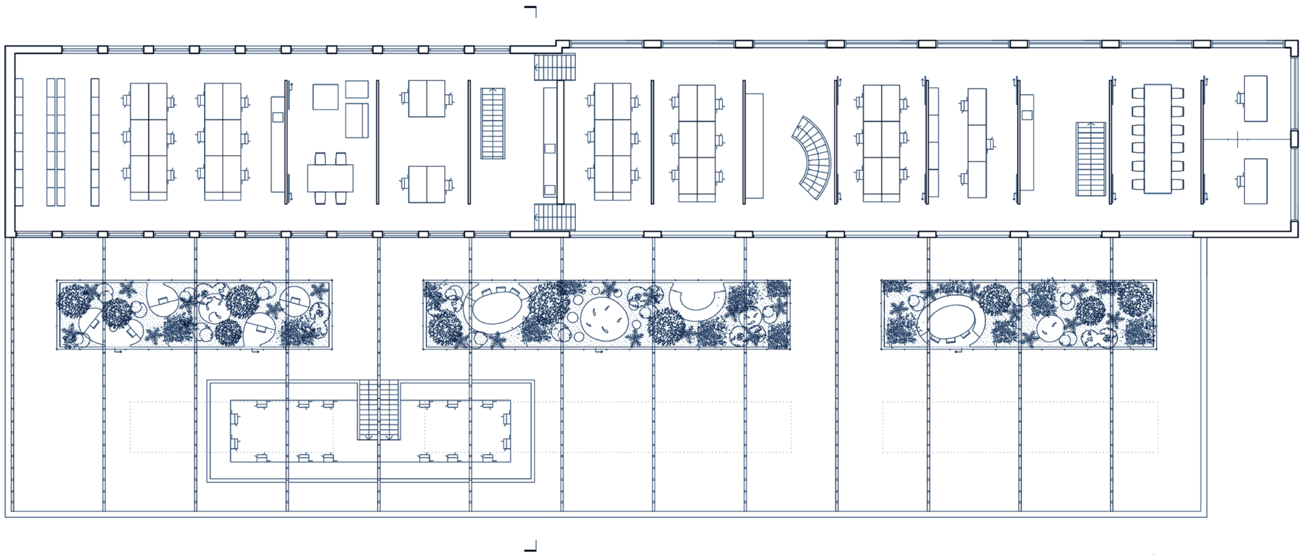


First Floor



scale: 1/500

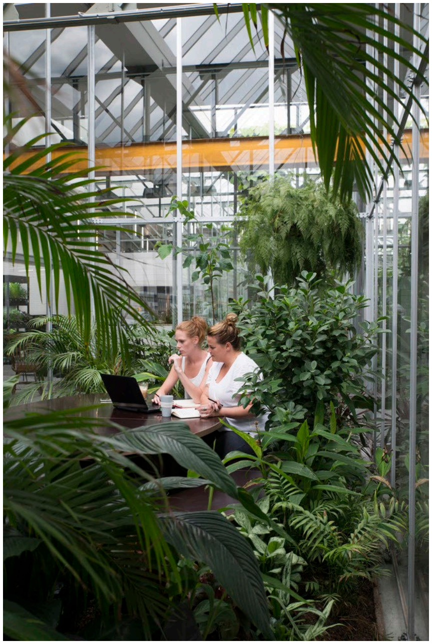
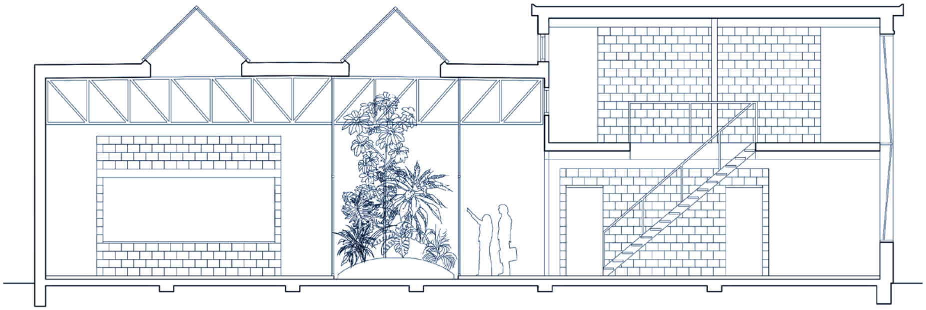
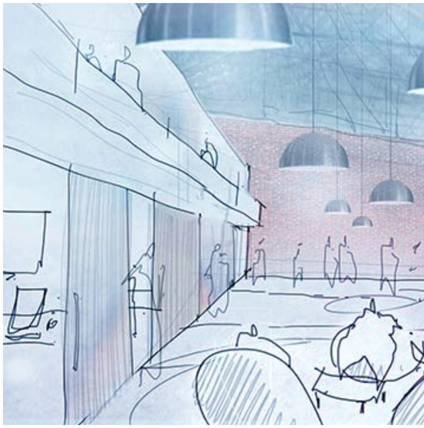
 

Figure 39 *Upper floor offices (Source: Archdaily Website)*

On the other side of the greenhouses, two stories of office space are designed. A curving staircase connects the two levels.



3.2.3 Sinergia Cowork Palermo / Emilio Magnone + Marcos Guiponi



-Location: Palermo, Uruguay

-Program: Transformation from a carpentry, mechanical workshop, movie studio and warehouse to office

-Gross floor area: 1400 m2

-Architect: Emilio Magnone, Marcos Guiponi

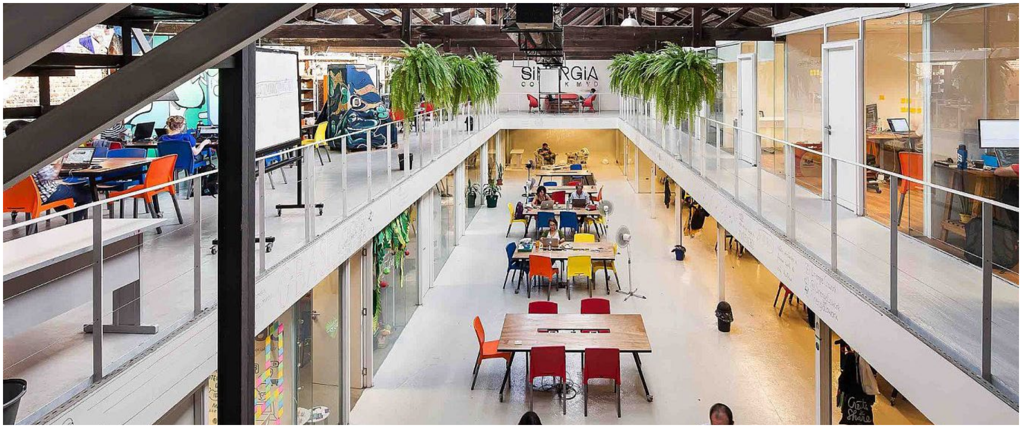
The Project is a transformation of former carpentry into an office building. The design of the new office is a co-work space where it offers a collaborative working environment and enhances social skills.

Relationship Between New and Old Masses:

New Interior

Design Approach:

Box in Box


SINERGIA


SinergiaCowork
@SinergiaCowork
SinergiaCowork
montevideo
SINERGIA

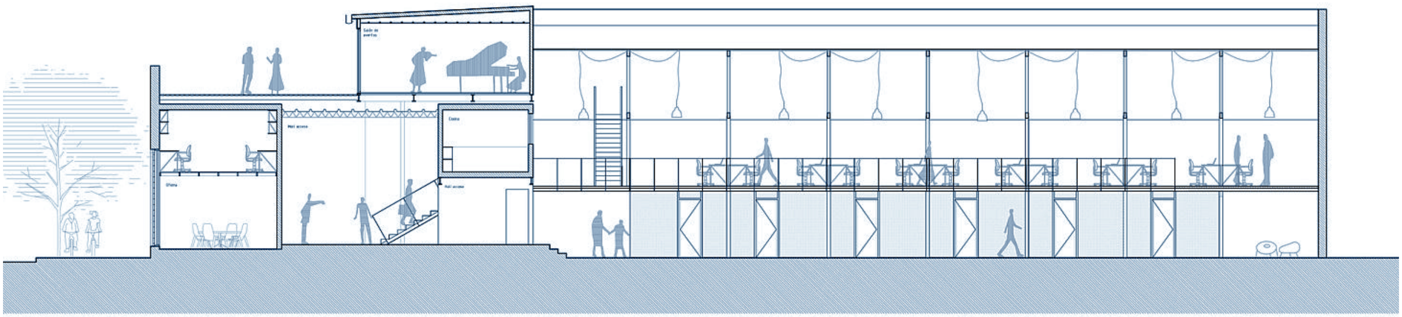
Figure 40 *Co-work space (source: Archdaily website)*

The Project emphasizes on keeking the aesthetics of the old structure. The new interventions are distinguished from the existing building by using lightweight fabrics, metal beams, structural insulated panels, and a neutral color palette (white and light gray), where the only color is given by the coworkers, vegetation and furniture.

Figure 41 *Co-work space (source: Archdaily website)*

The interior void has high ceilings, and an industrial vibe is present in the design.

The ground floor consists of a central void that hosts co-work spaces and meeting areas. On the upper level, there are smaller offices and some inclosed spaces together with a 3d-printing, flexible open plan co-work spaces, photography studio, and a living room.



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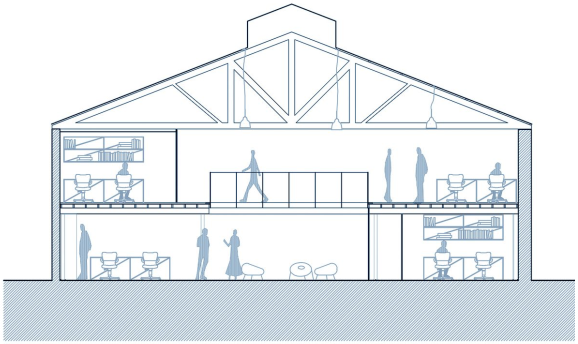
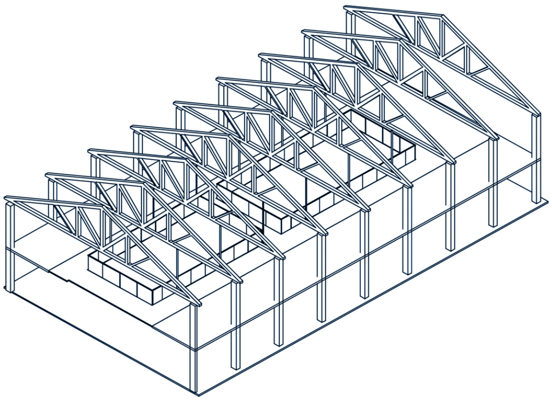
Through the original wooden roof truss, you can access an event room with an outdoor deck for meetings and interactions among employees to relax and communicate with each other during weekends.





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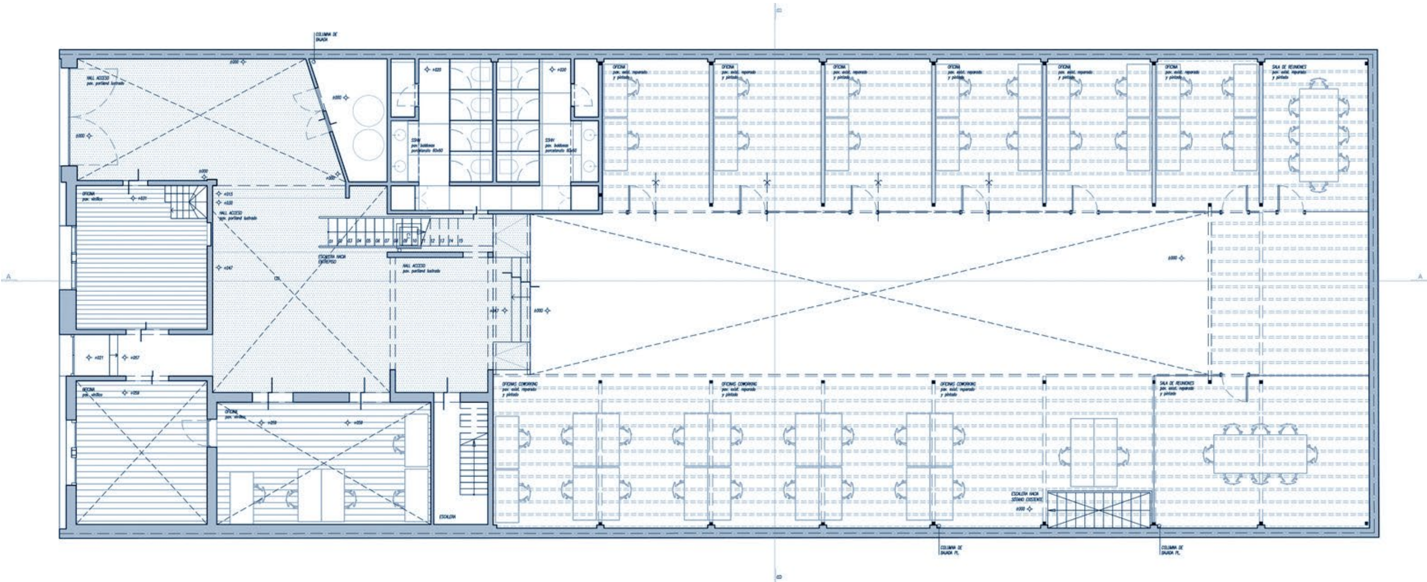
Ground Floor



Lower Level

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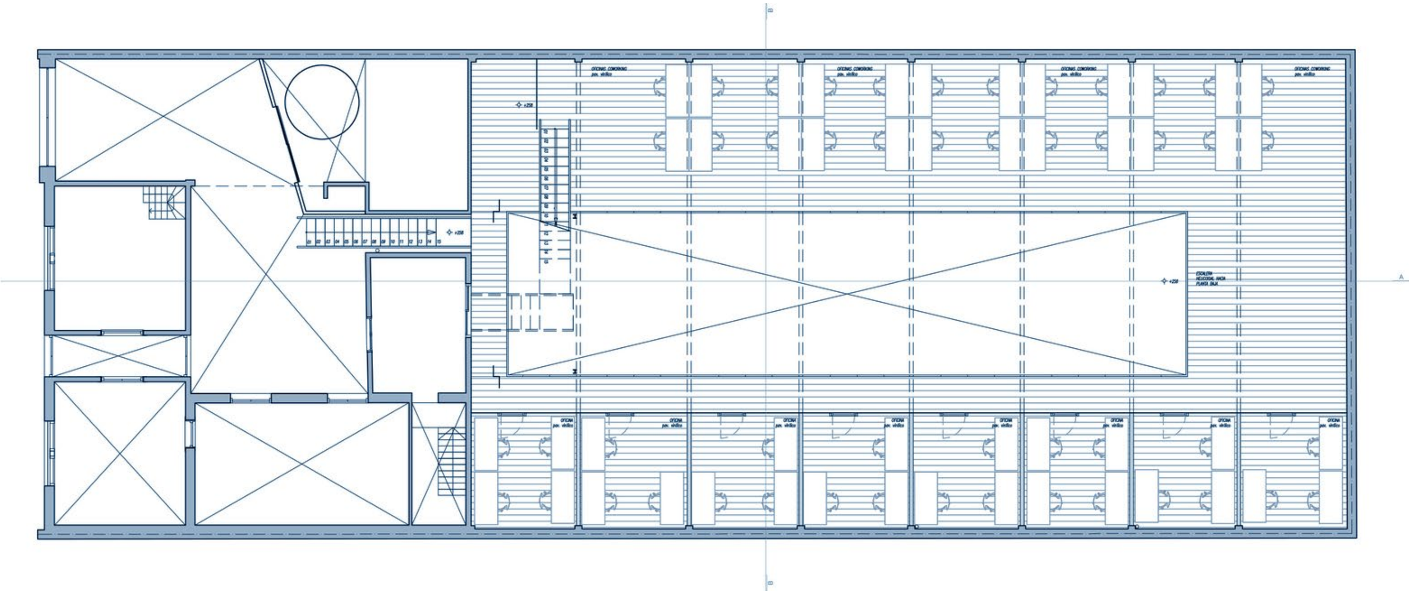
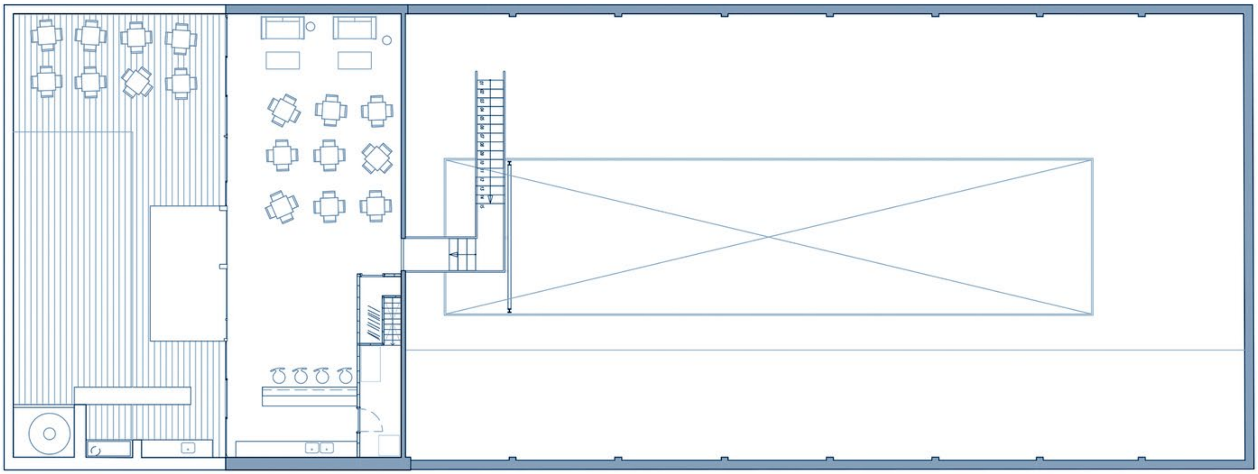
First Floor





Second Floor

scale: 1/300

3.2.4 JM0 open-space / FUSO atelier d'architectures

-Location: Outskirts of Paris, France
-Program: Transformation from former storage facility to office
-Gross floor area: 1330 m2 + 920 m2 outdoor
-Architect: FUSO atelier d'architectures

The Project is a transformation of a former storage facility into an office building.

Figure 42 *prefabricated timber panels(source: Archdaily)*

Relationship Between New and Old Masses:

New Interior

Design Approach:

Box in Box

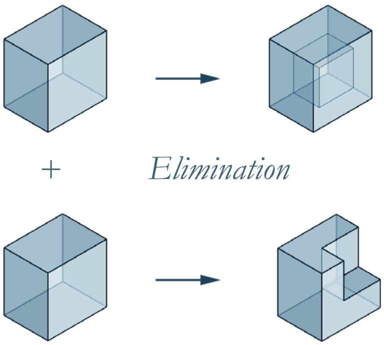


Figure 43 *prefabricated panels (source: Archdaily)*

Figure 44 *Hallway (source: Archdaily Website)*

Figure 45 *Hallway (source: Archdaily Website)*

One of the main interventions in this Project is creating closed working spaces with the aim of prefabricated timber panels that create a warm and cozy atmosphere.

Using these mentioned prefabricated structural wooden panels for offices and meeting rooms, enabled rapid implementation on-site without the struggle of lifting the equipment.

They structure the inclosed spaces detached from each other in a way to let natural light comes into the depth of the volume.

Figure 46 *The previous state of the roof (source: Archdaily)*

The patios are Cut from the volume of the old storage room, and they bring natural light into the building. Furthermore, it breaks the barrier between inside and outside spaces, and the employees can relax and have meetings inside the patios. They also offer a frame of the sky to the users.

Figure 47 *The new patio created inside the existing patio (source: Archdaily)*

Figure 48 *scheme of the operational levels, facade during night (source: Archdaily)*

Figure 49 *scheme of the operational levels, facade during day (source: Archdaily)*

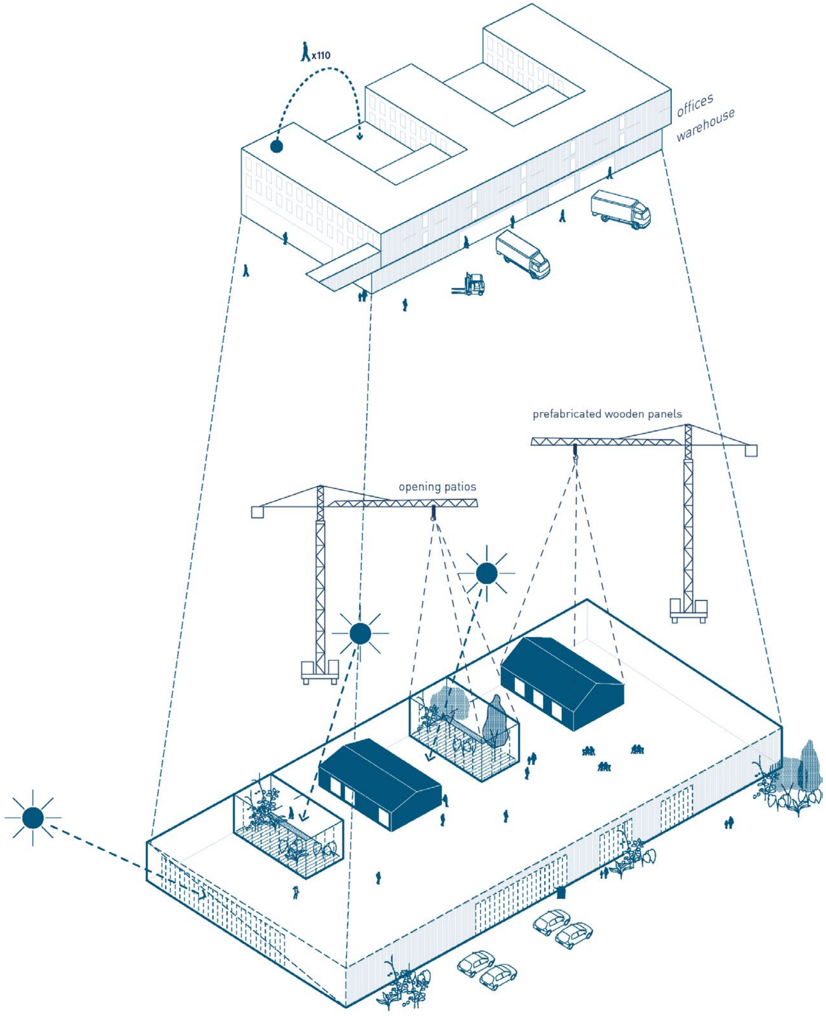
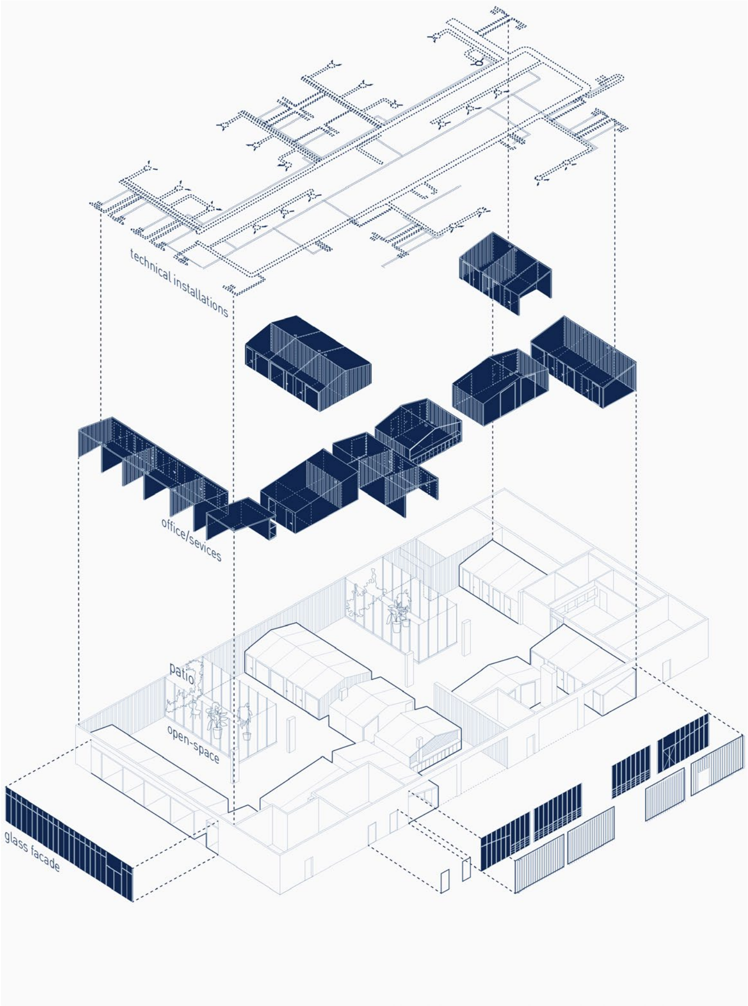

x110
offices
warehouse
prefabricated wooden panels
opening patios

Figure 51 *the new patios allow an open working space (source: Archdaily website)*

Figure 50 *free cooling and acoustic systems plugged on the roof (source: Archdaily website)*


technical installations
office/sevices
patio
open-space
glass facade

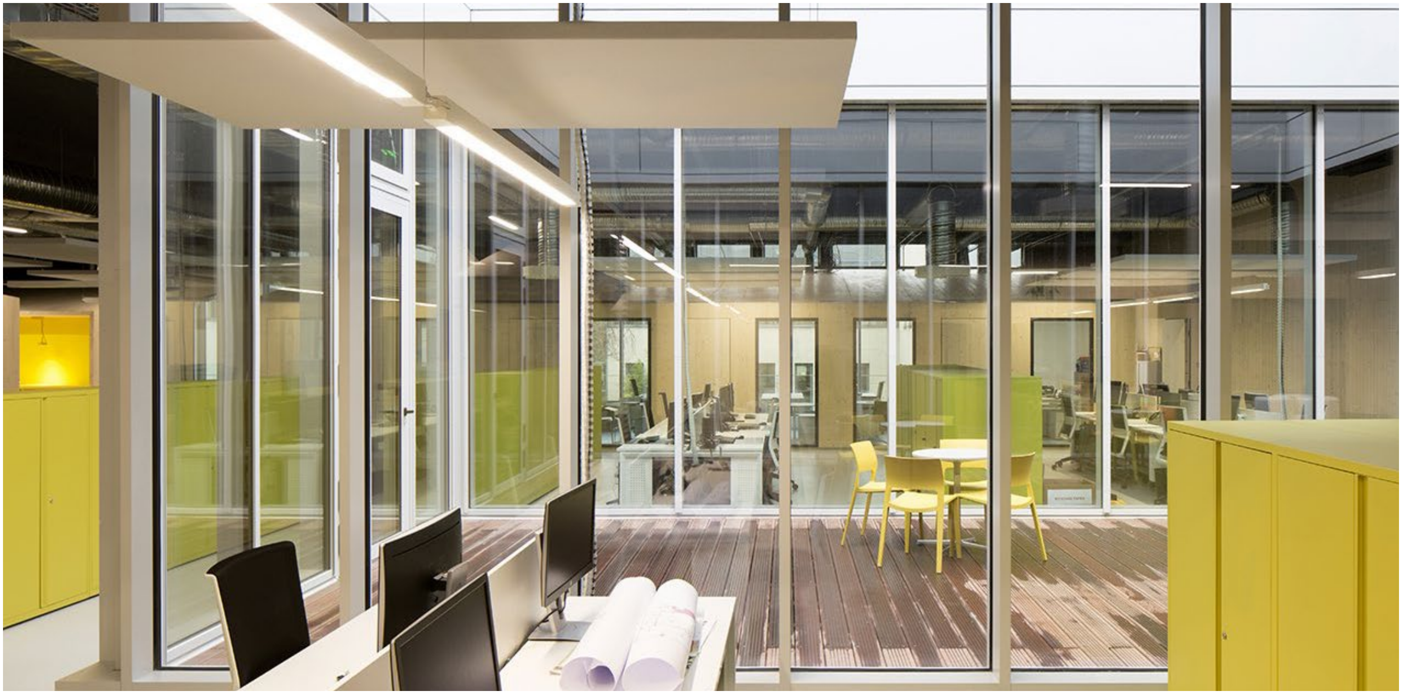


Figure 52 *View from inside to the new patios (source: Archdaily website)*

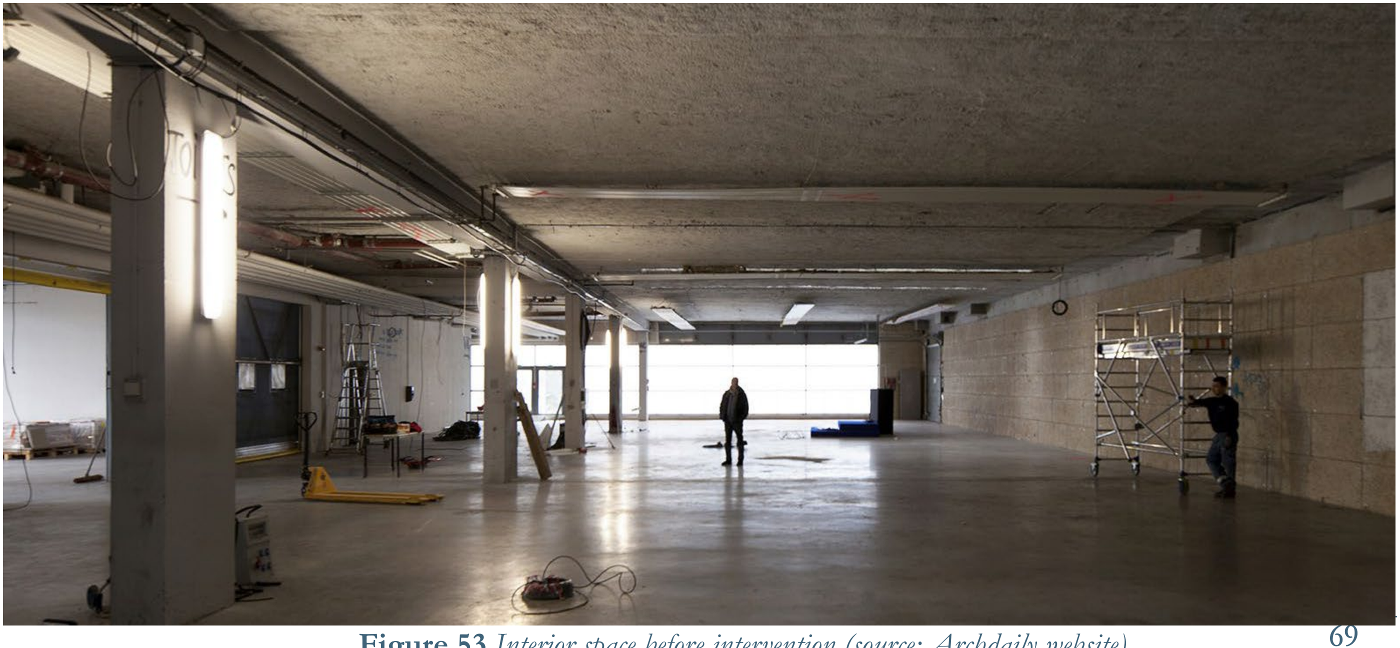
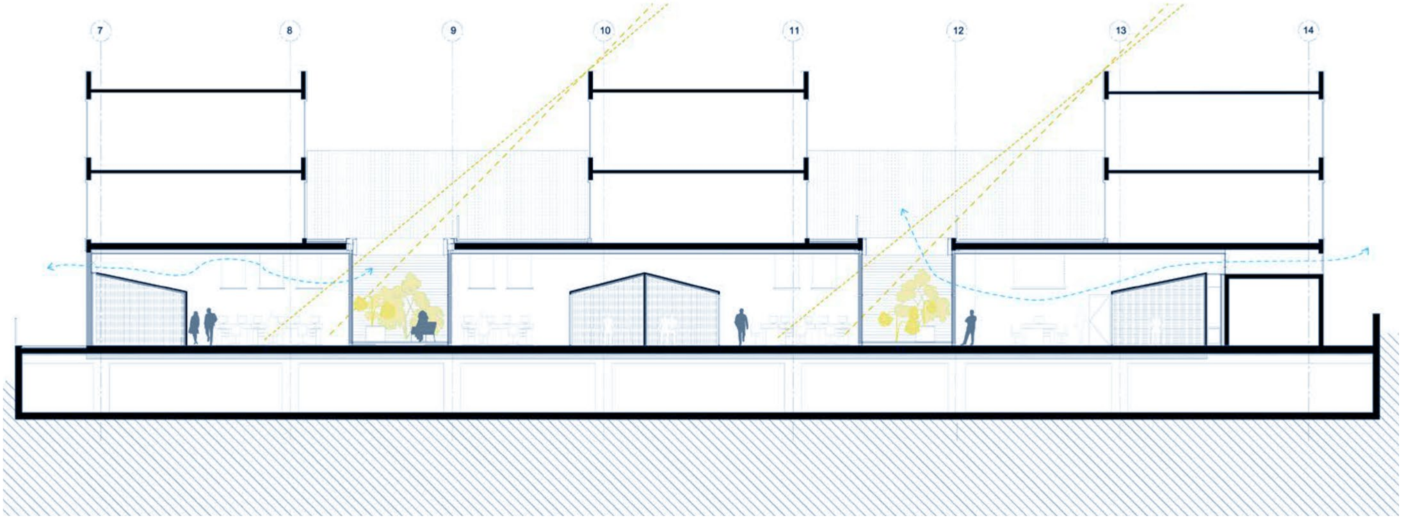


Figure 53 *Interior space before intervention (source: Archdaily website)*

scale: 1/250



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Passive Design Methodology

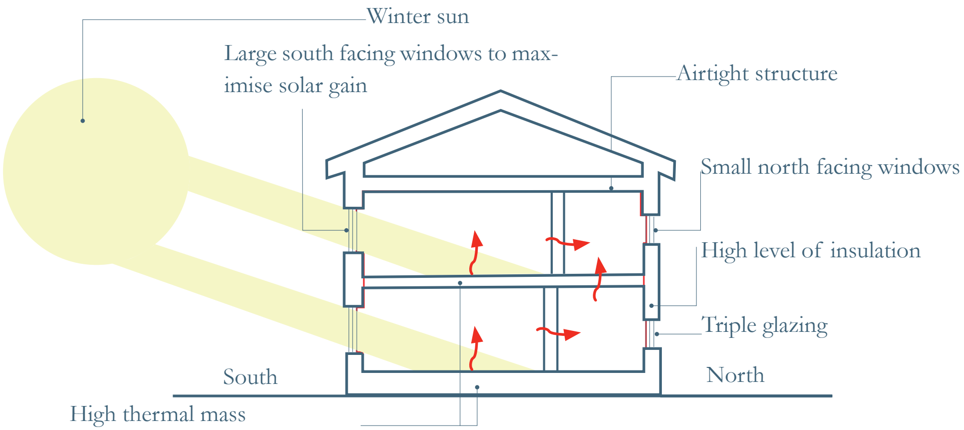
In this chapter, the principles of passive design are studied. Furthermore, Passivhaus standards and principles are being described. Finally, the Denby Dale Passivhaus project is presented as a successful example of this methodology.

4.1 Introduction to Passive design

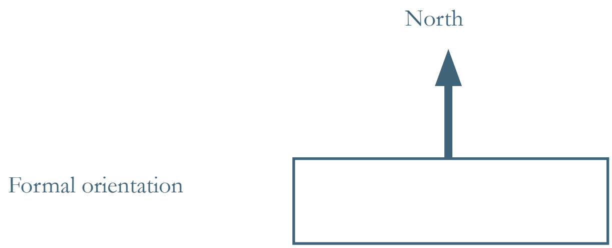
The Passive House (PH) concept considers the application of an efficient strategy to reduce the energy consumption of a construction. The principles of passive design are listed as following[11]:

1-**Solar gain**: Solar gain as one of the fundamental principles in passive design utilizes sun energy to provide light and required heat for creating a comfortable internal environment.
To maximize the benefits from solar gain, considering orientation is a crucial element in passive design. In order to obtain the maximum needed sun energy, the long facade should face the south with a high level of glazing. In contrast, the north facade glazing should be kept a minimum.
Considering the form of the property, if possible, the plan should be narrow and rectangular to the light, and heat penetrates deep into the house.
Due to the position of the sun in the sky in summer, which is high and closer, using overhang or brise soleil is advised to prevent overheating during this season.
Solar water heating is also one mandatory aspect of the passive house design. By means of solar panels (collectors), it is possible to use solar energy to heat the water.

11. https://passivedesign.org/overview-of-passive-design



Winter sun
Large south facing windows to max-
imise solar gain
Airtight structure
Small north facing windows
High level of insulation
Triple glazing
South
North
High thermal mass

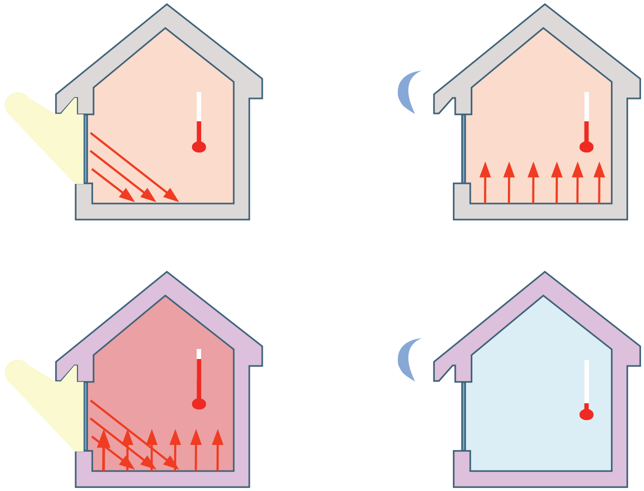


North
Formal orientation

2-**Thermal mass:** Thermal mass helps to moderate temperature fluctuations throughout the space by using some building materials that absorb, store, and later release this amount of heat steadily over a period of time. If the building materials have low thermal mass, the temperature rises quickly, and there will be no heat absorbed to release it during the day. For example, concrete has a high thermal mass. In contrast, timber and insulations have low thermal masses.

High thermal mass

Low thermal mass



3-**Super Insulation**: The level of super insulation as a crucial aspect of the passive design should meet the passive standard of 0.10 - 0.15 W/m2K. In order to achieve this standard, the passive design should minimize thermal bridging and air leakage throughout the structure to eliminate any possible heat loss.

3-**Airtightness**: Airtightness is referring to airflow control, within a structure to prevent unexpected air leakage and cold air infiltration.

- In the *Block cavity system*, there are two main methods of making the block airtight. The first method is *plastering*. For instance, the concrete blocks are porous, and they are not airtight. Therefore covering the inner surface with plaster is vital. The surface area should be fully covered from very top to the bottom to be completely sealed. Once it is covered, the surface is usually covered with a thin coat of skim. As a result, the surface will be protected from any air leakage.

In the second method, a *service cavity* is provided. There will be an airtightness membrane fitting against the inner leaf to prevent any air leakage. Then there is a service cavity, which is typically around 60 mm and is filled with services and insulation. Finally, the plasterboard is applied to ensure the airtightness of the construction.

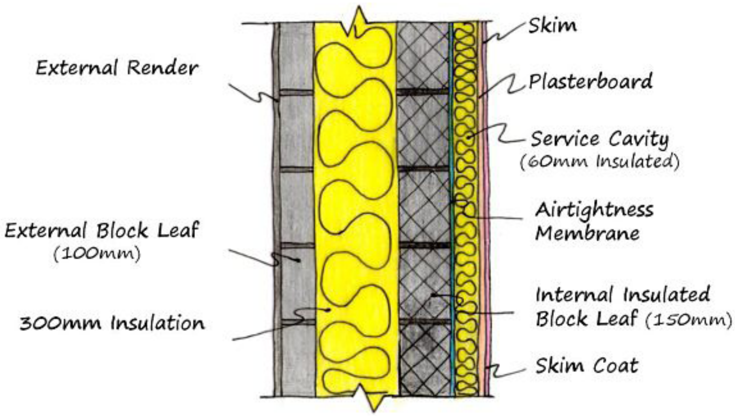


Figure 54 *Detail of block cavity system* [11]

- In a *timber frame system,* there are also two main methods to airtight the structure. In the *service cavity method*, which is the most common one, the timber frame itself should be sealed. The load-bearing studs are insulated. Furthermore, an airtightness membrane is installed. In some cases, to provide more airtightness, an OSB board is fitted on the studs, and then, airtightness membrane is applied to the OSB board. Once the airtightness membrane is installed, the service cavity, which is consists of some battens, is provided to create a space outside the airtightness layer. This service cavity is insulated, and they are not installed until the airtightness level of the structure is checked and meets the standards. Finally, the plasterboard is applied and skimmed.

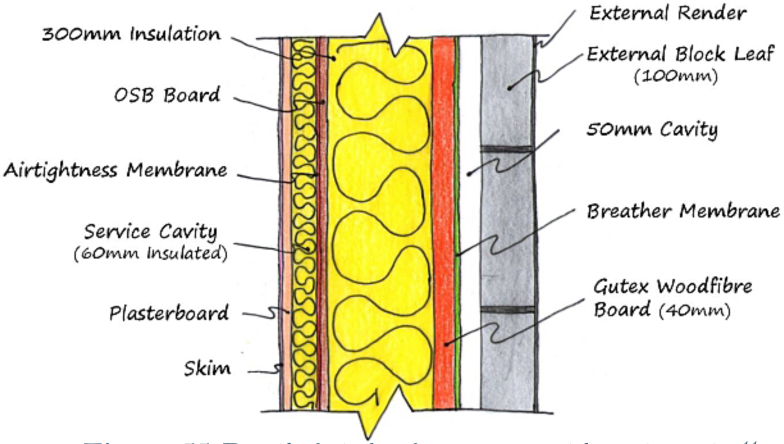


Figure 55 *Detail of timber frame system with service cavity* [11]

- The second method is *making the inner leaf airtight* by using airtightness membrane. In this method, there is no service cavity, and the services are put within the load-bearing studs. The studs are insulated carefully. Then, an OSB board and an airtight membrane are applied. It can also be done without an OSB board. The airtightness membrane can prevent air penetration in its own right. At last, the plasterboard is installed and skimmed to cover the whole surface area. This also improves the airtightness level of the structure.

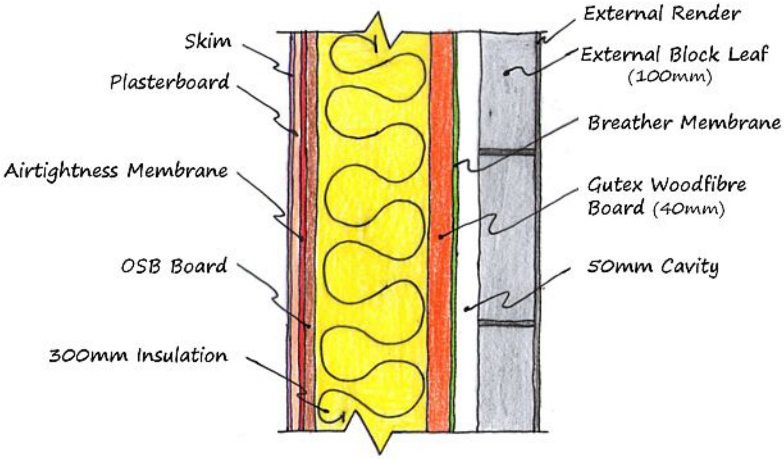
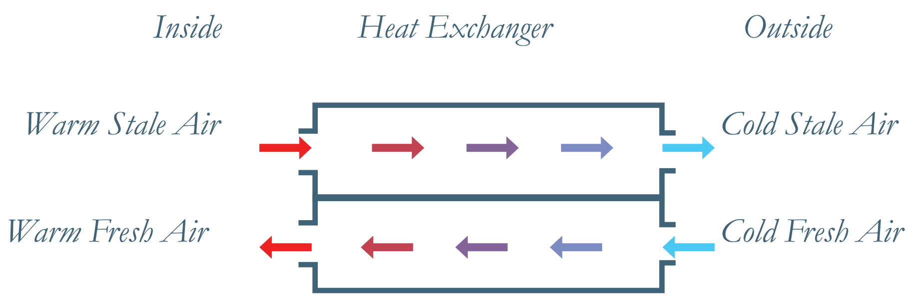


Figure 56 *Detail of timber frame system with making the inner leaf airtight* [11]

4-**MVHR**: When the building is airtight and insulated well, it means we may face the problem of ventilation. Therefore, the mechanical ventilation heat recovery unit or MVHR system is needed. The cold fresh air is brought into the house, and it gets the heat of the warm stale air existing in the house. Therefore it produces warm fresh air for inside spaces. The warm stale air and cold fresh air do not mix. However, the exchange of heat is taking place.



The stale warm air comes from the wet rooms of the house, like the kitchen and bathrooms, to provide fresh air for dry rooms like living rooms and bedrooms.
The MVHR systems are 80 to 90 percent effective, and they can run as little as 15 watts per hour. These systems reduce the consumption of heat energy and eventual costs. At the same time, they reduce the emissions of CO_2.

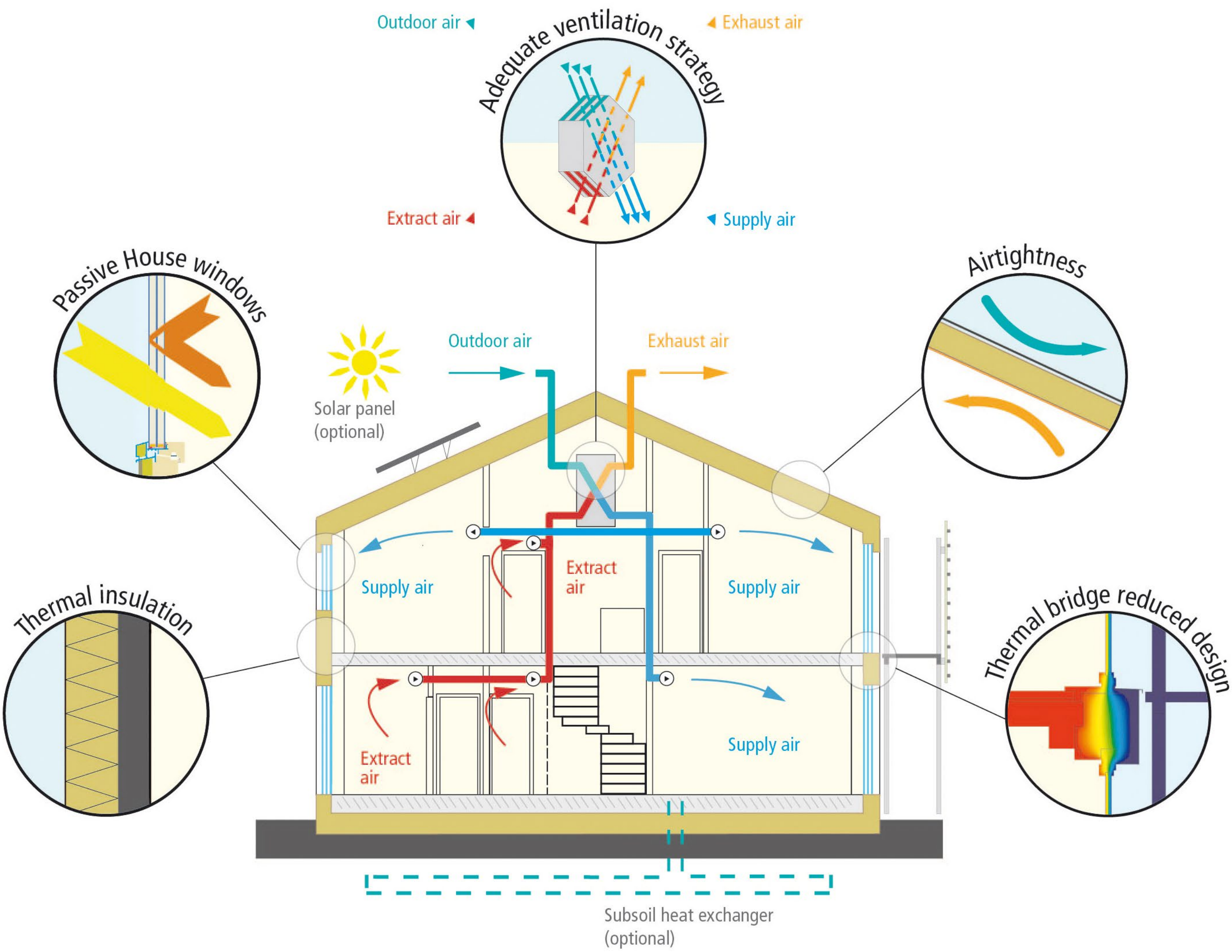


Figure 57 *Skeme of Passive Houses Construction Principles* [12]

12. https://passivehouse.com/02_informations/02_passive-house-requirements/02_passive-house-requirements.htm

4.1.1 *What is Passivhaus*

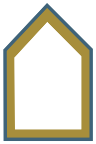
Passivhaus buildings provide a high level of comfort while using less energy for heating and cooling. It was developed first in Germany by Professor Wolfgang Feist with Professor Bo Adamson at the beginning of the 1990s. In Passivhaus buildings, the heat loss is reduced to a minimum.

"The heat losses of the building are reduced so much that it hardly needs any heating at all. Passive heat sources like the sun, human occupants, household appliances, and the heat from the extract air cover a large part of the heating demand. The supply air can provide the remaining heat if the maximum heating load is less than 10W per square meter of living space. If such supply-air heating suffices as the only heat source, we call the building a Passive House." Professor Wolfgang Feist founder of Passivhaus Institut, Germany

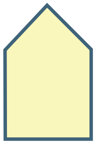
4.1.2 principles of Passivhaus

The principles of the Passivhaus are listed as following [13]:

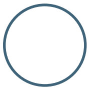
1- **Super insulation**: The U-value of all elements of the external envelope of the building should not be more than 0.15 W/(m2K).



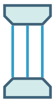
2- **Space heating**: In the passive design approach, conventional central heating is no longer needed, and the amount of heating required can be produced by a combination of waste heat from appliances, ventilation air recovery as well as body heat from people.



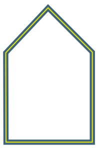
3- The **ratio of volume** to external surfaces should be high.



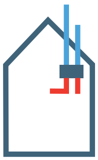
4-Triple-glazed **advanced window technology**. The U-value of Glazing and frames combined together should not be more than 0.8 W/(m2K).



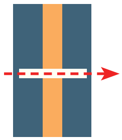
5- **Air-tightness**: Air leakage through unsealed joints must be less than less than 1 m3/hr/m2 @ 50 Pa.



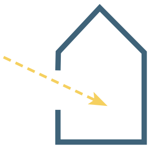
13. http://www.greenspec.co.uk/building-design/passivhaus-introduction/



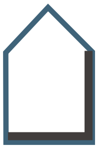
6- **mechanical ventilation** should be applied for the entire property with a heat recovery rate of no less than 80%.



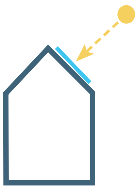
7- **Elimination of cold bridges**: utilizing bridge-free connection details and calculate losses at heat bridges.



8- Usage of **passive solar gain** as one of the fundamental principles of passive design.



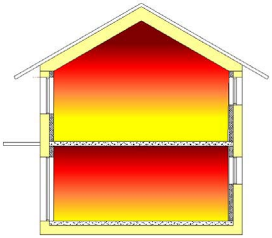
9- Application of **thermal mass** to overcome summer overheating, maintain stable temperatures during winter, and decrease the possibility of overheating in autumn and spring.



10- The beneficial use of **renewable energy**, particularly for generating electricity and water heating, should be considered.

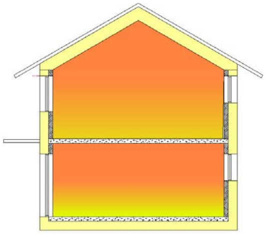
Air and surface tempreture

Typical case



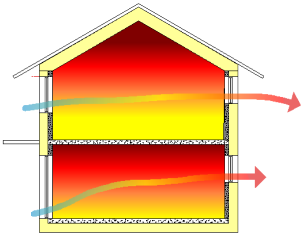
- Different layers of air temperature
- Difference between surface temperature and air temperature

Passivhaus

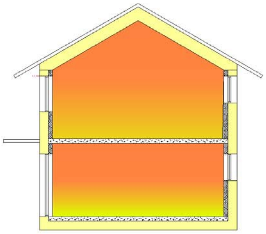


- Even air temperature
- Almost equal temperature between surface and air

Movement of air



- Feel draughty
- Heat loss
- Risk of interstitial condensation



- No draughts
- Less heat loss
- Dry building fabric

Figure 58 *by Jon Bootland, Chief Executive of Passivhaus Trust*

4.1.3 Case Study of Passive Design
Denby Dale Passivhau\Derrie O'Sullivan

-Location: West Yorkshire, England

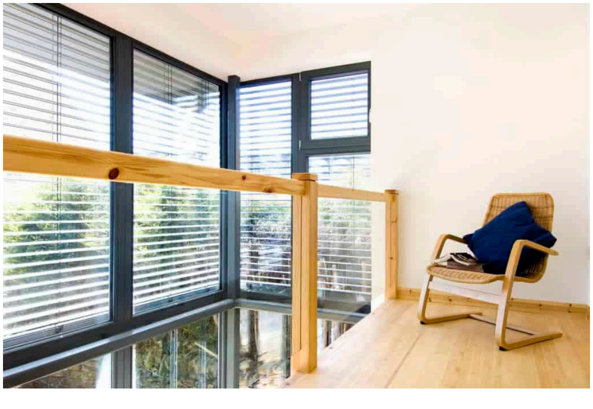
-Year of Intervention: April 2010

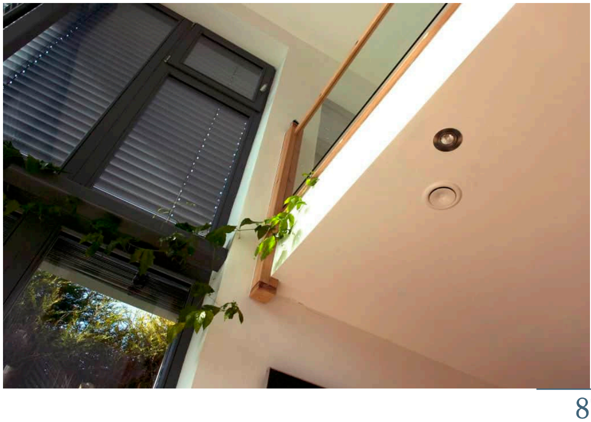
-Area of Intervention: 18m2

-Total Cost: £ 141,049.34

The Project of a solid-walled, three-bedroom, 100-year old detached house was one of the first certified Passivhaus in the United Kingdom. The program is a combination of German Passivhaus methods and British vernacular methodology. It is a pioneer in cavity wall construction.

The design causes a 90 percent reduction in energy use compared to the Uk average usage.

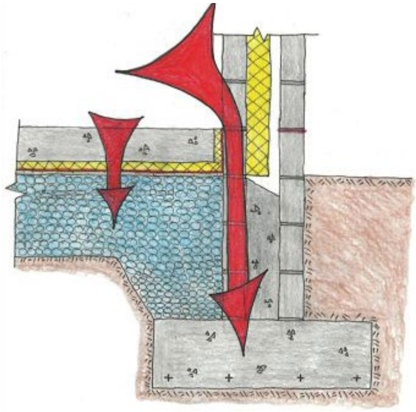




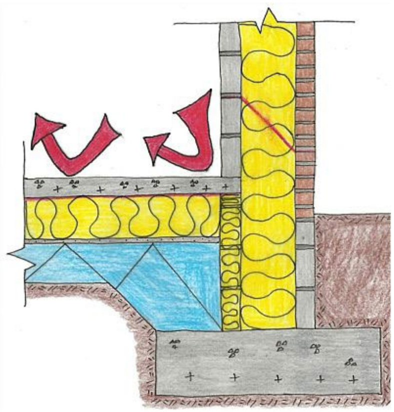
The foundation used in Denby Dale Passivhaus is very similar to the Irish strip Foundation. However, it has one main difference. This foundation eliminates all the thermal bridges within the structure despite the Irish strip foundation, as it is shown in the following sketch. The traditional Irish strip foundation has a U-value of 0.21 W/m2K, which hinders its performance compared to the U-value of Denby Dale Passivhaus foundation, which is around 0.10 – 0.15 W/m2K.

the Denby Dale Passivhaus foundation is applied by the following steps:

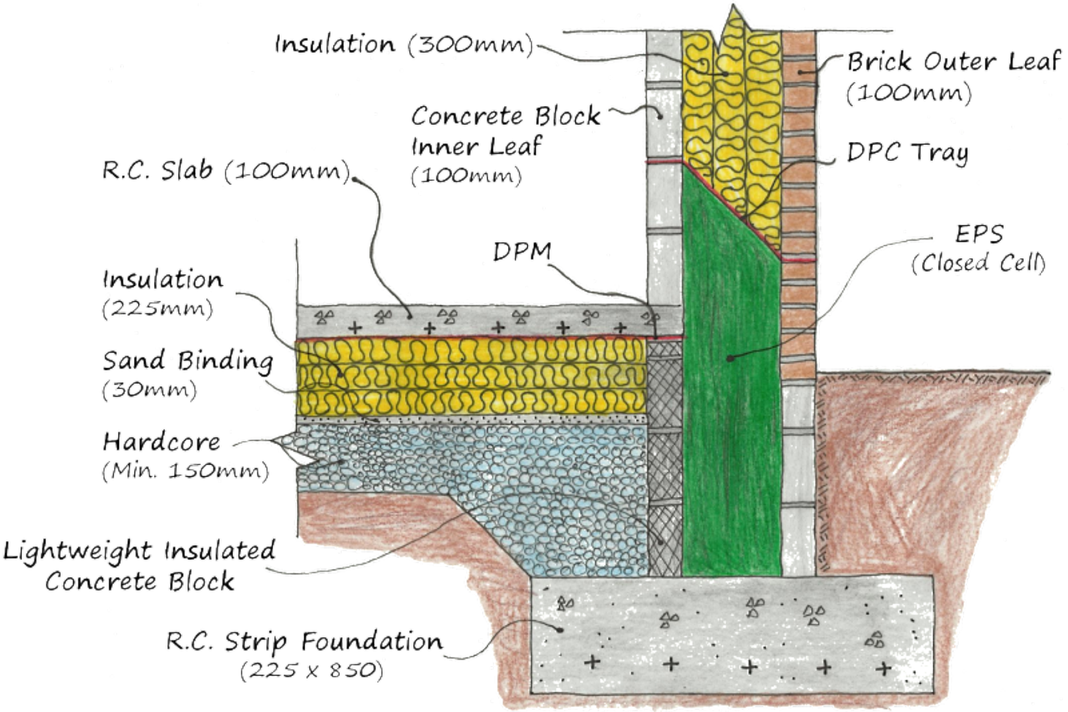
- Installation of lightweight insulated concrete blocks on the inner leaf between the floor slab and the foundation in order to prevent any thermal bridging down the inner leaf.
- Installation 225 mm of insulation beneath the floor slab to prevent heat loss through the floor.
- The insulation provided in the wall below the DPC tray (red) is rigid and closed cell expanded polystyrene or EPS to ensure it will not soak up any water. Furthermore, its rigidity is to compensate for lateral loads below ground.
- Installing 300 mm insulation in the cavity. This insulation which continues down to the foundation to prevent any thermal bridges through the walls or from the foundation.



The traditional Irish strip foundation



The Simple sketch of Denby Dale foundation



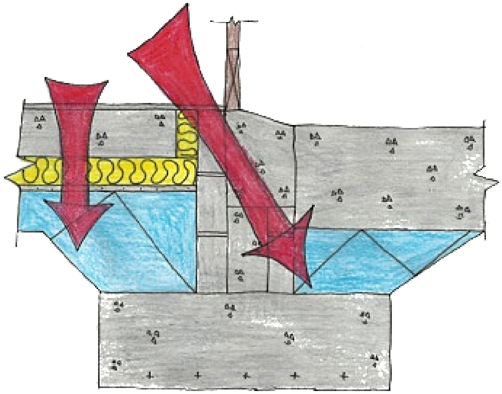
More detailed sketch of Denby Dale foundation

The DPC tray between the wall batts and the EPS insulation cut at an angle

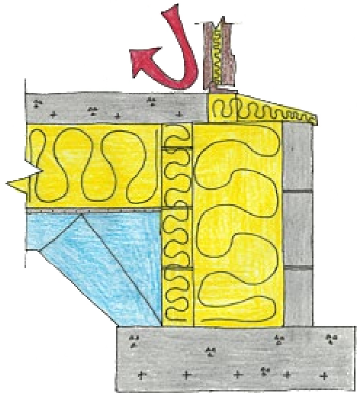
One of the most critical areas in terms of eliminating thermal bridges is the door thresholds. In the standard Irish block cavity door threshold, there is a considerable amount of heat loss, as it is evident in the following sketch. Therefore it is essential to design in a way to eliminate this amount of energy loss. In Denby Dale door threshold design, there is a 300 mm closed cell EPS insulation in the cavity, which makes it moisture resistant and provides rigidity for the build.

There is also a 255 mm of insulation under the floor, just like its foundation. Furthermore, the blocks provided in the inner leaf are lightweight insulated blocks.
However, these actions were not sufficient to eliminate all the thermal bridges through the floor slab. Therefore the concrete block was cut back, and 100 mm by 100 mm fiberglass box section filled with polyfoam insulation was inserted in its place. Moreover, the doorstep itself was created by EPS that is covered by a layer of chequered galvanize to provide more durability.

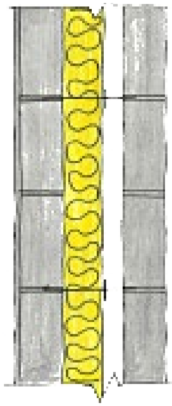
The difference in the level of insulation between the traditional block cavity wall and the Denby Dale block cavity wall is shown in the following sketch. In the inner leaf of the Denby Dale Passivhaus block cavity wall, there is a 100 mm concrete block. In the cavity, there is 3x100 mm Dri-Therm fiberglass insulation batts, and the outer leaf is consists of 100mm natural stone.



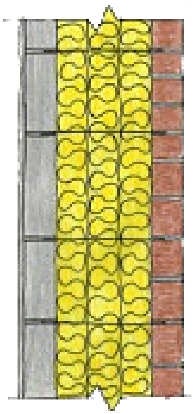
The traditional Irish door threshhold



Door threshhold based on Passivhaus standard



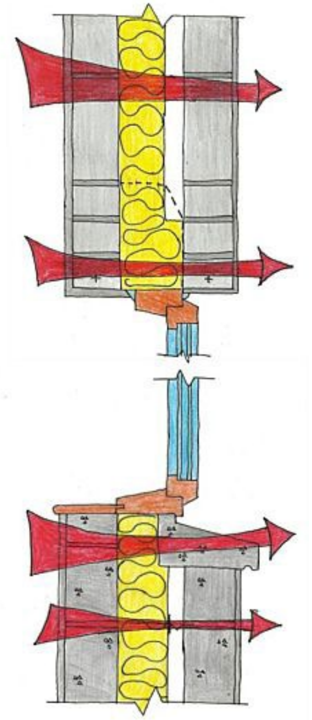
The traditional block cavity wall

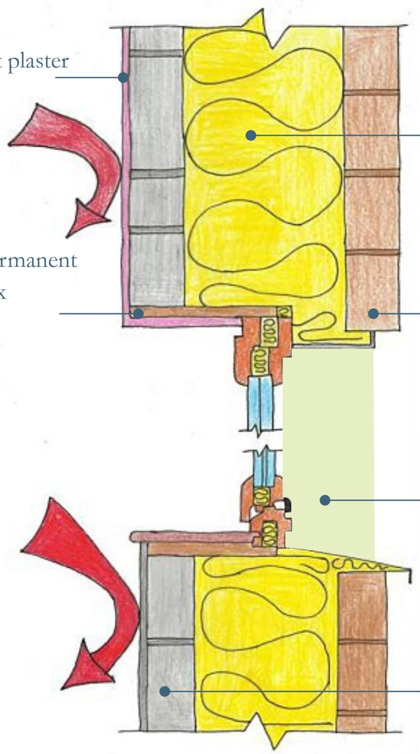


Denby Dale block cavity wall

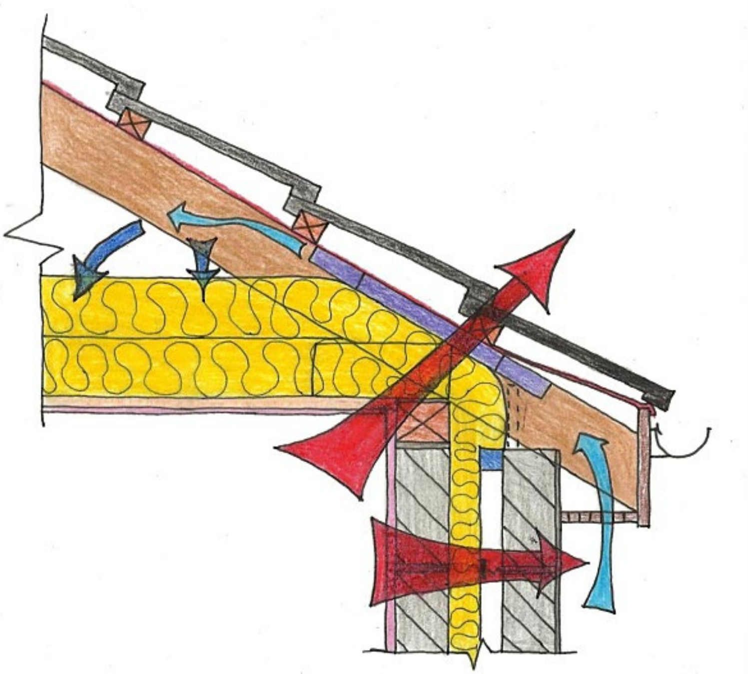
Despite the traditional window systems, in Denby Dale Passivhaus window systems, there is an insulation of 300 mm to prevent heat loss. The windows are positioned half-way of the insulation layer. Therefore, the exposed fiberglass needs to be sealed by a cavity closer. The cavity closer is consists of a three-sided pre-formed aluminum closer. In order to minimize heat loss, an Ecopassiv timber window was used, and they have a whole-window U-value of just 0.8 W/m2K in total.

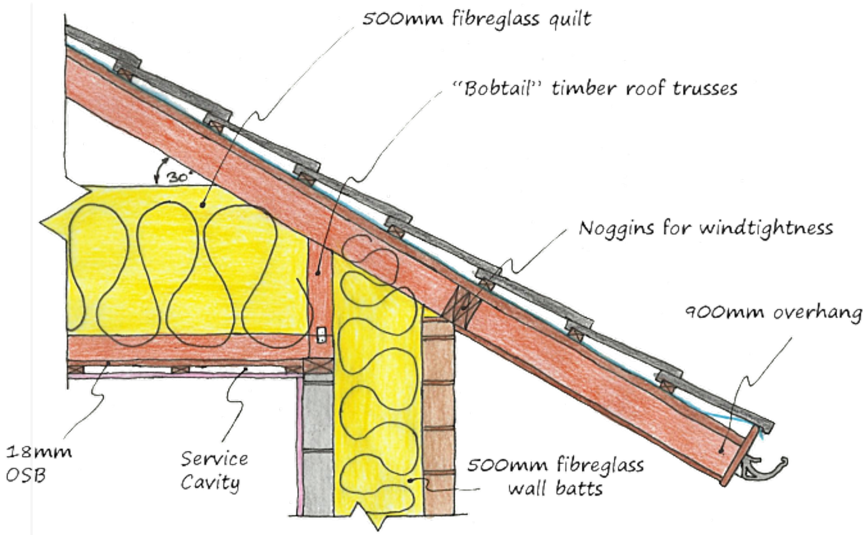
In block cavity construction, the plaster is airtight. However, to prevent air leakage in the junctions, where we have different movements through different materials, the windows are positioned within a plywood box. The plywood box, which is designed specifically for this project, is a four-sided box screwed and glued with foamed PVA glue. This is a reasonable basis for the air-tightness of the system.
Two coat wet plaster is applied on the concrete block wall internally, which is airtight in its own right.




Two coat wet plaster
300 mm Dritherm 32 fibre glass insulation
18 mm ply permanent formwork box
100 mm natural Yorkshire stone in lime/sand mortar
Preformed aluminium cavity closer powder coated
100 mm dense concrete block in cement/sand mortar

The U-value of an Irish block cavity roof, which is 0.16 W/m2K, is very similar to the U-value of the Passivhaus standard, which is 0.10 - 0.15 W/m2K. However, it does not satisfy the optimum condition. Due to some flaws present in the design of the Irish block cavity roof, there is a considerable amount of heat loss within the structure. Utilizing parging the walls and ceilings, we can achieve the right level of airtightness



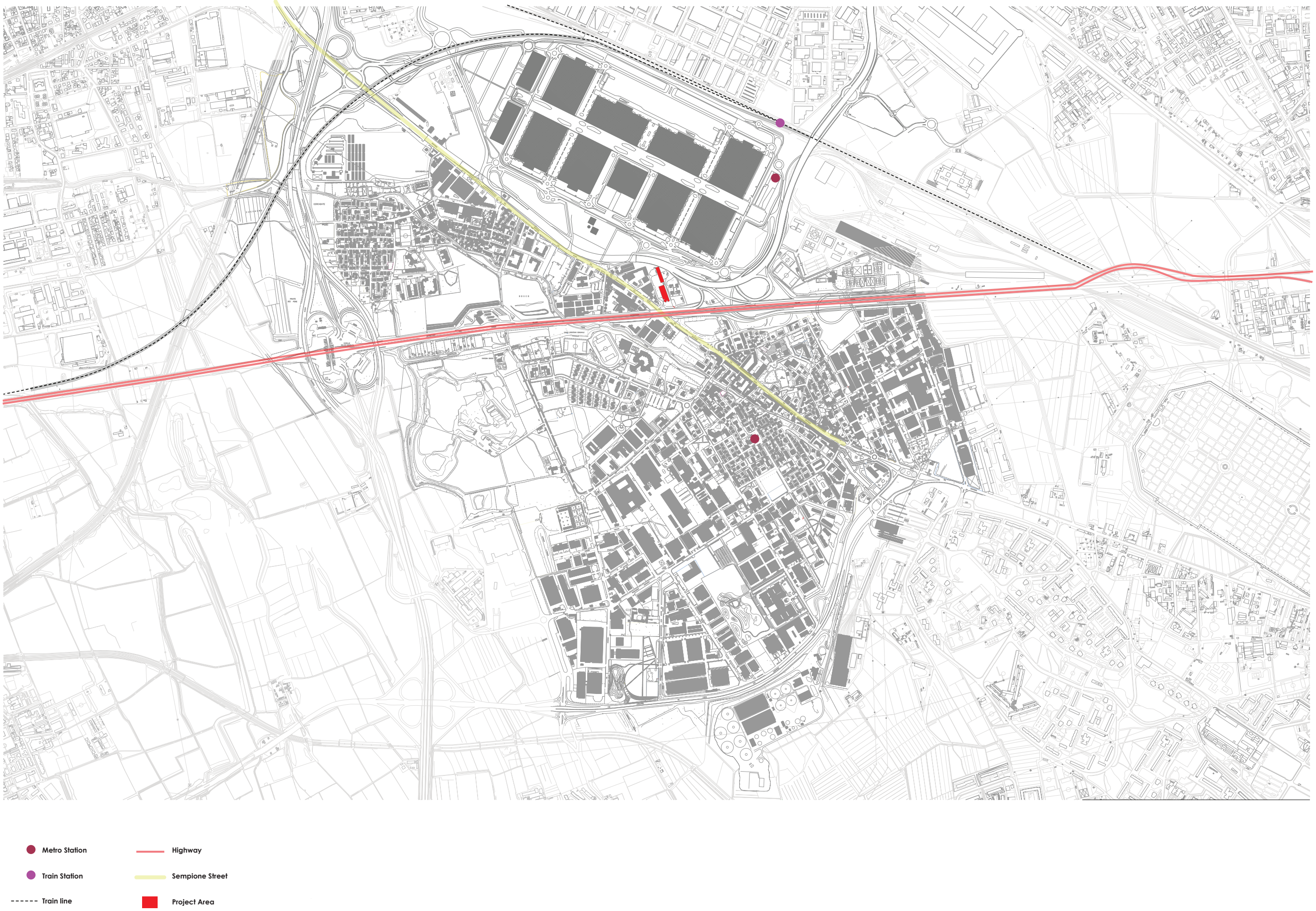


500mm fibreglass quilt
"Bobtail" timber roof trusses
30°
Noggins for windtightness
900mm overhang
18mm
OSB
Service
Cavity
500mm fibreglass
wall batts

Project

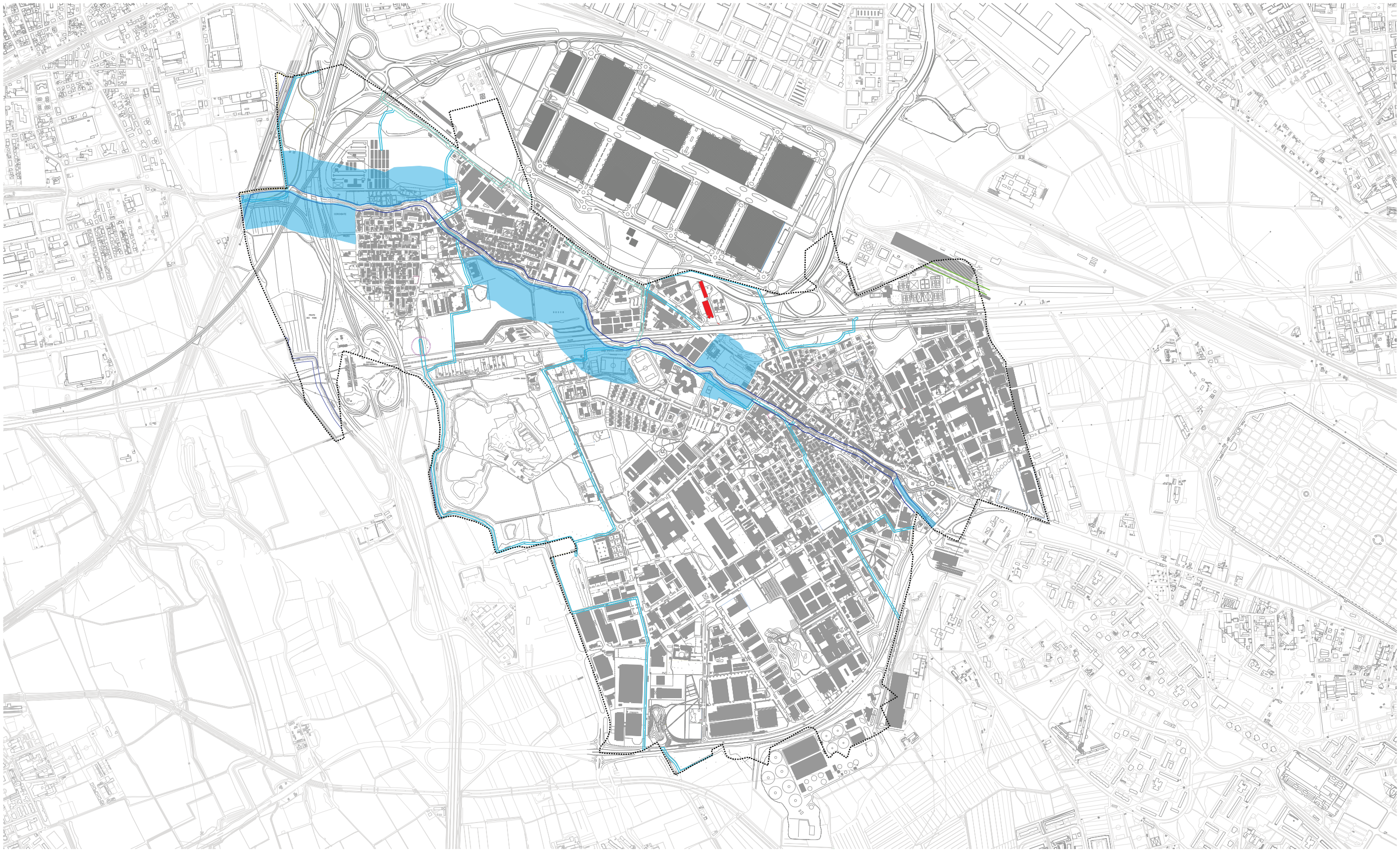
5.1 Site Analysis

Connections



There are two metro stations in the vicinity of the project area. The A4 Torino Trieste highway passes close to the south of the project which causes noise polution for the project. The A52 Fiera-Milano highway also passes from the north side of the site.

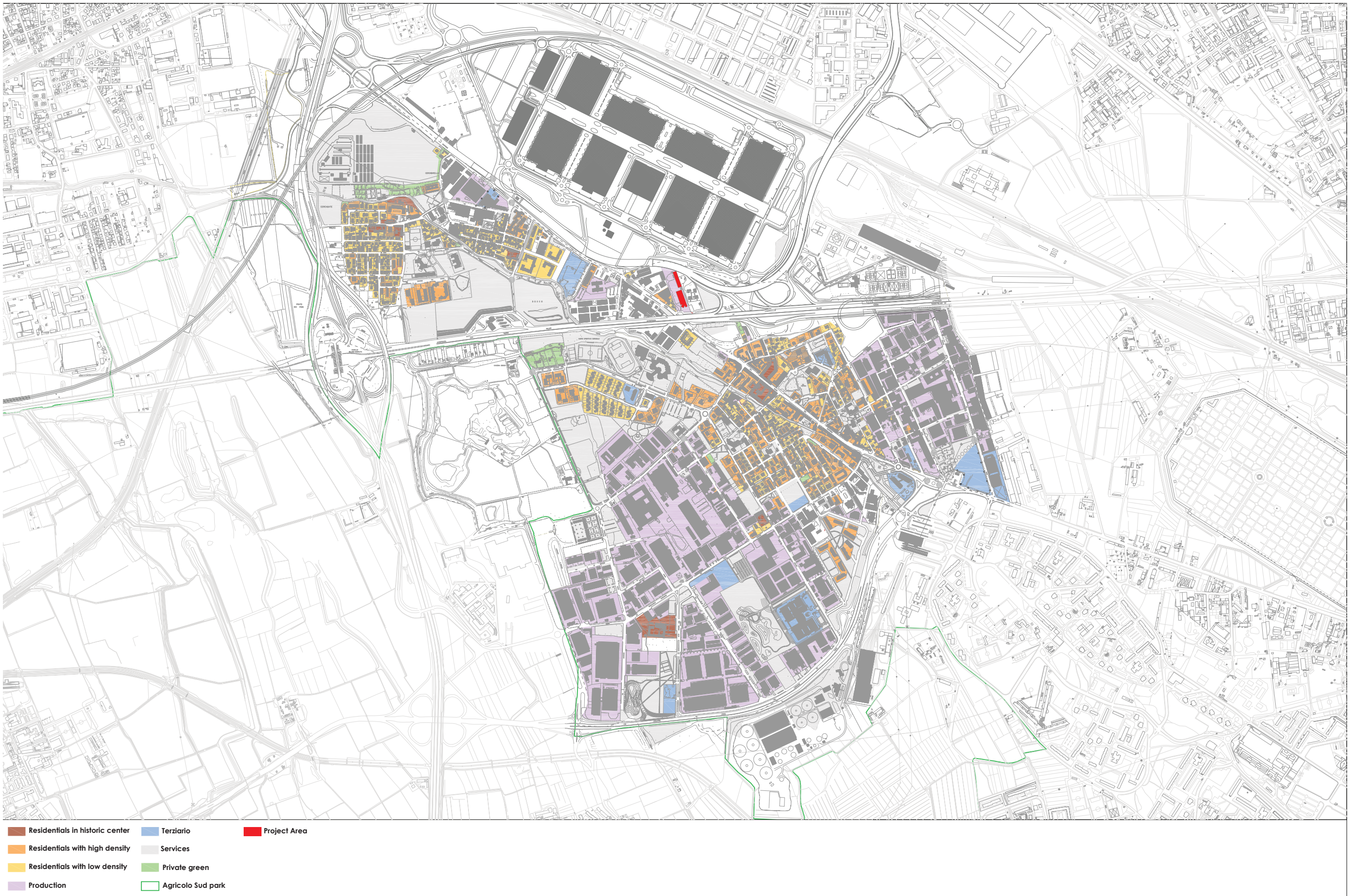
Site Analysis



Pero Municipality
10 meters from the external embankment of the Olona river
5 meters from the edge of branch channels
6 meters from the edge of branch channels
Waterways
Project Area

Water constrains

Site Analysis



Functions

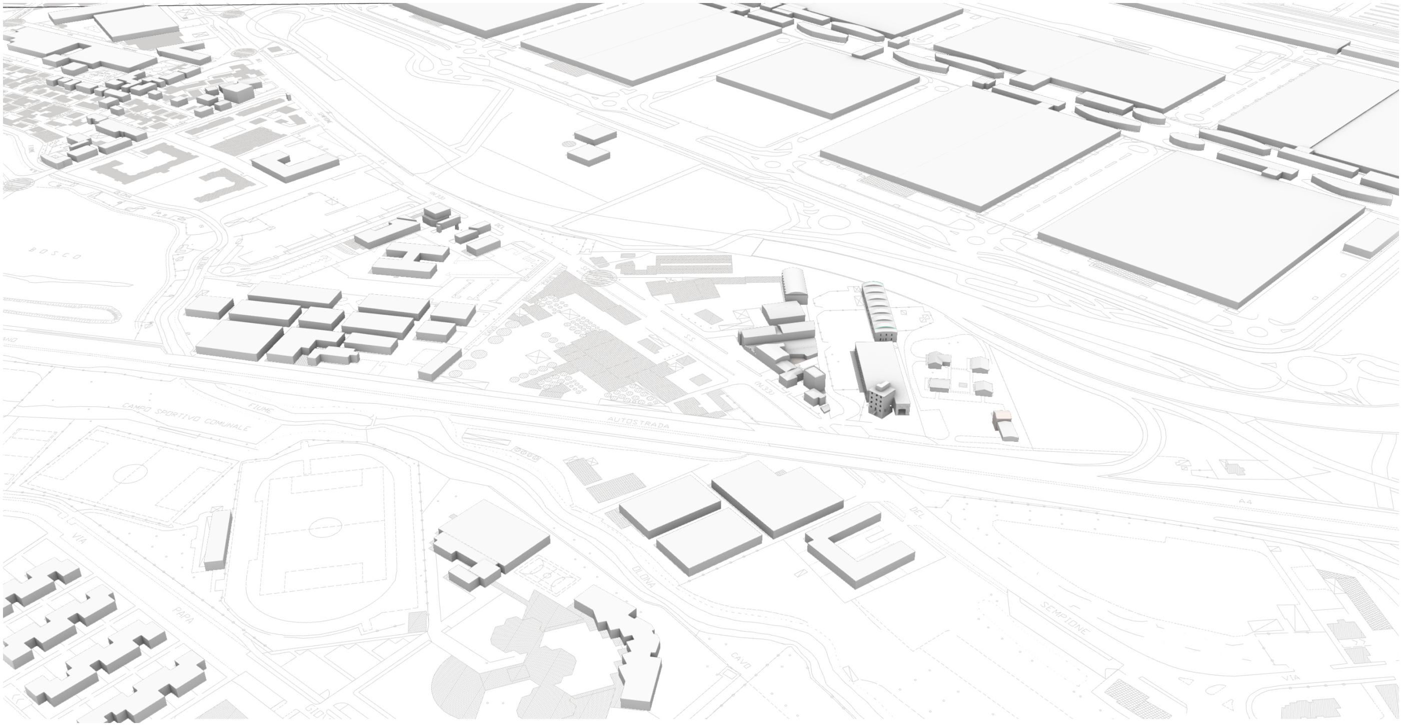
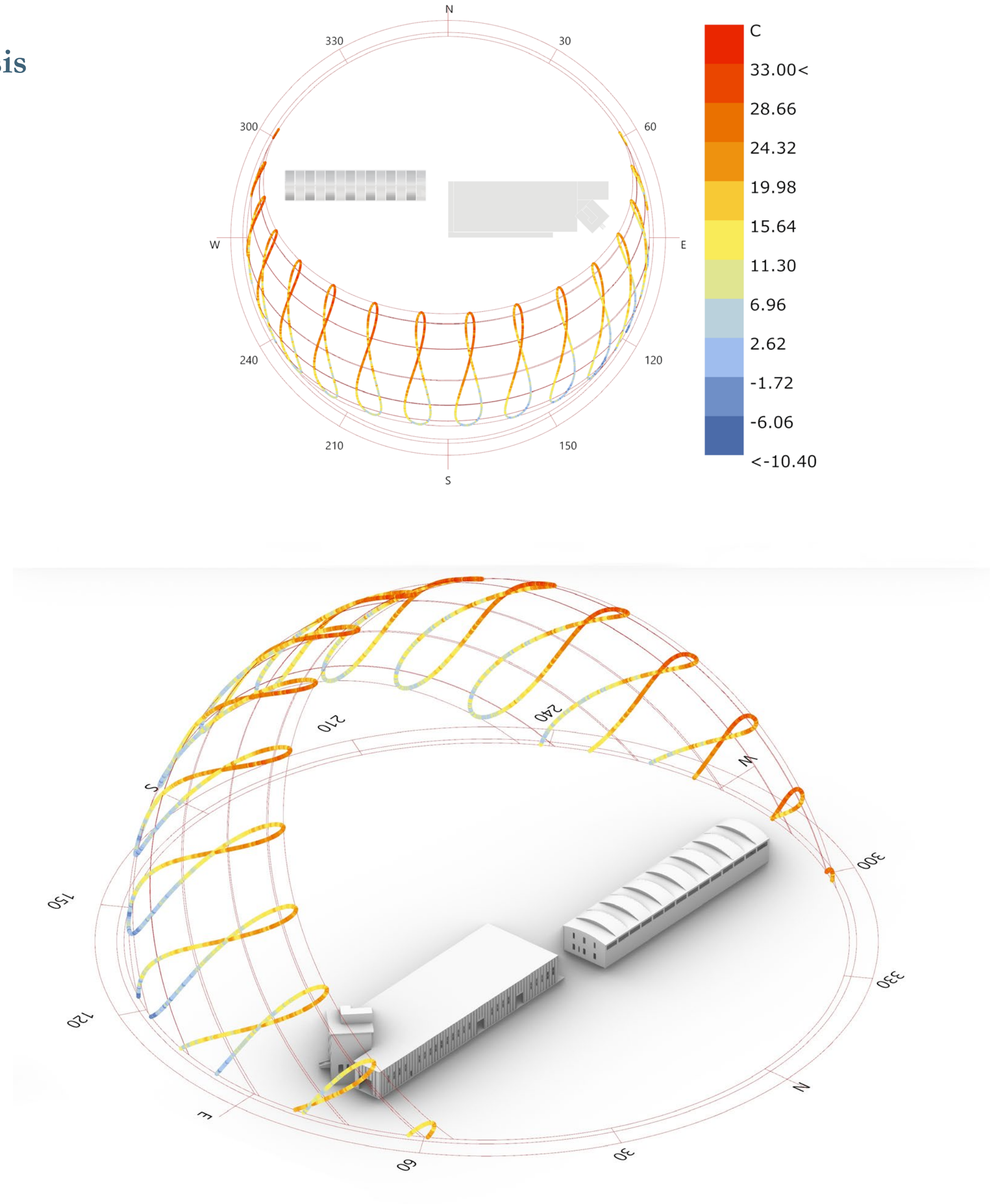
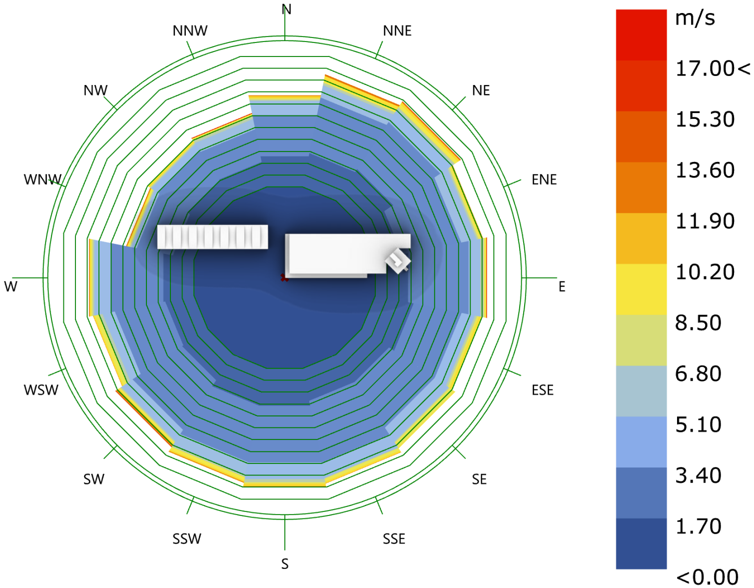


Figure and ground

Site Analysis



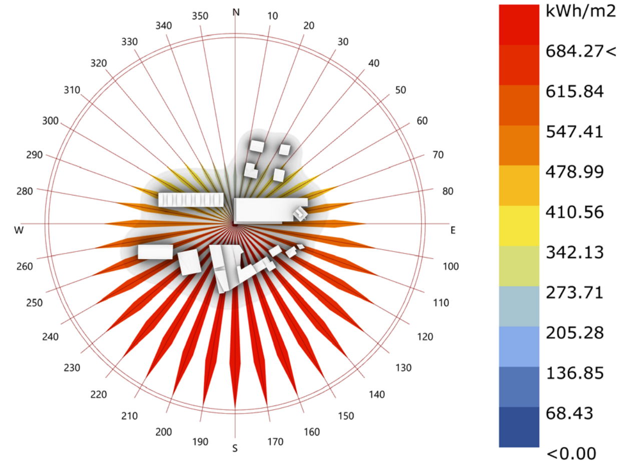
Sunpath analysis



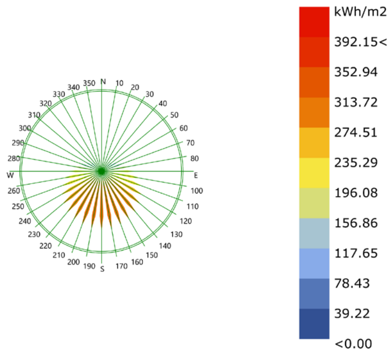
Wind-Rose
Milano-Malpensa_ITA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 47.00% of the time = 4117 hours.
Each closed polyline shows frequency of 0.4%. = 33 hours.

Wind analysis

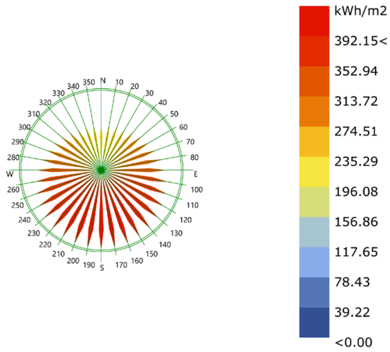
Site Analysis



Total Radiation(kWh/m2)
Milano_Malpensa_ITA_2005
1 JAN 1:00 - 31 DEC 24:00



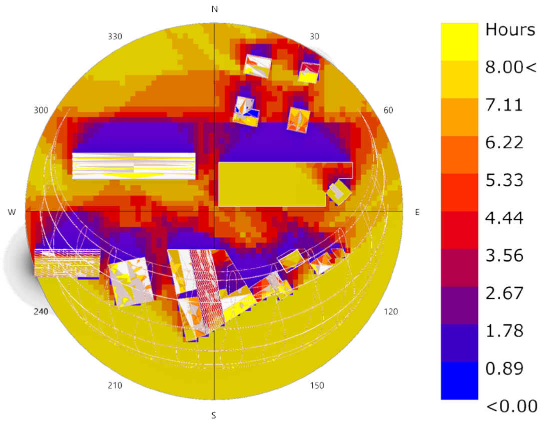
Direct Radiation(kWh/m2)
Milano_Malpensa_ITA_2005
1 JAN 1:00 - 31 DEC 24:00



Radiation analysis

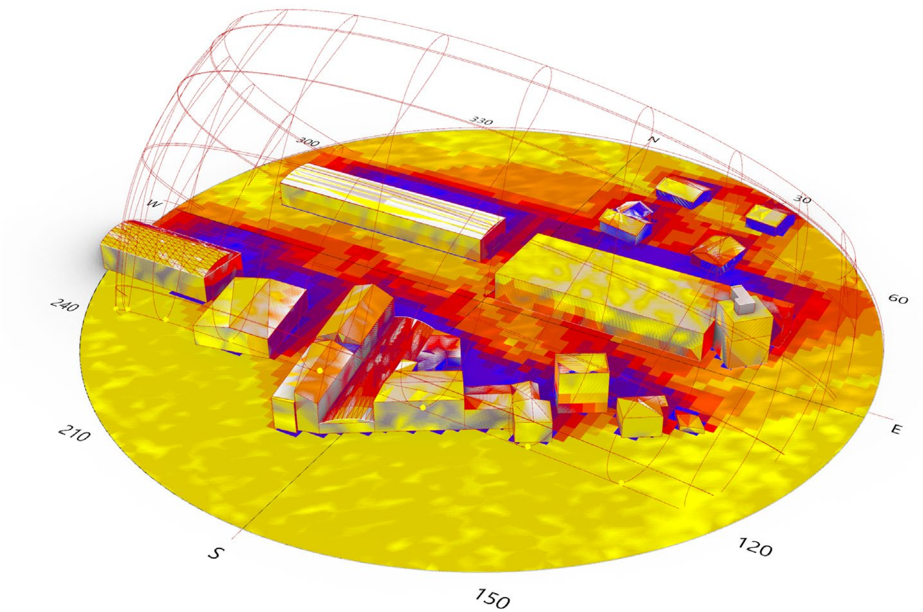
Diffuse Radiation(kWh/m2)
Milano_Malpensa_ITA_2005
1 JAN 1:00 - 31 DEC 24:00

Site Analysis



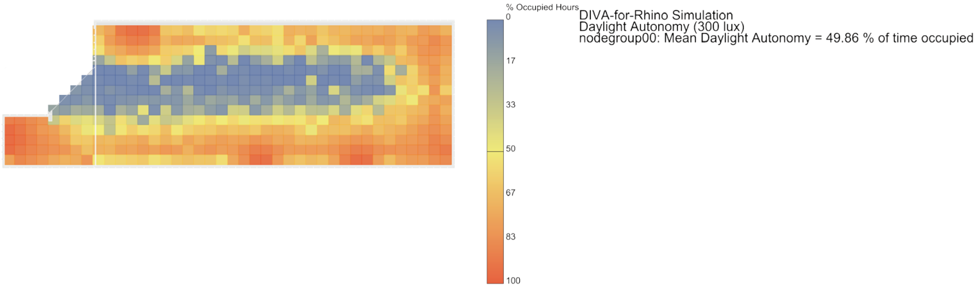
SunlightHours Analysis

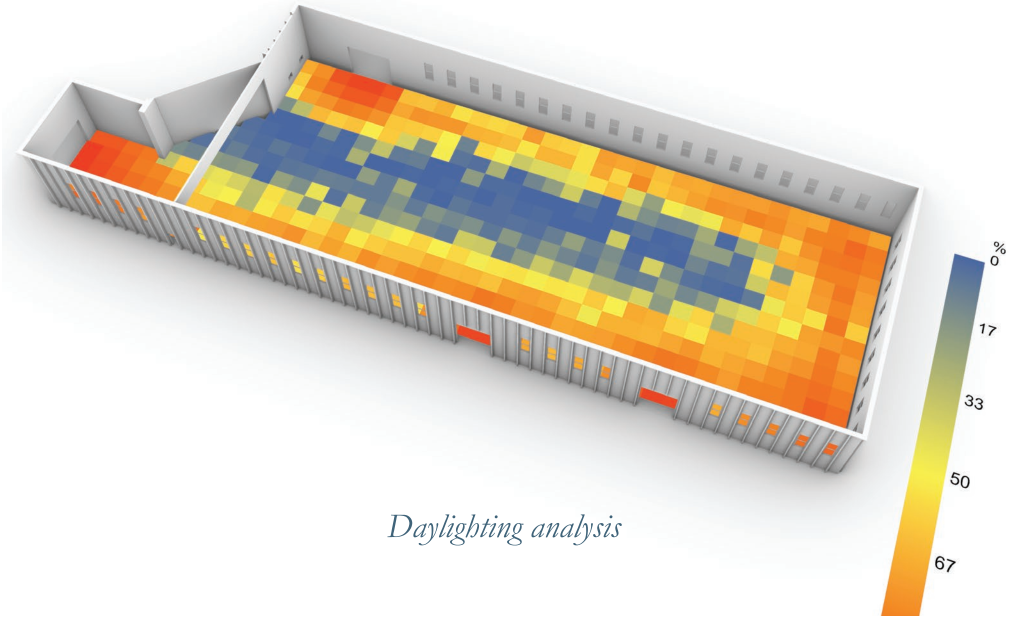
Shadow Analysis



Shadow Analysis

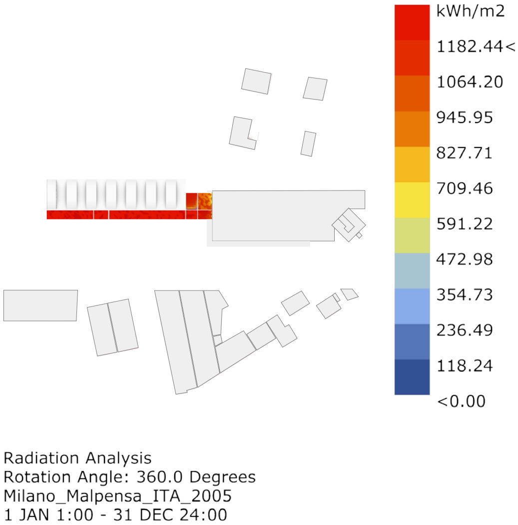
Site Analysis

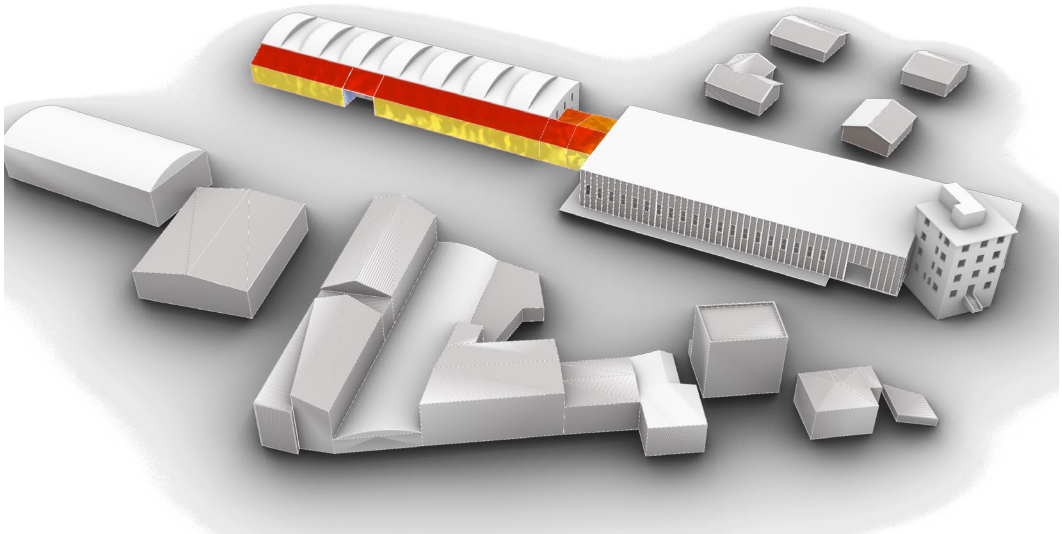




Daylighting analysis

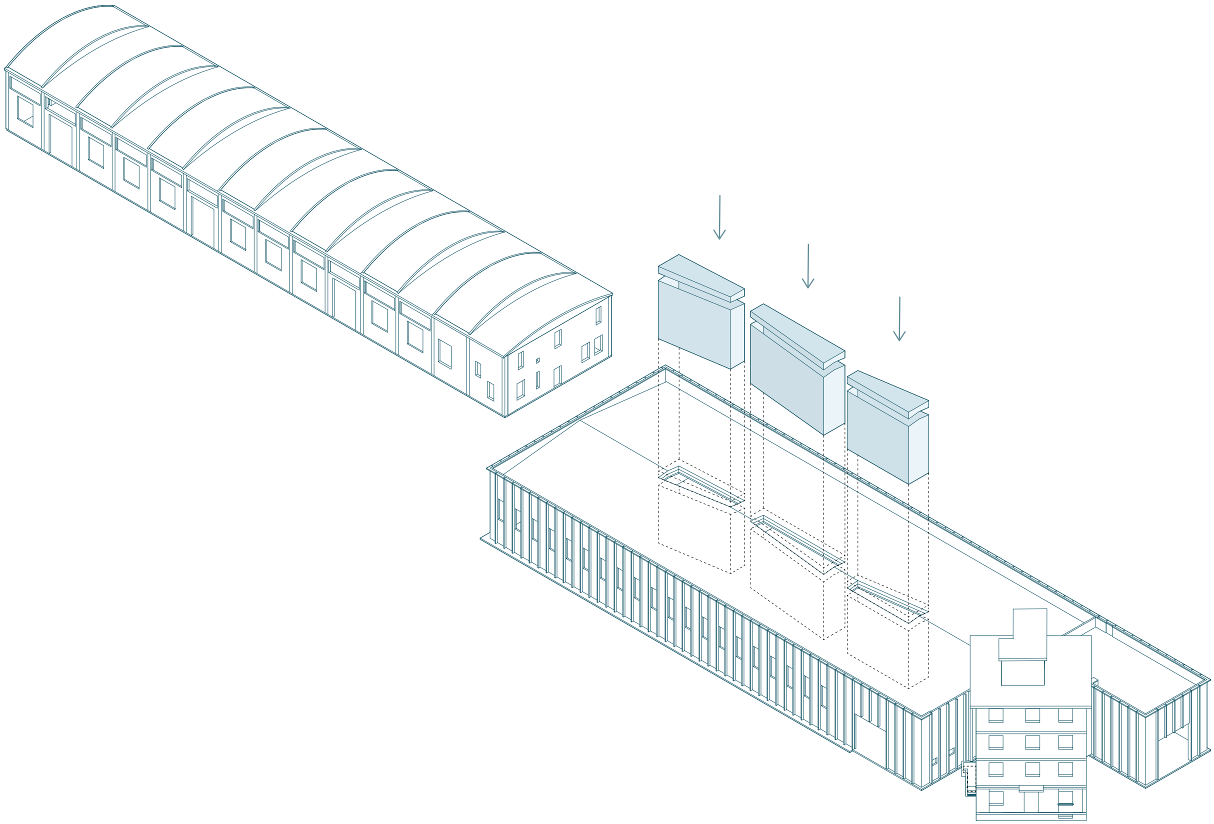
5.2 Design Process





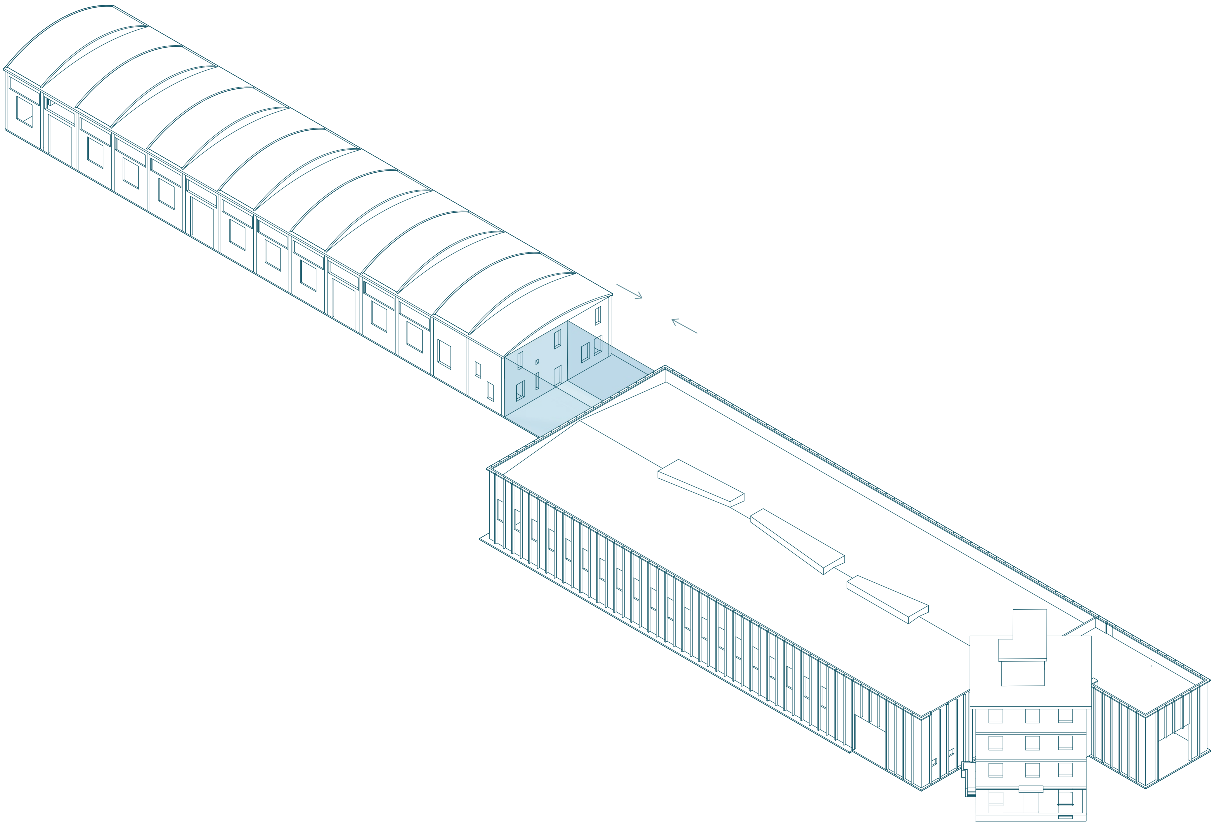
Formal analysis in response to highest radiation

Design Process

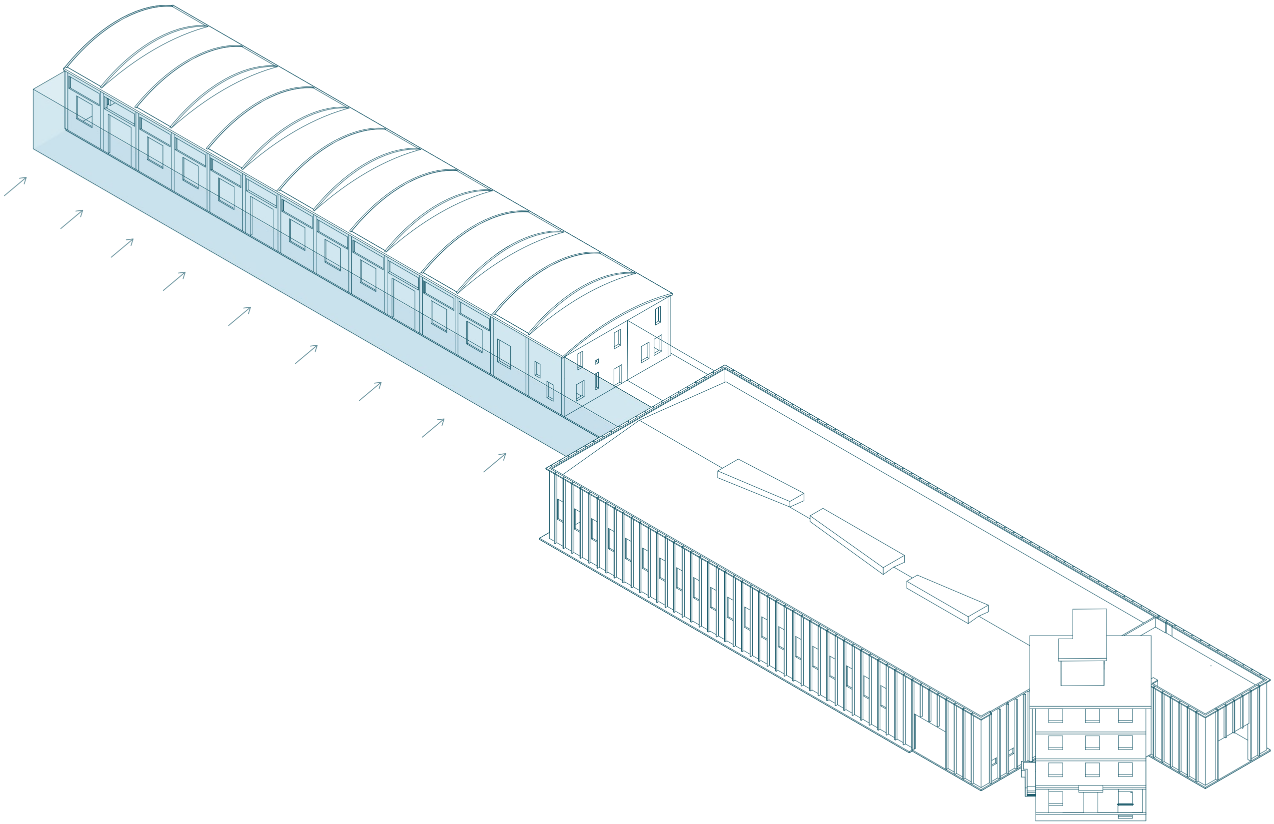


Inserting greenhouses and skylights

Design Process

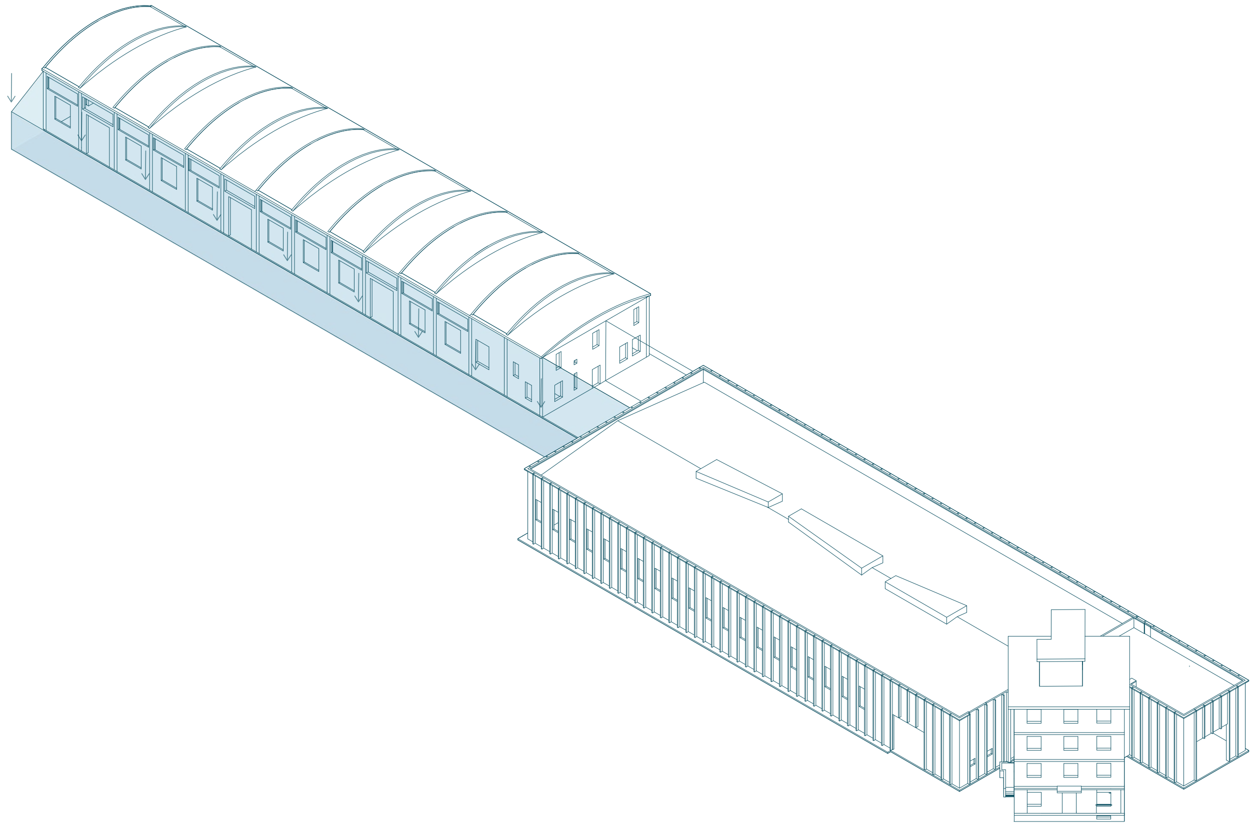


Connection between two volumes



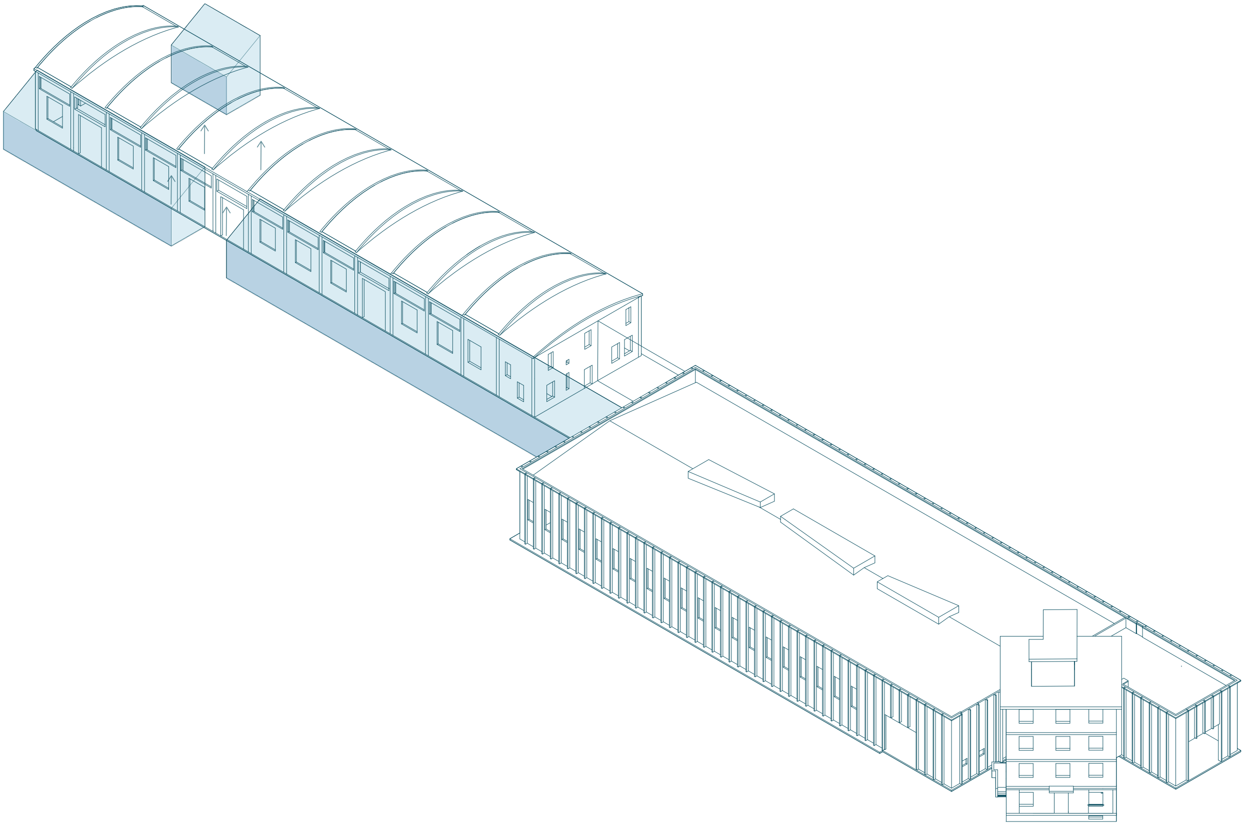
Shaping in response to highest radiation

Design Process



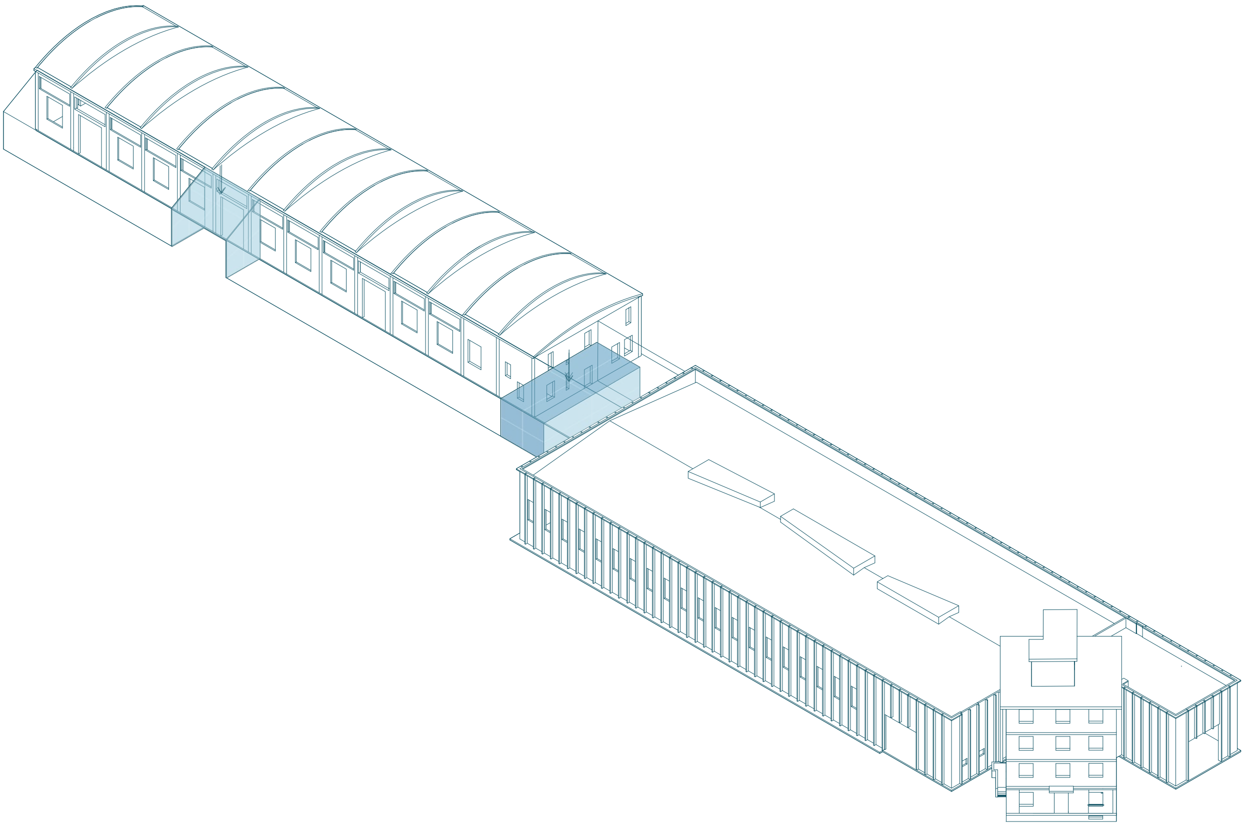
Connection between two volumes

Design Process



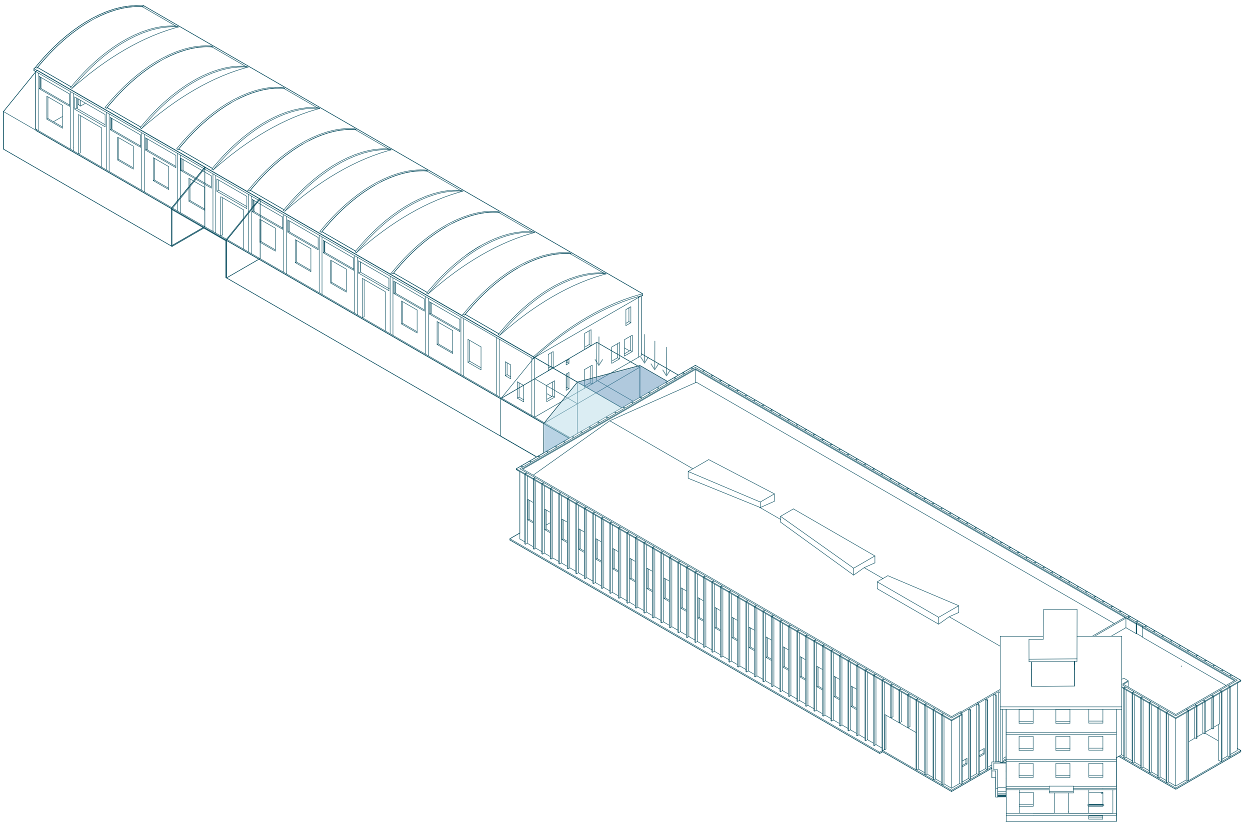
Breaking the butter into two zones and creating entrance

Design Process



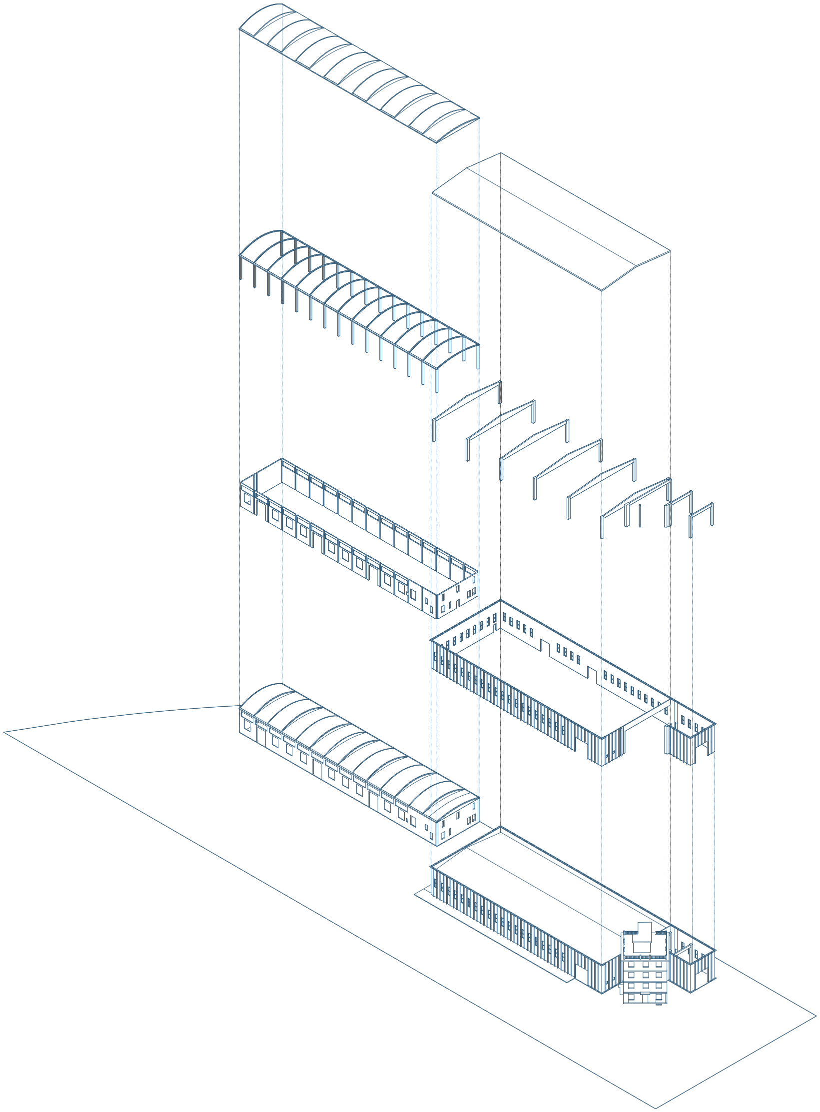
Inserting solid volumes inside the buffer zone

Design Process

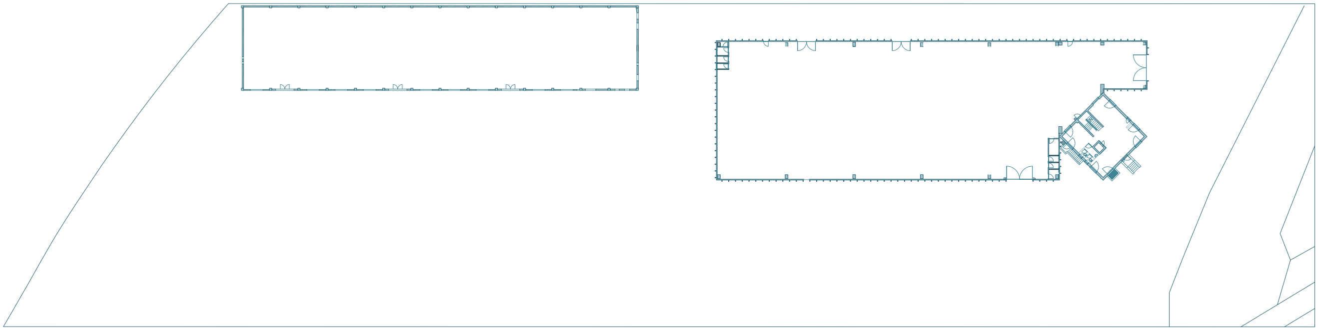


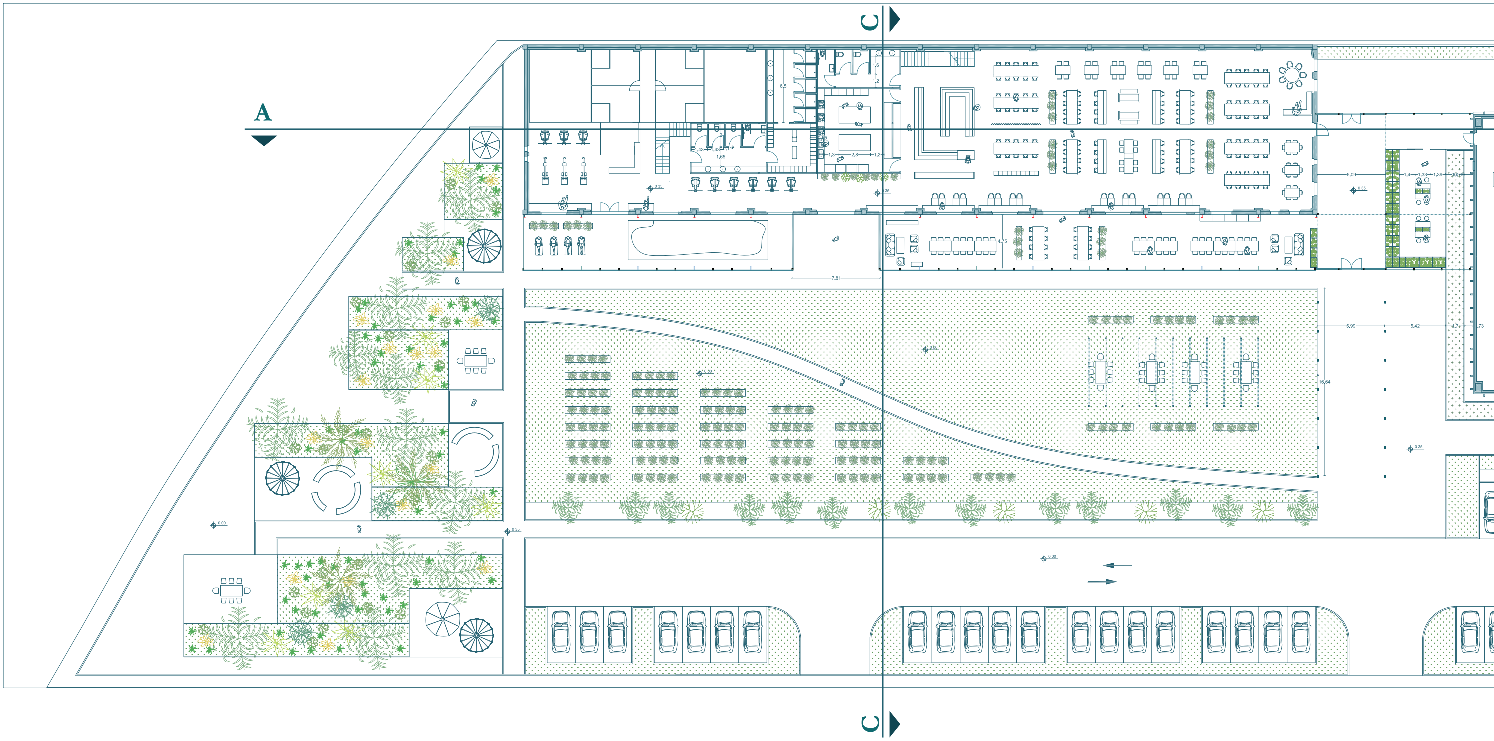
Shaping Volume

Current Structure



Exploded axonometric before intervention

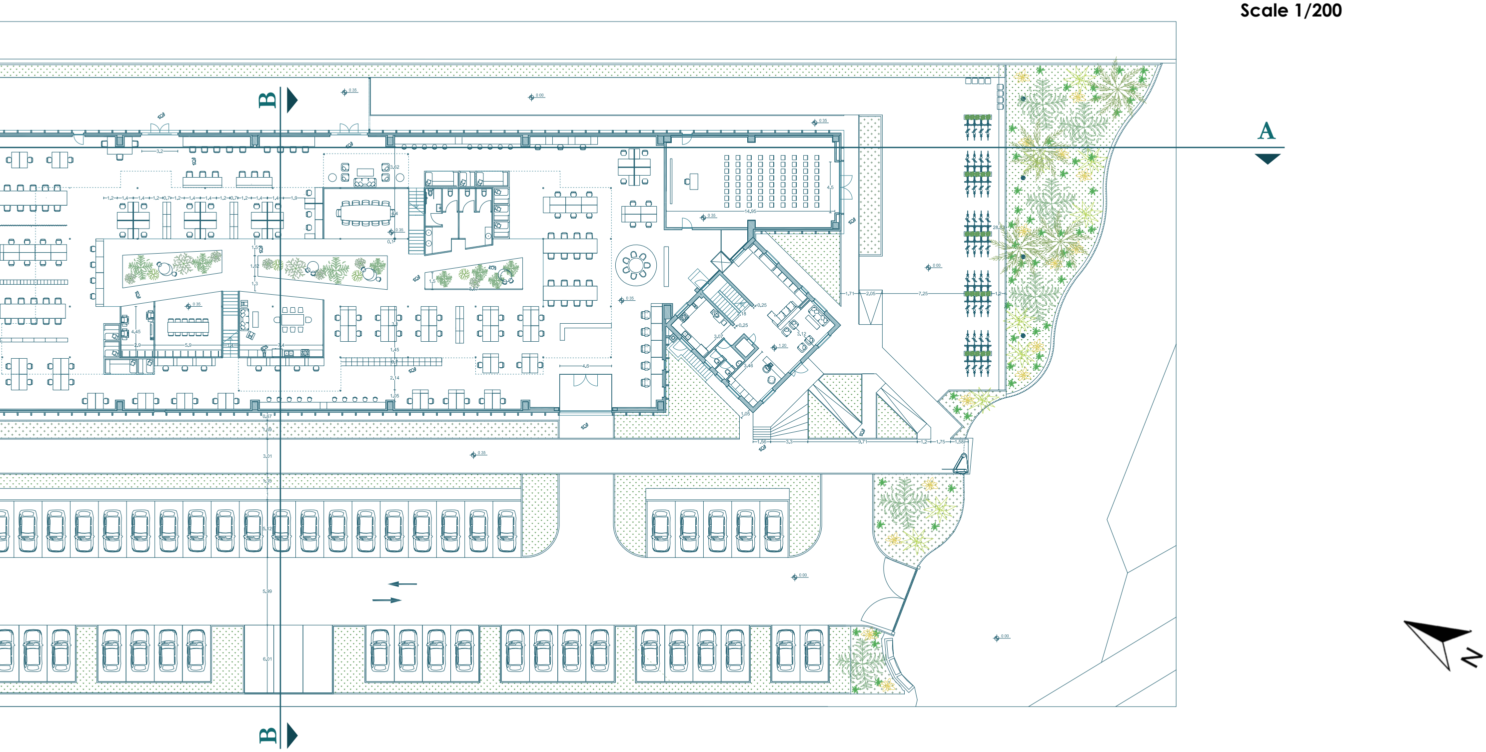


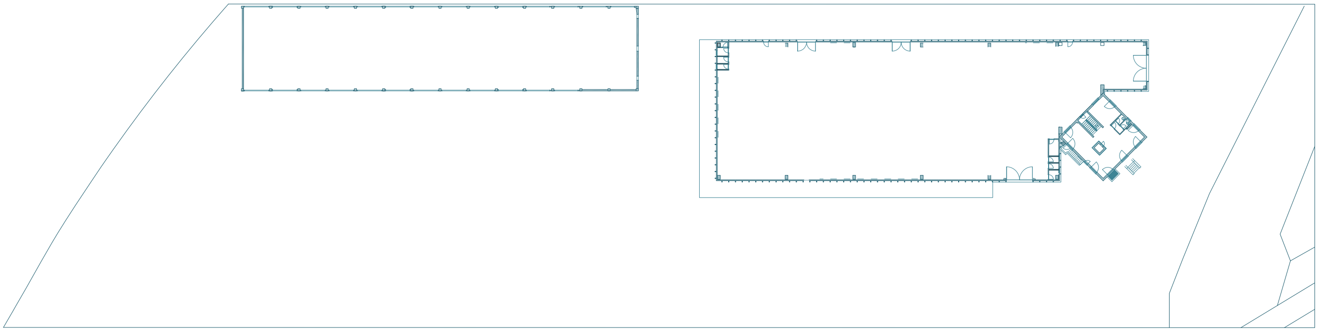


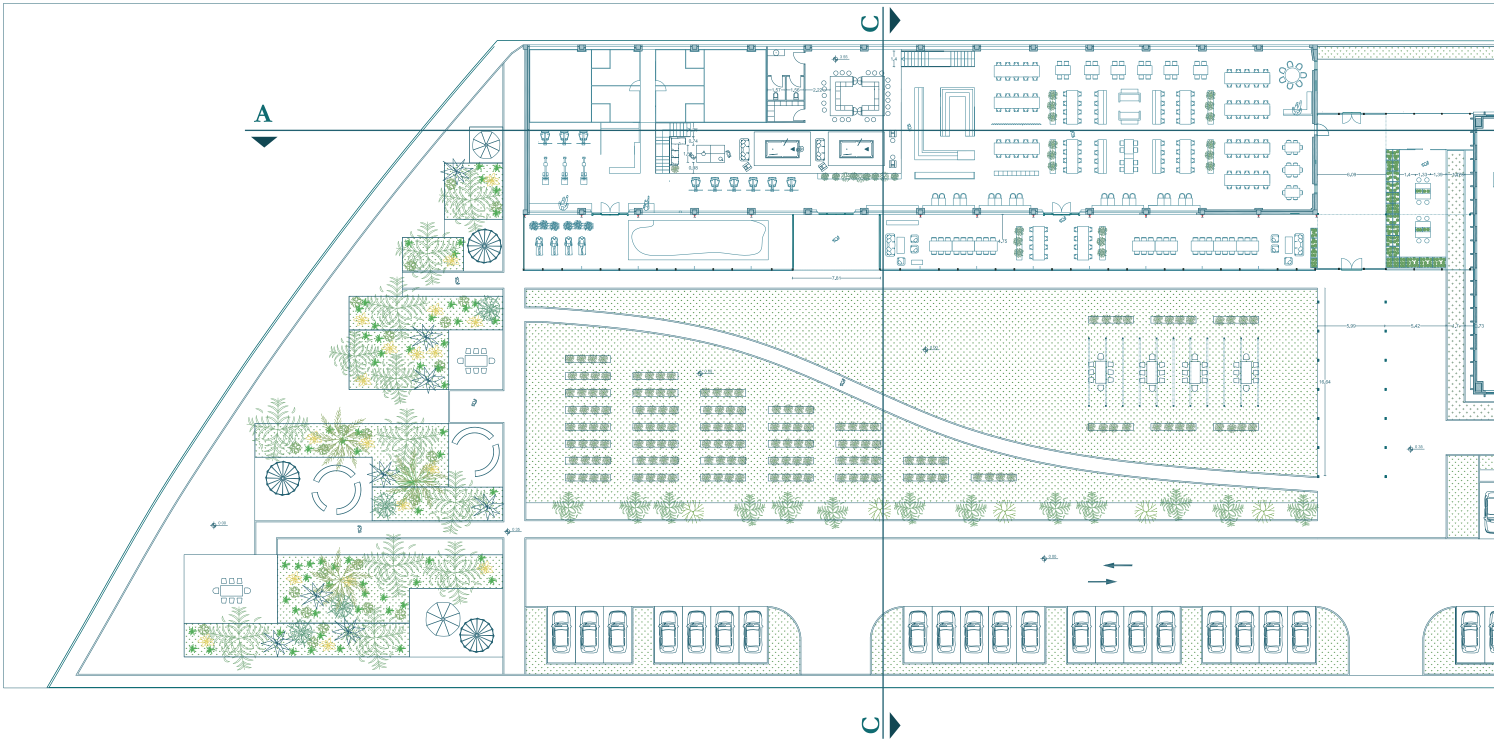
C
A
C

Current Situation
Ground Floor

Intervention
Ground Floor
Scale 1/200

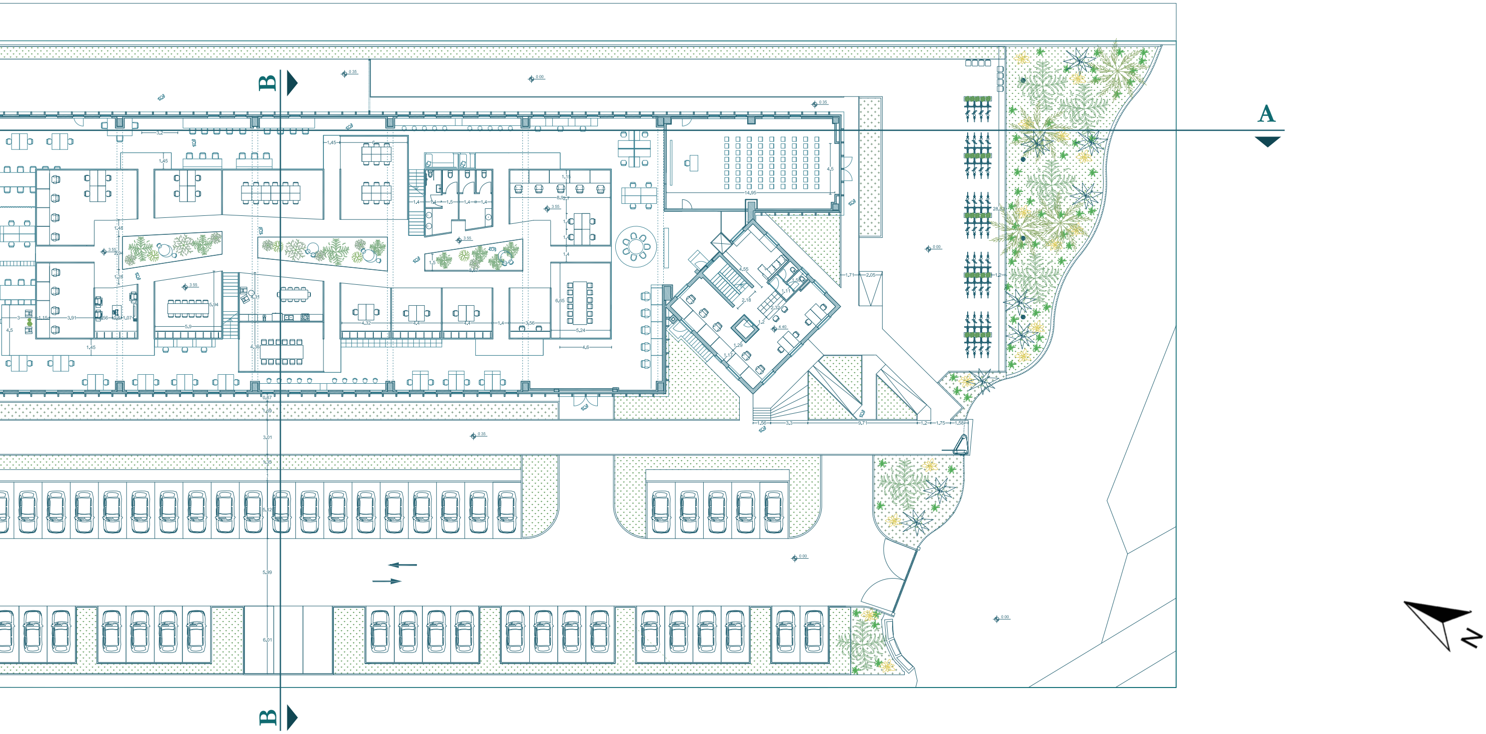




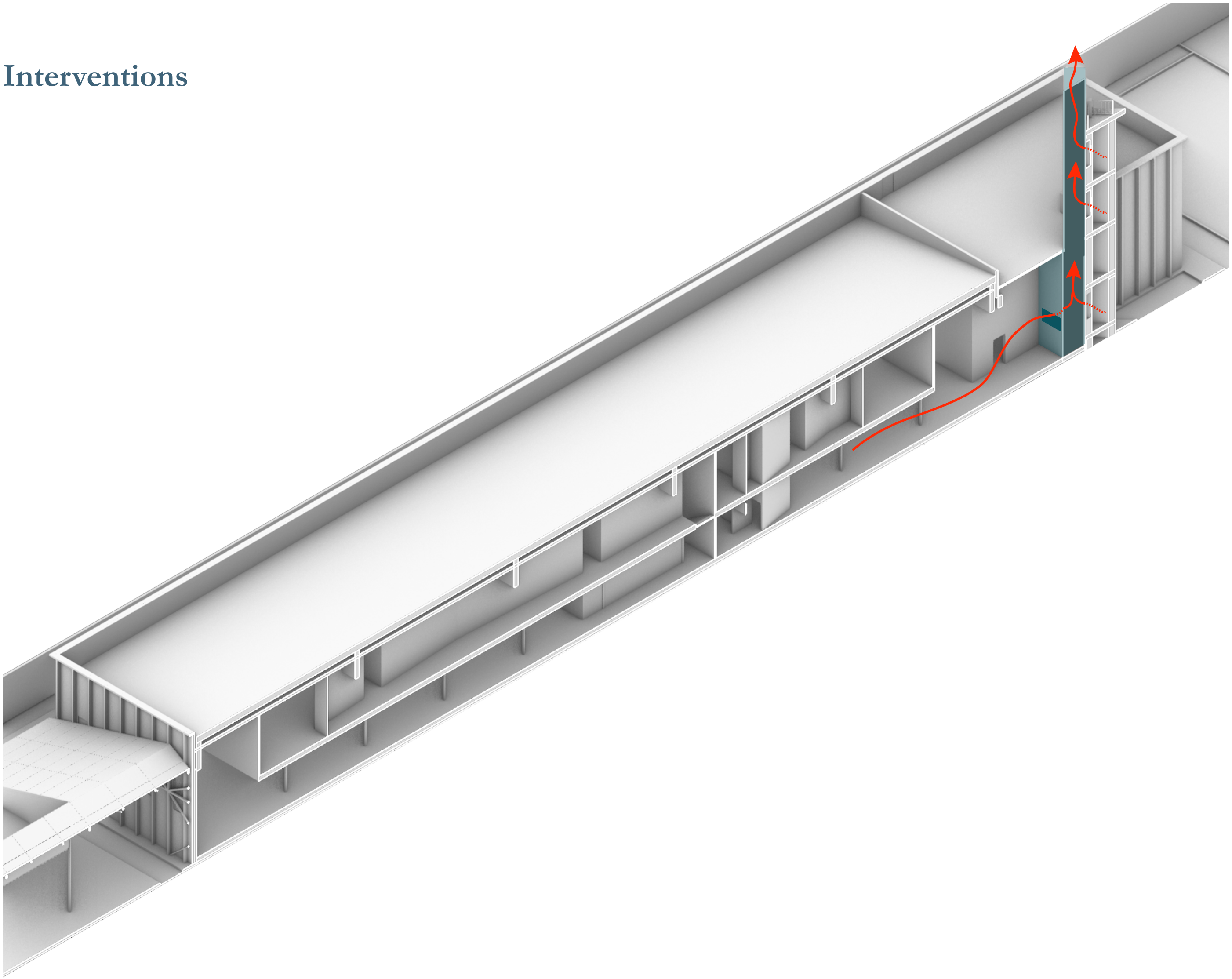

C
A
C

Current Situation
First Floor

Intervention
First Floor
Scale 1/200

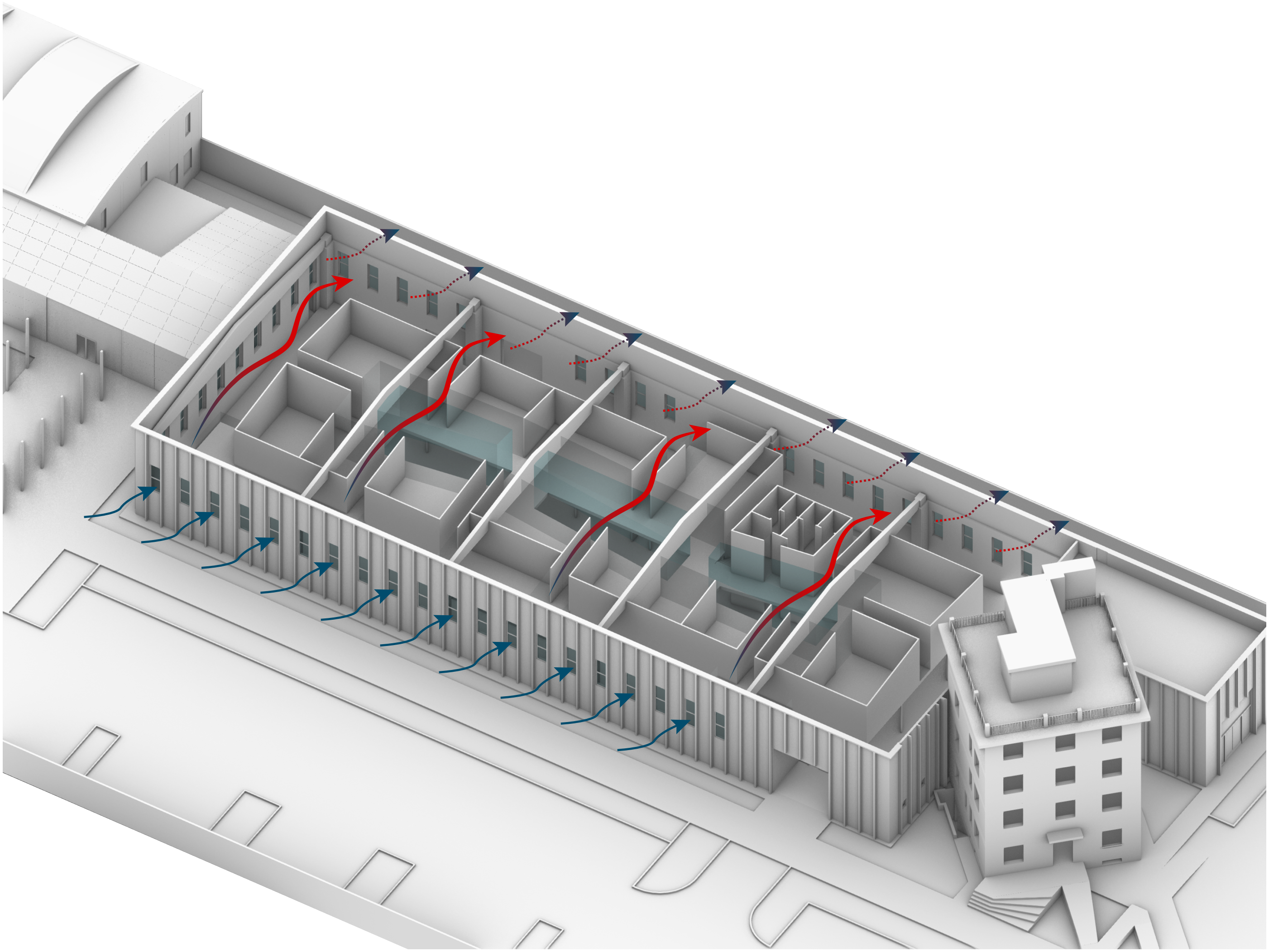


Interventions

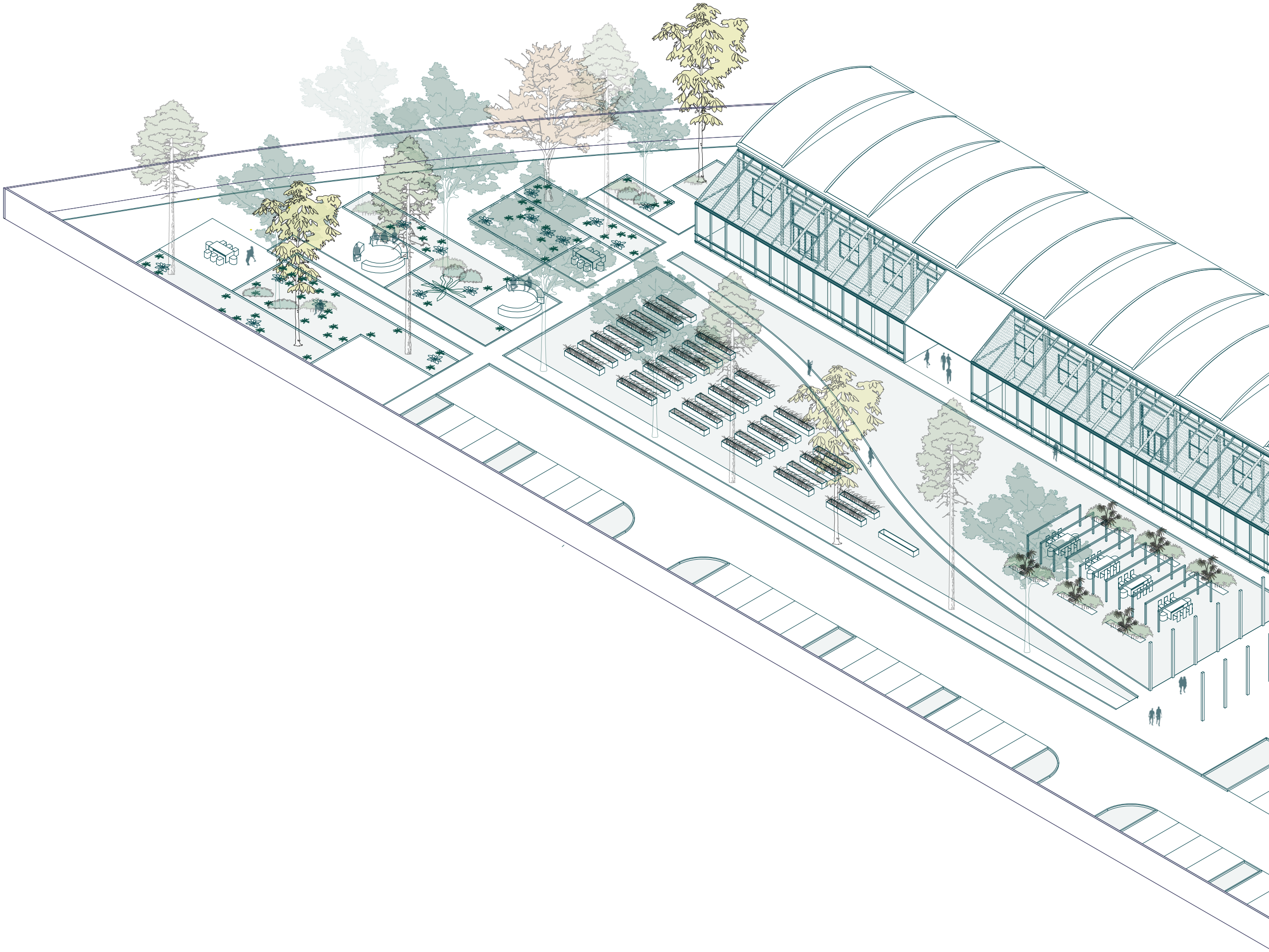


Solar Vent System

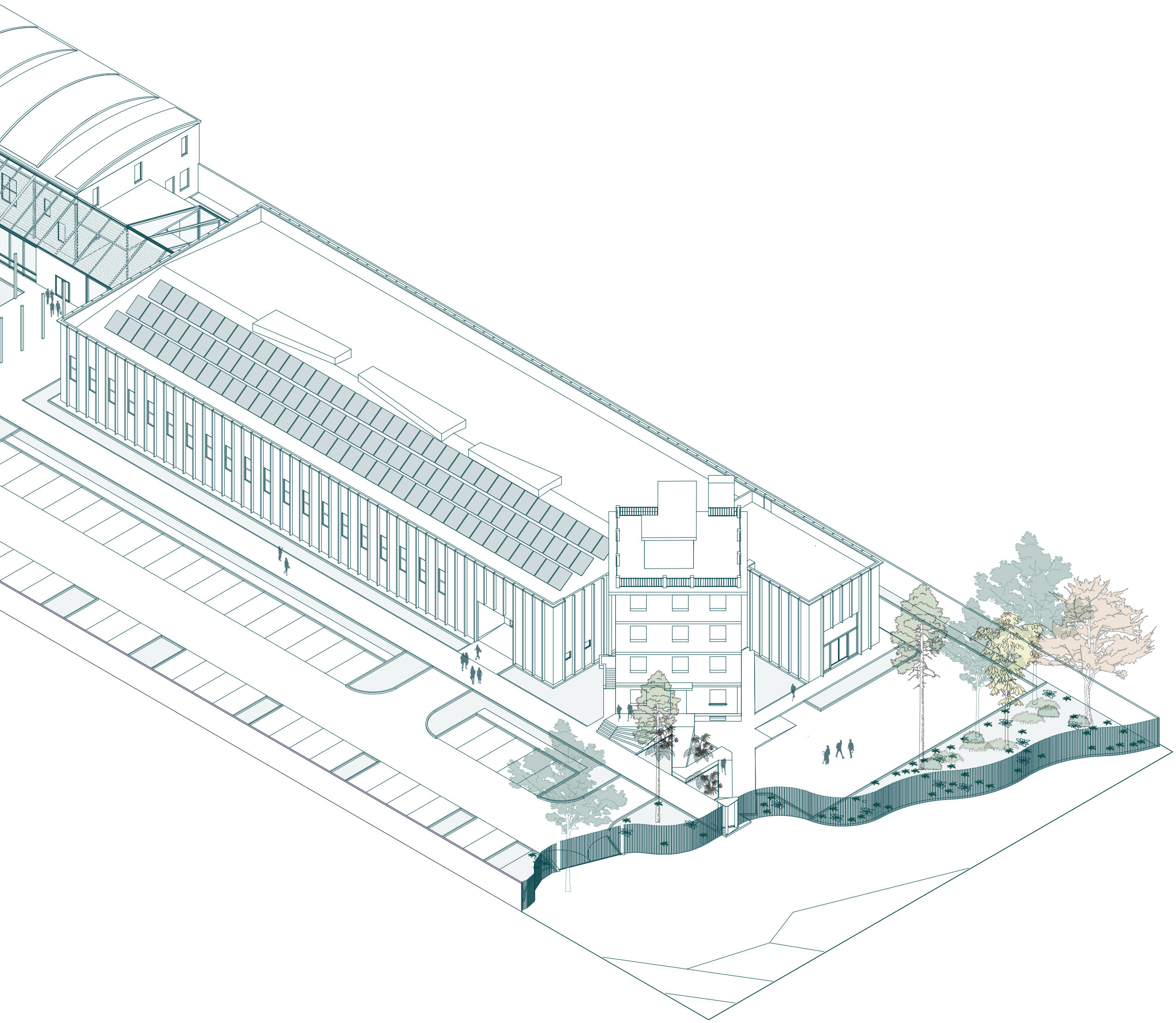
Interventions



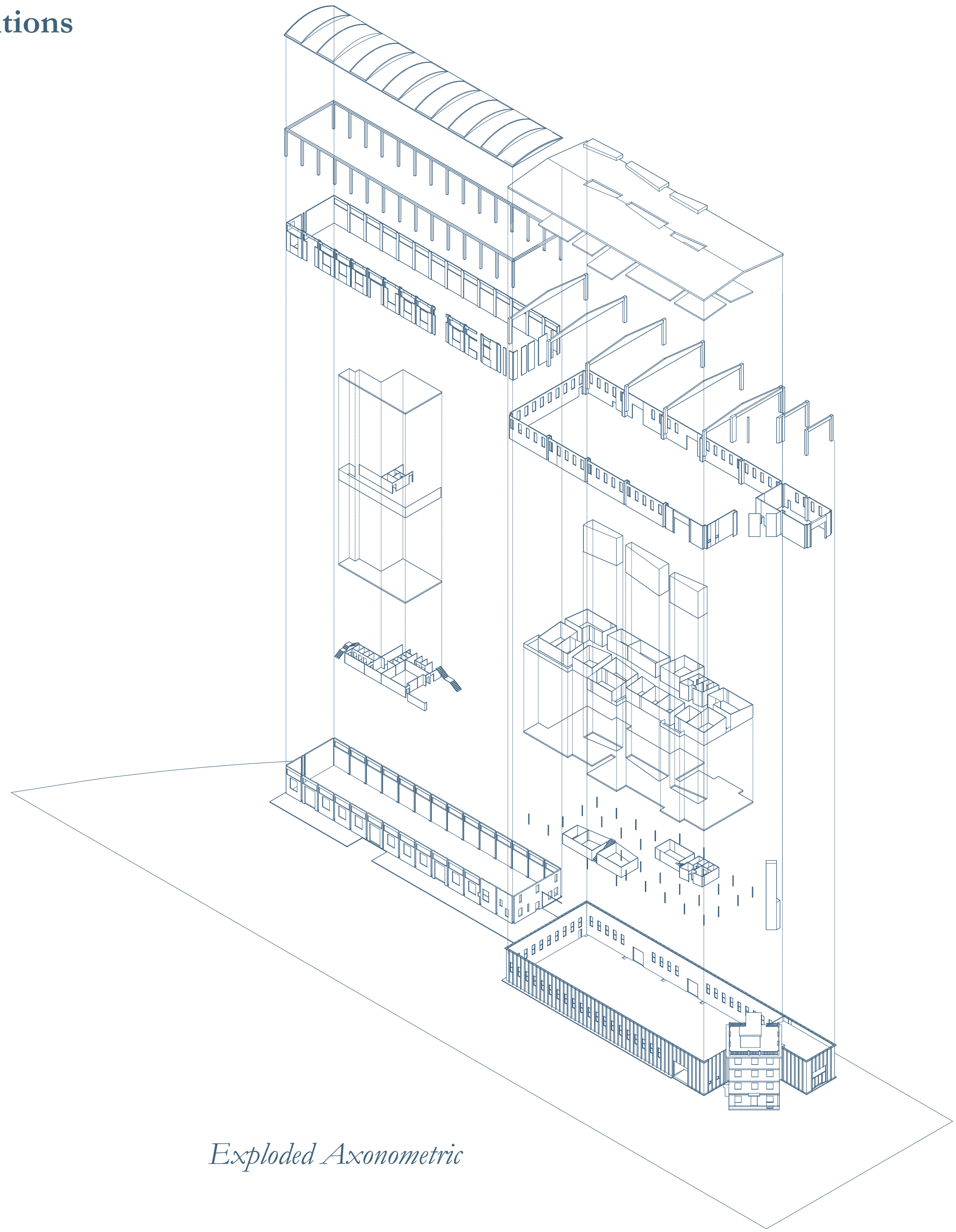
Cross Ventilation



Site Isometric

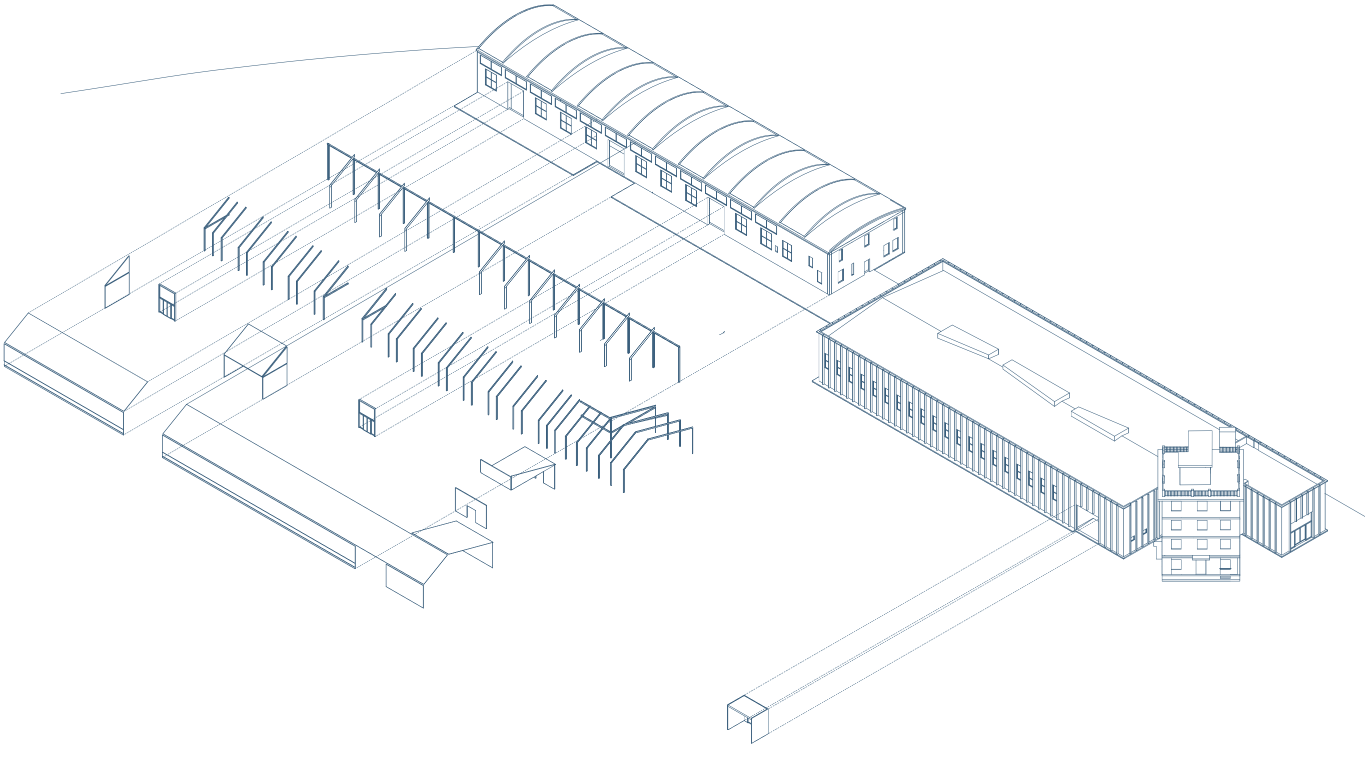


Interventions

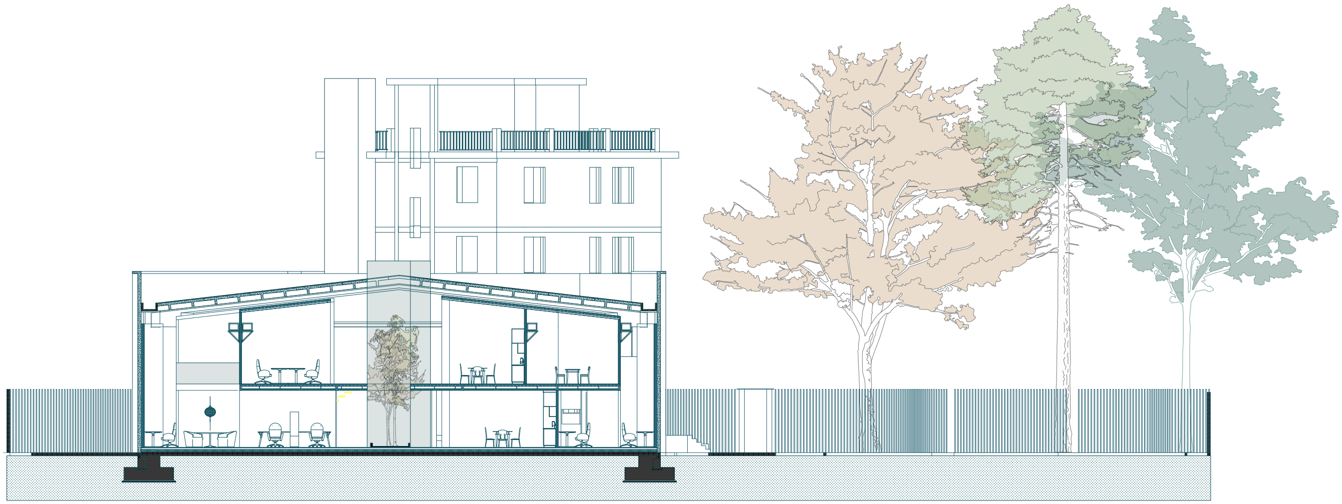


Exploded Axonometric

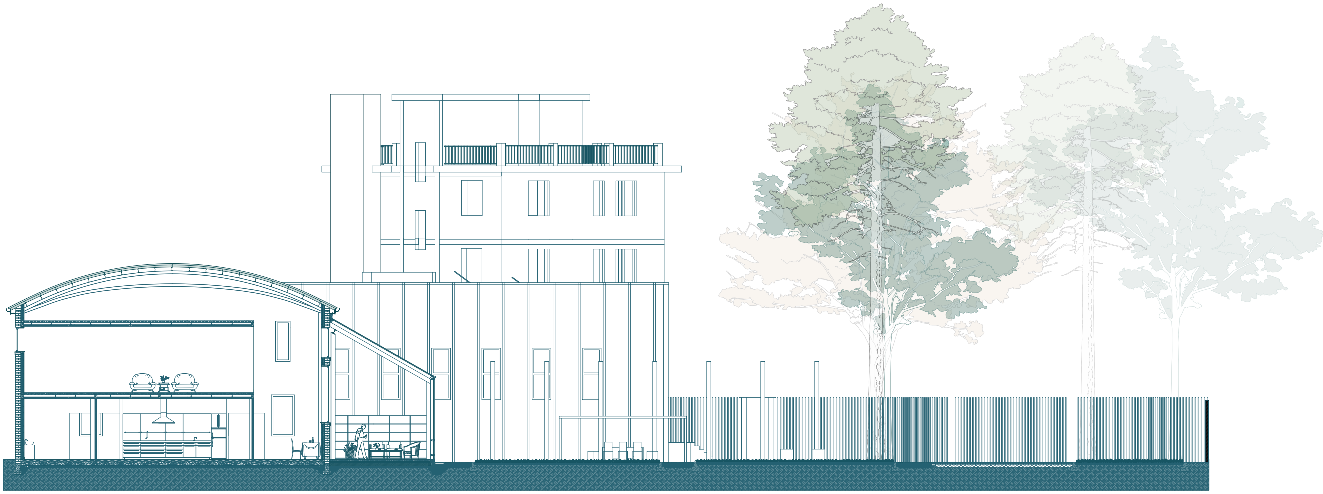
Interventions



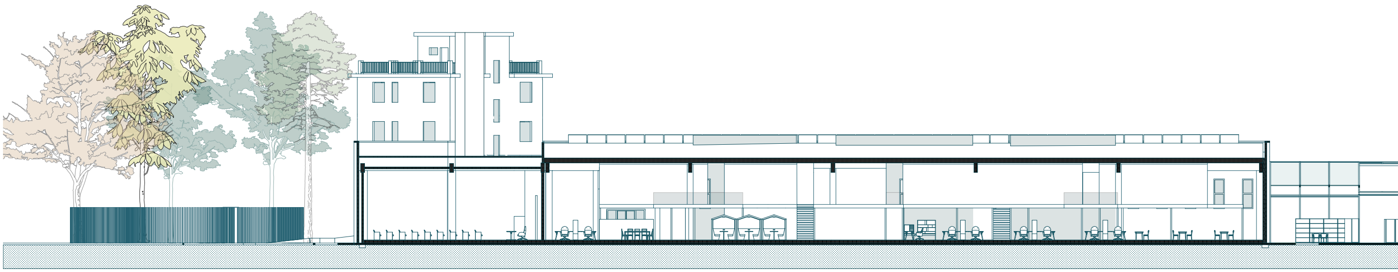
Exploded Axonometric



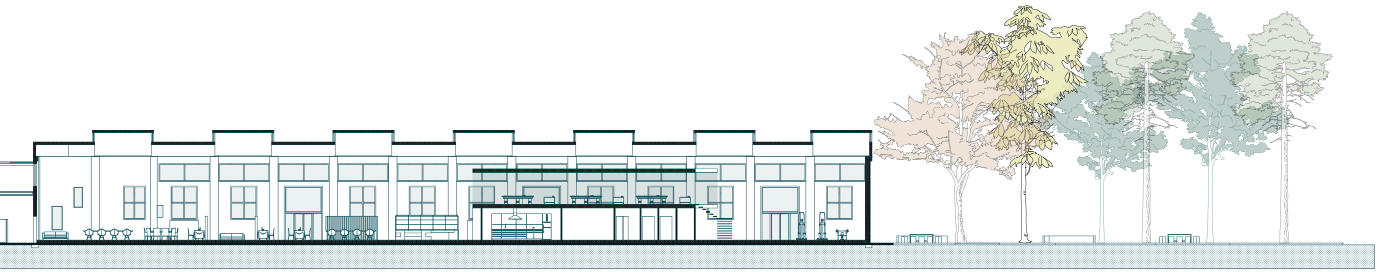
Section B-B



Section C-C



Section A-A



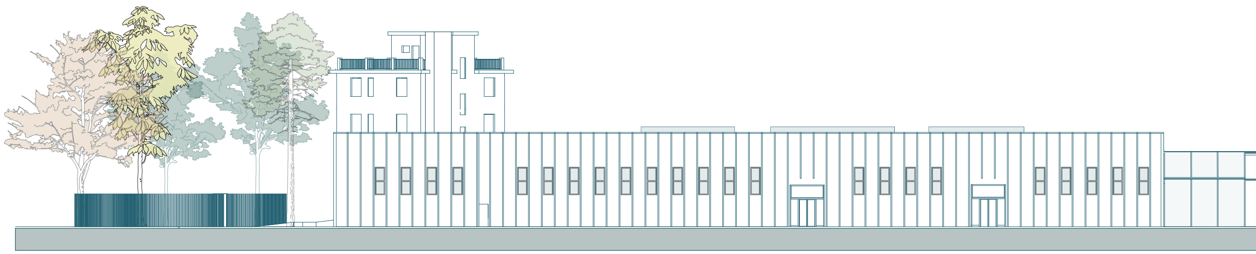
North Elevation

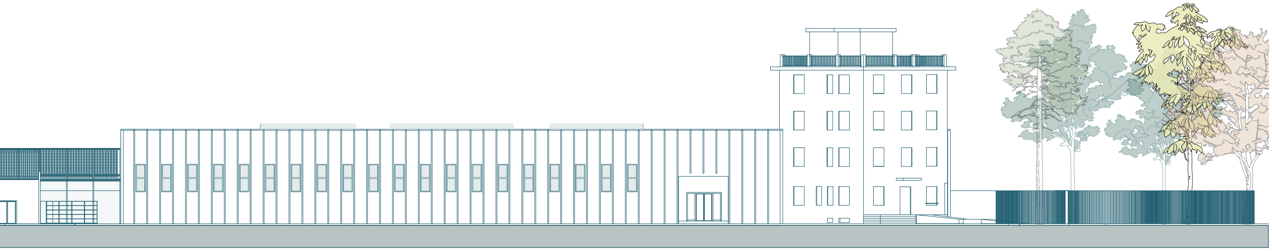
South Elevation

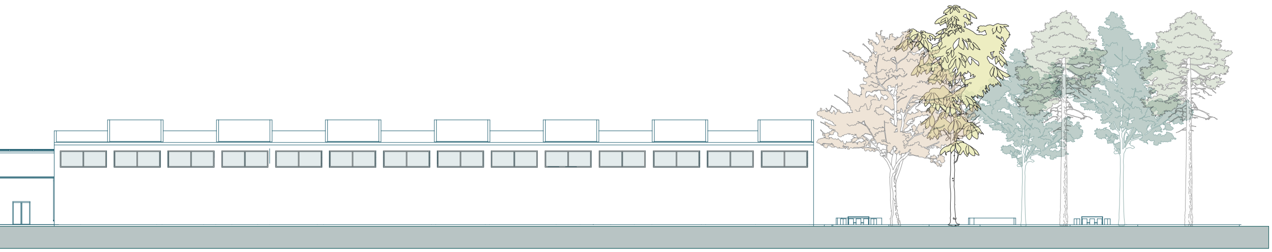
Interventions

West Elevation

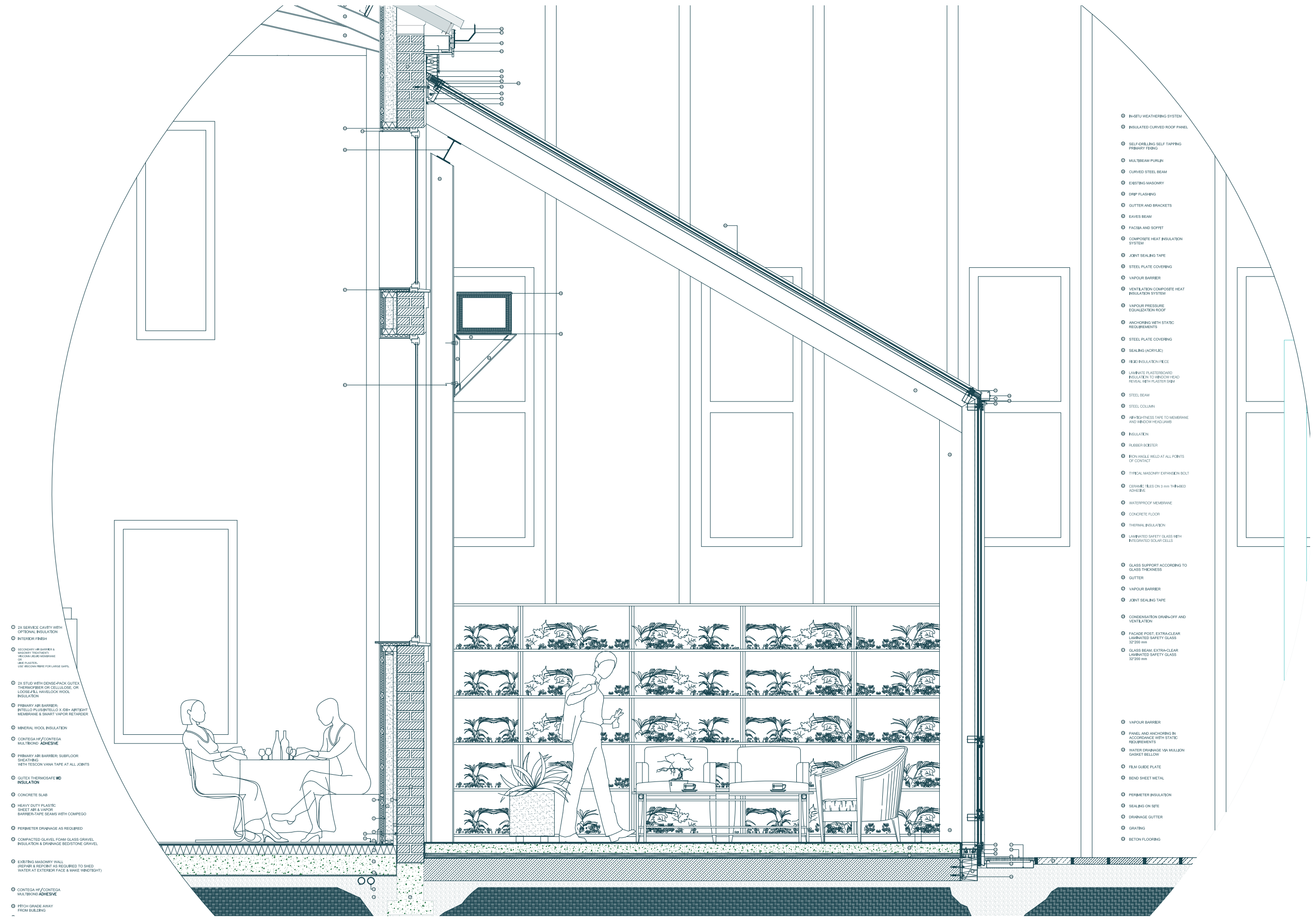
East Elevation







Interventions



Detail

Exterior Render

Exterior Render

Interior Render- Greenhouse

Interior Render-Buffer zone

Interior Render- Office Restaurant