# HYBRID HOUSING

*Housing in an Urban Context*

# TITLE PAGE

### TITEL PAGE

Hybrid Housing - Housing in an Urban Context

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# ABSTRACT

The project is based on the brief from the idea competition "Hamburg Hybrid Housing Competition" presented by CTRL+Space in 2015, that deals with the combination of a high density building and the existing urban environment in St. Pauli, Hamburg. The scope of the project is to create different types of housing units that can attract both elderly, couples, couples with children and students. Furthermore, different types of commercial spaces, such as shops, entertainment and offices will be included to ensure that the project will adapt to the surrounding urban fabric and bring life into the site.

Within the project, environmental and social sustainable parameters will be included, by combining these parameters with both urbanity and living a highly holistic design solution will be achieved. To deal with the challenge, the initial program investigates the three terms of sustainability, urbanity and living as a method for thinking hybrid architecture.

The proposed design solution deals with the notions of public and private and how the building can position itself in this field, going from the public nature of the urban environment to the privacy of home.

# THEME ANALYSIS

*Framing the Project*

# METHODOLOGY

## METHODOLOGY

Creating a hybrid building within the district of St. Pauli is complex in terms of program, combining both domestic and commercial functions. The complexity of the project is only increased by the context and how the building relates to it and the citizens in St. Pauli. Therefore, it is a necessity to have an iterative process with a critical approach, in order to accentuate both architectural and engineering methods in the project.

Integrated design process (Ill. 1) is used to obtain a holistic design, where aesthetic, functional and technical parameters influence the design equally. The process is divided into 5 different phases; the problem/idea phase, the analysis phase, the sketching phase, the synthesis phase and the presentation phase, where an iterative process, between the phases will occur. (Knudstrup 2004)

In order to integrate both architectural and engineering parameters an interpretation of the Vitruvian triangulation is used as a method for fully grasping the complexity between sustainability, urbanism and living. The following will, within the different phases in the integrated design process, describe the different approaches and methodologies used within the different phases.

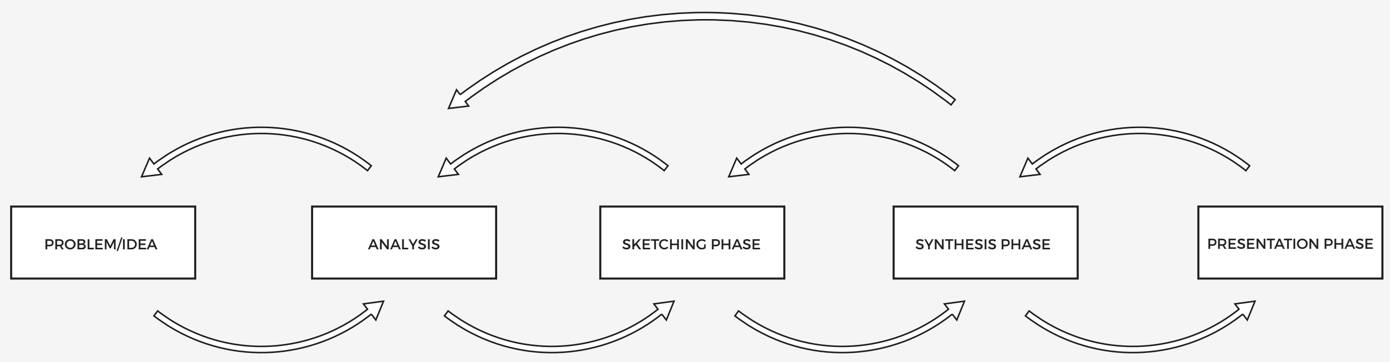
## PROBLEM/IDEA PHASE

The basis of the project is a competition brief compiled by CTRL+SPACE as part of a new development in St. Pauli, Hamburg. As part of the initial investigation of the problem, the competition brief is critically analyzed in order to compile the essence of the project. These investigations lead to the reinterpretation of the Vitruvian triangle where the terms of sustainability, urbanism and living is incorporated to create the framework for the project.

## ANALYSIS PHASE

In this phase investigations upon the contextual setting, which includes the architectural and socio-cultural fabric of the area surrounding the site, will be compiled. This will be done in order to develop a program that will be the basis for the subsequent phases.

Empiric methods and hermeneutic analyses will be used in order to compile correct information about the social context, physical context and the framework for the terms of sustainability, urbanism and living. Furthermore this analysis will be used to compile information about technical parameters such as building regulation both in Germany and Denmark. Furthermore a deductive empiric method is used to clarify climate conditions in and around the site.




Ill. 1 Integrated deisgn process

Mappings are used as a cartographic analysis to get an understanding of building heights, functions, infrastructure, blue/green areas and urban areas within the local environment. The approach will convey to the overview of the area, giving general understanding of the local area and St. Pauli.

A phenomenological method is used in order to characterize the atmosphere and the materiality in the local around the site. This perceptive approach will be illustrated through pictures and text.

## SKETCHING PHASES

The aim of the project is to create a holistic design both in terms of aesthetics and technical parameters which will be done by having an iterative working procedure within media (writing, drawing, physical model, 3D-modelling, section, plans, Be10, BSim and other calculations) and scale (context, building and detail).

Architecturally, this phase will deal with the design of preliminary concepts by using the compiled knowledge from the analysis phase in relation to technical parameters. The technical focus of the project will be performance-based studies that are primarily used to investigate the performance of energy consumption and indoor climate in relation to the building and the domestic functions and secondary used to investigate the performance of the structure within the building.

In this preliminary phase the digital tools will be used to both visualize and clarify if the performance of the building is acceptable according to preliminary technical parameters.

This phase is in general very iterative, judging all concept ideas according to both architectural and technical parameters in order for the finished concept to emerge. Material gathered from the studies is evaluated critically in relation to analyses, function, aesthetic and technical qualities.

## SYNTHESIS PHASE

The final concept, is in this phase further developed by iterating architectural and engineering parameters into the final design. There will also in this phase be an inconstant use of both media and scale in order to implement a wider range of parameters at once. The focus will be on creating coherence between the building and the city and creating the optimal place for living while still having a highly sustainable development. In this phase more drawings, models and calculations will be made to develop the final design.

## PRESENTATION PHASE

In the presentation phase the focus will primarily be on making final presentation material in terms of plans, section, facades, technical details etc. in order to create the final project report.

# INTRODUCTION

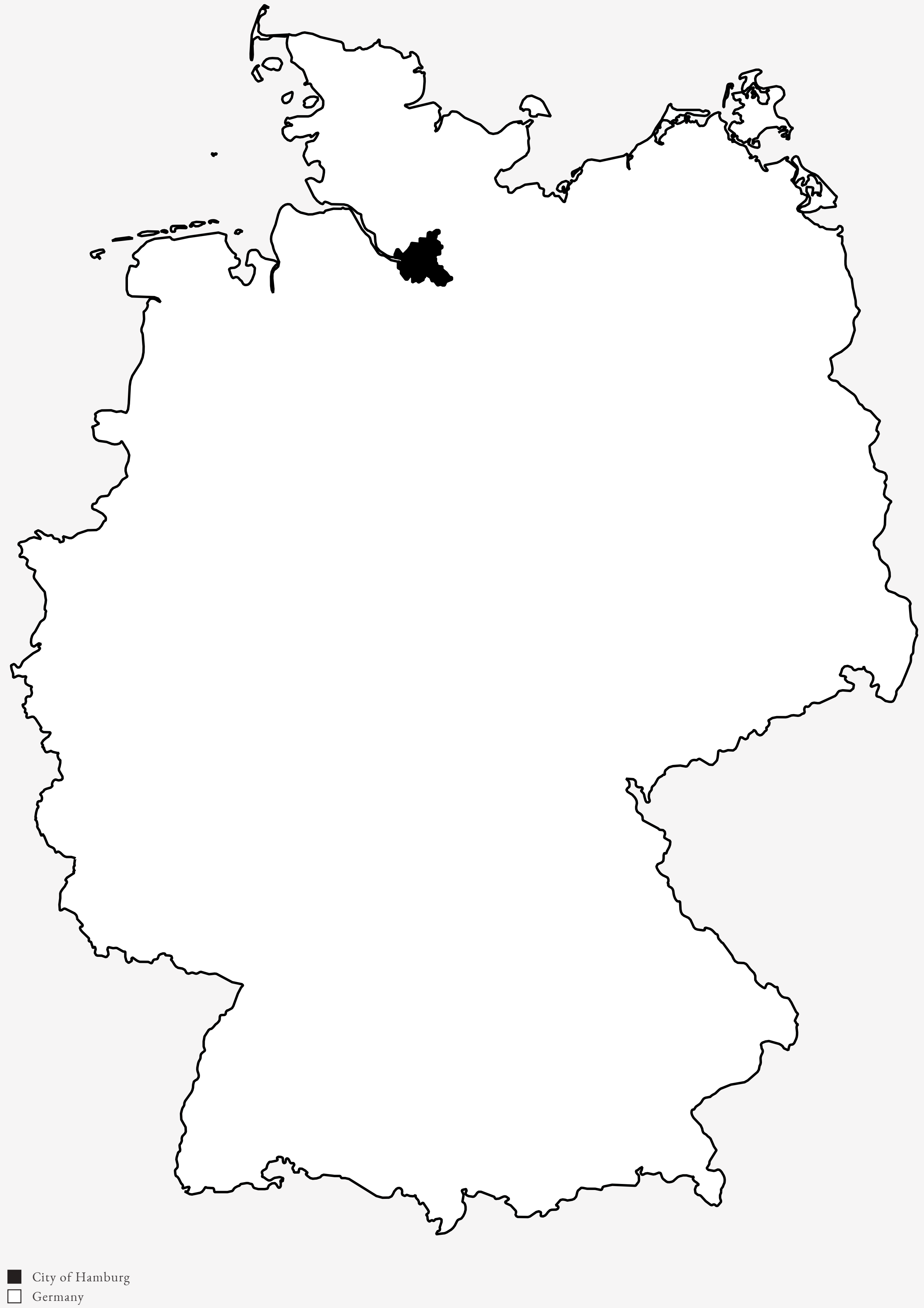
The population within the cities has, since the industrial revolution, continued to grow and so has the demand for domestic and public property. This tendency is also present in the City of Hamburg (Ill. 2), where the population increased with 16.500 people from 2013 to 2014 (www.statistik-nord.de 2015) Especially Hamburg-Mitte has experienced an increase in the population with 2.700 people in 2013. (www.hamburg-news.hamburg/en 2014)

The scope of the project is to accommodate these changes and to develop dense architecture, in this case hybrid architecture that relates directly to the surrounding heterogeneousness of the urban setting. This has to be done while still implementing both an environmental and social sustainable approach.

The project will investigate the three terms of sustainability, urbanity and living as a method for thinking hybrid architecture. This is done in order to develop a high density building that relates to the existing urban fabric and creates the best possible setting for living.

In order to fully comprehend the extensiveness of the project, an analytic and interdisciplinary methodology will be used, based on methods of the integrated design process.






Ill. 2 Map of Germany

# COMPETITION BRIEF

Hamburg Hybrid Housing Competition was an idea competition presented by CTRL+SPACE in 2015 that deals with the combination of a high density building and the existing urban environment in St. Pauli, Hamburg (Ill. 3). The challenge is to make the site interact with and improve the existing urban fabric, while still creating a building that meets the growing demand for domestic property within the city center of Hamburg. It is to be considered how the density is increased without it having a negative effect on the urban environment and how both domestic and public functions is integrated while creating a highly functional building that reflects the community. (CTRL+SPACE 2015)

The focus within the brief is to combine dense domestic and commercial functions and thereby creating different typologies and environments that ensure social sustainability within the development by attracting a wide range of people. Furthermore, the aim is to investigate the relation between the urban spaces and the individual domestic unit. (CTRL+SPACE 2015)

## FOCUS

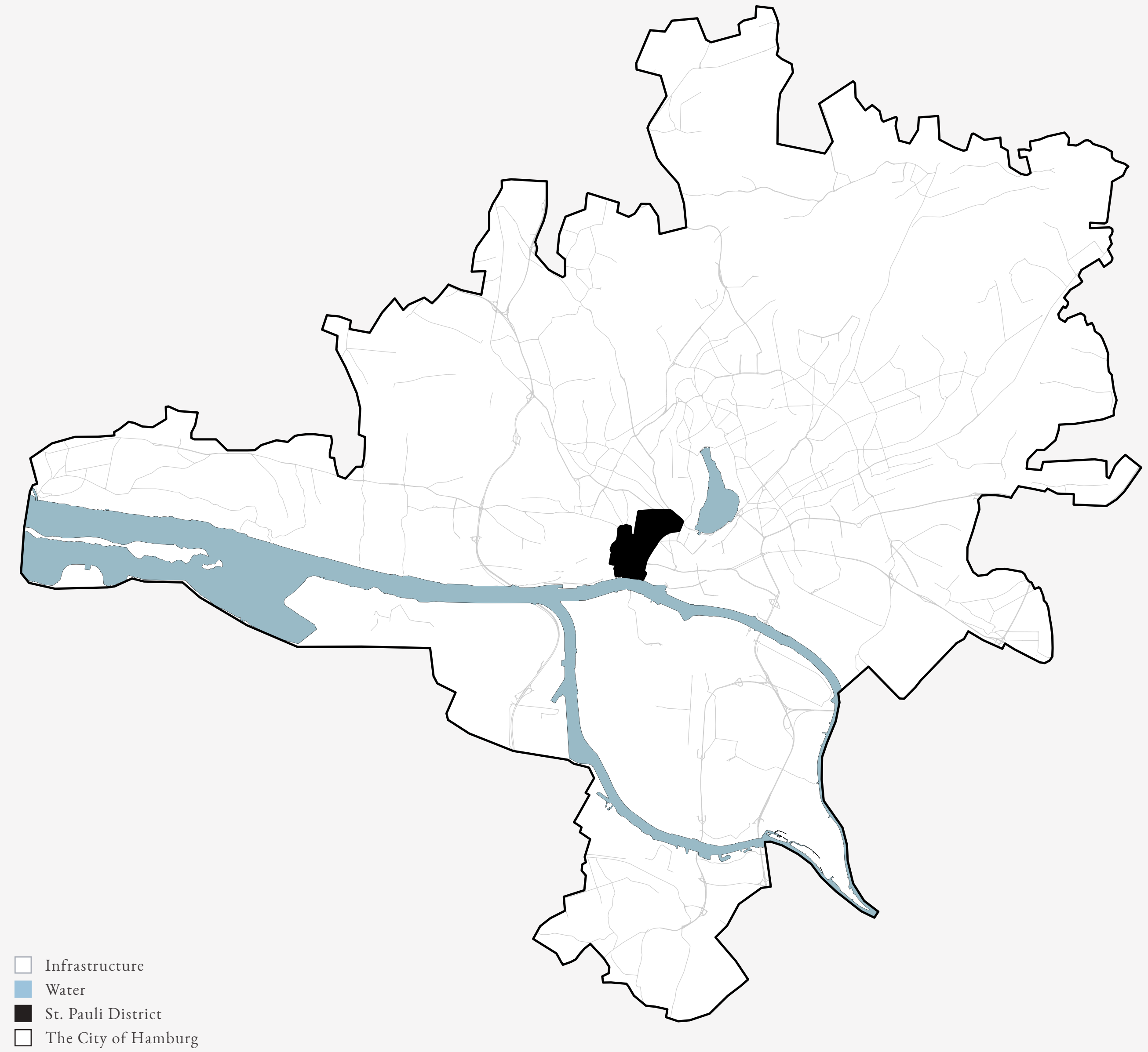
The scope of the program is to create different types of housing units that can attract both elderly, couples, couples with children and students. Furthermore, different types of commercial spaces, such as shops, entertainment and offices will be included to ensure that the project will adapt to the surrounding urban fabric and bring life into the site.

The different apartment types will consist of 30 units of 80-90 $m^2$ for students, 30 units of 90-100 $m^2$ for couples with more than one child, 30 units of 70-80 $m^2$ for couples with one child, 30 units of 60-70 $m^2$ for couples without children and 50 studio units of 30-40 $m^2$. Common areas also have to be added to the maximum area for the domestic functions with a total gross area of 15.000 $m^2$. To underline the heterogeneousness of the St. Pauli district, a backpacker hostel is included in the commercial functions and will take up 500 $m^2$ of the total 2.000 $m^2$ for commercial use. The total gross area of the project is therefore 17.000 $m^2$, of which maximum 20% can be interior accesses and hallways. Furthermore, parking facilities should accommodate 200 vehicles and if under ground be maximum 1 level. (CTRL+SPACE 2015)

In relation to sustainability, the main focus of the competition brief is to deal with energy production and consumption. But in addition to this environmental approach to sustainability, the social aspect of the term will also be included especially in relation to creating a socially diverse development. (CTRL+SPACE 2015)

As part of the competition brief it is required to implement ways of dealing with energy production and consumption, but in order to implement






Ill. 3 Map of Hamburg

environmental sustainability fully, the Danish energy frame 2020 of 20 kWh/$m^2$ pr. year will be fulfilled. The energy frame includes heating, cooling, ventilation and domestic hot water but one important parameter is not taken into consideration when looking at sustainable housing; user behavior. Therefore this parameter will be added as well as the energy frame in order to create an environmental sustainable hybrid building.

## DELIMITATION

Due to the extent of the project, all the aspects of the above mentioned topics will not be thoroughly discussed, a prioritization of the most relevant aspects and topics is necessary to achieve a good project within the timeframe.

Aspects such as economy, operation and maintenance of the building will not be discussed in the project, though it is highly relevant aspects that are managed within the building industry, though it is not seen as advantageous within this project.

The main focus of this project is the domestic functions both architecturally, functionally and technically, creating the best setting for living, while creating a relation between built and the urban fabric of the surroundings. Due to the extensive focus on the domestic functions, the remaining commercial functions, will not be as detailed. In this case, the commercial functions will remain as an overall scheme.

# LOCATION

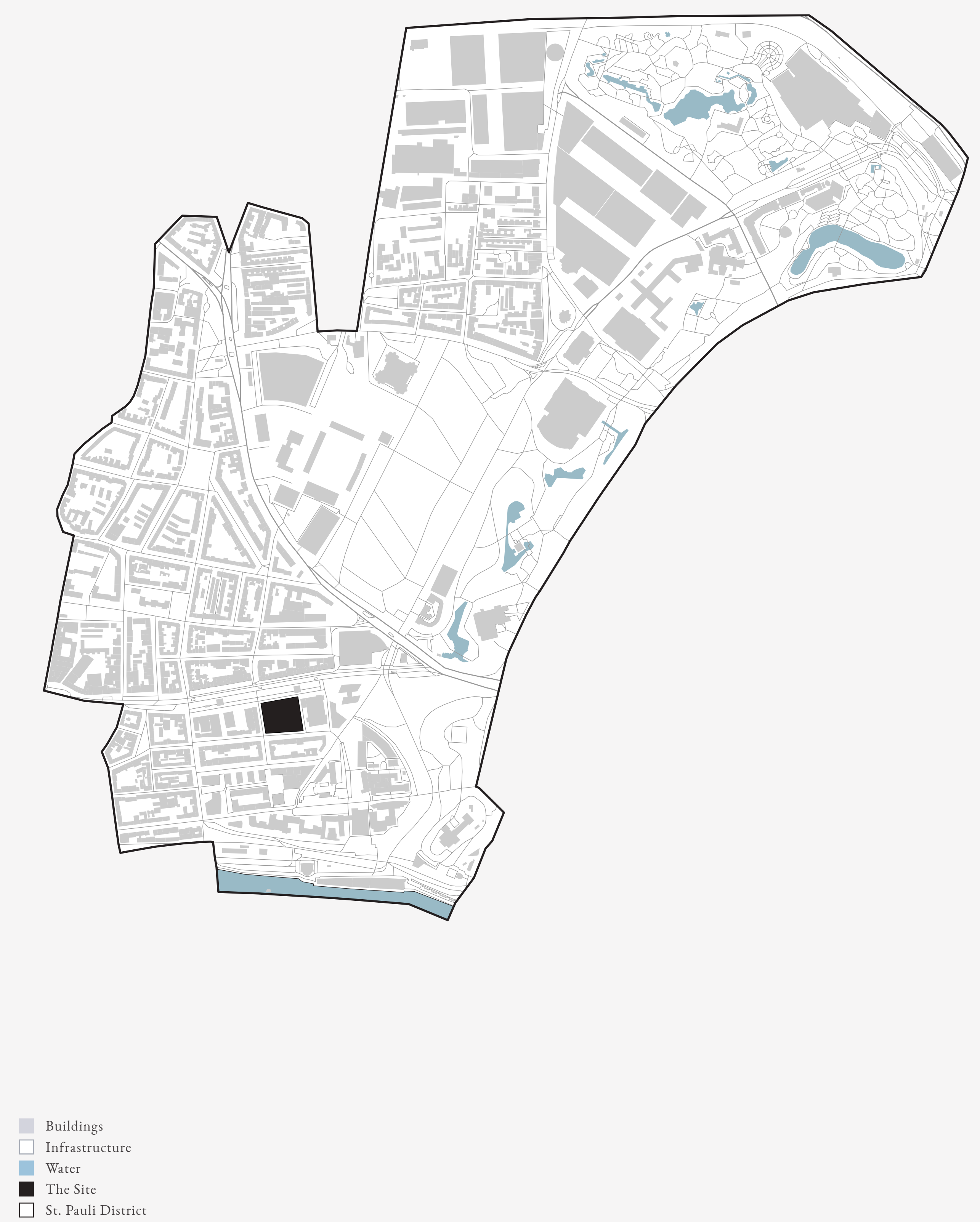
Located in the St. Pauli district (Ill. 4), the site is facing Spielbudenplatz, once a square for entertainment now a center for public events. First build in 1795, smaller wooden structures occupied the square, creating the setting for different performance shows. The wooden structures was later substituted by more permanent structures while still preserving the same atmosphere. Today, the square still functions as a center for different public celebrations and activities. (CTRL+SPACE 2015)

## DEVELOPMENT OF THE DISTRICT

Historically the district of St. Pauli was a residential working-class area, but over the last decade changes in the urban setting has entailed that the district has changed both in terms of functions and population. Within the population there has been a decrease in the number of immigrant taking up residence and furthermore a general shift in the population has resulted in the area no longer being dominated by low-income citizens. There has also been a shift in the functions in the area from being dominated by smaller businesses to focusing on entertainment and nightlife. These changes have made the district of St. Pauli into one of the most costly areas of Hamburg today and have highlighted the area as being the center for entertainment and the red light district of Hamburg. (CTRL+SPACE 2015)

Architecturally, the district of St. Pauli was marked by the Second World War. What once was cinemas, theaters etc. had to be rebuilt, which meant that the district went through many changes. (CTRL+SPACE 2015) The site itself has also changed appearance over time. Occupied by the Esso-Häuser complex until recently, the site accommodated both domestic and commercial spaces. From 1958, the project consisted of 110 apartments divided into two 8-storey buildings. (CTRL+SPACE 2015)






Ill. 4 Map of St. Pauli

# HYBRID BUILDING

Over the last few years high density architecture has become more prominent due to e.g. increases in the value of land, development of new economic zones and in general growth in the economy worldwide. (Per et al. 2014) But what does the term hybrid building entail? When looking at the definition of the word hybrid, the Oxford dictionary states the term as: "something that is the product of mixing two or more different things." (www.oxforddictionaries.com 2016)

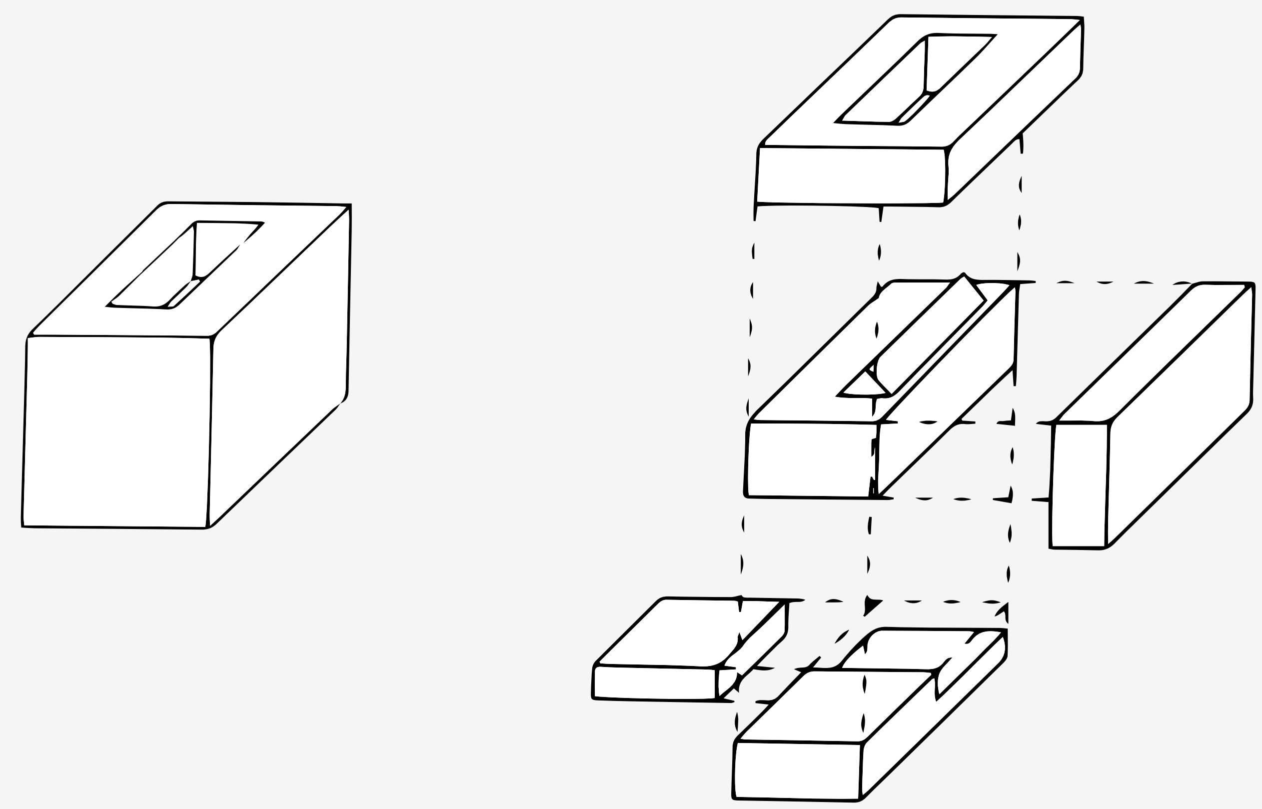
In 1985, Joseph Fenton added to this definition by stating it as: ".. the complex relationship between form, function, technology, urban context and society, with the hybrid building establishing a coherent balance of parts." (Fenton 1985, p.5) This relates both to the mixing of functions and the city and the people within it. Before this time, the term 'Hybrid Building' had not been recognized as a building type due to the fact that hybrid buildings were seen as mixed-use buildings. (Per et al. 2014, p.13) When looking at the definition of mix-use it is stated as: "combining commercial and residential development; zoned for commercial and residential use." (www.dictionary.reference.com 2016) It becomes clear when looking at the two definitions that there is a difference; a mixed-use building only deals with the functions within the building itself whereas a hybrid building deals with more complex structures because it includes the functions and the surroundings both physically and mentally.

## HYBRID IN THE PAST

The use of hybrid buildings as a typology is not newly invented, but has rather been reinvented. When looking further back in history, mixing functions, densification of the cities and the land value has naturally been associated with one another. At the time where the primary transportation method was by foot, the functions within the villages had to be closely connected. This meant that when constructing new buildings or expanding the older, the functions either had to be merged and/or combined into one space, which also can be described as densification. The development of the cities evolved, growing bigger, and alongside this the need for the dense building type decreased. Later, due to the industrialization, citizen's mobility increased and the division of functions was executed by modern urban planning, creating different areas for domestic, commercial, offices and industry. (Per et al. 2014, pp.12–13)

The hybridization of buildings was used in a small scale up until the 19th century, where the development in construction materials (steel) and technological developments (elevator) ensured that it was possible to build in a much larger scale that earlier experienced. (Per et al. 2014, p.13) As Joseph Fenton describes it: "The modern city has acted as fertilizer for the growth of architectures from the homogeneous to the heterogeneous in regard to use. Urban densities and evolving building techniques have affected the mixing of functions, piling one atop another, defying critics who contend that a building should 'look like what it is'" (Fenton 1985, p.3)





Ill. 5 Fabric Hybrids (Pamphlet Architecture no. 11: Hybrid Buildings, Princeton Architectural Press, New York, 1985)

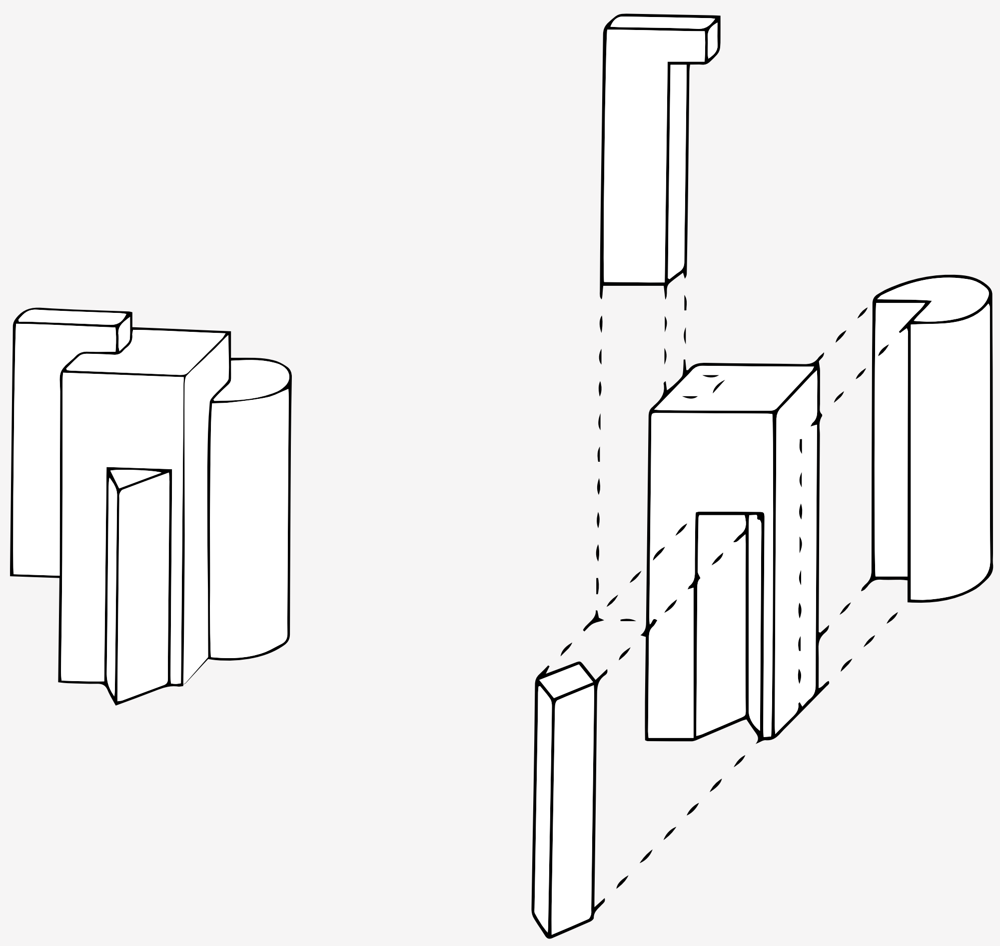
## PRINCIPLES

Joseph Fenton made a classification of hybrid buildings based on multiple analyses of hybrids, which resulted in three types; fabric hybrids, graft hybrids and monolith hybrids.

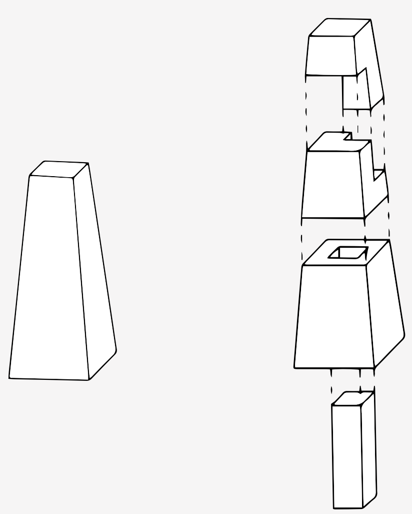
Fabric hybrids (Ill. 5) are clear in their form, so the building should be perceived as one volume and not as parts put together to create the volume. The program within the building is unobtrusive in relation to the building as a whole, which means that the functions follow the form. Furthermore the shifts in the facades, such as proportion of windows and change in materials, can indicate changes in the program.

Graft hybrids (Ill. 6) can be described as the opposite of the fabric hybrid having the form follow the function which makes the program of the building perceivable when looking at the building. Due to the fact that the building is shaped according to the functions, it becomes evident that different masses are put together to create one building.

Monolith hybrids (Ill. 7), on the other hand, are monumental in their scale, creating one building in which functions of the city are included.



Ill. 6 Graft Hybrids (Pamphlet Architecture no. 11: Hybrid Buildings, Princeton Architectural Press, New York, 1985)



Ill. 7 Monolith Hybrids (Pamphlet Architecture no. 11: Hybrid Buildings, Princeton Architectural Press, New York, 1985)

The discussion of hybrid buildings often deals with big-scale vertical structures, such as skyscrapers, where the relation between $m^2$ and single functions are not equal, therefore a bigger variety of functions are needed in order to utilize all the $m^2$. (Per et al. 2014, p.13) The vertical hybrid, which is the most used, became relevant in the 1900's New York, due to small building plots and the wish for mixing functions. (Fenton 1985) But the hybrid building typology also includes the horizontal structures. The scale of the typology is simply described based on the juxtaposition of the program in section and can therefore include both vertical and horizontal hybrids. (Per et al. 2014, p.41)

## INTEGRATION OF THE SURROUNDINGS

One of the elements that a hybrid building deals with is integrating the surrounding landscape and/or urban fabric, which can be done by continuing it either horizontally or vertically onto or over the building. This entails that a hybridization of the program and the urban/green surrounding occurs. (Per et al. 2014, p.19) Due to the relation to the urban fabric, the definition of hybrids entails that the typology relates to the city both in terms of the following the grid of the city and interacting with the urban fabric of the surroundings. Therefore the hybrid typology becomes a social condenser for the city by being of the edge of both urban planning and architecture. (Per et al. 2014, p.41)

## REFLECTION

A hybrid building is complex, diverse and varied in its program and implements both the private and public sphere, which ensures life in and around the building both day and night. It is stated in the following: "Hybrid buildings are organisms with multiple interconnected programs, prepared to house both planned and unplanned activities in the city." (Per et al. 2014, p.40)

A hybrid building should reflect the surroundings in which it is placed; always continue to evolve both in terms of functions and their relation to each other in order to keep up with the changes in the social and physical setting. As Joseph Fenton states it: "The hybrid building is a barometer recording the evolution of our society. Each new juxtaposition reflects a willingness to confront the present, and to extend exploration into the future." (Fenton 1985, p.41)

Ill. 8 View of the port



# SOCIAL CONTEXT

*History, Mentality and Vision*

Ill. 9 Port of Hamburg

# THE CITY OF HAMBURG

Hamburg is one of 16 states creating the Federal Republic of Germany. It has 1,7 million citizens, making it the second biggest city in Germany. The territory of Hamburg covers 755 km² of which more than 40% is recreational areas or public spaces, making Hamburg one of the lEast populated cities in Europe with 2.305 citizens pr. km². (Beretta 2014)

In order to fully understand the density of Hamburg, it can be compared to the city of Copenhagen. The territory of Copenhagen covers 167,1 km², which makes the city 4,5 times smaller than the city of Hamburg. But with 704.108 citizens, the density of the city is almost double the density of Hamburg, with 4.213,7 citizens pr. km². (Danmarks Statistik 2012)

## HISTORIC OVERVIEW

The City of Hamburg has throughout history been ruled by many different foreign parties, since it was founded in 808 by Emperor Charlemagne and it has undergone many tragedies which have formed the city into what it is today.

The port (Ill. 9) has, since the city was founded, been the source of revenue for the city of Hamburg due to tax-free access to the lower part of the River Elbe, granted by Frederick Barbarossa in 1189. The city's independent status as Free and Hanseatic City of Hamburg, which was officially received in 1.300, allowed the city to grow economically.





Up until the 18th century, the port was one of the centers of trade in Europe which left the city prosperous. But as Napoleon invaded Hamburg in 1810, most of the trade was cut off and poverty within the city increased. After the Napoleonic defeat the city again obtained the status as a free city.

In 1842, the city was devastated by the Big Fire where over a third of the city was burnt down, including many historical buildings, and approximately 20.000 citizens were left homeless. Over a 40 year period different initiatives in relation to reconstruction were made and the port was yet again prosperous.

Furthermore, the City of Hamburg was greatly influenced by both the First and the Second World War. The First World War influenced the economy of the city greatly, due to a decrease in trade, which again left the city in poverty and and in addition to this, approximately 40.000 citizens lost their lives. The Second World War left big human losses and materiel damage as well. 600.000 citizens lost their lives and approximately 50 % of private property, 40 % of industrial property and 80 % of the port destroyed. (www.hamburg.de n.d.)

After the Second World War, the focus of the city was the economic growth and reestablishing of the city, but what was not expected was the flood that hit the City of Hamburg in 1962. The great flood killed more than 300 people, many of them being refugees from the East, living in poverty in the poor quarters. (Shroder et al. 2015)

Throughout history, the City of Hamburg has had to overcome many tragedies. Since 1842 the city constantly had to rebuild, renew and improve itself in order to keep up with challenges it faced.

Looking throughout history, the industrialization is one of the culminations that had a great influence on the city, especially the port, factories and the oil refineries. But alongside the technological development the focus on the environment within the city became more distinct. Since 1909, the City of Hamburg has had a clear vision of strengthen the green areas, redevelop and development of urban areas, increase the amount of sustainable mobility and preserving the architectural history that had not been destroyed during the Big Fire and the two World Wars. (Beretta 2014)

## THE GERMAN MENTALITY

German culture is based on Prussian values, and has been since 1871, which focuses on formal spheres instead of the private. The behavior and attitude of the Prussians, which is based on discipline, order, responsibility, duty and obedience, has become the moral code and etiquette of the German people. The different spheres of life are affected by this attitude and way of behaving, making a clear separation of public and private spheres. The emotionalized and informal aspect of the private sphere is separated from the rationalized and formal aspects of the public sphere. (Kavalchuk 2012) When visiting Hamburg, the division of the different spheres become evident. One example of this is gated entrances to apartment blocks, which can be seen as a way of securing the home but it can also be seen as a way of clearly defining and separating public and private spheres. The Nederland's is an example of how there are no distinction between public and private spheres. No gated communities are visible and the dwellings are rarely pulled back from the street, which obliterate the invisible boundary between the spheres.

When comparing the German mentality to the Danish mentality as we know, the division between the spheres depends on situation. When looking at the dwelling, the Danish mentality dictates that there is a clear boundary between public and private spheres just as experienced in Hamburg. But when comparing the professional environments in Germany and Denmark, the Danish way of interacting in this type of environment is different. The boundary between the private and public sphere becomes obliterated instead of having a very clear distinction between the two as in Germany.

# GREEN VISION

The Green Network is the strategy for the city of Hamburg towards combining the urban fabric of the city and the countryside (Ill. 10). The network consists of an inner green circle, an outer circle, and landscape axes that radiates from the inner to the outer circle.

The inner circle follows the former fortification lines, which is located in a radius of approximately one kilometer from the city hall. Furthermore, the outer circle is located in a radius of 8-10 kilometer from the city hall and thereby creating a 90 kilometer green boundary from the inner to the outer city.

The Green Network provides the citizens of Hamburg with a broad range of both recreational areas and public spaces, and furthermore it contributes to the diversity on an ecological level and in terms of micro climate. (Stadtentwicklungsbehörde Hamburg 2011)

## HISTORY

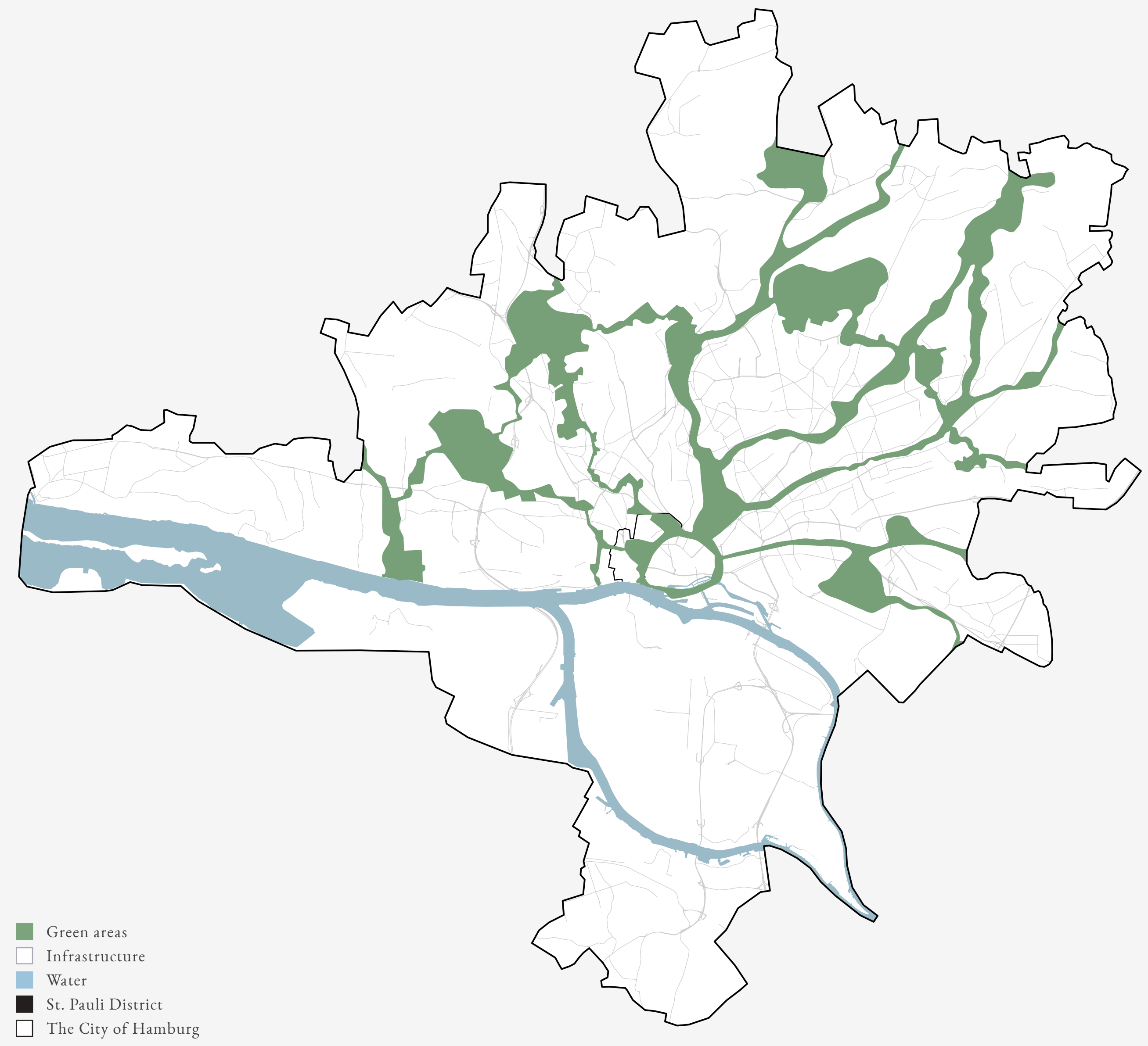
The development of the green network started in 1919, where Fritz Schumacher, Head of Hamburg's Building Department from 1909-1933, created the Axial Concept. With this concept, Fritz Schumacher wanted to connect the city center and the suburbs by creating axes whereupon the further development of the city would take place. The surplus space between the residential axes should thereby connect the residential areas with open green areas and connect the open green areas with the countryside and become green corridors.

In 1925, Gustav Oeksner, Building Officer and Senator for Architecture in Altona, from 1924 to 1933, created the Green Belt Plan. This plan encircled Altona, a district within the city center, with a semi-circular shape. This created the conceptual basis for what today is the inner circle.

Both the Masterplan of 1947 and the Reconstruction Plans of the 1950's and 1960's increased the recreational quality of the axes. Furthermore, the Development Model for Hamburg and Hinterlands and the Unitary Development Plan respectively from 1969 and 1973, combined both the Axial Concept and the Green Belt Plan, creating what is now seen as the basis of the Green Network.

The Open Space Concept was drawn up in 1985, which included the Landscape Axes Model. This model further developed the green corridors into Landscape Axes, taking the surplus space between the residential axes and cultivating it. As part of the Landscape Program, the Open Space Concept was formed, which combined the landscape axes with the two green circles. The program was officially implemented as the environmental blueprint of the city parliament in 1997. (Stadtentwicklungsbehörde Hamburg 2011)






Ill. 10 **Green areas in Hamburg**

## THE FUTURE OF THE GREEN NETWORK

The Green Network covers more than 40% of the territory of Hamburg (Beretta 2014) but an increase in the development of infrastructure such as roads and residential and commercial areas has challenged the Green Network. Especially the inner circle has been affected by progress in the building sector. Therefore, it is the aim of the city to secure the existing green areas and add more where it is needed.

# SUMMARY

The project deals with the development of a Hybrid Building in St. Pauli, Hamburg. The development has to combine both domestic and commercial uses in order to relate to the surroundings while still having a social and environmental sustainable approach.

A hybrid building is a development that combines both domestic and commercial functions while still integrating the physical and social surroundings, which also sets it apart from a mix-use building. Hybridization ensures the mix of private and public spheres which also reflects in the life in and around the site day and night. Furthermore, the hybrid building has to follow the change of the physical and social setting, creating new juxtapositions when it is needed in order to keep up with the changes.

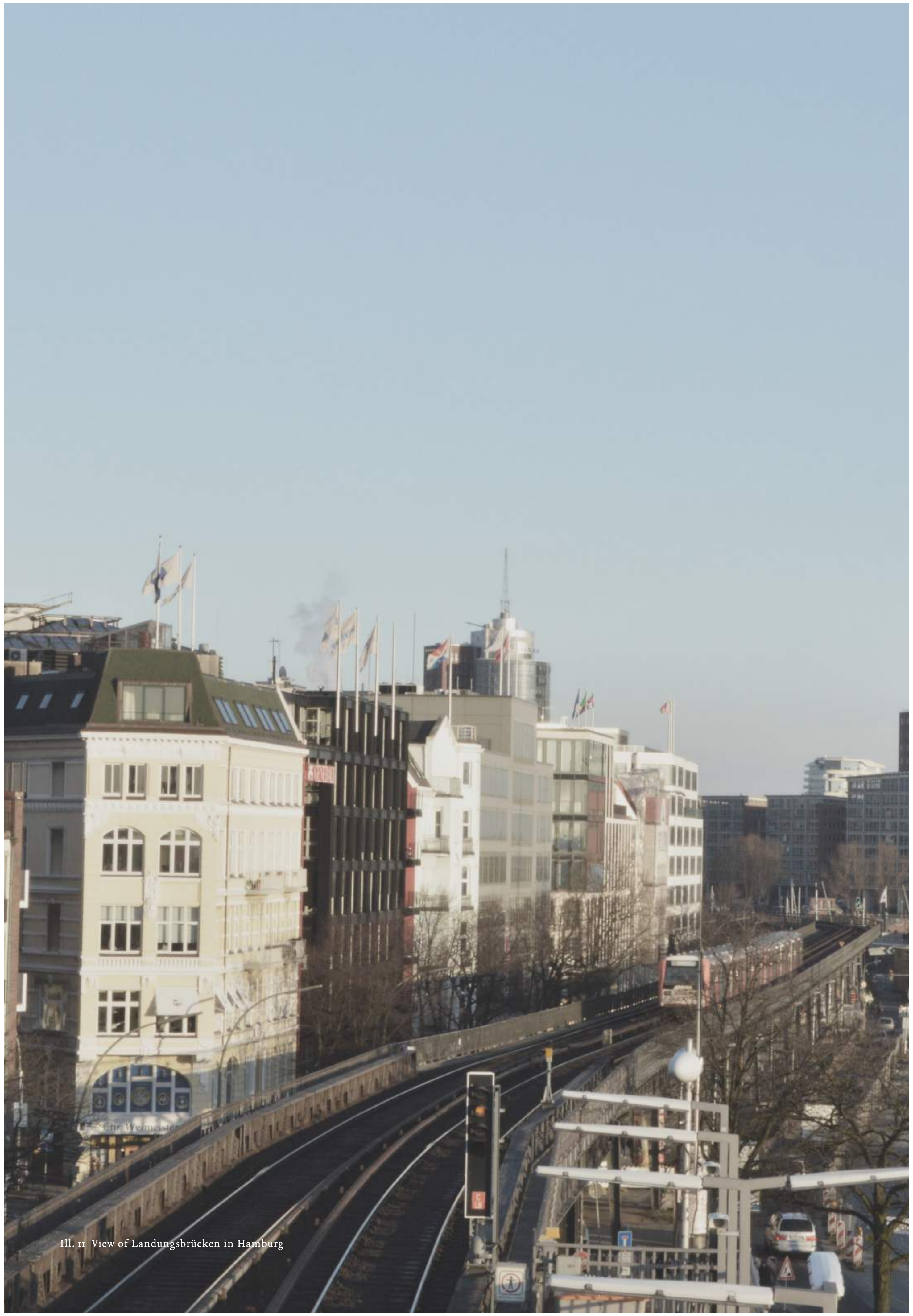
The city of Hamburg has throughout history undergone many disasters as the great fire in 1842, the two World Wars and the great flood in 1962, bringing the total dead toll too approximately 660.300. The harbor has always been the main income for the City of Hamburg and became especially prosperous during the industrialization, where the technological development made the harbor more efficient.

Since the 1900's there has been a great focus on the green areas within Hamburg. This has now resulted in green areas covering over 40% of the territory. The Green Network, as it is called, consists of two green circles, one surrounding the inner city and one surrounding the outer boarder of the territory, where different green axes radiates from the inner to the outer circle.

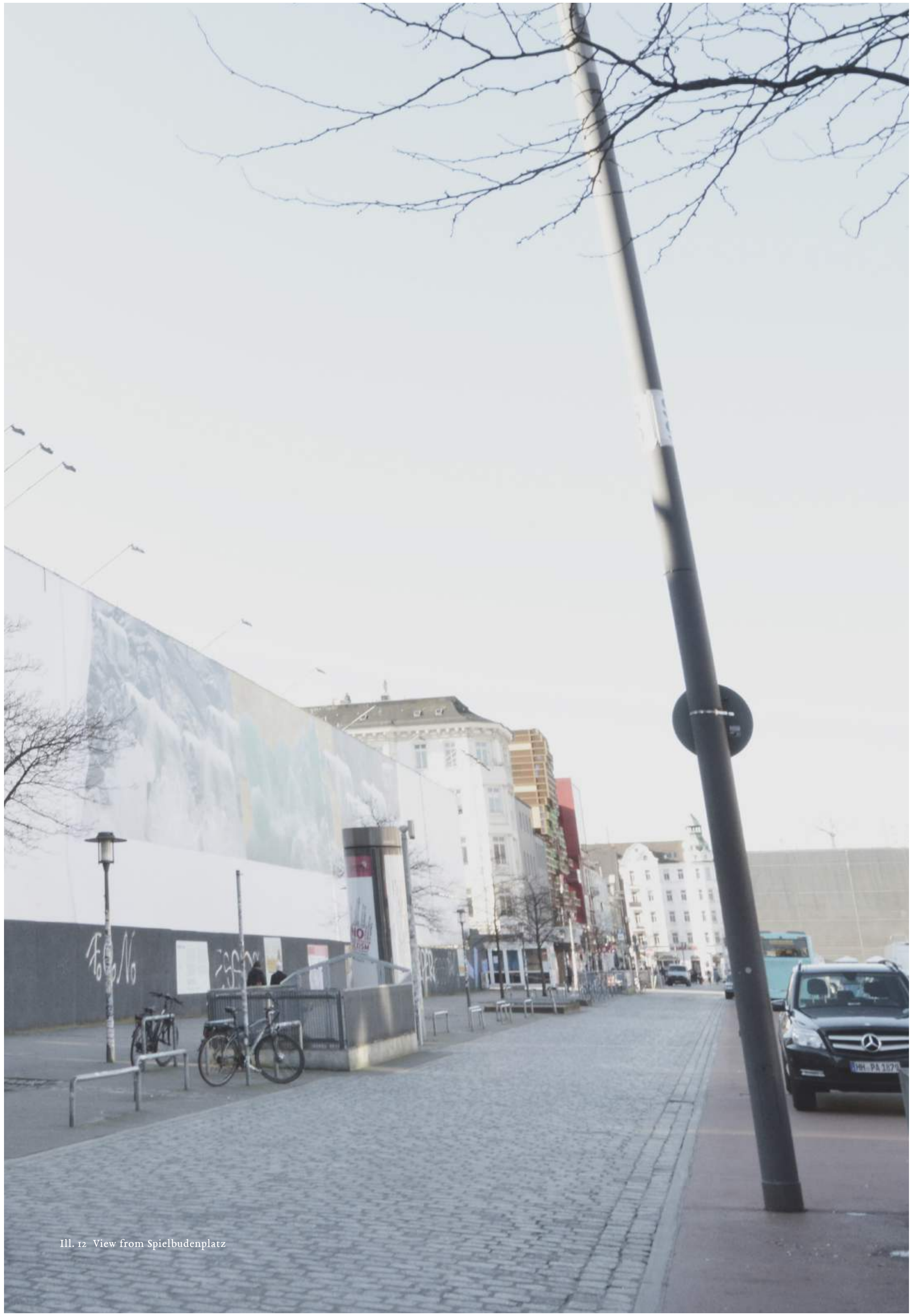
St. Pauli is a district located in the center of Hamburg, previous being a working-class area that vacated port workers and pilots. During the Second World War a big part of the district was destroyed and had to be rebuilt. The area has changes over the last decades, which entails an urban renewal and change in population. Earlier dominated by low-income families, St. Pauli has become an expensive and popular area in the City of Hamburg.

The German history has been crucial for the German mentality. Based on discipline, order, responsibility, duty and obedience, it describes the etiquette and moral code of the German people. This attitude is reflected in the separation of private and public spheres, clearly differentiating the rationality and formality of the public sphere with the emotionality and informality of the private sphere.





Ill. 11 View of Landungsbrücken in Hamburg


Ill. 12 View from Spielbudenplatz



# PHYSICAL CONTEXT

*Site Analysis*

# MAPPINGS

### THE SITE

The site is located in St. Pauli, Hamburg (Ill. 13), and faces the famous Reeperbahn towards the North. The built environment at the site was recently demolished leaving it empty. By adding a new and sustainable development, architectural and urban qualities of the area can yet again be enhanced by relating to functions, building heights, infrastructure, urban area and the green/blue structures.

### BUILDING HEIGHTS

In the surrounding area of the site, the scale of the buildings varies from 1 to 22 storeys (Ill. 14), which, in relation to building heights, create a big diversity. Closely surrounding the site, the most frequent building heights varies from 3,5 to 5,5 storeys with a few 1 to 3 storey and 6 to 8 storey buildings as well. Looking past the close surroundings the scale of the buildings increases and buildings of 14 to 22 storeys emerges. Though the new development at the site does not have to relate directly to these big scale buildings, they are important for the total impression of the area.

### FUNCTIONS

The site is surrounded by a wide variety of functions (Ill. 15) and a clear distinction between the areas in the South/East and the North/West becomes evident. The South/East is dominated by domestic and office functions whereas the North/West can be characterized as the red light district of Hamburg. The areas here are dominated by bars and mixed-use buildings where domestic, commercial and/or entertainment functions are linked. This contrast in functions create a clear tension across the site, when having to relate these otherwise incompatible functions.

The Site

Ill. 13 Mapping showing the site

1-3 Storeys
3,5-5,5 Storeys
6-8 Storeys
14-22 Storeys

Ill. 14 Mapping showing building heights

Offices
Commercial
Domestic, Commercial, Entertainment
Domestic
Bars, Others
Hotel, Commercial
Hotel
Cultural

Ill. 15 Mapping showing functions

### INFRASTRUCTURE

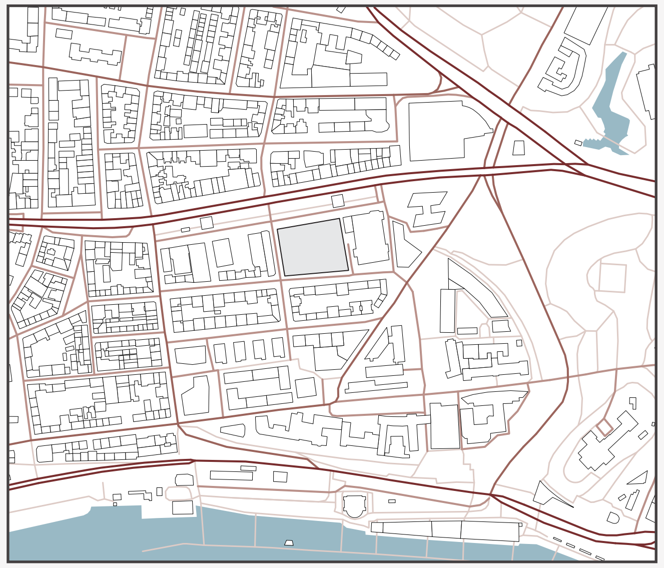
A bigger range of infrastructure is investigated in order to assure accessibility to the site (Ill. 16). The investigation clearly shows that except from Reepberbahn, which is heavily trafficked but is distanced from the site by Spielbudenplatz, a big part of the area surrounding the site either has light traffic or relates only to pedestrians. This ensures both a low pace in the area and a low volume of sound affecting the site.

### URBAN AREAS

The site is located in an urban area (Ill. 17), which means that except from the blocks just South of the site, the site is directly connected to various urban areas and spaces. Spielbudenplatz, just North of the site, creates a natural distance to the busy Reeperbahn and is a gathering point for St. Pauli as a whole. South of the site is an urban area that mostly relates to the offices and domestic functions by acting as an access area. Other urban areas such as Hans-Albers-Platz and Landungsbrücken are also located in the area, but does not relate directly to the site.

### BLUE/GREEN STRUCTURES

When looking at the blue and green structures (Ill. 18) in the Southern part of St. Pauli, it becomes evident that the site is close to both the River Elbe and bigger green areas. The location of the site is just West of the inner green circle, which ensures recreational qualities close to the city. Furthermore a short distance from the site to the harbour front emphasizes the recreational qualities of the area, creating an urban area in close connection to both green and blue structures.




Ill. 16 Mapping showing infrastructure


Ill. 17 mapping showing urban areas


Ill. 18 Mapping showing green/blue structure

# MICRO-CLIMATE

### SUN/SHADOW

June 21. Morning, 7-8 am (Ill. 19):

The tall hotel and office building West of the site has a significant impact on the site conditions in the morning hours of the summer period. At around 8 am its long shadow covers around a third of the site, and the site is not fully covered with sunlight until late morning, even on the longest day of the year. On the other side of the site, the theatre has very little impact.

June 21. Evening 19-20 (Ill. 20):

In the summer evenings the five storey block buildings have an impact on how the ground-level zones can be used. Not much of the Western and Southern site border have direct sun exposure at 7 pm, so potential outdoor urban spaces that benefits from evening sun would be ideally placed at the South-East corner of the site.

June 21. accumulated (Ill. 21):

It is evident that the sun conditions in the summer time are fairly equal on the site, in terms of total number of sun hours. The North border of the site has more sun hours, but this area will be shaded by the new building proposal. Otherwise this result is correlated with the evening result that shows more sun light on the South-East corner.

1 > Hour
< 0 Hour

Ill. 19 June 21. 8am

1 > Hour
< 0 Hour

Ill. 20 June 21. 7pm

15 < Hours
13 Hours
11 Hours
9 Hours
7 Hours
5 Hours
3 Hours
< 1 Hours

Ill. 21 Average June 21.

March 21. accumulated (Ill. 22):

Here the interesting result is that, even though the previous analysis for June 21. showes more sun to the South-East, this analysis suggest better sun conditions on the Western edge of the site. Sun conditions in the ground-level zones shift during spring and summer time, which will further inform placement of urban functions and spaces.

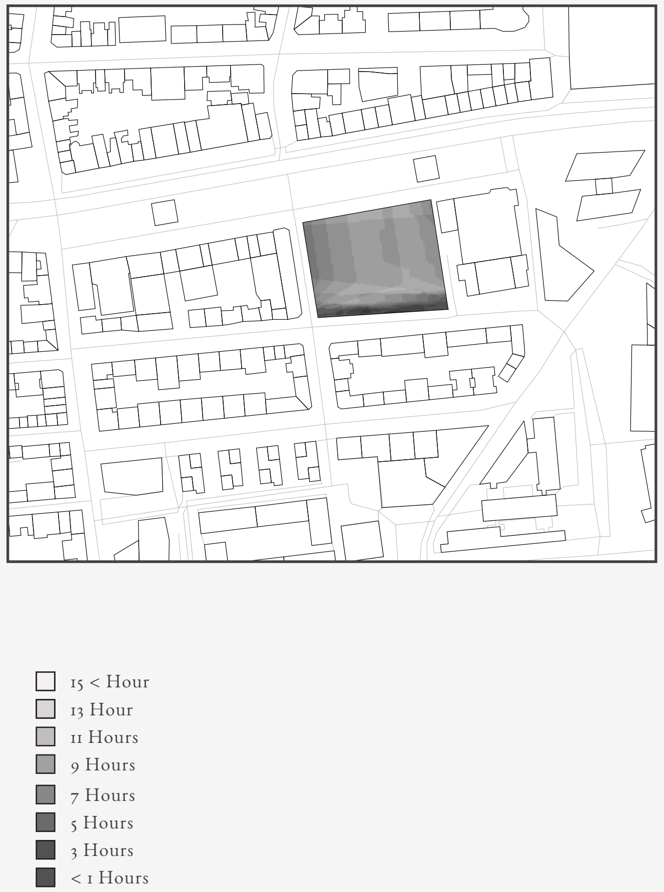
December 21. accumulated (Ill. 23):

Almost all of the site will in the winter time be in total shadow, which suggests that the ground level will have very little direct sunlight in the winter season. This will inform the storey height of the ground floor, if it becomes an issue.

## WIND DIRECTION

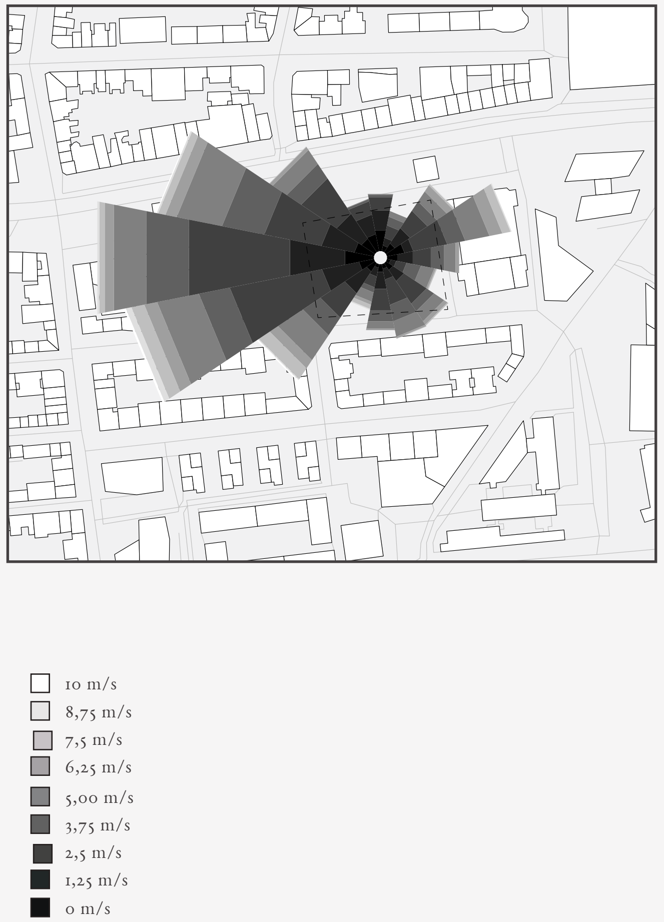
May 1. – October 1. (Ill. 24):

The wind data shows the amount of wind in different directions and speeds in the summer period. This becomes relevant when designing potential solutions for natural ventilation in the building, and where in- and out-takes should be placed as well as interior functions in the building that requires special consideration for ventilation.




Ill. 22 Average March 21.


Ill. 23 Average December 21.




Ill. 24 Average Wind

# ATMOSPHERE

The area around the site is both dynamic and diverse in terms of functions, appearance and demography. It is evident when walking around in the area South of Reeperbahn that the St. Pauli district was tremendously affected by the Second World War. Many of the blocks, especially those close to the site, was built in the beginning of the 1950's but an urban renewal of the area has resulted in modern structures being implemented in the otherwise old setting, creating a varied environment both in terms of architecture and functions.

This area in Hamburg is characterized by having domestic, commercial and entertainment functions, which in relation to each other makes the setting inconstant. The setting becomes further inconstant at nighttime where the area changes from being an area for tourists walking Reeperbahn, locals working in the surrounding office buildings and using local cafes and restaurants to being lit up by neon lights from all the clubs, theaters, etc. and being an adult entertainment area.

The inconstancy can also be experienced in the atmosphere of the area surrounding the site. Within a relatively small radius of the site, 4 contrasting atmospheres can be experienced; the blocks closely surrounding Reeperbahn which also includes half of the site, the classical blocks towards the South which includes the rest of the site, the urban renewed area that stretches from the South of the site to the East and the last experienced atmosphere is the one found within the older blocks towards the West.

## REEPERBAHN

Reeperbahn (Ill. 25) is characterized by being the center for entertainment in the City of Hamburg where everything from opera, theater, casinos, amusement arcades, restaurants and various shops and clubs of a sexual nature can be found. At daytime, tourists and locals walk along these shops and clubs, many of them being closed, either to experience the area or use the street as transit to the nearby office blocks, the green areas and public transport. At night time, Reeperbahn becomes a mini Las Vegas where all buildings are lit up by different types of lighting, creating an area that is full of color and life. More people are lured into the area, also during the weekdays, by the before mentioned functions that opens in the late hours of the day.

Spielbudenplatz (Ill. 26), which separate the site and Reepberbahn, becomes a barrier both in terms of noise and sight, due to the width and the functions put into the site, some of them are raised to increase this barrier. These functions include small stalls and benches that activates the area in the summer and a scene that center for different celebrations and exhibitions.



Ill. 25 Day view of Reeperbahn

Ill. 26 Spielbudenplatz at daytime


Ill. 27 Street South of the site


Ill. 28 Difference in new and old areas close to the site


Ill. 29 Urban renewed area and the urban space

Ill. 30 Urban area used for transit


Ill. 31 Seperation of private and public sphers

Ill. 32  Old area towards the West


Ill. 33  Adult Entertainment in the older area


Ill. 34  Mixed functions in the older area

## CLOSE AROUND THE SITE

The blocks that surrounds the site towards the South, is built as part of the reconstruction of St. Pauli after the Second World War. Even though the area is only one block away from Reeperbahn, the atmosphere changes dramatically (Ill. 27) and instead the area becomes a calm residential area that is less crowded. Here one will experience elderly and families strolling around in a much slower pace than on the Reeperbahn (Ill. 28).

Parallels can be drawn to residential areas within Østerbro, in Copenhagen, where the functions are mainly residential and the atmosphere has the same character. The one big difference between these two areas is the size, the area in Hamburg only includes approximately three blocks whereas Østerbro is a district within the City of Copenhagen.

## URBAN RENEWAL

The newly developed area that surrounds the site from the South and East is part of the urban renewal of the district of St. Pauli. This area is characterized by being the center of multiple office buildings, retail and apartment blocks (Ill. 29). This results in the area being active during the day due to the many people working in the area and being introverted at night due to the many empty office buildings and the gated entrances to the apartment blocks.

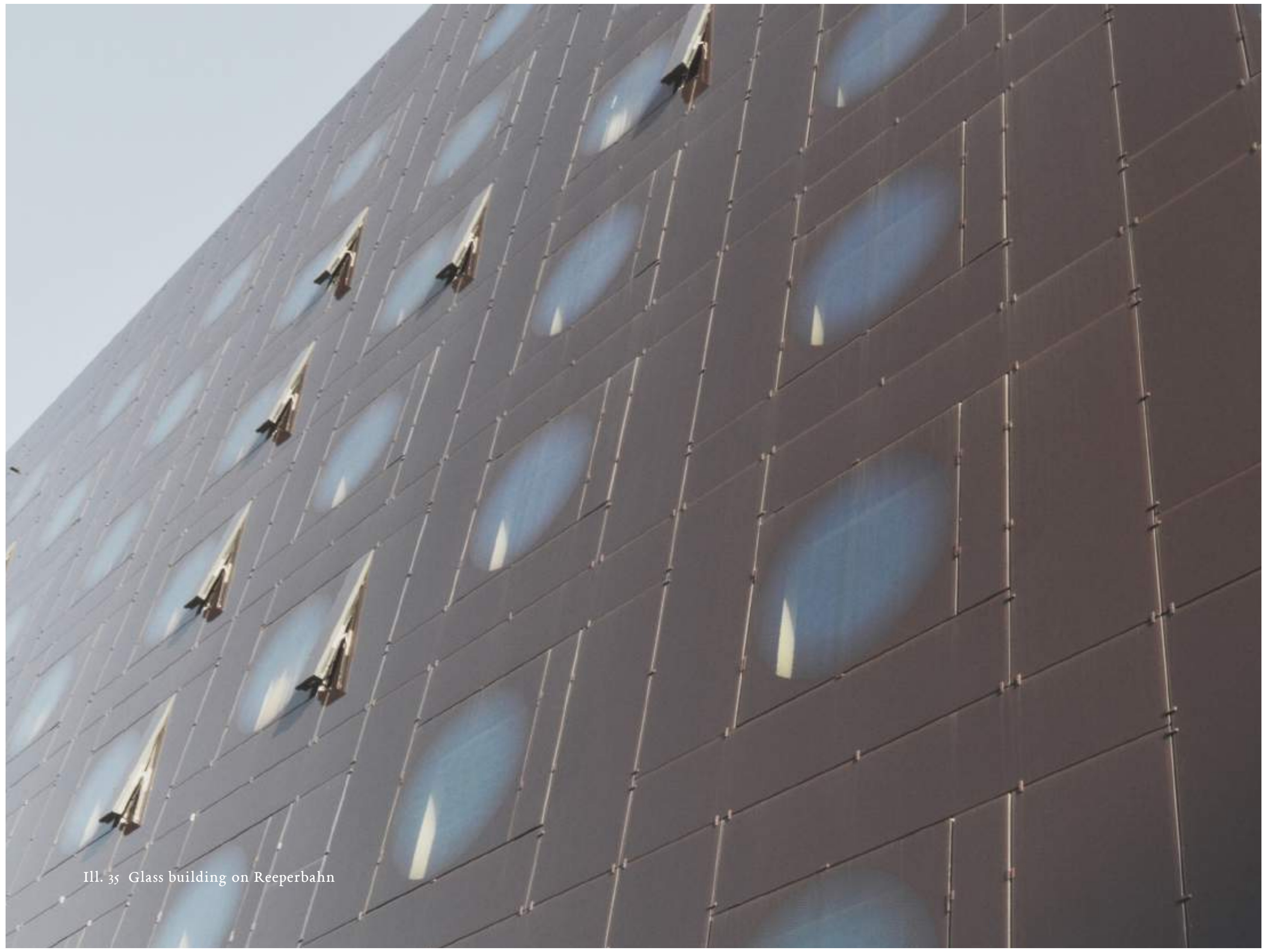
The urban spaces within this area are greatly influenced by the activity during the day (Ill. 30) and the lack of it at night. The gated entrances create a clear division of private and public spheres and together with the private gardens between the buildings often leave the urban spaces empty or as passages (Ill. 31).

## OLD BLOCKS WITH MIXED USE

The older neighborhood towards West is characterized by having blocks that has mixed functions; apartments, schools, commercial spaces and nightlife. The area appears both as a calm family oriented neighborhood (Ill. 32) but also as an extension of Reeperbahn, having a school only a few blocks from clubs with a sexual nature where no women or under aged people are allowed (Ill. 33). Introverted and extroverted functions are implemented into one smaller area (Ill. 34), creating a contrasting environment both for families and entertainment.

## CONCLUSION

It is evident that the area is contrasting both in terms of functions and appearance. The site will be facing both the extroverted Reeperbahn as well as the introverted blocks, becoming the connecting link between the areas. Therefore, the site will have to both relate to all the different functions, atmospheres and appearances as well as becoming a typology on its own.



Ill. 35  Glass building on Reeperbahn

## MATERIALITY

This analysis is made to further investigate the tactility and materiality that also influences the atmosphere of the area. Atmosphere and materiality is closely connected and, as earlier mentioned, the area is very dynamic in terms of functions which also becomes evident in the wide variety of materiality and tactility found in the area.

### REEPERBAHN

As in the 'Atmosphere'-paragraph, the materiality changes depending on the area and when looking specifically at Reeperbahn there is a distinct use of glass, metal and concrete. The rough materials are reflected in the neighborhood, as it is a red light district. All the different functions fights for the attention of the spectator, trying to both entertain and lure people in, which is the reason for the very colorful and lit facades. Some of the newer facades are grander than the older, using glass, metal and lights in order to appear clearly between the other buildings (Ill. 35).

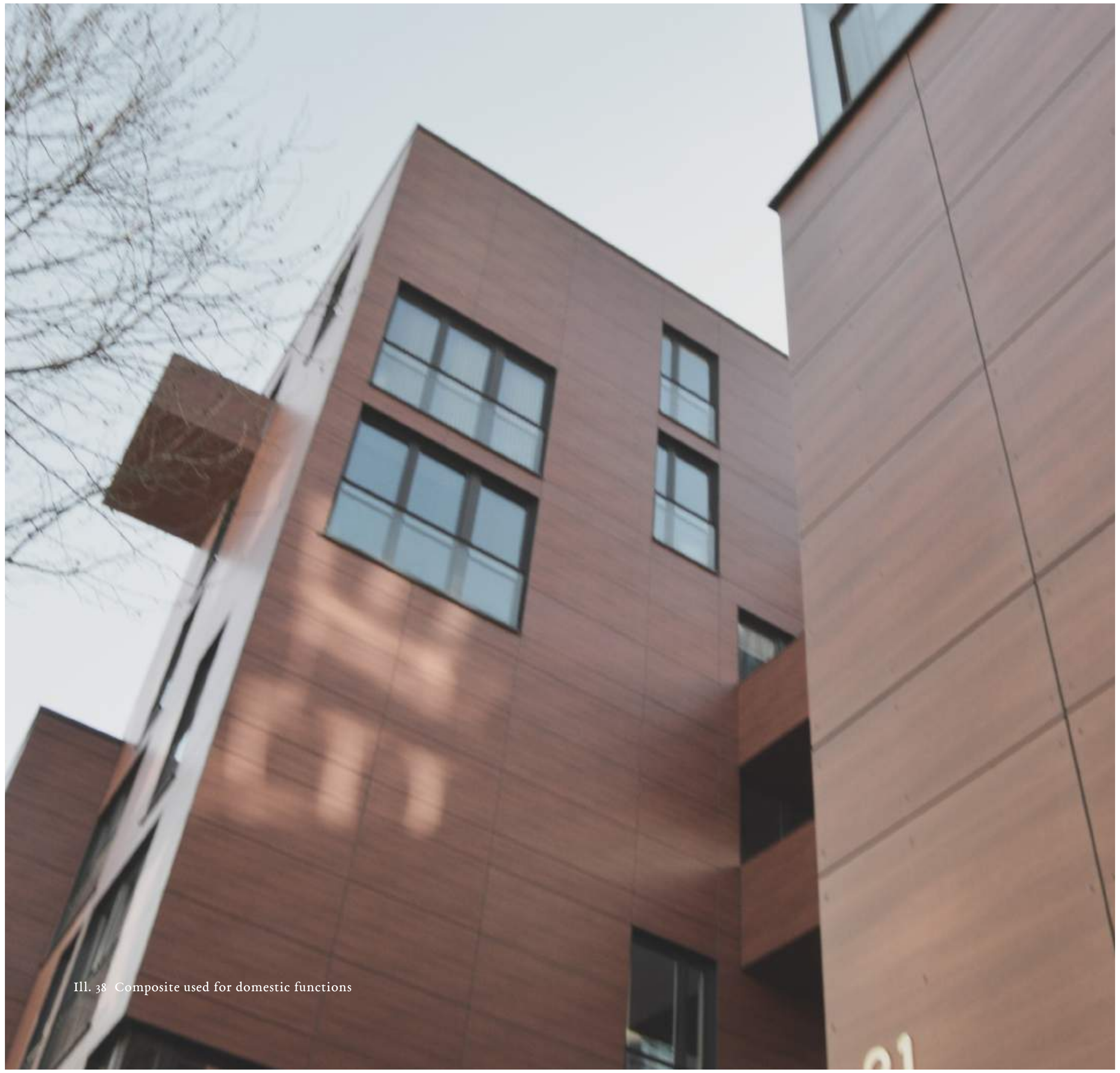
### OLDER AREAS

The older areas were built after the Second World War, which means that the materiality, in the area just surrounding the site (Ill. 36) and the older area (Ill. 37) towards the West, is characterized by a prevalent use of brick and painted brick facades. The roughness



Ill. 36  Use of different types of stone

Ill. 37  Brick and painted facades



Ill. 38 Composite used for domestic functions

Ill. 39 Bricks used for domestic functions

Ill. 40 Highrise where glass and metal are used

and tactility of the old brick has in many cases become less prominent by painting the facades, creating many colorful compositions in the scene of the streets.

## URBAN RENEWAL

The newly developed area South of the site is different in the choice of materials, of course some of the materials relate to the surroundings by using brick (Ill. 39), but mainly metal, glass (Ill. 40), composite (Ill. 38) and render materials are used for the facades. These types of materials are often seen in newer office building (glass and metal) and apartment blocks (composite and render), the functions that also occupy this area. The materiality of the office buildings come across as being cold due to the big amount of glass and metal used, whereas the apartment blocks come across as both warm and rough due to the use of brick, reddish toned composite and white render.

## GENERAL REFLECTION

In general the materials used tell a story of an area being affected by the Second World War, being rebuilt after many buildings were destroyed and having to transform the rebuilt in order to have a good building standard. The transformation has had an influence on the materiality, especially in relation to the otherwise rough materials in the surrounding area. Therefore it quickly becomes evident that the coherence in the materiality is not equally prevalent when looking at all the areas as one.

## SUMMARY

The site is located in a diverse area St. Pauli, facing Reeperbahn that is characterized by being the red light district in Hamburg. When looking at the area both in terms of building heights and functions, the diversity of the area increases. The buildings in the area vary from 1-22 storeys which include entertainment functions, apartment blocks, offices and cultural functions. Closest to the site the buildings have a general height between 3,5-5,5 storeys, which the new development has to relate directly to. In terms of functions, the site has to relate to cultural functions, such as theatres and an opera, domestic functions and mixed-use buildings where domestic, commercial and entertainment functions are included.

When investigating the site in a broader perspective infrastructural patterns, urban area and green and blue structures emerge. The infrastructure is characterized by having heavy traffic along the Reeperbahn, which is separated from the site by Spielbudenplatz, and otherwise having light traffic in the close surroundings. This creates an optimal environment for pedestrians, which is enhanced by the amount of urban spaces in the area. Furthermore, the site is located not long from the inner green circle and one of the radiating green axes towards the East and the Elbe River to the South.

The site is enclosed by 5 storey buildings both to the West and South, with the addition of a few 20 storeys building further away. This creates possible issues of achieving desirable sun conditions in the lower placed dwellings and at ground-level, especially at the South edge of the site. Even though sun conditions are rather equal in the summer period seen over a whole day, the analysis results shows that the conditions change a lot troughout the day, and different areas have better conditions and different times of the day.

As earlier mentioned the area is diverse in terms of functions but also in terms of appearance and atmosphere. The atmosphere can be spilt into 4 contrasting areas; Reeperbahn towards the North, the classical blocks towards the South, the urban renewed area and older blocks towards the West. The areas are different in the way of relating introvertly or extrovertly to their surroundings, which underlines the diversity within the area. The atmosphere is emphasized by the difference in the materiality, having the Reeperbahn that is colourful and sometime cold in the materials, the older areas, where mostly red brick is used and then the urban renewed area, where the materials are an image of the functions within the buildings.



Ill. 41 Hans-Albers-Platz close to Reeperbahn


Ill. 42 Spielbudenplatz with view to Reeperbahn (www.commons.wikimedia.org)



# FRAMEWORK

*Sustainability, Urbanity and Living*

# OUTLINE

Designing buildings within a certain context is always a complex issue, or rather it should be. Whether the architects wish to design a building that stands out as an iconic figure, demanding attention, or a building that adapt to its surroundings, the context should never be ignored. The Cambridge Dictionaries Online defines complexity as; "the state of having many parts and being difficult to understand or find an answer to" (Cambridge University Press n.d.) and indeed complexity first occurs when several contexts (or parts of it) are introduced. There are the obvious contexts; the physical and the social, as introduced earlier. But this chapter will further introduce three concepts, though there are nothing new about these, we will introduce them as a contextual concept, all part of a holistic approach to building design. The concepts are Sustainability, Urbanity and Living. These are relevant to discuss as they have always been present, but definitions and views changes over time, as they respond to societal changes and future prospects. It is within this scope that the concepts as these appear as contextual parameters, as they are subjected to personal opinion. The architecture is inevitably a product of the specific understanding of what is sustainable, how our cities should be shaped and how we live in our homes. For this reason it will be discussed how these notions are understood within this specific project and how they influence each other, and specific design parameters will be extracted.

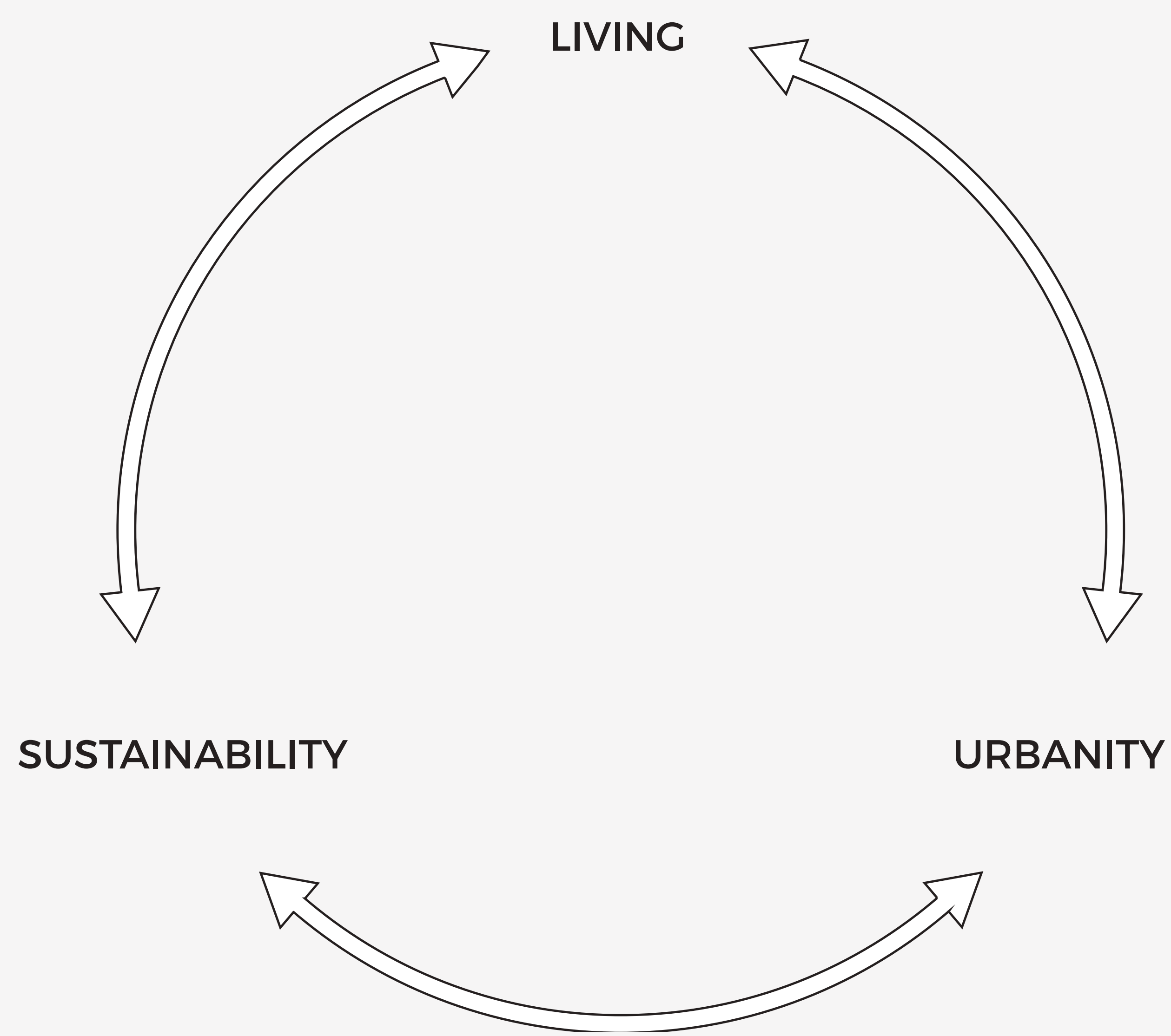
### SUSTAINABILITY

In the building industry the term sustainability is often varied. The wording itself suggest something with the ability to sustain certain conditions on a long-term basis, a description that is here considered to be insufficient. To reach a sufficient definition the possibility of improving, or ideally solving, present and future problems in our society will be added. This regards both environmental and social aspects; such as energy efficiency, green areas in our cities, rapid urbanization, social diversity and personal comfort. A design solution will never be able to solve all of these issues, but this is the definition it will be evaluated against.

### URBANITY

When assessing the quality of a city, you look at its parts; its buildings, parks, open spaces, infrastructure and then you try to understand how all of these elements connect in a form of symbiosis. In any case the quality of the city depends on how its singular elements interact with the rest of the city. Therefore, it is important when designing one of these singular elements, in this case a building, that it is carefully considered how it will connect to the city and add value to it, so that the building will not just be in the city, but will become a part of the city.






Ill. 43 Diagram showing design approach

### LIVING

When designing new sustainable housing it is important not to forget that at the end of the project these houses will have to be turned into homes. This is the place we spend most of our lives, so there should be comfortable indoor environment, plenty of light and it should be a safe and relaxing place that can be a break from the busyness of the city.

# SUSTAINABILITY AND LIVING

## ENERGY STANDARDS

When discussing sustainability of buildings, a good place to start is to choose which set of building standards to follow. In this project the Danish Energy Frame 2020 (BR2020) and the German Passive House Standard (PHS) is considered most relevant, based on our prior experience with the Energy Frame 2020 and the site location in Germany.

There are some differences in the way the two standards calculate the energy demands and the required key demands also differ (Ill. 44).

Even though the units used seem the same that is not the case. The Energy Frame 2020 uses heated floor area when calculating the energy demand. This is calculated by adding the gross areas of all parts of the building that are within the building envelope, measured from the external surface of the external walls, which means that both external and internal construction elements are included in the total area. In the Passive House Standard the area used is called Treated Floor Area (TFA). This is the usable living area and it excludes both outer and inner walls. (Intenational Passive House Association n.d.)

When calculating the energy use, the term ‘primary energy’ is used when comparing different energy types. In the Energy Frame 2020 energy from district heating is multiplied by a factor of 0,6 and electricity by 1,8. These are politically decided factors that are changed from time to time and are supposed to take energy loss during transportation of different energy types into consideration. These factors vary nationally and are not the same in the PHS.

What is actually included in the two different calculations also vary a lot. The main difference is the inclusion of lighting, auxiliary electricity and electrical appliances, which all are highly related to differences in user behaviour. As an example, families with teenagers will likely have a much higher electrical use from appliances than a family with small children; a difference the Energy Frame 2020 does not require the designer to recognize (Ill. 50).

Even though the two standards are calculated very differently and are very difficult to directly compare, both are considered to be high demanding energy standards. In the framework of this project it is considered to be of less importance what standard to follow because, while having in mind that certain criteria must be upheld from a legislative point of view, it is important to realize that the energy standards should not be the end goal itself. They should rather be the means to the end, where the end is sustainable quality buildings. With this in mind it has been decided to use the Danish Energy Frame 2020 because of access to and experience with its accompanying certification software Be10, but with the addition to make an effort to take user behaviour into account as well.

## USER BEHAVIOUR

It is not hard to imagine how measures of sustainability influence how we live in our homes and vice versa. The performance of low energy houses is in practicality closely linked to the different habits and idiosyncrasies of its inhabitants. If the buildings calculated energy frame should reflect the real-life situation, then user behaviour should be taken into account. Recently, a study by the Danish Statens Byggeforskningsinstitut showed a disappointing tendency in newer low-energy houses in Denmark. Comparing these to older, and less performing, houses, the differences in heat consumption was much lower than anticipated by only being slightly lower in the new houses. The study showed a considerable inconsistency between the calculated energy frame and the actually usage, a difference credited to a change in behaviour of house occupants. When people renovated their house to better energy performance or moved into a newer building, they seemed to change their behaviour accordingly, as one of the interviewed in the study said, “We probably have it a little warmer now, than before we got the heat pump.” (Gram-Hanssen 2015, p.12) Though the author of the study states there are some insecurities in the precise average values, the conclusion still holds. As the author states: “The objective of energy saving in our homes only is reachable, if we in the future include the users everyday habits in our work with energy saving.”(Gram-Hanssen 2015, p.13)



| COMPARISON | Energy Frame 2020 (BR2020) | Passive House Standard |
|---|---|---|
| Total energy frame | 20 kWh/m² per year | 60 kWh/m² per year (Classic standard) |

| COMPARISON | Energy Frame 2020 (BR2020) | Passive House Standard |
|---|---|---|
| Included | Heating | Heating |
| | Cooling | Cooling |
| | Domestic hot water (DHW) | Domestic hot water (DHW) |
| | - | Dehumidification |
| | - | Lighting |
| | - | Auxiliary electricity |
| | - | Electrical appliances |

Ill. 44 Comparison of the Danish and German energy frames

## USER TYPES

While the above mentioned might be presented as a static situation, this is not the case. On the contrary, it is important to understand that these habits of the user change over time. In a given home, living needs will change in many different ways and therefor living settings should as well. New inhabitants can move into the house, the conditions of the exiting user can change; a child being born, older kids moving out, divorces, etc. or social structures might evolve, over a larger time span, into whole new ways of living. Flexibility must then be inherent in the design of the building to accommodate these changes. By flexibility is meant “internal alterations and additions to dwellings created to express and accommodate different patterns of life.” (Dalziel & Sheila Qureshi 2012, p.26) Examples of ways to achieve flexibility can be mentioned; absence of hierarchy in the main rooms, understood as rooms that can be used for a variety of purposes; clear structural spans to allow multiple configurations of spaces; ease of adding to, changing or updating services such as plumbing, ventilation and wiring. (Dalziel & Sheila Qureshi 2012, pp.28–29)

## ECO-EFFICIENCY AND ECO-EFFECTIVENESS

When discussing sustainability on a more conceptual level, there are two general aspects to it. One is to reduce the buildings negative impacts and the second is to increase its positive impacts on the environment. These two approaches are notions from the Cradle To Cradle certification and is called eco-efficiency and eco-effectiveness respectively. (GXN & Vugge til Vugge Danmark 2013, p.13) The first idea often relates to how little energy a building uses and reducing its consumption, while the other has more to do with achieving positive outcomes that are beyond what is just sustainable. Where eco-efficiency can be seen as ‘doing less bad’, eco-effectiveness can be seen as ‘doing more good’. This can be comfort in people’s homes, healthy daylight conditions or quality of life in general.

## URBANITY AND SUSTAINABILITY

The buildings we live and work in are increasingly better performing in terms of energy consumption, but while this is a positive development, it is also a necessity to focus on what happens between our buildings; transportation. It is important to increase the use of low energy consuming modes of transportation such as walking, bicycle and public transport. An obvious solution is to decrease the distances of which we travel on a daily basis so it is possible to bike to work and school, have a supermarket within walking distance, etc. Robert Dalziel arguments: "Not only does the compact city have the potential to be a more enjoyable, richer environment, but it is indisputably a more practical and more sustainable one, reducing, as it does, the time, distance, energy consumption and exhaustion associated with the journeys we all regularly make." (Dalziel & Sheila Qureshi 2012, p.18)

So when aiming to achieve this 'compactness', it is worth discussing how density of our cities is evaluated. Is the aim to maximize the number of supermarket and schools in a city district? Or is it the number of dwellings per $km^2$? The answer could be neither and both. Urban functions in a district need a certain critical mass of inhabitants in the area to be supported, so even though a high density of urban functions is desirable it needs to match the density of inhabitants. This means that the number of dwellings per $km^2$ is not sufficient either, because it does not differentiate between large and small dwellings. (Dalziel & Sheila Qureshi 2012, p.19) Better is habitable rooms per $km^2$, because it is closer related to population density in an area. In the end it is more important not to be too concerned with the quantity of density, but rather the quality of what effects a certain density brings to the city district.

### POTENTIALS OF DENSITY

The potentials of dense cities, as Robert Dalziel mentions in 'A House in the City', goes beyond lessening energy consumptions. When a city become denser, the quality of life in the public spaces become increasingly important. (Lampugnani 2012) A dense city will, in most cases, result in less private space per capita and as Dieter Hoffmann-Axthelm puts it: "A promising model would be to cut back on (ultimately a cultural process) private self-realization within one's four walls, which entails a significant amount of space, in favour of societal options – meaning less luxury in the private sphere yet more in the public realm."(Hoffmann-Axthelm 2012, p.113)

This luxury can come in many ways, but the most essential is rich cultural and social opportunities. To insure a thriving city it is important to have e.g. sports facilities or similar where kids can grow social bonds, music venues, theatres, bars, cinemas and parks as leisure activities. Green areas are also a source of increasing the quality of life; as recent research indicates, moving from less green urban areas to



Ill. 45 View of Spielbudenplatz, St. Pauli (www.spielbudenplatz.eu)

greener urban areas have positive and long lasting effects on mental health. (Alcock et al. 2014)

It is also important to realize that cultural and social needs change over time; our cities and by extent our buildings, need to be able to adapt to these changes. If a building is not designed with principles of adaptation in mind, the functionality of the design will only be rational at its initial usage. As functional needs of the urban area/district changes historically, so does the demands of the given building and if its functional space cannot change, neither will the usage of the building. In this situation there will be a discrepancy between design and needs, which is in no way sustainable. (Sennet 1976)

Social diversity is presently a pressing issue with continues immigration to European cities and the related social issues around Europe. This is due to the clash of vastly different cultural and religious ethnicities, but it should be noted that having a high demographic diversity in the cities makes it possible to achieve a critical mass for a wider range of social and cultural functions. Achieving a high social diversity is desirable as the interplay between different cultures and groups can spark unforeseen and multi-layered urban dynamics. (Mueller Inderbitzin 2012)

There is little doubt that there is a need to increase density within the cities and the main challenge from a design perspective is summed up by Hans Gangoly in the editorial of an issue of the Gras Architectural Magazine: "Therefore, the issue of spatial conditions in a densified city must be associated with urban design approaches the defines forms which makes us want to move closer together."(Gangoly 2012)

# LIVING AND URBANITY

Invigorated public spaces and ground-level zones are a desired product of high population density and it will lead to lively and vibrant urban atmospheres as part of the daily city life. But as an inherent part of a social diversification, not all people will have the same needs or behaviour. Even though our cities should "support all manner of ethnic, religious, intellectual and social pursuits ...and be full of places to meet, to work in, to celebrate." (Dalziel & Sheila Qureshi 2012, p.18), homes should be designed to be places for shelter and privacy. When discussing the model for inner-urban expansion Ida Pirstinger states that: "Tending to a varied need for interaction is an advantageous equilibrium between privately and collectively used areas as well as the preservation of clear spatial separation between private and public space, higher population numbers and social diversification; and, thanks to the involved diversity, these factors also foster chances both for cultivating sociable activities and for sustaining privatness and anonymity." (Pirstinger 2012, p.235)

## APPROPRIATION OF SPACE

This spatial separation can take many forms, but the boundary between private or public have many purposes. It clearly marks where the private sphere begins and where the public are no longer 'allowed' to enter or stay. Jane Jacobs states this aspect as the first of three key qualities that a well-functioning city street must have for it to be a valuable part of the city. Because having a clear demarcation between what is private and public lets the residents of a given community or household adopt this boundary, letting them make their own in a sense. This is important because it leads to the second key quality by Jacobs. Having natural proprietors of the street will ensure that crime will be discouraged and safety for both the residents and strangers maintained, due to the eyes on the street. The third key quality is that the sidewalk must be used regularly, because as she states "Both to add to the number of effective eyes on the street... and nobody enjoys sitting on a stoop or looking out a window at an empty street." (Jacobs 1961, p.117) and "That the sight of people attracts still other people."(Jacobs 1961, p.119)

Different typologies of building and urban design facilitate this to different degrees. Spaces can be designed with a specific use in mind that are unconsciously understood by its users, but Michael Walzer goes further and emphasizes the 'mindedness' of spaces. While the purpose of a certain space is predetermined by its designer; you walk on the sidewalk or you eat and drink in the café, the mindedness of the spaces is how "Its design and character stimulate (or repress) certain qualities of attention, interest, forbearance and receptivity... what it means to be 'there', and because of the look and feel of the space itself." (Walzer 1986) He distinguishes this in two main categories, single-mindedness and open-mindedness. As examples he gives the green belt as being single-minded, the city park or playground as open-minded and the housing project as single-minded, the urban block as open-minded. The green belt invites to little more than the originally thought functionality. It might be aesthetically appealing and bring a certain quality to the area, but its function is fairly fixed. The city park on the other hand stimulates a wider range of activity. It is less restrictive in its use and leaves more to the creativity and needs of its users. Not to say that one is better than the other, but the idea of open mindedness is central when discussing the user's appropriations of a certain urban space.

In order for a space to be receptive for appropriation and customization it must be designed with the



Ill. 46 Gated entrance to domestic building in St. Pauli

notion of open mindedness in mind. Nigel Bertram have trough many years of architectural research and design practice tried to find the answer to how human experience metropolitan-scale decisions. He notes that environments where form and function are perfectly fitted and controlled, do not encourage improvisation; "On the contrary, a lack of fit or loose fit between a given situation and what is required of it are catalyst for modification and appropriation."(Bertram 2013, pp.55–66) In other words, how residents of a building take ownership of the surrounding streetscape cannot be precisely controlled through the design of it, but the intention and opportunity should necessarily be present.

## DEGREES OF PRIVACY

Going from the privacy of the living room to the public of the city's town square, Jan Gehl states that in between there exist the semi-private and the semi-public. He talks about degrees of privacy in the physical structures and how these must be seen in relation to social structures and group sizes. The scale between private and public can be differentiated to different decrees, but the subdivision is important as "establishing residential areas so that there is a graduation of outdoor spaces with semi-public, intimate, and familiar spaces nearest the residence makes it possible to know the people in the area better" (Gehl 2011, p.59) and the appropriation of the space between what is considered private and public will benefit residents sense of belonging to the area. Also the establishment of communal spaces at various levels will permit movement from smaller social groups and spaces into gradually larger and urban spaces, giving a greater feeling of security.

# SUMMARY

### GENERAL SUSTAINABILITY

To summarize, this projects aims to culminate in a truly holistic design proposal that links environmental and social sustainability with ideas about how we live in our homes and cities. The final proposal will be designed with a high energy performance, specifically to comply with the demands in the Danish Energy Frame 2020, in a way that are resilient and accommodating to differences in user behaviour and types. It should be both flexible and adaptable to fit with variations of initial users and to changes to fit future needs. The proposal will not only seek to minimize its potential negative effects on the environment, but also to have a positive impact on is surroundings, by implementing measures of social sustainability.

### SOCIAL SUSTAINABILITY

The design will address issues of social diversity by creating a basis for interaction across different cultural and social groups, both between the building occupants internally and between its occupants and the surrounding community. In the design proposal there will also be a focus on comfort and health of its residents by securing good daylight conditions and good access to different types of green structures. Furthermore, there will be a balance between individual needs of the occupants and the collective needs of the surrounding context of the city.

### CITY AND BUILDING CONNECTION

If a building should take part of the qualities of a city, it should also give something back. There should be a symbiosis between city and building so that the individual building is a part of the overall qualities of the city. The building will participate in the densification of Hamburg, but rather than being too concerned with the quantity of density, the attention will be on the effects a certain density will have on the city district and what qualities it brings with it. Commercial functions in the building will be balanced with the existing population density and urban functions in the area, so that there will be a critical population mass to support them.




Ill. 47 Urban life in St. Pauli (www.evoke.ie)


Ill. 48 Port of Hamburg



# PREFACE

*Vision and Programmatic Basis*

# VISION

The aim of the project is to create a hybrid building that includes both domestic and commercial functions in the district of St. Pauli Hamburg. The project has to contribute to the existing qualities of the urban setting while still creating the optimum conditions for living.

Within the project, environmental and social sustainable parameters will be included, by combining these parameters with both urbanity and living a highly holistic design solution will be achieved.

| DOMESTIC | People | Rooms | $m^2$ | Units | Total $m^2$ |
|---|---|---|---|---|---|
| Students | 4 | 4-5 | 80-90 | 30 | 2400-2700 |
| Couple + 2 kids or more | 4 | 4-5 | 90-100 | 30 | 2700-3000 |
| Couple + 1 kid | 3 | 3-4 | 70-80 | 30 | 2100-2400 |
| Couple | 2 | 2-3 | 60-70 | 30 | 1800-2100 |
| Elderly couple | 2 | 2-4 | 60-70 | 30 | 1800-2100 |
| Studio | 1 | 1 | 30-40 | 30 | 900-1200 |
| TOTAL | | | | | 11700-13500 |

| COMMON AREAS | People | Rooms | $m^2$ | Units | Total $m^2$ |
|---|---|---|---|---|---|
| Laundry room | - | - | 100 | 1 | 100 |
| Kitchen | - | - | 75 | 2 | 150 |
| Lounge/common rooms | - | - | 100-200 | 3 | 450 |
| Toilet | - | - | 10 | 6 | 60 |
| TOTAL | | | | | 760 |

| OUTDOOR AREAS | People | Number | $m^2$ | Units | Total $m^2$ |
|---|---|---|---|---|---|
| Urban/green area | - | - | 2890 | - | 2890 |
| Playground | 60 | 1 | 150 | - | 150 |
| Bike parking | - | 375 | 110 | 6 | 660 |
| TOTAL | | | | | 3700 |

| COMMERCIAL | People | Rooms | $m^2$ | Units | Total $m^2$ |
|---|---|---|---|---|---|
| Backpackers hostel | +100 | 20 | - | 1 | 500 |
| Shopping | - | - | 100-500 | 1-5 | 500 |
| Offices | - | - | 500 | 1 | 500 |
| Entertainment | - | - | 100-500 | 1-5 | 1000 |

Ill. 49 Room program

# ROOM PROGRAM

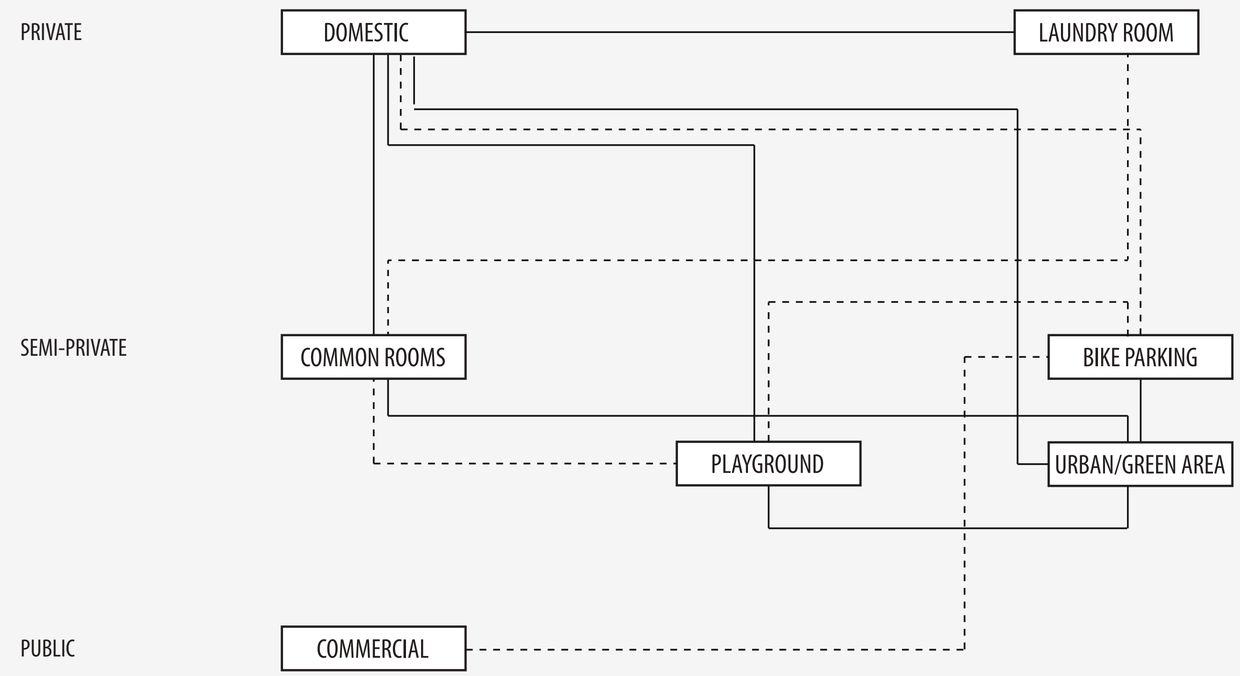
## ROOM PROGRAM

The room program (Ill. 49) is based on the competition brief from CTRL+SPACE, which means that especially the domestic functions in terms of size and numbers of units are inflexible. The project will have a total gross area of 17000 $m^2$ whereof the domestic functions should take up 15000 $m^2$ and the commercial functions should take up 2.000 $m^2$. This means that the focus of the project is on the domestic function, and that the commercial functions not will be detailed. The aim with the project is to create a development with a coherence between the building and urban space and furthermore create interior spaces that focuses on terms of living and optimal conditions for this, both in relation to spatial and technical parameters.

The technical demands of both the commercial and domestic functions will fulfil the Danish building regulation of 2020, which establishes some demands in terms of energy, temperature, ventilation and light that has to be fulfilled.

The function diagram (Ill. 50) shows the relation between the different functions and how private or public the function is. The continued line communicate that the functions are related directly to each other, on the other hand, the dashed lines communicates that the connection between the functions are indirect.





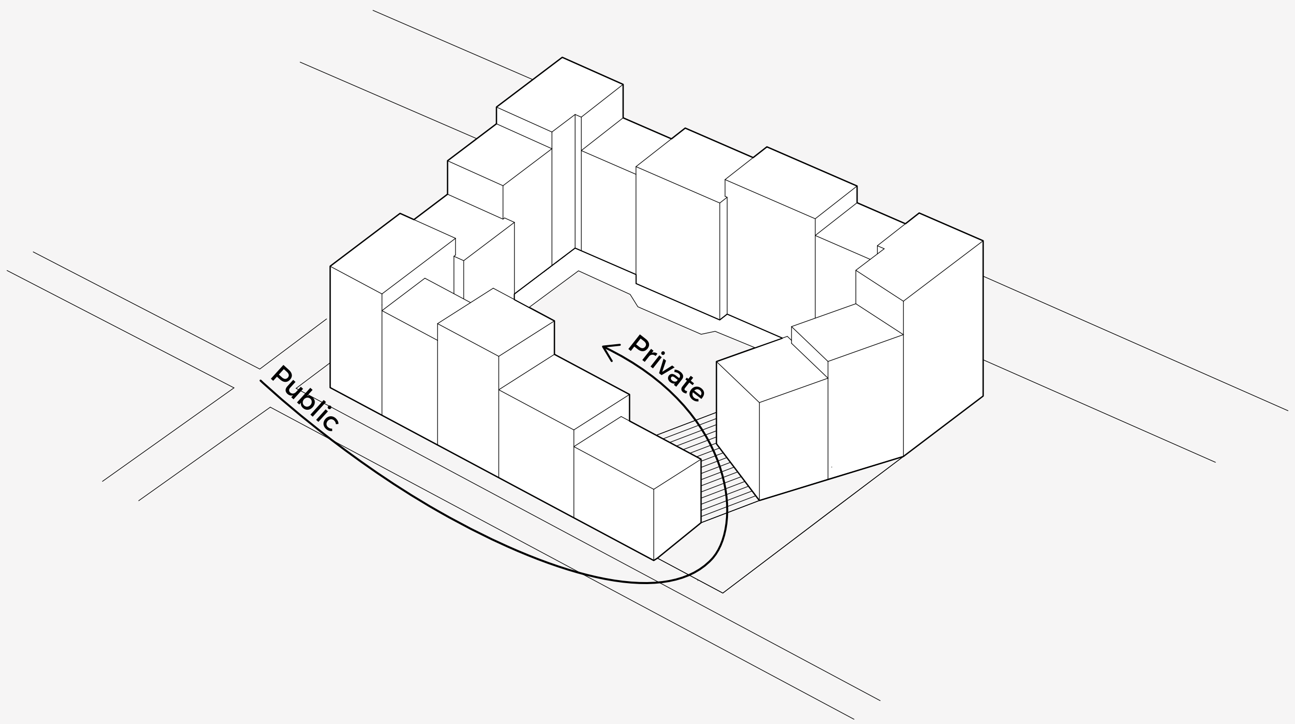

Ill. 50 Function diagram

# PRESENTATION

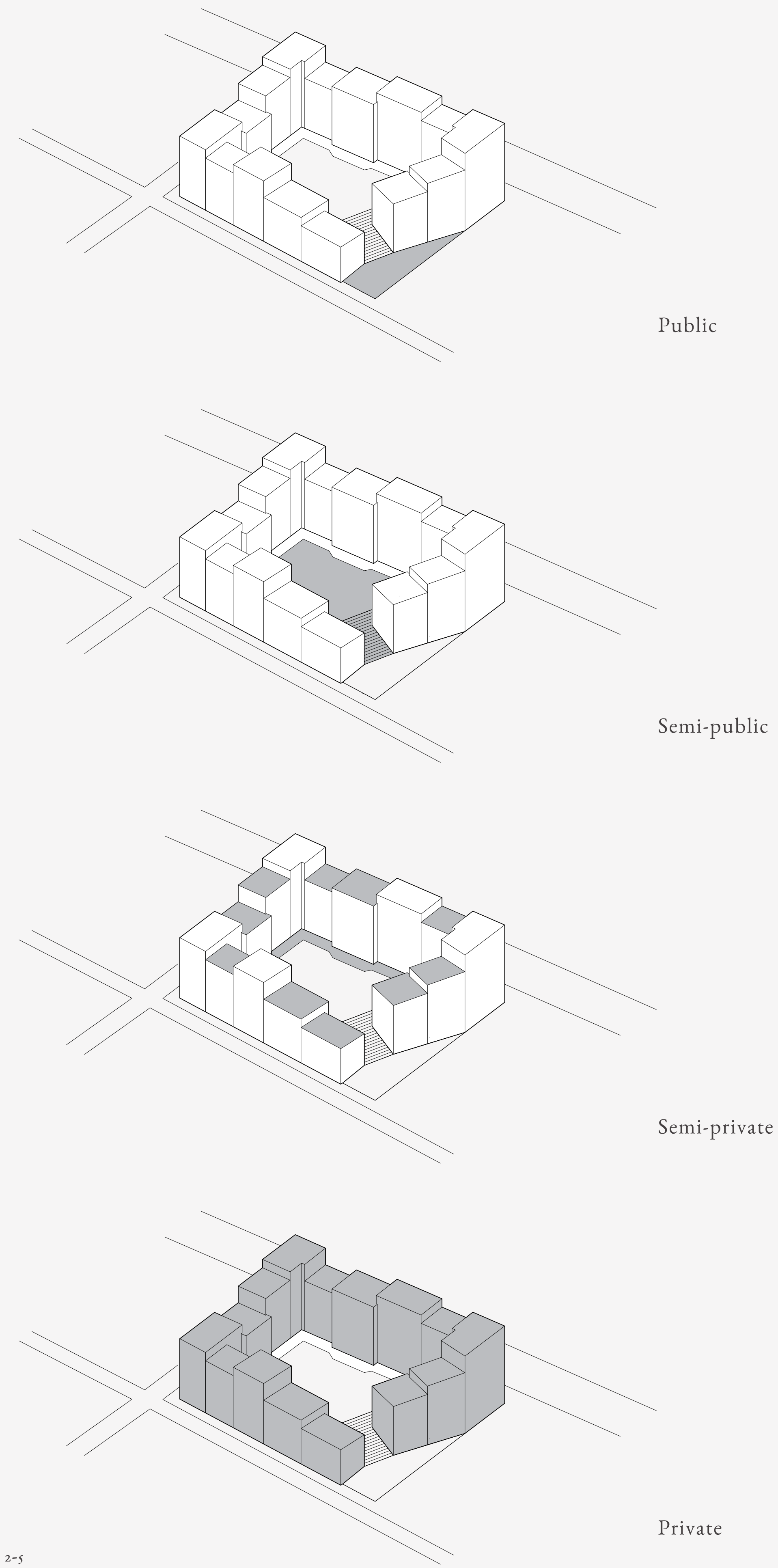
*Visualizing the Project*

View from the South East illustrates the streetscape in the courtyard in relation to the building volume.

Ill. 51 View from South East




Ill. 52 Concept diagram step 1




Ill. 53 Concept diagram step 2-5

## CONCEPT

The design proposal deals with the transition from public to private, moving between the two notions and engaging the city surrounding the building while still obtaining privacy for the residents. Located in a contrasting urban context, the building addresses both the extroverted character of the Reeperbahn towards the North and the introverted character of the domestic area towards the South, creating a hybrid building that ensures both privacy and easy access to public functions.

The building concept (Ill. 52 and Ill. 53) is exemplified as a set of interconnected spaces that represents different qualities in the spectrum between public and private, in order to obtain the needed privacy for the residents while providing qualities to the city.

A streetscape created by an elevating landscape defines a public sphere in front of the building that will be perceived as a gesture of openness. As the streetscape evolves the atmosphere becomes gradually more private, creating various thresholds that will be perceived throughout the courtyard. Residents can use spaces near the facades and on the roofs as semi-private common areas that clearly expresses a less public nature.

## SITE PLAN

The site plan (Ill. 54) shows how the block structure opens up towards the South East and connects the urban and green structures of the city with the courtyard, thus creating a streetscape. The courtyard consists of varying plateaus, ramps and stairs, creating both smaller niches for recreation, gatherings and three bigger programmed areas for the residents of the block, adding to the sense of community. By having multiple levels within the courtyard more privacy in the gardens are ensured, due to the main activities taking place on the plateaus below the level of the gardens. To add to the sense of community within the singular blocks, rooftop terraces are added as well as balconies, creating smaller semi-private and private spaces for the residents.

Ill. 54  Site plan 1:500

Ill. 55 Private gardens

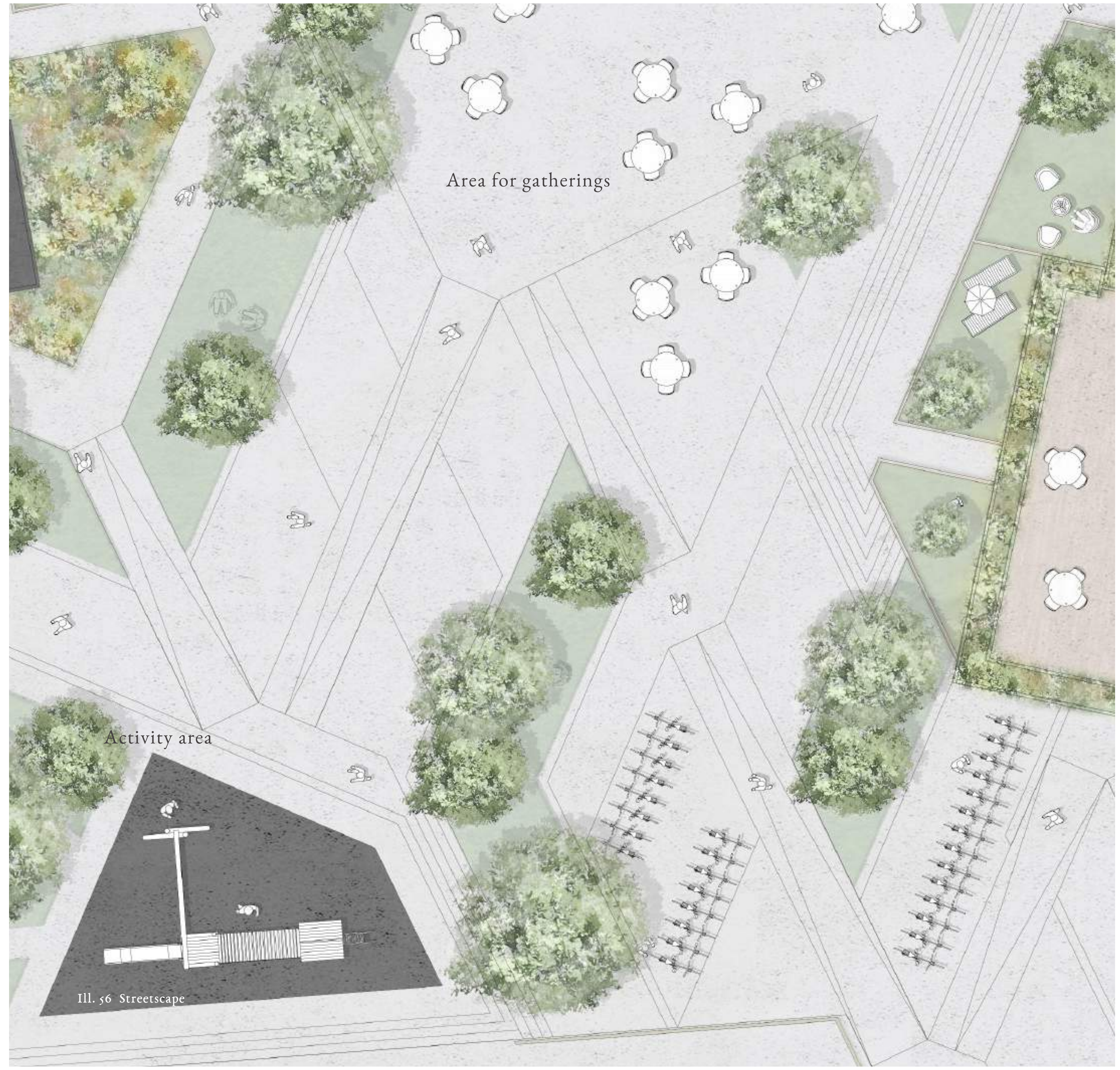
# OUTDOOR SPACES

The transition from public to private is expressed in the different types of outdoor areas. The courtyard is a semi-public streetscape (Ill. 56) that embraces the sense of community in a bigger scale, inviting all residents and other people to activate the space. By adding programmed areas such as an activity area, an ornamental garden and a space for gatherings as well as the non programmed areas on different plateaus, the courtyard invites all to interact.

Within the courtyard, on the Western, Northern and Eastern sides, private gardens (Ill. 55) are added in order to provide private outdoor spaces to the apartments on this level. As well as conveying privacy in the gardens a smaller path to the entrance of the singular blocks is formed, creating a more privatized entrance. In order to provide all apartments with private outdoor areas, balconies are added. The angled balconies ensure privacy as well as good daylight conditions.

The rooftop terraces (Ill. 57) are intended for the singular block, creating an outdoor space for the close neighbors to meet.





Ill. 56 Streetscape

Ill. 57 Rooftop terraces

The view from Reeperbahn shows how the building relates to the inferno of light that dominates Reeperbahn at night.

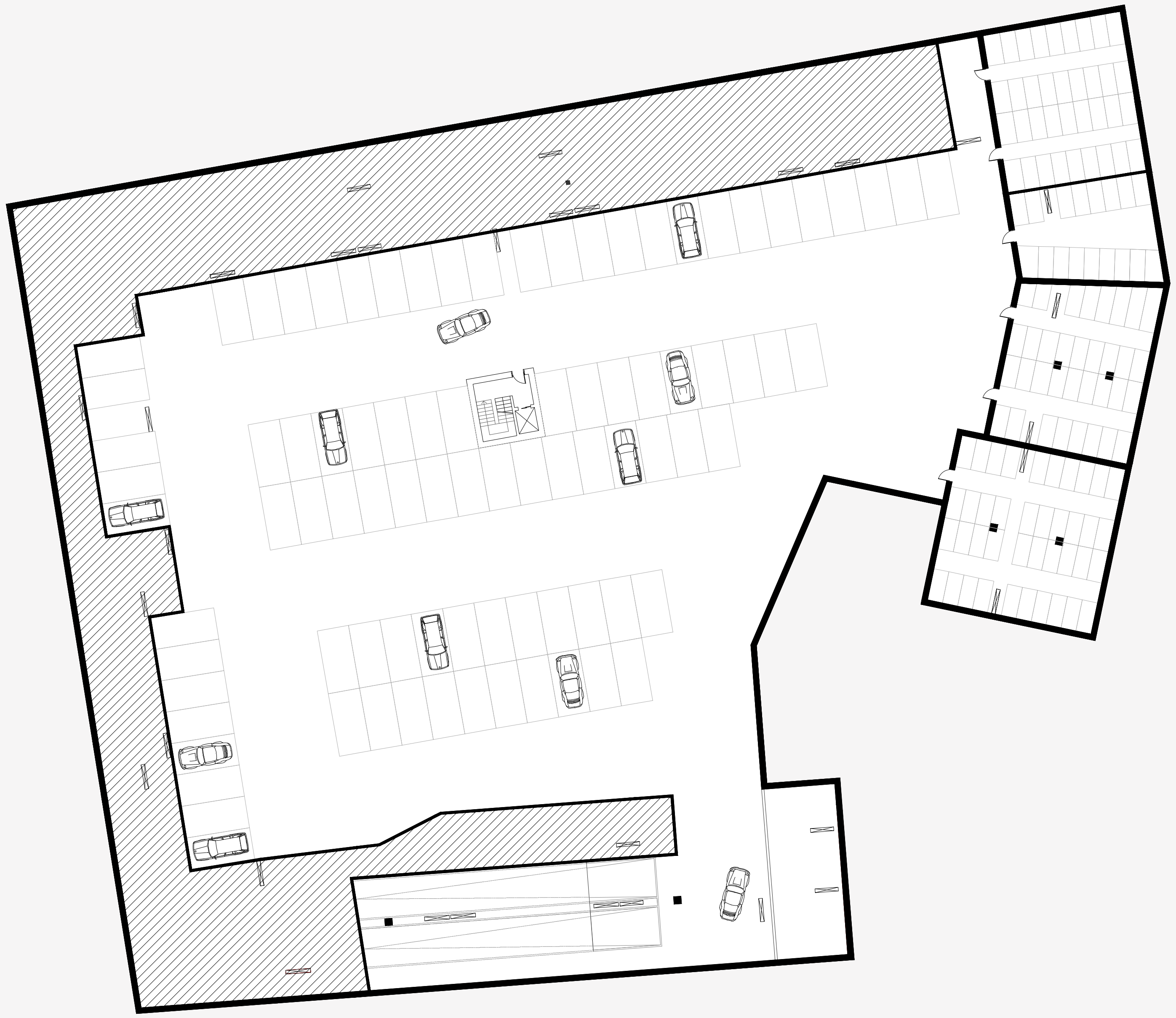
Ill. 58 View from Reeperbahn

# FLOOR PLANS

The floor plans (Ill. 59-Ill. 68) are designed with the notion of functionality in mind, ensuring the optimum layout of the apartments, creating the best possible setting for the residents.

The ground floor illustrates a proposal for the commercial functions that are orientated towards Reeperbahn and Taubenstrasse, a Back Packer Hostel and parking for the residents. When arriving by car, the entry to the parking is found on the South East side of the building to distance the residents from the otherwise high pace of the Reeperbahn and the commercial functions on Taubenstrasse. In order to ensure life and flow in the courtyard as well as interaction between the residents, access from the parking to the blocks takes place from the upper level of the courtyard, still providing level-free access to all blocks.

When entering the courtyard, the residents have access to the common areas on the first floor as well as access to the singular blocks, apartments and rooftop terraces.

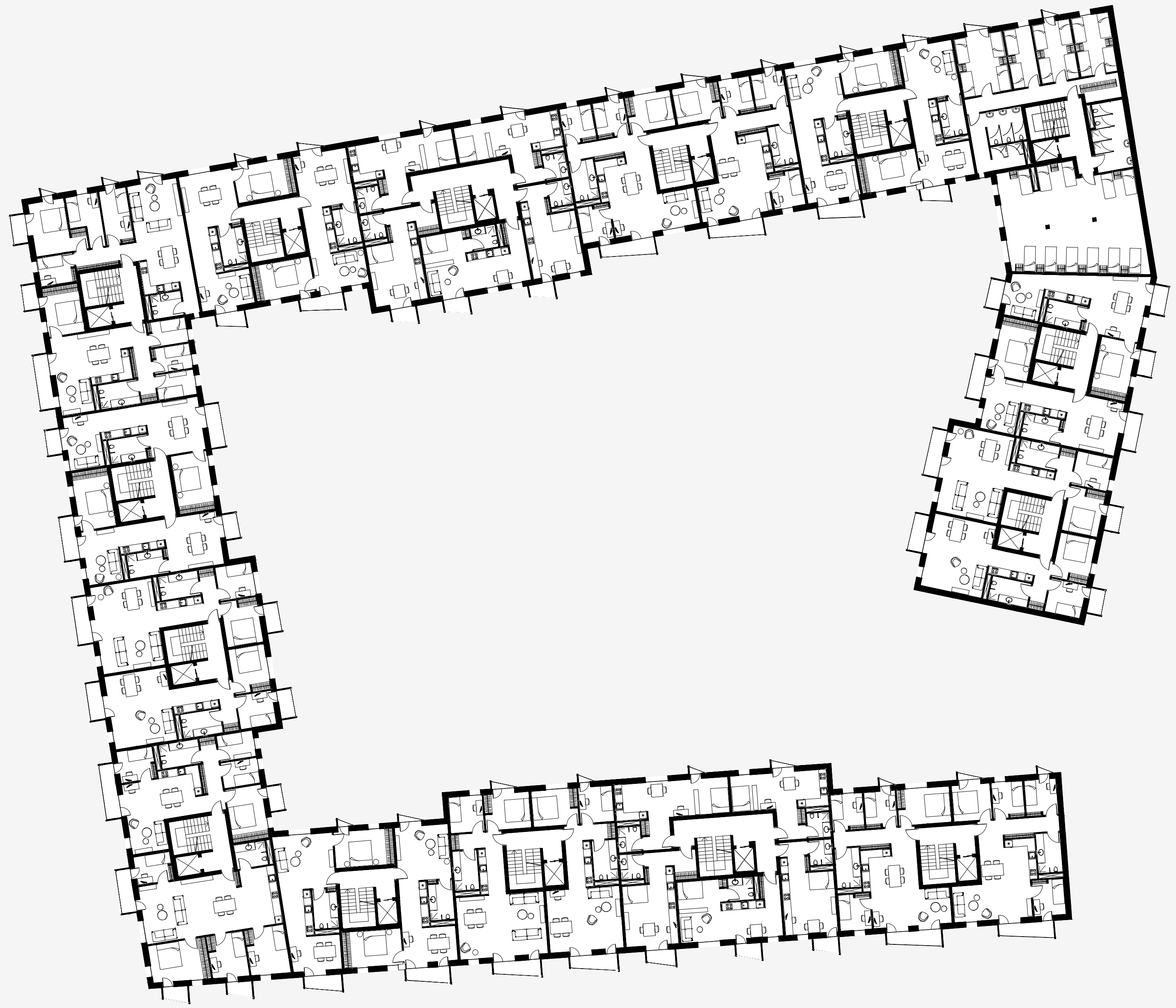


Technical rooms, storage, etc.

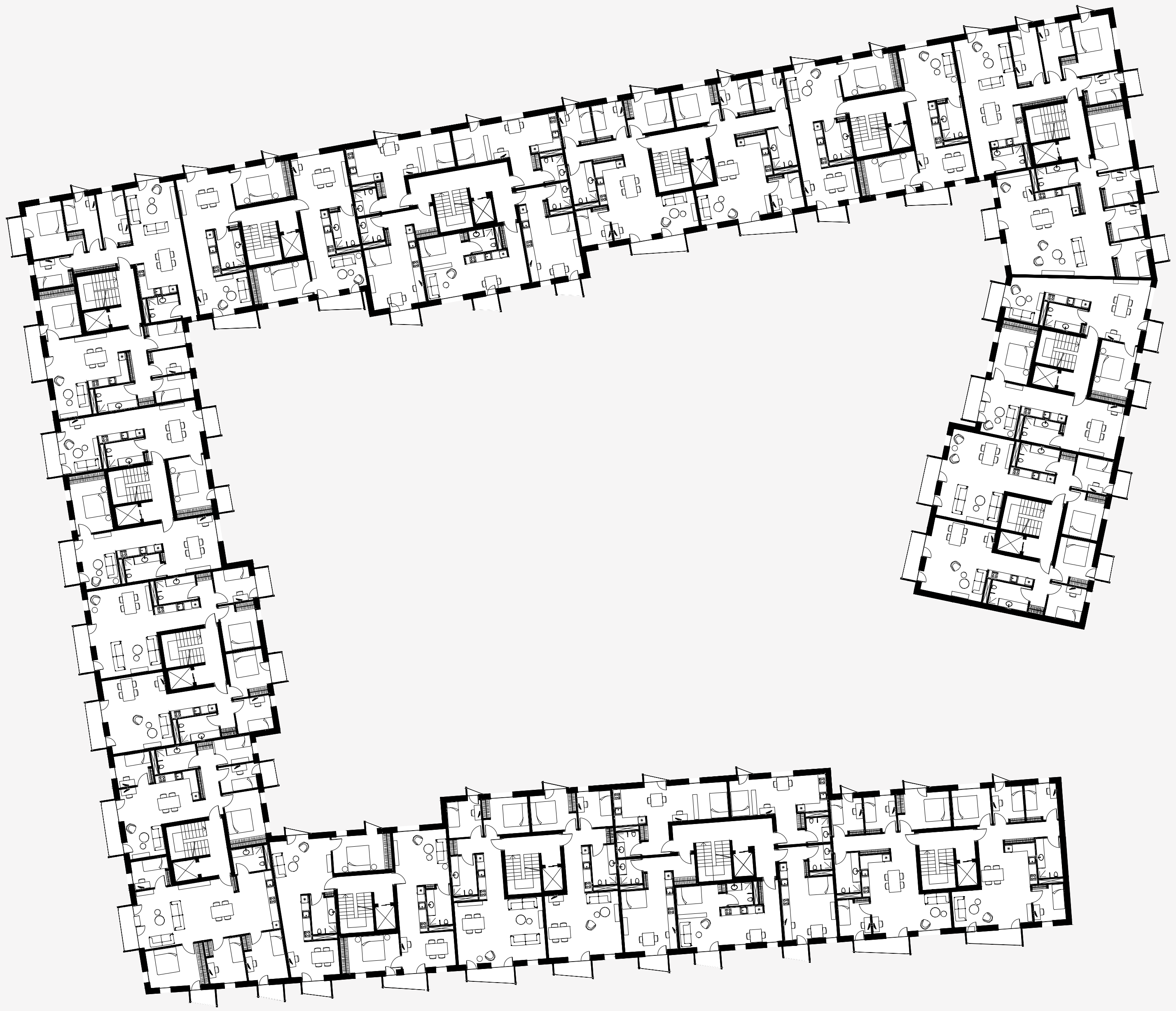
Ill. 59 First basement 1:500

Ill. 60 Ground floor 1:500

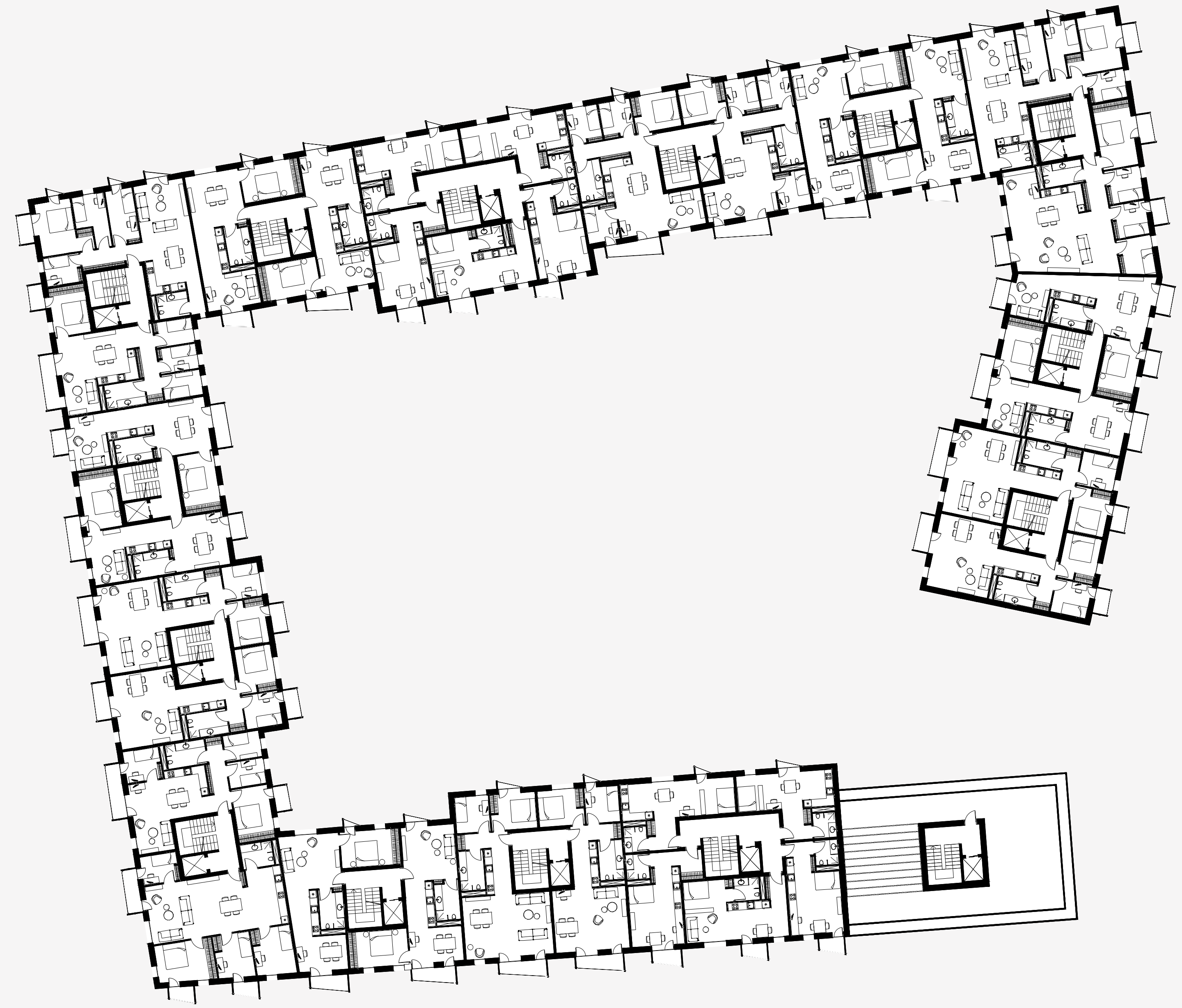
Ill. 61  First floor 1:500



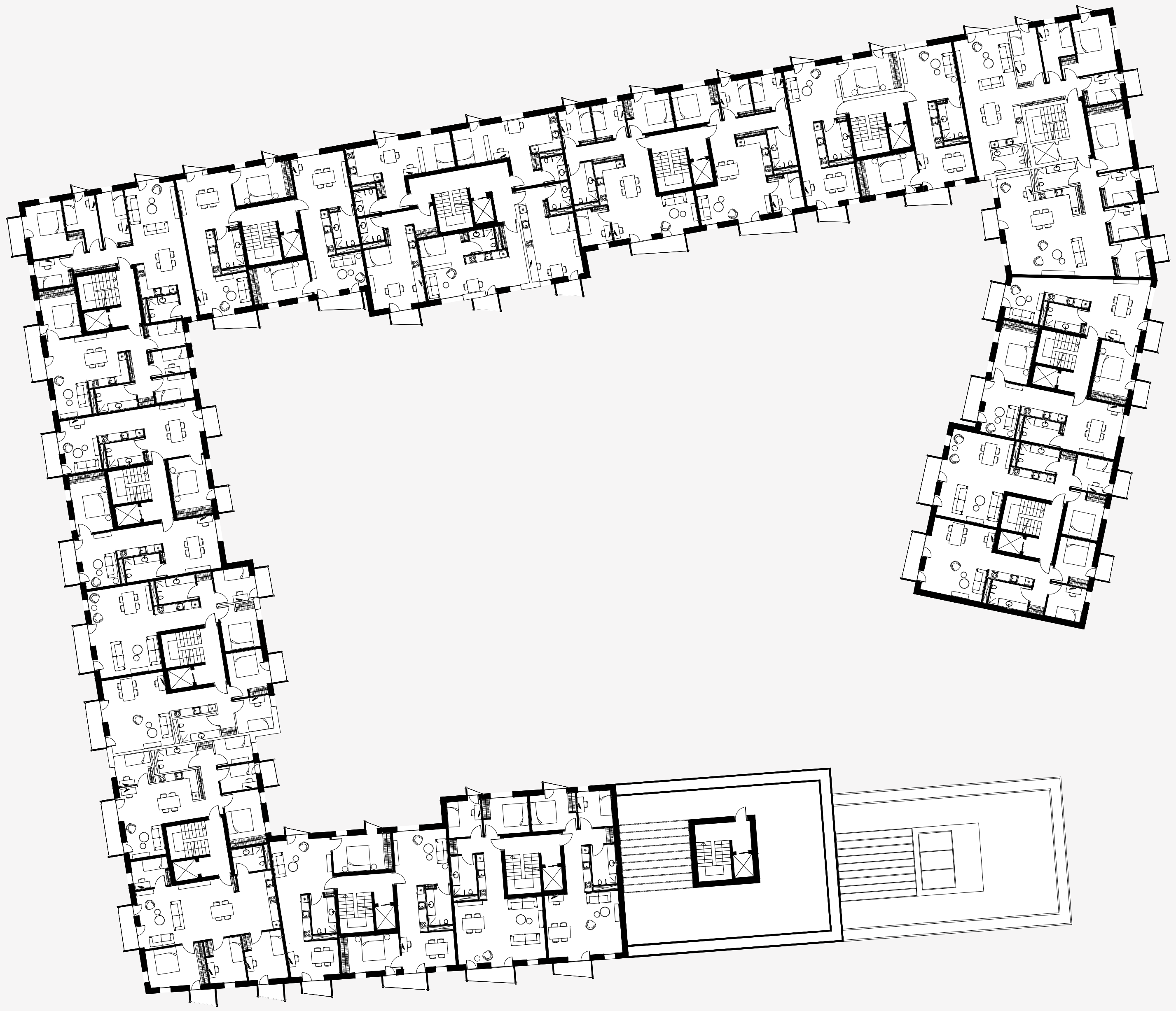
Ill. 62  Second floor 1:500



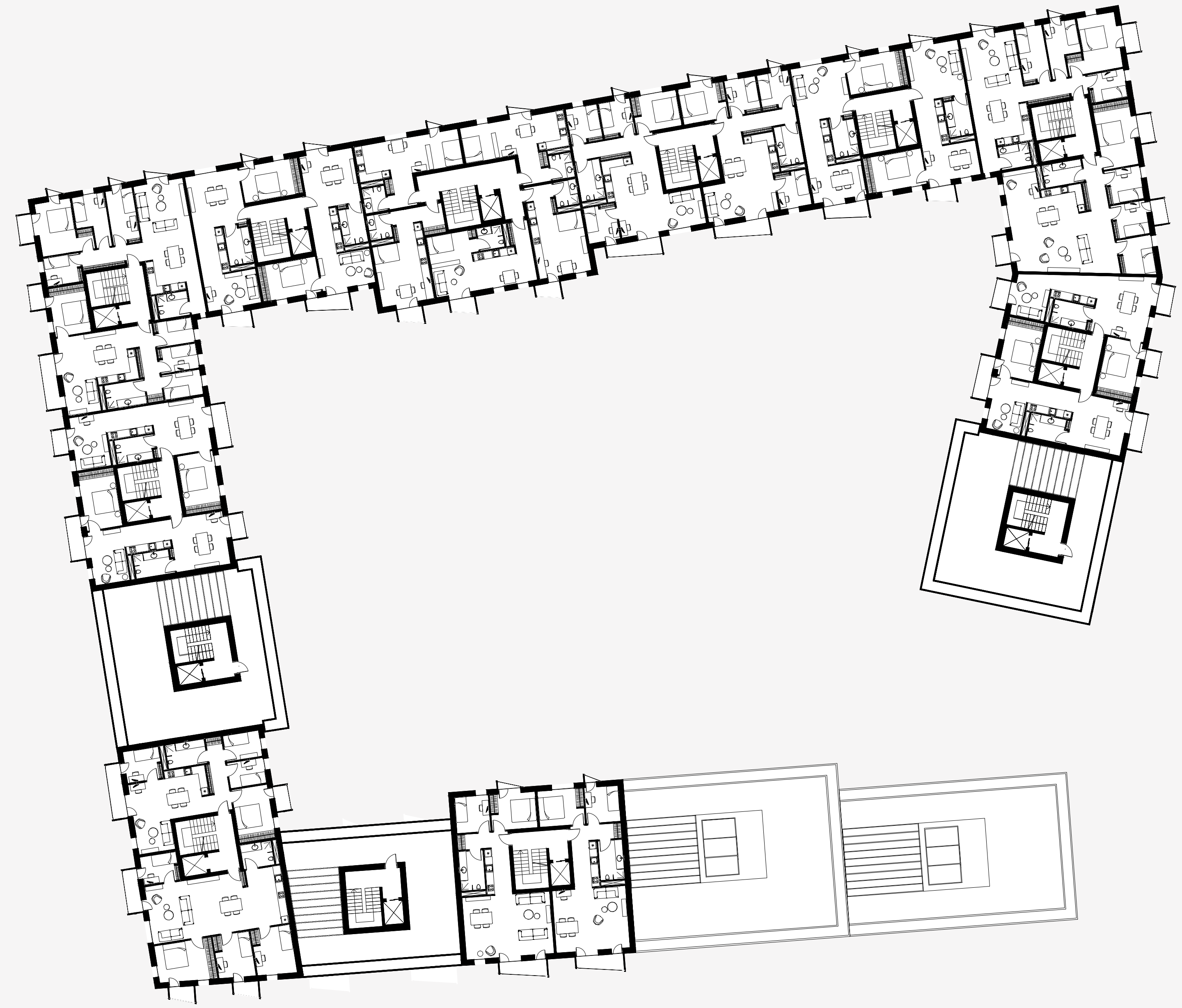
Ill. 63  Third floor 1:500



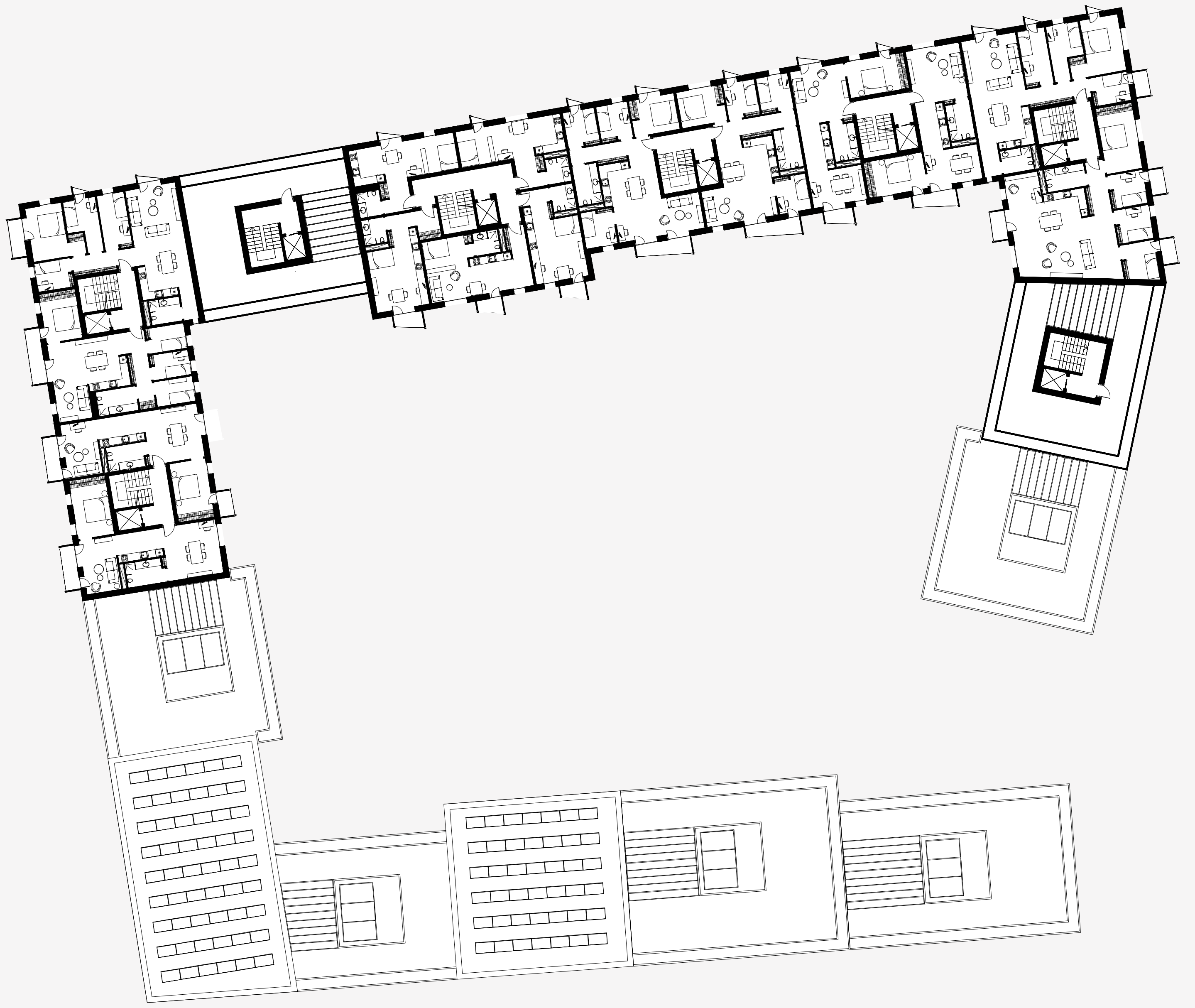
Ill. 64  Fourth floor 1:500



Ill. 65  Fifth floor 1:500



Ill. 66  Sixth floor 1:500



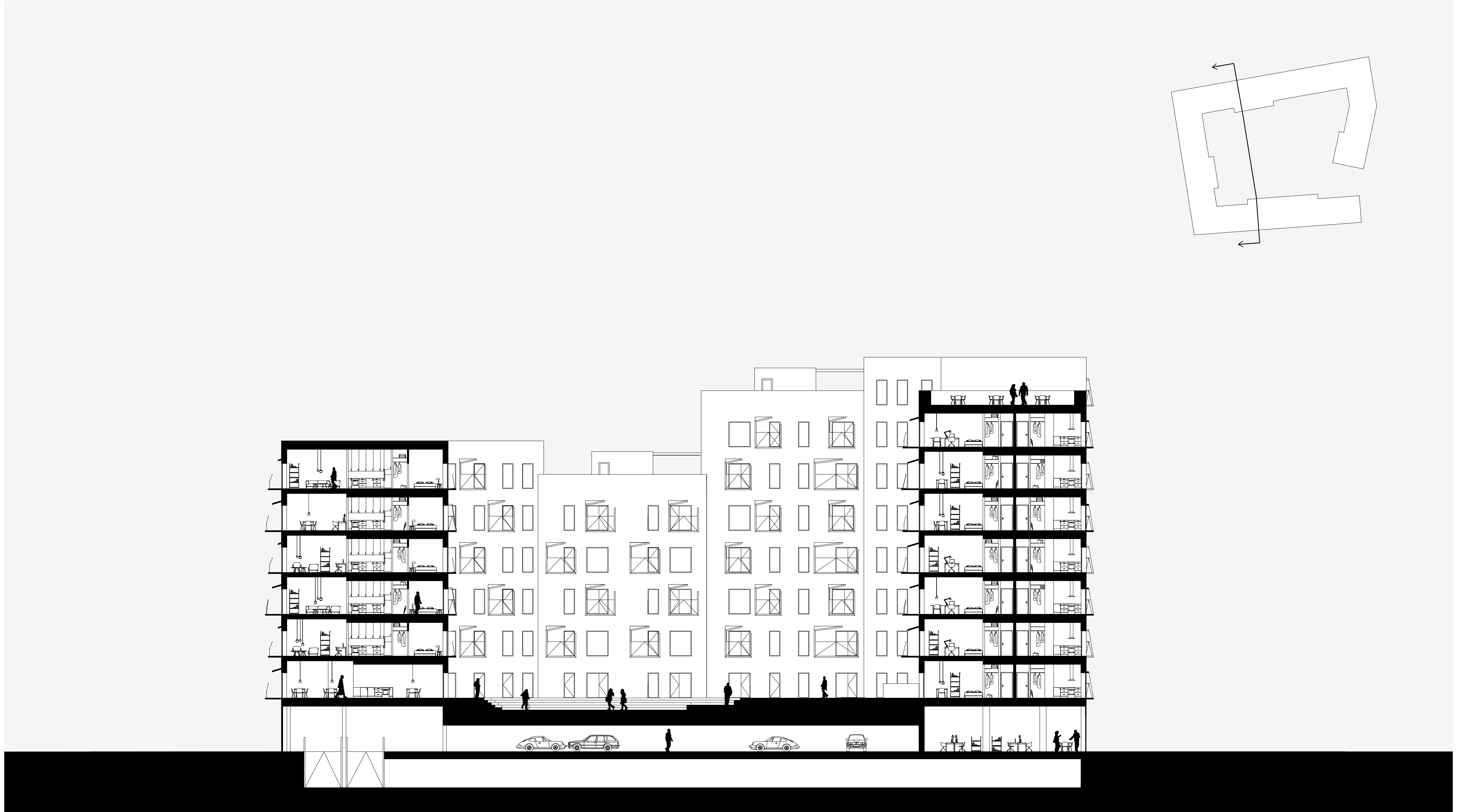
Ill. 67 Seventh floor 1:500

Ill. 68 Eighth floor 1:500

## CROSS SECTION

The section (Ill. 69) shows the relation between the varying height of the singular blocks and the courtyard. The variation in heights and depths create a dynamic space within the courtyard which also ensures privacy on the rooftop terraces.

By raising the courtyard it is possible to achieve both privacy and better light condition in the lower apartments as well as in the courtyard, making room for parking and the commercial functions on the ground floor.



Ill. 69 Cross section 1:400

# LONG SECTION

Walking into the streetscape (Ill. 70), the residents immediately sense the openness of the courtyard and the small journey centers around activity, creating a vibrant space that is welcoming to its visitors. A safe environment in the unrestricted courtyard is ensured by having all residents overlooking the space.

Ill. 70 Longsection 1:400

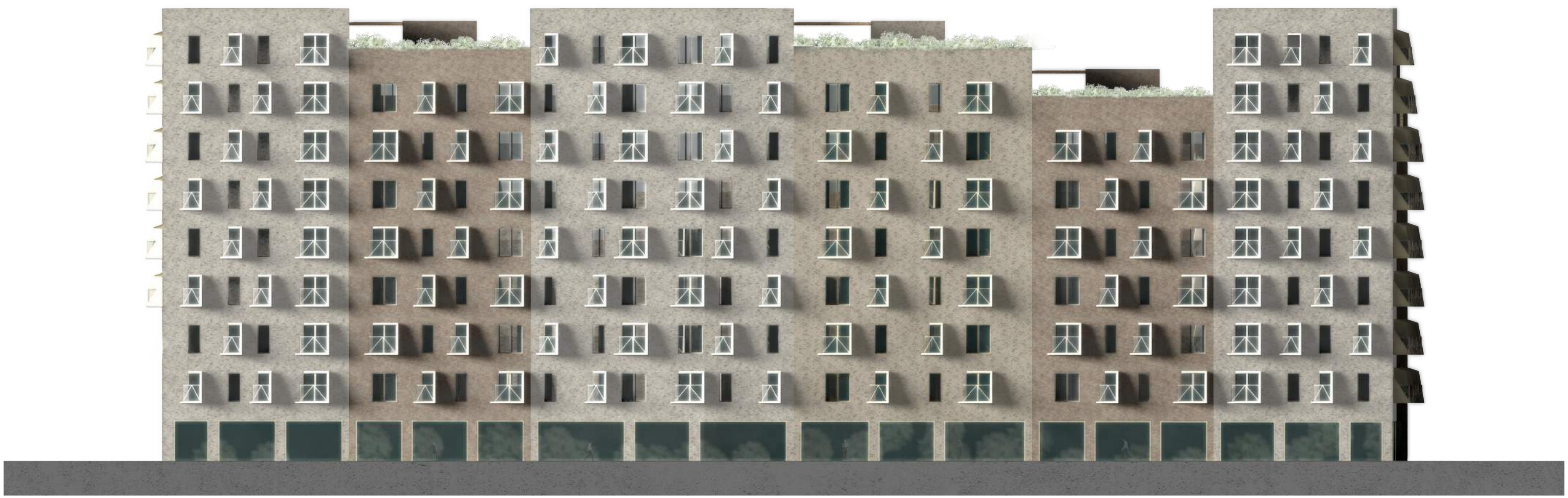
# ELEVATIONS

The facades (Ill. 71-Ill. 73) show variation in openness and closeness according to the functions. The extroverted commercial functions are underlined with big glazed areas whereas the introverted apartment is privatized by balconies. In order to continue the appearance of openness in the ground floor on the South facade and to establish a more atmospheric experience when entering the parking area, a dissolved brick pattern is used.

The facade materials consist of 4 different variations of bricks, one for each type of singular block. The rhythm created is defined by how the different types of apartments are sited within the block. This composition mimics the diversity of the surrounding buildings, while still creating a coherent block. Furthermore, the rhythm of the balconies shifts as well, creating a dynamic variated facade expression.

Ill. 71 West facade 1:300

Ill. 72 South facade 1:300



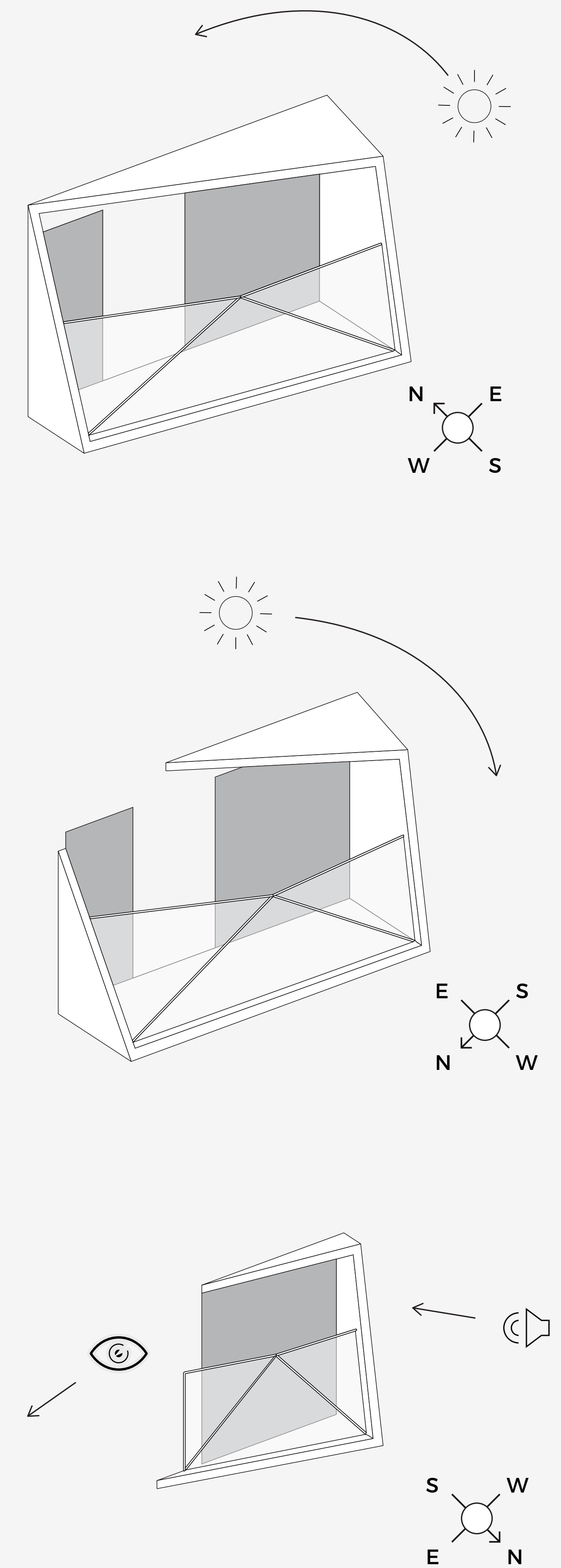
Ill. 73 North facade 1:300

# BALCONIES

Each facade orientation has its own balcony design, shaped by performance and function (Ill. 74). Orientation towards South requires a great amount of solar shading so the top and East surface is protruding far out to shade the morning and noon sun. The East and West oriented balconies are designed by using the same principle, but with less exposure to direct sunlight. A smaller top surface allows more daylight from North to enter the apartments.

An inherent part of the design  is to creating a small outdoor area for the residents to enjoy without feeling overlooked by others. By pushing in one top corner of the geometry, late afternoon and evening sunlight is allowed on the balcony, while the side walls provides shelter and privacy.

The North facade facing Reeperhabn has been populated with smaller French balconies, which shield from the noise and light polution that characterizes Reeperbahn at night and orients towards the parks, East of the site.



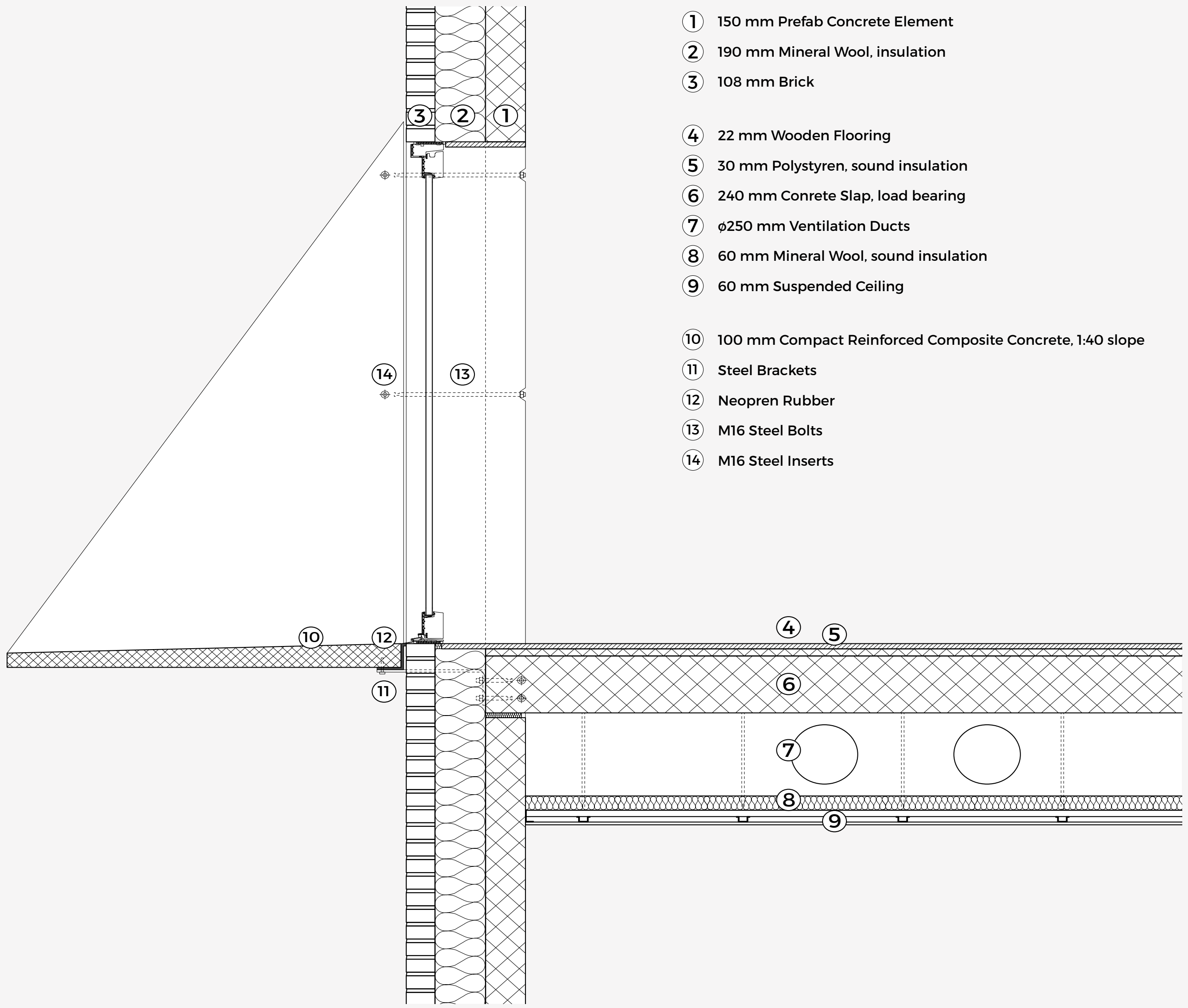

Ill. 74   Principle for balconies on the Southern, Eastern/Western and Northern facade

## CONTRUCTING THE BALCONIES

The construction detail (Ill. 75) shows how the balcony is attached to the facade. Prefabricated concrete elements are cast with steel inserters that can be slid in place at the construction site. The hidden connection secures a clean facade expression where the white concrete elements and brickwork stands out. Compact reinforced composite concrete is used for the balcony in order to construct the slabs with a thickness of 100 mm at the facade connection and 60 mm at the edge.

From inside the access to the balcony is level free so the outdoor space is perceived as an extension of the living room when opening the door. For general construction principles see appendix 4.



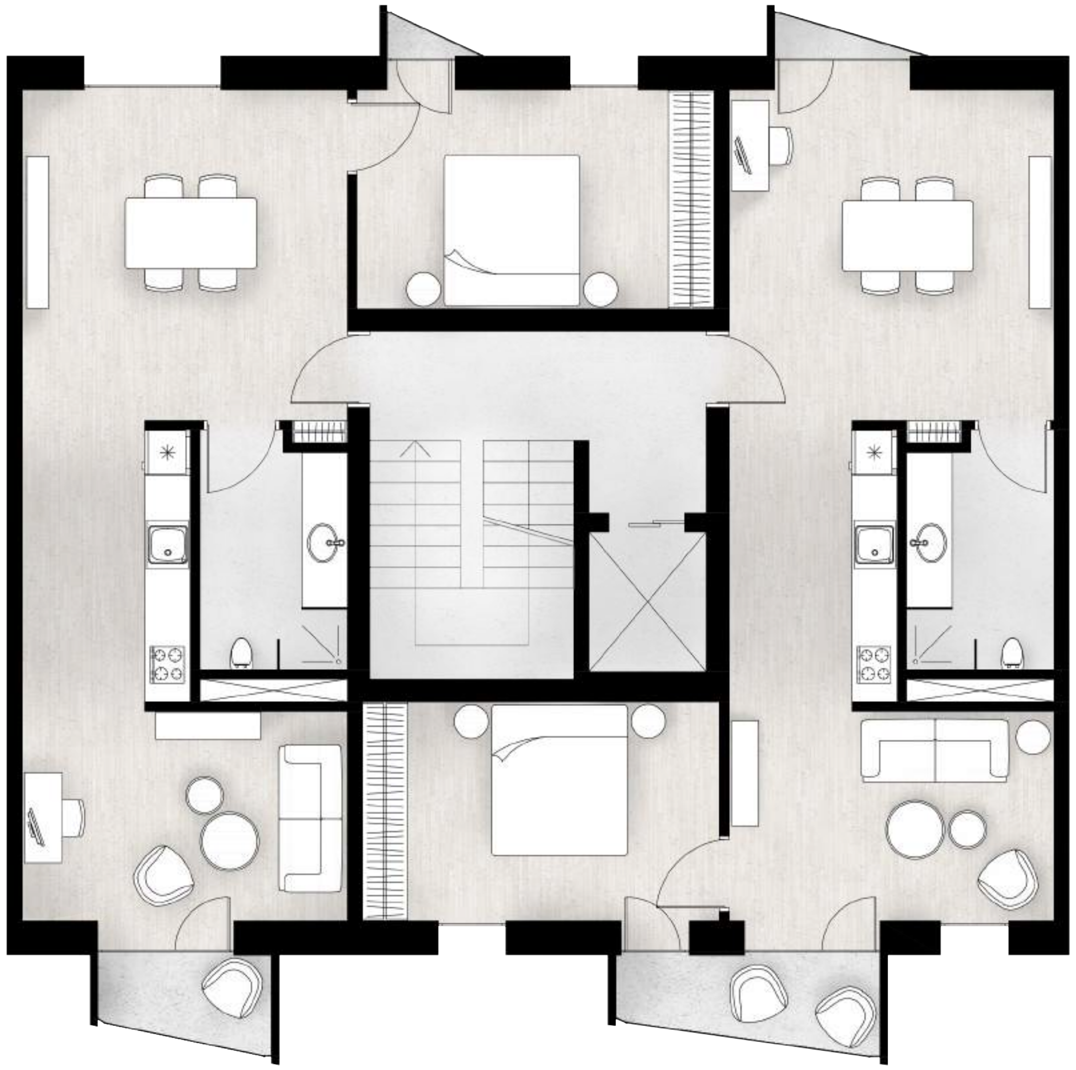



Ill. 75 Detail showing the meeting of the exterior wall, floor and balcony

# APARTMENTS

## COUPLE

The apartment is intended for a couple with no children or an elderly couple and is approximately 70 m² in size (Ill. 76). The space is optimized by having the bathroom and kitchen in the middle of the apartment, using the kitchen as connection between the living room (Ill. 78) and the dining area (Ill. 77), creating well-lit rooms.



Ill. 76 Couple apartment

View from dining area visualizing the flow though the apartment, looking towards the kitchen and living room.

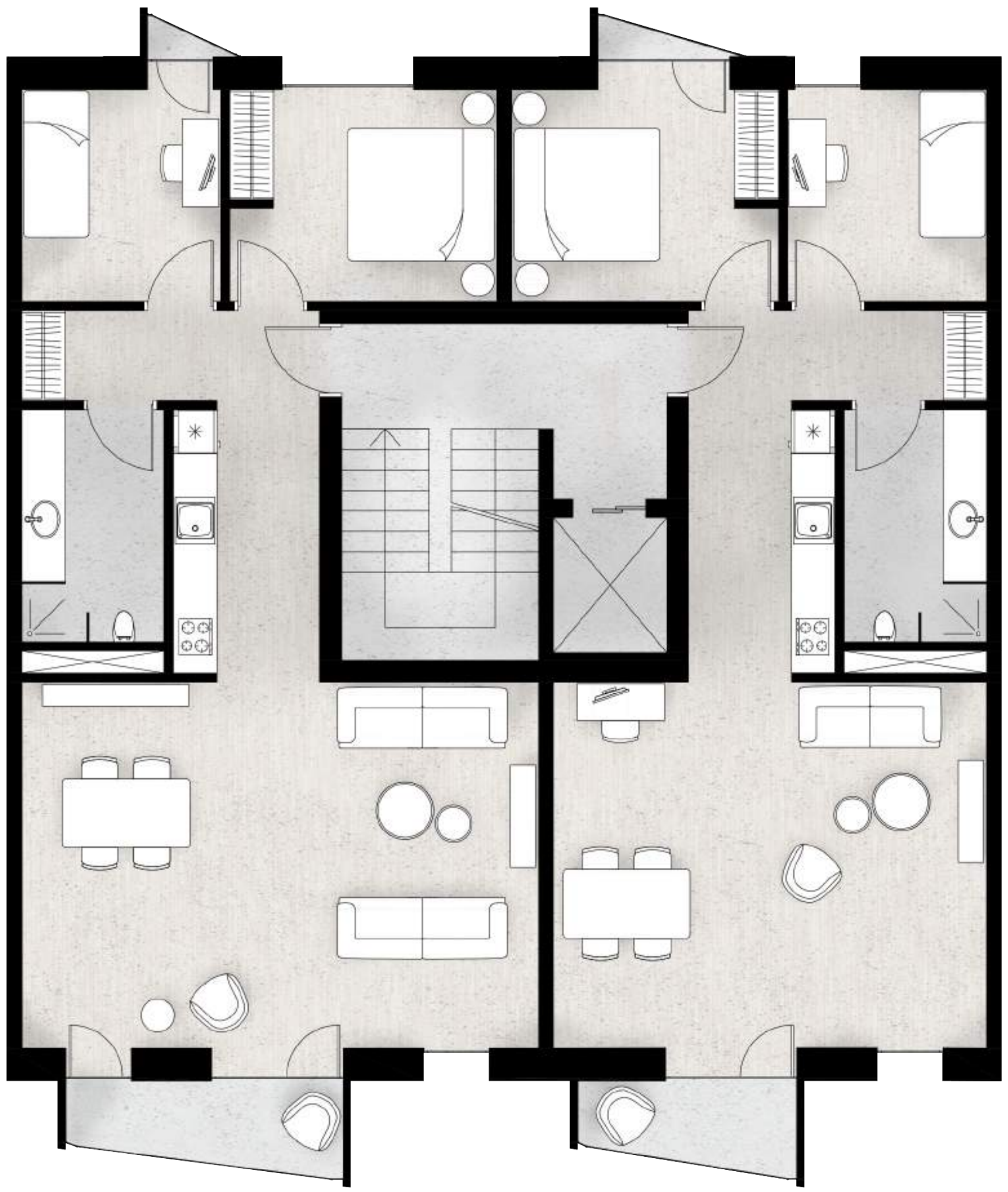
Ill. 77 Visulization of the dining area

View into the living room visualizing the good daylight conditions and access to a private balcony.

Ill. 78 Visulization of the living room

### COUPLE WITH ONE CHILD

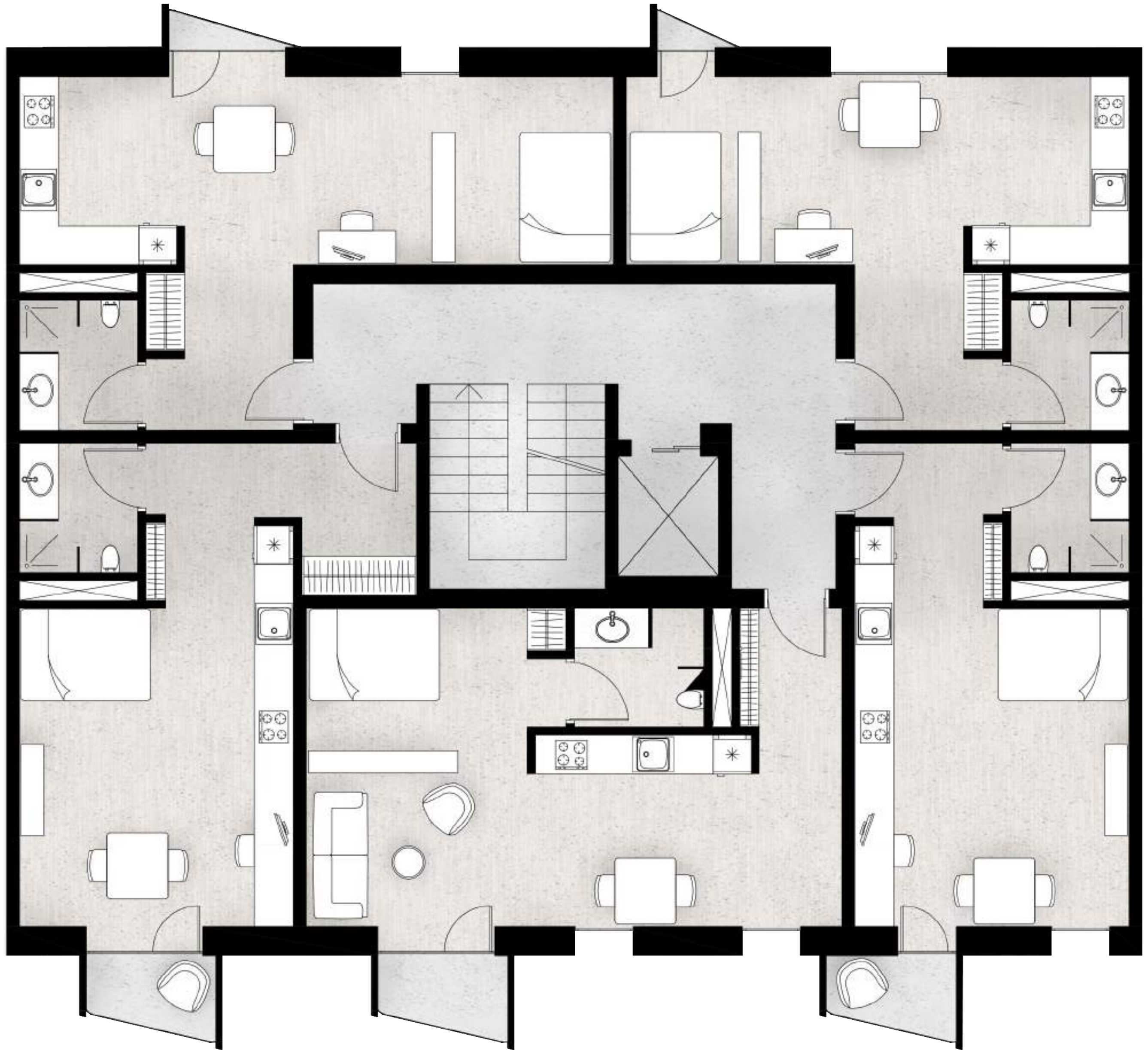
With a size of approximately 80 m², the apartment is designed for a couple with one child (Ill. 79). The kitchen and bathroom is located in the center of the apartment creating a distinction between the bedrooms and a regular living- and dining area.



Ill. 79 Apartment for a couple with one child

## STUDIOS

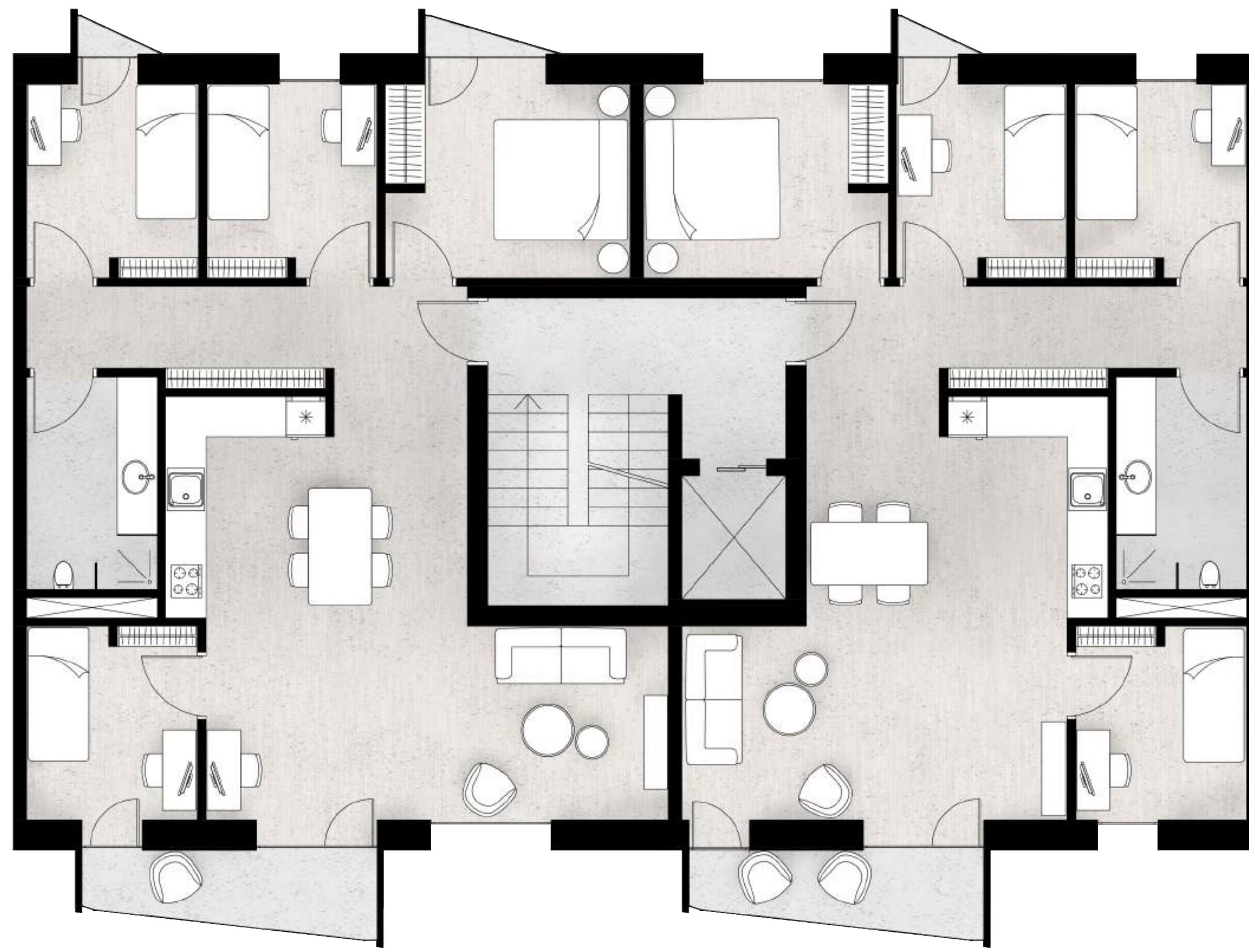
With a size of approximately 40 m² the layout of the studios vary (Ill. 80). With regularity in mind, the studios are designed in order to utilize the space in the best possible way. The space can be divided with furniture creating both private and semi-private spaces in the studio.



Ill. 80 Studio apartment

## COUPLE WITH 3 CHILDREN OR 4 STUDENTS

This apartment is with a size of approximately 100 m² intended for either a couple with 3 children or 4 students (Ill. 81). In order to maximize the space, the kitchen and bathroom is again located in the center of the apartment, making room for 3 well-lit bedrooms on one side and a well-lit bedroom, kitchen, dining area and living room on the other.

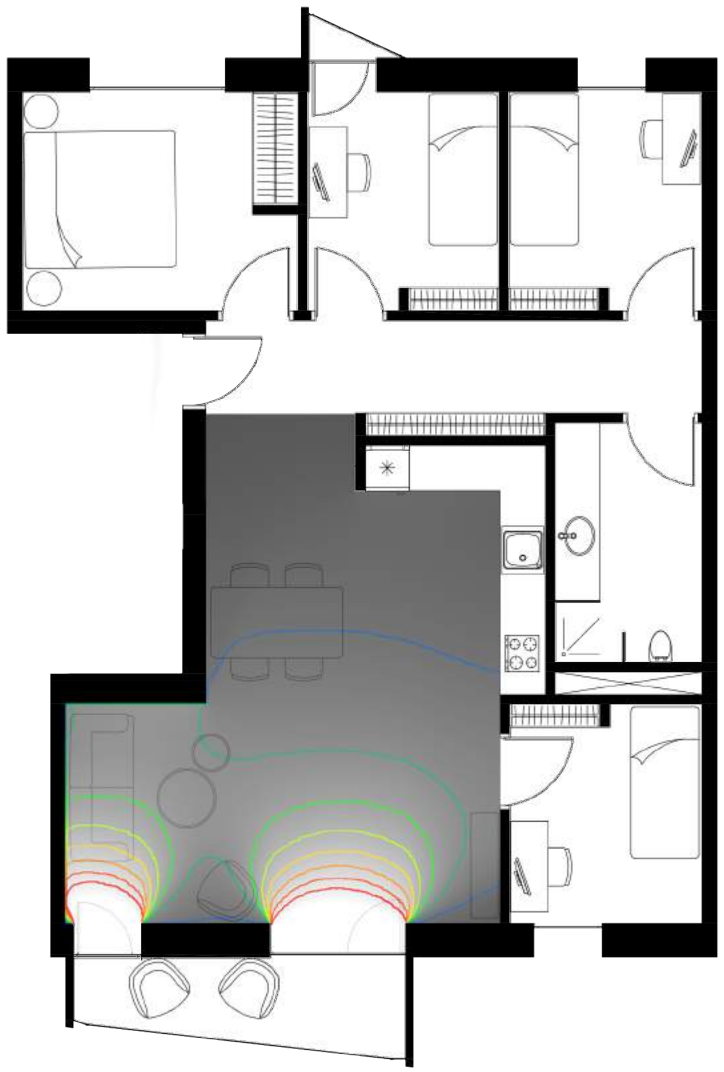


Ill. 81 Apartment for a couple with 3 children or 4 students

## DAYLIGHT

The effective solar shading strategy offers the possibility to place large windows in the facade and thus allowing good daylight conditions in the living area (Ill. 82). Two window sizes with a height of 2,1 m relates to the human body and have been used in order to ensure good daylight conditions within the apartment. The smaller window type is 0,9 m wide and allows the width of a body to fill the frame. The larger window is 1,8 m wide and gives a good sense of daylight even deep into the apartment and a great visual connection to the outside.

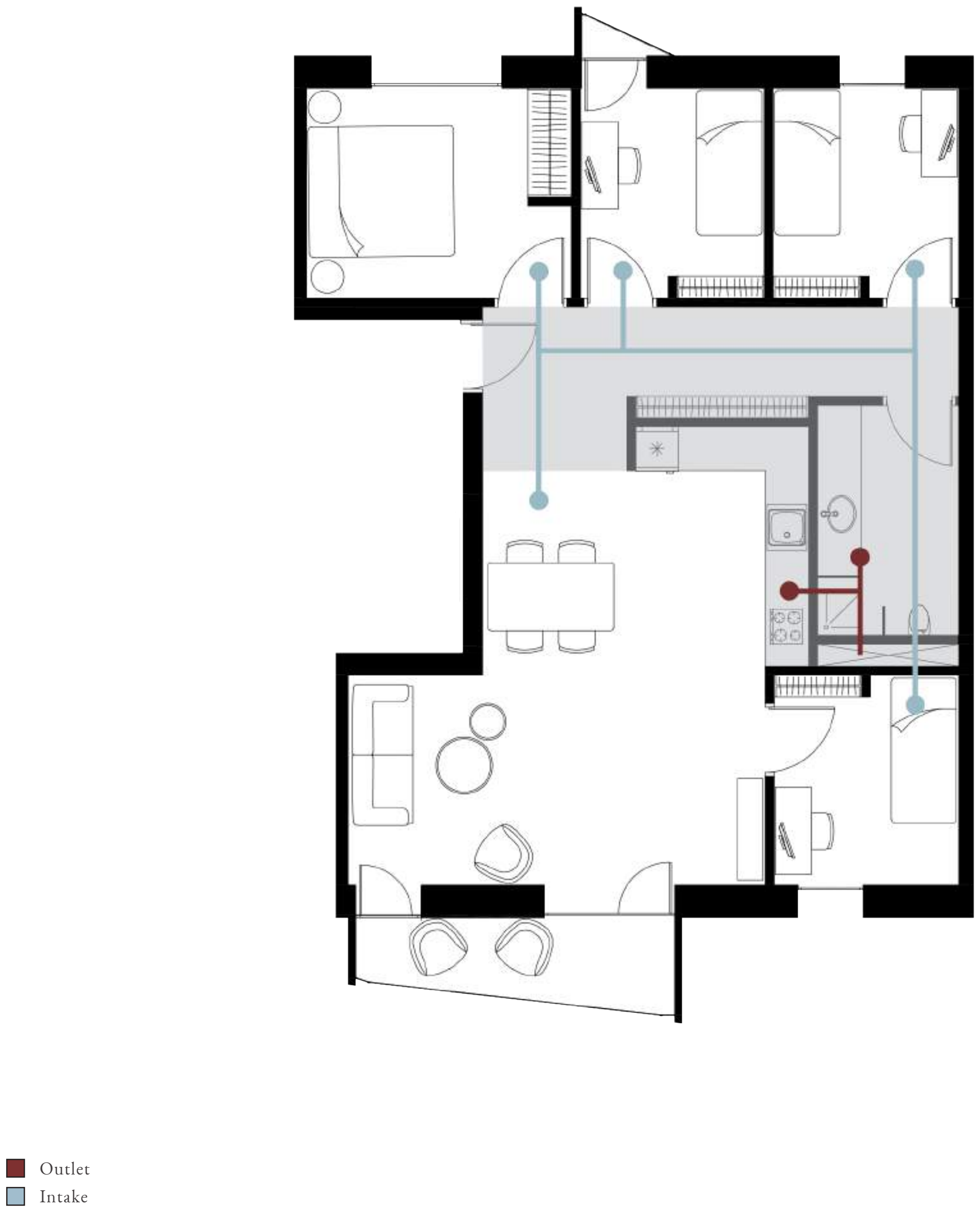
The daylight documentation has been done with the software Velux Daylight Visualizer. A daylight factor over 2% is achieved in the primary living space, while and average factor of 1% is reached in the kitchen area.



Ill. 82 Diagram showing the amount of daylight in the biggest apartment

## VENTILATION PRINCIPLE

A central shaft for ventilation ducts is placed close to both the bathroom and kitchen area, see appendix 3. Ill. 83 creates an overview of where the ceiling is lowered in order to have air intake for the mechanical ventilation system in all rooms. The central placement eliminates the need for lower ceiling height in the rest of the apartment and minimizes distances and pressure loss in the system. The lowered ceiling also adds to the spatial experience of the space, where the entrance area is expressed and set apart from the living area.



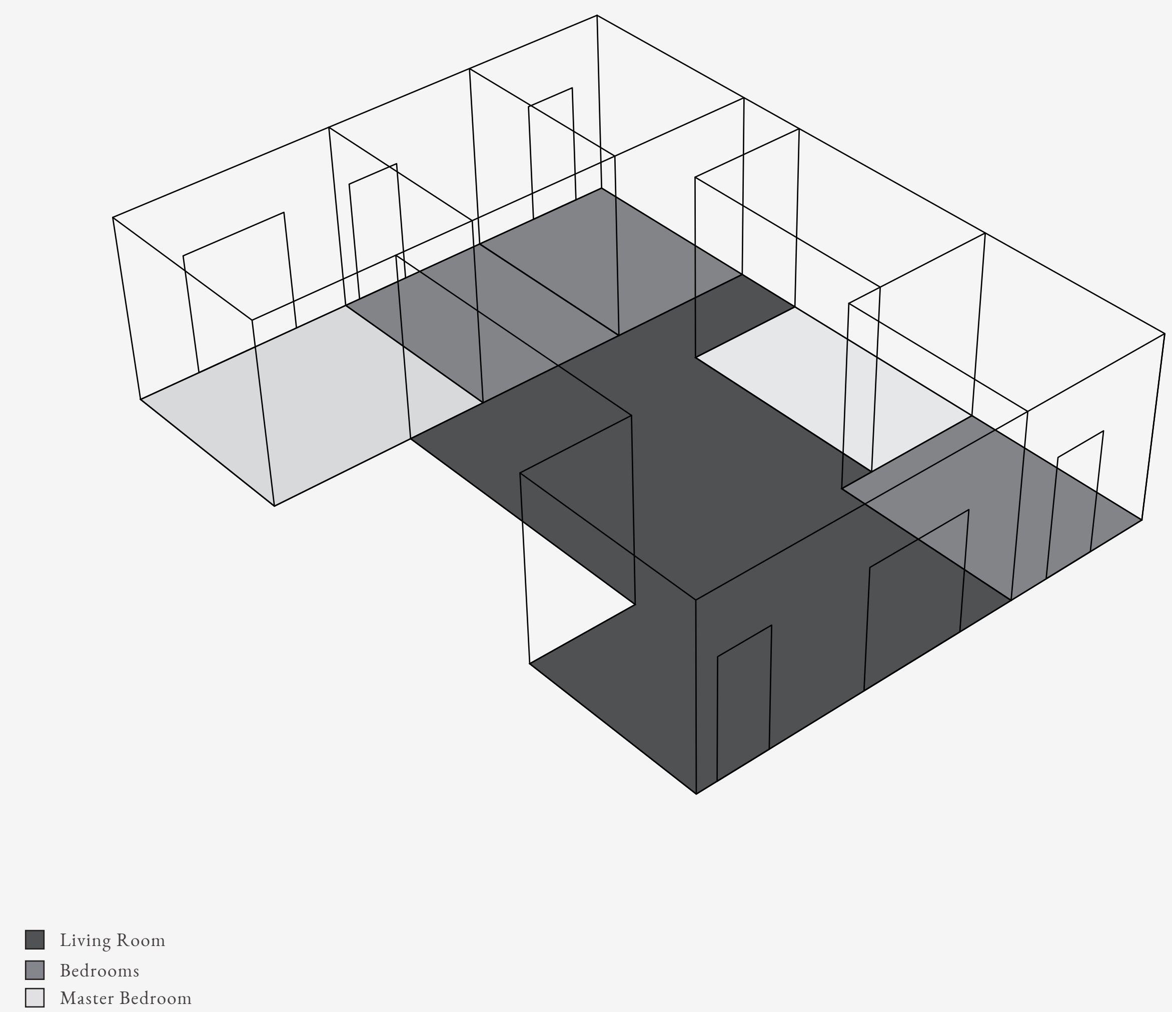

Ill. 83 Plan illustrating the ventilation pinciple

# INDOOR CLIMATE

For the indoor climate simulation in BSim a 4 bedroom apartment (Ill. 84) with other apartments on all sides is chosen as being representative as the worst case scenario in terms of overheating. This is due to the high people load in the apartment and minimal exterior envelope areas that can transmit heat away from the building during summer nights. The apartment has mechanical ventilation during the heating season and natural ventilation otherwise.

The indoor thermal comfort (Ill. 85) will be evaluated against the requirements set out by the Danish Building Regulations, BR15 which states that the indoor temperature must not exceed 27 C° for more than 100 hours and 28 C° for more than 25 hours per year.

Also the indoor air quality will be assessed according to the Danish Standard CR1752 category B for perceived air quality, which states that the indoor CO2 level must not be more than 660 parts per million (ppm) over the outdoor level of 350 ppm, which is a total of 1110 ppm. The ppm values presented is the average and maximum for the month with the highest average value. The simulation values show that some days the temperatures are above the mentioned threshold, but it is well below the maximum number of hours allowed. The average CO2 values are at an acceptable level and the simulation shows that natural ventilation keeps the maximum value under the threshold when needed. For complete data see appendix 5.




Ill. 84 Diagram showing thermal zones

| COMPARISON | hours >26 C° | hours >27 C° | $CO_2$ ppm, mean | $CO_2$ ppm, max |
|---|---|---|---|---|
| Master Bedroom | 70 | 16 | 560,2 | 1100 |
| Bedrooms | 62 | 15 | 683,0 | 1100 |
| Livingroom | 79 | 25 | 614,3 | 1100 |

Ill. 85 Comparison of temperature and $CO_2$-concentrations

# ENERGY FRAME

During the sketching and synthesis phase calculations in Be15 was continuously updated to keep track of the energy implications of design decision and to make sure that the building design would uphold the 2020 energy frame requirements.

The final design proposal has two calculation sheets supplementing it, see appendix 2. One with only passive energy strategies taken into account and one with photovoltaic panel laid out one five of the roof areas (Ill. 86). The PV's are all facing South and are laid at a 30° angle and a distance of 1 meter in order to secure that the PV's will not cast shadows upon each other. The energy frame calculation for the passive strategies showed a satisfying result with only 13,8 kWh/$m^2$ per year which is well below the 2020 demands at 20 kWh/$m^2$ and with the added PV panels the result became 9,7 kWh/$m^2$ (Ill. 87).

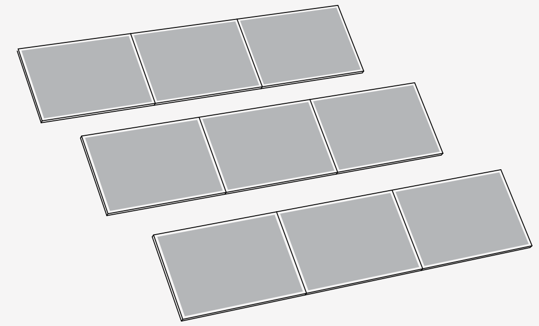
## PASSIVE ENERGY STRATEGIES

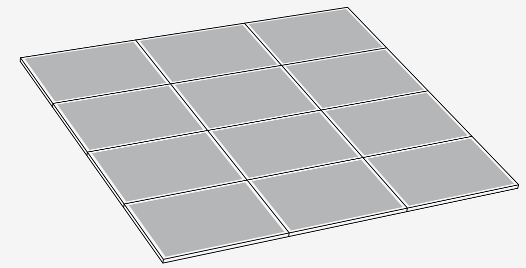
The low energy need was achieved by the incorporation of passive energy strategies. Compactness of the overall building design ensures minimal surface area of the building envelope where transmission losses occurs. High insulating exterior constructions further decrease the transmission losses and keep the heating demand at a minimum. In the summer where overheating of the apartments is a risk, effective solar shading from the balconies make cooling unnecessary and ensures that natural ventilation from the large windows is sufficient to keep comfortable temperatures.

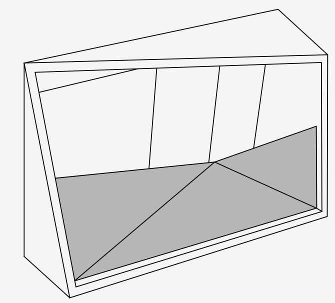
Because the passive strategies proved this successful, two further scenarios have been presented (Ill. 87) to explore the possibility of reaching zero energy. One possibility is to install the PV's flat on the roof to increase the number of panels on the surface area, which despite of the decrease in efficiency gives a result of 8 kWh/$m^2$. The other possibility is to add thin film photovoltaics in the glass of the parapet in the South facing balconies that are not in general shadow from other buildings. While this might be an expensive and somewhat inefficient solution it brings the total energy calculation down to 6,2 kWh/$m^2$.

The conclusion is to propose installation of less but more efficient PV panels at a 30° angle. Adding 240 $m^2$ flat laying panels or 290 $m^2$ thin film PV's yielded to low a gain in the energy calculation. For the roof panels monocrystalline panel are chosen over polycrystalline. The efficiency rate for monocrystalline panels are typically 15-20%, while the rate for polycrystalline is 13-16% and because the focus has been on fewer, but more efficient panels, the polycrystalline technology is chosen.





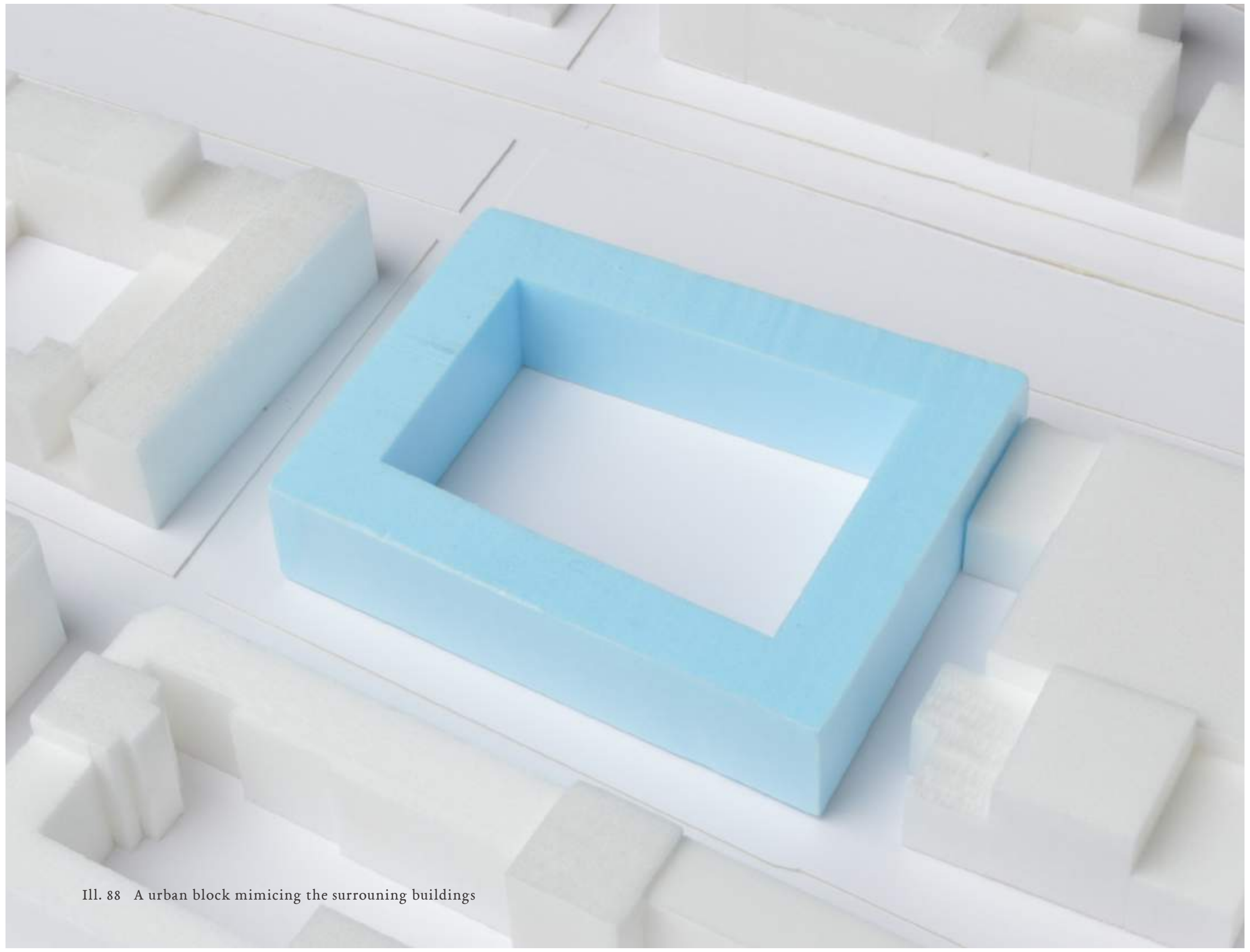

Ill. 86 Possible integrations of PV's

| COMPARISON | By passiv strategies | PV's at 30° | PV's at 0° | Adding thin film PV's |
|---|---|---|---|---|
| Area $m^2$ | - | 360 | 600 | 290 |
| 2020 Energy Frame kWh/$m^2$per year | 13,8 | 9,7 | 8 | 6,2 |

Ill. 87 Comparison of PV placements

# DESIGN PROCESS

*The Creation of a Project*

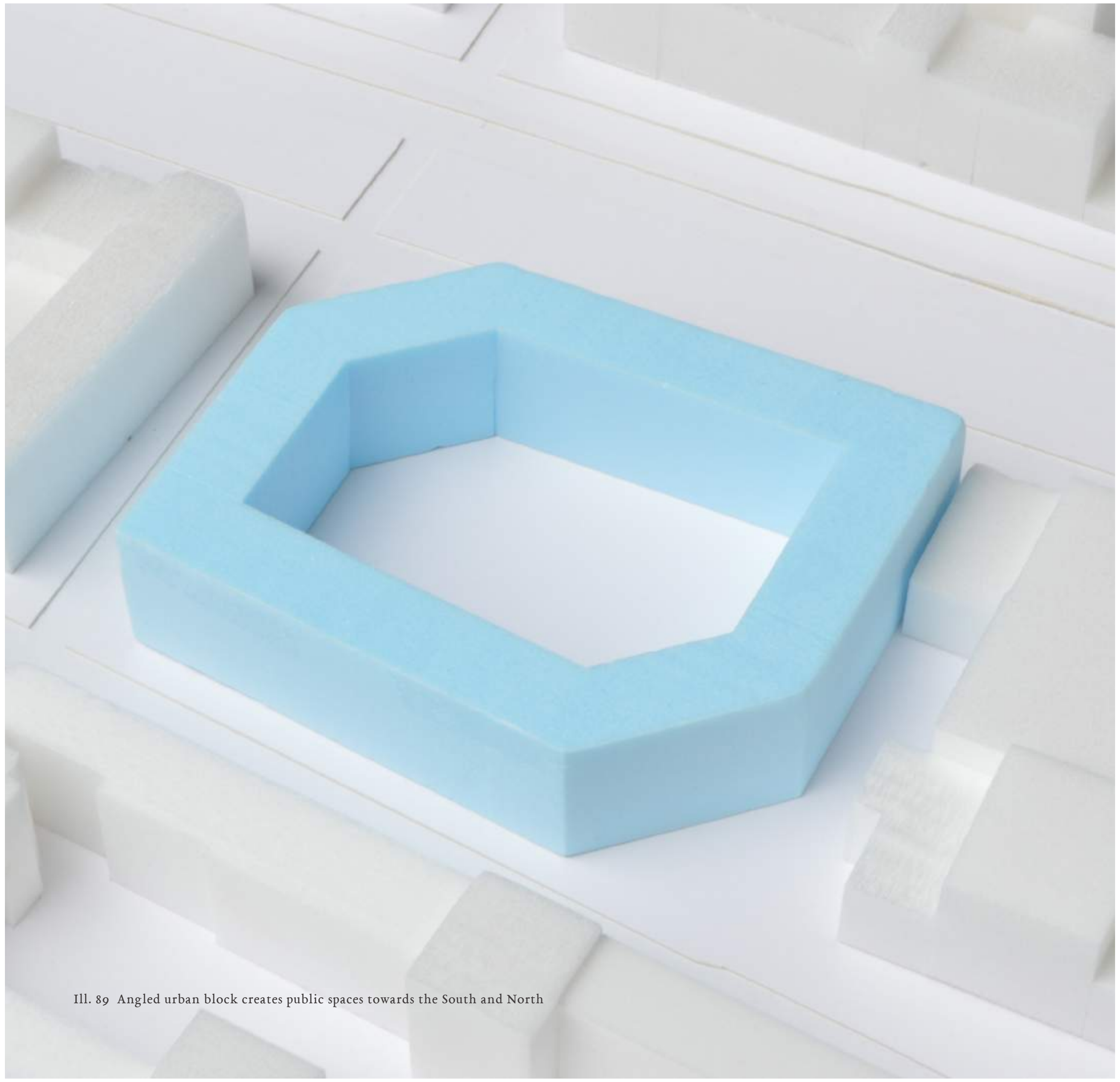

Ill. 88 A urban block mimicing the surrouning buildings

# INITIAL VOLUME STUDIES

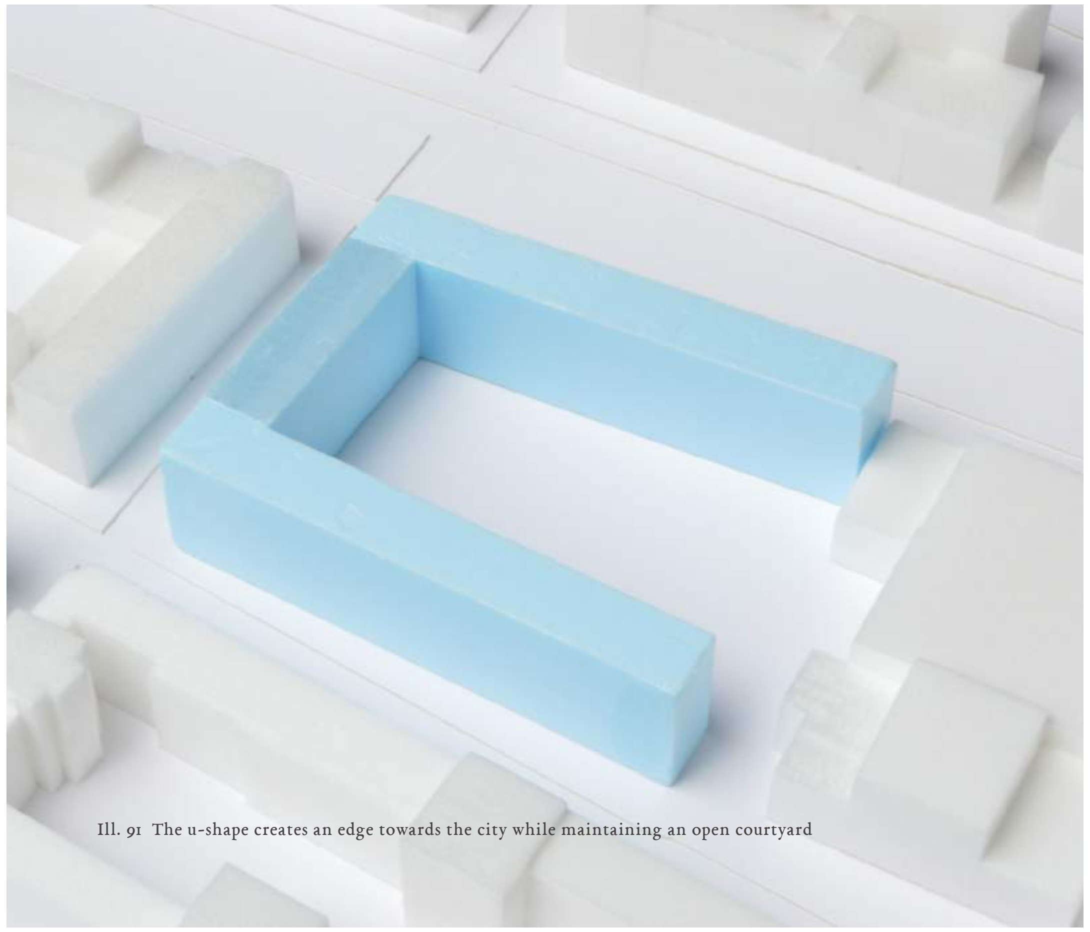
Many different typologies were tested in the earliest phases, but variations of the classic urban peripheral block seemed the most interesting. It provided the desirable contrast of the private interior and the public exterior that seemed suitable in the context. The urban block was further investigated in different configurations to fulfill the demands for a high density building while finding potentials for outdoor spaces of a quality. The block was deconstructed in different ways to test possible qualities when connecting the courtyard to the city (Ill. 90, Ill. 93 and Ill. 94). Another main investigation was how the block could shape urban areas and how these could add qualities to the surroundings (Ill. 89, Ill. 92 Ill. 94).

Positioning an opening towards the courtyard at the South East corner was favorite (Ill. 96) and further iterations of raising the ground floor and how building heights could vary in order to create an interesting overall shape and usable rooftop areas (Ill. 99 and Ill. 100)



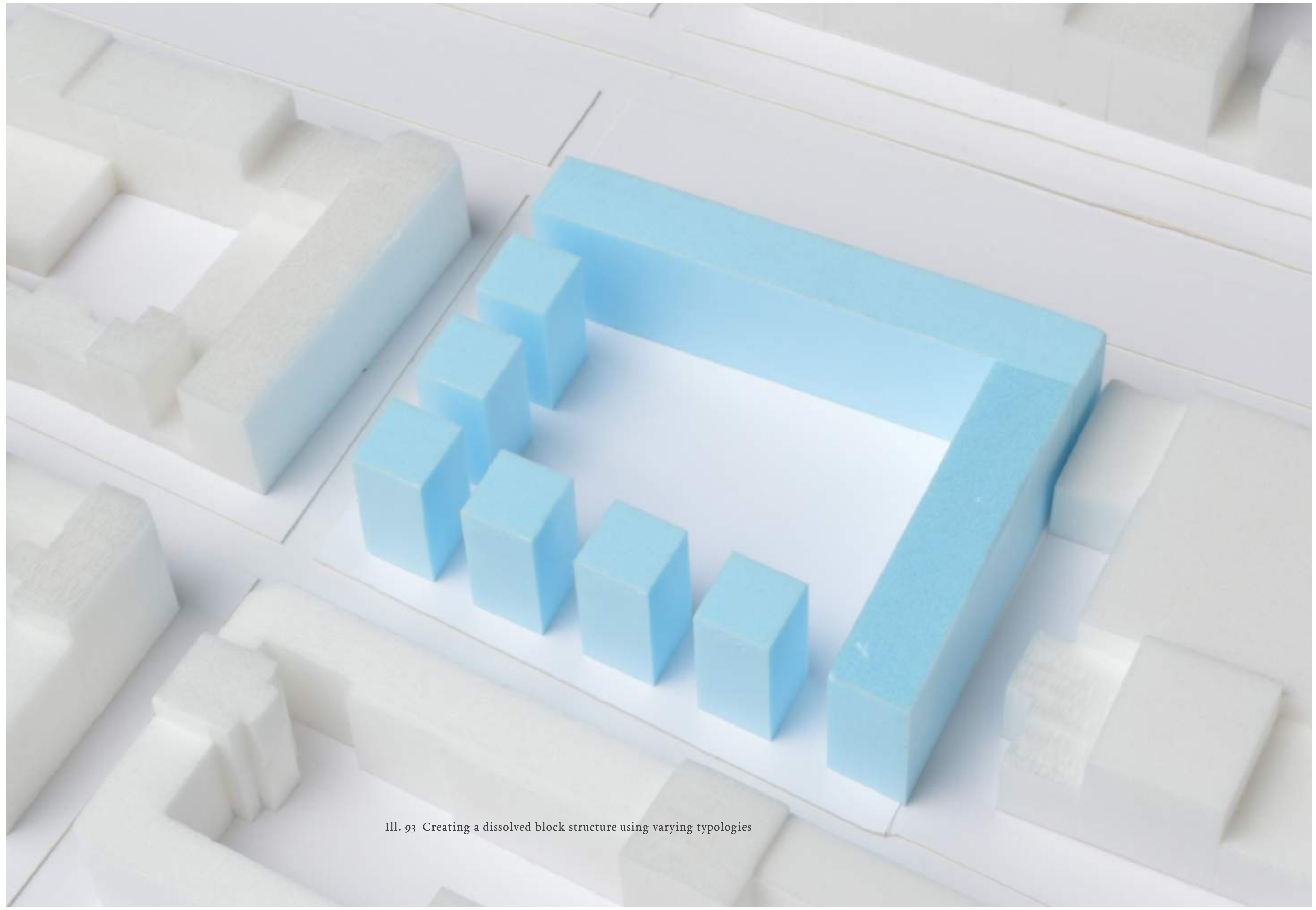

Ill. 89 Angled urban block creates public spaces towards the South and North


Ill. 90 The dissolved blocks opens up to the city

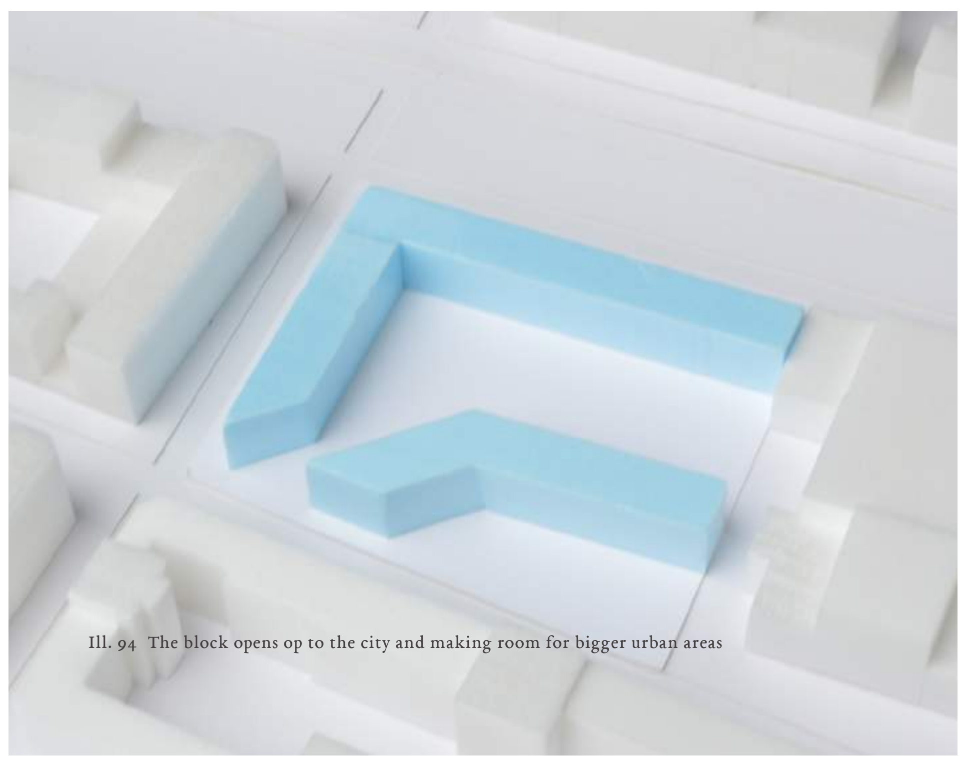


Ill. 91  The u-shape creates an edge towards the city while maintaining an open courtyard

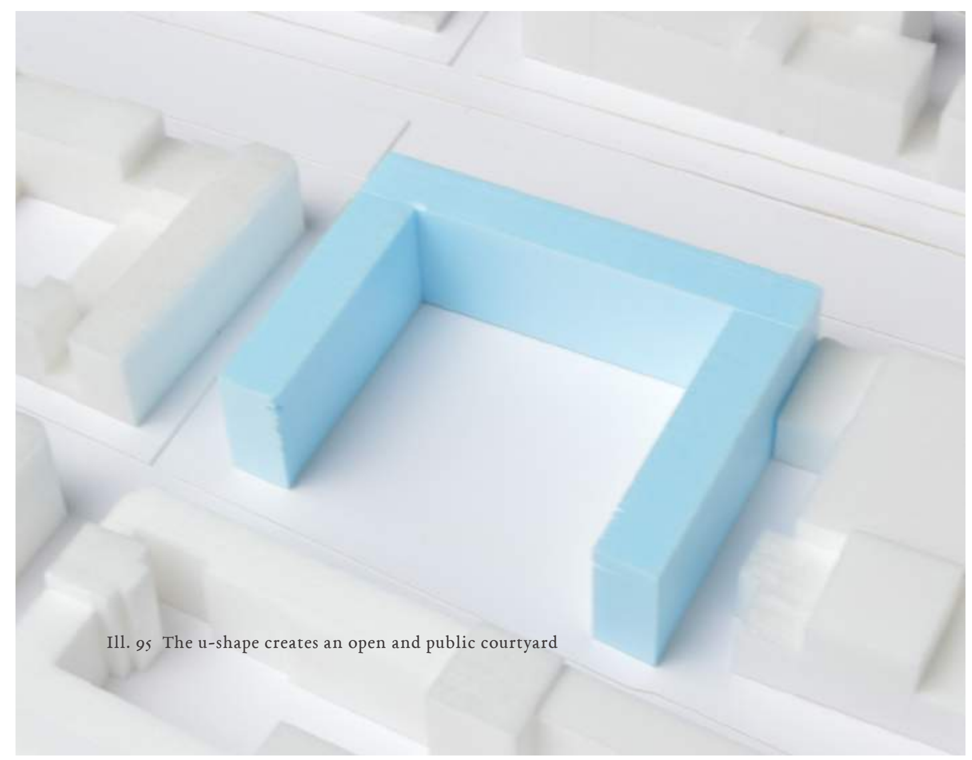
Ill. 92   The block  creates a public urban area towards the South



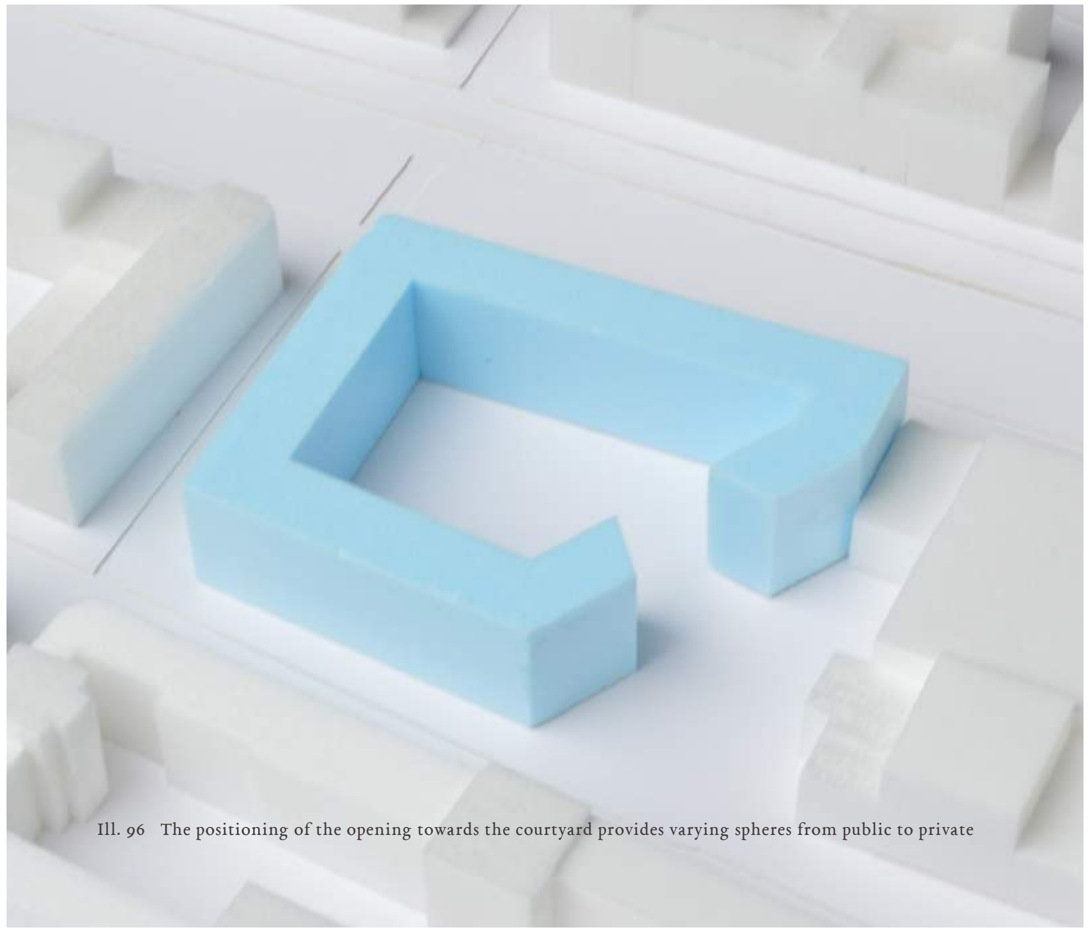
Ill. 93  Creating a dissolved block structure using varying typologies



Ill. 94  The block opens op to the city and making room for bigger urban areas

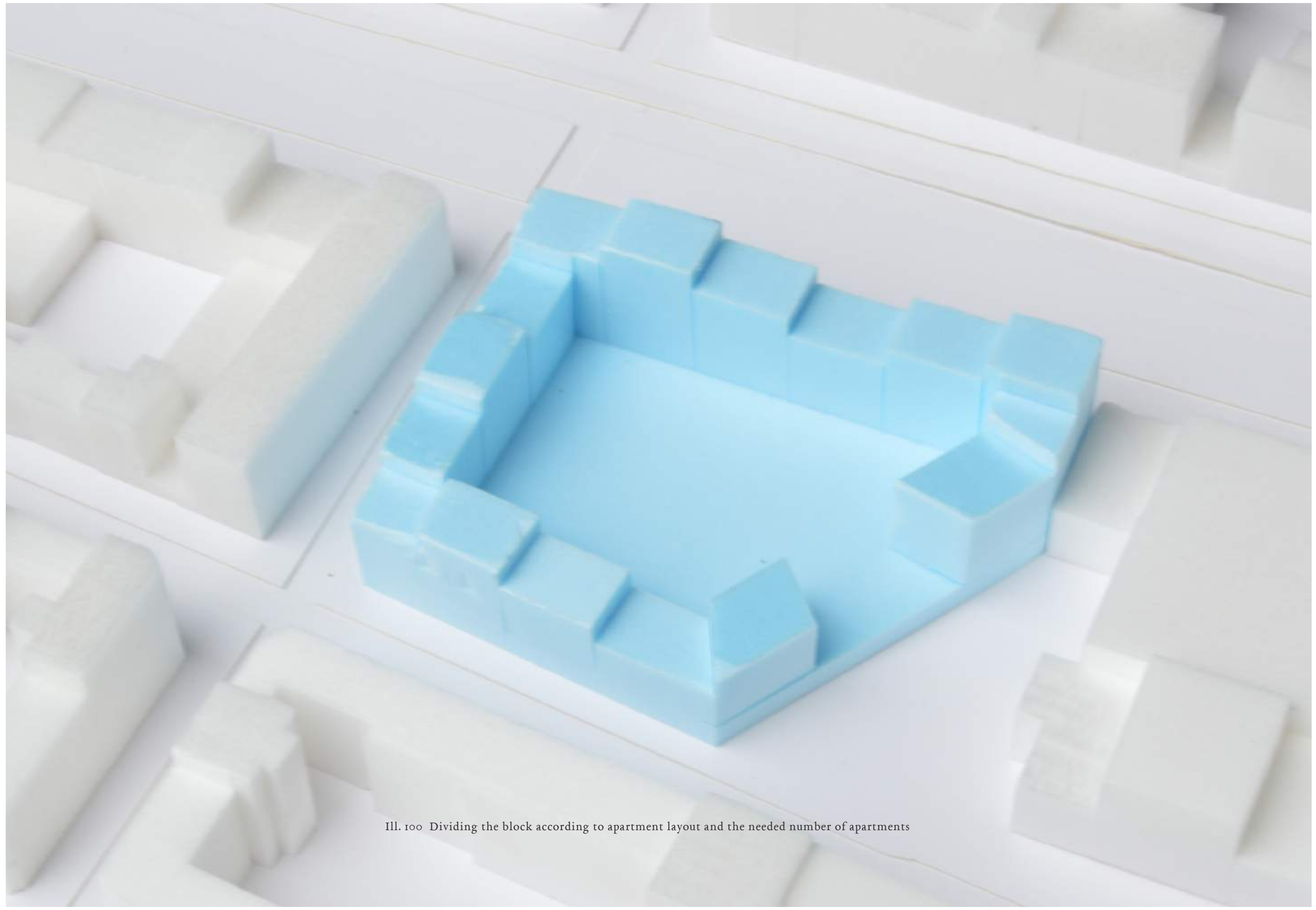


Ill. 95  The u-shape creates an open and public courtyard



Ill. 96 The positioning of the opening towards the courtyard provides varying spheres from public to private

Ill. 97 By withdrawing the block urban spaces are created



Ill. 100 Dividing the block according to apartment layout and the needed number of apartments

Ill. 98 By withdrawing the block urban spaces are created

Ill. 99 The blocks opens up towards the South and makes room for green rooftops

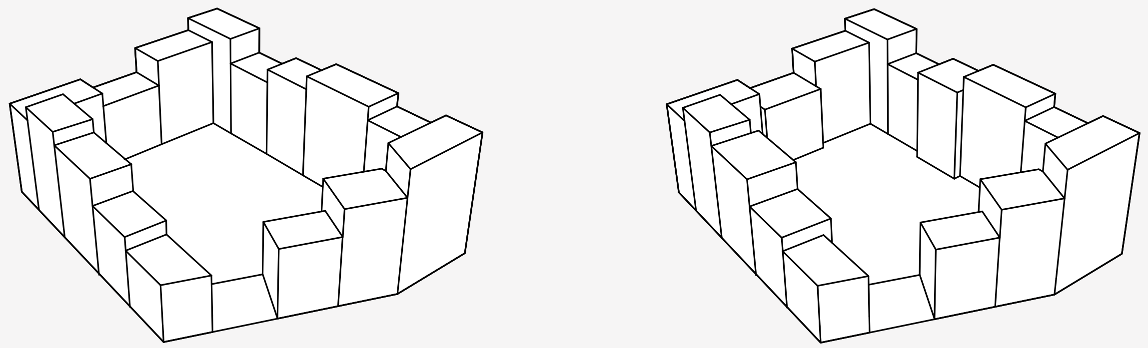
Ill. 101 Varying depths of the blocks provide optimum apartment layouts and increases the density of the block

| COMPARISON | Planar facades | Shifting facades |
|---|---|---|
| Areas m² | - | - |
| North | 3839 | 3900 |
| South | 3435 | 3512 |
| East | 1892 | 1982 |
| West | 2097 | 2188 |
| South/East | 600 | 600 |
| North/West | 480 | 480 |
| Facade | 12343 | 12662 |
| Unheated space | 1612 | 1732 |
| Roof | 2448 | 2594 |
| Terrain | 1442 | 1504 |
| Transmission loss W | 69737,3 | 71520,2 |

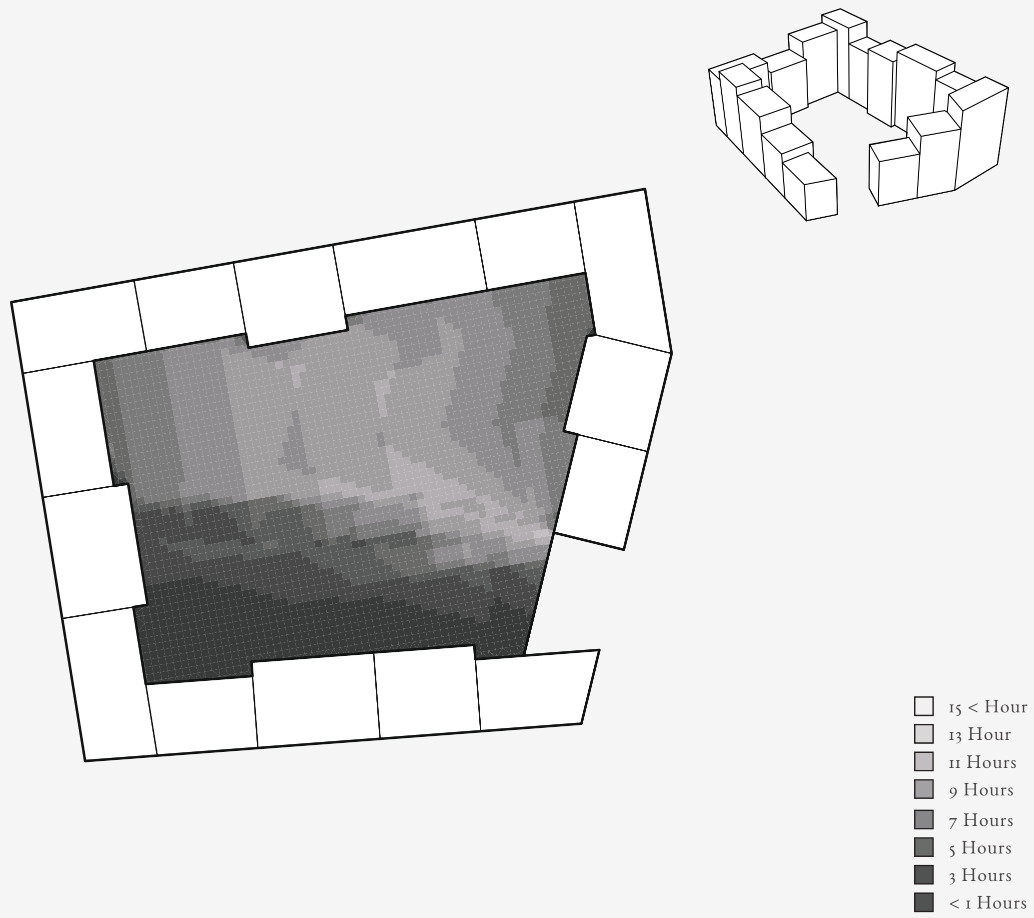
Ill. 102 Comparison of transmission loss when having planar or shifting facades

# BLOCK VARIATIONS

An overall shape was decided upon and investigation in how the individual apartment blocks could vary both in height and depth (Ill. 101) was done in order to optimize apartment layouts, give the individual blocks distinct identities and create roof spaces suitable for terraces. This process was done with the 2020 energy frame requirements in mind, which meant that a calculation was done to test the impact the increased surface area of the shifting facades had on the overall heat loss (Ill. 102 and Ill. 103). The calculations showed a difference of less than 2,5% in transmission losses between a design with planar facades and one with shifting facades.



Ill. 103 Planar and shifting facades

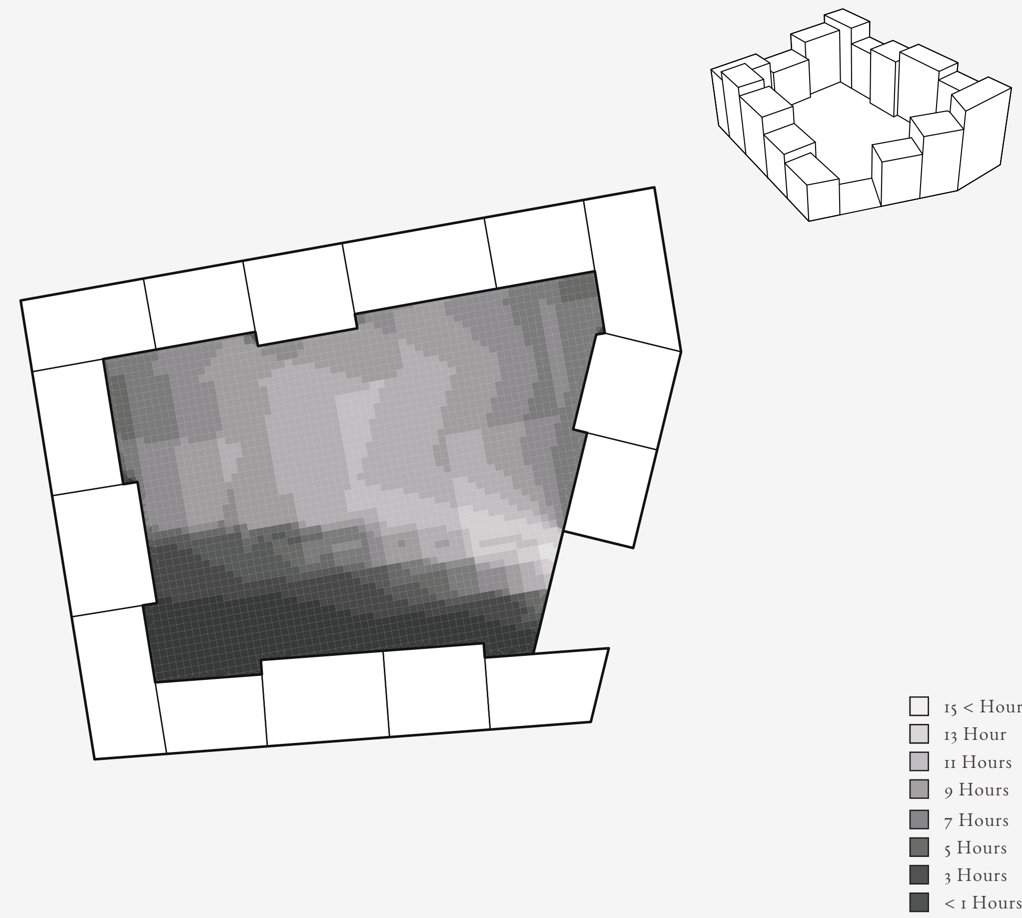



Ill. 104 Study showing sun/shadow conditions in the couryard if placed on the ground floor

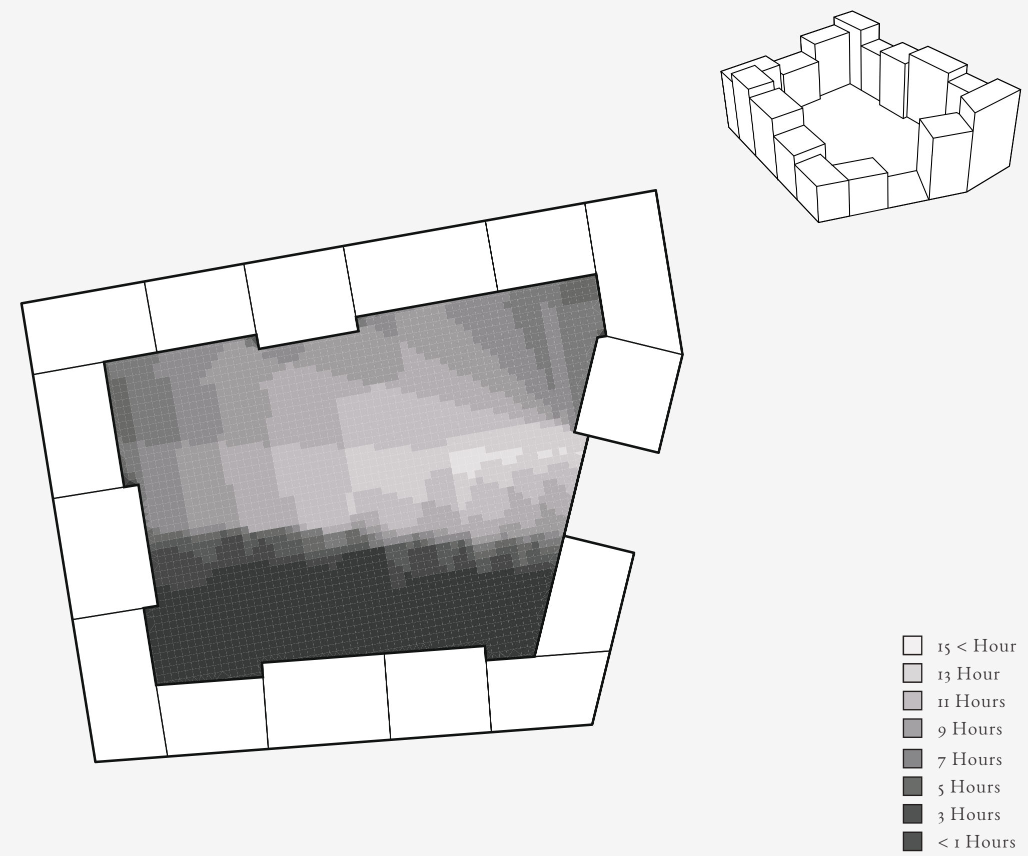
## SUN LIGHT STUDIES

The amount of sunlight hours in the courtyard greatly affects the quality of the space, which meant that certain design decision was done based on sun light studies. Raising the ground level and adding outdoor spaces on top, as proposed in an earlier phase, was tested and it showed to greatly improve the quality of the outdoor space (Ill. 104 and Ill. 105). The precise location of the courtyard entrance was also tested and having the entrance further to the South (Ill. 105 and Ill. 106) allows the lower morning sun the reach deep into the courtyard.

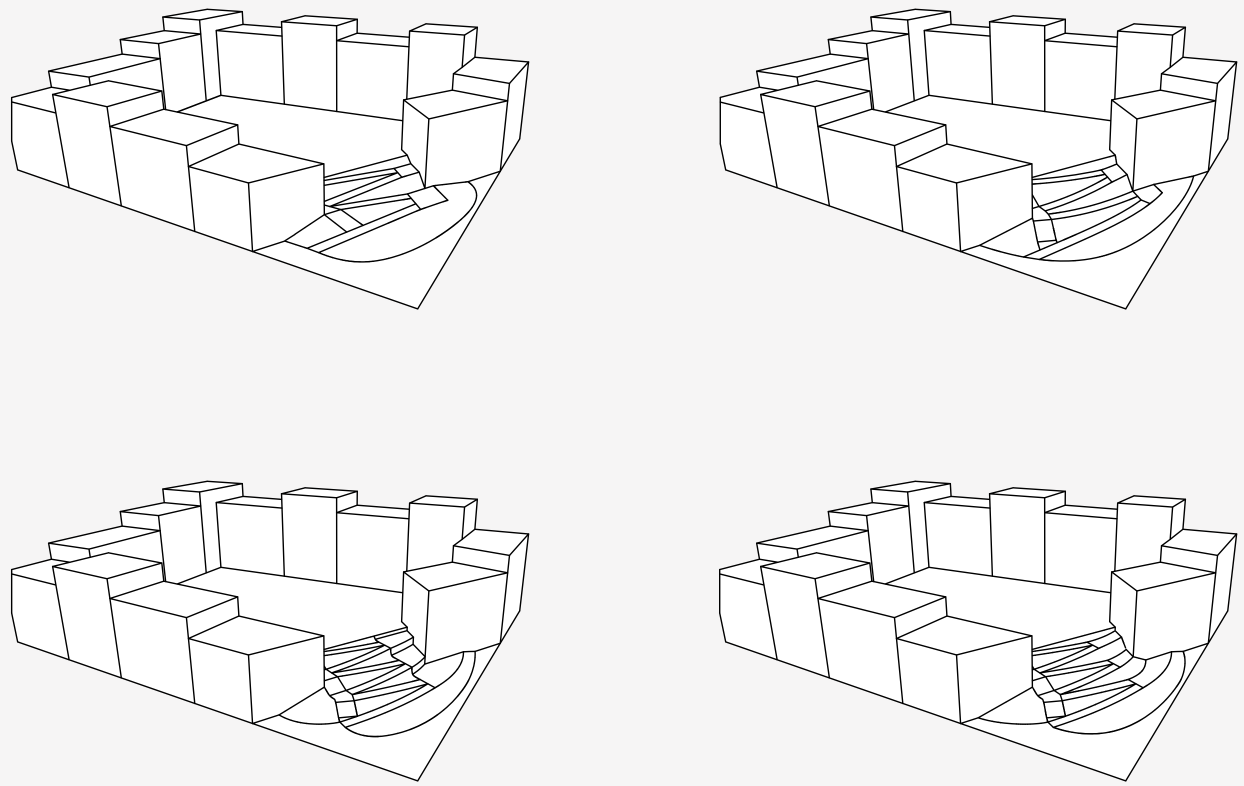





Ill. 105 Study showing sun/shadow conditions in the couryard if placed on the first floor




Ill. 106 Study showing sun/shadow conditions in the couryard with a moved opening



Ill. 107 Design studies of the ramp leading into the courtyard

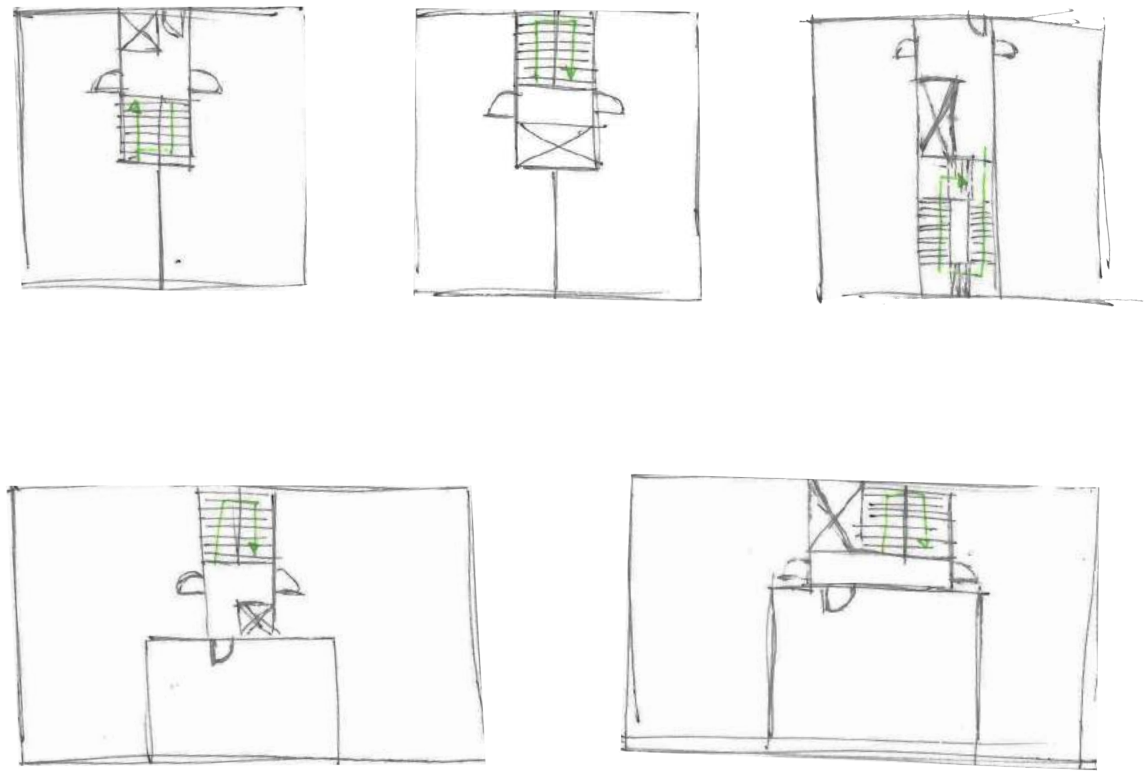
## COURTYARD

When deciding to raise the courtyard on top of a parking space, the issue of creating an access friendly connection between the urban surrounding and the courtyard itself arises. A concept evolving around a ramp (Ill. 107) connecting different functions and spaces at various heights was mapped out based on the maximum slope of an access ramp suitable for wheelchairs. Important aspects in this phase was how the ramp and stair system would be a part of the urban space the general building creates outside of the courtyard and how the ramp would link the different experiences together (Ill. 108).





Ill. 108 Design studies of the streetscape



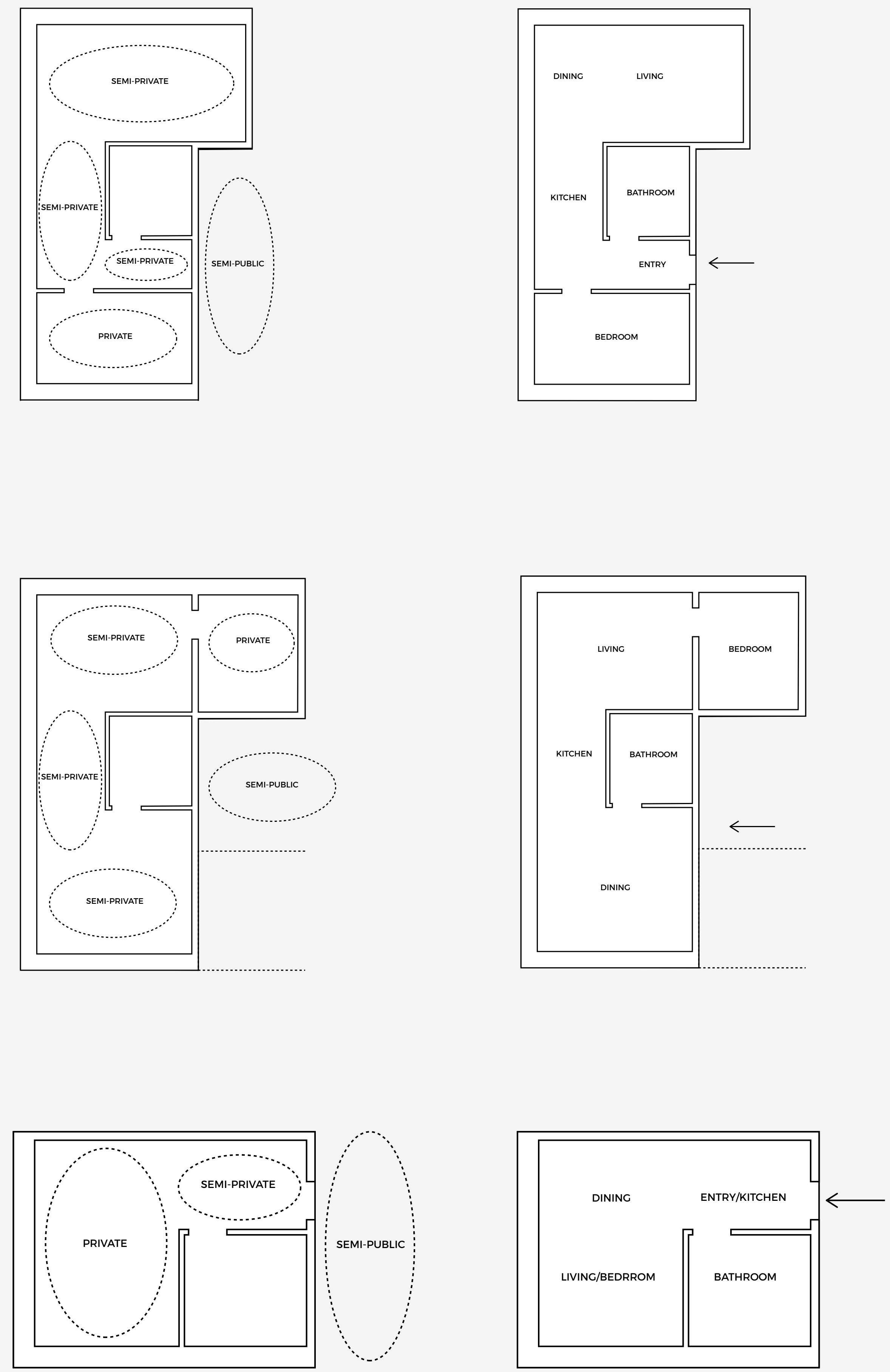
Ill. 109 Studies showing placing of the core in the block

# APARTMENT DESIGN

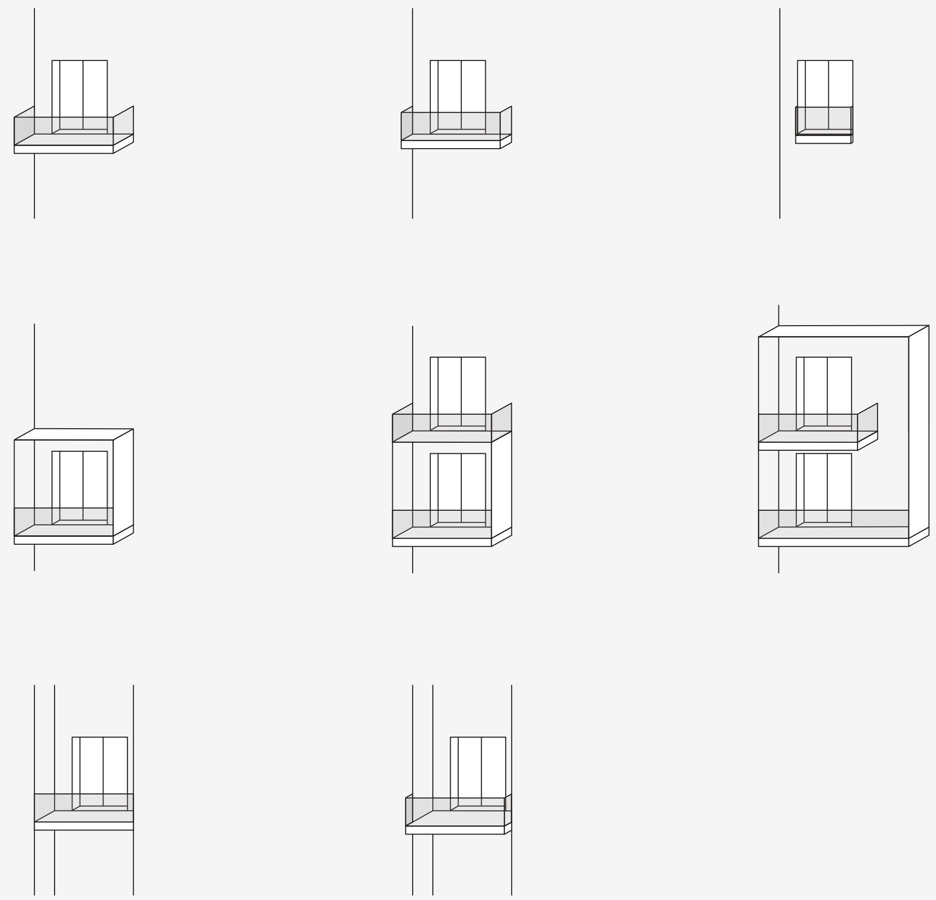
Investigations on the placement of access structures in the apartment plan was made to reach a plan concept that was both space efficient and pleasant to live in (Ill. 109) By placing the access structure in the middle of the plan, more area along the exterior wall could be a part of the living spaces.

The apartment concepts are based on space efficiency in everyday situations. With the compact living space, one of the investigations was how to achieve a good balance between private and semi-private spaces (Ill. 110) when having guests visiting and how it would affect the flow from the entry door into the rest of the apartment.






Ill. 110 Development showing the transition from semi-public to private within the apartments



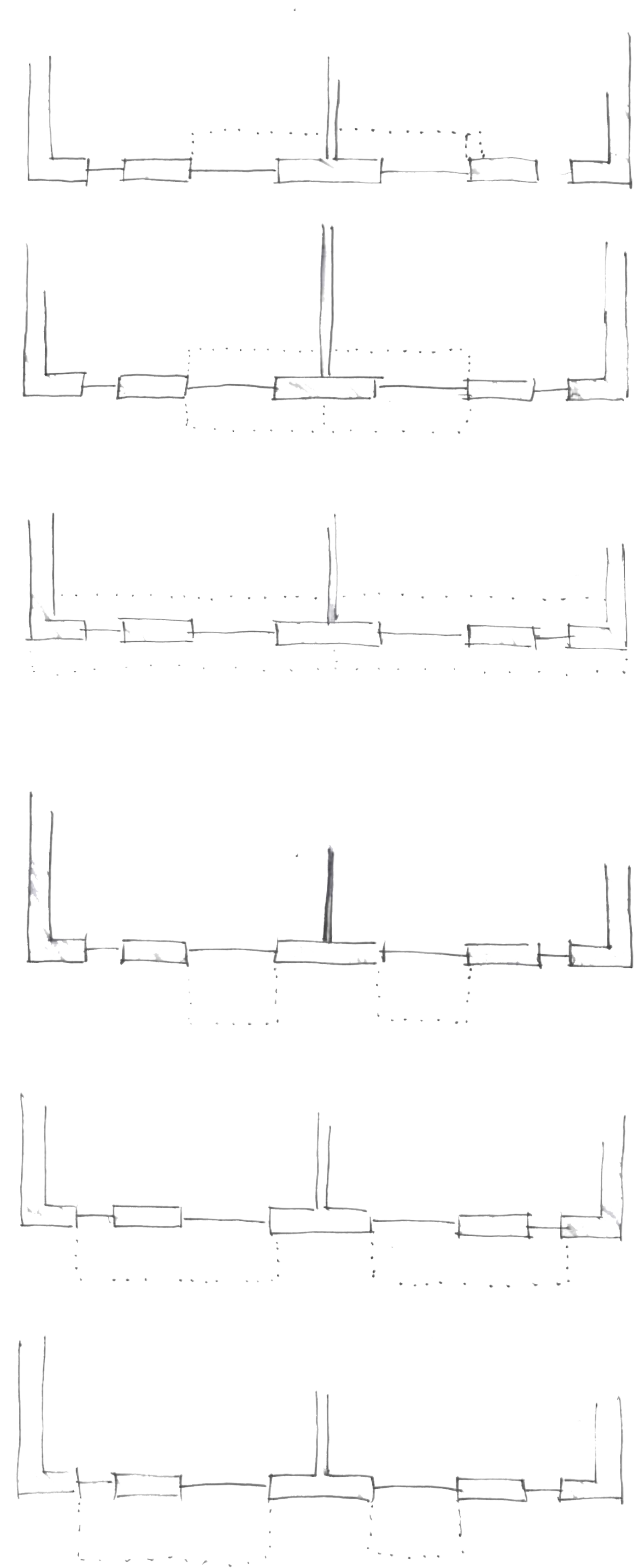
Ill. 111 Balcony studies in perspective

# BALCONY INVESTIGATIONS

Studying balcony typologies, four different aspects were discussed; how to provide privacy, relation to interior space, facade expression and shading performance (Ill. 111 and Ill. 112). Because of the dense urban context and energy goals, privacy and shading performance became important qualities for the further process, but another conclusion was that different apartment types and facade orientations could have varying balcony solutions according to the specific needs. A 4 bedroom apartment would need more space than a studio apartment and a South oriented balcony would have different sun condition than an East facing one, hence the variation in the design.







Ill. 112 Balcony studies in plan

Ill. 113 Initial balcony studies

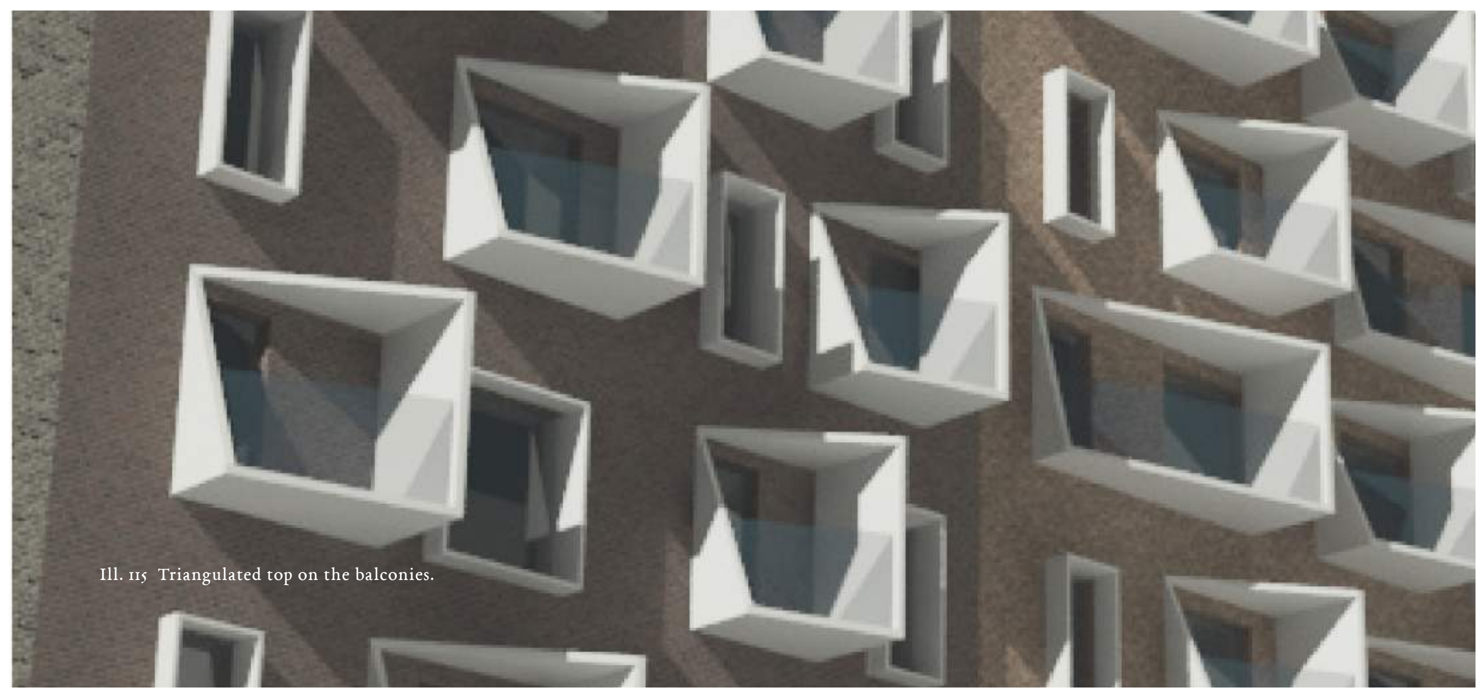
## BALCONY CONCEPT

A concept idea dealing with a balcony structure that could double as a spacious outdoor area and as an efficient shading device arose and was continuously investigated both according to solar shading performance (Ill. 121) and as aesthetic features in composition with the brick facades. From the first box shape (Ill. 113 and Ill. 114) the balconies became more dynamic in shape (Ill. 115 and Ill. 116) to correspond to solar shading needs.

Simultaneously different ways to deal with the windows without balcony was also designed, from a simple box frame (Ill. 116) to more expressive solutions (Ill. 117) before settling on pushed in windows (Ill. 118).



Ill. 114 Close up of boxed balcony



Ill. 115 Triangulated top on the balconies.


Ill. 116 Triangulated and sloped top surfaces


Ill. 117 Shading on windows without balconies


Ill. 118 Withdrawn windows


Ill. 120 Material studie of yellow brick and the concrete balconies


Ill. 119 Material studie of a red brick facade and the concrete balconies

# BALCONIES AND INDOOR CLIMATE

When building low energy houses a common problem is dealing with overheating. Thick and well insulated exterior walls and big windows for good daylight conditions results in low transmission loses and high amounts of solar gain, which can cause the indoor temperature to reach uncomfortable levels. The following process was used as a tool in the facade design to secure the thermal comfort of the end design while maintaining a high daylight factor.

The building simulation software BSim from The Danish Building Research Institute (Sbi) was used to simulate the indoor climate of the building. This was coupled with the environmental analysis tool Ladybug (Roudsari n.d.), which is a plugin for the parametric CAD program Rhino/Grasshopper, in order to work with the data from BSim in a fast and design friendly process.

The general workflow was comprised of three steps(Ill. 121). First a BSim simulation with generic placement and sizes of windows to simulate the maximum level of solar radiation wanted for good thermal comfort. This data was then used as a guideline when designing balconies in Rhino with Ladybug continuously calculating the amount of solar radiation hitting on the glazed surface of the window. Lastly the design was simulated again in BSim for final verification of the indoor environment.

The simulations were done on the apartment for a couple with two or three children, because this was considered to be the apartment with the highest internal energy gains due to the number of people per $m^2$.

### STEP 1

A BSim model was set up of the apartment with simulation parameters and systems as close to reality as possible, so that the window sizes and resulting solar gain would be the only changing parameters from the preliminary study to final verification in BSim. The windows were given fictional shading devices that were adjusted until thermal comfort was achieved in the BSim model.

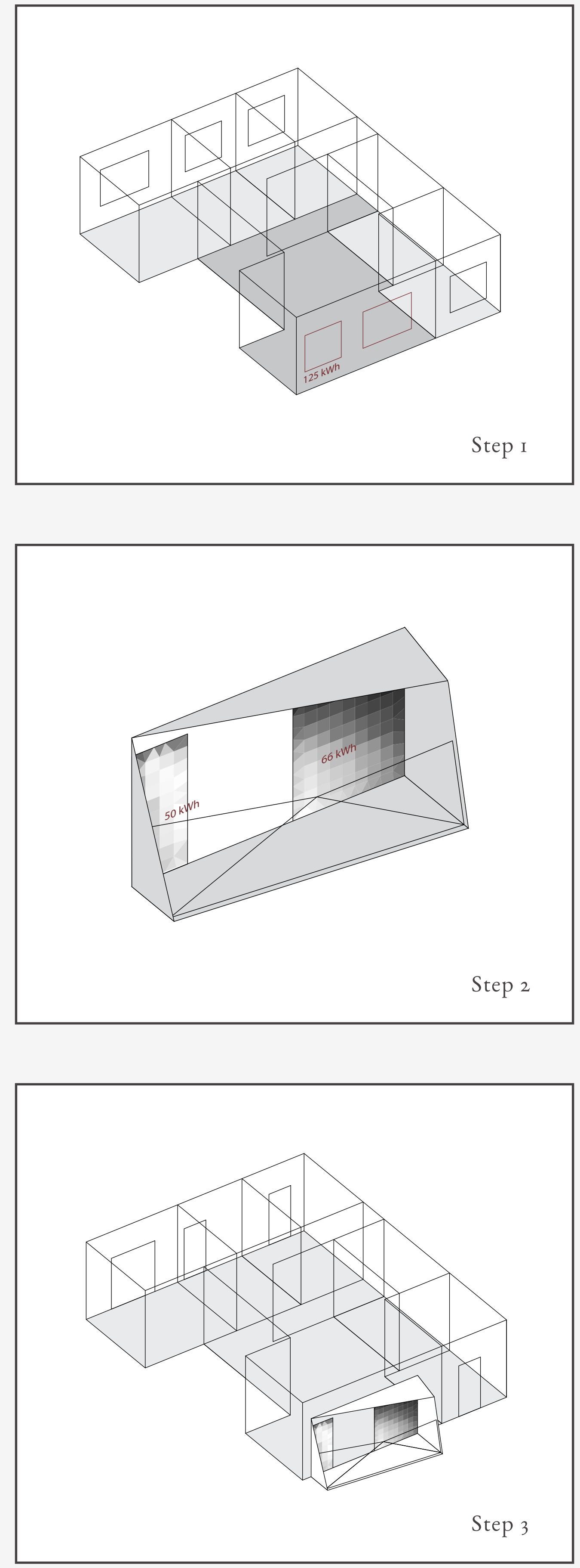
The living room showed to be the thermal zone with the highest temperatures, which meant that the solar gain from this room was used in step 2. The value for the accumulated solar gain in July was 125 kWh.

### STEP 2

Before implementing Ladybug in the design process, it was tested against BSim to show potential dissimilarities in their results. Both software used the same weather data and solar radiation model in their simulation, the Perez model (Roudsari n.d., chap. GenCumulativeSkyMtx), but it was unclear if the software was directly comparable. A simple model was tested for both software and the results showed values from Ladybug to be around 10% higher in the summer months. This was accounted for in the further Ladybug simulations and the dissimilarities were considered acceptable for use as guidelines in the design process. See appendix 1 for the simulation comparison.

### STEP 3

Verification of the indoor climate performance was done to conclude the design process. As expected, the final BSim simulation showed good thermal comforts with only few hours with overheating. These results were considered to be applicable to all other apartments. As a conclusion the workflow showed to be both useful and effective in the design phase of the project.




Ill. 121 Step one to three

# EPILOUGE

*Summary of the Project as a Whole*

# CONCLUSION

## BACKGROUND

The project deals with creating a hybrid building that incorporates commercial and residential functions for a diversified variety of users with different backgrounds and permanence, ranging from families, elderly, singles, students and a hostel.

Various site analyses were made in order to comprehend the physical and social context of the site and its surroundings. The site is located in a dense urban area in Hamburg, with the dynamic Reeperbahn on one side and a quieter residential and business area on the other. The site analyses revealed a very diverse and challenging area with many contrasting element, which lead to extensive theoretical framework that was set up in order to deal with the complexity of the task. The three notions; urbanity, living and sustainability, was introduced, elaborated and used in the following design phase.

## FROM VISION TO DESIGN

The vision for the project was to design a hybrid building that can become an active part of the city and the life within it, while still maintaining the private sphere that is needed for high quality living conditions. Instead of disconnecting the private sphere from the urban setting, the project proposes a streetscape that connect the private with the public realm and creates linked spaces that gradually transitions from public to semi-public, semi-private and private.

The theoretical framework of combining ideas of urbanity, quality of living and sustainability into a holistic approach showed to be possible. During the design process the three notions proved to be compatible and mutually inclusive. When designing for high density while creating big and sun lit outdoor areas, the overall building shape became very compact, which showed to be an advantages when aiming for low energy consumption. Another example is the design of the balconies as solar shading devices, which ended up covering three sides to be able to reflect the needed amount of solar radiation. This extra cover creates a private and intimate outdoor space that shelters from overlooking neighbours, which is much appreciated when living in a dense urban context.

Questions about social sustainability are handled by giving the residents varying outdoor spaces that correspond to different levels of social interaction with their neighbours and local community.

The residents have the private space with a spacious balcony, shared roof top terraces that is shared with the neighbours and the possibility for social interaction with the community in the courtyard.

# REFLECTION

In the whole scope of designing sustainable buildings a big question is how much energy it uses. In Danish context there is several terms which cover different decrees of energy use: the 2020 energy frame, low energy, nearly zero energy and zero energy. While some of these definitions are somewhat fluent, there is a clear hierarchy in what label you want to put on your building, and seen from an energy point of view nearly zero is obviously more desirable than low energy, and zero energy even better yet. This project resulted in a design that best can be described as being a low energy building, but while the focus have not been to reach zero energy, it is relevant to reflect upon what could have been done to reach the zero energy mark.

An approach could have been to increase the impact of the passive strategies already implemented. The overall building shape could have been more compact, the envelope could have been even further insulated or windows could be smaller to decrease the total heat transmissions area. Another approach is to aim for a deeper integration of active energy solutions in the early design phases. Setting up concepts for optimal utilization of photovoltaic panels could have shaped roofs or facades and could have yielded larger areas for either photovoltaics or solar heating installations.

While aiming for a zero energy building design is admirable, one has to consider the implication it can have on the design process.  If focus was to lower the energy use, it would have taken focus from somewhere else, in this case designing for living in a dense urban context. As showed in this project it is possible to obtain a low energy design with focus on conditions for quality of life, simply be using simple design choices that do not compromise with its main focus.

Shelter and privacy was a big theme already from the start of the project due to the specifics of the site context with its locations in the very dynamic and colourful Reeperbahn. Therefore it made sense to work with the classic urban block, because it is historically successful at providing exactly this in an dense urban context. In hindsight, the choice to work with the urban block presented a sort of contradiction. The idea of designing a hybrid building was taken from the competition brief the project is based on and was included in the project program. A hybrid building is defined as a building that integrates into its surroundings and implements both the private and public spheres. So combining two typologies that in one case shelter a private space from the surrounding urban environment and in another case connects a public space to the city was a choice that there should have been more awareness about from the beginning. In the project the solution became to transform the urban block from its classical configuration into something else and the courtyard became a sort of streetscape instead of a sheltered private sphere. But investigating the integrations of these typology in a decided way could have shown interesting results.

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# ILLUSTRATIONS

1-4: Own illustrations

5-7: Pamphlet Architecture no. 11: Hybrid Buildings, Princeton Architectural Press, New York, 1985

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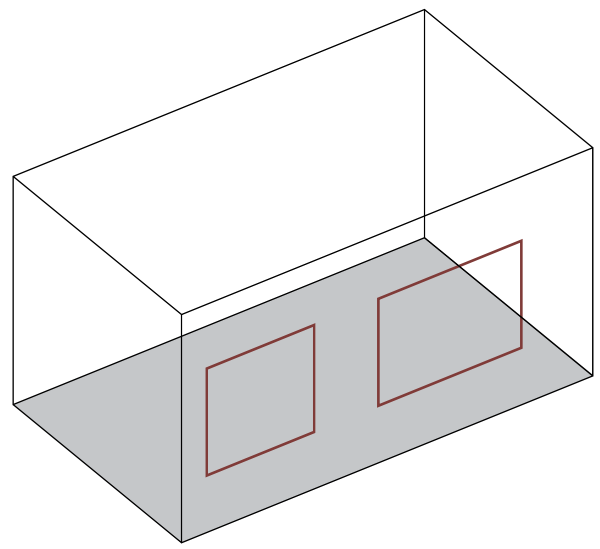
48-122: Own illustrations

# APPENDIX

# APPENDIX 1: BSIM AND LADYBUG

A simple model was simulated with both BSim and Ladybug to evaluate potential difference in their output data. The BSim simulation was done without any shading devices for the windows to have data comparable with the ladybug analysis.

Surprisingly the comparison showed a large dissimilarity overall. But the relevant comparison is between the summer months, which had a lot smaller deviation between the 2 software. In the less simplified BSim simulations, august was the month with the highest solar gain value, which meant that the deviation from that month on 12,6 % was used to adjust the Ladybug simulation data in the designprocess.



| COMPARISON | Jan | Feb | March | April | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BSim, kWh | 45 | 93 | 155 | 192 | 200 | 181 | 177 | 191 | 149 | 113 | 74 | 36 |
| Ladybug, kWh | 57 | 112 | 189 | 228 | 221 | 190 | 190 | 215 | 179 | 139 | 91 | 45 |
| Percentage deviation | 25,6 | 20,7 | 22,1 | 18,6 | 10,6 | 5,1 | 7,5 | 12,6 | 19,9 | 23,1 | 23,1 | 24,9 |

# APPENDIX 2: BE15

Only passive strategies applied

Nøgletal, kWh/m² år

| Renoveringsklasse 2 | | |
|---|---|---|
| Uden tillæg | Tillæg for særlige betingelser | Samlet energiramme |
| 110,2 | 0,0 | 110,2 |
| Samlet energibehov | | 16,3 |

| Renoveringsklasse 1 | | |
|---|---|---|
| Uden tillæg | Tillæg for særlige betingelser | Samlet energiramme |
| 52,6 | 0,0 | 52,6 |
| Samlet energibehov | | 16,3 |

| Energiramme BR 2015 | | |
|---|---|---|
| Uden tillæg | Tillæg for særlige betingelser | Samlet energiramme |
| 30,0 | 0,0 | 30,0 |
| Samlet energibehov | | 12,9 |

| Energiramme Byggeri 2020 | | |
|---|---|---|
| Uden tillæg | Tillæg for særlige betingelser | Samlet energiramme |
| 20,0 | 0,0 | 20,0 |
| Samlet energibehov | | 9,7 |

| Bidrag til energibehovet | |
|---|---|
| Varme | 17,4 |
| El til bygningsdrift | -0,4 |
| Overtemp. i rum | 0,0 |

| Netto behov | |
|---|---|
| Rumopvarmning | 3,2 |
| Varmt brugsvand | 13,2 |
| Køling | 0,0 |

| Udvalgte elbehov | |
|---|---|
| Belysning | 0,0 |
| Opvarmning af rum | 0,0 |
| Opvarmning af vbv | 0,0 |
| Varmepumpe | 0,0 |
| Ventilatorer | 1,8 |
| Pumper | 0,0 |
| Køling | 0,0 |
| Totalt elforbrug | 32,5 |

| Varmetab fra installationer | |
|---|---|
| Rumopvarmning | 1,0 |
| Varmt brugsvand | 0,1 |

| Ydelse fra særlige kilder | |
|---|---|
| Solvarme | 0,0 |
| Varmepumpe | 0,0 |
| Solceller | 2,3 |
| Vindmøller | 0,0 |





Including PV's on the roof areas

Nøgletal, kWh/m² år

| Renoveringsklasse 2 | | |
|---|---|---|
| Uden tillæg | Tillæg for særlige betingelser | Samlet energiramme |
| 110,2 | 0,0 | 110,2 |
| Samlet energibehov | | 22,0 |

| Renoveringsklasse 1 | | |
|---|---|---|
| Uden tillæg | Tillæg for særlige betingelser | Samlet energiramme |
| 52,6 | 0,0 | 52,6 |
| Samlet energibehov | | 22,0 |

| Energiramme BR 2015 | | |
|---|---|---|
| Uden tillæg | Tillæg for særlige betingelser | Samlet energiramme |
| 30,0 | 0,0 | 30,0 |
| Samlet energibehov | | 18,5 |

| Energiramme Byggeri 2020 | | |
|---|---|---|
| Uden tillæg | Tillæg for særlige betingelser | Samlet energiramme |
| 20,0 | 0,0 | 20,0 |
| Samlet energibehov | | 13,8 |

| Bidrag til energibehovet | |
|---|---|
| Varme | 17,4 |
| El til bygningsdrift | 1,8 |
| Overtemp. i rum | 0,0 |

| Netto behov | |
|---|---|
| Rumopvarmning | 3,2 |
| Varmt brugsvand | 13,2 |
| Køling | 0,0 |

| Udvalgte elbehov | |
|---|---|
| Belysning | 0,0 |
| Opvarmning af rum | 0,0 |
| Opvarmning af vbv | 0,0 |
| Varmepumpe | 0,0 |
| Ventilatorer | 1,8 |
| Pumper | 0,0 |
| Køling | 0,0 |
| Totalt elforbrug | 32,5 |

| Varmetab fra installationer | |
|---|---|
| Rumopvarmning | 1,0 |
| Varmt brugsvand | 0,1 |

| Ydelse fra særlige kilder | |
|---|---|
| Solvarme | 0,0 |
| Varmepumpe | 0,0 |
| Solceller | 0,0 |
| Vindmøller | 0,0 |

# APPENDIX 3: VENTILATION

Atmospheric comfort

| | |
|---|---|
| People | $5$ |
| Floor area | $38{,}15\ m^2$ |
| Room volume | $106{,}82\ m^3$ |
| Pollution from building | $0{,}1\ olf$ |
| Total pollution | $\frac{5}{38{,}15 m^2} + 0{,}1\ olf = 0{,}23 \frac{olf}{m^2}$ |

According to Danish Standard, DS1752, no more than 20% should be unsatisfied with the air quality I city with moderate air pollution. That means a limit of 1,4 decipol.

| | |
|---|---|
| Flow rate | $V_l = \frac{10*q}{c-c_i} = \frac{10*0{,}23}{1{,}4-0{,}1} = 1{,}77 \frac{l}{s} = 244{,}11 \frac{m^3}{h}$ |
| Air change: | $n = \frac{V_l}{V} = \frac{244{,}11}{106{,}82} = 2{,}29\ h^{-1}$ |

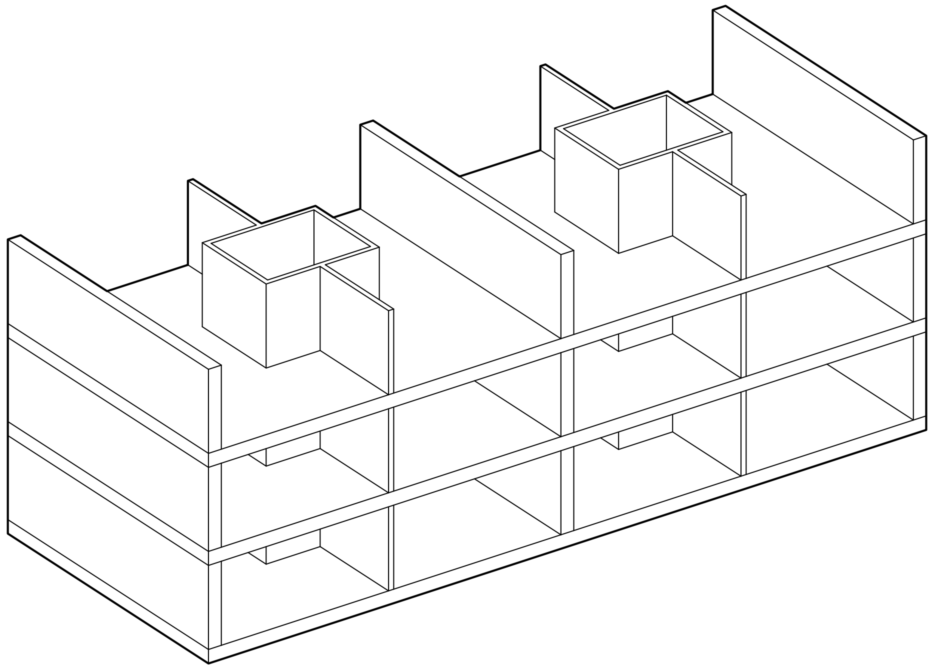
According to diagram a duct size of ϕ200mm is needed, but is airflow requirements for the bathroom demands a duct size of ϕ250mm

Carbon dioxide

| | |
|---|---|
| Gh | $19 \frac{l}{h}\ per\ person$ |
| | $0{,}0053 \frac{l}{s} per\ person$ |
| q | $0{,}13$ |
| Chi | $900\ ppm$ |
| Air flow | $V_l = \frac{q*G_h}{C_{hi}-C_{h0}} = 0{,}77 \frac{l}{s} = 105{,}56 \frac{m^3}{h}$ |
| Air change | $n = 1{,}59\ h^{-1}$ |

According to diagram a duct size of ϕ160mm is needed.

Construction principle



# APPENDIX 4: CONSTRUCTION

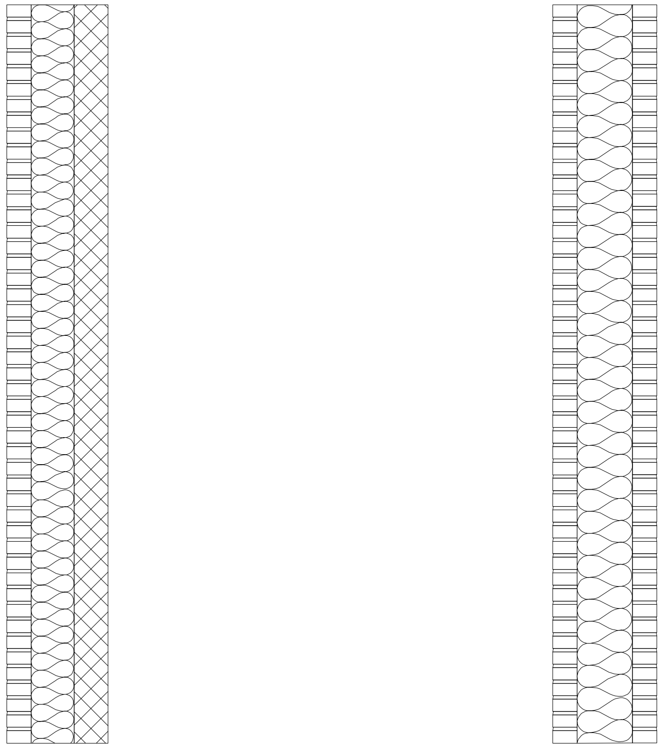
The building is constructed of loadbearing prefabricated concrete elements. The vertical loads are carried by the walls dividing the apartments with the floor slaps spanning across. Internal cores are stabilizing the structure in the horizontal direction.

In the design phase, a calculation was made in order to determine the u-values of two potential constructions for the exterior walls; one with brick on the internal side of the construction and one with concrete element. A construction with brick on the exterior and concrete on the interior was chosen, because of it being the thinnest of the constructions while upholding approximately the same u-value.





Construction types



| | |
|---|---|
| 108 mm brick | 108 mm brick |
| 190 mm insulation | 190 mm insulation |
| 150 mm concrete | 108 mm brick |
| total = 448 mm | total = 461 mm |
| u-value = 0,15 W/m^2K | u-value = 0,14 W/m^2K |

# APPENDIX 5: BSIM

Couple with 3 children or 4 students

**tsbi5 2016-05-20 - Thesis-Hamburg-endelige3.dis ((Couple with children and students))** **22.05.2016 15.26 Page 1**

Year 2011, tstep=120, RadModel=Perez, Options: optimized xsun longwsky longwave latheat

| Month | Sum/Mean | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| qHeating | 4669,44 | 756,51 | 668,19 | 594,66 | 453,32 | 186,85 | 0,00 | 0,00 | 0,00 | 62,58 | 514,36 | 653,15 | 779,83 |
| qCooling | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| qInfiltration | -1112,76 | -139,14 | -137,58 | -123,98 | -103,30 | -70,06 | -52,05 | -45,58 | -42,66 | -63,55 | -85,56 | -113,59 | -135,71 |
| qVenting | -2007,33 | 0,00 | 0,00 | 0,00 | 0,00 | -255,28 | -454,55 | -490,10 | -471,31 | -336,09 | 0,00 | 0,00 | 0,00 |
| qSunRad | 2645,13 | 74,50 | 130,18 | 225,63 | 298,86 | 341,91 | 338,40 | 344,10 | 318,66 | 240,36 | 173,20 | 102,89 | 56,44 |
| qPeople | 2487,24 | 214,13 | 190,66 | 208,80 | 205,42 | 211,46 | 202,75 | 214,13 | 208,80 | 202,75 | 214,13 | 202,75 | 211,46 |
| qEquipment | 1716,21 | 146,25 | 131,63 | 145,35 | 141,23 | 145,80 | 140,78 | 146,25 | 145,35 | 140,78 | 146,25 | 140,78 | 145,80 |
| qLighting | 1187,53 | 130,70 | 112,59 | 116,42 | 103,11 | 96,63 | 43,83 | 48,52 | 50,63 | 109,90 | 122,00 | 122,68 | 130,51 |
| qTransmission | -2904,34 | -354,21 | -340,43 | -319,63 | -267,69 | -207,67 | -135,29 | -130,64 | -124,74 | -140,97 | -235,84 | -297,82 | -349,43 |
| qMixing | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| qVentilation | -6681,12 | -828,73 | -755,23 | -847,25 | -830,93 | -449,65 | -83,86 | -86,67 | -84,73 | -215,77 | -848,54 | -810,85 | -838,91 |
| Sum | 0,00 | 0,00 | 0,00 | 0,00 | -0,00 | 0,00 | 0,00 | -0,00 | -0,00 | -0,00 | -0,00 | -0,00 | 0,00 |
| tOutdoor mean(°C) | 8,6 | 1,7 | 0,1 | 4,1 | 6,5 | 12,3 | 15,4 | 16,4 | 16,9 | 13,1 | 9,3 | 4,8 | 2,4 |
| tOp mean(°C) | 21,7 | 21,1 | 21,1 | 21,1 | 21,2 | 22,0 | 22,8 | 22,7 | 22,8 | 22,1 | 21,2 | 21,1 | 21,1 |
| AirChange(/h) | 5,6 | 6,6 | 6,6 | 6,6 | 6,6 | 5,2 | 3,8 | 4,1 | 4,2 | 4,1 | 6,6 | 6,6 | 6,6 |
| Rel. Moisture(%) | 39,1 | 28,2 | 23,9 | 29,5 | 31,1 | 41,3 | 50,9 | 52,3 | 56,7 | 50,6 | 41,8 | 32,1 | 30,6 |
| Co2(ppm) | 429,3 | 395,0 | 394,7 | 394,3 | 395,0 | 444,8 | 504,7 | 464,6 | 466,3 | 507,5 | 395,3 | 394,2 | 395,0 |
| PAQ(-) | 0,4 | 0,6 | 0,7 | 0,6 | 0,6 | 0,4 | 0,2 | 0,2 | 0,1 | 0,3 | 0,4 | 0,6 | 0,6 |
| FanPow | 4776,85 | 549,33 | 496,17 | 549,33 | 531,61 | 345,89 | 150,17 | 155,18 | 155,18 | 213,74 | 549,33 | 531,61 | 549,33 |
| HtRec | 31870,31 | 5031,47 | 5041,42 | 4320,88 | 3417,74 | 1407,91 | 292,77 | 203,52 | 174,00 | 583,53 | 2623,72 | 3921,44 | 4851,91 |
| ClRec | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| HtCoil | 1435,22 | 251,88 | 297,99 | 188,88 | 132,35 | 40,90 | 2,76 | 0,44 | 0,85 | 6,92 | 78,10 | 164,74 | 269,42 |
| ClCoil | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Humidif | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| FloorHeat | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| FloorCool | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentHeatPumpPow | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentCoolingPow | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentHeatPump | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentCooling | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |

**tsbi5 2016-05-20 - Thesis-Hamburg-endelige3.dis (Living Room)** **22.05.2016 15.28 Page 1**

Year 2011, tstep=120, RadModel=Perez, Options: optimized xsun longwsky longwave latheat

| Month | Sum/Mean | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| qHeating | 513,84 | 107,02 | 88,10 | 56,24 | 23,98 | 7,77 | 0,00 | 0,00 | 0,00 | 2,48 | 34,40 | 77,25 | 116,60 |
| qCooling | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| qInfiltration | -488,26 | -60,46 | -59,84 | -54,37 | -45,79 | -31,18 | -22,97 | -20,20 | -18,94 | -28,02 | -37,93 | -49,60 | -58,96 |
| qVenting | -1048,01 | 0,00 | 0,00 | 0,00 | 0,00 | -130,45 | -234,76 | -253,50 | -249,79 | -179,51 | 0,00 | 0,00 | 0,00 |
| qSunRad | 1256,42 | 39,82 | 71,64 | 117,93 | 146,00 | 154,70 | 140,58 | 144,53 | 145,11 | 117,79 | 89,73 | 58,16 | 30,44 |
| qPeople | 1435,20 | 125,40 | 109,92 | 118,92 | 119,16 | 122,16 | 115,92 | 125,40 | 118,92 | 115,92 | 125,40 | 115,92 | 122,16 |
| qEquipment | 990,06 | 84,09 | 75,95 | 84,09 | 81,38 | 84,09 | 81,38 | 84,09 | 84,09 | 81,38 | 84,09 | 81,38 | 84,09 |
| qLighting | 99,60 | 9,60 | 8,19 | 8,32 | 7,71 | 7,73 | 7,19 | 7,72 | 7,73 | 7,90 | 8,90 | 8,98 | 9,61 |
| qTransmission | -1316,17 | -125,21 | -126,73 | -134,49 | -129,49 | -114,17 | -87,34 | -88,03 | -87,12 | -85,27 | -104,66 | -111,46 | -122,21 |
| qMixing | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| qVentilation | -1442,68 | -180,26 | -167,24 | -196,64 | -202,94 | -100,65 | 0,00 | 0,00 | 0,00 | -32,67 | -199,93 | -180,63 | -181,73 |
| Sum | 0,00 | 0,00 | 0,00 | 0,00 | -0,00 | 0,00 | -0,00 | 0,00 | -0,00 | -0,00 | 0,00 | -0,00 | 0,00 |
| tOutdoor mean(°C) | 8,6 | 1,7 | 0,1 | 4,1 | 6,5 | 12,3 | 15,4 | 16,4 | 16,9 | 13,1 | 9,3 | 4,8 | 2,4 |
| tOp mean(°C) | 22,1 | 21,3 | 21,3 | 21,5 | 21,8 | 22,5 | 23,3 | 23,2 | 23,2 | 22,6 | 21,6 | 21,4 | 21,2 |
| AirChange(/h) | 1,9 | 2,0 | 2,0 | 2,0 | 2,0 | 1,9 | 1,6 | 2,0 | 2,1 | 1,3 | 2,0 | 2,0 | 2,0 |
| Rel. Moisture(%) | 41,6 | 32,8 | 28,4 | 33,0 | 33,9 | 42,6 | 51,9 | 52,5 | 56,5 | 52,3 | 44,2 | 35,9 | 34,9 |
| Co2(ppm) | 508,9 | 481,6 | 478,8 | 475,8 | 480,2 | 520,0 | 589,6 | 520,6 | 507,9 | 614,3 | 482,4 | 476,3 | 479,8 |
| PAQ(-) | 0,4 | 0,5 | 0,6 | 0,5 | 0,5 | 0,3 | 0,1 | 0,1 | 0,1 | 0,2 | 0,4 | 0,5 | 0,5 |
| Hours > 21 | 6429 | 321 | 315 | 466 | 557 | 675 | 720 | 744 | 744 | 702 | 520 | 362 | 303 |
| Hours > 26 | 79 | 0 | 0 | 0 | 0 | 6 | 53 | 6 | 14 | 0 | 0 | 0 | 0 |
| Hours > 27 | 25 | 0 | 0 | 0 | 0 | 0 | 23 | 0 | 2 | 0 | 0 | 0 | 0 |
| Hours < 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FanPow | 789,70 | 105,52 | 95,31 | 105,52 | 102,12 | 51,06 | 0,00 | 0,00 | 0,00 | 17,02 | 105,52 | 102,12 | 105,52 |
| HtRec | 6145,32 | 1011,68 | 1016,47 | 864,61 | 681,17 | 243,92 | 0,00 | 0,00 | 0,00 | 49,80 | 518,94 | 783,73 | 975,00 |
| ClRec | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| HtCoil | 24,66 | 3,11 | 9,17 | 1,69 | 0,78 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,06 | 1,17 | 8,68 |
| ClCoil | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Humidif | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| FloorHeat | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| FloorCool | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentHeatPumpPow | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentCoolingPow | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentHeatPump | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentCooling | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |



**tsbi5 2016-05-20 - Thesis-Hamburg-endelige3.dis (Bedrooms)** **22.05.2016 15.27 Page 1**

Year 2011, tstep=120, RadModel=Perez, Options: optimized xsun longwsky longwave latheat

| Month | Sum/Mean | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| qHeating | 820,67 | 153,35 | 137,26 | 101,25 | 55,17 | 17,37 | 0,00 | 0,00 | 0,00 | 5,47 | 69,27 | 121,63 | 159,90 |
| qCooling | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| qInfiltration | -296,10 | -36,77 | -36,31 | -32,64 | -27,11 | -18,81 | -14,31 | -12,61 | -11,85 | -17,31 | -22,52 | -29,98 | -35,88 |
| qVenting | -534,66 | 0,00 | 0,00 | 0,00 | 0,00 | -74,87 | -116,45 | -127,08 | -116,52 | -99,75 | 0,00 | 0,00 | 0,00 |
| qSunRad | 889,31 | 23,84 | 40,19 | 71,47 | 98,53 | 117,17 | 120,84 | 122,74 | 109,70 | 79,58 | 55,70 | 31,54 | 18,01 |
| qPeople | 590,04 | 51,05 | 45,22 | 49,32 | 48,82 | 50,18 | 47,95 | 51,05 | 49,32 | 47,95 | 51,05 | 47,95 | 50,18 |
| qEquipment | 463,35 | 39,84 | 35,52 | 38,94 | 38,25 | 39,39 | 37,80 | 39,84 | 38,94 | 37,80 | 39,84 | 37,80 | 39,39 |
| qLighting | 563,90 | 74,60 | 62,40 | 61,60 | 52,30 | 46,30 | 0,00 | 0,00 | 0,00 | 57,00 | 66,60 | 68,70 | 74,40 |
| qTransmission | -1196,81 | -135,88 | -129,84 | -116,38 | -94,32 | -90,50 | -75,84 | -73,93 | -69,60 | -81,83 | -83,71 | -111,33 | -133,65 |
| qMixing | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| qVentilation | -1299,70 | -170,03 | -154,44 | -173,57 | -171,63 | -86,23 | 0,00 | 0,00 | 0,00 | -28,92 | -176,22 | -166,31 | -172,35 |
| Sum | 0,00 | 0,00 | 0,00 | 0,00 | -0,00 | 0,00 | 0,00 | -0,00 | 0,00 | -0,00 | -0,00 | -0,00 | 0,00 |
| tOutdoor mean(°C) | 8,6 | 1,7 | 0,1 | 4,1 | 6,5 | 12,3 | 15,4 | 16,4 | 16,9 | 13,1 | 9,3 | 4,8 | 2,4 |
| tOp mean(°C) | 21,9 | 21,1 | 21,1 | 21,2 | 21,3 | 22,4 | 23,3 | 23,2 | 23,3 | 22,6 | 21,2 | 21,1 | 21,1 |
| AirChange(/h) | 2,6 | 3,2 | 3,2 | 3,2 | 3,2 | 2,3 | 1,2 | 1,5 | 1,6 | 1,4 | 3,2 | 3,2 | 3,2 |
| Rel. Moisture(%) | 40,2 | 28,8 | 24,6 | 30,1 | 31,6 | 42,3 | 53,7 | 54,1 | 58,3 | 53,0 | 42,1 | 32,7 | 31,2 |
| Co2(ppm) | 491,4 | 404,8 | 404,2 | 403,4 | 404,6 | 513,7 | 683,0 | 606,0 | 606,1 | 657,5 | 405,2 | 403,4 | 404,5 |
| PAQ(-) | 0,4 | 0,6 | 0,7 | 0,6 | 0,6 | 0,3 | 0,1 | 0,1 | 0,0 | 0,2 | 0,4 | 0,6 | 0,6 |
| Hours > 21 | 5452 | 230 | 211 | 297 | 408 | 620 | 720 | 744 | 744 | 674 | 353 | 237 | 214 |
| Hours > 26 | 62 | 0 | 0 | 0 | 0 | 5 | 37 | 5 | 15 | 0 | 0 | 0 | 0 |
| Hours > 27 | 15 | 0 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hours < 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FanPow | 789,70 | 105,52 | 95,31 | 105,52 | 102,12 | 51,06 | 0,00 | 0,00 | 0,00 | 17,02 | 105,52 | 102,12 | 105,52 |
| HtRec | 6144,52 | 1011,42 | 1015,57 | 864,93 | 681,42 | 243,93 | 0,00 | 0,00 | 0,00 | 49,80 | 518,96 | 784,01 | 974,47 |
| ClRec | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| HtCoil | 25,51 | 3,45 | 10,01 | 1,33 | 0,52 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,03 | 0,88 | 9,28 |
| ClCoil | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Humidif | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| FloorHeat | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| FloorCool | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentHeatPumpPow | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentCoolingPow | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentHeatPump | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentCooling | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |

Master bedroom

**tsbi5 2016-05-20 - Thesis-Hamburg-endelige3.dis (Master Bedroom)** **22.05.2016 15.28 Page 1**

Year 2011, tstep=120, RadModel=Perez, Options: optimized xsun longwsky longwave latheat

| Month | Sum/Mean | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| qHeating | 1056,61 | 172,00 | 152,44 | 134,65 | 103,56 | 37,35 | 0,00 | 0,00 | 0,00 | 11,77 | 122,27 | 149,64 | 172,92 |
| qCooling | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| qInfiltration | -135,40 | -16,89 | -16,69 | -14,90 | -12,26 | -8,43 | -6,61 | -5,86 | -5,51 | -7,91 | -10,14 | -13,72 | -16,48 |
| qVenting | -364,58 | 0,00 | 0,00 | 0,00 | 0,00 | -43,26 | -88,34 | -92,42 | -86,66 | -53,90 | 0,00 | 0,00 | 0,00 |
| qSunRad | 499,40 | 10,84 | 18,34 | 36,24 | 54,33 | 70,04 | 76,97 | 76,84 | 63,85 | 42,99 | 27,77 | 13,19 | 8,00 |
| qPeople | 374,40 | 30,24 | 28,80 | 33,12 | 30,24 | 31,68 | 31,68 | 30,24 | 33,12 | 31,68 | 30,24 | 31,68 | 31,68 |
| qEquipment | 131,40 | 11,16 | 10,08 | 11,16 | 10,80 | 11,16 | 10,80 | 11,16 | 11,16 | 10,80 | 11,16 | 10,80 | 11,16 |
| qLighting | 341,53 | 31,00 | 28,00 | 31,00 | 28,10 | 27,10 | 21,63 | 25,30 | 27,40 | 30,00 | 31,00 | 30,00 | 31,00 |
| qTransmission | -744,80 | -82,33 | -79,69 | -76,31 | -66,65 | -55,40 | -46,14 | -45,26 | -43,35 | -40,53 | -58,50 | -70,48 | -80,16 |
| qMixing | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| qVentilation | -1158,56 | -156,02 | -141,28 | -154,96 | -148,11 | -70,24 | 0,00 | 0,00 | 0,00 | -24,91 | -153,81 | -151,11 | -158,12 |
| Sum | -0,00 | 0,00 | 0,00 | -0,00 | -0,00 | 0,00 | 0,00 | -0,00 | -0,00 | 0,00 | -0,00 | -0,00 | 0,00 |
| tOutdoor mean(°C) | 8,6 | 1,7 | 0,1 | 4,1 | 6,5 | 12,3 | 15,4 | 16,4 | 16,9 | 13,1 | 9,3 | 4,8 | 2,4 |
| tOp mean(°C) | 21,8 | 21,0 | 21,0 | 21,0 | 21,0 | 22,1 | 23,4 | 23,3 | 23,4 | 22,6 | 21,0 | 21,0 | 21,0 |
| AirChange(/h) | 5,0 | 6,8 | 6,8 | 6,8 | 6,8 | 4,1 | 1,6 | 2,0 | 2,0 | 2,1 | 6,8 | 6,8 | 6,8 |
| Rel. Moisture(%) | 37,8 | 27,0 | 22,8 | 28,9 | 30,6 | 40,7 | 48,6 | 49,8 | 54,3 | 48,8 | 41,4 | 31,3 | 29,6 |
| Co2(ppm) | 440,5 | 383,0 | 385,2 | 386,5 | 384,5 | 485,0 | 545,1 | 490,7 | 511,7 | 560,2 | 383,3 | 385,9 | 385,1 |
| PAQ(-) | 0,4 | 0,6 | 0,7 | 0,6 | 0,6 | 0,4 | 0,2 | 0,2 | 0,1 | 0,2 | 0,5 | 0,6 | 0,6 |
| Hours > 21 | 3668 | 23 | 22 | 80 | 94 | 461 | 720 | 744 | 744 | 633 | 87 | 30 | 30 |
| Hours > 26 | 70 | 0 | 0 | 0 | 0 | 5 | 45 | 8 | 12 | 0 | 0 | 0 | 0 |
| Hours > 27 | 16 | 0 | 0 | 0 | 0 | 0 | 13 | 2 | 1 | 0 | 0 | 0 | 0 |
| Hours < 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FanPow | 789,70 | 105,52 | 95,31 | 105,52 | 102,12 | 51,06 | 0,00 | 0,00 | 0,00 | 17,02 | 105,52 | 102,12 | 105,52 |
| HtRec | 6126,83 | 1007,46 | 1009,78 | 863,79 | 680,84 | 243,93 | 0,00 | 0,00 | 0,00 | 49,80 | 518,91 | 782,46 | 969,88 |
| ClRec | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| HtCoil | 43,10 | 7,40 | 15,84 | 2,43 | 1,04 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,08 | 2,44 | 13,87 |
| ClCoil | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| Humidif | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| FloorHeat | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| FloorCool | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentHeatPumpPow | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentCoolingPow | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentHeatPump | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| CentCooling | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |