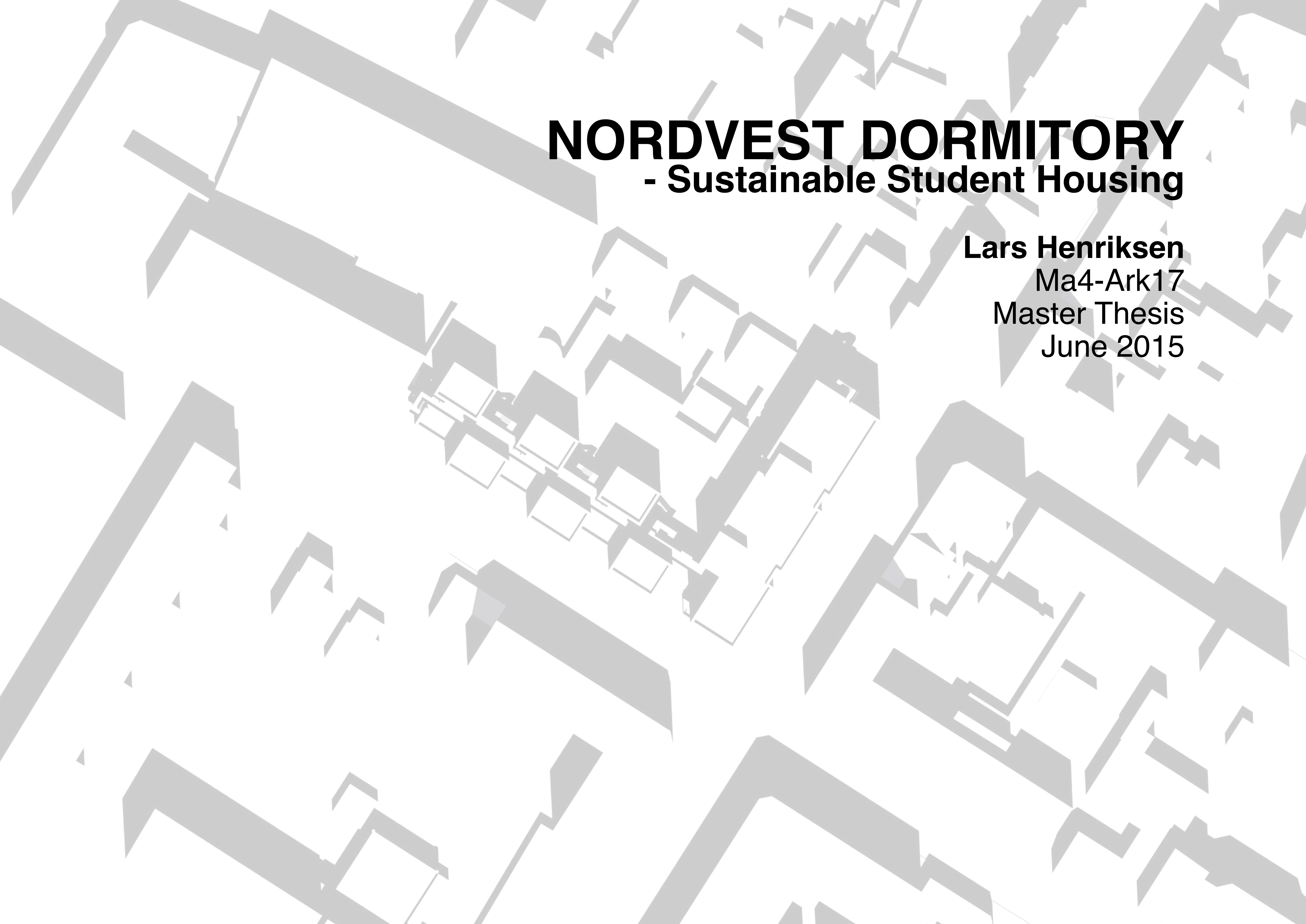

NORDVEST DORMITORY
- Sustainable Student Housing

Lars Henriksen
Ma4-Ark17

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Title Page

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Abstract

Motiveret af den håbløse boligsituation for mange unge studerende i København, er hovedformålet med dette speciale at skabe nye studieboliger i et relevant område af København. Med et udvidet fokus på bæredygtig arkitektur, ønskes det at opnå et projekt der både er socialt og miljømæssigt bæredygtigt, det sidste manifisteret i et mål om at opnå bygningsklasse 2020 indenfor helholdsvis energiforbrug og indeklima. Den foreslåede byggegrund for projektet findes gennem en analyse af byen, og valget falder på et interessant, indtil for nyligt forladt byggetomt i det relativt socialt belastede område Nordvest, på kanten af et underområde med en stærk industriel karakter. Den foreslåede brugerprofil inkluderer forskellige boligtyper samt andre funktioner, som bidrager til både social interaktion og aktivitet og tryghed i gadebilledet. Ved at anvende en integreret designproces hvor projektet bliver udviklet på baggrund af både tekniske, funktionelle og æstetiske overvejelser, opnås et design der formår at opfylde 2020 kravene, samtidig med at skabe gode rum og rammer for at bo og leve, og være identitetsforstærkende for området. Det foreslåede design indeholder fysisk to bygninger, som tager højde for kontekstens skala og bevægelser, ved at variere i både udtryk og form i forskellige retninger, men fremstår alligevel som en hel, forbundet bygning gennem materialevalg og formmæssige forbindelser.

Reading guide

The report includes all elements of the integrated design process, but is not presented in a consecutive order. To better follow the steps/iterations of the sketching and synthesis phase, the project is presented in full before these chapters.

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INTRO

The following chapter is an introduction to the project, including motivation for the theme leading to the preliminary problem, as well as an explanation of the methods applied in the project.

Motivation

As a young student who has recently moved to Copenhagen, I have experienced first hand how hard it is to find a place to live that is both affordable, liveable, and within fair distance to school or ones place of internship, central in Copenhagen. The waiting lists for public dormitories are several years long, and the private housing market is mostly financially out of reach for the average student. Furthermore, the current effort to address this issue seems to only cater to people with wealthy families able to support them, or those willing, and able, to go into huge debt. A recent example is the renovation of an old school in Husumgade in Nørrebro, turned into youth housing by a private developer. The smallest apartment, a 38m2 studio, costs 1000 DKK more than the monthly support from the government, a student's primary source of income. A 66m2 apartment with two rooms costs roughly the double of SU [Politiken.dk, 2014].

The core of the problem is about supply and demand. The amount of young people in Copenhagen in the need for a small, affordable dwelling is much larger, and increasing faster, than the supply of these dwellings [Politiken, 2013]. The problem is a consequence of not prioritising student dwellings in new developments on a municipal level. In Aalborg, who also experience a large growth in the student and youth population, the situation is quite different. The municipality has a vision of making Aalborg the best city for education in Denmark. One of the initiatives has been to prioritise student dwellings in new building projects, and also providing students with a 'roof-over-your-head' guarantee [AKU-Aalborg, 2014].

However, the municipality of Copenhagen is beginning to acknowledge the problem, and is making new efforts and strategies to meet the challenges [Politiken, 2014], aiming for, among other things, development of 6.000 new youth dwellings before 2025. An ambitious number, and a much needed effort. However, considering an expected increase of 33.000 people between the age of 18-29 by the same time, as well as an increase in the overall population, the situation might get a lot worse [Københavns Kommune, 2012].

The housing situation is of social character, and the current development seems unsustainable. Sustainability, and making sure new development is sustainable, is an important aspect to include, in architecture as well as other industries. Sustainability is a very broad term, and includes much more than the social aspect. In relation to architecture, the environmental aspect is very important, and probably receiving the most attention. Common, international visions regarding this issue is illustrated in future legislative demands for new buildings in Denmark, with very specific limits for energy consumption [Bygningsreglementet, 2014]. Making further initiatives for sustainability in architecture is not necessary in a legislative sense, but encouraged by certifications such as LEED, DGNB or BREEAM, or classifications such as netZEB (net Zero Energy Building).

In many cases, current approaches to sustainability in architecture separates the aesthetic and technical aspects, resulting in incoherent designs where technical solutions can appear superimposed, attached instead of integrated. A reason being that the technical knowledge is often included too late in the design process. This results in conflicts between the architect and the engineer, creating suboptimal compromises in the final design. Focusing on better technical integration will result in better performing buildings, both regarding sustainability, functionality, aesthetic value and overall satisfaction. If we continue to approach sustainability as a 'technical problem' or limitation, a lot of potential for great architecture will be left unfulfilled.

Preliminary problem

As an architecture student I realise I have the possibility to address this issue with my master thesis, while at the same time achieving a better understanding of the city I currently reside in, by asking:

How can sustainable architecture be approached as an opportunity instead of a limitation?

How can sustainability be integrated in the design process, so the final solution becomes coherent in both technical, functional and aesthetic concerns?

Where can the city be densified without compromising, or maybe even improving the existing quality of public open space for the affected citizens and companies?

Ill. 9.1: Desperate students occupy the town hall of Copenhagen to voice their dissaproval of the current housing conditions of Copenhagen. Photo By Jens Dresling, Politiken.

Methodology

General Approach

Continuing the path laid out by Aalborg University, the approach to the thesis is based in the method of Problem Based Learning (PBL). The first step of the thesis is to formulate a problem, derived from my motivation and selection of theme. Relevant subjects are then researched, and knowledgde necessary to solving the problem are aqquired - the problem leads the project.

The formulated problem should closely reflect a realistic, current situation, ensuring relevant experience and aqquired skills and knowledge.

It is encouraged to work in groups with at least three members to gain the full potential of the PBL method, which has been the approach in all past semesters. However, for my thesis I have chosen to create an individual project, challenging myself and hopefully proving that I have aqquired skills, knowledge and competenecies throughout my time studying architecture adequate to fullfilling the final learning goals.

[AAU, 2011]

Design Process

In this type of project, the solution to the problem will be in the form of a building and its immediate surroundings, requiring a process of creative work, also called designing. As a student of Engineering Architecture, where aesthetic and technical aspects are treated with equal importance, the Integrated Design Process (IDP), formulated by Mary-Ann Knudstrup in 2001 [Knudstrup, 2004], is utilised in order to ensure optimal synergy between the two aspects. The process contains five phases: Problem, analysis, sketching, synthesis and presentation. The phases are approached in the written concession, however with iterative loops meaning that knowledge or results from one phase could create the need for change in an earlier phase, and that many of the phases are interrelated (see ill. 10.1 for a simplified rendition). The phases have different purposes described below.

The problem phase

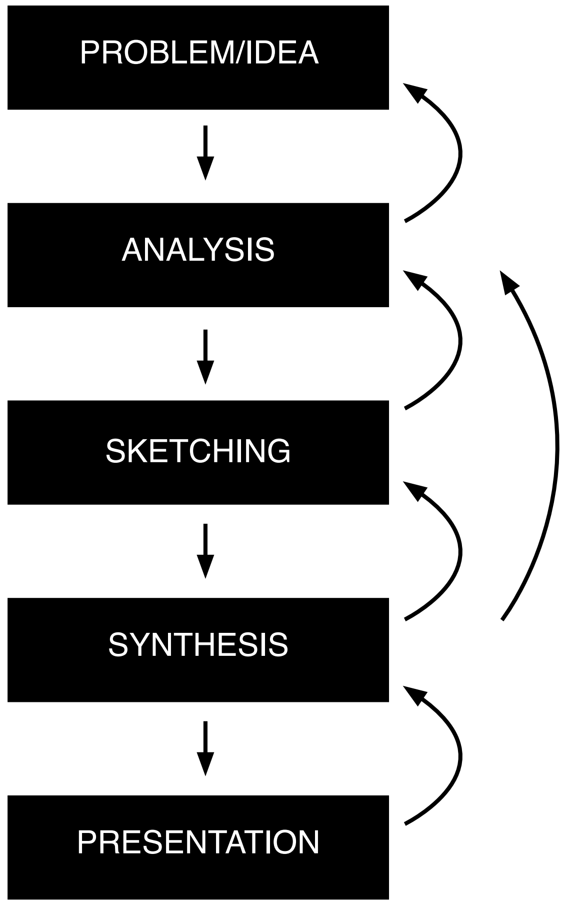
The problem phase is the point of departure for the project, and should result in a specific formulated problem, which the remaining phases then aim to solve. For this project the problem arises from a first-hand experience of a social situation, or challenge, in the city of Copenhagen. The problem is confirmed by references to current news articles and research.

The analysis phase

The purpose of the analysis phase is to obtain knowledge about the subjects and themes necessary to solve the problem. For this project, this includes research and analysis regarding sustainable architecture, young students, the city of Copenhagen and the final site.

Regarding the subject of sustainable architecture, current knowledge is referenced in terms of articles, publications, scientific research etc., and discussed in order to gain a personal definition and approach.

Regarding the user analysis, existing cases of student housing is studied and compared. From this, along with the defined approach to sustainable architecture, a user profile, or target group for the final building is formulated.



Ill. 10.1: A simplified illustration of the phases and iterative loops of the Integrated Desing Process

Regarding the city and site analysis, the idea is to analyse the city in order to find an appropiate site for the project. The city of Copenhagen is first described, and an overall discussion is made to narrow down to a smaller area. This area is then mapped using Nolli maps, named after the Italian architect Giambattista Nolli, who made an iconic map of Rome, characteristic in the use of few contrasting colors (black and white), clearly illustrating, in Nolli's case, the public and private areas of Rome [Arnold, 2003]. For this project, the same methods is applied to gain a clear understanding of different urban elements, in order to find a relevant site for the project.

The chosen site is then studied in terms of surrounding and local conditions, including elements from Kevin Lynch's mapping method [Lynch, 1960] as well as a phenomenological approach to describing the atmosphere of the surrounding area.

The sketching phase

The sketching phase is where the design take form, based on the results of the analysis phase. With the chosen subject for the project, the design is approached on two scales, namely typology and unit scale. The typology study will, through extensive model study (either 3D, physical foam or a combination) compared based on performance in categories found in the analysis phase, lead to a clear concept for the overall typology and form of the building. This is then adapted to the results of a unit study, finding the most suitable concept for the individual units through plan and section studies, compared in performance using simulation software such as BSim, Velux Visualizer and Be10 for indoor environment and energy performance. However, the process will be iterative, meaning results from each study will be affected by the other, potentially going back and forth until the final concept is found.

The synthesis phase

In the synthesis phase, the concept is detailed to fulfil the goals and criteria of the building, in terms of energy performance, indoor environment and room program to name a few. The detailing could reveal problems or challenges in the concept found in the sketching phase, requiring a step back, an iterative loop.

The presentation phase

The presentation phase is all about creating the material relevant to presenting the project in the most suitable way. The material should provide an understanding of the layout and flow of the building, the form, the construction, the expression, materials and tactility and the atmosphere of the spaces created, and highlight unique features, creating a wholesome perception of the project, that makes it stand out. Depending on the final design, different tools and approaches could be used, but will include plan, section, elevation and detail drawings in scale, as well as perspectives, likely in the form of 3D renderings with post-processing, and one or more physical models in scale.

The layout and structure of this report will somewhat follow the structure of the IDP as described, but not necessarily use the same names and concession of the phases, as the most suitable way of presenting the project, telling the story, could differ.

ANALYSIS

The following chapter contains the analysis phase of the project, which include a discussion on sustainability in general and in architecture, an analysis of how students live, as well as an analysis of the city of Copenhagen, the area of Nordvest, and the final site. The chapter is concluded with reflections of the analysis as well as a list of design parameters, a room program and a vision for the final design.

Sustainability

Sustainability is the first step in the analysis needed to answer the preliminary problem. This section aims to provide a discussion of the subject, first on a general level, then in relation to architecture, resulting in specific strategies used in the further design process.

Definition

According to the dictionary [Mirriam-Webster, 2015], *sustainable* has the following definition:

"sustainable": adjective -
- "able to be used without being completely used up or destroyed"
- "able to last or continue for a long time"
[Merriam-Webster:sustainable, 2015]

As an isolated word or concept, it has no use. It needs context in order to be relevant. On a global scale, it received such context in the late 1980's, where a world commision established by the UN published a report called "Our Common Future" [United Nations, 1987]. This report, also commonly reffered to as "The Brundtland Report" studies and questions existing world development across many different categories, and concludes that the current development was unacceptable and unsustainable. The report calls for new development to be sustainable, and defines it as such:

"...development that meets the existing needs without compromising the ability of future generations to meet their needs." [Our Common Future, 1987, p. 16]

This definition is simple and clear in terms of explaining the meaning of the word, but at the same time very broad, and needs further elaboration.

The Three Pillars

At the UN World Summit in 2005, the member-country representatives reaffirmed their common commitment towards sustainable development, and added:

"These efforts will also promote the integration of the three components of sustainable development – economic development, social development and environmental protection – as interdependent and mutually reinforcing pillars." [United Nations, 2005, 2005 World Summit Outcome, p. 11-12]

This addition represents a global consensus of what considerations should be included in sustainable development, and is widely acknowledged and used when discussing sustainability internationally. As described by the OECD [Bayley, Strange, 2014] the concept of 'the three pillars' of sustainability represents the idea of an inter-relation between humans (social sustainability), nature (environmental sustainability) and economy (economic sustainability). A reasonable concept, but still on a very general level. No specific criteria for each aspect is provided, so further elaboration is needed.

Social Sustainability

Social sustainability is probably the least mentioned of the three aspects, when looking at popular media such as news articles, shows, publications and general debate, but is starting to gain more attention. In a recently published sustainability strategy by The Danish Government [The Danish Government, 2014], the same three-pillar approach to sustainability is used. When describing the social aspects, terms like social mobility, social heritage, equity, health, life span and education are used. The Danish guide to the DGNB sustainability certification states several of the same values when measuring social sustainability, and adds diversity, safety, accessability, public spaces and flexibility to name a few [Leerberg, 2014].

Environmental Sustainability

The environmental aspect of sustainability is probably the most discussed and understood aspect. Climate change, CO2 emission, rain forest degradation and pollution are terms most people are familiar with. Simply put, it is about how we manage and use the finite ressources in the Earth's biosphere, and that energy, food, water, clothes, commodities, building materials, experiences, everything we need to sustain life, and our current lifestyle, is based on environmental ressources. A sustainable development ensures that the regeneration of said ressources is equal to or bigger than the rate of consumption. For some ressources this is impossible, examples being fossil fuel-based energy (oil, natural gas, coal) and extinction of animal and plant species. For other ressources, regeneration is possible, such as renewable energy (solar, wind, thermal, etc.), timber production, food production, etc.

Consequences of current consumption rates are not only lack of ressources and biodiversity. Another environmental consequence is global climate change, with overwhelming consensus that it is caused by emission of green house gases caused by humans. The threats of climate change include rising sea levels, droughts, wildfires, increase in extreme natural disasters, etc.
[NASA, 2015]

Economic sustainability

Economic sustainability can have different meanings depending on the scale on which it is defined, eg. global, government, company or object (building). As an example of a governmental, country-scale approach, is the Danish Goverment's definition of economic sustainability, that aims for a growth in the GDP and overall employment [The Danish Government, 2014]. Growth is also the main goal for most companies and organisations, aiming for a growth in turnover, profits, etc., in order to develop further, and/or to sustain their activities in competitive global markets. As a consequence, overall production and consumption also needs to grow.

However, considering that economic sustainability is only one of the three pillars of sustainability, this approach seems to be contradicting. A growth in production also means a growth in the use of natural ressources, making the condititions for ensuring environmental sutainability worse. A holistic approach to sustainability must include a different approach to the economic aspect. Defining the aspect on a smaller scale seems less contradicting. Looking again at the Danish Guide to DGNB, it evaluates selected construction and maintenance costs as well as robustness in terms of long-term flexibility. A high score equals a longer expected life of the building, decreasing the environmental impact and making it more profitable. A more integrated, and more efficient approach to economic sustainability.

Sustainable Architecture

In industrialised countries, builidings account for 73% of electricity concumption, and roughly 40% of all CO2 emission, predominantly from operational use [DAC, 2014]. This is a huge environemental impact, but only concerns energy use. Considering the vast amount of natural ressources used for building materials as well, it should be clear that environmental sustainable development is especially relevant, and necessary, in the building industry.

Architecture also greatly affects human life and economy, the other two pillars of sustainability. How spaces are designed greatly affects the users both physically and mentally, and the life and flexibility of a building greatly affects costs and profitability.

Furthermore, architecture also affects many other aspects of sustainable development. Architecture is often mentioned as the common denominator when discussing so-called ghetto areas, areas with social and cultural challenges [Arkfo,2013]. Besides the actual building and the spaces inside, architecture therefore also has the potential to address different societal issues in its context, for example by creating a new, or strengthened identity for an area, providing spaces for social interaction, or by improving the quality of public spaces to name a few.

Legislative requirements and classification

In Denmark, all new building has to live up to the requirements listed in the Building Regulations [BR10, 2014]. The regulations have been made to ensure the overall quality of buildings, including safety, architectural quality and use of natural ressources. The requirements related to sustainable development is mostly found in chapter 6 (indoor climate) and chapter 7 (Energy consumption), which contain different guidelines for designing, as well as more specific requirements for certain values. As mentioned, the regulations cover all new buildings, but also includes expected requirements for buildings build after 2015 (classified as low-energy building class 2015) and 2020 (classified as building class 2020, currently the most progressive legaslative classification).

A further progression could be to aim for a zero-energy building. Many definitions exist, but common for all is that the total energy balance (however defined) should be 0 or less, meaning some kind of renewable energy production is needed.

The question is whether to settle with living up to current requirements, or to aim for a more progressive classification such as building class 2020 or a zero-energy building. From an environmental sustainability point of view, zero-energy would arguably be the aim. In terms of energy, such a building could theoretically be self-sufficient. However, such a decision should be based on a holistic approach to sustainability, as well as include contextual considerations. Will a focus on zero-energy influence other aspects of sustainability negatively, and if so, what is a reasonable balance? Does a zero-energy approach make sense in Denmark, a country famous for wind-mills and renewable energy initiatives? Valid arguments likely exist for both approaches, but one does not exclude the other. By aiming for building class 2020, the most progressive legislative classification, without elimating the possibility of renewable energy production, but instead approaching it as a possible strategy depended on context, the most reasonable and balanced design is achieved.

For the scope of this project, a residential building, the most relevant values from the Building Regulations are:

Indoor climate:

Thermal comfort:
hours above 26°C per year ≤ 100
hours above 27°C per year ≤ 25

Daylight:
Glass-to-floor area ratio ≥ 0,15 or,
Simulated daylight factor ≥ 2%

Energy consumption:

Total energy used for heating, venting, cooling and hot water: <20 kWh/m^2 per year

Conflicting priorities

Many design strategies used to improve a certain aspect of the building, can potentially worsen other aspects. A basic understanding of some of these conflicts is necessary in order to achieve a balanced outcome.

Daylight and heat loss:
One strategy for increasing daylight could be to increase the window areas. Larger, or more windows equals more daylight. However, increasing window area also means a higher total U-value of the envelope of the building, assuming a higher U-value of the window compared with the wall/roof/floor of the building.

Daylight and thermal comfort:
The same strategy, if used on surfaces facing the sun, can also affect the thermal comfort. Increasing window area also increases solar gain, making overheating issues more likely in cooling seasons. However, in heating seasons the increased solar gain is an advantage.

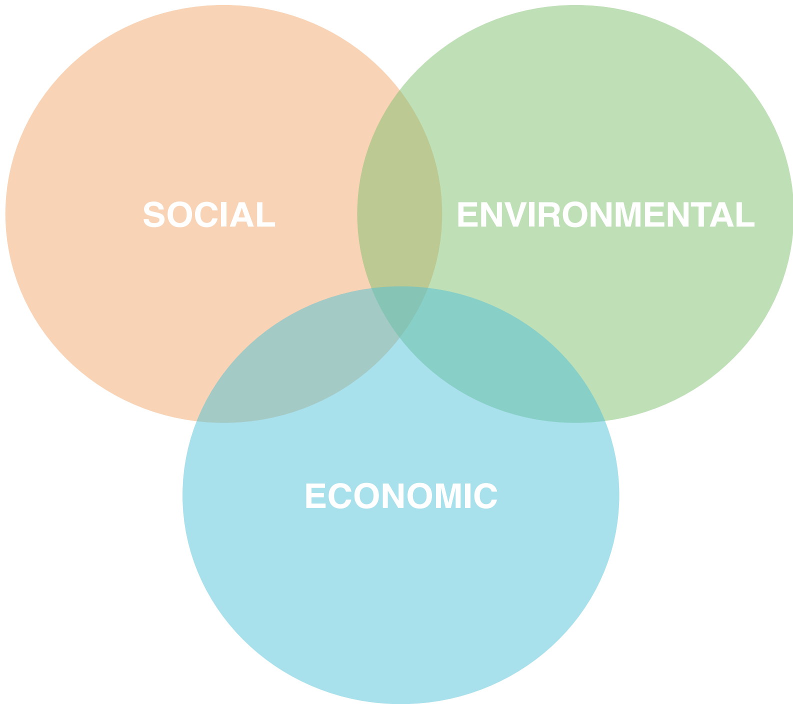
Surface-to-area ratio and daylight:
The more compact a building is in terms of surface-to-area ratio, the more energy efficient it is, at least in terms of energy use per m^2. However, making a building more compact, squeezing in more squaremeters, can result deeper, lower floors, where daylight conditions are not optimal.

Energy efficiency and architectural diversity:
Making design decisions by only comparing energy efficiency could lead to a very monotone development in architecture, where the same materials, details, technology and form are used. Energy efficiency is important, but should be balanced with aesthethical and functional considerations.

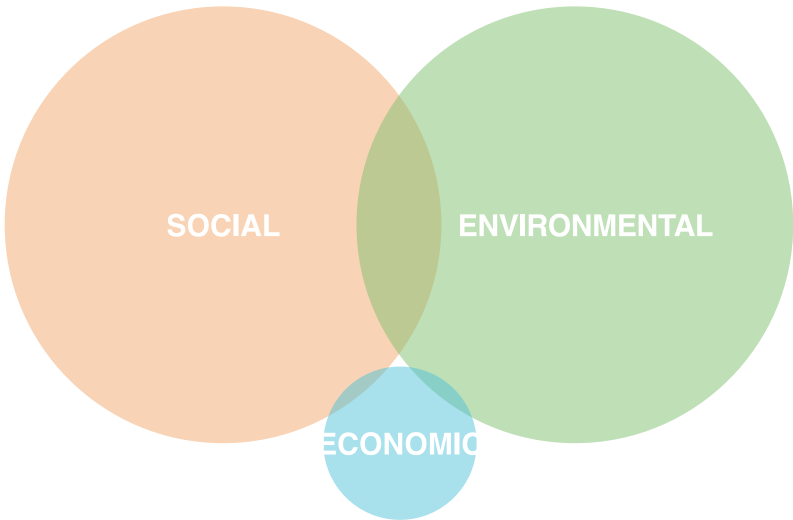
Other conflicts likely exist, which is why it is important to evaluate multiple parameters of different design decisions, so the best, most balanced decision can be made.

Conclusion

Focusing on sustainability in architecture is necessary if the overall goal of sustainable development is to be reached. The impact of the architectural industry is vast, and designers have a great responsibility to design sustainable buildings. Compared to the general definition of the three pillars of sustainability, architecture primarily impacts the social and environmental aspect, at least in a direct sense. The directly connected economic consid-



Ill. 16.1: The three pillars of sustainable developement

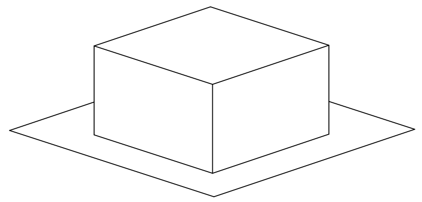


Ill. 16.2: Architecture's impact on the three pillars

erations of architecture, such as budget and profitability, is usually decided by owners and contractors, and not designers. However, the indirect economic impact can be very significant, because architecture plays a great part in an areas' overall identity and experience, influencing the realestate prices, local businesess, people's well-being, etc. This impact is hard to measure, especially in a hypothetical, unbuilt project like this thesis.

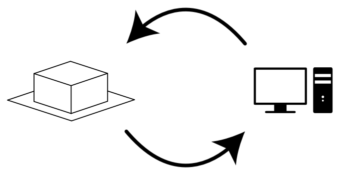
Approach To Sustainable Architecture

For this project, the following strategies are formulated, to be used further in design process. The strategies represent what I believe are the most important aspects of sustainable architecture, and should ensure a social and environmental sustainable project, which, if succesful, indirectly influences the local economy to some extent.



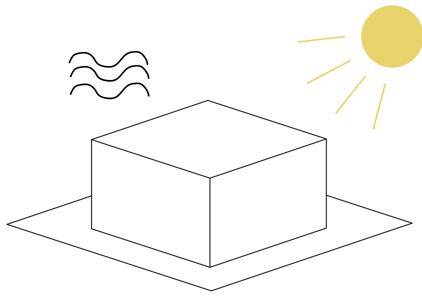
Compactness

The surface-to-area ratio should be considered when designing the overall geometry of the building.



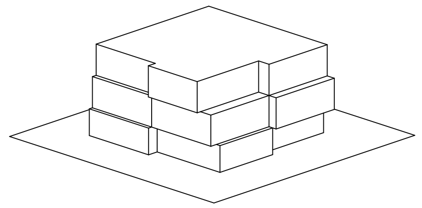
Performance-aided design

Design options should be compared and tested with relevant simluation software such as Be10, BSim or Velux Daylight Vizualiser.



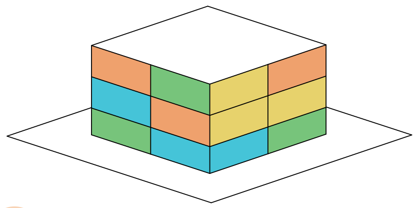
Relevant orientation and form

The orientation and form should utilise the local climatic conditions, shading/exposing to the sun, guiding or blocking wind, etc.



Diversity in expression

The form and facade should represent a diverse user group, creating an inspirational atmosphere and feeling of identity.



Diversity in functions

Several different user-types and functions should be added to the main function of the building, ensuring a diverse demographic development.

User Analysis

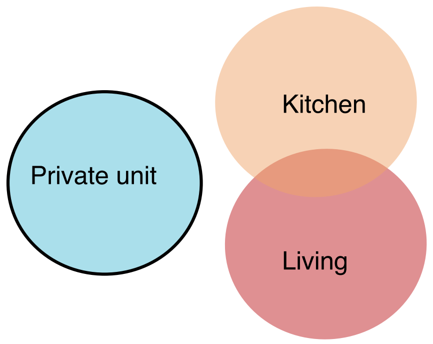
From the motivation of the project, it is clear that the main user of the building will be young students. The purpose of this section is to elaborate on the needs and desires of this category, as well as expand the category to other user groups, following the strategy of diversity in users from the previous section.

Students

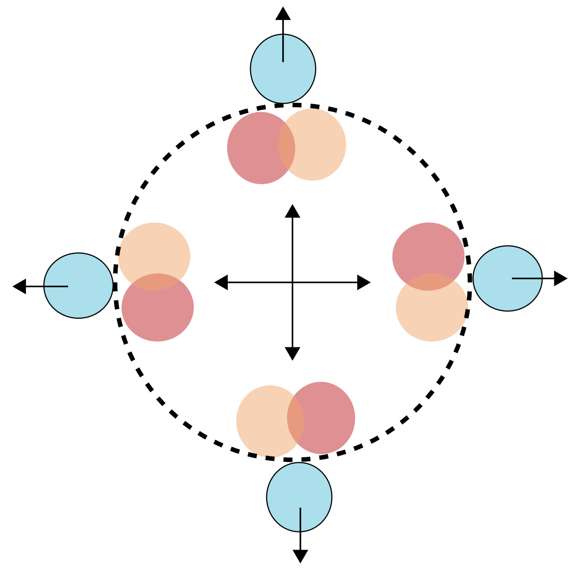
Depending on preferences, personality and availability there are two overall types of designated student housing, when looking at some of the main administrators of student housing in Denmark [KKIK, 2015; AKU, 2015]: Dormitories and youth housing.

Dormitories

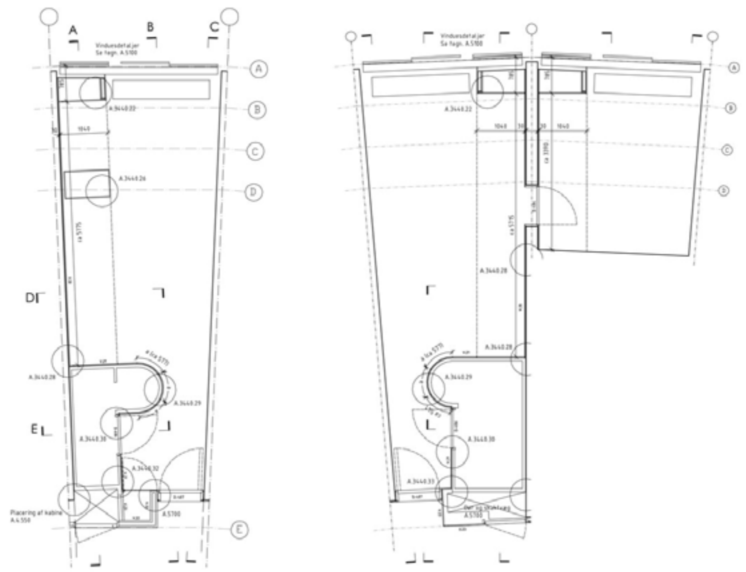
Dormitories are best suited for students who are socially inclined, sharing most functions with other students. Representing this category, the Tietgen dormatory in Ørestaden by Lundgaard & Tranberg Architects, built in 2003-2006 is selected as a reference. Here, residents are provided with a private living unit, either 1 or 2 rooms, with private bathroom, from 26 to 45 m² in size (see ill. 18.3). For each 12 units a shared kitchen and living room is provided. Furthermore, the building contains several other shared functions, such as workshops, laundry, reading hall, event room, terraces, etc. The Tietgen Dormitory is organised so all shared functions and hallways have visual connections across a central courtyard, creating a sense of activity, and discovery of social events in other clusters. The private units are oriented outwards, providing privacy and views (see ill. 18.2). [Tietgen, 2015]



Ill. 18.1: Dorm unit organisation. Kitchen and living room is not included in the private unit, but shared with other residents.



Ill. 18.2: Organisation of the Tietgen Dorm floor plan. Shared functions are orientet towards a central courtyard visually connected. Private units are organised outward.

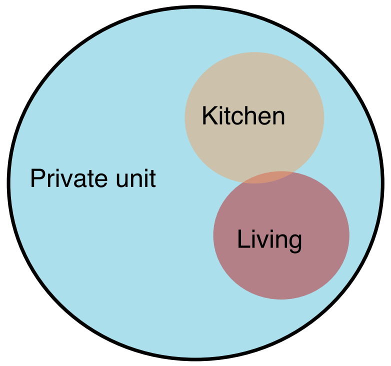


Ill. 18.3: Tietgen Dorm unit plans

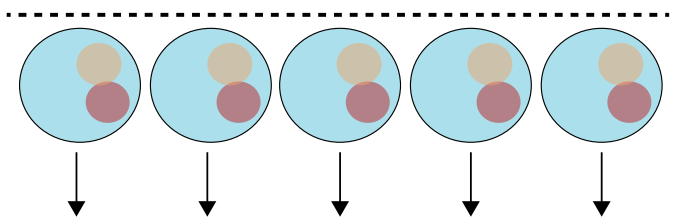
Ill. 18.4: The central courtyard of the Tietgen Dorm. Extrovert space encouraging social interaction and visual connections.

Youth housing

Youth housing is apartments, or other housing unit types, designated for young people, often smaller and cheaper than 'normal' apartments/living units, usually consisting of 1 or 2 rooms, a toilet/bathroom and a small kitchen. In the case of Godsbanen, a new housing development in Aalborg designed by KPF Architects, containing both youth housing and common housing, the youth housing units all have more or less the same size (roughly 50m^2), but come in two different plan solutions, a 1-room studio, or a 2-room apartment (see ill. 19.3). Both include private bathroom and kitchen. The units are organised next to each other, with gallery acces (see ill. 19.2). [AKU-Aalborg, 2015]



Ill. 19.1: Youth apartment organisation. Kitchen and living room is included in the private unit.



Ill. 19.2: Organisation of the Godsbanen youth housing. Units are access by gallery access, and oriented towards views.

Ill. 19.3: Godsbanen youth apartment plans

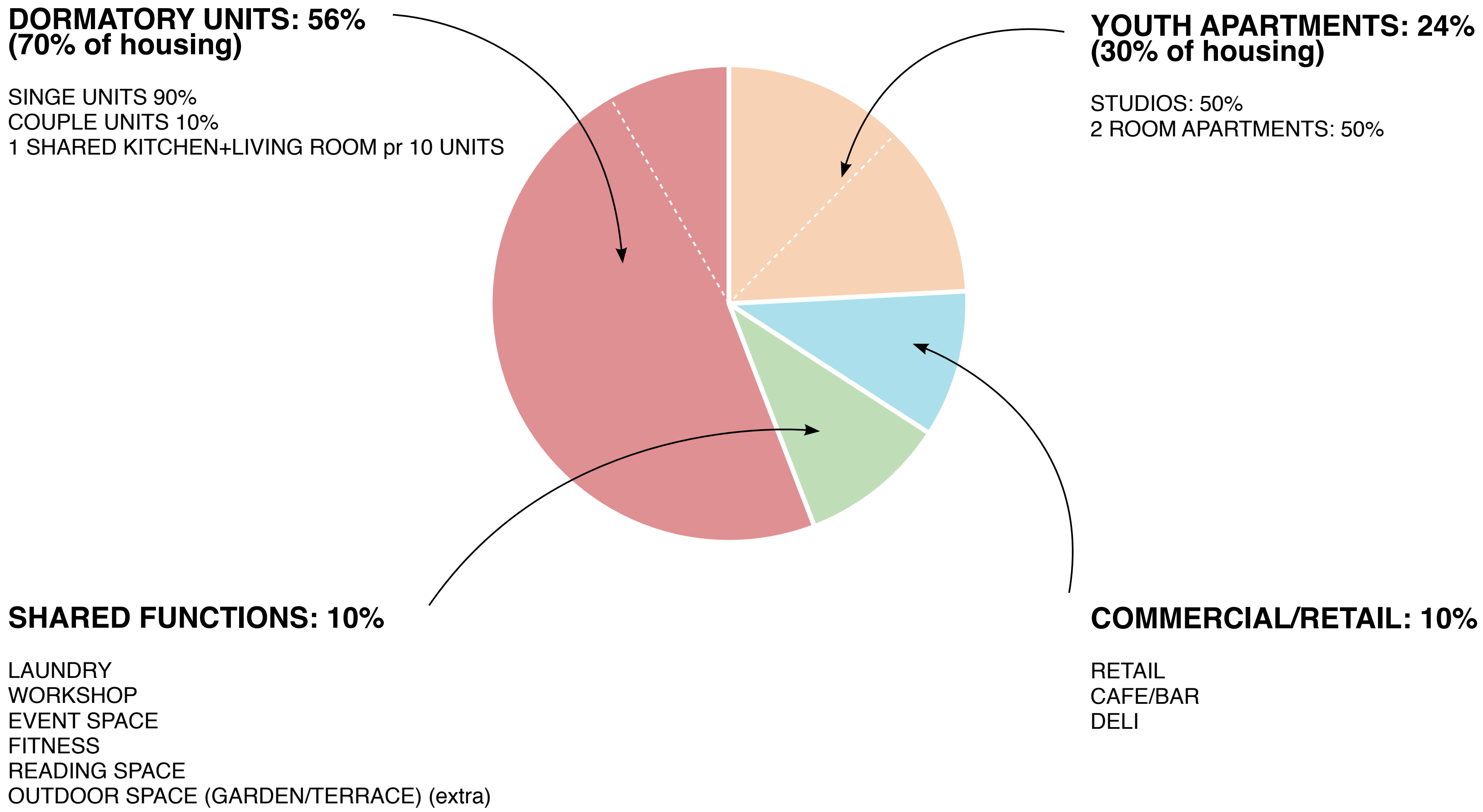
Ill. 19.4: The central courtyard of the Godsbanen youth housing. Introvert, desolate space.

User Profile

The two types have different qualities, and attract different types of people. The most striking being the size of the functions, private as well as shared, and the level of privacy and social interaction. Keeping in line with the strategy of diversity in functions, it could be argued that the optimal user profile would be to include both dormitory and youth housing unit types, and further to include units in both categories suitable for both singles and couples. The ratio of each category reflects the current data of young people's residential status, found in the publication "Unges Boligsituation" (translation: Young People's Residential Status) from KORA, the Danish Institute for Local and Regional Government Research [KORA, 2008].

Other functions

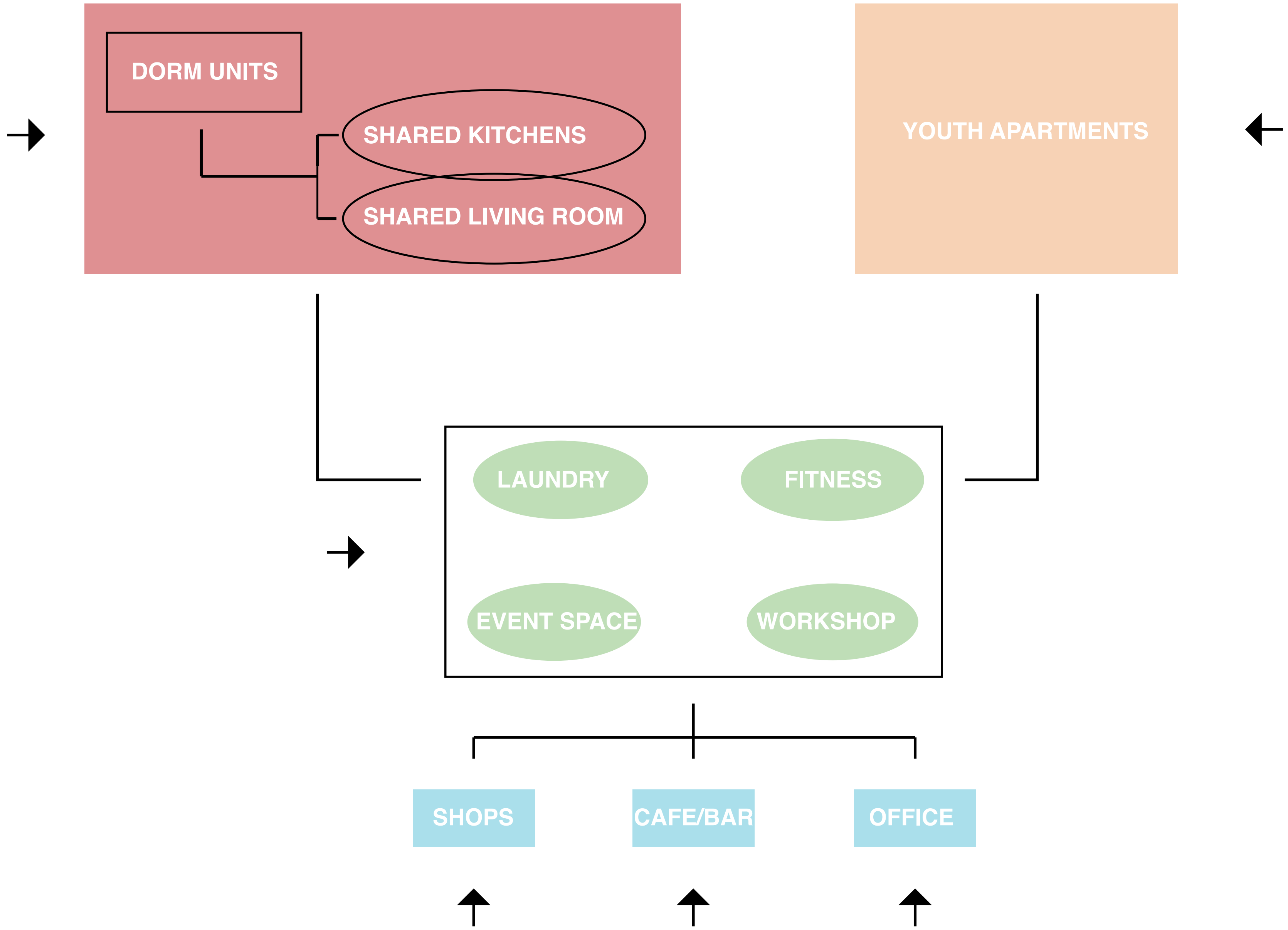
In order to further enhance the diversity of the building, more functions could be added, either related to the residents, the surroundings or a combination. Adding shared functions for the residents such as laundry, reading hall, workshop and garden space provide a better quality of living, ensuring space for maintaining your stuff (clothes, furniture, bike, etc.) as well as providing space for social interaction with the other residents. Adding commercial functions such as a bar, cafe, shop or restaurants ensure activity in and around the building, and interaction with the local community. The organisation of the functions could relate to the transition between public and private.



Ill. 20.1: Proposed user profile

Function organisation

By seperating the different types of functions, a graduation from public to private is possible, with the shared functions working as a central gathering point for all functions.



Ill. 21.1: Proposed function organisation diagram

City Analysis

Copenhagen is the capital of Denmark, and with a population of 1.2 million also the biggest city. Copenhagen is an attractive city to live, study and work in, and as a consequence, is experiencing consistent growth in the population. The Municipality of Copenhagen expects the population to increase with 100.000 by 2025, with roughly 33.000 being young people between 18-29 [Københavns Kommune, 2012]. A lot of the young people are, and will be, students with relatively low income. The current housing market is not accommodating the need for affordable housing for students, and it will only get worse in the future. Development of more affordable youth housing is needed.

To find a relevant location, several aspects could be considered: Distance to places of interest, cost of living, infrastructure, access to public transportation, etc. Comparing the districts of Copenhagen in terms of cost of living and distance to places of interest, a good candidate for further studies can be selected. A students' places of interests mainly includes the university or school, and the students' home. Looking at the map on the other page, most of the educational locations are gathered in and around the central districts, with a few locations in outer areas such as Amager and Sydhavn. Isolating this aspect, the perfect location for most students would be in the district of Inner City.

However, another aspect to include is cost of living. Commodities and food are assumed to be at the same level in all districts, but not cost of housing. Even though student housing is usually rented, and not owned, real estate prices have elements of demand, cost and popularity of an area embedded in the price, and serves as a good indication of the expected level of rent. Looking at the average prices per. m2 in the districts, Inner City is the most expensive area, more than double the price of the cheapest district Brønshøj. Other central districts such as Vesterbro and Frederiksberg have great locations, but are very expensive as well. As expected, the cheapest districts are located farther from the city centre.

Considering both location and price, the district of Nordvest seems as a good candidate. It is the second cheapest of the listed, but with a relatively good location, with one educational location within its boundaries, and many in directly adjacent areas. A fair compromise between location and cost of living.

Average price per m^2 housing, in DKK:

Amager:	23.528
Brønshøj:	15.851
Frederiksberg:	27.785
Inner city:	31.319
Nordvest:	18.063
Nørrebro:	22.973
Sydhavn:	29.292
Valby:	22.480
Vanløse:	19.044
Vesterbro:	28.138
Østerbro:	26.911

[Boligsiden, 2013]

Map legend:

Educational location

District boundary

Ill. 23.1: Satelitte photo of Copenhagen

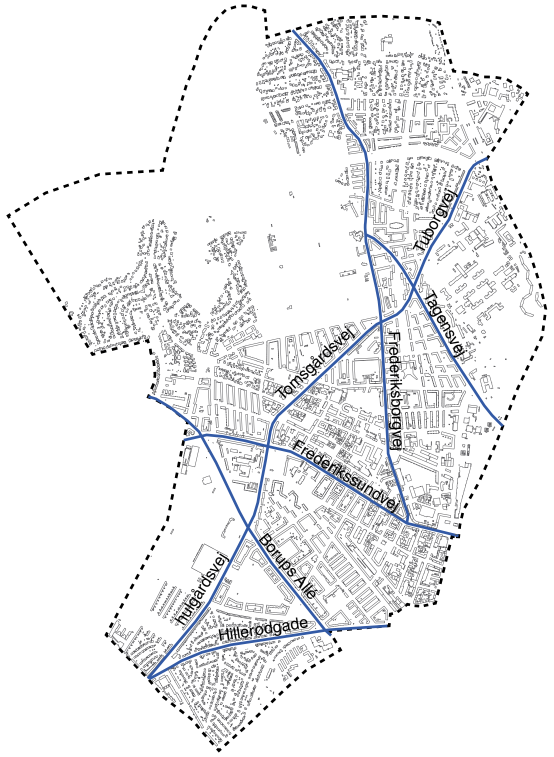
Area Analysis

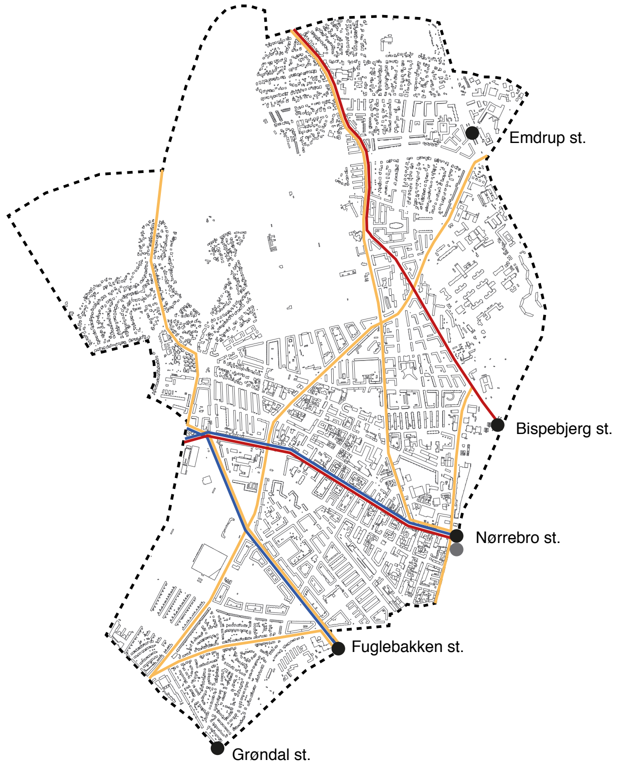
With a combination of relatively low real estate prices and relatively short distance to the city centre and educational locations, the area of Nordvest seems fitting for future student housing development, and is further examined in this section. A general description is provided, and several studies are made concerning e.g.. infrastructure and buildings

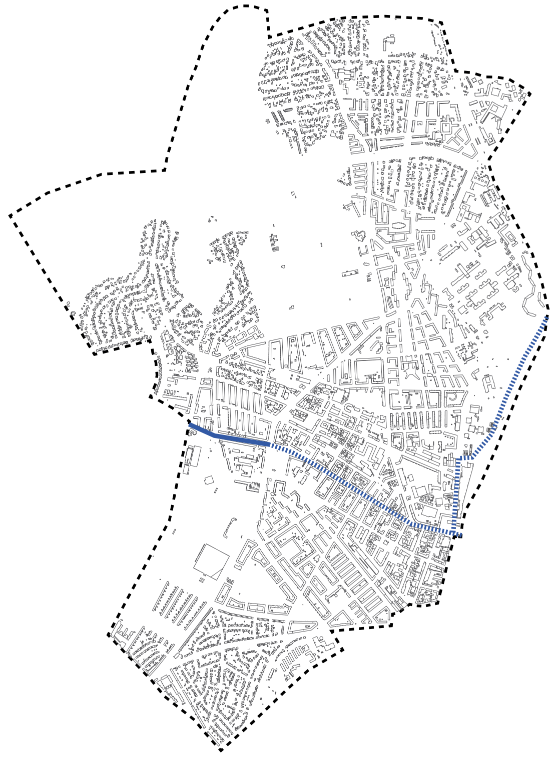
Description

The area of Nordvest, defined in this project as the area covering addresses with the postal code 2400. The area is facing social problems such as a relatively low income, low level of education, and more than twice the concentration of immigrants compared to Copenhagen averages. Furthermore, the area also faces physical problems, with many old, ineffective buildings from the 1930s. As a consequence, the area is perceived as unsafe and undesirable, filled with graffiti and other symptoms of vandalism. Many initiatives have been made to redeem the area, but because of the overall state of the area, people who show a positive development tend to leave [Københavns Kommune, 2012]. However, the area is not all negative. Is is located close to both large recreational nature parks and the inner city and has both cultural and functional landmarks, as well being substantially covered by public transportation options.

Ill. 24.1: Satelitte photo of Nordvest







Main roads and connections

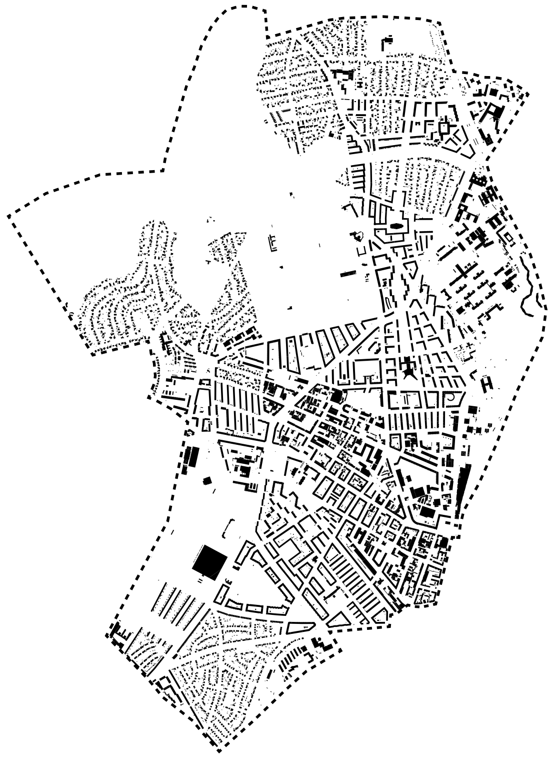
Several main roads run through the area, connecting to the surrounding areas in all directions. The highlighted roads are relatively busy, with Tuborgvej/Hulgårdsvej being the busiest. The three NW/SE roads Borups Alle, Frederikssundvej and Tagensvej are all extensions of some of the so-called 'bridge-roads', providing clear and foreseeable access to the city centre and adjacent areas, with 'The Lakes' as a central node.

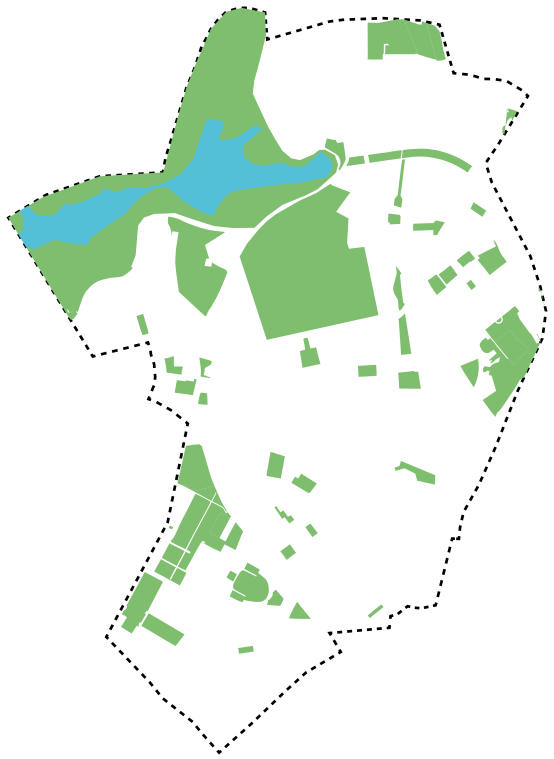
Public transportation

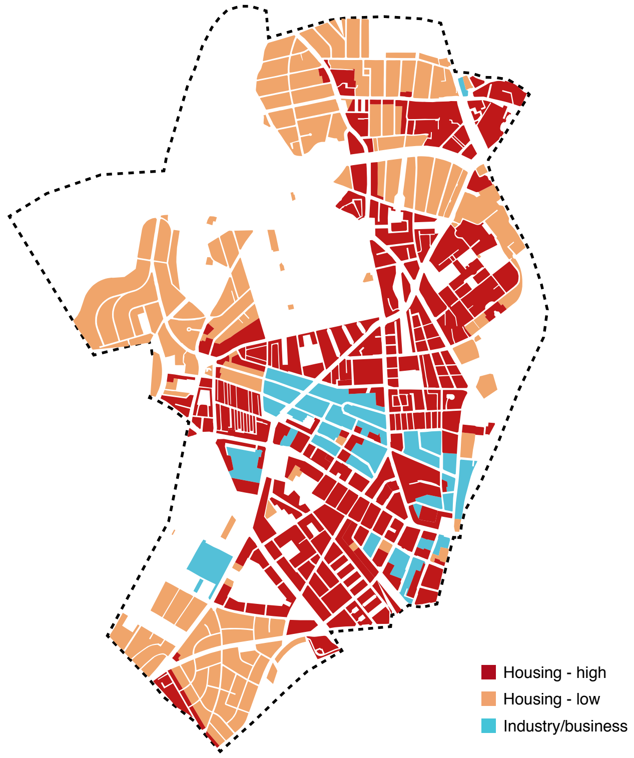
Copenhagen has a great offer of public transportation including bus-, train- and metro-lines. The Nordvest area offers mostly bus-lines, with train stations only at the outer edges. Besides Emdrup Station, the train stations only connect to the F-line, a ring line going around the city. However, construction of a new metro line and station at Nørrebro station is ongoing, connection this station to the inner city as well.

Bicycle highways

As an ambition to be the greatest city for bicycling in the world, the Municipality of Copenhagen has created what they call 'super bike paths'. Currently, two have been created, with one of them starting in Nordvest, and going all the way to Farum, roughly 21 km long. Expansion is planned for the coming years, in both directions, creating optimal conditions for both commuting and leisure cyclist.







Building mass

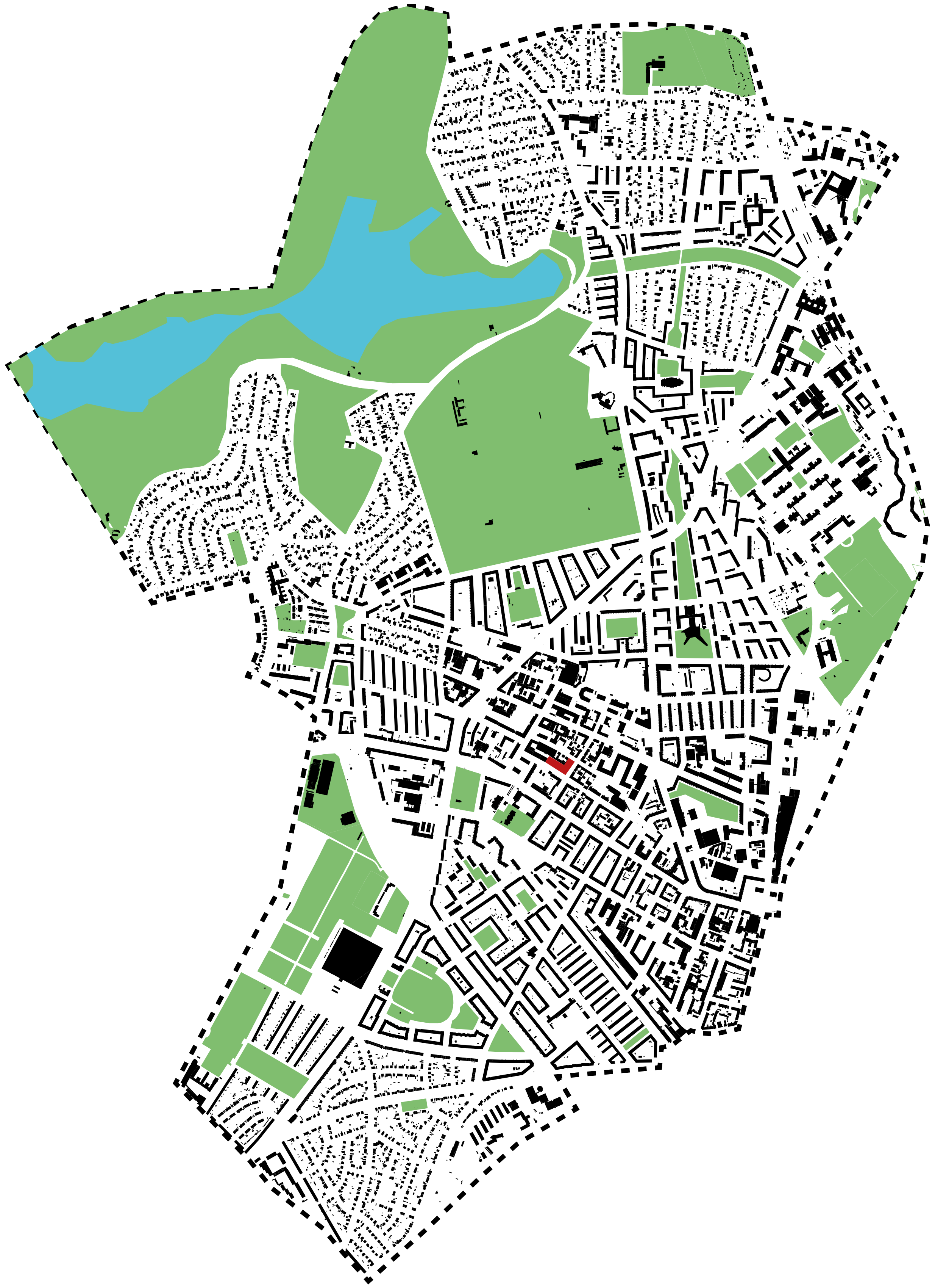
By mapping the footprint of all buildings in the area, the density of the area, as well as the different typologies, becomes more clear. Towards the southeast of the area, the typology looks to be mostly city blocks, and in the north and northeast part, farther from the city centre, the typology changes to smaller blocks, row houses and detached houses. Without other information, Nordvest seems to contain a vast amount of unbuilt space.

Green space

Looking at the green spaces in the area (including parks, lakes, wild nature, cemeteries and sport fields), it is clear that a lot of the unbuilt space is unbuilt for a reason. Green space in a city is a great quality, and should be prioritised and preserved. The area has most green space in the northern part, in large due to the preserved Utterslev Bog. In the remaining part, the green spaces seem to be evenly distributed.

Scale and functions

The area seems to contain a lot of different functions and scales, which can contribute to creating a diversity in both demography, activity, architecture and functions. However, it seems that the different functions are clustered together, especially illustrated in the industrial and business-related buildings.



Potential site

Combining all studies of the area, as well as area visits and thorough use of satellite photos, a site is found that offer great potential for student housing, with optimal conditions for the users, as well as potential to improve the area where it is located. The scale of the site is fitting for the scope of this project, there seems to be a gap in the urban fabric, and it is greatly connected in all directions. This site is further analysed in the following part.

Site Analysis

The chosen site is described and analysed on two levels: surrounding conditions and local conditions. Determining the surrounding conditions provides an understanding of the location of the site, as well as the atmosphere of the area. The local scale covers immediate adjacent conditions that relates to the site in a way that directly influences the design of the project.

Surrounding conditions

To understand where the site is located, the surrounding area is described in terms of geographical location, surrounding functions, access and public transportation.

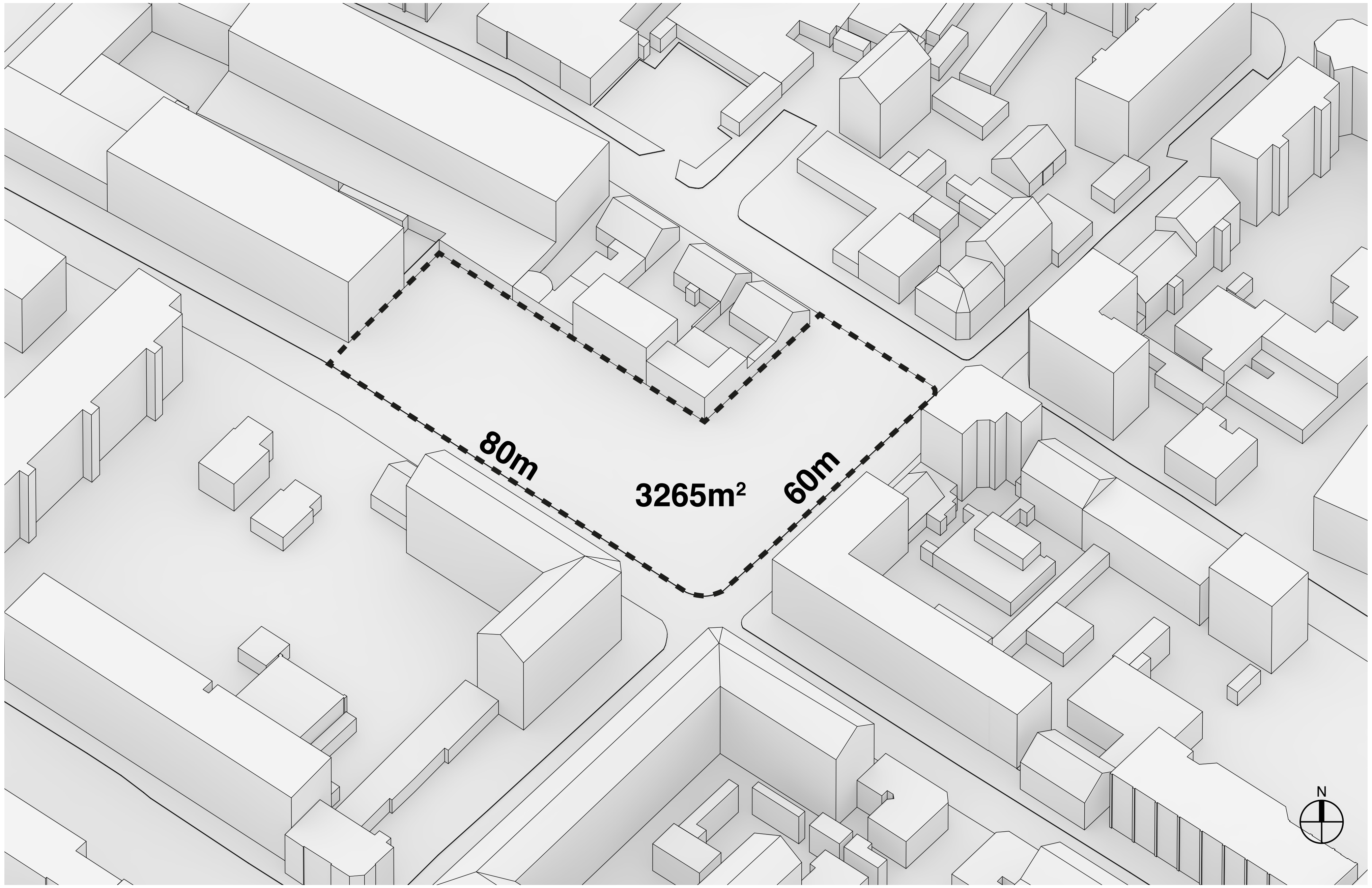
The site is located in the core of the Northwest area, inside the triangualar area created by the main roads Tomsgårdsvej, Frederisksborgvej and Frederikssundvej (see area analysis). It sits on a corner of Provstevej (a side street to Frederikssundvej) and Theklavej, in the outer perimeter of the cluster of industrial building mentioned in the area analysis, with both housing and industry/business as neighboors. On Frederikssundvej, one block away, the street is filled with several different shops and restaurants.

The site is surrounded by relatively quiet streets, providing several access ways for both car, bike and pedestrian traffic. Going in any direction from the site quickly leads to a main road for convenient connections to other areas. The closest bus stop is located on Frederikssundvej, within 150 meters of walking distance, and further down the road, roughly 1km, is the Nørrebro train staion.

Map legend:

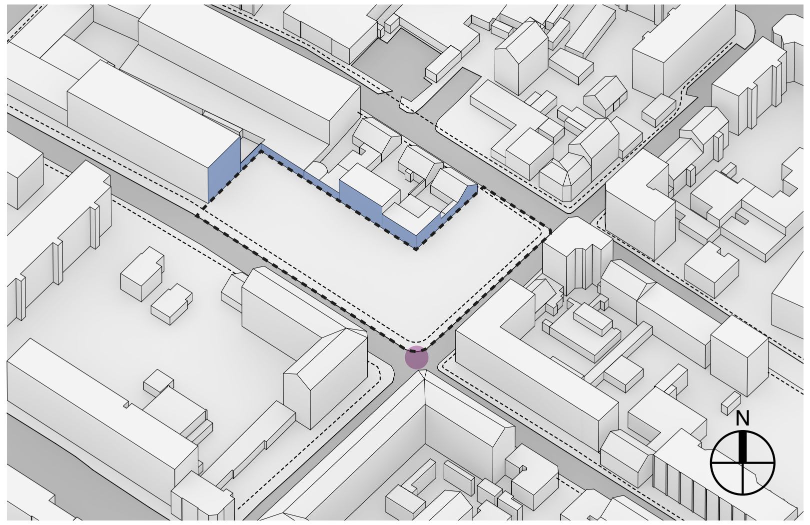
- Bus stop
- Shops/restaurants
- Main road
- Secondary street

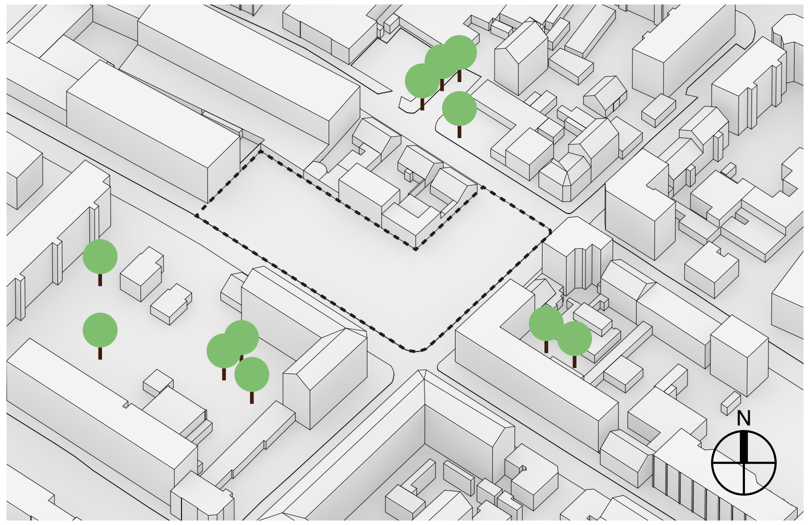
Ill. 28.1: Satellite photo of the site

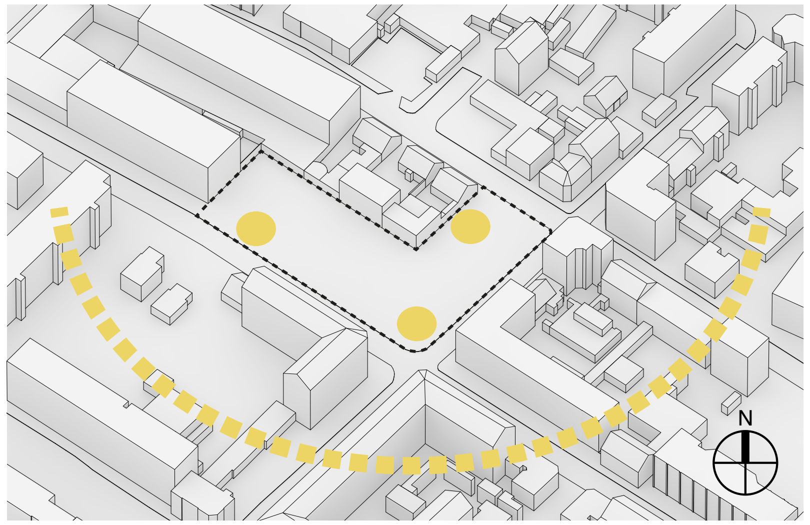


Geometry

The site has a unique L-shape, with an area of 3265 m^2, covering two corners of a city block. On the long side of the 'L' it spans 80 meters, and on the short 60 meters. The site is almost completely flat, sloping only 1 meter across the whole site. The geometric composition appears to give the site a central 'focus', the south corner.







Mapping

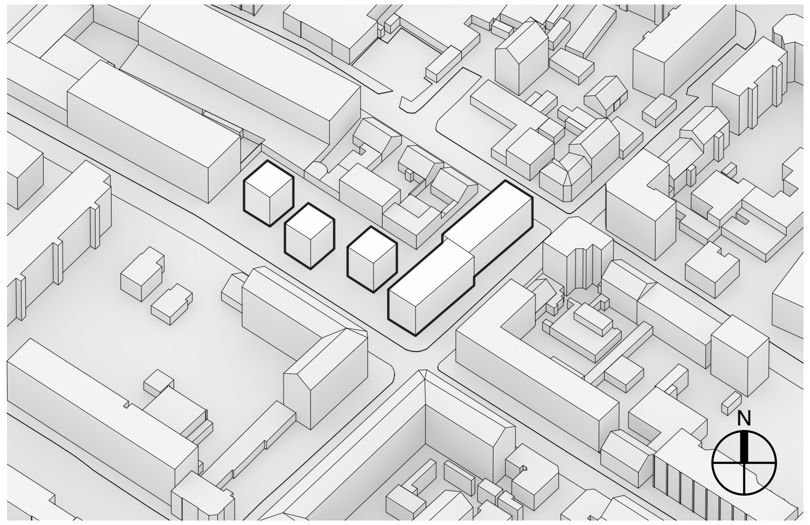
The site is quite open towards the street, bordered by sidewalks. The back of the site, facing other buildings, is more like a barrier, with blocking walls and fences. These conditions create a natural front and back of the site, with the front being the two southfacing edges (and the north east facing one), and the back being the northern edges. The southfacing corner could act as a future node, being the balanced center of the site, as well as being nearest to the closest main road.

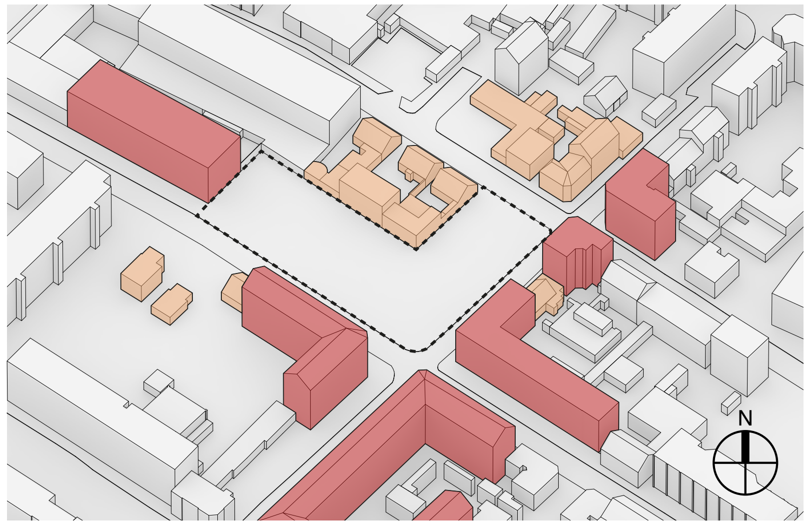
Vegetation

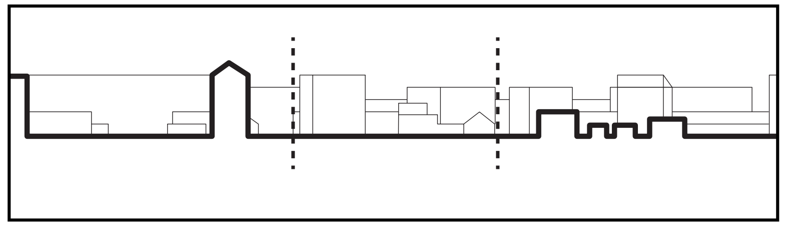
As a consequence of being vacant for many years, the site is almost completely covered in more or less wild vegetation, such as high grass, bushes and small trees. No individual trees or the like worthy of preservation. There are several trees in the surrounding area, but most are in courtyards or gardens, not visible from the streets.

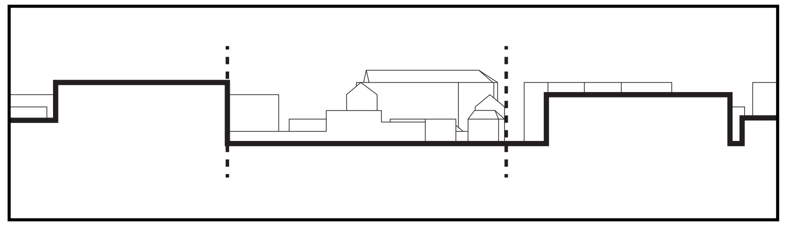
Climatic conditions

The site has a great orientation in terms of sun exposure, being open towards southeast-southwest. The open corner as well as the small scale of some of the adjacent and opposite buildings creates potential spots where a minimum of shade is experienced. Depending on the final design this could either benefit the outdoor spaces or the solar gain through windows on the facade, but should also be considered in terms of overheating.









Local Plan

The local plan for the area is studied in terms of limitations and potential. The site is covered by the municipal local plan no. 261 [Københavns Kommune, 1996], located in subdistrict I. The plan for this district is a combination of housing and commercial functions. The local plan contains a list of rules and limitations for new development. It includes:

Building percentage: max 110% = 3.591 m^2
Facadeelements: max 25m
Open space: 60% of floor area
Building height: 2-3,5 floors
Ribbon development towards Provstevej
Predominantly ribbon development towards Teklavej og Thoravej

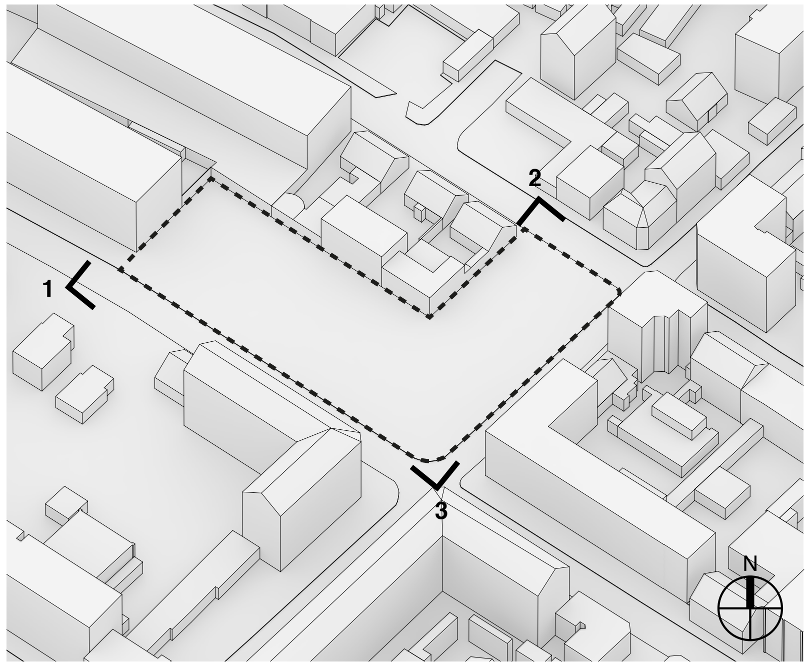
Scale

The immediate area varies a lot in scale, ranging from 2-storey houses or buildings to 6 storey blocks. However, most of the buildings directly across from the site, those who would eventually face the new building, are more consistent in scale, from 4-5 storeys tall.

Approaching the site

The series of images show the visual appearance of the site and surrounding buildings when approaching the site from three directions. The three directions are very different both in terms of surrounding scale and perception of the site. From the east direction, the scale is relatively small, and the site appears the same. From the west direction the scale is large, and the site appears long. From the south, the scale is large as well, but the site appears more clear and balanced.

Ill. 32.2: View from angle 1.



Ill. 32.1: Annotation of camera angles.

Ill. 32.3: View from angle 2.

Ill. 33.1: View from angle 3.

Ill. 34.1: Photo from the site showing the current state.

Atmosphere

The site and the surrounding area is described in terms of the experienced atmosphere. The purpose is to formulate, or find, the identity of the area, it's qualities and characteristics.

Current state of the site

As a consequence of being vacant for many years without development, people from the local community occupied the site and started using it for recreational purposes, creating small gardens, playgrounds and hang out spaces. However, the current state appears messy and vandalised, with a lot of graffiti on the walls and trash, broken furniture and empty beer and wine bottles laying around. It is experienced almost as a forgotten space, left to it self, gradually deteriorating and owergrown with weeds.

Atmosphere of the area

Walking around in the area, a combination of different characteristics is experienced: Industry, old housing and vandalism.

Industry

As a consequence of the functions of the area (see last page), a lot of industrial buildings are present in the area. They appear in the form of warehouses, garages, old factories and office buildings. However, many of the buildings seem to be used for new purposes, with fitness activity in old warehouses, office hotels in old factories, etc. Using old industrial spaces for new uses, while keeping the raw and industrial spatial characteristics and quailties, such as large open spaces, exposed structural elements and

Ill. 35.1: Photo from the area. Old industrial buildings now house small, creative shops.

large windows create an interesting contrast of new and old. Walking past these buildings a certain sense of curiousity of creativity is experienced.

Many of the industrial buildings are garages, and there are several auto repair shops in the area, filling the area with broken cars, tires and spareparts. This creates very interesting environments and spaces, as well as providing a lot of activity in the area in the daily hours.

Old housing

Besides the industrial buildings, the remaining buildings are mostly housing, both detached houses and 4-6 storey blocks. Many buildings appear to be old, either from the late 19th/early 20th century, or the 1930s, now, or soon, in the need of renovation or demolition. Some buildings have already been demolished (such as those on the site), some are in the process of being demolished or renovated and few new buildings have already been built. This gives the sense that the area is undergoing a transformation.

Vandalism

Common for the whole area is the amount of vandalism, mostly in the form of graffiti, but also broken windows and the like. Clearly present on the site, but also on most other buildings and streets. Combined with the overall deteriorating state of the area, it can be experienced as unsafe and unattractive.

Ill. 36.1: Photos from the area. Old industrial buildings are a common site (top), many with new uses, such as a crossfit gym (bottom).

Ill. 37.1: Photo from the area. Worn down houses and vandalism fills the area.

Reflections

Copenhagen needs more student housing, and it turns out that there are several places relevant for such development. The area of Nordvest is especially relevant due to a combination of location, price and current situation. The new student housing would be relatively close to university locations and other areas of Copenhagen, as well as being adequately covered by public transportation and bicycle path connections, while being substantially cheaper than comparable areas. A new building could also improve the current state and atmosphere of the area, making it both an economic, social and environmental choice.

The atmosphere of the area is very industrial, which has great qualities. Taking inspiration from this in the design of a new building could improve the identitiy of the area.

The chosen site is interesting in its shape, and there is great potential to improve the surroundings. The site currently appears as a hole in the street, with trash, wild vegetation and vandalism being the main elements of the place. A new building could potentially define a more clear structure of the streets and movement of the area.

By considering both scale, geometry and how the site is approached, the natural center of the site seems to be in the south facing corner.

Being on the southern edge of a block, a new building would be greatly exposed to the sun, which is both a quality and a potential risk

Design Parameters

A list of design parameters is formulated and elaborated, representing the most important aspects of the analysis phase.

Diversity

The project should express diversity both in terms of funcionality and architecture.

Identity

The project should strengthen the identity of the area, by taking inspiration from the industrial qualities of the surrounding atmosphere, regarding both interior and exterior exrepssion.

Interaction

The project should invite to social interaction both within and across different user types.

Living

The project should create spaces for living that can accomodate the basic needs of students, as well as being comfortable in terms of indoor climate corresponding to the requirements listed for the 2020 building classification.

Energy

The project should meet the requirements for the 2020 building classification in terms of energy consumption, without compromising the spatial and architectural quality.

Room Program

	Function	m²	#	Description	Needs	Light	Atmosphere
DORMATORY	Single unit	15-20	-	Basic living unit for single dorm residents	Storage space, bed, desk, bathroom, close to shared kitchen and living	Daylightfactor >2%, direct sunlight	Private, cozy
	Couple unit	20-35	-	Basic living unit for couples form residents	storage space, seperate bedroom, bathroom, close to shared kitchen and living	Daylightfactor >2% direct sunlight	Private, cozy
	Shared kitchen	30-40	1/12 units	Shared kitchen for dorm clusters	Dining space for all in cluster, cupboards, stove, sink	Daylightfactor >2% direct sunlight	Open, shared, visual connections
	Shared living	30-40	1/12 units	Shared living room for dorm clusters	Flexible, able to be furnished with lounge furniture, activities, etc.	-	Open, shared, visual connections
	Outdoor space		-	Balcony, terrace or courtyard	Space for chairs, tables, etc.	Direct sunlight	Open, green
YOUTH APARTMENTS	Single apartment	30-40	-	Apartment for singles	Same as dorm, but with added kitchen and living/dining space, direct access to outdoor space	Daylightfactor >2% direct sunlight	Private, cozy
	Couple apartment	40-70	-	Apartment for couples	Same as dorm, but with added kitchen and living/dining space and enclosed bedroom, direct acces to outdoor space	Daylightfactor >2% direct sunligt	Privat, cozy
SHARED FUNCTIONS	Laundry	60	-	Laundry for residents and locals	street level access	-	Public, open
	Event space	100-150	-	Event space residents, for parties, gatherings, etc.	Open space, kitchen, toilets, wardrove	-	Open, party, gatherings
	Reading hall	50	-	Reading hall for residents, for studying, group work, etc	Desks, tables		Intimate, quiet, isolated
	Workshop	60	-	Workshop for residents, for fixing your bike, woodshop, fixing things	Flexible, work tables	Daylightfactor >2%	Open, noisy, messy
	Vegetable garden	100	-	Garden for residents, to grow vegetables	Planter boxes or designated areas, toolshed	Direct sunlight most of the day	Open, green
	Fitness	50-100	-	Fitness room for residents	Flexible, space for weights, machines, mats, etc.	-	Open, noisy
	Commercial	-	-	Commercial functions such as small shops, restaurant, cafes etc	Direct acces from streetlevel, possibility for outdoor serving, visible for pedestrians/ bypassers		Open, public

Ill. 39.1: Proposed room program

Ill. 40.1: Empty bottles and trash found on the site

Vision

To create a project that is both socially and environmentally responsible, ensuring equality, interaction, and a brighter future. To create a project that contributes to the overall improvement of the area, strengthening its identity and setting the level for future development.

PRESENTATION

The following chapter contains drawings, illustrations and text presenting the final design proposal. this includes plans, sections and elevations and detail drawings as well as selected visualisations and diagrams, all accompanied by elaborative text.

The Context

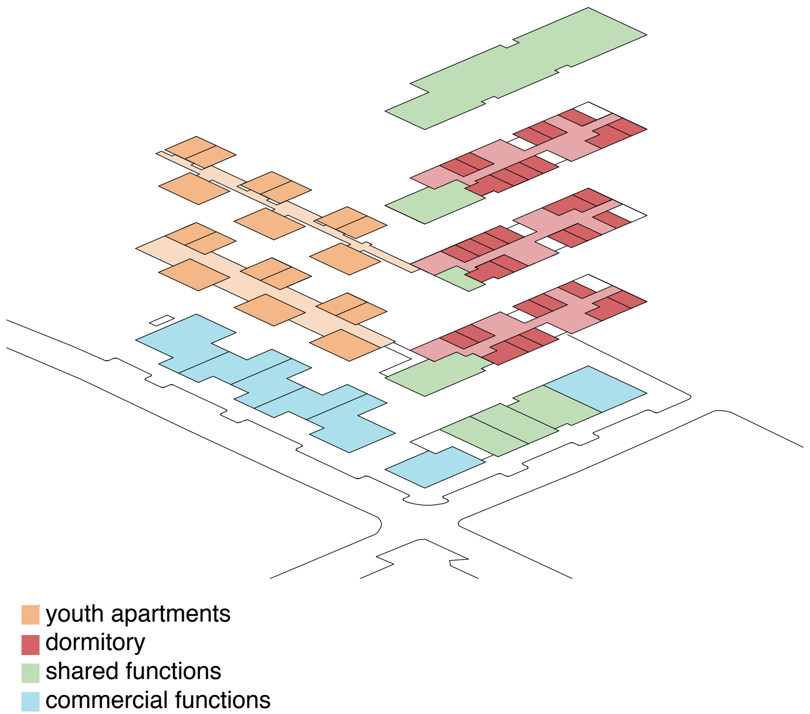
Seen from an aerial perspective, the project fits very well into its context, as well as following the visions of the local plan. The east wing articualtes the northeast/ southwest orientation of the street, emphasising that as a connection through the area from Frederikssundvej to Rentemestervej further north. The west wing is smaller in scale, and more broken up in terms of following the street, creating a more intimate experience.

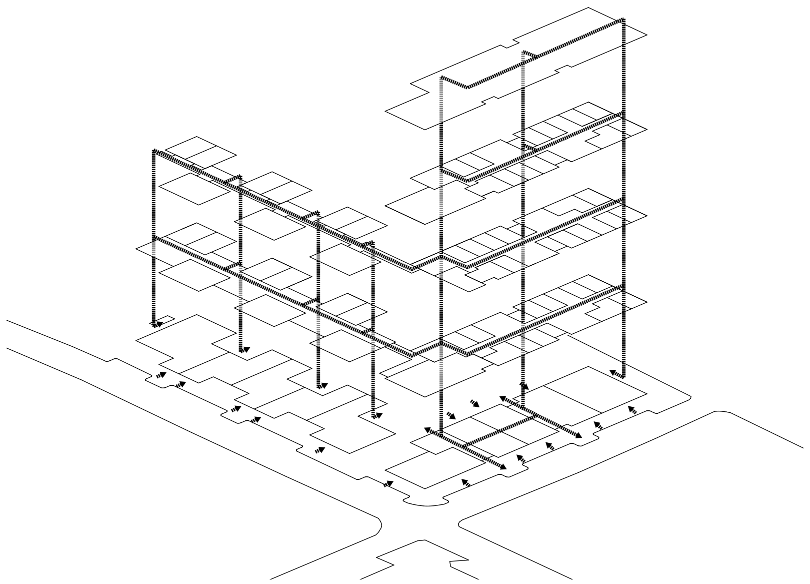
Ill. 45.1: Situation plan, scale 1:500

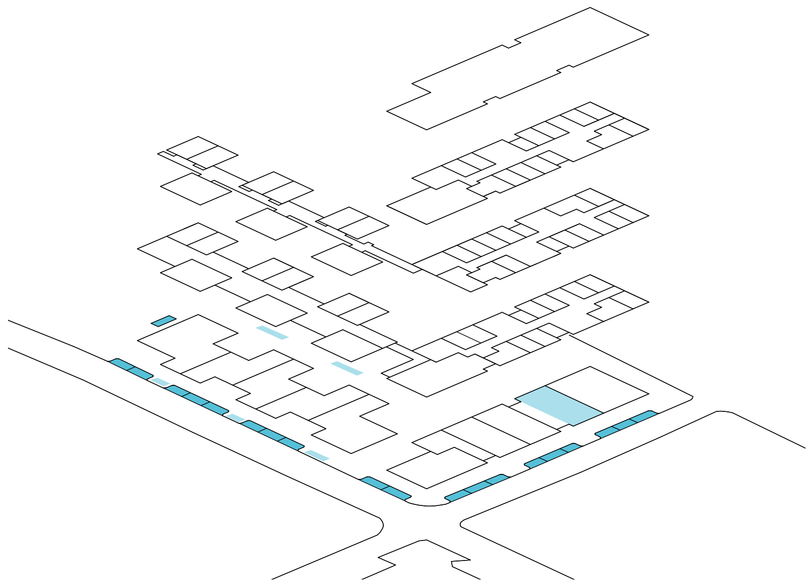
Building Overview

Site area	3265 m²
Building footprint	1313 m²
Gross floor area	3854 m²
- housing (dorm+youth)	2239 (1440+799) m²
- shared	676 m²
- commercial	939 m²
Building percentage	118%
No. of living units	50
- dorm single	26
- dorm couple	6
- apartment single	12
- apartment couple	6
Bike parking	
- residents	62
- public	60
Car parking	20
- Handicap parking	3

Ill. 46.1: Aerial axo view







Functions

The building includes four caterories of functions: dorm, youth apartments, shared functions and commercial functions. The two living functions are organised in two wings, connected by the shared functions located in the center of the building. Additional shared functions are located on the ground floor along with all commercial functions.

Access

The building has one elevator and staircase core located in the central point close to shared functions. Throughout the building several staircases, both internal and external provide short distances to street level, as well as plenty of escape routes in case of evacuation.

Parking

Parking is done at street level, all expcept one along the storefronts. The total number of parking spaces provides 1 parking space per commercial unit, and one per 4 living units. Bike parking for residents is located in sheds in the courtyard as well as on the groundfloor of the dorm wing. Between the parking spaces additional public bike parking is located.

Expression

The overall expression of the building is experienced from the street, from southwest along Theklavej, and from southeast along Provstevej. The project is perceived as two buildings connected by dark corten steel walkways, and perceptually connected in form and materials. The building along Theklavej is perceived as a bottom volume with two rows of smaller volumes floating on top, seperated by a change in material with brick in the bottom and concrete in a tiled pattern on top, as well as gutter further enhancing the perception of floating. The bottom volume is withdrawn following the rhytm of the two rows of volumes on top. Variation in window sizes, type and placement creates a diversity in the facade, further enhanced with dynamic solar shading screens.

Ill. 48.1: SW Elevation, scale 1:250

Along Provstevej, the building is perceived more as one large volume, one storey higher. The volume is withdrawn in vertical lines, highlighting the entrances to the dorm, as well as creating a similar rhythm as that experienced along Theklavej.

Ill. 49.1: SE Elevation, scale 1:250

Seen from the central corner, considered the main way of approaching the building, the separation of the two buildings is less clear, and in stead the building appear more coherent, perceived as several volumes similar in proportions but varying in scale.

Ill. 51.1: Exterior visualisation, seen from the south corner


STOP JYDEN

Street Life

The ground floor of the building is designated for a variety of commercial functions and shared functions such as laundry, workshop and bikeparking. This creates a higher activity in the street and surrounding area throughout the day. The commercial functions are mainly located towards the southwest, creating the possibility for outdoor serving from midday to evening during warm weather. By withdrawing the front of the building from the street, small niches are created that provides more public space, as well as shelter from wind, and a wider sidewalk increasing accessability.

Ill. 52.1: Reference to café atmosphere, Kafe Magasinet, Gothenburg, by Robarch Arkitektur, photo by Henrik Lindén

Ill. 52.1: Reference to sidewalk atmosphere, Brick Lane, London, photo by lemetropolitanblog.com

Ill. 53.1: Situation floor plan, scale 1:500

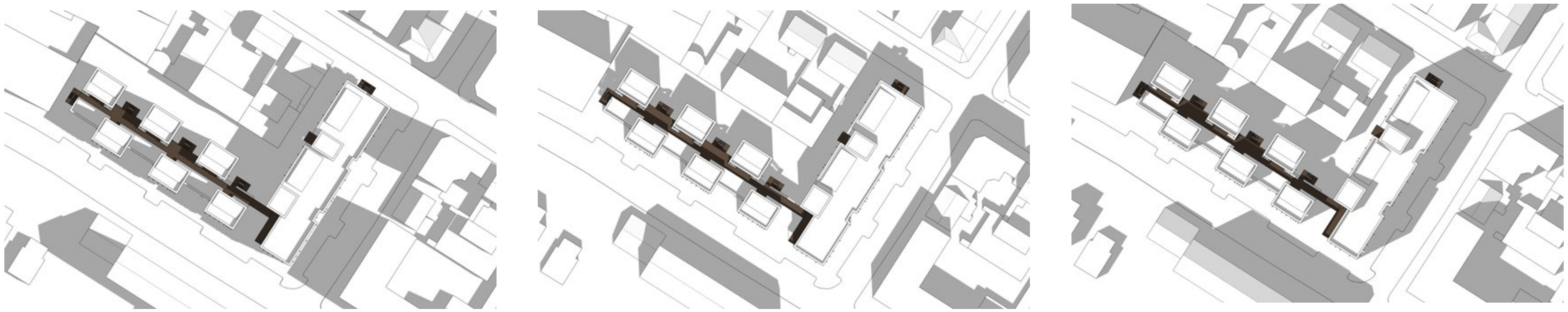
Sun/Shade

By placing the outdoor spaces on the front side of the west wing, and raised above streetlevel, as well as on the roof of the dorm, instead of in the back courtyard seen in traditional urban blocks, the outdoor spaces have great exposure to direct sunlight, maximising the use of these spaces. Looking at the diagrams for 21 March, this becomes clear. The courtyard is shaded almost all of the day, but the youth apartment terraces receives sun from around noon to the afternoon. Even more on the roof terrace of the dorm wing, which is sunlit all day.

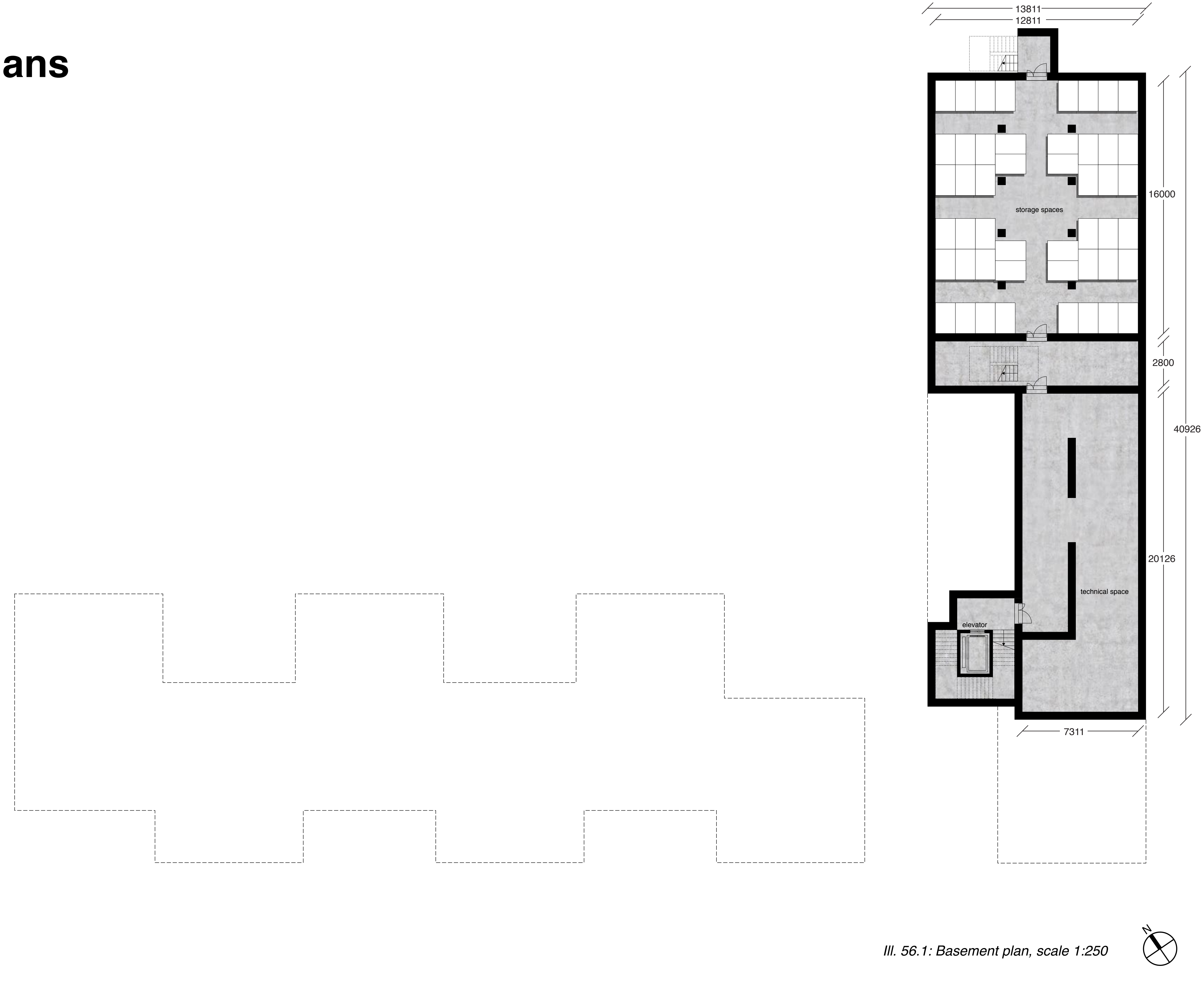
December 21:
from left:
0900
1200
1500

March/September 21:
from left:
0900
1200
1500

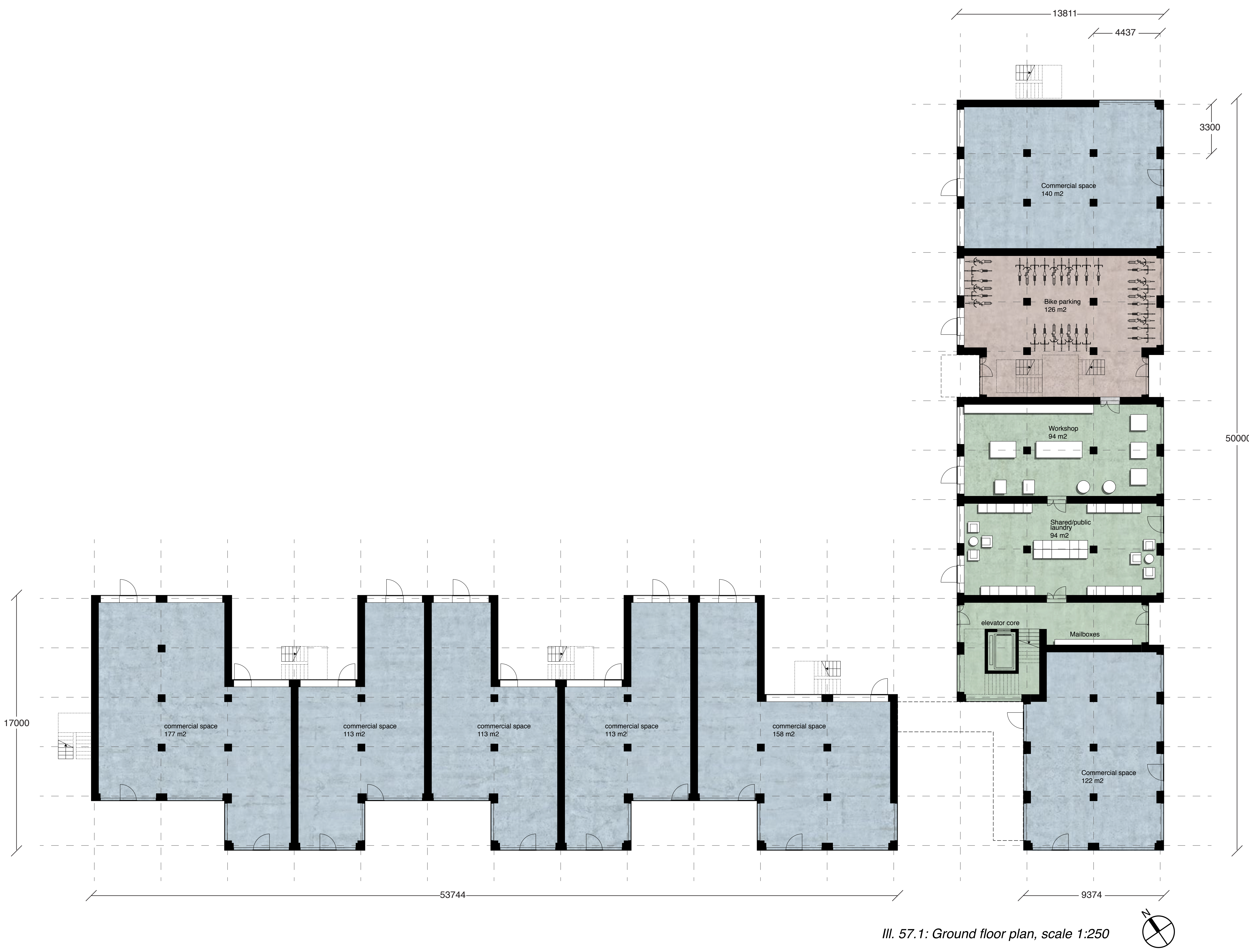
June 21:
from left:
0900
1200
1500



Floor Plans

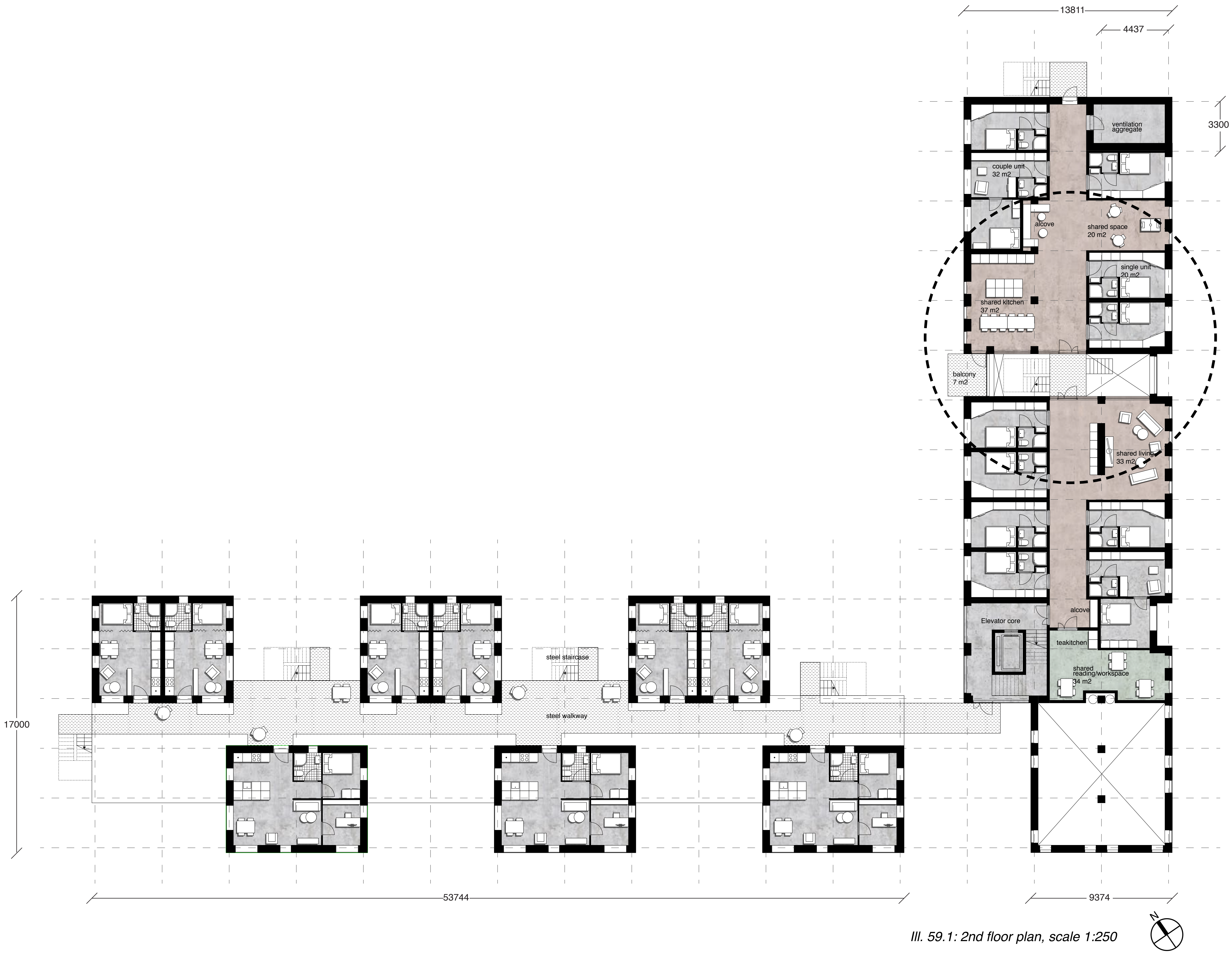


Ill. 56.1: Basement plan, scale 1:250

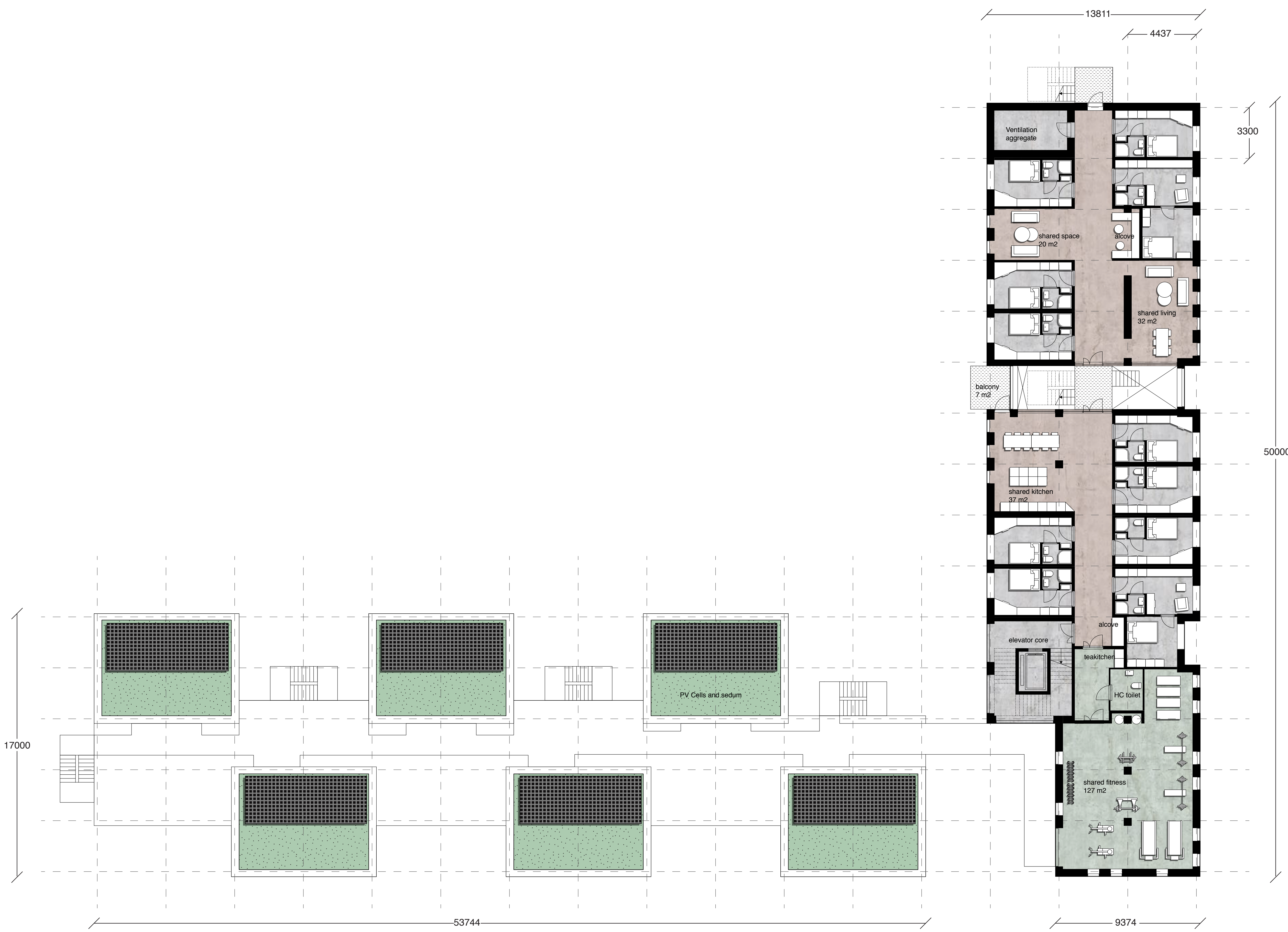


Ill. 57.1: Ground floor plan, scale 1:250

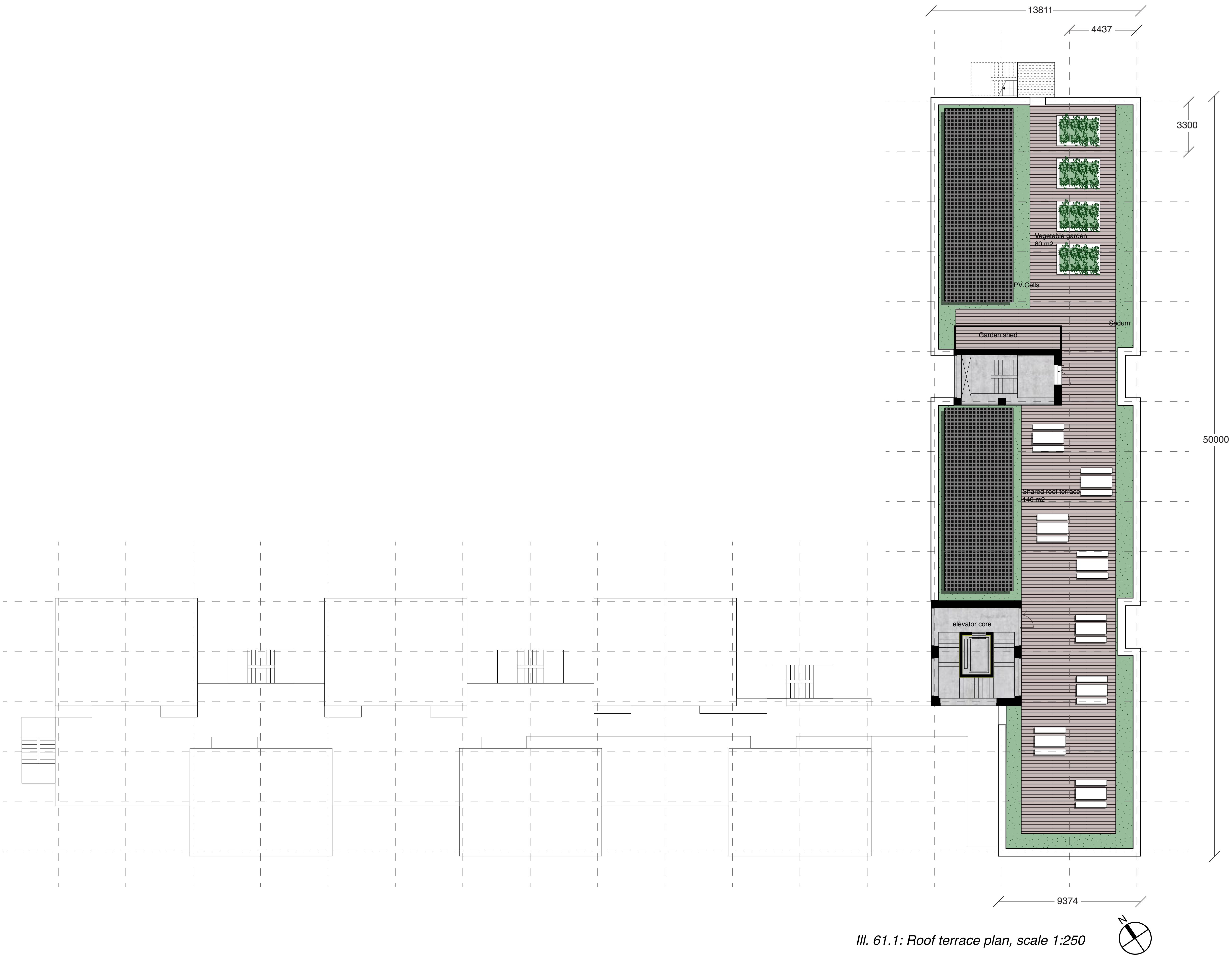
Ill. 58.1: 1st floor plan, scale 1:250



Ill. 59.1: 2nd floor plan, scale 1:250



Ill. 60.1: 3rd floor plan, scale 1:250

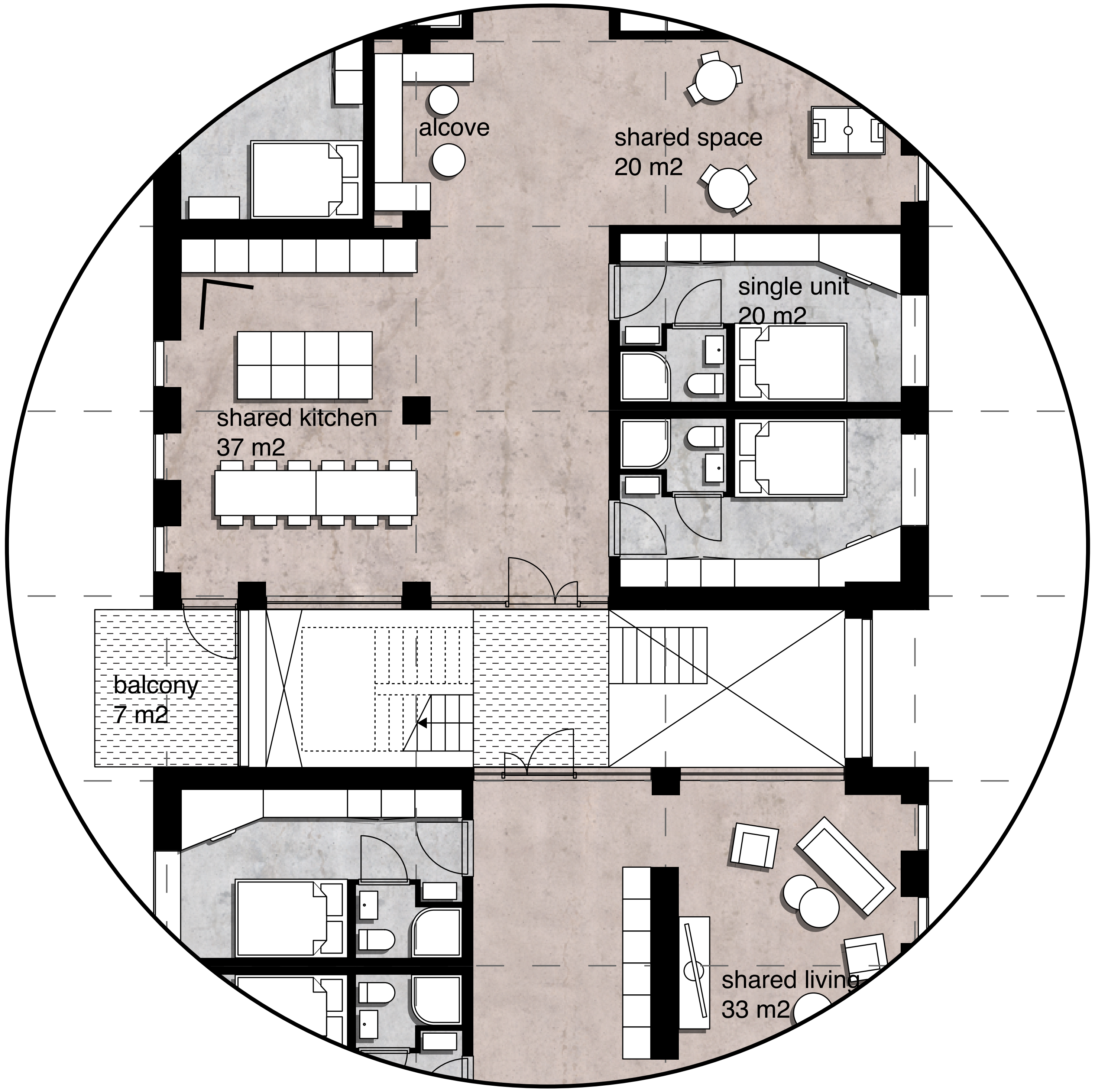


Ill. 61.1: Roof terrace plan, scale 1:250

Dorm Living

The dorm is organised around a central, transparent staircase void, vertically connecting all floors as well as the roof terrace and garden. The two main shared functions, kitchen and living room, are located adjacent to this staircase on opposite sides, creating a visual connection in between. The placement of the shared functions shifts on the next floor, creating a visual vertical connection across floors as well. Throughout the hallways, small niches or alcoves are placed, which provides the dorm residents with the possibility to gather in more intimate spaces. The materials, mostly kept in raw concrete and dark corten steel, and the exposed ventilation ducts create a strong industrial expression, referencing the context and the overall identity of the building.

Ill. 62.1: Reference of industrial atmosphere with raw concrete and exposed venting ducts, Performers House Silkeborg, SHL Architects



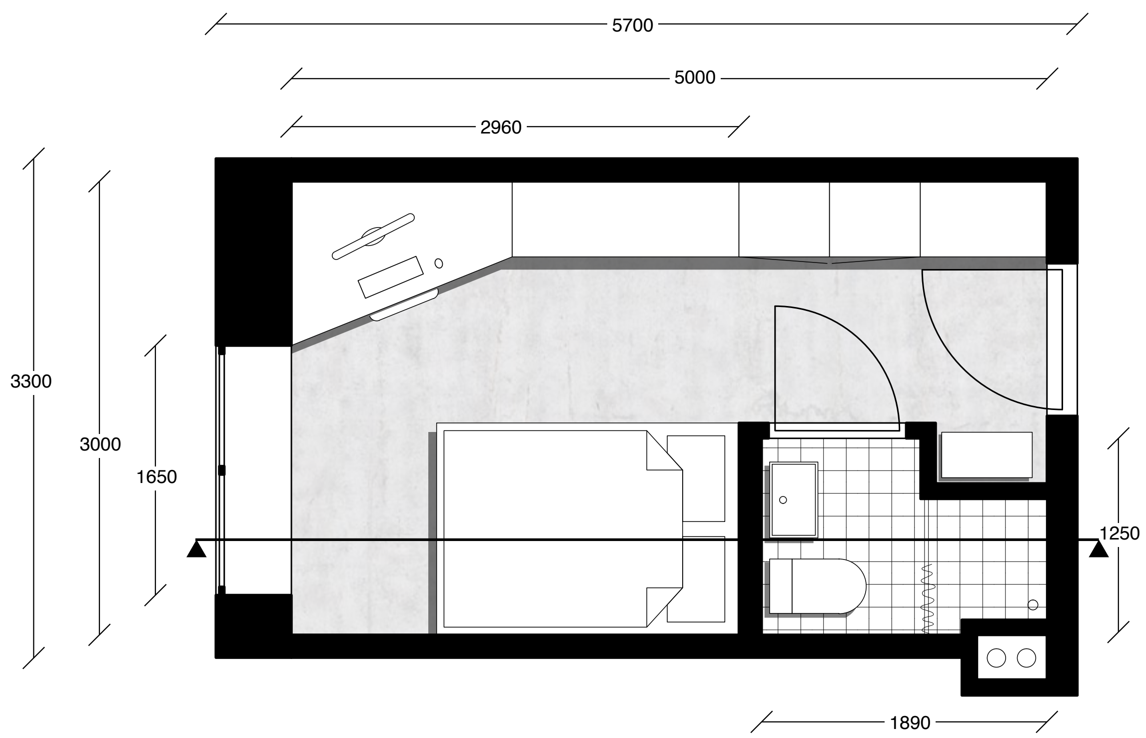
Ill. 62.2: Zoom in on dorm floor plan, scale 1:100

Ill. 63.1: Visualisation of dorm kitchen atmosphere, showing visual connections to the corten steel staircase connecting all floors and the shared living room on the other side of the void.

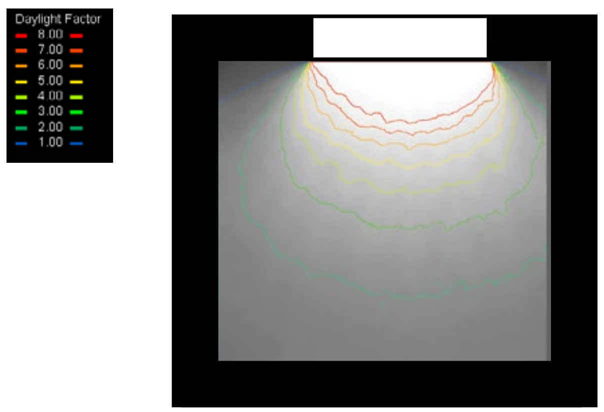
Dorm Single Unit

Gross area: 18,8 m^2
Net area: 15 m^2

The single unit consists of a bathroom and a bedroom, with storagespace and a small desk installed along the wall opposite of the bed. By utilising the low window as a small niche for sitting, the total floor area is kept at a minimum. The materials follow the overall expression of the building, with raw concrete on most surfaces, contrasted by the use of plywood for closets and shelves, as well as the window frame.



Ill. 64.2: Plan of the dorm single unit, scale 1:50



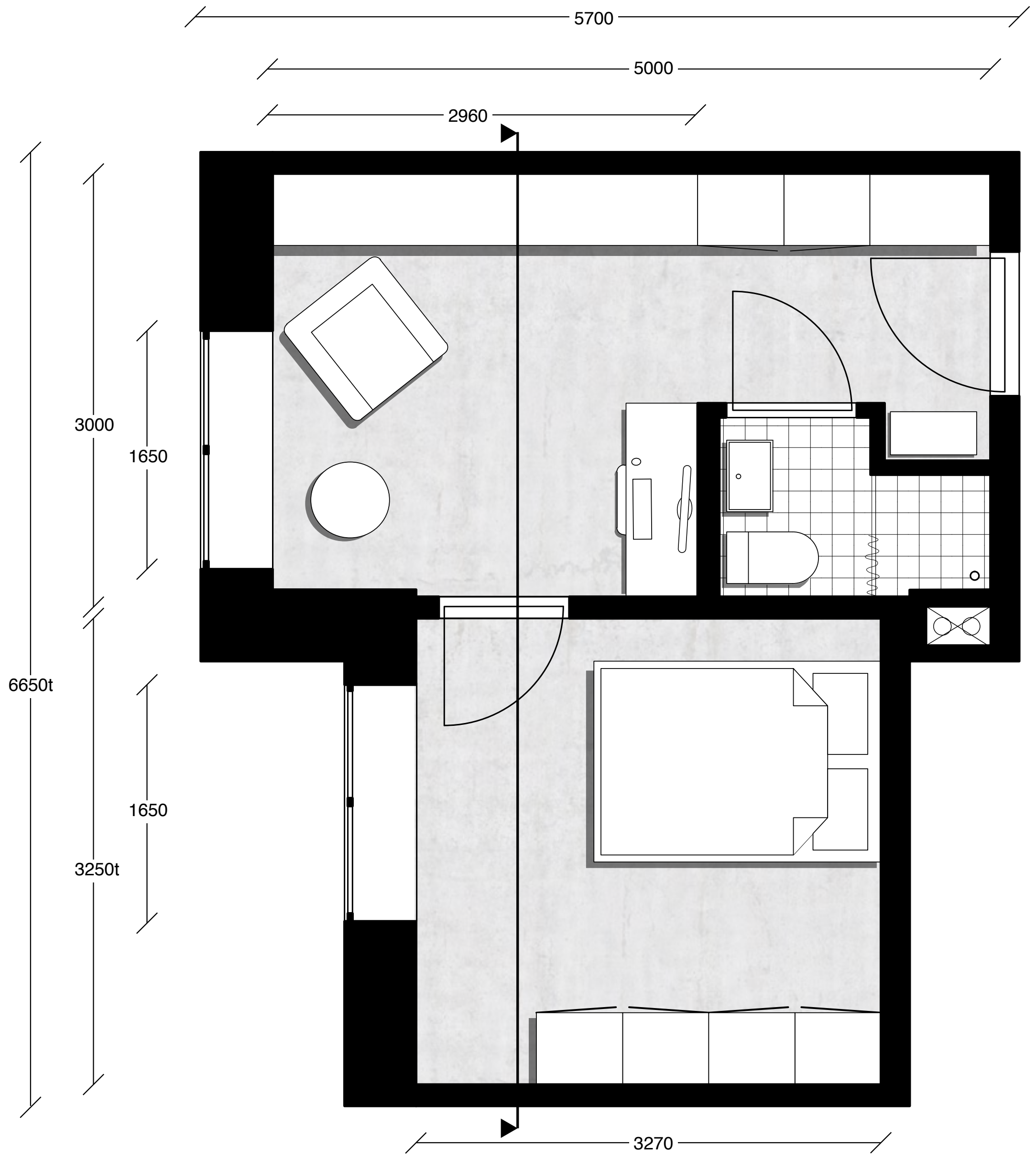
Ill. 64.1: Simplified daylight simulation of the single unit.

Ill. 64.3: Section of the dorm single unit, scale 1:50

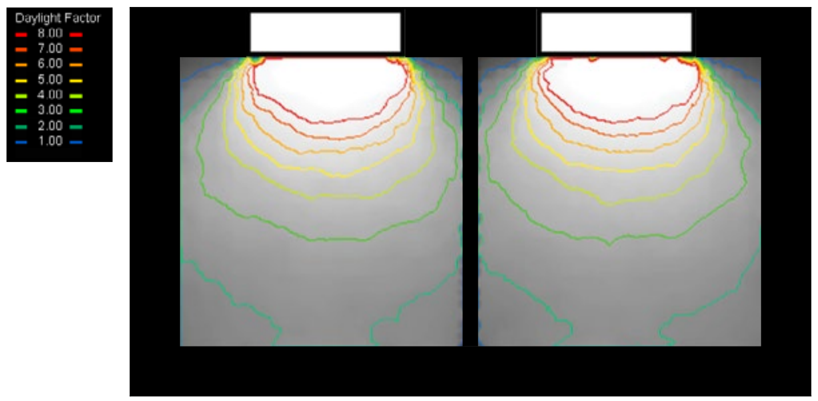
Dorm Couple Unit

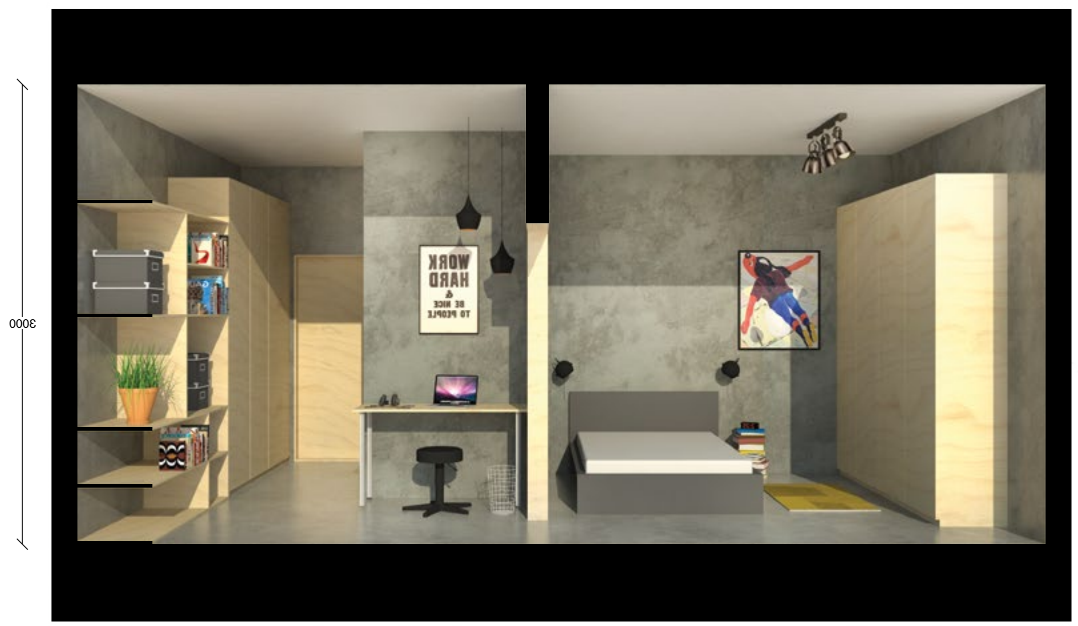
Gross area: 32 m²
Net area: 25,7 m²

The couple unit is almost similar to the single unit, but with an added room, providing extra space for storage and living, as well as the possibility to withdraw from either space if needed. The materials are the same as the sinlge unit.



Ill. 65.2: Plan of the dorm couple unit, scale 1:50





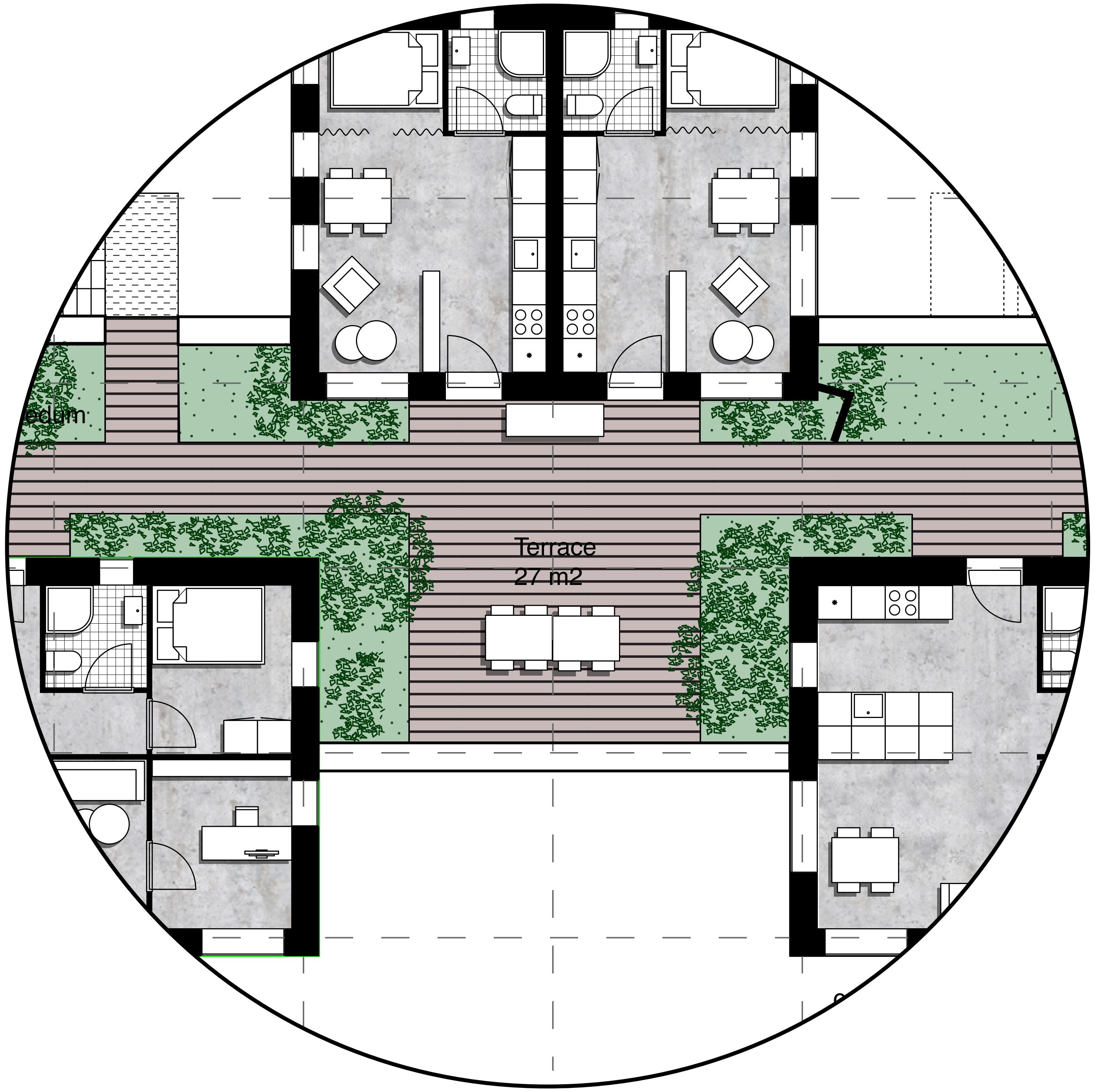
Ill. 65.1: Simplified daylight simulation of the single unit.

Ill. 65.3: Section of the dorm couple unit, scale 1:50

Youth Apartment Living

The youth apartments are organised almost like beads on a string, shifting from one side to another around a central access way. Between the volumes, three small outdoor spaces oriented towards southwest is created. The outdoor spaces are designed as a combination of wild vegetation and wooden terraces, creating small, green oases above the urban asphalt environment.

Ill. 66.1+2: References of roof terrace atmospheres, New York City. Photo by grotrends.com (top) and edelight.de (right).



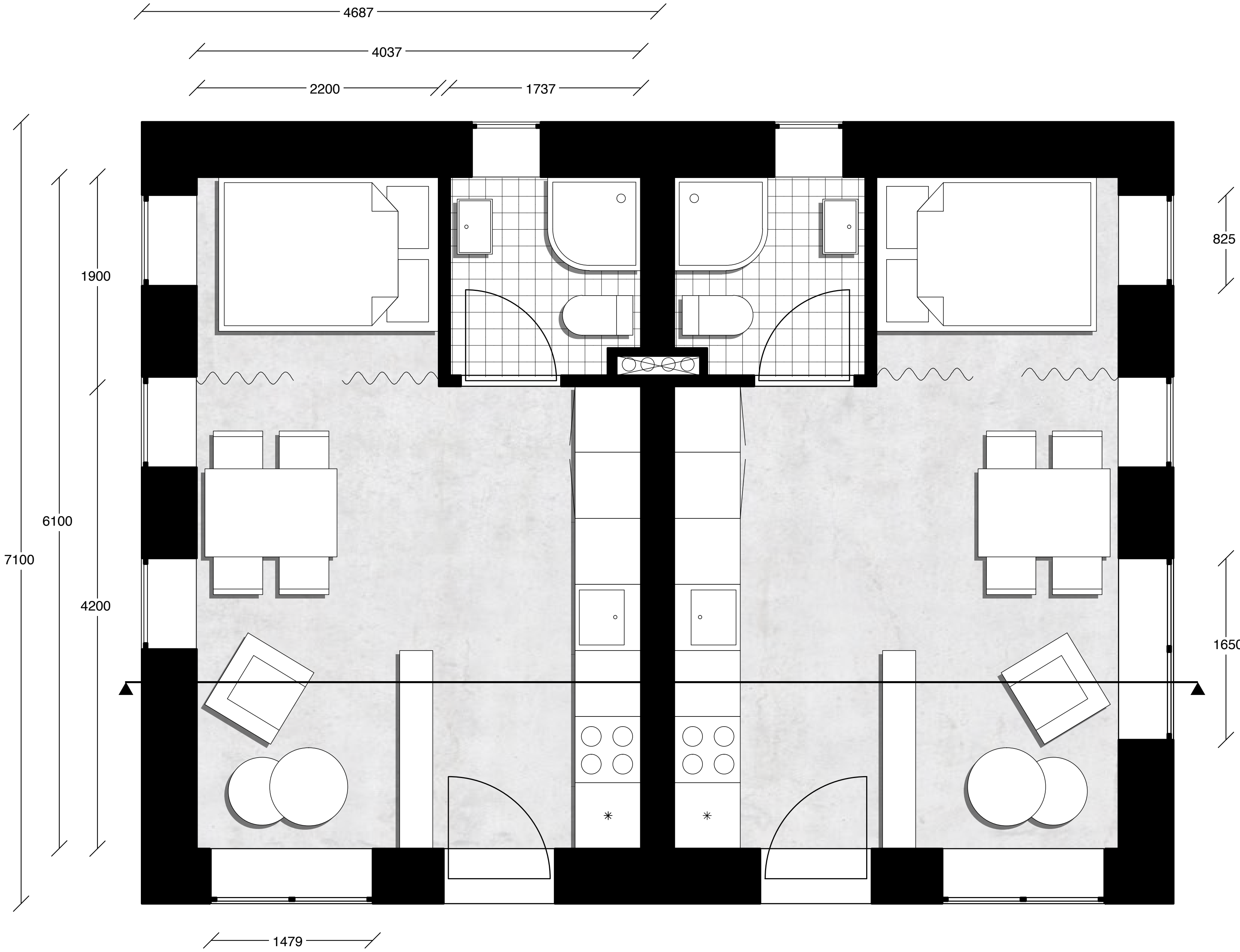
Ill. 66.3: Zoom in of the youth apartment wing, scale 1:100

Ill. 67.1: Visualisation of the central walkway and terrace niches of the youth apartment wing.

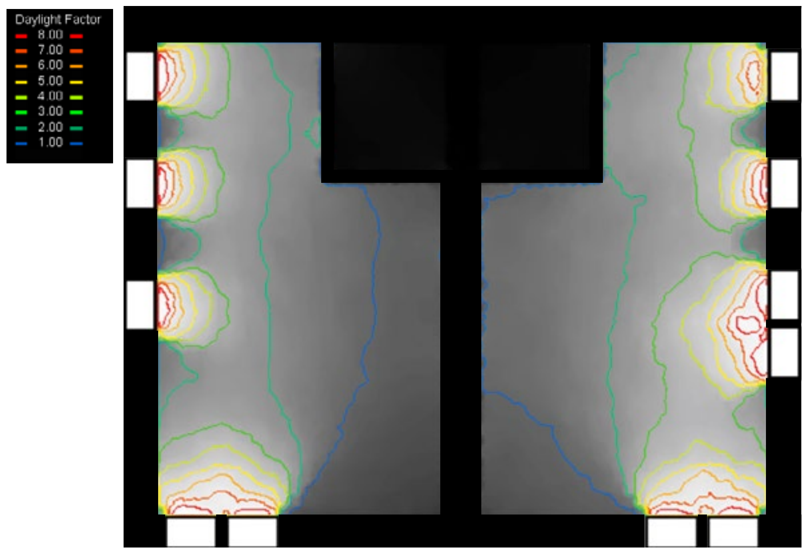
Single Apartment

Gross area: 33,2 m^2
Net area: 25,5 m^2

The single apartments are located in the back row of the youth apartments, with the access and living functions oriented towards the outdoor space. The bedroom and bathroom is located in the back of the unit, providing a stronger sense of privacy. The open plan provides a flexible solution where the bedroom niche can be utilised as an extra living space, keeping the floor area at a minimum.



Ill. 68.2: Plan of the single youth apartment, scale 1:50



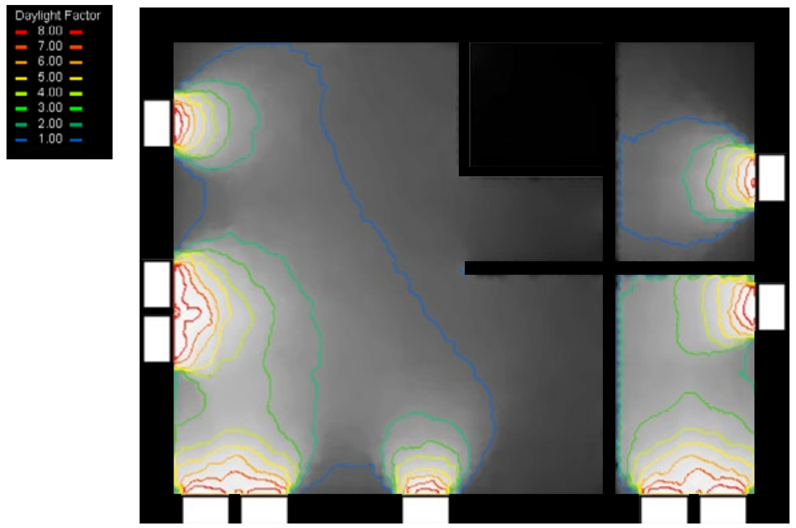
Ill. 68.1: Simplified daylight simulation of the single youth apartment

Ill. 68.3: Section of the single youth apartment, scale 1:50

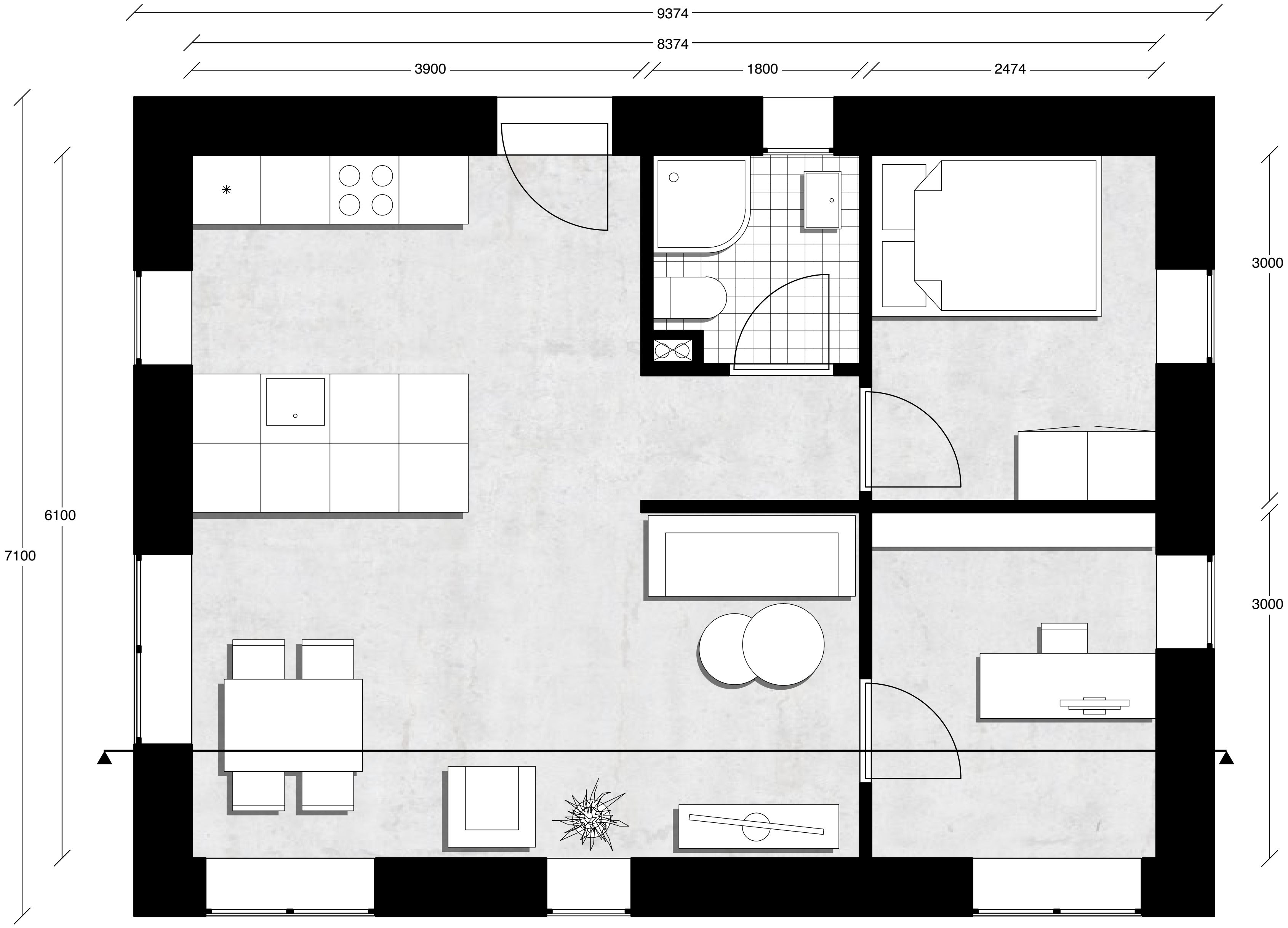
Couple Apartment

Gross area: 66,5 m²
Net area: 51 m²

The couple apartments are located in the front row towards the street. The outer volume is the same as the single apartment, making it double the size. With this added space, it is possible to increase the living an kitchen area, as well as an enclosed bedroom and an extra room.



Ill. 69.1: Simplified daylight simulation of the couples youth apartment.

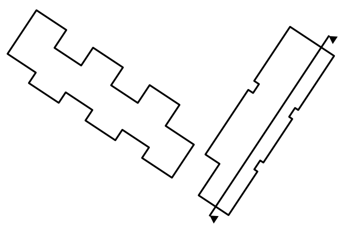


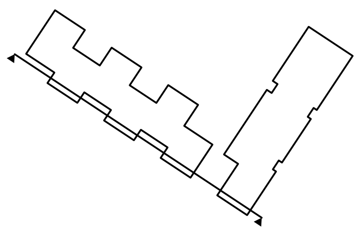
Ill. 69.2: Plan of the couples youth apartment, scale 1:50

Ill. 69.3: Section of the couples youth apartment, scale 1:50

Sections

Ill. 70.1: Section of the dorm wing, scale 1:250





Ill. 71.1: Section of the youth apartment wing, scale 1:250

Structural Principle

Overall Principle

The overall structural principle of the project is quite straight forwads, and consists of bearing outer walls combined with supporting column and beams inside the building, and horizontal decks following the spacing grid of the living units. The outer walls ensure stability in the vertical planes, and the decks ensure stability in the horizontal plane.

Ill. 72.1: Reference to a similar gutter detail, here on the Administration Building of the North Shanghai Gas Company in Jiading by Atelier Deshaus. Photo by Shu He

Detailing

Two joints are identified as requiring a detailed elaboration, shown on the opposite page: The gutter detail between the ground floor and 1st floor, and the end of the outer wall towards the roof, both shown on the opposite page.

Roof railing:

1: Zink plate, 5mm
2: Roofing felt
3: Plywood board, 20mm
4: Fiber concrete plate, 10mm

HIBE* Prefabricated sandwich element, U-value 0,08:

5: Fiber concrete plate, 30mm / Brick cladding 30mm
6: PUR insulation, 320mm
7: Reinforced concrete, 150mm

Roof with terrace, U-value 0,08**:

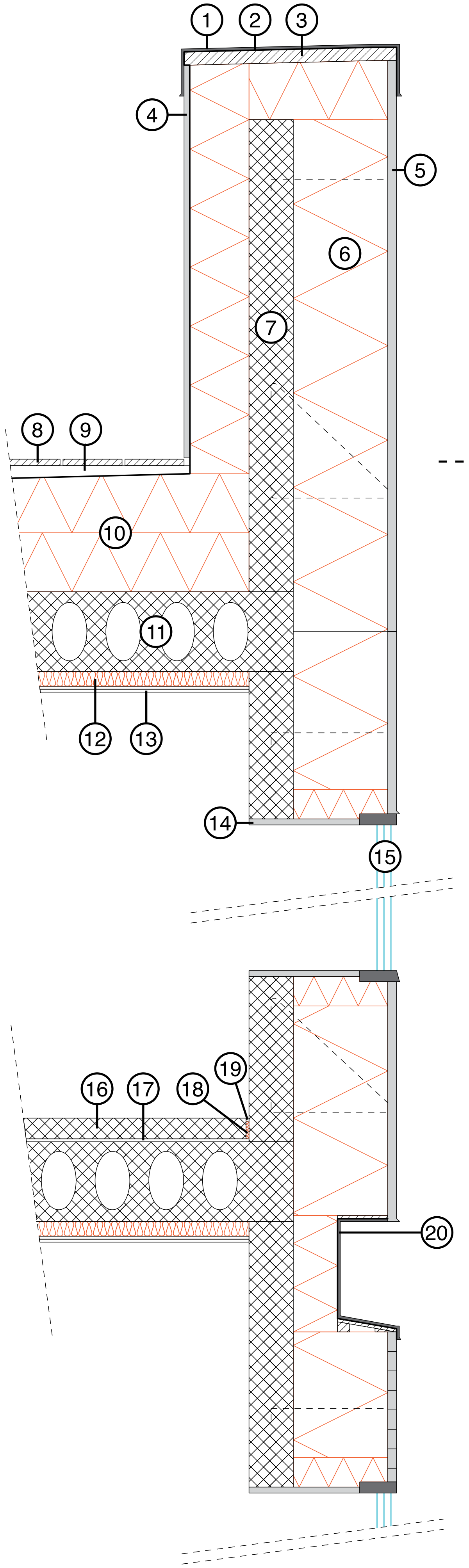
8: Wood planks, 22mm
9: Lateral spacer bars
10: Sundolitt*** pressure resistant insulation, 400mm
11: Concrete hollow core slab, 270mm
12: Rockwool insulation, 50mm
13: Plasterboards, 20mm

Pro-tec X-frame window, U-Value 0,8:

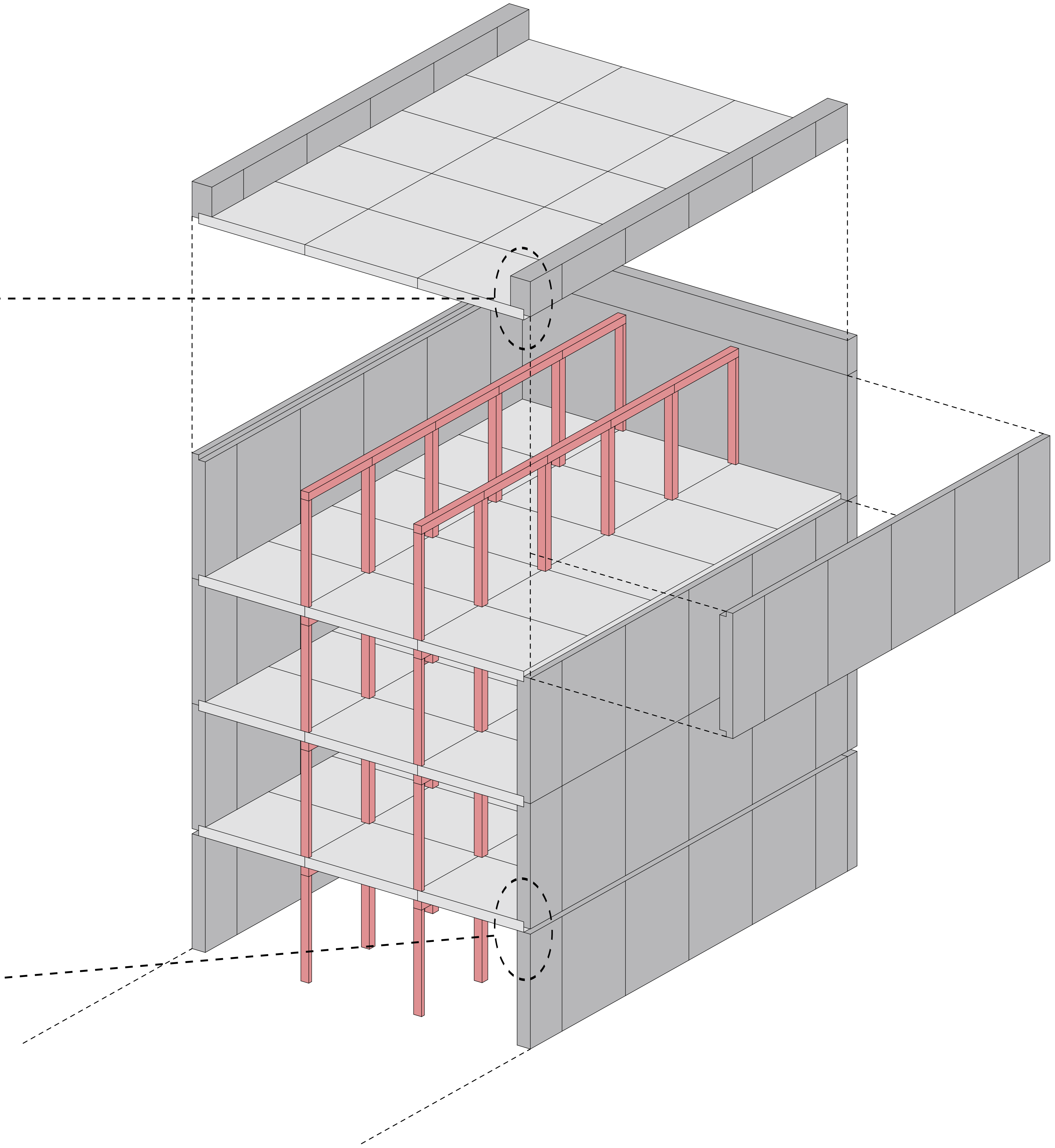
14: Fiber concrete plate, 10mm
15: Triple layered glass

Deck and gutter:

16: In-situ poured concrete, 70mm
17: Flexible acoustiv mat, 10mm
18: Pressure resistant insulation, 10mm
19: Mortar finish
20: Black steel plate, 5mm



Ill. 73.1: Detail drawing of the gutter detail and roof railing plus window, deck and ceiling/roof joint.



Ill. 73.2: Simplified diagram of the structural principle of the dorm wing

Building Performance

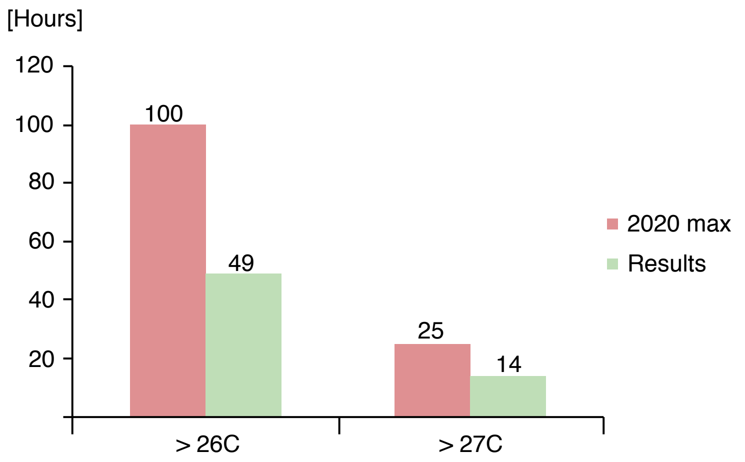
By using a combination of passive and active strategies, the goal of fulfilling the building class 2020 is achieved, both in terms of energy consumption and overheating. The total energy performance of the building is just below the energy frame for BC2020 for the residential functions, divided in youth apartments and dorm. This is achieved mainly from the following initiatives/strategies (see other page for a visual explaination):

Building envelope:
All of the building envelope is highly insulated, ensuring a minimal transmission heat loss. Furthermore, by using high performing pre-fabricated concrete elements, it is possible to avoid line-loss in door and window-joints. Furthermore, window sizes are adjusted according to oirentation, to allow for maximum solar gain in the winter for south facing windows, and minimum transmission loss for north facing windows.

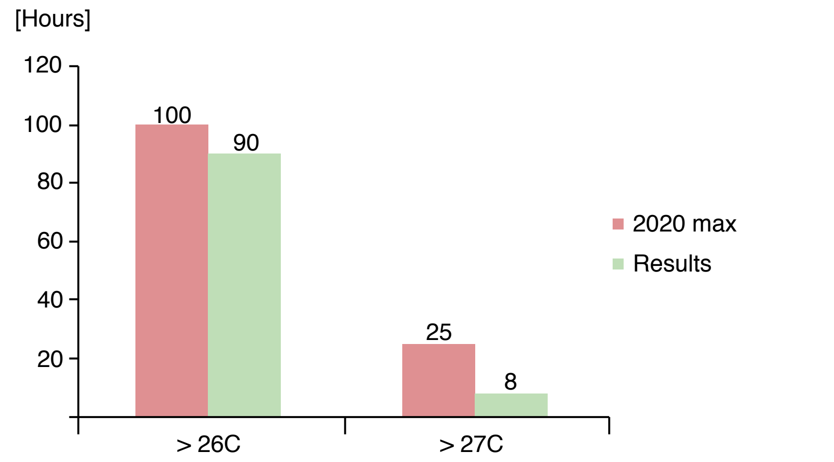
Hybrid ventilation:
By using a mix of natural and mechanical ventilation with heat recovery, energy required for heating is kept at a minimum.

Dynamic solar shading:
By installing dynamic solar shading screens on south-east and southwest facing windows, overheating is pre-vented without excessive need for natural ventilation, or mechanical cooling.

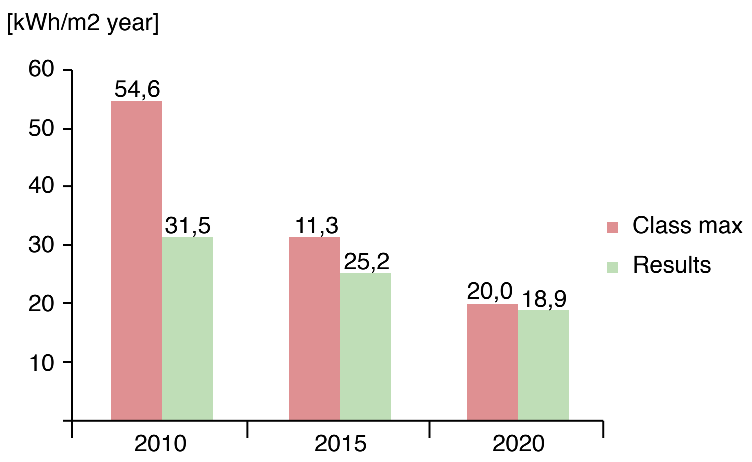
Renewable energy production:
By installing PV cells on the roof of the buildings, and slightly varying the orientation spanning from southeast to southwest, energy is produced during most of the day, contributing to the overall energy frame, as well as ensuring further contribution to energy use not included in the energy frame.



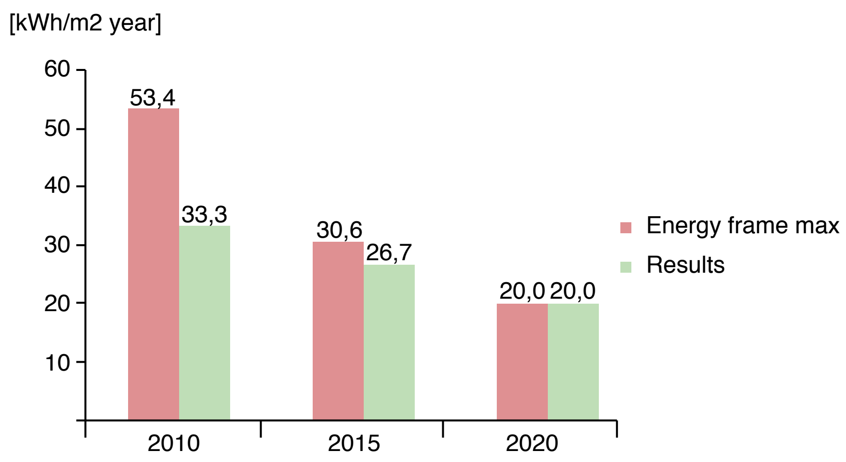
Ill. 74.1: Overheating in the couples youth apartment.



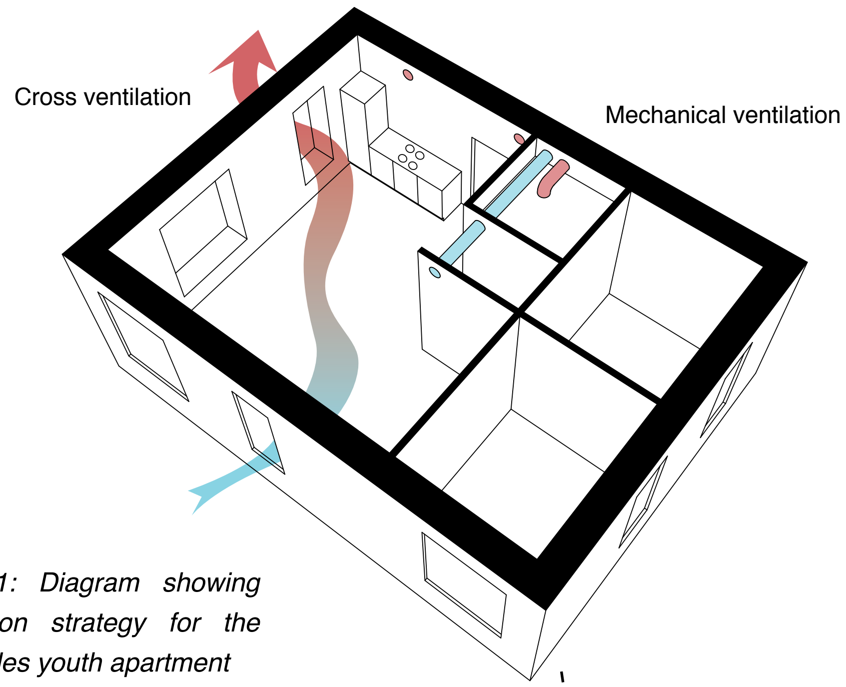
Ill. 74.2: Overheating in the dorm single unit.



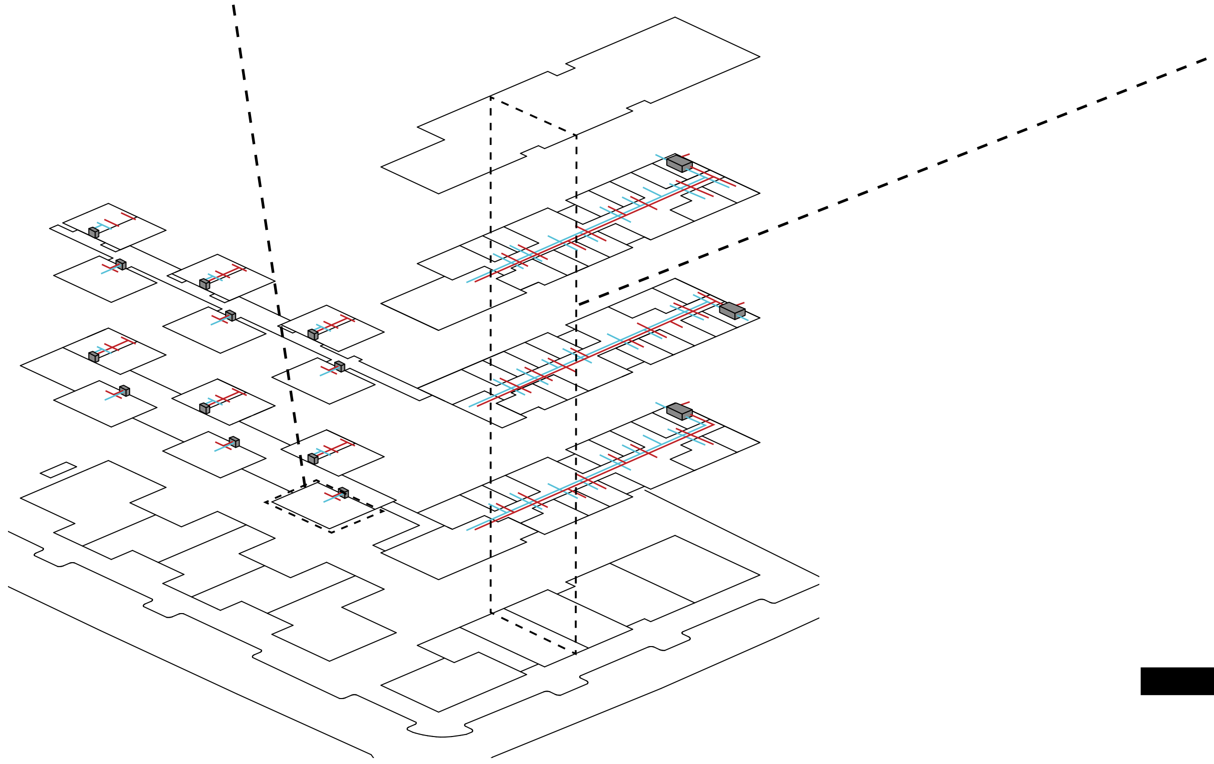
Ill. 74.3: Energy frame for the youth apartment wing.

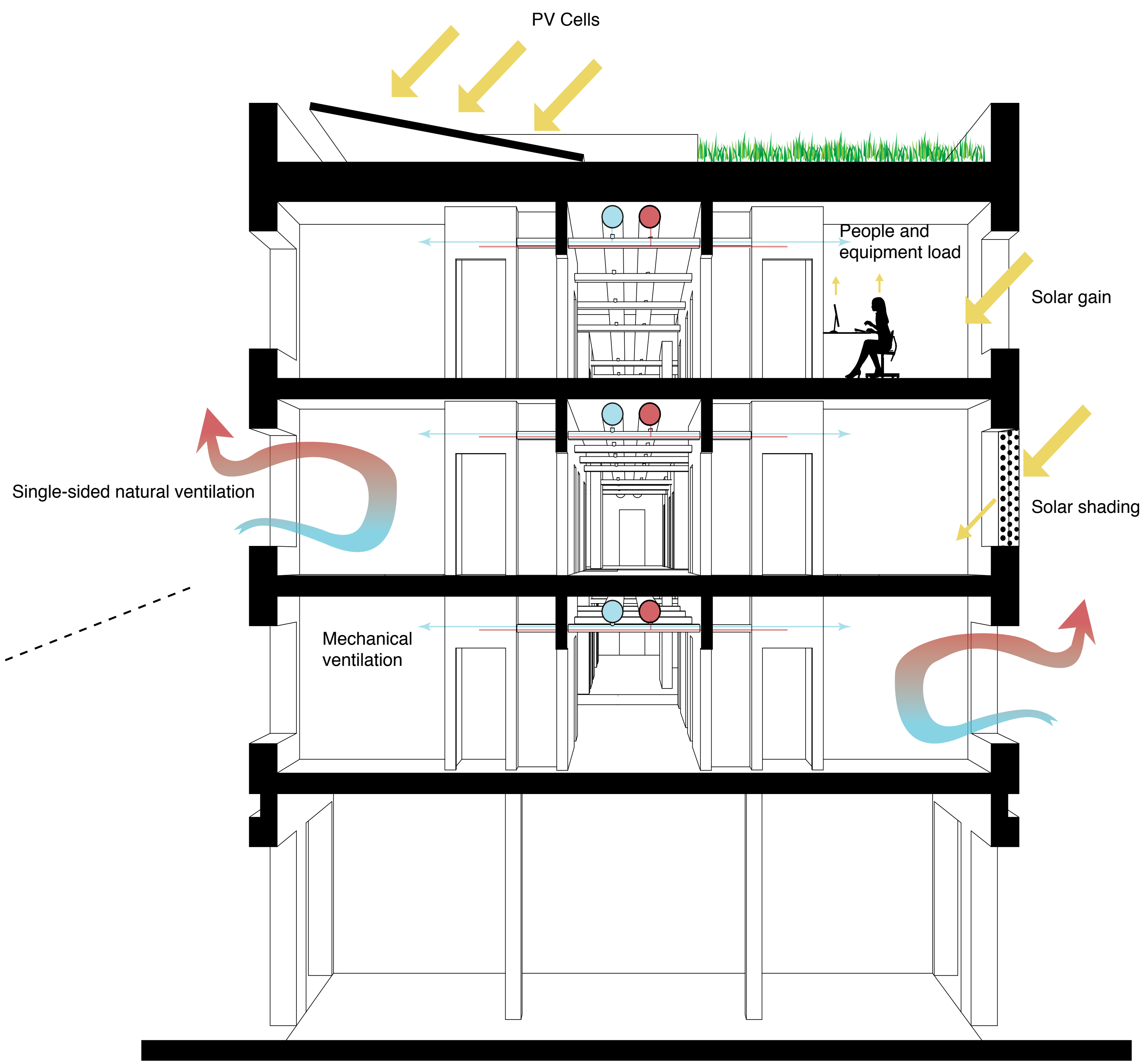


Ill. 74.4: Energy frame for the dorm wing.



Ill. 75.1: Diagram showing ventilation strategy for the couples youth apartment





Ill. 75.2: Diagram showing mechanical ventilation ducts and aggregate locations

Ill. 75.3: Diagram showing energy and ventilation strategies for the dorm wing

SKETCHING

The purpose of this chapter is to illustrate a selection of the most important studies and results made in the sketching phase. It starts from the outside, the concept, and moves down in scale towards interior solutions and detailing. The chapter includes selected studies spanning typology, organisation of functions, living unit design and materiality and expression, evolved through both aesthethical, functional and technical considerations. How it is presented here does not necessarily reflect the actual process, as it can be very unstructured at times, and also does not include all steps and sketches of the design.

Concept Development

Located in a dense urban context, it seems relevant to approach the concept development from the outside, solving the plan and unit development subsequently.

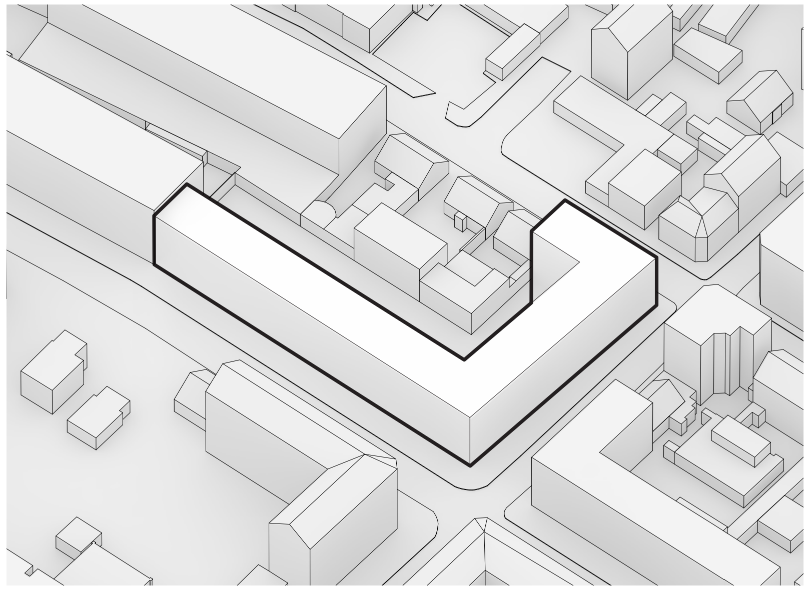
Typology

To get an overview of the possibilities of the site in terms of building volume and shape, a typology study is made. Besides subconscious thoughts and considerations from the analysis, no constraints or obstructions are set in this study, everything is allowed. By using physical foam modelling as a media, the result is a series of models than can be observed from all angles, quickly interchangeable on the context model, and easily comparable in

The main elements examined in the typology study is related to the buildings physical impact on it's surroundings, such as scale, urban space and sun/shade, as well as access and flow.

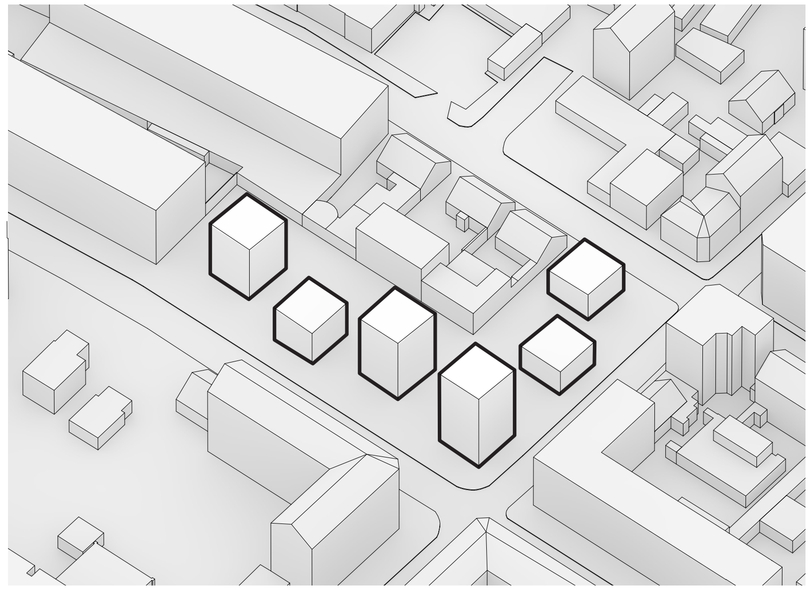
The result of the typology study is a wide range of different, more or less unique proposals to a typology and initial form of the building(s). However, many have similarities, making it possible to categorise them. In this case, the proposals have been sorted into three overall categories: The block, the individual buildings, and the plinth. The qualities and disadvantages of these are compared on the opposite side, and the most relevant is then selected as the further approach.

Ill. 78.1: Collage of a selection of typology proposals.



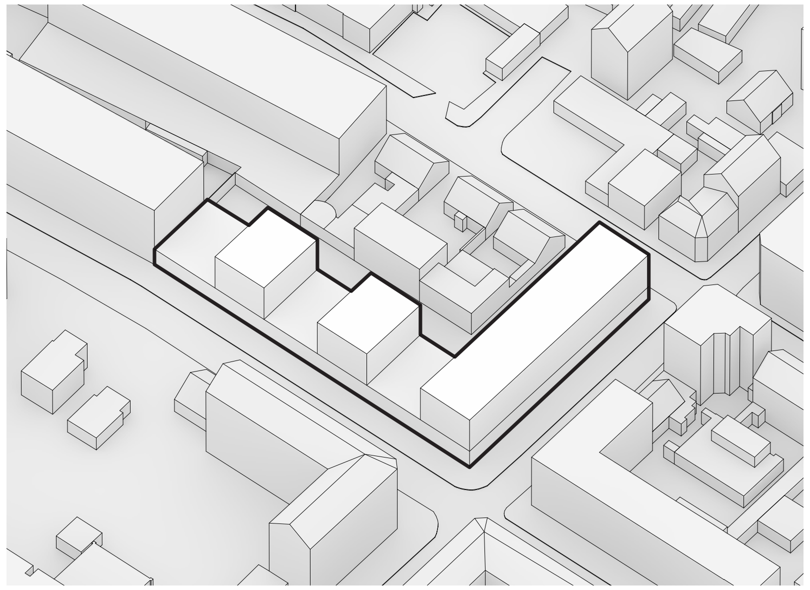
The block

Many of the proposals can be categorised as slightly modified versions of the straightforward block typology, which fills the gap on the site by continuing the lines from the adjacent buildings. It creates a front which emphasises the street and sidewalk flow, while also creating a boundary to the courtyard on the back side. It is clear in terms of private (back) and public (front) space, but does not perform well in terms of scale and sun/shade. With a homogenous height, the scale is the same in all orientations, which does not fit into the surroundings, as well as not respecting the local plan. If pushed fully toward the sidewalk, the block shades for the courtyard most of the time, minimising the use of this space.



Individual buildings

Another proposal is to create a series of individual buildings, which could vary in sizes, related to considerations of scale, function or sun/shade. The advantages are better outdoor spaces and more freedom in handling scale, but the individual buildings have issues when considering the impact on the flow of the street, as well the distinction between private and public space. The surrounding space of the buildings somehow become too open.

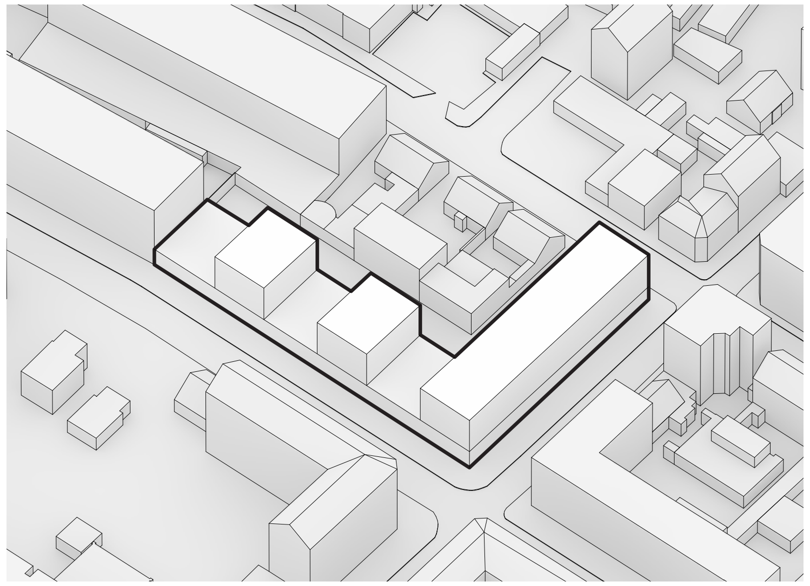


The plinth

The plinth can be seen almost like a combination of the two other categories. The bottom floor acts as the block typology and articulates the flow of the street, while also acting as the connecting element that binds the project together and make it appear as one project. By utilising the roof of the bottom floor betwen the top buildings as outdoor spaces, better sun conditions are achieved, and by seperating it from the street level a seperation between public and private is achieved. The plinth proposal provides the same level of freedom as the individual building, as well as maintaining the qualities of the block typology. The proposal also seem to have a more clear potential in terms of programming the building.

Plinth study

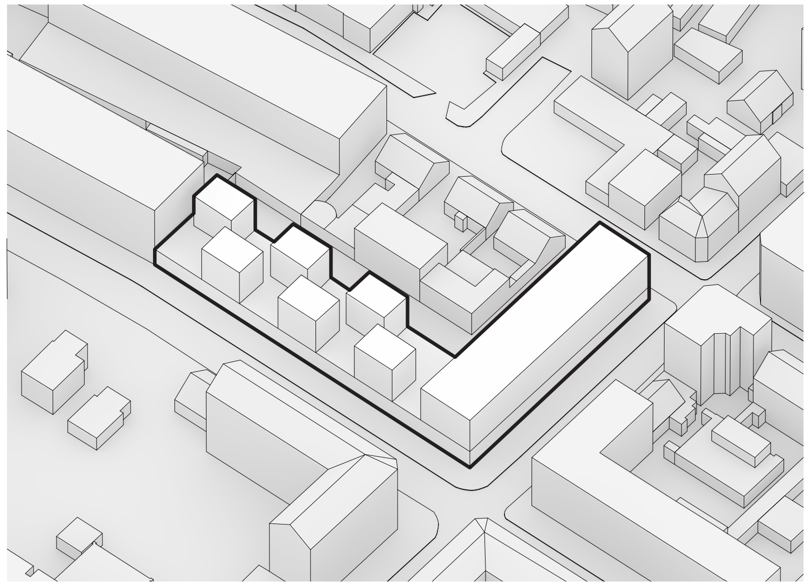
The plinth typology is further studied in relation to programming and access. As stated earlier, the plinth-typology has a certain obvious seperation, at least in terms of bottom and top. Keeping this seperation when programming the building, a clear concept is achieved where the functionality is reflected in the form. There are several ways the functions can be arranged, with different qualities requiring different forms. The following is a discussion of some of the possible configurations, gradually shaping the concept further.



Three boxes

This concept is very clear in form, with a strong coherence and a certain rhytm in the southwest elevation, with the top volumes having similar proportions, besides being diffferent in length.

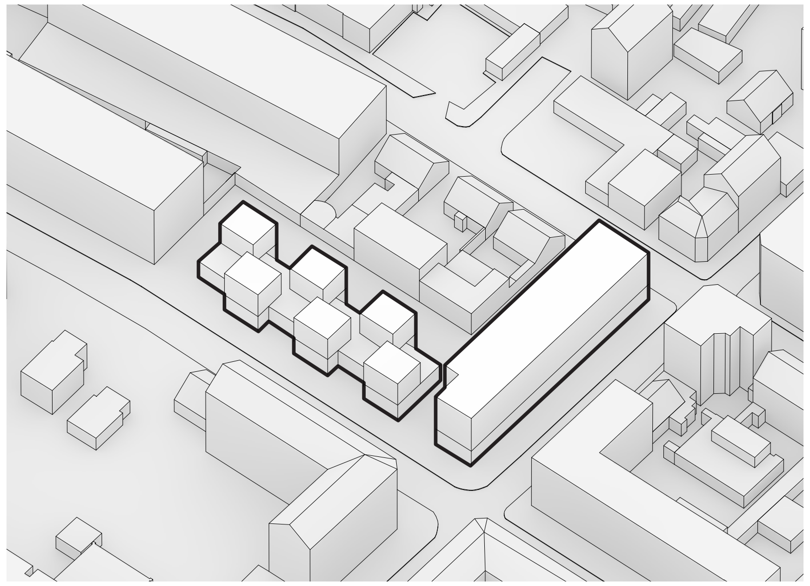
It seems obvious to arrange commercial functions in the bottom volume, creating a seperation of private and public functions as discussed earlier. However, considering the dorm and youth apartment units have different needs, the top volumes would not necessarily reflect this. Also, the elevated outdoor spaces seem random, undefined and unequal, with one of the spaces connected awkwardly to the gable of the neighboor building. The concept has merit in terms of clarity and coherence in form, but lacks functionality.



Village and slab

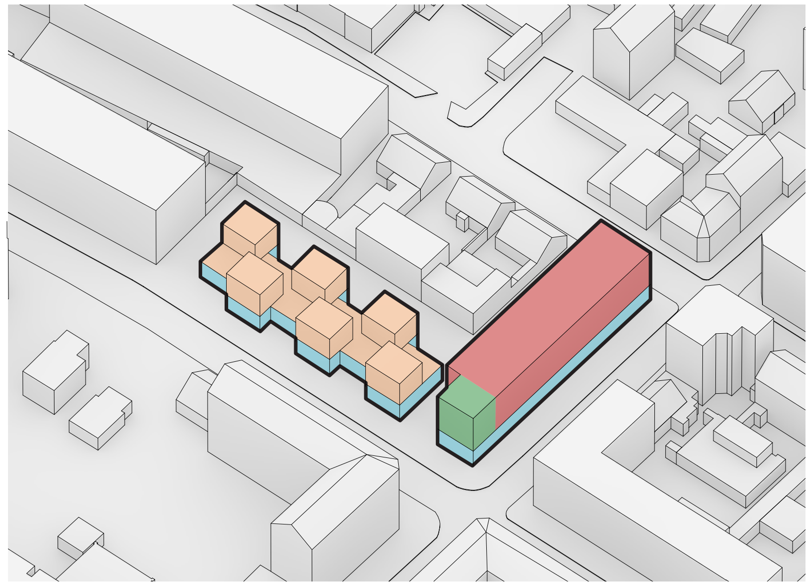
By breaking up the two short top volumes into smaller volumes, a clear seperation is created in the top, with a small, village-like scale in the west wing and a larger slab in the east wing. The two wings have different qualities, more fitting to the different needs of the user types. The youth apartments, requiring more individual spaces, could be programmed in the west wing, with fewer units sharing access and outdoor spaces, while the dormitories could be placed in the slab, being closer together.

While being more clear in functionality, the concept loses a bit of coherence in the overall form, which, if it was not for the bottom volume, could be interpreted as two completely different projects. Furthermore, the outdoor space created in the concept seem to only benefit the residents, not providing any particular qualities to the bottom volume.



Village and slab modified

To make the project appear more coherent, and to make the outdoor space more equal, the bottom volume is broken up, and pushed back between the top volumes. The slab is also pushed back above, creating the same width in the elevation as shown in the illustration to the right, providing the same sense of rhytm as seen in the previous ‘three boxes’ concept. This achieves a stronger coherence in the elevation, as well as providing small outdoor niches for the bottom floor, and more intimate outdoor spaces for the top west wing. Furthermore, the gap in the bottom floor also provides better opportunities for access. Also, the scale is modified to better suit the surroundings, as well as further enhance the visions of the local plan. However, from an aerial perspective, the project is no longer connected by the bottom floor, which seems to work against the coherence. Seeing as the project is mostly experienced from a street level perspective, the sense of coherence should be achievable anyway, by considering it in the further detailing.



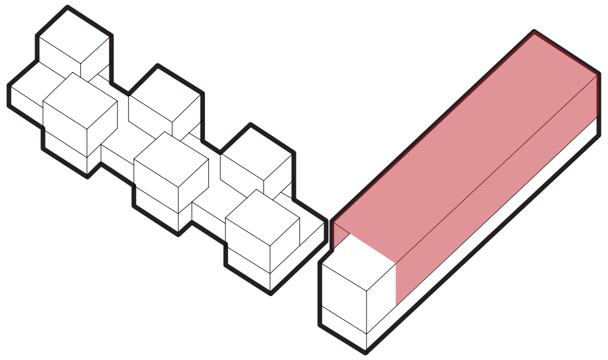
Functions

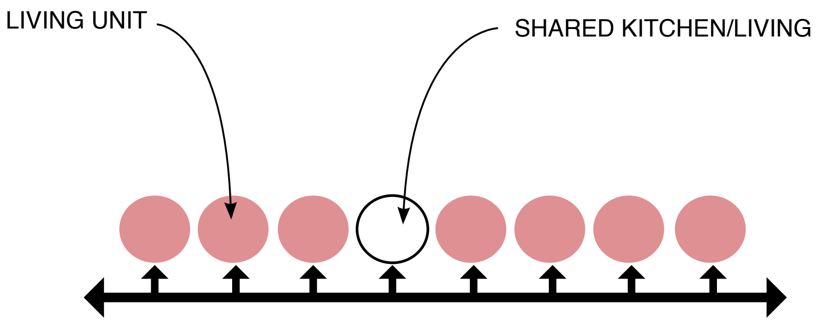
The modifications provide a natural division of the functions, which fits with the qualities of the different characteristics as well as the ratio of the different functions. The largest volume houses the dorm units, and the small volumes houses the youth apartments. The bottom floor is allocated for commercial and more public functions, connected to the street. In the central corner, acting as a connection between the dorm and youth apartment, the shared functions is placed.

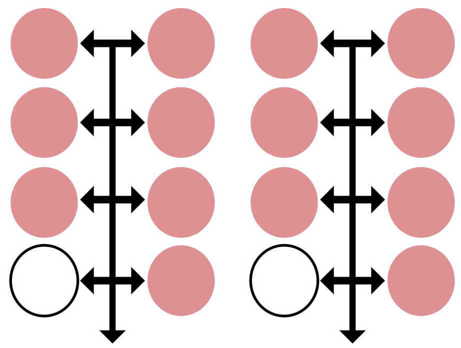
Dorm Wing Development

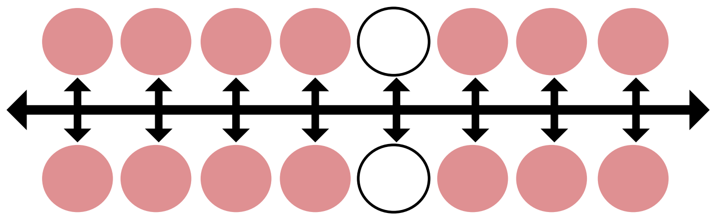
Access

Before developing the units, the organisation of the units must be determined, as different solutions require different considerations. The purpose of this section is to discuss different options in terms of efficiency, compactness, flow and social interaction. Three different solutions are identified: Gallery access, staircase access and halway access.









Gallery acces

The option of gallery access has the advantage of potential daylight from two directions, as well utilisting the gallery for added outdoor space. However, it requires a lot of access space, as well as creating long distances. Also, assuming the gallery is exterior, the units become “seperated”, not being under the same roof. Also, the potential number of units is lower than the other solutions.

Staircase access

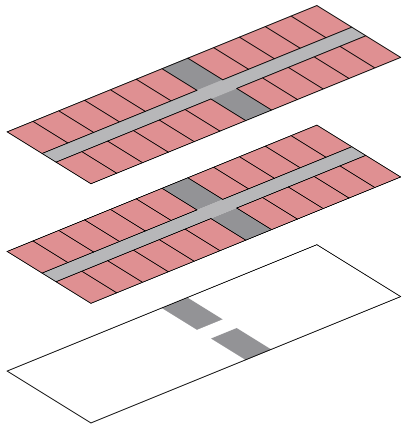
Stairway access is more compact than gallery access, providing more units than gallery access. It does however require more vertical accessways (staircases) per unit, meaning a lower ratio of usable space. With no access between staircases, the units become seperated in smaller clusters, which lowers the amount of social interaction across clusters.

Hallway access

Hallway access can gather more units on each floor, enhancing the social interaction, as well as being more efficient in terms of required access space. While being more efficient, the units only receives daylight from one side. However, considering the relatively small sizes of the units, this should not be a concern. Combining all parameters, hallway access seem by far to be the superior solution.

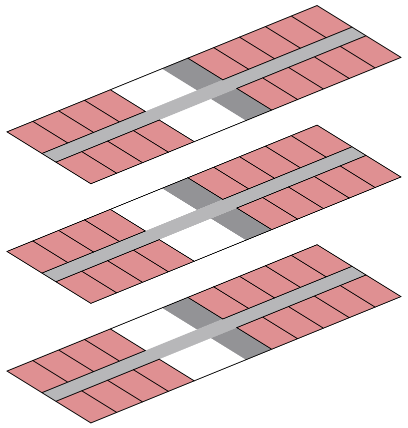
Floor Plan

By choosing the concept of hallway access, the dorm is seperated into floors. This creates different options for organising the dorm in terms of the relationship between living units and shared functions (kitchens and living rooms), as well as across clusters. The following is a discussion of different options, leading to an optimal approach.



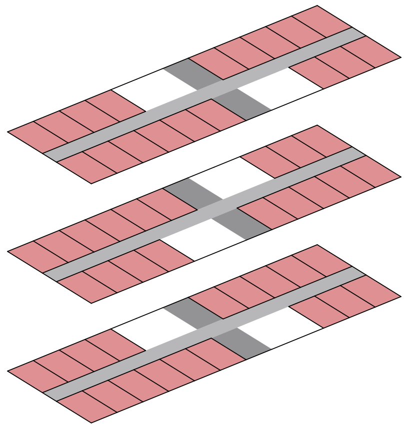
Gathering shared functions in one floor

One option could be to gather all shared functions on one floor. This gathers all social interaction in one place, making it appear as one large cluster, in stead of seperated clusters on each floor. The resulting experience in the hallways of the living units would however be very uniform, with long hallways without activity. Furthermore, assuming three floors of space, allocation one whole floor for shared functions provides less space for number of living units compared to the other solutions.



Seperating clusters by floor

By making each floor a cluster with a set of living units with kitchen and living rooms on the same floor, the long hallways can be broken up by the shared spaces, creating a more dynamic and activated hall way space. Furthermore, it provides space for more living units, and a more equal distribution of the living units, assuming a central location of the shared functions. Furthermore, by placing vertical access ways in the ends as well in connection to the shared functions, plenty of escape routes are provided, as well as short distances between the shared spaces of the clusters.



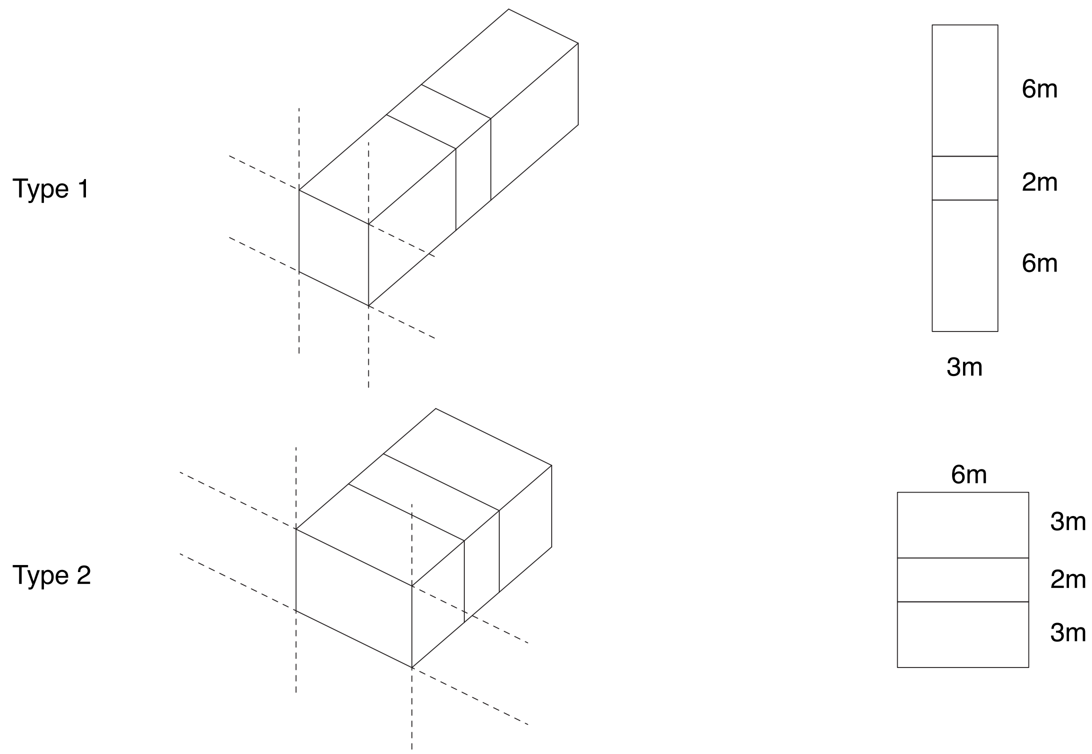
Shifting the shared functions

To connect the clusters even more, the shared functions are shifted throught out the floors, with the central access in the middle, providing potential visual connections between floors. Furthermore, it provides an even more dynamic hallway on each floor, with more variety, and the potential to create different atmospheres.

Dorm Unit Design

Initial Geometry Study

Knowing the organisation of the dorm wing, it is now possible to develop the living units. As a first step, the overall proportions are studied in terms of energy performance. Considering most of the units will be located in between other units, with only one exterior surface, the calculation is made with such a unit as an example. Two different geometries are tested, one narrow, type 1, and one wide, type 2. Both have a 2m wide hallway in the middle. Type 2 might appear more compact than type 1, but considering the fact that it is located in between other units, it has more exterior envelope per floor area than type 1, making it less compact. The performance however, is almost similar, with only a slight difference in the two, the reason being that the wider geometry receives more solar gain due to its' larger windows. The study is very general, but can still be used as an initial factor for deciding the geometry of the units.



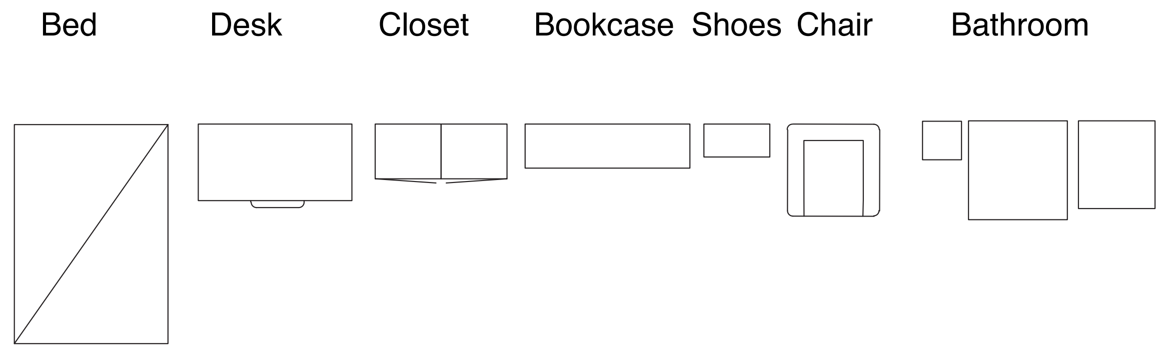
Ill. 84.1: Diagram showing the proportions of the two tested geometries

	SW Windows ratio [-]	NE Windows ratio [-]	total wall area [m2]	SW window area [m2]	NE window area [m2]	total windows area [m2]	Surface/area ratio [#]	Energy use (2020) [kWh/m2]
Type 1	0	25	19,4	0	2,8	2,8	0,53	24,4
	25	25	16,7	2,8	2,8	5,6	0,53	19,4
	50	25	13,9	5,6	2,8	8,3	0,53	16,3
	75	25	11,1	8,3	2,8	11,1	0,53	14,5
	100	25	8,3	11,1	2,8	13,9	0,53	13,0
Type 2	0	25	38,9	0,0	5,6	5,6	0,93	26,7
	25	25	33,3	5,6	5,6	11,1	0,93	20,0
	50	25	27,8	11,1	5,6	16,7	0,93	16,5
	75	25	22,2	16,7	5,6	22,2	0,93	14,5
	100	25	16,7	22,2	5,6	27,8	0,93	13,3

Ill. 84.2: Initial result of the two tested geometries,

Dorm Unit Plan Development

Starting with the geometry of type 1, and what is considered to be essential elements for a student, the plan is developed. The aim is to make it as efficient as possible. The largest improvement comes from taking advantage of the thick, highly insulated walls, and utilising the window sill as a lounge chair. A good example of approaching the ambitious 2020 goals as an opportunity in stead of an obstruction. By further modifying the plan, more space is created for storage.



6x3m
All basics

5x3m
No chair, but low, deep window as furniture

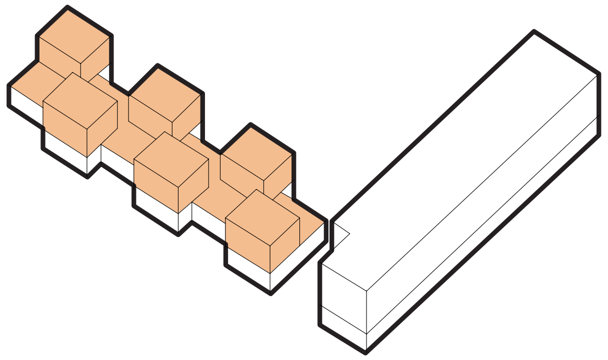
5x3m
Alternative layout

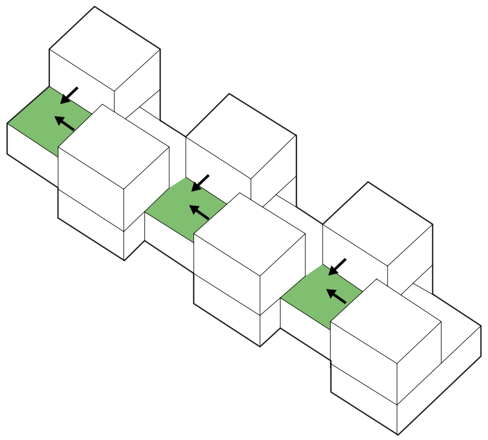
5x3m
Reverse bathroom door, wider entrance, more storagespace.

Ill. 85.1: Dorm unit plan development

Youth Apartments Development

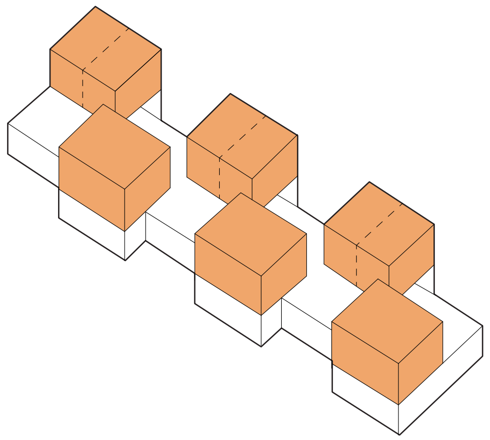
The youth apartment wing consists of 6 equally sized volumes, all two floors in height. They can be divided in two rows, the front (towards the street) and the back. The two rows have different orientations towards the central corridor and the outdoor niches, as well as different level of sun exposure. The same can be said about the outdoor niches, which also consists of 6 spaces. The following discussion develops the concept further in terms of orientation, function and access.





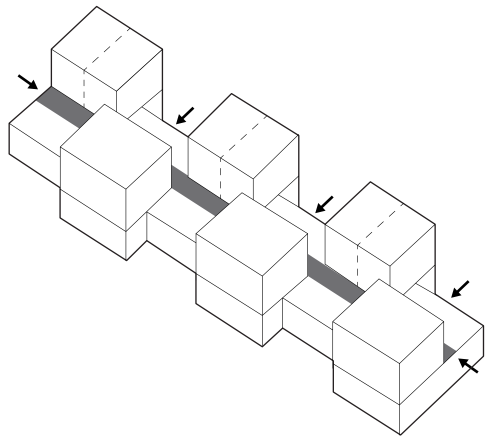
Orientation

Identifying the front niches as the main outdoor spaces, three seperate spaces are created, connected to two volumes each, one front and one back.



Function

The orientation of the volumes allows for the back row to be split up into smaller units, allowing for different unit types, fitting to the program of both single and couple units.



Access

By locating the access in the end points and the back, the front niches can be utilised to the fullest, as well as providing maximum street exposure for the bottom commercial floor.

Youth Single Apartment Plan Development

The youth apartments have the same basic needs as the dorm units, but also require a kitchen, as well as a dining space. For the single units, a few options are discussed.

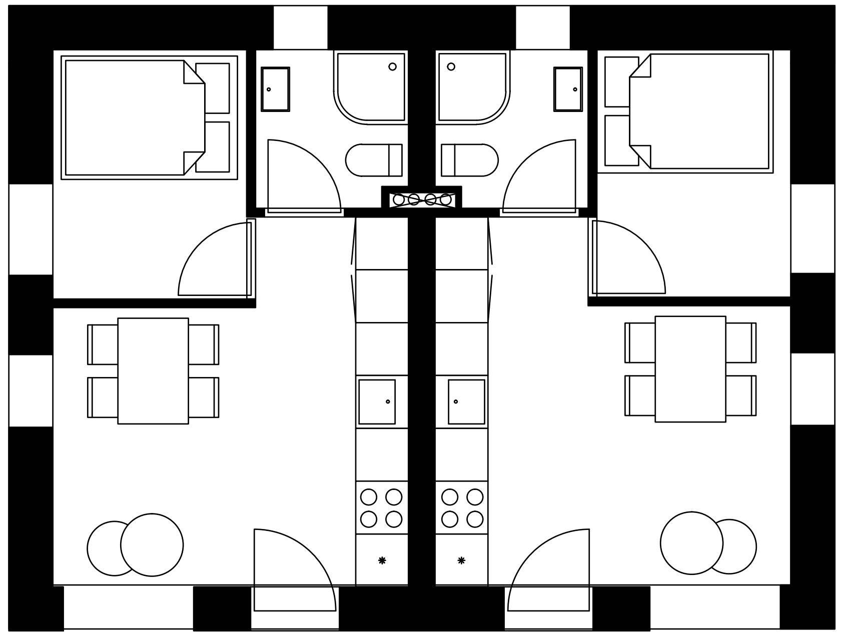
Two room apartment

In the first sketch, the unit is proposed to have a bedroom that is seperated from the main living/kithcen area with walls and a door, creating a two room apartment. It is possible, but the living space seems quite cramped, not allowing much freedom in the interior solutions.

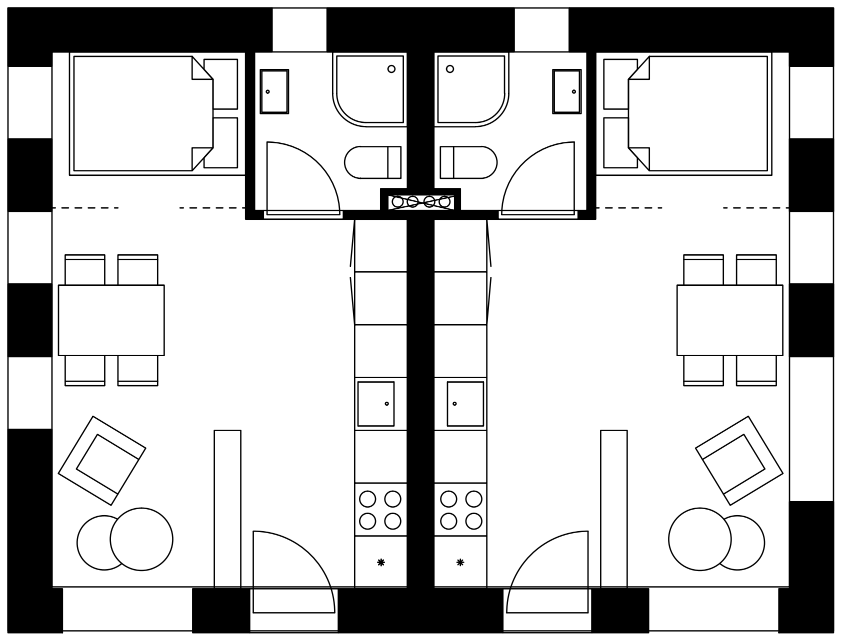
Studio with bed niche

In the modified solution, the bedroom is no longer a seperated room, but instead seperated by a curtain or similar, providing more space for the living room. Considering that the unit is deisgned for a single person, a need to seperate the bedroom from the living room does not quite exist. Instead, having a flexible solution in form of a curtain, the bedroom niche can act as flexible space when having guests, where the bed can be used for sitting, without being seperated from the rest of the unit. Furthermore, if desired, the user has more freedom to change this configuration, where as the two room solution seems more fixed in terms of funcitonality.

Two room solution



Studio with bedroom niche

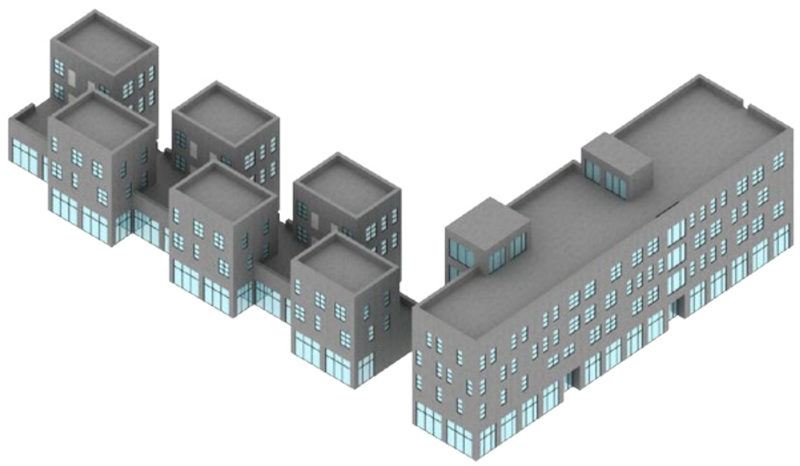


Expression

Detailing the overall expression of the project influences the identity of the building, as well as how its functionality is articulated. The goal is to make the project appear as a coherent building, even though it technically is two buildings, and has a lot of different functionality, and to somehow express this diversity in the functionality.

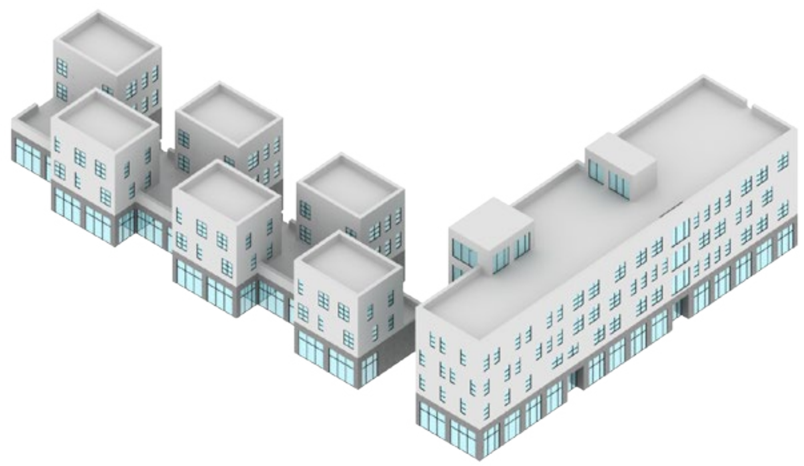
Expressing functionality

The overall shape of the building already expresses a difference in functions between the two wings, as they are both different in shape, as well as physically disconnected. However, in its current condition the building does not express a difference in top and bottom. There are many ways to achieve this, either in choice of materials, or further alterations in form, or a combination. The following is a discussion of these options.



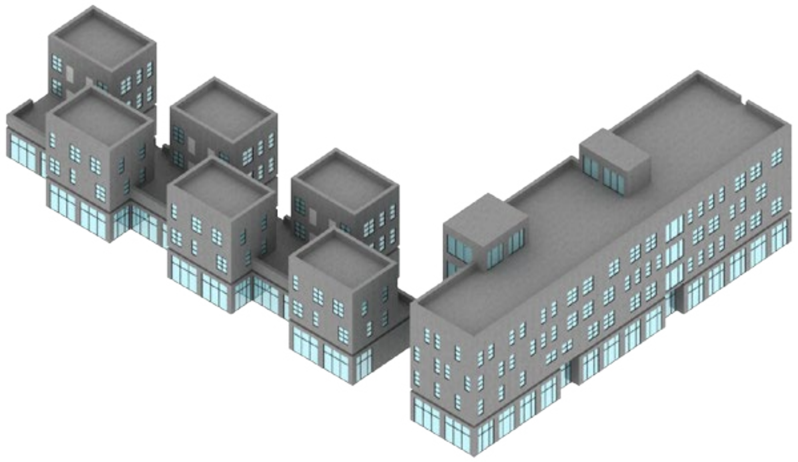
Monotone shape and material

Rendered in the same material/tone all over, does not quite articulate the difference between top and bottom. besides the difference in window types.



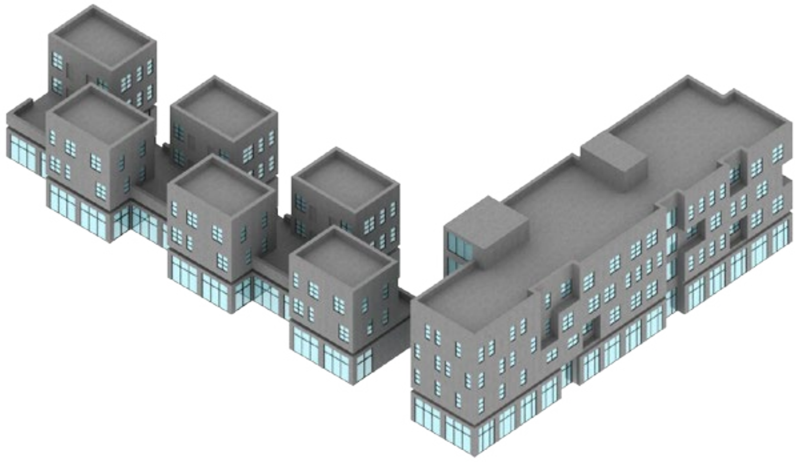
Two tones

One way to articulate the difference would be to simply differentiate the materials between the top and bottom. Depending on the actual material choice and tone, this solution achieves the desired effect, but on a very basic level. No added depth in the expression, or any connection to form.



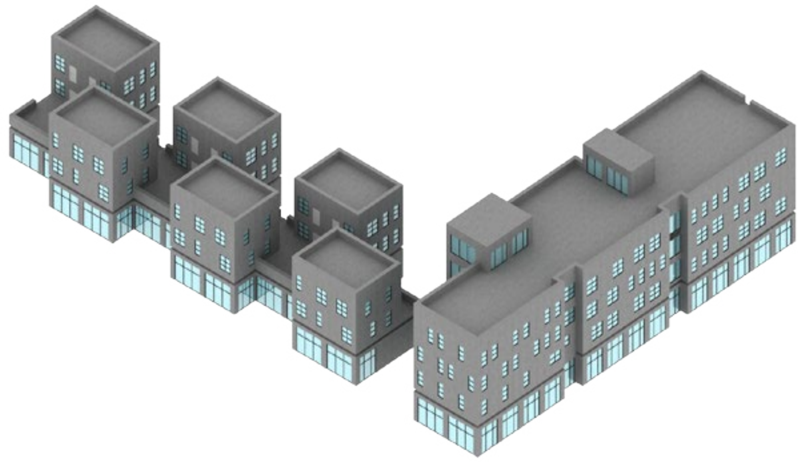
Detailing the seperation

Instead of differentiating the materials, an alteration in the form could be a solution. By adding a gutter along the 1st floor level, the top volumes appear to be floating, thus in a sense physically detached from the bottom. Compared to simply differentiating the materials, this solution seem more sophisticated, connecting form, detailing and expression.



Variety in the dorm facade

Due to its relatively long proportions, the facade of the dorm wing appear quite monotone. To add more variety, the facade is pushed in all places where the plan allows it. The result is a more broken volume, which no longer appears large and monotone, but instead more broken up and random in its' expression. It has qualities in terms of variety in the facade, but makes the dorm wing stand out compared to the youth apartments. Also, the overall compactness of the building is decreased, meaning a likely increase in energy consumption.



Alternative variation in the dorm facade

Another solution could be to break up the dorm volume in more even parts, alligned to the two entrances. It also achieves a sense variety in the facade, but in a more clear and subtle way. It also strengthens the coherence of the whole project, having a similar sense of rhytm compared to the youth apartment wing.

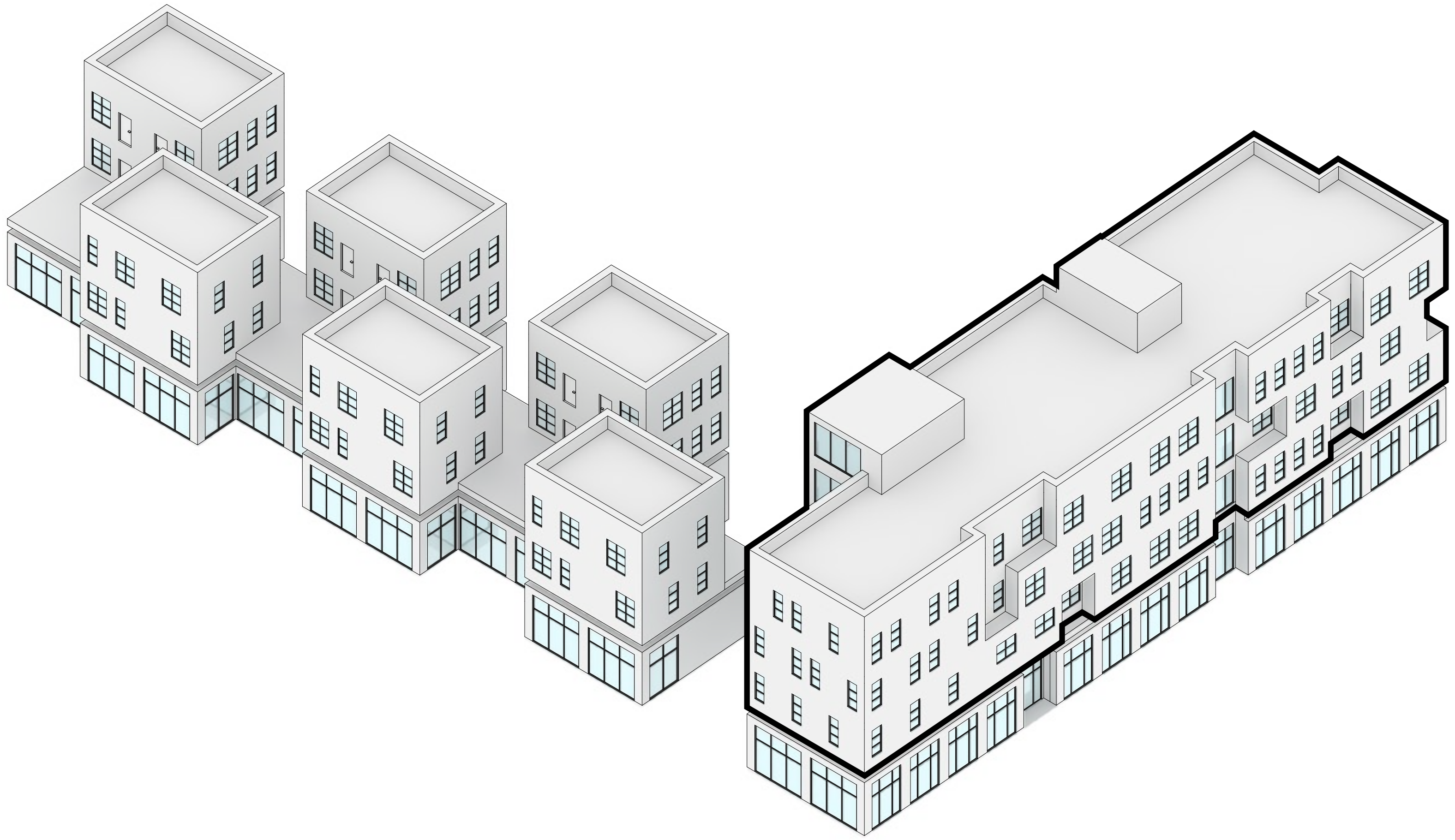
SYNTHESIS

The purpose of this chapter is to illustrate the synthesis phase the design has been through in order to live up to the 2020 Building Classification. Starting from the results and knowledge of the sketching phase, the design is improved step by step. Be10, BSim and Velux Visualizer has been utilised along the way, in order to compare and illustrate the different modifications where relevant.

Dorm Wing Performance

The dorm wing is chosen as the representation of the synthesis calculation, as it is more complex, and is estimated to have a bigger impact on the total performance compared to the youth apartment wing. Furthermore, the dorm wing is simplified to include only the residential functions, removing the commercial functions in the ground floor, as these have different requirements. The same reasoning and results are also applied to the youth apartment "wing", but only documented in terms of final results in the presentation phase.

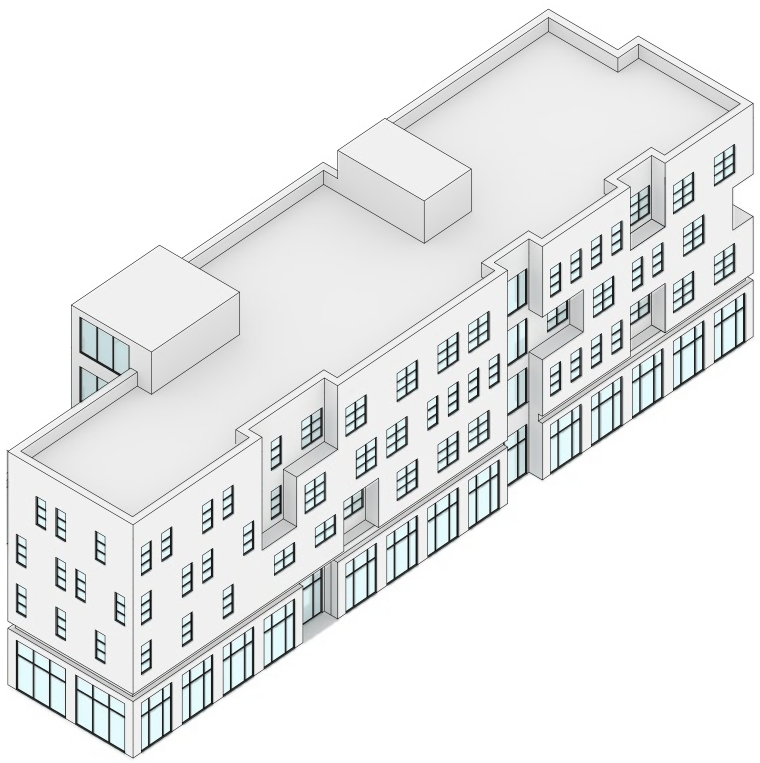
The chosen output relates to the energy performance of the whole building, relevant for the building regulation requirements, and the indoor climate of the living units, as this is where the users are expected to spend most of their time, and the use and internal loads being more consistent.



Ill. 92.1: Illustration highlighting the dorm wing

Step 1 - Random Form

The ‘random’ form of the previous phase is tested, with no modifications or installations applied. As expected, the energy frame is quite far from the 2020 requirements. Also, the overheating of the southeast facing living units is critical, much higher than the allowed values.



Ill. 93.1: Dorm wing ‘random’ form

Selected input and key values*:

Geometry	
Total floor area	1733,9 m^2
Total envelope area	2915,6 m^w
Floor/envelope ratio	0,59
North windows/north envelope ratio	0,30
South windows/south surface ratio	0,36
Window size SE unit	3,3 m^2
Window size NW unit	3,3 m^2
Ventilation	
Winter	Natural - 0,4 l/s
Summer	Natural - 2 l/s

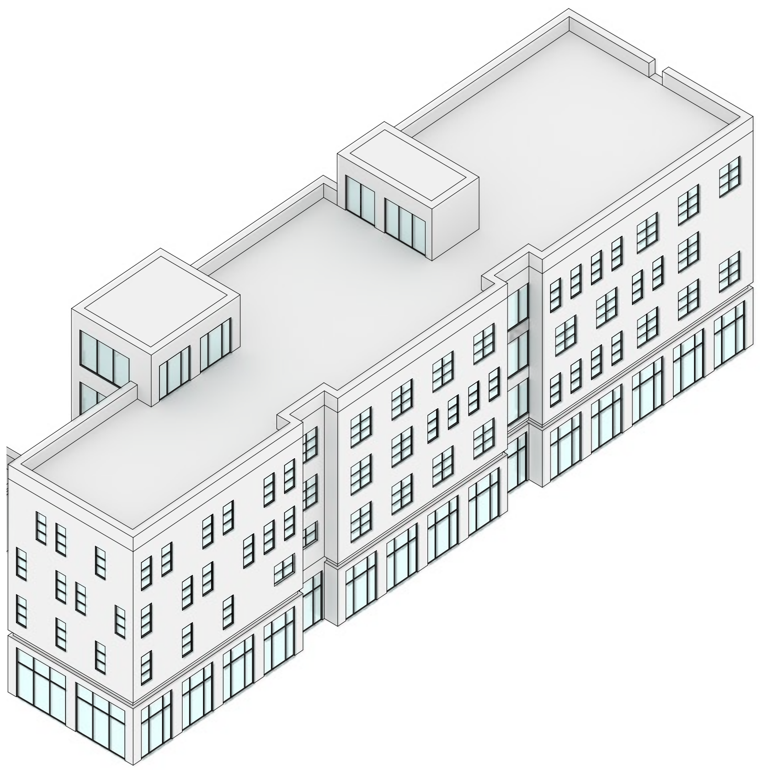
Selected results*:

Energy	
2020 requirements	20 kWh/m^2 year
Result	31 kWh/m^2 year
Indoor climate	
Hours above 26C in SE unit	1586 hours
Hours above 27C in SE unit	1221 hours
Average daylight factor SE unit	3,0
Average daylight factor NW unit	3,0

Step 2 - Compact Geometry

The more compact geometry is tested as well. As expected, it performs slightly better. The floor/envelope ratio is slightly higher, resulting in a small reduction in the energy requirement. There is no change in the indoor climate.

The geometry could be made even more compact, but considering the relatively small contribution to the overall energy requirements as seen in this step, as well as the relatively large impact it would have on the expression, no more efforts are made to improve the compactness.



Ill. 93.1: Dorm wing 'compact' form

Selected input and key values*:

Geometry	
Total floor area	1794,2 m^2
Total envelope area	2883,6 m^w
Floor/envelope ratio	0,62
North windows/north envelope ratio	0,30
South windows/south surface ratio	0,36
Window size SE unit	3,3 m^2
Window size NW unit	3,3 m^2
Ventilation	
Winter	Natural - 0,4 l/s
Summer	Natural - 2 l/s

Selected results*:

Energy	
2020 requirements	20 kWh/m^2 year
Result	30,6 kWh/m^2 year
Indoor climate	
Hours above 26C in SE unit	1586 hours
Hours above 27C in SE unit	1221 hours
Average daylight factor SE unit	3,0
Average daylight factor NW unit	3,0

Step 3 - Adding Mechanical Ventilation

To further improve the energy performance of the building, mechanical ventilation with heat recovery is added in the heating season, while natural ventilation is maintained in the rest of the year. Even though the ventilation aggregates require power to run, the energy gained from the heat recovery is much greater, resulting in a relatively large improvement in energy performance.

Selected input and key values*:

Ventilation	
Winter, q_m	0,4 l/s m²
Winter, q_n	0,13 l/s m²
Summer, q_n	2 l/s m²
Air change winter	0,5 n/h
Air change summer	2,5 n/h
SEL	1,4 kJ/m³

Selected results*:

Energy	
2020 requirements	20 kWh/m² year
Result	25,1 kWh/m² year
Indoor climate	
Hours above 26C in SE unit	1586 hours
Hours above 27C in SE unit	1221 hours

Step 4 - Adding Solar Shading

The last few steps have only improved the energy performance, but not the indoor climate, where overheating for the south east facing units remains a critical issue. To improve this issue, several different strategies can be used, such as decreasing the window size, changing window type to one with a smaller g-value, increasing the natural ventilation rate, adding mechanical cooling or adding solar shading. Changing the windows either way affects the energy performance negatively (for south facing windows), because the solar gain is reduced. Increasing the natural ventilation in the summer has no immediate negative side effects in terms of energy performance, but the maximum achievable rate has a certain limit. Mechanical cooling should be the very last resort, since it requires a lot of energy. Solar shading seems more relevant, with little to no sideeffects on the energy performance depending on the specific solution (permanent/fixed or dynamic). It does however have a great impact on the expression of the building (see examples on the opposite side)

Looking at the different examples of solar shading, each have both advantages and disadvantages. Similar to all solutions is the added feeling of depth in the facade, as well as an added sense of diversity, although strongest in the dynamic solutions. Also similar to all is the possibility to create some level of contrast or coherence in the facade, choosing materials that either pops out from the facade material, or blend in.

Combining efficiency and aesthetic potential, the folding screens are selected, and used in the the calculation. A panel shading 80% of the sun is used, and it is defined as being in use when the temperature goes above 24 C.

The solar shading has a huge impact on the indoor climate, solving the overheating issue, bringing down the number over hours above 26 C and 27 C to a level below the requirements for the 2020 Building Class. In terms of energy, the addition of solar shading has only slightly increased the total energy frame.

Solar shading also affects the amount of daylight, which is hard to avoid. Even though the calculated average for the SE unit is very low, it should be be noted that it is an average value, meaning that the value closer to the window, where the user is expected to stay for working or reading, is higher. Furthermore, the value is calculated in overcast conditions, which does not correspond to conditions where the solar shade is in use (more clear skies), making it potentially lower than experienced.

Selected input and key values*:

Geometry	
Shading type	Dymamic
Shading coefficient	0,2
In use	>24C
Shading factor	-0,6

Selected results*:

Energy	
2020 requirements	20 kWh/m^2 year
Result	25,6 kWh/m^2 year
Indoor climate	
Hours above 26C in SE unit	90 hours
Hours above 27C in SE unit	8 hours
Average daylight factor SE unit with closed solar shade	0,8
Average daylight factor NW unit	3,0

Fixed frame

Adding a frame to the windows in a certain depth creates a permanent shade, as well as a permanent expression to the facade, which is now perceived with more depth and variation.

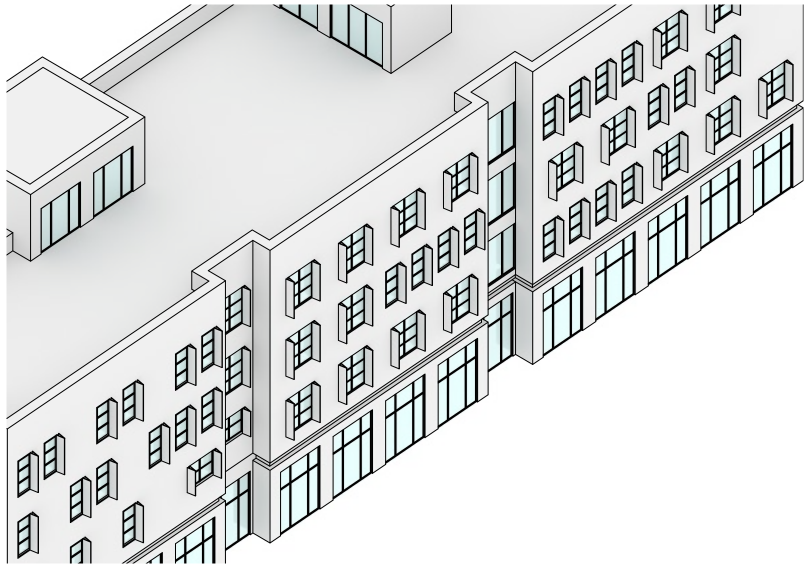
A fixed type of shading has the advantage that there is no margin of error due to user behavior. Other advantages are low maintenance and a relatively low price compared to other solutions.

The disadvantage of a fixed frame is the low level of efficiency. With relativly high windows, the depth of the frame would have to be quite extreme, which would impact viewing angles from the inside as well as decrease the amount of daylight permanently. Furthermore, a fixed frame would most likely decrease the amount of solar gain in the winter.

Sliding screens

As an example of a dynamic type of solar shading, sliding screens come to mind. In the example shown, the material is similar to that of the facade, which creates a perception of the top part being more solid, like a massive block carried by the more slender columns of the ground floor. The aesthetic qualities strengthen the contrast between top and bottom, as well a dynamic and varied expression which follows the behavior of the residents.

The dynamic sliding screens have a better efficiency, and have the advantage of being able to adapt to the seasonal conditions. However, the efficiency is based on the knowledge and behaviour of the user, which could be a margin of error. The disadvantages of a dynamic system is the relatively higher level of maintenance required, as well a higher price compared to simpler solutions such as the fixed frame.



Folding screens

Another example of a dynamic type of shading is the folding plates. Compared to the sliding plates, the folding plates are more visible when not in use, sticking out from the facade, creating a similar expression to the one seen with the fixed frame. When in use, it would be expected that the plates would be drawn in various extents, providing a dynamic sense of depth in the facade.

The folding plates have a high efficiency when in use, similar to the sliding plates, but have the disadvantage of creating shade from the sides when not in use.

Step 5 - Adjusting Window Sizes

Until now, the windows have been the same sizes regardless of orientation. Considering the fact that windows have a much higher U-value than the remaining facade wall, it should be possible to improve the overall energy frame by making the northwest facing windows smaller. This has an effect on daylight, but existing conditions are well over the minimum, so it should be possible to remove enough window area to observe a noticeable change.

The northwest facing windows are changed from 1,65m x 2m to 1,4m x 1,6m, leaving enough space to still use the window as a chair/sofa.

The change in window/envelope ratio for the north facing windows is almost reduced by 50%, indicating quite a change in the window area. However, the energy requirement is only reduced by 0,2 kWh/m^2 year. The explanation for this is that most of the energy required at this point it related to the domestic hot water use and electricity to power the ventilation fans, meaning any change regarding geometry (form, windows) will only have a relatively small impact.

However, considering that windows are expected to be more expensive in materials than the wall pr. m2, and that the daylight and interior conditions remains satysfying, combined with the improvement in energy performance, the change is arguably valid.

Selected input and key values*:

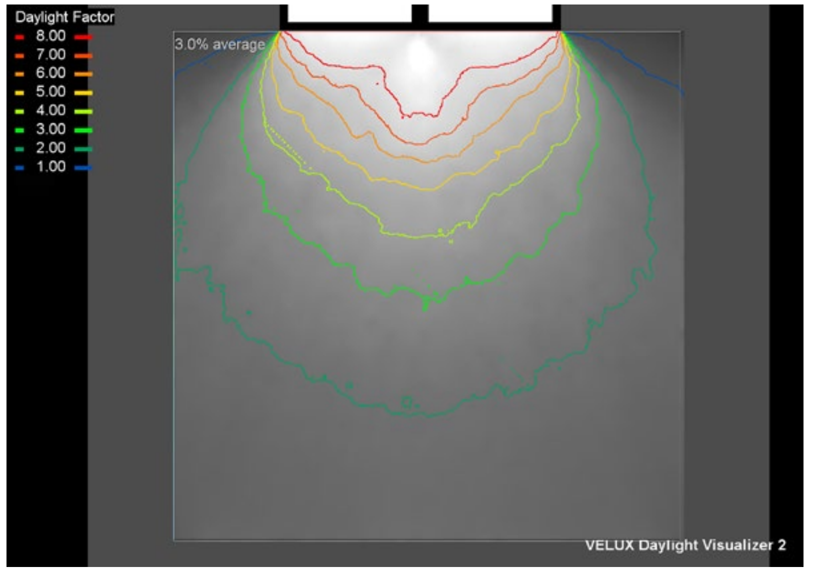
Geometry	
Total floor area	1794,2 m^2
Total envelope area	2883,6 m^w
Floor/envelope ratio	0,62
North windows/envelope ratio	0,18
South windows/surface ratio	0,36
Window size SE unit	3,3 m^2
Window size NW unit	3,3 m^2
Ventilation	
Winter	Mechanical - 0,4 l/s
Summer	Natural - 2 l/s

Selected results*:

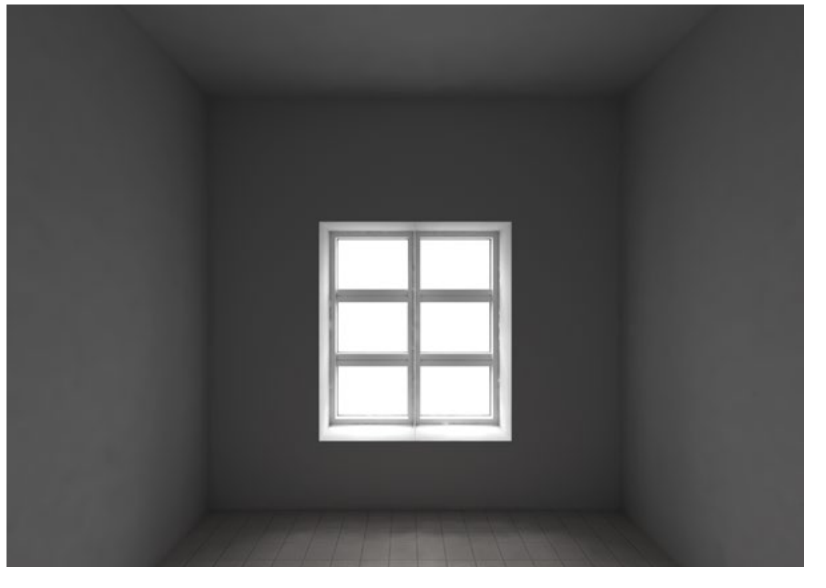
Energy	
2020 requirements	20 kWh/m^2 year
Result	24,9 kWh/m^2 year
Heat requirement**	33,1 kWh/m^2 year
Electricity requirement**	2,8 kWh/m^2 year
Indoor climate	
Hours above 26C in SE unit	90 hours
Hours above 27C in SE unit	8 hours
Average daylight factor SE unit	3,0
Average daylight factor NW unit	1,5

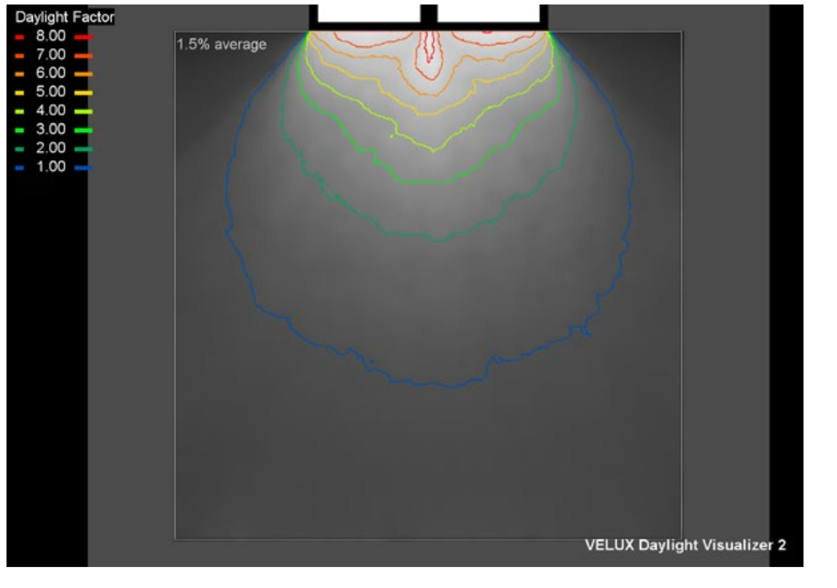
** not adjusted according to primary energy factors

Existing window:
width: 1650 mm
height: 2000 mm
window sill: 500 mm
total height: 2500 mm
total area: 3,3 m²



Modified windows:
width: 1400 mm
height: 1600 mm
window sill: 500 mm
total height: 2100 mm
total area: 2,24 m²





Ill. 99.1: Testing the daylight for different windows in the dorm unit.

Step 6 - Ddding Energy Production

As the last step towards fulfilling the 2020 Building Class requirements, renewable energy production is added. There exists many options for renewable energy production, such as wind mills, geothermal energy, solar heat, or solar electricity. Choosing the right one(s) should be based on the context and conditions for the specific project as well as efficiency of the energy source.

For this project, the urban context combined with disadvantages (noise, low efficiency, only producing electricity) rules out wind mills. As stated in the previous step, most of the remaining energy relates to domestic hot water use and electricity to power ventilation fans. Looking at the numbers (see previous step), the largest part relates to heat. Considering this, the most relevant energy production would be a combination of heat and electricity. Solar energy can provide both, and the existing design have space for solar panels on the roof. PV cells (producing electricity) are the most efficient considering the primary energy factors for BC2020, but only have potential to reduce the total requirements by 2,8 kWh/m^2 year (5 kWh/m^2 after primary energy adjustment). This does not take up much space, and actually puts the total to be exactly as the 2020 frame requirements (20 kWh/m2 year to be exact). The next seemingly logical step would be to to add solar heat collectors as well, reducing the energy requirements even more, although for classification purposes it is not needed. Any further addition to the energy frame should arguably be based on more hollistic considerations to sutainability, and it could be argued that adding more PV cells would be the better choice.

There are several reasons for this, with one being the primary energy factors. They favor electricity production 3 times more than heating (if heat comes from district heating), because current electricity production have a higher environmental burden and total energy use per delivered unit than district heating, which often is produced by excess heat from eg. waste management. Another reason to choose PV cells over solar heat collectors is that in peak times, excess electricity can be distributed to the remaining network, which is not the case for excess heat, which baiscally just go to waste. Furthermore, the actual electricity production of the building is far higher than the 2,8 kWh/m^2 year, since use for lighting and appliances is not included in the energy frame.

By applying the same strategy for the youth wing, but with an orientation towards SW, the shading conditions are considered, and a more even production throughout the day is ensured.

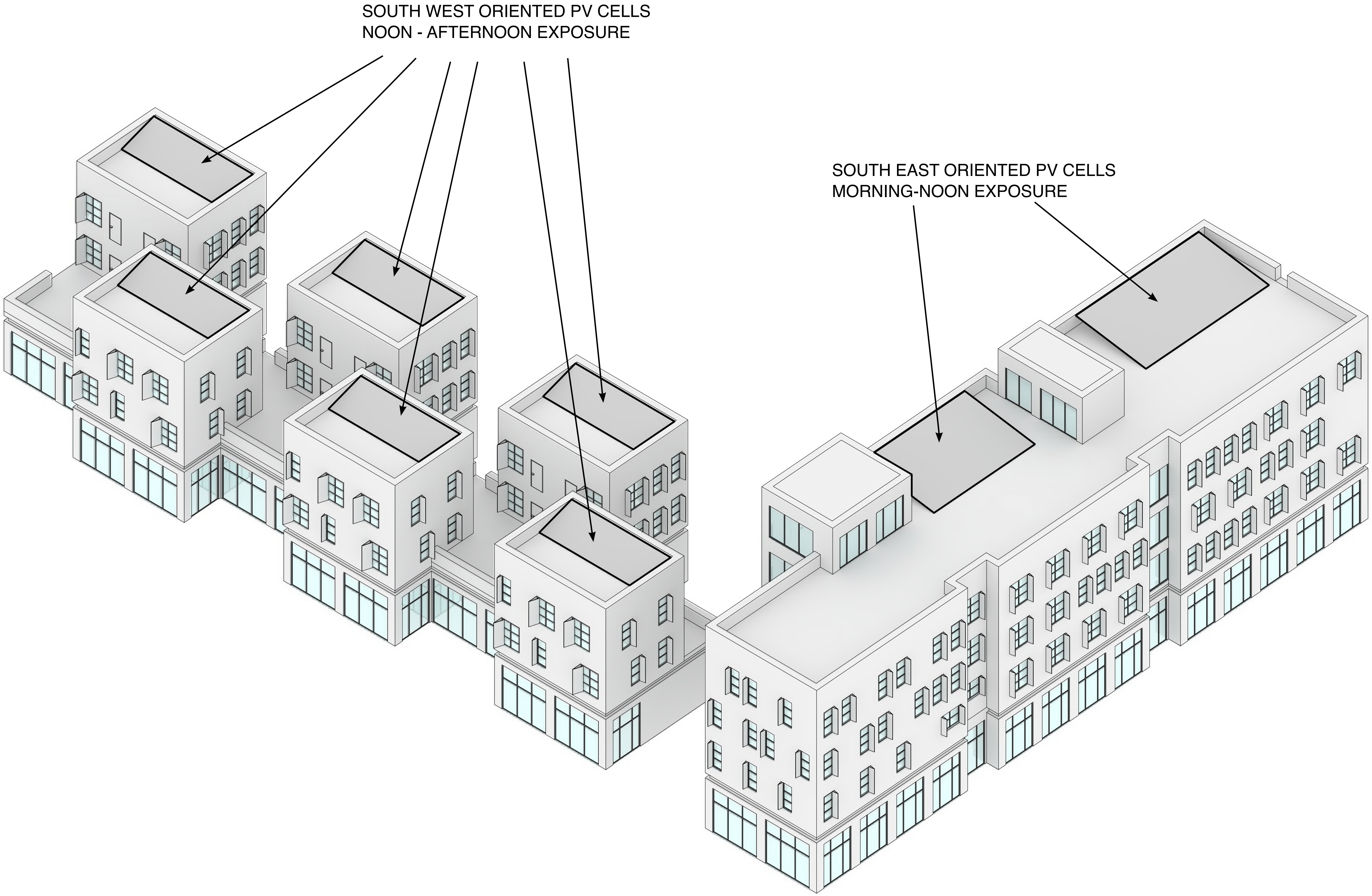
By installing the panels on the roof, hidden by the extended facade that also works as railing, the aesthetic impact is non-existing from the street. It is however very present on the roof terraces, but this could work as a great symbol, reminding the users of the sustainable approach, likely impacting their behaviour.

Selected input and key values*:

Geometry	
Total roof area	1794,2 m^2
Angle of PV cells	10 degrees
Peak power	0,3 kW/m^2
System efficiency	0,75
Orientation	SE
Area needed for max. potential	22 m^2

Selected results*:

Energy	
2020 requirements	20 kWh/m^2 year
Result	20 kWh/m^2 year
Energy from PV cells	5 kWh/m2 year



Ill. 99.1: Testing the daylight for different windows in the dorm unit.

OUTRO

The final chapter concludes the project in a conclusion comparing the final design with the initial aim and final design parameters and vision, as well as an overall reflection of the process and results. Furthermore, the chapter includes reference lists and appendix.

Conclusion

The result of this thesis, in the form of a proposed design for new student housing in the area of Nordvest in Copenhagen, is the product of a vision about sustainable architecture and identity.

Sustainable Architecture

The approach to sustainable architecture, determined in the beginning of the report, focuses on social and environmental architecture.

The proposed program and organisation of the functions encourages social diversity and different levels of social interaction, both within and across different functions. Commercial functions provide activity and invites locals and bypassers to the site, for short and long stays. All floors in the building are accessible with elevator, providing level free access to all units and functions, including the roof terrace. All units are documented in terms of daylight and overheating, with the same concepts and strategies applicable for the rest of the building.

Through an integrated design process, the goal of reaching building class 2020 is achieved, meaning the energy requirement of the building is kept at a minimum, without comprimising the architectural quality. Different strategies are applied, both in the sketching and synthesis phase. Renewable energy production in the form of PV cells has been added to reach the 2020 goal. Placed on the roof, visible and approachable from the roof terrace and garden, they stand as a symbol of environmental sustainability, reminding the residents of being conscious about their behaviour as consumers.

Identity

The site is located in a socially challenged area, with a lot of vandalism and worn down houses. However, there seem to be a certain industrial character of the place, which might get lost in new development. The proposed design finds inspiration in this character, and aims to provide a strengthened identity to the area. The materials used in the project includes typical industrial favorites such as concrete, steel and bricks, combined in a way to articulate the functionality of the building, as well as coherence. The expression is raw yet sophisticated, and combined with the relatively conservative form and adaptive scale, an overall humbleness is achieved. The final building stands as a great example of what is achievable with simple, cheap materials and detailing, and could hopefully help shape future development, which unevitably is on its way through gentrification, as housing prices keep soaring in the city.

Reflection

A design process often leaves many questions unanswered, and many paths unexplored, and this project is no exception. Some results and approaches can be discussed, and reflected upon.

First the topic of performance versus functionality and aesthetic quality. Where is the limit to performance optimization? The proposed design has been through several steps where this was the main discussion. At times, the performance was the main priority, and many proposals were quickly discarded due to a high surface/area ratio (low compactness), and at other times, performance was put on hold while functionality and aesthetic qualities were in focus. The right balance is probably impossible to determine, and very untangible if tried. The important thing is to compare results. If performance is compromised, what in turn is gained in functionality or aesthetic value? And vice versa. And how do these results compare to the vision of the project? The proposed design sits somewhere in the middle, with a relatively moderate expression, but with variety in the form creating a unique urban typology with public and outdoor spaces with great qualities.

In terms of energy performance and sustainability, further initiatives could be discussed. The proposed design achieves the 2020 goals, but have the potential to reach a zero-energy balance with added energy production. The project discusses this a bit, proposing more PV cells than needed in terms of maximising the 2020 frame. Instead, solar thermal collectors could be added, reducing the energy frame even more, as hot water consumption is one of the largest contributors to the final energy frame.

The project includes commercial functions in the user profile, creating space for several small shops, cafés ect on the ground floor of the building. In a relatively quiet area, it could be argued that such commercial functions would have a hard time surviving, and few people with pass by. This observation might be relevant, and it might not. Maybe the surrounding streets are quiet as a consequence of lacking these kinds of functions, or maybe these functions are lacking bevause the streets are quiet. Whatever the case, the future of the area should also be a consideration. With more and more small houses and industry being demolished, and larger housing buildings being built in their place, the overall density of the area will rise, with following higher needs for local commercial functions.

The choice of materials for the proposed design might not appear as the most environmentally friendly materials. Steel, bricks and concrete have large carbon footprints when looking at manufacturing and transportation. However, new technology in prefabricated elements have reduced the amount of concrete significantly, and combined with the low level of maintenance as well as the thermal properties of the materials, and not to forget aesthetic qualities, the choice of materials represent a balanced approach.

Untraditionally, the site for the project was not given to begin with. The first step of this thesis was to find a relevant site for the project, through analysis of the city. Based on price and location, Nordvest was selected as the best candidate. Could it have been somewhere else? Most likely yes. But having studied Nordvest, and experienced its qualities, both good and bad, it seems very unique, and perfect for new student housing. It could be the next popular area for young people, when Nørrebro and Vesterbro (soon) become to expensive to live in, and/or there are no more available housing. The future of Nordvest, and especially in the surrounding area of the chosen site, greatly depends on how new development is designed, and who it designed for.

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Illustrations

Ill. 9.1: Photo by Jens Dresling, for Politiken.dk, 2014
Ill. 18.3: Tietgen unit plans, Lundgaard & Tranberg Architects
Ill. 18.4: Photo by Lundgaard & Tranberg Arhitectes
Ill. 19.3: Godsbanen unit plans, AKU Aalborg
Ill. 19.4: Photo by KPF architects
Ill. 52.1: Photo by www.lemetropolitanblog.com
Ill. 52.2: Photo by Henrik Lindén
Ill. 62.1: Photo by SHL Architects
Ill. 66.1: Photo by www.grotrends.com
Ill. 66.2: Photo by www.edelight.de
Ill. 72.1: Photo by Shu He

Appendix A
BSim

To study and document indoor climate in terms of overheating and air quaility, BSim is utilised. The purpose of this appendix is to explain how it has been used, using the dorm unit study as an example. For a more detailed elaboration of the values used in the model, as well as results from the various steps of the synthesis phase, see the spreadsheet “BSim” on the attached CD.

Geometry

The first step of modelling the unit is to define the geometry. First, the geometry of the dorm unit is simplified to be a single rectangle, and a window is added. For each element, further specification is added. For surfaces, that includes thickness, materials and material properties. For the window, it includes several performance values, such as solar transmission (solar value) and light transmission (only relevant if used for daylight studies).

Defining zones

The next step is to add the zones of the project. For this study, only one interior zone is relevant.

Adding systems

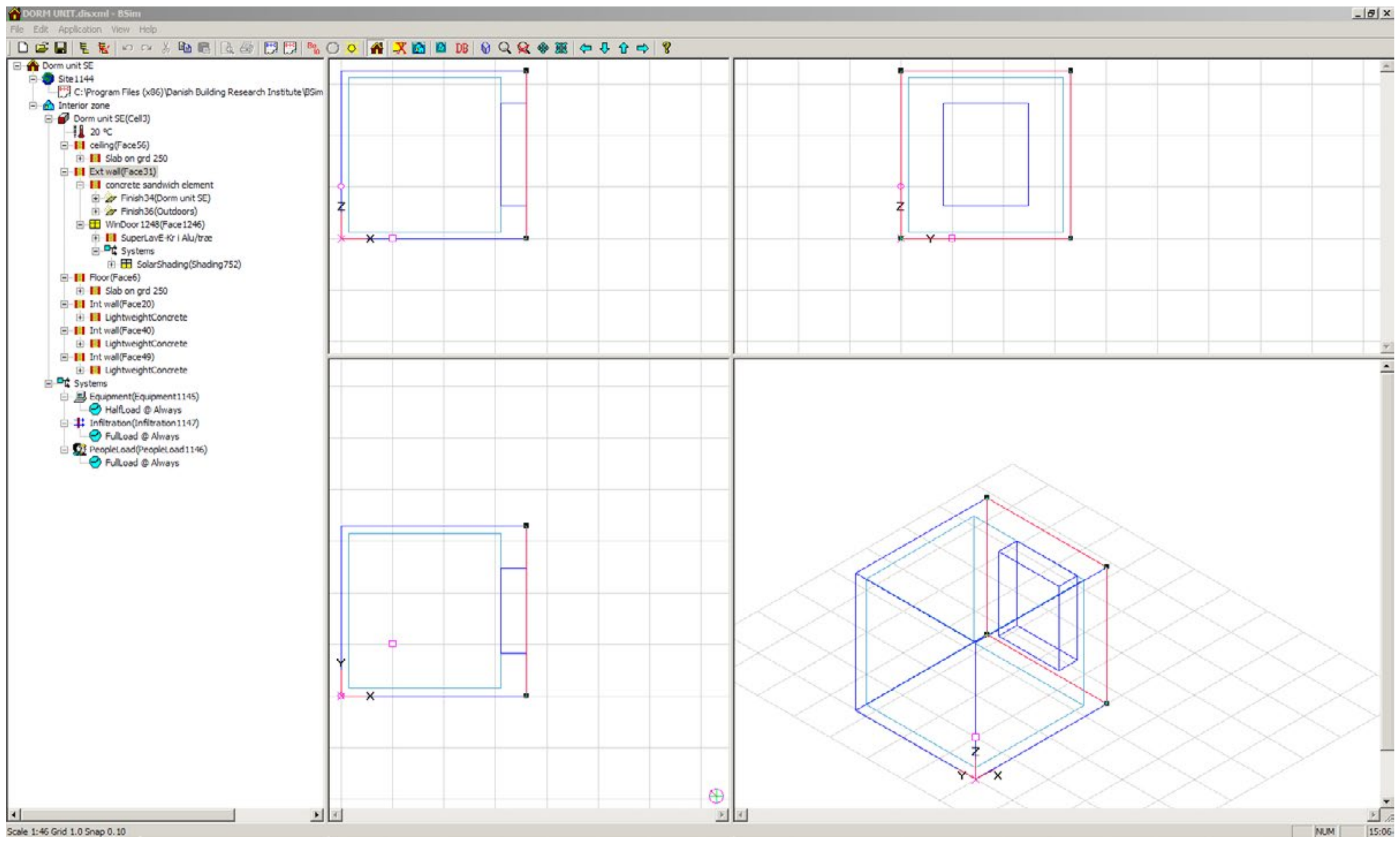
The next step is to define the systems that affect the given interior zone(s), which could include cooling, equipment, heating, infiltration, people loads, ventilation, etc., basically all systems that could somehow have an impact on the indoor climate in the zone. For this study, only equipment (such as computer, tv, etc.), people load and infiltration (used as natural ventilation) are relevant.

Defining site properties

The final step is to define the location and climate data of the project.

Simulation

When the model is complete, the indoor conditions can then be simulated. For this study, the purpose is to document the temperature levels in the unit. For overheating the goal is to be below the requirements in the building regulations regarding building class 2020, which is measured in hours per year above 26 and 27 degrees respectively.



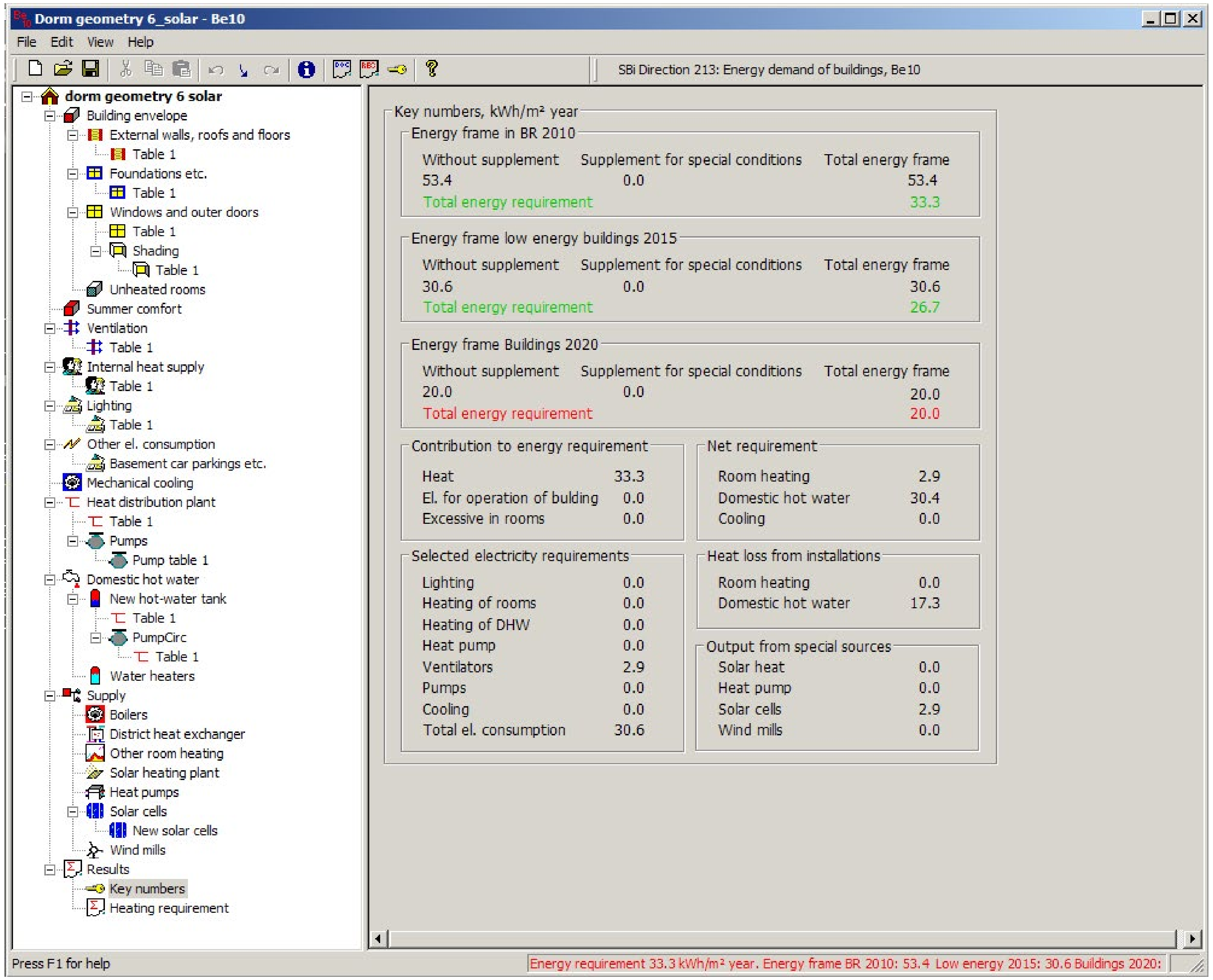
Ill. 107.1: Screenshot from BSim sotfware.

Appendix B
Be10

To study and document energy consumption, the validation software Be10 has been utilised. The purpose of this appendix is explain how it is used, and to show the results of the final dorm wing. For a detailed eleboration of how the values are calculated or defined, as well as results for both the dorm and youth apartment, see the spreadsheet "Be10" as well as the actual be10 files on the attached CD.

The principle of Be10 is somewhat similar to BSim, but has no 3D interface, and as used, only concerns energy consumption. Basically, all elements expected to use or lose energy is included, such as the envelope of the building, ventilation, hot water use, as well as elements that add energy, such as windows (southfacing), mechanical ventilation with heat recovery and internal heat supply

The screen shot to the right shows the elements considered in the simulation, as well as the final results of the dorm wing with solar cells.



Ill. 108.1: Screenshot from Be10 software.

Appendix C
Velux Visualizer

To study and document daylight conditions in the living units, Velux Visualizer has been utilised. The purpose of this appendix is to explain the use of the program. The software uses a step by step structure to modelling, starting from the outer geometry of the space, moving on to more detailed elements. Files with models of the different units can be found on the attached CD.

Floor/walls

The first step is to define the geometry of the walls. The options are either exterior or interior walls. Thickness and height is defined by value, and length is then drawn with the mouse.

Roof/ceiling

The roof is defined as either flat, slope or pitched, and it's properties are defined (such as height of the pitch).

Location

Location and orientation relative to north are then defined.

Window/doors

Windows and doors are then added. The dimensions of the elements, as well as design (such as mullions) and depth of installation are required.

Surfaces

Surfaces on all previous elements can now be determined, both in terms of texture (for rendering visualisations) and reflective and light transmitting properties (for daylight calculation purposes).

Furniture

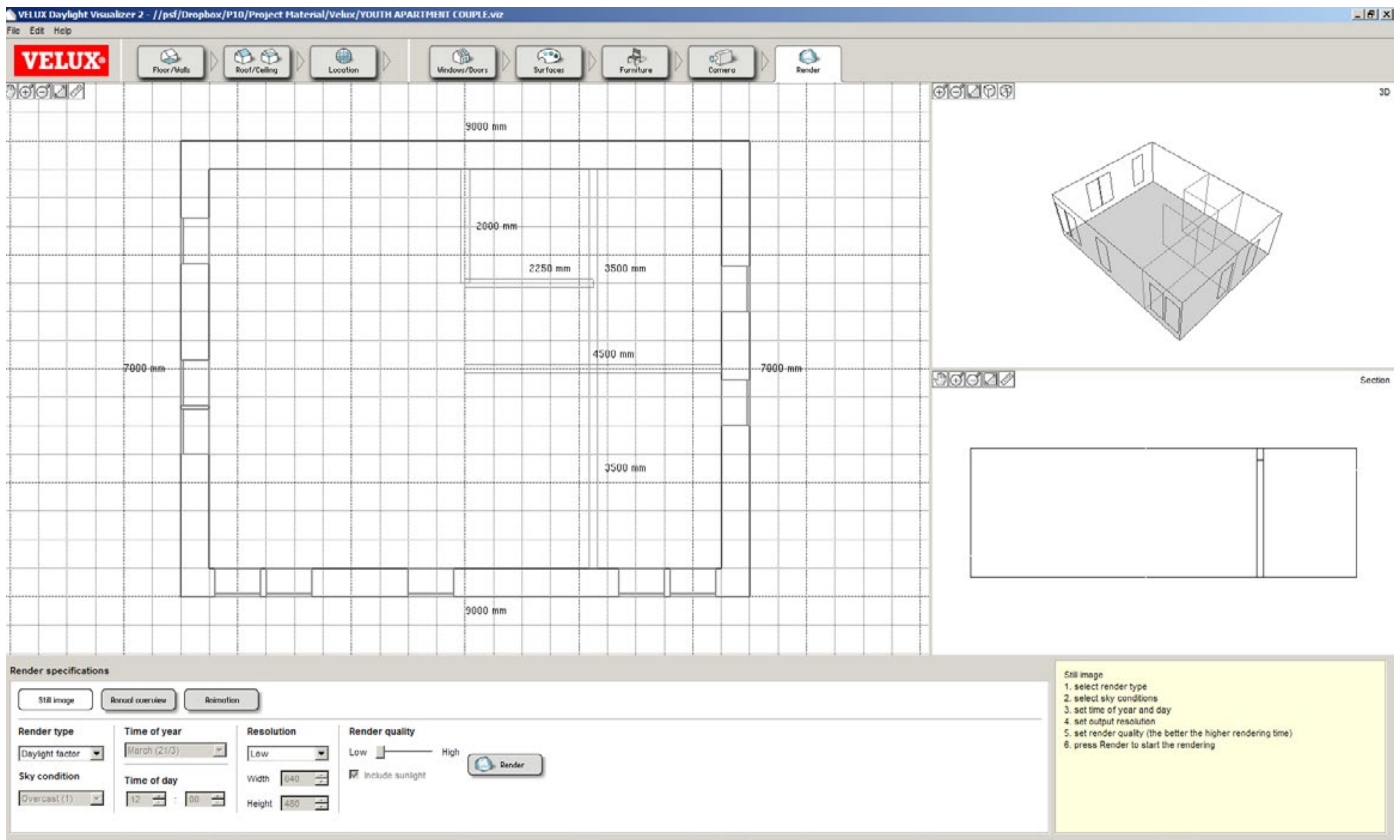
A selection of furniture can then be added for a more detailed visualisation if desired.

Camera

The camera is then set defined in terms of angle, location, height etc.

Render

Finally the desired output is selected. For this project, daylight factor is used, rendering a plan view with colored curves along the floor, representing increments in the daylight factor of 1%.



Ill. 109.1: Screenshot from Velux Visualizer sotfware.