Refurbishment and extension of SIT student housing in Klostergate 56, Øya

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ABSTRACT

The main goal for this proposal is to design a ZERO-emission student housing in Klostergate 56 that will accomodate 106students. Refurbishing the existing concrete building and designing for the expansion will save a large amount of material which is fundamental in sustainable approach. The three pillars of sustainability will be achieved in this proposal, the environmental protection, economic viability, and social equality.

Implementing passive house standard to a more energy efficient building is the solution that will be adopted for both refurbishment and extension of the existing student housing in Øya. Integrating renewable energy into the design will help balance the material and operational carbon emission.

Multiple simulations and analysis were conducted to evaluate the right materials and strategies to be used to design this energy efficient building towards ZERO emission. Autodesk Revit, SIMIEN, Rhino with grasshopper and climate studio were used for the analysis of this proposal. The Life Cycle Assessment (LCA) was done with the collaboration with my partner Fiona Marie Dy to investigate which materials and system is more sustainable. The use of ZEB tool and Once click LCA is used.

The refurbished and extended designed structure showed that it has a less carbon emission compared to the new constructed building. Enhancing the ventilation and heating system including the huge amount of material saved from the existing building, resulted to a lower environmental impact.

ACKNOWLEDGEMENT

I would like to thank my supervisor, Tommy Kleiven, for the guidance through out the whole process of my thesis project. His tips and suggestions contributed a lot for the developement of the proposal. You thought me how to listen carefully of your design inputs and made me think on how to interpret your ideas. This resulted to etter way of solving the challenge for designing a sustainable student housing.

I would like to thank Håvard Prytz from SIT who presented the new student housing proposal in Klostergate 56 and guided us in the site visit. He gave information regarding the current situation of the building.

I would also like to thank Bunji Izumi for structural part of the project. He contributed ideas on what will happen when adding new structure on top of the existing building. This made me decided to add just one floor on top and with lighter contruction material.

Thank you Fiona Dy, my classmate and friend who I worked with everyday from the start of the project until the final submission. She is working on her Master thesis about LCA, carbon emission in early stage of a project. She used my proposal as her case study.

Thanks for all our professors who made the two years study program possible. For all the knowledge that we are going to bring with us and share what we have learned about sustainability in the construction industry.

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I. INTRODUCTION

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Background

Trondheim is known as the best student city in Norway having 36 948 students in 2019. According to Norwegian student organization, the number of students continuously increasing as well as the number of housing units compared to their previous national goal of covering at least 20% of the housing demand. In 2019, 21.4% of the student has availed the student housing but this is not local based goal. In the city of Trondheim, only 15.32% of the housing demand was covered by the Student Welfare Organization.

The student welfare organization aims to continuously provides new housing units for the students while implementing number of measures to reduce the negative environmental impact of their construction projects. One their projects is the student housing in Klostergate 56, Øya aiming to increase the number of students to be accommodated considering that the site has a very huge potential for expansion.

The proposed project is an existing student housing that was built in 1991 located in Øya, Trondheim. It is strategically situated at the intersection of Klostergate, Raghildsgate and Mauritz Hansens gate. The existing building has 63units with three floors and a basement which is used as car parking for the students. The building footprint is 673sq. meters and has a total floor area of 1618sq. meter. Each floor level is divided into three sections. Each section has a common kitchen and toilet shared by the seven occupants with 12 sq. meter bedroom unit each.

Existing buildings already embody significant carbon emissions, therefore opting for refurbishment over demolition to build a new building, will help reduce the negative environmental impact of the new project. The proposed project will retain all the prefabricated sandwich external walls and concrete hallow core flooring. This strategy clearly yields the amount of material and energy saved. Another advantage of refurbishment project is the architectural and aesthetic qualities of the existing building. The adjacent buildings are also concrete except for the wooden houses across the road. The design of the 31-year-old structure fits very well with the context.

The refurbishment and extension of the SIT student housing will accommodate maximum 110 student with 95units. This proposal is the best solution for achieving the sustainability goal of the Student Welfare Organization (SIT).

View from Klostergate

GOALS

1. The main goal of this proposal is to design a ZERO-emission housing in Klostergate 56.

2. Prolong the lifespan of the existing building by improving the building elements.

3. To reduce the carbon emission by saving as much as 50% of the materials to be used for adding more units to accommodate more student.

To achieve the target goals, I used the following strategies and guidelines

REDUCE

- The environmental impact by refurbishing the existing building, choosing the right material, adopting suitable methods and techniques in building construction.
- The materials to be used by optimizing the function of each space and circulation.

The main goal is to design a ZERO-emission building, I opted to refurbishing the existing building to save the amount of material to be used for accommodating additional 47 students. Traditional timber framed construction building elements will be used for the proposed project. One floor will be added to the existing building, and seven floor will be constructed on the northern part of the site. 30% of the existing interior timber framed walls will be refurbished while 70% will be sent to the recycling site due to proper circulation purposes. The circulation and quality of living will be prioritized over the amount of material that can be saved. 90% existing exterior walls will be retained and 95% of the existing haloow core floor slab will be refurbished to reduce the amount of carbon emission by saving as much material as possible.

OPTIMIZE

- The existing building spaces. Future plan of the municipality for densification will lead to optimizing the availability of the empty spaces for future expansion of the existing structure.
- The site has a huge potential, accessibility to campuses, recreation, parks, hospital, shops, and public transport.
- Enhance ventilation and heating system to ensure good air quality.
- Adopt passive house standards to optimize the energy demand of the building.

The available space located at the northern side which is used as parking space has 493sq. meters and 243sq.meters is huge enough to fill up the block and accommodate more students instead of cars that is not included in the future densification plan of the municipality. The structure is centrally located where accessibility to everything is the most important aspect that everyone is looking for.
Designing an energy efficient building will ensure good air quality and prioritizing the health of the users. Adopting the passive house standard will optimize the energy demand of the building.

PRODUCE

- Energy using geothermal heat pump and Photovoltaic panels to compensate for the carbon emission from materials and operational stage of the building.

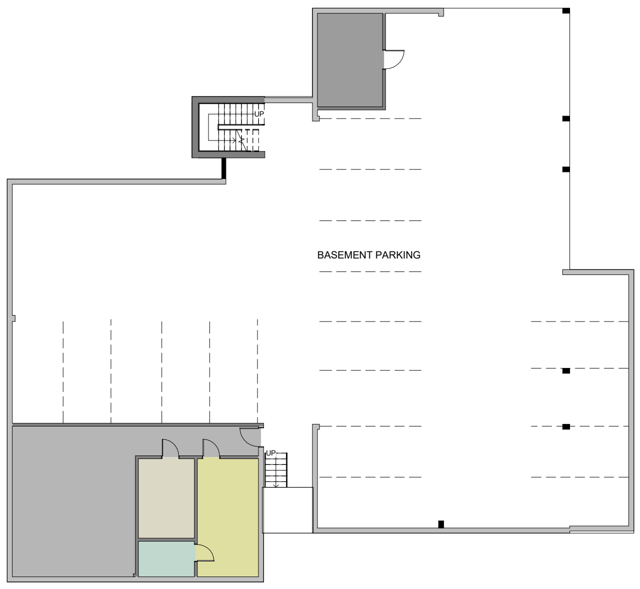
The greenhouse gas emission from materials and operational stage of the building will compensated using renewable energy sources. It is undeniable that there will be huge environmental impacts from the PV panels but the trade off will be beneficial in the long run. Passive strategies will be adopted to minimize the energy demand.

EXISTING BUILDING

Total floor area 1618sq.m
Bldg. footprint 673sq.m
63 units with 12m2 per unit.

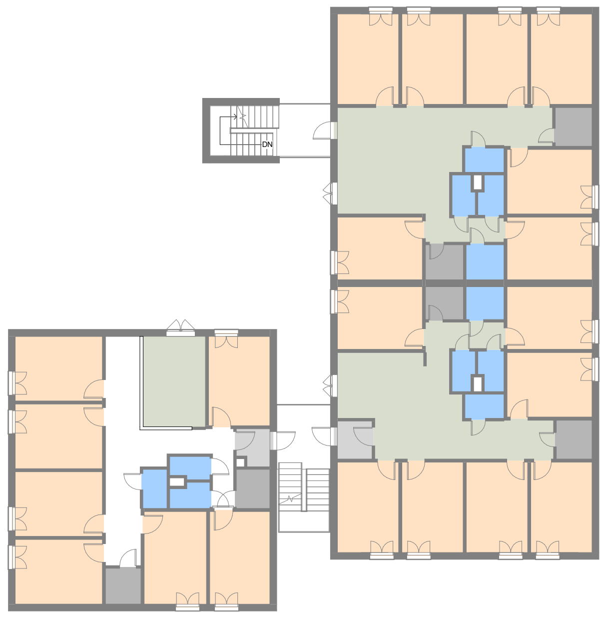
Room Legend

- Bed
- Entry
- Kitchen
- Storage
- T&B
- Electric Room
- Garbage Room
- Parking
- Storage
- Technical Room
- Washing Room



Basement Plan

Plan 1



Plan 2-3

South Facade along Klastergate

West Facade along Schwachs gate

North Facade facing Nidelva

METHODOLOGY

Understanding the initial project proposal was the first step that was done. Meeting with a representative from Student welfare organization (SIT) together with my supervisor was conducted for further understanding what the goals of the owner are. The provided condition analysis performed by Multiconsult, made a huge impact on the decision to refurbish the existing building. Personal site investigation was the next step. Gathering more information from the supervisor and the Trondheim municipality website is of great importance throughout the process. The following methods was conducted towards zero emission building.

1. The copy of the existing drawings was handed and laid out using AutoCAD Revit since the proposal is refurbishment. The original layout of the interior of the building was redesigned to create good circulation and better quality of living for the users. 30% of the interior walls were kept and improved the insulation and sound proofing.

2. Initial analysis of the building was conducted using Rhino and grasshopper to simulate the how much solar radiation and sunlight duration that the building is receiving. The adjacent buildings are very close, and the heights affects the design. The physical model was made to investigate closely the different heights of the surrounding buildings. This has a huge impact in the process of designing considering that the available space for new construction is limited. It is very important to do this part at the very early stage of the design process.

3. The solar, wind and daylight analysis was conducted using climate studio, Rhino, and grasshopper. The correct size and placement of the windows determines the amount of daylight and energy demand of the building. The aesthetic part of the design does not necessarily compromise to save energy.

4. SIMIEN was used to analyze the initial energy demand during the preliminary stage of the project. Referring to the Norwegian building standard for passive house for the requirements to reached below the minimum requirement for the energy demand.

5. PV panels is used to maximize the amount of solar radiation as well as it will compensate the amount of carbon emission for the new building. The excess energy produced during summer will be exported to the grid and this is a way of giving back to the community. The electricity production is determined using SIMIEN.

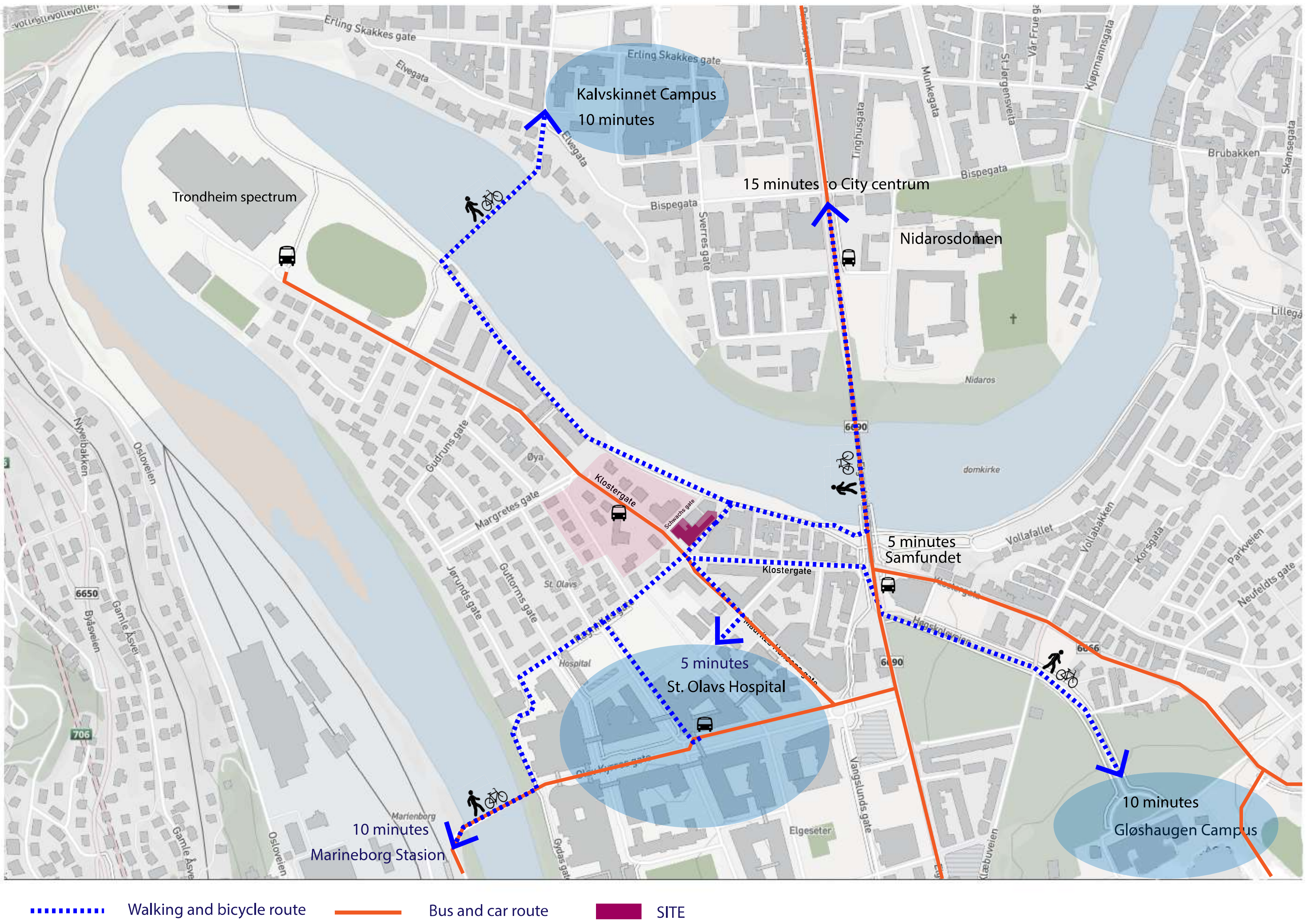
6. The existing building enveloped was improved by adding more insulation to the exterior wall and the basement was turned into heated space used for other student facilities. Building elements details are based on the recommendation from Byggforsk. Regarding the structural part, a meeting with Bunji Izumi, assistant professor from the university was conducted for different suggestions on how to strengthen the existing elements to support the additional structure on the top.

7. The emissions from the operational energy and materials were calculated with the help of Fiona Marie Dy who is doing the master thesis on the Life Cycle assessment of my proposal at the early stage. The ZEB tool and One click LCA is used to calculate the carbon emission of the proposal.
8. Auto Cad Revit was used for the final drawings. Photoshop and InDesign for the final presentation of the project.

II. SITE AND CONTEXT

SITE ANALYSIS

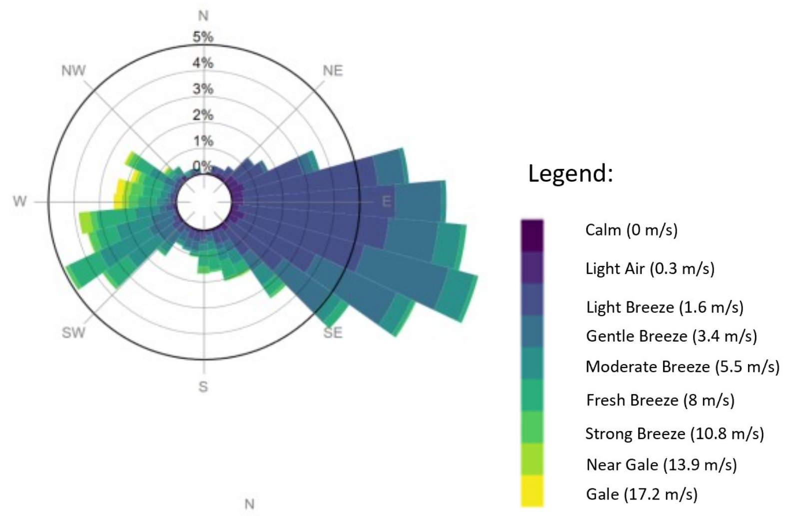
The site

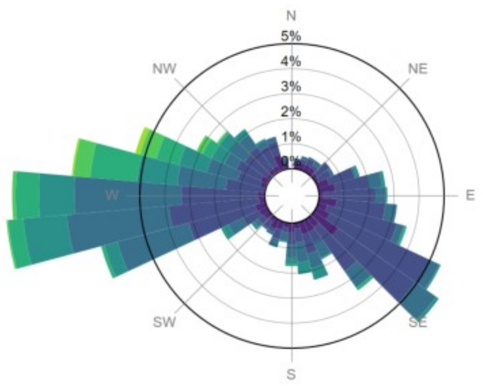


TEMPERATURE AND WIND

Trondheim city lies inside large and deep Trondheim fjord that flows into the west coast with a colder winter, but less rain compared to places exposed to the Atlantic Ocean. During winter season, the comfort range temperature is between 21 and 24 degrees Celsius in while during summer season it lies between 24 and 27 degrees Celsius. The southwest façade is directly exposed to the sun with a maximum of 829kWh/m2 in summer.

The prevailing wind throughout the is coming from the south-southeast direction. During summer, the strongest wind is coming from west-southwest and with an average windspeed of 3m/s and can reach up to 10.8m/s. The average windspeed of 4m/s from the east-southeast direction which can also reach up to 10.8m/s is experienced during cold season. The five-storey coop prix building is located on the east side of the existing building and that is why it is protected from the winter wind.





SITE ANALYSIS

STRENGHTS	WEAKNESS	OPPORTUNITIES	THREATS
Centrally located with a walking distance from all the campuses in the city including student Samfunndet, training centers, and Trondheim spectrum.	Cars and busses passing every day. Level of sound facing Klostergate exceeded the minimum requirement of 55dB for housing.	Limited lot area for outdoor recreational space is a requirement. The roof top can be use as outdoor common space for students.	Densification and future plans for the city.
Direct access to Nidelva for recreational, bicycle and walking paths along the river.	Public areas and private areas such as the courtyard for students is challenging because public can have direct access to the ground level.	Improve the outdoor areas around the building for both students and the public. Turn the road from coop prix to Student Samfunndet a walking street.	Building restrictions
4-mins walk to Student Samfunndet bus stop at Elgeseter gate.	Intersection between Klostergate and Mauritz Hansen's gate is quite busy.	Improve the outdoor areas around the building for both students and the public.	More vehicles and bus trips
5 mins walk distance to St. Olav's hospital and health services.	Expensive and attractive site. Expect for higher rental cost.	Add bicycle lanes and safer walking streets.	
Coop prix is across the road on the east side of the building.	The Regional rehabilitation center located on both sides of the building must be taken into consideration. Fire safety regulations with minimum 8meters distance between buildings.	Façade facing Klostergate must be aesthetically pleasing to attract safety for people to walk or use bicycle every day.	
Existing concrete building can be refurbished.	Building does not comply with latest building regulations.	Some exemptions to the building's regulations can be applied. Expansion	

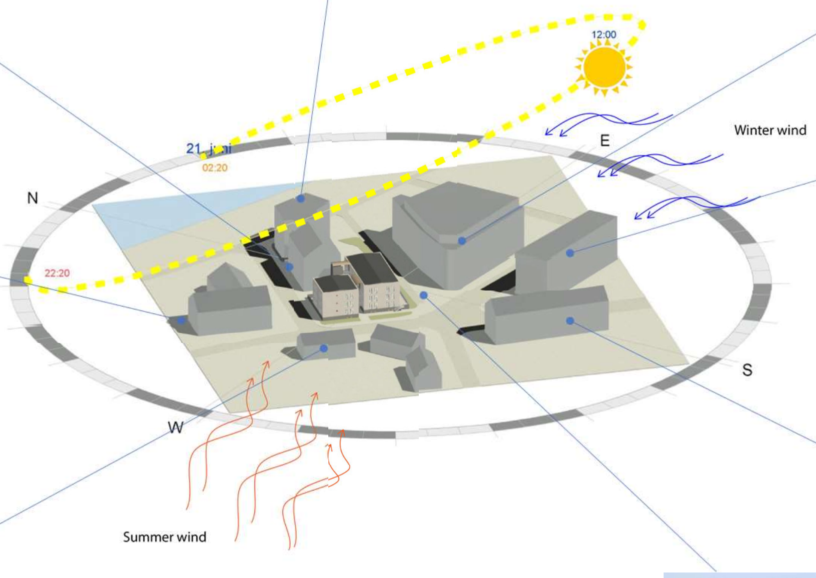
THE SURROUNDING BUILDINGS

Heritage protected concrete building which serves as the Regional Trauma center located the back of building along Schwachs gate.

Extension of St. Olavs Hospital building for rehabilitation center in concrete and metal construction located at the northern side of the student housing with great view of the Nidelva.

On the east side is a 5-storey building in concrete and metal cladding façade on the top floor. Coop prix food shop on the first floor and the rehabilitation center on the upper floors.

Heritage protected building in bricks and concrete.



At the intersection between Klostergate and Mauritz gate lies numbers of apartment buildings in concrete including the coop prix building on the left side of the road.

Heritage protected traditional two-storey wooden houses across the street.

View of the Nidarosdomen is a very important part of the square where the passageway going to the greenery along the river lies between the student housing and the coop prix building.

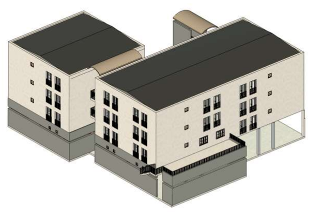
A four-storey concrete building apartment located in the intersection between Klostergate and Mauritz Hansens gate.

III. CONCEPT AND FORM

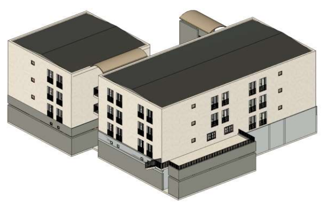
Form
Site development plan
Illustrations
Floor plans
Facades
Site sections

FORM

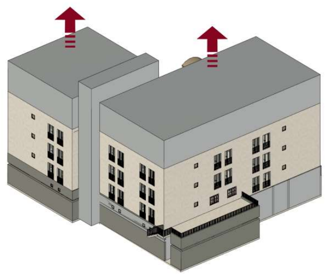
DEVELOPMENT OF THE FORM



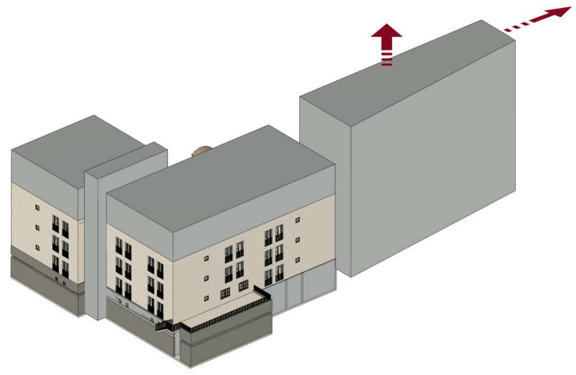
Existing three level building with car parking in the basement.



New concrete floor and heated rooms in the existing basement carparking space.

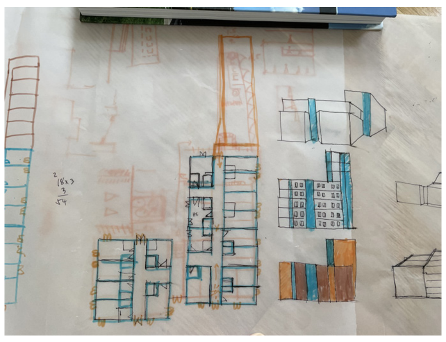


New kitchen on top of the existing roof on west wing of the building.
Additional one floor with 12units on top of the existing roof on the east wing.



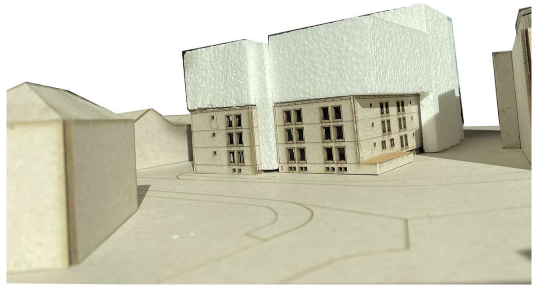
Maximizing the lot area and completing the block. Additional 6 floors with main kitchen on the first level.

The form is simple and the height of the facade along Klostergate was maintained. The extension at the north wing completed the block and is only one floor higher than the adjacent building. The purpose is to accomodate more students without sacrificing the quality of living as well the aesthetic quality that fits well into the neighborhood. Different options for the extension was developed until the final form was made and that is adding one floor on top of the existing building and new seven floor building is built at the existing car parking space.



Started making sketches using the existing floor plans to improve circulation inside and how it will connect to the new building.

Option 1



Option 2

Option 3

Option 4

North side facing Nidelva

Option 5 is the final form in consideration for the structural capacity of the existing building.

SITE DEVELOPMENT PLAN

ILLUSTRATIONS

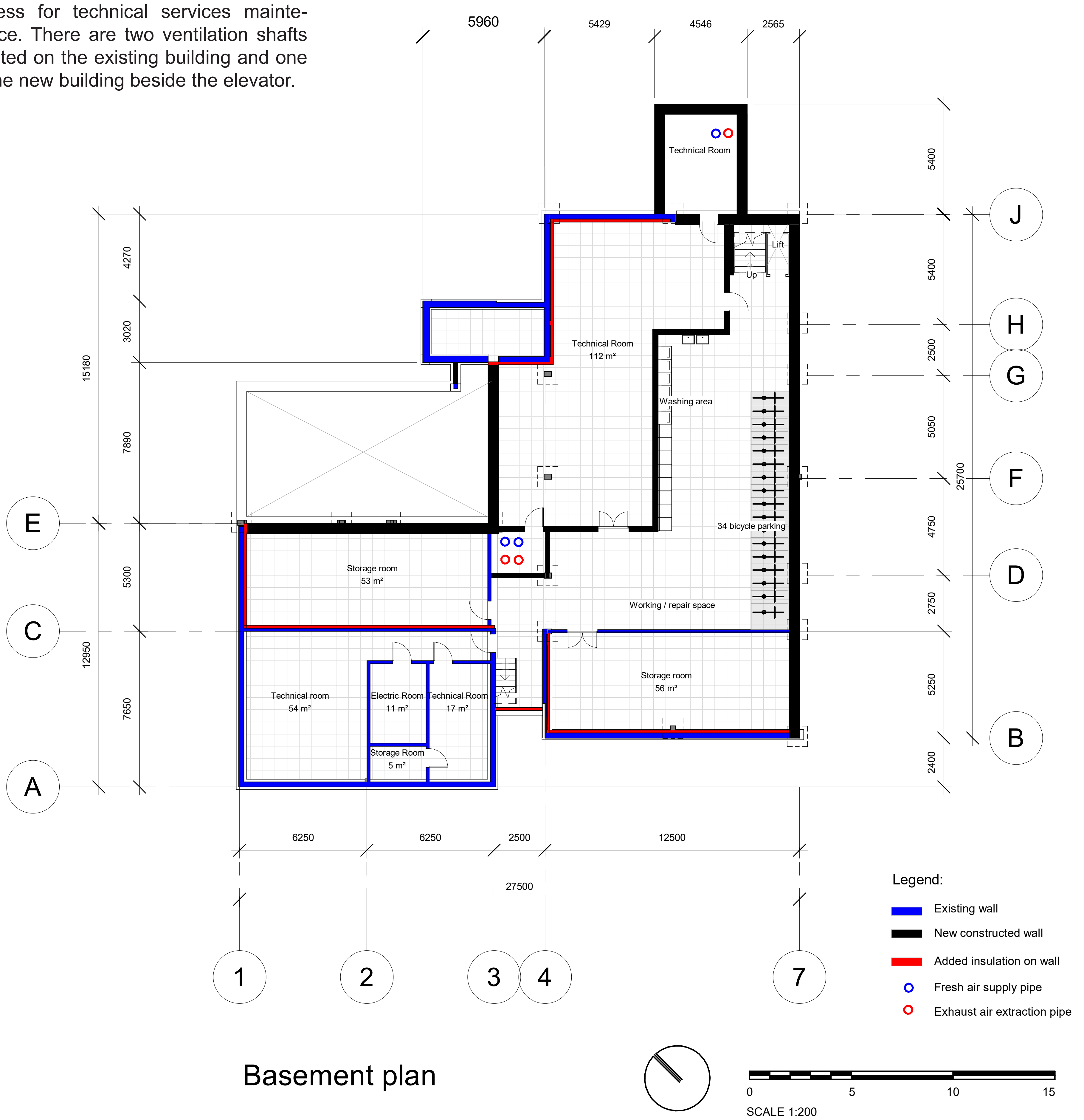
The space between buildings serves as the extension of the kitchen and direct access to the park along Nidelva.

Existing car parking for the student. There is already shading after 12.noon on this side of the adjascent building.

Total floor area 3482sq.m
93 units
- 52 single bed
- 9 double beds
-21 collective
-11 units (HC)

The proposal has 93 units that will accomodate 103 students but it can reach up to 106 students if the 19sq. meter room wil be shared by couple. The existing housing accomodates 63 students. Additional 40 students will be a good solution for lack of student housing in Trondheim city.

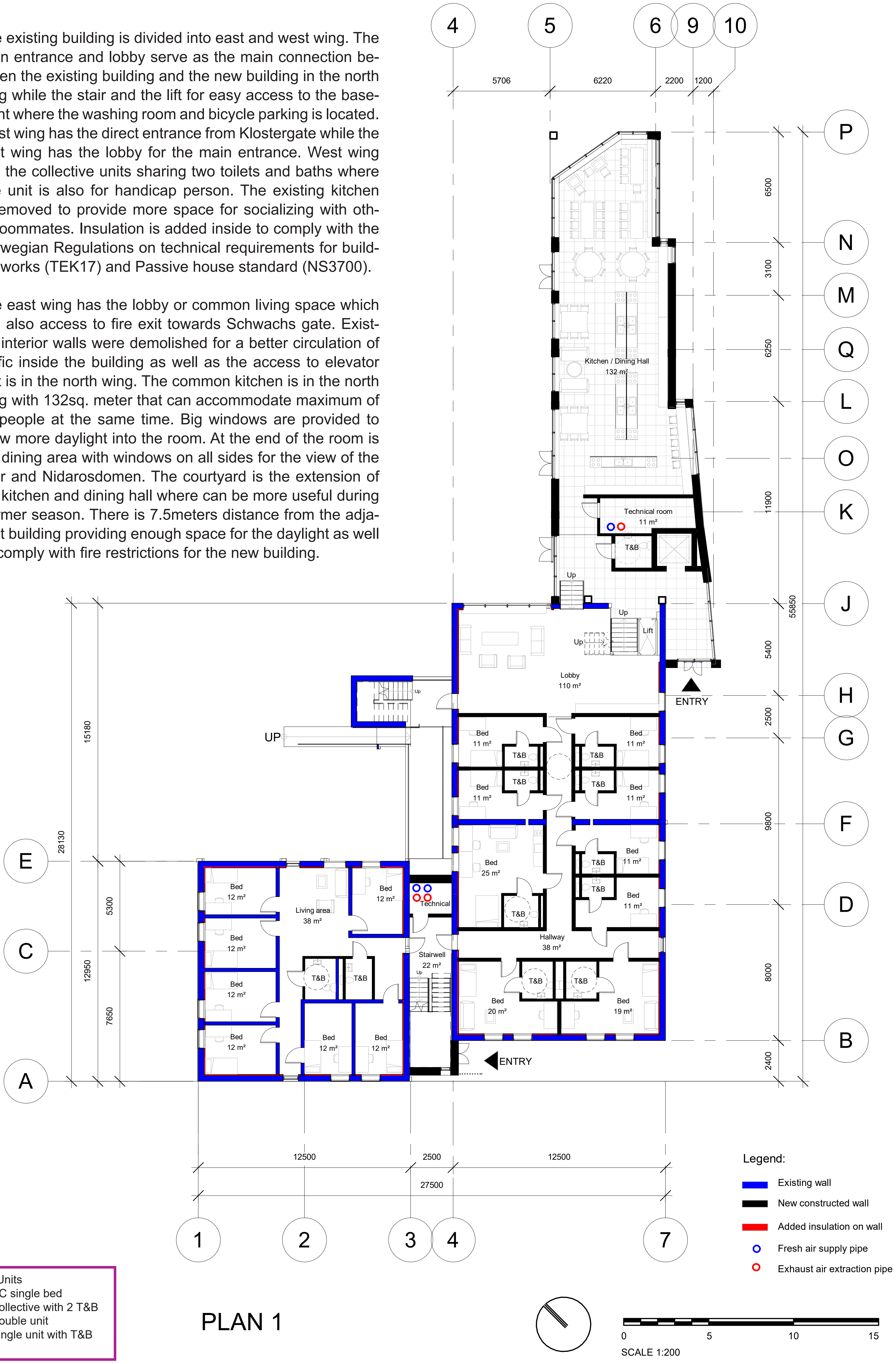
The existing basement is insulated, and additional mechanical room was added for the new extended building. Washing area, bicycle parking provided with working or repair space. There will be no need for cars since public transportation is available and has easy access to campuses in the city. Ventilation system and water tank is in the basement for easy access for technical services maintenance. There are two ventilation shafts located on the existing building and one at the new building beside the elevator.



Basement plan

The existing building is divided into east and west wing. The main entrance and lobby serve as the main connection between the existing building and the new building in the north wing while the stair and the lift for easy access to the basement where the washing room and bicycle parking is located. West wing has the direct entrance from Klostergate while the east wing has the lobby for the main entrance. West wing has the collective units sharing two toilets and baths where one unit is also for handicap person. The existing kitchen is removed to provide more space for socializing with other roommates. Insulation is added inside to comply with the Norwegian Regulations on technical requirements for building works (TEK17) and Passive house standard (NS3700).

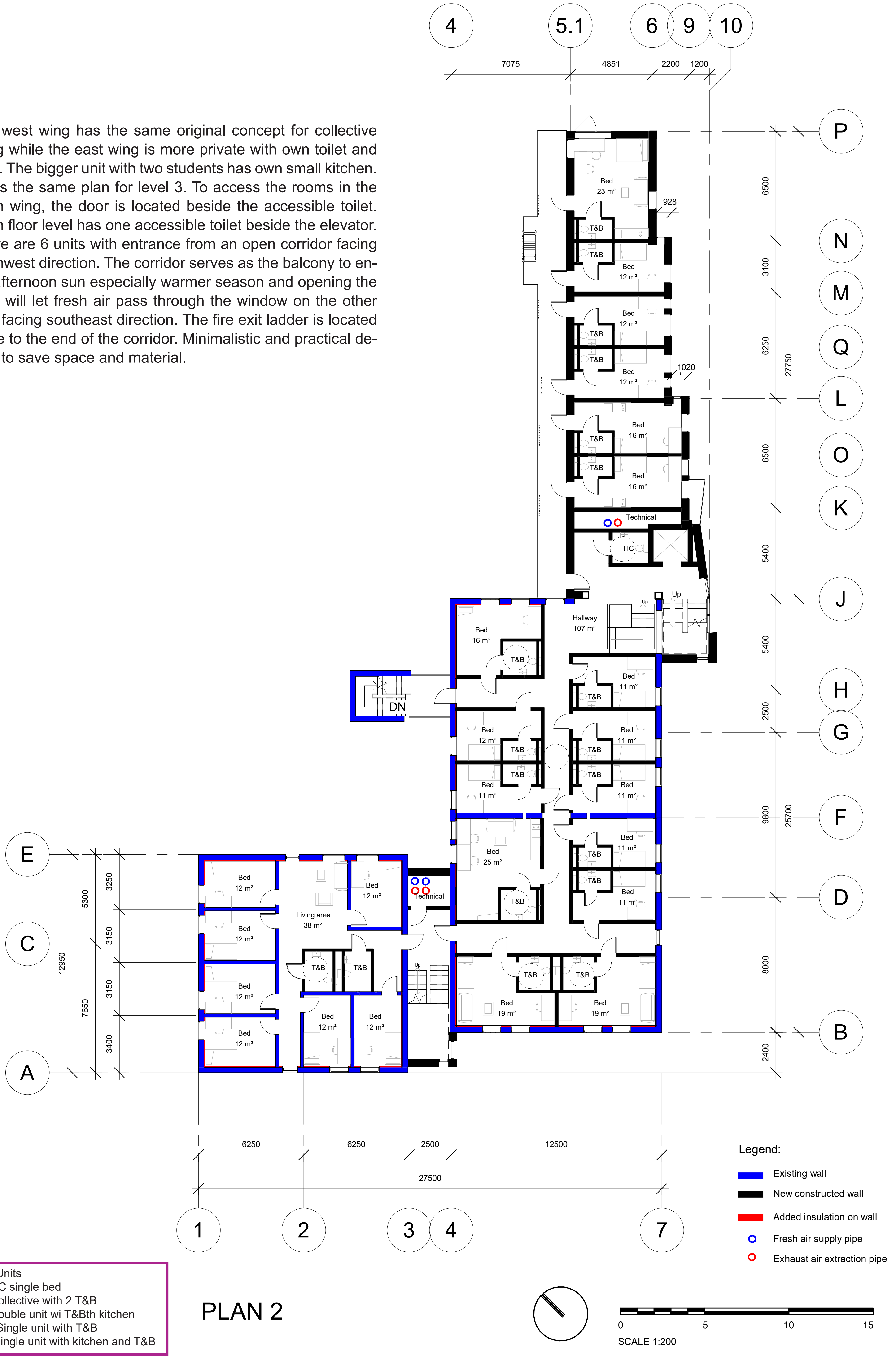
The east wing has the lobby or common living space which has also access to fire exit towards Schwachs gate. Existing interior walls were demolished for a better circulation of traffic inside the building as well as the access to elevator that is in the north wing. The common kitchen is in the north wing with 132sq. meter that can accommodate maximum of 60 people at the same time. Big windows are provided to allow more daylight into the room. At the end of the room is the dining area with windows on all sides for the view of the river and Nidarosdomen. The courtyard is the extension of the kitchen and dining hall where can be more useful during warmer season. There is 7.5meters distance from the adjacent building providing enough space for the daylight as well as comply with fire restrictions for the new building.



16 Units
2-HC single bed
7-Collective with 2 T&B
1-Double unit
6-Single unit with T&B

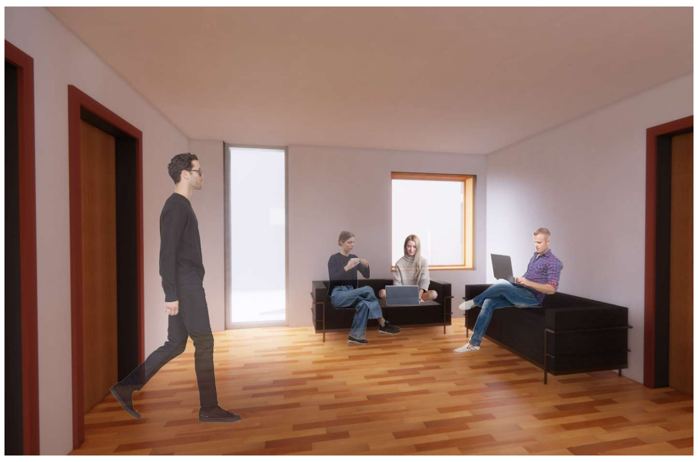
PLAN 1

The west wing has the same original concept for collective living while the east wing is more private with own toilet and bath. The bigger unit with two students has own small kitchen. It has the same plan for level 3. To access the rooms in the north wing, the door is located beside the accessible toilet. Each floor level has one accessible toilet beside the elevator. There are 6 units with entrance from an open corridor facing northwest direction. The corridor serves as the balcony to enjoy afternoon sun especially warmer season and opening the door will let fresh air pass through the window on the other side facing southeast direction. The fire exit ladder is located close to the end of the corridor. Minimalistic and practical design to save space and material.



24 Units
3-HC single bed
7-Collective with 2 T&B
2-Double unit wi T&Bth kitchen
10-Single unit with T&B
2- Single unit with kitchen and T&B

PLAN 2



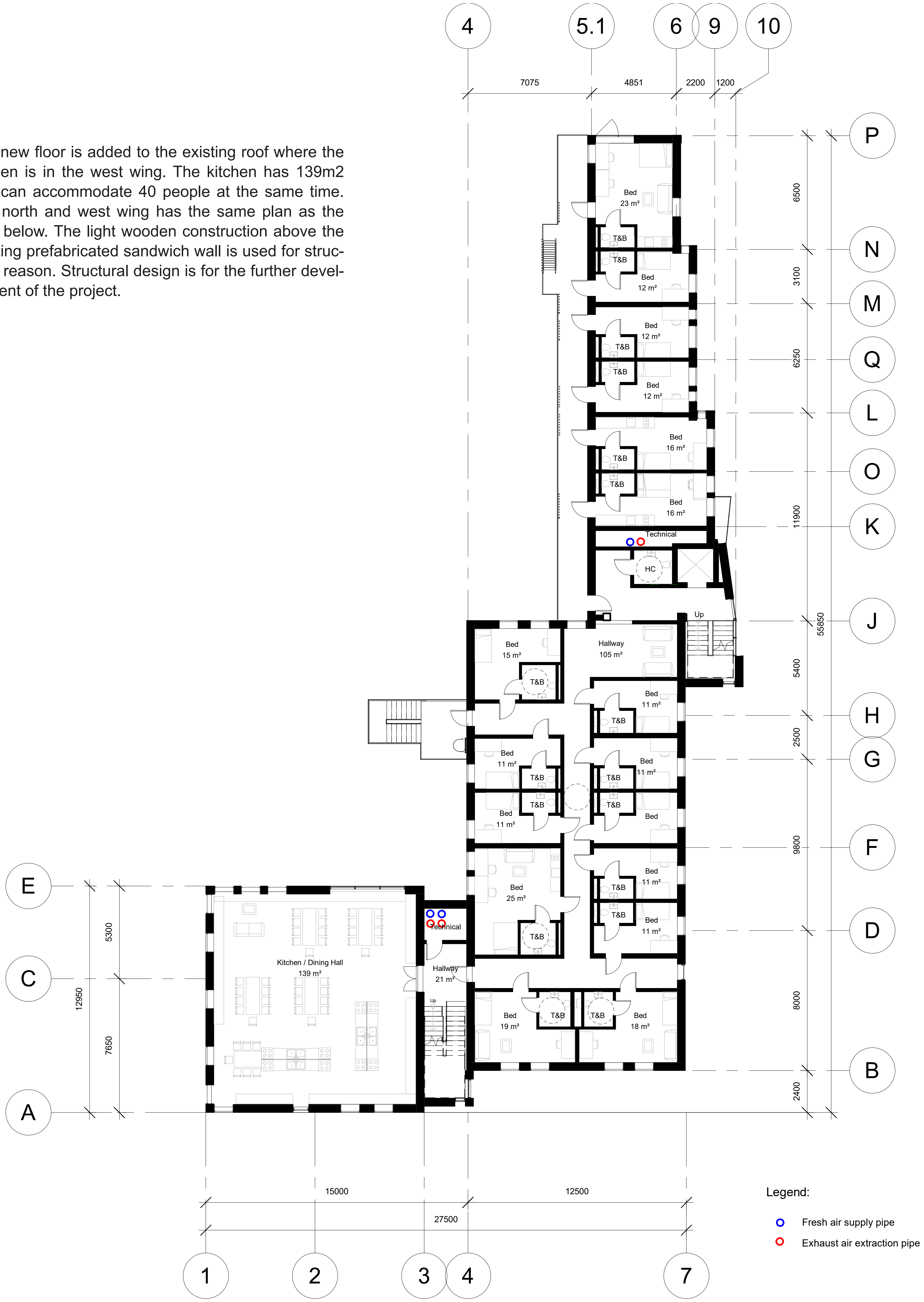
New living area for students to share.

Existing kitchen is removed will have shered kitchen in ground level and level 4.

24 Units
3-HC single bed
7-Collective with 2 T&B
2-Double unit wi T&Bth kitchen
10-Single unit with T&B
2- Single unit with kitchen and T&B

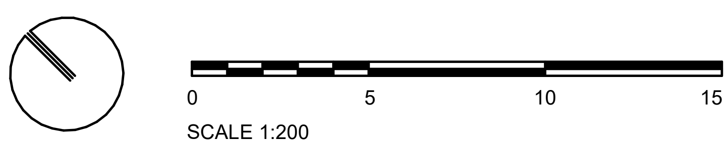
PLAN 3

The new floor is added to the existing roof where the kitchen is in the west wing. The kitchen has 139m2 that can accommodate 40 people at the same time. The north and west wing has the same plan as the plan below. The light wooden construction above the existing prefabricated sandwich wall is used for structural reason. Structural design is for the further development of the project.



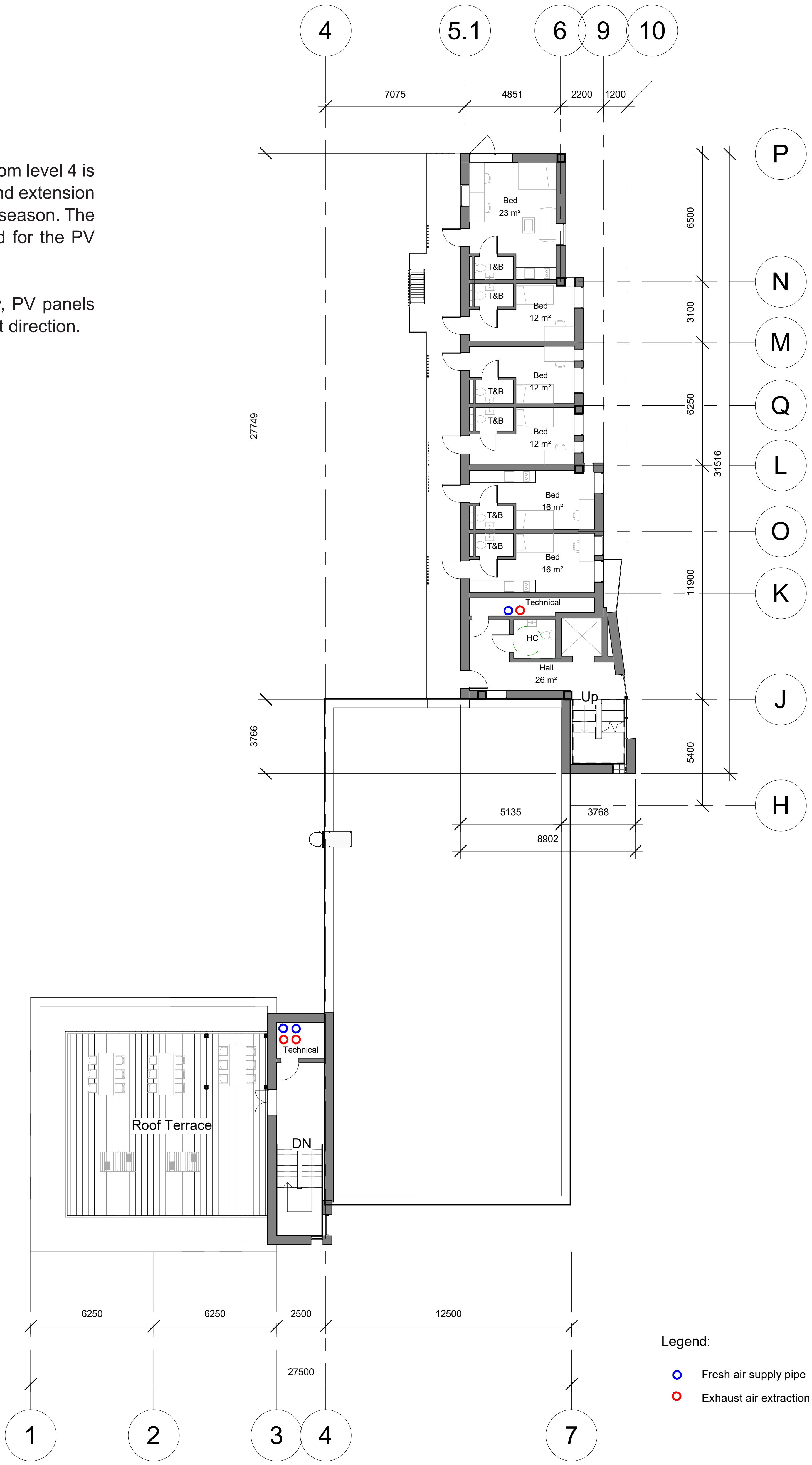
17 Units
3-HC single bed with T&B
2-Double unit wi T&Bth kitchen
10-Single unit with T&B
2- Single unit with kitchen and T&B

PLAN 4



The roof above the kitchen from level 4 is used as the outdoor space and extension of the kitchen during warmer season. The roof in the west wing is used for the PV panels.

To optimize the solar energy, PV panels are installed facing East-west direction.



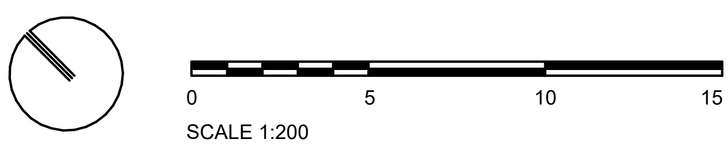
Legend:

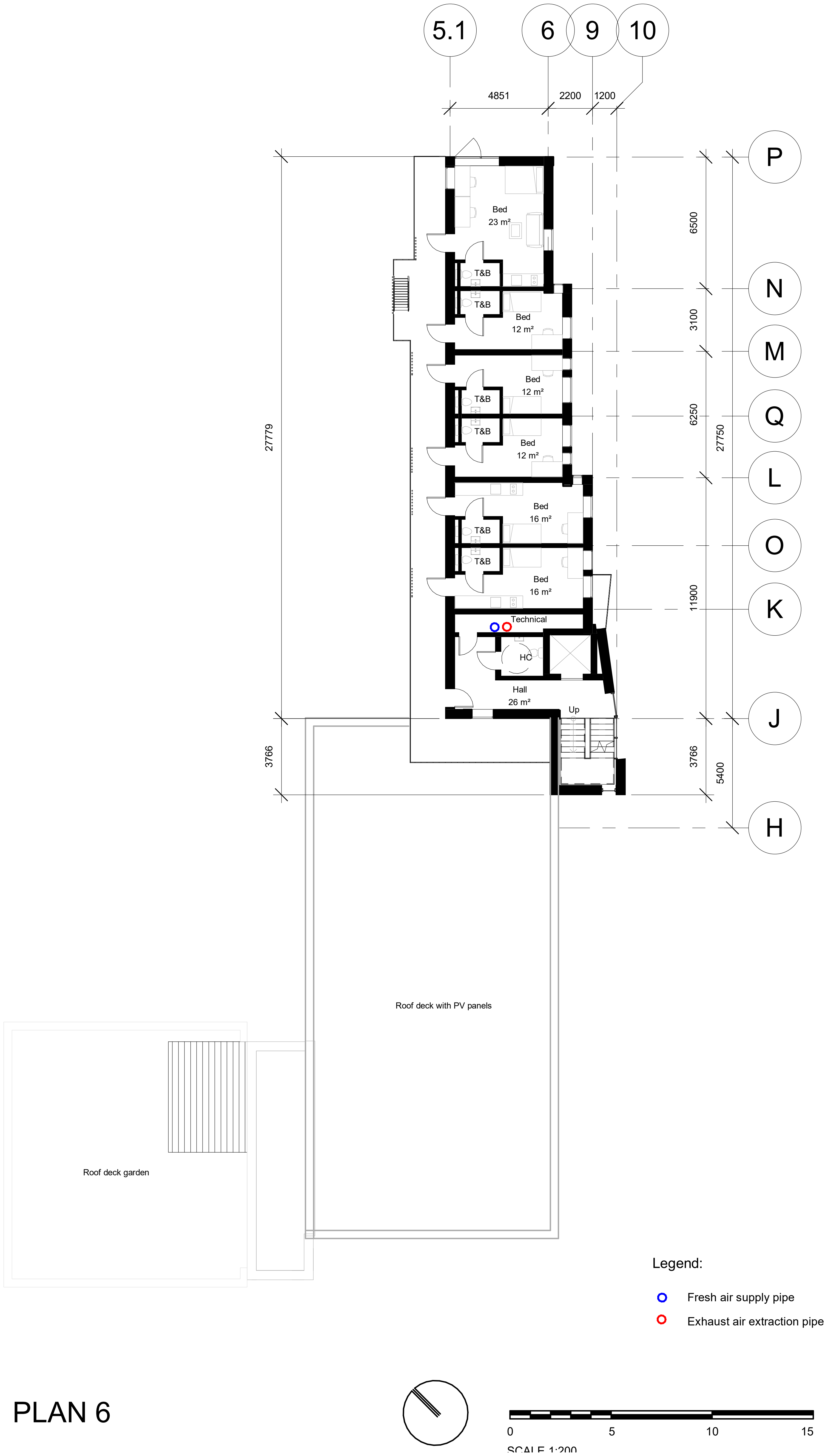
Fresh air supply pipe

Exhaust air extraction pipe

6 Units
1-Double unit with kitchen and T&B
3-Single bed with T&B
2- Single unit with kitchen and T&B

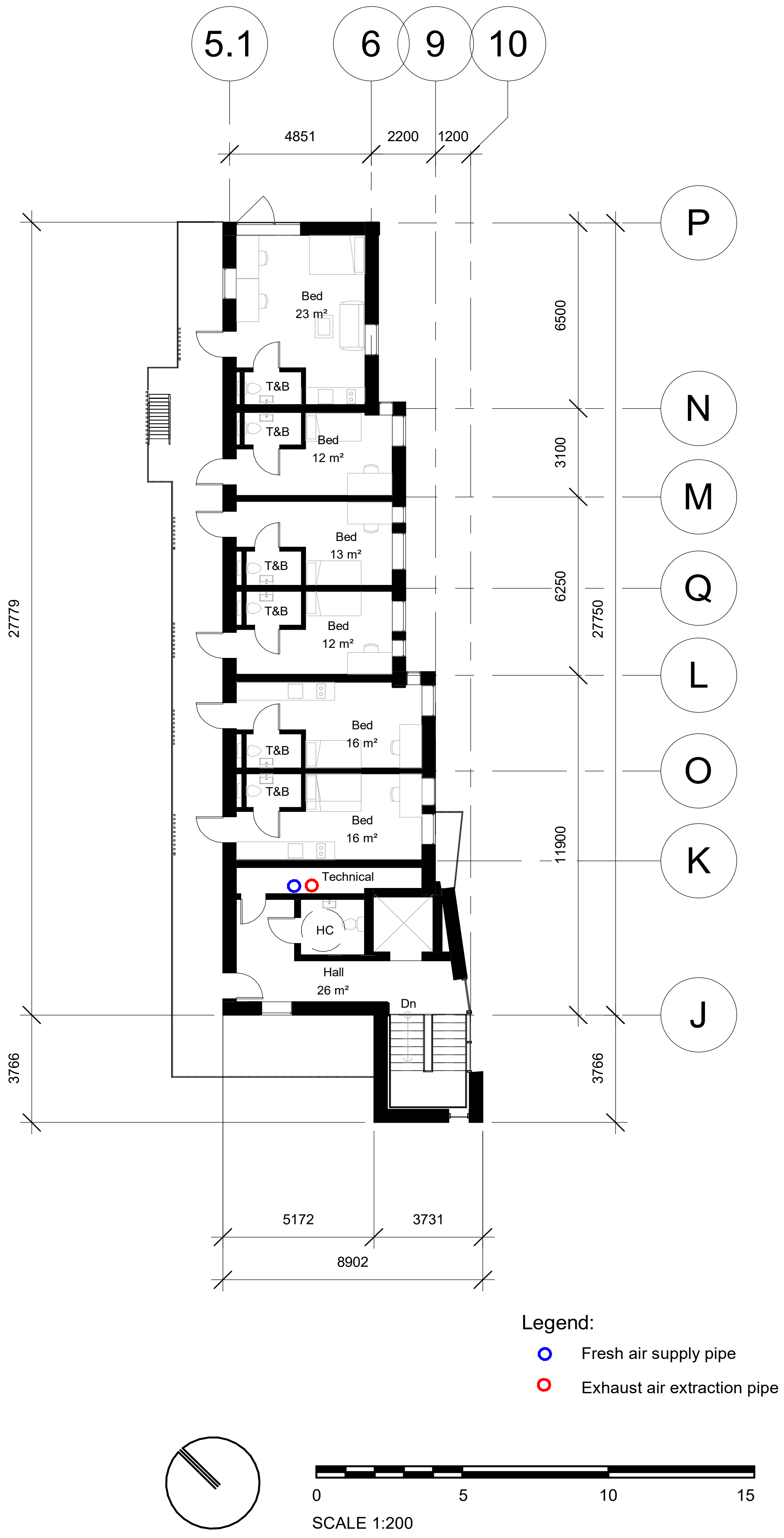
PLAN 5





PLAN 6

6 Units
1-Double unit with kitchen and T&B
3-Single bed with T&B
2- Single unit with kitchen and T&B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T&B
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Technical
HC
Hall
26 m²
Dn
5172
3731
8902
Legend:
Fresh air supply pipe
Exhaust air extraction pipe
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10
15
SCALE 1:200

PLAN 7

East Facade

Existing East facade

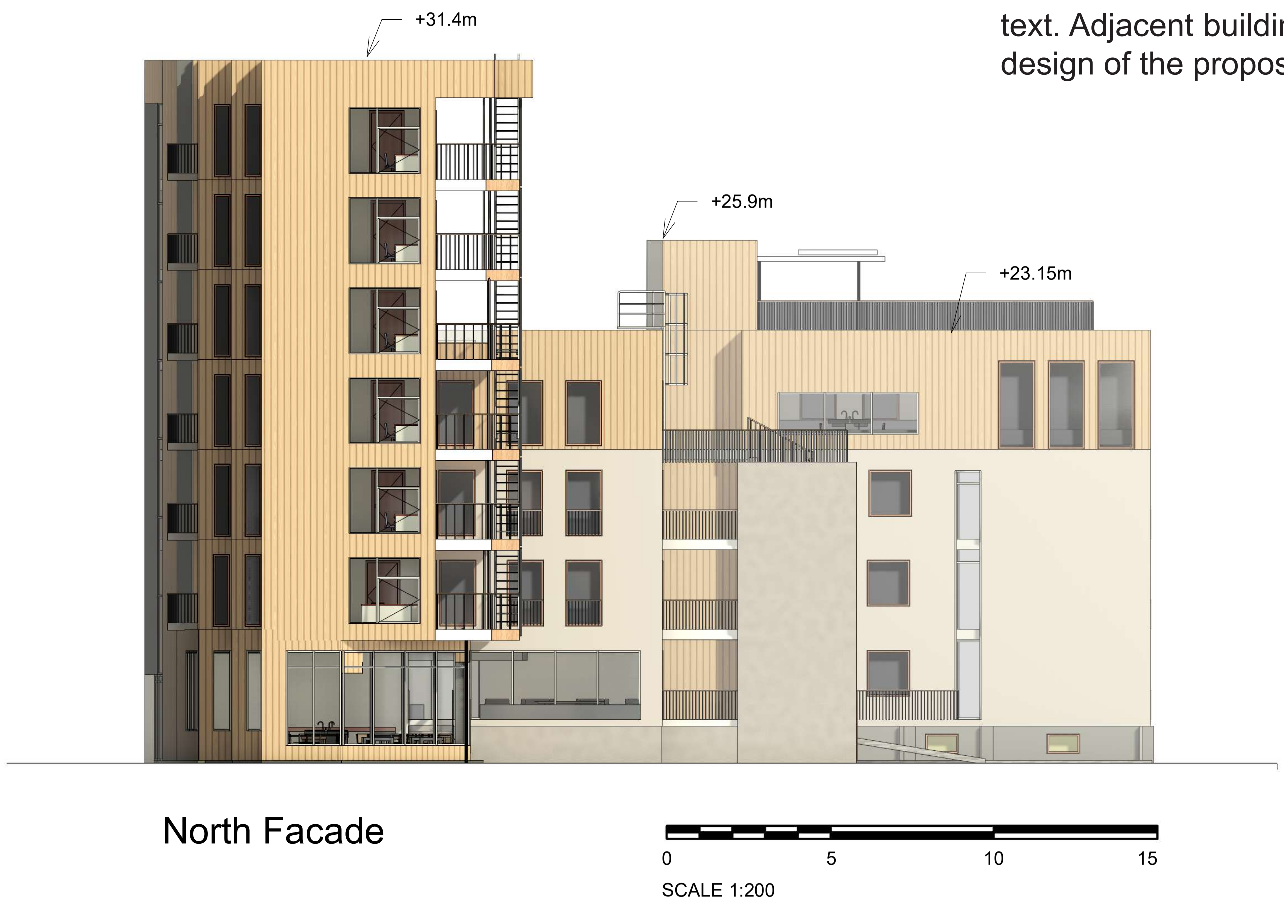
The extension of the student housing improves the aesthetic quality of the neighborhood. Two adjacent buildings are modern with concrete and metal façade. The mixed use of materials made the building more interesting.

West Facade

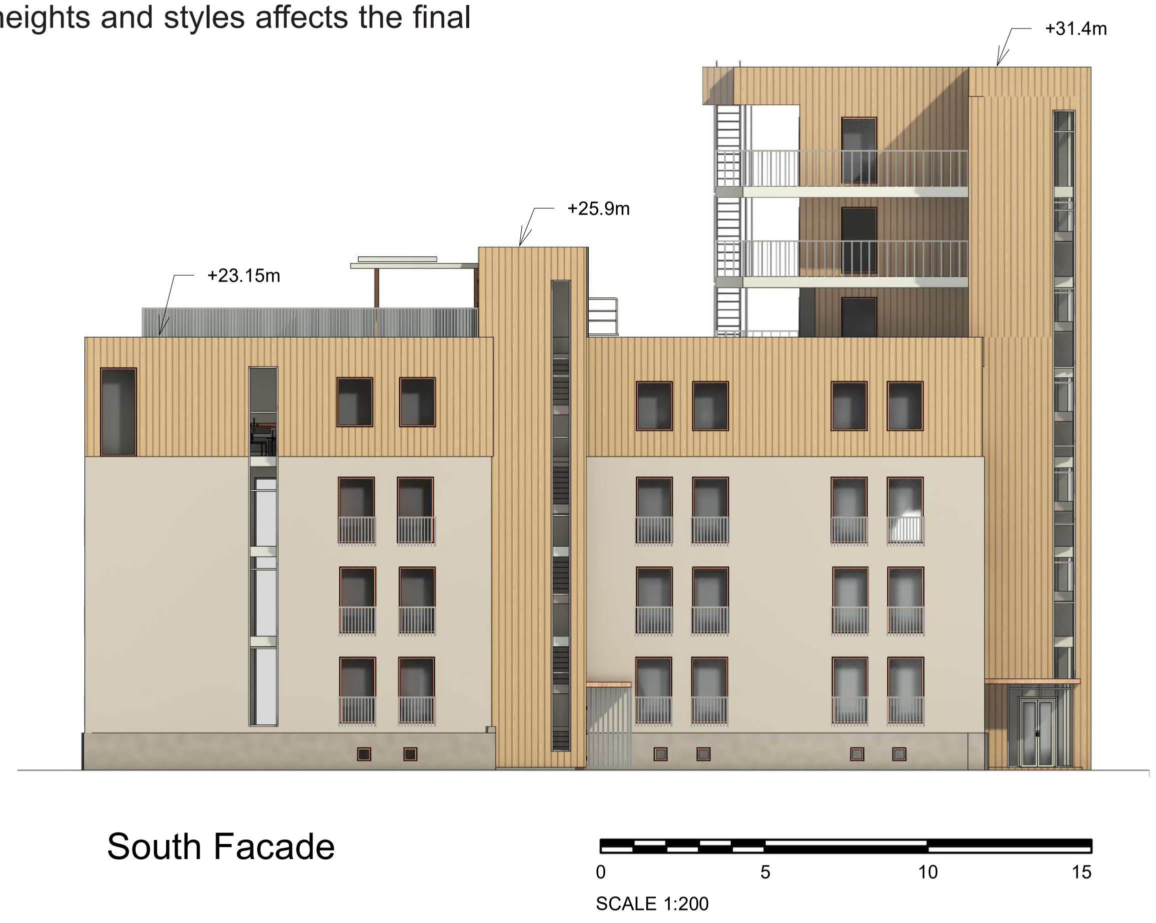
Existing West facade

The west façade of the extension is facing the 3-storey Regional Trauma Center which is also a heritage protected concrete building. The courtyard serves as the “breathing space” between two buildings. There is only one window for each level at the end of the corridor to avoid direct view to the adjacent building.

Variation of heights of the building is the result of multiple attempts on how the refurbishment and extension project will fit into the context. Adjacent building of varying heights and styles affects the final design of the proposal.



North Facade

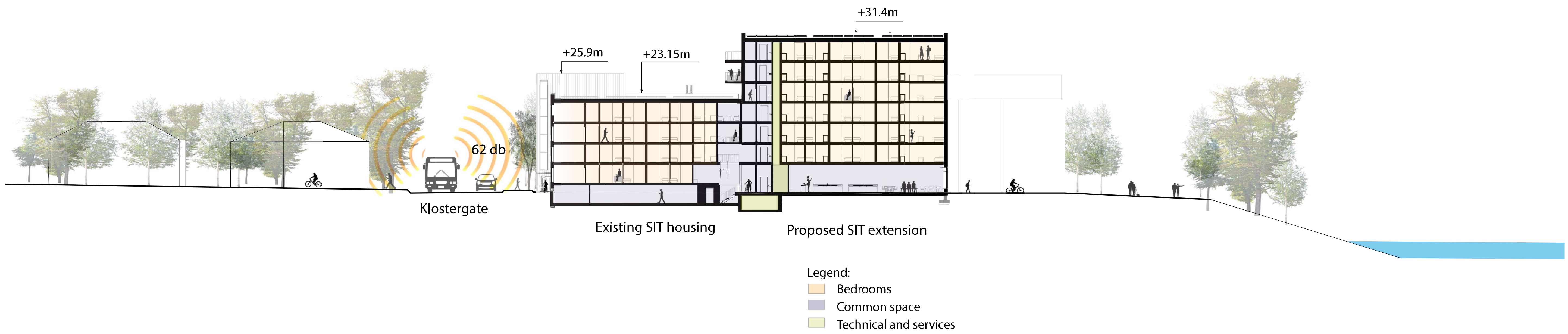


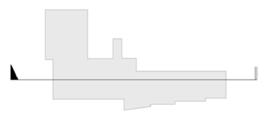
South Facade

Existing North facade

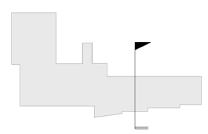
The dining area for the two kitchens has direct view of the river. The kitchen in the ground floor has direct access to courtyard garden and the greeneries along Nidelva while the kitchen in level 4 has view of the mountains and the river in the north direction with easy access to roof terrace.

Existing South facade





North-South Section



East-West Section

ILLUSTRATIONS

Proposed facade along Klostergate

Existing facade along Klostergate

IV. MATERIALS

Materials and U-values
Details
Main material with corresponding GWP

Materials

To comply with the Norwegian standard 3700- Criteria for passive house and low energy house, certain rules must be followed. These rules and guidelines are important to reduce the energy demand of the building. The requirement for heat loss can get through the floors, walls, doors especially the windows. Air leaks through ventilation also has impact in heat loss.

The floor on ground has 80mm concrete on 300mm EPS insulation having u-value of 0.11. Since the existing basement is insulated both walls and flooring. The flooring used the same floor construction principle as the kitchen in the ground level. But the kitchen and dining hall will have hydronic heating system installed under the floor tiles. See wall and floor on ground detail.

The existing hollow concrete floor up to roof level is still in use. The existing roof construction is refurbished since the new floor is added. Only one floor is added and is in light wooden construction. The existing building does not have columns and the exterior wall serves as the bearing structure that caries the load from the hollow core floors. Further structural details can be included in the next stage of the project.

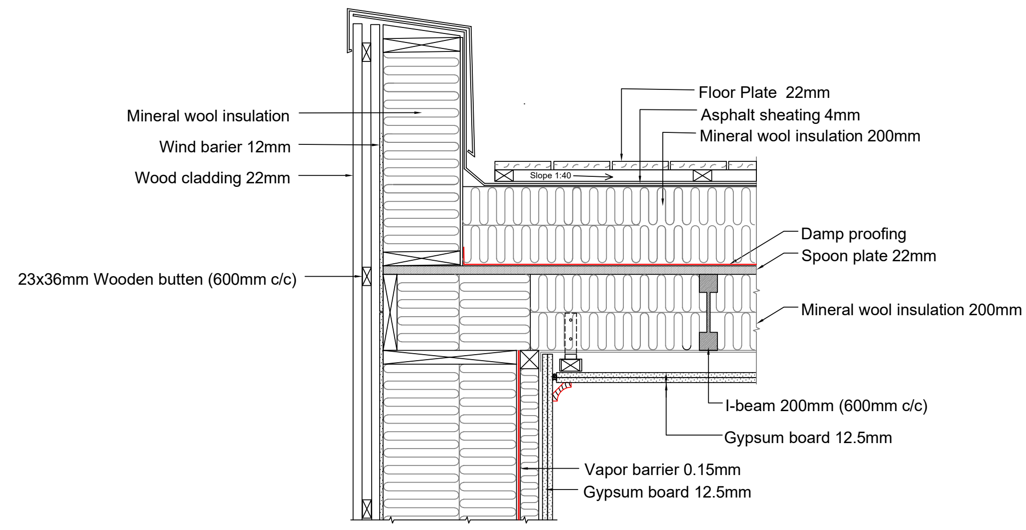
The wooden flooring with 200mm I-joist spaced at 600mm and insulated with 200mm mineral wool and 22mm spoon plate under the floor finish. The U-value is 0.10. See wall and bearing floor detail.

The exterior wall has 350mm I-profile with 400mm insulation. The vapor retarder is continuous from the floor to wall to keep it airtight. Based on the noise report from Brekke Strand and the Norwegian building standard, the average level of noise outside window is 55dB but the today is already reaching 62dB because Klostergate is a busy road and is predicted to increase up to 80dB in near future. See wall and bearing flooring detail.

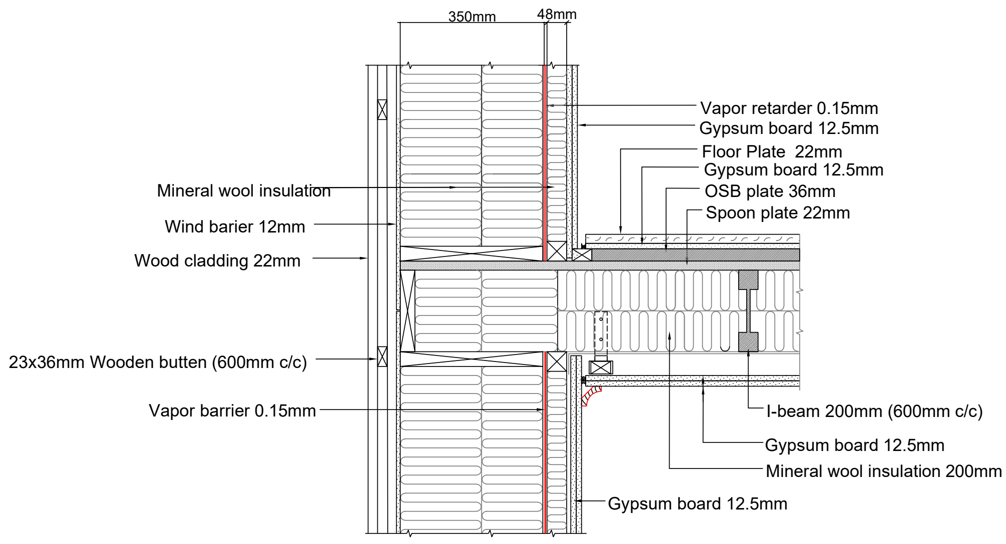
The roof has 200mm I-profile with 200mm mineral insulation, above is 22mm spoon plate with continues dam proofing membrane and 200mm insulation under the roof membrane. The roof of the kitchen on level four will be used as the roof terrace with out plants. 22mm wooden plates will be the finishing floor material. The required minimum u-value for the roof is 0.10. See roof deck detail.

The existing windows has never been changed since it was built and has U-value of 2.4 according to Norwegian standard (Byggforsk-TEK 1987) . The new windows are triple glazed with u-value of 0.80. Windows facing southwest and north west will have automatic outdoor window blinds to avoid overheating. The glazing ratio used is 20% for the building to be more energy effecient.

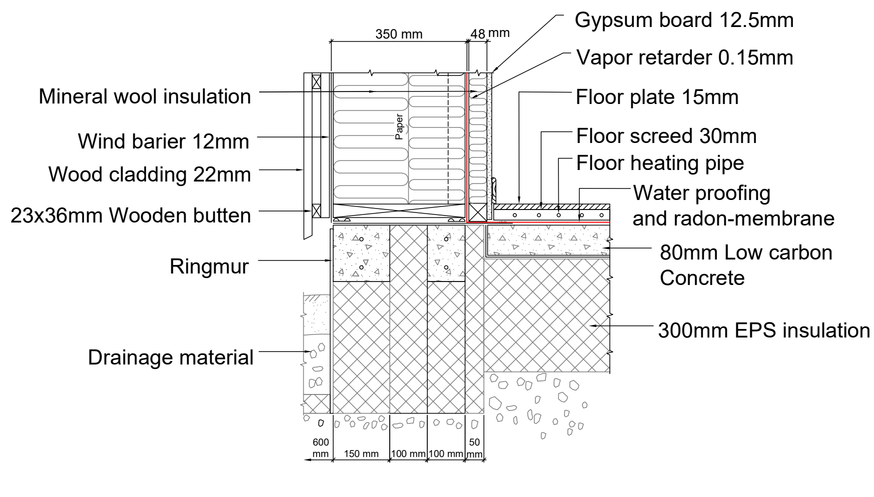
Details



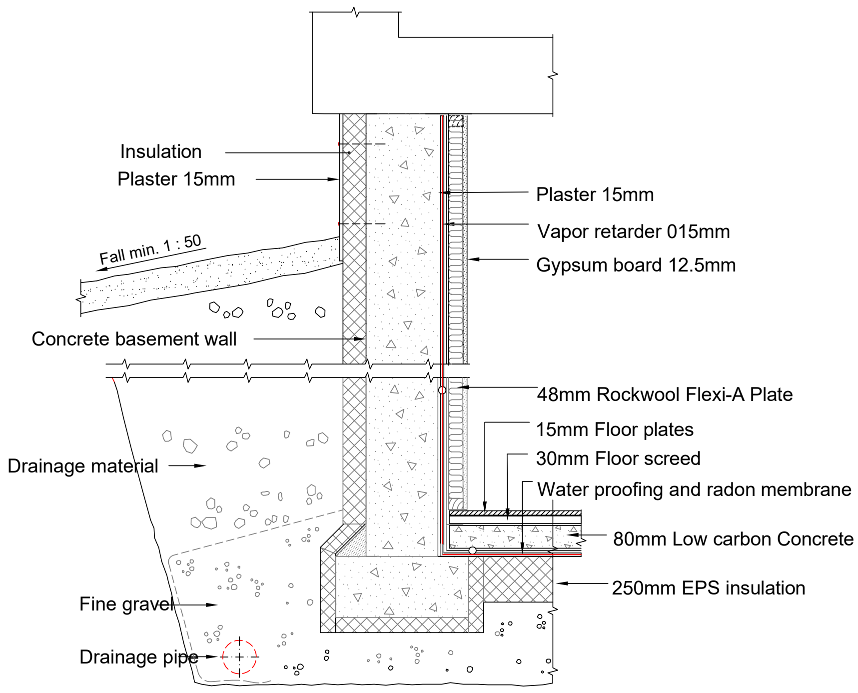
Roof deck detail



Wall and bæring floor detail



Wall and floor on ground detail



Basement floor and wall detail

Materials

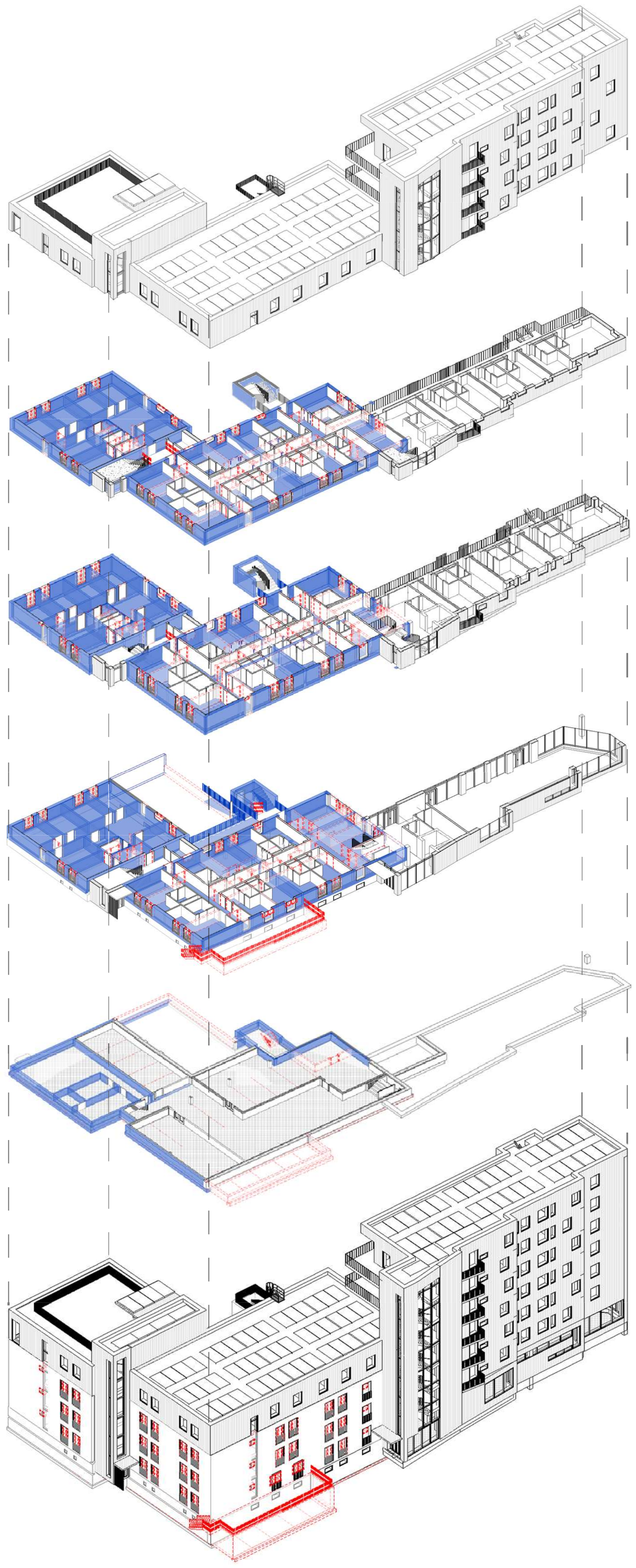
Level 4-7

Level 3

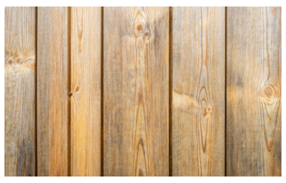
Level 2

Level 1

Basement level



Main materials used with corresponding GWP



Kebony Scots pine external cladding
GWP = 6.86kgCO2eq/m2
Total = 8.7tons CO2eq

I-Joist wood
GWP = 2.4kgCO2eq/m2
Total = 1.3tons CO2eq

Isover Standard 40Roll (Saint Gobain)
GWP = 0.42kgCO2eq/m2
Total = 3.9tons CO2eq

Ready-mix concrete Low-carbon Class A
GWP = 184.55 kgCO2eq/m3
Total = 32tons CO2eq

EPS insulation panels
GWP = 46.05kgCO2eq/m3
Total = 10tons CO2eq

Axonometry

Element	Existing	Re-used	Demolished	Percentage Re-Used
Windows	150.7m2	0	0	0
Pre-fabricated floor slab	1840m2	1840	0	100%
Prefabricated sandwich wall	1111m2	1001m2	110m2	90%
Interior wall	1469m2	581m2	888m2	40%

Legend:

Existing element

Demolished

V. STRATEGIES AND ANALYSES

Daylight analysis
Renewable energy
Heating system
Ventilation system

DAYLIGHT ANALYSIS

According to the Technical Regulations to the Planning and Building act, the minimum requirement for daylighting is 2%. Since this is an existing structure and the original design was retained, the windows size is 1.2mX2m was decided to be used again and receiving an average daylight factor of 3.9%. Rhino and grasshopper was used to simulate the daylight analysis for the room size of 2.9mx6.0m having a minimum of 2.2%. The window size is 1.2mx1.4m and 0.8m above the floor level and is located closer on one end of the room as shown on fig..... Whereas the window of the same size that was placed on the middle of the room, the day light factor changed to 2.5% as shown on fig.... Some of the northwest and north facing rooms have double size windows since these rooms does not have a better view but have more daylight factor of 4% (Fig....).

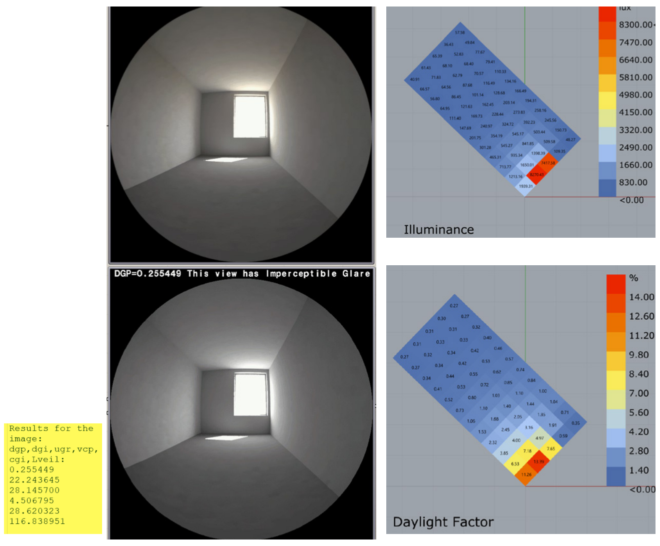


Fig.1 (DF:2.2%)

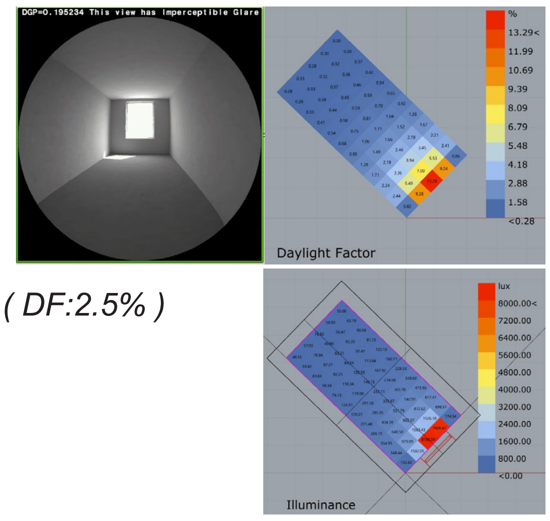


Fig.2 (DF:2.5%)

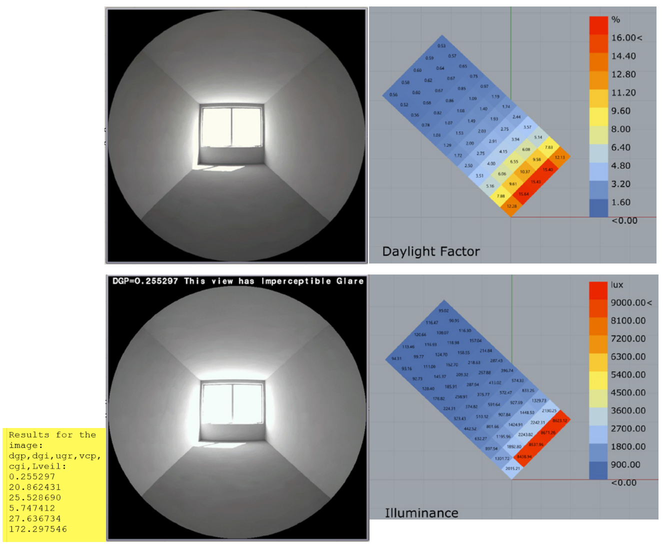
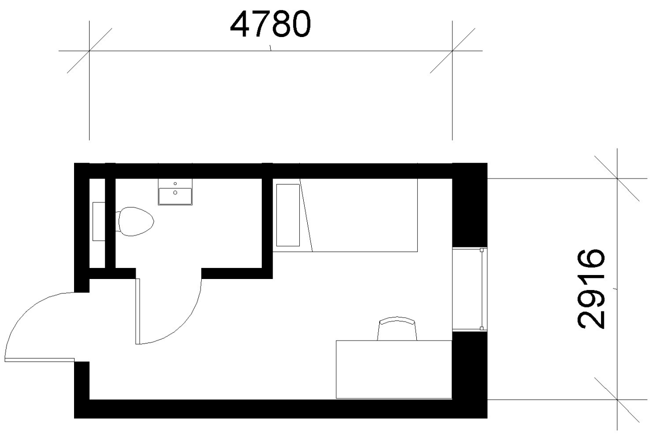


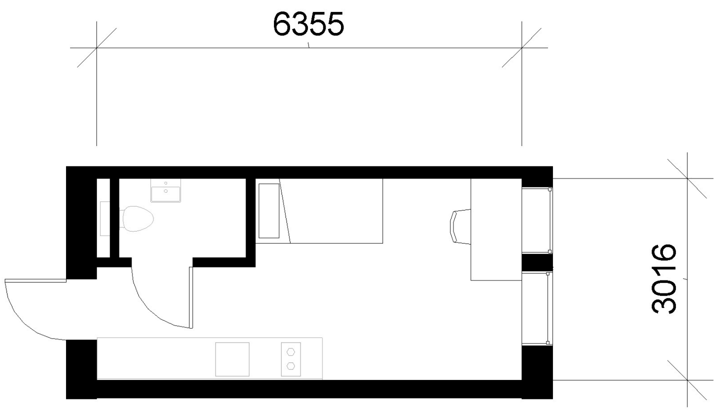
Fig.3 (DF:4%)



Plan

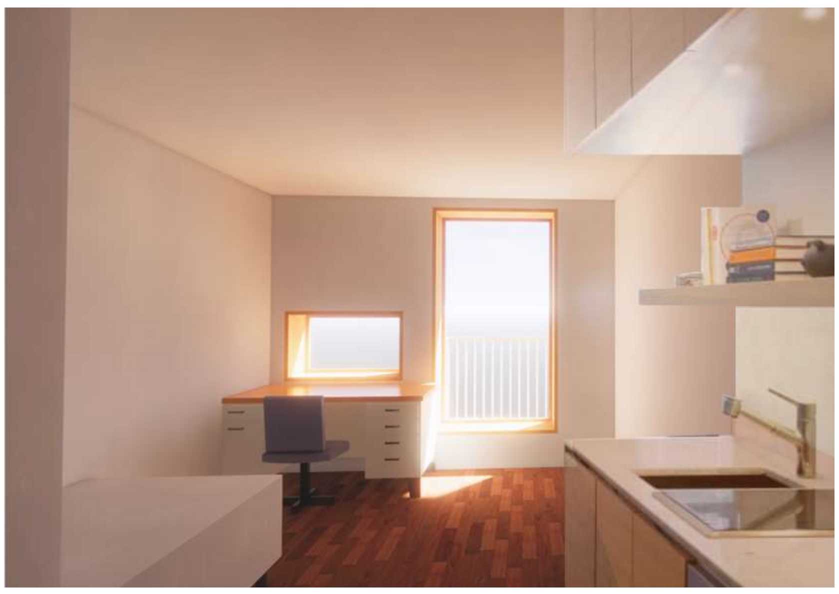
The unit has 11m2 floor area with toilet and bath. The windows used for this room is 1.2mx1.4m with 2.5% daylight factor. The window is facing southeast and recieving the morning sun. Indoor window blinds can be used for the glare issues. Light painted interior walls and ceiling makes the room feels bigger and reflects light through out the space.

Window facing southeast with DF of 2.5%.



Plan

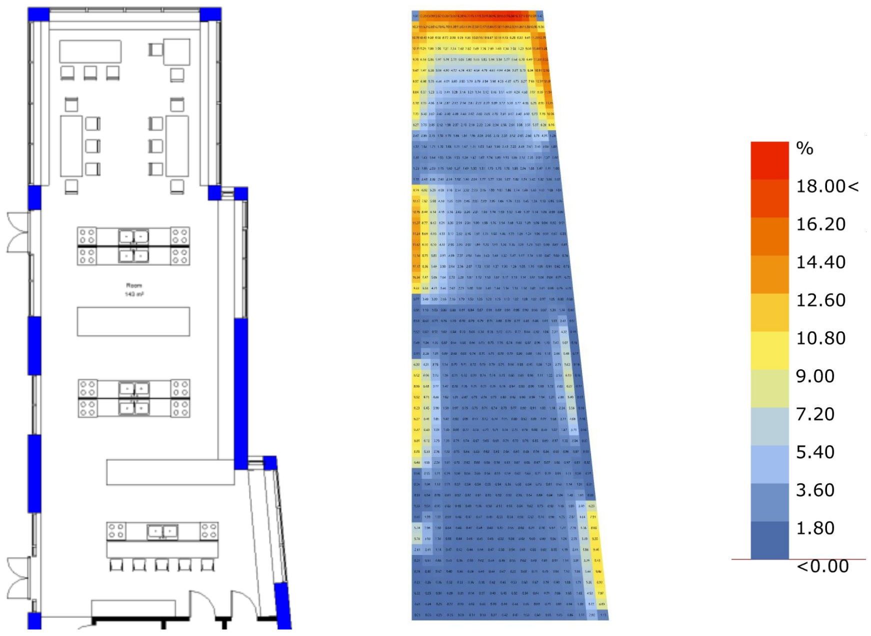
This unit has 16m2 floor area with small kitchen, toilet and bath. The window is facing southeast and recieving the morning sun. Indoor window blinds can be used for the glare issues. Bigger windows were used since it is bigger and provides more daylight for the kitchen area.



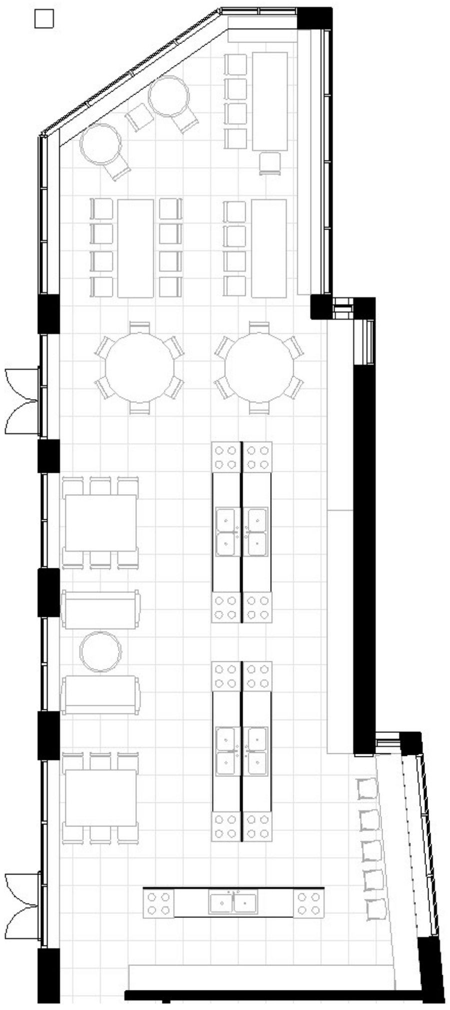
Window facing southeast with bigger room area.

DAYLIGHT ANALYSIS

The kitchen and dining hall on the ground floor has a higher daylight factor because of the big windows where the north-east side of the room gives abundant daylighting as well as a good view of the river and Nidarosdomen. The view outside is a very important consideration in designing a common space.



Prelimenary plan was used as basis for determining the amount of glazing and the DF was simulated using grasshopper.

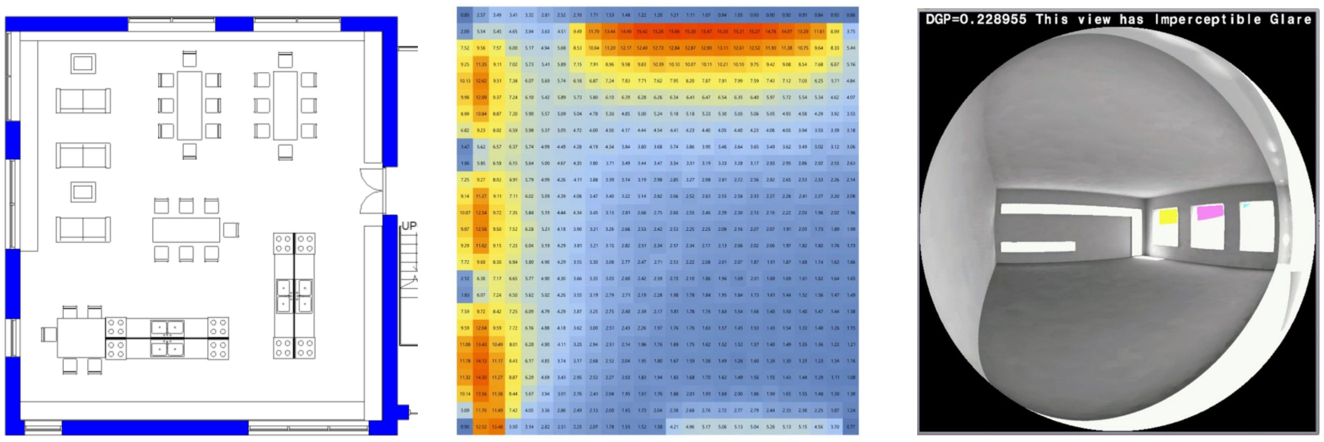


Final kitchen plan at ground level

Illustration of Kitchen with morning sun

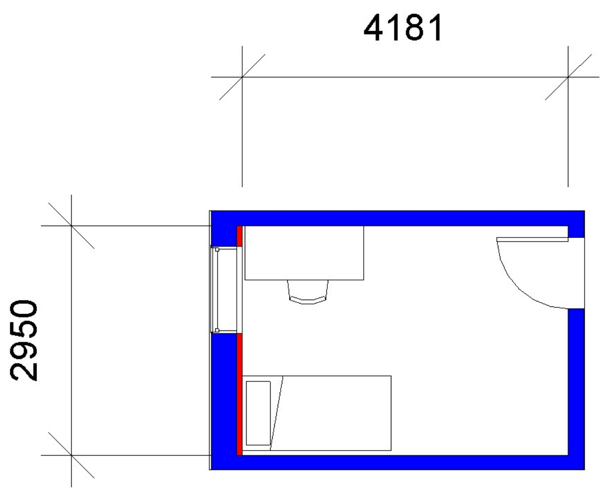
The final plan of the kitchen shows the diagonal wall in the end of the room to open up the backyard making it more inviting and alive. The dining area has a direct view of the Nidelva and Nidarosdomen, and has a direct access to the greeneries along the river. The kitchen also has direct access to the Coop prix food shop on the east side of the builing. The big windows facing the backyard makes the kitchen and dining space as part of the garden where the doors can be openned during summer season to avoid overheating. The water based heating system is used under floor tiles in this common space for dining and cooking. The space is shared by 50 student with 10 cooking plates.

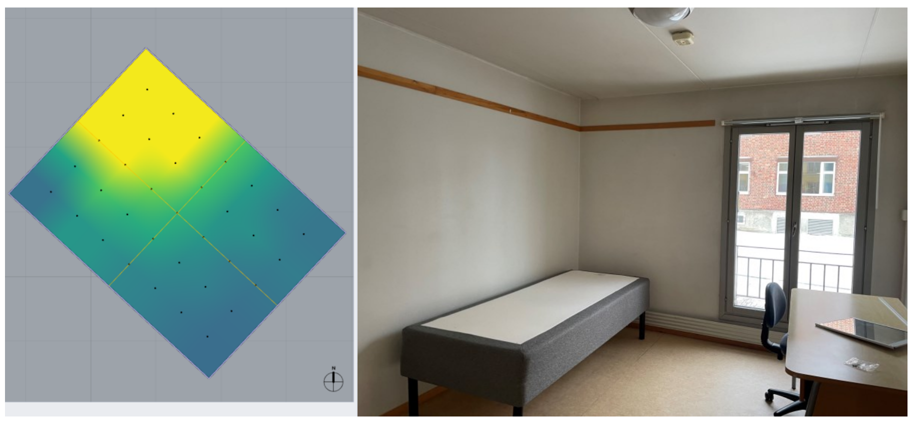
DAYLIGHT ANALYSIS



Kitchen located at plan 4

The kitchen on the fourth floor has daylight factor of 8%. This serves as the common space for the students where more lighting is needed, and windows has automatic outdoor window blinds to avoid overheating. The height of the ceiling is 3meters with 139m2. The view of the mountains and the river north direction of the building is an important consideration in the process of design the additional floor on top of the existing building that will be socially beneficial for the students.





Existing unit facing northwest

Existing unit plan

The blue wall indicates existing wall and the red line indicates the added thermal insulation to comply with the present building requirement.

The existing window size is 1.2mx2.0m and placed on end of the room giving an average daylight factor of 3.9%. All the units facing facing south-east and southwest direction have issues with higher amount of glare but with the use of outdoor automatic window blinds this can solve issues with both glare and direct heat from the sun.

RENEWABLE ENERGY

Radiation analysis

Figure 4 illustrates that the roof is receiving a maximum of 921kWh/m2 of solar radiation during summer while the southwest façade receives 830kWh/m2 on the higher level of the building. Based on this analysis, placing of big windows on the southwest façade was not a very good idea because of the sun exposure during summer. Since the project has already existing bigger windows, these will be replaced with triple glazed windows with U-value of 0.80 with automatic outdoor window blinds to avoid overheating during summer.

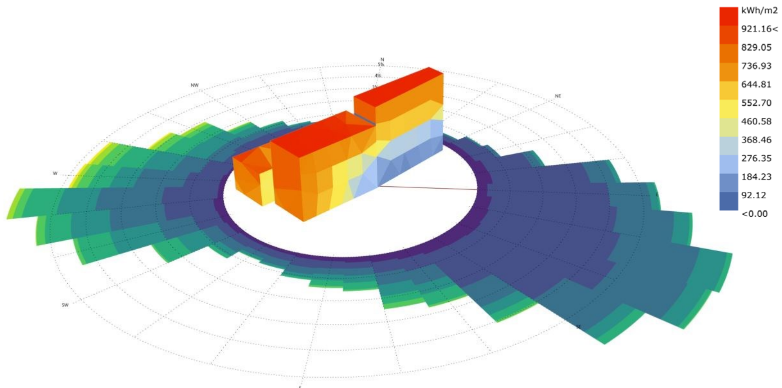
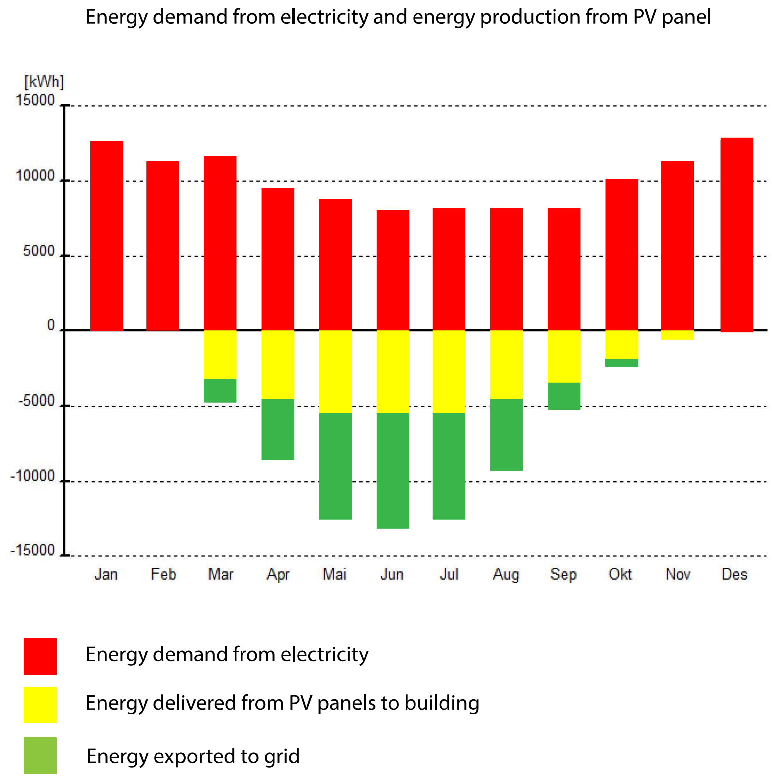


Fig. 4

Photovoltaic Panels

To optimize the amount of radiation from roof, photovoltaic panels facing east-west direction and installed on top of the roof in east and north wing with 490m2 producing a total of 69151kWh per year. The delivered energy is 34101kWh per year and the rest is delivered to the grid. The graph in fig...illustrates the amount of energy produced and delivered from PV panels. The efficiency of PV panels used in the SIMIEN simulation is 20%.

Pv panels 490m2 (20% effeciency)	
Produced energy kWh/yr	69150
Delivered energy kWh/yr	35056
Exported to grid	34094



Geothermal Energy source

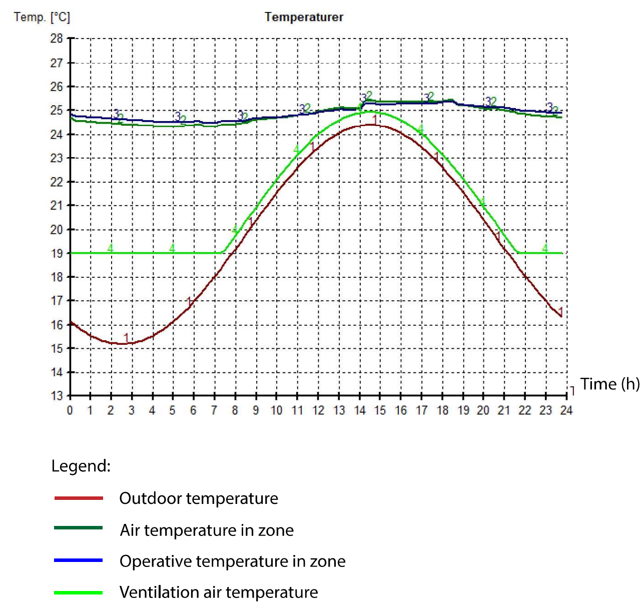
Geothermal energy is more sustainable source of energy where it can supply heating and cooling of air as well as pre heating of domestic hot water for users consumption. Water heating account for 38% of the energy budget for the operational of the student housing. The heat pump gives 25kWh/m2 for domestic hot water and 13.5kWh/m2 for space heating. The specific energy delivered from heat pump is 14.2kWh/m2. The amount of carbon emission from the heat pump is 1.8kgCO2eq/m2.

HEATING SYSTEM

SPACE HEATING

Hydronic radiant floor heating is used in the kitchen in the ground floor level installed under concrete floor. The main advantage of radiant heating is the higher level of comfort and lower energy cost since the system will use the geothermal heat pump. The existing building is using the water-based radiator heating system that is connected to district heating. The existing radiators will still be used, and all the units for the new construction will also have radiators including the toilets with separate controllers so that temperature can be adjusted or turned off when not in use. The washing area and bicycle parking with working space will have radiators and the rest of the basement will not be heated. The coefficient of performance (COP) for heat pump used for the SIMIEN simulation is 3.2 for room heating.

The average temperature during summer is 25.4degrees considereing that there is automatic outdoor window blinds to protect from direct sunlight comming from southwest direction facing Klostergate and southeast direction for the last two levels in the north wing.

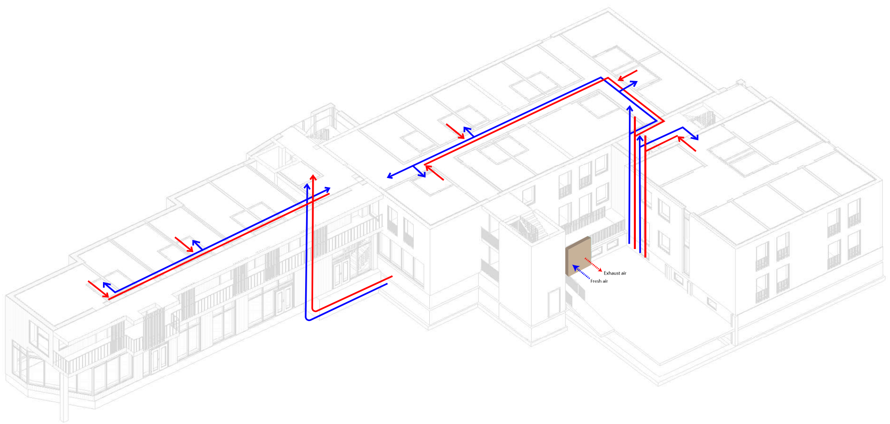


The hourly temperature distribution during summer season.

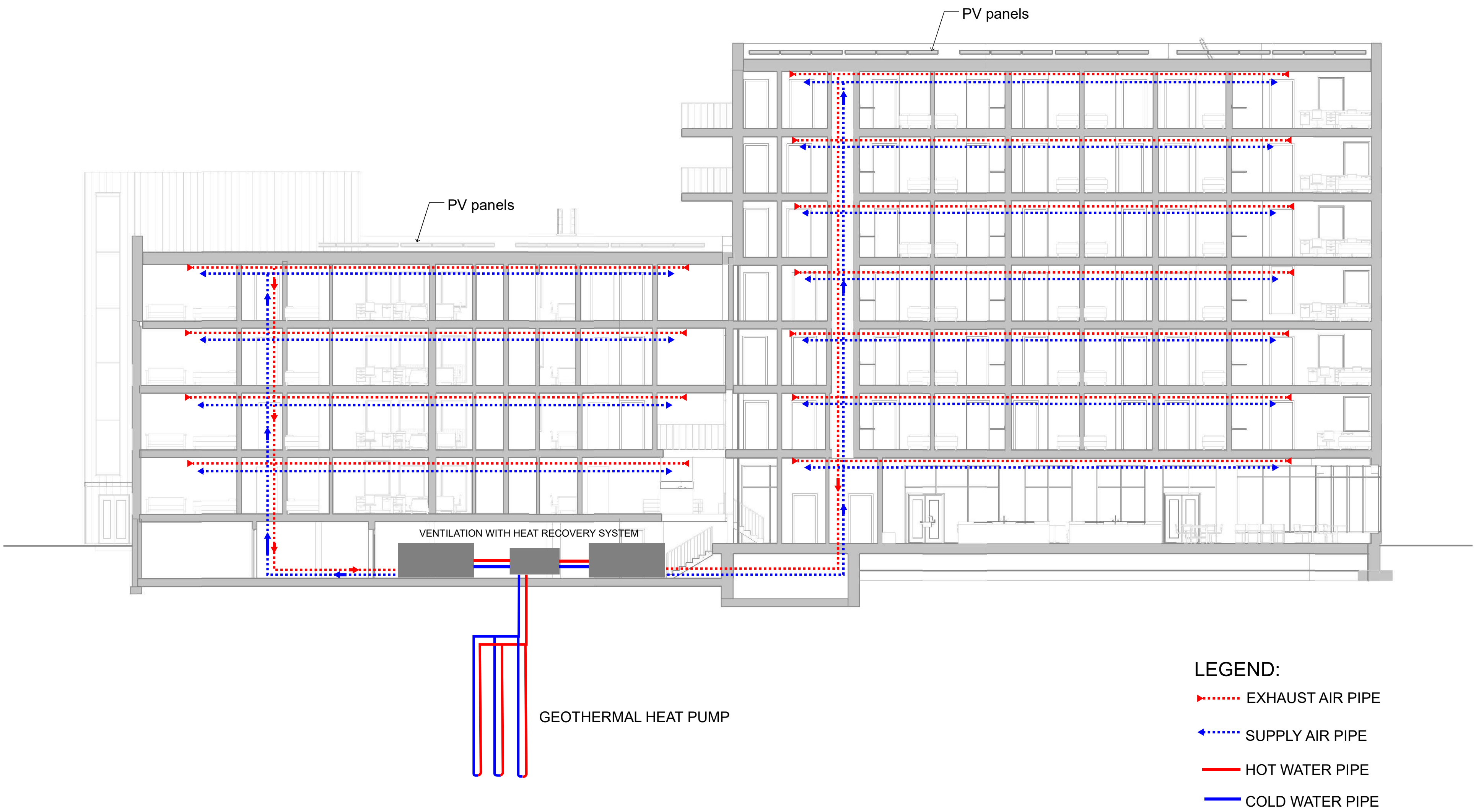
VENTILATION SYSTEM

The building is divided into three wings. The existing building has the east and west wing with four floors including the common kitchen on the west wing on level 4. The new extension is the north wing with six floors for living units and the dining hall and kitchen on the ground level. Hybrid balanced ventilation system is used for a better indoor air quality and the use of the heat recovery saves heating demand during winter. Natural Ventilation is used during summer season since all the windows can be opened including the two common kitchen. Every room has sensor that when the windows are open then the heating system will automatically turn off.

The technical rooms for ventilation, heating and water supply tank are in the basement where the fresh air inlet and exhaust air vent is in the west wing facing the bicycle parking along Schwach gate. Pipes from the basement runs through the ventilation shafts provided in each wing. The air duct in the north wing are located above the main door of each unit where the ceiling height is 20cm lower than the sleeping area while in the east wing runs through the hallway and into the bedrooms. The average air supply is at 2.0m3 per hour per square meter during occupation.



Ventilation distribution principle each level.



Ventilation system with Geothermal heat pump. The fresh air inlet and exhaust air vent is located in west wing facing Schwach gate. Boreholes will be located outside the existing building.

VI. ZEB BALANCE

Operational energy analy-
sys and carbon emission
Emission from materials

OPERATIONAL ENERGY ANALYSIS AND CARBON EMISSION

According to Norwegian building standard (TEK 17) the standard energy demand for building apartment is 95kWh/m2. To minimize the energy demand, different strategies were adopted to this project. The passive house standard (NS3700) was used to save energy demand as well as integrating renewable energy to optimize the solar energy. To determine the energy demand and energy delivered, SIMIEN was used considering the floor to ceiling height is the same for the whole building with a total heated area of 3482m2 and 8460m3 building volume.

The total energy needed is 228778 kWh per year with a specific energy need of 65.7kWh/m2 which is lower than the standard demand of 95kWh/m2 (TEK17). The most energy consumption is from domestic hot water of 86906kWh equivalent to 38% of the energy budget followed by room heating with 46885kWh that accounts for the 21% of the energy budget. See fig. 5.

The total energy delivered to the building is 49890kWh and specific energy delivered is 14.3kWh/m2. The total specific electricity delivered is 20kWh/m2.

Figure 6 shows how much heat is lost from each building element. The higher the heat lost the higher the energy is used.

The amount of carbon emission for the operation is 4.4kg/m2. Since the photovoltaic panels were used, the total amount of carbon was compensated by the amount of energy produced resulting to 1.9 kgC02eq/m2 per year. See fig.7.

Building data

Heated floor area (m2)	3482
Heated volume (m3)	8460
Area roof (m2)	673
Exterior wall area	2650
Exterior wall (U-value)	0,11
Roof (U-value)	0,09
Floor slab (U-value)	0,1
Windows and doors (U-value)	0,8
Window to wall ratio (%)	18
Normalized thermal bridge (W/m2K)	0,03
Ventilation rate (m3/h/m2)	2.0
Heat recovery efficiency	0.86

Annual energy demand and delivered

Annual energy need (kWh/yr)	228778
Annual specific energy need (kWh/m2/yr)	65.7
Annual energy delivered (kWh/yr)	49890
Annual specific energy delivered (kWh/m2/yr)	14.3
Operational carbon emission (kgCO2eq/yr)	6486
Specific annual carbon emission(kgCO2/m/yr)	1.9

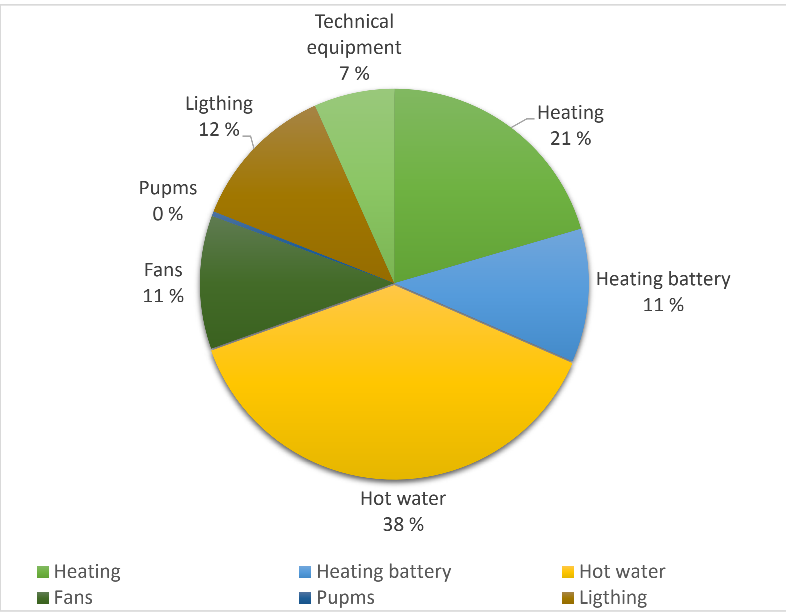


Fig.5 Annual energy demand

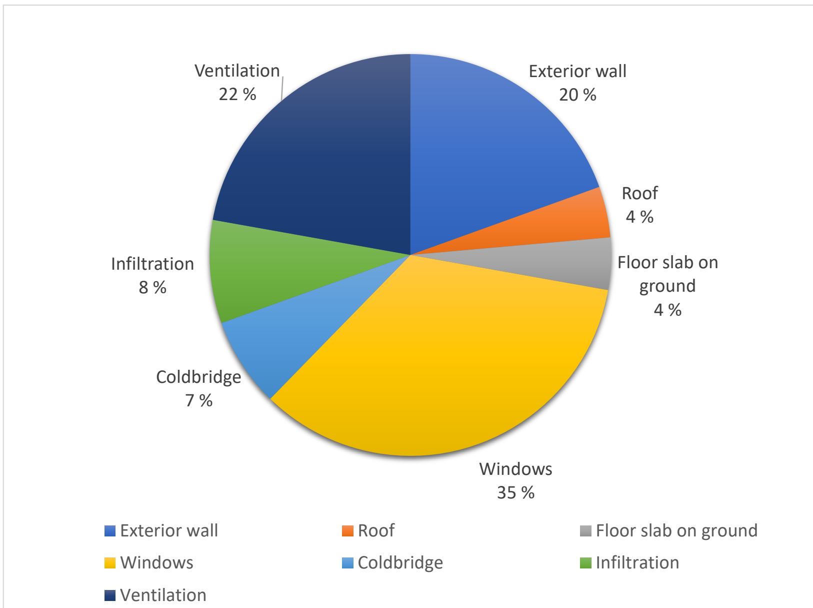


Fig.6 Heatloss budget

Årlige utslipp av CO2		
Energivare	Utslipp	Spesifikt utslipp
1a Direkte el.	9046 kg	2,6 kg/m²
1b El. til varmepumpesystem	6429 kg	1,8 kg/m²
1c El. til solfangersystem	0 kg	0,0 kg/m²
2 Olje	0 kg	0,0 kg/m²
3 Gass	0 kg	0,0 kg/m²
4 Fjernvarme	0 kg	0,0 kg/m²
5 Biobrensel	0 kg	0,0 kg/m²
6. Annen energikilde	0 kg	0,0 kg/m²
7. Solstrøm til egenbruk	-4433 kg	-1,3 kg/m²
Totalt utslipp, sum 1-7	11042 kg	3,2 kg/m²
Solstrøm til eksport	-4556 kg	-1,3 kg/m²
Netto CO2-utslipp	6486 kg	1,9 kg/m²

Fig.7 SIMIEN carbon emission result

EMISSION FROM MATERIALS

The carbon emissions for the proposal are 184758kgCO2 from material production (A1-A3), 93654kgCO2 for replacement (B1-B5), 50380kgCO2 for the waste disposal over 60 years. The direct electricity needed is 69586kWh/year. The total carbon emissions is 1.79kgCO2eq/m2/year.

Based on a study conducted by my fellow student where another scenario was made for the calculation of carbon emissions, refurbishment has a lower result for carbon emission compared to new contruction. Carbon computation for a totally new constructed building using mainly wood materials compared to my proposal refurbishment with extension using wood as main material. It shows that the totally new constructed building has 2.4kgCO2eq/m2/yr while the refurbished proposal has 1,79kgCO2eq/m2/yr. This result shows that by refurbishing the existing building can save 24% of carbon emission from raw materials early stage A1-A3, while the total amount of carbon saved per square meter is 25% including the replacement, waste processing and waste disposal of materials. See fig.8

Base on the table in fig.10 shows that emission from A1-A3 is the highest emission but the flooring roof and ceiling also showing high emission in B5 stage this is because of maintenance and replacement. Some of the elements has average lifspan of 25 to 30 years.

Take note that this emission does not include emission for the A1-A3 for Photovoltaic panel of 490m2 which is 102,900kgCO2. The carbon emission from the PV panels is high but the trade off for the amount carbon from production is compensated by the amount of energy it can give to the operational energy demand of the building. The amount of energy that the PV panels produces for building use is 34101kWh/year resulting to 9.8kWh/m2. A reduction of 1.3kgCO2eq/m2/year for the delivered energy to the building and 1.3kgCO2eq/m2/year for the exported energy to the grid. Research studies shows that PV panels today can reach 96% recycling efficiency and that is why it's becoming more popular and cheaper now a days considering its sustainability.

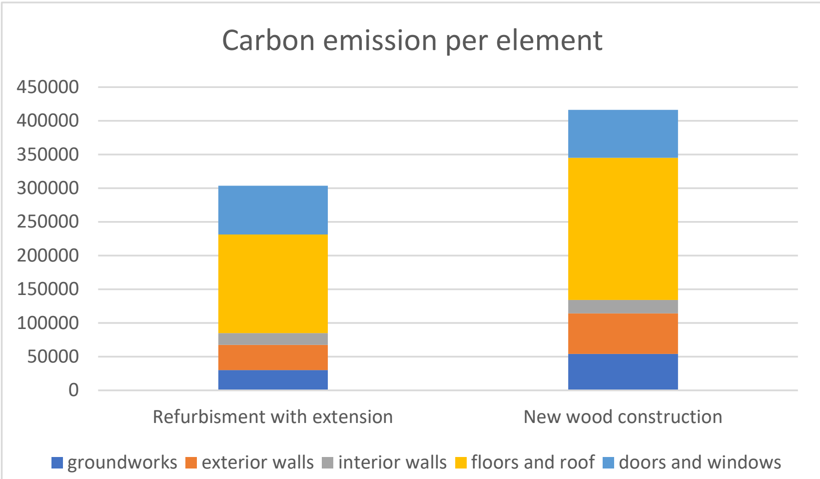


Fig. 8
(Source: Colaboration with Fiona Dy - Thesis report on LCA)
(LCA calculation from Oneclick LCA)

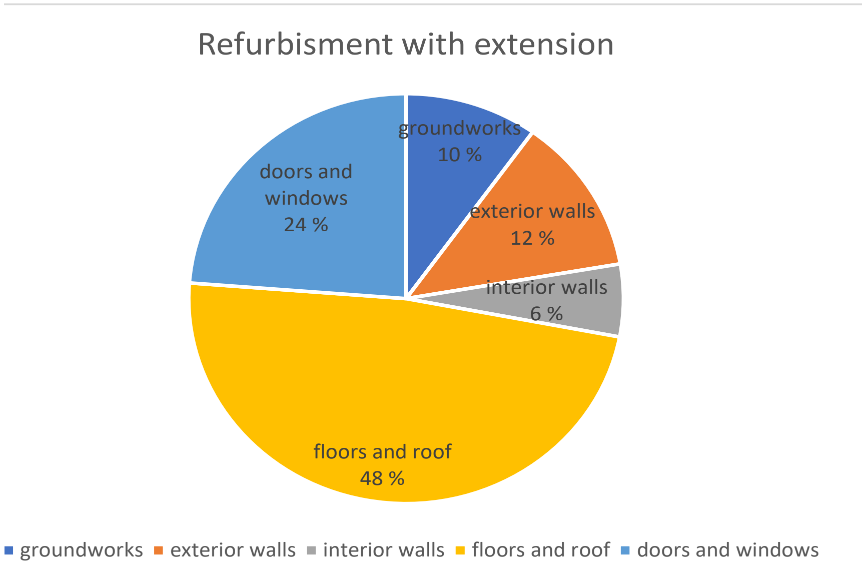


Fig. 9 Carbon emission contribution per element
(Source: Oneclick LCA)

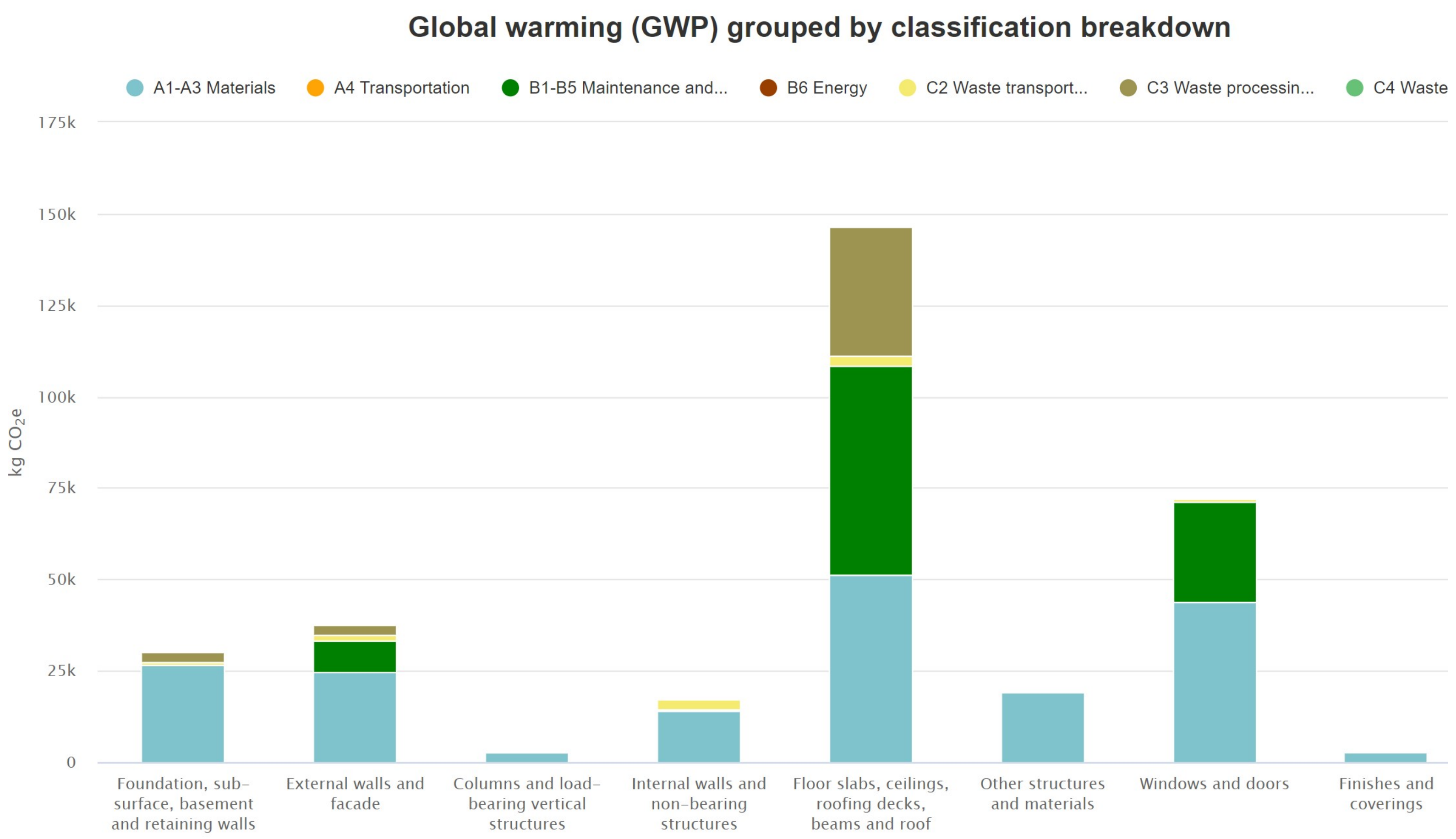


Fig. 10
(Source: Oneclick LCA)

CONCLUSION

The main goal for this proposal is to design a ZERO-emission student housing in Klostergate 56 with 106students. According to a report conducted by Fiona Dy, doing the master thesis about LCA of my proposal, the result for carbon emission shows that refurbishment with extension resulted to 1.79kgCO2eq/m2 for materials used which is 25% lower than the new wooden construction of the same building design. After doing the SIMIEN energy simulation, the carbon emission from energy used is 1.9kgCO2eq/m2 and this is the result using geothermal heat pump for heating and domestic hot water as well as using PV panels as renewable energy source.

Implementing passive house standard NS3700 and using the regulations on technical requirements for building works (TEK17) resulted to a lower environmental impact.

Thorough selection of material with lower GWP combined with material efficiency and recycling is crucial in designing a ZERO emission building. The ventilation system and renewable energy source must be carefully planned to balance the energy used.

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https://www.sit.no/sites/default/files/TUN%20OG%20T%C3%85RN%20med%20MDH%2BArne%20Henriksen%2BMASU_%20A3.pdf

https://oneclicklcaapp.com/app/sec/design/results?childEntityId=6274feef19208721c0c14434&indicatorId=BuildingLifecycleAssess-ment2&entityId=61e6b4a1742c3f0b032c40a8

Energy Manual, *Sustainable Architecture*, Hegger,Fuchs,Stark,Zeumer

refurbish - Life-cycle assessment, EN-15978 Project basic information

Commercial usage is forbidden. One Click LCA Student (International) Business + Carbon Designer, EDUCATION, Marianne Cabildo 17.05.2022 18:43

329 Tons CO_2e | 1.79 kg CO_2e / m^2 / year | 16 45

› Carbon Heroes Benchmark

⌄ Results

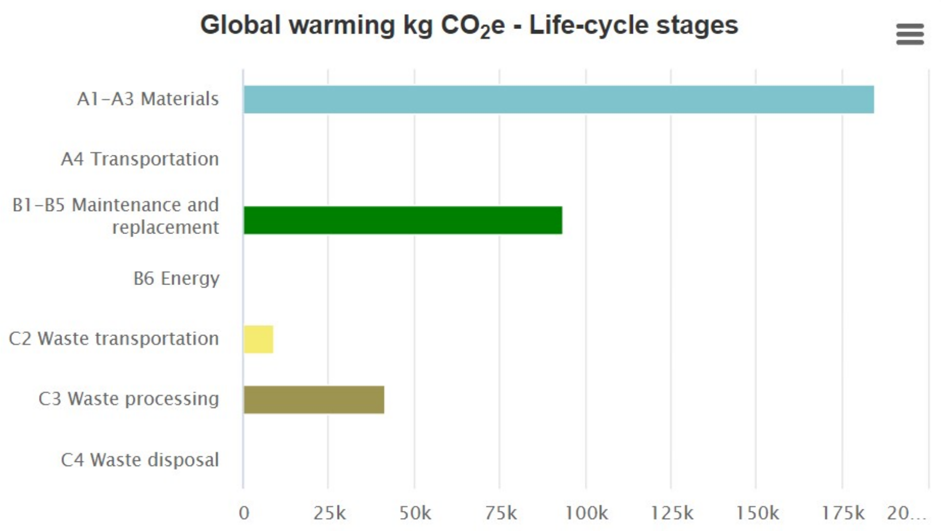
Life-cycle assessment results

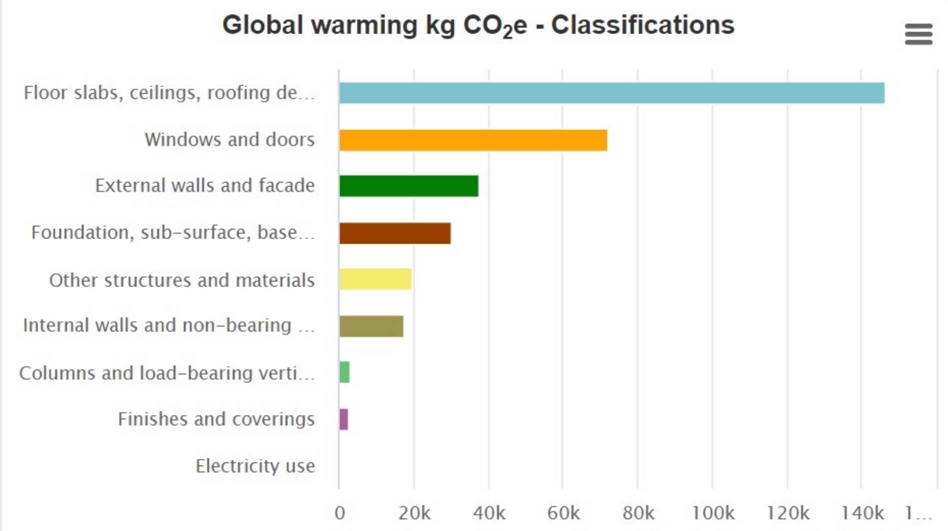
Download Results Summary

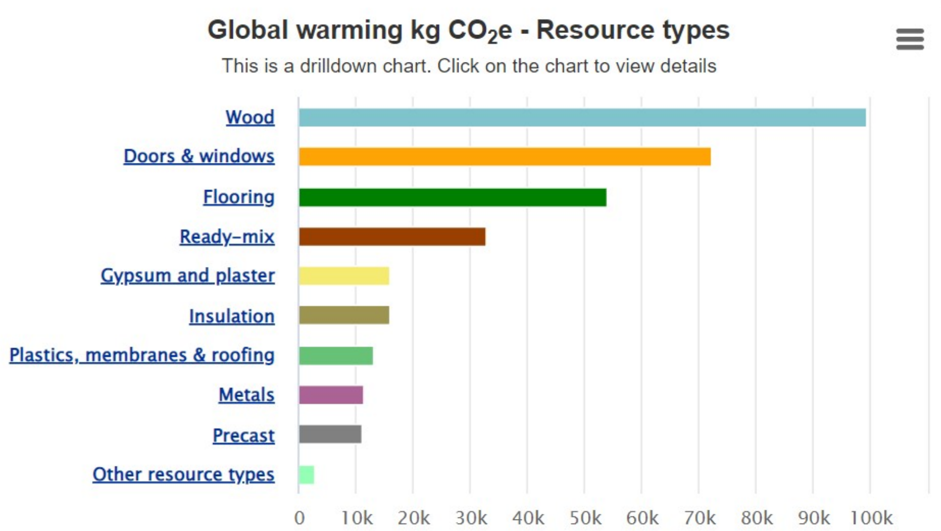
	Result category	Global warming kg CO_2e	Acidification kg SO_2e	Eutrophication kg PO_4e	Ozone depletion potential kg CFC11e	Formation of ozone of lower atmosphere kg Ethenee
A1-A3	Construction Materials	1,85E5	1,32E3	3,08E2	1,89E−2	1,72E2
A4	Transportation to site	1,63E2	7,53E−1	1,64E−1	3,23E−5	9,22E−3
A5	Construction/installation process					
B1-B5	Maintenance and material replacement	9,37E4	1,41E3	2,58E2	1,96E−2	9,66E1
B6	Energy use	5,89E1	2,24E−1	4,32E−2	5,24E−6	1,02E−2
B7	Water use					
C1-C4	End of life	5,05E4	8,33E1	1,86E1	3,17E−3	2,85E0
D	External impacts (not included in totals)	−5,27E4	−3,13E2	−6,88E1	−2,66E−3	−1,97E1
	Total	**3,29E5**	**2,82E3**	**5,85E2**	**4,17E−2**	**2,72E2**
	Results per denominator					
	Oppvarmet bruksareal (oppv. BRA), Norway 3482.0 m^2	9,45E1	8,09E−1	1,68E−1	1,2E−5	7,81E−2
	Gross Internal Floor Area (IPMS/RICS) 3072.0 m^2	1,07E2	9,17E−1	1,9E−1	1,36E−5	8,85E−2
	Number of users 110.0	2.99E3	2.56E1	5.32E0	3.79E−4	2.47E0

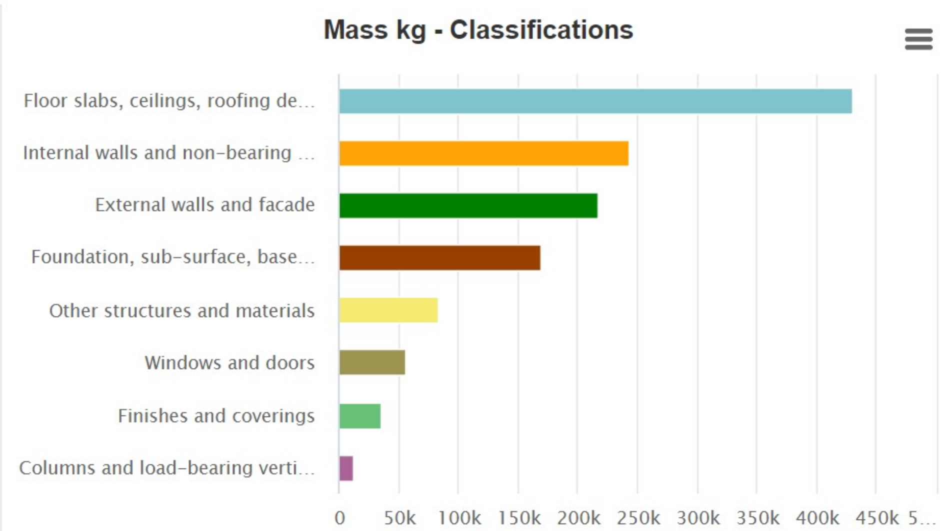
Life-cycle overview of Global warming

Pie | **Bar** | Column | Treemap









Most contributing materials (Global warming)

Compare data (4)

No.	Resource	Cradle to gate impacts (A1-A3)	Of cradle to gate (A1-A3)	Sustainable alternatives	
1.	Ready-mix concrete ?	32 tons CO_2e	17.1 %	Show sustainable alternatives	Add to compare
2.	Top Swing Window ?	25 tons CO_2e	13.3 %	Show sustainable alternatives	Add to compare
3.	Laminated plywood, waterproof ?	23 tons CO_2e	12.3 %	Show sustainable alternatives	Add to compare
4.	Wooden entrance door, per unit ?	13 tons CO_2e	6.9 %	Show sustainable alternatives	Add to compare
5.	Moisture resistant particleboard ?	11 tons CO_2e	6.1 %	Show sustainable alternatives	Add to compare
6.	Steel products, powder coated ?	11 tons CO_2e	6.0 %	Show sustainable alternatives	Add to compare
7.	EPS insulation panels ?	10 tons CO_2e	5.4 %	Show sustainable alternatives	Add to compare
8.	Wood Scots Pine Cladding ?	8,7 tons CO_2e	4.7 %	Show sustainable alternatives	Add to compare
9.	Concrete staircase and intermediate landings ?	7,9 tons CO_2e	4.3 %	Show sustainable alternatives	Add to compare
10.	Gypsum fibreboard ?	7,1 tons CO_2e	3.8 %	Show sustainable alternatives	Add to compare
11.	High pressure laminate floor covering ?	6,2 tons CO_2e	3.3 %	Show sustainable alternatives	Add to compare
12.	Glass wool insulation ?	3,9 tons CO_2e	2.1 %	Show sustainable alternatives	Add to compare
13.	Wooden interior door, per unit ?	3,5 tons CO_2e	1.9 %	Show sustainable alternatives	Add to compare
14.	Plastic vapour control layer ?	3,1 tons CO_2e	1.7 %	Show sustainable alternatives	Add to compare
15.	Aluminium frame glass door ?	3 tons CO_2e	1.6 %	Show sustainable alternatives	Add to compare
16.	Glued laminated timber (Glulam) studs and columns ?	2,7 tons CO_2e	1.4 %	Show sustainable alternatives	Add to compare
17.	Ceramic tiles, Italian average ?	2,6 tons CO_2e	1.4 %	Show sustainable alternatives	Add to compare
18.	Self-leveling screed, fiber-reinforced ?	2,3 tons CO_2e	1.2 %	Show sustainable alternatives	Add to compare
19.	PVC-waterproofing sheet ?	2,2 tons CO_2e	1.2 %	Show sustainable alternatives	Add to compare
20.	Concrete sandwich wall, insulated ?	1,7 tons CO_2e	0.9 %	Show sustainable alternatives	Add to compare
21.	I-joist, wood ?	1,3 tons CO_2e	0.7 %	Show sustainable alternatives	Add to compare
22.	Windbreaker ?	1,2 tons CO_2e	0.6 %	Show sustainable alternatives	Add to compare
23.	Hollow core concrete slab, low-carbon A ?	1,1 tons CO_2e	0.6 %	Show sustainable alternatives	Add to compare
24.	Wooden roofing ?	1 tons CO_2e	0.6 %	Show sustainable alternatives	Add to compare
25.	Radon and moisture membrane for site construction, PP ?	0,55 tons CO_2e	0.3 %	Show sustainable alternatives	Add to compare

Building materials		Amount
cast in situ concrete		171,21 m3
prefabricated concrete		
	wall	11,6 ton
	slab	11,4 ton
	column	0,6 m3
	stairs	31,71 m3
screed		16,61 ton
vapour retarder		8651 m2
waterproofing		203 m2
EPS insulation		5728 m2
gypsum board		16039 m2
mineral wool insulation		41951 m2
vinyl		24 m2
profile sheet		
windows		563,34 m2
wood panel		
	cladding	35,48 m3
	roofing	1,08 m3
wind barrier		1993 m2
moisture resistant particle board		1796 m2
wood sheathing		7655 m2
glue laminated colum		24,29 m3
roof felt		563 m2

INFORMATIONS FROM BYGGFORSK WEBSITE

Tabell A.10 angir summert energimengde per år for varmtvann, teknisk utstyr, personer og belysning for hver bygningskategori.

Tabell A.10 – Energi per år i en normert beregning

Bygningskategori	Varmtvann kWh/(m²·år)	Teknisk utstyr kWh/(m²·år)	Personer kWh/(m²·år)	Belysning kWh/(m²·år)
Småhus	25,0	17,5	13,1	11,4
Boligblokk	25,0	17,5	13,1	11,4
Barnehage	10,0	5,0	16,0	13,0
Kontorbygning	5,0	18,8	13,0	12,5
Skolebygning	5,0	8,8	26,0	9,9
Universitet/høyskole	5,0	15,6	19,0	14,0
Sykehus	15,0	47,0	18,0	29,0
Sykehjem	10,0	23,0	26,0	23,3
Hotellbygning	30,0	6,0	18,0	17,5
Idrettsbygning	10,0	3,0	26,0	14,5
Forretningsbygning	10,0	40,0	38,0	28,1
Kulturbygning	5,0	3,0	9,0	17,2
Lett industri/verksteder	5,0	23,0	5,0	10,5

Terrengskjermingskoeffisienter benyttes i tillegg C for å beregne luftskifte ved infiltrasjon basert på lekkasjetall, n_{50}. Tabell A.11 angir standardverdier for terrengskjermingskoeffisientene.

Tabell A.11 – Standardverdier for terrengskjermingskoeffisientene e og f

Beskrivelse	Koeffisient, e	Koeffisient, f
Alle bygningskategorier og skjermingsklasser	0,07	15

Tabell: Energirammer

Bygningskategori	*Totalt netto energibehov [kWh/m² oppvarmet BRA per år]*
Småhus, samt fritidsbolig over 150 m² oppvarmet BRA	100 + 1600/m² oppvarmet BRA
Boligblokk	95
Barnehage	135
Kontorbygning	115
Skolebygning	110
Universitet/høyskole	125
Sykehus	225 (265)
Sykehjem	195 (230)
Hotellbygning	170
Idrettsbygning	145
Forretningsbygning	180
Kulturbygning	130
Lett industri/verksteder	140 (160)

b) Kravene gitt i parentes gjelder for arealer der varmegjenvinning av ventilasjonsluft medfører risiko for spredning av forurensning eller smitte.

Tabell 421
Isolasjonstykkelser som vanligvis er nødvendig i passivhus[1)]

Bygningsdel	Isolasjonstykkelse (mm)	
Vegg	300–350	
Tak	400–500	
Golv på grunnen	300–400	Avhenger av golvets geometri

B.2.3 *U*- og *g*-verdier på vinduer og solskjerming

Tabell B.2 gir veiledende verdier for *U*-verdi og *g*-verdi på vinduer, glass og solskjerming.

Tabell B.2 – Veiledende verdier for *U*-verdi og *g*-verdi på vinduer, glass og solskjerming

Glasstype	*U*-verdi for vindu W/(m²·K)	*g*, rute	Total solfaktor, g_t		
			Utvendige persienner	Utvendig duk	Innvendig solskjerming
Enkeltglass i treramme	4,8	0,80	0,12	0,18	0,68
2 koblede glass i treramme	2,8	0,75	0,11	0,17	0,64
2-lags energiglass i treramme	2,0	0,70	0,11	0,15	0,60
2-lags solreflekterende glass i treramme	2,0	0,40	0,06	0,09	0,34
3-lags energiglass i treramme	1,6	0,50	0,08	0,11	0,43

Tabell 17
Minstekrav i henhold til NS 3700 og NS 3701

Alle bygningskategorier	Passivhus	Lavenergibygning[2)]
U-verdier for dører og vinduer, se pkt. 41	≤ 0,80 W/(m²K)	≤ 1,2 W/(m²K)
Normalisert kuldebroverdi, se pkt. 42	≤ 0,03 W/(m²K)	≤ 0,05 W/(m²K)
Årsgjennomsnittlig temperaturvirkningsgrad for varmegjenvinner, se pkt. 53	≥ 80 %[1)]	≥ 70 %
SFP-faktor (spesifikk vifteeffekt) for ventilasjonsanlegg, se pkt. 54	≤ 1,5 kW/(m³/s)	≤ 2,0 kW/(m³/s)
Lekkasjetall ved 50 Pa trykkdifferanse, se pkt. 43	≤ 0,60 h⁻¹	Boligbygning[2)]: ≤ 1,0 h⁻¹ Yrkesbygning: ≤ 1,5 h⁻¹
Kun yrkesbygninger	Passivhus og lavenergibygning	
Behovsstyring mht. dagslys, se pkt. 62	Minst 60 % av effekten til belysning behovsstyres	
Behovsstyring mht. tilstedeværelse, se pkt. 62	Minst én styringssone per rom eller per 30 m² i større rom	

1) For bygninger hvor varmegjenvinning medfører risiko for spredning av forurensning eller smitte er minstekravet 70 %.
2) For boligbygninger gjelder kravene for lavenergibygning klasse 1.

1 Byggeforskrift 1987 (BF)

11 Krav til varmeisolering

Byggeforskriftens kapittel 53:2 lyder som følger:

Isolering mot varmetap
Gjennomsnittlig varmegjennomgangskoeffisient (U-verdi) for bygningsdeler skal ikke overstige verdiene i tabell 53:2.
Tabellverdiene for yttervegg gjelder når vindusarealet utgjør høyst 15 % av bygningens bruttoareal etter NS 3940 inntil 5 m fra yttervegg. For bygninger som er bredere enn 10 m kan vindusarealet økes med 3 % av den del av bruttoarealet som ligger mer enn 5 m fra yttervegg.

Tabell 53:2 Varmegjennomgangskoeffisient (U-verdi) for bygningsdeler

Bygningsleder	U-verdi i W/m²K ved innetemperatur		
	> 18 °C 1	10-18 °C 2	0-10 °C 3
Fasader:			
yttervegg	0,30	0,60	0,80
vindu	2,40	3,00	–
dør, port	2,00	2,60	–
Tak	0,20	0,40	0,60
Golv:			
mot det fri	0,20	0,30	0,40
mot ikke oppvarmet rom	0,30	0,50	0,60
på grunnen[1)]	0,30	0,50	0,60

1) For golv direkte på grunnen gjelder kravet både som gjennomsnitt for hele golvet og for et 1 m bredt randfelt langs bygningens yttervegger.

TIMELINE

January
- City scale
- Investigate the site
- Define the scope
- Methodology

February
- Define concept
- Diagrams, sketches, models for rehabilitation using Revit
- Review materials used for the existing building
- Sustainability aspect- preliminary LCA for rehabilitation in collaboration with Fiona
- Daylight simulation for existing building using Rhino and Climate Studio

March
- Refine concept- focus on sustainability, strategies to be used
- Building scale- energy and daylight simulation using Simien, Rhino and climate studio, LCA in collaboration with Fiona
- Architectural design – advance development based on preliminary findings

April
- Develop project details – integrate results from simulations
- Finalize results from daylight, energy and LCA
- Start Model making

May
- Finalized architectural design and details
- Model making final

Klostergata 56, Trondheim
Støyfaglig utredning for detaljregulering, Trondheim
BREKKE STRAND

3.2 Retningslinje T-1442/2016

3.2.1 Grenseverdier

Klima- og Miljødepartementets retningslinje for behandling av støy i arealplanlegging T- 1442/2016 skal legges til grunn ved arealplanlegging og behandling av enkeltsaker etter plan- og bygningsloven. For å tilfredsstille retningslinjens krav til støy på utendørs oppholdsareal og utenfor vinduer for bolig må grenseverdier i tabell 1 oppfylles. Mer utfyllende gjennomgang av T-1442 er gitt i vedlegg.

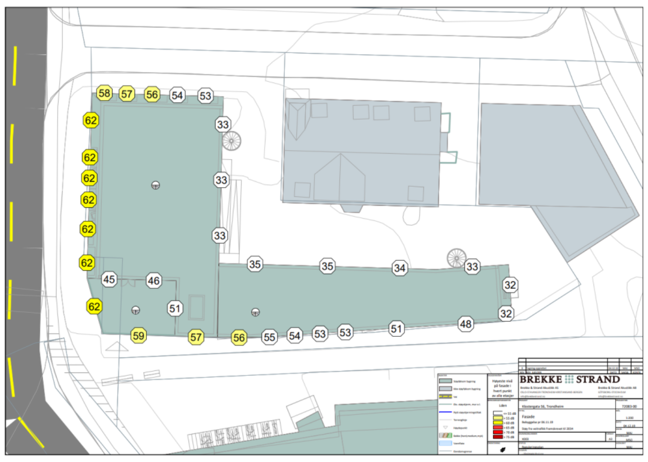
Tabell 1 – Grenseverdier for støy, på utendørs oppholdsarealer og utenfor vinduer, innfallende lydtrykknivå.

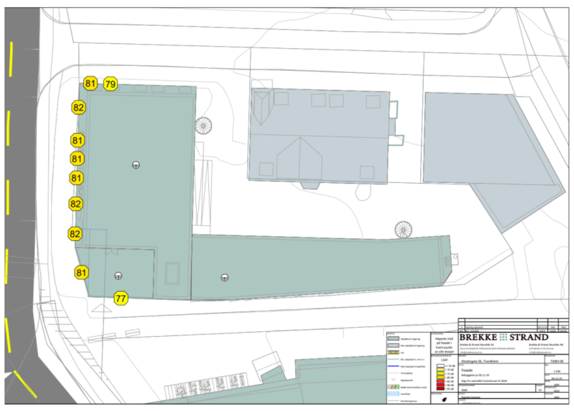
Støykilde	Støynivå på uteoppholdsareal og utenfor vinduer til rom med støyfølsomt bruksformål	Støynivå utenfor soverom, natt kl. 23-07
Vei	L_{den} 55 dB	L_{5AF} 70 dB
Flyplass	L_{den} 52 dB	L_{5AS} 80 dB

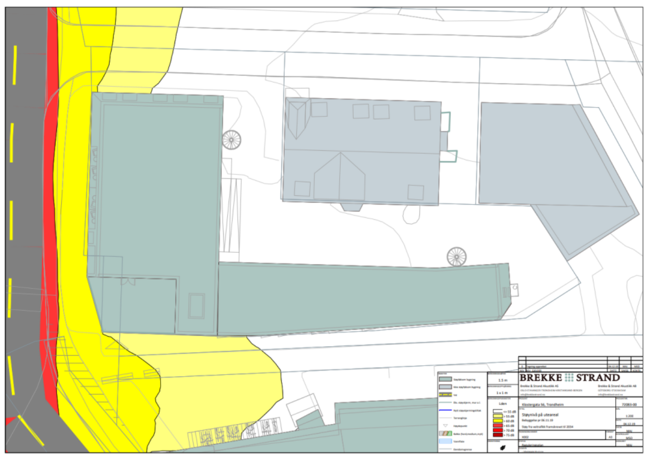
3.2.2 Støysoner

I retningslinje T-1442 opereres det med to typer støysoner for vurdering av arealbruk på overordnet nivå:
Rød sone regnes vanligvis som uegnet til støyfølsomme bruksformål.
Gul sone er en vurderingssone hvor støyfølsomt bruksformål kan oppføres dersom avbøtende tiltak gir tilfredsstillende støyforhold.

Nærmere beskrivelser av støysoner og anbefalinger og unntak fra anbefalingene (avvik) er gitt i vedlegg.







ENERGY SIMULATION DATAS AND RESULTS FROM SIMIEN

SIMIEN
Resultater årssimulering

Simuleringsnavn: Årssimulering
Tid/dato simulering: 08:36 19/5-2022
Programversjon: 6.016
Simuleringsansvarlig: Marianne
Firma: Undervisningslisens
Inndatafil: C:\...\Refurbished Klostergate 56_balanced ventilation.smi
Prosjekt: Klostergate 56
Sone: SIT bygg

Energibudsjett

Energipost	Energibehov	Spesifikt energibehov
1a Romoppvarming	46885 kWh	13,5 kWh/m²
1b Ventilasjonsvarme (varmebatterier)	25401 kWh	7,3 kWh/m²
2 Varmtvann (tappevann)	86906 kWh	25,0 kWh/m²
3a Vifter	25421 kWh	7,3 kWh/m²
3b Pumper	819 kWh	0,2 kWh/m²
4 Belysning	28093 kWh	8,1 kWh/m²
5 Teknisk utstyr	15253 kWh	4,4 kWh/m²
6a Romkjøling	0 kWh	0,0 kWh/m²
6b Ventilasjonskjøling (kjølebatterier)	0 kWh	0,0 kWh/m²
Totalt netto energibehov, sum 1-6	228778 kWh	65,7 kWh/m²

Levert energi til bygningen (beregnet)

Energivare	Levert energi	Spesifikk levert energi
1a Direkte el.	69586 kWh	20,0 kWh/m²
1b El. til varmepumpesystem	49454 kWh	14,2 kWh/m²
1c El. til solfangersystem	0 kWh	0,0 kWh/m²
2 Olje	0 kWh	0,0 kWh/m²
3 Gass	0 kWh	0,0 kWh/m²
4 Fjernvarme	0 kWh	0,0 kWh/m²
5 Biobrensel	0 kWh	0,0 kWh/m²
6. Annen energikilde	0 kWh	0,0 kWh/m²
7. Solstrøm til egenbruk	-34101 kWh	-9,8 kWh/m²
Totalt levert energi, sum 1-7	84940 kWh	24,4 kWh/m²
Solstrøm til eksport	-35050 kWh	-10,1 kWh/m²
Netto levert energi	49890 kWh	14,3 kWh/m²

SIMIEN
Resultater årssimulering

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Dekning av energibudsjett fordelt på energikilder

Energikilder	Romoppv.	Varmebatterier	Varmtvann	Kjølebatterier	Romkjøling	El. spesifikt
El.	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	20,0 kWh/m²
Olje	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²
Gass	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²
Fjernvarme	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²
Biobrensel	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²
Varmepumpe	13,5 kWh/m²	7,3 kWh/m²	25,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²
Sol	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²
Annen	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²
Sum	13,5 kWh/m²	7,3 kWh/m²	25,0 kWh/m²	0,0 kWh/m²	0,0 kWh/m²	20,0 kWh/m²

Årlige utslipp av CO2

Energivare	Utslipp	Spesifikt utslipp
1a Direkte el.	9046 kg	2,6 kg/m²
1b El. til varmepumpesystem	6429 kg	1,8 kg/m²
1c El. til solfangersystem	0 kg	0,0 kg/m²
2 Olje	0 kg	0,0 kg/m²
3 Gass	0 kg	0,0 kg/m²
4 Fjernvarme	0 kg	0,0 kg/m²
5 Biobrensel	0 kg	0,0 kg/m²
6. Annen energikilde	0 kg	0,0 kg/m²
7. Solstrøm til egenbruk	-4433 kg	-1,3 kg/m²
Totalt utslipp, sum 1-7	11042 kg	3,2 kg/m²
Solstrøm til eksport	-4556 kg	-1,3 kg/m²
Netto CO2-utslipp	6486 kg	1,9 kg/m²

SIMIEN
Resultater årssimulering

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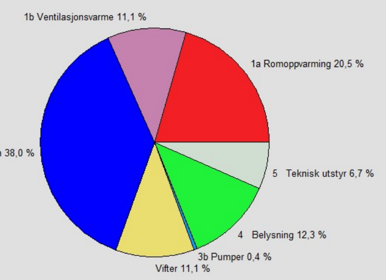
Programversjon: 6.016
Simuleringsansvarlig: Marianne
Firma: Undervisningslisens
Inndatafil: C:\...\Refurbished Klostergate 56_balanced ventilation.smi
Prosjekt: Klostergate 56
Sone: SIT bygg

Årlig energibudsjett



1a Romoppvarming	46885 kWh
1b Ventilasjonsvarme (varmebatterier)	25401 kWh
2 Varmtvann (tappevann)	86906 kWh
3a Vifter	25421 kWh
3b Pumper	819 kWh
4 Belysning	28093 kWh
5 Teknisk utstyr	15253 kWh
6a Romkjøling	0 kWh
6b Ventilasjonskjøling (kjølebatterier)	0 kWh
Totalt netto energibehov, sum 1-6	228778 kWh

SIMIEN
Resultater årssimulering

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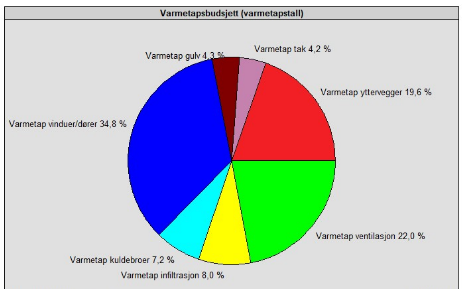
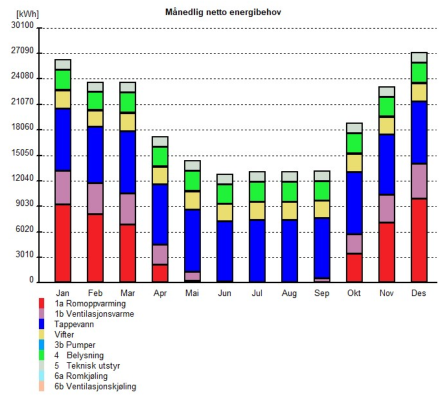
Varmetapsbudsjett (varmetapstall)



Varmetapstall yttervegger	0,08 W/m²K
Varmetapstall tak	0,02 W/m²K
Varmetapstall gulv på grunn/mot det fri	0,02 W/m²K
Varmetapstall glass/vinduer/dører	0,15 W/m²K
Varmetapstall kuldebroer	0,03 W/m²K
Varmetapstall infiltrasjon	0,03 W/m²K
Varmetapstall ventilasjon	0,09 W/m²K
Totalt varmetapstall	0,42 W/m²K

SIMIEN
Resultater årssimulering

Simuleringsnavn: Årssimulering
Tid/dato simulering: 08:36 19/5-2022
Programversjon: 6.016
Simuleringsansvarlig: Marianne
Firma: Undervisningslisens
Inndatafil: C:\...\Refurbished Klostergate 56_balanced ventilation.smi
Prosjekt: Klostergate 56
Sone: SIT bygg



Simuleringsnavn: Årssimulering
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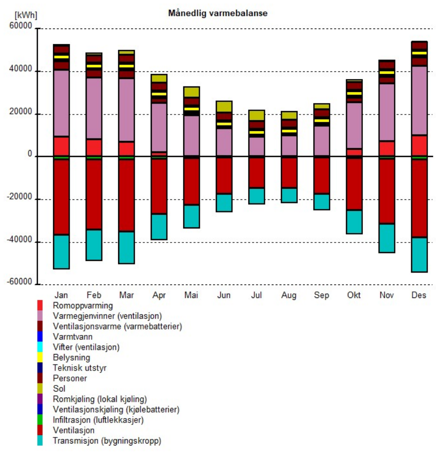

SIMIEN
Resultater årssimulering

Simuleringsnavn: Årssimulering
Tid/dato simulering: 08:36 19/5-2022
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Månedlige temperaturdata (lufttemperatur)

Måned	Midlere ute	Maks. ute	Min. ute	Midlere sone	Maks. sone	Min. sone
Januar	-1,2 °C	8,5 °C	-19,5 °C	19,0 °C	19,3 °C	19,0 °C
Februar	-1,7 °C	9,0 °C	-16,7 °C	19,0 °C	19,4 °C	19,0 °C
Mars	-0,2 °C	10,7 °C	-12,0 °C	19,0 °C	19,5 °C	19,0 °C
April	3,8 °C	14,2 °C	-5,6 °C	19,2 °C	19,9 °C	19,0 °C
Mai	7,4 °C	20,1 °C	-2,4 °C	19,9 °C	21,7 °C	19,0 °C
Juni	11,1 °C	22,7 °C	1,2 °C	21,2 °C	23,0 °C	19,8 °C
Juli	13,8 °C	23,6 °C	4,8 °C	22,0 °C	23,0 °C	21,2 °C
August	13,7 °C	25,0 °C	3,5 °C	21,8 °C	24,5 °C	20,2 °C
September	10,1 °C	20,8 °C	0,6 °C	20,2 °C	22,0 °C	19,0 °C
Oktober	5,2 °C	15,5 °C	-3,3 °C	19,1 °C	19,6 °C	19,0 °C
November	1,0 °C	10,7 °C	-11,1 °C	19,0 °C	19,3 °C	19,0 °C
Desember	-1,9 °C	9,6 °C	-17,6 °C	19,0 °C	19,3 °C	19,0 °C

Månedlige temperaturdata (operativ temperatur)

Måned	Midlere ute	Maks. ute	Min. ute	Midlere sone	Maks. sone	Min. sone
Januar	-1,2 °C	8,5 °C	-19,5 °C	19,0 °C	19,3 °C	19,0 °C
Februar	-1,7 °C	9,0 °C	-16,7 °C	19,0 °C	19,3 °C	19,0 °C
Mars	-0,2 °C	10,7 °C	-12,0 °C	19,1 °C	19,4 °C	19,1 °C
April	3,8 °C	14,2 °C	-5,6 °C	19,2 °C	19,9 °C	19,1 °C
Mai	7,4 °C	20,1 °C	-2,4 °C	19,9 °C	21,6 °C	19,1 °C
Juni	11,1 °C	22,7 °C	1,2 °C	21,3 °C	22,9 °C	20,0 °C
Juli	13,8 °C	23,6 °C	4,8 °C	22,0 °C	23,0 °C	21,4 °C
August	13,7 °C	25,0 °C	3,5 °C	21,9 °C	24,5 °C	20,3 °C
September	10,1 °C	20,8 °C	0,6 °C	20,2 °C	21,9 °C	19,1 °C
Oktober	5,2 °C	15,5 °C	-3,3 °C	19,1 °C	19,6 °C	19,0 °C
November	1,0 °C	10,7 °C	-11,1 °C	19,0 °C	19,2 °C	19,0 °C
Desember	-1,9 °C	9,6 °C	-17,6 °C	19,0 °C	19,2 °C	19,0 °C

Simuleringsnavn: Årssimulering
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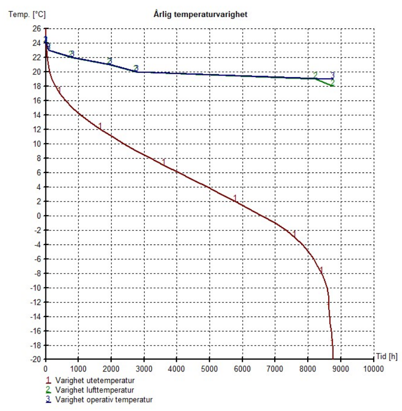

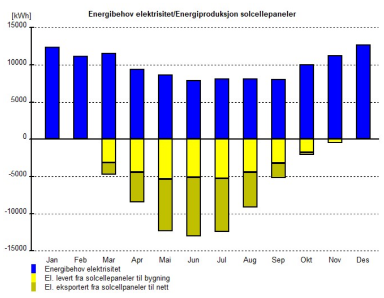

Energiproduksjon solceller [kWh]

Panel	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug	Sep	Okt	Nov	Des	Totalt
Produsert PV panels	0	0	4824	8661	12431	13237	12589	9325	5315	2214	555	0	69150
Levert til bygning	0	0	3213	4554	5411	5244	5362	4558	3320	1883	555	0	34101
Eksportert til nett	0	0	1611	4107	7021	7993	7227	4767	1994	330	0	0	35050

Inndata energiforsyning

Beskrivelse	Verdi
1a Direkte el.	Systemvirkningsgrad romoppv,: 0,81 Systemvirkningsgrad varmtvann: 0,98 Systemvirkningsgrad varmebatterier: 0,89 Kjølefaktor romkjøling: 2,50 Kjølefaktor kjølebatterier: 2,50 Energipris: 0,80 kr/kWh CO2-utslipp: 130 g/kWh Andel romoppvarming: 0,0% Andel oppv, tappevann: 0,0% Andel varmebatteri: 0,0 % Andel kjølebatteri: 100,0 % Andel romkjøling: 100,0 % Andel el, spesifikt: 100,0 %
1b El. til varmepumpesystem	Systemvirkningsgrad romoppv,: 3,20 Systemvirkningsgrad varmtvann: 3,30 Systemvirkningsgrad varmebatterier: 3,00 Kjølefaktor romkjøling: 2,50 Kjølefaktor kjølebatterier: 2,50 Energipris: 0,80 kr/kWh CO2-utslipp: 130 g/kWh Andel romoppvarming: 100,0% Andel oppv, tappevann: 100,0% Andel varmebatteri: 100,0 % Andel kjølebatteri: 0,0 % Andel romkjøling: 0,0 % Andel el, spesifikt: 0,0 %

Dokumentasjon av sentrale inndata (1)

Beskrivelse	Verdi	Dokumentasjon
Areal yttervegger [m²]:	2650	
Areal tak [m²]:	673	
Areal gulv [m²]:	726	
Areal vinduer og ytterdører [m²]:	634	
Oppvarmet bruksareal (BRA) [m²]:	3482	
Oppvarmet luftvolum [m³]:	8460	
U-verdi yttervegger [W/m²K]	0,11	
U-verdi tak [W/m²K]	0,09	
U-verdi gulv [W/m²K]	0,09	
U-verdi vinduer og ytterdører [W/m²K]	0,80	
Areal vinduer og dører delt på bruksareal [%]	18,2	
Normalisert kuldebroverdi [W/m²K]:	0,03	
Normalisert varmekapasitet [Wh/m²K]	87	
Lekkasjetall (n50) [1/h]:	0,60	
Temperaturvirkningsgr. varmegjenvinner [%]:	86	

Dokumentasjon av sentrale inndata (3)

Beskrivelse	Verdi	Dokumentasjon
Driftstid kjøling (timer)	0,0	
Driftstid ventilasjon (timer)	24,0	
Driftstid belysning (timer)	17,0	
Driftstid utstyr (timer)	10,0	
Oppholdstid personer (timer)	24,0	
Effektbehov belysning i driftstiden [W/m²]	1,30	
Varmetilskudd belysning i driftstiden [W/m²]	1,30	
Effektbehov utstyr i driftstiden [W/m²]	1,20	
Varmetilskudd utstyr i driftstiden [W/m²]	0,72	
Effektbehov varmtvann på driftsdager [W/m²]	2,85	
Varmetilskudd varmtvann i driftstiden [W/m²]	0,00	
Varmetilskudd personer i oppholdstiden [W/m²]	1,50	
Total solfaktor for vindu og solskjerming:	0,04	
Gjennomsnittlig karmfaktor vinduer:	0,20	
Solskjermingsfaktor horisont/utspring (N/Ø/S/V):	0,41/1,00/0,43/0,63	

Inndata CAV

Beskrivelse	Verdi
Navn:	Ventilasjon (CAV ventilasjon)
Ventilasjonstype	Balansert ventilasjon
Driftstid	24:00 timer drift pr døgn
Luftmengde	I driftstiden: tilluft = 2.0 m³/hm², avtrekk = 2.0 m³/hm² Utenfor driftstiden: tilluft = 2.0 m³/hm², avtrekk = 1.2 m³/hm² Helg/feridag: tilluft = 2.0 m³/hm², avtrekk = 1.2 m³/hm²
Tilluftstemperatur	19.0 °C
Varmebatteri	Ja Maks. kapasitet: 8 W/m²
Vannbåren distribusjon til varmebatteri	Delta-T: 20.0 °C SPP: 0.5 kW/(l/s)
Kjølebatteri	Nei
Varmegjenvinner	Ja, temperaturvirkningsgrad: 0.86
Vifter	Plassering tilluftsvifte: Etter gjenvinner Plassering avtrekksvifte: Etter gjenvinner
SFP-faktor vifter	1.50 kW/m³/s

Dokumentasjon av sentrale inndata (2)

Beskrivelse	Verdi	Dokumentasjon
Estimert virkningsgrad gjenvinner justert for frostsikring [%]:	86,0	
Spesifikk vifteeffekt (SFP) [kW/m³/s]:	1,50	
Luftmengde i driftstiden [m³/hm²]	2,00	
Luftmengde utenfor driftstiden [m³/hm²]	0,00	
Systemvirkningsgrad oppvarmingsanlegg:	3,22	
Installert effekt romoppv. og varmebatt. [W/m²]:	23	
Settpunkttemperatur for romoppvarming [°C]	19,0	
Systemeffektfaktor kjøling:	2,50	
Settpunkttemperatur for romkjøling [°C]	0,0	
Installert effekt romkjøling og kjølebatt. [W/m²]:	0	
Spesifikk pumpeeffekt romoppvarming [kW/(l/s)]:	0,50	
Spesifikk pumpeeffekt romkjøling [kW/(l/s)]:	0,00	
Spesifikk pumpeeffekt varmebatteri [kW/(l/s)]:	0,50	
Spesifikk pumpeeffekt kjølebatteri [kW/(l/s)]:	0,00	
Driftstid oppvarming (timer)	24,0	

Inndata bygning

Beskrivelse	Verdi
Bygningskategori	Boligblokker
Simuleringsansvarlig	Marianne
Kommentar	

Inndata klima

Beskrivelse	Verdi
Klimasted	Trondheim
Breddegrad	63° 30'
Lengdegrad	10° 22'
Tidssone	GMT + 1
Årsmiddeltemperatur	5,1 °C
Midlere solstråling horisontal flate	102 W/m²
Midlere vindhastighet	4,6 m/s