Rødovre Town Hall

ARC6841 SUSTAINABLE ARCHITECTURE DESIGN PROJECT 1

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Deep Retrofit

"We cannot tell our grandchildren that we failed

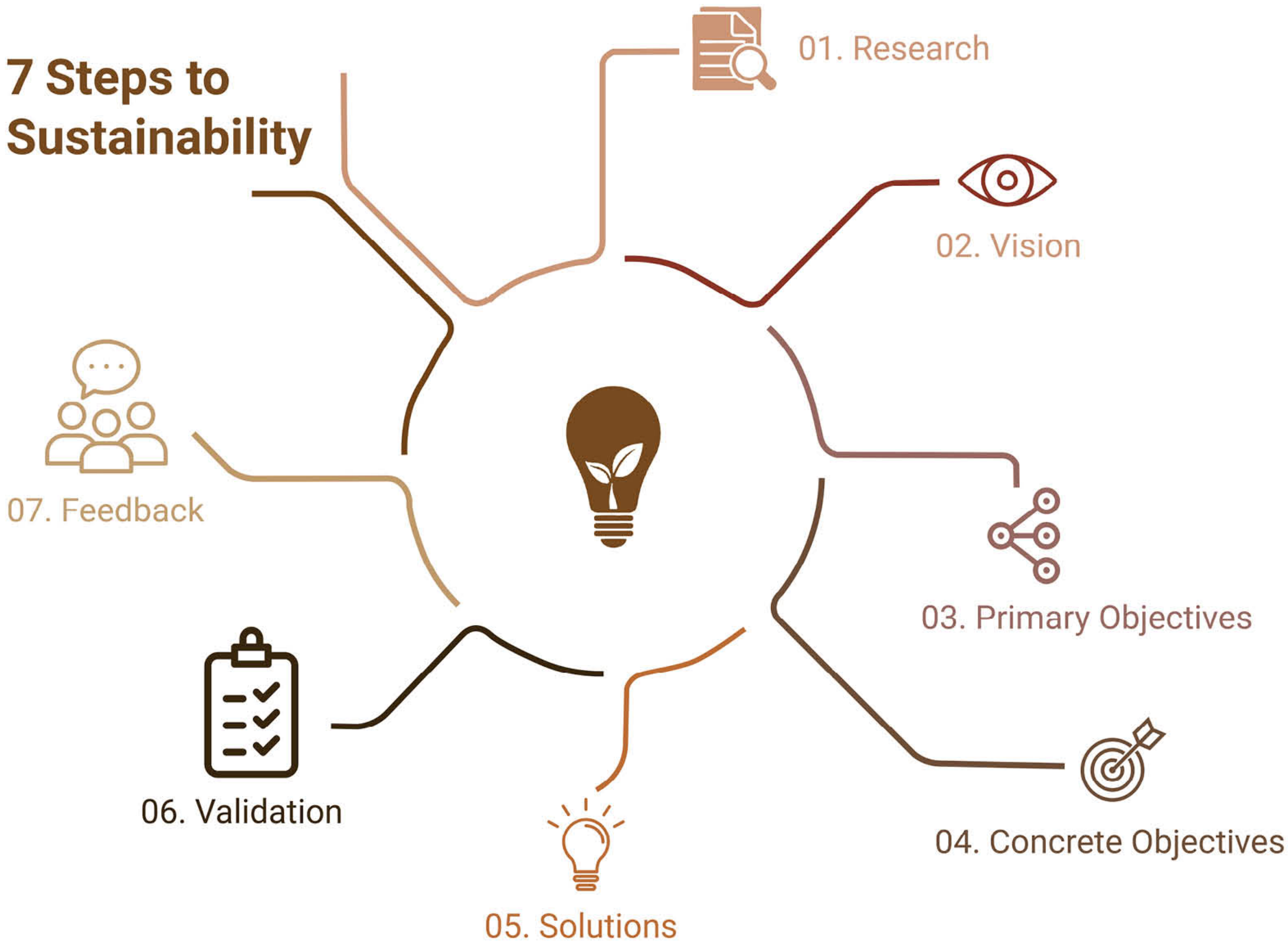
to protect the planet because we were too focused

on protecting our own well-being.

We must act now."

CEO, Henrik Poulsen

CONTENTS

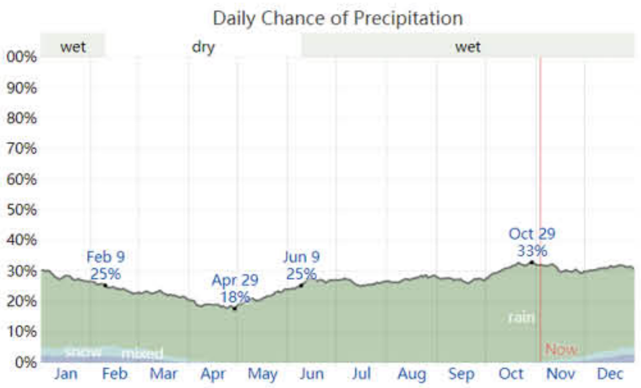

7 Steps to Sustainability
01. Research
02. Vision
03. Primary Objectives
04. Concrete Objectives
05. Solutions
06. Validation
07. Feedback

01. Research

1.1.1 Climatic Conditions in Copenhagen, Denmark

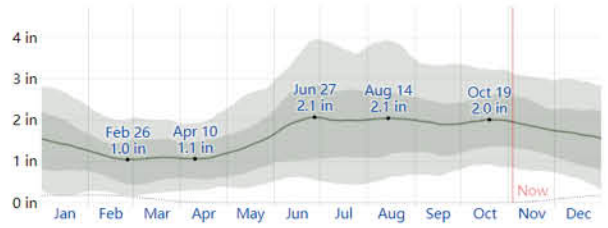
Climate Condition of the Region

Precipitation Level



Precipitation is around 30% throughout the year.

Rainfall Level

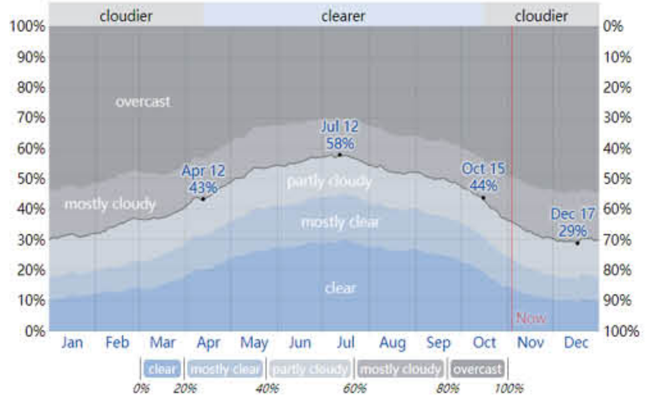


The wetter season lasts 8.0 months, from June 9 to February 9, with a greater than 25% chance of a given day being a wet day. The chance of a wet day peaks at 33% on October 29.

Sunshine Hours

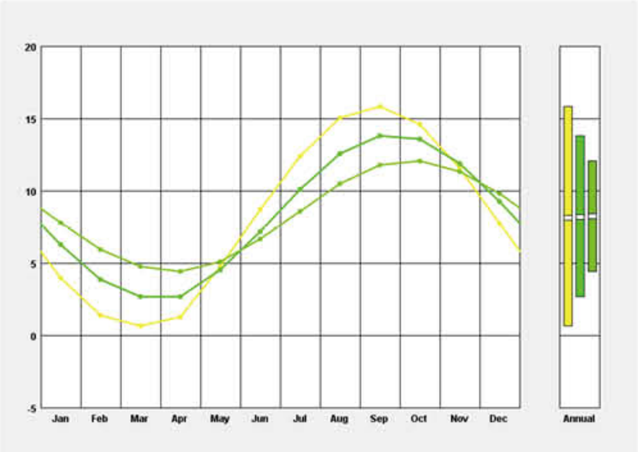
The length of the day in Copenhagen varies extremely over the course of the year. In 2020, the shortest day is December 21, with 7 hours, 1 minute of daylight; the longest day is June 20, with 17 hours, 32 minutes of daylight.

Sky Cover Range



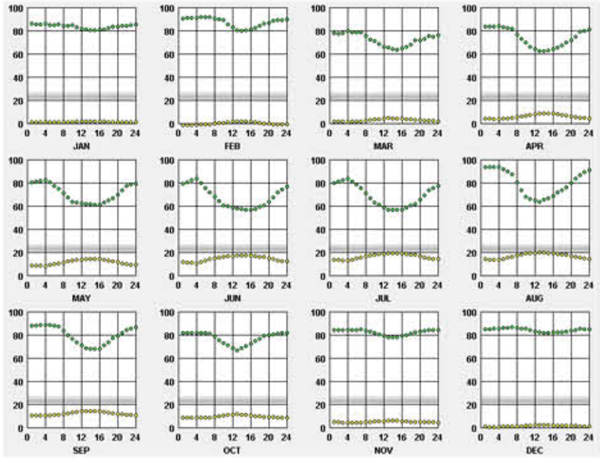
The sky is densely clouded throughout the year.

Ground Temperature



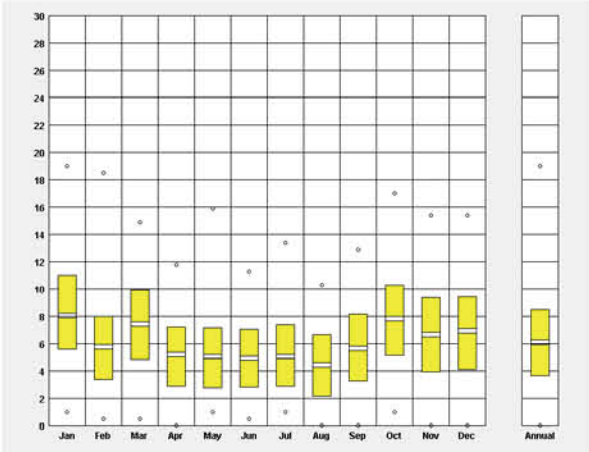
At the depth of 4 m under the soil, the surface temperature tends to be more stable and the range of temperature change is the smallest.

Dry Bulb x Relative Humidity



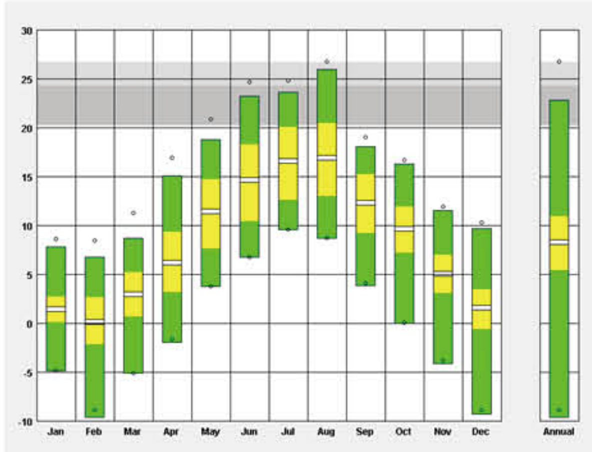
Relative Humidity is very high to dry bulb temperature.

Wind Velocity



Annual Mean Velocity is around 20 m/s.

Temperature Range



Annual Mean Temperature range is around 7C.

Summary:

Results from Climate Simulation suggestion:
1. Wind Protection of Building
2. Internal Heat Gain
3. Passive Solar Direct Gain
4. Dehumdification

Site is located in Denmark.Denmark is a Scandavian Country and located in northern Europe.

References:

Wikipedia,Simulations are from Climate Consultant

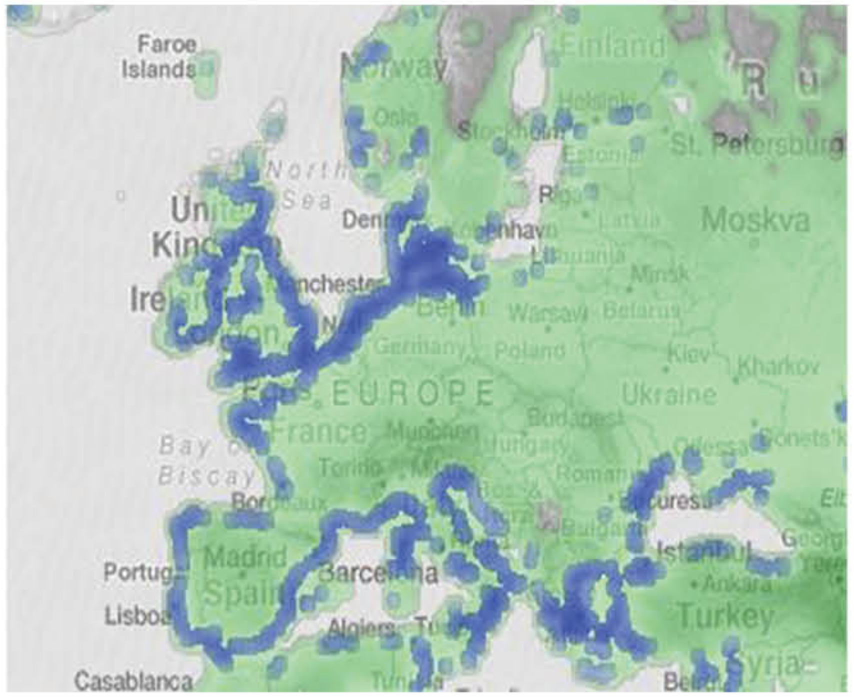
1.1.2 Future Climatic Change Projections

Research | Climate

Located in Northern Europe, Denmark consists of many islands and peninsula of Jutland. The whole country is a low land. The surface is formed by Ice Age glaciers and glacial streams. the coastline has a length of 7100 km

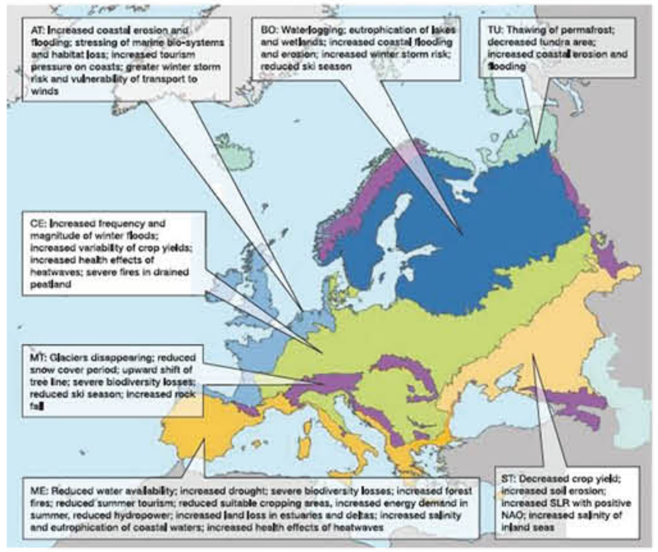
Danish climate is temperate, with mean annual temperature 7.7 degree Celsius. The country experiences precipitation throughout the year with mean annual precipitation of 712mm. the mean annual wind velocity is 6 miles per hour.

Rodovre is located in eastern Denmark. In northern and eastern Denmark uplift of land is in line with the rise in sea level.



Change in coast line, due to rise in sea level.

Global mean sea level rose by around 17cm over the twentieth century, driven mostly by thermal expansion and melting glaciers associated with anthropogenic global warming. Over the last Century, a linear trend of 4cm per century can be observed in Copenhagen water level data from coastal authority.



Key vulnerabilities of European systems and sectors to climate change during the 21st century for the main biogeographic regions of Europe.

Scenario	A2		B2		EU2C	
Year	2006-2035	2071-2100	2006-2035	2071-2100	2006-2035	2071-2100
Land						
Annual average temperature	**+0.6° C**	**+3.1° C**	**+0.7° C**	**+2.2° C**	**+0.7° C**	**+1.4° C**
Winter temperature	+0.6° C	+3.1° C	+0.7° C	+2.1° C	+1.0° C	+2.0° C
Summer temperature	+0.5° C	+2.8° C	+0.6° C	+2.0° C	+0.7° C	+1.3° C
Annual precipitation	**+2 %**	**+9 %**	**+2 %**	**+8 %**	**0 %**	**0 %**
Winter precipitation	+8 %	+43 %	+6 %	+18 %	0 %	+1 %
Summer precipitation	-3 %	–15 %	-2 %	–7 %	-2 %	–3 %
Maximum daily precipitation	+4 %	+21 %	+5 %	+20 %	+11 %	+22 %
Seas						
Average wind speed	+1 %	+4 %	+1 %	+2 %	+1 %	+1 %
Maximum sea level on the west coast		+0.45-1.05 m				
Both sea and land						
Maximum storm force	+2 %	+10 %	0 %	+1 %	+1 %	+1 %

Estimated Danish climate change expressed as the change compared to 1961-1990 for the three climate scenarios.

The climate changes, that the three scenarios give rise to in Denmark in the short and long terms, have been mapped out by DMI. The table shows that we can expect a warmer climate under all three scenarios. Since 1873, the temperature in Denmark has risen by about 1.5°C and precipitation has increased by about 15%.

Effect of Change in Climate Condition

These will lead to following changes:

1. More warm Summer
2. Strong Winds
3. Milder Winters
4. Low Crop Yeilds
5. Changes in Bio diversity

References:

1. http://globalfloodmap.org/Denmark
2. http://www.eea.europa.eu
3. DMI

1.1.3 Future Climatic Change Projections | Urban Flooding

The Danish coastline has a perimeter of 4 605 km and it border with the Baltic Sea on the east and the North Sea on the west. On the western side of the coastline Denmark consists of a large main peninsula named Jutland. The country consists also of many secondary islands such as Zealand and Lolland and its hundreds minor islands often referred to as the Danish Archipelago.

The Danish Meterological Institute (DMI) has created a Climate Atlas based on both own and IPCC data to show the impact of climate changes upon the country.

From these researches, it came out that Copenhagen, as a low-lying city, is vulnerable to coastal and urban flooding. In general, in the last 115 years it has been measured a risen of the sea level.

Change of the Danish coast line with the rise of the sea level of 10 ft.

Change of the Danish coast line with the rise of the sea level of 5 ft.

Analyses carried out by following both global and regional
climate models demonstrated some main changes in the Danish climate between the period of 2071-2100 in relation to 1961-1990.
1. An increase of 10-40% of precipitation during winter and a reduction of 10-25% in summer precipitation.
2. A tendency towards havier rainfall during midseasons
3. The possible highest sea level in the more extreme cases could rise by 5-10% relative to today which is about 0.3 m on the west caused (as shown in the figures aove).
(Danish Ministry of the Environment, 2005)

The figure below show the municipalities of Denmark that are at risk of future flooding.
The Danish governament has not taken any coastal defence measure to protect against flooding and extreme weather events but it plans to undertake them only when there will be a concrete need for it.
Therefore, some adaptation actions have been taken on a sub-national level from single Danish municipalities.

Physical and socio-economic indicators	North sea	Baltic Sea
Sea Level Rise	High	Low
Coastline length	4 605 km	
10 km coastal zone below 5 metres elevation	22%	
Coastline subject to erosion	607 km (13%)	
GDP in 50 km zone (€ million)	104 043 (72%)	
Population in 50 km zone	5 397 640 (100%)	

Copenhagen Plan of Action:

'What we are creating is a new infrastructure that works alongside the regular sewer system. Sewage will be in the sewers; water will be in the parks'. Lykke Leonardsen, the Head of Copenhagen's Climate Unit.

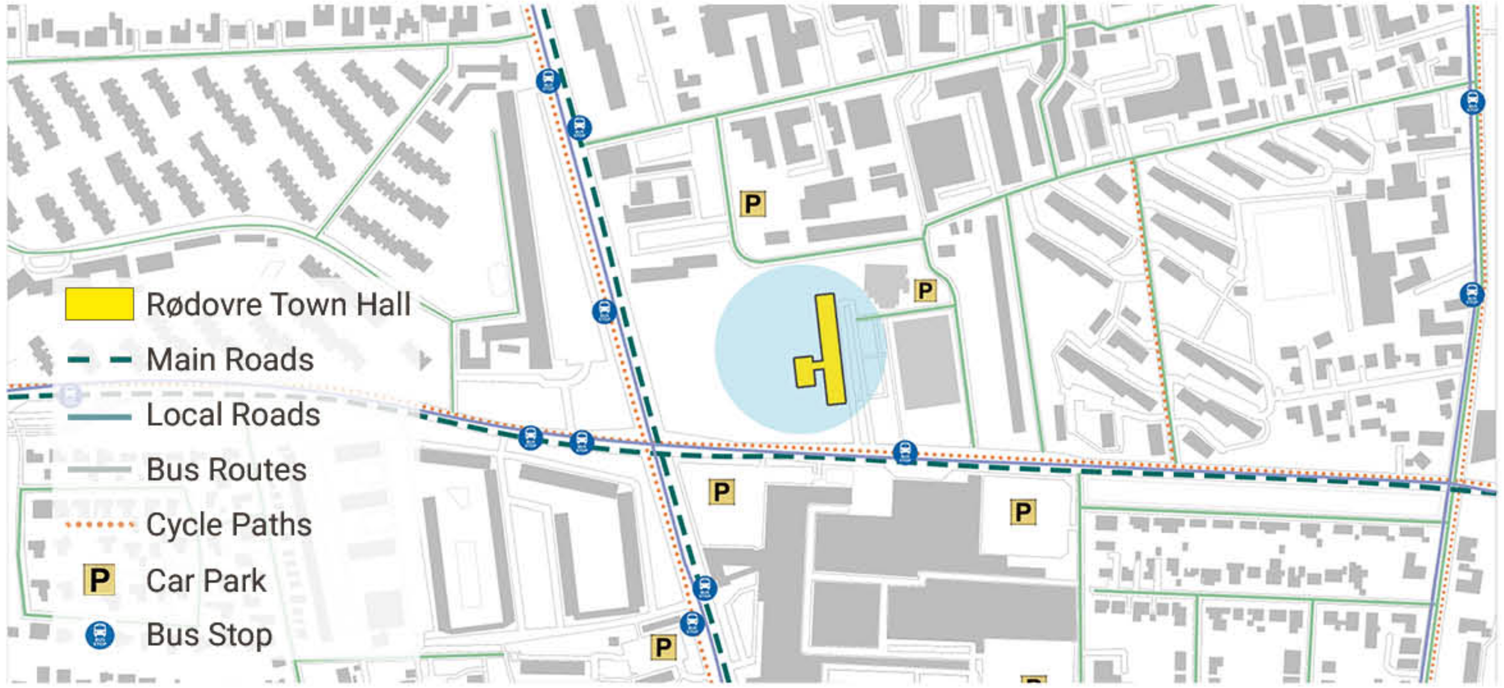
The strategy adopted by Copenhagen consists of the redesign of parks with artificial hill, new trees and lowering of the level of the park. In case of urban flooding, the low-lying parks will trap the water away from buildings. City planners in Copenhagen call this strategy 'pocket parks'.
' Pocket parks are a unique opportunity to create drops of urban green close to where Copenhageners live' Klaus Bondam, Mayor for Technical and Environmental Administration, City of Copenhagen

1.2.1 City Mapping and Site Introduction

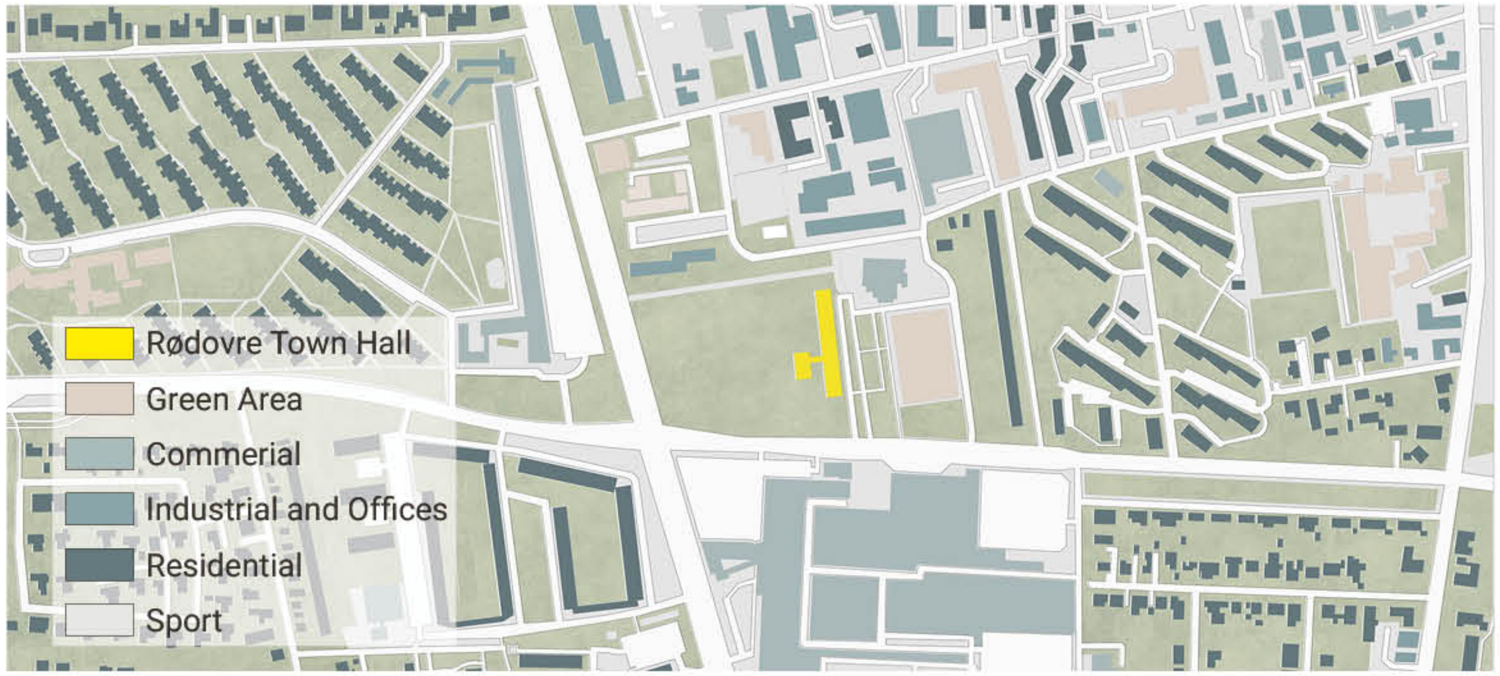
Research | Site Analysis

City Mapping

Transportation and Access to Site



Site and Sorrounding Functions



Summary:

The Town Hall is located on the west side of a public square.The library is situated on the east side of the square and its entrance faces the entrance of the town hall.On the south side of the public square there is a main road, Rødovre Parkvej, and opposite to it, there is a shopping complex. On the west dife of the site there is a green area that separtes the Town Hall with another main road, Tarnvej.The site has a great access to public transportation and it is also easily accessible by foot or cycle.Noise pollution does not represent a major problem of the site. In fact, the adjacent roads are not busy and the neighbourhood is mainly residential.

1.2.2 Topography and Demographic Structure

Geologiocal Map

1.Distribution of geological features in Rødovre

2.Thickness of quaternary clay deposits

3. Areas of action for groundwater protection

Figure 1 represents the primary source of information for various aspects of land-use planning, including the siting of building and transportation systems. The site is characterized by a soil made of boulder clay, which is formed out of the ground moraine material of glaciers and ice-sheets.
Figure 2 shows that the clay layer thickness in most of Rødovre is between 5-15 m.
Clay textures are often more stable than sand textures because they have better structure. However, a mix of particle sizes (and pore sizes) is best for engineering (just as it is best for growing crops). It is also important that soil is stable through wetting and drying cycles, so that expanding soil does not crack roads or foundations.

Topographic Map

FIGURE 4: Topography of Rødovre

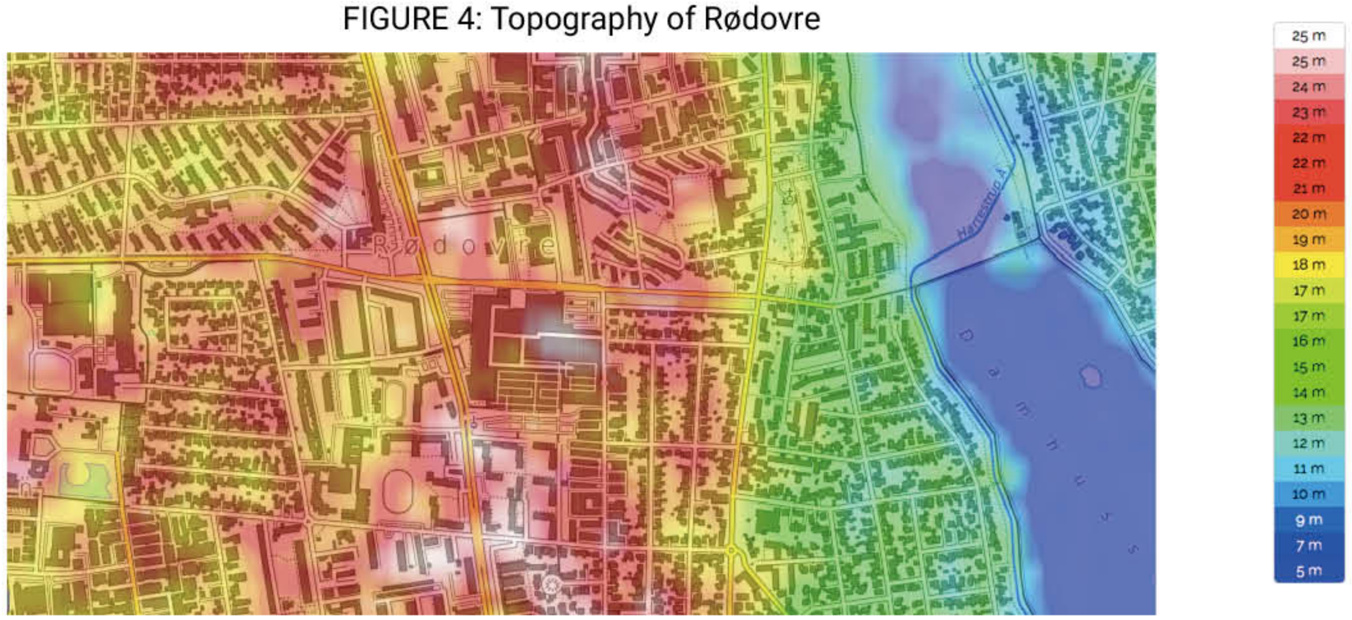
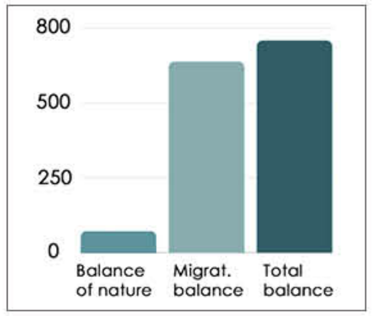
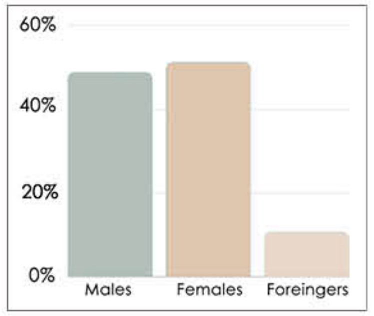


Figure 4 shows the elevation of Rødovre's elevation. Rødovre Town Hall is located 21 meters above the sea level. Climate change impacts on urban flooding in Copenhagen have been assessed for two high-end scenarios of climate change (6°C global warming scenario in 2100 and the so-called RCP8.5 scenario). Both flooding due to sea surge and rain has been assessed.

Demographic Balance (2018)



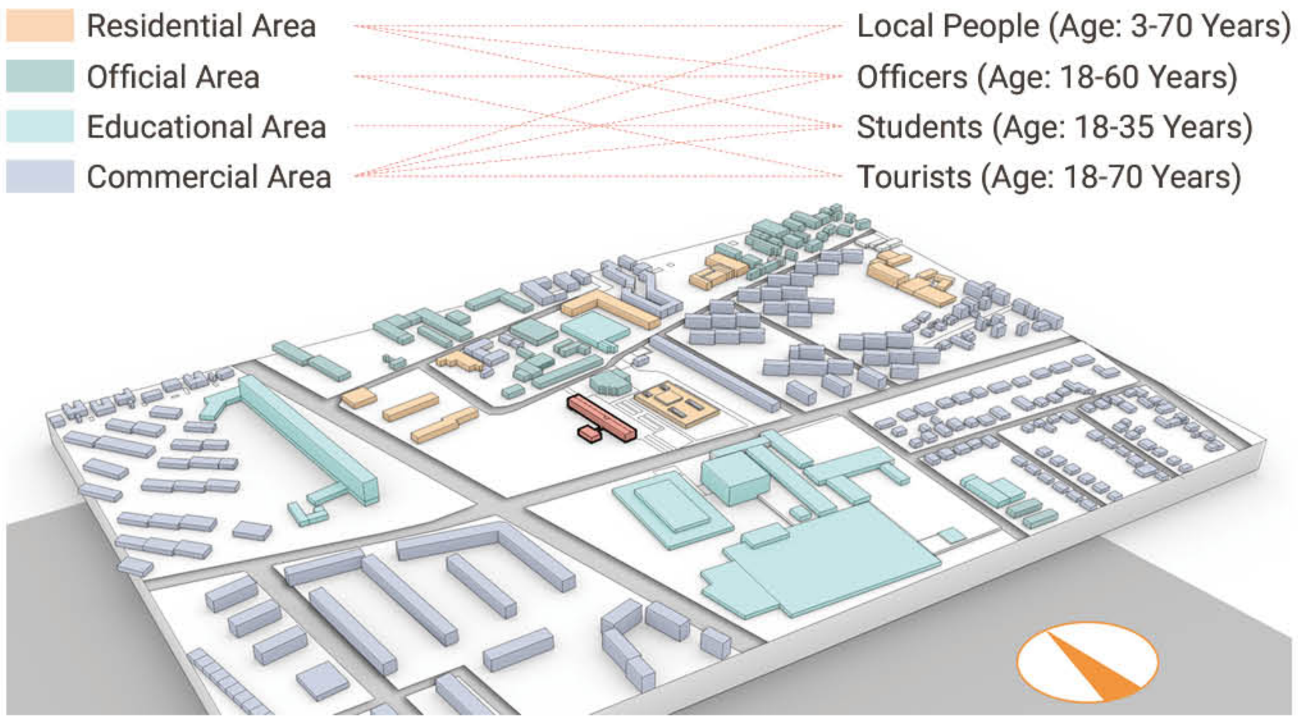
Demographic Balance (2018)



Demographic Data (2018)

INHABITANS (n.)	40,052	FOREIGNERS (%)	10.6
FAMILIES (n.)	18,621	AVERAGE AGE (years)	40.3
FEMALES (%)	51.3	AVERAGE ANNUAL VARIATION (2014/2016)	+1.50
MALES (%)	48.8		

Site User Analysis and Surroundings



Summary: 1. The lower the site elevation, the smaller the site relief, the lower the site roughness, and higher the likelihood that the site will experience urban flooding.
2. The groundwater reservoir in Rødovre Municipality must be described as vulnerable, as it is a limited clay layer thickness and the consequent increased risk of seepage of pollution.

1.2.3 Site Photos and Microclimatic Conditions Analysis

Site Photos

Views from the Stie

North-east view from the site, Viften

East view from the site, Rødovre Hovedbibliotek

West view from the site, Shopping complex

Views of the Stie

North view of the building

South view of the building

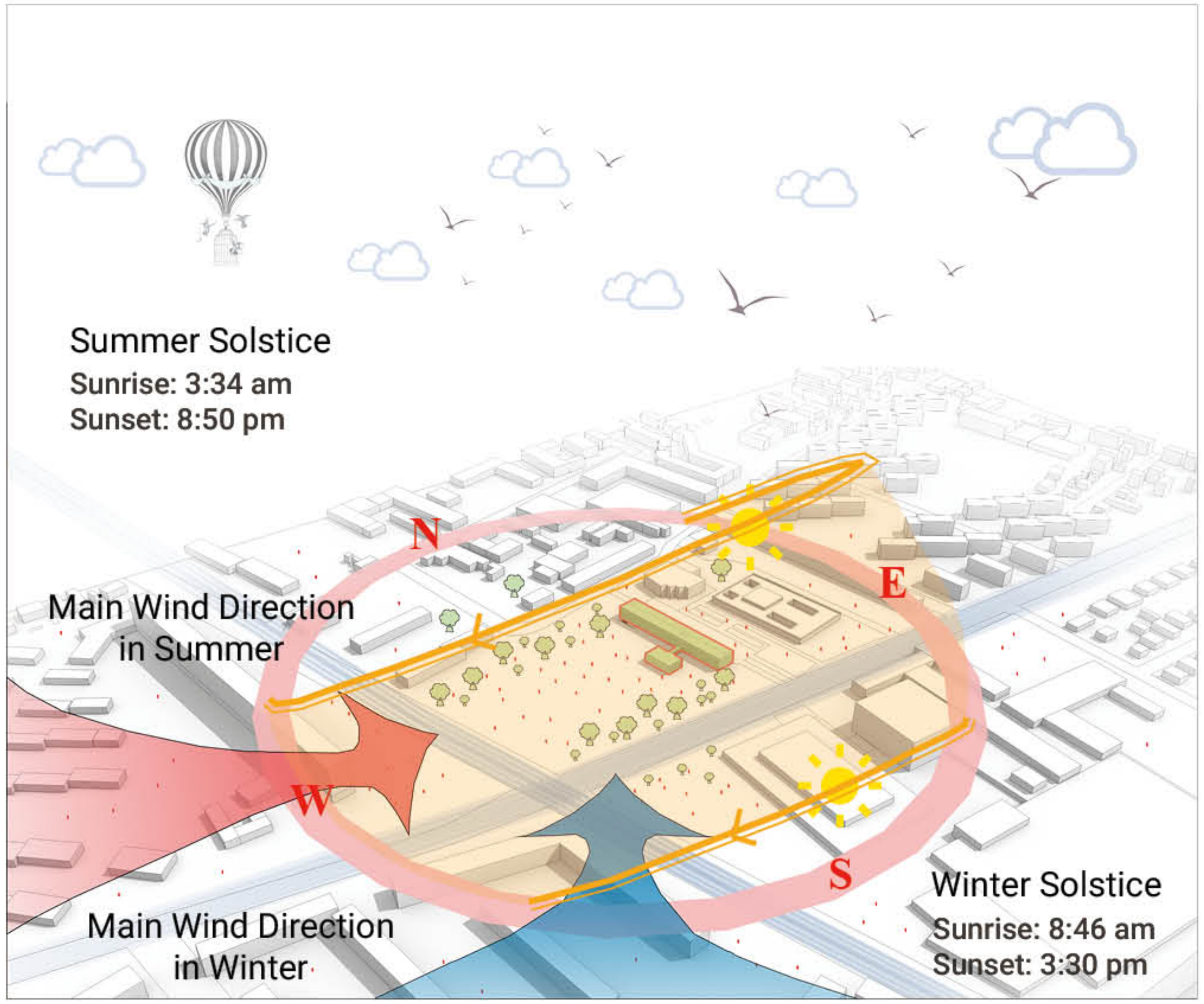
East view of the building

Entrance of the building

View of the building from Tårnvej

North view of the building

Microclimatic Conditions

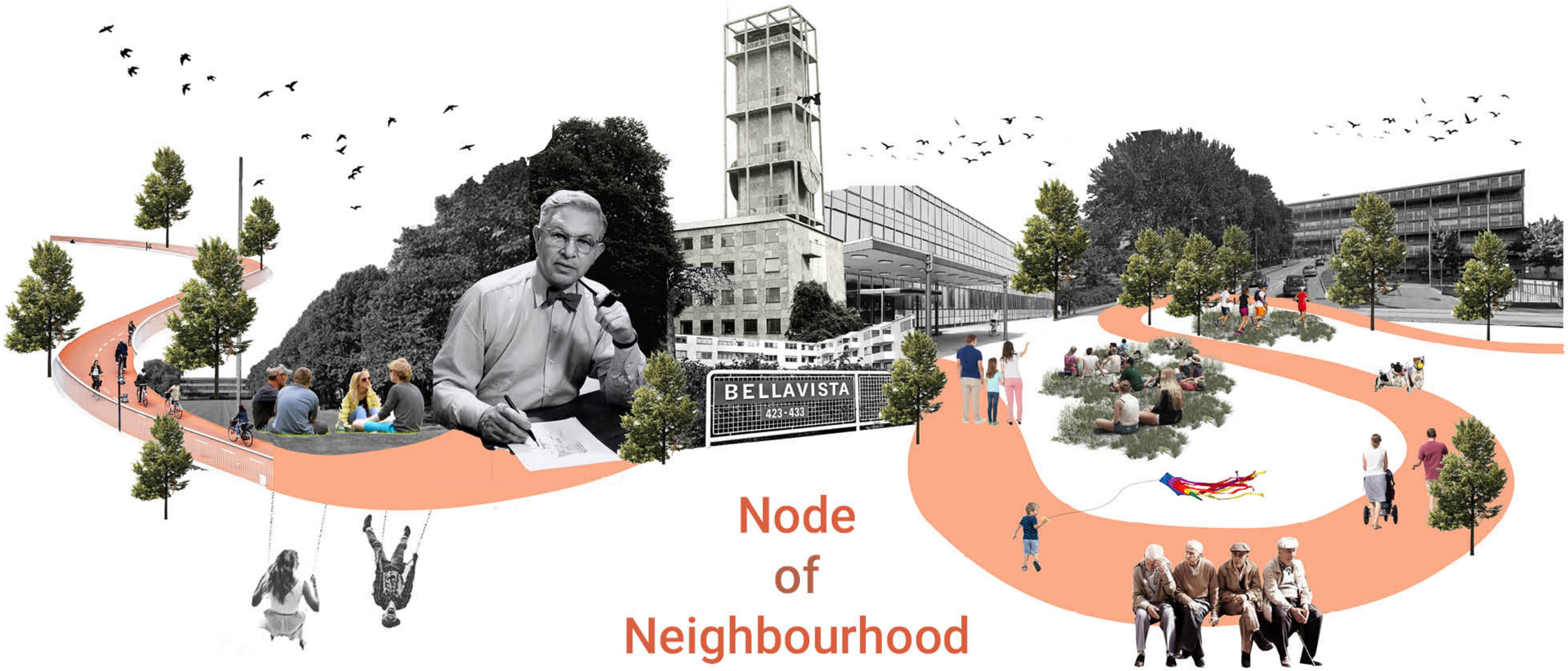


Summary:

1.In general, there is a large area of open green space within the site, with tall trees on both sides of the green space.

2.In summer, the wind direction is mostly westerly, and in winter, the wind direction is mainly southwest wind.

1.3.1 Architect and Existing Building Introduction



About Building

Designed - 1954 Completed - 1956 Area - 5000sqm

History & Use

Originally designed to serve as public civic building, housing the administrative functions of the municipality. The complex consists of two wings connected by a glass corridor. The three-storey wing, with a basement, 91 m long and 14 m wide hosts the municipal offices. The single storey large pavilion-like building is 22 m long and 13 m wide, and hosts the council chamber.

Architect

Arne Jacobsen (1902-1971) was undoubtedly one of Denmark's most prominent architects and is internationally recognized for his marvelous buildings and design- also including his clock and watches.Jacobsen's architecture is still admired internationally and was a proponent of using local materials in his designs.

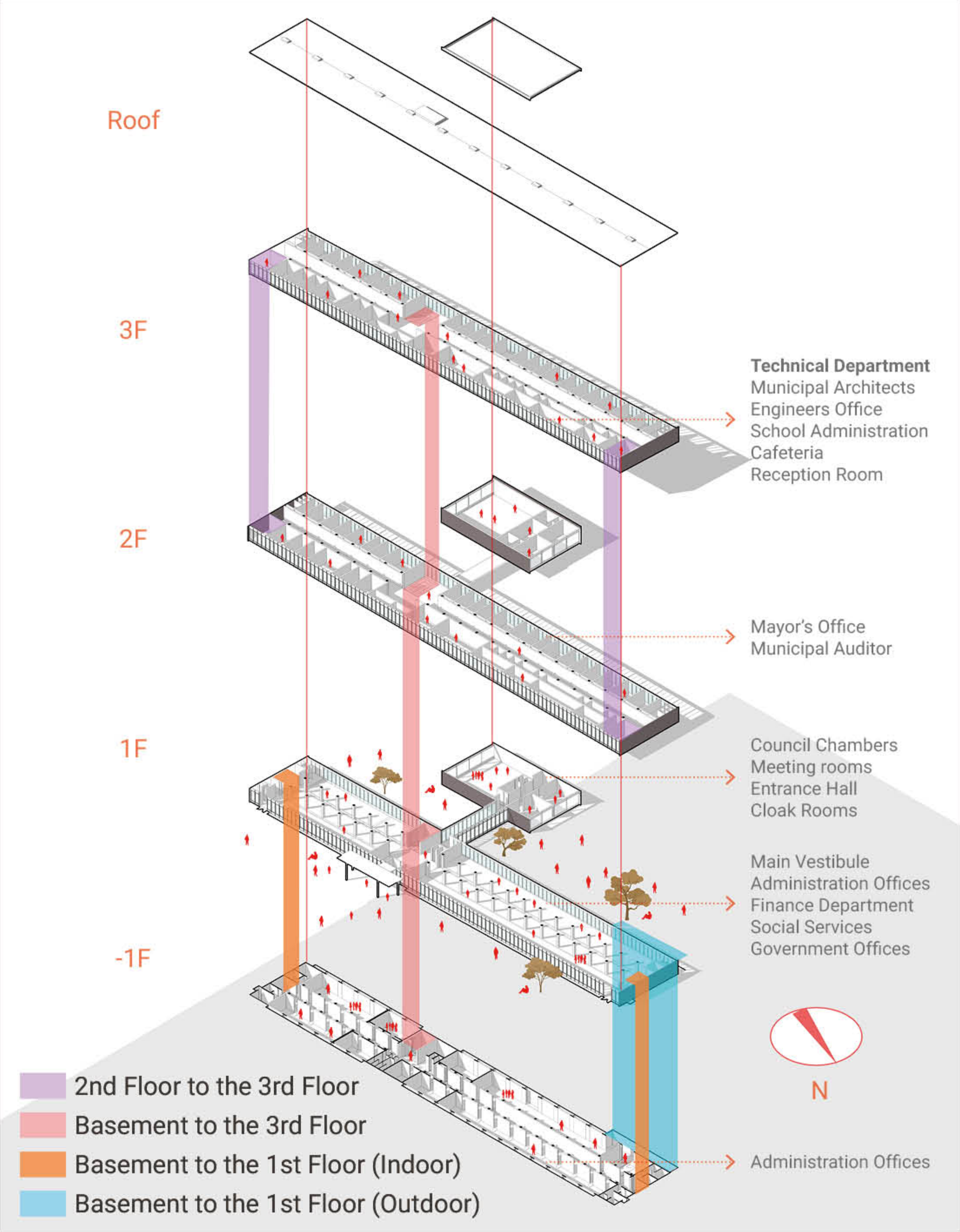
Our vision is to restore the Town Hall to be the Municipalities node of activities that promote wellbeing and sustainability. Restoring its civic use to ensure the citizens are served efficiently and the officer users are comfortable.

Inspiration

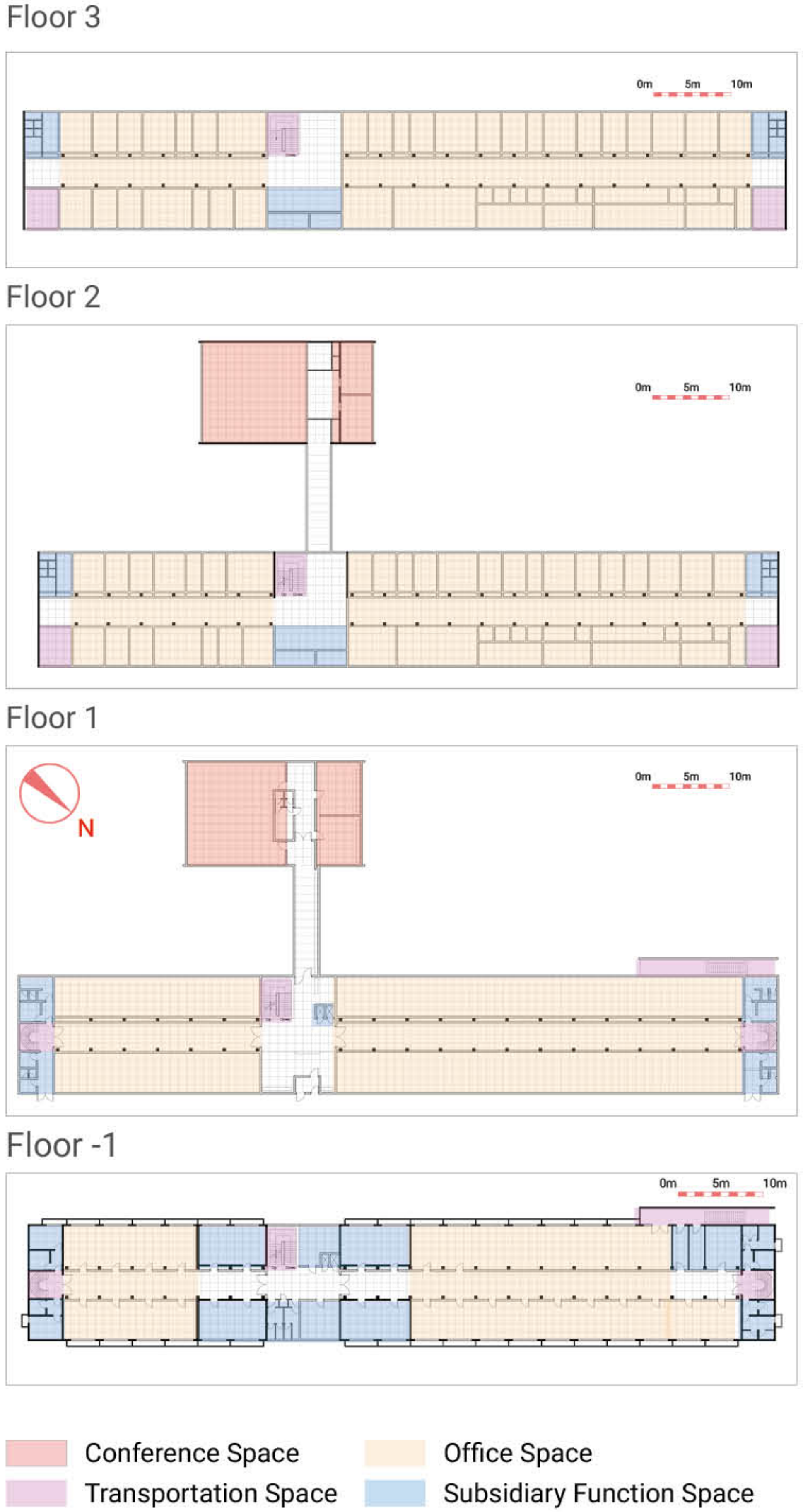
The Rodovre Town Hall design was inspired by the prevailing architecture movement at the time. Jacobsen was particularly attracted by the minimalistic work of Miles van der Rohe, Eliel Saarinen, Skidmore, Owings and Merrill. The Bauhaus movement was pro-minimalism with a rational structure, which is evident in the Town Hall in Rodovre.
While the town Hall in Rodovre was inspired by Saarinen's General Motors Technical Center, its proportions and details are unmistakably the work of Jacobsen.

Eero Saarinen's General Motors Technical Center

Existing Building Circulation Analysis



Floor Plan and Functions Analysis



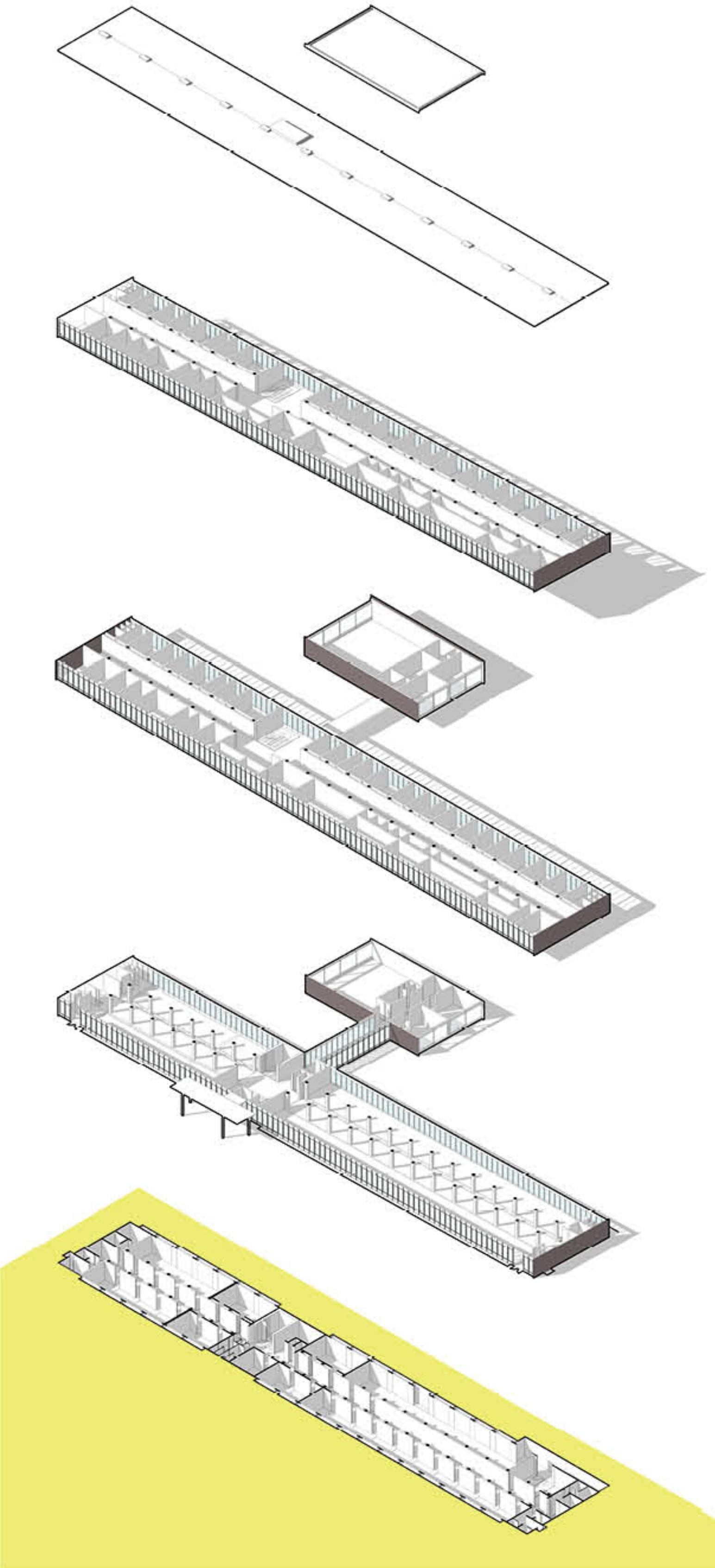
Summary:

1. The main function of the building is the office space, the small volume building space is the conference room, and the other small part is the subsidiary space. The main traffic space is a long corridor.

2. Lack of barrier-free design, no elevators , ramps and other facilities inside the building, wheelchair users are unable to move freely in the building.

1.3.3 Building User Analysis and Interior of Existing Building

Building User Analysis



Workers (age 18-60):

The main users of the existing building are the people working in the offices. They do different typology of jobs, as shown from the diagram on the previous page.

Citizens (age 3-70):

Because of the functions within the Town Hall, the building contains citizens that visit the building for administrative procedures, weddings etc.

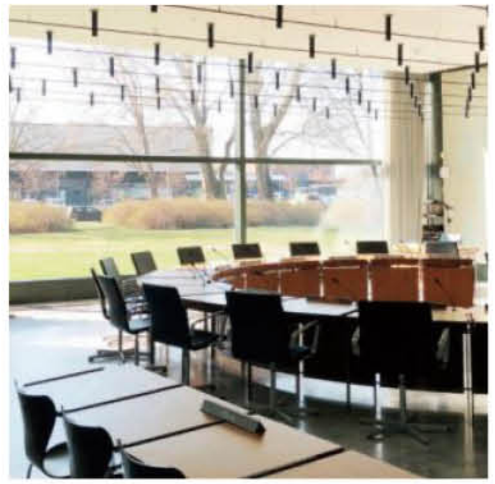
Tourists (age 18-70):

The location and the importance of the building attract tourists inside and around the site.

Interior Photos of the Existing Building

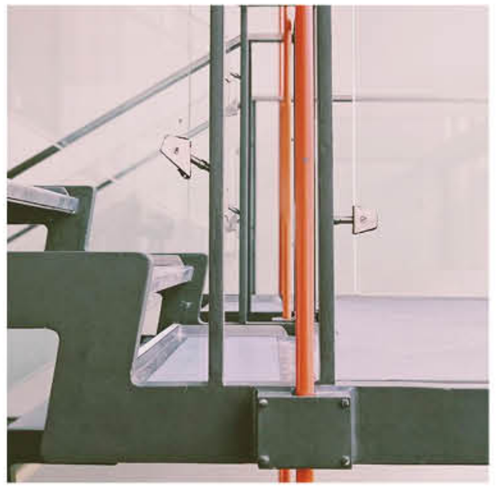
Interior space of the building

View from the main staircase

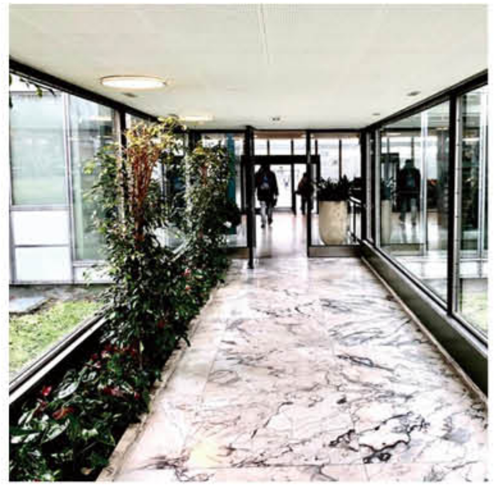


Council Chamber view 1

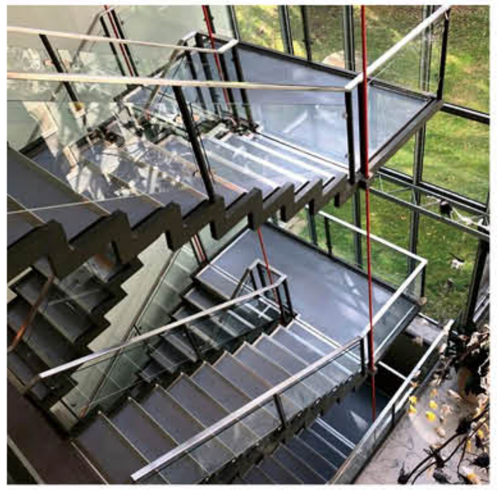
Council Chamber view 2



Detail of the main staircase

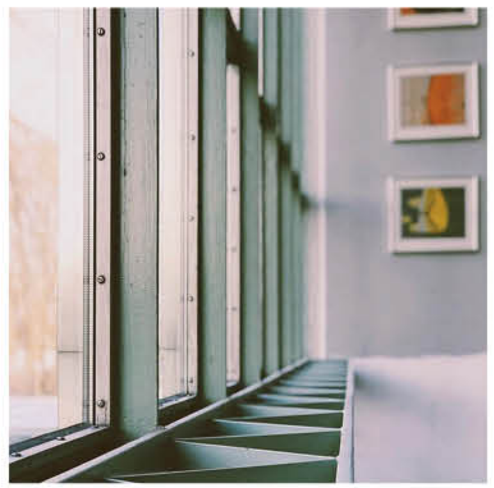


Corridor to the main entrance



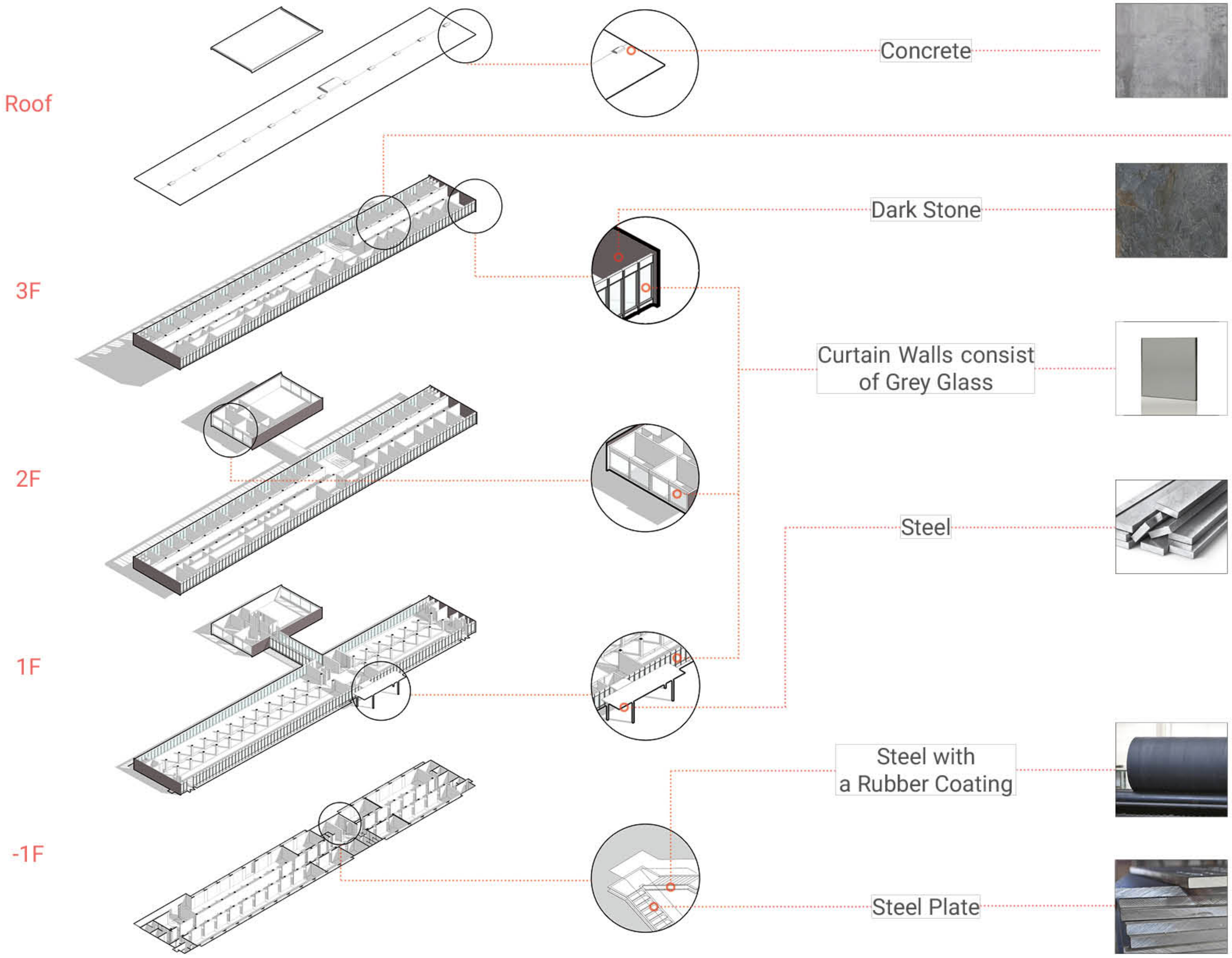
View of the main staircase

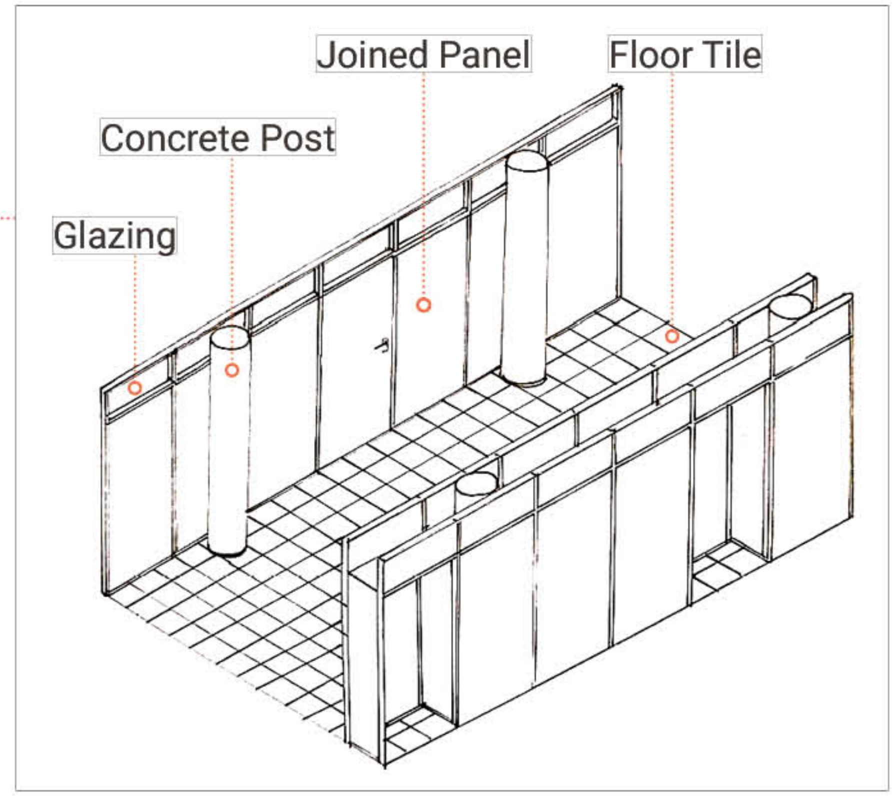
Arne famous staircase



Detail of openings

1.3.4 Material Analysis






Curtain Wall

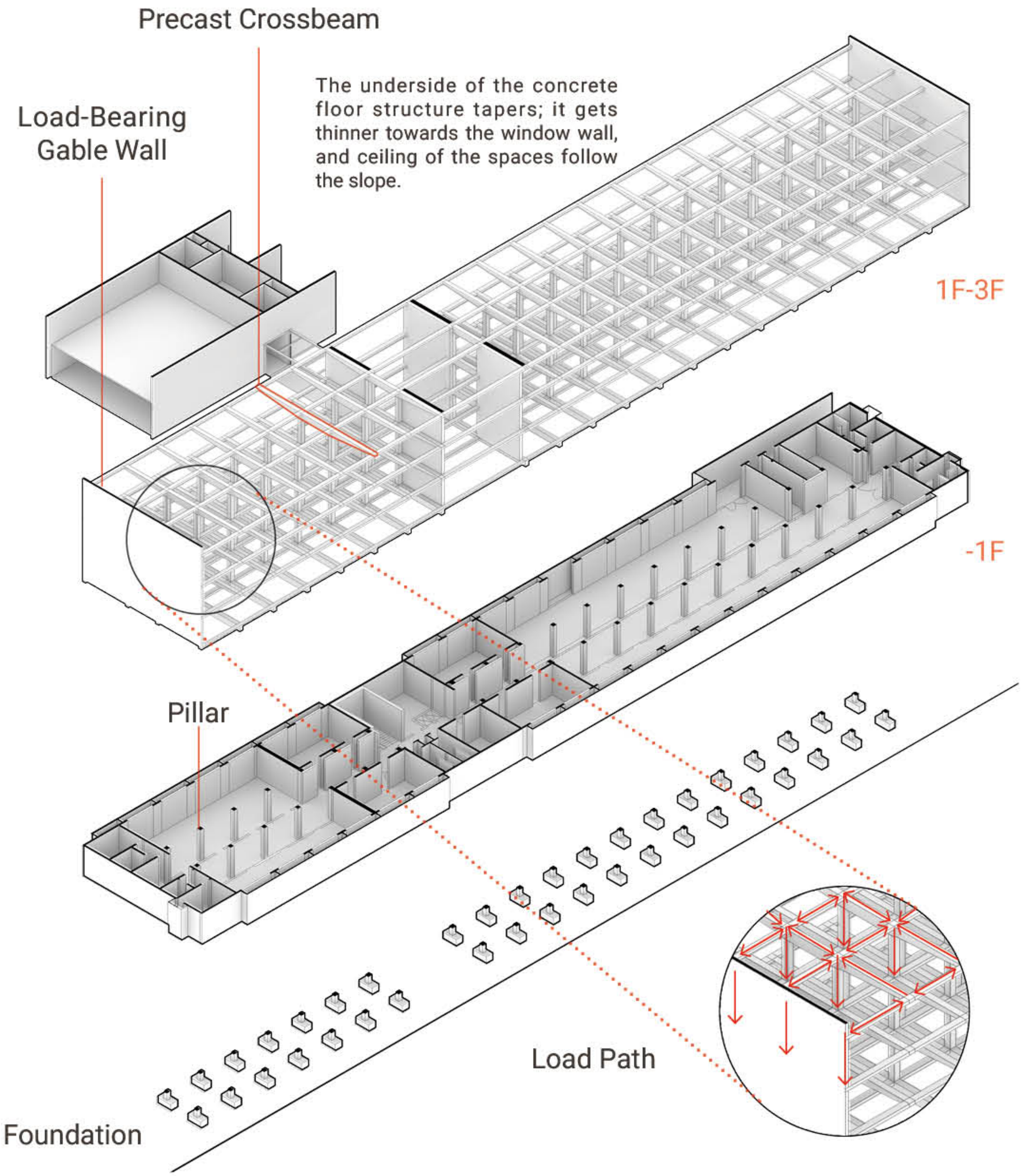

Gable

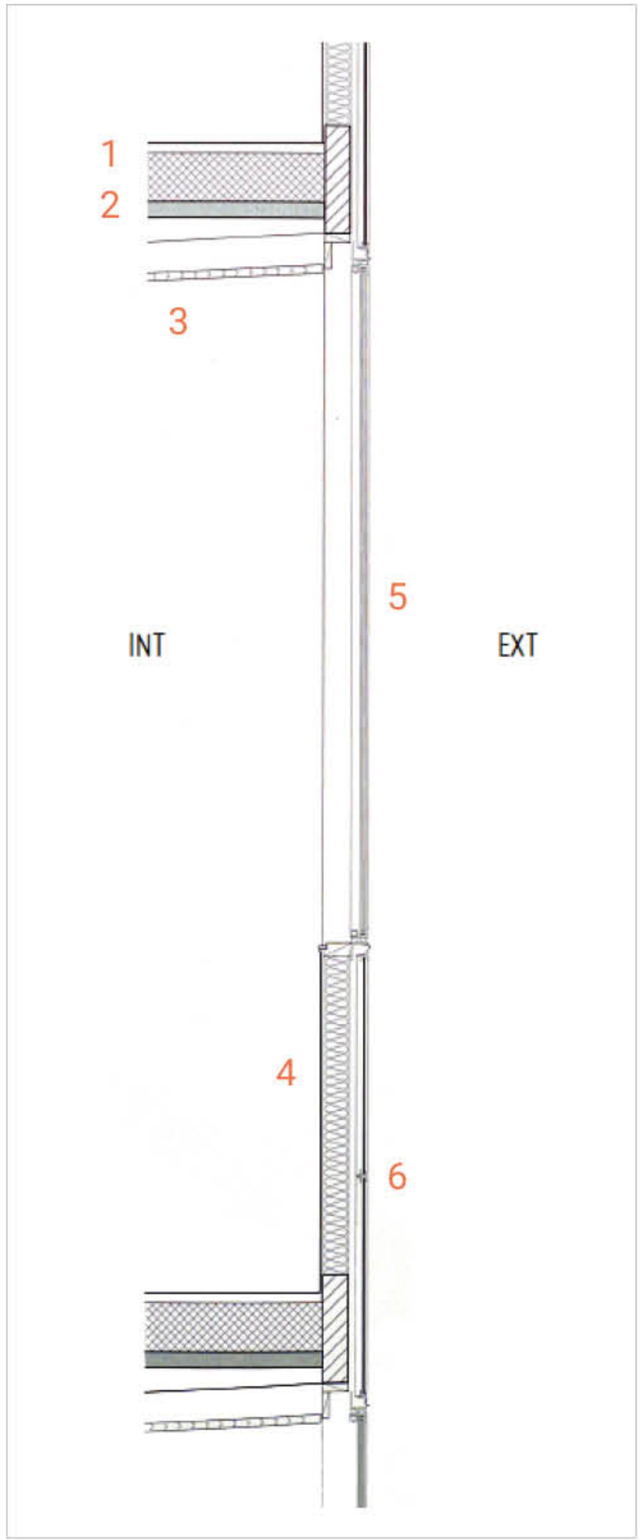

Entrance

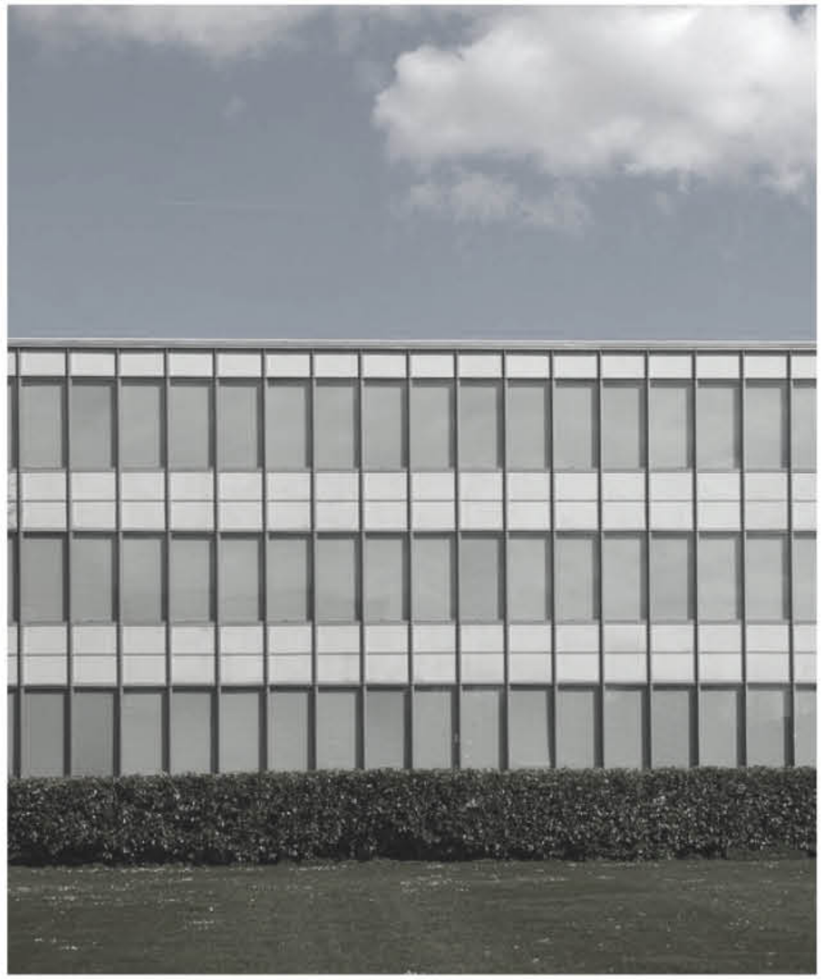

Stairs

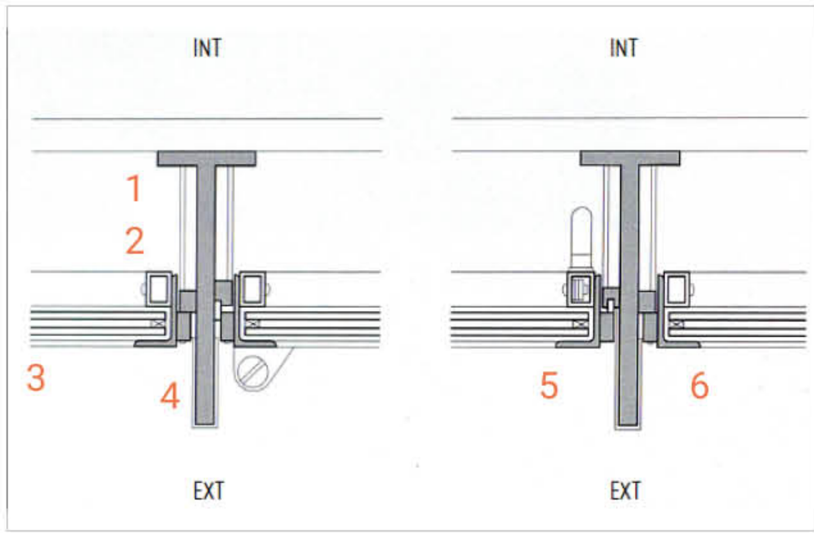
Summary: It is constructed of pillars, precast crossbeams and floor slabs. The load-bearing gable walls are clad in dark stone while the longitudinal curtain walls consist of grey glass set in metal frames with stainless steel trimmings. The wing consists of 1 m facade modules, flexible partitions and a central corridor. Its longitudinal facades are clad in dark stone while the gables are continuous windows.

1.3.5 Structural Analysis









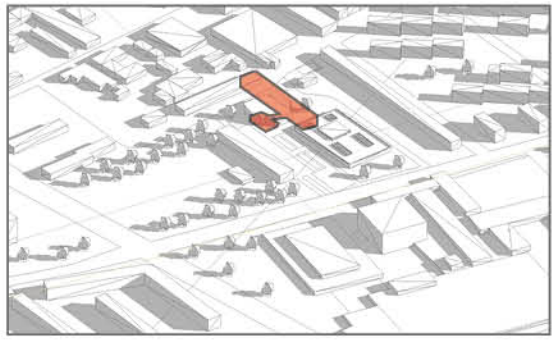
Summary: The building bears a strictly rational structure. This is achieved by central pillars, precast crossbeams, floor slabs and loadbearing gable walls at the ends. The longitudinal form allows for the load to be evenly spread from the central of the building, along that axis. Crossing walls where staircases cut are useful to reinforce the structure. The precast structural system allows for malleability of the floor plan to conform to retrofit solutions.

1. Vinyl Tiles on Sound Insulation
2. Precast Concrete Slab
3. Ceiling Composed of Joists and Acoustic Tiles
4. Painted Woodwork
5. Insulated Window
6. Translucent Glass Spandrel

1. Steel Mullion with Welded Corner Frames
2. Aluminum Glass Stopper
3. Insulating Glass
4. Stainless Steel Mullion
5. Dormant
6. Translucent Glass Spandrel

1.3.6 Building Solar Analysis (Sunpath and Shading)

SPRING/AUTUMN EQUINOX



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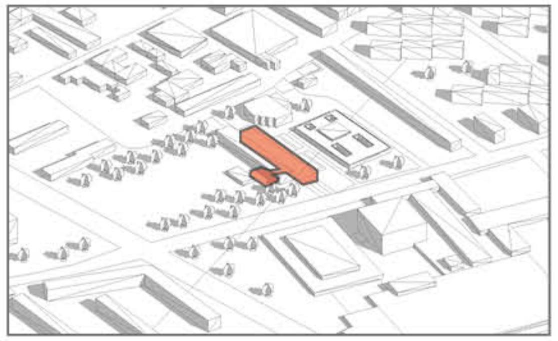

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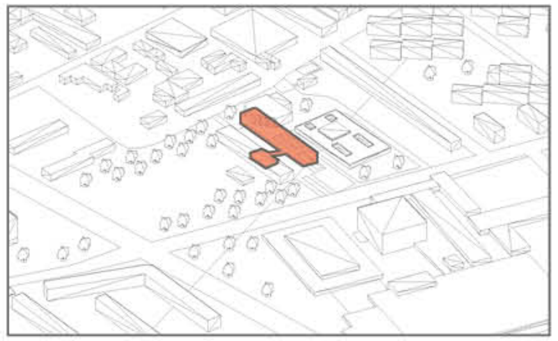

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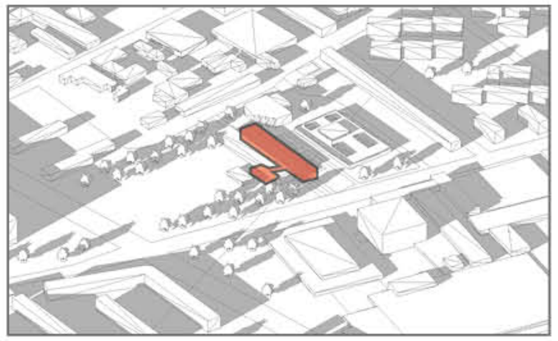
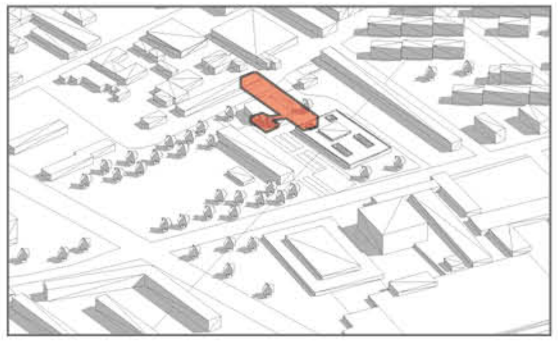


17:00

SUMMER SOLSTICE



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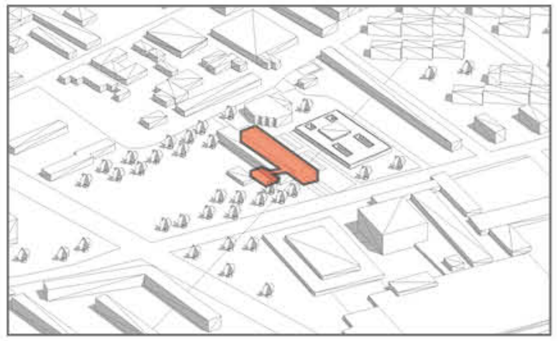

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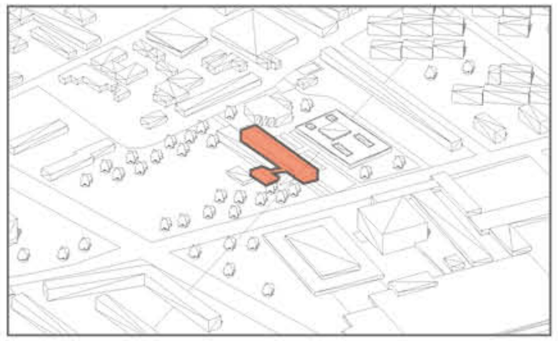

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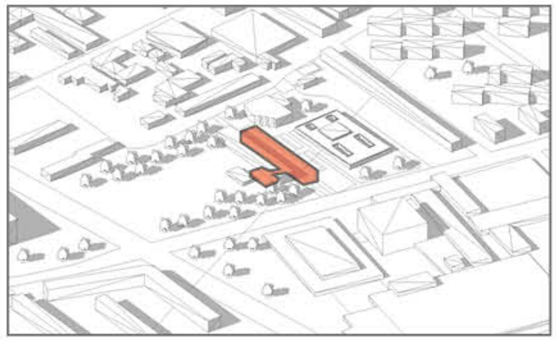
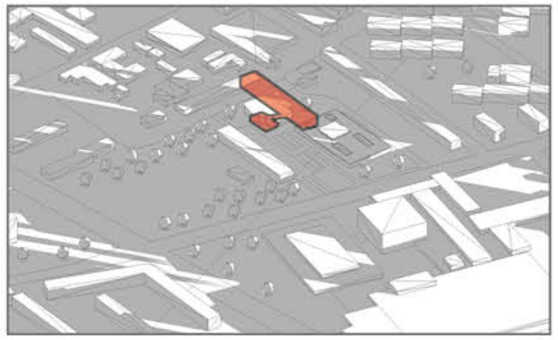


17:00

WINTER SOLSTICE



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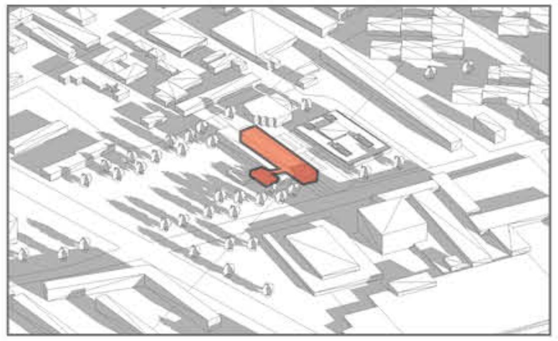

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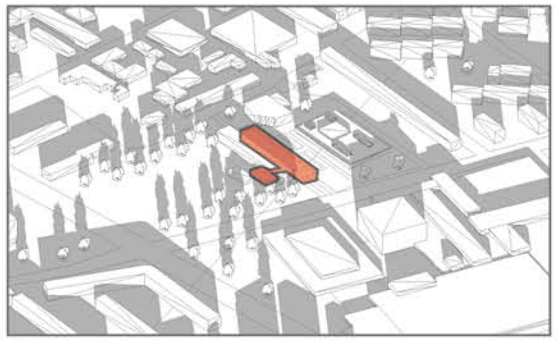

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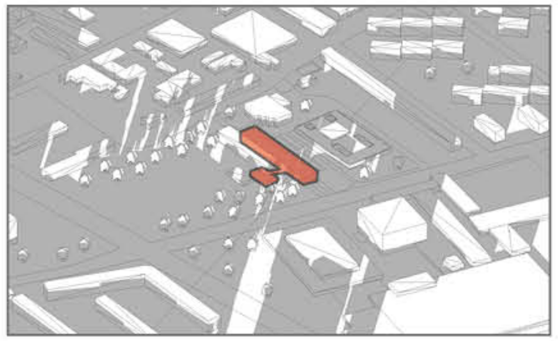
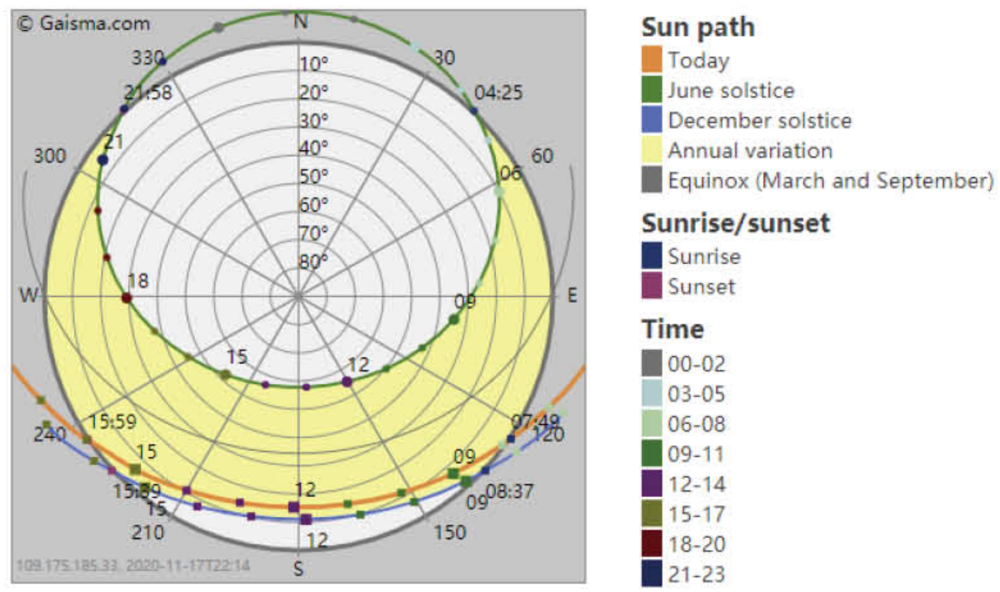


17:00

SUN PATH DIAGRAM



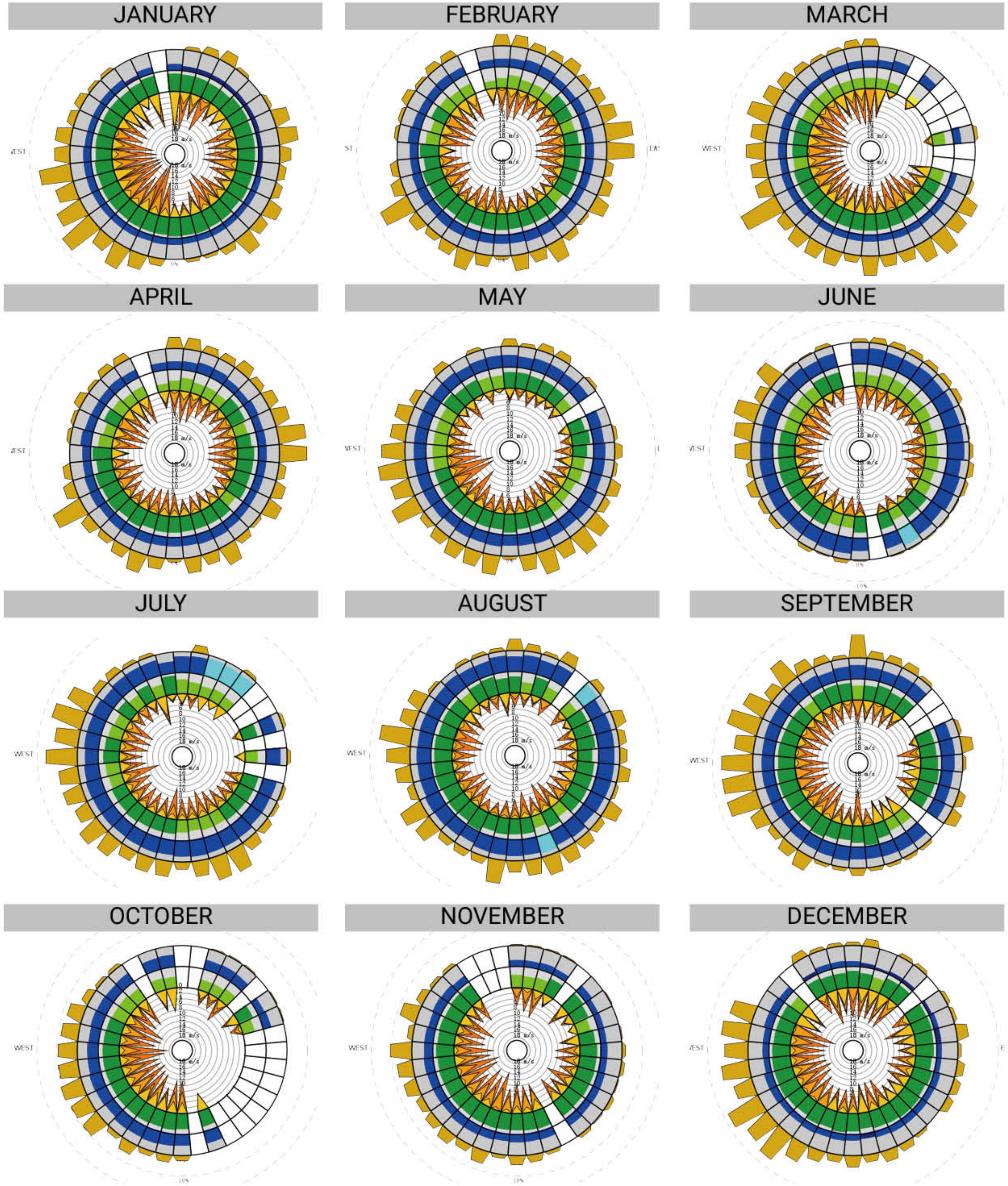
Summary:

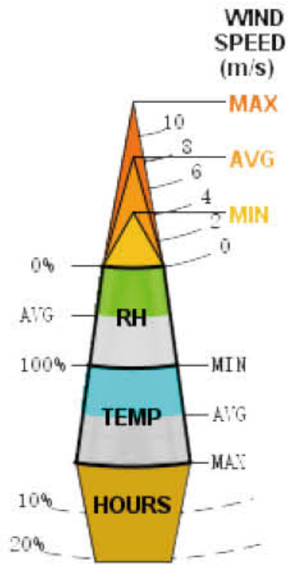
1. In general, the building is not obscured by the shadows of other buildings

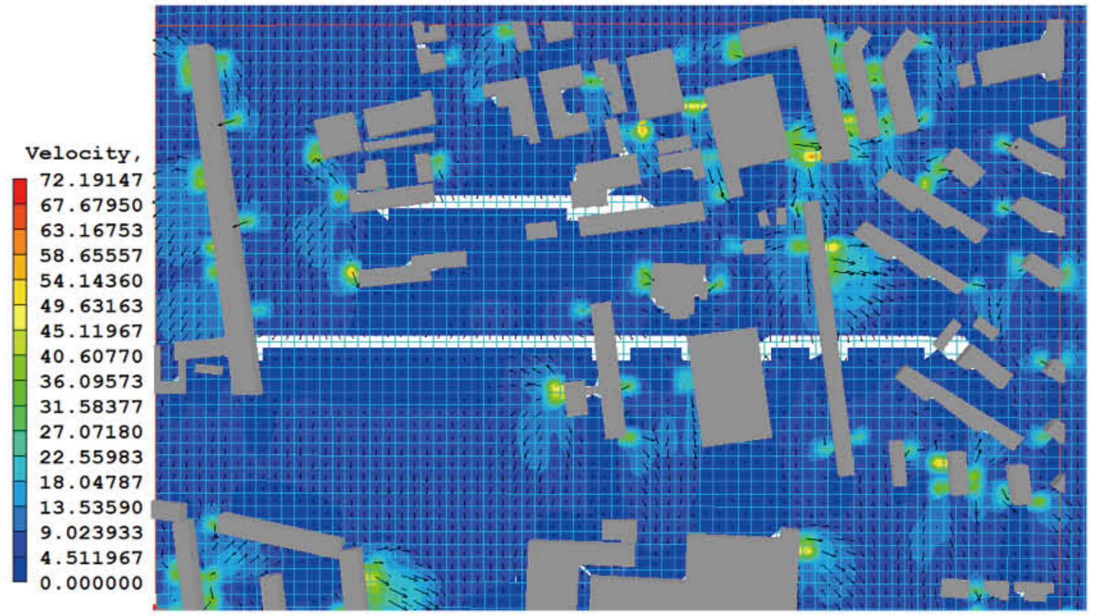
2. The west facade is not blocked, the building gets plenty of light in a year.

3. The tall trees on the north and south sides do not block the north-south facade of the building.

1.3.7 Wind Analysis

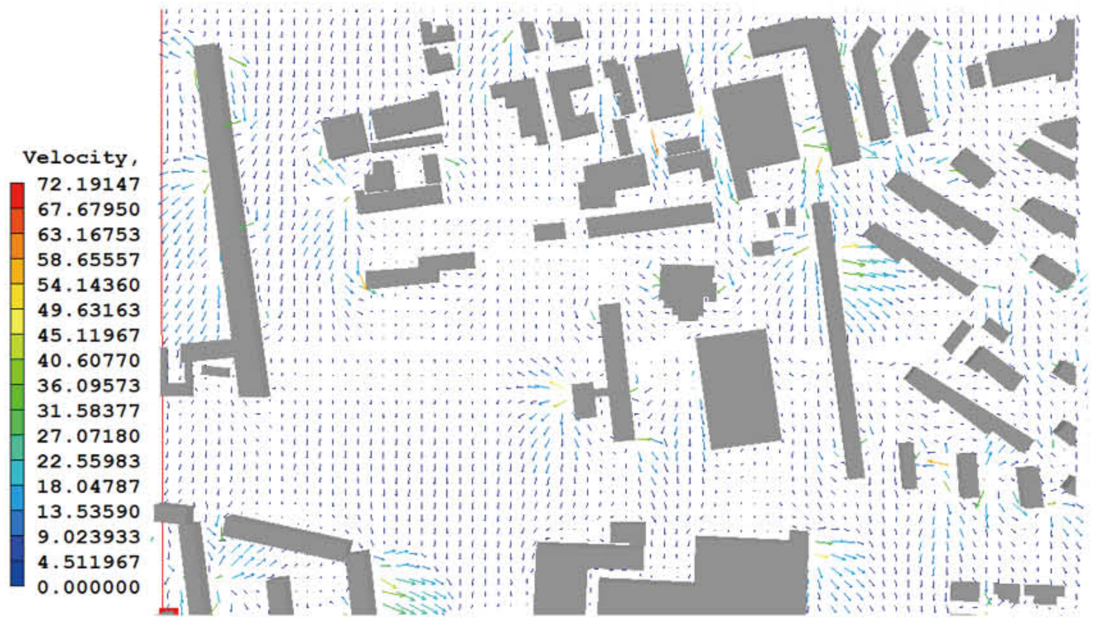






WIND VELOCITY AROUND BUILDING

Velocity range - 0-72 m/s



WIND DIRECTION AROUND BUILDING

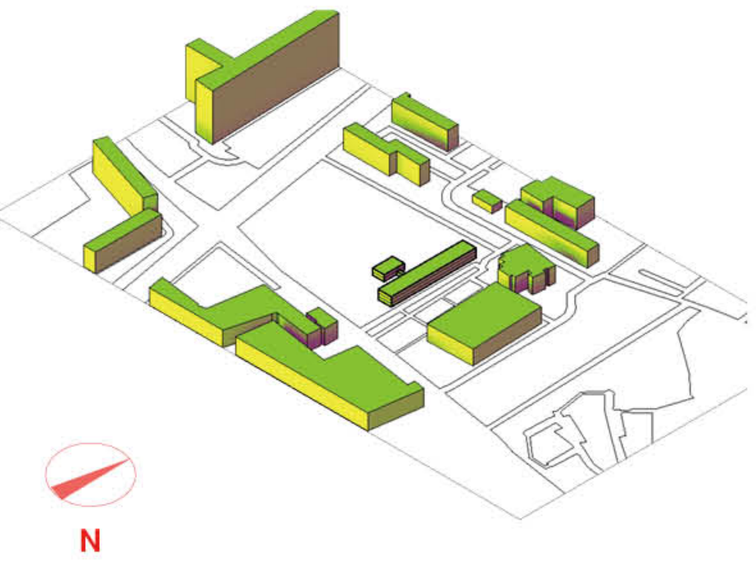
Velocity range - 0-72 m/s

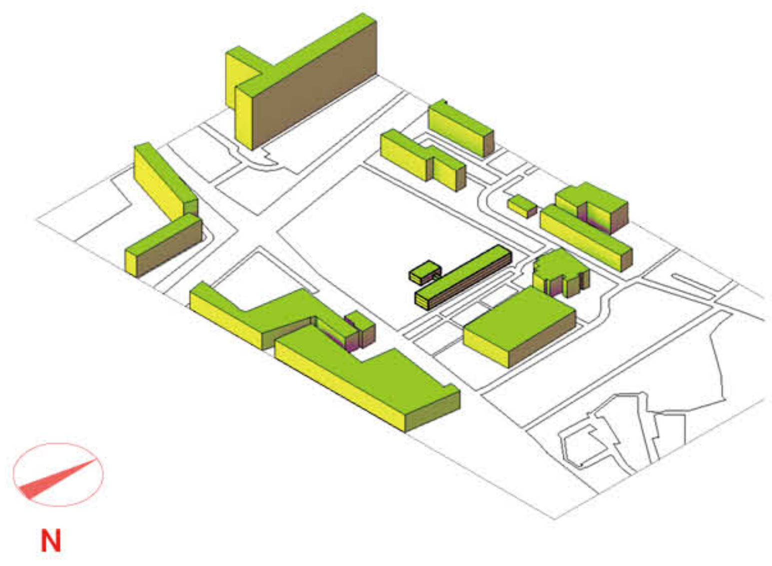
Summary:
The wind velocity is dominant on eastern side throughout the year. The diagrams show the wind direction around the building. The eastern facade faces the higest pressure.

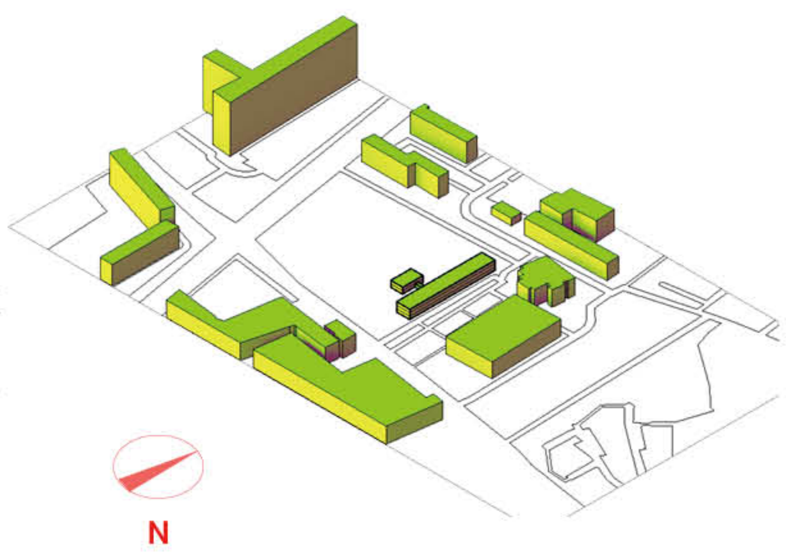
1.3.8 Solar Radiation Analysis

WINTER SOLSTICE | **SUMMER SOLSTICE** | **SPRING SOLSTICE**

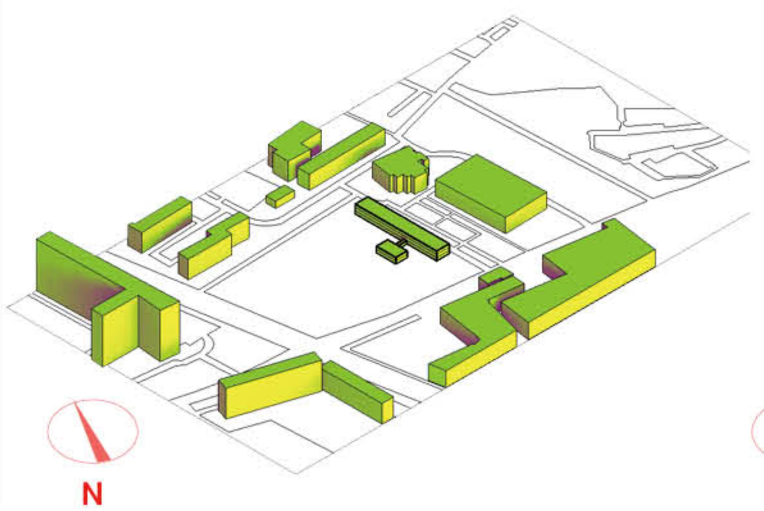
EAST FACADE

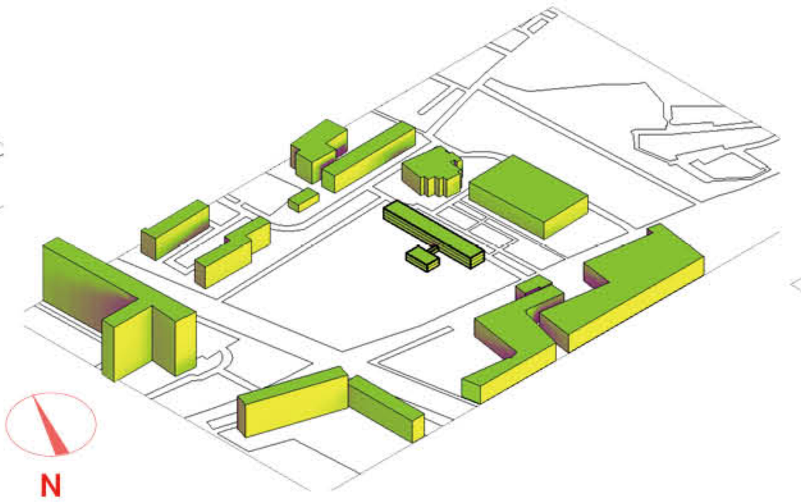


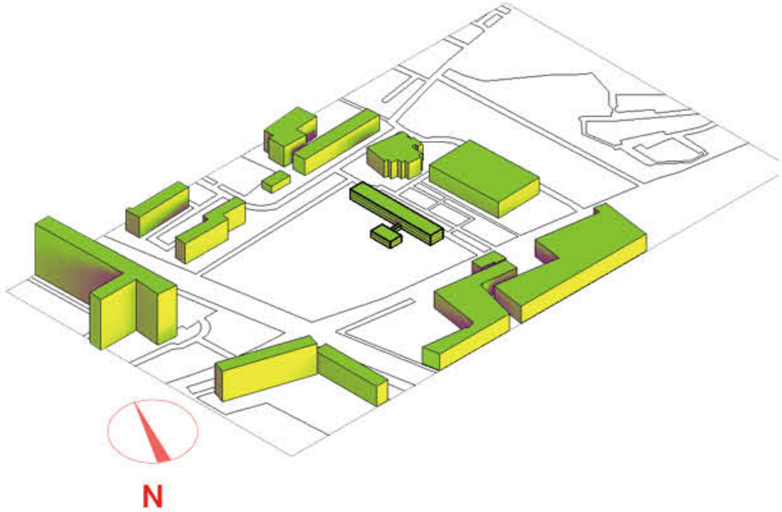




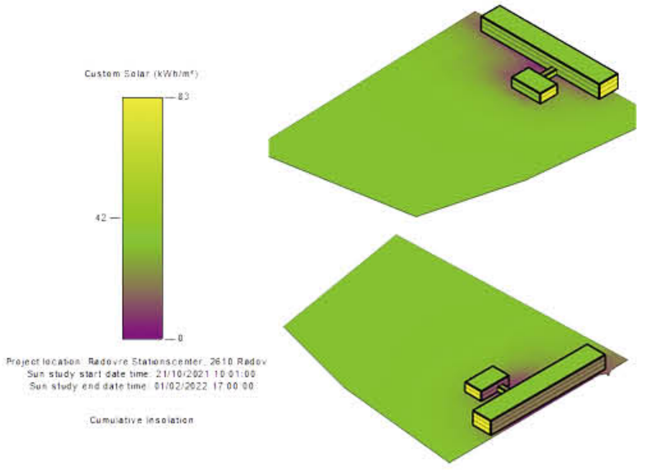
WEST FACADE

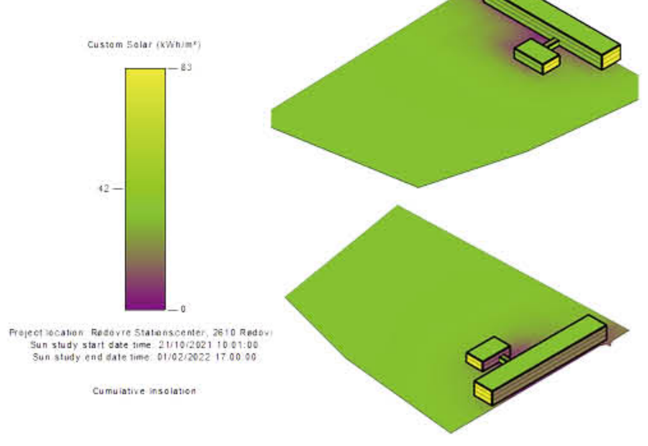


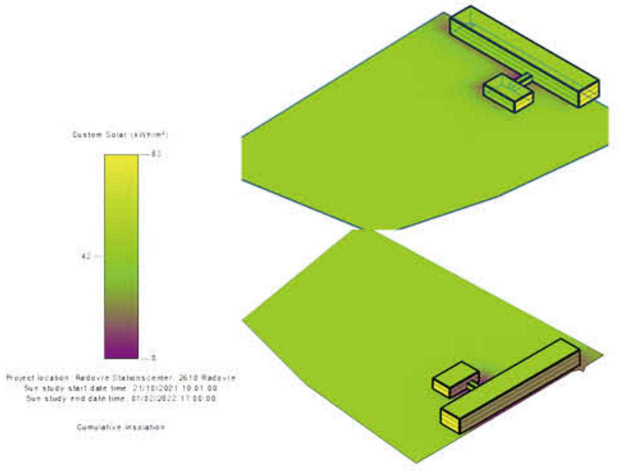




SITE & SCALE





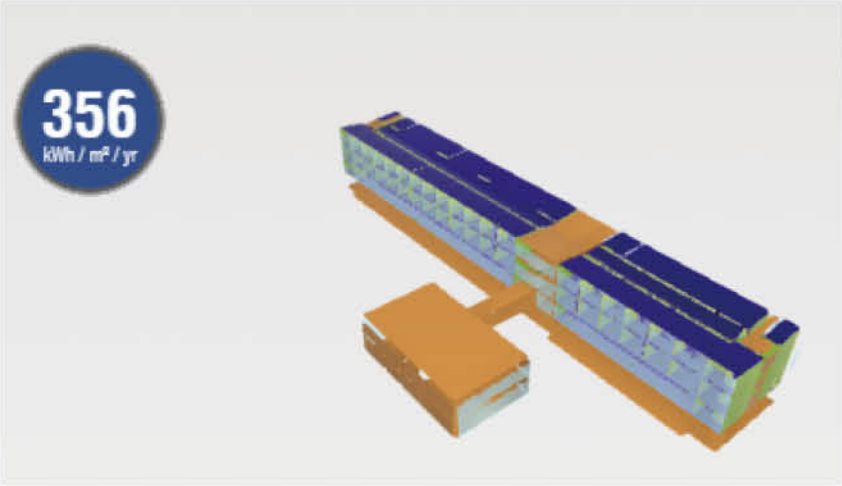


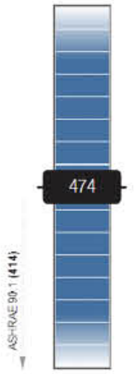
CONCULSIONS

- The simulation shows that in summer the East facade gains solar radiation upto 320 kWh/sqm. However, in springs and winter, the radiation doesn't exceed the 83 kWh/sq.m.
- The East elevation is not obscured by the surrounding buildings.
- The material on this side is the combination of aluminium and single glazed glass. That can lead to further heating up the interiors.

- The simulation shows that in summer the West facade gains solar radiation upto 320 kWh/sqm. However, in springs and winter, the radiation doesn't exceed the 42kWh/sq.m.
- The West elevation is not obscured by the surrounding buildings, but holds a view to green space of site. Trees has the potential to cast shadow on the west facade of the building.
- The material on this side is same as east facade

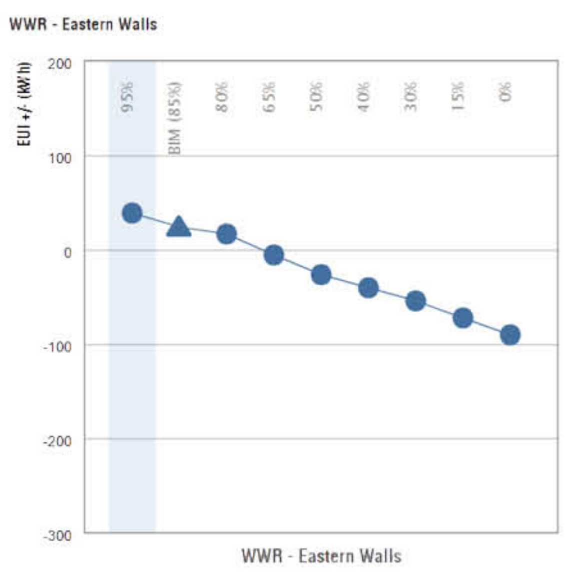
- The annual scale ranges from 0 to 304 kWh/ sq.m. The site is flat land which lead to solar radiation on ground.
- Overall, the building is unaffected by its surroundings. The southern facade faces high amount of solar radiation thoughout the year.



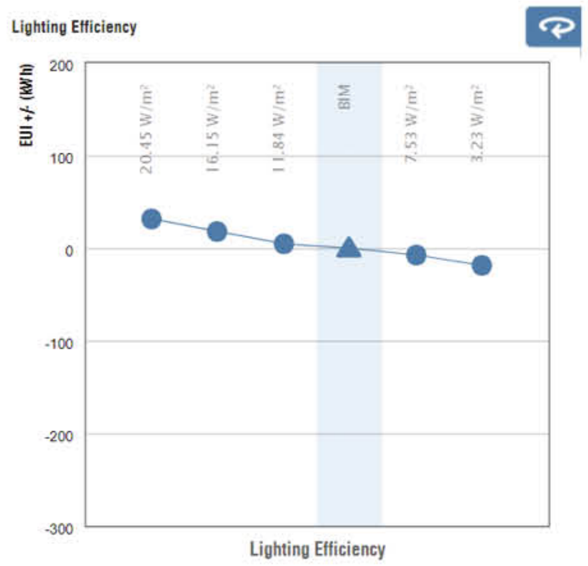


Summary:
The energy performance analysis highlights the energy demand of the buildings. From the simulations we can conclude, western and eastern facade , HVAC system and roof construction needs to be improved to lower the energy demand of the building.

WWR- EASTERN WALLS

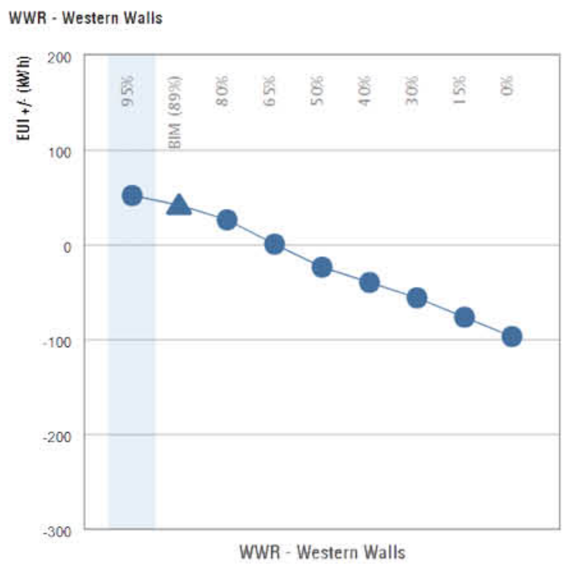


LIGHT EFFICIENCY



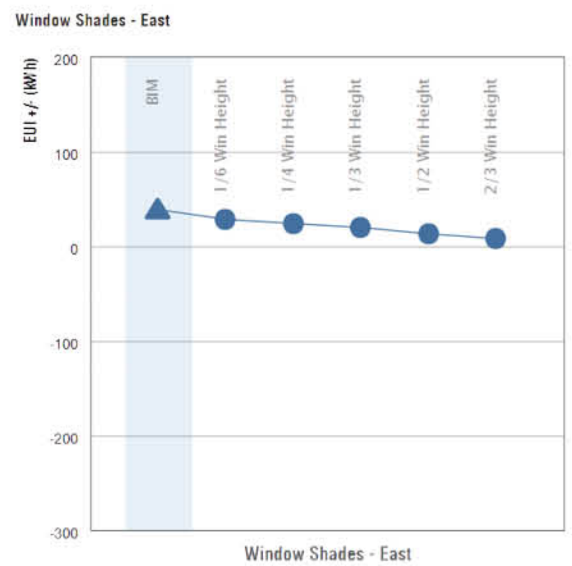
WWR- NORTHERN WALLS

WWR- WESTERN WALLS

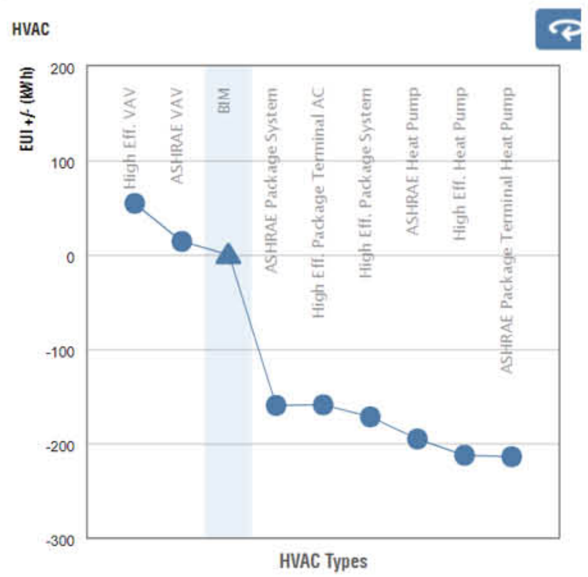


ROOF CONSTRUCTION

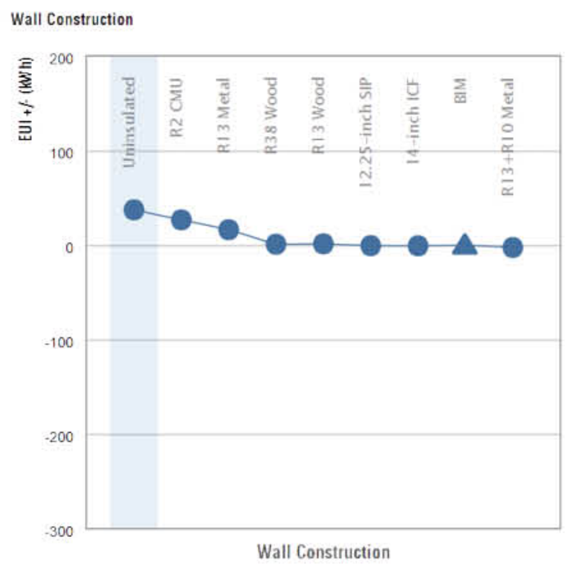
WINDOW SHADES- EAST



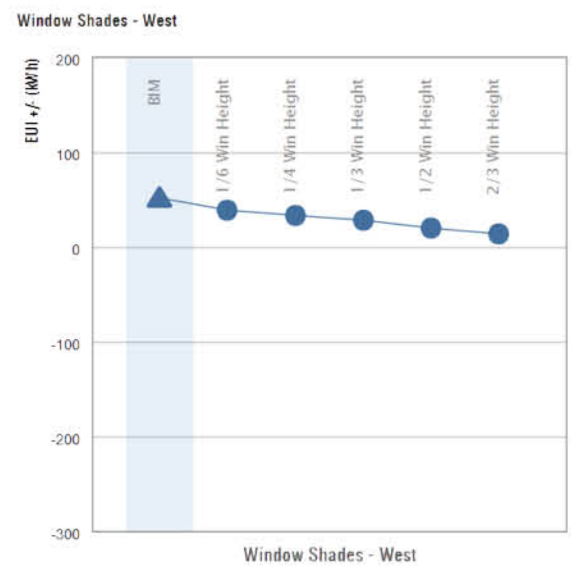
HVAC



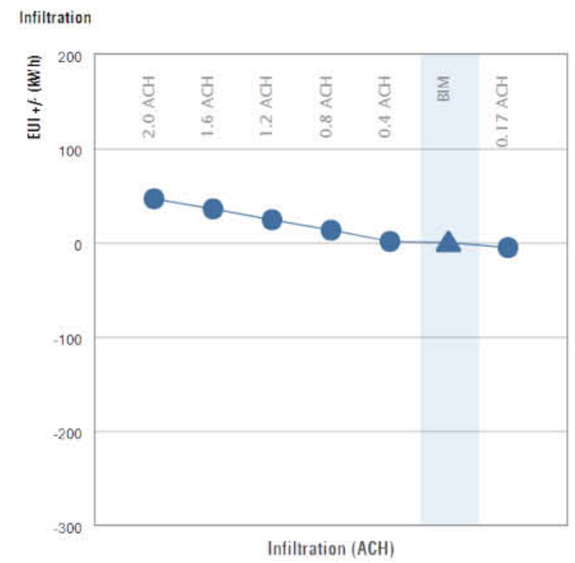
WALL CONSTRUCTION OVERALL



WINDOW SHADES- WEST

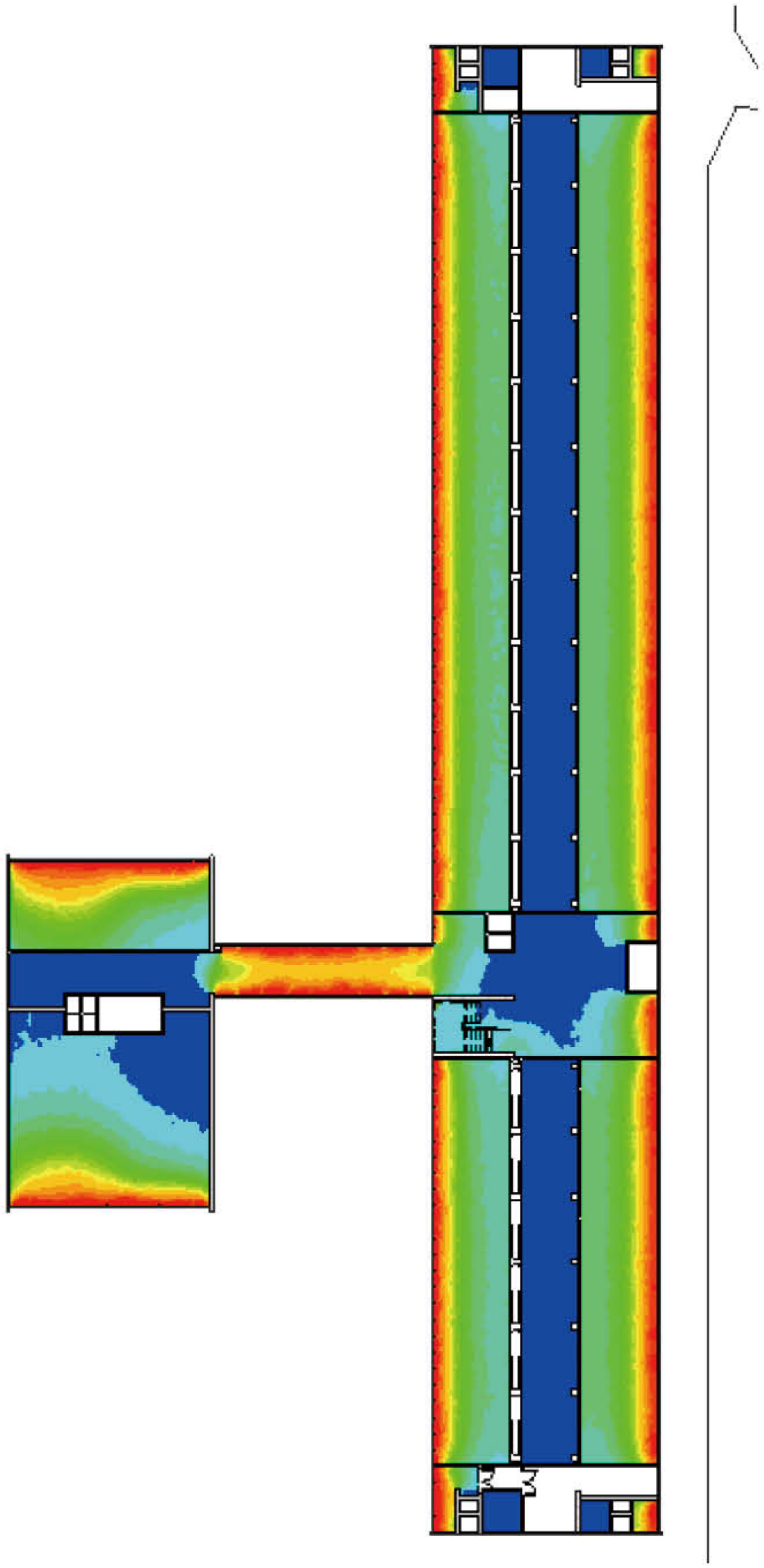


INFILTRATION

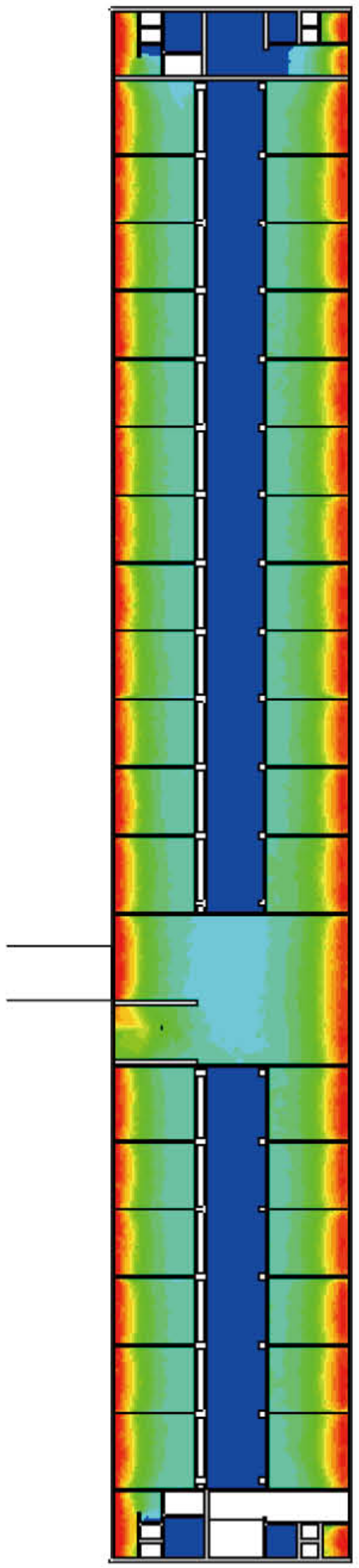


1.3.10 Building Daylight Analysis

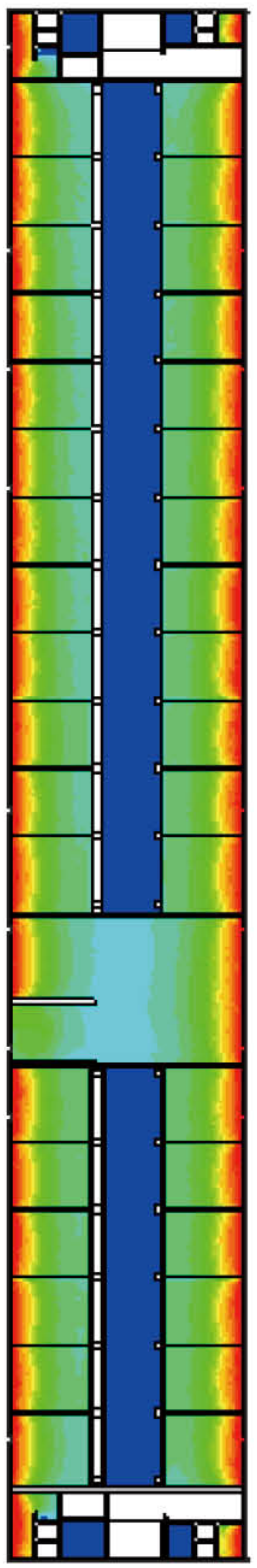
GROUND FLOOR



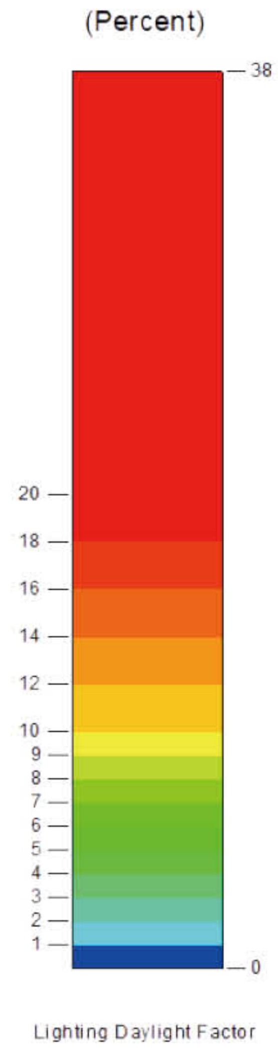
FIRST FLOOR



SECOND FLOOR



CONCLUSIONS

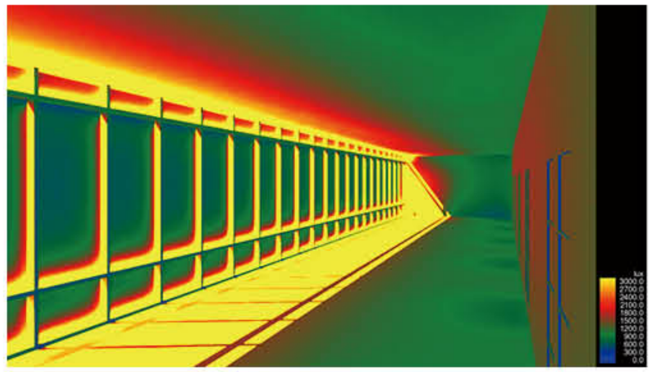
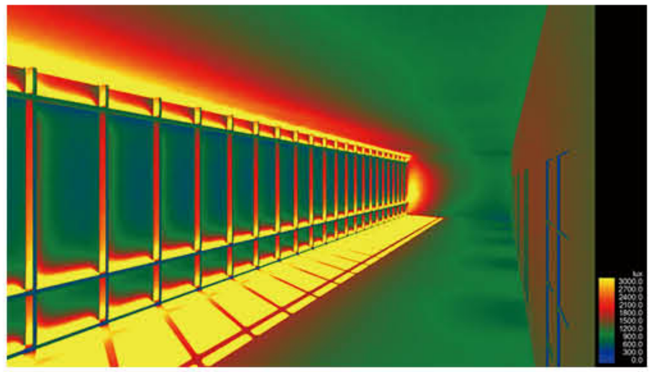


The corners receive 20 % of the daylight. However , the planning does not illuminate the corridors. The working spaces receive only 10% illumination.

The planning has to be improved to allow the uniform distribution throughout the floor area. Further skylights have to be incorporated to invite more light to the place.

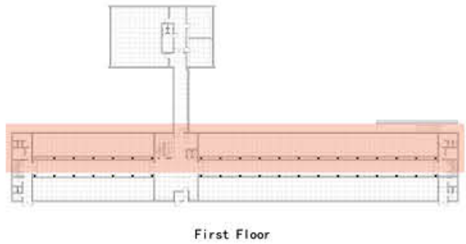
1.3.11 Interior Illuminance

SUMMER SOLSTICE	WINTER SOLSTICE

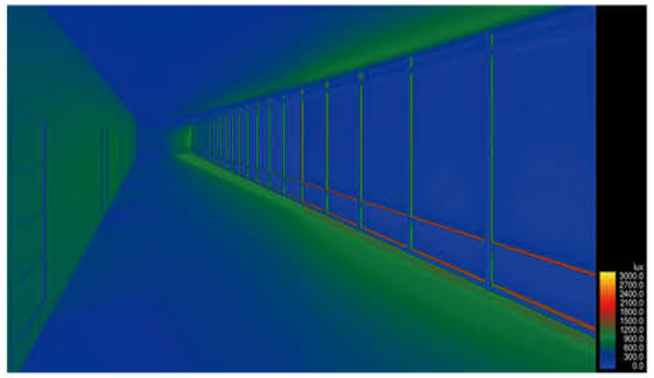
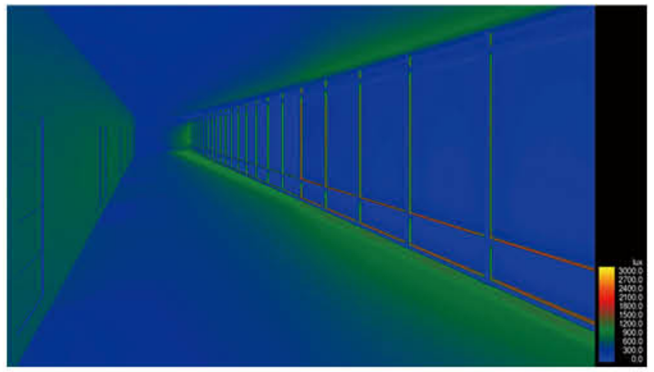



WEST FACING ROOM

Illuminance level - 1200 to 3000 lux

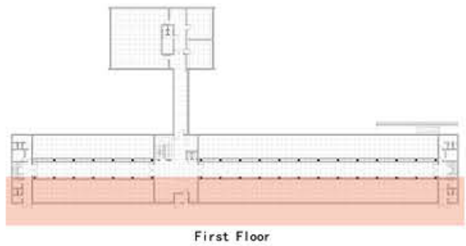


The west side does not require shading on the western facade as the lux level meets the requirement.

EAST FACING ROOM

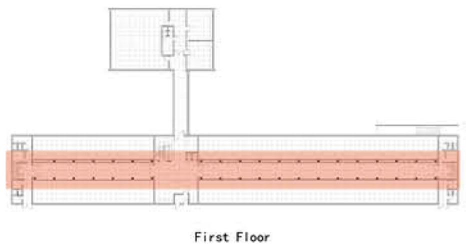
Illuminance level - 300 to 1200 lux



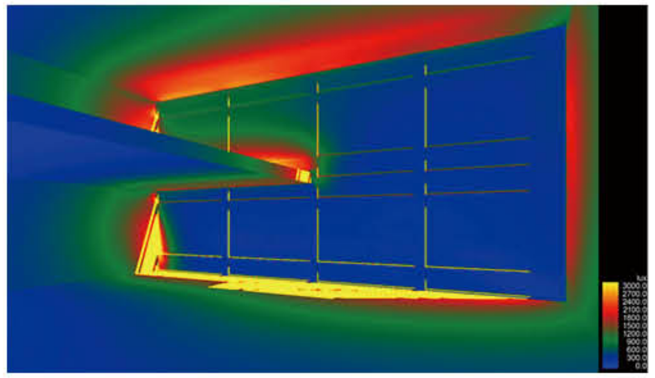
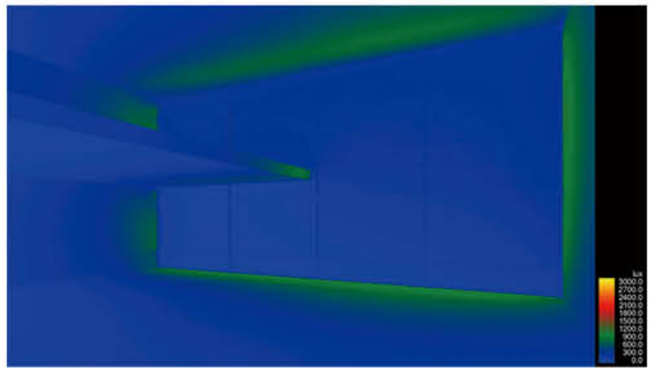
The orientation is favourable to have optimum solar radiation in the east side facing rooms.


CORRIDOR

Illuminance level - 0 lux

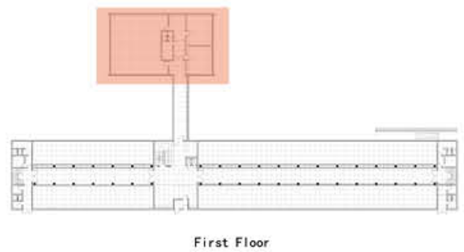


The corridors are packed with solid walls on both sides, leading to no daylight illuminance. This further increases dependency on artificial lighting throughout the year.

EXHIBITION AREA

Illuminance level - 0 -3000 lux



The exhibiton area has glass opening on northern and southern facade. The southern facade needs louvers to protect it from summer sun.

One Angel Square, Manchester, UK

Summary:

Strategies to be adopted:
1.Bringing new activities to the building.
2.Stack Systems
3.Geothermal heating system
4.Double skin Facade

References:

Copenhill-
https://www.architectmagazine.com/project-gallery/copenhill_o
https://www.archdaily.com/925966/copenhill-the-story-of-bigs-iconic-waste-to-energy-plant/5d9a804a284dd1ffa40000
a2-copenhill-the-story-of-bigs-iconic-waste-to-energy-plant-photo

One angle Square-
https://www.archdaily.com/337430/1-angel-square-3d-reid
https://sites.psu.edu/aroundtheworld/2019/02/01/one-angel-square-england/
https://www.3dreid.com/project/one-angel-square/

Selection Criteria:

1. Copen Hill-
Reviatlisation of Space
Study the climate condition
2. One Angle Square-
Study of strategies adopted by other cities with same climatic condition.

Retrofit Sustainability

The building has received the highest BREEAM (Building Research Establishmnet Environment Assesment Method) score in the country with 95.6 %. The building is designed considering the furture climatic condition, thus can function with rise in temp. up to 3-5°. Strategies adopted to bring this design are:

Double Skin Facade:

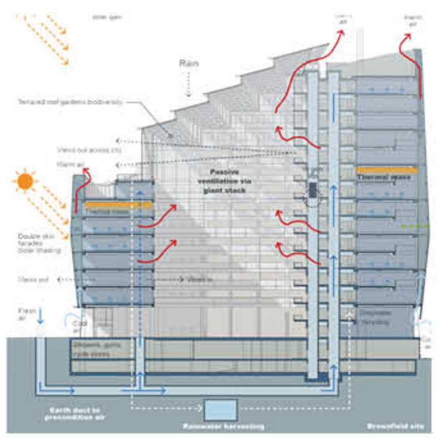
The two facades are placed in such a way that allows the air to flow in the building. It allows great coling and ventilation. Further open vents at the top of the building, let the air pass.

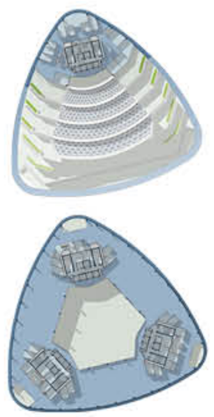
Geothermal and Cooling Heating:

Underground concrete earth tubes provide an amount of free heat and cooling for the incoming fresh air.

Concrete - Low Thermal Conductivity:

The building's concrete material is exposed to direct sunlight, acting as a sponge and soaking up heat.





Area - 30,000 sq.m.
Function - Office Building
Completion Year- 2012

1. Section through the atrium
2. Terrace plan
3. Typical floor plan

Copenhill, Copenhagen, Denmark

Area - 41,000 sq.m.
Function - Industrial , mix use building
- waste to energy plant
Completion Year- 2019

Hedonistic Sustainability

The architect shared the vision of bringing fun, more enjoyable alternatives to the idea of sustainability. By incorporating different activities to the extisting building, new character can be brought up, further increasing the community participation.

Facade of the building

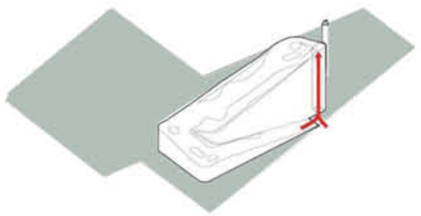
The facade is covered with aluminium bricks and glass in a staggering pattern, such that the daylight is evenly distributed throughout the building.

Form and Space

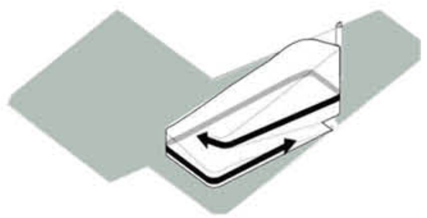
The building is given a mountain like form, that provides the citizen of Copehagen to enjoy the mountain in the flat land city.

Function of the Building

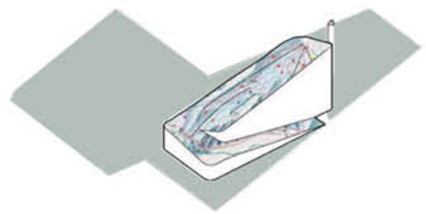
The building functions as a waste to energy power plant, that provides energy to the households, parallel to skiing ground designed by architect. Now the function is not just power plant but a picnic spot for the residents.



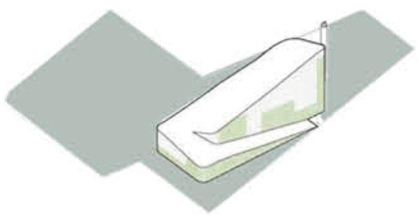
1. Accessibilty to ski paths through glass elevators.



2. Continuous facade made out of aluminium brick.



3. Roof inspiration from Alpine skiing, allowing users to ski throughout the year.



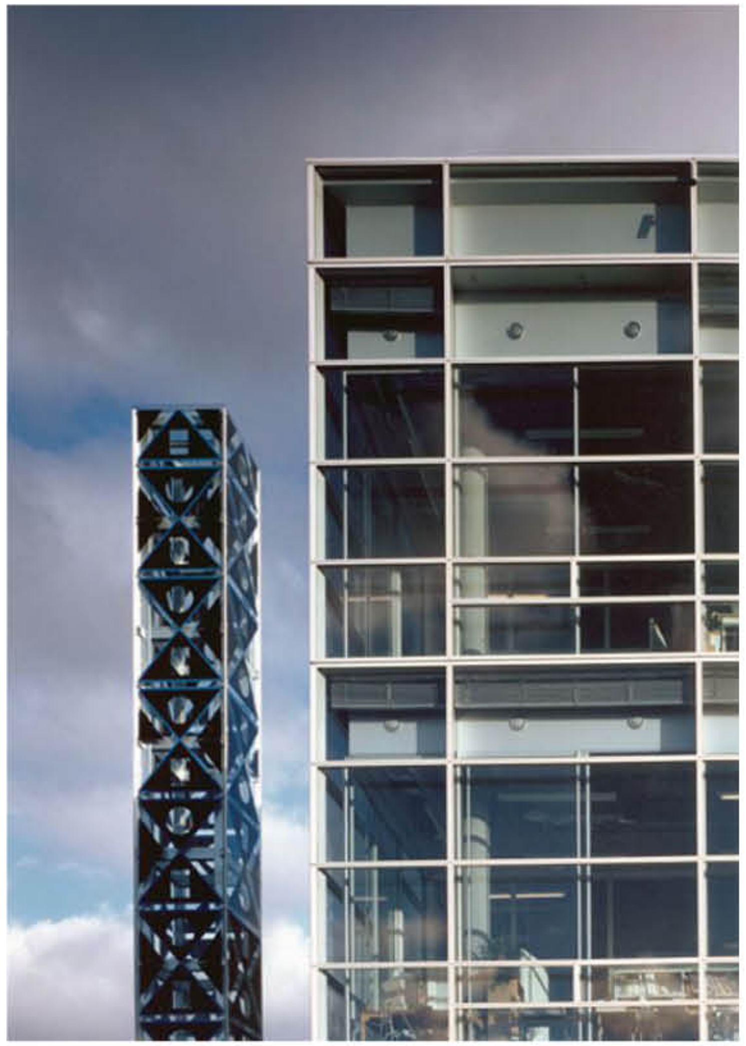
4. Green wall facade functions as planters.

5. Roof functions as a ski slope, hiking trail, green forest and climbing wall.

6. Geometry of theslope supports three slopes of different gradient.

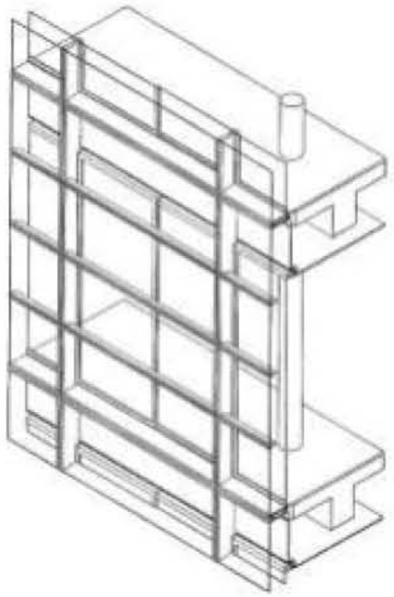
1.4.2 Royal Library Copenhagen and Inland Revenue Centre | Double Skin Façade

Royal Library, Amager, Copenhagen, Denmark



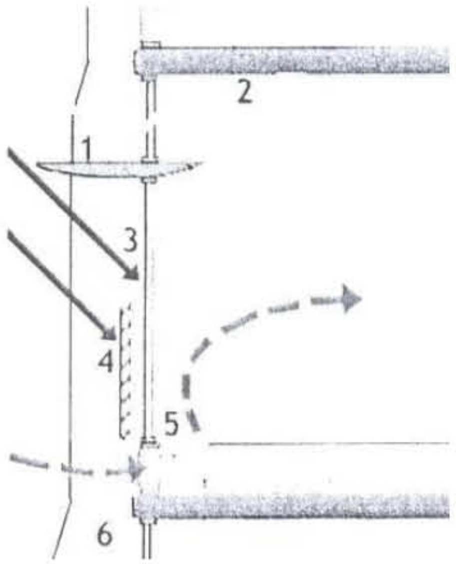
Double skin façade:

The double skin facade can be used with both natural and mechanical ventilation systems.
It consists of low emissivity double glazing with solar reflective coating on the outside skin and a single layer glazing on the internal one. The profile system in the outer layer is special designed with insulation against cold bridges.
The air gap within the double skin facade system has a thickness of 30 cm and it contains perforated louver blinds to not run the visual connection with the surroundings. The cavity is used as a buffer zone in the heating season to reduce heat loss and cold down draught. 'The extract of air from the offices are lead through gaps below the sliding doors and are further extracted via outlets in the horizontal division'. Furthermore, in summer season the building utilizes an automatic system of windows in the outer layer and sliding doors are used for supplementary venting of the offices (Byggeindustrien, 1999).



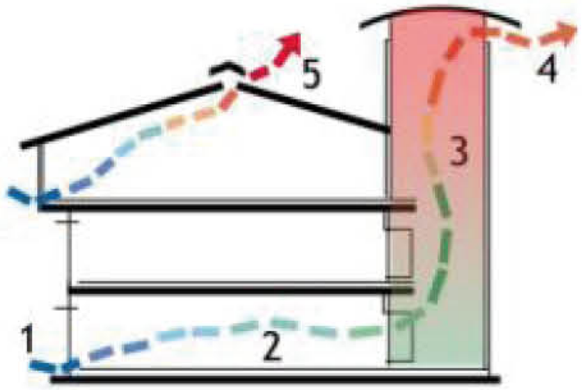
Architects: Dissing + Weitling
Location: Copenhagen, Denmark
Year: 1997

Inland Revenue Centre, Nottingham, UK



Double Skin Façade and ventilation system:

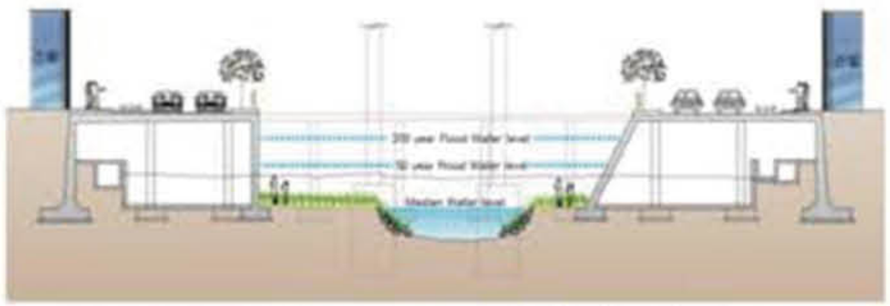
Fresh air is drawn through an underfloor duct and grill which can be mechanically-induced. Warm air exhaust through the door, connected to the stair tower. The solar gain in the tower increases the effect of thermal buoyancy in which warm air is drawn up through the tower by stack effect.
External brick piers provide lateral solar shading to the façade.
Cross ventilation is created by openable windows in the area of the offices. The design of the building relies on two main strategies, maximising daylight and engineering natural ventilation.



Architects: Dissing + Weitling
Location: Copenhagen, Denmark
Year: 1997

Cheonggycheon River Restoration Project, Seoul South Korea

In 2003 a river restoration project was launched to bring environmental benefits back to the river. The overall aims were for; 1. An ecologically sensitive pedestrian corridor which improves the environment. 2. To dismantle the elevated freeway and concrete deck above the stream. 3. Improve the quality of life of people in Seoul. 4. To remove the safety risks posed by the decaying freeway built over the top of the river.5. To increase business competitiveness and connectivity either side of the river (North and South).6. Revitalize Cheonggyecheon's natural environment in order to design a more "human-oriented public space" and how to return the stream, aquile water resources, manage sewage, traffic and historical assets.

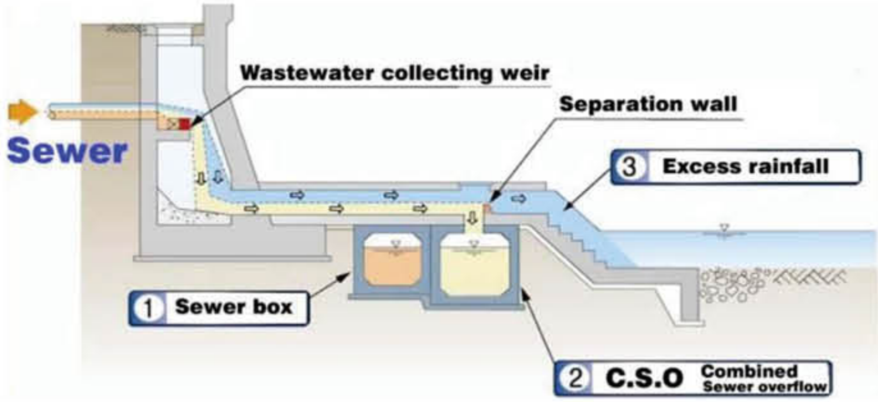


<Figure 10> Cross-section view of Cheonggyecheon and estimated flood elevation

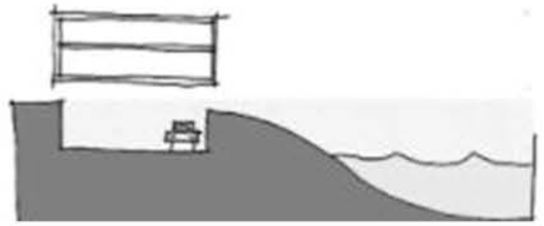
Section of the site:

Area - 10 acres /**Function -** Park/ OPen space+ Stream Restoration/**Completion Year-** 2005

Sewage Section

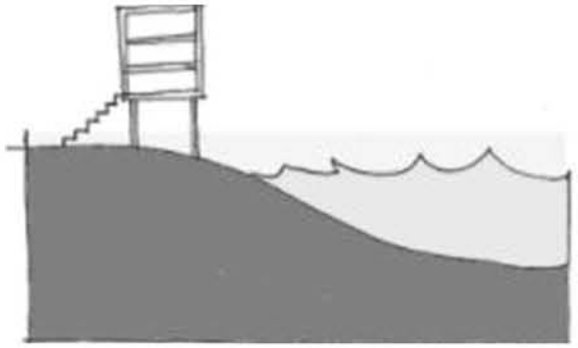


Mitigation Startegies for Flood Resilient Buildings

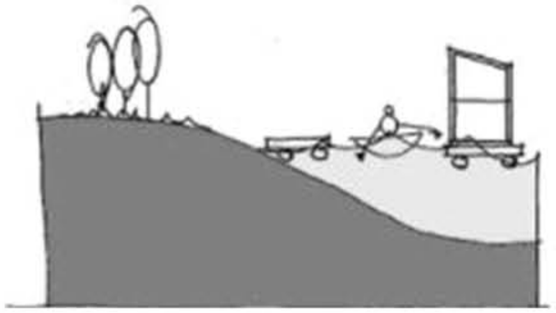


Sacrifical Basement/ Ground floor
Wet Flood Proofing - Designing the Ground floor with fixed material for less damage.

Flood Resiliant Building through sealant
Dry Flood Proofing through Sealants and material makes it a permanent solution.



Building on Stilts



Floating Buildings

Summary: The case study represents an ongoing strategy again a urban flooding. It provides flood protection for up to a 200 years flood event and can sustain a flow rate of 118 mm/hr.Strategies to be adopted:1.Design a sacrifical lower floor in tone building.
2.Use of sealant 3.Use of stilts 4.Floating buildings.

Introduction

The periods preceding the time the Rodovre Town Hall was designed had affordability and availability being the key factors that determined the choice of materials to use. This was driven by a full focus on functionality of the buildings. The later styles demonstrate harmonious and simplistic appearance with no decorative structures whatsoever.

Anne Hvides Gård Source: Wikipedia

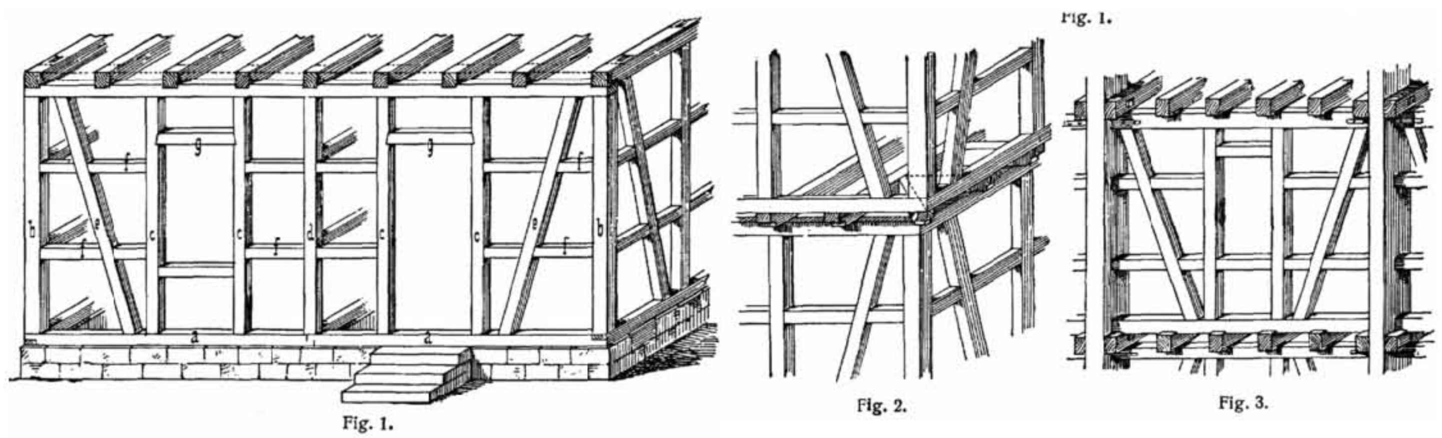
Half-timbered Buildings

During the late Middle Ages, a slow transition began from the traditional wooden (Danish Townhouses) houses towards half-timbered properties. One of the oldest in Denmark is Anne Hvides Gård, which was constructed in 1560.

Functionalism

Affordable materials, full focus on functionality and a harmonious and simplistic appearance with no decorative structures whatsoever.
Functionalism, which began in the 1930s, relied on rational architecture making use of bricks, concrete, iron and glass, preferably to meet social needs.

Detail from Århus Kommunehospital (1935) by C.F. Møller. Source: Wikipedia



Summary:

Architecture in Denmark shows a positive trend of adapting the use of materials to suit the social needs and affordability. This demonstrates a strong sustainability background. in the choice of vernacular materials such as timber.
Rødovre Town Hall, completed in 1956, shows how well Jacobsen combined the use of different materials: sandstone, two types of glass, painted metalwork and stainless steel.

02. Vision, Objectives and Solutions

Vision

Combining aesthetics and sustainability to provide a building that can stand future climate challenges, further encourages community participation, while incorporating strategies that will enhance energy management.

Primary Objectives:

1. Energy
   - Energy efficiency
2. Daylight
   - Improvement of daylight in the building
3. Functions
   - Improvement of the relationship between the governament and community
4. Floods
   - Flood resilient building

Concrete Objectives:

a. Reduce energy consumption by 50% b. 30% renewable energy supply off grid	a. 100% comfortable lux for all spaces by daylighting b. All spaces access natural daylight	a. More than 40% of the building will be designed for community use	a. More than 80% of the building will be flood resistant

Solutions:

a. Double skin facade b. Geothermal heating and cooling system c. Insulation of thermal envelope / double glazing d. Photovoltaic panels e. Use of mix mode ventilation	a. Layout design b. Improving the window performance c. Improve functionality of the building	a. Improving activities within the building b. Design a new landscape of the green area to attract the community c. Incorporate cycle tracks in the site	a. Elevate the building b. Wetlands and change of the topography of the site c. Soft perforated landscape to replace hard surfaces

03. Solutions

3.1 SWOT Analysis

Solutions

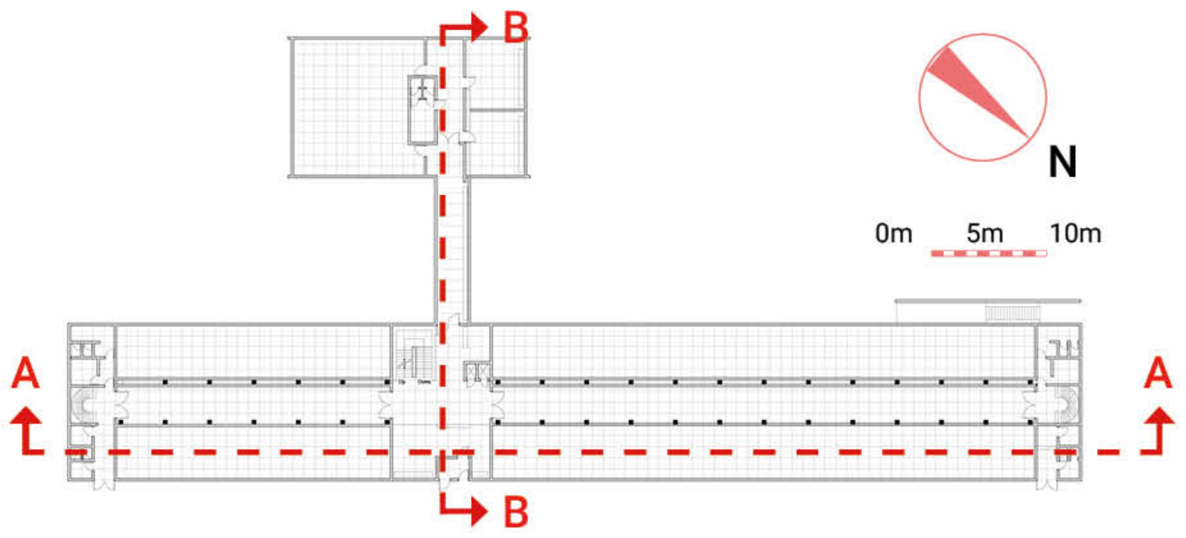
- Orientation - maximise on solar heat gain.
- Structure - Adaptable, simple and strong structure.
- Precast building elements.

- Lighting - Poorly lit passage ways along the buildings centre.
- Ventilation - Mechanical ventilation.
- Poor Indoor Air Quality.
- Lack of universal access and circulation.
- Interactivity - Enclosed working spaces. Poor visual connection.
- Poor thermal envelope - Single glazed window.
- Functionality - underutilised office spaces.

- Location - connection to neighbourhood.
- Access - Easily accessible by the public through sustainable transport (walking and cycling).
- Ventilation - potential for cross ventilation for improved Indoor Air Quality.

- Flooding - Destruction by flooding water.
- Excess solar heat gain leading to overheating.
- Detatched from the public.
- Solar glare on working spaces in summer and winter.

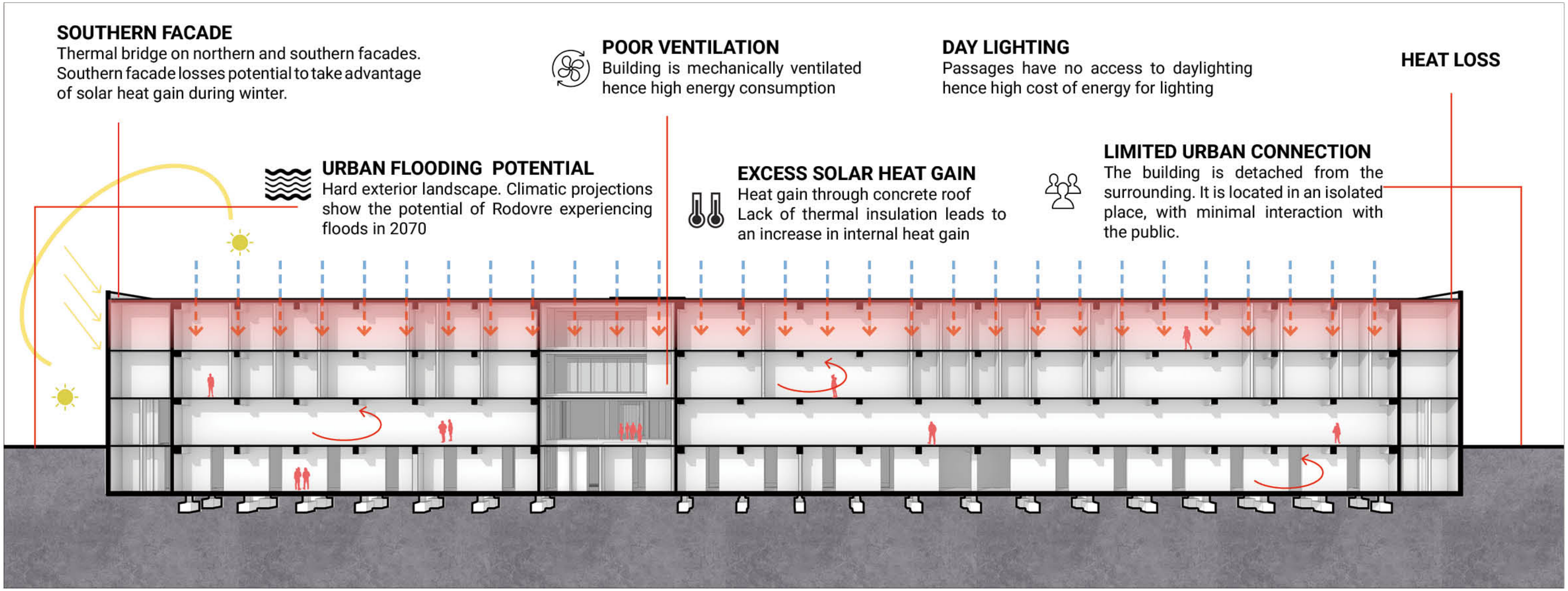
3.2.1 Environmental Section A-A | Problems

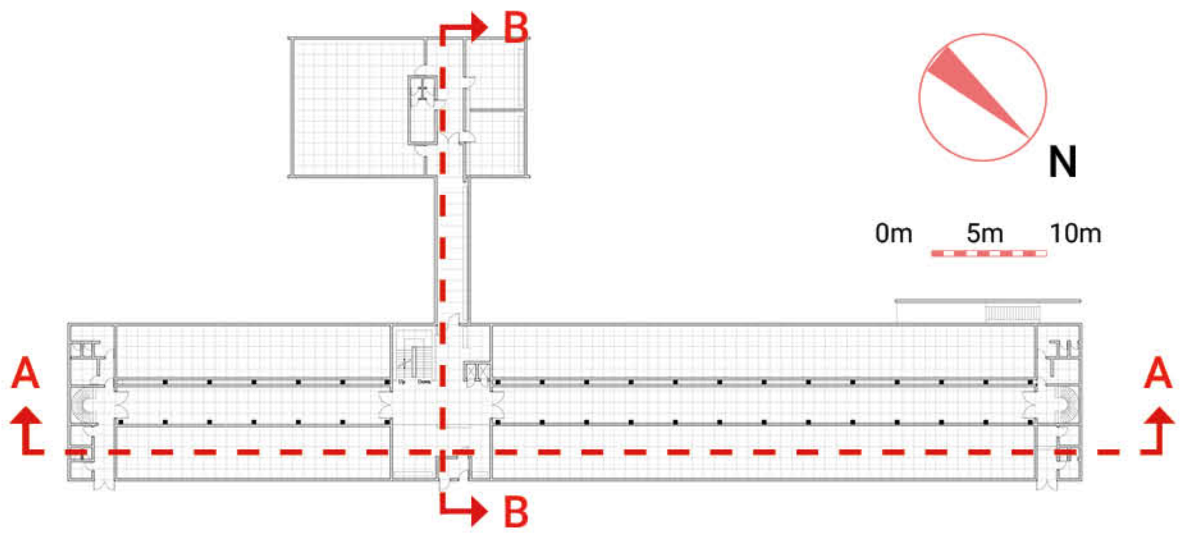


Summary:

1. Flooding - Due to expected rise in sea level, site is prone to flooding and strong winds.
2. Poor Ventilation - Building is enveloped with fixed glass, making it fully rely on mechanical means of ventilation.
3. Daylight - Some parts of building don't have access to natural daylights.
4. Excess Solar Heat Gain - The building's longer sides are facing east and west direction, leading to more heat gain.
5. Underutilized green space - Being a landmark of the town, the site has the potential to connect the community. But no space is being used for any activity.

Section A-A





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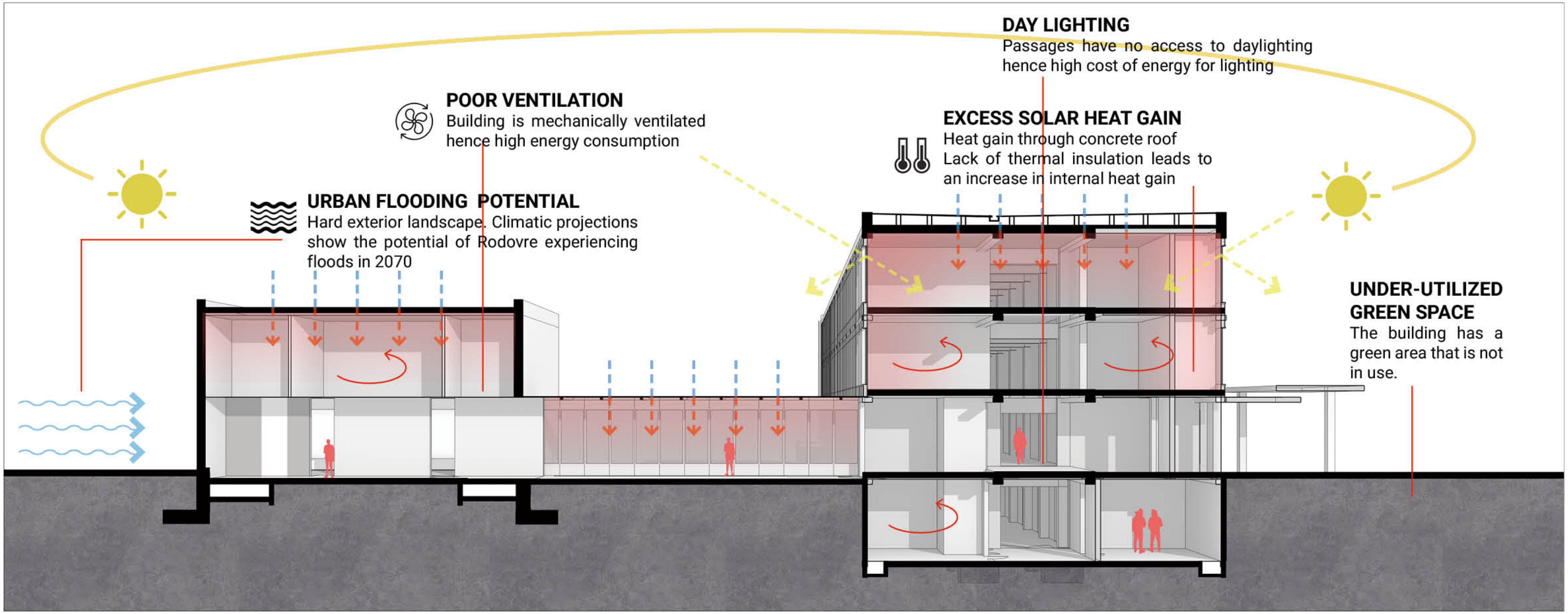
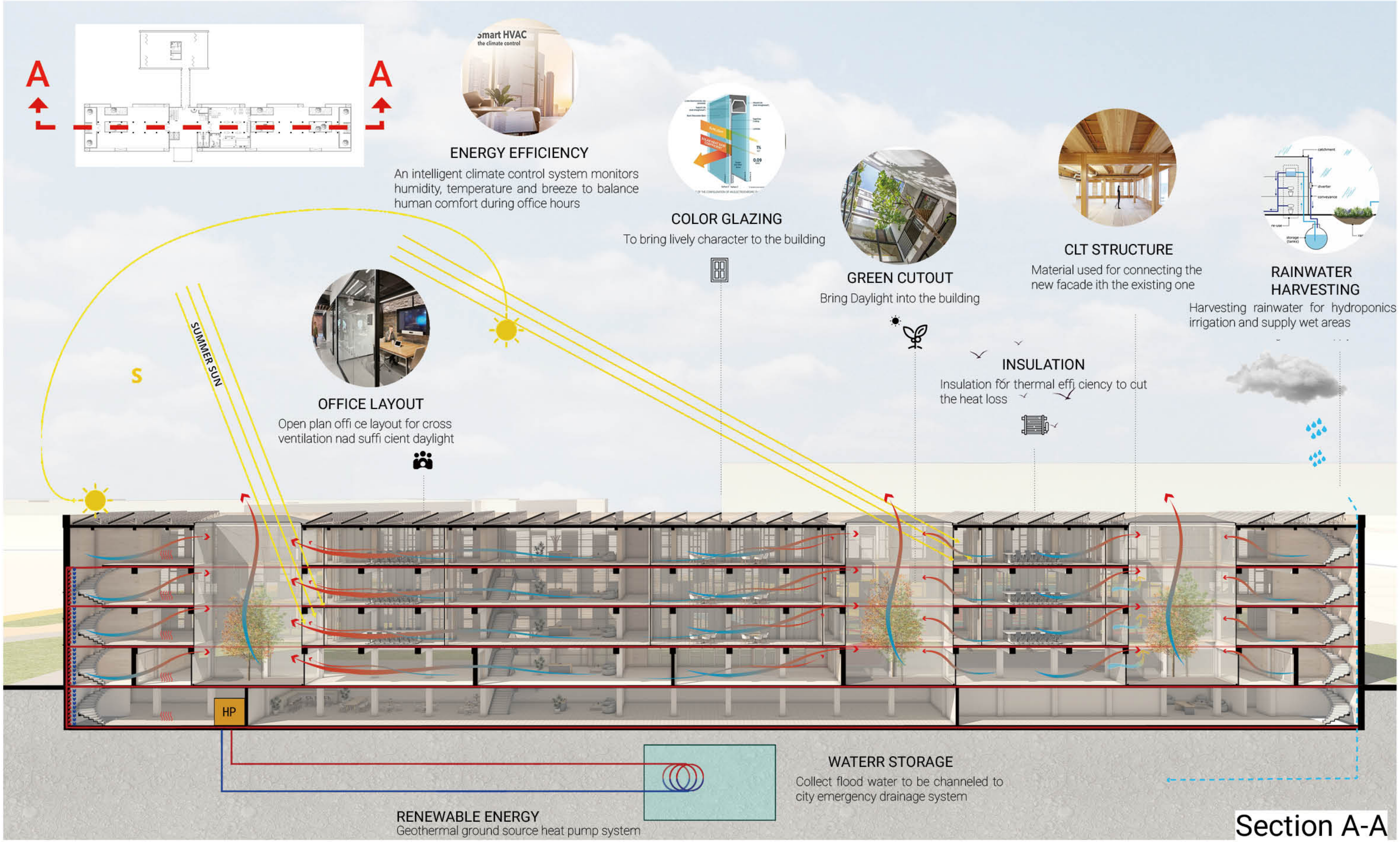
Section B-B



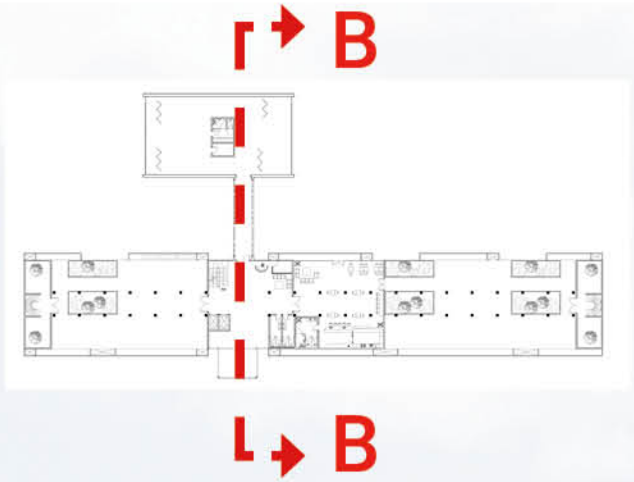
3.2.3 Environmental Section A-A | Solutions

Environmental Section



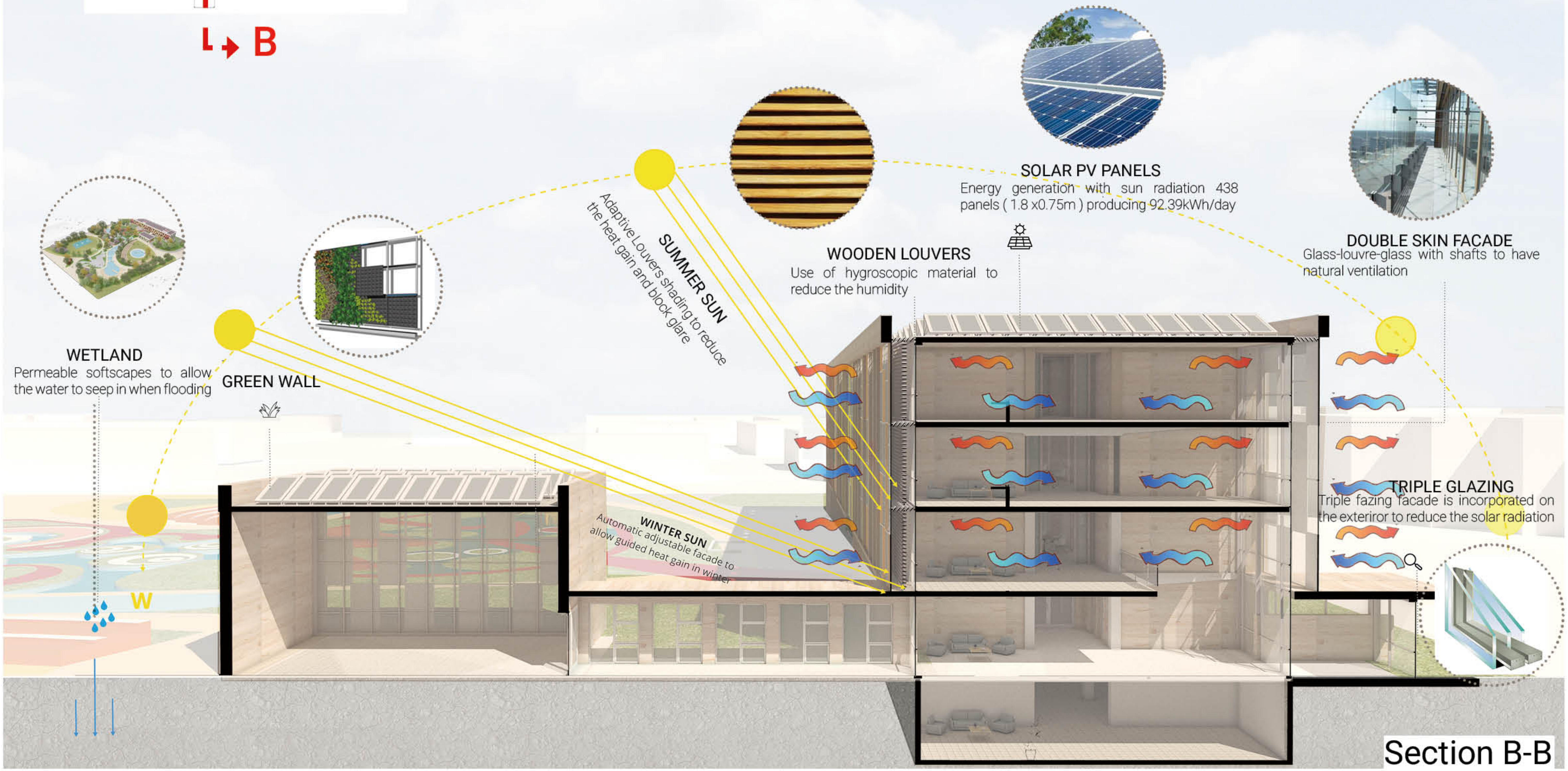
3.2.4 Environmental Section B-B | Solutions

Environmental Section

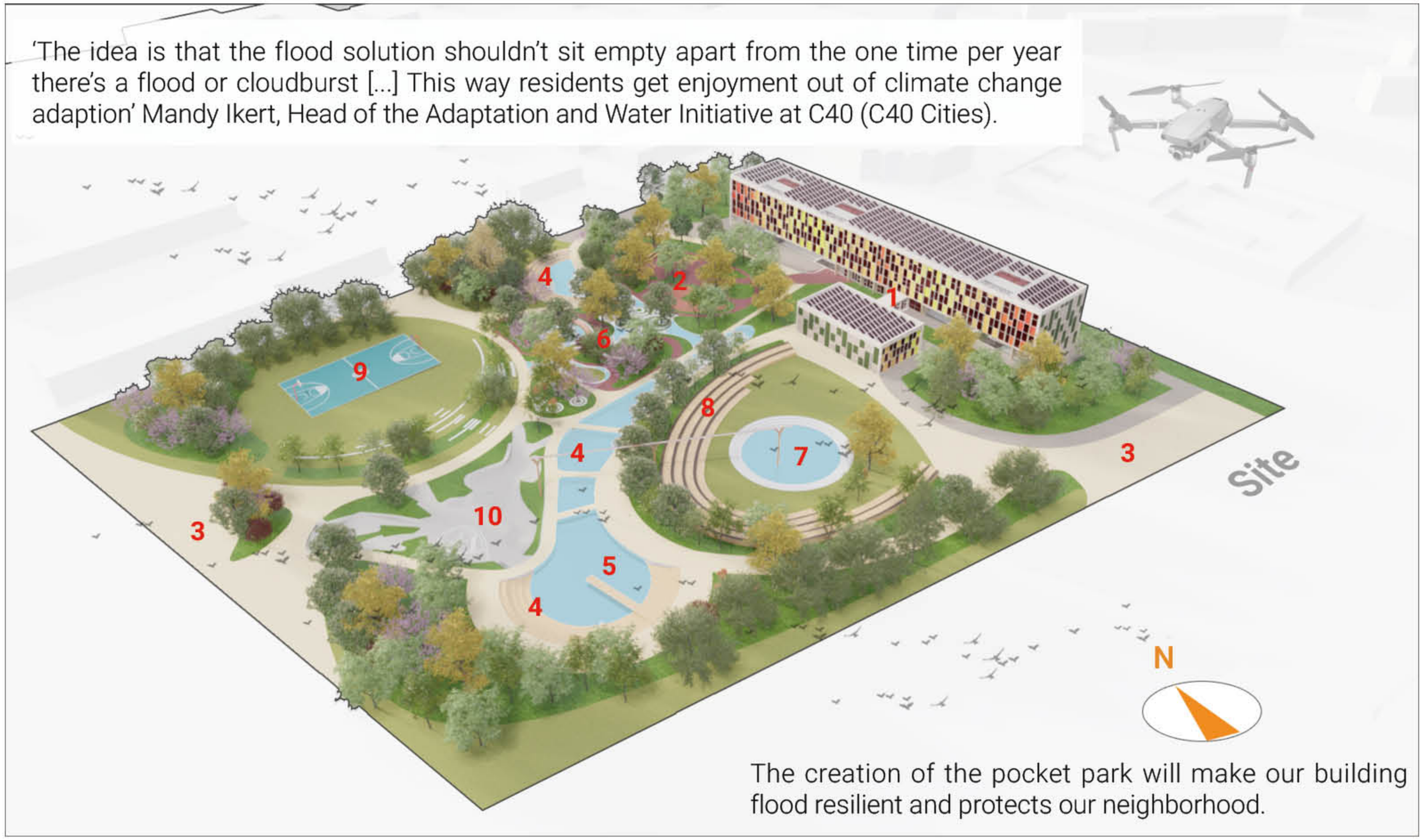


Summary

1. Wetlands, water reservoirs and planning on stilts are some of the strategies adopted for flood resilient building.
2. To reduce the solar transmittance and illumination louvers and triple glazing glass is suggested
3. Double Skin facade is one of the strategies to imrove the cross ventilation in the building.
4. To generate electricity, Solar PV panels are adopted on roof.

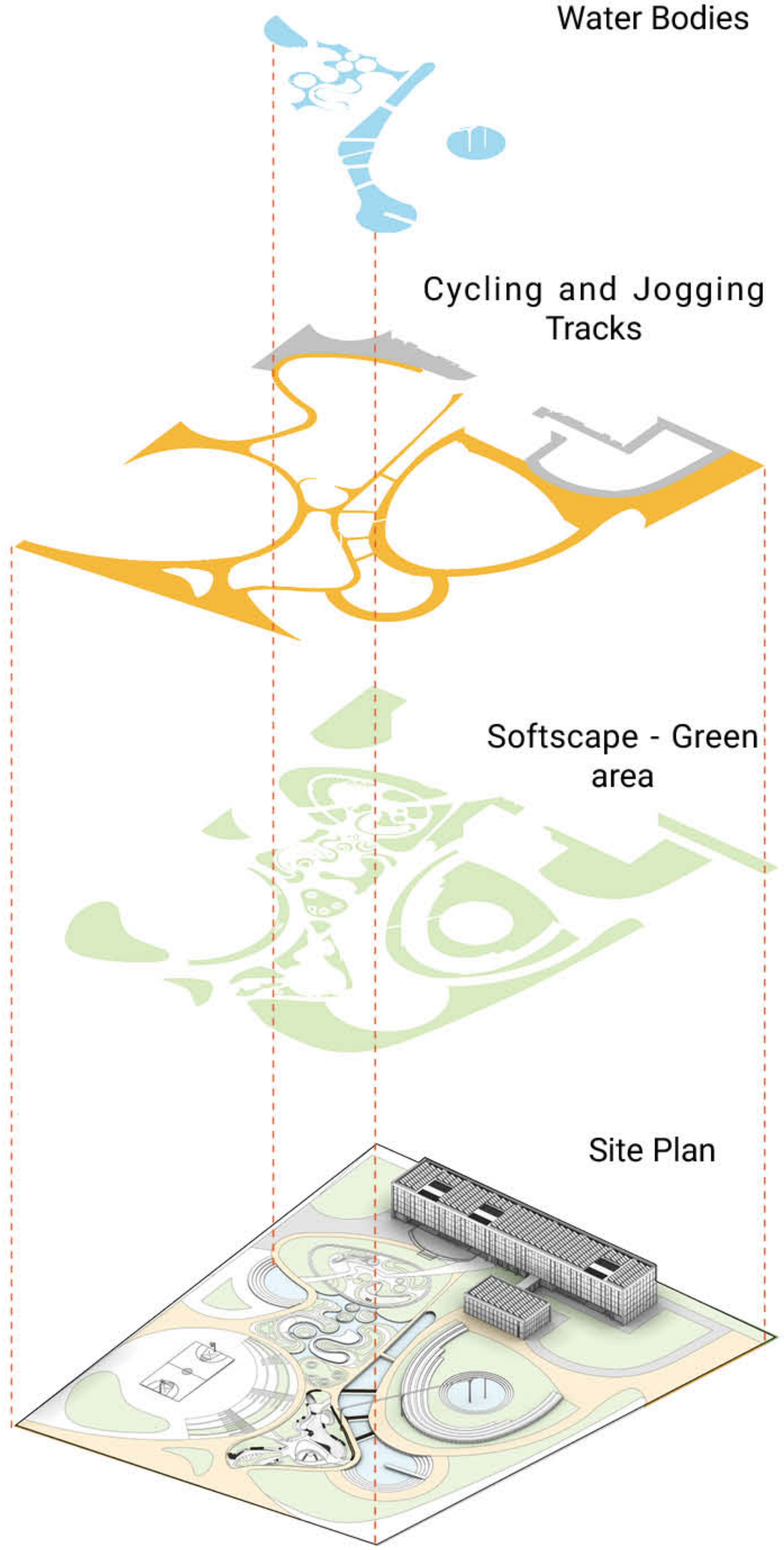


‘The idea is that the flood solution shouldn’t sit empty apart from the one time per year there’s a flood or cloudburst [...] This way residents get enjoyment out of climate change adaption’ Mandy Ikert, Head of the Adaptation and Water Initiative at C40 (C40 Cities).



The creation of the pocket park will make our building flood resilient and protects our neighborhood.

1. Proposed Builidng
2. Play Area
3. Entry Plaza
4. Waterfront Stepping Seat
5. Lakeside Wood Deck
6. Ecological Wetland
7. Water Reservoir
8. Terracing Seat
9. Basketball Court
10. Skateboard Area



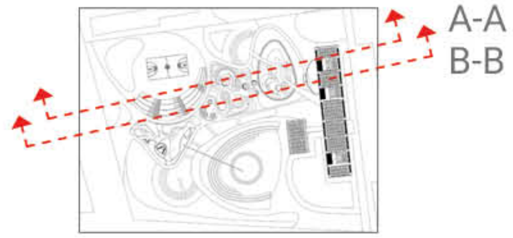
Summary: Landscape is introduced to the site to improve the social character of the building. As the site is node of the city, we have incorporated the cyclng tracks, parks and waterbodies to increase the neighbourhood participation on the site. Further, topograghy and trees are introduced to reduce the solar radiation on the site, helping communities to acces the site.

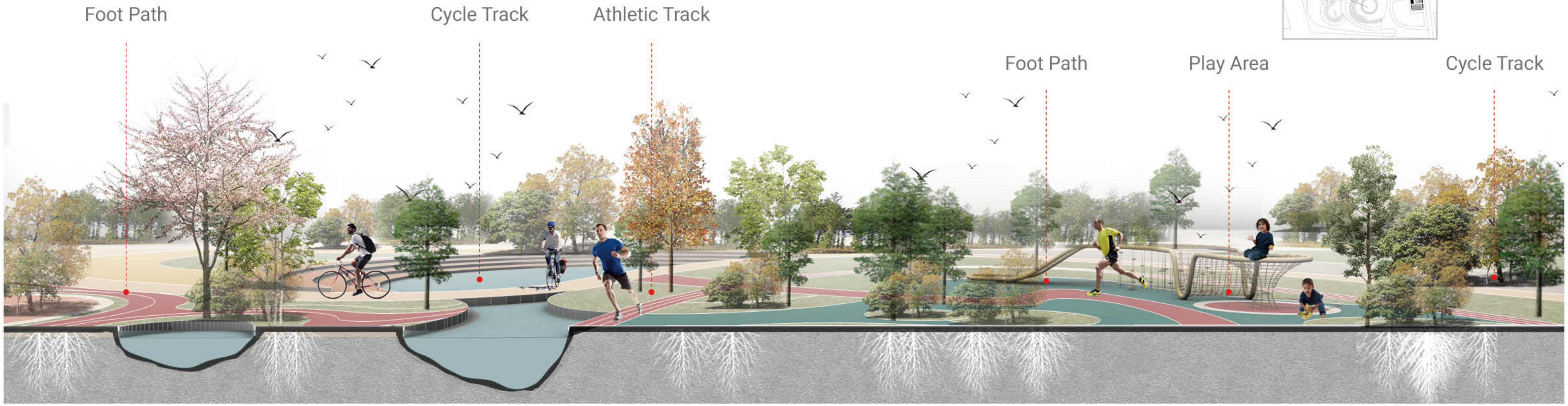
The site is expected to face flooding by 2070, as a result of climate change, the sea level will be increased. The site has large water storage areas, that has the capacity to hold water and further recharge the ground level, with softscape.

3.3.2 Activities and Wetland Design

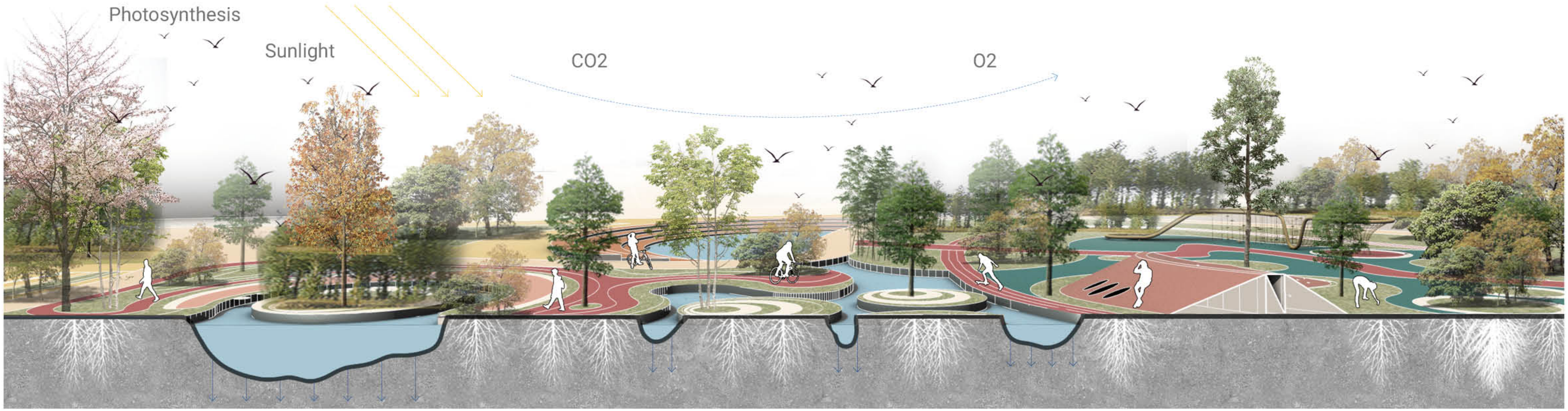
Solution 1 | Landscape Design

Activities | Section A-A





Wetland | Section B-B



3.3.3 Wetland and Water Reservoir | Flooding

Solution 1 | Landscape Design

ACTIVITIES ON WETLAND BEFORE FLOODING	ACTIVITIES ON WETLAND AFTER FLOODING

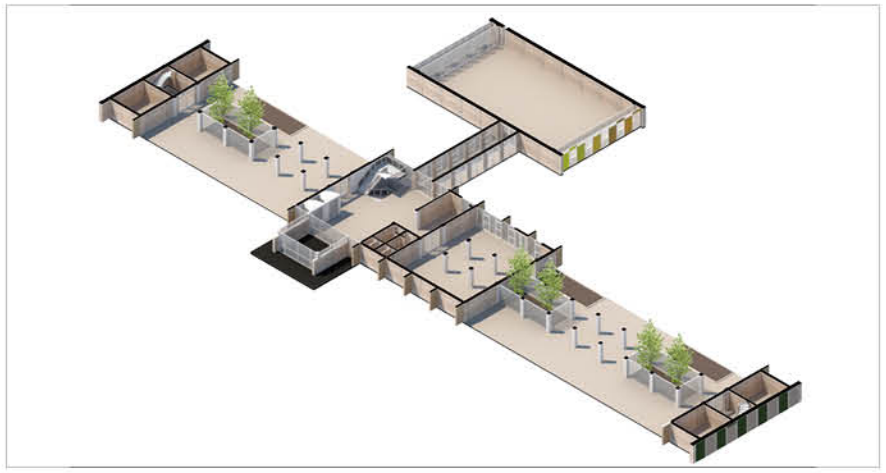
Summary: The site is bound to experience floods and high precipitation by 2070, due to climate change leading to rise in water level. Thus we have incorporated spaces like amphitheatre and parks that works as water collection points and wetlands, perventing the city from flooding. The Scape will further help recharge the ground level, as the parks and and tracks have penertrative tiles helping collect the water, that can further be used for irrigation.

3.3.4 Flooding Resilient Measures on Building

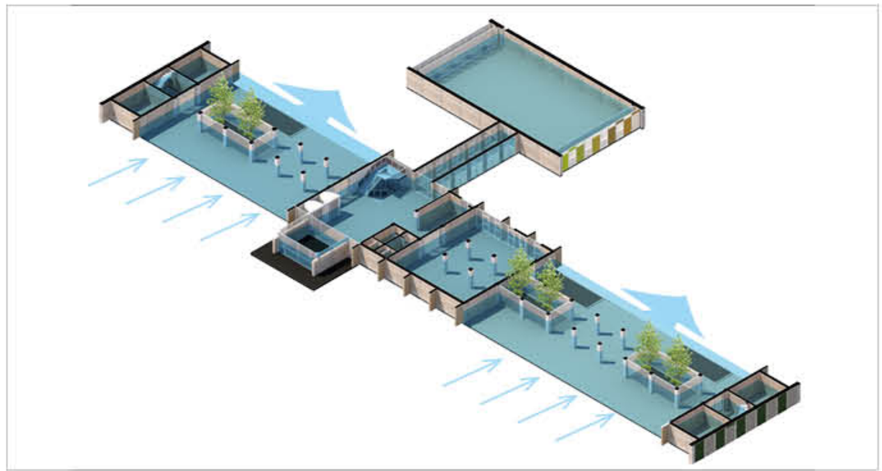
Solution 1 | Landscape Design

DAMAGES ON SITE WHEN IT HITS THE FLOODS

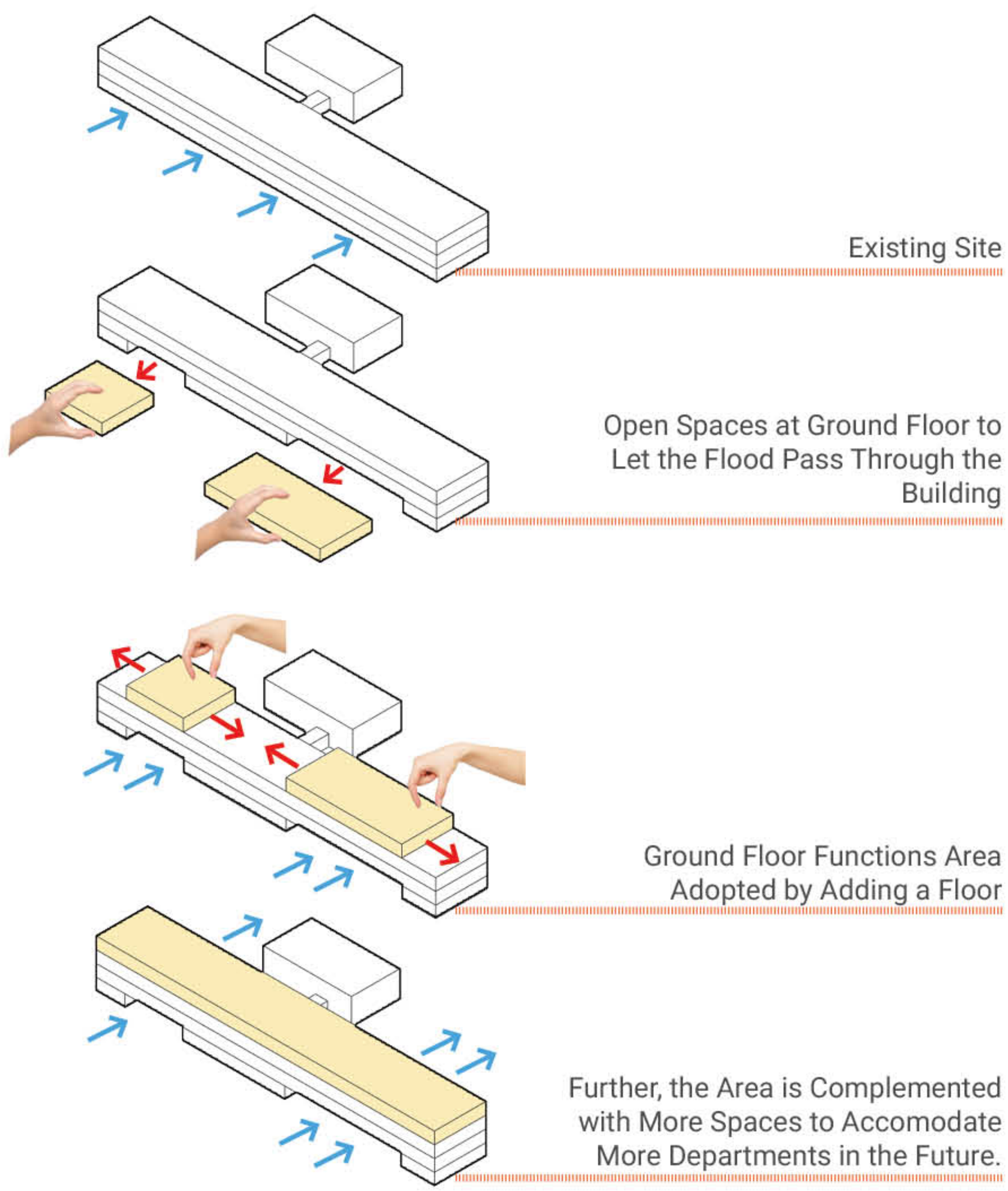
BEFORE FLOODING



ENCOUNTER FLOODING



DESIGN STRATEGIES FOR FLOODING

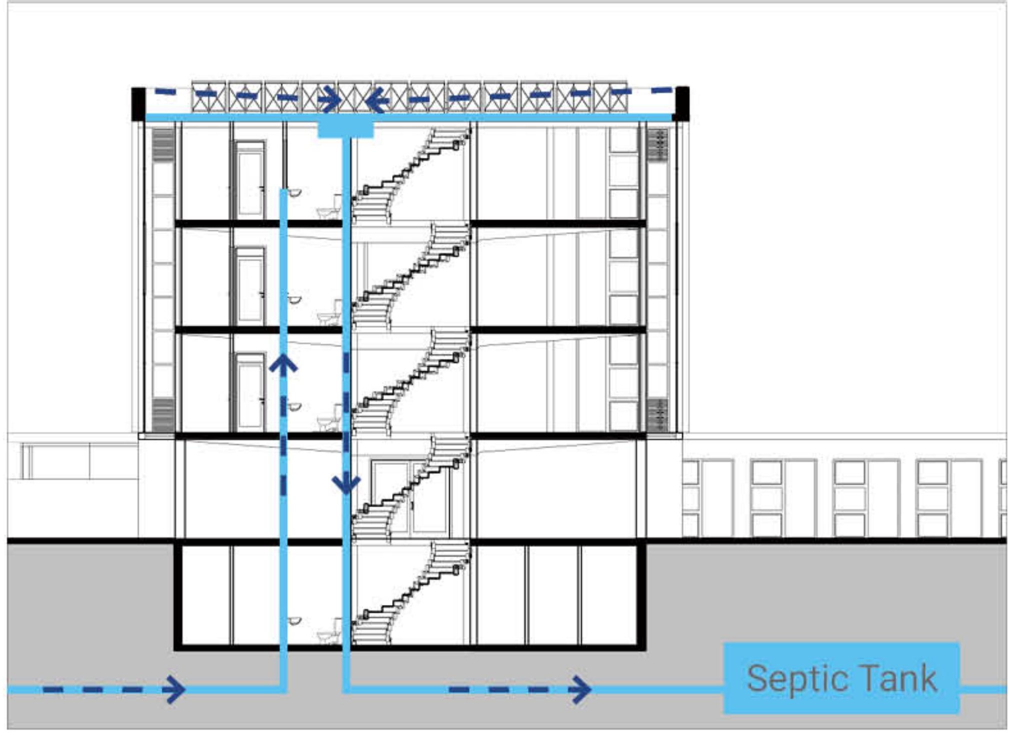


Summary:
Strategy for Flood Resilient Building:
The building is lifted on stilts to let the flood water pass from the ground.
The functions on the ground floor involves fixed furniture, so that there is less damage during floods and recovery is faster post flooding.

3.3.5 Rain Water Harvesting System

Solution 1 | Landscape Design

Rainwater Collection



Landscape Distribution Chart

Resist Levels According to Flood Intensity

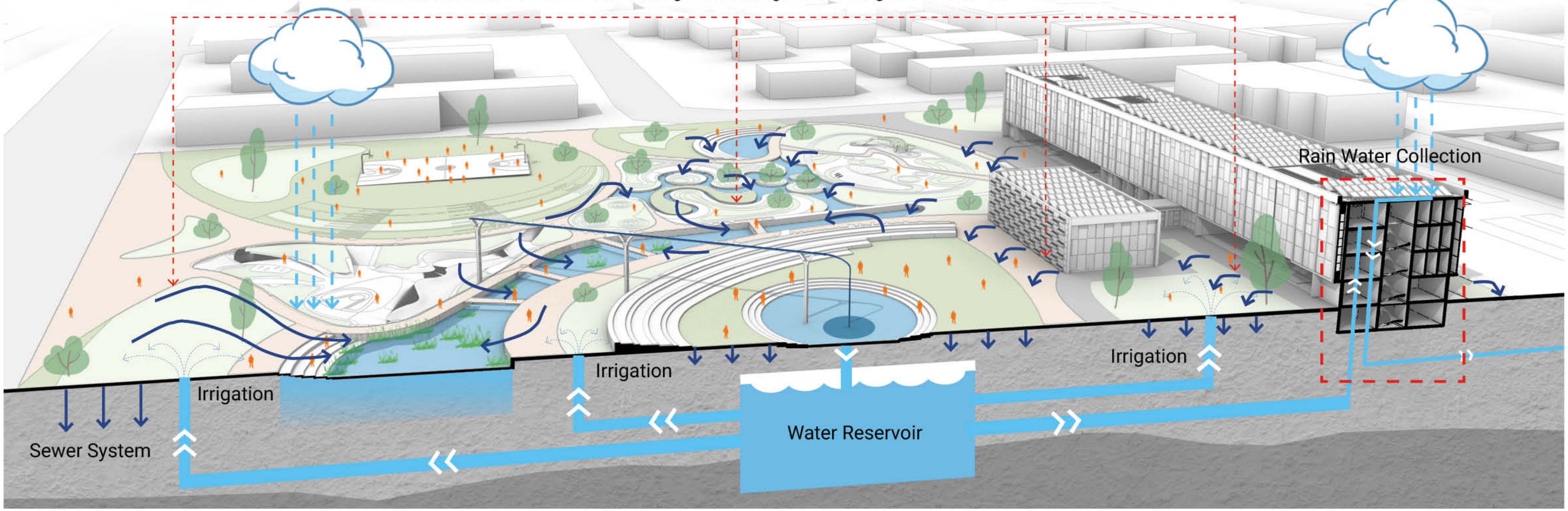
Light

Heavy

I. Park with Wetland
II. Rain Water Collection
III. Topography
IV. Sewer System
V. Open Spaces at Ground Floor

Summary:
As the site has large covered area. The strategy is adopted to collect water and use it to recharge ground water level and irrigation. Further the water will be used for water services like flushing and washing hands. The terrain will guide the flow direction of the rian water.

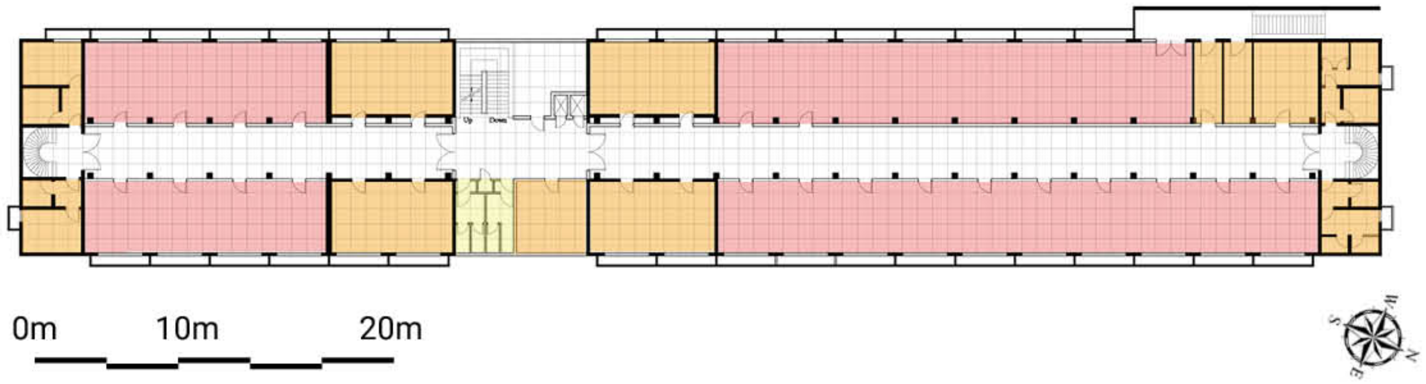
Guide the flow of rain water through the change of the height of the terrain



Basement Plan (Existing Building)

Legend:

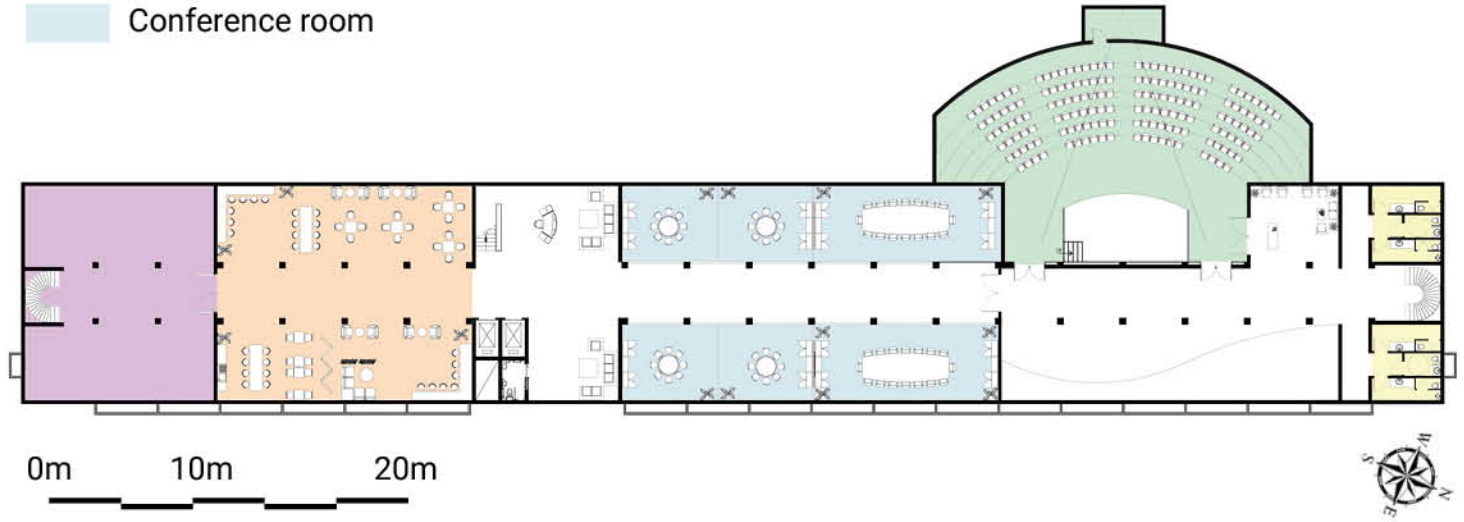
- Office spaces
- Subsidiary function spaces
- Toilets



Basement Plan (Proposed Building)

Legend:

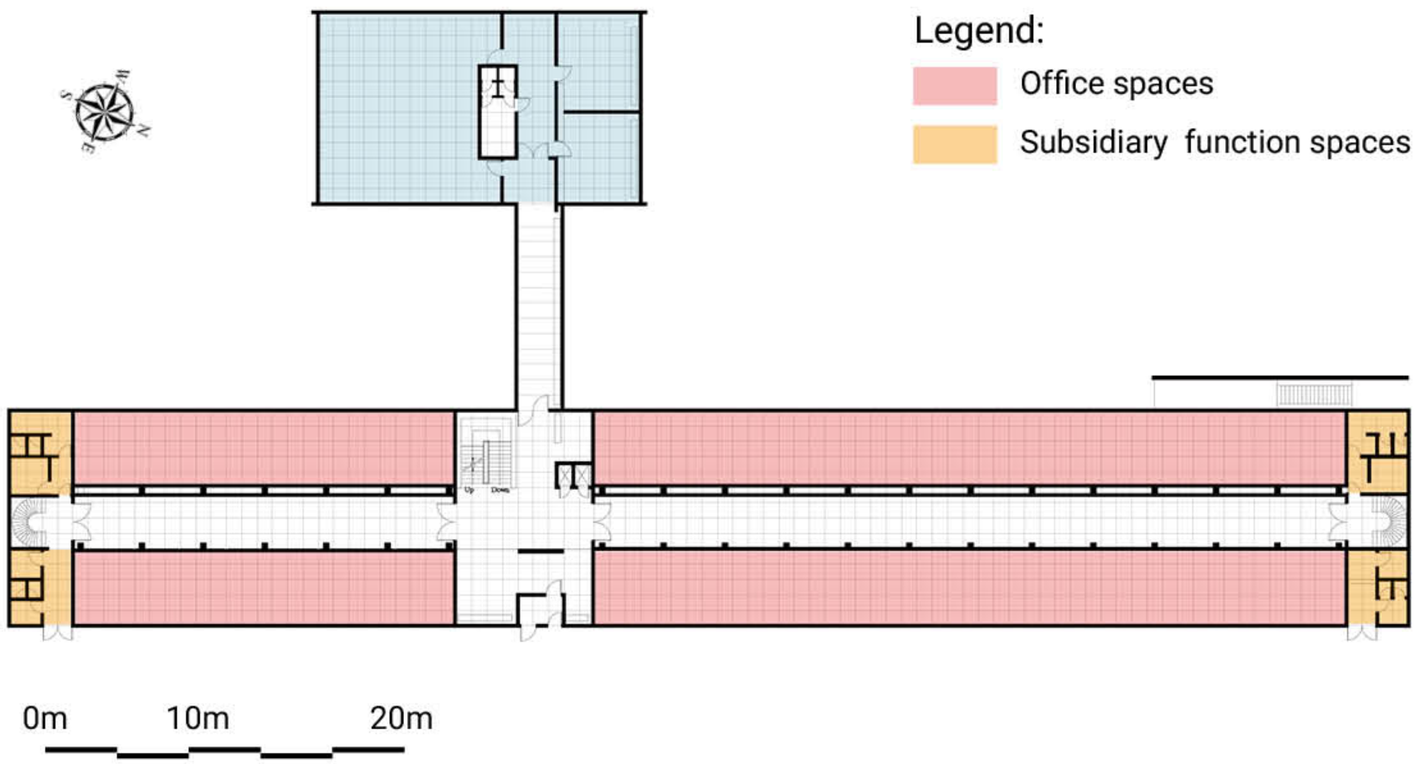
- Mechanical system
- Auditorium
- Co-working spaces
- Toilets
- Conference room



Groundfloor Plan (Existing Building)

Legend:

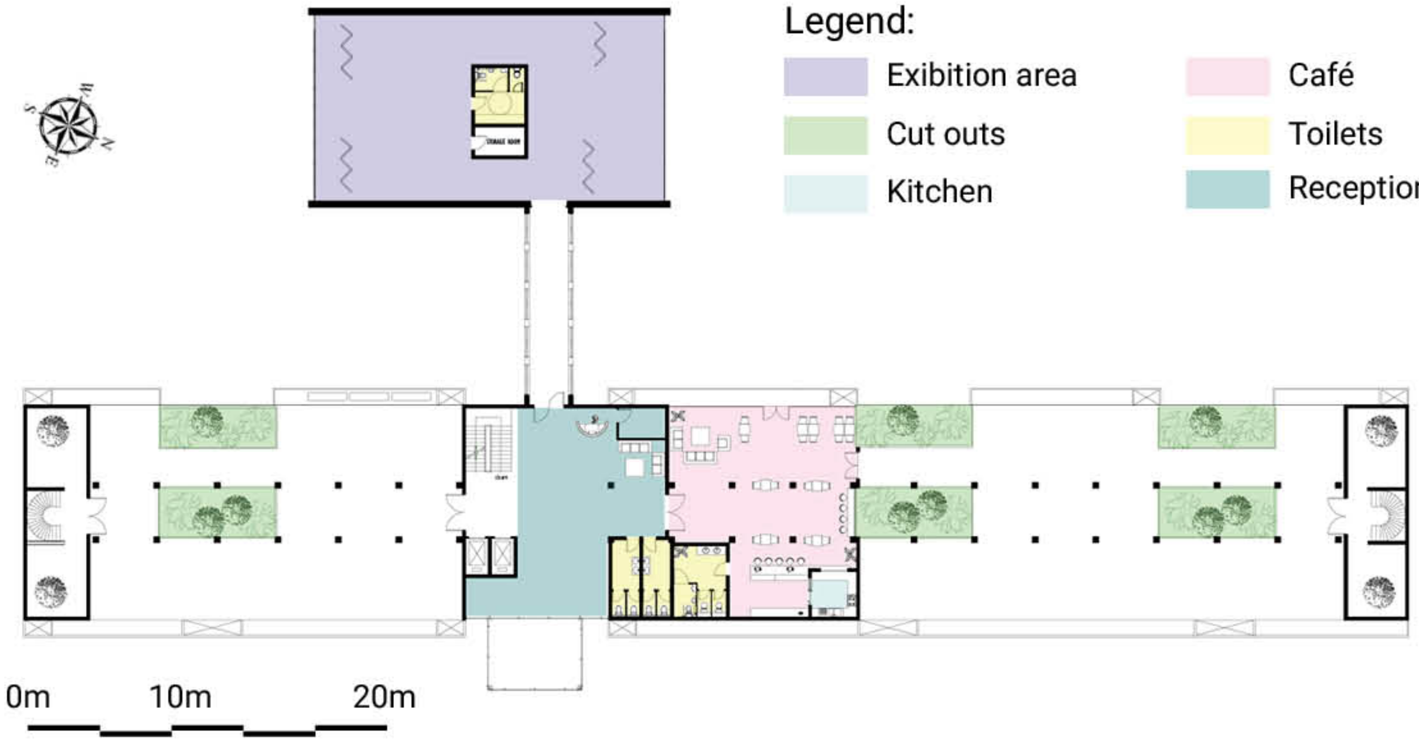
- Office spaces
- Subsidiary function spaces



Groundfloor Plan (Proposed Building)

Legend:

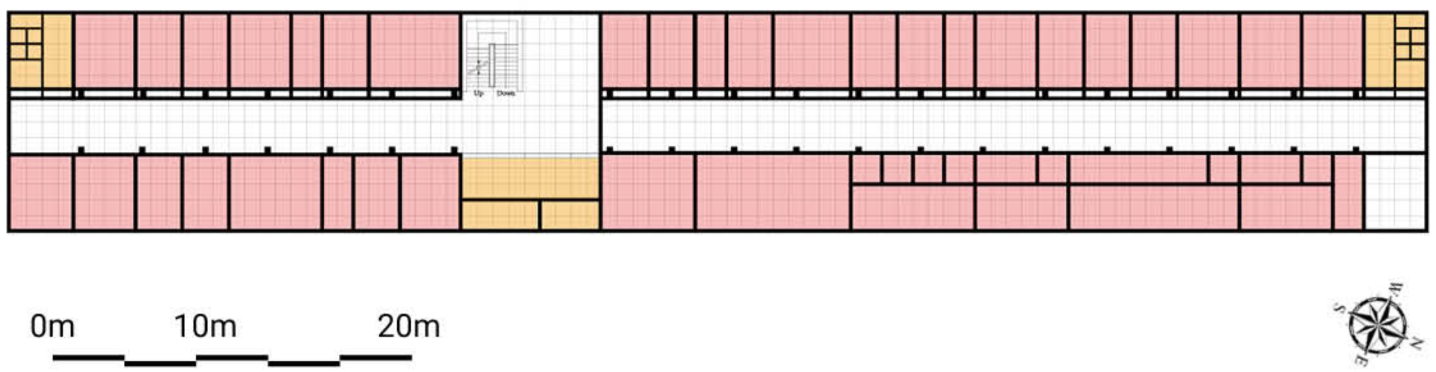
- Exibition area
- Café
- Cut outs
- Toilets
- Kitchen
- Reception



First Floor Plan (Existing Building)

Legend:

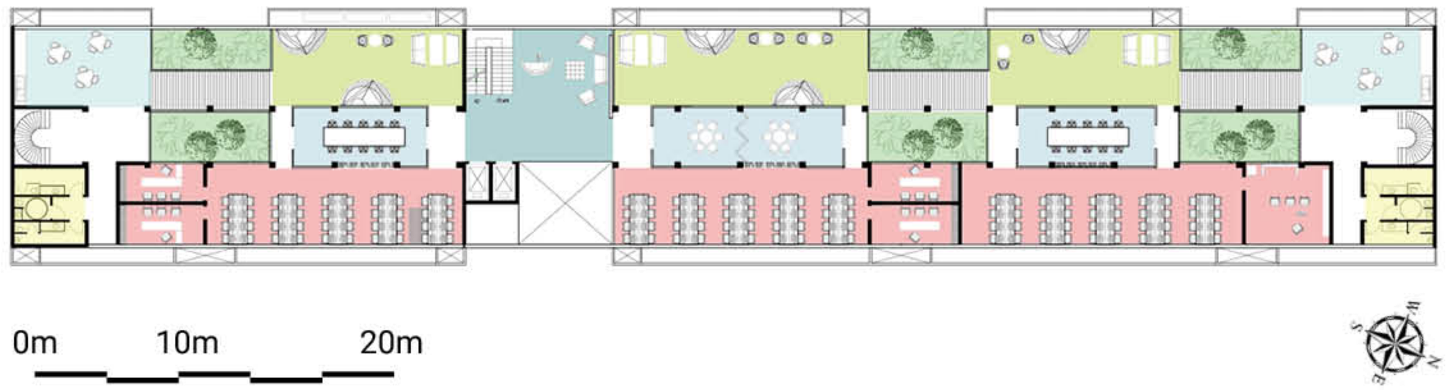
- Office spaces
- Subsidiary function spaces



First Floor Plan (Proposed Building)

Legend:

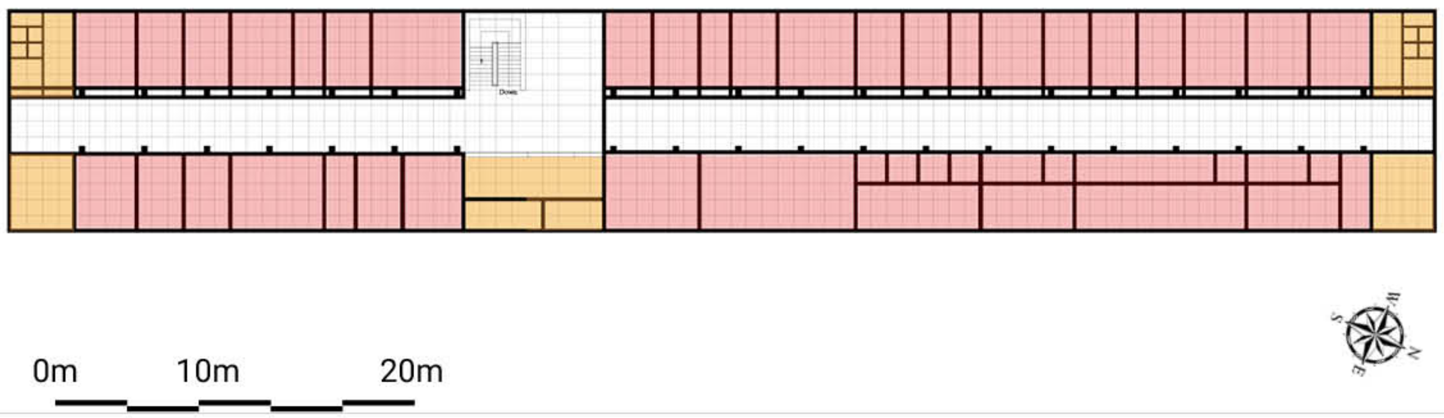
- Pantry area
- Flexible working spaces
- Conference room
- Toilets
- Cut outs
- Working spaces



Second and Third Floor Plan (Existing Building)

Legend:

- Office spaces
- Subsidiary function spces



Second and Third Floor Plan (Proposed Building)

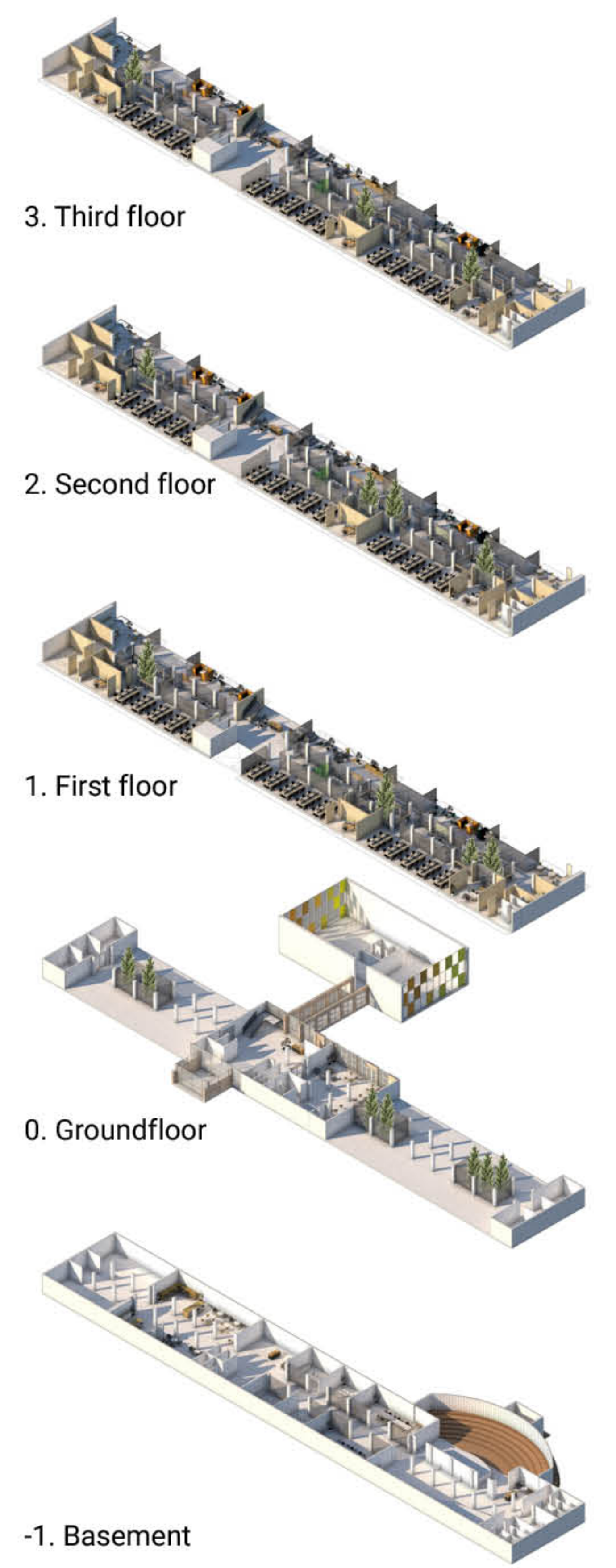
Legend:

- Pantry area
- Flexible working spaces
- Cut outs
- Toilets
- Working spaces
- Conference room

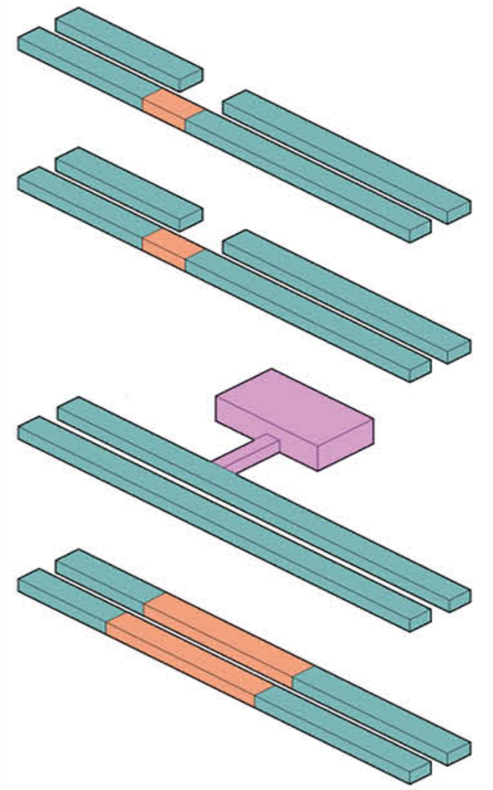
3.4.2 Layout Solutions

Solution 2 | Interior Functions

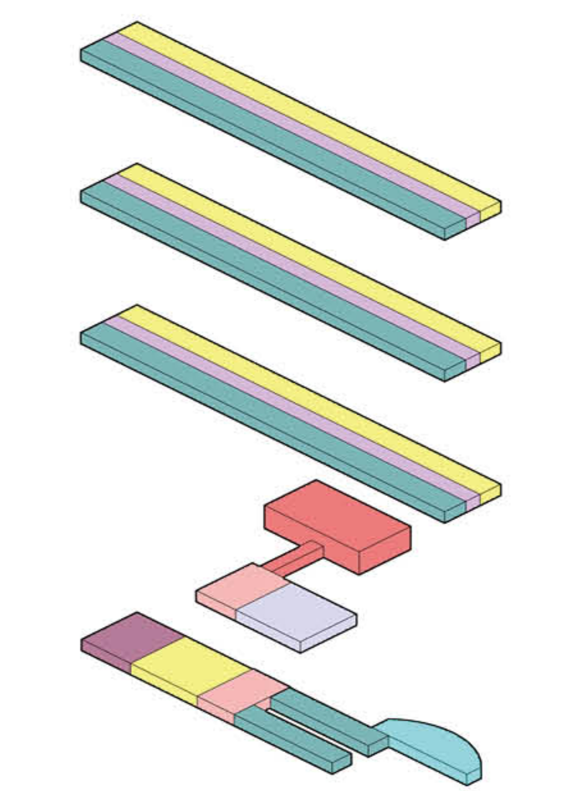
Exploded diagram of the proposed building



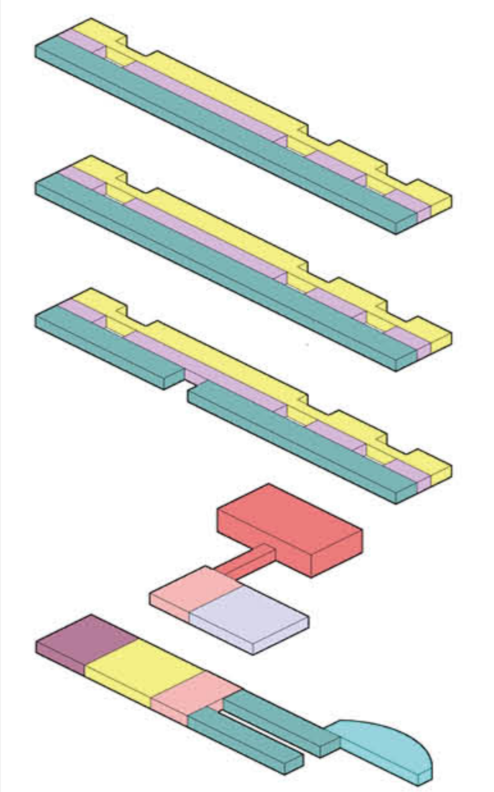
Existing Layout Scheme



Proposed Layout of New Activities



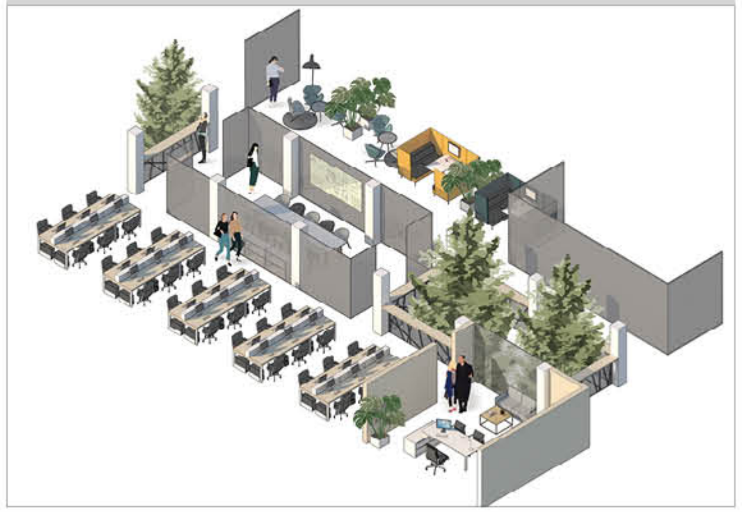
Cut outs to Improve Daylight



Legend:

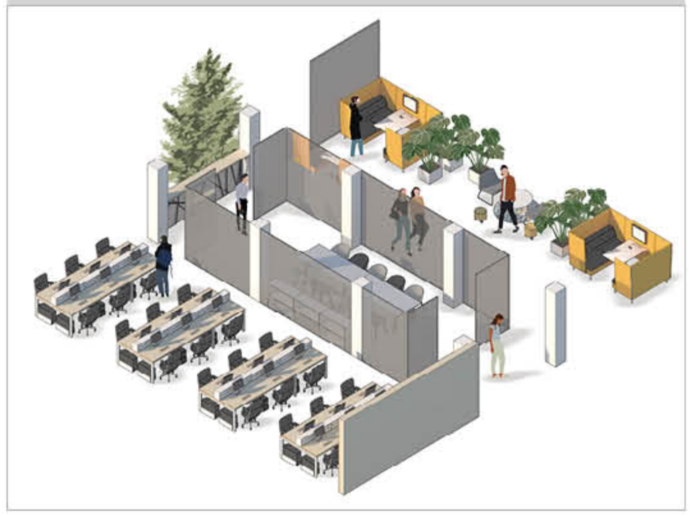
- Flexible working area
- Office spaces
- Conference room
- Auditorium
- Exhibition area
- Mechanical system
- Reception
- Café
- Council Chamber
- Office spaces
- Subsidiary function spces

Office Space Layout 1



Office Space Layout 2

Office Space Layout 3



Summary:

In order to achieve a better functionality of the building, new activities have been designed in the new project. An exhibition area has been desinged on the groundfloor that the community can cheaply rent for gatherings and other functions. The basement has been opened to the public and it hosts an auditorium, conference rooms and co-working spaces that people can rent. The upper three floors are designed to contain office spaces.

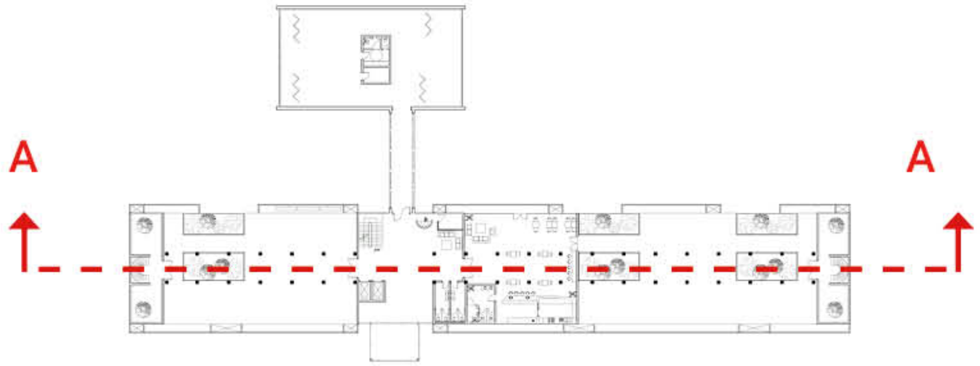
The office space layout has been designed keeping in mind three factors:

1. Simulation analysis showed that the existing building layout highly compromised the daylight within the building, so the proposed plan consists of a open office plan without the need of long and narrow corridors.
2. The solar analysis of the existing building showed that the west façade of the building gains a high level of heat, so in order to improve the environment within the office, the proposed building provided only flexible working layout on that side of the building (Office Space Layout 1,2,3).
3. Improve the value of the culture of the working culture by designing a more open and modern office scheme.

3.4.3 Visual Connection

Solution 2 | Interior Functions

View from the cut out



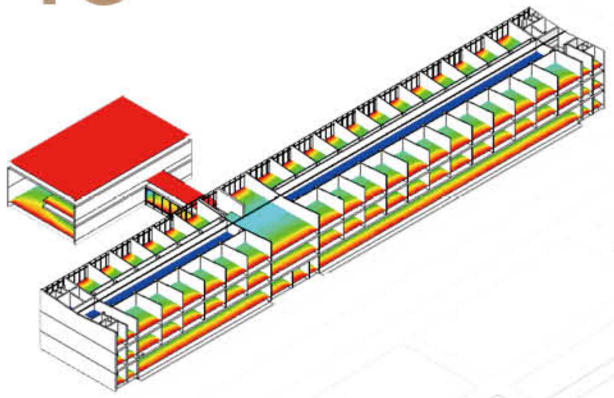
Summary:
The design of the cut out has multiple function in the building. Firstly, they improve the entry of natural light in the building. Secondly, they help to imporve the atmosphere and the creation of a more biophilic design. Moreover, the cutouts also create visual connections between each floor, making the building appear more dynamic for the people inside it.

Section A-A

Visual Connection System

3.4.4 Daylight Factor Index and Daylight Analysis Simulation

Evaluation | Proposed Building



DAYLIGHT FACTOR INSIGHT

Perez All weather sky

Scale 0-28 %

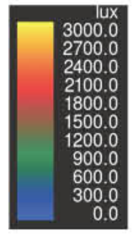
The daylight distribution is uniform throughout the floor plan. The west facade has louvers protecting it from harsh solar radiation.

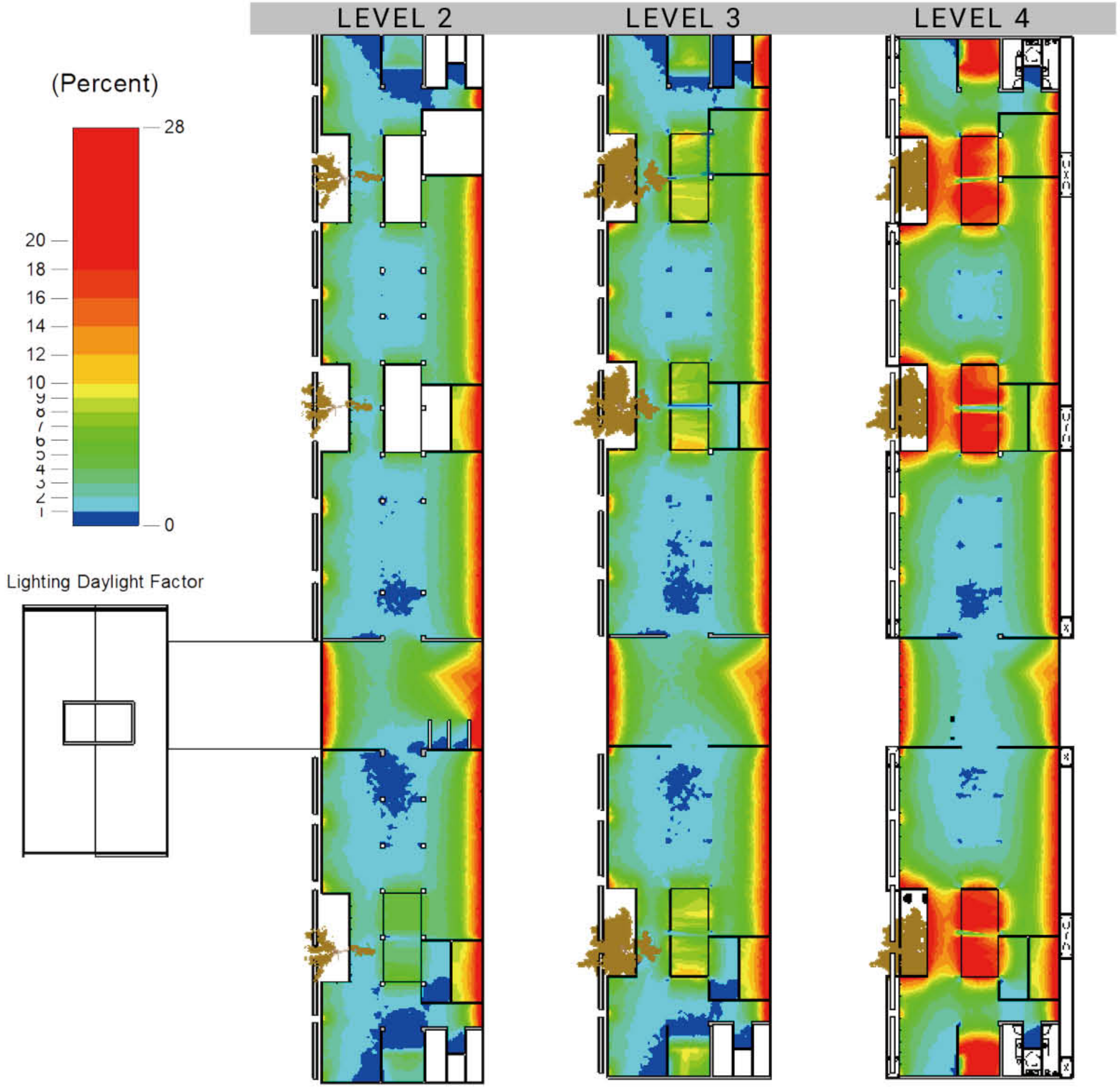
DAYLIGHT ANALYSIS SIMULATION

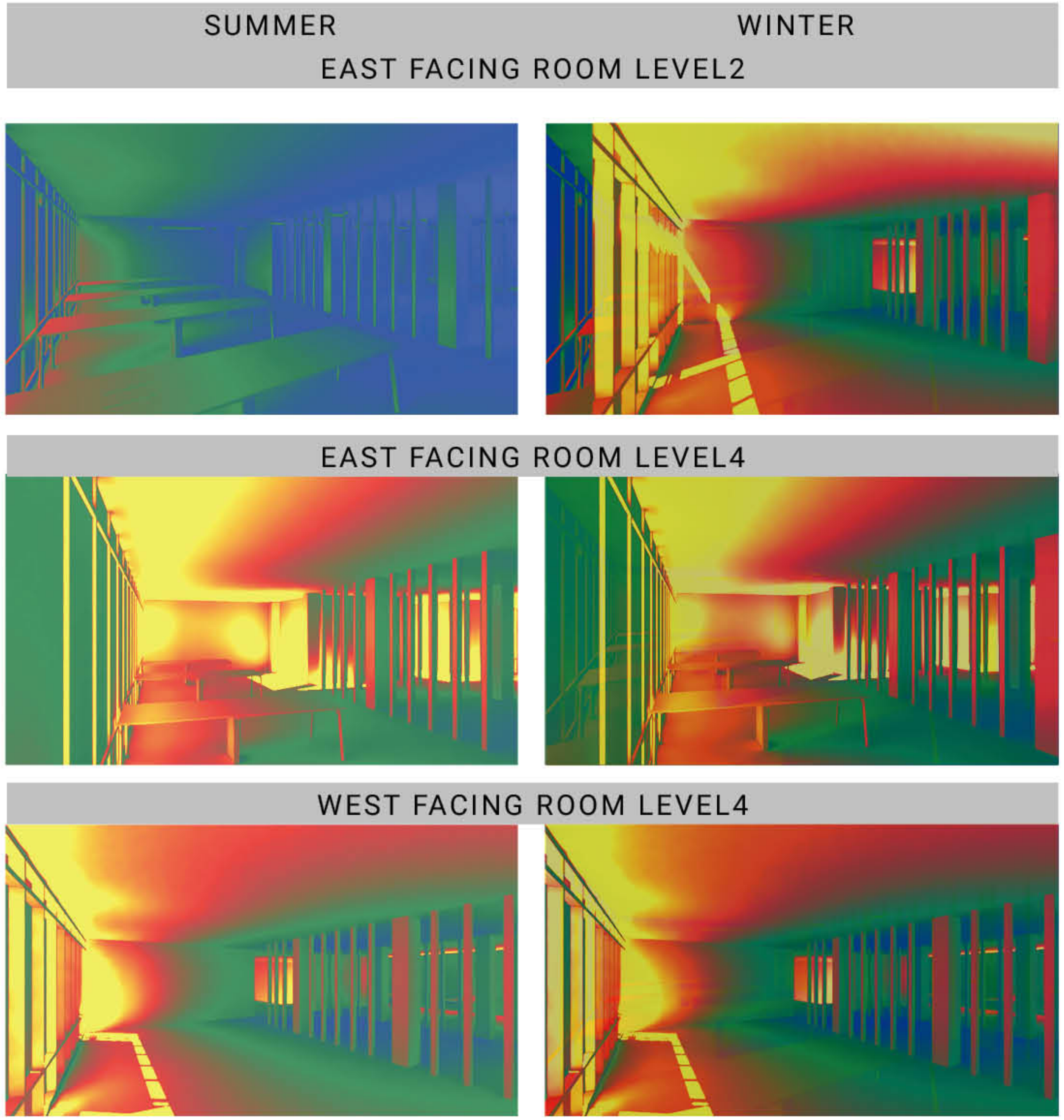
Perez All weather sky

Illuminance level - 300 to 1200 lux

To check the illuminance level of working spaces in office, we conducted the simulations. The results show deduction in illuminance at western side rooms. Due to the open planning, all the spaces have achieved optimum illuminance level.







3.5.1 Elevation Design Of East and West Side

Solution 3 | Proposed Building

When constructed in 1956, Rodovre Town Hall was to serve as a point of reference for the municipality. Our retrofit proposal seeks to uphold this by not only embracing the architectural style but also incorporating materials that have defined construction in Denmark for a long time.

EAST ELEVATION

Instead of Almuminium, CLT is used as a connection detail for glass on facade and existing building. Further the CLT is fitted to the slab through metal connectors.

The east and west facade holds double skin facade as the both the faces are experiencing high solar radiation throughout the year.

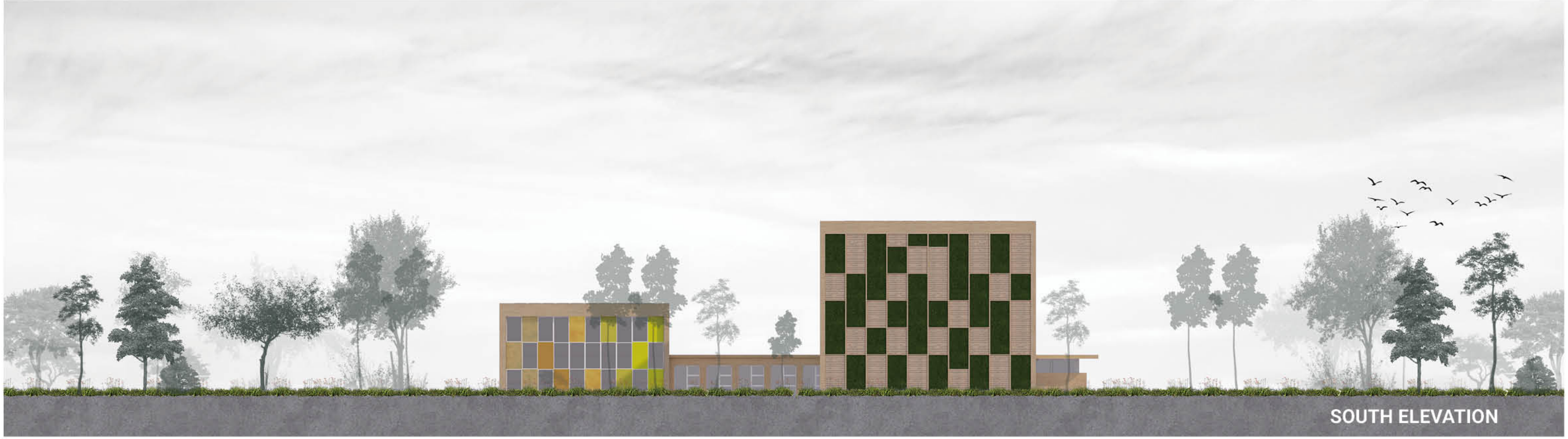
Materials used in the building is the combination of glass and CLT. Glass is triple glazed with U-value between 0.9-1.0 reducing the radionint her space

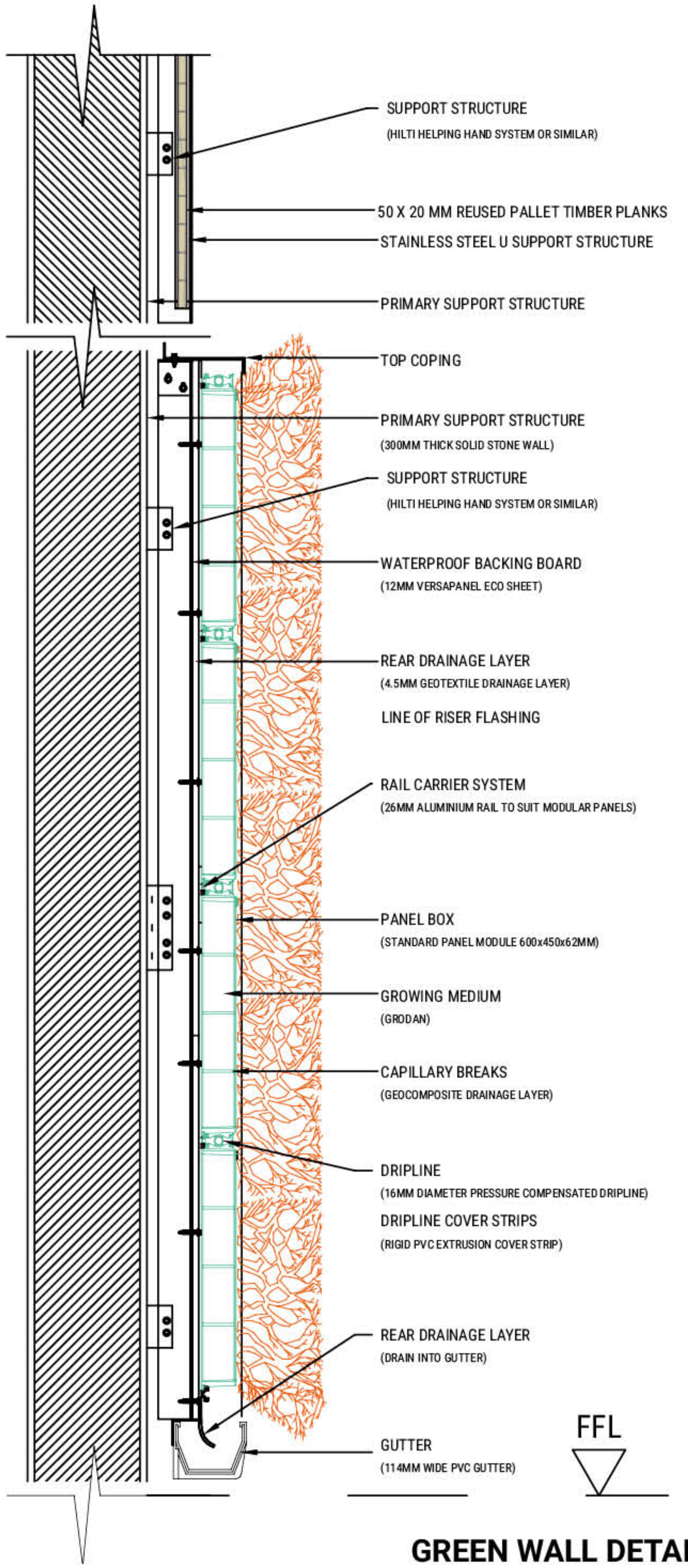
WEST ELEVATION

3.5.2 Elevation Design Of North and South Side

Solution 3 | Proposed Building

The northern and southern side of the building is the combination of green wall and reclaimed pallet wood. The green wall is proposed to increase the thermal mass of the building.





GREEN WALL DETAIL

LIVING GREEN WALL

A living green wall has been used on the South/ North facade to increase thermal insulation, reduce heat loss and replenish the modified landscape/green cover to maintain the biophilic ambience through the building facade.

This will also serve to purify the air by absorbing carbon dioxide and releasing oxygen, reducing the effects of pollution to the environment around the Rodovre Town Hall.

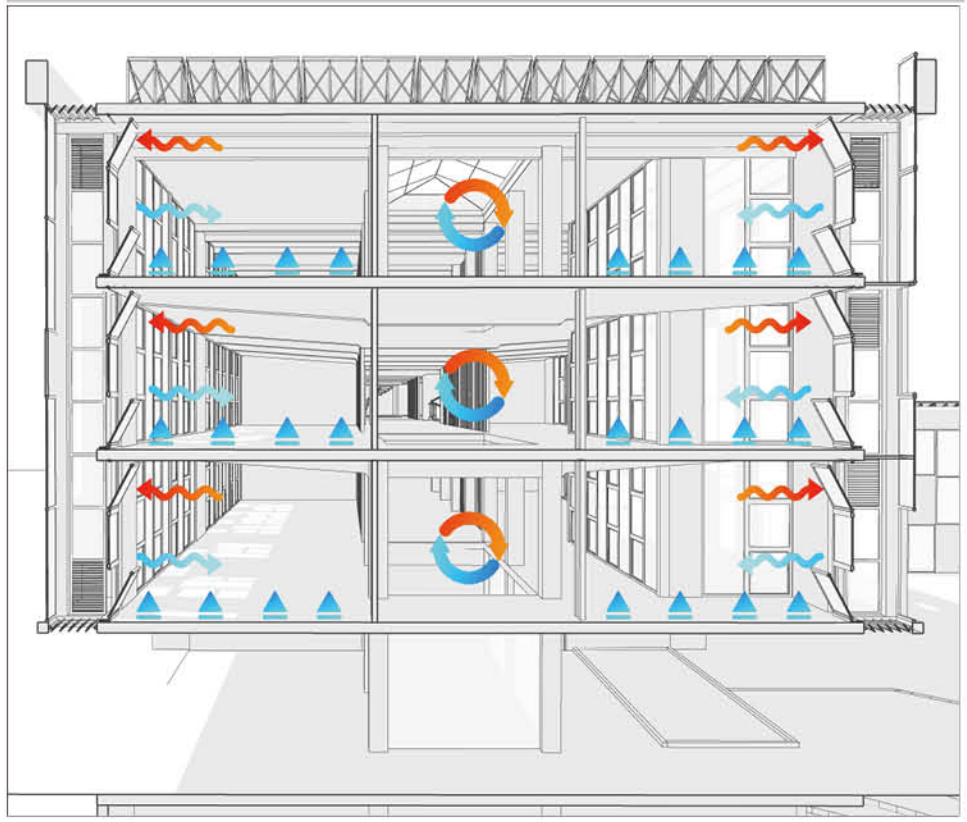
A simple drip irrigation and maintenance method is adopted which is cost effective.

RECLAIMED PALLET WOOD

The pallet wood is obtained from reclaimed pallet boxes at the nearby Kobenhavns Havn (Port of Copenhagen). Our retrofit proposal aims to continue with the precedence of adapting the use of local materials.

Pallet wood that bears a lower thermal conductivity of 0.15 W/m.K will reduce the thermal transmittance on the original stone facade (1.3 W/m.K)

VENTILATION IN SUMMER



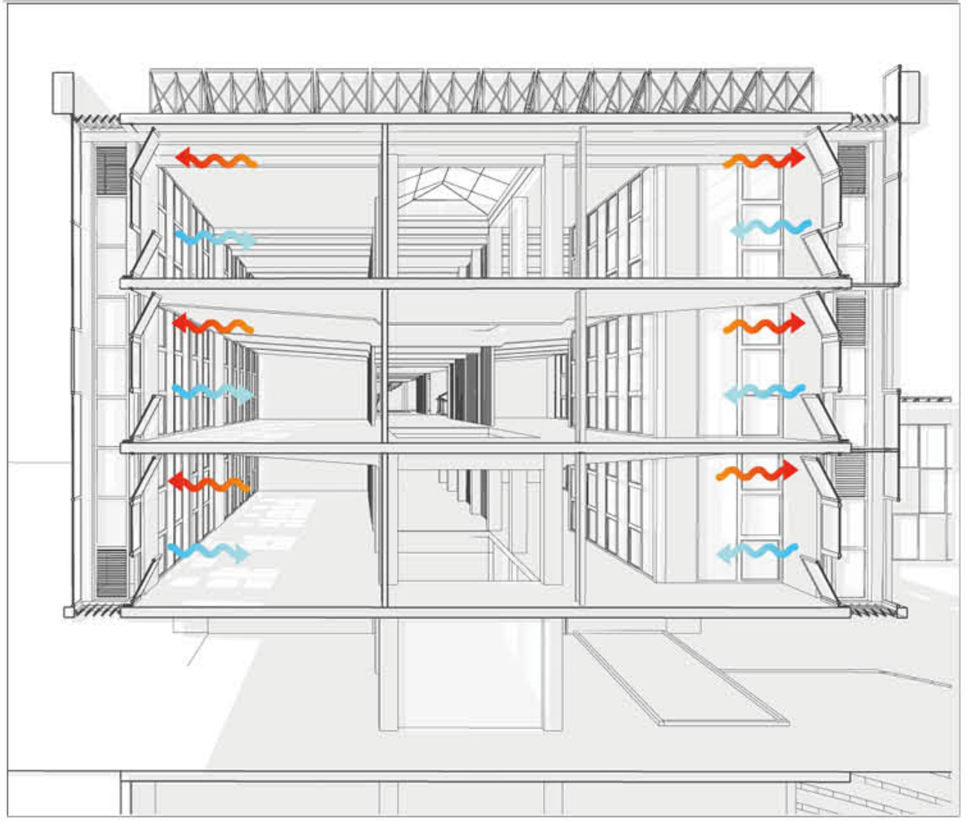
NATURAL VENTILATION + MECHANICAL VENTILATION

Natural Ventilation works as a passive startegy for energy effiecient design. Taking advantage of the concurrent winds coming from western side, **cross ventialtion system** will provide users with fresh air supply and some cool air, so that excess heat gain can be reduced naturally, without use of excess energy.

Mechanical System will be ecouraged with the use of **geo thermal sytem** to provide cool air at a low air velocity, to equip the space with alternative cooling startegy whenever the space becomes unbearable for occupants.

Operable windows at the bottom and top to allow the cool and hot air to flow.

VENTILATION IN SPRING

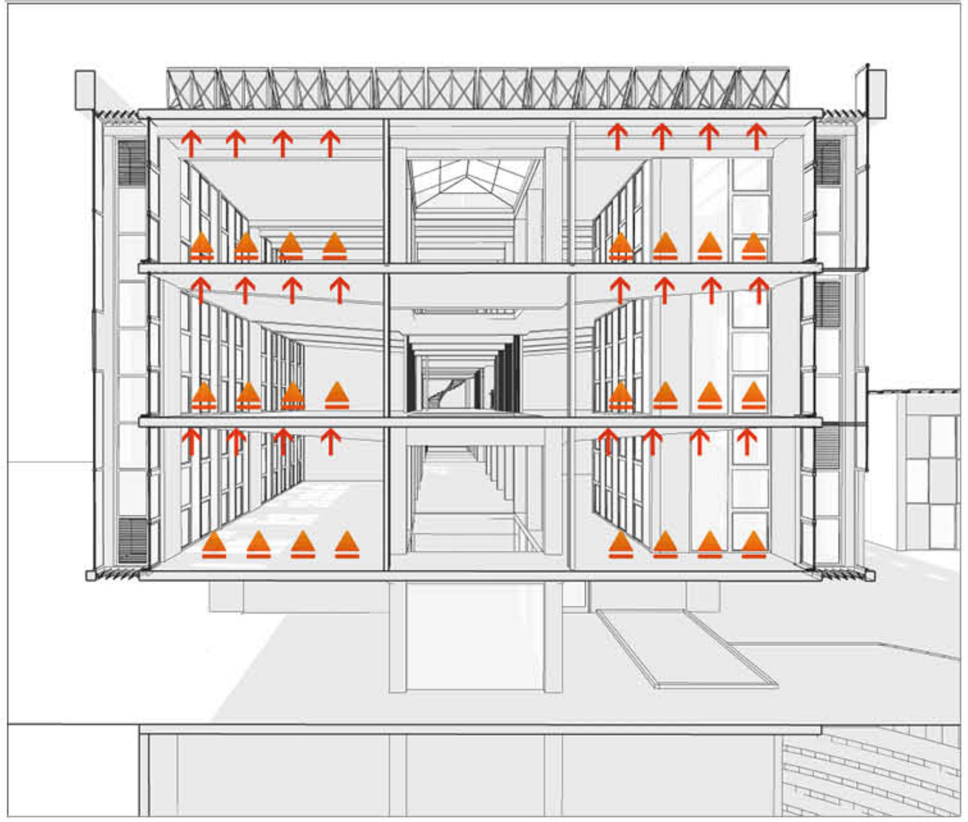


NATURAL VENTILATION

The building is oriented to take advanatge of the prevailing winds to catch breeze for **effective cross venilation**. Further the temperature range in the spring time is appropriate for occupant's thermal comfort. However, some spaces will still be dependent on mechanical ventilation system. The **operable windows** at occupant's level are casement windows with opening at upper and lower level to catch the prevailing breeze and allow the heat air to flow out of the top window. **Mehanical system** can be switched off on this season. This approach makes the building more breathable and energy efficient.

Operable windows at the bottom and top to allow the cool and hot air to flow.

VENTILATION IN AUTUMN



MECHANICAL VENTILATION

An **underfloor air distribution system** provides fresh conditioned air closer to the occupied level via manually operated floor diffusers, and then **removes warm polluted air via return air and exhaust devices** placed in the ceilings. The hot air will be supplied through geo thermal system. **Geothermal heat pumps** with a desiccant dehumidification system can be used for heating in the winter. This will keep the air circualtion constant and fresh throughout the window.

Further, if the occupant wants to open the window for fresh air, they can have hot air, as the temperature of the hot air coming from outside will be increased while passing throught the **double skin facade.**

Operable windows at the bottom and top, but preferable to remain closed for solar heat gain

3.7.1 Working of Natural Ventilation

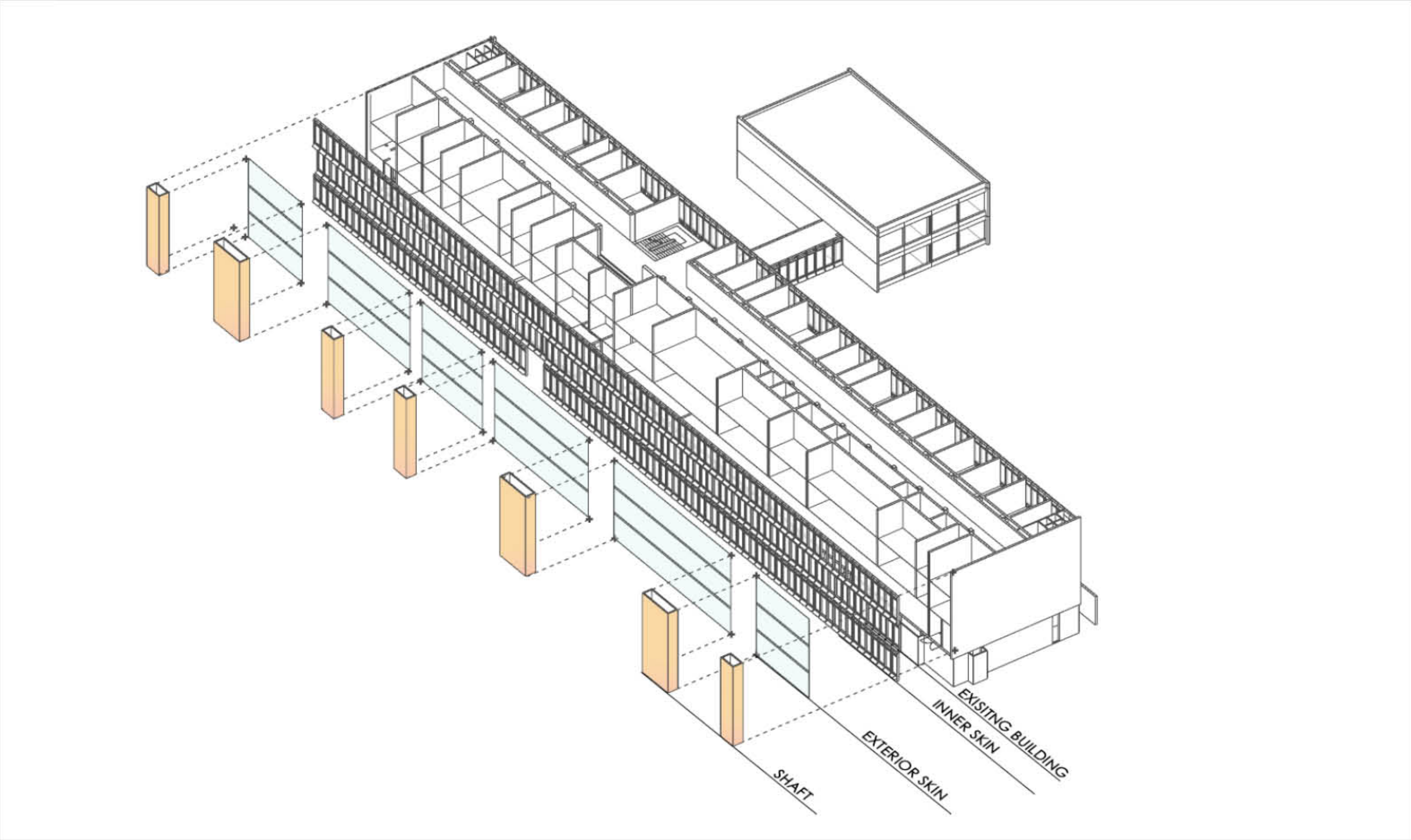
Solution 5 | Double Skin Facade

Double skin facade is a good solution for adverse enironmental conditions.. The solution has an effective way of managing the **solar heat gain and daylight** through operable blind system in the cavity. Further it allows to improve the ventilation of the building through cavity configuraton. The double skin facade can minimize the drafs in naturally ventilated space and improve the air quality.

SECTION THROUGH BUILDING

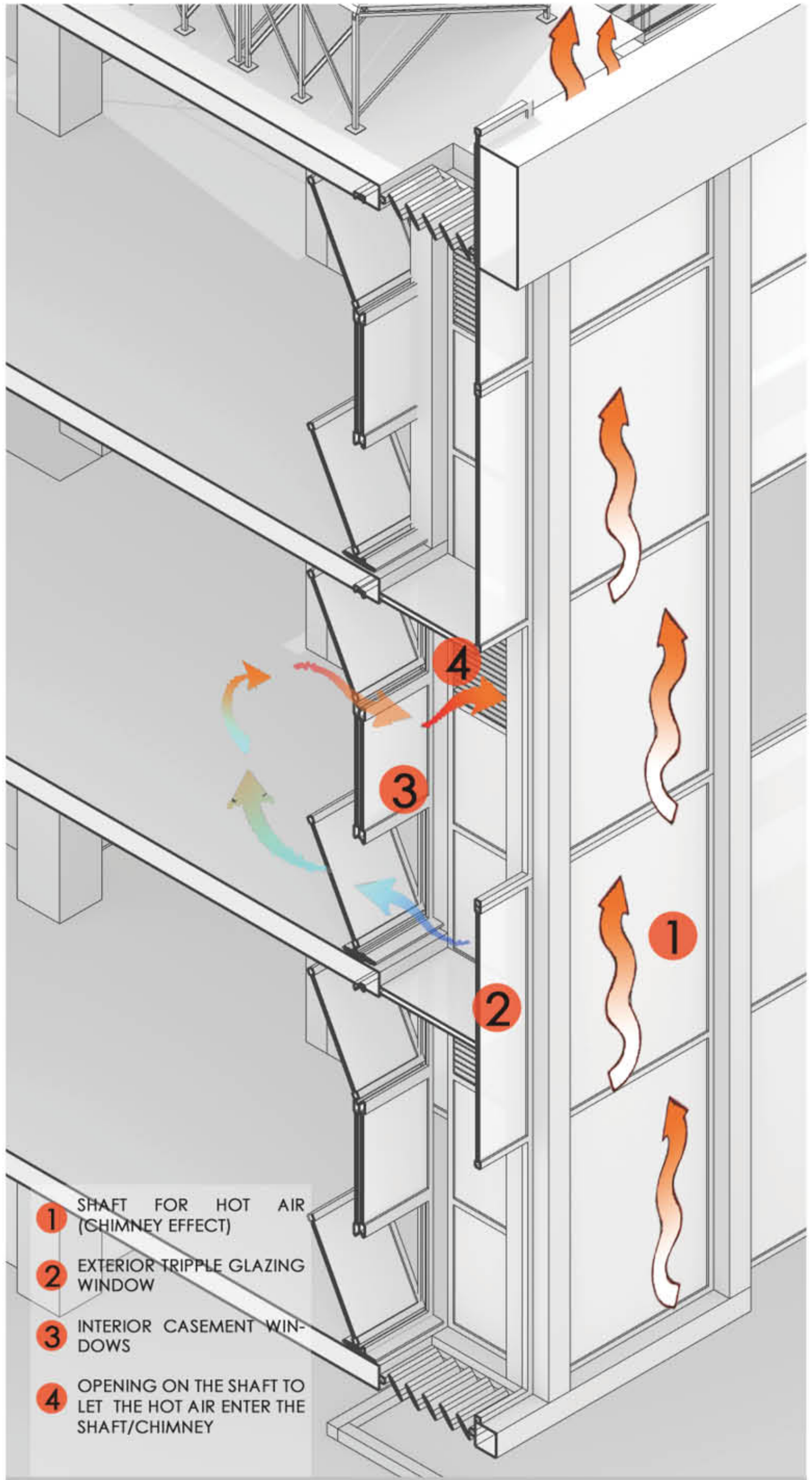
The study of air movement through the building openings, allowing hot air to stack in the chimney and cold air to move around the building.

Working of Doube skin facade for natural ventilation. The design consists of 3 components- **inner skin with operable windows, outer skin of high performance glass and vertical shafts**.(refer below). The air will pass from the outer skin and enter the building through lower window into the building. Through buoancy effect, the warm air fom the room will be escaped out through top window and will be stacked in the chimney like shaft.



ISOMETRIC OF WINDOW

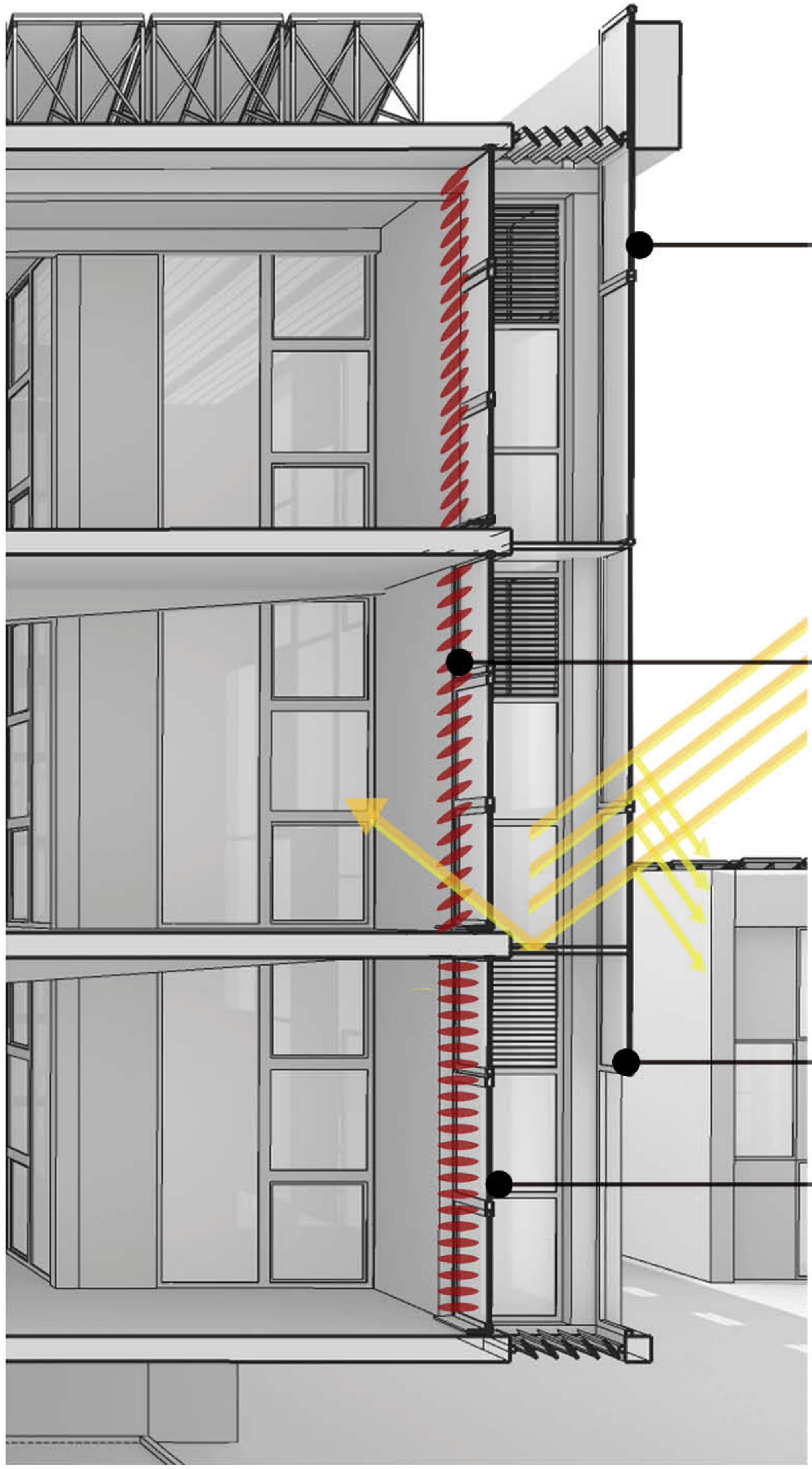
Diagram explaining the skins of the building.



WORKING OF DOUBLE SKIN FACADE

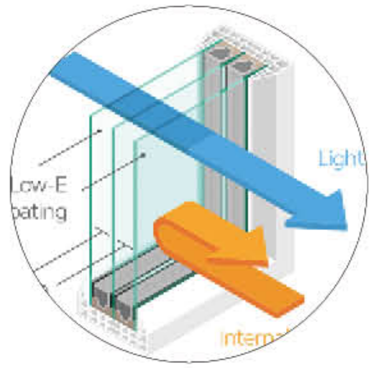
3.7.2 Solar Heat Gain

Solution 5 | Double Skin Facade



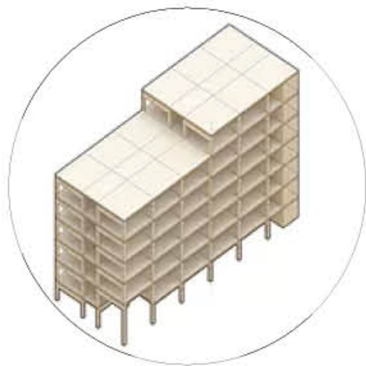
Exterior Facade: Glass should have a high solar heat gain coefficient (SHGC) to increase collection and storage of solar energy in the passive solar buildings during the daytime.

Triple Glazed window has low U - Value and high solar heat gain coeffiecient value. So it can work as an indoor envelope to maintain the energy.This reduces our dependency on heat loading systems.



Venetian Blinds: As the Sun elevation is lower in winter, the office users are will prone to **direct glare** from the windows. Without disturbing the direct solar heat gain, the inner side of the windows are provided with Venetian blinds. Inner side, also makes it operable by the users.

CLT is product with low carbon emission and absorbs carbon from the environment. Futher the CLT produces no waste as it is recylclable material.



Interior Facade- Single glazed operable window, operable at the top and bottom allowing the free flow of air.

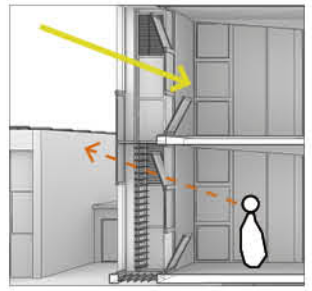
SECTION THROUGH BUILDING

The section explain the impact of solar gain throught solar radiation on the building.

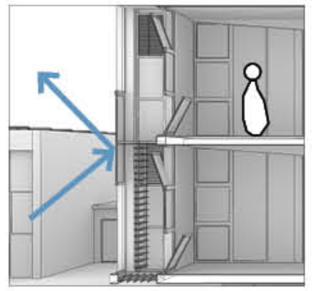
Solar Direct Gain

The direct gain is the most common passive solar system in architecture. In a direct gain structure, the actual living space is a solar collector, heat absorber and distribution system. Sunlight enters the building through the aperture, south-facing glazing material made of transparent or translucent glass. The sunlight then strikes the walls and ceiling that can store heat, which to be released at night through convection.

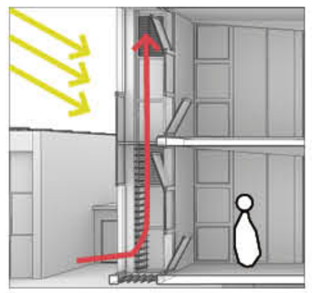
Other Advantages of Double Skin Facade



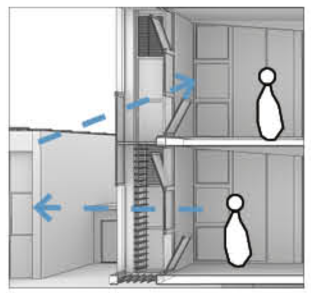
Daylight/View out



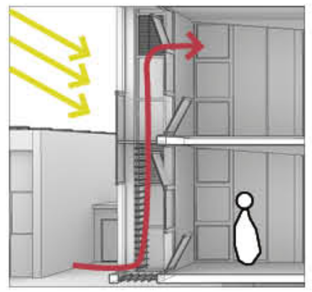
Noise



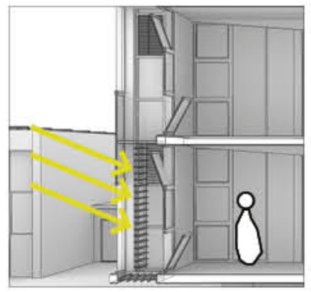
Removal of Heat



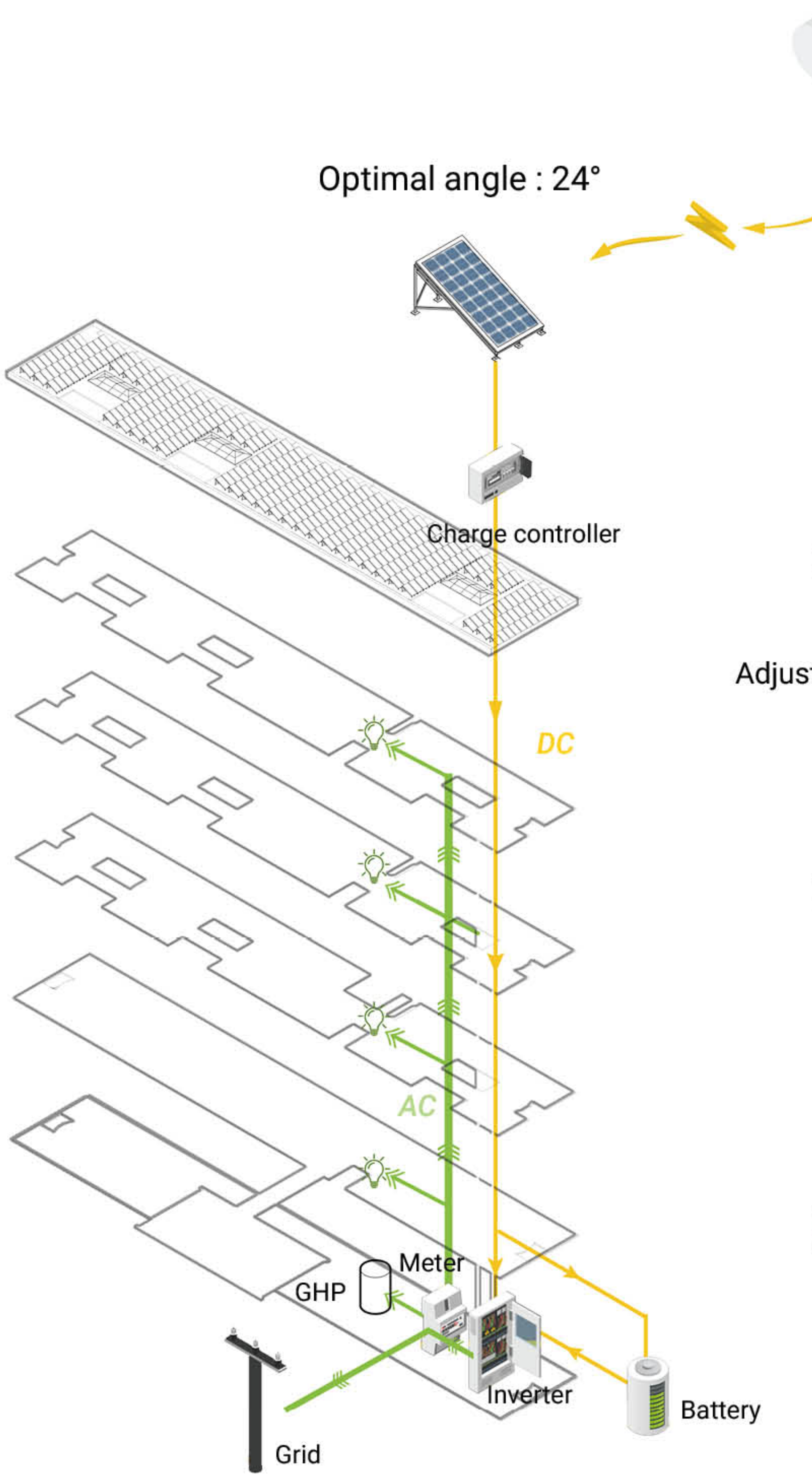
Transparency



Preheating of Inlet Air



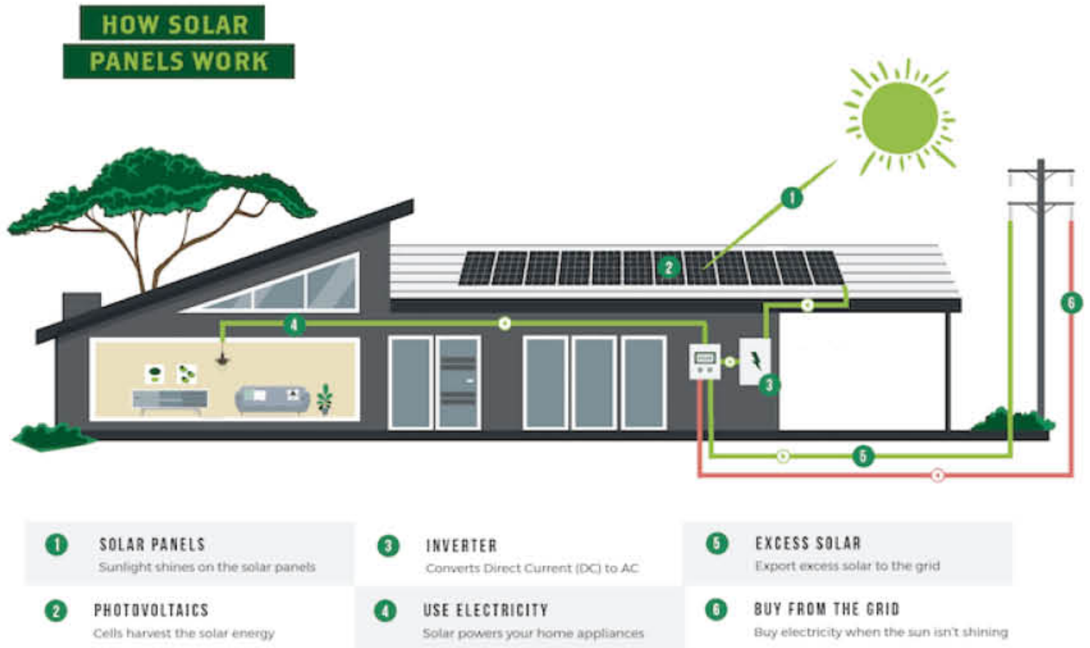
Solar Shading



Adjustable Mounting Rack

Solar Battery

Solar inverter



Angle:

Ideally, solar panels installed in Denmark should face a south direction. Acceptable panel angle range is 19° to 29° and the optimal angle is 24°.

Number of pv panels: 438 **Size:** 1800×900mm

other related information:

Solar irradiation in Denmark: 4.33 kWh/sq m/day

Wind speed: 5.53 m/s Air pressure: 100.84 kPa Humidity: 75.38%

Calculation:

The global formula to estimate the electricity generated in output of a photovoltaic system is :

$$E = A * r * H * PR$$

E = Energy (kWh)

A = Total solar panel Area (709.56 square meters)

r = solar panel yield or efficiency (20%)

H = Annual average solar radiation on tilted panels (shadings not included)

PR = Performance ratio, coefficient for losses (range between 0.5 and 0.9, default value = 0.75)

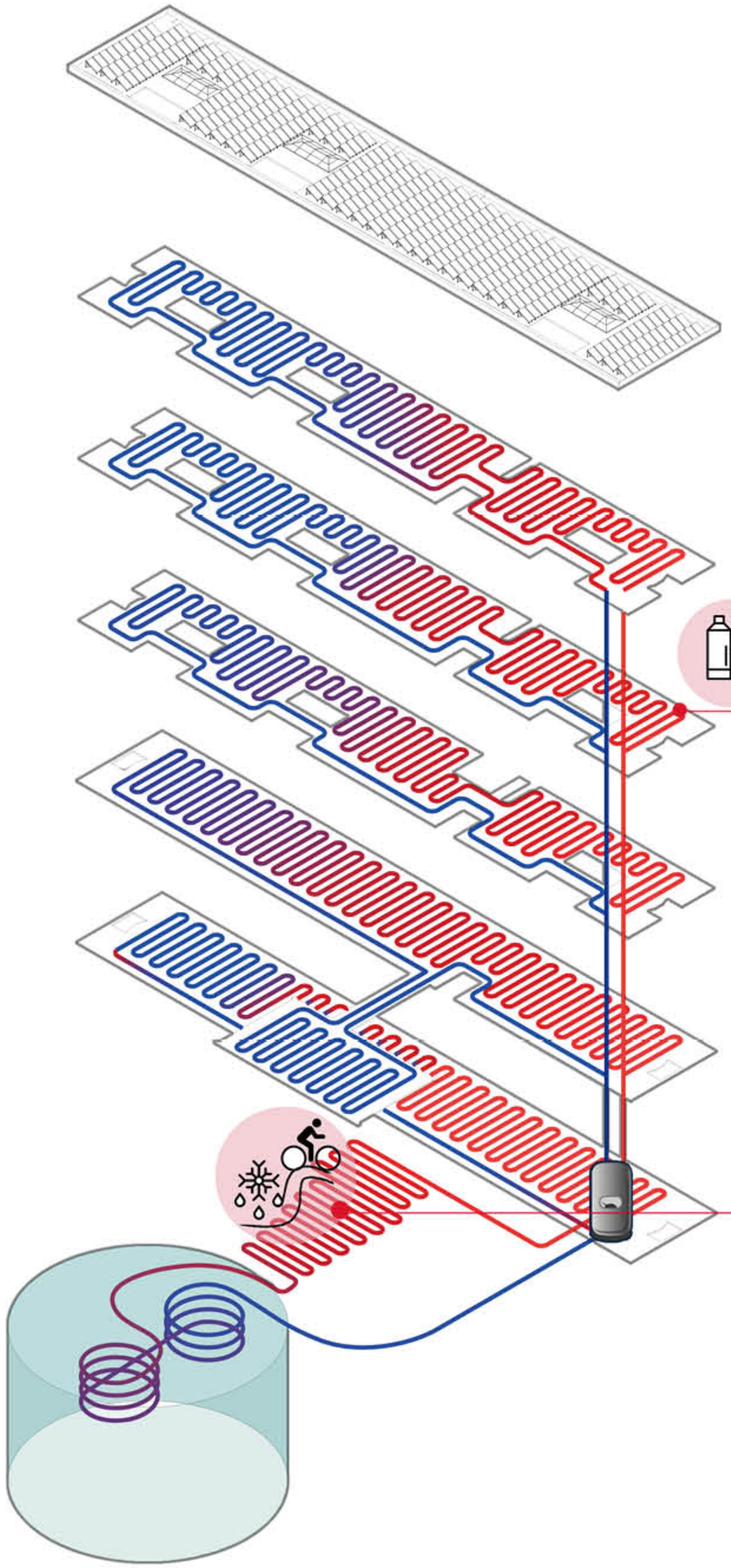
Result:

Annual energy output=154,329Kwh/Year

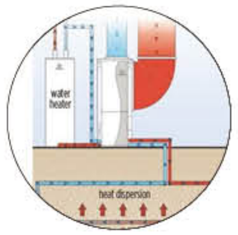
(≈25.8% Building engergy demand)

Summary:

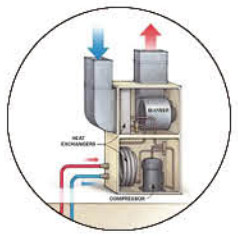
The PV panels are oriented facing southern side and 90% of the roof is covered with PV panels. The amount of electricity generation exceed the requirement, thus th extra will be distributed to the grid.



Pipes under floor



Providing hot water

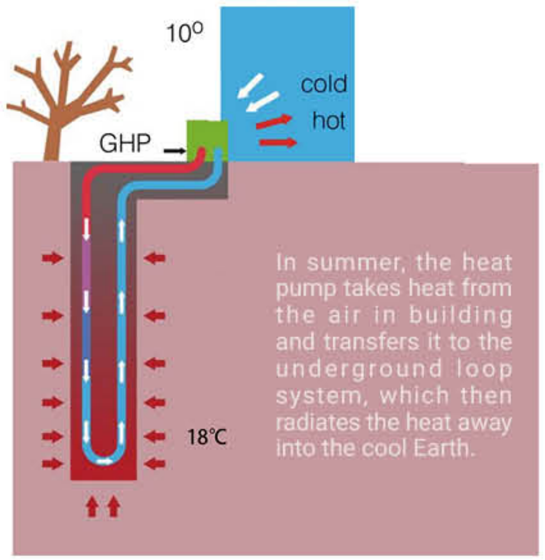


HP details

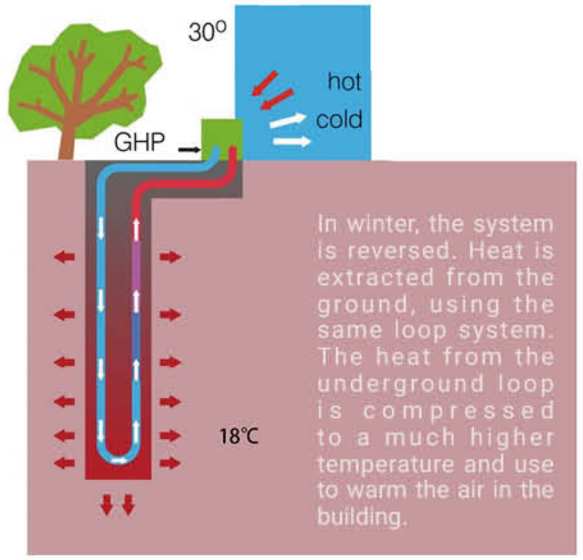
Melting snow on walkways and lanes

Pond loop system

In Summer



In Winter

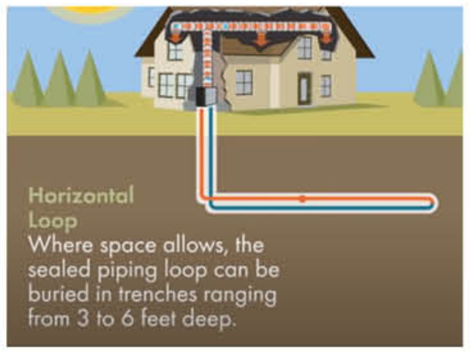


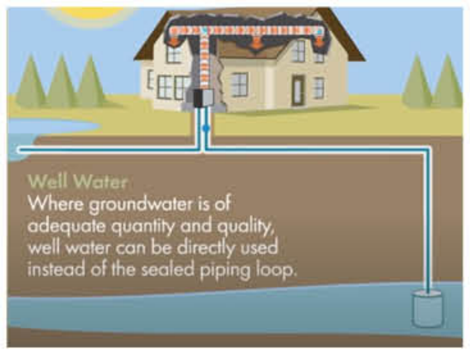
How it works:

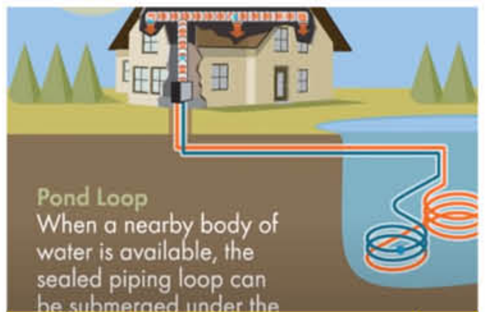
A geothermal heat pump is connected to a series of underground loop pipes to access the stable underground temperature.

Then, water mixed with an environmentally safe antifreeze solution is pumped through this loop pipe system.

4 Ways to Install a Geothermal System





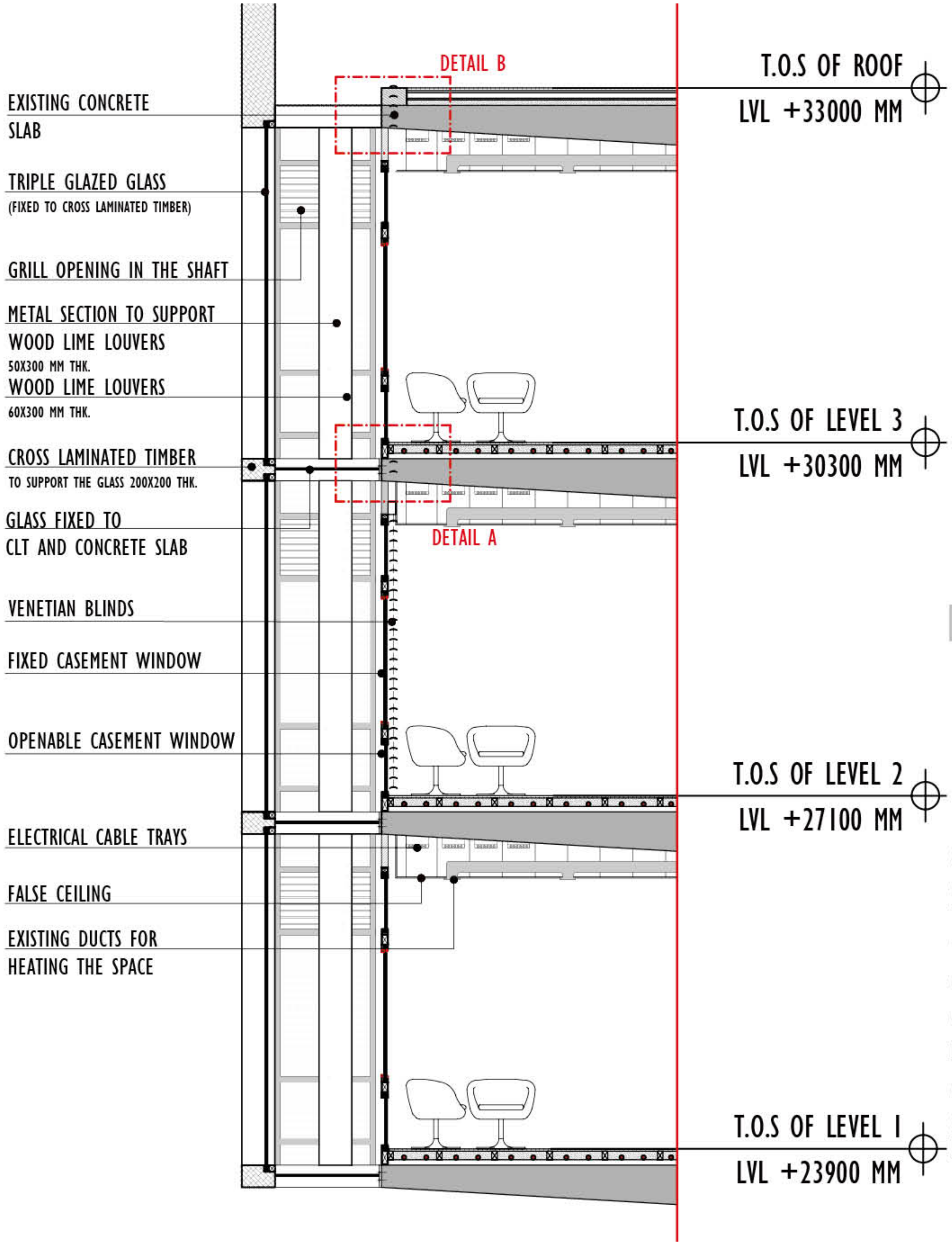


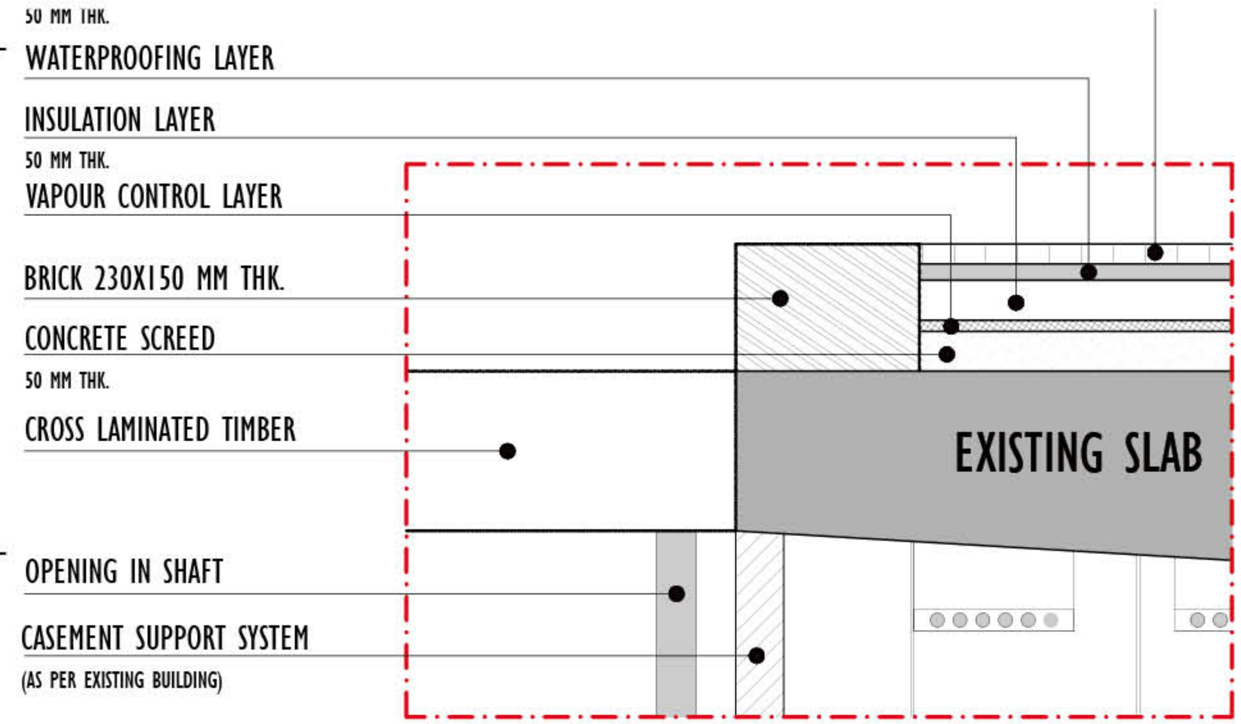
we adopt with our reservoir

Summary:
The closed loop geothermal system is adopted with the pond in our landscape design to harness the stable underground temperature to provide heating, cooling, and hot water at remarkably high efficiencies.

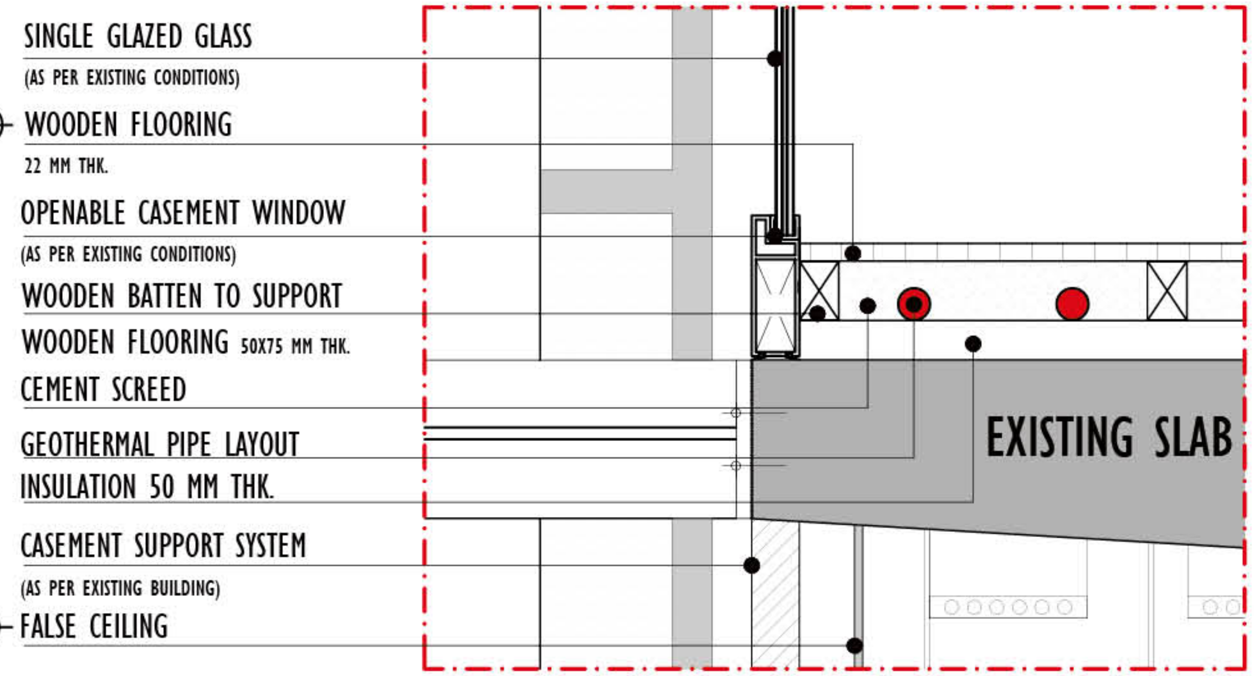
3.8.3 Geothermal System | Construction Details

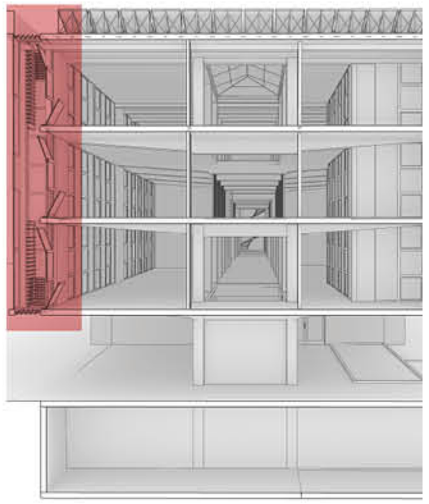
Solution 6 | Mechanical Systems





ROOF CONSTRUCTION DETAIL (DETAIL -A)





KEY SECTION

SECTION THROUGH WESTERN SIDE ELEVATION TO UNDERSTAND THE WORKING OF CONSTRUCTION DETAILS OF FLOORING

FLOORING DETAIL EXPLAINING THE INSTALLATION OF GEO-THERMAL STRATEGY(DETAIL A)

04. Materiality

The Copenhagen Resource and Waste Management Plan 2018 declares:

'It is important to have focus on choice of materials and building methods in connection with new building or renovation in order to cause the least possible burden to the environment and mini- mize resource wastage when the buildings are to be demolished or renovated in the future'. (WASTEMAN, 2014, p25)

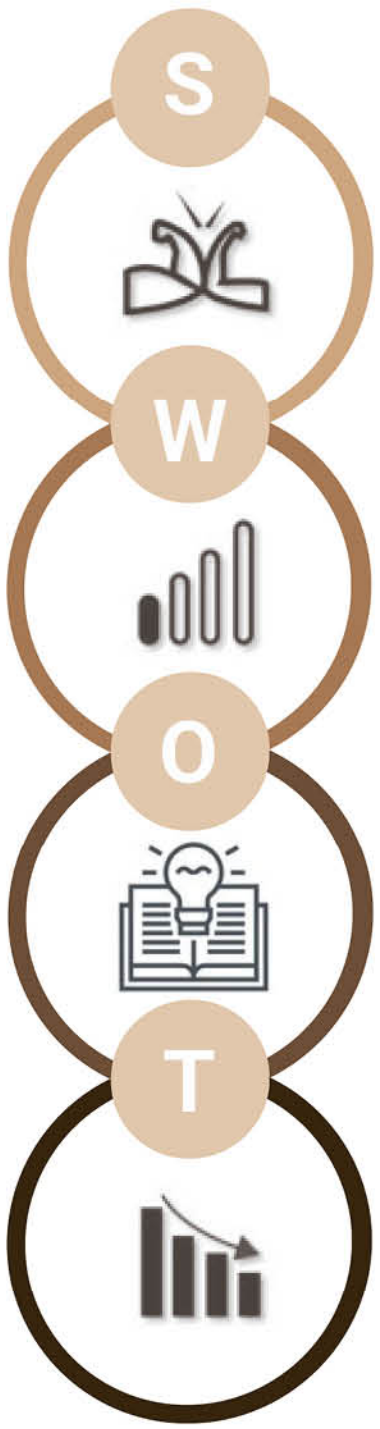
Proposal Material: CLT (Cross-Laminated-Timber)

01. Strengths
a. Timber is a renewable material
b. CLT production has proven to use less energy and produce less CO2.
c. CLT elements coul be reused, recycled or atincinerated to produce energy
d. CLT buildings are light, therefore they will require cheaper foundations

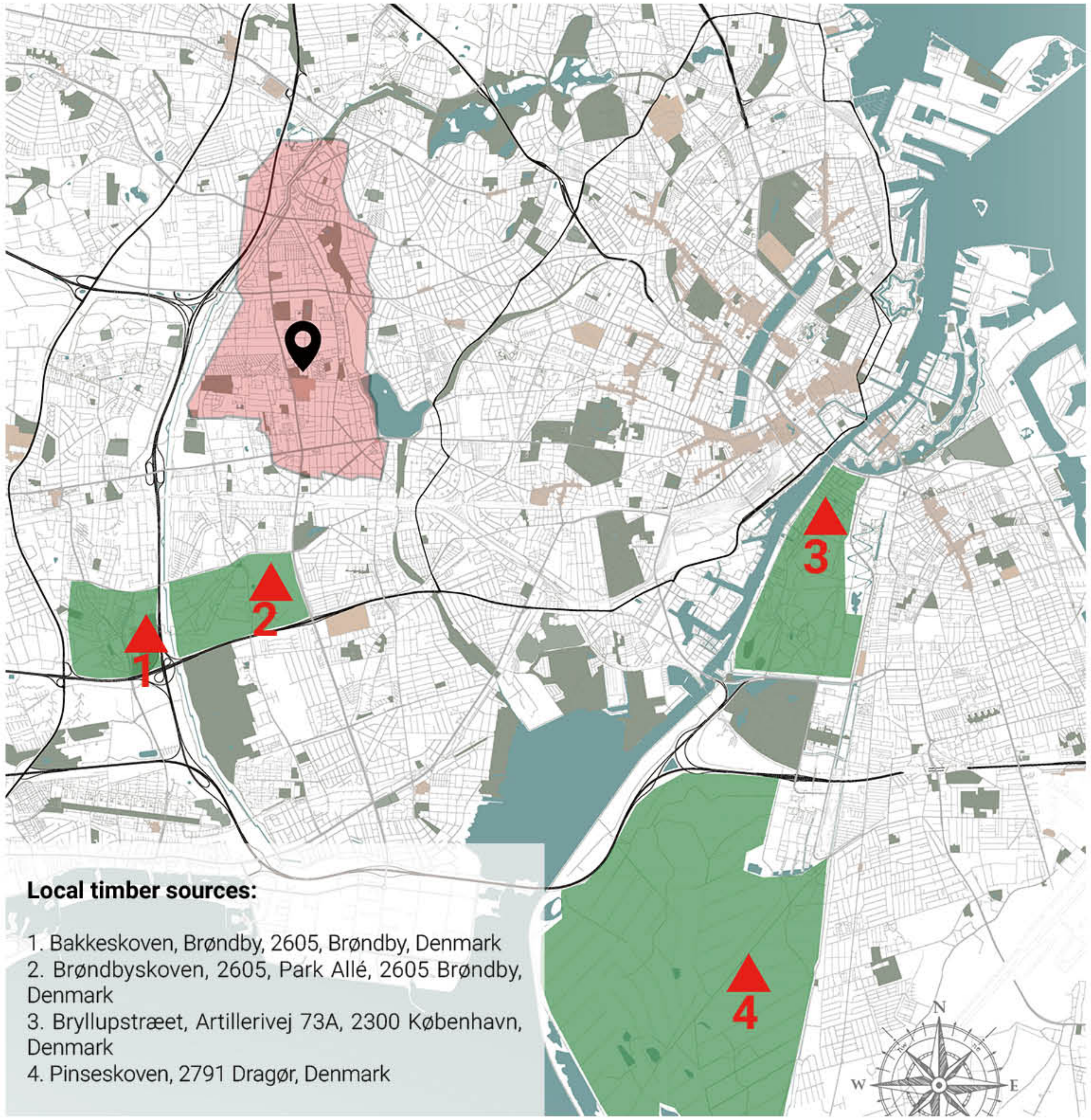
2. Weaknesses
a. CLT elements per se have poor acoustic properties
b. CLT structures may require weather protections during the construction phase
c. Danish building regulations for fire safety do not permit the construction of more than 4 storeys in timber

3. Opportunities
a. CLT construction can improve the possibility of Copenhagen's project to become the world's first CO2 neutral city by 2025

4. Threats
a. Other materials, like Precast Concrete, are at the moment dominant in the Danish construction system
b. Clients and contractors may not want to risk by adopting an emerging material and play safe in terms of costs.



Local Availability Map



CLT timber structures are used to lower the CO2 footprint of the building while also adding an outstanding aestetic to the design. CLT is new to the Danish market, but in record time has attracted interest among architects, who emphasize the shape of the wood and constructive qualities and just as the builders have an eye for the environmental benefits of construction in wood.

01. Extraction
The first phase of the life cycle assessment of CLT consists in the harvesting of trees from local forests. Trees absorb CO2 as they grow, giving the wood a negative carbon footprint.

0.2 Transportation to factory
The timber will be transported from the forests to a factory named CLT Denmark Aps. The factory is located only 5.6 kilometers from the selected site.

0.3 Processing and Manufacturing
The third phase comprehends the processing of trees into individual timber elements and the creation of the finished material. This second stage of production consists in the drying and planing of timber boards, the application of glue between each layer under pressure and the finishing of the material.
During the stage of production of timber boards, the wasted material (chips and shavings) can be recycled.

04. Distribuition
CLT construction has proven to be easier than similar concrete construction, which can reduce the costs of transportation until 80%. The light weight of the material helps to facilitate its transport.

05. Construction
CLT constructions do not provide the need of special trnasport and the clt elements are quickly assembled at the construction site.

06. Maintenance
CLT buildings require the same maintenance regime of other timber-frame ones.

Life Cycle Assessment of Cross Laminated Timber

07. Demolition
The joints used in the construction of the buildings allow the entire structure to be separated at the end of life of the building. In this way the wood can be reused in future projects and the design of the building can be changed easily.

08. Reuse
At the end of life of the building, the CLT will be treated according to the Copenhagen Resource and Waste Management Plan 2018 respecting the following waste hierarchy:
a. preventing
b. reuse
c. recycling
d. other recovery
e. disposal

CLT can be both recylced for the construction of new building elements or reused into new wood products.

Lastly, timber can be also incinerated and converted into energy to produce hot water and imprpve the City's district heating supply.

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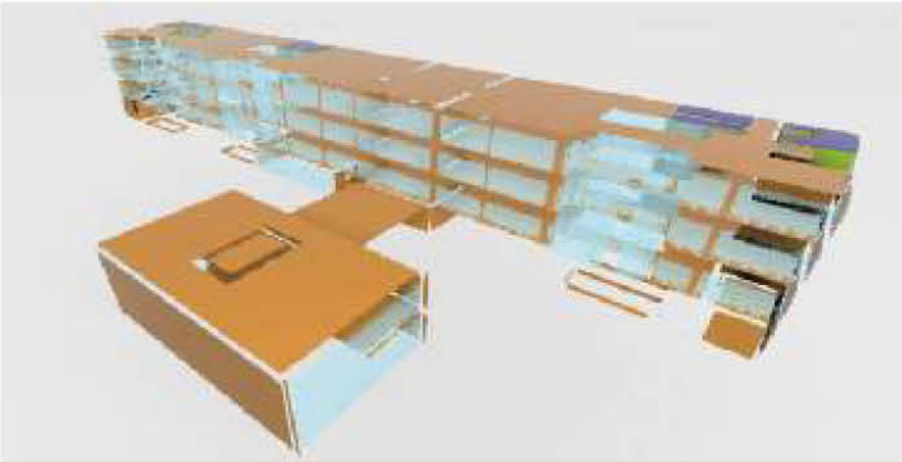
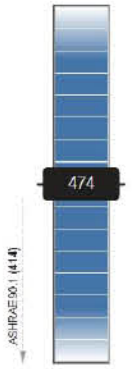
05. Validation and Testing

5.1 Energy Performance Comparison

Validation and Testing

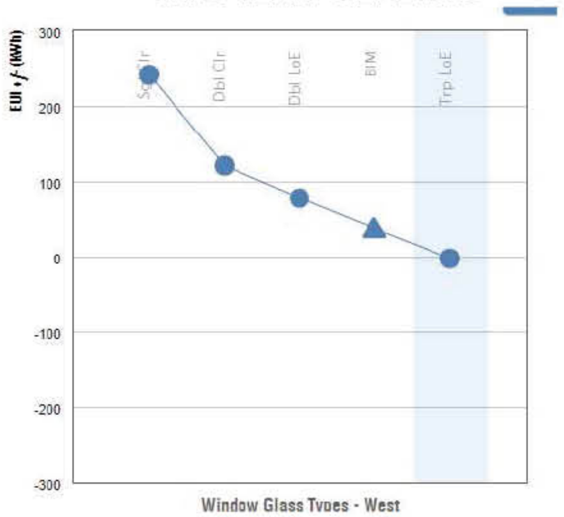




Main strategies adopted area:

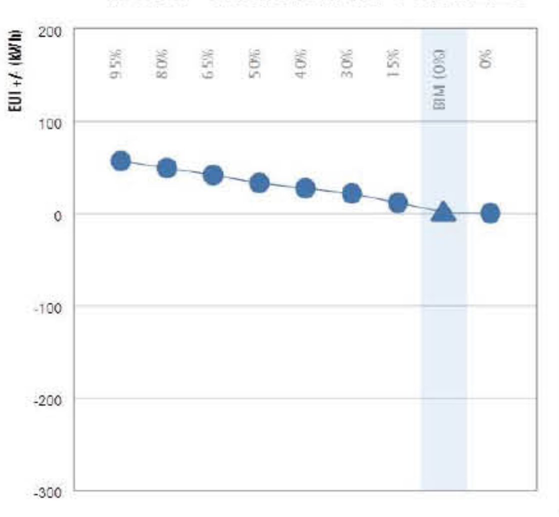
Improve the performance of east and west facade with shading devices
Used underfloor heating system, Solar panels and Rain water harvesting system to make the building more energy efficient.
Open plans are designed to improve the illumniance level throughout the building

WESTERN GLAZING

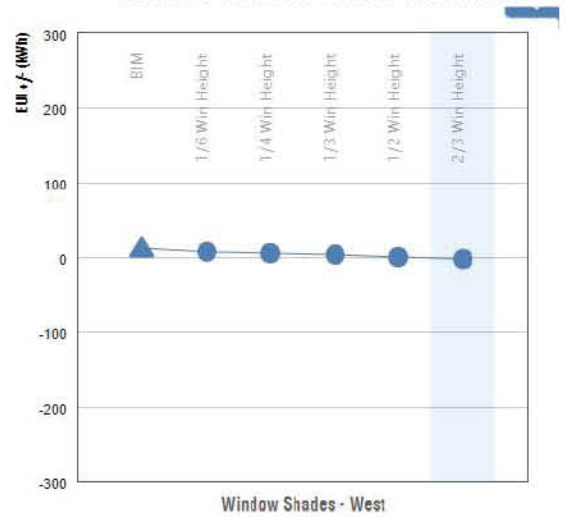


EAST GLAZING

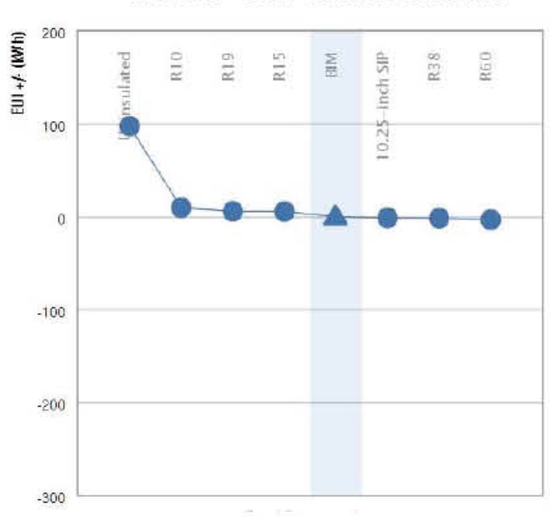
WWR- NORTHERN WALLS



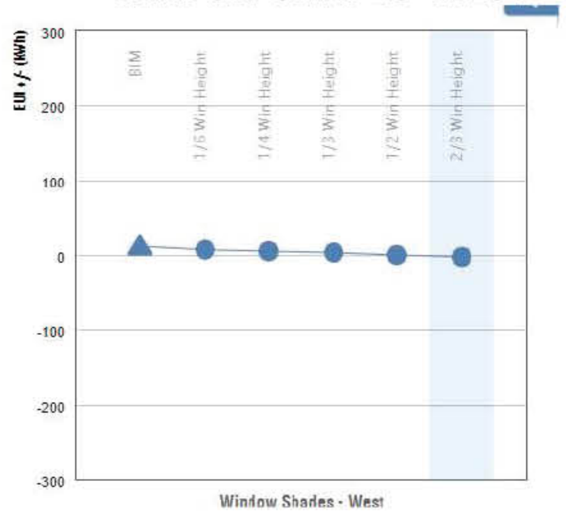
WWR- WESTERN WALLS



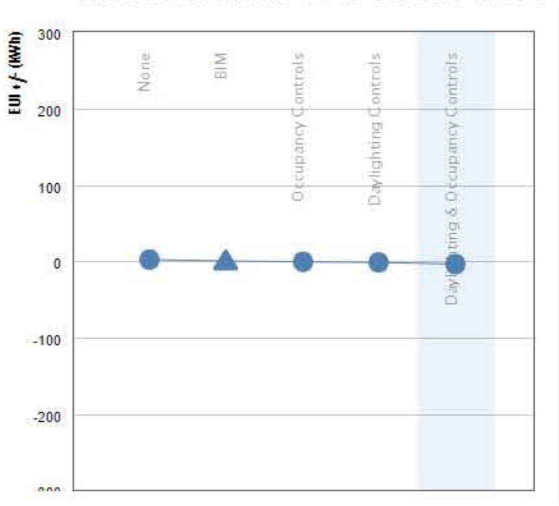
ROOF CONSTRUCTION



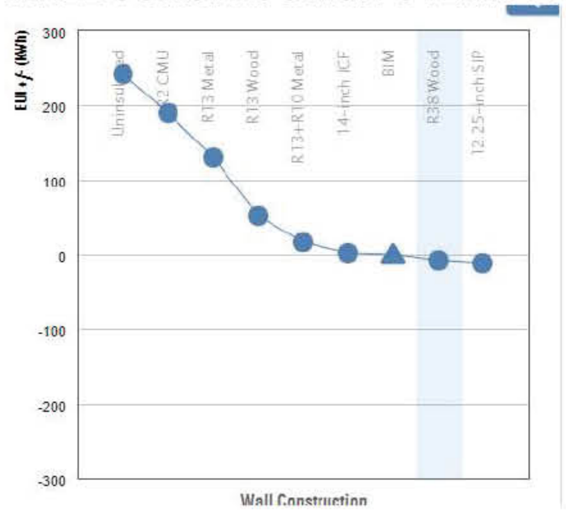
WINDOW SHADES- WEST



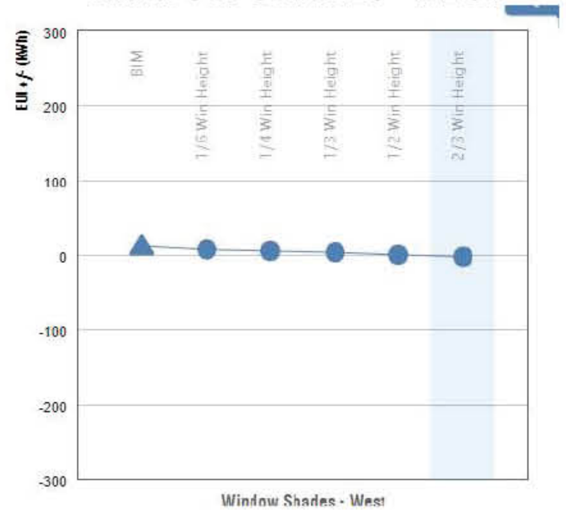
DAYLIGHT AND OCCUPANCY



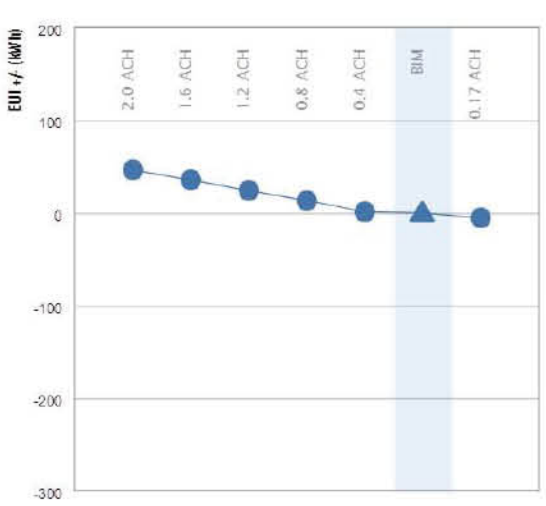
WALL CONSTRUCTION OVERALL



WINDOW SHADES- WEST



INFILTRATION



06. Visuals

6.1 Exterior Rendering

Visuals

View of the building with landscape design

View of the one of the activities of the landscape

View from building interior showing the cut-out

6.2 Interior Rendering

Visuals

View from building interior showing the cut-out

6.2 Interior Rendering

Visuals

View from building interior showing the flexible working spaces

View from building interior showing the circulation core

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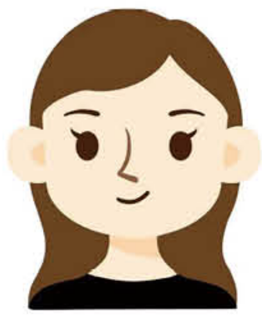
08. About Us

GROUP ZC

Anushka Singla



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Project Video: https://drive.google.com/file/d/1joHg95z4c92e8BXl01A78sPXXfWjywR8/view?usp=sharing