[Figure 1]

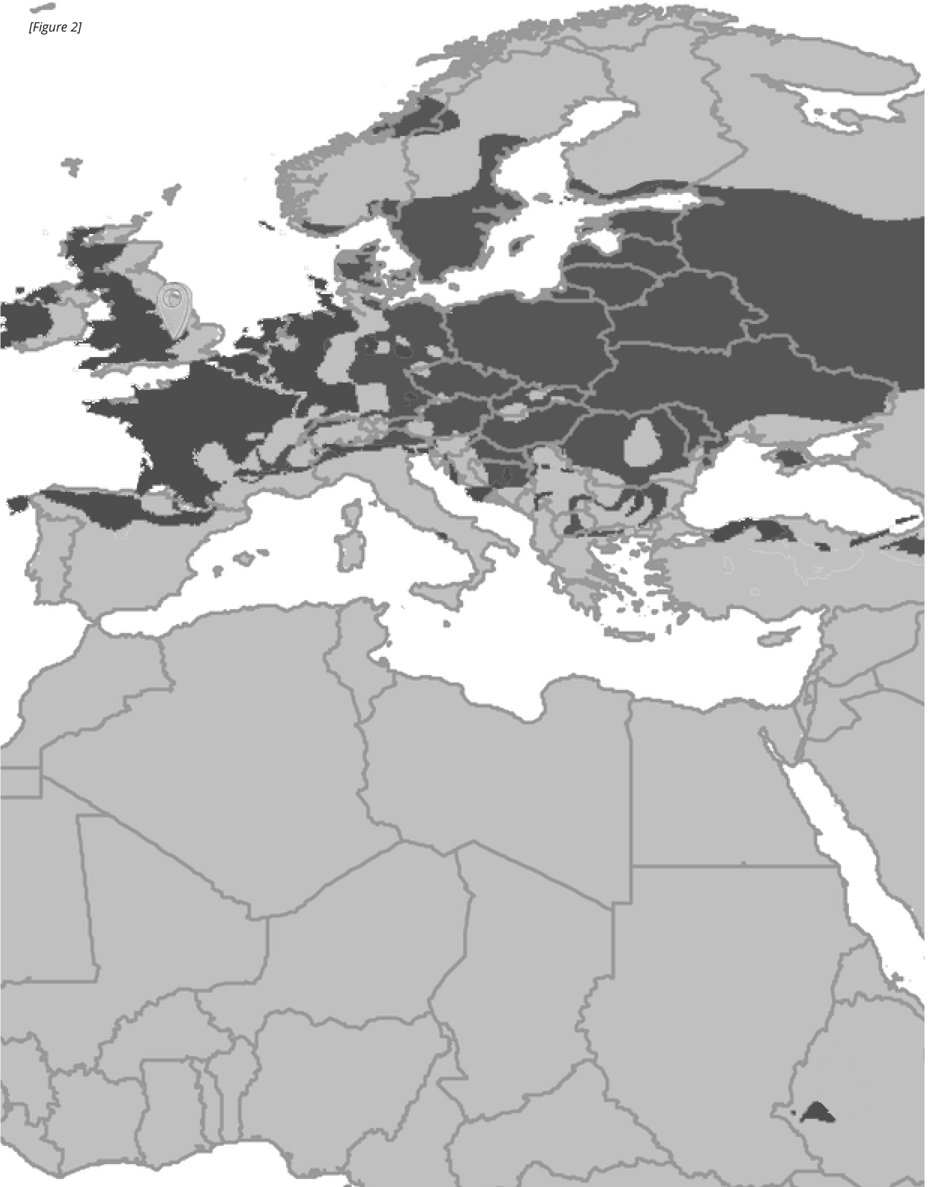
Team ZH

THE POWER STATION OF PASILA KONEPAJA
Helsinki, Finland

Anupama Rao, Han-Chieh Lee, Jiacheng Yu
Mari Taylor, Yingchen Liu,

Content

[Figure 2]

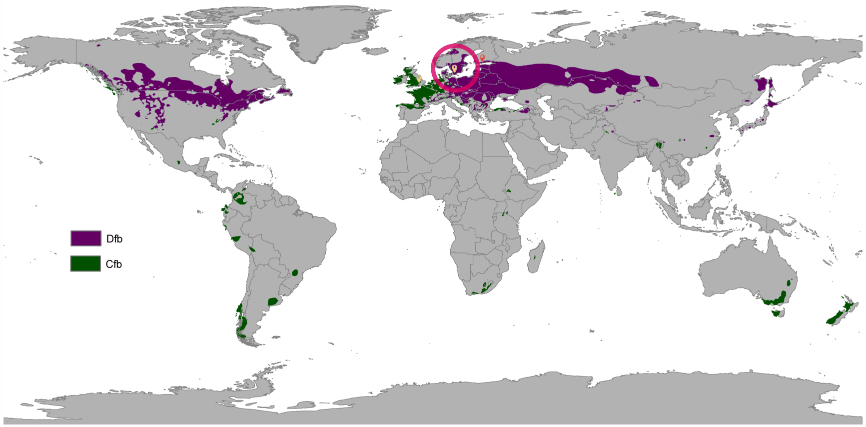


Climate Analysis - Helsinki

THE POWER STATION OF PASILA KONEPAJA

1.1 Climate Analysis

Location



[Figure 3]

Helsinki Climate Region Dfb - Cfb

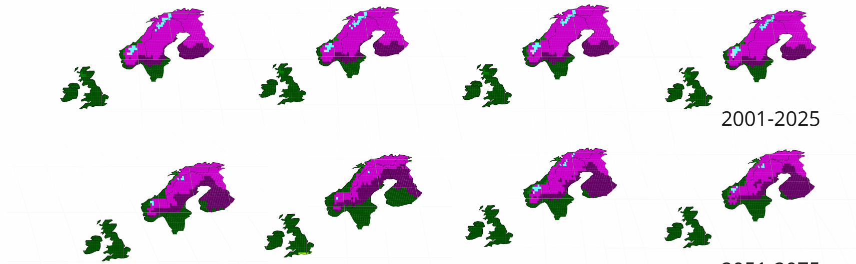


Figure 2

The Dfb climate

Generally in the high 40s and low 50s latitudes in North America and Asia, and also extending to higher latitudes in central and eastern Europe and Russia, between the maritime temperate and continental subarctic climates.

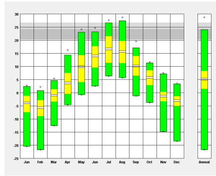
These climates have an average temperature above 10 °C (50 °F) in their warmest months, and the coldest month average below 0 °C (or −3 °C (27 °F), as noted previously.

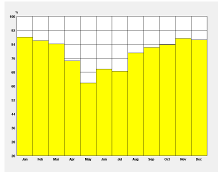
Similar Cities

Goteborg, Sweden is also a Dfb climate, which is the same climate classification as Helsinki. This analysis was undertaken to study differences and strategies within the same climate zone. The 2070 predicted climate classification of Helsinki will change to Cfb, here we will take London as a reference.

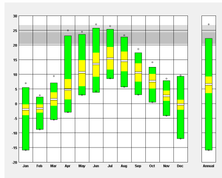
average temperature **relative humidity**

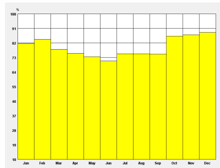
Dfb
Helsinki



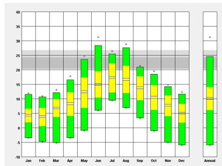


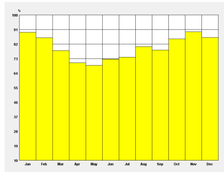
Dfb
Goteborg





Cfb
London





[Figure 4]

By Koppen_World_Map_Hi-Res.png: Peel, M. C., Finlayson, B. L., and McMahon, T. A.(University of Melbourne)derivative work: Me ne frego (talk) - Koppen_World_Map_Hi-Res.png, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=14796741

Sources: climate consultant software

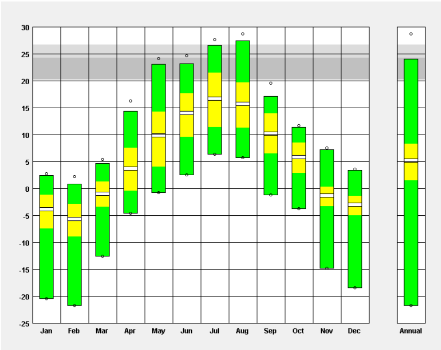
Summary

- Helsinki climate classification is **Dfb** in 2001-2025 and predicted to become **Cfb** in 2051-2075.
- From **D: snow to C: warm temperate**
- **The winter will increase around 5-6°C, the maximum summer temperature will rise, however, the average will be similar.**

1.2 Helsinki Climate Condition

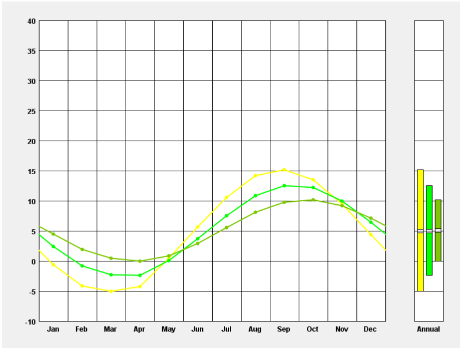
Climate Analysis

Average Temperature



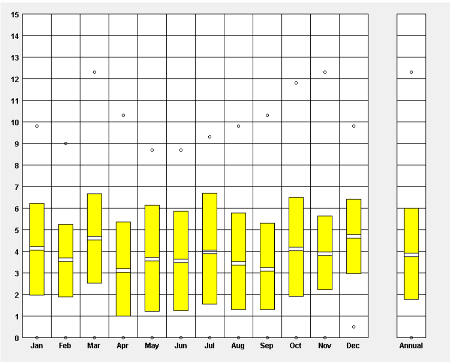
Highest temperature: 27°C
Lowest temperature: -22°C
Average annual temperature: 2°C to 7°C
Comfort zone is 20°C to 24°C; only July's average high temperature is in the comfort zone.

Ground Temperature



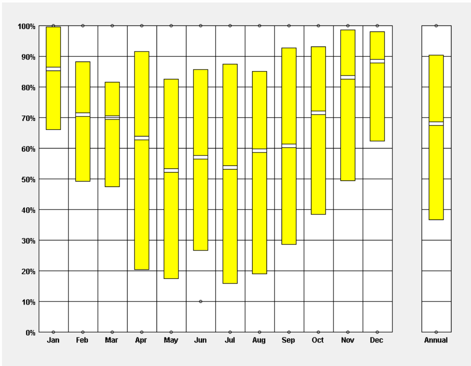
Yellow: 0.5m depth
Light green: 2m depth
Green: 4m depth

Wind Velocity



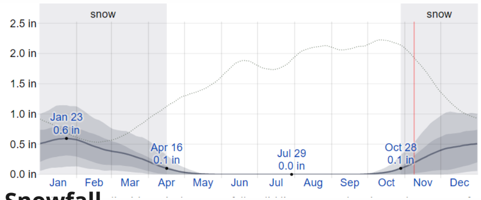
Average annual high wind velocity: 6m/s.
Average annual low wind velocity: 1.8m/s.

Sky Cover Range



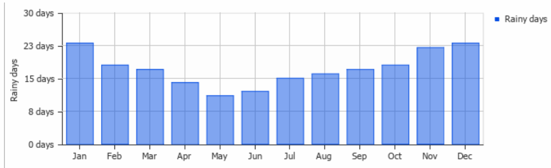
Average annual sky cover range: 70%

[Figure 5]

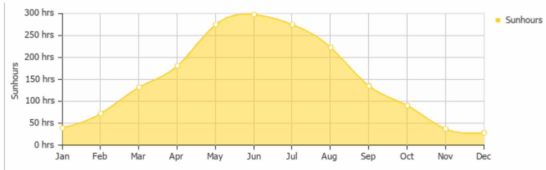


Snowfall

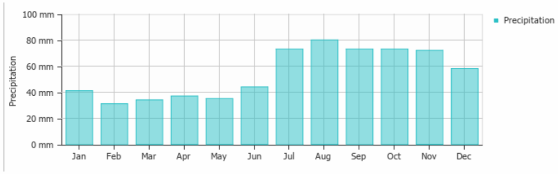
[Figure 6]



Rainy Days



Sun Hours



Precipitation

[Figure 7]

https://weatherspark.com/y/91632/Average-Weather-in-Helsinki-Finland-Year-Round

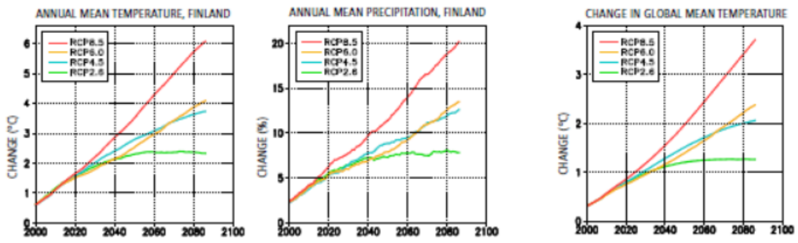
Summary

- Helsinki's temperature remains around or below **freezing for a few months (Nov. to March)** every year.
- There are **less rainy days** in summer (May, June)
- There are a significantly **low** number of **sun hours** in **winter**. (less than 50 hours per month) and usually, it is overcast (70%)

1.3 Helsinki Climate Risk

Climate Analysis

Risk 1 - Heatwaves (Summer/Winter)



[Figure 8]

- In Finland, the average temperature is estimated to **rise by 2.3 to 6°C** by the end of the century compared to the period 1986–2005.
- **Urban Heat Island effect**
- Heatwaves will cause health problems
- Snow may be thicker and icy layers may form inside the snow cover. (Winter)
- A decrease in ground frost may cause the compaction of clay soil. （Winter）

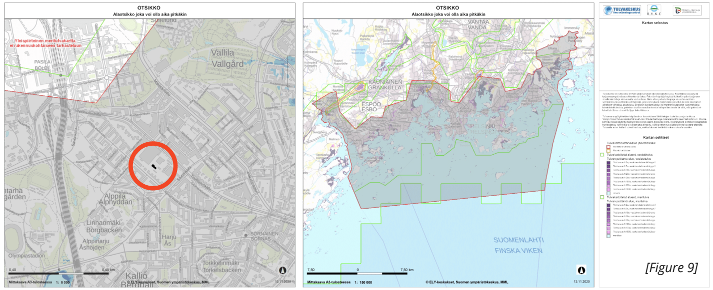
Risk 3 - Less Sunlight (Winter)

- Less sunlight in the winter will cause psychological, physical and mental illness (seasonal affective disorders (SAD).
- Most often it is overcast

Risk 4 - Food Shortage (Winter/Autumn)

- The climate restricts grain farming to the southern and western regions of the country in Winter and Autumn.
- The growing period of northern crops is shorter, leading to a lack of crop growth and food transportation in autumn and winter.

Risk 2 - Extreme Weather - Flooding and Storms



[Figure 9]

- **In winter**, **precipitation** (both mean and maximum) **increases** substantially and there **will be more rainy days.**
- **Storms** - In summer, the mean precipitation will remain largely unchanged, while **heavy precipitation events will intensify.**
- The **reduction of impermeable surfaces** is contributing to the risk of flood substantially.
- **Sea levels will rise**
- The most common damage caused by storms includes fallen trees, torn roofs and water damage caused by heavy rainfall and broken pipes.

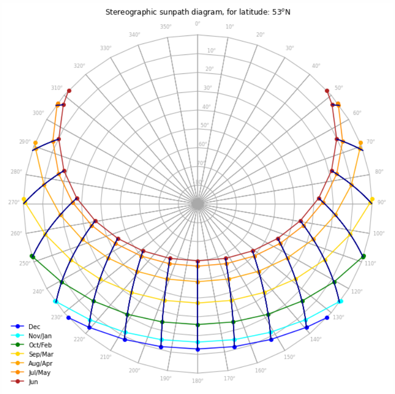
Summary

- The rise in temperature will lead to **overheating and heatwaves.**
- Increasing **precipitation and storms** in winter and spring will bring to a high flooding possibility.
- **Less sunlight in winter** will cause physical and psychological problems.
- There will be a **lack of food growth and transportation** in winter and autumn.

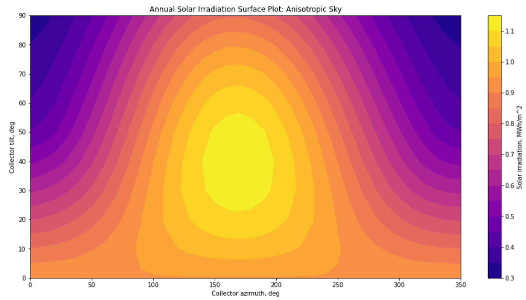
1.4 Helsinki Renewable Sources

Climate Analysis

Sunpath

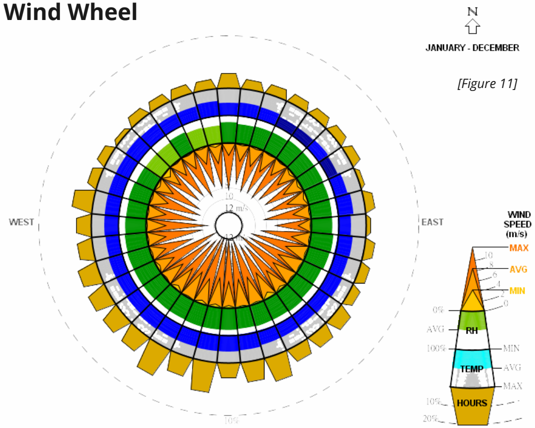


Solar Irradiation Surface Plot



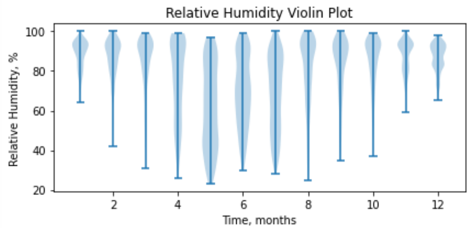
PV solar panel collector : (Y) angle and (X) orientation

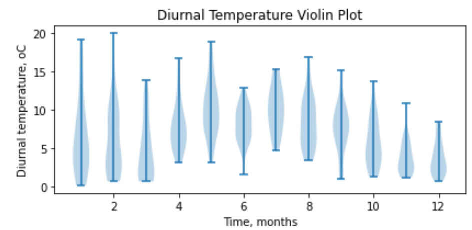
Wind Wheel



[Figure 11]

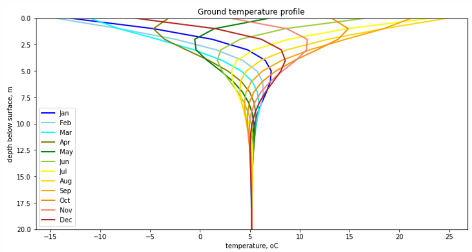
Mostly from southern west, and average wind speed about 4m/s





[Figure 10]

Ground Temperature plot



Under 10m from the ground, the temperature turns to about 5°C, from around -15 to 25°C.

Summary

- **Solar power** will be less efficient in winter due to the **sun hours**, and the **angle** of the collector.
- Wind comes mainly from the **south-west** and the average speed is over **4m/s**.
- The **diurnal temperature** shows the potential of **passive solar high mass**.
- The ground shows **good heat storage performance**, using a **ground source heat pump** can absorb the heat of the land.

[Figure 12]

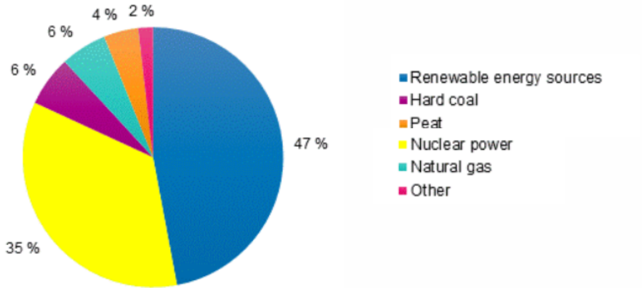
Helsinki Information

THE POWER STATION OF PASILA KONEPAJA

2.1 Energy Usage

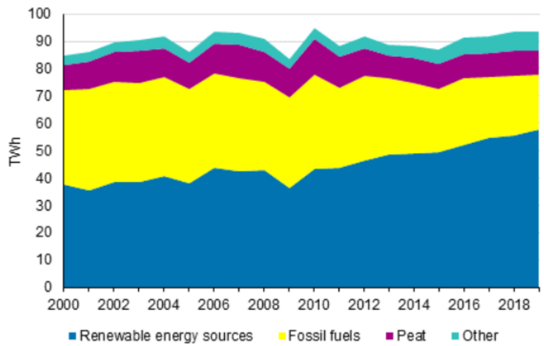
Finland Energy Structure

Finland's electricity CO_2 fuel intensity (Carbon dioxide pollution from burning one kilowatt of electricity) is 0.197 kg CO_2 per KWH. The main reason for low carbon pollution is their high use of renewable energy (47%).



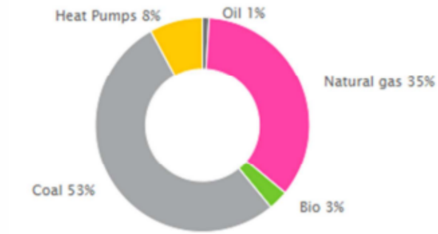
Sources of district heat production

- In 2019, the production of district heat in Finland amounted to 38.1 TWh, of which 15.3 TWh were produced with renewable fuels, 13.2 TWh with fossil fuels, 5.7 TWh with peat and 4.0 TWh with other energy sources.
- The share of electricity produced with fossil-free energy sources – renewable energy sources and nuclear power – was 82%

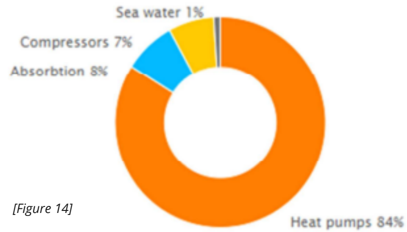


[Figure 13]

Helsinki origin of district heating



Helsinki origin of district cooling



[Figure 14]

Summary

- **Renewable energy** is the main source of energy supply in Finland - at **47%**
- The heat production of the district heating system meets the heating need of most of Helsinki in the summer.
- There is a high usage of coal for district heating in Helsinki.

2.2 Helsinki Economic & Culture & Architecture

Economy & Industries

- **Main industry**: Forestry is the main industry in Finland.
- **Import:** More than half of Finland's total imports consequently pass through the port of Helsinki, making it essential for Helsinki's economy.
- **Natural Resources**:
  Wood- Forests are a major natural resource
  Clay- Helsinki's ground is mainly clay with an average thickness of 3m.
  Rock (Granite)-Great number of buildings are constructed of local granite.

[Figure 15]

Eastern Finland traditional building

[Figure 16]

1852 Helsinki's Oodi Central Library

Architecture:

- **Vernacular architecture**：The vernacular architecture of Finland is generally characterised by the predominant use of wooden construction.
- **Vernacular Architect**: Alvar Aalto(1898 – 1976)
  Masterpiece: Helsinki's Oodi Central Library, Aalto University, Kohta Train Station.
- **Common types**: Modernism, functionalism and the largest concentration of Art Nouveau buildings.
- **Building structure**: Wood and masonry structures(until 1950) ~ precast concrete(from1970s).

Culture

- **Lifestyle**: Finns value being close to nature; the agricultural roots are embedded in their lifestyle.
- **Historic buildings:** Helsinki Cathedral, Ateneum Art Museum, Olympic Stadium etc.

[Figure 17]

1852 Helsinki Cathedral

[Figure 18]

1938 Olympic Stadium

- **Religious belief:** As of 2016, 72.8% of the people belong to the Evangelical Lutheran Church.

Summary

- **Helsinki's economy** relies on **forestry** and imports.
- **Timber** is widely used as a **construction material**.
- Granite can also be used owing to its abundance.
- Vernacular Architecture comprises mostly of wood and stone structure.

2.3 Helsinki Social Condition

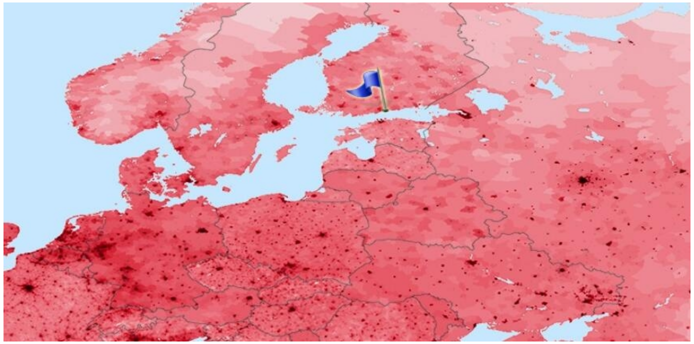
Population

- 11.38% of the total Finnish population reside in Helsinki.
- Aged people account for 16 % of the city's population.

Housing situation

- **Housing density**: High but also with green spaces.
- **Vacancy rates:** Have a negative correlation with population and population change. However, there is a positive correlation with the share of the elderly and vacancy rates.

[Figure 19]



(population density: 2,739.36 people per square kilometre)

Social acceptance of renewable energy technologies for buildings:

Solar technologies and ground source heat pumps are the most preferred options.

Summary

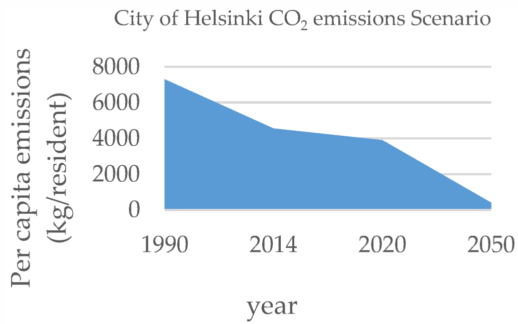
- **Helsinki** holds a **high percentage** of the total **Finnish population** with a high account of the aged population (higher than the other cities)
- Buildings' **carbon emissions** must be **reduced by 82%** according to **sustainability aim**.

Sustainability Aims - Carbon Neutral

Helsinki's goal is to be carbon neutral in 2035. Carbon neutrality means that the geographic region of Helsinki does not produce atmospheric emissions. In practice, **carbon neutrality means an 80% emission reduction, with the remaining 20% being compensated by reducing emissions elsewhere from Helsinki**.

- the energy efficiency of buildings can be improved
- energy can be produced based on an individual building's requirements
- waste heat can be actively collected from air and water

[Figure 20]



Sustainability Aims - Sound and Healthy Minds
The wellbeing of children and young people

Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

The Carbon-neutral Helsinki action plan includes education-related guides, **the goal** of which is to **increase climate change and circular economy know-how** at all **education levels** from comprehensive education to course-selection of adult education centres.

2.4 Mental Health Research in Finland

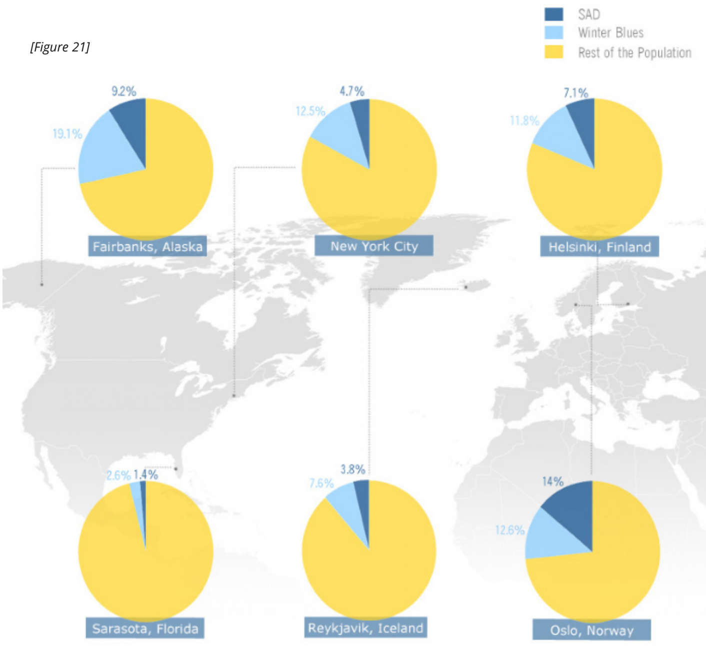
The Situation in Finland
In the EU, on an estimate, 1 in every 6 people experiences a mental health problem. In Finland, this number is close to 1 in every 5 people. Mental illness has a high economic cost – the cost of treatment, social security programmes, lower employment and lost productivity. All these add up to a total average of 4% of GDP in EU countries. In Finland, it is higher still. An estimate of 5.3% of GDP in 2016.

Lack of light in South Finland
In winter, darkness dominates several months. Nights are very long, so much so, that in some Northern cities the sun doesn't rise. In Finland, this is called kaamos (or polar night, in English).
In the south of the country, although it cannot be strictly said that kaamos occurs, days are still very short. In Helsinki, there can be less than six hours of daylight. This means that the sun sets by 15:00 hours.

Effect on Lifestyle
It is evident that activities on the streets are very low in the winters. People do not go outside as days are shorter and colder. This adversely affects their mental health.
Due to the lack of natural light, some suffer from depression and some from **seasonal affective disorder**. According to the Finnish Association for Mental Health, **low illuminance levels can cause anxiety, hopelessness and self-destructive thoughts**.
It has been proven that severe depression occurs most during the autumn and winter months. The risk of suicides increases from November to March when there is little sunlight.

Poor lighting often gets overlooked in the workplace. Poor lighting is associated with a range of ill-health effects, both physical and mental, such as eye strain, headaches, fatigue and also stress and anxiety in more high-pressured work environments. As we spend much of the day in artificial lighting, there is evidence that the lack of natural sunlight has an adverse effect on the body and the mind, and can result in conditions such as seasonal affective disorder (SAD). Whilst aiming at improving mental health and well-being, our focus is now firmly on creating happier and healthier workplaces.

[Figure 21]



Who is affected - https://visual.ly/community/Infographics/health/how-beat-seasonal-affective-disorder-and-winter-blues

Summary

- Research indicates that in places like Helsinki and Norway there is a very prominent relationship between mental health and daylight hours.
- Our proposal would therefore focus on bringing in as much natural light as possible

[Figure 22]

Site Analysis

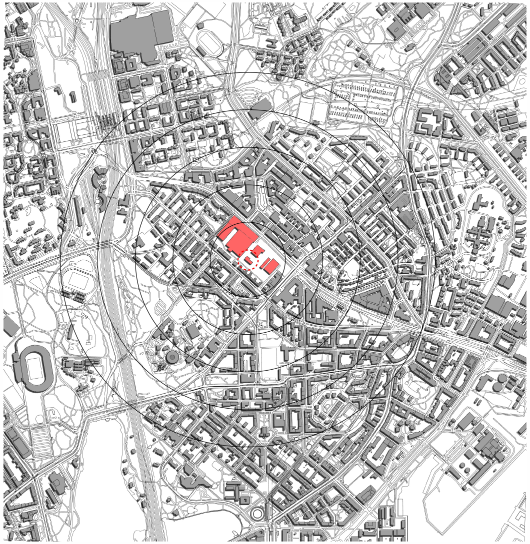
THE POWER STATION OF PASILA KONEPAJA

3.1 Site and The Surroundings

Site Analysis

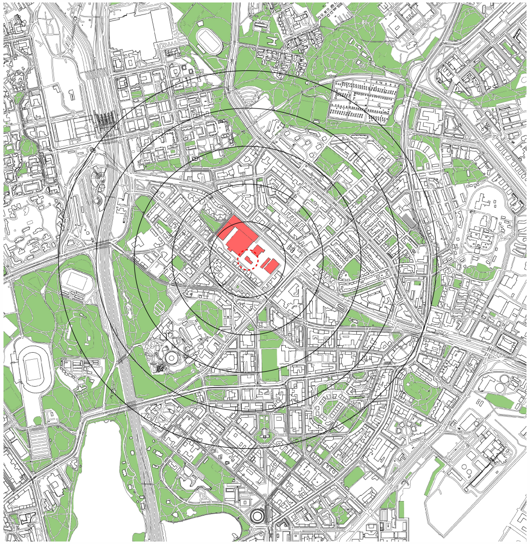
Surrounding Buildings

[Figure 23]



Green Areas

[Figure 24]



- The site is located in the south of Helsinki with a moderate density of surrounding buildings. The surrounding area is mainly small blocks with an area of about 3,200 to 13,000㎡. The largest block is about 24,000㎡. The main buildings are concentrated within a radius of 1km from the centre of the site.
- The height of the surrounding buildings is mostly around 14-28m.
- Large green space is located in the north and southwest of the site 1km away. There are scattered green areas within a 600m radius of the site, while there are almost no green areas within a 200m radius.

Function of surrounding buildings

[Figure 25]

- Surrounding the site (within a radius of 400m), residential areas sit in the south-west and office buildings sit in the north-east.
- Education and government buildings are mainly located in the northeast.
- Other factory buildings in the site currently have temporary functions such as bars, restaurants and venues.

Industrial Building

Residential Building

Office Building

Educational Building

Gov & Social Service

Retail building

Summary

- There are many **small blocks** around the site, and the main crowds around are **residents and white-collar workers**. The function of the building can be considered to serve these two groups of people.
- The living function around the site is **optimal**, but the green space is **extremely lacking**.

3.2 Transportation Analysis

Transportation Hubs: Urban Scale

[Figure 26]

Helsinki is located in the south of Finland, it has an airport and two of Finland's busiest train stations. The site is close to all transportation hubs.

Summary

- The site is located in the **core** area of Helsinki, with a **efficient and convenient transportation system**.
- There is a **high density** of bus stations around the site.
- There is **easy access**s to the airport, railway stations and other core transportation hubs.

Bus Stations

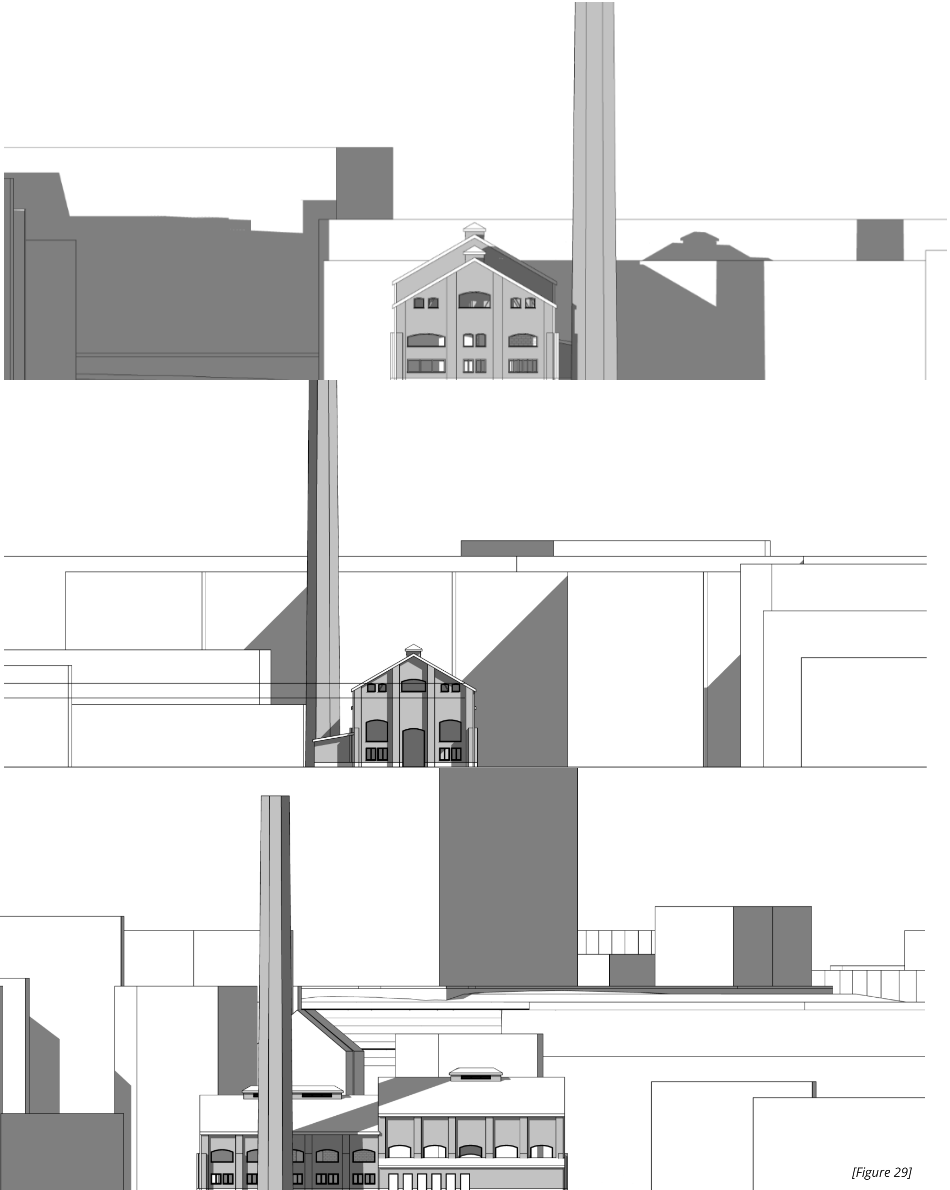
- There are 7-8 bus stops and tram stops on the main road around the site.
- There are 3-4 bus stops and tram stops on the branch roads around the site.
- Approximately 30 bus stops are located within one kilometre of the site.

[Figure 27]

City Roads

- The main roads and the branch roads are staggered within two kilometres of the site.
- The bus lines surround the site are from four directions.
- About 2kms northwest of the site is a medium-sized railway station-Pasila Station.

[Figure 28]



[Figure 29]

Building Information

THE POWER STATION OF PASILA KONEPAJA

THE POWER STATION OF PASILAN KONEPAJA

[Figure 30]

THE POWER STATION
Interior

[Figure 30]

4.1 Information and History

Name The Power Station to the Finnish Railway Train factory and part of the Pasilan Konepaja complex

Location Between the Alppila and Vallila Districts, Helsinki, Finland

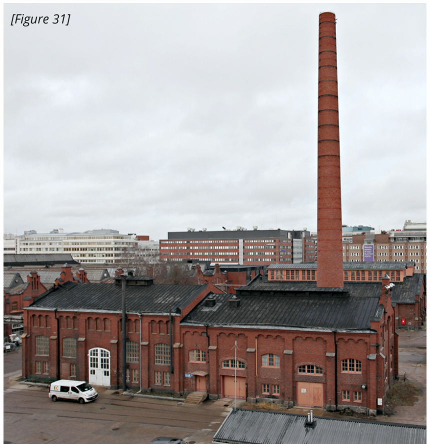
Building Footprint approx 850m2

Site approx 18000m2

Height 14m (single storey)

Age 1901

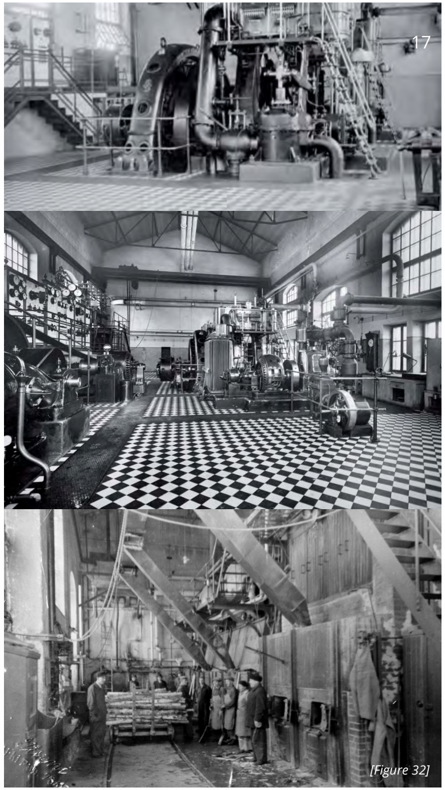
Architect Bruno F. Granholm



[Figure 31]

History

- The power plant is part of the first Pasila machine shop, and is one of the earliest buildings during the construction phase there.
- The power plant produced heat, electricity, steam and compressed air to meet the needs of the machine shop.
- The left side is the engine room and the right is the boiler and the steam room.
- In 1966-1970, use was discontinued of the power station due to an advance in technology.
- In 1970, students were moved in for school education with an entrance on the west side. They also added a second floor and filled parts of the windows in order to do this. The school facilities were divided into three classrooms, a lobby, office and social facilities.
- Students were then moved out in 1998, the upper floors were used as a VR training centre for workers and staff.
- The 2nd and 3rd floor were split into two offices.
- The ground floor was used half for maintenance work and the other half as a forklift.
- The original train factory discontinued operations on trains shortly after in 2003.



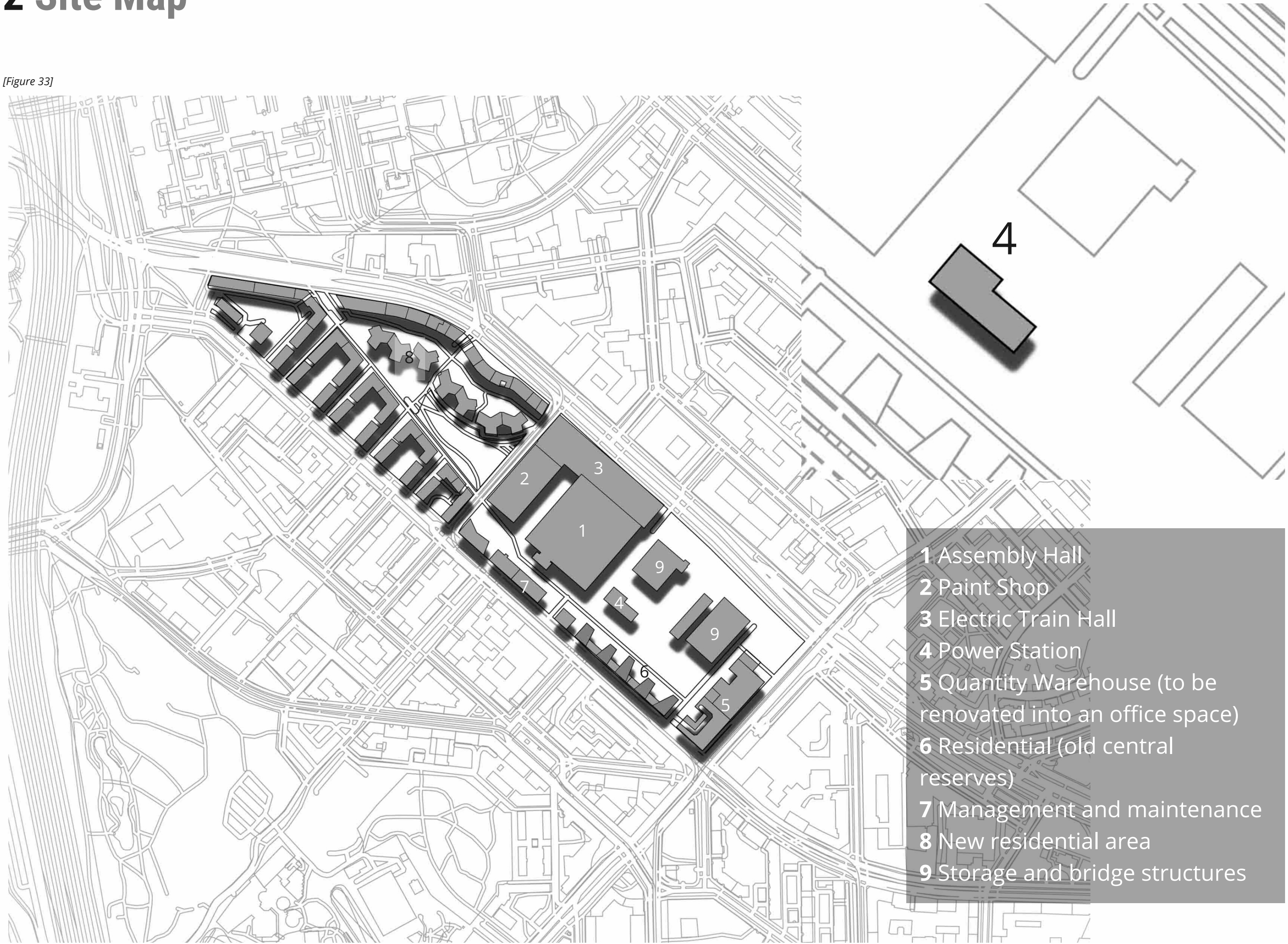
[Figure 32]

Summary

- Rich **history**
- The building has been adapted functionally **multiple times** for **different uses**, however not in a sustainable context.
- It is an old **industrial building.**

4.2 Site Map

[Figure 33]



4.3 Cultural Significance

Railway

- The construction and industrial historical **significance of the workshop is widely recognized**.
- It is a part of Finland's public utility construction since the period of autonomy.
- Railways were a great economic effort for society
- These machine shops were made all over the country and the **Pasila workshop was the largest**.
- It sits as a part of **historical importance** in Finnish railway architecture.
- It was the *"second generation workshop"*, progressing on lessons learnt from previous machine shops and international influences.
- The Pasila workshop was made the largest of the State Railways, **providing many jobs** for the people of Helsinki:
    - **1917** - over **900** employees
    - **1938** - over **1,100** employees
    - **1960** - over **1,500** employees

School

- A school educating **engineers** and **skilled workers** for Finnish Railway and Helsinki as a city. It provided jobs and education **for the community**.
- The school started from 1921, when the power plant ceased energy production to the main machine shop.
- Originally, it was used to **train graduates** to become locomotive drivers and skilled workers. Some of which were also experts of upholstery and painting for the machine shop, whilst being paid a normal workers salary.
- 1984-1893: Of the **21% of employees** whom had graduated the engineering school, **2⁄3** remained in railways and **1⁄2** were employed in other **highly skilled places.**

Power Plant

- Central location providing:
    - Steam
    - Compressed air
    - Electricity
- Distributed through:
    - Cables
    - Canals
    - Air bridges
    - Pipelines

...in different directions to heat all of the surrounding buildings to~ power machinery.

- **Architecturally compliment**s the look of the surrounding machine shop
- **Production of energy ceased in 1921** when the workshop was connected to the city's electricity grid as a result of technological advancement.
- The building is used in the same way that it originally was.
- It has **connections** and **bridges through pipelines** to Paja, Kokoonpanohalli and further to Maalaamo, as well as an underground canal to Alkk.
- The **barrel** and **chimney** is a **visible landmark** and the loss of which would be detrimental to the look and orientation of Konepaja's outdoor spaces.
- The building has been **proposed for protection** in a draft town plan amendment from **2003**.
- The power plant's boilers were originally designed to run on **coal** however practically **transferred to wood** (burning up to 200m3 of firewood logs a day, brought in through a trolley along tracks).
- A significant part of the building is the **steel-structured cable-stayed bridges** leading in the direction of the Assembly Hall and Paja. This is because they tell a story about the technology and industrial history of the workshop and were later extended by a footbridge.

Important considerations for our proposal

"The starting point for the repair shall be the original or comparable structures of the building and its valuable interiors, the building components and their preservation of details, materials and colours." [39]

"Public service premises, industrial premises that do not cause disturbance to business, offices and the environment, educational, training, studio and exhibition premises, meeting rooms, café and restaurant premises, leisure facilities. "

Summary

- A place of huge **economic, social, cultural** and **historical** importance
- The railway provided many **economic and social benefits** as well as cultural and historical **significance**, it was the largest train factory in Finland at the time of construction and emerged during a time of huge industrial transportation progression within Finland.
- The power plant provided **central energy distribution** to enable the efficient running of the machine shop and was a **major asset** to this, physically represented through **structural elements.**
- The school provided a huge benefit to the **community with education and jobs**, as well as in turn benefitting the **economic status** of the machine shop
- We must consider these significances largely when preparing to retrofit the power plant.

Pasilan Konepaja

4.4 Surrounding Renovations

Company Arkkitehtuuritoimisto B & M Oy

Where? Sturenkatu (site of original warehouses) situated south-east of the Power Station

What? Office Space

Size 26,000m2

Client City of Helsinki/City Planning Department

Status Concept

[Figure 34]

[Figure 35]

Company ARK-house arkkitehdit Oy

Where? Teollisuuskatu (original of woodworking, train painting and warehouses) situated north-west of the Power Station

What? Residential

Client KSV, YIT Rakennus Oy

Status Built

[Figure 36]

Company GVA Sawyer
In partner with AHR Global, AHR Architects, Saatsi Arkkitehdit and Livady.

Where? Paint Shop *6,208m2*
Assembly Hall *13,154m2*
Electric Train Hall *6,892m2.*

What? " Intense centre of creative and community life":

- Creative retail space
- Office/craftsmanship/light industrial centre
- Street food market
- Events platform of mixed-use
- Modern gym and paddle tennis courts
- Supermarket
- High rise hotel, residential and office buildings (in place of the Electric Train Hall)
- Podium/underground parking

Client Centre of Helsinki

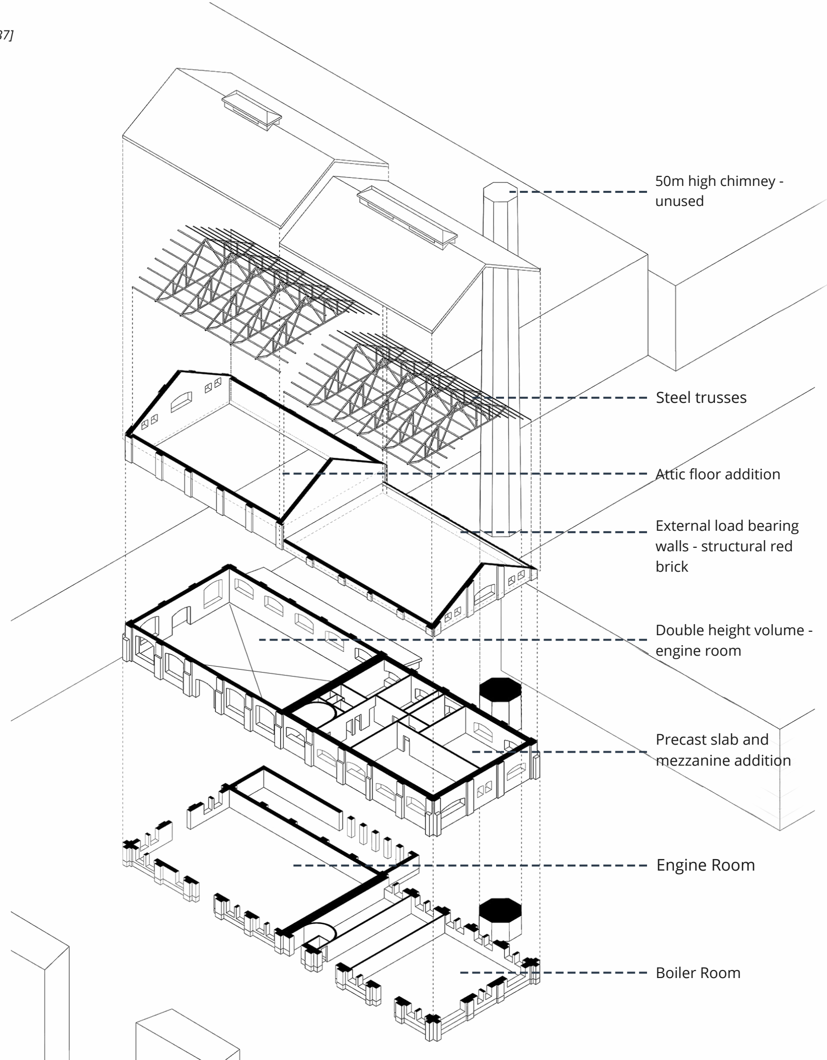
Status Concept

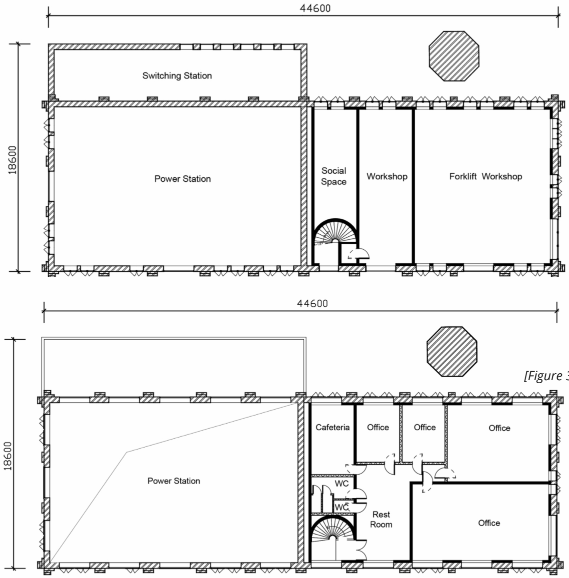
Summary

- There are **many renovations** surrounding the site, 2 of which are in **conceptual stages** and 1 has been **completed**.
- The renovations include **office spaces, residential spaces and a large scale renovation** of retail, hospitality and mixed use which includes a high rise hotel.

4.5 Orthographics

[Figure 37]





[Figure 38]

The brick-built Power Plant was originally only two spaces, separated by a partition - the engine room and the boiler room.
The **engine room** is a **bright double-height** space with a checkerboard floor that receives plenty of natural light. On the contrary, the **boiler room** is **divided by** the pre-cast concrete **mezzanine** floor - limiting natural ventilation and illuminance.
The **steel trusses** form a predominant architectural element and the **50-meter high chimney** next to the building, although unused behaves as a **landmark** to the neighbourhood

Summary

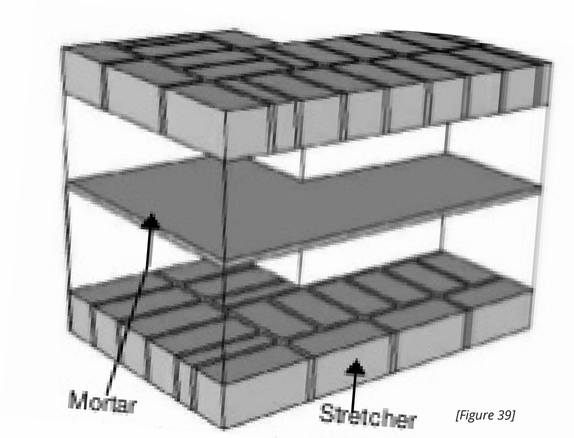
- **Large windows** provide opportunities to utilize **natural ventilation and daylight strategies**
- A clear height of 10m allows for the addition of floors
- The overall planning is not complex and leaves possibilities for modification

4.6 Construction Materials & Structure

Construction

The Power Station completes the first phase of the Pasilan Konepaja workshop buildings Walls built with **structural red brick and stone piers**. The red bricks were **bonded with lime mortar** and flint. The external walls are load-bearing and constructed with the 'English Bond' technique.

The English bond is composed of alternate courses of headers and stretchers. The headers are centered on the stretchers and joints between stretchers in all courses are aligned vertically.

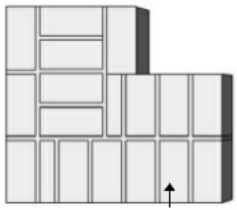


[Figure 39]

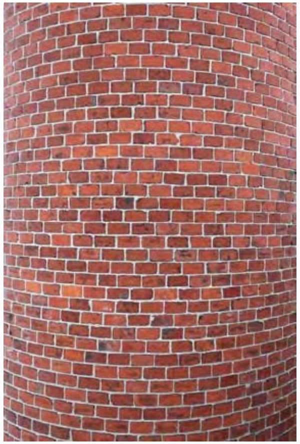
The chimney is bricked of specially sized chimney bricks, and there is no alternation in the masonry - Header bond.

Four different lengths of bricks that were used: 150mm, 200mm, 250mm and 300mm.

All buildings within the **Pasilan Konepaja complex** follow the **similar language of brick and steel construction** with a granite plinth and concrete piles.



[Figure 40]



Above (left): Steel used in roofing
Above (right): Granite plinth
Left: Chimney's header bond
Below: Load bearing walls in English Bond

Summary

- **Lime mortar** allows for **easy disassembly** of the brick wall. Therefore, rendering it to be reusable.
- The load-bearing capacity of stone piles is adequate and the foundation has also been modified during 1970 to include concrete piles.
- The construction technique of brick walls identified as **two brick thick English bond walls.**

4.7 Material Reusability

Reusing Old Bricks

According to 'Zero Waste Europe', a Danish company, GamleMursten ApS demonstrates the **reuse of old bricks** by means of a **feasible and sustainable approach**. This European funded project, called REBRICK, allows for converting waste into a useful product and saving 500g of CO_2 for every brick that is reused. It **increases the life cycle of the product** and its manufacture **creates jobs across Europe**.

The Process - The REBRICK project technology utilizes a **patented vibration-based system** that sorts the demolition waste and cleans mortar from the old bricks **without having to use any amount of water or chemicals** - making it an environmentally friendly process.
The machinery can be dismantled and easily transported. Hence, it is technically possible to locate the facility close to areas with huge demolition potential and later, once the buildings are demolished, to move the entire facility to a new location (Zero Waste Europe, 2014).

Reusing Steel

Reusing structural steel over the common practice of recycling by remelting scrap offers significant environmental benefits and potential cost savings (PBC Today, 2019). **Design for deconstruction** is **key to the circular economy**. (A circular economy is an economic system aimed at eliminating waste and the continual use of resources (Wikipedia, 2020)).
Structural systems that are bolted together are easy to dismantle and reuse. The SCI Steel knowledge protocol proposes a new system of investigation and testing to establish material characteristics. If these characteristics are determined accurately, the salvaged steelwork may be fabricated and CE marked in accordance with BS EN 1090.
Increased structural steel reuse will support both of the circular economy aims and **stimulate new local business opportunities by substituting steel imports**.
Analysis reveals that the long-term price differential between the cost of structural steel and scrap sections is over £300 per tonne. This represents the potential profit opportunity through structural steel reuse (PBC Today, 2019).

[Figure 40]

Summary

- All buildings within the complex are built with red brick and steel. These buildings have **future proposals** laid out for the **conversion of the train station into a cultural hub**. **Material scraps** from the remodel can be **reused** in the proposal for the power station.
- **Reuse over recycle - to reduce carbon emissions**.

4.8 Common problems associated with old brick buildings

Mortar Deterioration

Caused primarily by moisture penetration. Other factors include wind erosion and bricks that have been coated with paint. These do not allow moisture to escape. The Fix - Repointing with mortar that matches the look, texture, colour, composition and hardness of the original mortar..

Brick Deterioration

Cracking or spalling occurs when excessive moisture enters the bricks and freezes in the winter. Other causes are foundation settling if the repointing work is done with mortar that is harder than the brick itself.

Brick Erosion

Caused if the bricks weren't burnt optimally leaving them soft or if they were formed from clay that is not dense enough to hold up over time. Other causes include abrasive cleaning techniques such as sand blasting or high-pressure washing.

Structural Failures in Your Brick Walls

Caused by excessive foundation settling or massive amounts of water entering brick walls. This water problem most commonly occurs from a roof leaking over a long period of time.

Stair-Step Mortar Cracks

Cracks that look like stair steps are primarily caused by foundation settling. If no other moisture or structural problems exist, the cracked mortar joints can be repaired by repointing.

Efflorescence

Caused when salts in the mortar or brick are dissolved by excess moisture. When the moisture evaporates, the remaining salts leave behind a white powdery film.
Efflorescence rarely happens to brick houses and buildings built before 1920, because the lime and sand mortar used up to this time did not contain Portland cement. Lime-based mortars have few, if any, salts in them.

Bricks Containing Surface Debris

Caused as a result of exposure to airborne pollution and particulates in the air that attach to the bricks and mortar. Often this natural patina is not damaging to your bricks and can be considered protective, so cleaning may not be necessary.

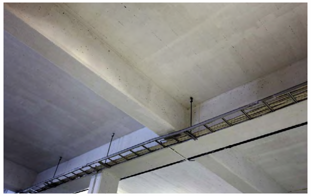
[Figure 41]

Summary

- Most predominant natural causes for brick damage - Moisture & winds. Damage due to errors can be rectified.
- **Lime mortar used is a positive attribute**. It helps the bricks to breathe by **allowing for moisture evaporation**. They also allow for flexible expansion of the bricks.
- As such, from the images of the existing building, there were no evident causes of brick damage and efflorescence but it was important for us to know them anyway.

4.9 Structural Renovations


[Figure 42]



Roof

- There is dust rising from the **mineral wool filling**: this dust consists of mineral wool, pulp waste and asbestos.
- **Sheet metal** has recently be renewed.
- **Ventilation lanterns** and **fire protection plates** are in the loft.
- The forces caused by the loads on the water roof are transmitted through **ridge-oriented steel beams** through end walls and through **steel trusses** to the side walls.
- The power plant's water roof structure has **remained original.**
- On top of the longitudinal steel beams is a wooden beam to which a lower surface is attached. It is nailed to the cut with nails fiber board.
- **Fiber gypsum boards** work with **wood** as fire protection of the roof structure.
- The **boiler room attic** is an open, unused, cold room.

Other preserved elements:

- There are **ventilation lantern hatches** on the roof of the boiler room which can be opened and closed using wires and are connected to the **ventilation lanterns** on the roof
- Transformation **sockets and switches** that are likely From the **1930s.** These devices are an important part of interior decoration.
- The main switchboard has a row of **wall lamps**, which are probably from the **1930s**

New precast concrete structure:

- A **reinforced concrete wall** has been cast on the side of the boiler room - it works as **load bearing** for the **precast concrete structure.**
- **Staircase walls, mezzanine** and the **second floor** is all precast reinforced concrete
- **Two double rooms** were built in the boiler room. Reinforced concrete **columns, partitions and slab** cast on them. This is how the room came to be **two floors and an attic**.

Internal walls

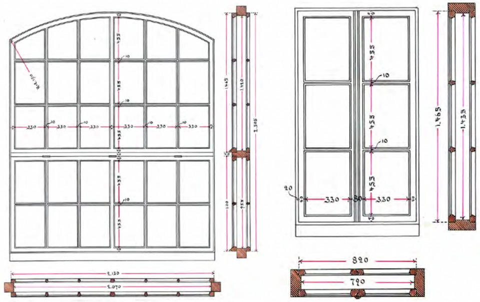
- The engine room office is **separated** from the engine room with **timber walls**.
- Some internal walls are **single brick**.

Summary

- The water roof emits **toxic chemicals** from the mineral wool filling used- most notably asbestos.
- Some **fire proofing** and **damp/water proofing** has been considered in the roof construction.
- There is an **internal self supporting reinforced precast concrete structure** to the boiler room in which creates the rooms for the school and workshop
- A mix of **brick, reinforced concrete** and **timber** are used for the internal walls
- A row of **original wall lamps** could act as integral to our human powered energy function.

4.10 Doors and Windows

[Figure 43]



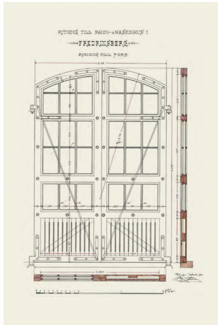
Windows

- **On the east facade:** brick has been used to close windows.
- **In the attic:** windows remain original
- Construction: nailed timber frames, in-and-out with linen oil
- **Top windows:** secured in place by sliding bolts (locking screws), the sled bolts are tightened on the inside with hex nuts.
- **The timber windows** have wooden glazing beads.
- **Thicker frames** were added to boiler room.
- **Windows:** in boiler room are all replaced, in engine room all original, and in attic all original
- There is **double glazing** on all windows.

Doors

- **Poorly fitted** garage doors/windows.
- Some doors **can't be opened** without dismantling.
- **On the north facade**- original doors and windows remain.
- **On the west facade**- doors are replaced with plywood doors, some windows converted to doors and some windows are **original**.
- The boiler room windows and doors are all **replaced**.
- **Original doors** remain the same in engine room.
- **Original arched doors:** 1 remains each on the south and west wall of the engine room (this is mainly because they were less frequently used).
- **Demolished arched doors:** replaced either retaining some shape using wooden doors or converted to windows.
- **Construction of doors:** concrete lower hinges are mounted on the anchorage and brickwork, the upper hinges fitted have all remained firmly in place (where doors have been renewed).
- **Five opening steel double doors** from the transformer room have been preserved as original
- **Materials:** some tin, some timber/plywood mirror doors.
- Other than school access/garage door, **all interventions are vaulted** and can not be opened, apart from some higher windows which are equip to open for ventilation purposes.

[Figure 44]



[Figure 45]

Summary

- Switching to regular garage doors has to some extent ruined the architecture of the building
- Replaced garage doors/windows are poorly fitted
- The space and atmosphere of the machine room has been well preserved as original - different to boiler room which has been completely changed
- All windows are double glazed
- Some tin doors act as thermal conductor bringing in the cold and are not so insulating

4.11 The Chimney

Construction

The Chimney is constructed with **structural red brick** owing to its property of being able to **withstand intense heat**. **Lime mortar** and renders to **allow for flexibility and expansion**, both important factors in chimneys.
The power plant is equipped with a 50-meter high chimney. The chimney has 1920s mounted structural steel rims installed at every 1.5 meters. These steel rims have been renewed in the 21st century but the chimney is no longer in use.
The interesting detail about this chimney is that it **sits separate from the power station** and does not share the external walls.

Common associated problems

A number of defects can afflict old chimneys and scaffolding is a major part of the cost of repairs.

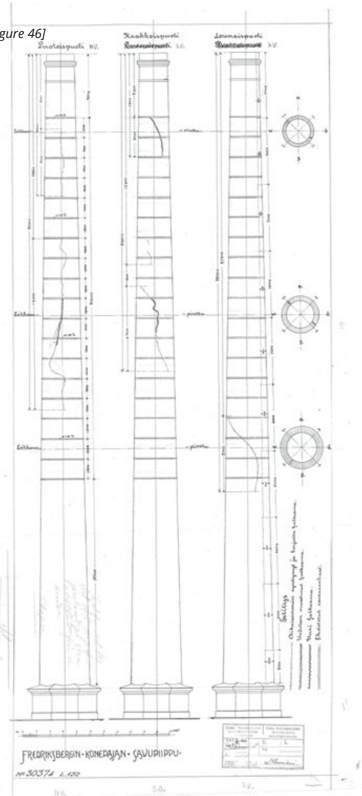
Erosion - **Hot gases, soot and condensation** combine to form corrosive acids which over years of use erode the **linings and walls of chimney stacks from the inside**. It could also erode the mortar pointing.

Stability - As a result of the erosion, the stack could be weakened over time. Signs of a chimney starting to fail include fragments of mortar and even stone coming down the chimney shaft and the escape of smoke into loft spaces or through the walls of the chimney stack (Traditional Buildings Health check, 2020).

Redundant fixtures - These can cause movement through wind shear or failure of the masonry as a result of bolts rusting and expanding within the stone.

Apart from the above-mentioned problems, common problems associated with old brick should also be taken into account for the revival/ reuse of the chimney stack.

[Figure 46]



[Figure 1]

[39]

Summary

- Chimney stack has now become more of an aesthetic element (a landmark); it could be repurposed for sustainable design.
- From the common problems, it is evident that **for the chimney to be reused** it must be covered with a **new flue lining to separate toxic gases**.
- Possibility of using the chimney as a power tower.

4.12 The Power Station Pros | Cons

Pasilan Konepaja

Pros

- **Appropriate size** - 850m2.
- **Height is appropriate**/enough for 3 storeys.
- Use of **reusable materials** i.e. brick laid using lime mortar.
- Use of **technology/power** has been thought through in the old design due to it's original function/use. This can link nicely to a retrofit design and perhaps creates a **connection to a sustainable vision/function/purpose** that progresses upon these **old elements** in the new proposal.
- Fairly **simple spaces** allows for lots/little adaptation.
- The building has some **beautiful, industrial characteristics** such as the brick laying design, window/door styles, prominent chimney (which has become like a landmark).
- A chance to enhance the **area of high importance** and draw the **community** to the building.
- **High availability of sustainable timber** due to enormous woodland coverage over Finland as a country.
- Surrounding buildings within the Pasila Konepaja complex are to be renovated accommodating for a **more 'attractive' area.**
- There are not too many structural load-bearing walls which allows for **easy adaptation of the interior.**
- Changing function over time allows for a new function to draw on this **'ever-changing' aspect of the building** which can be constantly adapting to **new life/culture**, which is ultimately a very sustainable use of the space for futures to come.
- Surrounding land is **spacious.**
- **Lots of information** found on the building.
- A space that is **not too large** and allows us to **focus on detail/maximising efficiency** in terms of sustainability.
- Building is **already connected to district heating** which brings opportunity to utilise it or enhance, especially due to the fact that **47%** of it is already from **renewable sources.**
- Very **well connected** and in a **prominent neighbourhood**.

Cons

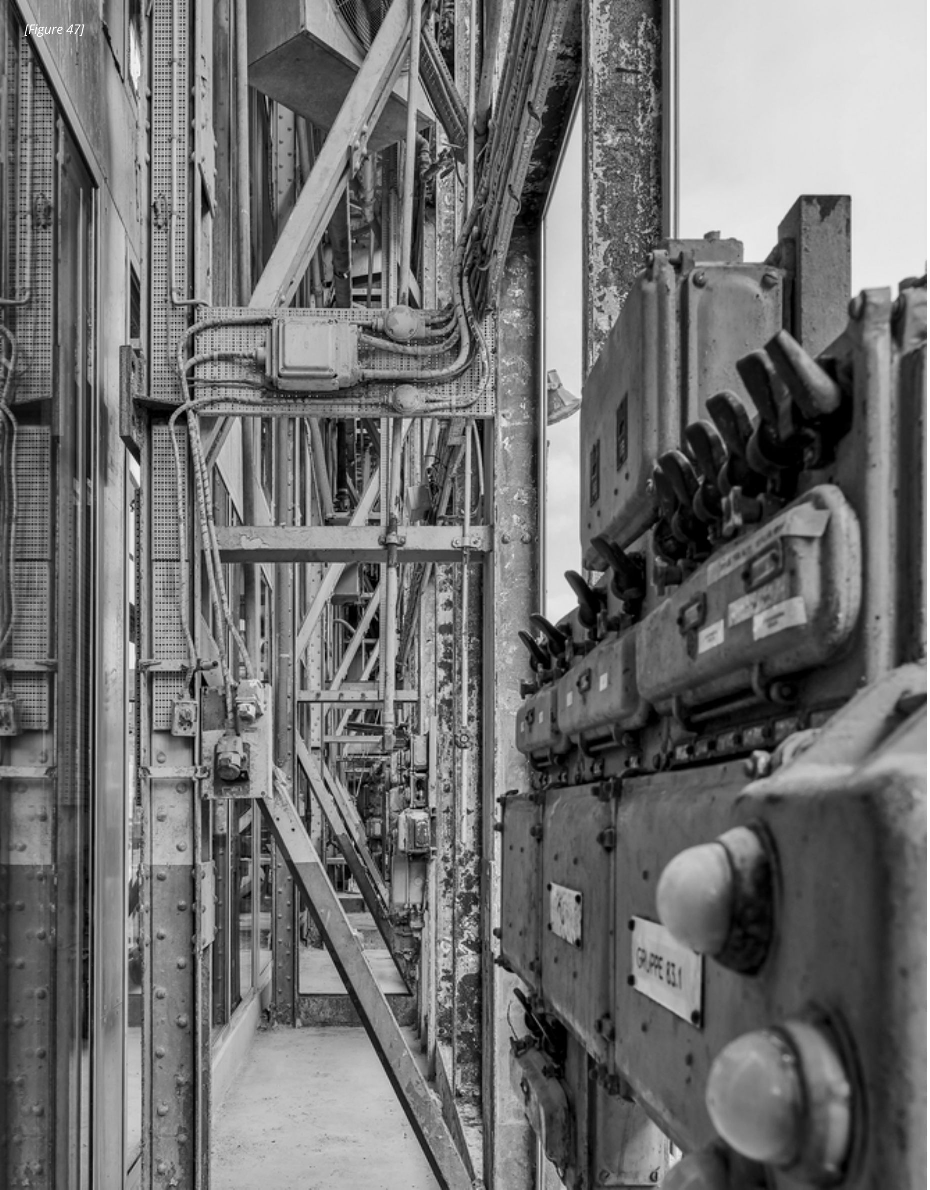
- A petition to become a **protected building,** which may make adaptation limited.
- Some **extremely dated materials** may need **demolishing**, many materials may not be reusable or recyclable.
- **Unsure about how much design can be done to the facade** if we are considering respecting the surrounding buildings and the original design/function of the building
- Potentially **removing a training centre for the community** by taking their educational space (however this can be integrated into a discussion of the function)
- **Foundation** may not allow a lot of flexibility and changes to the structure
- The **existing structure** is a very **thick brick wall** making a retrofit of the wall structure a difficult task with regards to moisture transfer, thermal transfer and cold bridging.
- The renovations regarding the **concrete slab** which has been inserted may create **difficult design** and **structural problems.**
- A lot of **doors** and **windows** will need **replacing**.
- The **roof emits toxic chemicals** from dampened mineral wool filling which needs a lot of attention to correct
- The **water installations are old**, from the early 1900s and would need replacing
- **Lack of green space** surrounding site

[39]

Summary

- More pros than cons.
- Cons have **potential solutions.**

[Figure 47]



Contextual Research & Case Studies

THE POWER STATION OF PASILA KONEPAJA

5.1 Case Studies

Strucure and Materials

Case1 Valby Machinery Halls- Denmark

- Støbehallen was renovated with a focus on **retaining** as many of the **original construction details and characteristics** as possible. This means that the **distinctive steel profiles** have been reused in the new construction of the hall, just as the new horizontal facades have been created with vertical and horizontal partitions marked with steel profiles as a reminder of the industrial building traditions of yesteryear.

[Figure 48]

- The red steel framing with the red partitioning sections create **a sense of history** and provide a clear **reference to the area's industrial past**. These are important features of the building that give the Valby Maskinfabrik area its distinct character.

- The architectural cut and roof form, the western facade and the two gables with steel framework, walls, windows and the large door openings are all worthy of preservation. The middle section with housing units has been rebuilt respecting the structure.

[Figure 49]

Case2 Kalevan Navetta Art and Culture Centre- Finland

- **Timber** is of domestic origin and **wood fibre** is used as **thermal insulation**.
- Painted steel is used as structural support.
- The roof above the cold attic storey had previously consisted only of timber boarding and sheet metal, and the blackened wooden pillars and roof supports were visible. Now the space in the Art Hall called Vintti ("Attic") has a **ceiling made of light-coloured boards** with grooves cut into them to give the look of battens, supported by a **black metal structure made from former railway rails**, retains the same atmosphere as before the renovations.

[Figure 50]

Summary

- The case studies **relate to the structure, material, design language** and most importantly, the buildings are **within the same climatic condition**.
- Most of the **building components** are **reused**, and **'the building inside the building method'** is adopted for **airtightness and insulation** whilst **retaining their historic significance**.

5.2 Finnish Vernacular Architecture

Evolution

- The vernacular architecture of Finland is generally characterised by the **predominant use of wooden construction**. The oldest known dwelling structure is the so-called Kota, a Goahti, hut or tent with a covering in fabric, peat, moss, or timber.
- This evolved into a rectangular hut by the tenth century which was made out of log sides and had a low gable birch-bark roof.

[Figure 51]

Kota

rectangular hut

The oldest surviving structures: Turku

The Luostarinmaki Handcrafts Museum is the best example of the oldest surviving architecture (Cloister Hill, Turku).

Courtyard interior

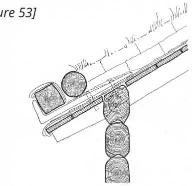
Streetscape

Note the low, clustered log structures, the **roofs** oriented to the street, the connected buildings, and the **raised foundation platforms**. Also note the **articulation of the street wall with pilasters**, entrances, **roof overhangs**, and windows and the use of fences and gates.

Sod roof

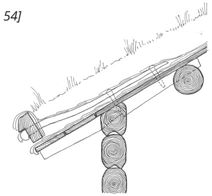
- A sod roof, or turf roof, is **a traditional Scandinavian type** of green roof covered with sod on top of several layers of birch bark on gently sloping wooden roof boards.
- A sod roof is an advantage because it **helps to compress the logs** and make the walls **more draught-proof**. Sod is also a reasonably efficient **insulator** in a cold climate. The birch bark underneath ensures that the roof will be waterproof.

[Figure 53]

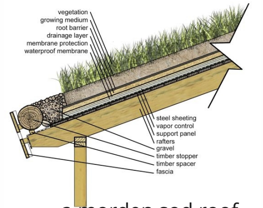


a traditional sod roof

[Figure 54]



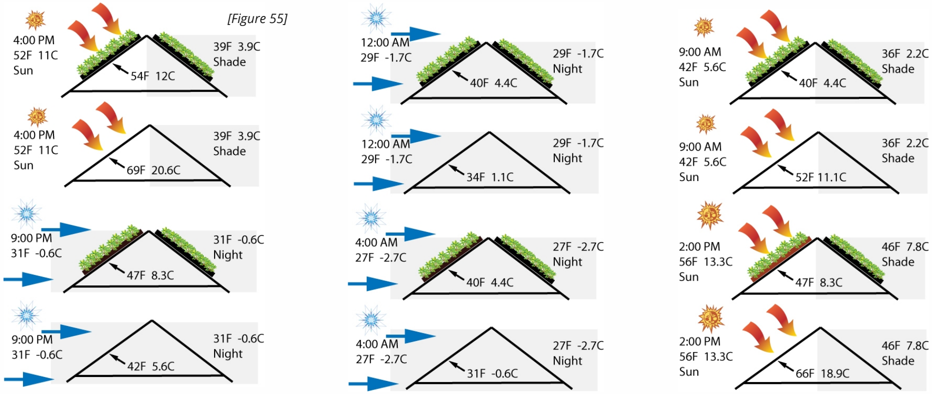
a Gudbrandsdal type sod roof



a morden sod roof

Green roof

[Figure 55]



Summary

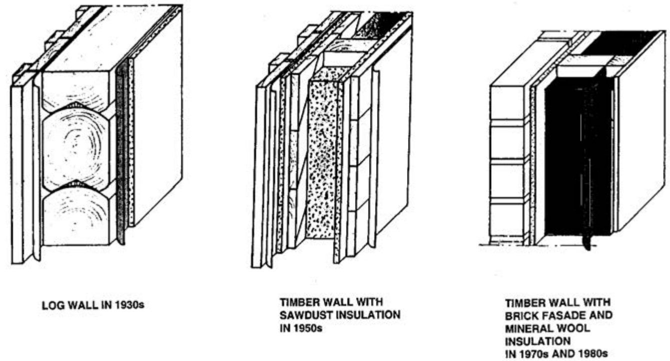
- Historically, the **vernacular architecture** in **Finland** is dominated by **wooden houses**.
- Sod/Green roof is the characteristic of a Finnish wooden house, which has good thermal insulation and waterproof performance.

5.3 Finnish Vernacular Architecture

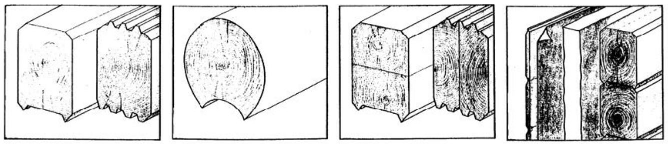
History

- **Wood** has always been a **natural building material** in Finland.
- In old constructions, wood was used in a multitude of ways
- From the 1700s, the facades were covered with boards.
- From the 1800s, boarding of log buildings became a prevailing practice.
- During the first decades of the 1900's a new American style lightweight timber frame construction method was imported to Finland.
- Recently the massive log structures have again become the objects of interest.

Evolution of the timber wall *[Figure 56]*

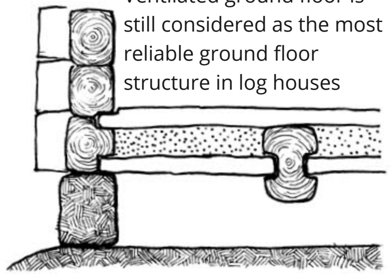


Different types of industrially produced logs *[Figure 57]*



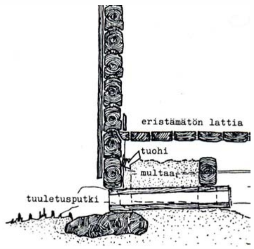
Wall and ventilated ground floor *[Figure 58]*

Hewing a log surface flat is traditionally done with a hewing axe. Flat wall surfaces came to be esteemed higher than round log walls. Hence round logs were first scored with a saw and then hewn flat with an axe.

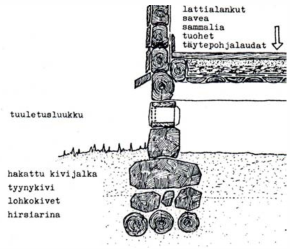


Ventilated ground floor is still considered as the most reliable ground floor structure in log houses

The foundation *[Figure 59]*



Foundation detail, old type

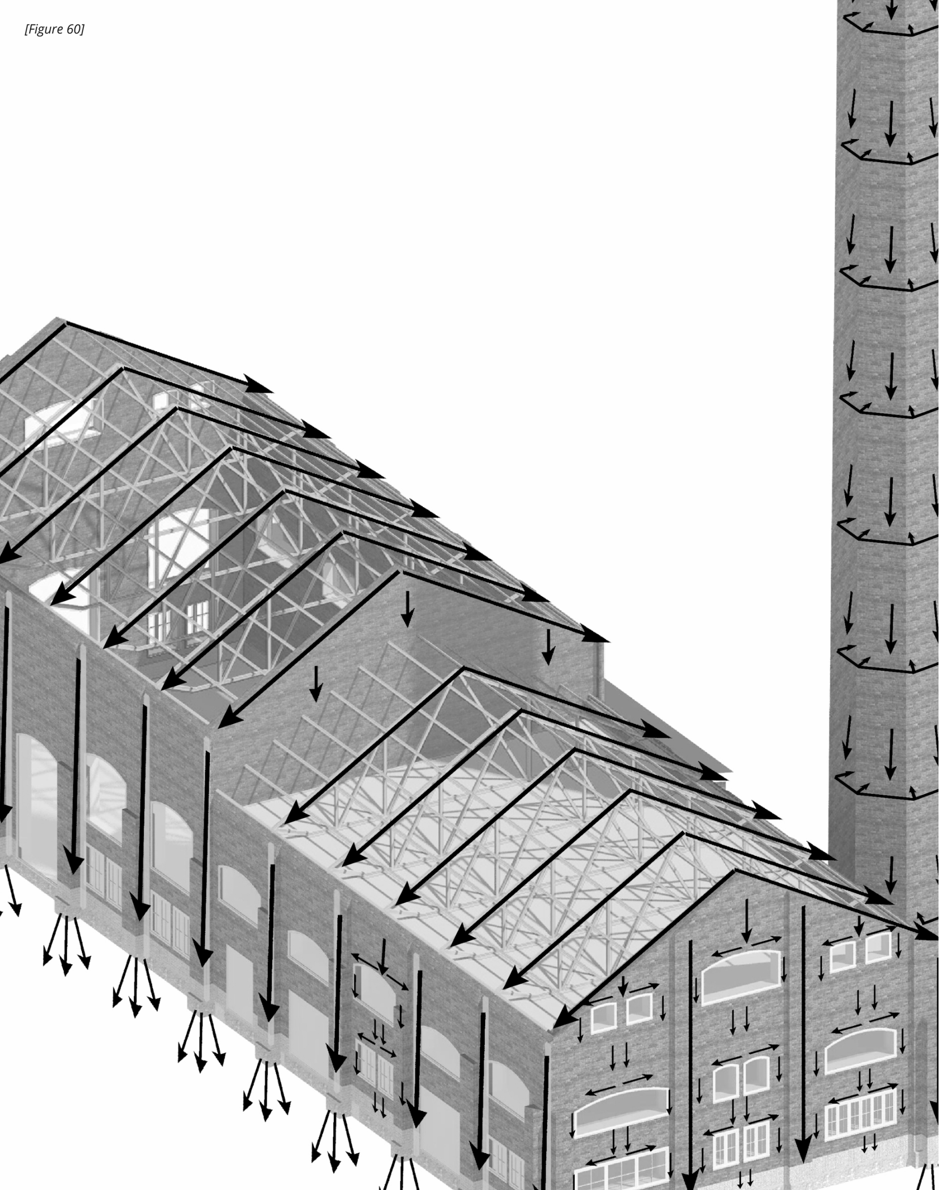


Foundation detail, new type

Summary

- Wood is a good insulation material, and Finland has a variety of **wood construction techniques**, from early log construction to modern light timber framing - due to the **forestry prominence** and the availability of wood.

[Figure 60]



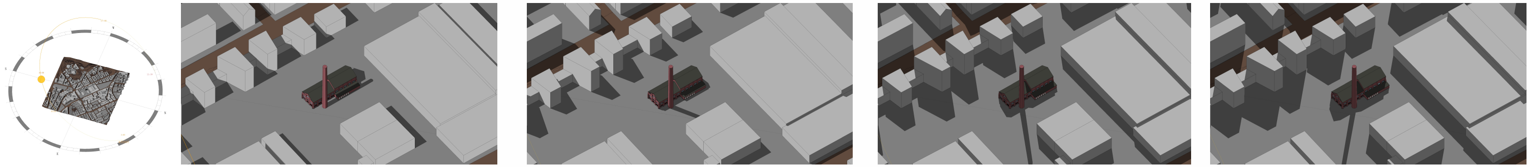
Building Performance Simulations

THE POWER STATION OF PASILA KONEPAJA

6.1 Shadow Analysis

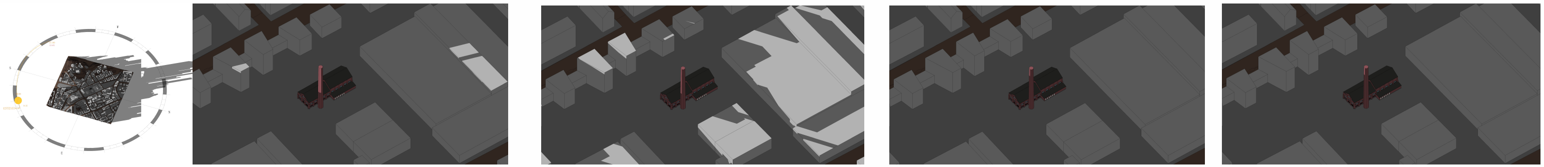
N

21 JUNE (Summer) *[Figure 61]*



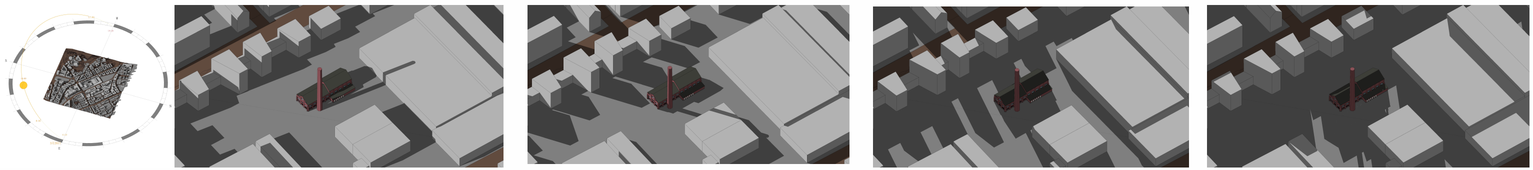
8:00 11:00 14:00 17:00

21 December (Winter) *[Figure 62]*



8:00 11:00 14:00 17:00

21 March (Spring) *[Figure 63]*



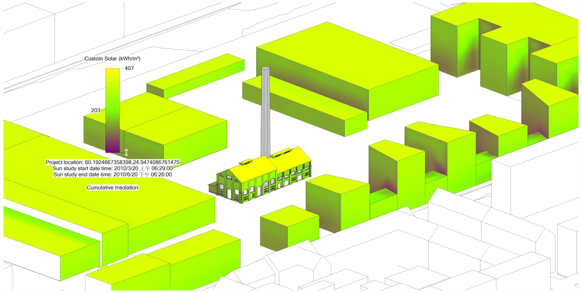
8:00 11:00 14:00 17:00

Summary

- The height of the building is about **14 meters,** and the surrounding buildings are almost the same height, with **little overshadowing**.
- The building gets almost **no sunlight in the winter**, and there is also a lack of sunshine in the **spring afternoon**.
- Due to the site's proximity to the north, the building **shadows are concentrated in the northeast**. So, it is suggested that measures should be taken to **strengthen the lighting** on the northeast side of the building in winter. And enhance summer sun on the southwest side in summer.

6.2 Solar Radiation Analysis

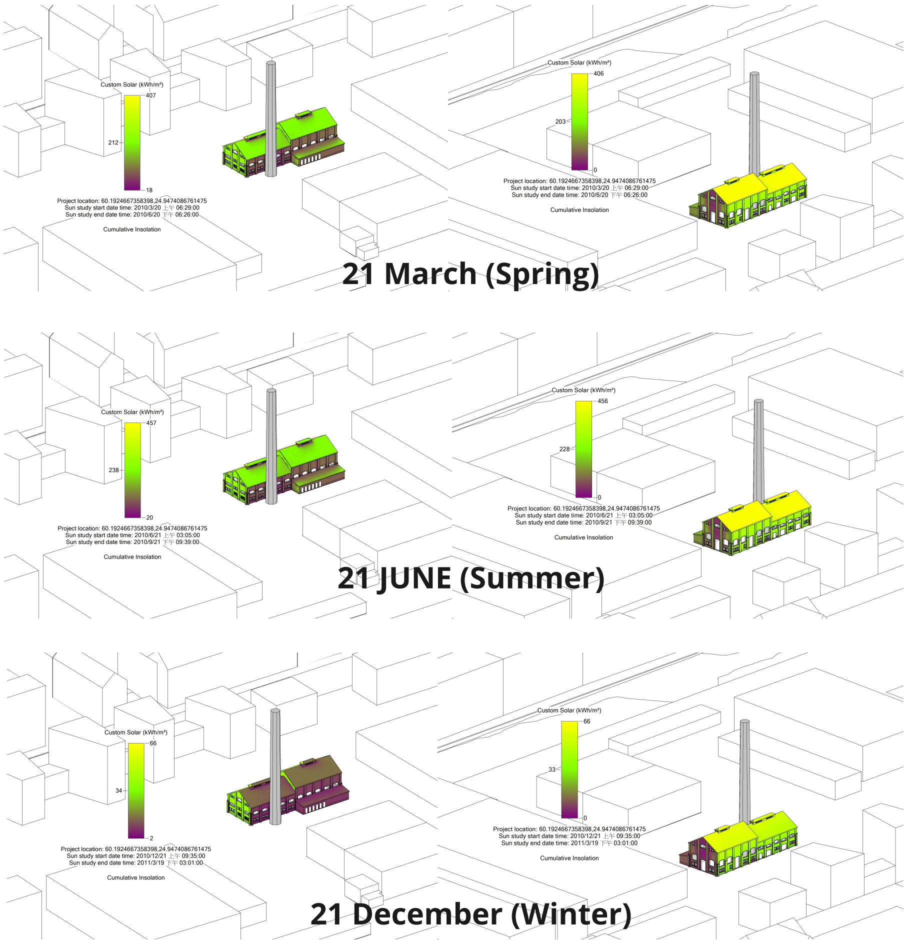
[Figure 64]



[Figure 62]

North East

South West

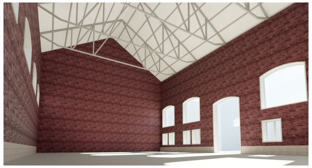


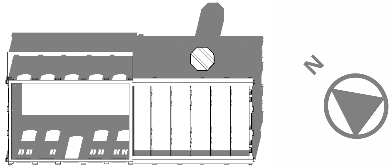
Summary

- The **north side** of building facade gains a **low amount of solar radiation.**
- The **highest level of exposure is during summer and spring** with the most exposure on **southern and western facades**.
- The southwest side of the roof has the potential for PV panels to be placed due to the high accumulation on these surfaces.

6.3 Illuminance Analysis - Overcast sky

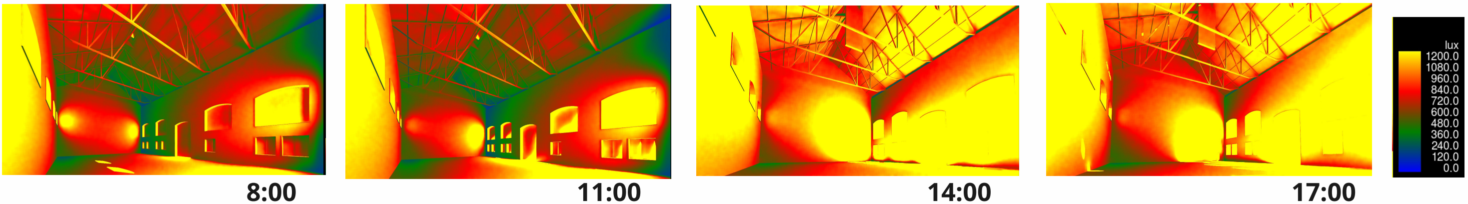
[Figure 69]





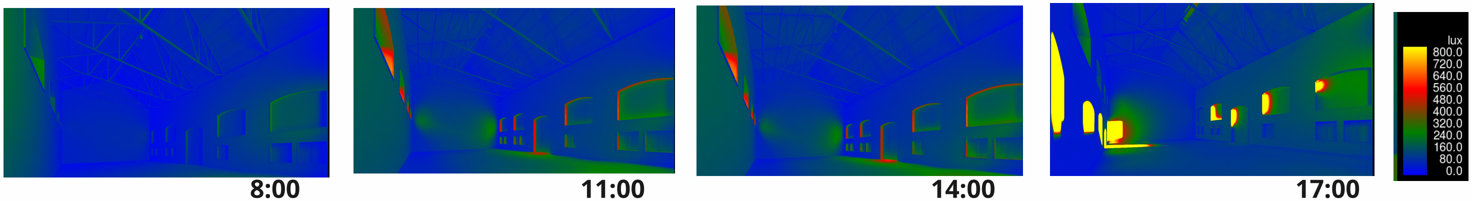
21 JUNE (Summer)

[Figure 66]



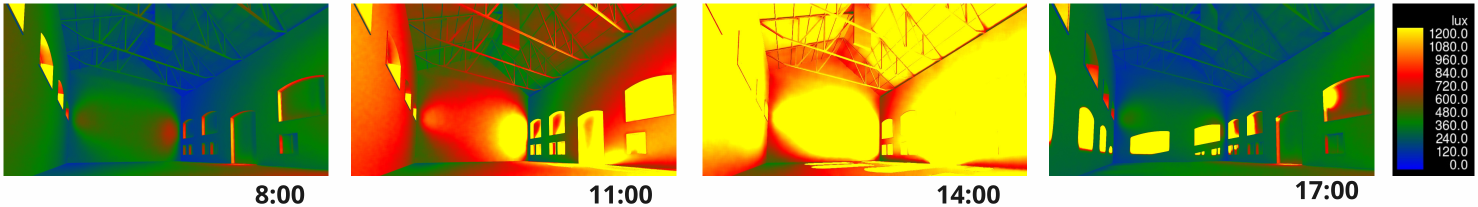
21 December (Winter)

[Figure 67]



21 March (Spring)

[Figure 68]

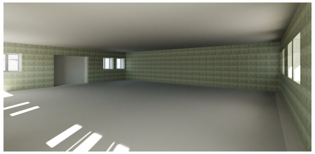


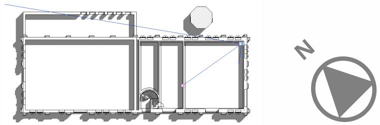
Summary

- The **winter indoor illuminance** of the main entrance is **significantly low**, mostly around **0-80 lux**.
- In **summer and spring/autumn**, internal illuminance is **over 480 lux**. However, the illuminance in the spring/autumn afternoon is slightly lower, under 480 lux.

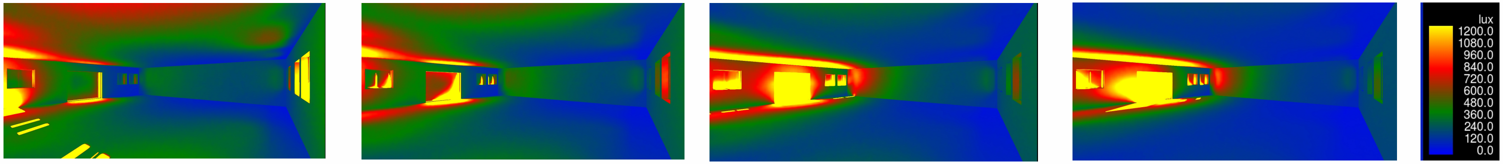
6.4 Illuminance Analysis - Overcast sky

[Figure 73]



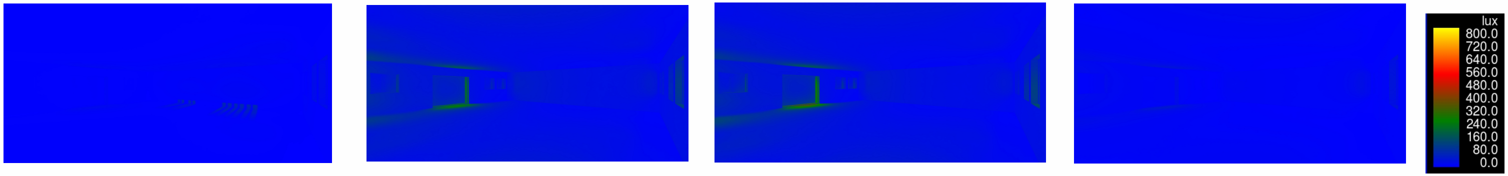


21 JUNE (Summer) *[Figure 70]*



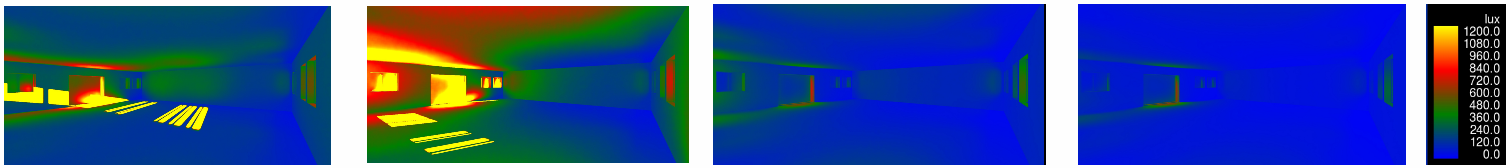
8:00 11:00 14:00 17:00

21 December (Winter) *[Figure 71]*



8:00 11:00 14:00 17:00

21 March (Spring) *[Figure 72]*



8:00 11:00 14:00 17:00

Summary

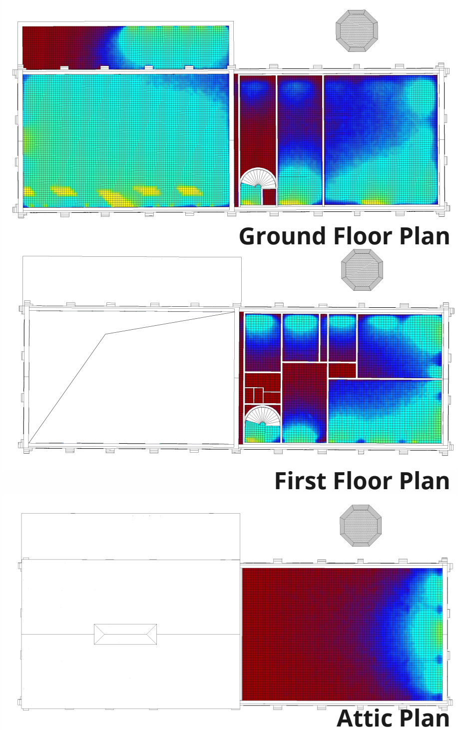
- The **boiler room's** illuminance quality is **extremely low** due to the **concrete slab** built after the original construction. The slab and ceiling reduce the illuminance and block sunlight from entering this area of the building.
- It is around **0-80 lux** all year round in this area of the building, so extremely low.

6.5 Illuminance Analysis

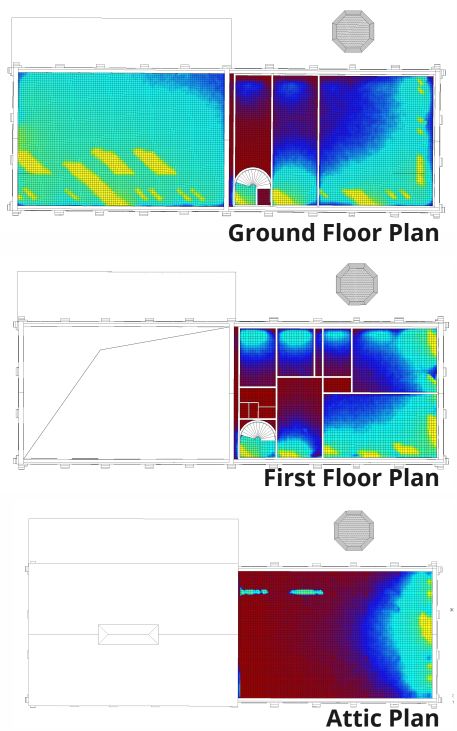
Metric:

- We use **Useful Daylight Index (UDI)** as the standard for evaluating the indoor illuminance of the building. It is used to study how much daylight you need for typical tasks.
- In our project, the building contains part of the educational function, so the recommended value of UDI is **300 to 3000 lux**.
- So the purpose of the illuminance simulation is to quantitatively check whether the current daylight meets the specifications.
- And it can also reflect where the current building space is insufficient and where the daylight is affected. This will provide suggestions for us to adjust the building space later on.

June 21 12:00 (Summer) *[Figure 75]*

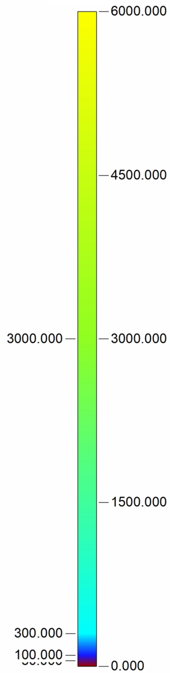


March 21 12:00 (Spring) *[Figure 76]*



Legend

Lux



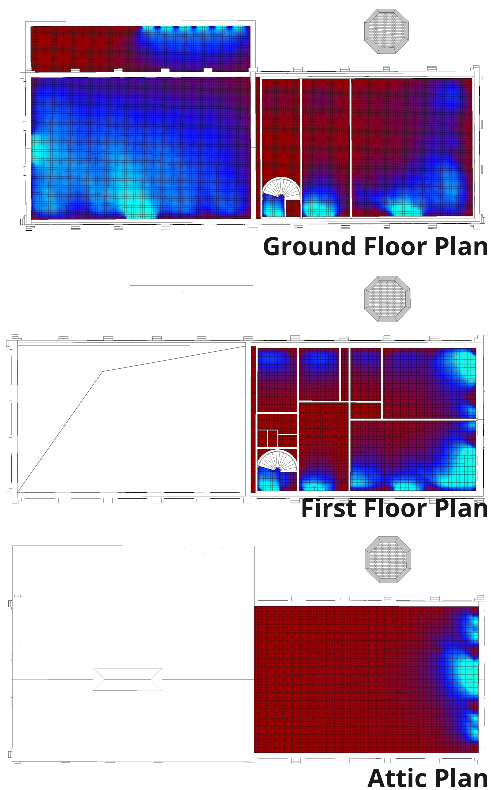
Summary

- The simulation shows the **best UDI** in each season (cloud cover is 0).
- According to our previous research, although the daylight duration in spring is less than in summer, this simulation shows that **spring has the highest UDI** throughout the year. This is due to the **lower sun incident angle** in Helsinki in the spring.
- The average UDI in spring and summer is concentrated in **300 to 1000 lux.**
- The UDI of the engine room (left) and boiler room (right) in the range of **300 to 3000 lux** is less than 80%, which **does not meet the standard.**
- For the engine room, the value is excessive in places.
- For the boiler room, this value is insufficient for nearly half of the area.

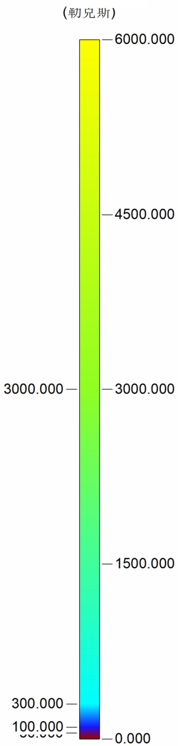
Building Performance Simulations

6.6 Illuminance Analysis

Dec 23 12:00 (Winter) *[Figure 77]*



Legend
Lux



Suggestions

Lack of sunlight


[Figure 78]

Using modular skylights, it can be partially opened in summer to take into account heat dissipation.


[Figure 79]

Use an oval concave dome to diffuse light and use reflective materials on the ceiling.

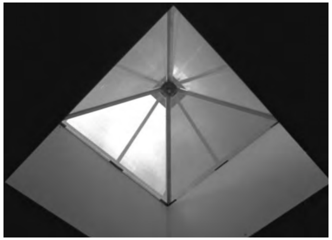
Note

The average UDI in winter is concentrated in **0 to 300 lux**. The UDI is insufficient, especially in the north boiler room.

Too much Daylight


[Figure 80]

Partial windows and skylights can increase the membrane structure layer to reduce direct sunlight.



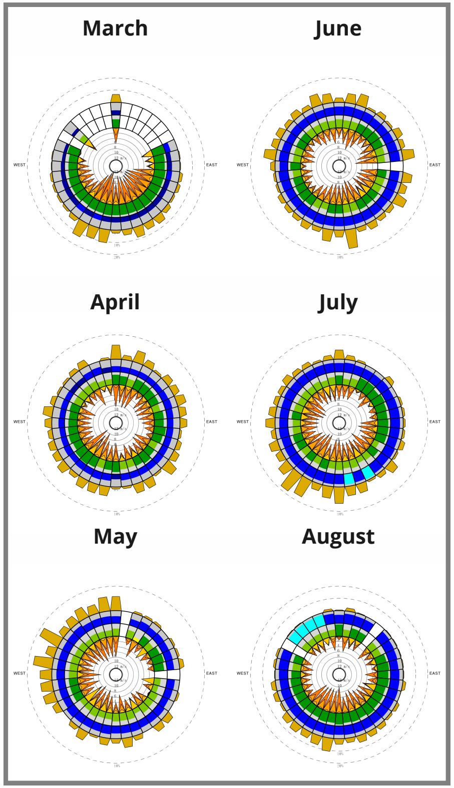
Using angular selective skylights. It can filter sunlight with high incident angle

Summary

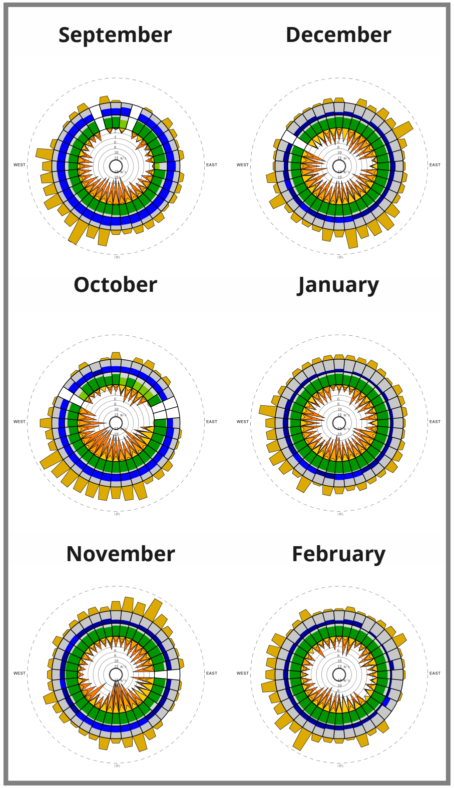
- In spring and summer, the **UDI of the engine room** is too high and the boiler room is insufficient. They are at **risk of overheating** near the windows.
- In winter, both buildings have **insufficient UDI**, especially the north facade of the boiler room.
- To increase UDI, we must employ solutions such as **modular skylights, oval concave domes, removing the concrete slab** and more.

6.7 Wind Wheel Analysis

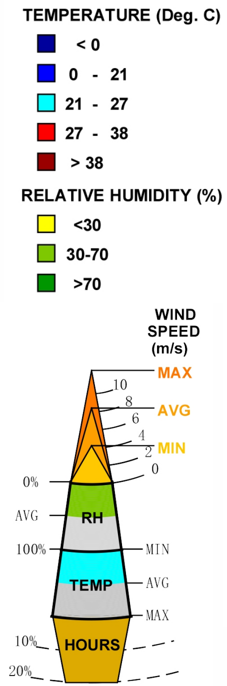
Spring/Summer *[Figure 82]*



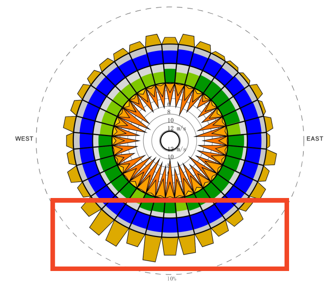
Autumn/Winter *[Figure 83]*



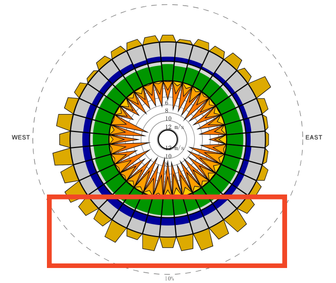
[Figure 84]



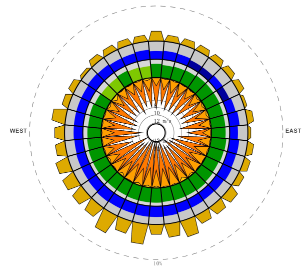
Summer(Jun/Jul/Aug)



Winter(Dec/Jan/Feb)



Whole Year



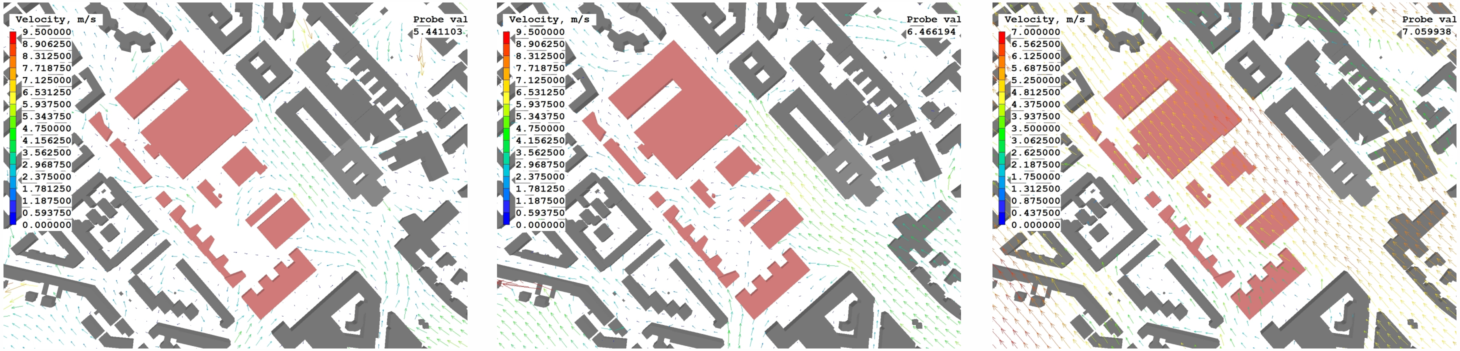
Summary

- The **prevailing wind** in Helsinki comes mainly from the **southwest** during the year, with a maximum wind velocity of **up to 12m/s.**
- The **annual average wind temperature** is about **-8 to 20°C**.
- Most of the **annual wind volume** is from **May to July** and From **September to November**.
- **Wind humidity** is higher in **autumn and winter**, around an **80% increase**.
- **January, June and December** have the **highest average wind velocity** than other months.

6.8 Site Wind Volocity Analysis (Summer)

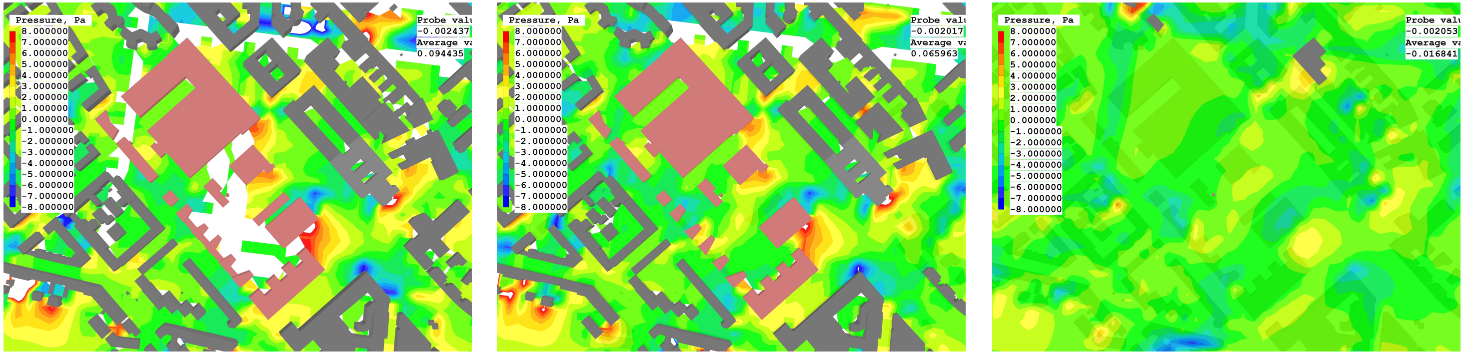
N

Wind Volosity Analysis In Summer (25 JUNE) *[Figure 85]*



Pedestrian Level (H=1.5m) **H=10m** **H=20m**

Wind Pressure Analysis In Summer (25 JUNE) *[Figure 86]*



Pedestrian Level (H=1.5m) **H=10m** **H=30m**

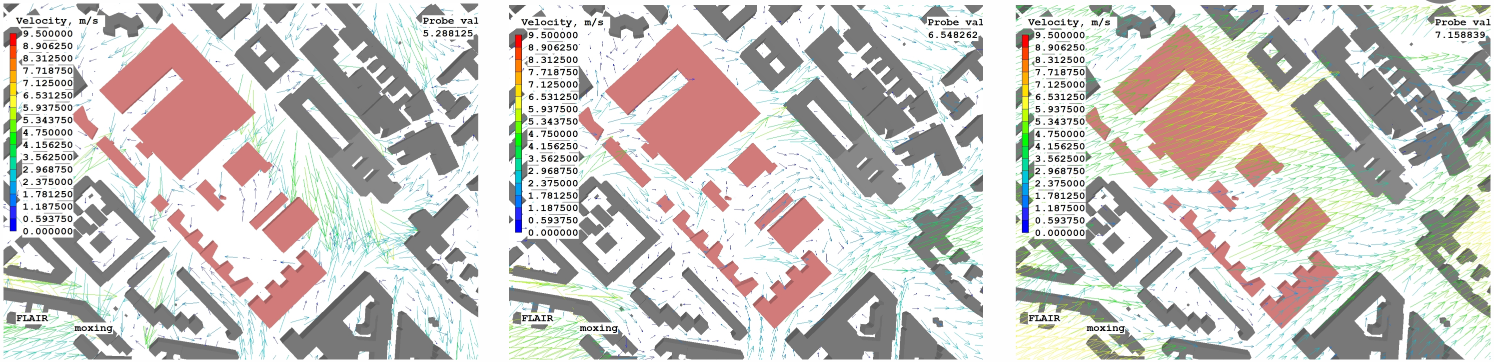
Summary

- **In summer**, the wind that flows through the site enters mainly from the **south and south east.**
- The wind speed can reach **3.5m/s below 15m** (at pedestrian level) and **8.3m/s from a 20-50m** elevation.
- In summer, the wind pressure in the southwest of the building is negative **(It's 2 to 3 Pa below standard atmospheric pressure).**

6.9 Site Wind Volocity Analysis (Winter)

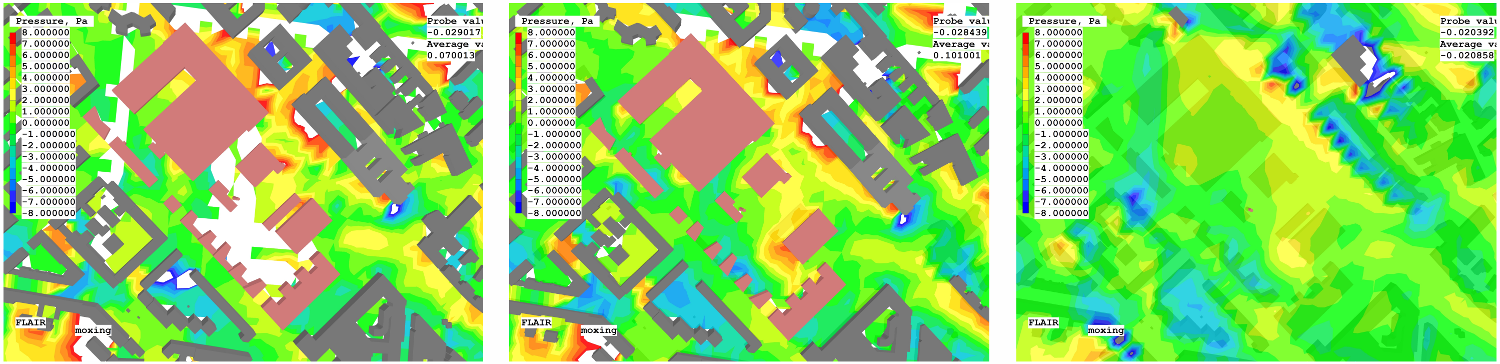
N

Wind Volocity Analysis In Winter (21 December) *[Figure 87]*



Pedestrian Level (H=1.5m) H=10m H=20m

Wind Pressure Analysis In Winter (21 December) *[Figure 88]*



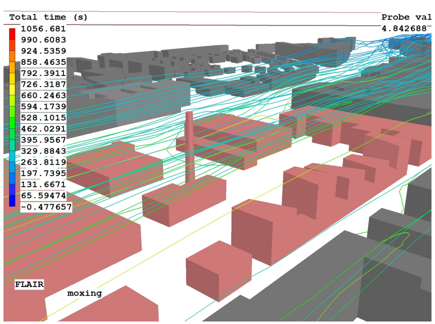
Pedestrian Level (H=1.5m) H=10m H=30m

Summary

- **In winter,** the wind that flows through the site enters mainly from the **south and south west.**
- The wind speed can reach **3m/s below 15m** (pedestrian level) and **8.5m/s at a 20-50m** elevation.
- **In winter,** the wind pressure in the northwest of the building is negative **(It's 2 to 3 Pa below standard atmospheric pressure).**

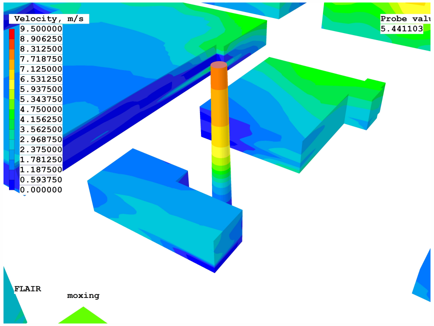
6.10 Building Surface Analysis

Wind Path In Summer (SE)



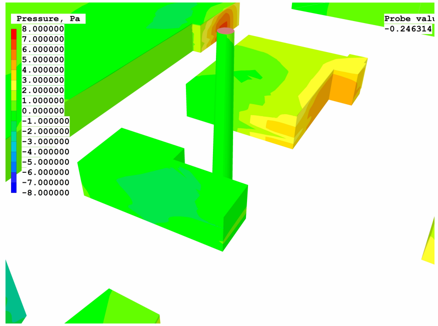
[Figure 89]

Surface Wind Velocity



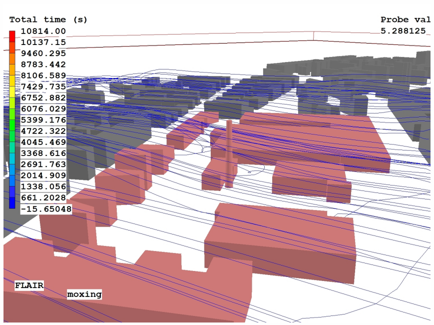
[Figure 90]

Surface Wind Pressure



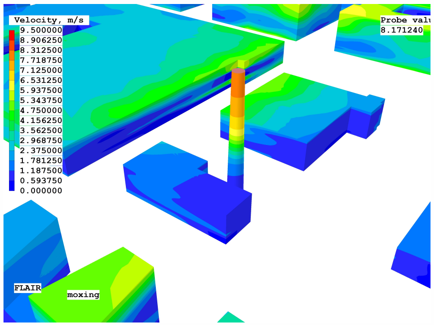
[Figure 91]

Wind Path In Winter (SW)



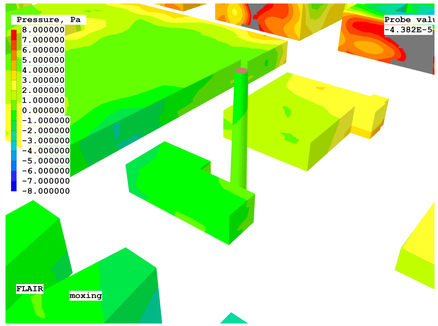
[Figure 92]

Surface Wind Velocity



[Figure 93]

Surface Wind Pressure



[Figure 94]

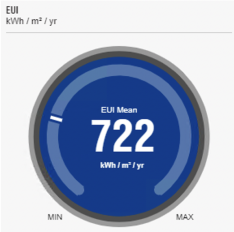
Summary

- Since most of the wind is **blocked by the surrounding buildings**, there is little difference in its speed passing through the building between **winter and summer.**
- The wind pressure in the **southwest of the building is generally low**, so it can be considered for natural ventilation.
- The top of the chimney has wind speeds of up to **9m/s**. So converting it into a wind power tower could be a consideration. The generator will generate electricity when wind speeds reach **2.7m/s.**

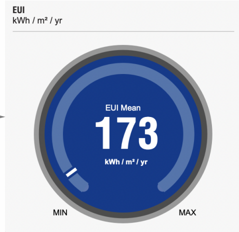
6.11 Energy Performance Analysis

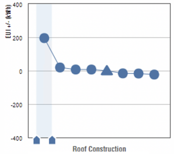
Building Performance Simulations

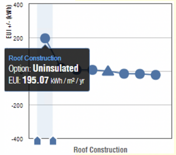
Total kWh/m2/yr of the building:



Total kWh/m2/yr (after making all changes):





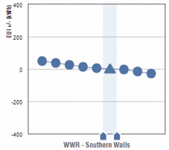


Roof Construction

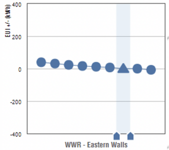
[Figure 95]

WWR (window:wall ratio)

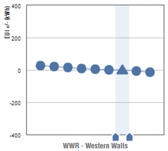
South Walls



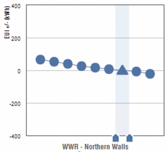
Eastern Walls

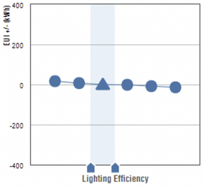


Western Walls

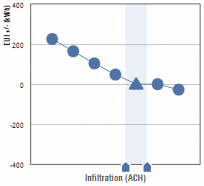


Northern Walls

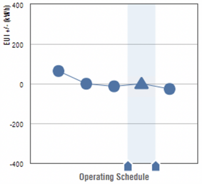




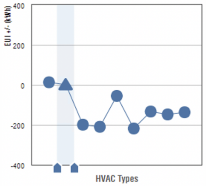
Lighting Efficiency



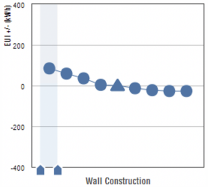
Infiltration

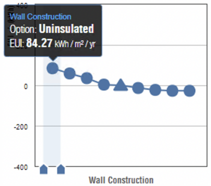


Operating Schedule



HVAC (heating, ventilation, air conditioning)

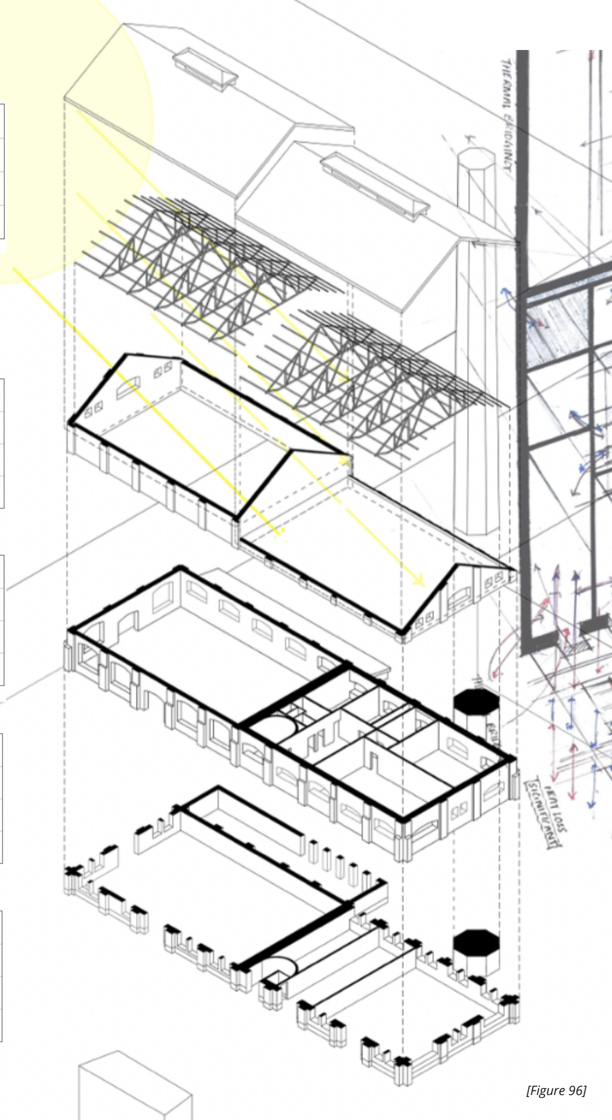




Wall Construction

Summary

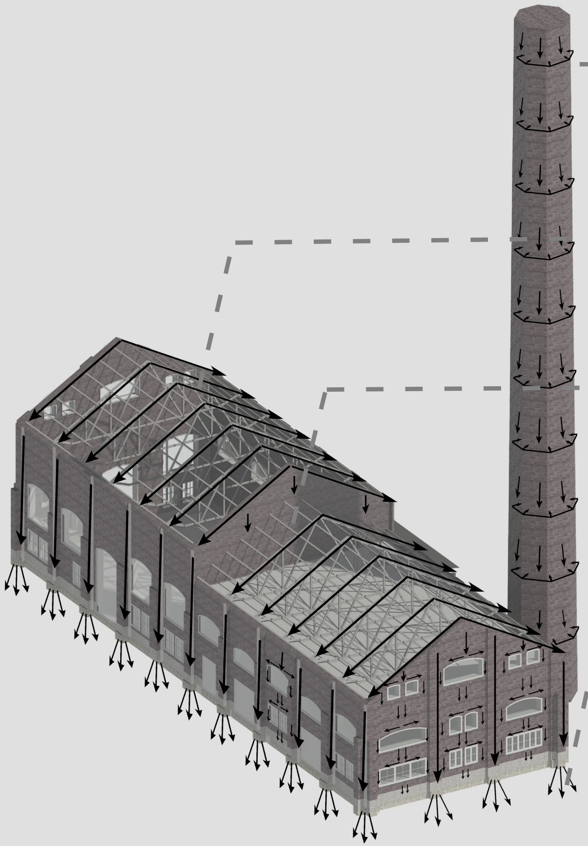
- ***The total EUI Mean for the Power Station is 722kWh/m2/yr***
- Some issues could be addressed but they would cause very minimal change and improvement to the overall energy performance of the building - around 100kWh/m2/yr
- The biggest changes that need to be made are the wall and roof construction and the HVAC type
- ***After making all improvements the total EUI Mean for the Power Station will drop from 722kWh/m2/yr to 172kWh/m2/yr***
- The potential improvement to energy use is 550kWh/m2/hr



[Figure 96]

6.12 Structural Analysis

Load Path



[Figure 97]

Chimney.

The 50-meter-high brick chimney is separated from the main building structure, The structural steel rims installed at every 1.5 meters behave as lateral compression rings

Truss structure

The load-bearing structure of the roof is a steel truss, and the end of the roof truss is rested on the exterior load bearing walls.

Firewall + External Load Bearing Walls

The load-bearing frame of the building is a brick wall that transfers all the loads from the truss and the lintels to the foundation.

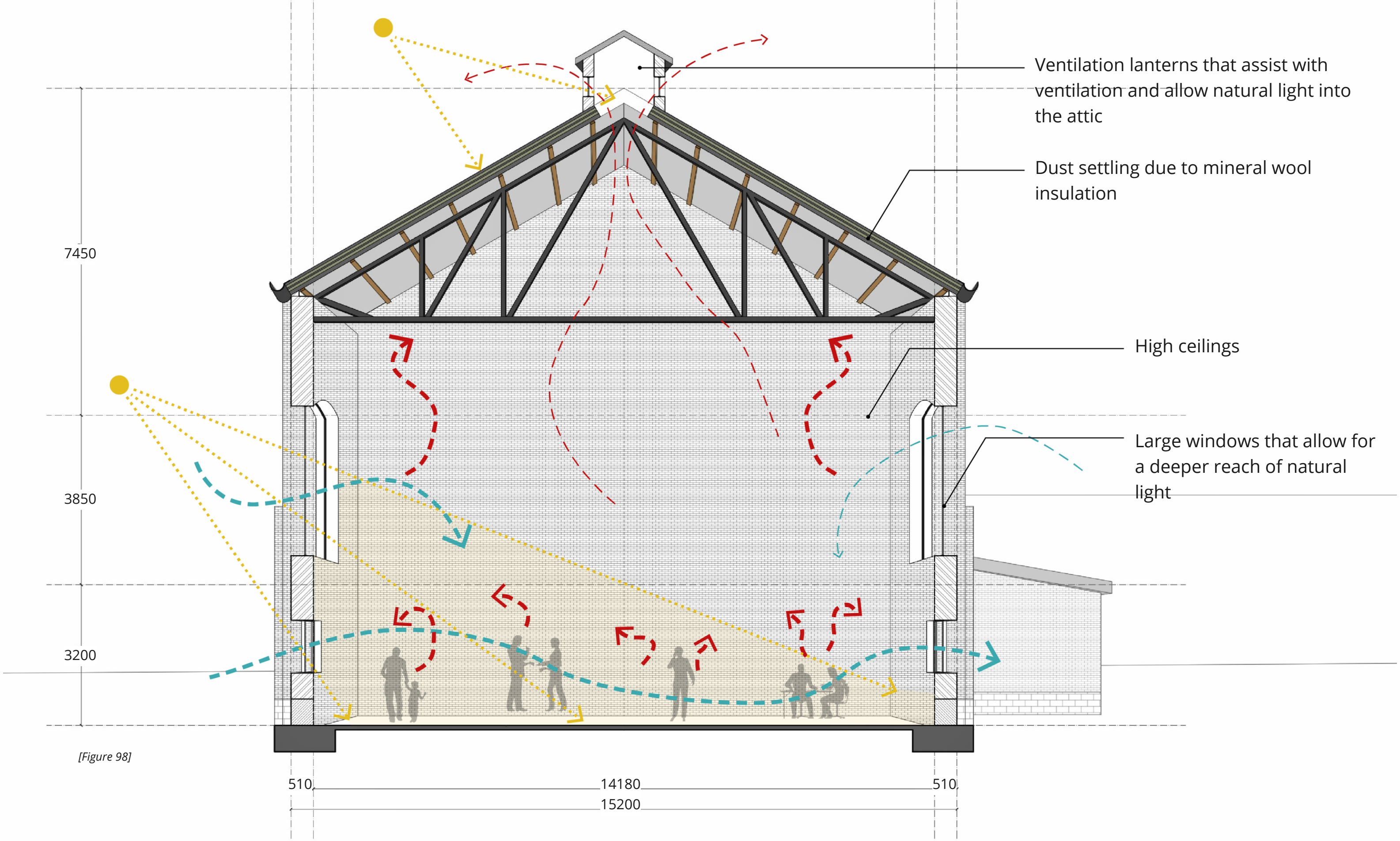
Foundation

The base is made of massive granite blocks, which ultimately transmits the load of the brick wall to the ground and finally to the concrete pile foundations.

Summary

- **Load Path** - The force generated by the load of water on the roof and its self-weight is transmitted through the trusses, down the load-bearing brick walls and finally to the pile foundations
- **Stone pilasters** on the external walls assist with transferring the lintel loads

6.13 Ventilation - Engine Room

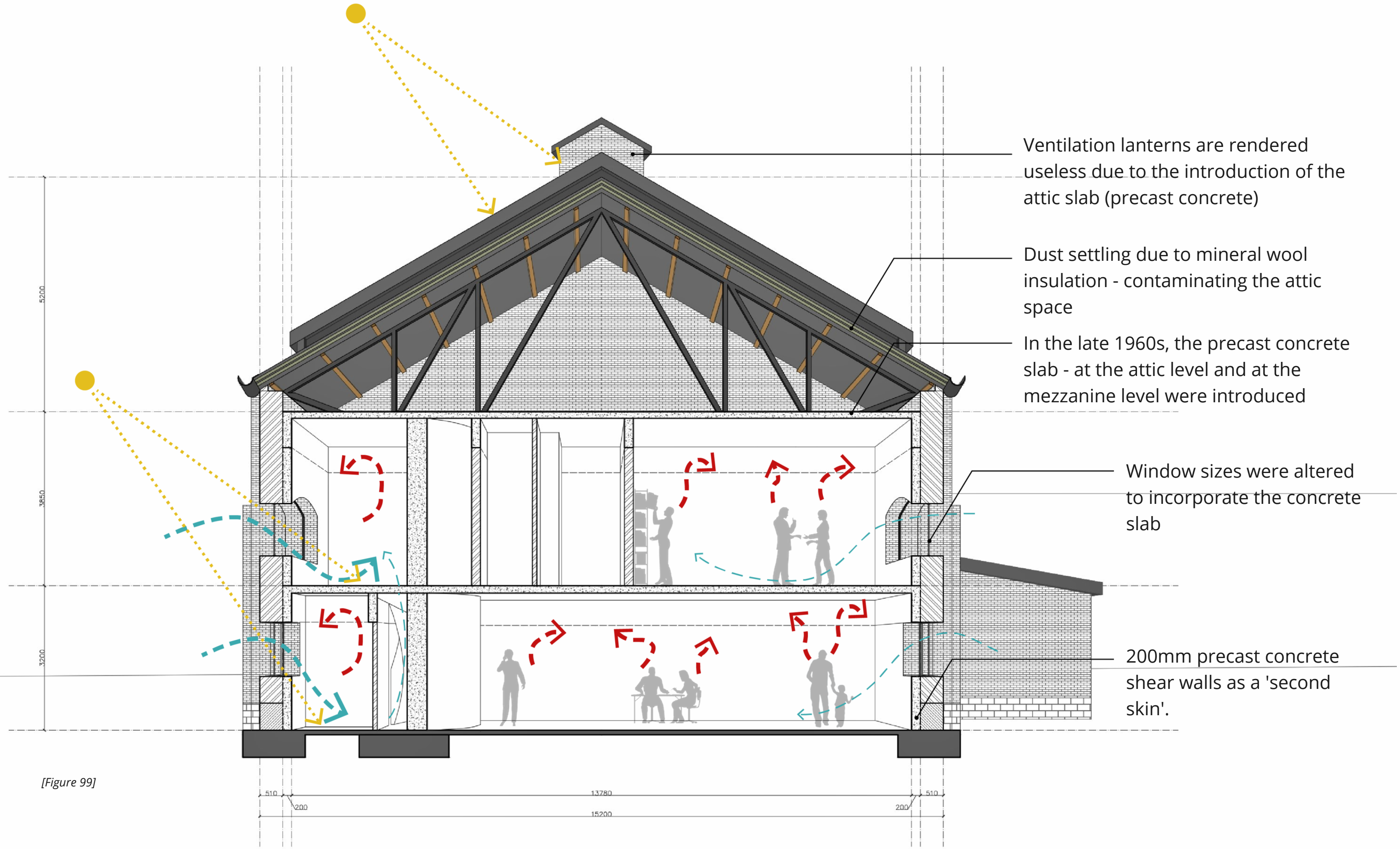


[Figure 98]

Summary

- The **double-height volume** of the engine room allows for both **cross ventilation and buoyancy airflow.**
- **Large windows** and **high ceilings** welcome **unobstructed natural light.**

6.14 Ventilation - Boiler Room

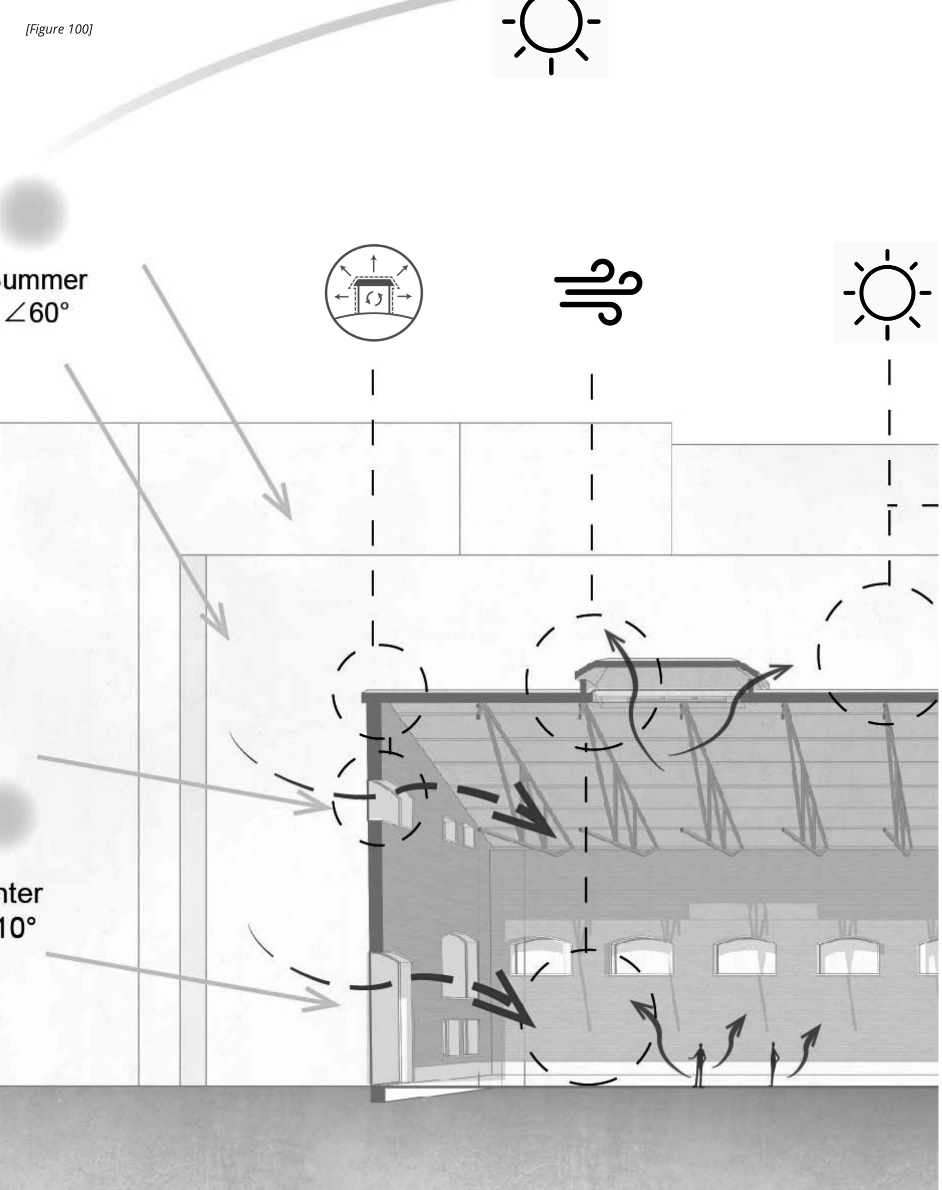


[Figure 99]

Summary

- On the contrary, the **pre-cast concrete slab dividing** the **boiler room hinders natural light and ventilation**. The alterations made to the window sizes in order to incorporate the pre-cast concrete structure did not take into account lighting and ventilation strategies. Neither did the inner concrete wall skin.
- Ventilation lanterns don't prove to be very effective due to the dust settling from the mineral wool insulation. This affects the well being of the occupants

[Figure 100]



Vision and Objectives

THE POWER STATION OF PASILA KONEPAJA

7.1 Vision, Objectives and Solution

Vision and Objectives

VISION

To create an interactive experience that educates the community in the production of energy, reconnecting them with the building's historical importance.
To simultaneously address the environmental challenges that come with Helsinki's Dfb climate classification and extreme winter conditions.

PRIMARY OBJECTIVES

I To employ a low life-cycle embodied carbon of all new materials

II Increase energy efficiency and performance of the building

III Increase illuminance internally to improve mental health of visitors

IV Improve community involvement and restore the historical significance of the power station

V Improve air quality whilst increasing air tightness inside the building

CONCRETE OBJECTIVES

I The total life-cycle embodied carbon to be **approx. 500kgCO2e/m2** (RIBA 2030 Challenge equivalent)

II Reduce energy consumption of the building by **75%** and produce **75%** of energy through renewable sources
Improve the U Value to **0.1W/m2K**

III Indoor lux levels between **300-3000 lux** (based off of UDI standards)

IV **100%** public access to the building, preserve **75%** of the existing structure

V Improve air tightness to between **1-3 m3/(m2/hr)**

SOLUTIONS

I ***Re-use and recycle*** existing materials
New design to use **low impact materials** e.g. local and sustainably sourced timber and wood fibre insulation

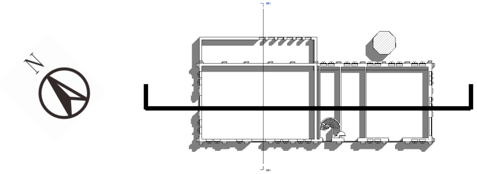
II Using solar **PV panels** and **VAWT** to produce power, employ the use of a **ground source heat pump**, employ the **'building within a building'** approach to improve the building fabric

III Considering the **glazing ratio** on individual facades more carefully, implementing a **skylight**, **strategically orienting** exterior glazing to reduce heat loss whilst still keeping illuminance high

IV Provide different spaces for people of **all ages**, create a space that hosts **activities and events** educating on and involving **human-powered energy systems,** retrofit the existing structure with **minimal demolition**

V Use of an **air tightness layer** within the building fabric, using **passive stack ventilation** to facilitate an **ERV**

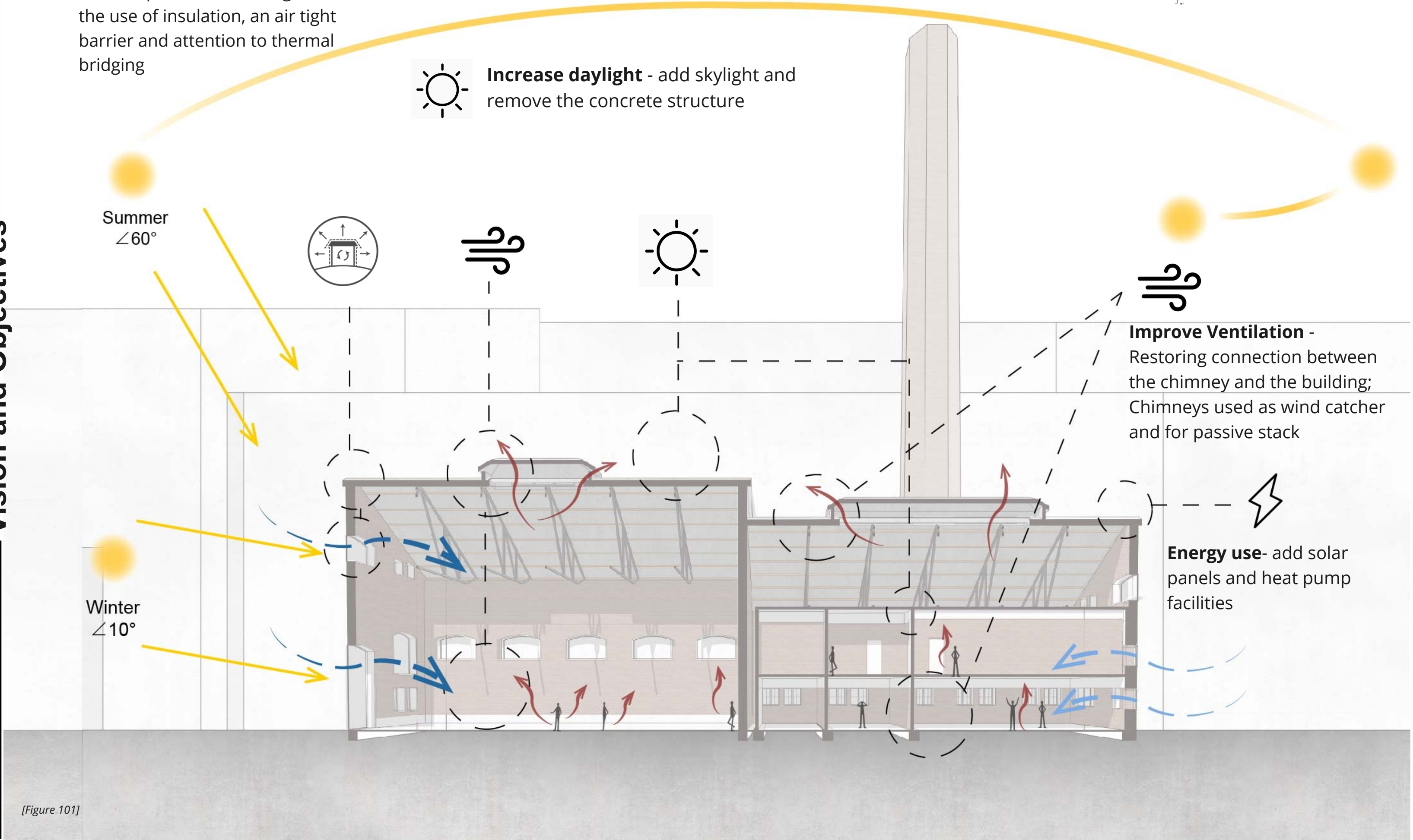
7.2 Environmental Section - Problems



Improve the building envelope for energy efficiency and minimal heat loss - improve the building fabric with the use of insulation, an air tight barrier and attention to thermal bridging

Improve Ventilation - ERV system;
Community Engagement -
All building systems displayed - to impart learning

Increase daylight - add skylight and remove the concrete structure

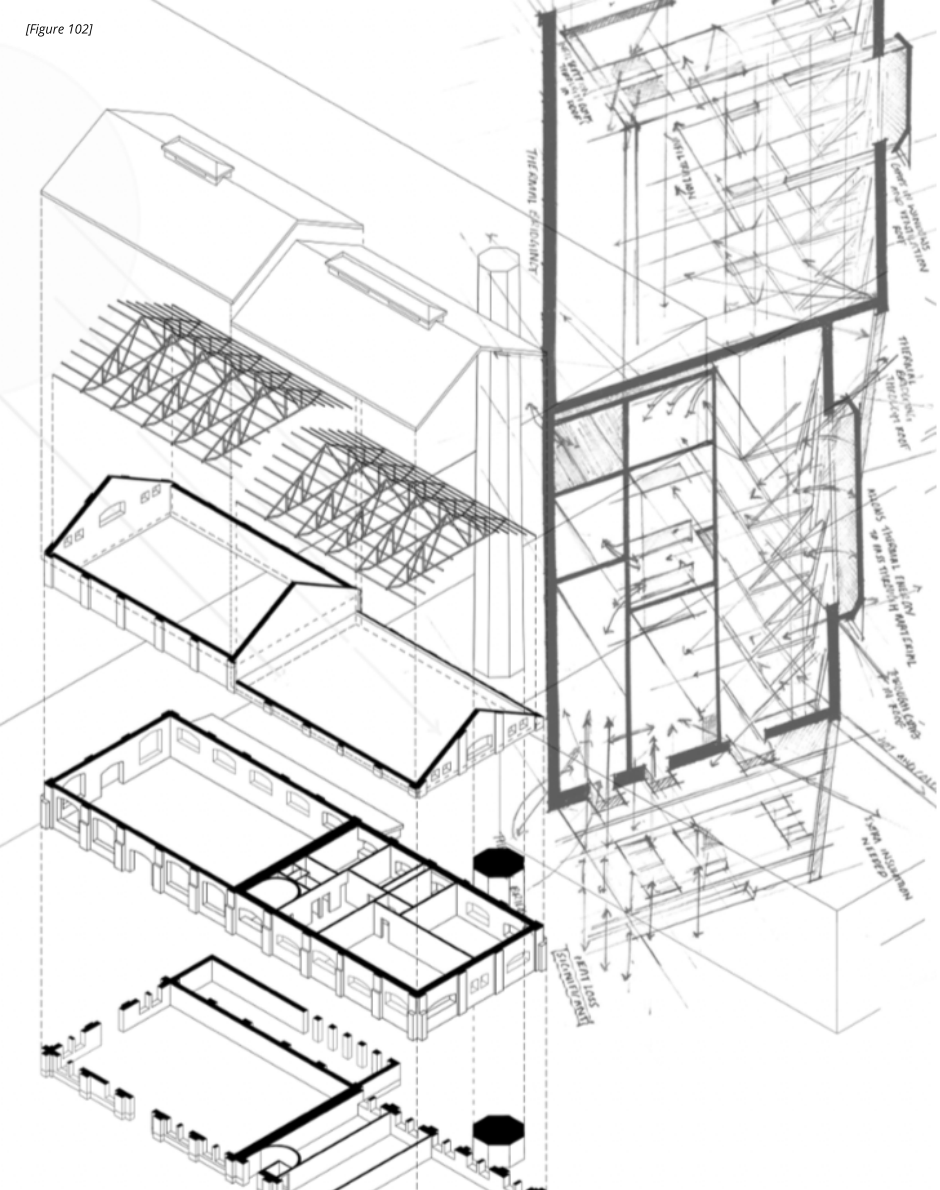


Improve Ventilation - Restoring connection between the chimney and the building; Chimneys used as wind catcher and for passive stack

Energy use- add solar panels and heat pump facilities

[Figure 101]

[Figure 102]



Solutions

THE POWER STATION OF PASILA KONEPAJA

Solution I: *Lower the Life-cycle embodied carbon of new materials*

8.1 Solution I: Sourcing Materials and Embodied Carbon

Re-use Steel (the old Electric Train Hall) | Glass (the old Electric Train Hall/Assembly Hall/Paint shop) | Brick (the whole site)

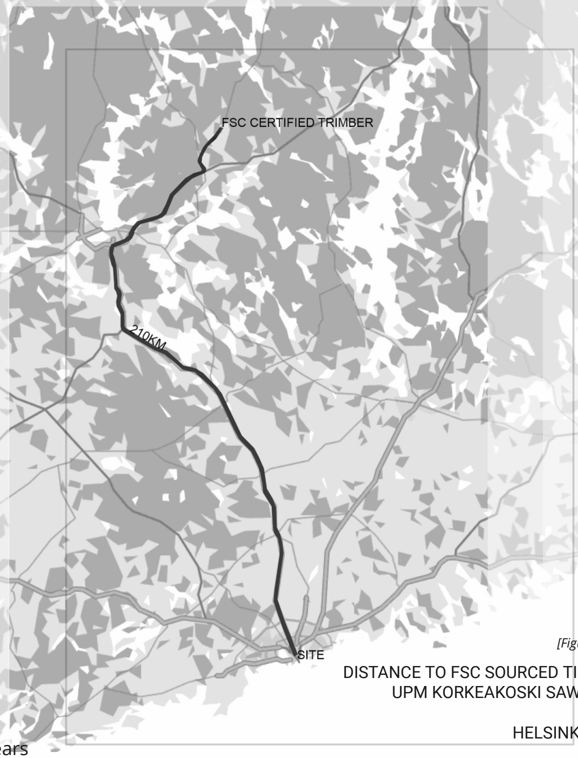
Recycle Excess materials from site (e.g. steel, glass)

New materials Timber

Finnish Forestry History
In Finland, "more than three-fourths of the land, some 26.2million hectares, is forested.

Sustainable forest management in Finland has roots in the 17th century and was first codified in the Forest Act of 1886, which declared that "You shall not devastate the forest." The principles of ecological, social and economic sustainability are laid out in the Forest Act of 1996.

Biodiversity in the forest environment was more strongly incorporated in forest management practices from the 1990s. The Forest Biodiversity Programme METSO was started in 2008. The programme aims to halt the decline of forest habitats and species as well as establish favourable trends in the forest ecosystems of southern Finland by 2025. The programme enlarges Finland ́s network of protected areas, increases the connectivity of protected forests and develops nature management methods used in commercially managed forests."



[Figure 103]

DISTANCE TO FSC SOURCED TIMBER
UPM KORKEAKOSKI SAW MILL
to
HELSINKI SITE

<u>Timber</u>
Source UPM Timber, Korkeakoski Sawmill, Finland
Type FSC Certified, Sawn Timber, Redwood
Distance 210km from site
Embodied carbon without transport 16kg/m3 of sawn timber
Embodied carbon of transport 0.024kg/m3 of sawn timber
Total embodied carbon 16.024kg per m3 of timber
Timber locks in carbon and stores it which offsets and neutralises emissions if building remains for 100 years
Method Brettstapel construction method (panels without glue, no bolts, simple dowels, used for easy deconstruction/adaptation)

<u>Steel, Brick, Glass</u>
Source On site (assembly hall and electric train hall
Type Re-used and reclamation (using waste product from surrounding renovations)
Distance 0km
Total embodied carbon Neutral

Summary

- We can source **FSC timber** within **210km**.
- R**euse of existing materials** will neutralise our embodied carbon level
- We will use the **Brettstapel construction method** for easy dismantling.

Solutions

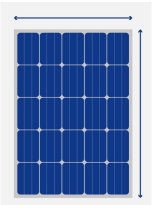
Solution II: *Increase energy efficiency and performance*

8.2 Solution II: Energy - Photovoltaic Panels

Solar energy

Solar heating systems use solar panels that can be fitted to the roof, mounted on a free-standing frame or even hung from a wal

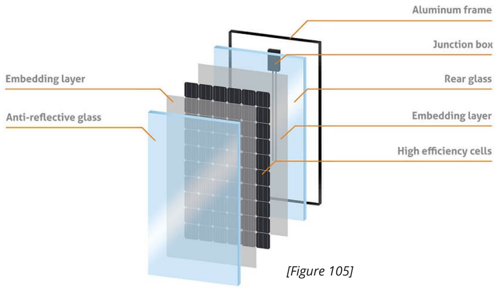
Solar PV output **E = A * r * H * PR** *[2]*



[Figure 104]

One panel

- 1.65 meters x 0.99 meters
- 350kW each panel (1.6m2)
- 4KW system solar panel area: 28m2 (16 panels)

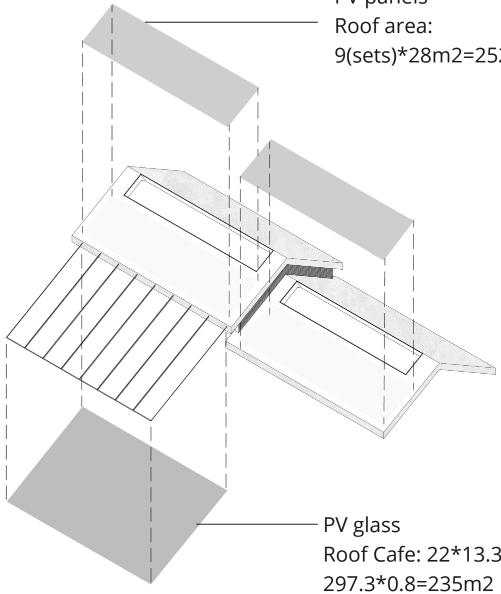


[Figure 105]

PV Glass

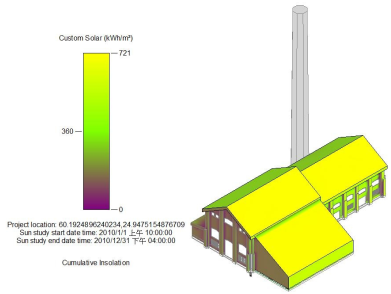
Glass-glass modules are solar panels with solar cells arranged between two glass panes.

[Figure 106]



PV panels
Roof area:
9(sets)*28m2=252m2

PV glass
Roof Cafe: 22*13.35=297.3
297.3*0.8=235m2



- Annual average irradiation: 850

[Figure 107]

E = A * r * H * PR

- **A=** 252+235=487m2
- **r=** 0.35/1.6=0.21(21%)
- **H=** 850 kWh/m2.yr
- **PR=** 0.82
-

E = 71601kWh/yr

Building energy analysis
aprox.**180**kWh/m2/yr

- after retrofit footprint : 983m2
- 71601kWh/yr/983m2 =72.84kWh/m2/yr

Solar PV panel can generate (%) of building usage: 72.84/180=40.47%

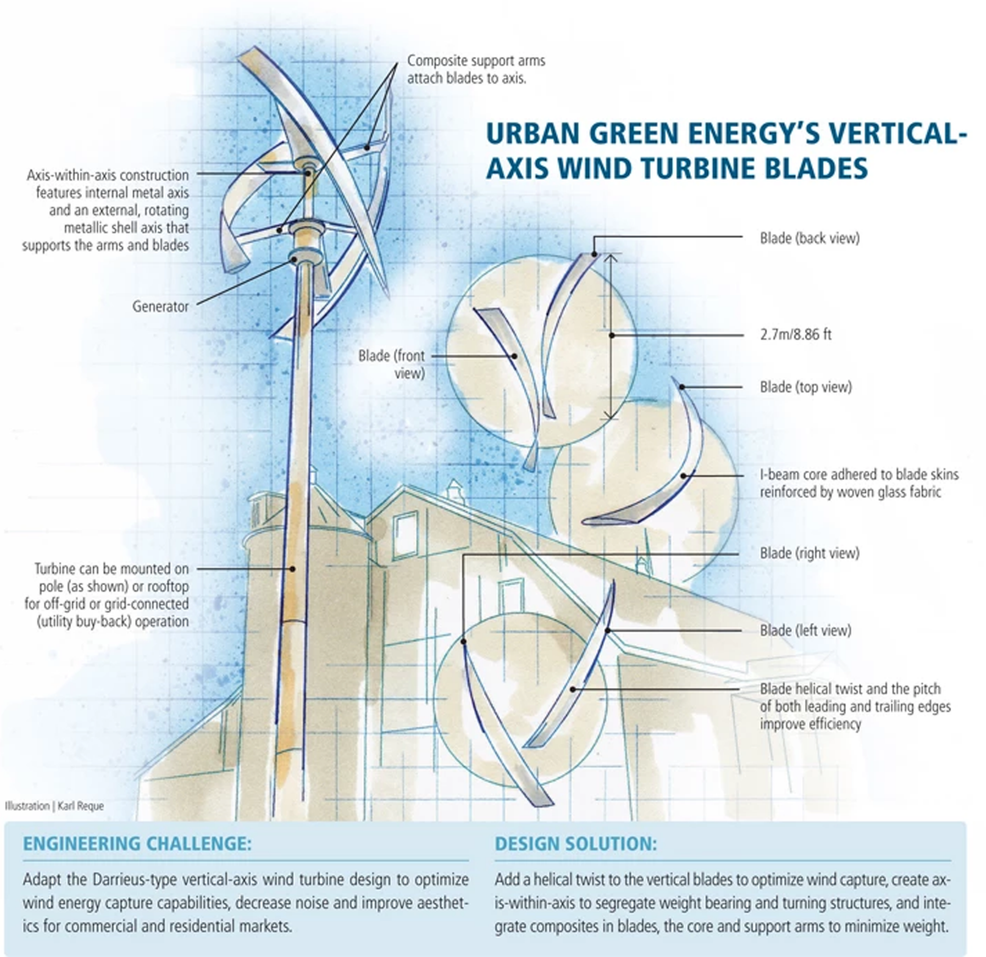
Summary

- Using **55% of the roof** for PV panels and **80% of cafe roof** for PV glass will generate **180kwh/m2/yr** of electricity
- Generating **more than 40%** of building energy usage.

Solutions

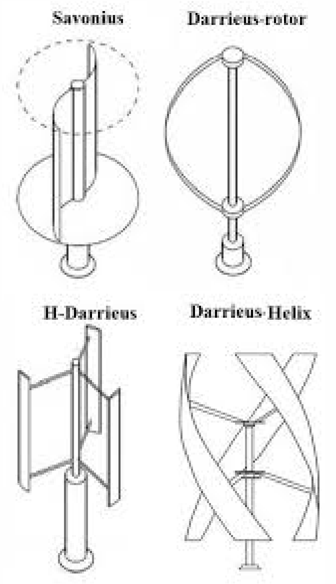
8.3 Solution II: Energy - VAWT

Utilising the Chimney *[Figure 108]*



Summary

- Reutilising the chimney as a **power tower** - **VAWT** are relatively light and can be fixed in place without affecting the structural integrity of the chimney
- Urban Green Energy's VAWT has a **helical twist** to the vertical blades to **optimize wind capture** and **improve it's efficiency.**



[Figure 109] Different kinds of vertical axis wind turbines (VAWT): (a) Savonius; (b) Darrieus with "egg beater" design rotor; (c) H-shape blades; (d) helix shape blades. Castellani, 2019

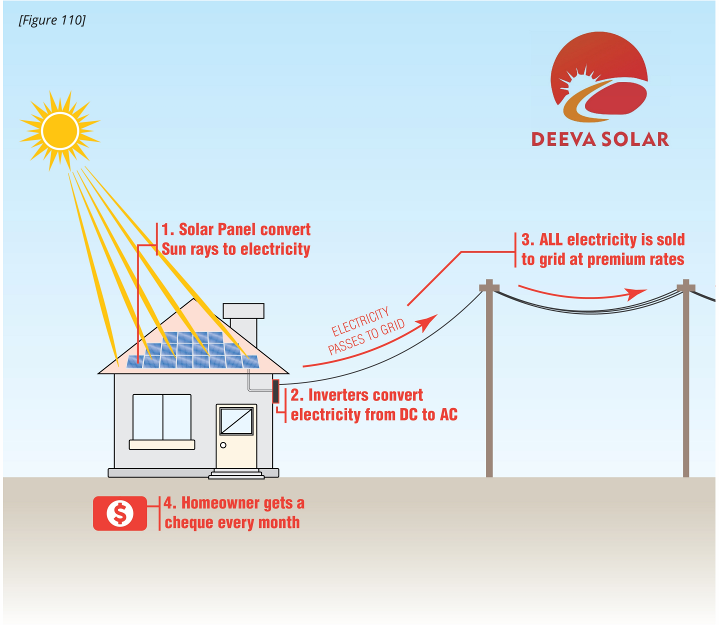
Solutions

8.4 Solution II: MicroFIT Program

What is it?

- Ontario based project
- It supports the **small development of small renewable electricity** generation projects such as solar panel installations.
- Suppliers are paid a guaranteed price over a 20 year term for the electricity they produce and deliver to the province/city/state's electricity grid.
- The building with the **micro-renewable energy generation** may then sell their energy to the grid and proceed to **use energy from the grid** to power the building.

[Figure 110]



[Figure 111]

Summary

- It is possible that if we can not produce enough energy via solar panels in the winter to power the building then we can **sell any micro-renewable energy to the grid** and **power our building through the grid.**
- This allows the building to **remain a power station**, still educating the community and also **reducing carbon footprint** of the building.

8.5 Solution II: Rainwater Harvesting System

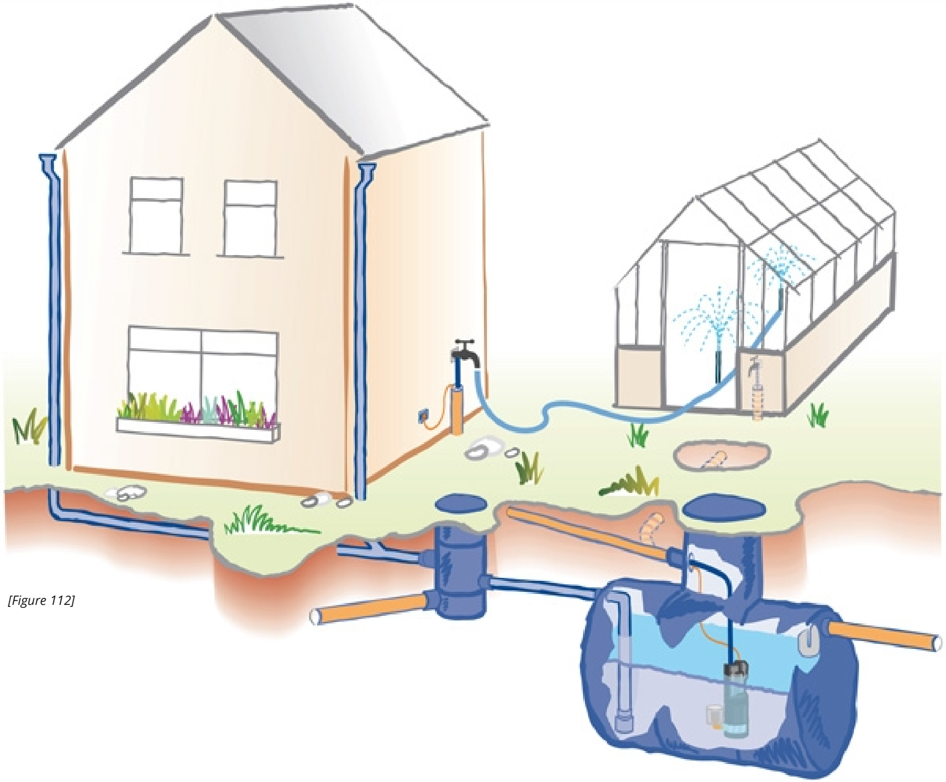
Benefits

A strategy of a flood management system:

- Rainwater is discharged into streams and rivers over time
- Provides an important contribution to avoiding potential drainage system failures during storm events
- Recharge pits help to absorb the water and filter into pipes to the storage tank so less water accumulates on the ground, which then reduces flood damage and flood severity
- Also protects against overflow from sewers

How it works

- Rain is funnelled through the gutters and recharge pits on the ground
- This water is filtered and stored in a collection tank
- This is then pumped back into the buildings and distributed to supply the plumbing system and any building systems that require flow of water
- It is also distributed around the site to other buildings due to the very large underground storage tank as this is more cost efficient



[Figure 112]

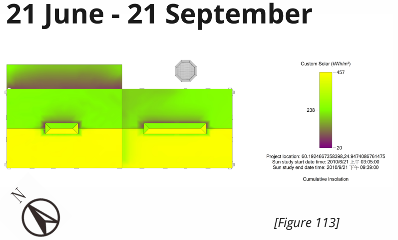
Summary

- To manage **future flood risk** of the Helsinki climate, we will use **rainwater harvesting and collection.**
- This can be employed by placing **guttering on the eaves** and also **guttering design to funnel the water** down the mullions of the exterior glazing.

Solution III: *Increase Illuminance*

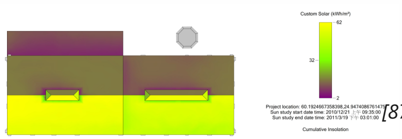
8.6 Solution III: Increase daylight - solar condition

21 June - 21 September

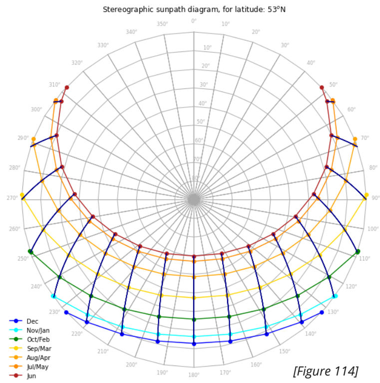


[Figure 113]

21 December - 19 March

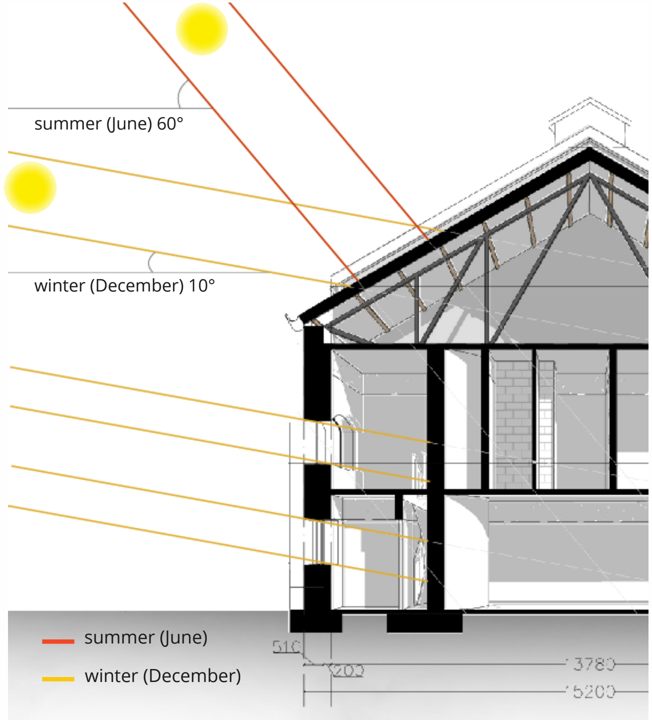


[87]



[Figure 114]

Winter and Summer solar tilt angle (noon) *[Figure 115]*



Orientation

- Building roof is facing south west and north east.
- The sunlight time is short and tilt angle is low in winter, in addition, the sun orientation is **130°-230°** (south east to south west)
- Daylight from north east has no overheat risk, and the amount of sunlight is very low in winter.

Solar Tilt Angle

- In December, solar tilt angle around **10-15°.**
- In June, the solar tilt angle around **40-60°.**
- In summer, the solar angle is around **30-60°** in daytime.
- In winter, the solar angle is around **10-25°** in daytime.

Summary

- **Opening the south west roof** will **improve the internal illuminance** because there is a lack of sunlight on north east side in the winter.
- Using the **difference of the solar tilt angle** between summer and winter will help to increase daylight and **prevent overheating.**

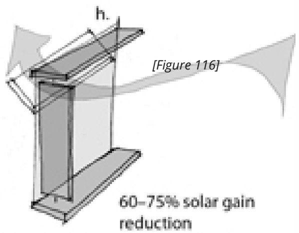
8.7 Solution III: Increase Daylight and Overheating

Solutions

Overheating

Shading Strategies

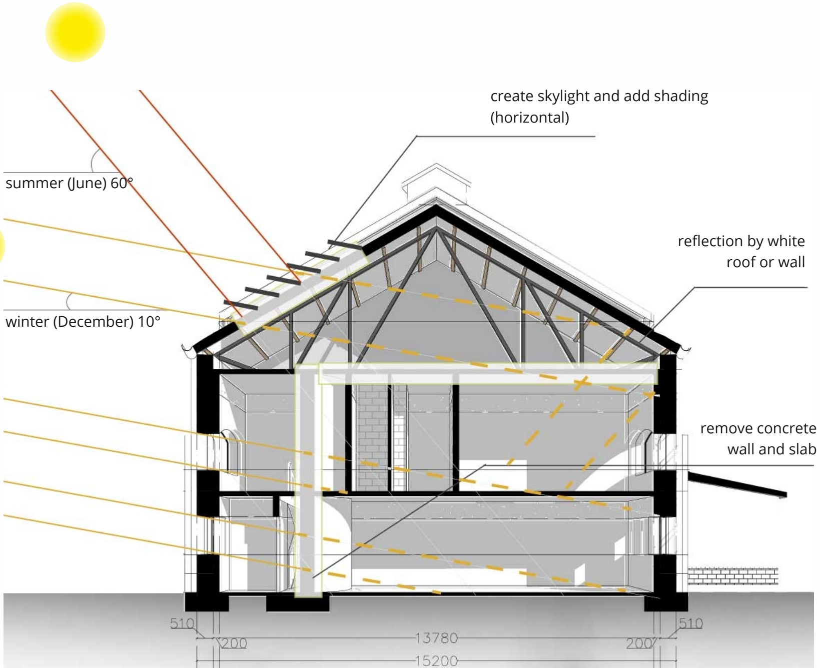
- Shading and blinds should be **reflective/light-coloured** solar panel shutter or fins).
- **Horizontal overhangs** with the angle can prevent summer daylight.



[Figure 116]


[Figure 117]

- **Deep reveal windows and horizontal shading** (the original building walls are thick enough to block summer daylight out).

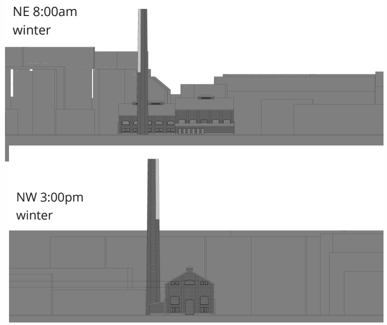


[Figure 118]

Summary

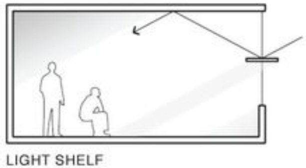
- We will use **white shading design** as it is a **reflective colour** (on the horizontal overhangs)
- We will use **skylights** to increase indoor illuminance quality.
- **Horizontal overhang angles** will be set to prevent overheating in summer and enable access to daylight in winter **(around 15-20°).**
- We will **remove the concrete slab** inserted in the 1970s to open the space up and improve the illuminance quality internally

Increase Daylight *[Figure 119]*
in winter



Skylight *[Figure 120]*

- **Open the roof** to have the longitude opening for increasing daylight.
- **Using mirror reflection** to increase indoor illuminance, due to the winter solar tilt angle in winter(10-20°).



Remove the slab and wall

- Remove the **concrete slab** and wall that was added in 1970 to make the whole space more connected/open, to access daylight.

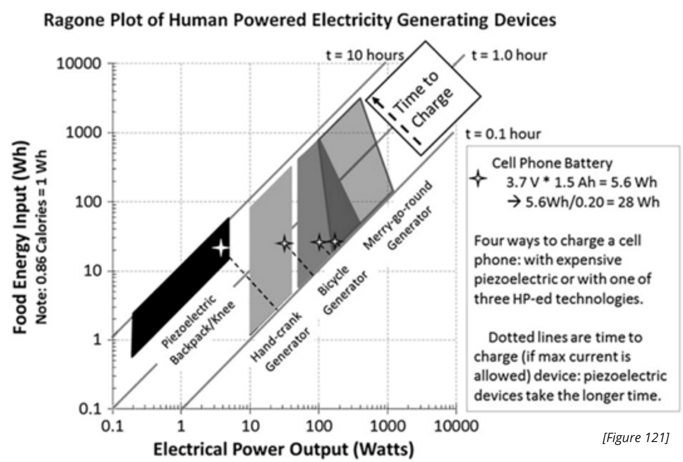
Solution IV: *Improve community involvement and restore the historical significance of the power station*

8.8 Solution IV: Energy usage-Human powered energy

1. Energy supply

$$P_{electrical} = \eta_{device} P_{Human\ mechanical\ output}$$

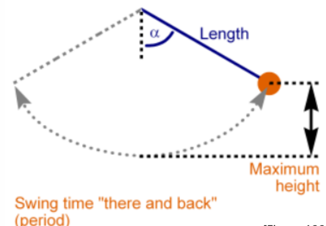
- *ηdevice* is the efficiency of the device.
- *PHuman mechanical output* is the mechanical power output of human muscles.
- Most healthy people in developing countries should be able to sustain an output of 100 W for at least an hour a day (or average power capacity of 4.2 W/Capita which is 21% increase from 20 W/Capita) .



[Figure 121]

- The energy produced by human power generation is related to the activity and the food intake of the individual.
- A typical person (68 kg, 150 pounds) **pedalling** at a moderate rate (19 km/hr, 12 mph) burns about **500 calories in an hour**. One calorie is **equivalent to 0.0012 kWh**, so that hour on a bike will **generate 0.6 kWh of electricity**.

1.Case study: CSIRO Infinity Swing - Sydney



[Figure 122]

- The Infinity Swing demonstrates one way to convert human power into electricity: a person on a swing whose movement causes a generator to spin.
- Assuming a generator with 100% conversion efficiency, a 68 kg person on that swing can generate about 222 Watts of power.The Swing has eight individual swings. Assuming each one is manned 24/7, the swing could generate about 300 kWh of electricity per week.
- It took 4000 people swinging over a five-day period to generate that much electricity.

[Figure 123]

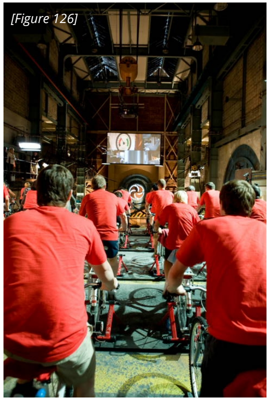
Summary

- Compared with other methods, the energy generated by **human power generation is small** and requires a continuous and large amount of human activities.
- The aim of **human power energy generation is educational**.

8.9 Solution IV: Electric Pedals

[Figure 124]


[Figure 125]


[Figure 126]


[Figure 127]


[Figure 128]


[Figure 129]

Electric Pedals

- A London based company that provides electricity-generating cycling events for communities
- Bike powered projects of theirs include:
  - *Art and installations*
  - *Cinema events*
  - *Evening light shows*
  - *School events and workshops*
  - *Competitions and challenges*
  - *Festivals*
  - *Workout classes*

- Working all over the UK, Europe and beyond, electric pedals specialise in human-powered events and offer a variety of interactive installations with a focus on energy awareness, education, exercise and community involvement

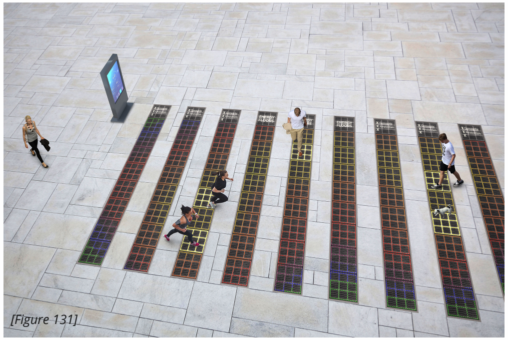
Summary

- **To educate and involve the community,** as proposed in our vision, on the production of energy and to relate to the power stations history, **we will use human-powered energy**
- We can **run events** like this London based company who educate communities on energy production through various events such as **cinemas, art, competitions, educational workshops.**

8.10 Solution IV: Energy Floors

ENERGY FLOORS

[Figure 130]



[Figure 131]

[Figure 132]

Energy Floors

- A company based in Rotterdam that provide electricity generating floors
- A playful introduction to sustainability and renewable energy sources

- Three floor types available:
  - *The gamer (suitable for outdoor spaces such as children's playgrounds)*
  - *The dancer (suitable for public events)*
  - *The walker (suitable for outdoor public spaces such as pavements and courtyards)*

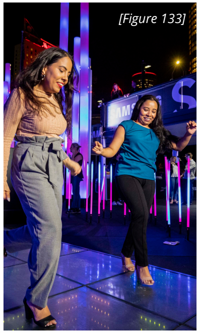
- "We design and build floors that generate energy, are smart, interactive and make sustainability visible. So everyone who steps on them realizes that they can really make an impact."

Sensors
9 sensors on every Gamer make the floor a powerful touchpad with endless possibilities

[Figure 134]

Interactive LED
The interactive LED Lighting can be programmed any way we want to. We are even developing a program where kids can program the LEDS themselves.

Active learning
Active learning is what can really stick with a kid. Jumping, hopping, climbing all build muscles, but they also build brains!



[Figure 133]

Summary

- **To educate and involve the community**, as proposed in our vision, on the production of energy to relate to the power stations history, **we will use this concept model.**
- We can use their **floor model inside and outside** our building.
- A particularly good option to **involve children** and create **a playful environment.**

Solution V: *Improve ventilation; Improve air tightness, vapour control, thermal bridging and insulation*

8.11 Solution V: Important considerations

Insulation

- The whole façade should be insulated
- Thermal bridging should be avoided
- Pipes, service boxes, boiler vents and similar – these must be removed and replaced over the insulation
- Fixings should be 'thermally broken' (i.e. not create a thermal bridge from inside to outside) and non-conductive, well-sealed and system-compatible rails, beads and so on should be used

Wind tightness

- It is important to stop air movement/thermal bypass between the insulation and the wall
- Important ensure that the insulation is fully bonded to the wall

Air tightness

- Close air leakage around windows, doors and areas where services penetrate the walls
- Potentially using a 'bonding' or 'slurry' coat behind the insulation where the building is poorly fitted

Damp and moisture

Focus on:

- The junction between the roof and external wall – particularly with regard to how eaves and verges are extended
- At ground level – particularly with regard to splashing
- Around openings (e.g. windows and doors)
- Existing architectural details
- Boiler flues
- Existing moisture within the walls – this can be trapped by EWI (External Wall Insulation) and result in damp and rot within the walls

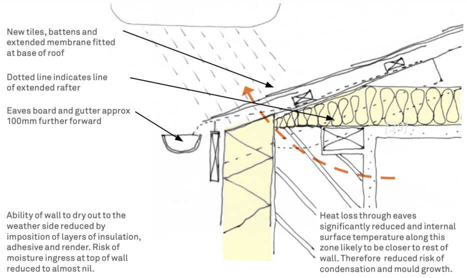
Application

- *Quality of installation:*
  - The contractors should strictly follow the design and specification
  - Installers should also be suitably trained and experienced
- *Weather:*
  - It is important that application of insulation is not undertaken where the insulation gets wet or if there is a risk of freeze-thaw damage to the render
  - Many render systems specify a minimum application temperature, 5°C for example
  - Winter work needs to be carefully controlled, and may be best avoided where possible
- *Capacity and caution:*
  - If there is not sufficient time or money, a job is likely to be poorly done, corners being cut or some areas left out
  - Make sure your time scales have some flexibility

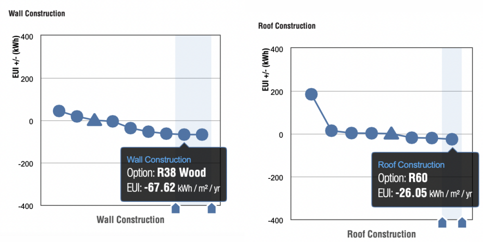
Insulation

- Use natural fibre insulation that is breathable (vapour permeable, and holds onto moisture in the fibres of the insulant, manages moisture much more safely) - *wood fibre, hemp, straw, cellulose, wool, cotton and flax*
- Don't use synthetic insulation
- Overhang is important for exterior wall protection
- Rainwater goods must be removed

Example of a good wall and roof retrofit: *[Figure 135]*



Insulation levels to optimise energy performance: *[Figure 136]*



Summary

- The whole fabric must be **insulated.**
- We must **avoid thermal bridging.**
- **Natural fibre insulation** should be used because it is more breathable (for example, wood fibre).
- Specific focus on insulation **around openings.**
- The **construction should be done in the summer** when there is no damp and moisture.

8.12 Solution V: Air Tightness and Thermal Performance Standards

[Figure 137]

	EnerPHit	Passivhaus
space heating demand	≤ 25 kWh/m² per year	≤ 15 kWh/m² per year
primary energy demand	≤ 120 kWh/m² per year	
airtightness (ach⁻¹) at 50 Pa	1.0	Max. 0.6
fabric U-values W/m²K	maximum 0.15	
window U-values W/m²K	maximum 0.8 and installed ≤ 0.85 W/m²K	
ventilation	MVHR (min. 75% efficiency calculated according to PH standards; usually ≥ 90% efficient unit as stated by manufacturer) → Jump to Section 6.7	

Building type	**Recommended best practice airtightness standards** (m³/m²hr at 50 Pa)	**Maximum airtightness standards** (UK Building regulations)
Housing – naturally ventilated	5	10
Housing – mechanically ventilated	1	3
Offices – naturally ventilated	3	10–15
Offices – mixed mode	2.5	
Offices – air conditioned and low energy	2	
Schools	3	
Hospitals	5	
Supermarkets	1	

Protect brick walls from rain by deep overhanging eaves and avoid water back-splash at ground floor.

- Construction U-values of 0.1– 0.15W/m2K are recommended.
- Insulation depths increase significantly for straw, wood fibre and wood wool. However, these have the added benefit of their thermal lag properties in lightweight construction walls and most roofs.

Wood fibre insulation

- Uses virgin wood, pulped, heated up, the natural resin then binds the fibres together
- Generally not using high value timber
- It is low in embodied carbon
- No toxic chemicals are emitted in process or from material
- It is breathable and excellent at moisture management

[Figure 138]

Summary

- The desired U value of our wall and roof must be **0.15W/m2K** or below
- The desired air tightness value for our building must be **3m3/m2hr** or below
- We must use a **vapour barrier membrane** to air tight the building
- **Wood fibre insulation** would be a successful low impact material for the type of construction required of the retrofit

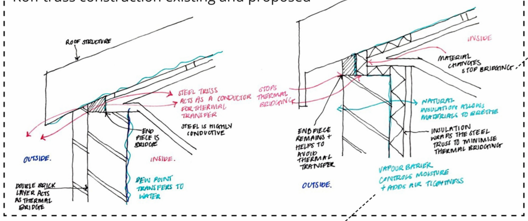
Solutions

8.13 Solution V: The Building Envelope

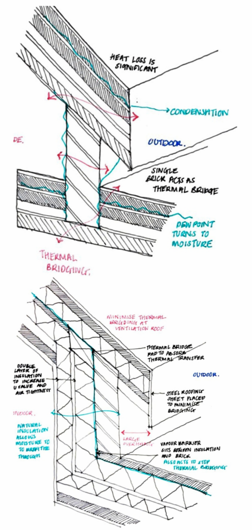
Summary

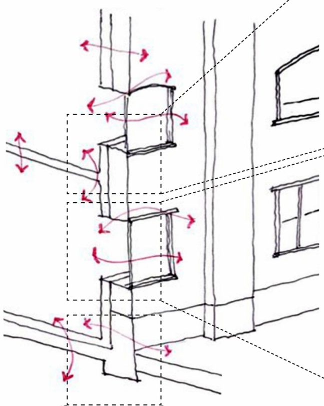
- We will add **vapour barrier** for moisture control.
- We will add insulation which has been calculated to bring the **U value below 0.15.**
- **Thermal bridging** has been addressed through **material change**s in the building envelope.
- **Air barrier** has been included to seal and increase air tightness in the envelope.

Roff truss construction existing and proposed

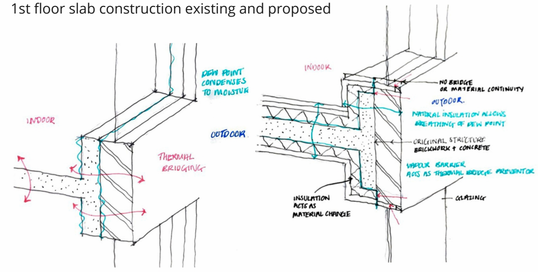


Ventilation roof construction existing and proposed

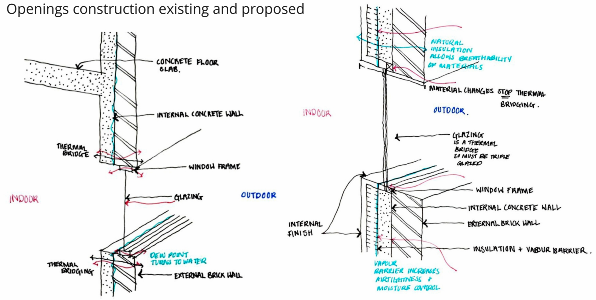




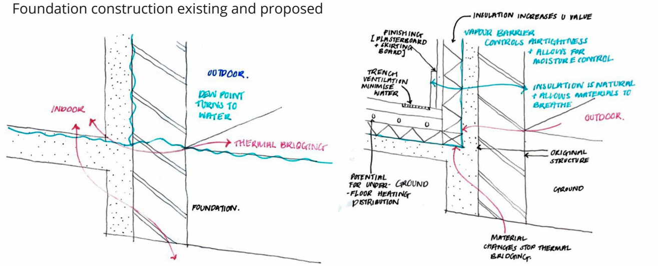
1st floor slab construction existing and proposed



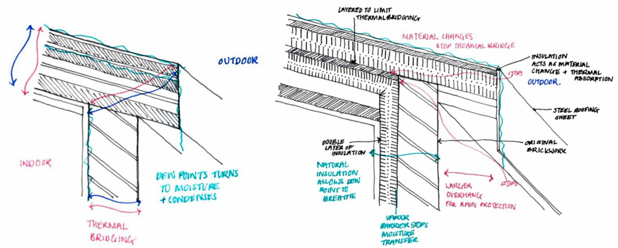
Openings construction existing and proposed



Foundation construction existing and proposed

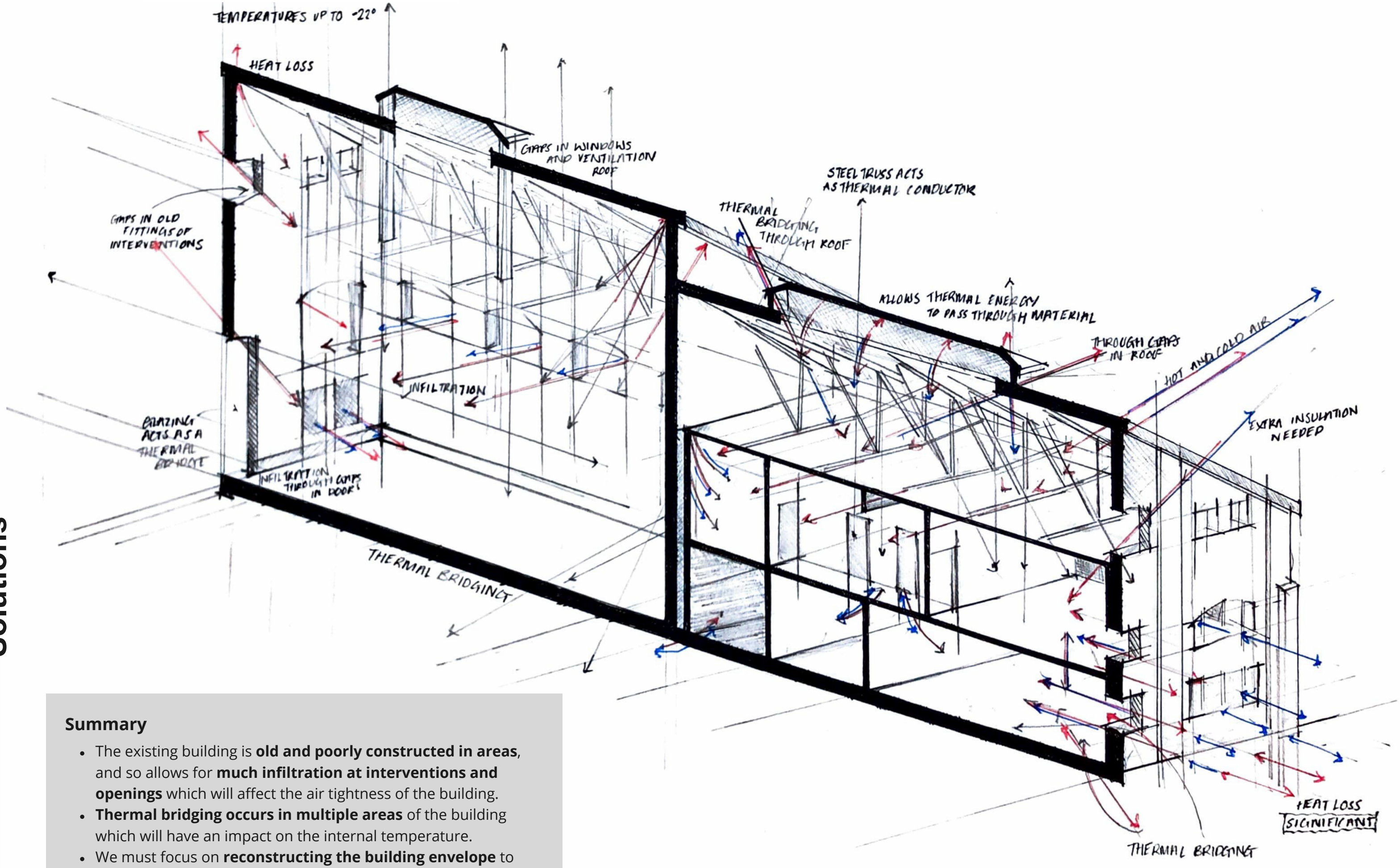


Roof construction existing and proposed



[Figure 139]

8.14 Solution V: Analysis of Thermal Bridging and Infiltration



[Figure 140]

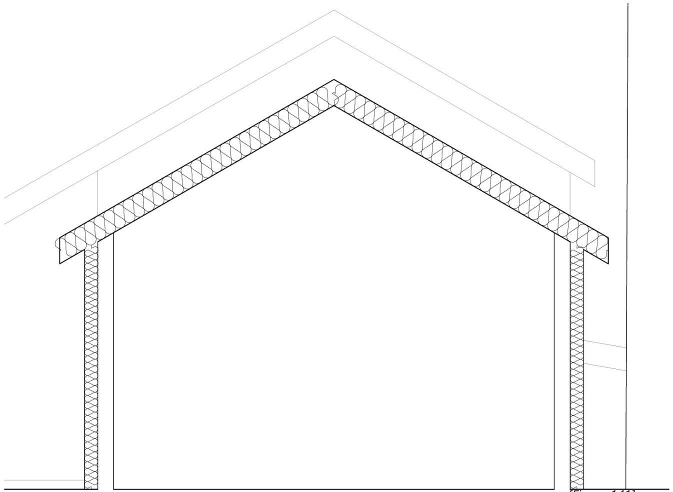
Summary

- The existing building is **old and poorly constructed in areas**, and so allows for **much infiltration at interventions and openings** which will affect the air tightness of the building.
- **Thermal bridging occurs in multiple areas** of the building which will have an impact on the internal temperature.
- We must focus on **reconstructing the building envelope** to increase air tightness, reduce thermal bridging, increase U value and also allow moisture to breathe.

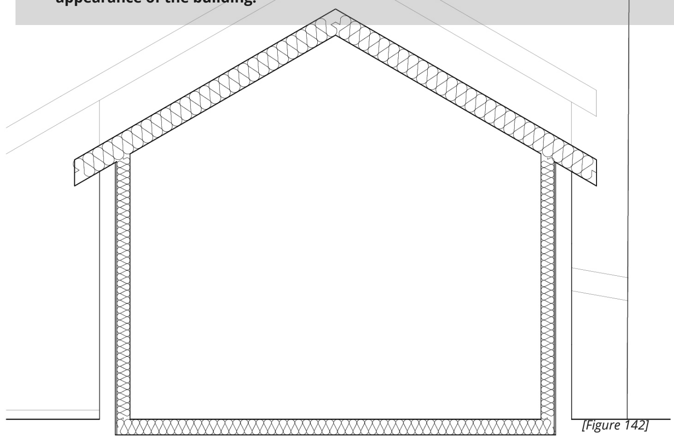
8.15 Solution V: External vs. Internal Wall Insulation

Summary

- **Internal wall insulation** fits better with our primary objectives to reduce heat lost, increase energy efficiency and retain the heritage of the building design.
- **External insulation** has lots of benefits however a major con was the **loss of the external appearance of the building.**



[Figure 141]



[Figure 142]

EXTERNAL WALL INSULATION

Pros:
- Protects brickwork
- Prevents penetrating damp entering
- Creates opportunity in construction to reseal any leaks and replace old pipework
- Reduces heat loss and improves energy performance of building through higher U value
- Good sound proofing
- Walls act as a thermal heat store (thermal mass) which can release heat when the building is not heated (also means no condensation build up)

Cons
- Loss of traditional building elements externally
- Hard to adapt to complex forms
- Finishing needs attention on different facades (for example, south facades see more sun and rain, therefore moisture retention and decay)
- It must be ensured that the insulation is attached to the wall using both adhesive and mechanical fixings (to reduce risk of it pulling away over time causing inconvenient maintenance)
- Planning permission may be necessary due to the building being amongst listed buildings and of historical importance

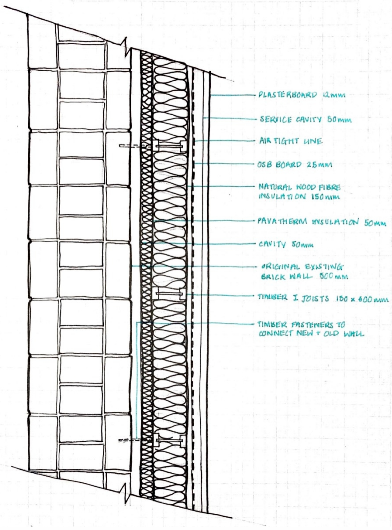
INTERNAL WALL INSULATION

Pros:
- Reduces heat loss and improves energy performance of building through higher U value
- No impact on the external appearance and preserves historical elements
- Relatively easy process - can be done a room at a time
- Good sound proofing
- Easily adapted to a complex frame

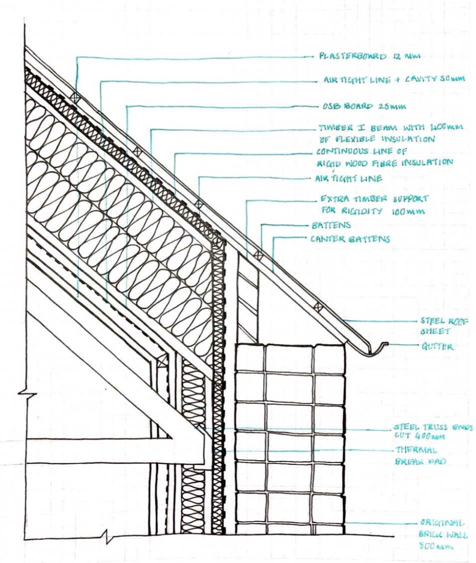
Cons
- Loss of internal space may limit the amount of insulation used
- Thermal bridging is very likely to occur so special attention to details must be considered (especially around floors and floorboards)
- Any penetrating damp issues must be sorted prior to installing the internal wall insulation, otherwise far worse issues can occur down the line
- Repointing/general maintenance still needs to take place on brickwork
- Not as efficient as external wall insulation however still can work in the same way if special care is taken
- Insulation needs to address moisture control and breathability

8.16 Solution V: The Building Fabric

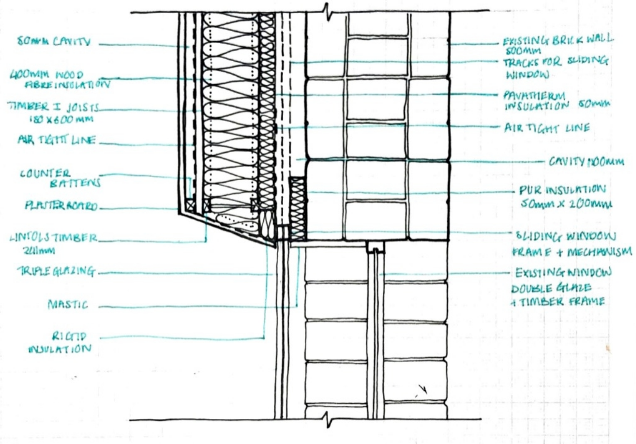
[Figure 143]



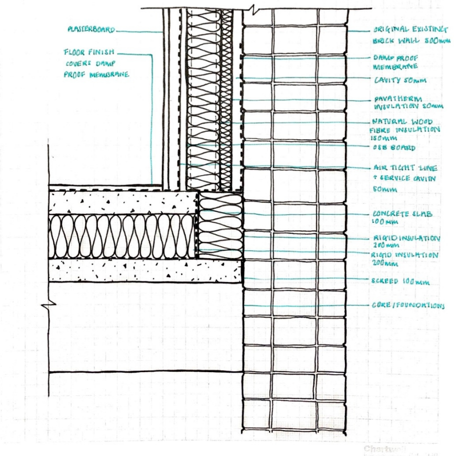
[Figure 145]



[Figure 144]



[Figure 146]



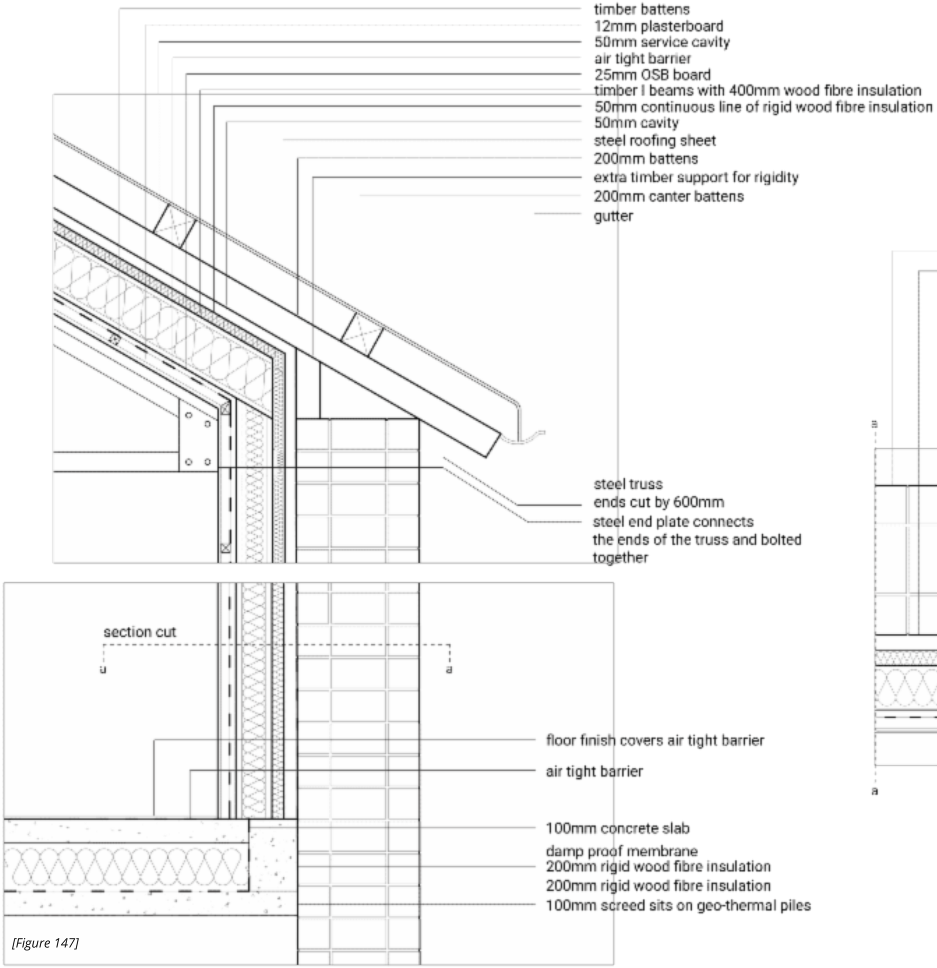
Summary

- Initial sketches of the building fabric, employing a **building inside a building** approach, will include the use of **300mm** of wood fibre insulation
- This new wall structure will bring our **U value down** to meet our concrete objectives.
- **Cutting the truss** and including a **thermal break pad** could reduce thermal bridging here.

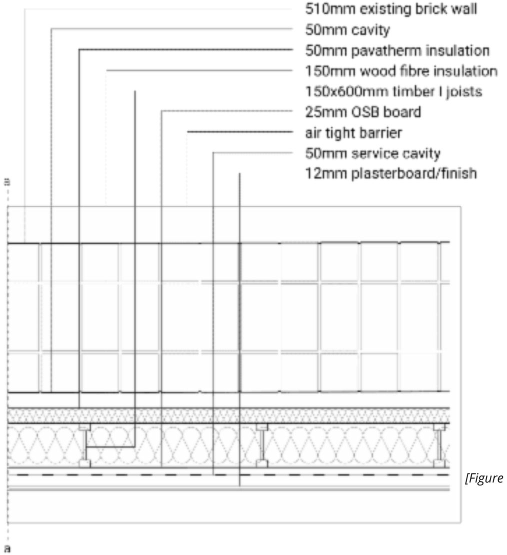
8.17 Solution V: Building Envelope Details

Summary

- We propose to build a **'building within a building'.**
- We will use the Passivhaus rules of thumb to construct our new structure.
- The new U value of the roof will be **0.05W/m2K**. The wall will be **0.1W/m2K** with this new construction.
- The truss will be cut at each end by **600mm** and met with **a steel end plate** attached via bolts to avoid thermal bridging.
- This will involve a wall and roof section which is as follows...



[Figure 147]

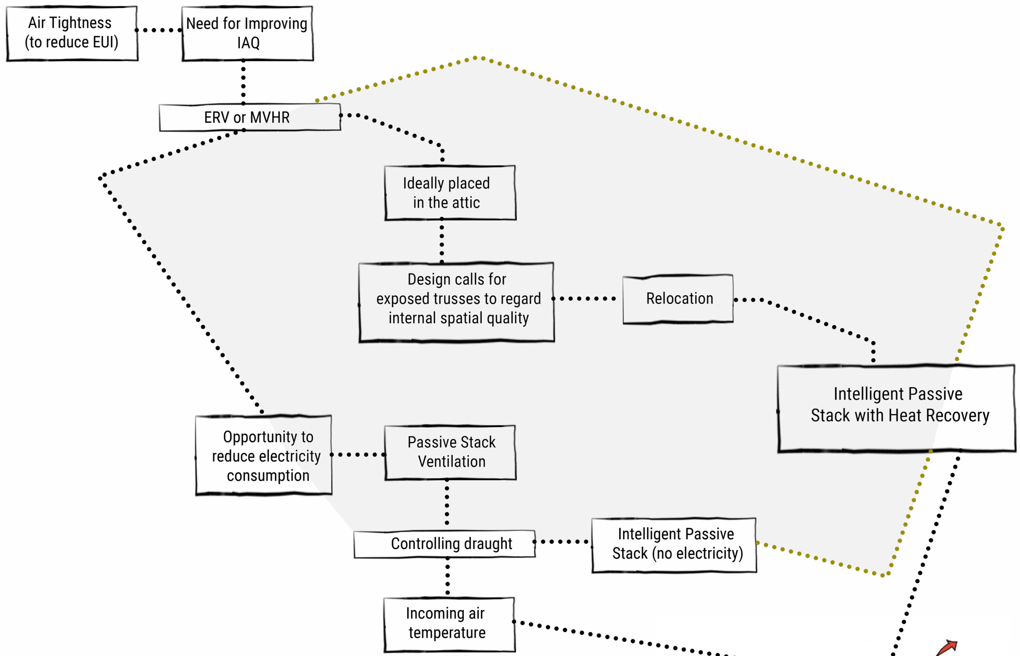


[Figure 148]

Solutions

8.18 Solution V: Improve HVAC efficiency

[Figure 149]

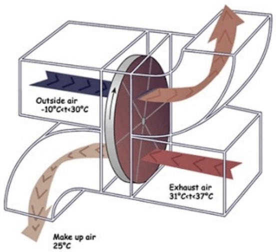


Summary

- Reusing the chimney by burning fossil fuels to generate heat doesn't agree with our net-zero aims.
- **Installing an ERV in the chimney stack reduces its dependence on electricity by benefiting from buoyancy airflows.**
- The **Intelligent Passive Stack with Heat Recovery** balances both IAQ levels and heating - **controlling draught** and **pre-heating incoming air**.
- Both these systems can work all year round, in the summers and the winter. **In** the **summer** the building could also function with just the **Passive Stack and Natural Ventilation**

Solutions

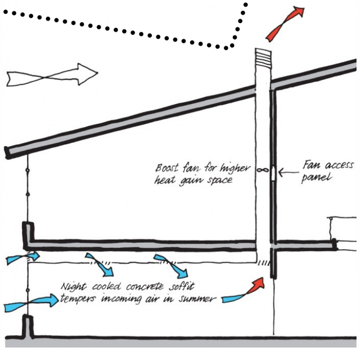
Energy Recovery Ventilator (ERV) - Heat Exchanger



A diagram of rotary heat exchanger or heat wheel

[Figure 150]

- Consists of 2 components - Intake ducts to bring fresh air into the system and Return-Exhaust ducts to remove stale air.
- The system **works effectively in the winters and summers** by supplying warm and cool air respectively.
- **70-90% of the heat gains are recovered in the winters.**



[Figure 151]

Intelligent Passive Stack with Heat Recovery

- Passive stack ventilation (PSV) is the most effective natural ventilation strategy as it uses a combination of cross ventilation, buoyancy (warm air rising) and the venturi (wind passing over the terminals causing suction) effect.
- When combined with heat recovery pipes and intelligent systems, issues of draught and warming incoming air are resolved.
- **Nylon filaments expand and contract on exposure to humidity which controls the aperture and therefore the draught.**
- **A new flue liner is fixed in the chimney to prevent the mixing of contaminants and old residues.**
- Installing heat recovery pipes in the chimney stack reduce its dependence on mechanical means due to the dependency on buoyancy airflows.

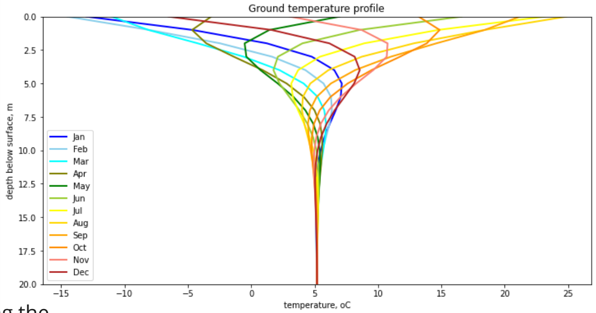
8.19 Solution V: Improve HVAC efficiency

Heating Strategies

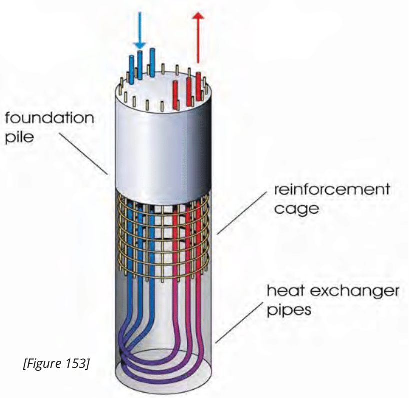
Ground Source Heat Pumps with Geothermal Piles

- The principle of a ground source heat pump system is to transfer heat to and from the earth.
- In cool weather, the earth's natural heat is collected through the loops and carried by heat transfer fluid to a unit in the building. This unit uses electrically driven compressors and heat exchangers to concentrate the earth's heat and release it inside the building at a higher temperature.
- In warm weather, the process is reversed in order to cool the building. The excess heat is drawn from the building and transferred to the heat transfer fluid, using the heat exchanger in the indoor unit. The heat then travels along the loop and is absorbed by the earth.
- The ground stays at a fairly constant temperature under the surface, so the heat pump can be used throughout the year.
- The length of the ground loop depends on the size of the room and the amount of heat needed.

[Figure 152]



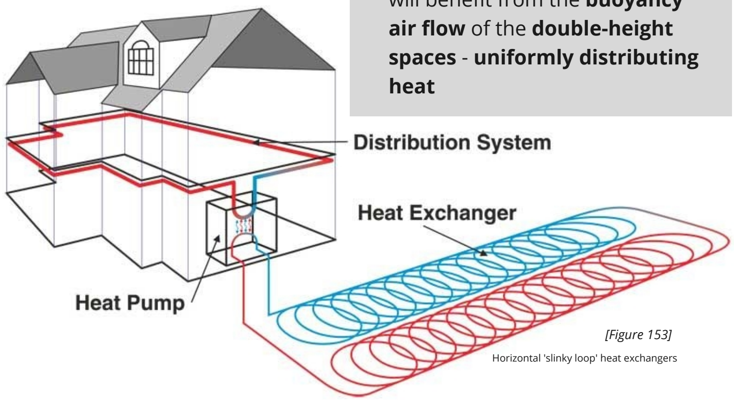
In January, when the air temperature is close to -15 degrees, the ground temperature at just 3m below ground is 7 degrees. This coupled with solar gains during the day makes for a very effective ground source heat pump.



[Figure 153]

Geothermal Piles

- Purpose: to provide support to the building, as well as acting as a heat source and a heat sink.
- Structural piles are turned into heat exchangers by adding one or more loops of plastic pipes down their length. In the construction of geothermal piles, the pile diameter and length should be designed to resist the applied structural loads and not increased to suit the geothermal requirements.



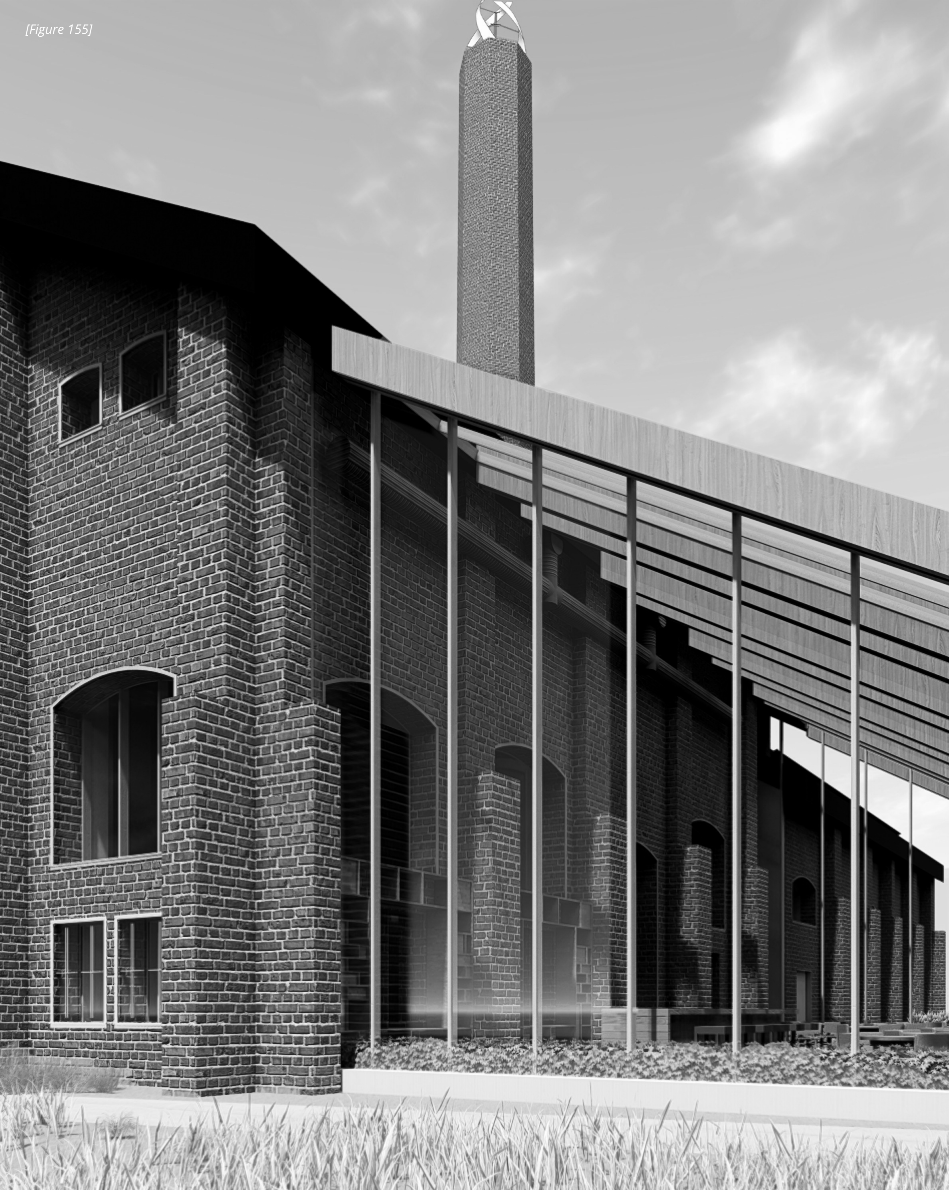
[Figure 153]

Horizontal 'slinky loop' heat exchangers

Summary

- The **structural modifications** to the **roof** require the **addition of new columns**. The **piles** that **support these columns** provide an **opportunity** to utilze **geothermal piles** for a **ground source heat pump system**.
- Validated by the **ground temperature profile**, Ground source heat pumps are widely used in Finland and benefited by these temperature readings. The need for such systems arises from the fact that the district heating in Finland is not completely based on clean energy. Therefore this system is used to meet the net zero aims of the project.
- **Underfloor heating strategy** will benefit from the **buoyancy air flow** of the **double-height spaces** - **uniformly distributing heat**

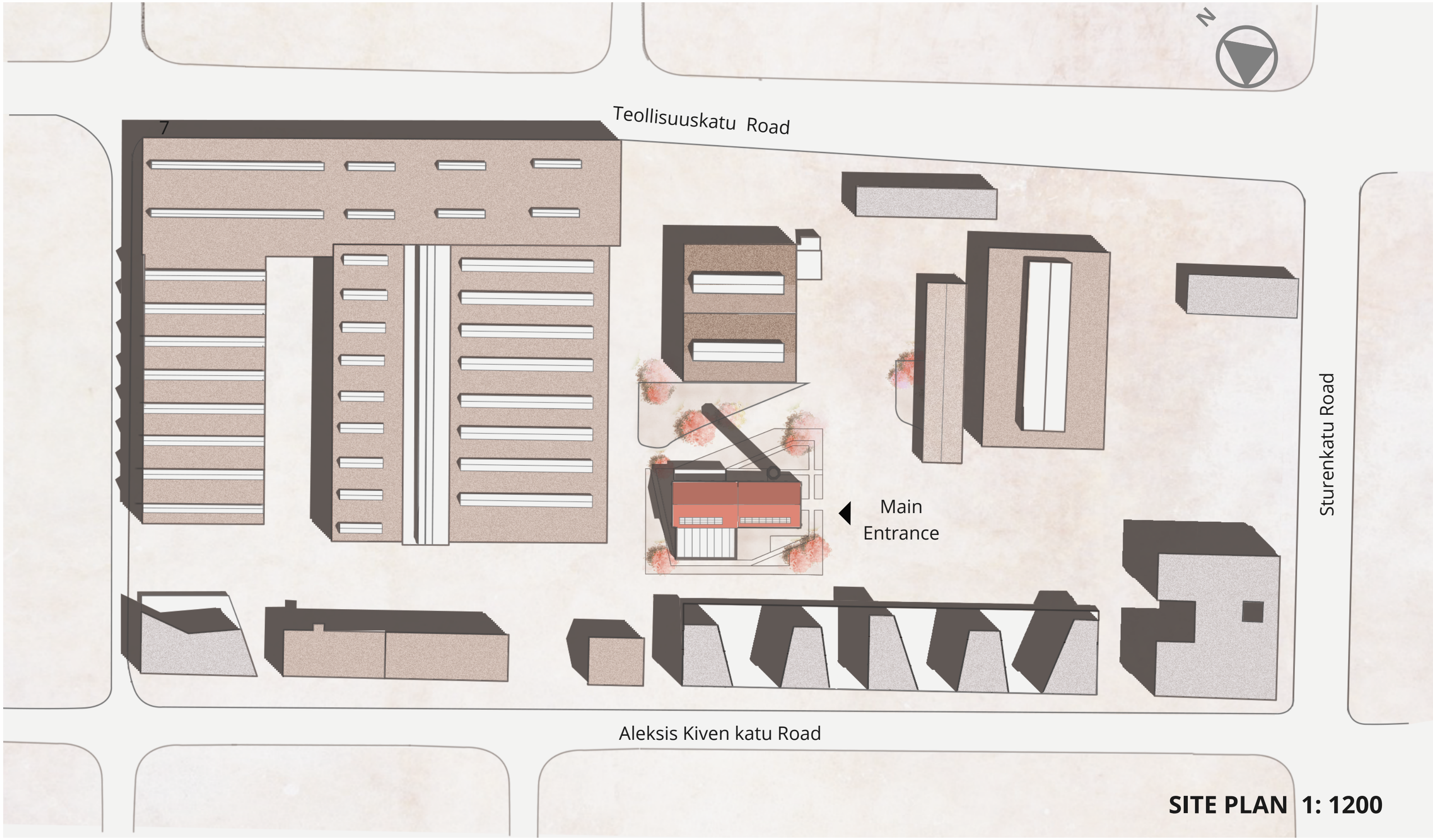
[Figure 155]



Design Proposal

THE POWER STATION OF PASILA KONEPAJA

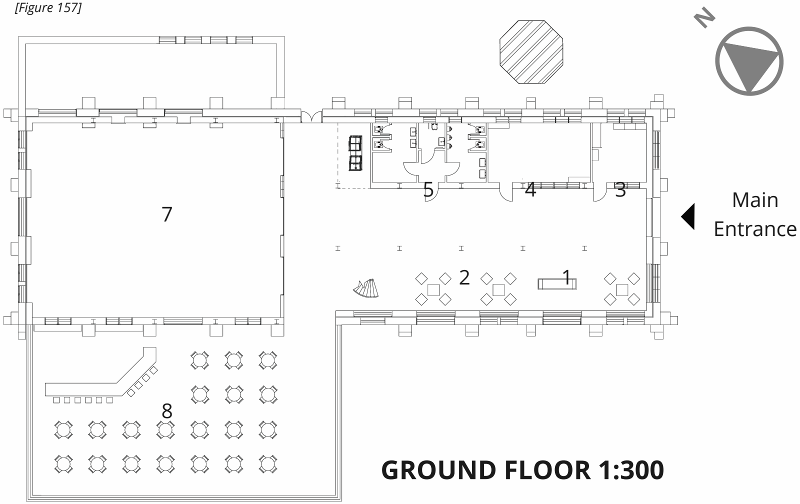
9.1 Site Plan



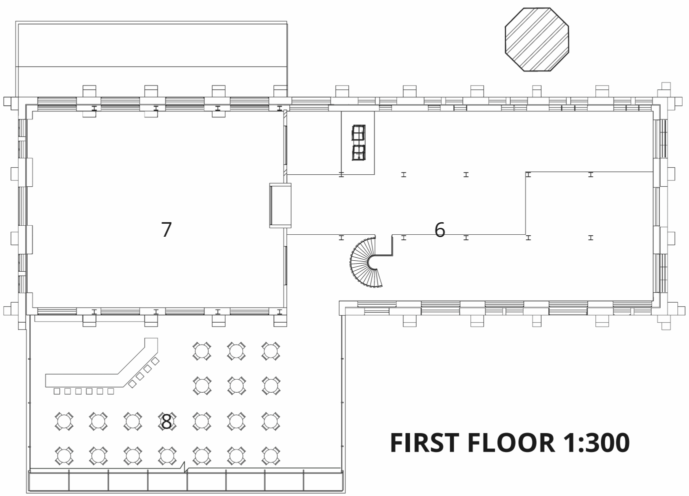
[Figure 156]

9.2 Plans

[Figure 157]

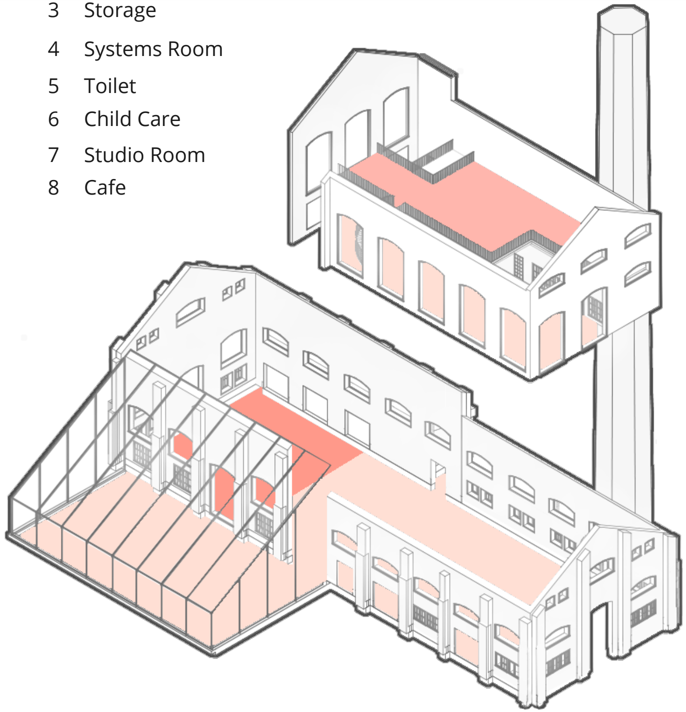


GROUND FLOOR 1:300



FIRST FLOOR 1:300

1 Reception
2 Seating Area
3 Storage
4 Systems Room
5 Toilet
6 Child Care
7 Studio Room
8 Cafe



Spaces for Teenagers and Adults
Spaces for Children
Spaces for Everyone

[Figure 158]

9.3 Building Inside a Building

[Figure 159]

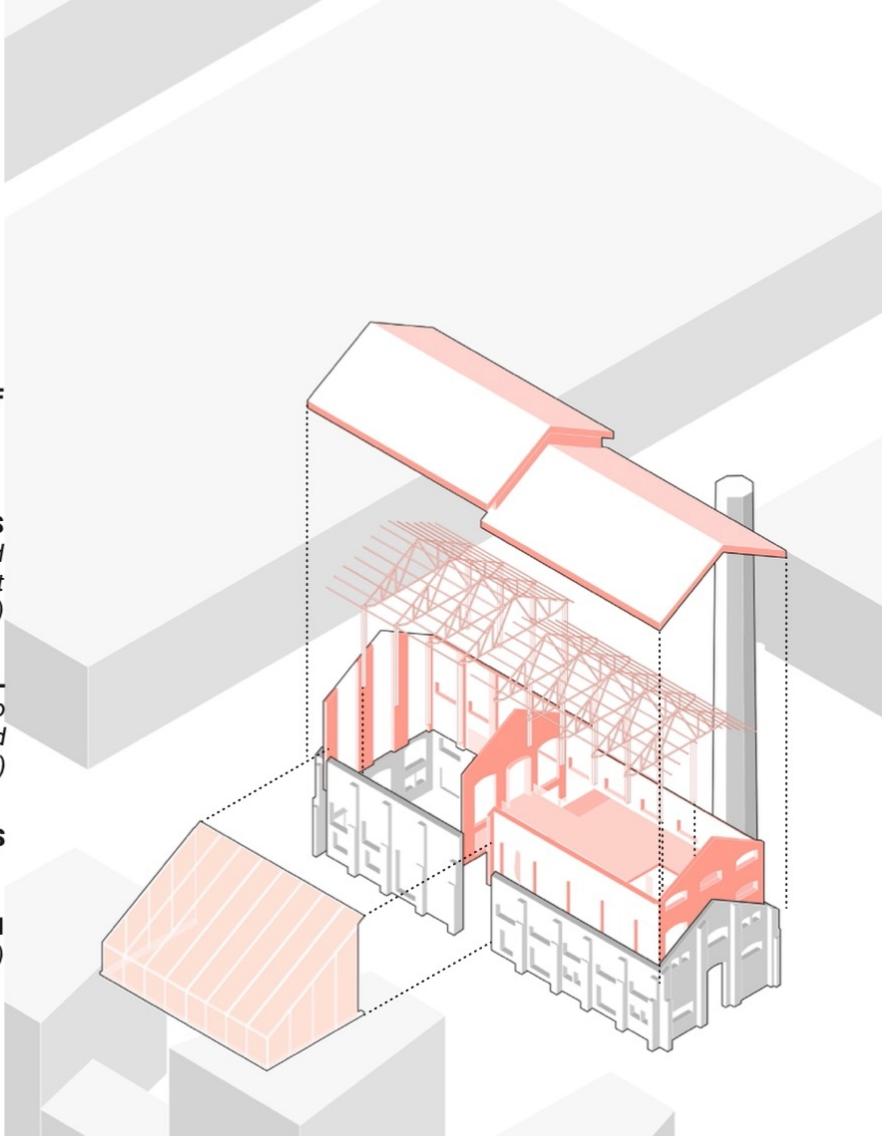
NEW ROOF

EXISTING STEEL TRUSS AND NEW BEAMS
(cut at each end to avoid thermal bridging and supported via recyled steel I beams which sit inside and outside to the internal walls)

NEW BUILDING WALL
(400mm taller than existing to accommodate new roof thickness and avoid thermal bridging)

EXISTING BUILDING EXTERNAL WALLS

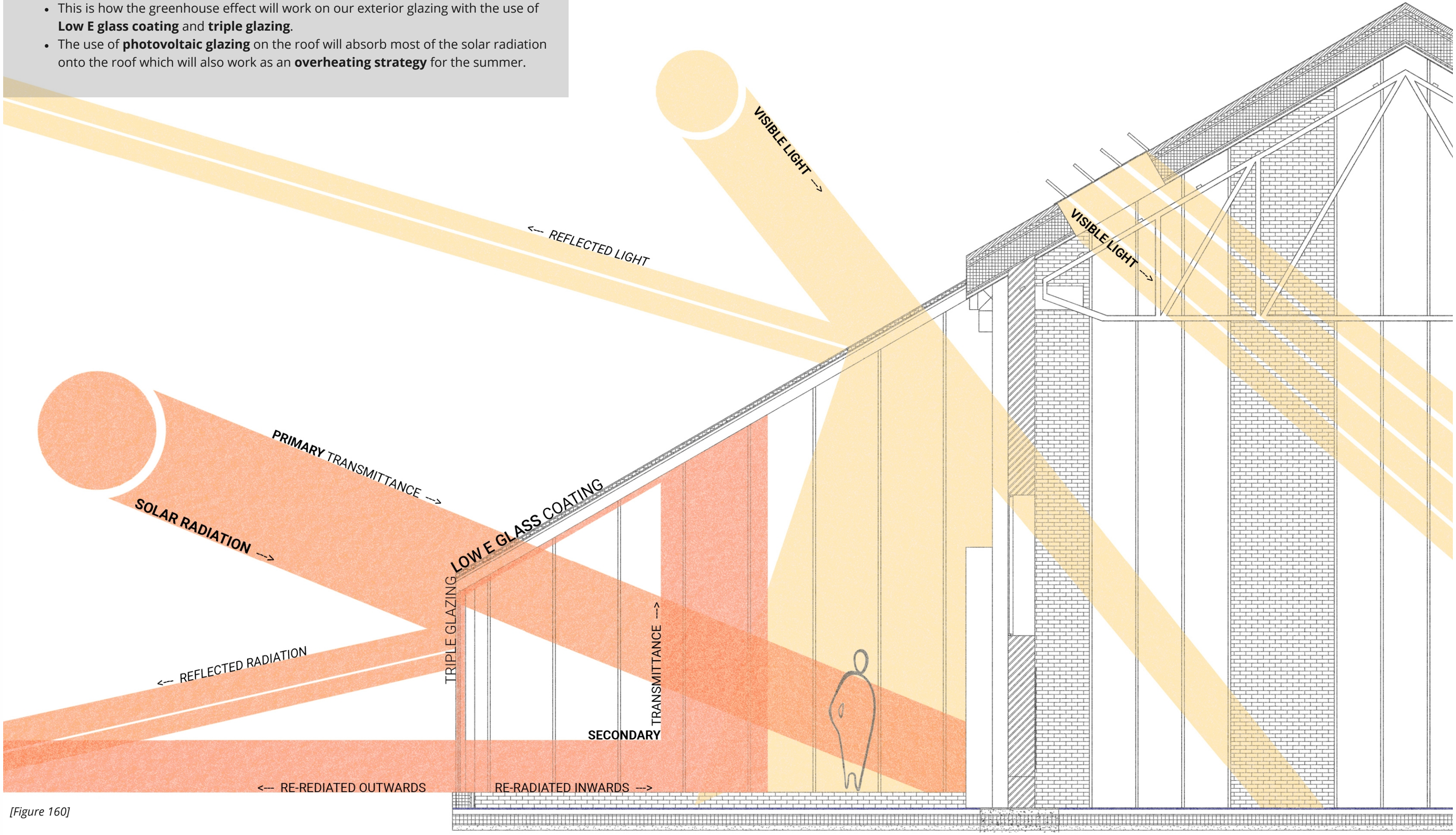
NEW GLAZING EXTENSION
(connects to new roof and walls)



9.4 Solar Gain on Exterior Glazing

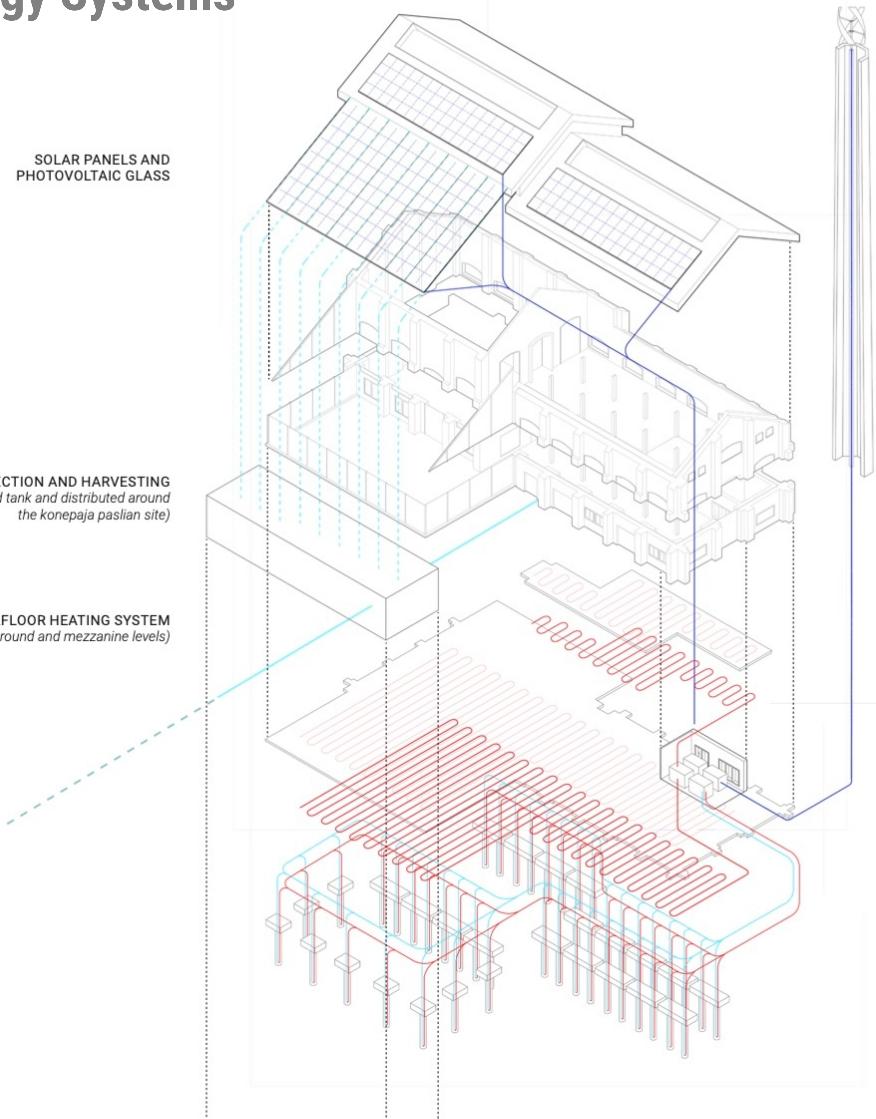
Summary

- This is how the greenhouse effect will work on our exterior glazing with the use of **Low E glass coating** and **triple glazing**.
- The use of **photovoltaic glazing** on the roof will absorb most of the solar radiation onto the roof which will also work as an **overheating strategy** for the summer.



[Figure 160]

9.5 Renewable Energy Systems

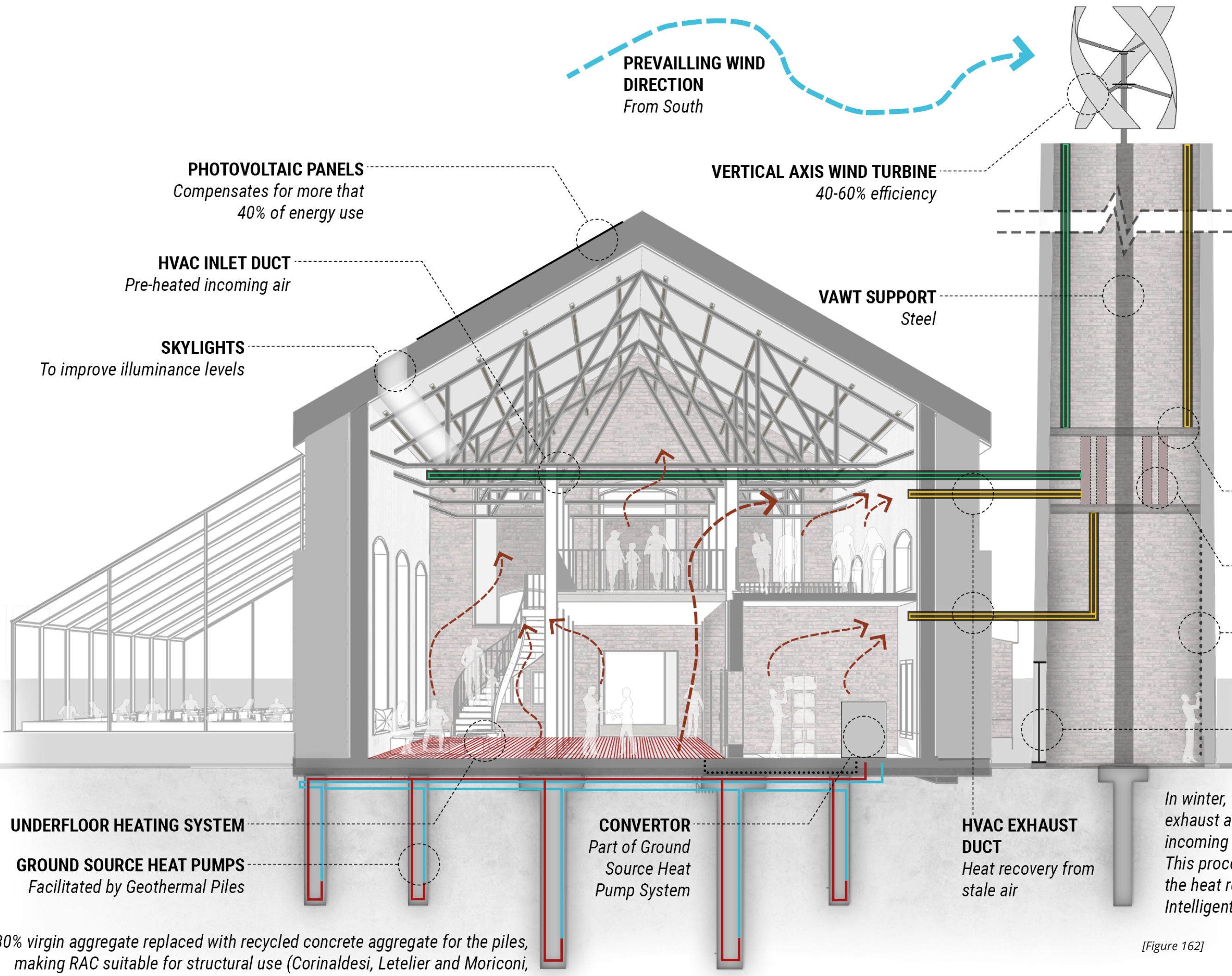


[Figure 161]

9.6 Cross Section - Building Systems

Summary

- **Working section** of all our **building systems** - heat recovery pipes in the Chimney, PV panels, geothermal piles & underfloor heating. and the VAWT.
- The **Geothermal piles** for the **ground source heat pumps** and **Intelligent PVHR** work together for **heating and ventilation**.
- The **VAWT and PV panels generate electricity** required by these systems.

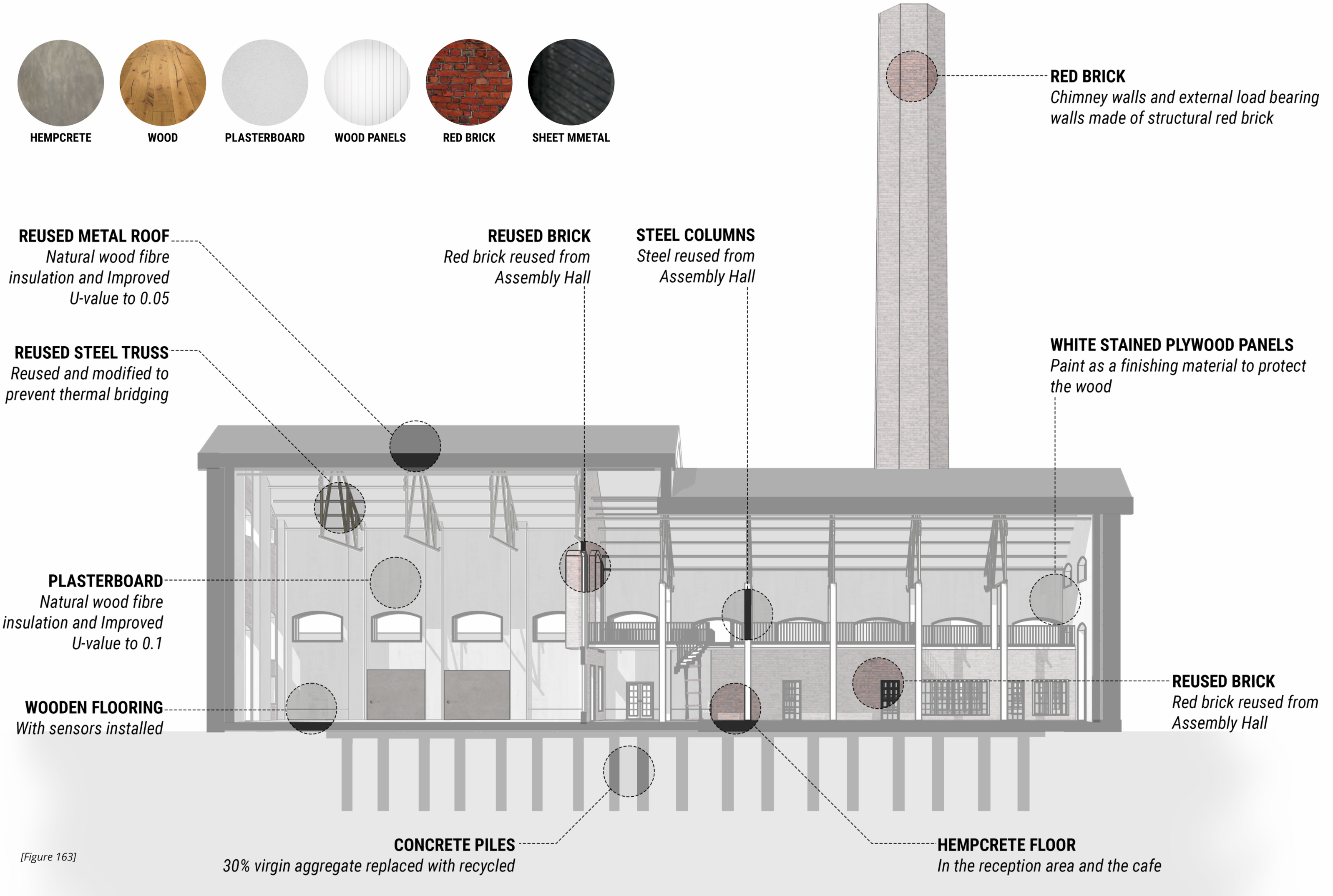


In winter, thermal energy from the exhaust air is transfered to the incoming fresh air, thus pre-heating it. This process is carried out by means of the heat recovery pipes and assisted by Intelligent Passive Stack

30% virgin aggregate replaced with recycled concrete aggregate for the piles, making RAC suitable for structural use (Corinaldesi, Letelier and Moriconi,

[Figure 162]

9.7 Longitudinal Section - Materials



[Figure 163]

9.8 Elevation

Preserving 75% of the existing structure.

- external wall (only one portion modified)
- window
- chimney
- truss

[Figure 164]

9.9 Exterior

[Figure 166]

[Figure 165]

North West facade (exterior) **Cafe and Studio**
The visual shows the way in which we addressed the lack of greenery on the site by adding relevant landscaping.

9.10 Exterior

[Figure 168]

[Figure 167]

South West + South East facade (exterior) **Entrance**

The visual shows the way in which we have addressed the lack of greenery on the site by adding relevant landscaping.

9.11 Interior

[Figure 170]

View of the original entrance space

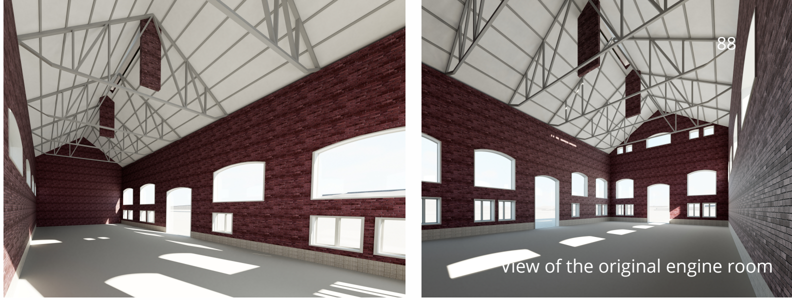
[Figure 169]

View of the new entrance reception space

A mezzanine was added, and the children's space is on this floor.

9.12 Interior

[Figure 172]



View of the original engine room

View of the new studio space *[Figure 171]*

This space is mainly used for people to organize activities, events and exercises. It is also a demonstration and experience space for human power generation.
Human powered energy is displayed on the sensor-equipped floor and the spinning bikes which can power lights around the room. We have used old lights/lanterns from the original power station building.

9.13 Interior

[Figure 173]

View of the cafe space

The glass in the cafe is triple glazed. Therefore, prevents excessive heat loss in the winter and enhances the visual experience to the outdoors.

9.14 Interior

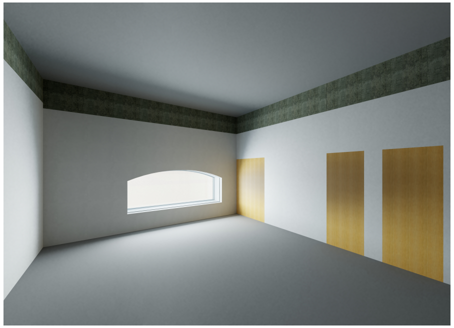
[Figure 174]

View of the second floor corridor space

The corridor is between the children's space on the second floor and the studio, where the children can observe the activities taking place in the studio and entrance. So, this is more like a fun space for children. There are also pads within the floor that sense movement and this kinetic energy can be converted into electricity, so children are encouraged to move and play.

[Figure 175]

View of the original first floor space



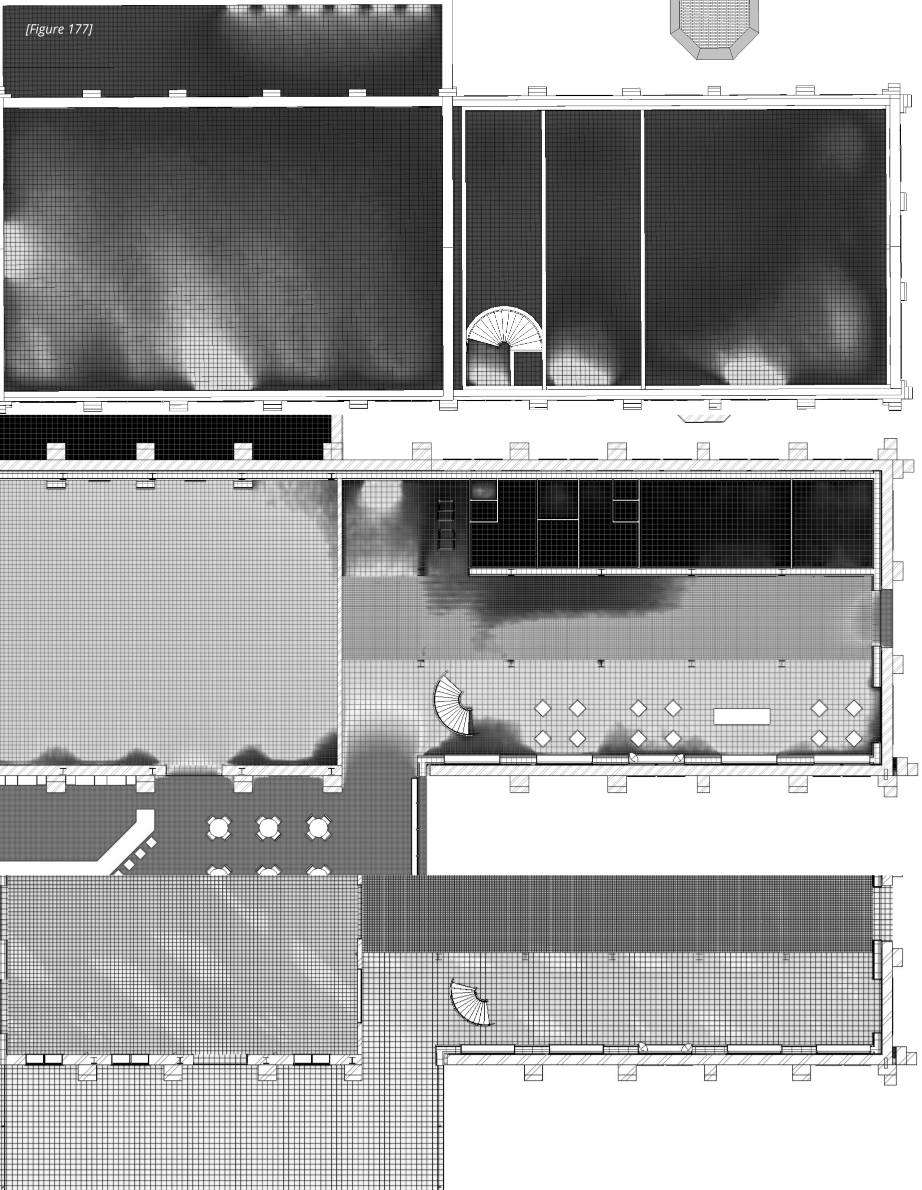
View of the original loft space

9.15 Interior

View of the entrance hall
Straight ahead in this view is the systems room and the staff office. This encourages interaction between the power production process and visitors. Therefore, what would usually be a hidden environment becomes open and engaging.

[Figure 176]

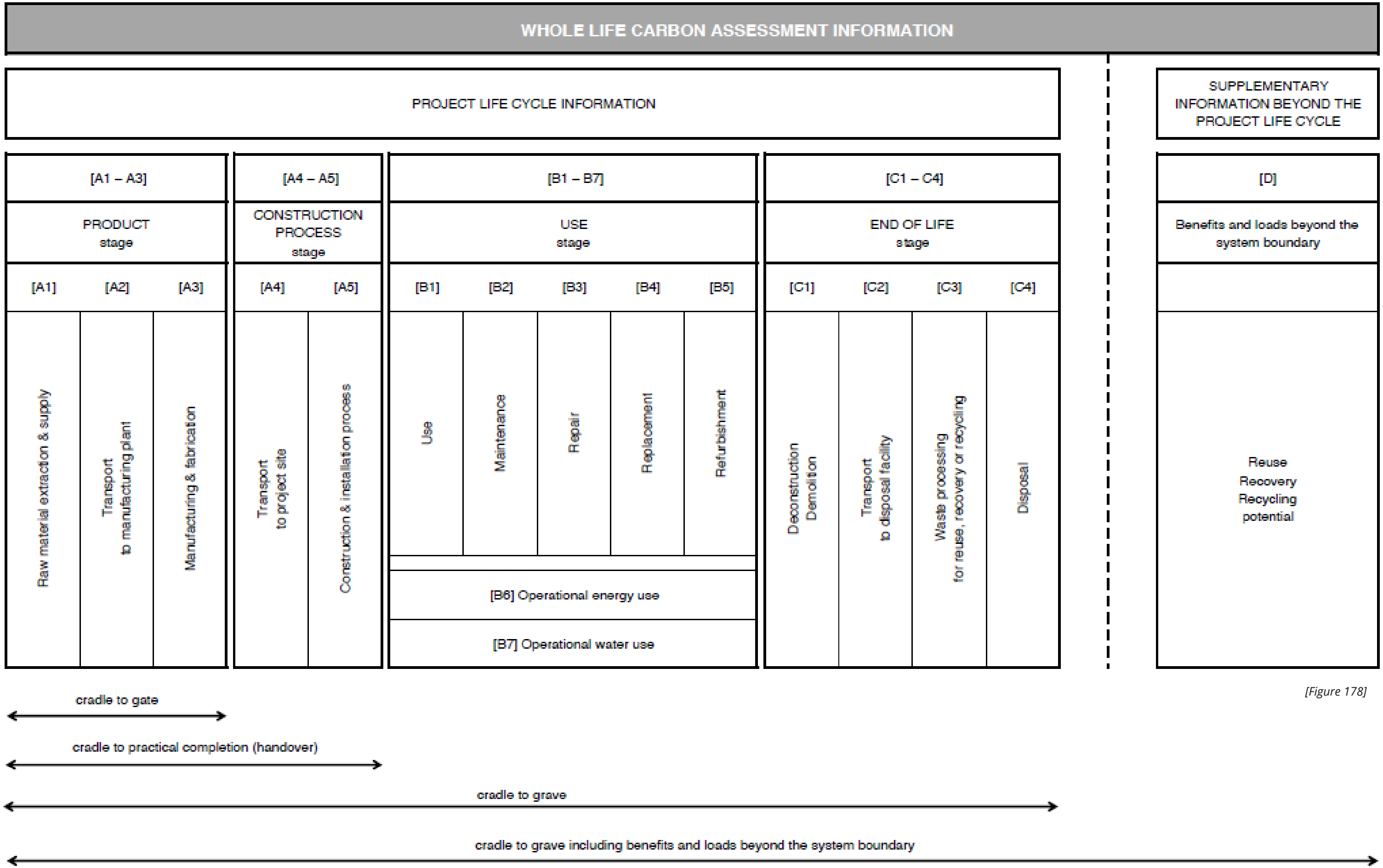
[Figure 177]



Validation of Design Proposal

THE POWER STATION OF PASILA KONEPAJA

10.1 Life Cycle Embodied Carbon Calculation



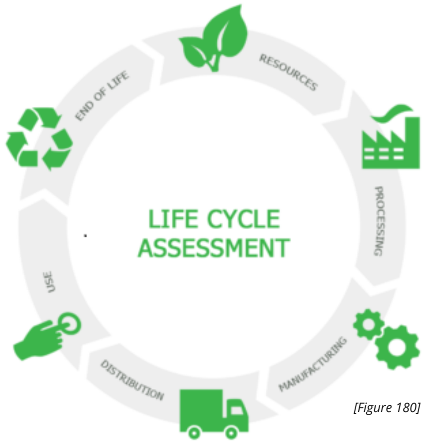
[Figure 178]

Summary

- FCBS Carbon Assessment Legend and Project Life cycle Stages

10.2 Life Cycle Embodied Carbon Calculation

Building Details	
Building Name	The Power Plant
Sector	Office
Sub-sector	Office
GIA	1005 m2
Associated with selected sub-sector	
Grid size	7.5 m
Partitions factor	0.1
RIBA 2030 Challenge Category	Non-domestic
Imposed floor load	2.5 kN/m2
User inputs required	
Building perimeter	146 m
Building footprint	850 m2
Building width	15.2 m
Floor-to-floor height	3.85 m
No. storeys ground & above	2
No. storeys below ground	0
Glazing ratio	63 %



[Figure 180]

Summary

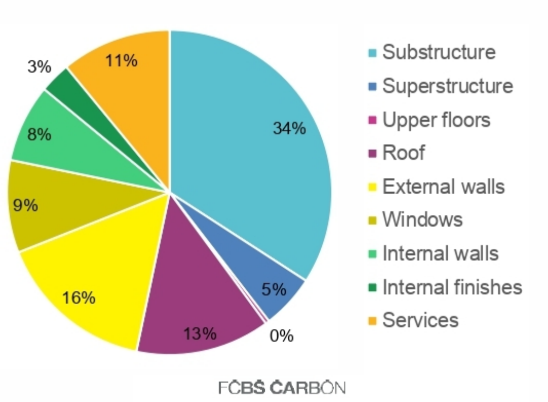
- The **FCBS Carbon Tool** is a platform to **calculate life cycle embodied carbon** so as to **validate** the benchmarks we aimed for.
- The software **assumes** certain **material standards based on** the **inputs of** the **building size**. These can be **altered** with respect to our **design proposal** by **inputting an adjustment factor**.
- **Quantities** - areas, volumes and schedules **from REVIT model**

Building Aspect	Building Element	Material	Existing fabric?	Adjustment Factor (%)	Designed for disassembly?	Estimated Quantity	Units	Life cycle embodied carbon estimate A - C (kgCO2e/m2)	A1 - A3 Biogenic carbon (sequestered kgCO2e/m2)	Potential benefits beyond the system boundary D (kgCO2e/m2)	Assumptions
Substructure	Piles	RC 32/40 70% GGBS (5	New	45%	No	49.6	m3	13.2	0.0	0.0	15 m depth, 600 mm diameter, 500 kN per pile
Substructure	Pile caps	RC 32/40 70% GGBS (2	New	250%	No	39.4	m3	18.2	0.0	0.0	0.75 x 2 x 1.5 m caps
Substructure	Capping beams	RC 32/40 70% GGBS (2	New		No	65.7	m3	30.4	0.0	0.0	750 x 600 mm beam sections
Substructure	Lowest floor slab	RC 32/40 70% GGBS (1	New		No	255.0	m3	101.1	0.0	0.0	300 mm slab thickness
Superstructure	Columns	Steel	Existing	105%	Yes	2.5	m3	4.3	0.0	-49.3	UC 254 x 254
Superstructure	Beams	Steel	Existing		Yes	4.5	m3	7.6	0.0	-87.3	UB 533 x 210
Superstructure	Secondary beams	Steel	Existing	158%	Yes	8.0	m3	13.8	0.0	-157.4	75% of material in primary beam
Upper floors	Jolsted floors	Timber Joists + OSB top	New		Yes	155.0	m2	1.8	-6.9	-8.5	See "Build-ups" sheet
Roof	Roof	Timber Pitch Roof	New		Yes	850.0	m2	15.5	-69.4	-82.4	See "Build-ups" sheet
Roof	Roof insulation	Woodfibre	New	160%	Yes	340.0	m3	45.3	-96.0	-134.1	250 mm insulation thickness
Roof	Roof	Metal Deck	Existing		Yes	850.0	m2	3.0	0.0	-34.4	See "Build-ups" sheet
External walls	Facade	Load Bearing Brick	Existing	349%	Yes	1451.7	m2	6.4	0.0	-73.1	See "Build-ups" sheet
External walls	Facade	Curtain Walling	New	129%	Yes	536.6	m2	50.9	0.0	-42.9	See "Build-ups" sheet
Internal walls	Partitions	Plasterboard + Timber St	New	127%	Yes	655.9	m2	20.5	-8.5	-25.7	See "Build-ups" sheet
Internal walls	Partitions	Plywood + Timber Studs	New	85%	Yes	439.0	m2	16.5	-21.4	-35.3	See "Build-ups" sheet
External walls	Facade	Load Bearing Brick	Existing	54%	Yes	224.6	m2	1.0	0.0	-11.3	See "Build-ups" sheet
External walls	Wall insulation	Woodfibre	New	120%	Yes	124.8	m3	16.6	-35.2	-49.2	250 mm insulation thickness
Internal finishes	Floors	Earthenware tile	New	60%	Yes	603.0	m2	11.0	0.0	-9.2	10 mm tile thickness
Internal finishes	Floors	Solid timber floorboards	New	40%	Yes	402.0	m2	3.7	-8.8	-11.9	18 mm floorboard thickness
Windows	Glazing	Double Glazing	Existing		Yes	7.6	m3	3.0	0.0	-34.1	Two panes of 6 mm glass
Windows	Glazing	Double Glazing	New		Yes	7.6	m3	40.5	0.0	-34.1	Two panes of 6 mm glass
Windows	Window frames	Timber	Existing		Yes	2655.9	m	0.5	-16.1	-21.6	See "Build-ups" sheet
Services	Services	Low	New		Yes	1005.0	m2	52.3	0.0	-44.0	40 kgCO2e/m2 flat rate estimate

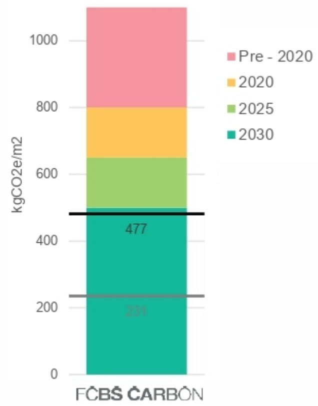
FCBS CARBON [Figure 179]

10.3 Life Cycle Embodied Carbon Calculation

[Figure 181] DISTRIBUTION OF EMBODIED CARBON



RIBA 2030 CHALLENEGE (EQUIVALENT)

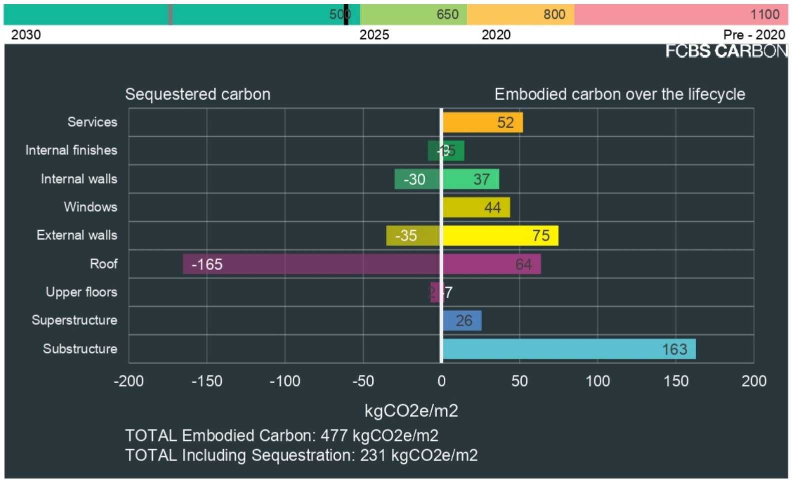


Embodied carbon over the lifecycle [A1-C4]

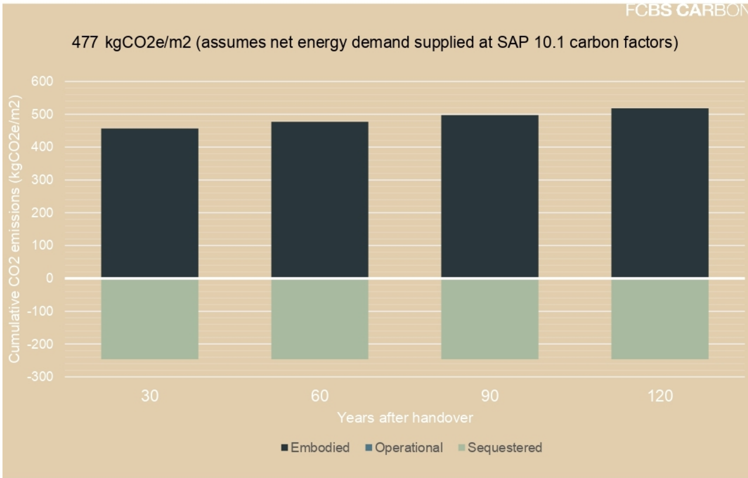
Including potential offsets from sequestered carbon

Summary

- The **results** of the analysis show that our design proposal meets the **RIBA 2030 challenge equivalent**. The **carbon emission** value of **477** could further be reduced to 231 if carbon sequestration is considered.
- The results show that **even after 120 years**, our values slightly change to **518 kgCO2e/m2**, which is still fairly around the 2030 challenge criteria.
- The software is as it is still in BETA testing. However, the FCBS Carbon Tool gives us a fair idea of our measure to meet sustainability aims.



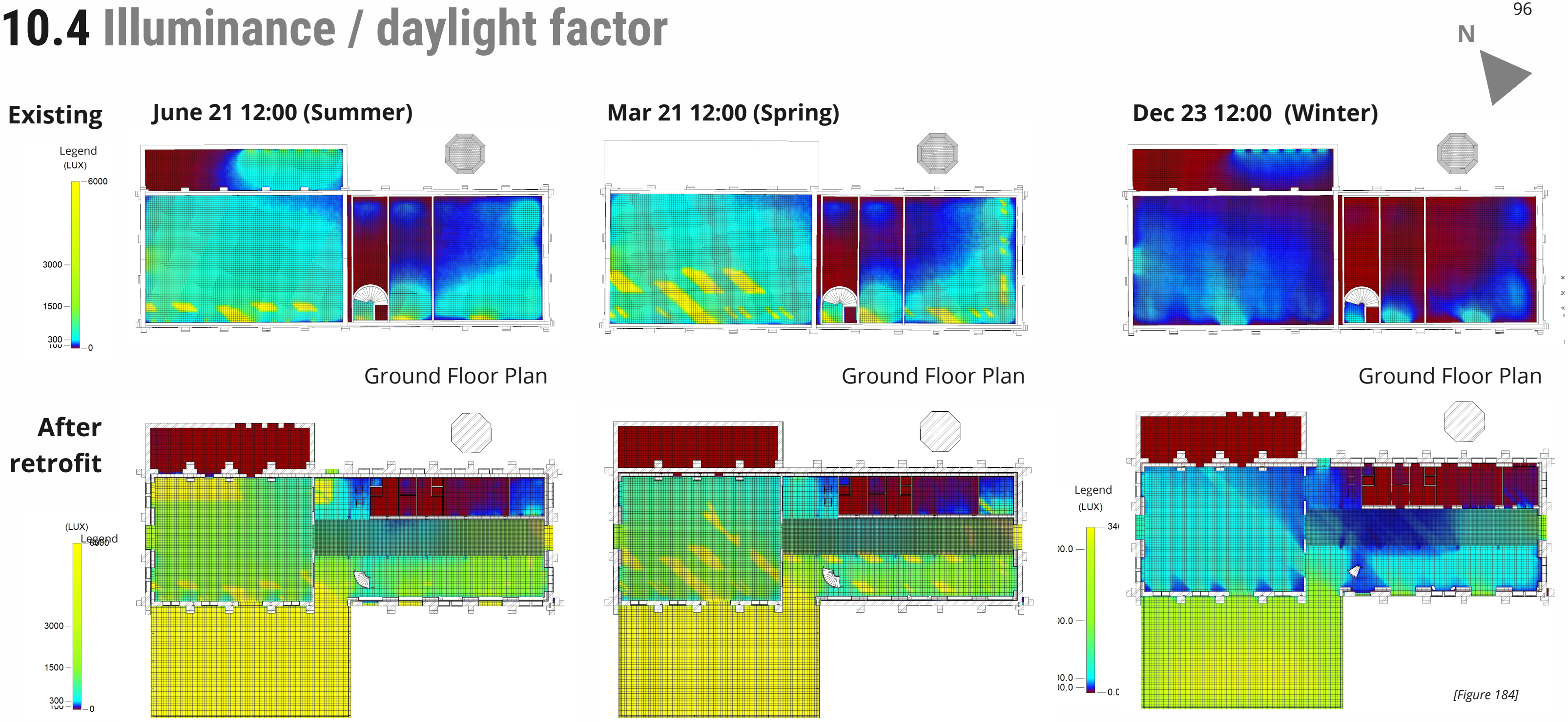
LIFECYCLE EMBODIED CARBON *[Figure 182]*



60-YEAR CARBON IMPACT *[Figure 183]*

10.4 Illuminance / daylight factor

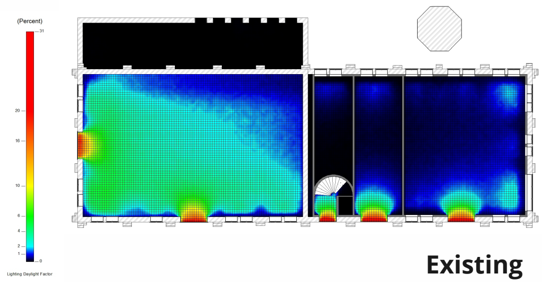
Existing | **June 21 12:00 (Summer)** | **Mar 21 12:00 (Spring)** | **Dec 23 12:00 (Winter)**



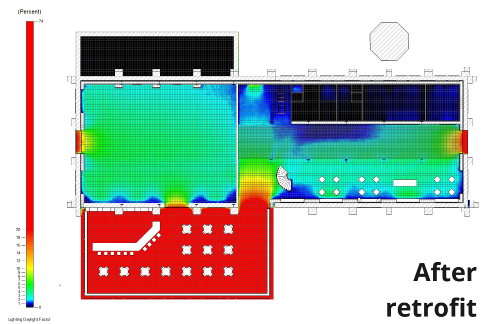
[Figure 184]

Validation

Daylight factor



Existing



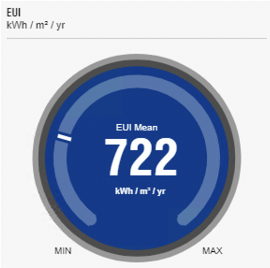
After retrofit

Summary

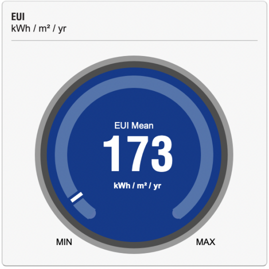
- There has been a significant improvement of internal illuminance, especially in the winter. Daylight factor has increased from **0~2% to 2%~5%.**
- **We have achieved the concrete objective** to maintain indoor lux levels between 300-3000 lux (based on UDI standards).
- Using moveable shading can help to prevent indoor lux levels reaching over 3000 lux.

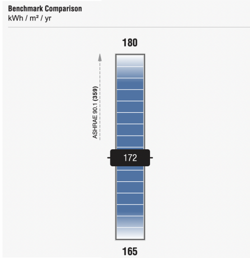
10.5 Energy Analysis Results

Total kWh/m2/yr of
the existing building:

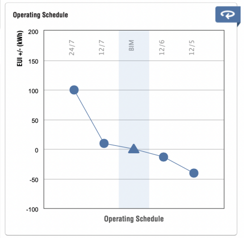


Total kWh/m2/yr of
the new building:

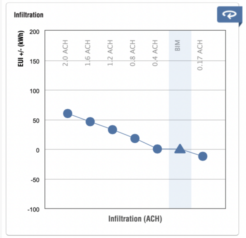




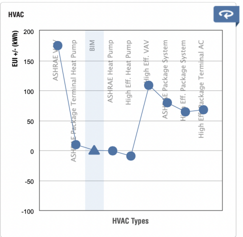
[Figure 186]



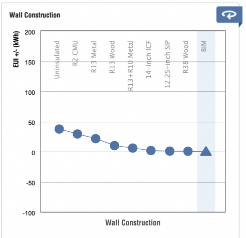
Operating Schedule



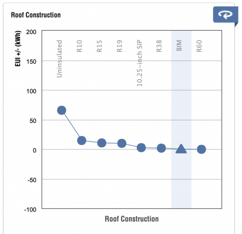
Infiltration



HVAC System (Heating, Ventilation, Air Conditioning)

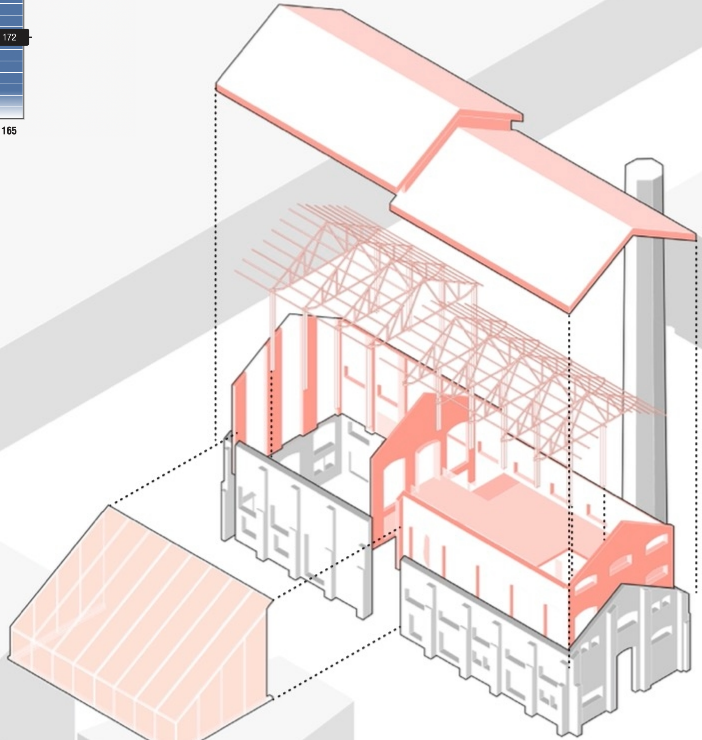


Wall Construction



Roof Construction

[Figure 185]



Summary

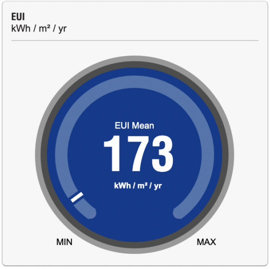
- ***The total EUI Mean for the existing Power Station was 722kWh/m2/yr***
- The biggest changes that were made are to the wall and roof construction and the HVAC type
- ***After making all improvements the total EUI Mean for the Power Station has dropped from 722kWh/m2/yr to 173kWh/m2/yr, reaching our goal set out in our concrete objectives.***
- The improvement to energy usage is 550kWh/m2/hr
- More reductions could be achieved by adjusting the operating schedule however this is not an option due to the function of the building.
- The U value of the wall structure has successfully dropped to **0.1W/m2K** and roof to **0.05w/m2K** to meet our **concrete objective**.

Validation

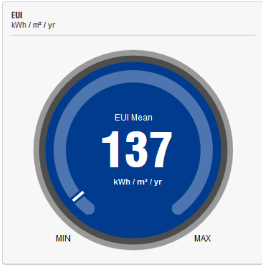
10.6 Energy Analysis without Extension

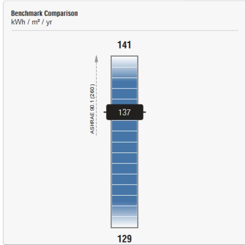
Validation

Total kWh/m2/yr of the new building:

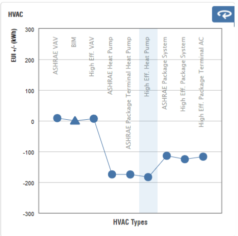


Total kWh/m2/yr of the building **without** the **cafe extension**:

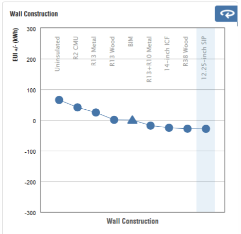




[Figure 187]



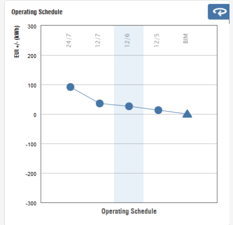
HVAC System (Heating, Ventilation, Air Conditioning)



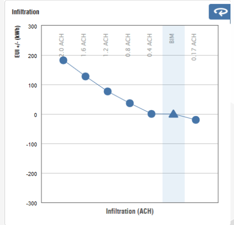
Wall Construction

Roof Construction

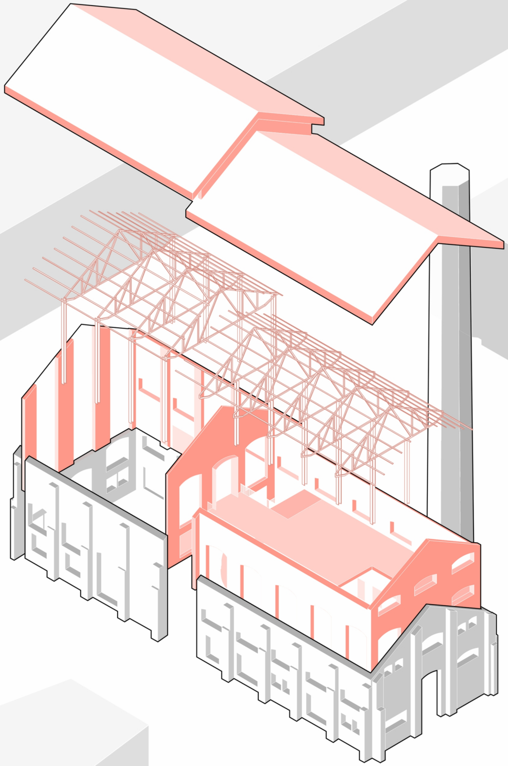
[Figure 188]



Operating Schedule



Infiltration



Summary

- We ran a new energy analysis simulation on the building if we were to remove the extension of the glazing (cafe area)
- Energy use simulations without the cafe indicate a significantly lower value of **137 kWh/m2/y**. However, research on several **post-occupancy evaluations** in Helsinki indicate the **need for social spaces** like restaurants and cafes with optimum lighting levels and a **'lively' atmosphere**. As a result, for the **building to behave as a community hub**, we have retained the cafe extension. This would contribute to the **wider social well-being of the community**, especially given that the Pasilan Konepaja complex is also a venue for the Oktoberfest. Thus retaining the spirit of the neighbourhood.
- **Over-heating** in the summer would be significantly **reduced on account of the photovoltaic glazing roof**. The wall **glazing** could also be **opened facilitating natural ventilation** and a physical connection to the outdoors.

10.7 Extension Glazing Reduction

We considered a reduction of the cafe glazing percentage in order to...

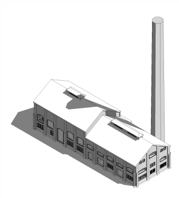
- cross-check energy consumption levels
- see the effect it had on the internal illuminance
- understand the visual impact

[Figure 189]

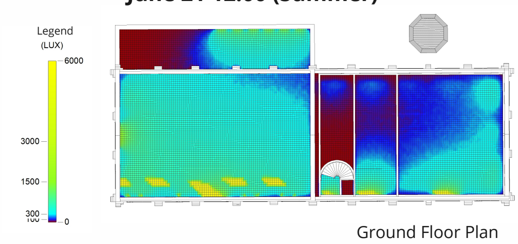
10.8 Extension Glazing Reduction - illuminance / daylight factor

Validation

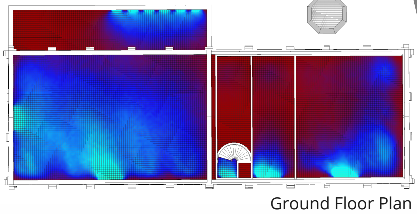
Existing



June 21 12:00 (Summer)



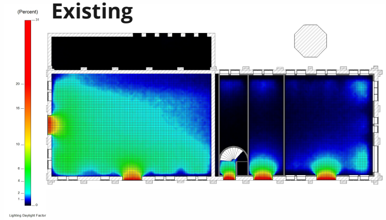
Dec 23 12:00 (Winter)



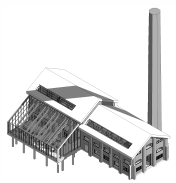
N

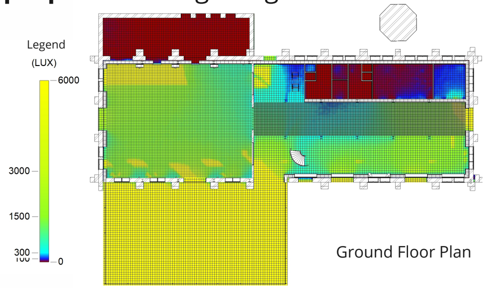
Daylight factor

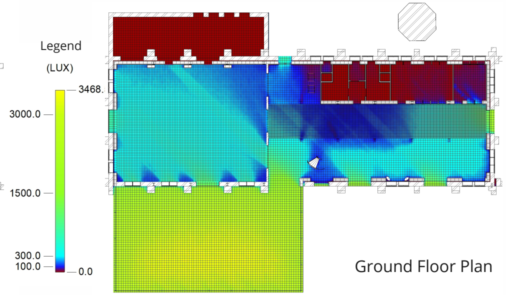
Existing



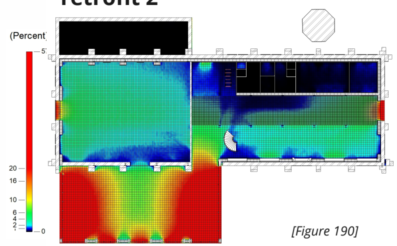
Original design proposal 100% glazing





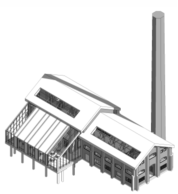


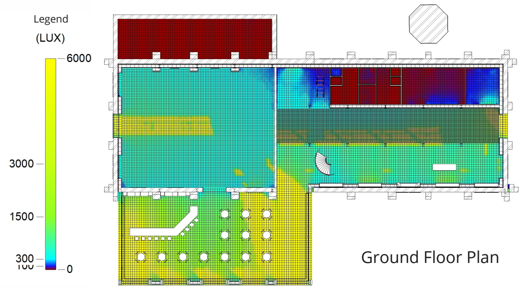
retrofit 2

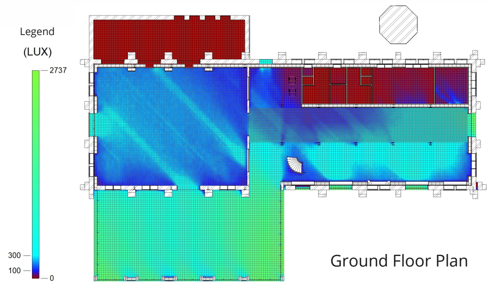


[Figure 190]

Alternate cafe design 40% glazing





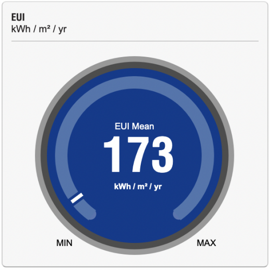


Summary

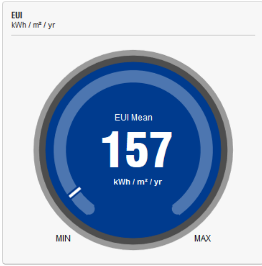
- In our original design proposal the illuminance levels **reached our concrete objectives** and were optimal.
- In the alternate cafe design we have covered **more than 50%** roof to prevent significant **solar gain in summer**.
- However, in the illuminance simulation of the alternate proposal, we found that the there was a **significant drop of indoor illuminance, mostly under 300 lux.**

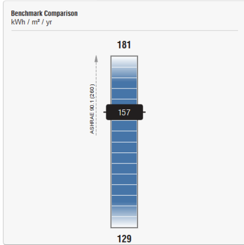
10.9 Extension Glazing Reduction - Energy Analysis

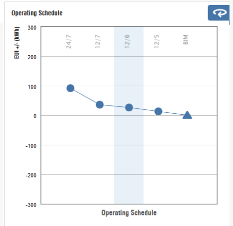
Total kWh/m2/yr of the new building:



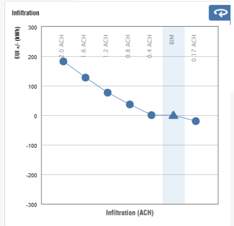
Total kWh/m2/yr of the building **with reduced cafe glazing**:



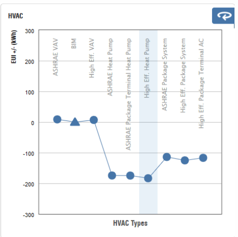




Operating Schedule



Infiltration



HVAC System (Heating, Ventilation, Air Conditioning)

Wall Construction

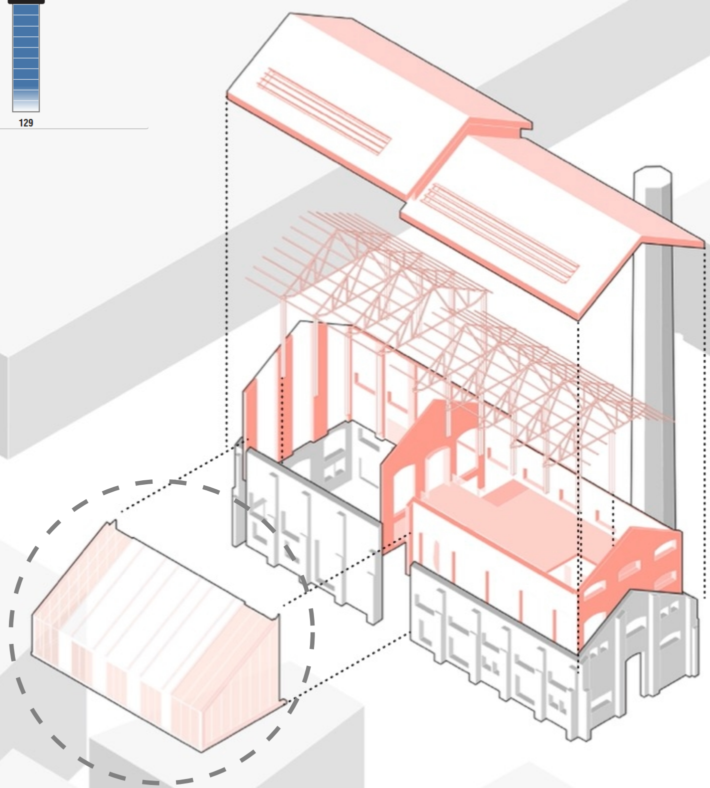
Roof Construction

[Figure 191]

Validation

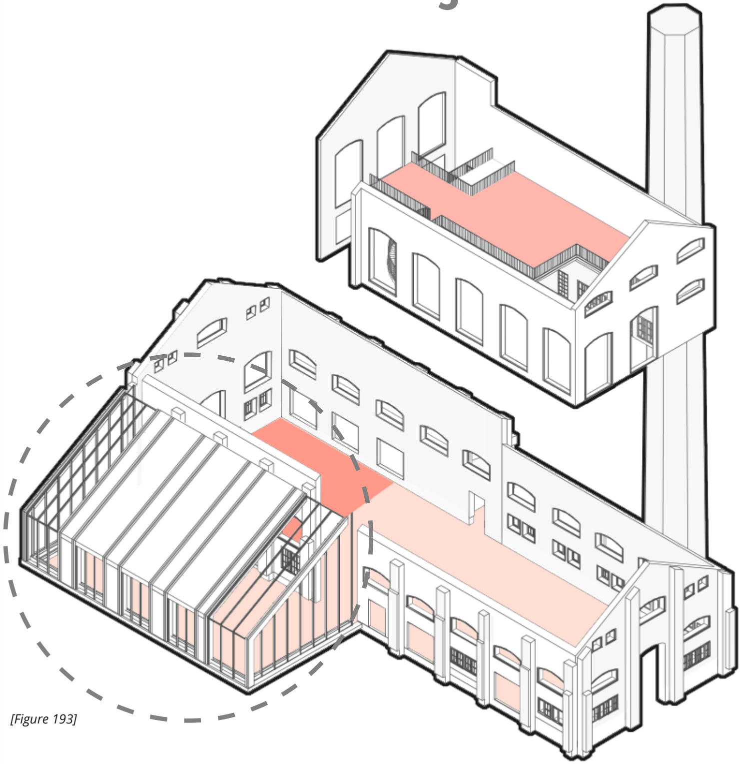
Summary

- We also ran an **energy analysis simulation** on the building if we were to **reduce the extension glazing (cafe area)**
- Energy use simulations indicate a minor reduction to **157 kWh/m2/y**.
- Over-heating in the summer would be slightly reduced further. However, the **visual connection** from the indoors to the outdoors (and vice-versa) would be **limited**.
- The **south facade** of the building would also be **impacted dramatically**. Given the **historic significance** of the building and the **importance of its aesthetics to the local community**, this option might **not** be the most **appropriate solution**.



[Figure 192]

10.10 Extension Glazing Reduction

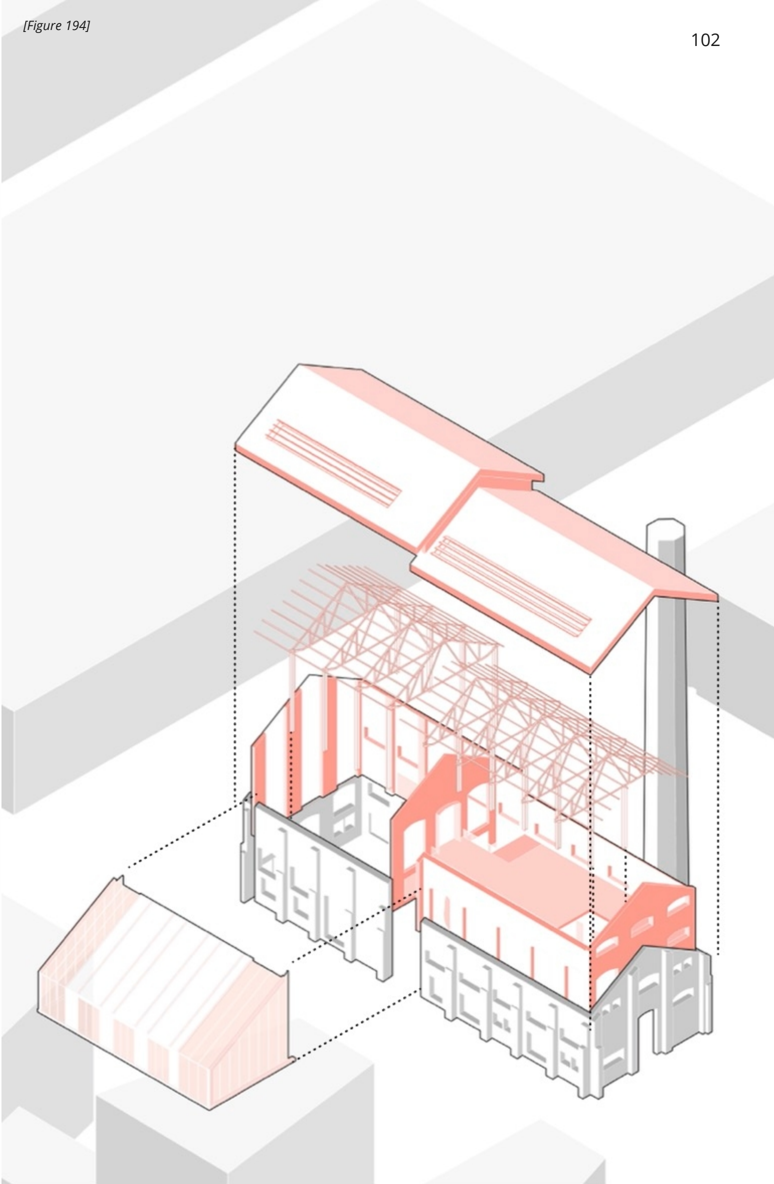


[Figure 193]

Summary

- We have **concluded**, from the simulations of a lower glazing percentage of the cafe area, **to retain the glazing as per the original design proposal.**
- Our **energy analysis** results were better, however only by a **small** amount (specifically, an **improvement of 16kWh/m2/yr**).
- However, our **illuminance analysis** proved that this **new cafe design** would result in a **significant loss of light in the studio space**, especially in winter, and this would **not meet our primary or concrete illuminance objective**.
- **We felt that 16kWh/m2/yr wasn't a significant enough improvement in our energy analysis on this design to sacrifice such a severe drop in internal illuminance levels**.
- Our primary and concrete objectives are still met in the original design proposal.

[Figure 194]



Bibliography: *Figures and References*

11.1 List of Figures

Bibliography

11.2 List of Figures

Figure 32: Livady. (2012). Voilmala Pasilan Konepaja Rakennushistorian Selvitys Ja Inventointi. Helsinki. Retrieved from https://livady.fi/wp-content/uploads/Konepaja_Voimala.pdf

Figure 33: Authors own. Authors own. Information taken from Livady. (2012). Voilmala Pasilan Konepaja Rakennushistorian Selvitys Ja Inventointi. Helsinki. Retrieved from https://livady.fi/wp-content/uploads/Konepaja_Voimala.pdf

Figure 34: B&M Architects Ltd. (2012). Konepaja Office Block. B&M Architects Ltd. Retrieved February 8, 2021, from http://www.bm-ark.fi/konepaja-office-block/

Figure 35: ARK-house arkkitehdit Oy. (2007). Pasilan Konepajan Alue. ARK-house arkkitehdit Oy. Retrieved February 8, 2021, from https://www.ark-house.com/pasila.html

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[Figure 1]

THANK YOU

THE POWER STATION OF PASILA KONEPAJA

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