



THE HIGH GARDEN

M. Arch II, UMA 5, (2019-2020)

Type Location

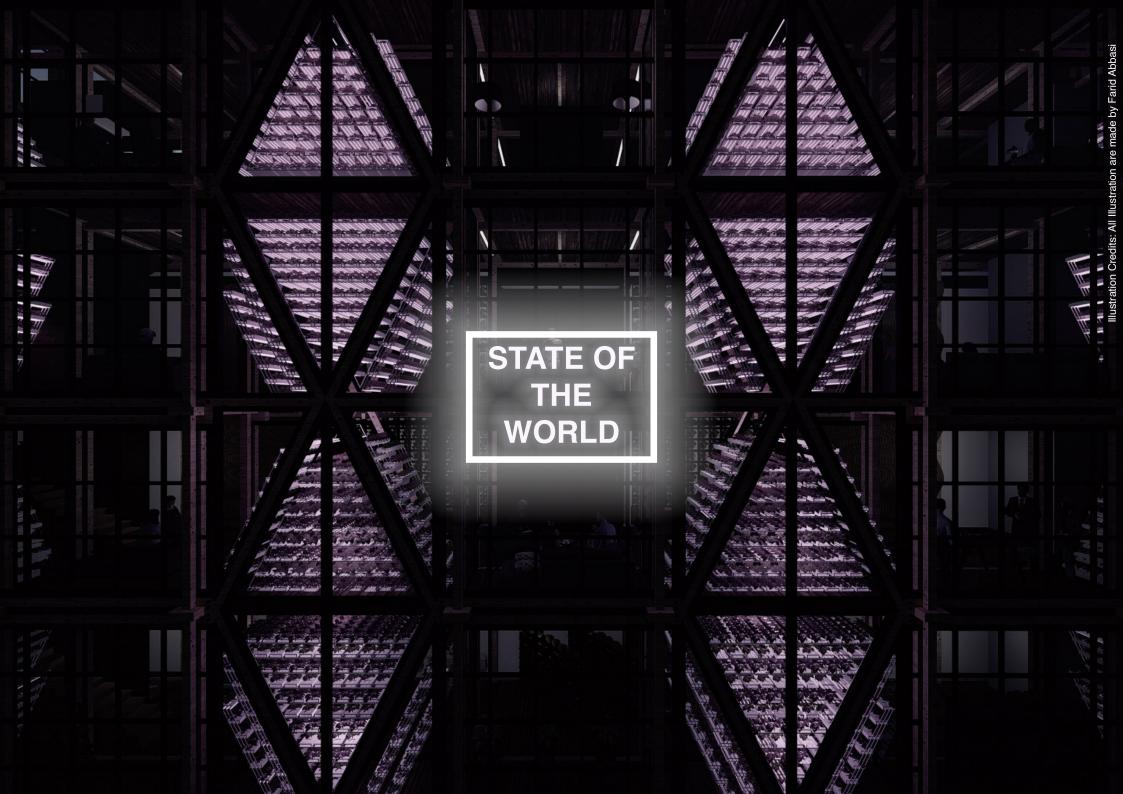
Typology

: M.Arch Thesis, Individual

: Stockholm , Sweden : Modular Extension

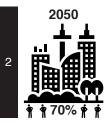
Area : Varies

The High Garden Is an Architectural exploration concerned about rapid urbanization, the sustainability of architecture, Climate change and food safety in urban centres. Inspired by Ancient Japanese Architecture, modern timber engineering and IoT in Architecture, the project develops and tests a series of tools. The High Garden develops an algorithmic analysis tool which analyses the cities and finds prospect sites for intervention. Through modular timber architecture and sun and exposure analysis, it forms a sustainable timber extension for buildings with possibilities of vertical farming. Formed by sustainable materials, it not only improves existing buildings insulation but opens new doors for the buildings and revitalizes them for the civic.



By applying the most conservative estimations regarding population growth provided by the UN, the world's population will increase by about 3 billion until

Growing at a slower pace, world population is expected to reach 9.7 billion in 2050 and could peak at nearly 11 billion around 2100, news, https://www.un.org/development/desa/en/news/population/world-population-prospects-2019.html



By the year 2050, approximately 70% of the earth's population will live in urban centres

https://www.un.org/development/desa/en/news/pop¬ulation/2018-revision-of-world-urbanization-prospects. html



As the world population continues to increase, it is projected that we will need to construct 3 billion units of affordable and sustainable housing over the next 30 years

Green, Michael, and Jim Taggart. Tall Wood Buildings: Design, Construction and Performance, Walter de Gruyter GmbH, 2017. ProQuest Ebook Central, https://ebookcentral.proquest.com/lib/umeaub-ebooks/detail.action?docID=4851850



Construction and demolition waste (CDW) is one of the heaviest and most voluminous waste streams generated in the EU. It accounts for approximately 25% - 30% of all waste generated in the EU and consists of numerous materials, including concrete, bricks, gypsum, wood, glass, metals, plastic, solvents, asbestos and excavated soil, many of which can be recycled.

Green, Michael, and Jim Taggart. Tall Wood Buildings: Design, Construction and Performance, Walter de Gruyter GmbH, 2017. ProQuest Ebook Central, https://ebookcentral.proquest.com/lib/umeaub-ebooks/detail.action?docID=4851850



concrete is already responsible for between 5 to 8 per cent of Global Greenhouse emissions. Furthermore, we produce approximately 3000 kilos of concrete for every person each year. Moreover, our second most used and common material in construction is steel and whilst it is less carbon-intensive compared to concrete, the production of steel results in 4 per cent of global energy use

The Intergovernmental Panel on Climate Change, IPCC, website,2007, Retrieved from http://www.ipcc.ch/PDF/assessment-report/ ar4/wg3/ar4_wg3_full_report. Pdf



In 2019, agriculture used 50% of global habitable land area

FAO. 2019. World Food and Agriculture – Statistical pocketbook 2019. Rome. https://ourworldindata.org/land-use



An estimated 109 hectares of new land (about 20 per cent more land than is represented by the country of Brazil) will be needed to grow enough food to feed this new number of people if same traditional farming methods are going to be used as they are practised today

Despommier, Dickson. The Vertical Farm: Feeding the World in the 21st Century. New York: Thomas Dunne Books/St. Martin's Press, 2010. Print. www.googlemaps.com



According to FAO (food and agriculture organization of the United Nations), Water use grew at almost twice the rate of population increase and on average and agriculture accounts for 70% of global freshwater withdrawals

Water for Sustainable Food and Agriculture, A report produced for the G20 Presidency of Germany http://www.fao.org/3/a-i7959e.pdf



WHO estimates that 844 million people lack basic drinking-water service and that by 2025, half of the world's population will be living in water-stressed areas

Water for Sustainable Food and Agriculture, A report produced for the G20 Presidency of Germany http://www.fao.org/3/a-i7959e.pdf



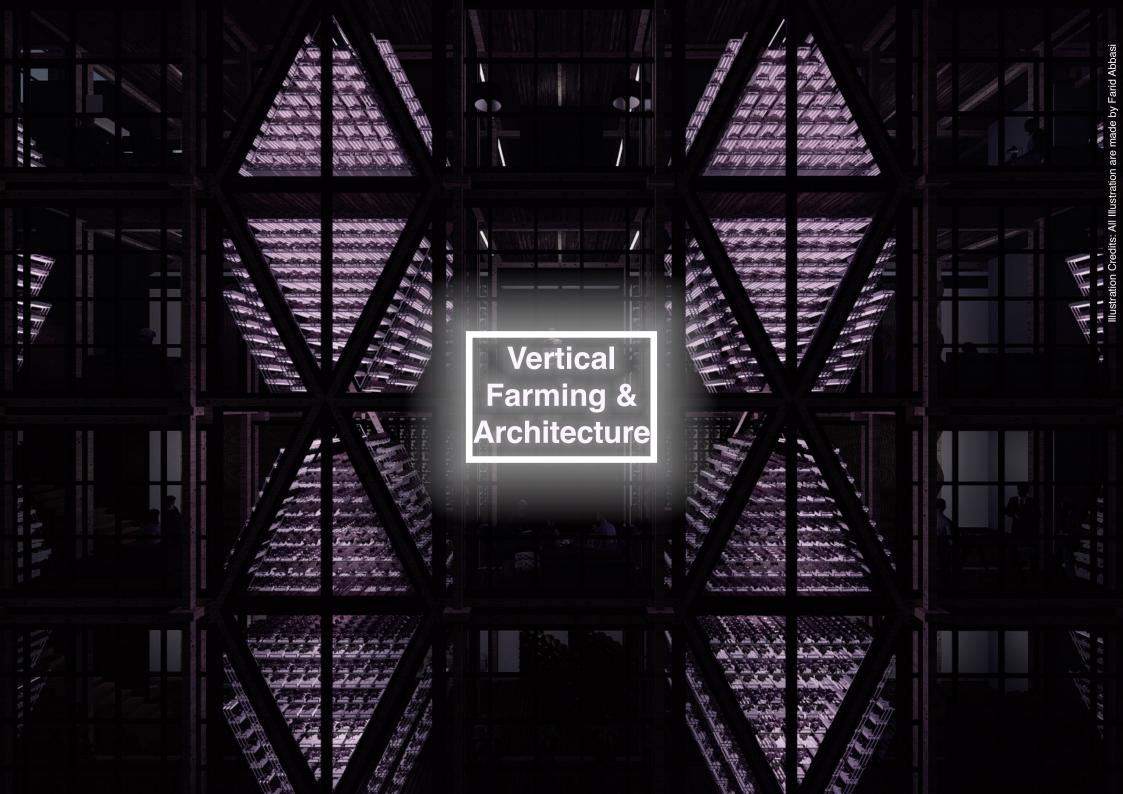
Some 795 million people in the world do not have enough food to lead a healthy active life. That means one in every 7 people globally.

www.wfp.org/hunger/stats



According to Professor Dickinson Despommier, by 2030, one of our most challenging problems is regarding food safety and access to healthy and nutritious food in urban centres. He argues that the only way that we can overcome this problem is to find ways to introduce vertical farming inside our cities .

Despommier, Dickson. The Vertical Farm: Feeding the World in the 21st Century. New York: Thomas Dunne Books/St. Martin's Press, 2010. Print. http://www.verticalfarm.com/.





Geoponic Farming

The conventional Farming method or Geoponics is a cultivation method whereby the seeds are planted inside the soil. Geoponics requires massive fertile lands and is affected by climate. Since it is planted inside the soil, it requires a lot of pesticides the majority of which are harmful to human's health by some extend. It requires a lot of freshwater resources and because the majority of farmlands are located outside of city centres, the produced food is therefore required to be transported. Food's transportation not only emits Co2, but it also takes time. Therefore, the majority of vegetables and fruits have already lost some or all of their nutritious value by the time they are consumed in urban areas. Lastly, because of the interval between cultivation, harvesting and consumption, a portion of food is wasted.

[1] Killebrew K., Wolff H. "Environmental Impacts of Agricultural Technologies". Evans School of Public Affairs. University of Washington. [(accessed on 1 December 2014)]. Available online:http://econ.washington.edu/files/2014/06/2010-Environmental-Impacts-of-Ag-Technologies.pdf

[2] Walls M. "Agriculture and Environment. MTT Agrifood Research Finland". December

Geoponic Farming Limitations



Requires massive fertile land over the Globe



Requires massive fresh water resources



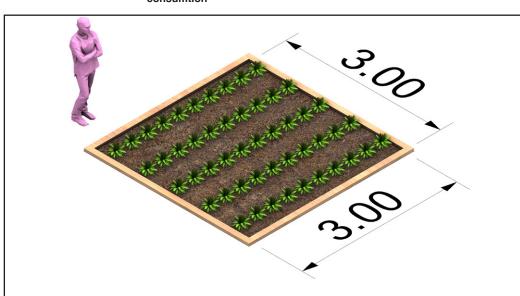
Requires harmful pesticides



A lot of Food is wasted before consumption



Food transportation emits Co2 and food loose a portion of their nutritious value before consumtion





Vertical Farming

The idea of using a large multi-storey building to cultivate agriculture products is not a new concept. Vertical Farming first was introduced by an American geologist, Gilbert Ellis Bailey which in his book titled Vertical Farming (1915/2011) [1]. Vertical farming is the practice of growing products in vertically stacked layers often in several storeys. The practice can use soil however hydroponics, aeroponics or aquaponics do not need soil for cultivation. Since all the farming in this method is undertaken in controlled environments the products are therefore not affected by the climate. Moreover, by utilizing vertical farming methods, we can lower the water usage to 98 per cent, pesticides to 100 per cent and land yield to only 9 per cent. Vertical farming typically uses a mix of natural light and artificial light. Artificial lighting is often (Blue Red) LED-based lighting and can be driven by renewable power sources such as solar or wind power.

[1] Killebrew K., Wolff H. "Environmental Impacts of Agricultural Technologies". Evans School of Public Affairs. University of Washington. [(accessed on 1 December 2014)]. Available online:

http://econ.washington.edu/files/2014/06/2010-Environmental-Impacts-of-Ag-Technologies.pdf [2] Walls M. "Agriculture and Environment, MTT Agrifood Research Finland", December

Vertical Farming Benefits



Produces fresh food every day all year long



Lowers the fresh water use to 98 per cent



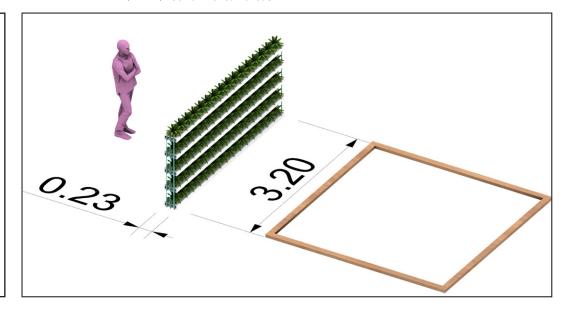
Does NOT requires harmful pesticides



Lowers the food waste



Lowers the food transportation. Benefits food safety and access to healthy food all year



Vertical Farming Solutions:

1: Nutrition Film Technique (NFT): NFT is one of the most user-friendly and common ways of utilizing vertical farming. AEROFARM® company is one of the most influential companies providing these solutions to their users. Through research and align to studying the impact of IoT in architecture, the thesis has developed an algorithm which uses AEROFARM design solutions and makes it an algorithm. Through using this algorithm, the designers are able to not only design their proper vertical farming NFT but get reports on how much electricity is needed, how much pipe is required, etc.

Picture of Aerofarm® nutrition film technique vertical farming solution. This illustration have been deleted in this publication due to copyright reasons

Growing Rack Floor Distance

Growing Rack Floor's No

Growing Rack Floor's No

Growing Rack Floor's No

Water Pipes

Farming Trey

Lights Farming

The Length of each seperate light

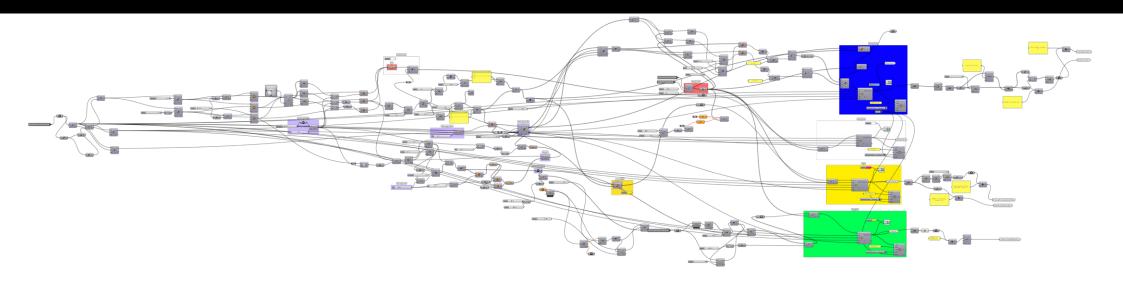
Number of Seperate Lights

Vegetable

Number Of Vegetables Report

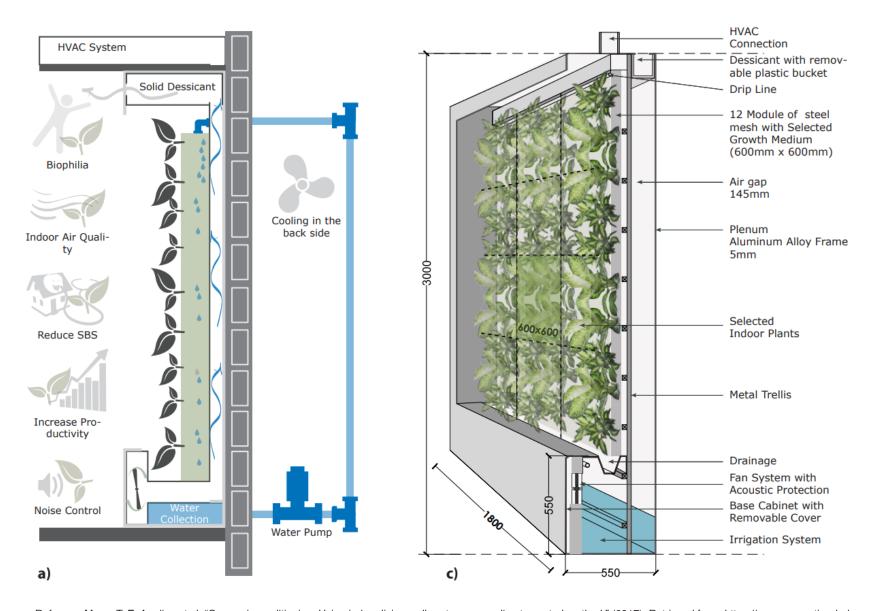
All Rights Reserved Aerofarm

Project Algorithmic Design Solution

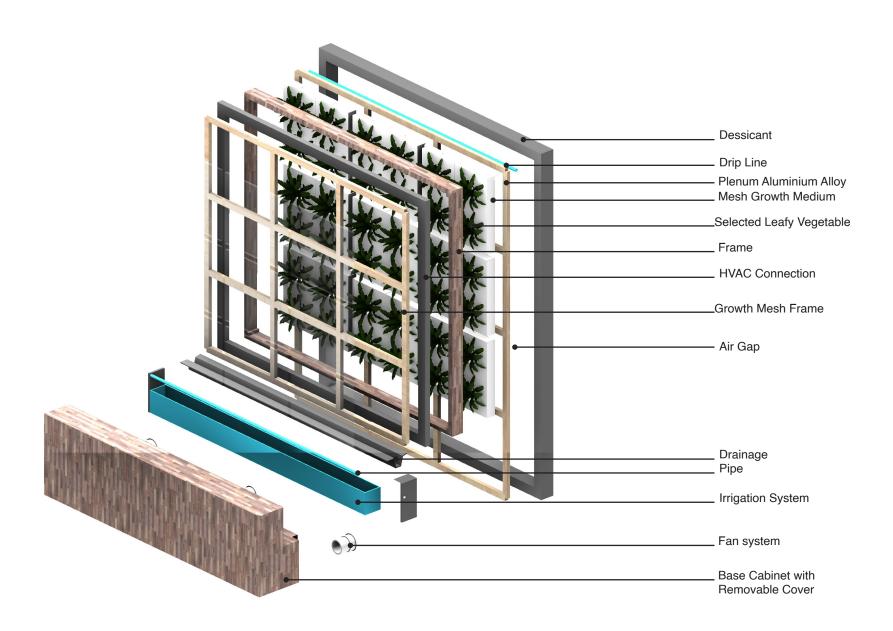


Vertical Farming Solutions:

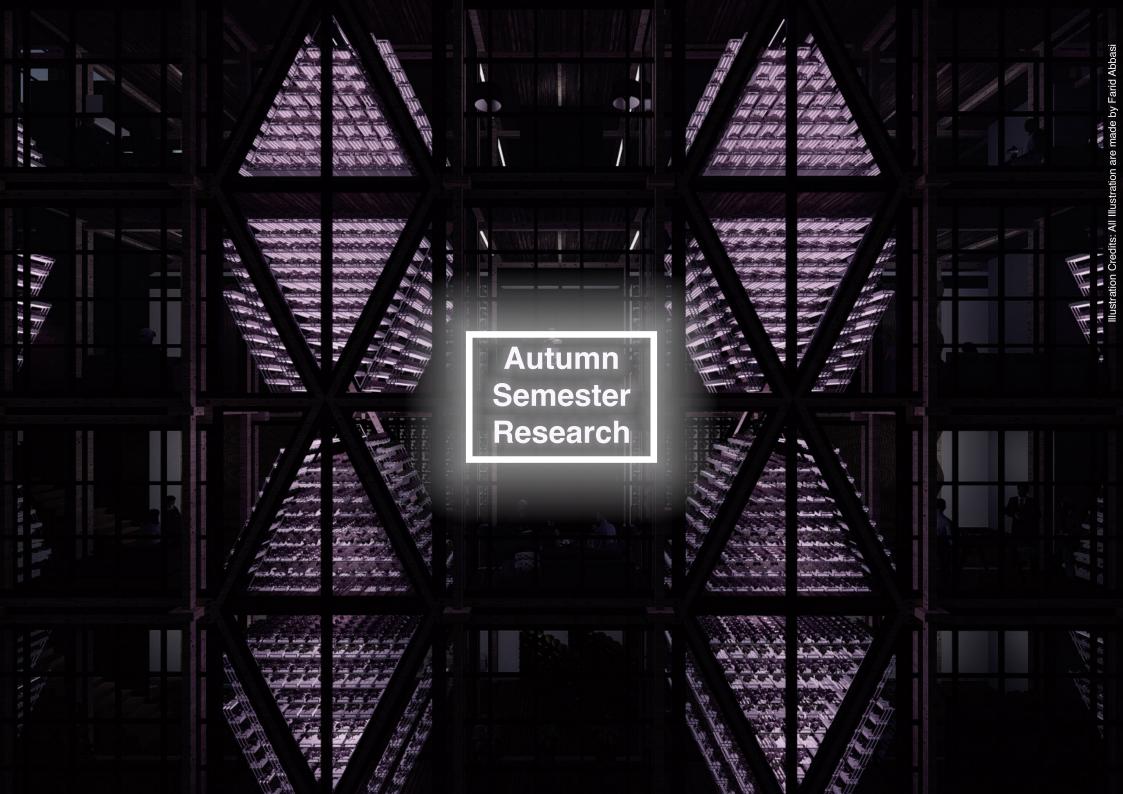
2: GREEN LIVING WALL: Through studying the principles of green wall design, The High Garden understands and utilizes this design principle to revitalizes interior walls of the design, Transforming the walls into growing solutions and maximizing the greenery and productivity of the design. These green walls have a positive impact on indoor air quality, have good sound insulation, increase resident's productivity and lastly, works with Biophilia sense in people, Bringing living greenery closer to humans.



Refrence: Moya, T. E. Armijos et al. "Green air conditioning: Using indoor living wall systems as a climate control method." (2017). Retrieved from: https://www.semanticscholar.org/paper/Green-air-conditioning%3A-Using-indoor-living-wall-as-Moya-Dobbelsteen/9a5a2a73829ce65e47817fc67407423135e938a3 Accesed (03/05/2020).









Modular Architecture



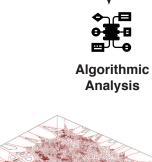








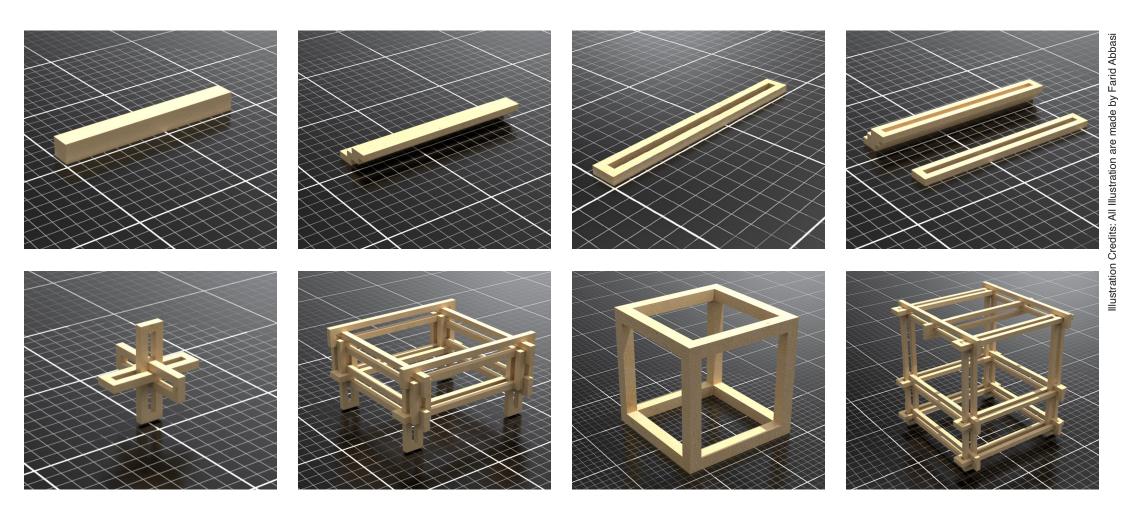






Autumn Semester Preparatory Research:

Autumn semester was divided into two parallel research. After understanding the State of the World and Vertical Farming, The thesis tried to develop a modular Architecture base on timber to give the project more flexibility in terms of its structural design. Moreover, dealing with a large amount of data and a large number of prospect sites, the thesis has developed an analytical algorithmic tool capable of analysing big plots of urban areas and pin-pointing possible intervention prospects. The modular timber structure of the thesis is aligned with the project's concerns about the sustainability of architecture and the Algorithm stems from the Author's argument on appendix 1 around impacts of IoT on Architecture and its benefits.



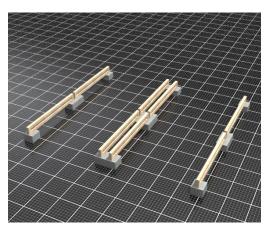
Ancient Japanese Architecture and Engineered Timber:

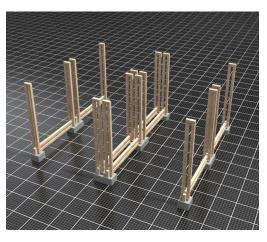
Inspired by Ancient Japanese Architecture and its interlocking elements, the project tries to utilize the same design thinking with contemporary engineered timber elements. Through using glulam and to lower the structural burdon of the timber elements and forming a lighter structure, the design divides the elements into series of smaller ones and by making their cores hollow, it tries to utilize the inner rigidity of the materials as an interlocking factor. Through using timber in this way, we lower the use of other materials such as steel and concrete for joineries and answer to the need for lowering the consumption of these Co2 heavy materials.

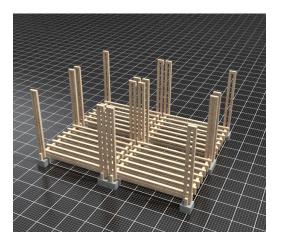
Benefits of the Structure:

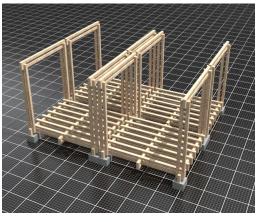
- 1 Wood is considered a local and a sustainable material in Sweden and compared to steel and concrete, has a positive impact on climate change
- 2 Wood is a smart and user-friendly material and is optimal for DIY or modular architecture since it is can easily be CNC milled and transported
- 3 By maximizing the use of wood, we can lower the use of other materials.

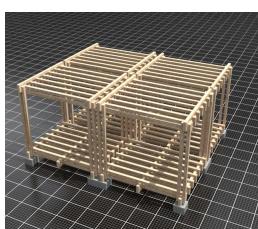


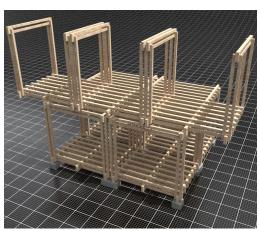


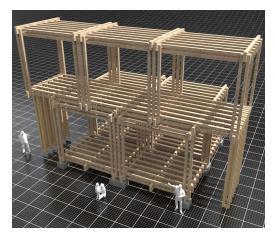


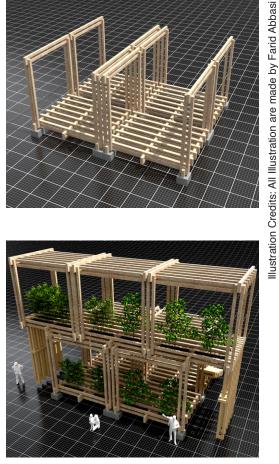












Testing Configuration 1 (Early Stages)

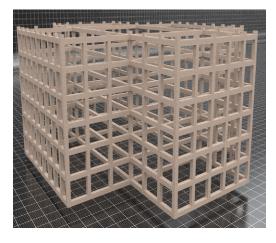
The module can be formed as a horizontal configuration for ground floor assemblies. This Module was an initial test of the system to realize the issues and challenges of the structure. Through Sun path analysis of the urban plots, the project realized there were a lot of rooftops and courtyard with good sun exposure and no visible activity. The design aims to harvest the potential of these spaces and design toward a more sustainable Urban fabric.

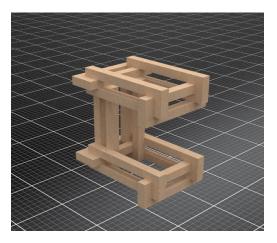


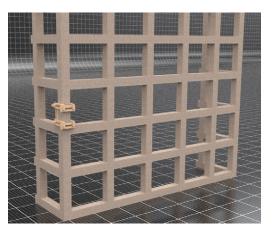
Modular Architecture

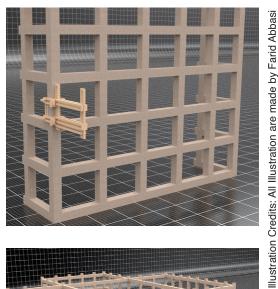
The issues found were:

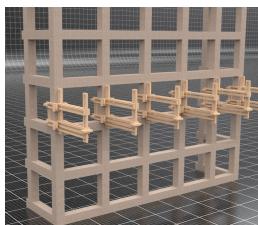
- Exess use of timber and therefore using redundant number of elements due to structual uncertainity and modularity of the structure
- Unknowing stress parts of the structure because of its timber structure and its rigidity in real world circumstances
- Stability of the interlocking timber joints





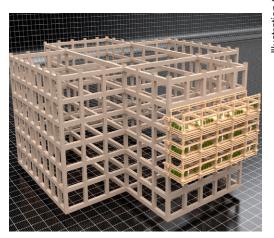












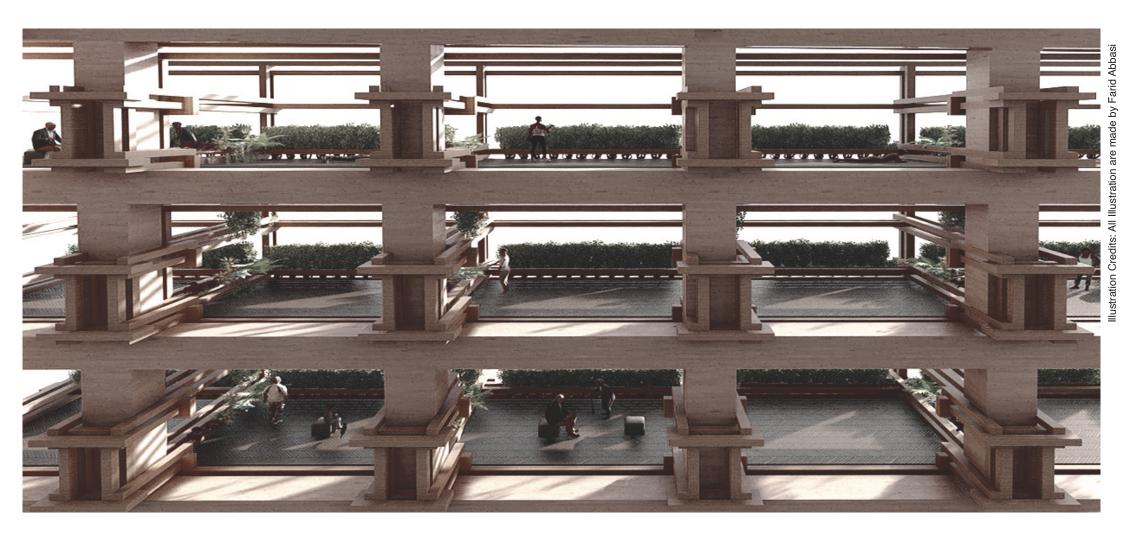
Testing Configuration 2 (Early Stages)



The module can form a modular timber extension for existing buildings. By forming an extension for the existing building, not only the system reconfigures and revitalizes the urban areas for the future, but helps existing buildings to perform better in terms of insulation. By considered design process, we can blend the borders of the facade and the street and open proper buildings to the public and their neighbouring streets.

The issues found were:

- 1 System self-holding properties. If the system is required to be connected to existing buildings, it may result in an unrealistic extra weight for the existing.
- 2 The space that is resulted by the extension, should form a joint platform if the project's aim is to utilize part of these spaces for vertical farming.
- For residential buildings and private owned properties, the extension requires a more challenging extension permits compared to public owned.



Autumn Semester Modular Design Reflections:

After designing an interlocking modular timber structure, it was evident that structure and thinking behind the project had potentials regarding the concerns of the project. The design and the critic's comments resulted in understanding the limitations and advantageous of the structure which formed the initial steps of the spring semester

The Potentials of the Modular Design Were:



The prefabricated modular system of the units offer enhances manufactoring precision, minimizes waste material, and decrerases cost and timeline of the construction.





Wood has been chosen to be the dominant material of the project. Timber has the potential to act as an environmental carbon capture technology and is the only construction material that captures and stores Co, both in growing and when they are used in construction.





As more people reside in urban centres, they are getting more divided to the nature and there are scientific studies which suggest that social wellbeing and health is affected by this trend. The projects paramount aim is to re-introduce civic with greenary and nature

Algorithmic analysis Tool.

- Impact of the IoT on Architectural Practice and its impact. Appendix



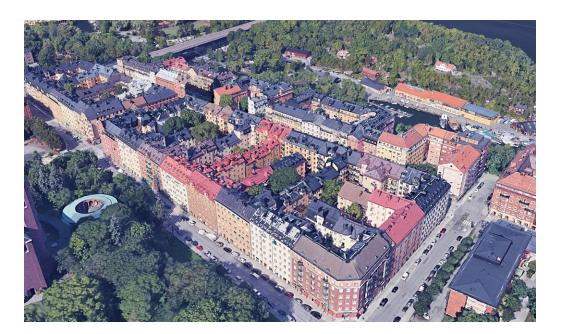
The Project starts with the understanding and analysing the current state of the world. Therefore it

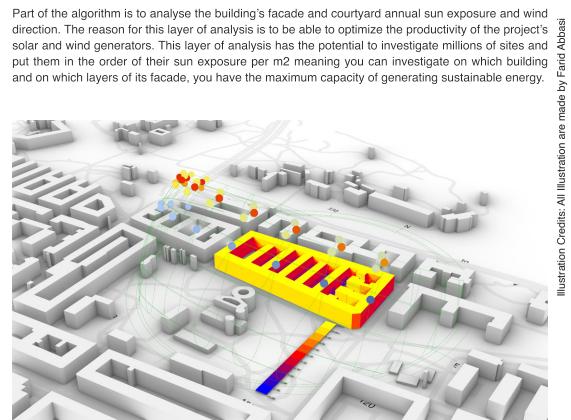
was also essential for the project to analyse the contemporary tools and their impact. One of the most

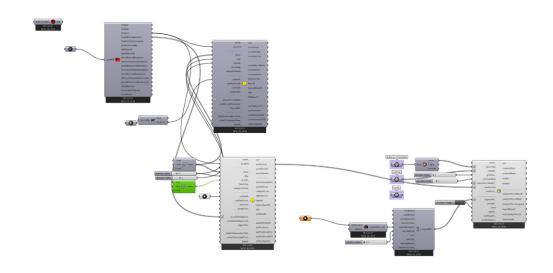
Algorithmic analysis Tool.

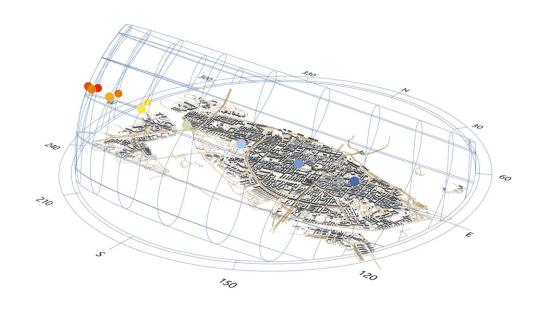
- Impact of the IoT on Architectural Practice and its impact. Appendix

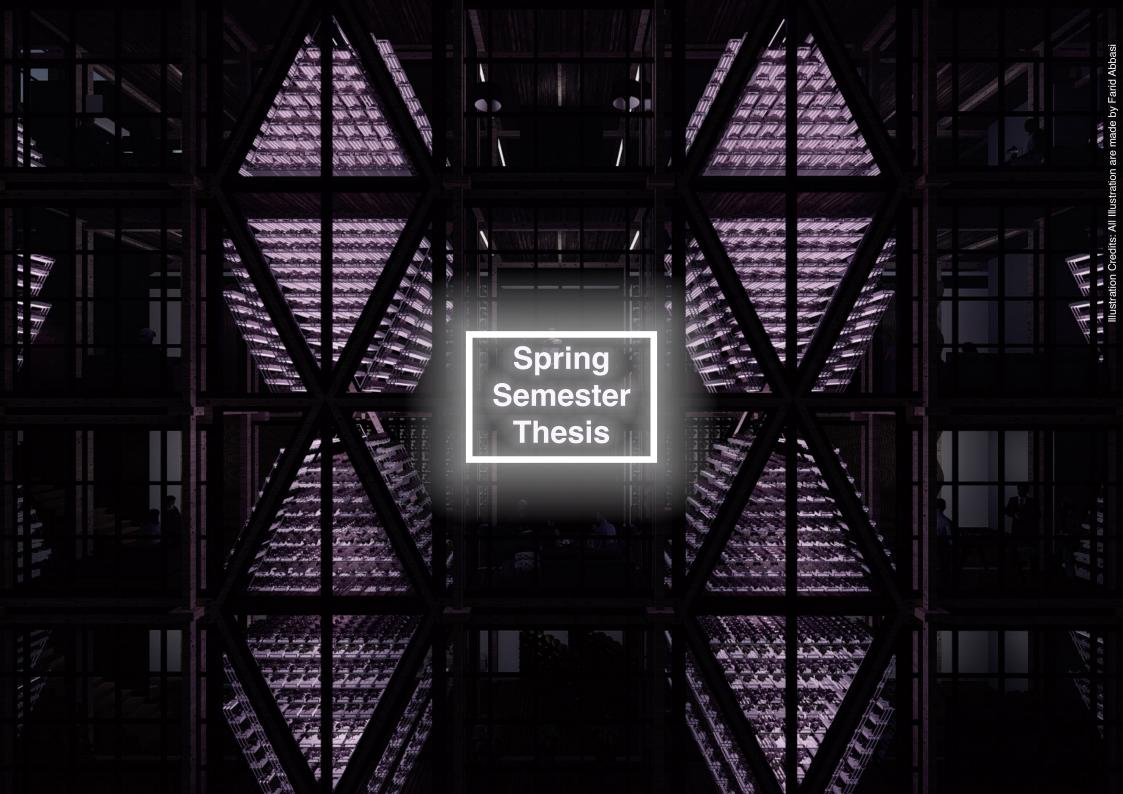
Part of the algorithm is to analyse the building's facade and courtyard annual sun exposure and wind







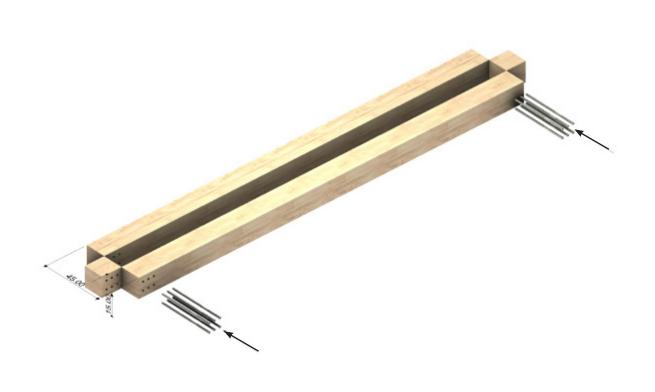


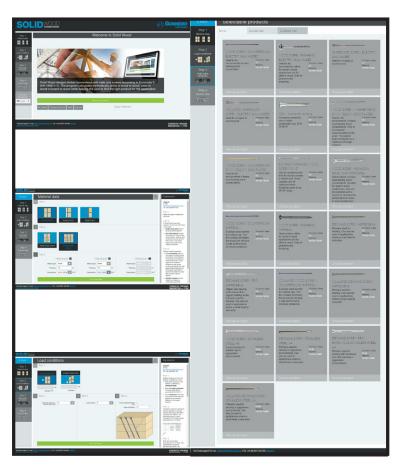




Structural adjustments and talking with engineers

After discussing the designed modules and aims of the project with Martinson's engineer and although the developed system was analyzed ok with him, we discussed the structure further and perfected the design to be more structurally valid, more resistant toward torsion and stress and be more reliable with humidity by using a special fastener called:
WOODEN SCREW DOUBLE THREADED SW-D





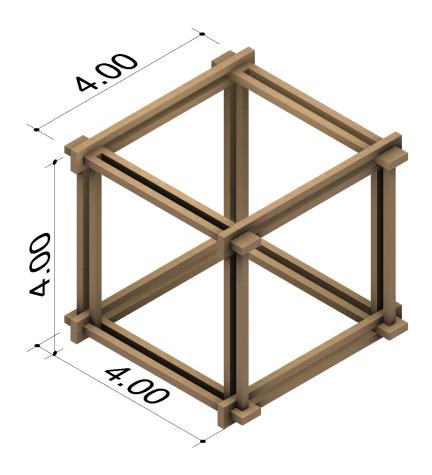
Solid Wood by Gunnebo Fastening. Retrieved from: http://solidwood.gunnebo-fastening.se/.

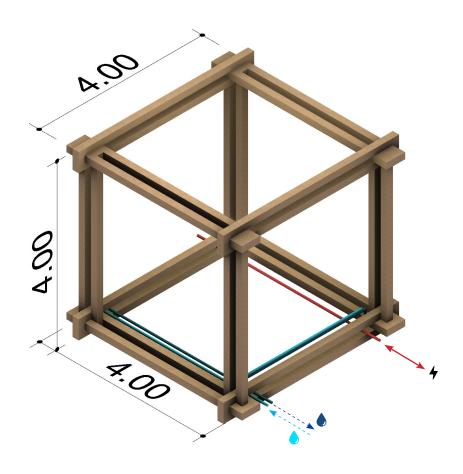
Structural Diagram of the timber structure: Made by Farid Abbasi



Forming Modules:

After consulting with an engineer and enhancing the design in terms of its structural value and also the rigidity of the timber joints, the project follows the base standards of the market and for a series of Alfa modules (A01, A02, A03). Formed by a 4m in 4m dimension, this modules uses the basics of the design to form a module capable of hosting varies activities. Even though the design elements are showcased as 4m *4m, the dimensions can be changed concerning the buildings. Due to the hollow core of the structure, regardless of the activity above the deck core, all the services will be distributed through the system.









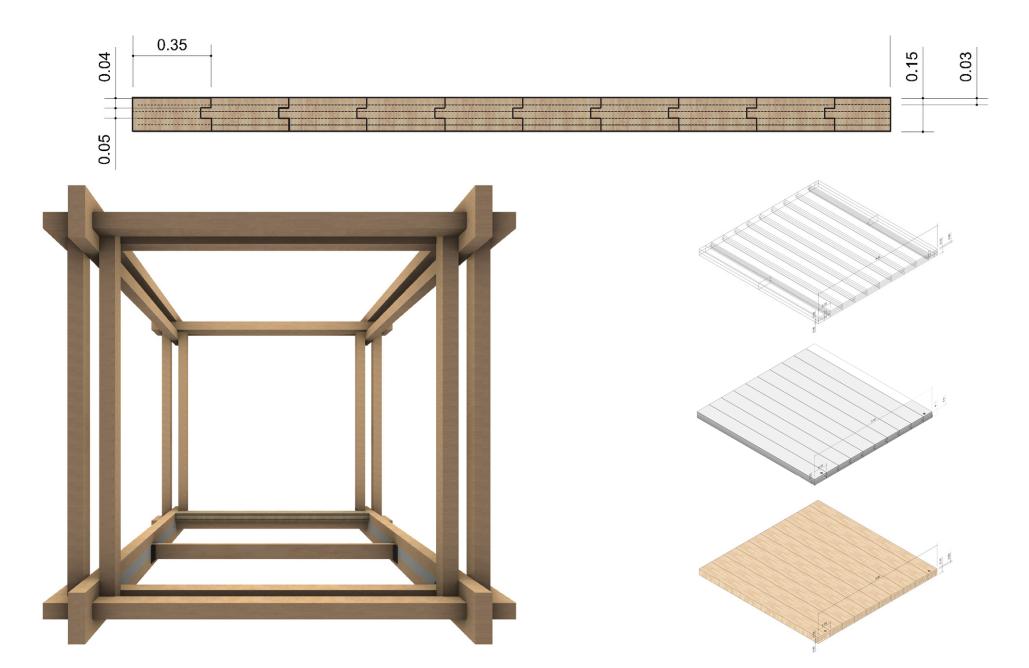
Fresh Water





Floor System:

For the floor system, a technique is used called a suspended timber floor with groove and tongue. According to Swiss sound insulation standards, the system offers good sound insulation alone and does not require extra sound insulation layers and is easily mountable and dismountable and is perfect for the modular and prefabricated system since it can easily be transported and adjusted on site. For extra structural rigidity of the floors, the system also has a timber joist with mechanical fasteners in the middle.





Modular Architecture



(A02) Modules are protected with the double glazed polycarbonate glazed panels from the environment outside. With openings, it is protected from the environment through cold periods and can be opened during summer for the people to be able to enjoy the summer breeze.

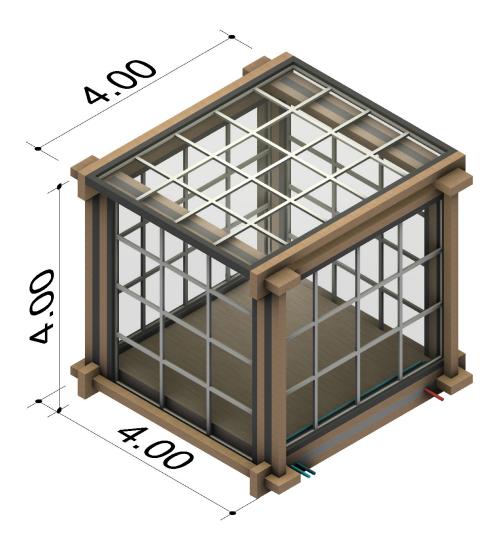


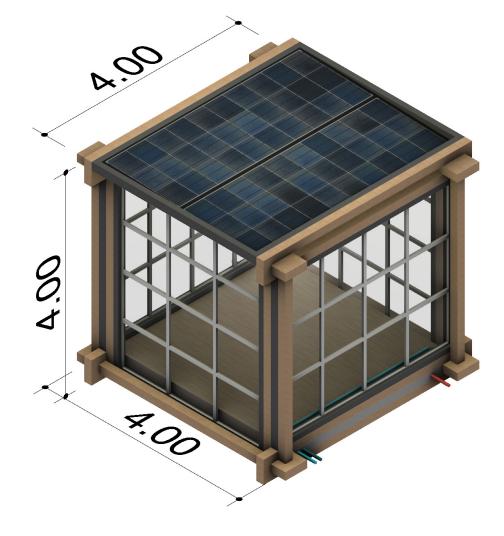






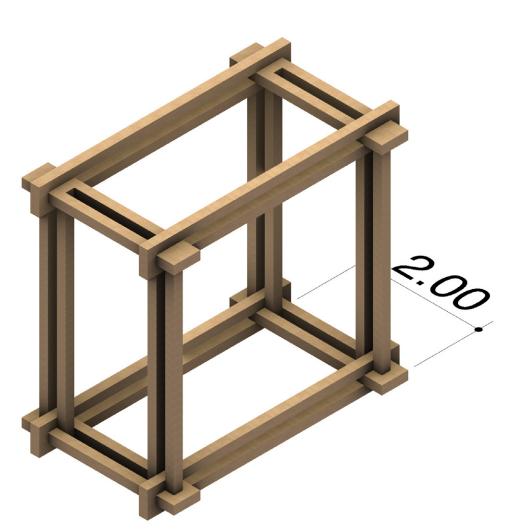
(A03) Modules can be integrated with solar panels instead of transparent polycarbonate glazing to generate sustainable energy for the system. the electricity henceforth is used to light the aeroponic farming integrated lights and generate heat for the system and the excess electricity afterwards can be used to charge mobile phones and electrical scooters and bicycles.







(B01) Modules are smaller in size. They are designed to give the modular system more adaptability and flexibility.





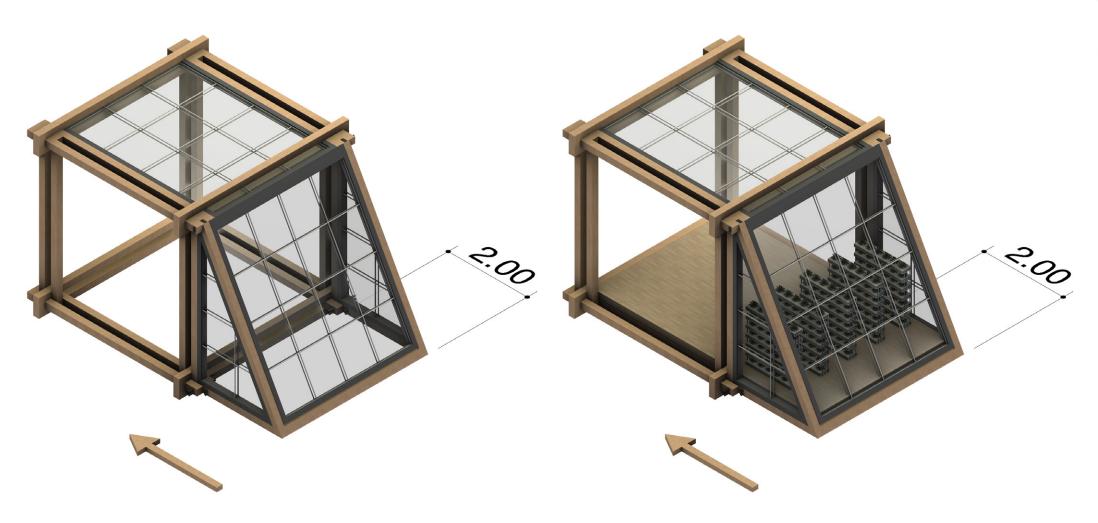
(C01) Modules are for lateral growth of the system where the extension is at the corners or just need a growing module for aeroponic trays.







Alfa Modules (A01, A02, A03) and C01





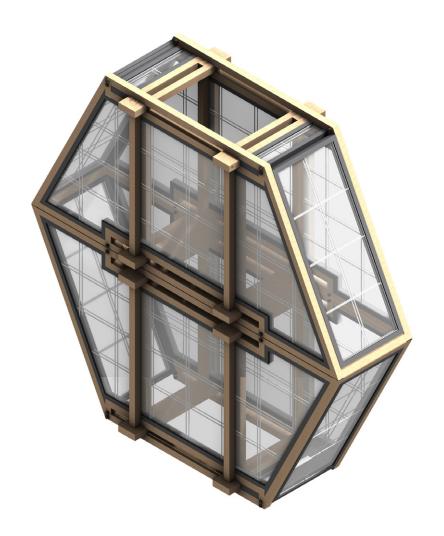


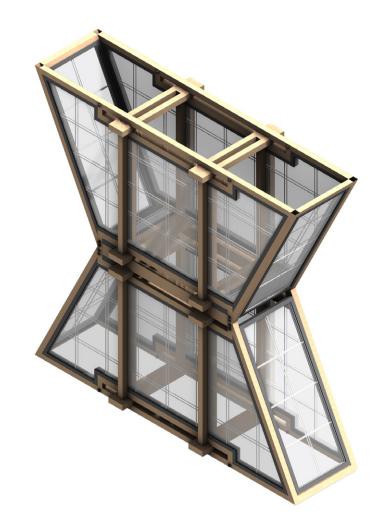






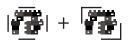
(B01 + 2(C01)) 2

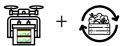






The system also includes a subscription service model for the periodic distribution of crops to households, businesses, and schools. with electromagnetic connection to the main system, the drone modules are needed the resources by the main modules.

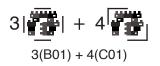








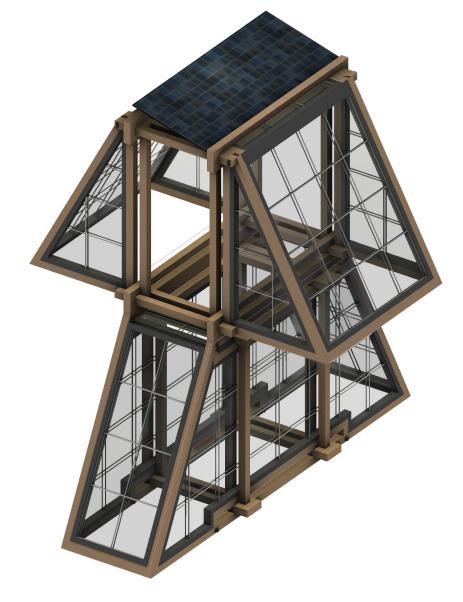




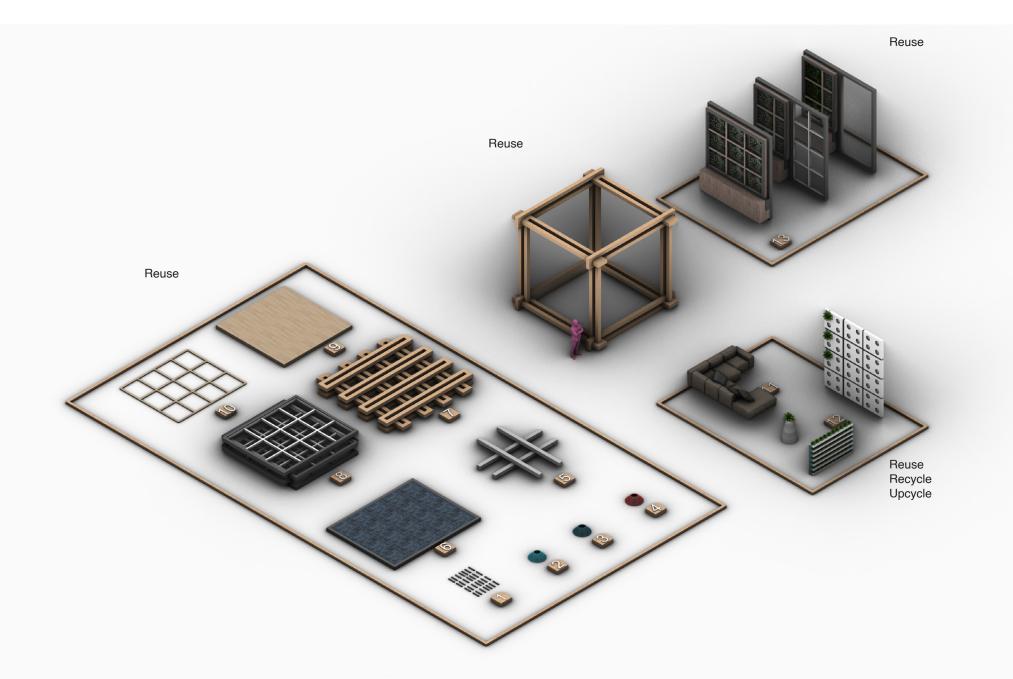




2(B01) + 4(C01)



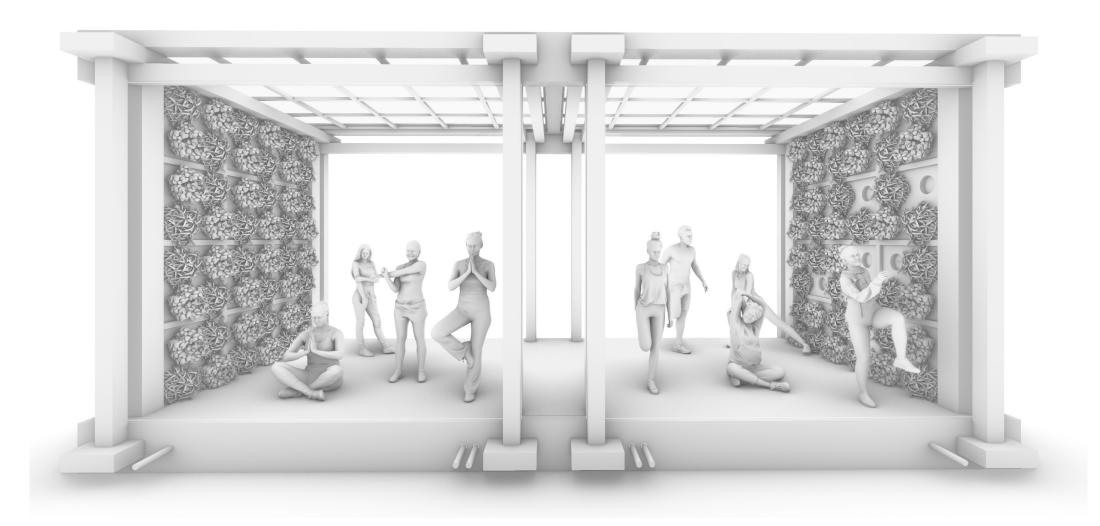
Prefabrication and Modular Architecture results in lower waste production, enhance the momentum of the construction and limit the environmental impact due to the LCA (Life Cycle Analysis) of the features.





Space Programmes:

The thesis main concern is food safety and citizens access to cheap and healthy local food, however, as an architectural exploration, the systems also provide different possibilities of programmes inside itself to revitalize urban spaces and dead city edges for the public. the project provides opportunities both for the users of the buildings and for the users of the urban area where it is located

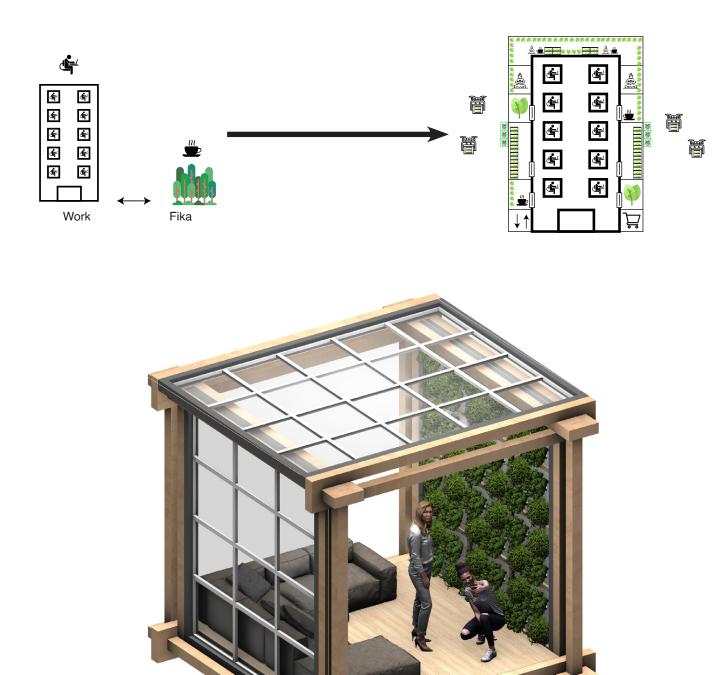




A Local shop of fresh greens for the neighbours and the civic. As the system provides fresh green food inside itself, it can then form local shops for the public to do their fresh vegetable shopping inside the system and therefore have access to cheap, healthy, nutritious food.

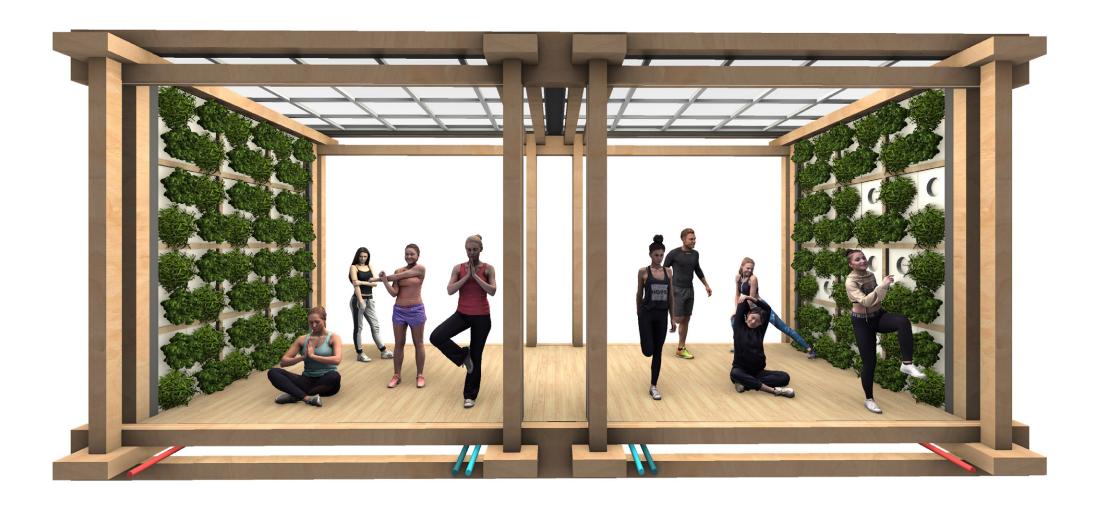
It generates money for the system and the owners of the buildings, it empowers the public and promotes social wellbeing and health.







Since the project is formed as an extension for existing buildings and it uses green walls for enclosing some spaces, the inside of these new spaces can form a new social bond among residents and give rise to activities such as Yoga and meditation and introduce new Zen areas for the building and its surroundings.





Test 1.

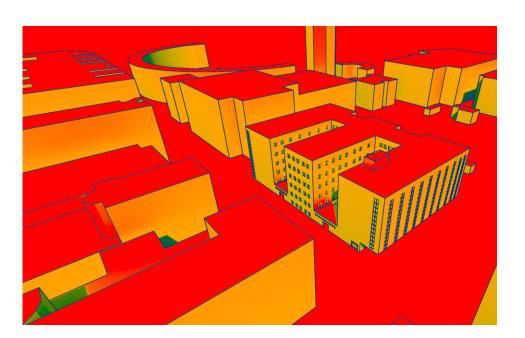
By using the previous analysis algorithms, we can find buildings with good facade sun exposure and no use and by implementing the sustainable system of the thesis, transform them into something green and productive

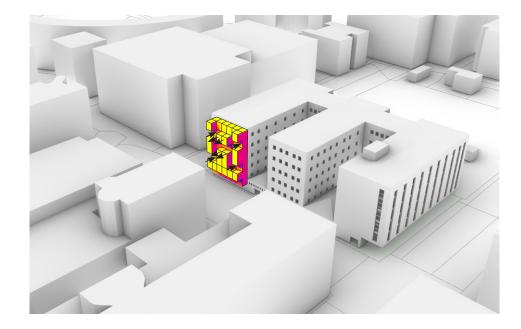
Office Building located in Södermalm, Stockholm



Retrieved From: Hitta.se

Through utilizing the analytic algorithm and running series of sun studies, the first test tried to maximize sun exposure for the extension





Extension Properties:

For this example, a combination of modules Alfa (A01, A02, A03) and C01 module is used. By only using 2 of the variations of the system and replicating the solid sun study of the algorithm, the system can form an extension with a variety of programs for the existing building.











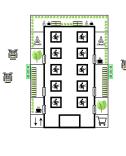












Extension Properties:

Not only the system offers possible opening from the existing building, but It also has interior vertical circulation inviting the public and the neighbours









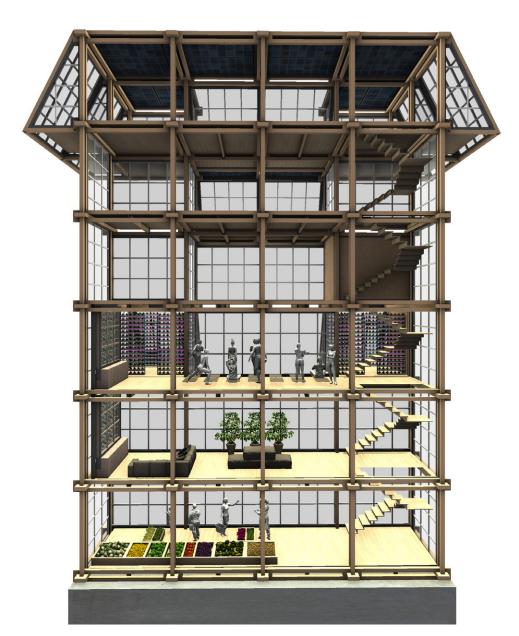








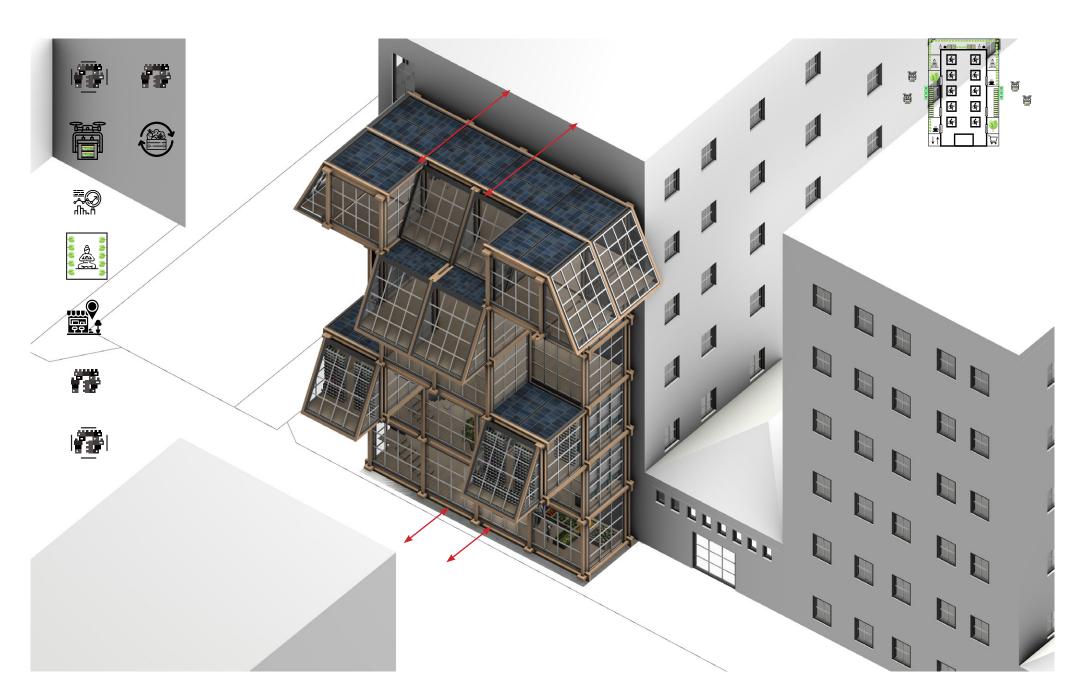






Oppenings

Not only the system offers possible opening from the existing building, but It also has interior vertical circulation inviting the public and the neighbours





Final Test

By using the previous analysis algorithms, we can find buildings with good facade sun exposure and no use and by implementing the sustainable system of the thesis, transform them into something green and productive

Tv Huss Building. Located in östermalm, Stockholm



Retrieved From: Hitta.se



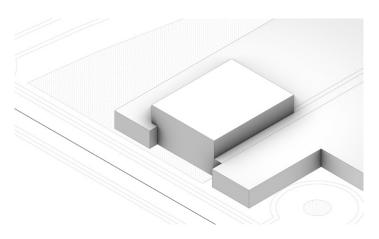
Retrieved From: Hitta.se. Editted by Farid Abbasi

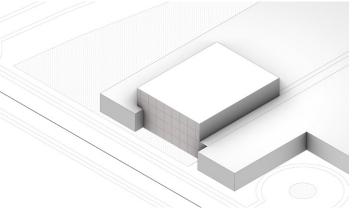
Final Design Integration

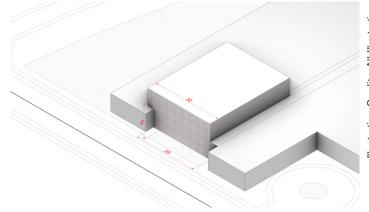


Through integrating both the Modular Architecture design of the project and analytical algorithm, project analyses and design is according to its site and its circumstances. Through analysing the edge and its annual sun exposure, the design tries to maximize and enhance its used space and sustainable energy production using solar panels.





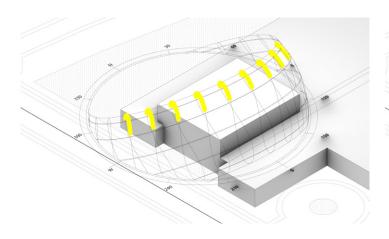


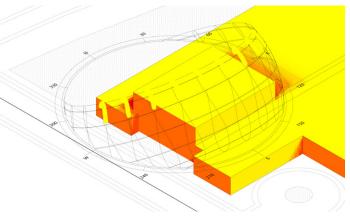


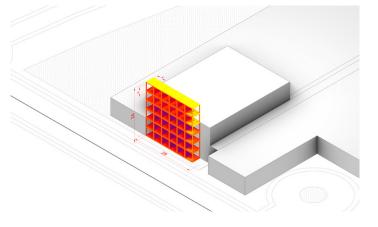
TV HUS Building

4*4 Facade Grid

Facade Dimension Analysis







Annual Sun Path

Annual Sun Exposure

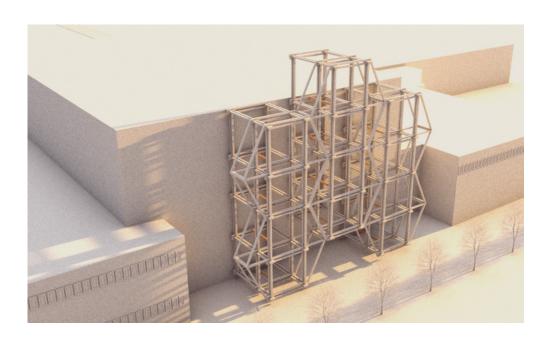
Extension Sun Analysis

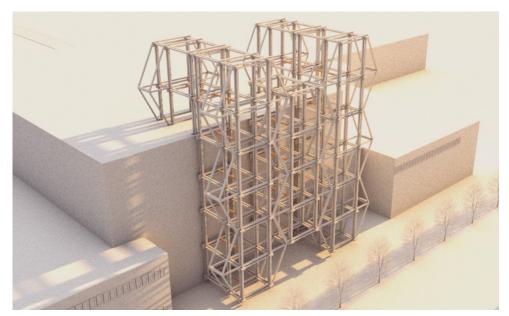
Different Configurations

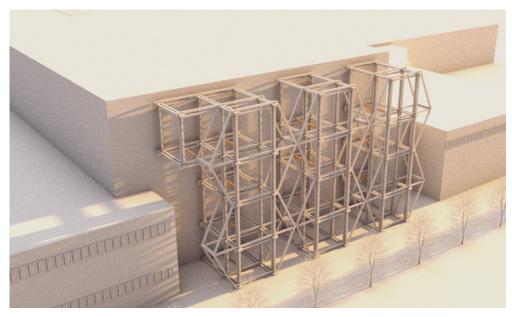


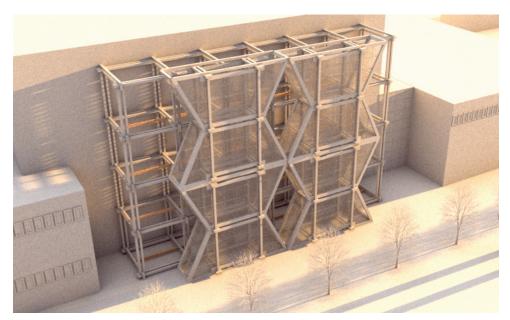
Since the design language follows the same modular feature, for every city edge there are several variations. This variation not only enhances the system and offers more flexibility to the design, but it also shows the extension's potential which can cope with different urban scenarios.









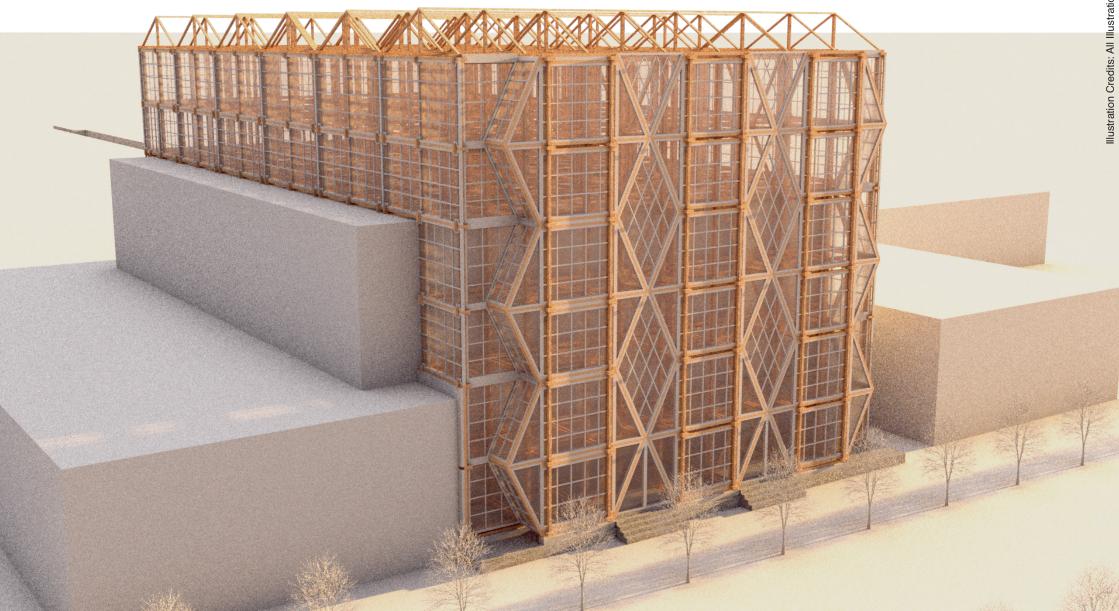


Final Design Integration - Maximizing Space use



For the final step of the design and to push the design until its current limits, a configuration is chosen which offers the maximum use of space both along the face and on the roof. The system is designed to work with its neighbourhood with a balance between imposition and yielding on its site, however, the design tries to show a vivid contrast between old and new and illustrates a working synergy between them. Made from wood and glass, the design's transparency and exquisite lighting of the farming system forms an everlasting light beacon for the neighbourhood through long dark winters of the Stockholm.



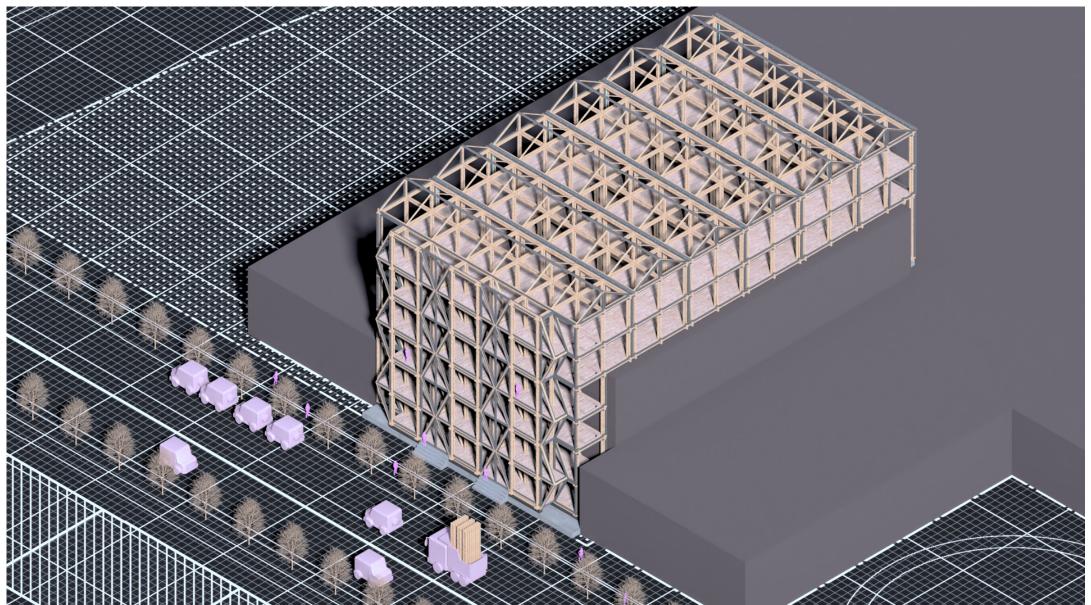


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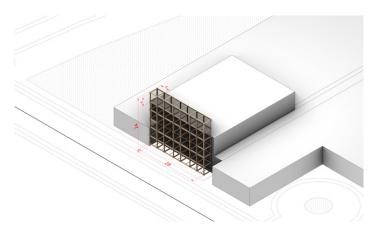


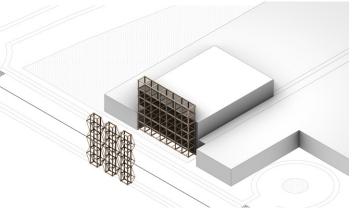
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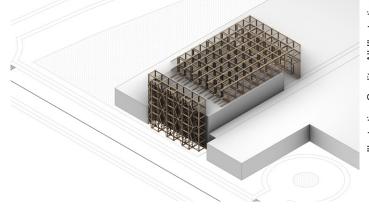


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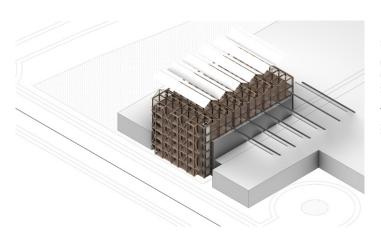


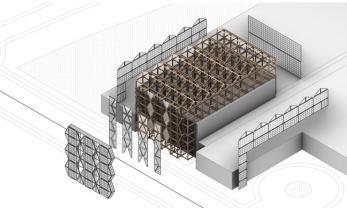


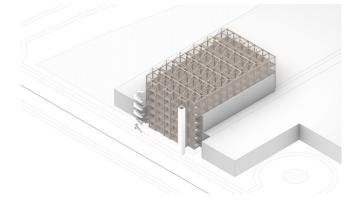
4*4 Alfa Modules

B01 and C modules as hexagons

Alfa modules on rooftop





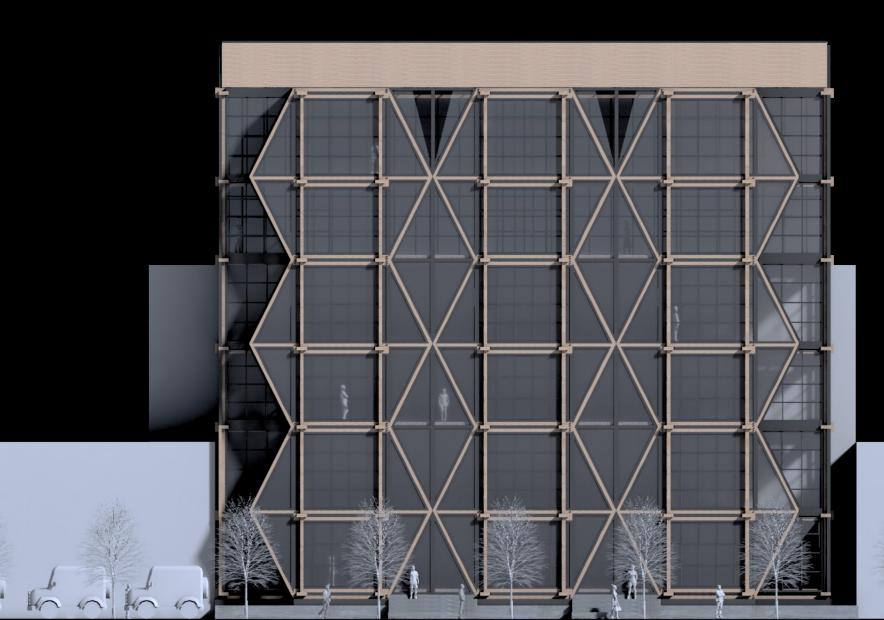


Street View Elevation



Formed and built by modularity and timber, the extension brings lightness and beauty to its neighbourhood. distinguished yet subtle, pedestrians can tell the difference between old and new but enjoy the synergy. Offering two entrance from the street and two from the building, the extension integrates the neighbourhood more than ever before.







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Southern Elevation

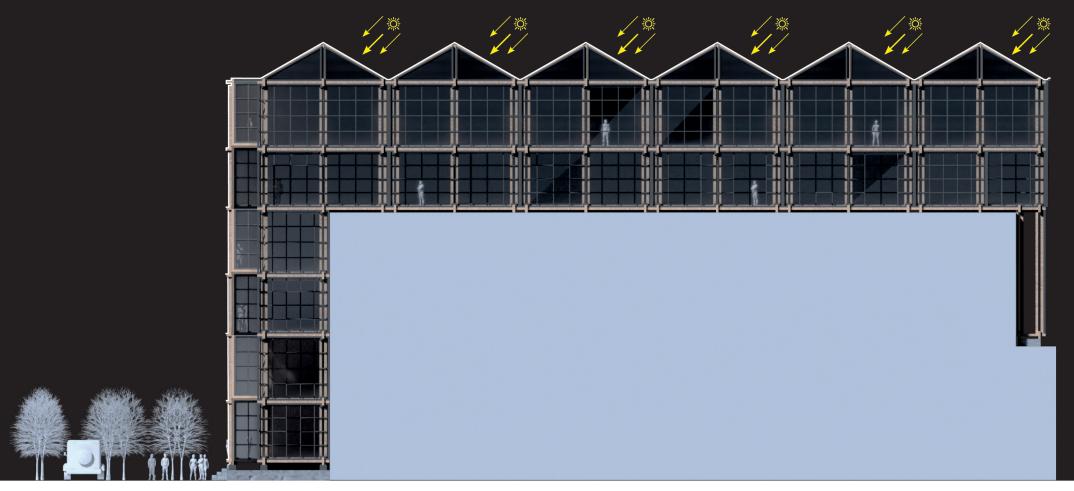


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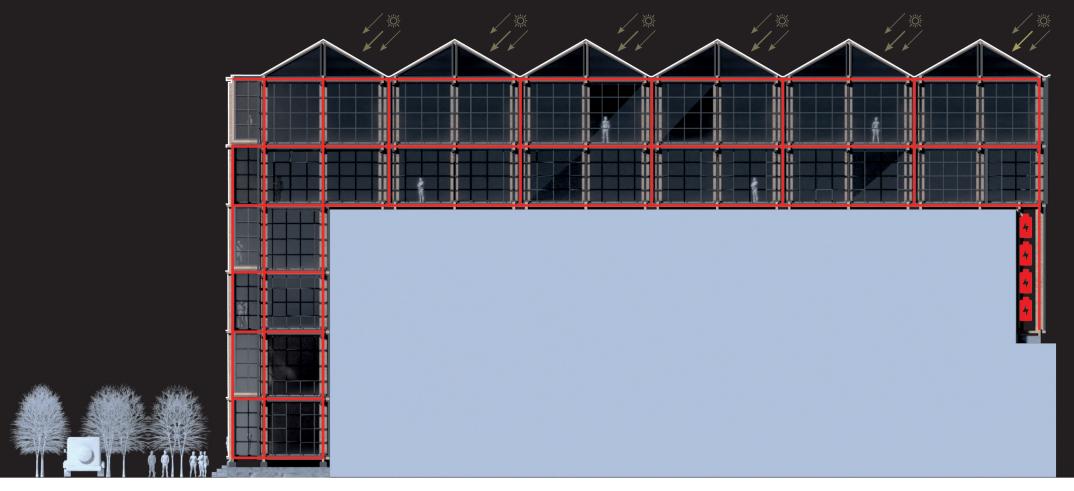






The generated energy is saved inside batteries and is used throughout the system





Rain Water Filteration

Rain water and snow is collected from the roof



Fish Tank



Living Filteration



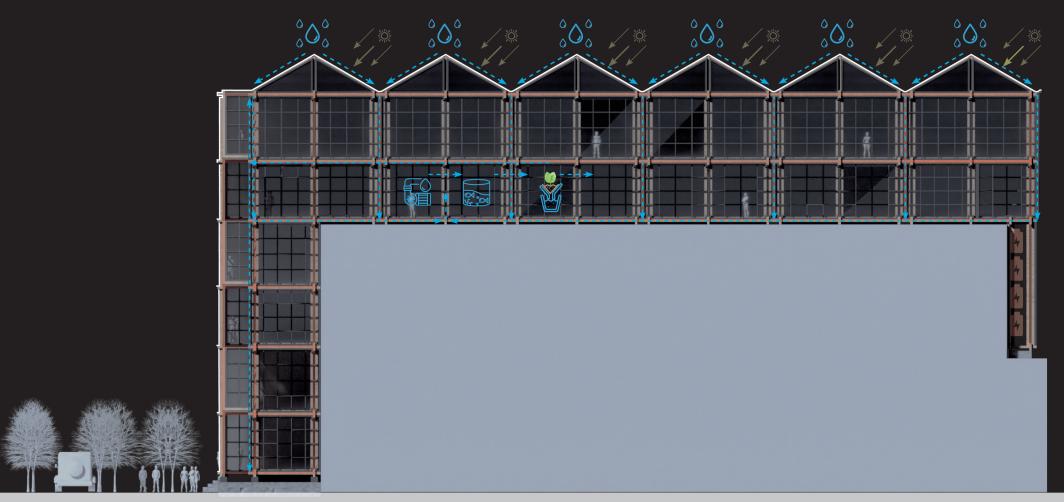






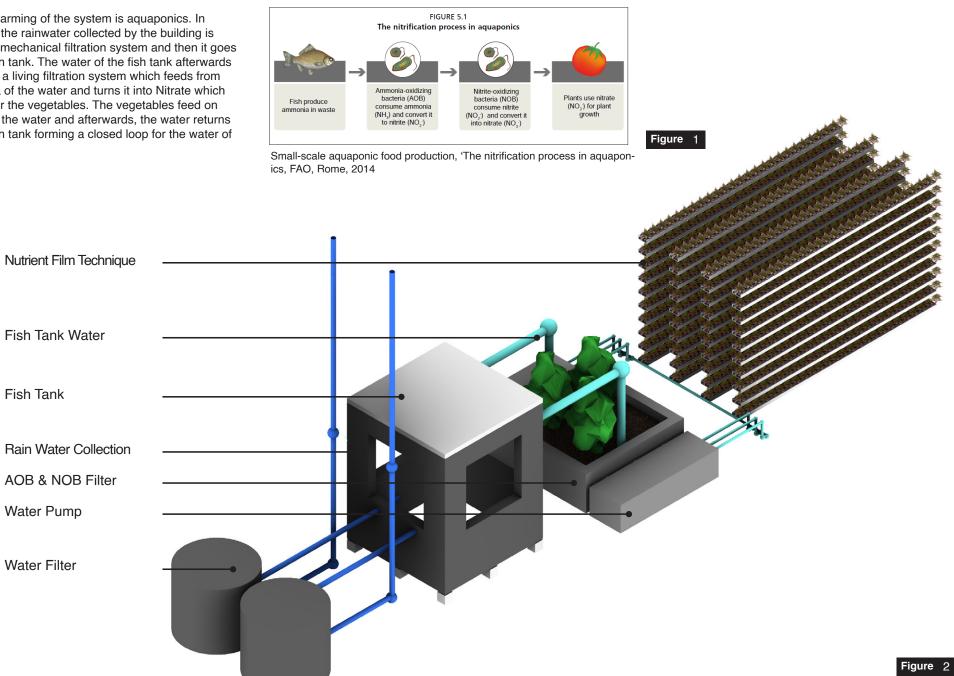






Aquaponics inside the Building

The vertical farming of the system is aquaponics. In Aquaponics, the rainwater collected by the building is driven into a mechanical filtration system and then it goes inside the fish tank. The water of the fish tank afterwards is driven into a living filtration system which feeds from the ammonia of the water and turns it into Nitrate which is the food for the vegetables. The vegetables feed on the nitrate of the water and afterwards, the water returns inside the fish tank forming a closed loop for the water of the system.





Rain Water Filteration

System has a sustainable closed water loop.



Fish Tan





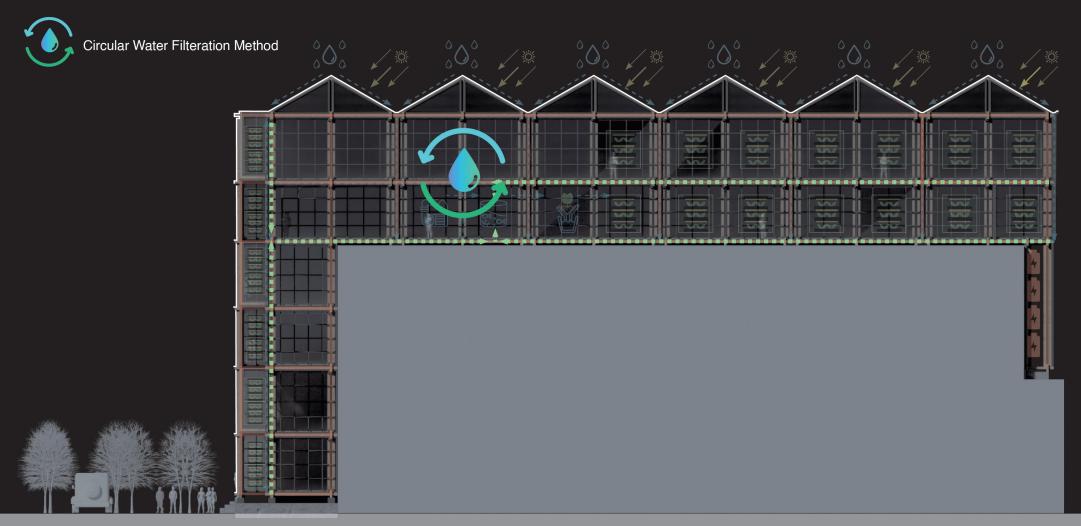








Living Filteration



Programes



The system offers a multitude of programs both for the residents and the public. Not only the design blurs the border between the street and the building, but it solves the food safety of its neighbourhood. Moreover, locals can enjoy green and organic shops and restaurants of the system, its green gym and daycare.





Green Daycare centre and Playground



Green Gym



Eco Restaurant



Green Social spaces



Ecologic Local Shop



Eco-Cafe takeouts and drinks



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Green sitting areas on the facade

The buildings provide green and peaceful sitting areas close to its facade bringing the possibility of enjoying your cup of coffee whilst watching outside. Furthermore, you can order food from the system's restaurant.



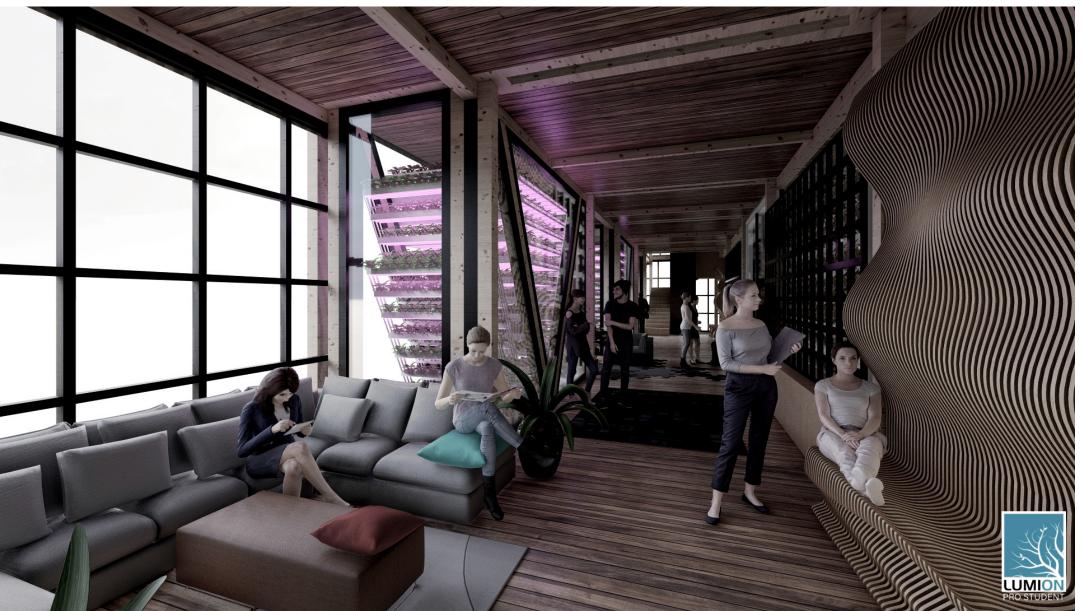
Local Shop

Providing fresh vegetable all year round, the locals and the residents can come to the building and shop their groceries from varies vegetables raised inside the system with maximum sustainability.



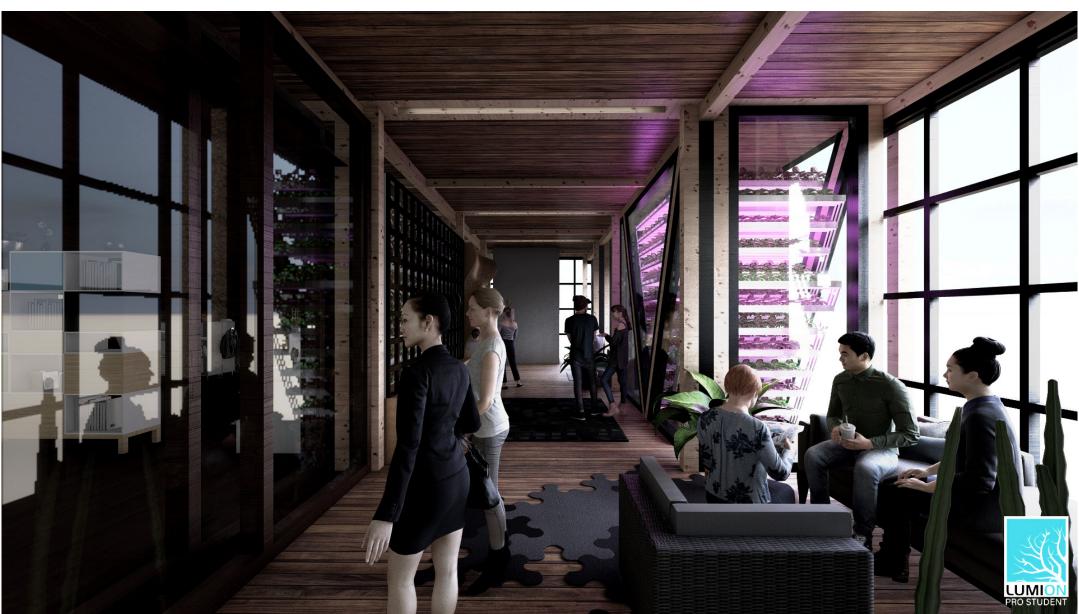
Green Public spaces

On all levels, the systems offer green sitting areas open to everyone. Not only you can enjoy the wooden furniture of the building, you can distance yourself from your hectic life and become peaceful.



Blur the borders

All year long, the residents of the building can distance themselves from their stress and enjoy their cup of coffee inside the extension. The extension always offers light and sitting area and you feel better when you realize no lighting is wasted in this system. The lightings than you are enjoying is providing food for you with maximum sustainability.



On top floors, the system offers a green restaurant. This place is where you can enjoy your salad as fresh as it can be and meet people.



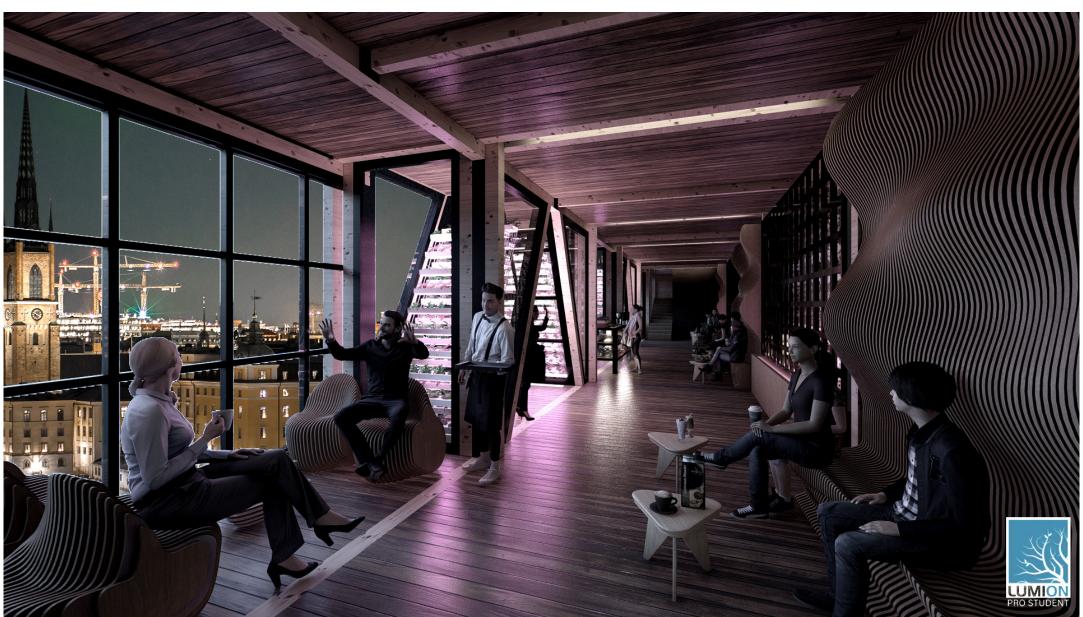
Aquaponics farming

Everywhere inside the building, you can see the vertical aquaponics. Although these spaces are closed to the public because of contamination, you can enjoy the green colour and the pure oxygen of the building nonetheless.



Exquisite lighting

During the nights and dark winters, you can always enter this building and enjoy the exquisite lighting it offers. Since the vertical farming requires Blue red lighting which appears purple, the system utilizes this lighting to its maximum sustainability and though the farming is in closed spaces, the system uses the lights they provide.



Green Gym

Nothing feels better compared to finishing your day with a exercise in the middle of the greenary. The system offers a gym close to its farming facilities and maximizes the oxygen it provides and uses the Co2 of the people in return.



The High Garden is Always Glowing