The green thread

From sawmill to sustainable neighborhood

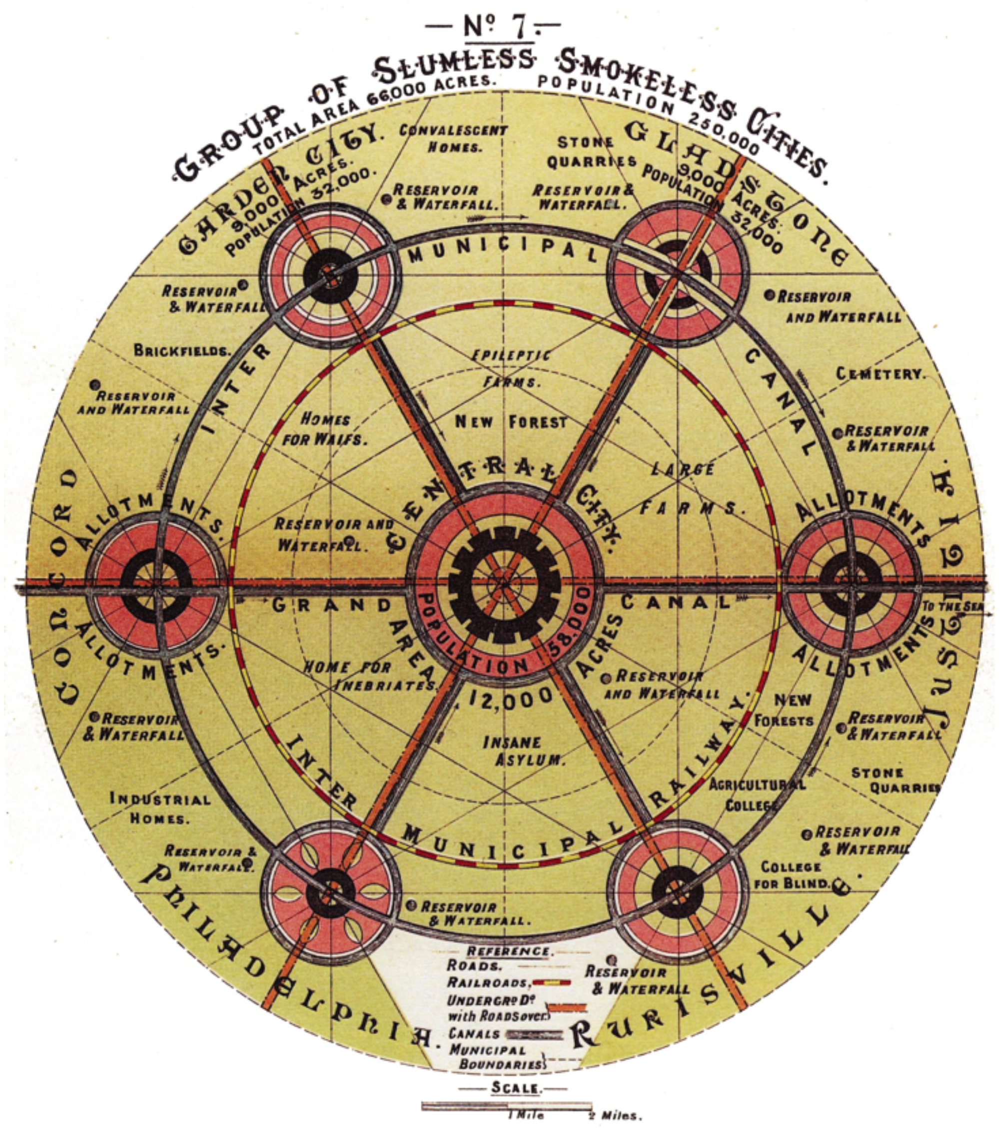
Contents

Abstract

The scope of this master thesis is developing a concept on an urban scale that ensures sustainability, both in environmental and social aspects and helps fulfilling the Sustainable Development Goals formulated by the UN. Inspiration is taken from historical examples such as the garden cities, translating the ideas into today's language, adjusting them to today's needs. Furthermore, possibilities for dealing with building stock on site are investigated. The focus of the urban design is creating an environment, that promotes sustainable development amongst the residents and the community, while the proposal for the buildings stock aims to provide an alternative solution instead of tearing everything down.
The site is located in Norway, about 60km North of Oslo and used to be an old sawmill area. Different typologies are chosen in different parts of the plot, according to local prerequisites. As a general concept the idea of self-sufficiency in food production is introduced, and mirrored in the form and development of the typologies. About 2/3 self-sufficiency in fruit and vegetable production can be achieved with this proposal, which covers the baseline in our diet. It has to be noted that full self-sufficiency is not a realistic goal in Norway, due to the limited species that can be grown effectively in Norway. Short distances are a key factor in the concept, therefore not only should it be possible to access functions like stores, restaurants, cafés and working areas within a short walk, also the goods in the stores, restaurants and cafés should not travel to far.
For the existing buildings, a transformation into a mixed-use greenhouse is proposed, combining food production with public and residential functions. The greenhouse is beneficial due to its characteristics in terms of indoor climate, while it can be used and designed as an outdoor space. The time where outdoor activities, such as for example sitting in a café or restaurant, going to the playground with the kids, and skating in a skate park, can be done in the greenhouse is much longer compared to outdoors. The list of possibilities is long and can always be adapted to the needs. Furthermore, it has a positive effect on the energy and/or insulation demand of the buildings inside.

Introduction

Sustainability is one of the keywords of this time. It is used in different ways, but the message is mostly the same: How do we handle climate change? What about social sustainability? Architecture can address both aspects and make sure that our current lifestyle does not compromise conditions for future generations. In 2015 the United Nations (UN) established the 17 Sustainable Development Goals (SDGs), which aim to reduce social and economic inequality, address climate, health and education issues, and preserving our planet. Several goals apply to the building sector including Goal 7 "Affordable and Clean Energy", Goal 9 "Industry, Innovation and Infrastructure", Goal 11 "Sustainable Cities and Communities", and Goal 12 "Responsible Consumption and Production". [1] A lot of these goals address issues in third world countries but looking back in time a similar situation can be seen in Europe. The industrialization brought wealth to some people, and bad conditions to other, problems arose like air and water pollution (SDG 6 & 11), and poor living conditions (SDG 11). With the shift between the 19th and 20th century, the garden city movement aimed to address these issues, first defined by Ebenezer Howard in his book "To-morrow" in 1898. [2] His goals include reducing the alienation of society form nature, integration into environment to ensure sustainable interactions, and addressing pollution issues, while combining the benefits from both city and country life to improve the standard of living. This was done by allocating satellite settlements on the outskirts of a large city, surrounded by farmland and nature and connecting them well to main city with public infrastructure, such as highways, railways and canals. The settlements should be organized in a cooperative way, including the residents, so it would be affordable, future proof and being taken care of over a longer period of time. The neighborhoods were usually designed with relatively small houses and large gardens to ensure self-sufficiency and independence to a certain degree. Public functions, such as schools, churches, town houses, marked squares and stores were located in the center, closely accessible for everyone. [3]



Scheme Garden City [2]

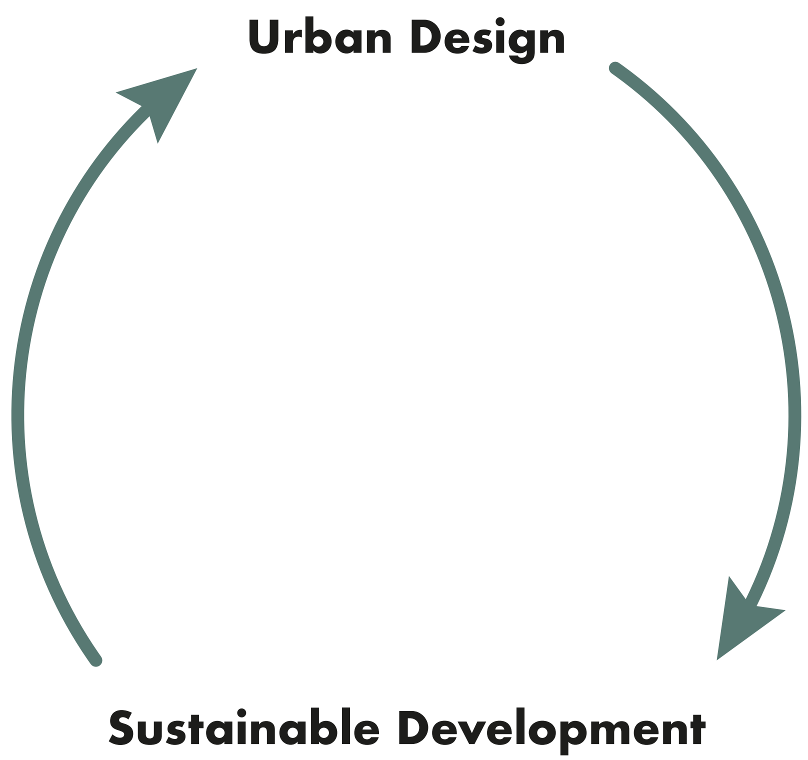
Garden city Berlin-Staaken

Objective

The scope of this master thesis is developing a concept on an urban scale that ensures sustainability, both in environmental and social aspects. Inspiration is taken from historical examples such as the garden cities, translating the ideas into today's language, adjusting them to today's needs.
Furthermore, possibilities for dealing with building stock on site, which served other functions in the past are investigated. Rather than tearing everything down and building everything new, a concept for reuse is developed, which not only saves emissions, but also provides added value to the neighborhood.
The focus of the urban design is creating an environment, that promotes sustainable development amongst the residents and the community. Once society is adapted to a more sustainable lifestyle, the impact that can be made is much bigger, than with outstanding pilot projects alone for example. Urban design can help accelerating this adaptation process. However, it is not a static process, it goes back and forth: Urban design can promote sustainable development in society, the way people think and act in their everyday life. On the other hand, every development in society changes the demands and in this particular case, sustainable development will change the needs in urban design.
The objective is to investigate how residential development has to adapt, to be able to provide good living conditions, not only now, but also in the future.

Influence
What influence does Sustainable Development have on Urban Design?

- *New building volume (demand, potential of reuse/refurbishment)*
- *Typologies*
- *Materials & construction methods*
- *Functions*
- *Infrastructure*

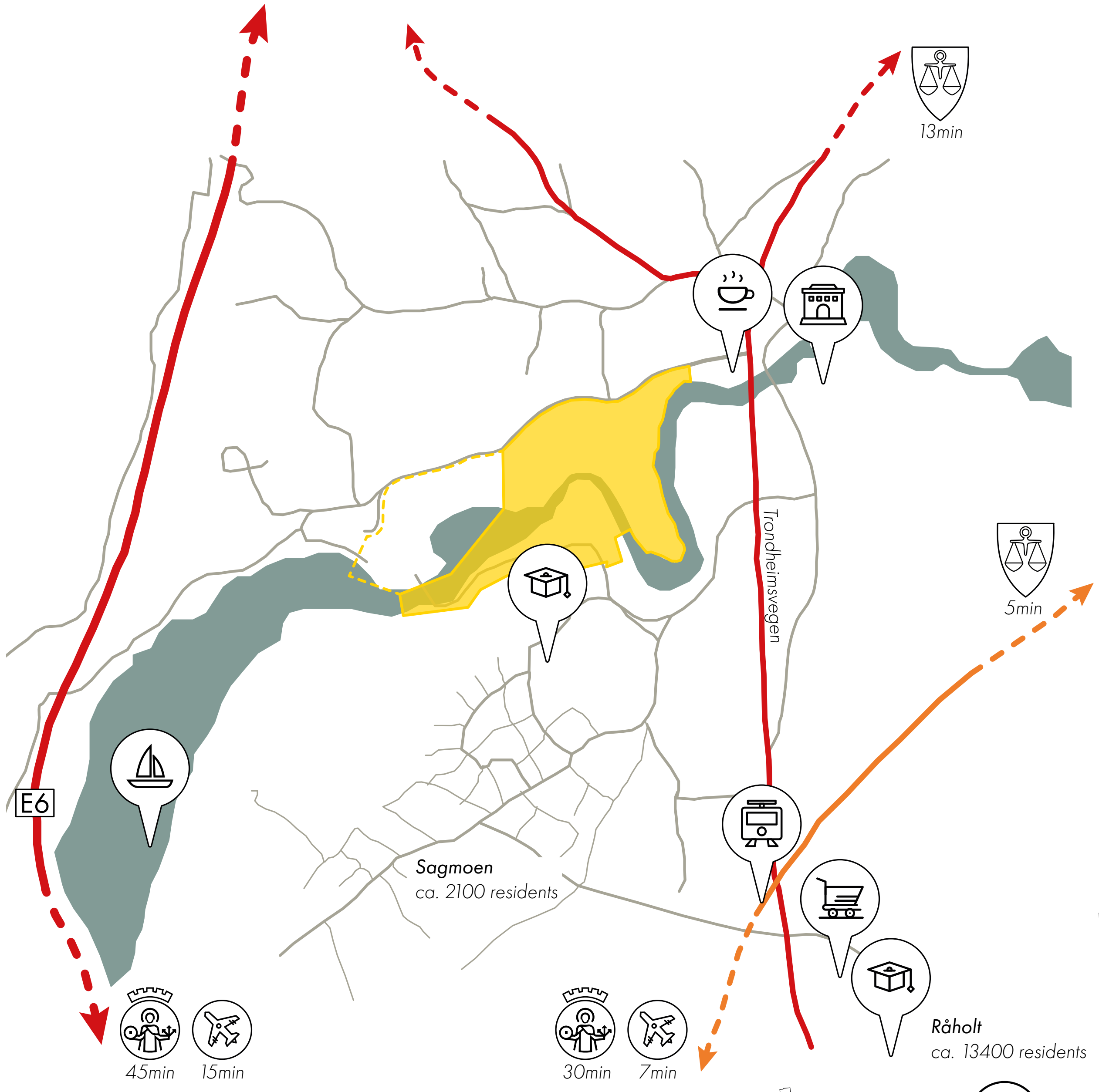


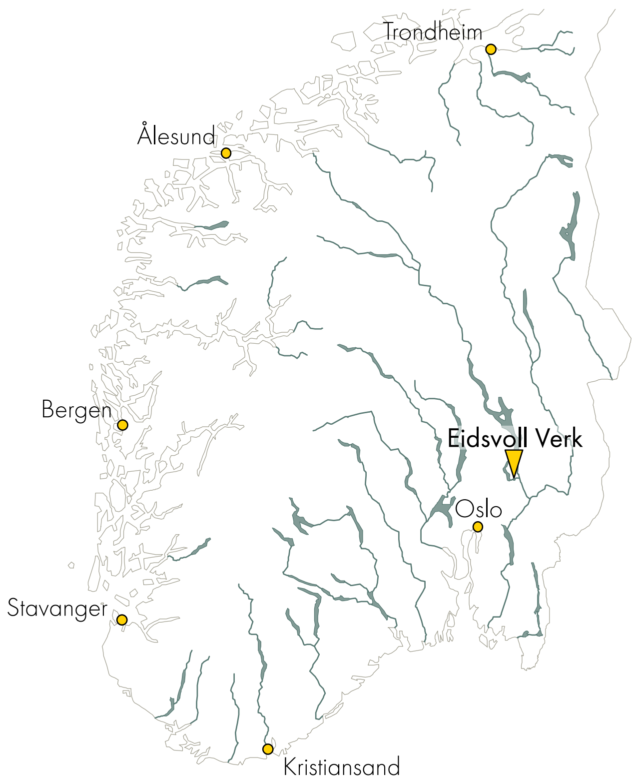
Promote
How can Urban Design promote Sustainable Development in society?

- *Raising awareness by immersion (subconscious)*
- *Pilot projects (actively showing/teaching)*
- *Changing habits, offer alternatives (public transport, locally produced goods,...)*
- *Involvement of residents (cooperative decision making)*

Location

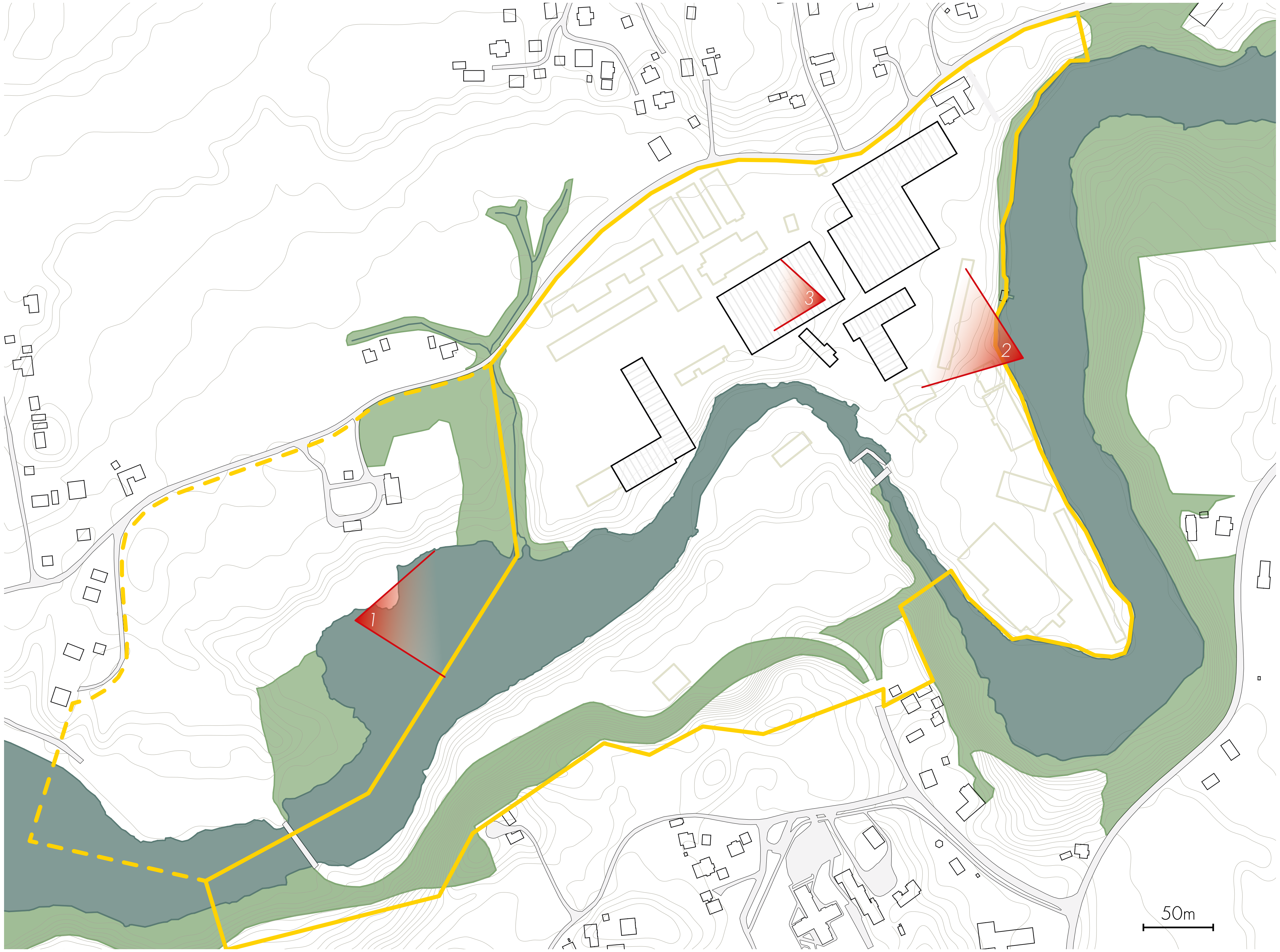
About 60 km North-East of Oslo, lays the town of Eidsvoll. Probably every Norwegian knows this place, since that is where the independence was declared. The site for this thesis is located at Eidsvoll Verk, which is an old sawmill area, right across the street of Eidsvollsbygningen. It takes about 30 min by train and 45 min by car to reach Oslo, the airport is even closer. A reference can be drawn here to the garden city concept, where the central city was in close reach. Interestingly enough, both the city center and the airport can be reached faster by train than by car. This makes it very attractive to use public transportation and with further improvement future residents might consider getting rid of their private car, thus reducing the number of cars and connected pollution. The plot is an old industrial area, which used to be one of Norway's oldest sawmills, where timber production started in 1670, until 2019 when it was taken out of operation. [4] It is surrounded by beautiful nature, yet very well connected to the infrastructure. Public functions, such as bus stops, primary schools and kindergartens are in close walking distance (under 10 min), stores, junior high schools and the train station can be reached in 20 min. However, creating a new neighborhood means adding more residents to the area, so it has to be expected that more public functions need to be added, especially kindergartens, primary schools and local stores, but also places for spare time activities, cafés and restaurants. Due to the proximity to Eidsvollsbygningen and the history of the site, a cultural function could be worth considering, for example an exhibition showing the almost 350 years history of the sawmill, so visitors that come for a cultural experience to Eidsvoll can combine both places.





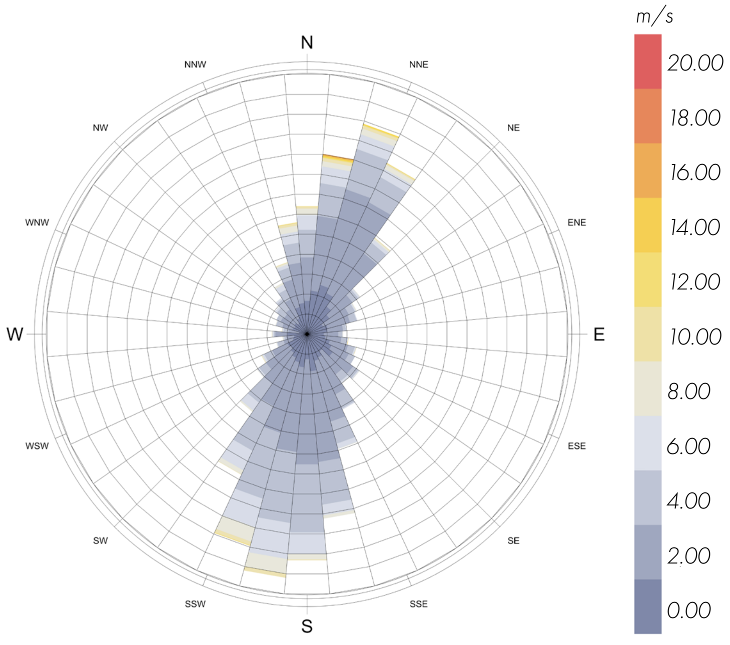
Site

Zooming closer into the site the current situation can be seen. The gray buildings are the ones that were in too bad condition in order to reuse them and are mostly already taken down. The ones marked in black are in acceptable condition where it would be worth thinking about a new purpose.
The plot owned by Moelven measures about 24ha, and this is where this project is focused on. However, the neighboring plot in the West is considered for further development as well and included as a pilot study to propose a more wholesome concept for the whole area. This adds another 10ha to the project. Big value comes from the nature in the area. The river, splitting the plot in two offers great potential for recreational area along its shoreline, for example parks, swimming areas or marinas. Together with the forests and the terrain, especially in the east, the plot is framed, sheltered from the surroundings, which can help building its own identity. The area itself is quite flat, so building there is not too challenging.

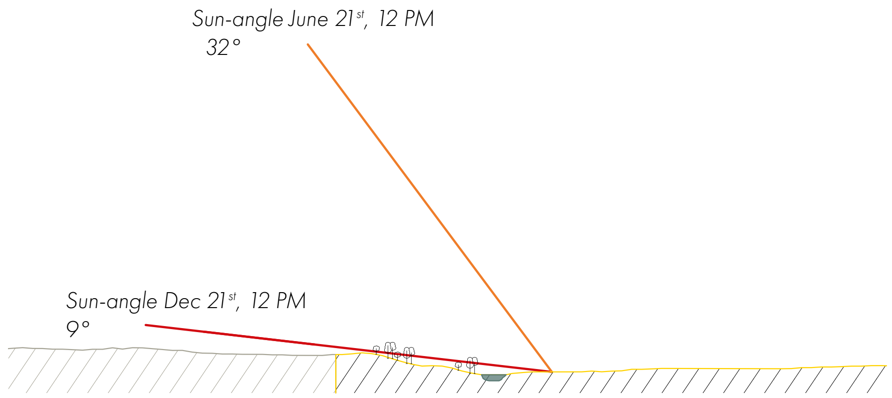


Climate

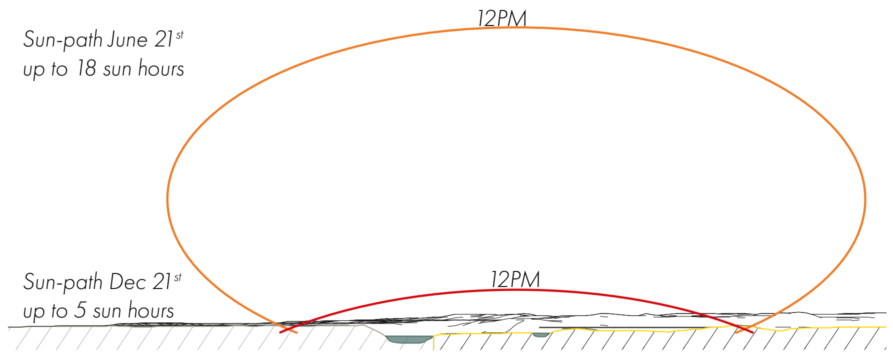
The climate in Eidsvoll Verk is considered cold without dry season and with cold summers (Dfc) according to the Köppen-Geiger classification. [5] This means, that the thermal energy load is mostly on the heating side and, using the right design strategies, overheating should not be an issue. However, it is expected that, due to climate change the summers will get warmer. [5] This is an important factor to consider and in the design process it has to be taken into account, that overheating might become more relevant.
Analyzing the wind rose it can be seen that the prevailing wind direction is quite consistently in the North-South axis. This would allow to optimize the building geometry to allow for natural ventilation, to tackle overheating issues.
The maximum solar angle range between 9° in winter and 32° in summer, and the maximum amount of sun hours per day range between five and 18 hours. The hillside in the South would cast some shading on minor parts of the plot, however the majority is not affected by that. Optimizing the design for maximum solar radiation the winter sun could probably be neglected, since the angle is so low and the sun hours quite short, in favor for the spring and fall sun, which is still not very high, but it shines for a longer period and can help with passive solar heating. One strategy in that regard could be adjusting the building heights and volumes, so they shade each other the least amount possible.



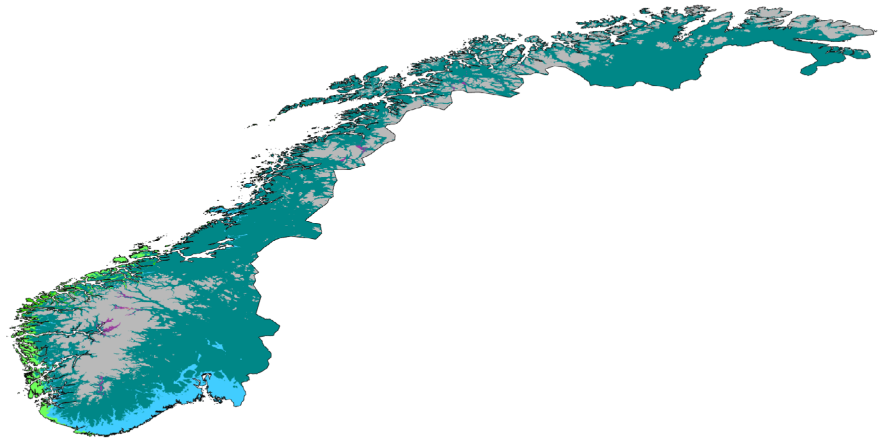
Yearly wind-rose



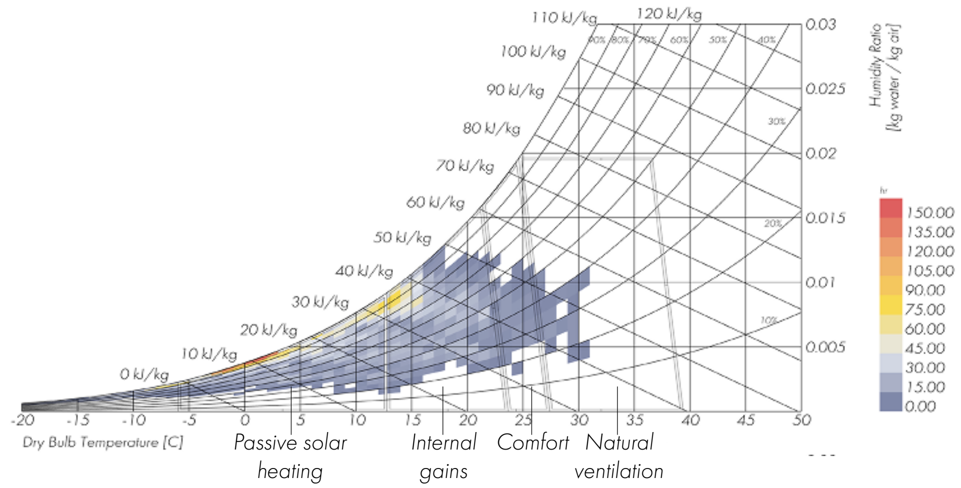
Sun-angle analysis



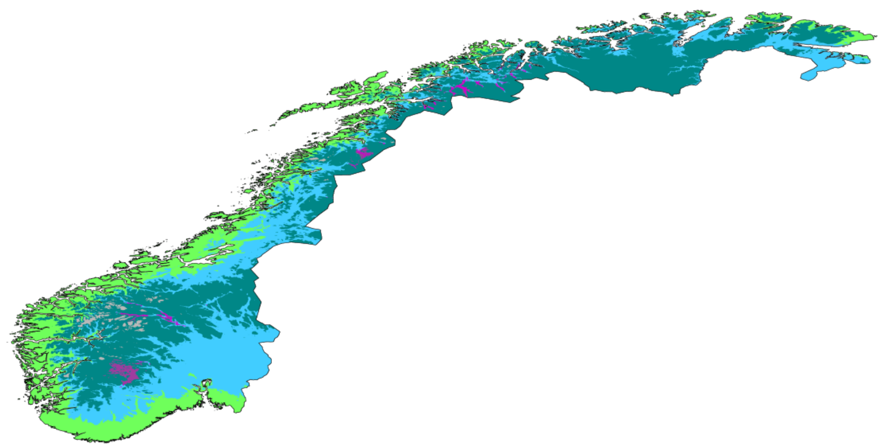
Sun-path analysis



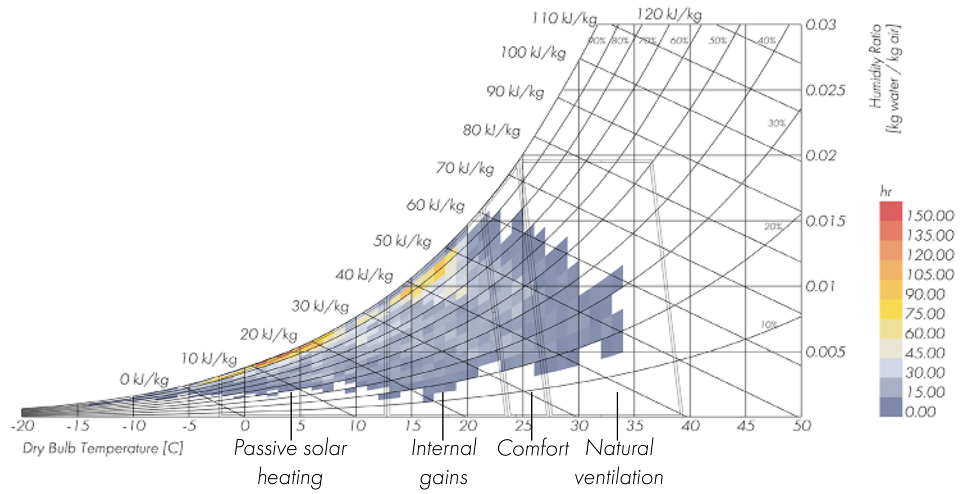
Köppen-Geiger climate classification scenario present [5]



Psychrometric chart present



Köppen-Geiger climate classification scenario future [5]



Psychrometric chart future

Case Study

Sustainable neighborhood development is not a new concept by any means. In the end of the 1990s the "Vauban" quarter in Freiburg (Germany) was developed and is considered to be a very successful example for sustainable development. It was started by a local initiative of citizens which was against the development plans of large real estate companies. Nowadays the administration and decision making of the quarter is organized cooperatively by the residents themselves. [6]
The central design guide is the infrastructure, everything is planned around green transportation. A tram line connects the neighborhood to the city center where stops are not further than 500 m apart from each other, ensuring that they are easily accessible for everyone. Furthermore, there is no private parking allocated to the houses, which means people coming by car have to park on a common parking lot on the border of the district. This reduces the traffic inside the residential area and promotes the use of alternative transportation methods, while it is still possible to drive inside the area for example if someone has to move or objects have to be delivered. Generally, the design is characterized by small scale buildings where public functions such as stores, cafés, offices, and other businesses are integrated in this pattern. This way they are within short distance and not concentrated at one spot where people would have to take their car to go there. Studies actually show that 70% of the residents does not own a private car. [6]
Residential buildings are required to achieve a yearly energy consumption for heating of less than 65 kWh/m² although a lot of the especially newer buildings perform a lot better, some are even plus energy houses. [7] Energy is produced locally with PV panels, solar thermal collectors and a combined heat and power generator (CHP). The latter runs on wood chips and is connected to a local district heating grid. Biogas is produced from organic household waste, which is used for cooking in the houses. [6]
Comparing the case study to the site in Eidsvoll, some similarities and differences can be found. First of all they are quite similar in size (Vauban: 41 ha, Moelven site and neighboring plot: 34ha), as well as access to nature is an important factor. However, the location of the Vauban quarter is integrated in a much more urban environment, in contrast to Eidsvoll Verk, which is pretty much on the country side.

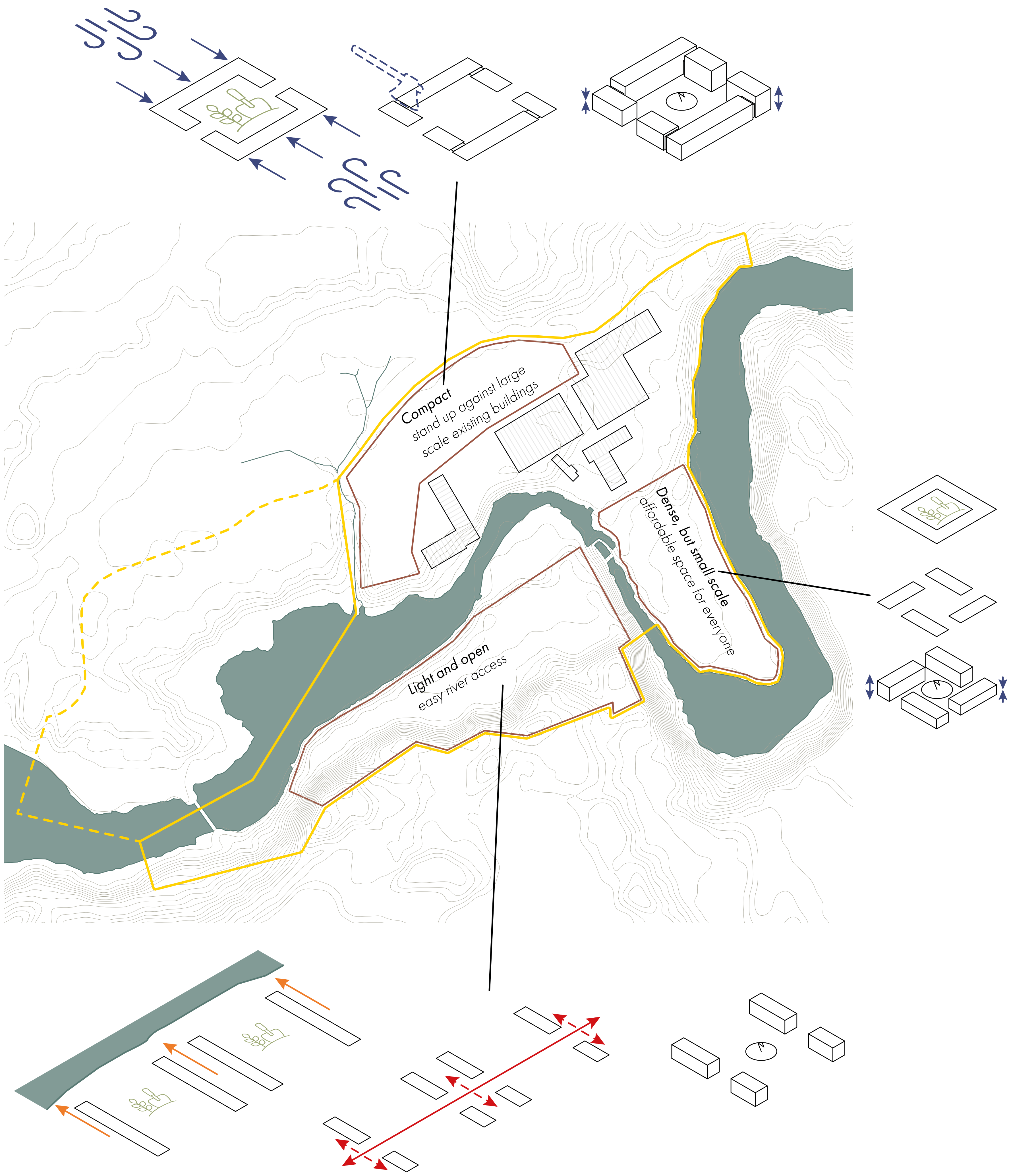
Plan Vauban [8]

Images Vauban [7]

Plan Eidsvoll Verk

Concept urban design

The plot is characterized by different qualities and challenges regarding development in different areas. There is the center with large scale existing buildings, which used to be industrial buildings housing sawmills, planing machines, drying and storage spaces. The location itself offers a lot of unobstructed area along the river, but borders to the surroundings very harshly as it is now. The typology to be designed here has to be able to create a transition between the surroundings and the industrial buildings, therefore a more compact structure is chosen. The block's edges are softened by breaking up the volume with set-back circulation cores, making it appear more small scaled, thus making it more friendly to the surroundings. Variations in height allow for more solar radiation to come inside the blocks. Furthermore, the block typology forms communities with a sheltered space inside.
The half- island in the South-East is surrounded by the river which makes it very private and very close to nature, on the other hand, the land is quite thin, so it is hard to find the right ratio of building volume to open space. Therefore, a small scale typology is chosen which is suitable for providing affordable space in this unique location. The windmill shape increases openness and variations in height allow for solar radiation to come into the plots, while breaking the rigid structure.
The southern side of the river stands out with its long waterfront. However, as already mentioned in the climate analysis, there is a small hill in the South which potentially shades the plots, especially during winter. Therefore, a linear typology was chosen to not add more shading potential. It also directs to the river, enhancing the connection.
For the existing buildings it is proposed to transform then into mixes-use greenhouses, where cultivation of fruit and vegetables, as well as public functions are placed, and residential units on a higher level above form this hybrid building.
Short distances are a key factor in this concept, therefore not only should it be possible to access functions like stores, restaurants, cafés and working areas within a short walk, also the goods in the stores, restaurants and cafés should not travel to far. Local food production is an important aspect in this concept, therefore private and common gardens are proposed where the residents can grow parts of their daily fruit and vegetable portions.

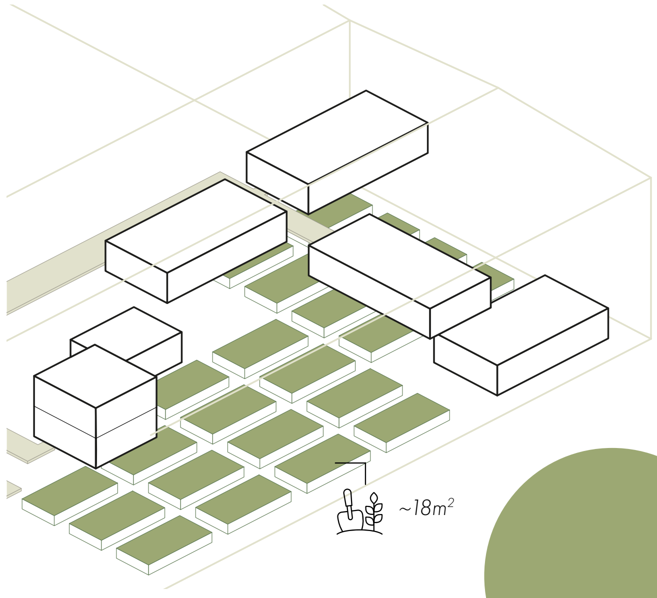


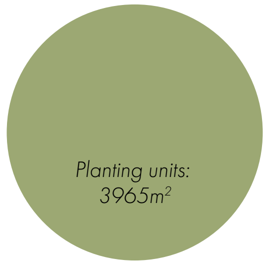
Concept gardening

Being self-sufficient makes independent and enhances a feeling of community and connection between the residents, especially when food is cultivated on a common area. Both the community and self-sufficiency aspect were important parts in the garden city concept, while it is still or even more important nowadays. Food production grew to a scale where it is an industry with a lot of influence. Globalization made it possible to eat whatever, whenever. But the question arises: Do we have to get our salad from the Netherlands? Cucumbers from Spain? Paprika from Israel? Do we need vegetables that are harvested half-ripe, wrapped in plastic and shipped through Europe? Or is there an alternative that puts tasty food on our table, which has a small carbon footprint and is affordable? Studies show that growing your own food can reduce its carbon footprint by 25-30% [9] while only paying for seeds and seedlings. Providing dedicated space for planting in the design promotes local production.
The World Health Organization recommends a daily portion of 400g fruit and vegetables for a healthy diet [10], which is used as a starting point in this example calculation on how much area is required to reach self-sufficiency. This also depends on the species, fast growing vegetables like carrots or cabbage achieve a higher yield while paprika and strawberries need a lot more space to reach similar results (see numbers below). [11] The average value of 15m² is used to calculate the demand, adding 20% for walking paths and inefficient area use. In the greenhouse planting units are used, so it is not necessary to account for walking paths. Furthermore, the units can be combined with a CNC based farm robot, increasing area and grow time efficiency, therefore less area is needed. [12]

	$g/m^2/day$	required m^2 for daily portion
Beets	30	13.26
Paprika	10	40.45
Cabbage	45	8.82
Carrots	55	7.22
Cucumber	38	10.57
Lettuce	63	6.30
Onion	45	8.84
Potato	30	13.39
Strawberries	8	53.15
Tomato	17	23.94
Zucchini	43	9.28
Average	27	14.66

Typology "Greenhouse"

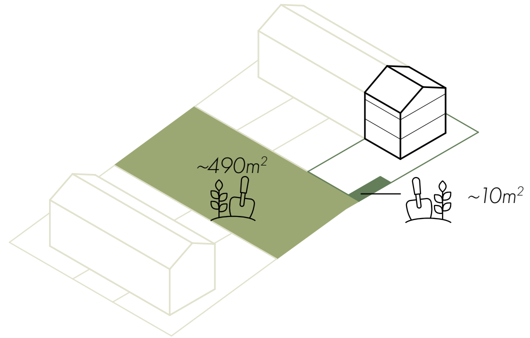


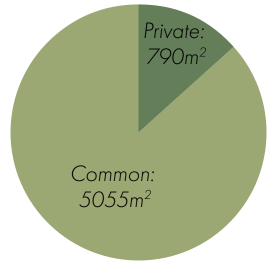


Total number of residents: 100
Required planting area per person: 15m²
Total required area: 150m²

Total: 3965m²

Typology "Riverside"

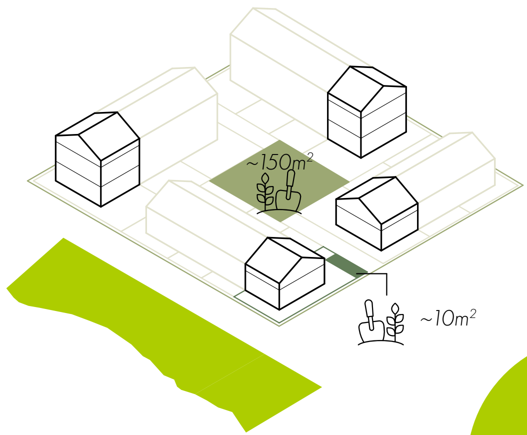


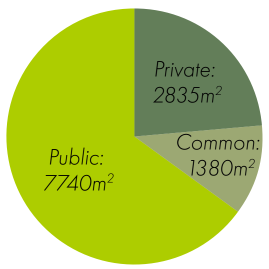


Total number of residents: 275
Required planting area per person: 18m²
Total required area: 4950m²

Total: 5845m²

Typology "Half-island"

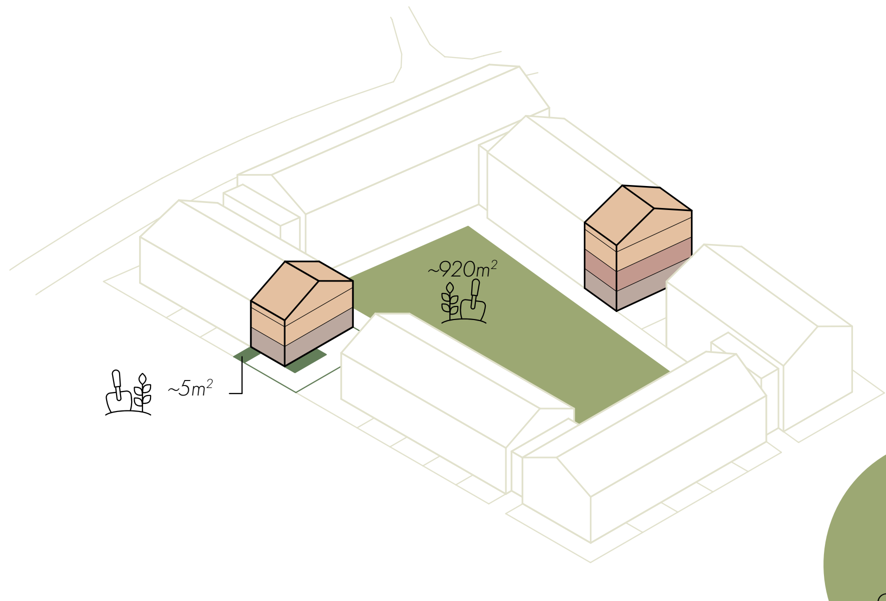


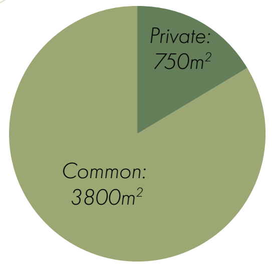


Total number of residents: 450
Required planting area per person: 18m²
Total required area: 8100m²

Total: 11955m²

Typology "Blocks"





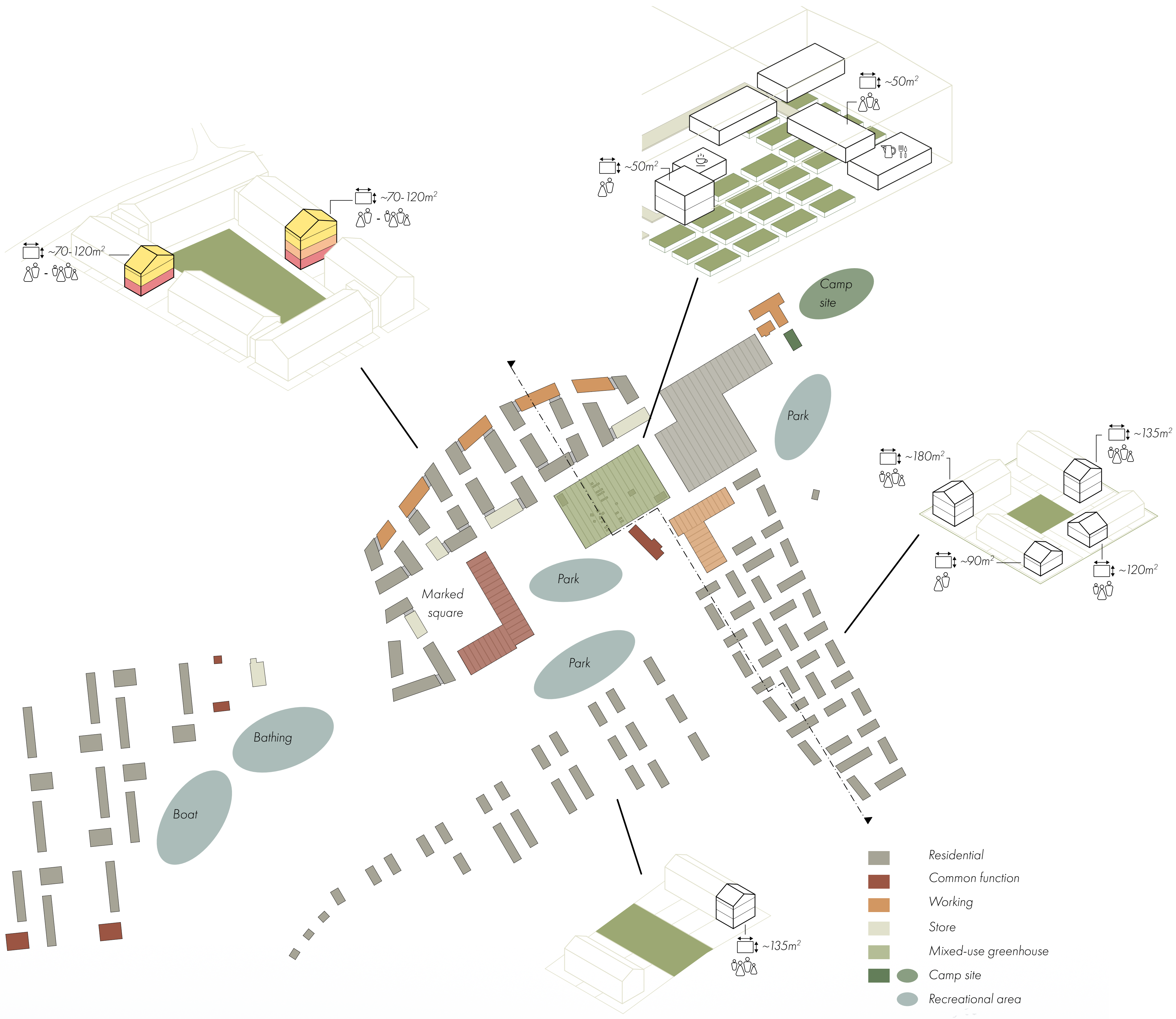
Total number of residents: 1500
Required planting area per person: 18m²
Total area required: 27000m²

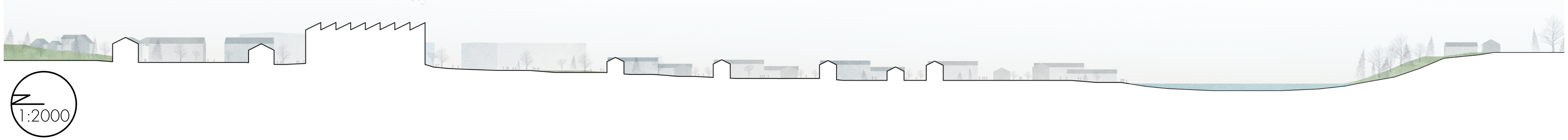
Total: 4550m²


Camp Site
Marked Square
Bathing area
Boat area
50m

Typologies

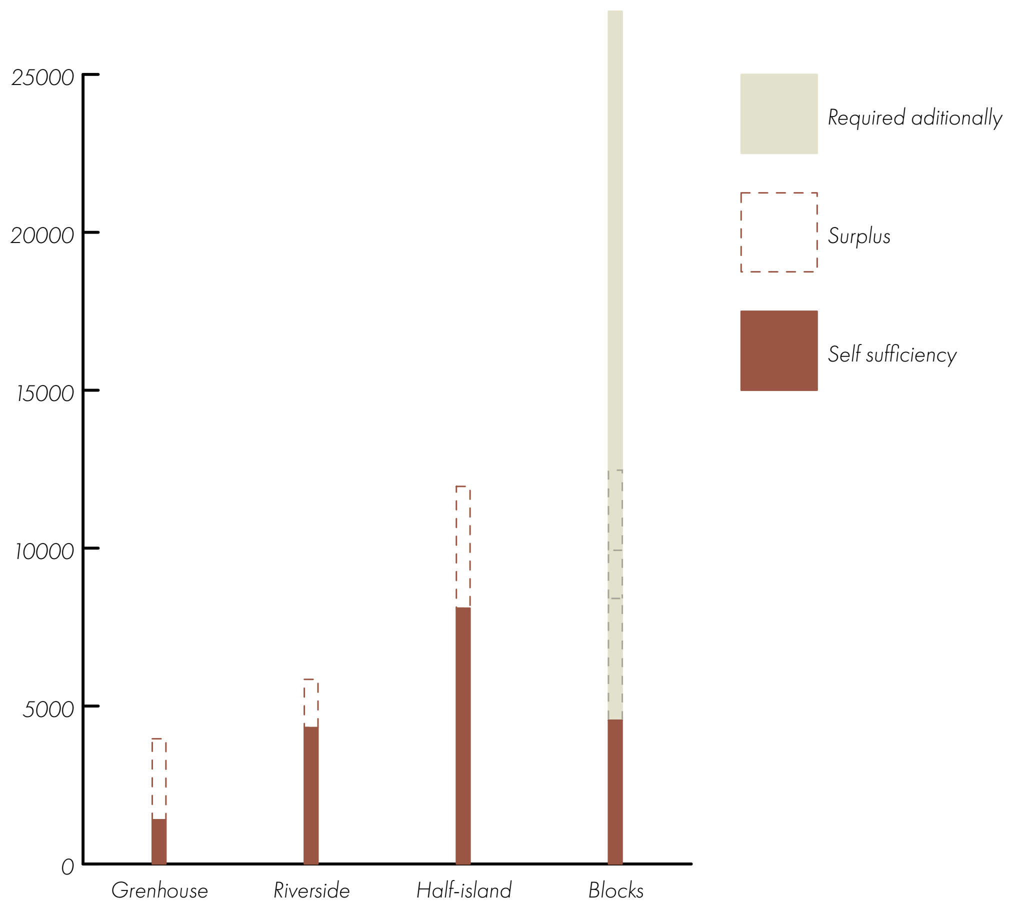
As already mentioned in the concept, different typologies are chosen in different areas of the site, according to the local pre-requisites. However, most of the apartments are in the range of 35 m^2 to180m^2, designed for up to 4 people.
The block structure in the North will provide different types of apartments from 70m^2 to 120m^2. The top level flats are designed as lofts, making use of two floors, while the ground floor has access to a small, private garden. The center of the block is dominated by a large common garden, where the residents can grow their own vegetables.
Inside the greenhouse the apartment size ranges from 35m^2 to 75m^2. Public functions, for example a café, restaurant, exhi-bition, library, co-working spaces, skate park or playground can be allocated there, drawing people from the surroundings inside as well. A lot of these functions would benefit from the climatic conditions in the greenhouse, so they could be used for a longer period of time or simply be more attractive.
On the half-island to and three story townhouses form a ring around a common garden, where food can be cultivated. The houses range from 90m^2 to 180m^2.
Along the river the buildings are quite similar to the ones on the island in term of shape and size, residents can live here on 120m^2 to 150m^2. Due to the more open typology, there is no need for variations in height.



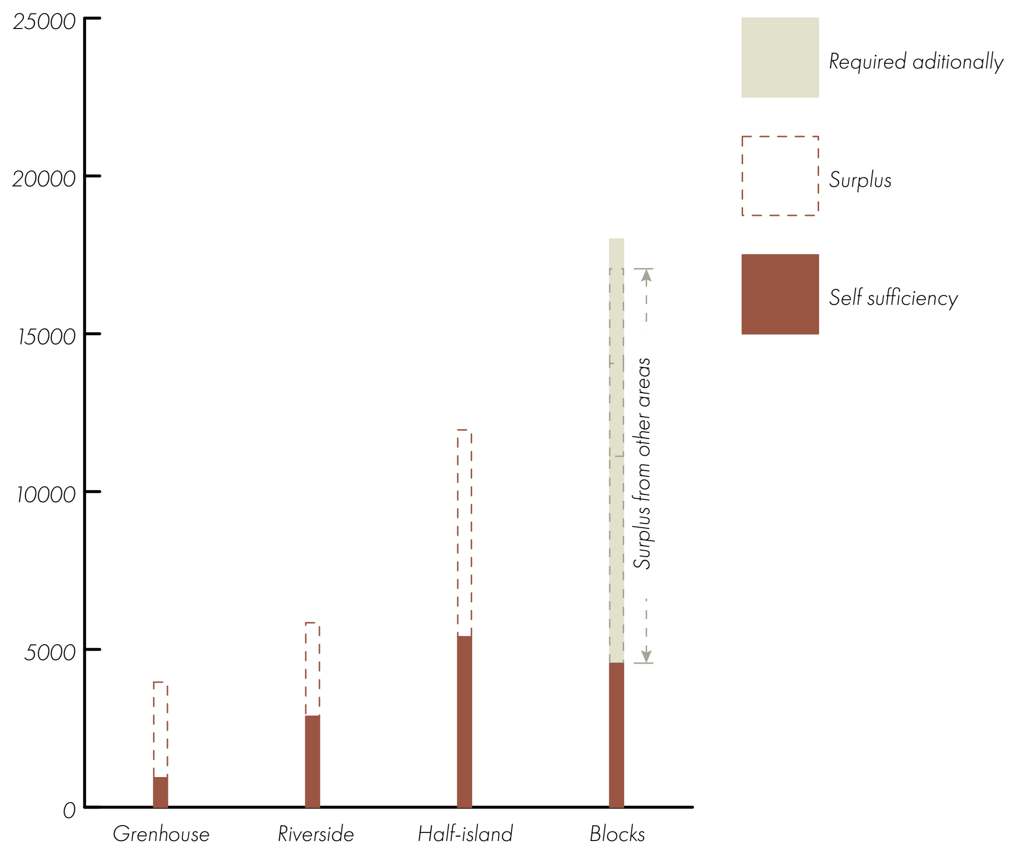


Self sufficiency calculation

Comparing available and required planting area, differences in the level of self sufficiency can be identified. While the majority has more area available than required, the blocks are not self sufficient at all. This is due to the compact typology where the density of population is higher, compared to the other typologies, with a smaller size of gardening area. This can be addressed by sharing areas between the different parts of the neighborhood. While this more than doubles the available area for the block typology it is still not even half of the demand.
The question is what level of self sufficiency is adequate? Is it reasonable to aim for full self sufficiency in modern days? In Norway? Do people want to eat potatoes, cabbage and carrots for most of the days, maybe a paprika or cucumber every now and then? While Norwegians are probably more used to this kind of diet than other Europeans it would be the wrong approach. It is illusive to assume that people would refrain from buying sweet potatoes, paprikas or avocados in the store. This would render the whole concept failed, land that was meant to be cultivated lying idle, which could be used for better purposes instead. However, self sufficiency of nearly 2/3 can be achieved in this setting, which would cover the baseline: potatoes as a side dish, lettuce for the salad and carrots as a healthy snack in between.



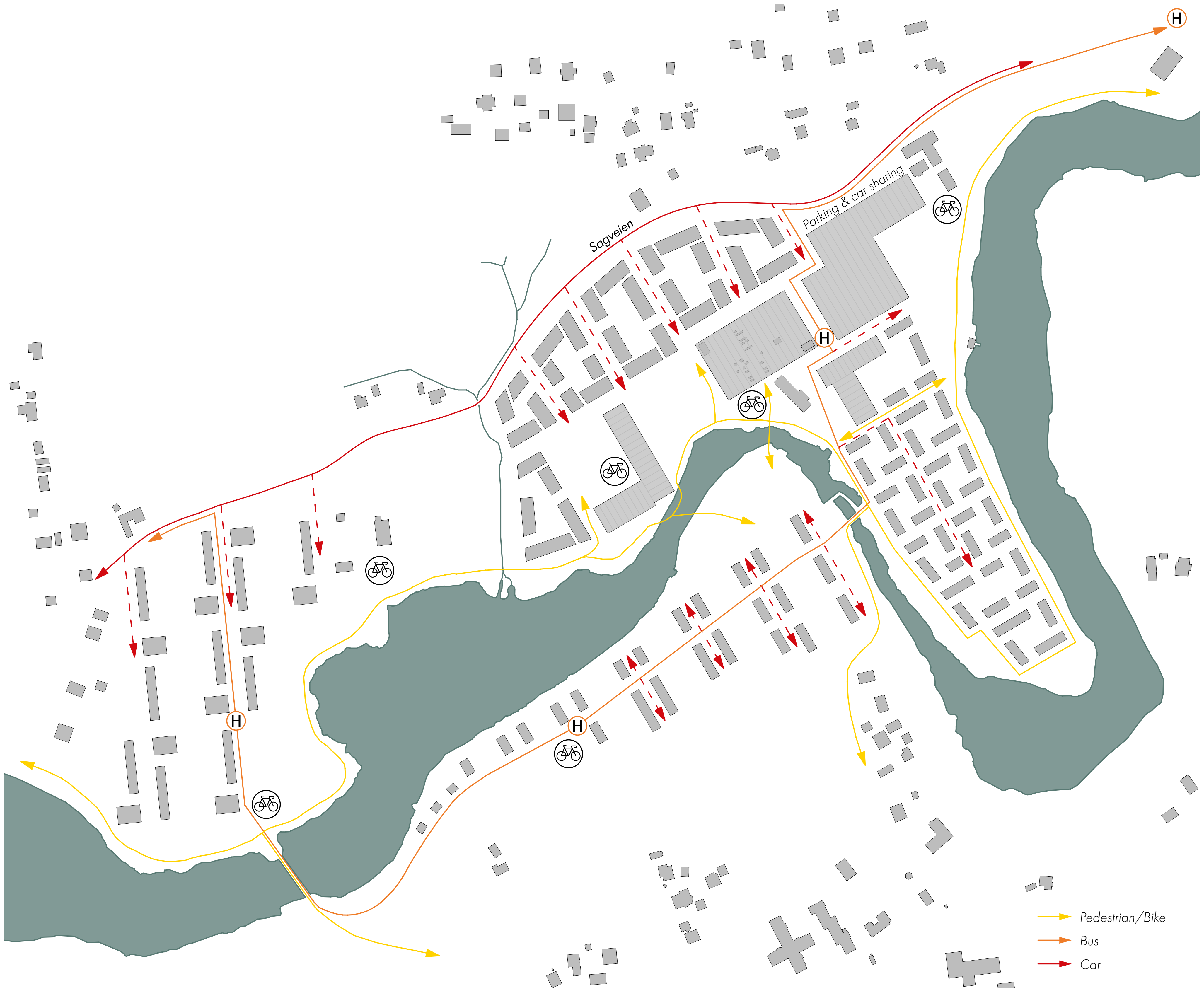
100% self sufficiency



2/3 self sufficiency

Scheme infrastructure

The new neighborhood is dominated by alternative transportation methods and private car traffic plays a secondary role. This attributes to significant changes expected in the future regarding our transportation system. With the development of autonomous cars the amount of privately owned cars will decrease drastically, so planning for example parking garages or private spots would mean a big effort in terms of construction and emissions, while they might be in use only for a few years, afterwards they are just dead space with little reuse potential.
But this does not mean there is no car access to the houses. It is possible to drive to every home, which is necessary for large deliveries or if people are moving, just to mention a few cases. However, due to speed limitations and the non availability of parking spots it is more convenient to abstain from using the car in the daily life and walk, go by bike or use public transportation.
The bus, which is currently going along Sagveien is redirected through the plot, with bus stops not further than 500m apart form each other, which are located close to places with public functions and where a lot of people live, such as for example between the greenhouses.
A bike and pedestrian axis is introduced to allow for easy travel in East-West direction. Implemented as a promenade along the river, away from the car traffic it connects the residential areas to the public areas, as well as the surroundings with Eidsvollbygningen in the East, Sagmoen in the South and eventually Hurdalssjøen in the West. Bike sharing spots are aligned along this axis, where primarily cargo bikes are offered, since most of the residents probably already have a bike. A cargo bike is a useful alternative to a car for doing the weekly grocery shopping, bringing the kids to kindergarten or transporting large objects.



Scheme nature

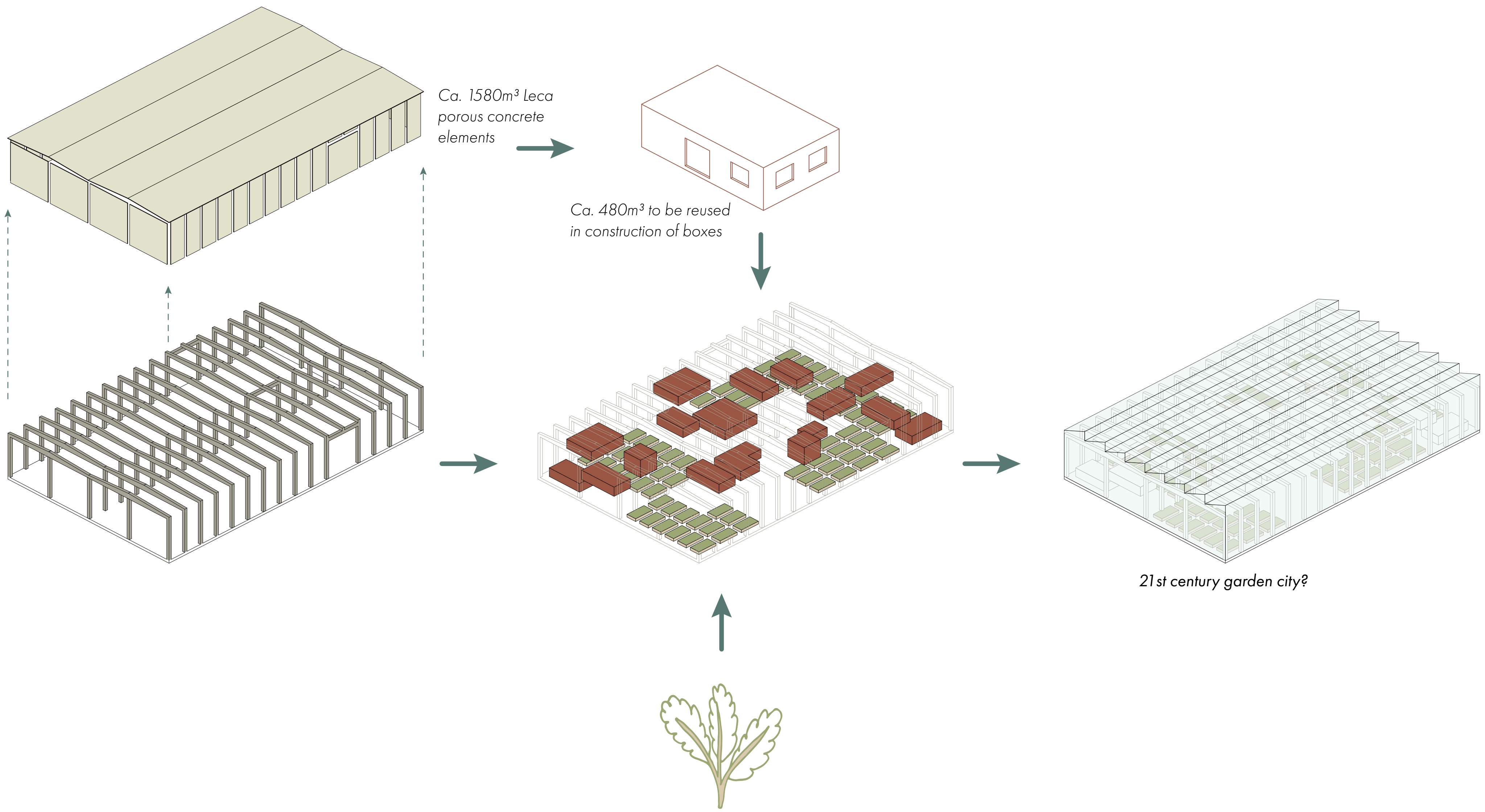
Visiting the site it became apparent that nature is an important factor and has to be dealt with carefully. The river is already prominent and very present, but also forest and open green areas are important, providing space for recreational activities. With the new design proposal, this is enhanced by creating parks around the industrial buildings, where timber production, storage and infrastructure used to be, bringing back greenery to these heavily used ares. The greenhouses are embedded in this green patch complementing the concept, thus strengthening the connection to the surrounding nature.


Taste COFFEE
GOURMET STREET KITCHEN


HOME GROWN

Concept greenhouse

The existing industrial buildings will be dealt with in different ways: Some of them will be torn down due to very poor condition, but some can be reused, filled with new functions or even be transformed into greenhouses. In this thesis, besides the urban design, the possibilities of a transformation to a greenhouse is investigated, analyzing the benefits and feasibility. This is done on the basis of one example building, but the same strategies could be applied to the other ones as well.
Generally, the structure of those buildings worth keeping is in good condition, but the wall and roof filling in between the concrete columns and beams show decades of industrial use and would not be suitable for the new functions. The fillings are made of Leca porous concrete elements measuring 17.5cm in thickness, 60cm in height and 5.55m in length (the whole distance between the columns/beams). [13] For the pilot building the total volume of elements accounts for ca. 1580m³. The greenhouse will become a hybrid building between food production, public and residential functions. The latter will take place in boxes, suspended from the concrete structure. Assuming that not all of the concrete elements are in terrible condition about 30% could be reused in construction of those boxes. Adding glass on the outside of the structure creates a passively conditioned thermal zone, where not only the time of comfortable "outdoor" condition is prolonged, it also reduces the energy and/or insulation demand for the residential functions. Furthermore, reusing the Leca elements would add additional thermal mass inside the greenhouse, contributing to a slow and even temperature change, which is desired to prevent from overheating in summer and helps keeping the temperatures higher in winter.



Transformation process

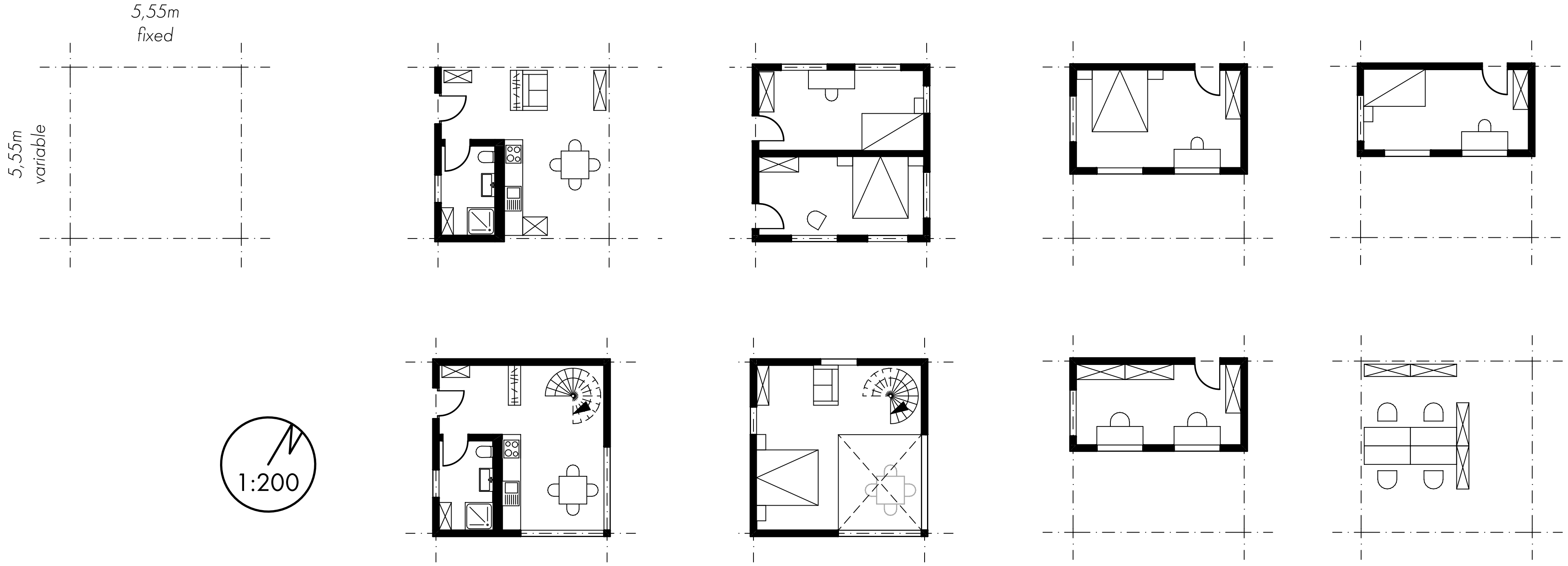
Transforming an old industrial building into a mixed-use greenhouse is far from conventional, therefore the suggested process would begin with transforming one building as a pilot project, learn from it and apply the gained knowledge in the development of the other buildings in the future. Meanwhile the other buildings can be used temporarily for relevant functions at the time such as car park or car sharing stations. This would be beneficial to bridge the gap until autonomous infrastructure is fully developed.
The different scenarios are thought possibilities, but can be adjusted to the need at the time.

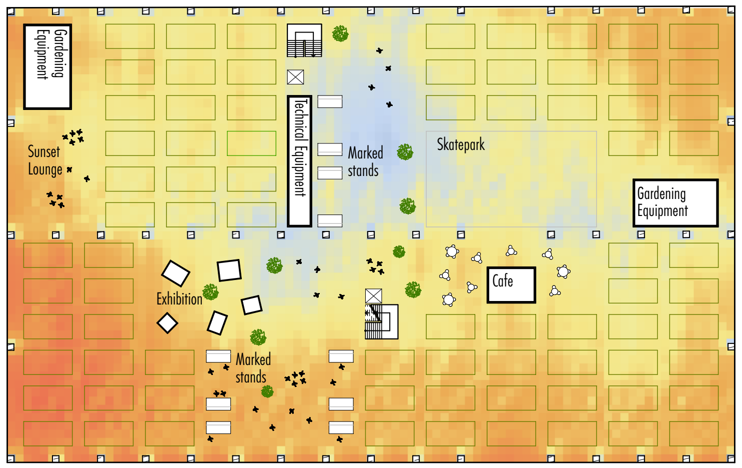
Greenhouse lower level

As described in the transformation process, the building the furthest to the West is chosen as a pilot. It used to be a warehouse, where the cut and dried lumber pieces were stored, waiting to be processed further. The building measures about 55m by 90m in size and is approximately 15m tall. The hefty concrete structure dominates the interior, columns and beams are set up in linear grid, with a distance of 5.55m in between. The location and orientation of the greenhouse is defined by the original building, however, the entrances are moved in a way that it connects the blocks in the North with the river in the South, creating an axis through the center of the building. This is where public functions are allocated and stairs and elevators lead to the upper level. Further to the edges the planting units are placed to allow for maximum solar radiation to hit them.

Greenhouse upper level

On the upper level the boxes are arranged in a way that they shade the lower level the least amount possible, more specifically the areas with planting units. This is shown in the solar radiation analysis below, the radiation intensity increases from blue to red. The boxes contain different functions: apartments for one to four people, a working space or a common kitchen. Since the distances between the boxes are quite short, the units are located on different heights and oriented in a way that it is impossible to see into each others private rooms.
The layout of the boxes is based on a modular system. The underlaying grid is 5.55m in East-West direction, defined by the concrete structure from which the boxes are suspended. In North-South direction the length is variable, but in most cases 5.55m is used as well, so the modules can be rotated by 90° and used in more flexible ways.
The base module is the kitchen-bathroom module with all the piping and wiring installed. Different modules have different "docking sides" where there is no necessary wall and where they can be connected to another module. Then there are different modules for different bedroom constellations and work places.
The modules are prefabricated, so the layout of the boxes and the whole upper level can be changed later. Without a big effort modules can be added, removed or replaced to fit the current demand.

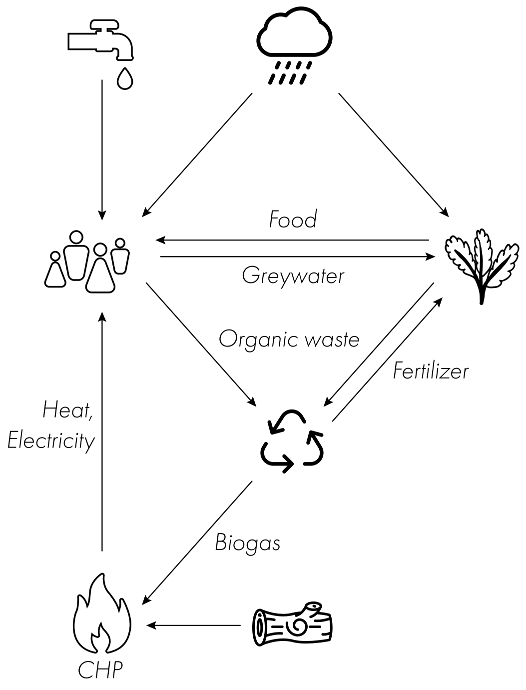


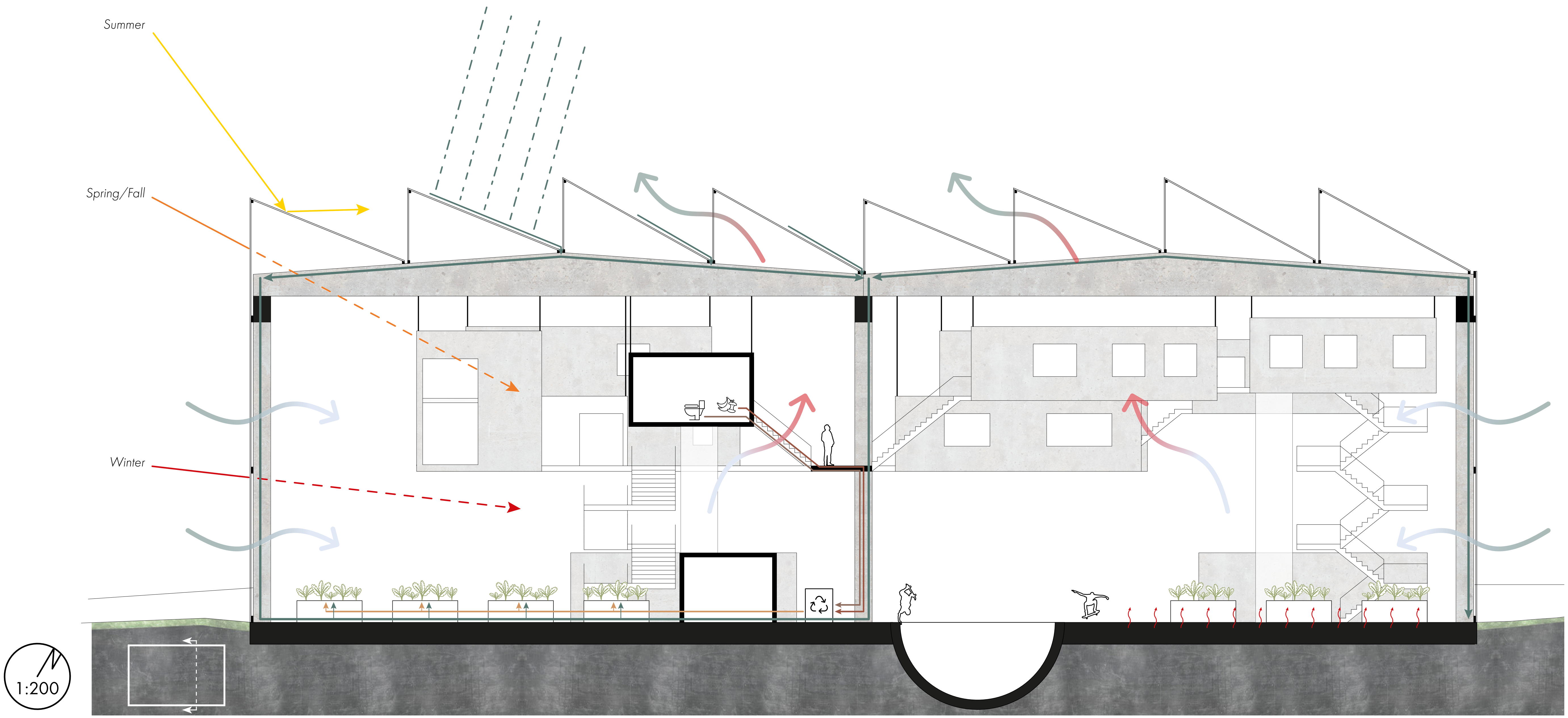


Yearly solar radiation analysis

Greenhouse strategies

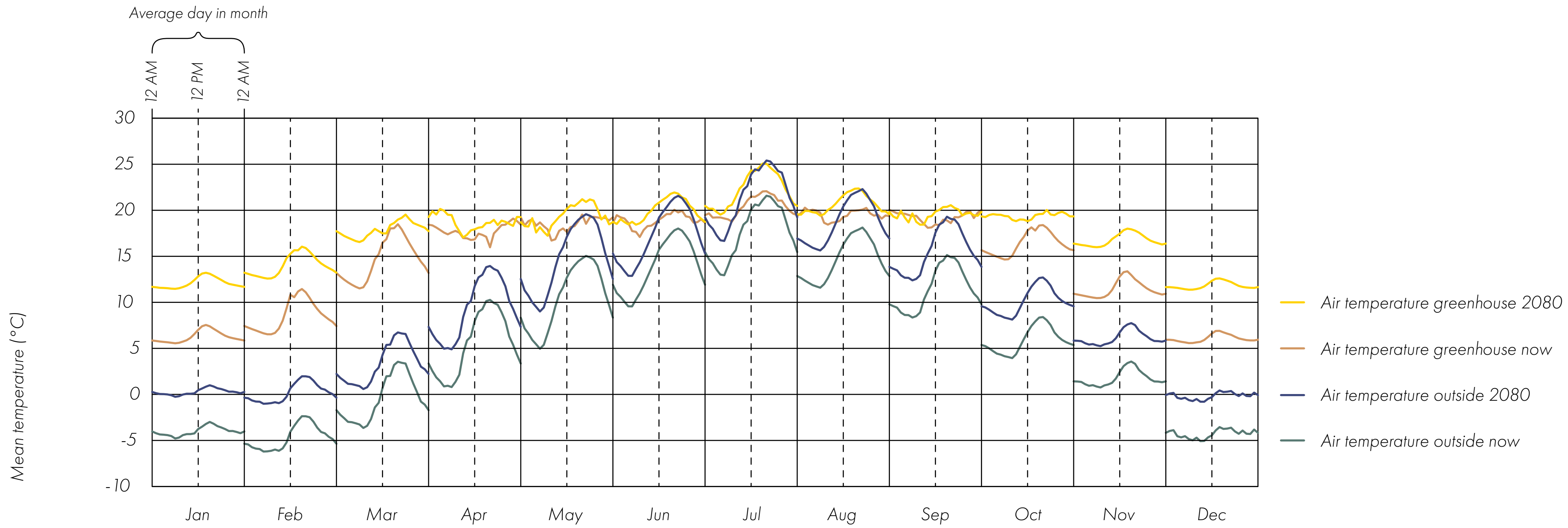
Transforming the existing buildings into a mixed-use greenhouses has many advantages. First of all it creates a shell against the weather, so for the functions and buildings inside, no measures against water, wind or snow have to be taken. Secondly, the inside of the greenhouse is a climatic buffer-space, where the temperature will be generally warmer than outside, due to the heating effect of incoming solar radiation. Both allow for an area to be designed as an outdoor-space, while extending the period, where the conditions are comfortable.
The technical systems are designed as a network, where resources are circulated until there is no use for them anymore. That way the amount of input and waste that cannot be recirculated are kept to a minimum.



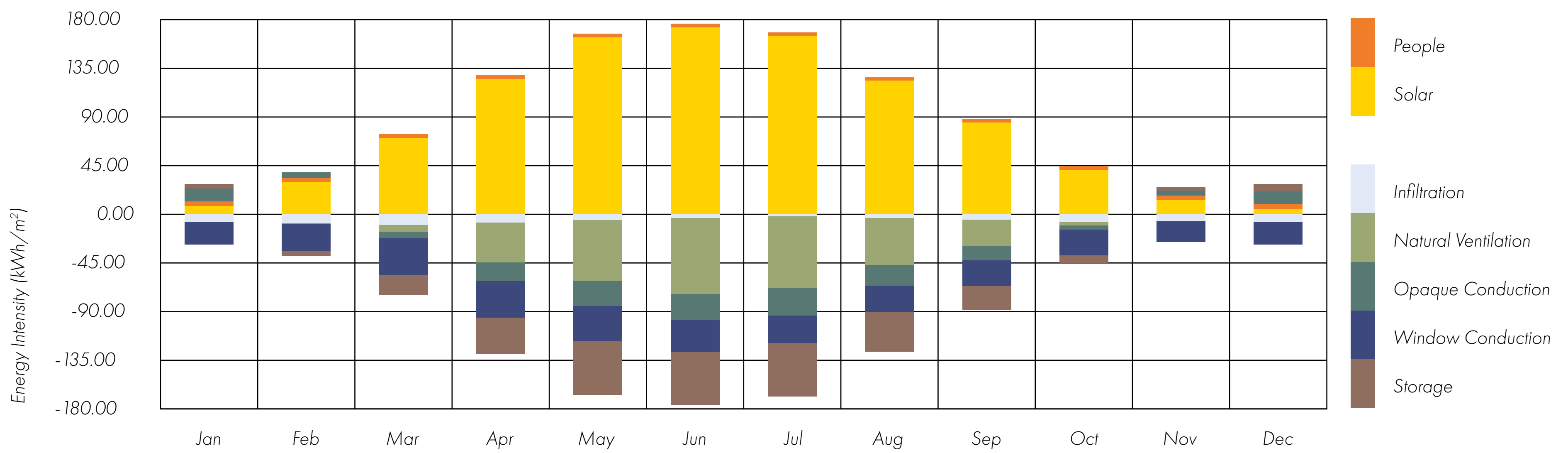


Greenhouse energy

The glass shell creates a passively conditioned climatic zone, heated through solar radiation and cooled by natural ventilation. Thermal mass, mostly the 1m thick concrete slab, but also the boxes, acts as a heat sink flattening out the amplitude of the air temperature. For this simulation a U-value for the glass of 1.0 W/m²k is assumed and standard values for the specific heat capacity of the concrete slab. [14] Only natural ventilation is considered as a cooling strategy for the greenhouse, due to the high air volume that has to be handled, which would be inefficient or not be possible at all using mechanical ventilation. For the boxes and technical spaces mechanical ventilation would be used, but that is outside the scope of this simulation. For peak ventilation load, especially during summer it is assumed that up to 50% of the facade and roof is openable. To simplify the simulation, the emitted heat from the boxes is not considered.
The results show the hourly mean temperature profile of an average day for each month. It can be seen that the temperature is higher in the greenhouse than outside, and natural ventilation successfully prevents overheating. Running the simulation for different climate scenarios, which takes climate change into account show, that even then overheating issues can be addressed. Furthermore, the greenhouse could probably be used all year long for planting, as well as recreational activities.



Hourly mean temperature profile



Energy balance

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